Threats to Spotted Turtle (*Clemmys guttata*) Habitat in Ohio[1]

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ABSTRACT. Spotted turtles (*Clemmys guttata*) primarily occupy permanent wetlands. Populations of these turtles have declined, mainly as a result of predation, collection, and habitat loss (Ohio has lost more wetlands than any other state, with the exception of California). This study involved the identification and qualitative analysis of known (recent and past) spotted turtle habitats in Ohio. We checked for presence of invasive plant species, which consisted of honeysuckle (*Lonicera* spp.), buckthorn (*Rhamnus* spp.), and cattails (*Typha* spp.), as well as local and regional habitat fragmentation in these areas. We noted if sites had been developed or otherwise changed, which would result in the local extirpation of the turtles. We visited 48 of 50 previously identified Ohio *C. guttata* habitats, of which 8 had been developed and were no longer habitable. Of the remaining sites, 57% had significant invasive species, 64% were regionally fragmented, and 51% showed signs of intrasite fragmentation. Only 5% (2 sites) showed no site-specific threats. Thus, most Ohio habitats were marginal for spotted turtle populations. Isolation also threatens turtle populations. These sites are widely separated from each other within three main regions in the state, in southwestern Ohio by approximately 20 km, 5.0 km in northwestern Ohio, and 30 km in northeastern Ohio. Given the current population isolation, presence of invasive species, fragmentation, and the increase in development of habitats, we conclude that spotted turtle habitats are at risk in Ohio, and that populations in the state will continue the decline noted in previous research.

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INTRODUCTION

Spotted turtles (*Clemmys guttata*) inhabit non-tidal wetlands from Florida to the northeastern United States and west to northeastern Illinois, including southeastern Canada (Ernst and others 1994). A small and aquatic species, spotted turtles characteristically are found in shallow, mud-bottomed bodies of water, including marshes, swamps, bogs (Graham 1995), and fens (Lewis and Faulhaber 1999). In Ohio, they historically have been abundant in remnant glacial features in the northern region of the state (Conant 1951; Lewis unpublished data). Conant (1951) listed 27 Ohio locations for spotted turtles, and the Ohio Department of Natural Resources Natural Heritage Database lists 48 records dated from 1958-2000.

Biologists across the United States have reported declines in turtle populations (Garber and Burger 1995; Hall and others 1999; Ernst 2001), including spotted turtle populations (Lovich 1987). Reasons cited for decline include habitat loss, increased predation, introduction of non-native plant species, over-collection, and other human impacts (Lovich 1987; Temple 1987; Garber and Burger 1995). As a result, the spotted turtle is listed as endangered in Illinois and Indiana, and is considered a threatened species in at least four other states, including Ohio (United States Army Corps of Engineers protected turtles web site, http://www.wes.army.mil/el/emrrp/turtles/turtle.html). In addition, concerns over the status of the spotted turtle have been raised in several states that do not have a legal designation for this species (Graham 1995). These statuses either provide legal protection (as is the case for most endangered species) or reflect an awareness of small population sizes and promote research that provides more information about state populations (ODNR 2002).

Wetlands, which are favorable for spotted turtle habitat, are threatened by invasive plant species (Dickerman and Wetzel 1985), fragmentation of habitat (Bender and others 1998; Wettstein and Schmid 1999), and encroaching development and subsequent habitat destruction (Given 1990; Oleksyn and Reich 1994). This provides reason to examine these characteristics in turtle habitats, as they afford insight into habitat quality. For example, a pond that is heavily populated by multiple invasive plant species, isolated by high traffic roadways, and located close to an expanding residential area is unlikely to provide adequate long-term habitat for a *Clemmys* population.

Invasive plant species can out-compete native flora for resources and, in extreme conditions, cause these plants to disappear from the area (Clay and Levin 1986). While there are numerous invasive species found in or adjacent to *C. guttata* habitats, we categorized honeysuckle (*Lonicera* spp.), glossy (*Rhamnus frangula*) and common buckthorn (*Rhamnus cathartica*), and narrow-leaved (*Typha angustifolia*) and broad-leaved (*Typha latifolia*) cattail as “invasive” for the purposes of this study, due to the relative ease of identifying these species. *Lonicera* includes deciduous shrubs and climbing vines that bear leaves longer throughout the year than most deciduous plants (Schierenbeck and others 1994). The species are prolific due to the spread of the berries that the plants produce (Luken and Mattimiro 1991). Birds eat and deposit these fruits at locations other than the site of consumption. *Rhamnus frangula* and *R. cathartica* are shrubs and small trees (Ratcliffe 1984; Schmidt and

