Conservation Limits and Management Opportunities

For Fall Migrants along the Lower Delmarva Peninsula

Center for Conservation Biology

College of William and Mary and Virginia Commonwealth University

Conservation Limits and Management Opportunities

for Fall Migrants along the Lower Delmarva Peninsula

Bryan D. Watts
Michael D. Wilson
Center for Conservation Biology
College of William and Mary
Virginia Commonwealth University
Williamsburg, VA 23187-8795

Recommended Citation:

Watts, B. D. and M. D. Wilson 2013. Conservation limits and management opportunities for fall migrants along the lower Delmarva Peninsula. Center for Conservation Biology Technical Report Series, CCBTR-13-05. College of William and Mary/Virginia Commonwealth University, Williamsburg, VA. 25 pp.

Project Funded By:
Virginia Coastal Zone Management Program
The Center for Conservation Biology

Cover Photo: Bryan D. Watts

The Center for Conservation Biology is an organization dedicated to discovering innovative solutions to environmental problems that are both scientifically sound and practical within today's social context. Our philosophy has been to use a general systems approach to locate critical information needs and to plot a deliberate course of action to reach what we believe are essential information endpoints.

Contents

EXECUTIVE SUMMARY

The lower Delmarva Peninsula is one of the most significant migration bottlenecks in eastern North America where large numbers of birds become concentrated within a relatively small land area. Habitats on the peninsula receive extremely high use by migrant landbirds during the fall months and are considered to have some of the highest conservation values on the continent. Past research has documented that the lower 20 km of the peninsula tip has a significantly greater density of birds compared to other areas.

Over the past 20 years, blocks of private land have been acquired by the state and federal agencies for the purpose of restoring habitat for migratory birds. The conservation and management community has two distinctly different avenues available to improve habitat for fall migrant birds on the lower Delmarva Peninsula; 1) expand the amount of conservation lands through acquisition, private landowner agreements, and voluntary means, or 2) improve existing lands so they may support higher densities of birds through restoration.

The purpose of this study was to establish a conceptual framework to place conservation progress and serve as a foundation for future efforts. The amount of land currently supporting forest cover represents only 30.3% of the study area suggesting that there is considerable opportunity to restore additional habitat to support migrants. Theoretically, there is space to triple the current footprint of forest habitat. Currently, conservation lands represent less than 14% of the upland landscape and support 16% of the total forest lands. Land that is currently ongoing restoration through conversion from unusable habitat to shrub or forest will nearly double the value of conservation lands to forest migrants and will ultimately increase the existing forest habitat within conservation lands by another 16%. Despite its relatively small land mass, the study area is estimated to support more than 4 million bird days during the migratory period. In order to break even energetically, these birds would require nearly 30 metric tons of food. Conservation lands are currently supporting less than 20% of the bird use within the study. However, if ongoing restoration projects are brought to their conservation endpoints they would more than double this contribution.

There are a number of information gaps that prevent a deeper assessment of conservation objectives for the lower Delmarva Peninsula. At the root of this gap is the need to better understand the standing crop of energy (i.e., food) within forest patches. Energy is the most important currency to assess whether the Lower Peninsula is an energy source for birds (i.e., birds are provided with opportunity for a net energy gain) or an energy sink (i.e., the peninsula cannot meet energetic demands). Another information need is to gain a better understanding on the relationship between the standing crop and foraging rates of migrants. Taken together with conservation objectives, if resource demand of migrants is higher than what reference patches can produce, then the only solution is to increase forested land base to accommodate the number of consumers. However, this option has its limit within a confined landscape of the Lower Delmarva Peninsula.

BACKGROUND

Fall migration on the Lower Delmarva Peninsula

The vast majority of nearctic-neotropical migratory birds are physically incapable of carrying enough energy to complete non-stop flights between their breeding and wintering areas. To overcome this problem, migrants make periodic stops en route to replenish energy reserves. Once in stopover areas, migrants encounter unfamiliar landscapes where they must maintain a positive energy balance often under severe time constraints and uncertain conditions. Individuals that are able to successfully negotiate these conditions presumably increase their probability of successfully completing migration by maximizing their rate of energy deposition. Since successful migration is a prerequisite for future breeding, habitat use decisions made within stopover areas have profound fitness consequences for migrants.

The lower Delmarva and Cape May peninsulas are the most significant migration bottlenecks in eastern North America, concentrating large numbers of birds within relatively small land areas. Habitats on these peninsulas receive extremely high use by migrant landbirds during the fall months and are considered to have some of the highest conservation values on the continent. Along the lower Delmarva Peninsula, fall migrants "fall out" in the early morning hours as they reach the mouth of the Chesapeake Bay and form a steep density gradient extending south to north within the lower 20 km (Watts and Mabey 1993, 1994). This pattern suggests that lands near the peninsula tip have very high conservation value. Research has documented significant levels of resource depression within this concentration area (Watts et al., Unpublished) suggesting that habitat availability/quality may directly influence the condition of migrants during stopover periods and presumably their likelihood of surviving migration.

Over the past 20 years blocks of private land have been acquired by state and federal agencies for the purpose of restoring habitat for migratory land birds. This activity represents a sea change in both the character and purpose of this landscape. However, there has been no conceptual framework established within which to place progress to date or to serve as a foundation for future efforts.

Conservation Limits and Opportunities

The conservation and management community has two distinctly different avenues available to improve habitat for fall migrants on the lower Delmarva Peninsula. The first is to expand the amount of habitat (e.g. footprint of conservation lands dedicated to supporting migrants) either through 1) direct acquisition (i.e. movement of lands from private to conservation control), 2) some type of agreement with private landowners that restricts the use of the land to benefit migrants, or 3) some education program that leads to voluntary changes in the management of private lands. The second is to improve habitat quality (i.e. the ability of lands to support higher densities of birds) through restoration. Both of these options have limits. A conceptual approach to understanding conservation limits and opportunities within the lower Delmarva Peninsula is illustrated in Figure 1.

