Data-driven Wildlife Ecology, Habitat Management and Environmental Sensing

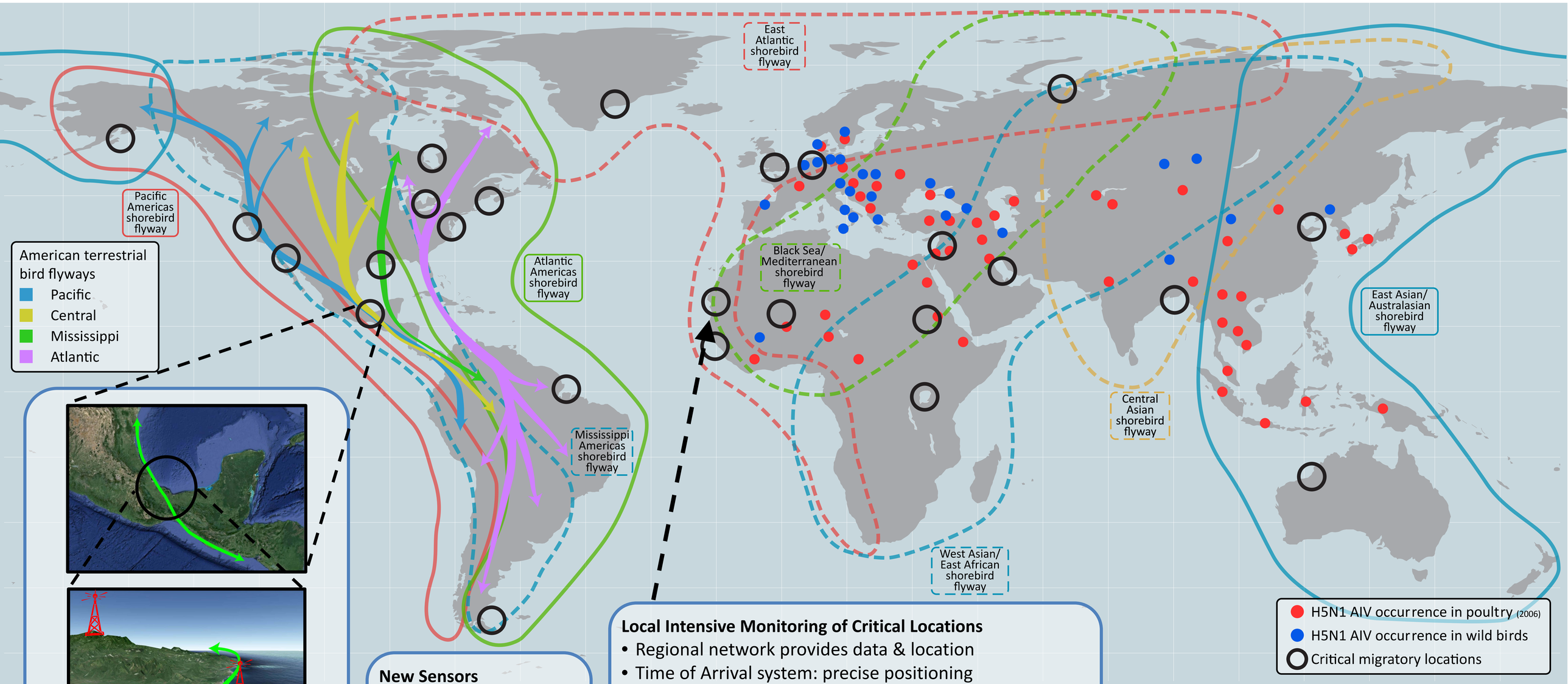
Robert MacCurdy Cornell University

- Worldwide bird population estimates: 200 – 400 Billion[1]; North American migrants: 3-5 Billion[2]
- Technical capabilities limit sample sizes to < 30!
- Zoonotic pathogens (H5N1, H7N3, WNV) attracting intense interest, but observations labor-intensive
- Migration routes utilize common stop-over sites, and include natural constrictions with very high bird density → an opportunity for instrumentation!

1. Kevin J Gaston and Tim M Blackburn. How many birds are there? Biodiversity & Conservation, 6(4):615–625, 1997.
2. Peter Blancher and Jeffery Wells. The boreal forest region: North America's bird nursery. Canadian Boreal Initiative and Bird Studies Canada. 9 pp., 2005.

