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Use of Terrestrial Habitat by Western Pond Turtles, *Clemmys marmorata*: Implications for Management

DEVIN A. REESE [1,2] AND HARTWELL H. WELSH[1]

[1]*USDA Forest Service. PSW Redwood Science Laboratory, Arcata, CA 95521, USA*
[2]*Current Address: USAID/G/ENV, The Ronald Reagan Building, Room 308. Washington. D.C. 20523-1812*

ABSTRACT: Despite its extensive range, the western pond turtle, *Clemmys marmorata*, is currently a candidate for federal listing. Understanding its use of the landscape has become increasingly important to the development of appropriate management plans. Using radiotelemetry, we examined movements of turtles in a two-mile stretch of the Trinity River (Trinity County, California). We observed frequent and prolonged use of terrestrial habitat for both nesting and overwintering activities; the turtles travelled into upland areas as far as 500 m from the river. Males utilized terrestrial habitat in at least ten months of the year, and females were on land every month as a result of their additional terrestrial behavior while gravid. Hatchlings overwintered in the nest. These observations suggest that the terrestrial habitat is as important as the aquatic habitat to the viability of western pond turtle populations. The implications for management are significant, considering the variety of development pressures on lands adjacent to waterways.

The western pond turtle, *Clemmys marmorata,* is the only extant aquatic turtle native to California. Western pond turtles have an extensive range (western Washington to northwest Baja California: Stebbins. 1985) and appear to fill a variety of aquatic niches. They are found in ponds, rivers, vernal pools, streams. ephemeral creeks. reservoirs, agricultural ditches. sewage treatment ponds. and estuaries. Despite the fact that they are widespread habitat generalists, western pond turtles are declining (Holland, 1992). *C. marmorata* became a candidate for federal listing in 1991 (*Federal Register,* 1991). It has been given legal status as "Threatened" in Washington State, "Sensitive" in Oregon, and "Of Special Concern" in California.

All other members of the genus *Clemmys* are semi-terrestrial. *C. insculpta* feeds in alder thickets and corn fields (Kaufmann, 1992) and *C. guttata* aestivates in terrestrial habitats (Ward, 1976). *C. muhlenbergii* can be found in riparian vegetation (Chase et al., 1989). Preliminary observations of western pond turtles indicated that they may also have terrestrial affinities:

- They frequently cross roads in agricultural areas of California (Reese. pers. obs.).
- Their underwater numbers decrease appreciably in the main stem Trinity River as winter approaches (Reese and Welsh, 1992, unpubl. data), suggesting that they probably leave the river.
- They nest on land, a feature common to all but one known species of aquatic turtle. Nesting sites for *C. marmorata* can be as far as 400 m from water (Storer. 1930, Holland. 1991a, 1991c; Rathbun et al.. l992).

