USDA

United States Department of Agriculture

Forecasting the Probability of Bird-Aircraft Collisions

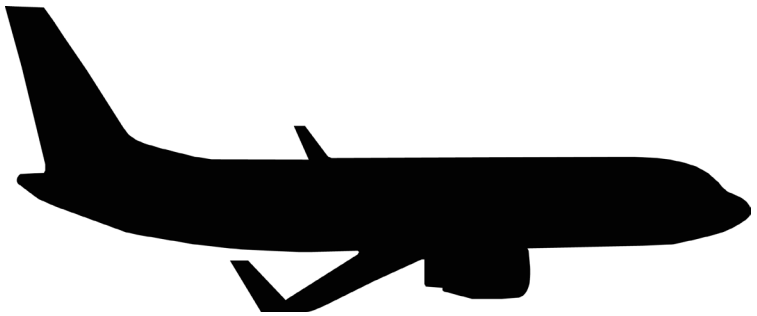
U.S. Aviation Wildlife Management Conference, August, 5th, 2026

Ryan Lunn, Ph.D., Lauren Hoskovec, Ph.D., Professor
Dave Koons, Ph.D., Kim Pepin, Ph.D., Mike Begier

What is wildlife-aircraft strike risk?

What is wildlife-aircraft strike risk?

- Relative Hazard Scores
- Collision Frequency
- Total Cost of Damage
- Operational Delays
- Closest Approach Point



What is wildlife-aircraft strike risk?

Defining wildlife-aircraft strike risk as an expected value:

$$E(X) = \sum x_i P(x_i)$$

x_i = Measure of Damage (e.g., Direct & Indirect Cost)

$P(x_i)$ = Probability of Damage Occurring

Defining risk as an expected value

$$E(X) = \sum x_i P(x_i)$$

For example: Should you go to the park based on the weather forecast?

x_i = A Rain Shower

$P(x_i) = 25\%$

Defining risk as an expected value

$$E(X) = \sum x_i P(x_i)$$

For example: Should you go to the park based on the weather forecast?

x_i = A Tornado Alert

$P(x_i) = 25\%$

What is wildlife-aircraft strike risk?

$$E(X) = \sum x_i P(x_i)$$

x_i = Sum of all direct and indirect financial costs

Allan 2001, Altringer et al., 2021

What is wildlife-aircraft strike risk?

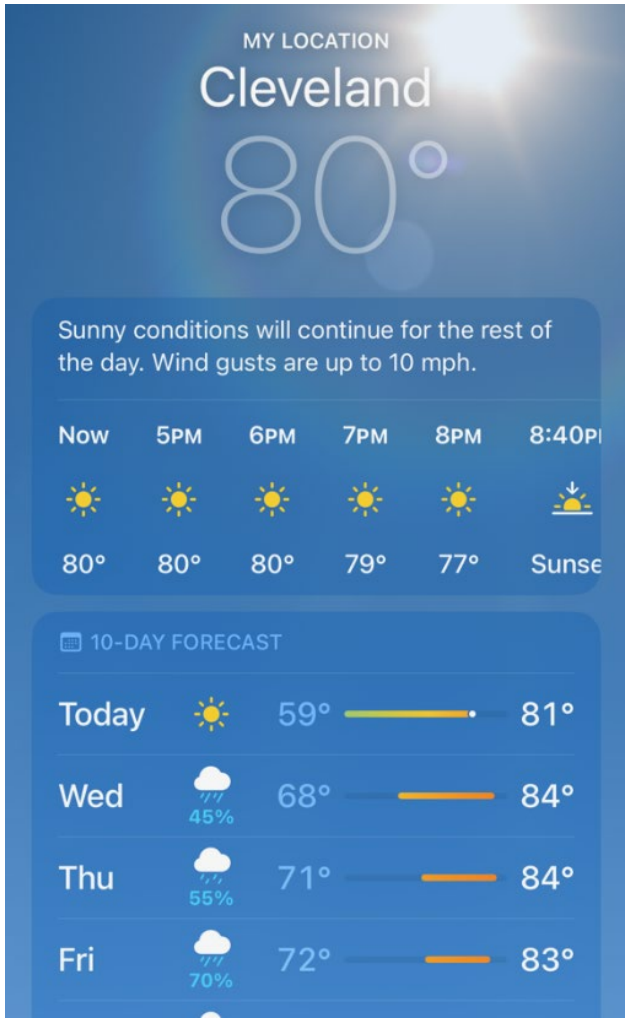
$$E(X) = \sum x_i P(x_i)$$

x_i = Sum of all direct and indirect financial costs

$$P(x_i) = ?$$

Allan 2001, Altringer et al., 2021

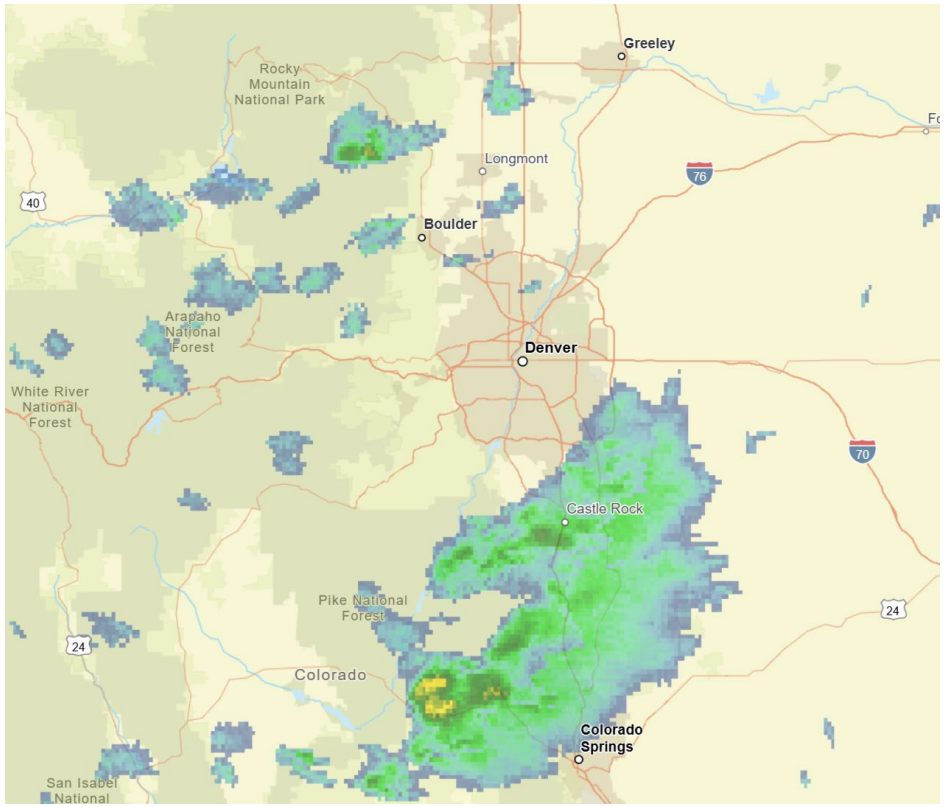
What is the probability of rain at 6:00p?



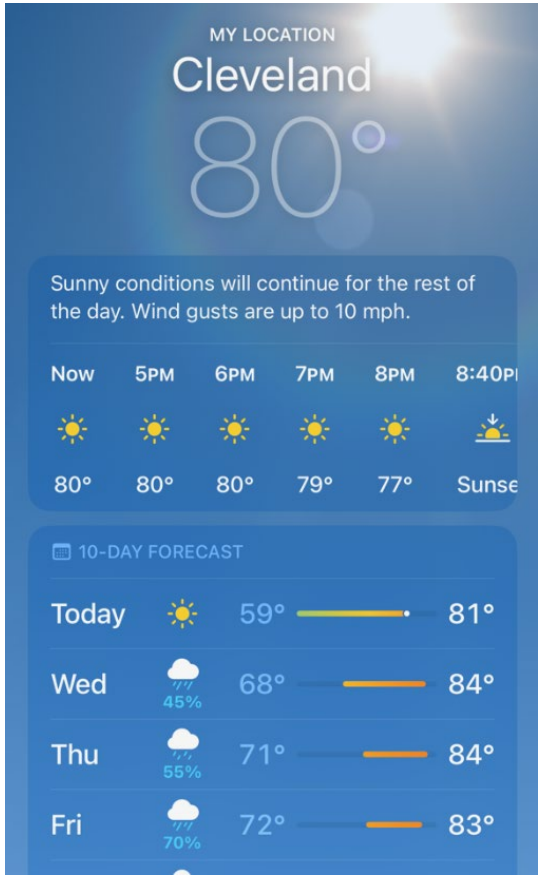
Forecast

What is the probability of rain at 6:00p?

Radar



Forecast



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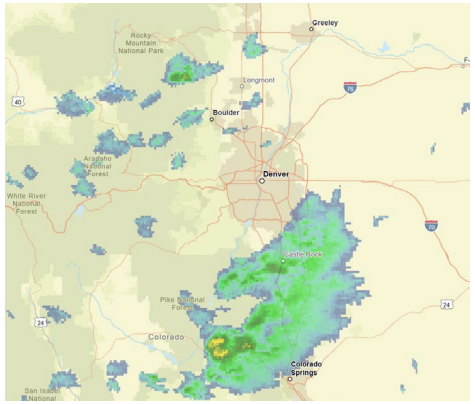

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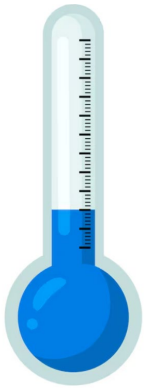
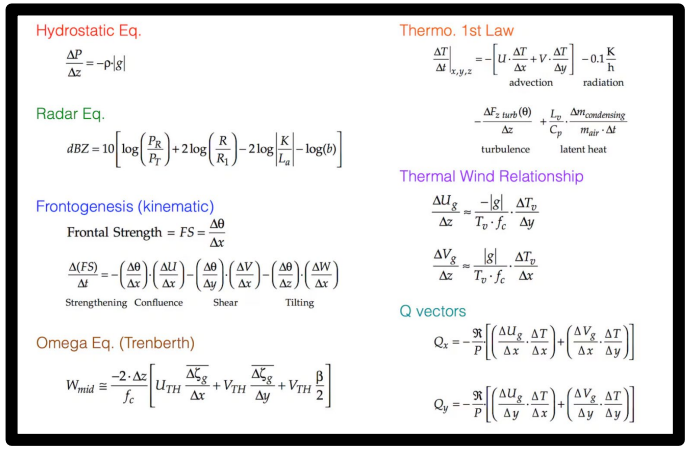
Data

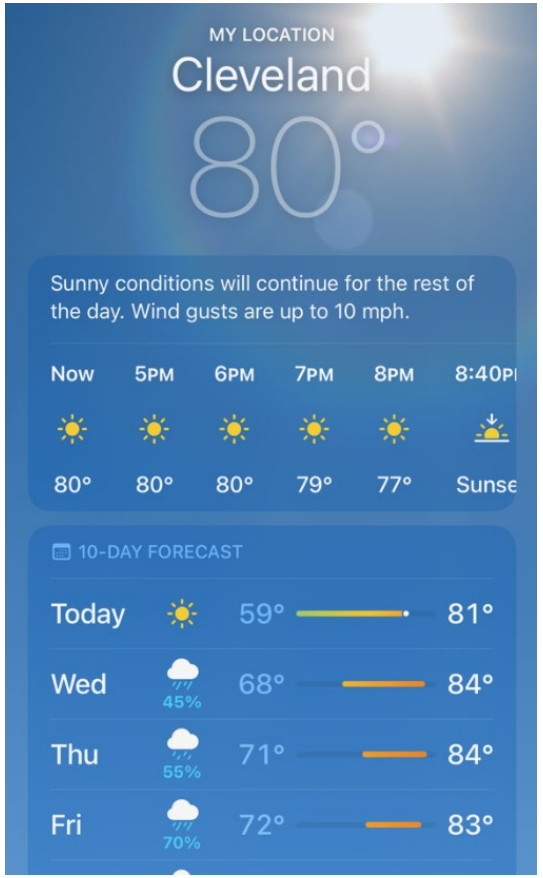


&

Modelling



Forecast



What is the probability of wildlife aircraft damage?

Radar

+

Data

Modelling

?

Forecast

The Goal:

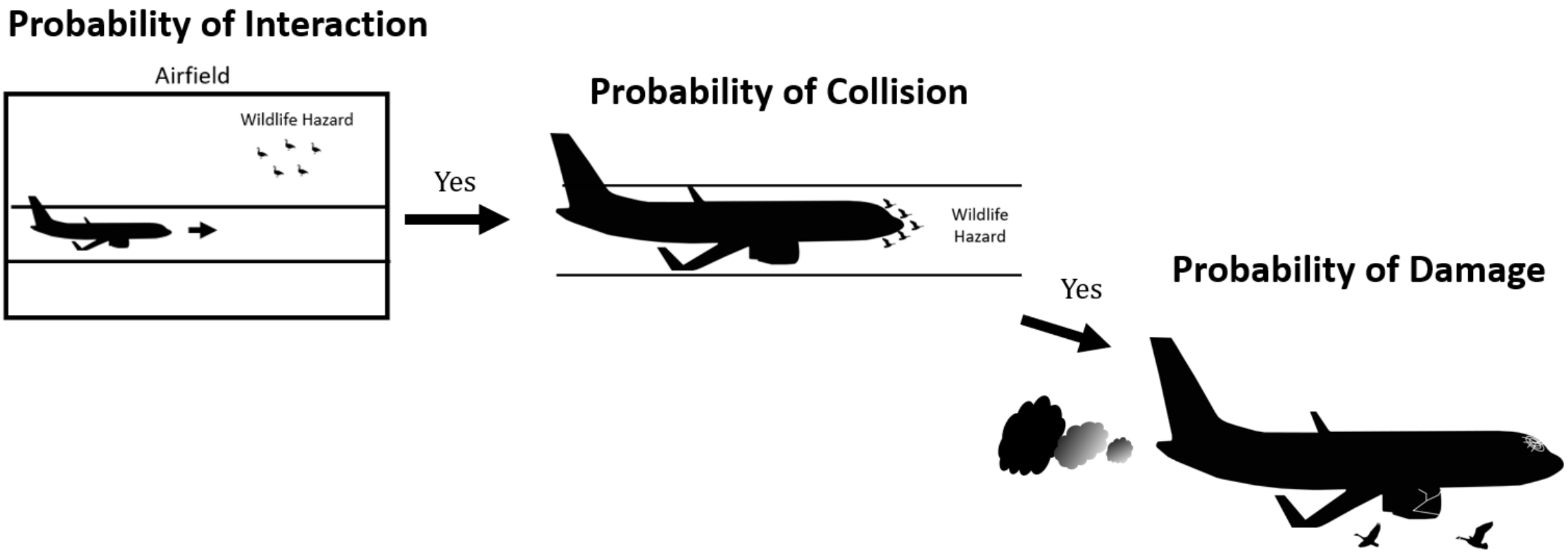
1. Establish the methodology for modelling the probability wildlife-aircraft damage

2. Identify and validate the data sources that exist that can inform estimates of the probability of wildlife-aircraft damage

