

# The “urban-*adapted*” bird: Does dietary plasticity allow some species of birds to thrive in urban habitats?

## 1. BACKGROUND

Urbanization during the latter half of the twentieth century has altered habitats, restructured avian communities, and influenced the range sizes and population dynamics of animal species (Mckinney and Lockwood 1999, Marzluff 2001, Chace and Walsh 2006). The unique characteristics of human-built environments confers a conflicting set of benefits and challenges that make it difficult to determine whether urban habitats are advantageous or constitute demographic sinks (Gates and Gysel 1978) for bird populations. As the developed land area in the United States is projected to nearly double between 2000 and 2025 (Alig et al. 2004), understanding how organisms respond to these habitats is of paramount importance. Despite the urgency of the problem for conservation, however, the population level consequences of urbanization on birds remain poorly understood (Shochat et al. 2006).

It is hypothesized that anthropogenic habitats may influence bottom-up controls on the distribution and abundance of populations of birds by affecting the resources that determine whether species are able to exist in these habitats (Shochat et al. 2010). Human-dominated environments often contain an abundance of consistent food resources for many species of birds. For example, supplemental feeding by humans, especially for overwintering resident birds, has been found to be positively associated with adult survivorship for a number of granivorous synanthropes (Doherty and Grubb 2002). Moreover, supplemental feeding has been hypothesized to be a primary driver in the northward range expansion of some seed-eating species, such as the Northern Cardinal (*Cardinalis cardinalis*) because it relaxes winter starvation (Robb et al. 2008). Likewise, human-dominated landscapes are also often dominated by ornamental and invasive species, which have been found to provide essential resources for frugivorous bird species during winter months and thus may facilitate win-

ter survival (e.g., Leston and Rodewald 2006, McCusker et al. 2010). The low temporal variability of resources in anthropogenic habitats is also hypothesized to support higher densities of individuals because they can persist in a state of reduced body condition relative to their rural counterparts (the Credit Card Hypothesis, Shochat 2004). Viewed cumulatively, the abundance and quality of avian food resources is expected to vary spatially along this gradient with resource subsidization as the primary driver of higher food availability at intermediate degrees of urbanization (Raupp et al. 2010).

Despite evidence that urban environments can present opposing selection pressures, our understanding of the processes and mechanisms that regulate species persisting in urban landscapes are poorly studied. Research to date on across life history stages (e.g., post-fledging survival, Whittaker and Marzluff 2007, Ausprey and Rodewald 2011 and nestling survival, Ryder et al. 2010, and Adult survival Rodewald and Shustack (2008, 2008a), Evans et al. 2015) have failed to document the negative impact of urbanization.

## **2. RESEARCH OBJECTIVE**

Here, we seek to assess the influence of urban land cover on avian diet and the effects of dietary habits on the health of birds across the rural-to-urban gradient.

Availability of winter fruit resources on non-native and ornamental plants may provide relaxation from starvation pressures during winter months when survival of the resident species is dependent on a consistent food supply (Shochat et al. 2010).

## **3. PROPOSED RESEARCH**

We examine the dietary and stress response of two species of birds: the Northern Cardinal (NOCA, *Cardinalis cardinalis*) and Carolina Chickadee (CACH, *Poecile carolinensis*). Both species exhibit some degree of omnivory, are non-migratory, and utilize bird feeders in suburban and urban habitats. Key differences between the life history of the species include differences in foraging strata (NOCA forage on the ground while CACH are foliage gleaners), nesting habits (NOCA are cup nesting and CACH cavity nesting species), and response to urbanization (NOCA are found at more urban sites than CACH).

## GENERAL METHODS:

This study was conducted from 2000 to 2012 within a 100 km spatial extent encompassing a rural-to-urban land use gradient in the greater Washington D.C. and Baltimore, M.D. metropolitan region. Research in urban environments is often limited by accessibility and adequate coverage of the urban gradient (Cooper et al. 2007). To alleviate this problem we utilized sites ( $n = 242$ ) that were part of Neighborhood Nestwatch (hereafter referred to as NN), which is an ongoing citizen science project run by the Smithsonian Migratory Bird Center. NN is the ideal sampling framework for studying the effects of urbanization on avian demography because it provides access to residential properties within core urban and suburban environments as well as forested and agricultural land cover types (Figure 3.1). By incorporating privately owned land within our study design, we are able to capture portions of the urban and suburban matrix not normally monitored in avian survivorship studies.

Annually, NN technicians visit participant properties during the avian breeding season (between the months of May and August, sites are predominantly visited by one technician). During each visit, technicians provide an educational banding demonstration for program participants and set two to eight mist nets for a period of three to five hours of mark-recapture. Birds are captured using target netting with playback of mobbing calls or conspecific song. Individuals are marked with a unique US Fish and Wildlife aluminum band and a unique combination of colored plastic bands. Technicians measure body mass (to the nearest 0.01 g) on an electronic balance and unflattened wing chord (to the nearest 0.25 mm) with a wing rule. Birds are aged into hatch year (HY) and after hatch year (AHY) age classes using plumage, skull ossification, or molt criteria (methodologies vary by species, see Pyle 1997).

