Using Machine Learning to Predict Hazing Success at Airports

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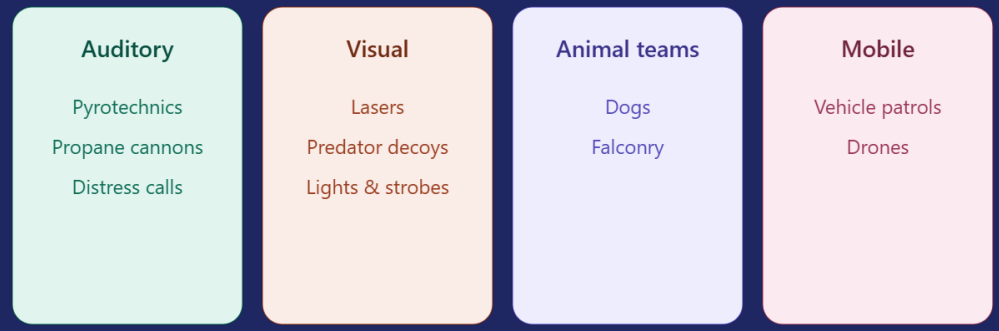
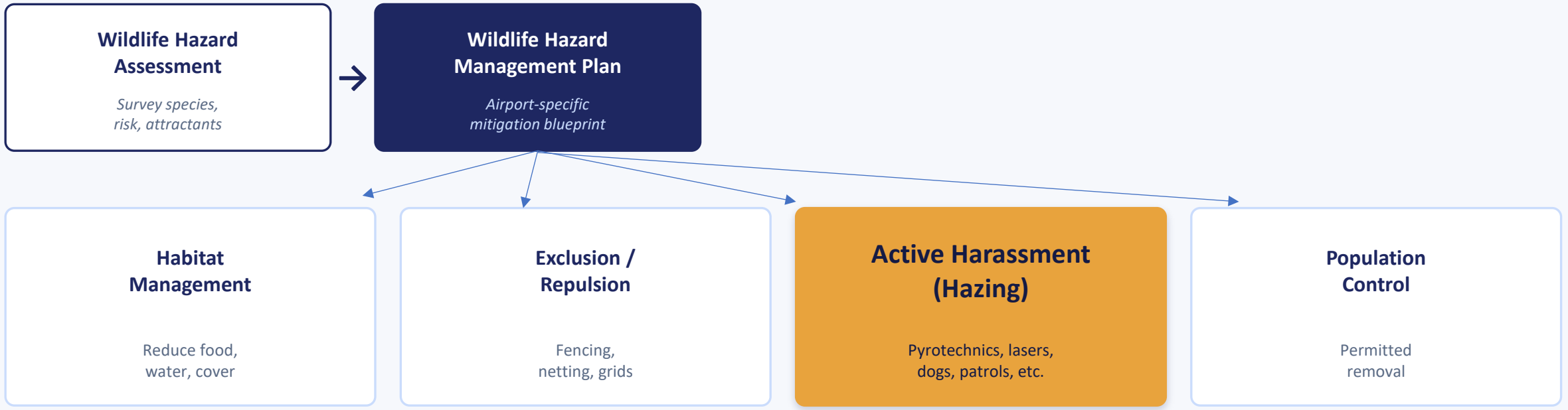


PURDUE UNIVERSITY

REGULATORY & OPERATIONAL CONTEXT

Wildlife Hazard Management

14 CFR § 139.337 requires FAA-certificated airports to take action to alleviate wildlife hazards, and to conduct a Wildlife Hazard Assessment and Management Plan.



Hazing: dispersal of wildlife from the airport operations area

Sources: 14 CFR § 139.337 (eCFR); FAA Advisory Circular 150/5200-38 (2018).

A rich data resource

- Every hazing event logged by airport wildlife biologists captures multiple variables.
- Accumulated over years of routine operations, these records form large, detailed datasets.
- These data are rarely analyzed beyond basic recordkeeping.

From routine records to predictive management

Goal

Apply Machine Learning algorithms to a hazing dataset from a Part 139 airport to:

1. Predict the required management response (monitoring, hazing, lethal take)
2. Predict the probability of success of a given hazing effort

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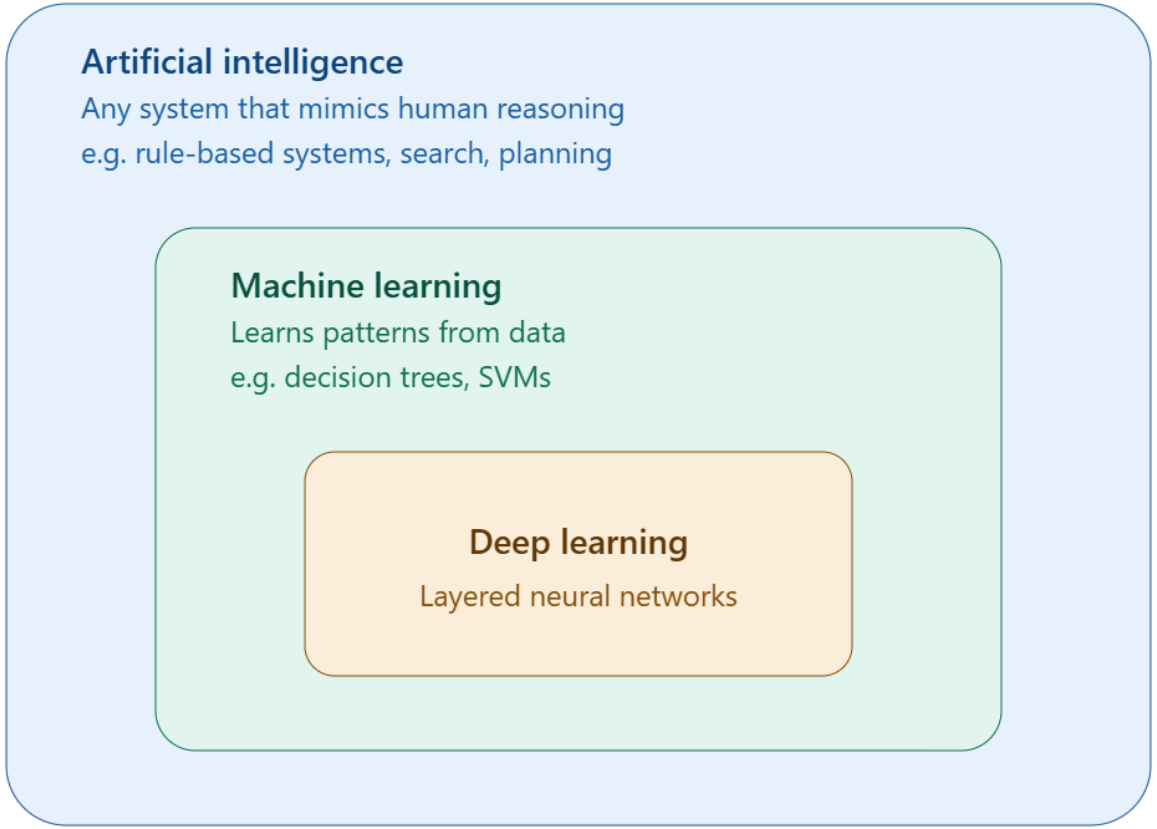
Why predictive management matters

Develop a quantitative tool to make evidence-based and location-specific management decisions at different times scales (hourly, daily, monthly, seasonally)

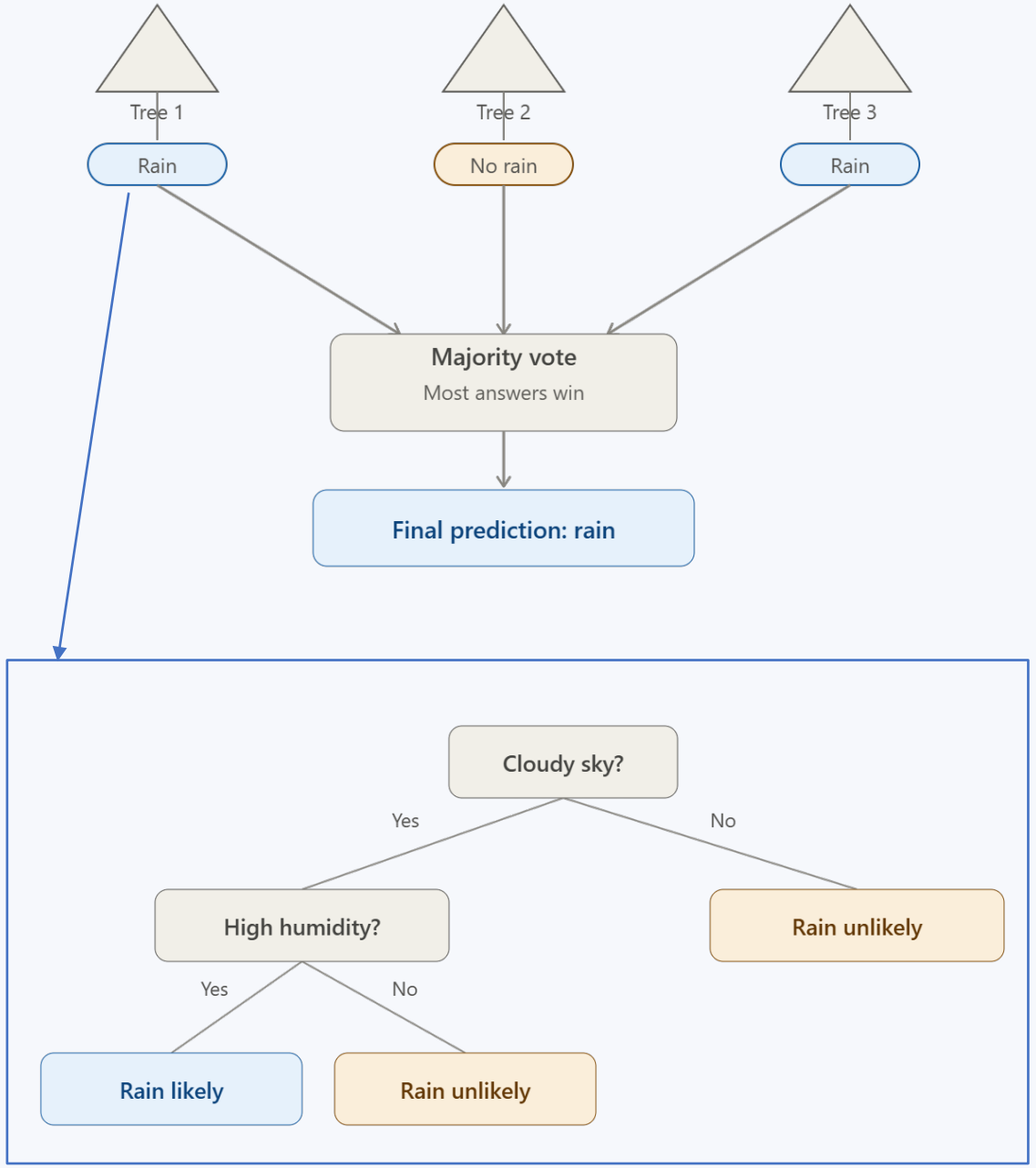

TOOL KIT

AN EMERGING ANALYTICAL TOOL



Machine Learning

Random forest algorithm

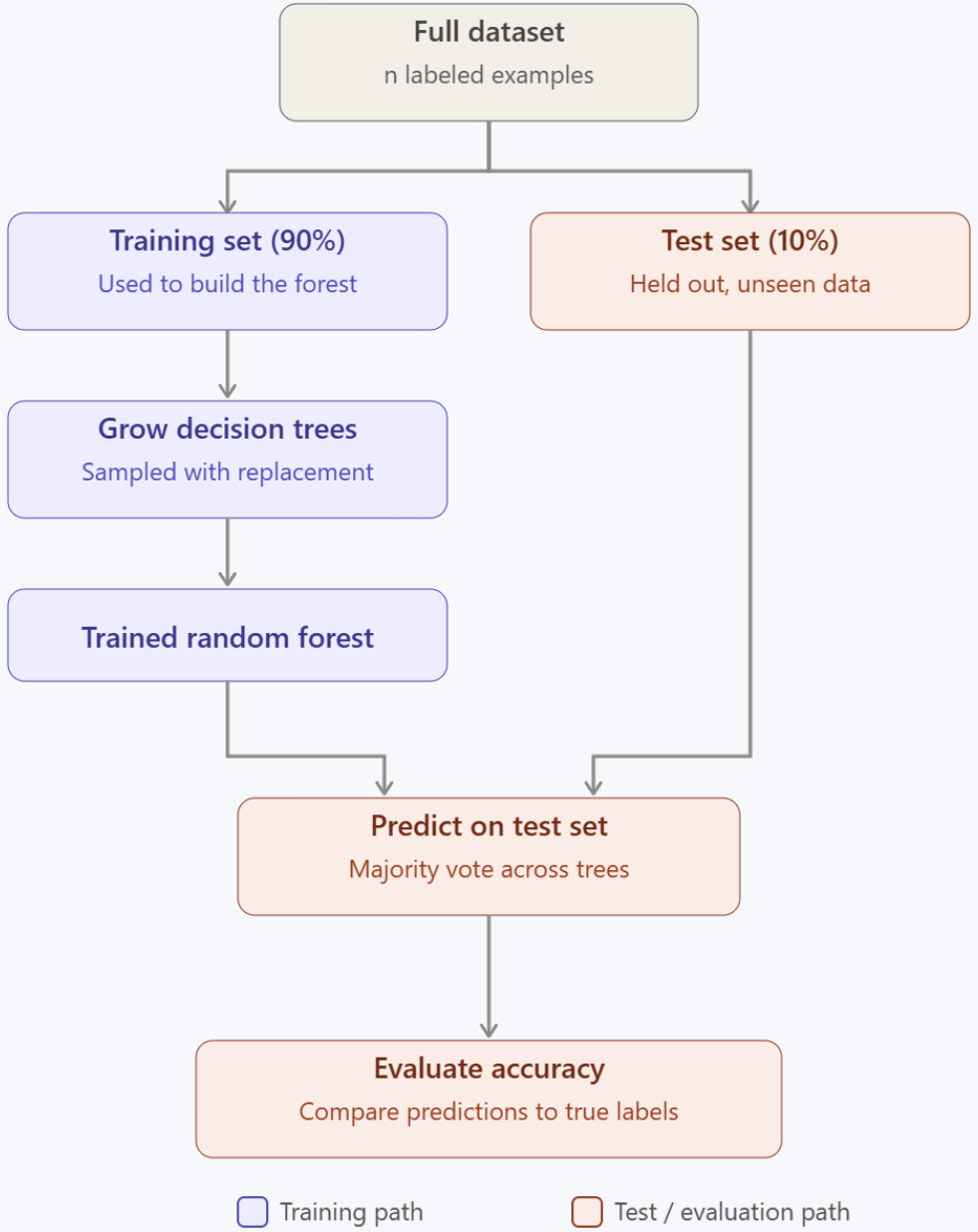


ML is increasingly used in ecology and wildlife management (species-distribution modeling, habitat prediction, and management decision-support) as it can handle large, messy, nonlinear datasets without requiring the relationships among variables to be known in advance.

Sources: Breiman, L. (2001), Machine Learning 45:5–32; Elith et al. (2006), Ecography 29:129–151.

