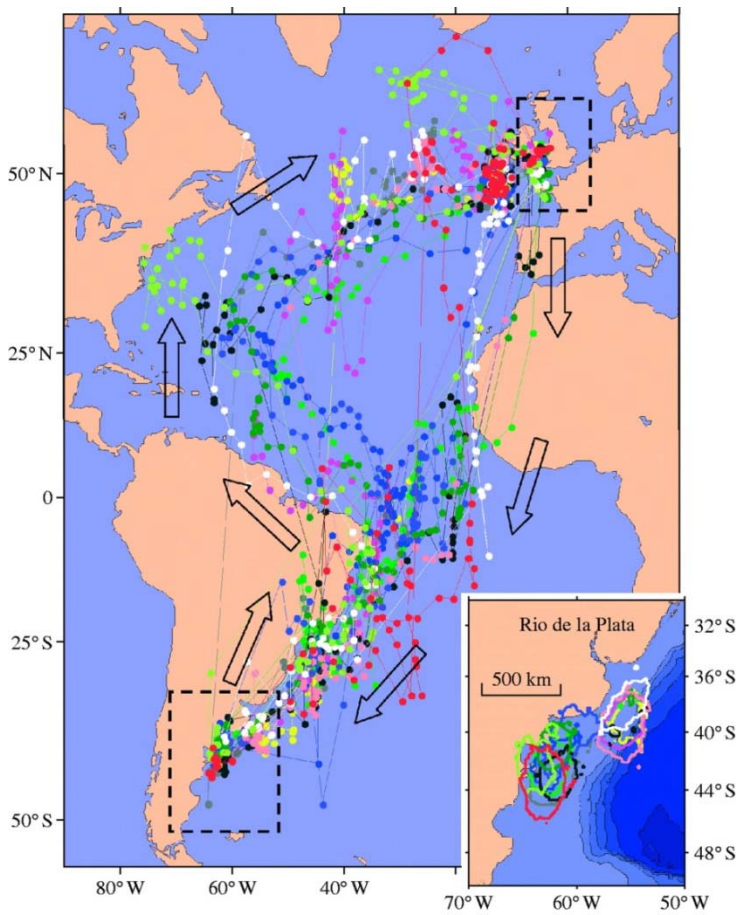
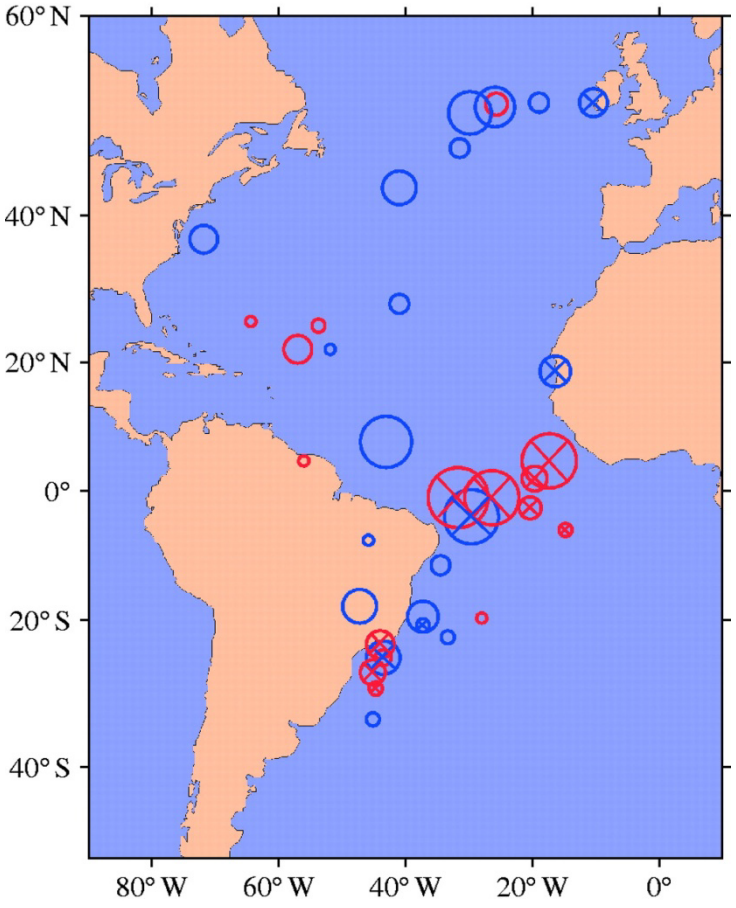
Stopover Biology of Migratory Birds: Meeting En Route Challenges

Frank R. Moore

Biological Sciences
The University of Southern Mississippi

MIGRATION AND STOPOVER OF MANX SHEARWATERS





Guillford et al. 2009. Proceedings Royal Society B.

INTERCONTINENTAL BIRD MIGRATION

Roughly two-thirds of all the bird species that breed in the forests of eastern North America migrate from temperate breeding grounds to more tropical wintering areas in the Caribbean, Mexico, and Central and South America.

MIGRANTS MAY EXPERIENCE THE BEST OF TWO WORLDS

- Increased reproductive performance by breeding in the food rich, competitor poor temperate habitats in summer

- Increased survival by spending the temperate winter in the tropics

MAYBE SO, BUT … .

- Estimated 30% or more of annual cycle in migration
- Estimated > 70% of time during migration spent stationary (stopover)
- Estimated 80% of mortality among migrant populations experienced during migration

- **Adjust to unfamiliar habitats**
- **Acquire food in short period of time**
- **Contend with competitors**
- **Avoid predators**
- **Resolve conflicting demands**
- **Maintain health**
- **Gain adequate sleep**
- **Find and maintain the right direction**
- **Cope with adverse weather**

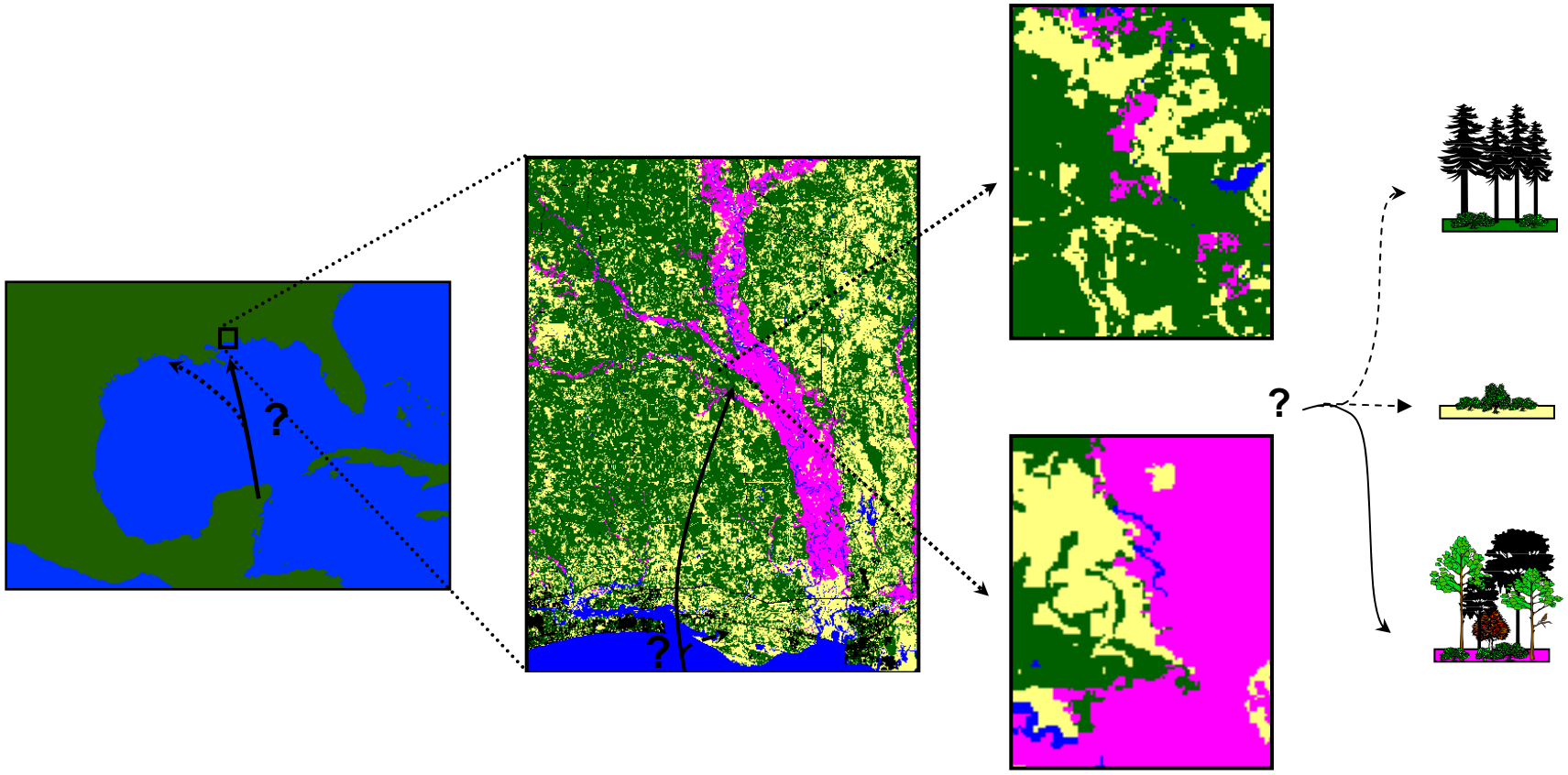
If she solves en route problems, she experiences a successful migration. Successful migration?

Survival and Reproductive Success

OBJECTIVES

- Examine migrant response to challenges that arise during stopover
- Emphasize that migrant - habitat relationship is scale dependent
- Appreciate linkage/transition between phases of the annual cycle

SCALE-DEPENDENT USE OF HABITAT



MIGRANT-HABITAT RELATIONSHIP: EXTRINSIC AND INTRINSIC FACTORS

EXTRINSIC FACTORS

- **WEATHER**
- **TIME**
- **ACCESSIBILITY**
- **HISTORICAL**

INTRINSIC FACTORS

- **FOOD**
- **PREDATORS**
- **COMPETITORS**
- **PARASITES & DISEASE**

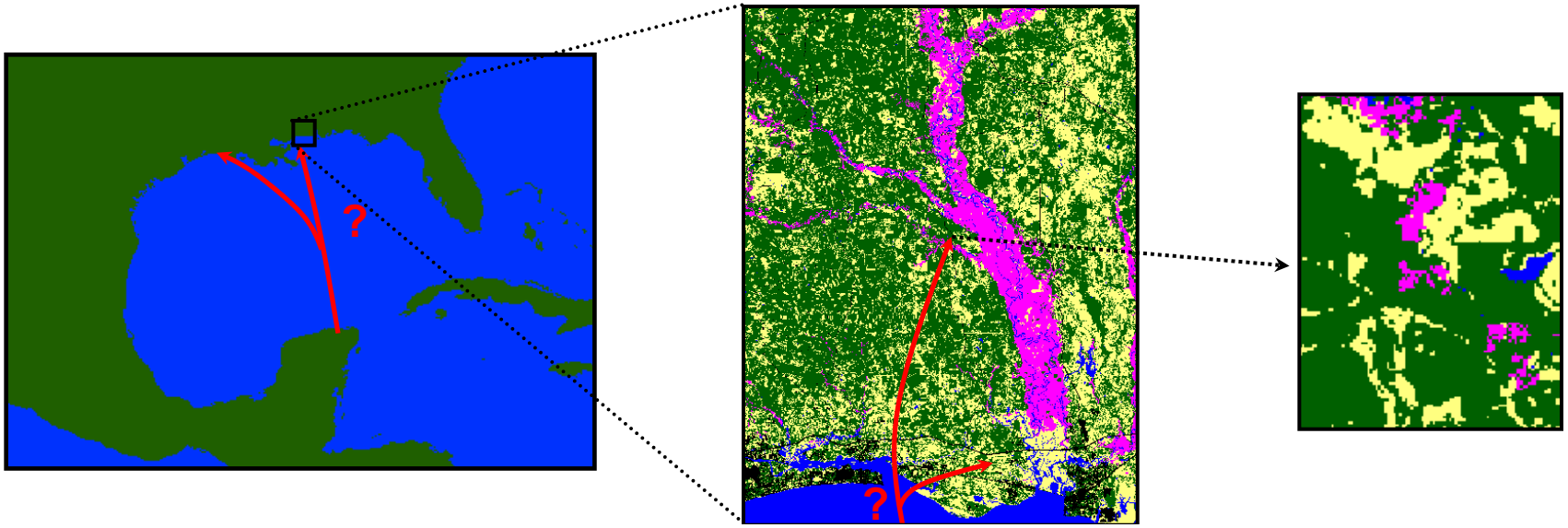
Relative Importance of Intrinsic and Extrinsic Costs and Benefits of Habitat Use as a Function of Spatial Scale

Geographic Scale or Distance Between Habitats	Types of Factors Contributing to Costs and Benefits of Habitat Use	
	Intrinsic	**Extrinsic**
Broad Scale, Distant	Unimportant	Important
Local Scale, Close	Important	Unimportant

.

HIERARCHY OF HABITAT USE

Extrinsic factors important at broad geographic scale

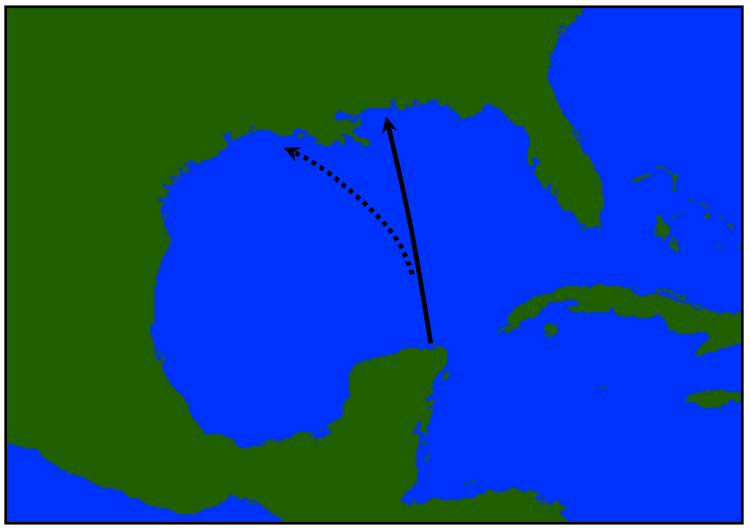


Intrinsic factors important at more local scale

TRANS-GULF MIGRATION
Wind, Weather & Where You Stopover:

White-eyed Vireo
Vireo griseus

Here or There?



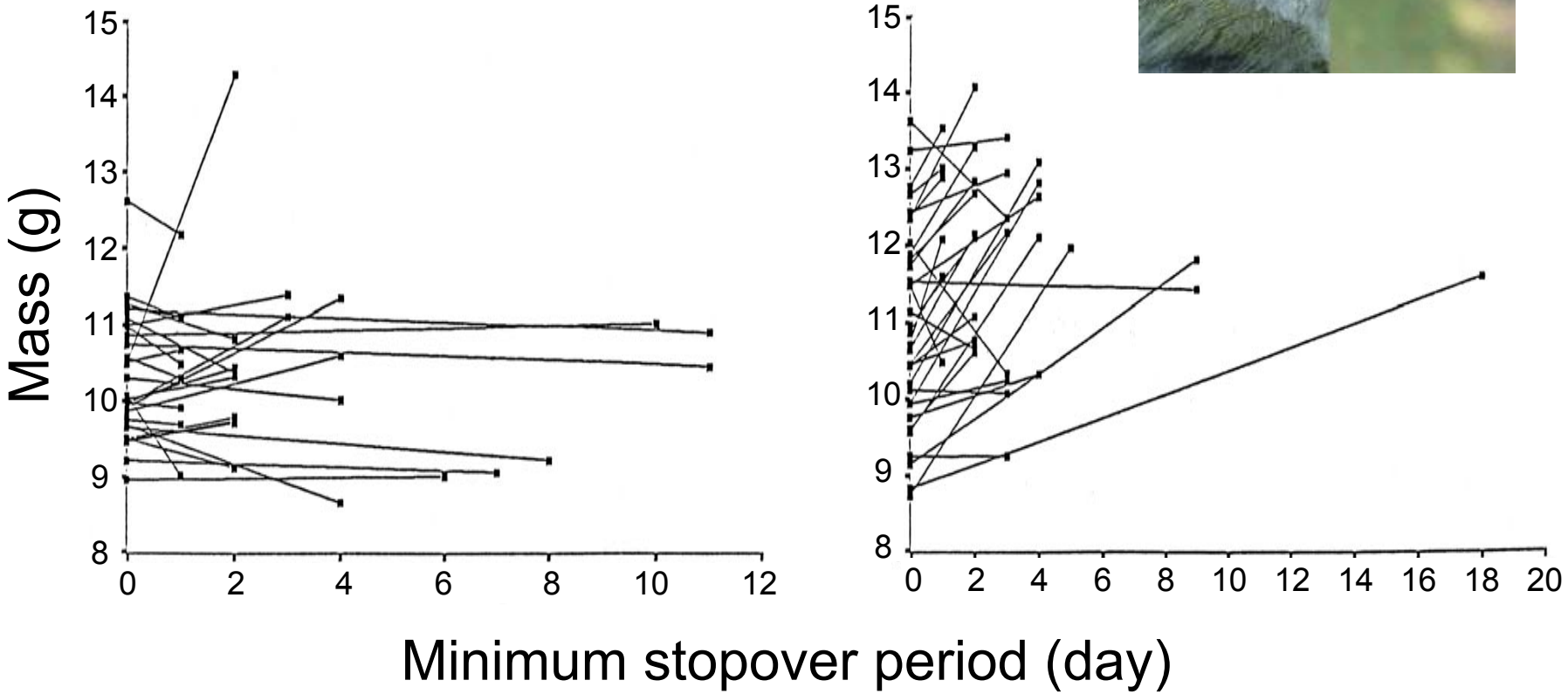
HABITAT USE
NORTHERN COAST GULF OF MEXICO
HERE OR THERE?

