Bird is the Word: Using Acoustic Data to Measure Urban Environmental Health

A Pilot Study

•••

Zoe Fairlie

Project Overview

- Acoustic monitoring of bird species within Oakland
  - Dark-Eyed Junco, Oak Titmouse, Killdeer, and American Crow
- Air Quality
  - Data from the Environmental Defense Fund
- Median Income
  - Census data
  - Measured per census tract
  - Commonly used to predict environmental health in an area
- Acoustic data as a measurement of environmental well being

Questions and Hypotheses

Are bird populations and frequencies correlated with air quality and/or median income?

Can bird populations be an indicator for the environmental health of an area?

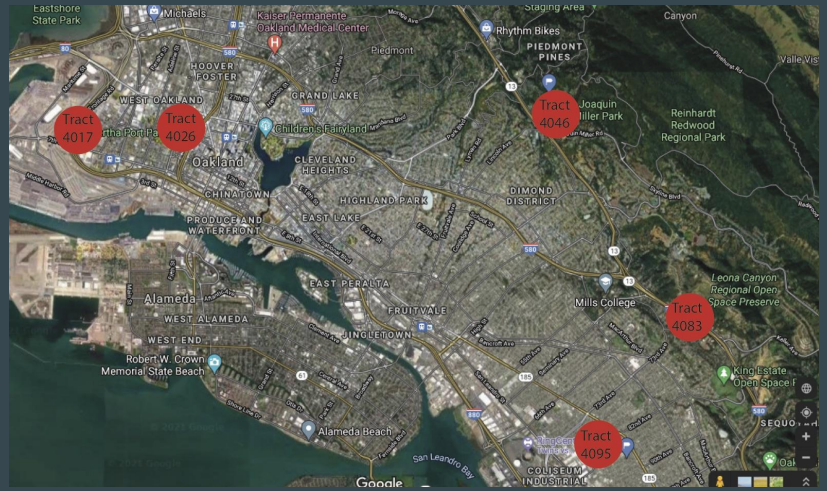
I hypothesize that bird populations and frequencies are correlated with environmental health (which in this study is proxied by air quality).

I am using median income as a correlated variable in this project to control for differences in bird populations regarding affluence.

Sampling Locations

Census Tracts: 4017, 4026, 4095, 4083, 4046*

NO Value	NO2 Value	BC Value	Air Metric	City	Tract	Median Income
1.50000007	3.46677216	0.04498049	5.01175273	Oakland	4095	38973
0.83125003	4.12382504	0.10322958	5.05830464	Oakland	4083	86012
433.833189	22.5342906	0.80894518	457.176425	Oakland	4026	23409
170.743212	22.8180008	1.02419972	194.585413	Oakland	4017	97472
				Oakland	4046*	161324



4046* was not chosen by air quality or median income level, just proximity to a large regional park; not used in data analysis

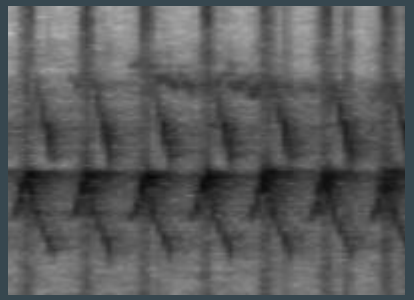
Sampling Procedure

Location Criteria:

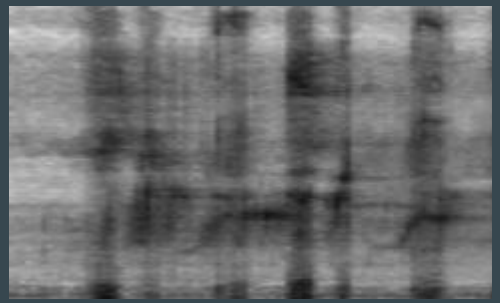
- No pets
- No bird feeders
- Limited/ no pesticide usage
- Within a block of a park/ green space

Data Collection

- Arbimon Platform
  - Random Forest Model
  - Using a 70/30 train/test split
- Models for Dark-Eyed Junco, Oak Titmouse, Killdeer, and American Crow
  - Based off of frequency patterns