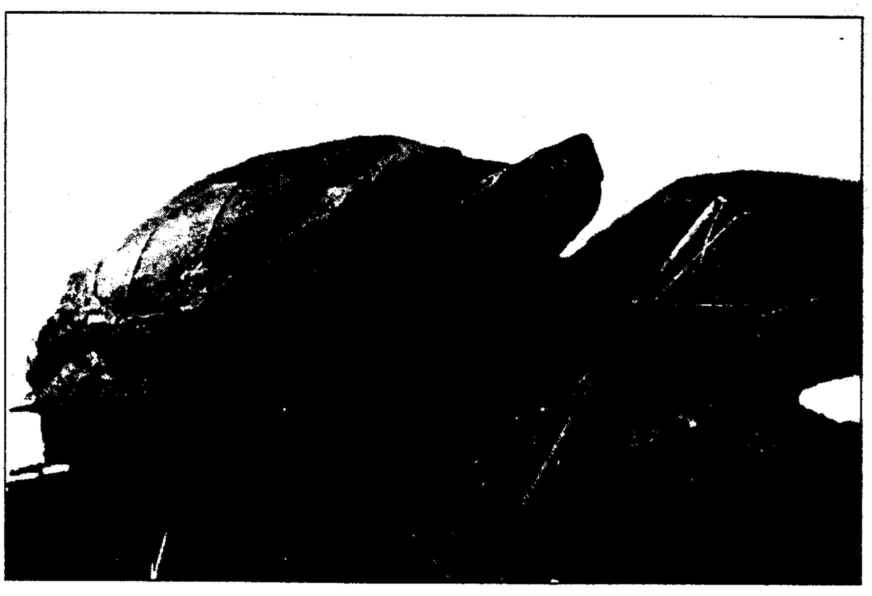

Figure 1. Ten-gram radio transmitter with whip antennae attached with epoxy cement. (Photo by Douglas Welsh).

Understanding the function of terrestrial movements could be helpful in the interpretation of range-wide trends. It may also allow us to predict the extent and nature of terrestrial habitat use by turtles at poorly known sites. Movements of emydid turtles onto land for nesting are documented for numerous species (Burger, 1975; Congdon et al., 1983; Schwarzkopf and Brooks, 1987: Quinn and Tate. 1991). Terrestrial overwintering is less well understood (Bennett et al., 1970). Other potential triggers for land travel include movements to escape unsuitable conditions (Gibbons, 1986) or movements within a home range that includes multiple bodies of water.

The objective of this study was to investigate the role of the terrestrial environment in the life history of the western pond turtle. Although information exists on location of nest sites, there are few data regarding the frequency and duration of terrestrial movements. With the advent and refinement of radiotelemetry for small animals, collection of this data became possible. Our intent was to investigate overland movements associated with nesting as well as identify new terrestrial destinations, such as overwintering sites.

Study Area

The study area was a 2.8 km stretch of the main stem Trinity River (Trinity County, California). The stretch (Figure 2) runs between Douglas City and Junction City in a relatively unpopulated section of river. Surveys conducted previously (Lind et al., 1992) found high densities of western pond turtles along this stretch. The surrounding land is divided in ownership between the U.S. Bureau of Land Management, the U.S. Forest Service. and private owners. The dominant riparian tree canopy species are white alder (*Alnus rhombifolia*) and yellow willow (*Salix lasiandra*).

The adjacent upland habitat is characterized as montane hardwood-conifer and montane hardwood (Mayer and Laudenslayer, 1988). The former applies primarily to the north-facing slopes, which harbor a diverse mix of hardwood and conifer species. Conifers, including Douglas fir (*Pseudotsuga menziesii*) and Ponderosa pine (*Pinus ponderosa*) form a high canopy. The subcanopy consists of Pacific madrone (*Arbutus menziesii*), tan oak (*Lithocarpus densiforus*), and California black oak (*Quercus kelloggii*). In contrast, south-facing slopes are dominated by hardwoods, including manzanita (*Arctostaphylos* sp.), Pacific madrone, several oak species, and gray pine (*Pinus sabiniana*).

METHODS

This three-year, ongoing study of western pond turtle movements and habitat use was initiated in May 1992. Results presented here were generated from radiotelemetry data collected during the first year of study. Results from the remainder of the study are reported in Reese (1996). Our intent was to radio track 12 western pond turtles for the duration.