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Whelan 1999) that form dense thickets and prevent sunlight from reaching less competitive native plants. They are also insensitive to herbivory (Schierenbeck and others 1994) and produce seedlings that inhibit regeneration of native trees and shrubs. *Typha* spp. are aggressive rhizomatous perennials that form thick, often monospecific stands (Dickerman and Wetzel 1985). They produce considerable shading that prevents proliferation of other plants. Vigorous growth allows *Typha* individuals to outcompete and exclude other species, and a relatively high photosynthetic rate allows for the domination of available resources (Dickerman and Wetzel 1985). The combination of these factors increases the invasiveness of cattails. Hybrids between *T. angustifolia* and *T. latifolia*, a native and the less invasive species of cattail, are frequent (Fasset and Calhoun 1952), making species delineation difficult. Therefore, some caution should be taken in considering cattail data alone as an indication of low quality habitat. Regardless, *Typha* spp. are not favorable in spotted turtle habitats.

Local and regional fragmentation (within and confining an area, respectively) threaten wetlands by isolating smaller areas (Mangel and others 1996). Extensive fragmentation separates wildlife habitats and their respective populations from each other, which prevents genetic mixing with other populations due to geographic distances and barriers. Loss in gene flow on a small scale and elimination of the species on a larger scale lead to a decrease in genetic diversity (Templeton and others 1990), fitness (Westemeier and others 1998), and species richness in such fragments (McCoy and Mushinsky 1994).

While few individual spotted turtle populations and habitats have been studied long-term in Ohio (Lewis and Ritzenthaler 1997; Lewis and Faulhaber 1999) or elsewhere (Ernst and Zug 1994), there have been no published attempts other than Conant (1951) to consider spotted turtles at a statewide level. The purpose of this study is to identify current and potential threats to known spotted turtle habitats (from the Natural Heritage Database and personal communication) in Ohio.

MATERIALS AND METHODS

The Ohio Department of Natural Resources (ODNR), Division of Natural Areas and Preserves (DNAP) maintains a database of state-listed species sightings in their Natural Heritage Database. These data include the individual who reported the sighting, the date and location (both directions to the site and longitude and latitude to the nearest minute) of the sighting, and the ownership of the site. These database records are dated from 1958 until 2000. We utilized aerial photographs and topographic maps in order to locate the sites. We obtained owner permission to go onto the land or, if permission could not be granted, we surveyed the land from a distance. Due to the small size of most habitats, this distance rarely exceeded 50 m.

We visited 46 of 48 historic reported locations between February 1999 and October 2000 and recorded local and regional habitat conditions. In addition, two sites not in the DNAP records were included, both of which were identified through personal communication during the study (Fig. 1). One site, Springville Marsh, included two sightings at different locations, and each was treated independently of the other (Table 1). Site ownership was determined from the site records and supplemented by locally apparent information such as signage. We recorded ownership as ODNR, private ownership, local government, The Nature Conservancy (TNC), or National Park Service (NPS), in order to determine if ownership dictated quality of habitats. At each site, we determined human use, on-site facilities, adjacent land use, current development, extent of fragmentation, and presence or absence of invasive plant species. Several photographs were taken at each site to validate our observations.

The presence or lack of invasive plant species, fragmentation at the site, and development within 100 m of the habitat were noted. If bush honeysuckle (*Lonicera* spp.), buckthorn (*R. frangula* or *R. cathartica*), or cattails (*T. angustifolia* or *T. latifolia*) inhabited the area in significant clusters (≥3 groups of at least 10 individual plants each), it was designated as containing invasive species (ODNR 2001). Fragmentation was assessed on two spatial scales. We defined local fragmentation as intrasite obstacles that would hinder turtle movements (Collinge 1996) from one part of the habitat to another (for example, banked path, non-raised boardwalk, railroad) or would facilitate predator-related edge effects (for example, a strip of woody vegetation through a wetland). Regional fragmentation is used to describe major obstacles that separate habitats from each other, thus isolating populations (for example, roads, development). Both of these reductions in turtle movements increase risks of genetic isolation (Templeton and others 1990).

RESULTS

Spatial analysis of the spotted turtle habitats in this study yielded distances between clusters of the sites (Fig. 1). These areas, known to have contained spotted turtles, are widely separated within three main regions in the state, in southwestern Ohio by approximately 20 km, 5.0 km in northwest Ohio, and 30 km in northeastern Ohio.