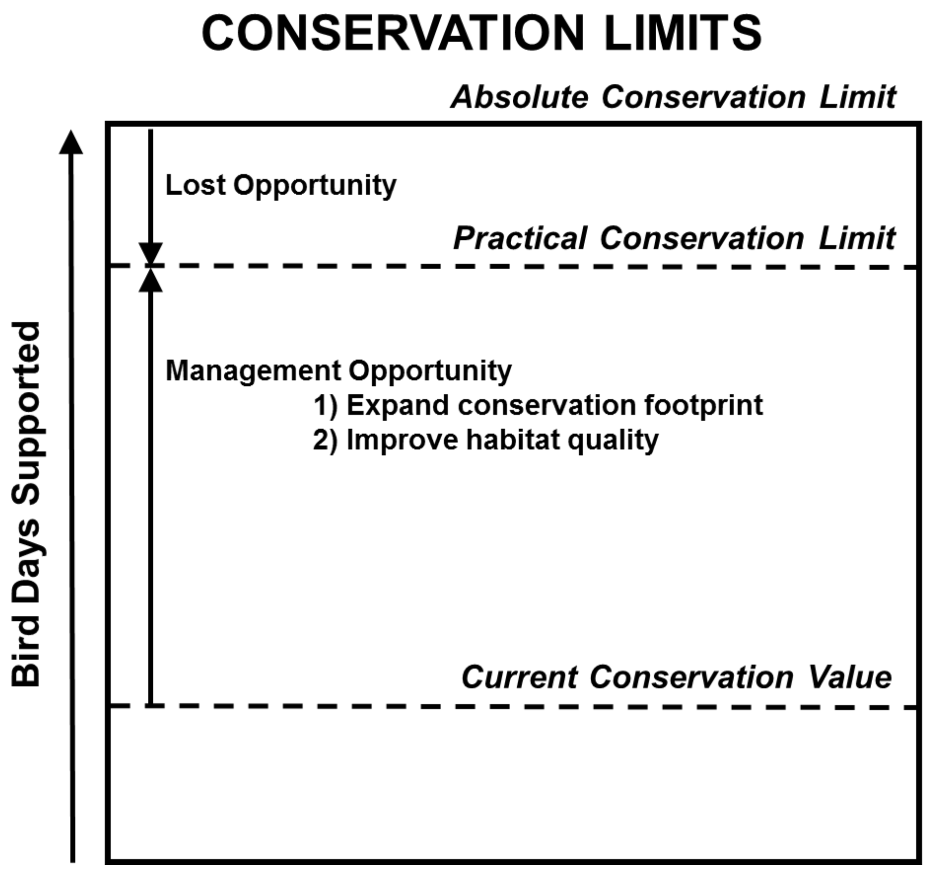

Figure 1. Conceptual diagram illustrating the relationship between conservation limits, current conservation value, and management opportunities.

<u>Expanding Conservation Footprints</u> - Our ability to provide forest habitat for migrants within the Delmarva Peninsula is bounded by available uplands. The "Theoretical Conservation Limit" would be reached if we restored the entire upland land surface with high quality forests. However, all of the upland landscape is not available for conservation objectives. Existing infrastructure such as roadways, buildings, right-of-ways, etc. has been permanently removed from the pool of conservation lands. The Practical Conservation Limit is the remaining upland landscape. In reality, because the majority of the landscape resides in private ownership, only a fraction of this limit could ever be realized. For forest migrants, the current footprint and condition of forest habitat within the lower Delmarva determines the current conservation

value. The difference between current value and the practical conservation limit represents the opportunities for conservation within the landscape.

Improving Habitat Quality – Improvements to habitat quality are bounded by some management endpoint that provides the highest value or services attainable within a particular site. We frequently refer to this upper limit as an ideal, reference, or model habitat type. Most habitats within any given landscape do not function on the level of the reference. Like land acquisition, management or restoration actions that drive habitat toward the reference condition move the overall land toward the Practical Conservation Limit.

Management Endpoints

Resource agencies have identified two management endpoints intended to improve conditions for migrants on the lower Delmarva Peninsula. These include maintained shrublands and forests. Because shrublands are an intermediate seral stage within a successional trajectory, long-term sustainability requires periodic management intervention. Because old-growth reference forests represent the end of the successional trajectory, once attained they do not require periodic management. However, when restoring habitat from agricultural fields, shrublands may be established very rapidly whereas establishment of reference forests would require several decades. The relationships between management costs and migrant benefits for these two endpoints have not been evaluated. Such an evaluation would be useful in conservation planning.

OBJECTIVES

Our objectives in this report are 1) to quantify Absolute Conservation Limits, Practical Conservation Limits, and Current Conservation Value for the lower Delmarva Peninsula both in terms of land area and season-wide bird use, 2) to quantify the future value of ongoing restoration projects both in terms of land area and season-wide bird use, 3) to estimate bird use for both reference and general forest habitat, 4) to estimate the season-wide energy demand of the migration community, and 5) to estimate the food equivalent of the energy demand. Due to inadequate information on migrant use of shrublands, we were only able to evaluate the benefits of the forest management endpoint.

METHODS

Study Area

We focused the analyses for this report within the southernmost 15 km of the Delmarva Peninsula in Northampton County, Virginia (Figure 2). This footprint was selected because it encompasses the core focus area for acquisition and restoration of lands to support fall migrating birds. The Delmarva Peninsula separates the Atlantic Ocean and the Chesapeake Bay, the last 100 km of which form a narrow land mass averaging less than 10 km in width. The landscape is highly dissected and dominated by agricultural fields. Forest tracts are generally small and isolated with mixed vegetation. Canopy trees are dominated by loblolly pine (*Pinus taeda*), Virginia pine (*P. virginiana*), red maple (*Acer rubrum*), and various oaks (*Quercus spp.*), and hickories (*Carya spp.*). Understory trees are dominated by flowering dogwood (*Cornus florida*), black cherry (*Prunus serotina*), hackberry (*Celtis occidentalis*) and American holly (*Ilex opaca*). The study area currently supports more than 865 hectares of government-owned conservation lands that are currently being managed for a variety of land-use objectives.

Reference Forest Patches

We defined “reference” or “model” habitats as natural forest patches that were greater than 100 years old. From previous work (Watts and Mabey 1994) these forest patches are known to support the highest densities of fall migrants within the Delmarva landscape regardless of geographic position. Loblolly patches of this age class have older, well-established understory trees that support high fruit production and due to ongoing senescence have broken crowns that lead to the development of hardwood canopy trees and dense understories. These characteristics represent the best available support for fall migrants and should be considered the model that management strives to achieve. Most forest patches within the study area are not of this quality. Improving overall forest quality either through active management or allowing patches to reach older age classes should be a management objective.

Bird Survey Data

Data from surveys conducted in 1993 were used to assess the number of bird-use days supported by forest patches on the lower Delmarva Peninsula. A total of 16 forest patches were used in the lower 15 km of the peninsula (Figure 3). Two of the forest patches included were classified as “reference” patches (Figure 3). All forest patches were isolated within an agricultural landscape and measured 4-13 ha with mixed canopies dominated by pine and deciduous trees. Within each forest tract, we established a network of six 30-m, fixed-radius survey plots. Each plot consisted of a coded wire flag at the center with the perimeter indicated with flagging tape. Plots were arranged along a marked survey route within each forest tract and separated by a minimum of 75 m.