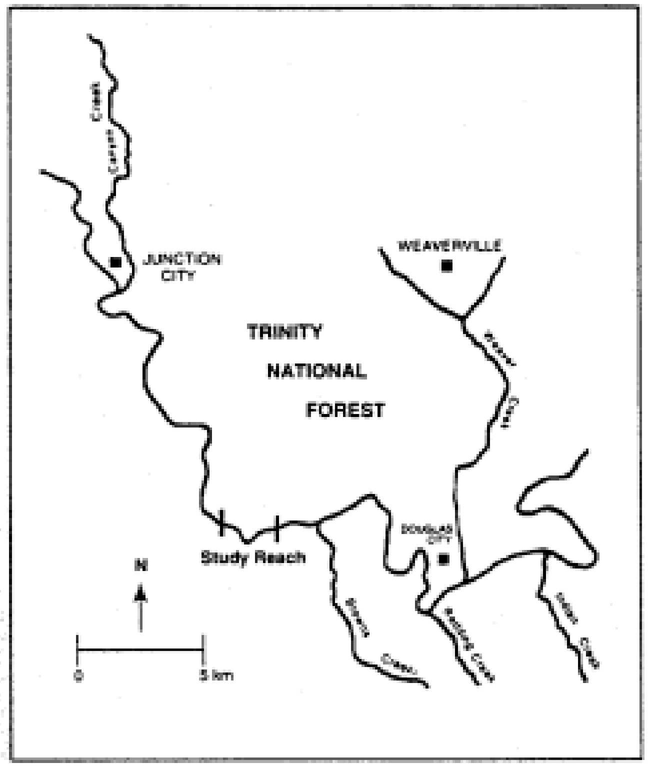

Figure 2. Location of study reach along the main fork of the Trinity River, Trinity County, California.

To minimize potential differences in observed behavior between males and females that may result from the location of capture rather than sex, we designated males and females found within 50 m of each other as pairs. We also required that pairs be separated by at least 300 m to minimize the degree of home range overlap, while keeping the study area to a manageable size for hiking to turtle locations. Juvenile turtles (<110 mm carapace length) were excluded.

Turtles were fitted with 160 MHz radios that have approximately a 2 km base range (AVM Electronics, Livermore, California). The 10 g radios (4.2 cm long, 3.3 cm wide, 1.0 cm thick) were affixed to the carapace using PC-7 overnight-drying epoxy cement (Protective Coating Company, Allentown, Pennsylvania) with the whip antennae attached to the marginals (Figure 1). The batteries were estimated to last approximately 12 months with a pulse rate of 85/min. The radio-equipped turtles were located weekly on a random day to avoid errors from systematic telemetry monitoring. (A systematic schedule could, for example, bias the results towards particular cyclical behaviors.) After a turtle was located its position and behavior were noted.

Turtles were disturbed only to the extent necessary to establish their locations on the ground. For terrestrial locations, this occasionally required manual searching through leaf and needle litter. For aquatic locations, triangulation was used to situate the turtle as precisely as possible. The following data were recorded for all terrestrial locations: shortest distance to the water, slope, aspect, canopy cover, and habitat type.

In addition to the 12 radio-tagged individuals, seven females were equipped with short-term radios to monitor nesting behavior. These females were checked every three hours from dawn to dusk while gravid. If they remained active after dusk, they were checked every three hours throughout the night. Monitoring continued for at least one week after nesting. For comparison, males were checked on a similar schedule during two weeks of the nesting season.

Active nests were covered with mesh cages to prevent predation of eggs or hatchlings (Holland, 1992), and this also ensured that we could ascertain the time of emergence.

Data Analysis

We calculated the proportion of turtles that spent time on land during each month from June 1992 to June 1993. A single location on land at least one meter from the water was considered sufficient to be designated a terrestrial sighting. This generated a conservative estimate of terrestrial behavior, considering that turtles may have made additional land trips during the week-long intervals between checks. We included the gravid females as well as females from the year-round set that were not gravid or of unknown reproductive status.

We calculated how many days gravid females spent on land during the weeks before and after nesting. The more intensive monitoring schedule (every 3 hours) during nesting season allowed us to generate these estimates. Analysis of radio-tracking data requires certain assumptions regarding the positions of individual turtles in the interim periods between successive locations. The following assumptions were chosen because they required the least conjecture and thereby seemed parsimonious:

1. If a turtle was in the same medium (river, land, or pond) at consecutive sightings. it was assumed to have remained there during the interim; and

2. If a turtle changed medium between consecutive sightings, the first location at the new medium was assumed to be the first time it was there.

