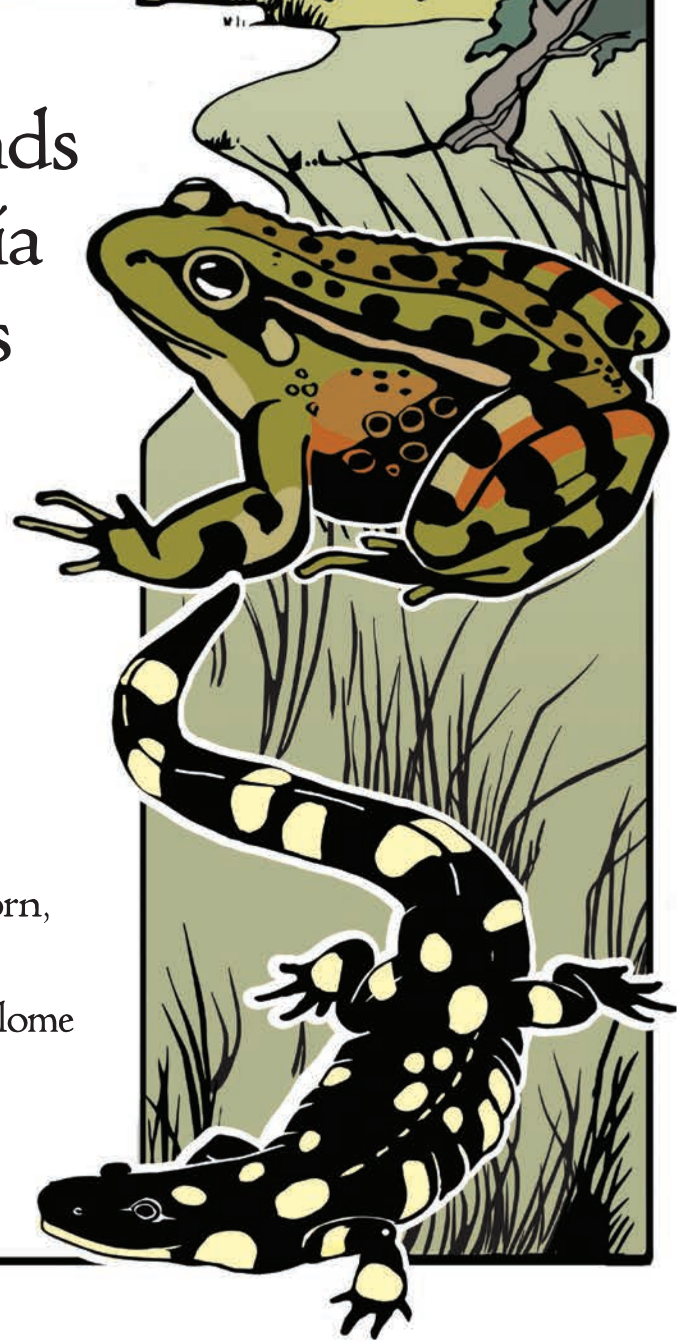
Managing Rangelands to Benefit California Red-Legged Frogs & California Tiger Salamanders



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Prepared for the Alameda County
Resource Conservation District

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Reviewers

The following individuals provided comments on an earlier draft of these guidelines. We aimed to address these comments, and to note substantial disagreements among reviewers. Inclusion on this list is not meant to imply all reviewers' full agreement with all of the statements made in these guidelines.

Mark Allaback, Biosearch Associates

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Introduction 1

California red-legged frogs (*Rana draytonii*) and California tiger salamanders (*Ambystoma californiense*) were once found throughout much of central California, from the Pacific coast to the Sierra Nevada foothills (Fellers 2005, Shaffer and Trenham 2005). As wildlands have been developed for human uses, however, their populations have suffered and their ranges have shrunk. Both amphibians are now rare outside of the central Coast Ranges. The California red-legged frog (CRLF) population is severely reduced in the Sierra Nevada foothills and southern California, and the species is federally listed as threatened (USFWS 1996). California tiger salamanders (CTS) are also federally listed as threatened, with the Sonoma and Santa Barbara County populations designated as endangered (USFWS 2004; CDFW 2010b). CTS are also state-listed as threatened (CDFW 2010b).[1]

There are many causes of these amphibians' declines, but habitat loss and habitat fragmentation are the chief factors. Many of the landscapes that constitute good habitat for both species—grassland, oak savanna, open woodland, and shrubland—have also been the prime sites for urban and agricultural development in California during the last 150 years. As a result of this development, substantial aquatic and terrestrial habitat for these animals has become unusable or been destroyed outright.

Fortunately for these amphibians, relatively large tracts of land within their original ranges have remained free of housing developments, highways, parking lots, channelized streams, and plowed fields. Where these areas provide suitable bodies of water for breeding and sufficient refuges during the dry season (seeps, springs, streams, and ponds for the frog and rodent burrows for the frog and salamander), these animals have hung on and even, in many cases, flourished. Much of this remaining CTS and CRLF habitat is used for livestock grazing.

Ranches and grazed public lands are vital to the California tiger salamander and the California red-legged frog not just because they have remained undeveloped but because grazing as a land use is compatible with—and to a great extent beneficial for—conservation of both of these rare amphibians. One important factor is that livestock ponds have become crucial breeding habitats for both animals (Fellers 2005; Holland et al. 1990). In addition, grazing significantly reduces the biomass of the exotic annual grasses that now dominate upland (terrestrial) habitat, lowering fire risk and preventing the degradation of habitat conditions that would occur if the grasses were left unmanaged. Because of these and other factors, the positive aspects of ranching and grazing have been increasingly recognized in discussions of

[1] Please refer to the Appendix for an overview of relevant regulations and protection status for these amphibians.

CRLF and CTS recovery (e.g. Stokstad 2004; USFWS 2004; USFWS 2006; USFWS 2010). Indeed, it was the conversion of *grazing* lands—not land in general—to housing, cropland, and other uses in recent decades that was cited by the US Fish & Wildlife Service (USFWS) as one of the primary reasons for listing the California tiger salamander. The Service also noted that the California red-legged frog would have an even smaller current distribution were it not for the creation and maintenance of livestock ponds by ranchers (USFWS 2010).

Clearly, range managers have a crucial role to play in the conservation of the CRLF and the CTS. By maintaining livestock ponds and managing rangelands with general conservation goals in mind, they can perpetuate populations of CRLF and CTS on ranches and public grazing lands. Many range managers, however, are motivated (or required) to do more. Rather than having survival of CRLF and CTS populations on the lands under their stewardship be a by-product of otherwise good management, they want to manage specifically *for* one or both of these rare amphibians, to help them thrive and increase their numbers. An increasing number of public and private land managers are confronting this challenge—to meet the requirements of a permit or easement, or simply out of concern for the wildlife that call a ranch home. This requires a knowledge of the amphibians' life cycles, behaviors, and biological needs, and how these intersect with rangeland management practices. Unfortunately, tapping this knowledge is often not as easy as it should be. Much of the available guidance has been contradictory, insufficient, or misguided.

There are reasons why sound advice on how to manage rangeland for the CRLF and CTS is hard to come by. Using livestock to meet habitat objectives is a complex project, and coming to valid conclusions about how to carry it out requires expertise in different disciplines as well as on-the-ground experience. Most of the managers, biologists, and others involved in management decisions, however, have training only in range management or in wildlife ecology (or neither). Compounding the problem, relatively little scientific research has been published on several important questions, such as the effects of different grazing regimes on upland (terrestrial) habitat. And the actual needs of the frog and salamander do not always conform to common assumptions about habitat quality. For instance, muddy stock ponds devoid of vegetation often provide high-quality CTS breeding sites even though they look barren.

The aim of this document is to provide management recommendations based on the best available information: existing scientific research on the CRLF and CTS and the expertise of individuals who study or manage CRLF and CTS habitat. To construct these guidelines the authors have reviewed the relevant literature (relying when possible on peer-reviewed scientific journal articles), consulted relevant reports from management agencies, and synthesized the extensive knowledge and field experience of various experts, including co-authors Dr. Norman Scott (CRLF), Dr. Pete Trenham (CTS), and Dr. James Bartolome (California rangelands), and numerous biologists and public and private land managers.

These guidelines are meant to apply range-wide to the frog and salamander. We note that there are habitat and population differences in different parts of the state, and that future research might indicate the need for different management strategies in different areas. This is particularly true for the Sonoma County and Santa Barbara County populations of CTS, both of which are genetically distinct from other populations (Shaffer et al. 2004). Sonoma County is also more developed and sub-divided than the rest of the land in the salamander's range, and it receives more rainfall (Cook et al. 2006). CTS in Sonoma County and the Central Valley also depend much more on vernal pools for breeding habitat than they do in many other regions. For CRLF, there may be relevant differences between coastal versus inland areas, and between relatively dry landscapes and those with abundant moist refuges.

This document is intended for use by anyone involved in the stewardship of CRLF and CTS habitat. These individuals include ranchers, public land managers, biologists, regulators, and extension professionals[2]. Ranchers and public land managers who voluntarily aim to improve habitat may refer to this document for current recommendations. We recommend that this include a review of each species' biology (Chapters 2 and 3). On-the-ground managers generally have unique knowledge of their properties and grazing operations and, with a full understanding of the goals, can be the best equipped to determine site-specific approaches. When formal planning is required, this document can provide all parties with the same understanding of habitat goals and appropriate management practices. The habitat goals also provide targets that can be used in formal or informal monitoring efforts. Managers already following an existing plan for the maintenance or enhancement of amphibian habitat may want to compare those plans to the information and recommendations contained here. Research scientists may find this booklet helpful in identifying the gaps or weaknesses in the current literature.

Our discussions focus on grazing by cattle, the most common and best-studied livestock animal on California rangelands. Other types of livestock can be used to achieve CRLF and CTS habitat objectives, to the extent that their foraging behaviors are suited to the management approaches recommended for the given objective. Many objectives relate to the consumption of annual grasses and are best suited to "grazers"—cattle, horses, and other livestock that prefer grasses and similar forage—and intermediate feeders such as sheep, as opposed to "browsers" such as goats that prefer non-grassy forage.

These guidelines should be viewed as a work in progress; updates will be needed as scientists and managers continue to learn about habitat needs and successful management techniques. Many of our suggestions and conclusions are based on observations in many habitats, but would ideally be tested with rigorous experimentation and adjusted accordingly.

[2] With this diverse audience in mind, we use English Imperial measurement units such as yards and miles, and have converted the metric values in journal articles to approximate Imperial equivalents.

California Red-legged Frog Biology 2

This is a brief overview of the biology of the California red-legged frog, focusing on issues relevant to managers. For more information, including maps of current distribution, please refer to Bulger et al. (2003), Hayes and Jennings (1988), and USFWS (2010).

Life History

The CRLF life cycle and the movements of individuals across the landscape are synchronized with the typical Mediterranean climate of warm, dry summers and early autumns, and cool, wet winters and springs (Scott and Rathbun 2006). Unlike many reptiles, mammals, and birds, which begin breeding as temperatures begin to warm in the spring, CRLF respond to the onset of the rainy season. When autumn rains soak the dry landscape, adult CRLF move from dry-season refuges to ponds and stream pools that can support breeding and successful tadpole development. Breeding behavior usually occurs from December to April. Females deposit large masses of eggs just below the surface of relatively still water. Eggs hatch within weeks after being deposited, depending on water temperature. Tadpoles generally take until late summer or early fall to complete metamorphosis (in some cases, tadpoles will over-winter and transform the following year [Fellers et al. 2001]). The maturing young frogs ("metamorphs," frogs in the first few months after metamorphosis) soon move to the shallow waters of their birth ponds or other water bodies where they take cover from predators, including adult frogs.

Adult frogs often remain year-round at perennial ponds with deep water, but some depart for dry season refuges once breeding is over. Metamorphs disperse with the onset of the rainy season, at the latest, even if the pond stays inundated year-round (Allaback et al. 2010.). Juveniles (frogs that are older than metamorphs but not yet sexually mature) disperse widely over the landscape during the first winter, and will take residence in almost any water source. Most males and some females start to reproduce in the late winter or spring of their second year following metamorphosis, and every year afterwards (Scott and Rathbun 2006). Only about one third of adults survive each year, but some will live up to eight years.

During the dry months of summer and fall, a frog's central challenge is often finding a suitable dry season refuge. These may include deep water holes in drying streams, springs and spring boxes, seeps, and ground squirrel burrows. To find these refuges, frogs will travel several hundred yards where suitable refuges are abundant, and up to three miles in moist coastal areas (Bulger et al. 2003; Scott and Rathbun 2006; Fellers and

Kleeman 2007). During their travels through terrestrial vegetation, CRLF can temporarily take refuge in damp leaf litter. The cycle repeats itself each year as adult frogs move toward their breeding sites in the fall and winter, sometimes traveling several months to reach one. During wet periods in the rainy season, they can wander widely and remain at temporary residences distant from any body of water.

Breeding Site Requirements

To breed successfully, California red-legged frogs need calm bodies of water that provide a particular set of characteristics essential to tadpole survival and metamorphosis. Breeding sites must also provide a safe environment for the adults that go there to mate and lay eggs.

Inundation Period

To support successful reproduction, breeding sites (ponds, stream pools, and marshes) must be inundated long enough to allow for tadpole development and metamorphosis. Eggs are laid as early as the beginning of December, and some tadpoles do not complete metamorphosis until September. Therefore the optimal inundation period is from December through September. However, an inundation period ending in July would allow some successful breeding. Breeding sites must have shallow sections during the winter for eggs and tadpoles; shallow sections can gradually dry after that so long as the pond or pool retains some water through August or September.

Vegetation

CRLF generally need breeding sites with a mix of open surface water and vegetated cover (Hayes and Jennings 1988), and appear to tolerate a wide range of edge and emergent cover amounts. Adult survival is dependent upon at least a small amount of emergent, submerged, floating, or edge vegetation to provide cover from predators; this is especially important if non-native predators such as bullfrogs or game fish are present. Emergent or submerged vegetation is also important in providing structure for attachment of eggs. However, ponds that become completely choked out by cattails and similar emergent vegetation are unsuitable as breeding habitat because the shading cools the water, which discourages breeding.[3] Managers at the East Bay Regional Park District have observed that CRLF were most common in ponds supporting up to 40% cover of emergent vegetation, but were found in ponds with as little at 5% cover (Bobzien and DiDonato 2007). However, consistent breeding of CRLF has been documented in a shallow perennial wetland that grows dense with vegetation in the summer but has some warm, unshaded water earlier in the season to support tadpole development (M. Allaback, pers. comm.).

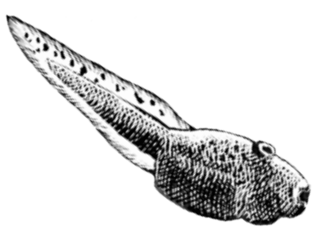
Water Depth

The depth of ponds and pools is important in how it affects water temperature, predator avoidance, growth of vegetation, and inundation period. Pond sections with deep water are typically needed for CRLF adults, and shallow areas are needed for tadpoles and juveniles (Scott and Rathbun 2002). The deeper areas should generally be deep enough

[3] Water temperatures in ponds with unshaded areas can be much warmer than the air temperature in cooler months. For instance, Rathbun (2012) measured temperatures in and above a largely unshaded pond in San Luis Obispo County, for six days in May, and found that average water temperatures were significantly higher than the average high air temperature for the period, especially near the surface. Air temperatures ranged from approximately 43 to 59 degrees Fahrenheit, while water temperatures ranged from approximately 63 to 84 degrees Fahrenheit.

(deeper than one yard) to provide adult frogs an escape from predators. Depths of at least five feet help to discourage cattails and bulrushes from establishing; these plants can choke the open surface and shade the pond. As noted above, tadpoles require water shallow enough to allow warming of the water in late winter (but generally no shallower than eight inches). CRLF generally lay their eggs in shallow waters, with eggs laid at depths averaging approximately six inches in a study of multiple breeding site types (Alvarez et al. in prep.).

The conditions described above are generally preferable, but other conditions can be sufficient. CRLF can successfully breed in shallow perennial wetlands (approximately 4–24 inches deep) that are free of non-native predators or have enough shallow, densely vegetated areas to allow CRLF to avoid predators (M. Allaback, pers. comm.). CRLF have been found breeding in eastern Contra Costa stream pools that were two feet deep, and in East Bay creeks that were even shallower for long stretches (J. Alvarez, pers. obs.). In the latter case, eggs were laid in waters less than six inches deep. (Evidence of breeding does not guarantee that tadpoles ultimately survived to metamorphosis, and it is not known just how tolerable these more shallow ponds are.)



Water Quality and Temperature

CRLF occur in a wide range of water quality conditions. Bobzien and DiDonato (2007) found CRLF to be disproportionally common in East Bay Regional Park District ponds with relatively clear water, although the frogs did tolerate a wide range of turbidity (median 4.6 NTU, range of 0.9–326 NTU). For dissolved oxygen and nitrate levels, ponds with CRLF did not markedly differ from ponds without the frog. CRLF were found in ponds ranging from 0–24.5 mg/L dissolved oxygen, and from 0–4.0 mg/L nitrates, reflecting the range of conditions observed across all ponds studied. Very high nutrient levels can lead to eutrophication and depleted oxygen levels, and have been linked to disease and deformation in amphibians in some Contra Costa stock ponds (J. Alvarez, pers. comm. and data in preparation). Some nutrients, however, are needed to support a food base for CRLF (pers. obs. by author Scott). CRLF prefer surface water temperatures above 60 degrees Fahrenheit, but are still common when temperatures are roughly 50 degrees (Scott and Rathbun 2006). Summer surface water temperatures above 80 degrees appear to be optimal.