We surveyed birds within established plots during the main peak of fall migration in 1993 (9 August - 15 November). Upon entering a forest patch, observers walked along the survey route until reaching a numbered plot. The observer then quietly searched the plot for a period of 5 min and recorded all birds encountered. Aural identification was not allowed and no playbacks or enticement calls were used. All plots were surveyed on the same field day twice/wk. Surveys commenced 0.5 hr after sunrise and were concluded within 4 hr. Six observers conducted the surveys. To reduce bias, we scheduled observers such that each observer surveyed all forest tracts in a pre-determined, random order over a period of six field days. Within field days, survey order was randomly determined to reduce any time-of-day bias. We did not conduct surveys during heavy winds or rain.

Bird Categories

We categorized all birds observed as residents, temperate migrants or neotropical migrants. Here, we consider residents to be those species that remain on territories throughout the year or only make local movements beyond the territory. Temperate migrants are those species that breed in the northern United States and Canada and fly relatively short distances to winter in the mid to lower latitudes of North America. Within the study area, this group includes those species that breed far to the north and only appear in the winter months, as well as, species that breed but move further south for the winter only to be replaced by birds moving in from further north. Neotropical migrants are those species that breed in North America and winter in Mexico, Central America, the Caribbean, and South America. The two migrant categories migrate during distinctly different times within the fall season, move different distances to reach wintering areas, and generally depend on different food resources during migration. For this reason, we analyzed the two migration groups separately. A complete list of species encountered and their migration status within the study area is presented in APPENDIX 1.

Bird-use Days

We used bird-use days as the unit of conservation value provided by forest habitat within the study area. A bird-use day is the equivalent of a bird using a forest for a single day. Bird-use days may be expressed for a standard area or time unit such as 10 bird days per hectare per week or for any other unit as appropriate. Because our primary interest is to examine the amount of conservation value provided by habitat for the period of fall migration, we express the number of bird-use days per season where the migration season includes the period from 15 August through 30 November. We used surveys (n=28) of the point-count network to estimate mean bird density (birds/ha/d) by species. We computed the number of bird-use days per hectare for the season by multiplying the mean daily density by the number of days in the season. Rather than developing species-specific passage windows, we approximated the passage period for neotropical migrants as 15 August through 15 October, for temperate migrants as 15 October through 30 November, and for residents as 15 August through 30 November. In order to characterize the model or ideal forest habitat, we computed bird-use days for “reference” and all patches separately.

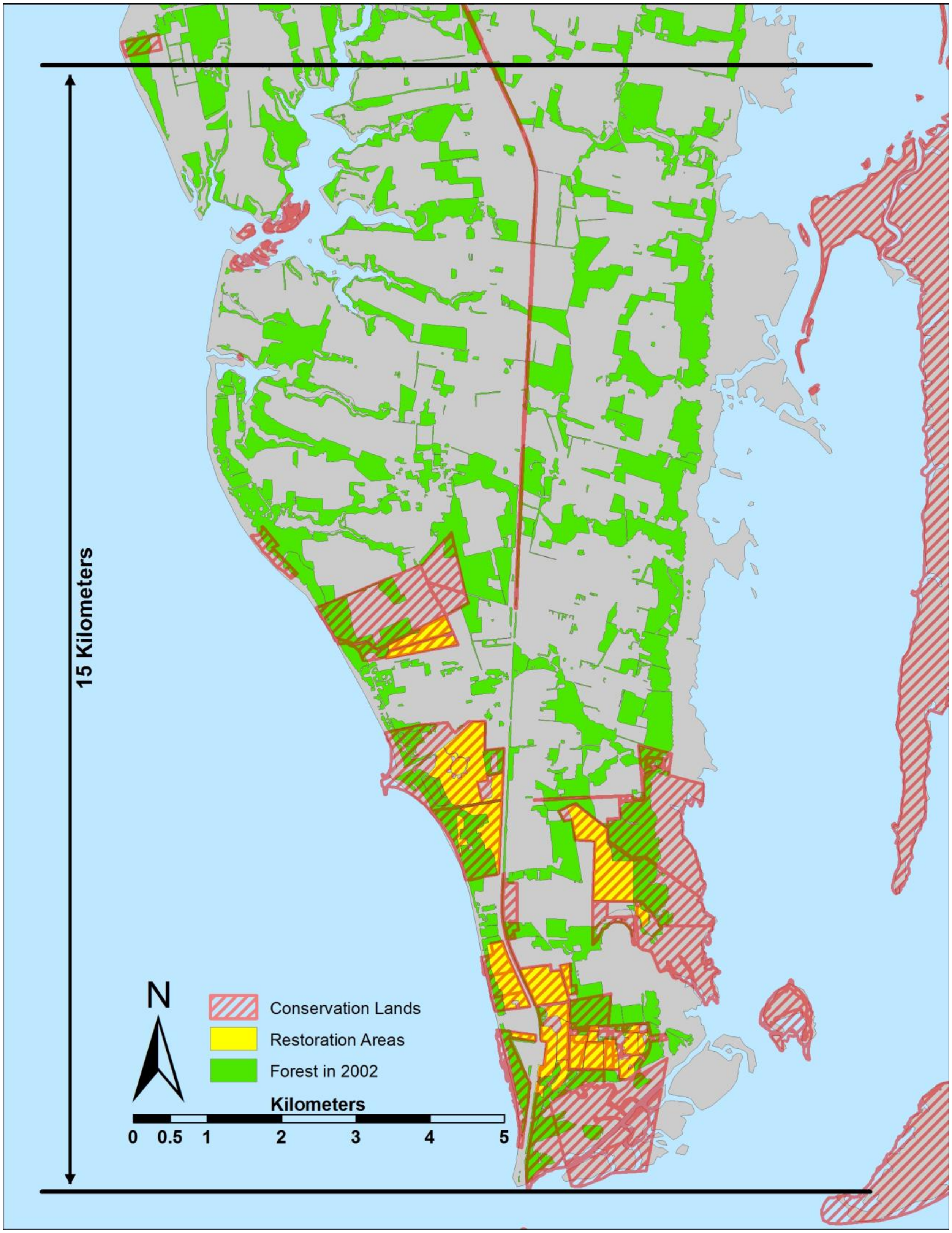

Figure 2. Map of lower Delmarva Peninsula study area indicating the position of conservation lands, restoration sites, and forest cover.

