

EASTERN BOX TURTLE ASSESSMENT

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INTRODUCTION

Since 1968, the Maine Department of Inland Fisheries and Wildlife (MDIFW) has developed and refined wildlife species assessments to formulate management goals, objectives, and strategic plans. Assessments are based upon available information and the judgments of professional wildlife biologists responsible for individual species or groups of species. This document represents the first planning effort by MDIFW for eastern box turtles (*Terrapene carolina carolina*), a reptile designated an “endangered species” in Maine.

Assessments provide the background for species planning initiatives. A “Natural History” section reviews biological characteristics of the species useful to understanding its status. The “Management” section recaps previous actions, strategic plans, relevant rules, and regulatory authority. Historic, current, and projected future conditions for the species are discussed individually for “Habitat,” “Population,” and “Use and Demand” analyses. The major points of an assessment appear in a “Summary and Conclusions.”

Owing to the extreme scarcity of eastern box turtles in Maine and limited information about them, this assessment draws heavily on studies and insights from other regions. Mark McCollough prepared two earlier drafts of this assessment.

NATURAL HISTORY

Description

The eastern box turtle is a small terrestrial turtle with a high-domed carapace and unique plastron (Figure 1). The carapace (top shell) has a slight median keel and is steeply sloped on the rear margin. It is brown-colored with variable yellow, orange, or olive patterns of radiating lines, spots, bars, or irregular blotches on each scute. An adult's carapace is 10 - 20 cm long (Smith 1961, Conant and Collins 1991). Maximum size is attained at ages between 12 - 20 years (Nichols 1939). Individuals from the North, especially New England, are larger than others (Milstead 1969, Klemens 1993).

The plastron (bottom shell) is tan to dark brown and variably mottled with yellow. A strong hinge on the plastron between the abdominal and pectoral scutes enables it to shut tightly against the carapace after withdrawing legs, head, and tail. This response is common among wild turtles, but not those which are pets. It seals soft body parts from external threats, an adaptation which accounts for the common name "box turtle."

The skin of eastern box turtles is black to reddish-brown with yellow or orange spots and streaks. Head markings vary. The upper jaw has a terminal hook and usually lacks a notch. Sexual dimorphism is marked (Ernst and Barbour 1972, Conant and Collins 1991, Klemens 1993). Most adult males have red or orange eyes; concave plastron; short, stocky, and considerably curved hind feet; long, thick tails; and relatively greater shell width and height than females. Females generally have yellowish-brown eyes; a flat plastron; longer, more slender, and straighter hind legs; and a shorter, slighter tail with the anus located more anterior. Hatchlings lack bright coloration.

Figure 1. An eastern box turtle (*Terrapene carolina carolina*).

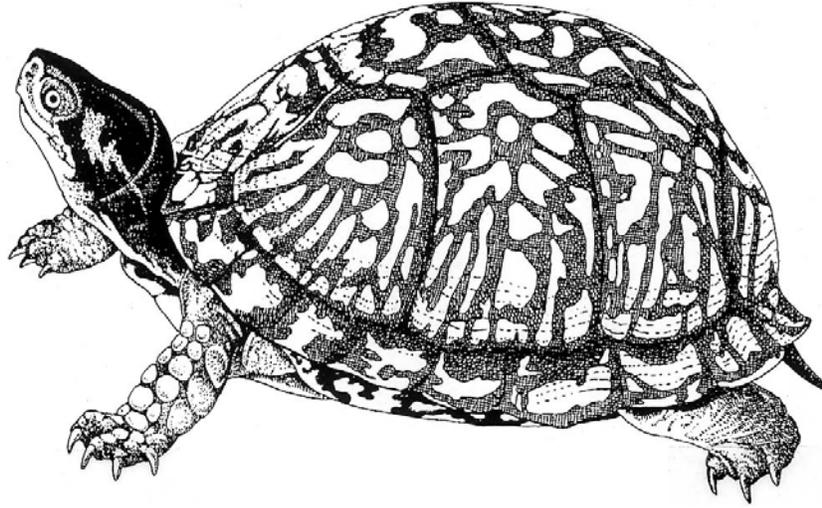
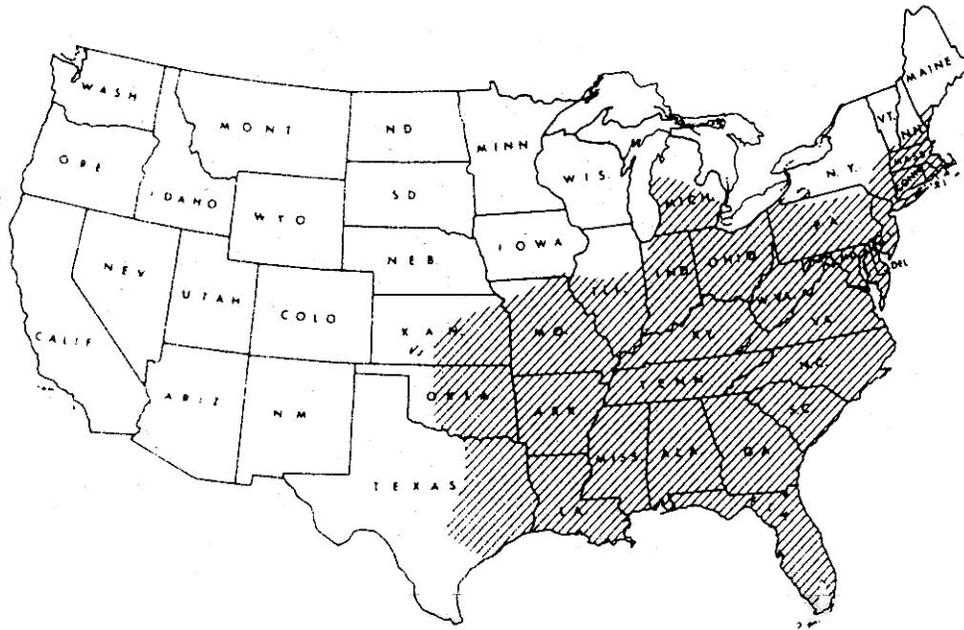


Figure 2. Range of the eastern box turtle (*Terrapene carolina carolina*, solid shading), other eastern box turtle subspecies (*Terrapene carolina*, crosshatched), and ornate box turtles (*Terrapene ornata*, hatched areas) across North America.



