The Effects of Urbanization Measures on Bird Species Richness in Massachusetts

Background

Documenting species distribution and determining the factors underlying those distributions are fundamental practices in ecology that allow us to direct monitoring efforts for species into appropriate habitat and to manipulate habitat to make it more suitable for species of conservation concern. In addition to aiding in species conservation efforts, studying animal behavior is sometimes a good indicator of areas that should be of concern to human health as well.

As might be predicted, urbanization tends to have negative effects on communities. With regards to avian communities, studies have found that bird densities increase, but richness and evenness decreased in response to urbanization.[1] While the pattern has been documented, it is unclear what mechanism underlies this relationship.

Virginia Rail
photo: Bill Schmoker

- Pied-billed Grebe (Endangered)
- American Bittern (Endangered)
- Least Bittern (Endangered)
- King Rail (Threatened)
- Common Moorhen (Special Concern)
- Sedge Wren (Endangered)

American Bittern
Photos: Bill Schmoker

Data Sources: MassWildlife
http://www.mass.gov/dfwele/dfw/nhesp/conservation/birds/marsh_bird_survey.htm

[1]Marzluff, J.M. 2001. Worldwide urbanization and its effects on birds. In *Avian Ecology and Conservation in an Urbanizing World* (Marzluff, J.M. et al., eds), pp. 19–38, Kluwer Academic Publisher.
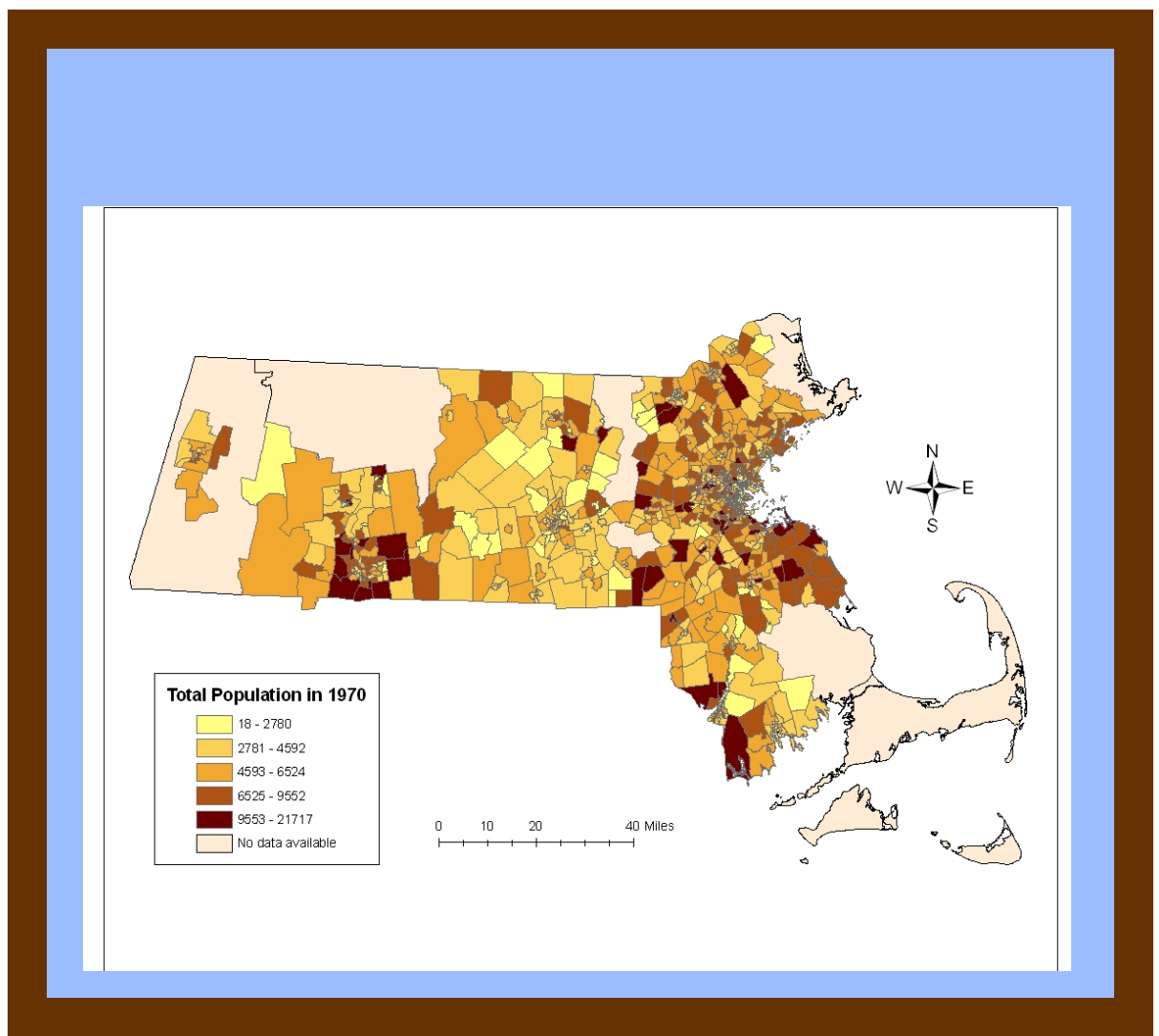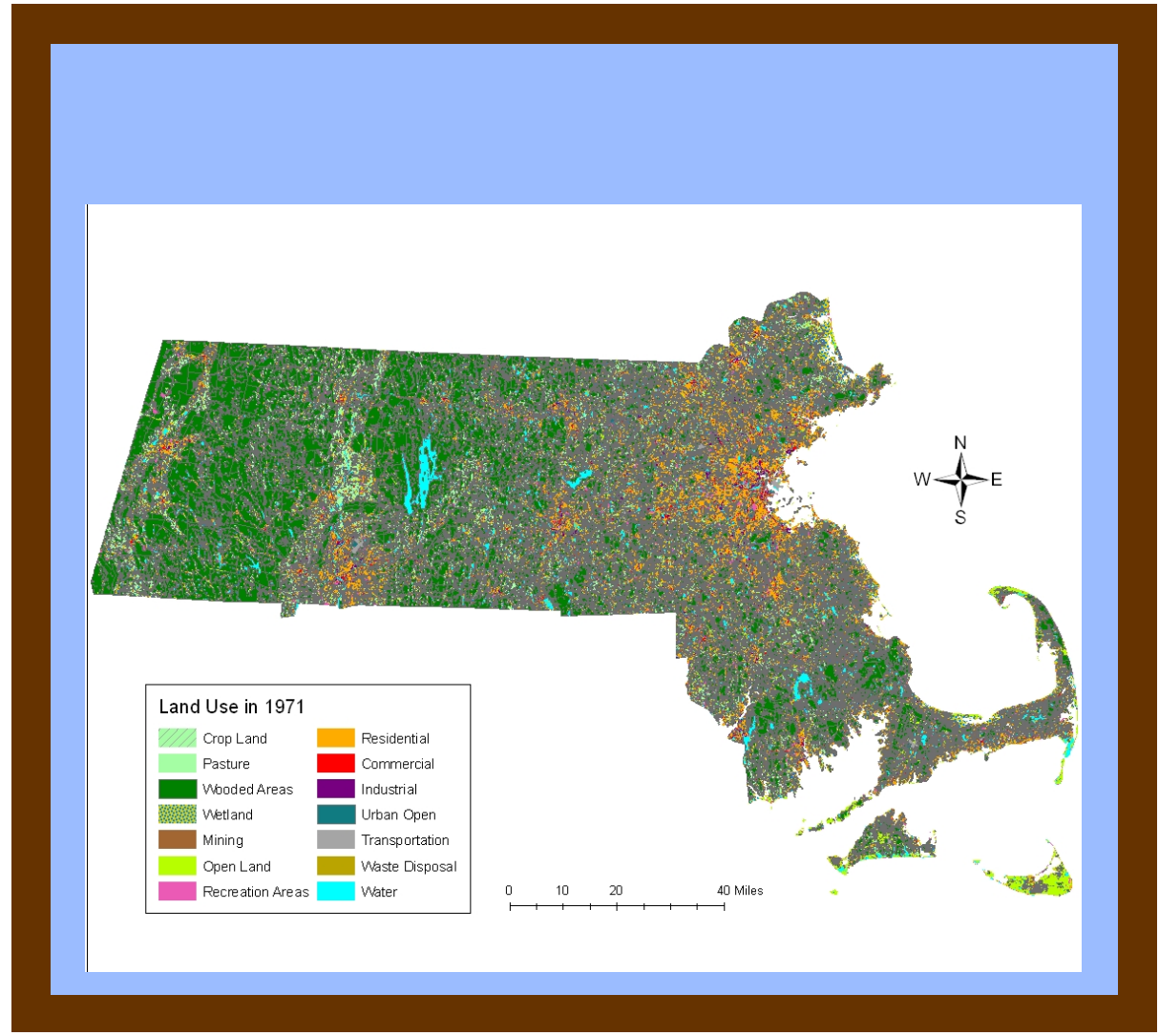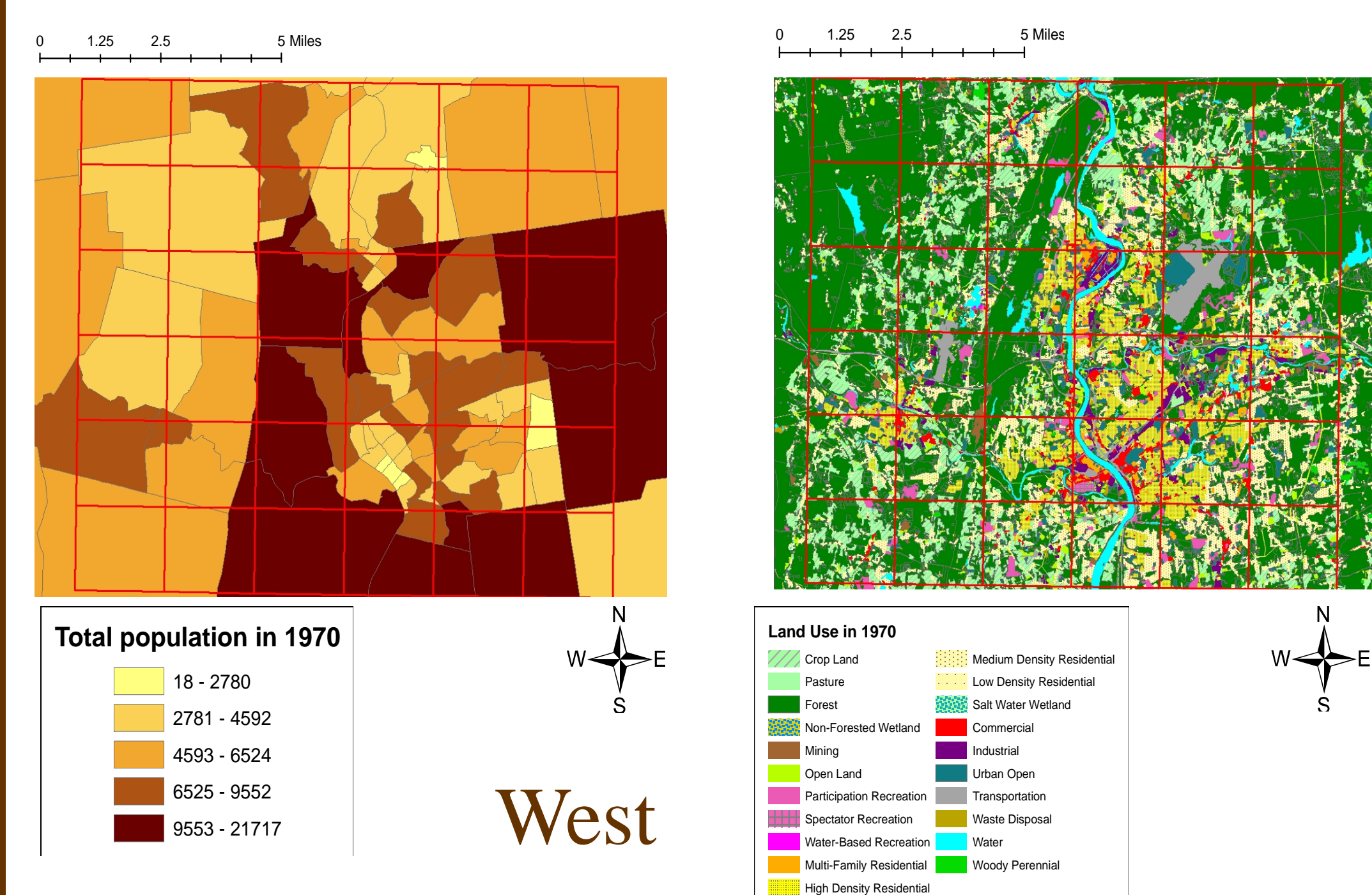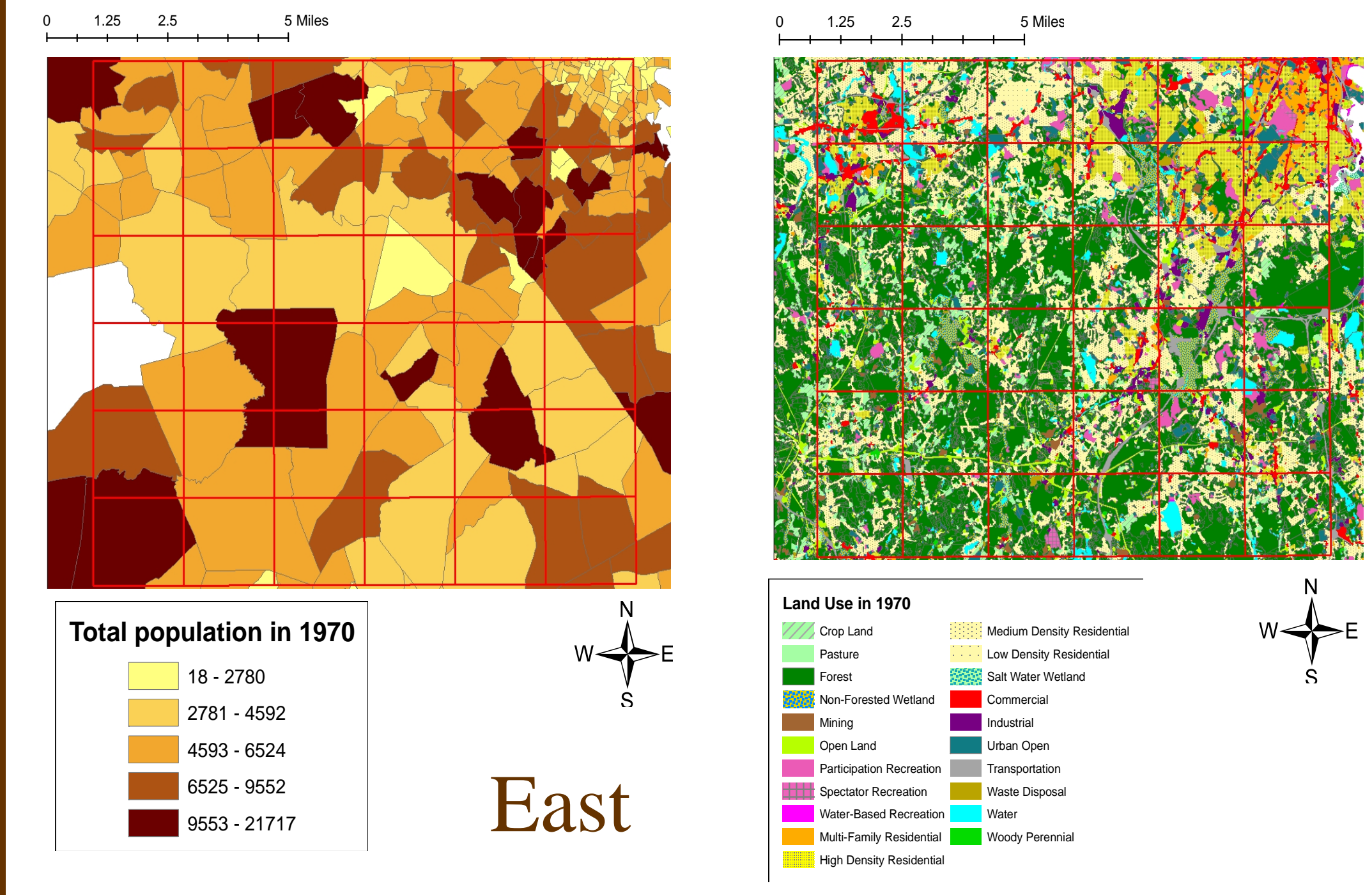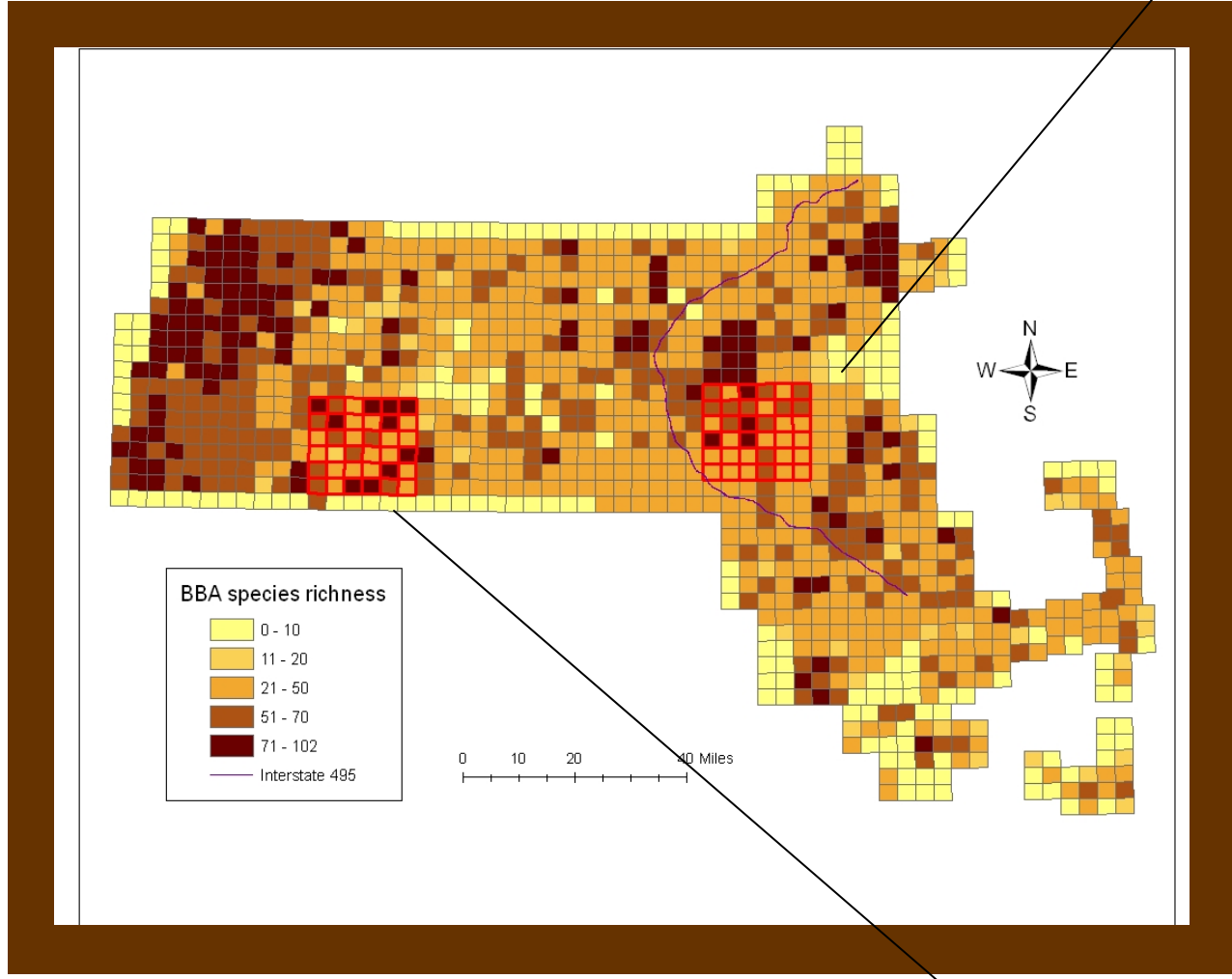
Overview

