FINAL PERFORMANCE REPORT

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Habitat Restoration and Population Assessment of Chicken Turtles and Crawfish Frogs at Boehler Seeps and Sandhills Preserve, Atoka County, Oklahoma

Oklahoma Department of Wildlife Conservation

January 23, 2012 through December 31, 2013

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OBJECTIVES:

1. To monitor changes in aquatic habitat at Boehler Seeps and Sandhills Preserve following habitat restoration. Temporal changes in pond area, depth, water temperature, and water quality will be provided in Performance reports.

2. To estimate the distribution and abundance of western chicken turtles and southern crawfish frogs by trapping, radio telemetry, and drift-fence and visual surveys for the Oklahoma Comprehensive Wildlife Conservation Plan. The locations, numbers, and demographics of each of the two species will be provided in Performance reports.

INTRODUCTION

Project Location.—Boehler Seeps and Sandhills Preserve, located in Atoka County, Oklahoma, is composed of an unusual mixture of bluejack oak woodlands and acid hillside seeps that are unique for the area, and the flora and fauna found in these habitats are more typical for Gulf Coast states, such as Texas and Louisiana, than for Oklahoma. This has resulted in a distinctive assemblage of reptiles and amphibians. Prior to 2012, 45 reptile and amphibian species had been documented at this 196-ha site (Patton and Wood 2009; J. Tucker pers. comm.). Four species (western chicken turtles [*Deirochelys reticularia miaria*], western mud snakes [*Farancia abacura reinwadtii*], western lesser sirens [*Siren intermedia nettingi*], and southern crawfish frogs [*Lithobates areolatus areolatus*]) are listed as Tier II Species of Greatest Conservation Need, and two of them (western diamond-backed rattlesnakes [*C. atrox*] and eastern river cooters [*Pseudemys concinna concinna*]) are listed as Tier III Species of Greatest Conservation Need (Oklahoma Comprehensive Wildlife Conservation Strategy).

Historically, many of the resident herps were most often found in and around two beaver-formed lakes (Boehler Lake and Hassell Lake); however, between 2002 and 2007, the dam forming Boehler Lake was breached, likely by local vandals, and much of the water drained. The beavers rebuilt the dam (Jona Tucker, The Nature Conservancy, pers. comm.). However, this dam was not substantial enough to restore the lake to its former depth, and sensitive species may not have been able to survive the changes. Therefore, our aim was to monitor the reptile and amphibian communities at Boehler Lake and Hassell Lake to see if the populations at Boehler

Lake were persisting despite the loss in habitat quality. We paid special attention to the species of greatest conservation need such as *D. r. miaria* and *L. a. areolatus*.

Chicken Turtles and Crawfish Frogs.—Both *D. r. miaria* and *L. areolatus* are biologically remarkable species that are in great need of conservation. Chicken turtles exhibit a number of traits that are unusual for turtles in the Emydidae family. For example, unlike most Emydids, they are primarily carnivorous, they inhabit small ephemeral bodies of water, they grow rapidly, and they have relatively short life spans (Gibbons and Greene 1978; Gibbons 1987; Buhlmann 1995; Jackson 1996; Demuth and Buhlmann 1997). Chicken turtles are also known to frequently leave water to estivate on land and escape desiccation when ponds dry (Bennett et al. 1970; Gibbons et al. 1983). Perhaps the most interesting aspect of chicken turtles' ecology is, however, their reproductive cycle. In contrast to most turtles, chicken turtles have dual spring and fall nesting seasons rather than the more typical summer nesting season that most North American turtles exhibit (Congdon et al. 1983; Buhlmann et al. 2009). They also have the ability to retain eggs for several months, and females can nest twice in a given year (Cagle and Tihen 1948; Buhlmann et al. 1995; Gibbons et al. 1982). Despite having so many novel traits, the research on chicken turtles has been restricted to the eastern chicken and Florida subspecies (*D. r. reticularia* and *D. r. chrysea*, respectively) and little is known about the western subspecies (*D. r miaria*).

Crawfish frogs also have an array of interesting traits. They are noted for their brief breeding season and extensive use of burrows (Smith 1934; Thompson 1915; Heemeyer and Lannoo 2010; Engbrecht et al. 2011). On rainy nights in early spring, *L. areolatus* migrate up to 1.2 km to fishless pools in order to breed (McCarley 1970; Heemeyer and Lannoo 2012; Engbrecht et al. 2013). Breeding usually occurs between February and April, but the exact dates vary across the species' range, and can be affected by weather (Bragg 1953; Busby and Brecheisen 1997; Williams et al. 2013). Outside of the breeding season, adults live in and forage at the mouths of crawfish burrows (Hoffman et al. 2010; Engbrecht and Lannoo 2012). These burrows are generally found in fields and grasslands, and they can be more than 1 m deep (Heemeyer et al. 2012; Williams et al. 2012a).

Like *D. r. miaria*, there is still much that we do not know about *L. a. areolatus.* Also like *D. r. miaria*, *L. areolatus* is a species that is in need of increased conservation efforts. Populations of both of these species appear to be declining throughout their ranges, and additional research is needed both for the sake of further scientific discovery and in order to aid conservation efforts (Paris and Semlitsch 1998; Engbrecht 2010). Therefore, in addition to collecting data on the general herpetological community, we also collected data on ecology of *D. r. miaria* and *L. a. areolatus*.

MATERIALS AND METHODS

Herpetological Survey.—We conducted continuous surveys from May–early July in 2012 and 2013. We also conducted shorter surveys of varying duration and intensity in other months. In order to thoroughly sample the herpetological community, we used seven different survey methods: pitfall traps positioned along drift fences, funnel traps along drift fences, funnel traps along logs, turtle traps (several models), artificial cover objects, automated recording systems, and incidental encounters.

We used a total of nine drift fences of various designs during the study (Jones, 1986; Enge 2001, 2005; Table 1). The locations of the fences were carefully chosen so that all habitat types were sampled (Fig 1). We used 18.9 L buckets for pitfall traps, and placed them such that the fences bisected them, allowing animals to enter the trap from either side of the fences. We used aluminum window screen to construct both single-ended (i.e. an opening on only one end) and double-ended (i.e. an opening on both ends) funnel traps 25 cm in diameter (Greenberg et al. 1994; Crosswhite et al. 1999). It has been demonstrated that traps with two funnels in series capture over twice as many reptiles and amphibians as traps with only one funnel per end; therefore, we installed two funnels on single-ended traps and four funnels on double-ended traps (Yantis 2005; Farallo et al. 2010). We installed single-ended funnel traps on the ends of drift fences, and placed double-ended funnel traps in the middle of the fences. Additionally, we positioned several single-ended funnel traps on logs (seven in 2012 and five in 2013; only two traps were in the same location both years). We placed a tarp over each funnel trap to shade it, and we placed wet sponges in the pitfall traps and funnel traps to prevent animals from desiccating (Gibbons and Semlitsch 1981; Todd et al., 2007). During 2012, we used aluminum "wings" to increase the capture rate of pitfall traps on drift fence #2, and in 2013, we used them sporadically on the funnel traps on drift fences #1, 3, 5, and 7 (McKnight et al. in press). We checked all of the traps every morning and removed animals from the vicinity of the fences before releasing them.

In February 2012, we placed 72 artificial cover objects (48 pieces of roofing tin and 24 tarps) at random locations in the preserve (Engelstoft and Ovaska 2000; Fig 1). To select locations for these objects, we used aerial maps to identify four 500 × 200 m sections of the preserve, then used a random number generator to select GPS coordinates for 12 pieces of tin and six tarps within each area. We placed 10 additional pieces of tin along the edges of each lake (randomized distribution was not feasible for these cover objects). During 2012, we randomly selected half of the pieces of tin and half of the tarps within each area and checked them every eight days. We checked the remaining cover objects every four days. Because of low capture rates in 2012, we checked the cover objects sporadically in 2013, rather than following a fixed schedule. We monitored the boards around each lake sporadically in both years.

From February–April 2012, we used automated recording systems (two at Hassell Lake and three at Boehler Lake; Wildlife Acoustics, Concord, Maine, USA) to monitor the anuran community (Peterson and Dorcas 1992, 1994). From 5 February–24 March, each unit recorded every evening for three-minute intervals at 1900, 2100, and 2300 hours, and from 25 March–30 April they recorded at 2000, 2200, and 0000 hours. The shift was made to compensate for increasing day length. These time ranges cover the peak calling times for most North American anuran species (Shirose et al. 1997; Bridges and Dorcas 2000; de Solla et al. 2005). To increase the accuracy of the results, we listened to recordings manually rather than using call recognition software (Waddle et al. 2009). We only recorded the presence or absence of anuran species rather than estimating the number of individuals. In order to record the temperatures at which the anurans were calling, we placed temperature data loggers (iButton 1922L, Maxim Integrated, Sunnyvale, CA, USA) beside an ARS at each lake.

We used a variety of traps to assess the aquatic turtle community. We used hoop nets (2.54 × 2.54 cm mesh) of the following diameters: 0.91 m (×6), 0.76 m (×2), 0.61 m (×2), 0.51 m (×2) (numbers in parentheses = the number of traps; Memphis Net and Twine Co., Memphis, Tennessee) (Cagle and Chaney 1950; Gibbons 1990). We also used 12 collapsible crawfish traps (1.0 × 1.0 cm mesh) with a 0.3 m diameter and an opening on both ends (#TR-503; American

Maple Inc., Gardena, California), eight steel minnow traps (0.6 × 0.6 cm screen) with a 0.2 m diameter and an opening on both ends (Plano Molding Company, St. Plano, Illinois), and two basking traps (Memphis Net and Twine Co., Memphis, Tennessee) (Ream and Ream 1996; Adams et al. 1999; Klemish et al. 2013). We attached 6-m leads to several of the hoop nets, and used a combination of baited and unbaited traps (Vogt 1980; Smith et al. 2006). We used sardines as bait in 2012, and we used both sardines and krill in 2013. Within each lake, we only baited half of the crawfish traps and minnow traps in 2012, and in both years, we did not bait one of the hoop nets on a lead. We placed half of each trap type in each lake, and checked all of the turtle traps every other day. Minnow traps and basking traps were only used in 2012. Additional traps were used sporadically in streams and seeps. We sexed, marked, measured, and weighed all turtles before releasing them. We used the Chapman (1951) modification of the Petersen (1896) method to calculate the turtle population sizes. It was not possible to calculate the population sizes for *D. r. miaria*, eastern river cooters (*Pseudemys concinna concinna*), or snapping turtles (*Chelydra serpentina*); however, based on recapture rates, it is likely that we captured the majority of individuals in those populations.

In addition to the animals detected using our various trapping methods, we recorded all encounters with reptiles and amphibians outside of traps and grouped them into an "incidental encounter" category. Incidental encounters included: hearing anurans, finding animals while moving between trap sites, finding animals under logs, and finding animals on the road bordering the preserve. Because of the high number of incidental encounters of some species, we did not record exact counts for anurans or larval salamanders.

Water Quality.—We placed temperature data loggers (iButton 1922L) at various locations throughout both lakes to monitor water temperatures. We attached several data loggers to floats so that they would record the surface temperatures, and we placed several data loggers on the bottom of the lakes. For each month, we averaged the maximum daily temperature recorded by any logger at a given lake, and we averaged the minimum daily temperature recorded by any data logger at a given lake. To compare the water chemistry between the lakes, we measured the dissolved oxygen, pH, NH_3, NH_4, NO_3, and PO_4 at each lake on 28 May 2012 and 7 July 2012. Finally, throughout both years, we took notes on the water levels of each lake.

Southern Crawfish Frogs.—Because of the conservation status of *L. a. areolatus,* we collected additional data for this species. First, in addition to the ARS units at the lakes, we placed an ARS (#1) and temperature data logger at a cattle pond on an adjacent property However, because of overlapping calls from neighboring ponds, the presence or absence of species other than *L. a. areolatus* were not noted (Fig. 1). This ARS was set to record on the same schedule as the other ARS units. All six recordings from each of the ARS units were analyzed for the presence of *L. a. areolatus* on all nights that *L. a. areolatus* were detected on any of the ARS units.