Distribution

Box turtles occur only in North America (Conant and Collins 1991). Collectively, the two species native to the United States (see “Taxonomy”) range from the Atlantic Ocean to the Rocky Mountains. The species addressed in this assessment, the eastern box turtle (*Terrapene carolina*), reaches its western limits and overlaps with a midwestern species, the ornate box turtle (*Terrapene ornata*) in Wisconsin, Illinois, Missouri, Kansas, Oklahoma, and Texas. Eastern box turtles are broadly distributed in the eastern and central U. S. from northern states nearly abutting the Canadian border southward to the Gulf coast and northern Mexico (Figure 2).

The subspecies native to Maine, *T. c. carolina*, occurs broadly over the Atlantic seaboard from southern Maine to northern Florida. It ranges westward through Illinois, Kentucky, Tennessee, and Mississippi to the Mississippi River. A crucial perspective to Maine, its northern limits, are traditionally depicted as: southern Maine; southeastern portions of New Hampshire, Vermont, and New York; across most of Pennsylvania and Ohio; central Michigan; and extreme southeastern Wisconsin (Behler and King 1979). Three other subspecies of eastern box turtles live in the South or Midwest.

Taxonomy

Approximately 250 species of turtles and tortoises belong to 12 different families in the taxonomic order Testudines (Tynning 1990). Box turtles (genus *Terrapene*) are members of the family Emydidae which contains the largest number of living turtle species. Commonly called the family of freshwater and marsh turtles, its members occur on all continents except Australia and Antarctica (Carr 1952). This family is

represented by 33 species in the U. S. and Canada (Collins 1997). All are aquatic or semiaquatic except for the two species of *Terrapene*. Although they resemble tortoises (family Testudinidae), box turtles have freestanding toes and some toe webbing: traits shared among all emydid turtles (Tynning 1990).

The genus *Terrapene* occurs exclusively in North America. Phalangeal formulae distinguish species and subspecies of *Terrapene* (Baur 1891, 1893; Taylor 1895; Minx 1992). The two species living in the U. S. are visually distinct. The ornate box turtle, *T. ornata*, is identified by distinct, bright colors on a keelless, low, and flattened carapace. The carapace of an eastern box turtle, *T. carolina*, is keeled and high-arched. They may cross breed in areas of range overlap in the Midwest (Smith 1961). Two others species live in Mexico: *T. nelsoni* and *T. coahuila*. At least 2 fossil species of *Terrapene* are reported from the southeastern U. S. (Hay 1907, Ernst *et al.* 1998).

There are 6 extant subspecies of *T. carolina*. (Collins 1997). Two live in northern Mexico: *T. c. mexicana* and *T. c. yucatanana*. Interbreeding among the four subspecies resident in the U. S. may occur where ranges overlap (Figure 2, Milstead 1969):

- T. c. carolina* (Linnaeus) - The eastern box turtle is the subspecies that occurs in Maine. It is differentiated by a brightly marked, short, and broad carapace with the marginals flared only slightly and nearly vertical at the posterior (Ernst and Barbour 1972).
- T. c. major* (Agassiz) - The Gulf Coast box turtle ranges along the coastal plain of the Gulf of Mexico from the Florida panhandle to eastern Texas. Its carapace often lacks yellowish markings, is elongate, and may exceed 20 cm in length.
- T. c. triunguis* (Agassiz) - The three-toed box turtle ranges from Kansas and Missouri south to Texas, Alabama, and Georgia. It has 3 toes on the hind foot and an obscurely marked, tan - olive carapace.
- T. c. bauri* (Taylor) - The Florida box turtle is restricted to peninsular Florida and the Keys. It also has 3 toes on the hind foot, but the carapace has a bright pattern of radiating lines. It has two characteristic stripes on each side of the head.

Habitat, Diet, and Movements

Habitats of eastern box turtles are generally terrestrial: woodlands, field edges, pastures, and thickets. Despite their terrestrial nature, they are never far from water (Allard 1948). Young box turtles are thought to be semiaquatic (Ernst and Barbour 1972), and adults are occasionally observed swimming in slow-moving streams and ponds. Sandy, well-drained soils typify most box turtle settings (Klemens 1993).

Regional variations are evident. In New York (Madden 1975) and Connecticut (Klemens 1993), box turtles favor areas of high habitat diversity such as “old fields” and deciduous forest ecotones (*e.g.*, power line corridors). They appear most often in open deciduous forests and mountain slopes in Massachusetts (DeGraaf and Rudis 1983). Bottomland forests are frequented in Maryland (Stickel 1950, 1989) and Pennsylvania (Strang 1983). Indiana woodlands dominated by maples were favored relative to those in upland settings like oak stands, steep-sided gorges, and utility corridors (Williams and Parker 1987). Schwartz and Schwartz (1974) noted a decrease in densities of box turtles going from heavily wooded to more open areas in Missouri.

Box turtles are omnivorous. Stomach contents of 40 individuals examined by Surface (1908) contained both animal materials (80%) and plant materials (62%). Young turtles are chiefly carnivorous and become more herbivorous with age (DeGraaf and Rudis 1983). Box turtle stomach contents (by volume) were 60% snails, 15% crayfish, and 12.5% plant material in one Kentucky study (Barbour 1950) and 52.5% snails and slugs, 10% caterpillars, 10% mushrooms, 4% beetles, and 3.5% centipedes in another (Bush 1959). Roots, stems, leaves, fruits, and some seeds are all eaten. Invertebrate foods include slugs, snails, earthworms, spiders, crayfish, millipedes,

grasshoppers, flies, beetles, ants, termites, cicadas, caterpillars, insect grubs, and maggots. Box turtles eat vertebrates such as small fish, salamanders, frogs, toads, lizards, and some snakes. Box turtles also consume carrion (Ernst and Barbour 1972).

Box turtles are ectothermic. Their behavior, movements, and habitat selection are dictated largely by ambient temperature and moisture. Three-toed box turtles in Arkansas maintained optimal conditions by selecting different microhabitats within their home range each day (Reagan 1974). They moved into microhabitats to keep body temperatures between 29 - 38° C. Ornate box turtles in Wisconsin utilize a broader, lower range of body temperatures than those in southern states (Ellner and Karasov 1993). Therefore, thermal preferences and activity periods vary regionally. This adaptation defies the generalization that turtles are strictly passive to thermal gradients across their range. Thermal conditioning of hatchlings may be influential (Curtin 1998).