EAST SHIP ISLAND

CHENIER PLAIN

WHITE-EYED VIREO

Vireo griseus

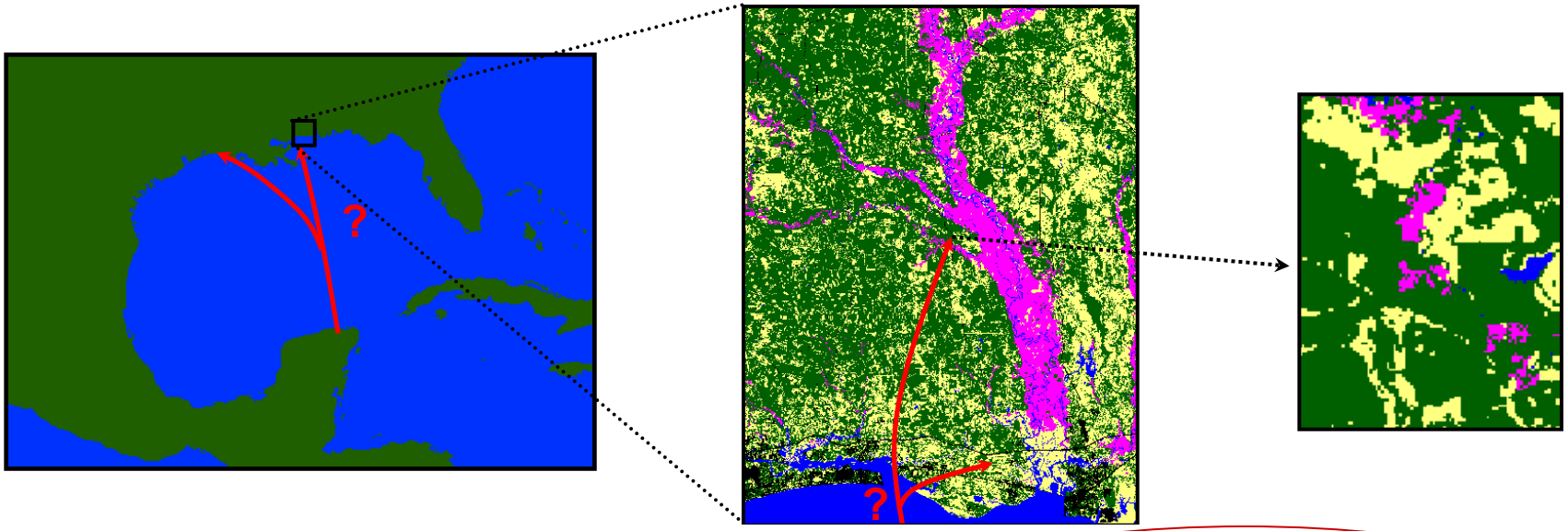


East Ship Island, MS

Peveto Woods, LA

HIERARCHY OF HABITAT USE

Extrinsic factors important at broad geographic scale



Intrinsic factors important at more local scale

EN ROUTE CHALLENGES

Adjust to unfamiliar habitats

Acquire food in short time

Contend with competitors

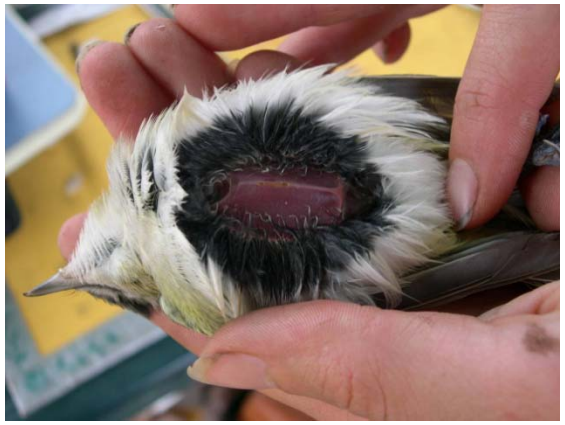
Avoid predators

Maintain health

Find/maintain the right direction

Gain adequate sleep

Cope with adverse weather



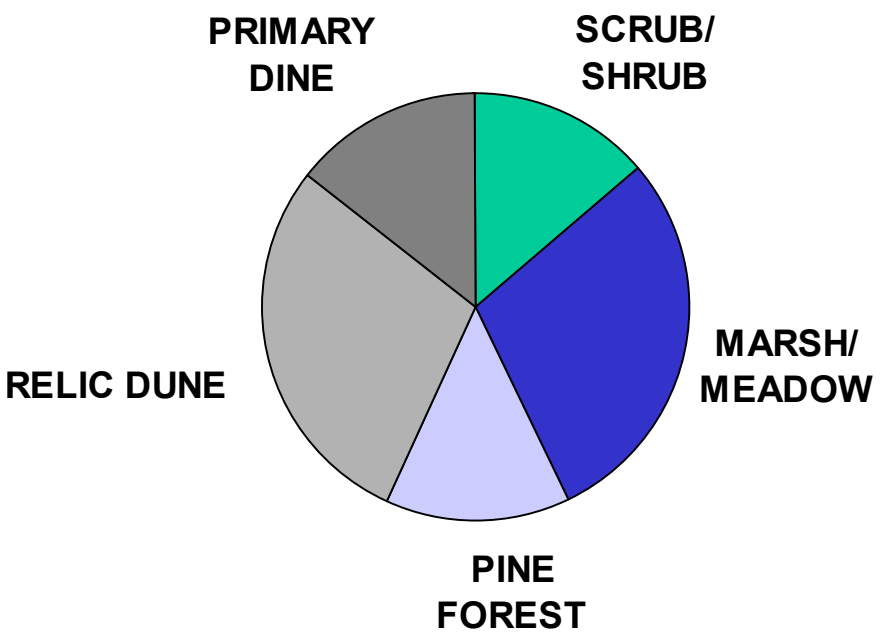
HABITAT USE DURING STOPOVER

Red-eyed Vireo
Vireo olivaceus

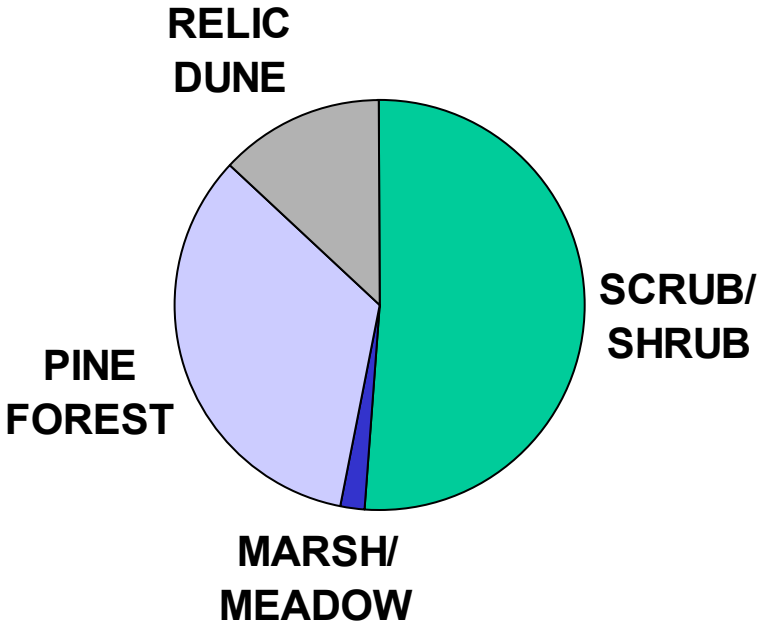
GUIS: Horn Island

SPRING HABITAT SELECTION
HORN ISLAND, MISSISSIPPI

AVAILABILITY



REVI HABITAT USE



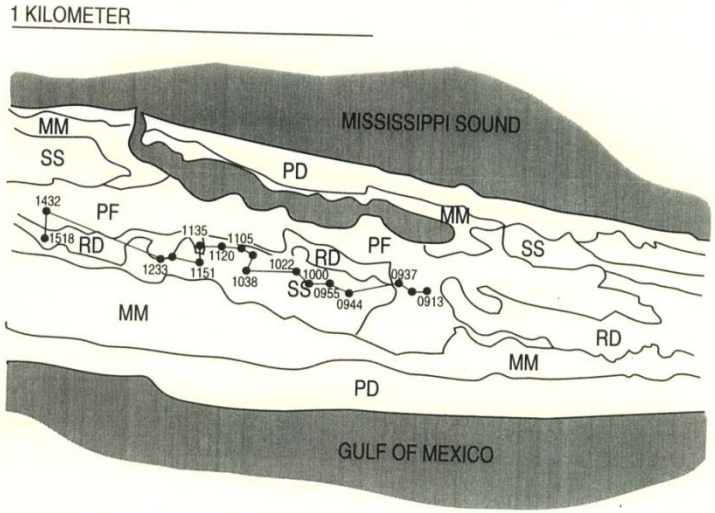
RADIO TELEMETRY

SUMMER TANAGER

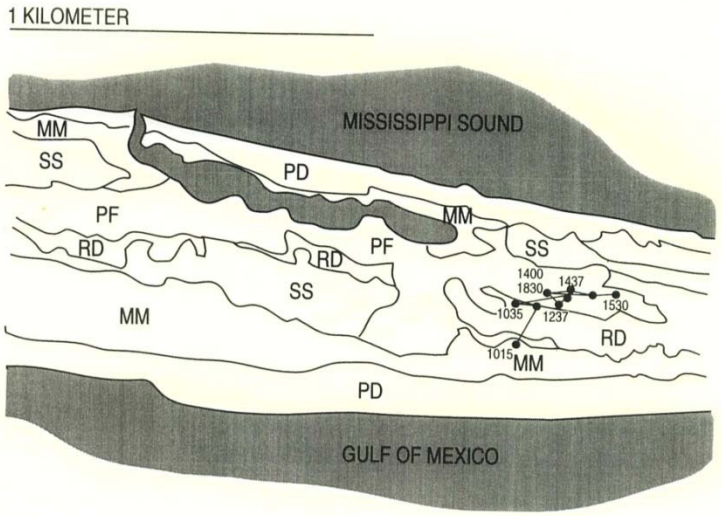
GUIS: HORN ISLAND

SUTA: RADIO-TRACKED MIGRANTS

LEAN

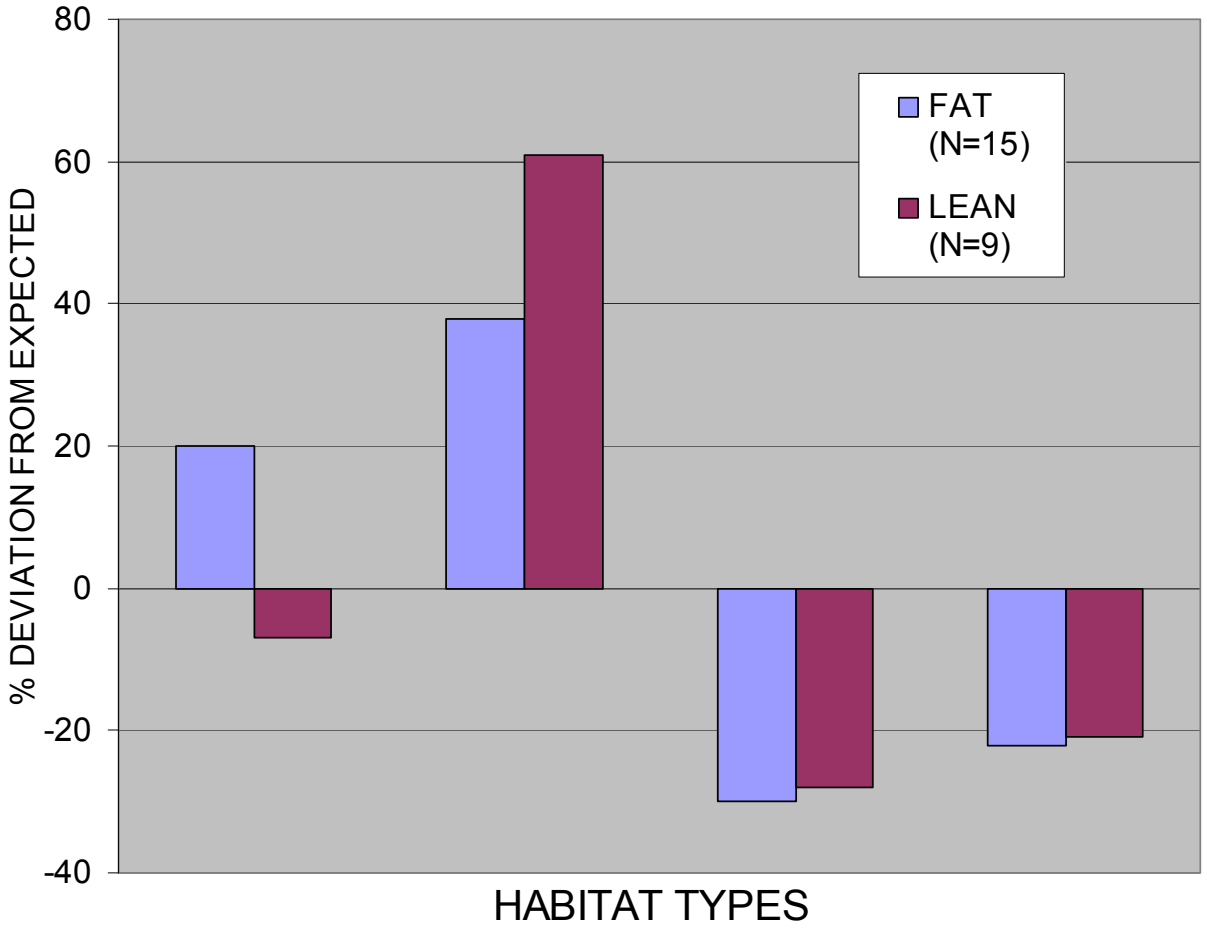


FAT

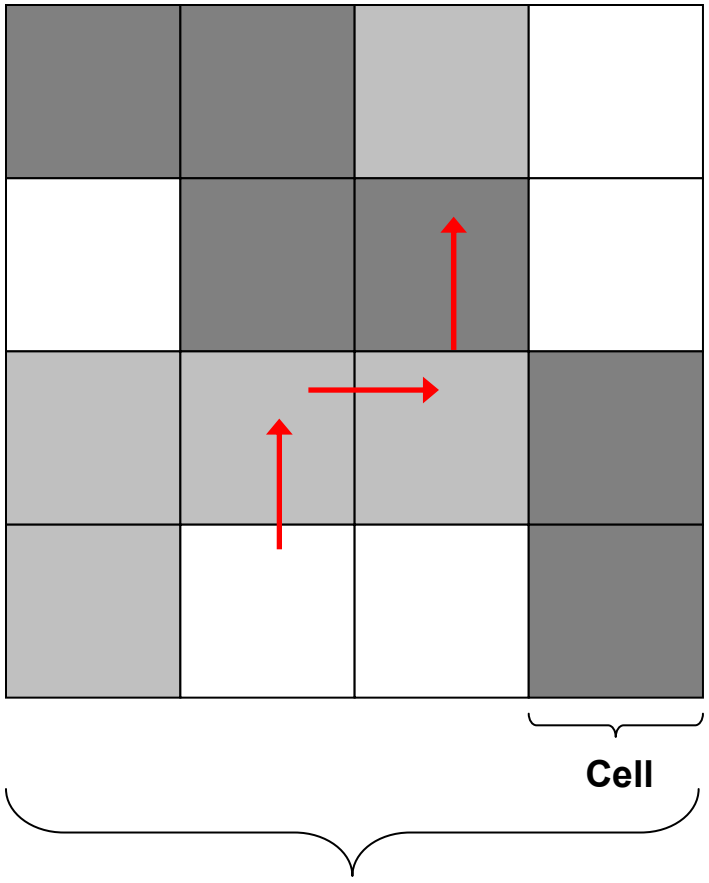


SUTA HABITAT USE HORN ISLAND:

PINE - SCRUB - MARSH - RELIC DUNE



Individual-based Modeling



Individual Bird (⟶)

- Grid landscape
- Cells = habitat types with a quality
- Quality = energetic cost & benefits
- Stepwise movements based on energetic status after a period of time in a cell and the quality of adjacent cells.
- Threshold energetic gain/loss = continuation of migration or mortality.

EN ROUTE CHALLENGES

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Avoid predators

Maintain health

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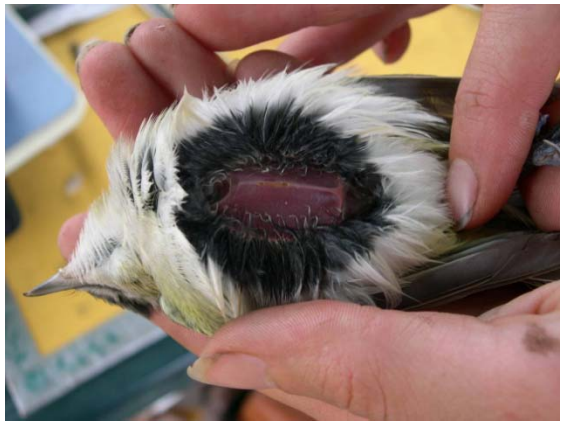
Gain adequate sleep

Cope with adverse weather



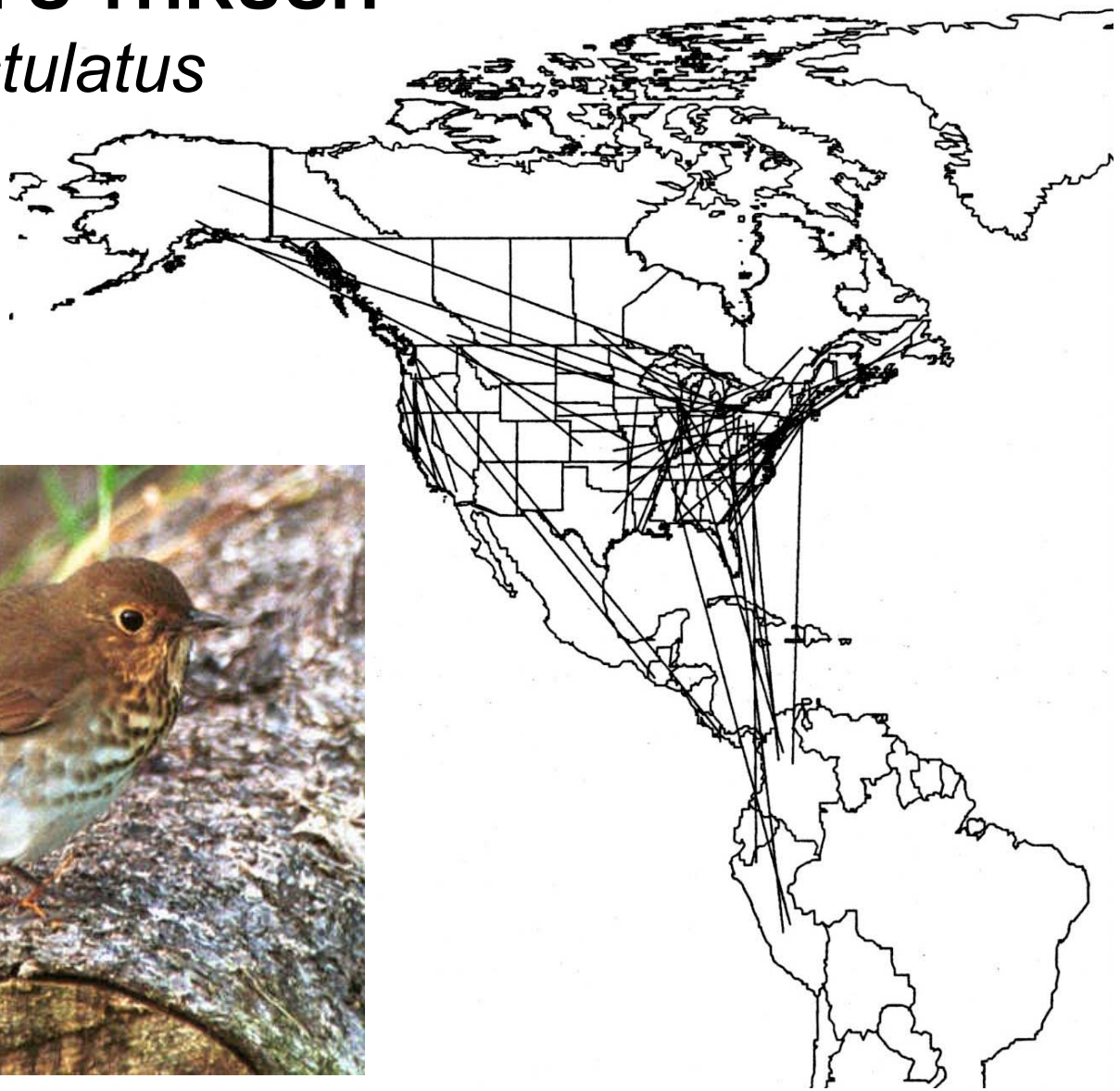
CHENIER PLAIN HABITAT
Northern Coast of the Gulf of Mexico

Wang Yong & "Assistant"