Predation and Other Causes of Mortality

Native predators of CRLF in breeding sites—eggs, tadpoles, metamorphs, and adults—include newts, snakes, raccoons, herons, hawks, owls, and a variety of other birds. Non-native predators, such as bullfrogs, crayfish, mosquitofish, and especially game fish (such as bass or bluegill), are a significant threat in perennial ponds and streams (Hayes and Jennings 1988; USFWS 2004; USFWS 2010), but are sometimes tolerated at low densities (Lawler et al. 1999; J. DiDonato pers. comm.). Hybrid tiger salamanders (discussed in the following chapter) also prey on CRLF tadpoles (Fitzpatrick and Shaffer 2007b). Deep water and vegetation can help tadpoles and adults avoid becoming meals for these other animals.

Some pesticides and herbicides are linked to CRLF mortality, and could seriously degrade contaminated breeding habitat. Upwind agriculture has been correlated with CRLF declines in otherwise unmodified locations (Davidson et al. 2002). The Environmental Protection Agency and US Fish and Wildlife Service are currently reviewing many pesticides and herbicides, including 2,4-D, diazinon, and glyphosate, to determine if they adversely affect the frog (CDPR 2013a).

Infectious pathogens, including ranaviruses and the chytrid fungus, can infect CRLF and are potentially harmful (V. Hemingway, pers. comm.). CRLF are also susceptible to infection, deformities, and mortality caused by the parasite *Ribeiroia ondatrae* (M. Shea, pers. comm.). The latter particularly affects ponds with eutrophic conditions and low amphibian diversity (Johnson et al. 2013), and may be reduced by desilting ponds (J. Alvarez and M. Shea, pers. comm.).

Requirements Specific to Streams

To support breeding, streams (or portions of streams) must be slow-moving and have pools that provide the conditions described above. Optimal habitat conditions for breeding include patches or strips of riparian vegetation (such as cattails, bulrushes, and willows) and patches of sunlight (Scott and Rathbun 2006). CRLF don't typically breed in densely shaded streams.[4] Dense riparian vegetation and associated woodlands just outside of streams can be important during episodes of flooding or increased salinity in coastal lagoons, or drought. Logs, rootwads, boulders, overhanging banks and other forms of cover are important (Tatarian 2008). Relatively level and slow-flowing stream reaches are preferred for breeding (Bobzien and DiDonato 2007). As discussed in the Water Depth section above, stream pools do not need to be as deep as ponds to serve as breeding sites (perhaps 1.5 feet or less, as compared to the one yard ideal minimum depth in ponds).

Non-breeding Habitat Requirements

Juveniles and non-breeding adults need moist areas in which to take refuge, and they need to be able to move safely between breeding and non-breeding sites.

Dry Season Refuges

Refuges must have enough moisture to allow survival throughout the non-breeding period and enough cover to moderate temperatures during hot and cold weather and to provide protection from predators. Refuges are probably most valuable when they exist within roughly a hundred yards of breeding sites and other occupied water bodies (Bulger et al. 2003; Tatarian 2008).

Ponds and streams can provide suitable non-breeding habitat even if they do not meet all the requirements for breeding. CRLF juveniles and adults will occupy streams with a very wide range of slope, especially for non-breeding habitat (Bobzien and DiDonato 2007). As is the case for streams used for

[4] It is possible that shade from willows is more suitable (B. Mori, pers. comm.), and shade from eucalyptus and bay laurel canopies especially unsuitable (J DiDonato, pers. comm.). CRLF tadpoles and egg masses have been observed in shaded creek pools in Contra Costa County (B. Mulchaey and J. Purificato, pers. obs.), although the number surviving to metamorphosis is not known.

breeding, streams with dense riparian vegetation, logs, rootwads, boulders, overhanging banks and other forms of cover are important in non-breeding habitat (Tatarian 2008).

Springs, accessible spring boxes, vegetated seeps, and similar moist habitats are important sources of dry season refuge (Scott and Rathbun 2006). These refuges, which generally remain moist year-round, even in drought years, are critical in areas where all the breeding sites are seasonal.

CRLF will also take shelter in less conspicuous upland locations. Ground squirrel and gopher burrows in particular can be helpful as refuges (this was a widespread observation among our reviewers). These burrows may be especially important where wetter refuges are lacking (Tatarian 2008). CRLF will sometimes spend the daytime hours in burrows near ponds, and then enter the ponds at night (J. DiDonato, pers. comm.). As noted earlier, accumulations of damp leaf litter or duff in semi-open or riparian woodlands can also serve as refuges.

Terrestrial Vegetation

CRLF will use or move through a variety of plant community types. Grasslands and savannas are the main terrestrial habitat used. CRLF will often take refuge under shrubs, and will move though a variety of habitat types including forest, woodland, and cropland (Bulger et al. 2003). Large expanses of closed-canopy forests and some shrubland types might pose a barrier to movement, but more research on this question is needed. CRLF in some areas use riparian corridors to move between breeding and dry season locations (Fellers and Kleeman 2007, Marin County), but in other areas do not tend to do so (Bulger et al. 2003, Santa Cruz County).

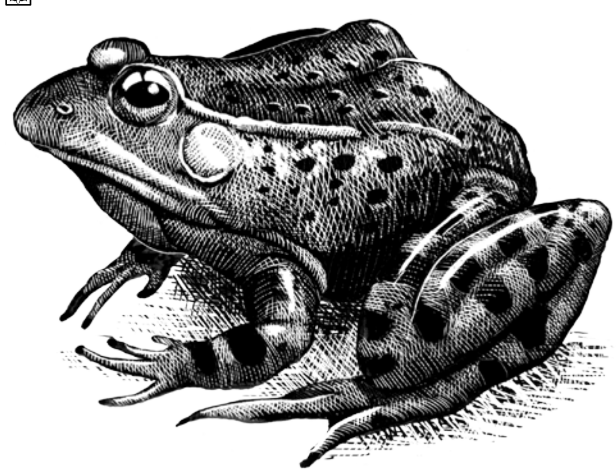
It is our opinion that dense, tall herbaceous vegetation may slow dispersal (pers. obs. by author Scott). Very dense herbaceous vegetation surrounding a breeding site could affect migration in or out of that site. CRLF have been observed moving through vole tunnels in dense grass (N. D'Amore, pers. obs.), but it is our opinion that CRLF are likely using such vegetation as shelter and not moving long distances through it.

Prey

Juvenile and adult CRLF primarily eat terrestrial invertebrates and small vertebrates such as mice. CRLF are usually not limited by prey availability in their terrestrial habitats (pers. obs. by author Scott), although heavy use of pesticides could reduce insect prey numbers to levels affecting adult survival. These frogs are most successful feeding where they find refuge at the covered edge of open water or open ground or in a mosaic of open ground and woody foliage or litter.

Predation and other Causes of Mortality

Predators of juvenile and adult CRLF include snakes, raccoons, a variety of predatory birds, bullfrogs, bass, and other game fish (Hayes and Jennings 1988; USFWS 2010). As they do for tadpoles and metamorphs, some pesticides and herbicides pose a risk to juvenile and adult CRLF.



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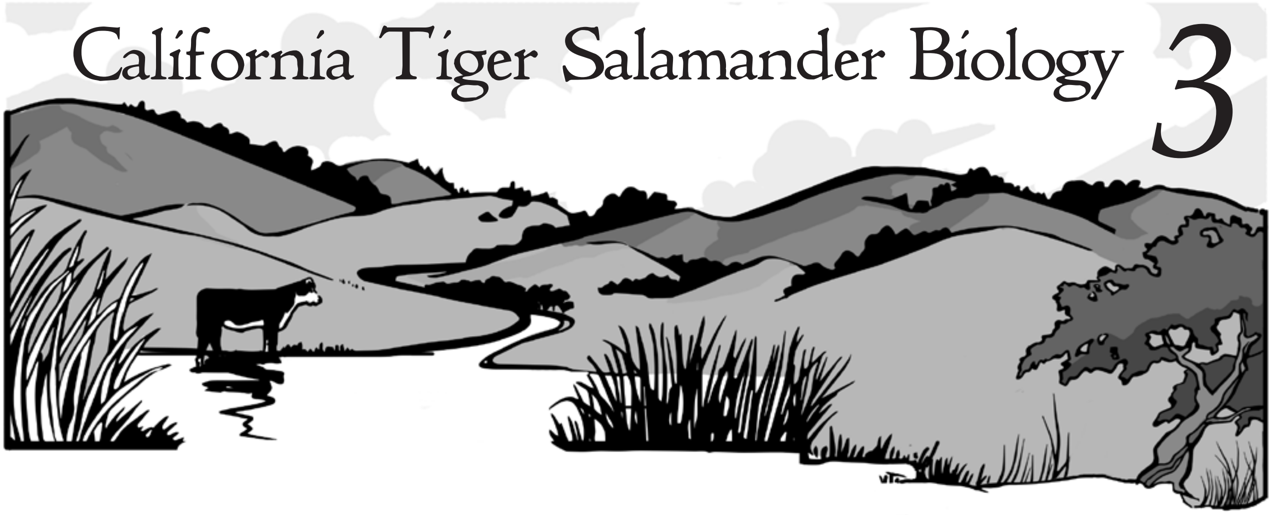


This is an overview of the biology of the California tiger salamander, focusing on the issues and facts relevant for managers. For more information, including maps of current distribution, please refer to USFWS (2004) and CDFW (2010a).

Life History

California tiger salamanders breed in ponds, vernal pools, and, on very rare occasions, streams (Alvarez et al. in prep). They spend the remainder of their life cycle primarily in grasslands and savanna, taking residence in the burrows of ground squirrels and other rodents.

Breeding adults can begin to migrate to aquatic habitat with small early rain events in mid-fall (Trenham et al. 2000; Searcy and Shaffer 2008), and large numbers often move with the first substantial rains later in the season (Twitty 1941; Loredo and Van Vuren 1996). The salamanders travel to breeding sites at night, generally during or following rains (Barry and Shaffer 1994; Loredo and Van Vuren 1996; Cook et al. 2006). Breeding success varies with precipitation. In wetter years there is more breeding activity and more larvae complete metamorphosis (Barry and Shaffer 1994); in drought years, breeding activity is reduced and many or all of the larvae produced at a pond may fail to survive to metamorphosis (since many ponds dry early). Breeding generally peaks mid-winter and can continue through spring (Loredo and Van Vuren 1996; Trenham et al. 2000), depending on rainfall and geography. Cook et al.'s (2006) study of a Sonoma County vernal pool revealed that CTS bred earlier in the year, and for shorter periods, than CTS in the central portion of the species' range. They noted that Sonoma County receives roughly twice the annual rainfall of Central Coast Range counties, and surmised that regional differences could extend to other aspects of the life cycle. They noted the need for studies on (for instance) the timing of metamorphosis in Sonoma County populations, and concluded that "data collected elsewhere may not be appropriate for guiding management in Sonoma County."

Males can enter and leave breeding sites several times a season, while females will generally enter a site for one to two weeks, mate and deposit eggs, and then return to upland habitat for the year. As they do in moving to their breeding sites, adults leaving breeding sites travel at night, generally during or soon after rain events (Trenham 2001).

CTS larvae generally require four to five months for successful metamorphosis (Shaffer and Trenham 2005), and longer inundation is associated with larger juveniles and increased survivorship. Metamorphosis appears to speed up as ponds draw

down. Metamorphosis and emigration generally occur in late spring and early summer, with some larvae remaining until late August in long-lived ponds (USFWS 2004; Shaffer and Trenham 2005). CTS larvae have been observed overwintering in ponds (Alvarez 2004), but have never been documented to become sexually mature while still larvae (as is commonly observed in the non-native *Ambystoma mavortium*). CTS migrate away from ponds after metamorphosis, and may move farther from their birth ponds in the rainy seasons of successive years (Trenham and Shaffer 2005; Searcy and Shaffer 2008). Most appear to settle in summer refugia soon after metamorphosis, with a smaller number making additional moves during the summer.

The underground phase of the CTS lifecycle is often referred to as aestivation (the summertime equivalent of hibernation), but actual aestivation has never been observed, and recent research has shown CTS to be active within their burrows (Van Hattem 2004; Trenham, pers. obs.).

In a seven-year study of a stock pond in Monterey County, Trenham et al. (2000) estimated that less than five percent of embryos survived to metamorphosis, and less than ten percent of metamorphosed juveniles survived to breed. Individuals typically first bred at four or five years old, and as early as one year old (Trenham 2001; C. Searcy pers. obs). CTS can live thirteen or more years (C. Searcy unpublished data). Based on these demographic data, Trenham and Shaffer (2005) constructed a population viability model indicating that terrestrial survivorship of juveniles and adults is vastly more important than the number of eggs deposited or larval survivorship. The authors emphasized that the most influential variable—survivorship of juveniles—is the least studied.

Non-native and Hybrid Tiger Salamanders

California tiger salamanders can form fertile hybrids with introduced barred tiger salamanders (*Ambystoma mavortium*), a larger but related species that was introduced from the central United States in the mid-twentieth century for use as fishing bait (Riley et al. 2003). Hybrids are now spreading through the Salinas Valley, forming a "hybrid swarm." The success of hybrids in this heavily farmed region may be due to hybrids faring better than native CTS in pesticide - contaminated ponds (Ryan et al. 2013). The amount of introduced genes drops off steeply at the edges of the hybrid swarm (Fitzpatrick and Shaffer 2007a). However, hybrids are moving into surrounding areas, with some introduced genes appearing as far north as Alameda County's Ohlone Wilderness (Fitzpatrick and Shaffer 2007a; M. Ryan, pers. comm.). Hybrids have also been detected in Merced County (Fitzpatrick and Shaffer 2007a) and Santa Barbara County (one hybrid individual, S. Sweet, pers. comm.).

Ambystoma mavortium, which evolved in landscapes with perennial ponds, has the ability to overwinter in ponds, and in some cases to become sexually mature as larvae. Hybrid CTS may have some of these features; this would explain why introduced genes are more common in perennial stock ponds while native genes are more common in breeding sites that dry seasonally (Fitzpatrick and Shaffer 2004, 2007a). Both perennial and seasonal ponds in the Salinas Valley, however, support high levels of hybridization.

Hybrid larvae grow faster and reach larger sizes than the larvae of native CTS, and research indicates that hybrids would reduce native CTS survival (Ryan et al. 2009). Since hybrids and native CTS interbreed, invaded populations quickly become hybrid. Increased larval survivorship in hybrids could result in increased predation on other prey, thereby altering ecological dynamics. CTS are not the only listed species negatively impacted by hybrid CTS. Other species that could suffer due to the predation of hybrid tiger salamanders include CRLF, long-toed salamanders, and fairy shrimp species (Fitzpatrick and Shaffer 2007b, pers. comms. from M. Ryan and C. Searcy).

Breeding Site Requirements

Ponds and vernal pools require certain conditions for California tiger salamander adults to breed, and for their larvae to survive to metamorphosis. A good deal is known about the conditions that CTS thrive in or will tolerate. The most important factors appear to be related to inundation period, amount of emergent vegetation, and predation—all factors that can be highly influenced by management.

Inundation Period

CTS breeding sites must remain inundated until at least into May to allow for any successful metamorphosis (Shaffer and Trenham 2005). Longer-lasting sites are important mainly because they produce significantly larger numbers of metamorphosing juveniles. Ponds and pools that dry early produce fewer and usually smaller juveniles than those that hold water longer. Ideally, CTS pools remain inundated into July or August. However, it is generally best if they eventually dry out. Perennial ponds can support CTS, but have been linked to reduced CTS numbers due to increased predation (Fitzpatrick and Shaffer 2004; Bobzien and DiDonato 2007; Ryan et al. 2013) and perhaps other factors (M. Ryan, pers. comm.). See “Predation and Other Causes of Mortality” below for further discussion of non-native predators, hybrid CTS, and predatory insects.

Vegetation

The “classic” CTS breeding site is free of emergent vegetation (pers. obs. by author Trenham). Breeding appears to be rare with more than moderate levels of emergent vegetation. Aquatic vegetation, especially when it remains submerged, can be compatible with CTS reproduction. In the 2000 survey of 33 CTS breeding ponds in the East Bay Regional Park District, most had 0–5% cover of emergent vegetation, and none had greater than 35% cover of emergent vegetation (Bobzien and DiDonato 2007). The majority had little to no submerged vegetation, but breeding was also observed in ponds with very abundant submerged vegetation. The study’s authors suggest that more-vegetated ponds may support more predatory aquatic insects that prey on CTS larvae. On the other hand, Shaffer and Fisher (1991) found that bullfrogs only reduced CTS numbers in ponds without vegetation; so some vegetation appears to help CTS persist in ponds with bullfrogs.

Water Depth

It is often ideal for a CTS breeding site to have both deep and shallow areas. Deeper ponds generally remain inundated longer, while the warmth of shallow waters is believed to promote faster larval development and metamorphosis. Deep areas can also help CTS avoid herons and other predators, especially if the water is clear and unvegetated. Sloping or benched sides will provide both aspects throughout the drawdown period (NRCS 2006). A three-year survey of a large (1.85 acre) Sonoma County pond found that the minimum depth required to initiate breeding varied by year, and ranged from approximately two to four feet, which corresponds to half-full and full (Cook et al. 2006).

Although deep areas are beneficial, they are not essential. For instance, vernal pools generally lack deep areas but some can still remain inundated long enough to serve as breeding sites. Very large shallow pools (such as Olcott Lake, an approximately 80-acre vernal playa in Solano County) provide an excellent combination of warm water and long inundation period (pers. obs. by author Trenham).