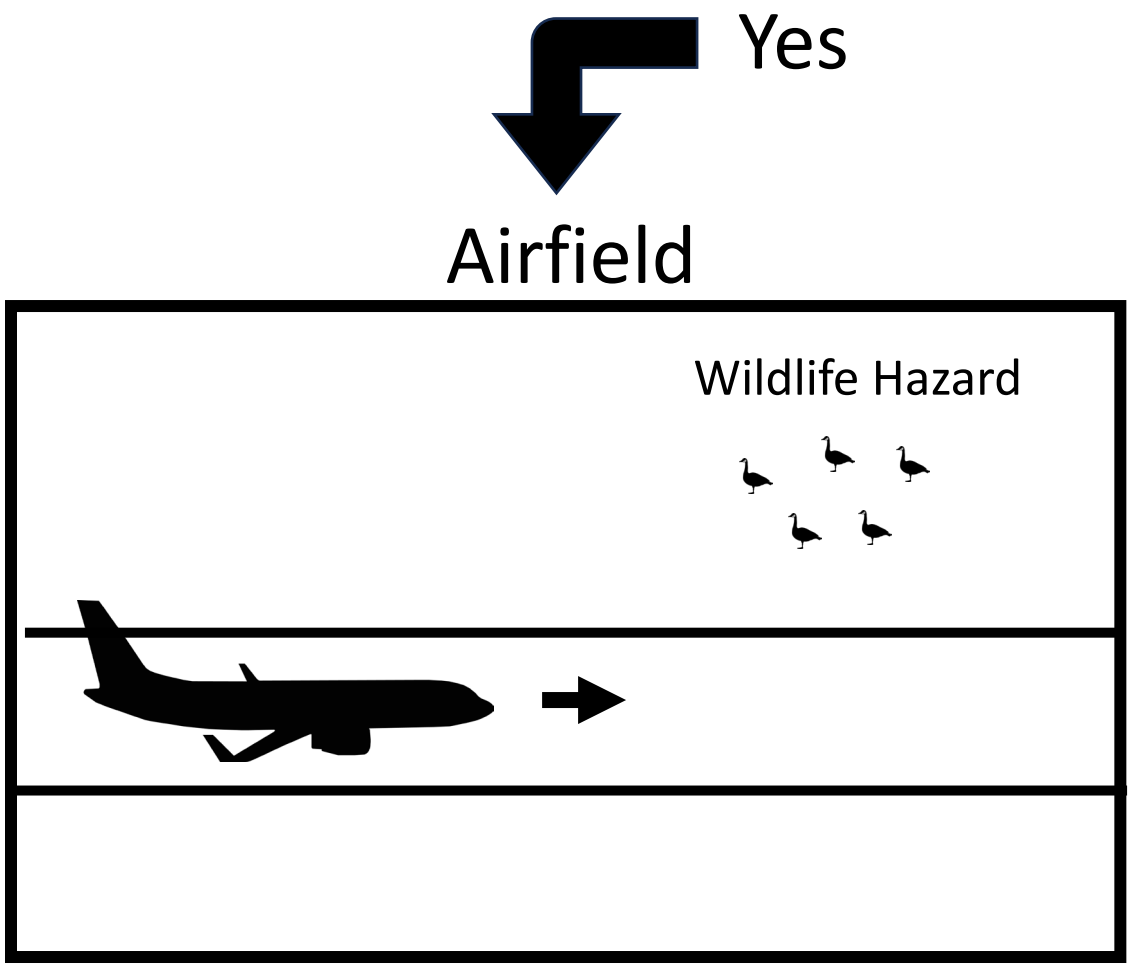
The Overarching Premise:

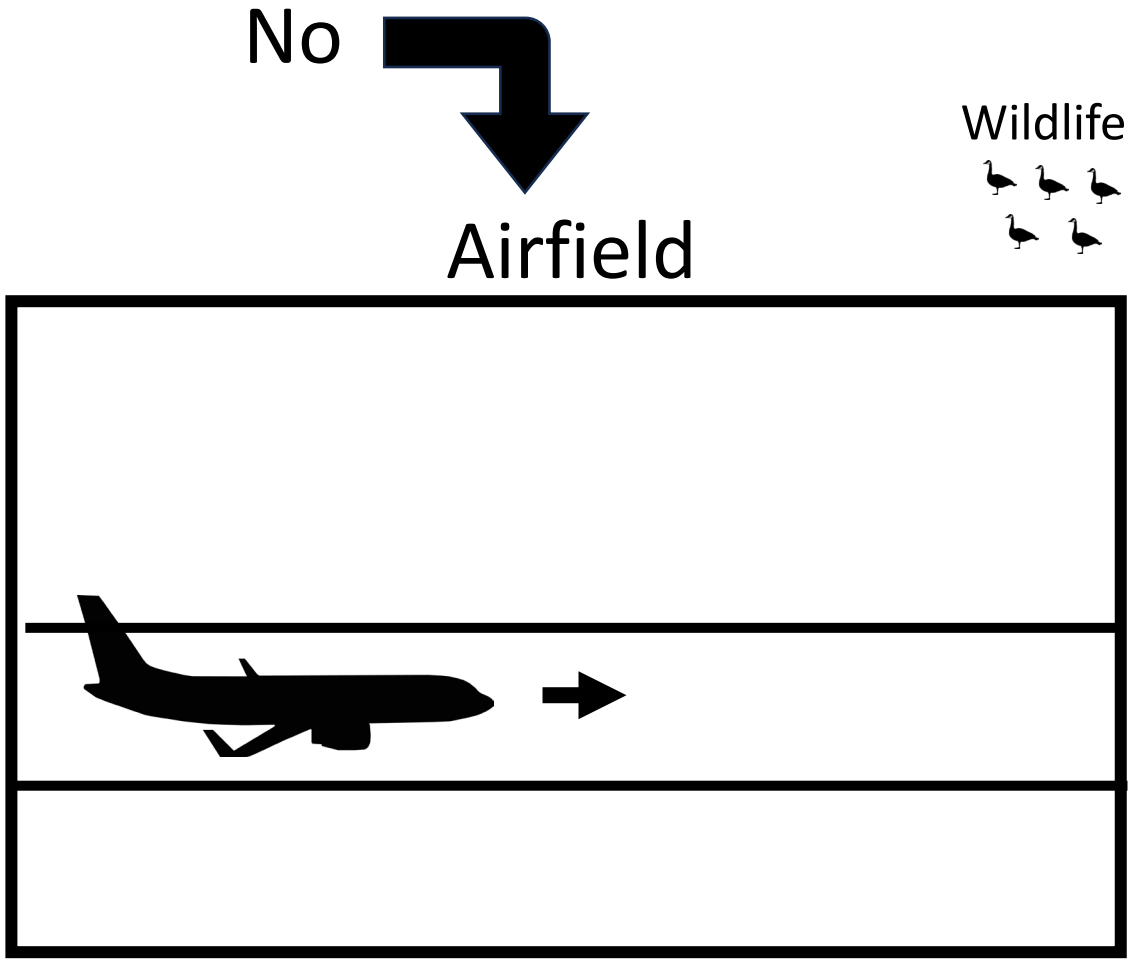
Establish a methodology to estimate the probability of a damaging bird strike as a conditional probability, with existing data sources, at three different airports (O'Hare, SeaTac, NAS Kingsville) for a subset of species of concern (Ross et al., 2025)

Modelling wildlife-aircraft damage as a CONDITIONAL PROBABILITY



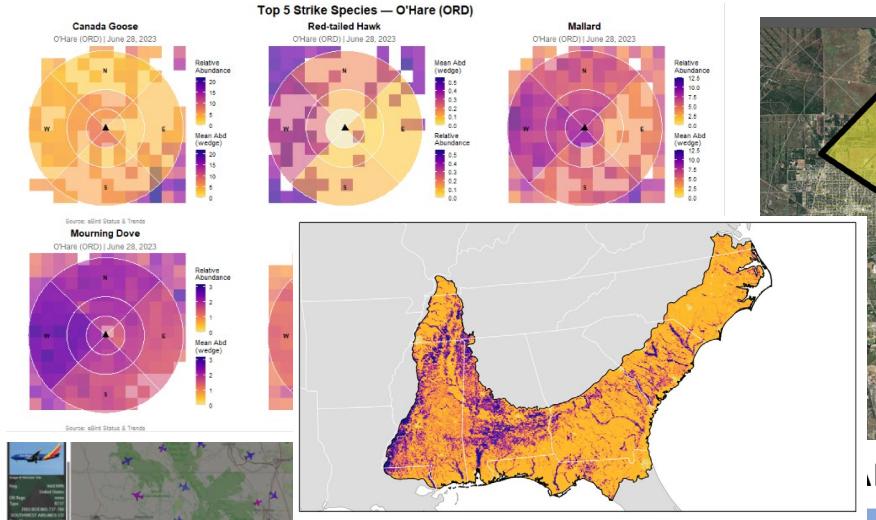
Probability Wildlife-Aircraft Interaction:

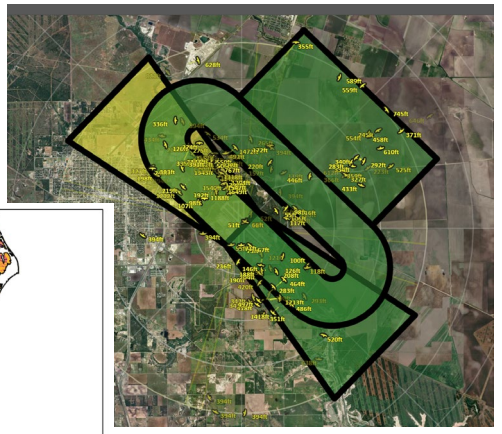




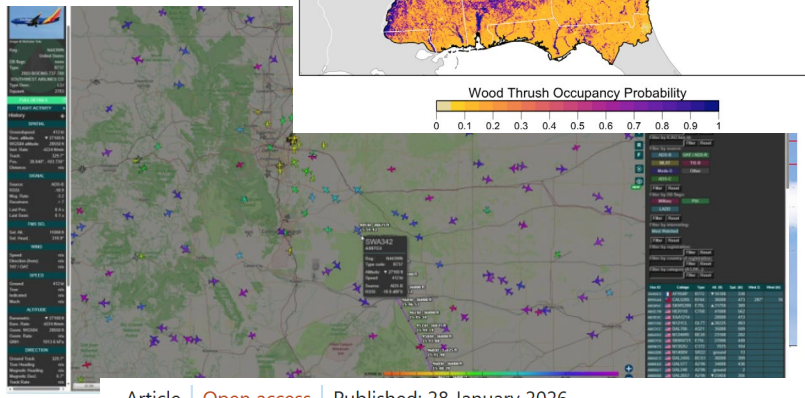
Probability Wildlife-Aircraft Interaction:

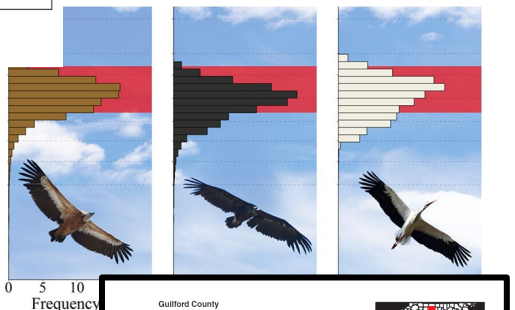
- eBird
- Species Distribution Modelling
- Radar Data
- Date
- Survey Data
- Movement Data
- Existing Theoretical Tools
- ADS-B
- ASPM Flight data

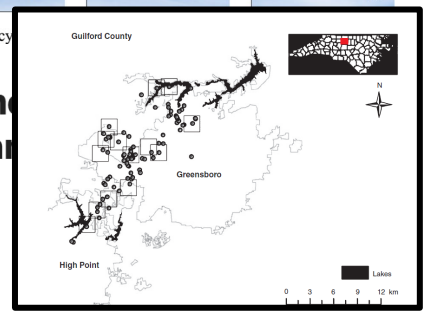




rrondo et al., 2021







Article | Open access | Published: 28 January 2026

**Research on spatiotemporal risk assessment m
bird strike at airports and precise prevention a
control strategies**

Yueya Shi, Jingwen Jia, Ruijun Lin, Jintao Chen, Xuedong Fang & Yun Sheng

Scientific Reports **16**, Article number: 6449 (2026) | Cite this article

Probability Wildlife-Aircraft Interaction:

OPEN ACCESS PEER-REVIEWED

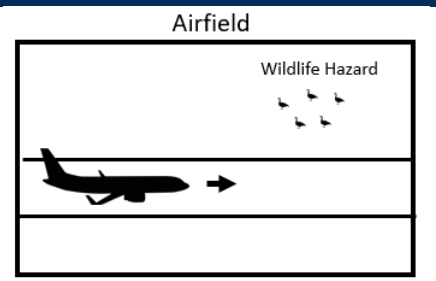
RESEARCH ARTICLE

Do more birds mean more bird-aircraft collisions? A meta-analysis testing a key wildlife management tenet

Shane Guenin, Yue Liu, Bradley F. Blackwell, Travis L. DeVault, Esteban Fernández-Juricic

Published: July 1, 2026 • https://doi.org/10.1371/journal.pone.0349352

Probability of Wildlife-Aircraft Collision |



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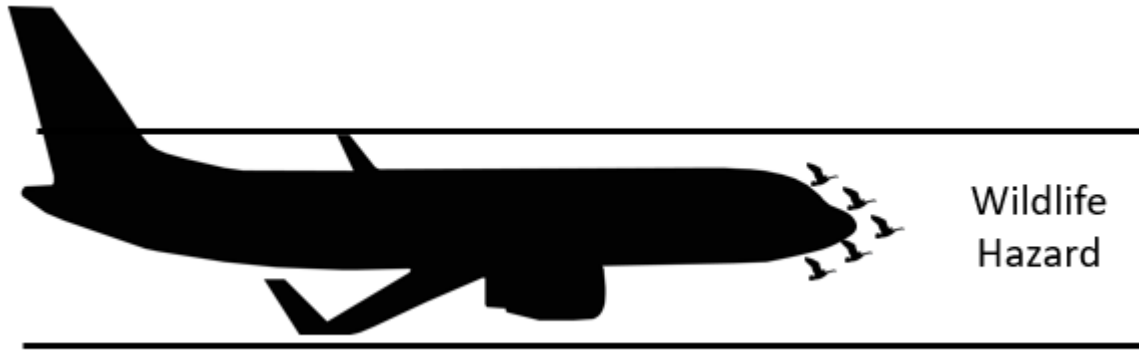