**Hypothesis 1. The dietary habits of conspecific birds vary in composition and breadth along the rural-to-urban gradient.**

Across bioregions, urban environments have been shown to favor dietary generalists and granivores and exclude birds with insectivorous diets. Indeed, in an assessment of avian

community composition across the rural-to-urban gradient in metropolitan Washington, D.C. we observed a sharp decline in the proportional abundance of obligate insectivores (Evans et al. 2015). (Note: Bearhop 2004 suggested that isotopes can be a proxy for niche width)

Prediction 1.1: *The ratios of  $\delta^{13}C$  and  $\delta^{15}N$  in feathers will reflect dietary shifts from insect to plant-based and anthropogenic food sources.* Analysis of  $\delta^{13}C$  and  $\delta^{15}N$  in feathers (and possible diet items including bird food?) will give us a sense of the the proportional composition of plant-based foods (Im hoping we can pick up a distinct signature for bird seed) and insects in the diet. We expect that with increasing urbanization diets will become more omnivorous and the ratio of insects to plant-based foods (including anthropogenic food sources) will decline. To test whether increased omnivory is advantageous to bird health, we use corticosterone as a proxy of avian condition. This last bit is the awkward one however, survival was higher for NOCA in urban habitats and we assumed that this was driven by resources. Using enhanced survival of NOCA as our guide, we might expect that a species exhibiting high plasticity (NOCA) would benefit from this dietary shift while those exhibiting low plasticity (e.g., CACH) would be negatively influenced by a shift from insectivory.

Prediction 1.2: *The dietary niche width among conspecifics, as measured as variance in the ratios of  $\delta^{13}C$  and  $\delta^{15}N$  in feathers, will increase with increasing urban land cover.* Change this bit, see Newsome's paper – Shannon-Weiner metric

Prediction 1.3: *Avian condition, as measured by corticosterone concentrations in feathers, decreases with increasing omnivory for NOCA but not CACH.* We expect ... To examine the adult condition of birds, we will measure the stress hormone corticosterone (CORT) in feathers using a methanol based extraction, modified from Bortolotti et al. (2008), and a commercial ELISA kit (Corticosterone ELISA kit; Neogen Corporation, Ayr, UK) following Carbajal et al. (2014). The concentration of CORT in feathers represents stress exposure during the time in which the feather was grown, a period of up to three weeks. Feather CORT has been found to be predictive of several biologically important indicators of bird health including breeding success (Crossin et al. 2013), body condition (Harms et al. 2010),

and survival (Koren et al. 2012). We will analyze CORT concentrations as a function of neighborhood and yard-scale habitat and management practices within a generalized linear model framework, using model selection to determine the variables most predictive of avian condition (see Burnham and Anderson 2002). Preliminary analysis of CORT in Carolina Chickadee (*Poecile carolinensis*) feathers at NN sites ( $n = 22$ ) exhibit elevated CORT concentrations in sites dominated by non-native plants ( $\beta = -3.2 \pm 1.4$ ,  $p\text{-value} = 0.04$ ) but no response to the degree of urbanization at a given site (proportion of impervious surface within 500 m,  $\beta = 0.2 \pm 0.3$ ,  $p\text{-value} = 0.47$ ). These results suggest that CORT concentrations may be highly reflective of the biological response of birds to yard-scale habitat features.

**Hypothesis 2. Urban habitats minimize starvation pressure by providing a more consistent temporal distribution of resources.**

This is a test of Shochats credit-debt hypothesis that we mentioned in the survivorship paper. Shochat suggested that the more natural environments have greater temporal variation which would increase starvation pressures. Under this scenario anthropogenic food sources and winter fruiting of non-native species would enhance survival. Hobson (1999) suggested that  $\delta^{15}\text{N}$  enrichment is representative of nutritional stress. To test this, we would have to sample birds during the non breeding season (perhaps early spring?) and expect higher  $\delta^{15}\text{N}$  ratios in rural habitats (relative to more urban ones). To test whether there is an influence of nutritional stress on bird health, we use corticosterone as a proxy of condition.

Prediction 2.1: *Birds will exhibit enhanced levels of  $\delta^{15}\text{N}$ , as measured in avian blood, along the rural-to-urban gradient.* text lorem ipsum yada yada.

Prediction 2.2: *Concentrations of corticosterone in avian blood will increase proportionally with  $\delta^{15}\text{N}$ .*

We will use Structural Equation Modeling (SEM; McCune and Grace 2002) to examine hypothesized relationships between environmental attributes, place meaning, place attachment, and place-enhancing behaviors (Fig. 3). SEM is a multivariate technique that allows

us to simultaneously analyze the complex, and often correlated, inter-relationships among measured (e.g., socioeconomics and land-cover) and latent variables (i.e., those estimated from measured values such as environmental attributes and place attachment) that comprise a coupled human-natural system. We will use a Bayesian framework to develop and test a priori SEM in JAGS, implemented in Program R (see Plummer et al. 2003). We will evaluate the influence of structural linkages using Markov chain Monte Carlo sampling and use Bayesian model selection to compare a priori models (see Raferty 1993). SEMs will include socio-economic factors since these characteristics might influence maintenance decisions, as well as personal histories (e.g., prior/other nature experiences from open-ended interviews) and the amount of urban land and tree cover in the neighborhood surrounding participants households (as described in the Research Overview section above). With SEM, we will distinguish the relative influence of environmental and sociocultural attributes on management decisions and the linkages among environmental/sociocultural attributes, place meanings, place attachments, and place-enhancing behaviors (Fig. 3). The SEM for Objective 3 will be incorporated into the SEM for the overall project model (see Synthesis section below).

#### **4. RELEVANCE OF THE PROPOSED RESEARCH**

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#### **5. ROLE OF THE SMITHSONIAN INSTITUTION**

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### **WORKS CITED**