Latitudinal variations and patterns of microhabitat selection for thermoregulation have not been similarly examined in eastern box turtles. Most depict them as “indifferent” towards thermoregulation (Madden 1975, Adams *et al.* 1989), although behavioral adjustments and specific microhabitats minimize their exposure to thermal extremes. Eastern box turtles avoid excessive solar radiation in summer and maintain body temperatures near the thermal regime of shaded settings (Russo 1972). They visit shallow wetlands in summer to cool themselves and obtain water. Basking sites (openings in the forest canopy) may be repeatedly used for warming when necessary.

Initial, meticulous studies of eastern box turtles in Maryland (Stickel 1950) and Tennessee (Dolbeer 1969) utilized a “trailing device:” a spool of thread attached to the turtle that unwinds during its daily course of movements (Claussen *et al.* 1997). Box

turtles proved to be strictly diurnal and most active during high humidity periods, often in early morning or after thunderstorms to avoid hot summer temperatures (Dodd *et al.* 1991, Klemens 1993). At night, box turtles create "forms," cavities in leaves, debris, or soil often under dense cover. In spells of dry, or unusually hot or cold weather, a turtle may stay in its form for days or weeks.

Most box turtles are sedentary. Home ranges of *T. c. carolina* on Long Island, NY had diameters <230 m and changed little over the years (Madden 1975), although one wandered more than 800 m (Nichols 1939). Smaller home ranges are reported for this subspecies in Tennessee: mean = 76 m diameter (Dolbeer 1969). Average home ranges were 1.13 ha (females) - 1.20 ha (males) in Maryland (Stickel 1950, 1989) and 10 ha (females) - 12 ha (males) in Michigan (Weatherby 1996). Home ranges of *T. c. triunguis* differed by age in Missouri (Schwartz and Schwartz 1974). Some individuals are transients and do not establish home ranges (Kiestler *et al.* 1982).

Box turtles are not territorial. All ages and both sexes coexist well. Individuals maintain stable home ranges for periods of up to 14 years (Stickel 1989). Movements of mated partners overlap broadly. Habitat use is not random; certain paths and activity centers may be used repeatedly (Weatherby 1996). Occasional forays do occur outside a home range, especially by females searching for nest sites (Stickel 1950).

Homing tendencies of box turtles are widely reported. Most adults (89.5%) found their home ranges after displacements of 800 -1200 m (Nichols 1939). Gould (1957) found that 50% moved homeward instantly when released up to 9000 m away. Long, unidirectional movements are typical (Lemkau 1970). Geomagnetism and solar cues contribute to their homing skills (DeRosa and Taylor 1980, Mathis and Moore 1988).

Winter Hibernation

Box turtles overwinter on land and hibernate when mean ambient temperatures drop below 16° C (Dolbeer 1971). Hibernation often follows first killing frosts (Schwartz and Schwartz 1974). Exposure to sudden temperature drops is a liability of terrestrial hibernation that may require longer inactivity than aquatic turtles. In Connecticut, box turtles are active between April 25 and October 22 (Klemens 1993). Hibernation periods of eastern box turtles averaged 141 - 142 days in both Ohio (Claussen *et al.* 1991) and New York (Madden 1975), and up to 168 days in Maryland (Stickel 1989).

Most box turtles hibernate in their summer home range (Dolbeer 1971, Schwartz and Schwartz 1974, Stickel 1989). No more than four are known in a hibernaculum (Ernst and Barbour 1972). In Oklahoma, three-toed box turtles hibernate with snapping turtles (*Chelydra serpentina*) and ornate box turtles (Carpenter 1957). Three-toed box turtles in Kansas often use communal hibernacula (Metcalf and Metcalf 1979). Many hatchling turtles survive brief freezing exposure (Packard *et al.* 1999) since they overwinter in the nest (Ernst and Barbour 1972, Behler and King 1979).

Hibernacula used by older turtles are typically under cover of logs, shrubs, brush piles, or leaf litter (Carpenter 1957). When entering hibernation, box turtles burrow into loose soil, sand, detritus, mud of ponds or streams, mammal burrows, or stump holes. Many use one hibernaculum in successive winters (Madden 1975, Stickel 1989). Some do not exhibit this fidelity and venture beyond their summer range (Gaines *et al.* 1996).

Hibernacula of eastern box turtles in Ohio were in woodland edges <10 m from grasslands at depths averaging only 4 - 5 cm (Claussen *et al.* 1991), but they may burrow up to 48 cm deep as the soil temperature drops (Cahn 1933, Dolbeer 1971).

Their orientation inside winter dens changes with air and soil temperatures (Congdon *et al.* 1989) and during spring emergence (Wetmore 1920, Allard 1935).

Many cite anecdotal evidence of high winter kill by freezing (Cahn 1933; Allard 1935, 1948; Neill 1948; Schwartz and Schwartz 1974; Metcalf and Metcalf 1979), but the extent of this phenomenon is debated (Grobman 1990). Losses likely occur only after prolonged subzero temperatures in hibernacula (Claussen *et al.* 1991). Warm spells in winter or early spring may cause premature emergence, and some are killed by rapid temperature declines (Ernst and Barbour 1972). Others may enter a new hibernation site (Allard 1935, Carpenter 1957). Change of winter burrows may occur early or late in the hibernation season (Congdon *et al.* 1989). Emergence followed five consecutive days of underground temperatures $>7^{\circ}$ C in Missouri (Grobman 1990).

Recent studies demonstrate that eastern box turtles can tolerate nearly complete freezing for periods of time during the winter (Costanzo and Claussen 1990; Storey and Storey 1988, 1992; Storey *et al.* 1993). Core body temperatures as low as -3.6° C, freezing periods of up to 73 hours, and ice contents as high as 58% of total body water are recorded for the species. Physiological adjustments by the liver boost the glucose content of vital organs and minimize extracellular ice formation (Storey 1990).

Reproductive Ecology

Box turtles mature at ages of 4 - 5 years in Kentucky (Ernst and Barbour 1972), 5 - 7 years in Pennsylvania (Shaffer 1991), 5 - 10 years in Indiana (Minton 1972), and approximately 20 years in the Northeast (Klemens 1993). At earliest maturity, carapace length is 10 - 13 cm (Carr 1952). Males grow more rapidly than females, and growth

rates lessen with advancing age (St. Clair 1998, Stickel and Bunck 1989).

