Wetland Occupancy and Landscape Connectivity for Blanding's and Western Painted Turtles in the Green River Valley

Bradley J. Cosentino[1]
Christopher A. Phillips[1]
Robert L. Schooley[2]

[1]Division of Biodiversity and Ecological Entomology
Section for Biotic Surveys and Monitoring
[2]Department of Natural Resources and Environmental Science, University of Illinois

Introduction

The metapopulation paradigm has been instrumental in guiding research on the ecological effects of habitat loss and fragmentation on wildlife species. In fragmented landscapes, metapopulation persistence is dependent on connectivity among habitat patches (Hanski 1997, 1999). Movement among patches can function to rescue small populations, maintain genetic variation, and increase patch-colonization probability (Mills and Allendorf 1996, Saccheri et al. 1998). Preserving an adequate level of connectivity is thus a critical goal of conservation in fragmented systems.

Landscape connectivity, the degree to which the landscape facilitates or impedes movement, depends on both structural characteristics of the landscape and an organism's functional response to those characteristics (Taylor et al. 1993, Tischendorf and Fahrig 2000, Taylor et al. 2006). Connectivity metrics informed by metapopulation theory typically model the effect of structural components (e.g., patch area, interpatch distance, etc.) on patch occupancy patterns (Moilanen and Nieminen 2002, Calabrese and Fagan 2004). In regards to dispersal, however, these metrics assume straight-line movements through a uniform matrix between patches. In reality, the matrix is a mosaic of habitat patches with varying levels of resistance to dispersing individuals, which means the effective distance between habitat patches can differ from Euclidean distance (Wiens 1997, Ricketts 2001).

Least-cost modeling is a recent, GIS-based approach to estimating effective distances between habitat patches (Adriaensen et al. 2003). By assigning resistance values to matrix habitats, least-cost modeling can be integrated into connectivity metrics to (1) determine whether matrix habitat influences movement behavior, and (2) identify critical habitat features affecting movement for a given species in fragmented landscapes (e.g., Chardon et al. 2003, Verbeylen et al. 2003). For wetlands species, such landscape approaches are essential for identifying wetland-upland linkages that can be modified by management practices.

We surveyed all wetlands in a 9277-ha area in Lee County, IL with the intention to use occupancy and least-cost modeling to assess how landscape structure affects the distribution and population connectivity of *Emydoidea blandingii* (state-threatened Blanding's Turtle) and the locally common *Chrysemys picta* (Western Painted Turtle). Both species are members of the Family Emydidae. Originally dominated by open marshes and sand prairie, the Green River valley in Lee County is now characterized by agricultural fields, roads, and fragmented patches of natural habitat. Surveys by the Lee County Natural Area Guardians and Illinois Natural History Survey (INHS) personnel resulted in *E. blandingii* captures in this area as recent as 2006. However, the current extent and status of this population was unknown. This research was conducted to (1) identify important habitat features affecting the occupancy and connectivity of the threatened Blanding's turtle and common Painted Turtle in and around managed sand prairie habitat, and (2) assess how occupancy and connectivity patterns vary for a species of conservation concern and a closely related, abundant species in the same landscape.

Materials and Methods

Study Area

The study area includes a 9277-ha area centered near Amboy, IL (Lee County; Figs. 1-5). The study area was selected using the following guidelines: (1) Recent surveys indicated *E. blandingii* and *C. picta* presence, (2) The landscape included a variety of upland and matrix land cover types (e.g., agriculture, open field/grassland, forest, water, urban), and (3) Many wetlands with varying areas and hydroperiods were present. A total of 90 permanent and semi-permanent wetlands were identified using aerial photographs, 1:24,000 scale topographic quadrangles, the Land Cover of Illinois 1999-2000 Classification, and 1:24,000 scale National Wetlands Inventory (NWI) quadrangles. The NWI

quadrangles were used to determine wetland hydroperiod, and all temporarily flooded wetlands were excluded.

Turtle Sampling

Wetlands were surveyed for up to four consecutive days during May – August in 2007 and 2008. We used baited hoop traps to detect *E. blandingii* and *C. picta* presence at each wetland (Legler 1960). Sampling effort was standardized by wetland area. No more than two-thirds of the traps were submerged, and traps were attached to stakes placed on the shoreline. Each trap was baited with sardines in olive oil, using Glad containers to hold the bait. Holes were punched in each Glad container lid, and containers were placed upside-down in the trap, allowing chemical cues and olive oil to slowly disperse through the water. Bait was changed on the third day of each trapping session. For logistical purposes, ponds were clustered into groups of 5-20, and we randomized the sequence of clusters surveyed each year.

Each turtle captured was given a unique shell notch (Cagle 1939). We used metric tree calipers to measure carapace length, carapace width, plastron length, and shell height. All turtles were weighed using digital scales. Sex was determined by examining the fore-claws and cloacal vent. Finally, blood samples of all individuals were taken from the cervical sinus for future genetic analyses. No more than 0.1 cc per 100 g turtle mass was taken, and all samples were stored in 100% ethanol and transferred to a -80°C freezer.

Habitat Characteristics

We collected data for a number of environmental variables thought to potentially influence the distribution and connectivity patterns of both species. We measured wetland perimeter and area using ArcGIS (ArcView 9.2). Since *E. blandingii* and *C. picta* require both aquatic and terrestrial habitats to complete their life cycles, we calculated metrics of habitat area to include open grassland or forest cover within 300-m of each wetland. Both species potentially use these habitats for nesting, and Bowne (2008) found that *C. picta* dispersers had a slight preference for forest habitats during movement. In each wetland, pH and conductivity was measured within the first 1 m of the shoreline. Based on observations during repeated visits to each site, we assigned each wetland to one of three hydroperiod categories (short = usually dries before fall, medium = usually inundated through winter but occasionally dries, permanent = does not dry). Wetland emergent vegetation cover was quantified visually using a semi-quantitative scale: ≤ 5%, 6-25%, 26-50%, 51-75%, 75-100%. Fish presence was documented using baited hoop traps. Detection probability for fish during sampling was high (B.J. Cosentino, *unpublished data*).