This study looks at how different urbanization measures are affecting bird species richness in Massachusetts since studies have shown urbanization does have an effect. Because the relevant bird data available was from 1970's, the urbanization data and bird species richness is from this time period. The measures used for this experiment include human population density and multiple land use categories. All of the land use types were left in, but certain urbanization measures such as crop land, mining, recreation areas, residential, commercial, industrial, urban open, transportation, and waste disposal were singled out for statistical analysis. The goal is to look at how the different urbanization measures are affecting bird species richness and then to look for differences in the effect in the highly urbanized east versus the more rural west. It also gives insight into how to overlay and compare the data from one data set to another in the same area using GIS techniques.

Methodology

1.) Using ArcMap 9.3, bird species richness was mapped from the breeding bird atlas (BBA) from the Mass Audubon. Then land use data from 1971 and human population census data from 1970 were mapped. Because the area of Massachusetts is so vast, the focus was on comparing arbitrary blocks of area in the east and west. East was separated from west by interstate 495, to the west of which becomes more rural.

2.) Since the BBA layer was divided into similarly sized blocks, the land use layer and census layer were intersected and cut to include only the information that was within an area of 6 blocks by 6 blocks– one in the east and one in the west. New layers were created from this clipped data and joined together. In ArcMap, a pivot table technique was used that rotated land use codes in a column to become column headings in the data table so we had the area of each land use type separated and organized for each block. Next, human population density was found for each block by converting the data to raster data and using zonal statistics under the spatial analyst tool to calculate the total population per block, which was later divided by the acres of the block.

3.) The land use and population density data was then compared to the species richness for that block, and the data from the east was compared to the data from the west. The information was prepared for principal component analysis, or statistical analysis to determine if there were any significant relationships within the data.

Total population in 1970
- 18 - 2780
- 2781 - 4592
- 4593 - 6524
- 6525 - 9552
- 9553 - 21717

Land Use in 1970

East

Total population in 1970
- 18 - 2780
- 2781 - 4592
- 4593 - 6524
- 6525 - 9552
- 9553 - 21717

Land Use in 1970

West

Results

From our species richness map, there seems to be a greater incidence of species richness in the far western part of Massachusetts. Urbanization, as might be expected, can be seen heavily in the eastern part of the state around the city of Boston. In our arbitrarily picked grids, there was less average species richness in the east but greater average human population density and total urbanized land use relative to the west.

It is possible to also determine data for one specific block, which is shown in the table below under the columns "western block 1" and "eastern block 1." These individual blocks showed patterns similar to those seen for the total blocks taken together. The block in the east had lower species richness but greater human population density and a much greater percentage of urbanized land use.

It appears that human population density, and residential, commercial, industrial, and urban open land uses are good indicators of bird species richness.

The next step in this project would be to run principal component analysis, or a statistical analysis that would determine if there is a significant relationship present between bird species richness and any of these factors.

Urbanization and Species Richness in Western and Eastern Massachusetts

	Western Block 1	Eastern Block 1	West All Blocks	East All Blocks
Species richness	72	62	51.75	49.53
Human Population Density (person/acre)	0.278	28.22	2.04	3.5
% Crop land	8.67	0.00	9.06	3.53
% Mining	0.00	0.00	0.50	0.81
% Participation Recreation	0.81	10.55	1.84	2.40
% Spectator Recreation	0.00	1.42	0.14	0.21
% Water Based Recreation	0.00	0.00	0.04	0.03
% Multi- Family Residential	0.00	27.63	0.70	1.36
% High Density Residential	0.03	21.43	6.72	7.07
% Medium Density Residential	1.70	1.18	9.67	13.31
% Low Density Residential	5.83	0.49	3.20	9.51
% Commercial	0.11	12.76	1.75	2.40
% Industrial	0.00	2.89	1.58	1.69
% Urban Open	2.43	11.07	3.12	3.39
% Transportation	0.07	3.69	2.33	1.57
% Waste Disposal	0.20	0.00	0.22	0.27
Total % Urbanized Land Use	19.85	93.10	40.88	47.56

"Western block 1" and "Eastern block 1" contain data from the uppermost right-hand block of the selected grids in the west and east, respectively. "West all blocks" and "East all blocks" contain mean species richness, mean population density, and land use percentages for the entire grid.

Land Use in 1971

Total Population in 1970

Tufts