Johnson's Bayou Chenier

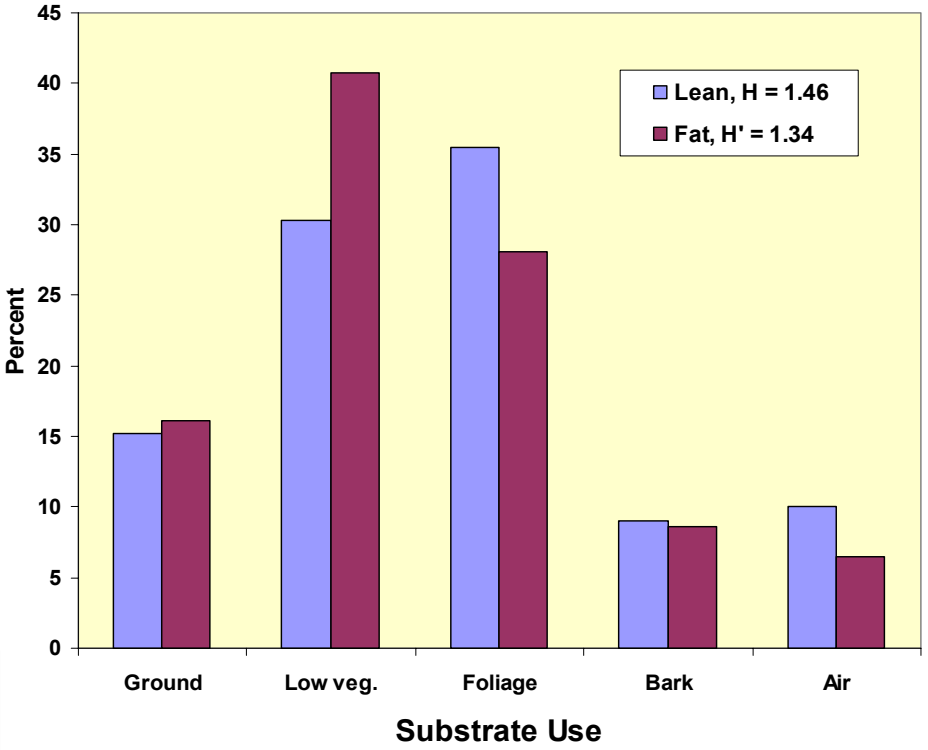
SWAINSON'S THRUSH

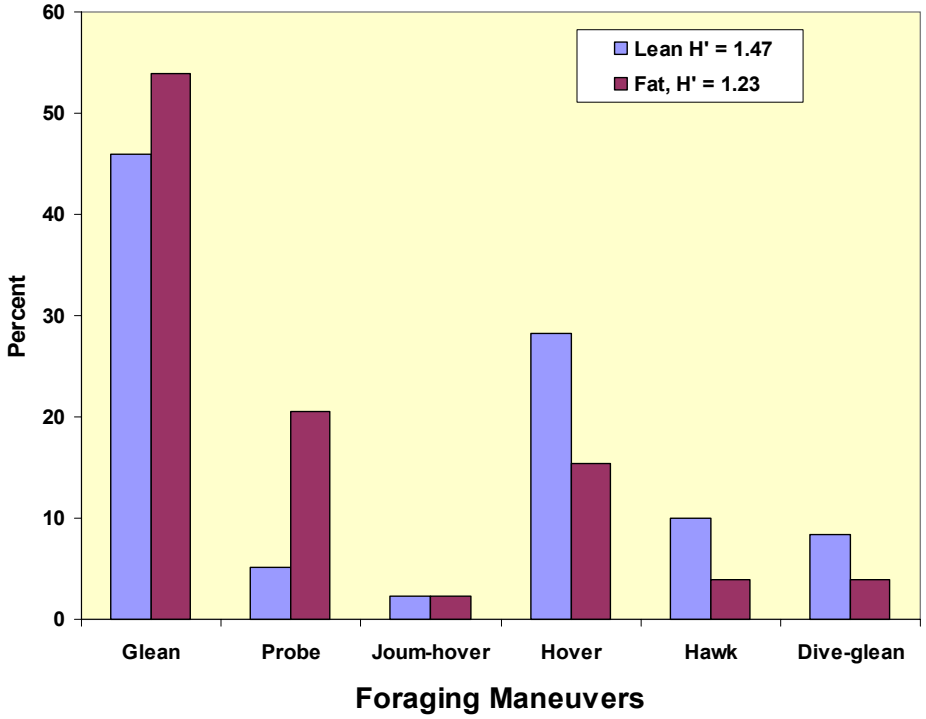
Catharus ustulatus



Do migrants adjust their foraging behavior in response to energetic demand?

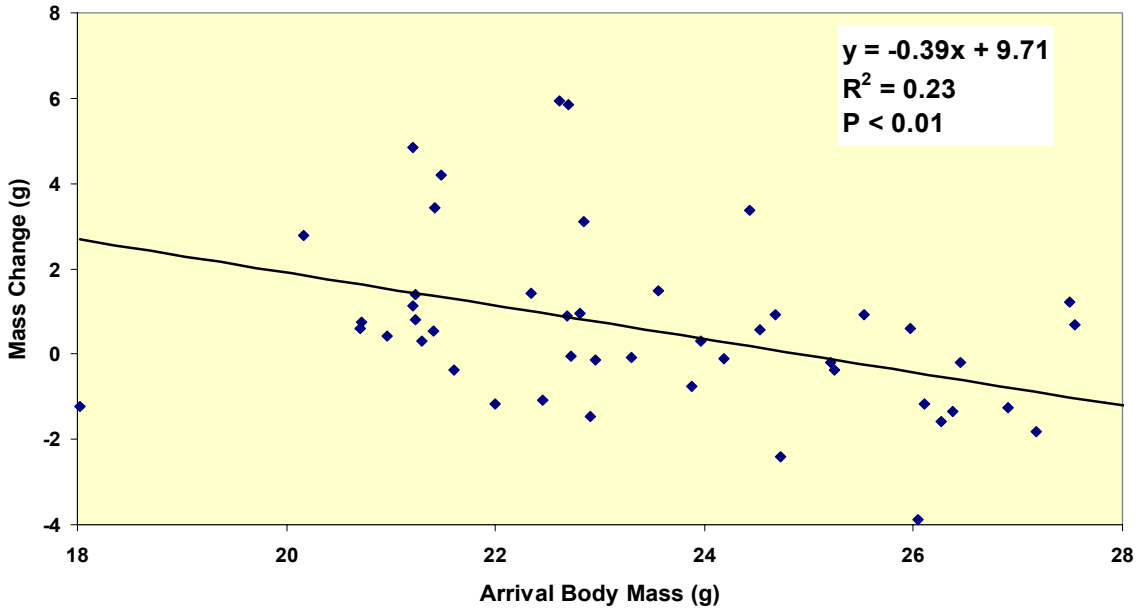
Lean migrants change their foraging behavior.



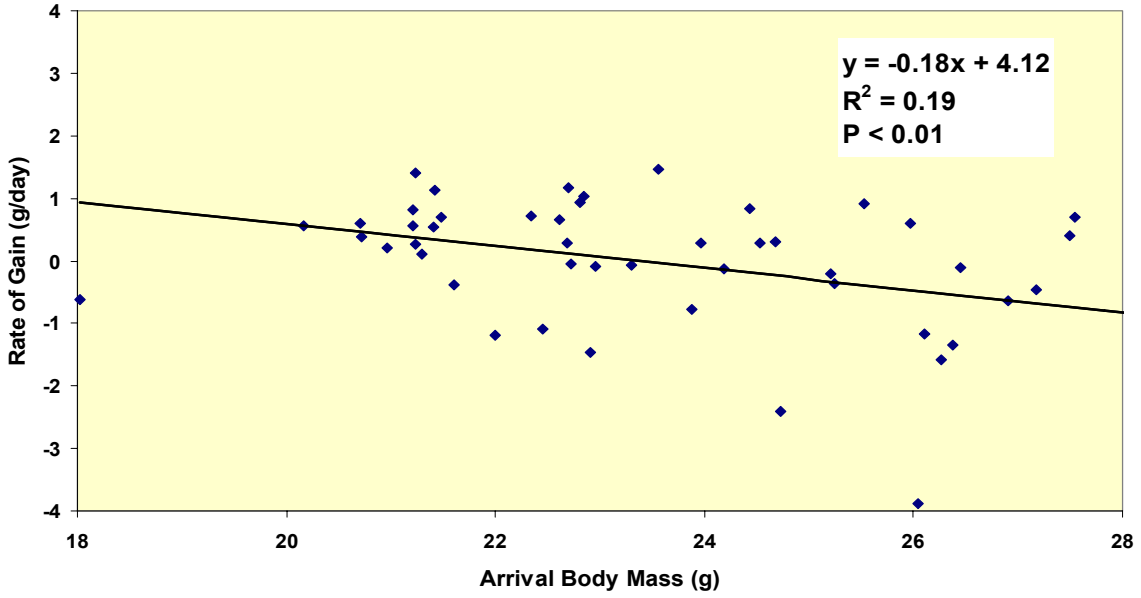


Does the change in behavior have consequences?

Mass Change



Rate of Mass Gain



EN ROUTE CHALLENGES

Adjust to unfamiliar habitats

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Avoid predators

Maintain health

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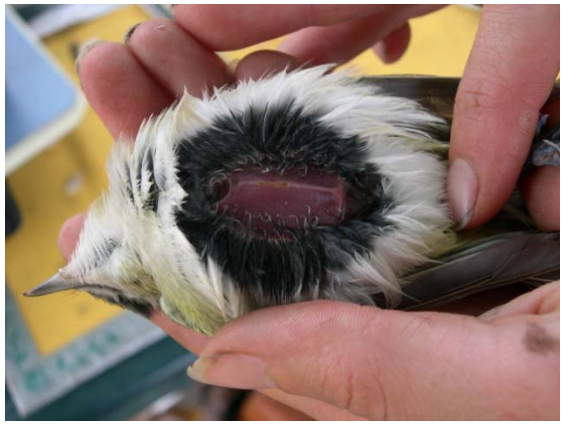
Gain adequate sleep

Cope with adverse weather



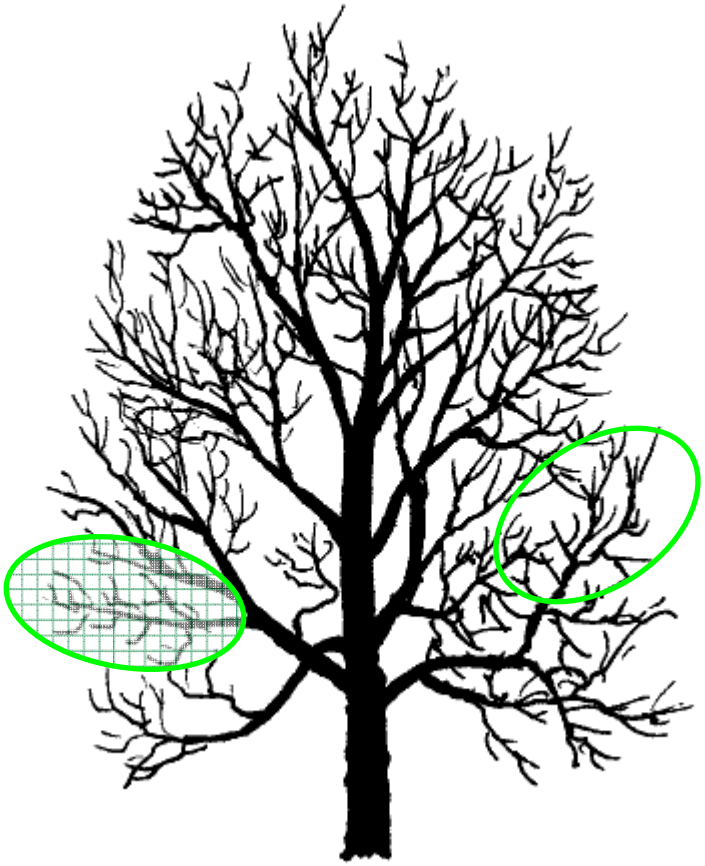
EN ROUTE COMPETITION

- Migrants often concentrated during stopover
- Depress availability of food: Exclosure Experiment
- Interfere with rate of food intake

En Route Competition: Exclosure Experiment

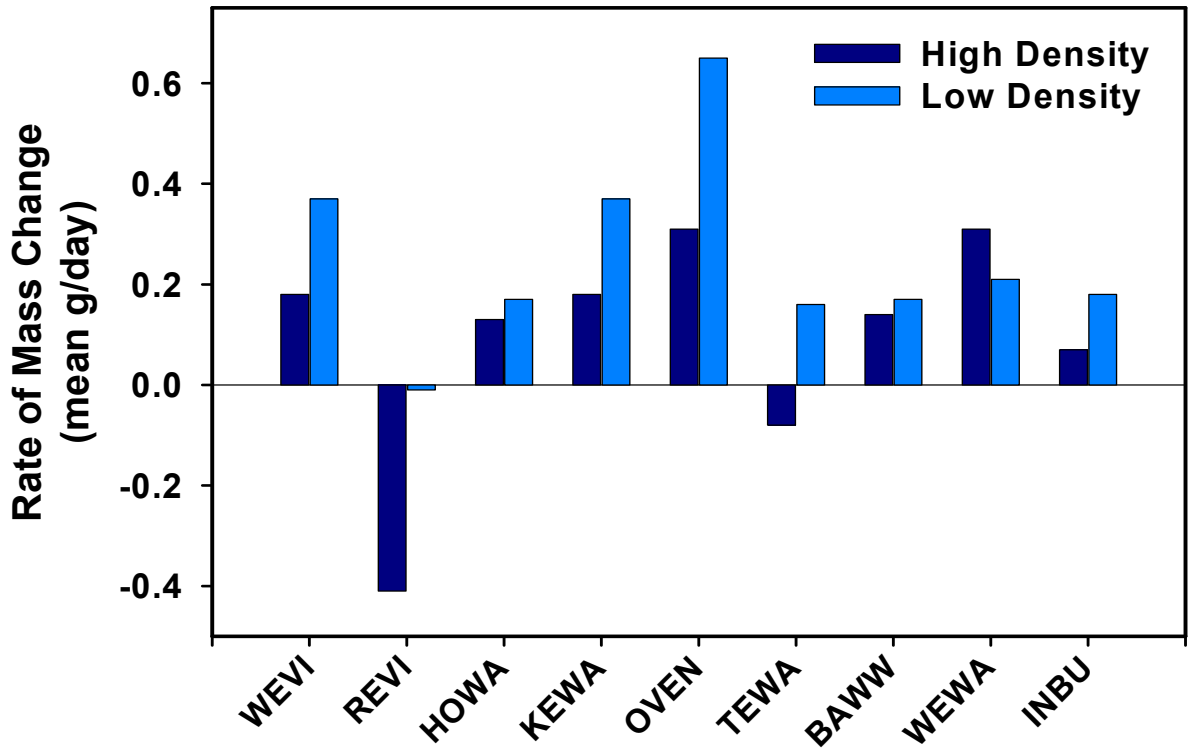
- Chenier study site
- Hackberry trees
- Paired design

- Significantly reduced insect numbers within exclosures
- Migrants depress food



CONSEQUENCES?

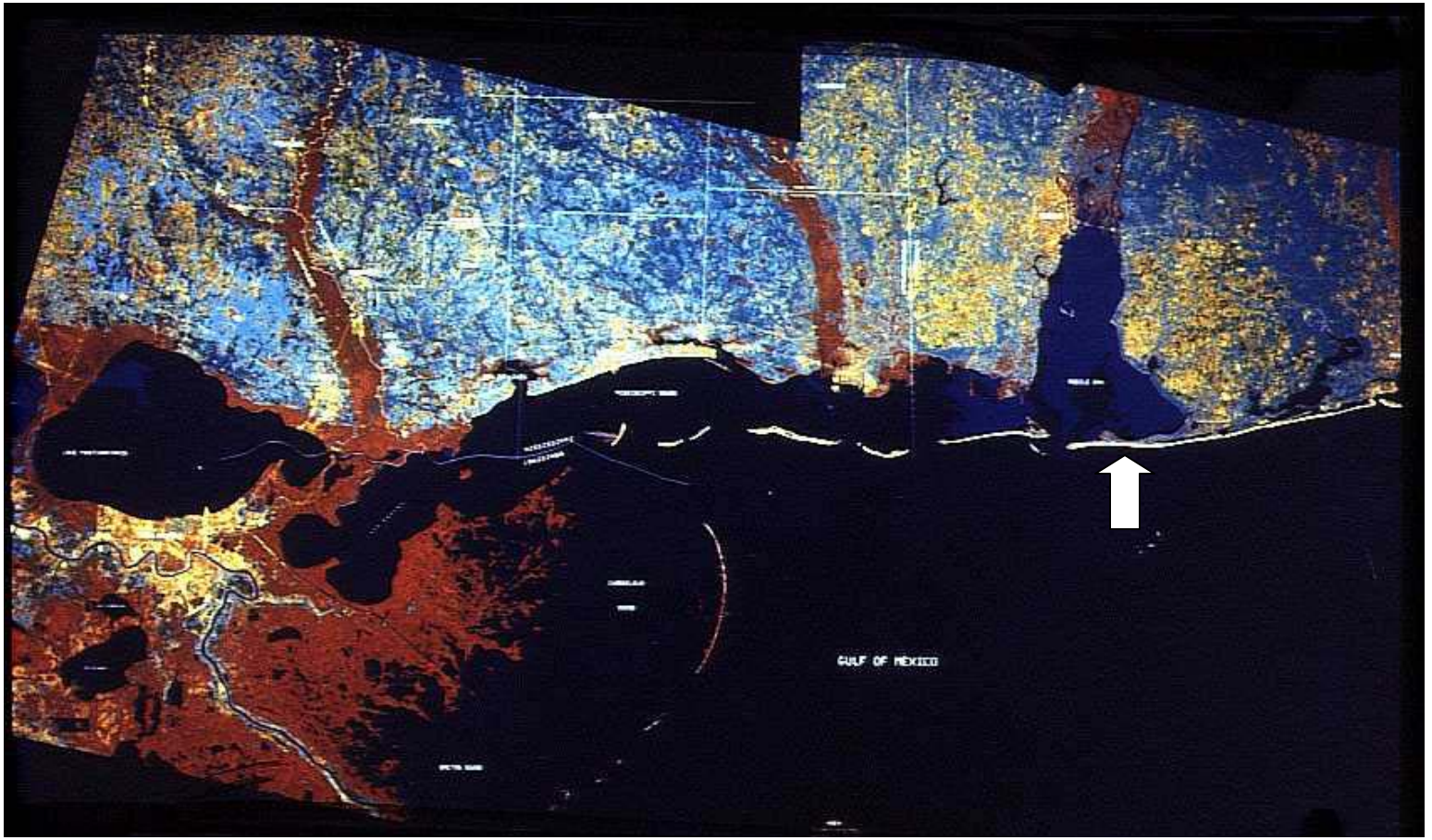
CONSEQUENCES OF COMPETITION



Risk of Predation

- Predation risk variable and unpredictable
- Migrants often carry large fat stores
- Migrants experience high energy demands
- Pressure to travel quickly
- Lack of information about predation risks and foraging opportunities

FT. MORGAN PENINSULA
Northern Coast of the Gulf of Mexico

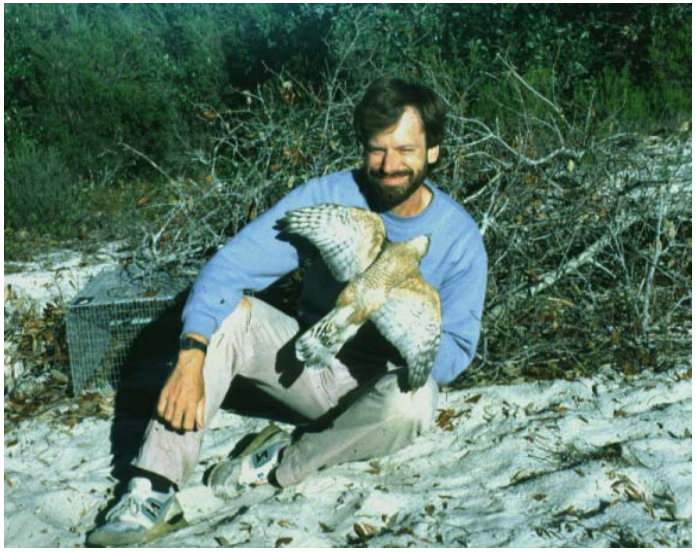


CONFLICTING DEMANDS AND RISK ASSESSMENT:

FAT versus LEAN
YOUNG versus OLD

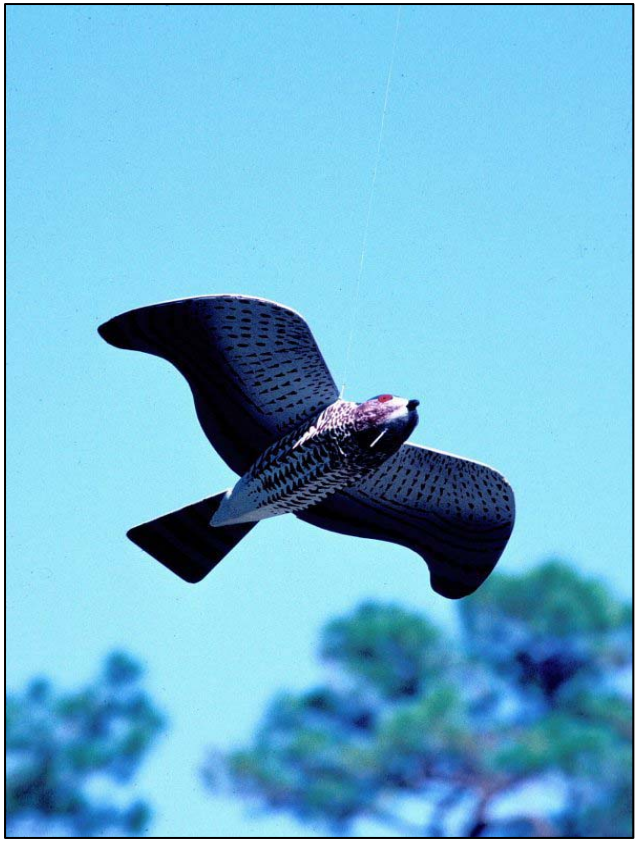
GRAY CATBIRD

COOPER'S HAWK MODEL



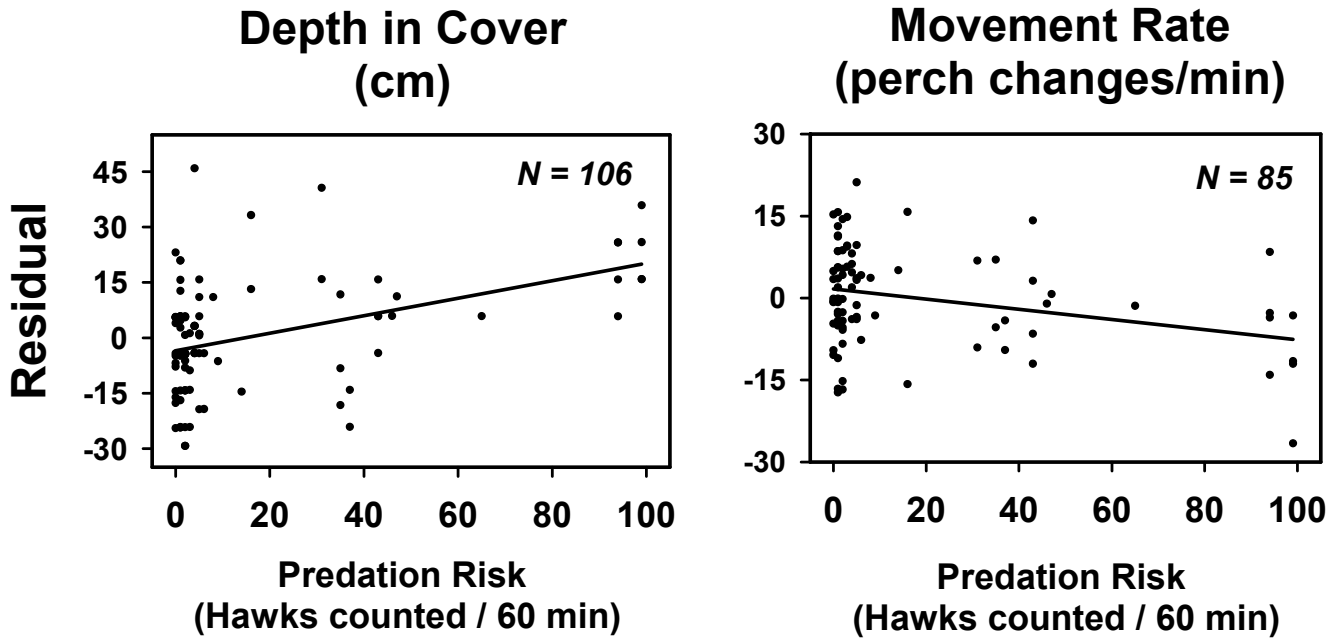
David Cimprich

Blue-Gray Gnatcatcher: Risk Assessment

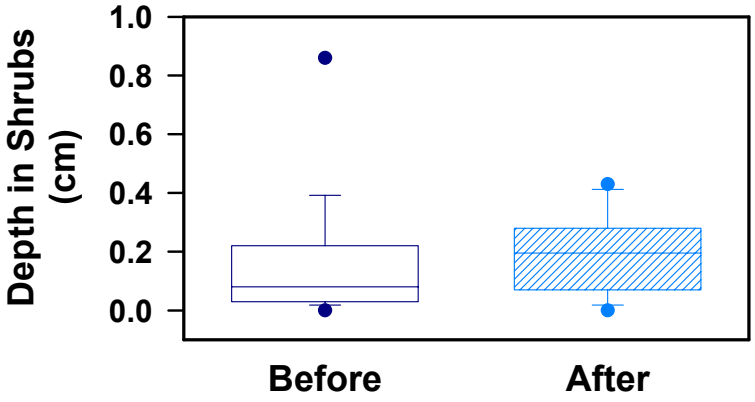


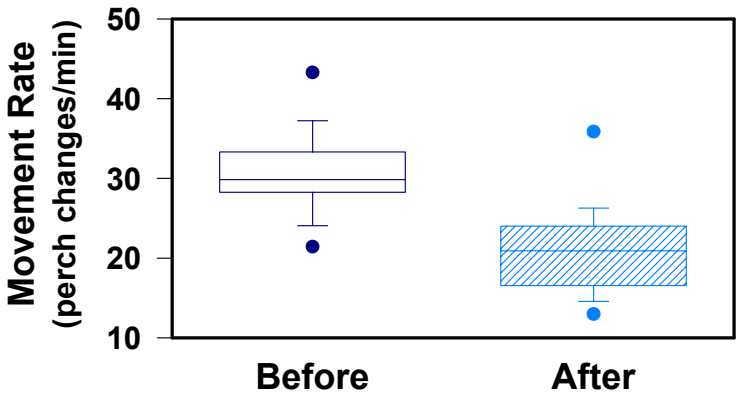
Sharp-Shinned Hawk Glide Model

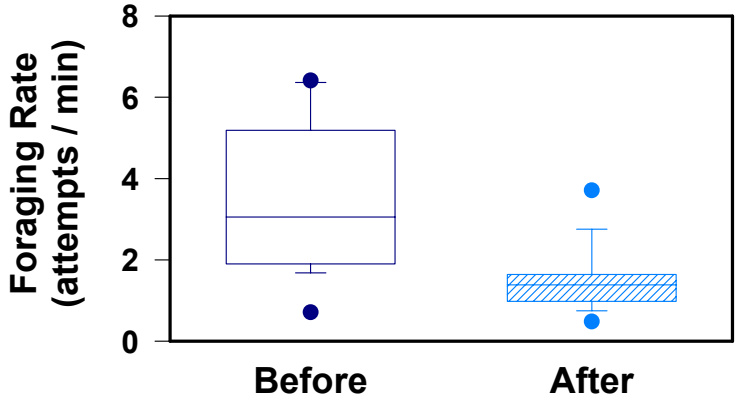
BLUE-GRAY GNATCATCHER RESPONSE TO FREE-FLYING AVIAN PREDATORS



BLUE-GRAY GNATCATCHER RESPONSE TO MODEL HAWK







Response to Risk of Predation Interpretation

- Migrants assess risk of predation during stopover
- Anti-predator responses may restrict food intake

