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Observations of Nocturnal Upland Habitat Use by the *Rana Draytonii* (California Red-Legged Frog), and Implications for Restoration and Other Activities

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Rana draytonii (California red-legged frog), listed as a threatened species in 1996 by the U.S. Fish and Wildlife Service (USFWS), is an example of a declining wildlife species for which many pieces of its natural history are still being assembled (Jennings and Hayes 1994, USFWS 2002, Lannoo 2005). This paucity of information is surprising given the considerable attention the species has received from researchers. In particular, upland habitat use has been studied using radio-telemetry (Rathbun and Murphey 1996, Bulger et al. 2003, Fellers and Kleeman 2007, Tatarian 2008) and through direct observation (Alvarez 2004, Surber 2019, Alvarez et al. 2021). Nevertheless, numerous aspects of the use of upland habitat by *R. draytonii* remain enigmatic, including the effect of restoration and enhancement projects within occupied habitat. Alvarez et al. (2002) included information on the positive response of *R. draytonii* to a habitat restoration project that included non-native fish removal, but the response of *R. draytonii* to such ecological restoration activities as *Lithobates catesbeianus* (American bullfrog) control, silt and vegetation reduction in stock ponds, or riparian zone enhancement has yet to be reported by ecologists involved in such projects (pers. obs.). To contribute to the natural history literature on the species, below we report a dramatic shift in nocturnal activity in upland habitat following a large-scale habitat restoration project that was installed in occupied habitat.

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We surveyed a 2.1 km (1.3 mile) perennial section of Kellogg Creek (Contra Costa County, CA) in the eastern San Francisco Bay Area in 2013, during both daylight (approximately 1500 hrs to 1800 hrs) and nighttime (approximately 2000 hrs to 2330 hrs), while conducting *L. catesbeianus* control. Our surveys were conducted once per month for two years, excluding the peak of the breeding season (i.e., December–February) for *R. draytonii*.

Surveys were conducted by walking the upper edge of the bank, outside of the stream channel, and scanning the creek channel from the open water to the top of the bank for both *R. draytonii* and *L. catesbeianus*. The dominant upland habitat type at the time of the surveys was heavily grazed annual grasslands with little to no riparian vegetation lining Kellogg Creek. We collected data on size cohort, location, and position for all anurans observed in or along the creek. Every *L. catesbeianus* encountered was collected, when possible; individual *R. draytonii* were left in place undisturbed. Water temperature, air temperature, and relative humidity were collected at the beginning of both daytime and nighttime surveys efforts.

During surveys conducted in the summer of 2013 our daytime observations averaged ≤ 5 individuals of each frog species (*R. draytonii* and *L. catesbeianus*) per visit, and we noted that all individuals were in or within 2.5 cm (1 in) of the water's edge. Data we collected during nighttime surveys on the same dates as daytime surveys were similar for *L. catesbeianus*, never exceeding seven individuals, all of which were in the water. Nighttime observations of *R. draytonii*, however, were different; each visit included ≥ 100 *R. draytonii* (max. = 141) observed, with 10% or fewer using water as their preferred habitat when observed during nighttime hours. The majority of *R. draytonii* (approximately 90% or more) were found on the top of the bank of the creek, outside of the stream channel, as much as 3 m (9.8 ft) from, and approximately 0.6 m (2 ft) to 4 m (13.1 ft) above, the water's surface.

The observations reported above preceded an extensive creek restoration project, lasting seven months, and designed to decrease bank slopes, increase vegetation adjacent to the creek, and improve habitat for native wildlife, in particular *R. draytonii* and *Actinemys pallida* (southwestern pond turtle). Heavy equipment was used as part of the restoration work to draw back slopes and contour creek banks. Although the site was originally comprised of heavily grazed annual grassland, the restoration project included hand-planted *Populus fremontii* (Fremont cottonwood), *Aesculus californica* (California buckeye), *Sambucus cerulea* (blue elderberry), *Frangula californica* (coffeeberry), *Rosa californica* (California rose), *Muhlenbergia rigens* (deergrass), and associated weed cloth, mulch, and irrigation piping. Vegetation was planted at a density and spacing that ranged from 2 to 3 m between plantings, and plants ranged from 0.5 m to 3 m tall at the time of planting.