Land cover types were classified in ArcView 9.2 using aerial photographs from 2005, the Land Cover of Illinois 1999-2000 Classification, and ground surveys. We calculated the area of roads, forest, and open grassland within buffers of 150 and 300 m. *E. blandingii* and *C. picta* females are likely to nest < 300 m from wetlands (Joyal et al. 2001, Baldwin et al. 2004).

Occupancy Model

Occupancy models were constructed to test two predictions of spatially-explicit metapopulation models (Hanski 1994, Hanski and Gilpin 1997), both rooted in island biogeography theory (MacArthur and Wilson 1967): 1) patch extinction probability is negatively related to patch area, and 2) patch colonization probability is negatively related to isolation (the inverse of connectivity). Since habitat quality also affects metapopulation dynamics (Fleishman et al. 2002, Armstrong 2005, Schooley and Branch 2007), we assess how occupancy, colonization, and extinction parameters were influenced by habitat characteristics.

Imperfect detection during surveys can bias estimates of occupancy (φ), extinction (ε), and colonization (γ) probabilities, so we used program PRESENCE (2.2) to build models that account for

imperfect detection probability (ρ; MacKenzie et al. 2003, MacKenzie et al. 2006). These models use maximum-likelihood to estimate ρ, φ, ε, and γ based on encounter histories (multiple occupancy surveys within a year) at each site, and a logistic link is used to assess how model parameters are functions of covariates. We built models with different combinations of site-specific covariates, and we used Akaike's Information Criterion corrected for small samples (AICc; Akaike 1973, Burnham and Anderson 2002) for model selection.

Connectivity Models

A measure typical of the incidence function connectivity model (IFM) was used to estimate wetland connectivity. IFM uses occupancy data to weight the effect of (1) distance to all source patches, and (2) area of all source patches on the connectivity of a focal patch (Hanski 1994, Calabrese and Fagan 2004). By using Euclidean distance, we parameterized this connectivity metric to represent the null hypothesis that matrix habitat does not influence movement behavior. To account for the effects of landscape structure on movement behavior and connectivity, least-cost modeling was used to estimate least-cost distances between all wetlands (Adriaensen et al. 2003). We determined whether landscape structure influences connectivity by including least-cost distance and Euclidean distance IFM metrics as covariates in our occupancy models (sensu Chardon et al. 2003, Verbeylen et al. 2003).

The PATHMATRIX tool was used to compute least-cost distances between wetlands in ArcView 9.2 (Ray 2005). Since there are no published data on how land cover types resist dispersing individuals, we assigned resistance values to habitats based on our field knowledge and basic natural history. Multiple resistance sets were created by varying the resistance values for each land cover type, and least-cost distances were calculated for each set (Table 1). Thus, our final model set included multiple least-cost connectivity metrics with varying resistance values. These landscape models represent alternative hypotheses to be tested with field data. By comparing these models to a Euclidean connectivity metric, we can make inferences about whether landscape structure influences connectivity, and how different land cover types influence movement. Additionally, our multi-year data allowed us to explore the relationship between wetland connectivity and colonization and extinction rates.

Results

We caught a total of 4 *E. blandingii* individuals ($N_{2007} = 2$, $N_{2008} = 2$) and 337 *C. picta* individuals ($N_{2007} = 205$, $N_{2008} = 132$) in 3337 trap-nights of sampling among sites (2007 = 1947, 2008 = 1390 trap-nights). Catch-per-unit-effort for *E. blandingii* and *C. picta* individuals was 0.0012 and 0.10 individuals per trap-night, respectively. Of the 33 *C. picta* individuals caught and marked in 2007 and subsequently recaptured in 2008, 14 were recaptured in the same wetland during both years, and 19 individuals moved among ponds. Neither of the 2 *E. blandingii* individuals captured in 2007 were recaptured in 2008.

In 2007 and 2008, two of 90 sites were occupied by *E. blandingii* (naïve φ = 0.022). For *C. picta*, 42 sites were occupied in 2007 (naïve φ = 0.467) and 48 sites were occupied in 2008 (naïve φ = 0.533). However, detection probability for *C. picta* was imperfect and varied both between years and among days within trapping session. During 2007, detection probability was 0.839 ± 0.0593 on the first day of each trap session and 0.483 ± 0.0457 on days 2-4. During 2008, detection probability was 0.588 ± 0.0747 on day 1 and 0.380 ± 0.0461 on days 2-4. After accounting for imperfect detection, occupancy for *C. picta* was 0.483 ± 0.0266 in 2007 and 0.632 ± 0.0198 in 2008. Between 2007 and 2008, there were 10 extinctions and 15 colonizations at the site level. Due to the limited number of captures of *E. blandingii* individuals, we were unable to conduct any analyses on occupancy and connectivity patterns for this species.

The highest-ranking occupancy model indicated that hydroperiod and habitat area had important influences on the local distribution of *C. picta* (Table 2). In 2007, larger habitats with longer hydroperiods were more likely to support *C. picta* populations than smaller habitats with shorter hydroperiods. Habitat area had an important influence on occupancy probability only when it included the area of forest cover within 300-m of each wetland.

When connectivity was included as a covariate to model heterogeneity in colonization probabilities among sites, the top-ranked model indicated that colonization probability was influenced by a least-cost metric of connectivity (Table 3). Dispersal costs for the top-supported connectivity metric represented the case where the cost of moving was lowest in open grasslands and forest, moderate in agriculture, and greatest in urban areas with a high degree of road cover. When we assessed whether the key metapopulation parameters explained variation in colonization and extinction dynamics, we found that colonization probability was positively related to effective connectivity, but habitat area was not an important predictor of extinction probability (Table 4).