Courtship and mating occur throughout warm periods from April into fall months (Stickel 1989). Peak sperm production occurs in July and August (Altland 1972). After ritualized mating behavior (Cahn and Conder 1932, Evans 1953), the male mounts a female and intromission occurs. A male can die after copulation by falling backwards in places where it cannot right itself (Allard 1935). Females may not breed every year (Legler 1960, Doroff and Keith 1990), but can store sperm and lay viable eggs for up to 4 years after mating (Ewing 1943). Egg output of western box turtles (*T. ornata luteola*) varies in response to environmental stresses (Nieuwolt-Dacanay 1997).

Nesting occurs from June to July in New England (DeGraaf and Rudis 1983). Females are very mobile prior to egg laying and may extend their home range (Stickel 1950, 1989). At such times, box turtles are often seen crossing roads (DeGraaf and Rudis 1983). Most nests are initiated at twilight and completed after dark (Ernst and Barbour 1972). *T. c. carolina* normally nests in cavities dug 8 cm below the surface in sandy or loamy soil with little vegetation or overhead cover (Allard 1948). Females put soft litter around eggs before covering a nest with excavated soil (Messinger and Patton 1995). Some use the same nest location for several years in succession (Stickel 1989).

Clutch size varies from 3 to 9 eggs and averages 4 - 5 (Ernst and Barbour 1972). Eggs are elliptical, thin-shelled, and ≤ 3 cm long (Shaffer 1991). Ewing (1943) reported a fertility rate of 78.6%. In New England, there are no records of multiple clutches in a year (Klemens 1993) as occurs in southern regions (Ewing 1935, Reimer 1981).

Incubation period is temperature dependent and is influenced by microhabitat (*i.e.*, soil, air temperature, solar exposure) of the nest site. Clutches at the same site in

Connecticut hatched after incubations intervals of 100 days one year and 123 days the next (Klemens 1993). Eggs generally require at least 87 - 89 days (overall range = 69 - 136 days) before hatching (Allard 1935). Sex determination in box turtles may be temperature dependent as in some other turtles (Vogt and Bull 1982).

Survival and Longevity

Most terrestrial turtles exhibit high hatchling and juvenile mortality that is offset by unusual longevity of a few individuals (Auffenberg and Iverson 1979). Juveniles comprised >15% of a healthy population in Florida (Dodd *et al.* 1991). Survival to 20 years of age was 15.6 - 36.0% (males) and 13.8 - 15.6% (females) among eastern box turtles in Indiana (Williams and Parker 1987). Patterns were similar in Maryland (Stickel 1978). Yahner (1974) cited 79.5% annual survival in Tennessee. Nearly identical rates (81 - 82%) were found in ornate box turtles from Wisconsin (Doroff and Keith 1990) and a study of three-toed box turtles in Missouri (Kiestler *et al.* 1982). Substantially lower survival was noted in another Missouri study (Schwartz and Schwartz 1974), as well as among ornate box turtles in Texas (Blair 1976) and Kansas (Metcalf and Metcalf 1985).

Longevity of box turtles is legendary. Many live 60 - 80 years (Nichols 1939, Schwartz and Schwartz 1991), and a few reputedly lived >100 years in New England (Graham and Hutchinson 1969). Many longevity records are derived from a practice of people carving a year on the plastron of a captured turtle. One *T. carolina* marked in this manner apparently lived 138 years in the wild (Oliver 1955). Causes of death most often cited among older turtles include human-related losses (e.g., vehicles, mowers, and farm equipment) and extraction from hibernacula by carnivores (Klemens 1993).

MANAGEMENT

Regulatory Authority

Federal jurisdiction is limited. All box turtles (*Terrapene* spp.) were added to the Appendix II of the Conservation on International Trade in Endangered Species of Wild Fauna and Flora (C.I.T.E.S.) on February 16, 1995 (Levell 1997). Appendix II of this treaty requires permits for importing or exporting listed species in order to (1) track international trade amongst 130 participating nations and (2) evaluate such trade as a threat of extinction. Also, live turtles <10 cm in carapace length and viable turtle eggs cannot be imported, sold, held for sale, or held for distribution except for scientific, educational, or exhibition purposes. Appropriate exhibition does not include the pet trade or any form of export program. This regulation relates to public health concerns from *Salmonella* transmission to man from turtles (U. S. Food and Drug Administration 21 CFR 1240.62; U. S. Public Health Service 42 CFR 71.52).

Enabling state statutes (12 MRSA Chapter 713) direct MDIFW to "preserve, protect and enhance the inland fisheries and wildlife resources of the state; to encourage the wise use of these resources; to ensure coordinated planning for the future use and preservation of these resources; and to provide for the effective management of these resources" (§7011). "Wildlife" is defined as "any species of the animal kingdom, except fish, which is wild by nature, whether or not bred in captivity, and includes any part, egg, or offspring thereof or the dead body parts thereof" (§7001).

Nevertheless, state law provides only minimal protection for most reptiles. The first restrictions on take or possession of snakes and most turtles from the wild were

bans on export, sale, or commercial uses enacted in 1993 (§7471). Wildlife (including reptiles) may be possessed for other uses in Maine, if appropriate permits are obtained:

- “exhibition” = any person intending to keep, purchase, sell, or transport wildlife for either exhibition or attracting trade (§7231);
- “transportation” = any person intending to take or transport wildlife within the state for breeding or advertising purposes (§7241);
- “importation” = import, receive, or introduce wildlife (§7237).

Scientific collection permits are not necessary to hunt, trap, possess, band, or transport reptiles or amphibians in Maine since §7242 applies only to "wild animals" (defined as mammals, by statute) and wild birds. Similarly, MDIFW has no jurisdiction for rehabilitation permits (§7235-B) issued for most reptiles or amphibians. MDIFW regulations (Chapter 7) govern the housing, care, and health standards for captive animals as well as criteria for determining that wildlife importation does not threaten native wildlife or humans. Such animals may not be displayed in licensed pet shops.

Special protection for this species in Maine stems from designation of *Terrapene carolina* (including the subspecies of concern, *T. c. carolina* = eastern box turtles) as “endangered” (§7753). It has been a state endangered species since Maine’s inaugural listing of vertebrate wildlife in 1986. Prohibitions for box turtles and other wildlife under Maine’s Endangered Species Act (1975) and a 1987 amendment include (§7756):

- hunting, trapping, or possession in the state;
- deliberate feeding, baiting, or harassment (except for educational or scientific purposes intended to enhance its survival or propagation);
- transport, delivery, carry, ship, sale, offering for sale or processing; and

- export from the state.

Incidental take is a new provision (§§7756.2-C, D) enacted in 1999 stipulating that lawful activities that do not threaten the recovery of listed species may occur under a plan that minimizes such takings and is approved by the Commissioner.

