IS THE LIKELIHOOD OF WATERFOWL PRESENCE GREATER ON CONSERVED LANDS?

by

Brian Vance Kearns

A Thesis Presented to the
FACULTY OF THE USC GRADUATE SCHOOL
UNIVERSITY OF SOUTHERN CALIFORNIA
In Partial Fulfillment of the
Requirements for the Degree
MASTER OF SCIENCE
(GEOGRAPHIC INFORMATION SCIENCE AND TECHNOLOGY)

May 2012

ACKNOWLEDGEMENTS

I thank the following parties for their involvement in and contribution to my Masters thesis: Travis Longcore and my thesis committee for guiding these analyses and assisting with theoretical and research concerns; Ducks Unlimited's Great Lakes Atlantic Region for funding and support of data collection that made this analysis possible; Kurt Anderson of Ducks Unlimited for his work developing stopover data and theory background which he was willing to share; Rob Paige of Ducks Unlimited for his work on data management and clean-up of the telemetry dataset; John Coluccy, Dane Cramer, and the biological staff of the Ducks Unlimited Great Lakes Atlantic Regional Office for their suggestions and contributions in developing my research questions; and the University of Southern California for providing the framework in which to execute this project and the knowledge to do so.

TABLE OF CONTENTS

Acknowledgements	ii
List of Figures	iv
Abstract	v
Introduction	1
Methods	5
Table 1. Counts of categorization of telemetry for HCat and PAD	15
Results	16
Discussion	19
Conclusion	23
References	25
Appendix A: Python code for “Add Field” tool	28

LIST OF FIGURES

Figure 1: Range map of *A. rubripes* 3

Figure 2: Workflow of data management 6

Figure 3: Satellite telemetry data and selection 7

Figure 4: Flight path and stopover event 9

Figure 5: Window of "Split Layer by Attributes" tool 11

Figure 6: Protected areas used by *A. rubripes* 12

Figure 7: Mean PAD values by stopover event 14

Figure 8: Count histograms of telemetry points, HCat 16

Figure 9: Count histograms of telemetry points, protected lands only 17

Figure 10: Distributions of mean PAD use 18

ABSTRACT

Waterfowl are one of our Nation's most precious and abundant natural resources, and preserving habitat well suited to their needs has long been a goal of private and public entities alike. In this study, I focused on the American Black Duck (*Anas rubripes*), a species seeing a large decline in numbers since the mid 20^{th} century. Using a satellite telemetry dataset collected by Ducks Unlimited during 2008 and 2009 in the context of the Protected Areas Database of the United States (PAD), I addressed the land use habits of *A. rubripes* to assess the efficacy of costly conservation efforts implemented through conservation easements and the maintenance of wildlife refuges and management areas. Most analyses were conducted at the stopover level, grouping telemetry points within a 0.5 decimal degree diameter. By creating distributions and studying correlations, this study finds that during wintering months *A. rubripes* registered more telemetry points in PAD lands where hunting is allowed in-season; during migration, lands outside of the PAD were more frequently used. This could be attributed to waterfowl specific management practices creating prime habitat during wintering and food needs being fulfilled by residual agricultural products during migration. This suggests an increased importance of management efforts in wintering habitats. Climate variables were also assessed to test reported influences of temperature and precipitation on distribution and stopover behaviors, but study data did not demonstrate a correlation between stopover length and temperature or precipitation at arrival and departure. A finer scale geospatial analysis using more detailed information about hunting status and protection level is recommended to further interpret available data.

INTRODUCTION

Land use has long been one of the key concerns for wildlife conservation efforts. Gaining an understanding about habitat dynamics and how animals interact with their respective biomes is one of our only pathways as researchers to implement measures that will provide benefit for species in increasingly disturbed ecosystems. Wetlands in particular are of conservation concern because they provide key habitat for migrating waterfowl, fish, invertebrates, shorebirds, songbirds, and are even important as a resource for humans (Kirby et al., 2008).

Though natural processes are certainly of interest, many wetland disturbances and subsequent disturbances to waterfowl populations are caused by anthropogenic factors. Whether through recreation, fertilization, or the conversion of land to agriculture, wetlands face a great deal of disturbance pressure. Filoso & Palmer (2011) documented the presence of excess nitrogen from fertilizer runoff in streams and also the tendency for this nitrogen to accumulate in downstream waters, often wetlands or estuarine ecosystems. Bennett (2011) presented a method for modeling the effects of recreation on the wetland habitat of the Black-crowned Night Heron, showing disturbance of critical breeding habitat. Naugle et al. (2001) also documented the negative effects of habitat fragmentation and the related edge effects on breeding waterfowl populations in shallow water wetlands. Beyond these factors, disturbances can dissuade animals from using habitat during migration (Vegvari et al., 2011).

To counteract these disturbances, conservation projects and programs have been developed to protect known sensitive areas or convert agricultural land back to wetland.

Various conservation organizations, both private and public, have been instrumental in the implementation of these programs. As human development increases, providing areas where animals can experience undisturbed habitat and resources becomes of greater concern and must be an important factor in land management decision-making.

Documents such as the North American Waterfowl Management Plan (NAWMP) indicate a growing need to provide habitat that caters to specific groups of organisms; they also guide many large-scale conservation efforts by the private and public sectors (Brasher et al., 2007). In relation, a recent study shows that stopover duration, a potential indicator of the benefit an individual organism gets from a particular habitat, is indeed positively correlated with foraging habitat quality specific to the forager (O'Neal et al., 2012). Because many restoration efforts focus on improving carrying capacity at particular key sites, a connection can be drawn between management practices and observed species-level benefits.

Although wildlife is often the key concern when managing habitat, delivery of conserved lands obviously must focus on selection and delineation of parcels where greatest benefit will be seen. Land is therefore set aside through various programs that work towards this goal. These programs include the Federal Wildlife Refuge System, as well as United States Department of Agriculture programs such as the Conservation Reserve Program (CRP), Wetland Reserve Program (WRP), Grassland Reserve Program (GRP), and more. CRP, WRP, and GRP allow landowners to establish easements and "to receive incentive payments for installing specific conservation practices that help protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water" (USDA, 2012).

These private easements have become paramount for wildlife. Especially in areas of the country with widespread agricultural development, they simultaneously preserve habitat and attempt to make developed land mimic its natural state. Efforts such as these help populations of threatened species stay robust. Unfortunately, despite these efforts, many areas still see loss of native habitat at a rate that cannot be mitigated by the current rate of easement creation (Gascoigne et al., 2011). Direction to where land conservation efforts are or would be most effective would be very beneficial.