Water Quality

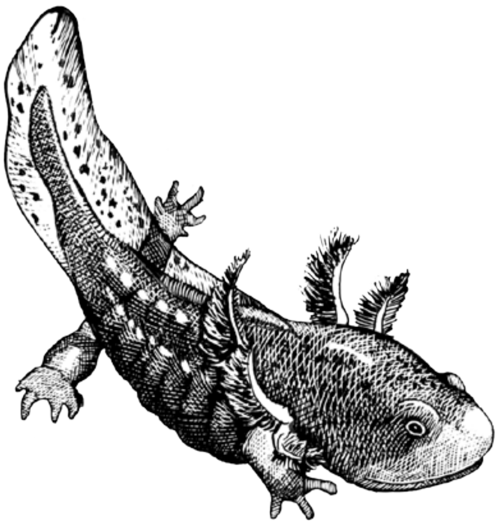
Bobzien and DiDonato (2007) compared the abiotic conditions of East Bay Regional Park District ponds with and without CTS. CTS were much more likely to occupy ponds with moderate to high levels of turbidity (median NTU of 35.5, range of 1.6–1000 NTU), and larval densities were higher in these ponds than in ponds with low turbidity. The general assumption is that turbidity can help CTS avoid predation (e.g. Jennings and Hayes 1994). The animals may avoid breeding in clear water, and/or suffer from heavy predation. Turbidity may be a factor only in relatively shallow ponds lacking emergent or submerged vegetation, where egrets, raccoons, and other natural predators can prey on CTS.

Very high nutrient levels can lead to eutrophication and depleted oxygen levels, and have been linked to disease and deformation in amphibians in some Contra Costa stock ponds (J. Alvarez, pers. comm. and data in preparation). Some nutrients, however, are needed to support a food base for CTS (pers. obs. by author Trenham). Bobzien and DiDonato (2007) did not find pronounced differences in the nitrate or dissolved oxygen levels of ponds with and without CTS, although they noted that all the ponds studied had low nitrate levels. CTS were found in ponds with median 1.0 mg/L nitrates (range of 0.0–4.5 mg/L) and median 8.7 mg/L dissolved oxygen (range of 3.2–30.1 mg/L).

CTS larval die-offs have been observed in a number of ponds suffering from pesticide contamination and perhaps other water quality impairments (Ryan et al. 2013). In one die-off observed in Salinas Valley, only hybrid CTS survived. The authors note that pesticides entering a pond can generally be expected to favor hybrid salamanders, because they tolerate a wider range of environmental conditions than native CTS and can persist on larger prey if invertebrate prey are reduced by pesticides. More research is needed. The Environmental Protection Agency (EPA) and USFWS are currently reviewing numerous herbicides, including 2,4-D and diquat dibromide, for potential impacts to CTS (EPA 2013).

Prey

CTS larvae mainly eat small zooplankton when young, while larger larvae eat a variety of amphibian tadpoles (and sometimes smaller CTS larvae) and invertebrates such as mosquito larvae and tadpole shrimp (Anderson 1968; Cook et al. 2005; pers. comms. from C. Searcy, S. Sweet, and P. Trenham). CTS larvae are an effective means of mosquito control because of their appetite for mosquito larvae (Cook et al. 2005).



Predation and Other Causes of Mortality

Native predators of CTS in ponds include herons, garter snakes, and predatory aquatic insects such as diving beetles, dragonfly nymphs, and water bugs (Shaffer et al. 1993; USFWS 2004). Small larvae will also be eaten by larger tadpoles, and sometimes by larger CTS larvae as mentioned above. Research on East Bay Regional Park District ponds revealed a significant negative correlation between the presence of predatory insects and the presence of CTS, especially in ponds with perennial water (Bobzien and DiDonato 2007). The authors also hypothesized that emergent vegetation increases the number of predatory insects.

In the above-mentioned larval die-offs reported by Ryan et al. (2013), the water quality problems made CTS larvae more susceptible to predation by water bugs. This suggests that more research is needed on the links between predatory aquatic insects and other pond factors.

Exotic predators are a threat to the survival and recovery of CTS (USFWS 2004). Game fish such as bass appear to be almost universally incompatible with CTS (Barry and Shaffer 1994). Other exotic predators include bullfrogs, mosquitofish, and crayfish (Shaffer et al. 1993). These exotic species require permanent water to survive or to persist in an abundance detrimental to CTS (Fitzpatrick and Shaffer 2004). In field experiments, mosquitofish had a large effect on CTS larval growth and survival in permanent ponds and no effect in seasonal ponds (Leyse et al. 2005). As discussed earlier, hybrid CTS larvae, which are favored in perennial ponds and those with pesticide contamination, will also eat native CTS larvae (Ryan et al. 2009).

Deep water, vegetation, and turbidity can help CTS avoid becoming meals for other animals. Turbidity can be particularly important since CTS will often use unvegetated and relatively shallow ponds.

Infectious pathogens, including ranaviruses and the chytrid fungus, may be harmful to CTS (Padgett-Flohr and Longcore 2005; Picco et al. 2007).

Non-breeding Habitat Requirements

As with California red-legged frogs, California tiger salamanders need safe refuge outside of their breeding ponds, and the ability to travel safely between breeding and non-breeding habitat. Unlike CRLF, CTS do not need or use wet or aquatic habitat outside of breeding. These salamanders depend instead on a few types of burrows for their primary residence. These burrows are most commonly made by ground squirrels and pocket gophers (Shaffer et al. 1993); kangaroo rat burrows are heavily used in Santa Barbara County (S. Sweet, pers. comm.). CTS are believed to generally use open, accessible burrows, but can push their way into plugged burrows (Jennings 1996). Whether the burrow is currently occupied by rodents or not does not appear to matter to the salamanders (Loredo et al. 1996). In fact, CTS have been observed in a burrow containing a nest of ground squirrel pups, with both parties apparently indifferent to the other's presence (pers. obs. by author Trenham).

CTS will use or move through a variety of plant community types. Grasslands and savannas are the main terrestrial habitats used. CTS will move through patches of shrubs (maritime chaparral being particularly conducive to travel) and through oak woodland to a lesser extent (Wang et al. 2009), but such habitat does not generally provide abundant burrows and cannot substitute for grassland (pers. obs. by author Trenham). Large expanses of closed-canopy forests and some shrubland types might pose barriers to movement, but more research is needed on this question. Dense herbaceous vegetation may impede dispersal (pers. obs. by author Trenham) and over the long term such vegetation is believed to reduce ground squirrel populations (see Chapter 7 for details).

CTS can be quite indiscriminate in choosing places to take shelter while moving between breeding and non-breeding sites. While adult CTS generally take refuge in burrows when migrating, juveniles have been observed in aboveground refuges, under litter or in cracks of the soil. Radio-tracked metamorphs commonly sought refuge in soil cracks and were able to survive for weeks during the summer in these refuges (pers. obs. by author Trenham). In a Contra Costa County study, Loredo et al. (1996) found that juveniles were roughly as likely to use soil cracks as burrows when first migrating from ponds. A few adults used soil cracks or hid under logs. (The authors noted that soil was moist and cracks were sealed shut during the rainy season, when adults were generally emigrating from ponds.) CTS have also been observed in artificial structures such as pipes, septic drains, basements, golf course valve boxes, under small boulders, and in moist boots left outside (Jennings and Hayes 1994; pers. comms. by M. Allaback, S. Orloff, and M. Swisher).

Research Needs

Regional differences

Are there regional differences in life history that have management implications?

Juvenile survivorship

What factors affect juvenile survivorship, and what can managers do to enhance it?

CTS hybrids

This is an ongoing subject of research that will likely yield new or refined recommendations.

Please see Chapters 5 and 8 for additional CTS research needs.

Management Goals and General Guidelines 4

Managing rangelands to benefit California red-legged frogs and California tiger salamanders requires an understanding of these amphibians' needs and preferences, the corresponding management options, and how these all relate to the property's other goals and constraints. Chapters 2 and 3 cover the first set of elements, and subsequent chapters translate this biological information into management recommendations for each type of rangeland habitat where CRLF and CTS are found. To prepare the reader for the specifics that follow, this chapter provides information designed to put our management recommendations into a broader context. It summarizes the most important habitat needs and recommendations, discusses general principles for sound planning, and details when and where species-oriented management is called for.

Core Habitat Needs and Management Priorities

Management objectives stem directly from the habitat preferences and requirements of the target species. Although the habitat requirements of both the CRLF and the CTS are discussed in detail in the previous chapters, managers will find a summary of the core needs of these species to be helpful. This information is presented in the table below. Management should focus on providing these core requirements. If a rangeland already possesses these qualities, management should focus on maintenance and any desired enhancement.

Core Elements of Suitable Habitat

Habitat Element		
Breeding habitat	Ponds, or still pools in slow-moving creeks, with a mix of open and vegetated areas, deep and shallow sections, few or no game fish or bullfrogs, and inundated at least through August (preferably September)	Ponds or vernal pools with no or minimal emergent vegetation, few or no game fish or bullfrogs, generally inundated at least through May, and preferably turbid if shallow and unvegetated
Dry season refuges (non-breeding habitat)	Areas that are moist in the dry season–such as springs, riparian zones, perennial ponds, and burrows–that offer cover and protection from predators	Burrows of ground squirrels, pocket gophers or other small animals
Landscapes	Networks of multiple suitable breeding sites and sufficient dry season refuges; all core habitat elements are connected (few significant barriers, breeding sites within dispersal distance of other breeding sites, grasslands generally grazed, especially in inland areas)	

A few key recommendations for rangeland managers correspond to these habitat goals:

- Maintain existing stock ponds as suitable habitat for one or both species: repair eroding or leaking dams and spillways, remove excessive silt and vegetation, and control non-native predators (see Chapter 5 for more detail).

- For CRLF, provide refuges that are moist year-round and offer dense vegetation or other protection from predators (see Chapter 7 for more detail).

- Don't eliminate burrowing rodents with intensive control efforts, and don't use rodent control methods (such as gas) that would also kill CTS or CRLF directly (see Chapter 8 for more detail).

- Manage grazing to maintain the desired amount of emergent vegetation in ponds, vernal pools, riparian habitat, and springs and other moist refuges, and to keep annual grassland generally short (see Chapters 5 through 8 for detail). Don't exclude grazing from extensive areas of grassland for more than one year (see Chapter 8 for more detail and potential exceptions).

- In regions occupied by CRLF or CTS, assume the species could be present throughout the property's grasslands, savanna and aquatic habitats, and manage to benefit these amphibians.

Many of the actions a manager might undertake to pursue these goals require little or no infrastructure (e.g. changing the timing of grazing, fencing out a small exclosure to let vegetation like willows or cattails establish, draining a pond periodically to kill fish or bullfrogs). Such actions can significantly improve habitat for a particular ranch or park, often for very little up-front cost. Maintaining existing breeding sites is likely to be a necessary expense at some point since ponds often silt up over time, become overgrown with cattails or other emergent vegetation, and/or require dam or spillway repair. Pond repair will likely be the most expensive management requirement. Re-introducing grazing will often require significant expenses for the construction or upgrading of grazing infrastructure (corrals, fencing, gates, and watering facilities).

Management Planning

We recommend that managers assess the current condition of the core habitat elements before making decisions about potentially costly habitat improvements and management actions. Managers should then determine priorities based on the greatest need for improvement and, within budget constraints, the greatest potential to maintain or increase habitat quality.

In developing plans (formal or informal) for rangeland management, managers must balance the goals and requirements related to wildlife conservation with those related to livestock, economics, soil health, water quality, fire risk, and invasive species, and they must do so on a site-by-site basis because each site has specific resource concerns and management constraints. In other words, species-focused objectives must be incorporated into a plan that is comprehensive, holistic, and site-specific. This means making compromises and setting priorities, with an eye on the big picture. Plans that are narrowly focused on one species or one habitat site may restrict management options in a way that hamstrings the manager's ability to provide for general rangeland ecosystem health, unintentionally leading to degraded habitat for these amphibians. With these issues in mind, decision-makers will need to distinguish between what is critical for CRLF and CTS, and what is beneficial but not essential.

In addition to dealing with a large number of potentially conflicting objectives, factors, and concerns, planners and managers must also contend with uncertainty and variability—properties inherent to all natural systems and especially important in our Mediterranean climate. Any plans must be flexible enough to allow for new science, new invasive species, wildfire, drought, and simply learning about the site through experience. Rigid grazing management plans with pre-set calendar dates and stocking rates do not work in California rangelands. We urge decision-makers to set clear goals, objectives, and performance standards, develop feasible monitoring schemes[5] that correspond to these parameters, and then adapt management accordingly—both within each grazing period and long-term—as circumstances change.

Overall, planners must recognize the budgetary, infrastructure, and staffing consequences of their plans, and work within the operation's limits. New management activities, infrastructure, and repairs might need to be prioritized and phased in.

The guidelines presented in the chapters that follow often distinguish between optimal and tolerable conditions. Beyond the need for compromise in meeting multiple management objectives, this distinction is important for several reasons. The first is that managers with limited resources will

[5] The details of a monitoring program for CRLF or CTS—the exact variables to be tracked and methods needed—will depend on the particular site and the monitoring effort's purpose and budget. There is no "one-size-fits-all" solution. Depending on the situation, it may be appropriate to monitor species presence or abundance, habitat variables, or a combination. Abundance will generally be the least feasible variable to monitor for these species.

need to prioritize the actions needed to maintain at least tolerable conditions. A second reason is that these amphibians can sometimes thrive in "merely tolerable" conditions. If a site does not meet our description of ideal conditions, but is occupied by a healthy population of one or both of the amphibians, then major changes to management (beyond what is needed to maintain sufficient conditions) should be approached with caution.

Where and When to Manage

It can be hard to tell if California red-legged frogs or California tiger salamanders are present on a site or property. Breeding sites might not be used every year, especially in dry years. Also, CTS and CRLF can be very difficult to spot in breeding sites, especially in turbid or densely vegetated ponds, and when they are not breeding both animals can remain largely or completely hidden. Unless a "USFWS protocol-level" presence/absence survey has been conducted, the safest approach is to manage as if the species are there—as long as the site is within the species' ranges and there is suitable breeding habitat onsite or within dispersal distance. If either species is known to occur on neighboring properties then the odds of onsite presence are good.[6]

As noted in Chapter 2, CRLF often travel hundreds of yards from breeding ponds to dry season refuges, and can travel up to three miles across a variety of terrestrial vegetation types and terrains (Bulger et al. 2003; Fellers and Kleeman 2007). Therefore, all habitat components—not just breeding sites, but also moist refuges and surrounding uplands—should be managed to benefit the species. Further, managers should not assume that all CRLF are in ponds during the winter and elsewhere in summer. CRLF can be found in breeding sites and moist refuges at any time of year. Juveniles, which do not breed, can remain in moist refuges while adults return to breeding sites. Conversely, adults (and sometimes juveniles) can reside year-round in breeding sites that retain enough moisture.

The habits and behaviors of CTS present a similar situation for managers. The salamanders can travel at least 1.4 miles from ponds (Trenham et al. 2001; Searcy and Shaffer 2008; Searcy and Shaffer 2011; Orloff 2011), and tend to live between approximately 100 yards and 0.6 miles (or more) away from their breeding sites. In addition to grassland and savanna, they will travel through chaparral (at least in coastal areas) and, to a lesser extent, through closed-canopy oak woodland (Wang et al. 2009). Breeding adult CTS can be found in ponds from the start of breeding through spring, and larvae can be found in wet breeding sites at any time of year. Juveniles and non-breeding adults reside in burrows and other refuges year-round. Thus managers should assume that CTS are present in grasslands within 1.4 miles or more of all breeding sites, and may be present in a variety of habitats, regardless of season.

6 If the property is in both species' range, then the presence of even one of these species on a neighboring property means there is a good chance that both species are present (Alvarez et al. 2013).

Managing Ponds 5

California red-legged frogs and California tiger salamanders appear to be more particular regarding conditions in breeding habitat than in other habitat elements, so rangeland managers will often need to focus much of their effort in managing breeding sites. Given that ponds are the most common type of breeding habitat, many readers will find this chapter to be particularly relevant for their situations and needs. Since most ponds on ranches and rangelands were built to provide water for livestock, we focus on stock pond management, while recognizing that other kinds of ponds can be suitable for CRLF or CTS and should be managed similarly (please see Chapters 6 and 7 for discussion of other types of breeding habitat for CTS and CRLF, respectively).

This chapter focuses on creating and maintaining suitable habitat conditions for reproduction, survival and growth of tadpoles and larvae, and metamorphosis. Ponds can also serve as important non-breeding habitat for juvenile and adult CRLF if they provide year-round moisture and protection from predators. Habitat goals specifically for non-breeding habitat are highlighted below, after discussion of breeding conditions (please see Chapters 7 and 8 for discussion of other types of CRLF non-breeding habitat).

CRLF and CTS have overlapping but distinct preferences for breeding habitat. Most of the recommendations for CRLF and CTS are mutually compatible, and indeed the two species will sometimes co-occur. The main factor in which their needs diverge is the amount of edge and emergent vegetation. A moderate amount of vegetative cover (10 to 35%) will probably be compatible with both species. The lower end of this range will basically be a "CTS pond" with enough cover to be tolerable to CRLF, and vice-versa at the higher end. Rarely will a single pond provide optimal habitat for both species.

Ponds can be managed to benefit the frog, the salamander, or both. Deciding whether to manage for one or both of these species depends on which species are potentially present (see Chapter 4) and what other ponds are nearby. Just because a pond can be managed for both species does not mean it should be. It can be preferable to manage it for just the frog or just the salamander. This is especially true if there are many other suitable breeding sites available nearby for one species but not the other. If a pond already meets most or all the desired conditions for one of the species, then it may be best to manage the pond primarily for that species.