A 1988 amendment to Maine's Endangered Species Act (§7755) created a mechanism for habitat protection. When implemented, special rules enable oversight of state and municipal functions potentially affecting the listed species in designated areas. These "essential habitats" are locales currently or historically providing physical or biological features essential to the conservation of the species and which require special management consideration. Essential habitats are defined and mapped by rule. Protection guidelines are promulgated by state rulemaking procedures. These rules direct that "a state agency or municipal government shall not permit, license, fund, or carry out projects within an essential habitat without review by MDIFW."

The Natural Resources Protection Act (38 MRSA Article 5-A) is also applicable. Habitats of endangered or threatened wildlife, including eastern box turtles, may be mapped for designation as "significant wildlife habitats." This statute, administered by Maine's Department of Environmental Protection (MDEP), requires permits for any alteration of soils, waters, vegetation, or permanent structures in a protected natural resource (§480-C), including significant wildlife habitats (§480-B).

To date, essential habitat and significant wildlife habitat have not been defined for eastern box turtles. Both designations provide advance notification of threatened or endangered species issues enabling MDIFW review and consultation with property owners or development interests. Case-by-case evaluations are subsequently based

on regulatory standards promulgated by state rulemaking procedures.

The Site Location of Development Act (38 MRSA Article 6) is among the few laws pertinent to protecting potential box turtle habitat such as shorelands, open woodlands, old field settings, etc. “Developments of state or regional significance that may substantially affect the environment” (e.g., those >20 acres, mineral extraction’s, most subdivisions >20 acres, transmission lines >100 kV, and several other large-scale projects; §§482, 487-A) require approval by MDEP or certified municipalities.

Another relevant statute is the Farmland Registration Act (7 MRSA Chapter 2-B). It discourages incompatible development of a 100-foot buffer on lands abutting registered farmlands (§56) and insures disclosure during adjacent realty transactions (§55). The Farm and Open Space Tax Law (36 MRSA: Part 2, Chapter 105) offers incentives to those interested in long-term conservation of farmlands, such as devaluation on property tax liability (§§1105-1106) and easement opportunities (§1111).

Maine’s Comprehensive Growth Management Act (30-A MRSA) lists state goals to guide local comprehensive planning and land use management, required in all municipalities (§§4312, 4321). The overall theme is to promote orderly development. Approved plans must include: “protection of the state’s other critical natural resources, including without limitation, wetlands, wildlife and fisheries habitat ...” Strategies that might benefit eastern box turtles include the maintenance of rural character and a minimization of sprawl in Maine communities. Both issues are currently being addressed as methods of effectively implementing land use plans. The Land Use Regulation Commission (12 MRSA) administers a comprehensive plan with similar purposes (§§685A-C) for “wildlands” in the state’s unorganized townships.

Past Goals and Objectives

MDIFW has not previously established specific goals and objectives for box turtles. Efforts undertaken thus far adhere to the basic theme of Maine's Endangered Species Act: to maintain the species as part of Maine's traditional wildlife heritage.

Past and Current Management

Eastern box turtles in Maine have received little direct management attention. Most recent records were obtained via the Maine Amphibian and Reptile Atlas Project conducted from 1984 to 1988 (Hunter *et al.* 1992, 1999). These data and a few additional sightings (Appendix) are compiled in MDIFW's Biological Conservation Database. Reputable records are included in Maine's Habitat Consultation Areas Mapping Project in order to identify sites with potential management concern and also are submitted to towns in Maine preparing comprehensive plans.

There have been no studies of box turtles or their habitats in Maine. Acquisition of 243 ha of uplands near Killick Pond by the Land for Maine's Future Board in 1987 protected a premiere habitat for the species. Managed by MDIFW as the Maynard Marsh Wildlife Management Area (Eldridge 1996), this parcel abuts properties owned by the Maine Department of Conservation, the Maine National Guard, and The Nature Conservancy. The combined 950 ha of open space in Hollis and Limington, York County is one of only 2 settings in Maine with multiple reports of box turtle occurrences. To date, there have been 3 enforcement actions involving the confiscation of box turtles kept as pets, but given their popularity in the pet trade, more box turtles (primarily imports?) are probably being held illegally in Maine.

HABITAT ASSESSMENT

Historic Trends

The few insights on eastern box turtles in Maine limit habitat analyses. Habitats frequented by the species elsewhere in its range (bottomland forests, old fields, and grassland - woodland ecotones) have changed markedly across the state over time. Native Americans and European settlers both created a patchwork of forest clearings in colonial Maine (Cronon 1983). Impacts from conversions of upland forests to farms, prevalent during the 1800's, are unknown. Ornate box turtles primarily use grasslands and prairies in the Midwest but avoid agricultural croplands (Doroff and Keith 1990).

The 1880 agricultural census tallied 591,865 ha of farmlands over the traditional range of eastern box turtles in 3 southern Maine counties: York, Cumberland, and Oxford. Farmlands diminished by 85% in these counties during the next 100 years. Most of the statewide decline, 76%, occurred since 1925. Through 1980, reforestation accounted for 72.5% of the reduction in farmland; the remainder experienced only rural development (Benson and Frederic 1982). Since reverting farmlands are frequented by box turtles, the prevailing 20th century land use trends in Maine seem favorable.

Current Assessment

Twelve recent occurrences of apparently wild eastern box turtles in southern Maine (see Appendix) fit the image of wet settings near open woodlands. Six were in residential neighborhoods. A habitat suitability model and quantified habitat indices are not yet possible without better documentation of box turtle status and habitats in Maine.

From 1987 to 1997, farmland acreage declined by >14% in 3 counties where eastern box turtles potentially occur. Conversions of rural land in many southern Maine communities increasingly involve industrial, commercial, and high-density residential developments (Benson and Frederic 1982). Although box turtles use diverse habitats, changes to intensive land uses erode the local carrying capacity by reducing the quality (and possibly, the quantity) of suitable settings.

Despite changing land uses over time, woodlands remain the dominant feature of Maine's landscape throughout recorded history. Some southern Maine farmlands revert to forests. A modest increase from 74% to 81% was recorded during 1960 -1982 (Ferguson and Longwood 1960, Powell and Dickson 1984). As much as **208,825 ha** of hardwood forests in York and Cumberland County appear to be potential habitat. Edge indices are greater in York County than any other region in Maine (Brooks *et al.* 1986). Woodland ecotones are typical habitat for eastern box turtles, but fragmentation from roads and housing are setbacks. Suburban and urban sprawl is prevalent in southern Maine: only eight of 49 towns in York and Cumberland County are now classed as "rural," twenty are "emerging suburban" areas, and twenty-one are urban / suburban.