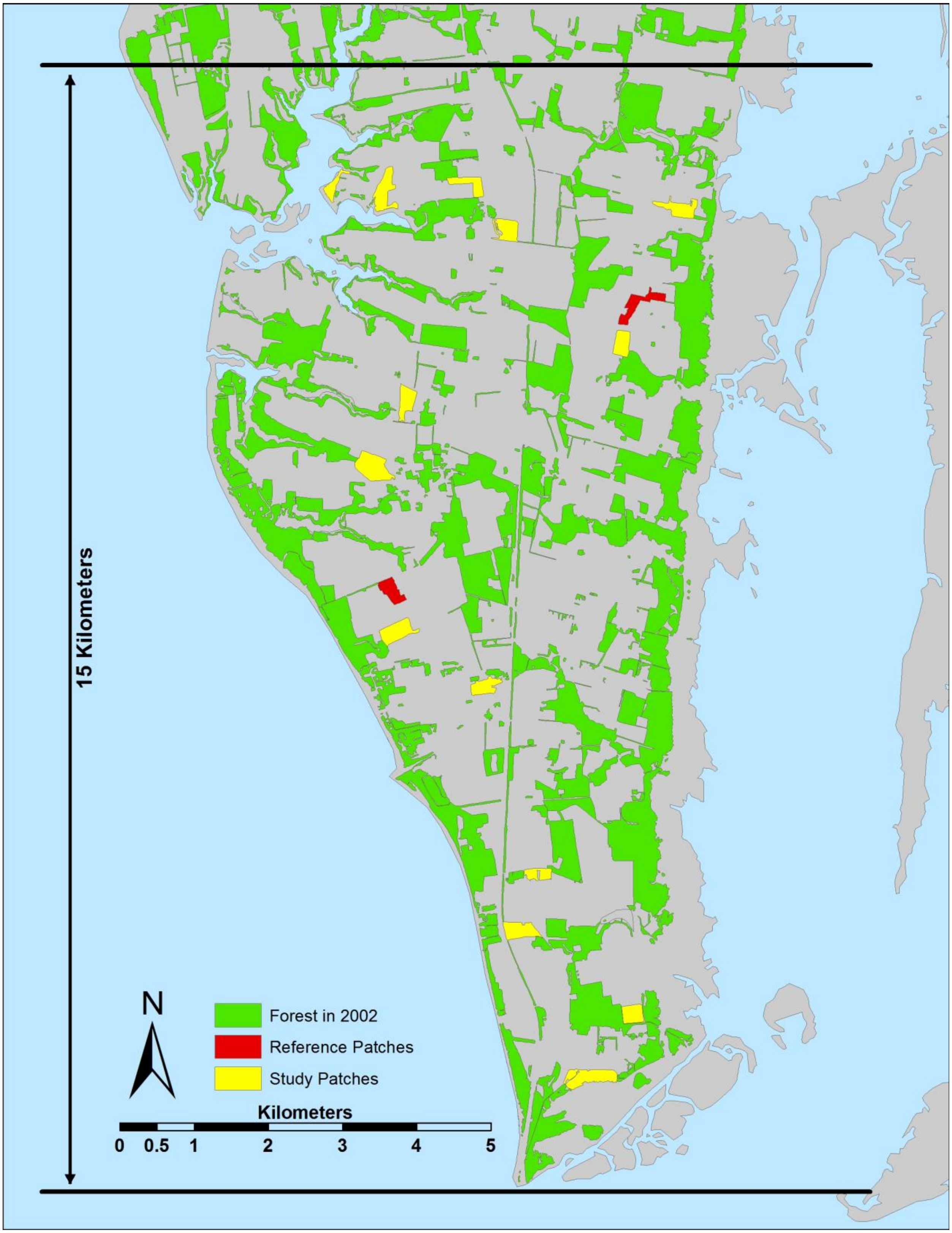

Figure 3. Map of forest patches, study patches and reference patches used for assessment of bird parameters.

Metabolic Demand and Diet Equivalents

We estimated the season-wide density of resource demand by multiplying seasonal bird-use days (per hectare) for each species by their field metabolic rate (FMR) and summing the values across the bird community. We made separate estimates for residents, temperate migrants, and neotropical migrants. FMR is the daily energy requirement of wild birds under normal conditions. FMR includes the costs of basal metabolism as well as energy required for foraging, thermoregulation, digestion and food detoxification, predator avoidance, and other activities. FMRs (Kj/day) were scaled for each species according to mass-specific equations presented by Nagy (1987). Average mass for all species observed during surveys was obtained from Dunning (1993). Normal FMR provides a conservative estimate of resource demand for this application since migrant birds within stopover sites must not only offset regular energetic costs but also replace or build energy reserves for migration. We estimated food equivalents (in grams) of resource demand using published conversions for arthropods (Bell 1990) and fall fruits (Smith et al. 2013).

Assessment of Conservation Limits, Values and Opportunities

We conducted a landscape analysis within the study area to assess conservation limits (e.g. absolute conservation limit, practical conservation limit, current conservation value) and the future value of ongoing restoration efforts (Figure 3). A collection of data resources was used to produce land cover layers including National Land Cover Data (Fry et al. 2011), Tiger Line Data (US Dept. of Commerce 2013), Virginia Conservation Lands Database (VA-DCR Natural Heritage 2013), Eastern Shore Forest Patch Cover (Paxton and Leclerc 2004), Table 1 provides a brief description of our approach to estimating land areas for the various land-use scenarios and for estimating the potential bird-use days supported. Because practical limits only reflect current impervious surfaces, they are clear overestimates of restoration potential and opportunities. A much larger effort that included an assessment of plans for private lands would be required to improve this estimate. Bird-use days recorded within reference forest patches were used when making estimates for limits or potentials since this management endpoint is assumed to be the ideal. Bird-use days recorded for all forests were used when estimating current or realized values since these reflect current forest conditions. For calculation of all bird-use values for limits and potentials we assume that bird use would increase in lockstep with forest expansion. We have no information on which to base an evaluation of this assumption. We consider restoration lands to be those parcels that were open as recently as the early 1990s that are undergoing habitat restoration. Since we do not have adequate bird use data for shrublands, potential value to migrants is assessed assuming that all lands will be restored to reference forest conditions.

Table 1. Description of benchmark areas used to determine conservation limits and opportunities and their associated estimates of value to migrants.

Benchmark	**Description**
Delmarva Landscape	
Absolute Conservation Limit	Upper limit of conservation potential within the study area. Realized if all uplands were restored to reference forests. Area estimate includes all uplands. Bird support estimate is the product of all uplands and the season-wide bird-use/ha of reference patches.
Practical Conservation Limit	Practical limit of conservation potential within the study area. Area includes all uplands less the area of known, permanent use conflicts (impervious surface). Bird support estimate is the product of remaining area and the season-wide bird-use/ha of reference patches.
Current Conservation Value	For forest migrants, lands currently in forest provide habitat value. Area includes all forest lands. Bird support estimate is the product of forest lands and the season-wide bird-use/ha of all forest patches.
Management Opportunities	For forest migrants, management opportunities reflect the restoration of non-forest lands and the improvement of forest lands to reference quality. Maximum opportunity is the difference between practical conservation limit and the current conservation value.
Conservation Lands	
Absolute Management Potential	Within conservation lands the upper limit of management would be realized if all upland was restored to reference-level forests. Area estimate includes all uplands within conservation lands. Bird support estimate is the product of all uplands and the season-wide bird-use/ha of reference patches.
Practical Management Potential	Practical limit of conservation potential within conservation lands. Area includes all uplands less the area of known, permanent use conflicts (impervious surface). Bird support estimate is the product of remaining area and the season-wide bird-use/ha of reference patches.
Realized Management Value	For forest migrants, lands currently in forest provide habitat value. Area includes all forests within conservation lands. Bird support estimate is the

	product of forest lands and the season-wide bird-use/ha of all forest patches.
Potential of Current Restoration	Several tracts of open field are undergoing restoration to habitat for migrants. Area includes all current restoration lands. Bird support estimate is the product of restoration lands and the season-wide bird-use/ha of reference patches.