Discussion

We found that both local habitat quality and key metapopulation parameters influenced the distribution and population dynamics of *C. picta*. After accounting for imperfect detection during surveys, *C. picta* occupancy probability was related to wetland hydroperiod and area of both wetland habitat and forest cover within 300-m of each site. Wetland colonizations outnumbered local extinction events, and wetland colonization probability was a function of connectivity. Importantly, colonization probability was related to a metric of effective connectivity rather than Euclidean distance, suggesting that habitat structure in upland areas has an important influence on *C. picta* dispersal patterns. However, contrary to one of the key predictions of metapopulation theory, wetland extinction probability was not related to habitat area.

Blanding's Turtle Status
Of concern is the limited number of captures of *E. blandingii*, especially given the large spatial extent of our sampling over the course of two years. We captured four adult females (Table 5), three of which were found on the property of the Richardson Wildlife Foundation (RWF), which is managed for sand prairie habitat. The fourth individual was captured in a wetland on private land just north of RWF's property. The failure to capture any individuals in agricultural areas surrounding RWF suggests that the *E. blandingii* population in Lee County is dependent on remnant or restored sand prairie habitat in areas relatively undisturbed by roads. Underscoring this view is the relatively common occurrence of *E. blandingii* observations at other reserves managed for sand prairie in Lee County (e.g., Green River State Wildlife Area, Nachusa Grasslands of the Nature Conservancy, and the Ryan Wetland and Sand Prairie Restoration; D. Carey, *personal communication*). Although we lacked the data to model the population structure of *E. blandingii* in our study area, the occurrence of this species in patches of sand prairie throughout Lee County suggests that metapopulation models may be useful for modeling population dynamics at an even broader spatial scale in future studies. If *E. blandingii* utilizes disjunct reserves, increased sampling effort at these sites would be an appropriate first step to understanding basic demographic patterns within sites in Lee County. Furthermore, molecular analyses can reveal the degree to which theses sites are genetically differentiated, and the degree of dispersal occurring among them.

Painted Turtle Connectivity and Metapopulation Dynamics
Our occupancy data suggests that hydroperiod and water levels have a substantial influence on the local distribution of *C. picta* among wetlands in any given year. Given that precipitation was greater in 2008 than 2007 by 16.97 inches (www.noaa.gov), and local colonizations outnumbered local

extinctions between 2007 and 2008, individuals may have dispersed to more ephemeral wetlands in 2008 to take advantage of temporary resources that are normally unavailable during drought. Bowne et al. (2006) found that pond connectivity for *C. picta* can vary substantially among years due to variation in precipitation and wetland inundation levels. They found that individuals moved from temporary wetlands to permanent sites for refugia during a drought. In our study area, a significant increase in occupancy probability in short and medium hydroperiod ponds from 2007 to 2008 suggests that *C. picta* individuals commonly move back to ephemeral wetlands when they refill (Fig. 8). The lack of a corresponding decline in occupancy probability in permanent wetlands may suggest that dispersal from permanent to ephemeral wetlands may be a density-dependent process.

Area of wetland habitat and forest cover within 300-m of ponds also had a positive influence on occupancy probability regardless of wetland hydroperiod (Fig. 6). Marchand and Litvaitis (2004) found that forest cover surrounding ponds was positively related to the proportion of *C. picta* males and adults in ponds. They suggested that forest cover may decrease soil temperature and thus incubation temperature of *C. picta* eggs compared to open habitats. Gender in *C. picta* is determined by the temperature at which eggs are incubated, and lower incubation temperatures usually result in the production of males (Ewert and Nelson 1991). Further work is needed to assess the relationship between forest cover and the spatial distribution of gender in our study area.

Our data suggest that forest and grassland habitats also facilitate dispersal and increase wetland connectivity at sites surrounded by a high proportion of these habitats. Landscape connectivity, the degree to which the landscape facilitates or impedes movement, encapsulates the idea that connectivity depends on both structural habitat characteristics and an organism's functional response to those characteristics (Taylor et al. 1993). Most landscapes, like ours, are heterogeneous, where dispersal cost should vary among habitats due to factors like resource availability (e.g., Charrier et al. 1997), habitat complexity (Wiens et al. 1997), and predation risk (e.g., Lima 1998). Hence, researchers have promoted the integration of theory from metapopulation biology with landscape ecology to understand connectivity (Wiens 1997). Although we do not have a mechanistic understanding of how *C. picta* movement behavior interacts with landscape structure, our least-cost analysis showed that a measure of effective connectivity (i.e. one that accounts for variation in dispersal costs among matrix habitats) explained more variation in wetland colonization probability than a Euclidean measure of connectivity that assumes a homogenous matrix (Fig. 6, Table 3). Importantly, forest and grassland habitats had the lowest dispersal costs (other than wetland) in the least-cost resistance set most supported by our data. Thus, individuals may choose to move through forest or grassland habitats rather than agricultural and urban areas to minimize predation risk, maximize resource availability, or minimize heat stress in areas of dense vegetation cover. Using telemetry, Bowne (2008) found that *C. picta* dispersers had a slight preference for forest habitat in Virginia, although individuals aestivating in terrestrial areas preferred open habitats.

Finally, connectivity had a positive influence on colonization probability (Fig. 6), but habitat area was not a strong predictor of local extinction risk (Table 4). Although the key metapopulation parameters, area and connectivity, are important predictors of wetland occupancy and colonization probability, extinction probability may be related to aspects of habitat quality that were not measured in our study. Seasonal precipitation levels may interact with wetland hydroperiod to influence local extinction probability (B.J. Cosentino, *unpublished data*). If variation in precipitation and wetland hydroperiod is driving *C. picta* extinction-colonization dynamics, managed landscapes should include a mix of wetlands with different hydroperiods, as well as forest and grassland areas to maintain wetland-upland linkages.

Summary

•Only four *E. blandingii* individuals were captured over two years, and each individual was captured either on the property of, or immediately adjacent to the Richardson Wildlife Foundation, which is a mix of restored and remnant sand prairie.

•No *E. blandingii* individuals were found in areas dominated by agriculture, suggesting that it is dependent on sand prairie habitat for resource acquisition and nesting.

