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INVESTIGATING ANNUAL VARIABILITY IN PELAGIC BIRD DISTRIBUTION AND ABUNDANCE IN OHIO'S BOUNDARIES OF LAKE ERIE

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INTRODUCTION

Currently no freshwater offshore wind facilities occur within the United States. Europe leads the world in the development and construction of offshore wind facilities. Unfortunately, very few post-construction mortality studies evaluating the potential impact on wildlife exist for offshore wind facilities. In part this is due to the difficulty conducting such surveys in an aquatic environment and the lack of baseline data on pelagic wildlife. Of the few studies conducted at offshore wind facilities, some have been inconclusive and others have suggested that these facilities may have both direct (mortalities from collisions) and indirect (avoidance and habitat loss) on pelagic and migratory birds (Bevanger et al. 2010). Mortality searches at onshore wind facilities in the Midwest have recorded that passerines comprise greater than 90% of the birds struck and only about 5% of the species struck are waterfowl (Erickson et al. 2008). However, with the lack of information from offshore wind facilities in freshwater environments, it is unclear what impacts wind facilities in the Great Lakes may pose to the pelagic wildlife.

In much of the Great Lakes region, offshore wind has been suggested or proposed. Not surprisingly the greatest wind energy potential in Ohio is over the waters of Lake Erie (NREL Ohio Offshore Wind Map 2010). Despite other Great Lakes having greater wind energy potential than Lake Erie, its shallow waters and proximity to electricity-load centers (e.g., Toledo, Cleveland, Detroit, and Buffalo) make it economically more feasible for wind energy facilities than some of the deeper lakes.

Lake Erie, the smallest of the Great Lakes in cubic volume, is constantly exposed to environmental and industrial fluxes, and thus is a dynamic ecosystem. The unique bathymetry of

the lake greatly influences the characteristics of water movement and upwellings, which often bring nutrient-rich water to the surface in specific areas of the lake. These nutrients can result in greater production of phyto- and zooplankton, which attract fishes and offshore birds. The abundance of fish also increases the concentrations of commercial fishing vessels, which in turn attracts pelagic birds attracted by the fish discarded by these vessels. Although we have limited data on quantity and species diversity, Lake Erie has been suggested to be a major stop-over and migratory route for pelagic birds. Furthermore, it has been suggested that a significant portion of North America's red-breasted merganser (*Mergus merganser*) population is on Lake Erie. Peterjohn (2001) recorded flocks of 210,000 individual mergansers on a single day near Sandusky, Ohio. Additionally, the Ohio Department of Natural Resources, Division of Wildlife (ODNR- DOW) conducts a bi-weekly aerial waterfowl survey within the nearshore boundaries of Lake Erie. Scaup (*Aythya* sp.) have been recorded exceeding 25,000 birds on lake during any one survey (Figure 1).

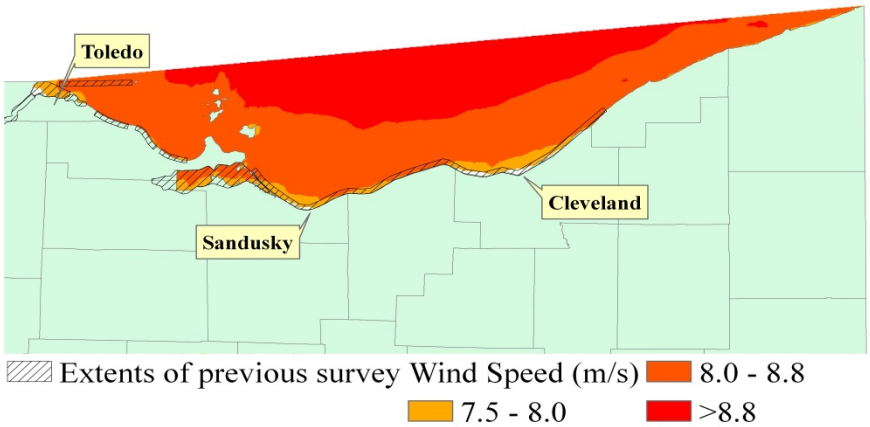

Figure 1. Ohio's Lake Erie wind speed potential with Ohio Department of Natural Resources Division of Wildlife waterfowl survey locations indicated with hatch-marks.

In 2009, ODNR-DOW and U.S. Fish and Wildlife Service (USFWS) recognized that large information gaps existed on pelagic birds within Lake Erie and such information is essential in siting any proposed offshore wind facilities. Therefore, to provide baseline data on the distribution of pelagic birds in Ohio's boundaries of Lake Erie, the ODNR-DOW in coordination with USFWS conducted fall and spring pelagic surveys in 2009 and 2010 (Lott et al. 2011). The objectives of this preliminary assessment were to (1) develop survey protocol using aerial transects, (2) survey and map the distribution of pelagic birds, and (3) preliminary identify areas of greatest concentration (thus risk from wind turbine placement) of pelagic birds. The ODNR-DOW received a grant to continue this baseline assessment for a second year (2010-2011). The purpose of this report is to provide the results of the second year, compare variability among years, and provide recommendations for future studies.

STUDY AREA

Our study was conducted within Ohio's boundaries of Lake Erie, including all areas between the 312-mile shoreline and the international boundary. Lake Erie is notable for having shallow waters, the average depth being only 19 m (62 ft) with depths ranging from 0 to 82 m (269 ft; Figure 2). The smallest Great Lake in volume, Lake Erie is approximately 119 cubic miles. The shoreline of the entire lake is 871 miles and the lake's surface is about 10,000 square miles. Sediment within the lake is predominately mud, but also includes bedrock, glacial till, sand, and gravel (Figure 3).

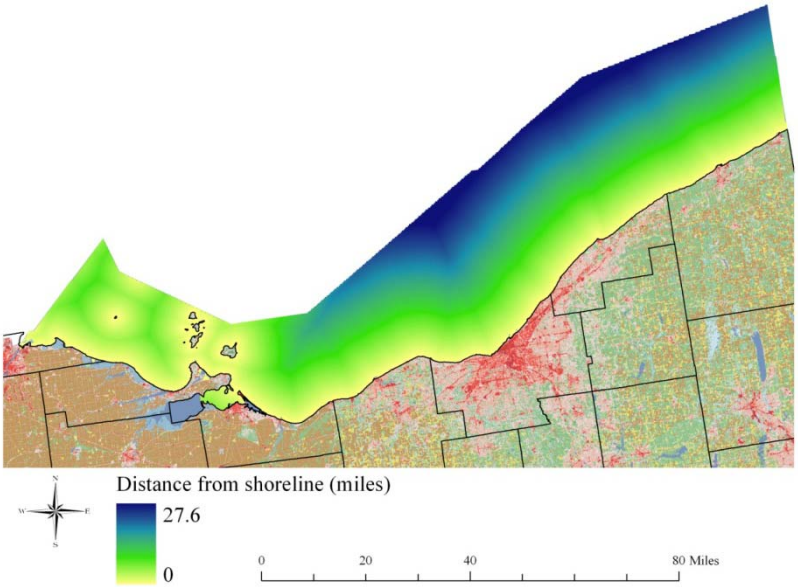

Figure 2. Map of Ohio's portion of Lake Erie and distance from shoreline.

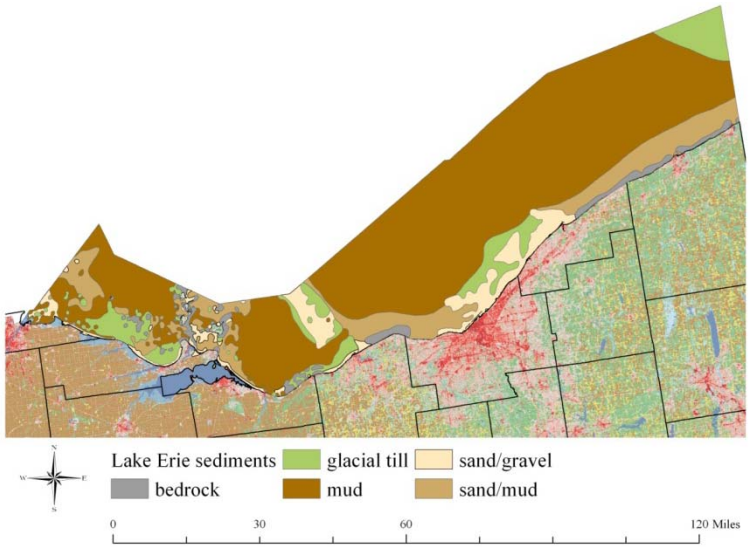

Figure 3. Map of Ohio's portion of Lake Erie and sediments.

METHODS

Survey methods—To evaluate pelagic bird distribution within Ohio's boundaries of Lake Erie, we flew 29 transects which zigzagged between the shoreline and the international boundary (Figure 4). Each transect varied in length (10 to 32 miles), but were evenly distributed along the shoreline and international boundary, and totaled 664 miles. For 2 years (2009-2010 [year 1] and

2010-2011 [year 2]), transects were flown once weekly during the fall (mid-October to mid-December) and spring (mid-March and mid-May), however due to the total length of the survey it took 2 days to complete each survey. Additionally, the 2 transects closest to the Camp Perry Training Center firing zone in Ottawa County were shortened within the safety fan when firing occurred at the training center. Because of this variability, the total miles flown were calculated for each completed survey. A twin engine Partenavia P68C was used to conduct the flights at an altitude of approximately 76.2 m (250 ft) agl, and at a speed of 120 knots (138 mph). It is important to note that the original flight height was 152.4 m (500 ft), however we quickly determined that detection and identification of individuals was too difficult and we needed to lower our flight height.

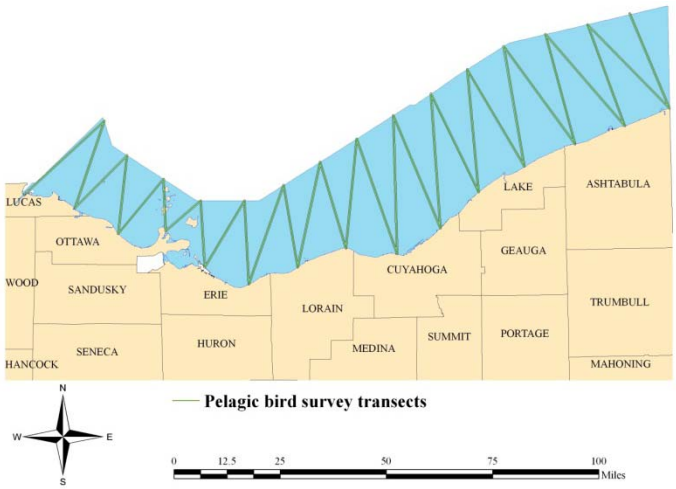

Figure 4. Pelagic bird aerial survey transects within Ohio's boundaries of Lake Erie, 2009-2011.

Observations were recorded on a Dell Axim handheld computer using ArcPad Version 7.0, which allowed for simultaneous recording of bird detections and spatial coordinates. Species detected, number of individuals and position along the transect were recorded. Birds were mostly identified to species, but we also consistently grouped some species together (e.g., herring and ring-billed gulls), due to difficulty differentiating species apart at our flight height.

Analyses—To compare variability among years in species abundance we calculated the mean number of birds detected per mile flown for each season (fall and spring) and each year (year 1 = 2009-2010 and year 2 = 2010-2011). We also provided distribution maps for all species in each year. Areas with the greatest densities of birds were identified using inverse distance weighting (IDW) for 804 m^2 (0.5 $mile^2$) grid cells in ArcGIS Version 9.3 to interpolate the number of birds within all Ohio areas of the lake. Using IDW, observations that are closest to a cell have the greatest effect on the value for each cell. We used the 20 closest observations to derive the value of each grid cell. To compare between years we conducted both yearly interpolations, as well as a comprehensive interpolation that merged the data from both years. We also assessed bird distribution relative to distance to shoreline for all species.

RESULTS

In year 1, we flew a total of 12,047 miles and recorded 10,644 observations which included 458,522 individuals consisting of 44 species (Table 1 and Appendix A). In year 2, we flew a total of 12,348 miles and recorded 13,996 observations which included 267,263 individuals consisting of 46 species (Table 1 and Appendix B). Ten species (lesser black-backed gull [*Larus fuscus*], Caspian tern [*Hydroprogne capia*], snow bunting [*Plectrophenax nivalis*], bald eagle [*Haliaeetus leucocephalus*], brant [*Branta bernicla*], American coot [*Fulica Americana*], rock

pigeon [*Columba livia*], black-crowned night heron [*Nycticorax nycticorax*], green heron [*Butorides virescens*], and red-winged black bird [*Agelaius phoeniceus*]) were detected in year 1 and not in year 2, whereas 7 other species (American wigeon [*Anas americana*], red-tailed hawk [*Buteo jamaicensis*], hooded merganser [*Lophodytes cucullatus*], northern pintail [*Anas acuta*], ring-necked duck [*Aytha collaris*], tree swallow [*Tachycineta bicolor*], and surf scoter [*Melanitta perspicillata*]) were detected in year 2 but not in year 1. Although greater and lesser scaup (*A.marila* and *A. affinis*) were the most abundant species (or groups) observed in both years (year 1: $\bar{x}$ = 18.86 birds/mi SE= 6.53, and year 2: $\bar{x}$ = 9.91 birds/mi SE = 3.80), year 1 was statistically greater than year 2 ($p < 0.001$, $\alpha = 0.05$). The second and third most observed species (or groups) were also different in each year (year 1: red-breasted merganser [*Mergus serrator*] $\bar{x}$ = 5.05 birds/mi SE= 2.20, and ring-billed and herring gulls [*Larus delawarensis* and *L. argentatus*] $\bar{x}$ = 4.01 birds/mi, SE= 0.90, and year 2: ring-billed and herring gulls $\bar{x}$ = 6.13 birds/mi SE= 0.75 and then red-breasted merganser $\bar{x}$ = 1.86 birds/mi SE= 0.81). For additional information on where species were located during our surveys Appendix C provides species-specific depictions for both years of the survey.

Not unexpectedly, in addition to yearly differences in overall abundance of birds observed, our results also suggest temporal variation among seasons and dates within a season (Figure 5 and 6). Birds observed per mile observed in the spring were less (year 1: $\bar{x}$= 13.35, SE = 4.37, n= 11 and year 2: $\bar{x}$ = 11.67, SE = 3.10, n = 11) than in the fall (year 1: $\bar{x}$= 55.75, SE = 13.45, n= 10 and year 2: $\bar{x}$ = 33.48, SE = 6.40, n = 10). For both years the peak date in which most birds per mile were observed was 22 November (137.75 birds/mi and 62.76 birds/mi in year 1 and year 2, respectively; Figure 6).

Table 1. Species observed during pelagic bird surveys over Ohio's portion of Lake Erie during 2009-2011. Mean ($\bar{x}$) number of birds observed per mile flown and standard errors (SE) calculated for years (year 1 = 2009-2010 and year 2 = 2010-2011) and seasons (fall = mid-October to mid-December and spring = mid-March and mid-May).

	Year 1 (2009-2010)				Year 2 (2010-2011)			
	Fall (n = 10)		Spring (n = 11)		Fall (n =10)		Spring (n = 11)	
Species	$\bar{x}$ (birds/mi)	SE	$\bar{x}$ (birds/mi)	SE	$\bar{x}$ (birds/mi)	SE	$\bar{x}$ (birds/mi)	SE
Gulls and Terns								
Herring/ring-billed gull	4.4320	1.1189	3.6257	1.4303	6.7586	0.8019	5.5669	1.2570
Greater black-backed gull	0.0081	0.0025	0.0078	0.0029	0.0083	0.0046	0.0262	0.0093
Lesser black-backed gull			0.0010	0.0010				
Glaucous gull	0.0006	0.0004	0.0004	0.0002	0.0009	0.0008	0.0003	0.0003
Bonaparte's gull	2.7518	0.4414	0.4253	0.1733	2.5195	0.4864	0.2549	0.0784
Tern sp.			0.0558	0.0386	0.0015	0.0015	0.0055	0.0055
Caspian tern			0.0015	0.0008				
Dabbling Ducks								
American black duck	0.1415	0.0892	0.0004	0.0002	0.1784	0.1227	0.1224	0.1122
American wigeon					0.0413	0.0413		
Mallard	0.9367	0.7703	0.0129	0.0077	0.4981	0.3869	0.0368	0.0176
Northern pintail							0.0015	0.0015
Diving Ducks								
Redhead	0.2026	0.2004	0.4107	0.4107	0.0386	0.0386	0.0424	0.0424
Long-tailed duck	0.0056	0.0054	0.0018	0.0018	0.0009	0.0008		
Goldeneye	0.0629	0.0495	0.0604	0.0312	0.0045	0.0028	0.6099	0.3671
Bufflehead	0.0983	0.0404	0.0490	0.0055	0.0892	0.0325	0.2247	0.1751
Ring-necked					0.0038	0.0038		
Ruddy	0.0139	0.0115	0.0241	0.0205	0.0441	0.0294		
Canvasback	0.0811	0.0760	0.1746	0.1710	0.0105	0.0064	0.0744	0.0680
Black scoter	0.0019	0.0018			0.0002	0.0002		
White-winged scoter	0.0038	0.0035			0.0003	0.0003		
Surf scoter					0.0002	0.0002		
Scaup sp.	32.8707	11.8968	6.1270	3.6169	19.0612	6.8998	1.5916	0.7624
Duck sp.	0.0083	0.0078	0.0219	0.0179	0.0139	0.0079	0.0048	0.0042
Mergansers								
Red-breasted merganser	9.0020	4.3193	1.4501	0.6756	2.3975	1.6599	1.3677	0.4800

Common merganser	0.0062	0.0043	0.0072	0.0057	0.1321	0.1296	0.2676	0.2152
Hooded merganser							0.0005	0.0005
Loons and Grebes								
Red-necked grebe	0.0002	0.0002			0.0002	0.0002	0.0003	0.0003
Horned grebe	0.1261	0.0406	0.0369	0.1070	0.1658	0.0591	0.0969	0.0275
Common loon	0.4971	0.1492	0.2372	0.1153	0.2889	0.1162	0.2409	0.0878
Red-throated loon	0.0041	0.0021	0.0002	0.0002	0.0008	0.0005	0.0013	0.0005
Geese and Swans								
Canada goose	0.1818	0.0624	0.1527	0.0877	0.1941	0.0474	0.0856	0.0511
Brant	0.0002	0.0002						
Trumpeter swan	0.0039	0.0027			0.0014	0.0014	0.0002	0.0002
Tundra swan	0.0079	0.0069	0.0067	0.0064	0.0108	0.0082	0.0015	0.0015
Mute swan	0.0034	0.0034	0.0004	0.0004			0.0001	0.0001
Colonial Waterbirds								
Double-crested cormorant	4.2478	3.7746	0.4531	0.1203	1.0083	0.4494	0.3349	0.1095
Great egret			0.0088	0.0039	0.0010	0.0005	0.0072	0.0046
Great blue heron	0.0004	0.0004	0.0167	0.0049	0.0002	0.0002	0.0113	0.0032
Snowy egret			0.0001	0.0001			0.0012	0.0007
Black-crowned night heron			0.0001	0.0001				
Green heron			0.0001	0.0001				
Other								
American coot	0.0384	0.0309						
American crow			0.0010	0.0007			0.0001	0.0001
Bald eagle	0.0003	0.0002	0.0018	0.0007				
Jaeger sp.	0.0003	0.0003			0.0001	0.0001		
Passerine sp.			0.0004	0.0002	0.0022	0.0022		
Red-tailed hawk					0.0002	0.0002		
Red-winged black bird			0.0001	0.0001				
Rock pigeon			0.0001	0.0001				
Sandpiper sp.	0.0002	0.0002					0.0005	0.0004
Snow bunting	0.0038	0.0038						
Tree swallow	0.0039	0.0027			0.0013	0.0013	0.0002	0.0002
Turkey vulture			0.0075	0.0075			0.0049	0.0048

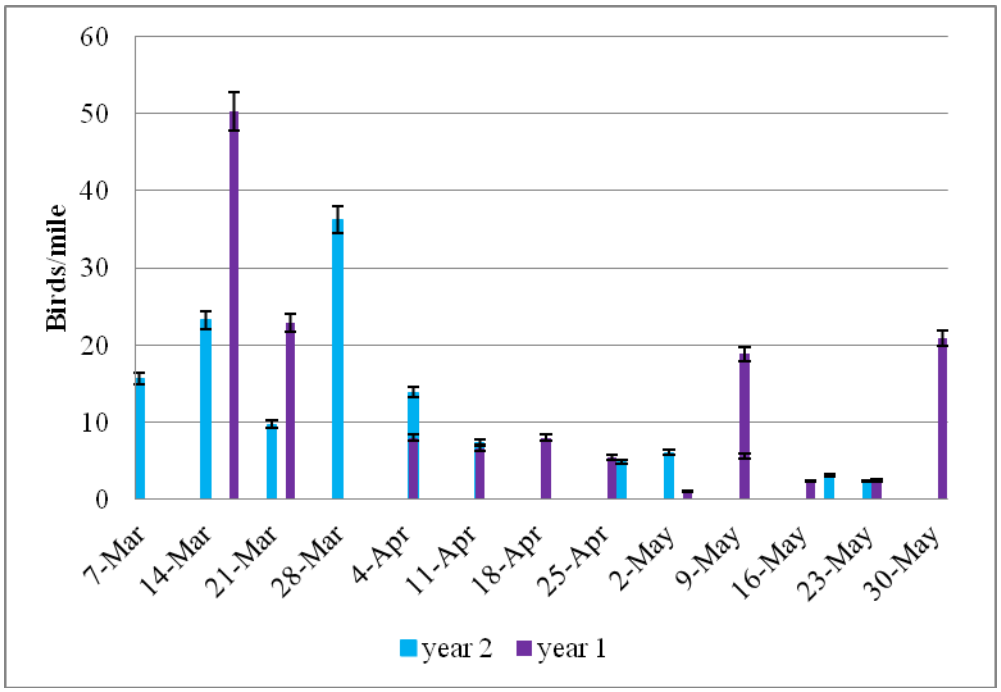

Figure 5. The temporal distribution of birds observed per mile during spring pelagic flights over Lake Erie during year 1 (2009-2010) and year 2 (2010-2011).

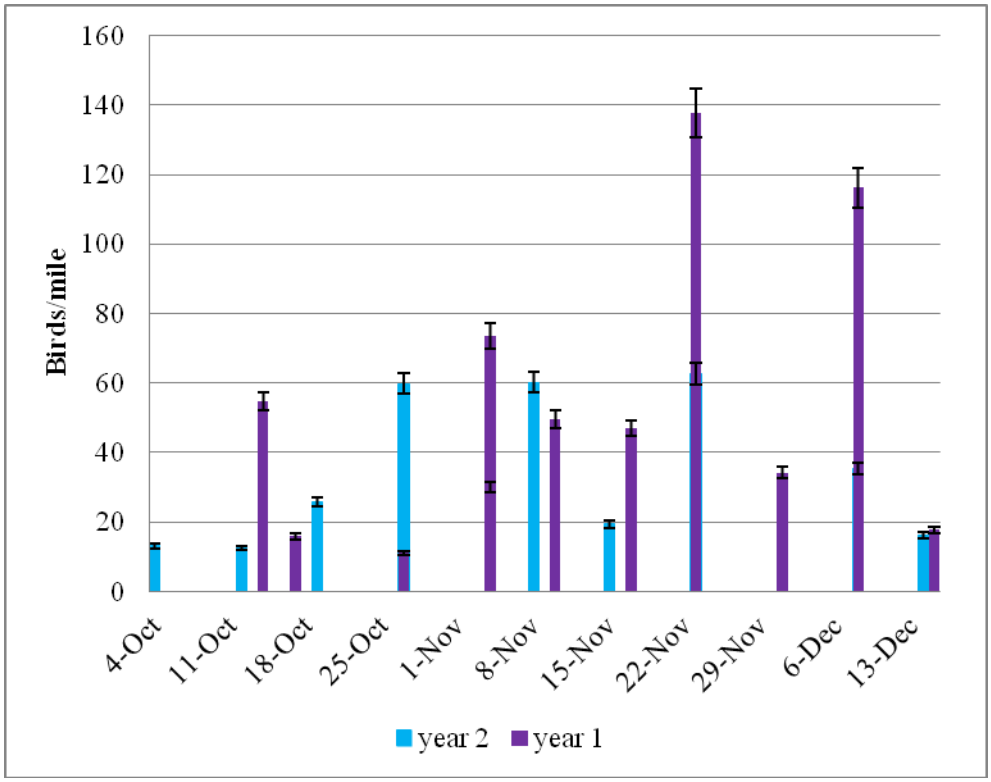

Figure 6. The temporal distribution of birds observed per mile during fall pelagic flights over Lake Erie during year 1 (2009-2010) and year 2 (2010-2011).

The overall trends for species distribution were similar among years—the further from the shoreline the less birds observed. One difference between years in the distribution of birds was that in year 2 we recorded >40,000 birds consistently between 0 and 6 miles from the shore, whereas in year 1 we did not record >40,000 birds beyond 2 miles of the shoreline (Figure 7 and Figure 8). For additional information on where species were located during our surveys Appendix C provides species-specific depictions for both years of the survey.

In year 1, we determined that the greatest number of birds were found near the islands within the western basin, and at the mouths of the Maumee and Cuyahoga rivers (Figure 9), as well as a couple of areas along the international boundary. Both years indicated similar trends, except in year 2 we did not observe greater densities further offshore along the international boundary and did have greater densities at the mouth of the Sandusky River (Figure 10). Our interpolation of both years' data provides a spatially explicit depiction of the trends we observed for pelagic bird distribution within Lake Erie (Figure 11).

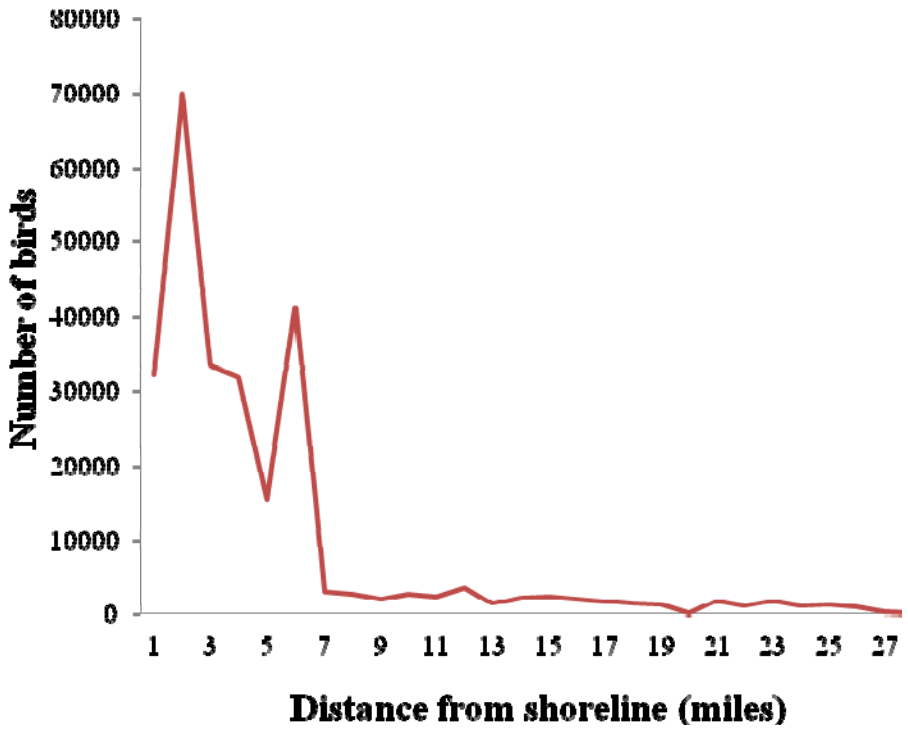

Figure 7. Number of birds recorded relative to the distance observed from shoreline in year 2 (2010-2011).

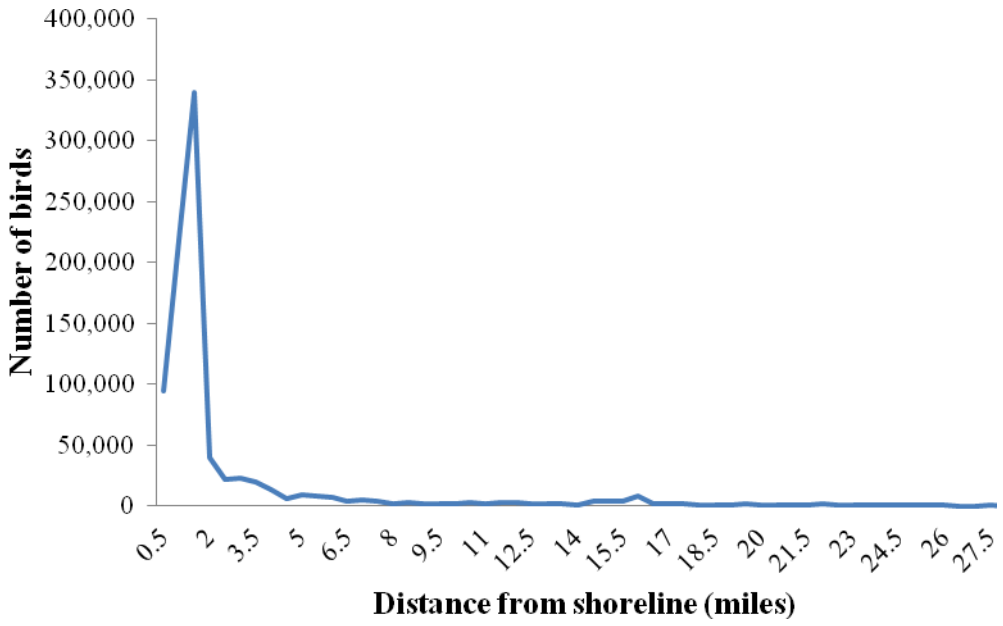

Figure 8. Number of birds recorded relative to the distance observed from shoreline in year 1 (2009-2010).

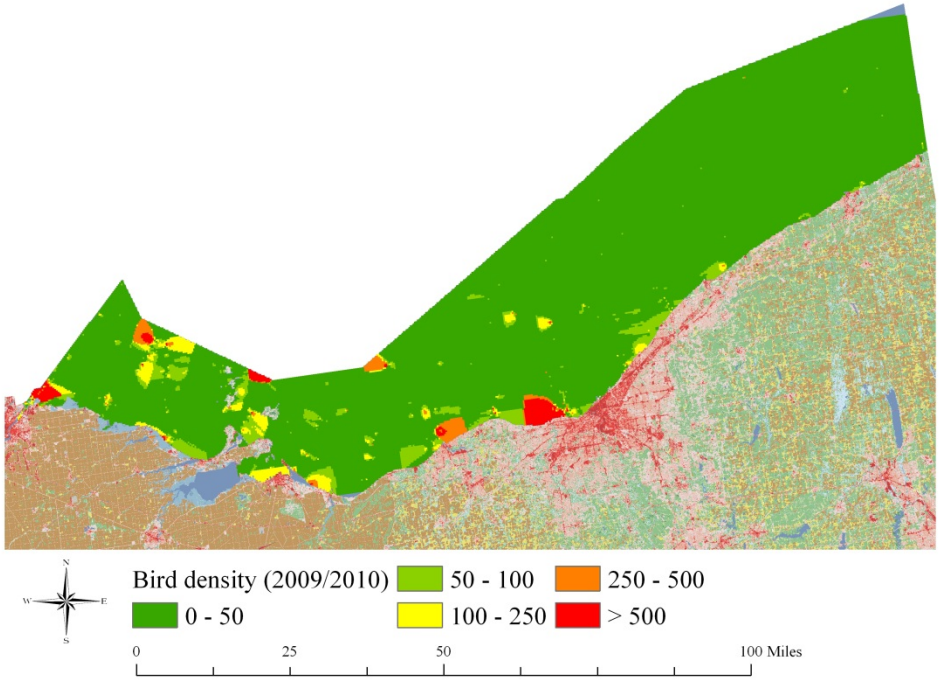

Figure 9. An interpolation of birds recorded during year 1 (2009-2010) pelagic survey in Lake Erie, Ohio using inverse distance weighting for 804 m^2 grid cells in ArcGIS Version 9.3.

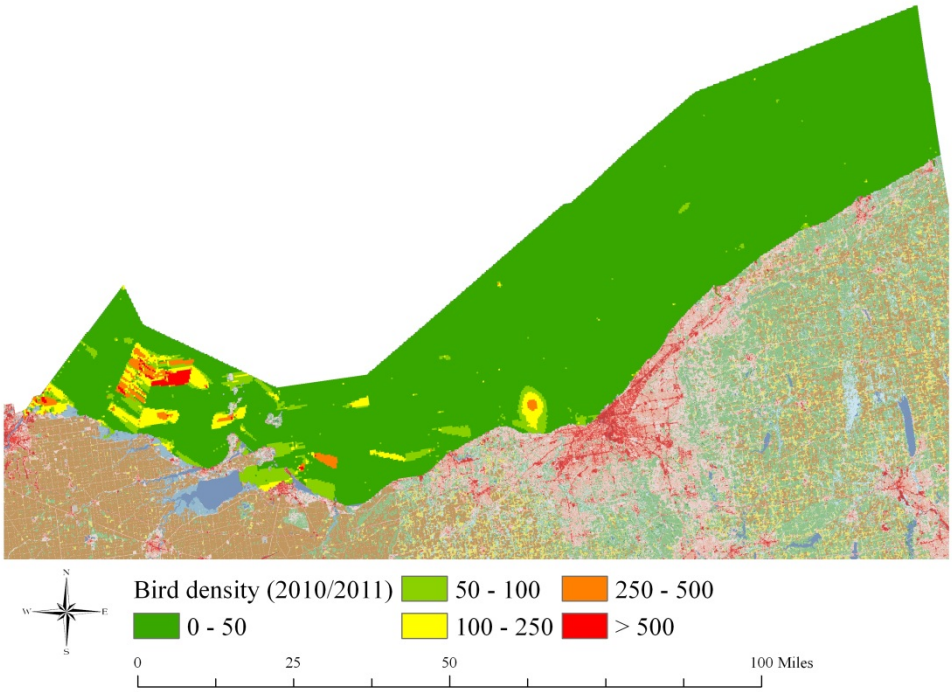

Figure 10. An interpolation of birds recorded during year 2 (2010-2011) pelagic survey in Lake Erie, Ohio using inverse distance weighting for 804 m^2 grid cells in ArcGIS Version 9.3.

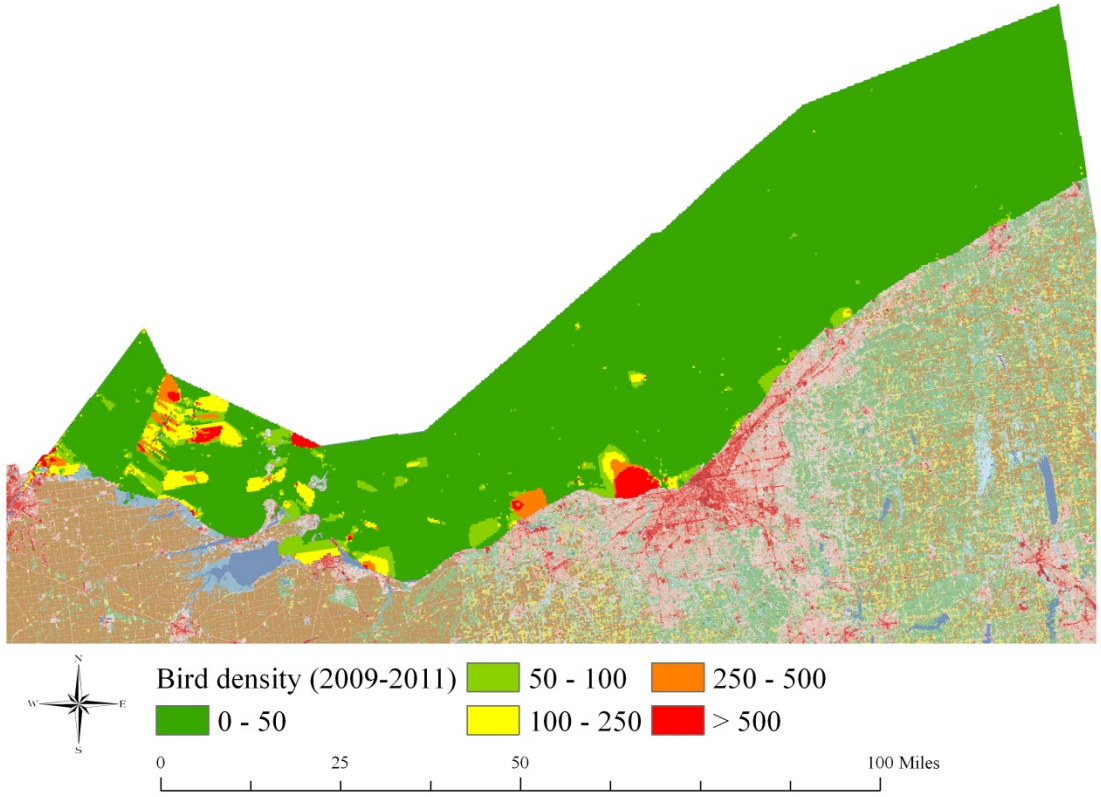

Figure 11. An interpolation of birds recorded combining data for 2 years of pelagic surveys (2009-2011) in Lake Erie, Ohio using inverse distance weighting for 804 m^2 grid cells in ArcGIS Version 9

DISCUSSION

Our study was the first to systematically evaluate pelagic birds in Ohio's offshore waters of Lake Erie. Results include temporally and spatially distinctive depictions of pelagic bird distribution in Ohio's boundaries of Lake Erie. Although we detected variability between years, our study provides some baseline information essential to assessing the potential impact of wind development offshore.

In both years there were no areas completely devoid of birds; however we observed fewer birds in the eastern section of our survey (Figure 11). We suggest that one explanation for the distribution we observed is the unique bathymetry and the differences in sediment of the lake (Figure 3). For instance, in the western basin we observed more birds, the bathymetry and sediment in this area are diverse and the water depths are considerably shallower than the central and eastern basins. If the bathymetry is variable water movements could also be varied causing upwellings, which could result in more nutrients, more phyto- and zooplankton, more fish, and thus more pelagic birds. Additionally, shallower waters provide easier foraging opportunities for diving ducks, such as scoters. Correlated to the bathymetry, the more sediment types the greater likelihood to have a diverse community structure within the water, which would provide pelagic birds with a larger prey base.

As suggested by Tasker et al. (1984) there are several factors that introduce bias when counting birds offshore to include: size of bird, color of bird and water, behavior of bird, meteorological factors (e.g., weather, ice-cover, wave heights), observer ability, and having different observers. The differences we detected in our results from each year could be due to these factors suggested by Tasker et al. (1984) or annual variation. To reduce and/or evaluate

these potential biases in future surveys, it is our recommendation that changes to the study protocol include consistent double observer methods and recording weather data and presence of fishing vessels (which can temporarily increase numbers of birds in an area). Additionally, incorporating distance sampling methods to the survey would provide detection probabilities and allow for correction factors to be applied to the data to account for some of the potential biases. We also recommend that the survey transects are more discrete from each other rather than the zigzag transects used in this study. At each turn from one transect to the next using the zigzag approach there was greater chance that birds were double-counted, thus over-estimating. In fact, this might be the reason our results in year 1 indicated greater numbers of birds in some areas along the international boundary, as well as some shoreline areas.

Although we recognize some limitations to this 2-year study, we believe that the innovative methods, as well as the baseline information we gained was critical. Conducting studies in future years (on Lake Erie) and on other Great Lakes, which incorporate what we have learned from this study will provide essential data on pelagic bird distribution in freshwater environments. Additionally, expanding the study to other Great Lakes may provide a more complete picture of how these birds migrate across the region.

ACKNOWLEDGEMENTS

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We thank the many observers that often volunteered their time including Jacob Gray, Caleb Shields, Andy Jones, Andrea Tibbels, John Pogacnik, Jim McCormac, Mark Shieldcastle, Kenn Kaufman.

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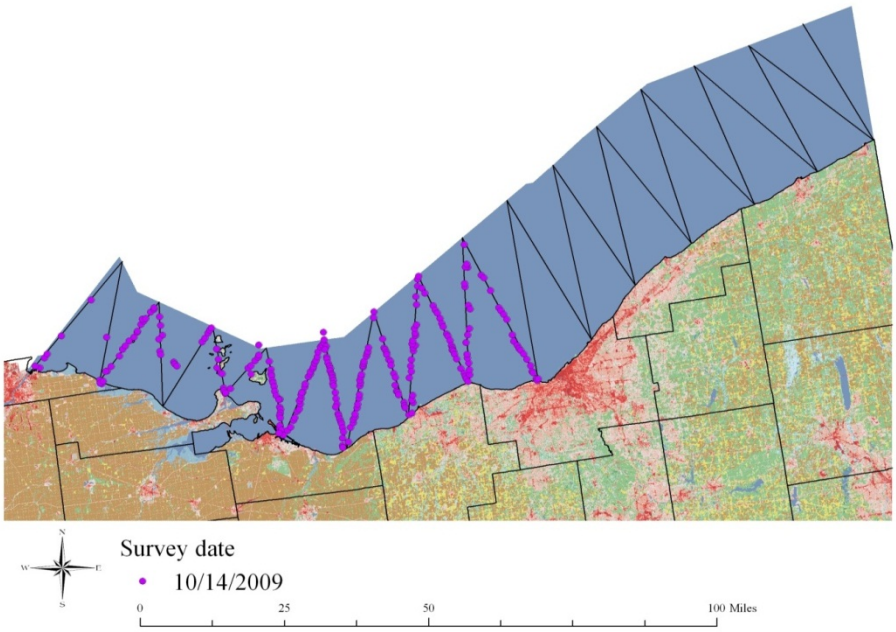
U.S. Department of Energy National Renewable Energy Laboratory. 2010. Ohio – 90 m Offshore Wind Speed.

