NORTHWESTERN NATURALIST 93:79–83 SPRING 2012

TEMPORALLY IRREGULAR BREEDING OF WESTERN SPADEFOOT TOADS (*SPEA HAMMONDII*) IN MANAGED WETLANDS

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Key words: amphibian, ARS, automated recording systems, breeding phenology, California, CEAP, Kern County, managed flooding, managed hydroperiod, Spadefoot Toad, *Spea hammondii*, vocalizations

The intensive cultivation of landscapes and associated practices, such as pesticide use, have been shown to negatively affect amphibian species (Marco and others 1999; Davidson and others 2002; Gray 2002; Kiesecker 2002; Fellers and others 2004; Ghioca-Robrecht and others 2010), and have been linked with marked declines of amphibians in California's Central Valley (Sparling and others 2001; Fisher and Shaffer 2002). In light of such issues, the United States Department of Agriculture (USDA) has undertaken the Conservation Effects Assessment Project (CEAP), which is a multi-agency effort to measure the environmental effects of federally-funded conservation practices and programs and develop the science base for environmentally responsible agricultural management. These assessments are performed at national, regional, and watershed scales focusing on croplands, grazing lands, wetlands, and wildlife. In California's Central Valley, CEAP assessments have focused on lands enrolled in the Wetlands Reserve Program (WRP). The WRP is a voluntary program administered by the USDA's Natural Resource Conservation Service that provides technical and financial support for landowners who elect to participate in conservation initiatives, such as wetland restoration.

Conservation practices and programs like the WRP are intended to protect, restore, and enhance habitat. While conservation methods are designed to support wildlife and provide ecosystem services, the effects on wildlife are not entirely clear; conservation efforts can potentially have both positive and negative effects on species. One commonly used method is the manipulation of flooding regimes at managed wetlands. It is known that changes in hydroperiod can influence the breeding phenology of aquatic species such as amphibians (Lannoo 1998; Sartorius and Rosen 2000; Horner 2001), but little is known about the effects on breeding of manipulated flooding regimes not managed in accordance with natural hydroperiods. The aim of our study was to assess whether Western Spadefoot Toads (*Spea hammondii*) opportunistically breed outside of known breeding periods in wetlands whose hydroperiods are managed according to WRP guidelines, rather than natural hydroperiods.

Western Spadefoot Toads range from northern California to northwestern Baja California, Mexico. In California, this species occurs throughout the Central Valley and associated foothills, as well as the Coast Ranges and coastal lowlands between San Francisco and northwestern Mexico (Fig. 1; Stebbins 2003; USFWS 2005). The Western Spadefoot Toad is a Species of Special Concern in California, where populations have been reduced by agricultural practices, urban development, and the introduction of nonnative predators (Jennings 1996; Davidson and others 2002). More than 80% of historically occupied Western Spadefoot Toad habitat in southern California, and more than 30% of such habitat in northern and central California, has been developed or converted to uses that are unsuitable for sustained populations (Jennings and Hayes 1994).

The Western Spadefoot Toad is a desert-adapted and opportunistic breeding species that synchronizes its reproduction with infrequent and unpredictable rainfall (Denver 1998). The

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FIGURE 1. Western Spadefoot Toad geographic range in California indicated with gray shading. Location of study denoted with star symbol in Kern County, California.

species remains dormant in subterranean burrows for 8 to 10 mo/y and typically emerges to breed with the onset of warm rains between January and March; however, individuals may also emerge anytime between October and April if favorable environmental conditions exist (Jennings and Hayes 1994; Stebbins 2003).

We deployed 4 automated recording systems (ARS) at 3 adjacent WRP wetlands between May and August 2009 to assess the frequency and temporal variation of Western Spadefoot Toad vocalizations. The 3 wetlands were located approximately 11 km southeast of Lost Hills in Kern County, California (Fig. 1). Each wetland ranged between 487 and 914 acres in size and was enrolled in the WRP between 2000 and 2001. Nearly all land within 5 km of the study area is extensively cultivated and supports a variety of crops under irrigation. The United States Fish and Wildlife Service's Wetland Mapper (http://www.fws.gov/wetlands/Data/Mapper.html) identifies freshwater emergent, and freshwater pond and lake habitats approximately 4 km east and southeast of the sites.