Machine Learning

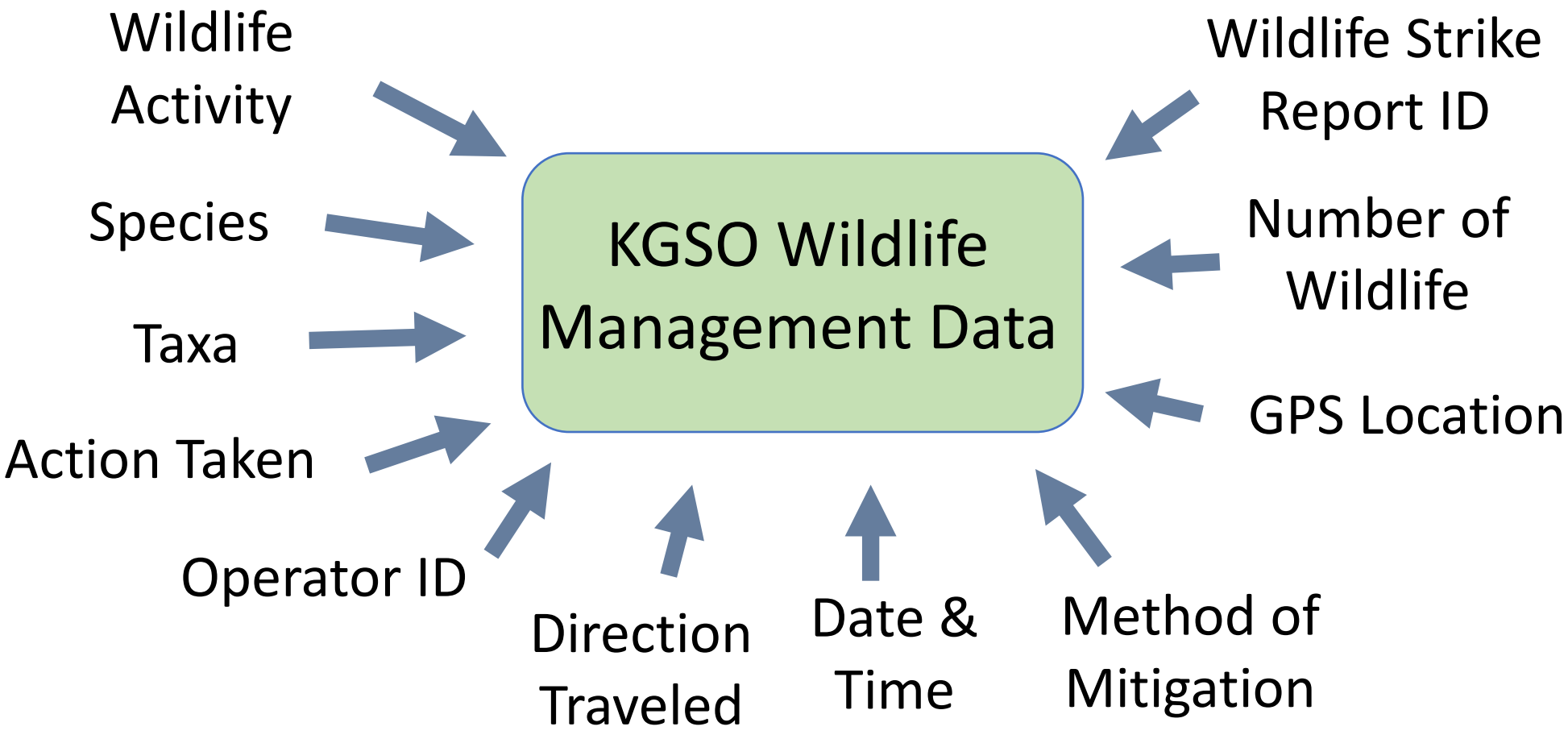
Random forest algorithm



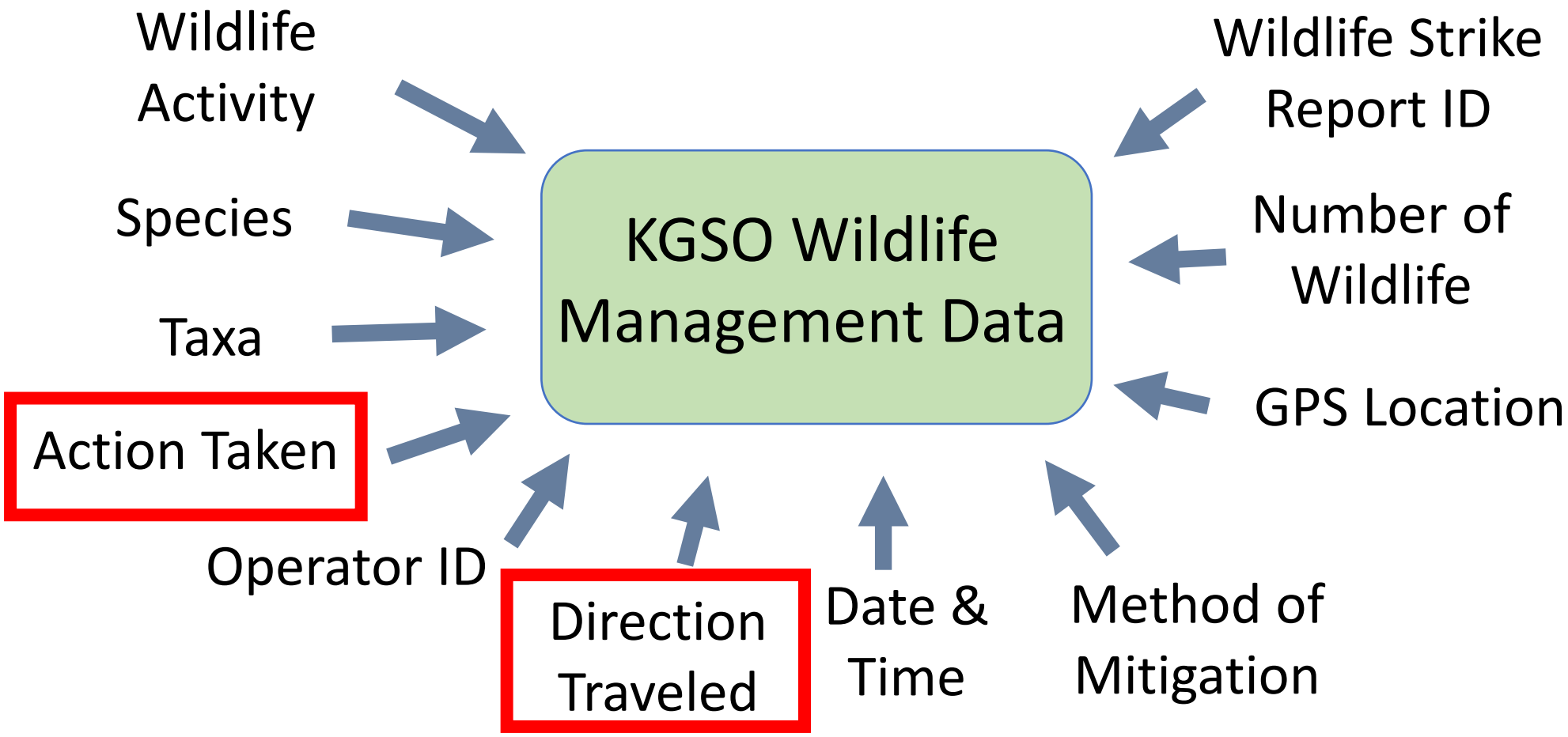
Methods

- **What:** 2,555 wildlife management interactions
    - Veoci system (comparable to Oracle)
- **Where:** Piedmont Triad International Airport (KGSO)
    - Located in Greensboro, NC
- **When:** July 12th, 2017 to December 12th, 2024

KGSO


Wildlife Activity
Species
Taxa
Action Taken
Operator ID
Direction Traveled
Date & Time
Method of Mitigation
GPS Location
Number of Wildlife
Wildlife Strike Report ID
KGSO Wildlife Management Data

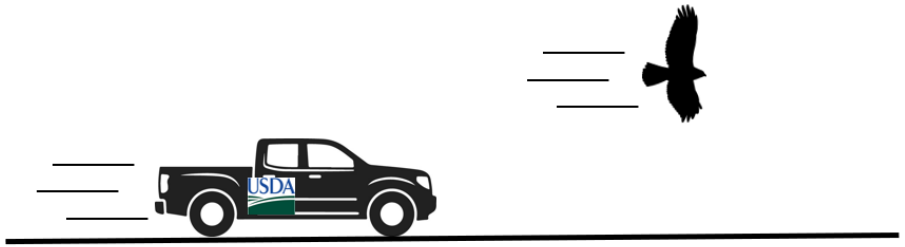
Methods


Wildlife Activity
Species
Taxa
Action Taken
Operator ID
Direction Traveled
Date & Time
Method of Mitigation
GPS Location
Number of Wildlife
Wildlife Strike Report ID
KGSO Wildlife Management Data

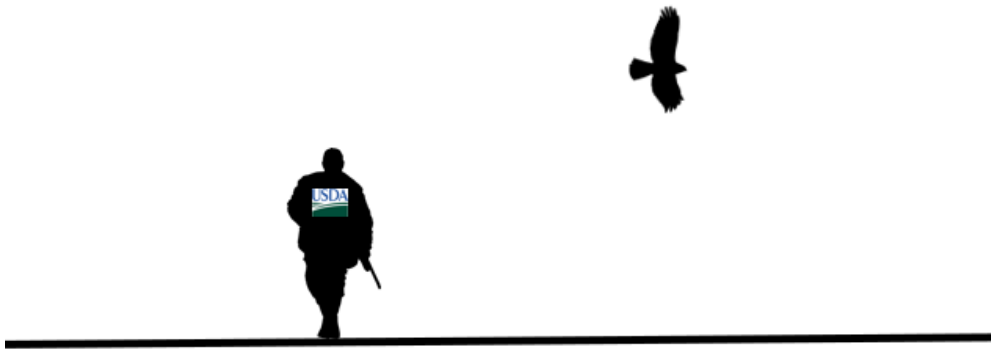
Action Taken (management decision)

- Observation

- Hazing (mitigation)

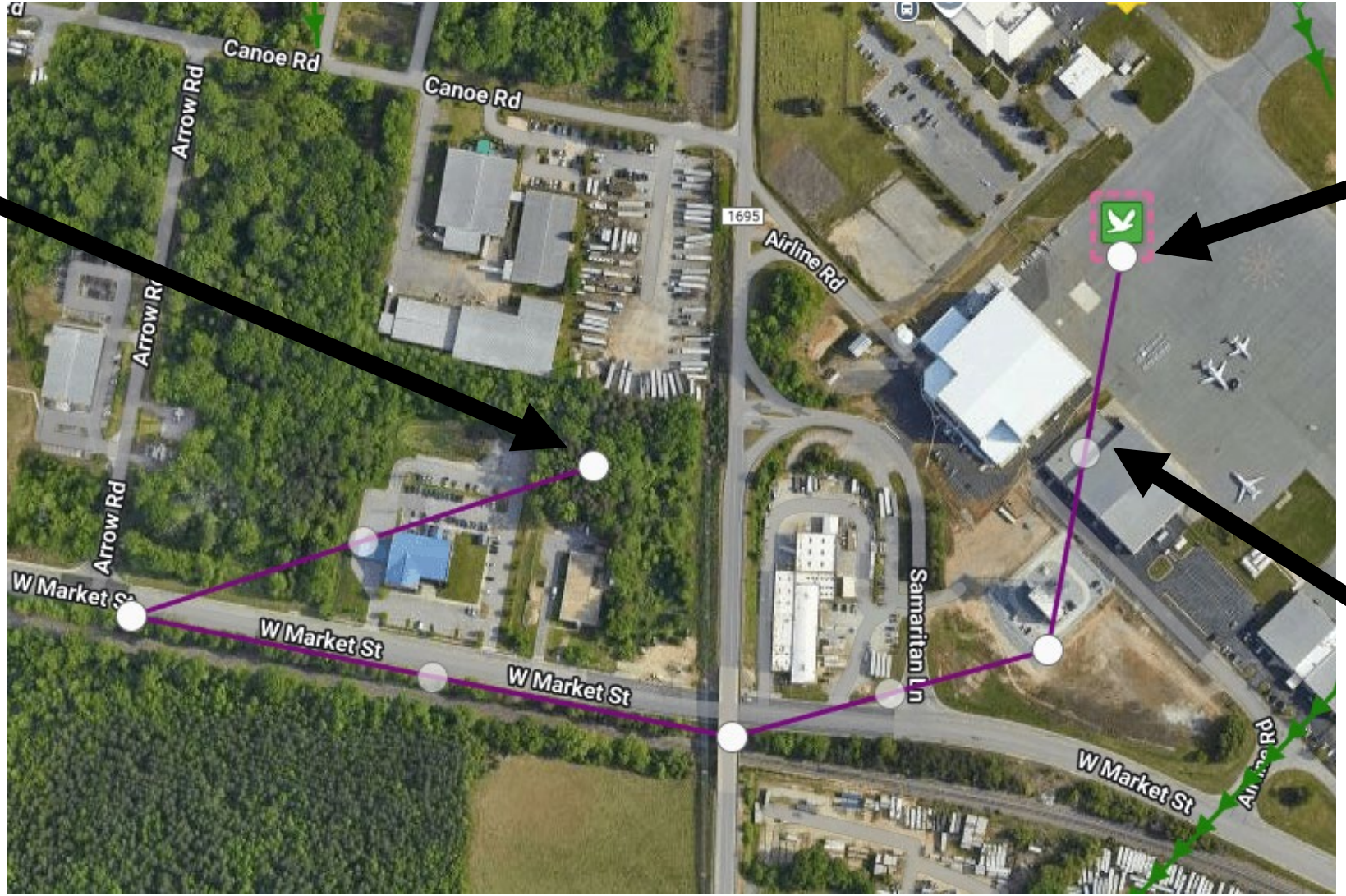


- Depredation



Direction Traveled

Final Location of Wildlife Interaction



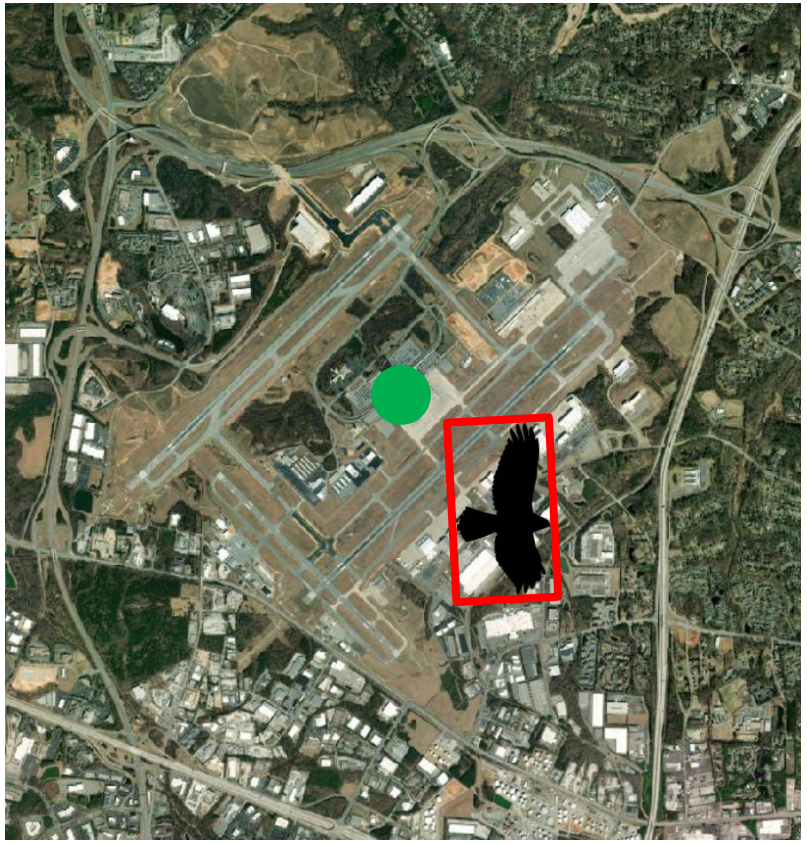
Initial Location of Wildlife Interaction