•Detection probability for *C. picta* was imperfect and was variable between years and among trapping days within session. Occupancy probability was positively related to wetland hydroperiod and the area of both wetlands and forest cover within 300-m of wetlands.

•Wetland colonization probability for *C. picta* was positively related to a metric of effective connectivity rather than Euclidean distance. Forest and grassland areas may facilitate dispersal and maintain wetland-upland linkages.

•*C. picta* occupancy probability in short and medium hydroperiod ponds increased during 2008, which may have been related to an increase in precipitation. Movement among ponds in wetland complexes is likely a common event for *C. picta*, and individuals likely move between permanent and ephemeral water sources depending on precipitation and wetland inundation levels.

Literature Cited

Adriaensen, F., J. P. Chardon, G. De Blust, E. Swinnen, S. Villalba, H. Gulinck, and E. Matthysen. 2003. The application of 'least-cost' modelling as a functional landscape model. Landscape and Urban Planning 64:233-247.

Akaike, H. 1973. Information theory as an extension of the maximum likelihood principle. In B.N. Petrov and F. Csaki, eds. Second International Symposium on Information Theory. Akademiai Kiado, Budapest, Hungary.

Armstrong, D.P. 2005. Integrating the metapopulation and habitat paradigms for understanding broad-scale declines of species. Conservation Biology 19:1402-1410.

Baldwin, E.A., M.N. Marchand, and J.A. Litvaitis. 2004. Terrestrial habitat use by nesting painted turtles in landscapes with different levels of fragmentation. Northeastern Naturalist 11:41-48.

Bowne, D.R. 2008. Terrestrial activity of *Chrysemys picta* in northern Virginia. Copeia 2008:306-310.

Bowne, D. R., M. A. Bowers, and J. E. Hines. 2006. Connectivity in an agricultural landscape as reflected by interpond movements of a freshwater turtle. Conservation Biology 20:780-791.

Burnham, K.P., and D.R. Anderson. 2002. Model selection and multimodal inference. 2nd ed. Springer-Verlag, New York.

Cagle, F.R. 1939. A system for marking turtles for future identification. Copeia 1939:170-173.

Calabrese, J. M., and W. F. Fagan. 2004. A comparison-shopper's guide to connectivity metrics. Frontiers in Ecology and the Environment 2:529-536.

Chardon, J. P., F. Adriaensen, and E. Matthysen. 2003. Incorporating landscape elements into a connectivity measure: a case study for the Speckled wood butterfly (*Pararge aegeria* L.). Landscape Ecology 18:561-573.

Charrier, S., S. Petit, and F. Burel. 1997. Movements of *Abax parallelepidpedus* (Coleopteran, Carabidae) in woody habitats of a hedgerow network landscape: a radio-tracing study. Agriculture, Ecosystems, and Environment 61:133-144.

Ewert, M.A., and C.E. Nelson. 1991. Sex determination in turtles: diverse patterns and some possible adaptive values. Copeia 1991:50-69.

Fleishman, E., C. Ray, P. Sjögren-Gulve, C.L. Boggs, and D.D. Murphy. 2002. Assessing the roles of patch quality, area, and isolation in predicting metapopulation dynamics. Conservation Biology 16:706-716.

Hanski, I. 1994. A practical model of metapopulation dynamics. Journal of Animal Ecology 63:151-162.

Hanski, I. 1999. Metapopulation ecology. Oxford University Press, Oxford.

Hanski, I., and M. Gilpin, editors. 1997. Metapopulation biology: Ecology, genetics, and evolution. Academic Press, New York.

Joyal, L. A., M. McCollough, and M. L. Hunter. 2001. Landscape ecology approaches to wetland species conservation: a case study of two turtle species in southern Maine. Conservation Biology 15:1755-1762.

Legler, J.M. 1960. A simple and inexpensive device for trapping aquatic turtles. Utah Academy of Science, Arts and Letters Proceedings 37:63-66.

Lima, S.L. 1998. Nonlethal effects in the ecology of predator-prey interactions. Bioscience 48:25-34.

MacArthur, R.H., and E.O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton, N.J.

MacKenzie, D. I., J. D. Nichols, J. E. Hines, M. D. Knutson, and A. B. Franklin. 2003. Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. Ecology 84:2200-2207.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: Inferring patterns and dynamics of species occurrence,

First edition. Academic Press, San Diego.

Marchand, M.N., and J.A. Litvaitis. 2004. Effects of habitat features and landscape composition on the population structure of a common aquatic turtle in a region undergoing rapid development. Conservation Biology 18:758-767.

Mills, L. S., and F. W. Allendorf. 1996. The One-Migrant-per-Generation Rule in Conservation and Management. Conservation Biology 10:1509-1518.

Moilanen, A., and M. Nieminen. 2002. Simple connectivity measures in spatial ecology. Ecology 83:1131-1145.

Ray N. 2005. PATHMATRIX: a GIS tool to compute effective distances among samples, Molecular Ecology Notes 5: 177-180.

Ricketts, T. H. 2001. The matrix matters: Effective isolation in fragmented landscapes. American Naturalist 158:87-99.

Saccheri, I., M. Kuussaari, M. Kankare, P. Vikman, W. Fortelius, and I. Hanski. 1998. Inbreeding and extinction in a butterfly metapopulation. Nature 392:491-494.

Schooley, R.L., and L.C. Branch. 2007. Spatial heterogeneity in habitat quality and cross-scale interactions in metapopulations. Ecosystems 10:846-853.

Taylor, P. D., L. Fahrig, and K. With. 2006. Landscape connectivity: A return to basics. *in* K. Crooks and M. Sanjayan, editors. Connectivity Conservation. Cambridge University Press, Cambridge, UK.

Taylor, P. D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivity is a vital element of landscape structure. Oikos 68:571-573.

Tischendorf, L., and L. Fahrig. 2000. On the usage and measurement of landscape connectivity. Oikos 90:7-19.

