SECTION 5.5.2.3 LIMITING FACTORS FOR CALIFORNIA RED-LEGGED FROG POPULATIONS

Introduction

The listing of California red-legged frog (CRLF) (*Rana aurora draytonii*) by the U.S. Fish and Wildlife Service (USFWS) as a “Threatened” species was effective on June 23, 1996 (61 FR 25813). The effect of this listing under the Federal Endangered Species Act (ESA) is to require formal consultation with the USFWS prior to carrying out any actions within the Carmel River Watershed that could harm CRLF. USFWS must issue a written biological opinion on proposed actions that contains steps to reduce the potential for harm. CRLF are found throughout the Carmel River Watershed and are a species of special focus regarding human impacts along the Carmel River.

At just over five inches long as an adult, the CRLF is the largest native frog in the western United States. The historic range of CRLF extends from the Sierra foothills to the coast, and from Shasta County to the boarder of Mexico, excluding the Coast Range north of Marin County. It is estimated that CRLF have disappeared from over 99 % of the inland and southern California localities within its historic range and have been extirpated from at least 70% of all localities within its entire historic range (Jennings, Hayes, and Holland 1992). CRLF occur throughout the entire Central Valley hydrographic basin, but the area from Ventura County south to the border of Mexico is the most depleted in California (Jennings, Hayes, and Holland 1993). Populations of CRLF in the Coast Range between Marin County south to Santa Barbara are more intact than populations in the rest of the state. The estimated disappearances of historical populations in the Coast Range are 50%. The Carmel River Watershed and the Santa Lucia mountain range have been identified as a core area (number 20), where recovery actions will be focused (USFWS, 2002).

It is thought that small coastal drainages contain the only remaining region in California where CRLF can still be found in significant numbers. In fact, when the CRLF were first protected under the ESA, only three localities were thought to support over 350 adult CRLF- Pescadero Marsh Natural Reserve in San Mateo County, Point Reyes National Seashore in Marin County, and Rancho San Carlos (now known as Santa Lucia Preserve) in Monterey County (Federal Register, 1996). Since that time, a fourth location, at the Elkhorn Slough National Estuarine Research Reserve, revealed 350 adult CRLF during a single night survey at ponds on the property.

The Carmel River Watershed meets the habitat requirements of CRLF, which have been observed in backwater and off-channel pools along the Carmel River and its tributaries (EcoSystems West Consulting Group 2001, Reis 2002, Reis 2003). These backwater and off-channel pools provide breeding habitat that is associated with still water. Emergent vegetation is also an important component in off-channel pools for egg mass attachment (S. Chubb, 1999). Upland habitat is important during periods of wet weather as refuge away from floods. Radio tagged frogs on the coast of San Luis Obispo County showed frog movement greater than one mile to upland areas (N. Scott and G. Rathbun, 1998). Frogs also spend considerable time in upland riparian areas resting and feeding in this moist foraging habitat (U.S. Fish and Wildlife Service, 2002).

In summary, with the known population at the Santa Lucia Preserve (formerly Rancho San Carlos) and recent data of CRLF reproduction along the Carmel River (EcoSystems West Consulting Group, MPWMD 1997 through 2003, Reis 2002 and Reis 2003), the Carmel River Watershed is extremely important to the current distribution of CRLF.

Limiting Factors

Many factors have contributed to the decline or loss of CRLF populations in their native range (Sierra Nevada foothills, central valley, and coastal areas all in California). Limiting factors include introduction of predators, loss of habitat and degradation from urbanization, agriculture, mining, overgrazing, recreation, timber harvesting, invasion from nonnative plants, impoundments, water diversion, and degraded water quality (65 FR 54893).

Introduced Predators

Many introduced predators such as bullfrogs, crayfish, bass, and mosquito fish impact CRLF in the Carmel Valley Watershed. Different life history stages of CRLF (adult, tadpoles, and eggs) have different predators.

Bullfrogs are consistently encountered in pools along the Carmel River during annual fish rescue operations. Mullen documented bullfrogs in the lower and upper Watershed up to Los Padres Reservoir and upper San Clemente Creek (Mullen, 1994). Research in California has shown cases where CRLF populations decline and eventually disappear after bullfrogs become established (Fisher and Schaffer, 1996). Bullfrogs have been known to prey on both CRLF adults and tadpoles and may have a competitive advantage for food, shelter, and reproductive space because of their larger size (Twedt, 1993). However, the CRLF tadpole life stage seems to experience the highest mortality rate. Lawler *et al.* (1999) found that the survival rate from hatching to metamorphosis is estimated to be less than five percent for CRLF tadpoles when bullfrog tadpoles are present.

