



# Urbanization and the Dynamics of Disease in a Natural Avian Population



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## CONDITION MEASURES

**Weight on Size:** The weight of the individual in relation to its size, measured by the length of the tarsus bone

**BCI:** The Body Condition Index. This is a categorical measure between 0 and 4 that describes the angle that the pectoral muscle makes relative to the keel bone

**Fat Index:** Also a categorical measure between 0 and 4, the fat index describes the amount of subcutaneous fat visible in the throat

**Corticosterone Levels:** A stress hormone that can be isolated from fecal samples. The level of this hormone can provide a good measure of chronic stress in an individual

**Hematocrit Concentrations:** Hematocrit, or packed red blood cells, levels can indicate the efficiency of Oxygen exchange in an individual as well as identify anemic individuals

## Urban Measures

Building Density

Pavement Coverage

Forest Density

Microclimate

Vegetation Type and Density

Water and Food Sources

## IMMUNOLOGICAL MEASURES:

**H/L ratio:** Heterophils and lymphocytes have very different functions in the immune response. Heterophils non-discriminately phagocytize foreign materials, while lymphocytes are involved in acquired immunity. We would expect the H/L ratio to decline if an individual is actively fighting an infection or experiencing stress (nutritionally, predation pressure, etc.)

**Total WBC:** The total white blood cell count (per 10,000 red blood cells) is used to measure the strength of the immune system in an individual

**Plasma Proteins:** Albumin (a major source of amino acids) and globulin (the part of the blood which contains antibodies) are measured from small plasma samples. As with the H/L ratio, the albumin/globulin ratio is expected to decrease in the presence of infection or if the individual is stressed

## OVERVIEW and OBJECTIVES

Two thirds of the earth's population will inhabit metropolitan areas by the year 2025, and these areas are expected to double in land coverage over this same time period. In addition, urbanization is the second most frequently cited cause for species endangerment in the U.S. Several studies examining the impact of urban development on biodiversity have found that species richness and diversity indices are negatively correlated with housing density, road density, and exotic flora. The presence or absence of wildlife species is important, but condition, survival and reproductive success are critical measures of the viability of wildlife populations in highly developed urban environments. Recently, infectious disease outbreaks in wild populations have become a major conservation concern. Indeed, human modification to the habitat has been implicated in several disease outbreaks including avian malaria in threatened, endemic Hawaiian bird species. This study examines mechanisms associated with pathogen transmission and host susceptibility to study the effects of urban environments on avian host parasite dynamics.

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## EXPERIMENTAL DESIGN

**FOCAL SPECIES:** Northern Cardinals (*Cardinalis cardinalis*) and Carolina Wrens (*Thryothorus ludovicianus*)

Year-long residents of the Piedmont (north-central) region of Georgia and can be found at all points along the urban gradient

Demonstrate aggressive territorial behavior which facilitates tracking and trapping

Differ in nest site preference, diet, and mating behavior which will allow for future examination of how the interaction between host traits and urbanization may affect overall condition and disease risk

Pilot data from 2004 field season showed that these 2 songbird species comprised 45% of all birds captured (N = 242) at 12 study sites

## DISEASE MEASURES:

**Salmonella:** An enteric bacteria responsible for food-borne illness in humans and outbreaks in many domesticated and wild species. In Scandinavia and New Zealand, human outbreaks have been associated with fecal contamination originating from bird feeders. The prevalence of *Salmonella* species in passerines in the Southeast US is not currently known. Work in collaboration with the CDC has begun to culture and isolate enteric bacteria from the fecal samples obtained in this project.

**Blood Parasites:** Both *Hemoproteus* and *Plasmodium* species affect songbirds to varying degrees. The samples collected in the summer of 2004 showed a 23% prevalence of *Plasmodium* in the Northern Cardinal population (no pattern across habitat type was seen).

**Ectoparasites:** Each individual is examined for both ectoparasitic feather mites and hippoboscoid flies.

**West Nile Virus:** Antibodies to West Nile Virus, an emergent disease of concern to the human population, will be measured in all individuals sampled. This work is conducted in collaboration with University of Georgia's Southeastern Center for Wildlife Disease Studies.

## OBJECTIVES

- Investigate the association between land use and the health and condition of wild birds along the urban-rural gradient
- Develop a composite measure that captures multiple features of urbanization across a network of field sites
- Quantify the body condition and immune parameters of wild songbirds as an index of host susceptibility and overall health
- Investigate the occurrence of four key pathogens among birds across the urban-rural gradient: enteric bacteria (*Salmonella*); a vector-transmitted virus (WNV) and blood protozoa (*Plasmodium*); and ectoparasitic arthropods (feather mites and hippoboscoid flies)

## QUESTIONS and PREDICTIONS

How is the structure of habitat related to disease risk in wild avian populations?

