Bird-Aircraft Collisions

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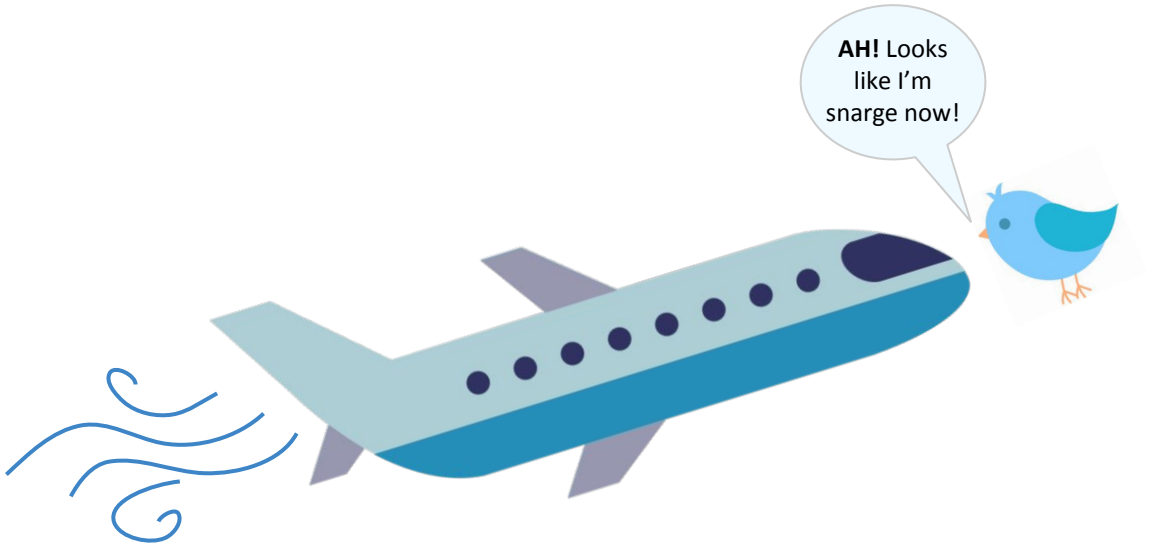


Introduction

A bird strike is commonly defined as a collision between a bird and an aircraft, which is in air, on take-off or on the landing strip. Bird strikes are very common and not only is it a threat to the safety of the aircraft, but also a significant threat to birds. The US Federal Aviation Administration (FAA) says there are more than 10,000 bird strikes a year, which works out to more than 26 hits a day. All aircrafts are highly vulnerable to loss of thrust, which can lead to birds getting caught in the engine air intakes, which is the most common type of bird casualty. To closely analyze this issue, the following presentation visually displays the data collected on bird strikes by the (FAA) between 1990 and 2015.

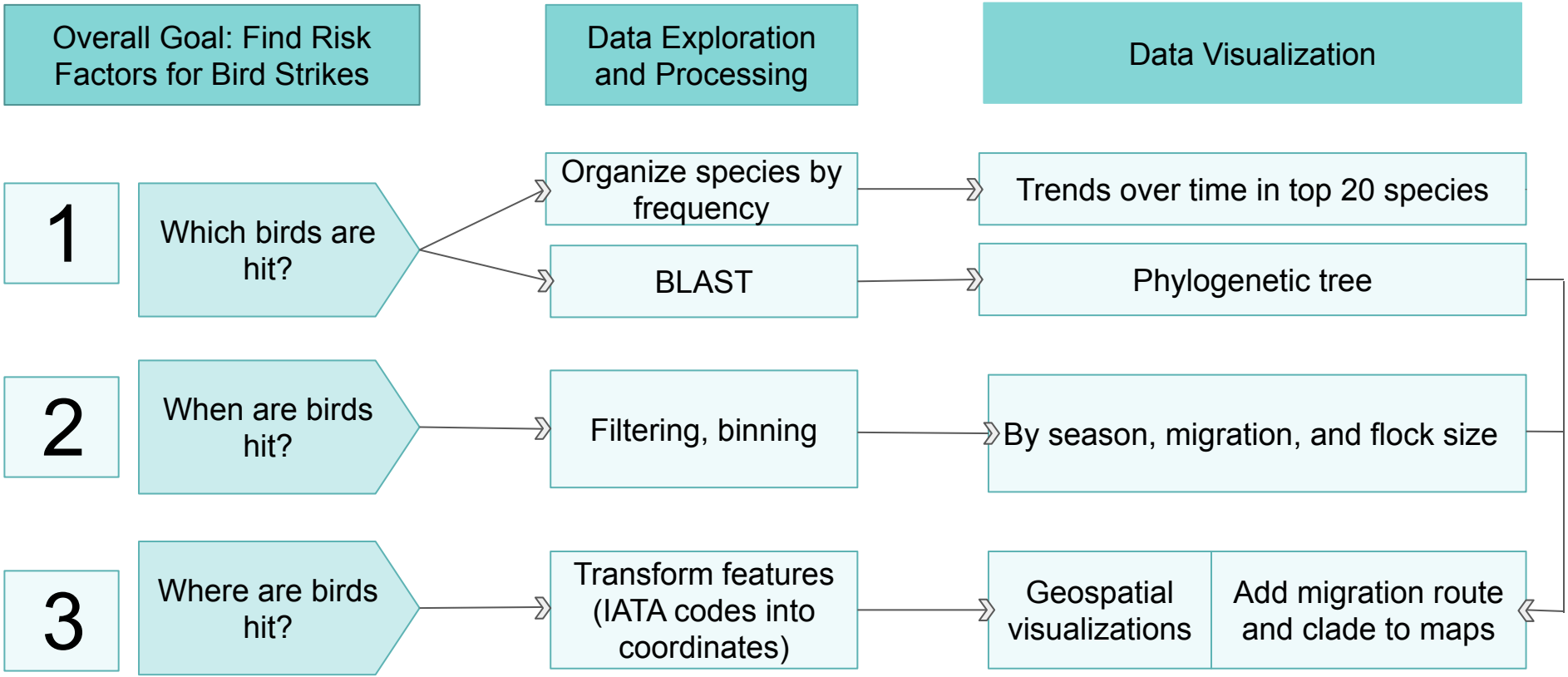
Hypotheses:

1) Five most common birds that will be involved in bird strikes are: doves and pigeons, geese, gulls and sparrows.

2) There will be an increase in bird strikes during the months of migration.

3) Bird strikes will be more frequent along the migration route of the Mississippi Flyway.

Workflow:


Overall Goal: Find Risk Factors for Bird Strikes
Data Exploration and Processing
Data Visualization
1
Which birds are hit?
Organize species by frequency
Trends over time in top 20 species
BLAST
Phylogenetic tree
2
When are birds hit?
Filtering, binning
By season, migration, and flock size
3
Where are birds hit?
Transform features (IATA codes into coordinates)
Geospatial visualizations
Add migration route and clade to maps

Section 1: Investigation of most common species in bird strikes

This section graphically displays the top 20 birds that are commonly involved in bird strikes and also looks at the trends of the most common birds to determine any differences over time. The section also investigates the most common clades of birds involved in strikes in each area via a phylogenetic tree.