Projections

The Maine State Planning Office predicts >0.85% annual growth of human populations in York and Cumberland Counties through 2010, rates 20% greater than the 1990 - 1998 average. Among 49 townships in these 2 counties, only five are likely to retain rural character by 2010. Only two rural townships are projected in southern Maine by 2050 if existing patterns of development continue.

POPULATION ASSESSMENT

Historic Trends

John Josselyn (1672) was the first to record box turtles in Maine. He noted them in Scarborough: "... The right land turtle; they are found in dry banks, under old houses and never go into the water." Norton (1929) believed "the right land turtle" to be *T. c. carolina*. The first catalogue of reptiles in Maine (Fogg 1862) lists *Cistudo virginica* (a.k.a. box turtles, *T. c. carolina*) as present in Maine but mentioned no localities. Babcock (1919) stated that the box turtle was present in all New England states, including Maine, but was not abundant in the region. No other data are available.

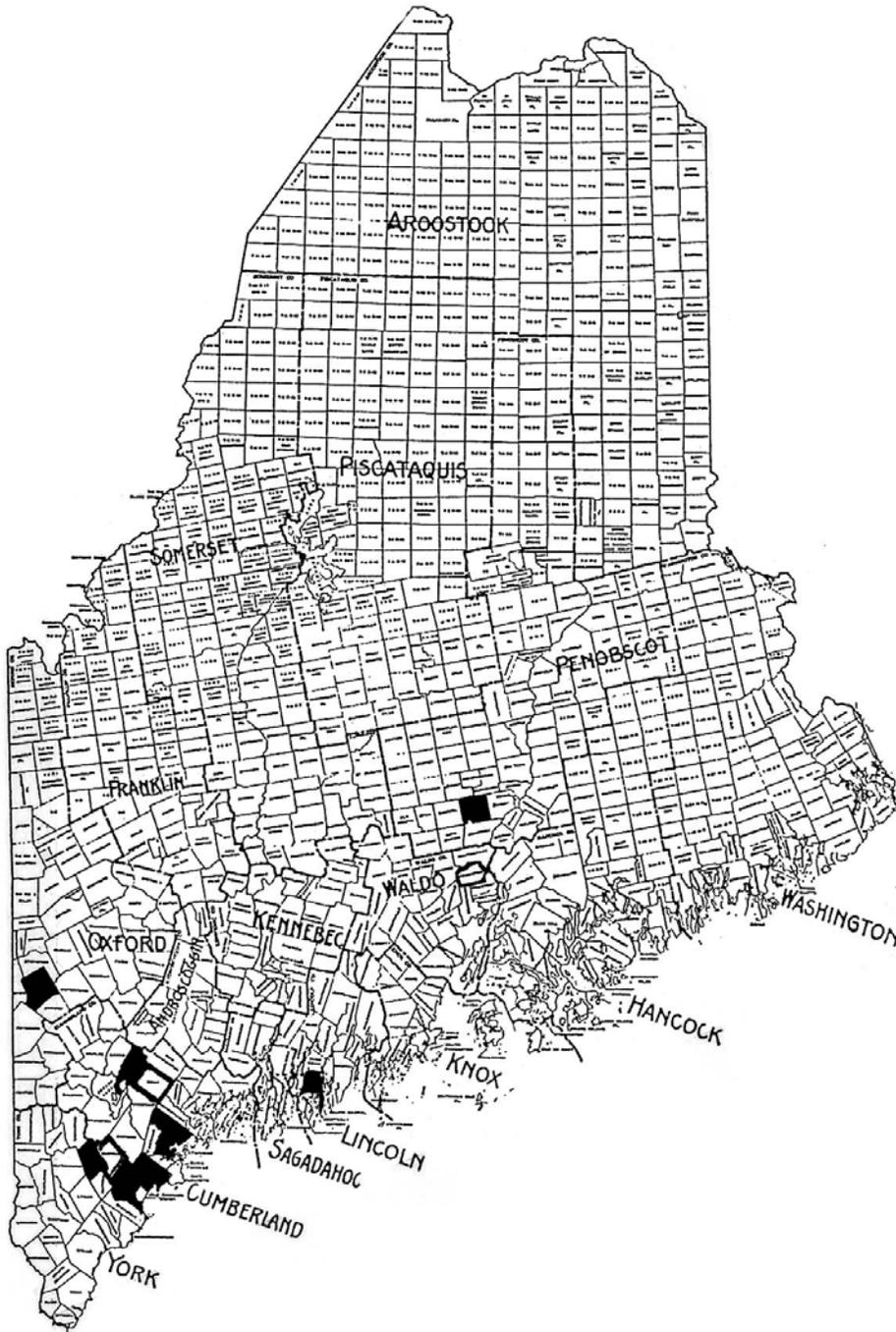
Current Assessment

Little has been learned about box turtles in Maine since they were reported 3 centuries ago (Josselyn 1672). Since, formal documentation began during the Maine Amphibian and Reptile Atlas Project (Hunter *et al.* 1992, 1999), only 11 specimens from 10 sites have been photographed or verified by experts (Figure 3, Appendix). As many as eight are either known or suspected to be released turtles. Another 13 recent reports are credible but not documented by specimen or photograph, and some are also dramatic range extensions or in circumstances otherwise suggestive of releases.

Box turtles are frequently kept as pets. Encounters with single individuals may only imply escaped or released pets, especially at or beyond the species' traditional range limits (Klemens 1993). As yet there is no way to determine whether box turtles found recently in Maine are remnants of a native population or introduced. There are

Figure 3. Potential range of the eastern box turtle in Maine.

- recent reports (> 1980)
- historic report (< 1980)
- suspected releases



no recently documented sightings of young box turtles in the state.

The traditional distribution of box turtles in Maine is uncertain. Many depict York and Cumberland Counties in southern Maine as the northern extent of the species' range (Ernst and Barbour 1972, DeGraaf and Rudis 1983, Conant and Collins 1991). However, confirmed sightings from Hermon (Penobscot County) in 1986 and again in 1988 and an unconfirmed report in nearby Frankfort (Waldo County) would extend the species' range by 150 km northeast (Figure 3, Appendix). A valid 1995 encounter in Rumford (central Oxford County) suggests a 70 km northerly extension of documented range and bolsters credibility of 3 unverified reports in southern Oxford County.

