International Journal of Biodiversity and Conservation Vol. 2(9) pp. 250-262, September 2010
Available online http://www.academicjournals.org/ijbc
ISSN 2141-243X ©2010 Academic Journals

Full Length Research Paper

Prioritization of watershed habitat for neotropical migratory birds

Kerri Schoenberg[1] and Timothy O. Randhir[2]*

[1]Wildlife Biologist, San Francisco, CA, California.
[2]Department of Natural Resources Conservation, University of Massachusetts, Amherst, MA 01003, United State.

Accepted 16 August, 2010

The decline in habitat for neotropical migratory (NM) bird species has become a major conservation issue. A regional prioritization of potential habitat is needed, particularly to identify areas that could maximize conservation benefits. This study identifies and evaluates habitats that support NM birds in the Connecticut River Watershed (CRW) using a landscape-based assessment. Habitat potential for the 25 high priority bird species throughout the CRW was evaluated using a spatial analysis. Generalist species are found throughout the entire watershed because of their ability to use a variety of habitats. Regional priority areas show western Massachusetts as a hot spot for interior species. The edge/early succession species of birds are sparsely scattered throughout the watershed with the highest densities occurring in the southern part of the watershed in western Massachusetts and the northern part of Connecticut. Priority habitats tend to congregate along the riparian corridors of the river. The regional prioritization identifies the riparian corridor at the border of Massachusetts and Connecticut as the area of highest species richness for edge/early succession species. The second densest occurrence of priority habitat is in the southern part of the watershed in southern Massachusetts and northern Connecticut. The southern half of the watershed in the more heavily developed sections of Massachusetts and Connecticut may provide significant potential habitat for our priority edge/early succession species. Conservation policies could be targeted toward regional clusters with maximum potential habitat.

Key words: GIS, habitat mapping, neotropical birds, migration, kernel density.

INTRODUCTION

Prioritization of watershed habitat for neotropical migratory birds

Protecting habitat for birds that migrate across long distances is of special interest to Conservation Science. The migration of birds between northern temperate and tropical regions is one of the major processes of population and community ecology (Dingle and Drake, 2007; Cox, 1985). An estimated 19% of world's 9,856 bird species are migratory, of which 11% are listed as threatened or near threatened (Kirby et al., 2008). Neotropical migratory (NM) birds migrate to wintering grounds in the tropics and sub-tropics and return to North America in the spring and summer to breed or feed. Of the more than 9,000 known species of birds in the world, 12 to 15% occur in the United States and its territories. Of these, approximately 500 species are known to migrate across its borders, with a large majority of these NM birds wintering in the Caribbean and Latin American countries (USFWS, 1997). Some of these species are threatened and are experiencing significant habitat losses resulting from deforestation and land development (Kirby et al., 2008). Klaassen et al. (2008) observe that landscape habitat properties have a profound effect on migratory performance of long-distance migrants. The NM birds have experienced significant declines due to habitat loss resulting from deforestation and land development, threatening the future survival of many species. Terborgh (1980) observe that NM birds breed through a vast area

*Corresponding author. E-mail: randhir@eco.umass.edu, kerrid10@hotmail.com.

of North America and an acre loss in wintering habitat can leave up to 8 acres of breeding grounds devoid of migratory birds. Understanding the variety of spatial and temporal scales and complexity of habitat use by NM birds is necessary for successful management and conservation (Faaborg et al., 2010). Petit (2000) observed that a lack of information on habitat use by birds during migration has prevented development of comprehensive strategies for their protection along migration routes, specifically identification of high priority habitat types and protection of specific sites that are critical to long-term persistence of those species. This study aims at prioritizing habitat for NM birds at a regional watershed scale for conservation planning.

The complex way of life of NM birds can be useful to maximize their survival and reproduction (Rappole and Tipton, 1992; Cox, 1985). Their annual cycles allow them to exploit habitats and food resources in widely separated geographic regions in order to survive and reproduce. However, these cycles may also expose migrants to a higher likelihood of extinction than resident species, because of the multiplicity of environmental risks that migrants confront in an annual cycle (DeGraaf and Rappole, 1995). Bird migration involves risks and energetic costs such as increased predation, lack of available food resources, increased stress and reduction of fat reserves, as well as the chance of encountering catastrophic weather events. For migration to sustain in evolutionary terms, the associated costs and benefits must balance (Gilg and Yoccoz, 2010). However, migration has evolved because the benefits provided by the chance of greater reproductive success in the insect-rich temperate zone or increased survivorship over the winter in the warm tropics (Berthold, 1993) outweigh the costs. Predation risk is also high for migratory birds in high latititudes (McKinnon et al., 2010). Mortality rates during migration are high; it is estimated that 50 percent of migrants heading south for the winter will not return to breed in the spring. This is due to many factors, but continued loss and degradation of stopover habitats is one of the primary reasons. A one-way trip for most neotropical migrants is at least 2000 km. Although birds accumulate fat reserves of up to 50% of their body weight in preparation for departure, the rigors of long distance flight require most birds to rest and feed several times before they reach their final destination. Without adequate stopover habitat that provides an adequate food supply for the quick replenishment of fat reserves, shelter from predators, and water for re-hydration, birds in migration will not survive their journeys (Ktitorov et al., 2008; Moore and Simons, 1992).

It has been suggested that migrant birds sometimes follow riparian corridors during migration for travel (Doherty and Grubb, 2002; Skagen et al., 1998) and to take advantage of abundance of food resources and habitat potential in these areas (Naiman and Décamps, 1997). The benefits of using riparian corridors include food availability, aerial visibility as linear features and relatively stable landforms. A study by the U.S. Bureau of Land Management (1999) supports the idea that birds and other vertebrates use riparian corridors and benefit from their existence. The study observes that at least 80% of all animals use riparian areas at some stage of their lives, and this habitat may harbor 2 - 10 times more individual birds compared to an adjacent, non-riparian area. A watershed-scale approach is used by Miller and Ralph (2005) to study the relationship between riparian habitat and land use by stream-foraging birds, thus, suggesting the importance of riparian corridors and watersheds to migratory birds.

Studies since the 1970's have suggested that NM birds have been declining in the northeastern U.S. (Sauer et al., 2001; Johnston and Winings, 1987; Briggs and Criswell, 1978; Lynch and Whitcomb, 1978). Other early studies have documented a consistent absence of several species of mature forest-dwelling NM bird species from small isolated forest fragments (Galli et al., 1976; Robbins, 1979; Whitcomb et al., 1981; Ambuel and Temple, 1983). Subsequent studies have been conducted throughout the region to examine whether population declines are occurring and the reasons for such declines (Askins et al., 1990; Hagan and Johnston, 1992; Askins, 1993; Robbins et al., 1989). Several different reasons were attributed to the decline of NM birds during the past 40 years. These include loss of breeding habitat (Rompré et al., 2009; USFWS Report, 1987; Galli et al., 1976, Ambuel and Temple, 1983; Lynch and Whigham, 1984; Robbins et al., 1989; Askins, 1993, 1994; Petit et al., 1995; Terborgh, 1989), habitat fragmentation (Harris, 1984; Wilcove et al., 1986; Saunders et al., 1991; Askins et al., 1990), area effect (Arrenhius, 1921; Cain and Castro, 1959; Gleason, 1922; MacArthur and Wilson, 1967; Ambuel and Temple, 1983; Askins et al., 1990; Freemark and Collins, 1992; Robbins, 1989), brood parasitism (Brittingham and Temple,1983; Lynch and Whitcomb, 1978; Robinson, 1992; Whitcomb, 1977; Wilcove, 1985; Rich and Dobkin, 1994; Bohning-Gaese et al., 1993) and stopover/wintering- ground habitat loss (Sader and Joyce, 1988). Other factors include: inter-specific competition, loss of critical microhabitats, climatic events, successional changes, contaminant poisoning, and regular population fluctuations.