To examine the effects of temperature on *L. a. areolatus* calling, we used a Mann-Whitney *U* test to compare the temperature at 1900 on nights when *L. a. areolatus* did and did not call during the *L. areolatus* breeding season (defined as the first night that they were detected to the last night that they were detected). Additionally, we calculated the mean air temperature at each body of water using the temperatures recorded at the times that *L. a. areolatus* were actually calling, instead of the temperature at 1900. When *L. a. areolatus* were heard simultaneously on two or more ARS units deployed at a single site, we scored it as one detection. Comparing these means statistically was not possible because of a lack of independence resulting from multiple recordings on the same night.

For the entire *L. a. areolatus* breeding season we recorded the number of days since the last rainfall event for each night (N = 20) that *L. a. areolatus* was detected, for each night that they were not detected (N = 24), and for 20 randomly selected nights. Days when it rained were scored as 0 for their respective category. We used a Kruskal-Wallis test ($\alpha = 0.05$) in R (version 3.0.2) to compare the mean ranks of these three categories.

Western Chicken Turtles.—In 2012, *D. r. miaria* were only captured at Boehler Seeps and Sandhills Preserve, but in 2013, several individuals were also collected at three other bodies of water (all < 8 km from the primary study site). Upon capture, we attached radio transmitters (RI–2B 10 g or RI–2B 15 g: Holohil Systems Ltd., Corp., Ontario Canada) to the turtles carapaces so that they could be relocated in the future. In 2012, we used waterproof epoxy (Loctite Marine Epoxy; Henkel Corp., Westlake, Ohio) to attach the transmitters, but the turtles frequently molted their carapace scutes, often resulting in the detachment of transmitters. Therefore, in 2013, we attached the transmitters by threading thin pieces of copper wire through holes drilled in marginal scutes two and three. The wires were used to make a harness for the transmitters, and the harnesses and transmitters were coated in a thin layer of waterproof epoxy to prevent the wires from snagging on obstacles and to ensure that the transmitters did not come out of the harnesses. We monitored ten turtles in 2012 (including two adult females), and 13 turtles in 2013 (including both females from 2012 and a third female). In April 2013, we collected data from four additional females; however, they were located on private property (BP5) to which we were not permitted to return later in the year. We also attached temperature data loggers (iButton 1922L) by using marine epoxy to secure them immediately behind the transmitters. The data loggers recorded the temperature every hour, and we used the resulting temperature profiles to determine the precise dates on which each turtle was estivating. In addition to be giving each *D. r. miaria* a unique notch code, we also inserted a passive integrated transponder (PIT) tag parallel to the bridge of the shell.

Whenever a *D. r. miaria* was captured in a trap, we used a portable ultrasound (Echo Camera SSD-500V, Hitachi Aloka Medical, Inc. Tokyo, Japan) to determine its reproductive condition. Additionally, transmittered turtles were tracked, captured, and sonogrammed approximately once every two weeks throughout their active season. We collected air temperature and rainfall data for both years from a weather station located approximately 17.5 km from the Boehler Seeps and Sandhills Preserve (Oklahoma Mesonet, http://www.mesonet.org/index.php/weather/station_monthly_summaries).

RESULTS

Herpetological Survey.—We documented 7,751 reptiles and amphibians representing 53 species (Table 2). Additionally, we found two subspecies and possible hybrids of the racer (eastern yellow-bellied racer [*Coluber constrictor flaviventris*] and southern black racer [*C. c. priapus]),* and an atypical three-toed box turtle (*Terrapene carolina triunguis*) that matches a published description of a three-toed box turtle/ornate box turtle hybrid (*T. ornata*; table 2) (Cureton et al. 2011). On several occasions, skinks escaped before they could be identified to species; therefore, we recorded these as "unidentified Plestiodon." Twelve of the species found in this survey had not been documented in a 2008 survey (Patton and Wood 2009), and five are listed as Species of Greatest Conservation Need in Oklahoma (southern crawfish frog

[Lithobates areolatus areolatus], western lesser siren [*Siren intermedia nettingi*], northern scarlet snake [*Cemophora coccinea copei*], western mud snake [*Farancia abacura reinwardtii*], and western chicken turtle [*Deirochelys reticularia miaria*]) (Oklahoma Department of Wildlife Conservation, 2005). Only one species (*C. atrox*) that had been previously reported at Boehler Seeps and Sandhills Preserve was not found for the duration of this survey.

The herpetological communities of Boehler Lake and Hassell Lake were very similar. The ARS units detected the same 14 species calling from both lakes, and individuals of all of those species were also captured in drift fences (Table 2; Fig. 2). Similarly, the turtle traps captured the same two salamander species (including *S. i. nettingi*), six turtle species (including *D. r. miaria*), and five snake species (including *F. a. reinwardtii*) in each lake. Although rarely captured in the turtle traps, both northern rough green snakes (*Opheodrys aestivus aestivus*) and western ribbon snakes (*Thamnophis proximus proximus*) were also frequently encountered in and beside both lakes. Finally, *C. c. copei* were captured in drift fences beside both Boehler and Hassell Lake.

Within the turtle communities, the common musk turtle (*Sternotherus odoratus*) was the most abundant species in Boehler Lake, but only the second most abundant species in Hassell Lake (Fig. 3). The Mississippi mud turtle (*Kinosternon subrubrum hippocrepis*) was the most abundant species in Hassell Lake, but only the third most abundant species in Boehler Lake. *Chelydra serpentina*, *P. c. concinna*, or *D. r. miaria* occurred in low numbers in both lakes.

Water Quality.—The temperatures of the two lakes were similar throughout both years, but Boehler Lake tended to be slightly warmer than Hassell Lake (Fig 4). The water chemistry of the two lakes was also similar (Table 3). The water levels of both lakes fluctuated seasonally. During both years, they were at their full depths in February, and remained at those depths throughout the spring. In 2012, the water levels began decreasing in late May, and by September they had dropped by over 30 cm. Neither lake completely dried, and by late January 2013, they had returned to their full levels. In 2013, there was more rain and lower average temperatures than there had been in 2012 (Fig. 5). As a result, the lakes remained at their full levels until June, at which point the water levels began to drop slowly. At Boehler Lake, the water level had dropped a few centimeters by late August, and it returned to normal by mid-November. In Hassell Lake, there was a small dam breach in late July, resulting in the water level lowering by at least 50 cm. By mid-November, however, the breach had been repaired by beavers and the water level had returned to normal.

Throughout both years, the beavers in Boehler Lake made frequent attempts to build a dam below the primary dam. By February 2012, a large dam had been constructed below both the current dam and the location of the original dam (Fig. 6). This dam had formed a large pool that was almost as deep as Boehler Lake itself, but a large storm in mid-March destroyed this dam and completely drained the lower pool (Figs. 6–8). By May, the beaver had partially rebuilt this dam, but it was only half the height of its predecessor. This small dam remained throughout the year, but was not enlarged until early in 2013. By mid-March 2013, it was almost as large as the previous dam, but a storm in April partially breached it, returning it to its May 2012 size. By early May 2013, the beavers had not only largely repaired this breach (Fig. 9), but they had begun rebuilding the original dam (Fig. 10). At this point, the water level of the lower pool was deeper than it had been at any other point following the breach in mid-March 2012 (Fig. 11). In mid-May, however, a large storm destroyed both the lower dam and the partial reconstruction of the original dam, once again completely draining the pool (Figs. 10 and 12). Beaver did not attempt to repair either dam until sometime after August, but by late November, the original dam had been partially reconstructed, and the water level of the pool was close to the level it had been at before the 2012 breach (Fig. 13). The beaver did not attempted to rebuild the lower dam. Boehler Lake's main dam was never breached during this period.

Southern Crawfish Frogs.—*Lithobates areolatus areolatus* were recorded by all six ARS units (Fig. 14). They were detected 14 times (nine nights) at Hassell Lake, 23 times (nine nights) at Boehler Lake, and 51 times (17 nights) at the nearby cattle pond. Based on the amplitude of the calls, some of the males detected at the cattle pond were probably calling from at least one neighboring pond (60 m away). In Boehler Lake, *L. a. areolatus* were detected most frequently on ARS #4, and least frequently on ARS #3. In Hassell Lake, they were detected on ARS #5 more often than on ARS #6. *L. a. areolatus* called most frequently at 2000 and 2100 (Fig. 15).

On average, *L. a. areolatus* called at Hassell Lake when it was 11.7 °C, at Boehler Lake when it was 16.9 °C, and at the cattle pond when it was 16.0 °C (Fig. 16). The mean ranks of the temperatures on nights when they were detected were significantly higher than the mean ranks on nights when they were not detected (W = 280, P = 0.0186). There was not a significant difference (χ^2 = 0.9601, df = 2, P = 0.6187) in the mean ranks of the number of days since the last rainfall event among nights when *L. a. areolatus* called, nights when they did not call, and 20 randomly selected nights (Fig. 17). Six recently metamorphosed *L. a. areolatus* were captured in pitfall traps near Boehler Lake (Table 4). Additionally, one adult male was captured in a cattle pond 1 (Fig. 18).

Western Chicken Turtle Populations.—We captured 56 individual *D. r. miaria* in southeastern Oklahoma (Table 5). Fifty-three were captured in bodies of water (Boehler Lake, Hassell Lake, BP4, BP5, and P1), two were found on the road, and one was captured in a drift fence (Fig. 18). Included among these turtles were four that had been PIT tagged in 2008 (out of a total of seven that received PIT tags that year).

At Boehler Seeps and Sandhills Preserve, nine *D. r. miaria* were captured in Boehler Lake, nine were captured in Hassell Lake, and one (#54) was captured in drift fence #5 (Table 5, Figs. 1 and 18). After being released, #54 left the property and entered cattle pond 1 (Fig. 18). Turtle #54 and three of the turtles in Hassell Lake were juveniles (estimated 2–3 years old based on scute annuli), and one of the turtles captured in Boehler Lake was a hatchling. Two mature females were captured in Hassell Lake, and one mature female was captured in Boehler Lake. Most individuals could not be sexed because they did not exhibit sexual dimorphisms. Thirteen of the *D. r. miaria* at Boehler Seeps and Sandhills Preserve were first captured in 2012, and all 13 of them were recaptured in 2013, so no mortalities were recorded for that year. In 2013, however, several mortalities were observed. First, the shell of #54 was found at cattle pond 1. The cause of death was unknown. Also, an unmarked individual was found dead on the road on the east side of Boehler Seeps and Sandhills Preserve. It was unclear if it was leaving or entering the preserve. Finally, while determining the estivation locations of #3 and 7, we recovered their transmitters, but we could not locate the turtles themselves. Given that the transmitters were wired to the shells, it is likely that the turtles were depredated.

Several turtles moved between bodies of water (Table 5). Most notably, one of the turtles with a PIT tag from 2008 was captured in BP4 which is roughly 7 km away from Boehler Seeps and Sandhills Preserve. This same individual left BP4 part way through 2013 and moved further east to an unknown location. Other individuals made smaller movements, such as #21 briefly migrating to a cattle pond (cattle pond 2) on adjacent property (Fig. 18).

Western Chicken Turtle Activity and Reproduction.—*Deirochelys reticularia miaria* were already active when trapping was initiated 3 March, 2012. They continued to be active and remained in the water until 3 June, at which point individuals began to move onto land, burrow into the sand, and estivate for the remainder of the year (Figs. 19–21). By 14 July, all 10 transmittered turtles were on land and estivating. No additional *D. r. miaria* were captured in the water after mid-July despite continued sampling of the rest of resident turtle community. The final trap date was 13 August.