Western Spadefoot Toads produce a loud and distinct snore-like call that facilitates detection via ARS. Accordingly, we deployed 4 SM1 Song Meters (Wildlife Acoustics, Inc., Concord, MA, USA), attached to 1-m wood stakes, at Sites A, B and C. One ARS was deployed at each of Sites A and B and positioned near areas believed to provide suitable breeding habitat. Two ARS were deployed at Site C and positioned near locations where we observed the species in 2008. Because of purchasing delays, ARS #2 was deployed at Site C approximately 3 wk later than ARS #1. The position of each ARS was modified throughout the monitoring period to maintain close proximity to inundated areas.

With the exception of ARS #2 at Site C, we programmed all ARS to record the first 20 min of each hour between 20:00 and 02:00 (20:00–20:20, 21:00–21:20, and so forth). We staggered the recording times of ARS #2 at Site C to record the second 20 min interval of each hour (20:20–20:40, 21:20–21:40, and so forth) to avoid recording repeat vocalizations with ARS #1. We aligned our recording times to correspond with the North American Amphibian Monitoring Program protocol (http://www.pwrc.usgs.gov/naamp/), which specifies that surveys begin 30 min after sunset or later, and be completed by 01:00. Following the monitoring period, we reviewed the first 5 min of each recording (20:00–20:05, 21:00–21:05, and so forth) at a standardized volume. If the first 5 min of any recording was inaudible due to wind or bird clamor for example, we reviewed the second 5 min interval (20:05–20:10, 21:05–21:10, and so forth), and so on. In total, we reviewed 62 h of recordings and tallied all Western Spadefoot Toad vocalizations.

No Western Spadefoot Toad vocalizations were recorded at Site A or B; however, vocalizations were recorded at Site C during 63 evenings over the 124-d monitoring period. Specifically, calling males were detected during 3 distinct intervals (Fig. 2). The 1st interval likely began prior to the start of our study, as calling males were readily detected during the 1st night of recording. The 2nd and 3rd intervals began on 13 June and 10 July, respectively. The number of vocalizations/evening recorded by both ARS at Site C ranged from 4 to 1259 (x = 284, s = 281) during times when males were calling. The average number of vocalizations/h was greatest during 21:00 for both ARS, but individuals were also quite vocal between 22:00 and 24:00 (Fig. 3). Under conditions with little ambient noise, we were able to track the

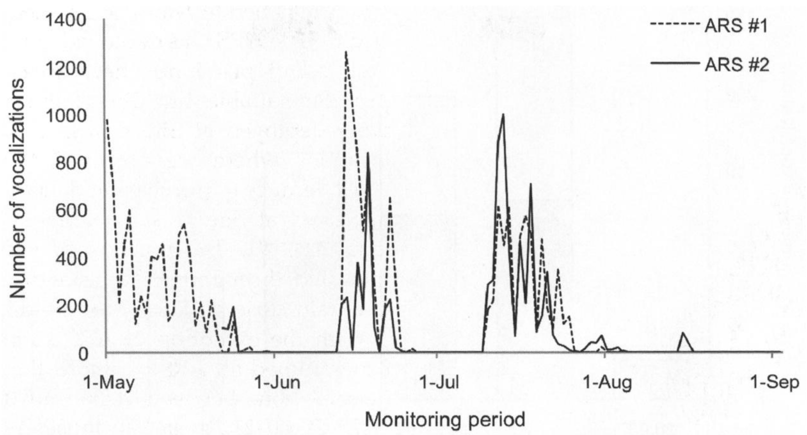

FIGURE 2. Number of Western Spadefoot Toad vocalizations/evening at Site C in Kern County, California, May through August 2009.

vocalizations of a single male 206 m to its calling location. While standardized visual encounter and dipnet surveys were not conducted, we did detect Western Spadefoot Toad larvae (Gosner Stage 39; Gosner 1960) on 1 July, confirming successful breeding at Site C.

