WETLAND RESOURCES

All of what wetlands do and all of what wetlands have are the wetland resources. We have all read about the functional resources of wetlands and how they serve us and our environment. However, there are so many wetland resources that most of us know little about.

The following article is a contribution to an ongoing series that will tell us of wetland resources that are not widely known. As in our series, "Wetland Soils" and "Dynamics of Wetlands", articles will not appear in every issue of the *Wetland Journal*. Articles are solicited from the readership and wetland experts regarding little known wetland resources.

Nesting Habitat Requirements of the Diamondback Terrapin: A Geographic Comparison

--Willem M. Roosenburg

Diamondback Terrapins have one of the greatest geographic distributions for a single species of turtle. Terrapins range from the Gulf Coast of Texas to Cape Cod, Massachusetts. Terrapin populations also penetrate far into inland waters, characteristically different habitats than coastal regions. This study compares terrapin habitats from an inland population in the Patuxent River, a tributary of the Chesapeake Bay, with other populations reported in the literature. Terrapins preferentially nest in open, sandy habitats. In coastal locations, nesting areas are found on sand dunes; inland, they occur close to the water's edge. Different threats to terrapin nesting habitats and how they may affect nesting success have been identified.

The Diamondback Terrapin, *Malaclemys terrapin*, is an estuarine emydid turtle that ranges from the Gulf Coast of Texas to Cape Cod, Massachusetts (Carr 1952). Terrapins spend most of their life in the water. However, to successfully reproduce, terrapins must transcend the high water mark and deposit their eggs in an area that will not remain inundated for prolonged periods of time. Failure to find appropriate nesting areas will result in the unsuccessful development of the embryos. Therefore, protection of terrestrial habitats where terrapins reproduce, and aquatic habitats where terrapins live, is critical for the maintenance of viable populations.

Unfortunately, most attempts to maintain fisheries species focus on sustaining population levels by supplementing populations via hatcheries or head start programs. Consequently, many fisheries species consist of individuals that originated from hatcheries or other artificial sources. Hatcheries and head start programs alone, are inappropriate for turtles; their life histories require comprehensive management that protects nesting habitats and older reproductive age-classes (Congdon et al, 1993). Protecting critical habitats rarely occurs because it does not result in immediate positive responses of threatened populations.

Protection and preservation of terrapin nesting sites *throughout their range*, is essential for the reproductive success of the species.

Nest site philopatry is the return of individual females to the same nesting beaches for repetitive nestings and occurs in terrapins, both within, and among years. This results in a potential increase in population fragmentation and a decrease in gene flow. These findings suggest that terrapin populations may be dependent on specific nesting areas and that these areas are important for the maintenance of locally-adapted populations.

Palmer and Cordes (1982) have constructed a habitat suitability model that attempts to identify habitats that would be appropriate nesting sites for terrapins. In this study, I compare the nesting habitats of three previously studied terrapin populations to my own study of the Patuxent River population and discuss how nesting requirements can vary among geographic locations. This study investigates the habitats necessary for reproduction, and thus, population viability for the Diamondback Terrapin, *Malaclemys terrapin*. In particular, I investigate the influence of variation in topography on the nesting requirements of terrapins throughout their range.

METHODS AND MATERIALS

Since 1987, an ongoing mark-recapture study of the diamondback terrapin has been conducted on the western shore of the Patuxent River near Mechanicsville, Maryland. The study site extends approximately 8 km (4.97 mi) along the Patuxent River from Long Point to Marsh Point. Several terrapin nesting areas have been identified in this region. Two nest-

ing areas, Marsh Point Beach and Burton's Beach, were monitored throughout the nesting season to investigate the reproductive biology of terrapins. Detailed behavioral information was collected on nesting females and the areas used by nesting terrapins. More specific details of the techniques and methodologies are discussed in Roosenburg (1990, 1991, 1992, 1993).

Nesting areas used by terrapins in the Patuxent population were compared to other populations throughout the range that have been reported in the literature. The nesting behavior and nesting habitats used by terrapins have been previously described for terrapin populations in Cape Cod, Massachusetts (Auger 1989, Auger and Giovannone 1979), Brigantine National Wildlife Refuge, New Jersey (Burger and Montevecchi 1975) and Merritt Island National Seashore, Florida (Seigel 1984).

