Herpetology Notes, volume 15: 383-386 (2022) (published online on 13 June 2022)

Use of spring boxes by the threatened *Rana draytonii* Baird & Girard, 1852 in California, USA

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Threatened species require habitat and microhabitat that suits their specific needs seasonally and spatially in order to reproduce, thrive, and recover (Briggs, 2009). Biphasic amphibians, in particular, can be challenging to manage since their populations require both aquatic (breeding) and terrestrial (non-breeding) habitats at different life stages and different times of the year (Wilbur, 1980; Semlitsch, 2000). Many larval amphibian species are adapted to exploit transient aquatic environments while the adult stage is adapted for dispersal and reproduction (Wilbur, 1980). Adult amphibians often seek out uplands for refugia during some portion of the year in order to estivate, while other individuals or species move among aquatic features (Duellman and Trueb, 1994; Stebbins and Cohen, 1995; Fellers and Kleeman, 2007). Species distributed in seasonally warm, dry climates, like the western United States, may frequently require secondary aquatic sites or an estivation site that can be used to avoid desiccation during periods when the primary aquatic refugia have dried (Alvarez, 2004; Fellers and Kleeman, 2007; Tatarian, 2008).

The California red-legged frog (*Rana draytonii*), a threatened species throughout its range, is known to make overland movements in order to find suitable upland and aquatic habitat (Bulger et al., 2003; Fellers and Kleeman, 2007; Tatarian, 2008; Surber, 2019). Allaback et al. (2010) observed that recently metamorphosed *R. draytonii* moved upland following rain events to disperse or to seek out refugia. When *R. draytonii* were occasionally encountered in upland areas (wet seeps, under dense vegetation, in small mammal burrows, etc.), they were presumed to have arrived serendipitously (Fellers and Kleeman, 2007). Storer (1925) reported a finding (by J. Dixon) of seven adult *R. draytonii* wintering within a 15-cm layer of silt in 30-cm-deep water, at the bottom of a wooden spring box. This observation in January 1924 was considered to involve a group of frogs in torpor, based on their immobility when they were being removed. Since Storer (1925) reported this event, observations of the use of spring boxes by *R. draytonii* has not been reported and was seemingly forgotten.

Spring boxes are common historic rangeland features that are still in use across much of California's working rangelands and are relict, but functional, in areas where grazing has long since ceased. They were created so that grazing cattle seeking drinking water would not degrade the quality of freshwater flowing from a spring by drinking directly from it, or by trampling it. When springs are protected, clear perennial water could be directed from the box, through a pipe, and to a trough or pool away from the spring. Spring boxes were most often placed to capture perennial or intermittent flows from seepage springs, and excavations for spring boxes were often chosen by the presence of hydrophilic plants, such as rushes (genus *Juncus*) or sedges (genus *Carex*). We hypothesized that the use of spring boxes by *R. draytonii* was unlikely to be an artifact of history, and that spring boxes might provide year-round habitat for frogs, not just overwintering habitat for animals in torpor, as reported by Storer (1925). Herein we report on observations of the long-term use of nine spring boxes by *R. draytonii* within two disparate California counties.

In Contra Costa and Sonoma Counties in northern California, spring boxes were generally pre-existing structures made of redwood (*Sequoia sempervirens*), many built by cattle ranchers up to 100 years ago. Spring boxes can vary widely in size and depth but those in Contra Costa County ranged from dimensions (length x width x height, in metres) of 2 x 2 x 2.5 to 5 x 5 x 0 and stand above the ground or lay at ground level (as in the 0 m height). All of the spring boxes we monitored in Contra Costa County were constructed above ground (Fig. 1) while those in Sonoma County were constructed such that the top edge was only slightly above the surrounding

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surface. Both designs were constructed to hold open a reservoir the size of the box. All six spring boxes in Contra Costa County were constructed at the head of a spring in annual grasslands. In Sonoma County, one spring box was constructed of mortar and native rock, capturing a perennial seep from a fault in the bedrock. This spring box had dimensions of ca. 1 x 0.5 x 0.5. A second box was constructed of redwood boards with the top set at ground level, measuring 9 x 0.5 x 0.5. This box is divided by a board that splits it into two compartments that feed separate water delivery systems. The third spring box was 5 x 5 x 2 and ringed by plantings of Lombardy poplar (*Populus nigra*), the root system of which has assumed the shape of the original redwood boards, which had long since disintegrated. In both locations, spring boxes were constructed or maintained in a manner that inadvertently allowed access to small animals and also allowed small amounts of water to seep out. With one exception in Sonoma County, each of the spring boxes was located far from aquatic breeding habitat such as ponds, lakes, streams, or other suitable wetlands.