Appendix A

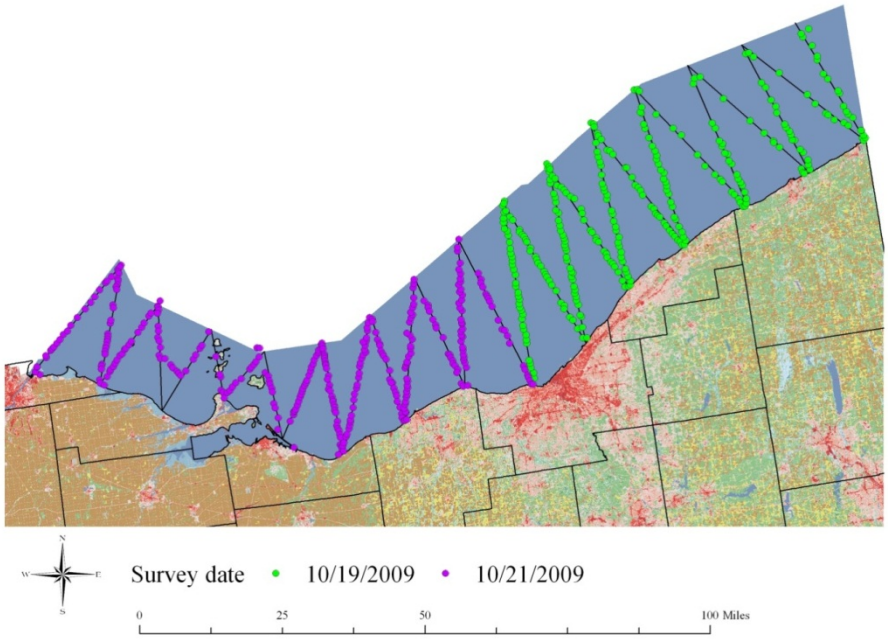
Year 1 (2009-2010) Survey Results

Date: 14 October 2009
Total species observed: 8 Distance flown: 290
Total number of individuals observed: 15,875 Birds per mile: 54.7

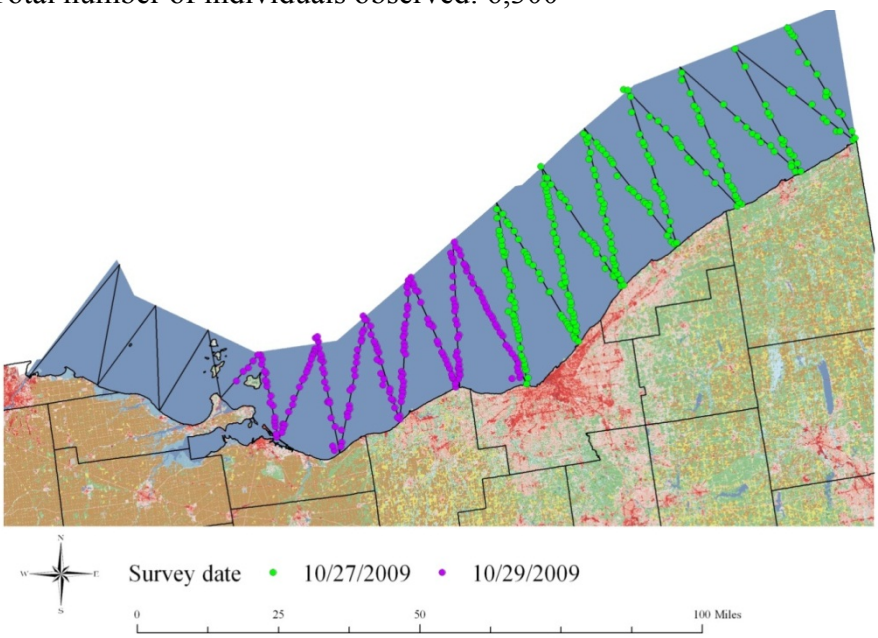


Date: 17, 19 October 2009
Total species observed: 10 Distance flown: 654

Total number of individuals observed: 10, 379 Birds per mile: 15.9

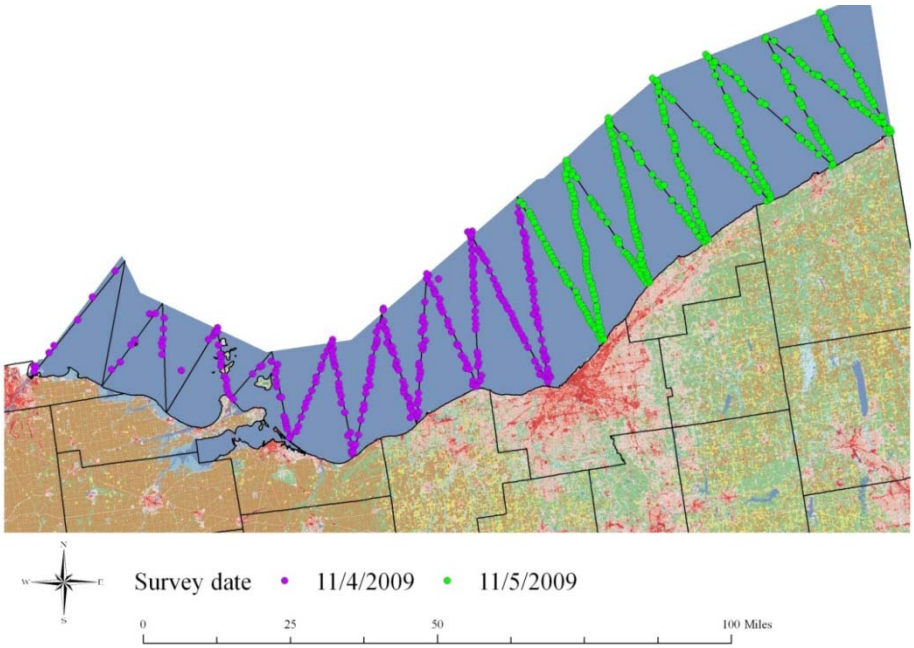


Date: 27, 29 October 2009
Total species observed: 14 Distance flown: 564
Total number of individuals observed: 6,300 Birds per mile: 11.2

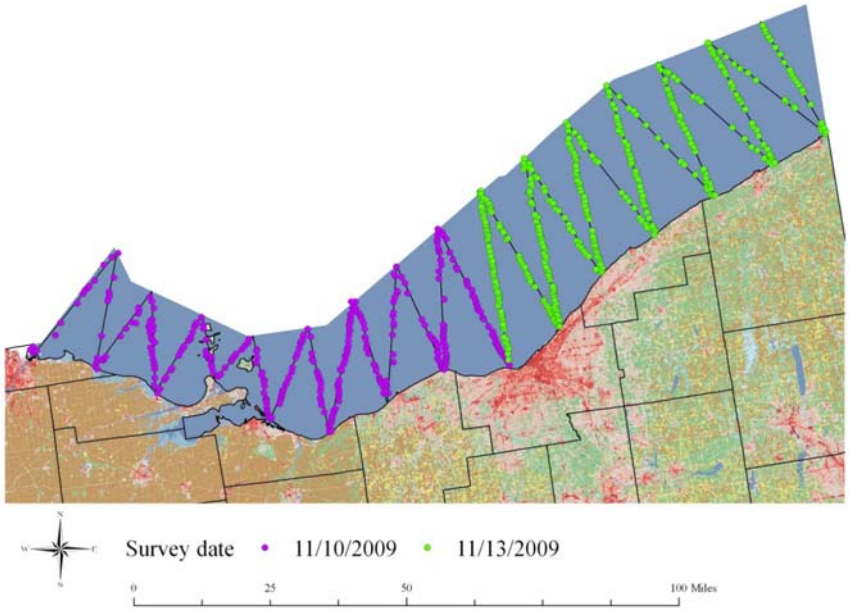


Date: 4, 5 November 2009
Total species observed: 18 Distance flown: 654

Total number of individuals observed: 48,002 Birds per mile: 73.4

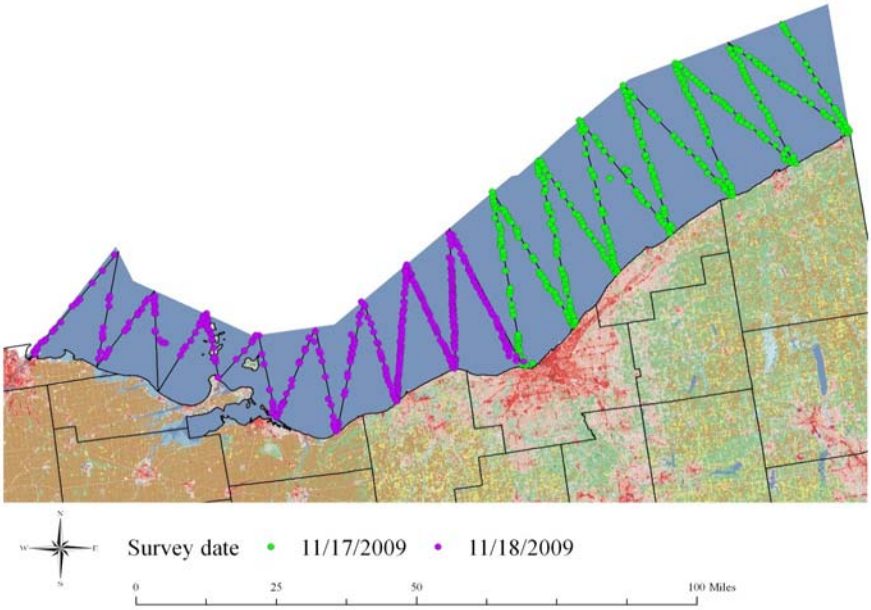


Date: 10, 13 November 2009
Total species observed: 14 Distance flown: 664
Total number of individuals observed: 32,894 Birds per mile: 49.5



Date: 17, 18 November 2009
Total species observed: 16 Distance flown: 654

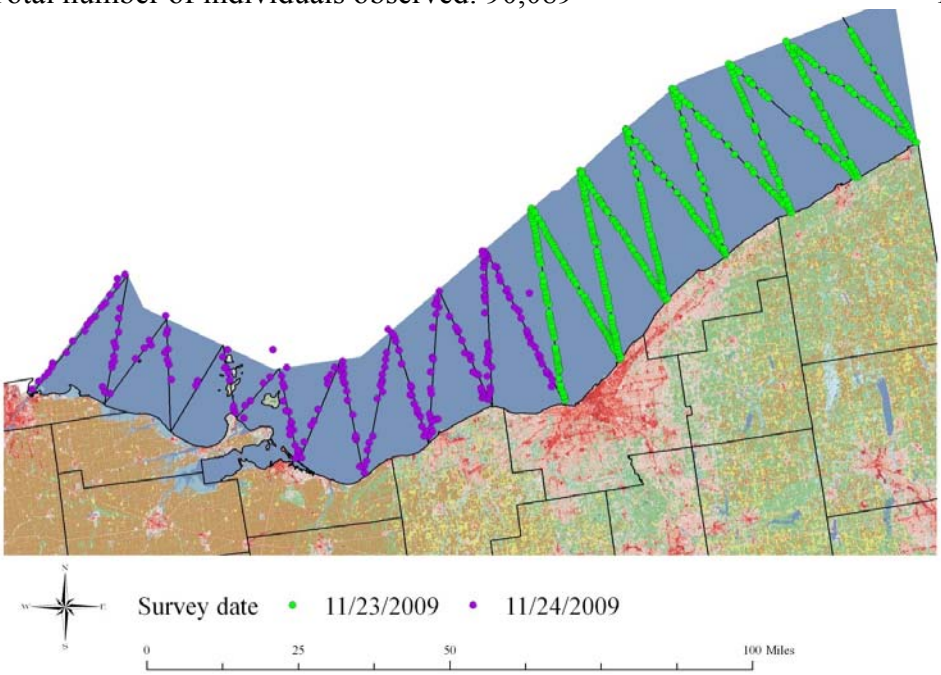
Total number of individuals observed: 30,723 Birds per mile: 47.0



Date: 23, 24 November 2009

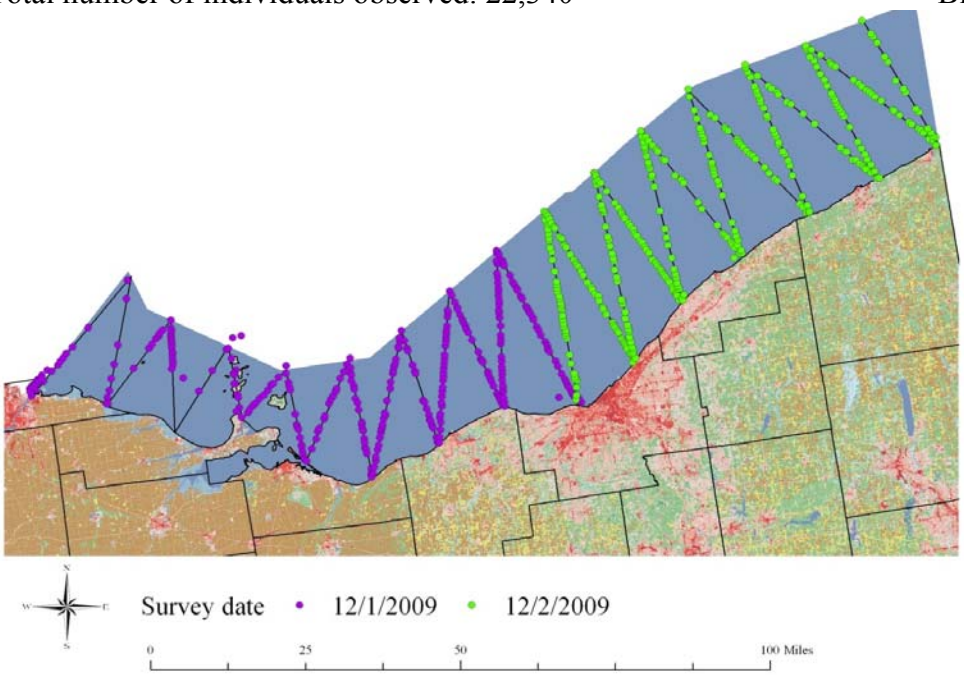
Total species observed: 17 Distance flown: 654

Total number of individuals observed: 90,089 Birds per mile: 137.8

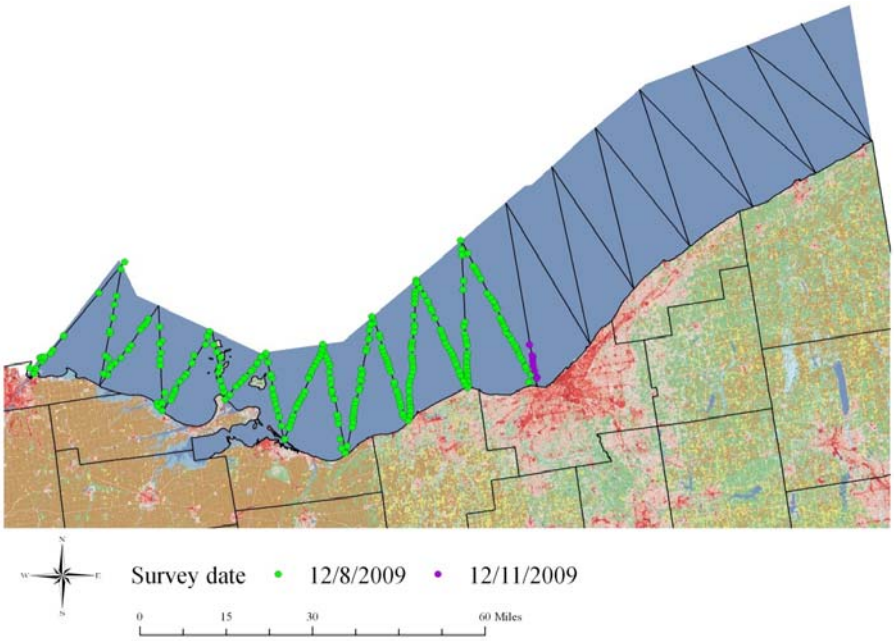


Date: 1, 2 December 2009

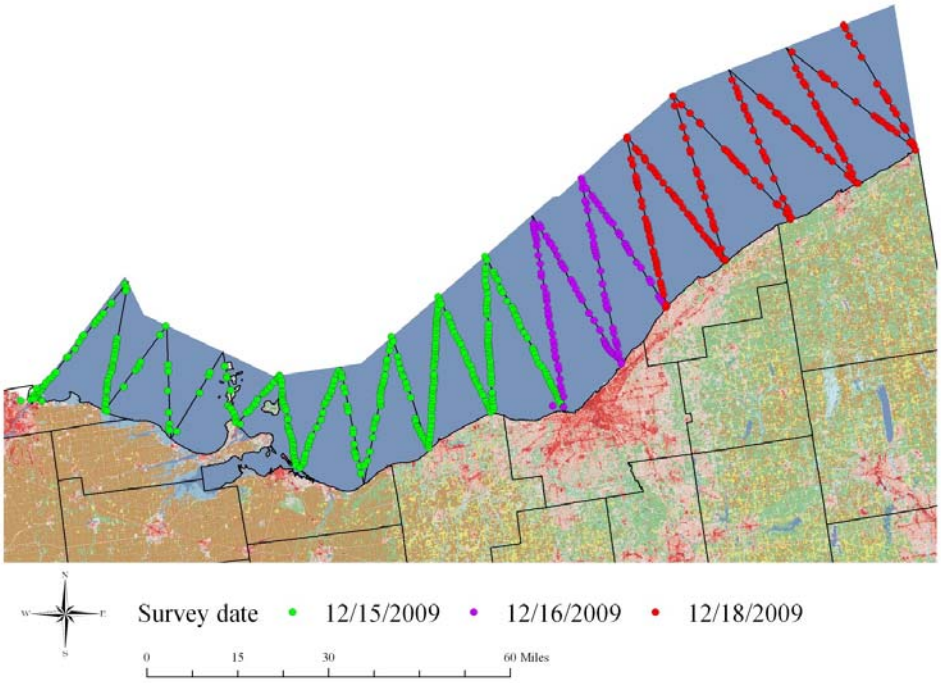
Total species observed: 18 Distance flown: 654
Total number of individuals observed: 22,340 Birds per mile: 34.2



Date: 8, 11 December 2009
Total species observed: 13 Distance flown: 324
Total number of individuals observed: 37,634 Birds per mile: 116.2



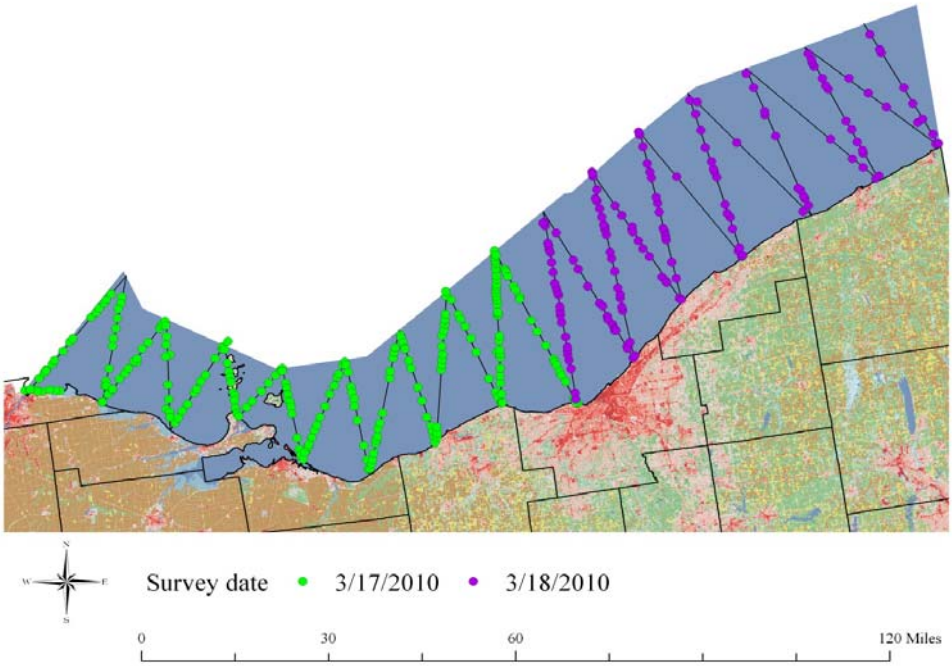
Date: 15, 16, 18 December 2009
Total species observed: 23 Distance flown: 664
Total number of individuals observed: 11,776 Birds per mile: 17.7



Date: 17, 18 March 2010

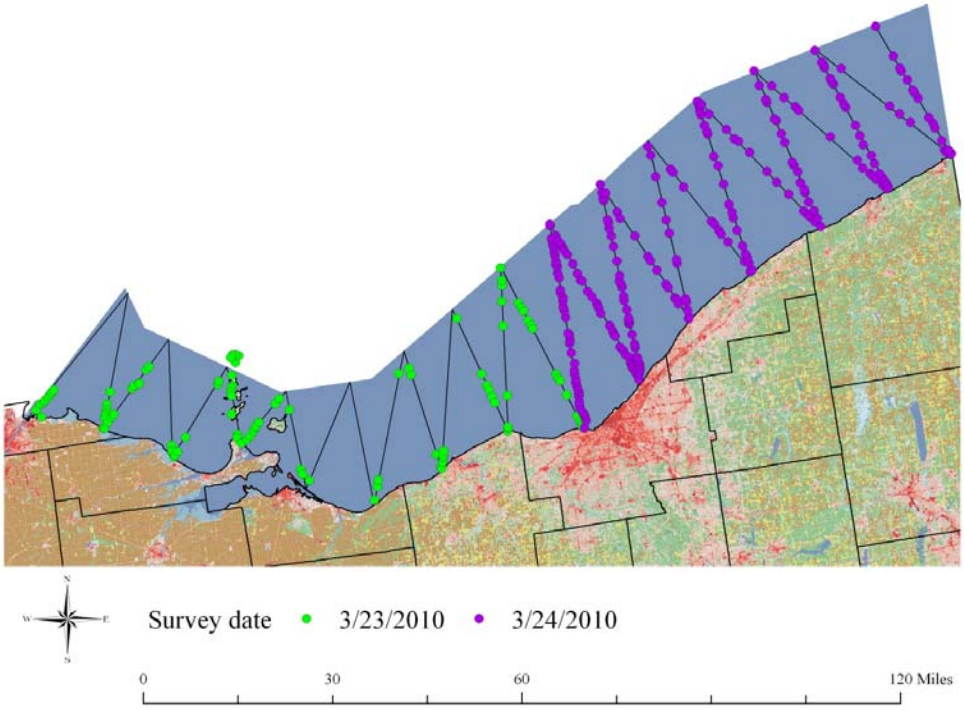
Total species observed: 21 Distance flown: 664

Total number of individuals observed: 33,408 Birds per mile: 50.3

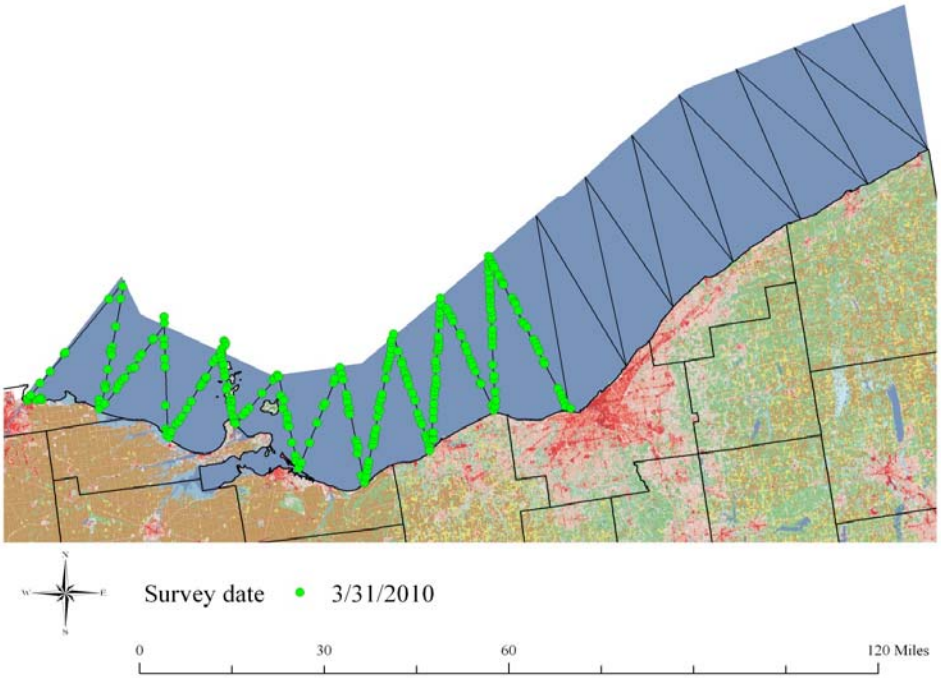


Date: 23, 24 March 2010

Total species observed: 17 Distance flown: 2664
Total number of individuals observed: 15,228 Birds per mile: 22.9

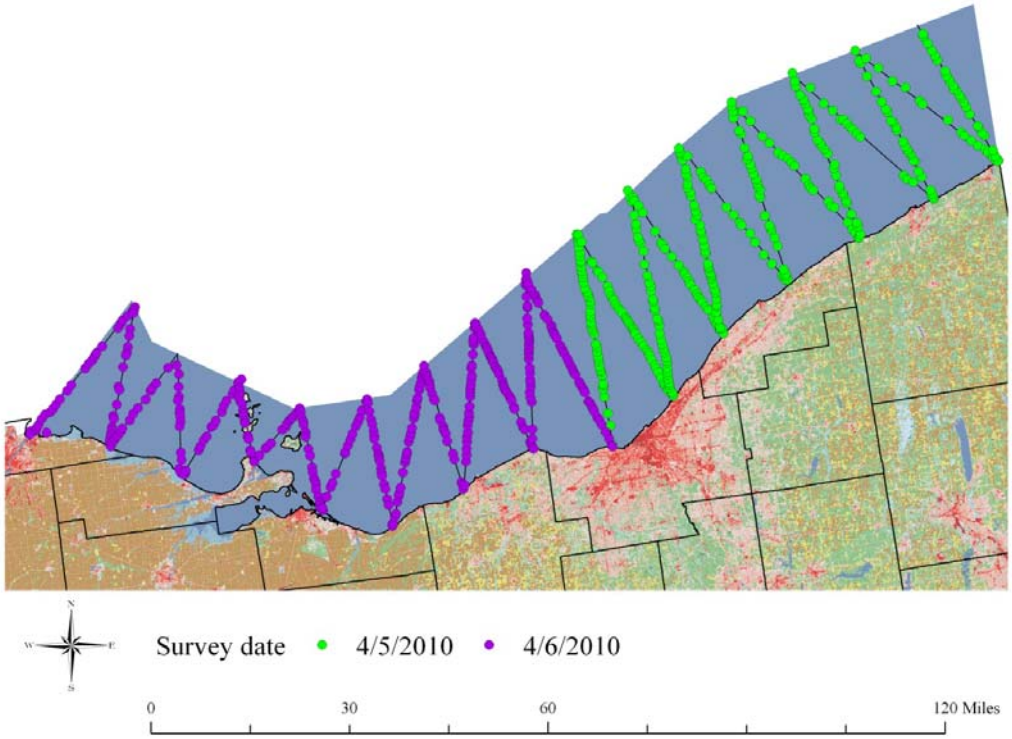


Date: 31 March 2010
Total species observed: 16 Distance flown: 300
Total number of individuals observed: 6,262 Birds per mile: 20.9



Date: 5, 6 April 2010
Total species observed: 19 Distance flown: 664

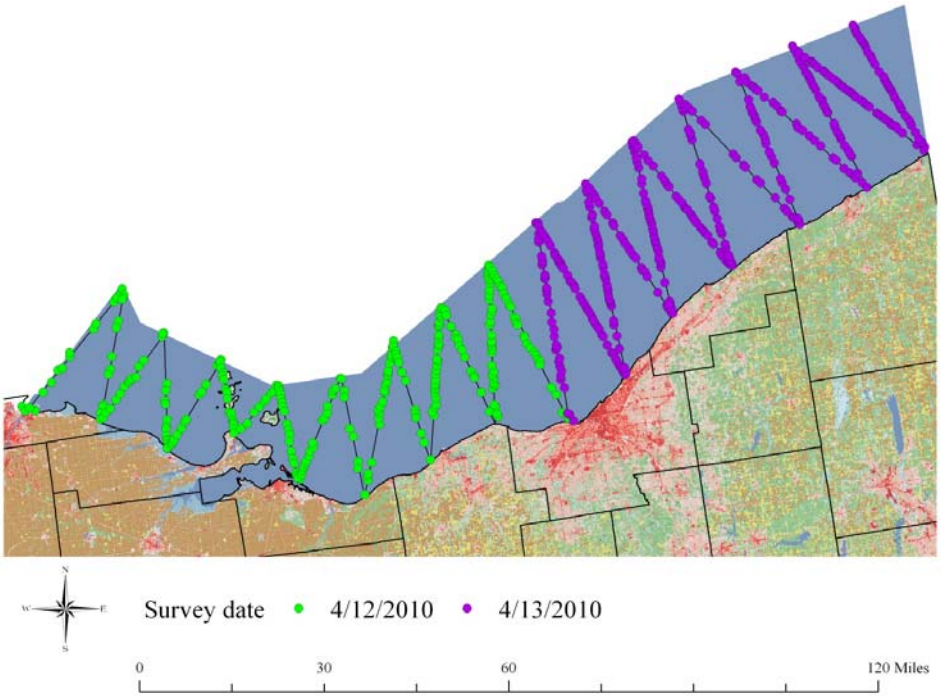
Total number of individuals observed: 5,321 Birds per mile: 8.0



Date12, 13 April 2010

Total species observed: 22 Distance flown: 664

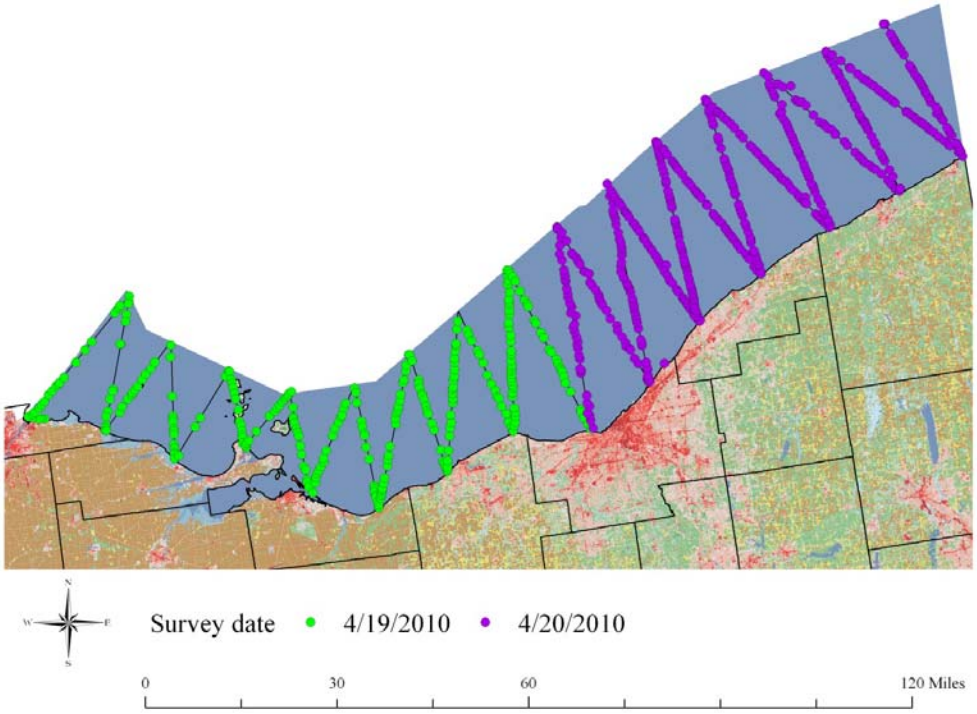
Total number of individuals observed: 4,371 Birds per mile: 6.6



Date: 19, 20 April 2010

Total species observed: 20 Distance flown: 664

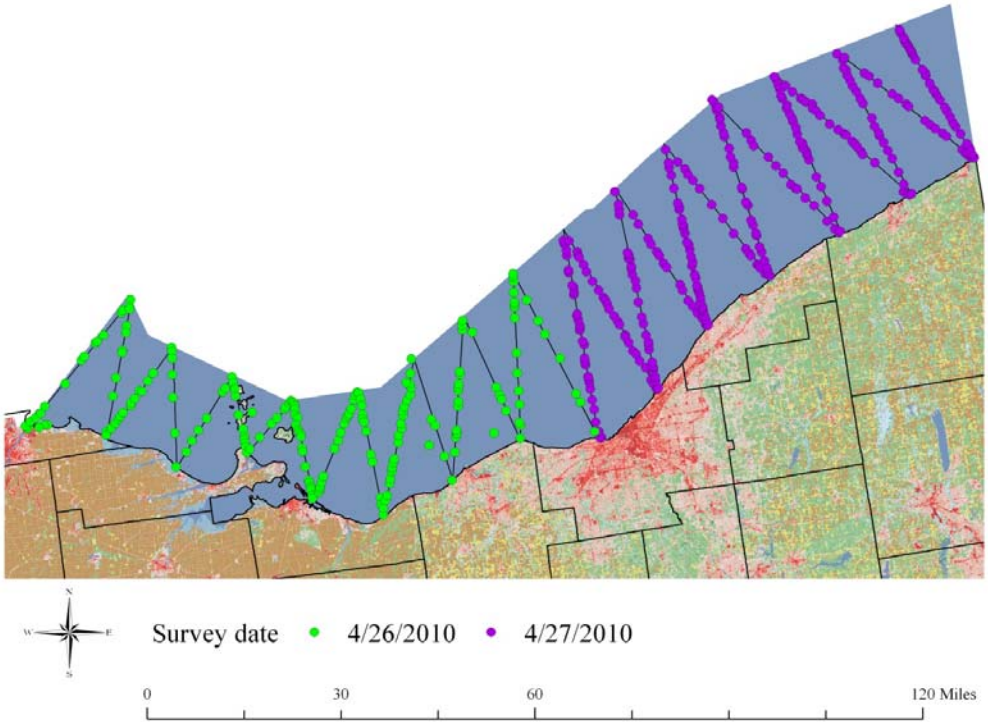
Total number of individuals observed: 5,312 Birds per mile: 8.0



Date: 26, 27 April 2010

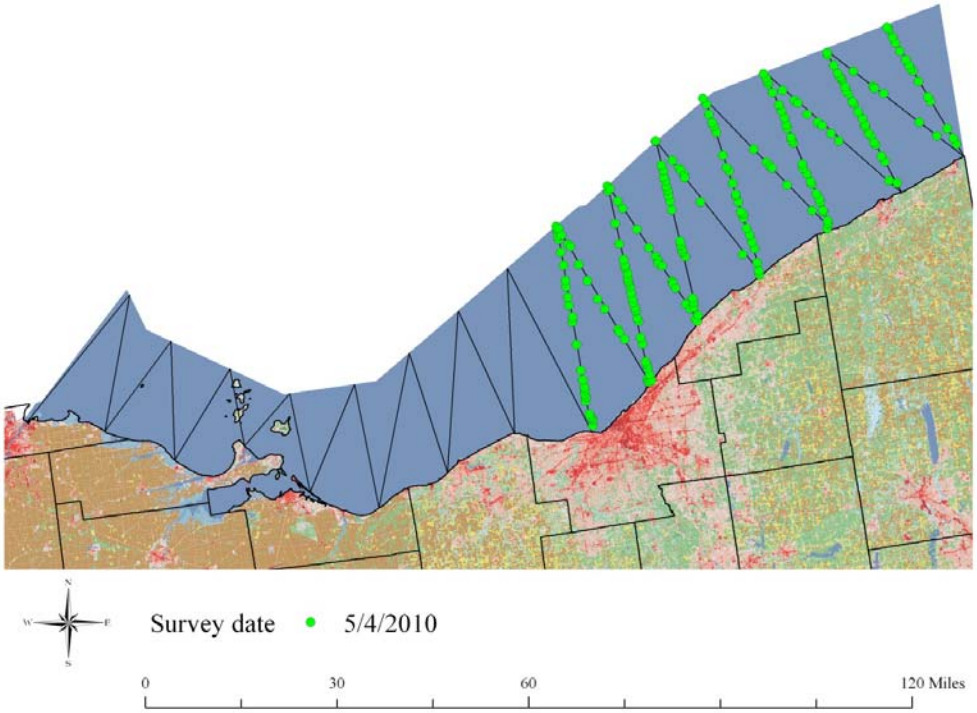
Total species observed: 12 Distance flown: 664

Total number of individuals observed: 3,628 Birds per mile: 5.5

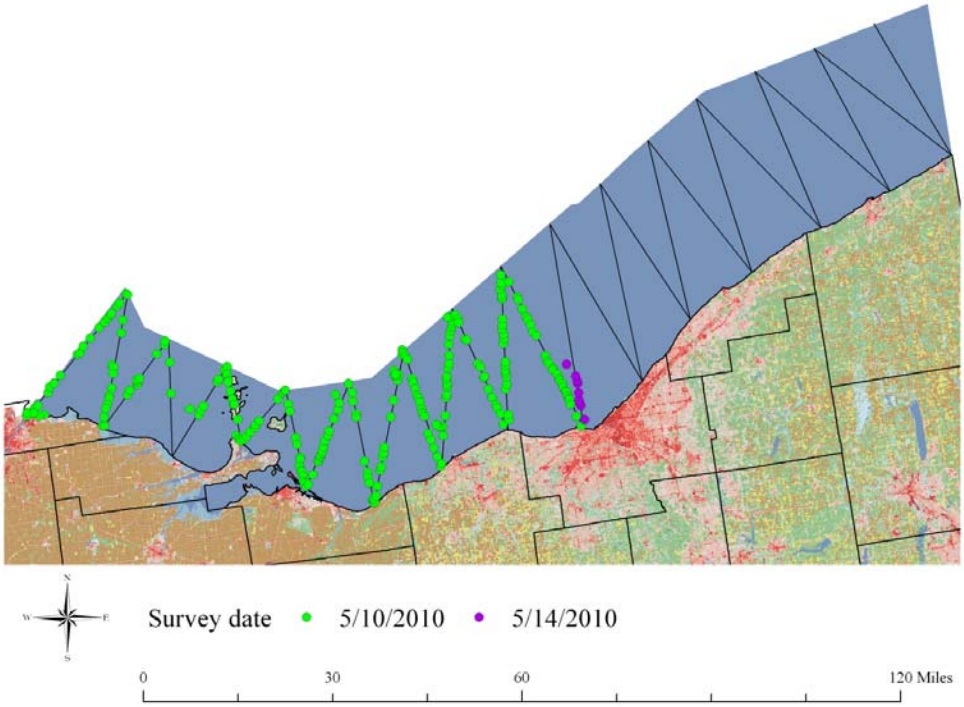


Date: 4 May 2010

Total species observed: 4 Distance flown: 364
Total number of individuals observed: 380 Birds per mile: 1.0

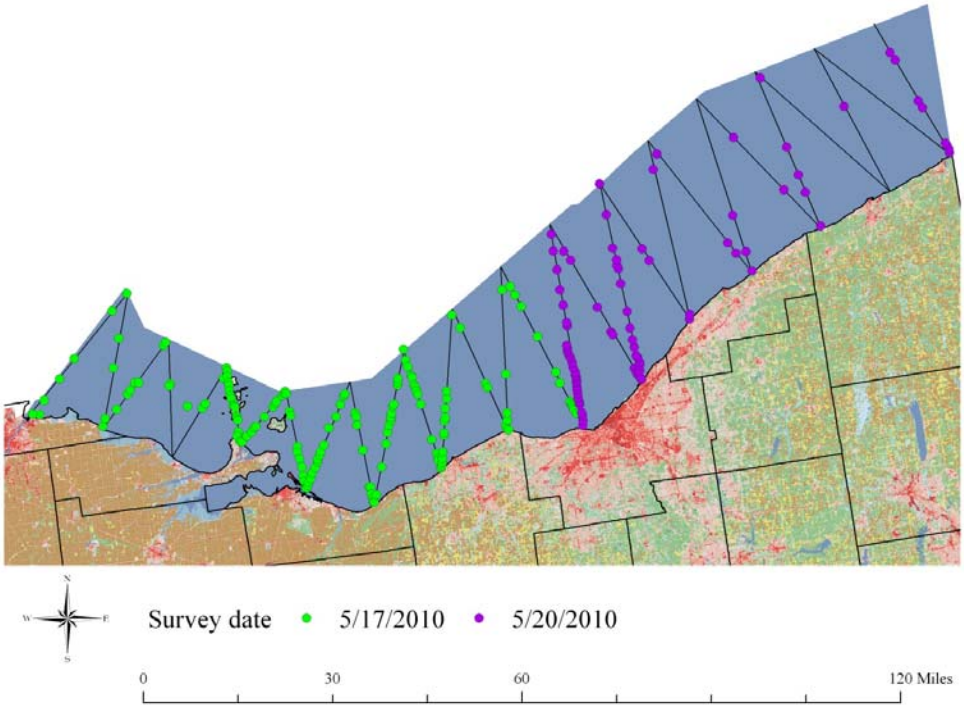


Date: 10, 14 May 2010
Total species observed: 7 Distance flown: 315
Total number of individuals observed: 5,933 Birds per mile: 18.8



Date: 17, 20 May 2010
Total species observed: 6 Distance flown: 654

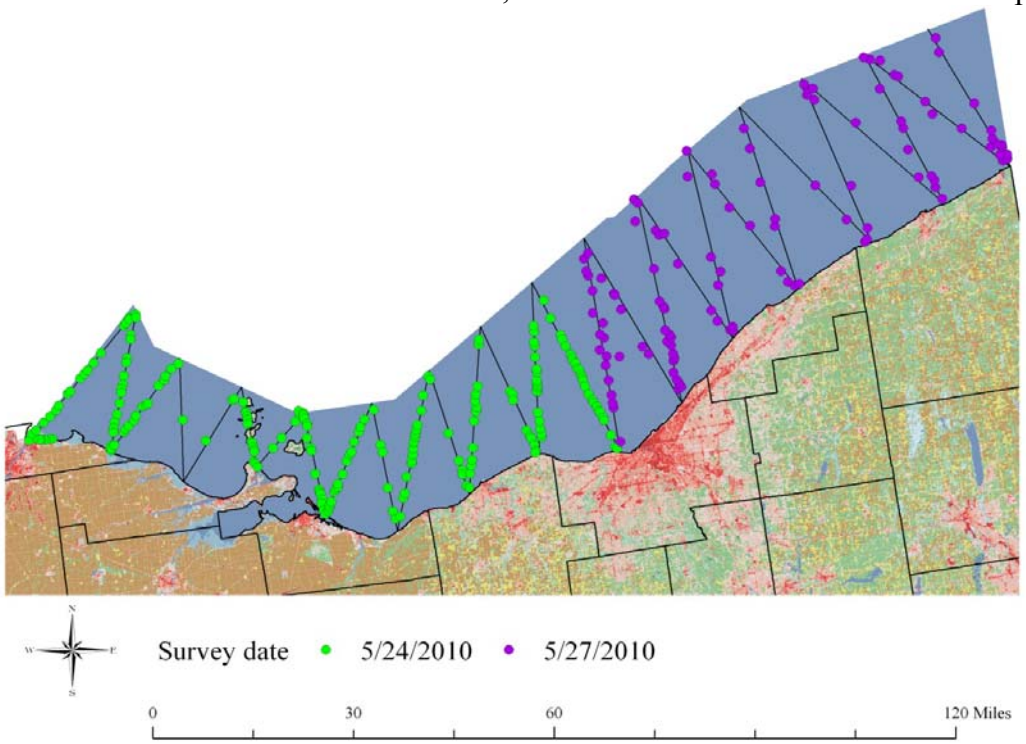
Total number of individuals observed: 1,521 Birds per mile: 2.3



Date: 24, 27 May 2010

Total species observed: 7 Distance flown: 654

Total number of individuals observed: 1,582 Birds per mile: 2.4



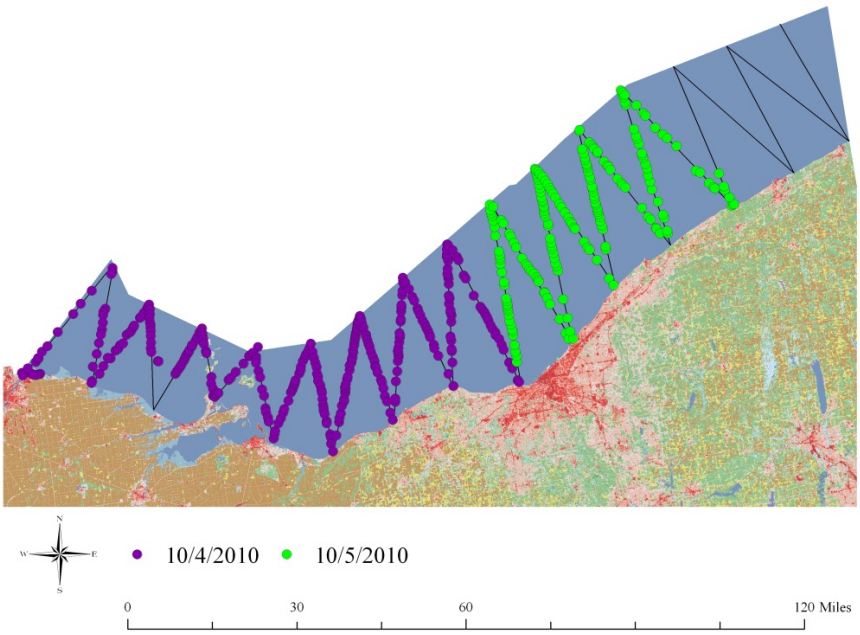
Appendix B

Year 2 (2010-2011) Survey Results

Date: 4, 5 October 2010

Total species observed: 10 Distance flown: 474

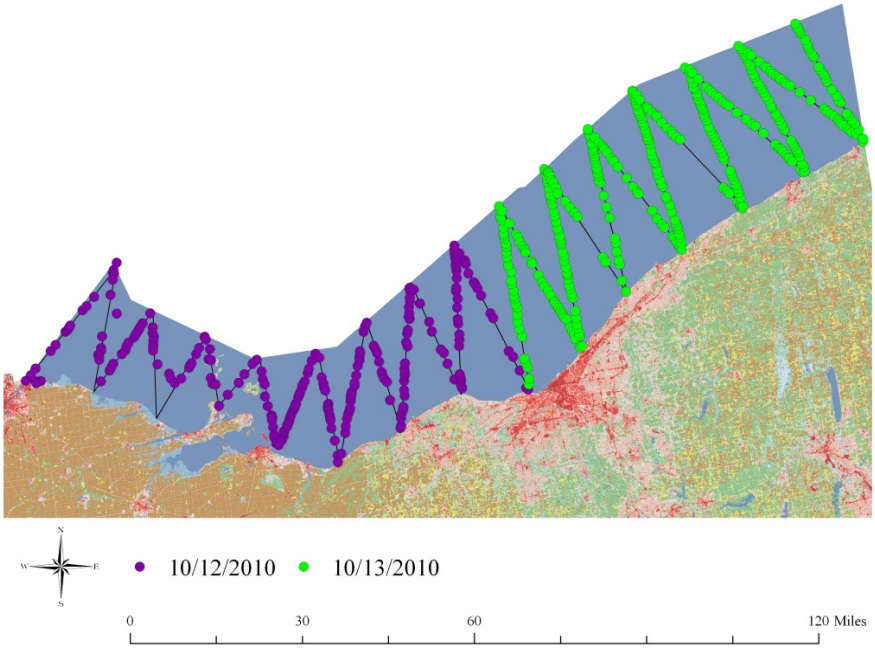
Total number of individuals observed: 6216 Birds per mile: 13.1



Date: 12, 13 October 2010

Total species observed:13 Distance flown: 654

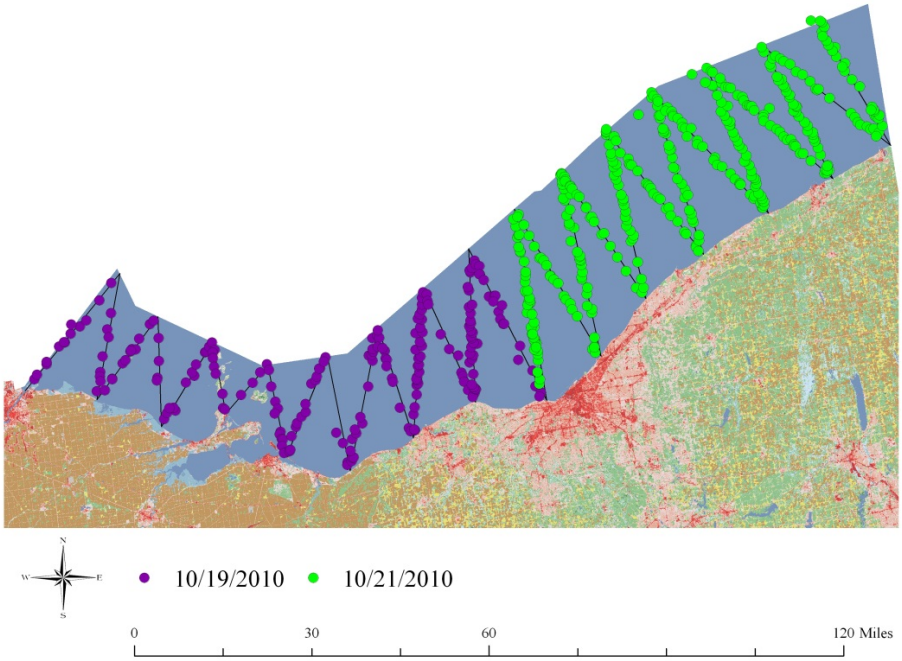
Total number of individuals observed: 8170 Birds per mile: 12.5



Date: 19, 20 October 2010

Total species observed: 11 Distance flown: 664

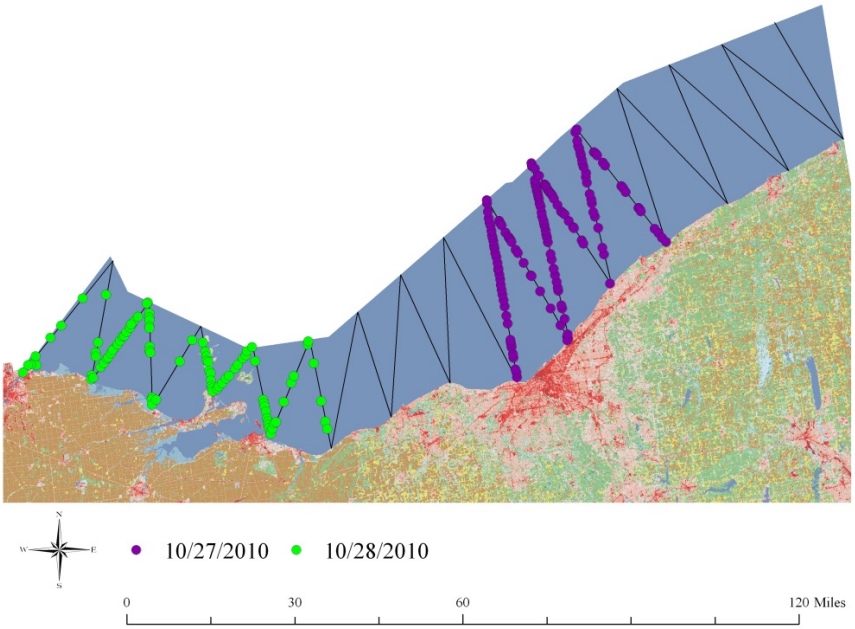
Total number of individuals observed: 17053 Birds per mile: 25.7



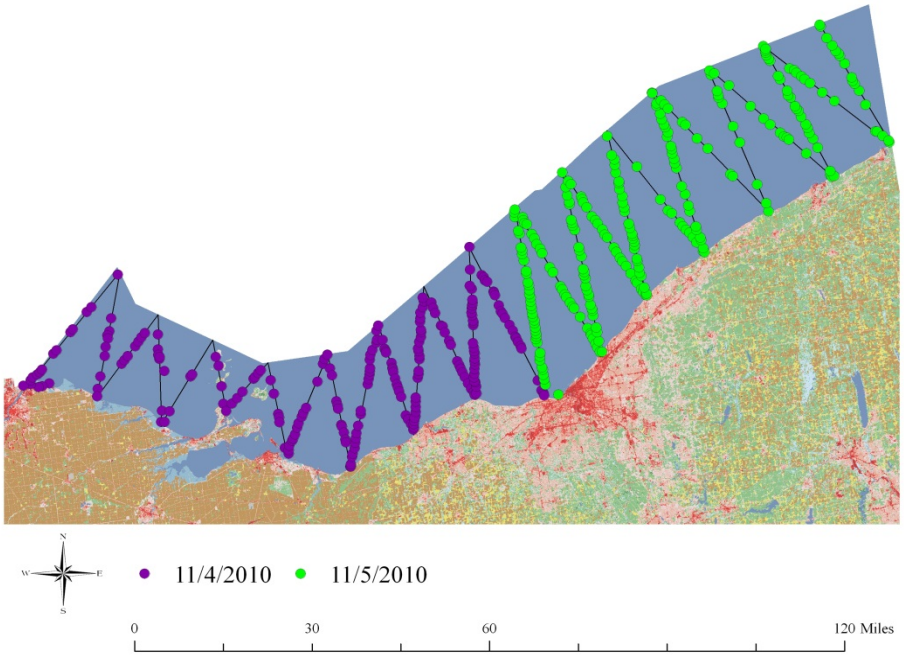
Date:27, 28 October 2010

Total species observed: 13 Distance flown: 349

Total number of individuals observed: 20861 Birds per mile: 59.8

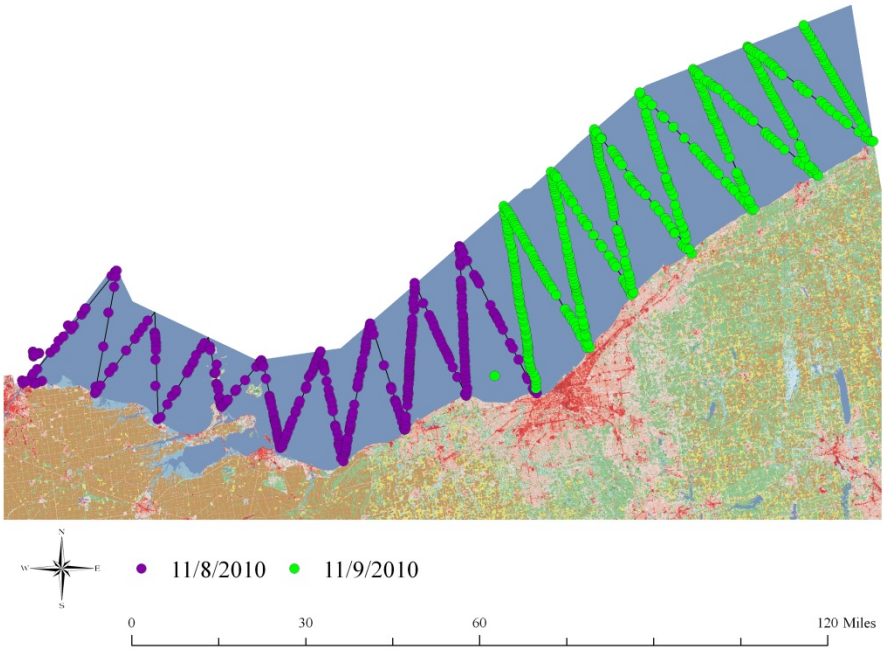


Date: 4, 5 November 2010
Total species observed:14 Distance flown: 664
Total number of individuals observed: 19927 Birds per mile: 30.0