RESULTS AND DISCUSSION

The Patuxent River is a large sub-estuary within the Chesapeake Bay. At the study site, the river is 3-4 km (1.86 - 2.48 mi) wide. The Patuxent's shoreline is bordered by small salt marshes [< 50 hectares (123.5 acres)] and sandy beaches. The beaches are often isolated by salt marshes from land. True sand dunes do not form along the Patuxent, instead, narrow sandy strips form at the interface of the open water and the mainland. The sandy strip is usually less than 10 m (33 ft) wide and 0.5 - 1.0 m (1.6 - 3.28 ft) above the mean high tide. When the topography behind the beaches continues to increase beyond 1.0 m (1.6 ft) above the high tide mark, the soil and vegetation change rapidly. The soil becomes more loamy and richer in organic matter. The vegetation changes from *Spartina* and other marsh related grasses, to wild Blackberries (*Rubus* sp.), Honey Suckle (*Lonicera* sp.), and deciduous trees. These habitats are unsuitable for terrapin nesting. The narrow sandy beaches are the primary nesting areas for terrapins in the Patuxent River. Terrapin nesting densities are usually higher on the beaches that are isolated from the mainland by salt marshes. Nesting occurs mostly in the open, sparsely vegetated areas on the beach; densely vegetated and shaded areas are avoided (Roosenburg 1992). Successful terrapin nests are laid on the flat upper reaches above the intertidal zone. Throughout the incubation period, wind-driven high tides may flood some of the nests. Terrapin embryos frequently survive this flooding; however, prolonged inundation can result in embryo mortality depending on the incubation stage and the length of time nests remain submerged.

Terrapin nesting in the Patuxent population begins on, or about, the first of June and continues until the end of July (Roosenburg 1991). Nesting occurs

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Table 1. Nesting behavior and habitats used by terrapins from locations in Sandy Neck, Massachusetts; Brigantine National Wildlife Refuge, New Jersey; Merritt Island National Seashore, Florida; and Patuxent River, Maryland.

Brigantine, New Jersey	*Sandy Neck, Massachusetts*	*Merrit Island, Florida*	*Patuxent River, Maryland*
Nesting diurnal	Nesting 45% nocturnal	Nesting diurnal	Nesting nocturnal
Nesting concentrated [220 nests in 1.4 hectares (3.5 acres)]	Nesting disperse [50 nests in 96 hectares (237 acres)]	Not reported	Nesting highly concentrated; varies [Marsh Point ± 225 nests in 0.2 hectares (.5 acres) Burton's Beach ± 60 nests in 0.25 hectares (.6 acres)]
Some facial sand probing	Facial sand probing	Not reported	Limited facial probing
No false nesting	False nesting standard (± 40%)	Not reported	2 observed false nestings in seven years
No nesting on unvegetated dunes	50% Nesting on vegetated dunes	Nesting on dikes, roads, and banks	Narrow sandy beaches; open areas away from shade; and dense vegetation (see text)
Nesting routes short [<100 m (328 ft); < 1 hr.]	Nesting routes long [to 1600 m (5,249 ft); 48 hr.]	Nesting routes probably short because dike roads were near the water	Most nesting routes <10 m (33 ft); average nesting time = 30 min; some, <1%, nest in agricultural fields moving great distances, ± 200 m (656 ft)
No overwintering in nest	Some overwintering in nest	Not reported, but unlikely	Some overwintering in nest
Burger and Montevecchi 1975	Auger and Giovannone 1979, Auger 1989	Seigel 1984	This study

TERRAPIN

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throughout the day and night, usually with a peak in activity from 1100 - 1300. Terrapins dig a small, flask shaped chamber and deposit an average of 13 eggs. The entire nesting process, from the time a female leaves the water until she returns, can occur in as little as 15 minutes but may take as long a 2 hours. The variation in time ashore is primarily a function of the amount of time a female terrapin spends searching for an appropriate nesting site. Terrapins are alert during nesting and can be disturbed easily. Female terrapins usually approach the nesting beaches in groups of 2, to often, more than 25 individuals, cautiously examining the beach from the water, sometimes for several hours. Emergence from the water does not insure that nesting will occur. Frequently, terrapins abandon nesting for several reasons. Predation is the primary reason for the apprehension of terrapins during nesting. Nest predation varies from 55 to 95% and appears to be density dependent (Roosenburg 1992). Adult female terrapins also are vulnerable to predation by raccoons and probably are preyed upon selectively because they contain energy rich eggs. Nesting beaches are linear habitats that can be stalked easily by raccoons to intercept nesting females. Frequently, raccoons are seen on nesting beaches during times of peak nesting. Terrapins killed by raccoons are bitten on the back of the head and the shell is entered and eviscerated through the inguinal region (area of the groin). Both young and adult terrapins are killed and eaten by raccoons, however, the majority are adult females that came ashore to nest.