In 2013, all of the transmittered turtles became active and returned to the water in mid-March. They remained active until 14 June, at which point individuals began to leave the water and estivate on land (Fig. 21). By 16 July, 11 of 13 transmittered turtles had entered terrestrial refugia, but two females remained in the water. Turtle #21 left the property in late June and we were unable to locate her again until 23 August because of restricted access to neighboring private property. Sometime during 4–23 August, turtle #21 returned to the property and commenced estivating. Turtle #7 remained on the property and did not leave the water to begin estivating until 29 August 2013.

All seven adult females appeared to be reproductively active. Enlarged follicles were present throughout the active season, but eggs were only observed from May–July (Fig. 22). The two females that were monitored in both 2012 and 2013 produced eggs in both years. Two females produced at least two clutches in a single year, and others may have laid 2–3 clutches; however, gaps in the ultrasound data made it impossible to determine the number of clutches with certainty (Fig. 22).

There was no evidence of females retaining eggs during estivation. In 2012, two females were unearthed and palpated shortly after they entered terrestrial refugia, and neither contained eggs. In 2013, females were not disturbed, but turtles #7 and #15 had been sonogrammed shortly before leaving the water, and neither contained eggs at that time.

DISCUSSION

Herpetological Community and Water Quality.—Our results suggest that that not only has the herpetological community at this site survived the recent ecological changes, but the species richness is even higher than was previously thought. Both lakes contained the same set of reptile and amphibian species, and even the rare species such as *F. a. abacura* and *S. i. nettingi* which had not been confirmed at this site in many years where detected in both lakes. This is an encouraging indication that the unique fauna of this site has persisted despite the loss of Boehler Lake's original dam and the resulting changes in the aquatic habitat. The water chemistry was also very similar in both lakes, providing further evidence that Boehler Lake's ecosystem has survived the transition. Nevertheless, there are still concerns about the future of this site. Most notably, giant cutgrass (*Zizaniopsis miliacea*), broadleaf cattails (*Typha latifolia*), and mats of floating vegetation are expanding and closing the areas of open water. If they continue to spread, they could fundamentally alter the habit and plant community. These lakes should continue to be monitored to determine if action is required to curtail the expansion of these species.

It is encouraging that only one previously documented species was not located in this study. This species (*C. atrox*) has not been seen at Boehler Seeps and Sandhills Preserve for several years and was not documented in the 2008 survey (Patton and Wood 2009). In interviews, people living next to the property claim to see them infrequently. Also, *C. atrox* tends to live in upland areas which were not surveyed as extensively as the wetlands. Therefore, it is possible that they are still present at the site, but occur in very low densities away from the wetlands.

Southern Crawfish Frogs.—Although *L. a. areolatus* were present in both lakes, their populations appear to be fairly small. Nevertheless, the presence of recent metamorphs in the drift fences indicates that recruitment is occurring. The fact that populations are present on neighboring properties is also encouraging for the long-term persistence of the species. While it is not evident that Boehler and Hassell lakes are sink populations, this proximity to other wetlands may allow new individuals to immigrate from neighboring populations and contribute to the small populations at Boehler and Hassell Lake.

Several of our results were unusual and present novel observations about the ecology of *L. a. areolatus*. First, our study has added the following species to the list of anurans with which *L. areolatus* will breed syntopically: green treefrogs (*Hyla cinerea*), American bullfrogs (*Lithobates catesbeianus*), pickerel frogs (*Lithobates palustris*), Cajun chorus fogs (*Pseudacris fouquettei*, Strecker's chorus frogs (*Pseudacris streckeri*), and Hurter's spadefoot toads (*Scaphiopus* hurterii; see Parris and Redmer 2005). It is interesting that *L. a. areolatus* chose to breed in bodies of water with so many other anurans. Although they will inhabit sites with high anuran diversity (Lannoo et al. 2009), breeding in bodies of water with such a large number of anuran species has not been previously reported, and *L. areolatus* tadpoles are purportedly poor competitors that exhibit decreased physical fitness in high densities (Parris and Semlitsch 1998; Williams et al. 2012b).

To our knowledge, this is also the first report of *L. areolatus* breeding in natural, permanent, fish-filled bodies of water (Smith 1934; Bragg 1953; Busby and Brecheisen 1997). Palis (2009) reported them breeding in a pond that was stocked with predatory fish, but in that case the pond was drained and restocked annually, and the size of the fish at the time when *L. areolatus* tadpoles were developing prevented the fish from feeding on them. Engbrecht et al. (2013) also noted a *L. areolatus* breeding pool that is now stocked with fish, but whether or not this population will survive the presence of the fish is presently unknown. In interviews, longtime residents living near Boehler Seeps and Sandhills Preserve stated that the beaver dams have been present at least since the 1960s, and the area generally retained some water even before the dams were built. One man reported that his father hunted ducks at the site that is now Boehler Lake at least as far back as the 1930s. Therefore, it seems likely that fish have been present at these sites for many years. Interestingly, in 2013, a large chorus of *L. a. areolatus* (too many to accurately estimate numbers) was heard at a pond 14 km from the preserve that is also known to have predatory fish (McKnight, pers. obs.). Given the size of this chorus and the fact that both males and gravid females were observed at this pond, annual recruitment is almost certainly occurring, despite the fish. More research on the *L. a. areolatus* populations in this part of the species' range is clearly warranted, as geographic differences in tolerance to fish presence appears likely.

In addition to the presence of predators and anuran competitors, Boehler and Hassell Lake are also somewhat unusual habitat for *L. a. areolatus* because of the extensive upland hardwood forest habitat surrounding them. *Lithobates areolatus* have been reported to utilize wetlands in wooded habitat (Bragg 1953), but they more typically breed in pools surrounded by grasslands, and they exclusively use primary burrows that are in open habitat (Busby and

Brecheisen 1997; Heemeyer et al. 2012; Heemeyer and Lannoo 2012; Williams et al. 2012a,c). The burrow locations of this population were not determined, and individuals might be migrating long distances to fields on neighboring properties. Alternatively, there may be adequate burrows present in the small clearings that are present beside each lake (Heemeyer and Lannoo 2012; Williams et al. 2012a).

Lithobates areolatus areolatus at our study site exhibited a tendency to chorus at temperatures that were notably lower than those previously reported. Busby and Brecheisen (1997) and Engbrecht (2010) both reported that *L. areolatus* typically called when temperatures were ≥ 13 °C, and Busby and Brecheisen (1997) noted that no calls were detected below 8 °C. In contrast, Williams et al. (2013) found that detection probabilities were highest when temperatures were ≥ 9 °C. In our study, 15/88 detections of *L. a. areolatus* occurred at temperatures < 9 °C, and 31 detections occurred at temperatures < 13 °C. While many of these occurrences consisted of only one or two calling frogs, there were some noteworthy exceptions. For example, the second largest chorus at Hassell Lake was recorded at the coldest temperature at which any *L. a. areolatus* were documented (4.1 °C). Also, the strongest chorus at Hassell Lake occurred at 9.6 °C, well below the optimal temperature reported by Busby and Brecheisen (1997) and Engbrecht (2010).

Several studies have reported a strong association between rainfall and *L. areolatus* breeding activity (Bragg 1953; McCarley 1970; Busby and Brecheisen 1997), but Engbrecht (2010) found that rainfall reduced detection probabilities. Williams et al. (2012b) suggested that rainfall has a greater positive effect on frogs migrating to the pools than it does on calling activity, and it is rain in the previous 24 h that is important. In contrast, Williams et al. (2013) found that there was a negative relationship between detection probabilities and rainfall in the previous 24 h. In our study, there was no apparent association between rainfall and nights on which *L. a. areolatus* called. Forty percent of the nights that they called were within 48 h of a rainfall event, but we interpret that to be an artifact of having many nights of rain, rather than a behavioral trait of the frogs. The reasons for these discrepancies among studies are not entirely clear. One possibility is that the first warm rains of the year trigger the initial migration to breeding pools, and, as Williams et al. (2013) suggested, subsequent rainfall events result in the immigration of new males that increase detection probabilities in small populations (such as those reported by Williams et al. [2012b]), but have little effect on the detection probabilities in larger populations. Thus, in many populations, after the initial rainfall event, calling will occur continuously irrespective of additional rainfall, unless conditions become unfavorable.

The times of day at which *L. a. areolatus* called were consistent with results from Indiana where calling intensity increased from 1900–2045 and then decreased thereafter (Williams et al. 2013). Although we recorded the number of detections, not calling intensity, our results followed a similar pattern with the number of detections increasing from 1900–2100, leveling off between 2100–2200, then decreasing after 2200. Therefore, the interval of 1900–2300 suggested by Williams et al. (2013) should be optimal for surveying for *L. a. areolatus* in Oklahoma.

The fact that males were frequently heard on one ARS, but were absent from simultaneous recordings from other ARS units has important implications for survey efforts. Male *L. a. areolatus* have very loud calls, and in theory one ARS at each lake could have detected all of the *L. a. areolatus* that called. In practice, however, *L. a. areolatus* calls were often masked by loud choruses of other anuran species, wind, and other background noises. Therefore, we recommend that surveys at large bodies of water use several ARS units to maximize detection.

Western Chicken Turtle Populations.—The status of *D. r. miaria* at Boehler Seeps and Sandhills Preserve appears similar to that of *L. a. areolatus*. Populations still exist in both lakes, and annual recruitment appears to occur, but the small size of these populations makes their future occurrence questionable. Encouragingly, there appears to be a fair amount of movement between different wetlands, suggesting that there is a large *D. r. miaria* metapopulation rather than many small isolated populations. This may allow larger populations to sustain the smaller populations with the immigration of new individuals, but it also creates a great conservation challenge because it could be essential to preserve not only the wetlands themselves, but also corridors that the turtles use to move among them. A better understanding of the population dynamics is clearly needed before such a conservation effort can be effectively undertaken.

Western Chicken Turtle Activity and Reproduction.—Our activity data make it clear that *D. r. miaria* is dormant for the majority of the other subspecies' nesting seasons. Further, our ultrasound data indicate that *D. r. miaria* has a single, discrete nesting season, rather than a bimodal nesting season. Also, this nesting season occurs in the early summer during a time of year when the other subspecies are generally not reproductively active (Jackson 1988; Gibbons and Greene 1990; Buhlmann et al. 2008). This nesting season is, however, consistent with most other North American emydids (Gibbons and Green 1990).

The consistency of the timing of estivation between two years that differed substantially in rainfall and temperature patterns suggests that this is a normal pattern for *D. r. miaria* in this portion of the subspecies' range. The two alternatives are that our results were either an artifact of our manipulations triggering a flight response from the water (Stone et al. 2011) or were part of a drought response rather than normal behavior. The fact that the turtles were handled throughout the active season but did not begin estivating until June of both years makes it unlikely that movement to terrestrial refugia was a stress response. Also, the differences in weather patterns between the two years suggest that the observed activity patterns were not a reaction to drought. *Deirochelys reticularia reticularia* is known to leave water and estivate to escape drying conditions, however, reports of this behavior have rarely involved an entire population (Gibbons 1969, 1986; Bennett et al. 1970; Gibbons et al. 1983; Gibbons and Greene 1978). In contrast, all of our transmittered turtles estivated in both years. Importantly, a drought-triggered flight from water would only be consistent with environmental conditions in 2012. The following year was not a drought year, and the lakes were full when the turtles began to estivate. Further, our results are consistent with a report from Arkansas in which *D. r. miaria* were only captured from March–July in 2006–2008 (Dinkelacker and Hilzinger 2009). Therefore, it appears that a prolonged period of annual terrestrial estivation is likely typical for *D. r. miaria* in southeastern Oklahoma. *Deirochelys reticularia reticularia* are also known to overwinter on land, but they typically do not leave the water until September or October (Buhlmann 1995; Buhlmann and Gibbons 2001).

