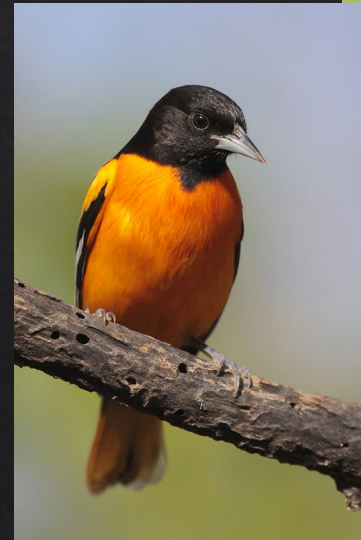
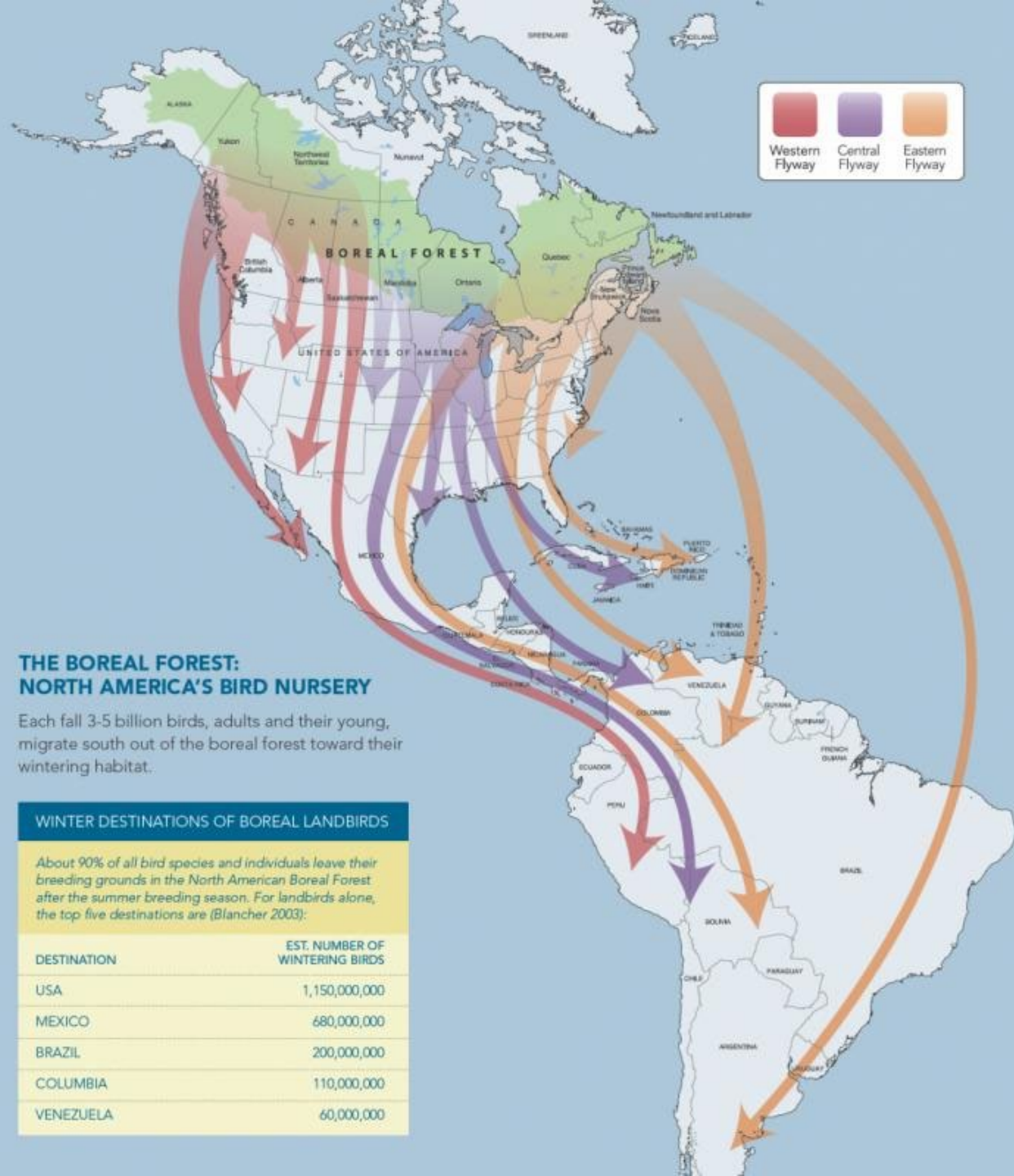