Methods: Section 1

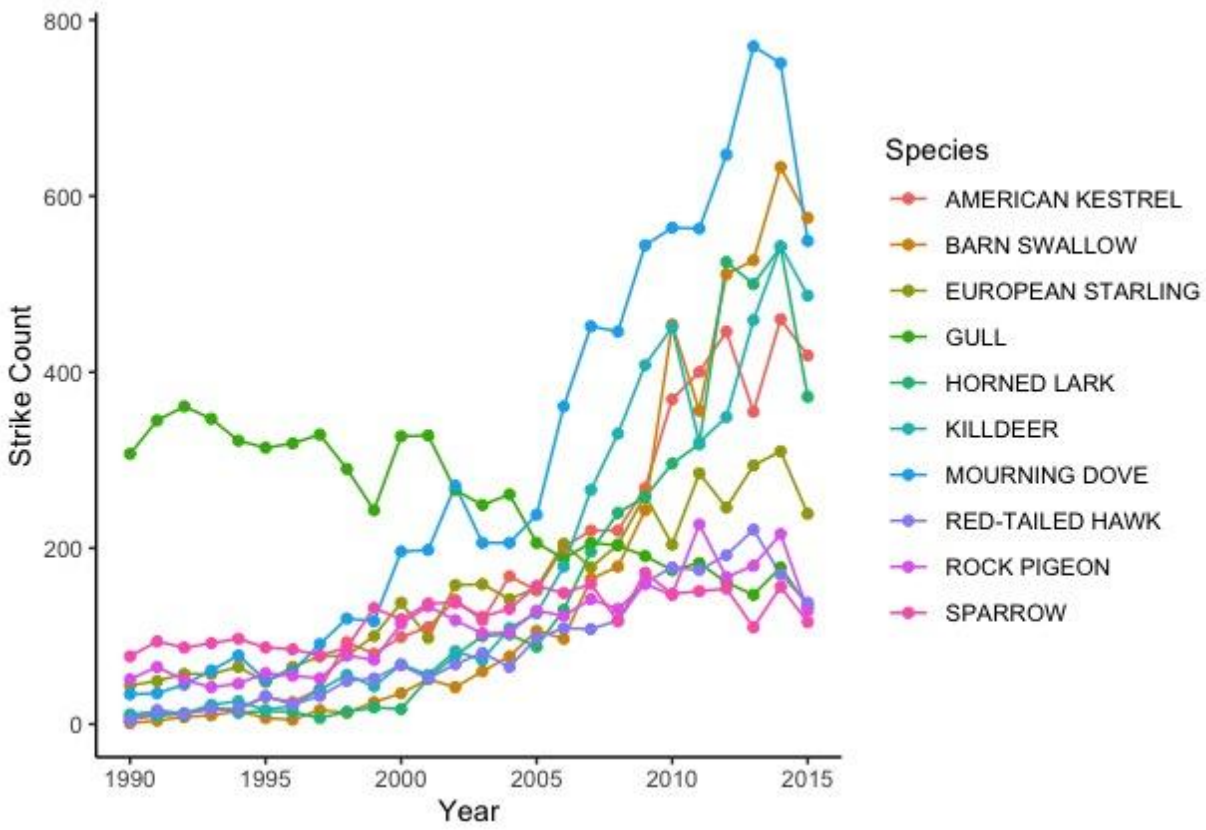
Investigate strike patterns

- First the dataset was condensed by removing sections that were not needed. Unknown species were also removed.
- The the remaining data was sorted by the frequency of incidence with each species in descending order.
- The remaining data was then converted into a dataframe, subsetted to top 10 and then plotted.
- To show the trend in five year chunks, the dataset was filtered to subsets of the years in question, and the same process as before was repeated.

Phylogenetic Tree

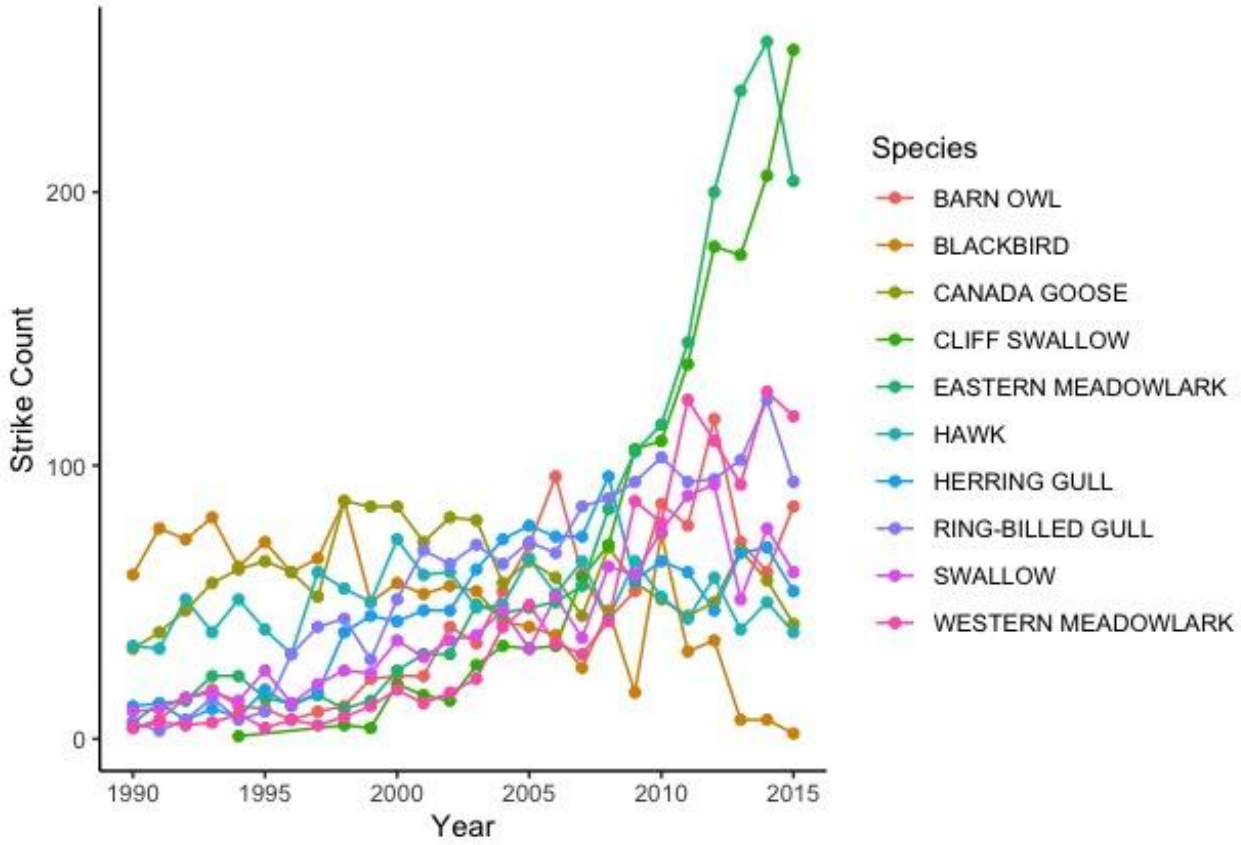
The 716 species in the dataset were sorted to pick out the most common species. This was done by organizing the species by frequency by using the **dplyr** package. Then, mitochondrial DNA was pulled from NCBI**,** after having retrieved entrez IDs using the **rentrez** package for the individual species from the nuccore database. The DNA sequences were aligned using the **muscle** package, the distance matrix was calculated using the **ape** package and the phylogenetic tree was created using **ggtree**.