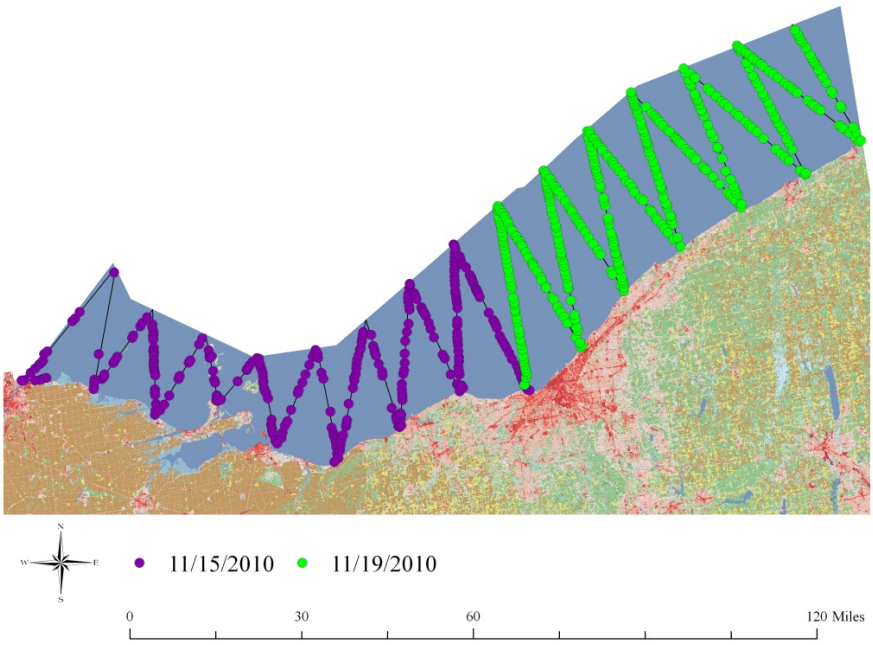


Date: 8, 9 November 2010
Total species observed: 20 Distance flown: 664

Total number of individuals observed: 39946 Birds per mile: 60.2

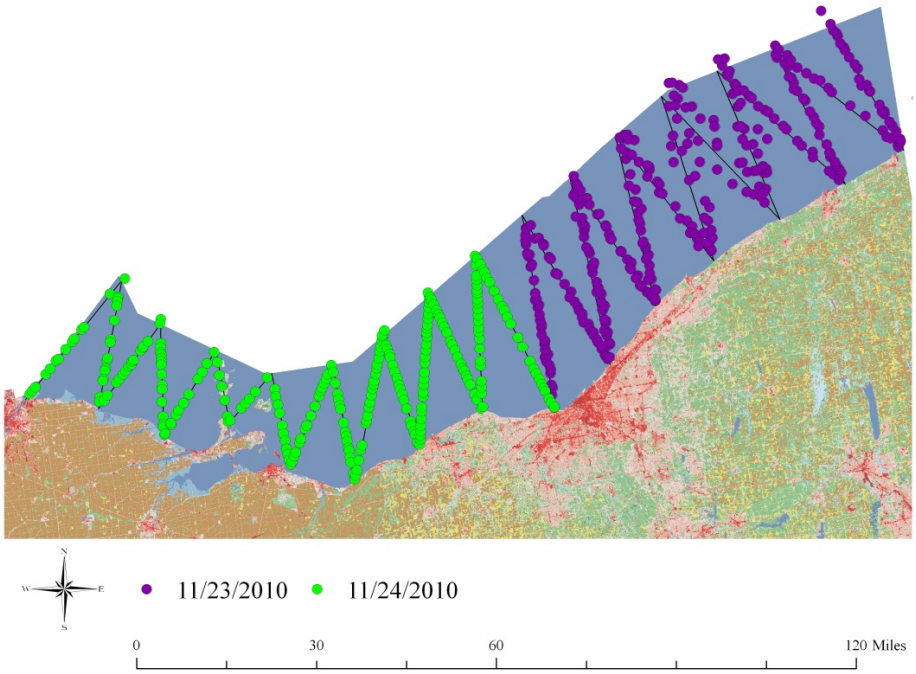


Date: 15, 19 November 2010
Total species observed: 19 Distance flown: 664
Total number of individuals observed: 12845 Birds per mile: 19.3



Date: 23, 24 November 2010
Total species observed: 19 Distance flown: 664

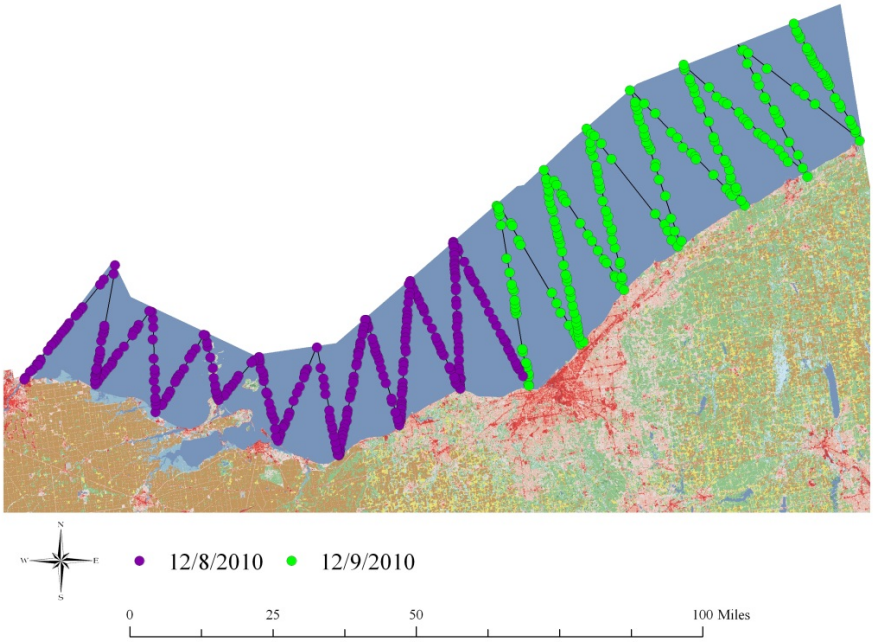
Total number of individuals observed: 41675 Birds per mile: 62.8



Date: 8, 9 December 2010

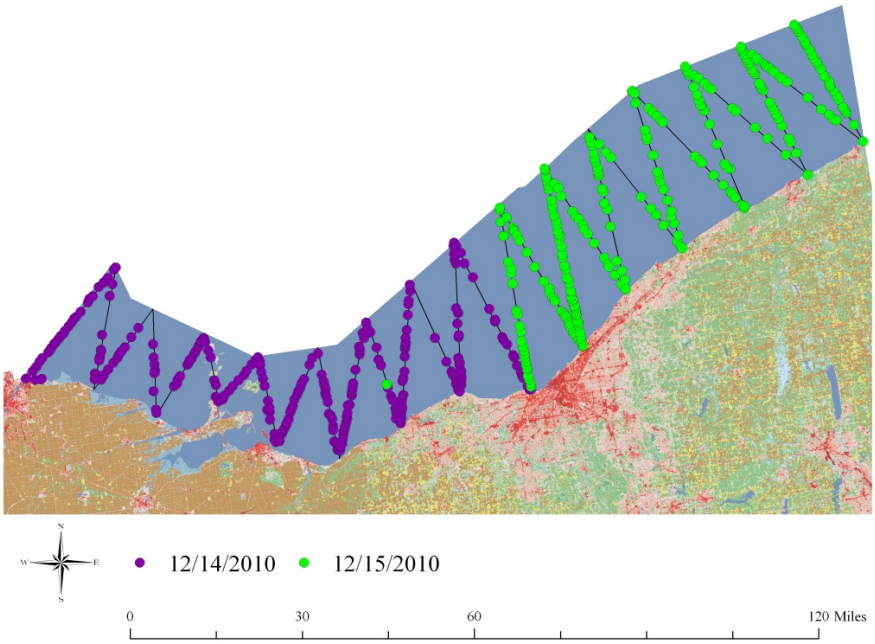
Total species observed: 16 Distance flown: 664

Total number of individuals observed: 23446 Birds per mile: 35.3

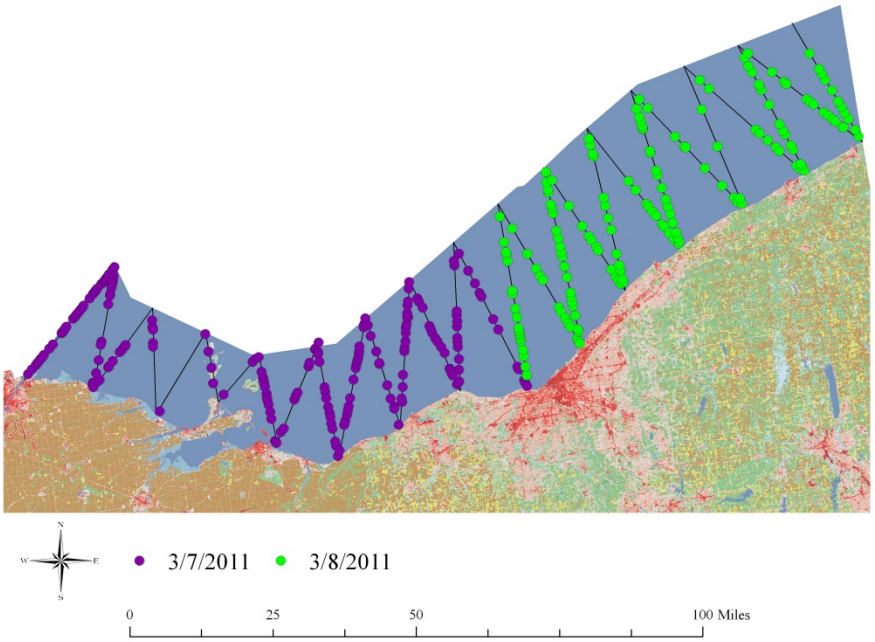


Date: 14, 15 December 2010

Total species observed: 17 Distance flown: 664
Total number of individuals observed: 10744 Birds per mile: 16.2

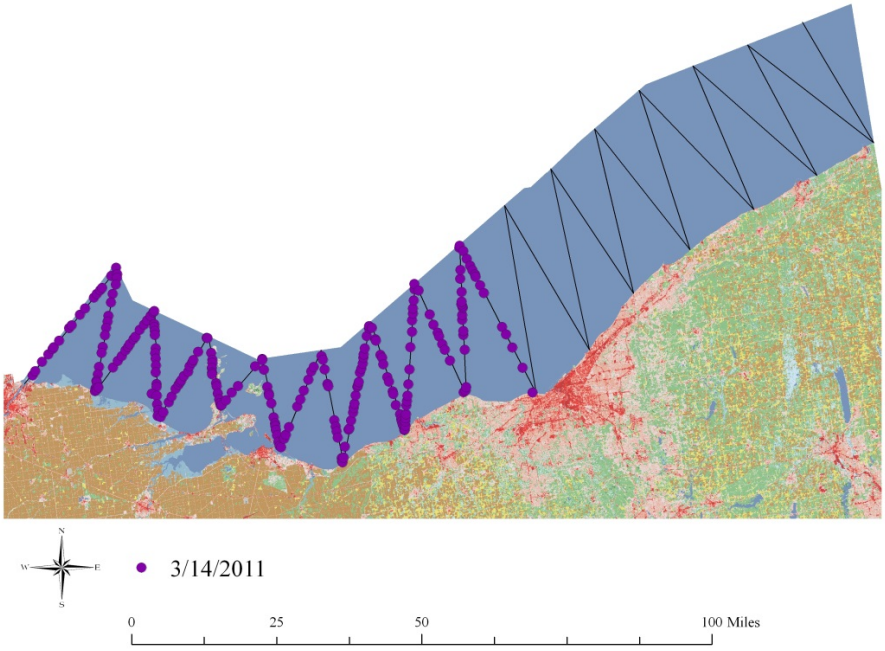


Date: 7, 8 March 2011
Total species observed: 9 Distance flown: 664
Total number of individuals observed: 10423 Birds per mile: 15.7

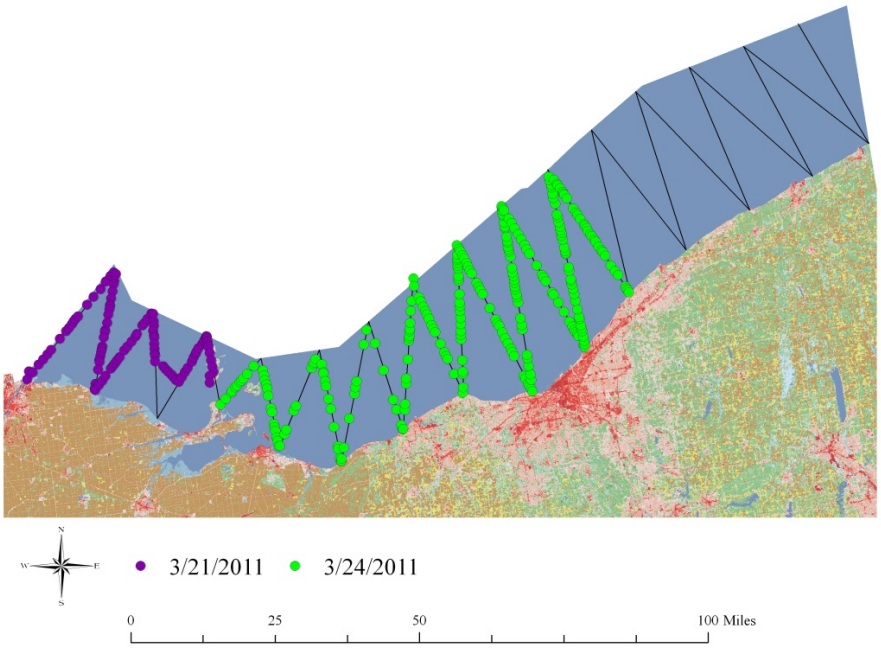


Date: 14 March 2011

Total species observed: 16 Distance flown: 300
Total number of individuals observed: 6968 Birds per mile: 23.2

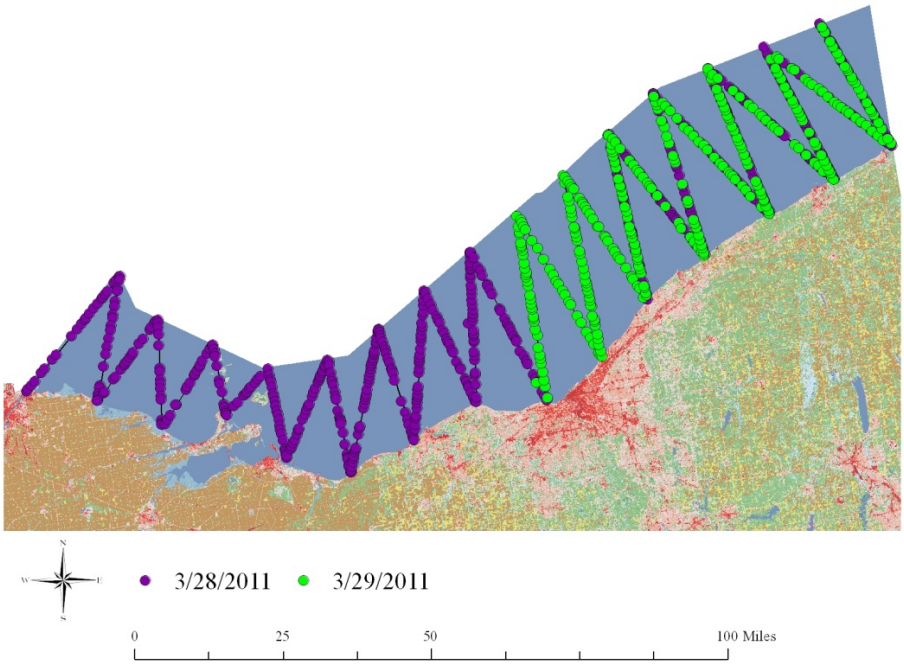


Date: 21, 24 March 2011
Total species observed: 14 Distance flown: 409
Total number of individuals observed: 3991 Birds per mile: 9.8

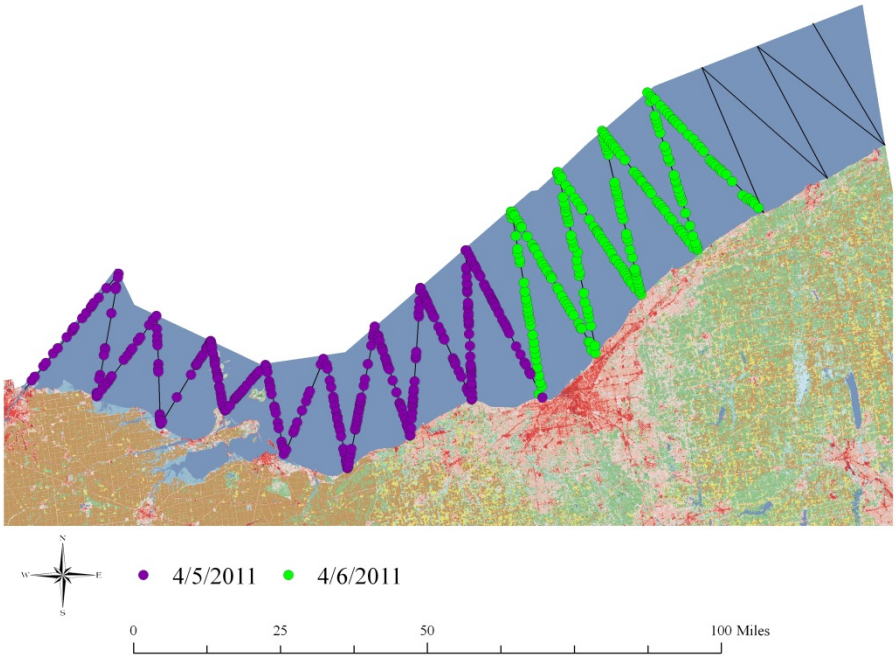


Date: 28, 29 March 2011

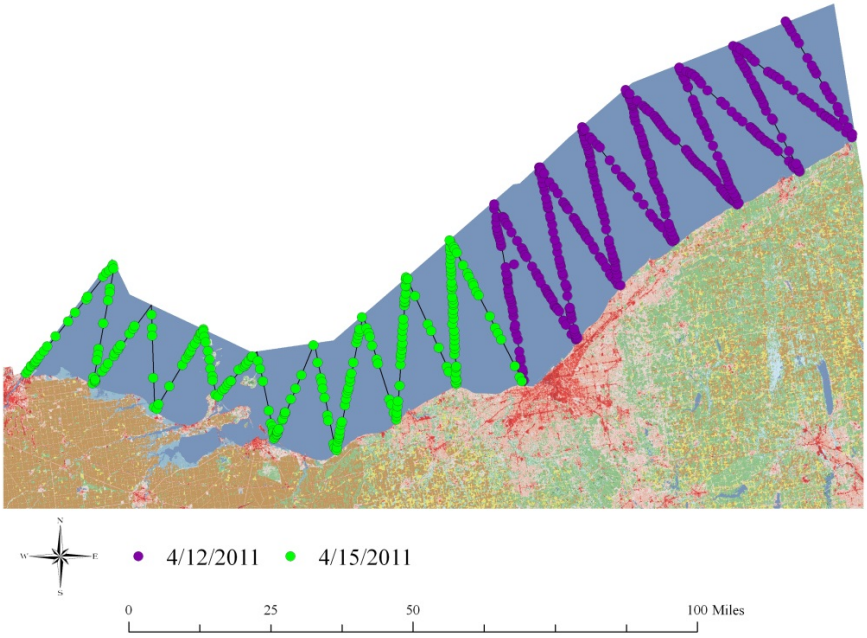
Total species observed: 21 Distance flown: 664
Total number of individuals observed: 24084 Birds per mile: 36.3



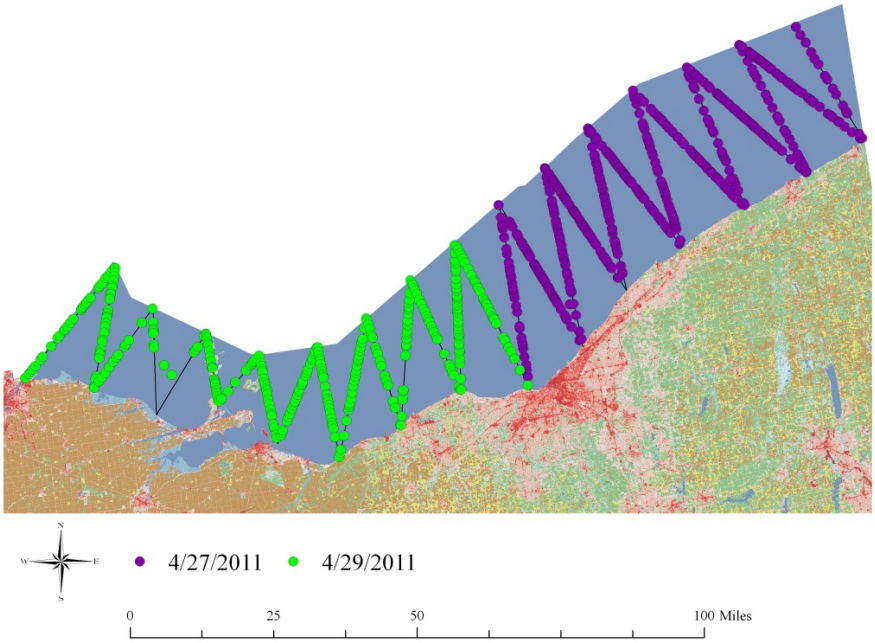
Date: 5, 6 April 2011
Total species observed: 19 Distance flown: 532
Total number of individuals observed: 7402 Birds per mile: 13.9



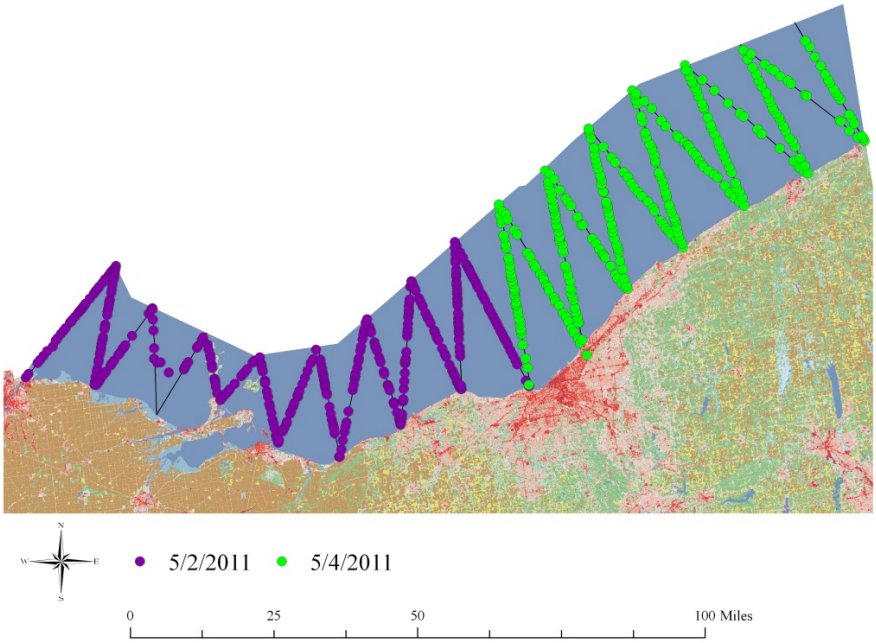
Date: 12, 15 April 2011
Total species observed: 16 Distance flown: 664
Total number of individuals observed: 4921 Birds per mile: 7.4



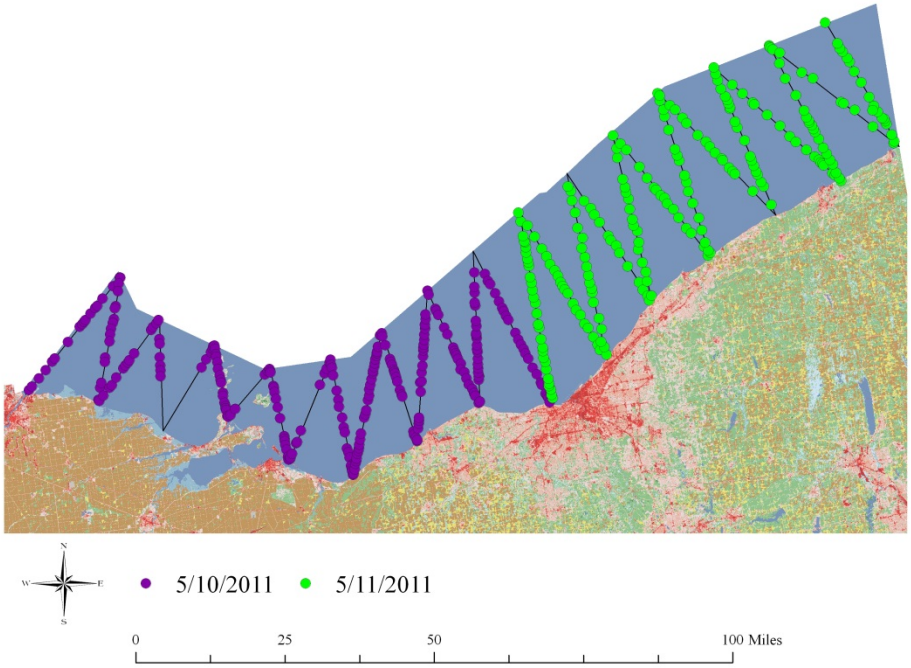
Date: 27, 29 April 2011
Total species observed: 14 Distance flown: 654
Total number of individuals observed: 3223 Birds per mile: 4.9



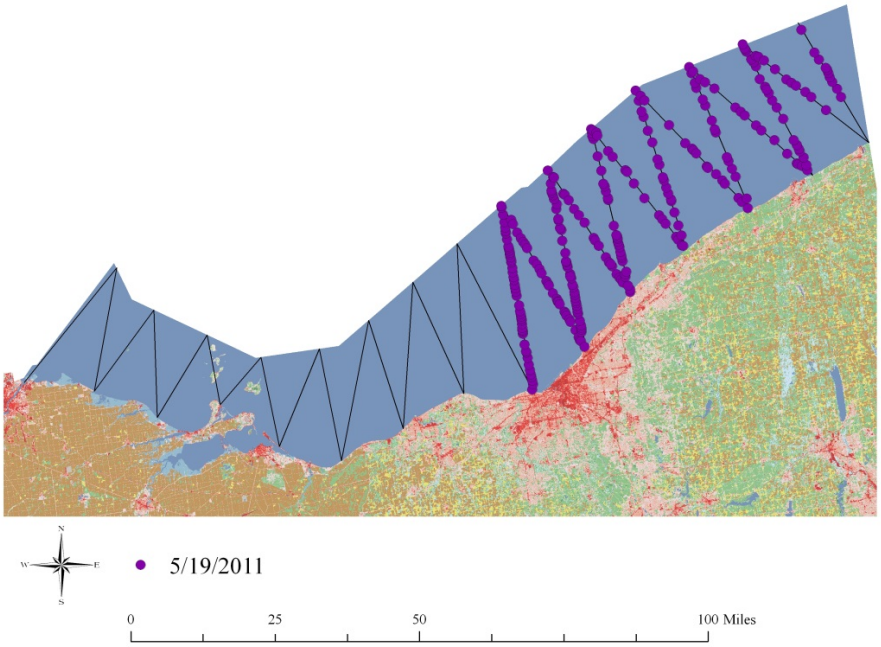
Date: 2, 4 May 2011
Total species observed: 12 Distance flown: 654
Total number of individuals observed: 3987 Birds per mile: 6.1



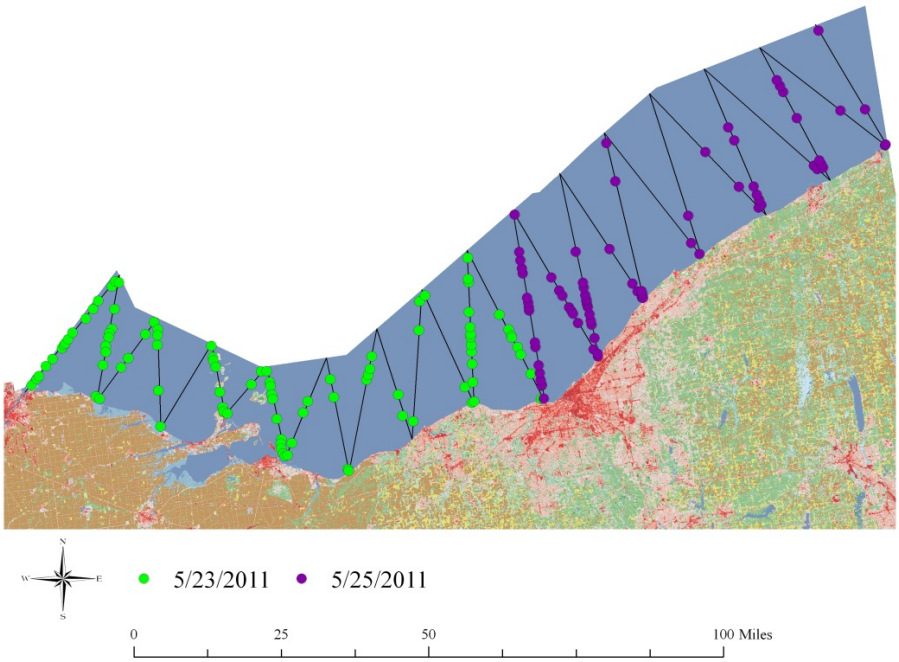
Date: 10, 11 May 2011
Total species observed: 13 Distance flown: 654
Total number of individuals observed: 3675 Birds per mile: 5.6



Date: 19 May 2011
Total species observed: 9 Distance flown: 364
Total number of individuals observed: 1116 Birds per mile: 3.1



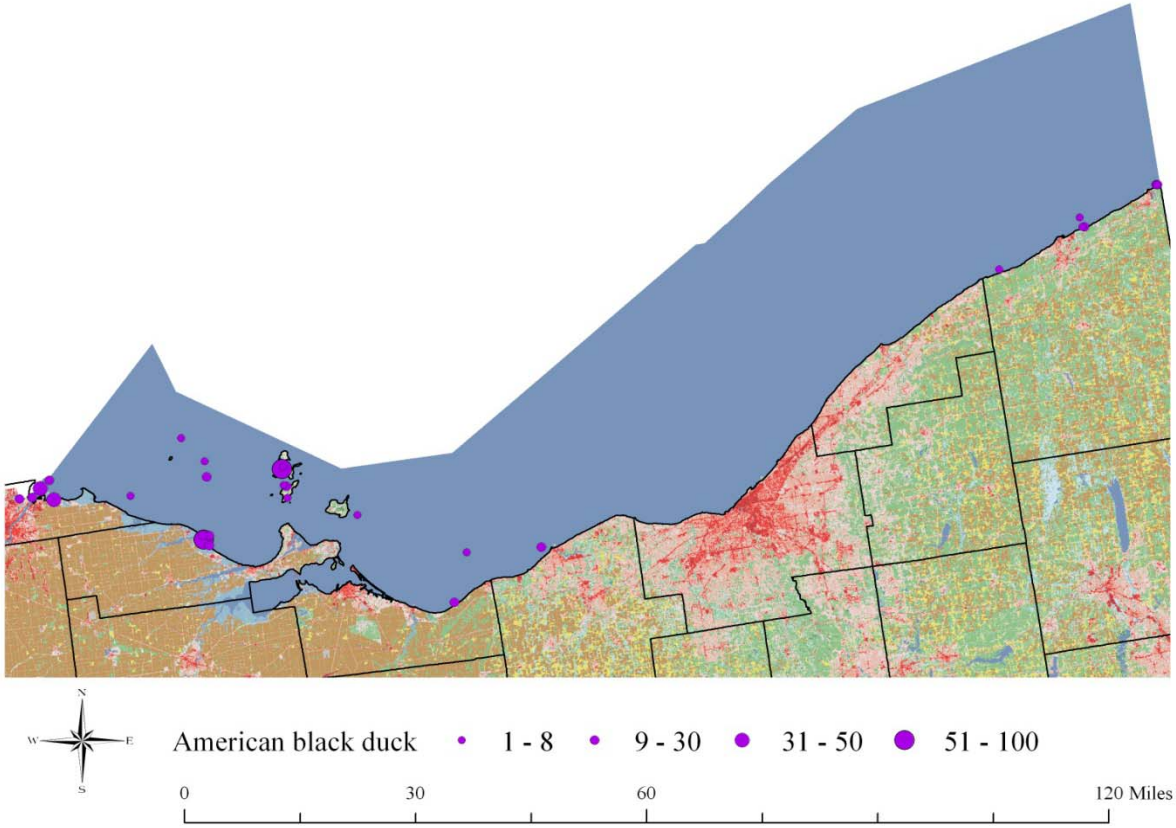
Date: 23, 25 May 2011
Total species observed: 8 Distance flown: 364
Total number of individuals observed: 1116 Birds per mile: 3.1



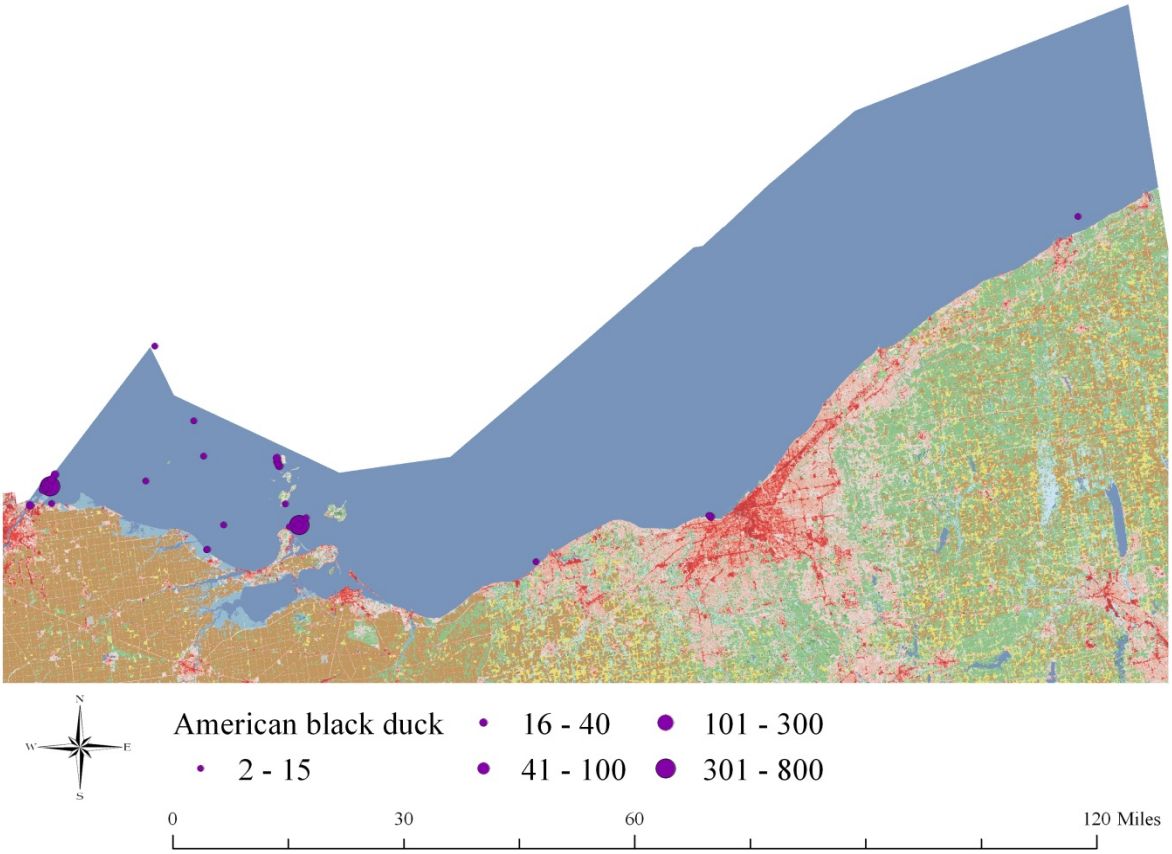
Appendix C

Species-specific Results

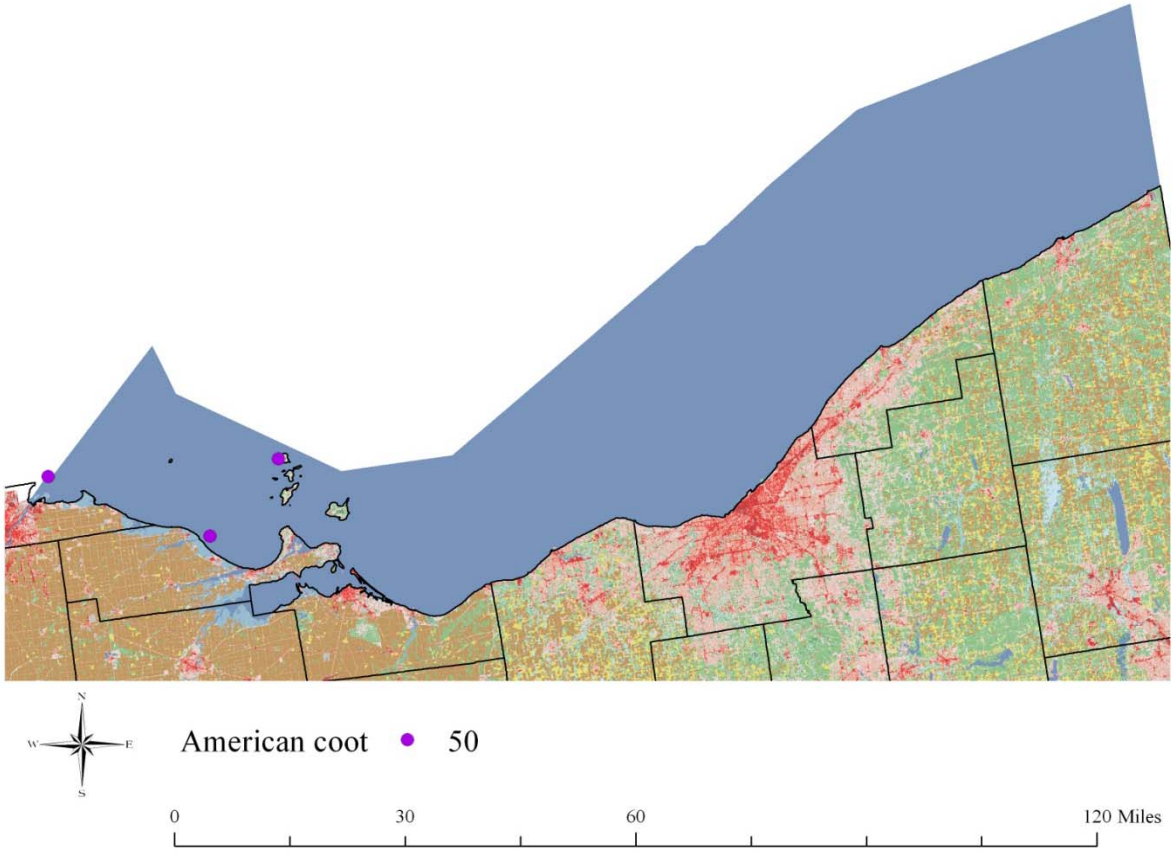
Year 1



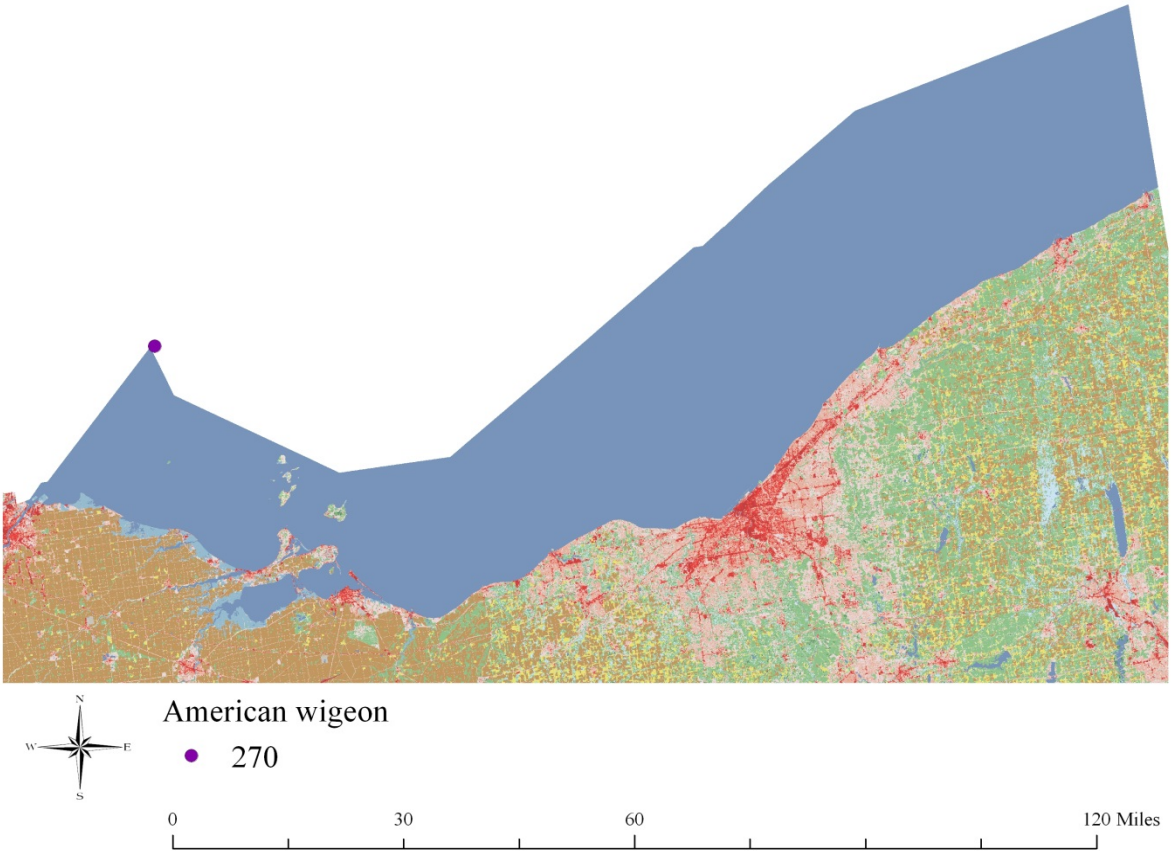
Year 2


N
W
E
S
American black duck
2 - 15
16 - 40
41 - 100
101 - 300
301 - 800
0
30
60
120 Miles