The ownership of the 48 sites was limited mostly to ODNR (n = 19) and private land (n = 20), which provides reason to examine these two types of ownership while excluding others (local government, TNC, and so forth) in determining if ownership dictates habitat quality (Table 1). Local fragmentation was similar at ODNR and privately owned sites, with 11 and 10 cases, respectively. Regional fragmentation was present at 13 sites with ODNR ownership and 13 sites with private ownership. Invasive plant species were present at more ODNR sites (n = 17) than at private areas (n = 7). Privately owned areas exhibited development at 7 sites, whereas one ODNR site had encroaching development.

Of the 48 sites visited, development or habitat alteration eliminated the potential for *C. guttata* populations in 8 sites (17%) to the point that we could no longer classify the habitat as a wetland under any reasonable definition or classification (for example, a parking lot or

FIGURE 1. Statewide distribution of *C. guttata* habitats (n = 50) according to sites listed in the Natural Heritage Database (n = 48) and those from personal observations (n = 2).

other development displaced the site). Of the 40 remaining sites, 34% allowed public access and 11% were adjacent to or within 100 m of significant development projects. We observed either local or regional fragmentation at 68% of existing visited sites, 38% of the areas were both locally and regionally fragmented, 51% had only intrasite fragmentation, and 64% exhibited solely regional fragmentation. Populations of the indicator invasive plants were present in 57% of the sites, with cattails being the most frequently observed invasive plant, and only 2.5% (n = l) showed no site-specific threats.

DISCUSSION

Ownership did not appear to directly impact habitat quality. Local and regional fragmentation were found in similar numbers of private and ODNR lands. While privately owned land may be expected to lack habitat management considerations, the fragmentation of state-owned land may be attributed to geographic barriers (for example, roads or fence lines) that existed when the land was acquired by the state. The considerable discrepancy in invasive plant species located at ODNR sites relative to private areas was unexpected, due to the extensive invasive plant management that is undertaken

TABLE 1

List of the 48 visited sites, with ownership, local and regional fragmentation, presence of invasive plants, and development of the site noted.

Site Name	Ownership	Local Fragmentation	Regional Fragmentation	Invasives	Development
Irwin Prairie	DNR	Yes	No	Yes	No
Watercress Marsh	PVT	Yes	Yes	Yes	No
Kent Bog	DNR	Yes	Yes	Yes	No
Cedar Bog	DNR	No	Yes	No	No
Lorain County Railroad	PVT	Yes	Yes	No	No
Pennline Bog	PVT	Yes	Yes	No	No
Thompson Ledge	LOC	No	No	No	No
Kitty Todd	TNC	No	Yes	No	No
Karlo Fen	DNR	Yes	No	Yes	No
Camp Asbury	PVT	Yes	Yes	No	No
Norton Bog	PVT	No	No	No	Yes
Route 534	PVT	No	No	No	Yes
Zimmerman	DNR	Yes	Yes	Yes	No
Eagle Creek	DNR	Yes	No	Yes	No
Kiser Lake	DNR	Yes	Yes	Yes	No
Gott Fen	DNR	Yes	Yes	Yes	No
Singer Lake	PVT	Yes	Yes	Yes	No
Cuyahoga Valley	NPS	No	No	No	No
Angola Road	PVT	No	No	No	No
Prairie Road Fen	DNR	No	Yes	Yes	No
Morgan Swamp	TNC	No	Yes	No	No
Resthaven	DNR	No	No	Yes	No
Jackson Bog	DNR	No	No	No	Yes
Springville Marsh	DNR	No	Yes	Yes	No
Route 44	PVT	No	No	No	Yes
Grand River	PVT	Yes	Yes	No	No
Brewster Bog	PVT	No	Yes	No	No
Springville Marsh	DNR	Yes	Yes	Yes	No
Mentor Marsh	DNR	Yes	Yes	Yes	No
Old State Road	PVT	Yes	Yes	Yes	No
Lake Cardinal	PVT	Yes	Yes	No	No
Bloom Road	PVT	No	Yes	Yes	No
Quinn Road	PVT	No	No	No	Yes
Gallagher Fen	DNR	No	Yes	Yes	No
Betsch Fen	TNC	Yes	Yes	Yes	No
Louis W. Campbell	DNR	Yes	No	Yes	No
Muck Farm	DNR	No	Yes	Yes	No
Route 2	PVT	No	No	No	Yes
McCracken Fen	DNR	No	Yes	Yes	No
Toledo Express	LOC	Yes	Yes	Yes	No
Oak Openings	LOC	No	No	No	No
Witchel Road	PVT	No	Yes	Yes	No
Solon Township Swamp	PVT	Yes	Yes	Yes	Yes
Penn Central Railroad	PVT	No	No	No	Yes
Indian Run	PVT	Yes	Yes	Yes	No
Spring Valley	DNR	Yes	Yes	Yes	No
Arnovitz	LOC	Yes	No	Yes	No