Section 1: Top Ten Species Involved in Strikes

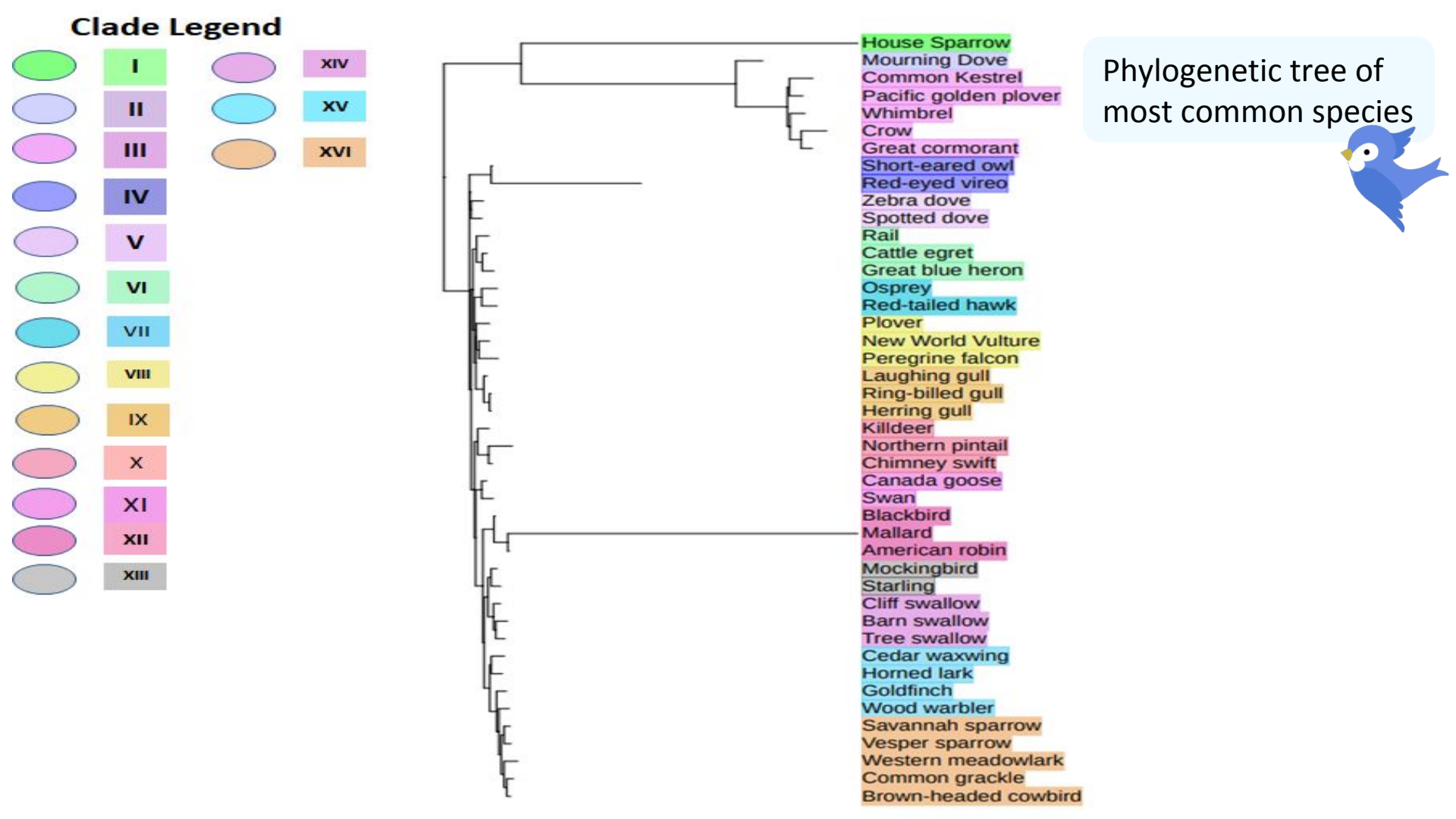


- General increase in strike count over years
- Decline in **gull** strikes
- Boom in **mourning dove** and **barn swallow** strikes

Section 1 Results: Next Ten Species Involved in Strikes



- Again, general increase in strike count over years
- Decline in **blackbird** strikes
- Boom in **eastern meadowlark** and **cliff swallow** strikes


Clade Legend
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
XV
XVI
House Sparrow
Mourning Dove
Common Kestrel
Pacific golden plover
Whimbrel
Crow
Great cormorant
Short-eared owl
Red-eyed vireo
Zebra dove
Spotted dove
Rail
Cattle egret
Great blue heron
Osprey
Red-tailed hawk
Plover
New World Vulture
Peregrine falcon
Laughing gull
Ring-billed gull
Herring gull
Killdeer
Northern pintail
Chimney swift
Canada goose
Swan
Blackbird
Mallard
American robin
Mockingbird
Starling
Cliff swallow
Barn swallow
Tree swallow
Cedar waxwing
Horned lark
Goldfinch
Wood warbler
Savannah sparrow
Vesper sparrow
Western meadowlark
Common grackle
Brown-headed cowbird
Phylogenetic tree of most common species

Section 2: The Effect of Migration

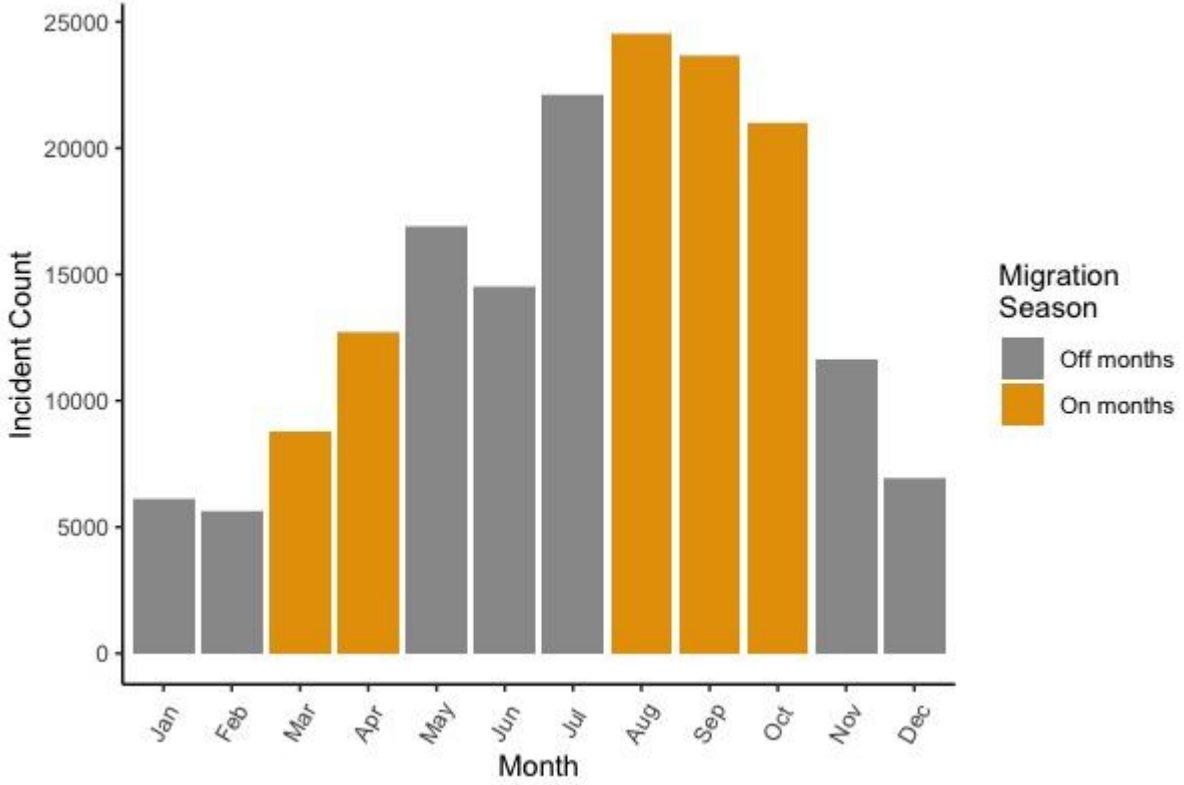
This section graphically displays the number of birds that are struck during the migration period and the severity of these impacts by month. This was done by comparing the frequency of bird strikes in non-migratory months to migratory months.