The forests of the northeastern United States are largely deciduous and mixed coniferous forests that support substantial populations of NM birds. Our study area, the Connecticut River Watershed (CRW) provides important habitats for NM birds in New England. A neotropical migrant bird stopover habitat survey conducted by Litwin and Lloyd-Evans (2006) shows that areas occurring immediately along the main stem of the Connecticut River, were most heavily used by spring migrants as stopover sites in all states and survey periods (1996 - 1998). They observed more birds in the southern end of the CRW than northern end and the overall density decreases by approximately 50% from south to north, as birds disperse from the main stem migration route. Of the approximately 110 species of NM birds that breed in the watershed, about 30% are considered to have declining populations (Lanza, 1997). Managers and planners recognize the need for reframing goals of “more” to “how much more” and “where” the conservation actions should take place to increase the effectiveness of management actions (Faaborg et al., 2010). There is a need for a watershed-scale priority-zation to protect habitat for neotropical migrants. Such a prioritization method needs to identify areas that require protection and areas that could generate maximum conservation benefits. There is a continued need of information to apply scientific knowledge to conservation theory and management, especially in the face of increasing population, resources consumption, and climate change (Faaborg et al., 2010). This study aims to identify and evaluate habitats that support NM birds in the CRW using a landscape-based assessment. Specific objectives of the study are: (i) To identify priority habitat for bird species using a variety of regional ranking schemes. (ii) To identify potential habitat for species of high priority conservation concern and (iii) To identify hotspots (We define a hotspot as location with relatively higher suitability in supporting the NM bird species based) for protection at a watershed scale.

METHODS AND MATERIALS

Study area

The Connecticut River is 410 miles long with its headwaters at the Canadian border. It empties into the Long Island Sound (Figure 2). The watershed encompasses an area of over 11,000 square-miles and includes parts of four states Connecticut, Massachusetts, New Hampshire and Vermont. The CRW is 80% forested, 12% agricultural, 3% developed and 5% under wetlands and water. There are 390 towns, villages and cities, which are home to 2.3 million people. The watershed is home to a rich diversity of species: 59 species of mammals, 250 birds, 22 reptiles, 23 amphibians, 142 fish, 1,500 invertebrates, and 3,000 plants. Ten federally listed endangered or threatened species occur within the watershed. The Connecticut River valley possesses some of the richest farmland in the Northeast. Its deep, well-drained soils are a product of annual floods and glacial Lake Hitchcock, which flooded much of the valley during the last period of glaciation (USFWS, 1995).

Data

The vegetation map produced as a substrate for the corridor analysis of the CRW was generated from three hyper cluster classifications provided by the multi-resolution land characteristics (MRLC) program of the national gap analysis program. The northern portion of the watershed vegetation map (NH and VT) was created based on the Northern New England GAP Analysis project. The minimum mapping unit is 30 m^2. The basins land use data were extracted for the CRW from the basins CD-ROMs from the U.S. environmental protection agency (EPA) Version 3.0 for Region 1 (New England). The land use data in BASINS version 3 is same as in latest version 4 and is based on USGS GIRAS land cover data. These data were re-projected to match the UTM, NAD 27, Zone 18 projection of the GAP Vegetation model and Priority Species models.

When deciding on a model for prioritizing land for conservation of birds or other species of animals, one must take certain factors into consideration, the scale of the area, the objectives of the conservation project, the quality of the habitat and most important, the behavior and habitat requirements/preferences of the species in question. To evaluate the model used in this study, two existing models were used to study alternative approaches and performance in prioritizing habitats for NM birds in the CRW. These models are TNC’s ELUM model (The Nature Conservancy’s (TNC) Ecological Land Units Model (ELUM), 1998; Anderson et al., 1998) and the Massachusetts Biomap model (Office of Environmental Affairs, Commonwealth of Massachusetts Technical Report 2001).

The habitat assessment is depicted in Figure 1, which is the synthesis of abiotic and biotic information into a system that uses landscape ecology elements to define the attributes of the factors influencing priority habitats for Neotropical migratory birds. These habitats affect bird species in general and neotropical migratory birds specifically, influencing their migration and breeding success. The biotic component was assessed using a combination of the GAP analysis (Gergely, 2010; Compton et al., 1996) and species habitat models based on DeGraaf and Rudis (1997). Anderson (1997) observed that available GAP vegetation maps were quite accurate with respect to the broadly defined cover classes. The status of 89 NM forest bird species was evaluated to determine conservation needs. 25 of those species were classified as high priority, using classification criteria presented in Table 1. The GAP analysis is a method of identifying “gaps” in the network of conservation land and water areas and is intended for quick overview of distribution and conservation status of several components of biodiversity (Jennings, 2000; Scott et al., 1993). It is a coarse filter approach to quantify status of biodiversity of vegetation and terrestrial vertebrates. Using the GAP analysis dataset for the southern New England region, the habitat requirements of these 25 species were identified using GIS overlays. Finally, overlaying the habitat models for the 25 highest-ranking species (Table 1) identified priority conservation areas for neotropical forest migratory birds throughout the Connecticut River Watershed. The empirical model (Figure 1), habitat assessment framework for NM birds is the synthesis of abiotic and biotic information into a system to define factors influencing priority habitats for neotropical migratory birds. These habitats affect bird species in general and NM birds specifically, influencing their migration and breeding success.

Species prioritization

The regional status of NM forest birds breeding in the Connecticut River Watershed was evaluated based on a synthesis of available species prioritization schemes. We used three schemes, the list of population trends developed by the Office of Migratory Bird Management (OMBM), U.S. Fish and wildlife service (1992), Partners-In-Flight (PIF) (Hunter et al., 1993) and the priority lists developed by Rosenberg and Wells (1995).

Each priority scheme was stratified into three physiographic provinces that occur in the watershed: Southern New England, Northern New England, and Spruce-Hardwood Forest. These physiographic provinces were considered as more natural divisions of bird habitat than political boundaries (Robbins et al., 1986). Priority bird species lists were compiled using three prioritization schemes for each physiographic province. The ranking used in this study uses the sum of 5 criteria for each bird species, which includes scores on global abundance, breeding distribution,

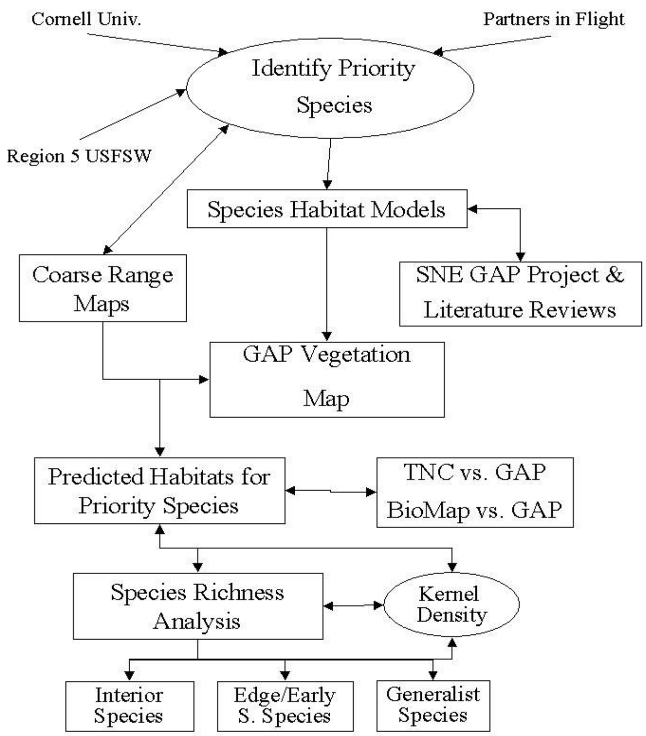

Figure 1. Empirical model of data flows.