The fact that two female turtles remained active into August in 2013 (#7 and #21) was atypical in our population. Both turtles nested in mid-June, and enlarged follicles (likely indicative of a newly developing clutch) were observed shortly thereafter. Because turtle #21 left the property in late June, we cannot be certain that its follicles were not reabsorbed rather than ovulated and shelled, but based on the periodicity of clutch formation by other females in our population, the period of time that it remained active would have been sufficient to produce an additional clutch of eggs. Unlike turtle #21, turtle #7 remained on the property and contained shelled eggs by early July. However, it was not possible to monitor its reproductive condition from 6 July–23 August. On 23 August, it had small, poorly developed follicles (or possibly corpora lutea), and it began estivating shortly thereafter (29 August 2013). While admittedly speculative, we suggest that the favorable conditions of 2013 allowed these two females to delay estivation long enough to produce an additional clutch of eggs.

Conclusion.—Despite the recent habitat changes at Boehler Lake, the herpetological community of this site appears to have endured, and most of the rare species that have been previously documented are still present. Both *L. a. areolatus* and *D. r. miaria* are still present at this site and annual recruitment appears to be occurring. Nevertheless, the populations are small and their survival may rely on careful management and recruitment from other populations. The presence of *L. a. areolatus* in these lakes is interesting because they are unusual habitat for *L. a. areolatus* and they contain many other anuran species and species of predatory fish. It is important to know that *L. a. areolatus* can be found in such an environment and that knowledge should be applied to survey efforts for this species. Our results on *D. r. miaria* are also novel. In contrast to the eastern and Florida subspecies of chicken turtle, *D. r. miaria* nests in the late spring and early summer, and is inactive on land for most of the year. Therefore, survey efforts for *D. r. miaria* should be conducted from mid-March–June.

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Table 1. Description of the designs of drift fences used in this study. # = an arbitrary label (see Fig. 1 for fence locations), PT = pitfall traps, FT = funnel traps.

#	Years used	Shape	Material	Height (m)	Length (m)	# of PT	# of single-ended FT	# of double-ended FT
1	2012– 2013	straight	aluminum	0.6	15.2	4	4	2
2	2012	Y	vinyl fabric	0.9	30.5 per arm	6 per arm	2 per arm	2 per arm
3	2013	straight	vinyl fabric	0.5	30.5	6	4	2
4	2013	straight	vinyl fabric	0.7	5.5	0	4	0
5	2013	straight	vinyl fabric	0.5	15.0	4	4	0
6	2013	straight	vinyl fabric	0.5	9.1	2	0	2
7	2013	straight	vinyl fabric	0.5	30.5	6	4	2
8	2012	straight	aluminum	0.5	3.0	0	2	0
9	2012– 2013	straight	aluminum	0.5	3.0	0	2	0

Table 2. Summary of all of the species of reptiles and amphibians that were documented in 2012–2013. The total number of captures, not individuals, is shown. IE = incidental encounters (any encounters not included in the other methods), ACO = artificial cover objects, PT = pitfall traps, FT (DF) = funnel traps on drift fences, FT (logs) = funnel traps on logs, TT = turtle traps, ARS = automated recording systems, All = the total number documented for each species, #M = the number of methods that detected each species.

Species	IE	ACO	PT	FT (DF)	FT (logs)	TT	ARS	All	#M
Anura[a]									
Acris blanchardi	many	0	17	154	0	9	many	>180	5
Anaxyrus americanus charlesmithi	many	0	40	7	1	1	many	>49	6
Anaxyrus woodhousii woodhousii	many	0	4	3	0	0	0	>7	3
Gastrophryne carolinensis	many	0	344	57	1	0	many	>402	5
Hyla cinerea	many	0	1	6	0	9	many	>16	5
Hyla versicolor	many	0	5	12	0	2	many	>19	5
Lithobates areolatus areolatus	1	0	6	0	0	0	many	7	3
Lithobates catesbeianus	many	0	0	2	0	79	many	>81	4
Lithobates clamitans	many	0	97	44	0	25	many	>166	5
Lithobates palustris	many	0	291	104	5	16	many	>416	6
Lithobates sphenocephala utricularia	many	1	786	462	11	28	many	>1288	7
Pseudacris crucifer	many	0	1	1	0	0	many	>2	4
Pseudacris fouquettei	many	0	0	3	0	0	many	>3	3
Pseudacris strekeri	many	0	21	7	0	0	many	>28	4
Scaphiopus hurterii	many	1	994	230	83	0	many	>1308	6
Unidentified tadpoles	many	0	0	0	0	222	0	>222	2
Caudata									
Ambystoma opacum	17	0	14	3	0	0	0	34	3
Ambystoma texanum	0	0	1	1	0	0	0	2	2
Notophthalmus viridescens lousianensis[b]	>12	0	239	93	8	5	0	357	5
Siren intermedia nettingi	1	0	0	0	0	17	0	18	2
Squamata (Lacertilia)									
Anolis carolinensis carolinensis	16	1	1	0	0	0	0	18	3
Aspidoscelis sexlineata viridis	160	0	10	3	0	0	0	173	3
Plestiodon anthracinus pluvialis	6	5	3	3	0	0	0	17	4
Plestiodon fasciatus	15	18	13	10	4	0	0	60	5
Plestiodon laticeps	2	1	2	5	1	0	0	11	5
Sceloporus consobrinus	225	9	48	29	2	0	0	313	5
Scincella lateralis	122	16	26	60	2	0	0	226	5
Unidentified *Plestiodon*[c]	14	22	1	1	0	0	0	38	4
Squamata (Serpentes)									
Agkistrodon contortrix contortrix	8	2	1	15	5	0	0	31	5
Agkistrodon piscivorus leucostoma	82	0	0	17	0	61	0	160	3
Carphophis vermis	1	0	5	0	0	0	0	6	2
Cemophora coccinea copei	0	0	2	8	1	0	0	11	3
Coluber constrictor.[d]	15	3	0	19	2	0	0	39	4
Coluber flagellum flagellum	3	2	0	5	1	0	0	11	4
Crotalus horridus	4	0	0	0	0	0	0	4	1
Farancia abacura reinwardtii	0	0	0	0	0	2	0	2	1
Heterodon platirhinos	1	0	0	2	0	0	0	3	2

Lampropeltis holbrooki	0	0	0	1	0	0	0	1	1
Nerodia erythrogaster	3	0	0	4	0	5	0	10	5
Nerodia fasciata confluens	7	0	0	0	0	23	0	30	2
Nerodia rhombifer rhombifer	2	0	0	1	0	7	0	10	3
Opheodrys aestivus aestivus	37	0	1	1	0	0	0	39	3
Pantherophis obsoletus	10	2	0	8	0	0	0	20	3
Sisturus miliarius streckeri	2	0	0	2	3	0	0	7	3
Storeria dekayi texana	1	0	2	2	0	0	0	5	3
Storeria occipitomaculata occipitomaculata	1	0	1	0	0	0	0	2	2
Tantilla gracilis	4	1	3	0	0	0	0	8	3
Thamnophis proximus proximus	48	9	1	16	0	1	0	75	5
Testudines									
Chelydra serpentina	2	0	0	0	0	18	0	20	2
Deirochelys reticularia miaria	2	0	0	1	0	75	0	78	3
Kinosternon subrubrum hippocrepis	5	0	0	0	0	518	0	523	2
Pseudemys concinna concinna	0	0	0	0	0	72	0	72	1
Sternotherus odoratus	2	0	0	0	0	269	0	271	2
Terrapene carolina triunguis[e]	28	1	0	0	0	0	0	29	2
Trachemys scripta elegans	8	0	1	0	0	812	0	821	3
Total number of encounters									
Anura[a]	many	2	2607	1092	101	391	many	>4194	7
Caudata[b]	>30	0	254	97	8	22	0	>411	5
Squamata (Lacertilia)	560	72	104	111	9	0	0	856	5
Squamata (Serpentes)	229	19	16	101	12	99	0	476	6
Testudines	47	1	1	1	0	1764	0	1814	5
All species[a,b]	>867	94	2982	1402	130	2276	many	>7751	7

[a]Because of the frequency with which most anuran species were encountered and detected on the ARS, exact counts were not recorded for incidental encounters or ARS recordings. This is reflected by a > sign in the sum column and rows.

[b]Twelve efts were found under logs, but many larvae were found in a drying pool. This is reflected by a > sign in the sum column and row.

[c]Occasionally, skinks escaped before they could be identified to species

[d]The eastern yellow-bellied subspecies (*C. c. flaviventris*), southern black subspecies (*C. c. priapus), and possible hybrids were found*

[e]One of these was a hybrid between *T. c. triunguis* and *T. ornata*

Table 3. Water quality measurements from Boehler Lake and Hassell Lake

Date	Lake	DO	pH	NH_3	NH_4	NO_3	PO_4
28 May 2012	Boehler	7	5.1	1.68	1.82	<1.1	0.26
28 May 2012	Hassell	7	6.1	2.04	2.21	<1.1	0.13
7 July 2012	Boehler	5	-	2.16	2.34	<1.1	-
7 July 2012	Hassell	6	-	1.92	2.08	<1.1	0.15

Table 4. Dates, sizes, and locations of the southern crawfish frogs (*Lithobates areolatus areolatus*) that were captured (see Fig. 1 for fence locations).

Date of Capture	Snout-vent length (mm)	Mass (g)	Sex	Location description
3 March 2012	68	41	Male	Cattle pond across road
10 June 2012	27	2.5	Juvenile	Drift fence #1
12 June 2012	31	-	Juvenile	Drift fence #1
2 July 2012	31.5	2.25	Juvenile	Drift fence #1
2 July 2012	31.5	2.75	Juvenile	Drift fence #1
8 July 2012	34	2.75	Juvenile	Drift fence #2
9 August 2012	37	3.5	Juvenile	Drift fence #2

Table 5. Sizes and locations of all the western chicken turtles (*Deirochelys reticularia miaria*) that were captured in 2012 and 2013.

ID	Carapace Length (mm)	Plastron Length (mm)	Mass (g)	Sex	Location
none	103	94	-	-	Dead on road
53	35	32	7.75	Juvenile	Boehler Lake
57	120	110.5	270	-	Boehler Lake
2	135	119	375	-	Boehler Lake
3	149	133	510	-	Boehler Lake
6	153	134	500	-	Boehler Lake
39	160.5	144.5	625	-	Boehler Lake
8	161	139.5	720	-	Boehler Lake
1	166	142.5	640	-	Boehler Lake
7	207	181	1325	Female	Boehler Lake[a]
52	139	125	405	-	BP4
51	143	122	380	-	BP4
50	152	134	520	-	BP4[b]
49	105	92.5	150	-	BP5
36	115	105	240	-	BP5
17	117	102.5	210	-	BP5
40	120	102	210	-	BP5
44	122	110	270	-	BP5
24	124	118	290	-	BP5
29	138	122	375	-	BP5
26	140	124	410	-	BP5
43	140.5	127	430	-	BP5
37	142	122	405	-	BP5
45	142	124	410	-	BP5
25	143	124	420	-	BP5
32	144	126	430	-	BP5
30	146	125	470	-	BP5
31	146	127	460	-	BP5
34	146	125	460	-	BP5
20	150.5	131	460	-	BP5
22	154	138	540	-	BP5
38	155	134	540	-	BP5
48	162	137	620	-	BP5
27	165	136	615	Male	BP5
41	166	142	680	-	BP5
33	169	144	735	Male	BP5
46	170	147	670	-	BP5
18	171	148	670	-	BP5
28	189	168	1000	Female	BP5
47	208	181	1250	Female	BP5

19	217	186	1500	Female	BP5[c]
42	220	195	1600	Female	BP5
54	74	68	68	Juvenile	Drift fence #5[d]
10	67	62	59	Juvenile	Hassell Lake
13	72	67	71	Juvenile	Hassell Lake
12	84	75.5	100	Juvenile	Hassell Lake
9	130	120	355	-	Hassell Lake
16	144	129	510	-	Hassell Lake
14	157	137	515	-	Hassell Lake
11	170	142	675	-	Hassell Lake
15	188	169	1025	Female	Hassell Lake
21	194	171.5	1175	Female	Hassell Lake[e]
56	61	54	40	Juvenile	Crossing road
58	110	94	190	-	P1
55	150	130	490	-	P1
23	153.5	133	530	-	P1[e]

[a]Originally captured crossing the road from Boehler Lake to Hassell Lake. It never actually entered Hassell and returned to Boehler in a few days.
[b]Originally captured and PIT tagged at Boehler Seeps and Sandhills Preserve in 2008. Was recaptured in BP4 in 2013, and eventually left the property and moved further east.
[c]Captured in BP5 in March 2013, and in April it was found 0.3 km north east in a tiny pool.
[d]Captured in drift fence 5, then moved across the road into cattle pond 1.
[e]Captured in Hassell Lake then moved to cattle pond two for several days before returning to Hassell..
[f]Captured in BP5 in April 2013 and was recaptured in P1 in June 2013.