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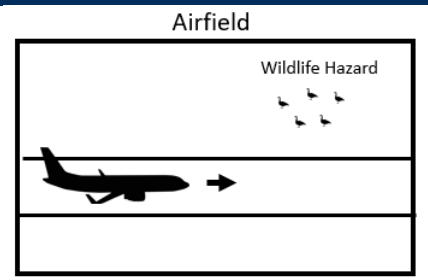
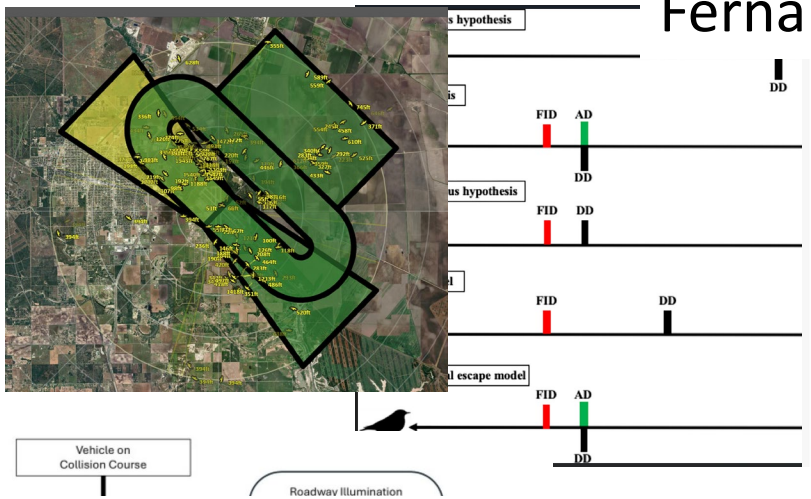
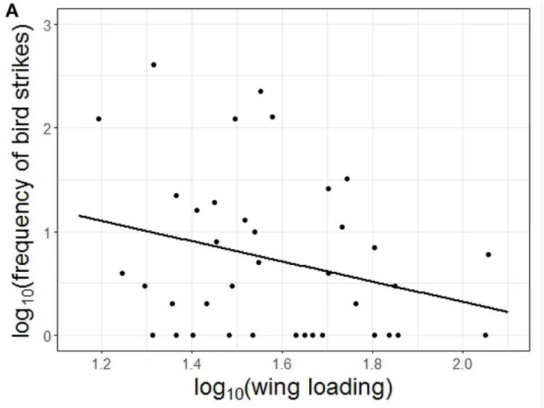
Probability of Wildlife-Aircraft Collision |



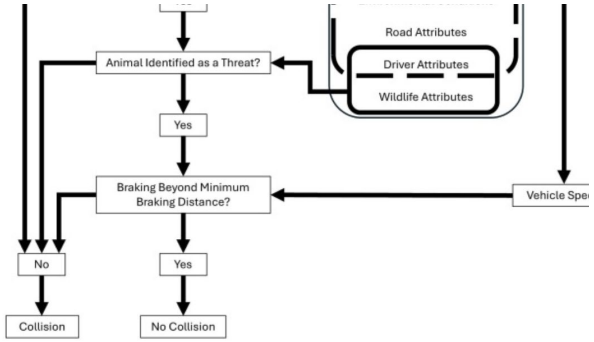
- Radar Data
- Species Morphology & Physiology
- Wildlife Behavior
- Pilot Behavior

Fernández-Juricic et al, 2018

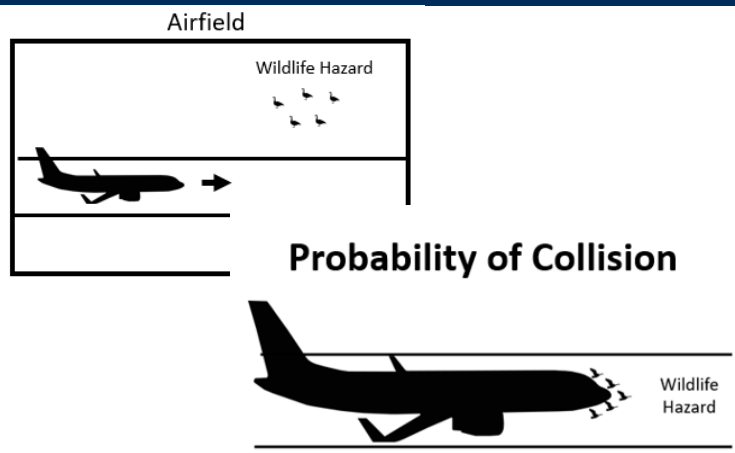




Pakula et al., 2026



Probability of Wildlife-Aircraft Damage |



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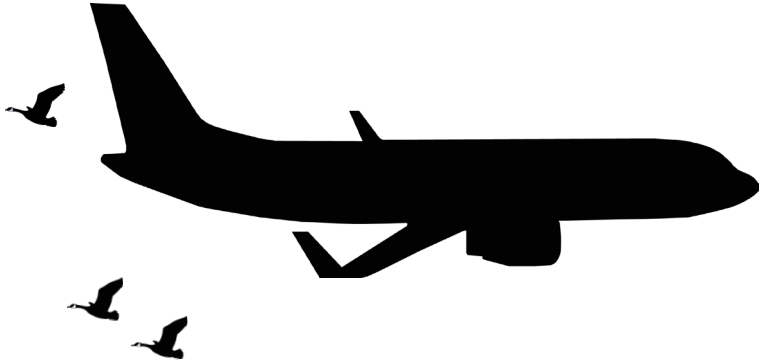

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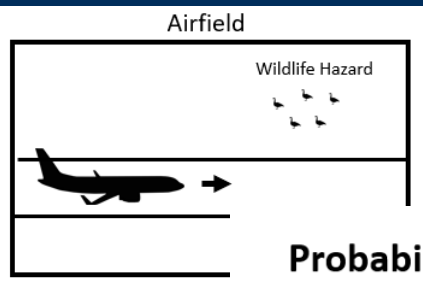
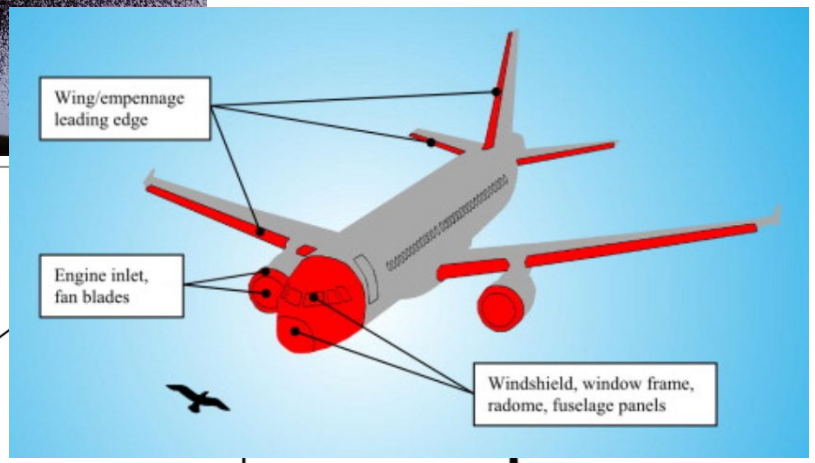
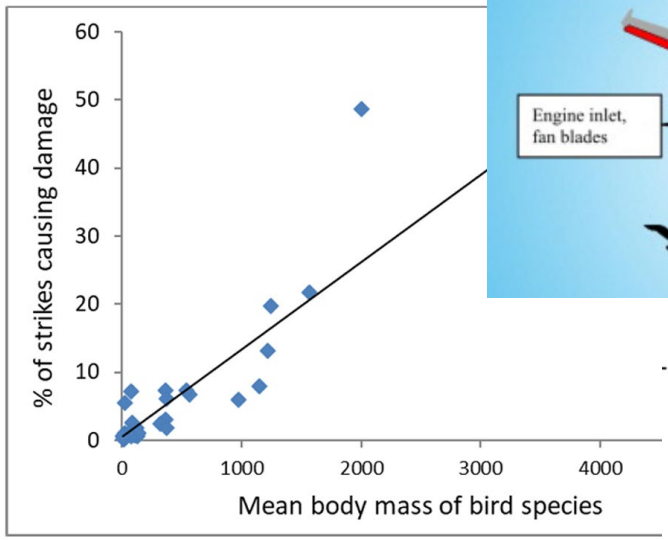
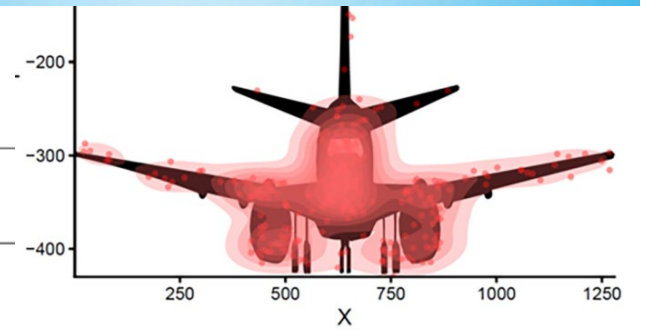


- Aircraft Speed
- Phase of Flight
- Aircraft Type
- Bird Body Size
- Bird Flock Size/Volume/Density

Probability of Collision







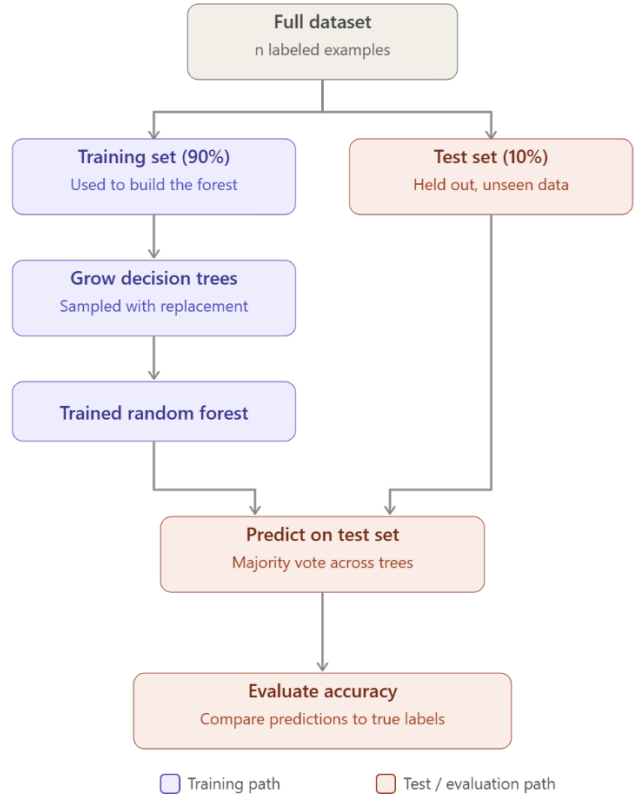
Hiembs 2011, Washburn et al., 2017, Shaui et al., 2024, Dolbeer et al., 2025

Airfields & Aerodomes are complicated places

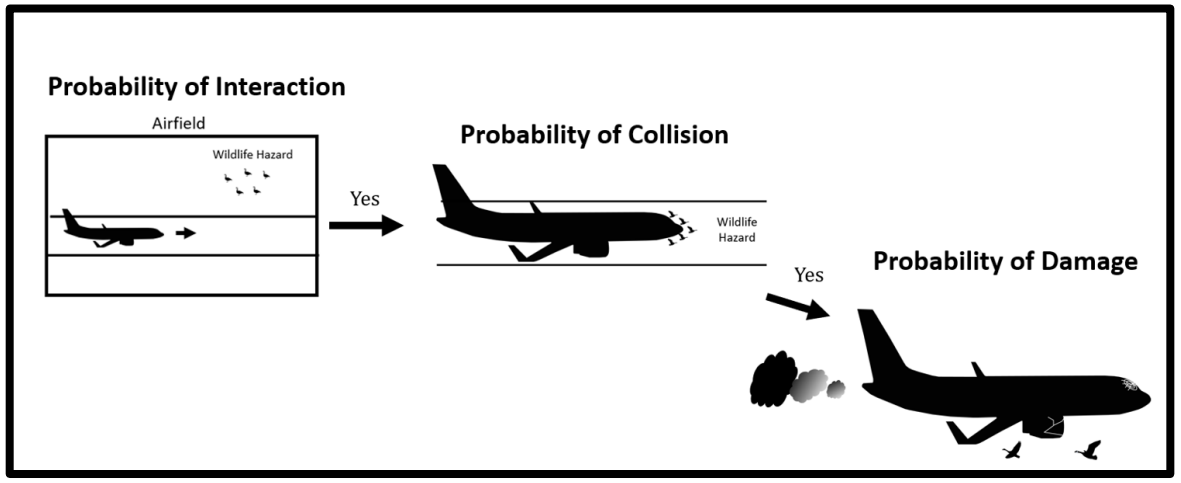
Existing Data Sources

Arrondo et al., 2021

Machine Learning



Modelling



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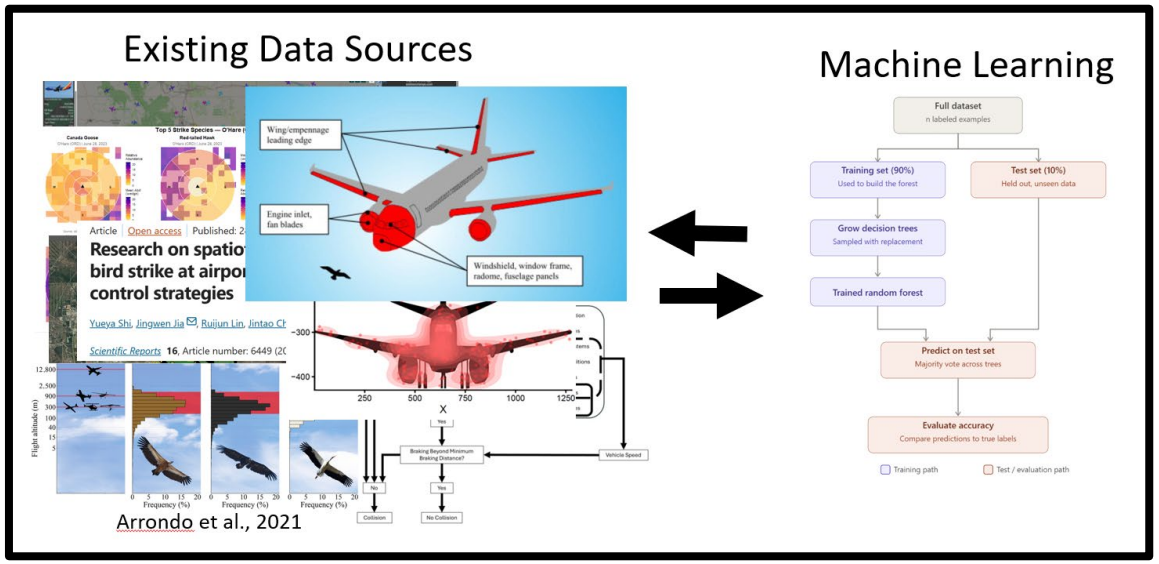
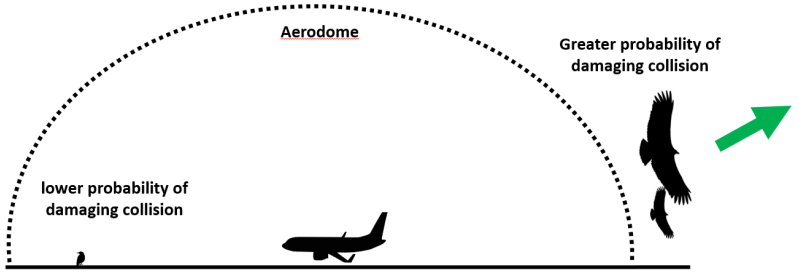


In Conclusion:

A robust system, not just birds in vicinity, capable of predicting the probability of damaging wildlife-aircraft interactions to inform:

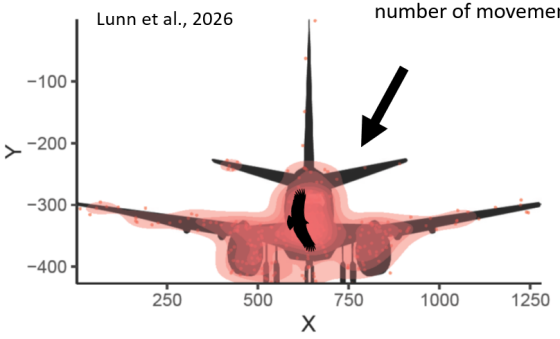
Flight Planning

Wildlife Management



Aircraft Design

E.g., Radome is likely to sustain X amount of damage over Y number of movements



Acknowledgements

Bradley F. Blackwell

USDA/APHIS/WS National Wildlife Research Center
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Applied ecology transportation ecology human-wildlife interactions birdstrikes animal-vehicle collisions

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Applied Statistics MS

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Questions?