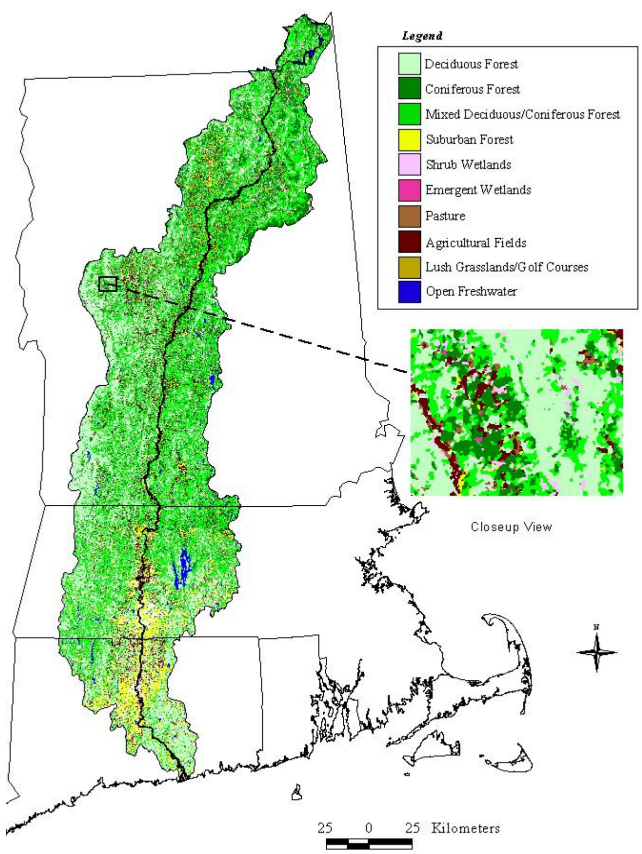

Figure 2. The connecticut river vegetation Map.

importance of physiographic region, threats to breeding grounds, and population trends. The scores were chosen based on the 10-year BBS population trend data. Species with scores above 14 were included in the PIF priority list. Birds that have insufficient population trend data scored 3 points for this criterion. Species might have been missed because there was not enough information about its population trend to give it a higher score.

Rosenberg and Wells (1995) provide a single list that ranked birds using the percent of the total population as a measure of the importance of the region to each species' long-term persistence in northeastern region of the U.S. These lists contained 11 - 22 bird species ranked as high priority species for each physiographic province. We synthesized these three priority schemes to develop a conservation priority list for the CRW. A rank of high (≥ 2), medium (1), or low (0) was assigned to each bird in each province. The list included 88 species of land birds that breed within the CRW, migrate outside the CRW for the winter and use forested habitat or forest edge habitat during the breeding season.

Habitat assessment

We used the species-habitat matrices developed by DeGraaf and Rudis (1987) and the forest stand characteristics developed by DeGraaf et al. (1992) for New England wildlife. These matrices were used to identify the habitat characteristics of each of the Neotropical migrant forest bird species in the watershed. In addition, using the Wildlife Worldwide CD-ROM database (National Information services corporation, 1996), we conducted a literature search for articles that pertained to habitat use by the 88 species of NM forest birds that occur within the watershed. Habitat descriptions for each species were updated when new information was identified. This information was from updates of Massachusetts Natural Heritage and Endangered Species Program (1995), Connecticut Department of Environmental Protection (1993), VT Fish and Wildlife Department's Natural Heritage Project (1995), NH Department of Fish and Game (1996) and the nature conservancy (1996). It is well recognized that birds often do not use the same habitat throughout their range (Block et al., 1995; Freemark et al., 1995; Morse, 1985). Consequently, the habitat descriptions used were based on studies done within or near New England. Habitat preferences of species are summarized in Table 2. More details on the model and algorithms are presented in Davis (2003).

Identification of priority areas

Habitat potential for the 25 high priority bird species (Table 1) throughout the CRW watershed was evaluated using Geographic information systems (GIS) analysis that involve defining the landscape in a grid and performing analysis for each grid unit (raster). The ArcGIS (ESRI, Redlands, CA, USA) software is used in conducting the raster analysis. The raster analysis involved defining biotic and abiotic conditions in each spatial unit (raster) and compiling habitat potential for each species in that raster. The habitat models were overlaid with the GAP vegetation map for 25 species of neotropical migrants identified in the high priority list using the "overlay" spatial function in ArcGIS. Due to the large scale of the watershed it was difficult to distinguish areas of high species richness without zooming in on areas of the map. Therefore, a classification scheme was created to better identify larger areas of high species richness. Such aggregation is useful in identifying large areas for conservation. Each of the 25 species of neotropical migrants was classified as interior nesters, edge/early successional species and generalist species, presented in Table 1. Interior nesters prefer the interior of the forest patch, while edge/ early succession species prefer edges or early succession forest

Table 1. Species of neotropical migratory forest birds ranked by priority level for the connecticut River watershed.

High priority[1]	**Medium priority**[2]	**Low priority**[3]
American redstart	American goldfinch	Acadian flycatcher
Black-billed cuckoo	Bay-breasted warbler	Alder flycatcher
Black-throated blue warbler	Bicknell's thrush	American robin
Black-throated green warbler	Black-and-white warbler	Blackpoll warbler
Blackburnian warbler	Broad-winged hawk	Blue-gray gnatcatcher
Blue-winged warbler	Brown-headed cowbird	Cape May warbler
Canada warbler	Cedar waxwing	Chipping sparrow
Chestnut-sided warbler	Cerulean warbler	Cooper's hawk[4]
Eastern wood pewee	Common yellowthroat	Dark-eyed junco
Golden-winged warbler	Eastern phoebe	Eastern bluebird
Gray catbird	Eastern towhee	Eastern kingbird
Great crested flycatcher	Indigo bunting	Hermit thrush
Louisiana waterthrush	Least flycatcher	Hooded warbler
Nashville warbler	Magnolia warbler	House wren
Northern oriole	Mourning warbler	Lincoln's sparrow
Northern parula	Northern waterthrush	Long-eared owl
Ovenbird	Olive-sided flycatcher	Mourning dove
Purple finch	Philadelphia vireo	Northern mockingbird
Rose-breasted grosbeak	Prairie warbler	Orchard oriole
Scarlet tanager	Red-eyed vireo	Palm warbler
Veery	Solitary vireo	pine siskin
Whip-poor-will	Swainson's thrush	Pine warbler
Wood thrush	Tennessee warbler	Red-shouldered hawk
Worm-eating warbler	Tree swallow	Red-tailed hawk
Yellow-billed cuckoo	White-throated sparrow	Ruby-crowned kinglet
	Willow flycatcher	Ruby-throated hummingbird
	Yellow-bellied sapsucker	Sharp-shinned hawk
	Yellow-throated vireo	Song sparrow
		Turkey vulture
		Warbling vireo
		White-eyed vireo
		Yellow warbler
		Yellow-bellied flycatcher
		Yellow-breasted chat
		Yellow-rumped warbler

[1]High priority species were given a high priority rank by at least two of the three schemes in at least one physiographic province.
[2]Medium priority species were given high priority rank by at least one of the three schemes in at least one physiographic province.
[3]Low priority species did not appear on any of the three schemes' high priority lists.

Table 2. Habitat preference types of priority species of neotropical migratory birds.

Interior habitat	Edge/early successional habitat	Generalist species
American redstart	Gray catbird	Canada warbler
Blackburnian warbler	Blue-winged warbler	Easter Wood pewee
Black-throated blue warbler	Chestnut-sided warbler	Black-billed cuckoo
Black-throated green warbler	Golden-winged warbler	Great-crested flycatcher
Louisiana waterthrush	Nashville warbler	Northern Oriole
Ovenbird	Whip-poor-will	Northern Parula
Scarlet tanager		Purple Finch

Table 2. Contd.