The species of concern in this study is the American Black Duck (*Anas rubripes*), a dabbling duck common to the Atlantic and Mississippi flyways (Longcore et al., 2000). Their wintering range is typically along the mid-Atlantic coast, while breeding and nesting takes place in the northeastern provinces of Canada (see figure 1).

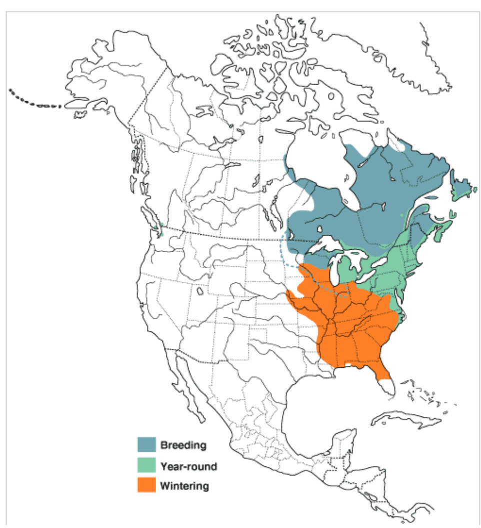


Figure 1. Range map of *A. rubripes*. Individuals migrate north to south; wintering occurs in the southeastern United States, while breeding takes place as far north as the Canadian province of Newfoundland and Labrador (Longcore et al., 2000).

A. rubripes and other dabbling ducks feed primarily on plants and macro invertebrates in shallow water wetlands, a habitat type that is often protected through conservation programs. In recent research efforts by Ducks Unlimited and other organizations, numbers of *A. rubripes* were observed to have declined by about 60% in many wintering areas since the 1950's (DU, 2010).

Conroy et al. (2002) identified three specific factors affecting and regulating populations of *A. rubripes*: loss in the quantity or quality of breeding habitat, loss in the quantity or quality of wintering habitat, and harvest through hunting. Although drops in *A. rubripes* populations can be partially attributed to habitat change, hunting and harvest are also important. I chose to study *A. rubripes* because declining numbers in waterfowl species are an important indicator of ecosystem health. Also, in an era where resources are scarce, they must be allocated efficiently through careful direction based on knowledge of wintering and migrating patterns on land.

Factors such as ecological carrying capacity, habitat availability, and level of harvest are important for this species, and land conservation and wildlife management likely affect these factors. This study seeks to evaluate the effectiveness of land conservation efforts using spatial tools to observe whether migration events of *A. rubripes*, namely stopovers and wintering, are affected by conservation projects. Although researchers have assessed habitat variables such as food availability and carrying capacity (which admittedly play a large role in initial management efforts, see Plattner (2010)), effects of widespread hunting disturbance have not been extensively explored in conjunction with land use of targeted species.

My hypothesis is that *A. rubripes* will prefer lands that are managed via land protection efforts and experience a lower degree of hunting pressure, one of the observed causes of *A. rubipes* population decline (Morton, 1998). Because of higher energetic carrying capacity, protected habitats should also be preferable while the waterfowl are in transit between wintering and breeding grounds (Brasher, 2007). Influence of temperature and precipitation, two important climatic factors affecting migration behaviors, on stopover time will also be investigated (Brook et al., 2009). Protected lands are created with wildlife and habitat management in mind, and should therefore represent as close to ideal habitat as is achievable through human efforts. This study should begin to indicate whether costly conservation efforts are protecting habitats that are preferentially used by a species at risk.

METHODS

This study investigates the distribution and land use of *A. rubripes* through data cross tabulation and classification. A satellite telemetry dataset was pared down and parsed out based on criteria relevant to the study, and points were then attributed with values based on overlay of the Protected Areas Database (PAD), a USGS project to that collects parcel information and attributes conservation easements and protected areas throughout the United States. Count histogram and mean value range histograms were then constructed to determine land use by birds during migration and wintering periods separately. Figure 2 shows a generalized workflow for the data management and tabulation portions of this analysis.

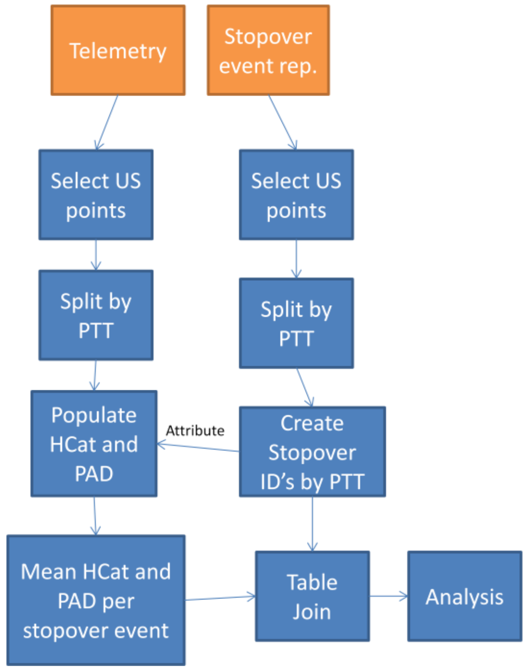


Figure 2. A generalized workflow, following data management steps through to the point before distributions were created.

Data Sources

Duck location data were derived from a satellite telemetry study conducted by Ducks Unlimited during 2008 and 2009. This study was conducted to determine the effects of habitat changes on declining populations of *A. rubripes*. Female *A. rubripes* were trapped and tagged with satellite transmitters in New Jersey and Delaware during wintering, and were monitored over subsequent seasons. This collection of points served as the raw data for this study (n = 33442) (see figure 3). Point locations were determined via GPS with an accuracy of approximately 10 m, an accuracy that is sufficient for regional analyses conducted in this study. Data ranged geographically from the state of Virginia to the northern reaches of the Canadian province of Newfoundland and Labrador. Birds were uniquely identified in data tables by the attribute field “PTT”, which refers to the unique radio frequency transmitted by the collar. This allowed the movements of individual birds to be analyzed independently, as discussed in more detail in the coming sections.