Throughout their range, terrapins nest in many different habitats (Table 1). Florida terrapins nest on dike roads while populations in Cape Cod and New Jersey nest on elevated sand dunes (Seigel 1984, Auger and Giovannone 1979, Burger and Montevecchi 1975). Cape Cod and New Jersey terrapins need to travel long distances to get to their nesting areas (Auger and Giovannone 1979, Burger and Montevecchi 1975). Nesting activity in New Jersey coincides with high tide, significantly reducing the distance traveled to nesting areas (Burger and Montevecchi 1975). Terrapin nests in New Jersey are more closely associated with vegetation than are nests in Cape Cod (Burger and Montevecchi 1975, Auger and Giovannone 1979). Terrapins in Cape Cod use a variety of nesting sites on a continuous expanse of dune and do not appear to be site fidelic (Auger 1989). Site fidelity has not been adequately studied in other terrapin populations; however, terrapins in both New Jersey and Cape Cod remain selective about where they nest, resulting in clumped distributions of nests (Burger and Montevecchi 1975, Auger 1989). Finally, nesting densities are lower in populations nesting on large dunes than those nesting on the small sandy beaches (Table 1).

Typical terrapin habitats are characterized as extensive salt marshes and lagoons that lie behind the barrier dunes. Terrapins in Florida live in coastal lagoons, while terrapins in New Jersey, Cape Cod, Delaware, and South Carolina are found primarily in the guts and channels of salt marshes (Auger 1989, Burger and Montevecchi 1975, Hurd et al. 1979, Seigel 1984, Tucker personel communication). Terrapins are rarely observed in the open water areas in these locations. Salt marshes in coastal areas are more extensive than marshes along the western tributaries of Chesapeake Bay and are large enough to support terrapin populations. Additionally, these marshes have high densities of gastropod mollusks which are a major food source for terrapins. The marshes along the Patuxent are small. Gastropod mollusks are not abundant enough to support large terrapin populations. Patuxent terrapins are most often found in the open water of the river, frequently in areas with a sandy bottom. These areas are rich in their main food source, soft-shelled clams (*Mya arenaria*) and razor clams (*Tagelus* sp.).

Although variable, typical terrapin habitats are characterized as extensive salt marshes and lagoons that lie behind the barrier dunes.

Terrapins occasionally nest in unusual habitats. Females have been captured several hundred meters from the nearest water with evidence that they were on their way to, or returning from, nesting. We have observed two nesting events taking place in agricultural fields and one nesting event on a gravel road. Finally, one nesting location used by terrapins consists of a narrow sandy strip (< 3 ft) abutting sandy-clay banks 6 - 9 ft high. Terrapins nest in the bank where the slope is flat enough for them to maintain their footing while digging the egg chamber. The sandy strip at the base of the bank submerges during mean high tides, eliminating it as a possible nesting area. The survivorship of nests in such precarious nesting areas is unknown; however, eggs taken from these habitats frequently die when brought back to the lab and placed in incubators. The clay particles in the soil clog the pores in the eggs, resulting in the insufficient gas exchange to support the developing embryo. In-situ studies of nest survivorship in these habitats would be extremely useful.

There are several possible reasons for terrapins nesting in marginal habitats. First, nest site fidelity may have a strong influence on nest site decisions, and as habitats change over time, areas that were once good nesting beaches may have deteriorated. The nesting areas I monitor change considerably from year to year because of erosion caused by wind-driven high tides combined with vigorous wave action. Second, preferred nesting areas of terrapins are used frequently by humans for recreation and living. Increases in human activity on nesting beaches may force terrapins to nest in areas where less disturbance occurs. Third, shoreline bulkheading may contribute to the use of marginal habitats, such as fields and roads, by forcing terrapins to find new nesting sites in areas where bulkheads block access to former nesting sites. Additionally, terrapin nests placed against bulkheads below the high tide mark are usually destroyed. Environmental sex determination (the sex of the developing embryo is determined by the temperature of the nest during the middle third of incubation) complicates the issue of nest site selection by terrapins (Roosenburg 1992). Nesting areas vary considerably in their thermal characteristics. Females must have available a complete range of microhabitat types to maintain balanced sex ratios (Roosenburg 1992).