Veery	Rose-breasted Grosbeak
Wood thrush	Yellow-billed Cuckoo
Worm-eating warbler	

patches. Generalists occur in any place suitable for nesting.

To further identify important areas for conservation, we focus on areas that support the highest numbers of priority species. These high priority areas where further aggregated using a statistical analysis to identify patterns. A kernel density estimate was used for each class resulting in the identification of large areas for conservation of the three classes of species. To perform this analysis each cell of a grid of the priority areas was converted to a point estimate in geographic space. These points were analyzed using kernel density estimation for a focal area of 32,400 m^2 (6 cells of the grid), resulting in an output cell size of 8100 m^2 (90 x 90 m grid). Kernel density estimation is a simple technique of data exploration, where point values are spread from the point to a specified radius. The sum of intersecting spreads is calculated for each focal area making it a smoother distribution of the density data (Bailey and Gatrell, 1995). The results were evaluated at various confidence intervals of 95, 75 and 55%. The confidence intervals indicate that the areas with 95% confidence have the highest probability of providing habitat for our priority species and could be targeted for protection. We use standard ninety-five percent level as it relates to 5% level of significance often used in interpreting statistical models.

RESULTS AND DISCUSSION

Habitat assessment

The generalist species that have broader niches and can tolerate larger changes in the environment are found throughout the study watershed (Figure 3). The wide distribution of generalists can be attributed to their ability to use a variety of habitats and to tolerate disturbances. The areas found to have highest density of habitat potential are in the southern part of the watershed in Connecticut, areas in northern Massachusetts and along the Connecticut River corridor in the lower and central part of New Hampshire and Vermont. The southern part of watershed is suburbanizing and show environmental tolerance of generalist under such conditions. Similar results were obtained by Bonier et al. (2007). The existence of higher habitat potential in riparian corridor can be due to stop over habitat (Litwin and Lloyd-Evans, 2006). There is also a location with higher density at the very tip of the watershed boundary in the northern section of the watershed in New Hampshire, where higher levels of unfragmented woodlands occur.

The edge/early successional species birds are sparsely scattered throughout the watershed (Figure 4) with the highest densities of NM bird habitats occurring in the southern part of the watershed in western Massachusetts and the northern part of Connecticut. This part of the watershed has higher fragmentation from suburban and agricultural uses that provide higher edge habitat. The role of edge effect is also observed by Banks-Leite et al. (2010). The priority habitats tend to congregate along the riparian corridors of the river, as also observed by Litwin and Lloyd-Evans (2006). There are additional smaller patches in the southern, middle and northern part of New Hampshire and Vermont along the river that coincide with forest and cropland landscapes.

The priority habitats for interior nesting birds are located mainly in the southern half of the watershed (Figure 5), occupying most of the area. There is a large density of priority habitat in the southern section of Massachusetts, which coincides with Berkshires and Holyoke mountain range. These ranges support forested areas that are unfragmented and support larger core areas. Similar observation was done by Robinson et al. (1995), who observe that reproductive success of forest nesting species is positively correlated to percent of forest interior of a region. This high density area is located in western Massachusetts along the Connecticut River, in the Berkshires, an area that is very rural and heavily forested. The white patches in the middle of this area are due to urban and suburban development along the river.

The habitat assessment through Biomap's approach coincided well with the GAP-based approach used in this study, but did not cover certain areas identified by our model. Biomap identifies 61,525 ha of core habitat in the CRW, approximately 29,928 ha or half, overlaps with our GAP priority areas. The Biomap core areas and supporting natural landscapes are clustered close to the Connecticut River corridor and the areas adjacent to them. The reason for this could be the occurrence of high quality habitats in these riparian areas or that these areas are easier to study and therefore, more data are available on them.

The highest coverage among classes of vegetation in the watershed is deciduous and mixed deciduous /coniferous forest. Since the watershed is 80% forested, this is quite a large area overall for forest bird species. The next most abundant type is coniferous forest, followed by suburban forest. Agriculture also represents a good portion of the watershed with a combined total of 23,967 ha. These types of habitats are beneficial for our variety of migrant bird species (Packett and Dunning, 2009) especially any large expanses of un-fragmented forest land and patches of forestland in close proximity to other patches.

It should be noted that the highest area of forest occupied by birds is used by 3 of our priority generalist species.

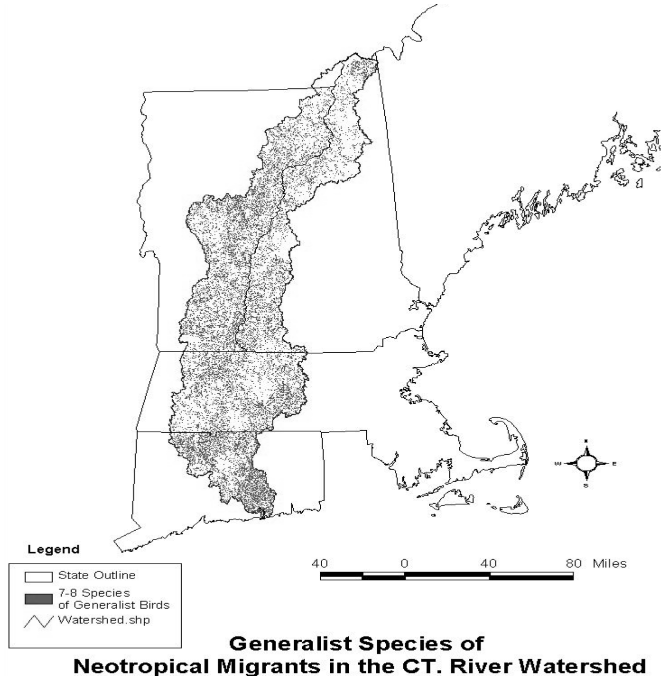

Figure 3. Highest class of generalist species of birds.

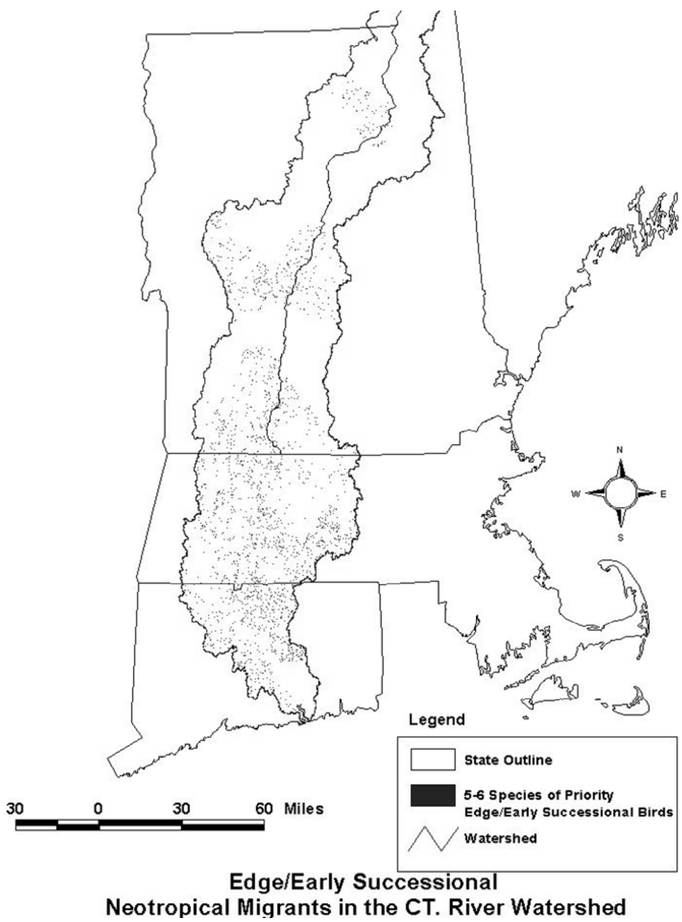

Figure 4. Highest class of edge/early successional birds.

