A bird’s-eye view of air pollution

Olivia Sanderfoot
osanderfoot@wisc.edu
About Me

– Graduated with a B.S. in biology, Spanish, and environmental studies from UW–Madison in 2015
– Currently finishing an M.S. degree at the Nelson Institute for Environmental Studies
– Will be starting a Ph.D. program at the School of Environmental & Forest Sciences at the University of Washington this fall
– Funded by the National Science Foundation (NSF) Graduate Research Fellow Program
Introduction to Air Quality

- Health-damaging air pollutants
  - reactive gases and aerosols that have direct, adverse impacts on human health
- Greenhouse gases (GHGs)
  - long-lived gases that contribute to global warming
Introduction to Air Quality

– Emissions of greenhouse gases are an important, but separate, issue from health-damaging air pollution.

– Climate change is expected to worsen air pollution and the adverse health impacts associated with poor air quality.
Air Quality & Human Health

- Air pollution is correlated with a number of adverse human health outcomes
- Exposure to tropospheric ozone, aerosols, and precursor species increases risk of...
  - Respiratory disease
  - Cardiovascular disease
  - Mortality
Air Quality Regulation

– The Clean Air Act gives the Environmental Protection Agency (EPA) the authority to regulate emissions to protect public health and safety.

– The National Ambient Air Quality Standards (NAAQS) regulate ambient concentrations of six criteria air pollutants.
The Big Six

- Sulfur dioxide (SO$_2$)
- Nitrogen dioxide (NO$_2$)
- Carbon monoxide (CO)
- Lead (Pb)
- Ozone (O$_3$)
- Particulate matter (PM)
NAAQS

– *Primary* standards protect PUBLIC HEALTH.

– *Secondary* standards protect PUBLIC WELFARE to improve visibility and reduce damage to infrastructure, vegetation, crops, and animals.
Air Quality & Birds

– Few studies have explored how poor air quality directly affects non-human species, especially in wild populations
– Birds are likely more vulnerable to air pollution
– Birds respire more efficiently than any other terrestrial vertebrate
  – *Unidirectional air flow*
  – *Cross-current gas exchange*
3 DIFFERENT WAYS TO BREATHE

HUMAN LUNGS
Mammals inhale by moving the diaphragm to lower the air pressure in the chest cavity and pull air into the lungs. The human chest cavity is always at a lower pressure than the outside environment (usually 760mmHg at sea level).

BIRD LUNGS
Birds have air sacs that store and pump air through the stationary lungs.

Unlike in mammals, air flows in only one direction through bird lungs. With the help of the air sacs, this allows birds to take in oxygen even during exhalation.

Birds can breathe at much higher elevations than mammals because of their more efficient lung structure.

GRASSHOPPER TRACHEA
Grasshoppers have no lungs and do not use their circulatory system to move oxygen. They transport air directly to tissue cells using tracheal tubes.

Grasshoppers use different breathing methods when they are resting, alert, hopping, or flying. The alert grasshopper shown here is pumping its abdomen to change the volume of its air sacs. This helps pump air through the trachea.
Responses to air pollution?

- Little is known about how reactive gases and aerosols directly impact birds
- Web of Science:
  - “air pollution” + “birds” → 132 results; top paper cited 161 times
  - “air quality” + “birds” → 87 results
Literature Review: Goals

– Conduct a comprehensive literature review to provide a summary of findings regarding avian responses to air pollution and discuss knowledge gaps to be addressed in future studies.

– Synthesize the work of physiologists, ornithologists, conservation biologists, and ecologists in order to provide foundational knowledge on avian responses to air pollution and support future work in bird conservation.
Literature Review: Findings

– Exposure to air pollution is linked to...
  – Respiratory distress and illness
  – Impaired reproductive success
  – Increased detoxification effort, elevated stress levels, and immunosuppression
  – Behavioral changes
  – Habitat degradation
  – Decreased population sizes, species diversity, and species richness
Knowledge Gaps

- Direct effects of both acute and chronic exposure
- Quantification of exposure
- Identification of sensitive species
Support for this project was provided by the National Aeronautics and Space Administration (NASA) Applied Sciences Program through the Air Quality Applied Sciences Team (AQAST) and Health & Air Quality Applied Science Team (HAQAST) initiatives.

This material is based upon work supported by the National Science Foundation Graduate Research Fellowship Program under Grant No. DGE-1256259.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
Contact

Olivia Sanderfoot
osanderfoot@wisc.edu
@osanderfoot

Tweet, tweet!