# Texas Coast Spring Migration







### THE BOREAL FOREST: NORTH AMERICA'S BIRD NURSERY

Each fall 3-5 billion birds, adults and their young, migrate south out of the boreal forest toward their wintering habitat.

#### WINTER DESTINATIONS OF BOREAL LANDBIRDS

About 90% of all bird species and individuals leave their breeding grounds in the North American Boreal Forest after the summer breeding season. For landbirds alone, the top five destinations are (Blancher 2003):

| DESTINATION | EST. NUMBER OF WINTERING BIRDS |
|-------------|--------------------------------|
| USA         | 1,150,000,000                  |
| MEXICO      | 680,000,000                    |
| BRAZIL      | 200,000,000                    |
| COLUMBIA    | 110,000,000                    |
| VENEZUELA   | 60,000,000                     |

# Evolution of Migration

- Migration is the result of past evolutionary forces that selected for individuals whose movements gave them the best opportunity to survive and reproduce.
- Drastic environmental change over time – e.g., 20 glacial cycles over last 2.5 million years
- Today's migrants descend from birds that have been adapting to such environments for millions of years
- Migration has evolved many times in different avian groups. Ancestral ability to migrate may be a shared trait of all birds.

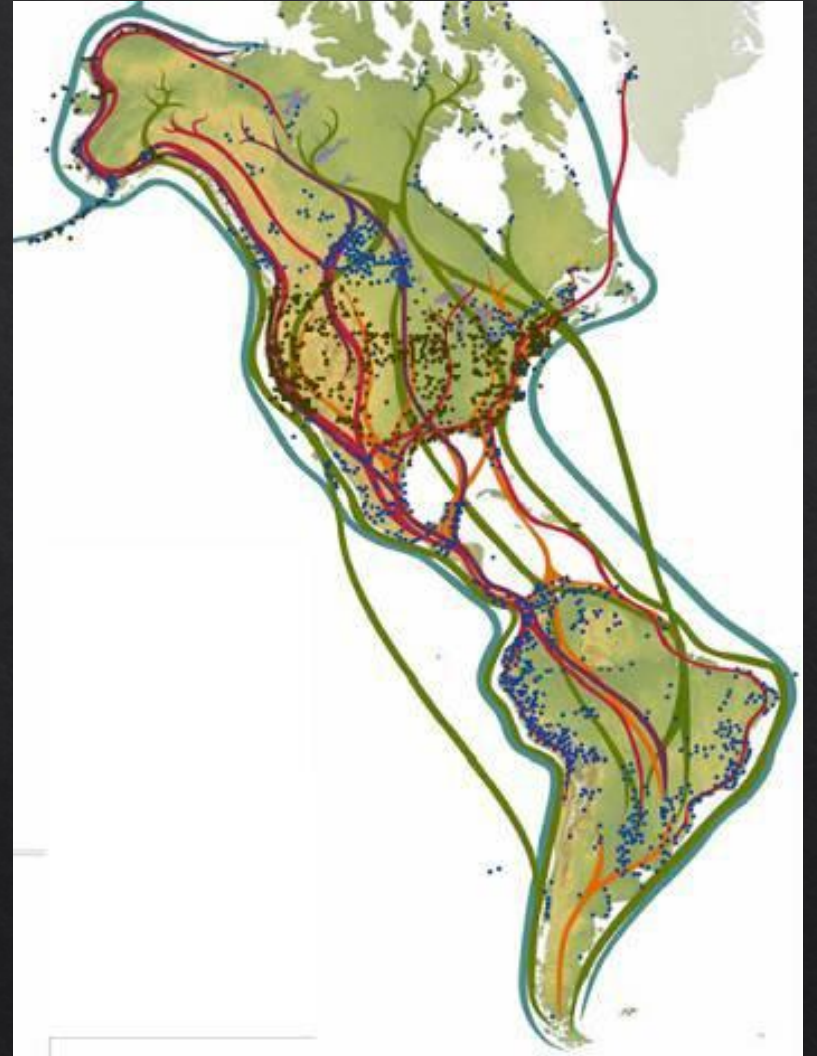
# Migration Strategies

- Different species undertake migrations that vary in length and duration.
- Hopping, skipping, and jumping
- During migration, paths are adjusted to changing conditions.
- Within a species, individuals of different ages and sexes often follow varied migration routes and occupy different non-breeding areas.



# Migration Strategies

- Flyways – Established migration routes used annually by large numbers of birds, with different species converging
- Migratory concentration points have vast numbers of birds pausing briefly at stopover sites to rest and refuel while waiting for favorable conditions



# Migration Timing

- Birds have internal biological clocks that help them monitor time and seasons.
- Birds can sense time of day and progression of seasons even without external light or seasonal cues.