EN ROUTE PROBLEMS

Adjust to unfamiliar habitats

Acquire food in short time

Contend with competitors

Avoid predators

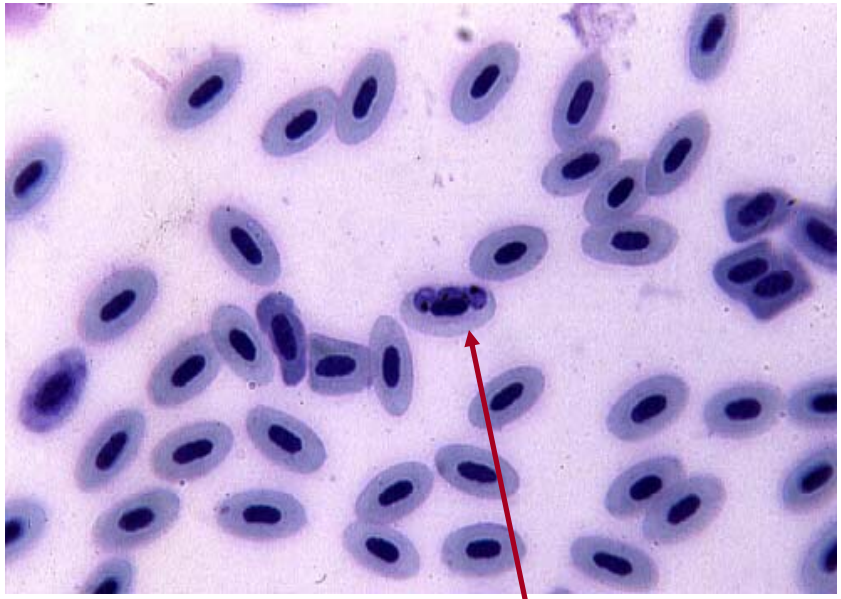
Resolve conflicting demands

Maintain health

Finding the right direction

Gain adequate sleep

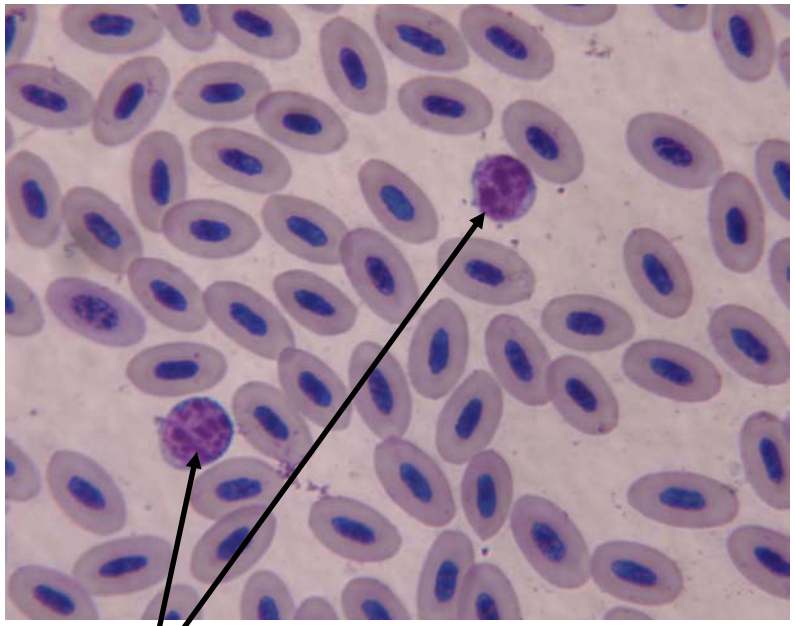
Cope with adverse weather



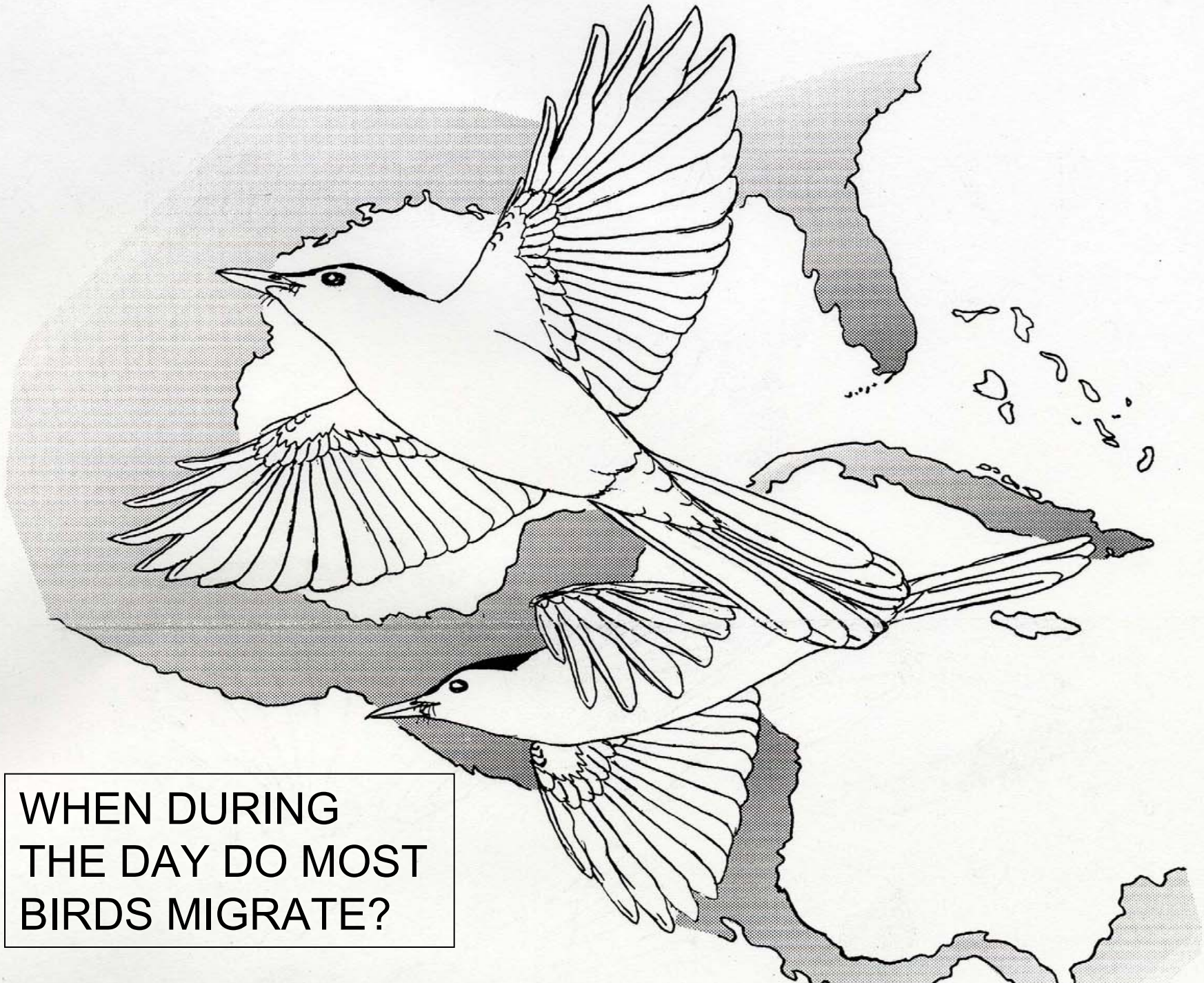
Haemoproteus
BLOOD PARASITE

PARASITES, MICROBES, AND IMMUNOCOMPETENCE

- Energetically Demanding Period
- Exposed to Diverse Flora & Fauna

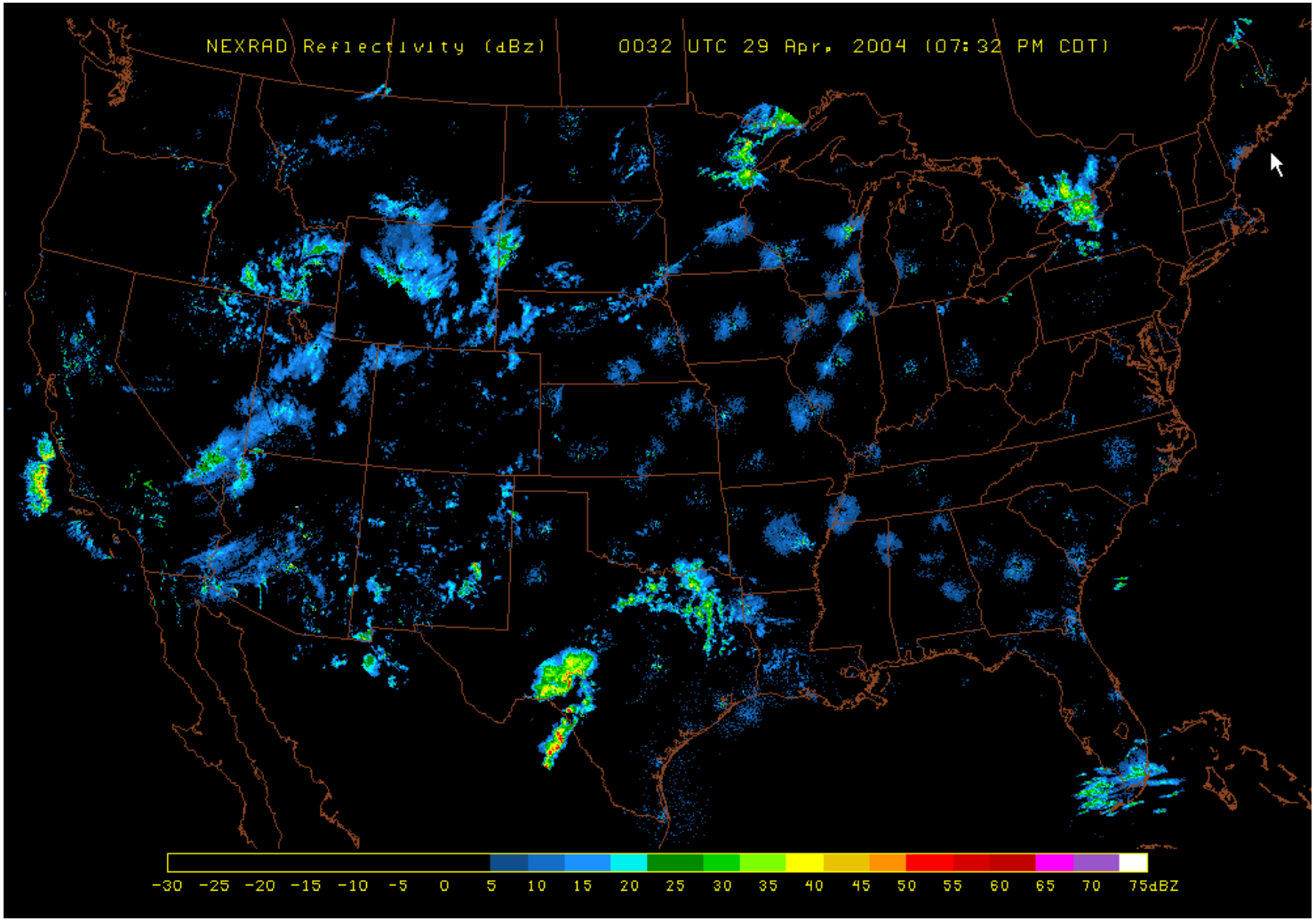


2 Lymphocytes (1000x)



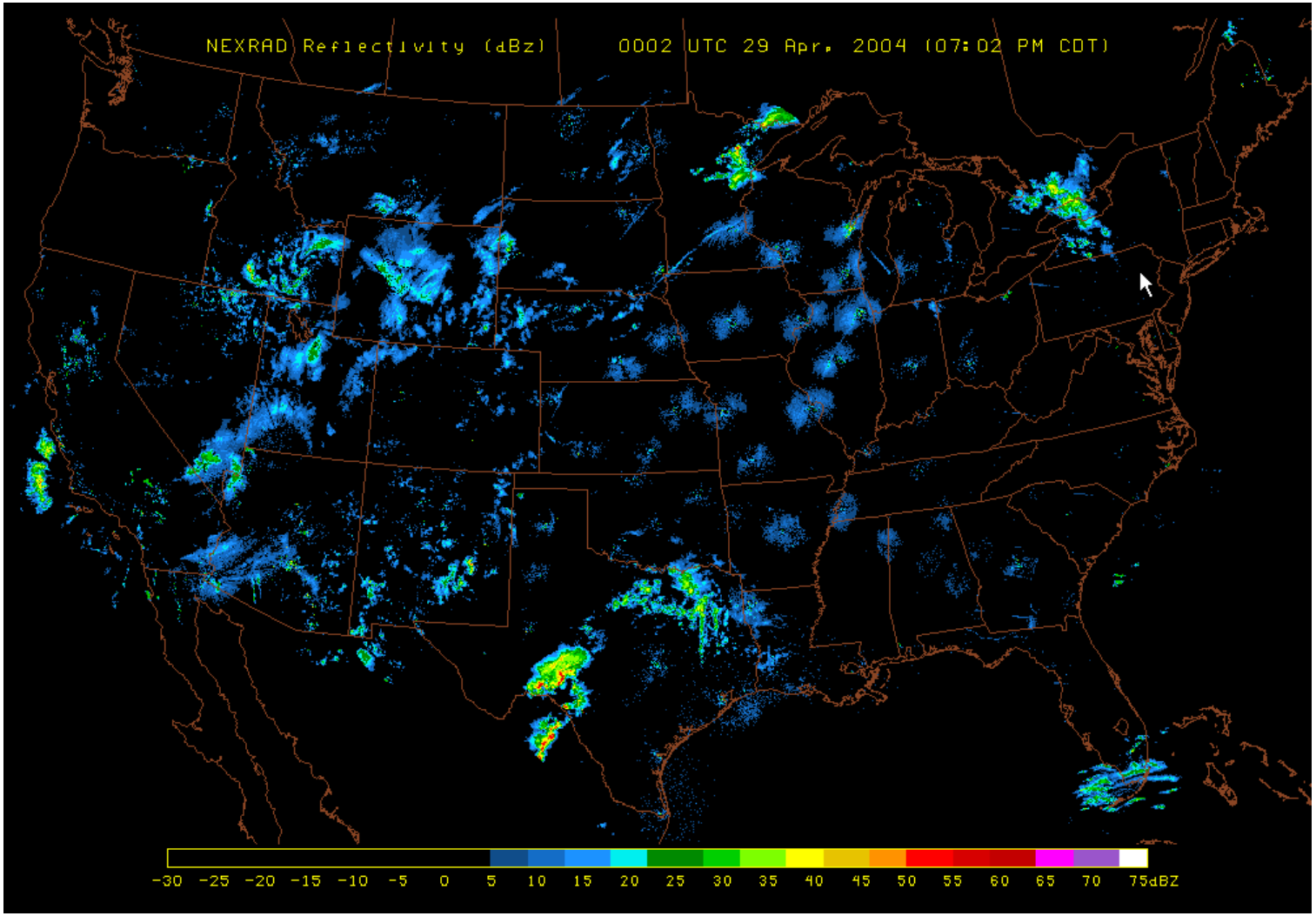
WHEN DURING THE DAY DO MOST BIRDS MIGRATE?

Spatial – Temporal Pattern of Migration



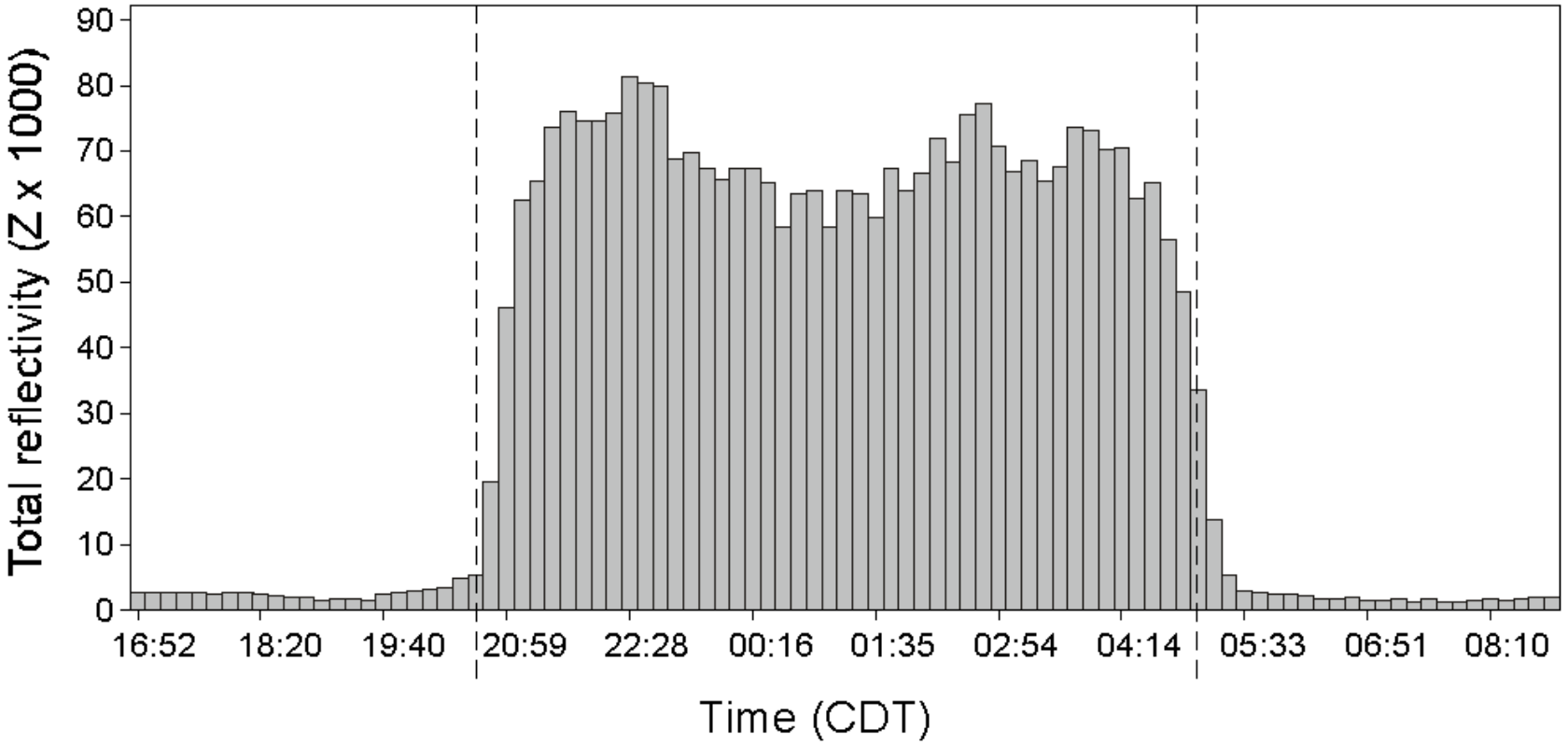
NEXRAD Reflectivity National Composite

Spatial – Temporal Pattern of Migration



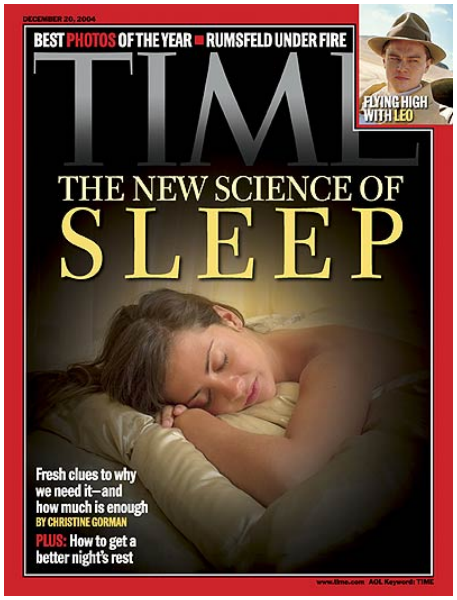
NEXRAD Reflectivity National Composite: Robert Diehl. Personal communication

DIEL PATTERN OF MIGRATION



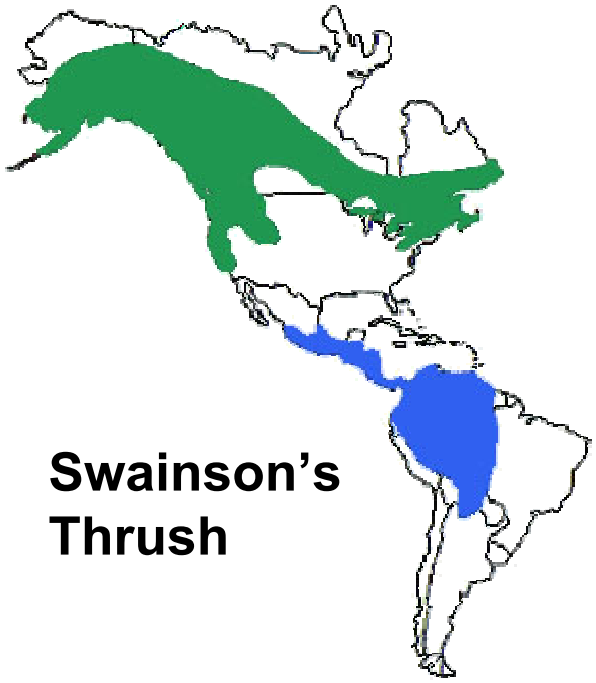
Diehl, R. H. and R. P. Larkin. 2007. Proc. Third International Partners in Flight Conference. (Ralph and Rich, eds.). USDA Forest Service, Albany, CA.

Migratory Birds and Sleep



- A migrant loses substantial opportunity for nighttime sleep during the migratory season.
- Negative consequences?
- In response, migrants likely evolved compensatory mechanism(s). For example, migratory birds might sleep more during the day. But too much daytime sleep might compromise a bird's ability to replenish energy supplies needed for subsequent flights and increase the risk of predation.
- Natural selection may have promoted other mechanisms for sleep compensation such as uni-hemispheric sleep.

Migratory Birds and Sleep Loss



Swainson's Thrush

- Tested hypothesis that migrants compensate for sleep loss through collaboration with neurobiologists at Bowling Green State University

- Conducted behavioral and electro-physiological analysis of sleep

Nighttime sleep

Back Sleep

Front Sleep

Drowsiness

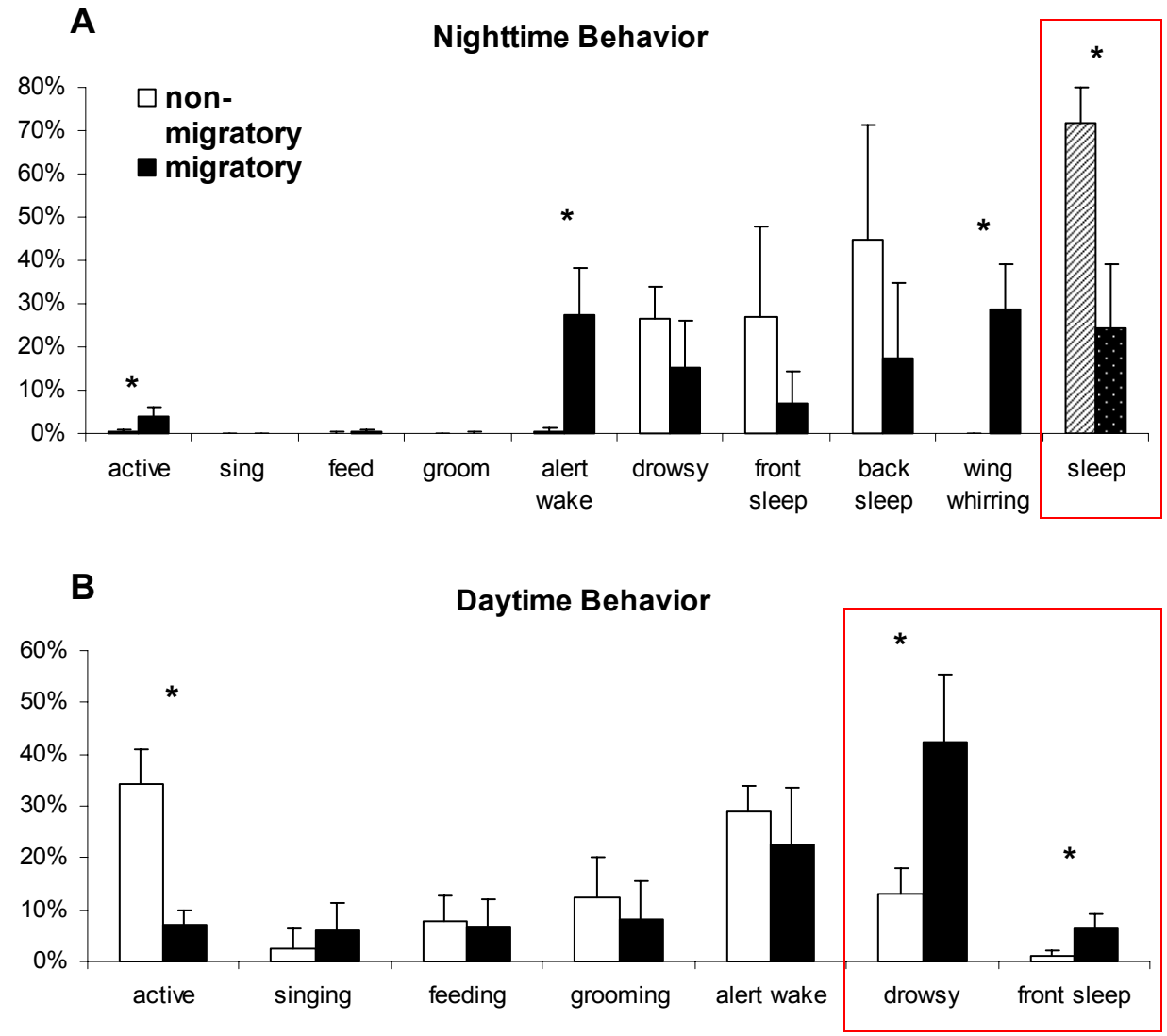
An intermediate state between sleep and wakefulness, occurring during day and night time.

Nocturnal activity (Migratory restlessness)

Wing Whirring

Quiet Wakefulness

Migratory vs. Non-Migratory State



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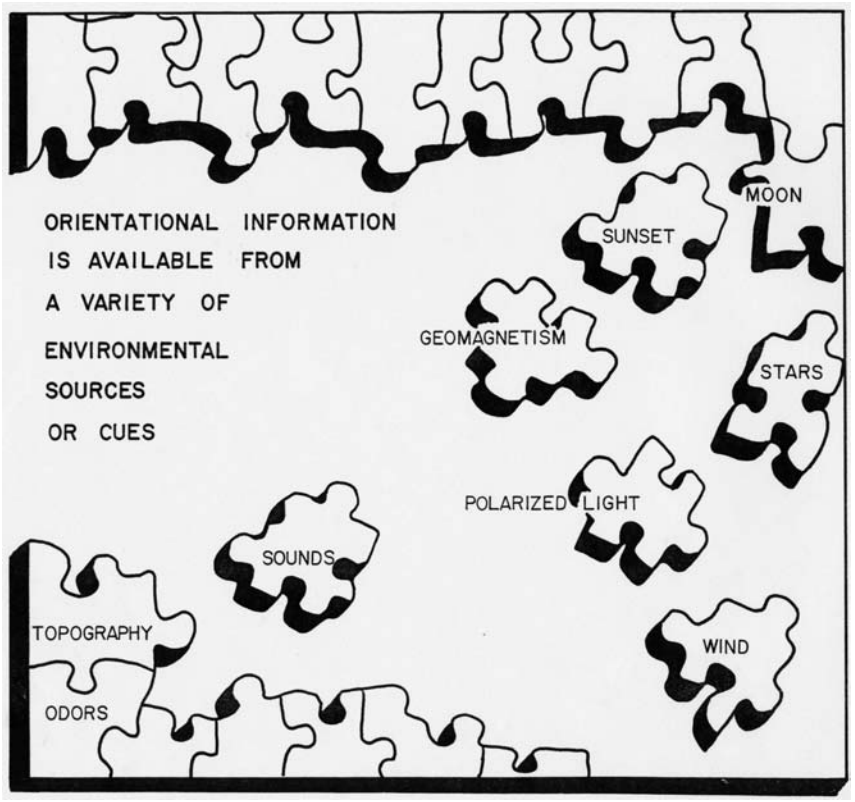
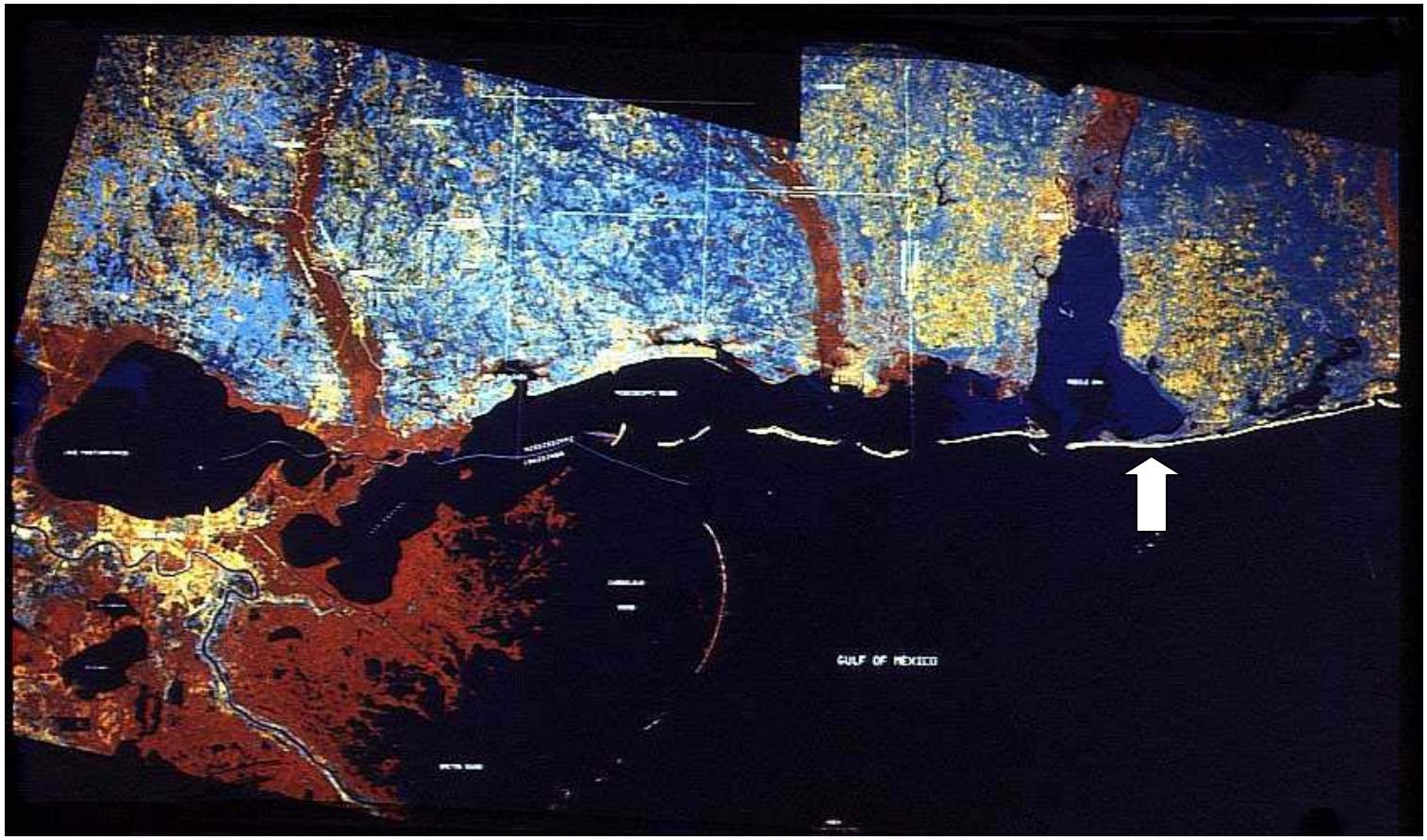