(a) (b)

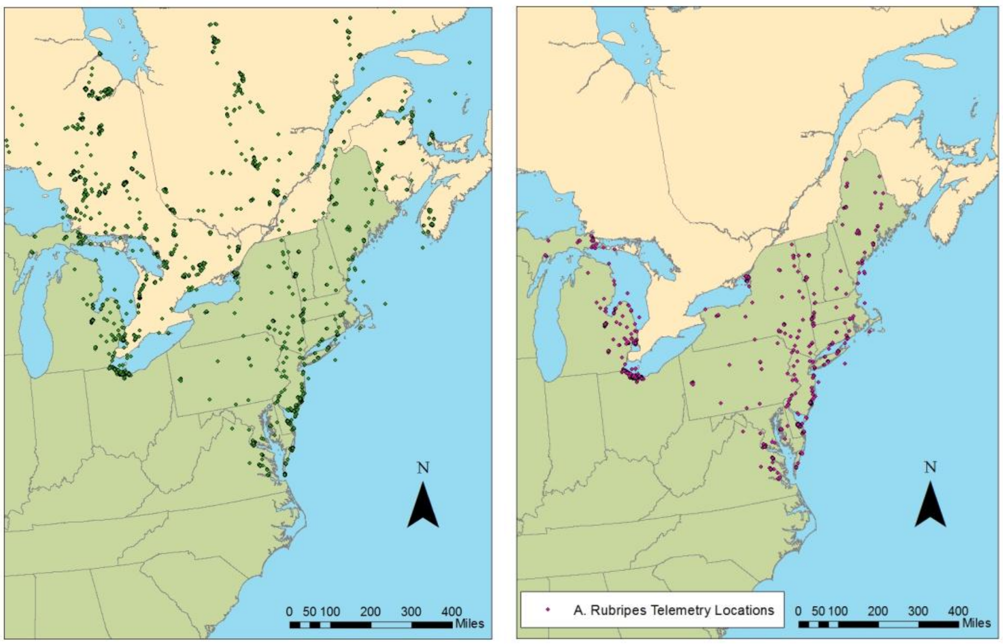


Figure 3. (a) All satellite telemetry locations collected from tagged *A. rubripes* during 2008 and 2009. (b) Telemetry points used for this analysis, which exclude points beyond 0.5 dd from the administrative boundary of the US.

Preparation of Telemetry Data

The data used for analyses were pared down and parsed out in several ways. First, the ArcGIS "Select by Location" function was used with a 0.5 decimal degree search distance around the polygon of the United States to produce a telemetry dataset containing points only in the US (n = 10670). This was necessary due to the lack of a PAD equivalent for Canada. The 0.5 decimal degree buffer was selected in response to research showing this to be the constraining range of a stopover event (Afton, 2008).

This also allowed for selection of data points that were beyond the actual land boundary of the United States, since these birds used lacustrine and estuarine habitats in addition to terrestrial ones (see figure 3).

In addition to selecting individual telemetry points, analyses were conducted to identify individual *stopover events* (n = 92). Points representing stopover events in this dataset were initially determined by Ducks Unlimited biologist Kurt Anderson (Anderson, 2009). Anderson defined stopover events as when two or more temporally consecutive telemetry points for the same bird (PTT) were clustered within a 0.5 dd diameter circular range of one another. Consequently, each stopover event had a varying number of telemetry points associated with it, but always from the same PTT. Stopover events were represented in Anderson's data by a single (x, y) coordinate from the original telemetry dataset. That was the first point in the temporal sequence of telemetry points composing each stopover event (see figure 4). Anderson used this single representational point to analyze variables such as stopover length, arrival and departure date, and general spatial distribution; in the context of my study, these points were used chiefly as a link between the stopover and telemetry datasets, which both contained information necessary for this analysis.

The clustering method used in my analysis was slightly non-standard, as the distance measure from the center of each cluster was not necessarily centered at the point representing the stopover event because of the temporal nature of the designation.

(a) (b)

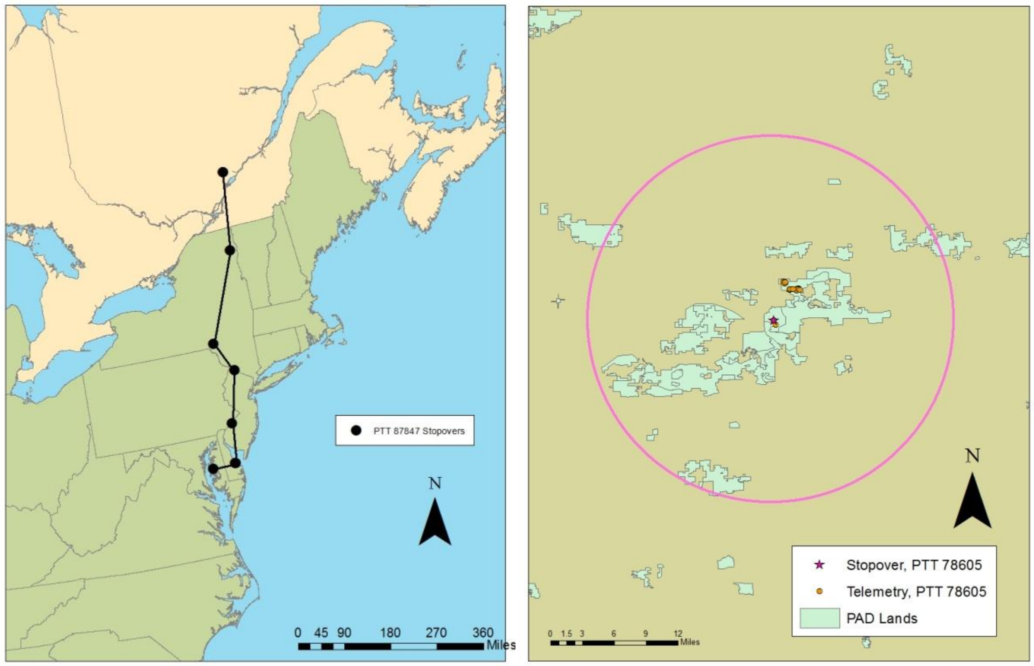


Figure 4. (a) An example of the migration route for bird with PTT 87847. Each point represents a stopover event during migration. (b) The stopover point (first temporal telemetry point) and telemetry points for the PTT code 78605 clustered within a 0.5 dd diameter of the first point.

Therefore, it was necessary for me to establish clusters manually in order to ensure the inclusion of all telemetry points within a stopover event. Each bird, represented by its PTT, had one to several unique stopover events of varying length throughout the monitoring period. For this analysis, all telemetry points contained within each single stopover event were selected via the clustering method described above and attributed with an additional unique identifier which consisted of the PTT of the bird conducting the stopover concatenated with an integer value to delineate different stopover events within a bird's migration (see figure 4).

Next, since telemetry points were collected during different *A. rubripes* life history periods, stopover events were separated into wintering (n = 37) and migration (n = 55) categories. The time at which birds transitioned from wintering to migration was originally determined by Anderson, and occurred when birds moved outside of the 0.5 dd range where they wintered. Data was queried from the original stopover table in ArcMap using the "Select by Attributes" utility. By exporting these data into two unique feature classes, I was able to examine these two very different life history periods separately during all further analyses.