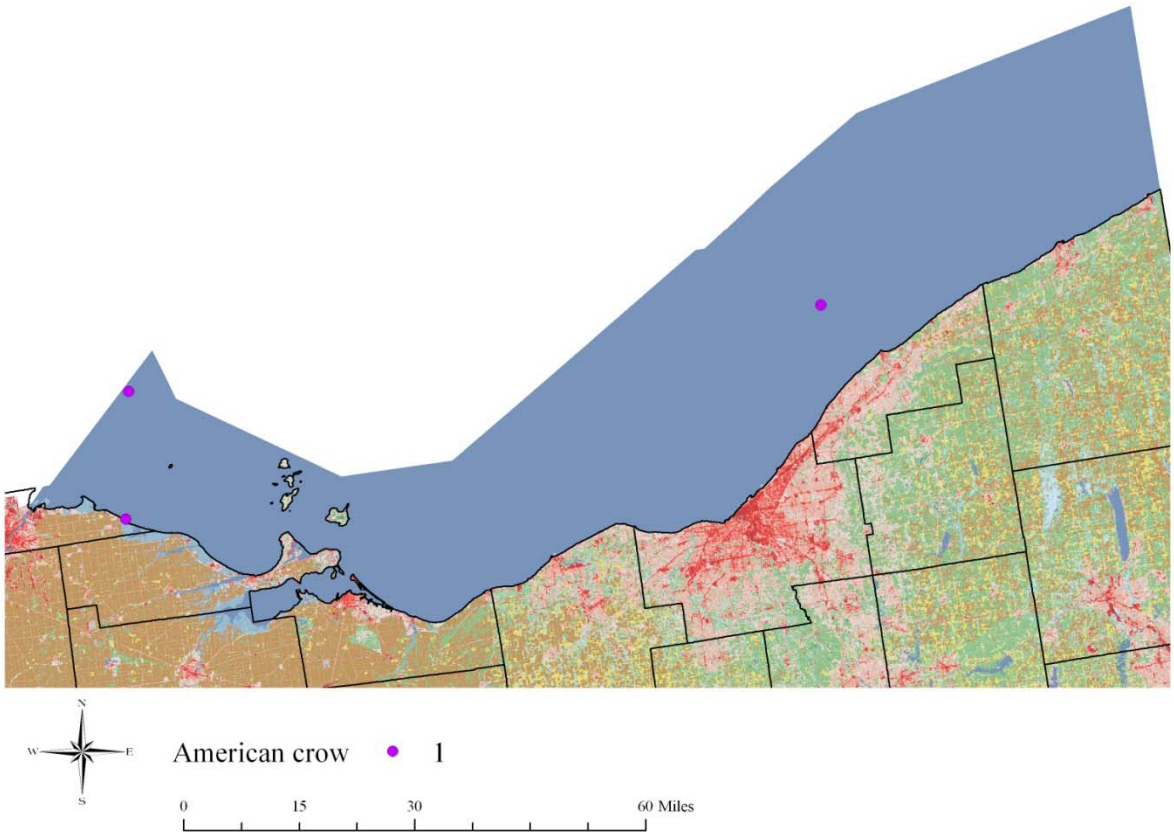
Year 1



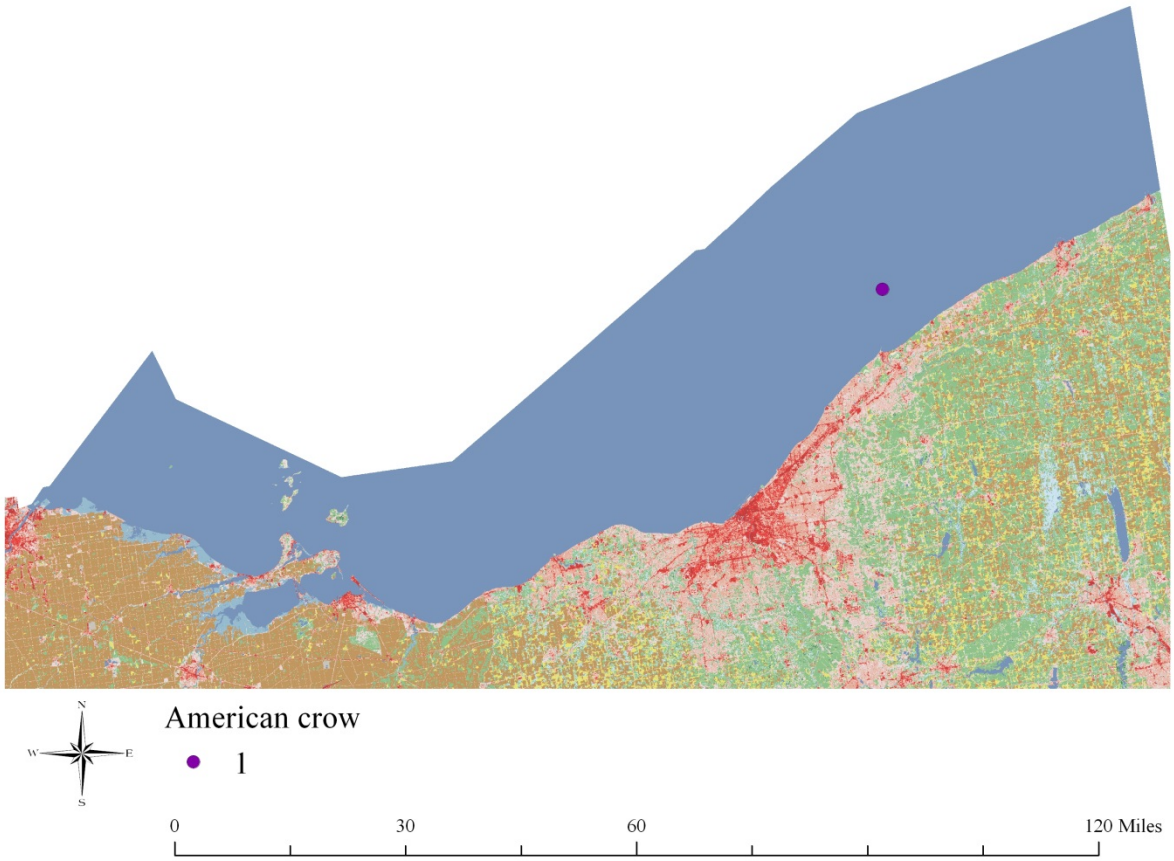
Year 2



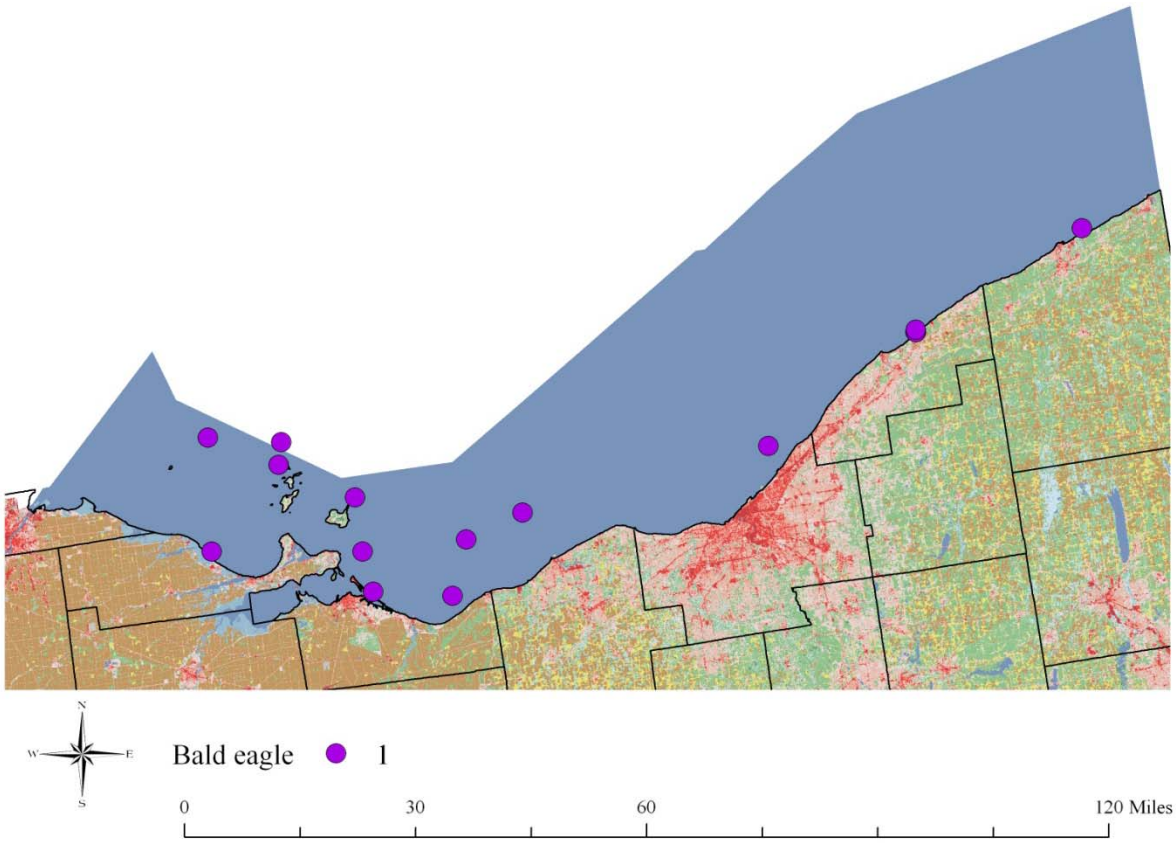
Year 1



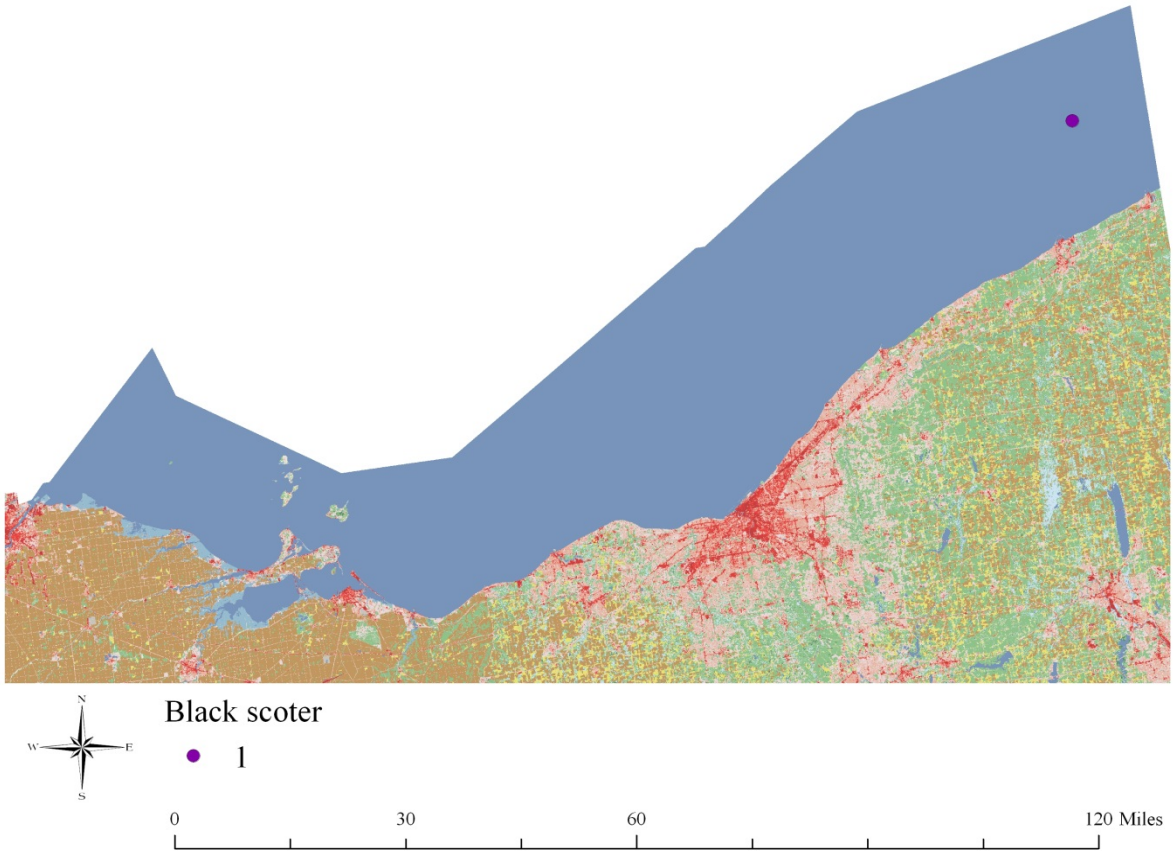
Year 2



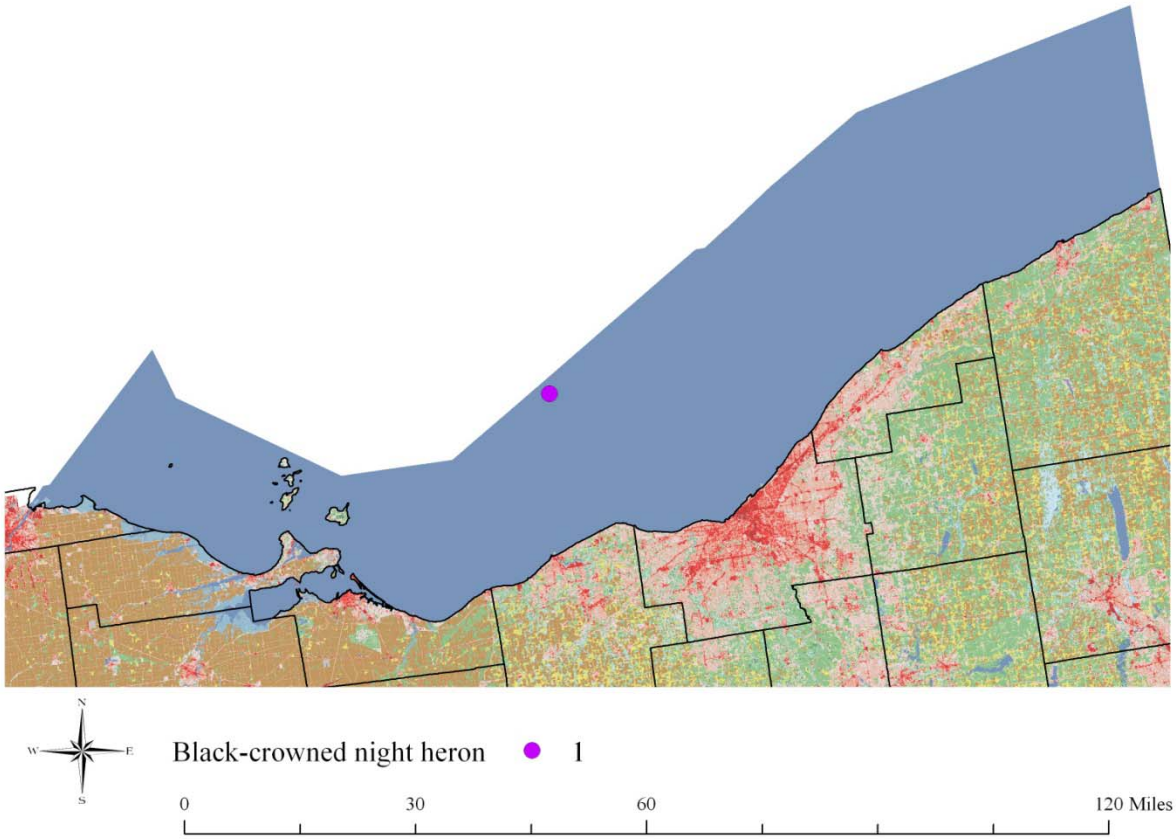
Year 1



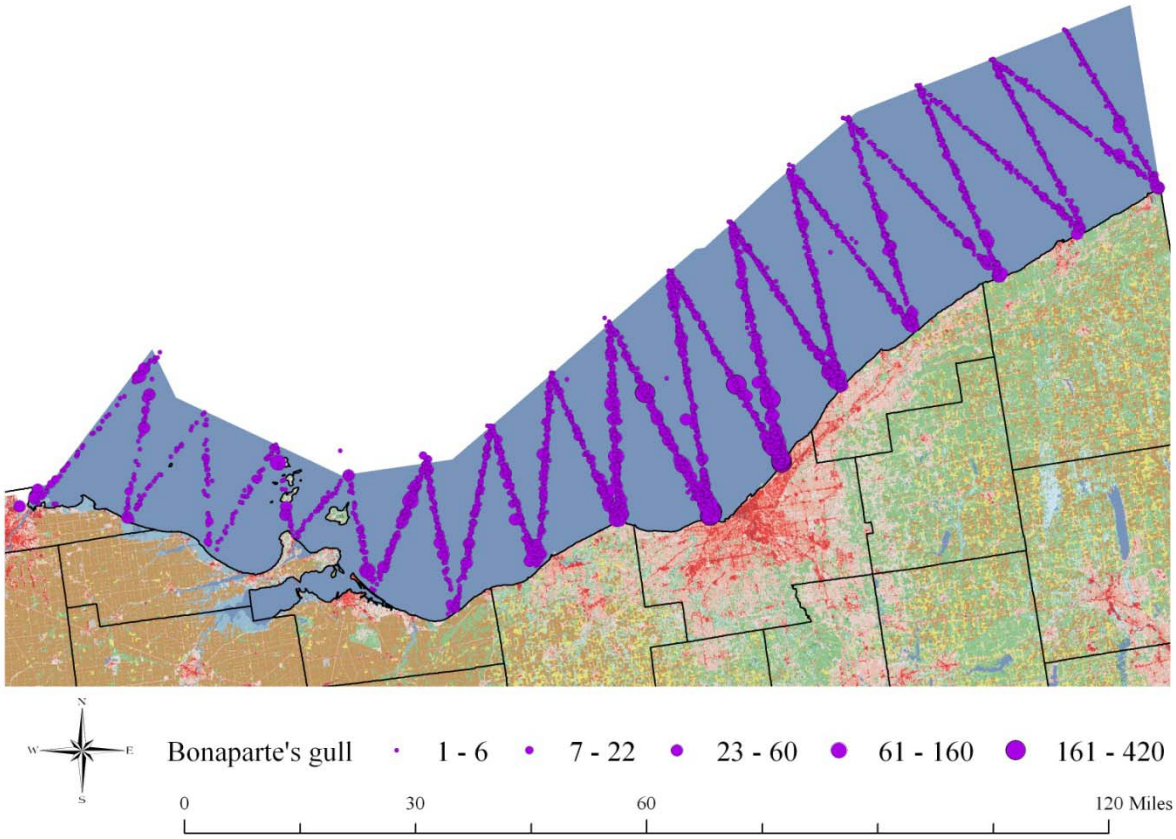
Year 2



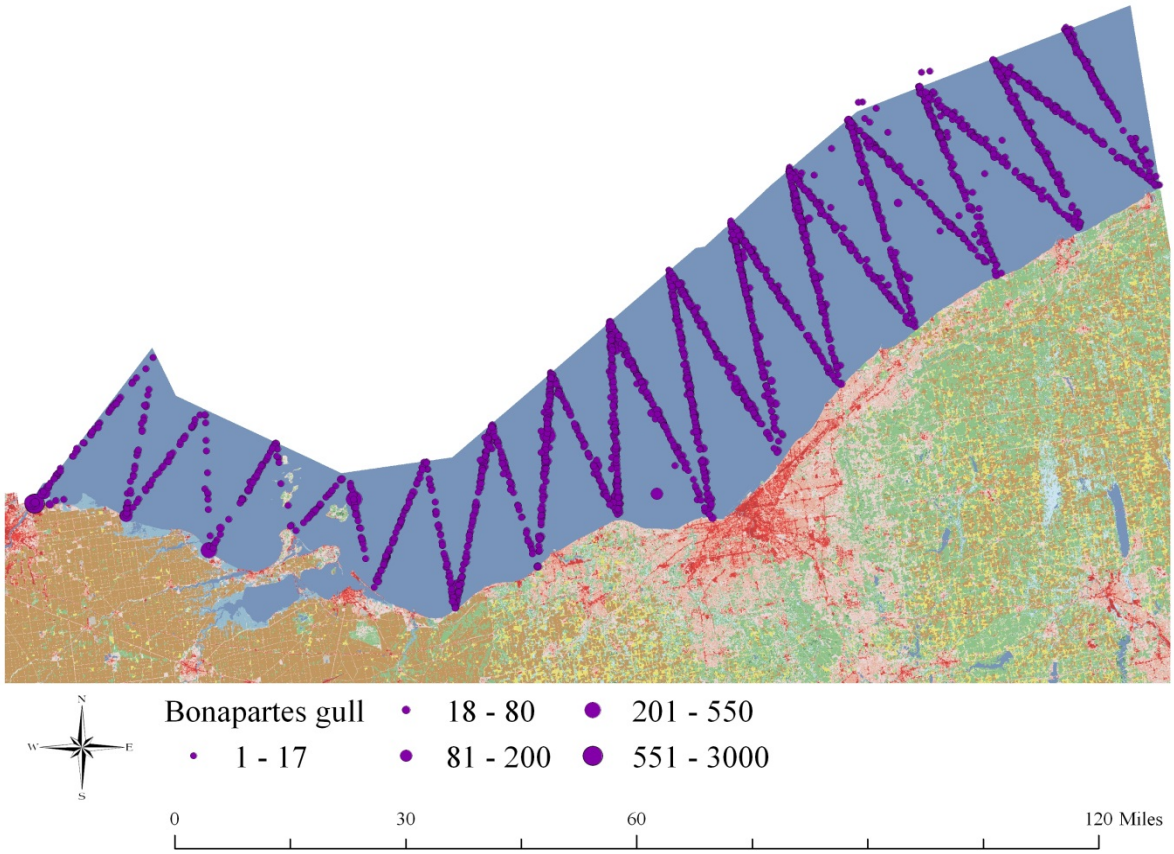
Year 1



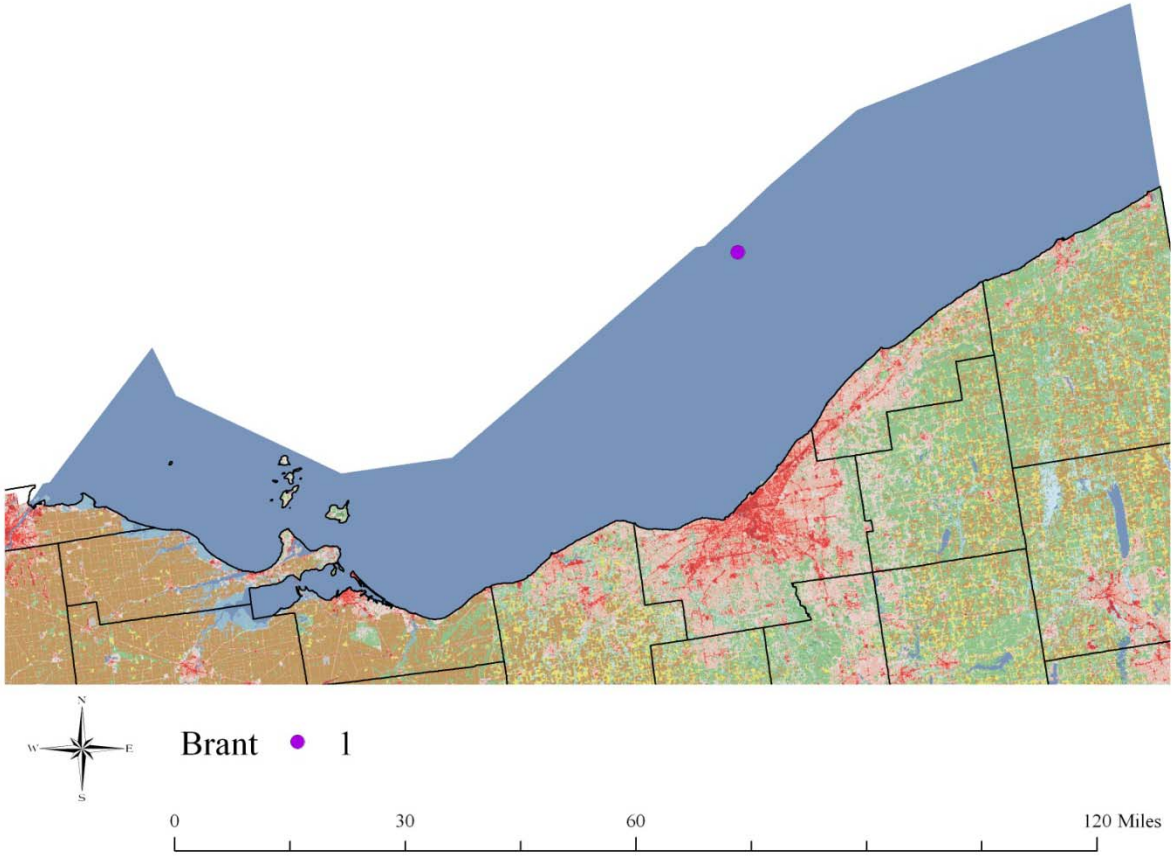
Year 1


N
W
E
S
Bonaparte's gull
1 - 6
7 - 22
23 - 60
61 - 160
161 - 420
0
30
60
120 Miles

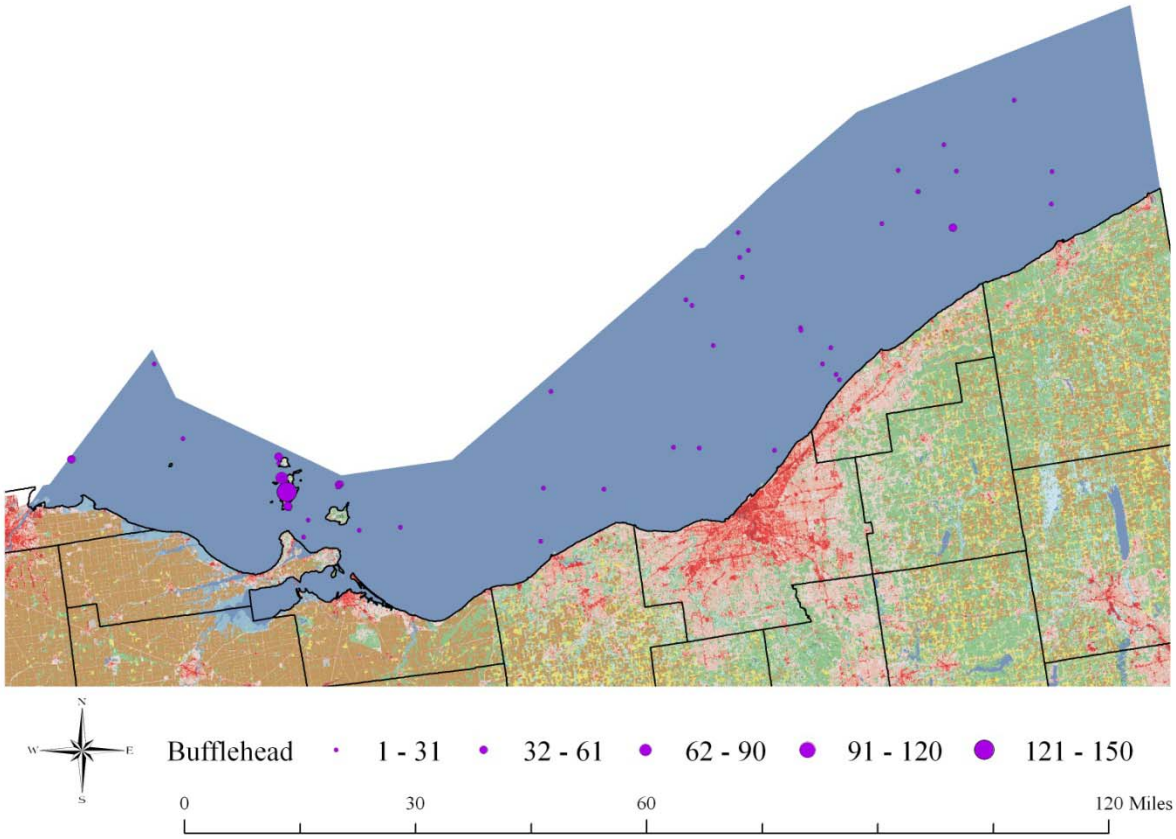
Year 2


Bonapartes gull
1 - 17
18 - 80
81 - 200
201 - 550
551 - 3000
N
W
E
S
0
30
60
120 Miles