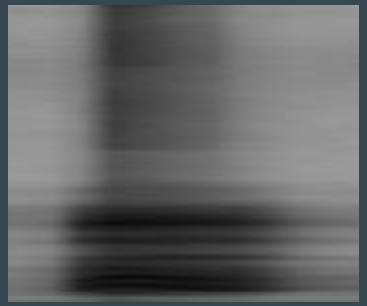


Dark-Eyed Junco



Oak Titmouse

Killdeer

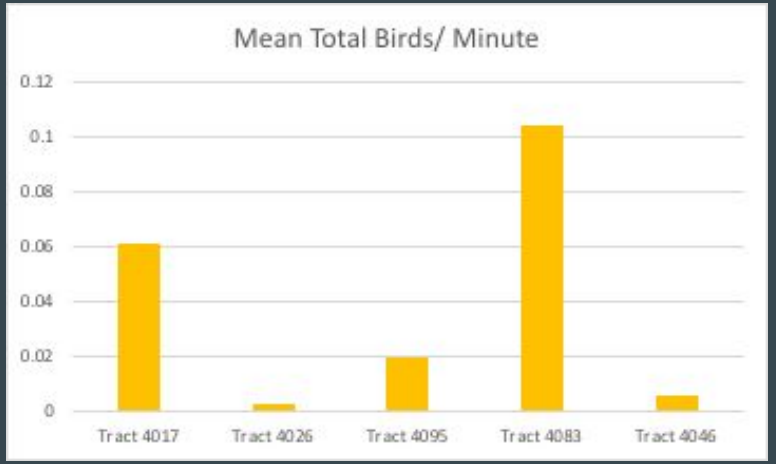


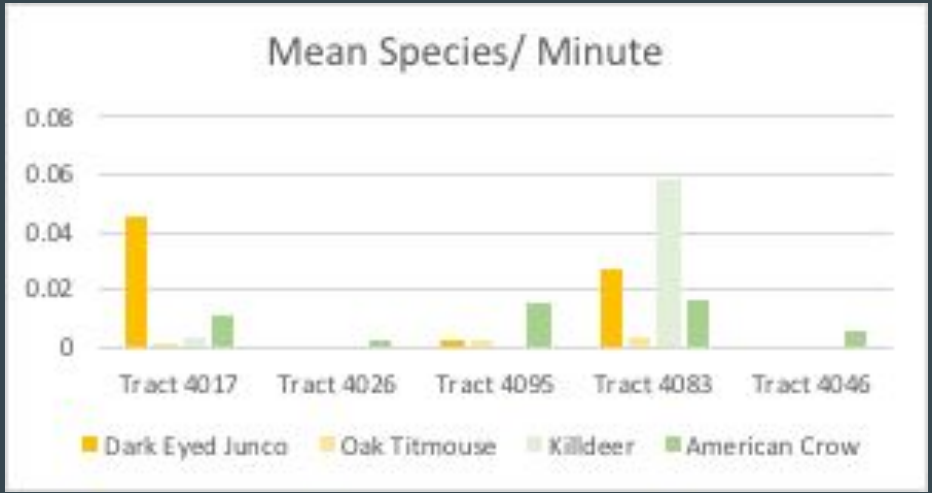
American Crow

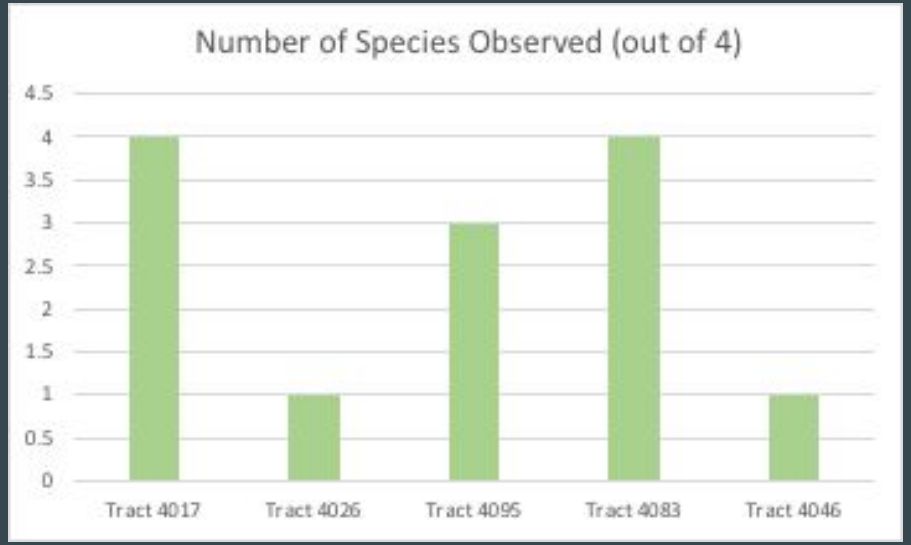