Location of Subsequent Wildlife Interaction

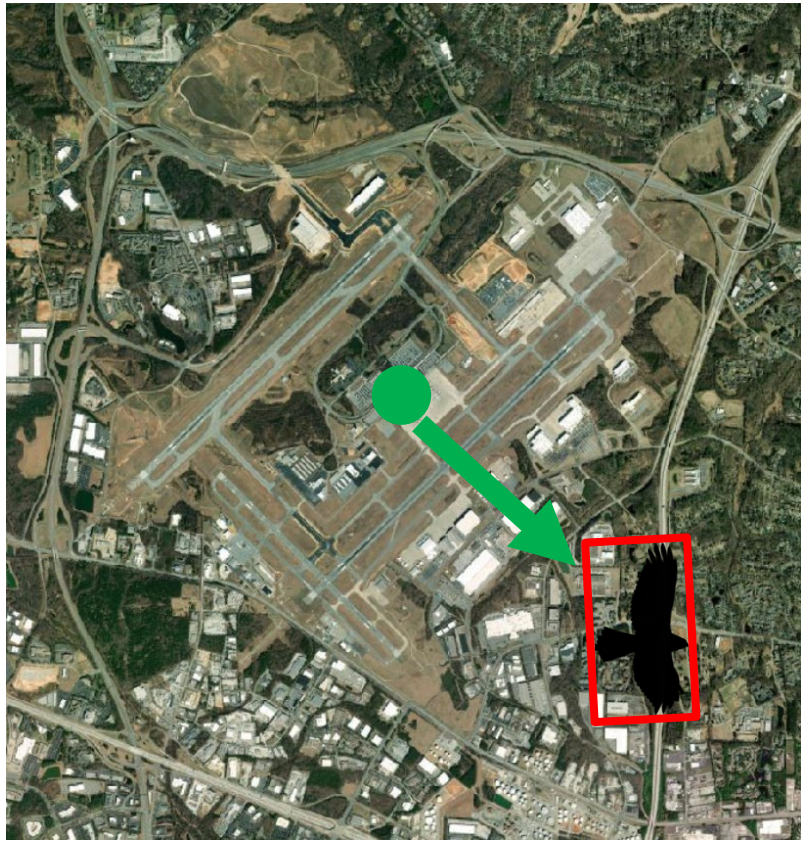
Defining a Hazing Success

Distance from the airport centroid increased

First Location



Final Location

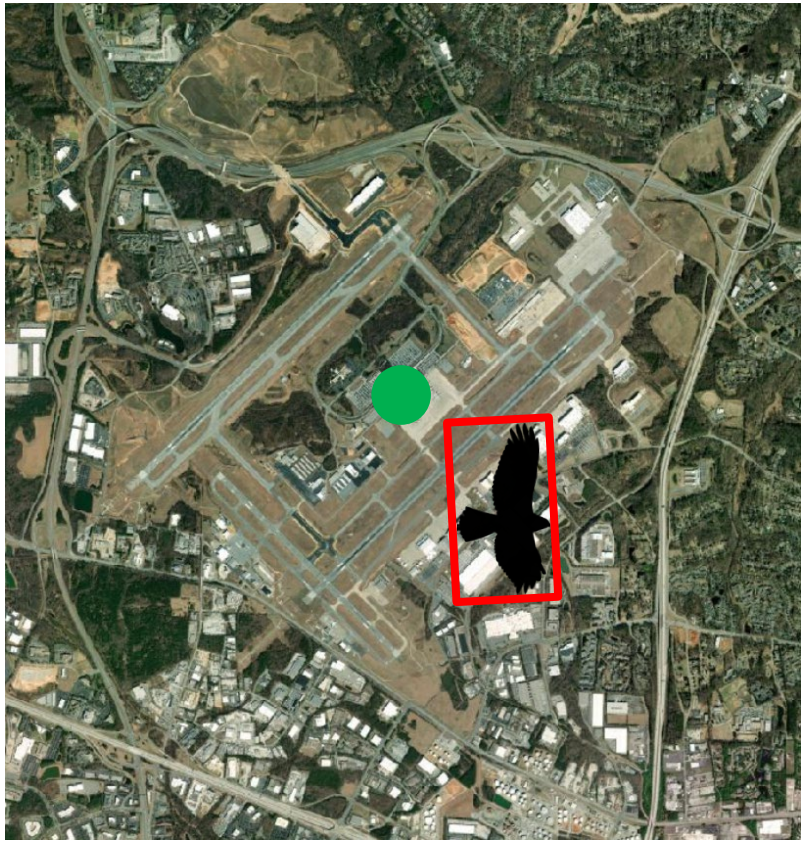


Success

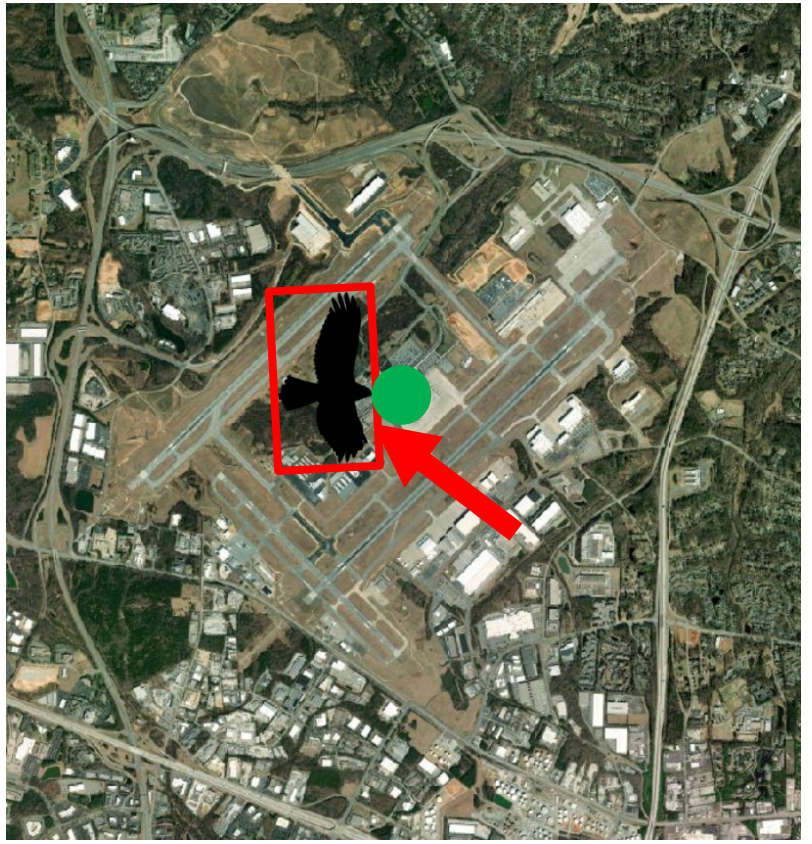
Defining a Hazing Success

Distance from the airport centroid increased

First Location



Final Location



Failure

X

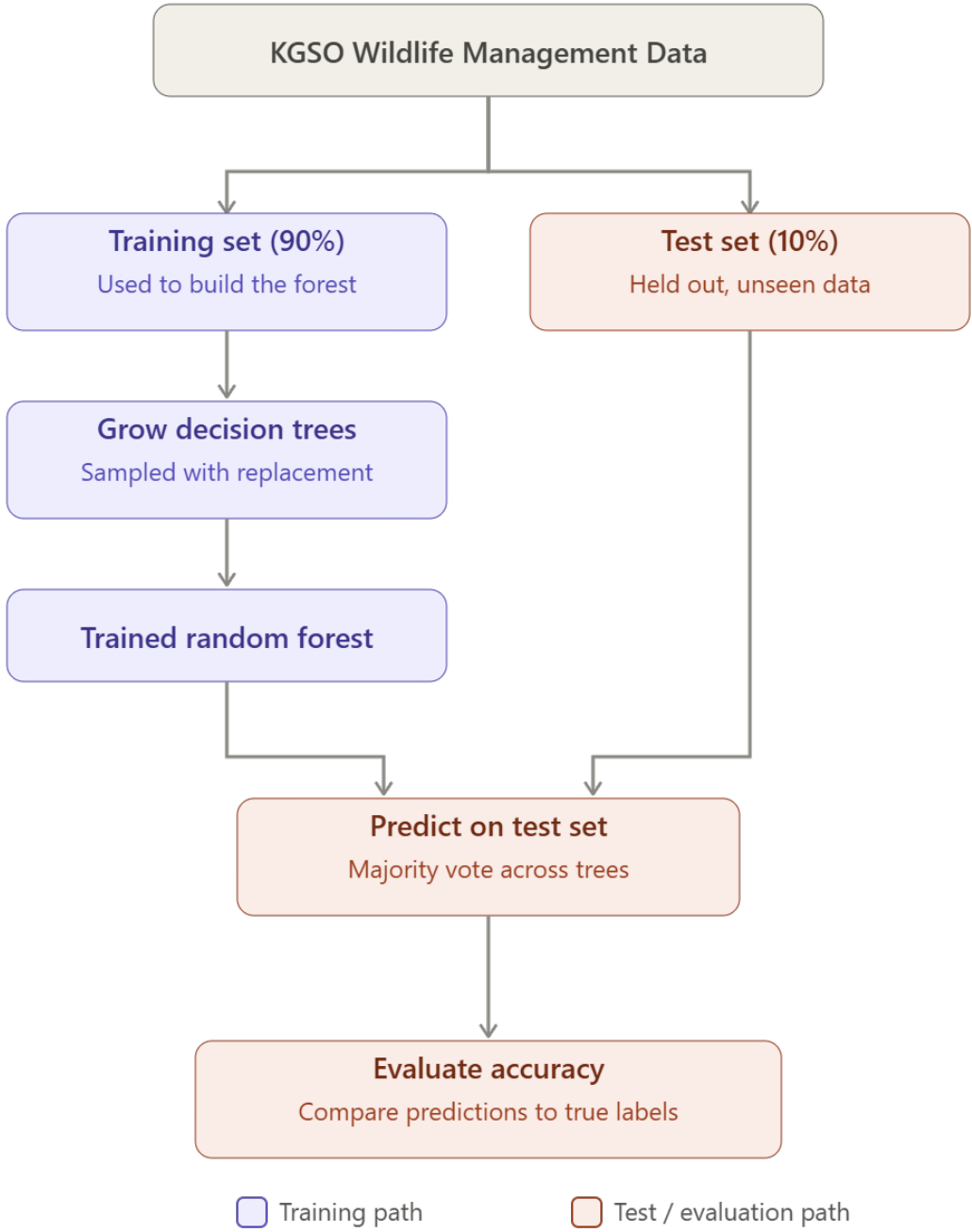
Data Processing

- De-Identified wildlife operators: 42 individuals
- Excluded interactions where operator(s) had less than 10 total interactions
- Grouped species
  - e.g., European Starlings, Eastern Meadowlarks, Brown-headed Cowbirds = Passerines
- Removed all species with 10 or fewer observations
  - e.g., Black Bear (n=1), Bald Eagle (n=4)

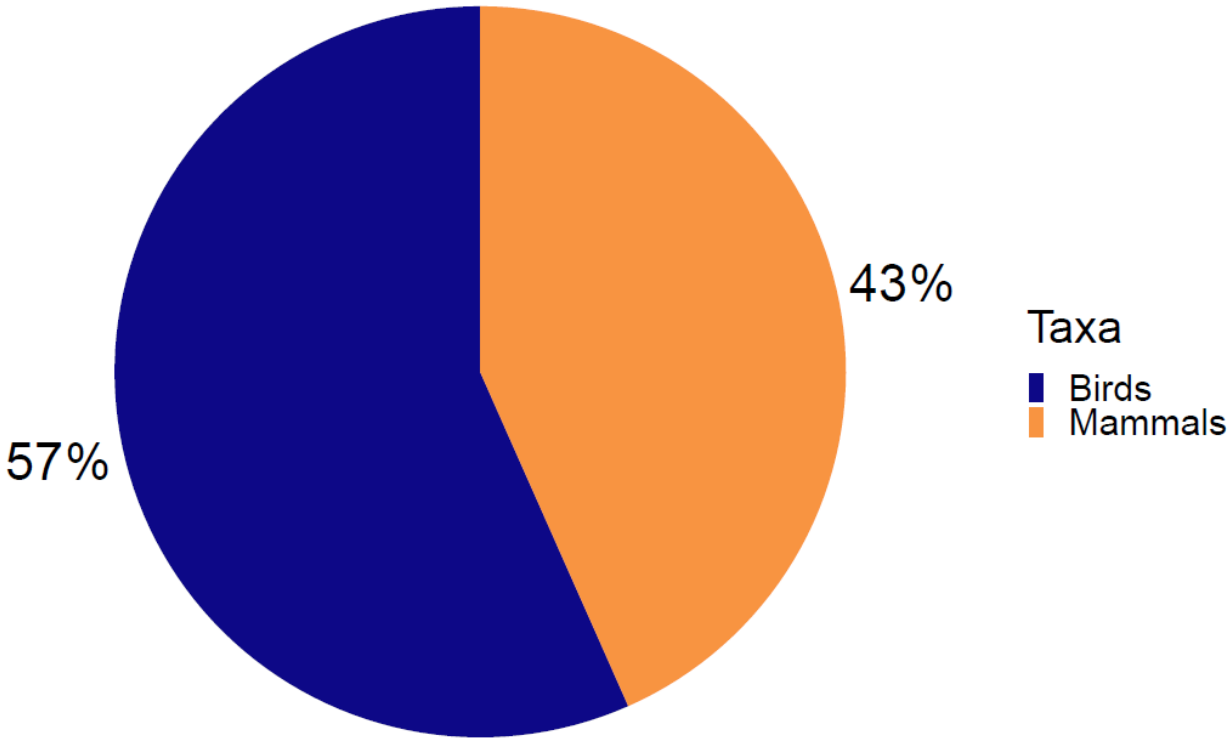
Sample size = 1,197

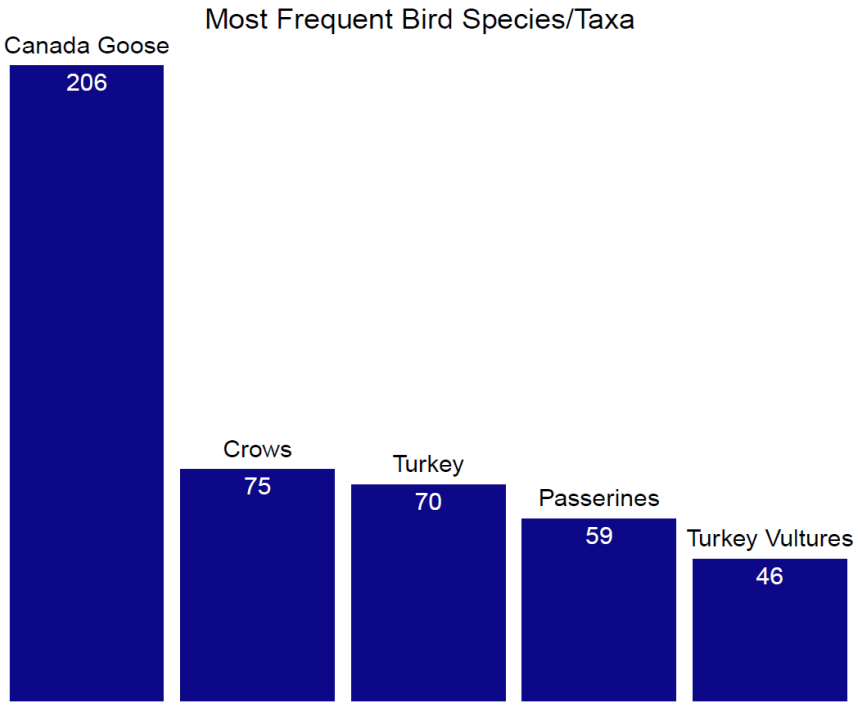
Proof of concept model

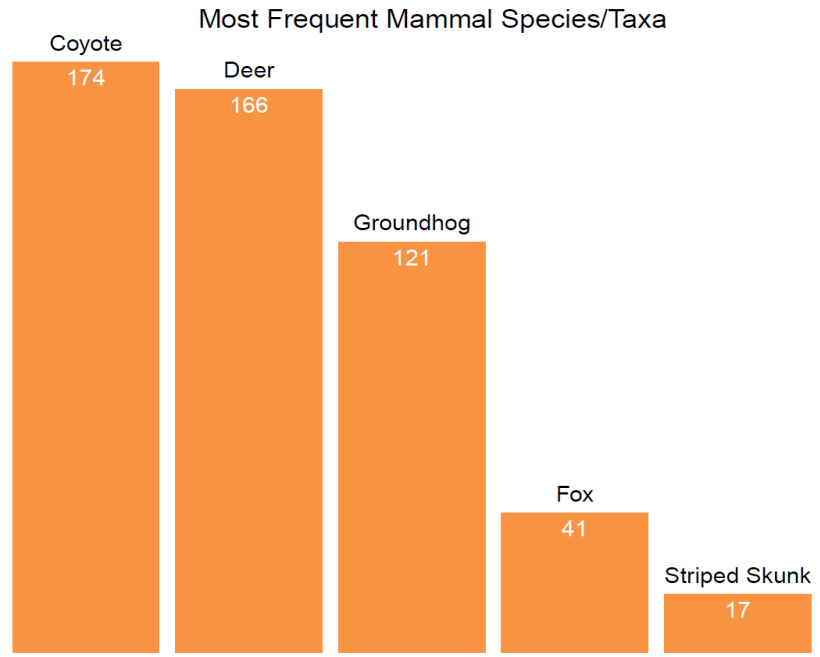
- ML Algorithm: Random Forest Classification
  - Train/Test: 90%/10%, 2000 Trees, Replacement, Node Size=1
- Dependent Variable/Response Variable:
  - Management Decision
  - Hazing Success
- Independent Variables
  - Species
  - Wildlife Activity
  - Number of Individuals
  - Initial Latitude
  - Initial Longitude
  - Time of Day
  - Time of Year (Date)
  - Wildlife Type (Mammal/Bird)****



