of an animal may have a different effect, as it could interfere with water absorption or respiration. Future study could use a respirometer to measure differences in oxygen consumption (e.g., Orlofske et al. 2009). Documenting rates of water loss and gain would also be of interest. We did not have the opportunity to follow animals in the field to examine how long the oil/powder mixture would remain on the animal. Given that much of the mixture had worn off the salamanders during the 12-hour period when they were enclosed in a resealable bag, we expect that in the field the mixture would not persist more than 24 h.

Although tracks left by amphibians will certainly differ from those left by carrots, we used this technique to assess track length under controlled field conditions. We were not yet ready to apply the oil to wild salamanders as the effect of leaving the mixture on for longer periods of time was still unknown. We found that using the oil-powder mixture allows us to follow tracks for almost three times the distance of plain powder tracks when tracks were exposed to rain. We believe this technique has enough value to warrant further study. Fluorescent tracking can be used in concert with other tracking methods and will allow scientists to collect more detailed movement data on target species.

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Literature Cited

Birchfield, G. L., and J. E. Deters. 2005. Movement paths of displaced northern green frogs (*Rana clamitans melanota*). Southeast. Nat. 4:63–76.

Charney, N. D., B. H. Letcher, A. Haro, and P. S. Warren. 2009. Terrestrial passive integrated transponder antennae for tracking small animal movements. J. Wildl. Manage. 73:1245–1250.

Connette, G. M., and R. D. Semlitsch. 2012. Successful use of a passive integrated transponder (PIT) system for below-ground detection of plethodontid salamanders. Wildlife Res. 39:1–6.

Dodd, C. K. 1992. Fluorescent powder is only partially successful in tracking movements of the six-lined racerunner (*Cnemidophorus sexlineatus*). Florida Field Nat. 20:8–14.

Eggert, C. 2002. Use of fluorescent pigments and implantable transmitters to track a fossorial toad (*Pelobates fuscus*). Herpetol. J. 12:69–74.

Furman, B. L. S., B. R. Scheffers, and C. A. Paszkowski. 2011. The use of fluorescent powdered pigments as a tracking technique for snakes. Herpetol. Conserv. Biol. 6:473–478.

Graeter, G. J., and B. B. Rothermel. 2007. The effectiveness of fluorescent powdered pigments as a tracking technique for amphibians. Herpetol. Rev. 38:162–166.

Hamed, M. K., D. P. Ledford, and T. F. Laughlin. 2008. Monitoring nonbreeding habitat activity by subterranean detection of ambystomatid salamanders with implanted passive integrated transponder (PIT) tags and a radio frequency identification (RFID) antenna system. Herpetol. Rev. 39:303–106.

Orlofske, S. A., K. L. Grayson, and W. A. Hopkins. 2009. The effects of fluorescent tracking powder on oxygen consumption in salamanders using either cutaneous or bimodal respiration. Copeia 2009:623–627.

Popescu, V. D., and M. L. Hunter, Jr. 2011. Clear-cutting affects habitat connectivity for a forest amphibian by decreasing permeability to juvenile movements. Ecol. Appl. 21:1283–1295.

Rittenhouse, T. A. G., T. T. Altnether, and R. D. Semlitsch. 2006. Fluorescent powder pigments as a harmless tracking method for ambystomatids and ranids. Herpetol. Rev. 37:188–191.

Roe, A., and K. Grayson. 2009. Repeated exposure to fluorescent powder does not affect survival or mass in eastern red-spotted newts, *Notophthalmus viridescens*. Appl. Herpetol. 6:295–299.

Stapp, P., J. K. Young, S. VandeWoude, and B. van Horne. 1994. An evaluation of the pathological effects of fluorescent powder on deer mice (*Peromyscus maniculatus*). J. Mammal. 75:704–709.

Stark, R. C., S. F. Fox, and D. M. Leslie, Jr. 2005. Male Texas horned lizards increase daily movements and area covered in spring: a mate searching strategy? J. Herpetol. 39:169–173.