Terrapins probably evolved in coastal habitats, and with the retreat of the last glaciation, expanded their range northward and inland. The most likely ancestral condition for terrapins is nesting on elevated dunes characteristic of coastal populations and as they expanded into inland estuarine habitats that differed in topography, the use of nesting habitats changed accordingly. The common feature of all nesting areas seems to be sandy

soils. Sandy soils have large particle sizes, and therefore, have higher rates of gas diffusion and lower water demand than clay or more loamy soils (Marshall and Holmes, 1979). The use of sandy habitats may be critical to the successful development of the embryos. Studies to examine the interaction between incubation and substrate on terrapin egg survivorship need to be conducted.

Erosion, shoreline development, recreational human activity, and bulkheading have diminished the diamondback terrapin nesting habitat.

Terrapins are opportunists, finding appropriate nesting areas throughout their range, yet they are specialized in the requirements of nest sites. Coastal populations take advantage of the large dunes that offer open sandy habitats for nesting. More inland populations, where large dunes are not present, use the narrow sandy beaches that surround the bays and estuaries. The smaller beaches may be more risky habitats for terrapin nesting because of the proximity of actual nesting site to the water and the unavailability of sites well above the mean high tide level. The differences in nesting areas throughout their range warrants individual evaluation of each nesting area and the best strategy for the preservation of these nesting areas. Unfortunately, general habitat suitability indices do not appear to be appropriate for this species. Terrapin nesting habitats require protection throughout their entire range, but protection of nesting beaches in areas where nesting occurs on smaller isolated beaches, may be critical to the conservation of terrapin populations in inland areas. The threats of bulkheading, shoreline development, and recreational use of nesting areas may prevent terrapins from reaching their preferred nesting areas, thus reducing reproductive success and increasing nest mortality. ❀

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REFERENCES

Auger, P.J. 1989. Sex ratio and nesting behavior in a population of *Malaclemys terrapin* dispalying temperature-dependent sex determination. Ph.D. Dissertation. Tufts University, Boston, MA.

Auger, P.J., and P. Giovannone. 1979. On the fringe of existence, Diamondback Terrapins at Sandy Neck. *Cape Naturalist* 8: 44-58.

Burger, J., and W.A. Montevecchi. 1975. Nest site selection in the Diamondback Terrapin, *Malaclemys terrapin*. *Copeia* 1975: 113-119.

Carr, A. 1952. The handbook of turtles. Cornell University Press, Ithica, New York.

Congdon, J.D., A.E. Dunham, and R.C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's Turtle (*Emydoidea blandingii*): Implications for conservation and management of long-lived organisms. *Conservation Biology* 7: 826-833.

Hurd, L.E., G.W. Smedes, and T.A. Dean. 1979. An ecological study of a natural population of Diamondback Terrapins (*Malaclemys t. terrapin*). *Estuaries* 2: 28-33.

Marshal, T.J., and J.W. Holmes. 1979. Soil physics. Cambridge University Press, Cambridge London.

Roosenburg, W.M. 1990. Final report: The Chesapeake Diamondback Terrapin investigations for the period 1987, 1988, 1989. Chesapeake Research Consortium Pub. No 133, Solomons, MD.

Roosenburg, W. M. 1991. Final report: The Chesapeake Diamondback Terrapin investigations, 1991. Chesapeake Research Consortium Pub. No 140, Solomons, MD.

Roosenburg, W.M. 1992. Life history consequences of nest site selection by the Diamondback Terrapin, *Malaclemys terrapin*. Ph.D. Thesis. University of Pennsylvania, Philadelphia, PA.

Roosenburg, W.M. 1993. Final report: The Chesapeake Diamondback Terrapin investigations, 1992. Chesapeake Research Consortium Pub. No 146, Solomons, MD.

Seigel, Richard A. 1984. Parameters of two populations of Diamondback Terrapins (*Malaclemys terrapin*) on the Atlantic Coast of Florida. Pages 77-87 *in* Seigel, R.A., L. E. Hunt, J. L. Knight, L. Malaret, and N. L. Zuschlag (eds.) Vertebrate ecology and systematics - a tribute to Henry S. Fitch. Museum of Natural History, University of Kansas, Lawerance, KS.

Diamondback Terrapin (hatchlings)
Malaclemys terrapin

The easily recognizable facial features, including black markings on the grayish-white neck and head, prominent black eyes, and the white lips give the Diamondback Terrapin the nicknane "clown-face". This terrapin has a low, broad, keeled carapace. Its polygonal scutes have noticeable concentric rings. The Diamondback Terrapin is found in bays, estuaries, salt marshes, tidal fresh marshes, lagoons, and Gulf shores; from Cape Cod to Texas, along the Atlantic and Gulf Coast. Highly esteemed as a delicacy at the turn of the century, its population has slowly revived, only to face new threats with the continuous loss and degradation of vital coastal marshes.

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