Influences on transmission probability

contact rates between hosts, between hosts and insect vectors, or hosts and pathogen in the environment

Influences on condition and susceptibility (stress and immune defenses) at the individual and population level

The roles of specific drivers in determining disease risk

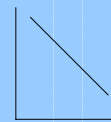
- Fragment size
- Population density and community diversity
- Food supplementation
- Microclimate

Specific trends are difficult to predict. Urbanization could improve (as in the case of increased food supplementation) or reduce (as in the case of smaller forest fragment sizes) avian health and their propensity towards

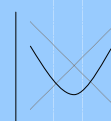
infection. In addition, non-linear trends may be observed if sites at the extremes of the urban gradient provided similar conditions but for different reasons, as illustrated in the example below:



Avian condition could increase with greater urbanization if food availability increases with human density



Avian condition could decline with greater urbanization if pollution or habitat degradation increases stress levels

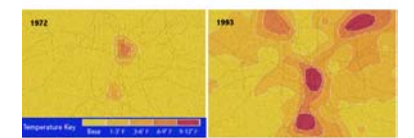


If food resources improve with increasing urban score, but stress, leading to increased susceptibility, also increases, we may observe non-linear patterns across the urban gradient

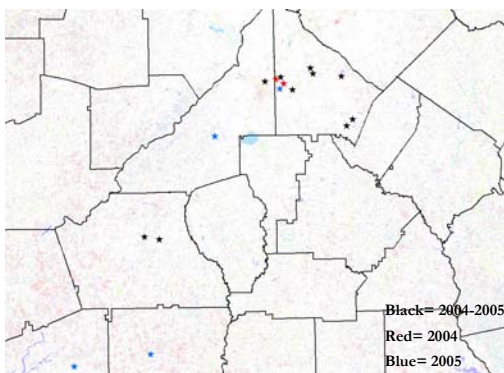
## BACKGROUND



These NASA satellite images show the progression of urban sprawl in Metro Atlanta between 1973 and 1997. According to Research Atlanta Inc. (1993), the population of the Atlanta metropolitan area increased 27% between 1970 and 1980, and 33% between 1980-1990. This growth is coupled with the increasing loss, degradation, and fragmentation of natural areas.



The above images, reproduced from the Atlanta Urban Heat Island Research website, show an increase in urban temperatures between 1972 and 1993. Heat islands result from the conversion of green spaces to concrete and pavement, the removal of trees, and the dark, absorbent materials used in construction. In addition to air quality, heat islands could also effect the breeding season of birds, persistence of pathogens in the environment, and the distribution of vector arthropods.

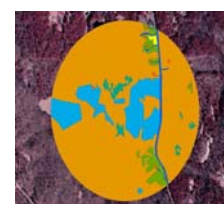


## SAMPLING SCHEME (2005):

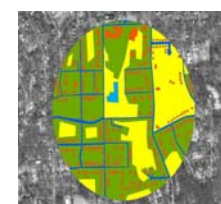
- Between May 1 and August 1, each site will be sampled 6 times
- 2-8 mist nets are placed in locations throughout the sample site from 6:30a.m.- noon
- Morphological and physiological data is gathered in the field and individuals are released shortly after capture
- In the summer 2005 season, the orthophoto landuse maps will be ground-truthed and detailed vegetation, water, and food data will be gathered

## FUTURE DIRECTIONS

In addition to field sampling in 2005 and 2006, two additional components to this project are planned. First, a simulation model to better understand how processes linked with urbanization influence host-pathogen dynamics through their impacts on host contact and abundance, pathogen transmission, and host susceptibility will be developed this summer. Based upon the results of this work, a manipulative field experiment will be designed to further explore the roles individual drivers, such as food supplementation, play in the interaction between habitat structure and condition and disease risk in natural avian populations.



US= -1.476



US= 0.120



US=1.518



## THE URBAN SCORE (US)

Using the landuse classes above, I created a landuse shapefile from the DOQQ of each site. I used the ArcView extension V\_Late (developed through the SPIN project, 2001-2004) to calculate the class area, edge to area ratio, and core area for each class. I then performed a principle component analysis (PCA) to develop a single measure of urbanization. The most robust measure contained building area, landscaped area, paved area, and impervious area and explained 87% of the observed variation. Above are the most rural (US= -1.476), the most urban (US= 1.518), and an intermediate site.

## SITES:

- 12-14 sites, including the Stone Mountain Songbird Habitat and Piedmont Park in downtown Atlanta
- Including Fulton, Dekalb, Coweta, Harris and Meriwether counties