Methods: Section 2

When were birds hit?

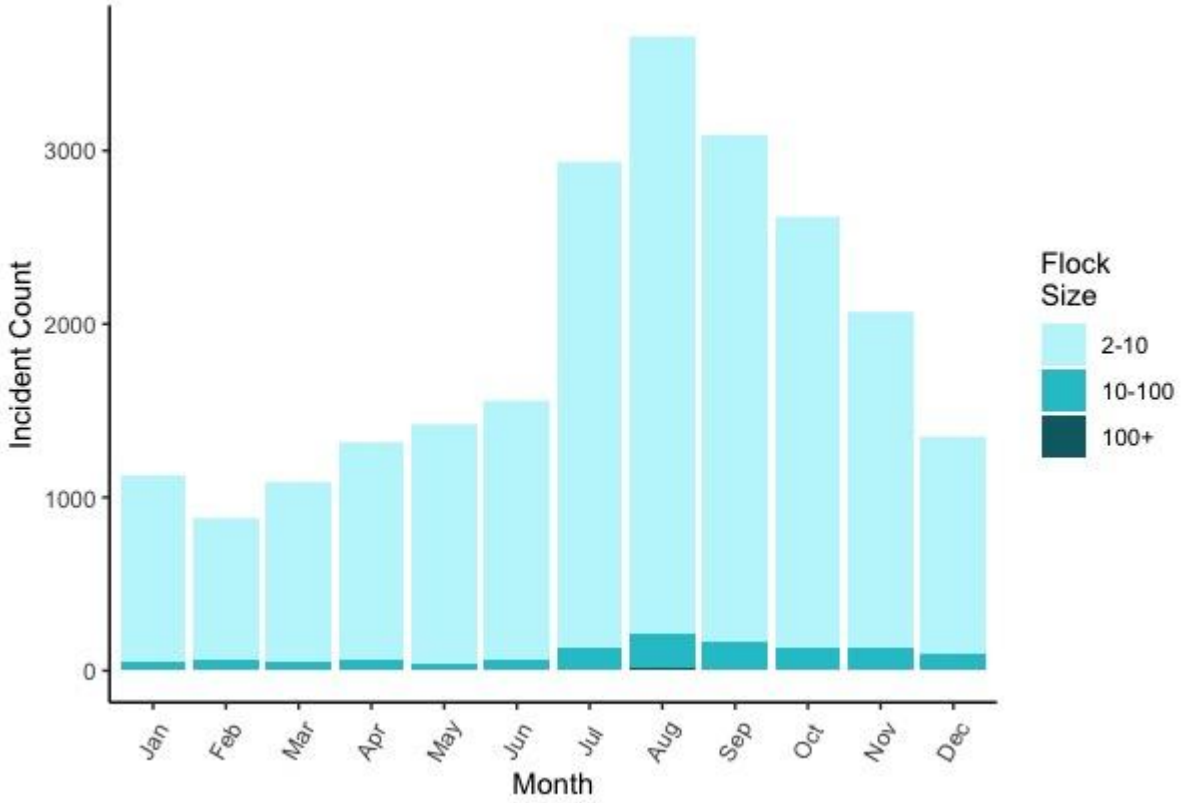
Using dplyr and ggplot

Section 2 Results: Frequency of Impacts by Month



- Strike frequency did change seasonally
- No apparent correlation to migration period

Section 2 Results: Severity of Impacts by Month



- Average size of flock hit appeared to be proportional to number of incidents
- No spike in flock impacts during springtime migration months

Section 3

This section investigates which regions are the worst offenders for bird strikes, in the USA and on a global scale. This section also investigates regions of bird strikes along the four major migration pathways of birds in North America (Atlantic, Mississippi, Central, and Pacific).Lastly, this section assesses the most common species of bird to be struck in each area.

Methods: Section 3

1) Found summary statistics for all airports in bird-aircraft collision dataset

2) Created new dataset with the sum of bird strikes for each of the 50 states, and DC
3) Calculated summary statistics for new dataset and plotted bird strikes across the states

4) Divided the number of bird strikes by the number of airports in each state, to control for the number of airports in each state
5) Summary statistics were calculated and the number of bird strikes per airport in each state was plotted

6) Downloaded a dataset of 22,930 US airports with information on their name, International Air Transport Association identifier (IATA code), latitude, longitude, elevation, etc
7) Found only 37 airports from the bird-aircraft collision dataset were missing from the US airports dataset
8) Recounted the number of bird stirkes without missing airports, appended longitudes and latitudes based on IATA codes
8) Plotted number of strikes at each airport over the first map

*Maps of the US were plotted with the package usmap. Worldwide maps were created with the ggplot and rworldmap packages.

Methods: Section 3

9) Downloaded a global airport dataset of 9,300 airports and 16 features for them such as name, IATA code, city, country, longitude, latitude, etc

10) Determined only 639 airports from the bird-aircraft collision dataset were included in the global airport dataset

11) Recounted the number of bird strikes without missing airports, appended longitudes and latitudes based on IATA codes

12) Plotted number of strikes at each airport on a global scale

13) Combined US airports and global airports datasets to obtain coordinates, and plotted both smaller US airports and global airports on the worldwide map

14) Found a map of migration paths in the US which roughly lined up with maps created with the usmaps package

15) Overlaid US airport points, scaled based on number of bird strikes on the migration paths map

16) Lastly plotted the most commonly hit species in each state

Results Section 3: Bird Strikes Overall

1. There are 2228 airports in the bird-aircraft collision dataset, with 1914 of them being in the US

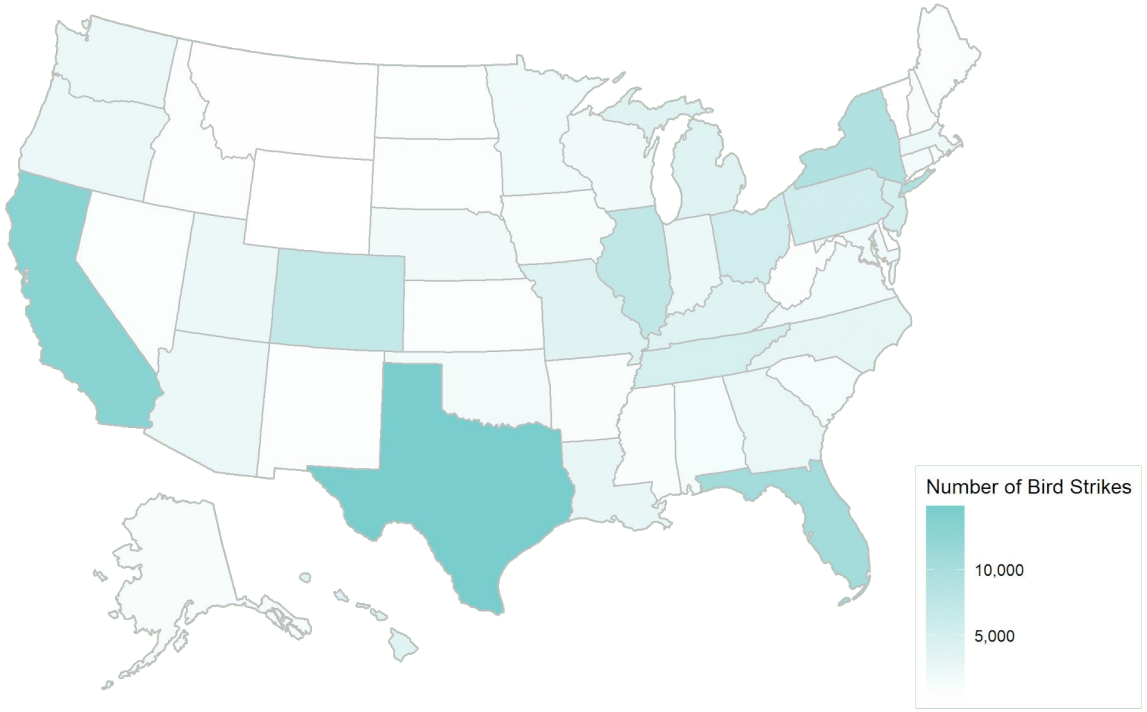
2. The median number of bird strikes per airport was 3

3. The mean number of bird strikes per airport was 78.14

4. The highest number of strikes per airport is 18,570 at the airport ZZZZ. This is a special code used when no code exists for the airport, such as helicopters running outside of an aerodrome.

