The value of acoustic technologies for monitoring bird migration

Andrew Farnsworth, Conservation Science Program

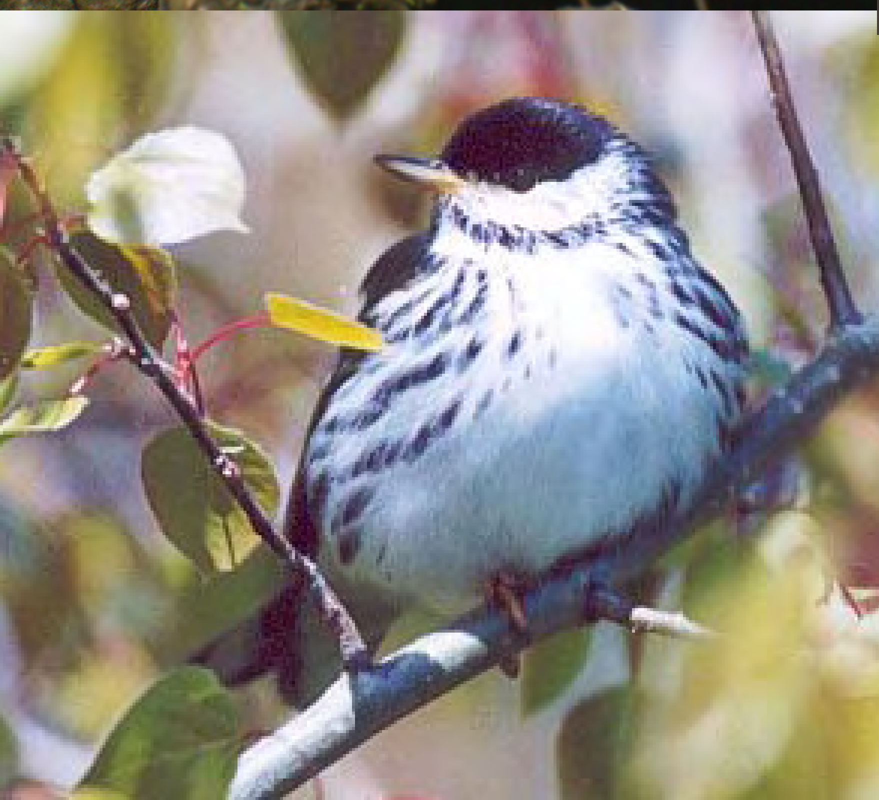
CORNELL LAB *of* ORNITHOLOGY

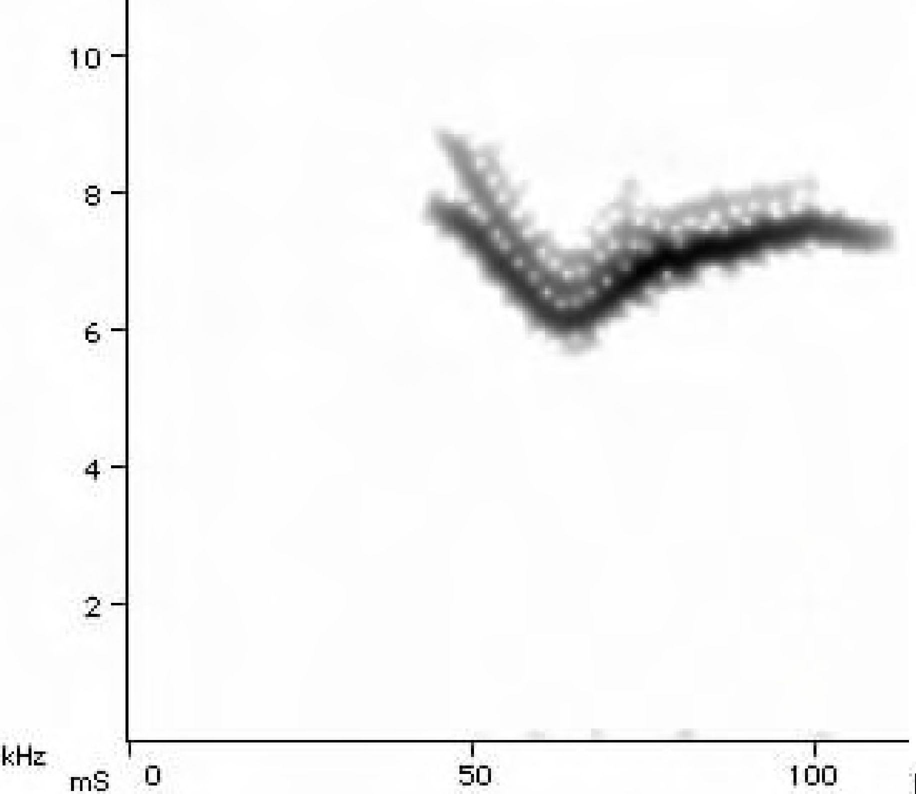
DEPARTMENT OF DEFENSE LEGACY PROGRAM

Monitoring using acoustic technologies

1) Informing traditional auditory monitoring
2) Monitoring species that are difficult to survey.
3) Monitoring migrants by recording flight-calls.







10
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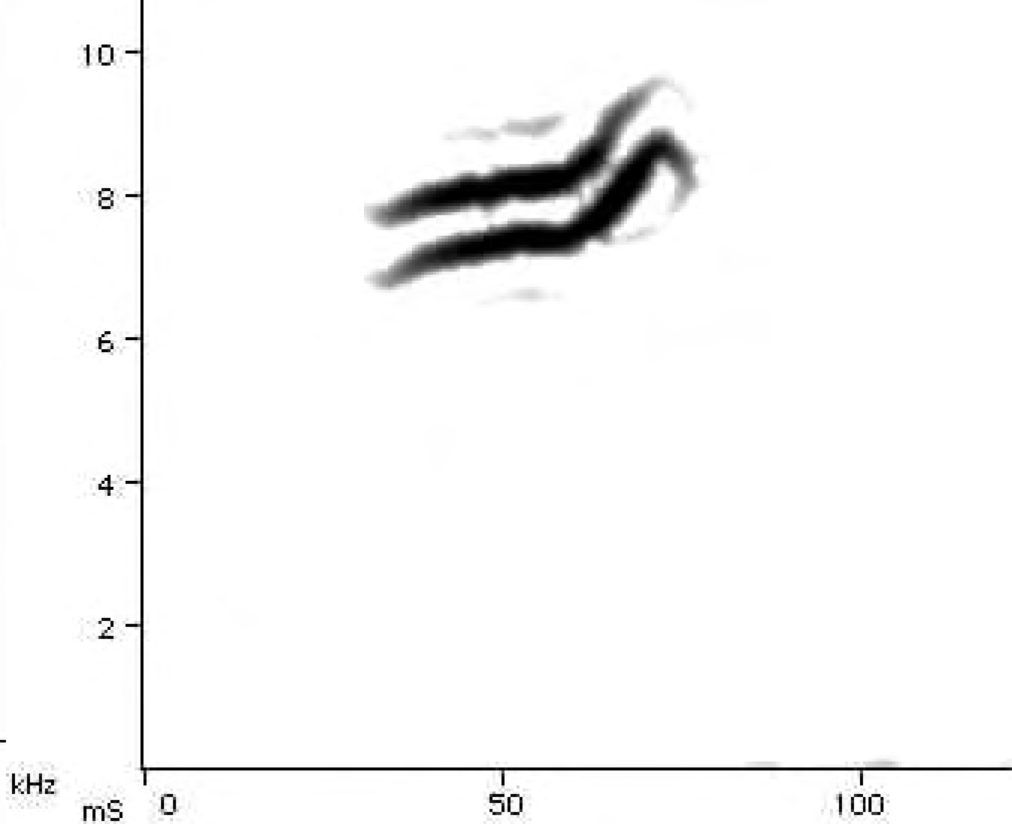
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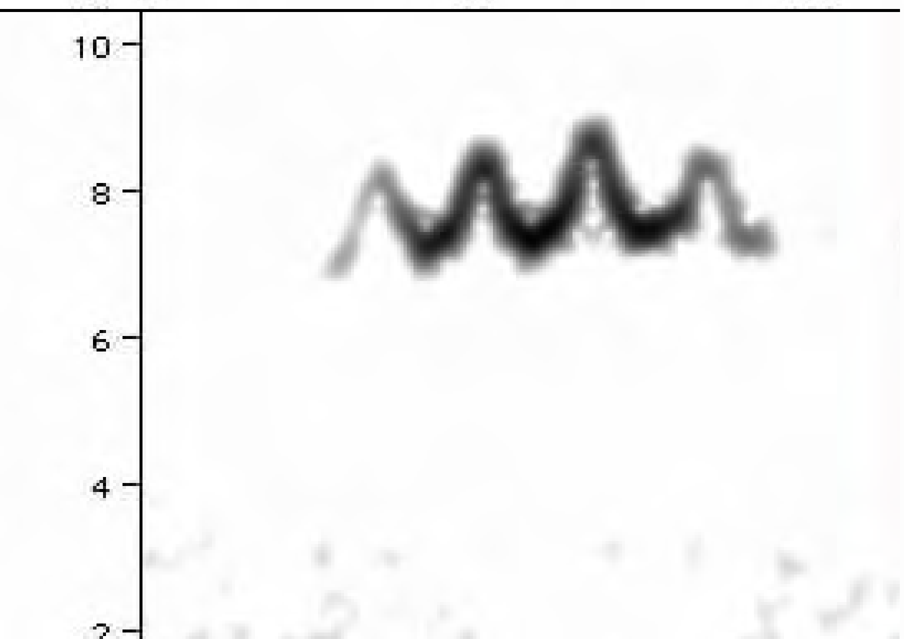

10
8
6
4

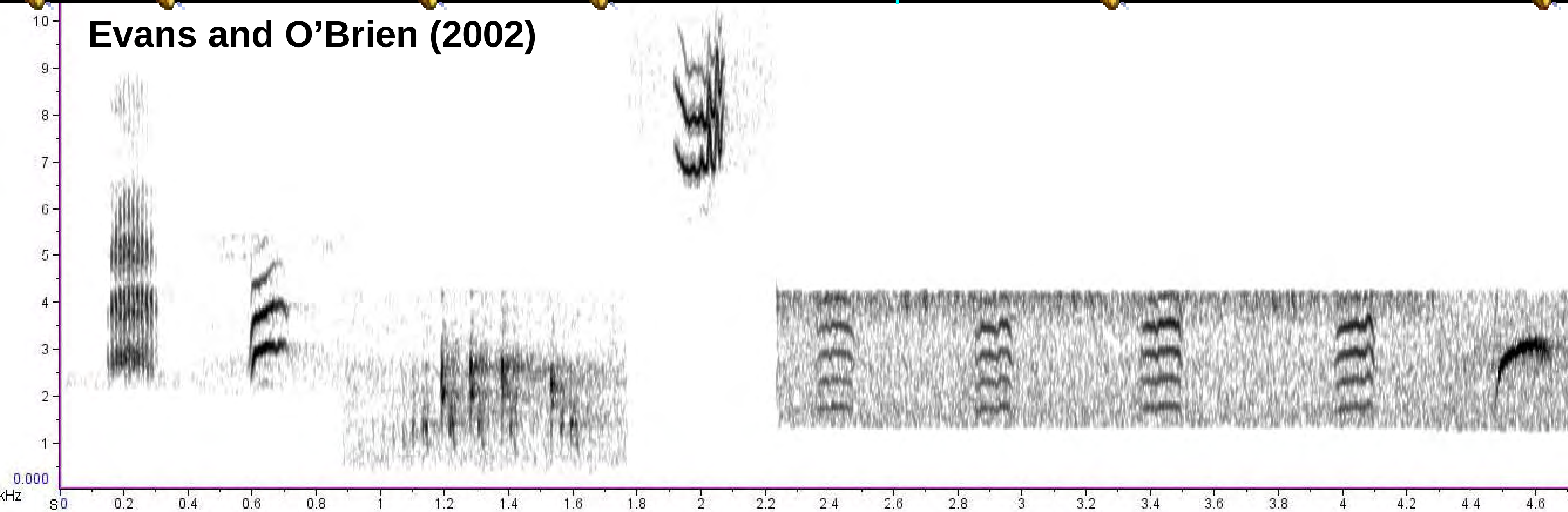

8
6
4
2

Many species produce flight calls: unique vocalizations, varying in frequency, duration, and pattern; primarily given in sustained flight, presumably for communication.

Dickcissel Black-billed Cuckoo Red-breasted Nuthatch

Bobolink White-throated Sparrow Swainson's Thrush

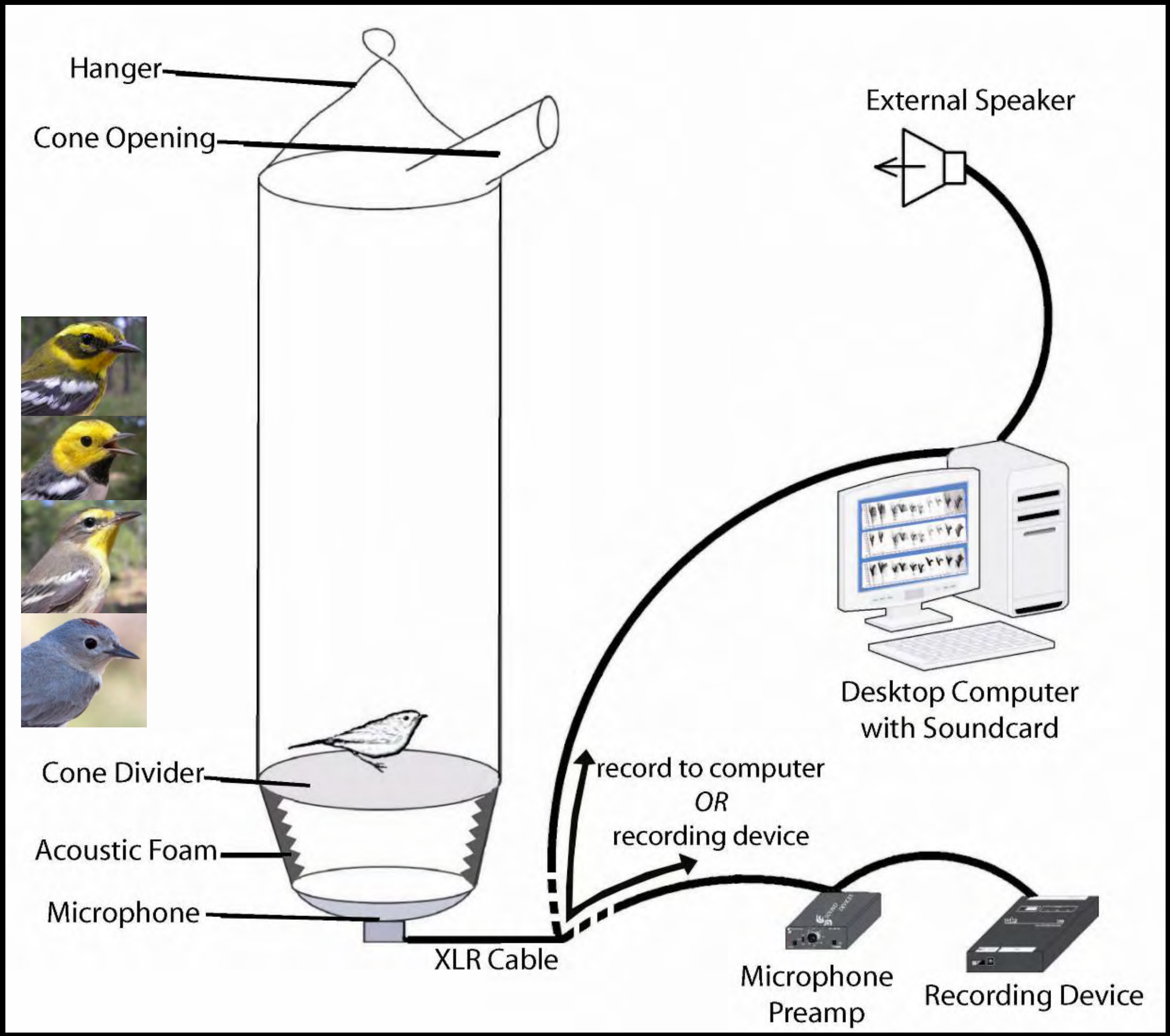
Evans and O'Brien (2002)



Recording flight calls: nocturnal

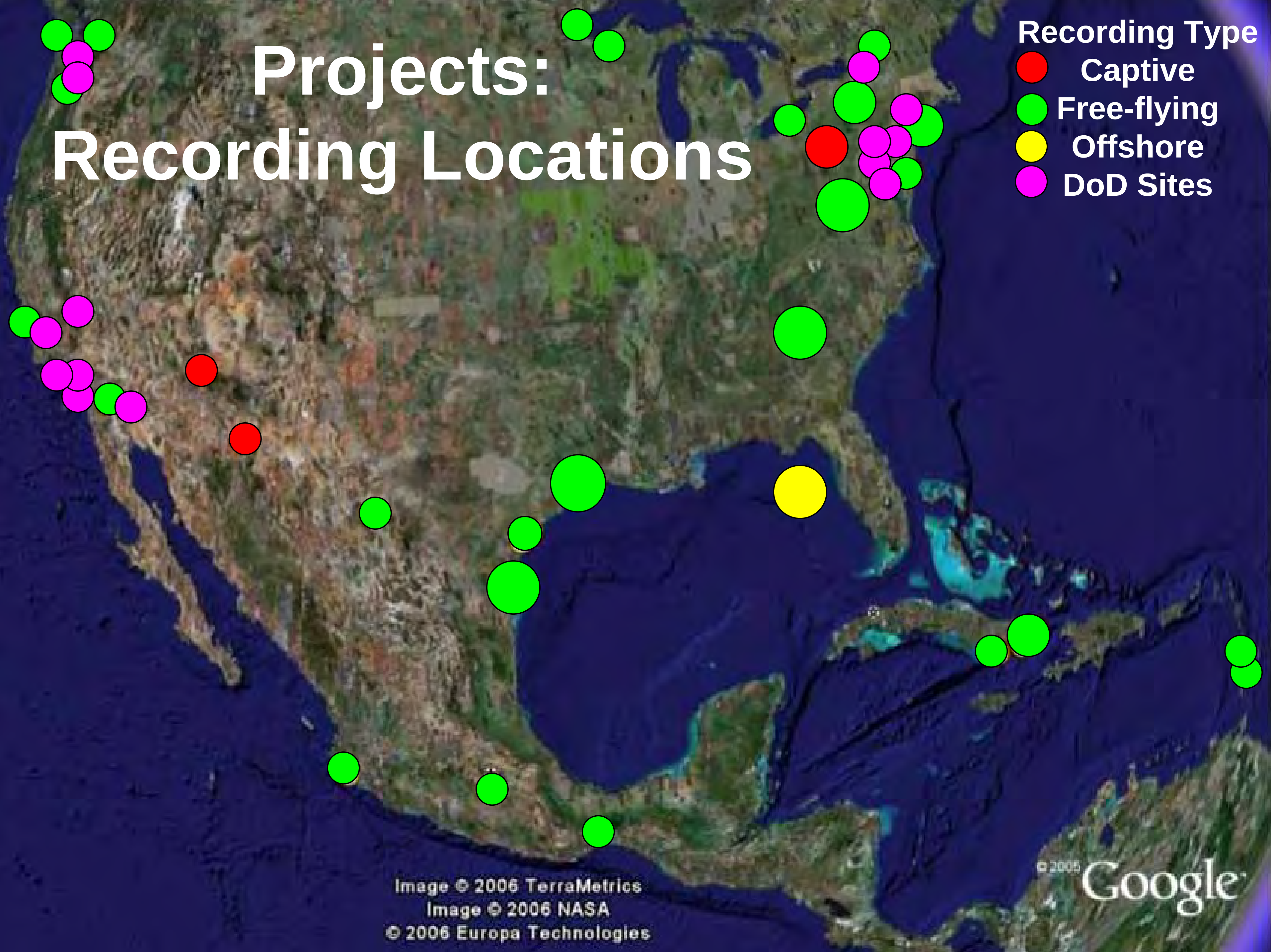
Recording flight calls: diurnal

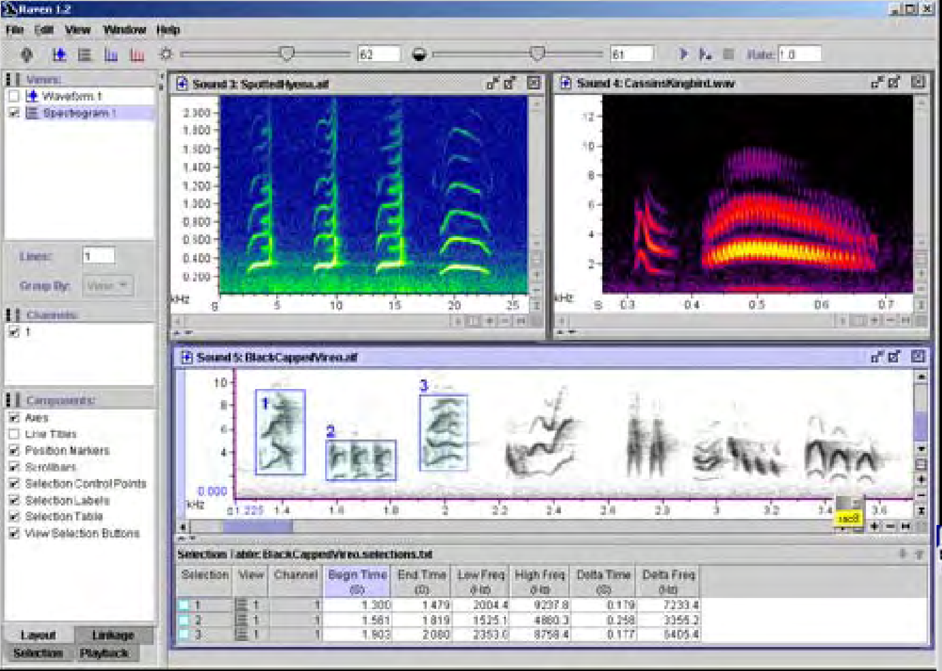
Recording flight calls: captive birds



Designed by M. Lanzone (Lanzone and Farnsworth submitted)

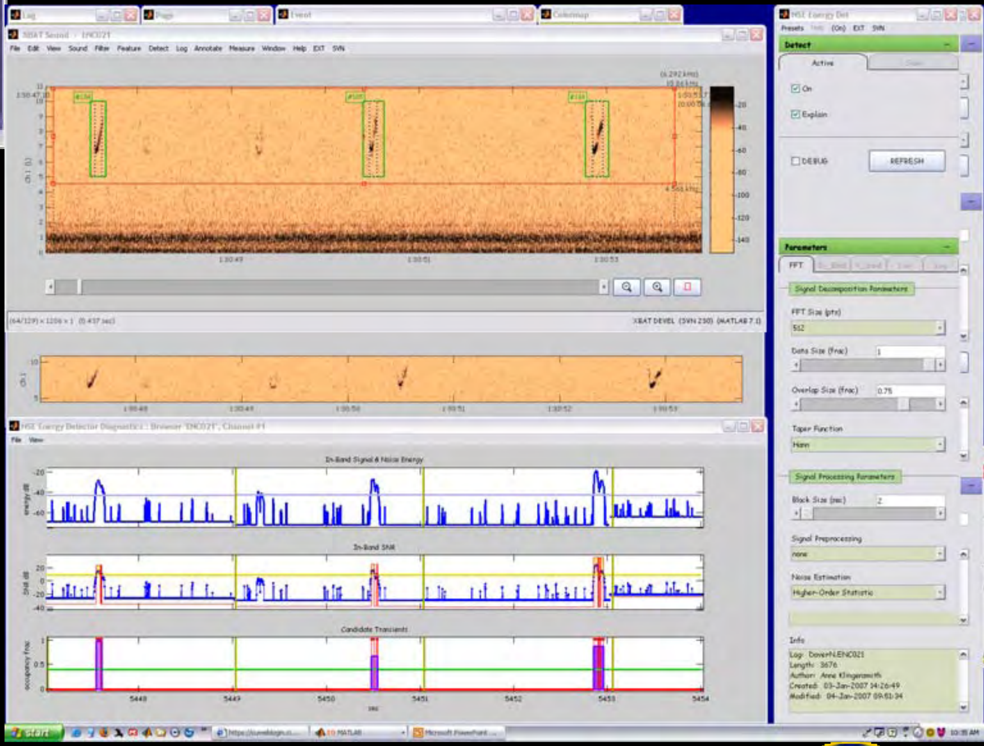
Projects: Recording Locations





Raven

birds.cornell.edu/Raven



XBAT

www.xbat.org

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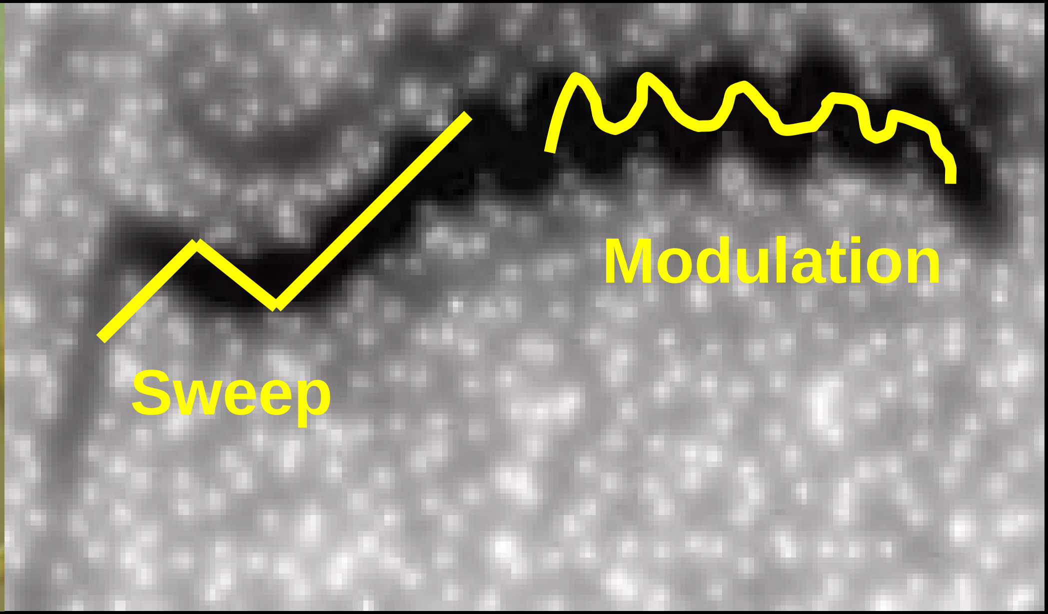
Traditional analysis