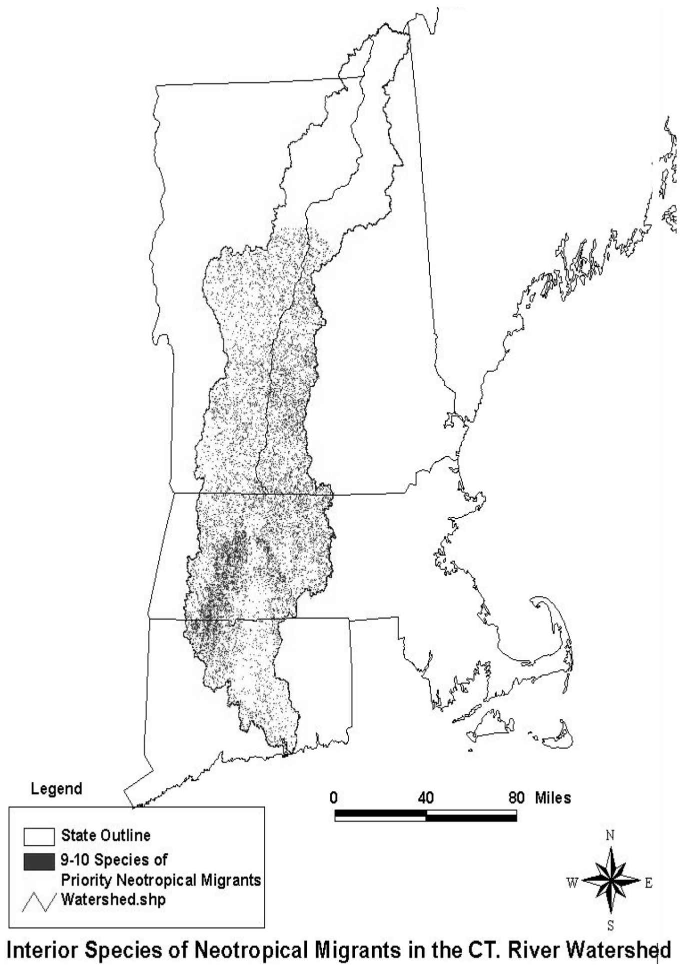

Figure 5. Highest class of interior nesting species of birds.

The highest area of urban land is occupied by 4 species. The interior species occupy the highest area of forestland with 853,791 ha under 7 species and 816,173 ha under 8 species, respectively. The second highest category is urban areas with 5 species occupying 121,516 ha. These data correspond to our predicted high priority sites for the interior bird species.

The highest among land classes is forest area, amounting to 318 and 114 ha for 2 species, 168,834 ha for 4 species and 166,850 ha for a single species. The second highest category occupied by the edge/early successional species is urban at 119,174 ha for one species. This corresponds with edge/early successional species preferring the edge created by urban and agricultural areas. Pasture also creates habitat for early successional species. The highest classification of suburban forest is 156,809 ha for edge/early successional birds at one species. The different and similar use of forested habitats corresponds to the behavior of these edge species.

The generalist species show the most widely variable use of habitats for each number of species present. This use pattern corresponds well with the more flexible use of habitats by generalist species and their distribution over the entire watershed. The interior species represent the highest number of bird species (7) occupying the highest number of hectares of deciduous forest (746,825). These birds require a higher forest interior to edge ratio. They also occupy the highest area of mixed deciduous/ coniferous forest at 584,345 ha for 8 species.

Density of high priority areas

A kernel density analysis can provide useful information on large areas to protect, to identify hot spots and areas with high species richness for priority species in the watershed. The results of this analysis are presented in Figures 6 to 8. In Figure 6, the area of highest species richness for edge/early successional species is at the border of Massachusetts and Connecticut along the riparian corridor. The second densest occurrence of species is the surrounding area in the southern part of the watershed in southern Massachusetts and northern Connecticut. This area is a more developed part of these states with urban and suburban environments. These environments contain large areas of the edge habitat preferred by these species. The agricultural component of this area also provides a significant amount of early successional habitat. Packett and Dunning (2009) discuss the role of such forest-agricultural landscape as stop over habitat for migrants. Two additional small clusters of species richness occur in the middle of the watershed along the river in Vermont, and a smaller patch is in the northern section of the watershed. These areas contain numerous agricultural fields mixed with suburban forests, a possible reason for their attractiveness to these birds. These areas can be a focus of conservation strategies to protect habitat neotropical migrants.

More of the watershed is covered by hot spots for generalist species (Figure 7). This distribution corresponds with the generalist species being less restricted by their habitat types. The densest area of hot spots, at a 95% confidence interval, is located in the Connecticut state, in the upper and lower parts of the watershed. Two other large patches are located within the 75% confidence interval along the riparian corridor in the southern sections of New Hampshire and Vermont, with more area on the Vermont side of the watershed. There is also a small patch in the eastern section of Massachusetts, which is significant for its connections to the other larger parcels. Another possible reason that the green "hot spots" are more attractive to generalist species is probably due to forest composition (Gil-Tena et al., 2007) and the proximity of open water resources. Besides the Connecticut River, there are several small ponds or lakes located within 10 to 12 miles of each of these hot spots.

Hotspots are located in the southern half of the watershed and not the northern parts (Figure 8). The