The extent of mosquito fish (*Gambusia*) in Carmel Valley is unknown, but this species is known to occur in private ponds and in the Carmel River. Mosquito fish are sometimes used in water bodies to control mosquito larvae. Mosquito fish are non-native opportunistic feeders, are significant predators of CRLF eggs, and are known to cause physical harm to CRLF tadpoles (Schmieder and Nauman, 1994). Mosquito fish are also known to be a competitive disadvantage to CRLF larva in artificial ponds (Lawer, Dritz, and Holyoak, 1999). CRLF have been known to coexist with bullfrogs and mosquito fish, but the combined predatory effects may lead to extirpation (Kiesecker and Blaustein, 1998).

Native Predators

Native predators of CRLF include skunks, opossums, raccoons, great blue herons, American bitterns, red-shouldered hawks, and garter snakes (Jennings and Hayes, 1990). Although native predators have their place in the ecosystem, translocation of raccoons, skunks, and opossums from cities to National Forest or rural areas can concentrate their populations and impact CRLF.

Urbanization
Carmel Valley has been impacted by urbanization and increased traffic. Approximately 1,600 parcels have been identified as having residential use in the FEMA-defined 100-year Carmel River floodplain. The majority of these structures are located in the lower six miles of the river. Residential development and three golf courses contribute to the fragmentation of CRLF habitat. Development also is increasing in upland areas that may have been used by CRLF in wet years. Carmel Valley Road also carries a significant amount of traffic that can constitute a barrier to CRLF. Heine (1987) found as little as 26 cars per hour can reduce the survival of toads crossing a road to zero. Fragmentation of habitat areas can lead to the isolation of specific CRLF groups and the loss of access to reproductive or dispersal areas.

Although an argument can be made that some golf course ponds can serve as habitat for CRLF, this is dependent on proper management, which includes minimizing water quality impacts from fertilizers, herbicides, and pesticides known to harm CRLF. Golf ponds also need emergent vegetation for egg mass attachment and both emergent vegetation and upland vegetation for adult cover if they are going to provide productive CRLF habitat. Removal of bullfrog adults and draining ponds in late fall to eliminate bullfrog tadpoles is also an important management practice.

Agriculture
Commercial agriculture began in Carmel Valley in the 1870s when Edward Berwick introduced pear orchards. Clearing for orchards and row crops removed natural habitat and cover for CRLF. Much of the historical riparian habitat along the Carmel River was cleared for agriculture. Currently, only a thin, narrow, discontinuous band of riparian area exists in much of the lower valley. Upland areas have been impacted by conversion of native oak forest and chaparral to large commercial and private viticulture use. Although the scale of agriculture and use of chemicals in Carmel Valley is not the same as in the central valley of California, San Joaquin Valley experienced drastic declines in CRLF due in part to water bodies being contaminated with fertilizers and pesticides (Fish and Shaffer, 1996). Pesticides can cause deformities, disease, abnormal immune system functions, and death (Schneeweiss and Schneeweiss, 1997).

Livestock Grazing
CRLF have been known to co-exist with properly managed livestock grazing operations (Bobzien, 1998). Stock ponds have even greater value if they are managed to prevent bullfrog reproduction. However, poorly managed live stock operations can severely impact pond and creek habitats for CRLF. Animal waste can over nitrify ponds if large concentrations of waste flow into ponds during rainfall events. Unmanaged cattle can trample riparian vegetation and reduce or eliminate plant cover (Gunderson, 1968). Riparian and emergent vegetation in creeks are important for channel complexity, which helps form pools. The exclusion of cattle grazing from the Simas Valley resulted in riparian tree recruitment and the formation of pools, which led to the expansion of frog populations (Dunne, 1995).

Impoundments and Water Diversion
CRLF habitat has been fragmented in the Los Padres National Forest by dams that block or hinder dispersal (U.S. Fish and Wildlife Service, 2002). The Carmel River Watershed has two

major reservoirs that impact the hydrologic regime of the Carmel River- San Clemente and Los Padres. The duration and extent of flow in the Carmel River to the lagoon is largely dependent on the amount of rainfall in the water year, groundwater pumping, and reservoir storage and release. In normal rainfall years, the Carmel River typically dries from above the Carmel River lagoon up to the Schulte Bridge area (River Mile 6.0 to 7.0) from mid-June to December.