The timing of the reproductive bouts documented during this study differs from reports in the primary literature. For example, Morey (2005), citing 6 primary literature articles, indicated that breeding is most likely to occur during February and March. Typically, the surface activity of this species "declines during the unbroken hot, dry periods of late spring, summer and fall", with individuals becoming dormant in their burrows by late summer (Morey 2005:516). This was not the case for the population we monitored. We suspect that the deviation from known breeding periods observed at Site C may be associated with the managed flooding regime of the study area.

We cannot determine the exact mechanism that lured individual Western Spadefoot Toads from their burrows to breed, as our study was not designed to do so; but we suspect that flooding practices, rather than rainfall, triggered breeding. Inundation of the study sites began in mid-April and ended in late August, with water remaining on the sites throughout most of September. Flooding was performed via a low-lift electric pump between 20 April and 14 June, and the pump ran nearly continuously during this period. After 14 June, flooding was performed on an as-needed basis via a gravity feed system. Rainfall occurred on only 3 d during the 124-d monitoring period of our study. Specifically, 8.9 cm were reported on 2 May, 0.8 mm on 5 June, and 0.8 mm on 6 June (http://www.cnrfc.noaa.gov). This precipitation pattern is consistent with that of recent years, as only 4% of all rainfall between 2002 and 2010 fell between 1 May and 31 August, whereas 95% fell between 1 October and 30 April (http://www.cnrfc.noaa.gov). The 2 May rainfall event may have influenced the 1st calling interval, but the association is difficult to determine since our monitoring period began on 1 May. Interestingly, the amount of precipitation produced during the latter 2 rainfall events was enough to elicit the emergence of other spadefoot toad species in a study by Dimmit and Ruibal (1980), but did not correspond with the 2nd and 3rd vocalization intervals detected in our study.

We have demonstrated that ARS are an effective tool for monitoring chorusing populations of Western Spadefoot Toads. Additionally, we have shown that Western Spadefoot Toads will breed, if appropriate conditions exist, during periods previously believed to be unsuitable for the species. To the best of our knowledge, Western Spadefoot Toad breeding has never been documented in the months observed during this study. While the ability of the species to adapt its reproductive bouts with environmental cues has been well documented (Denver and others 1998; Morey and Reznick 2004), the ability to correspond these bouts with managed hydroperiods is not well understood. Because the WRP is intended to promote conservation, further research is need-

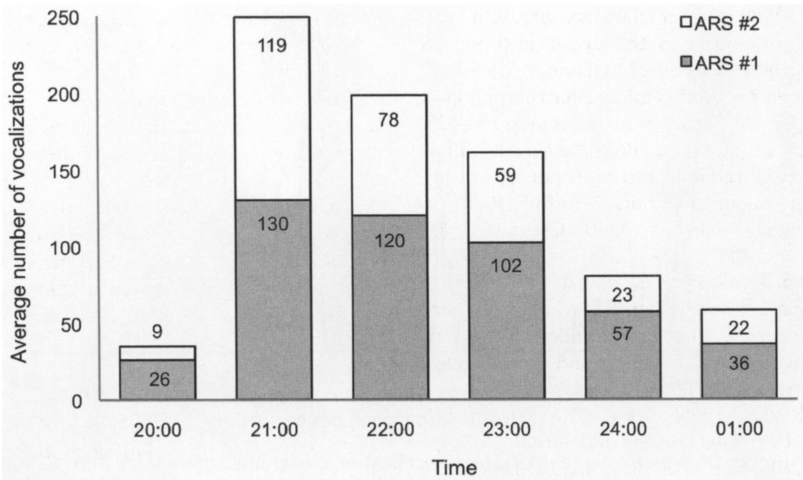

FIGURE 3. Average number of Western Spadefoot Toad vocalizations/h at Site C in Kern County, California, May through August 2009.

ed to determine if temporally irregular breeding results in successful recruitment or is in some way damaging to the population. We speculate that other species and taxa are also affected by such conservation practices and strongly urge researchers to investigate how multiple species within biological communities respond to manipulated hyrdoperiods in managed wetlands.

Acknowledgments.—We thank the NRCS CEAP-Wetlands program for funding this research and B Hartnack for facilitating the project and providing on-site support. We also thank B Hossack, S Marks, and J Bettaso for their review of this manuscript.

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