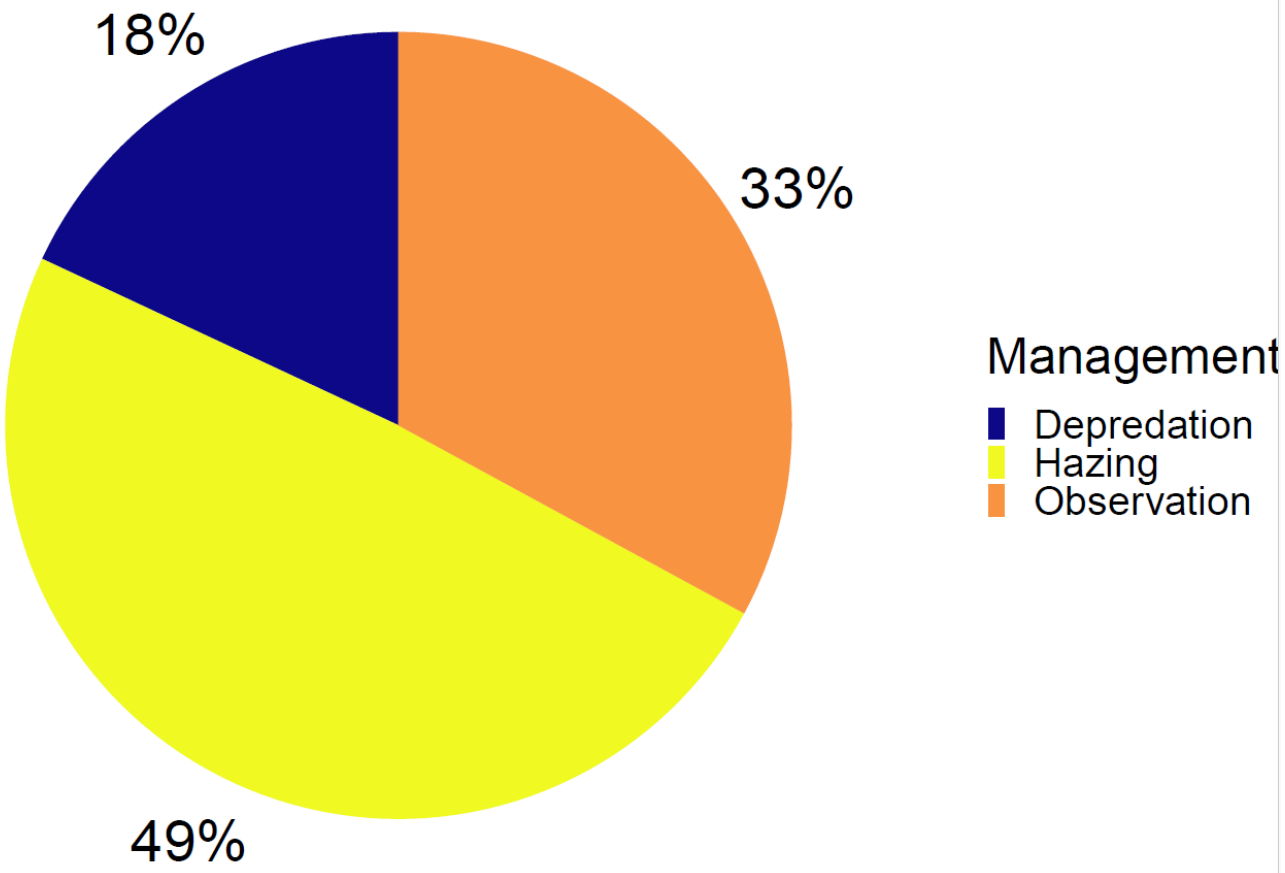
Summary Stats

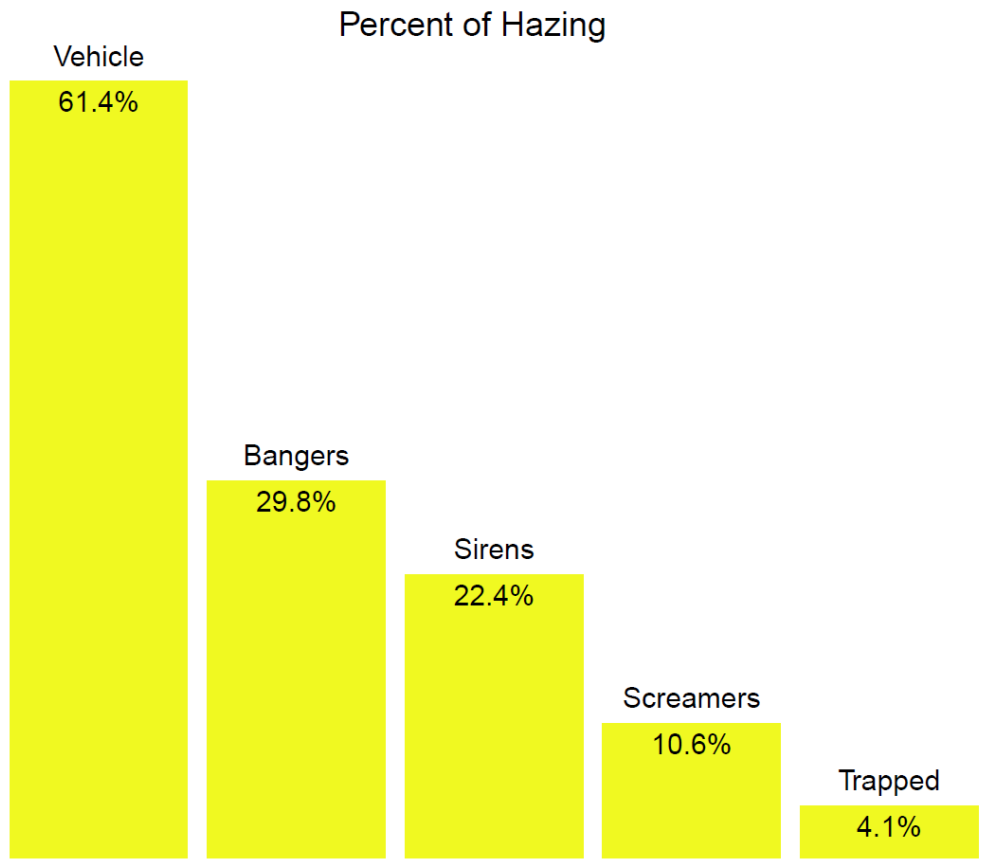






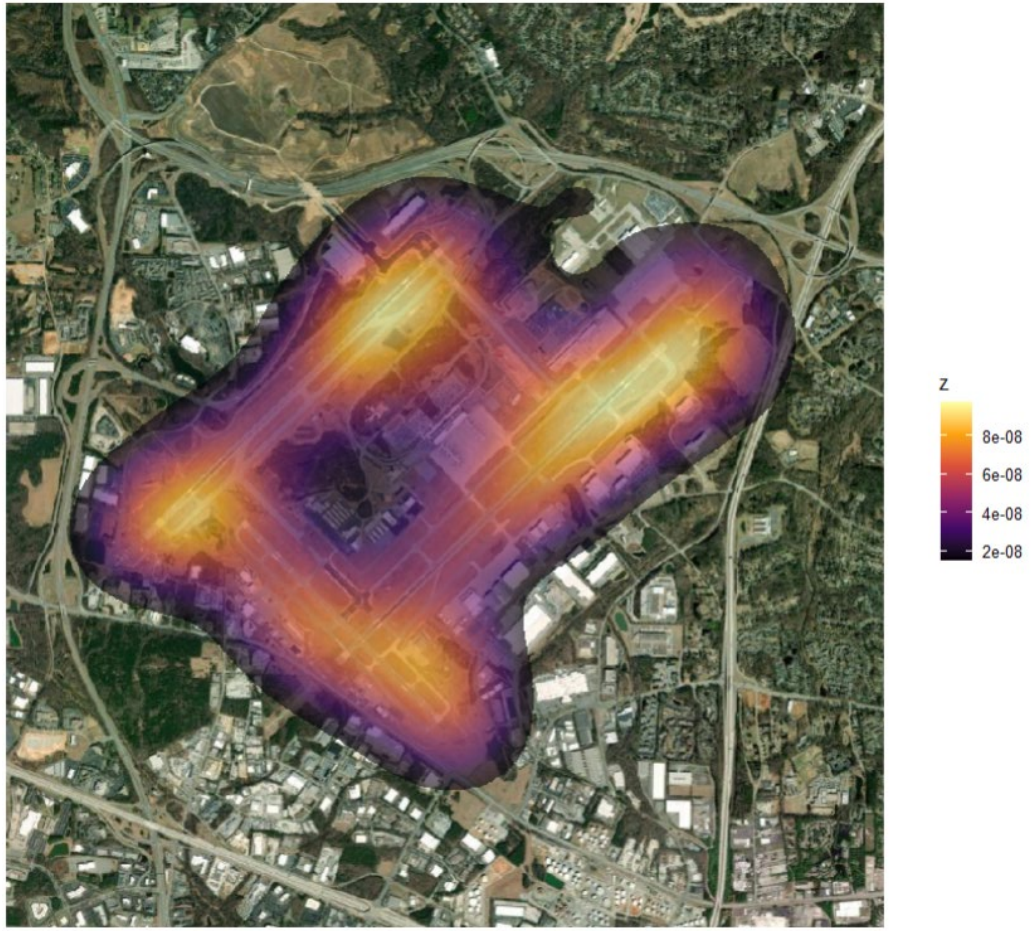
Summary Stats



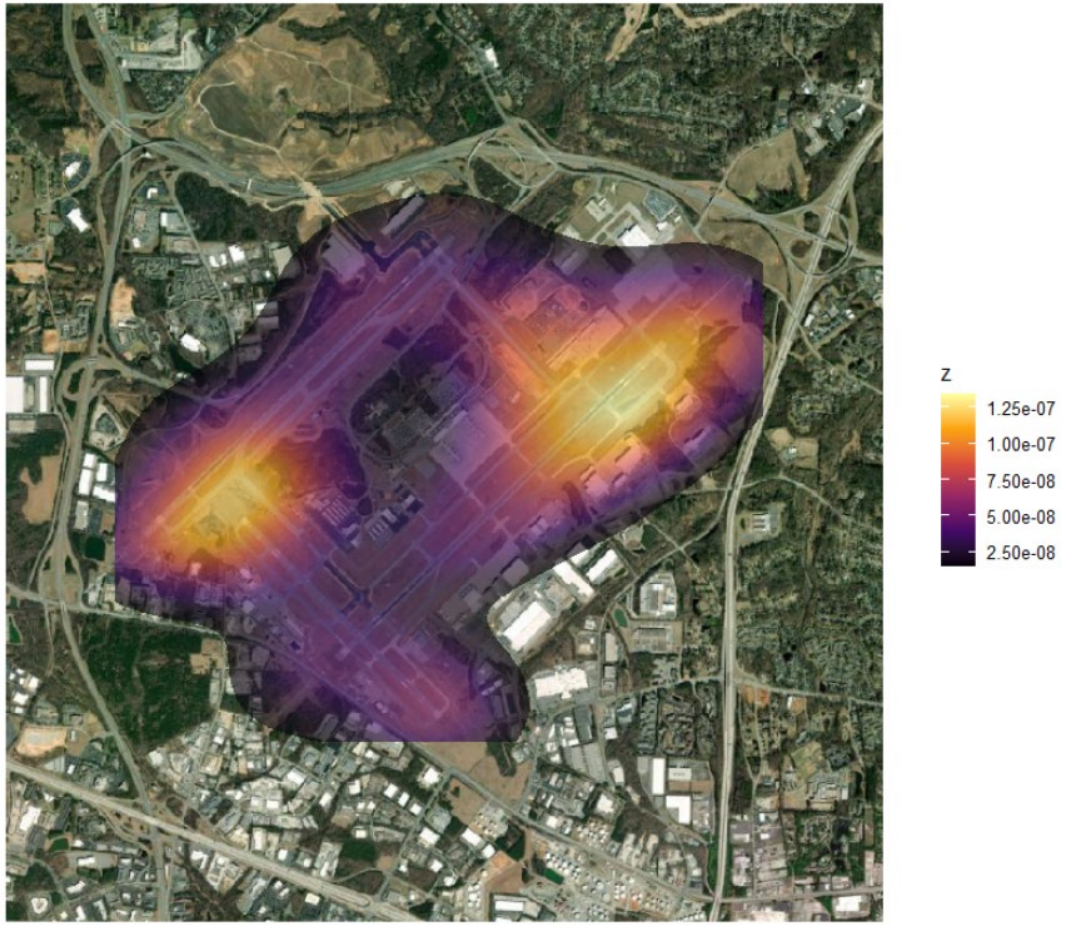


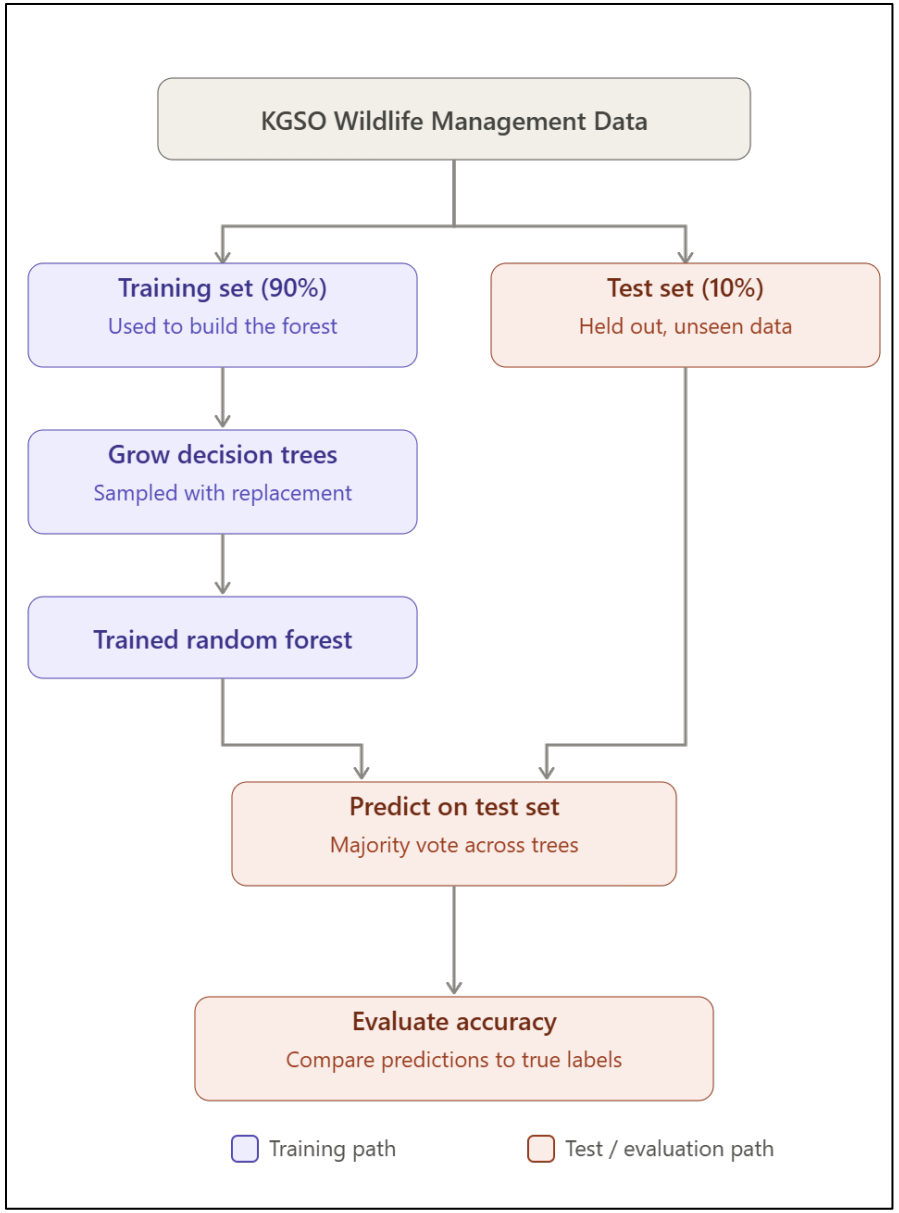
Interaction locations on airfield

All bird Interactions

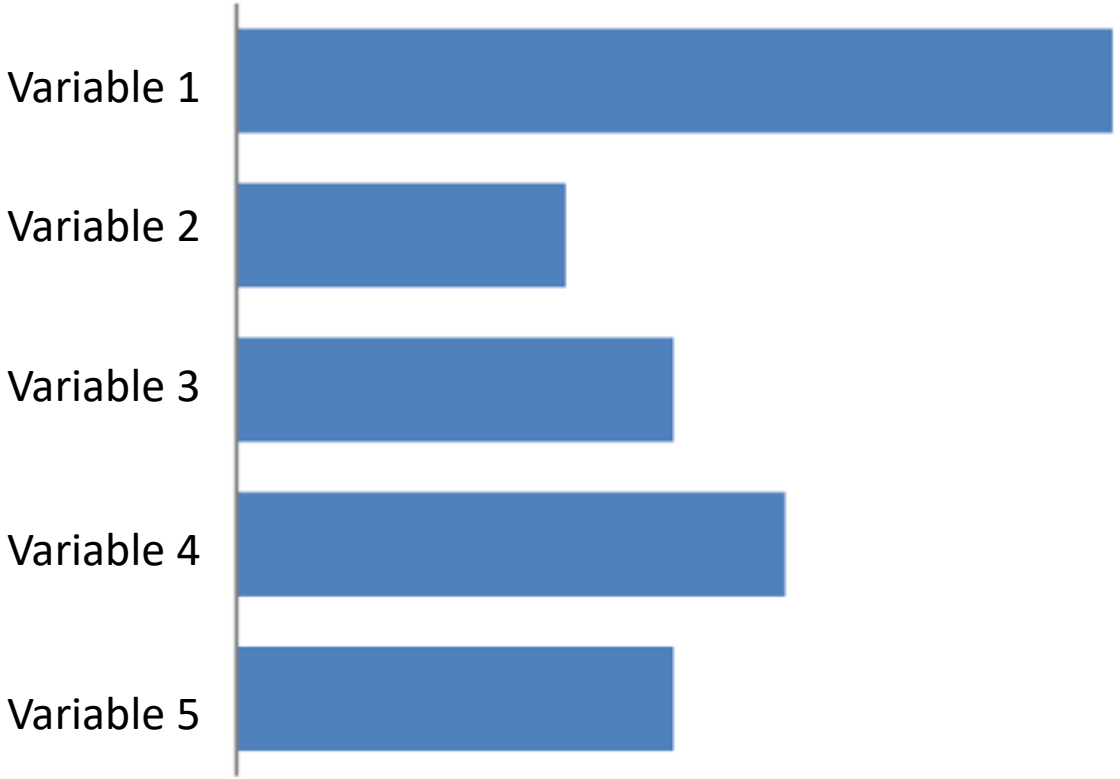


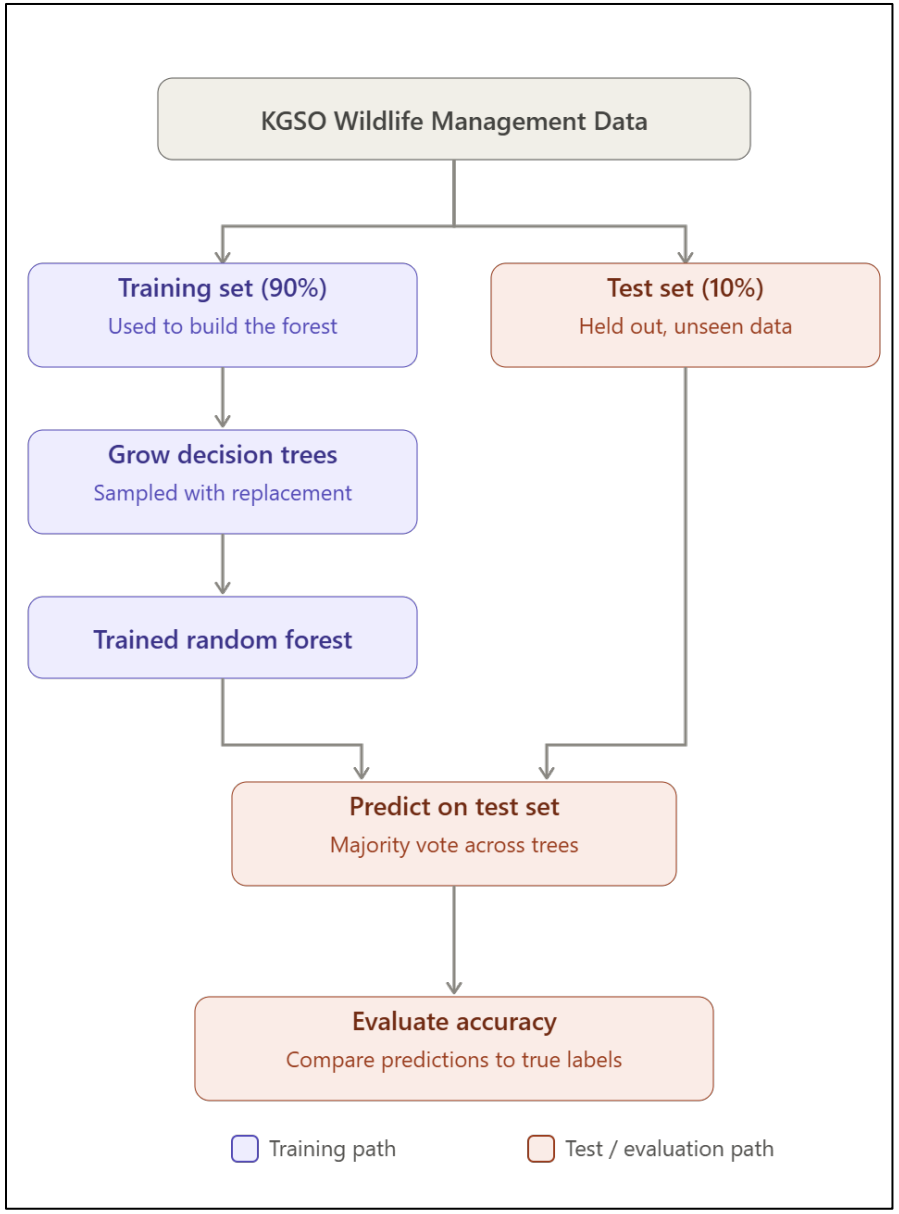
All mammal Interactions





Relative contribution of individual variables into classification of events





Confusion Matrix