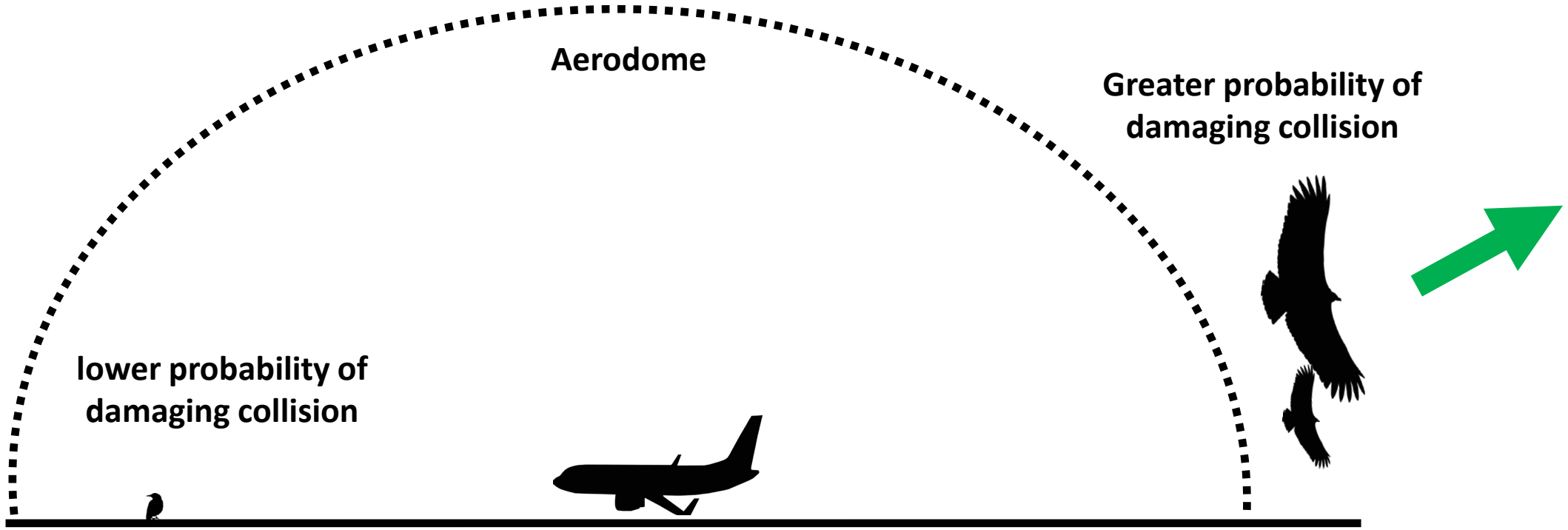
Ryan Lunn, Ph.D.,
email: rlunn@purdue.edu

Management Implications:

1. Flight Planning & Safety: providing estimates of the probability of a damaging bird aircraft collision for specific flight paths & locations

Management Implications:

2. Management Operations: Prioritizing management practices on the airfield to target species of concern. (i.e., Wildlife Hazard Management Plans)

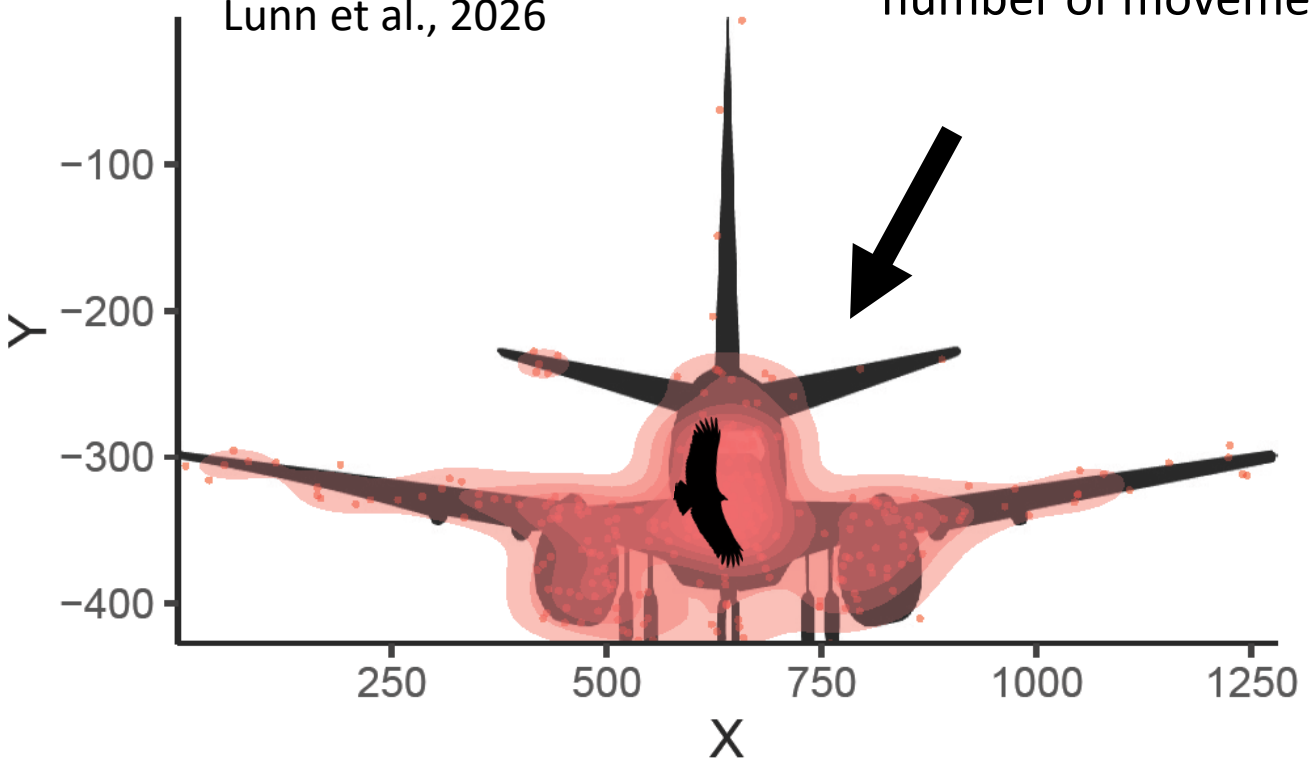


Management Implications:

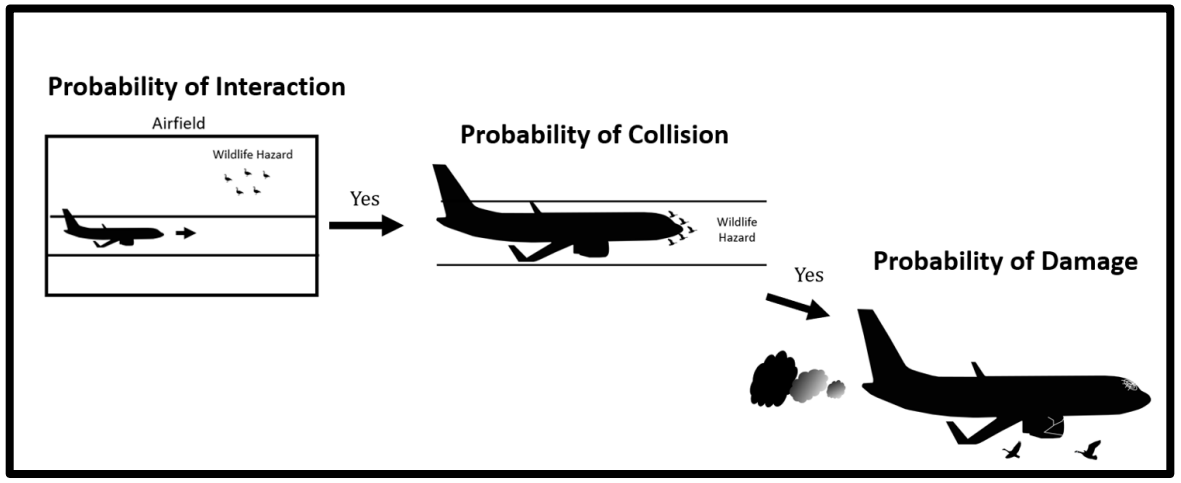
3. Informing decision making regarding aircraft repairs and components

Lunn et al., 2026

E.g., Radome is likely to sustain X amount of damage over Y number of movements



Modelling



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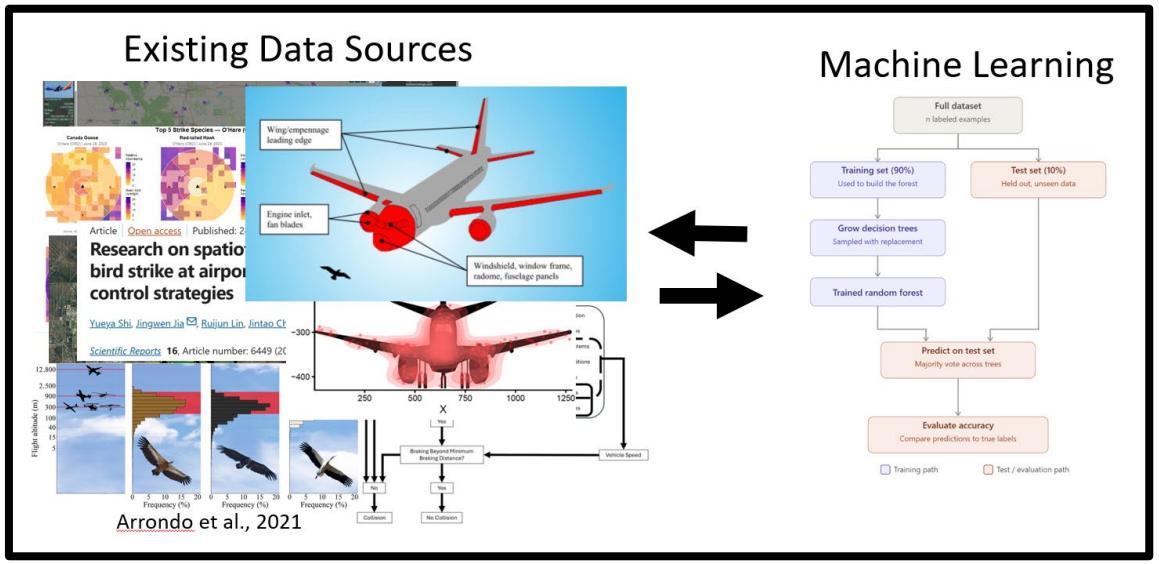
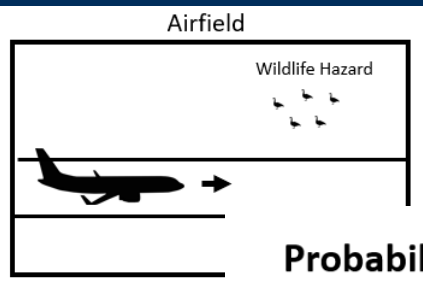


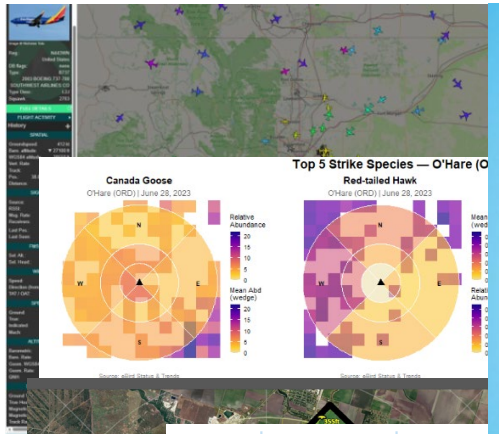
Probability of Wildlife-Aircraft Damage |

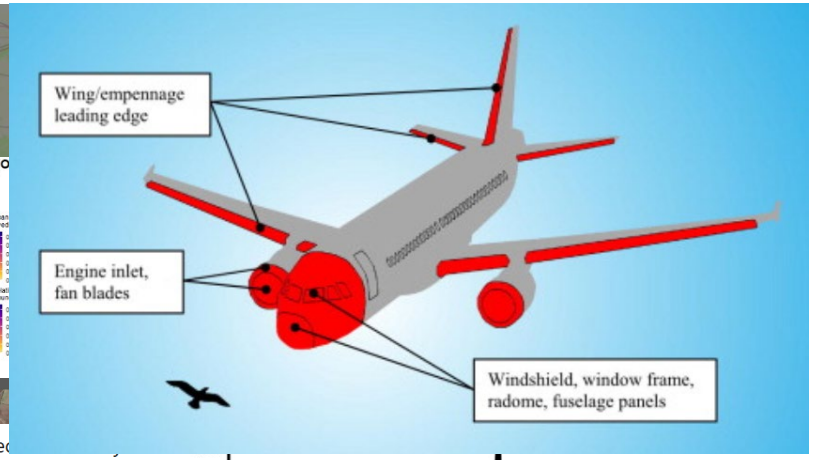


Probability of Collision

Probability of Damage

Probability Wildlife-Aircraft Interaction:





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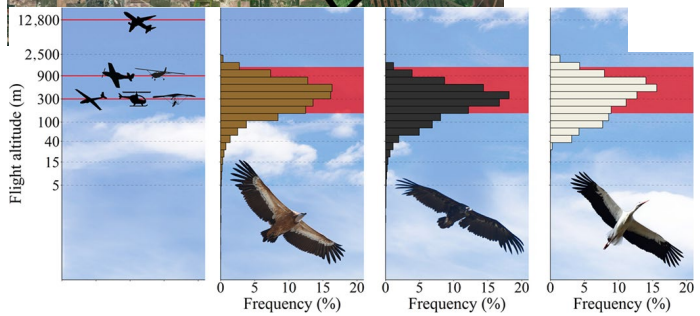
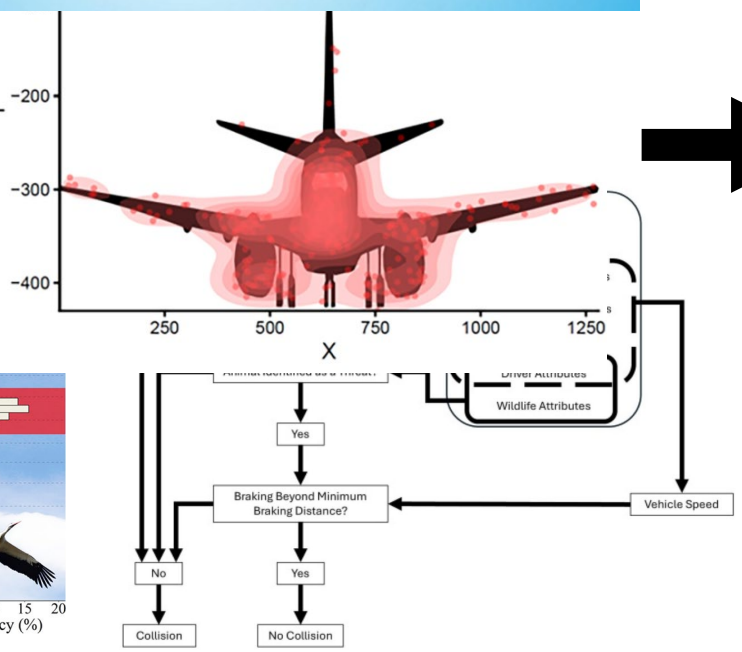
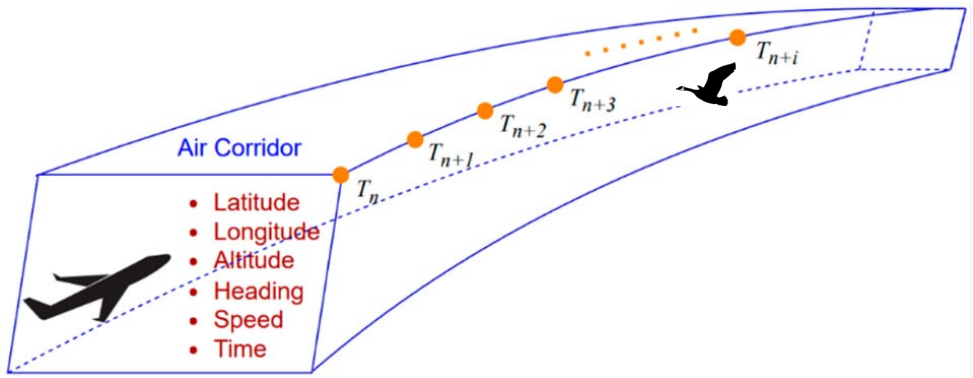
Scientific Reports **16**, Article number: 6449 (2026)

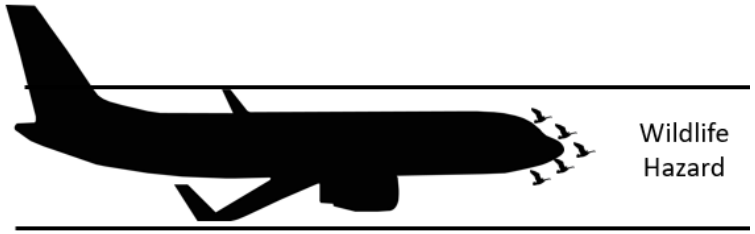


Arrondo et al., 2021



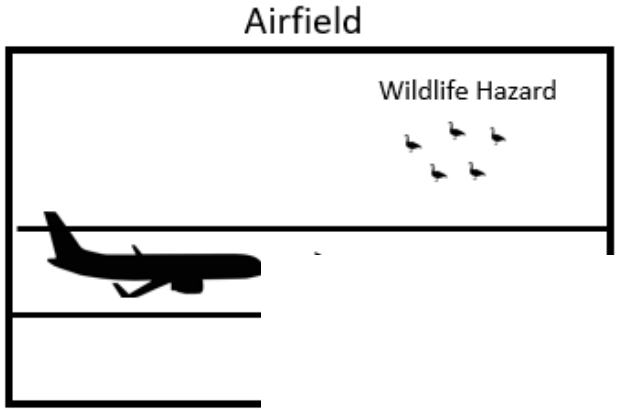


Hashemi et al., 2023



Yes

Probability of Interaction



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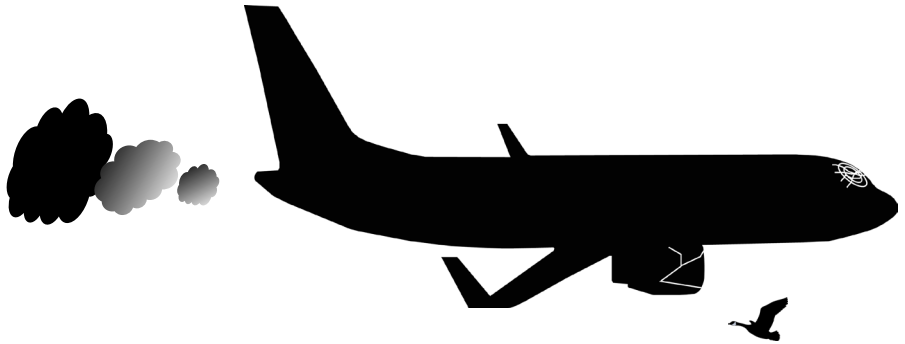
Probability of Collision

Probability of Damage

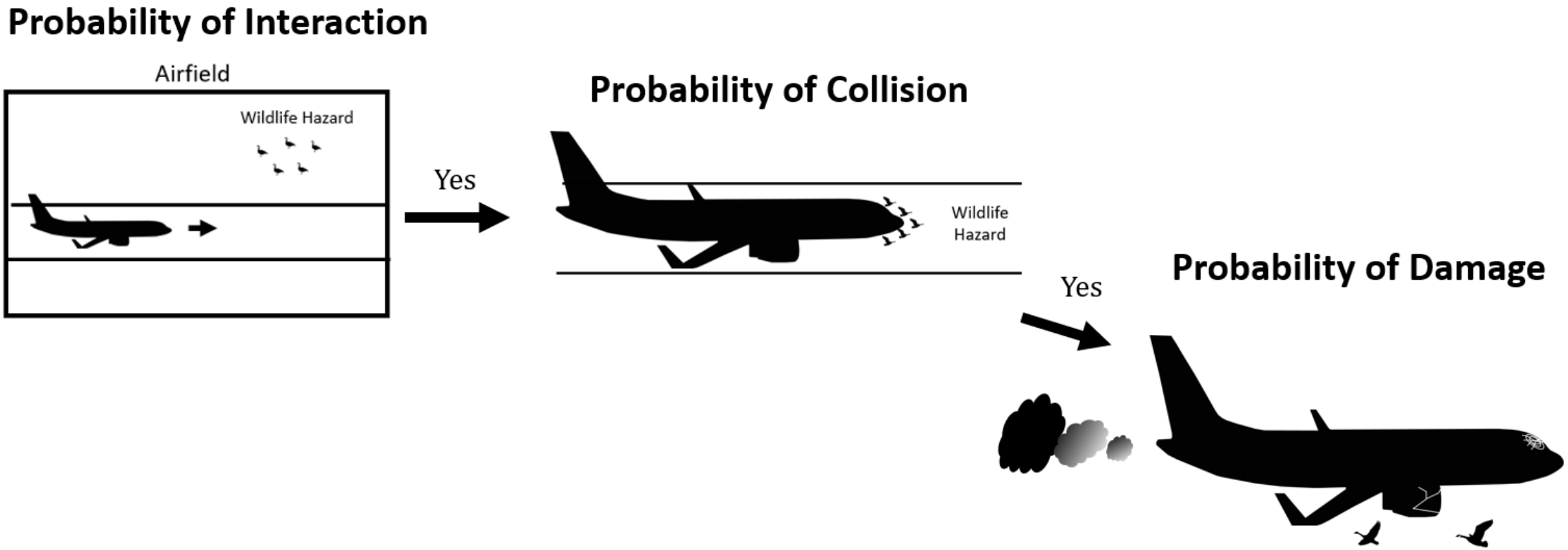
Probability of Damage



What is the probability of a damaging bird strike?

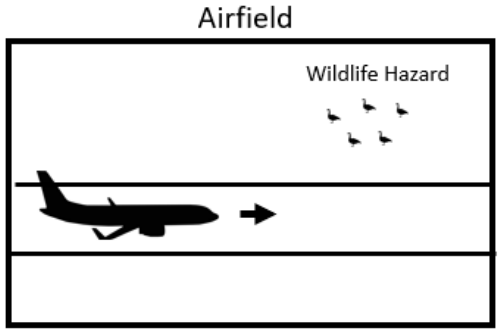
Modelling

Modelling wildlife-aircraft strike damage as a CONDITIONAL PROBABILITY



Wildlife-Aircraft Strike Risk: A Conditional Probability

Probability of Collision |



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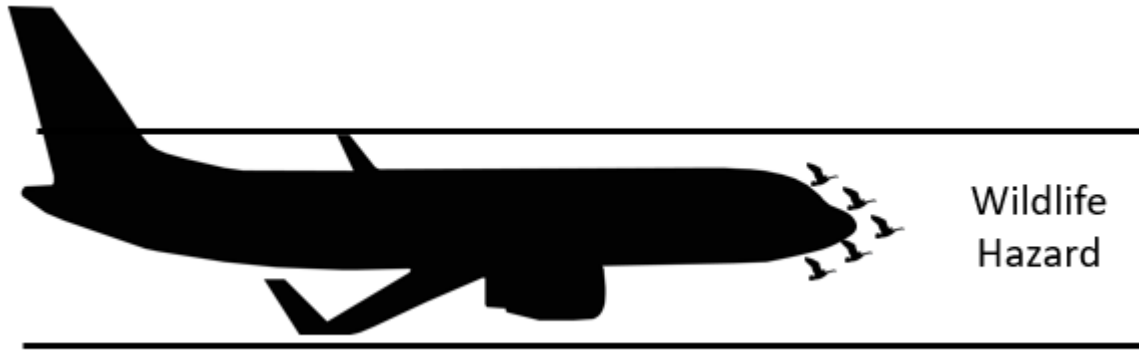
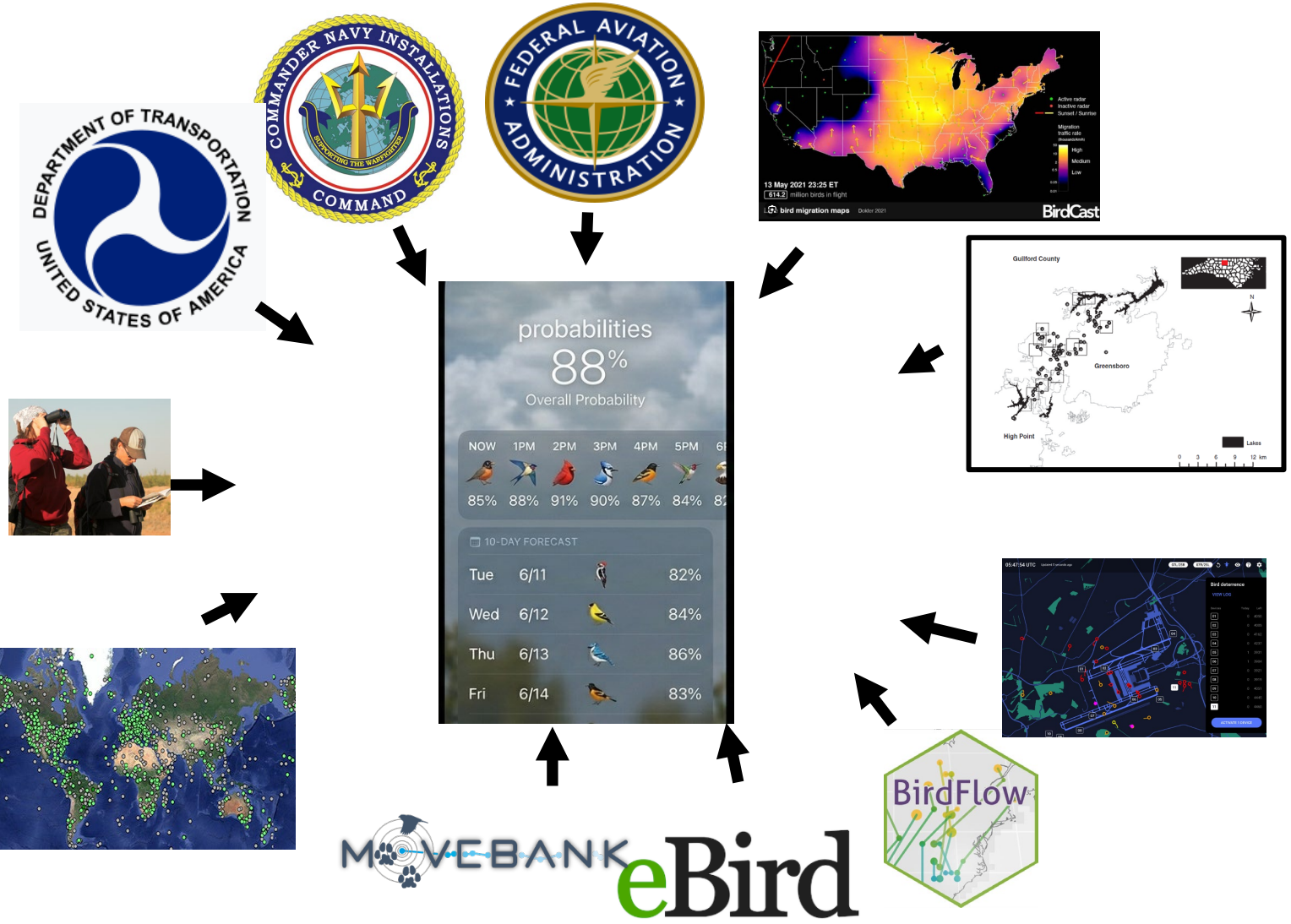


No

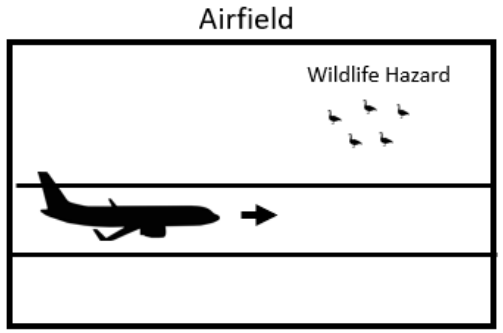
Harnessing *"Big Data"* to quantify the probability of bird strikes at airports

- Citizen Science (e.g., eBird)
- Weather Radar Data (e.g., BirdCast)
- Radar Systems (site specific)
- Flight Numbers (e.g., DOT)
- Collisions Reported (e.g., FAA Database)
- Scientific Literature
- Survey Data (e.g., Airfield Biologist)

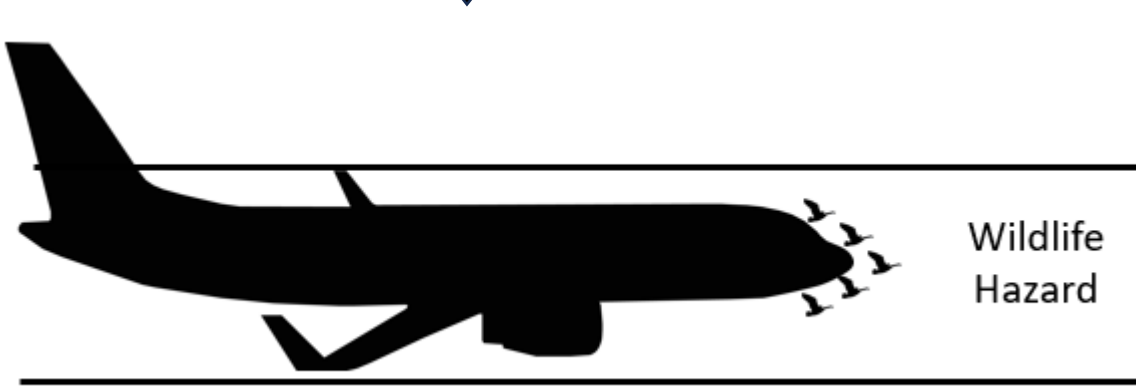


How does wildlife negatively impact flight operations?