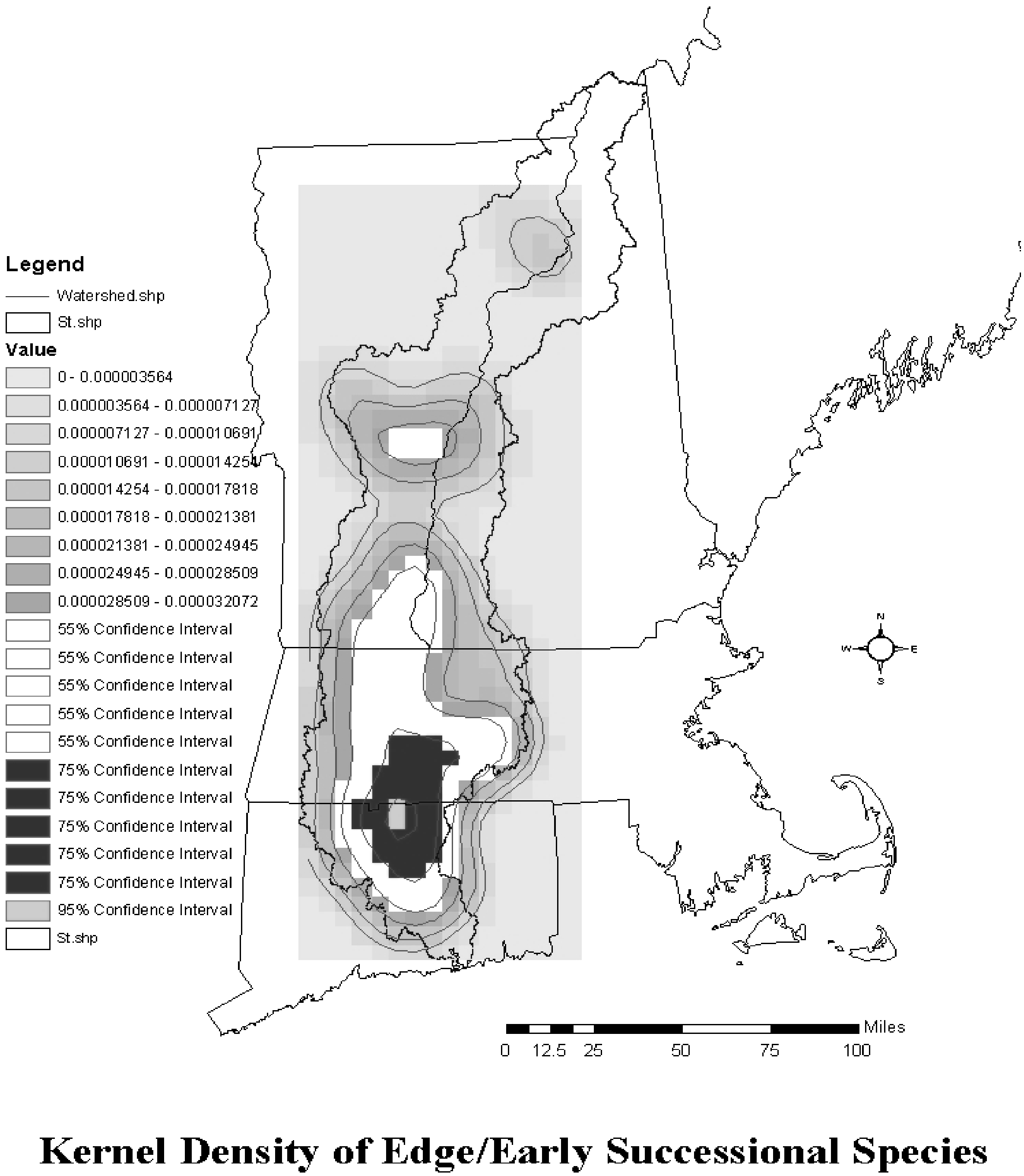

Figure 6. Species richness map of edge/early successional priority bird species.

densest area is at the 95% confidence interval in western Massachusetts, particularly located in the Berkshires and along the Connecticut border. Smaller areas located near developed areas are significant in providing habitat for priority interior species. In addition, some hot spot areas where near within 12 to 25 miles of open water. Although most birds prefer larger habitats, these data indicate that western Massachusetts is very important for these NM bird species.

Conclusion

The decline of neotropical migratory bird species region-wide has become a major conservation issue in the Northeast and elsewhere. Loss of habitat due to development and habitat fragmentation are major factors that threaten the future survival of these species. Protection of neotropical migrant bird habitats has become essential for maintaining stable breeding populations.

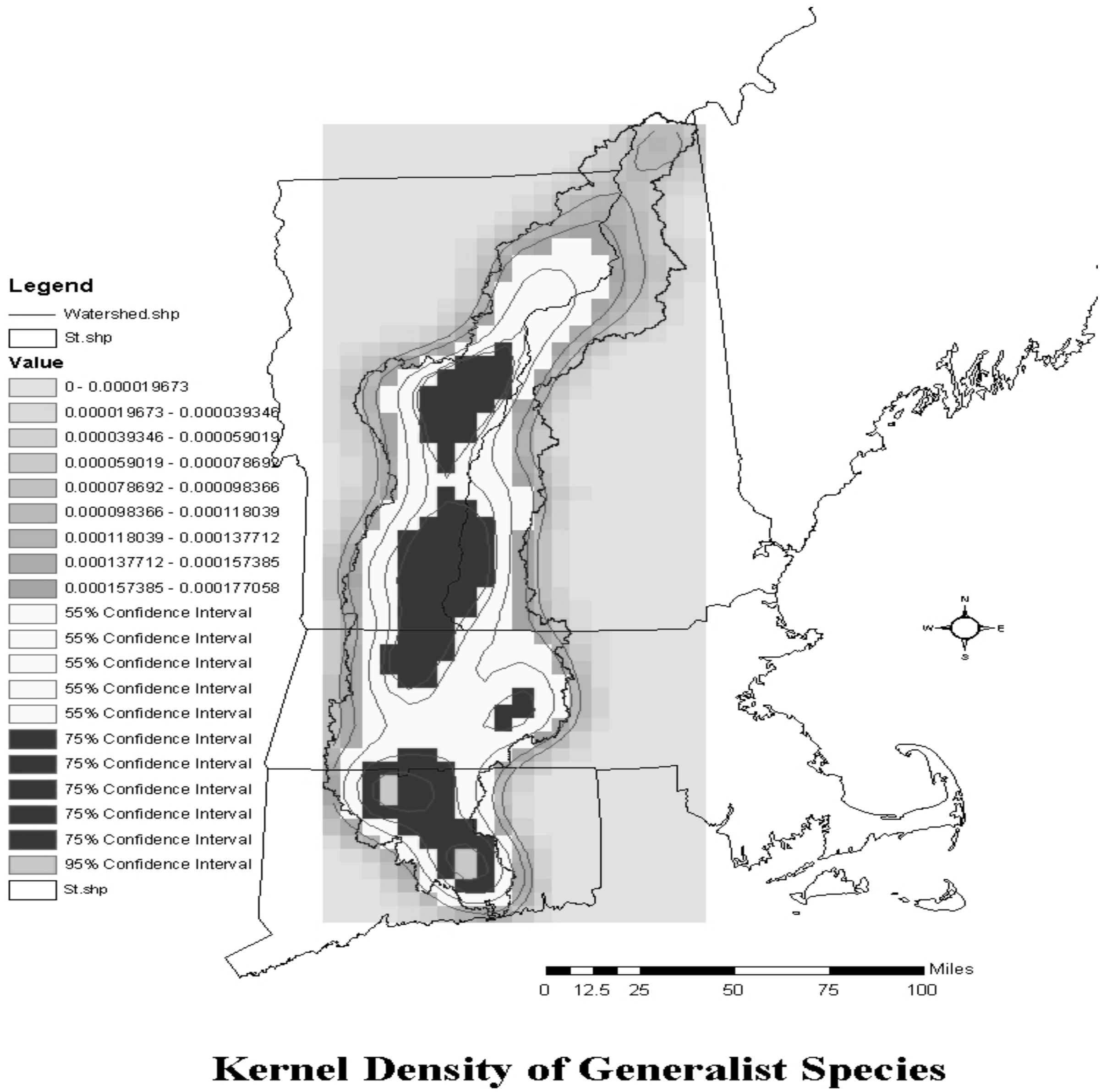

Figure 7. Species richness map of generalist priority Bird species.

This study provides a framework for prioritizing birds and habitats with the goal of improved management decisions. When deciding on an approach to manage a landscape, a model such as the GAP model and the use of GIS as a predictive tool are cost effective ways of addressing conservation priorities for neotropical migrants. It is important to note that these models are not predictors of bird occurrence, but rather a way to identify potential habitat over a large geographical area. This fact is important to understand when deriving policies for conservation. Transboundary issues affect the protection of NM birds, since these birds migrate and live in multiple continents, watersheds and ecosystems. Protecting NM birds requires a collaborative effort that involves multiple countries, regions and interests groups at a variety of scales.