Exploratory Data Analysis

Pilot Sample Sites

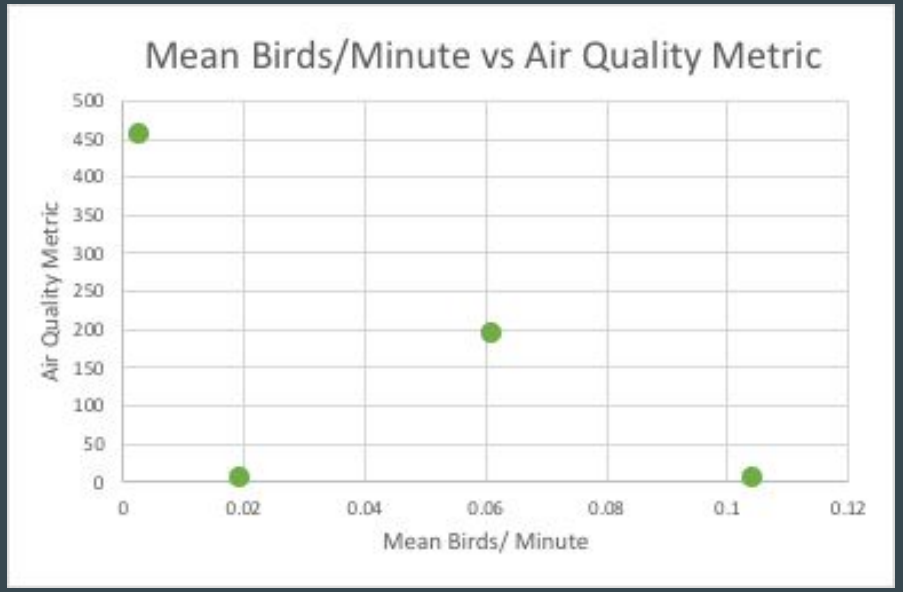
4017: high income, poor air quality
4026: low income, poor air quality
4095: low income, good air quality
4083: high income, good air quality
4046: semi-control