- Internal clocks synchronized by environmental cues, especially photoperiod. Hormonal changes regulated.
- How birds adjust internal clock with changing latitude during migration remains a mystery.

# Migration Timing

- Internal clock signals beginning of migration
- Migratory restlessness and building of fat reserves
- Birds will delay departure with adverse conditions or inadequate preparation



# Orientation and Navigation

- Birds have remarkable navigational abilities
- Orientation – judging compass direction
- True Navigation – estimating absolute position and planning routes
- Long distance displacement experiments – birds displaced often return to their starting point even when moved vast distances, often at a pace that indicates a straight-line return.
- Experienced migrants perform better than first-time travelers.

# Orientation and Navigation

- Solar Cues – using sun's position combined with internal clock
- Polarized Light – Patterns shift throughout the day and refine solar navigation. Used to calibrate magnetic compass at sunrise and sunset.
- Sense of Smell and Infrasonic Detection
- Celestial Cues
- Detection of earth's magnetic field

# Orientation and Navigation

- Studies at planetariums show that birds don't have a map of stars, but determine direction based on stars' rotation.



# Orientation and Navigation

Birds detect magnetic fields using a pigment called cryptochrome in their retinas, which may allow birds to “see” magnetic directions.

- Formation of radical pairs – light activates cryptochrome in retina, triggering a chemical reaction that creates two molecules with unpaired electrons
- Quantum Spin States – the unpaired electrons can exist in two quantum spin states. The earth’s magnetic field influences the interconversion between the two states.
- Magnetic Sensitivity – the rate at which the radical pair transitions between the states depends on the orientation and strength of magnetic field. Leads to different chemical reactions.

# Migration and Weather

Weather significantly affects migration:

- Clouds and Fog – obscures orientation cues
- Rain– complicates flight and thermoregulation
- Wind– has the most profound effect on flight efficiency