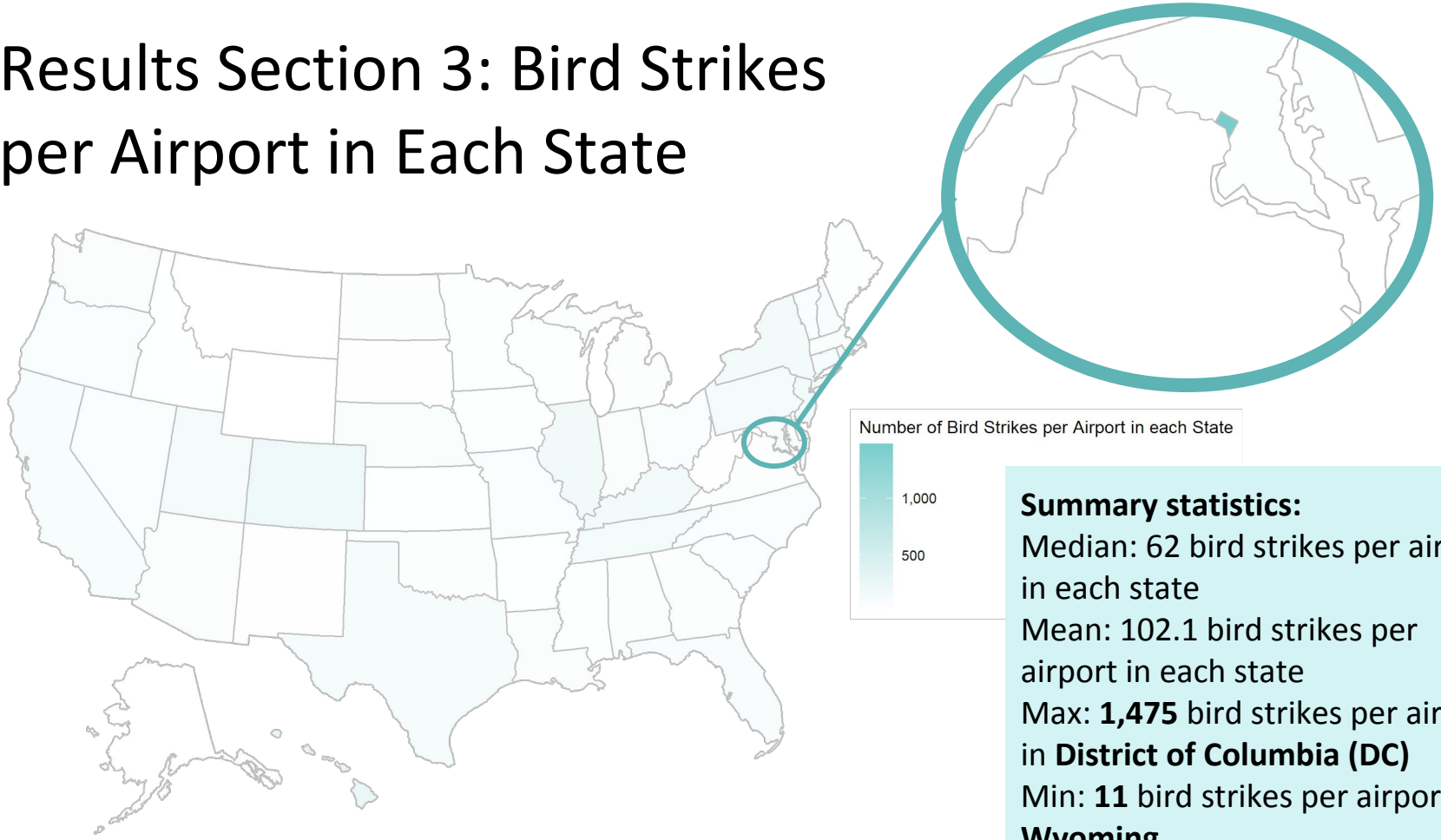
5. There's 2147 airports with 1 strike, which is the lowest number of recorded strikes.

Results Section 3: Bird Strikes in Each State



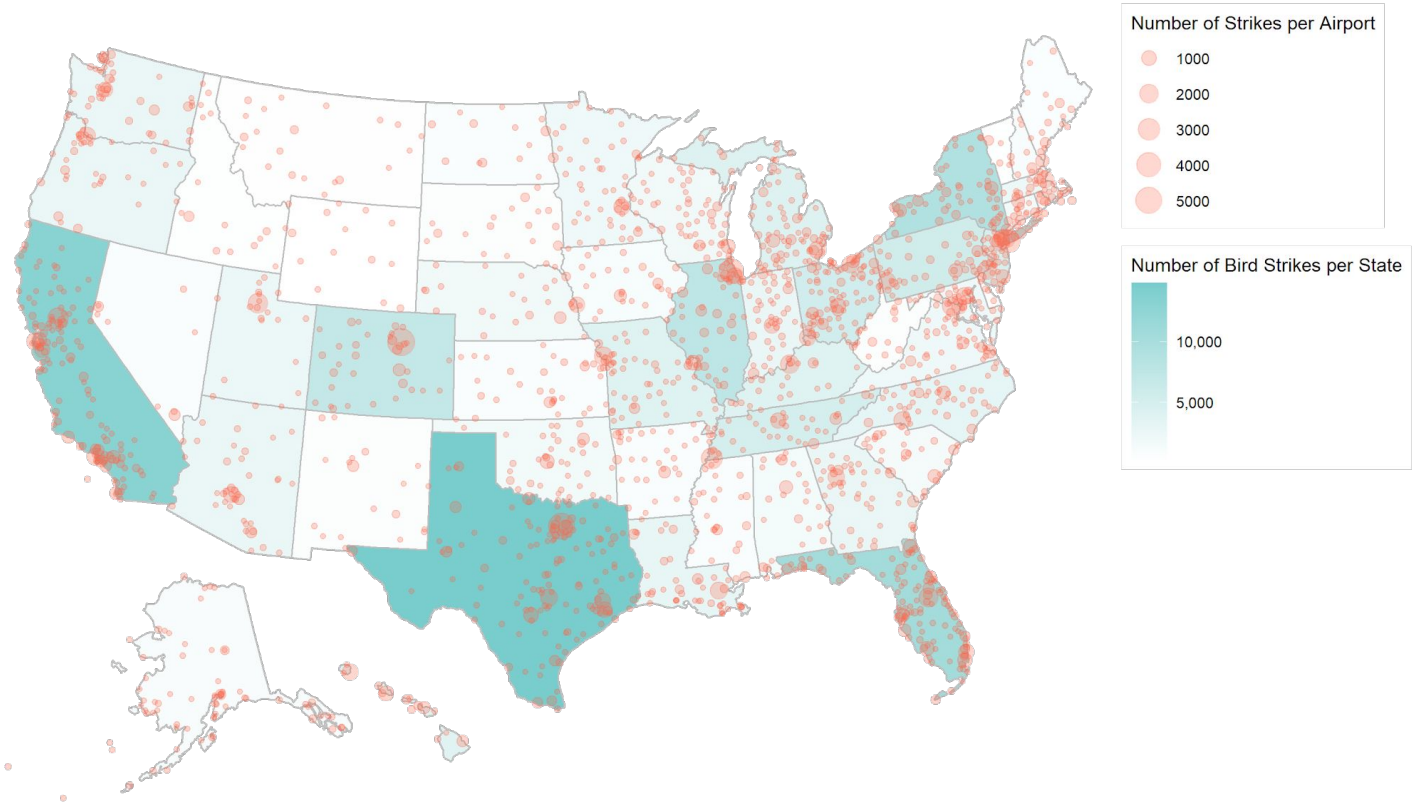
Summary statistics:
Median: 1910 bird strikes per state
Mean: 2960 bird strikes per state
Max: **14,854** bird strikes in **Texas**
Min: **166** bird strikes in **Delaware**
*It is also worth noting that Texas is the second largest state after Alaska, and Delaware is the second smallest state after Rhode Island, so the number of strikes is skewed by the number of airports in each state