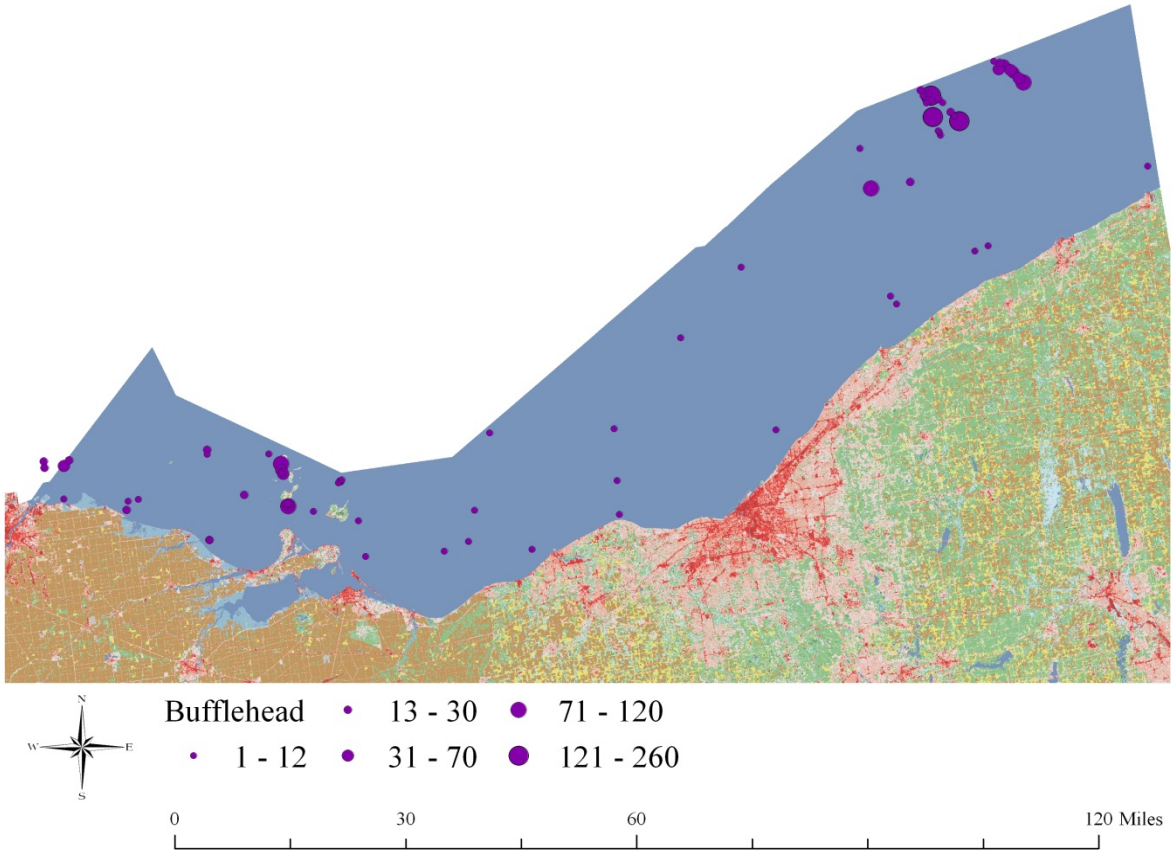
Year 1



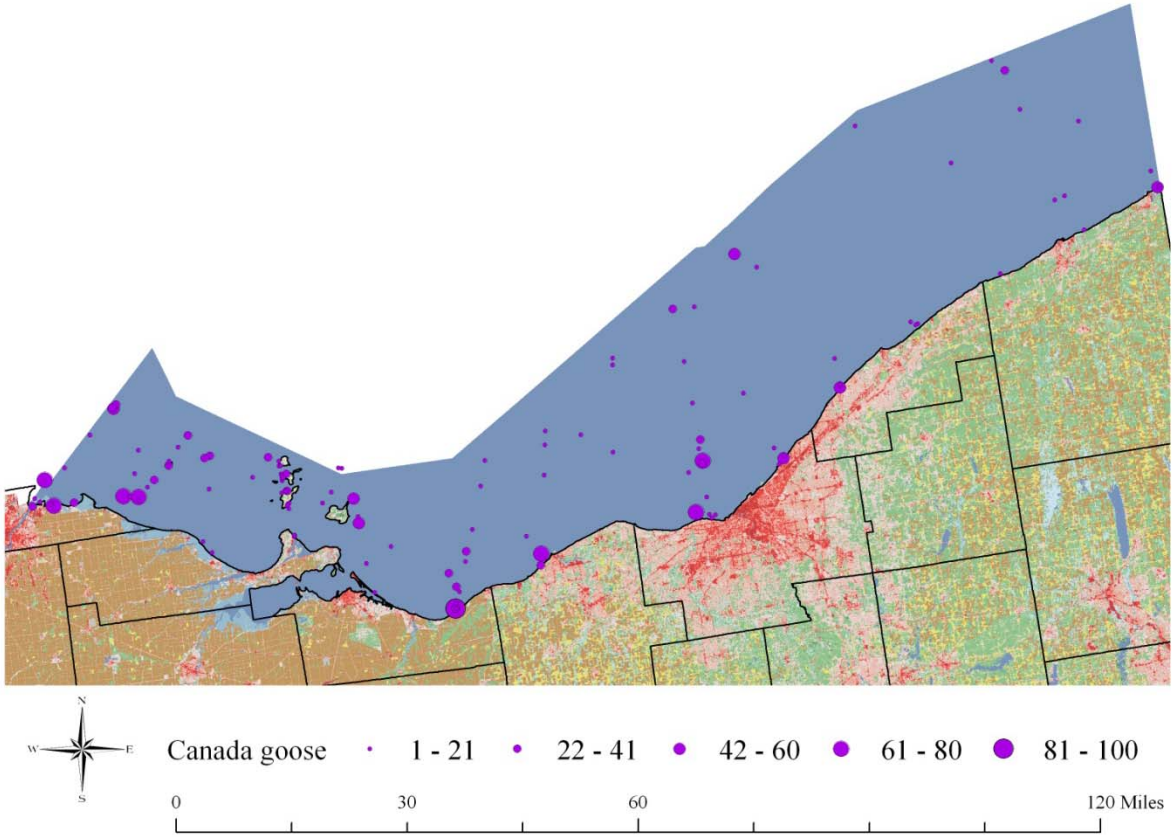
Year 1



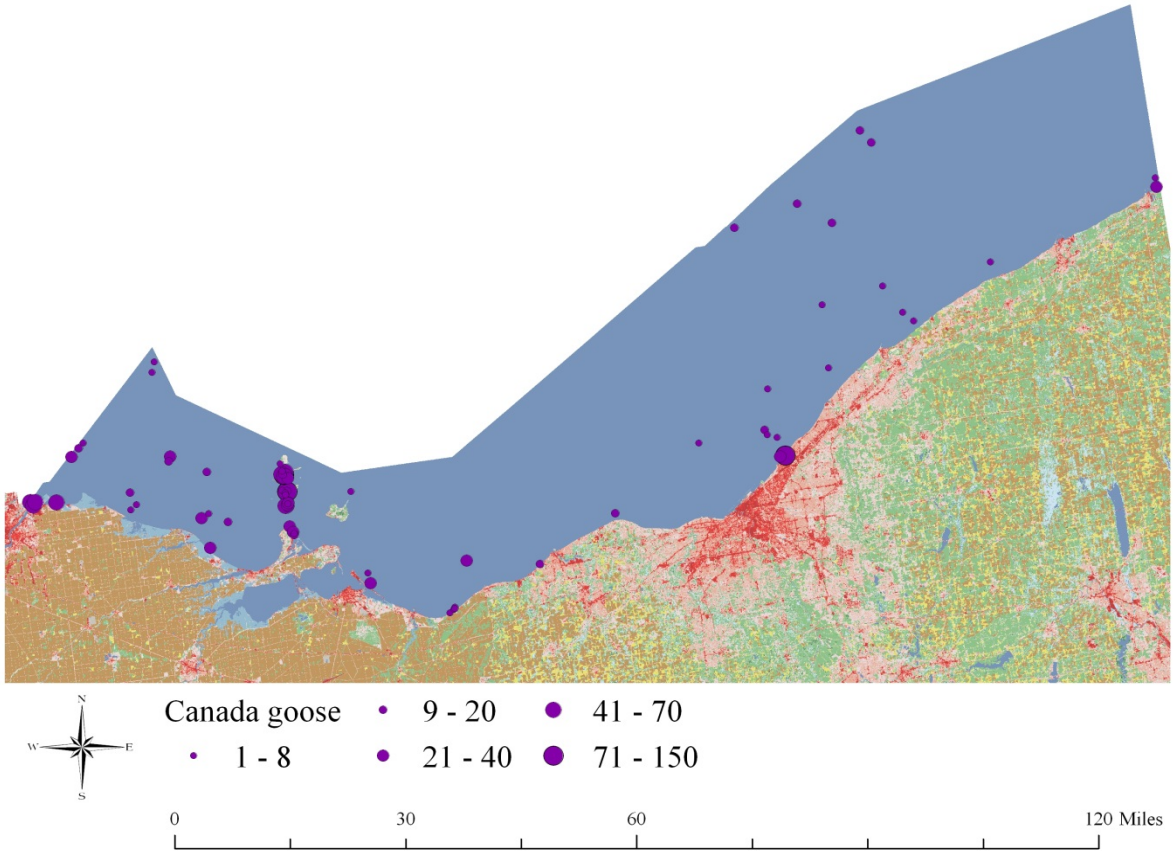
Year 2



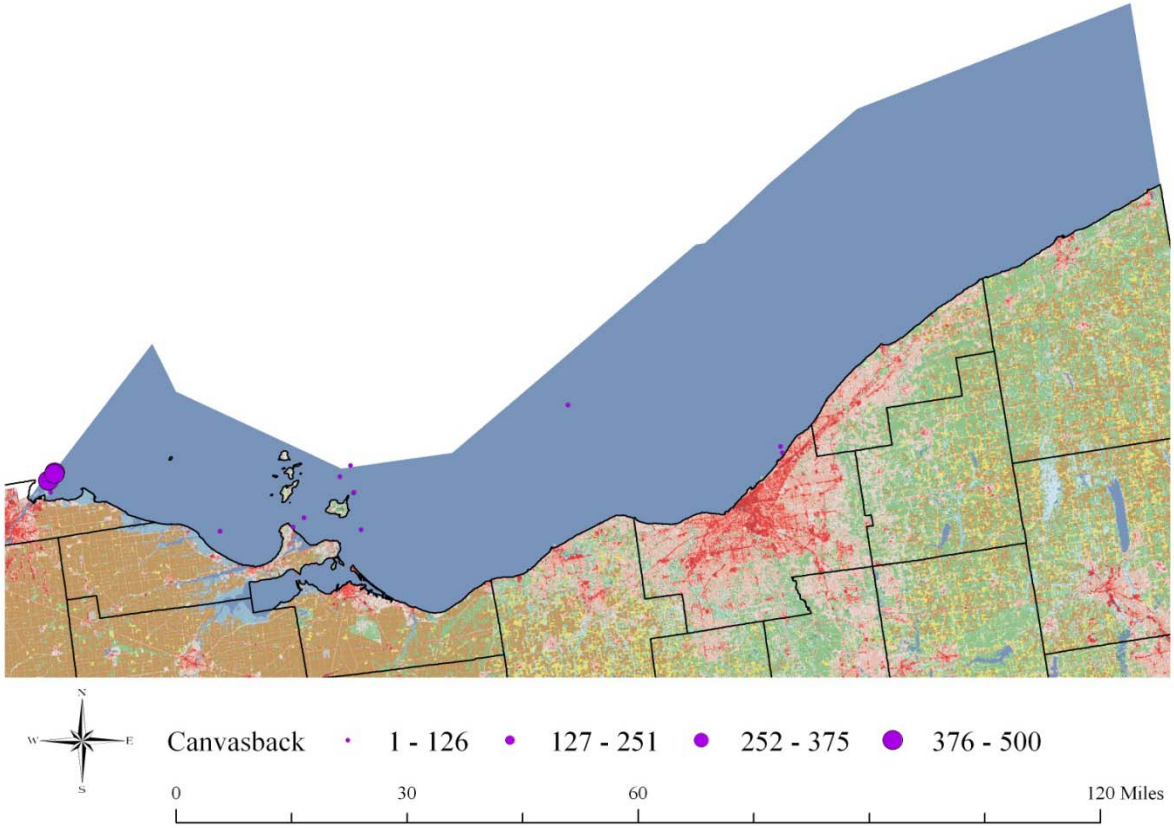
Year 1



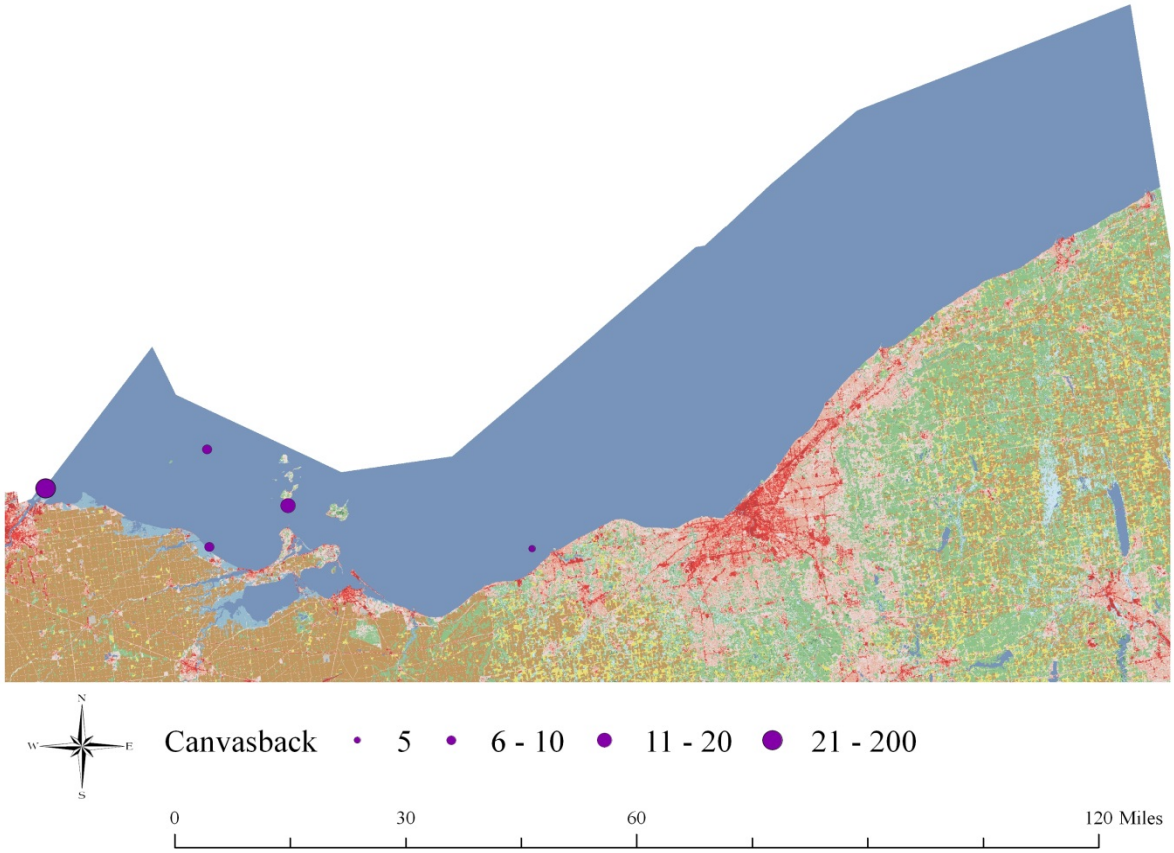
Year 2



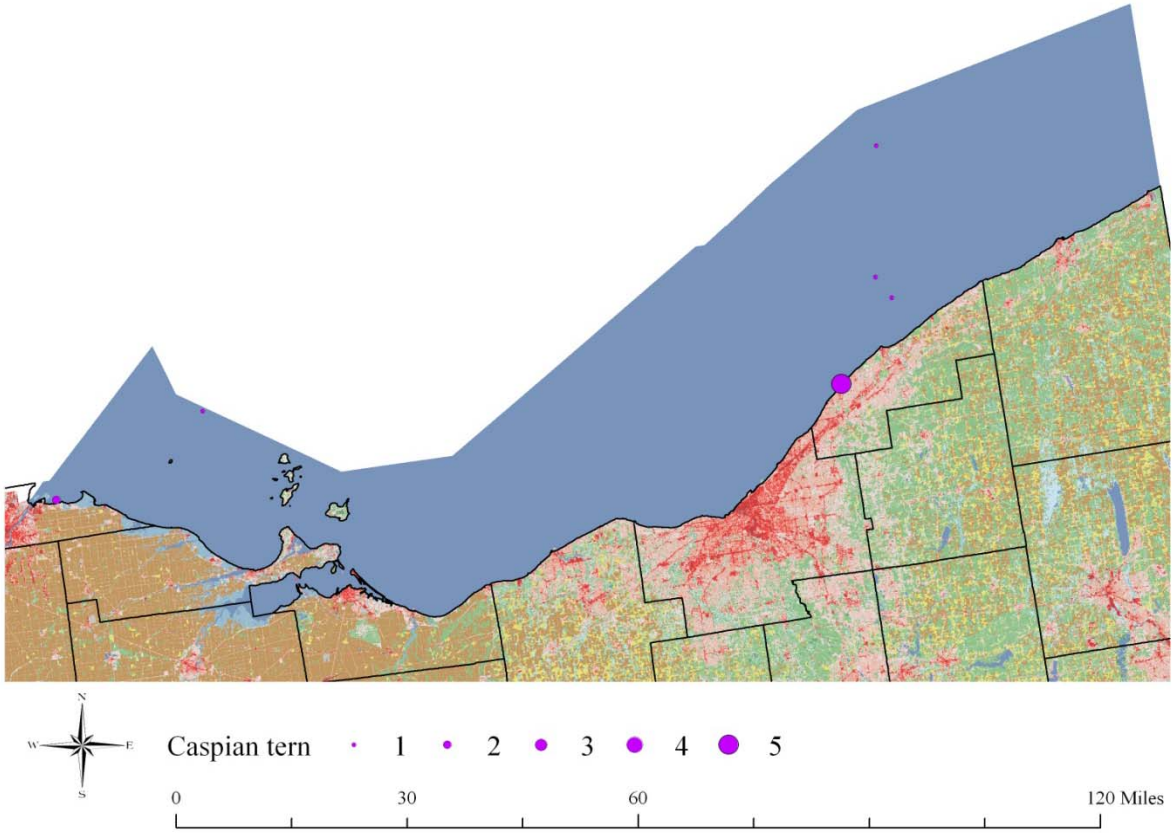
Year 1



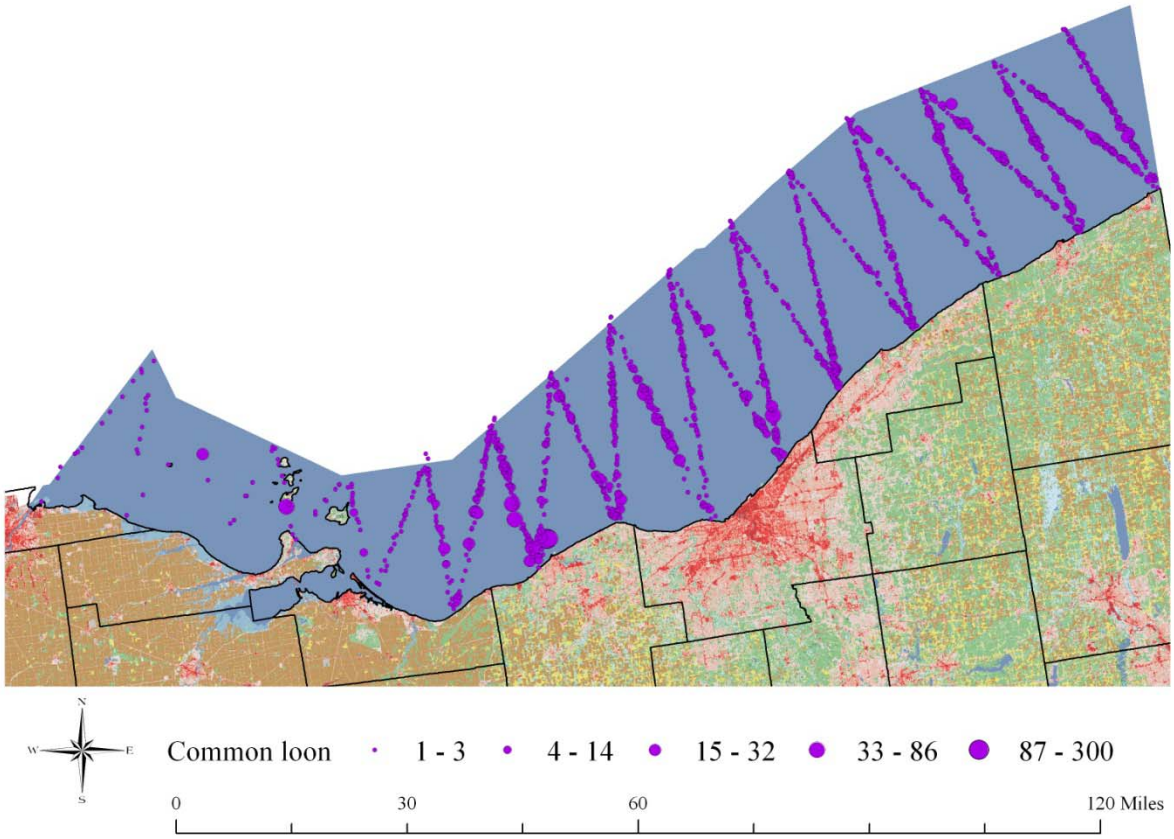
Year 2



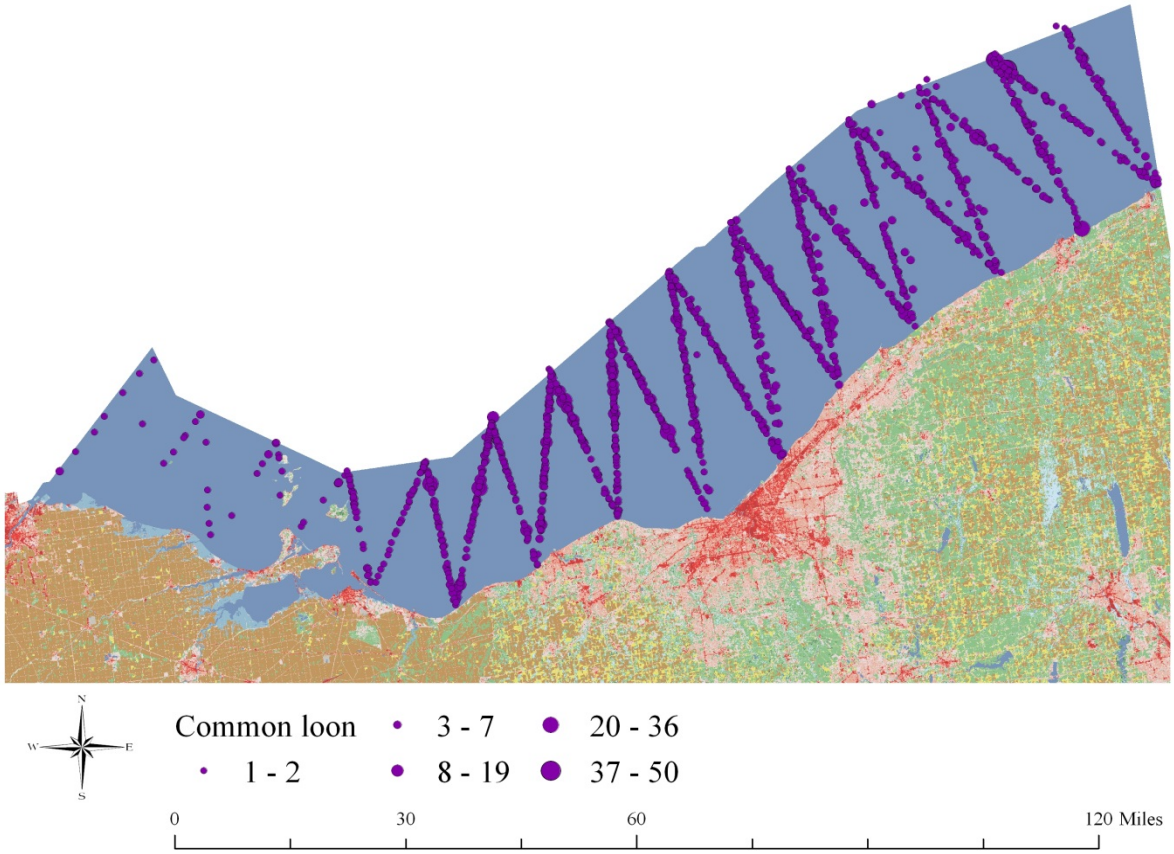
Year 1



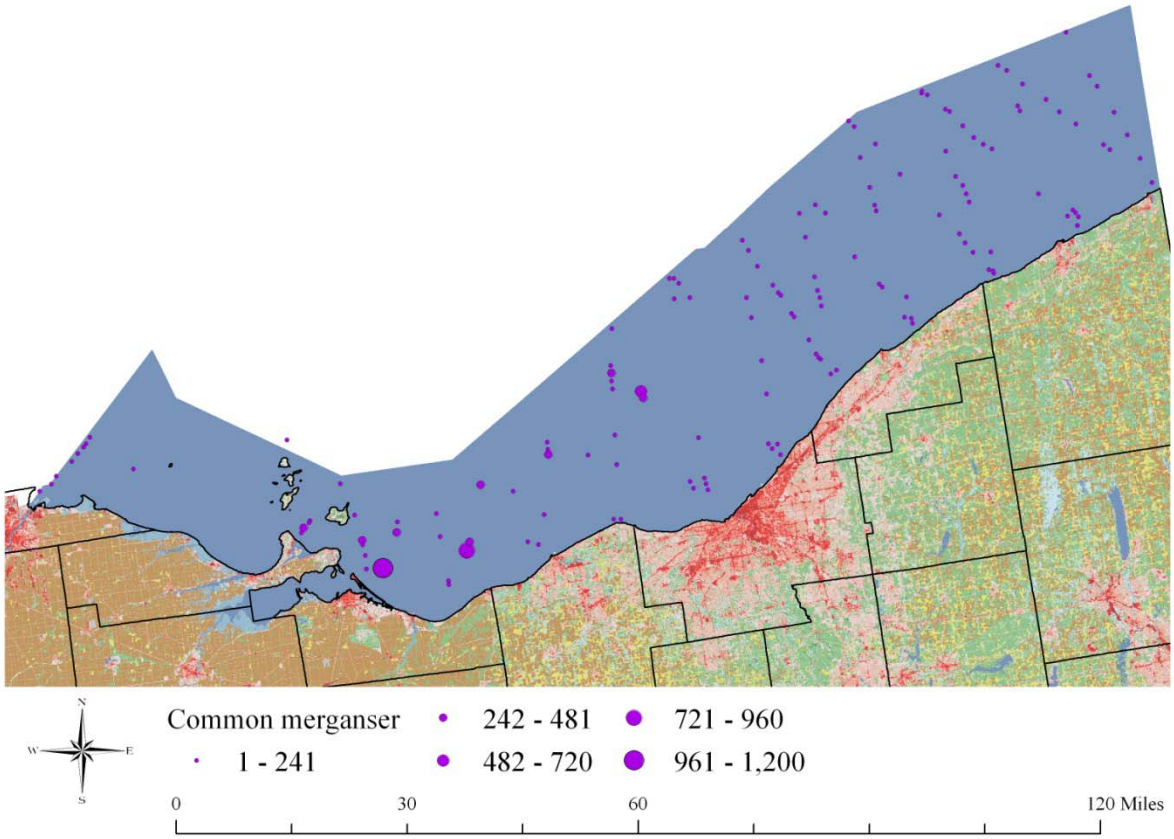
Year 1



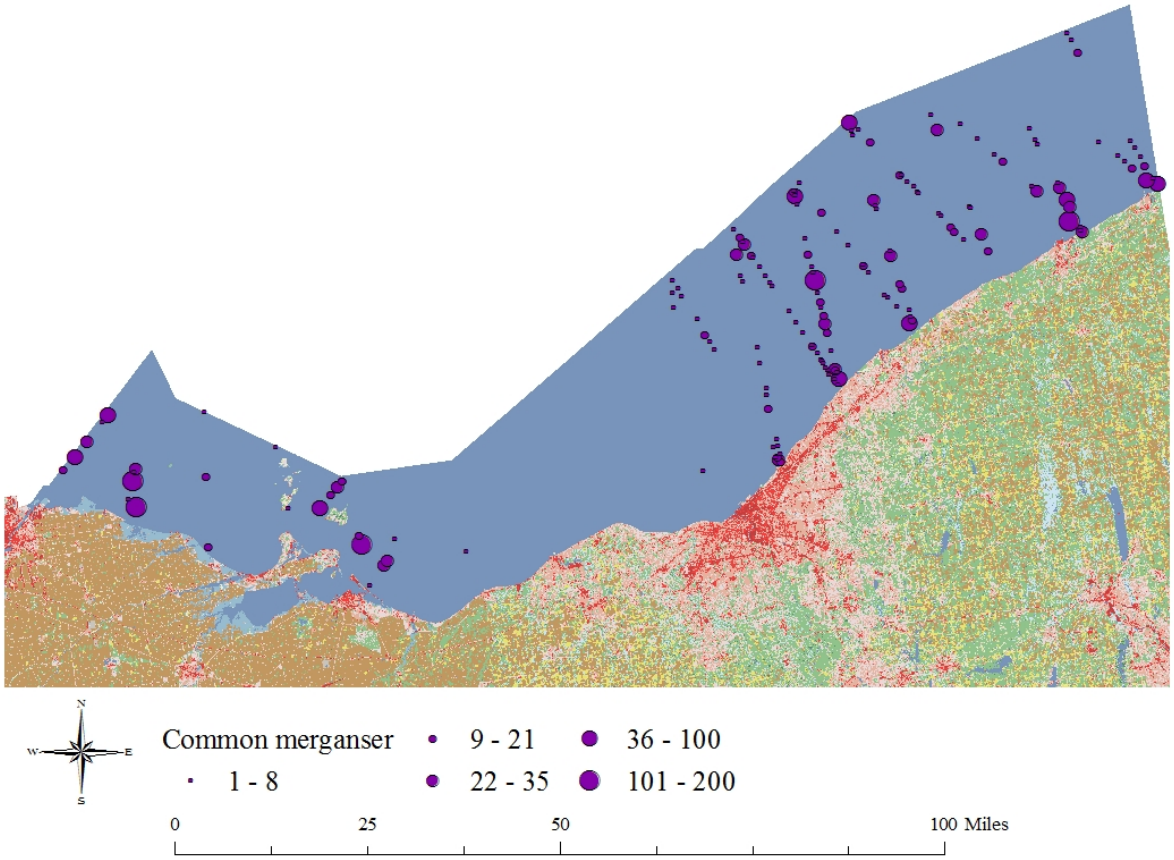
Year 2



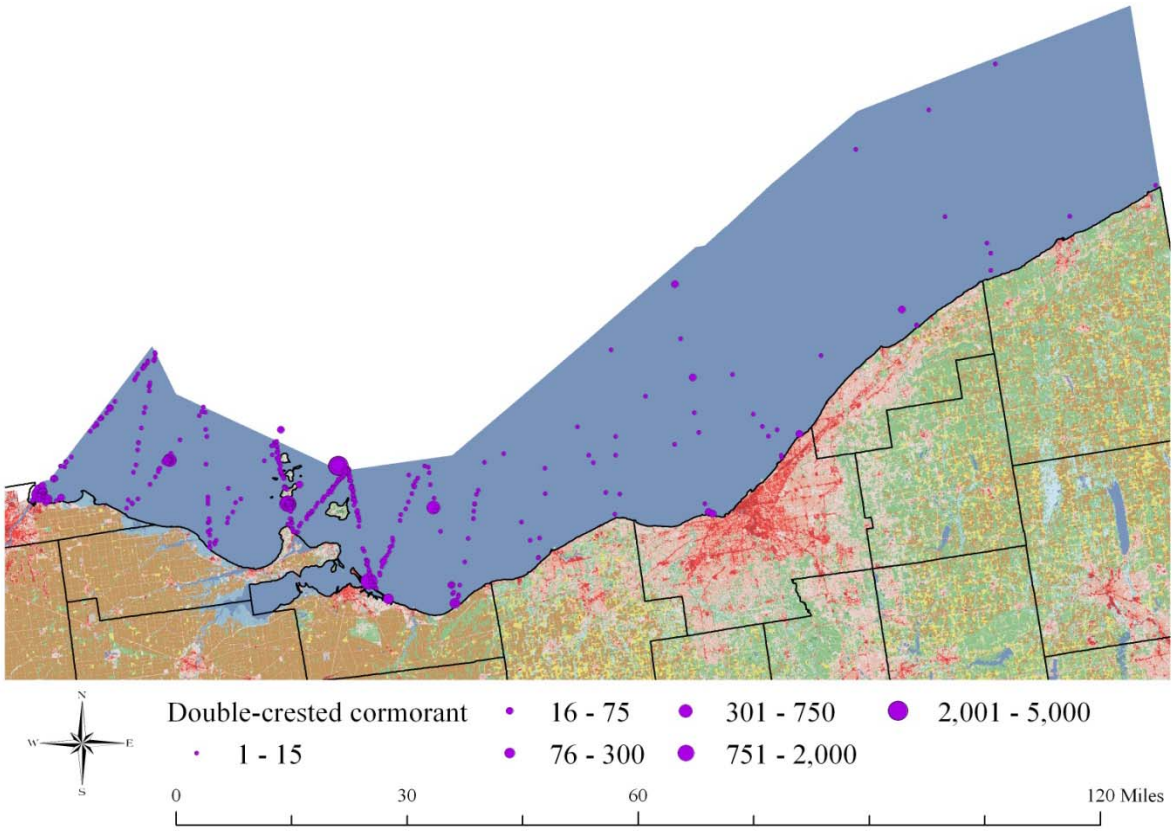
Year 1


Common merganser
1 - 241
242 - 481
482 - 720
721 - 960
961 - 1,200
N
W
E
S
0
30
60
120 Miles

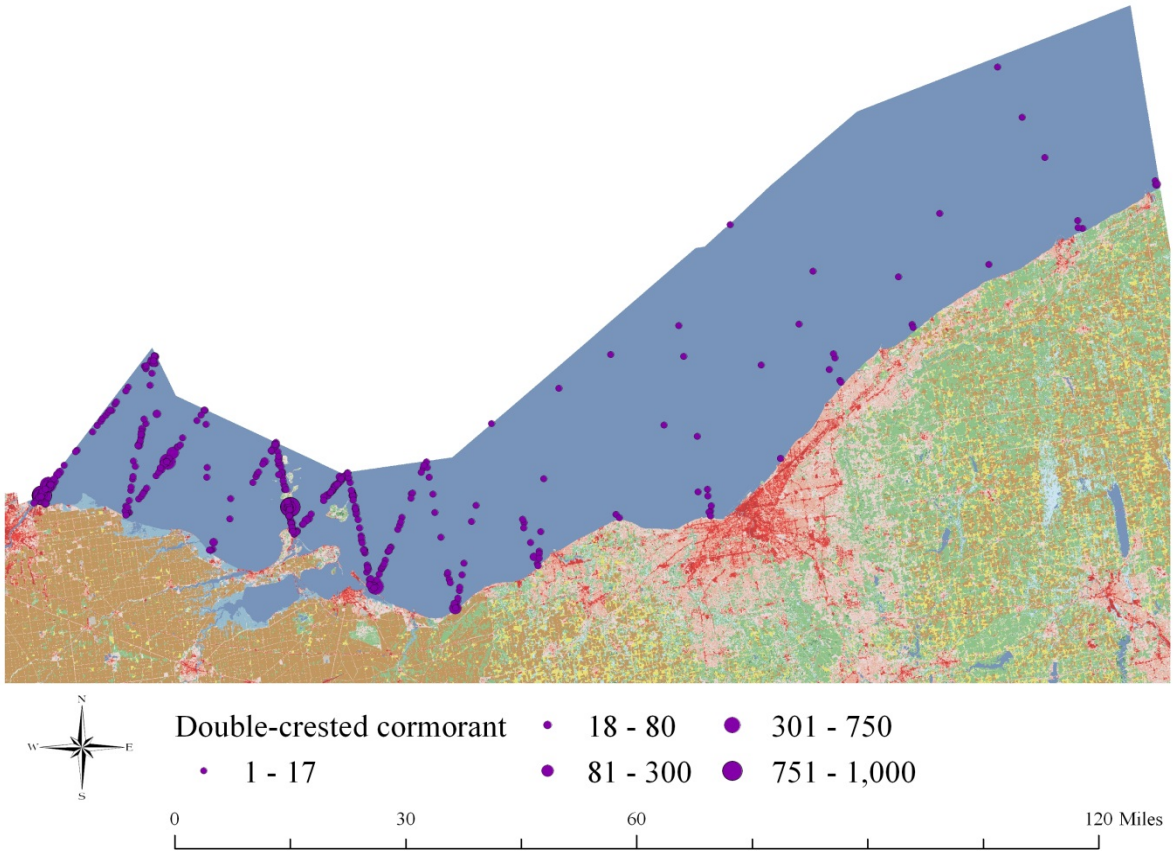
Year 2


N
W
E
S
Common merganser
1 - 8
9 - 21
22 - 35
36 - 100
101 - 200
0
25
50
100 Miles

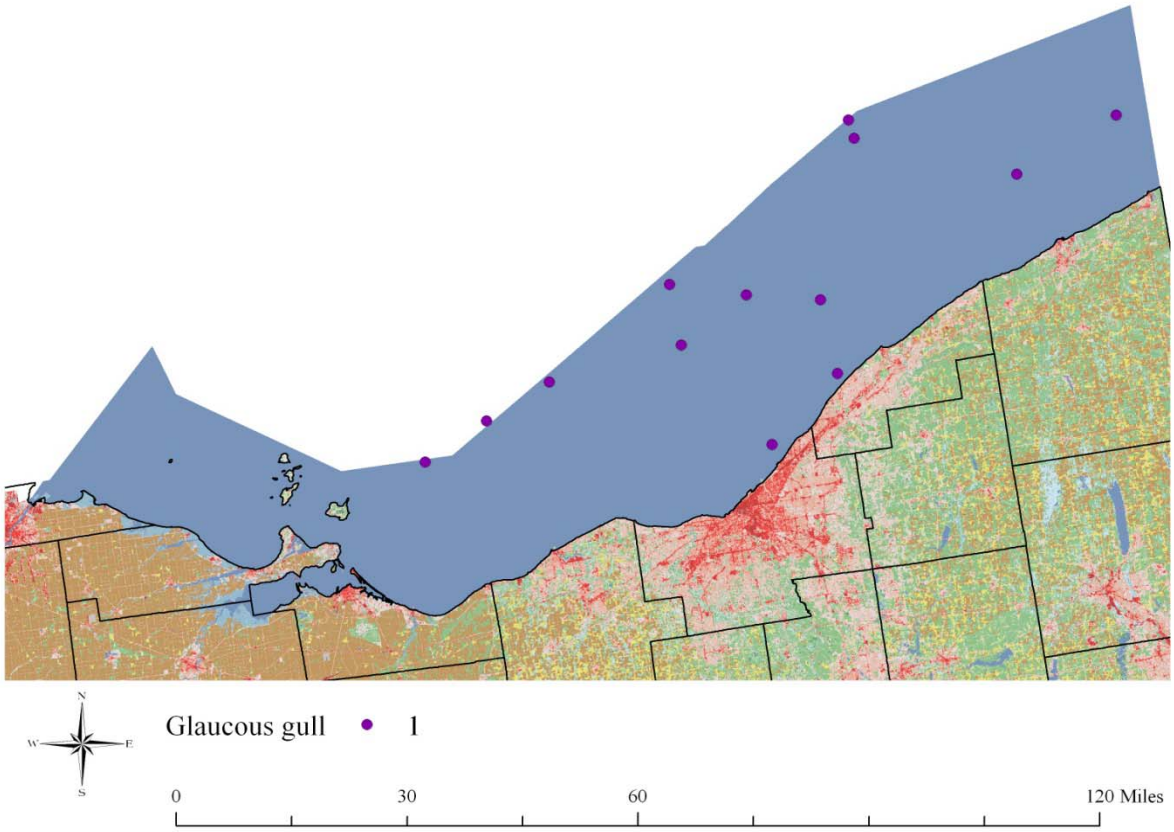
Year 1


N
W
E
S
Double-crested cormorant
1 - 15
16 - 75
76 - 300
301 - 750
751 - 2,000
2,001 - 5,000
0
30
60
120 Miles

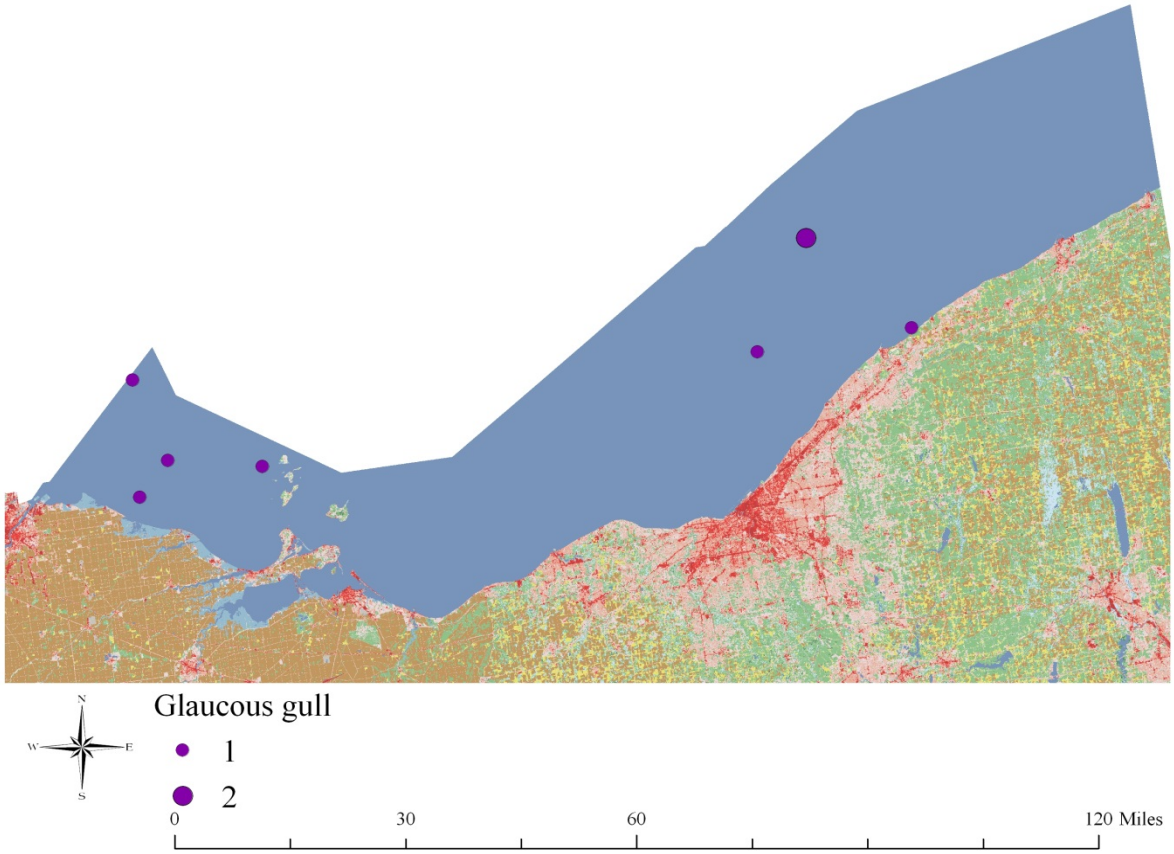
Year 2


N
W
E
S
Double-crested cormorant
1 - 17
18 - 80
81 - 300
301 - 750
751 - 1,000
0
30
60
120 Miles