RESULTS

Terrestrial movements were most common during the summer and winter (Figure 4). The result is best described as a bimodal distribution representing seasonal changes in level of terrestrial activity. The peak in June of each year represents movements of gravid females during nesting season. The winter peak represents movements of both sexes to overwintering sites. The graph shows a high level of terrestrial behavior: females spent time on land during every month of the year, whereas males spent tune on land during all months except July and August. As described above, these are likely to be minimum estimates of the amount of actual terrestrial behavior in the monitored population.

Nesting

Although we observed only one female actually depositing its eggs, we were able to estimate the times the others nested. based on their behavior and reproductive status. Nesting occurred from mid-June to mid-July. Females were highly terrestrial while gravid, making multiple trips (ranging from 2 to 11) onto land. which were initiated as early as one month prior to nesting. While on land each female burrowed and was partially or completely concealed beneath leaf or needle litter (Figure 3). Females remained buried in single locations for as long as three days. occasionally changing orientation. The amount of time spent on land was greatest just before nesting and declined thereafter (Figure 5).

Figure 3. *Clemmys marmorata* partially buried beneath leaf and needle litter. (Photo by Douglas Welsh.)

The female that was observed nesting had travelled at least 31 m from the river's edge assuming that it had taken the shortest route. Located in a clearing surrounded by mixed hardwood, the nest was excavated in hard-packed silty soil on a slight. east-facing; slope only a few meters from the riparian zone. Oviposition occurred in the evening and the female remained by the nest overnight before returning to the river. Hatching emerged from the nest the following March (eight months later). Hatchlings did not immediately leave the nest area after emerging, spending as many as nine days under leaves.

Overwintering

Following the high level of terrestrial activity associated with nesting in June, there was a lull during which few turtles were found on land (Figure 4). A second period of terrestrial behavior began in September. when all 12 radio-equipped turtles left the river. It was not possible to establish the exact departure dates. as the turtles were monitored weekly.

Between September and early December, turtles made as many as four changes in position on land. At each location, they were found completely buried under leaf or needle litter. The locations eventually occupied for the duration of the winter were all in upland habitat beyond the riparian zone at a mean distance of 203 m from the water. However, they varied with respect to microhabitat features (Table 1). Vegetation type included both hardwood-dominant and conifer-dominant woodlands. Two turtles overwintered in lentic bodies of water. whereas the other ten remained on land.

Return movements to the river from overwintering sites began in February 1993 and were not completed until as late as June. Turtles visited a variety of locations along the way; the average return time to the river was seven weeks. Although travel speed (meters travelled per day on average) was not related to distance of overwintering sites from the river, there was a significant correlation between travel speed and order of initiation of return movements ($P < .02$, Spearman rho, two-tailed). Specifically, turtles that initiated their return trips later travelled faster. The two individuals that overwintered in other bodies of water (slough and lake) were the last to initiate their return trips, and their movements overland were the fastest (Figure 6). The routes followed to overwintering sites were in some cases different from the return routes. For example, two individuals stopped for a few weeks at a vernal pool that had been dry in the fall during their outbound trip.

DISCUSSION

The western pond turtles we monitored exhibited considerable terrestrial activity. Females naturally travel onto land for nesting, but the large number of overland trips they made before actually ovipositing is noteworthy. Rathbun et al. (1992) also reported multiple trips by gravid females. It is possible that females gain a thermoregulatory advantage by spending time buried on

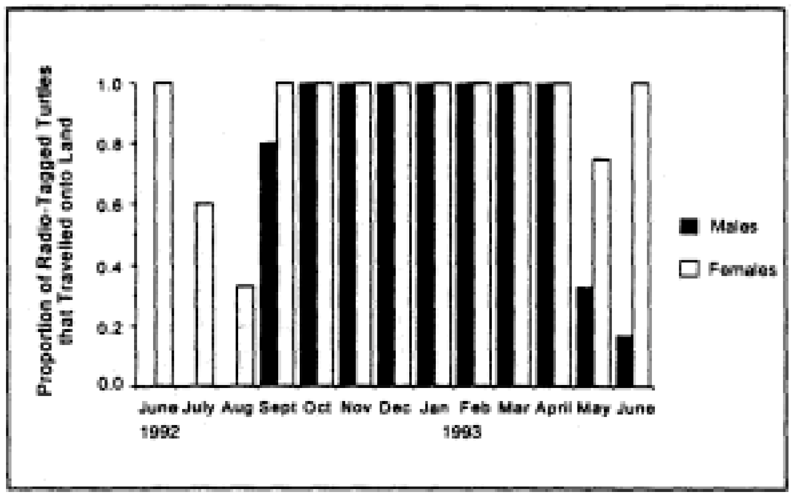

Figure 4. Proportion of radio-tagged turtles in the Trinity River study reach that travelled onto land during each month.