at many state-owned sites. Although the exact causes for the difference in presence of invasives cannot be determined from this study, possible justification may be related to species that were endemic prior to land acquisition. Only one ODNR site had encroaching development, while seven private areas were developed or had local development. The acquisition of land by the state government allows for protective measures to be taken to prevent development that removes habitat, while private property ownership does not guarantee such measures. Through management practices, the ODNR is generally able to prevent loss of vegetation and wildlife, which gives reason to acquire desirable land. Although private property may be owned by conservation-minded individuals, these people may not have necessary resources, skills, or time for proper management of habitats. Therefore it is beneficial for government or private professional groups such as TNC to acquire and manage wetlands.

Ohio has lost more than 90% of its original wetland to development (Mitsch and Gosselink 1993) and consequently, spotted turtle habitat that we studied in Ohio is fragmented into small patches of wetland. These patches, however, are crucial for maintaining or at least decelerating the decline of regional biodiversity (Semlitsch and Bodie 1998). From the site visit data, we are able to conclude that spotted turtle habitat is degraded through fragmentation and invasion by non-native plant species, and is threatened by continued development. Furthermore, traveling from site to site showed clearly how isolated each of the habitats was from other sites.

Fragmentation, present in many of the Ohio sites, can isolate or separate populations, increasing the probability of extirpation (Lindenmayer and Lacy 1995). Biotic systems exhibit limits to the stress they can experience and still remain viable (Christensen and others 1996). Franklin (1980) indicated that populations require 50 individuals for short-term viability and 500 individuals for long-term survival. Populations that are too small to be viable may persist for long periods of time, however, due to the longevity of its individuals (Saunders and others 1991). Animal movement from one habitat patch to another is essential for the persistence of wildlife populations (Lindenmayer and Lacy 1995), as it promotes genetic diversity, circumvents detrimental effects of disease and reduced resources, and prevents isolation that could otherwise lead to extinction in extreme circumstances.

Fragmentation can also alter interspecies interactions. Temple (1987) reports increased predation on turtle nests near ecological edges. Any barrier that locally fragments habitat creates additional ecological edge. Banked paths running through a wetland habitat create a walkway for not only human use, but for predatory mammals that rely on edges to reach spotted turtle nests. We can extend our definition of local fragmentation to patches of significantly different vegetation that divide a larger type of habitat into smaller sections. For example, patches of woody shrub invading and extending into a fen create longer stretches of ecological edge and more access for predators such as raccoon (*Procyon lotor*), skunk (*Mephitis mephitis*), red fox (*Vulpes fulva*), and opossum (*Didelphis virginiana*) (Temple 1987).

In addition to predator access, an increase in ecological edge increases the potential for invasion by non-native species. Biological invasions have been argued to be one of the most important adverse impacts that humans have had on ecosystems. Small seed mass, short juvenile period, rapid growth, and short mean interval between large seed crops allow non-native species to out-compete native vegetation (Rejmanek 1996). The impact of such species on spotted turtles is indirect, yet significant, as disturbance such as this can change flora composition, cause declines in fauna production, and reduce water quality downstream (Detenbeck and others 1999). Spotted turtles are omnivorous, but a substantial portion of the diet of some populations is grass stems (Ernst and others 1994). When cattails invade a wetland (caused often by soil phosphorus levels and deep water tables; Wu and others 1997), they can form a dense wall of shoots, which prevents light from reaching lower vegetation. Grasses are out-competed by the cattails, and thus this portion of the spotted turtle diet is eliminated. Buckthorn and bush honeysuckle, two woody species, can exist at the edge of wetlands, and cause local changes in soil composition and hydrology (Ehrenfeld and Schneider 1991), which over time allows the species to gradually restrict the boundaries of the wetland.

Human disturbance, much like fragmentation, has a direct negative impact on *C. guttata* populations. Industrial, commercial, and residential development replace suitable habitats with roads, buildings, and lots. The danger is that the area is either reduced to a degree of vulnerability to any human interaction, or to the point at which the habitat is lost altogether (Bradshaw 1977). Similar to invasive species out-competing plants that *C. guttata* consumes in its diet, development changes the balance and distribution of vegetation. Joyal and others (2001) indicated that spotted turtles are unlikely to be capable of maintaining viable isolated populations if development is allowed to encroach into these areas.