We visited six spring boxes in Contra Costa County (upper Kellogg Creek watershed) five times per year between 1998 and 2016, and three boxes in Sonoma County (upper Copland Creek Watershed) were visited monthly from 2011–2021. Visits were designed to determine if special-status wildlife species were using the spring boxes, and if so, census the animals and their life stages. During visits to the spring boxes in Contra Costa County, *R. draytonii* were encountered in 100% of the visits at every spring box. A single egg mass was observed at one spring box during a single year (2008), and larvae were noted at a second spring box during two consecutive years (2009, 2010). Adult frogs were also present at spring boxes and were found basking on floating debris or floating in open water along the box edges (Fig. 2). In 2007 maintenance was conducted at a single spring box on Contra Costa County that included silt removal and rebuilding. During this activity, 44 adult *R. draytonii* were hand-collected from the spring box, then returned following maintenance and reconstruction of the box.

In Sonoma County, two of the three spring boxes had 100% occupancy (i.e., encountered at 100% of visits) by *R. draytonii*; the box made of stone had approximately 80% occupancy. No evidence of reproduction in any of these spring boxes in Sonoma County has been evident over the past 11 years. The stone spring box normally supported between one and three adult frogs. The smaller,

Figure 1. Two typical pre-existing spring boxes placed within a spring in Contra Costa County, California, USA. Each spring box supports California red-legged frog (*Rana draytonii*) adults, and also supports breeding activities and larvae. Pipes from spring boxes allow water to flow down-hill to a concrete trough used to water cattle.

Figure 2. A California red-legged frog (*Rana draytonii*) basks against a redwood (*Sequoia sempervirens*) board, the wall of a remote spring box in Sonoma County, California, USA.

divided spring box normally supported between one and three adult *R. draytonii*. The largest spring box supported a mean of eight frogs of varying sizes, from recently metamorphosed to large adults.

Our long-term observations of occupied spring boxes indicate the importance of these anthropogenic structures for *R. draytonii*. Using radiotelemetry in coastal habitat, Bulger et al. (2003) and Kleeman and Fellers (2007) concluded that *R. draytonii* move through upland areas without regard to riparian corridors or topography. Inland, Tatarian (2008) reported that *R. draytonii* move regularly between aquatic and terrestrial sites, suggesting a frequent trans-landscape movement pattern. These studies, along with the observations of Surber (2019), clearly show that this species moves frequently through upland areas, unimpeded by topography. It is this ability to freely move through uplands that allows this species to colonize novel sites, a behaviour critical to species recovery. Although occasionally used for breeding, spring boxes appear to represent non-breeding habitat to which *R. draytonii* travelled facultatively. These spring boxes provide all of the characteristics that Fellers and Kleeman (2007) suggest were required of non-breeding habitat for the species, which is essential to the survival of these frogs. However, further study into how these remote spring boxes support *R. draytonii* is warranted to determine if these frogs derive fitness benefits from using spring boxes or whether they simply seek short-term refuge.

A current study being conducted in Sonoma County (Wilcox et al., unpubl. data) suggests that some *R. draytonii* individuals take up residence at springs for extended time periods. These data suggest that using subdermal passive integrative transponders to mark individuals has facilitated following the long-term movements of frogs as they travel between geographic features in the landscape (e.g., Blomquist et al., 2008). Frequent visits to spring boxes revealed that some frogs make brief stops at remote spring boxes, while others may reside at spring boxes for months. Further studies should investigate whether *R. draytonii* populations rely on spring boxes for foraging, as temporary refugia during dispersal and seasonal movement, or as permanent non-breeding habitat where resources provide opportunities for provisioning egg masses away from the potential predators that more regularly patrol breeding habitats such as ponds and streams (Orrock et al., 2010).

We contend that the use of remotely located spring boxes is not the result of serendipitous encounters by dispersing frogs, but rather a destination facultatively sought for unknown benefits. This infrastructural artifact associated with cattle grazing should be considered a valuable micro-habitat for *R. draytonii*, which has populations in decline throughout its range, and should be maintained to provide access for *R. draytonii* and other species. Spring boxes should be properly maintained or rebuilt where warranted, and biological monitoring should be a part of

those maintenance activities in order to determine further use, as well as to reduce or eliminate injury or mortality to this declining species. We feel that well-maintained spring boxes may provide suitable refuge habitat for this declining species, and others, when this frog makes overland movements throughout the year, allowing it to successfully disperse or colonize new unoccupied habitat.

Acknowledgements. Access to the Mitsui Ranch was provided by the Sonoma Mountain Ranch Preservation Foundation, Cincinnati, Ohio, USA, and access to the upper Kellogg Creek watershed was provided by the Contra Costa Water District, Concord, California, USA. Frogs in Contra Costa County were collected and handled under the Programmatic Biological Opinion (08ESMF00-2012-F-0646) held by the Contra Costa Water District, and in Sonoma County by an individual recovery permit (TE-068745). A pre-peer review was conducted by Lisa Surber, who improved the manuscript's content and readability. We also thank Werner Conradie for useful and constructive suggestions to the manuscript.

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Accepted by Werner Conradie