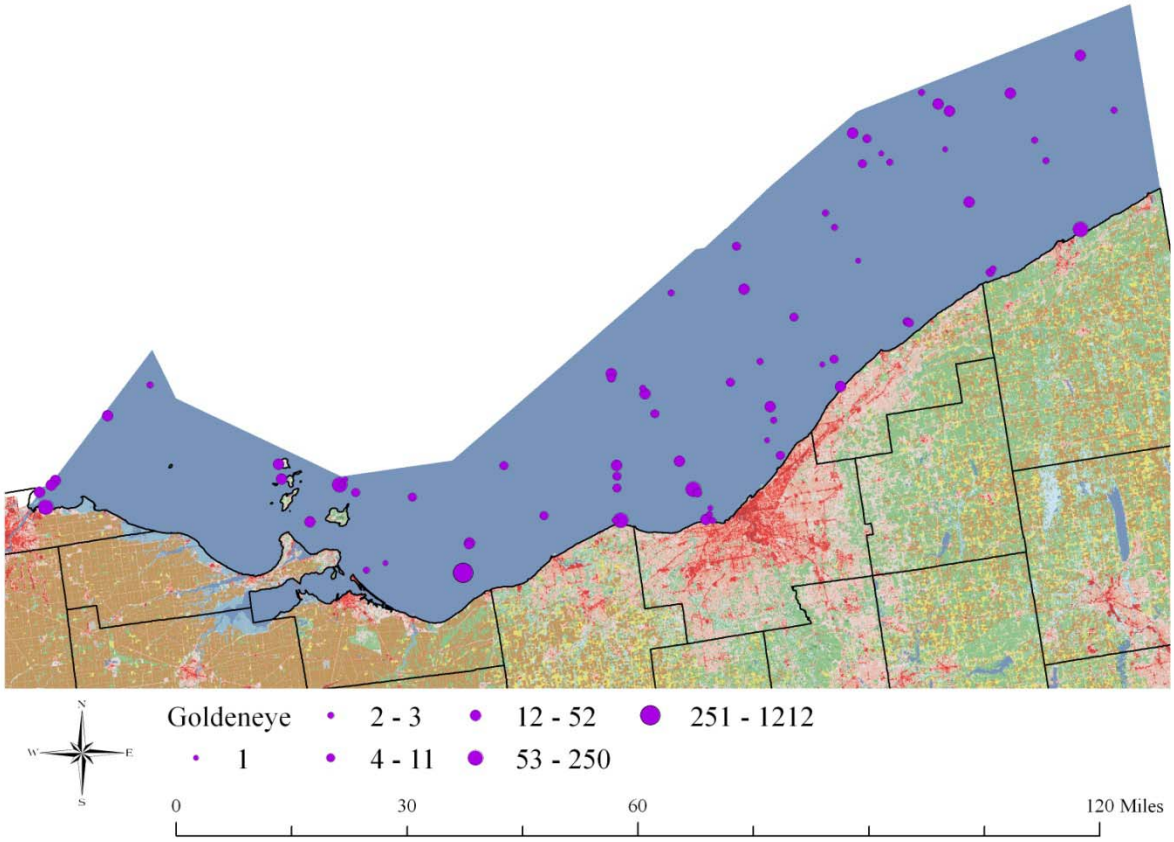
Year 1



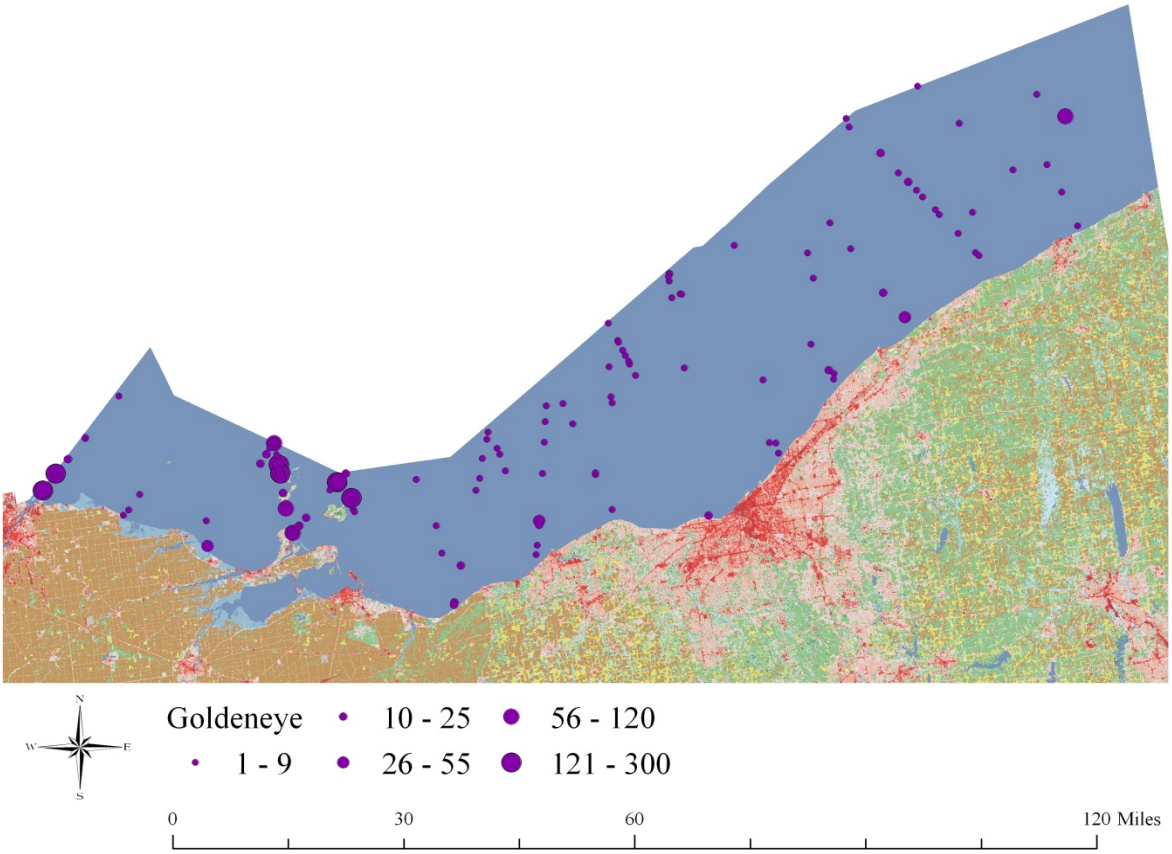
Year 2



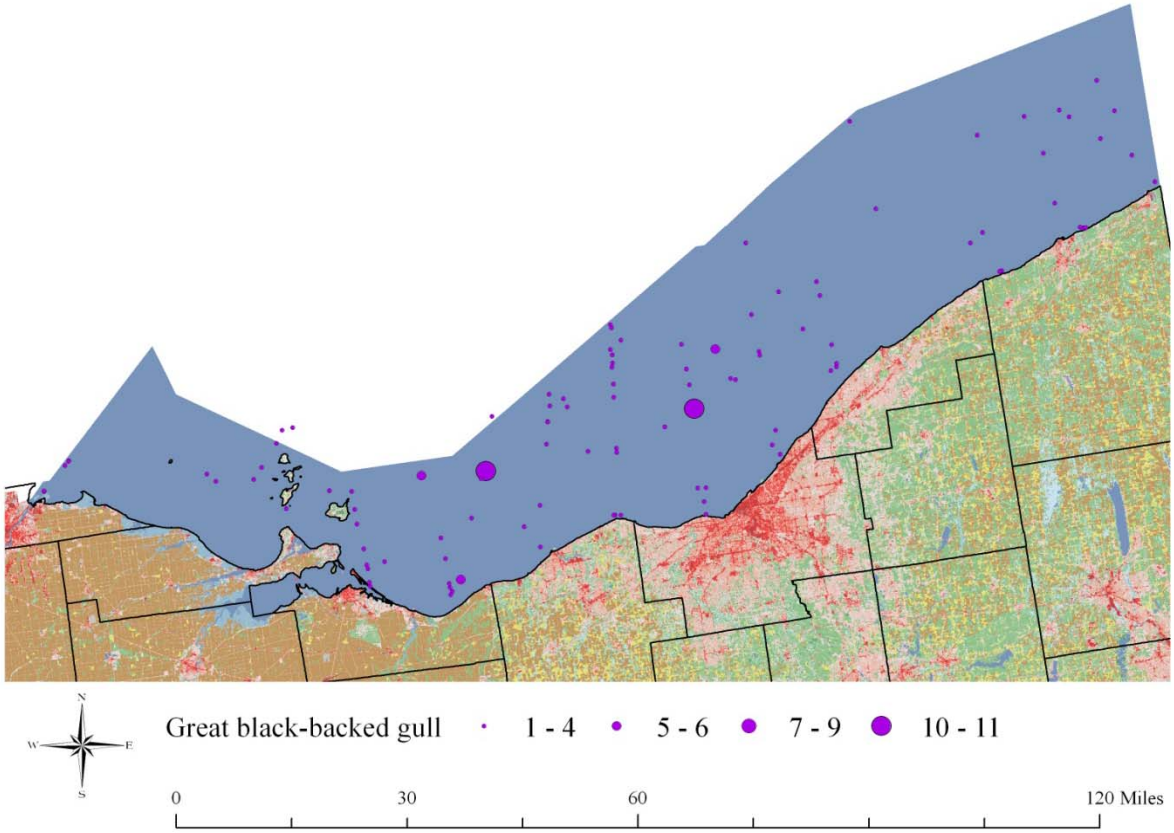
Year 1



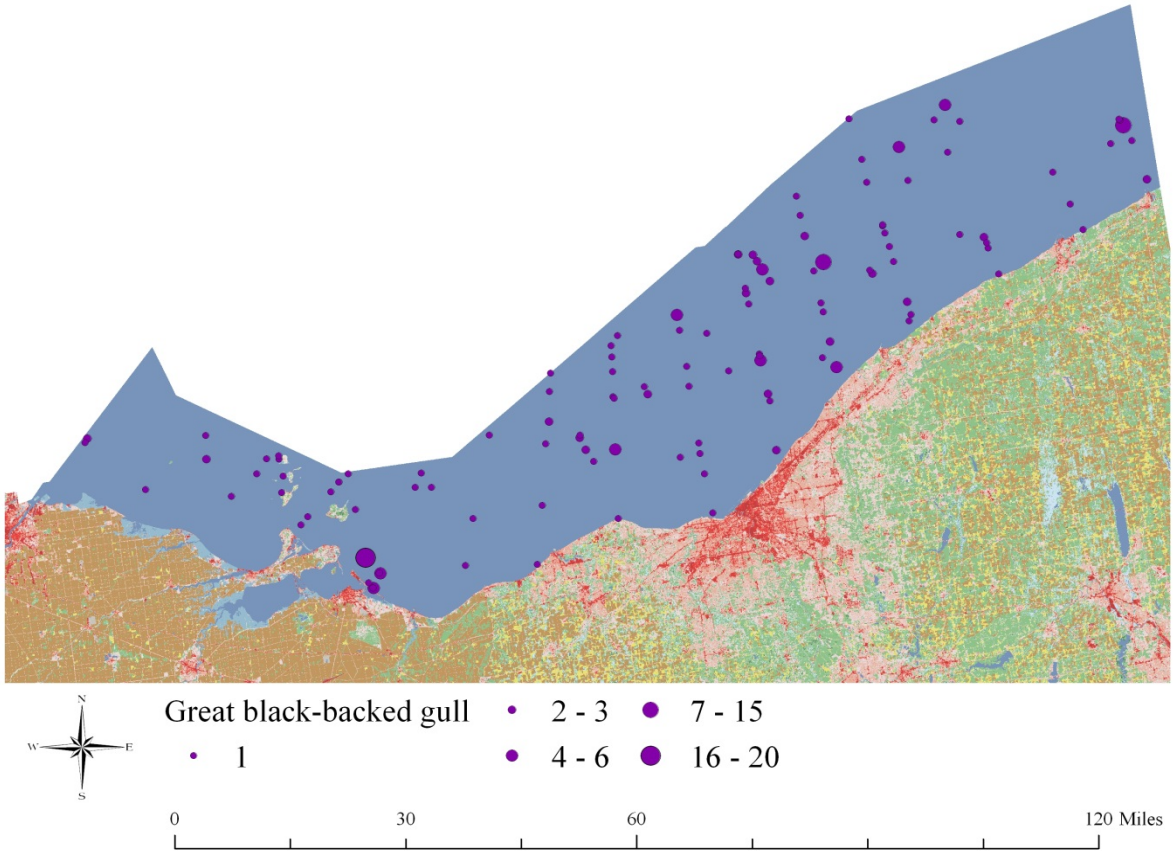
Year 2



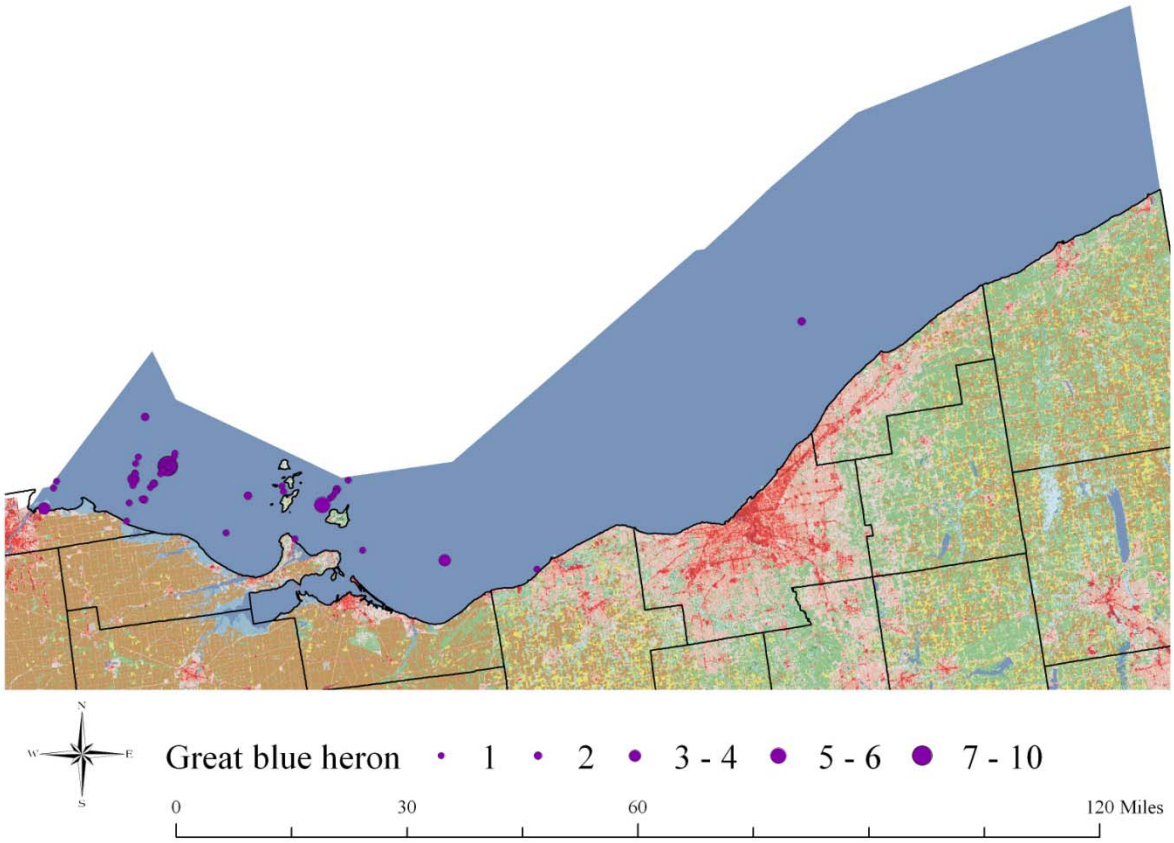
Year 1



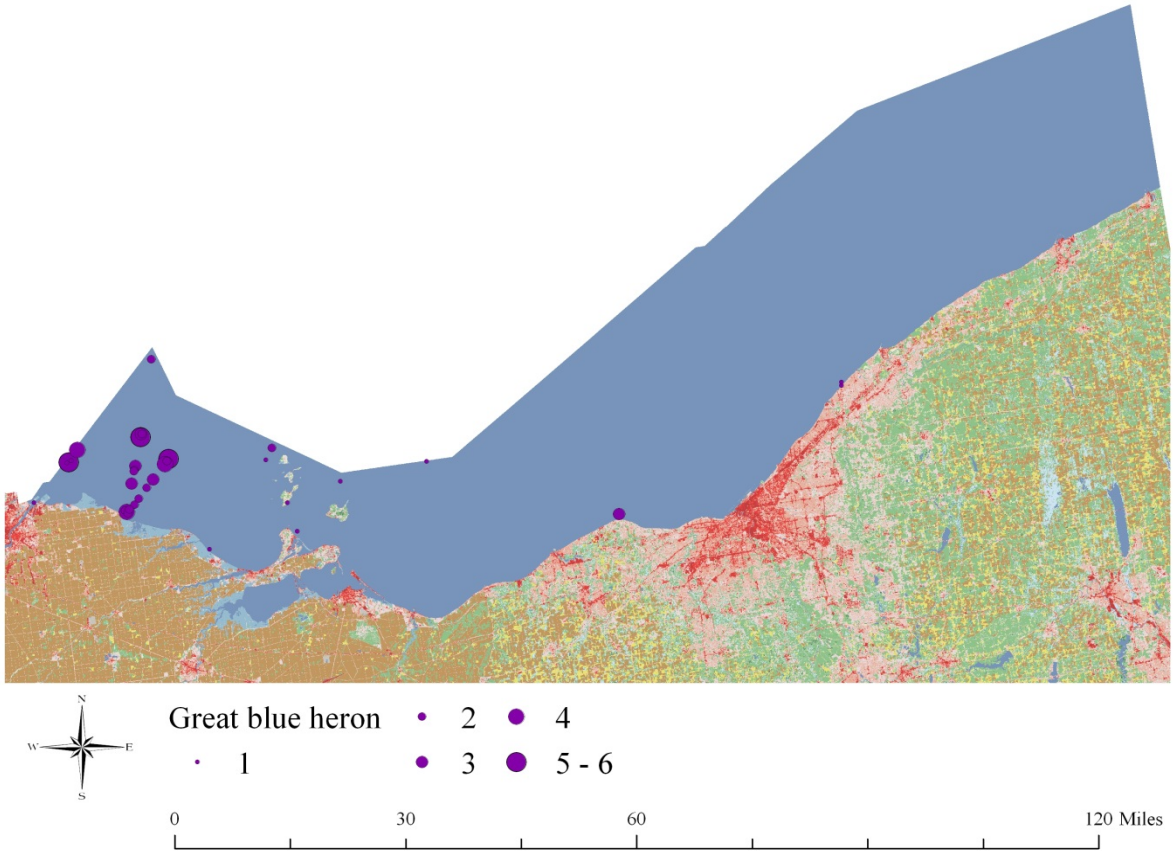
Year 2



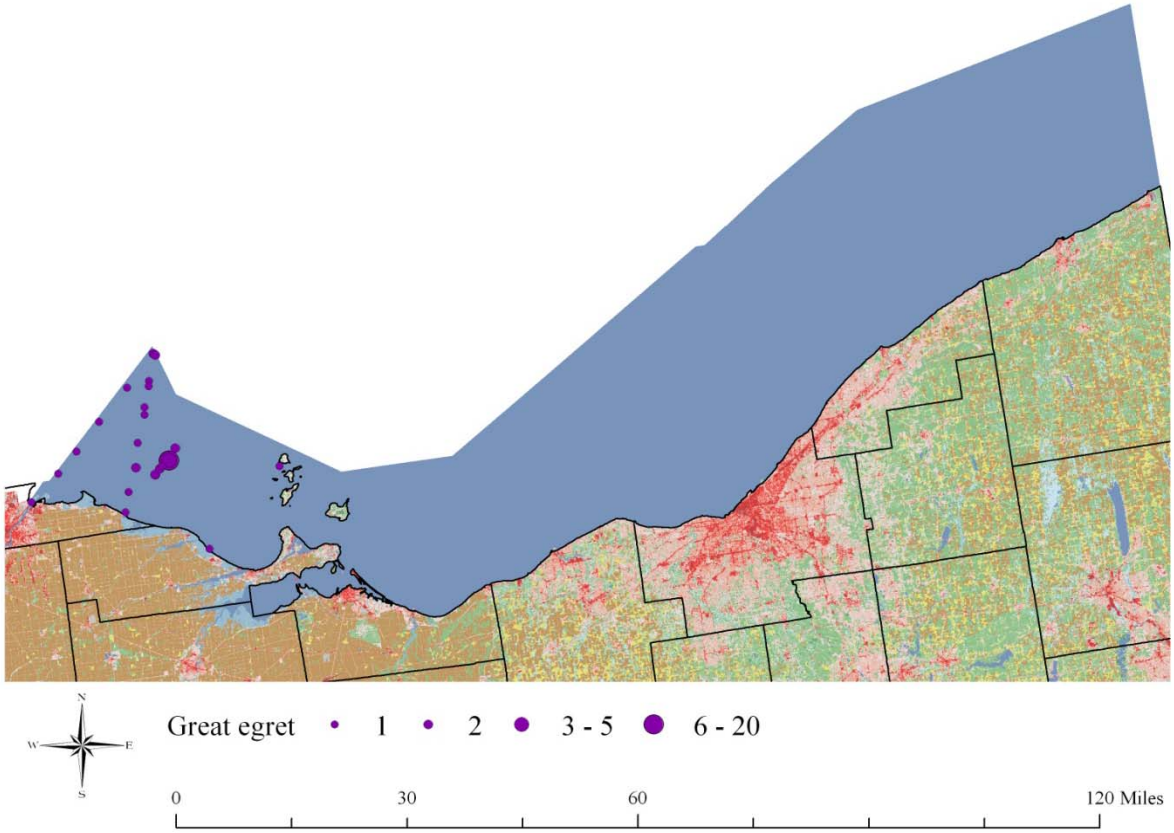
Year 1



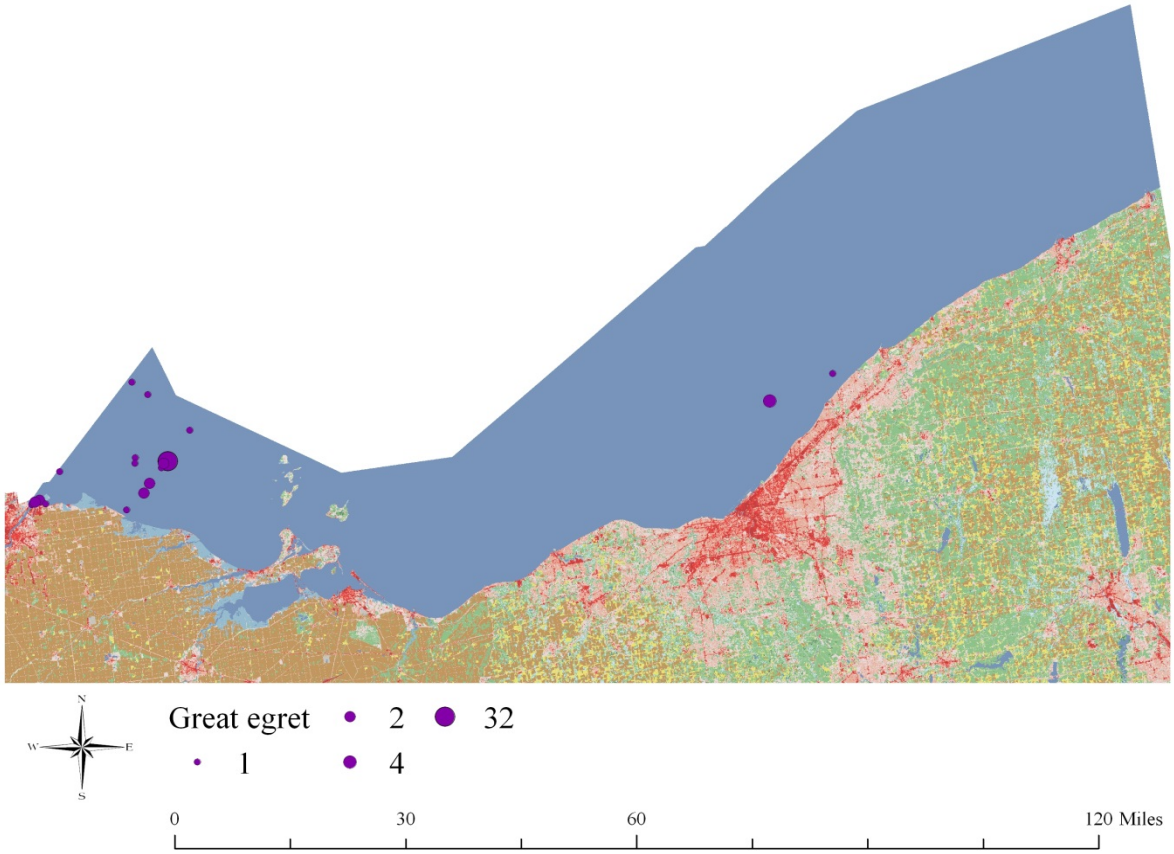
Year 2



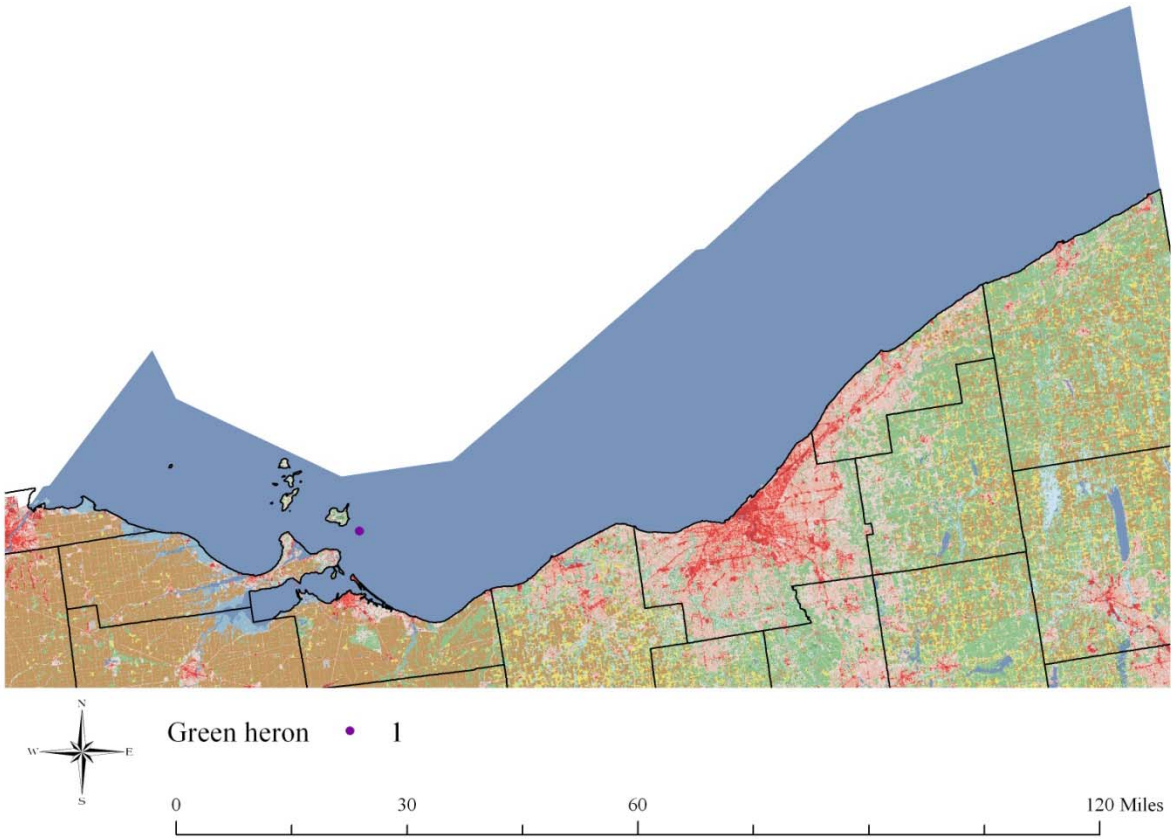
Year 1



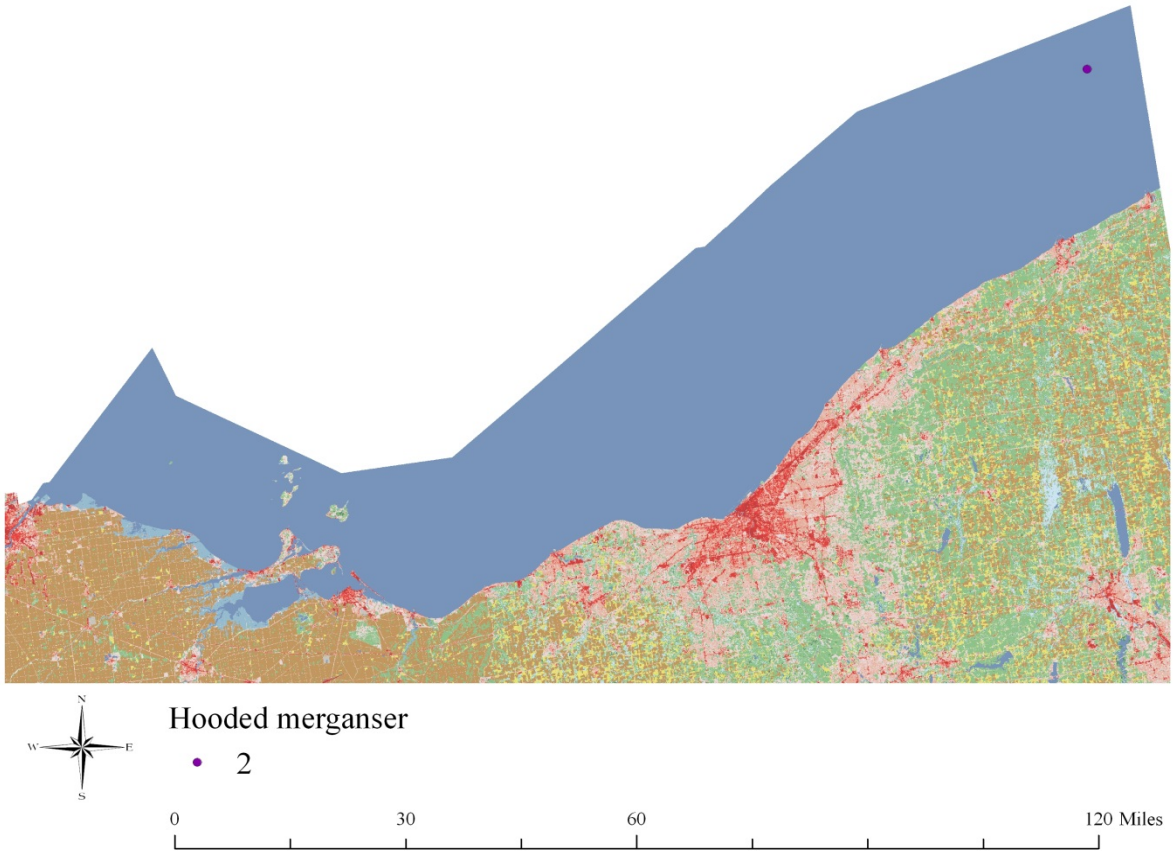
Year 2



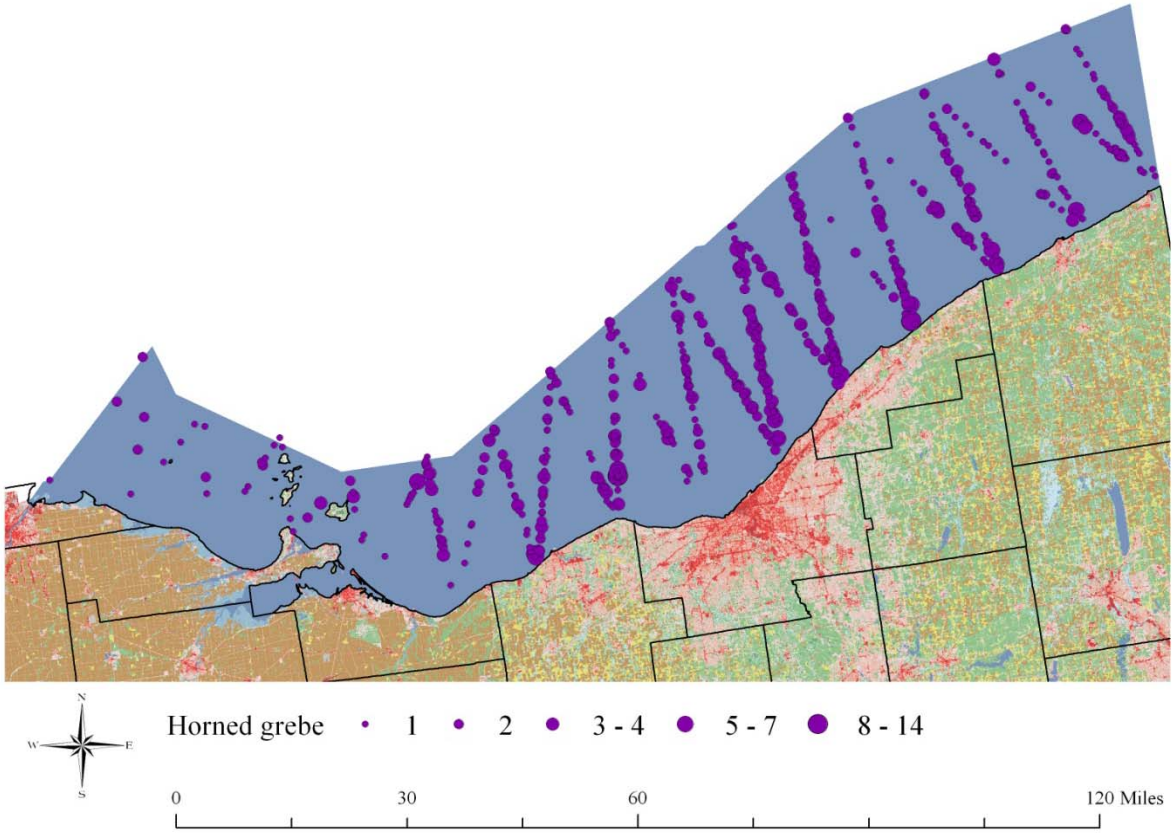
Year 1



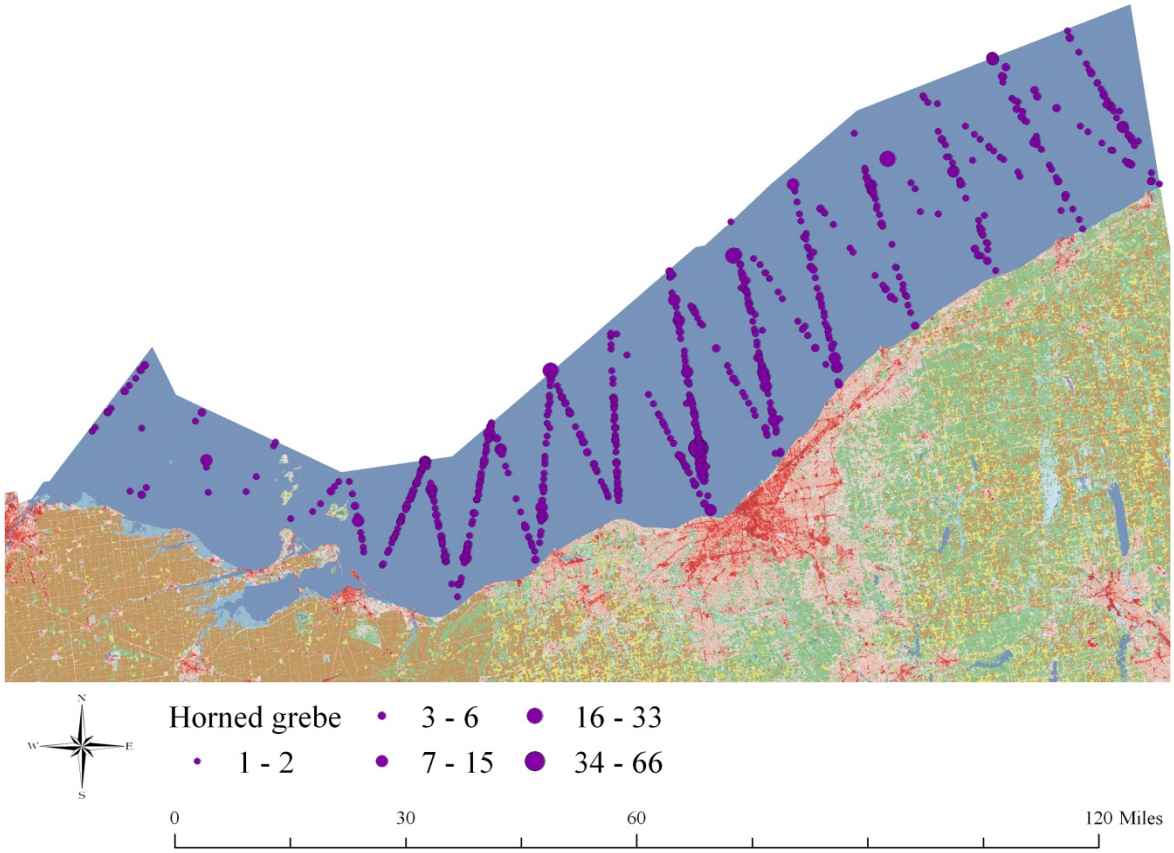
Year 2



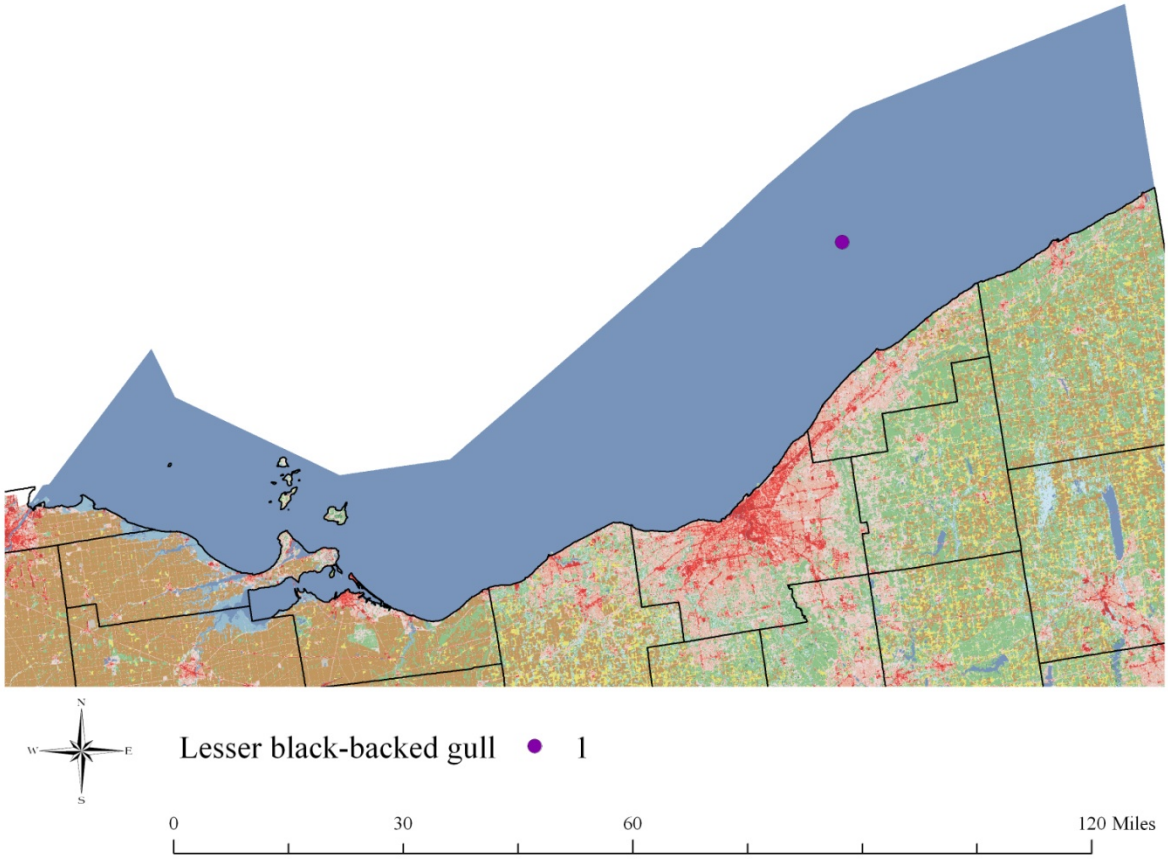
Year 1



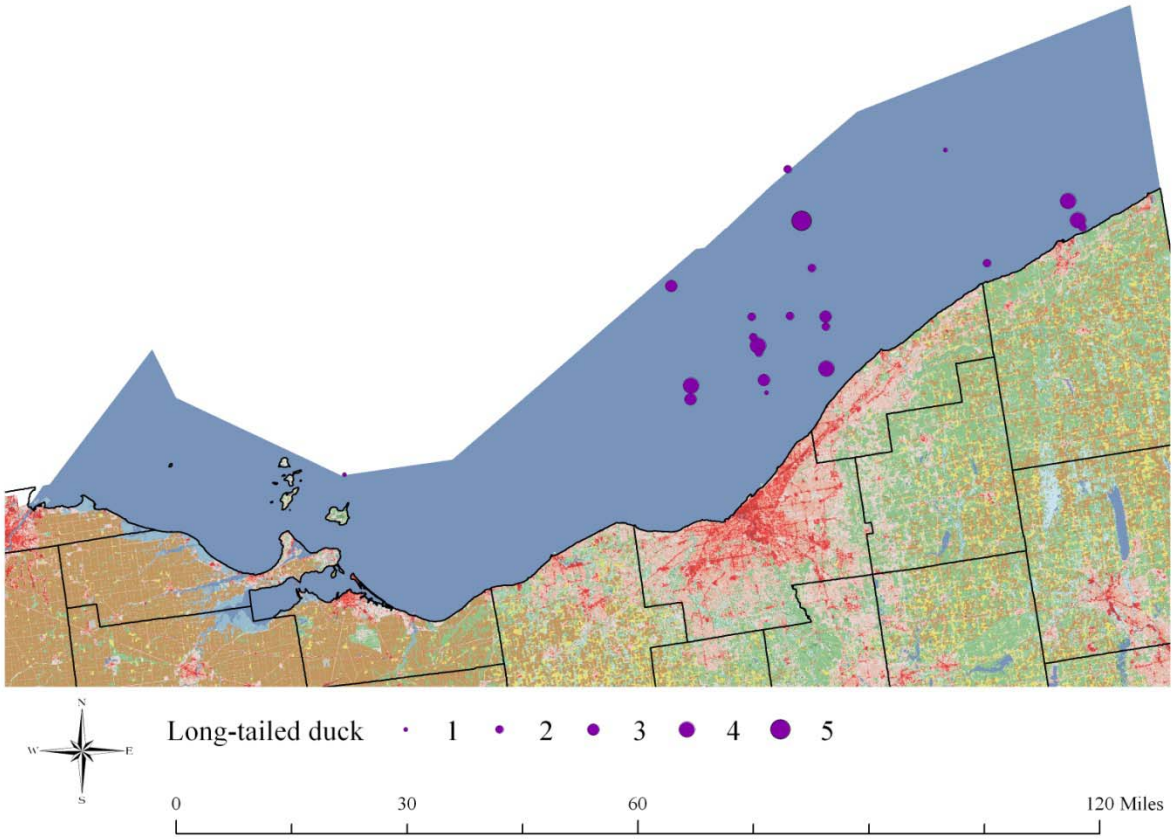
Year 2



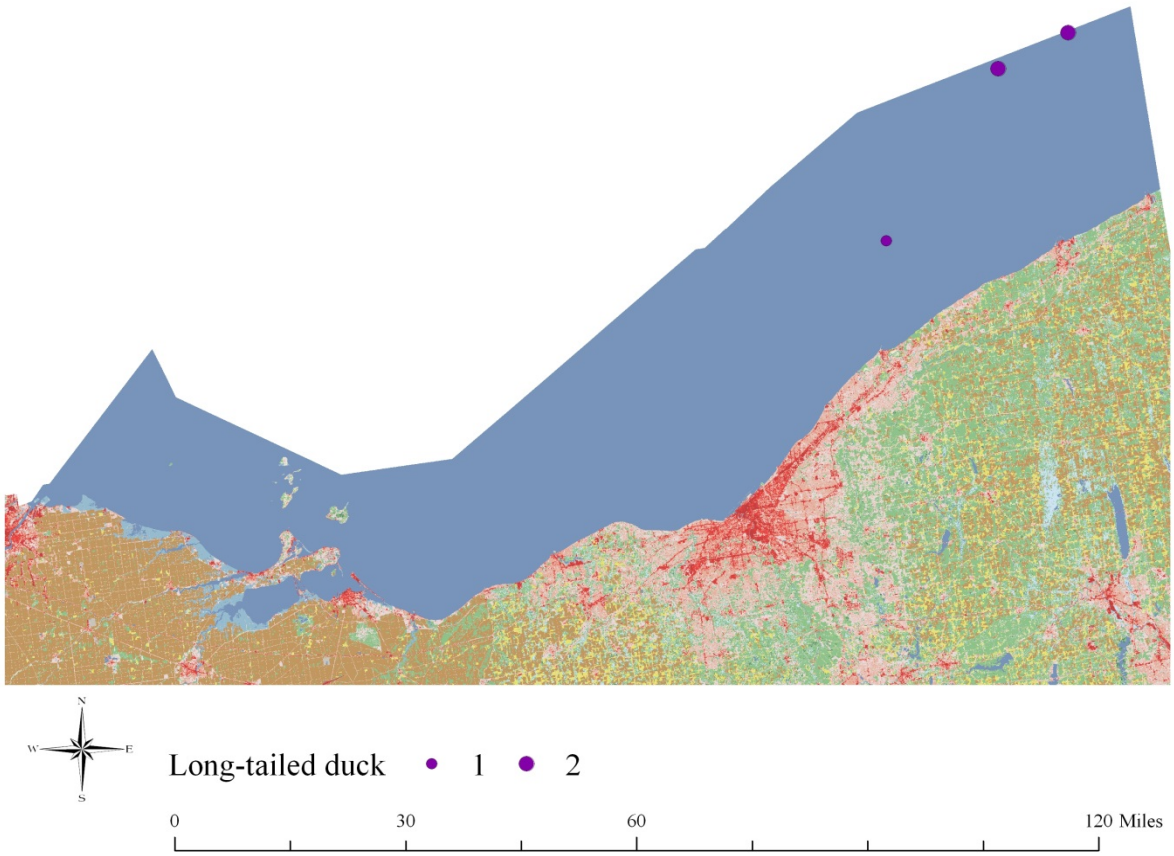
Year 1



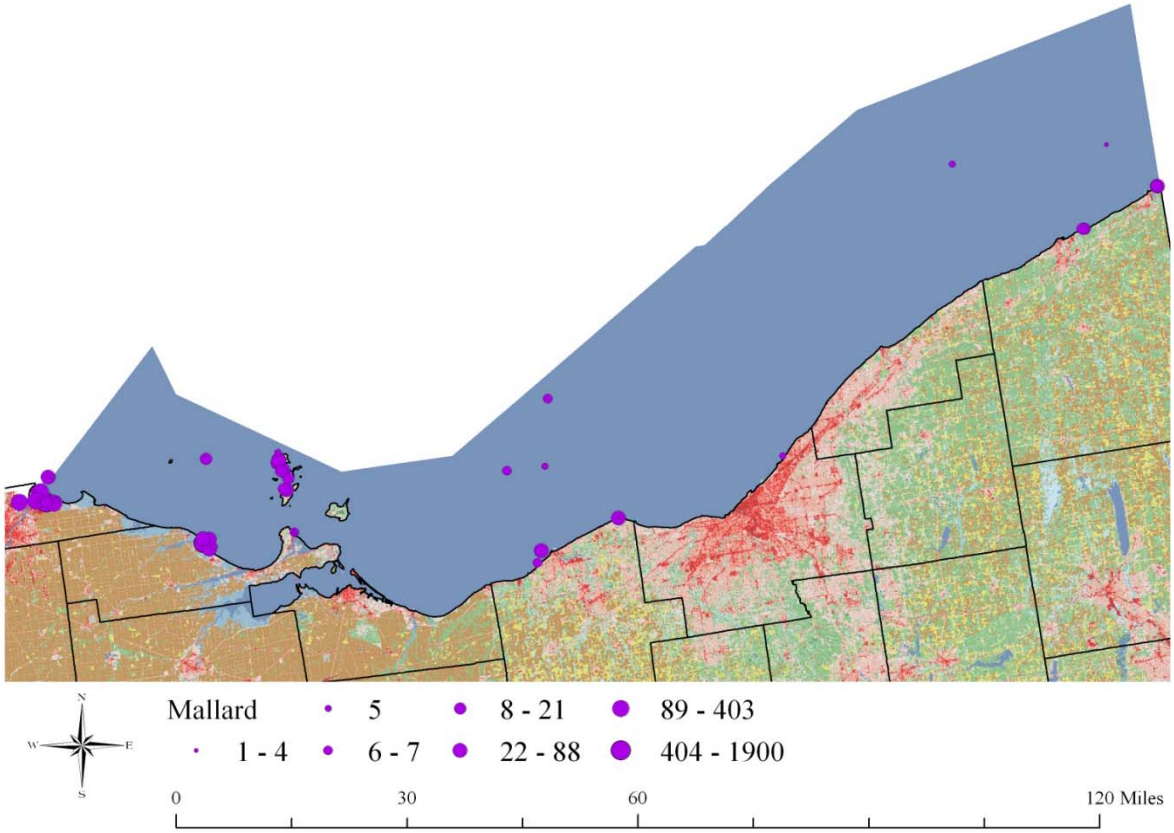
Year 1



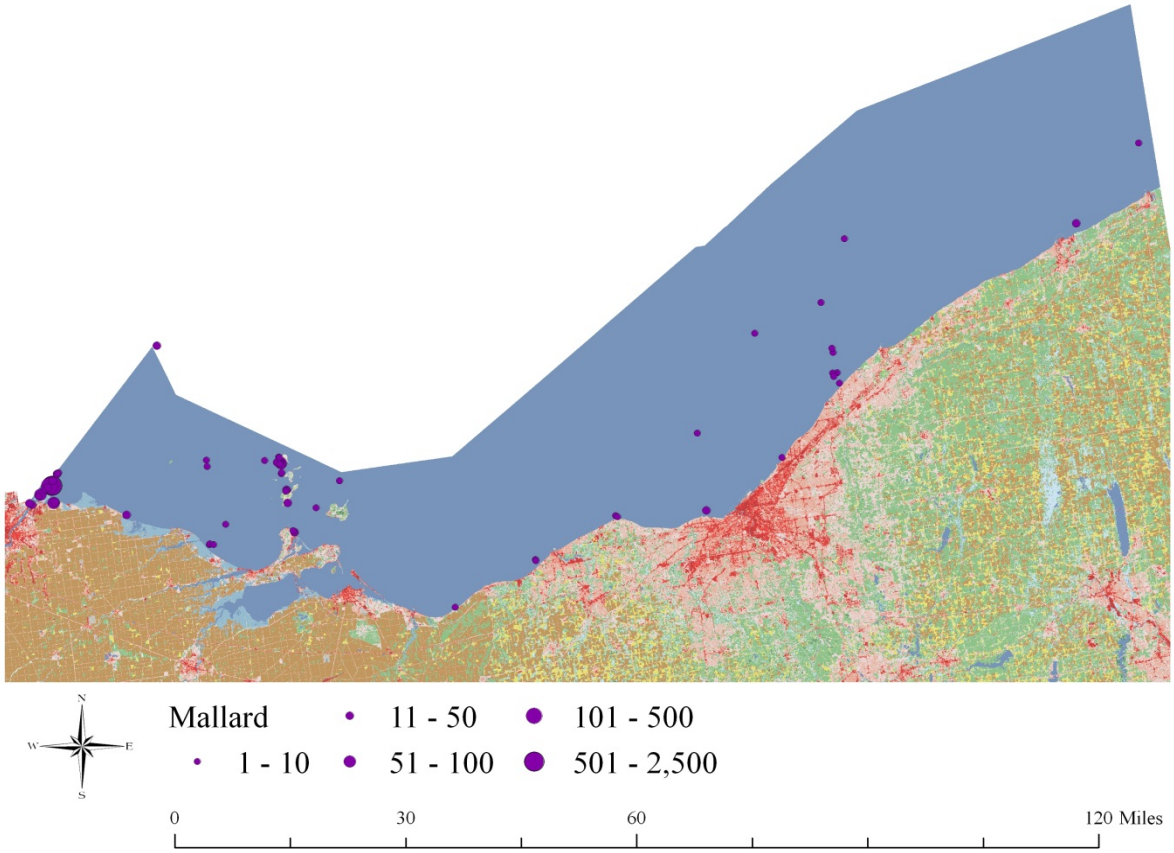
Year 2



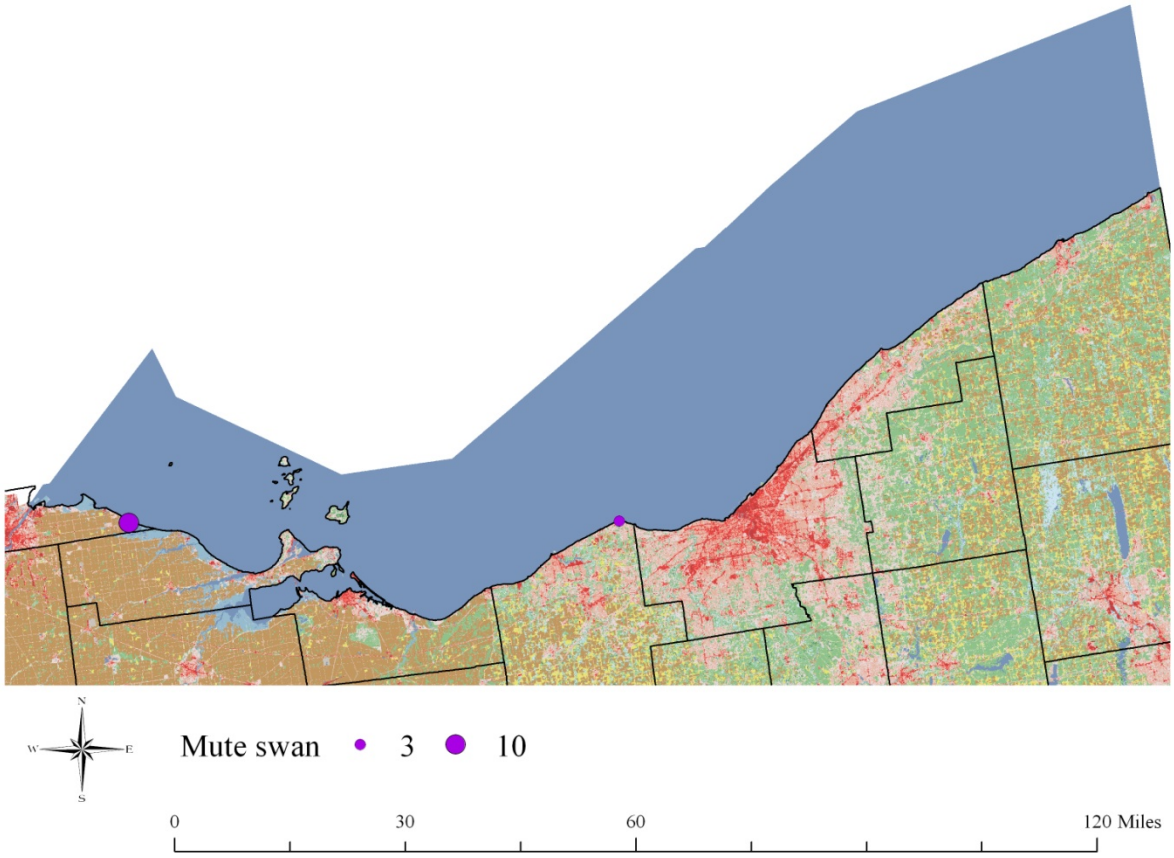
Year 1



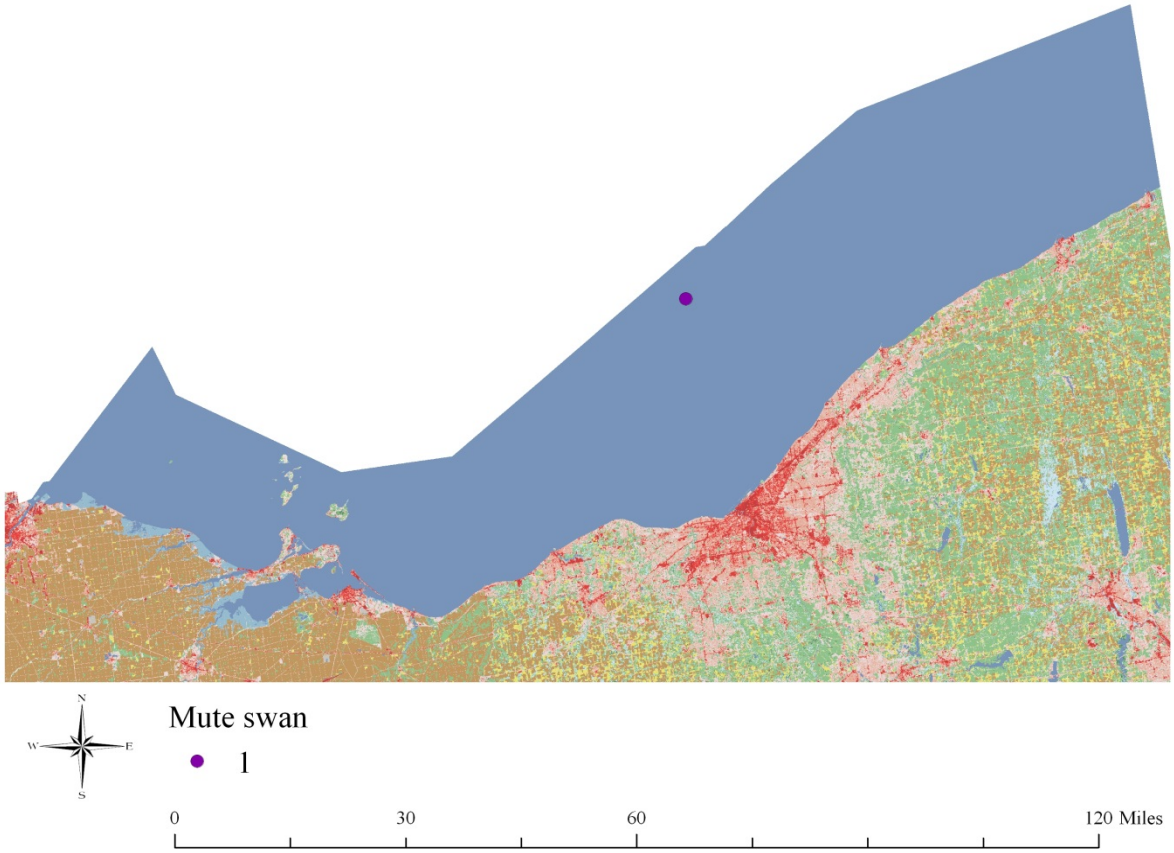
Year 2



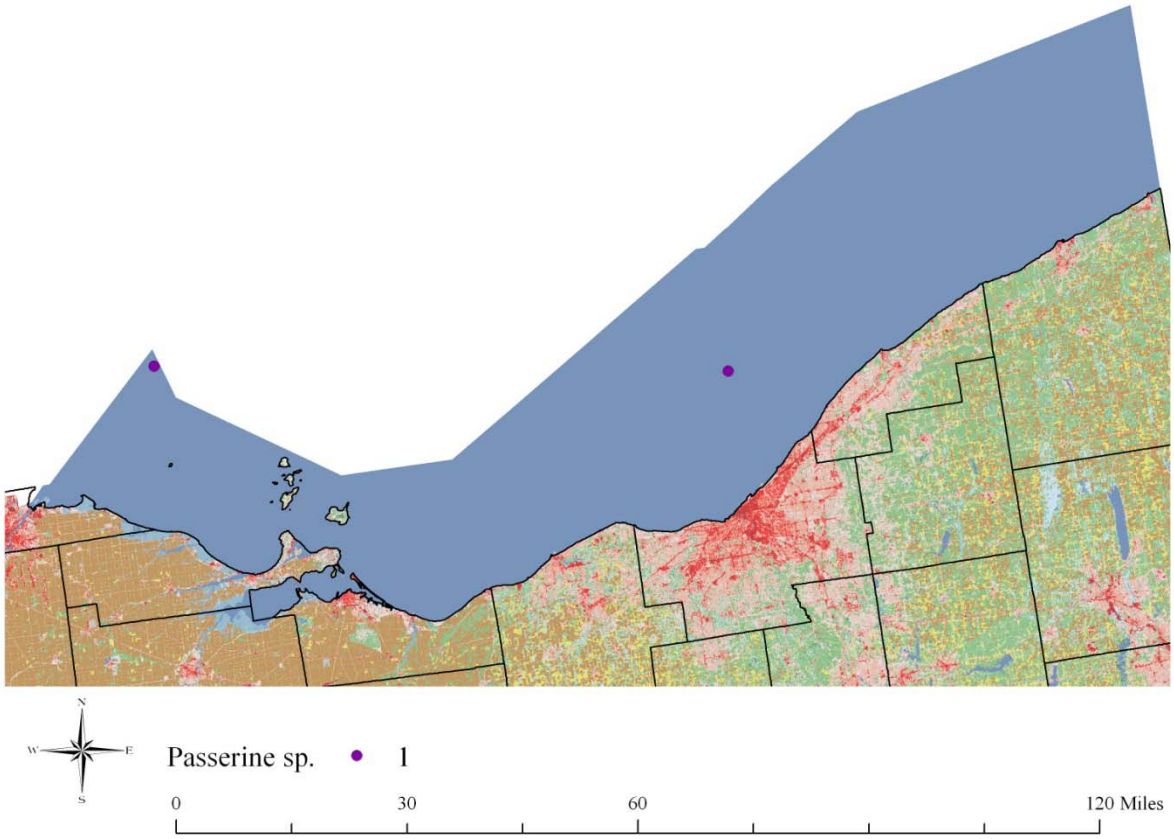
Year 1



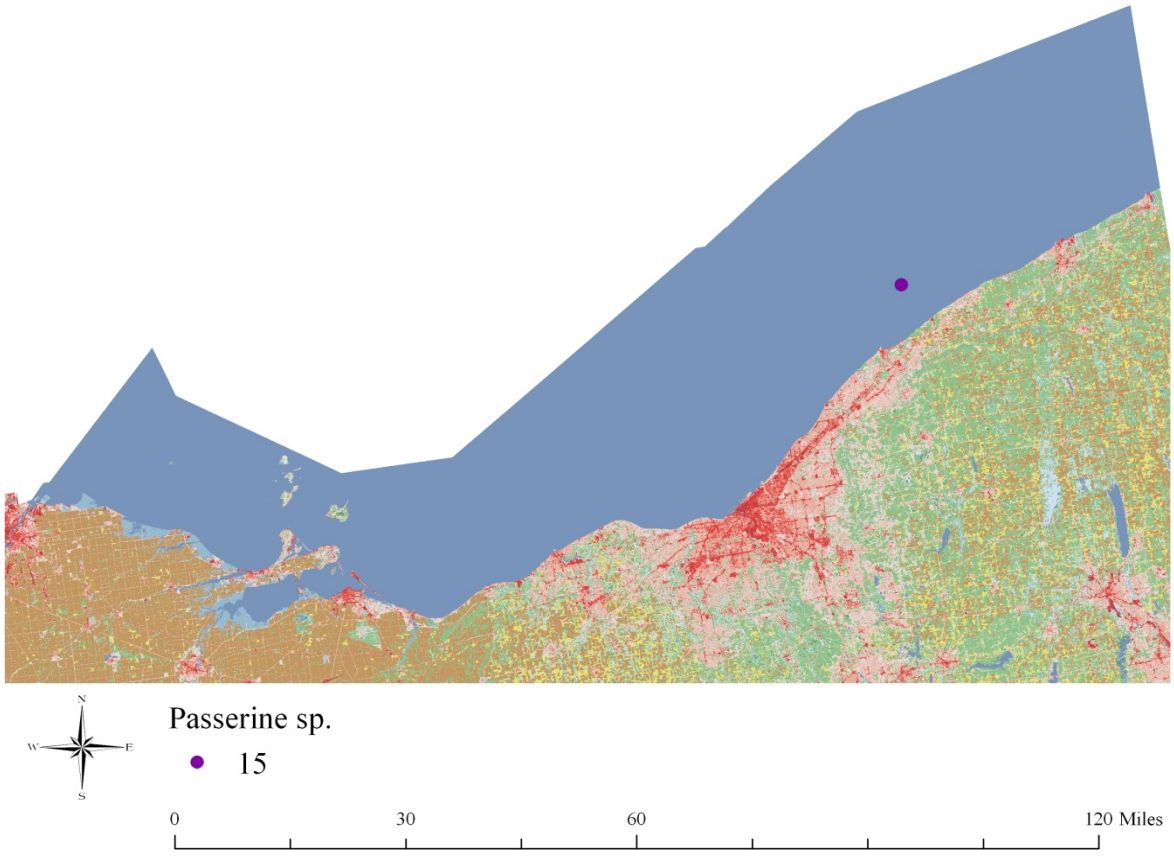
Year 2



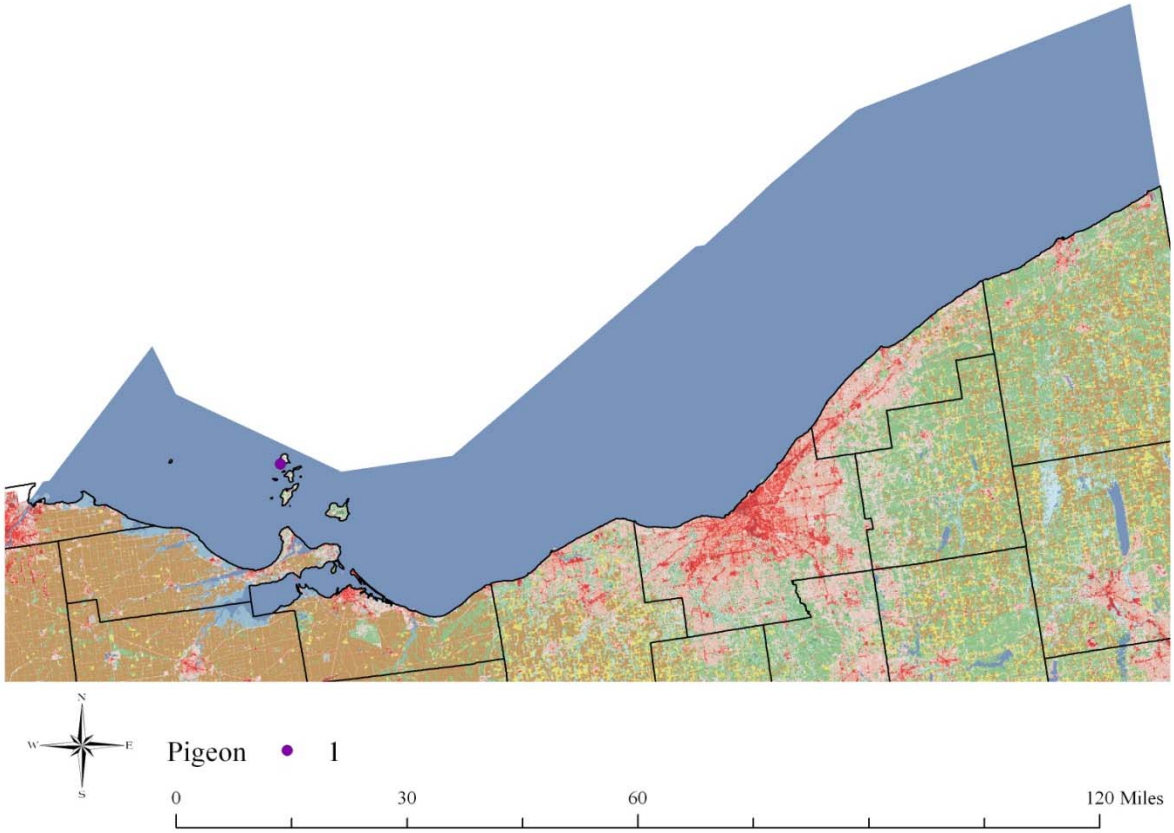
Year 1



Year 2



Year 1



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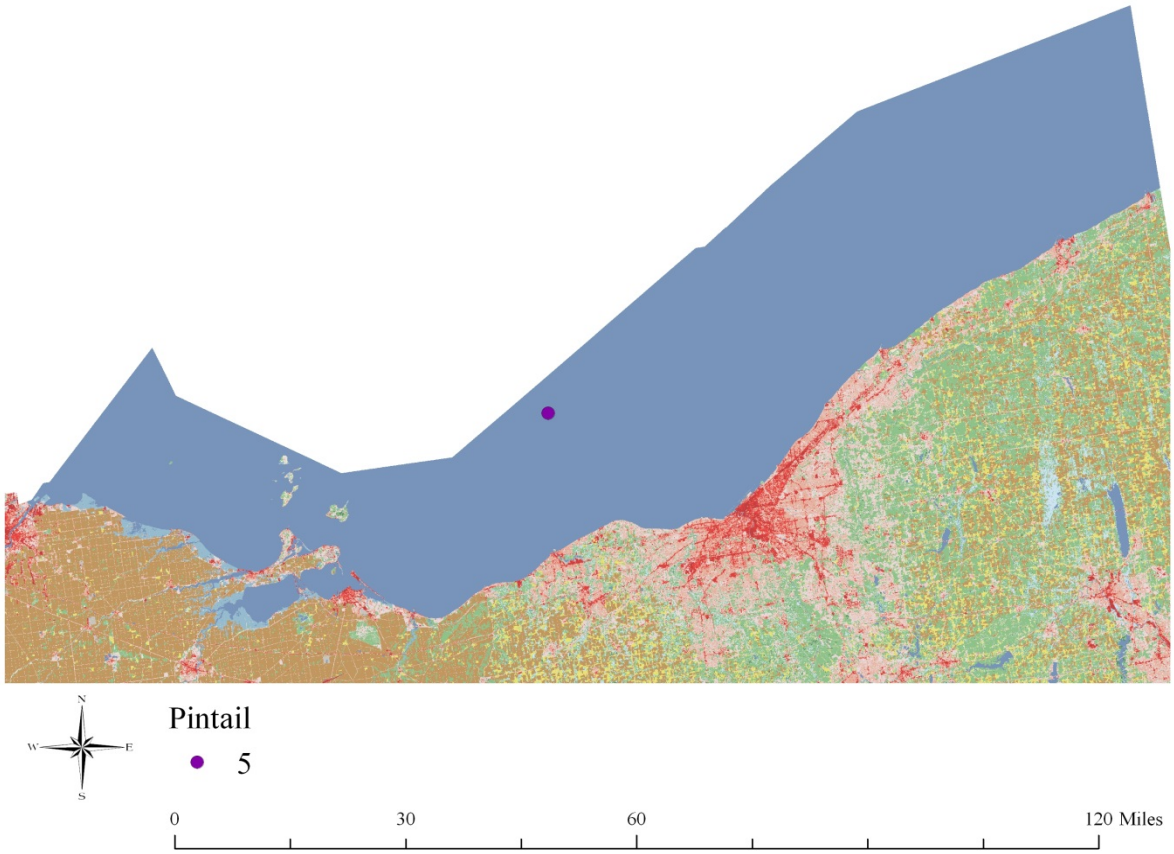
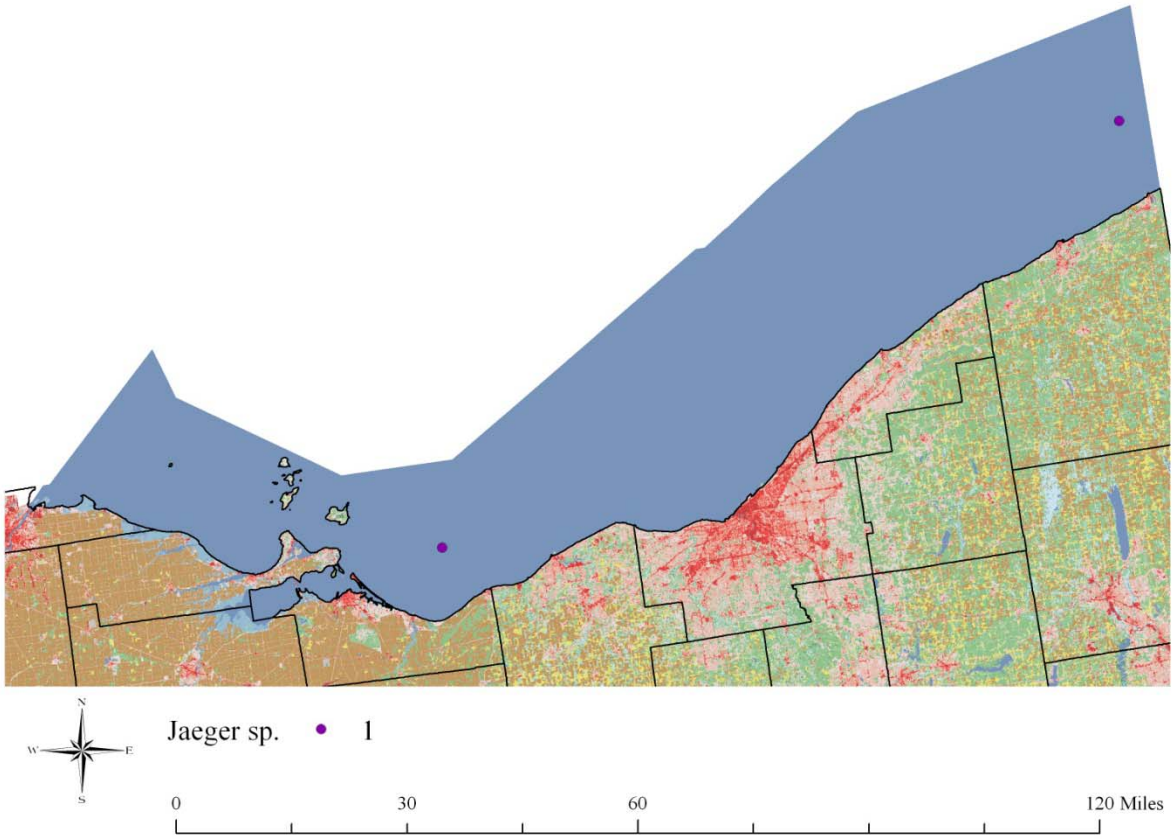