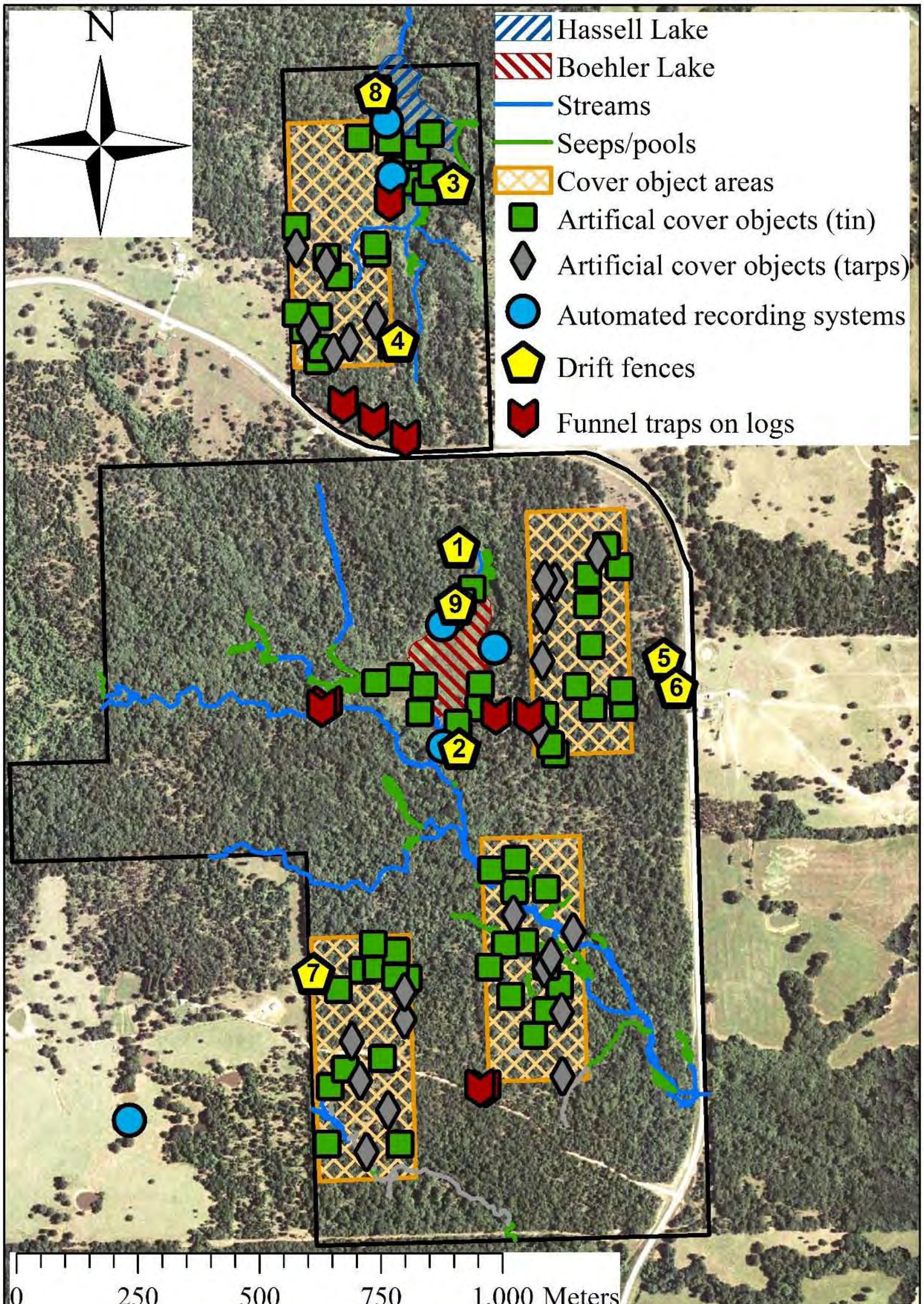

Figure 1. A map of Boehler Seeps and Sandhills Preserve showing the locations where each of our survey methods were employed. Drift fence numbers correspond to the fence descriptions in Table 1.

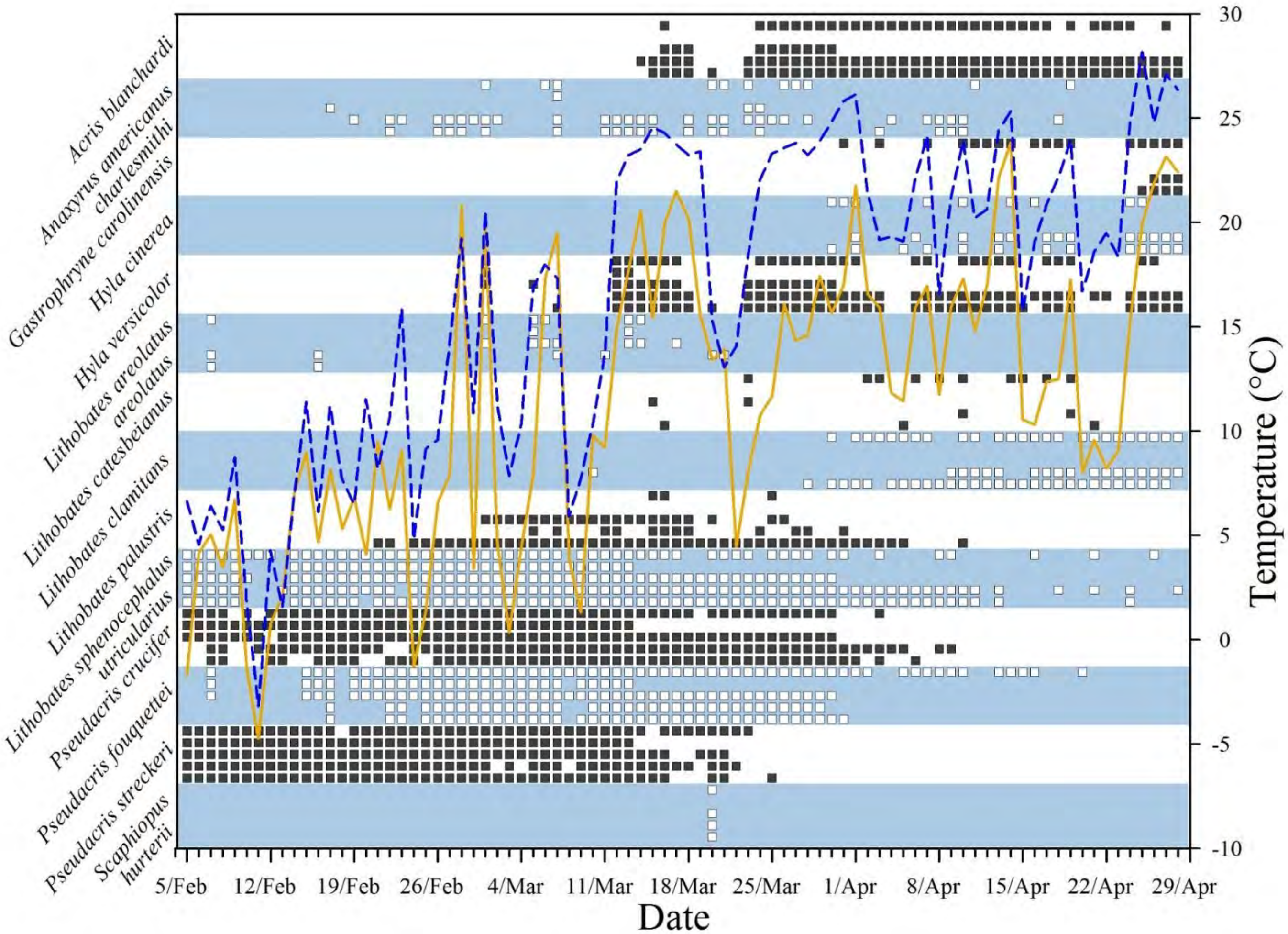

Figure 2. Results of the automated recording units (ARS). Each alternating white and light-blue band contains data for a single species. Within each band, the topmost row is ARS #2, the second row is ARS #3, the third row is ARS #4, the fourth row is ARS #5, and the fifth row is ARS #6. ARS #2–4 were positioned near Boehler Lake. ARS #5 and #6 were near Hassel Lake. Squares indicate nights when a species was detected on any of the three recordings taken by a single ARS. The dashed blue line is the mean air temperature for both lakes at 1900, and the solid yellow line is the mean air temperature for both lakes at 0000. Data collected from the additional recordings that were analyzed when listening for southern crawfish frogs (*Lithobates areolatus areolatus*) are not included.

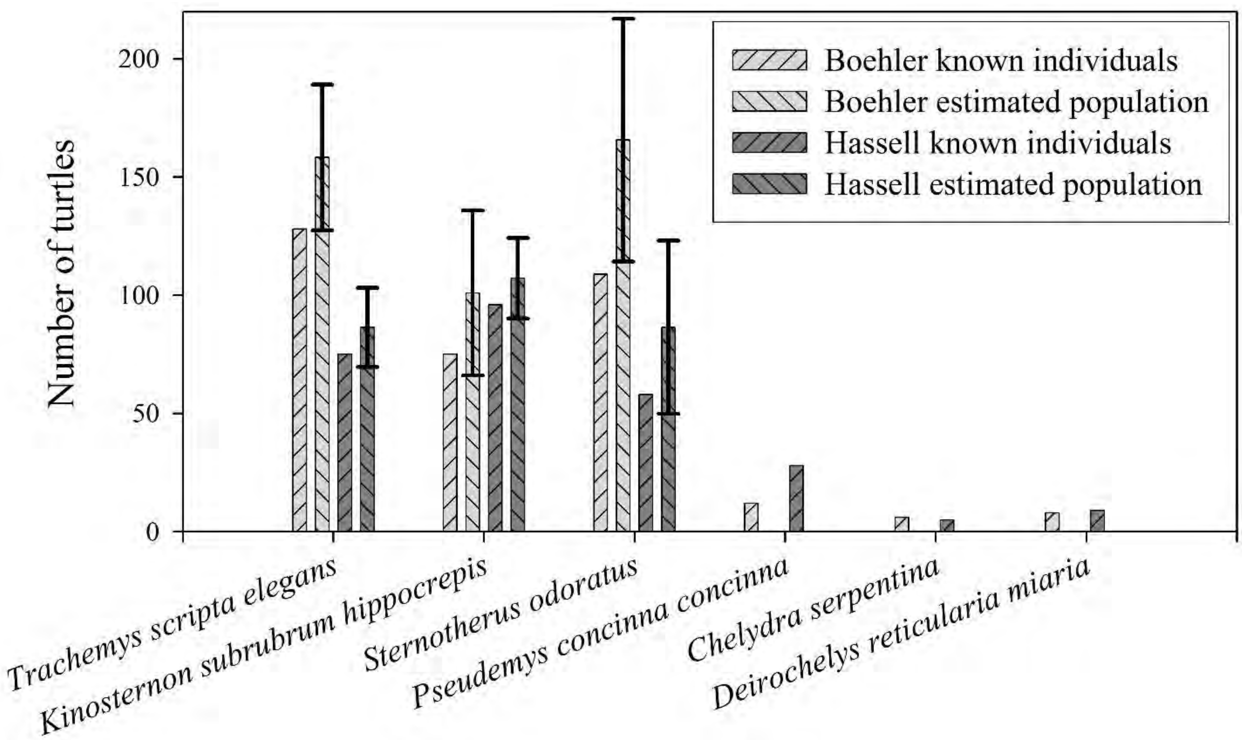

Figure 3. Known and estimated numbers of each turtle species in each lake. Population estimates were not possible for *P. c. conncina*, *C. serpetina*, and *D. r. miaria*. Error bars show the confidence intervals for population estimates. The Chapman (1951) modification of the Petersen (1896) method was used to calculate population sizes, and the normal approximation method was used to calculate the confidence intervals.