RESULTS

Bird use and resource demand

Forest patches along the lower Delmarva Peninsula receive very high levels of use during the period of fall migration (Table 2, Appendix 1). The collective number of bird-use days per hectare is extraordinarily high. Use by migrants was nearly twice that of residents and use by temperate migrants was more than 4 fold higher than neotropical migrants. Temperate migrants that account for particularly high levels of use within all forest patches include American robin (514 bird days/ha), yellow-rumped warbler (151), golden-crowned kinglet (97), blue jay (55), and northern flicker (51). Prominent neotropical migrants include American redstart (102), black-and-white warbler (20), black-throated blue warbler (15) and gray catbird (15). Overall bird use of old-growth, reference forest patches was nearly 30% higher compared to general forest patches (Table 2). For migrants this disparity increased to nearly 40%.

Table 2. Summary results of bird use, collective energetic requirements (FMR) and collective food demand by migration class and forest patch category. Results are presented as average density values. Individual species results are presented in Appendix 1.

	All Forest Patches			**Reference Forest Patches**		
Migration Class	**Bird Use (days/ha)**	**Energy (Kj/ha)**	**Food (Kg/ha)**	**Bird Use (days/ha)**	**Energy (Kj/ha)**	**Food (Kg/ha)**
Resident	718.5	102,491	5.4	789.8	103,924	5.5
Neotropical Migrant	261.7	16,111	0.9	338.4	19,588	1.0
Temperate Migrant	1,076.9	165,124	8.8	1,519.9	256,370	13.6
Total Birds	2,057.1	283,726	15.1	2,649.1	379,888	20.1

In keeping with the high consumer density within forest patches, energetic demand throughout the fall season was very high with temperate migrants accounting for a large portion (Table 2). Surprisingly, within all forest patches just 4 species of temperate migrants including American robin, common grackle, blue jay, and yellow-rumped warbler accounted for nearly 60% of the entire seasonal food demand.

Conservation Limits, Value, and Opportunities

The study area includes a relatively small land mass that remains rural in character (Table 3). The amount of land currently supporting forest cover represents only 30.3% of the study area (Figure 2, Table 3) suggesting that there is considerable opportunity to restore additional habitat to support migrants. Theoretically, there is space to triple the current footprint of forest habitat. Currently, conservation lands represent less than 14% of the upland landscape and support 16% of the total forest lands. Ongoing restoration projects will nearly double the value of conservation lands to forest migrants and will ultimately increase the existing forest habitat by another 16%.

Despite its relatively small land mass, the study area is estimated to support more than 4 million bird days during the migratory period. In order to break even energetically, these birds would require nearly 30 metric tons of food. Current bird support represents only 25% of the landscape's potential. Conservation lands are currently supporting less than 20% of the bird use within the study area. However, if ongoing restoration projects are brought to their conservation endpoints they would more than double this contribution.

DISCUSSION

Due to its geographic position within the Atlantic Flyway and north of the Chesapeake Bay mouth, the lower Delmarva Peninsula currently supports a large number of fall migrants. Forest patches, in particular, may further concentrate birds because they are very limited within the landscape and isolated within an agricultural matrix. The concentration of birds on the lower shore results in densities that are greater than those typically detected at other migratory stopover and winter locations. The density of migrant birds on the lower Delmarva Peninsula was 7 times greater than that reported along the shoreline of the Great Lakes in autumn (Ewert et al. 2011), and over two times greater than observed for spring migrants at East Ships Island, Louisiana (Kuenzi et al. 1991). Similarly, bird density on the lower Delmarva was nearly 4 times greater for migrants and nearly 2 times or combined total of migrants and residents than wintering areas of the U.S. Virgin Islands (Askins et al 1989). Landscapes that concentrate migrants in a similar fashion as the lower shore are more analogous. Migrant density on the lower Delmarva was only 50% higher than that reported from urban areas of Ohio (Rodewald and Matthews 2005) and agricultural landscapes in Idaho (Carlisle et al. 2004) and Pennsylvania (Rodewald and Brittingham 2002). These landscapes were similarly

Table 3. Summary of landscape analysis within the study area on the lower Delmarva Peninsula. Lands refer to the area within different conditions (see Table 1). Bird days refer to the estimated number of seasonal bird days supported by the benchmark landscape. Food refers to the estimated weight of food required for birds to break even under normal circumstances. Calculation of limit and potential bird days assumes that bird use of restored forest would be comparable to current use.

Benchmark	**Land Area (ha)**	**Bird Days (N)**	**Food (Metric Tons)**
Delmarva Landscape			
Absolute Conservation Limit	6,530	17,293,373	131.3
Practical Conservation Limit	5,993	15,870,736	120.5
Current Conservation Value	1,978	4,069,624	29.9
Management Opportunities	4,014	11,801,112	80.7
Conservation Lands			
Absolute Management Potential	867	2,295,556	17.4
Practical Management Potential	819	2,167,997	16.5
Realized Management Value	321	660,367	4.8
Potential of Current Restoration	290	766,757	5.8

composed of small forest patches embedded in a much larger inhospitable matrix.

Migrants that fall out on landscapes that force birds to concentrate within a small number of patches are more challenged to replenish energy reserves than migrants within landscapes with abundant forest that disperses birds. Migrants are not only faced with a declining abundance of food associated with the natural phenology of autumn (e.g., insect dormancy) but also from the overwhelmingly large concentration of other migrants consuming food. Areas with high concentrations of migrants may undergo faster losses of standing energy crops compared to areas with lower concentrations of birds. Previous studies have shown migrant density is positively related to the rate of arthropod depression throughout a season (Watts et al., Unpublished, Moore and Yong 1990, Beall 2011). A conservation strategy that expands the amount of forest is one possible method to provide greater habitat opportunities for birds in concentration areas.