California's variable climate can make a given pond or pool vary in habitat quality from year to year, and a site that is marginal as breeding habitat in most years may become important in a particularly wet or dry year. In our opinion, having breeding sites with different characteristics (size, depth, vegetation, etc.) increases the odds that at least one site will have good reproductive output in a given year. Ideally every pond on a property will have conditions sufficient for CRLF, CTS, or both, but there will be some variety from one pond to another.

Habitat Goals

Chapters 2 and 3 summarize the required, preferred, and tolerable biological conditions for CRLF and CTS, respectively. This information drives our management recommendations. To help decision-makers best apply these recommendations, we begin by reviewing the goals that managers should set when considering management actions (or inaction) that could affect pond conditions. This provides important context for the management recommendations that follow. Please refer to Chapters 2 and 3 for more detailed and species-specific information on pond habitat goals.

Sufficient Inundation Period

To support successful reproduction, aquatic habitats must hold water long enough to support successful metamorphosis. Mimicking California's seasonal water cycle, which would inundate a typical "natural" breeding site by mid-winter and make it dry by mid-fall, is a good rule of thumb. Perennial ponds can support overwintering CRLF and CTS, but are liabilities in areas with non-native predators and hybrid CTS.

To fully support CRLF breeding and metamorphosis, the ideal inundation period is from December through September. Inundation through August will generally allow some successful breeding. Inundation into early autumn is preferred, especially in drier inland areas.

Productive CTS ponds will generally last through May; ideally they will last longer but dry out before autumn rains (Shaffer and Trenham 2005).

Limited Emergent Vegetation

Ponds can support a wide variety of vegetation, from submerged or floating algae to cattails, rushes, willows, and other plants that emerge from the pond surface or grow along the edge. CRLF and CTS differ in the amount of emergent and edge vegetation they prefer or tolerate. Neither species, however, thrives when emergent vegetation completely takes over the pond's surface. Thus, an important habitat goal is to limit the amount of emergent vegetation present, with the desired amount dependent on which of these amphibians is present. As noted in the introduction to this chapter, if both species are present then 10–35% cover of emergent vegetation is a suitable compromise.

CRLF need a mix of open surface water and vegetated cover (Hayes and Jennings 1988), and appear to tolerate a wide range of vegetation conditions in the pond and at its edge. Adult survival requires at least a small amount of emergent, submerged, floating, or edge vegetation, especially if non-native predators are present. Aquatic vegetation is also important in providing structure for attachment of eggs. Ponds that become completely choked out by emergent vegetation become cold enough to discourage breeding. In the East Bay Regional Park District, CRLF were most common in ponds supporting up to 40% cover of emergent vegetation, but were found in ponds with as little at 5% cover (Bobzien and DiDonato 2007). CRLF can also breed in shallow, densely vegetated, fishless perennial wetlands, especially if the vegetation does not become dense until summer—a situation that would still provide tadpoles with warm, unshaded water in the cooler months (M. Allaback, pers. comm.).

CTS often thrive in ponds lacking any emergent vegetation (pers. obs. by author Trenham). Breeding appears to be rare with more than moderate levels of emergent vegetation, and one extensive study in the East Bay did not detect breeding in ponds with greater than 35% emergent vegetation (Bobzien and DiDonato 2007). Ponds with abundant emergent vegetation may support more aquatic insects that prey on CTS larvae. CTS can do well with minimal or abundant *submerged* vegetation; such cover would in fact be important for predator avoidance in shallow, clear water. Some amount of vegetative cover appears to help CTS persist in ponds with bullfrogs.

Appropriate Depth

A mix of deep and shallow water is generally preferred, especially for CRLF. The deeper areas help frogs and salamanders avoid predators, and make the pond more likely to have a sufficient inundation period. Shallower waters provide warm conditions beneficial to tadpoles and larvae. Sloping or benched sides will provide both aspects throughout the drawdown period (NRCS 2006).

The deeper areas of the pond should be at least a yard deep, to provide adult frogs an escape from predators. Ideally, they will be greater than five feet deep to discourage cattails and bulrushes from "choking out" the pond (although control of emergent plants might also be achieved through grazing, as discussed in "Livestock Access" below). For tadpoles, some of the pond should be unshaded, shallow enough to allow warming of the water in late winter, but generally at least eight inches deep. As discussed above, CRLF can also do well in shallow perennial wetlands lacking deep areas, as long as there is enough vegetation to provide cover.

Deep water is beneficial but not necessarily essential, provided the inundation period is sufficient. Deep areas can be important for predator avoidance if the water is clear and unvegetated.

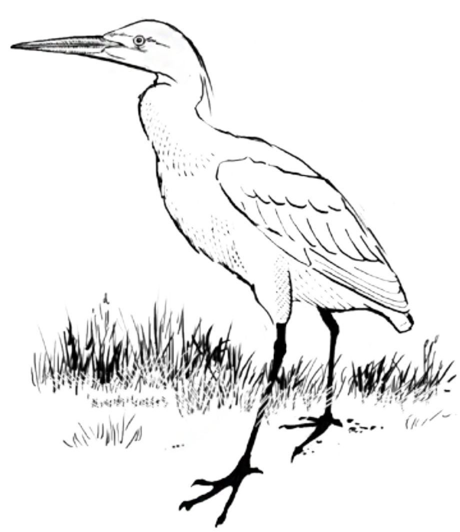
Predator Evasion Features

Deep water, vegetation, and/or turbidity can help CRLF and CTS avoid becoming meals for other animals. Vegetation (at least some) appears to help both CRLF and CTS in ponds with bullfrogs (Shaffer and Fisher 1991).

Turbidity is particularly important for CTS in shallow, unvegetated ponds, which they are more likely to use than CRLF.

Few Or No Non-Native Predators

As discussed in Chapters 2 and 3, non-native predators (including hybrid CTS) are a significant threat for both animals (Hayes and Jennings 1988; USFWS 2004; USFWS 2010), and their control should be factored into how ponds are managed and maintained.



Since native predators have ecological value (and some may themselves be special-status), the goal is to make it as easy as possible for CTS and CRLF to hide from and avoid these predators, rather than to kill or exclude them (see "Predator Evasion Features" above).

Water Quality

Some pesticides and herbicides have been associated with mortality, especially on ranches downwind or downstream from conventionally farmed row crops (Davidson et al. 2002; Ryan et al. 2013). The EPA and USFWS are reviewing the effects of several chemicals on CRLF and CTS. Both species can be negatively affected when nutrient levels are either very high (J. Alvarez, pers. comm. and data in preparation) or very low (pers. obs. by authors Scott and Trenham). Bobzien and DiDonato (2007) compared the nitrate and dissolved oxygen levels in ponds with and without these two amphibians and did not find major differences (although the nitrate levels were generally low in all the ponds studied). Their results did indicate that turbidity levels were important to both species.

CRLF occur in a wide range of turbidity conditions ranging from clear to highly turbid, but have been observed to be more common in relatively clear water (Bobzien and DiDonato 2007).

CTS breeding has been found to benefit from moderate to high levels of turbidity (Bobzien and DiDonato 2007). Turbidity is widely believed to help CTS avoid predation; this may only be important, however, in relatively shallow ponds lacking emergent or submerged vegetation.

Water Temperature

As discussed above, warm conditions in at least some parts of the pond are important to CRLF tadpoles and CTS larvae.

CRLF prefer surface water temperatures above 60 degrees Fahrenheit, but are still common when temperatures are roughly 50 degrees (Scott and Rathbun 2006). Summer surface water temperatures above 80 degrees are optimal. CRLF may avoid breeding in ponds in which too much emergent or edge vegetation shades the pond surface and doesn't allow sufficient winter warming.

Non-breeding Habitat

Ponds that hold water after amphibian metamorphosis can potentially provide valuable non-breeding habitat. This is primarily a concern only for CRLF, since CTS don't generally use ponds for non-breeding habitat (but see below). For either species, the value of a perennial pond as non-breeding habitat must be weighed against the risk of non-native predators.

Ponds that retain water past the breeding season—and especially perennial ponds—can be valuable non-breeding habitat for CRLF. Aquatic or edge vegetation is needed for predator evasion purposes as discussed above. Non-breeding habitat does not require the shallow, warm, open areas needed by tadpoles; however, these conditions may be ideal because they will support any over-wintering tadpoles. Because juveniles leave the breeding sites they were born in, and move to other moist refuges, perennial breeding sites alone cannot fulfill a population's need for non-breeding habitat.

CTS larvae do on occasion remain in perennial ponds and over-winter. If a pond is known to support over-wintering CTS then the habitat goals for breeding ponds will apply year-round.

Management Tools and Activities

There are a number of ways that managers can meet the habitat goals listed above. Managing the amount and timing of grazing is fundamental because it has important consequences for emergent vegetation and water quality. Maintaining ponds and controlling non-native predators are also crucial activities that will likely need to be undertaken periodically. These topics are discussed below, along with other management activities that bear on habitat quality, including plant establishment, pest plant[7] control, and the use of herbicides and pesticides.

Livestock Access and Grazing

Livestock use of ponds is generally beneficial for both CRLF and CTS (USFWS 2004; USFWS 2010). Depending on its amount and timing, grazing in and around ponds can produce positive effects on vegetative cover, nutrient levels, and turbidity. Artificial ponds that support CRLF and/or CTS are typically open to livestock grazing, and many have a long track record of supporting healthy populations. In the East Bay Regional Park District, all ponds known to support CTS breeding (not including vernal pools in rock outcrops) are accessible to cattle, and ponds excluded from grazing have lower-quality CRLF habitat quality and are less likely to be occupied by the frogs or to support breeding (Bobzien and DiDonato 2007). Keeping ponds suitable for use by livestock is also frequently an important motivation for land managers to periodically maintain ponds by removing silt or repairing eroding dams and spillways.

Livestock, however, can have negative impacts as well. Chief among them is the risk that excessive herbivory by livestock can leave ponds with too little emergent vegetation for CRLF. There is some potential for livestock to crush frogs and salamanders at any stage from egg to adult, and raise nutrient levels in ponds to undesirably high levels with their manure. Below we discuss ways to maximize the positive impacts and minimize the negative impacts of livestock access.

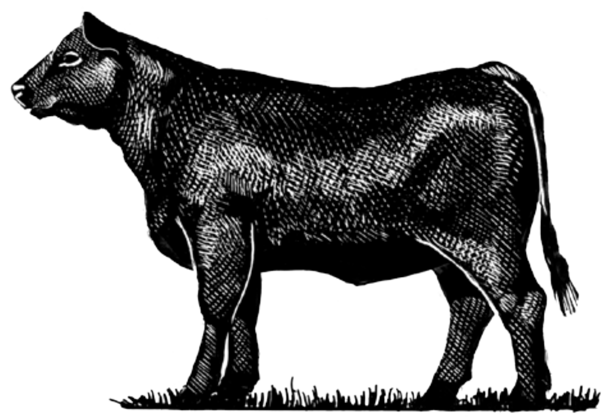
As noted above, cattails and similar emergent vegetation can be important sources of cover, but if left undisturbed will often produce a denser cover than CRLF and CTS prefer. Allowing livestock access to ponds is often the most feasible method of preventing or controlling excessive emergent vegetation. Access may need to be managed in order to avoid the opposite condition—insufficient vegetation—but often the existing topography of the pond and banks will lead to the desired results. Vegetation growing in shallow waters may be eaten by wading cattle or other livestock, while the vegetation growing in deeper water beyond the reach of the wading animals will remain untouched. Since emergent vegetation often cannot establish in deep areas (more than four to five feet deep), allowing livestock access to a pond with a deep central area can result in a doughnut- or crescent-shaped vegetated area bordered by warmer waters, which is beneficial to CRLF. Allowing livestock unrestricted access to shallow ponds can prevent most emergent vegetation from growing, creating a condition preferred by CTS.

[7] We use the phrase "pest plant" to describe undesirable non-native plants, including weedy naturalized species and invasive species.

When unrestricted livestock access to ponds does not yield the desired results for amphibian habitat, managers have several options. Managers can control the timing of grazing to increase or decrease the amount of edge and emergent vegetation. Generally, pond and edge vegetation can end up severely grazed in summer and fall, when there is little other green forage available, and be scarcely used in spring. Restricting the timing or extent of cattle access may help increase vegetative cover for CRLF (see below). Fencing can be used at shallow, trampled pond inlets to promote dense growth by sedges, rushes and similar vegetation; such vegetation can act as a "filter strip" to reduce pond sedimentation.

Bank trampling is a common and often inevitable side effect of using grazing to prevent emergent vegetation from exceeding the amounts of cover preferred by CRLF and CTS (see below for details). Although some managers believe that bank trampling is inherently harmful to these amphibians (on its own and not because it is associated with less emergent vegetation), there is no direct evidence supporting this view, at least when managing a pond as breeding habitat for CRLF or CTS. Indeed, in a pond managed for CTS, bank trampling may actually be desirable because it produces the turbidity preferred or required by the salamander. There are many healthy and persistent populations of CRLF and CTS in ponds with varying degrees of cattle access and bank trampling (USFWS 2004; USFWS 2010; see also the Case Examples). We have observed ponds with completely trampled banks produce large numbers of metamorphs year after year (pers. obs. by author Scott for CRLF, and authors Trenham and Van Hoorn for CTS). Our position is that the amount of emergent vegetation is more important than the amount of trampling; there is general but not universal consensus for this view.

A potential downside of allowing livestock access to ponds is the possibility that the animals will crush CRLF or CTS eggs or individuals with their hooves. There have been observations of cattle access resulting in trampled eggs or individuals (pers. obs. by P. Kleeman with CRLF and S. Sweet with CTS).[8] Based on our extensive observations and those of several other reviewers, and the presence of healthy CRLF and CTS populations at many grazed breeding sites, we believe that trampling of eggs and individuals is probably



unusual, and in general does not appear to impact a site's population. In fact, CRLF and CTS are often seen using pond-edge hoof prints as refuges during the day. If trampled individuals are frequently witnessed at a particular pond, the manager may wish to experiment with approaches—such as temporary fencing, rotation to other fields, or alternative watering facilities—that would reduce livestock access in late spring and summer (when metamorphs are leaving the pond). The risk is that this may result in clear water and increased

[8] S. Sweet states that trampling of CTS might be significant in Santa Barbara ponds with adobe clay edges; we have observed healthy CTS populations in Alameda County ponds with adobe clay edges and unrestricted cattle access.

predation by birds on CTS. Access may still be needed at other times of year to prevent excessive emergent vegetation.

Livestock manure adds nitrogen and other nutrients to stock ponds. It has been our experience that the nutrient levels found in most stock ponds are compatible with healthy populations of CRLF and CTS, but more research is needed on this topic. Bobzien and DiDonato (2007) found low nitrate levels in all of the East Bay Regional Park District stock ponds they surveyed. On the other hand, very high nutrient levels were found in some Contra Costa stock ponds, and these high levels were linked to disease and deformation (J. Alvarez, pers. comm. and data in preparation). Although excess nutrient levels are always undesirable, the opposite condition—very low nutrient levels—is also problematic. In cases where the pond is supplied by relatively clean piped-in water, which by itself may not have enough nitrogen and other nutrients to support enough of a food base for amphibians, livestock access may be needed to raise nutrient levels (pers. obs. by author Scott).

There has been speculation that livestock can shorten the inundation period of some ponds by drinking the water; the validity of this concern is unknown. It may be difficult to distinguish between livestock drinking and evaporation as the cause of a pond's reduced water levels. If livestock do appear to be excessively reducing the inundation period, then managers can exclude livestock in late spring (from the field or, with temporary fencing, just from the pond) and/or provide alternative watering facilities away from the pond.

The objectives of managing a pond as amphibian habitat must be integrated with those of livestock production. Leaving part of the pond accessible provides a watering source, which can be critical to a livestock operation if few other sources are available. If pond draining for predator control in late summer conflicts with the need for livestock watering, then alternative watering facilities should be developed either from another source or with a temporary catch basin or storage tank below the drained pond.

Livestock use of pond water will be greater if the pond is the only source of water or green forage; in such cases development of alternative watering facilities will often reduce livestock impacts. Cattle generally prefer the cooler, cleaner water from troughs, but will congregate in ponds during hotter summer months. Troughs should be fitted with wildlife escape ramps to prevent frogs and other wildlife from drowning and fouling the drinking water (ramp design and installation guidance is available from Bat Conservation International and the USDA Natural Resources Conservation Service [NRCS].)

Although CRLF can tolerate a wide range of vegetation conditions in ponds, both excessive vegetation and the absence of vegetation make a pond undesirable habitat for either breeding or dry-season refuge. Therefore, using grazing to achieve the ideal conditions in a pond can be a balancing act. Grazing can lead to insufficient vegetation if all vegetated areas are accessible (not too deep or too steeply banked), especially if grazing occurs in summer and fall when green forage is scarce. Changing grazing practices can address this. One method is to avoid grazing a field when green forage is scarce, or to substantially limit access during those periods. Installing a water trough in the field may be needed if the pond is currently the only source of water. Alternatively, installing partial exclusionary fencing around a quarter to half of the pond can be a simple and effective method for increasing vegetative cover if it is insufficient (Scott and Rathbun 2002; see the Los Vaqueros case examples in Chapter 10 for successful examples).[9] The placement of exclosure fencing will ideally leave a mix of deep and shallow sections accessible and allow for pond access from multiple areas (dispersing cattle traffic impacts). As applicable, exclosure fencing might also exclude livestock from patches of adjacent stream habitat (see the Chapter 7 discussion of riparian habitat).