True Positive
Model said yes, and it really was yes

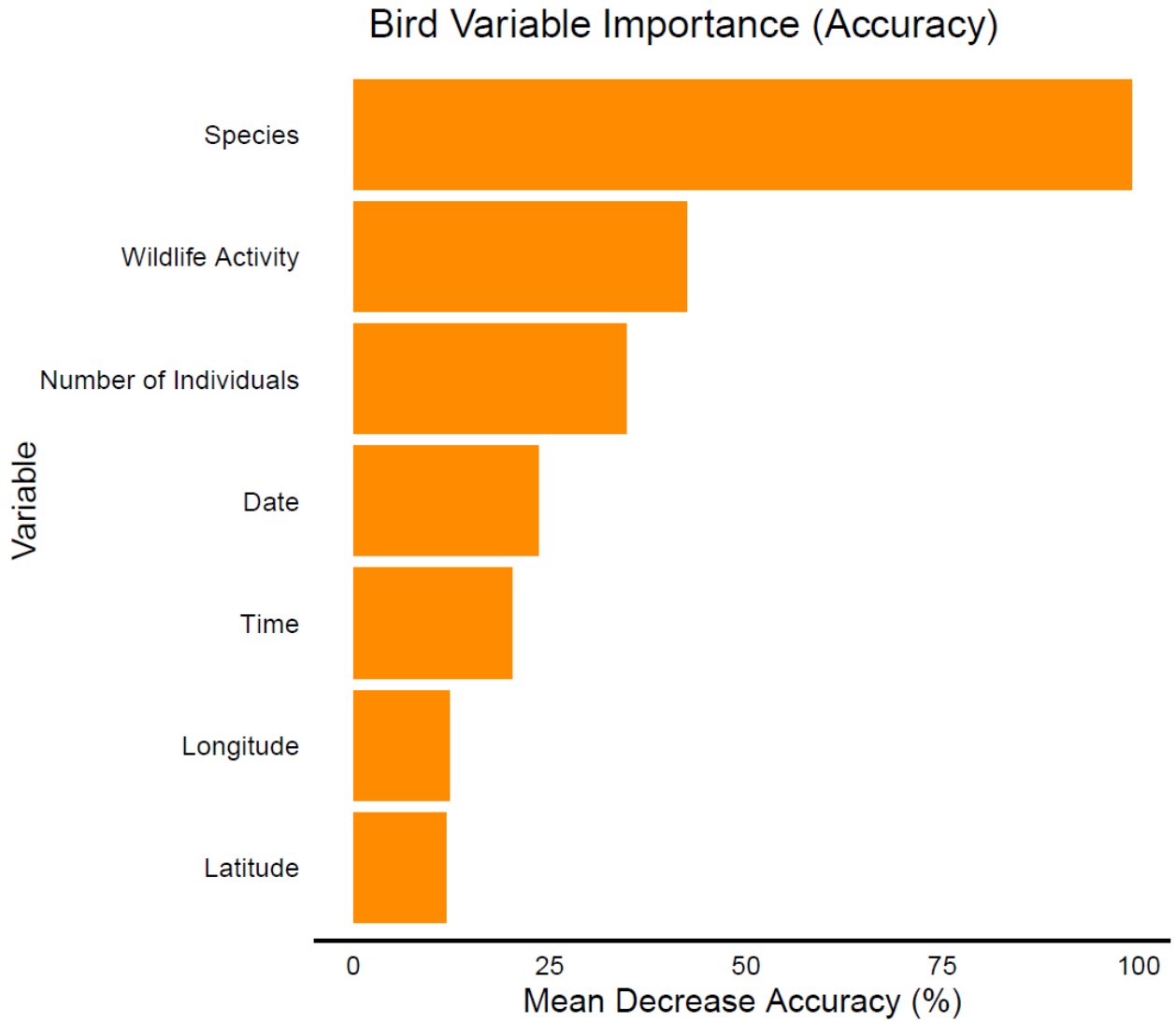
False Negative
Model said no, but it really was yes

	Predicted: Positive	Predicted: Negative
Actual: Positive	TP	FN
Actual: Negative	FP	TN

False Positive
Model said yes, but it really was no

True Negative
Model said no, and it really was no

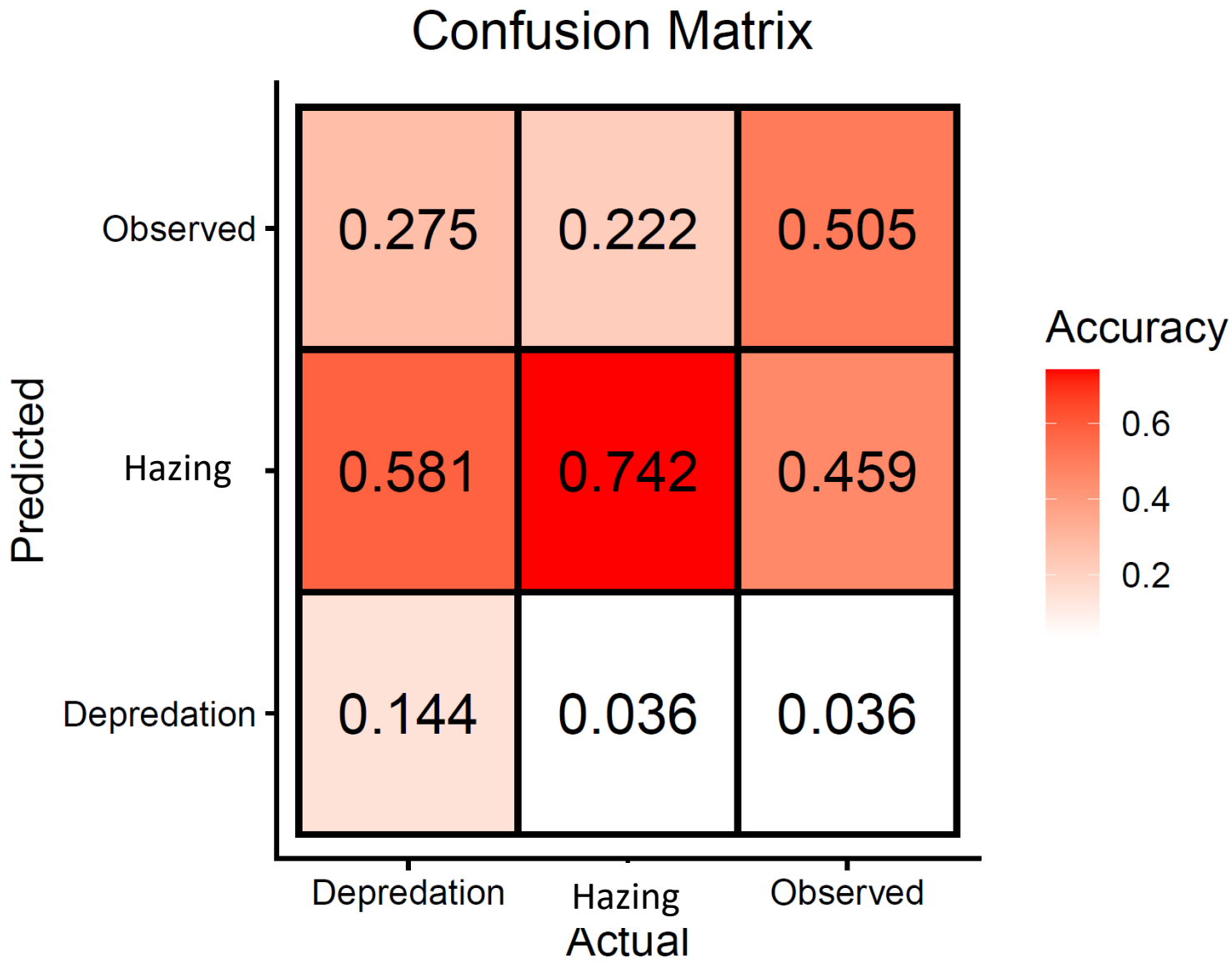
Management Action (Birds)



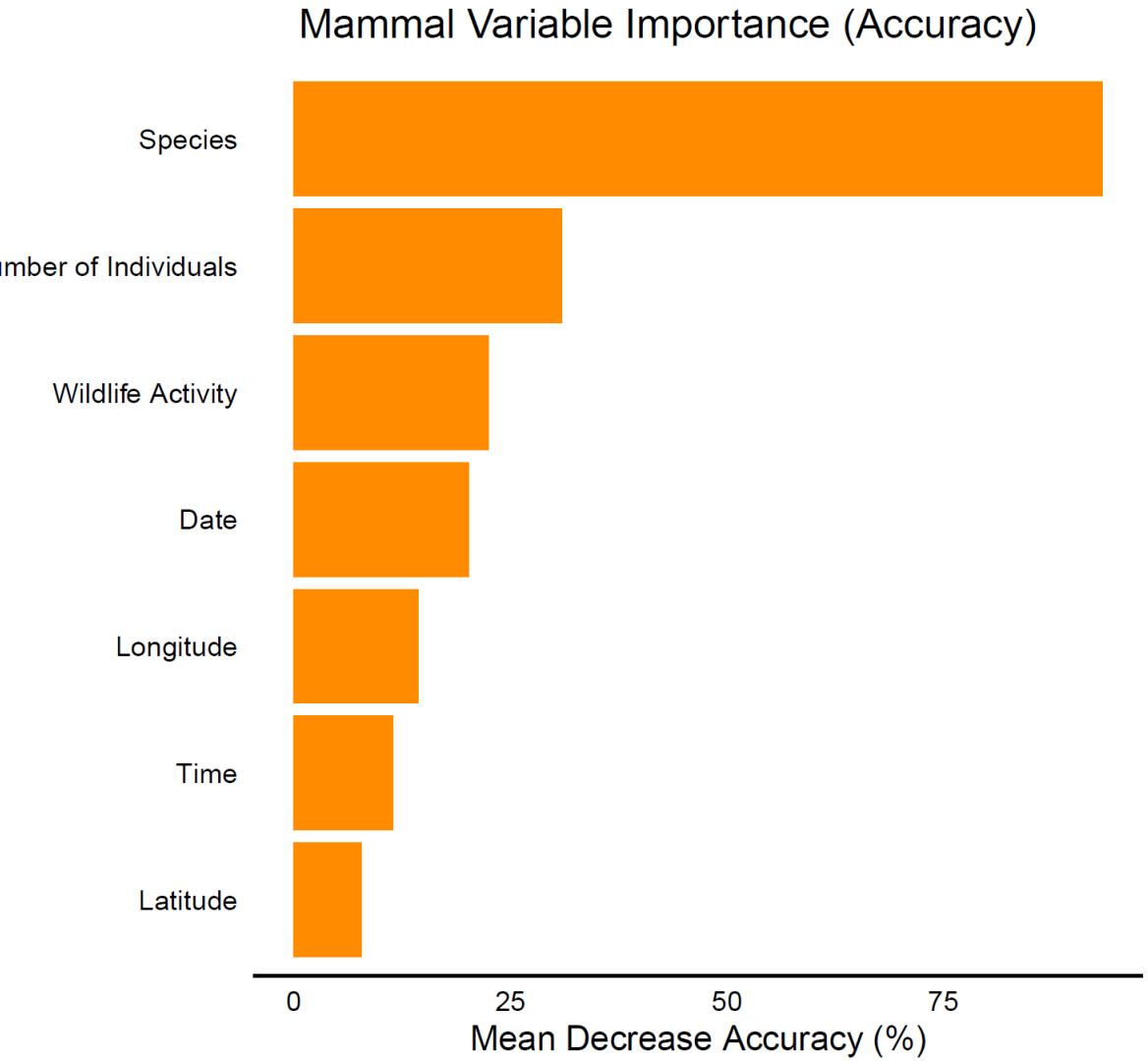
<u>Overall test accuracy:</u> 52.1% [48%, 56%]