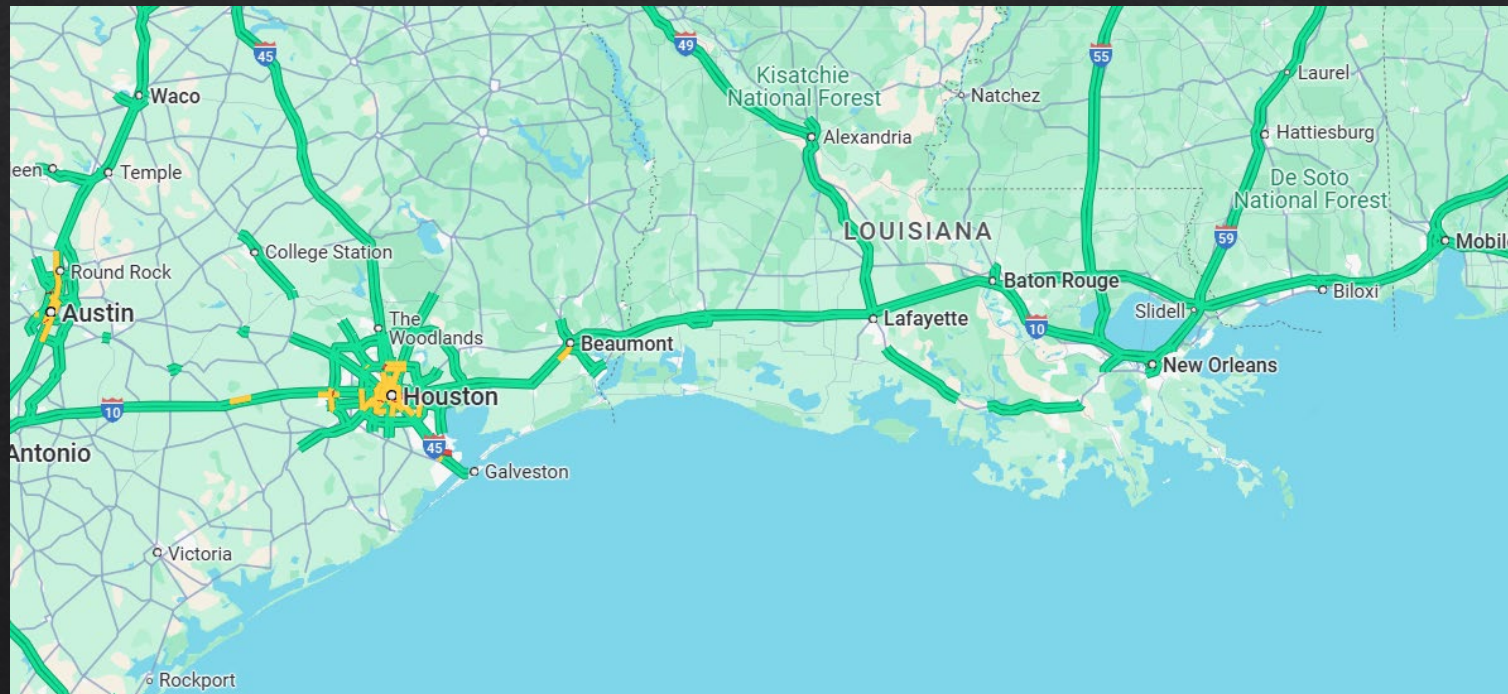
# Neotropical Migration

- Four primary routes – Pacific, Central, Caribbean, Trans-Gulf
- Trans-Gulf migrants funnel up from South and Central America, stage on Yucatan Peninsula to prepare for 600 mile flight