The approach used by the nature conservancy (TNC (ELUM), 1998.), although important for identifying large parcels of land that birds could occupy, ignores habitat preferences for certain species as well as discounting smaller areas in the southern, more developed sections of the CRW. The method used in this study has advantages over other methods because of its emphasis on bird behavior and habitat preferences (i.e., Species Habitat Models). This model also incorporates a finer scale approach than the TNC (ELUM) model, addressing smaller patches of habitat with regard to connectivity, proximity to other forest habitats, and area-sensitivity of

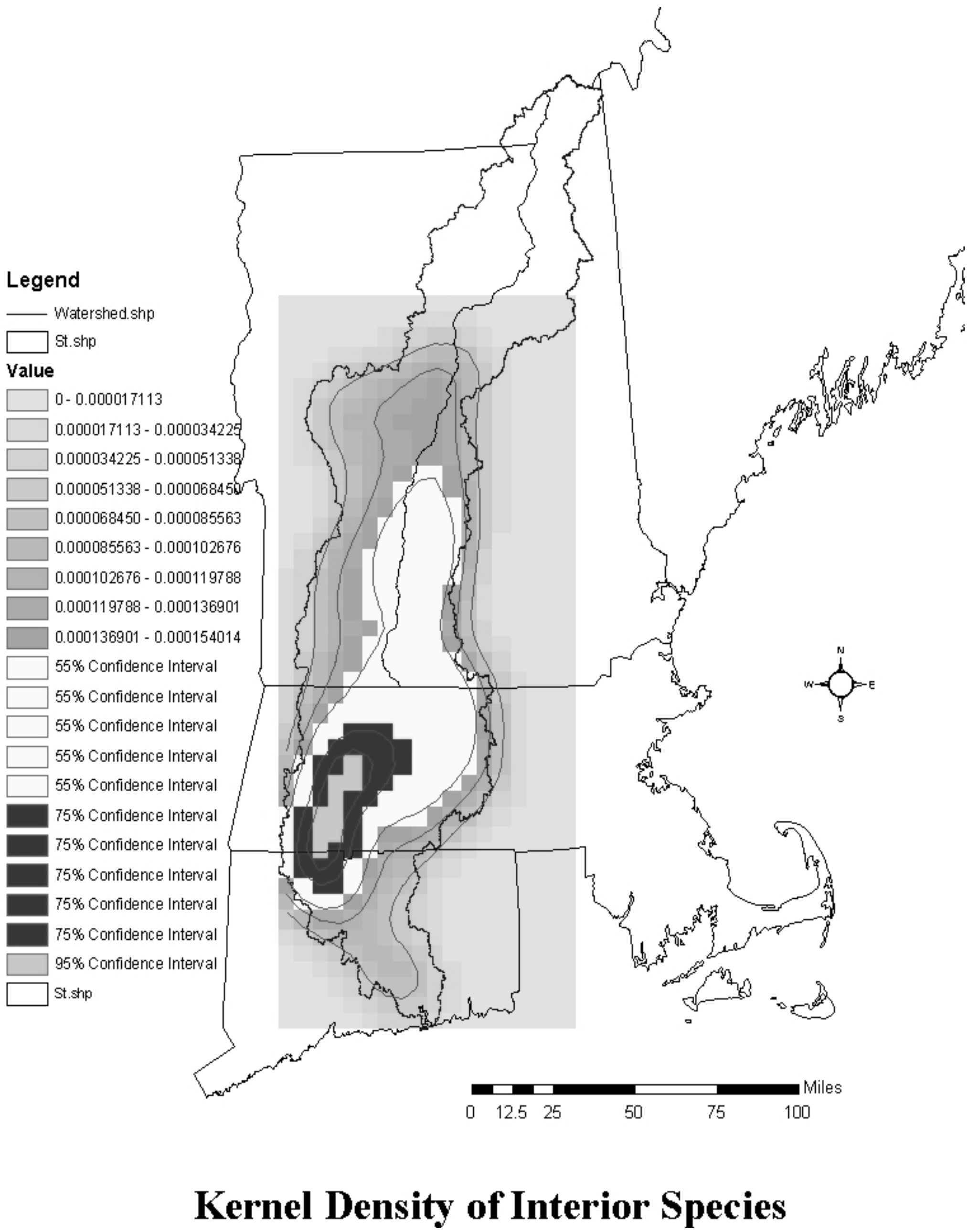

Figure 8. Species richness map of interior priority bird species.

target species. To further refine the model we would consider using a combination of the GAP model with a model such as the Biomap to incorporate known locations of critical species, while also addressing issues of habitat size and area.

Several key findings of this project are the results of the kernel densities for interior species of birds. These maps identify the southern half of the watershed and specifically western Massachusetts as potentially being a hot spot for interior species. Since interior species are much more habitat specific, a study by Robbins et al. (1989) suggests two alternative approaches when preservation of large contiguous forest tracts is not a realistic option. First, if other habitat attributes also are considered, smaller forest patches may provide suitable breeding sites for relatively rare species, and second, smaller tracts in close proximity to other forests may serve to attract or retain area-sensitive species. For generalist species, areas of open water appeared to influence the density of birds in these areas whereas, there were several small ponds or lakes located within 10 to 12 miles of each of the generalist hot spots. Also the southern half of the watershed in the more heavily developed sections of Massachusetts and Connecticut may provide significant potential habitat for our priority edge/early successional species. The importance of adaptive management framework that includes monitoring, evaluation and modification of practices (Williams et al., 2007) is important in conservation of NM birds.

This research could be tested on a larger area such as the Northeast and include more groups of species. This would allow the identification of important habitats for a broader group of species. This research could be combined with field observations to allow for “ground truthing” of our model with actual bird count data. Our literature search indicated that detailed descriptions of forest types and stand characteristics for NM birds in New England are generally lacking. Most quantitative habitat studies have focused in smaller study areas, and do not encompass the wide range of forest types and structural features that occur in the New England region, representing only a limited portion of a species’ range. Quantitative sampling of habitats over large areas of species ranges is needed to address these issues.

ACKNOWLEDGEMENTS

We would like to thank Dr. Curt Griffin and Prof. Tom Litwin for providing advice during this research. This material is based upon work partially supported by the Cooperative State Research Extension, Education Service, U.S. Department of Agriculture, Massachusetts Agricultural Experiment-Station, under Projects MA500864, MAS000943, NE-1024, MS 11, and MAS 00924.

REFERENCES

Ambuel B, Temple SA (1983). Area-dependent changes in the bird communities and vegetation of southern Wisconsin fores.. Ecol. 64(1): 1057-1068.

Anderson MG (1997). An assessment of the ability to identify vegetation alliances from GAP vegetation cover maps. Connecticut river watershed initiative: project summary and progress report. The Nature Conservancy. Boston, MA.

Anderson MG, Merrill MD, Biasi FB (1998). Connecticut River Watershed Analysis: Ecological communities and Neo-tropical migratory birds, Eastern Conservation Science Boston Satellite Office, The Nature Conservancy.

Askins RA (1993). Population trends in grassland, shrubland and forest birds in eastern North America. Current Ornithology 11: 1-34.

Askins RA (1994). Open corridors in a heavily forested landscape: Impact on shrubland and forest-interior birds. Wildlife Society Bulletin 22: 339-347.

Askins RA, Lynch JF, Greenberg R (1990). Population declines in migratory birds in eastern North America. Current Ornithology 7: 1-57.

Bailey TC, Gatrell AC (1995). Interactive Spatial Data Analysis. Longman, Harlow.

Banks-Leite C, Ewers RM, Metzger J (2010). Edge effects as the principal cause of area effects on birds in fragmented secondary forest. Oikos, 119(6): 918-926.

Berthold P (1993). Bird Migration: A General Survey. Oxford University Press Inc., New York.

Bonier F, Martin PR, Wingfield JC (2007). Urban birds have broader environmental tolerance. Biology Letters 3(6): 670-673.

Briggs SA, Criswell JH (1978). Gradual silencing of spring in Washington: Selective reduction of species of birds found in three woodland areas over the past 30 years. Atl. Nat. 32: 19-26.

Compton BW, Milam JC (1996). Southern New England GAP Analysis.

Cox GW (1985). The Evolution of Avian Migration Systems between Temperate and Tropical Regions of the New World. American Naturalist 126(4): 451-474.

Davis K (2003). Assessing Priority Habitats for Neotropical Migratory Birds in the Connecticut River Watershed. Unpublished graduate professional paper submitted to the Department of Natural Resources Conservation, University of Massachusetts, Amherst.