San Clemente Dam, with an original reservoir storage capacity of 1,425 acre-feet, was constructed in 1921 and was the first major dam built on the main stem of the Carmel River. The 106-foot high and 300-foot long structure located in a steep canyon is a partial barrier to CRLF movement and to some extent isolates the CRLF population and prevents it from dispersing to downstream habitat. Currently, the reservoir is almost completely filled with sediment. This sediment has caused the Carmel River to braid behind the dam and has created favorable off-channel breeding sites within the reservoir area. Because of the coarse nature of the sand and gravel in these off-channel pools, they are hydraulically connected to the surface water. San Clemente Reservoir, which is operated by the California-American Water Company (Cal-Am), currently undergoes draw down during the spring to comply with orders from the California Division of Safety of Dams to meet seismic safety standards for the dam. Draw down can expose tadpoles and cause desiccation when done at a rapid rate. Several mitigation measures are carried out to help prevent the CRLF populations in and around the reservoir from being impacted by the draw down. Mitigations include tadpole relocation from areas that are projected to dry before metamorphosis is complete and CRLF adult relocation in order to protect them from bullfrog predation as deep water refuge areas are reduced by the draw down.

The second major dam and reservoir constructed along the main stem was Los Padres (original storage capacity of 3,030 acre-feet), built in 1948. Currently, more than one half of the 3,030 acre-foot reservoir is filled with trapped sediment. CRLF habitat in and around Los Padres Reservoir is not as well documented as at San Clemente Reservoir, but CRLF have been observed at the upstream end of the inundation zone. In this zone, summer draw down may also impact off-channel areas where the Carmel River enters the reservoir. However, summer releases from Los Padres Reservoir may contribute enough water to help prevent premature draw down of reproductive sites in the lower Carmel River.

Water diversion by well pumping can significantly impact CRLF by rapidly dewatering reaches of the Carmel River. The majority of wells capable of dewatering reaches of the Carmel River during the low flow season are Cal-Am production wells. In water year 2003 Cal-Am used 18 wells in Carmel Valley to produce at total of 11,076 acre-feet of water (MPWMD, 2003). Some of Cal-Am's lower valley wells are capable of pumping three to five cubic feet per second (cfs). During the low flow summer season the Carmel River may only be flowing 3-10 cfs so these wells can rapidly dewater off-channel pools where tadpoles are maturing. Cal-Am experienced one of these incidents in 1997 during late August – early September in a segment of the Carmel River near Cal-Am's Scarlett No. 8 well. This situation resulted from an unexpected shut down of the Cañada well, which automatically shifted pumping to the Scarlett well. This led to the stranding of many CRLF larvae.

In addition, Carmel Valley has approximately 561 private wells, including wells in the alluvial aquifer and upland areas. In water year 2003, production from these private wells equaled

2,475.8 acre-feet (MPWMD, 2003). The cumulative impact of these wells reduces the amount of water available for CRLF.

CRLF usually lay egg masses in the Carmel River main stem in February or March, after high winter flows (Reis and Gunderson pers. obs.). Eggs require around 20-22 days to develop into tadpoles and then, based on temperature, 11 to 20 weeks to develop into terrestrial frogs (Bobzien et al., 2000). Therefore, during summer months, it is critical for surface water to be present so CRLF frog larvae can complete metamorphosis. However, CRLF in the Carmel River usually metamorphose from tadpoles to terrestrial frogs by late August or early September (Dawn Reis, pers. comm.). Bullfrog tadpoles require two years for development. CRLF have an advantage if reproductive areas dry down in late October because this breaks the reproductive cycle of bullfrogs. These sites are more suitable for CRLF reproduction than for bullfrog reproduction.

Channelization

The Carmel River may not be thought of as a traditionally channelized river, however, levees and rip-rap bank protection structures along the river have reduced the natural floodplain width and ability of the river to meander and change course, therefore limiting off-channel pool development. Property owners and government agencies have traditionally used streambank hardening as a preferred method for preventing erosion associated with floods. In 2000, MPWMD estimated that 45 % of the streambanks in the alluvial portion of the Carmel River had received some kind of treatment. The historical incision and rip-rap bank protection may also increase main stem water velocities in certain reaches and prevent the use of these areas for CRLF egg attachment.

Water Quality and Temperature

Amphibians have complex life cycles, which subjects them to multiple routes of exposure to contaminants (U.S. Fish and Wildlife Service, 2002). The Carmel River is not known for having high levels of contaminants, but varying amounts of herbicides and pesticides enter the waterways from golf course ponds, sediment catch basins, adjacent agricultural areas, and urban development. There are a vast number of pesticides and herbicides used that can kill, paralyze, or mimic estrogen, which may impact reproduction (Berrill et al., 1993 and Jennings, 1996). It is not clear how many of these are used in Carmel Valley, but common herbicides containing surfactants such as Roundup® have severe negative effects on amphibians when used close to water. The USFWS addresses the toxicity of a number of potential herbicides and pesticides in their Recovery Plan for the California red-legged frog.