Year 1



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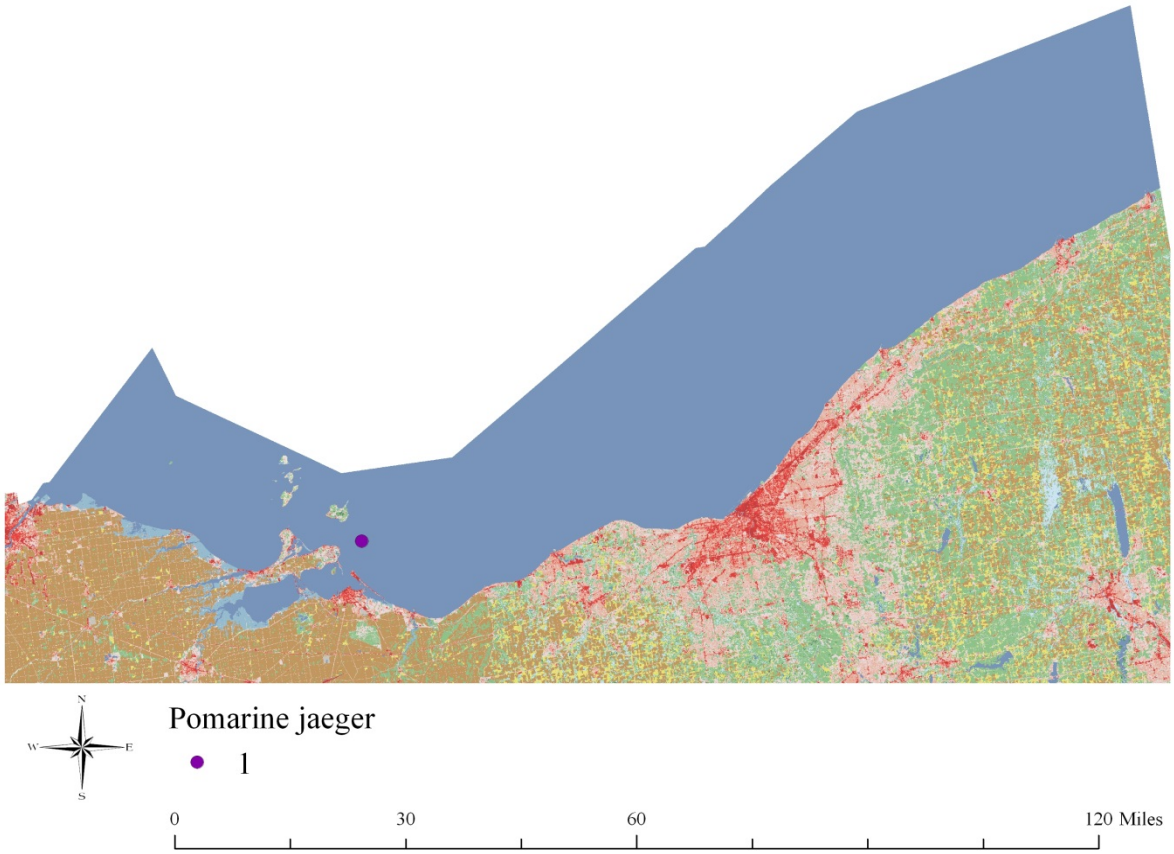
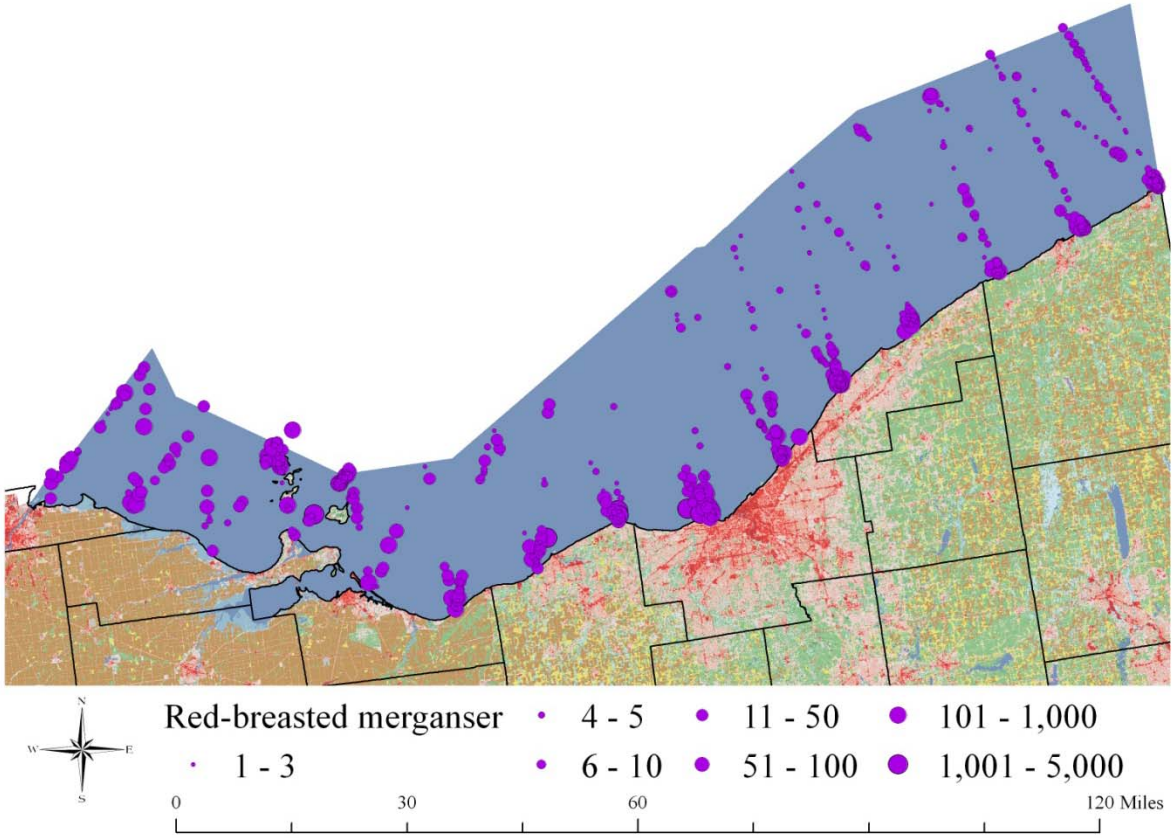
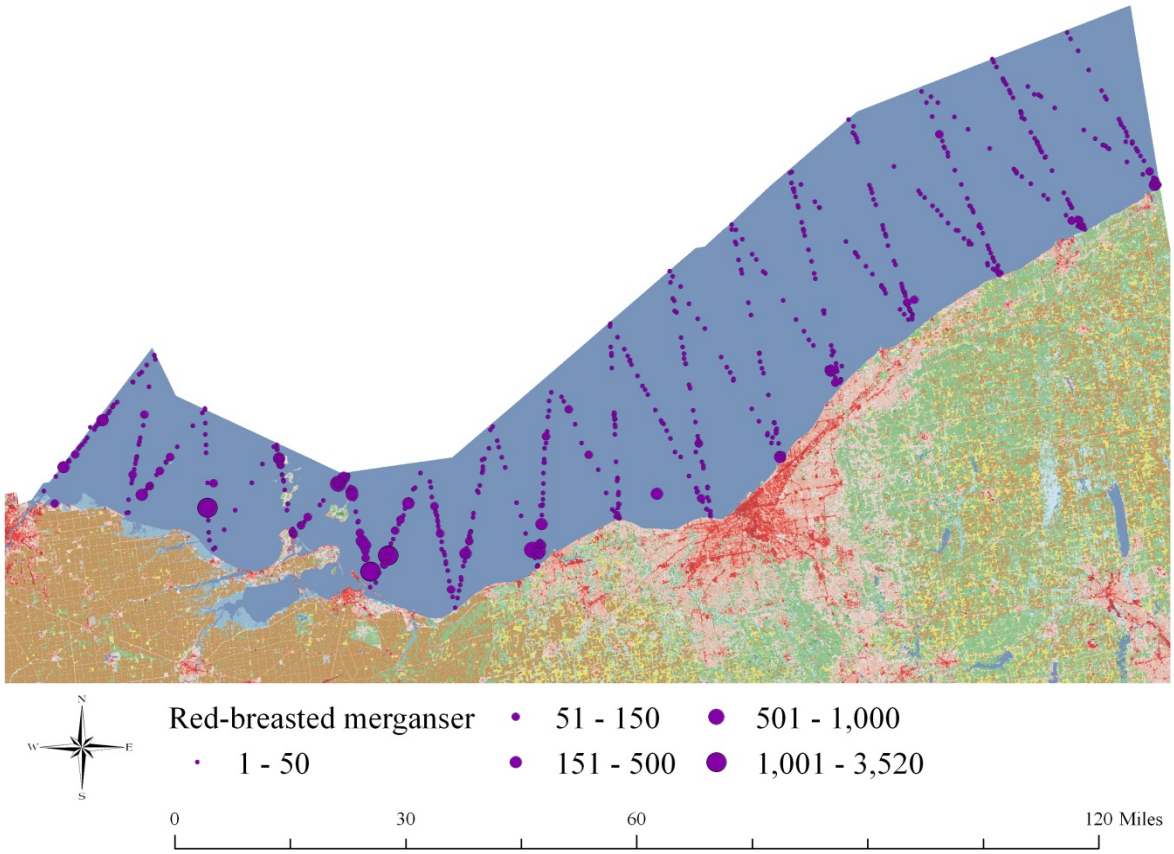


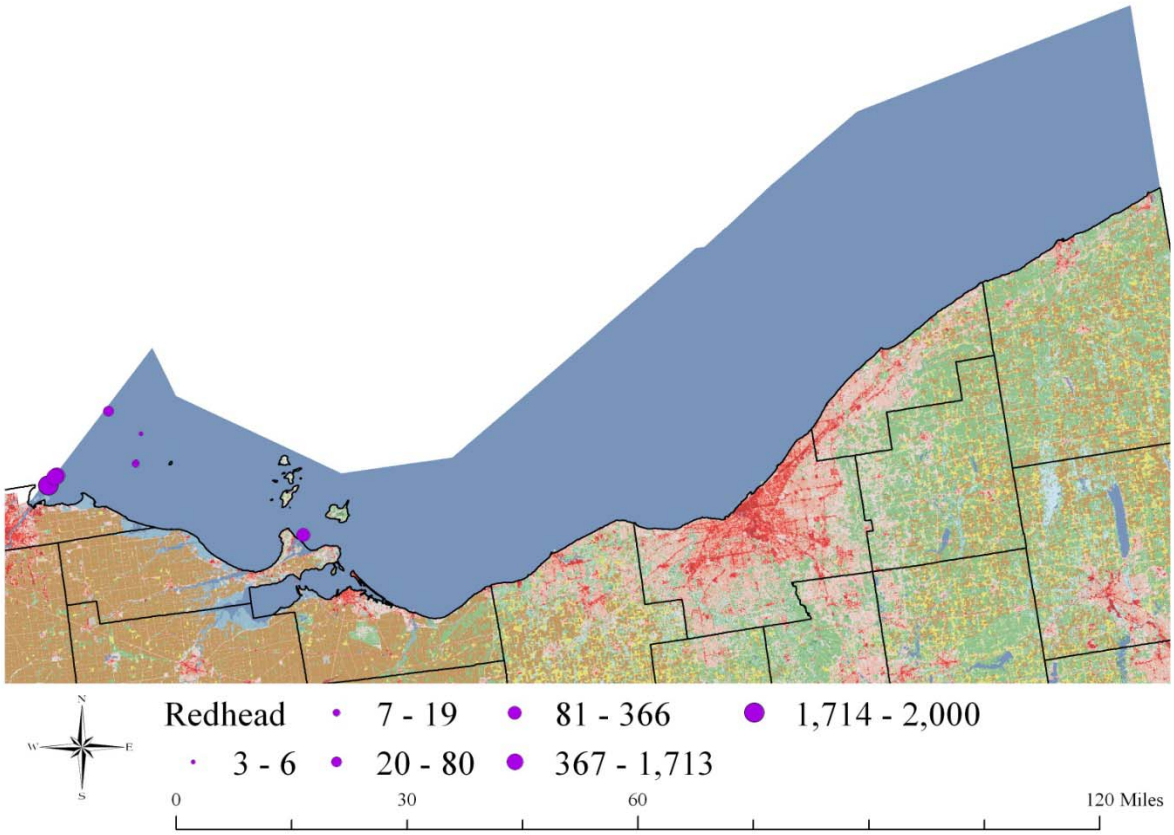
Year 1


Red-breasted merganser
1 - 3
4 - 5
6 - 10
11 - 50
51 - 100
101 - 1,000
1,001 - 5,000
0
30
60
120 Miles
N
W
E
S

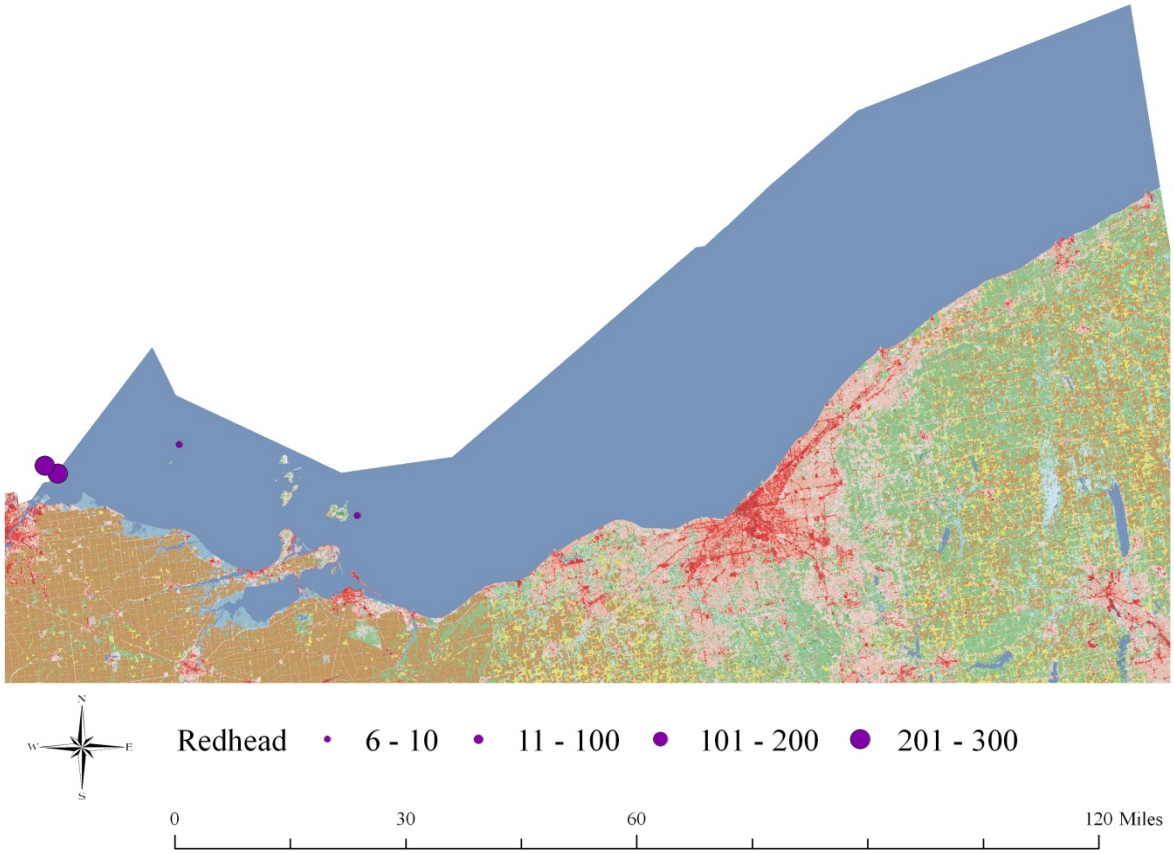
Year 2


N
W
E
S
Red-breasted merganser
1 - 50
51 - 150
151 - 500
501 - 1,000
1,001 - 3,520
0
30
60
120 Miles

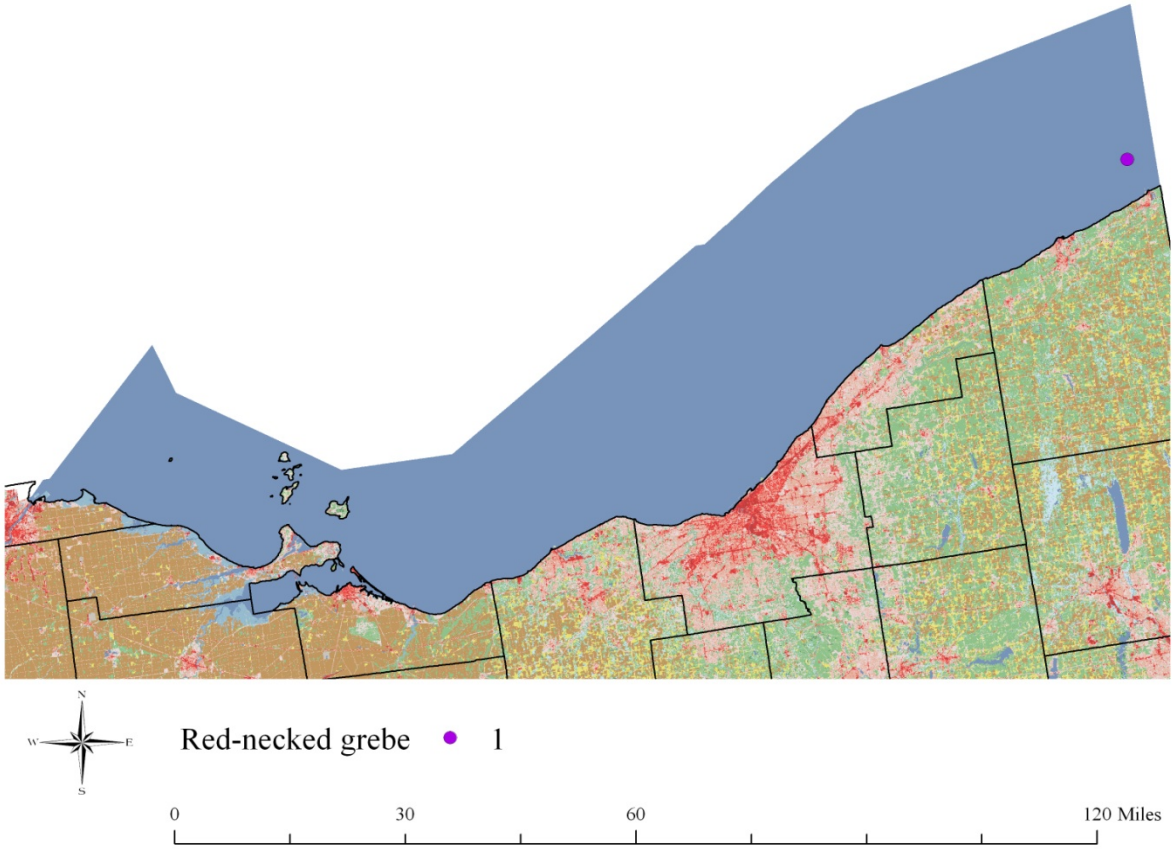
Year 1


Redhead
3 - 6
7 - 19
20 - 80
81 - 366
367 - 1,713
1,714 - 2,000
N
W
E
S
0
30
60
120 Miles

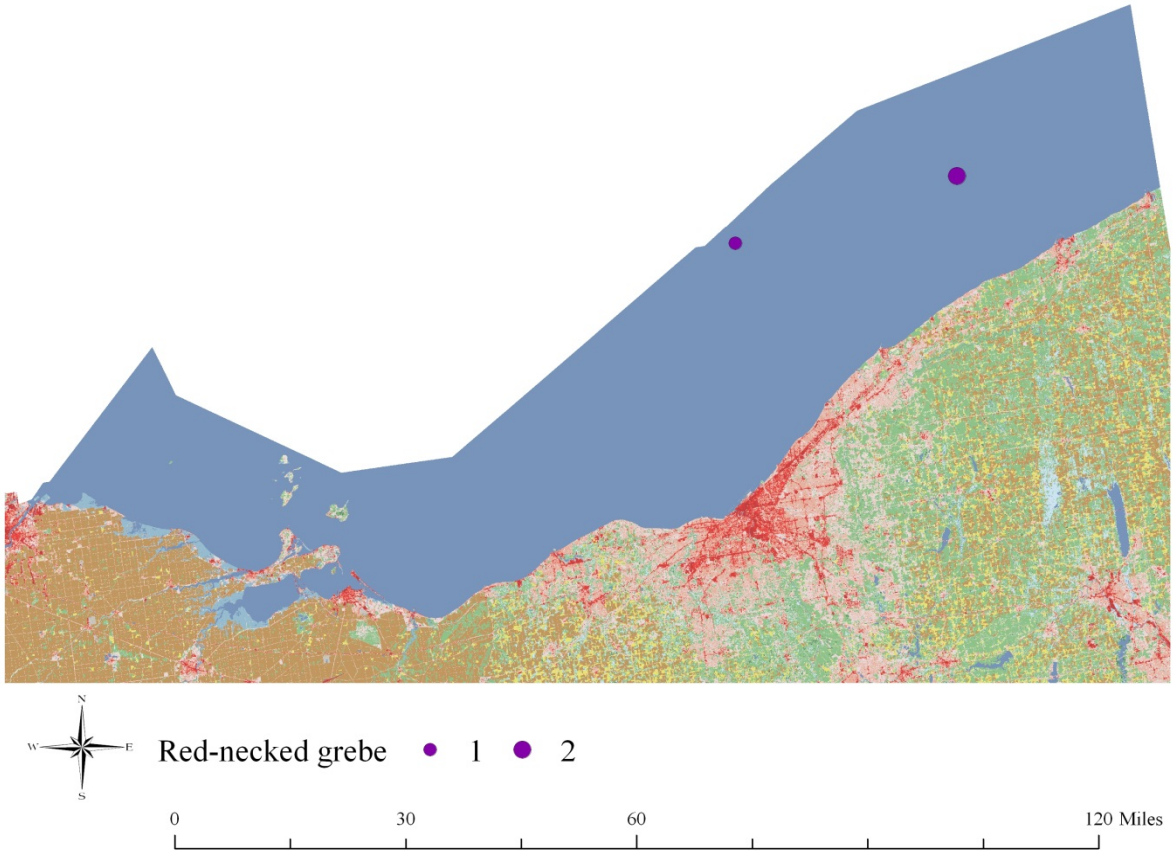
Year 2



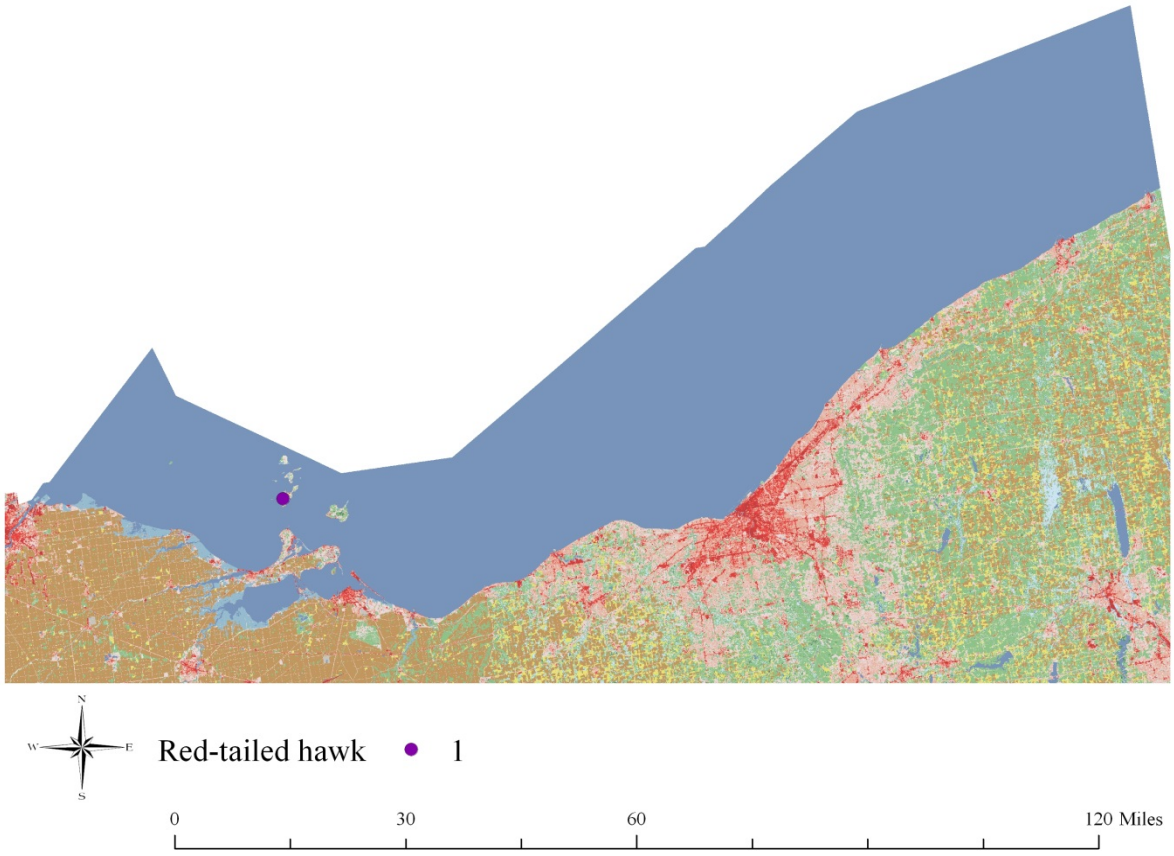
Year 1



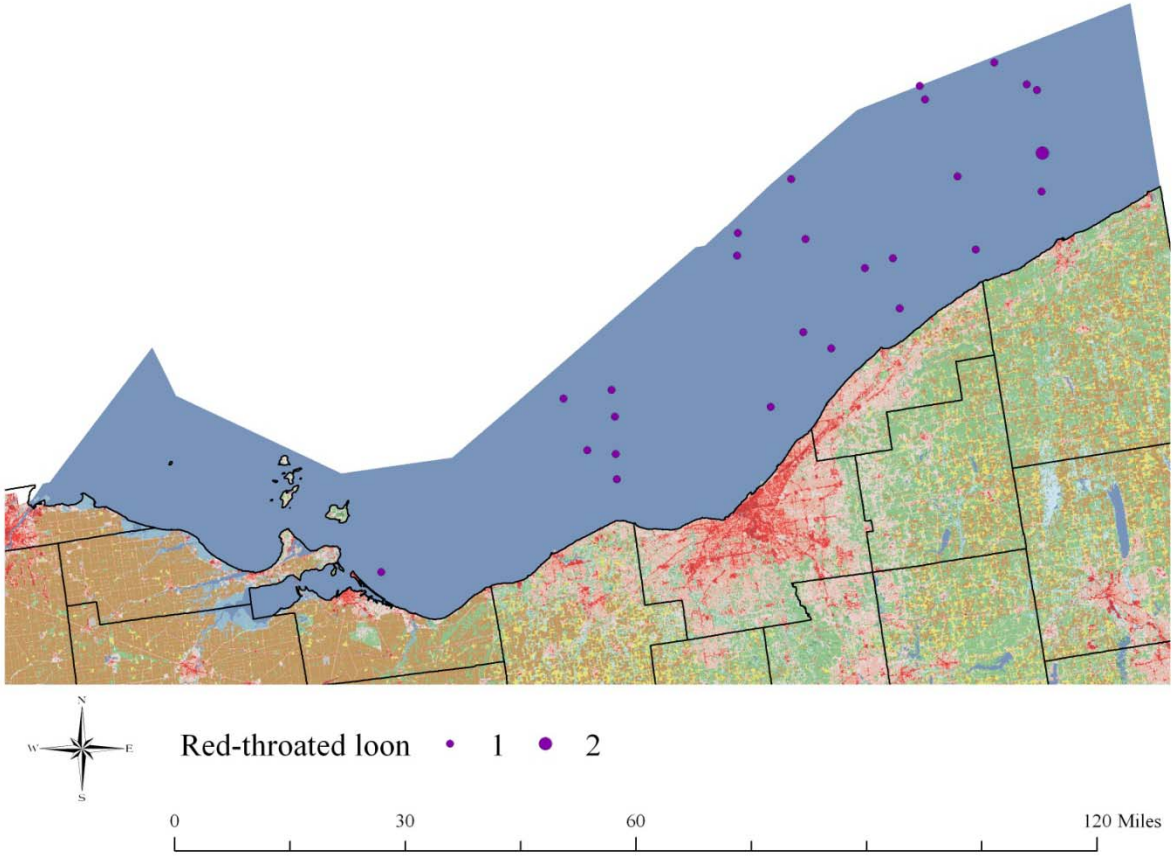
Year 2



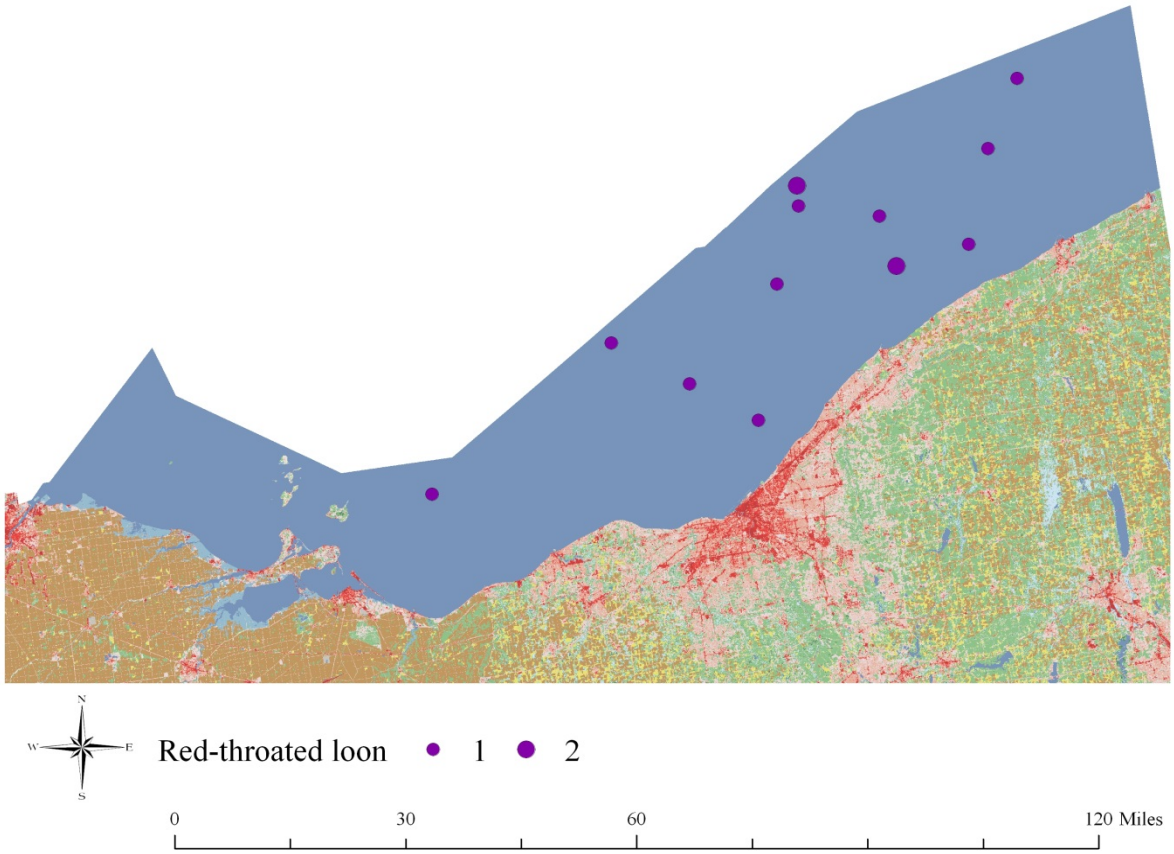
Year 2



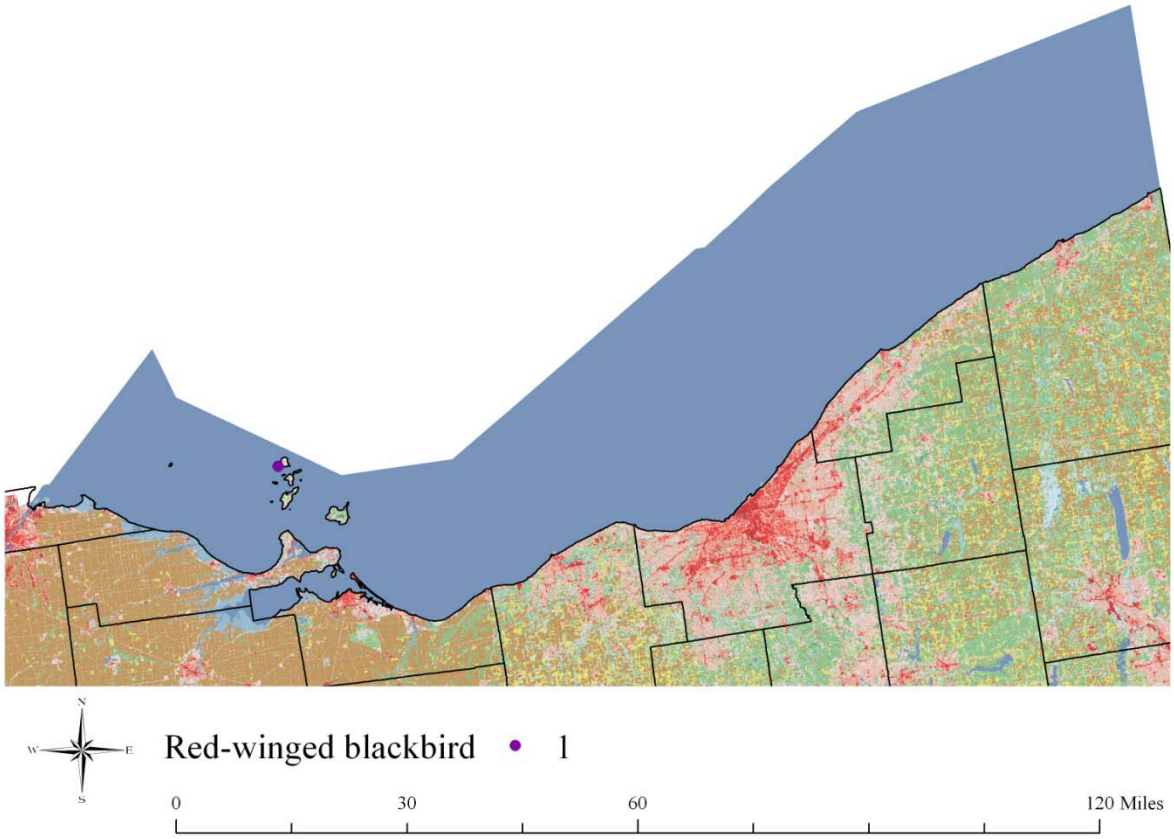
Year 1



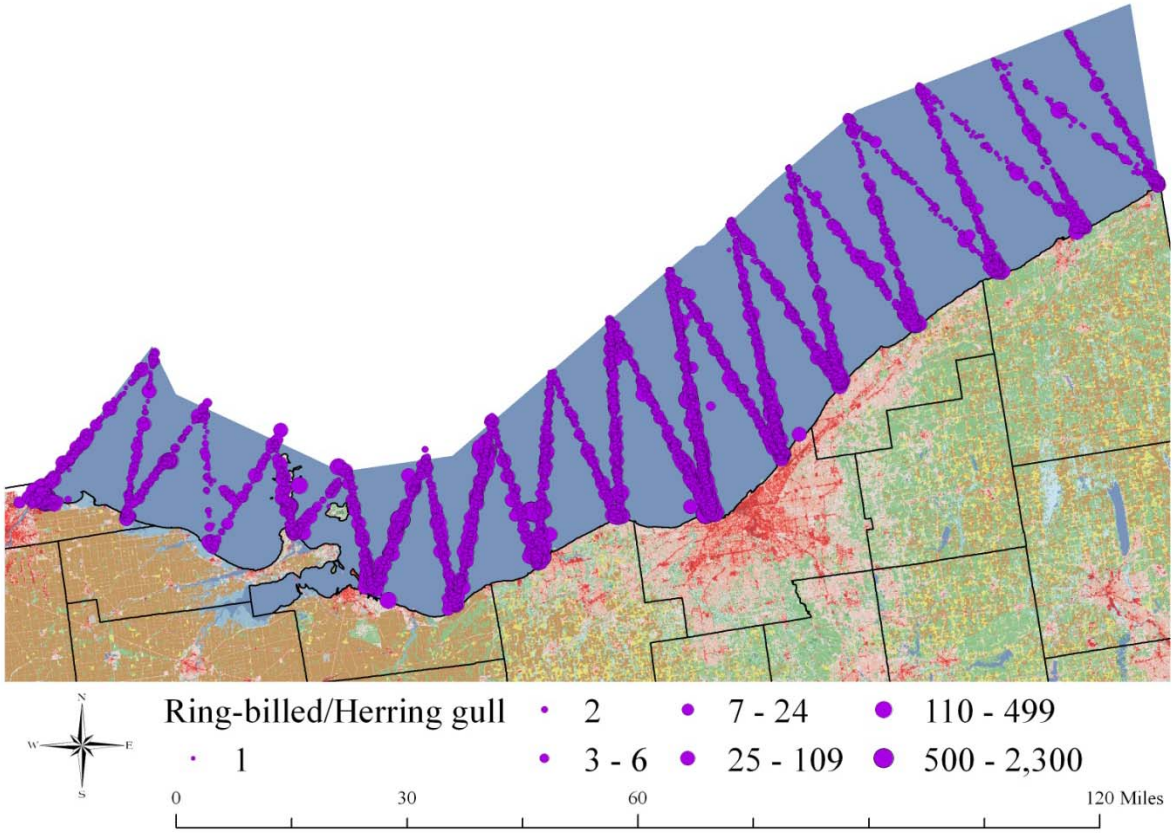
Year 2



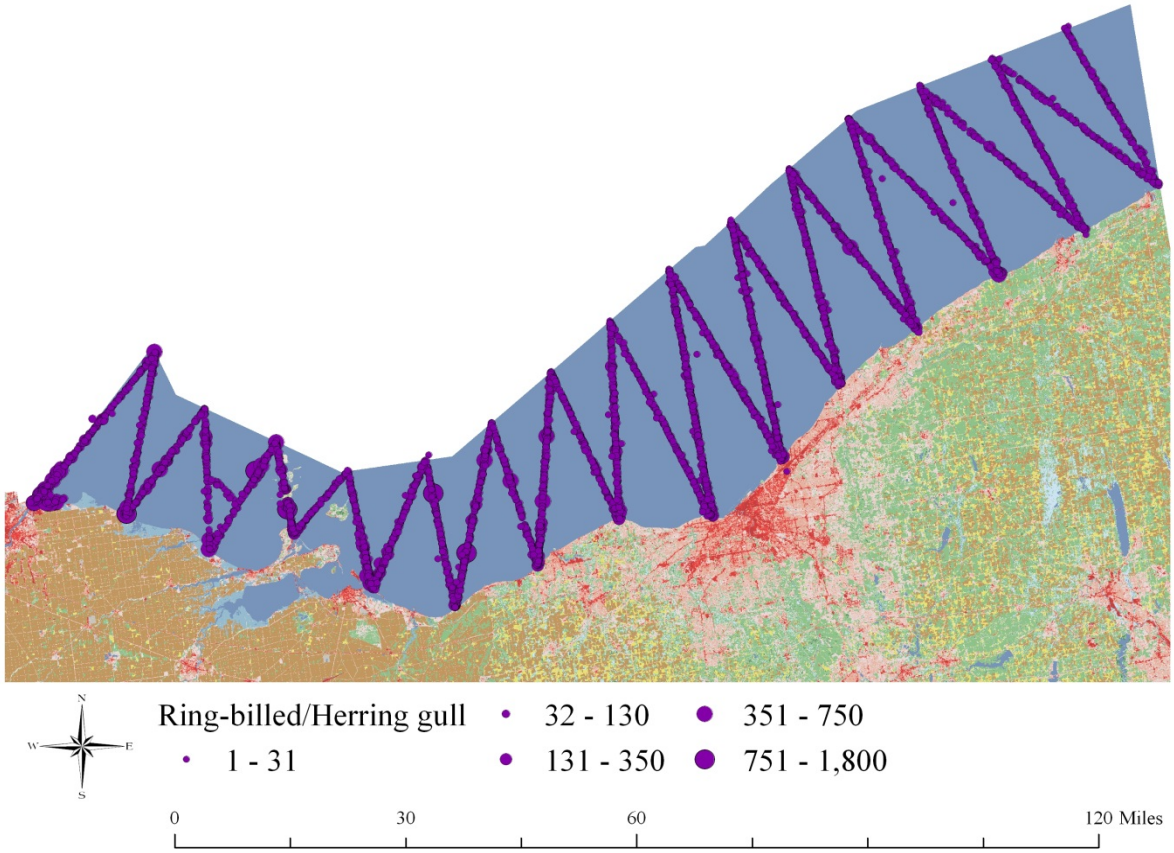
Year 1



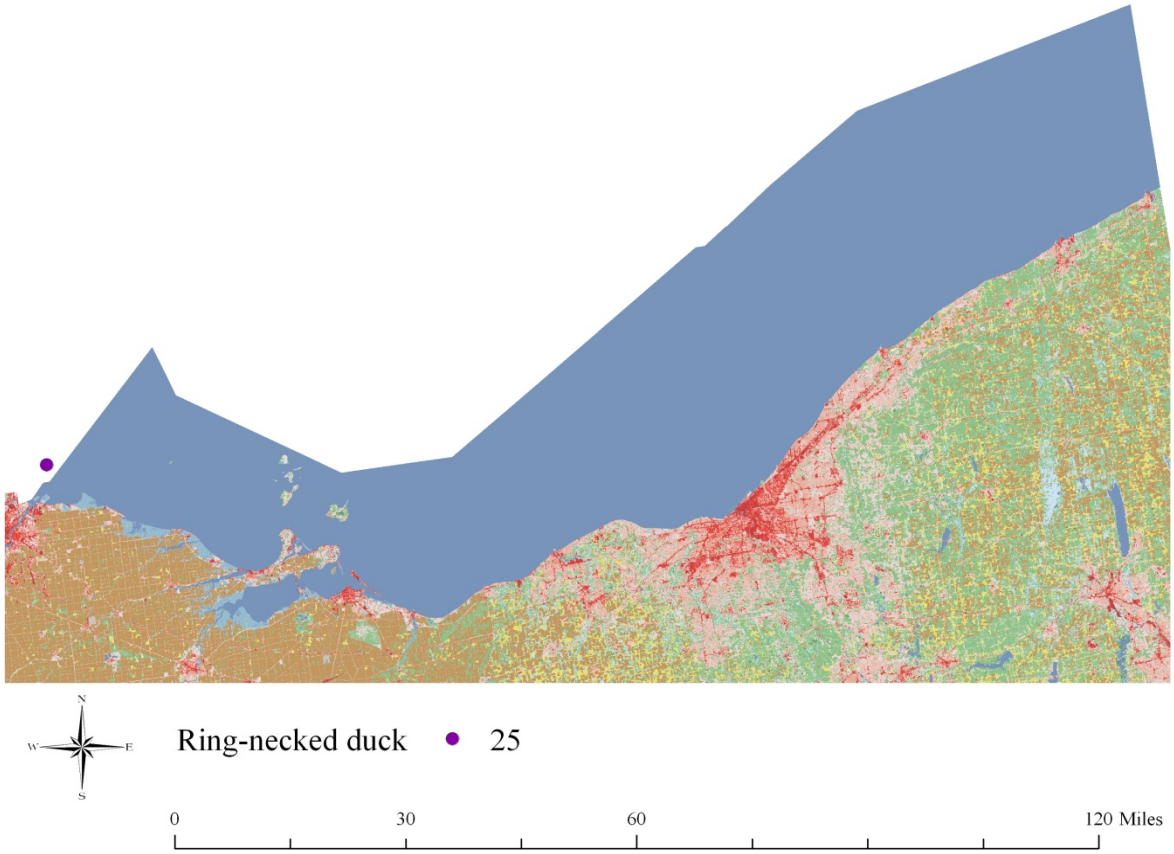
Year 1


Ring-billed/Herring gull
1
2
3 - 6
7 - 24
25 - 109
110 - 499
500 - 2,300
N
W
E
S
0
30
60
120 Miles

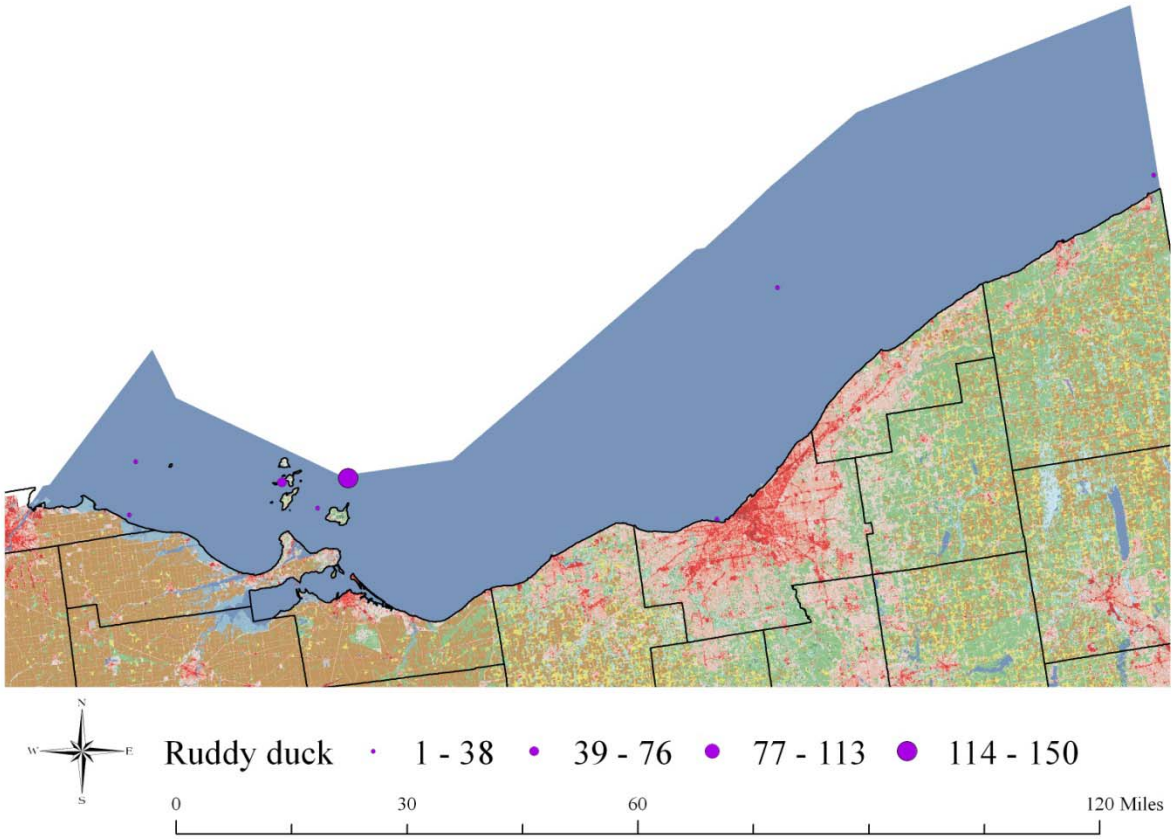
Year 2


N
W
E
S
Ring-billed/Herring gull
1 - 31
32 - 130
131 - 350
351 - 750
751 - 1,800
0
30
60
120 Miles