Syllabic measurements



Spectral and temporal measurements

Maximum

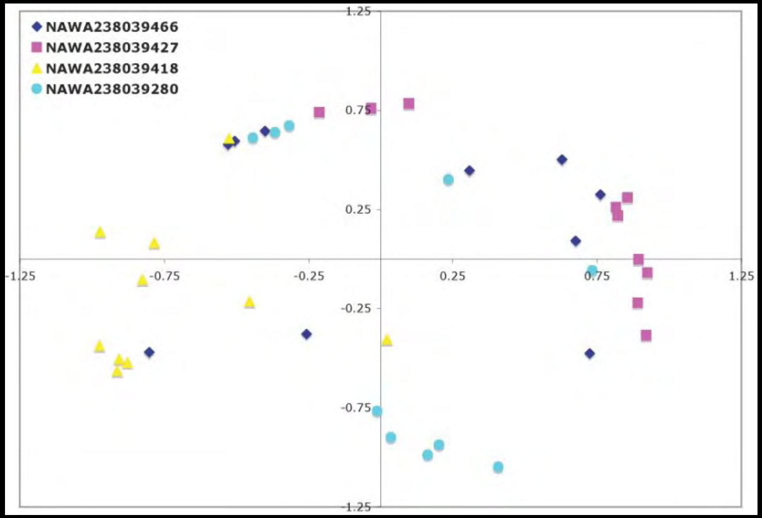
Bandwidth

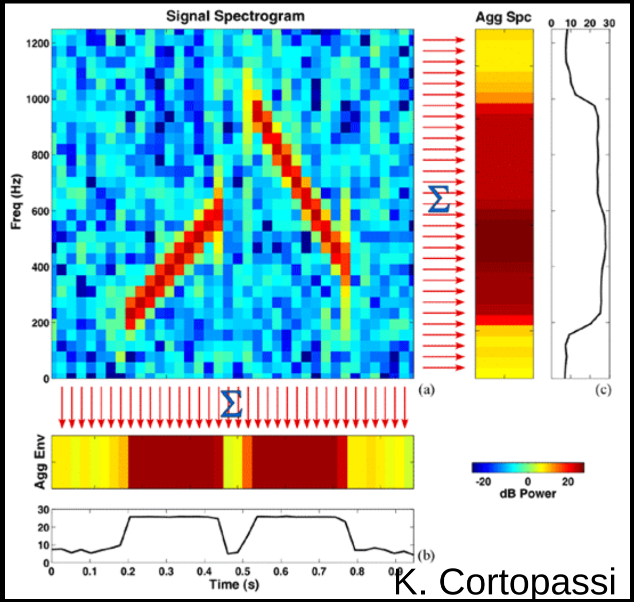
Minimum

Duration

New ways of representing flight-calls

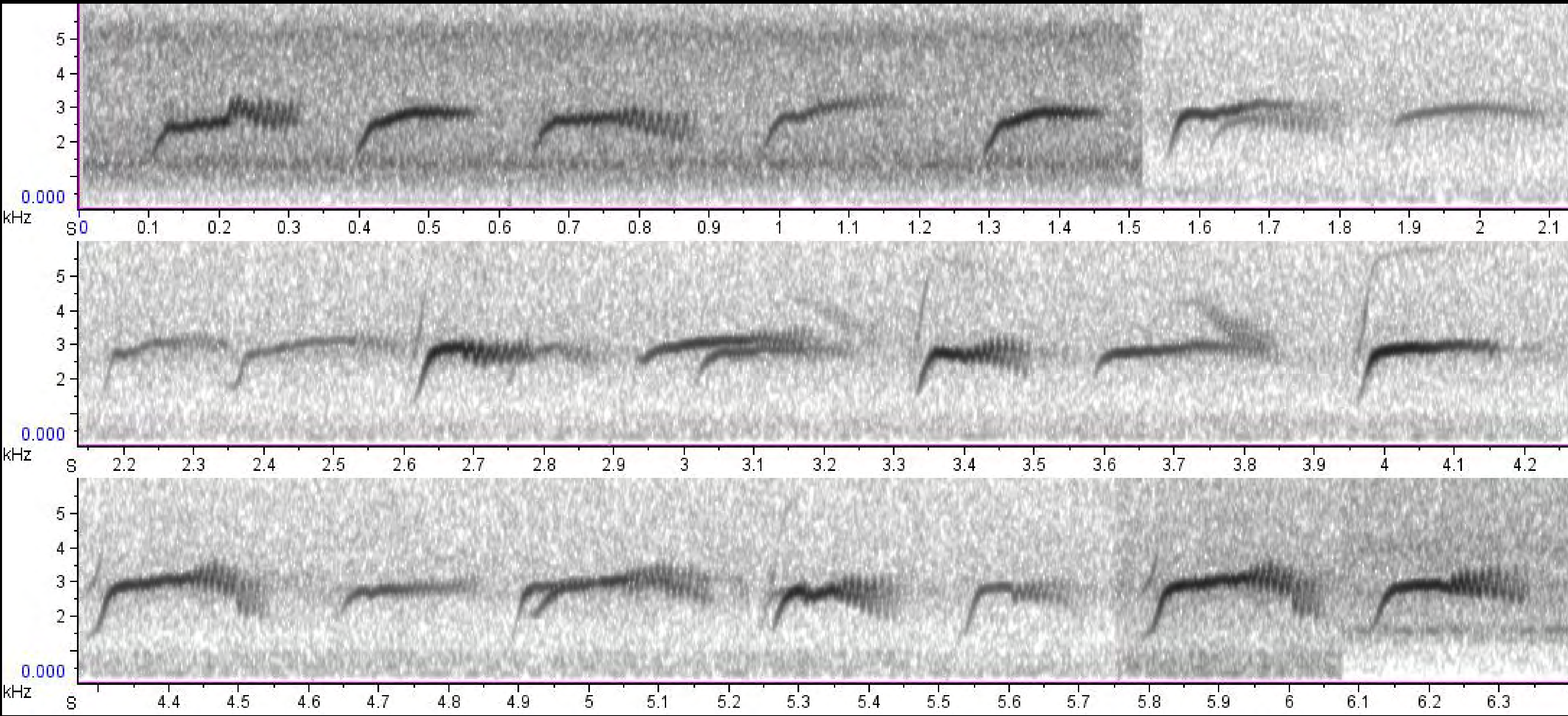
- Spectrogram Cross Correlation
  - acoustic (particularly "syllabic") similarity among species
  - identify flight-call "template" for each species that best correlates with remaining calls
- ACOUSTAT/XBAT
  - treat spectrogram data as probability distributions
  - characterize using order statistics (e.g. median)





K. Cortopassi

Swainson's Thrush variation



- Learn the variation in a species you hear often
- Note the differences in trailing modulation, duration, and initial upsweep in these calls

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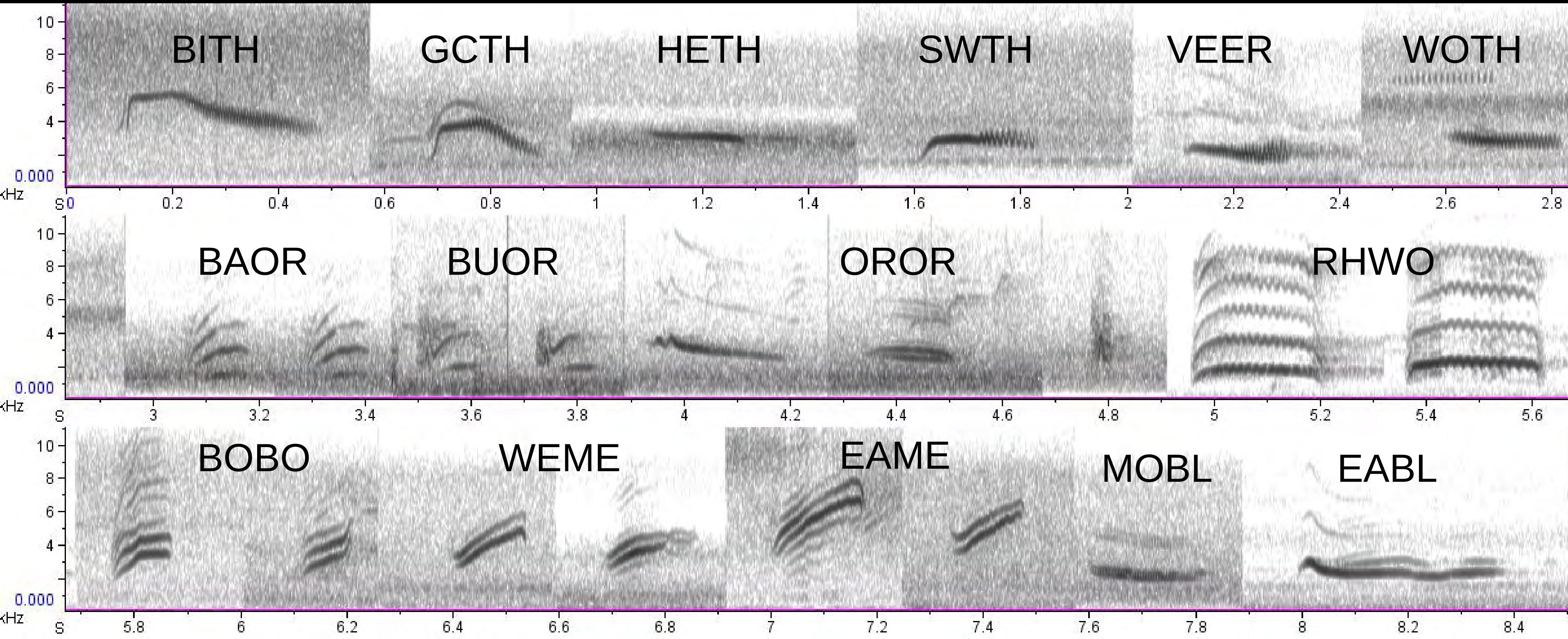
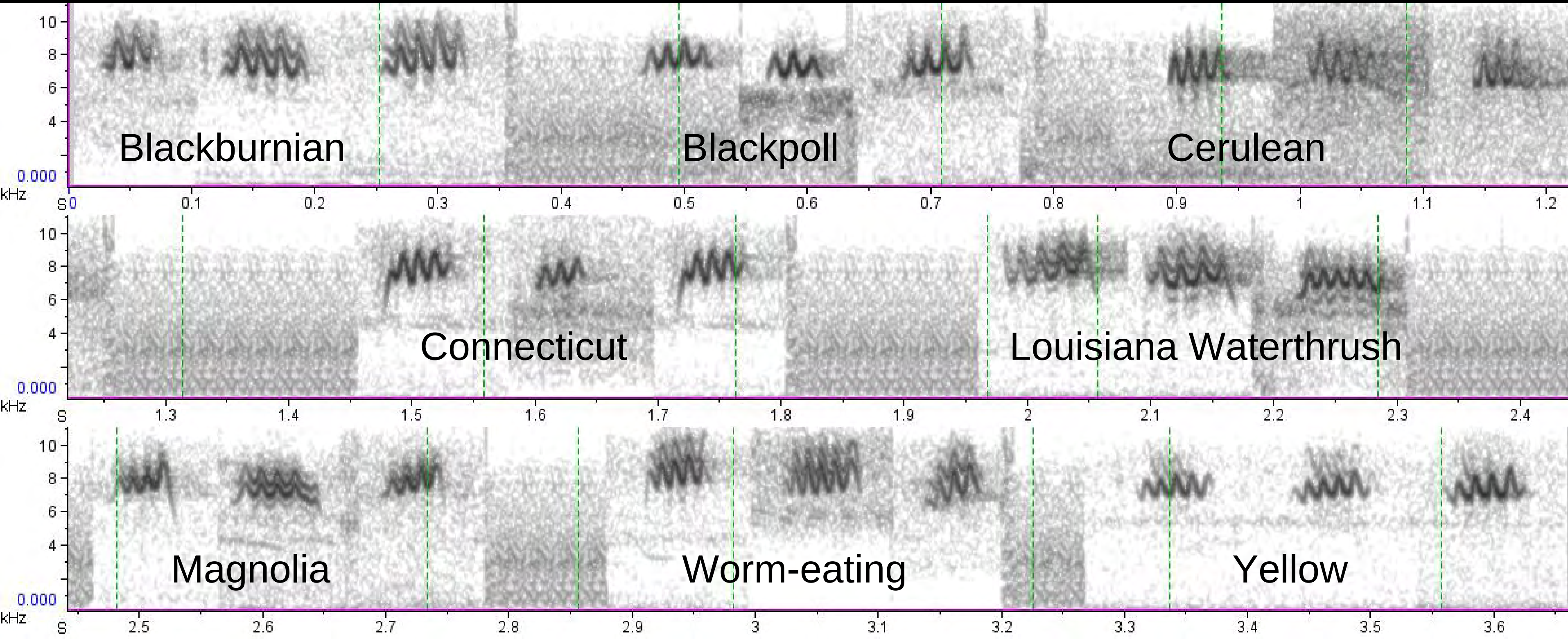
Low frequency, thrush-like calls



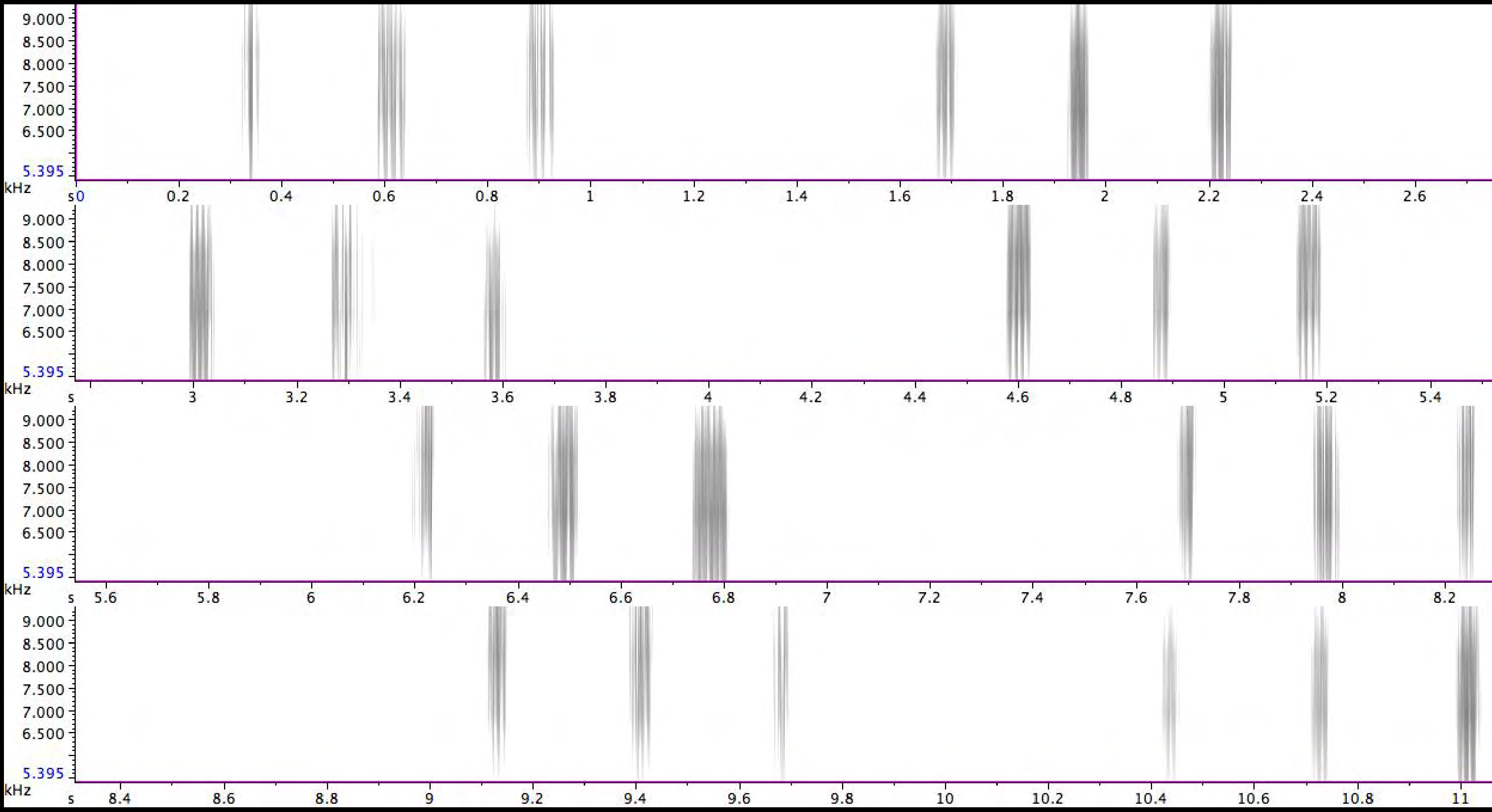
• These calls exhibit a wide array of frequencies, degrees of modulation, sweeps, and shapes. However, when heard in passing, these identifications can be challenging.

“Zeep” Complex

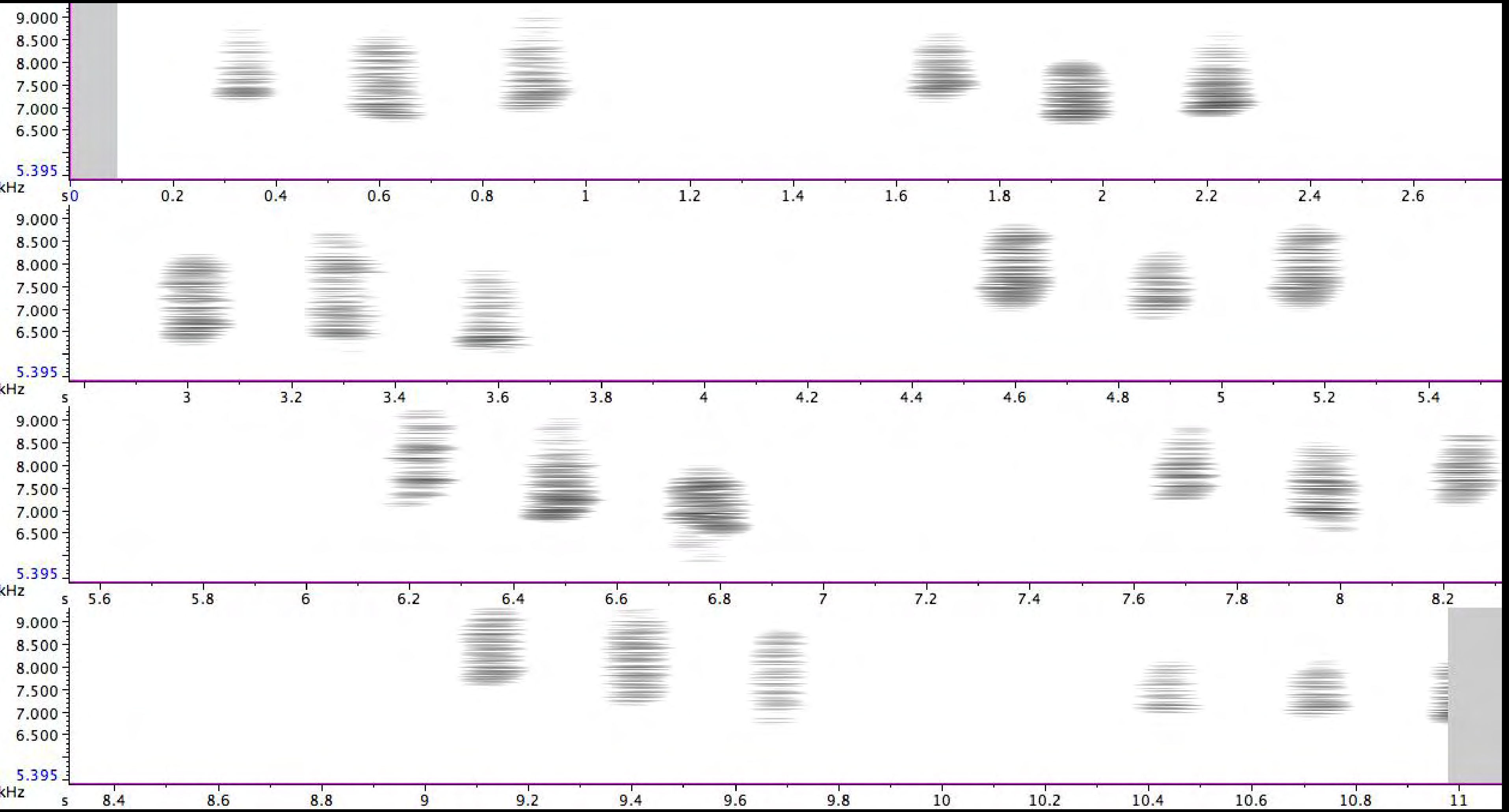


- Similarity in duration and “shape” for all of these species; slight differences in frequency ranges, degree and depth of modulation.