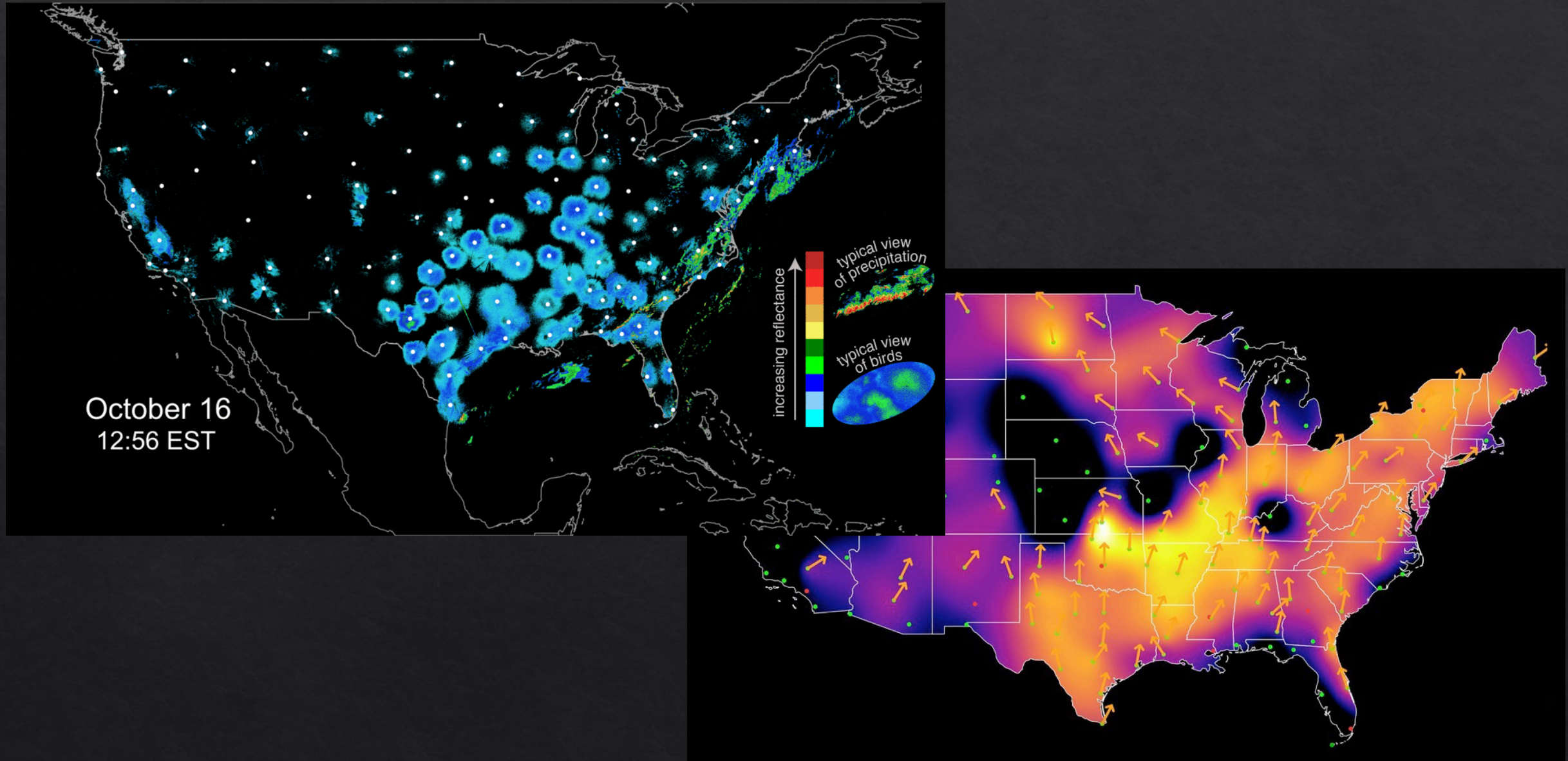


# Transgulf Migration

- Migrants depart within 30-45 minutes of sunset
- Ascend to 1,000-3,000 meters
- 16-20 hour flight time
- Arrivals mid- to late-afternoon
- With favorable winds will continue inland into forested areas



# Radar Ornithology and BirdCast

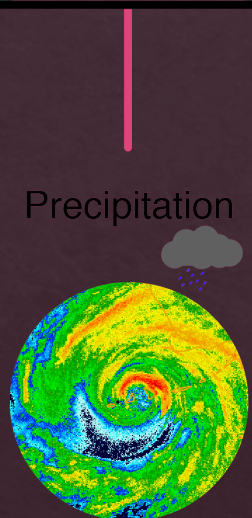
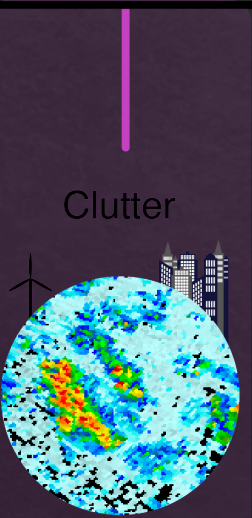