An additional key geoprocessing task in this study was to separate the complete dataset containing telemetry values for all birds in order to conduct data analysis for individual birds. This was accomplished using a tool called "Split Layer by Attributes" which was obtained from the Esri ArcGIS Geoprocessing Gallery (Patterson, 2011). The process coded by this *.tbx file selected attributes from the telemetry and stopover event feature classes by consecutive PTT values and exported them to separate shapefiles (see figure 5). This created a telemetry and stopover event feature class for each unique PTT. One pitfall of this tool for this particular study was its lack of support for the Esri Geodatabase. This was remedied by exporting the shapefiles resulting from the tool into folders, and then importing them into a File Geodatabase entitled "BlackDuck" which was constructed for the storage of telemetry and stopover event points. Within this file geodatabase I constructed separate feature datasets for telemetry points and stopover events. This facilitated other geoprocessing tasks, which are discussed below.

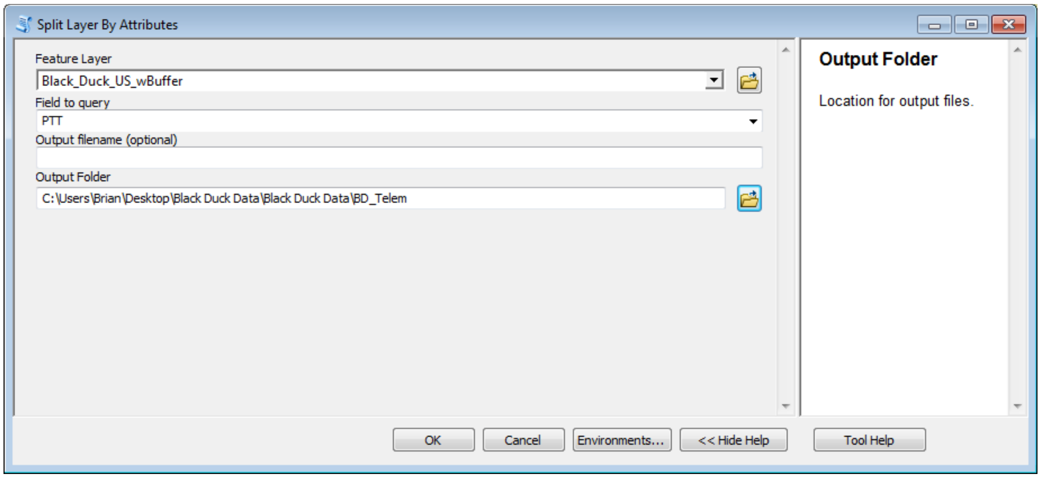


Figure 5. An example of parameter inputs for the "Split Layer by Attributes" tool. This tool was used to split stopover and telemetry feature classes by PTT value.

Preparation of Land Characterization and Hunting Data

Telemetry data were analyzed in conjunction with land parcel data from the Protected Areas Database (PAD), GIS data for which was obtained from the gap analysis program of the United States Geologic Survey (USGS, 2011). This dataset includes a set of land parcels that are officially designated as protected lands within the United States, including private conservation easements, lands owned by non-profits or other entities, and land managed under state and federal fish and wildlife programs such as wildlife refuges or wildlife management areas.

For this study, land parcels on which *A. rubripes* telemetry locations occurred were extracted from the PAD using an ArcGIS "Select by Location" function with a "contains" parameter (see figure 6). This was executed for ease of data manipulation, since the attributes of parcels without telemetry locations were not included in this study. Parcel name, acreage, state, and other attributes were all included as data fields. Consequently, land parcels included in the analysis were owned by federal, state, and private entities (such as The Nature Conservancy) and private landowners with conservation easements through state and federal programs (e.g. CRP, WRP, New Jersey Green Acres Program, etc.). As mentioned, because a protected lands dataset for Canada was not available, this study was limited to the telemetry points located within the United States, and consequently includes mostly wintering and spring migration points.

To indicate protected land status in this analysis, an additional attribute was added to the telemetry data to indicate whether the points were on PAD lands (PAD = 1) or not on PAD lands (PAD = 0). This allowed for numeric analysis of PAD status as described below.

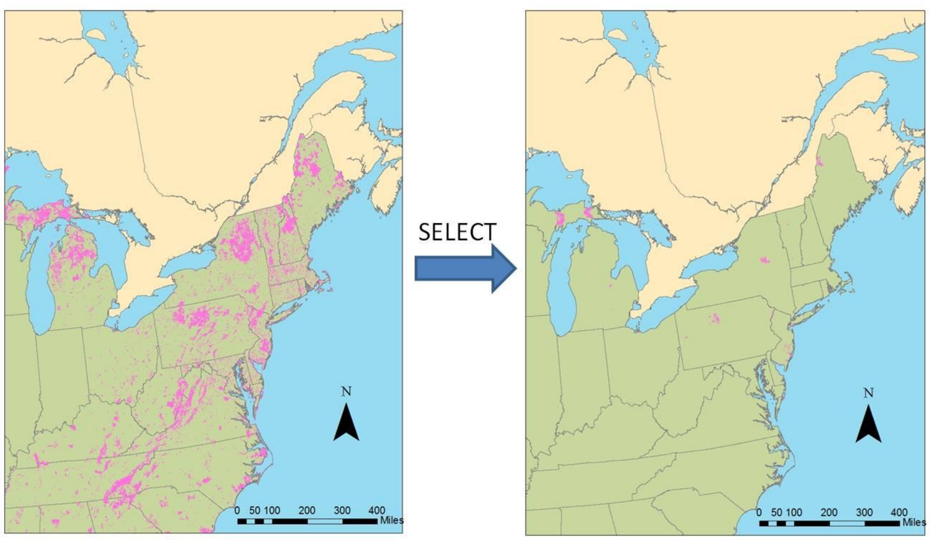


Figure 6. Distribution of all PAD lands in the states where *A. rubripes* telemetry points were present, and PAD parcels used by migrating and wintering *A. rubripes* in 2008-2009; the selection display results from a "Select by Location" operation using the telemetry feature class.

The level of hunting disturbance is also a variable of great interest, so I had to determine the extent to which this was a factor for stopover and wintering events on protected lands. To create a hunting status (HCat) attribute, I established a classification system using an ordinal variable with three values: 0 = hunting is not permitted, 1 = hunting is conditionally allowed (e.g. by limited draw permit or by private landowner permission, assumed to both be of moderate impact), and 2 = hunting is allowed as delineated by state regulations. Lands that were not included in the PAD were classified as HCat 1 because hunting was a potential factor, but disturbance was assumed to be moderate because of reduced hunter traffic. For the scope of this study, contacting land owners for all telemetry points not accounted for by the PAD was not feasible so this generalization was necessary.