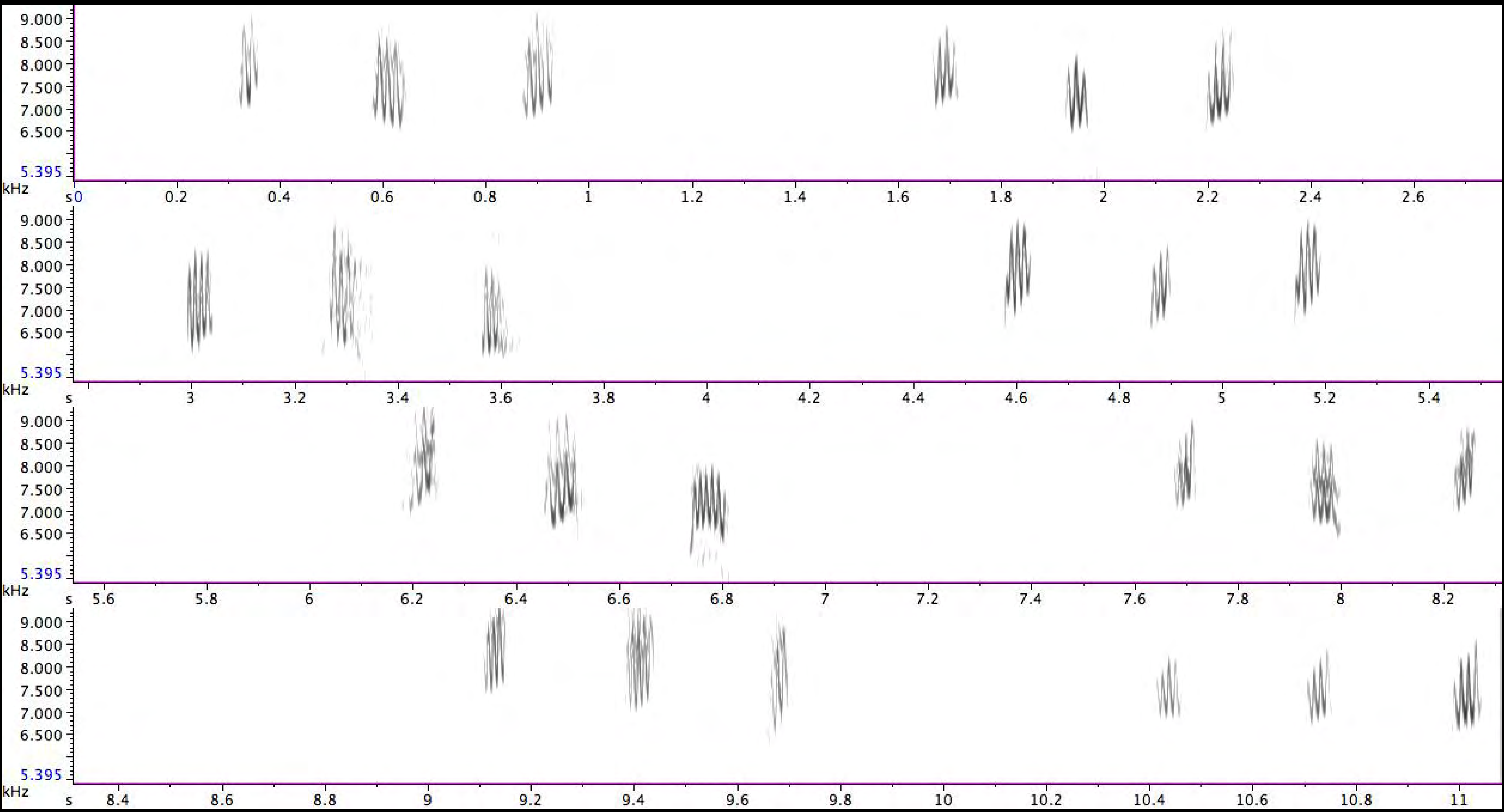
Sound Spectrogram Settings



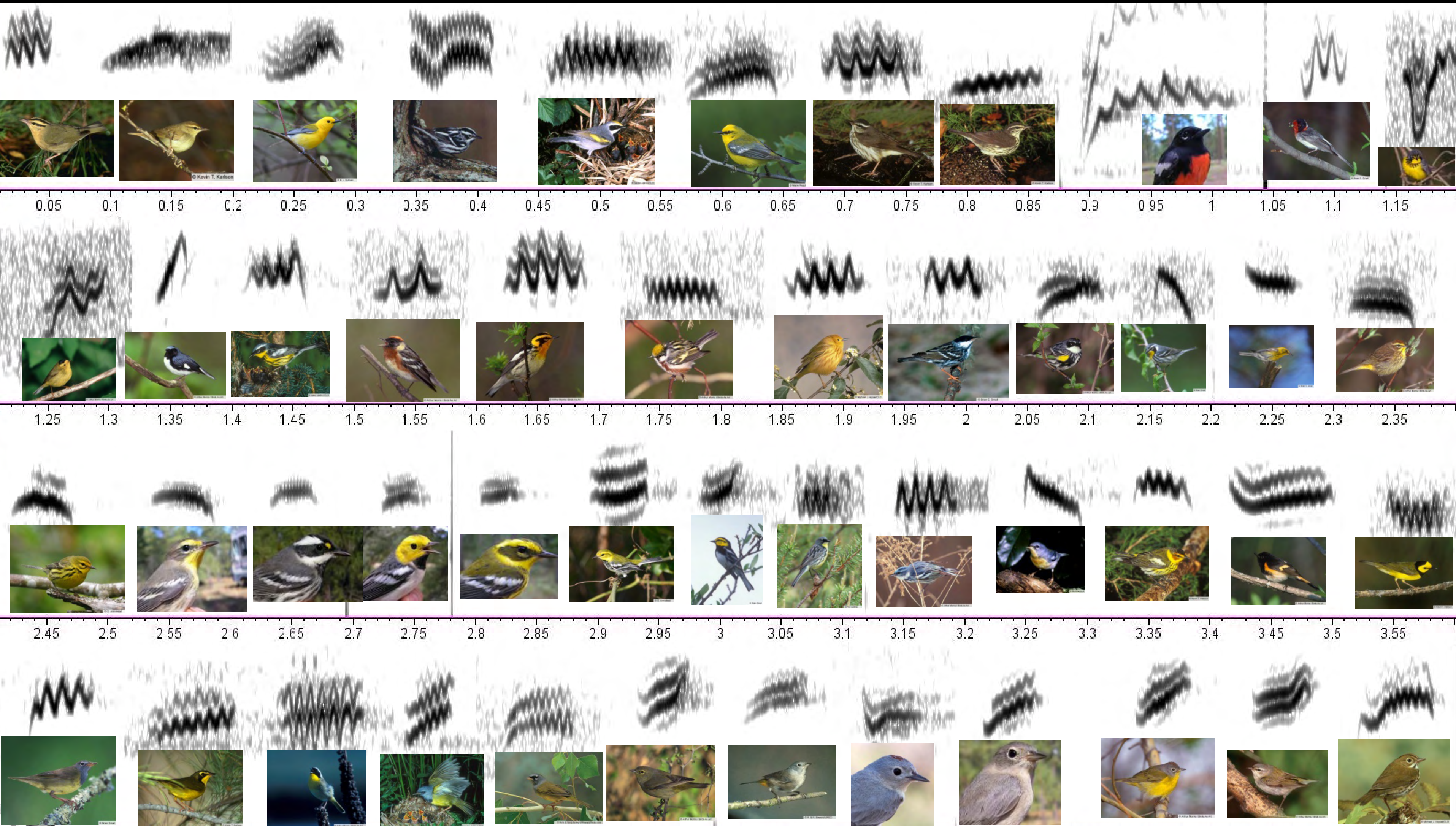
Sound Spectrogram Settings



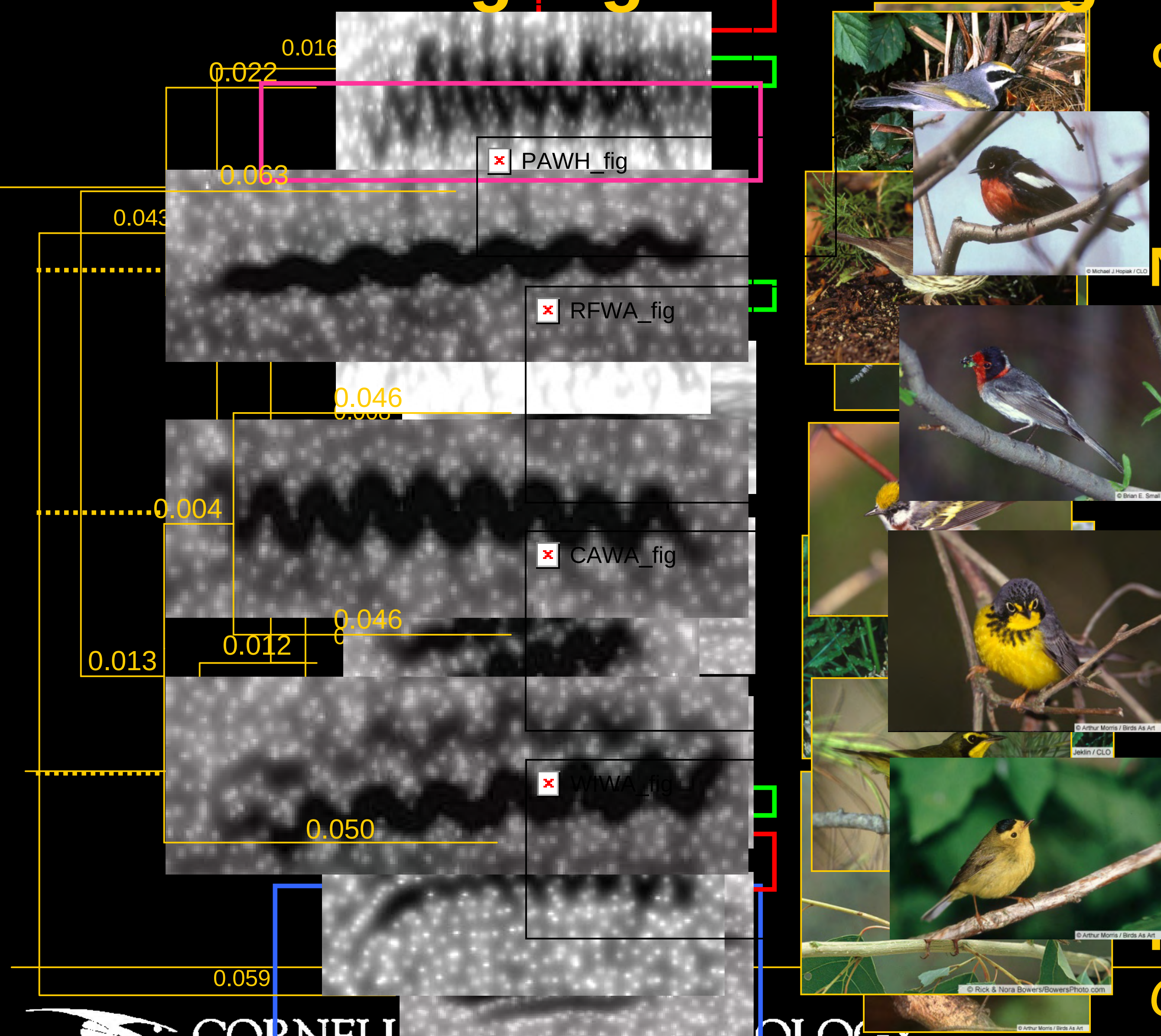
Sound Spectrogram Settings



“The Rosetta Stone. . .”



Highlights: Vermivora
Highlights: Species-pairs
Highlights: Divergence?
Highlights: Convergence?



Orange-crowned Warbler
Vermivora lutescens

Golden-winged Warbler
Vermivora chrysoptera

Painted Whitestart
Myioborus pictus

Colima Warbler

Northern Waterthru
Seiurus noveboracen

Blue-winged Warbler
Vermivora pinus

Red-faced Warbler
Cardellina rubrifrons

Lucy's Warbler
Vermivora luciae

Virginia's Warbler
Vermivora virginiae

Chestnut-sided War
Dendroica pensylva

Canada Warbler
Wilsonia canadensis

Nashville Warbler
Vermivora ruficapilla

Wilson's Warbler
Wilsonia pusilla

MacGillivray's Warbler
Oporornis tolmiei

Kentucky Warbler
Oporornis formosus

Tennessee Warbler
Vermivora peregrina

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Black Rail Surveys in Virginia

Mike Wilson, College of William and Mary

- Threatened species in VA
- Never systematically surveyed, though anectdotal records from remote marshes
- Determine status
- Point count/playback
- ARUs in known territories to record calling rates
- Still analyzing (!): many other rails, nightjars recorded

Monitoring stopover and migration hotspots Yuma, AZ

PIs: Rich Fischer; Sid Gauthreaux

- Ground truth and radar to index abundance, composition, location, patterns
- Acoustic data **<u>for comparison</u>**, collected with 6 ARUs in spring 2007
- Knowledge of characteristics, dynamics of migration in SW riparian areas
- Preliminary analyses show correlation between ground truth observations and acoustic recordings in terms of species composition.
- However, some species not detected visually were recorded on ARUs (Yuma Clapper Rail, Swainson's Thrush, Yellow-billed Cuckoo)
- Data still being analyzed at CLO for planned manuscript

Examples:

2005-2007 highlights: 120+ species detected

- **Waterbirds** - American & Least Bitterns, Great Blue & Green Herons, Snow Goose, “Yuma” Clapper & Virginia Rails, Sora, Greater Yellowlegs, Short-billed Dowitcher, Pectoral Sandpiper, Caspian Tern

- **Owls. Nightjars, and Cuckoos**: Barn Owl, Common Nighthawk, Whip-poor-will, Chuck-will’s-widow, Yellow-billed & Black-billed Cuckoos

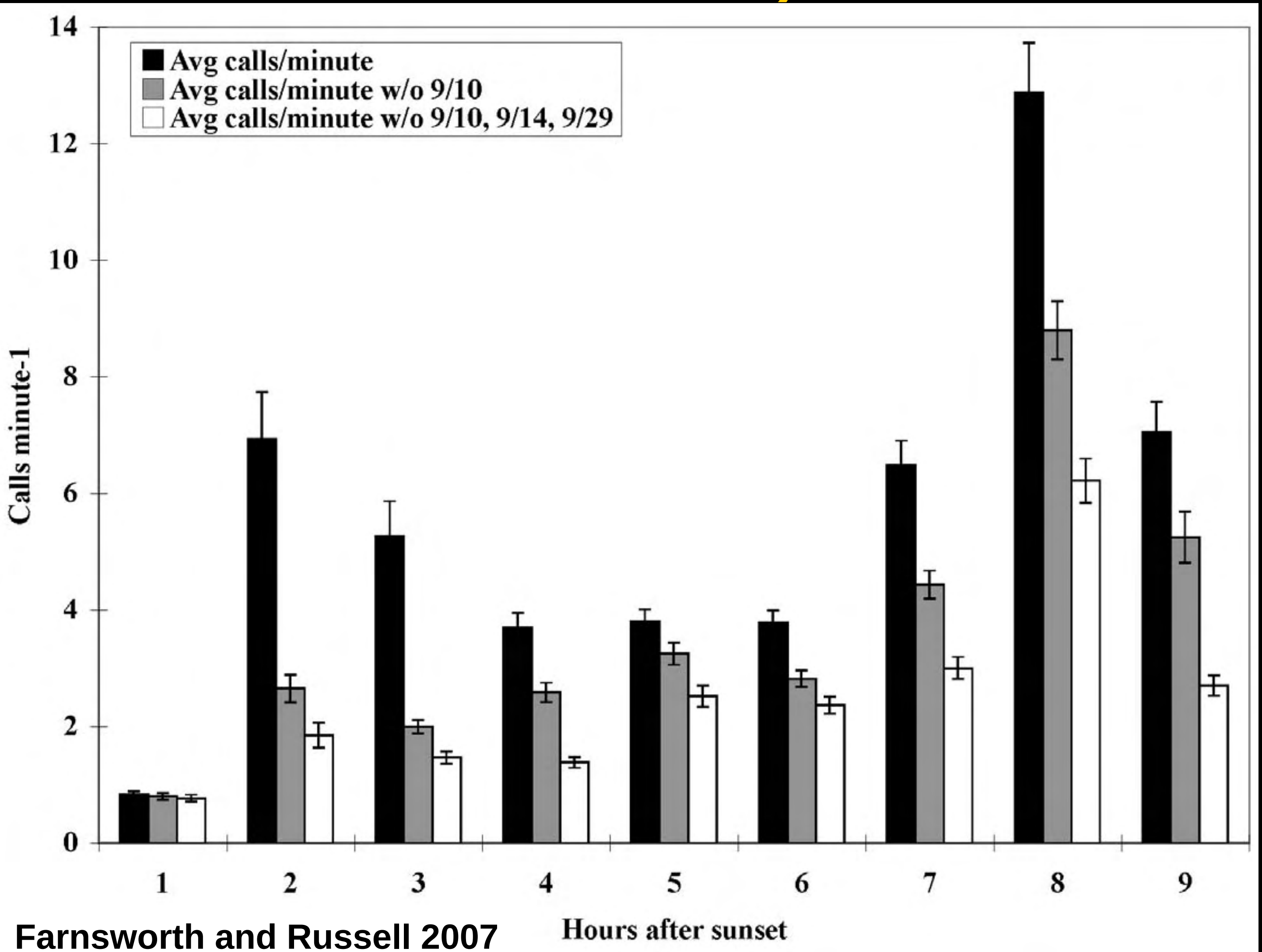
- **Thrushes** - Wood, Hermit, Swainson’s, Gray-cheeked, Bicknell’s, Veery

- **Wood-warblers** - 23 spp. including Black-throated Blue, Canada, Connecticut

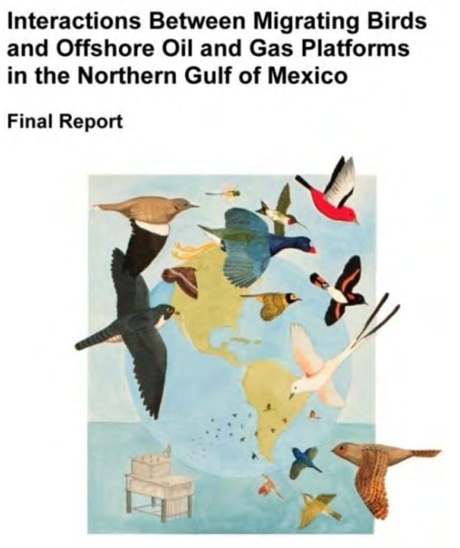
- **Emberizids and Cardinalids**: Savannah, White-throated, White-crowned, Brewer’s, & Chipping Sparrows, Dickcissel, Blue Grosbeak, Indigo & Lazuli Buntings, Rose-breasted Grosbeak, Scarlet & Western Tanagers

Observations and acoustic recordings correspond in terms of species composition, but some species detected acoustically only (Yuma Clapper Rail, Swainson’s Thrush, Yellow-billed Cuckoo).

MMS 2005-009, MOGP



Farnsworth and Russell 2007



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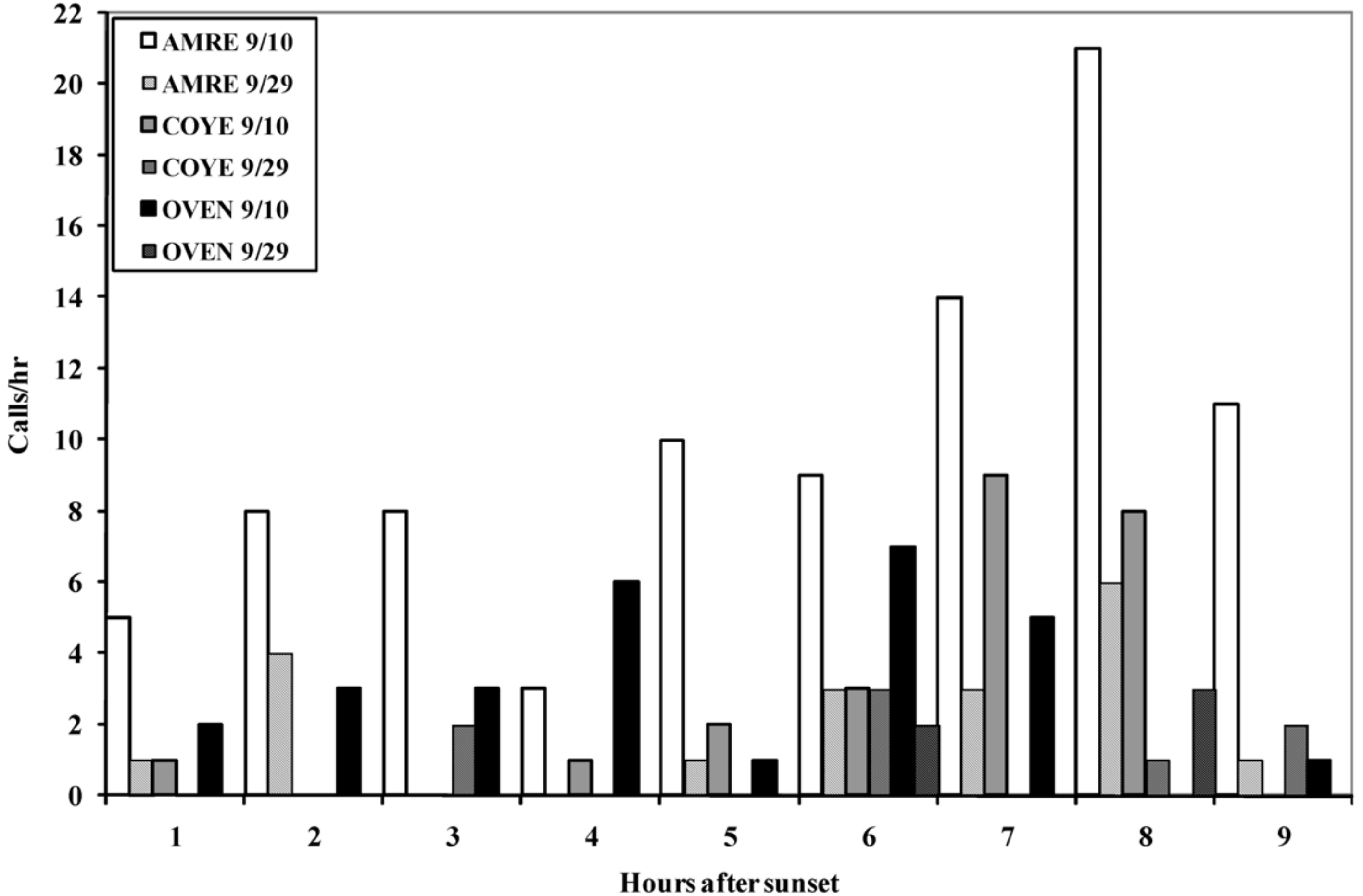
MMS 2005-009, MOGP



Farnsworth and Russell 2007

Interactions Between Migrating Birds and Offshore Oil and Gas Platforms in the Northern Gulf of Mexico

Final Report

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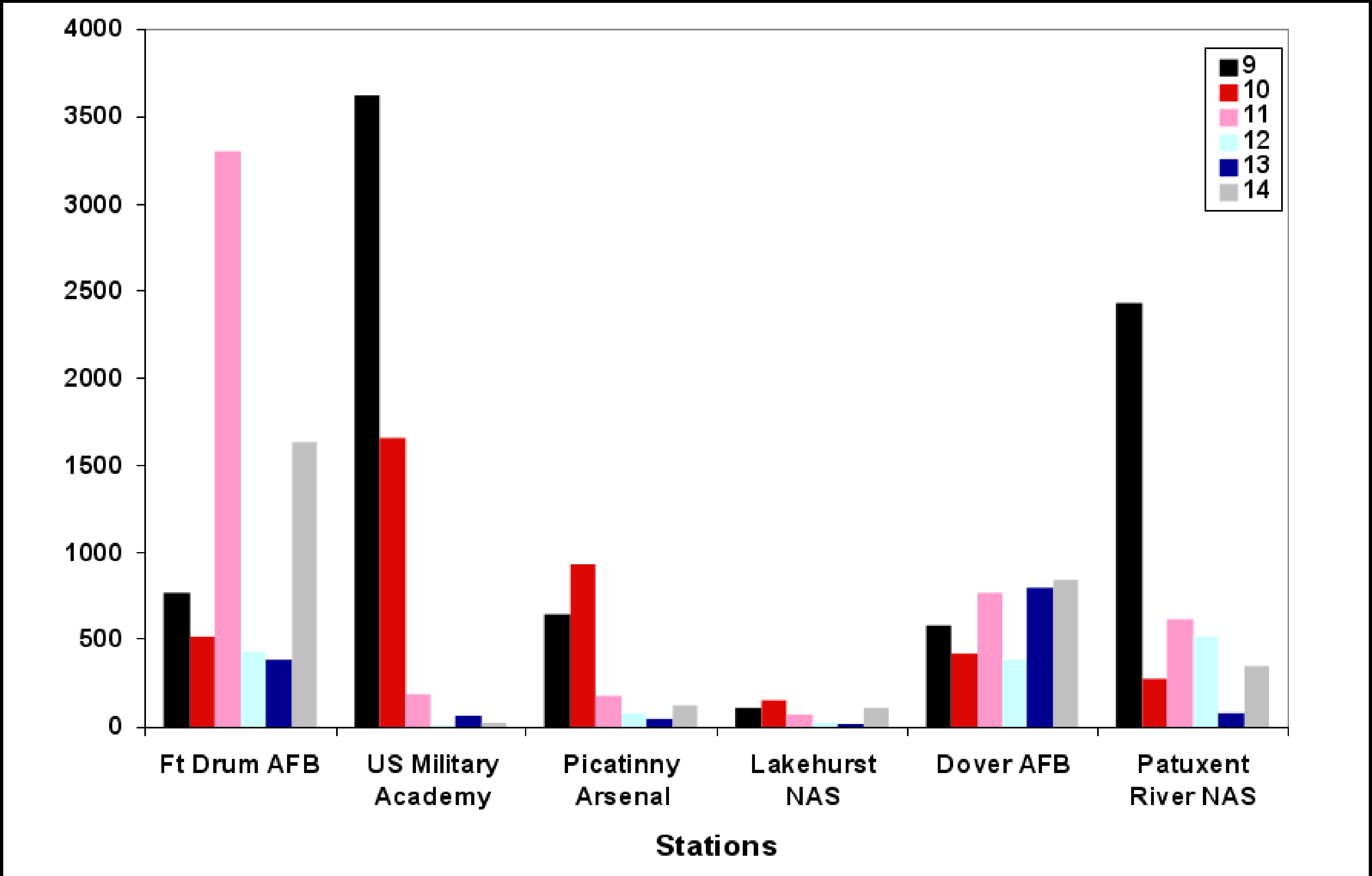
Call Count/Night, 9-14 Oct 2005



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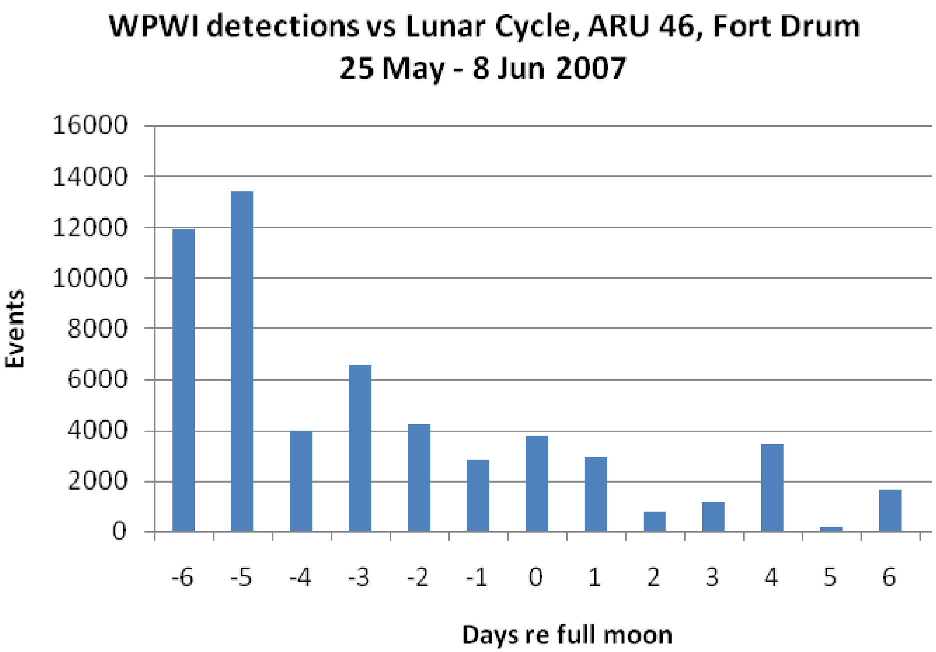
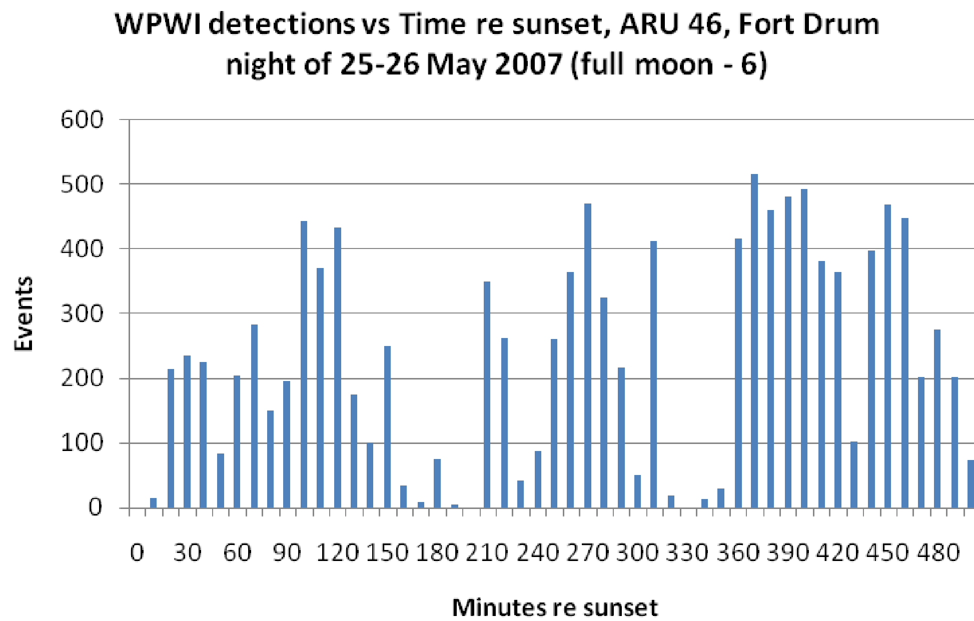
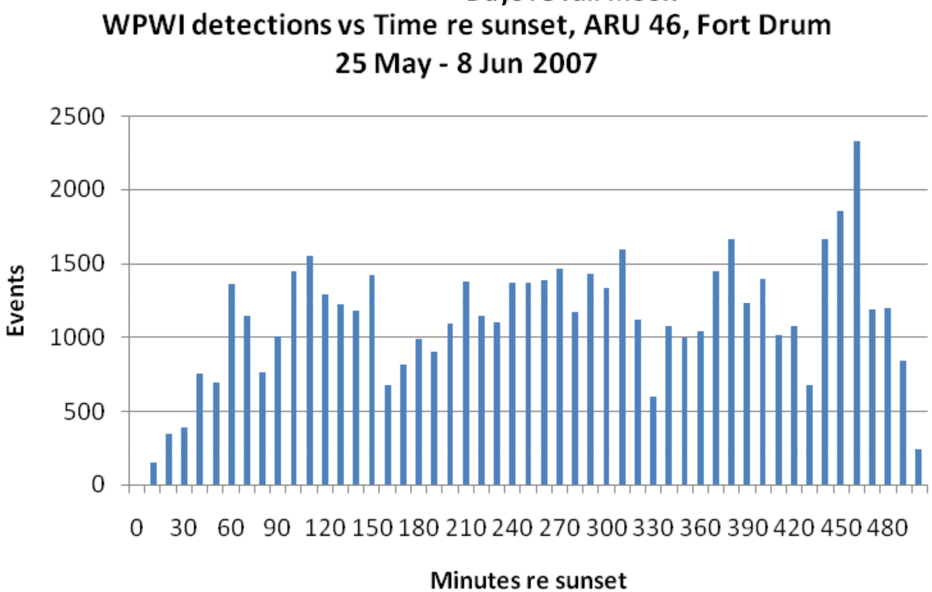
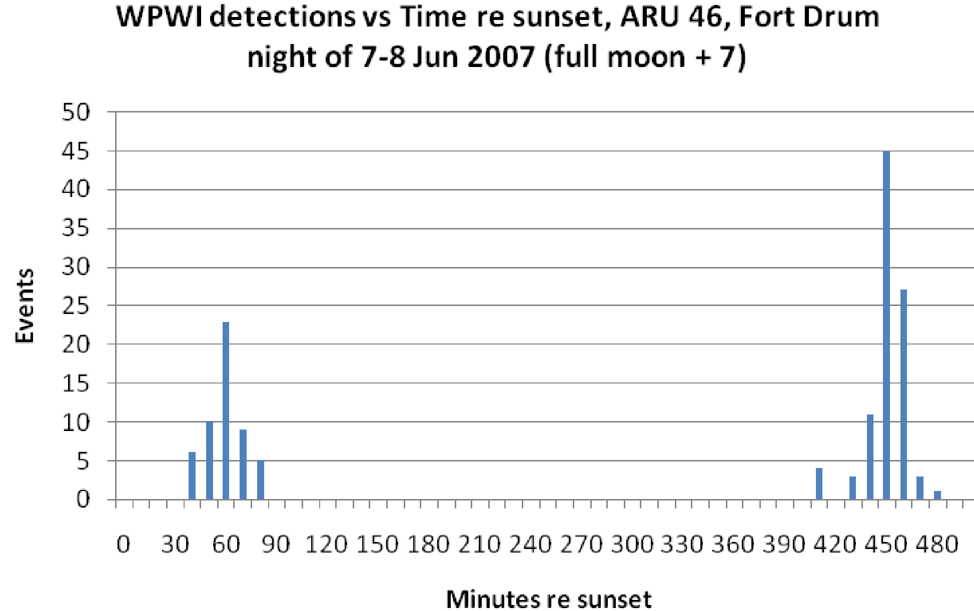
Whip-poor-will calling phenology