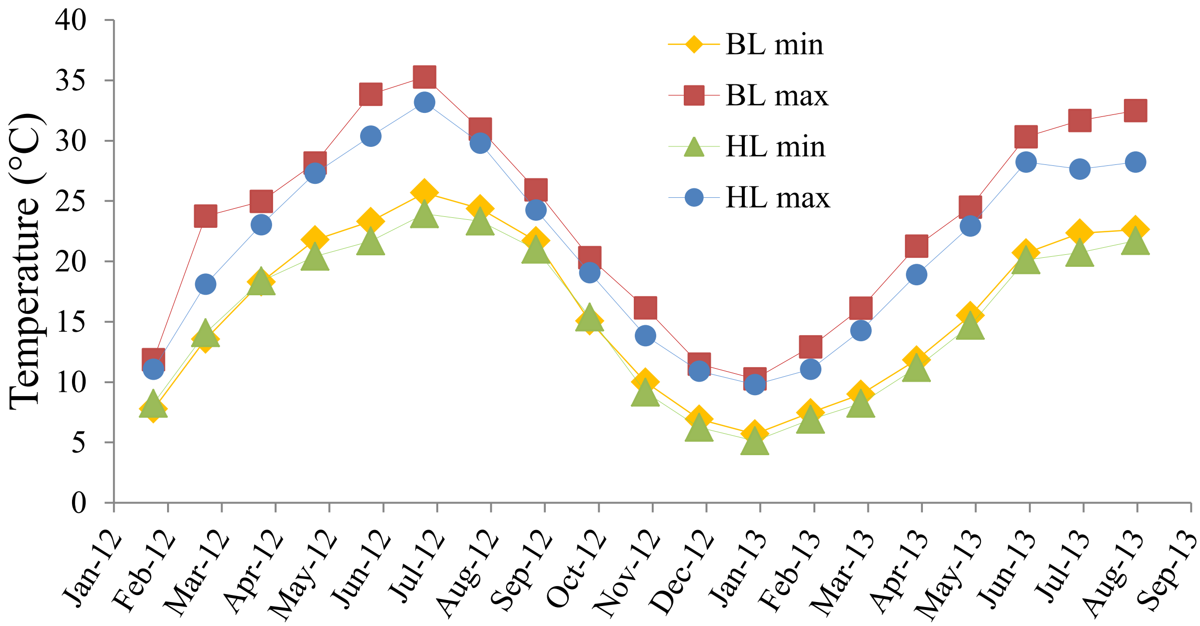

Figure 4. Mean daily maximum (max) and minimum (min) temperatures for Boehler Lake (BL) and Hassell Lake (HL) for each month that data is available.

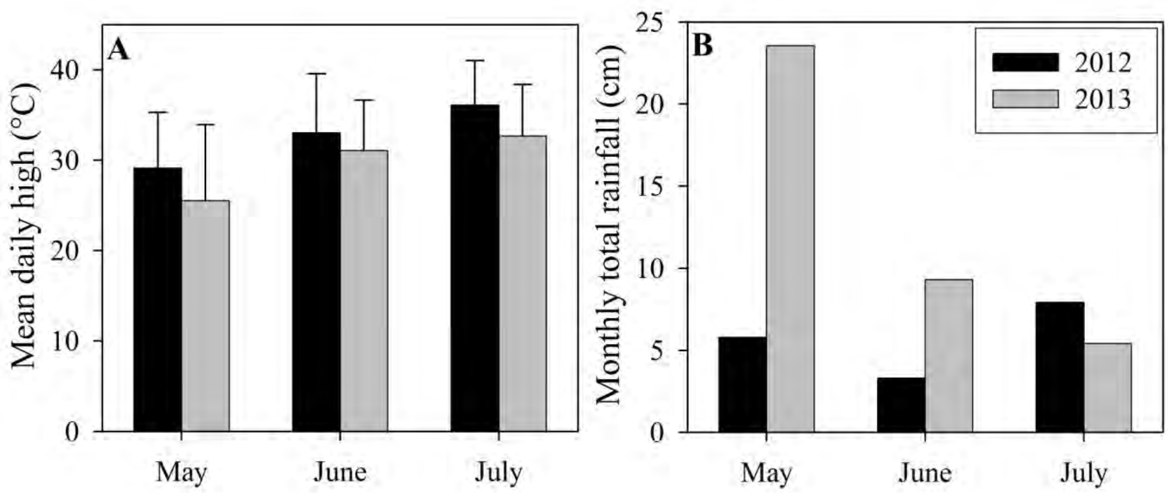

Figure 5. Weather data obtained from a station roughly 17.5 km from the study site (Oklahoma Mesonet). (A) Mean daily high temperatures for 2012 and 2013. Error bars represent one standard deviation. (B) Total monthly rainfall for 2012 and 2013.

Figure 6. (A) A secondary dam built by TNC below both the current Boehler Lake dam and the original dam (4 February 2012). (B) A breach in the dam following a large storm (taken on 20 March 2012, the day after the breach).

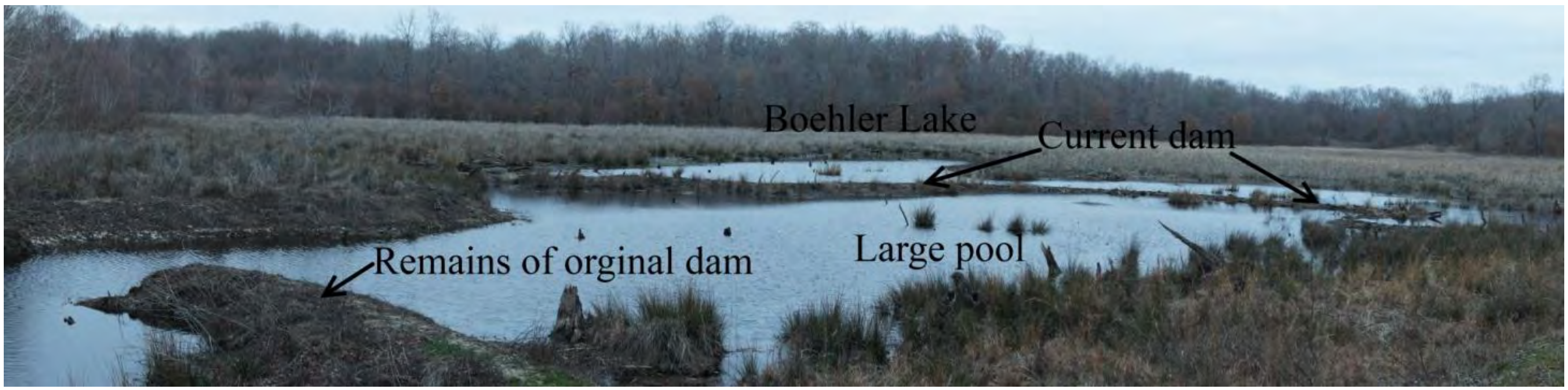

Figure 7. A large pool formed by a secondary dam built by TNC below Boehler Lake (4 February 2012).

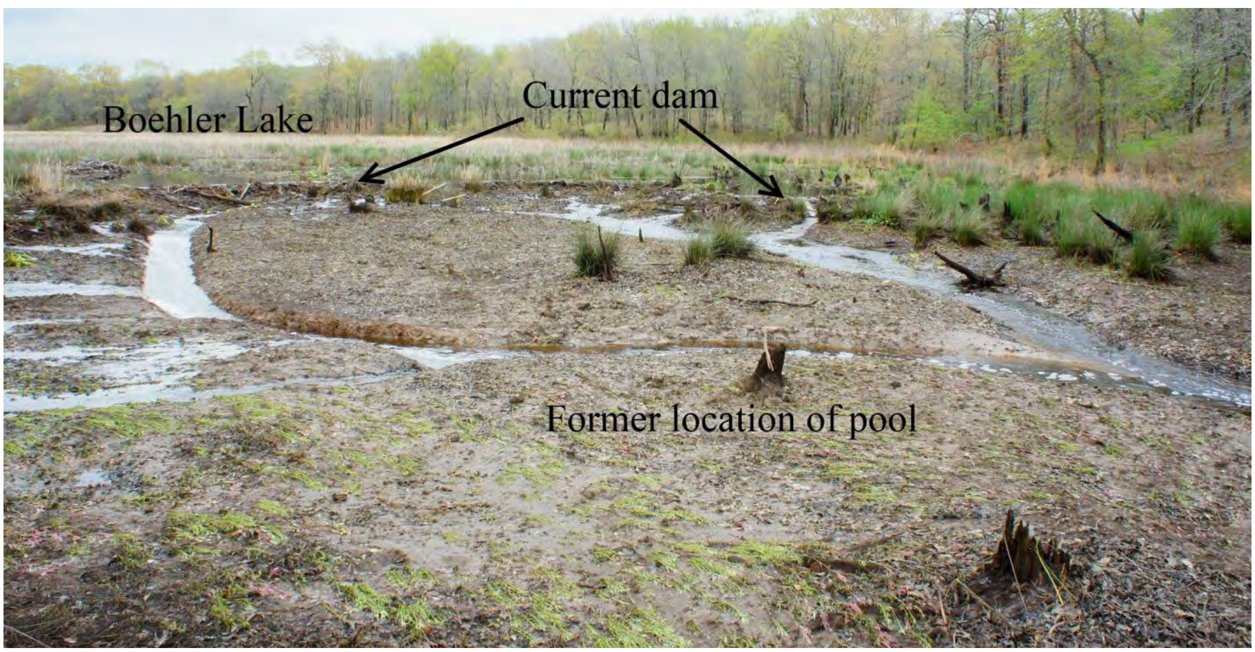

Figure 8. The reamins of a pool that drained when the lower dam at Boehler Lake was breached (taken on 20 March 2012, the day after the breach).

Figure 9. The lower dam reconstructed by the beavers on Boehler Lake (11 May 2013).

Figure 10. (A) A previous partial repair of the original dam at Boehler Lake (11 May 2013). (B) The original dam following a storm (taken on 23 May 2013, the day after the breach). The storm cut out the bank around the dam.

Figure 11. A large pool formed by beavers partially repairing the lower dam and the original dam (11 May 2013).

Figure 12. The original Boehler Lake dam (11 November 2013).