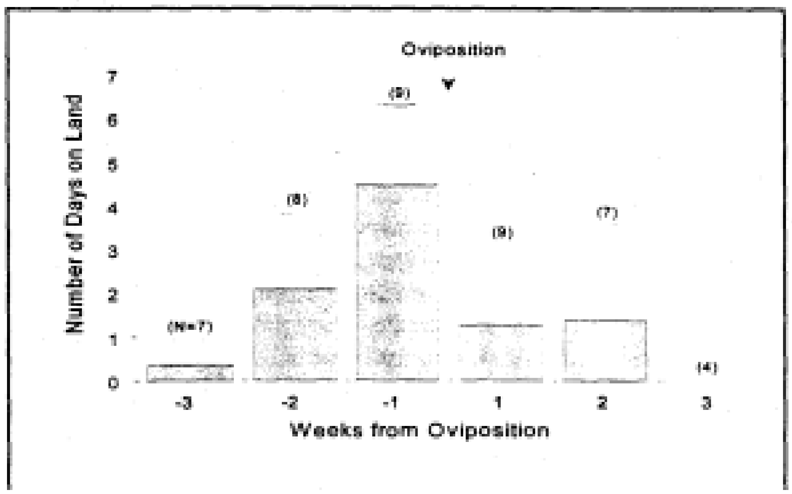

Figure 5. Mean number of days spent on land by gravid females during the weeks before and after oviposition.

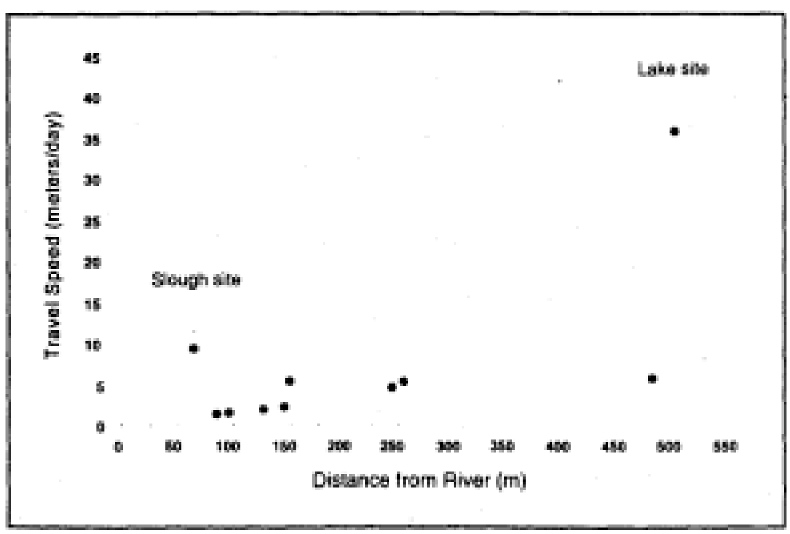

Figure 6. Travel speeds of turtles from overwintering sites in spring of 1993.

TABLE 1

Overwintering habitat of turtles on main stem Trinity River during 1992-1993. Douglas fir dominant = ≥ 75% Douglas firs; hardwood dominant = ≥ 75% hardwoods; conifer dominant = mix of conifers with none comprising more than 75%; mixed hardwood/conifer = neither comprising more than 75%; mixed alder/willow = neither comprising more than 75%.