Numbers and trends of box turtles in Maine are unknown. Other than reports to the Maine Amphibian and Reptile Atlas Project (Hunter *et al.* 1992, 1999), there have been no coordinated efforts to collect site, population, habitat, or biological information on this species. Intensive studies of other turtles in southern Maine failed to yield any additional box turtle encounters. Considered rare over all but a few portions of New England early in the 20th century (Babcock 1919), many examples of local population decline have been cited recently (DeGraaf and Rudis 1983).

Long-term studies of box turtle populations have clearly documented substantial declines in recent decades. In Maryland, numbers of *T. c. carolina* declined by 40% during 1945-1975 (Stickel 1978) and 75% during 1945-1995 (Hall *et al.* 1999). Altered hydrology and periodic flooding are foremost causes. Williams and Parker (1987) reported a 50% reduction among *T. c. carolina* in Indiana between 1970 and 1983. Another rapid loss, 43% during 1965 -1973, occurred in a *T. c. triunguis* population in Missouri (Schwartz and Schwartz 1974). Dramatic range losses are cited in Michigan

(Harding and Holman 1990). Habitat loss and degradation were the primary reasons given for losses in these latter studies in the Midwest.

Projections

Rarity has proven to be the best predictor of vulnerability to extinction (Terbourgh and Winter 1980). A minimum viable population size has yet to be determined for box turtles but is thought to be in the range of 500 - 1000 individuals for many species (Thomas 1990). In small, isolated populations the probability is great that numbers inevitably fluctuate low enough to enter "extinction vortices" and ultimately decline to extinction (Gilpin and Soule 1986). For long-live species like turtles, remnants of vanishing populations may persist for >100 years before extirpation inevitably occurs.

Rare species are particularly sensitive to habitat fragmentation. Fragmented populations are less able to survive stochastic fluctuations. Further setbacks in the quantity, quality, or connectiveness of suitable habitats in Maine could jeopardize genetic interchange of small, disjunct populations. Population declines, range reductions, and even local or statewide extirpation are immediate risks for this species.

Limiting Factors

Factors limiting box turtles in Maine and New England are unknown and require further study. The species may be limited in Maine, the northward extent of its range, by winter mortality related to subterranean soil temperatures especially the depth, duration, and intensity of freezing. Turtle reproduction can be impaired by natural and climatic factors as well. Prolonged wet spells and poor drainage of soils with a high

clay content reduce hatchability (Messinger and Patton 1995).

Like other endangered and threatened species, box turtles may be limited by habitat loss and degradation. Habitat fragmentation, especially in southern Maine, may isolate populations and thus increase their probability of extinction (Gilpin and Soule 1986). Fragmentation also alters patterns of habitat use: roads block migration routes to nesting areas or winter hibernacula (Gaines *et al.* 1996). Many sightings of box turtles in Maine are of individuals crossing roads. Increased vehicle traffic on roads bisecting box turtle habitat may be a major source of mortality and deplete populations (Stickel 1950, DeGraaf and Rudis 1986). Even when suitable habitats are physically maintained, functional values can diminish and lead to declining turtle populations because of intense human recreation pressures (Garber and Burger 1995).

USE AND DEMAND ASSESSMENT

Historic Trends

Direct interactions between people and eastern box turtles appear to have been infrequent in Maine. Josselyn (1672) reportedly labeled them “the right turtle” because “They are good for the ptisic and consumptions, and some say for the morbus gallicus.” The ailments “ptisic” and “morbus gallicus” escape contemporary definition, but it is clear that they were attributed medicinal values in colonial Maine, as elsewhere. In other areas of the Northeast, pre-colonial use of box turtle populations may have extirpated them from much of their former range in western New York (Adler 1968, 1970). The species was prominent in Iroquois Indian culture. The generic name *Terrapene* is derived from the Algonquin word for “turtle.”

Box turtles have always been highly valued as pets but became prominent in commercial trade. There are no indications of “take” in Maine of wild turtles as pets, owing mostly to low numbers and scant knowledge of them. Easily captured when seen, they are often kept as pets across their range. Some box turtles in Maine are released transplants and pose potential threats to native turtles. Local overcollections are widely reported elsewhere in their range. Concerns escalated when the pet trade in Eurasian markets shifted to North American box turtles after bans on tortoises. Annual exports of *T. carolina* and *T. ornata* averaged >23,000 and 11,800 (respectively) nationwide during 1992 - 1995 (U.S. Fish and Wildlife Service 1996). The value of a box turtle in western Europe ranged up to \$100 (Lieberman 1994).

Current Assessment

Opportunities to observe wild box turtles are likely confined to southern Maine, primarily York and Cumberland Counties. Very few individuals encounter them, but some enjoy seeking box turtles. General interest in Maine's herpetofauna has grown, especially as a result of projects like the Maine Amphibian and Reptile Atlasing Project (Hunter *et al.* 1992, 1999). Box turtles contribute to the biological diversity of our state, and their presence adds to the ecological values of uplands in southern Maine's changing landscape. Approximately 91% of resident adults engaged in some non consumptive use of wildlife and spent > \$50 million in 1988 (Boyle *et al.* 1990). This intrinsic value of box turtles as a rare element of Maine's wildlife heritage is the basic theme in the preamble to the Maine Endangered Species Act (1975):

"The Legislature finds that various species of fish or wildlife have been and are in danger of being rendered extinct within the State of Maine, and that these species are of esthetic, ecological, educational, historical, recreational and scientific value to the people of the State. The Legislature, therefore, declares that it is the policy of the State to conserve, by according such protection as is necessary to maintain and enhance their numbers, all species of fish or wildlife found in the State, as well as the ecosystems upon which they depend."

In addition to biodiversity issues, box turtles garner much notoriety themselves. As one of the most popular pets in the world, widespread public familiarity ultimately leads to greater appreciation and concern for the species. The "Box Turtle Research and Conservation Newsletter" has been published since 1994. Scientists examine box turtles for ecological and evolutionary insights. These interests include its apparently transitional nature between aquatic and terrestrial lifestyles (*c.f.*, Summers *et al.* 1998),

cold adaptations by an ectothermic animal (*c.f.*, Storey 1990), orientation / homing skills (*c.f.*, Mathis and Moore 1988), locomotion studies (*c.f.*, Marvin and Lutterschmidt 1997), phylogeny (*c.f.*, Burke *et al.* 1996), important agents of seed dispersal (Rust and Roth 1981, Braun and Brooks 1987), and ecological roles in community productivity (*c.f.*, Dodd 1998).