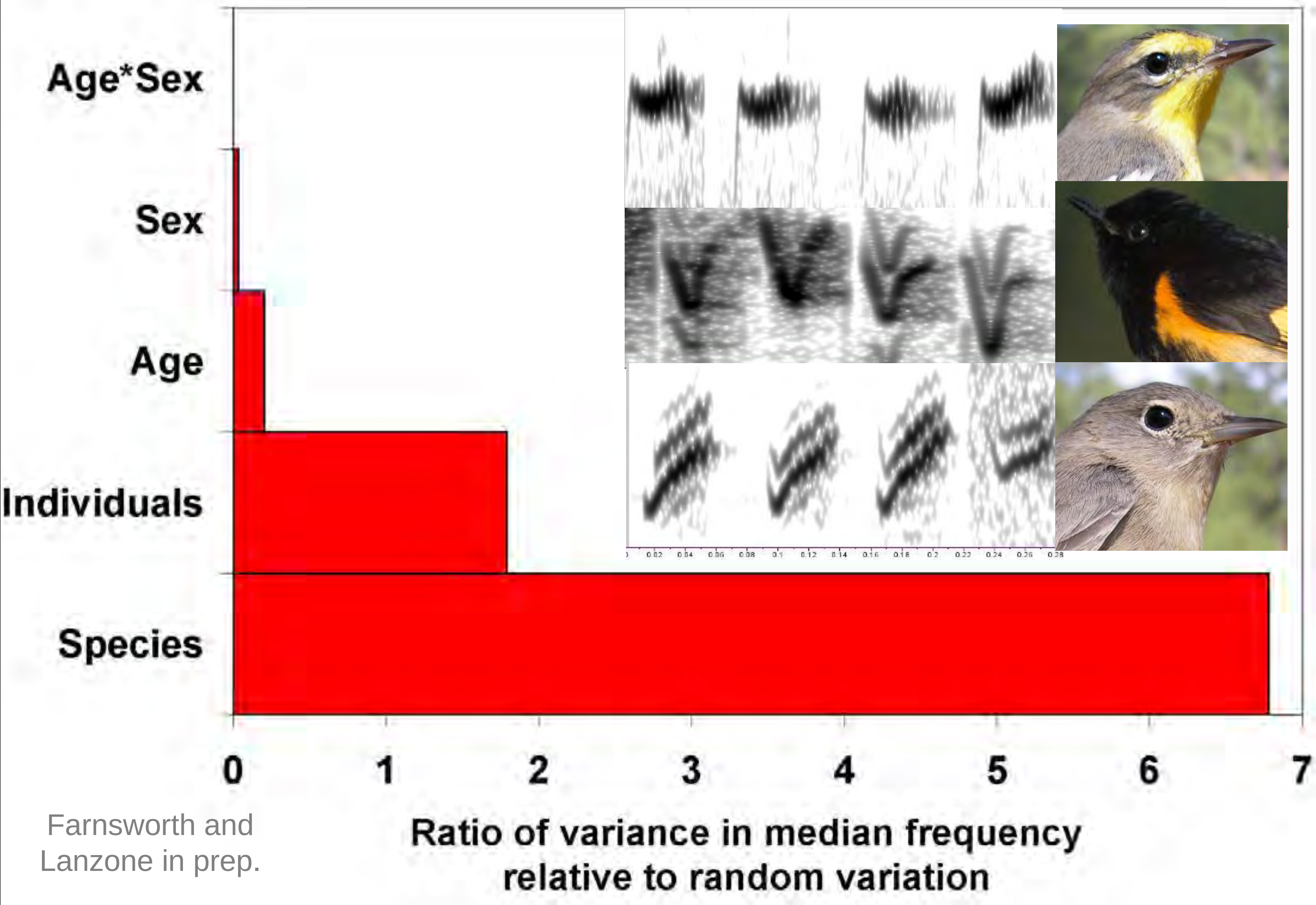




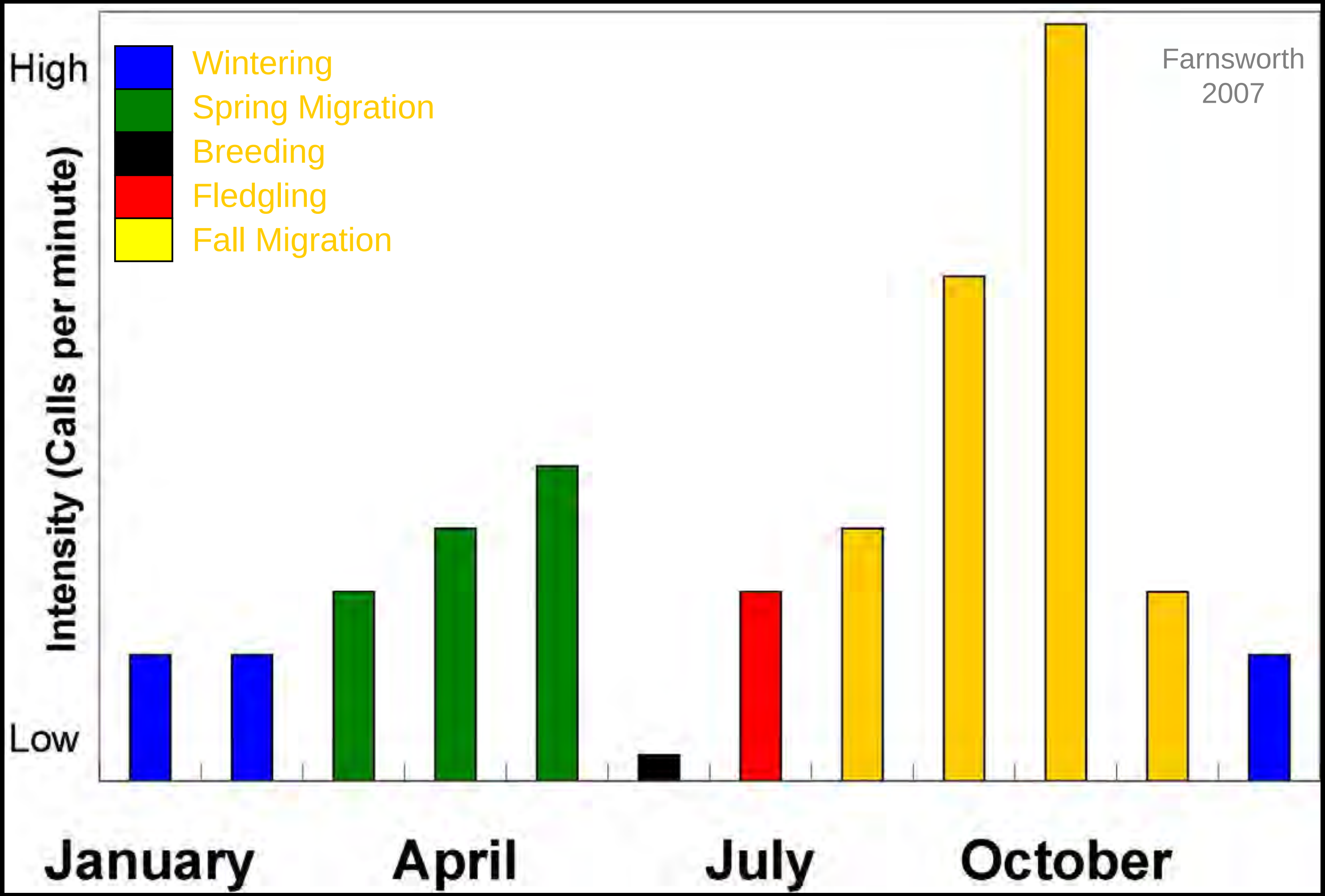




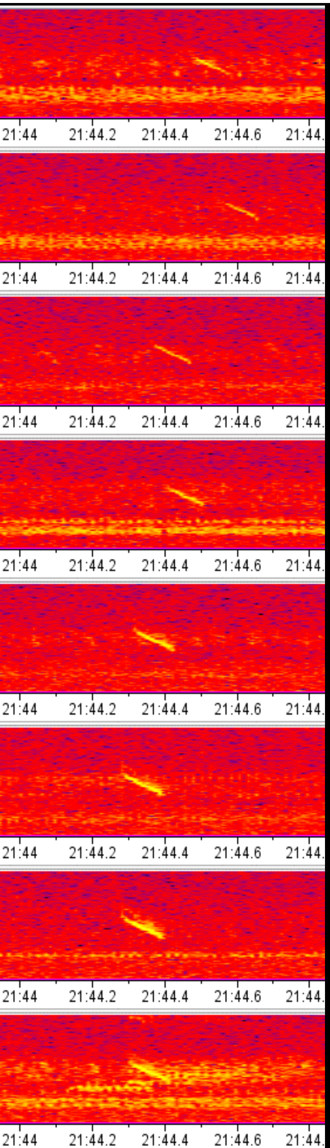
Variation among species <u>is greater</u> than variation among individuals and ages and between sexes.

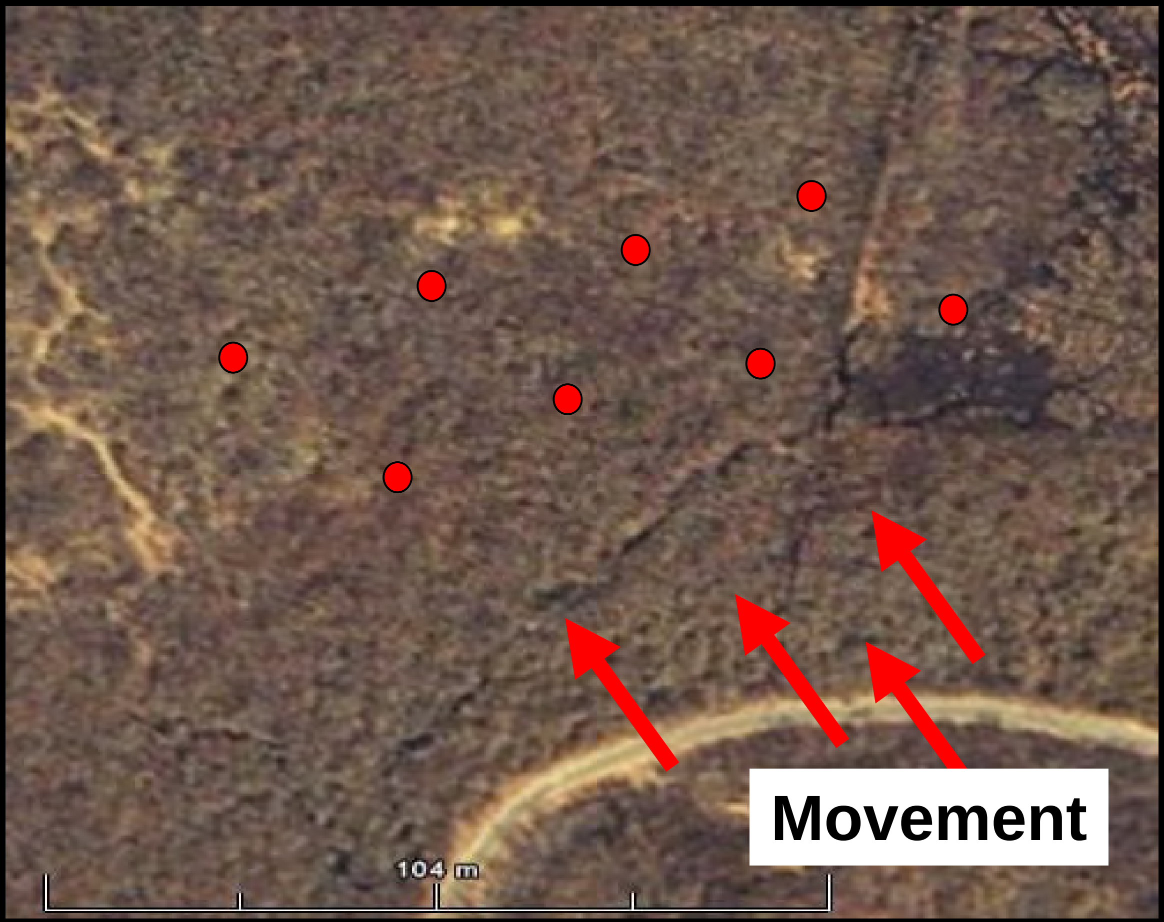


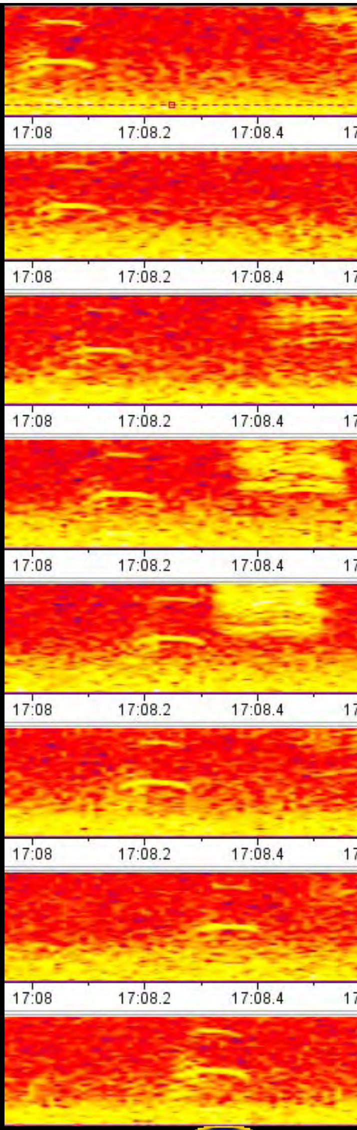
Flight-calling behavior is **not** limited to migratory periods in warblers.



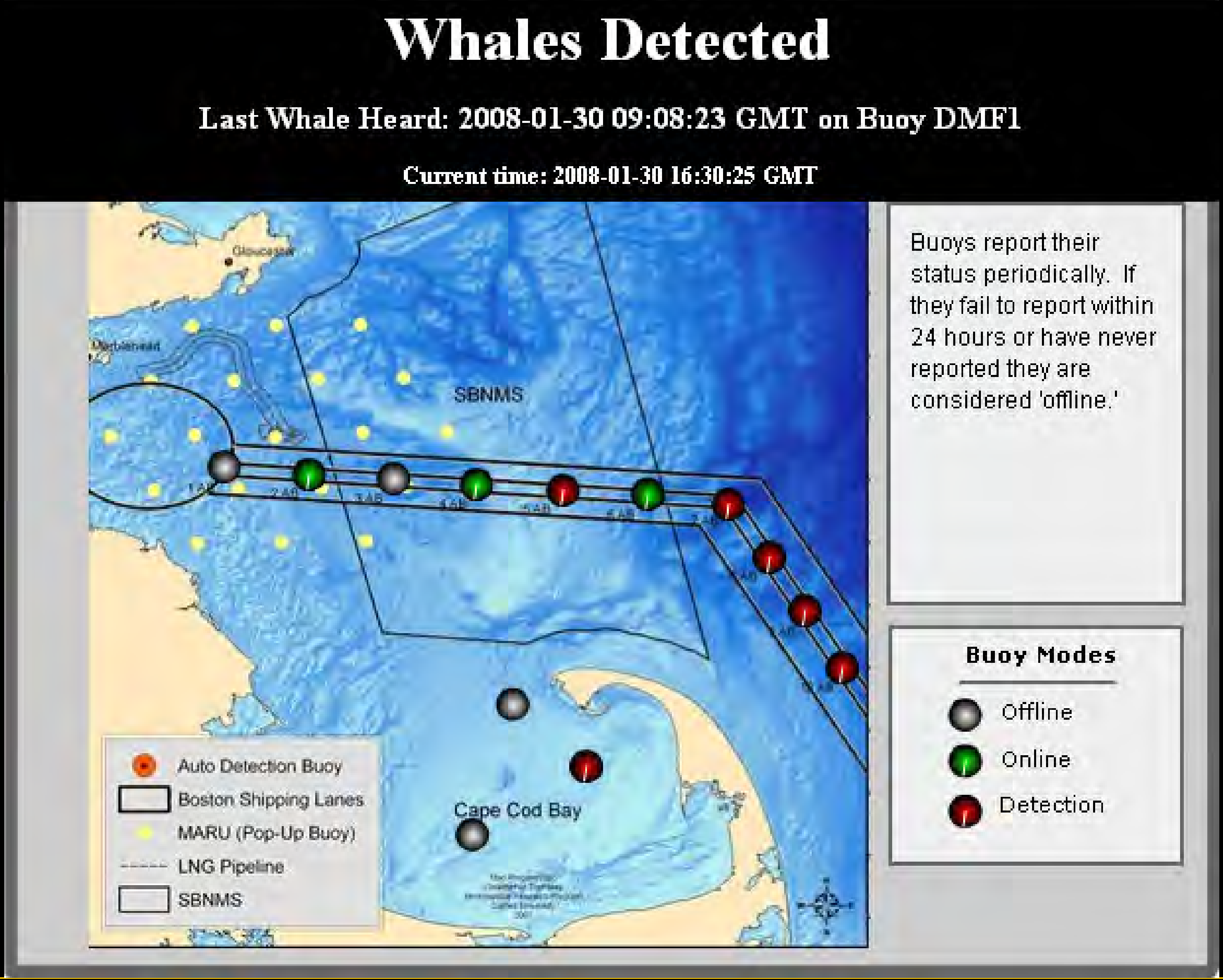
8-Channel Microphone Array, Oct 2007



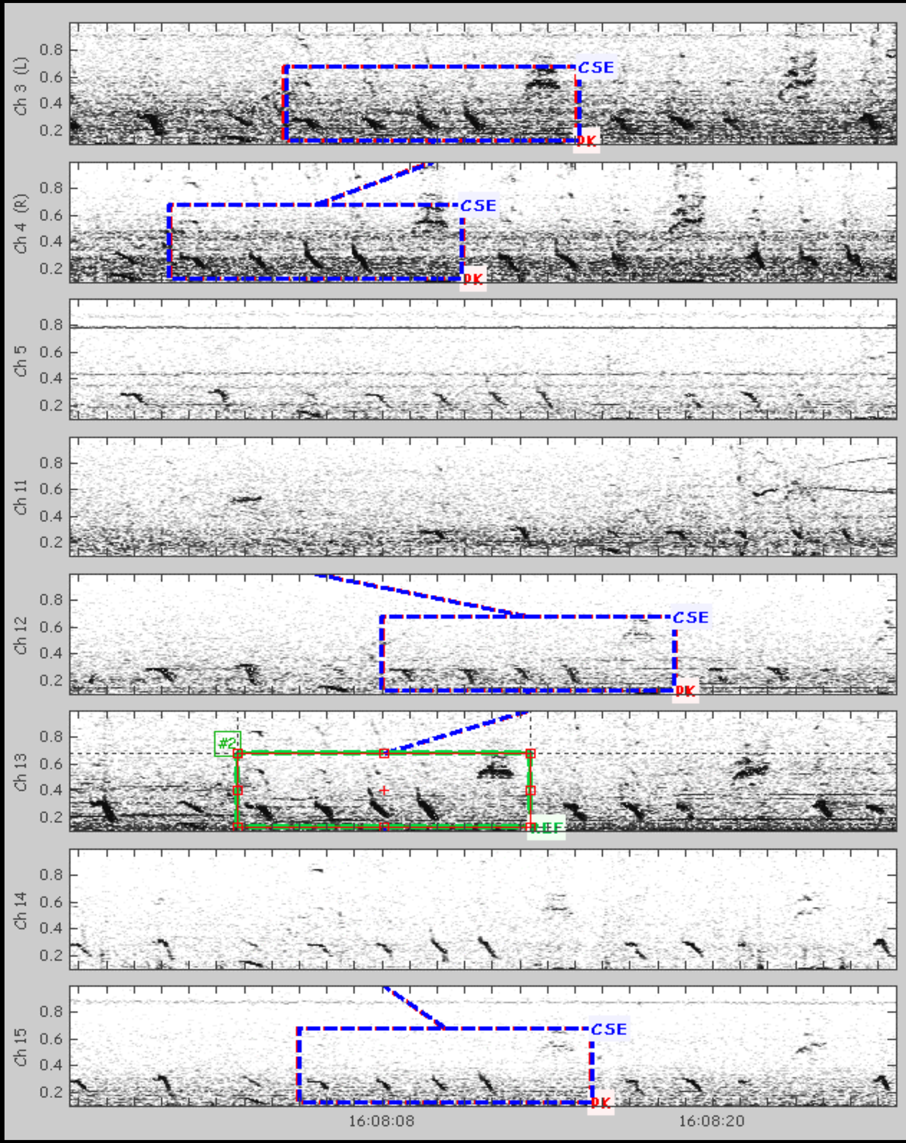


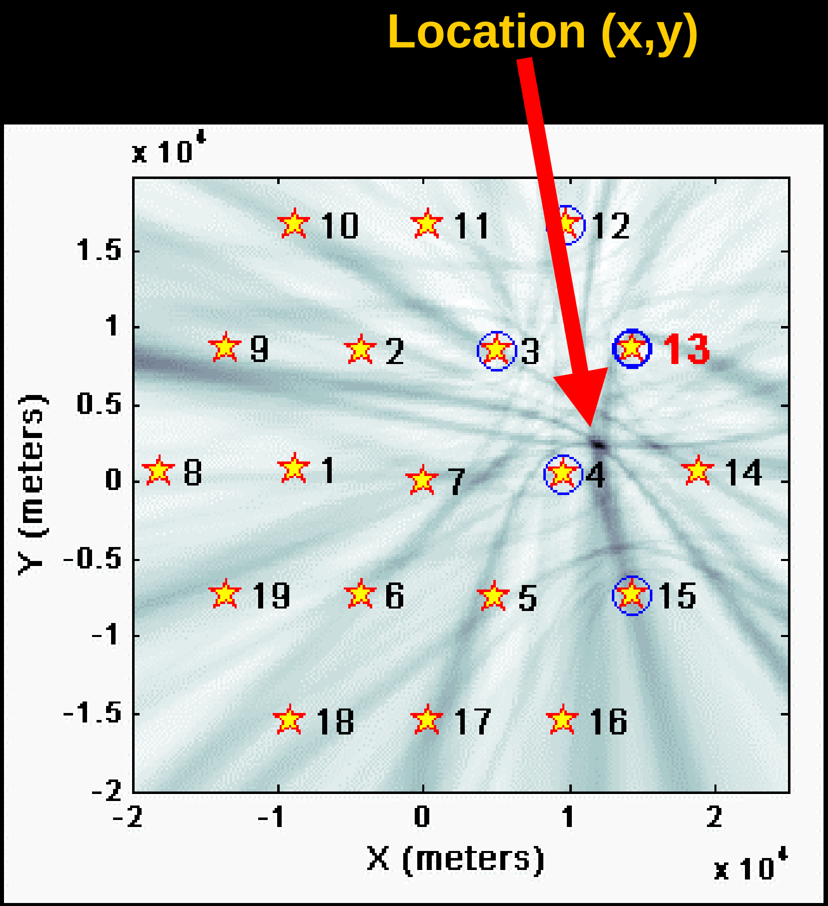


Real-time Auto-detection Network: Boston Shipping Lane



Call Location on 19-Channel array – 14 Sept 2007





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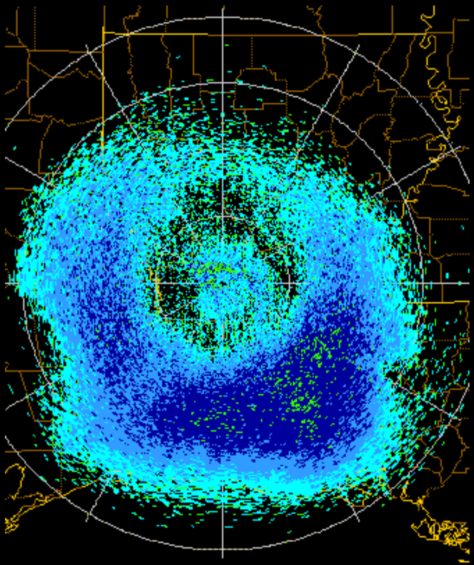
Why study migrants and migration using acoustic technology?