Final Preparation of Feature Classes for Analysis

After telemetry points were associated with a particular stopover event, several fields were added to all feature classes in the File Geodatabase using an original Python script (see appendix). Fields containing values for HCat and PAD were added and manually populated for all telemetry points.

Data Analysis

Once the datasets were fully populated with attributes from the spatial data, the final analyses of the tabular data could begin. Mean values for HCat and PAD were calculated for all telemetry points within each stopover event (see figure 7). Mean values were determined via the “statistics” utility in the telemetry attribute table, and then associated with the individual stopover event feature classes via a table join. These mean values can be interpreted as the percentage of time that a bird spent in protected lands within each stopover event.

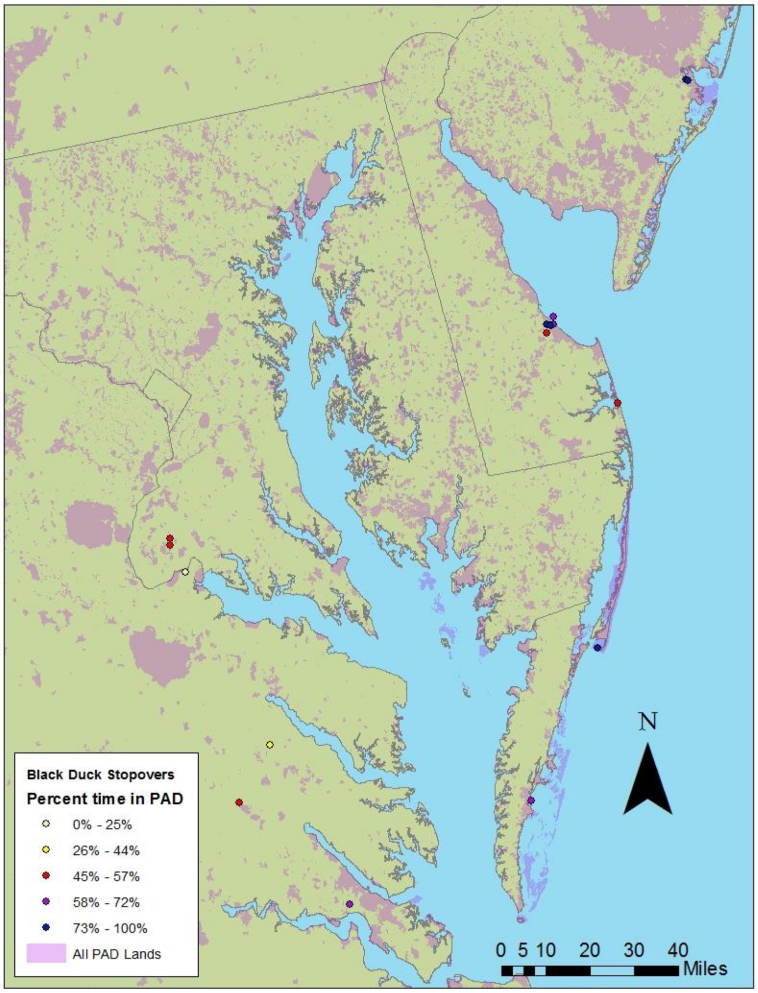


Figure 7. A map showing the percentage of time spent in PAD lands for a subset of stopover events from birds with various PTT values in the Chesapeake Bay region. A great deal of variation is seen depending on location.

Next, distributions were constructed to explore mean PAD status for stopover events and wintering. This was conducted for migration and wintering periods separately to assess potentially different ecological needs. As described above, mean PAD values were determined from all telemetry points associated with each stopover event. These values were then plotted on a range histogram.

HCat values were analyzed slightly differently. This variable was strongly correlated with PAD status because HCat 1 was very often an indicator of PAD 0 due to category definitions (see table 1). This prompted the distribution of HCat values to be assessed for only the data points where PAD = 1. A separate distribution was constructed with telemetry points from both PAD values for comparison and to assess model differences and biases when these categories were altered. Results are discussed in the section following.

Table 1. Counts of categorization for HCat and PAD for each telemetry point in wintering and migration periods. A value of 1 for HCat was assigned for private lands where no other information was available. Consequently, PAD = 0 and HCat = 1 are highly correlated.

	PAD=0	PAD=1
Hcat= 0	3	386
Hcat=1	4562	1957
Hcat=2	3	2650

Climate Variables

Temperature and precipitation are also known to affect migratory behavior and distribution of waterfowl species (Conroy et al., 2002). Therefore, historical weather data was obtained from “weatherunderground.com”, which accesses historical National Weather Service data to provide temperature and precipitation levels for a desired area and temporal period. For the purposes of my analysis, climate variables were delineated by ZIP code, as this was found to produce an analytic surface with a suitable scale. It should be noted that although climate data were presented at this scale, values came from weather stations that were most often spaced more distantly. Therefore, some reduction in the level of precision and true spatial resolution should be considered with these data and results. These data were continuous, and were kept as such for my analysis.

The first temporal point in each stopover event was overlaid with a ZIP code administrative layer in ArcMap and attributed with the appropriate value. Then, data were collected from "weatherunderground.com" for temperature and precipitation values at arrival and departure. Appropriate attribute fields were added in feature classes containing stopover events and then populated with these values to be used in regression. Regressions were calculated using the JMP statistics program developed by SAS.

RESULTS

As a first indicator, I assessed a basic count of telemetry points that were contained within the various hunting category values in all land areas (see figure 8) and then only in land parcels contained within the Protected Areas Database (see figure 9).