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Use of Stationary Microchip Reader for Monitoring Interpond Movement of Freshwater Turtles

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Studying overland movement patterns of freshwater turtles is critical to understanding population dynamics and establishing buffer zones for species protection (Bodie 2001; Burke and Gibbons 1995; Semlitsch and Bodie 2003). Numerous methods have been applied to investigate different aspects of the movement patterns for freshwater turtles (McDiarmid et al. 2011) such as pitfall traps (e.g., Gibbons 1990; Roe et al. 2009), radio telemetry (e.g., Forsythe et al. 2004; Litzgus et al. 2004), and traditional aquatic trapping methods (e.g., crab pots and hoop nets; House et al. 2010; Roe and Georges 2008; Thomas and Parker 2000). Terrestrial and aquatic traps are associated with capture-mark-recapture techniques that rely on the ability to recapture marked turtles. Trapping is usually seasonal or done at intervals, but rarely conducted continuously, or if so not on a long-term basis (e.g., every day of the year during multiple years). Traps are usually checked daily, but the information on specific times of the day that turtles are likely to be active is lacking. In addition, captured individuals remain in traps until the traps are checked, preventing movement or dispersal data aside from differing points of recapture. Radio telemetry can give more precise data on the overland activity and correlate such activity to environmental factors (Roe and Georges 2008). However, the radio tracking period affects such models (Roe and Georges 2008) and high-resolution monitoring of overland activity using radio telemetry would require locating turtles several times/day for extended periods of time.

Passive integrated transponders (PIT) have usually been associated with capture-mark-recapture techniques. However, the technology has evolved to afford identification with stationary readers, reducing the labor to only capture-mark because animals do not have to be physically recaptured, they need only to pass through the stationary reading system. The system has been applied to monitoring the use of drain culverts by desert tortoises (Boarman et al. 1998), monitoring fish through small stream passages (Zydlewski et al. 2007), and monitoring bat movements (Ellison et al. 2007). The purpose of the present study was to test the utility of the stationary PIT tag reader for recording the overland activity of freshwater turtles. We introduce PIT tags and non-invasive stationary reader system for monitoring interpond movement of freshwater turtles, including the addition of camera traps for assisting in determining the direction of the movement alongside detection of individuals. We sought to create a less labor intensive and simultaneously less invasive approach to studying overland activity of freshwater turtles.

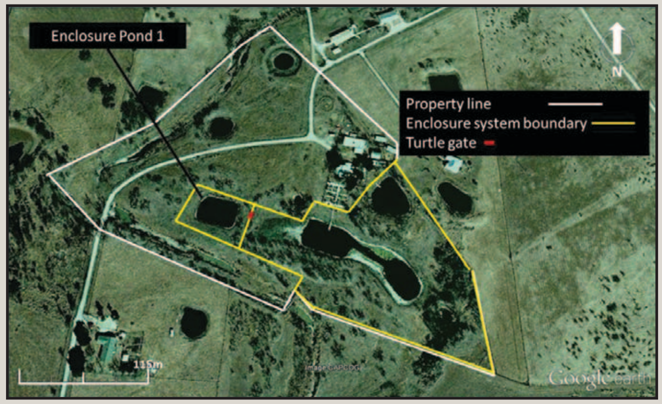

Fig. 1. Aerial image of the study area used to monitor the interpond movement of freshwater turtles. The image shows the enclosure system boundary (primary system) that includes 4 ponds that are completely fenced off with a 2 cm × 4 cm horse fence panels to restrict global overland movement of turtles in and out of the system. In addition, Enclosure Pond 1 was fenced off from the remaining ponds, with a single opening allowing movement (turtle gate).

Fig. 2. Stationary reader system placed at the only opening (turtle gate) of otherwise enclosed area (Enclosure Pond 1). While the reader scanned PIT-tagged turtles that pass through the gate, the game camera recorded the images and the direction of the movement.

Materials and Methods.—For the stationary PIT tag reading system, we used Biomark© Portable Transceiver System, model FS2001F-ISO, that has the ability to store scanned tag codes. This model is not traditionally used as a stationary system; therefore, we purchased the Elpac AC power supply to provide continuous power to the reader. We used the Biomark© OEM Racket Antenna with Line-X coating for durable protection and a 2-m antenna cable. To mark turtles, we used 12-mm AVID© PIT tags. Although the tags and the reader were produced by two different manufacturers, the tags were not encrypted by the producer and the reader was able to recognize the codes. In addition, we used a RECONYX© game camera in order to get images of the turtles as they were passing through the system.