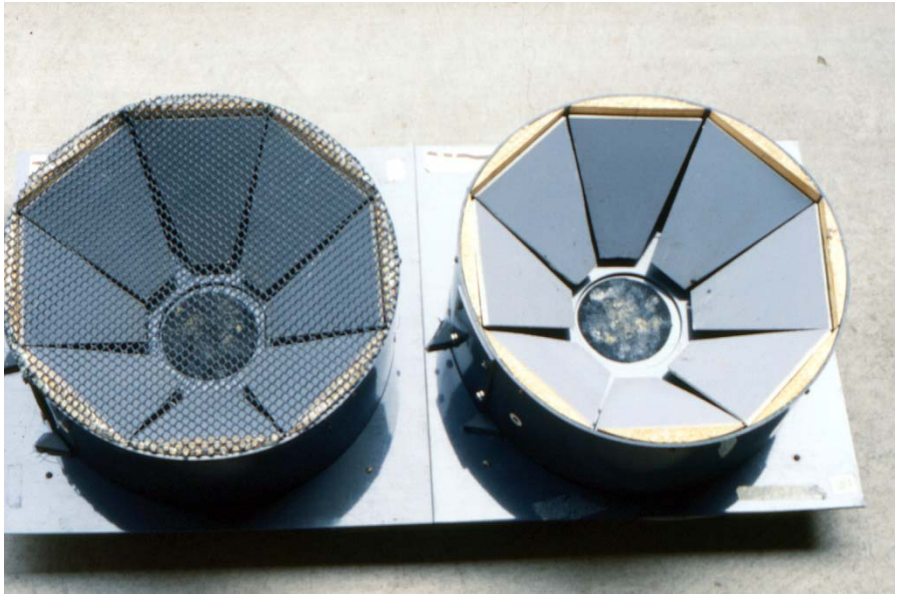
RESEARCH HYPOTHESES

- Energy Stores Influence the Decision to Migrate
- Energy Stores Influence the Choice of Migratory Direction
- Geographic Context Influences Integration of Directional Information

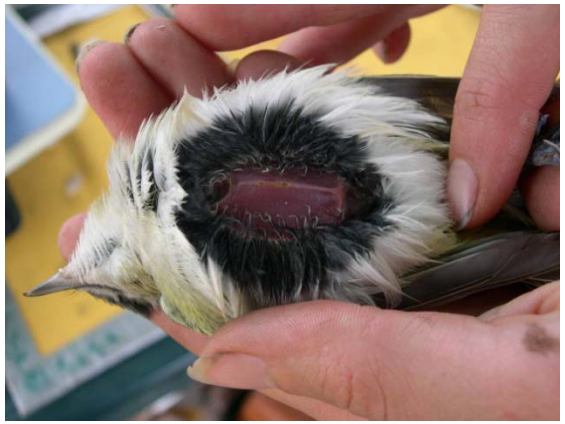
FT. MORGAN PENINSULA
Northern Coast of the Gulf of Mexico



RED-EYED VIREO
Vireo olivaceus

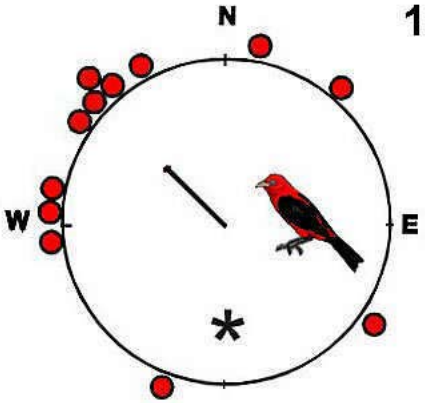


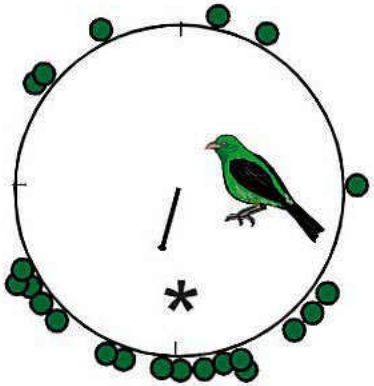
ORIENTATION – ACTIVITY CAGES



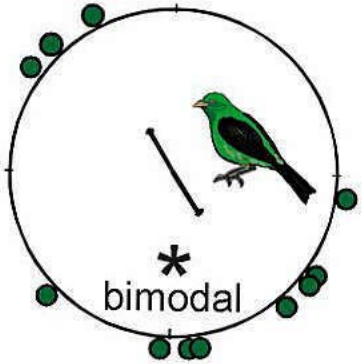
Red-eyed Vireo
1997 -1998

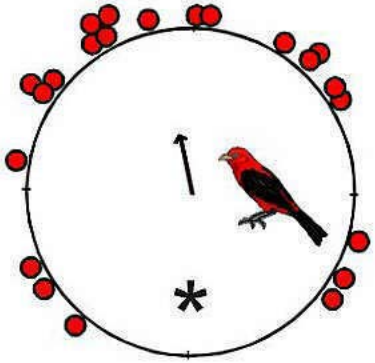
Test 1.





2.





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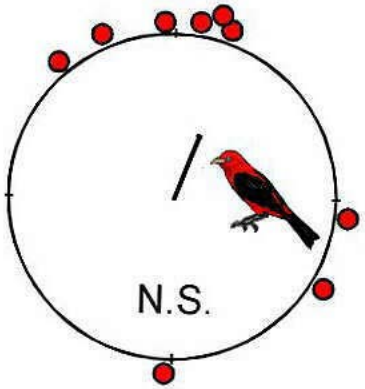
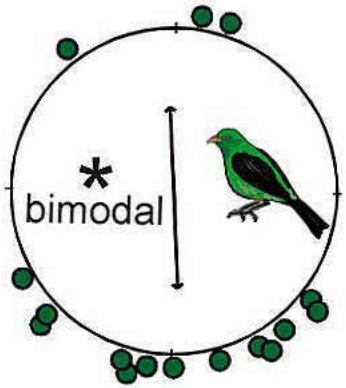


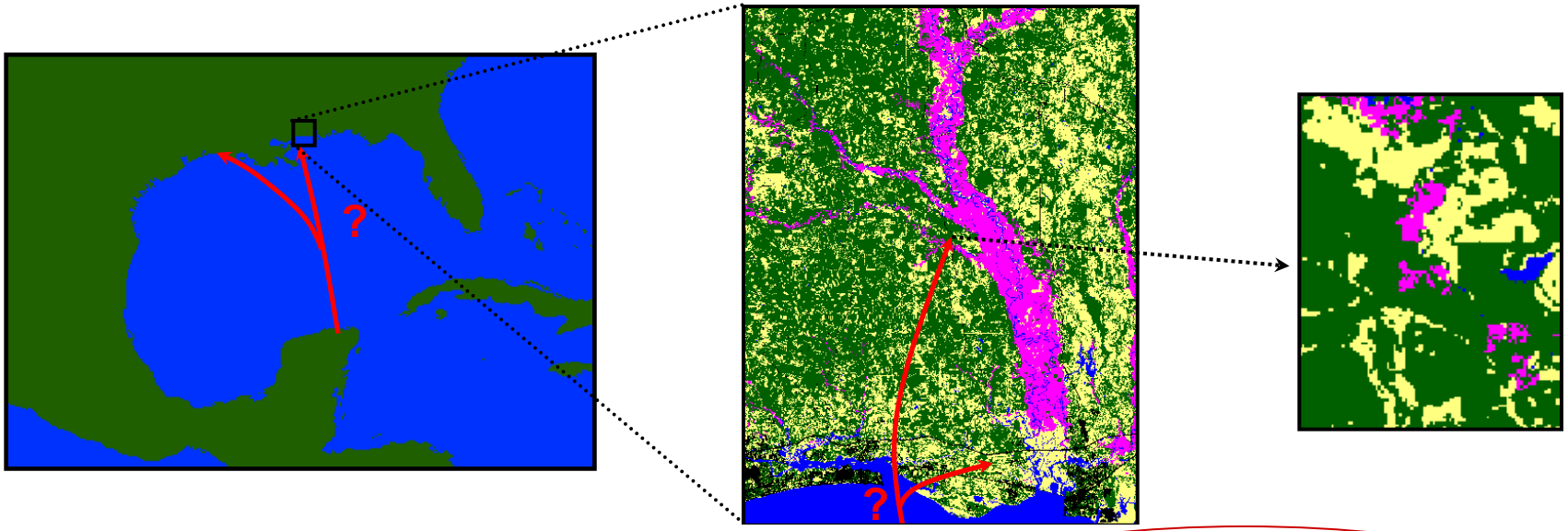


OBJECTIVES

- Examine migrant response to challenges that arise during stopover
- Emphasize that migrant - habitat relationship is scale dependent
- Appreciate linkage/transition between phases of the annual cycle