Sample size = 618

Confusion Matrix (Birds)



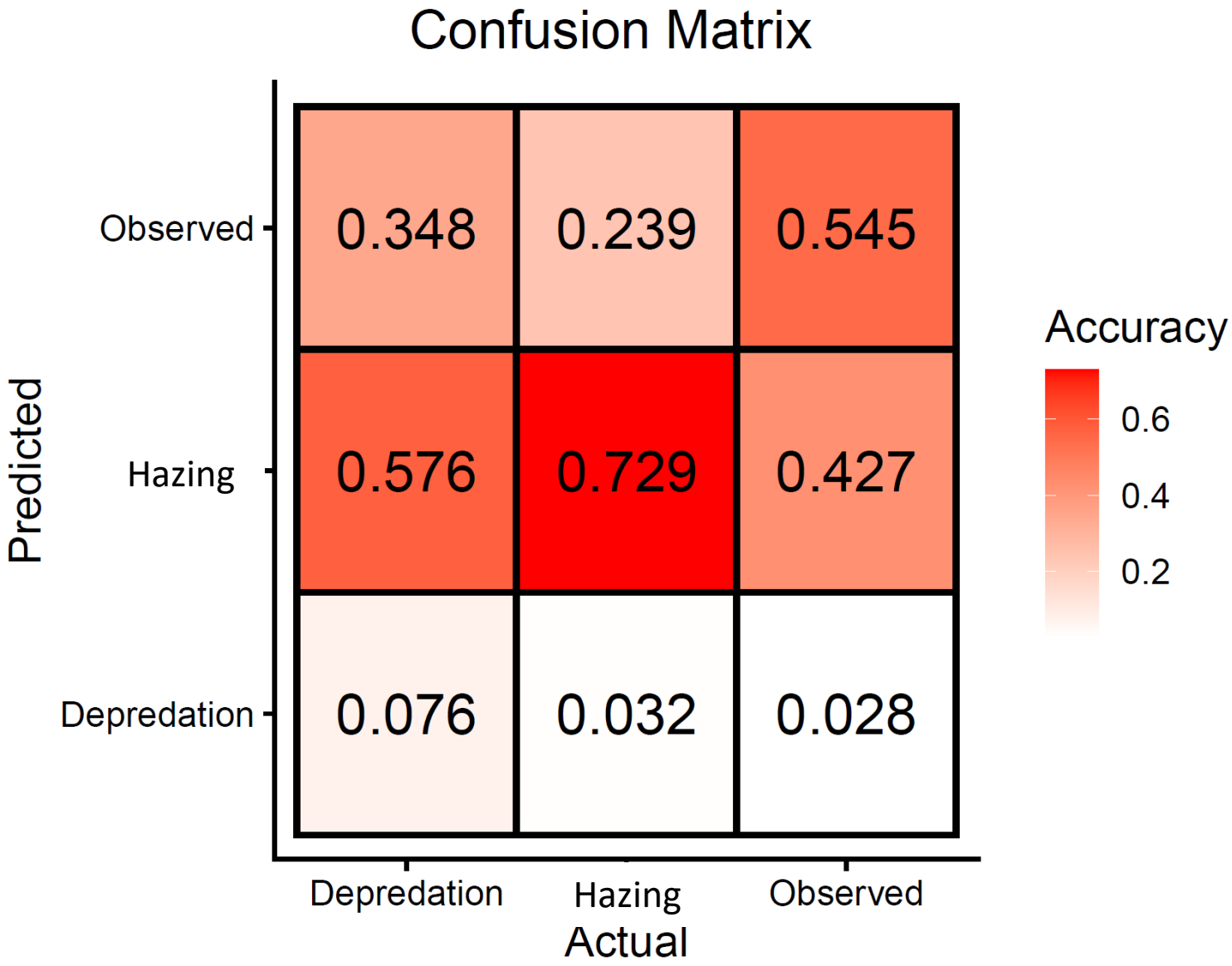
Management Action (Mammals)



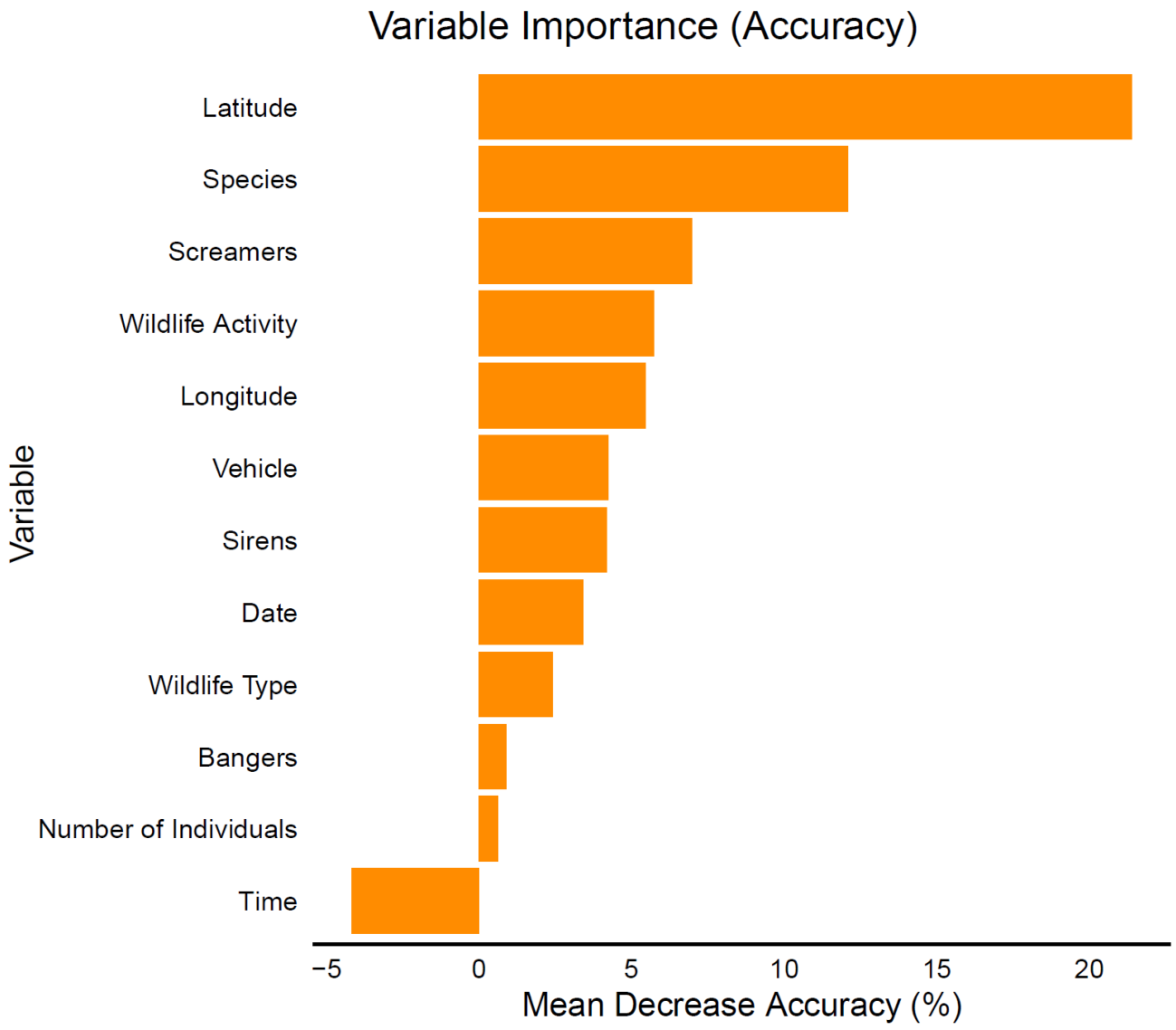
<u>Overall test accuracy:</u> 51% [47%, 75%]

Sample size = 518

Confusion Matrix (Mammals)



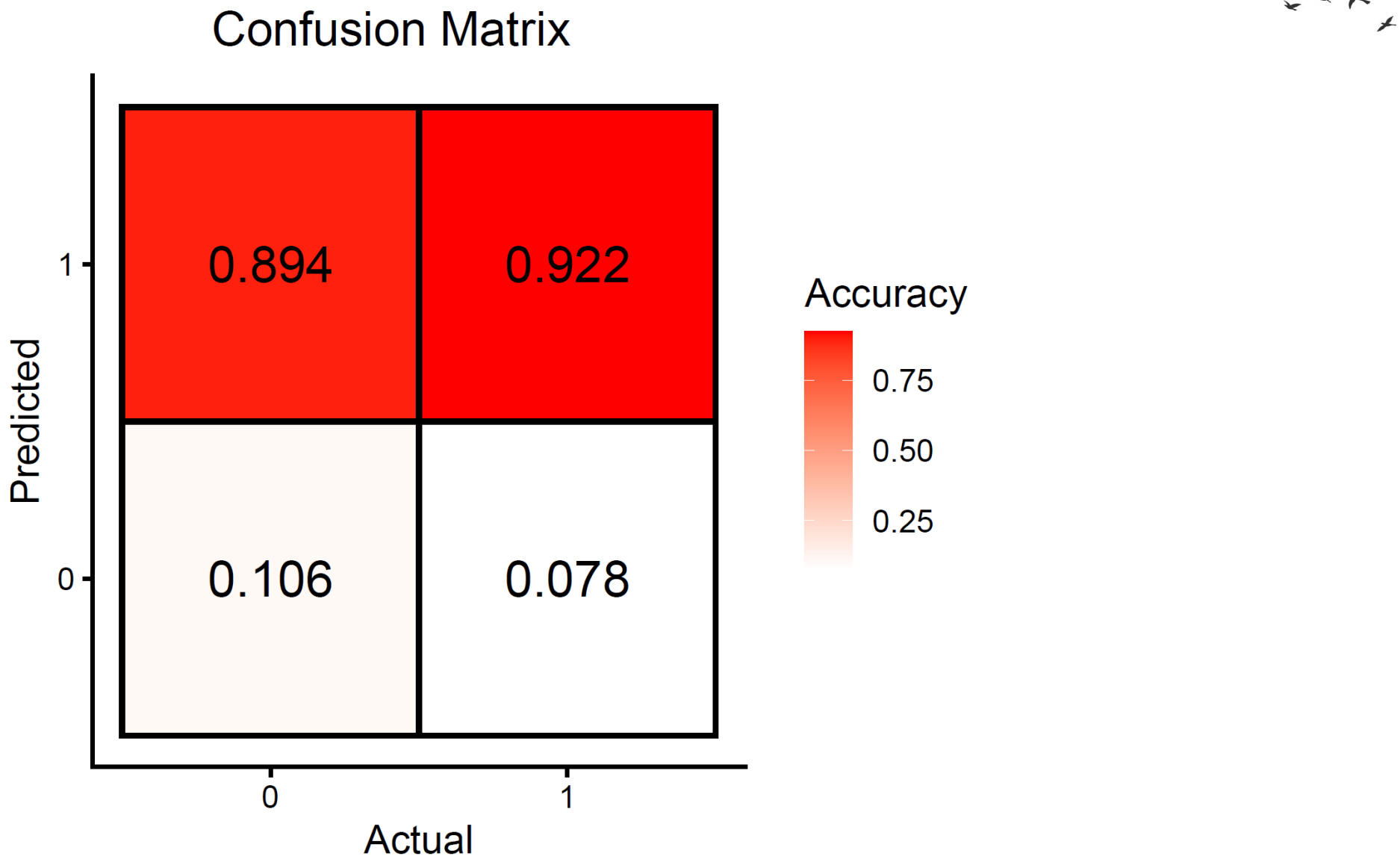
Hazing Success (Birds)



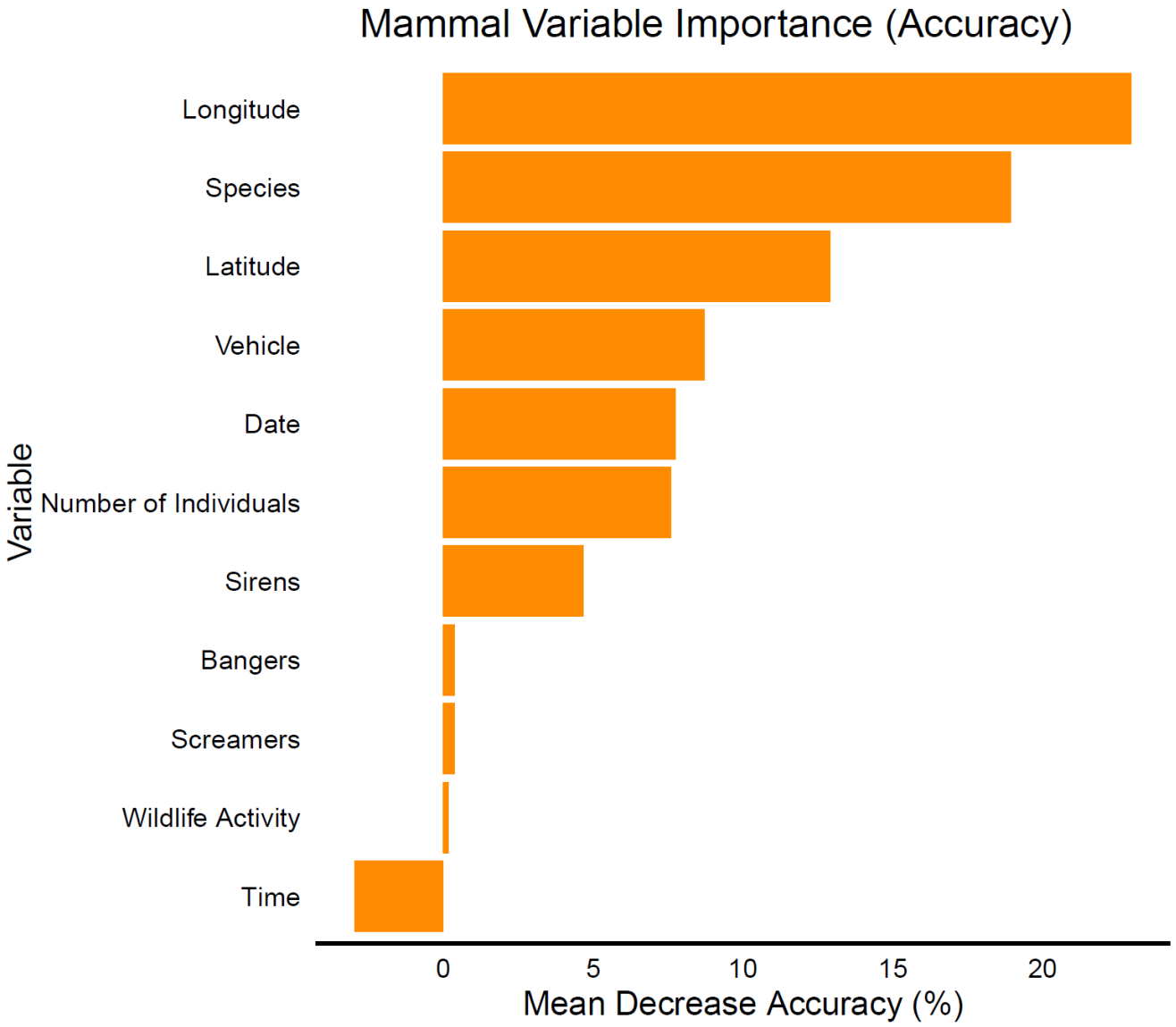
<u>Overall test accuracy:</u> 64.6% [57%, 71%]