Verbeylen, G., L. De Bruyn, F. Adriaensen, and E. Matthysen. 2003. Does matrix resistance influence Red squirrel distribution in an urban landscape? Landscape Ecology 18:791-805.

Wiens, J. A. 1997. Metapopulation dynamics and landscape ecology. *in* I. Hanski and M. Gilpin, editors. Metapopulation dynamics: ecology, genetics, and evolution. Academic Press, New York.

Wiens, J.A., R.L. Schooley, and R.D. Weeks, Jr. 1997. Landscapes and animal movements: do beetles percolate? Oikos 78:257-264.

Expenditures

Date	Description	Amount	Type
1/7/08	Plotter Charge	$ 22.16	Supplies
5/8/08	Digital Thermometer, Weather Meter	$ 136.73	Supplies
5/9/08	Mileage	$ 120.00	Travel
5/12/08	Digital Thermometer	$ 30.90	Supplies
6/30/08	Payroll	$ 56.12	Fringe Benefits
6/30/08	Payroll	$ 721.35	Wages
8/1/08	Bait	$ 89.39	Supplies
8/1/08	Bait	$ 119.18	Supplies
8/1/08	Mileage	$ 204.22	Travel
8/1/08	Mileage	$ 531.95	Travel
8/31/08	Payroll	$ 55.80	Fringe Benefits
8/31/08	Payroll	$ 720.00	Wages
9/25/08	Mileage	$ 312.95	Travel
11/4/08	Payroll	$ 51.27	Fringe Benefits
11/4/08	Payroll	$ 19.53	Fringe Benefits
11/4/08	Digital Scale	$ 166.53	Supplies
11/4/08	Payroll	$ 661.50	Wages
11/4/08	Payroll	$ 252.00	Wages
11/11/08	Payroll	$ 14.65	Fringe Benefits
11/11/08	Payroll	$ 5.05	Fringe Benefits
11/11/08	Payroll	$ 189.00	Wages
11/11/08	Payroll	$ 65.18	Wages

Tables and Figures

Table 1. Least-cost resistance sets representing different hypotheses about how landscape structure influences *C. picta* movement. Large values represent habitats that are resistant to movement, and low values represent habitats that facilitate movement. Each set has been assigned a number and set "EU" represents the Euclidean hypothesis that habitats do not vary in their effect on movement.

Habitat	Resistance Sets									
	01	02	03	04	05	06	07	08	09	EU
Agriculture	200	200	200	200	1	50	50	50	50	1
Open	100	50	50	1	1	50	100	200	100	1
Forest	50	50	100	1	1	50	100	100	200	1
Urban	400	400	400	400	400	400	400	400	400	1
Water	1	1	1	1	1	1	1	1	1	1
Road	300	300	300	300	300	300	300	300	300	1

Table 2. Model selection for *C. picta* for occupancy probability only. Additive effects of covariates on parameters* are in parentheses. Models were ranked by the difference between model AICc and AIC for the best model (ΔAICc). Akaike weight for model *i* (ω_i) is the probability of each model, and K is the number of parameters.

Model	ΔAICc	ωi	K
ψ (Hydroperiod+Area), γ (.), ε (.), ρ(Year-Day)	0.00	0.953	9
ψ (Hydroperiod), γ (.), ε (.), ρ(Year-Day)	7.24	0.026	8
ψ (Area), γ (.), ε (.), ρ(Year-Day)	9.12	0.010	8
ψ (Fish), γ (.), ε (.), ρ(Year-Day)	10.89	0.004	8
ψ (pH), γ (.), ε (.), ρ(Year-Day)	11.15	0.004	8
ψ (Emergent Vegetation), γ (.), ε (.), ρ(Year-Day)	11.90	0.002	8
ψ (Distance to Nearest Road), γ (.), ε (.), ρ(Year-Day)	15.43	0.000	8
ψ (.), γ (.), ε (.), ρ(Year-Day)	16.79	0.000	7
ψ (Conductivity), γ (.), ε (.), ρ(Year-Day)	18.61	0.000	8
ψ (Road Cover 300-m), γ (.), ε (.), ρ(Year-Day)	18.73	0.000	8
ψ (Road Cover 150-m), γ (.), ε (.), ρ(Year-Day)	19.16	0.000	8
ψ (.), γ (.), ε (.), ρ(.)	38.10	0.000	4

*φ = occupancy, γ = colonization, ε = extinction, ρ = detection

Table 3. Model selection for *C. picta* when least-cost connectivity metrics are used to model heterogeneity in colonization probability among sites. Additive effects of covariates on model parameters are in parentheses. Each least-cost connectivity metric is indicated by CONNECT followed by a number representing different resistance sets (Table 1). CONNECT_EU represents the hypothesis that landscape structure does not influence movement. Models were ranked using AICc (see Table 2 for explanation).

Table 4. Model selection for *C. picta* to assess how key metapopulation parameters (i.e. connectivity, area) influence colonization and extinction probabilities. Additive effects of covariates on model parameters are in parentheses. Models were ranked using AICc (see Table 2 for explanation).

Model	ΔAICc	ωi	*K*
ψ (Hydroperiod+Area), γ (CONNECT_02), ε (.), ρ(Year-Day)	0.00	0.750	10
ψ (Hydroperiod+Area), γ (CONNECT_02), ε (Area), ρ(Year-Day)	2.44	0.222	11
ψ (Hydroperiod+Area), γ (.), ε (.), ρ(Year-Day)	7.11	0.021	9
ψ (Hydroperiod+Area), γ (.), ε (Area), ρ(Year-Day)	9.48	0.007	10
ψ (.), γ (.), ε (.), ρ(.)	45.21	0.000	4

Table 5. *Emydoidea blandingii* captures. Individual mark represents marginal scute notches (R = right marginal scutes, L = left marginal scutes). Location is given in UTM with Easting and Northing.