Non-native species are more likely to invade disturbed areas (Rejmanek 1996), and disturbance is usually a function of human activity. Increased human use of wetlands for recreation leads to more encounters with turtles and subsequently to over-collection (Lovich 1987; Ernst and others 1994; Graham 1995). Garber and Burger (1995) documented the decline of wood turtles (*Clemmys insculpta*) in a Connecticut preserve and correlated its timing with the opening of the preserve to human recreational use. They found that for every 19 permits issued for recreational use on the property, one turtle was removed from the preserve.

Spotted turtles, even without threats from predation, exhibit low recruitment rates, which make habitat quality important. The average life span of a spotted turtle is 30-75 years, with delayed sexual maturity (Ernst and others 1994). One study of an Ohio population suggests that female spotted turtles nest every other year and lay 3-4 eggs per clutch (Kalb personal communication), and nest productivity is estimated at 30% (Ernst and others 1994). The result is a reproductive rate of, at most, 1-2 offspring per female every other year. This suggests that if populations are being impacted by threats to habitat, they do not have the juvenile recruitment to maintain a stationary population (for example, no numeric change). In addition, the slow reproductive rate prevents rapid recovery from stochastic or environmental events that diminish the population. Such populations depend on dispersers to supplement the local population (Fahrig and Merriam 1994).

Clemmys individuals and other ectotherms utilize hibernacula during cold temperatures induced by winter (Lewis and Ritzenthaler 1997). These microhabitats are characterized by thermal stability and are habitually used by spotted turtles. Hibernacula are located underground and typically can support a large number of individuals. Lewis and Ritzenthaler (1997) found 34 turtles in a single hibernaculum. The authors found that 50% of the known spotted turtles within the study population occupied just 9 hibernacula. These large aggregations of turtles have implications in the viability of the population. For example, if few hibernacula are affected by a negative event (such as localized pollution), and they contain a large proportion of the turtles within an area, the population may be depressed to a point beyond recovery, eventually leading to extirpation.

Hawkins and Lewis (2002) studied a population of spotted turtles located at Prairie Road Fen in southwestern Ohio. Individuals were collected from 1981 until 2001, totaling 178 turtles. The largest populations were found around 1990 (n = 75) and numbers have declined to only 20 turtles in 2001. This is considered to be the largest viable population in the state and yet there is no interaction of Prairie Road individuals with those of other habitats (Lewis and Faulhaber 1999). Smaller Ohio populations exist in areas that are highly fragmented within the site and separated extensively from other turtle habitats.

When habitats are fragmented, as with Ohio spotted turtle populations, dispersers cannot reach other populations. The loss in genetic variability and fitness can be significant (Lynch and Gabriel 1990; Westemeier and others 1998) and is an inevitable result of such isolation (Soulé and Mills 1998). An increase in homozygosity also decreases the variability of offspring, which reduces the chance of individuals surviving a sudden environmental change (Ralls and others 1986). In such populations, non-genetic stochastic events could cause local extinction of a population before the effects of inbreeding impact the population (Mills and Smouse 1994).

A study by Parker and Whiteman (1993) utilized DNA fingerprinting to examine the effects of fragmentation of habitat on genetic diversity in *C. guttata*. The authors tested individuals located at five sites in Indiana, three of which were small (<15 ha) in size and two of which were at least 50 ha in area. Minisatellite analysis yielded significantly larger similarities (proportion of bands shared) between individuals in the small, isolated areas relative to the large wetlands. Due to the accepted notion that the degree of similarity between random pairs of individuals is inversely proportional to genetic diversity, the authors concluded that spotted turtles located within small patches of habitat are significantly less diverse than those inhabiting larger, less geographically restricted areas.

Lewis and Faulhaber (1999) found maximum turtle movements from a source area in one southern Ohio site of 731 m (average 154.6 m). The distance between this site and the closest known habitat is approximately 2500 m and are separated by a large reservoir and several major roads. The probability of exchange of individuals between the two populations is most likely very low. The habitats identified here are divided into three regions in the state, in southwestern Ohio, northwest Ohio, and northeastern Ohio, and are separated within each region by 20 km, 5.0 km, and 30 km, respectively. This degree of separation indicates that there is no genetic mixing. Even if we assumed each historic turtle habitat had a population as large as the largest known in Ohio (averaging some 50 turtles), the genetic isolation makes long-term viability doubtful. However, few sites are actually known to currently contain any turtles.

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