Projections

Recent trends will likely continue for the foreseeable future. Public demand will promote conservation of the greatest diversity of species possible at state, national, and global levels (Kellert 1980). These desires reflect increasing public perception of the scientific, utilitarian, and cultural values of biological diversity. Many side with ethical arguments for preserving species that are endangered by the actions of society. Even inconspicuous species, such as eastern box turtles, will gain importance because of their role as "flagship" species by virtue of their rarity (Gibbons 1988).

SUMMARY AND CONCLUSIONS

The eastern box turtle has been listed an "endangered species" by MDIFW since 1986. Although box turtles are terrestrial, easily identified, and often caught, sightings in southern Maine accrue only at the rate of one or two per year. Historical evidence suggests that box turtles are native to the state and may have persisted for centuries despite having always been rare in Maine and perhaps limited by ecological factors.

Box turtles are likely the rarest reptile in Maine. Basic information on the status and ecology of this species in Maine is nonexistent. It is crucial to learn whether viable box turtle populations in Maine exist, their demography, and habitat requirements. Natural limiting factors have a major influence in Maine. The role of subterranean soil temperatures and depth of freezing as limiting factors for box turtles in the northern part of their range needs further investigation.

The status of the species is unclear in other northern regions. Ontario (Johnson 1989), Vermont (DesMeules 1997), and New Hampshire (Taylor 1993, 1997) have all been depicted as part of the species' traditional range, but (like Maine) cannot clearly document an extant wild population. Transplanted pets which escape or are released confuse status evaluations in these and many other jurisdictions (Smith 1961, Klemens 1993). Furthermore, they pose serious threats to remnant wild populations (Belzer 1996, Tynning 1997).

Eastern box turtles have been intensively studied in many areas. Local declines are widespread through their range. Optimal habitats include large contiguous blocks of hardwood-predominated forests and associated seral stages. Fragmentation from

roads and land use conversions to intensive agriculture or residential developments are widely associated with local setbacks for the species. Perhaps analogous to Maine, the species has disappeared from much of its range in Michigan (Harding and Holman 1990). Roadless blocks of upland habitats ≥ 100 ha are prescribed for endangered ornate box turtles in Wisconsin (Doroff and Keith 1990).

Concerns for box turtle conservation soared during commercial harvesting and exports. Despite regulations in many states, at least ten reported illegal trade and a total of sixteen cited evidence of decline (Lieberman 1994). All box turtles species were C.I.T.E.S. - listed in 1996 to monitor the impact of exports and prevent extinction due to international trade. Overcollections exacerbate the impacts of habitat loss. Models suggest that annual adult mortality rates $>5\%$ lead to long-term population declines (Doroff and Keith 1990).

Eastern box turtles (*T. c. carolina*) are also listed as “endangered” in Indiana and “special concern” in Massachusetts and Michigan. Their designations as “protected” or “controlled” provide protection from take or importation in New Hampshire, New Jersey, New York, and Rhode Island (Levell 1997). Related species are listed elsewhere, symptomatic of the vulnerability of turtle populations and their rapid demise in recent times (Tynning 1997). Ornate box turtles are designated “endangered” in Wisconsin and “threatened” in Iowa. The Coahuilan box turtle or aquatic box turtle (*T. coahuila*) in Mexico is recognized as endangered under the U. S. Endangered Species Act.

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APPENDIX 1.

Appendix 1. Historic and recent records¹ of eastern box turtles in southern Maine, by county and township.

County Township	Month /Year	No. of racers ²	Location: Habitat	Source ³
Cumberland County				
Baldwin	7/1993	[1]	Gull Brook: on Burnell Road - mixed woods, swamp	MDIFW (<i>fide</i> Mayo)
Cumberland	8/1986	[1]	Piscataqua River - crossing road near fields, mixed woods, residential	MARAP (<i>fide</i> Dyer)
Gray	10/1989	1	Gray Meadow: Rt 115, small woodlot, residential	MARAP (<i>fide</i> Albright)
Raymond	6/1987	1	Thomas Pond outlet: on Hawthorne Road	MARAP (<i>fide</i> Fricker)
Scarborough	1672	?	locally resident	(Josselyn 1672)
	9/1988	1	Nonesuch River: Scotow Bog south of Rt. 114 bridge	MARAP (<i>fide</i> Hunter)
Oxford County				
Albany	7/1984	[1]	Songo Pond: open woodlands, roadside	MARAP (<i>fide</i> Wight)
Brownfield	9/1985	[1]	Burnt Meadow Pond: sandplain, mixed woods	MARAP (<i>fide</i> Kamys)
Lovell	7/1985	[1]	Farrington Pond: north end - mixed woods, bogs	MARAP (<i>fide</i> Moore)
York County				
Hollis	1970's	[>1]	Killick Pond outlet: dirt road, streamside & open	MDIFW (<i>fide</i> Pancoast)
	1988	[1]	woodlands	MDIFW (<i>fide</i> Pancoast)
	8/1990	[1]	" "	MDIFW (<i>fide</i> Pancoast)
Saco	10/1989	[1]	Goosefare Brook: mixed woods, residential	MARAP (<i>fide</i> Jurgen)
Sanford	7/1998	[1]	Old Falls Pond: crossing Whicher's Mills Rd.	MDIFW (<i>fide</i> Mitchell)
York	5/1993	1	York Village: suburb, hayfield, and woodlands	MDIFW (<i>fide</i> McCollough)

¹ Excludes dubious reports = dramatic range extensions and apparently released turtles: Cumberland Co. - Long Island (1977, 1984, 8/1997; *fide*); Franklin Co. - New Vineyard (, Hunter *et al.* 1992); Kennebec Co. - Skowhegan (9/1994, *fide* Townsend); Lincoln Co. - Boothbay Harbor (7/1988, *fide* Schick); Oxford Co. - Rumford (7/1995, *fide* Klemens) Penobscot Co. - Hermon (9/1986, 1988 *fide* Lucey); Piscataquis Co. - Katahdin Iron Works (10/1997, *fide* Dow, Weik); Waldo Co. - Frankfort (1989,);

² Occurrence in brackets aren't documented by specimen, photograph, handling or verification by experienced observers.

³ Organizational sources: MARAP = Maine Amphibian and Reptile Atlas Project, MDIFW = Maine Department of Inland Fisheries and Wildlife.