Results Section 3: Bird Strikes per Airport in Each State



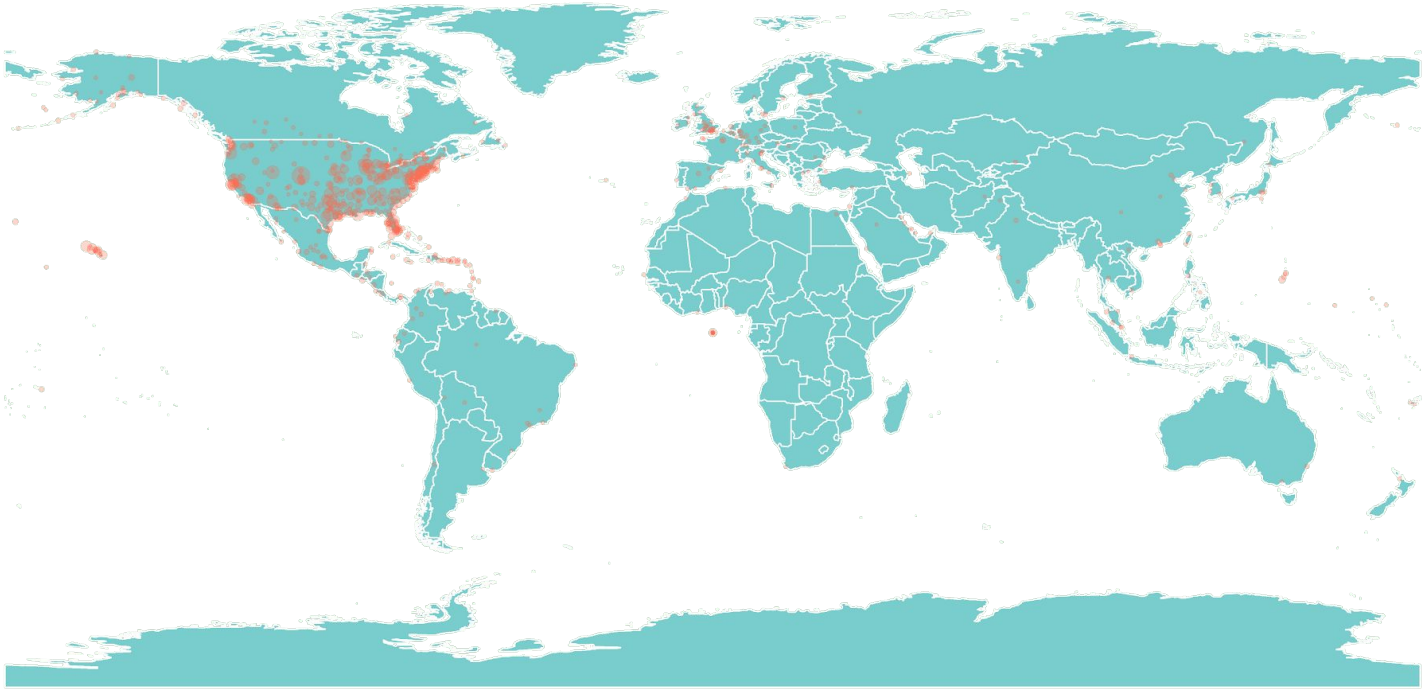
Summary statistics:
Median: 62 bird strikes per airport in each state
Mean: 102.1 bird strikes per airport in each state
Max: **1,475** bird strikes per airport in **District of Columbia (DC)**
Min: **11** bird strikes per airport in **Wyoming**

Results Section 3: Number of Bird Strikes per Airport in Each State



Summary statistics:
Median: 3 bird strikes per airport
Mean: 80.4 bird strikes per airport
Max: **5,434** bird strikes at the **Denver International Airport**
Min: **1** bird strike per airport in 675 airports
*map includes 1,877 airports across the US

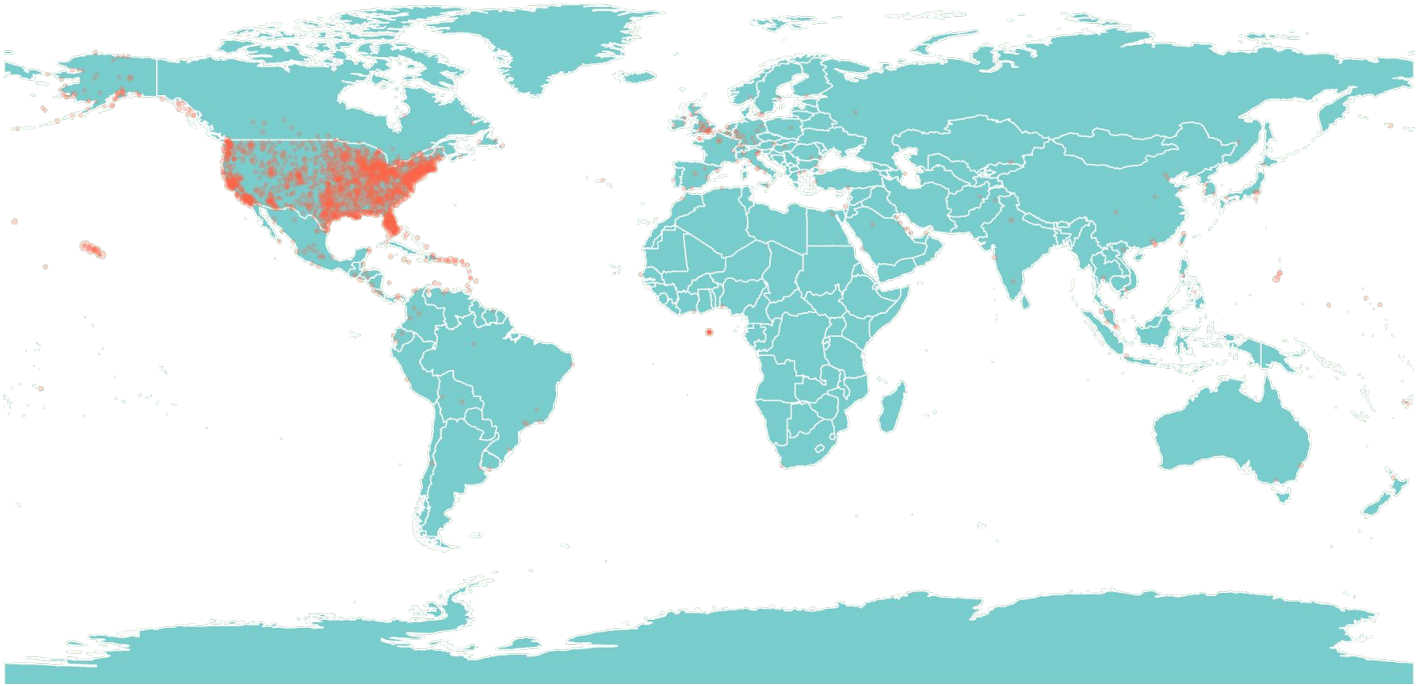
Results Section 3: Worldwide Bird Strikes