Within forest patches, migrants also concentrate within micro-habitats that provide the best energetic reward. Because birds at stopover areas have emanated from other geographic locations, they are utilizing landscapes with no prior information on the distribution of food. Here, they often use standard physical cues of where food may be expected to be more plentiful. One physical cue birds may use to quickly assess the expectation of higher food availability is vegetation volume. In general, both the number of arthropods and fleshy fruits available for migrant birds is positively related to the amount of vegetation. Birds often concentrate in areas of dense vegetation that form in shrublands, tree-fall gaps, and tree crowns. Likewise, birds that rely on fruits during migration often concentrate in forest patches with high densities of fruit producing plants. Dense understory vegetation at tree-fall gaps and other canopy breaks is a result of the positive response of plant growth from light penetration to the ground. Because of this, the amount of vegetation in the understory can be under management control. Older forests can be managed with open canopy breaks to provide a relatively high volume of vegetation in ground, midstory, and canopy layers. Overall, increasing the amount of vegetation within existing forest patches can provide energetically better habitats for migrating birds.

Resource agencies have identified shrublands and climax forest as two management endpoints to improve and restore habitats for migrating birds. Shrublands provide migrants with dense vegetation that can be established within 3-5 years and requires management at regular intervals to halt succession to secondary forest. Maintaining patches in shrub cover can be produced by 1) mowing the entire patch and allowing re-growth, 2) subdividing the patch and rotating mowing among parcels to maintain some constant availability of shrubs, or 3) selected tree removal or herbicide use to dissuade canopy closure. Management of an entire patch by mowing removes it from production for migrant birds for 3-5 years.

Establishment and maintenance of forested habitat takes a much longer amount of time relative to the shrubland management endpoint. Unlike shrub patches that require regularly timed management, some forest restoration practices rely on simply letting the forest naturally progress through successional stages until it reaches climax condition. However, in the absence of active forest management forest patches can undergo several lapses in production for migrant birds. Regenerating forests naturally progress from a tree sapling stage to form closed a closed canopy that reduces light penetration to the understory. As a result, ground-level shrubby vegetation during this period is significantly reduced. Most regenerating forests remain in this state until thinned mechanically or naturally through tree senescence. The “downtime” for migrants during mid-successional closed canopy states can last 20 or more years unless opened earlier through management. Canopy gaps created by thinning trees or natural senescence reduces the number of trees, open the forest canopy, and allow growth of understory vegetation. Management of habitats in open canopy conditions is recommended for providing productive forest habitats for migrant birds.

Although the relative comparison of shrub versus forested habitat has never been conducted on the Lower Peninsula, reports from other studies indicate that shrub habitats provide a greater density of aerial arthropods and fruiting plants compared to forest (Smith and Hatch 2008). Moreover, spring migrant densities in that study were statistically greater in shrub habitat compared to forest patches. Monitoring of food resources and migrant use of shrub patches on the Lower Peninsula would be beneficial for developing or refining management priorities in the future.

There are a number of information gaps that prevent a deeper assessment of conservation objectives for the lower Delmarva Peninsula. At the root of this gap is the need to gain a better understanding of the standing crop of energy within forest patches. Energy is the most important currency to assess whether the Lower Peninsula is an energy source for birds (i.e., birds are provided with opportunity for a net energy gain) or an energy sink (i.e., the peninsula cannot meet energetic demands). Whether or not the habitats on the lower Delmarva landscape can support the energetic demands of migrant birds given the observed densities is unknown. The number of bird–use days as we have used provides an index of relative conservation value of forest patches per area but does not suggest that these forest patches provide enough food for migrants during stopover to replenish energy reserves and continue their migration. A more accurate measurement of the conservation value of forest patches for migrant birds would be to determine how many migrants-days can be supported based on the amount of food energy the forest area produces. Comparing the number of bird-support days to the number of bird-use days would provide an indication of the overall energy balance for birds during the season. Currently, it is not known whether the resource demands of migrants on the lower Delmarva Peninsula are being met by forest productivity. Moreover, it is unknown whether or not the energetic demands of migrants can be met with increased management, in the form of providing more forest cover or increasing the intrinsic value of existing forest patches such as matching reference sites.

Another information gap needed to move conservation objectives forward is a better understanding on the relationship between the standing crop and foraging rates of migrants. This information is critical because the amount of food from collected samples may or may not translate into food availability for migrating birds. Knowing the standing crop of energy resources and the bird's ability to acquire them through a metric such as foraging rates will better inform conservation strategies of "how much habitat is enough". Taken together with conservation objectives, if resource demand of migrants is higher than what the best reference patches can produce then only solution is to increase land base to accommodate the number of consumers. However, this option has its limit within the confined landscape of the Lower Delmarva Peninsula. It is possible that there is no suitable conservation resolution in this landscape but this notion needs to be assessed after closing significant information gaps.

ACKNOWLEDGMENTS

This project was funded by the Virginia Coastal Zone Management Program; Task 1.01. We thank Laura McKay and April Bahen from the Virginia Department of Environmental Quality, Coastal Zone Management for administrative assistance throughout this project. Also, Erica Lawler and Jane Lopez of the Office of Sponsored Programs, College of William and Mary for fiscal and administrative oversight. Finally, we are grateful to Bart Paxton and Marie Pitts for GIS technical assistance.

LITERATURE CITED

Askins, B. A., E. N. Ewert, and R. L. Norton. Abundance of wintering migrants in fragmented and continuous forest in the U.S. Virgin Islands. Pp197-206, *In* Ecology and conservation of neotropical migratory birds, J. M. Hagan III and D. W. Johnson (eds.). Smithsonian University Press, Washington DC.

Beall, S. M. 2011. The effect of area on resource competition among migrants at a stopover site. M.S. Thesis. Georgia Southern University.

Bell, G. P. 1990. Birds and mammals on an insect diet: a primer on diet composition analysis in relation to ecological energetics. In, Studies in Avain Biology (J. Jehl, ed), No 13. Pg 416-422. Cooper Ornithologial Society.

Carlisle, J. D., S. L. Stock, G. S. Kaltenecker, and D. L. Swanson. 2004. Habitat associations, relative abundance, and species richness of autumn landbird migrants in southwestern Idaho. Condor 106:549-566.

Dunning, J. B. (ed). 1993. CRC Handbook of Avian Body Masses. CRC Press. Boca Raton, FL.

Ewert, D. N., M. J. Hamas, R. J. Smith, M. E. Dallman, and S. W. Jorgenson. 2011. Distribution of migratory landbirds along the northern Lake Huron shoreline. Wilson Journal of Ornithology 123:536-547.

Fry, J., G. Xian, S. Jin, J. Dewitz, C. Homer, L. Yang, C Barnes, N. Herold, and J. Wickham. 2011. Completion of the 2006 National Landcover Database for the Conterminous United States. PE&RS 77:858-864.

Kuenzi, A. J., F. R. Moore, and T. R. Simons. 1991. Stopover of neotropical landbird migrants on East Ship Island following trans-Gulf migration. Condor 93:869-883.

Nagy, K. A. 1987. Field metabolic rate and food requirement scaling in mammals and birds.