Probability of Collision|



Yes



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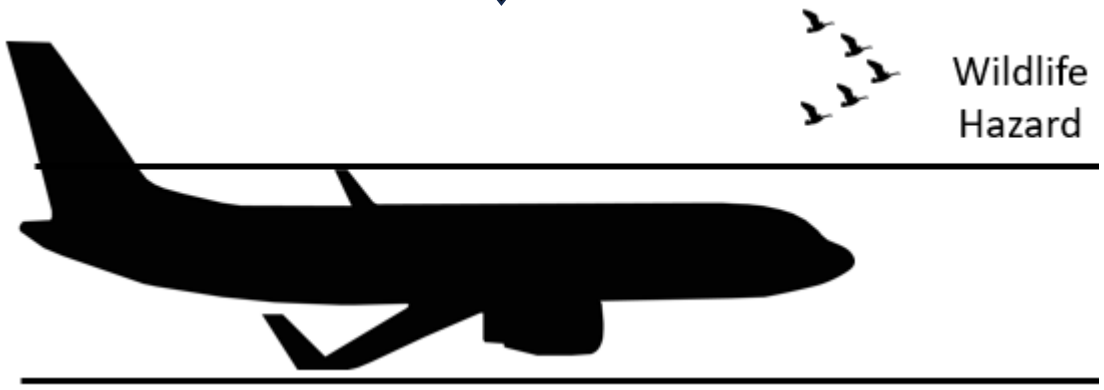

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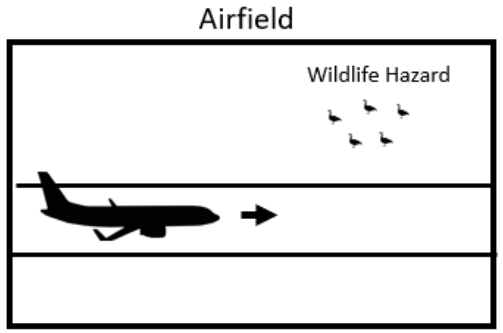

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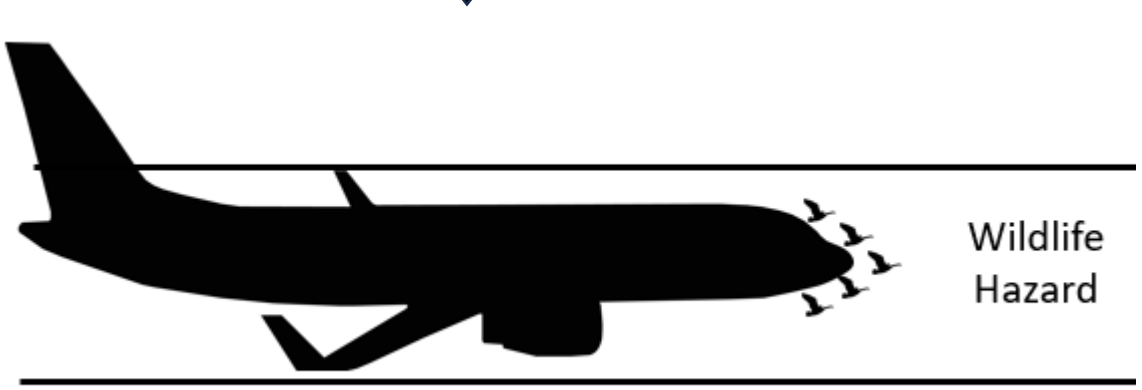
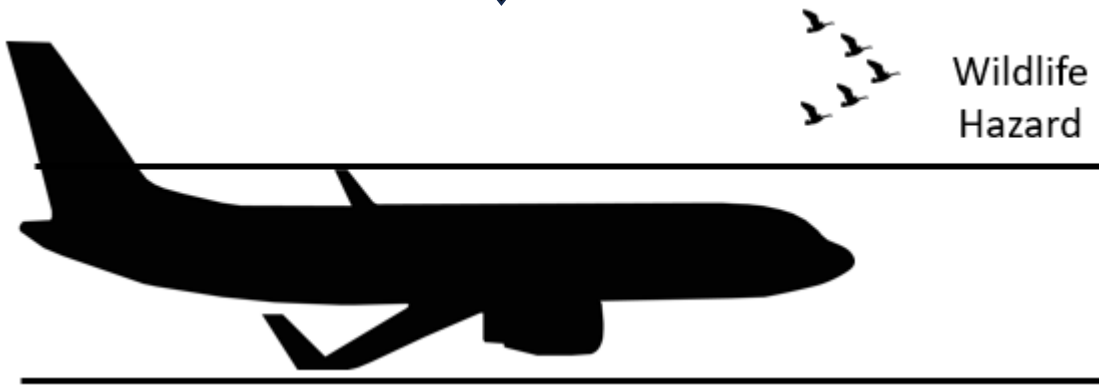
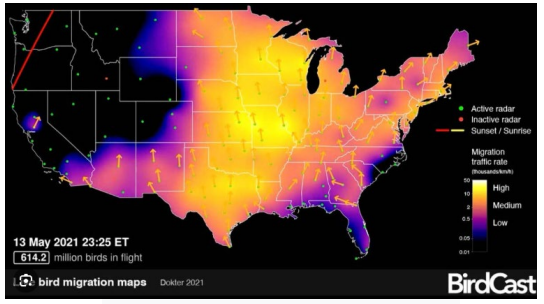
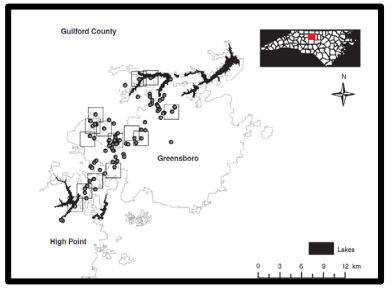


No



Claude Harnessing *"Big Data"* to quantify the probability of bird strikes at airports





Defining risk as an expected value

$$E(X) = \sum x_i P(x_i)$$

For example: Should you go to the park based on the weather forecast?

x_i = A Tornado Alert

$P(x_i) = 25\%$

What is wildlife-aircraft strike risk?

Measure of consequence (e.g., Direct & Indirect Cost)

Likely Stakeholder Specific

- Direct Repair Costs
- Indirect Costs (e.g., flight delays, lost income)

What is the probability of a consequence occurring as the result of wildlife & aircraft interaction?

Defining wildlife-aircraft strike risk as an expected value:

$$E(X) = \sum x_i P(x_i)$$

x_i = Measure of consequence (e.g., Direct & Indirect Cost)

$P(x_i)$ = Probability of consequence occurring

What is wildlife-aircraft strike risk?

Measure of consequence (e.g., Direct & Indirect Cost)

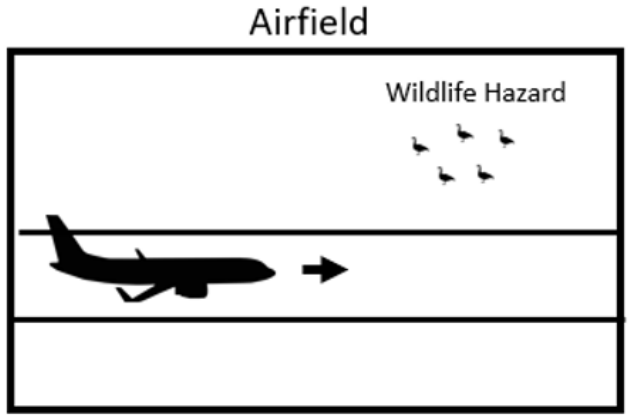
Likely Stakeholder Specific

- Direct Repair Costs
- Indirect Costs (e.g., flight delays, lost income)

What is wildlife-aircraft strike risk?

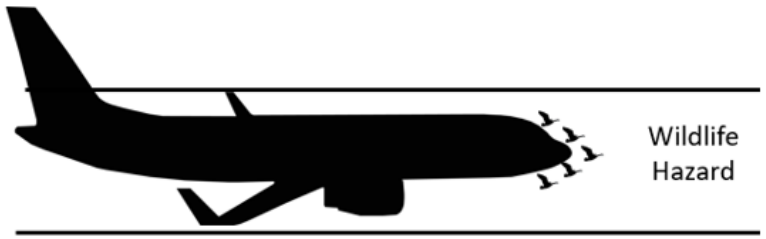
$$E(X) = \sum x_i P(x_i)$$

Probability of Interaction



Yes

Probability of Collision



Yes

Probability of Damage

Harnessing *"Big Data"* to quantify the probability of bird strikes at airports

Harnessing *"Big Data"* to quantify the probability of bird strikes at airports

- Citizen Science (e.g., eBird)
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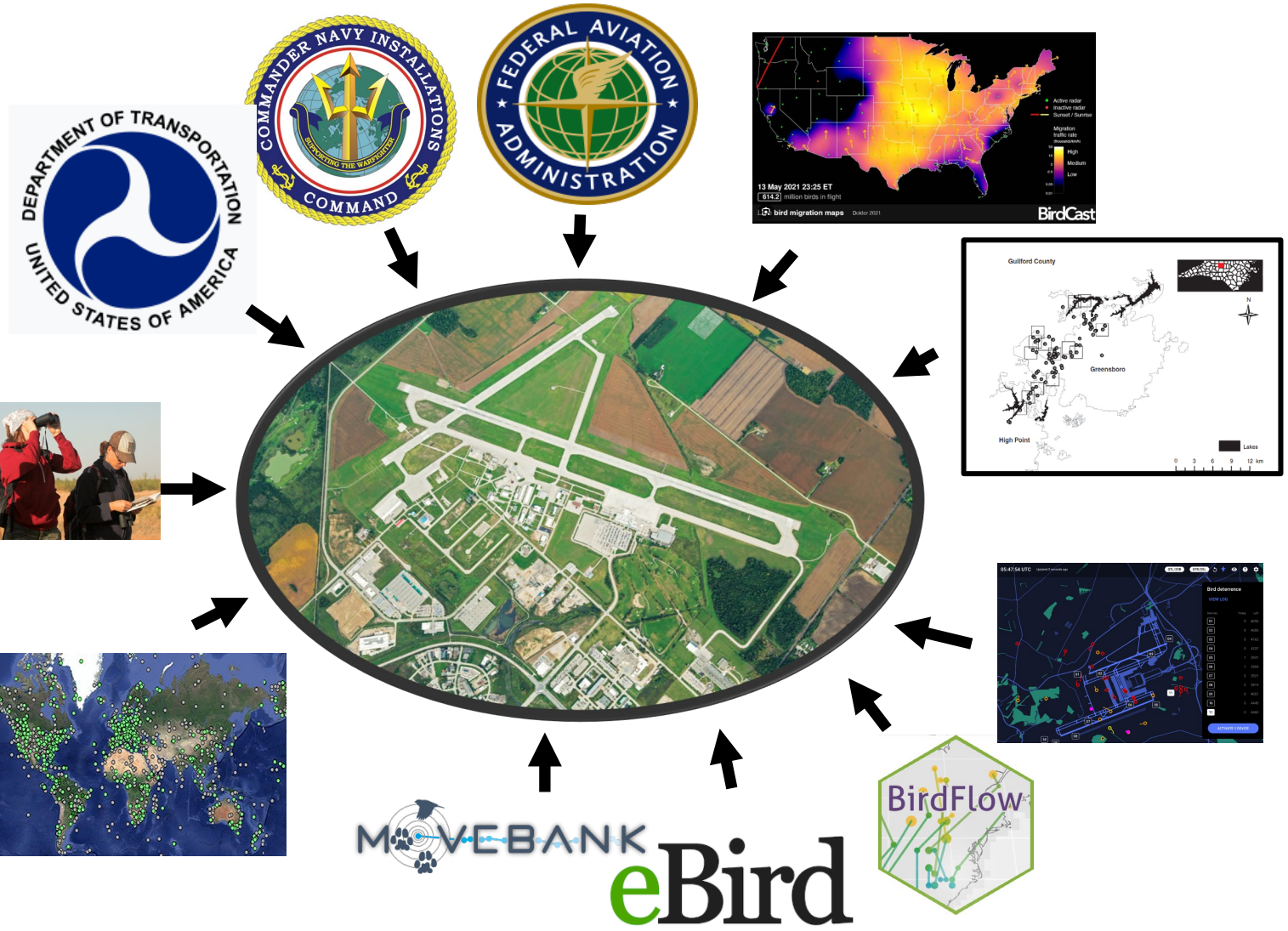
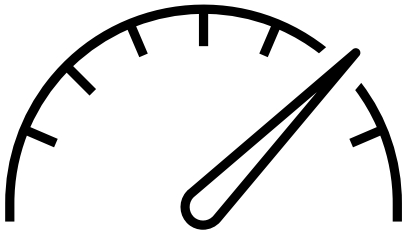


Project Objectives

- Forecast the probability of bird strikes

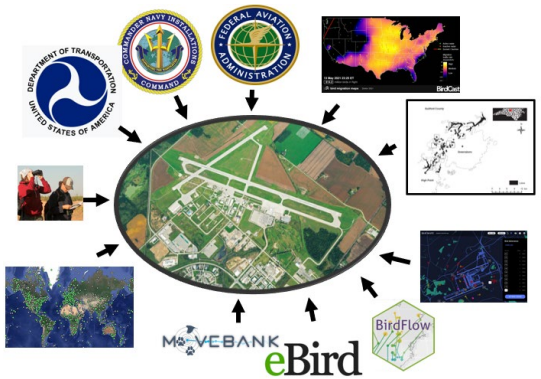
- Evaluate effectiveness of current BASH management practices