Mineral fertilizers used on crops, lawns, and golf courses also impact CRLF. Schneeweiss and Schneeweiss (1997) found up to 100 percent of amphibians dead in pitfall traps located on fertilized fields, but no dead amphibians on fields not fertilized during simultaneous monitoring. Nitrate levels below the standard for drinking water were found to increase mortality to Northern red-legged frog larvae (Marco et al., 1999).

Although warmer water can help tadpoles mature at a faster rate, studies of Northern red-legged frog tadpoles have shown critical maximum water temperature near 25°C and adult CRLFs have been shown to die of heat exposure at 29.0 °C (Calef, 1972 and Jennings and Hayes, 1990).

Water temperature in the Carmel River is seldom a limiting factor for CRLF based on data; however, as water depth is reduced in summer months, areas that lack vegetative cover for shade could potentially reach critical maximums (Ecosystems West, 2001). Reis (2003) reported that water temperatures came close to critical maximums in 2002 and 2003 in the Carmel River between the Carmel River RV Park and Schulte Road Bridge, and upstream of the footbridge at the DeDampierre Ball Park.

Conclusion

Many factors in combination can lead to declines in CRLF populations. In general, CRLF are threatened by more than one factor in streams (U.S. Fish and Wildlife Service, 2002). The upper Carmel River Watershed (above Los Padres Reservoir) is not impacted by urbanization, agriculture, and water extraction. CRLF reproduction locations occur upstream of and around Los Padres Reservoir and in Cachagua Creek. However, urbanization, agriculture, channelization, bullfrogs, and water extraction are factors that can damage habitat in the lower Carmel River. Groundwater extraction and reservoir operations are currently being managed to reduce the threat to CRLF. Bullfrog control and urbanization are more tenuous problems.

CRLF would benefit from a management plan that addresses: pond management, water quality, non-native predators, habitat fragmentation, and water diversion. The Carmel River Watershed Council could help CRLF by educating private landowners on issues such as pesticide residues, fertilizer contamination, and non-native predator control. Although CRLF are found throughout the whole watershed, **Table 1** summarizes some of the top limiting factors for defined reaches on the main stem of the Carmel River.

Table 1. General Reach-by-Reach Assessment of Limiting Factors for CRLF on the Carmel River

Subreach Number	Upstream Station	Downstream Station	Limiting Factors
1	Upstream limit of Carmel River Watershed	Confluence with Miller Fork	Native predators and bullfrogs
2	Confluence with Miller Fork	Danish Creek	Native predators and bullfrogs
3	Danish Creek	Los Padres Dam	Reservoir operations, bullfrogs, and dam dispersal barrier issues
4	Los Padres Dam	Cachagua Creek	Reservoir operations, bullfrogs, dam dispersal barrier issues, and urban run-off
5	Cachagua Creek	Upstream end of San Clemente Reservoir	Native predators and bullfrogs
6	Upstream end of San Clemente Reservoir	San Clemente Dam	Reservoir operations, bullfrogs, and dam dispersal barrier issues
7	San Clemente Dam	Sleepy Hollow	Native predators and bullfrogs
8	Sleepy Hollow	Tularcitos Creek	Native predators and bullfrogs
9	Tularcitos Creek	Hitchcock Canyon Creek	Native predators, bullfrogs, and stock pond management
10	Hitchcock Canyon Creek	Garzas Creek	Bullfrogs, Carmel Valley Road, and urbanization
11	Garzas Creek	Randazzo bridge	Bullfrogs, Carmel Valley Road, and urbanization
12	Randazzo bridge	Robinson Canyon Road bridge	Bullfrogs, Carmel Valley Road, and urbanization
13	Robinson Canyon Road bridge	Schulte Road bridge	Bullfrogs, Carmel Valley Road, urbanization, agriculture, private and commercial well pumping
14	Schulte Road bridge	Valley Greens Drive bridge	Bullfrogs, Carmel Valley Road, urbanization, agriculture, private and commercial well pumping
15	Valley Greens Drive bridge	Highway 1	Bullfrogs, Highway 1, Rio Road, urbanization, agriculture, private and commercial well pumping, channelization
16	Highway 1	Pacific Ocean	Bullfrogs, Highway 1, Rio Road, urbanization, agriculture, channelization

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