Grazing can be an important tool in maintaining the minimal levels of emergent vegetation preferred by CTS. Livestock presence can also increase pond turbidity, which can help CTS avoid predation, and raise nutrient levels in the pond high enough to support more of the algae that form the base of the food pyramid on which larvae depend (pers. obs. by author Trenham). If an ungrazed pond is shallow, unvegetated, and clear, but otherwise has the potential to support CTS, the manager should consider grazing the pond to increase turbidity. If a pond has more than the desired amount of emergent vegetation, managers should consider grazing the area for a short period in summer or fall.

Draining of Perennial Ponds

Perennial ponds are often a liability because they can support non-native predators such as bullfrogs, introduced game fish, and crayfish. Perennial ponds also favor hybrid CTS over natives. As noted above, non-native predators and hybrid CTS can be significant threats to both CRLF and CTS, and so steps should be taken to prevent them from establishing and, ideally, to reduce or eliminate existing populations. The most effective means of both control and prevention of repopulation is draining the affected ponds at regular intervals. Draining is less important in some arid areas and in landscapes with widely distributed ponds that do not already support non-native predators, and where fish stocking and other release of predators is not a significant risk.

The ideal time to drain a pond for predator control is after August and before the start of the next rainy season. This timing assures the least impact on reproduction of CTS and CRLF. Screens should be placed over the drain pipe or hose in order to exclude any CRLF or CTS, and the drained water should not be allowed to cause erosion (pumping into filter bags or spraying onto vegetated areas are two potential solutions). The pond must dry completely to effectively control the predators. Draining should be repeated once every three to four years,[10] especially where bullfrogs occur nearby or the risk of reintroduction is significant (Doubledee et al. 2003). Ponds are typically drained with a pump; installing a drain will facilitate periodic draining and may be cost-effective in the long run, especially if combined with other repairs.

Ponds being treated for bullfrogs require special effort because of these animals' ability to burrow into the mud remaining in a drained pond or simply leave the pond and find temporary refuge elsewhere. Any bullfrogs attempting to leave a drained pond should be gigged if possible. To ensure that no tadpoles remain alive in the ponds they are treating for bullfrogs, managers at the East Bay Regional Park District cover the bottoms of the drained ponds with dirt, compact the dirt with heavy equipment, and then regrade the ponds to the desired depth roughly two weeks

[9] A few reviewers cautioned that partial fencing can lead to amphibian eggs becoming stranded on the fenceline, while others noted that such stranding also occurs on native vegetation. It has been our experience that partial fencing can be an overall benefit, whether or not stranding is a concern.

[10] One to two years may be necessary (B. Mori and M. Allaback, pers. comm.)

later (S. Bobzien, pers. comm.). Ponds without CRLF or CTS should ideally be drained quickly, to minimize the number of bullfrog tadpoles that can transform (M. Allaback, pers. comm.).

If there are CRLF and/or CTS in the pond—but no bullfrogs—then the ideal approach would be to drain the pond slowly over several weeks in late September to early October, so that any late tadpoles and larvae can complete metamorphosis and to minimize the period that juvenile and adult CRLF have to go without a wet pond (M. Allaback, M. Shea, and T. Tatarian, pers. comm.). This approach will not always be logistically feasible, especially if there are several ponds to be drained on the property or if additional restoration measures such as dam repair also need to be completed before fall rains. The late timing also increases the risk that rain will make draining impossible; this is also a concern for some spring-fed ponds, which may begin to fill in late summer, before the rainy season. The most important considerations are to begin draining late enough to allow for metamorphosis (after August if there are still CRLF tadpoles; after July if there are CTS larvae) and to complete the draining before the fall rains (and, in the case of ponds fed by seasonally flowing springs, before the spring typically begins to flow).

In areas with hybrid CTS, perennial stock ponds could be drained or pumped dry in early summer, which should favor native CTS genes over non-native genes. Hybrids are not always able to complete metamorphosis in quickly drying ponds (M. Ryan, pers. obs.). Ponds with both CRLF and hybrid CTS may require compromise—perhaps delaying draining until July or August. However, we note that addressing hybrid CTS is a complex challenge involving ecological and regulatory questions that are not yet well resolved.

For ponds fed by perennially flowing streams or springs, complete draining may not be an option. Partial draining, however, may still be very worthwhile in controlling the population numbers of non-native predators or hybrid CTS, and (depending on the level of draining achieved) may be effective in eliminating fish. Where ponds are on-stream, managers should consult with regulatory agencies before beginning this type of habitat improvement project.

Draining can also be required as part of pond repair—please see below for more information.

Introduction of Non-Native Predators

Ponds are sometimes stocked with game fish, bullfrogs, and exotic salamanders for fishing or as a supply of bait. This practice can have grave consequences for local native amphibians and—because bullfrogs and non-native salamanders can move from one pond to another—can be impossible to undo. Mosquitofish prey on both CRLF tadpoles and CTS larvae and should therefore not be introduced to ponds; they are not needed as mosquito controls because mosquito larvae tend to fare poorly in ponds (S. Gennet, pers. comm.), especially perennial ponds (pers. obs. by author Trenham). Stocking water troughs with mosquito fish, a common practice, does not affect CRLF or CTS because these amphibians do not use troughs for breeding.

Vegetation Establishment

The planting of willows, mulefat, or similar vegetation at pond edges can be a desired enhancement for CRLF refuge. New plantings may require fencing until established.

Pond Maintenance, Repair, and Restoration

Most stockponds require occasional maintenance to remove excessive sediment or vegetation, and leaky or eroding dams or spillways need to be repaired. Eroding dams and spillways must be repaired to prevent the loss of the pond and the release of substantial sediment downstream. Repairs should be made when the ponds are dry, or at least in late summer or early fall after amphibian metamorphosis. It is important to note that excavation and spillway repair require permits and technical advice.

We recognize that maintenance and restoration projects can result in harm to some individuals of these threatened amphibians, and there can be temporary impacts to emergent vegetation when removing sediment. However, we emphasize that failure to maintain ponds and their dams would often result in the complete loss of the breeding habitat—and potentially in the local extirpation of the species. Inaction, therefore, is far worse than the temporary impacts of maintenance. Because of this, the US Fish and Wildlife Service considers pond maintenance a routine ranching operation with conservation benefits to CTS and CRLF, and does not generally require a permit for pond repairs on private land (USFWS 2004; USFWS 2010). Several other permits are potentially required, however, including ones from the California Department of Fish and Wildlife,[11] Regional Water Quality Control Board, Army Corps of Engineers, and the county's grading or public works department. Permit streamlining and other incentives to encourage voluntary conservation activities are urgently needed to reduce the regulatory barriers to pond maintenance. Because CRLF and CTS often need these ponds more than cattle and ranchers do, we urge decision-makers to view these (often expensive) projects as habitat restoration and not simply as ranch infrastructure maintenance.

Periodic removal of accumulated sediment will generally be necessary to maintain adequate pond depth and inundation period. De-silting also appears to reduce infestations of the parasite *Ribeiroia ondatrae*, which can harm and kill CRLF (pers. comms., J. Alvarez and M. Shea). The resulting pond profile should provide the mix of shallow and deep areas described in the "Appropriate Depth" habitat goal above. It is generally wise to avoid excavating below the original depth, which could breach the seal of the pond; excavator operators can generally judge this based on soil resistance and color.

Emergent vegetation will generally be removed in the course of de-silting. It can be desirable, however, to leave some emergent vegetation for CRLF. This can be challenging—as sediment is removed, the sediment in other areas generally slumps down—but sometimes emergent vegetation can be preserved along an edge of the pond. Regardless, emergent vegetation can be expected to recolonize shallow or intermediate depths. (Please refer to "Livestock Access and Grazing" above for recommendations on the management of re-established emergent vegetation in ponds with CRLF and/or CTS.)

[11] Until January 2013 this agency was known as the Department of Fish and Game.

Excavators can also be used to remove emergent vegetation that exceeds the desired maximum amount, either in conjunction with de-silting or as a separate operation.

In some cases, cattle can become stuck in the muddy edges of excavated ponds (pers. obs. by author Van Hoorn). If this occurs or seems likely based on substrate, the manager should consider excavating the area to harder material (often the original depth) or fencing off the dangerous area.

To stem the spread of infectious pathogens between ponds, the USFWS recommends that CRLF and CTS surveyors decontaminate their equipment and clothing before and after working in a pond (USFWS 2005a). We encourage surveyors, managers, and equipment operators to follow these guidelines as well when working in ponds on different properties.

Additional information on pond maintenance is available from the Alameda County Conservation Partnership (NRCS 2006; also refer to Appendix 1).

Control of Pest Plants

Non-native plants that invade a pond and grow densely will degrade breeding conditions if they exceed the amount of emergent vegetation that CRLF or CTS prefer. At pond edges, the primary threat would be if the pest plant grows in a stand that is too dense at ground level for a frog or salamander to crawl through, and too tall for CRLF to jump over. (This may be more likely to be a problem for CRLF than for CTS, since CTS can navigate through denser vegetation.[12]) The risk posed by pest plants is compounded if they are accompanied by lush growth of annual grasses or other aggressive plants. This is one reason why we do not recommend completely fencing off ponds.

Relying solely on herbicides to control pest plants is not recommended. Managers should evaluate the potential for control through grazing, manual or mechanical weed control methods, or an Integrated Pest Management (IPM) approach combining multiple methods. As discussed above, some pesticide and herbicide contamination in ponds is linked to CRLF and CTS mortality. Please see the following section for more information on the use of herbicides in and around ponds and other habitat for these amphibians.

Use of Herbicides and Pesticides

The use of certain pesticides and herbicides is currently restricted in and around certain amphibian habitats. A 2006 injunction by the U.S. District Court for the Northern District of California imposed no-use buffer zones around CRLF frog upland and aquatic habitats for several listed pesticides, including 2,4-D and glyphosate, until USFWS determines whether each pesticide is unlikely to adversely affect the frog (CDPR 2013a). The injunction requires that the pesticides not be used within 60 feet of designated habitat (including all upland and aquatic habitat types) for ground applications and within 200 feet for aerial applications. The injunction only applies in specified portions of 33 counties, and there are exceptions in specified circumstances. In 2010, the same District Court issued an injunction against the use of numerous herbicides, including 2,4-D and diquat dibromide, in much of eastern Alameda and Contra Costa Counties, until these herbicides are deemed not likely to adversely affect CTS and several other listed species (EPA 2013). Specific locations, exceptions and further details and updates are currently provided online (CDPR 2013a; EPA 2013).

[12] Some reviewers agreed and others did not.

The use of chemicals to control pest plants and animals requires determination of which chemical is legal and best suited for the specific site and situation, based on up-to-date legal and scientific information. At a minimum, managers should confirm with their Agricultural Commissioner or a Certified Pesticide Applicator that the use of a particular herbicide or pesticide is legal in the area to be treated. Managers concerned about the effects of chemicals on amphibians should develop a pest management plan. The plan should incorporate non-chemical methods and avoid use of pesticides and herbicides that might harm any sensitive amphibians. The plan should follow the principles of IPM.

Ideally, the chemicals affected by the injunctions should be avoided even in areas not subject to the injunctions, until they have been deemed acceptable, and other chemicals should be used with restraint. Further guidance is available from local Agricultural Commissioners' offices, the University of California Cooperative Extension and the NRCS.

Research Needs

Non-Native Predators

What frequency of pond drainage is most effective? What other methods of predator control work? In what circumstances are game fish, mosquitofish, or bullfrogs tolerable?

Water Quality

What water quality conditions are ideal, and what range of conditions is tolerable, particularly for nutrient levels?

Livestock Access

What are the situations in which ungrazed ponds support healthy populations of CRLF and CTS? What level of trampling of eggs or individuals is a concern to the population? Are there practices that can minimize the risk of trampling while maintaining the benefits of access? How does one determine if and when to exclude livestock from a livestock pond (or the field it is in) if it appears that livestock use is excessively shortening the inundation period?

Increased CTS Mortality in Vegetated and Perennial Ponds

Increased CTS mortality has been linked in various studies and reports to high levels of vegetation cover, perennial inundation, water quality impairments, deep ponds, and presence of predatory aquatic invertebrates. How important are each of these factors? How do they interact?

Pest Plant Effects

How do pest plants affect CRLF and CTS? What species and density levels are most detrimental? What are the most effective and least harmful means of control?

Plants as Barriers

How dense at ground level must a stand of plants become to reduce access to a pond or otherwise reduce dispersal?

Herbicides, Rodenticides, and other Pesticides

There is need for further research on the direct and indirect effects of these chemicals on CRLF and CTS.

Managing Vernal Pools 6

Vernal pools can serve as breeding sites for California tiger salamanders, provided they meet the salamanders' requirements as described in the "Habitat Goals" section of Chapter 5. In fact, vernal pools were once a core source of breeding habitat for the species, especially in the Central Valley (Shaffer and Trenham 2005), before row crops and development destroyed much of this habitat and before ranchers began building stock ponds in the Coast Ranges. Vernal pools are still important habitat where they remain, especially in the Central Valley and Sonoma and Solano Counties. The small size and shallow depth of most vernal pools does create a few challenges that do not generally arise in ponds. For example, vernal pools are susceptible to invasion by non-native annual grasses, which can substantially reduce the pool's inundation period because of the large volume of water drawn up by the roots of these grasses. Regardless of management, many vernal pools are too small to provide a long enough inundation period to support breeding (Jennings and Hayes 1994).

Vernal pools also provide habitat for a number of other rare species not addressed in these guidelines. Information and recommendations regarding habitat management for fairy shrimp, rare plants, and the other sensitive species found in vernal pools can be found in documents such as USFWS (2005c) and Vollmar (2002).

Livestock Access

Ungrazed vernal pools can and do support CTS populations, but grazing is generally beneficial and can be critical. Removal of cattle grazing has been shown to greatly decrease vernal pool inundation period, below that required by CTS to complete metamorphosis (Marty 2005). In a study of sites throughout the Central Valley, Pyke and Marty (2005) found that grazed vernal pools remained inundated an average of 50 days longer than ungrazed vernal pools. The researchers believe that grazing helped preserve the inundation period by controlling annual grasses (the bulk of which are non-native in California annual grasslands). Soil compaction by livestock might also be important in extending the inundation period.

Another benefit of livestock access is that it can increase pool turbidity. As is the case with stock ponds, CTS are more commonly found in turbid vernal pools than clear ones (Robins and Vollmar 2002), most likely because the muddy water helps them evade predation.

Ideally, managers should observe whether livestock movement is eroding or lowering any sections of the margins of vernal pools so as to create a lower outlet and reduce the pool's capacity. This would indicate the need to restrict cattle access in winter months when soil is more compactible. As noted above, research indicates that cattle access provides a net benefit to inundation period, so the risk presented by erosion may be unusual, or generally offset by other factors. Because grazing appears to be beneficial overall, any grazing reduction should be done on a trial basis and the effects on non-native grass abundance monitored.

Concerns about annual vegetation and soil erosion would of course not apply to vernal pools found in rock outcrops.

If trampled individuals are frequently witnessed at a particular vernal pool, the manager may experiment with approaches—such as temporary fencing, rotation to other fields, or alternative watering facilities away from the pool—that would reduce cattle access when metamorphs leave the pool in late spring and summer. The risk is that this may result in clearer water and increased predation by birds on CTS, or increased growth of any non-native herbaceous plants present. Access may still be needed at other times of year to prevent excessive growth of non-native vegetation.

Robins and Vollmar (2002) present an excellent discussion of the effects of grazing on vernal pool species (with a focus on Merced County). For several rare plant and animal species, the authors found evidence and general expert consensus that (1) some amount of grazing is beneficial or important, and (2) severe under-grazing and severe over-grazing both are generally harmful to habitat conditions. However, there was generally little understanding of the relative ecological effects of different grazing schemes (timing and intensity) within the range of moderate to heavy grazing. In the face of this uncertainty the authors recommend flexibility in grazing management (within the accepted middle ground), monitoring, and adaptive management.

Pest Plant Control

Any pest plants that invade a vernal pool and grow densely would be expected to shorten the inundation period and degrade breeding conditions. In addition, dense growth of pest plants between vernal pools could make dispersal more challenging for CTS if the pest plant species grows too densely at ground level for a salamander to crawl through. The risk posed by pest plants would be compounded if accompanied by lush growth of annual grasses or other aggressive plants. Such problems can be intensified where grazing has been excluded. The available options for control would depend on the species in question.

The use of grazing, manual and mechanical weed control methods, or an IPM approach will nearly always be preferable to reliance on herbicides. As discussed in Chapters 3 and 5, pesticide and herbicide contamination in ponds may be connected to CTS mortality. Other rare vernal pool plant and animal species could be directly harmed as well. If herbicide use is contemplated, however, the manager should consult "Use of Herbicides and Pesticides" in Chapter 5.

Other Management Activities

The inundation period of vernal pools can be affected by other forms of land management. For instance, they could be made to hold water permanently through irrigation, which could allow exotic predators to establish (USFWS 2005b, peer review section). It is important to avoid soil disturbances in vernal pools that could breach the hardpan layer (Jennings and Hayes 1994).

Managing Streams, Springs, and Other Moist Habitat 7

Streams can provide breeding habitat for California red-legged frogs, and on very rare occasions for California tiger salamanders (Alvarez et al. in prep). Streams and adjacent riparian vegetation can also be important for CRLF use as dry-season refuges (USFWS 2006; Fellers and Kleeman 2007). In some areas, CRLF also use riparian areas as migration corridors to move between breeding and dry-season locations (Fellers and Kleeman 2007, Marin County).

Like riparian habitat, springs, seeps, and similar moist areas can serve as important dry-season refuges for CRLF, especially in areas where all the breeding sites are seasonal (Scott and Rathbun 2006). They are not used in this way by CTS. Suitable refuges include spring boxes and the moist vegetation around springs and seeps.