- Develop interactive dashboards for airport operations and flight planning

Data Processing

1. Collate data



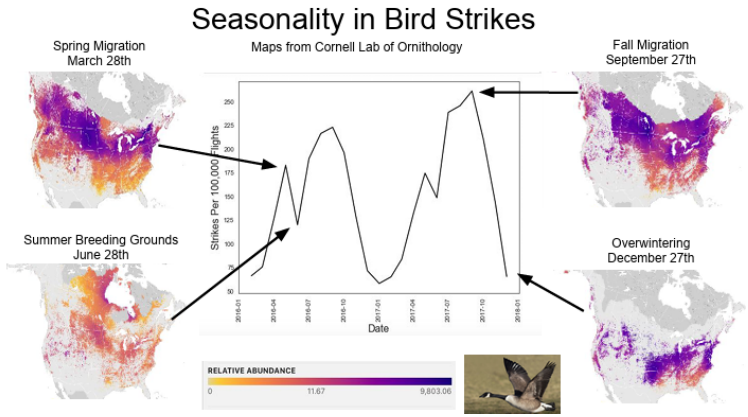
2. Build & Automate Pipelines

Pipelines

Modeling & dashboard development

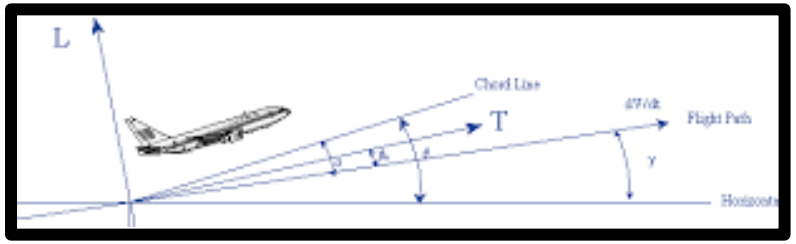
4. Forecasts of strike probability

3. Develop & evaluate predictive models of strike probability



5. Transfer to dashboard with automatic updating

6. Predict strike probability & assess mitigation strategies



Development an iterative process

Data Processing

1. Collate data

2. Build & Automate Pipelines

Modeling & dashboard development

3. Develop & evaluate predictive models of strike probability

4. Forecasts of strike probability

5. Transfer to dashboard with automatic updating

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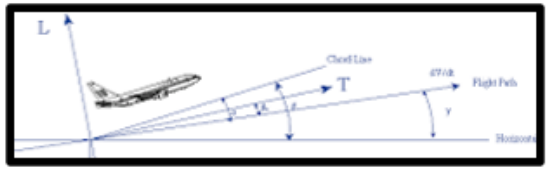
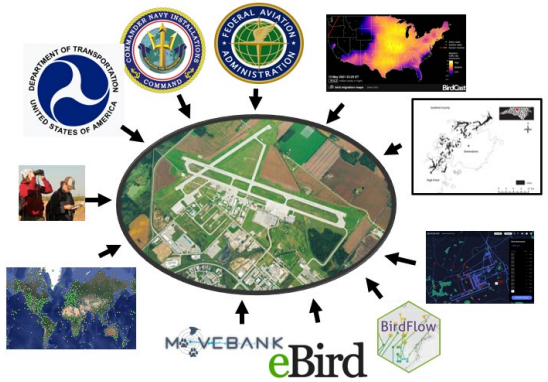
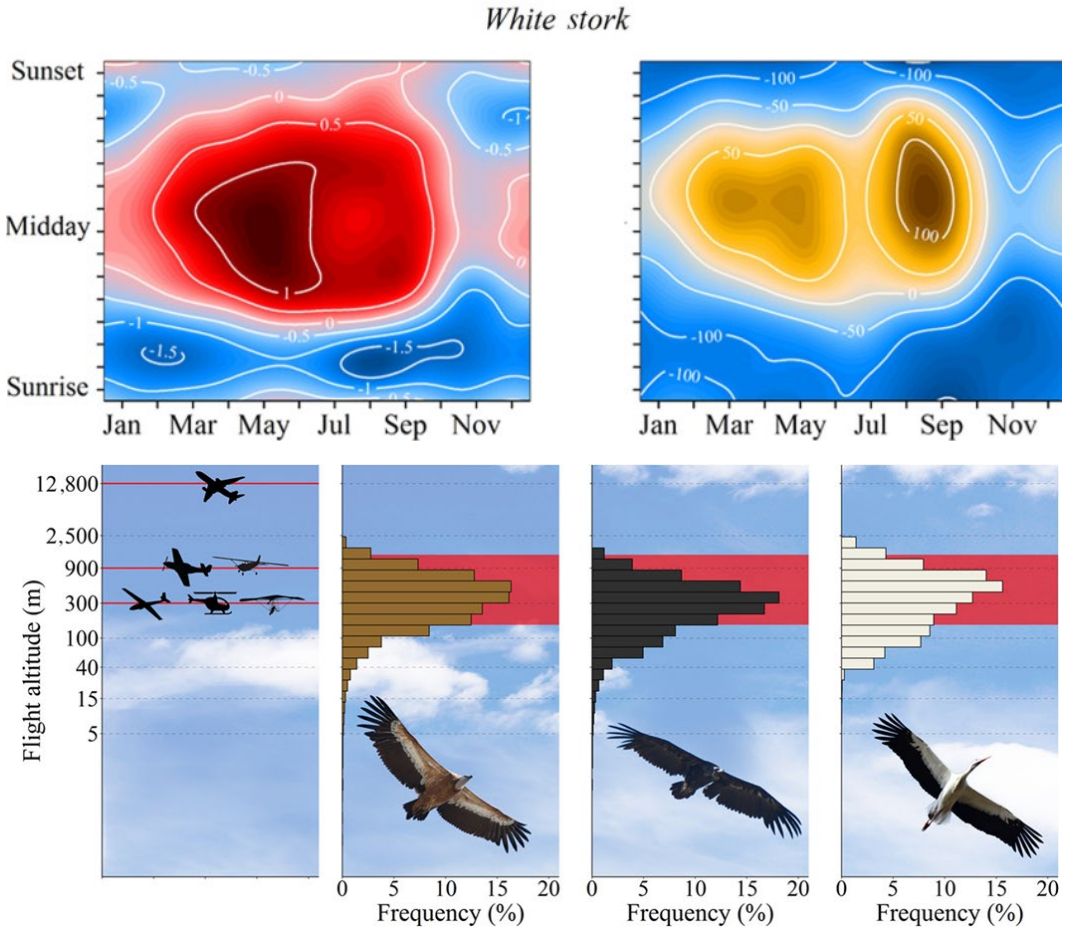


Next Research Steps:

1. Identify, gather, & assess the utility of existing data sources





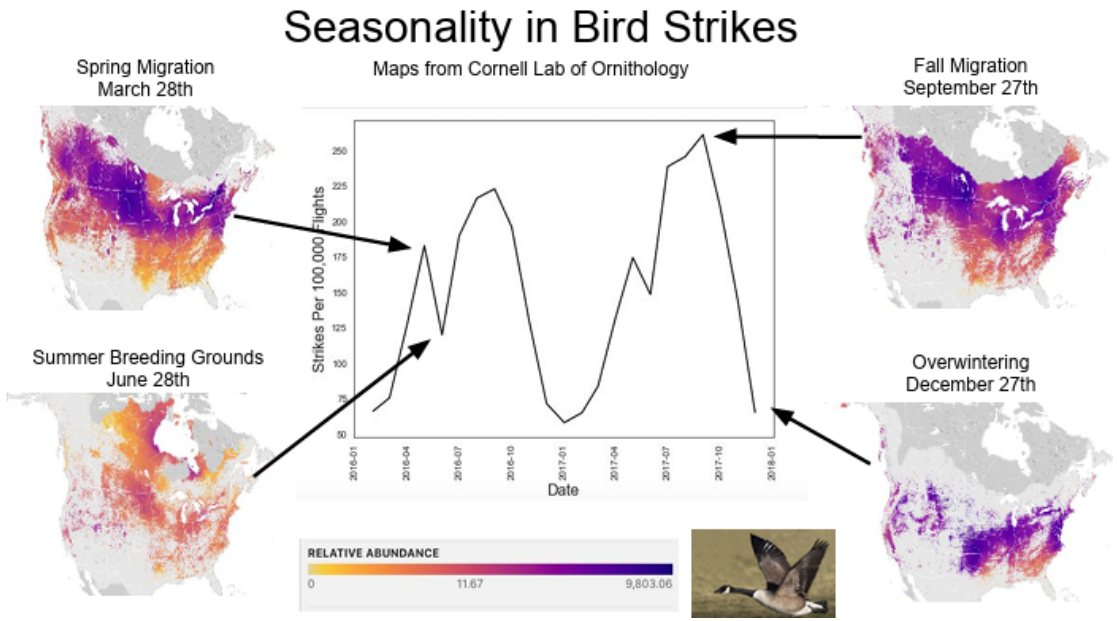
Arrondo et al., 2021

In the process identify

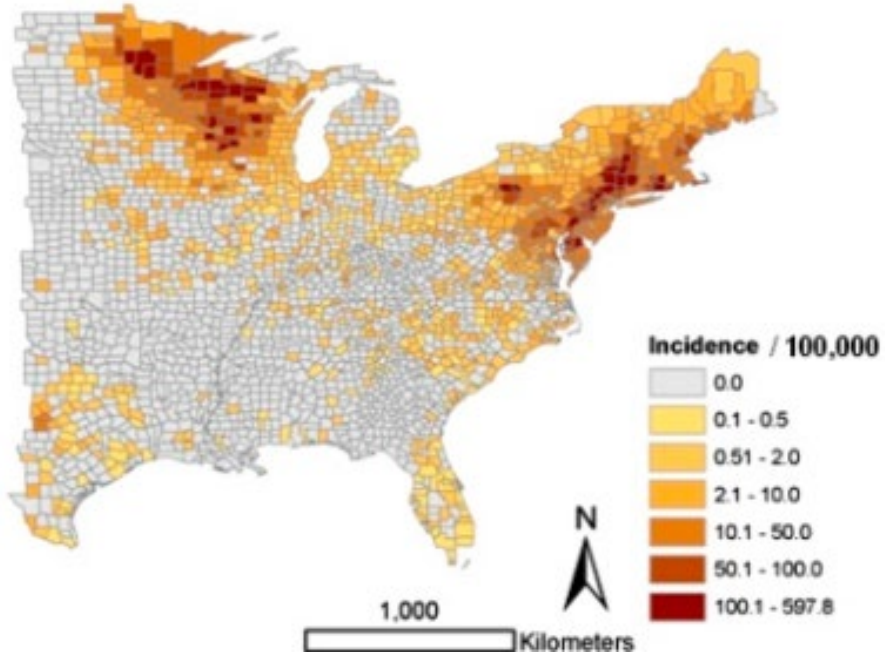
- Spatial and temporal scale
- Species of concern
- Critical variables (e.g., landcover, altitude, speed, etc.)

Next Research Steps:

3. Implement species distribution modeling in 3D around the airfield to forecast the probability of a bird strike



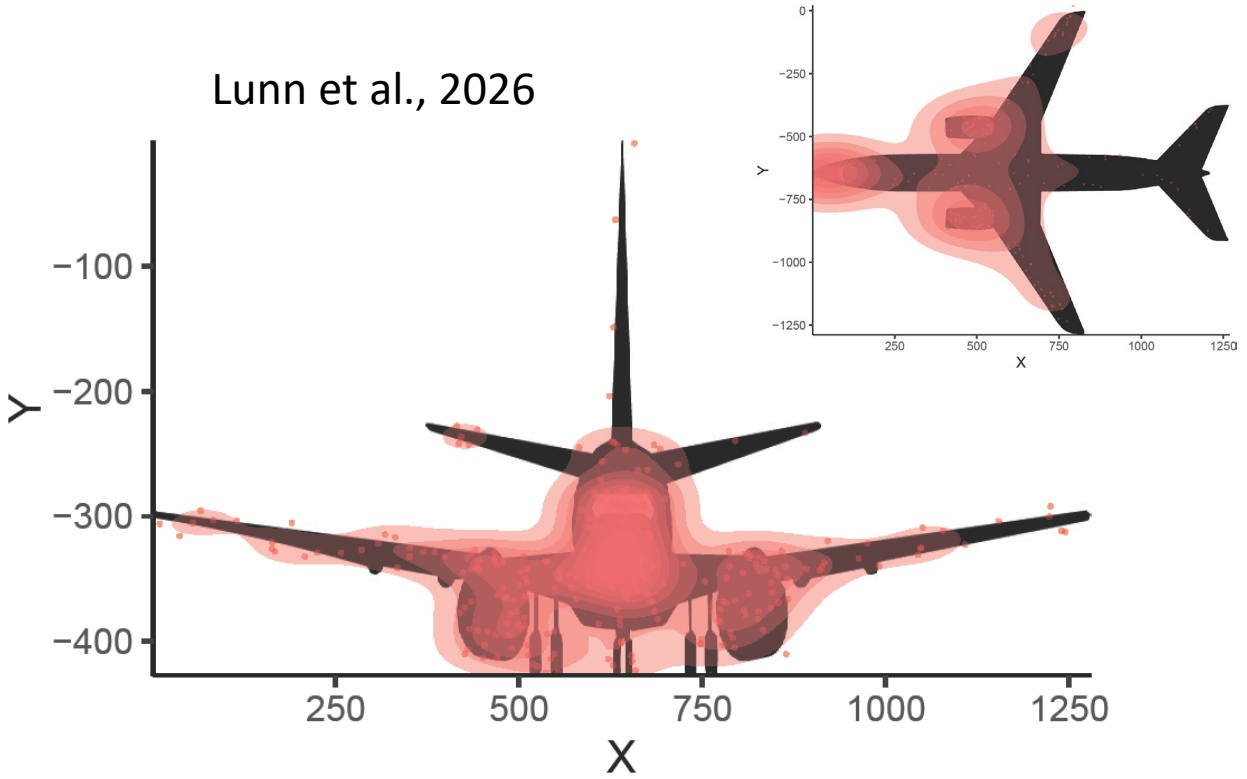
Pepin et al., 2012



Next Research Steps:

4. Develop an accessible system for the probability of bird strike estimates to aid stakeholder decision making (i.e., flight planning, material use)

Lunn et al., 2026

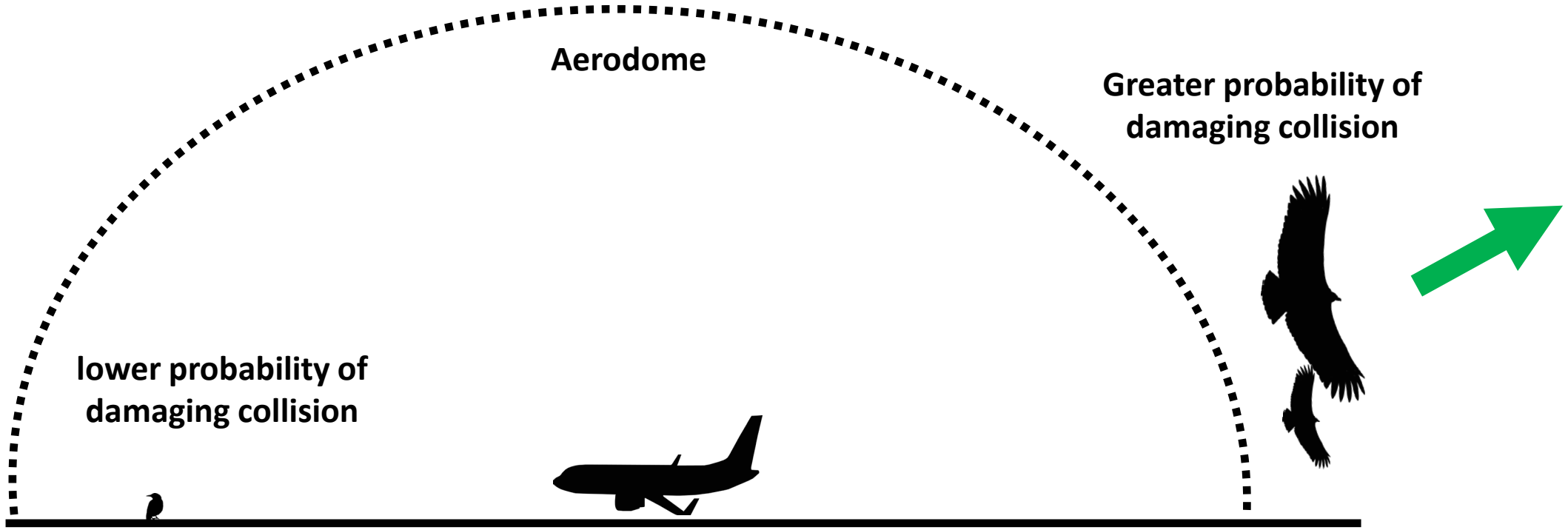


Management Implications:

1. Flight Planning & Safety: providing estimates of the probability of a damaging bird aircraft collision for specific flight paths & locations

Management Implications:

2. Management Operations: Prioritizing management practices on the airfield to target species of concern. (i.e., Wildlife Hazard Management Plans)

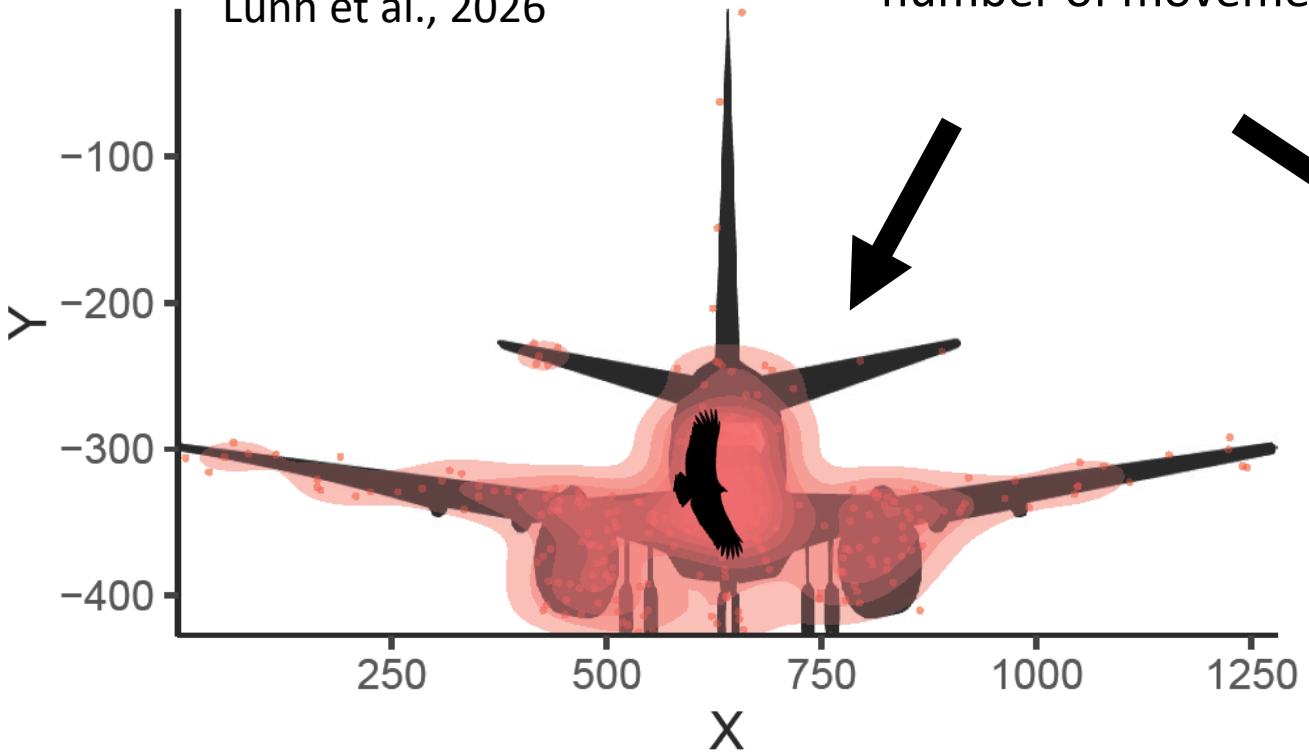


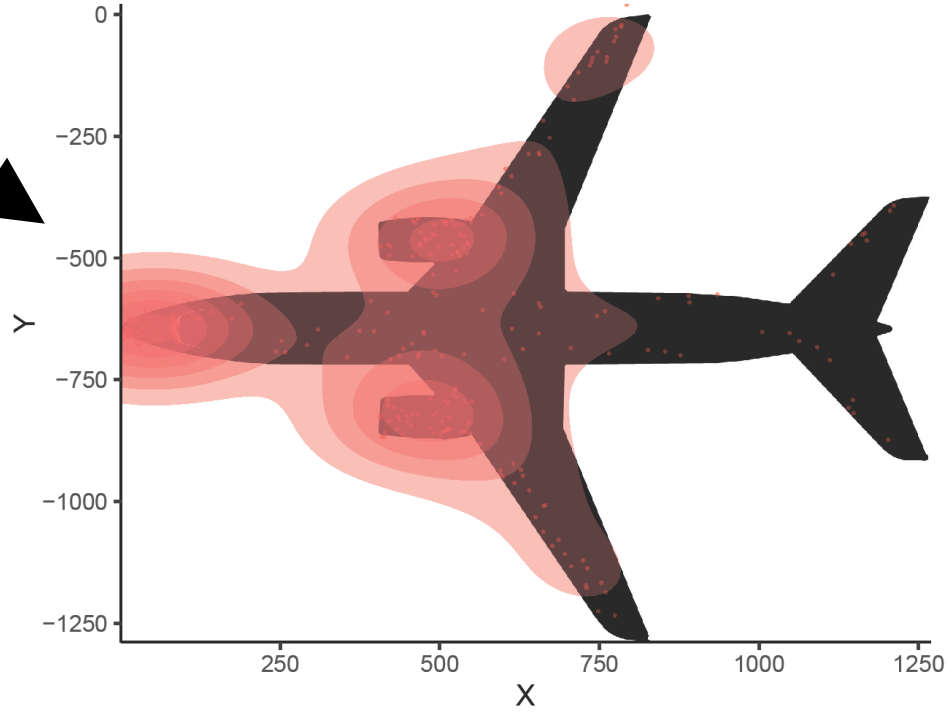
Management Implications:

3. Informing decision making regarding aircraft repairs and components

E.g., Radome is likely to sustain
X amount of damage over Y
number of movements

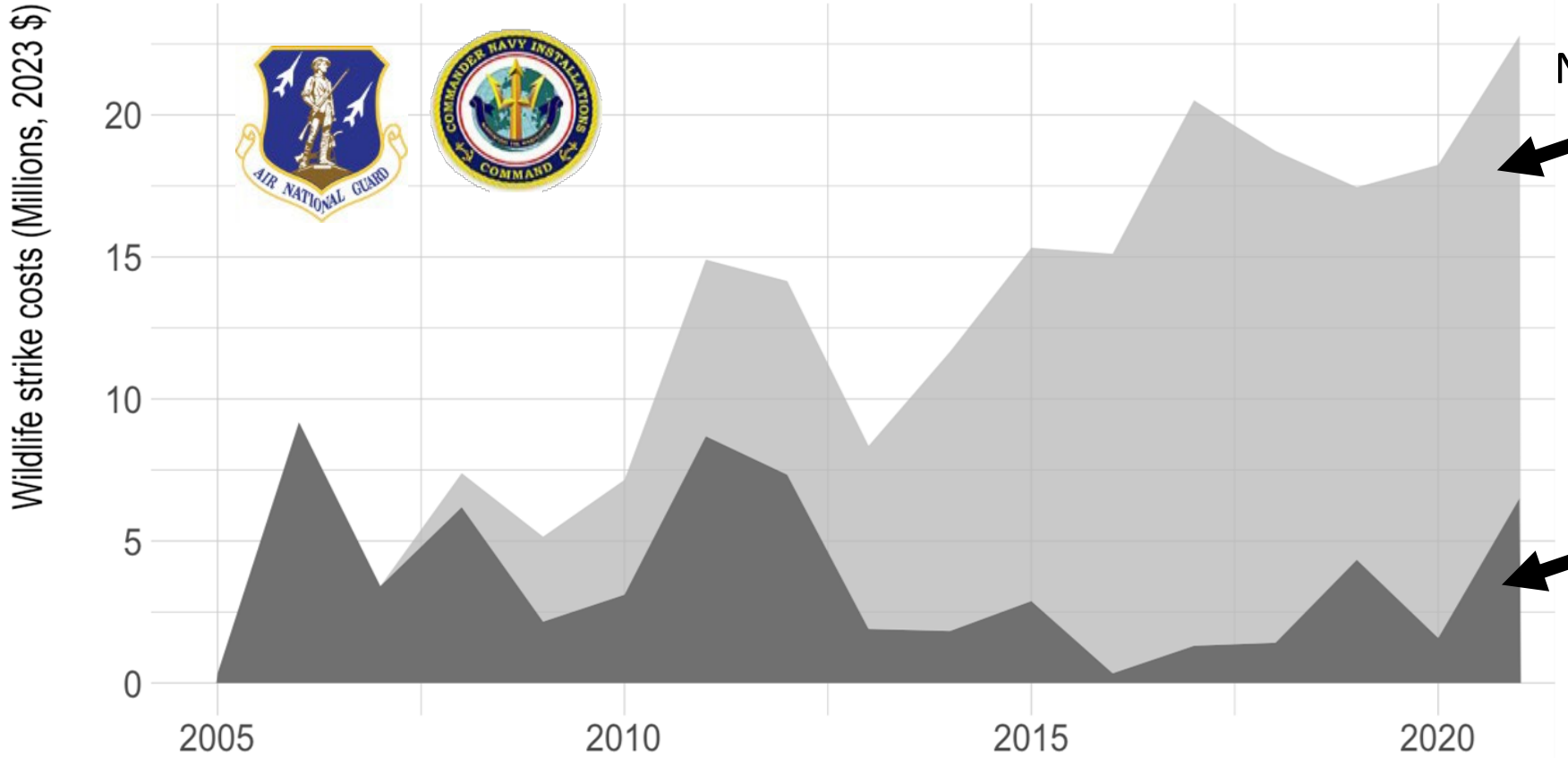
Lunn et al., 2026





The economic benefits of a BASH program (2005-2021)

BASH Management Programs averted 147 million in costs



Altringer et al., 2024

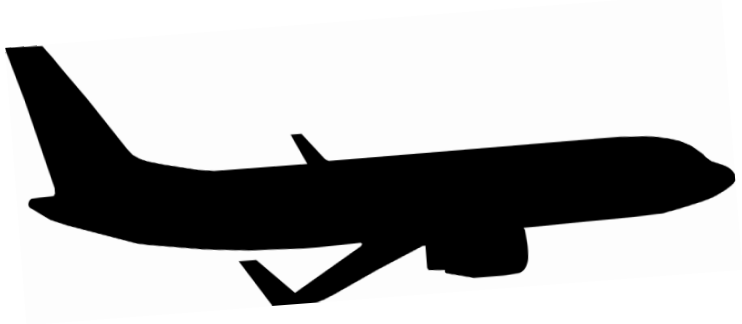
Questions ?

mike.begier@usda.gov 202-341-7377

Bird Aircraft Collisions & the P-8 Poseidon Aircraft

Total Repair Cost: $8.3 million (2814 Incidents, 125 Aircraft, 2012-2026)

- Birds Reported: $7.54 million (1576 Incidents, 46 Mishaps)
- Birds Not Reported: $757,774 (1153 Incidents, 18 Mishaps)



Bird Aircraft Collisions & the P-8 Poseidon Aircraft

Birds Reported: $7.54 million (1576 Incidents, 46 Mishaps)

- Severe: $0 (7 Incidents, 0 Mishaps)
- Moderate: $179,386 (229 Incidents, 8 Mishaps)
- Low: $5.86 million (1274 Incidents, 34 Mishaps)
- Unknown: $1.49 million (66 incidents, 4 Mishaps)

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- Low: $5.86 million (1274 Incidents, 34 Mishaps)
- Unknown: $1.49 million (66 incidents, 4 Mishaps)

The ability to identify the risk or predict the probability of economic damage is limited

Next Research Steps:

1. Review Methodologies of Bird Strike Risk Estimation & Build upon existing theoretical frameworks

Literature

Ranking the hazard level of wildlife species to aviation

Richard A. Dolbeer, Sandra E. Wright, and Edward C. Cleary

Research on spatiotemporal risk assessment model of bird strike at airports and precise prevention and control strategies

Yueya Shi, Jingwen Jia ✉, Ruijun Lin, Jintao Chen, Xuedong Fang & Yun Sheng

Scientific Reports **16**, Article number: 6449 (2026) | Cite this article

921 Accesses | Metrics

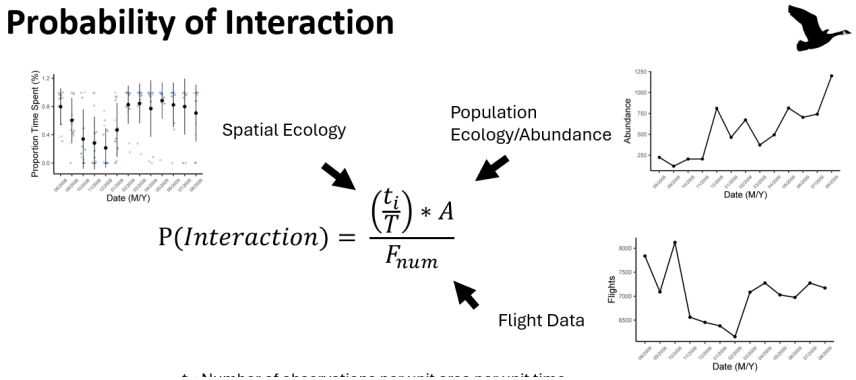
Human–Wildlife Interactions 5(2):249–268, Fall 2011

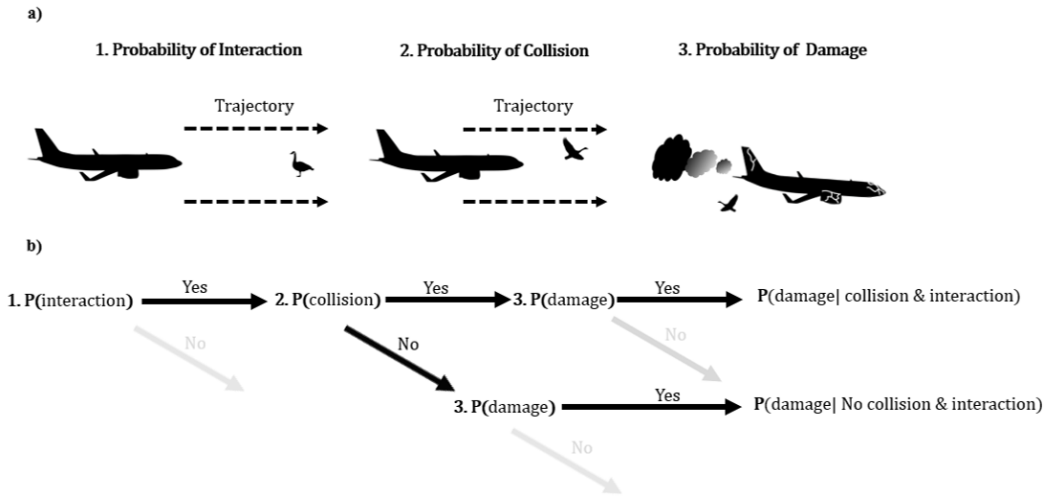
Using avian radar to examine relationships among avian activity, bird strikes, and meteorological factors

Peter S. Coates, U.S. Geological Survey, Western Ecological Research Center, Dixon, CA 95620, USA *pcoates@usgs.gov*

Theory

Probability of Interaction





Defining wildlife-aircraft strike risk as a conditional probability