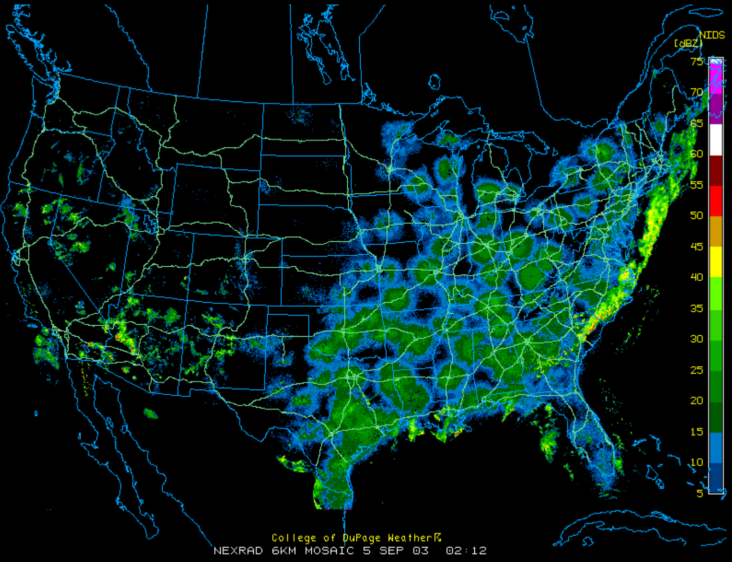
At present, flight call recording represents only reliable method for directly identifying birds migrating at night.

Additionally, acoustic technologies facilitate:

- sampling species beyond range of traditional protocols;
- collecting for extended periods at difficult-to-access sites;
- recording secretive species that vocalize infrequently;
- generating permanent record for repeated sampling;
- estimating variation in probabilities of detection

Monitoring bird migration using radar





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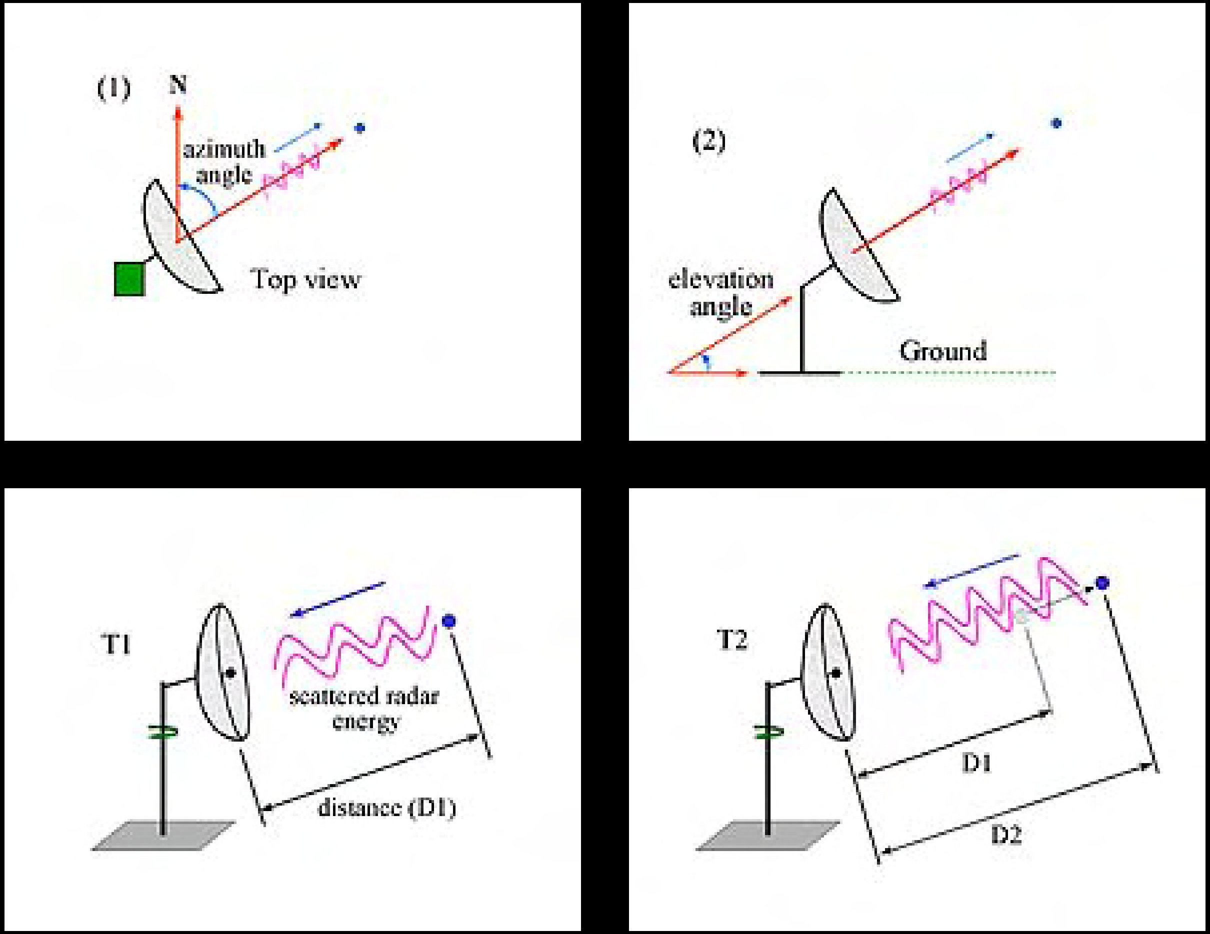
Radar Basics

- **Radars detect targets, measuring reflected radio signals.**
  - The greater in size and number the targets, the stronger the reflected, scattered signals.
  - Reflectivity magnitude relates to the number and size of the targets encountered.

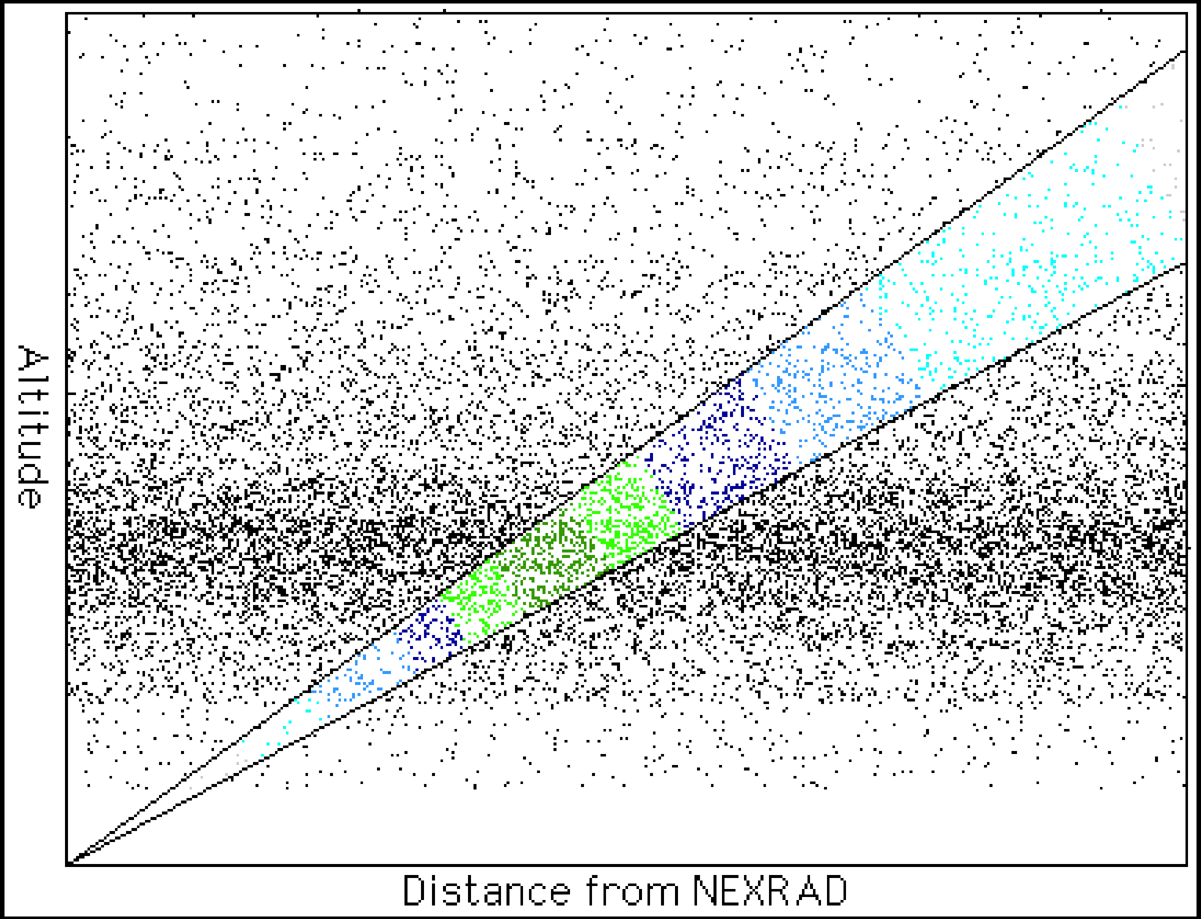
- **Radar determines target location and measure “radial velocity," the component of target velocity moving toward or away from the radar.**

Radar Basics



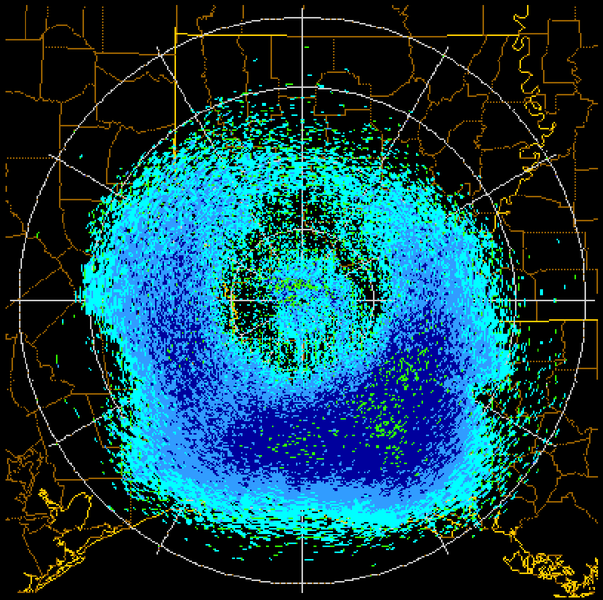
From NJ Audubon website, after D. Mizrahi and CUROL

Radar Basics



Weather **S**urveillance **R**adar-88**D**

- Doppler radar (~150 across the US)
- Antenna elevation angle 0.5°
- Resolution of 1 km x 0 .96° beam width
- At 37 km this beam samples an altitudinal band 150-760m above ground level.



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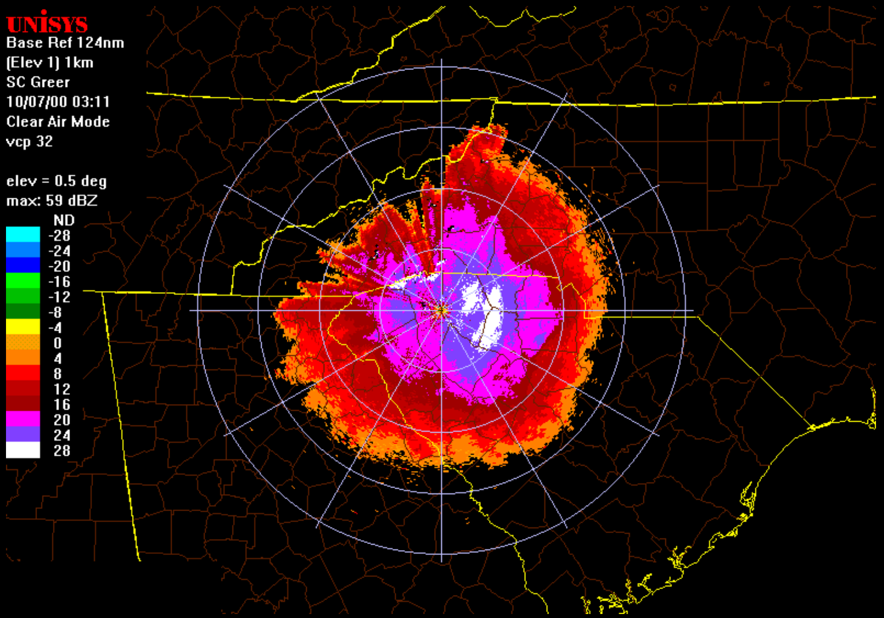
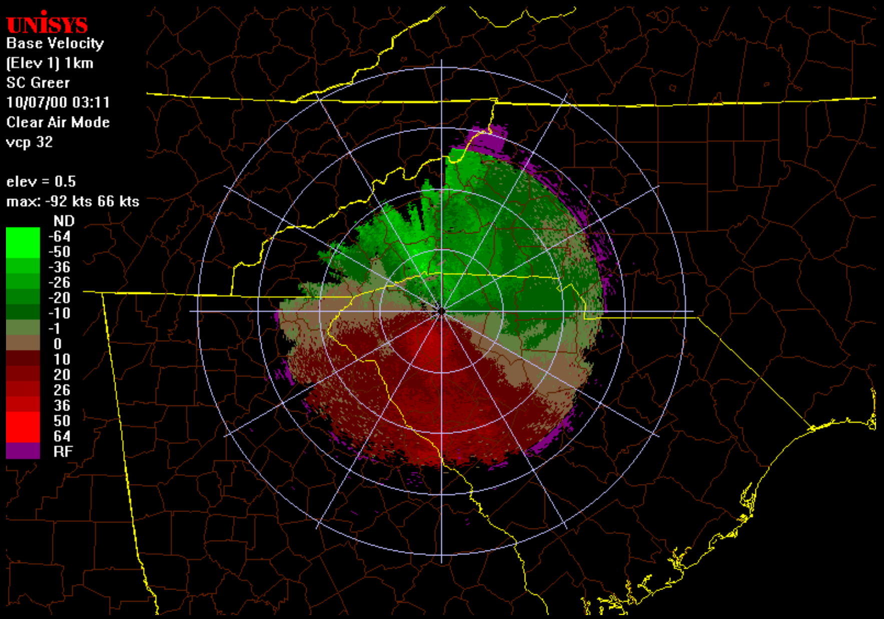
WSR-88D Products

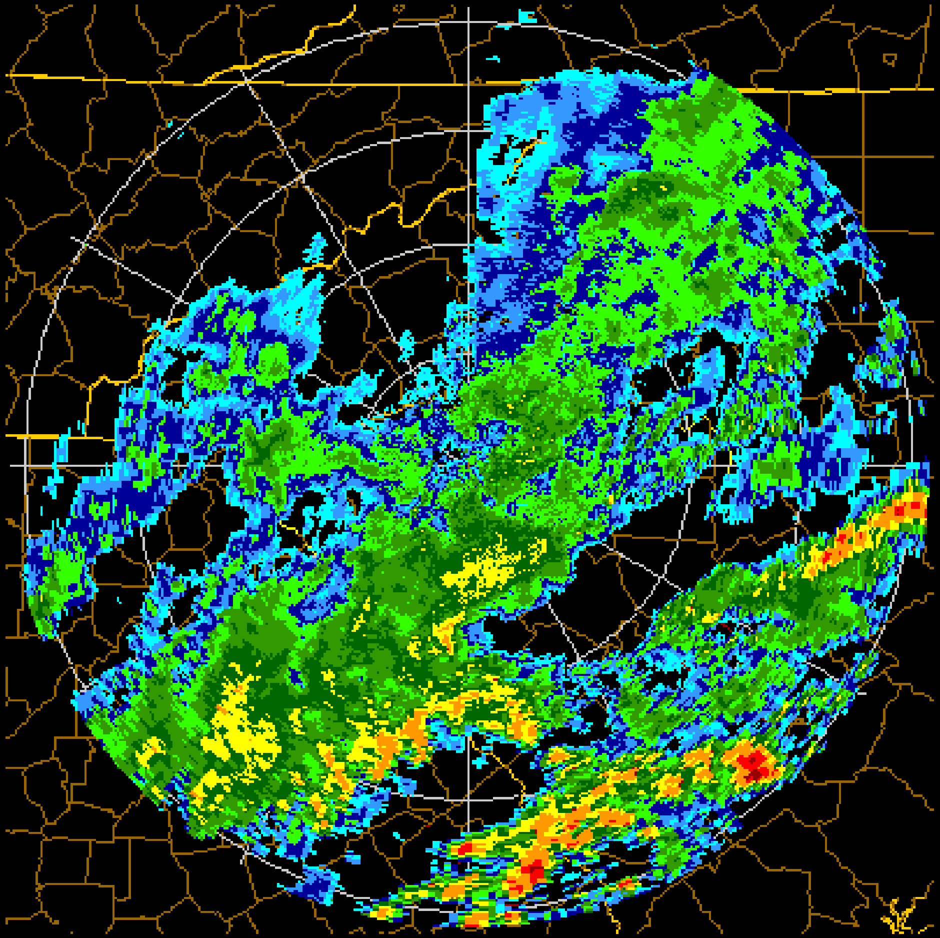
Base reflectivity: relative amount of reflected energy from targets detected in a radar scan.

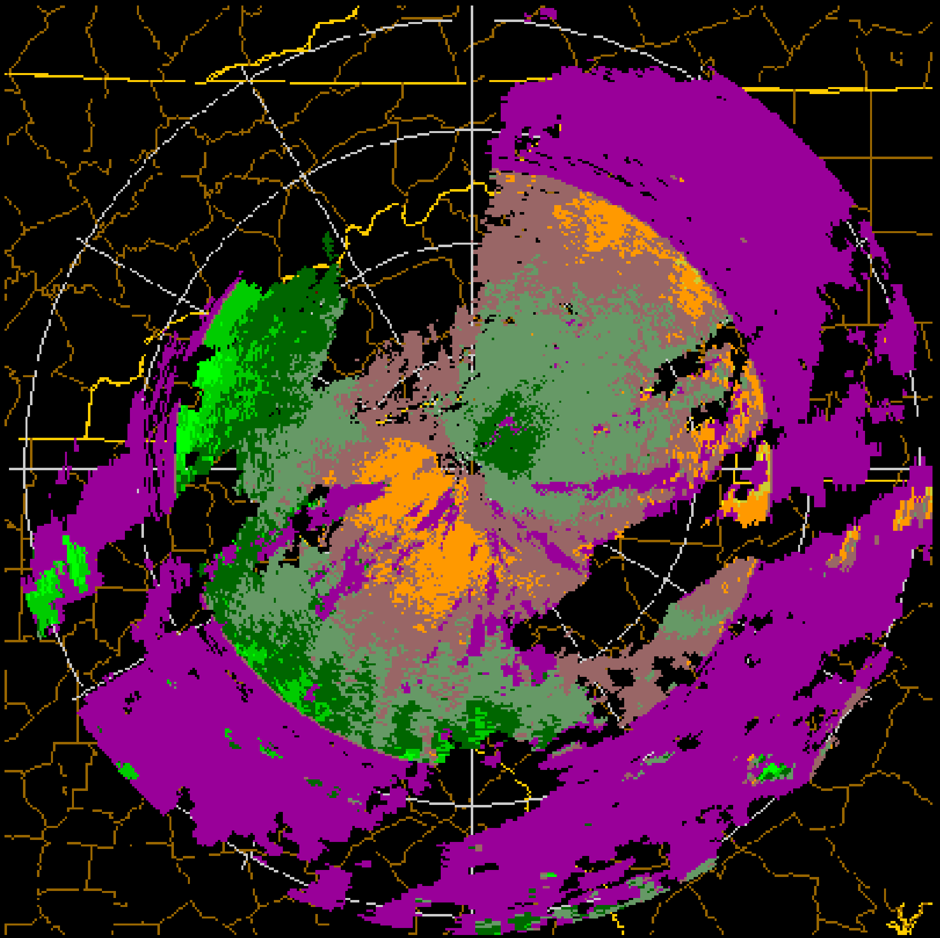


Radial velocity: component of target velocity moving toward or away from the radar.



Precipitation





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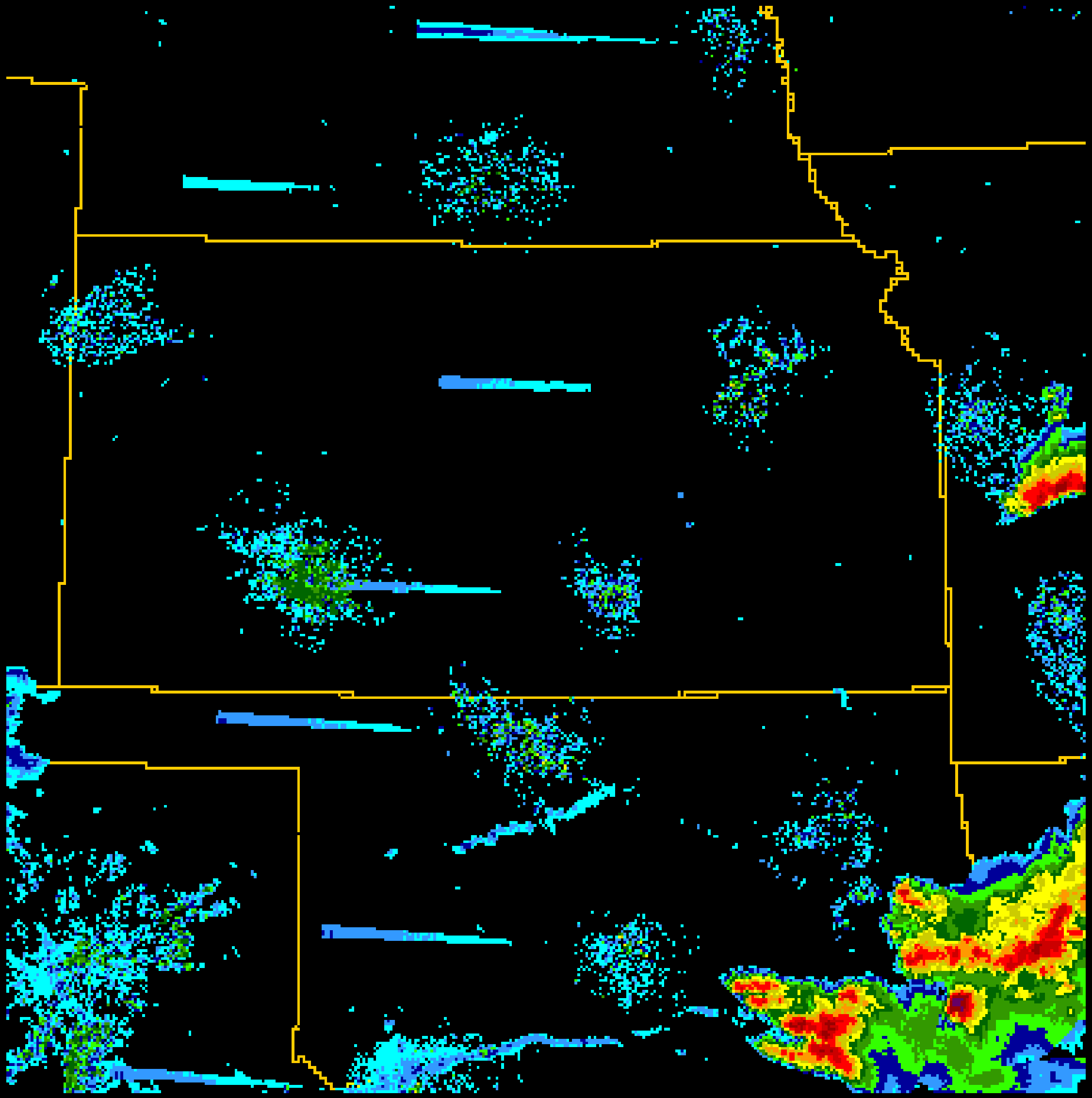
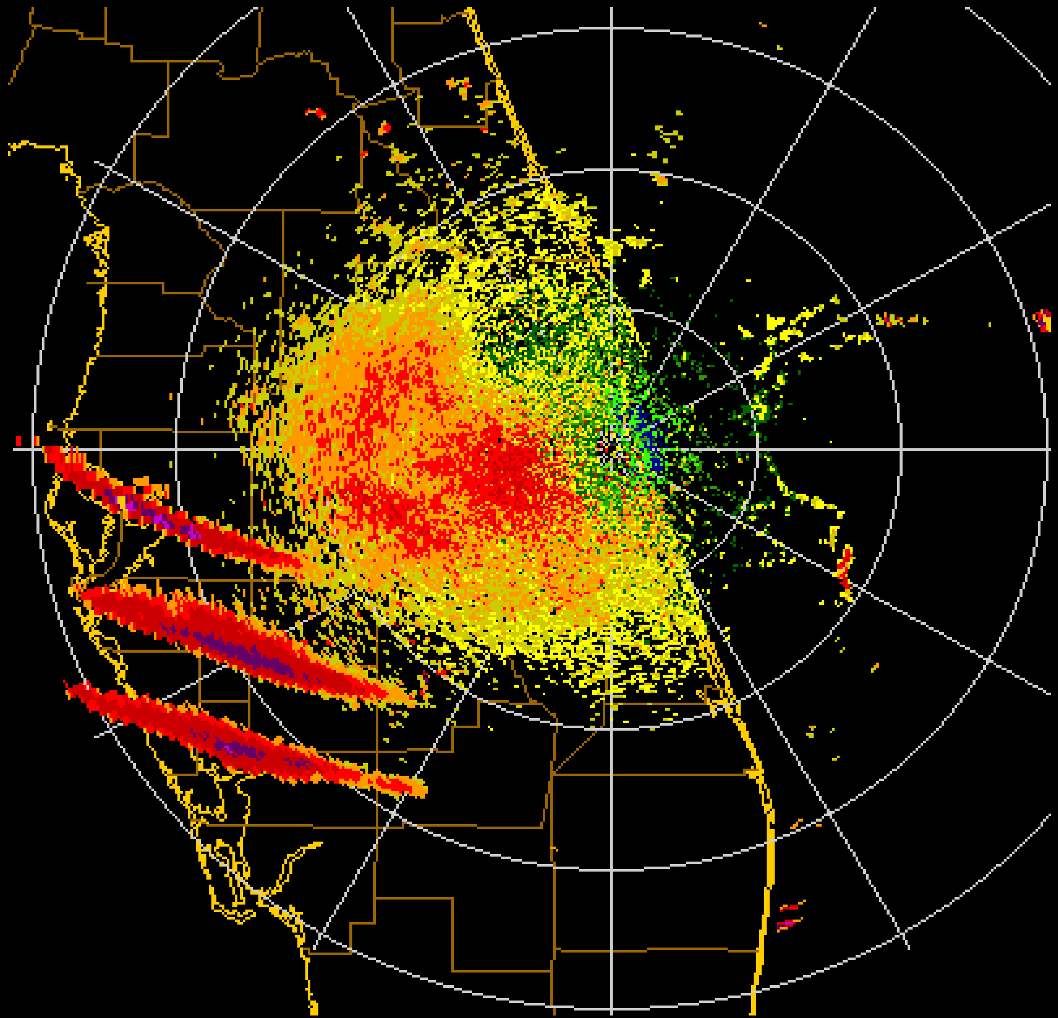
Sunset