Sample size = 403

Confusion Matrix (Birds)



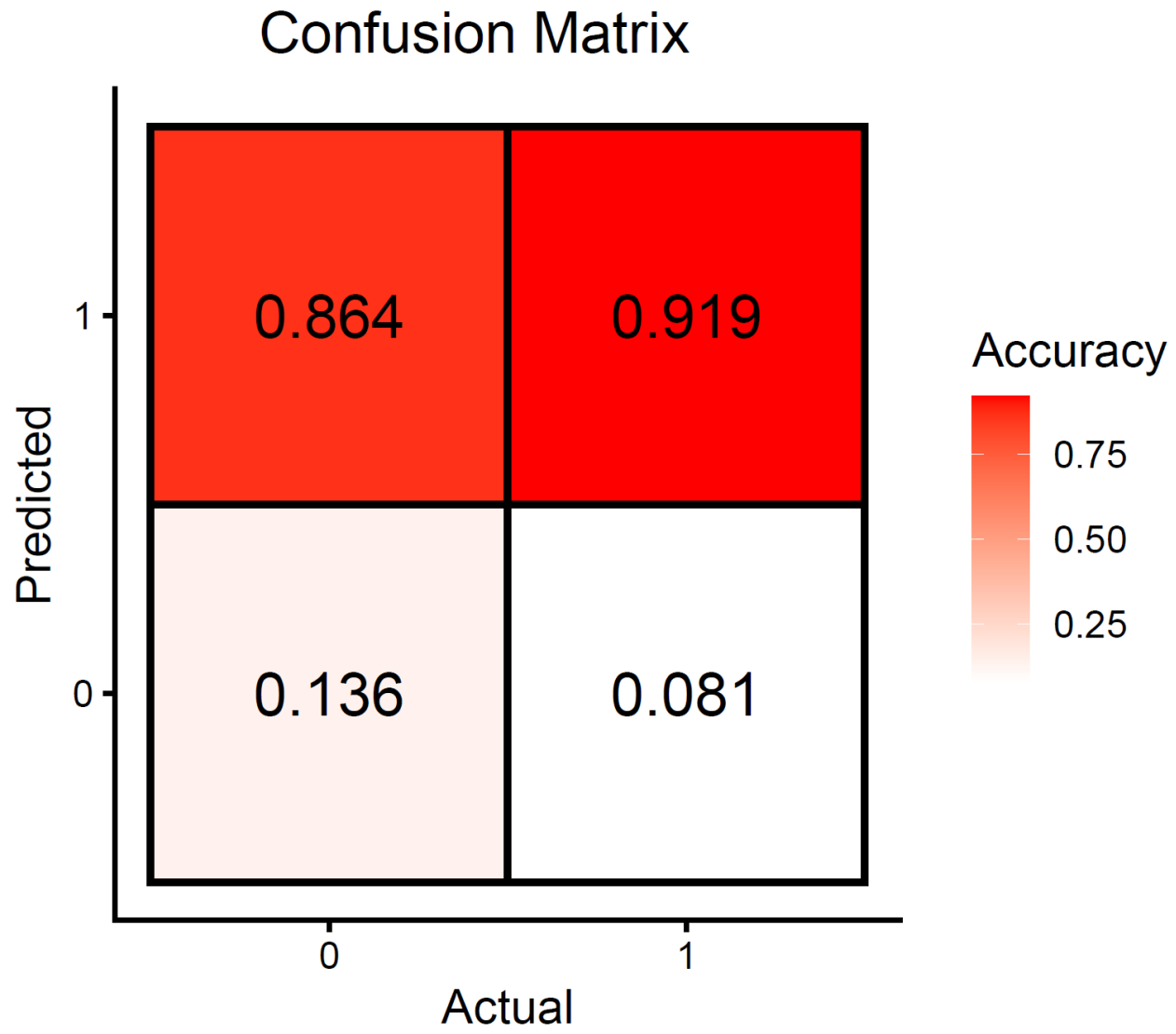
Hazing Success (Mammals)



Overall test accuracy: 64.4% [59%, 69%]

Sample size = 154

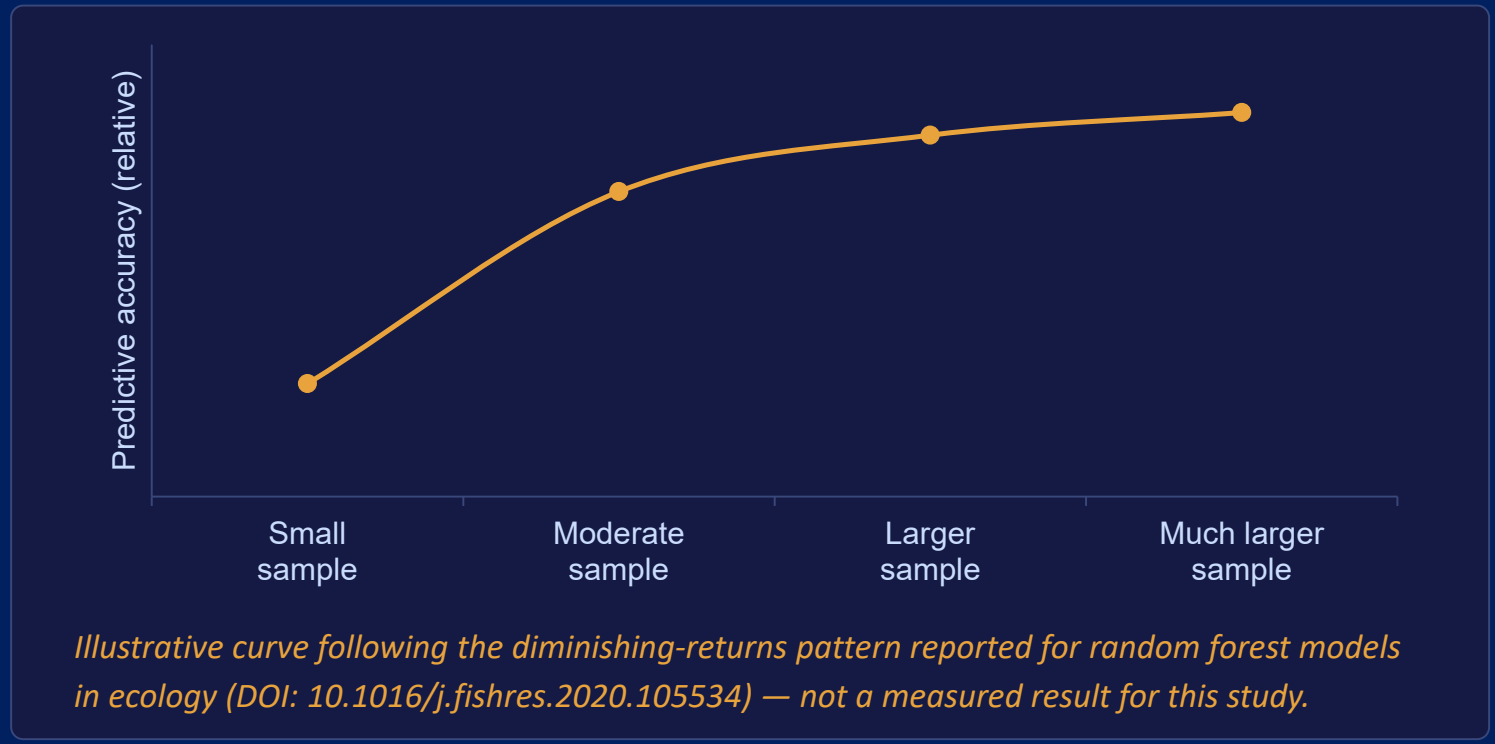
Confusion Matrix (Mammals)



LOOKING AHEAD TO IMPROVE THE PREDICTION ACCURACY OF OUR MODEL

- **Using other ML algorithms**
- **Applying weighting to hazing events**
- **Incorporating weather conditions, air traffic, etc.**

We anticipate that prediction accuracy can be substantially improved by training on larger datasets



Illustrative curve following the diminishing-returns pattern reported for random forest models in ecology (DOI: 10.1016/j.fishres.2020.105534) — not a measured result for this study.

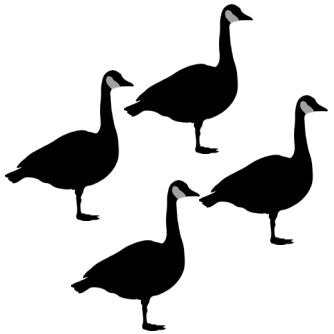
Hazing data collected at airports have potential to develop predictive hazing models

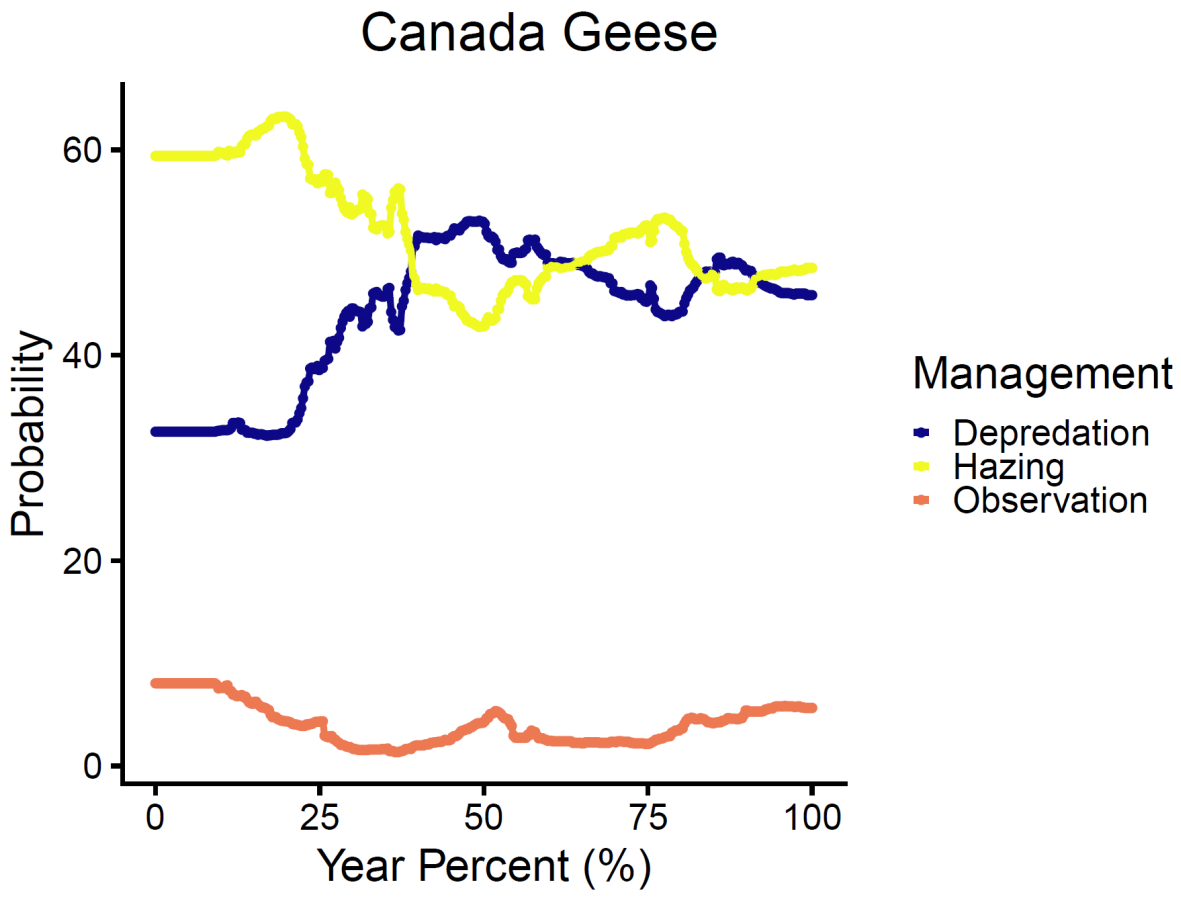
Quantitative guidance for species-specific management

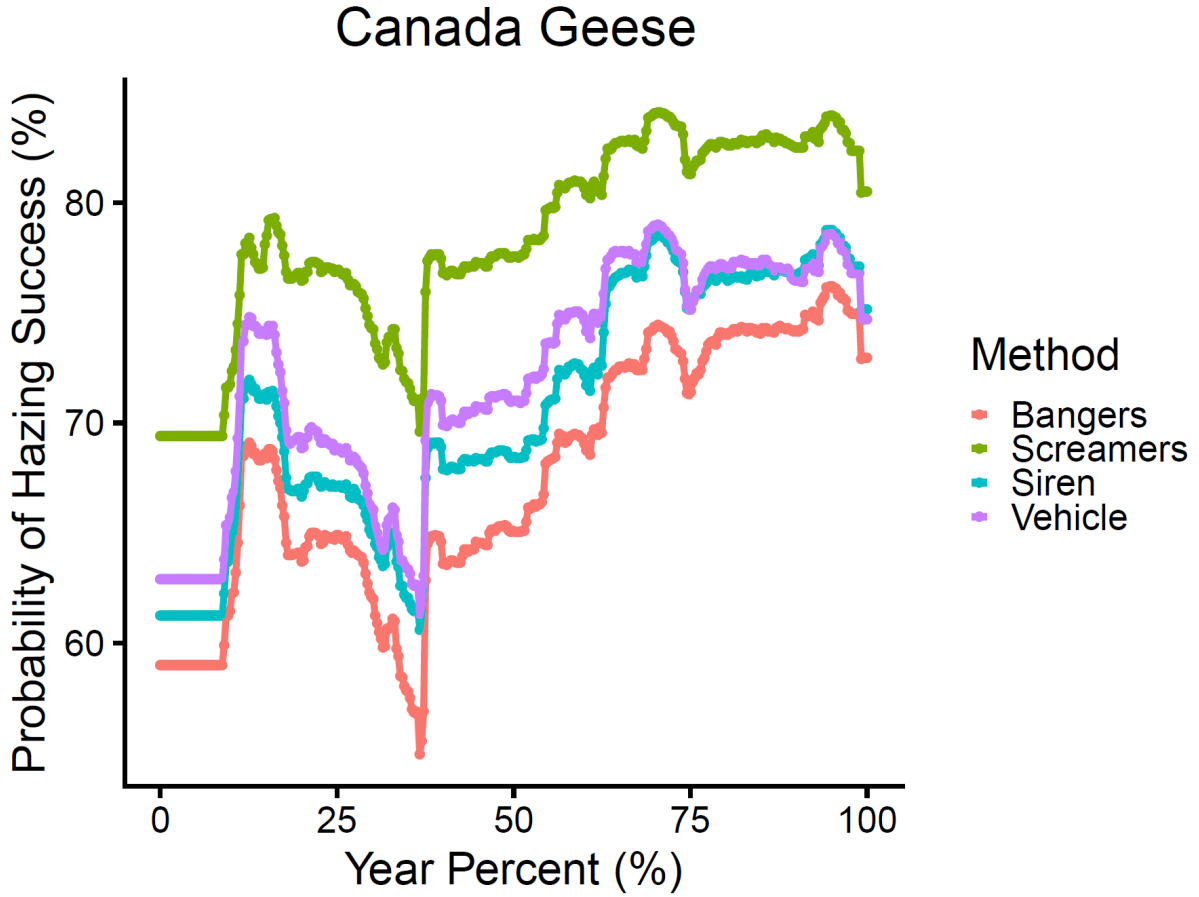
Species differ substantially in how they respond to hazing

- DOI: 10.1002/ece3.71752
- DOI: 10.21315/tlsr2025.36.1.7
- DOI: 10.1098/rspb.2008.1368
- DOI: 10.3758/s13420-025-00678-z
- DOI: 10.1002/ece3.5561
- DOI: 10.1098/rspb.2018.2945
- DOI: 10.1371/journal.pone.0107883
- DOI: 10.1111/jeb.12272
- DOI: 10.1093/cz/zoz005
- DOI: 10.1111/bij.12706
- DOI: 10.1371/journal.pone.0219845
- DOI: 10.1002/ece3.5193
- DOI: 10.1098/rsbl.2013.0417
- DOI: 10.1098/rsos.240332
- DOI: 10.1016/j.scitotenv.2022.156939
- DOI: 10.1038/s41598-021-92273-1
- DOI: 10.1163/1568539X-00003559
- DOI: 10.1016/j.anbehav.2021.07.008
- DOI: 10.1371/journal.pone.0064634
- DOI: 10.3389/fevo.2017.00066