CRLF are not generally believed to be prey-limited in streams, riparian areas, springs, and moist habitats, but a variety of management activities can have a significant impact on other aspects of these habitats' suitability.

Habitat Goals

We begin with a brief overview of the conditions that are necessary and preferable in these habitat types. The desired conditions depend largely on whether the habitat is being used as breeding or non-breeding habitat, with protection from predators as a common element.

Suitable Breeding Habitat

To support breeding for CRLF, streams must be slow-moving (or have slow-moving portions) and have pools that provide the appropriate depth, inundation period, emergent vegetation cover, temperature, water quality, and predator evasion features. In addition, non-native predators cannot be present in large numbers. (Chapter 2 discusses the CRLF's specific requirements for suitable breeding habitat; Chapter 3 does the same for CTS, which, as noted above, do breed in streams on rare occasions.) Optimal conditions for CRLF breeding include patches or strips of riparian vegetation (such as cattails, bulrushes, and willows) and patches of sunlight (Scott and Rathbun 2006). CRLF do not typically breed in densely shaded streams.[13] However, dense riparian vegetation and associated woodlands just outside of streams can be important during episodes of flooding, drought, or increased salinity in coastal lagoons. Relatively level and slow-flowing stream reaches are preferred for breeding (Bobzien and DiDonato 2007). As discussed in Chapter 2, stream pools do not need to be as deep as ponds to serve as breeding sites (they can be about two feet deep or less).

Predator Evasion Features

As with ponds, vegetative cover and deep pools in streams can provide CRLF with cover from predators. Logs, rootwads, boulders, overhanging banks, and other forms of cover are also important (Tatarian 2008). Bullfrogs and CRLF can coexist in riparian corridors, especially if there is diverse habitat structure to help CRLF avoid bullfrog predation (Doubledee et al. 2003).

Other moist refuges must also allow CRLF to avoid predators. Dense vegetation, water deeper than half a yard, and artificial structures (such as spring boxes or covers of wildlife guzzlers) that allow access to CRLF but not predators all provide CRLF with predator evasion opportunities.

Moist Shelter

Stream corridors, springs, and other dry-season refuges must have enough moisture to allow survival throughout the non-breeding period, and enough cover to maintain moderate temperatures during hot and cold weather. The forms of cover listed above as predator evasion features are all useful in this regard. Accumulations of damp leaf litter or duff in semi-open or riparian woodlands can also serve as moist refuges.

Management Tools and Activities

Grazing and related ranching activities such as water developments and pest plant control can be managed to promote their beneficial aspects and minimize negative impacts on streams, springs, and other moist habitats. Managers can also implement a variety of restoration projects specifically to create or enhance breeding and non-breeding habitat.

Livestock Access

Grazing can be used to manipulate vegetation and create optimal habitat conditions in riparian areas and near springs and seeps. In general, we recommend that managers limit the amount and, especially, the timing of grazing, and avoid complete exclusion unless there is a small patch of vegetation that needs special protection. Excluding

[13] It is possible that shade from willows is more suitable (B. Mori, pers. comm.), and shade from eucalyptus and bay laurel canopies especially unsuitable (J. DiDonato, pers. comm.). CRLF tadpoles and egg masses have been observed in shaded creek pools in Contra Costa County (B. Mulchaey and J. Purificato, pers. obs.), although the number surviving to metamorphosis is not known.

livestock from large stretches of riparian habitat is undesirable, especially compared to the other alternatives presented here. Fenced-out areas can become too dense and shaded for CRLF (pers. obs. by author Scott; some reviewers disagree), and impacts can become concentrated in any watering or crossing areas left accessible to livestock. Excluded areas frequently become dominated by a few weedy species, which is undesirable for general ecosystem health.

Completely unrestricted access, however, can result in a loss of woody and tall herbaceous vegetation from creeks, springs, and seeps. Areas with low levels of vegetative cover can be enhanced by shifting the grazing period to the spring. Willows, cattails, sedges, and similar vegetation can be very susceptible to grazing in summer, fall, and early winter, when green forage is scarce in surrounding uplands. Grazing only when annual grasses in the surrounding uplands are green can allow the desired vegetation to establish and persist. If the desired vegetation is present, no additional managements steps are indicated.

Grazing in winter, when soils are wet, also increases the risk that overhanging banks may become trampled or seeps and springs excessively "punched up." If these impacts are occurring at a site, grazing should be minimized or avoided in the wet season.

Establishing a riparian pasture (wide enough to graze as a small field, with fencing set back far enough to include grassland as well as riparian habitat) allows managers to graze riparian areas for short periods in early spring to early summer. This approach can require more time, monitoring, and general commitment by the manager, but also gives the manager a great deal of control over riparian conditions. Any excluded areas should be monitored periodically for shifts to undesirable plant species. Managers may wish to try one or more alternatives before installing permanent fencing in riparian areas.

Small exclosure fencing at a spring or seep, or along short stretches of a creek, can also be used to protect vegetation and soil. This approach lacks the flexibility of a riparian pasture, but requires less management time and oversight.

Fencing is not always needed to achieve the habitat goals. Installation of off-stream water troughs and/or shade can also limit the negative impacts of grazing on riparian and spring vegetation and soil. These practices will have the best chance of succeeding when the field is not grazed, or minimally grazed, in summer through winter.

Plantings

Streams, springs, and seeps lacking tall or woody vegetation can be planted with willow stakes, shrubs, cattails, rushes, or similar vegetation. These plantings might require small fencing exclosures until established. Long-term management recommendations are described in "Livestock Access" above.

Pest Plant Control

Non-native plants that invade a stream can reduce habitat quality as discussed for ponds. In shallow moist habitats such as seeps, pest plants could also draw excessive water from the ground. As discussed previously (Chapters 2, 3, 5, and 6), the use of grazing, manual and mechanical weed control methods, or an IPM approach, will nearly always be preferable to sole reliance on herbicides. If herbicide use is contemplated, however, the manager should consult "Use of Herbicides and Pesticides" in Chapter 5.

Non-native Predator Control

CRLF can benefit from the control of existing non-native predators, especially game fish in streams with otherwise suitable breeding pools. Unfortunately, this can be very challenging in a stream because draining is not an option. Control methods that may impact resident CRLF should be avoided.

Stream Restoration and Management

Stream restoration projects can create or enhance breeding and non-breeding habitat for CRLF. Projects that create pools in slow-moving sections will create the possibility of use as breeding habitat. Other practices that slow water flow, stabilize eroding banks, or add vegetative cover will also benefit CRLF. Bank channelization practices that remove natural bank habitat and accelerate stream flows should be avoided or minimized. (As with pond repair and restoration, riparian restoration requires several environmental permits.) Large woody debris can be beneficial in providing cover or creating pools in streams (J. Purificato and M. Van Hattem, pers. comm.), and should generally be left in place.

Spring Development, Maintenance, and Enhancement

Spring developments, and rehabilitation of existing developments, should be done so as not to dry up moist spring or seep areas. Overflows are beneficial to CRLF because they can provide water to new or existing moist areas. Ideally, old spring boxes that are accessible to CRLF should not be replaced with new ones that are completely sealed, unless ample other refuges are present nearby or can be created (for instance, with a wildlife guzzler as described below).

Wildlife Guzzlers

Where naturally occurring moist refuges are lacking, managers can install wildlife guzzlers at sites with year-round sources of water available. A guzzler can be constructed relatively simply by installing an old bathtub, trough, or other small water reservoir flush with the ground in the uplands near a breeding area and piping in water. A float valve is needed to maintain the water level at a depth greater than half a yard for protection from raccoons. A secure lid or grate covering part of the reservoir can provide additional protection from predators. Escape ramps should be installed to prevent birds and mammals that fall in from drowning. Plantings adjacent to the guzzler will add additional cover and shade.

Research Needs

Riparian Understory Conditions

What types and density of understory herbs or shrubs are tolerable or beneficial for CRLF dry-season habitat in riparian woodland?

Stream and Bank Conditions

What particular water quality and stream architecture characteristics are most beneficial for CRLF breeding, juvenile rearing, and summer refuge by adults? Besides removal of riparian vegetation, what potential negative impacts to riparian areas should managers avoid? What degree of bank trampling is an issue for CRLF, and how can managers minimize negative impacts?

Riparian Corridors as Migration Routes

To what extent do juveniles and adults use riparian corridors as migration routes? Are behaviors different in drier areas with few refuges outside of riparian corridors?

Habitat Abundance and Location

How many stream pools suitable for breeding are enough? How many vegetated stretches suitable for dry season refuge are needed? How many other moist refuges are enough, and how close do they need to be to ponds in order to be useful?

Managing Terrestrial Habitat 8

When California red-legged frogs and California tiger salamanders are not in ponds or other moist habitat, they are mainly inhabiting rangeland plant communities—grassland, savanna, and shrubland (the latter more so for CRLF than for CTS). Both species will also move through a variety of other habitat types, including farmland and small patches of dense woodland. This chapter discusses how to manage the terrestrial habitats the amphibians may occupy so as to provide for their needs. Please refer to Chapters 2 and 3 for information about when CRLF and CTS will use upland habitat, and to Chapter 7 for recommended management of the vegetation in and adjacent to the streams, springs, and seeps found within rangeland landscapes.

Habitat Goals

Rangeland managers aiming to provide good upland habitat for CRLF and CTS should seek to ensure that both species have safe refuges for shelter and foraging and are able to move between breeding and non-breeding locations.

Presence of Rodent Burrows

Burrows made by ground squirrels, gophers, and other small mammals are vital to CTS and can be helpful or important sources of refuge to CRLF as well. Although it is not known how many burrows are needed to support the CTS or CRLF associated with a particular breeding site or network, scientists agree that burrow-producing rodents should be at least relatively common if an area is to provide suitable habitat for CTS—and for CRLF if moist refuges are scarce in the area.

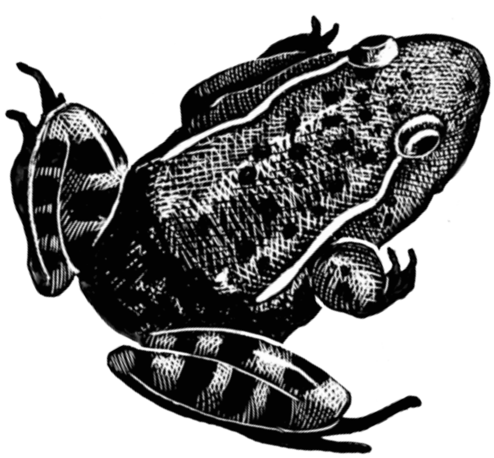
Ground squirrel burrows provide homes to a number of species other than CTS and CRLF, and the squirrels themselves are an important source of food to many rare and common species of wildlife. They play a central role in the grassland ecosystem and are thus considered a "keystone species." Many landowners, however, consider them to be pests.

Although burrows are not central to the California red-legged frog's life cycle, they can be helpful sources of refuge (a widespread observation among our reviewers), and may be especially important where other refuges (such as seeps, springs, or vegetated riparian corridors) are few or lacking (Tatarian 2008). CRLF will also spend the daytime in burrows near ponds, and enter the ponds at night (J. DiDonato, pers. comm.).

CTS spend most of their lives underground in small mammal burrows. These burrows are most commonly made by ground squirrels or pocket gophers (Shaffer et al. 1993); kangaroo rat burrows are heavily used in Santa Barbara County (S. Sweet, pers. comm.). Along with pond management, keeping these rodents present and at least relatively common is one of the major concerns for CTS-oriented management. CTS are believed to generally use open, accessible burrows, but can push their way into plugged burrows (Jennings 1996). Whether the burrow is currently occupied or not by rodents does not appear to be a factor (Loredo et al. 1996). CTS have been observed in a burrow containing a nest of ground squirrel pups, with both parties apparently indifferent to the other's presence (pers. obs. by author Trenham).

Generally Short Grasslands

Grassland with generally low vegetation is the most suitable non-breeding habitat for California tiger salamanders. It is also highly suitable for California red-legged frogs, especially if other types of dryland shelter or moist refuges are nearby (see below, and Chapter 7, respectively). Ease of movement is thought to be one reason that low vegetation is beneficial. For CTS in particular, generally low vegetation has an even more important benefit: ground squirrels and pocket gophers —and therefore their burrows—are most abundant in short grasslands (e.g. Loredo-Prendeville et al. 1994). Domination by tall or dense herbaceous vegetation is believed to reduce ground squirrel populations over the long term; however, *patches* of tall grass help ground squirrels avoid predators and appear to be tolerable or beneficial to the squirrels, if not essential (Fitzgerald and Marsh 1986).



Other plant community types that often occur adjacent to grassland, including shrubland and oak woodland, do not generally provide suitable habitat for ground squirrels. This means that shrub expansion into grassland is likely to reduce habitat for both ground squirrels *and* CTS (and possibly CRLF too). Shrub expansion is more likely in areas influenced by moist marine air (such as along the coast) that are not burned or grazed in the dry season (Ford and Hayes 2007).

For CRLF, the importance of short grasslands appears to vary by locality. In areas with abundant moist refuges in close proximity to breeding sites, CRLF may be less likely to migrate across upland landscapes or to need burrows as refuges. In these areas, therefore, the benefits of short vegetation—ease of movement and higher rodent populations—may be less important. Conversely, abundant rodent burrows and ease of movement may be important for the frog in areas where burrows are the main refuges available in proximity to breeding sites.

Presence of Other Types of Dryland Shelter

CRLF and CTS can be opportunistic about the refuges they inhabit, especially if these are only temporary stops in a foraging excursion or a longer migration between a breeding site and preferred non-breeding habitat. Acceptable refuges will generally be available for CTS if managers are meeting the other habitat goals described in these guidelines. For CRLF, managers should strive for some heterogeneity in the type and condition of rangeland vegetation.

CRLF will often take refuge under shrubs (Bulger et al. 2003), and can use vole tunnels in dense grass as shelter (or perhaps for dispersal). It is desirable, therefore, for upland habitat to have some vegetative diversity. Dryland shelter may be less important in areas with abundant moist refuges as described in Chapter 7.

CTS, especially metamorphs and juveniles, will take refuge in a variety of locations besides burrows. CTS have been observed under litter or logs, in cracks of the soil (Loredo et al. 1996), as well as in artificial structures such as pipes, septic drains, and basements (Jennings and Hayes 1994).

Prey Availability

CRLF and CTS prey on small invertebrates, and CRLF will also eat mice and other small vertebrates. Neither species is generally limited by prey availability in their terrestrial habitats (pers. obs. by authors Scott and Trenham). Management that maintains or encourages some habitat diversity (species and structure) and works toward the other goals described here is likely to facilitate hunting efforts by CRLF and to support abundant prey. Managers should not undertake efforts to eliminate insects or mice on rangeland habitat.

Relatively Unrestricted Movement Between Breeding and Non-breeding Sites

CRLF and CTS will use or move through a variety of plant community types. Grasslands and savannas are the main terrestrial habitats used by both species. Dense, tall herbaceous vegetation may slow dispersal (pers. obs. by authors Scott and Trenham). Very dense herbaceous vegetation surrounding a breeding site could affect migration into or out of that site. Large expanses of closed-canopy forests and some shrubland types might pose a barrier to movement, but more research is needed on this question. Please refer to Chapter 9 for additional discussion of dispersal and movement at the landscape scale.

Management Tools and Activities

The habitat variables discussed above are highly influenced by management. Grazing affects the amount of burrows and other refuges available, and the type and condition of upland vegetation experienced by CRLF and CTS as they forage in upland habitat or move from one aquatic or moist habitat to another. Refuge availability, prey foraging opportunities, and ease of movement can also be highly affected, for better and worse, by other ranching activities such as pest control and brush management.

Grazing

Healthy populations of both amphibians have been observed in a wide range of grassland vegetation conditions, including both ungrazed and heavily grazed situations (Bobzien et al. 2000; Bobzien and DiDonato 2007; pers. obs. by authors Scott and Trenham). It is our opinion, however, that large-scale, long-term exclusion of grasslands from grazing is generally detrimental to CRLF and CTS. This opinion is based on the following studies and observations from field experience in a variety of habitats:

- Moderately to heavily grazed sites appear to support greater abundance of CTS than ungrazed sites (pers. obs. by author Trenham).

- A lack of grazing often produces a dense ground cover that can impede CRLF and CTS movement (pers. obs. by authors Scott and Trenham).

- Ground squirrels and kangaroo rats prefer grazed over ungrazed annual grassland (Linsdale 1946; Howard et al. 1959; Germano et al. 2012). When these rodents are scarce, there are fewer burrows for CTS and CRLF.

- Cessation of grazing will in many areas lead to conversion of grassland to shrubland (Ford and Hayes 2007), substantially decreasing the populations of burrowing rodents.

Our conclusion may not apply to CRLF habitat in coastal areas with abundant moist refuges near breeding sites[14] or to areas with sandy or nutrient-poor soils that remain relatively open without grazing.

If a land manager is aiming for ideal terrestrial habitat, especially for CTS, the conservative approach would be to use grazing to keep most herbaceous vegetation fairly low throughout much of the year (but see below) and to prevent large stands of very dense vegetation from forming around breeding sites, especially in inland areas. Alternative means of obtaining these results—such as burning and mowing—may also be feasible options for a given site, but they are rarely feasible for extensive areas. Shrub invasion of grassland is another problem that is often best controlled by grazing (although some pre-grazing treatment to reduce shrub cover might be necessary). Where shrub invasion is occurring and will exceed 50% cover in a grassland matrix, we recommend grazing during the summer to control the invasion. (See "Brush Control" below for recommendations involving control methods other than grazing.)