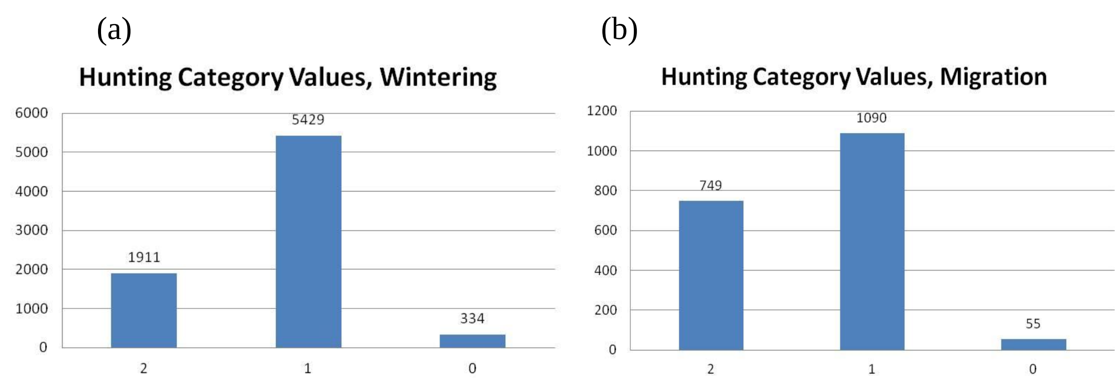


Figure 8. Counts of Telemetry points by HCat in (a) wintering and (b) migration. These distributions contain telemetry values from PAD = 0 and PAD = 1 areas, and are used to demonstrate HCat variable correlation with PAD.

(a) (b)

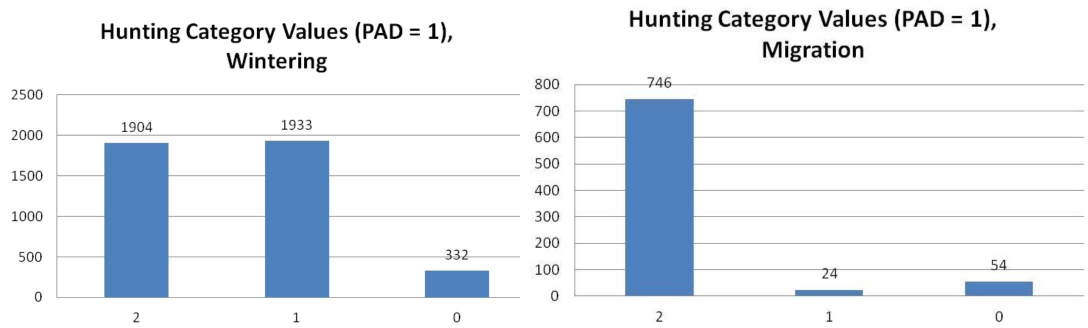
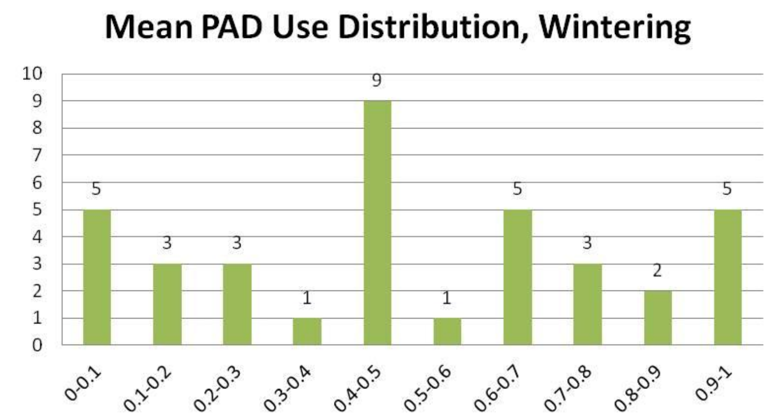


Figure 9. Telemetry points representing HCat values where PAD = 1 in (a) wintering and (b) migration.

Despite a lack of hunting pressures during spring migration, hunting category values were assessed for both wintering and migration periods due to the potential effects of management practices associated with hunting. *A. rubripes* land use in areas that either allowed hunting outright or via permitted harvest remained relatively similar and high during wintering in protected lands. Conversely, lands where open hunting took place in-season were strongly preferred during migration when birds were observed in protected lands. This suggests a higher use of lands that have either open or permitted hunting; in the case of migration, HCat 2 values, or open hunting, are almost universally used given the analysis of only lands within the Protected Areas Database. One can also observe that *A. rubripes* has an increased use of lands with lower hunting pressures during wintering when hunting season is open, while choosing open hunting lands during spring migration when hunting pressure is not a factor. Finally, it can be seen that when PAD = 0 lands are removed from the hunting category analysis, private non-protected lands cease to bias trends of land use. This implies the need for more detail regarding private lands.

Next, I examined the distribution of mean values for PAD per stopover event. This was accomplished by averaging the PAD values for each telemetry point associated with a particular stopover or wintering event. Mean PAD land use values for wintering were relatively evenly spread, while PAD use during migration seems to be skewed towards the "0" category, or land not included in the PAD (see figure 10).

(a)



(b)

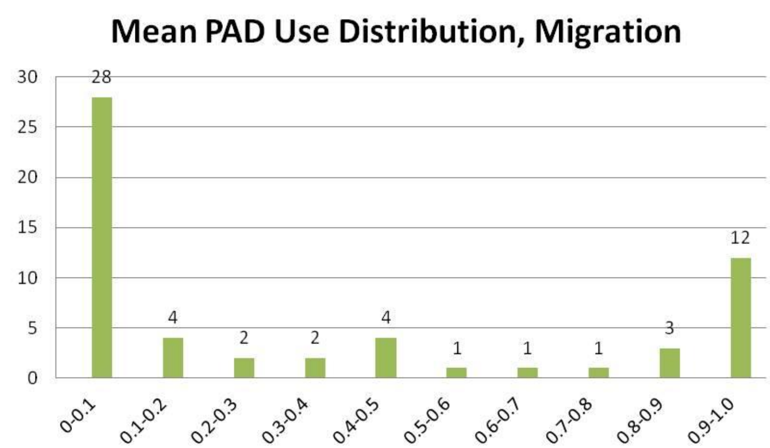


Figure 10. (a) Distribution of mean PAD values for wintering habitat. (b) Distribution of mean PAD values for stopovers during migration.

This suggests that the use of protected areas by wintering birds was more strongly favored than that of birds that were in migration, which were observed more frequently outside of protected land parcels.

Lastly, I assessed climate variables to see whether climatic factors had an effect on the observed length of stopover events. For this, I conducted linear regressions for arrival temperature, departure temperature, arrival precipitation, and departure precipitation against stopover length ($n = 55$). A small selection of values was omitted due to lack of available climate data. Although some potential correlation was observed, adjusted r-squared values were too low to suggest any type of compelling implication; therefore, these results were not explored further.

DISCUSSION

The relative distributions of *A. rubripes* telemetry points between wintering and migration life history periods prove to be one of the more interesting results of this study. *A. rubripes* were indeed observed more often on land with permit-limited hunting than in other areas, and while within protected land parcels, open and permit-limited hunting areas were used more than areas where hunting was prohibited. This suggests that even during hunting season when disturbance is direct and present, birds are still choosing managed areas where hunting is allowed over non-managed areas or hunting-prohibited areas.