Distributed Dynamic Biological Sensor Network (DDBSN) would utilize animals as mobile environmental sensing platforms by applying inexpensive long-lived wireless sensor nodes (tags) to them, and linking those nodes with data aggregation and analysis tools

Key Technology Challenges
- Communications
  - Satellite; Aerostat; UAV; Manned aircraft; Local terrestrial
- Energy
  - Efficiency; Energy harvesting; New Batteries
- Sensors
  - Gas; Blood chemistry; Pathogens; Env. Contaminants
- Data Management
  - Archival (huge data volumes); Mining; Display & UI

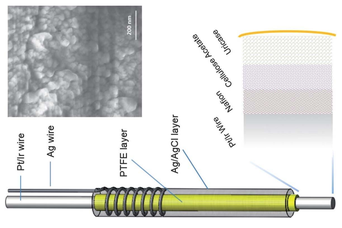


A "Digital Turnstile" for birds

- Natural constrictions in the migration path increase the density of birds during migrations
- "Critical migratory locations" due to: terrain, water, natural resources
- Ideal location for communications infrastructure:
  - Logged data can be downloaded
  - New commands uploaded
  - Intensive localized monitoring (tracking) possible in these regions

New Sensors

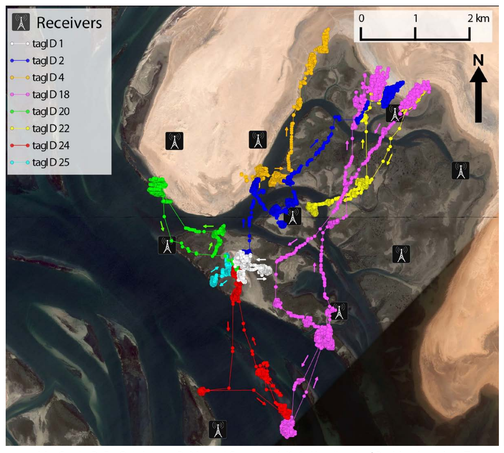
- Uric Acid (metabolism)
- Cortisol/cortical sterol (stress)
- Viral/bacterial infections (lab-on-chip)
- Chemical (weapons / accidental release



A Gumus, S Lee, K Karlsson, R Gabrielson, DW Winkler, and D Erickson. Real-time in vivo uric acid biosensor system for biophysical monitoring of birds. Analyst, 139(4):742–748, 2014.

Local Intensive Monitoring of Critical Locations

- Regional network provides data & location
- Time of Arrival system: precise positioning
- Thousands of animals can be tracked simultaneously
- Multi-year lifetime; multiple seasons

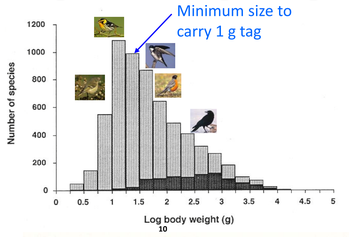


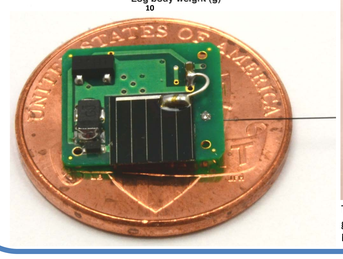
- Inexpensive tags (<$50)
- Sub-gram mass
- +/- 10 m accuracy
- Portable system

MacCurdy, R. B., Gabrielson, R. M., and Cortopassi, K. A. Handbook of Position Location: Theory, Practice, and Advances , 1129–1167 (2012).
MacCurdy, R. B., Gabrielson, R. M., Spaulding, E., Purgue, A., Cortopassi, K. A., and Fristrup, K. M. Journal of Communications 4(7), 487–495 (2009).

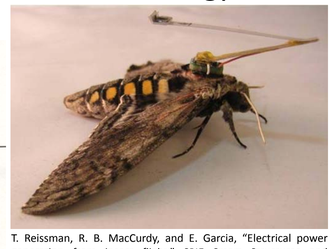
Energy ~ Mass

- Tags must be lightweight to be widely applicable





- 1 gram can be carried by 50% of bird & bat species
- Efficiency!
- Harvest energy



T. Reissman, R. B. MacCurdy, and E. Garcia, "Electrical power generation from insect flight," SPIE Smart Structures and Materials, 2011, pp. 797702–797702.