This study was conducted in a complex of ponds within a 7-ha private property parcel in Guadalupe County, Texas (Fig. 1). The primary system includes four ponds that are completely fenced off with a 2 cm × 4 cm horse fence panels that enabled us to restrict global overland movement of adult turtles in and out of the system by opening or closing a series of gates. This primary system is surrounded by a third-order ephemeral stream and three additional ponds. In our initial test of the enclosure system, one pond (Enclosure Pond 1; Fig. 1) was fenced off from the remaining ponds using 152-cm vertical horse panels with 5 cm × 10 cm openings. The Enclosure Pond 1 was pumped dry in the spring of 2009 in order to allow complete removal of turtles to enable this investigation. After the turtles were removed, the pond was visited for an additional week. To ensure there were no turtles left, we searched for tracks exiting the pond or the mud and conducted hand searches of the mud itself. The pond was then refilled and a single unmarked turtle (juvenile male *Trachemys scripta*) was released into the pond. For the months following, no other turtles were observed in the system, but the introduced male was routinely observed basking or at the pond's surface confirming that the pond perimeter fencing was "turtle-proof." In addition, we regularly inspected the fence to ensure its integrity. Then a single 0.36 m × 0.2 m "turtle gate" was created, enabling interpond turtle movement. In this gate opening we placed the reader antenna just subsurface within the gate. We placed the rest of the reader in a dry box on the shelf built next to the gate to enable long-term protection (Fig. 2). The reader was connected to the power source located ~50 m from the gate using an outdoor run of 120V A/C. We mounted the game camera 1 m vertically above the gate opening and parallel to the ground.

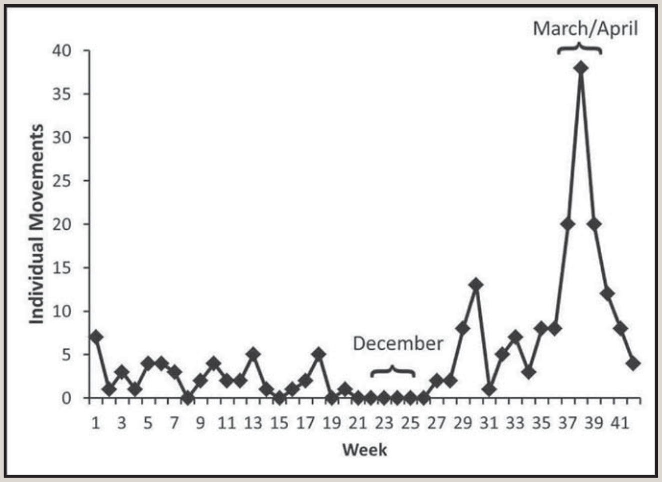

Fig. 3. Number of individual movements recorded by the stationary chip reader sorted by the week since opening the turtle gate in July 2011. The movement activity was seasonal, with very few movements in the winter and the highest activity in spring.

Fig. 4. Red- eared Slider (*Trachemys scripta elegans*) passing through the turtle gate. The image was captured with a RECONYX© game camera that was mounted 1 m vertically above the gate opening.

In the spring of 2011, we captured turtles from the primary and secondary pond systems using baited hoop nets and used the captures to populate Enclosure Pond 1. We PIT tagged captured turtles by injecting the chips into the body cavity in the anterior inguinal region parallel to the spine (Buhlmann and Tuberville 1998). We tagged two Texas Spiny Softshells (*Apalone spinifera emoryi*), four Texas River Cooters (*Pseudemys texana*), and 57 Red-eared Sliders (*Trachemys scripta elegans*). The turtle gate was kept closed for a period of one month after the "stocking" event in an effort to prevent disturbance-related dispersal and then opened in July 2011. This initial test of the system then continued to March of 2012 (9 months).