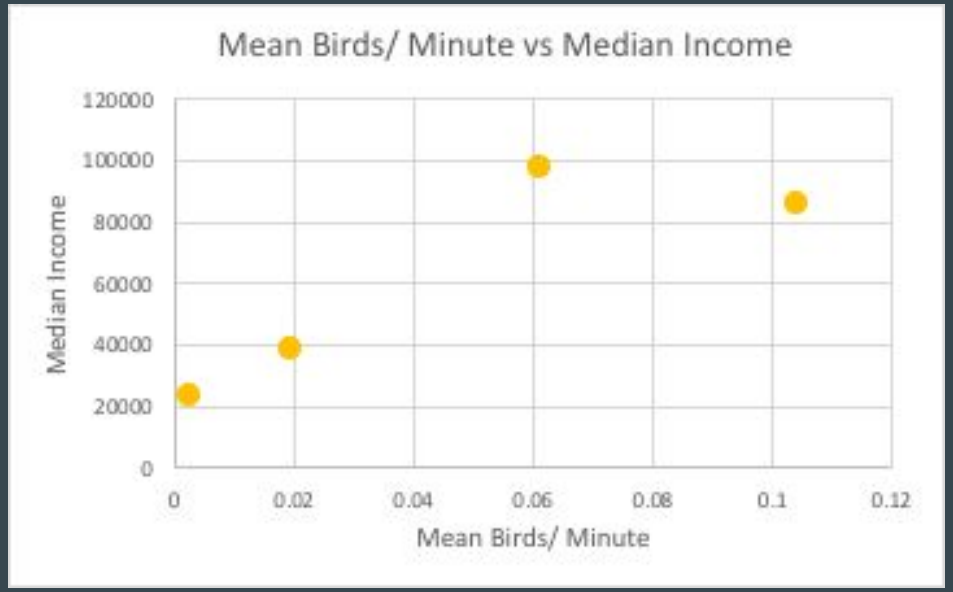






Air Quality and Median Income as Explanatory Variables for Bird Populations





*A low air metric denotes good air quality and a high air metric denotes bad air quality

```
Call:
lm(formula = air_metric ~ income_scaled + mean_birds, data = birds)

Residuals:
      1       2       3       4
-231.29   20.34  179.78   31.16

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)    252.8026   363.4007   0.696    0.613
income_scaled    0.1459     0.9571   0.152    0.904
mean_birds    -3791.2037  7583.1152  -0.500    0.705
```

```
Call:
lm(formula = air_metric ~ income_scaled + proportion, data = birds)

Residuals:
      1       2       3       4
 18.535 -59.345  -6.178  46.988

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)    578.6808   105.3951   5.491    0.115
income_scaled    0.7878     0.2866   2.749    0.222
proportion    -1198.9877   292.2204  -4.103    0.152
```

Exploratory Regressions with a Small Sample Size

Neither regression shows significance, and this is likely affected by my small sample size

However in both models you can see that a one unit increase in mean birds/ minute and in the species proportion is associated with a decrease in the air quality metric denoting better overall air quality

Conclusions

- Bird species counts and frequencies can predict air quality so they may be a good measure for environmental health. Bird species counts and frequencies also are correlated with income levels and when we take income into account the bird metrics can still predict air quality.
- Since this was a pilot study my sample size (number of recording locations) was low and in follow up research it would be important to sample from more census tracts
- Demonstrated that audio data in cities is possible to collect but there is likely a decent amount of error in presence/ absence modeling

Big Thanks to...

The SPUR Program and alumni who provided funding.

Professor James Sallee

Rainforest Connection

References

Frommolt, Karl-Heinz, et al. “Computational Bioacoustics for Assessing Biodiversity.” *Federal Agency for Nature Conservation*, 2007.

Melles, Stephanie J. J. “Urban Bird Diversity as an Indicator of Human Social Diversity and Economic Inequality in Vancouver, British Columbia*.” *URBAN HABITATS*, vol. 3, no. 1, 2005, www.urbanhabitats.org.

Germaine, Stephen S., et al. “Relationships Among Breeding Birds, Habitat, And Residential Development In Greater Tucson, Arizona.” *Ecological Applications*, vol. 8, no. 3, 1998, pp. 680–691., doi:10.1890/1051-0761(1998)008[0680:rabbha]2.0.co;2.

Temple, Stanley A., and John A. Wiens. “Bird Populations and Environmental Changes: Can Birds Be Bio-Indicators?” *Population Study* , 1989,www.researchgate.net/profile/John_Wiens3/publication/267855385_Bird_populations_and_environmental_changes_Can_birds_be_bio-indicators/links/54cbc9e30cf24601c0898e36.pdf.

Khanna, Neha. “Measuring Environmental Quality: an Index of Pollution.” *Ecological Economics*, vol. 35, no. 2, 2000, pp. 191–202., doi:10.1016/s0921-8009(00)00197-x.

Schell, Christopher; Dyson, Karen; Fuentes, Tracy L. et al. “The ecological and evolutionary consequences of systemic racism in urban environments.” Science. https://doi.org/10.1126/science.aay4497