# Radar Ornithology and BirdCast

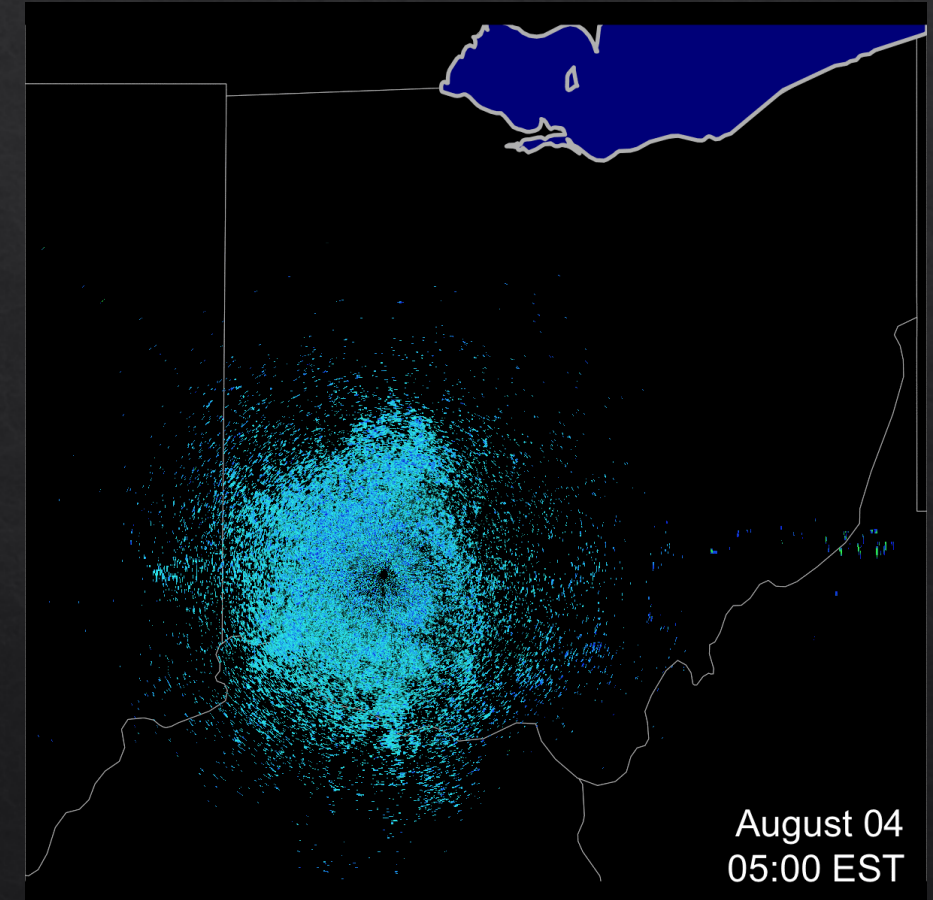
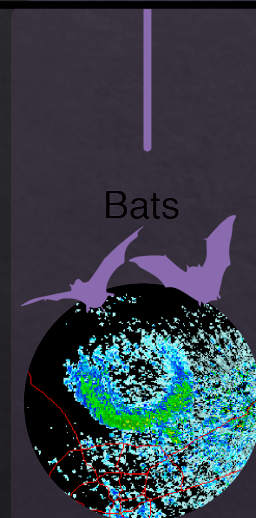
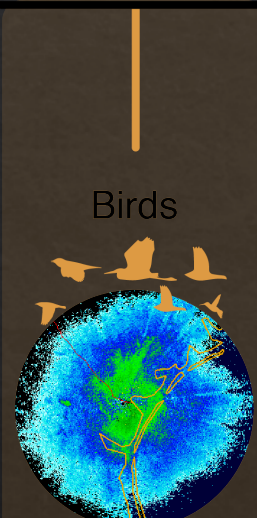
Radar Ornithology – use of Doppler weather radar to estimate bird migration densities.

## Radar classification

### Non-biological



### Biological



# Radar Ornithology and BirdCast

BirdCast – Provides real-time predictions of bird migration

Inputs:

- 20+ years of historical migration data
- Medium-range weather model determines favorability of weather conditions
- Computer analysis of real time doppler radar 3 hours after sunset