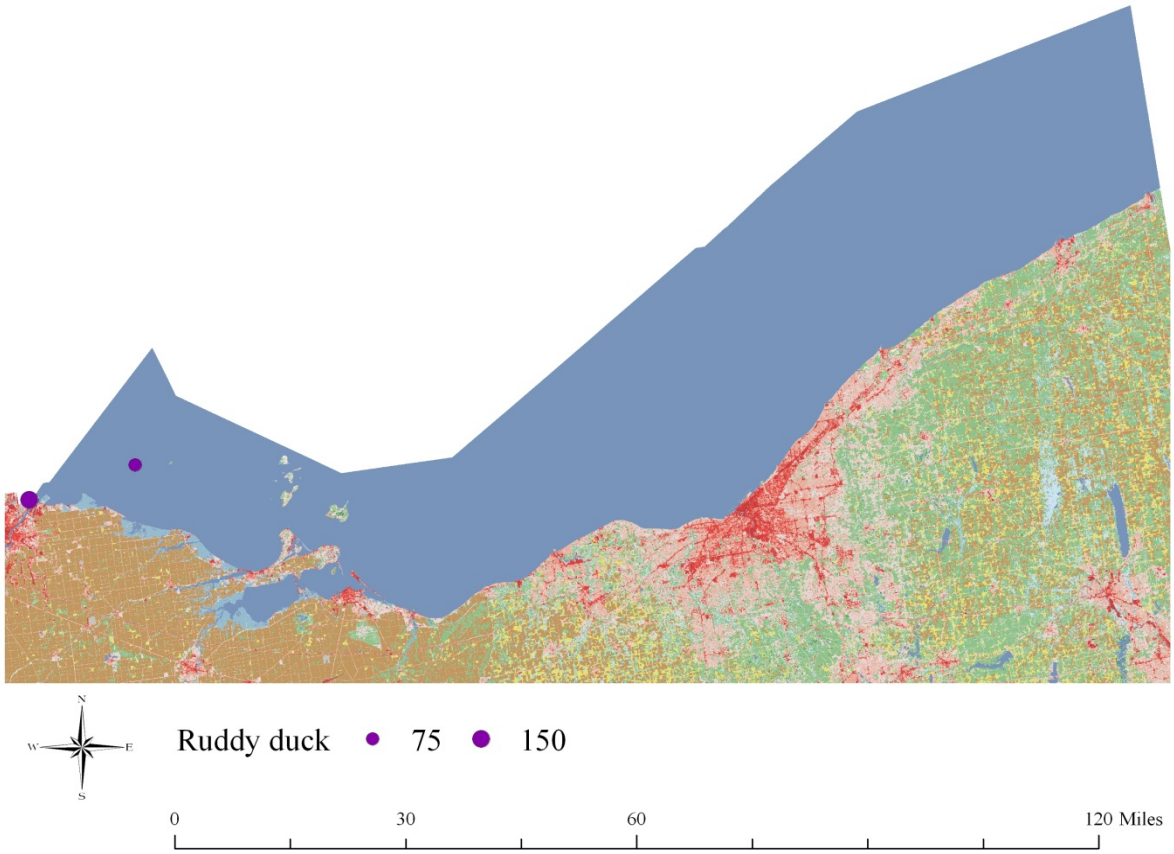
Year 2



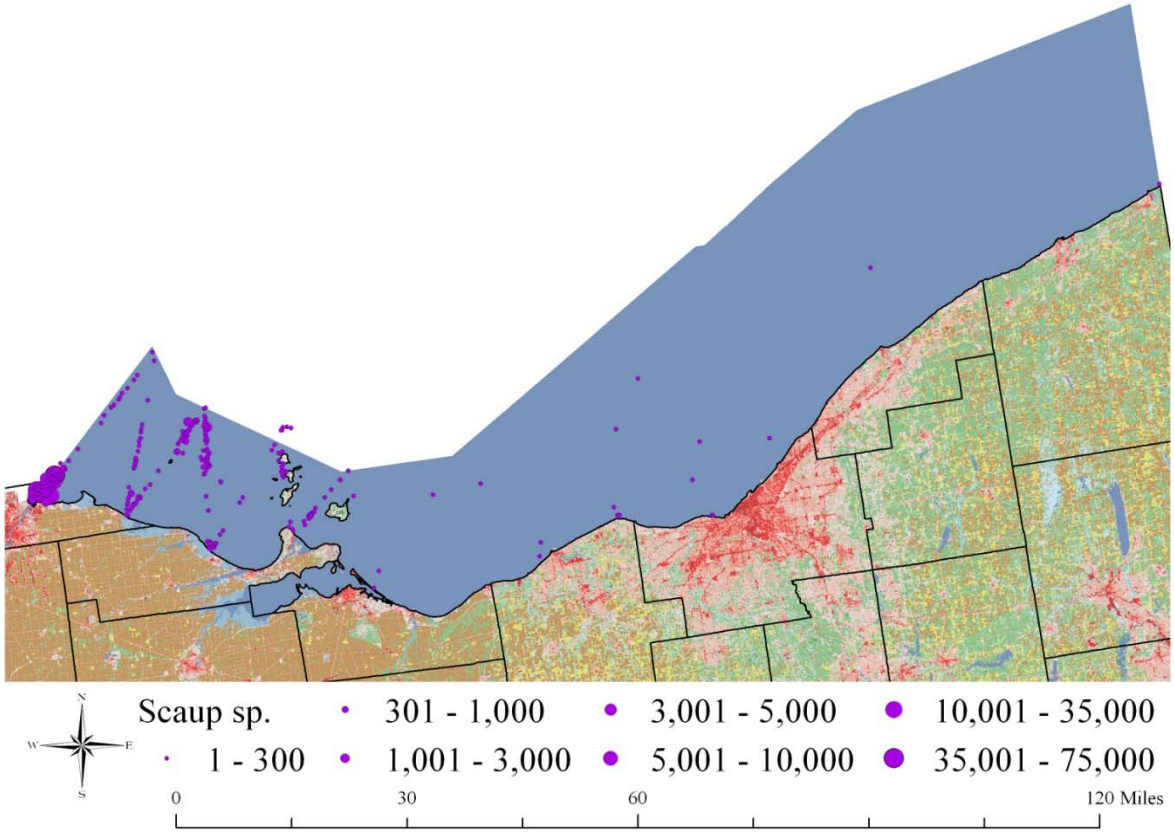
Year 1



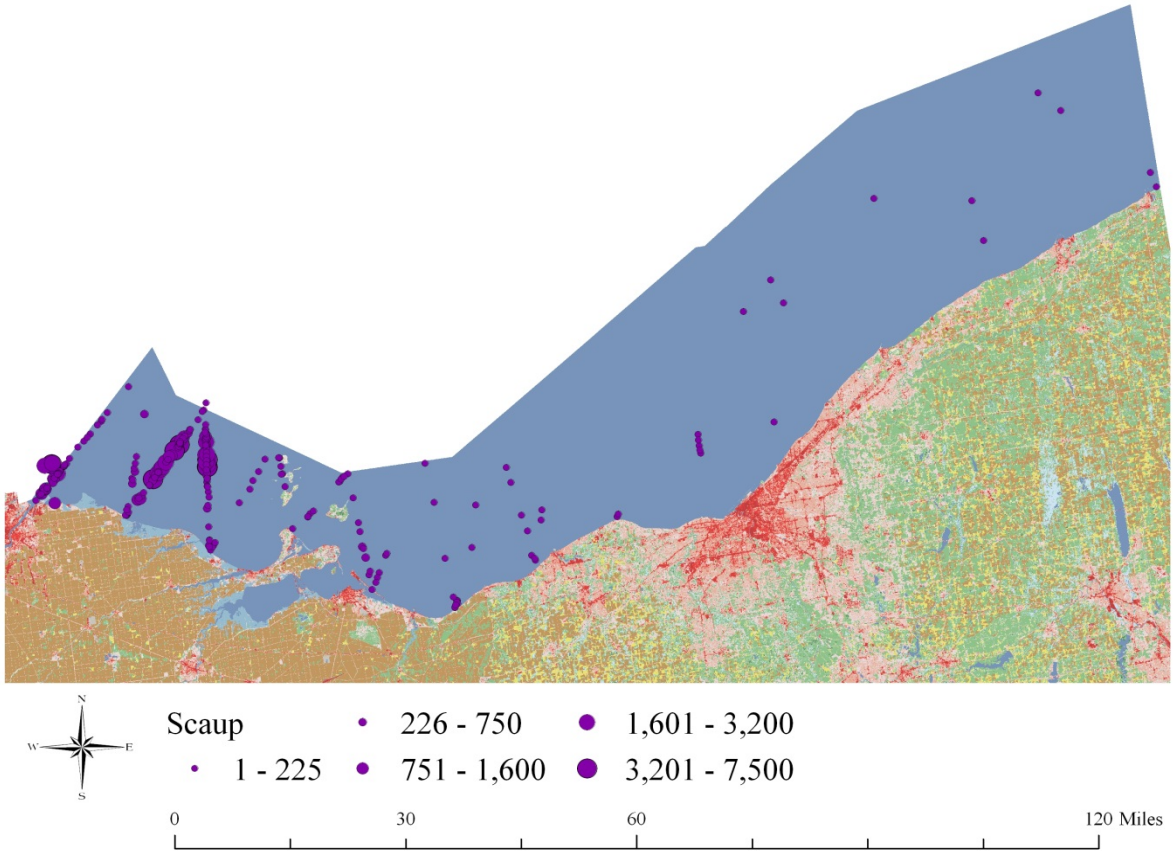
Year 2



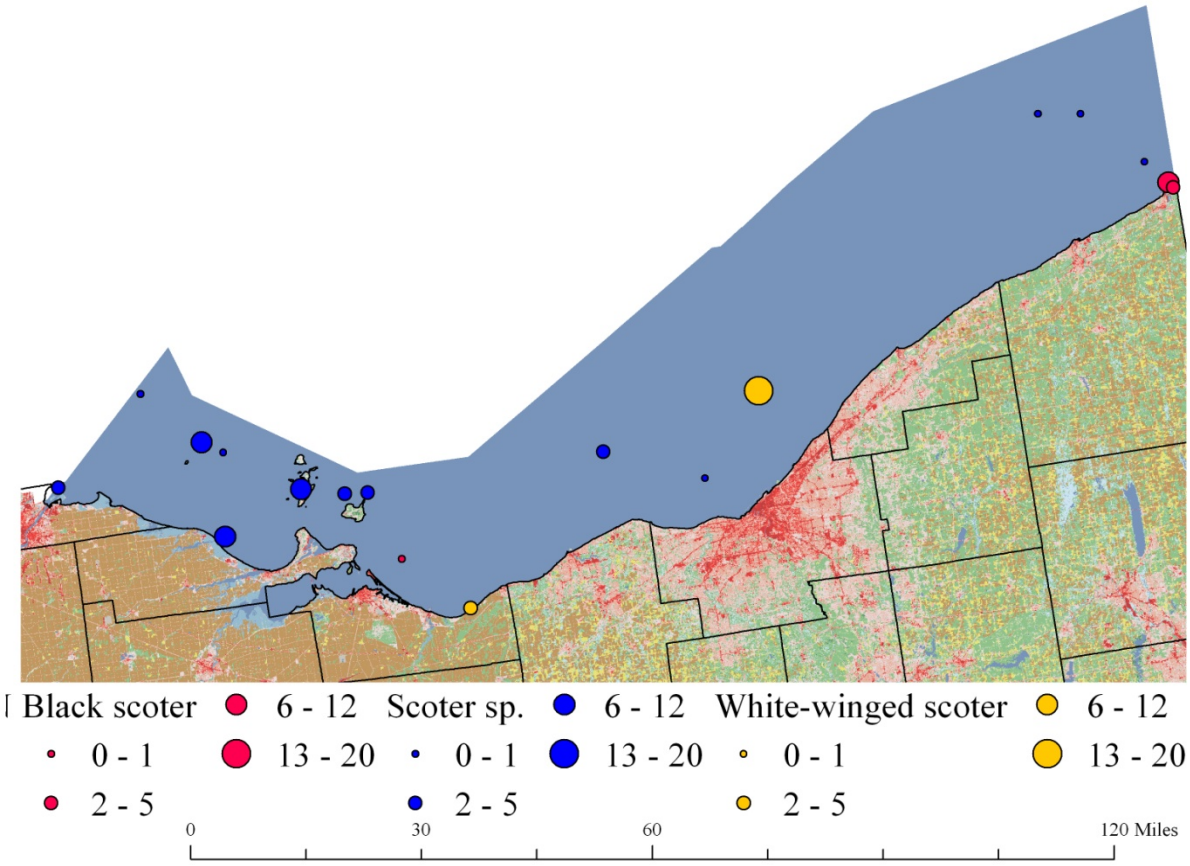
Year 1


Scaup sp.
1 - 300
301 - 1,000
1,001 - 3,000
3,001 - 5,000
5,001 - 10,000
10,001 - 35,000
35,001 - 75,000
N
W
E
S
0
30
60
120 Miles

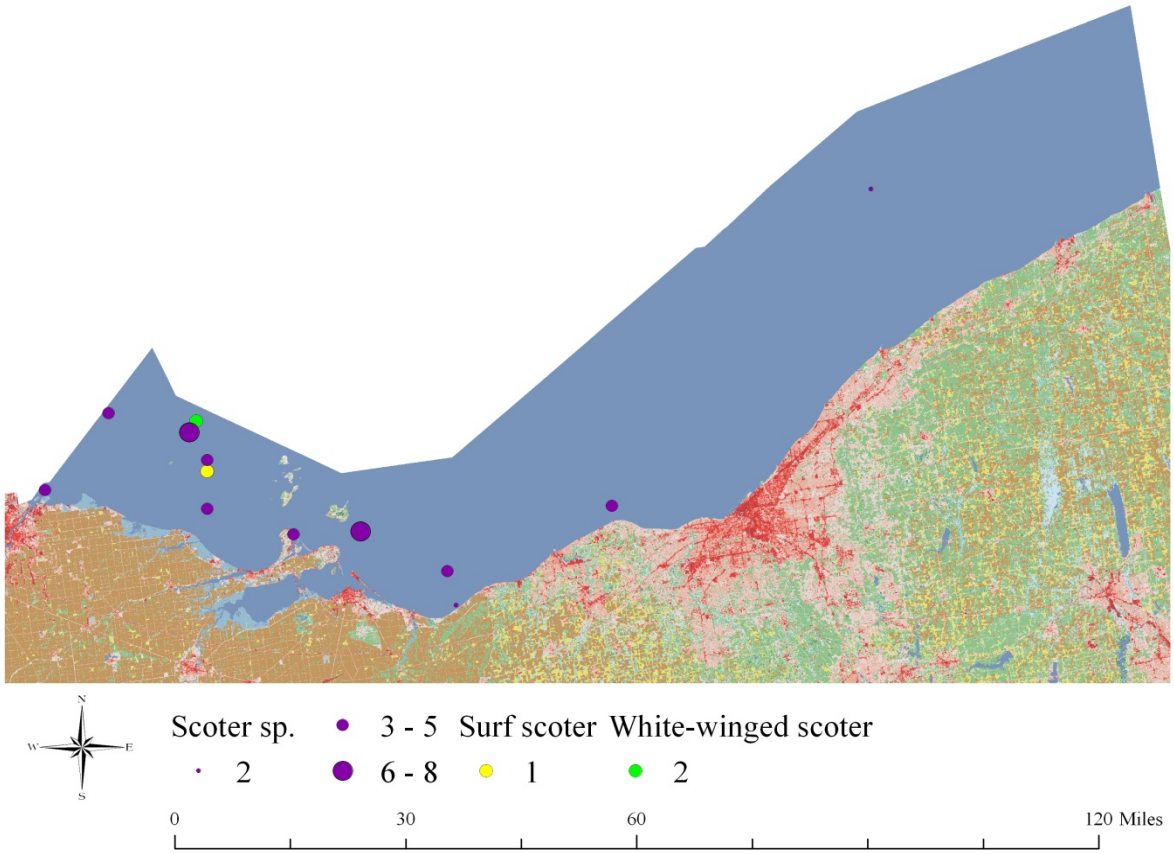
Year 2


N
W
E
S
Scaup
1 - 225
226 - 750
751 - 1,600
1,601 - 3,200
3,201 - 7,500
0
30
60
120 Miles

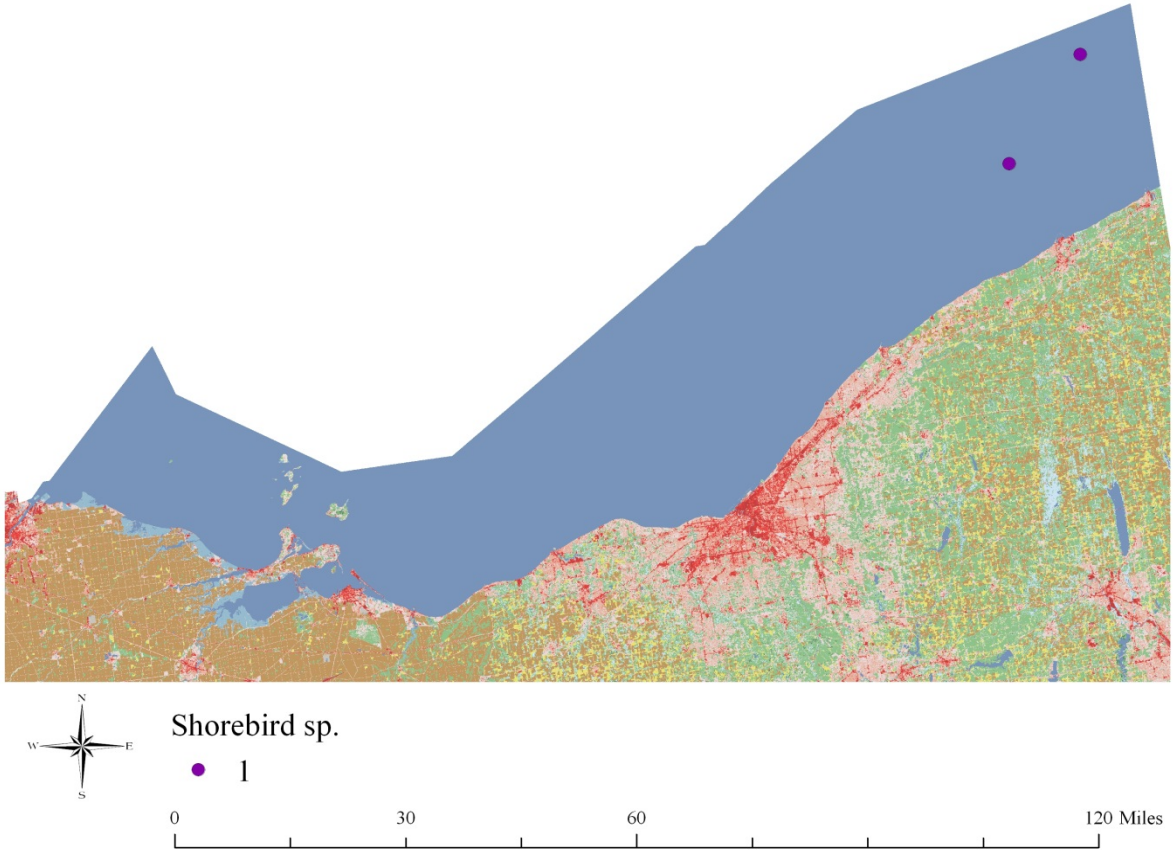
Year 1


Black scoter
0 - 1
2 - 5
6 - 12
13 - 20
Scoter sp.
0 - 1
2 - 5
6 - 12
13 - 20
White-winged scoter
0 - 1
2 - 5
6 - 12
13 - 20
0
30
60
120 Miles

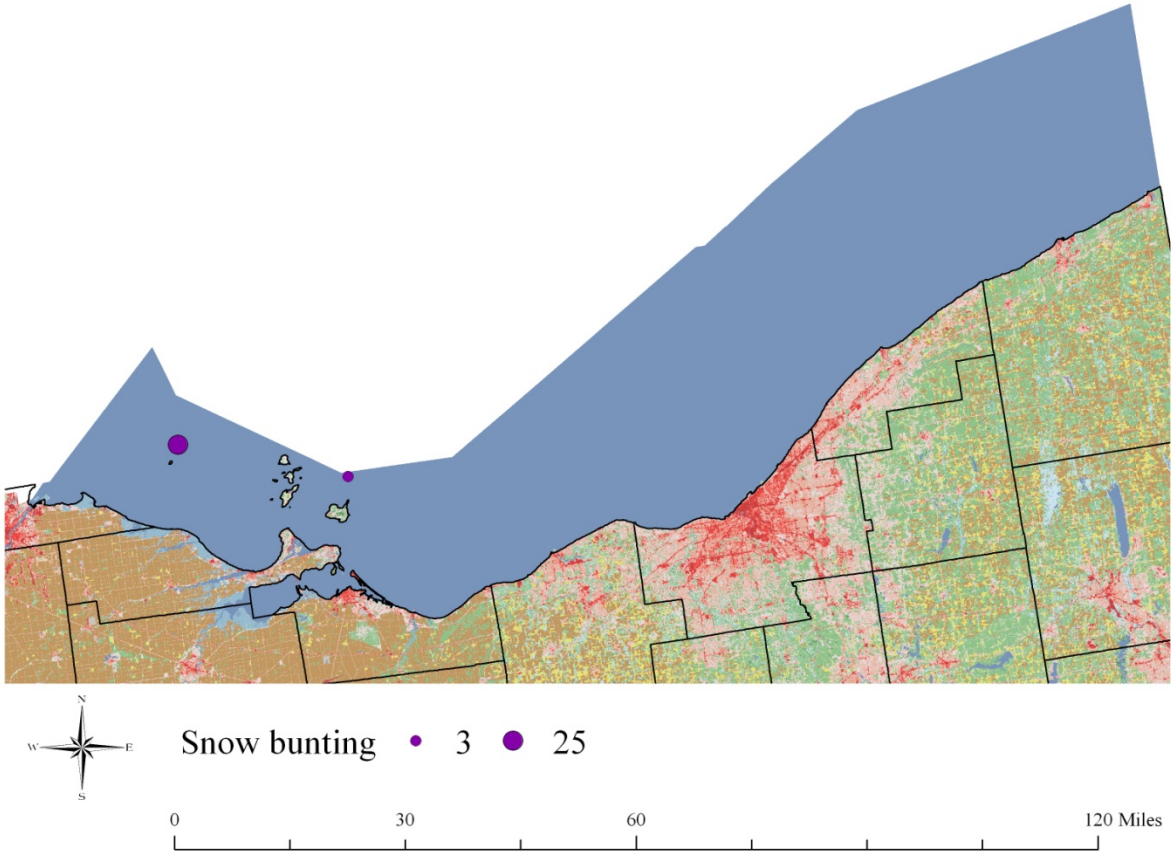
Year 2


N
W
E
S
Scoter sp.
2
3 - 5
6 - 8
Surf scoter
1
White-winged scoter
2
0
30
60
120 Miles

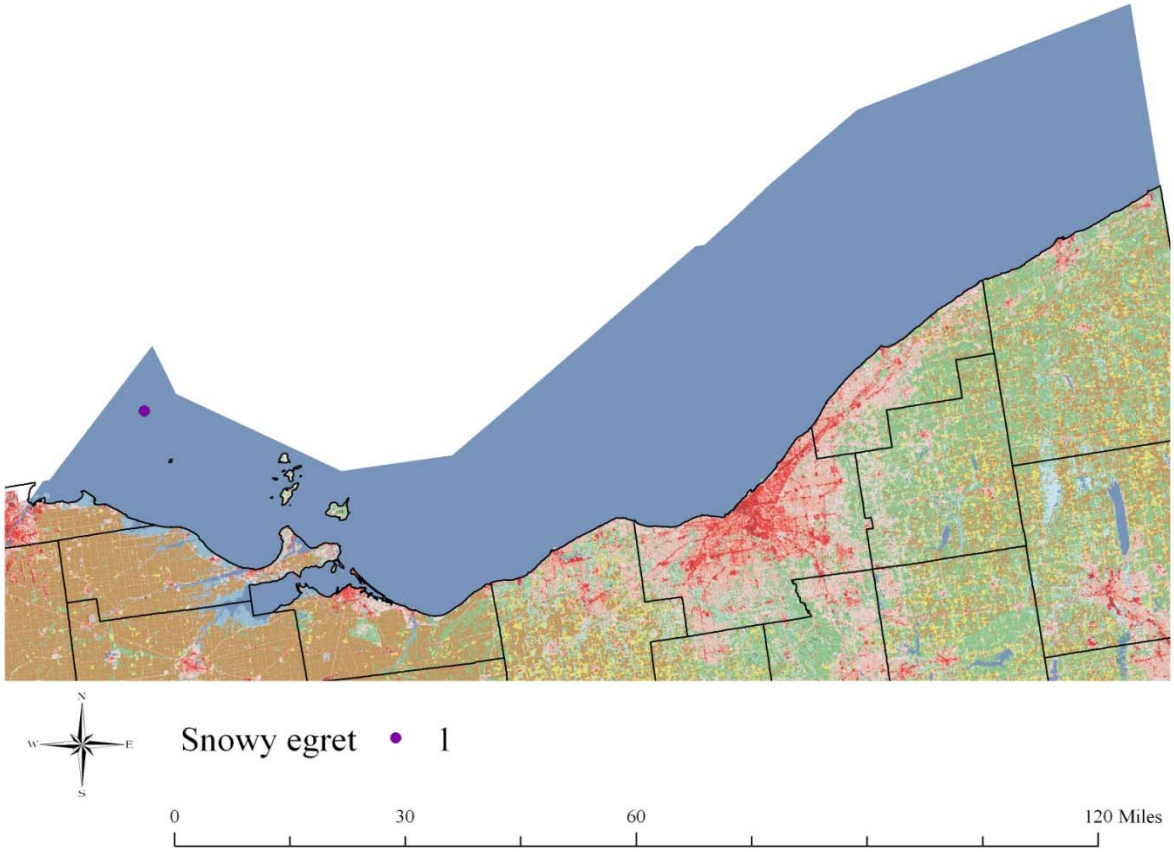
Year 2



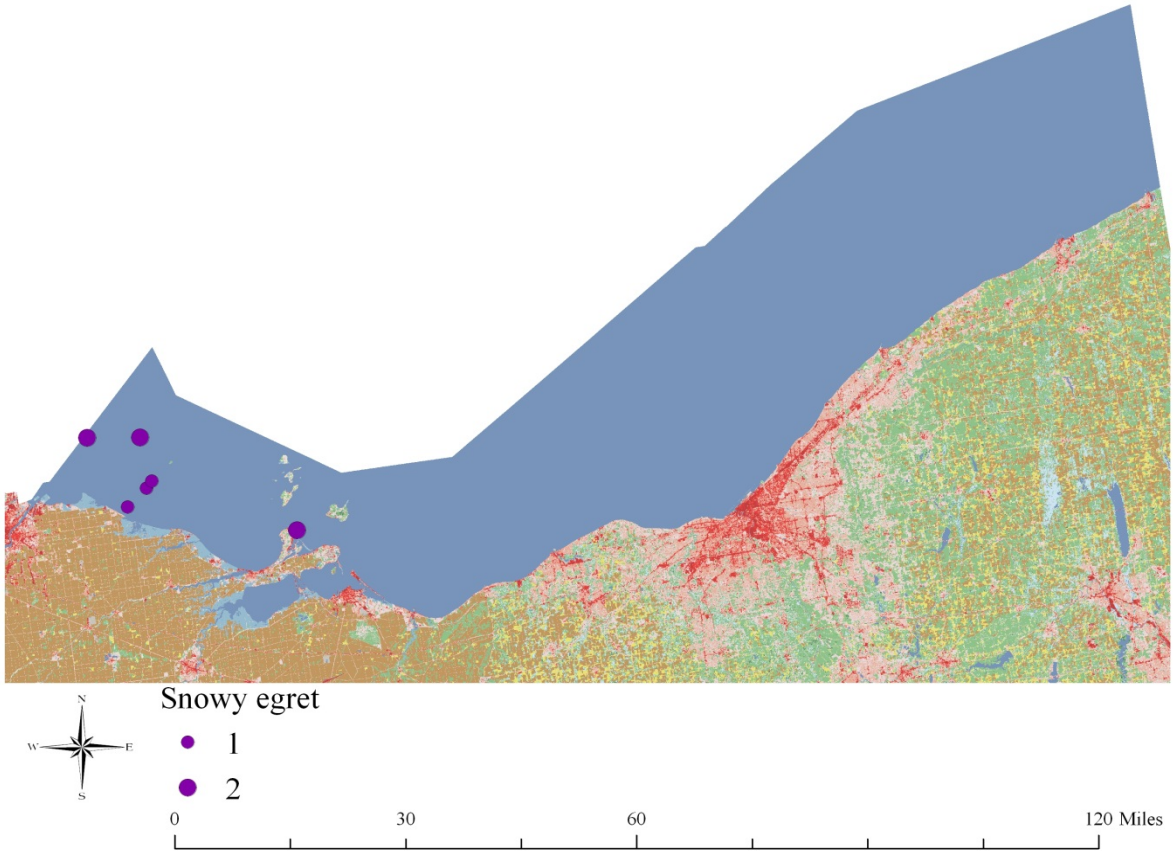
Year 1



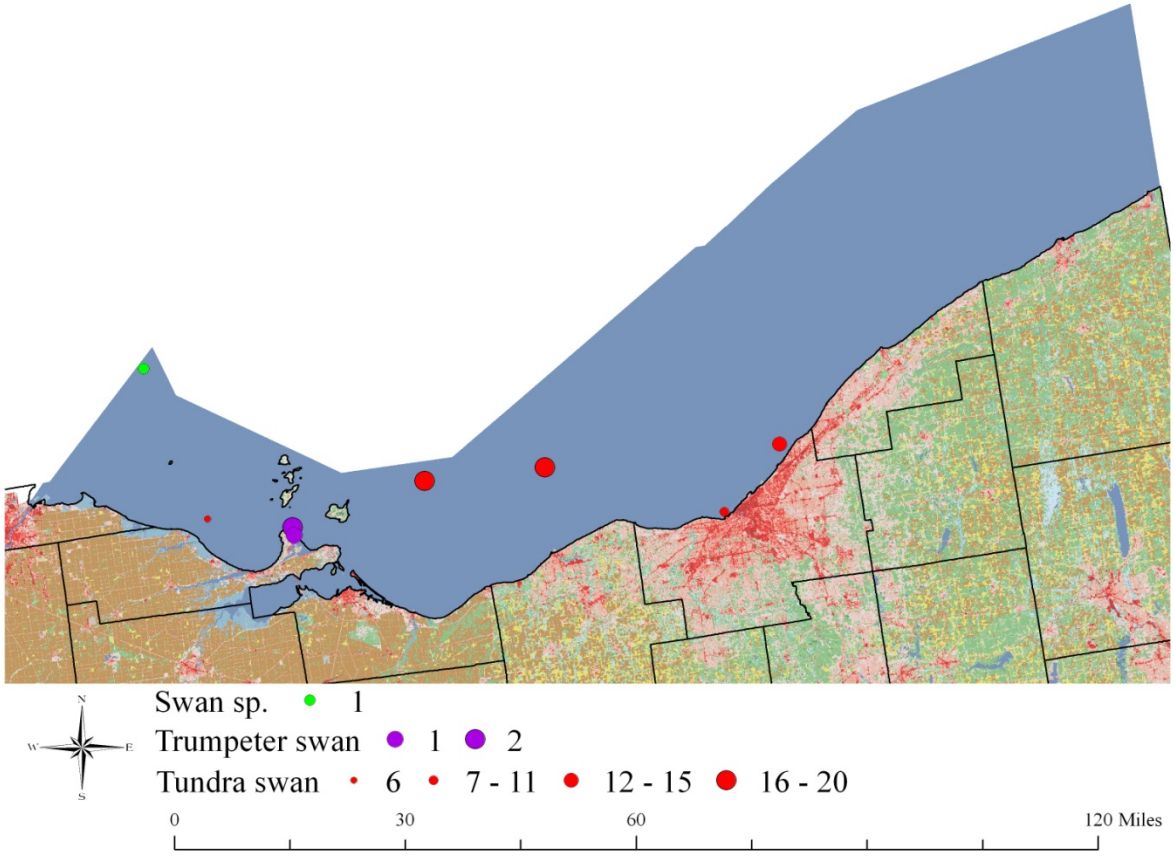
Year 1



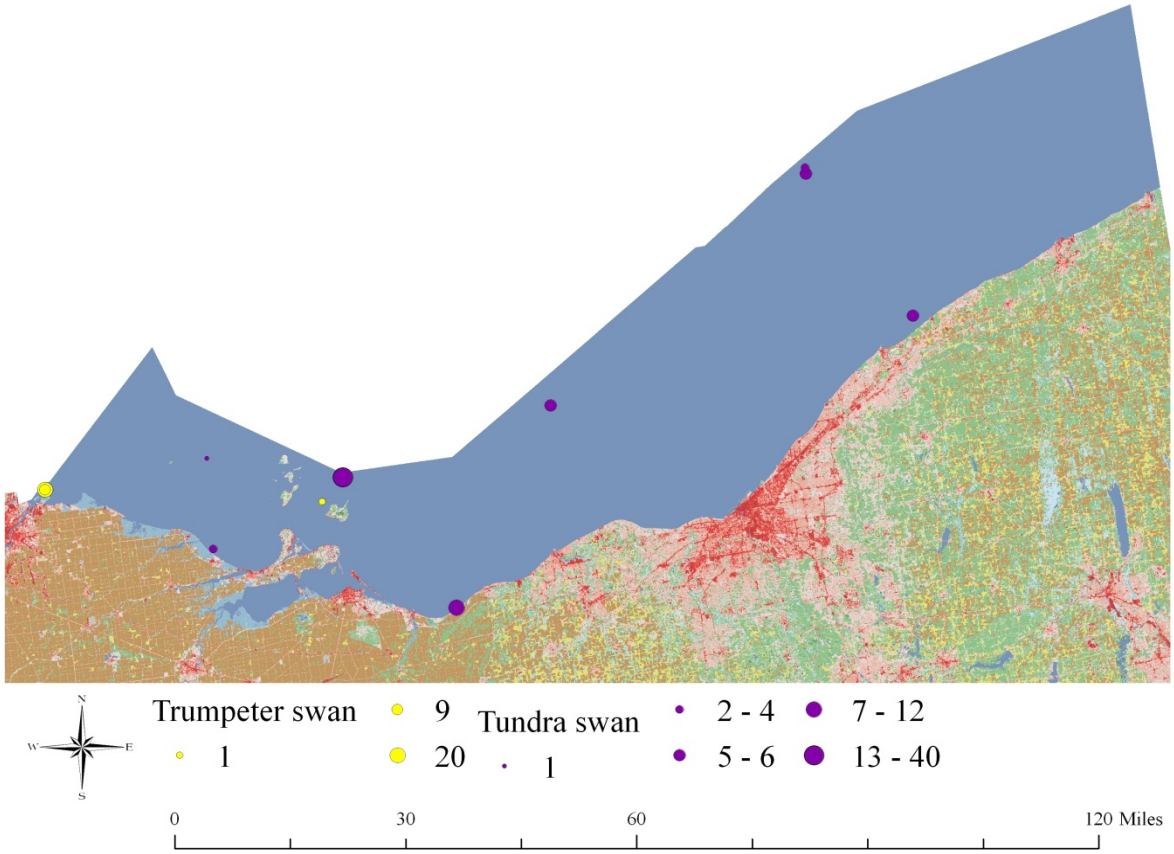
Year 2



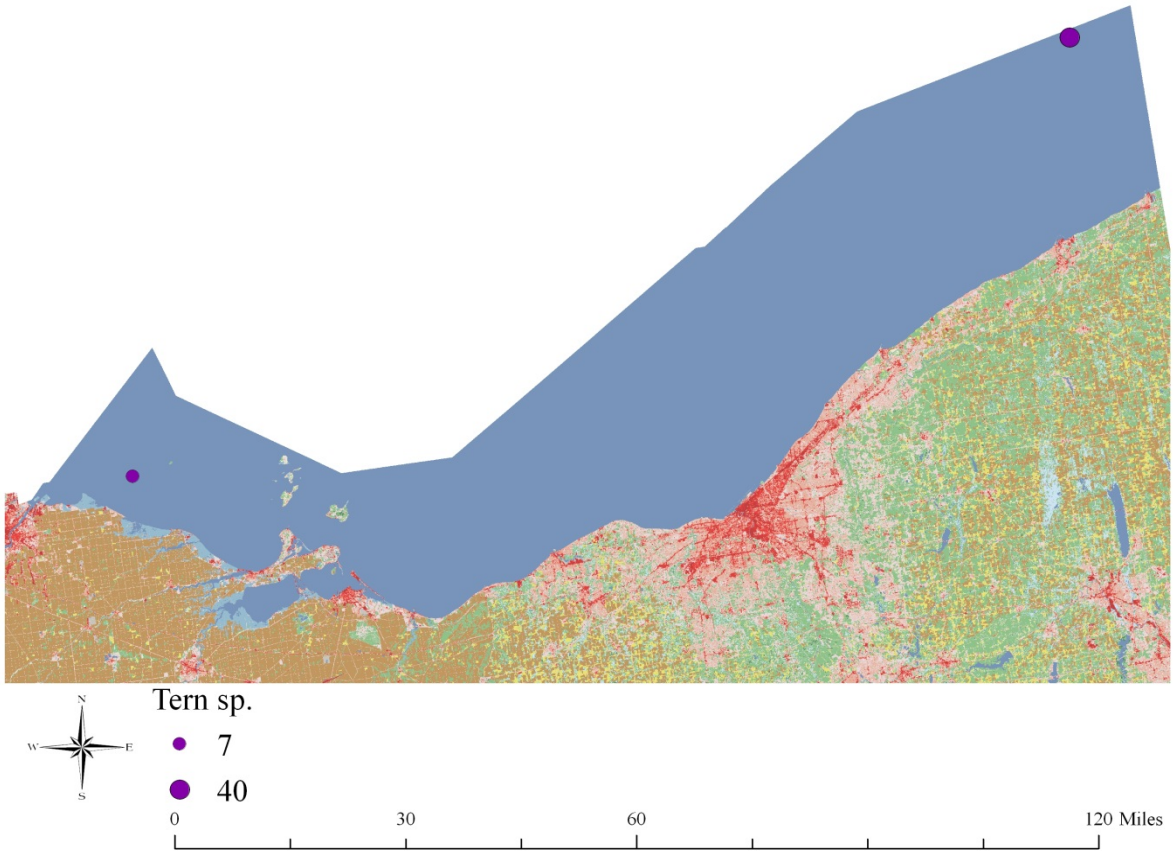
Year 1


N
W
E
S
Swan sp. 1
Trumpeter swan 1 2
Tundra swan 6 7 - 11 12 - 15 16 - 20
0
30
60
120 Miles

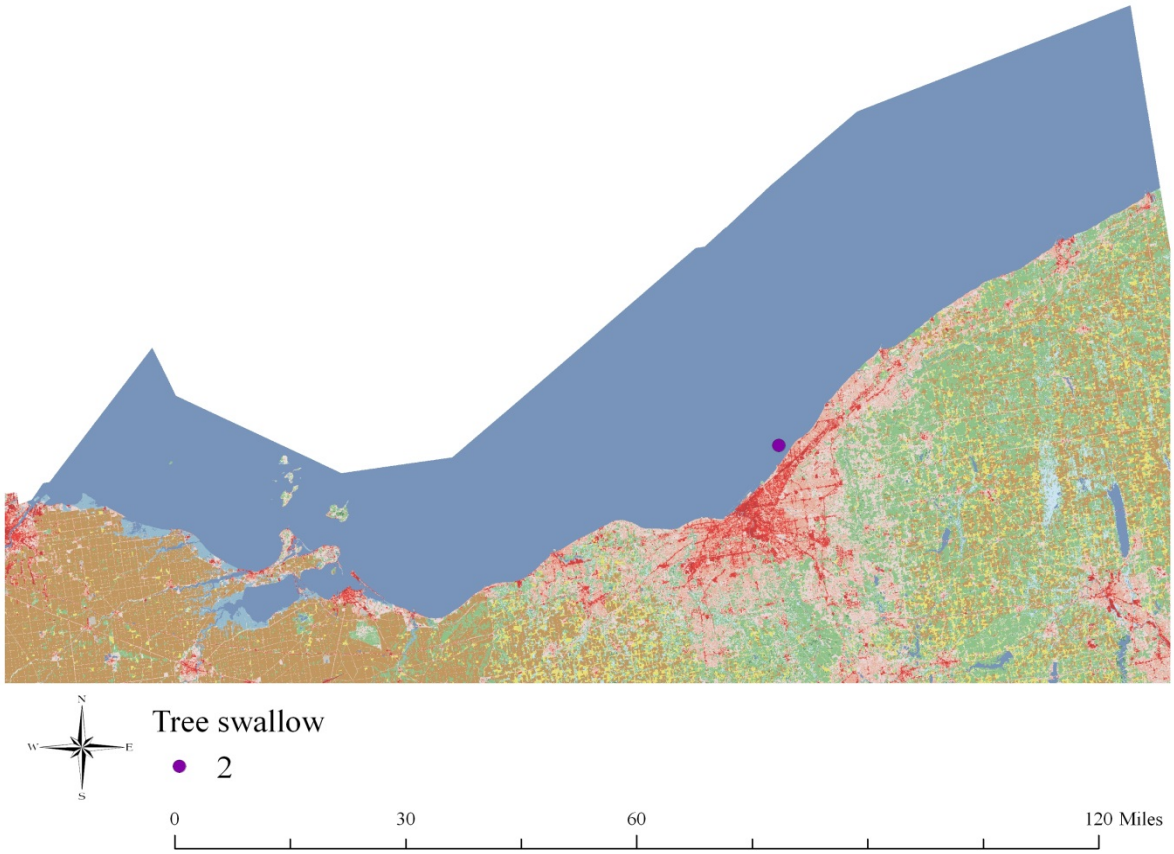
Year 2


Trumpeter swan
1
9
20
Tundra swan
1
2 - 4
5 - 6
7 - 12
13 - 40
N
W
E
S
0
30
60
120 Miles

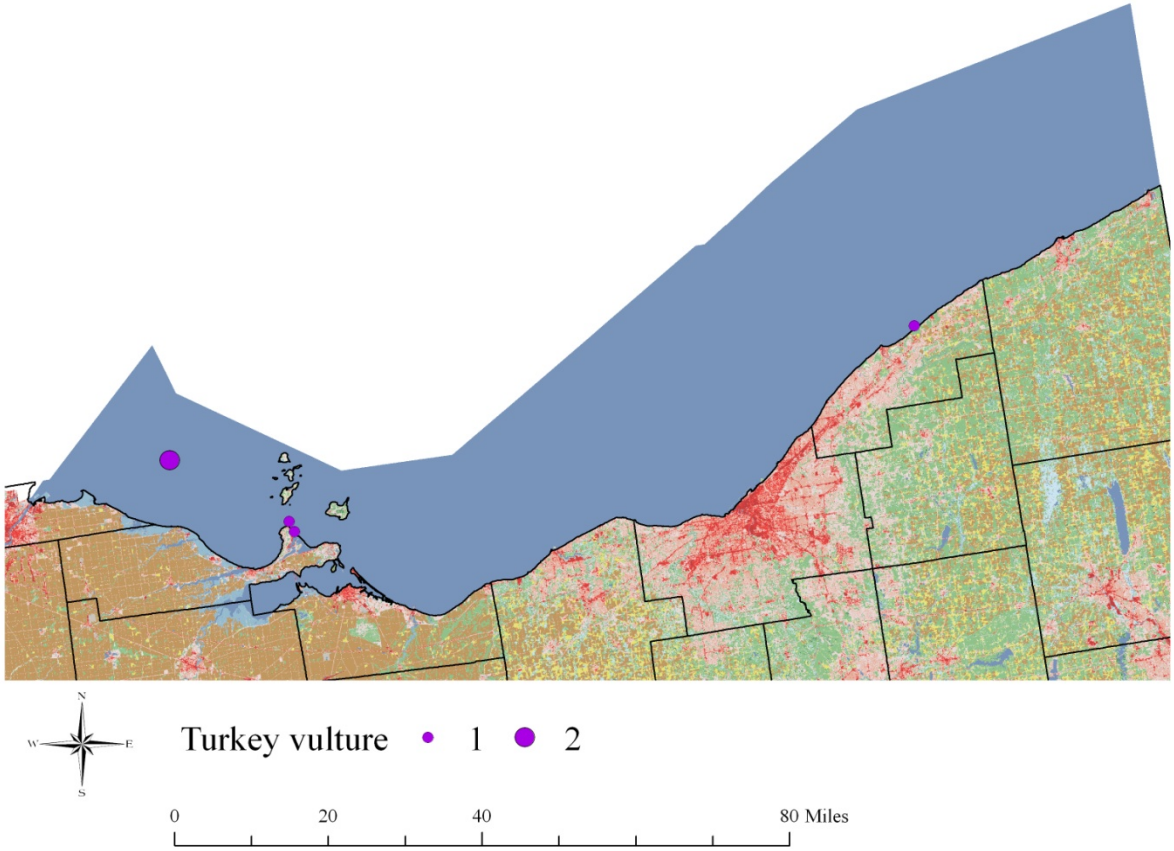
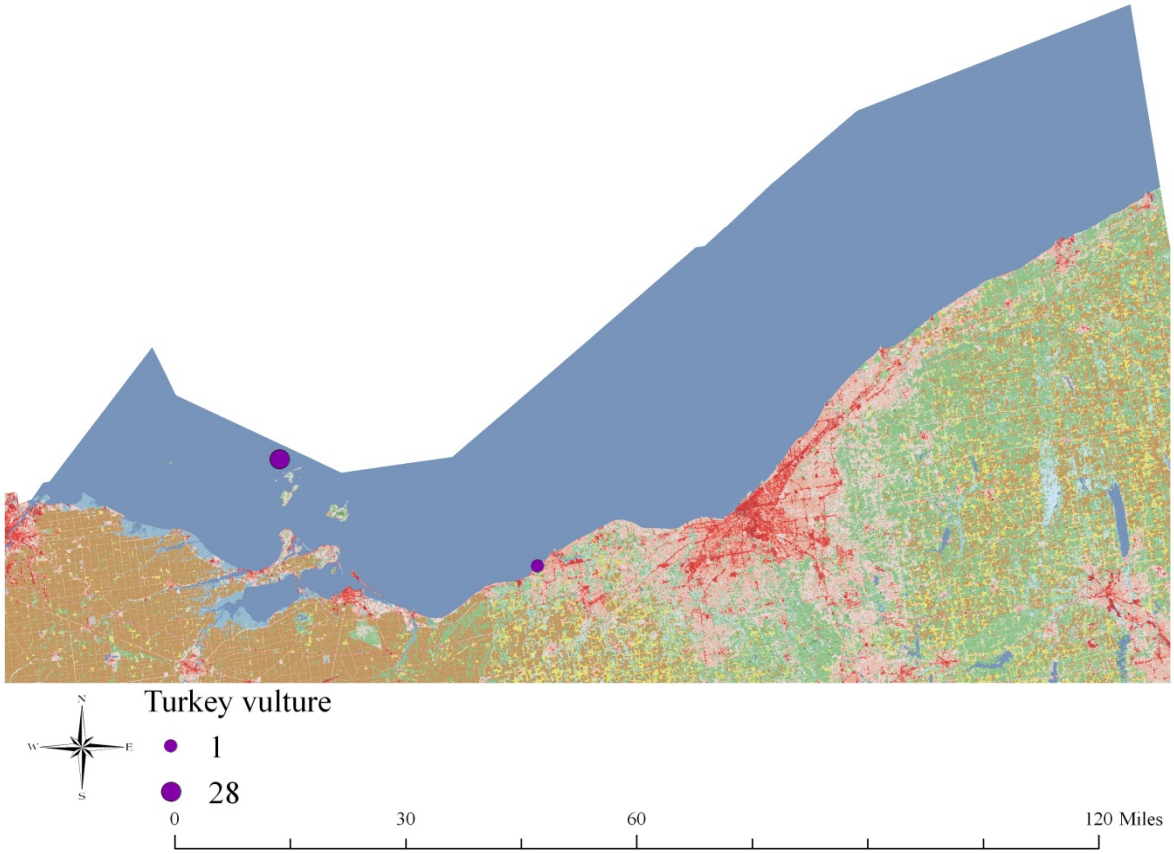
Year 2



Year 2



Year 1



Year 2