Results.—The reader proved to be a reliable method for recording the passage of turtles through the gate. For example, within the first 9 months, 46 PIT-tagged turtles (73% of all chipped turtles) passed through the gate and were recorded by the reader on 105 different occasions. Movement did not appear to be sex biased: 23 females, 22 males, and one juvenile were recorded. The number of individuals' movements varied from 1–12. Twenty-eight turtles moved on only one occasion while 18 moved more than once. Six individuals moved in and out of the system on several occasions during a single day (range = 2–4, mean = 2.3). Preliminary results revealed predictable seasonal activity in winter, with 0–1 movement events per week, and highest activity in the spring, with up to 37 passages per week (Fig. 3). All turtles were active during the day, with no nocturnal activities recorded. Out of 105 movement occasions, 42 were recorded in the morning (0630 to 1200 h DST) and 63 in the afternoon (1200 to 2030 h DST). Based on the original placement of tagged turtles (Enclosure Pond 1), we could speculate on the direction of the movement. However, because the reader was set to continuously record the tags, the data often consisted of numerous readings of the same tag within a short period of time (several minutes), which created some level of uncertainty of the final direction of the movement using the reader alone. However, the combination of the chip reader and the camera recording the time enabled us to validate the direction of the movement of each tagged turtle using the camera images (Fig. 4). The camera recorded 31 additional images of untagged turtles.

Discussion.—We demonstrated that it is simple and useful to convert a portable Biomark© chip reader system into a stationary PIT tag reader system enabling us to monitor freshwater turtle interpond movement. This technique requires initial trapping and PIT tagging individual turtles, however it is a subsequently noninvasive way to study fine-scale movement patterns. It is less labor intensive than either consistent trapping or long-term radio telemetry, and if the equipment is properly maintained, the system can run for extended periods of time (several years). Although the reader did not record the exact times turtles exited the water bodies but rather the times of the passage through the gate, this method is likely to be a suitable way to link weather conditions and periods of the day to the turtle movement patterns.

Our study was conducted on a private property with a nearby access to an electric power source. One way to improve this system would be to use solar energy as a source of power, especially for monitoring projects in more remote areas. We constructed only one reader station and used a relatively small enclosed area for proof of concept testing. Our study potentially underestimated the magnitude of movement, due to the possibility that some individuals did not walk along the fence but rather returned to the water. We believe that such occurrence was minimal, due to the small scale of the experiment (e.g., small fence perimeter) and the fence was simply serving the role of the aluminum flashing in commonly used drift fences (Gibbons 1990). This system was designed to be expanded using additional gates that open the primary system to the secondary system and allow the movement between the ephemeral creek and the additional ponds. On even larger landscape level, monitoring movement in this manner would be costly, because it would require enclosing larger sections and purchasing additional chip readers and PIT tags. However, high-resolution interpond movement dynamics of freshwater turtles on a larger landscape level are still poorly understood and expanding this approach to a larger scale could be useful in contributing to the understanding of these movement patterns.

For the resolution we sought on the dynamics of movement, other alternative methods are actually more expensive. For example, while radio telemetry would address these same questions, the labor costs and implementation necessity for shift work across 24-hr, everyday schedules is dramatically (and prohibitively) more costly. We evaluated alternatives to achieving the same level of data intensity prior to this installation. One way to reduce the cost for a larger-scale study would be to modify the way the area is enclosed. For example, Gibbons (1990) used aluminum flashing to enclose several miles of perimeter of experimental water bodies in order to study the interpond movement of slider turtles. Therefore, instead of using a costly fence system, one could use aluminum flashing that is commonly incorporated during the construction of drift fences, with pitfall buckets being replaced with reader systems. Unfortunately, this alternative has its own trade-offs. We consider flashing to be very disadvantageous in its relative instability to tree fall, livestock, and vehicular passage, all of which are overcome using fencing. Further, the urban wildland interface in many states provides an opportunity to create larger scale studies that follow our new approach with relatively minor changes to existing fencing systems (bottom integrity, gate installation, and readers). All methods seeking to document wild animal movements in real time have tradeoffs. We consider this new approach to minimize several negative aspects of radio telemetry costs and provide data at a finer resolution than can be achieved by other methods. Even in the study by Gibbons (1990), once trapped, the animals were contained until release, while in our system they are constrained in an exit point but not in movement beyond that single constraint. While this too is a tradeoff, we argue that it is a lesser one than daily point observations from telemetry or daily capture locations in a large field enclosure with pitfalls.