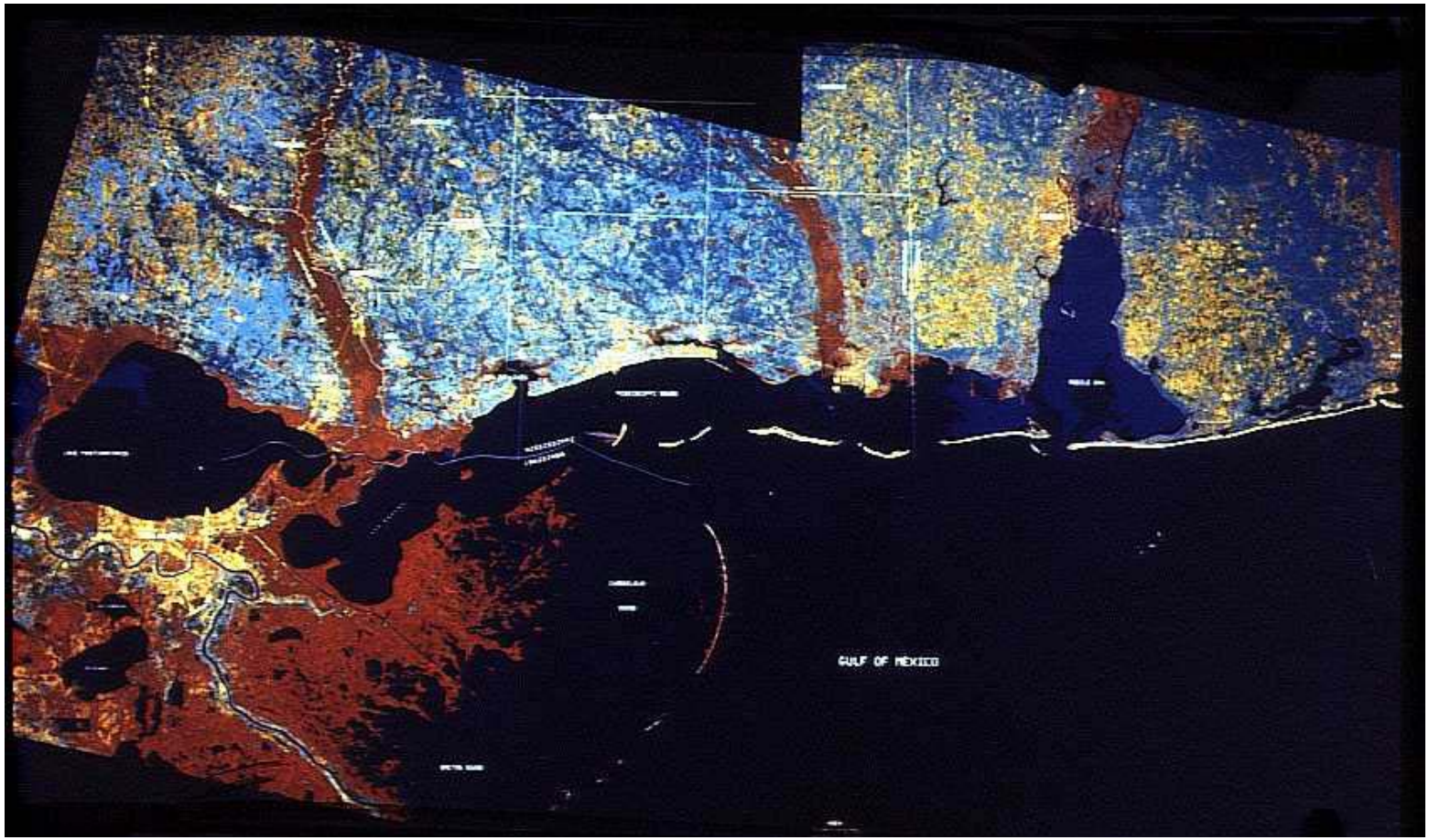
HIERARCHY OF HABITAT USE

Extrinsic factors important at broad geographic scale

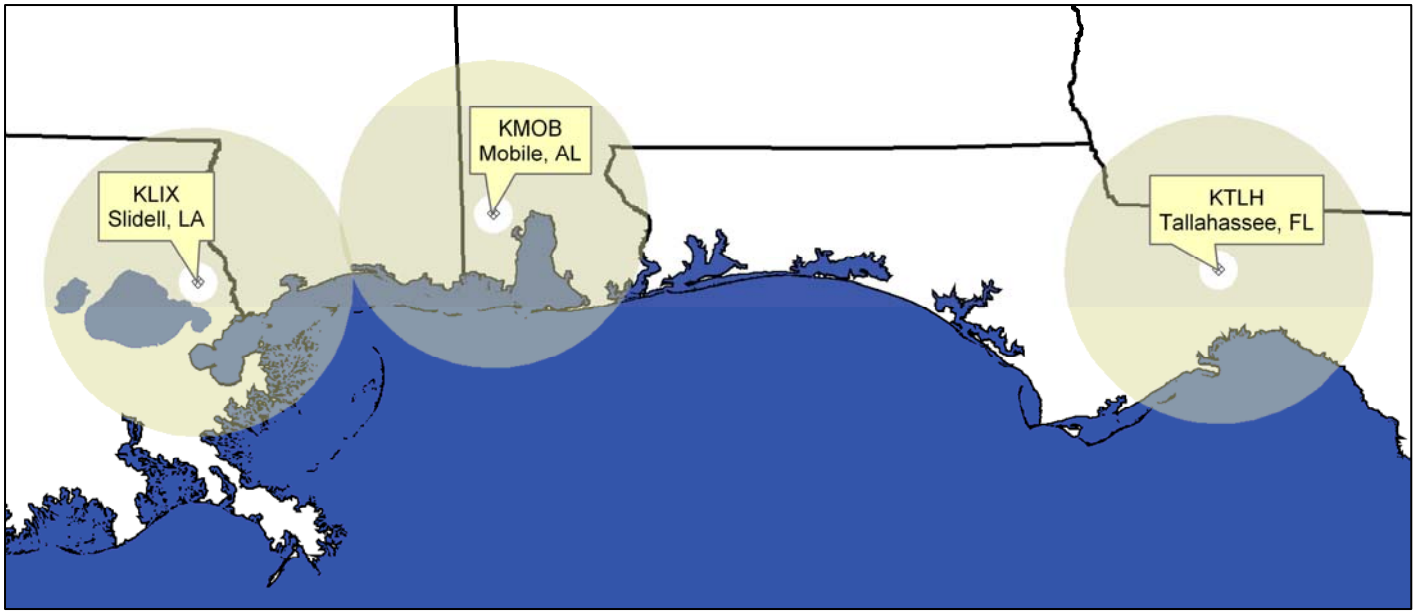


Intrinsic factors important at more local scale

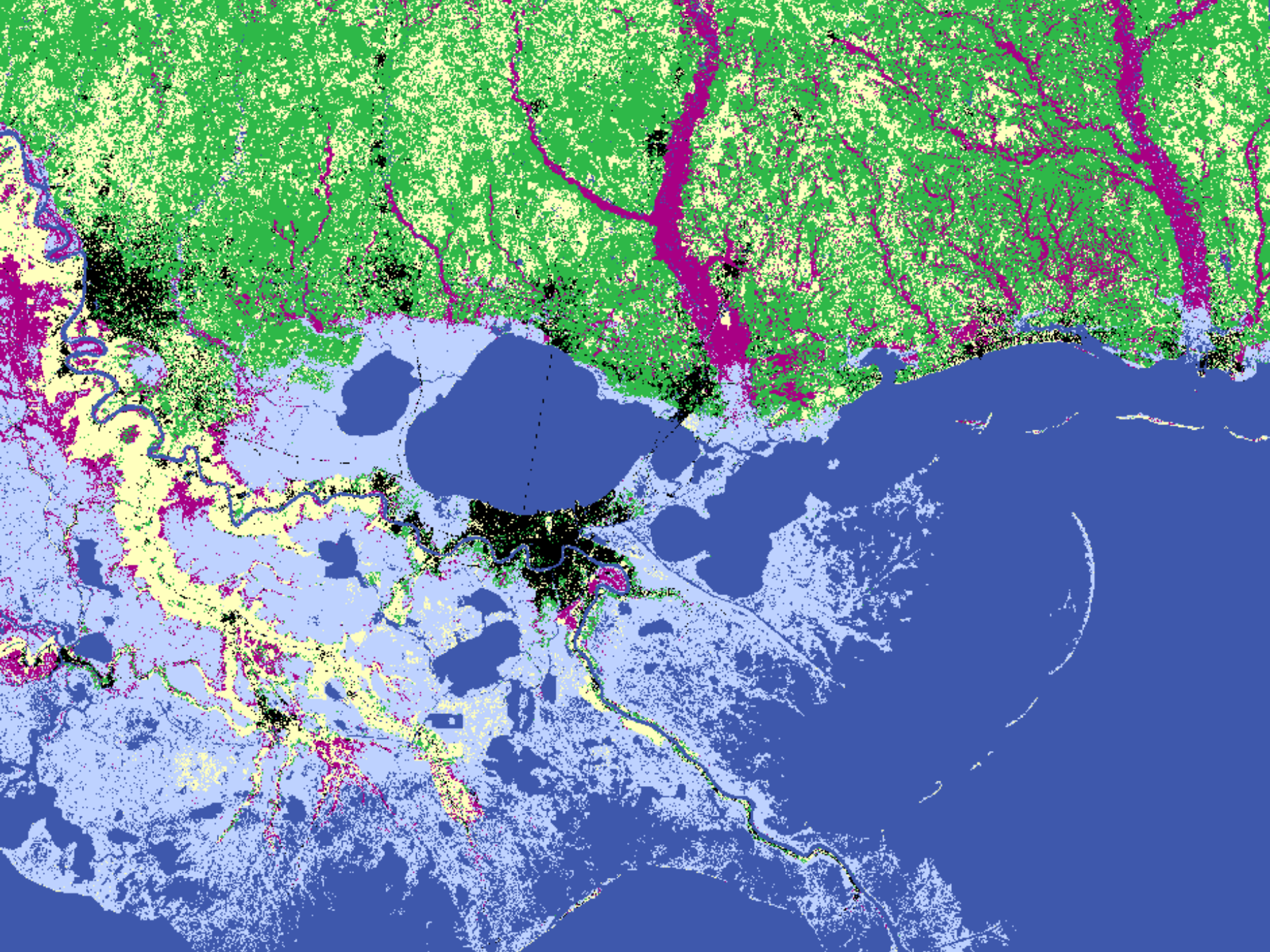
Northern Coast of the Gulf of Mexico

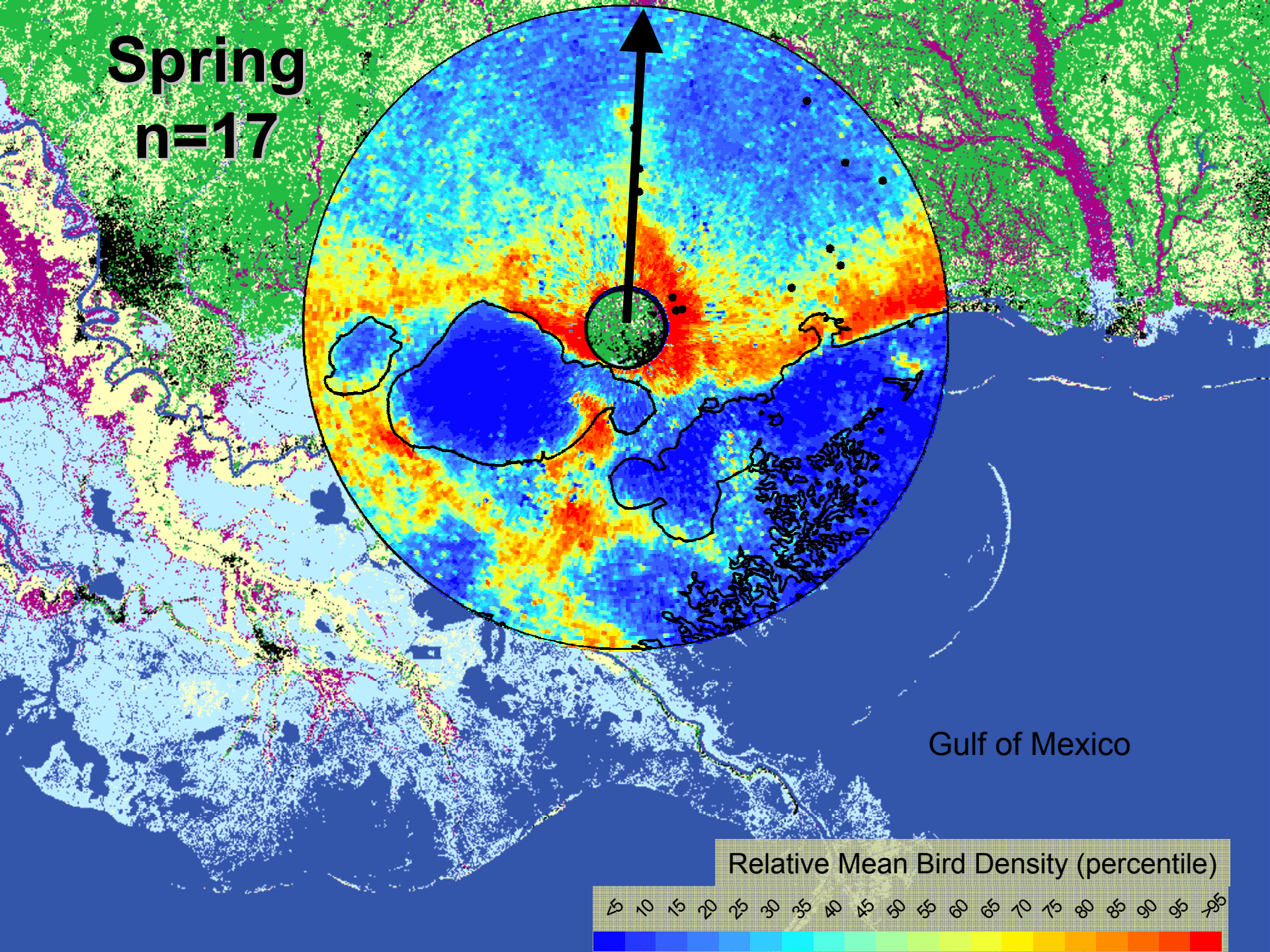


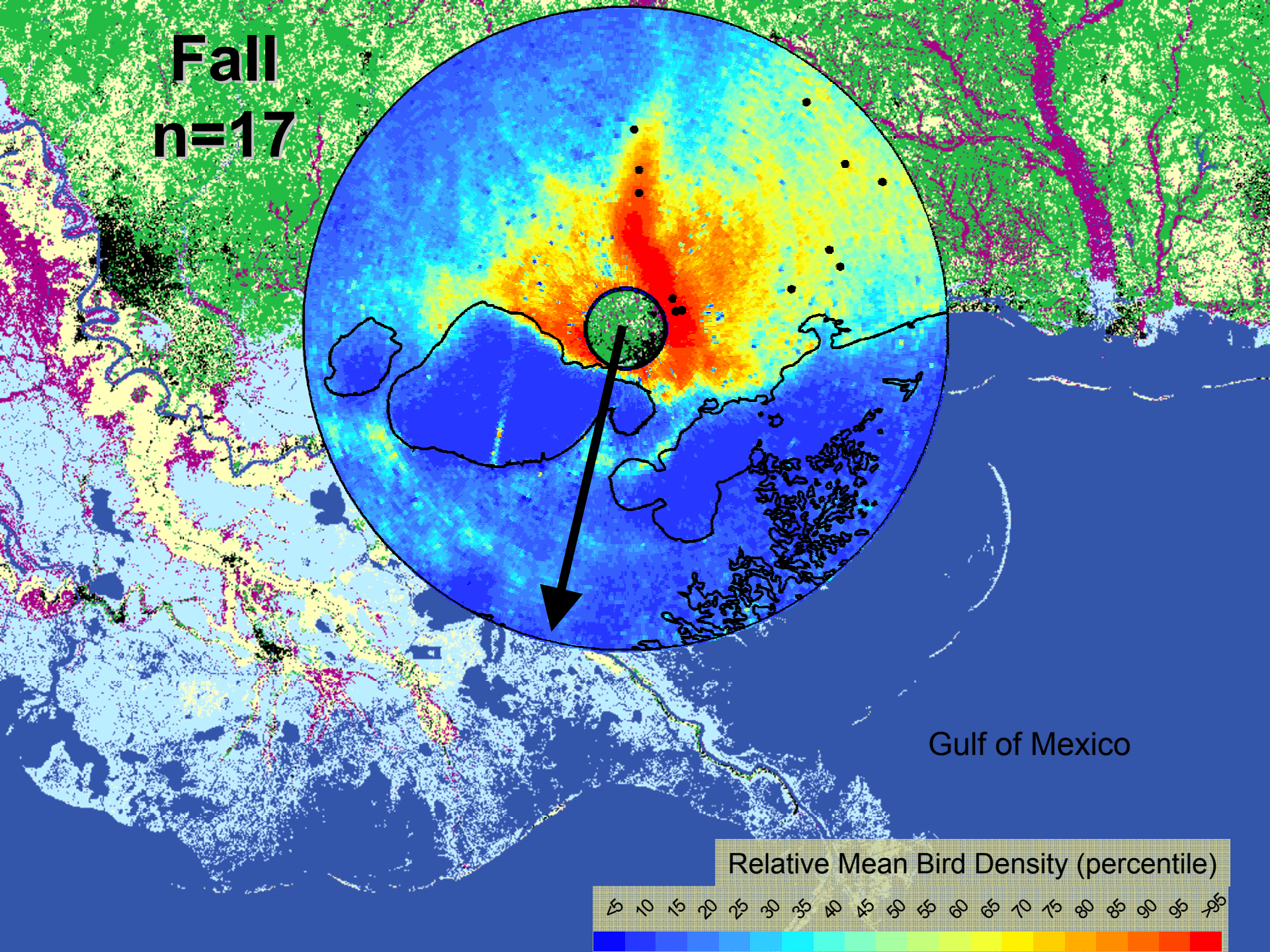
Solution to En Route Problems Depends on the Migrant's Relationship to Habitat



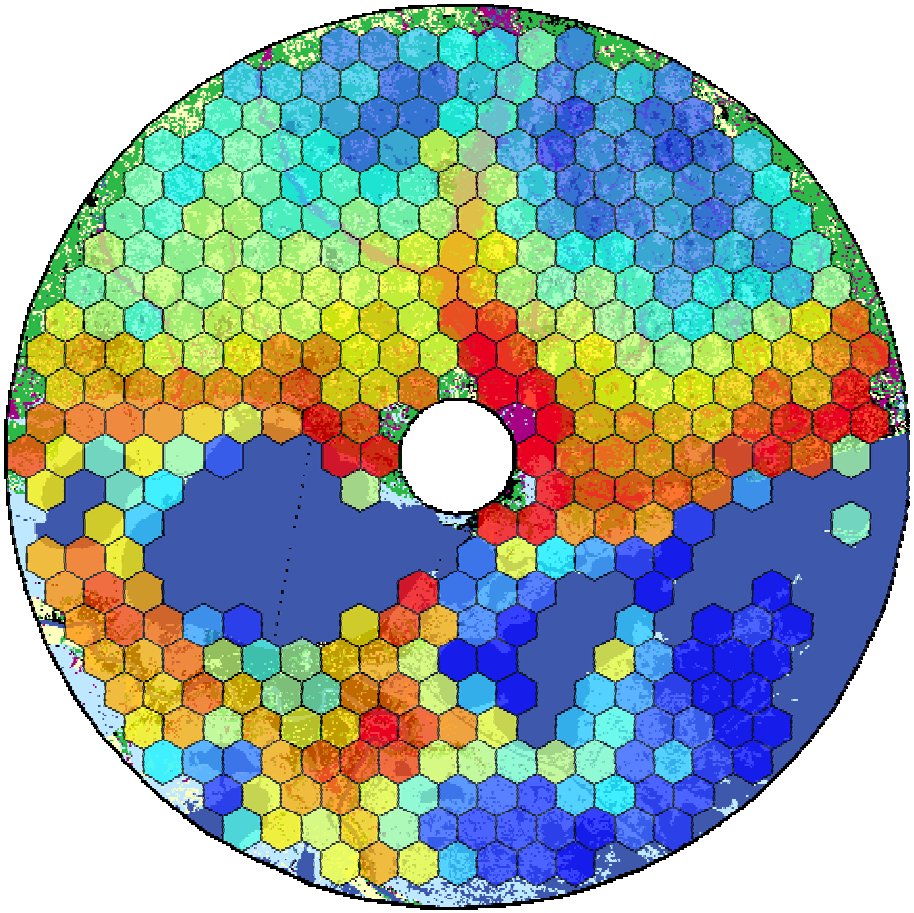
NEXRAD Weather Surveillance Radar




Spring
n=17
Gulf of Mexico
Relative Mean Bird Density (percentile)
<5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
>95

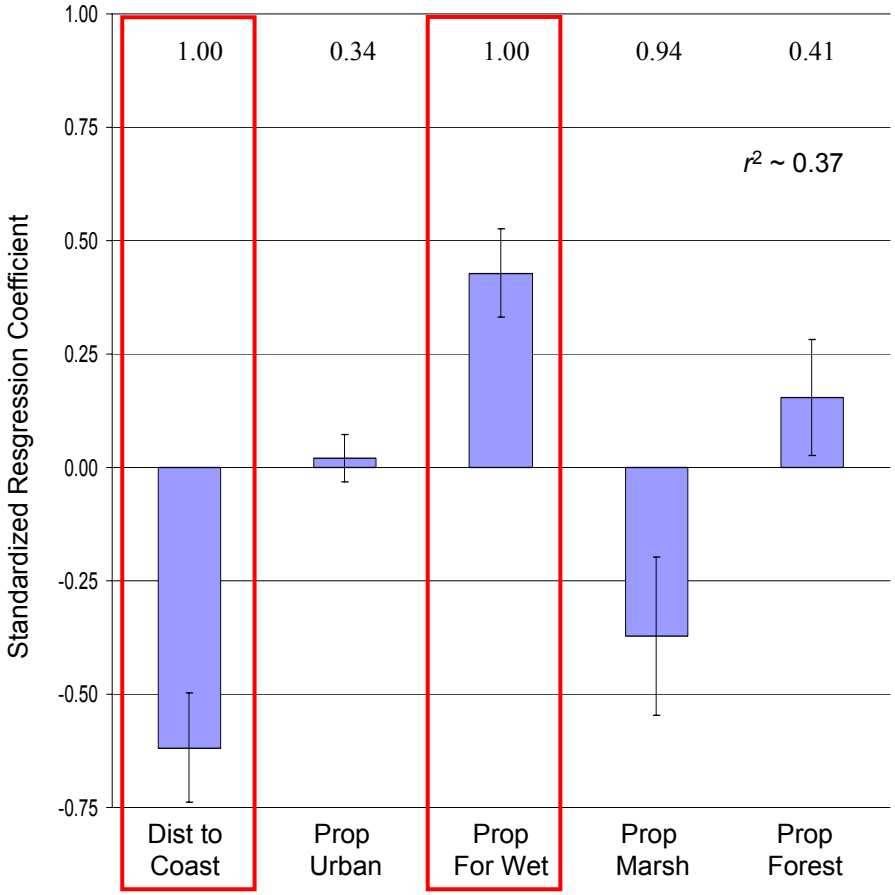

Fall
n=17
Gulf of Mexico
Relative Mean Bird Density (percentile)
<5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
>95

LINEAR MODEL VARIABLES

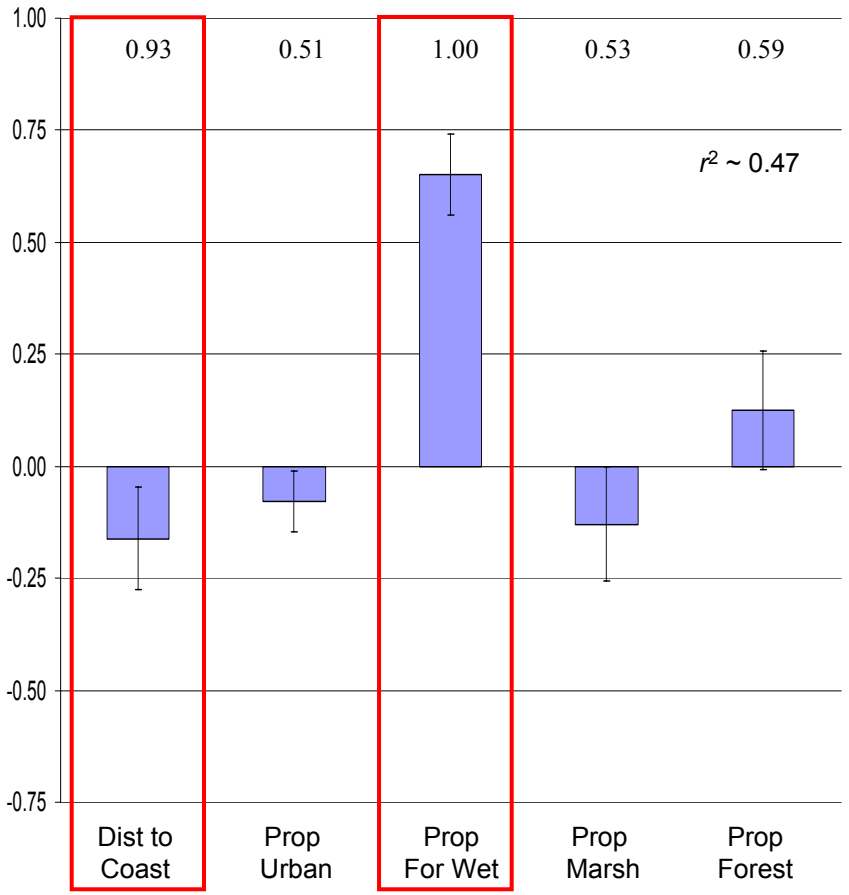


1) Distance to coastline
2) Proportion of urban area
3) Proportion of forested wetland
4) Proportion of marsh
5) Proportion of forested land

Spring

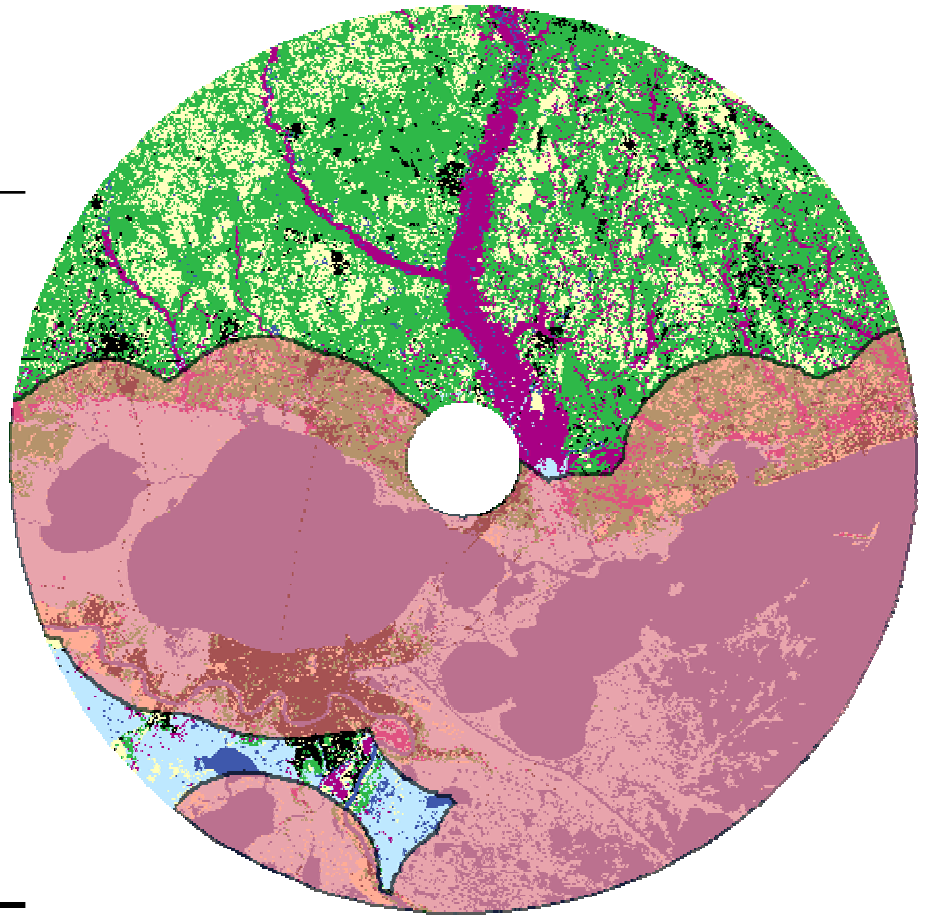

Standardized Resgression Coefficient
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
1.00
0.34
1.00
0.94
0.41
r2 ~ 0.37
Dist to Coast
Prop Urban
Prop For Wet
Prop Marsh
Prop Forest

Fall


1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
0.93
0.51
1.00
0.53
0.59
r2 ~ 0.47
Dist to Coast
Prop Urban
Prop For Wet
Prop Marsh
Prop Forest