There are a few implications of these results. The fewest observations are found in hunting-prohibited areas because the area covered by protected lands with this designation is comparatively very small. Permitted hunting areas and private lands show the highest count of telemetry observations since they also include all areas not accounted for by the Protected Areas Database. With the removal of biasing points outside of the PAD, however, we see more even usage of open and permit-limited hunting areas. Although the level of hunting disturbance is likely higher in these areas, the level of management for creating habitat specific to the needs of waterfowl is likely higher to boost population sustainability for harvest and species well-being.

For instance, St. Clair Flats Wildlife Area in Michigan possesses many water control structures and converted agricultural land areas where water level is specifically tailored to appropriate dabbling duck feeding depths (MDNR, 2002). This may well draw in wintering birds that require a reliable winter food source. In another case, land modifications, such as marsh terracing, were found to increase the numbers of wintering water birds in an estuarine ecosystem, and even prompted increased count volumes in certain species around anthropogenic features such as pathways or towns (O'Connell and Nyman, 2011). Although it cannot be guaranteed, one could assume that conservation efforts involving water control structures and other infrastructure are likely to be more intensive in protected areas. These findings suggest that land management benefits might outweigh hunting disturbances in wintering habitat in terms of habitat choice, and have positive effects outside of hunting season during migration.

Although distributions of utilized PAD lands remained somewhat similar during migration, this temporal period has a unique set of conclusions to be drawn from it given a significantly lower use of PAD parcels. The mean PAD values' distribution for telemetry points during stopover events confirm that non-protected areas seem to be used more frequently during migration than during the wintering period (see figure 10). The literature does not seem to suggest a particular reason why this pattern would vary, other than to say that migrating waterfowl in various regions tend to favor areas with better habitat conditions and greater nutrient reserves to replenish large amounts of expended energy (Lok et al., 2011). Another connected factor might be residual grains left in agricultural lands that likely would not be protected under conservation programs while still under harvest. Especially as migration locations approach the Great Plains, this becomes a much more important variable and potential management concern (Foster et al., 2010, Sherfy et al., 2011). I also conjecture that the lower use of managed lands may simply be due to necessity during long migration journeys; protected lands are not evenly distributed geographically and given similar habitat conditions, protected and non-protected land will be used during the course of migration.

The lack of correlation between climatic factors and stopover length is somewhat surprising. Many studies in the past have found that climate seems to, at the very least, affect distribution of dabbling duck species (Brook et al., 2009, Schummer et al., 2010). Therefore one would expect that migratory behaviors might be affected as well, especially in months with more extreme weather conditions. The most likely cause for this study's lack of correlation would seem to be attempting to extrapolate two discrete values over extensive periods of time. For example: assessing mean temperature on the day of arrival of a 30-day stopover is likely a gross generalization for examining actual dynamics. Instead, better results might be observed analyzing average snow cover over the duration of the stopover since this has been shown to affect *A. rubripes* survey studies taken during spring migration as the birds fly further north towards their nesting grounds (Chaulk and Turner, 2007). Furthermore, I would suggest that rather than taking temperature and precipitation data readings from the beginning and end of the stopover, a more continuous spatio-temporal analysis be employed to attempt to correlate patterns in temperature fluctuations with the initiation of bird movements. Although the first inclination might be to use average temperature over a stopover event, this method has the difficulty of accounting for large differences in stopover length given that this dataset contained values between 4 and 1000 hours. This variable is still relatively poorly studied owing to the difficulty of establishing long term data sets, so these are potentially very good areas for future research.

Lastly, the correlation and resulting bias occurring between HCat and PAD categories in this study should be remedied in future research efforts. The strong connection between HCat = 1 and PAD = 0 resulted from a lack of information about hunting conditions on non-protected lands. This could be addressed by conducting more detailed research on lands not contained within the PAD. Including additional categories for HCat that represented hunting practices on private lands where *A. rubripes* were observed would help to refine the analysis for non-protected lands. Unfortunately, given the time frame and resources of this study, extensive landowner research could not be conducted.

In addition, many National Wildlife Refuges or Wildlife Management Areas have hunting sites delineated within the boundaries of the larger property. One could hypothesize that sub-sites within management areas where hunting pressures were lower might foster more usage by *A. rubripes* and similar species. This information would, if collected, provide an excellent way of assessing the effect of fine scale intermediate hunting disturbances on migrating and wintering waterfowl.

CONCLUSIONS

Although hunting is one of the principal disturbances associated with *A. rubripes* population decline, wintering habitat where hunting is allowed is used extensively by ducks. This is demonstrated by a large proportion of telemetry observations occurring in protected and managed lands where hunting is a prevalent recreational activity.

My chief research question of whether or not protected areas in and of themselves have an effect on waterfowl migration seems to have several answers, and those answers are largely based on temporal factors that require further investigation. During wintering, birds seem to more often choose lands where hunting is allowed in-season at varying degrees, potentially due to greater land manipulation and management to create habitat best suited to the wildlife of concern in these areas. This could also be attributed to the establishment of these sites in areas with high inherent habitat quality. During migration, telemetry points occurred largely outside protected areas of any kind. These data suggest that either habitat requirements are different during migration (assuming all of the best habitats are protected) or that not all of the best habitats are protected (assuming habitat preferences are unchanged during migration). When ducks were recorded in protected areas during migration, they were predominantly found in sites where hunting was openly permitted when in season.

Further research in this area would be productively directed towards climate-related variables and further exploration of stopover length. These concepts are somewhat nebulous and a bit difficult to manage in a spatio-temporal sense, especially in the vein of determining an effective model for tracking weather changes over the course of a stopover event. It is quite probable that dynamics of temperature, precipitation, and snow-cover over the course of a stopover event, rather than just two discrete points, would be more descriptive of resource allocation, food availability, and carrying capacity; further investigation is certainly warranted.

At a more basic level, this study would benefit greatly from more ancillary data development. Contacting individual land owners where birds landed during stopover events and discovering their hunting practices would be a great addition. This would aid in seeing the effects of hunting on birds while they move, specifically during fall migration (were these points to be collected by future surveys). For PAD lands, analysis using not only the outlines of the wildlife areas in question but also digitizing hunting sites within said areas could give different results; perhaps birds avoid areas within managed sites where hunting is allowed in favor of less disturbed areas. Providing greater resolution for HCat and PAD categories and developing more robust datasets would grant better results, but the descriptive analyses conducted here suggest that these behaviors warrant further research.