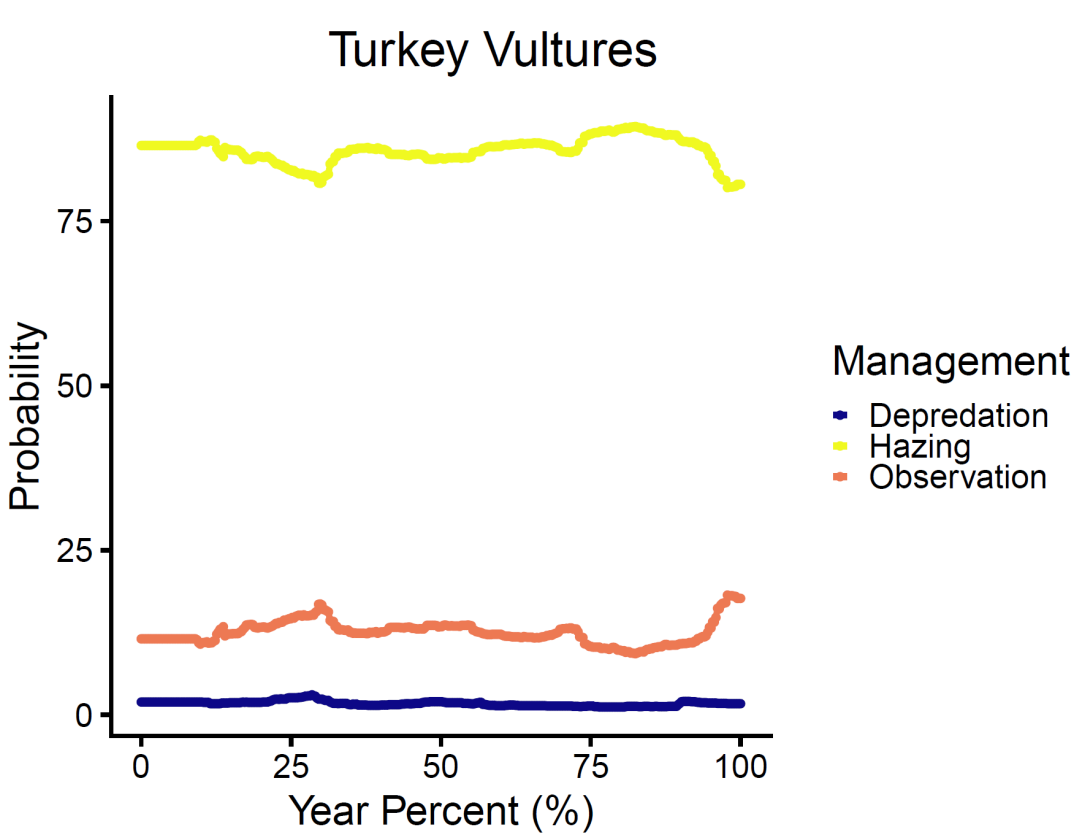
Species-specific management planning

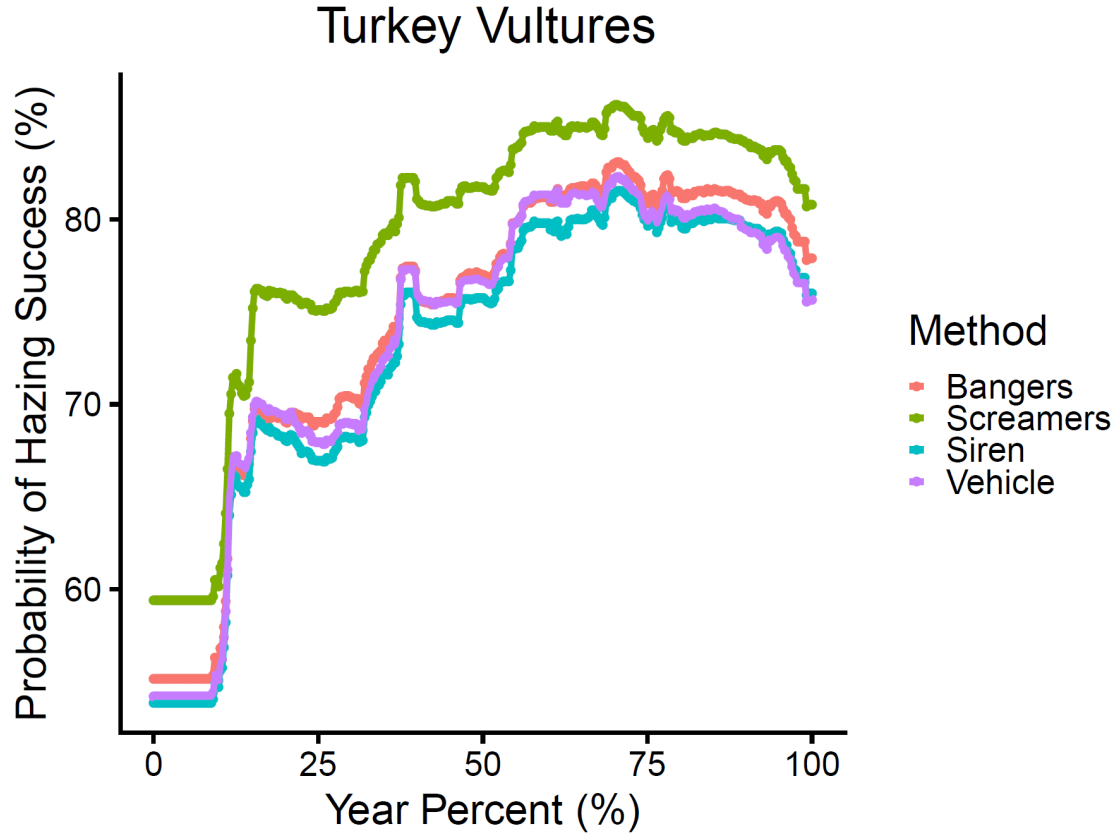




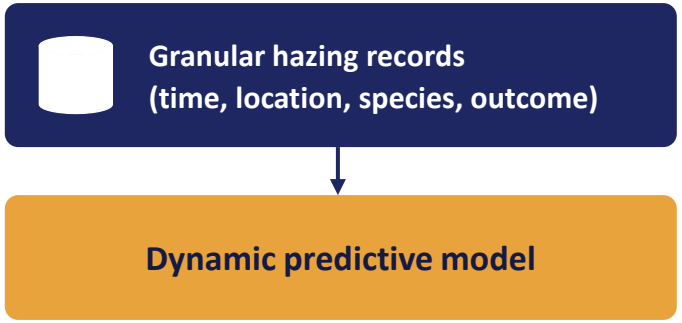


Species-specific management planning





Forecasting tailored to place, time, and species



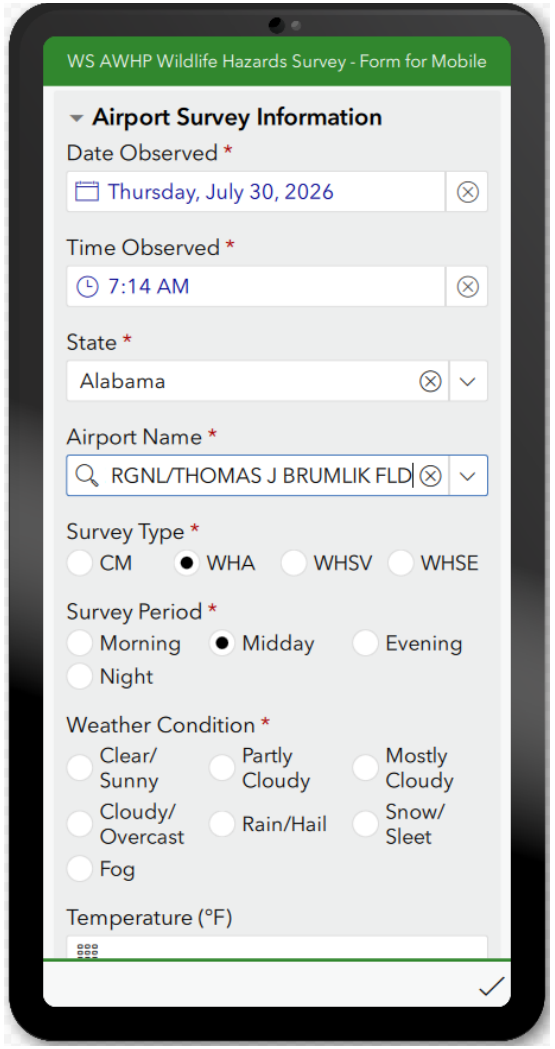
Temporal resolution

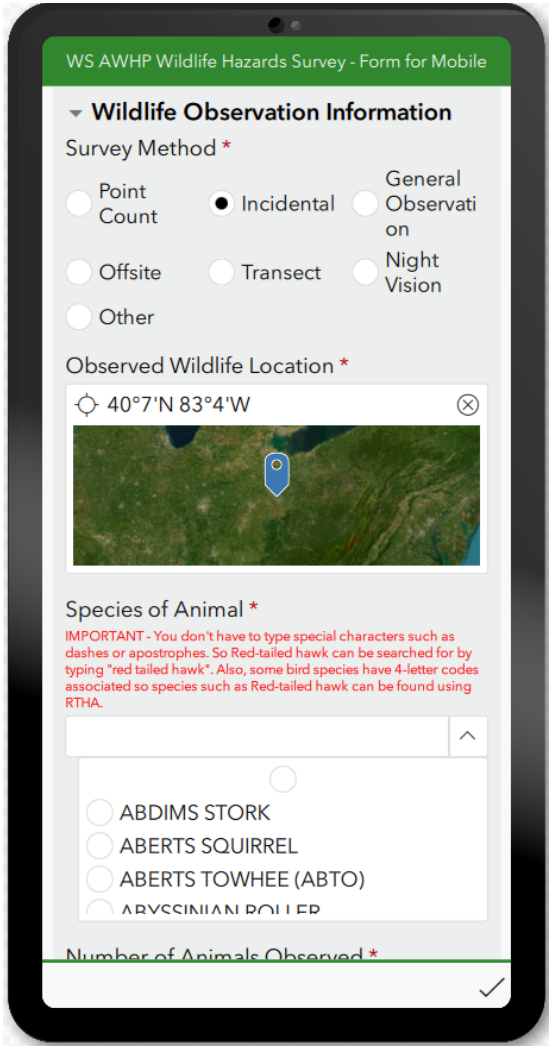
- Hourly
- Daily
- Seasonal

Contextual specificity

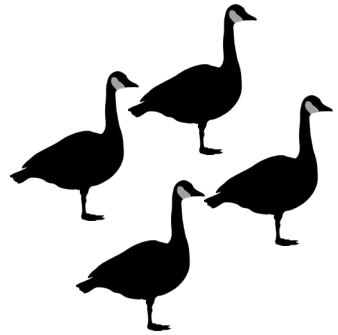
- Airport
- Topography
- Climate
- Species

Addition to the USDA Survey123 App?





Information provided:

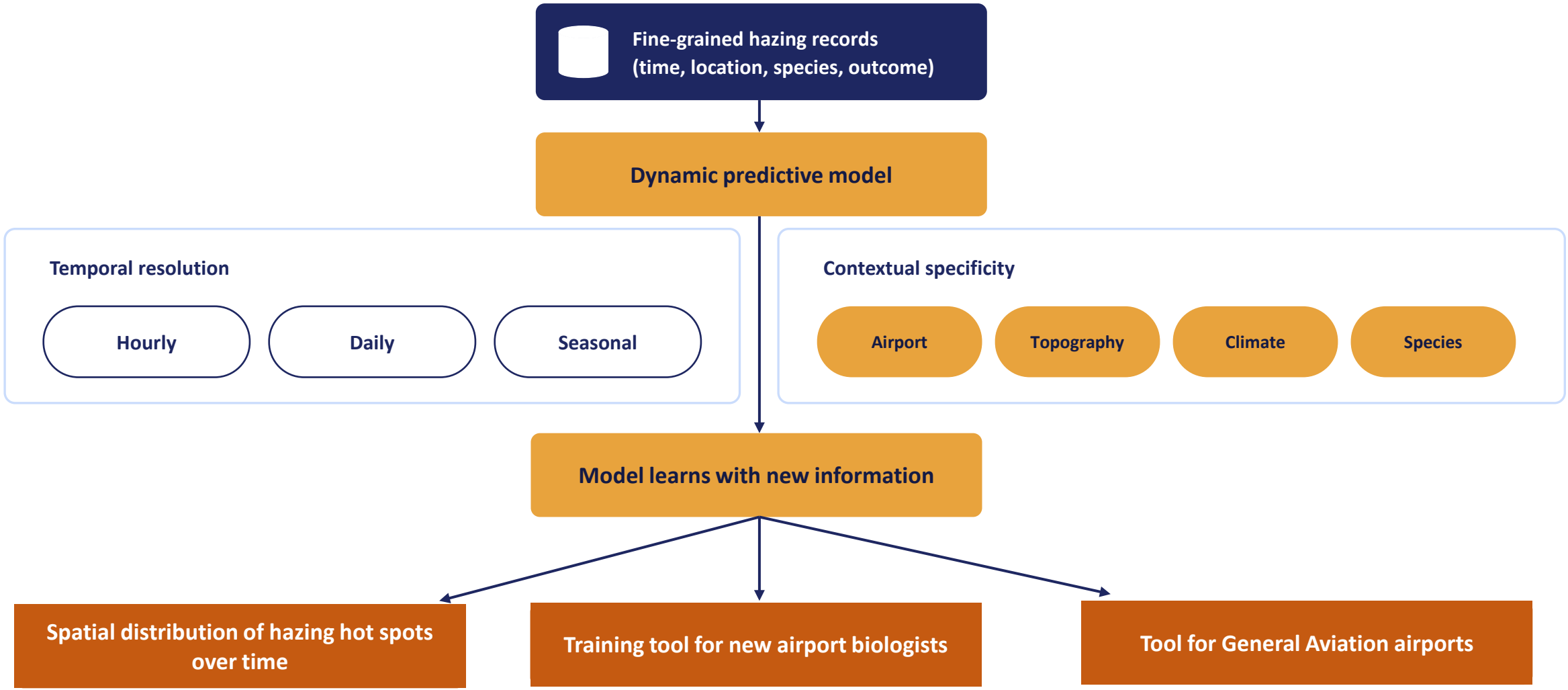


- Species: Canada goose
- Wildlife Activity: Loafing
- Number of Individuals: 4
- Initial Latitude:
- Initial Longitude:
- Time of Day: 8:00a
- Time of Year (Date): August 5th

Machine Learning model output:

- **Management Action: Depredation**
  - **Observer: 2.7%**
  - **Depredation: 49.85%**
  - **Hazing: 47.45%**
- **If hazing: Screamers + Vehicle**
  - **Screamers: 80.95%**
  - **Sirens: 72.65%**
  - **Bangers: 69.45%**
  - **Vehicles 75.0%**

Forecasting tailored to place, time, and species



Airport Hazing Database…?

Federal Aviation Administration

FAA Home | ARP Wildlife | Login

Home | Report a Strike | Update/Print a Strike Report | Search the Database

As of August 1, 2026 current strike validation progress is as follows:

- 5200-7 processed through July 30, 2026
- 5200-7E processed through May 28, 2026
- Mandatory Occurrence Reports (MOR) processed through May 28, 2026
- Carcass found online report processed through May 31, 2026

If you have any issues submitting strikes via this new interface, please contact matthew.nelson@ees-net.com. For those using the automated 'One-Stop' Reporting function (i.e. Web Service), please contact wesley.major@faa.gov to ensure that your system is compatible with this new wildlife strike reporting software or to inquire if this service is right for your organization.

FAA Wildlife Strike Database

The FAA Wildlife Strike Database contains records of reported wildlife strikes since 1990. Strike reporting is voluntary. Therefore, this database only represents the information we have received from airlines, airports, pilots, Mandatory Occurrence Reports (MOR), incident/accident information, and other sources.

Search the Database | **Report a Strike** | **Update a Strike Report**