While rangeland managers should ideally aim for generally low herbaceous vegetation, some amount of heterogeneity is beneficial to CRLF, and neutral or beneficial to CTS. In particular, patches or stands of shrubs, trees, or dense herbaceous vegetation can help CRLF to find dry-season refuge and forage for prey. Patches of tall grass may benefit ground squirrels, which may indirectly benefit CTS and CRLF. The temporarily tall and abundant grass growth often observed during spring is not known to pose any concerns.

Beyond the general requirements that grasslands support healthy rodent populations, not be overly tall or dense for large stretches of time or space, and preferably (for CRLF) have some heterogeneity, there is no evidence that CRLF or CTS prefer any specific values or ranges of residual dry matter, herbaceous mass, height, or density, or specific composition of herbaceous species.

The most common measurement used for rangeland planning and management—residual dry matter (RDM), the amount of herbaceous matter remaining before the first fall rains—is not perfectly suited to describe grassland habitat quality for CRLF or CTS. Rangeland planners and managers often use minimum or target levels of RDM to prevent erosion and maximize forage production and quality. Standards for RDM have been determined for a variety of grassland and savanna habitat types (Bartolome et al. 2006). Maintaining appropriate RDM is important for general rangeland health, and for preventing erosion (which could silt up ponds and pools). But because RDM is measured only in the fall, it does not provide information on grassland conditions in the other seasons, when CRLF and CTS are moving across grasslands. Grazing management that results in RDM near the standard, however, will likely be compatible with healthy populations of both amphibians (e.g. Bobzien and DiDonato 2007)—but this may depend on how forage is

[14] Several biologists working in coastal areas did not agree with our assessment of the importance of grazing, while several biologists working in drier inland areas stated that grazing is necessary.

managed within the growing season, and may not be the case if herbaceous vegetation becomes very abundant for long periods.

If a habitat manager wanted to measure the vegetation conditions related to amphibian habitat quality for research or adaptive management purposes, then herbaceous mass at or near ground level, measured when amphibians are moving across the landscape, would likely be the most relevant factor (although it is not a perfect proxy for the degree of obstruction). Any vegetation-related variables should be mapped at a scale relevant to the species, showing conditions around ponds and other habitat features rather than a single average for a large field.

Rodent Control

Ground squirrels and gophers are considered pests by many ranchers, who attempt to control or even eradicate them with poisoned bait stations and other methods. Since CTS, and sometimes CRLF, rely on these rodents, there is the potential for control practices to have negative impacts on these species. Nevertheless, it has been our experience that ranches that control squirrels generally still have numerous squirrels, and many ranches with decades-long control efforts have abundant amphibian populations. The effects of control are often short-lived, as ground squirrels will generally re-invade from neighboring populated areas (Stroud 1982). Eradication appears to be rare.[15]

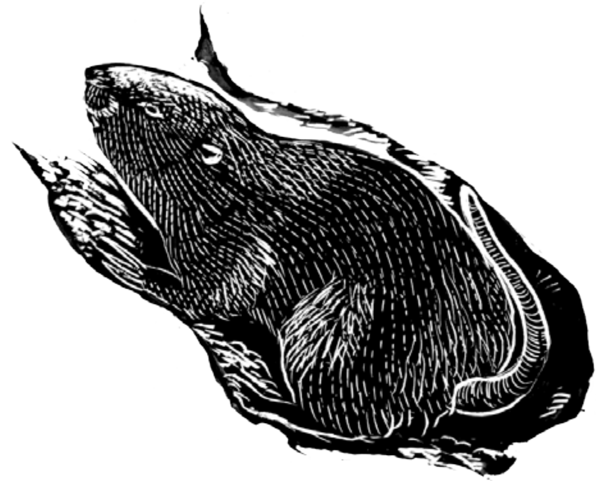
While rodent control can be compatible with CTS- and CRLF-focused management, some control methods should always be avoided because they can harm or kill CTS and CRLF directly. Fumigation is believed to have a much higher chance of direct and indirect impacts to CTS compared to granular rodenticides (USFWS 2004). Another control method with rising popularity is to inject combustible gas into burrow complexes and then ignite the gas. Since CTS and CRLF occupy burrows year-round, there is no safe time of year to use either fumigation or combustion. Some managers will only fumigate burrows when there is evidence of squirrel use, following the faulty theory that other animals are not present. This strategy does not protect CTS or CRLF since they will share burrows with squirrels (and it is not a reliable strategy for protecting other non-target wildlife either). Regardless of method, any rodent control effort that is successful enough to significantly reduce rodent populations over the long term would reduce the number of burrows and would therefore be detrimental to CTS, and potentially to CRLF. In other words, it is only the relative ineffectiveness of most rodent control efforts that allow them to remain consistent with managing for CTS and CRLF.

We recommend the use of wildlife-friendly rodent control practices such as owl boxes and raptor perches (to attract predators), and lead-free ammunition when shooting squirrels (to avoid lead poisoning of scavenging wildlife).

15 We note that some reviewers have observed ranches where ground squirrel control has been highly effective (P. Greer, S. Gennet and L. Serpa, pers. comm.).

Ground-disturbing Activities

Some ground-disturbing activities can affect burrows, and may trap resident CTS or CRLF. Destruction of burrows by deep ripping to a depth of 18 inches was shown to significantly delay squirrel re-colonization (Gilson and Salmon 1990) whereas ripping to a depth of 12 inches did not (Salmon et al. 1987). The area subjected to deep ripping should be minimized in general, and the practice should be avoided completely in areas with vernal pools. Large areas of grassland should not be tilled on a regular basis. Infrequent tilling of firebreaks and other small areas is probably not a concern, although mowing would be preferred (pers. obs. by author Trenham), especially in areas with known colonies of burrowing rodents or CTS.



Although the construction of fencelines and the laying of pipelines to supply livestock troughs with water involve some ground disturbance, the disturbance is limited compared to wider-ranging soil ripping and tilling. Moreover, livestock fencing and water developments are necessary ranching practices and key management tools for responsible rangeland stewardship, and they co-occur very frequently with healthy CRLF and CTS populations on public and private grazed lands. When installing new fencelines or water developments, managers striving for ideal habitat conditions should minimize the degree to which the route runs through known colonies of ground squirrels, pocket gophers, or kangaroo rats, providing a wide buffer around burrows where feasible.

Burrow Creation

Cook et al. (2006) found that CTS colonized a formerly unoccupied area near a breeding pool in Sonoma County after artificially placed friable dirt was used to attract pocket gophers. CTS used these burrows, but appeared to mainly use other upland habitat. The authors concluded this approach can provide burrowing habitat that, though apparently suboptimal, would improve conditions for CTS in areas that have limited burrowing habitat due to land conversion.

Brush Control

Where invaded shrub cover exceeds 50%, it might be appropriate to reduce shrub cover through prescribed burns[16] or mechanical controls, and then to use grazing to control additional spread and density. The needs of shrub-dwelling animals (including any sensitive species such as the Alameda whipsnake) and regulatory concerns should be evaluated before shrub clearing. Depending on the nature of the invading vegetation, grazing alone may be an effective control method (see "Grazing" above). This is generally true for Northern Coastal Scrub, which is dominated by coyotebrush and typically occurs on soils suitable for grassland (Ford and Hayes 2007). Shrubs should not be cleared in areas where they have historically always been (in other words, where they are not invading) or on steep slopes with shallow soils.

[16] Permits for prescribed burning may be difficult to obtain due to safety and air pollution concerns.

Pest Plant Control

As noted elsewhere in this document, pest plants can impede amphibian migration if they form stands or thickets that are too dense at ground level for a frog or salamander to crawl through. The risk posed by pest plants is compounded if accompanied by lush growth of annual grasses or other aggressive plants. Harding grass and velvet grass are two examples of non-native grassland plants that can grow in dense stands and might become problematic for CTS or CRLF. Plants with toxins (such as eucalyptus) or spines (such as yellow star thistle) could also pose a threat (the latter may also reduce burrowing rodents; D. Bland, pers. comm.).

Although pest plants have the potential to be detrimental to CRLF and CTS, control of pest plants is most frequently implemented for reasons other than to benefit CRLF or CTS habitat. Regardless of the motivation, decision-makers should consider the needs of these amphibians when selecting a control strategy. Manipulating the timing and intensity of grazing can be a powerful method for controlling some pest plant species. Other options include burning, manual and mechanical removal, herbicides, and a combination of multiple methods.

The use of non-chemical methods to control pest plants, or a combination of methods that minimizes the need for chemicals, is nearly always preferable to a reliance solely on herbicides. As discussed in Chapter 5, some herbicides may be harmful to CRLF or CTS. If herbicide use is contemplated, the manager should consult "The Use of Herbicides and Pesticides" in Chapter 5. Further guidance is available from local Agricultural Commissioners' offices, the University of California Cooperative Extension and the NRCS.

Research Needs

Barriers

What are the characteristics of plant communities (extent, density at ground level, canopy cover) that would pose a significant barrier to movement of CTS or CRLF?

Dispersal by Juvenile CRLF

Little is known about the dispersal patterns of immature CRLF, or how their needs may differ from adults when moving across the landscape.

Grazing and Grassland Characteristics

What circumstances of excessive or insufficient grazing result in inadequate habitat quality for CRLF or CTS, or for their predators and prey? Are there generally optimal approaches for coastal vs. inland areas? What are the rangeland metrics best suited for assessing and monitoring habitat quality, including heterogeneity of species and structure?

Disturbance

How do disturbances to upland habitat—such as fire, landslides, and drought—affect CRLF and CTS?

Maintenance Operations Effects

Do any activities related to property maintenance, road management, vehicle operation, and other manager operations negatively impact CRLF or CTS or the quality of their upland habitat? If so, what best management practices would decrease or avoid the effect? Should the installation or maintenance of fence or pipeline (for water tanks and troughs) be a concern in CTS habitat? If so, how can any impacts be minimized to a level acceptable to CTS and regulatory entities?

Burrows

How many rodent burrows within dispersal distance of a given pond are enough to provide a sufficient or optimal amount of upland habitat for a population of CTS? How does grazing influence the number of burrows?

Ground Squirrel Control

Do commonly used rodenticides have direct impacts on CRLF, CTS, or their prey?

Planning at the Landscape Scale 9

The previous chapters have discussed each habitat element one by one. Of course, frogs and salamanders must move between these elements, and the amphibians residing in, for instance, a pond can be affected by how the neighboring grasslands are managed. We now take a step back and consider issues involving multiple habitats and their spatial arrangement or connection on the landscape, for which managers must take a bird's eye view. Consideration of these issues in formal or informal planning efforts may trigger adjustments to how specific habitat elements are managed and how projects are prioritized.

Breeding Site Networks

Each breeding site should be viewed not in isolation, but as part of a larger network of breeding sites. For both species, having a network of breeding sites close enough to each other to allow individuals to move between them is crucial in maintaining a population over the long term. If a breeding site has a poor year, it can be readily re-colonized later if there are other individuals breeding nearby. California's variable weather can make a given pond vary considerably in habitat quality from year to year, so having multiple ponds with different characteristics (size, depth, vegetation, etc.) increases the odds that at least one pond will have suitable conditions in a given year and have good reproductive output (pers. obs. by authors Scott and Trenham).

For a collection of breeding sites to function as a network, individuals must be able to move between them (this is often described as "connectivity" between breeding sites). This is a function not only of the distance between sites, but also of the conditions of the terrain at an amphibian scale. Potential barriers include some roads (see below), long stretches of walls or silt fences, very dense vegetation, and large stands of dense woodland or forest. Where significant change in management has occurred, such as termination of grazing, new impediments might arise due to excess herbaceous growth during a productive year or encroachment of woody plants (see Chapter 8). Invasions of densely growing pest plants might also create barriers. Options for mitigating barriers caused by growth of vegetation are discussed in Chapter 8 above.

A viable and robust population of California red-legged frogs needs multiple breeding sites (Scott and Rathbun 2006). Networks can consist of suitable ponds and/or streams with pools up to three miles apart and preferably closer.

California tiger salamanders also rely on networks of ponds. CTS can travel between ponds at some distance from each other, and regularly do so. In a three-year study of ten breeding ponds on the Hastings Reserve in Monterey County, approximately a quarter of recaptures were found at a pond other than the original capture location (Trenham et al. 2001). CTS can travel at least 1.4 miles between ponds.

The issue of connectivity relates not only to breeding sites but to the ability of CRLF and CTS to move between breeding sites and associated non-breeding habitat features (see below). The same barriers that might reduce dispersal or migration to other breeding sites will also limit the more routine seasonal movement between ponds, vernal pools, or streams and burrows or moist refuge.

Landscape-scale Factors for Prioritizing Management Activities

Looking beyond individual sites, at the level of the landscape (or ranch or property), provides a holistic context within which to evaluate how limited resources should be distributed amongst competing management demands. At a minimum, there should be ample non-breeding habitat within dispersal distance of breeding sites, and few potential barriers to movement between breeding sites, associated non-breeding habitat, and the other breeding sites in a network.

Geographic Focus of Management for Non-breeding Habitat

Research on how CRLF and CTS use and move across the landscape provides information that can guide managers aiming to benefit the non-breeding habitat most likely to be needed by the CRLF and CTS that breed in a given pond or pool.

CRLF move between breeding and dry-season habitat in different ways, depending (at least in part) on the habitat types present, and they vary in the distance they will travel. In a Marin County study, CRLF moved from breeding ponds to the nearest suitable non-breeding habitat (Fellers and Kleeman 2007). The average distance was approximately 380 yards. CRLF that traveled longer distances tended to follow riparian corridors. In one study in Santa Cruz County, radio-tracked migrants moved overland in approximately straight lines, without apparent regard to vegetation type or topography (Bulger et al. 2003). Some of the frogs studied moved relatively short distances (less than 325 yards) while others moved relatively far, up to approximately two miles. These migration routes were not fixed, but were often habitual, with frogs repeatedly using pathways that had allowed successful movement when the frog was young. Taken together, this research supports the need for an area of at least one square mile of suitable terrestrial habitat with multiple moist refuges (Scott and Rathbun 2006). The most valuable areas in which to maintain, enhance, or restore moist refuges for CRLF would be within roughly a hundred yards of breeding sites (Bulger et al. 2003).

Stream-breeding CRLF may offer somewhat different circumstances. In a study of stream-breeding CRLF in eastern Contra Costa County, CRLF stayed in the stream to move between ponds (Tatarian 2008). Where streams provide breeding habitat, therefore, we support Tatarian's conclusion that the stream reaches between suitable pools be managed as habitat, as well as a roughly 330-foot-wide buffer around the stream (including riparian vegetation as well as any grassland or other terrestrial vegetation).

Connectivity between ponds and upland burrow habitat is also important for maintaining viable populations of CTS. CTS have been observed up to 1.4 miles away from a breeding pond (Orloff 2011). Contrary to some assumptions, non-breeding CTS do not generally reside in the grasslands immediately adjacent to ponds. Trapping studies conducted in Monterey and Solano Counties (Trenham et al. 2001; Trenham and Shaffer 2005; Searcy and Shaffer 2011) indicate that almost all CTS appear to reside more than 100 yards away from their breeding ponds, but within approximately 0.6–1.2 miles of those ponds. Ideally, therefore, the majority of terrestrial vegetation within roughly 1.2 miles of a breeding site (a circle with an area of roughly three thousand acres) should be managed in a manner consistent with use by CTS. The species does not, however, need this entire acreage to maintain a viable population—some extent can be used for ranch residences and other infrastructure, or non-rangeland uses. More research is needed on the number of burrows or suitable grassland acres needed for a given breeding site.

Although grasslands within 100 yards of pond are not preferred by CTS for residence, this area is still of course important for allowing connectivity between breeding and non-breeding habitat. CTS appear to take more or less straight routes to and from ponds (Trenham and Cook 2008 and unpublished tracking data from Trenham). Therefore the areas between a pond and existing suitable upland habitat will be the most important to manage for CTS. However, Trenham and Cook (2008) found that CTS often exited a pond in a different direction from which they had come. The authors concluded that "broad areas of suitable habitat adjacent to breeding pools will be needed to minimize losses due to the tendency to wander." Although this tendency to wander when exiting breeding sites has not always been observed (for instance, Orloff 2011), the most conservative approach is to manage the majority of surrounding uplands within 1.2 miles of breeding sites to benefit CTS.

Creating New Ponds and Repairing or Enhancing Existing Ones

Repairing or enhancing an existing pond or creating a new one will have the most benefit to the local population if the site is already occupied or is within dispersal distance of another occupied breeding site. The pond should also be as far as possible from predator source-areas (one mile; possibly much more if the predators in question are bullfrogs [Ingram and Raney 1943]). Repair of a pond will be a high priority if it has an eroding spillway or dam and is releasing sediment to a nearby pond downstream, or threatening to. Bullfrog control measures at a breeding site (see Chapter 5) are important if the general area has bullfrogs, even if the site is more than a mile from the nearest known bullfrogs. Please refer to Chapter 5 for further discussion of methods, regulatory concerns, and reasons these projects should be viewed by managers, regulatory agencies, and funders as crucial habitat restoration projects and not merely ranch infrastructure maintenance.

Buildings, Roads, and Other Infrastructure

In general, ranch infrastructure does not appear to present major concerns for CRLF or CTS habitat. We recommend that managers use erosion-avoiding best management practices when installing and maintaining infrastructure, especially uphill from ponds or streams. Managers aiming for optimum conditions should try to minimize the number of burrows affected by new infrastructure, especially if burrows are not abundant in the area.

Roads and associated culverts are a common cause of gullies, and can be a major source of sediment in rangelands (Lewis et al. 2001). Such sediment can end up downstream and silt up ponds, stream pools, and moist refuge areas. To avoid these problems, managers should follow best management practices for low-maintenance, low-erosion roads and culverts, and address existing gullies caused by roads. Guidance is available from local NRCS offices and Resource Conservation Districts.