Turtle/Sex	Slope aspect	Habitat type	Canopy cover (%)	Distance from shore (m)
698 ♀	25 NE	Douglas fir dominant	75	480
773 ♀	15 NE	Hardwood dominant	50	255
949 ♀	5 E	Hardwood dominant	50	75
749 ♀	None	Mixed hardwood/conifer	75	85
215 ♀	10E	Mixed hardwood/conifer	90	126
868 ♀	5 N	Conifer dominant	75	215
678 ♂	None	Conifer dominant	80	245
725 ♂	20 E	Conifer dominant	15	95
528 ♂	None	Hardwood dominant	70	145
560 ♂	Lake	Hardwood dominant	0	500
377b ♂	14 NE	Mixed hardwood/conifer	50	65
335b ♂	Slough	Mixed alder/willow	59	65

land during preovipositional development of the embryo (e.g., *Podocnemis expansa).* The air on the Trinity River is consistently warmer than the water at this time of year (USFWS temperature records, Lewiston station). It is also possible that females are responding to our presence with preovipositional arrest, a mechanism that allows them to retain eggs until conditions are favorable (Ewert, 1985). In either case, their tendency to burrow under litter is consistent with known behavior of other species (e.g., *Kinosternon subrubrum* and *Clemmys insculpta)* during periods spent on land (Bennett, 1972; Kaufmann, 1992).

It is of interest that hatchlings did not emerge from the nest until spring. Hatchlings of other emydid species are known to remain in terrestrial nest cavities through their first winter (Hartweg, 1946; Gibbons and Nelson, 1978; Gibbons, 1990). Feldman (1982), who based his observations on captives, suggested that *C. marmorata* hatchlings may do the same. It is also possible that egg development was suspended and hatching delayed until just prior to the March emergence time. This phenomenon of embryonic diapause occurs in a number of turtle species (Ewert, 1985). Either strategy may be an adaptive response to unfavorable conditions on the Trinity River in the fall, such as high water levels or low temperatures. Gibbons and Nelson (1978) suggested that delayed emergence may provide the benefit of sanctuary during a period when the growth benefits gained from early emergence are likely to be outweighed by predation or by mortality from harsh environmental conditions.

All of the radio-equipped turtles spent seven months of the year away from the river at overwintering sites. These included both terrestrial refuges and lentic bodies of water as far as 500 m from the river. This overwintering strategy may be an adaptive response to winter flooding. However, reasons for the long distances the turtles travelled, well beyond the flood zone, are unknown. It is also of interest that most turtles overwintered on relatively cool north- and east-facing slopes rather than south- and west-facing slopes.

Microhabitat characteristics of the overwintering sites were variable. There did not appear to be an association with any single habitat type. The timing and duration of movements during the 1992-1993 winter varied with the individual turtles. The departure from the river was asynchronous and the spring return even more so. Turtles that left the river later travelled faster, which may be attributable to the warmer temperatures and consequently higher activity potential.

CONCLUSIONS

This study provides a preliminary framework for developing management programs for the long-term survival of this species. Western pond turtles travel onto land for a variety of reasons and consequently occur in the terrestrial environment during all times of the year. These findings prescribe a management strategy that provides protection for not only waterways but also adjacent lands. The upland area used by turtles at this study site far exceeds the size of traditionally protected buffer zones alone rivers. Unfortunately. with our current knowledge we cannot predict specifically which portions of the terrestrial environment are critical for western pond turtles. They utilize a variety of upland habitats as well as the network of creek. ponds. and ephemeral bodies of water associated with riverine systems.

The riparian habitat serves an integral role in the life history of the western pond turtle. and many other species may cross the uncertain boundary between river and land because of their specialized. seasonally varying requirements. We must therefore reevaluate our view of riparian habitat as "buffer zone;" which connotes a supportive rather than primary role in the ecosystem. Terrestrial riverine habitat warrants consideration aside from its function of buffering the aquatic habitat from external impacts. Management strategies that address the functioning of entire watersheds are more likely to afford adequate protection for these vagile, semi-terrestrial species.

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