Figure 1. *R. draytonii* on the top of bank along Kellogg Creek, east Contra Costa County, California, September 2013. This individual—one of 130 *R. draytonii* out of the water—was found in annual grassland habitat, approximately 4 m above and 3 m away from the water's edge. *Image credit: Jeffery T. Wilcox.*

During our monthly field surveys (subsequent to the restoration project) we noted a precipitous decrease in *R. draytonii* observations within the area described above. In the months following the restoration project, the counts of *R. draytonii* decreased greatly each month. Eight months following the restoration project we observed only four *R. draytonii* during nighttime counts, a 98% reduction from our high count of 141 in summer 2013. During the two-year period (2014 and 2015) following our peak observations of 2013, and following the installation of the restoration project, we saw a continued pattern of low numbers of observations of *R. draytonii* (≤ three individuals per visit). However, observations of *R. draytonii* in areas downstream of restoration site remained relatively stable eight months following the restoration project and increased during the two years (2014 and 2015) that followed (14% and 19% increases, respectively).

We acknowledge that detection probability is a confounding issue in wildlife sampling. Not all species or individuals present are detected with the same probability (van Heezik and Seddon 2017). Species behavior, survey conditions, and habitat can influence an observer's ability to detect species. Our analysis did not specifically account for detection probability in the habitat before and after restoration activities. However, since the littoral zone within the creek and the immediate creek bank was unchanged by the restoration activity, we assumed no change in our ability to detect frogs in this area. Because the creek bank, which was bare, with widely scattered plantings was more exposed after restoration, we assumed our ability to detect the frogs would have increased. Therefore, variations in detection probability due to habitat change alone was unlikely to explain the sizeable decreases in our survey data.

These data may suggest that our original observations of nocturnal upland habitat use by *R. draytonii* may have been more significant than we understood at the time of our work. Upland habitat structure was greatly modified, and habitat complexity (increased with new plantings of shrubs, trees, and associated infrastructure) was changed significantly by the restoration project. This may have altered microhabitat that was used by this frog species or altered its prey base. We speculated that cover sites (e.g.,

burrow presence and density, natural brush piles, and microtopography) that was present prior to the restoration, and was missing following restoration may have played a role in limited upland habitat use following restoration. A potentially confounding concern was the absence of ground cover following the restoration. Although vegetative complexity and diversity were increased by the restoration project, the ground cover was missing after heavy equipment apparently removed what may have been a thin topsoil layer from the site. These changes to the habitat and microhabitat were unmeasured but may have influenced site suitability.

Similar to reports by Bishop et al. (2014) and Surber (2019), it appears that *R. draytonii* on our study site clearly used uplands for foraging, basking, or for micro-movements within their habitat. The presence of *R. draytonii* in the uplands has also been reported by others (Bulger et al. 2003, Fellers and Kleeman, 2007, Tatarian 2008). Our observations of frequently encountered individuals in the upland area surrounding occupied aquatic habitat ascribe a high level of importance to this microhabitat, which appears to be utilized frequently, if not daily (Figure 1).

Surber (2019) suggested that upland areas adjacent to aquatic sites may be used for thermoregulation and for basking activity, and that frogs in these areas may be vulnerable to disturbance. Bishop et al. (2014) speculated that, based on the frequency of terrestrial prey items in the diet of *R. draytonii* they analyzed, uplands must play a significant role in the natural history of this species and this habitat should therefore be protected, particularly areas adjacent to aquatic breeding habitat. Our observations support the recommendations of Bishop et al. (2014), and Surber (2019). We further suggest that land managers and habitat restoration specialists strongly consider this nocturnal behavior and upland habitat use by *R. draytonii* when preparing land management plans or conducting habitat modifications. In the case of our study site, it may have not been necessary to conduct habitat restoration activities when *R. draytonii* were already present in high and stable numbers. Because the project was conducted outside of our control and involvement, there was no ability to conduct a measurable study to determine if the project was a reasonable benefit or not. However, our basic visual-encounter observations suggest that when the species is already present, restoration projects that alter the habitat may not produce higher levels of suitability and may, in fact, reduce suitability.

We contend that two or more nighttime surveys should be conducted before any habitat-altering (i.e., construction, development, habitat restoration, etc.) activities begin. To further protect *R. draytonii* foraging and thermoregulatory habitat, management actions should include implementing a buffer around occupied aquatic habitat by excluding habitat modifying projects, including restoration projects, until this natural history aspect is further studied. This exclusion buffer area should include an area extending several meters beyond the upper extent of the stream channel. The maximum extent to which (number of meters) this buffer is needed remains unknown and should be studied and reported. Careful consideration should be made for the placement of public trails, sidewalks, roadways, and other structures that could impact this vulnerable zone used by *R. draytonii*.

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