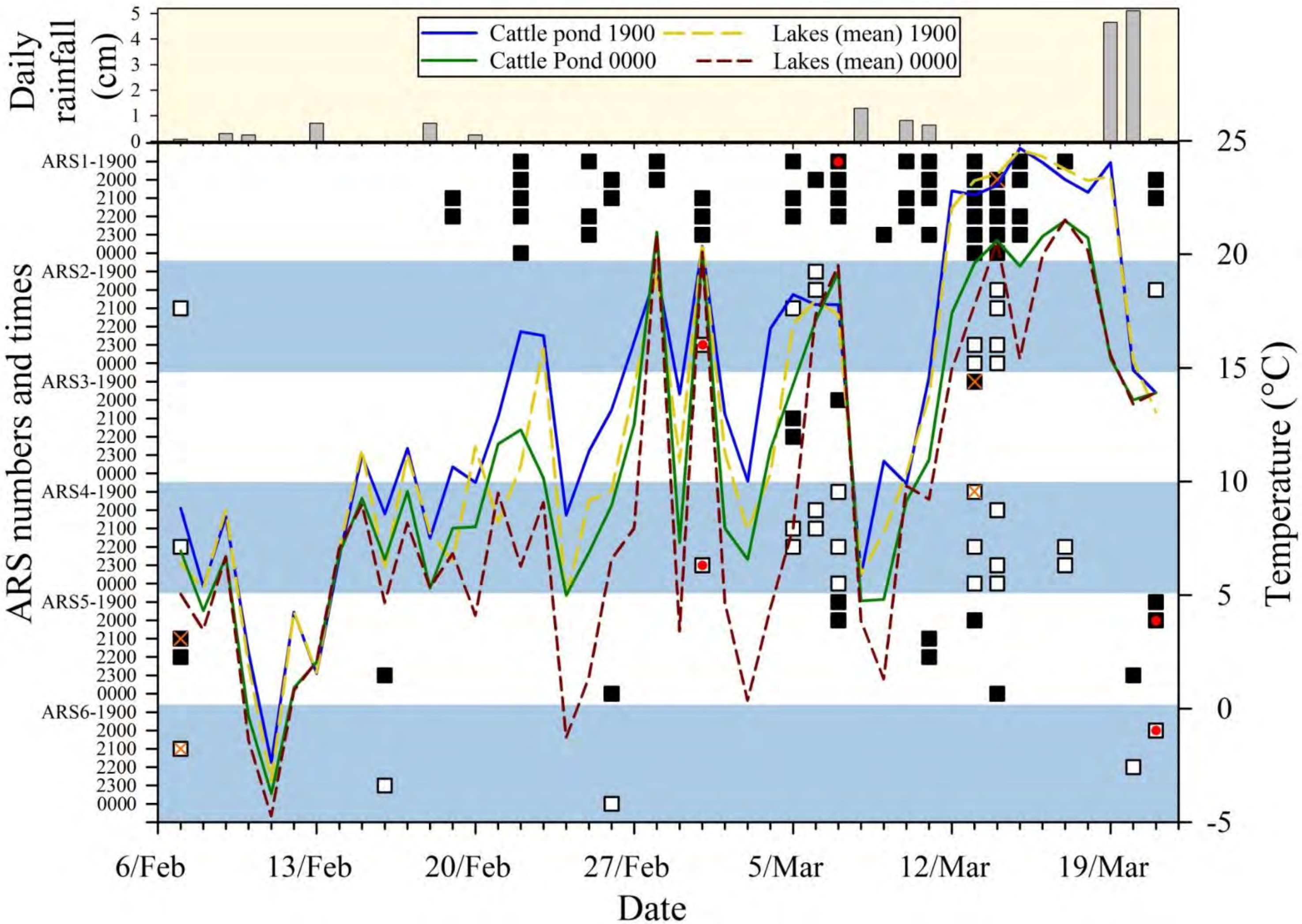

Figure 14. Results of the anuran calling survey for southern crawfish frogs (*Lithobates areolatus areolatus*). Air emperature data were averaged for Boehler Lake and Hassel Lake (there was little variation between them). There was no rainfall in the days preceding the interval displayed. Red dots indicate the recording with the greatest activity for that body of water, and orange × symbols identify the recordings with the second greatest activity for that body of water.

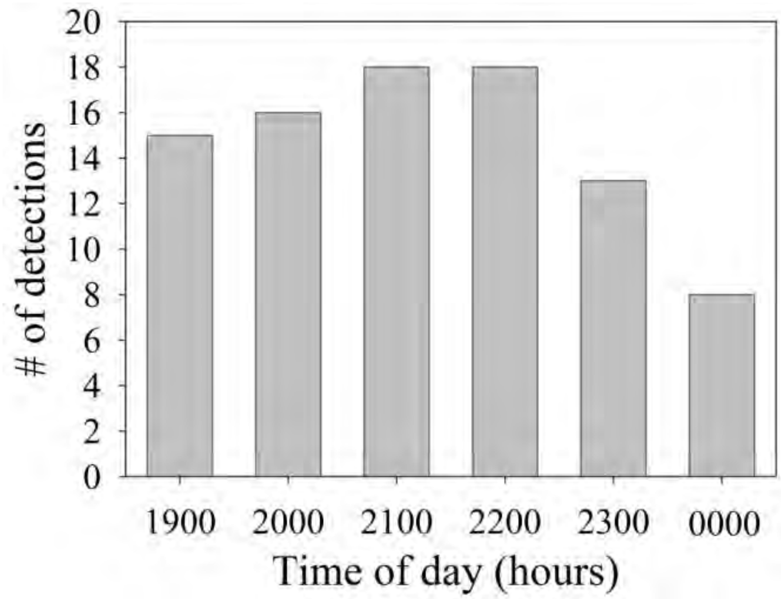

Figure 15. The number of recordings that detected southern crawfish frogs (*Lithobates areolatus areolatus*) at each of the sampled time periods. Data from all automated recording systems were combined, but if *L. a. areolatus* was heard on multiple simultaneous recordings at a given body of water they were scored as a single detection.

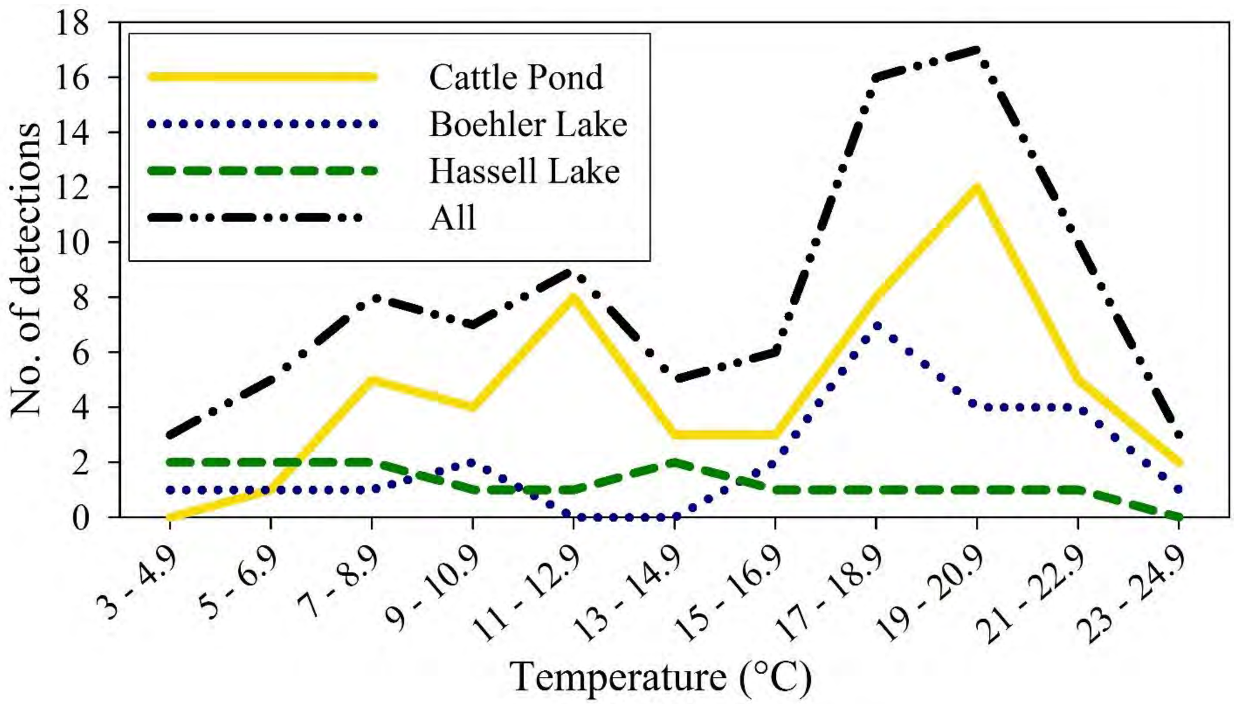

Figure 16. The number of detections of southern crawfish frogs (*Lithobates areolatus areolatus*) at each temperature. *Lithobates a. areolatus* that were heard on multiple simultaneous recordings at a given body of water were scored as a single detection.

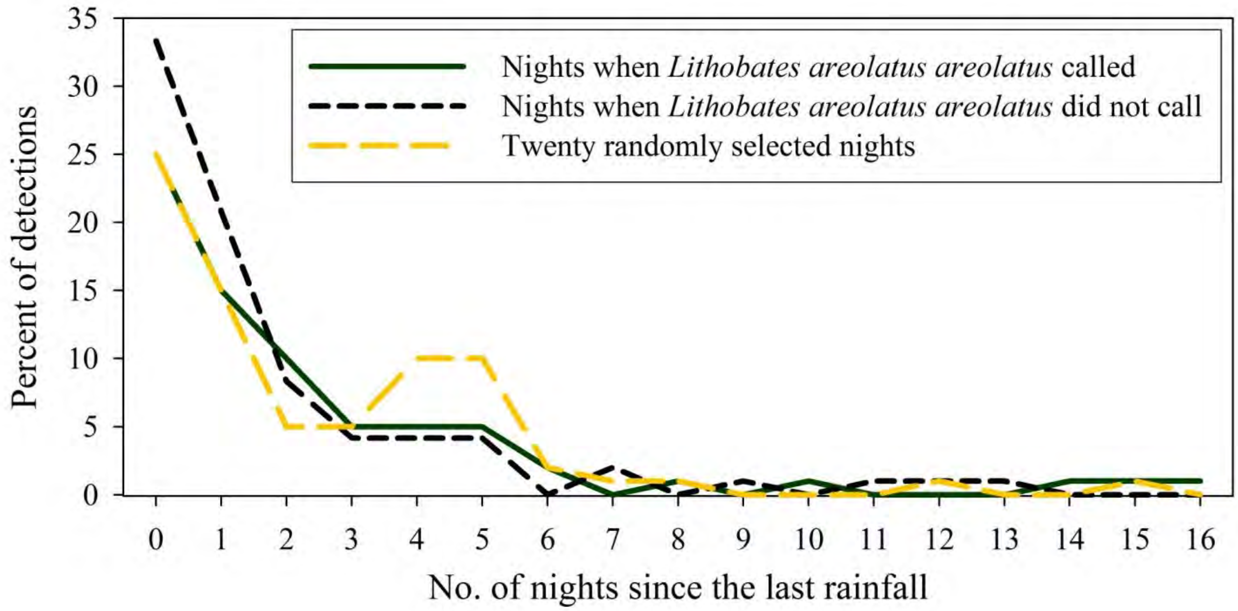

Figure 17. The number of days since the last rainfall event for nights when southern crawfish frogs (*Lithobates areolatus areolatus*) called, nights when they did not call, and 20 randomly selected nights. Results are displayed as percentages of all nights in a given category.