REFERENCES

AFTON, A. D. 2008. Chronology and rates of migratory movements, migration corridors, and habitats used throughout the annual cycle by female Lesser Scaup radio-marked on Pool 19 of the Mississippi River. Baton Rouge, LA: Louisiana State University.

ANDERSON, K. A., BOWMAN, J.B., COLUCCY, J.M., & YERKES, T. 2009. *Spring Migration Ecology of American Black Ducks Determined by Satellite Telemetry*. Master of Science, University of Delware.

BENNETT, V. J., FERNANDEZ-JURICIC, E., ZOLLNER, P. A., BEARD, M. J., WESTPHAL, L. & FISHER, C. L. L. 2011. Modelling the responses of wildlife to human disturbance: An evaluation of alternative management scenarios for black-crowned night-herons. *Ecological Modelling,* 222**,** 2770-2779.

BRASHER, M. G., STECKEL, J. D. & GATES, R. J. 2007. Energetic carrying capacity of actively and passively managed wetlands for migrating ducks in Ohio. *Journal of Wildlife Management,* 71**,** 2532-2541.

BROOK, R. W., ROSS, R. K., ABRAHAM, K. F., FRONCZAK, D. L. & DAVIES, J. C. 2009. Evidence for Black Duck Winter Distribution Change. *Journal of Wildlife Management,* 73**,** 98-103.

CHAULK, K. G. & TURNER, B. 2007. The timing of waterfowl arrival and dispersion during spring migration in Labrador. *Northeastern Naturalist,* 14**,** 375-386.

CONROY, M. J., MILLER, M. W. & HINES, J. E. 2002. Identification and synthetic modeling of factors affecting American black duck populations. *Wildlife Monographs***,** 1-64.

DU. 2010. *Black Duck Study* [Online]. Memphis, TN: Ducks Unlimited. Available: http://www.ducks.org/conservation/black-duck-study/black-duck-study [Accessed March 18 2012].

FILOSO, S. & PALMER, M. A. 2011. Assessing stream restoration effectiveness at reducing nitrogen export to downstream waters. *Ecological Applications,* 21**,** 1989-2006.

FOSTER, M. A., GRAY, M. J. & KAMINSKI, R. M. 2010. Agricultural Seed Biomass for Migrating and Wintering Waterfowl in the Southeastern United States. *Journal of Wildlife Management,* 74**,** 489-495.

GASCOIGNE, W. R., HOAG, D., KOONTZ, L., TANGEN, B. A., SHAFFER, T. L. & GLEASON, R. A. 2011. Valuing ecosystem and economic services across land-use scenarios in the Prairie Pothole Region of the Dakotas, USA. *Ecological Economics,* 70**,** 1715-1725.

KIRBY, J. S., STATTERSFIELD, A. J., BUTCHART, S. H. M., EVANS, M. I., GRIMMETT, R. F. A., JONES, V. R., O'SULLIVAN, J., TUCKER, G. M. & NEWTON, I. 2008. Key conservation issues for migratory land- and waterbird species on the world's major flyways. *Bird Conservation International,* 18**,** S49-S73.

LOK, E. K., ESLER, D., TAKEKAWA, J. Y., DE LA CRUZ, S. W., BOYD, W. S., NYSEWANDER, D. R., EVENSON, J. R. & WARD, D. H. 2011. Stopover Habitats of Spring Migrating Surf Scoters in Southeast Alaska. *Journal of Wildlife Management,* 75**,** 92-100.

LONGCORE, J. R., MCAULEY, D.G, HEPP, G.R., RHYMER, J.M. 2000. Anas rubripes: American Black Duck. *Birds of North America*.

MDNR 2002. St. John's Marsh Wildlife Area: Special Use and Hunting Rules. *In:* RESOURCES, M. D. N. R. (ed.). Clay Township.

NAUGLE, D. E., JOHNSON, R. R., ESTEY, M. E. & HIGGINS, K. F. 2001. A landscape approach to conserving wetland bird habitat in the prairie pothole region of eastern South Dakota. *Wetlands,* 21**,** 1-17.

O'CONNELL, J. L. & NYMAN, J. A. 2011. Effects of Marsh Pond Terracing on Coastal Wintering Waterbirds Before and After Hurricane Rita. *Environmental Management,* 48**,** 975-984.

O'NEAL, B. J., STAFFORD, J. D. & LARKIN, R. P. 2012. Stopover duration of fall-migrating dabbling ducks. *Journal of Wildlife Management,* 76**,** 285-293.

PATTERSON, D. 2011. Split Layer By Attributes. *In:* ESRI (ed.) *ArcGIS Resource Center*.

PLATTNER, D. M., EICHHOLZ, M. W. & YERKES, T. 2010. Food Resources for Wintering and Spring Staging Black Ducks. *Journal of Wildlife Management,* 74**,** 1554-1558.

SCHUMMER, M. L., KAMINSKI, R. M., RAEDEKE, A. H. & GRABER, D. A. 2010. Weather-Related Indices of Autumn-Winter Dabbling Duck Abundance in Middle North America. *Journal of Wildlife Management,* 74**,** 94-101.

SHERFY, M. H., ANTEAU, M. J. & BISHOP, A. A. 2011. Agricultural Practices and Residual Corn During Spring Crane and Waterfowl Migration in Nebraska. *Journal of Wildlife Management*, 75**,** 995-1003.

USDA. 2012. *Conservation Programs* [Online]. United States Department of Agriculture. Available: http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=landing [Accessed March 18 2012].

USGS. 2011. *Protected Areas Database of the United States* [Online]. Available: http://gapanalysis.usgs.gov/padus/data/ [Accessed February 25 2012].

VEGVARI, Z., BARTA, Z., MUSTAKALLIO, P. & SZEKELY, T. 2011. Consistent avoidance of human disturbance over large geographical distances by a migratory bird. *Biology Letters*, 7**,** 814-817.

APPENDIX: PYTHON CODE FOR "ADD FIELD" TOOL

```
import arcpy
#set environment
arcpy.env.workspace = "C:/Users/Brian/Desktop/Black Duck Data/Black Duck
Data/Black Duck 2.gdb/Stopover"
arcpy.env.overwriteOutput = True
#create list of datasets in blackduckspoints.gdb
fcList = arcpy.ListFeatureClasses()
#create a loop to add fields
for fc in fcList:
   arcpy.AddField_management(fc, "Arrival_Date", "Text", "", "", "8", "ArrDate",
   "NULLABLE", "")
```

For use in other settings, the workspace would need to be modified to suit the individual computer being used. Additionally, parameters of the field should be adjusted to fit the need in the final "for" loop.