Non-biological, non-meteorological
Chaff – military activities



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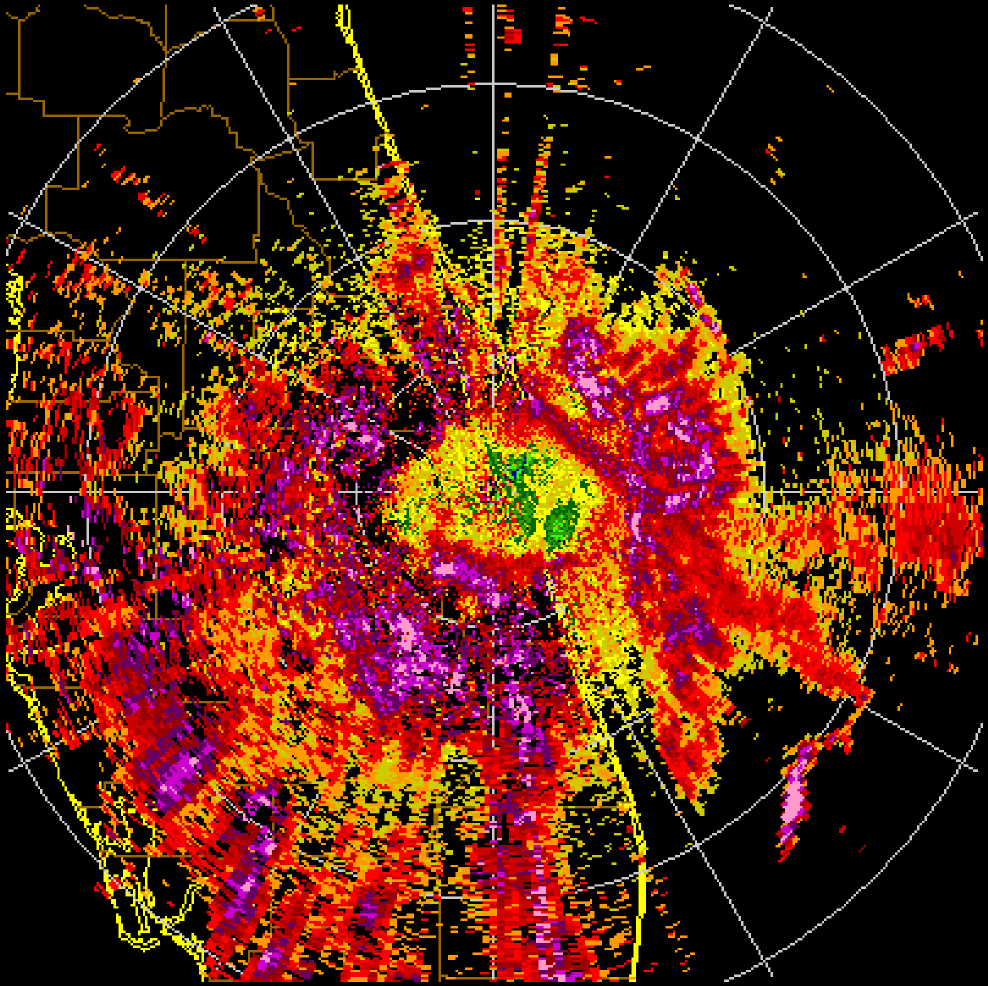
Non-biological, non-meteorological
Strobes and Anomalous Propagation



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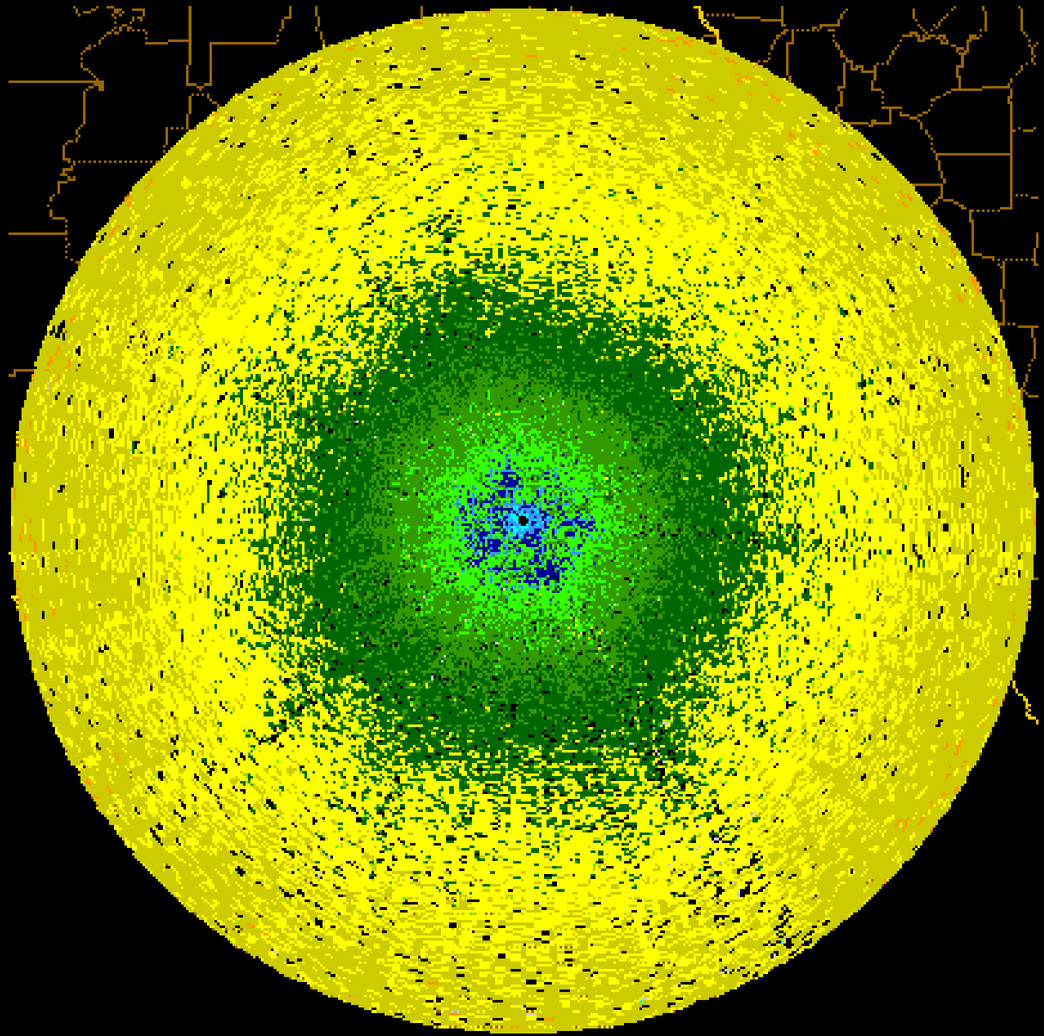
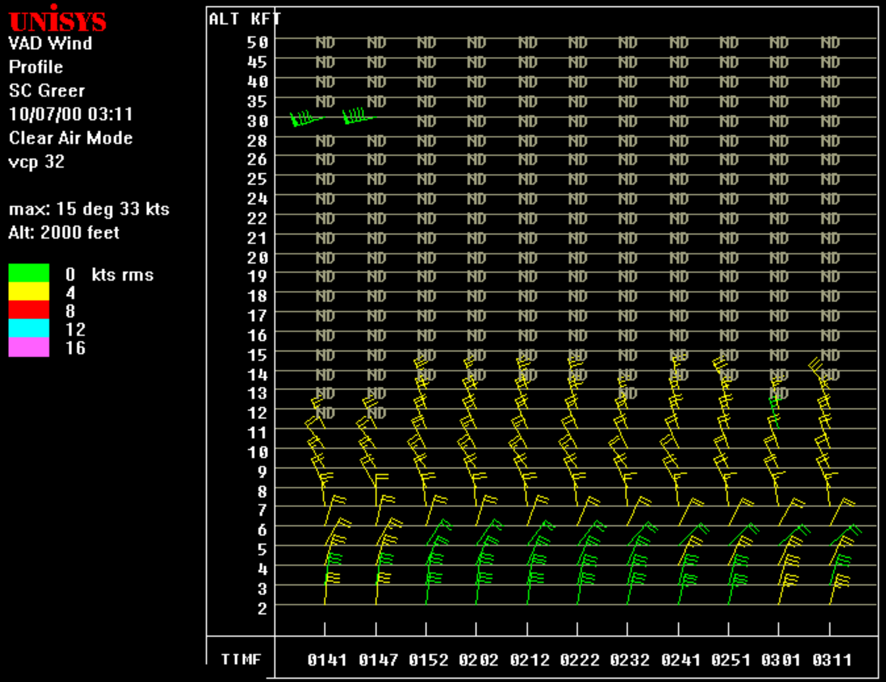
Non-biological, non-meteorological Critical station Error



Wind-related products

Vertical wind profile shows the velocity and direction of windborne targets above the radar.

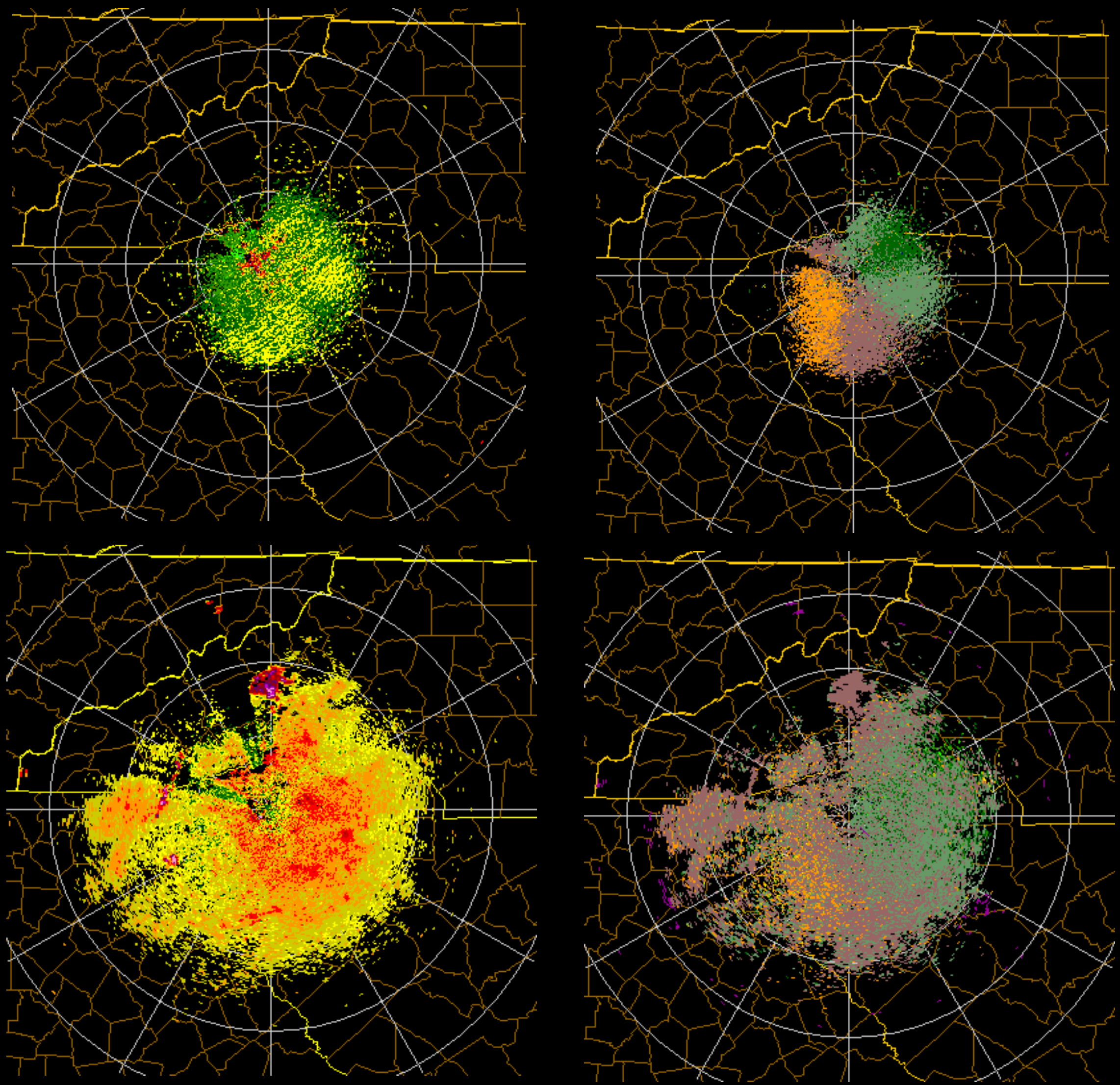


SkewT samples wind speed and direction at specified levels of the atmosphere from a balloon launch.

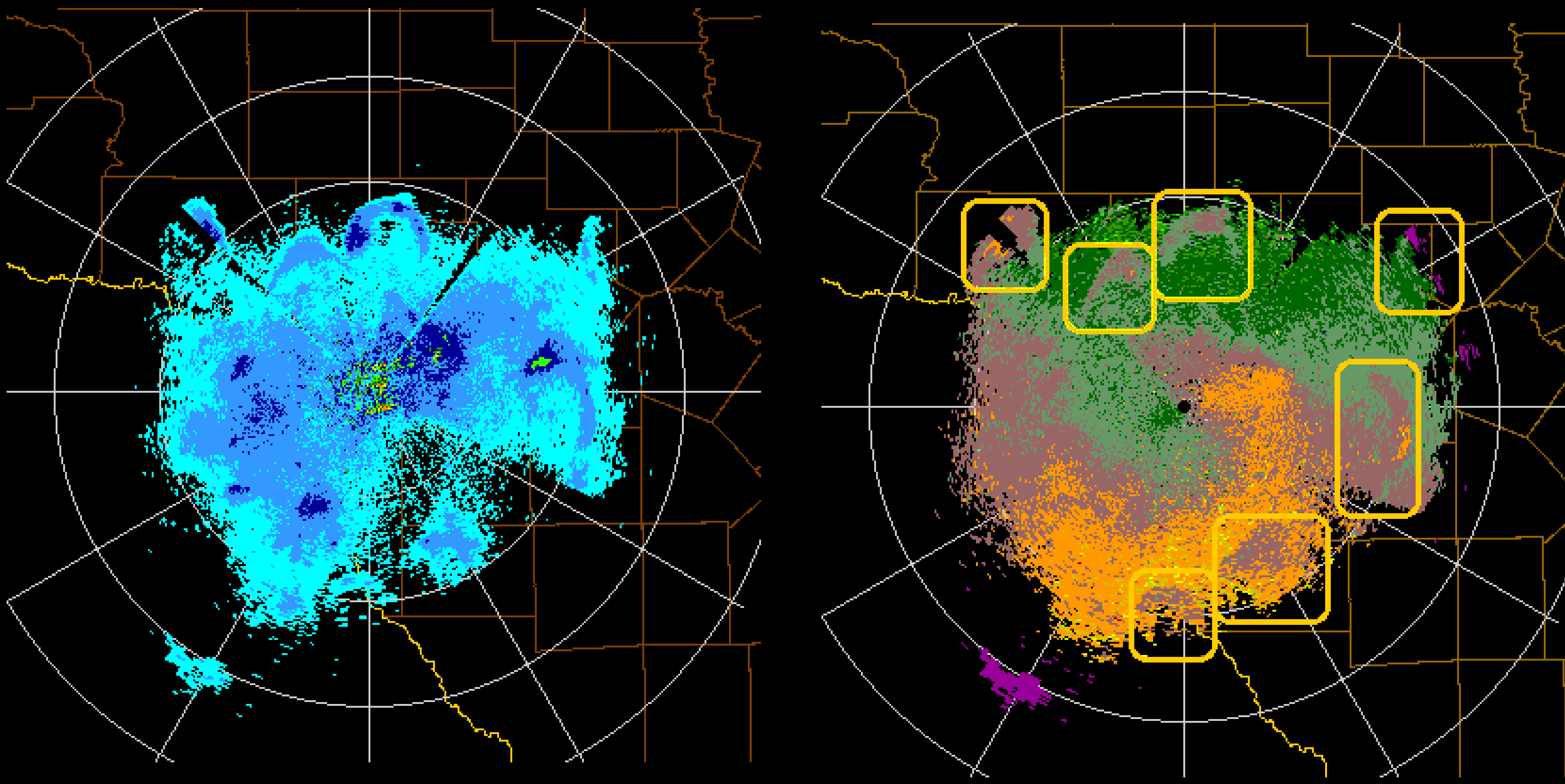
BRO Brownsville Intl Airport: Observation at 00Z 02 April 2002

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1010	7	24.6	15.6	57	11.15	110	13	296.9	329.4	298.9
1000	97	22.6	15.6	65	11.26	110	13	295.8	328.4	297.8
976.1	305	20.4	15.2	72	11.22	105	13	295.6	328.1	297.6
942.2	610	17.3	14.5	84	11.15	105	11	295.4	327.7	297.4
931	713	16.2	14.3	89	11.12	105	10	295.3	327.5	297.3
925	768	16.8	9.8	63	8.28	105	9	296.5	320.8	298
923	786	17	8	55	7.34	106	9	296.9	318.6	298.2
909.3	914	17.4	5.7	46	6.33	110	8	298.6	317.5	299.7
884	1155	18.2	1.2	32	4.74	114	6	301.8	316.4	302.7
877.4	1219	18	1	32	4.71	115	6	302.2	316.8	303.1
850	1490	17.2	0.2	32	4.59	155	4	304.1	318.4	305