Capture Date	Stage	Sex	Mark	Location (UTM)
6/5/07	Adult	Female	R01R02	317467 4620068
6/8/07	Adult	Female	R02R03	317361 4620518
6/19/08	Adult	Female	R02R03L03	317467 4620068
7/23/08	Adult	Female	R02R09L03L10	318086 4621548

Figure 1. Aerial photograph and 90 study sites in and around the Richardson Wildlife Foundation in Lee County, IL. Study sites are indicated by white circles.
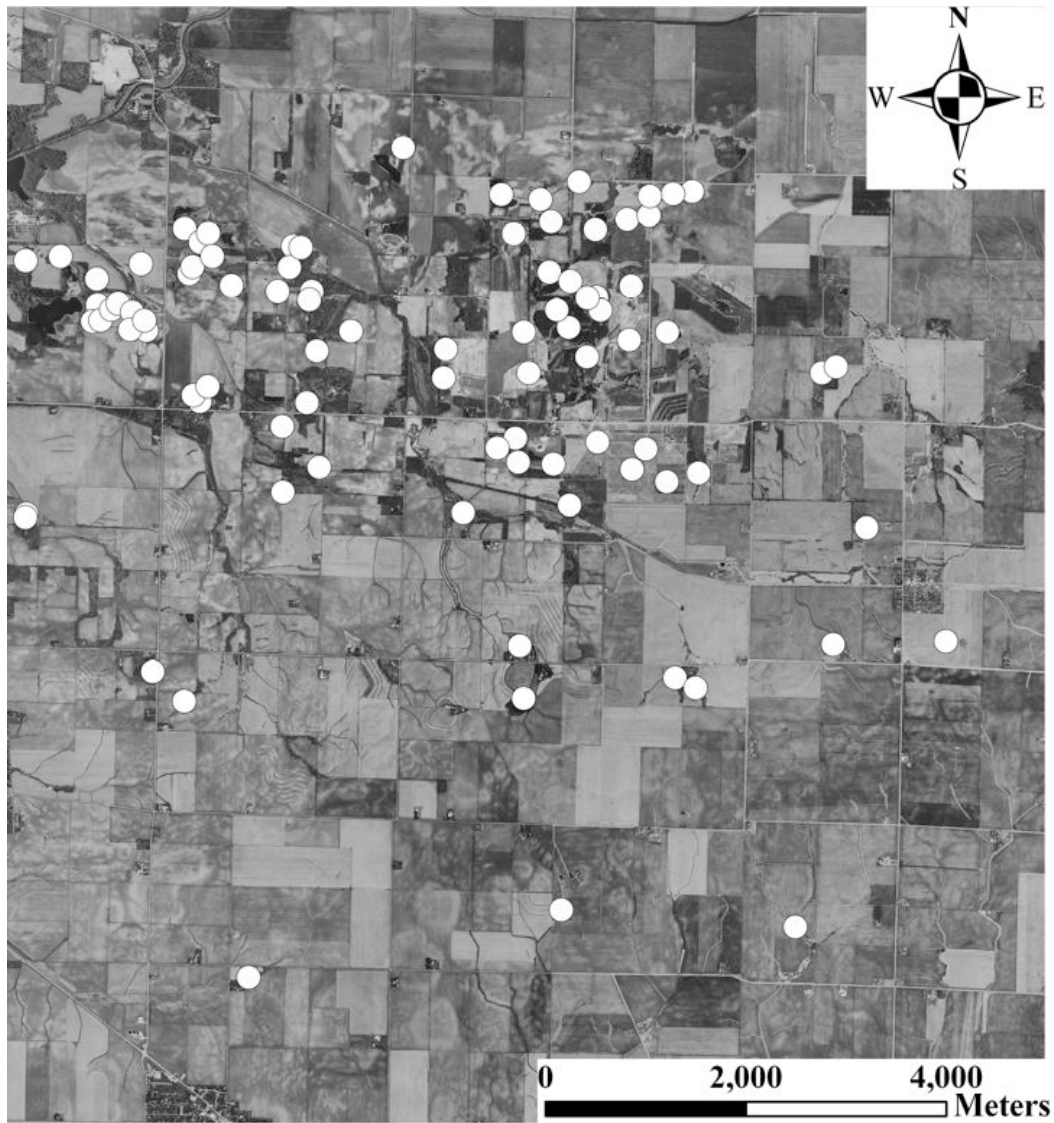
Figure 2. Distribution of *C. picta* among 90 wetlands in and around the Richardson Wildlife Foundation in Lee County, IL in 2007.
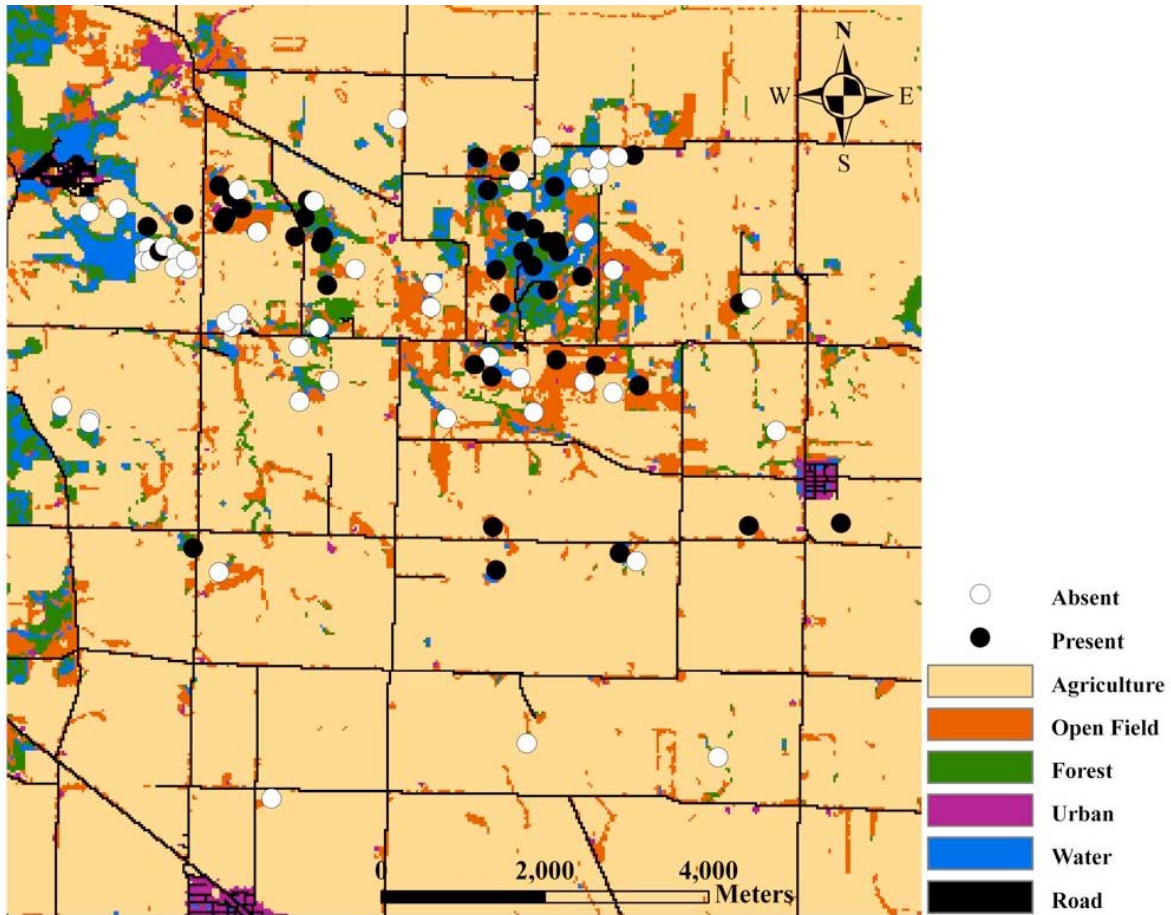