Summary statistics:
Median: 13 bird strikes per airport
Mean: 197.5 bird strikes per airport
Max: **5,434** bird strikes at the **Denver International Airport**
Min: **1** bird strike per airport in 112 airports
*map includes 639 airports across the globe

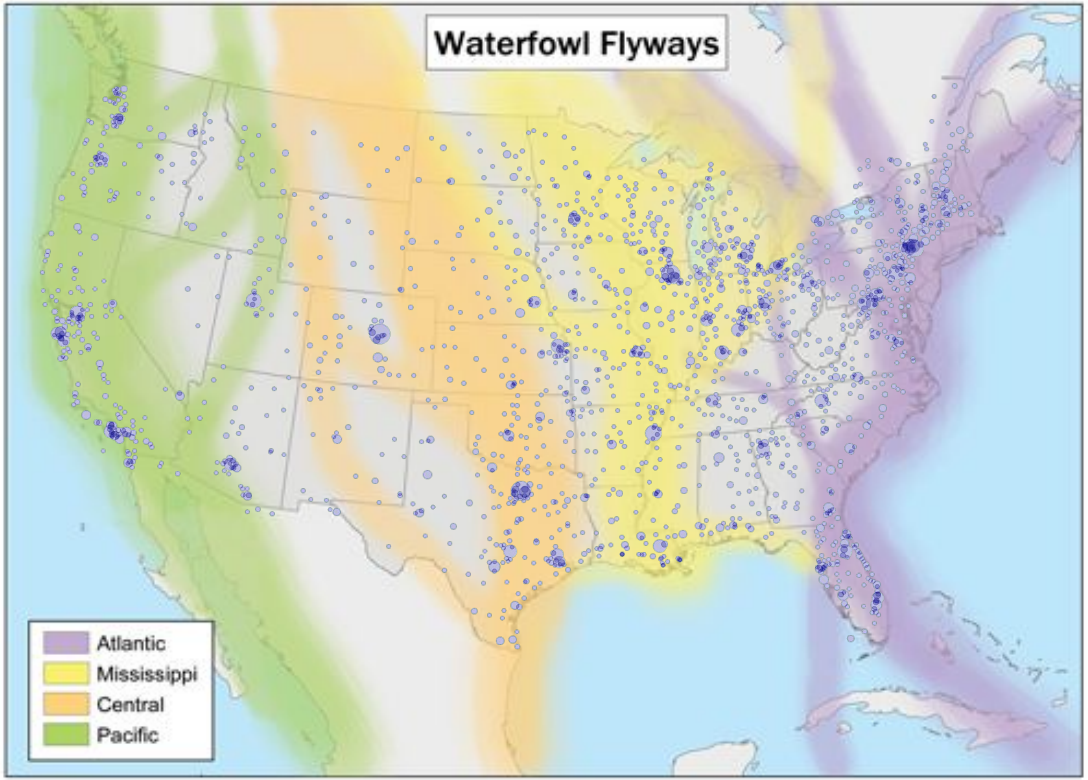
Results Section 3: Worldwide Bird Strikes

Including smaller US airports!



Summary statistics:
Median: 3 bird strikes per airport
Mean: 71.6 bird strikes per airport
Max: **5,434** bird strikes at the **Denver International Airport**
Min: **1** bird strike per airport in 758 airports
*map includes 2,159 airports across the world

Results Section 3: Migration Pathways



Bird aircraft strikes are prominent along migration routes, especially along the Mississippi flyway path.