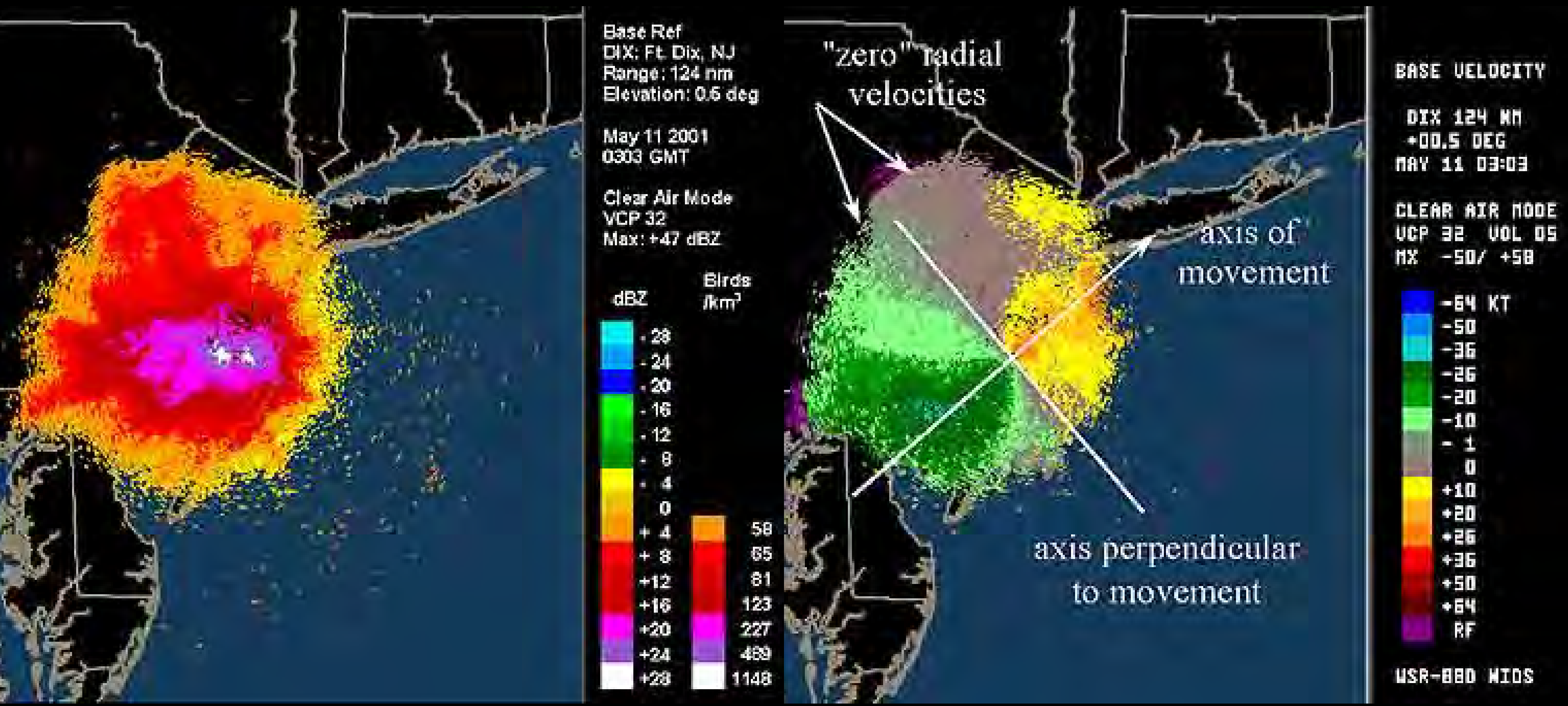
Insects



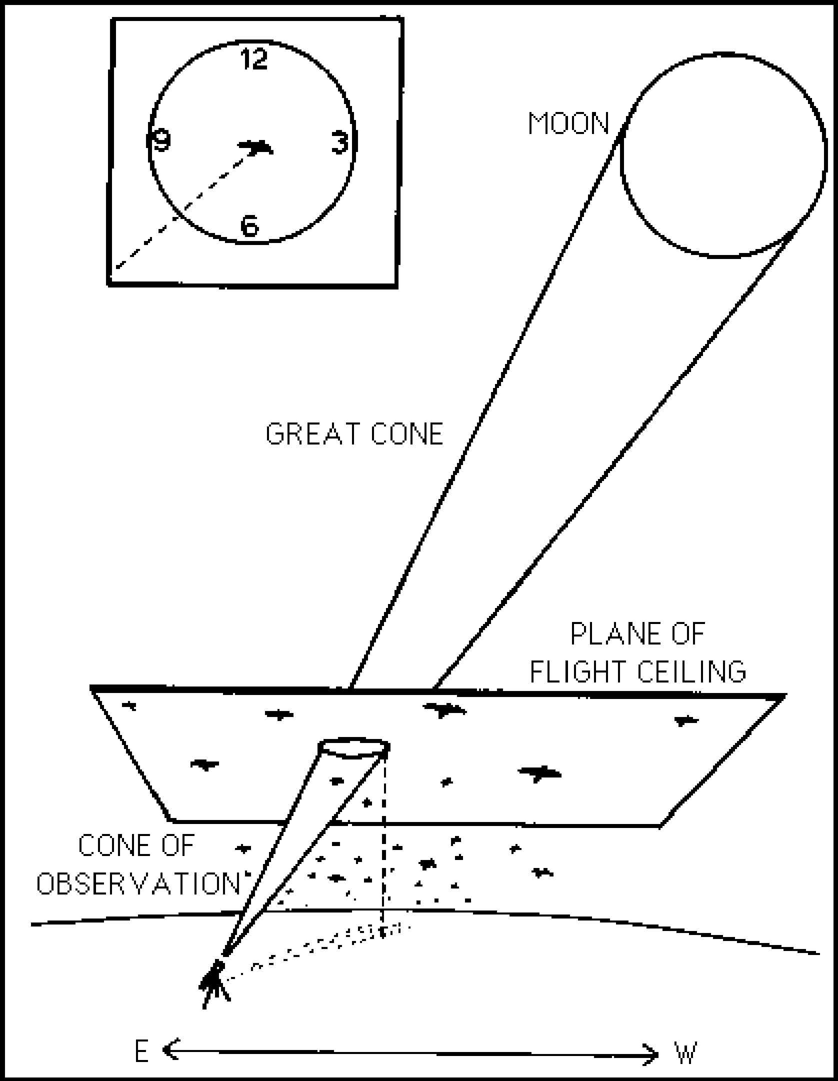
Bats



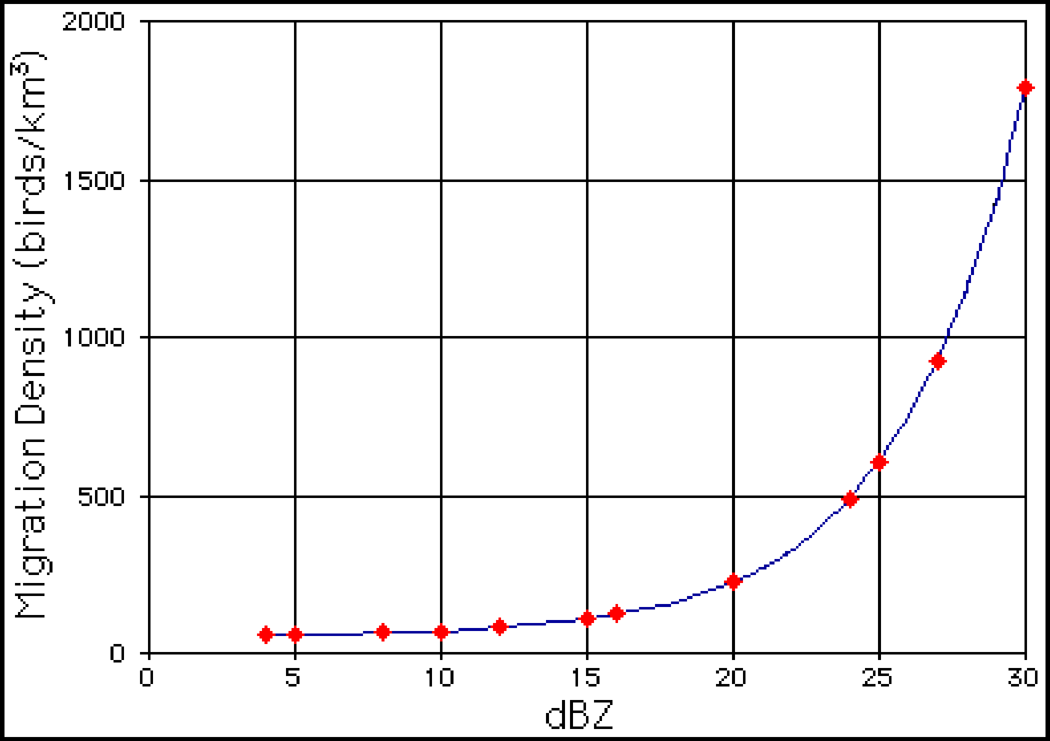
Interpretation of bird movements



Relating bird density and radar reflectivity

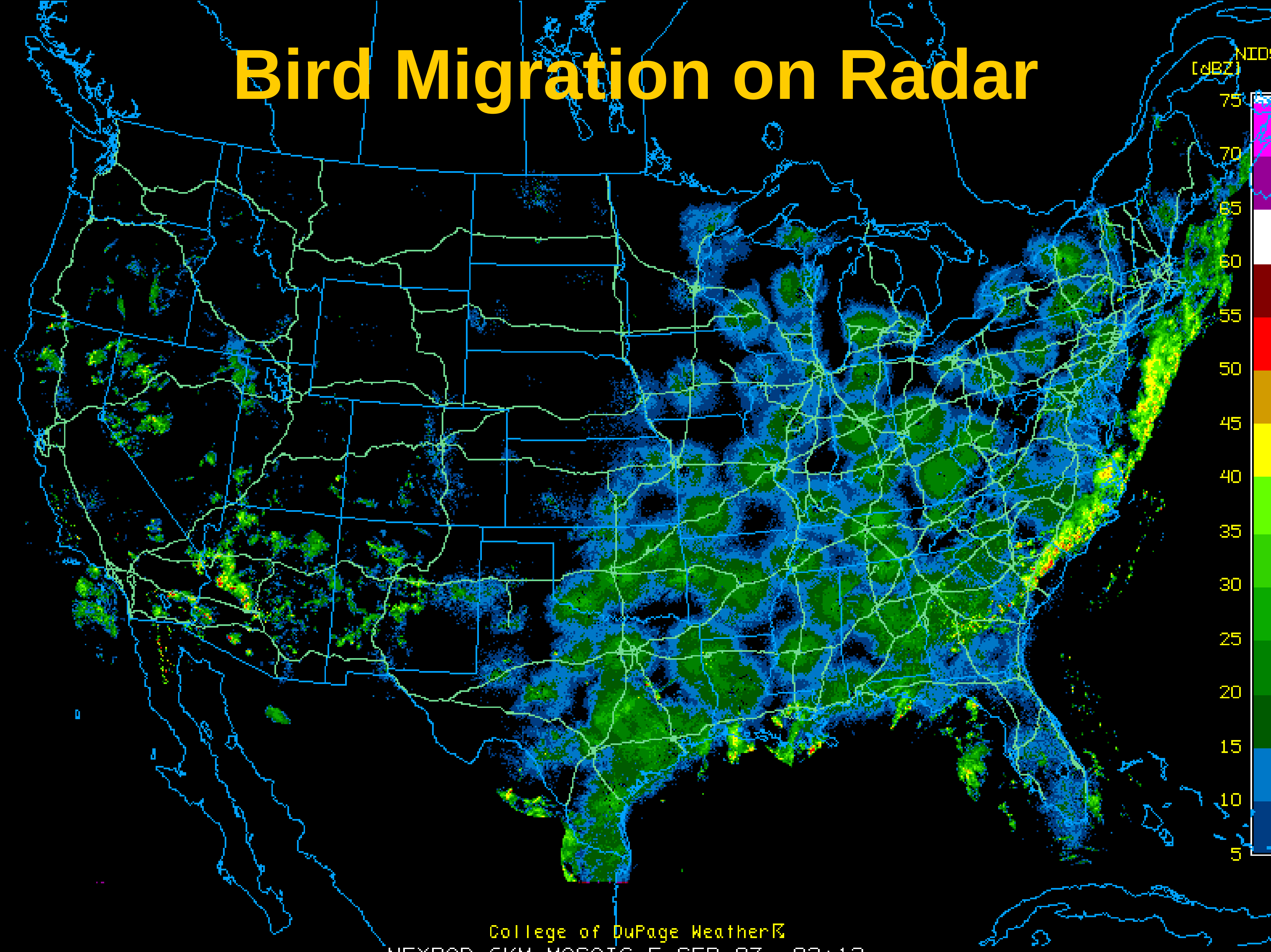


Lowery (1951) and Lowery and Newman (1955)

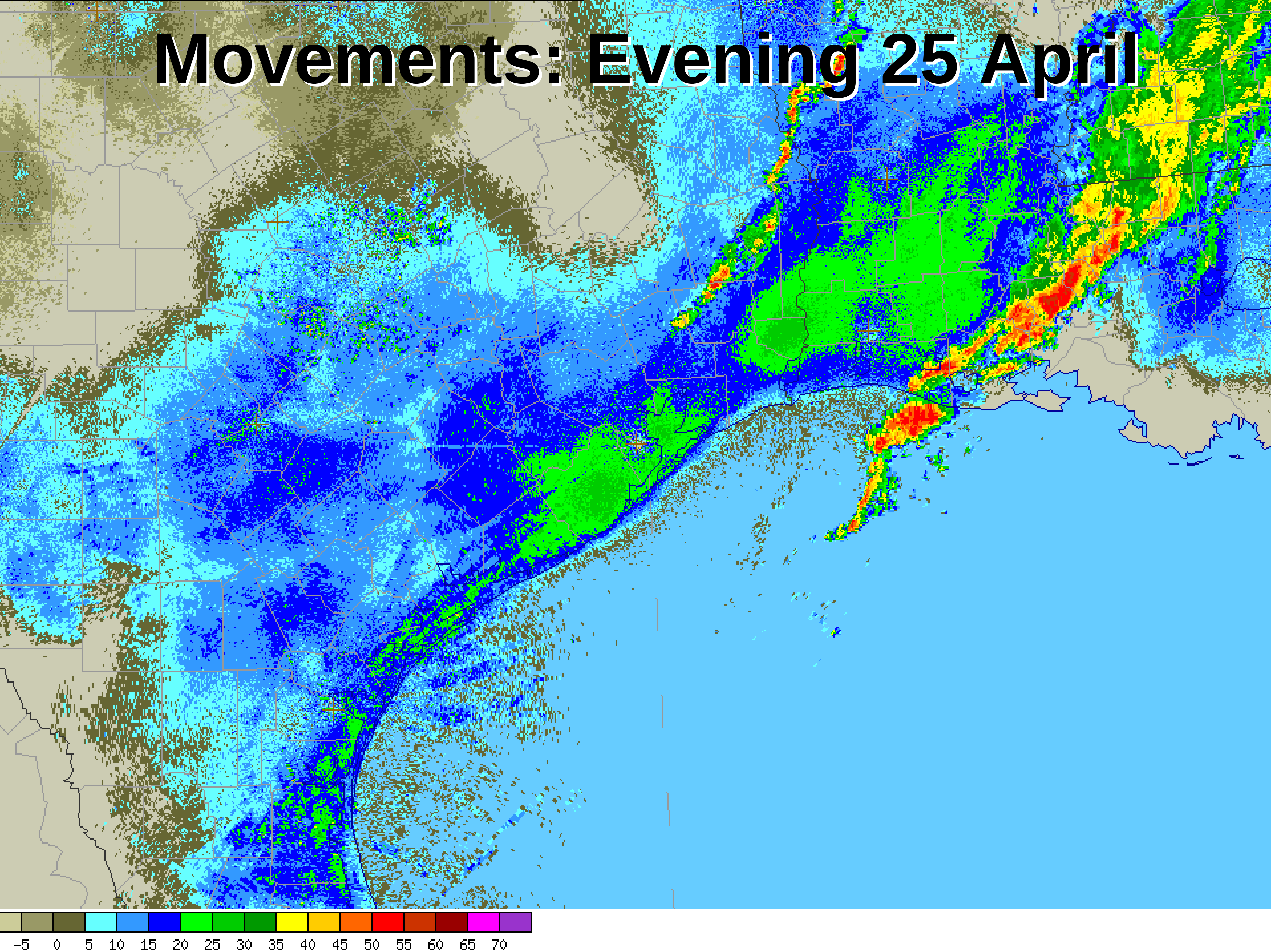


Gauthreaux and Belser (1998,1999)

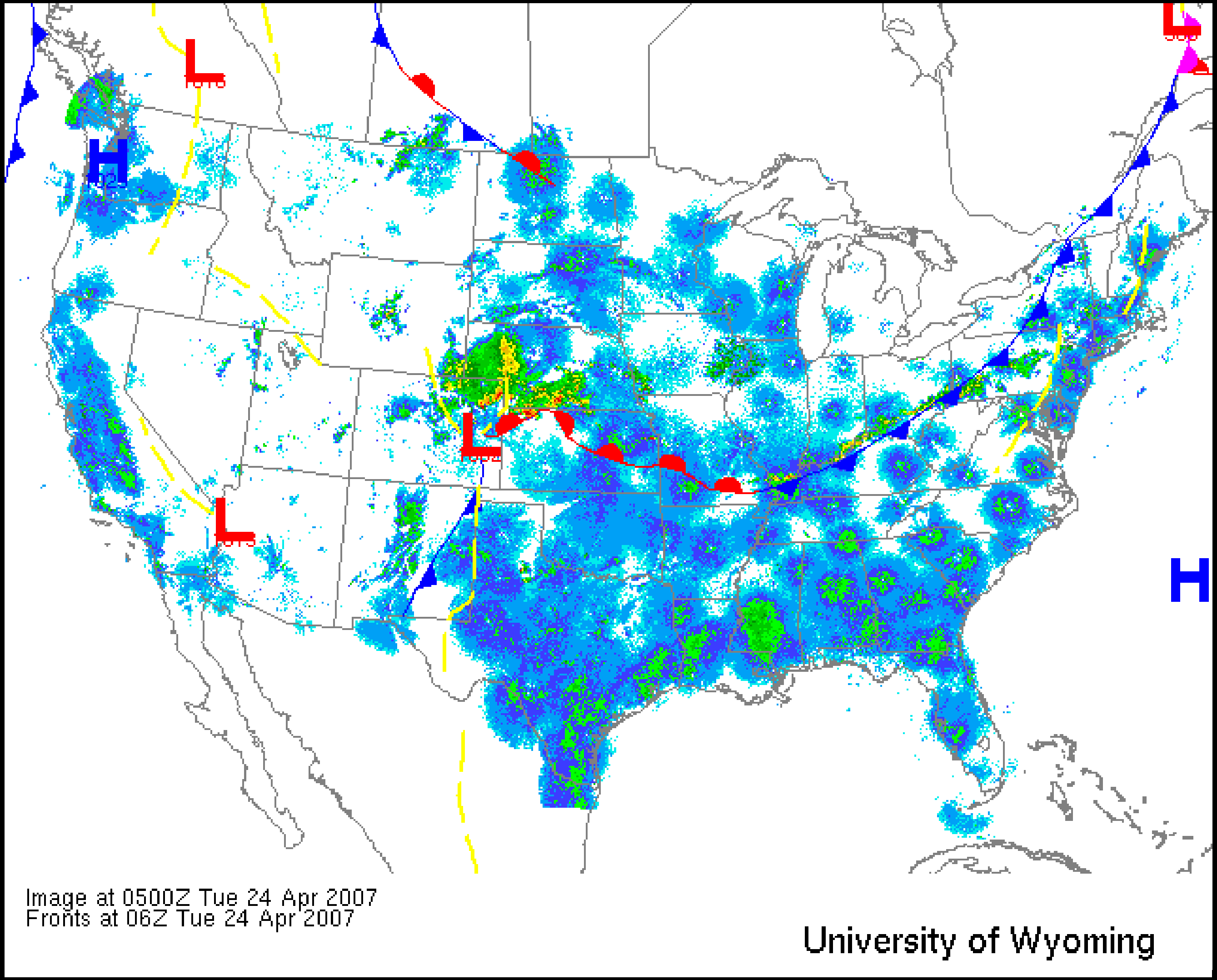
Bird Migration on Radar



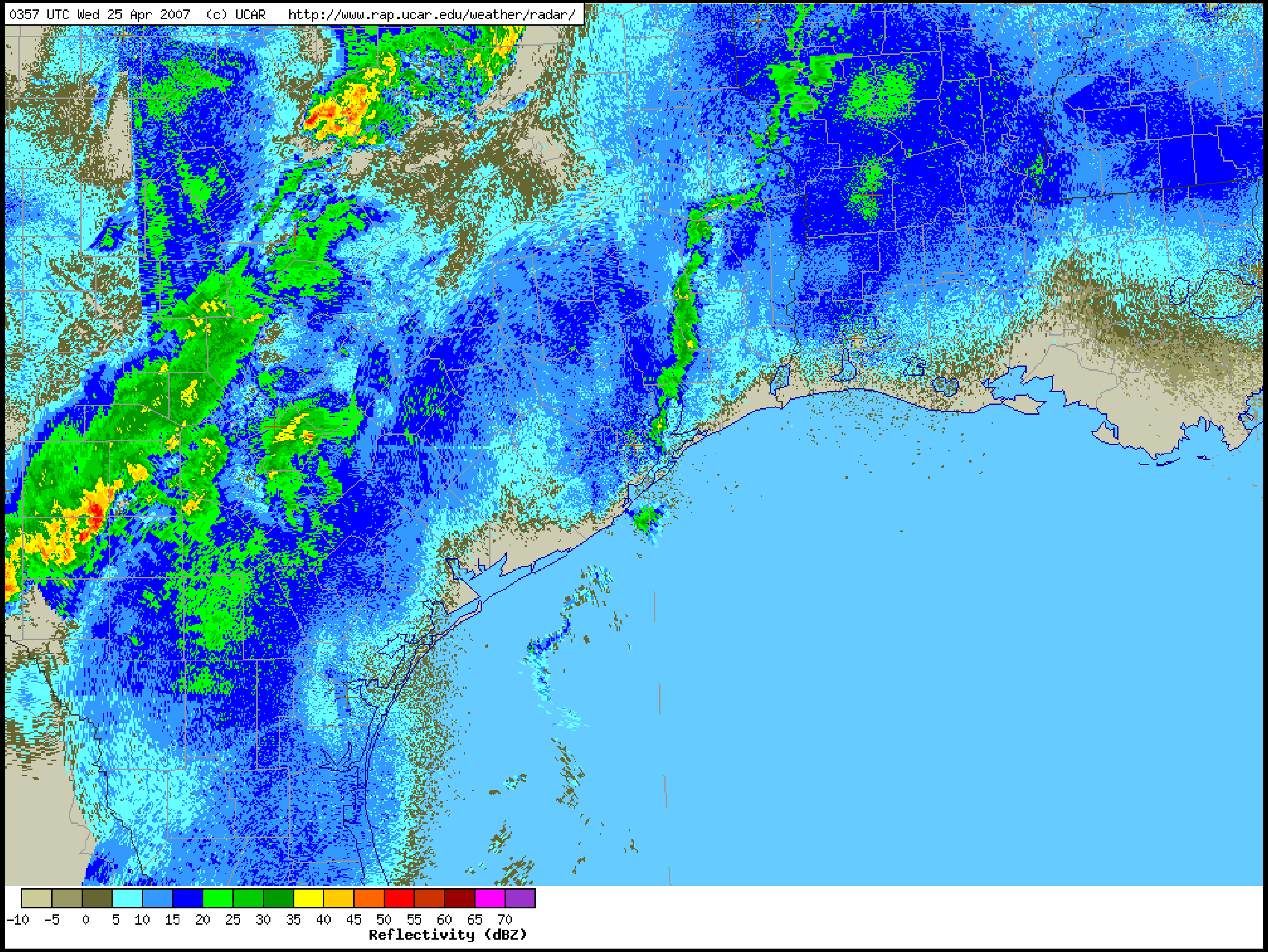
Movements: Evening 25 April



Bird Migration on Radar



Movements: Evening 24 April



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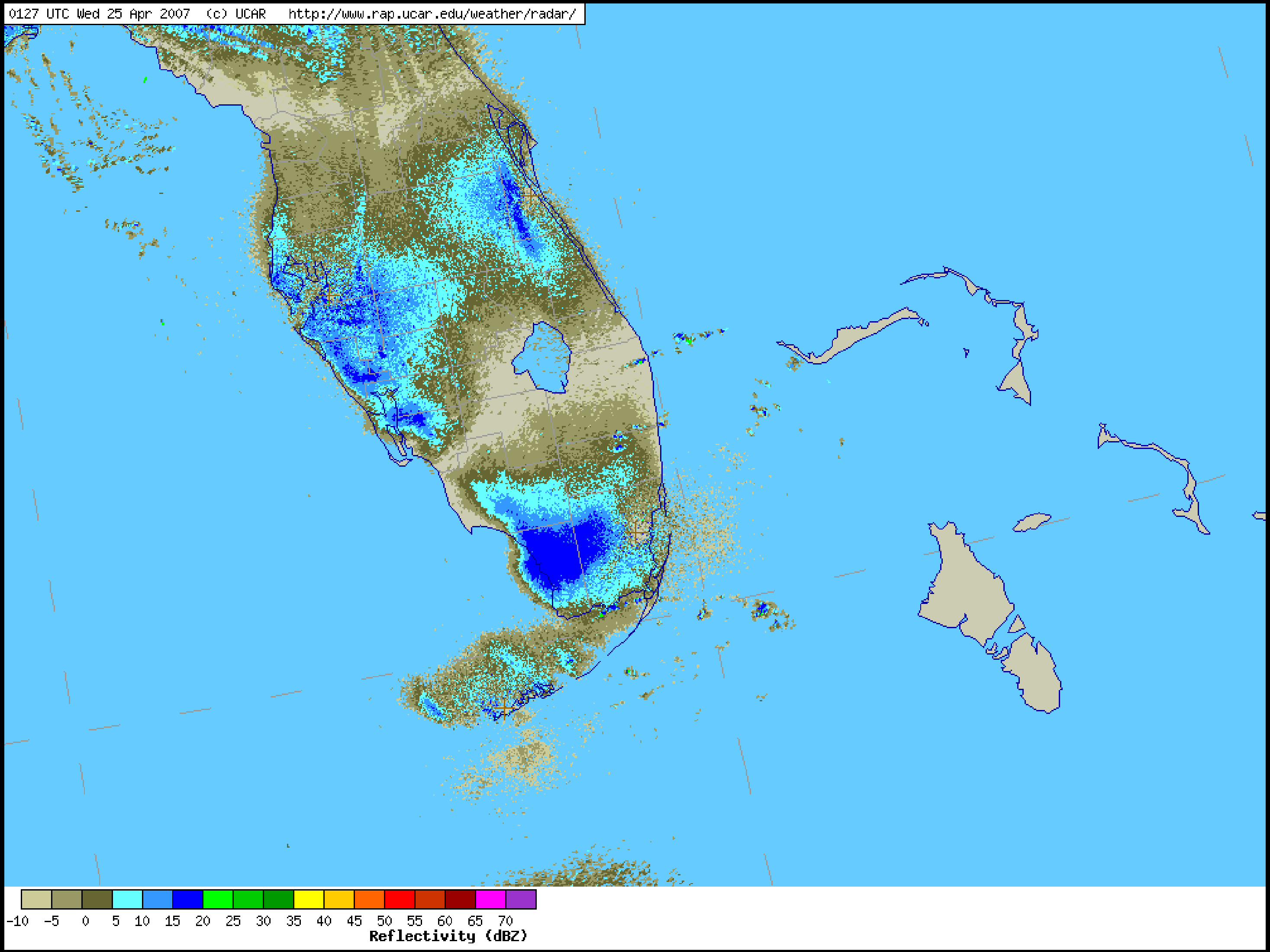
Movements: Evening 24 April



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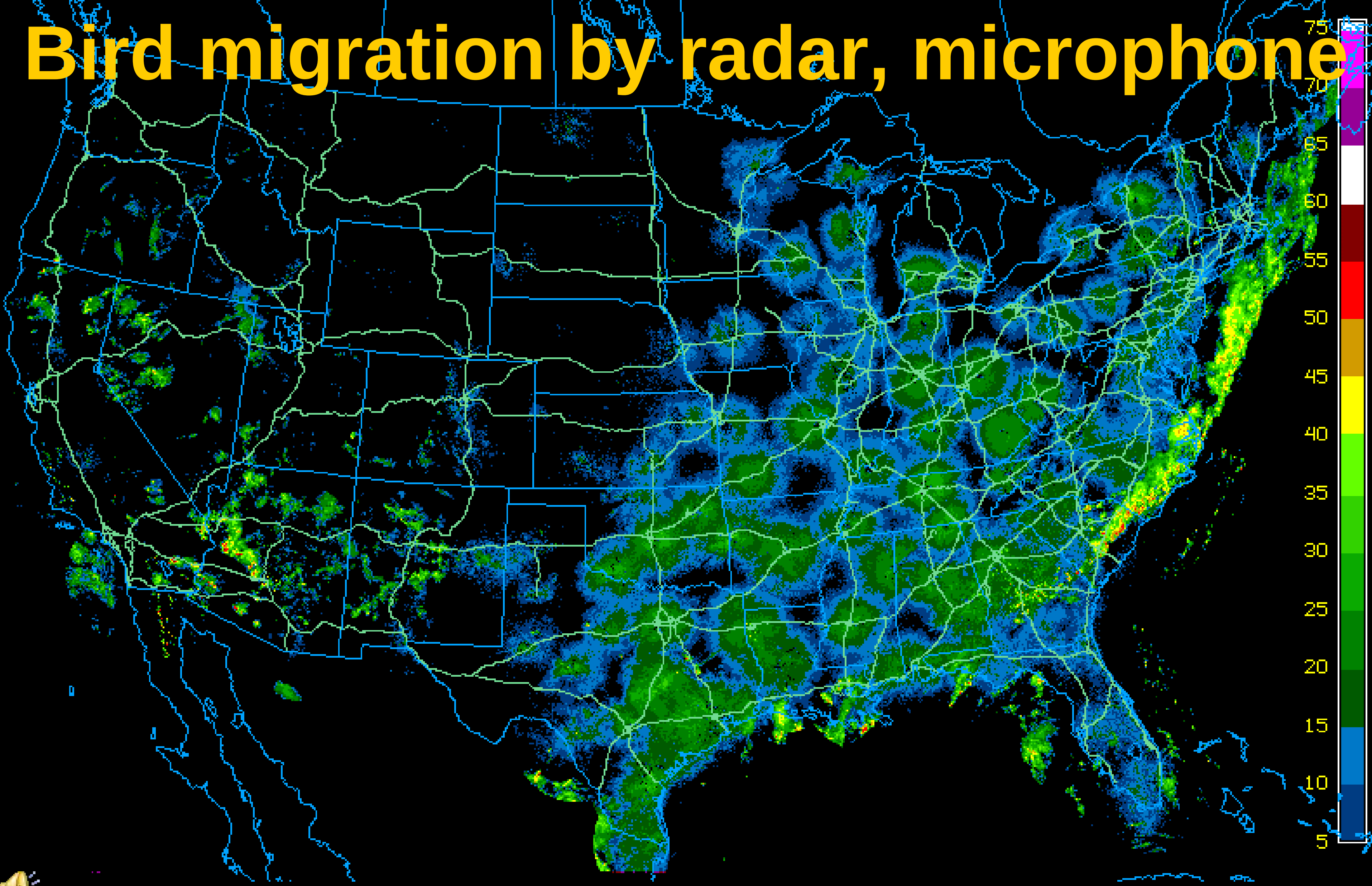
Bird migration by radar, microphone



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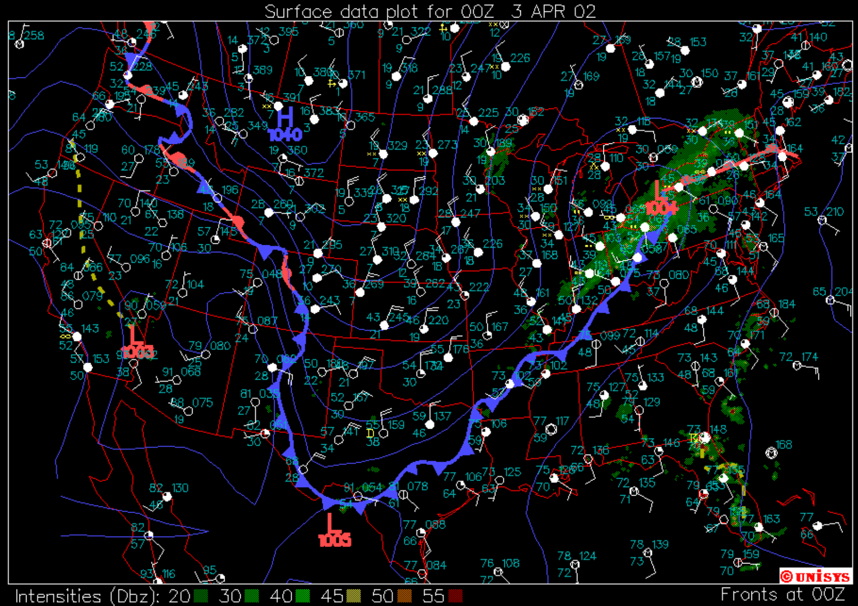
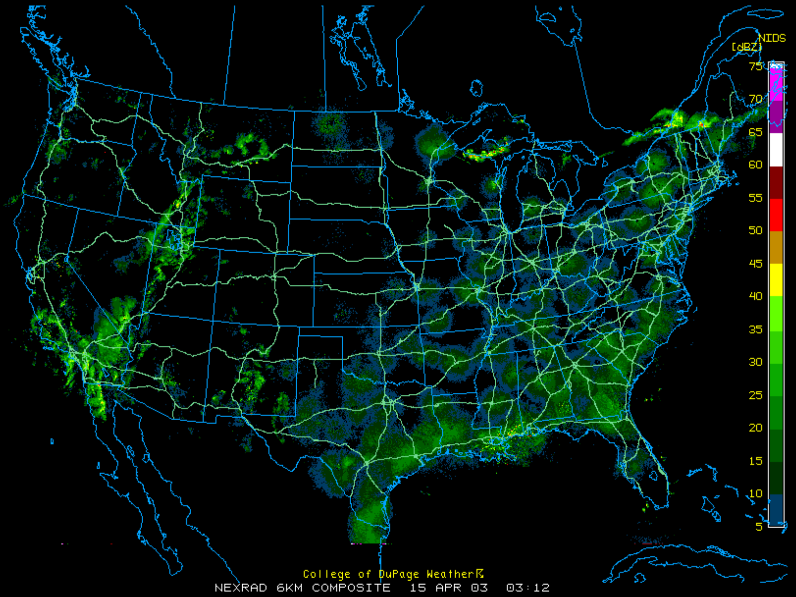
Birds and weather