DeGraaf RM, Rappole JH (1995). Neotropical Migratory Birds: Natural History, Distribution, and Population Change. Ithaca, NY and London, Cornell University Press.

DeGraaf RM, Yamasaki M, Leak WB, Lanier JW (1992). New England Wildlife: Management Forested Habitats. Gen. Tech. Rep. NE-144. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, p. 271.

DeGraaf RM. Rudis DD (1986). New England Wildlife: habitat, natural history and distribution. Gen. Tech. Rep. NE-108. US Department of Agriculture, Forest Service, p. 491.

Dingle H, Drake A (2007). What is Migration? Bioscience 57(2): 113-121.

Doherty PF, Grubb TC (2002). Survivorship pf permanent-resident birds in a fragmented forested landscape. Ecol. 83(3): 844-857.

Executive Office of Environmental Affairs (2001). Commonwealth of Massachusetts, BIOMAP Project, Technical Report.

Faaborg J, Holmes RT, Anders AD, Bildstein KL, Dugger KM, Gauthreaux SA, Heglund P, Hobson KA, Jahn AE, Johnson DH, Latta SC, Levey DJ, Marra PP, Merkord CL, Nol E, Rothstein SI, Sherry TW, Sillett TS, ThompsonFR, Warnock KN (2010). Conserving migratory land birds in the New World: Do we know enough? Ecol. Appl. 20(2): 398-418.

Galli AE, Leck CR, Forman RTT (1976). Avian distribution patterns in forest islands of different sizes in central New Jersey. Auk 93: 356-364.

Gergely K (2010). GAP Analysis: Program Overview, GAP Analysis Bulletin 17: 3-4.

Gilg O, Yoccoz NG (2010). Explaing bird migration. Sci. 327(5963): 276-277.

Gil-Tenaa A, Sauraa S, Brotonsb L (2007). Effects of forest composition and structure on bird species richness in a Mediterranean context: Implications for fores. Eco. Manage. For. Ecol. Manage. 242(2-3): 470-476.

Hagan JM, Johnston DW eds. (1992). Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington.

Hunter WC, Carter MF, Pashley DN, Barker K (1993). The Partners in Flight prioritization scheme. Pages 109-119 in Finch DM, Stangel PW Eds. 1993. Status and management of Neotropical migratory birds. Gen. Tech. Rep. RM-229. Fort Collins, CO: U.S. Dept. of Agriculture, Forest Service, Rocky Mtn. Forest and Range Exp. Sta.

Jennings MD (2000). Gap analysis: concepts, methods, and recent results. Landscape Ecol. 15(1): 5-20.

Johnston DW, Winnings DI (1987). Natural History of Plummers Island, Maryland. Proc. Biol. Soc., Washington.

Kirby JS, Stattersfielda AJ, Butcharta SHM, Evansa MI, Grimmetta RFA, Jones VR, O'Sullivan J, Tucker GM, Newton I (2008). Key conservation issues for migratory land- and waterbird species on the world's major flyways, Bird Conservation International, 18: S49-S73.

Klaassen RHG, Strandberg R, Hake M, Alerstam T (2008). Flexibility in daily travel routines causes regional variation in bird migration speed, Behav. Ecol. Sociobiol. 62(9): 1427-1432.

Ktitorov P, Bairlein F, Dubinin M (2008). The importance of landscape context for songbirds on migration: body mass gain is related to habitat cover, Landscape Ecol. 23(2): 169-179.

Lanza H (unpublished). Habitat Conservation Priorities for Neotropical Migratory Forest Birds in the Connecticut River Watershed. Amherst, MA, University of Massachusetts.

Litwin T, Lloyd-Evans T (2006). Silvio Conte National Fish and Wildlife Refuge neotropical migratory bird stopover habitat survey. Clark Science Center, Smith College, Northampton, MA. http://www.science.smith.edu/stopoverbirds/ index.html

Lynch JF, Whigham DF (1984). "Effects of forest fragmentation on breeding bird communities in Maryland, USA." Biol. Conserv. 28: 287-324.

McKinnon L, Smith PA, Nol E, Martin JL, Doyle FI, Abraham KF, Gilchrist HG, Morrison RIG, Bêty J (2010). Lower Predation Risk for Migratory Birds at High Latitudes. Sci. 327(5963): 326-327.

Miller SL, Ralph CJ (2005). A Watershed-Scale Survey for Stream-Foraging Birds in Northern California. USDA Forest Service Gen. Tech. Rep. PSW-GTR-191: 537-540.

Moore FR, Simons TR (1992). Habitat suitability and the stopover ecology of neotropical passerine migrants. In: Hagan J, and Johnston D, editors. Ecology and Conservation of neotropical Migrant Landbirds. Washington, DC:Smithsonian Institution Press pp. 345-355.

Naiman RJ, Décamps H (1997). The Ecology of Interfaces:Riparian Zones. Annual Rev. Ecol. Sys. 28: 621-658.

Packett DL, Dunning JB (2009). Stopover habitat selection by migrant land birds in a fragmented forest–agricultural landscape The Auk, 126(3): 579–589, DOI 10.1525/auk.2009.08198.

Petit DR (2000). Habitat use by land birds along nearctic-neotropical migration routes: Implication for conservation of stopover habitats. Stud. Avian Bio, 20(1): 15-33.

Robbins CS, Sauer JR, Greenberg RS, Droege S (1989). Population declines in North American birds that migrate to the neotropics. Proceedings of the National Academy of Sciences of the United States of America 86: 7658-7662.

Robinson SK, Thompson FR, Donovan TM, Whitehead DR, Faaborg J (1995). Regional forest fragmentation and the nesting success of migratory birds. Sci. 267: 1987-1990.

Rompré G, Robinson WD, Desrochers A, Angehr G (2009). Predicting declines in avian species richness under nonrandom patterns of habitat loss in a Neotropical landscape. Ecological Applications. doi: 10.1890/08-1207. : 19(6): 1614-1627.

Rosenberg KV, Wells JV (1995). Importance of Geographic Areas to Neotropical Migrant Birds in the Northeast. U.S. Fish and Wildlife Service Report, Region-5, Hadley, MA, p. 120.

Sauer JR, Hines JE, Fallon J (2001). The North American Breeding Bird Survey, results and analysis 1966–2000. Online: http://www.mbr-pwrc.usgs.gov/bbs.

Scott JM, Davis F, Csuti B, Noss R, Butterfield B, Groves C, Anderson H, Caicco C, D'Erchia F, Edwards Jr. TC, Ulliman J, Wright RG (1993). Gap analysis: A geographic approach to protection of biological diversity. Wildlife Monographs 123: 1-41.

Skagen SK, Melcher CP, Howe WH, Knopf FL (1998). Comparative Use of Riparian Corridors and Oases by Migrating Birds in Southeast Arizona Conserv. Bio. 12(4): 896-0909.

Terborgh JW (1980). The conservation status of neotropical migrants: present and future. in. Keast A, Morton ES editors. Migrant birds in the neotropics: ecology, behavior, distribution, and conservation.
. Smithsonian Institution Press, Washington, D.C., USA, pp. 21–30.

The Nature Conservancy (1998). Ecological Land Units Model, technical report, 1998. The Nature Conservancy.

USFWS, (1987). Migratory nongame birds of management concern in the United States. Washington, D.C., U. S. Dept. of the Interior, Fish and Wildlife Service: p. 15.

White D, Minotti PG, Barczak MJ, Sifneos JC, Freemark KE, Santelmann MV, Steinitz CF, Ross KA, Preston EM (1997). Assessing Risks to Biodiversity from Future Landscape Change. Conserv. Bio. 11(2): 349-360.

Williams BK, Szaro RC, Shapiro CD (2007). Adaptive management: the U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, D.C., USA.