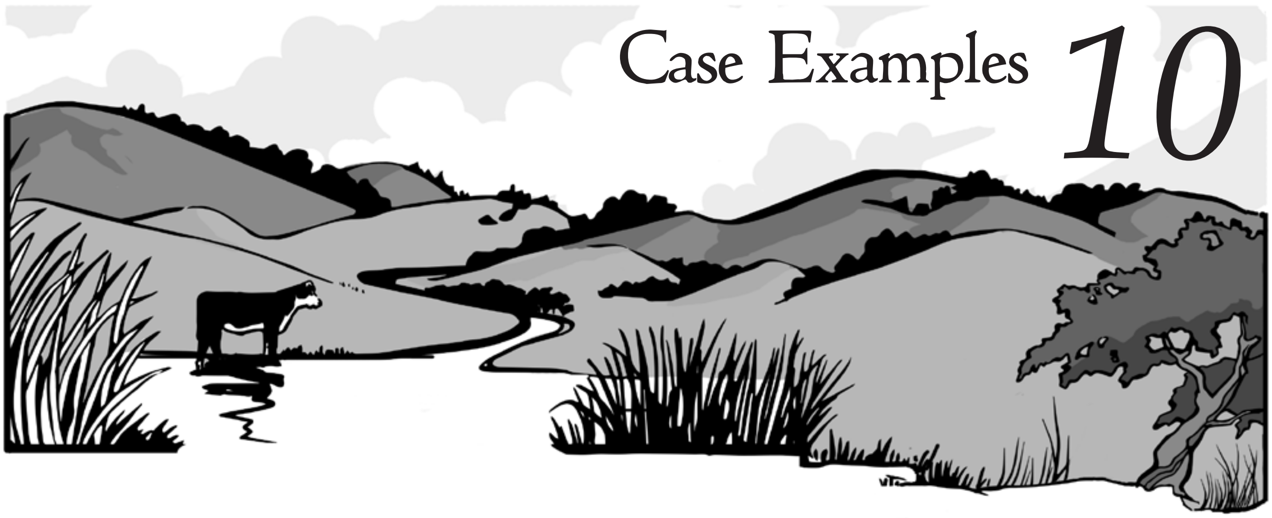
Ranch roads are not believed to present significant direct risk to either CRLF or CTS (pers. obs. by author Trenham). These roads see little traffic, especially where and when it matters most—near ponds and on rainy nights. Roads can reduce or block CRLF and CTS movement, and separate nearby ponds, if they include physical barriers such as solid road dividers and storm drains (and, for CTS, vertical curbs) (Trenham and Cook 2008). Vehicle traffic (at night) can cause direct mortality, with traffic of more than 12,000 cars per day believed to be a complete barrier to migrating amphibians (Cook et al. 2006, citing Hels and Buchwald 2001).

Research Needs

Movements Within the Breeding Network

Much research is still needed on the factors (vegetation, density and spatial arrangement of breeding and refuge sites, etc.) that determine how CRLF and especially CTS use their landscapes. How much acreage is needed to support a stable population, or to link two breeding sites, under different circumstances?

Case Examples 10



Here we present descriptions of several examples of healthy habitat for California red-legged frogs and California tiger salamanders, on a private ranch and on the watershed lands of a water district. These case examples are not meant to show the "one right way" to manage, but instead to give a few brief examples of suitable habitat and successful management approaches.

Unless otherwise noted, all photographs are © Joseph DiDonato, Wildlife Consulting and Photography, and were taken in Alameda County.

Koopmann Ranch, Sunol

Case Example 1: California Tiger Salamander

Los Vaqueros Watershed, Brentwood

Case Example 2: California Red-Legged Frog

Case Example 3: California Red Legged Frog and California Tiger Salamander

Koopmann Ranch, Sunol

Case Example 1: California Tiger Salamander

The Koopmann Ranch encompasses 850 acres of grassland, oak woodland, and riparian habitat. Twelve and a half hectares (31 acres), including a CTS breeding pond and surrounding uplands, have been managed as a CTS mitigation easement since 2003. The pond has been a reliable breeding site, even in drought years.

Koopmann CTS Pond view 1, 2008 (by L. Ford).

Pond Characteristics: The pond is a natural catchment (reportedly formed during the 1906 San Francisco earthquake) fed by rainwater and surface run-off (Figures 1 and 2). Typically the pond dries out once or twice every ten years. Emergent vegetation is virtually absent, and limited to a few grassland species at the pond's margins. The pond has a maximum depth of six feet and maximum width of 70 feet. Great blue herons are occasionally observed. Bass, perch, bullfrogs, and western pond turtles occur within a half mile but have not been observed here.

Pond Management: There is no fencing around the pond, and cattle have open access during the winter and summer grazing periods. The pond has been cleaned of sediment twice in the last 56 years (most recently in 1996), using a small bulldozer when the pond was dry.

Terrestrial Vegetation and Management: The vegetation around the pond is annual grassland with patches of native perennial grasses, and oak woodland. Yellow star thistle covers less than 1% of the easement area and is manually removed each year. The Koopmanns use a five-pasture rotational grazing system (four grassland pastures and one riparian pasture) for their cow/calf operation. In a normal year the 200-acre "CTS Pasture" is grazed for four to six weeks in February and March and again for four to six weeks in summer. Watering sources in the pasture are the pond and a trough half a mile away. Light to moderate grazing typically leaves 1,100–1,500 lbs/acre of RDM in the fall. Prior to 1999, ground squirrels were controlled by broadcast rodenticide-laced grain. Currently, squirrels are managed by shooting and a healthy raptor population.

Monitoring: The easement requires biannual monitoring of range management (conducted by a Certified Rangeland Manager) and CTS presence (conducted by a permitted biologist). Since 2003, CTS have been observed each monitoring year, including the drought years of 2007 and 2009.

Koopmann CTS Pond view 2, 2002 (by the Conservation Partnership).

Los Vaqueros Watershed, Brentwood

Pond H1 view 1, Contra Costa County, 2009 (pond on the right; by P. Van Hoorn).

The Los Vaqueros Watershed (LVW), owned and managed by Contra Costa Water District (CCWD), encompasses 18,500 acres of grassland, oak savanna, and chaparral in Contra Costa and Alameda Counties. Both CRLF and CTS occur in a mosaic of habitats managed for both species. Sixty-seven stock ponds, seventeen semi-permanent marshes, and five alkali marshes are maintained at LVW. After a survey of all CCWD ponds in 1996, fourteen of the stock ponds were designated as "key" based on presence of CRLF, amounts of emergent vegetation, and pond inundation through July. These Key Stock Ponds are expected to provide aquatic habitat for successful CRLF breeding in most years. The two case examples that follow highlight a pond that supports CRLF and another pond that supports both CRLF and CTS.

Case Example 2: California Red-Legged Frog

At Pond H1 (Figures 3 and 4), designated a Key Stock Pond, CRLF have been consistently observed in surveys that have been conducted several times a year, beginning in 1998.

Pond H1 view 2, Contra Costa County, 2009 (by P. Van Hoorn).

Pond Characteristics: H1 contains at least some water year-round and is within 0.5 mile of another pond with year-round water. During a typical year, H1 has the following characteristics: 65% open water; two to five feet of water depth; 35% cover of emergent vegetation (bulrushes and cattails); and 40% edge vegetation (spikerushes, annual grasses, bulrushes, and cattails). No riparian vegetation occurs near the pond. The nearest paved road is Los Vaqueros Road, approximately 0.75 miles from H1. Livermore, approximately 3.5 miles from H1, is the nearest developed area. Some CRLF likely reside at H1 year-round because there is permanent water. CRLF have been observed in cracks in the pond's dam.

Pond Management: As with all of the Key Stock Ponds, Pond H1 is partially fenced to exclude livestock from a portion of the pond. Roughly a third of the pond was fenced in 1997. Livestock are periodically allowed inside the exclosure to graze pond vegetation. Performance standards for management of this and the other Key Stock Ponds are as follows: (1) $\geq$ 10% of the shoreline is vegetated; (2) 30%–60% of the exclosure has emergent vegetation; and (3) 40%–70% of the exclosure is open water.

Terrestrial Vegetation and Management: The terrestrial vegetation surrounding the pond is annual grassland. Ground squirrel burrows are plentiful in the uplands near H1. Yearling cattle graze this 1,151-acre field from December or January to June or July. Watering sources for livestock in this field include Pond H1 and the adjacent Pond H1B, nine other ponds, and a spring-fed trough. Six of these other watering sources are within 0.5 mile of H1. Animal Unit Months (AUM) in this field vary: 134 AUMs were recorded in 2007 and 76 in 2008. October RDM values ranged from approximately 1100 to 2200 lbs/acre between 2006 and 2008. Management to enhance and protect CRLF habitat includes grazing to decrease non-native annual grasses.

CRLF adult, 2012.

Predator Control/Predators: Non-native fish and bullfrogs were controlled throughout the Watershed, by draining the ponds and by fishing. Drift fencing is used at the northern edge of the watershed to prevent bullfrog immigration. Mosquito fish remain in a few ponds, which also support healthy CRLF populations. LVW also has a feral pig control program.

Monitoring: Surveying for CTS/CRLF has been conducted six times per year at every pond since 1998. Monitoring is primarily conducted by CCWD staff and periodically with assistance from a consultant. CRLF monitors must be approved by the USFWS. CTS monitors must possess a Federal Recovery Permit 10A/1A. Monitoring of rangeland health is conducted by CCWD staff in June and October. This includes Residual Dry Matter (RDM) mapping, and monitoring for rodent populations and pest plants. CCWD has no RDM standards specifically for CRLF or CTS habitat, but they use the following RDM standards to benefit San Joaquin kit fox habitat: at least 500–800 lbs/acre in unfavorable forage production years and 1,500–2,000 lbs/acre in favorable forage production years.

Case Example 3: California Red Legged Frog and California Tiger Salamander

Several ponds at the Los Vaqueros Watershed have supported both CRLF and CTS. This case example discusses one of these ponds—Pond D5 (Figures 5 and 6). CRLF have been observed here every year since surveys began in 1998. Although formal surveys detected CTS in only three of the first eleven years, a CCWD consultant has observed them every year. Please see the previous case example on Pond H1 for general information on the Los Vaqueros Watershed, and for details on the property's predator control and monitoring practices.

Pond Characteristics: D5 typically fills with water starting with November rains. During some years, D5 retains water year-round, while in other years it dries by August or September. When D5 dries, there is no water augmentation. Three semi-permanent marshes about 0.5 mile downstream are typically inundated until at least September 15. During a typical year, D5 has the following characteristics: 80% open water; two to five feet of water depth; 30% cover of emergent vegetation (tules and cattails); and 25% cover of edge vegetation (cattails and bulrushes). One willow tree occurs near the pond. The nearest paved road is Walnut Blvd, approximately 1.5 miles from D5. Brentwood, approximately three miles from D5, is the nearest human development.

Pond Management: Approximately a third of D5 is fenced to exclude livestock. Livestock are periodically allowed inside the exclosure to graze non-native pest plants.

Terrestrial Vegetation and Management: The terrestrial vegetation surrounding the pond is California annual grassland, with some native forbs such as milkweed and California fuchsia. A non-native thistle is the primary weed of concern at D5. Ground squirrel burrows are present in the adjacent uplands. Cow/calf pairs graze this 1,274-acre field from November or December to August or October. Livestock have access to five ponds and three water troughs in this field. These ponds typically contain water until late summer or early fall. D5 is within 0.25 mile of one pond and within 0.75 to one mile of the three other ponds. D5 is more than a mile from all the other livestock watering sources in the field. In 2007 and 2008, there were 81 AUMs available in the field. October RDM values ranged from approximately 1100 to 2300 lbs/acre between 2006 and 2008. Grazing is intended to improve CTS movement through the uplands by reducing non-native annual grasses.

Pond D5 view 1, Contra Costa County, 2009 (pond dry; dam to right, fence in center; by P. Van Hoorn).

Pond D5 view 2, Contra Costa County, 2009 (by P. Van Hoorn).

Species Photos

CRLF adult, 2013.

CRLF egg mass, 2010.

CRLF tadpole, 2002.

Pond occupied by CRLF and CTS, 2009.

CRLF juvenile, 2009.

Recently transformed CTS juvenile, 2006.

CTS adult underwater, 2013.

CTS eggs, 2007.

CTS larva, 2012.

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Pond occupied by CTS, 2009.

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Appendix: Sources of Additional Information on Rangeland Management for California Annual Grasslands

A. *Regulations and Protection Status*. The US Fish and Wildlife Service (USFWS) maintains a comprehensive website with updated information about regulations and protection status for endangered species, in addition to references on the biology and management of such species. (http://www.fws.gov/endangered).

1. CRLF: CRLF was listed as "Threatened" by the USFWS on May 23, 1996. It is also a California Species of Special Concern. The USFWS released the final Recovery Plan for the CRLF on May 28, 2002. The Recovery Plan describes protection of existing populations through reduction of threats, such as elimination or degradation of habitat from land development and land use activities and habitat invasion by non-native aquatic species. The plan also describes restoration and creation of habitat, surveying and monitoring of populations, research needs, and re-establishment of populations within the historic range.

2. CTS: The Santa Barbara County and Sonoma County populations of CTS were listed as "Endangered" by the USFWS in 2000 and 2002, respectively. The entire population was listed as "Threatened" in 2004, although the Santa Barbara and Sonoma populations later regained their Endangered status. In 2010, the species was listed as "Threatened" by the State of California's Fish and Game Commission.

B. *California Rangeland Management* (http://californiarangeland.ucdavis.edu/). The website of the California Rangelands Research and Information Center (CRRIC) at UC Davis provides a comprehensive source of current scientific documents from University of California scientists about California rangeland management (including planning, livestock production and grazing, vegetation, biodiversity, monitoring, social issues, and water quality) and about rangeland management education opportunities and history of the profession in California.

C. *California Rangeland Conservation Coalition (CRCC)* (http://carangeland.org). The CRCC is a ground-breaking partnership between environmental, agricultural, scientific, and government agencies and organizations that are working together to ensure the continued viability of California's ranching industry. The Coalition began in 2005 when a diverse group of organizations recognized a growing common interest in preserving and protecting private rangelands and all the environmental benefits that they provide, such as wildlife habitat, open space, healthy watersheds and cultural legacy. Its California Rangeland Resolution declares the member groups will collaborate to protect and enhance the grassland and oak woodland landscape that encircles California's Central Valley, including the Sierra Nevada foothills and the interior Coast Ranges. Today, the Coalition is composed of more than 100 organizations representing the ranching community, conservation groups, academia, and state and local government entities. The Rangeland Coalition is working in the areas of policy, research, project implementation, education, and outreach to achieve the long-term goal of conserving more than 28 million acres of private grasslands while maintaining the viability of the ranching industry in California.

D. *Coastal Training Program (CTP) at the Elkhorn Slough National Research Reserve* (http://www.elkhornsloughctp.org). The CTP provides workshops and field trips for professionals to learn about and review the science available on important topics about the management of coastal resources. Past workshops have focused on CRLF and CTS, grasslands monitoring and management, coastal prairie, maritime chaparral, serpentine grassland, riparian areas, and tidal wetlands. Educational opportunities also include scientific review panels, a website supporting a large set of scientific documents from the workshops, and endangered species fact sheets. Measures of the program's success are the full meeting halls, high attendance rates of consultants and agency officials, who usually can't afford the time, and extensive post-event positive evaluation data. Future plans include customized short workshops and topic synopses for planning agencies at their sites.

E. *Alameda County Conservation Partnership* (http://www.acrcd.org). The Alameda County Resource Conservation District and the USDA Natural Resources Conservation Service (NRCS) collaborate as the Conservation Partnership to serve as the lead conservation agency in Alameda County. They provide technical and educational services for natural resource conservation and agriculture enhancement, including workshops on CRLF, CTS, and other special resources. The fundamental principles of the working landscape, conservation and enhancement, and of the local agricultural heritage provide focus for the Partnership's work. For example, NRCS cost-share programs provide financial assistance to install practices that not only improve conservation values, but also enhance the viability of the agricultural landowner, in turn fostering continuance of the farming and ranching heritage in the county. A permit coordination program assists landowners with the onerous challenge of completing all the interacting and expensive permits required to conduct conservation improvements. In addition, this group is a well-known source throughout Central California for technical and policy information about NRCS programs and advising about conservation issues and practices.

F. *Specialized Skills for Rangeland and Endangered Species Management and Related Professional Activities.* The California Code of Regulations and Public Resources Code require licensing as a Certified Rangeland Manager (CRM) to conduct professional planning and management activities for non-federal rangeland landscapes with the ecological potential to support significant stands of native tree cover (http://www.rangelands.org/casrm/HTML/certified.html). Possession of the license assures colleagues and prospective employers that educational and experience standards have been met and a code of ethics is followed. The California-Pacific Section of the Society for Range Management (CalPac) operates the certification program. The Foresters Licensing Office of the California Board of Forestry and Fire Protection licenses the CRMs after they pass a comprehensive exam in rangeland resource ecology, management, economics, measurement, and policy.

Certified or licensed professionals in other specialties are often required for (a) studies and handling of special species (entomologists, wildlife biologists, and botanists must be permitted by the USFWS to work with each listed species); (b) plans for erosion and sediment control (Certified Professionals in Erosion and Sediment Control are certified by the professional association, CPESC, Inc.) and stormwater quality (Certified Professionals in Stormwater Quality are certified by the professional association CPSWQ, Inc.); and (c) applications of pest controls and pesticides (Certified Pesticide Applicator licenses are awarded by the California Department of Pesticide Regulation [CDPR 2013b]).

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