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Literature Cited

Boarman, W. I., M. L. Beigel, G. C. Goodlett, and M. Sazaki. 1998. A passive integrated transponder system for tracking animal movement. Wildl. Soc. Bull. 26:886–891.

Bodie, J. R. 2001. Stream and riparian management for freshwater turtles. J. Environ. Manage. 62:443–455.

Burke, V. J., and J. W. Gibbons. 1995. Terrestrial buffer zones and wetland conservation: a case study of freshwater turtles in a Carolina bay. Conserv. Biol. 9:1365–1369.

Buhlman, K. A., and T. D. Tuberville. 1998. Use of passive integrated transponder (PIT) tags for marking small freshwater turtles. Chelon. Conserv. Biol. 3:102–104.

Ellison, L. E., T. J. O'Shea, D. J. Neubaum, M. A. Neubaum, R. D. Pearce, and R. A. Bowen. 2007. A comparison of conventional capture versus PIT reader techniques for estimating survival and capture probabilities of big brown bats (*Eptesicus fuscus*). Acta Chiropterol. 9:149–160.

Forsythe, P., B. Flitz, and S. J. Mullin. 2004. Radio telemetry and post-emergent habitat selection of neonate box turtles (Emydidae: *Terrapene carolina*) in central Illinois. Herpetol. Rev. 35:333–335.

Gibbons, J. W. 1990. Life History and Ecology of the Slider Turtle. Smithsonian Institution Press, Washington, D.C. 368 pp.

House, W. J., I. M. Nall, and R. B. Thomas. 2010. Interpond movements of western painted turtles (*Chrysemys picta*) in east-central Kansas. Southwest. Nat. 55:403–410.

Litzgus, J. D., T. A. Mousseau, and M. J. Lannoo. 2004. Home range and seasonal activity of southern spotted turtles (*Clemmys guttata*): implications for management. Copeia 2004:804–817.

McDiarmid, R. W., M. S. Foster, C. Guyer, J. W. Gibbons, and N. Chernoff (eds.). 2011. Reptile Biodiversity: Standard Methods for Inventory and Monitoring. Univ. California Press, Berkeley and Los Angeles. 412 pp.

Roe, J. H., A. C. Brinton, and A. Georges. 2009. Temporal and spatial variation in landscape connectivity for a freshwater turtle in a temporarily dynamic wetland system. Ecol. Appl. 19:1288–1299.

———, and A. Georges. 2008. Terrestrial activity, movements and spatial ecology of an Australian freshwater turtle, *Chelodina longicollis*, in a temporally dynamic wetland system. Austral Ecol. 33:1045–1056.

Semlitsch, R. D., and J. R. Bodie. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. Conserv. Biol. 17:1219–1228.

Thomas, R. B., and W. S. Parker. 2000. Intrasexual variations in overland movements of slider turtles. Journal of Herpetology 34:469–472.

Zydlewski, B. G., G. Horton, T. Dubreuil, B. Letcher, S. Casey, and J. Zydlewski. 2006. Remote monitoring of fish in small streams: a unified approach using PIT tags. Fisheries 3:492–502.

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Use of Clove Oil as an Anesthetic for PIT Tagging and Surgery with the Three-toed Amphiuma (*Amphiuma tridactylum*) and Determination of Recovery Time as a Function of Body Mass

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Amphiuma tridactylum is a large (up to 1 m and 1.5 kg), slimy, aquatic salamander that can deliver a powerful bite, and thus is difficult and potentially dangerous to handle (Fontenot Jr. 1999; Fontenot Jr. and Seigel 2008). Even simple tasks like PIT (Passive Integrated Transponder) tag implantation and measuring body length are virtually impossible without restraining the animal. Physical restraint is undesirable because it can result in skin abrasion, physical trauma to internal organs (e.g., liver damage), and potentially death. Using a plastic snake tube to restrain *Amphiuma* (Brown and Forstner 2009) can facilitate handling *Amphiuma* in the field, but is of limited use for accurate body