Eco. Mon. 57:11-128

Moore, F. R., and W. Yong. 1991. Evidence of food-based competition among passerine migrants during stopover. Behavioral Ecology and Sociobiology 28:85-90.

Paxton, B. J., and J. E. LeClerc. 2004. Assessement of forest habitat in Northampton County, VA. Center for Conservation Biology Technical Report Series CCBTR-04-12. College of William and Mary, Williamsburg, VA. 9p.

Rodewal, P. G., and M. C. Brittingham. 2002. Habitat use and behavior of mixed species landbird flocks during migration. Wilson Bulletin 114:87-98.

Rodewald, P. G., and S. N. Matthews. 2005. Landbird use of riparian and upland forest stopover habitats in an urban landscape. Condor 107:259-268.

Smith, S. B., S. A. Desendo, and T. Pagano. 2013. The value of native and invasive fruit-bearing shrubs for migrating songbirds. Northeastern Naturalist 20:171-184.

Smith, R. J., and M. I. Hatch. A comparison of shrub-dominated and forested habitat use by migrating landbirds in northeast Pennsylvania. Condor 110:682:693.

U.S. Department of Commerce. 2013. 2013 Tiger/Line Shapefiles. Accessed at http://www.census.gov/geo/maps-data/data/tiger-line.html

VA-DCR, Natural Heritage 2013. Conservation Lands Database. Accessed at http://www.dcr.virginia.gov/land_conservation/tools02a.shtml

Watts, B. D. and S. E. Mabey. 1993. Spatio-temporal patterns of landbird migration on the lower Delmarva Peninsula. Center for Conservation Biology Technical Report, CCBTR-93-01. College of William and Mary, Williamsburg, VA. 57pp.

Watts, B. D. and S. E. Mabey. 1994. Migratory landbirds of the lower Delmarva: habitat selection and geographic distribution. Center for Conservation Biology Technical Report, CCBTR-94-05. College of William and Mary, Williamsburg, 101pp.

Appendix I. Energy requirements and bird day use of the lower Delmarva peninsula and reference forest patches for species included in study. Migrant Class: R = Resident, TM = Temperate Migrant, NM = Neotropical Migrant

Species	Species Name	Migrant Class	Bird Mass (g)	FMR (Kj/day)	Seasonal birds/ha Lower Delmarva	Seasonal birds/ha Reference Forest
Northern Bobwhite	*Colinus virginianus*	R	178.0	46.01	4.93	1.13
Green Heron	*Butorides virescens*	TM	212.0	52.44	0.43	0.00
Sharp-shinned Hawk	*Accipiter striatus*	TM	138.5	38.13	2.99	1.71
Broad-winged Hawk	*Buteo platypterus*	NM	455.0	92.92	0.26	0.00
Red-tailed Hawk	*Buteo jamaicensis*	TM	1,136.0	184.39	0.86	1.71
American Kestrel	*Falco sparverius*	TM	115.5	33.28	0.21	1.71
American Woodcock	*Scolopax minor*	TM	197.5	49.73	1.28	0.98
Mourning Dove	*Zenaida macroura*	R	119.0	25.03	6.57	4.51
Yellow-billed Cuckoo	*Coccyzus americanus*	NM	103.0	1.61	2.99	2.68
Great-crested Flycatcher	*Bubo virginianus*	NM	33.5	123.38	2.08	2.68
Chuck-will's Widow	*Caprimulgus carolinensis*	NM	120.0	24.57	0.13	0.00
Ruby-throated Hummingbird	*Archilochus colubris*	NM	3.15	21.00	0.65	0.89
Red-headed Woodpecker	*Melanerpes erythrocephalus*	R	71.6	16.69	5.09	33.80
Red-bellied Woodpecker	*Melanerpes carolinus*	R	61.9	14.97	16.43	43.94
Yellow-bellied Sapsucker	*Sphyrapicus varius*	TM	50.3	17.85	1.50	0.98
Downy Woodpecker	*Picoides pubescens*	R	43.6	11.51	21.85	25.91
Hairy Woodpecker	*Picoides villosus*	R	66.3	15.75	3.29	7.89
Northern Flicker	*Colaptes auratus*	TM	132.0	26.39	51.98	112.95
Pileated Woodpecker	*Dryocopus pileatus*	R	287.0	47.22	0.49	1.13
Eastern Wood Peewee	*Contopus virens*	NM	14.1	64.53	2.21	7.14
Acadian Flycatcher	*Empidonax virescens*	NM	12.9	60.37	0.26	0.00
Least Flycatcher	*Empidonax minimus*	NM	10.3	51.01	0.13	0.00

Species	Species Name	Migrant Class	Bird Mass (g)	FMR (Kj/day)	Seasonal birds/ha Lower Delmarva	Seasonal birds/ha Reference Forest
Eastern Phoebe	*Sayornis phoebe*	TM	19.8	83.22	4.92	6.85
Great-horned Owl	*Myiarchus crinitus*	R	1543	231.93	0.82	1.13
Eastern Kingbird	*Tyrannus tyrannus*	NM	43.6	150.31	1.17	0.00
White-eyed Vireo	*Vireo griseus*	NM	11.4	55.03	1.69	0.89
Blue-headed Vireo	*Vireo solitarius*	NM	16.6	72.92	0.26	0.89
Red-eyed Vireo	*Vireo olivaceus*	NM	16.7	73.25	8.59	3.57
Blue Jay	*Cyanocitta cristata*	TM	86.8	251.74	55.19	107.81
American Crow	*Corvus brachyrhynchos*	R	448.0	860.61	11.83	12.39
Fish Crow	*Corvus ossifragus*	R	285.0	613.31	6.74	0.00
Carolina Chickadee	*Poecile carolinensis*	R	10.2	50.45	135.23	150.98
Eastern Tufted Titmouse	*Baeolophus bicolor*	R	21.6	88.82	28.10	16.90
Red-breasted Nuthatch	*Sitta canadensis*	TM	9.8	49.14	26.10	22.25
White-breasted Nuthatch	*Sitta carolinensis*	R	21.1	87.27	0.49	0.00
Brown-headed Nuthatch	*Sitta pusilla*	R	10.2	50.63	0.33	0.00
Brown Creeper	*Certhia americana*	TM	8.4	43.78	8.13	17.11
Carolina Wren	*Thryothorus ludovicianus*	R	18.7	79.73	196.68	170.13
House Wren	*Troglodytes aedon*	NM	10.9	53.21	0.78	0.00
Winter Wren	*Troglodytes troglodytes*	TM	9.9	49.51	13.05	30.80
Golden-crowned Kinglet	*Regulus satrapa*	TM	6.3	35.29	97.33	80.43
Ruby-crowned Kinglet	*Regulus calendula*	TM	5.7	32.75	18.82	22.25
Blue-gray Gnatcatcher	*Polioptila caerulea*	NM	6.0	34.03	2.73	3.57
Eastern Bluebird	*Sialia sialis*	R	31.6	118.10	0.16	0.00
Veery	*Catharus fuscescens*	NM	31.2	116.98	3.39	3.57
Gray-cheeked Thrush	*Catharus minimus*	NM	32.8	121.45	0.91	1.79
Swainson's Thrush	*Catharus ustulatus*	NM	30.8	115.86	0.91	0.00
Hermit Thrush	*Catharus guttatus*	TM	31.0	116.42	20.96	13.69