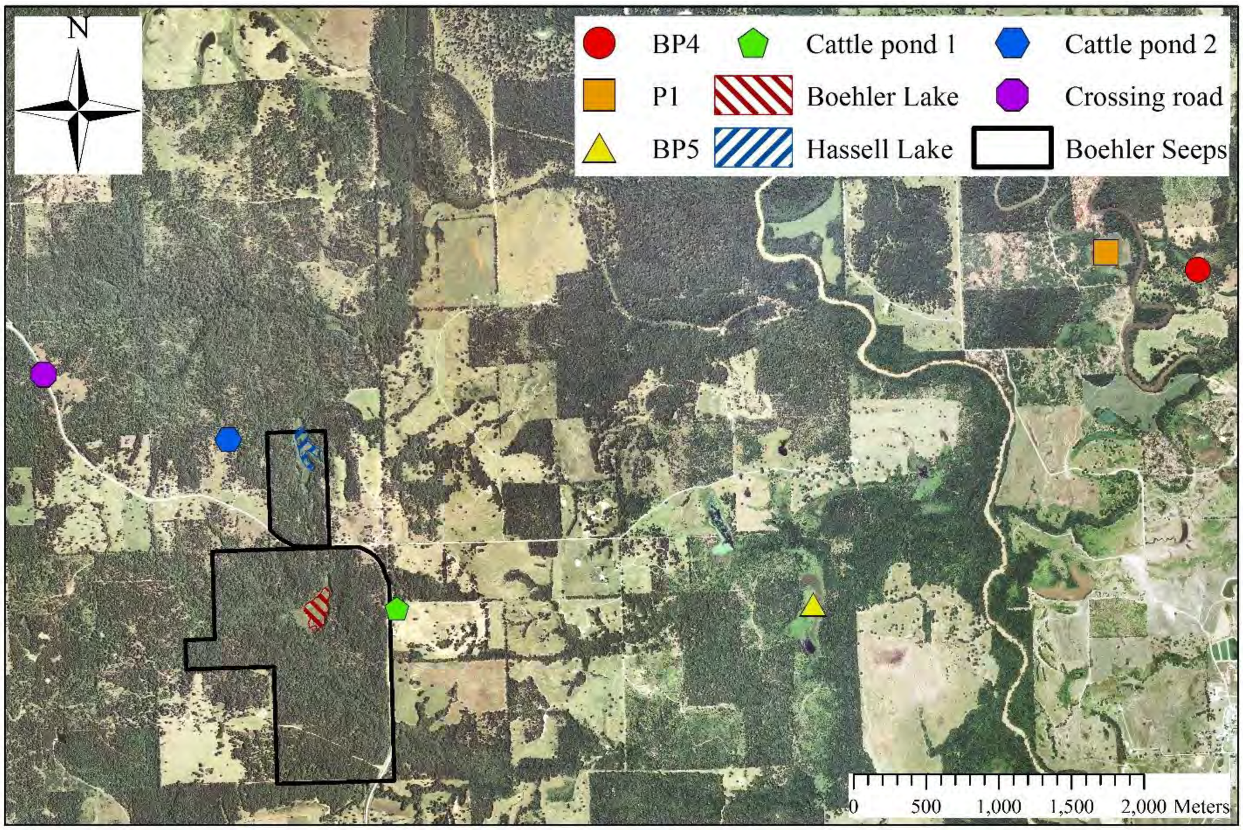

Figure 18. A map of the locations where western chicken turtles (*Deirochelys reticularia miaria*) were captured. No turtles were trapped at either of the cattle ponds, but transmitter turtles were tracked to them.

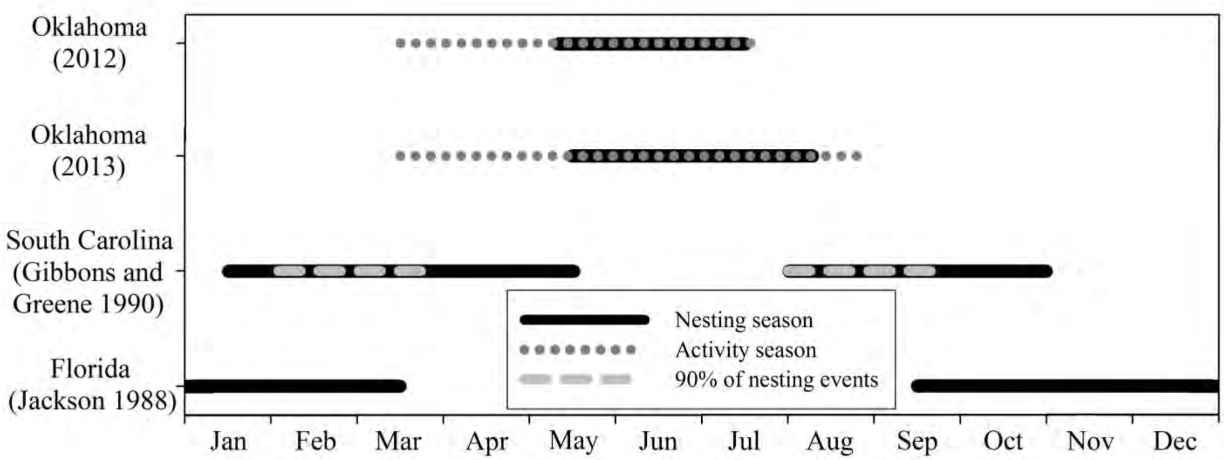

Figure 19. The nesting seasons of chicken turtles (*Deirochelys reticularia*) in South Carolina (*D. r. reticularia*), Florida (hybrid zone of *D. r. reticularia* and *D. r. chrysea*), and Oklahoma (*D. r. miaria*).

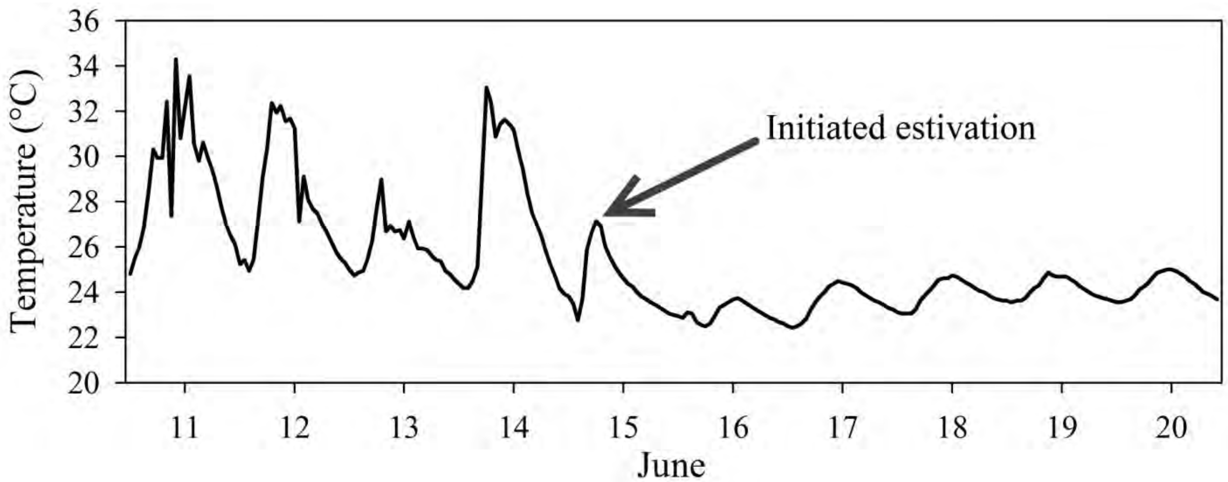

Figure 20. The thermal profile of a western chicken turtle (*Deirochelys reticularia miaria*) before and at the start of its estivation period. It was active until 15 June, at which point it left the water and began estivating on land.

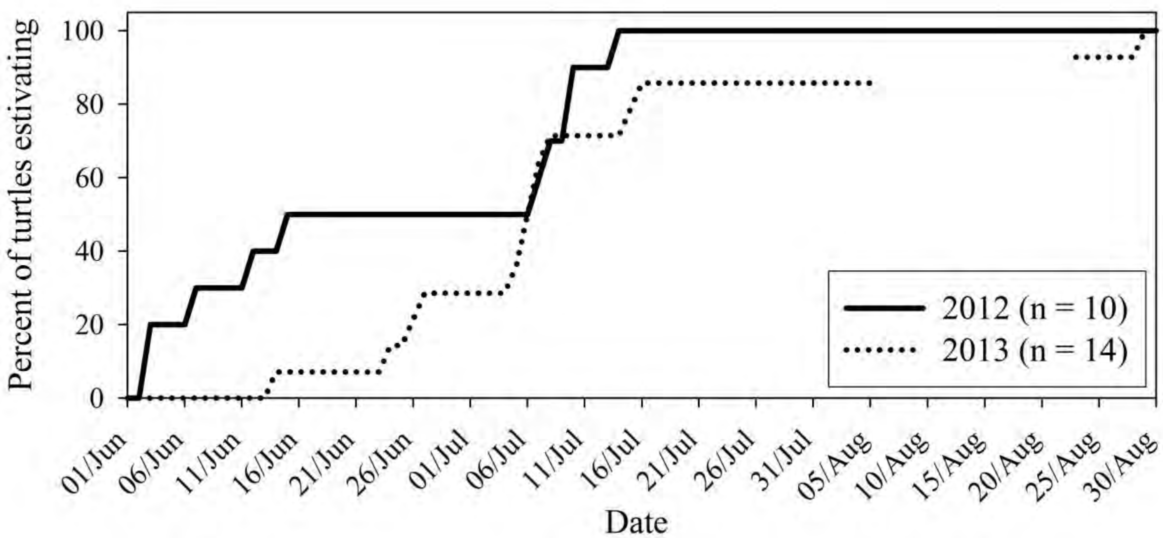

Figure 21. Percent of transmittered turtles that were estivating on a given date. One individual in 2013 began estivating between 4–23 August, but the exact date is not known. This is reflected by a gap in the line for 2013.

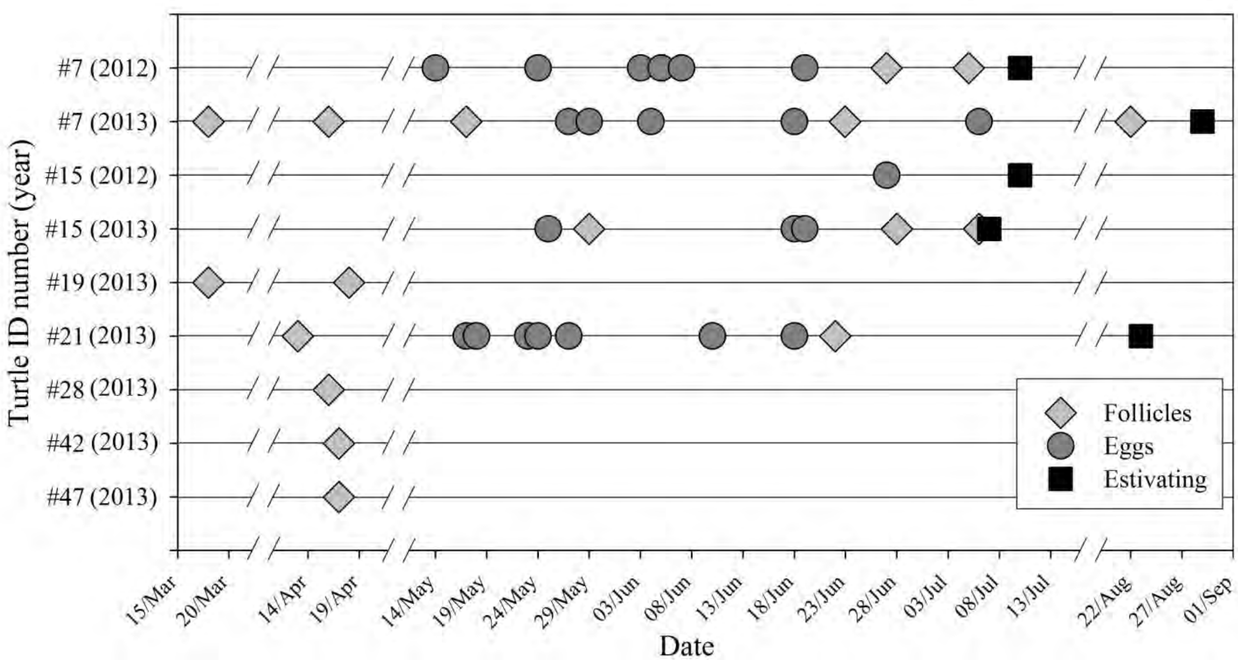

Figure 22. Results from sonogramming female western chicken turtles (*Deirochelys reticularia miaria*). Each row represents one year of data for an individual female. Turtles #19, 28, 42, and 47 were on private property, and we were not permitted to return after April.