Figure 3. Distribution of *C. picta* among 90 wetlands in and around the Richardson Wildlife Foundation in Lee County, IL in 2008.
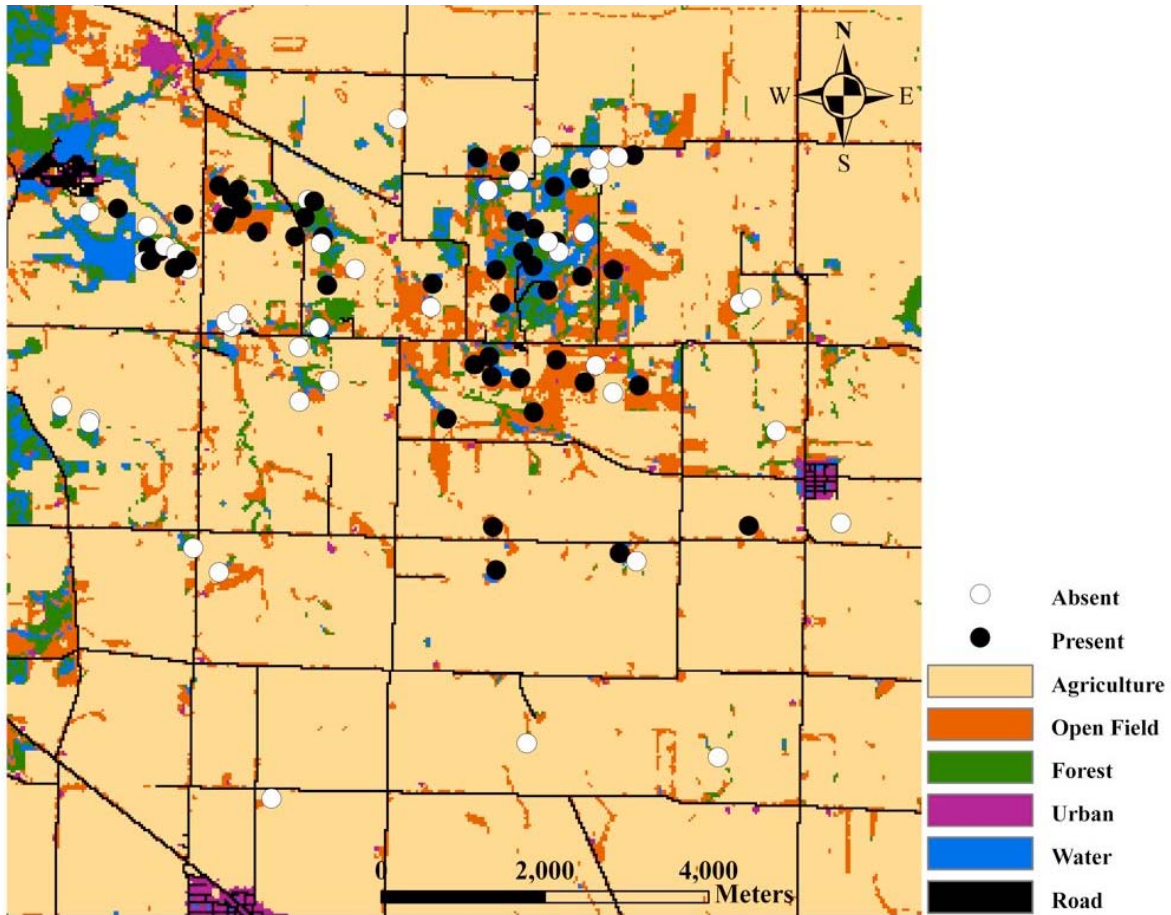
Figure 6. Relationship between habitat area (both wetland area and area of forest cover within 300-m of each wetland) and occupancy probability of *C. picta* in 2007 for short, medium, and long hydroperiod wetlands.
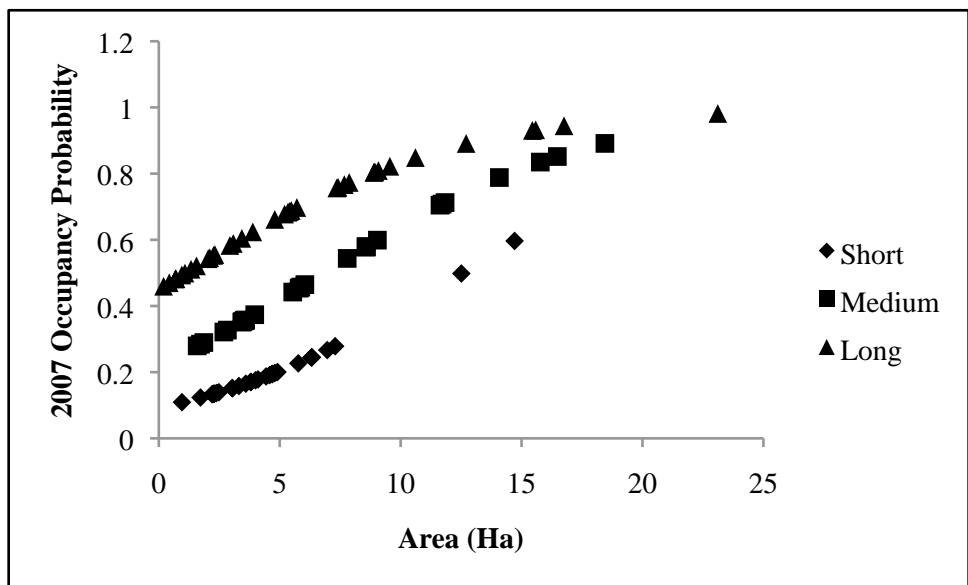
Figure 7. Relationship between effective wetland connectivity and colonization probability for *C. picta* between 2007 and 2008. This metric of connectivity represents an effect of landscape structure on dispersal, and it was parameterized using least-cost resistance set 2 (Table 1).