Number of Strikes per Airport

1000

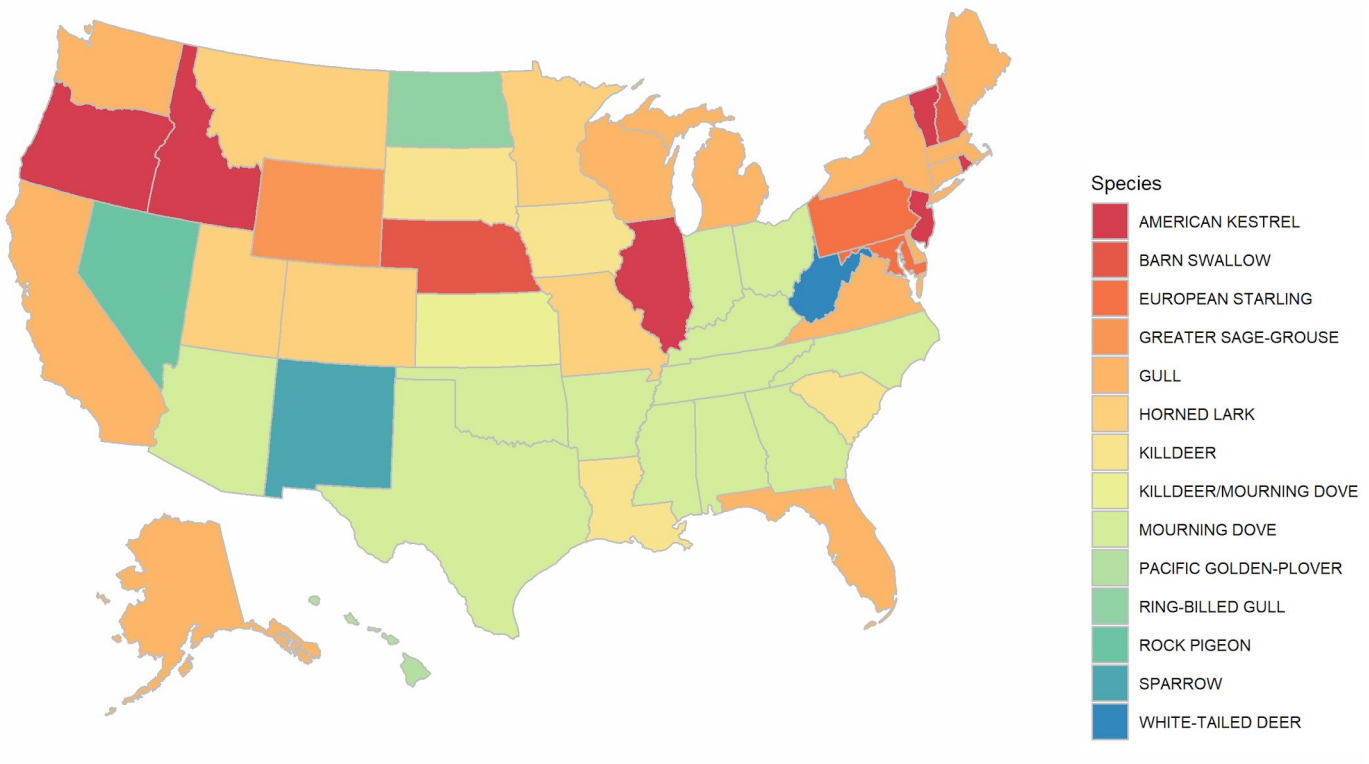
2000

3000

4000

5000

Results Section 3: Most Commonly Hit Species

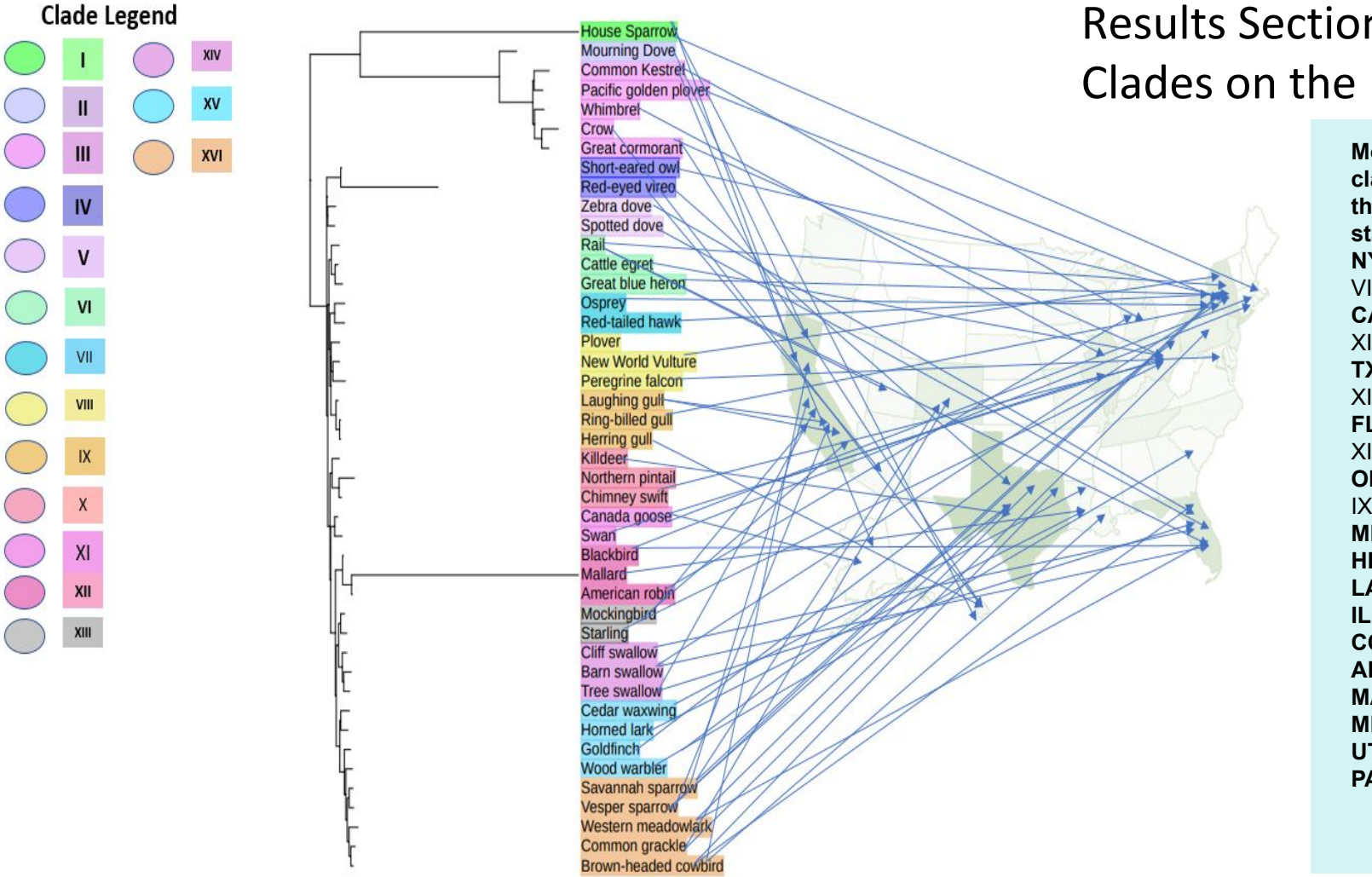


Summary Statistics:

- Most common species hit is Gull in 13 states
- Most commonly hit species with the highest number of strikes is the Horned Lark in Colorado (1483 strikes)

- On average each commonly hit species is striked 260 times

Results Section 3: Clades on the US Map



Most common clades in each of the common state(s)

NY: IV, VI, VII, VIII, XIV, XV, XVI
CA: II, III, IV, IX, XIV, XV, XVI
TX: V, VIII, IX, XIII, XIV, XV.
FL: IV, VI, X, XII, XIV, XV, XVI
OH: IV, VII, VIII, IX, X.
MI: II, XI
HI: I, II, III, IX
LA: X, XIII, XV
IL: II, IX
CO: XIV, XV, XVI
AK: III, XI
MA: II, X, XI
MD: VIII
UT: VI
PA: XVI

Discussion/Conclusion

Bird strikes are by no doubt a significant threat to flight safety. They often occur during take-off, on-landing or during low-altitude flights. The aim of this presentation was to visually display the common species involved in bird strikes, which migration route is the most affected, and to observe the five year trend of bird strikes given the dataset from 1990-2015. As can be seen from our data analysis, more than 5,000 bird strikes occur annually in the United States, alone. The frequency of bird strikes especially increase during the spring (March to May) and fall migratory months (August to October) with about 10,000 - 22,000 strikes combined. Particularly, Canada geese, gulls, pigeons and doves are by far the top four species involved in bird strikes with ~600 collisions every five years. In order to address the ongoing issue of bird collisions, airlines are required to collect more data, using thorough avian survey methods, conducting risk assessments and providing adequate training to aircrew; and attempt to distinguish between bird collisions and other foreign-object collisions, to be able to produce a more accurate and polished analysis. This will allow airlines to organize the data according to different species (at risk vs not at risk), strikes during migratory and non-migratory months etc. to better identify bird strike prevention strategies and create a predictive model for future analysis.

Section 1 Results: Potential Confounding Variable

Pattern:

- Strikes involving catch-all names are apparently declining (eg: gull, blackbird)

Potential confounding variable:

- Common names were replaced with more specific names as identification techniques improved

Future Directions - Part 1
Active Management

Active management seeks to employ dispersal methods to scare or remove birds from airport premises. There are various methods available, some of which have limited effects in the long-term due to habituation. However, active management is only successful when combined with passive management strategies (discussed in the next slide)..

Dispersion Strategies	- Use of pyrotechnics (pistols that produce a loud noise to scare birds) - Loud sirens
Lethal Strategies	- Recommended as a last resort - NEVER to be used as a primary management tool - Used to reinforce non-lethal management strategies or when other methods have not worked - Ex. falconry - using birds of prey to capture unwanted birds
Hazard Communication	- Communicate with pilots to warn of flocks of birds in air route - Must include: species, location of flock in airfield, and height of the hazard(s)

Future Directions - Part 2
Passive Management

Passive management strategies seek to reduce the attractiveness of airports by focusing on eliminating food and water sources and availability of shelter. The use of these methods results in a long-term reduction of the number of birds at the airport and, consequently, reduction of the risk of bird strikes.

Food and water Management	- Remove any sources of food and water to reduce attraction of airports - May include mowing grass to eliminate food sources
Habitat modifications	- Removal of pre-made nests - Installation of anti-perching spikes and wires
Movement monitoring strategies	- New ROBIN radar system to warn aircrew of approaching flocks [1] - Avoid common migratory pathways

References

1. Systems, R. R. (n.d.). We are Robin Radar Systems: Technology Leader in Radar Tracking. Retrieved from https://www.robinradar.com/
2. Linnel, A. M., Conover, R. M., Ohasi, J. T. (1996). Analysis of Bird Strikes at a Tropical Airport. *The Journal of Wildlife Management*, 60(4), 935-945.

Thanks for reading! Stay safe and have a great summer!