Species	Species Name	Migrant Class	Bird Mass (g)	FMR (Kj/day)	Seasonal birds/ha Lower Delmarva	Seasonal birds/ha Reference Forest
Wood Thrush	*Hylocichla mustelina*	NM	47.4	160.01	1.04	0.00
American Robin	*Turdus migratorius*	TM	77.3	230.81	513.82	838.54
Gray Catbird	*Dumetella carolinensis*	NM	36.9	132.65	15.36	17.86
Northern Mockingbird	*Mimus polyglottos*	R	48.5	162.79	3.29	3.38
Brown Thrasher	*Toxostoma rufum*	R	68.8	211.52	4.60	7.89
European Starling	*Sturnus vulgaris*	R	82.3	241.90	54.39	145.34
Cedar Waxwing	*Bombycilla cedrorum*	TM	31.9	119.08	14.97	0.00
Blue-winged Warbler	*Vermivora pinus*	NM	8.9	45.72	0.39	0.89
Nashville Warbler	*Vermivora ruficapilla*	NM	8.9	45.72	0.26	0.89
Northern Parula	*Parula americana*	NM	8.6	44.56	4.56	4.46
Chestnut-sided Warbler	*Dendroica pensylvanica*	NM	9.6	48.39	0.26	0.89
Magnolia Warbler	*Dendroica magnolia*	NM	8.7	44.95	1.82	0.00
Cape May Warbler	*Dendroica tigrina*	NM	11	53.58	1.43	0.00
Black-throated Blue Warbler	*Dendroica caerulescens*	NM	10.2	50.45	15.23	16.07
Myrtle Warbler	*Dendroica coronata*	TM	12. 6	59.14	151.24	88.99
Black-throated Green Warbler	*Dendroica virens*	NM	8.8	45.33	1.69	3.57
Blackburnian Warbler	*Dendroica fusca*	NM	9.8	48.95	0.26	0.00
Yellow-throated Warbler	*Dendroica dominica*	NM	9.4	47.63	1.04	0.00
Pine Warbler	*Dendroica pinus*	NM	11.9	56.83	23.05	28.57
Prairie Warbler	*Dendroica discolor*	NM	7.7	40.82	0.26	0.00
Palm Warbler	*Dendroica palmarum*	NM	10.3	51.01	2.34	0.00
Bay-breasted Warbler	*Dendroica castanea*	NM	12.6	59.14	0.39	0.00
Blackpoll Warbler	*Dendroica striata*	NM	13.0	60.72	1.17	0.89
Black-and-White Warbler	*Mniotilta varia*	NM	10.8	52.85	20.18	20.54
American Redstart	*Setophaga ruticilla*	NM	8.3	43.39	101.69	174.11
Prothonotary Warbler	*Protonotaria citrea*	NM	16.2	71.60	0.13	2.68

Species	Species Name	Migrant Class	Bird Mass (g)	FMR (Kj/day)	Seasonal birds/ha Lower Delmarva	Seasonal birds/ha Reference Forest
Worm-eating Warbler	*Helmitheros vermivorum*	NM	13.0	60.72	1.56	0.00
Ovenbird	*Seiurus aurocapilla*	NM	19.4	81.95	7.42	7.14
Northern Waterthrush	*Seiurus noveboracensis*	NM	17.8	76.84	0.39	0.00
Common Yellowthoat	*Geothlypis trichas*	NM	10.1	50.26	1.30	0.00
Hooded Warbler	*Wilsonia citrina*	NM	10.5	51.56	0.65	0.89
Canada Warbler	*Wilsonia canadensis*	NM	9.8	49.14	0.39	0.00
Summer Tanager	*Piranga rubra*	NM	28.2	108.45	3.26	7.14
Eastern Towhee	*Pipilo erythrophthalmus*	TM	40.5	142.23	8.34	23.96
Chipping Sparrow	*Spizella passerina*	TM	12.3	58.26	4.28	1.71
Field Sparrow	*Spizella pusilla*	R	12.5	58.96	1.48	4.51
Fox Sparrow	*Passerella iliaca*	TM	32.3	120.06	0.43	0.00
Song Sparrow	*Melospiza melodia*	TM	20.8	86.19	1.71	5.13
Swamp Sparrow	*Melospiza georgiana*	TM	17	74.23	1.50	0.00
White-throated Sparrow	*Zonotrichia albicollis*	TM	25.9	101.76	47.70	121.50
Dark-eyed Junco	*Junco hyemalis*	TM	19.6	82.58	8.34	11.98
Northern Cardinal	*Cardinalis cardinalis*	R	44.7	153.01	122.08	110.42
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	NM	45.6	155.44	1.30	0.89
Blue Grosbeak	*Passerina caerulea*	NM	28.4	109.03	0.91	3.57
Indigo Bunting	*Passerina cyanea*	NM	14.5	65.90	2.47	3.57
Red-winged Blackbird	*Agelaius phoeniceus*	R	269.5	588.15	0.16	0.00
Rusty Blackbird	*Euphagus carolinus*	TM	98.0	275.69	10.91	0.00
Common Grackle	*Quiscalus quiscula*	R	113.5	307.75	89.88	43.94
Brown-headed Cowbird	*Molothrus ater*	R	43.9	151.08	0.33	0.00
Baltimore Oriole	*Icterus galbula*	NM	33.8	124.21	9.24	6.25
Purple Finch	*Carpodacus purpureus*	TM	24.9	98.80	4.28	1.71
House Finch	*Carpodacus mexicanus*	R	21.4	88.20	1.31	4.51

Species	Species Name	Migrant Class	Bird Mass (g)	FMR (Kj/day)	Seasonal birds/ha Lower Delmarva	Seasonal birds/ha Reference Forest
Pine Siskin	*Carduelis pinus*	TM	7.72	4.39	0.21	0.00
American Goldfinch	*Carduelis tristis*	TM	12.9	60.37	1.71	1.71
UID Bird		-		1.00	3.08	0.00
UID Crow		R	590.5	671.37	0.49	0.00
UID Flycatcher		NM	12.4	58.61	1.04	0.89
UID Hawk		TM	576	79.56	1.07	1.71
UID Sparrow		TM	18	77.48	0.64	1.71
UID Thrush		NM	31.6	118.10	0.52	0.00
UID Warbler		NM	10.7	52.48	9.51	8.93