- Migration and weather
  - Frontal passages provide combinations of atmospheric conditions that facilitate migration
- Interpreting maps
  - Position of pressure centers and frontal boundaries
  - Orientation of isobars
  - Distribution of precipitation





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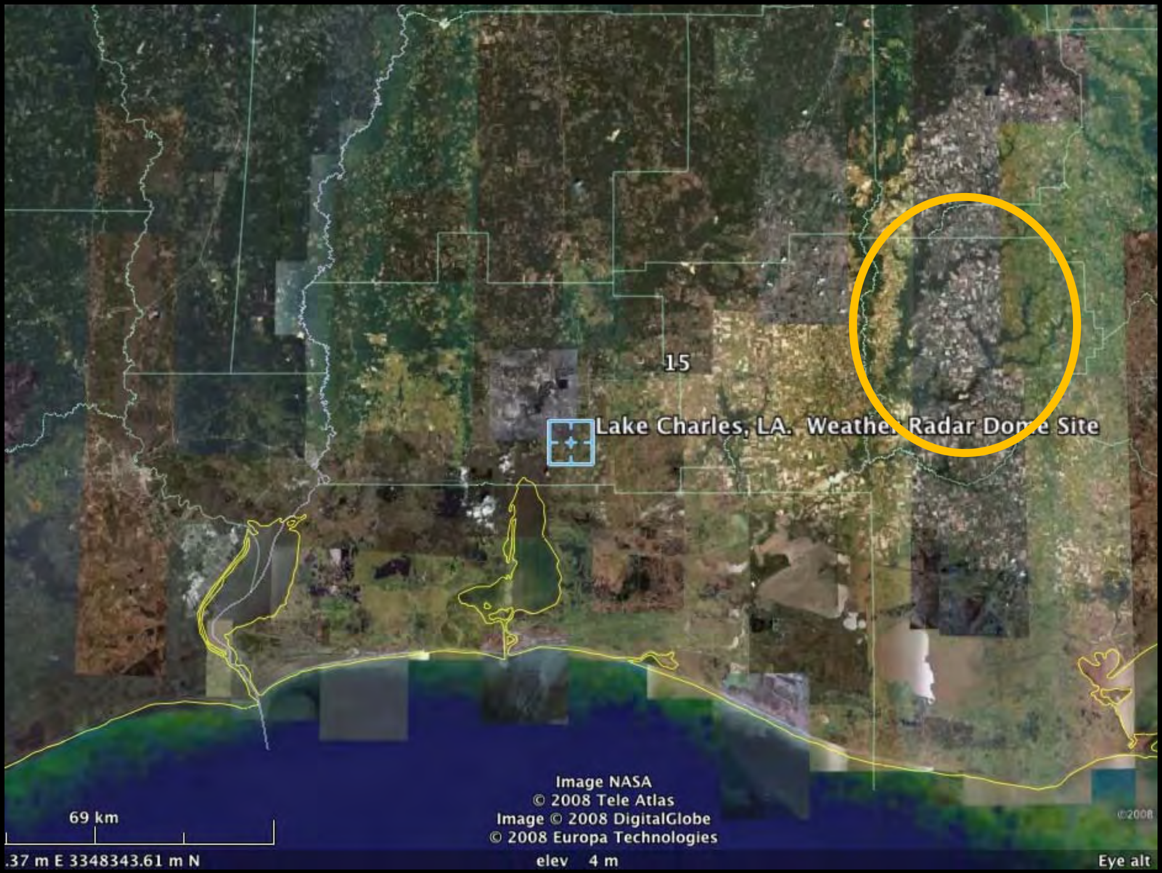
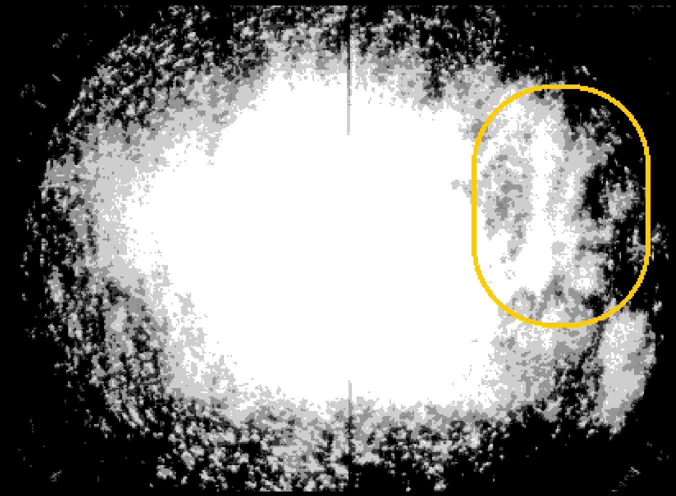
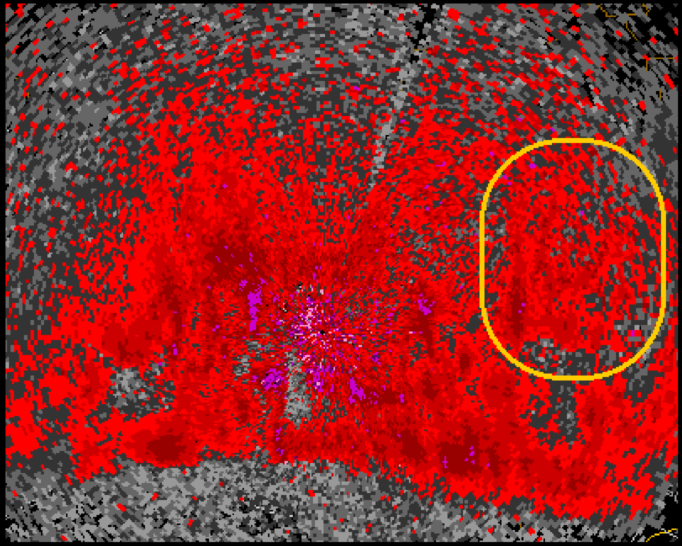
Identifying key stopover habitats







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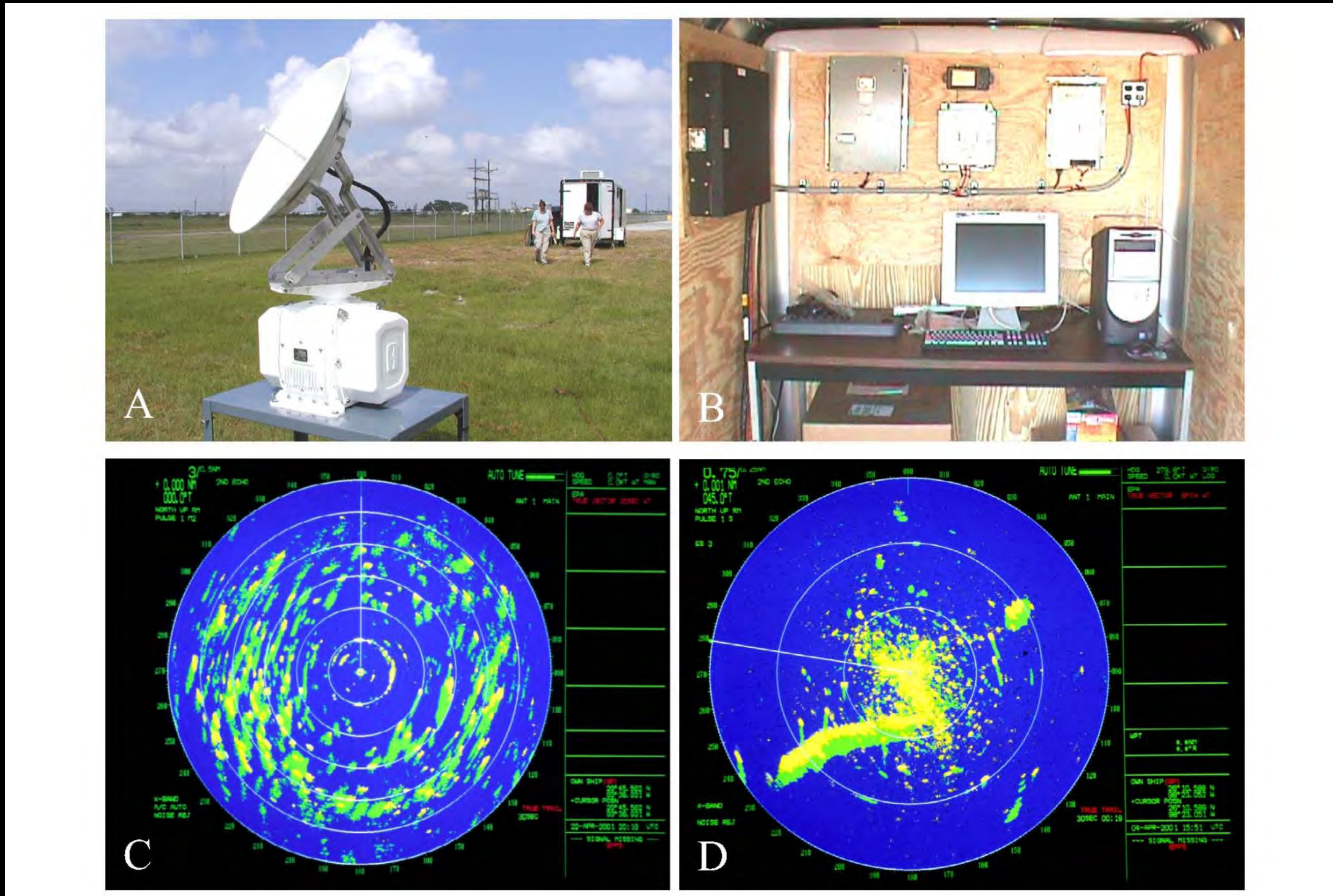
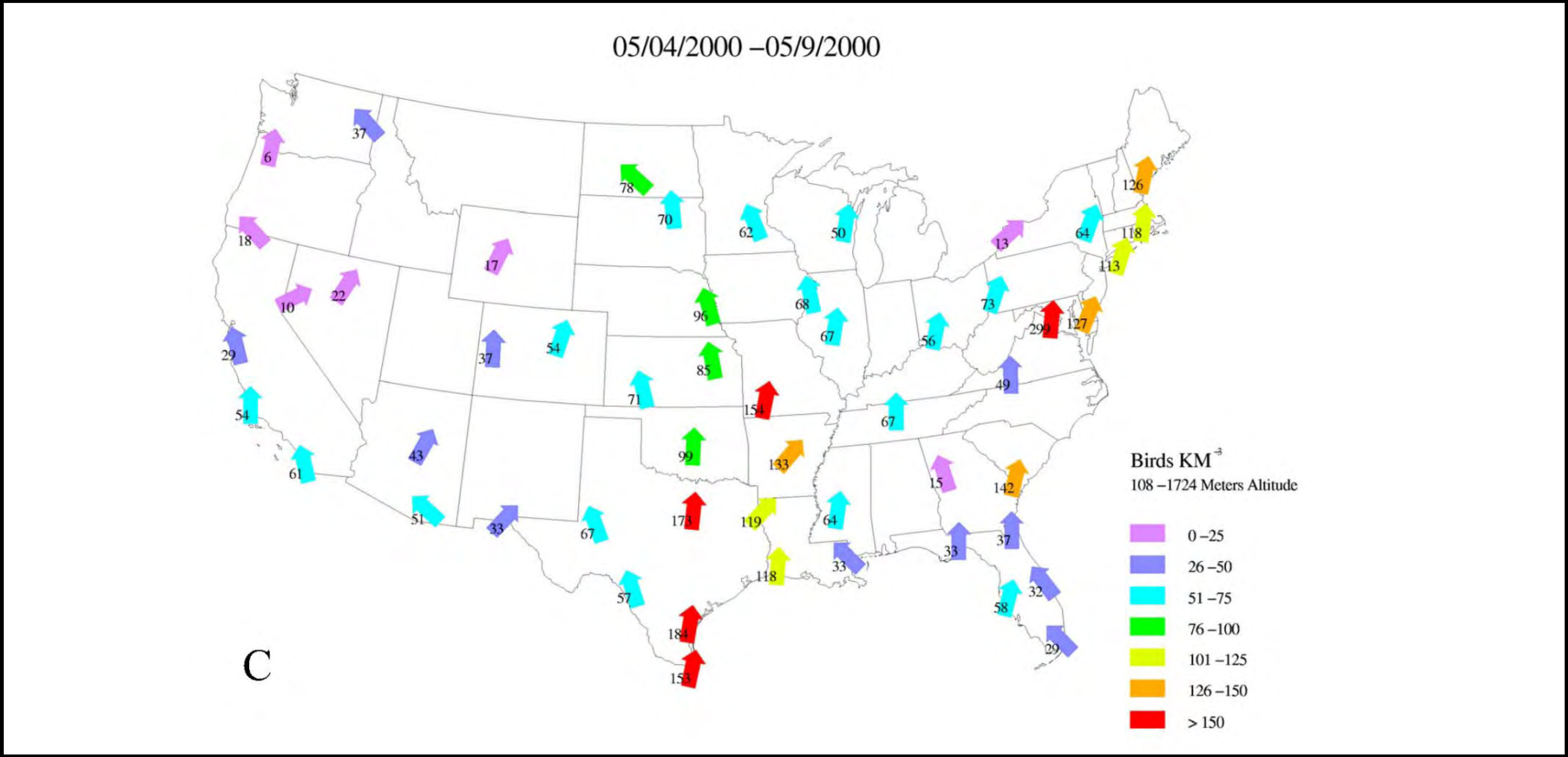
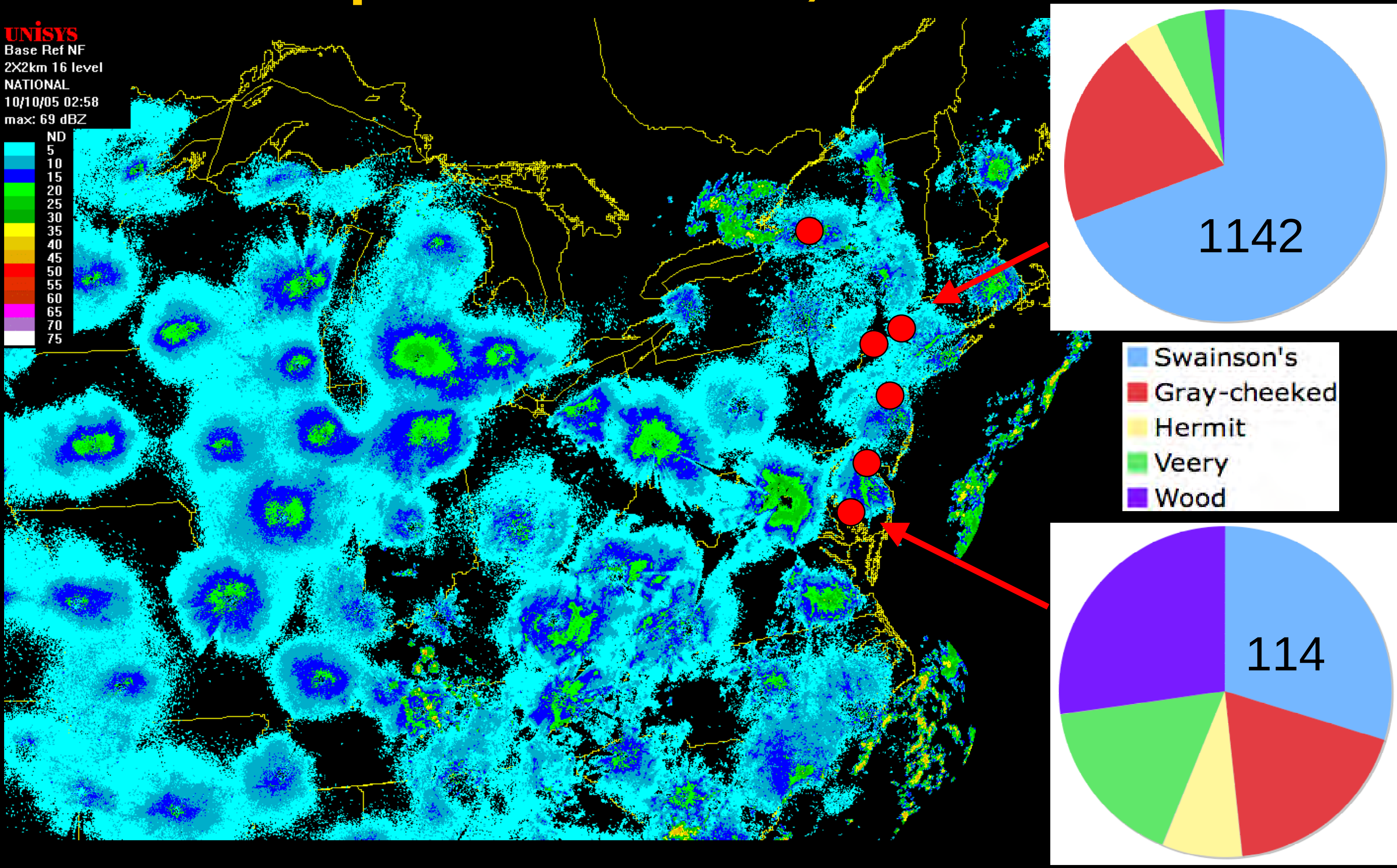
Migration at the local scale



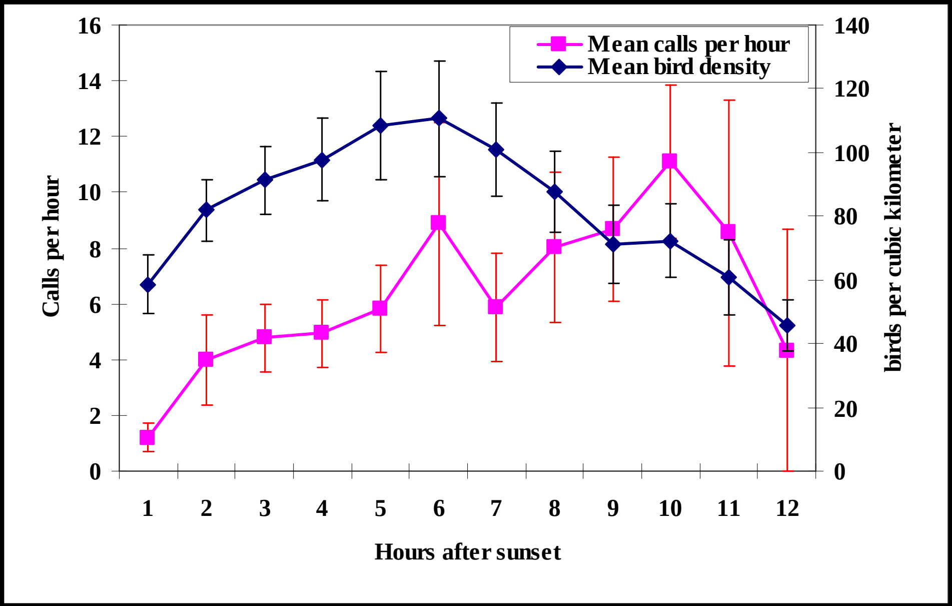
Migration at the continental scale

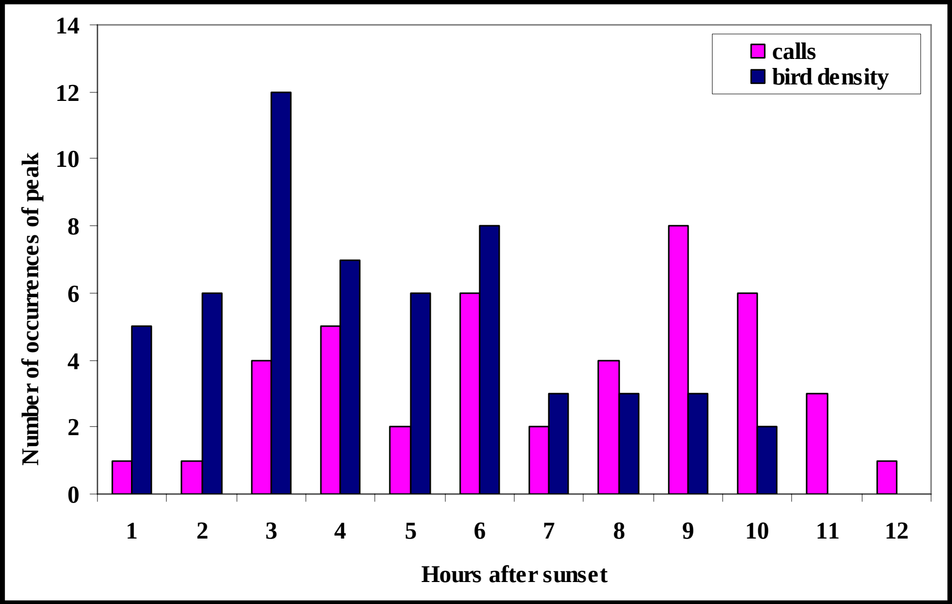


Examples: Thrushes, 9 Oct. 2005



Patterns of bird density and flight call counts exhibit wide variation.





Nightly temporal pattern of bird density and flight-call counts

Frequency distribution of peaks of bird density and flight-call counts

Farnsworth et al. 2004

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Why study migration using radar?

Radar provides unique information to quantify the magnitude, direction, speed, and location of migrating birds.

Additionally, radar technologies facilitate:

– sampling at a variety of scales from 10s to 1000s km;

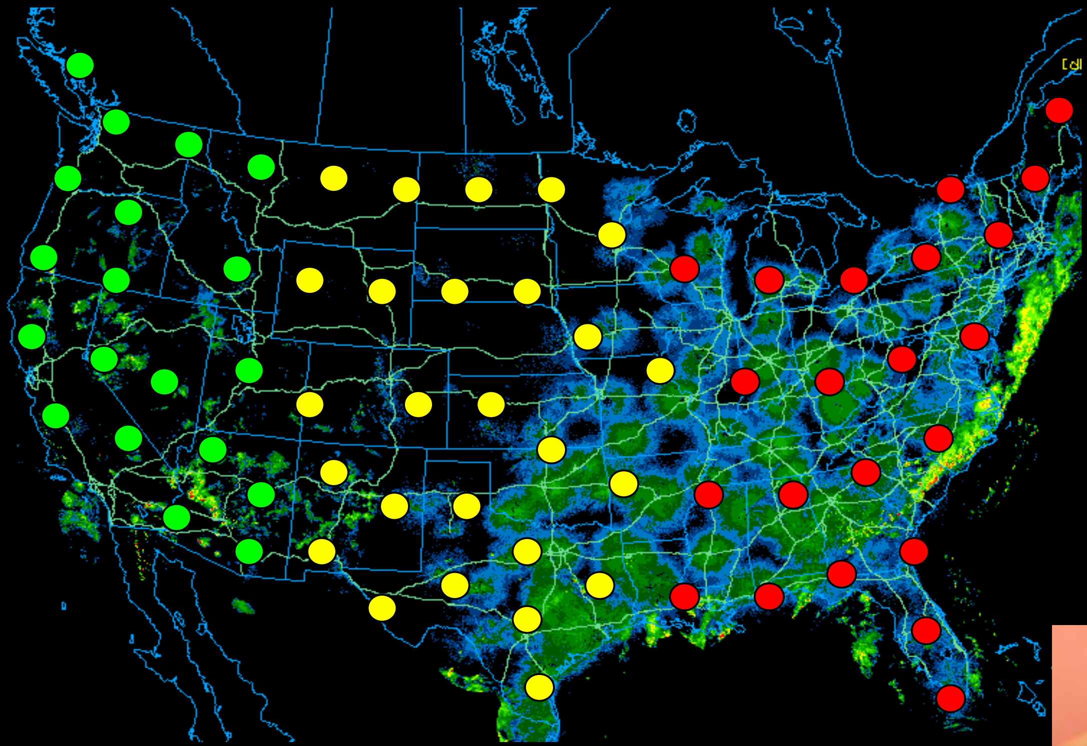
– collecting for extended periods at difficult-to-access sites;

– collecting ancillary data on atmospheric conditions and changes in these conditions;

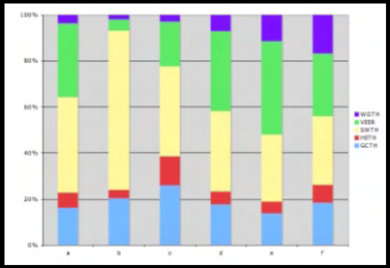
– collecting data during periods when other methods are unavailable (cloudy conditions, high wind)

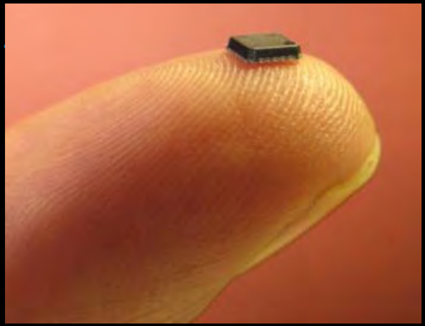
– Relating bird densities on radar to habitat features on the ground

Future plans for monitoring migrants



ebird





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Why study migrants and migration using acoustic technology?

Survey “boreal-breeders” that winter in Amazonia

Monitor humans activities that create new hazards

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Why study migrants and migration using acoustic technology?

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Useful Websites

CUROL - www.clemson.edu/birdrad
DuPage – www.weather.cod.edu/analysis/analysis.radar.html
UW - http://weather.uwyo.edu/mapper/
NCAR - http://www.rap.ucar.edu/weather/radar

Bill Evans' Oldbird, Inc.: www.oldbird.org
Flight calls at Cornell: birds.cornell.edu/birdcalls
PARC: http://www.powdermill.org/bioacoustic.htm
XBAT: www.xbat.org
RAVEN: http://birds.cornell.edu/Raven
GlassoFire: www.oldbird.org/GlassoFire.htm
Clemson Radar Lab: www.clemson.edu/birdrad