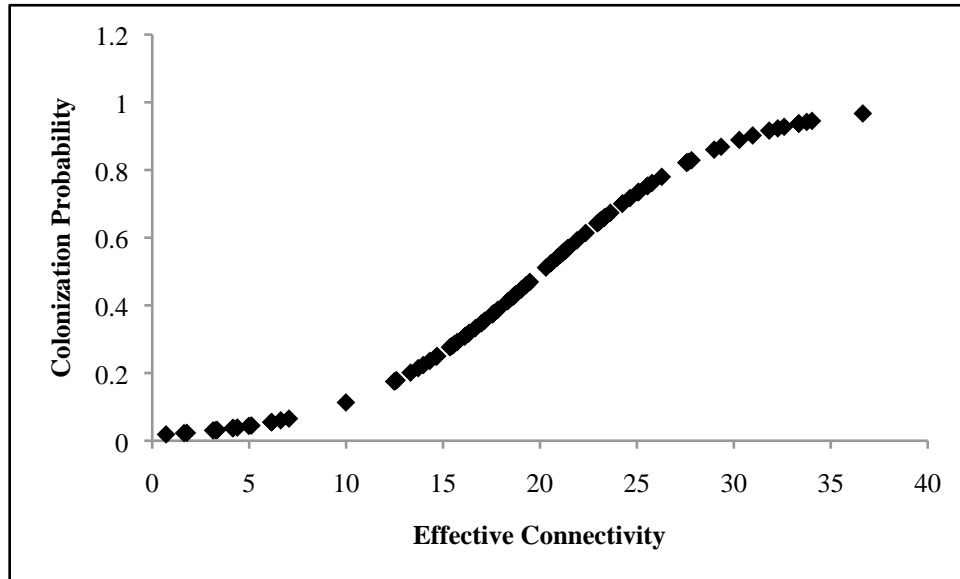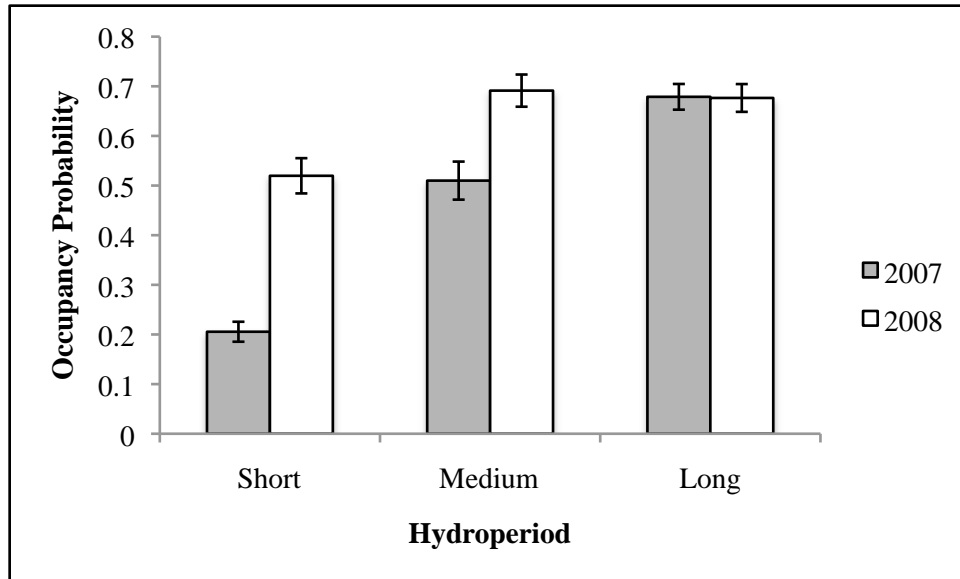
Figure 8. Influence of wetland hydroperiod on *C. picta* occupancy probability for 2007 and 2008.
Error bars indicate 1 SE.

Digital Images

Dove Pond at the Richardson Wildlife Foundation, West Brooklyn, IL.

Hatchling painted turtle (*Chrysemys picta*).

Nesting painted turtle (*Chrysemys picta*) near Dove Pond at the Richardson Wildlife Foundation, West Brooklyn, IL.

Adult female Blanding's Turtle (*Emydoidea blandingii*).

Adult female Blanding's Turtle (*Emydoidea blandingii*).

Checking a hoop trap for turtles near West Brooklyn, IL.