CONSERVATION IMPLICATIONS

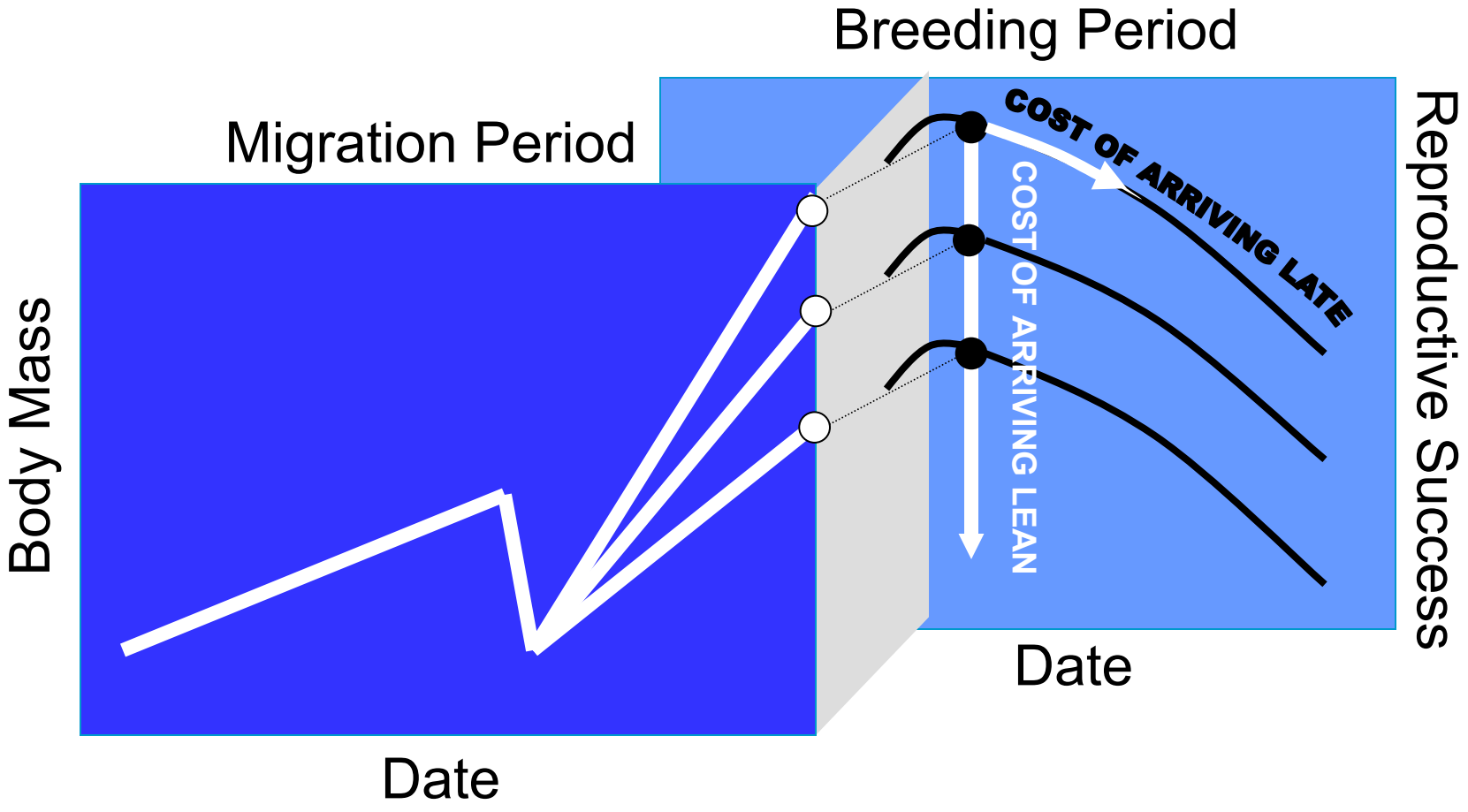
Land area within 15km of coast	
Percent of migrating birds in spring	60%
Percent of land area not including marsh and water	25%
Percent of urban land cover	21%



OBJECTIVES

- Examine migrant response to challenges that arise during stopover
- Emphasize that migrant - habitat relationship is scale dependent
- Appreciate linkage/transition between phases of the annual cycle

LINKAGE/TRANSITION BETWEEN SEASONS

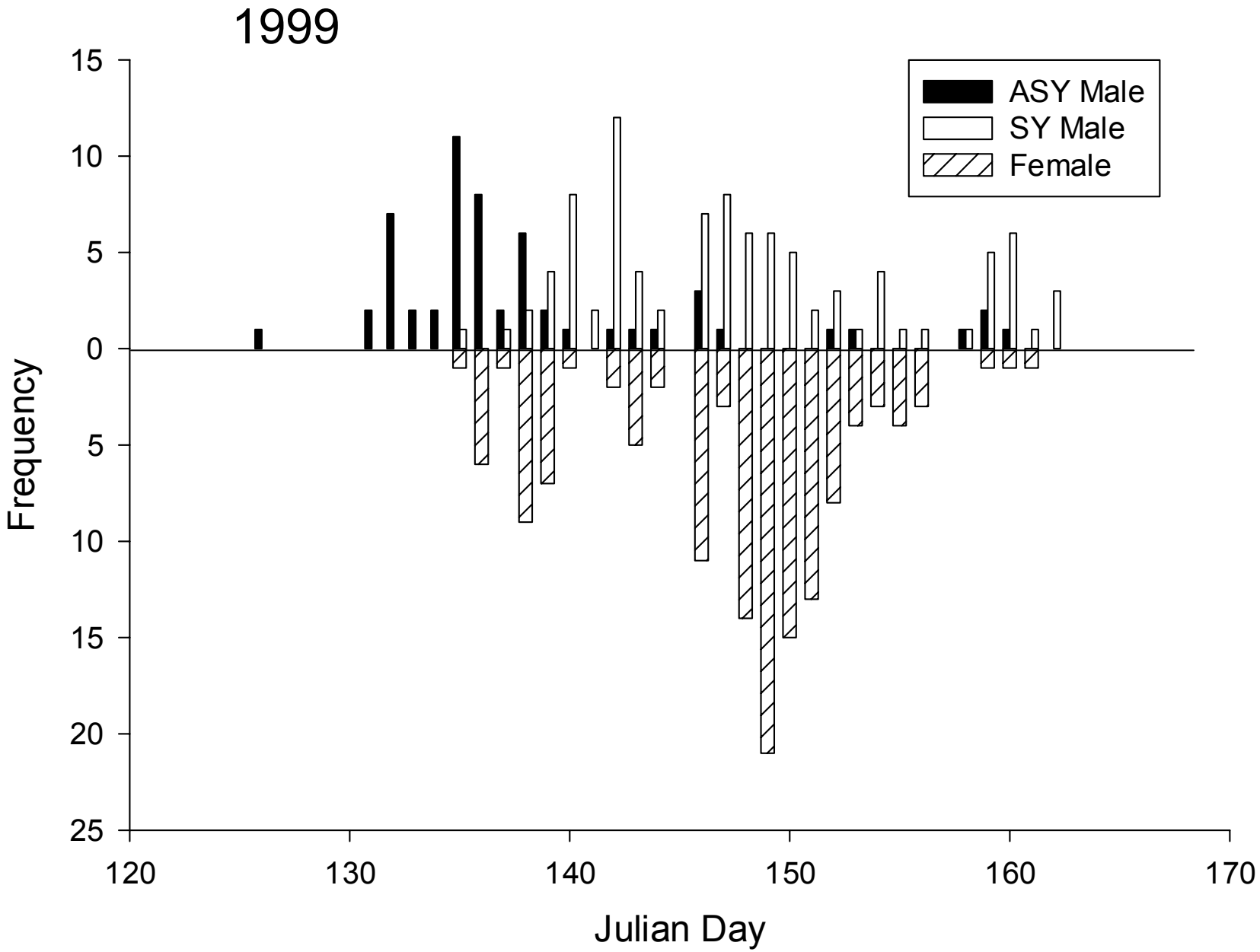


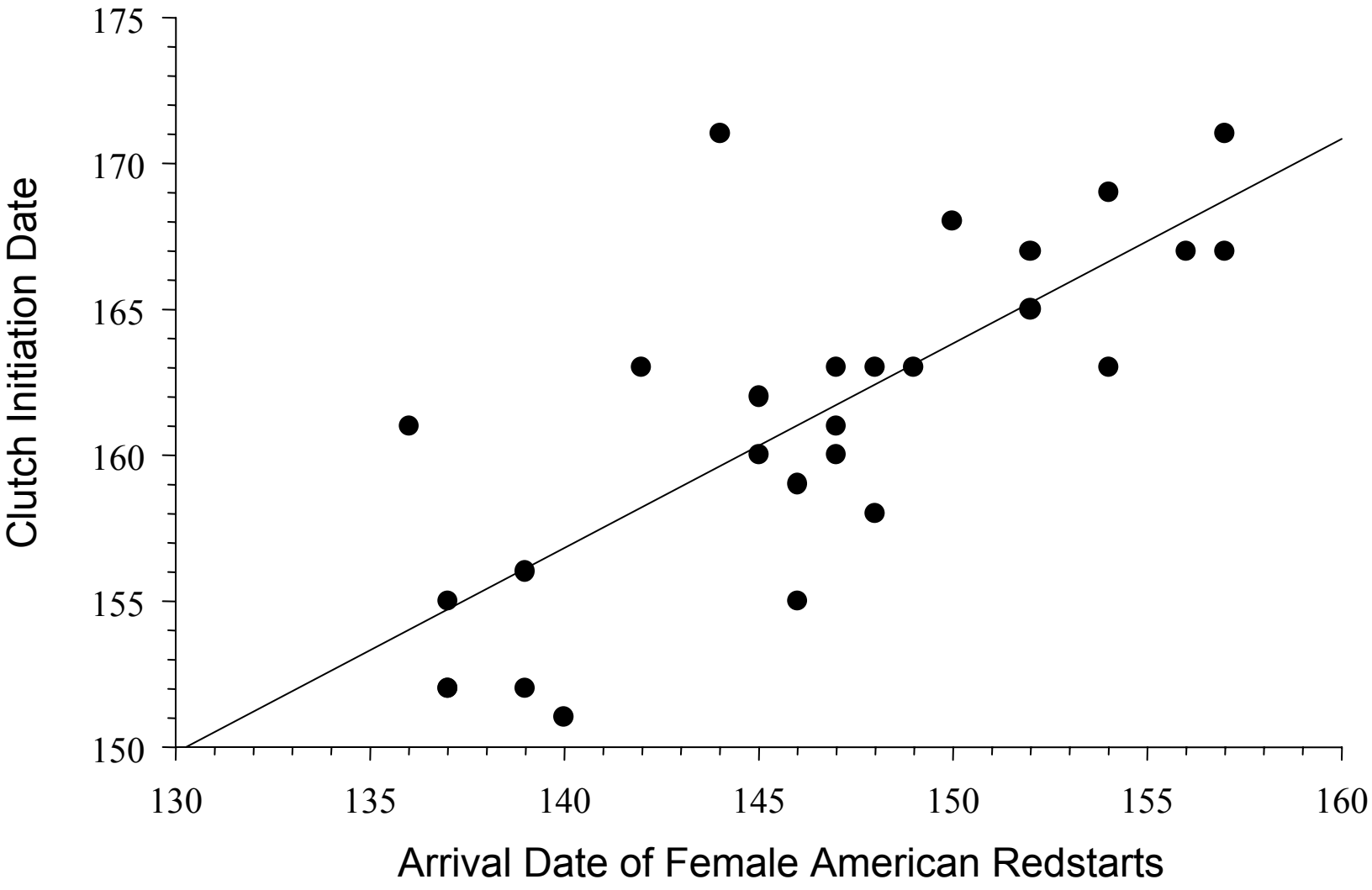
Adapted from B. Ens and T. Piersma

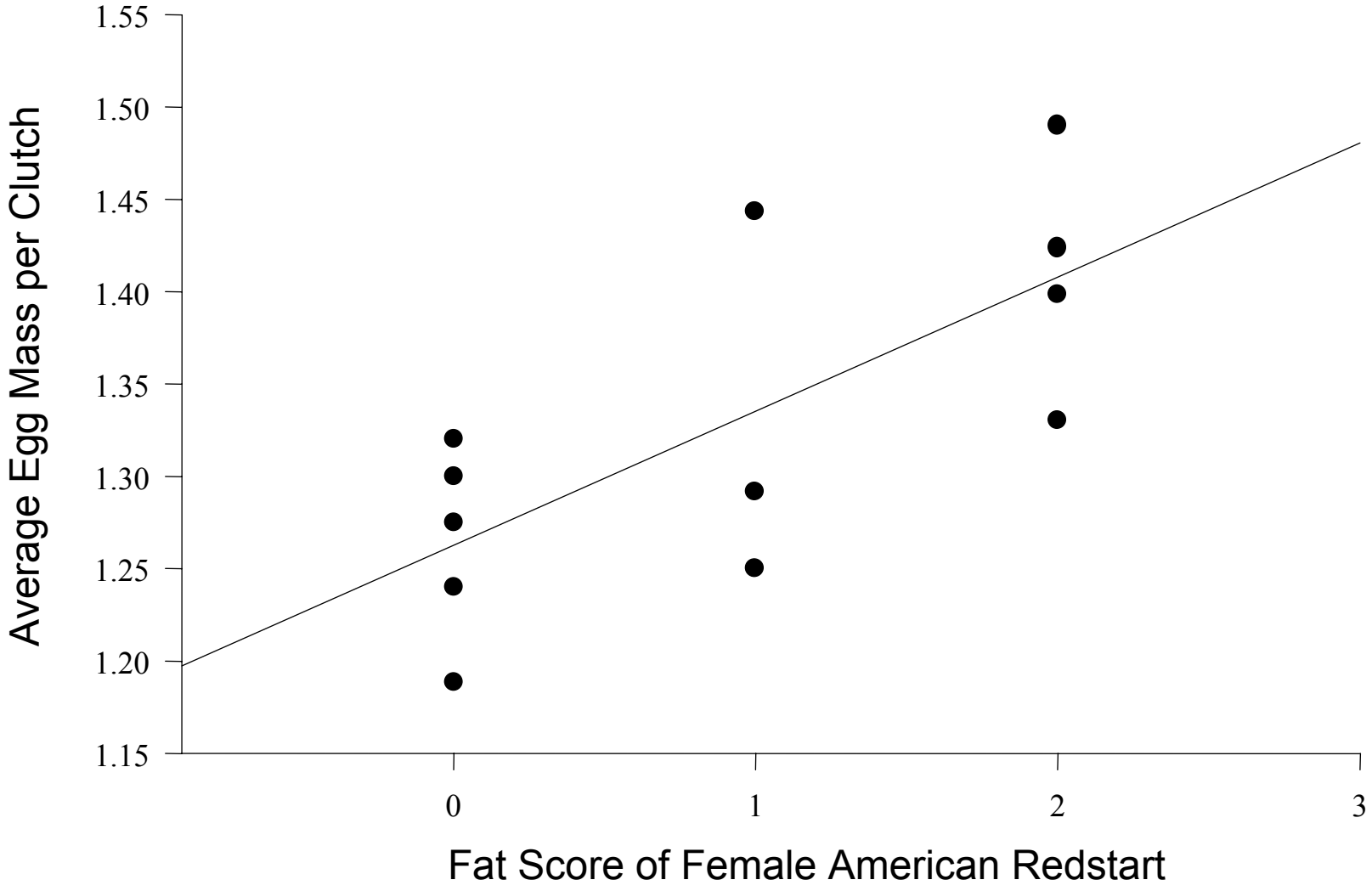
AMERICAN REDSTART

Setophaga ruticilla

Upper Peninsula, Michigan Lake Huron Shoreline


1999
ASY Male
SY Male
Female
Frequency
15
10
5
0
5
10
15
20
25
120
130
140
150
160
170
Julian Day


Clutch Initiation Date
175
170
165
160
155
150
130
135
140
145
150
155
160
Arrival Date of Female American Redstarts

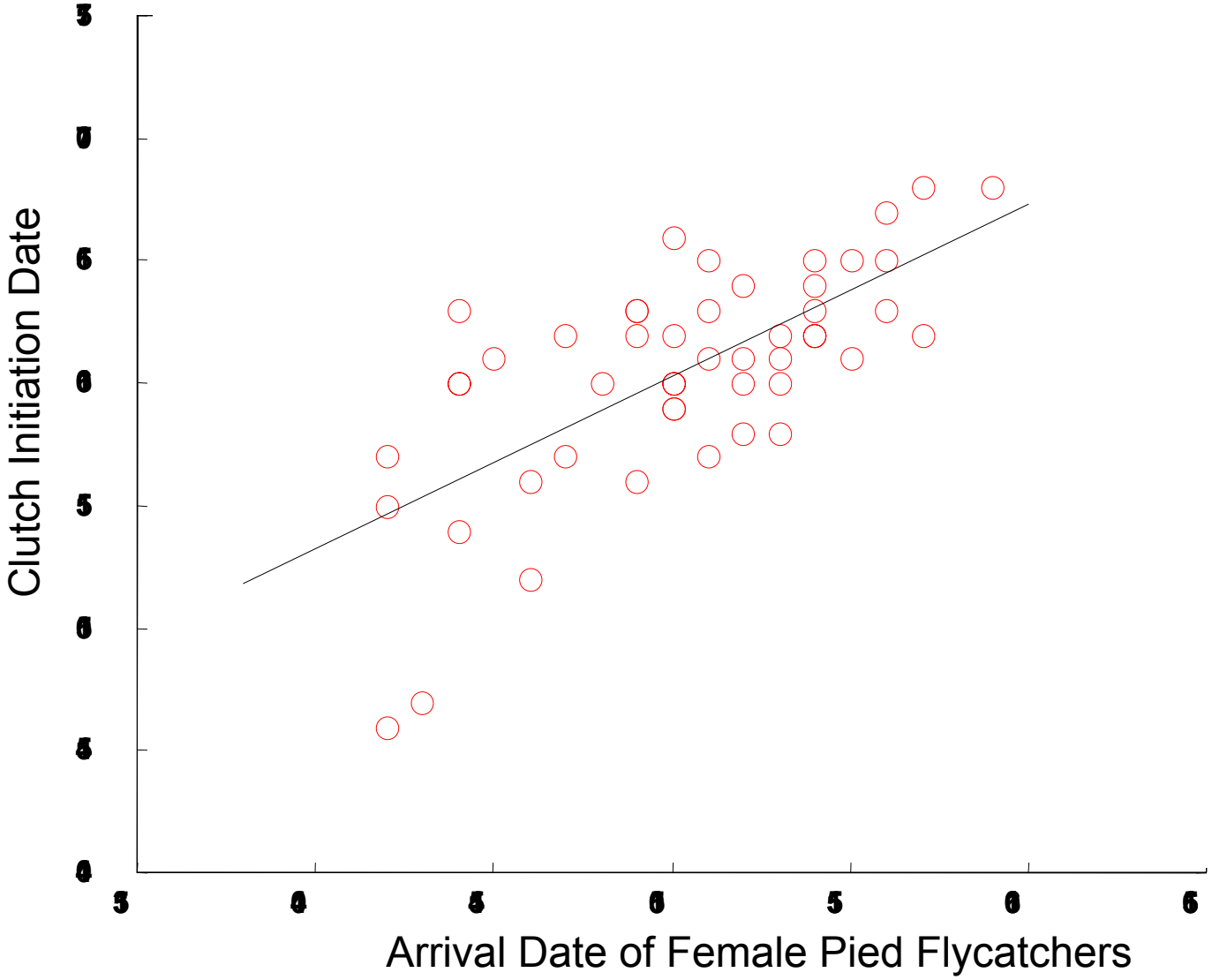

Average Egg Mass per Clutch
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
0
1
2
3
Fat Score of Female American Redstart

Ammarnäs, Sweden

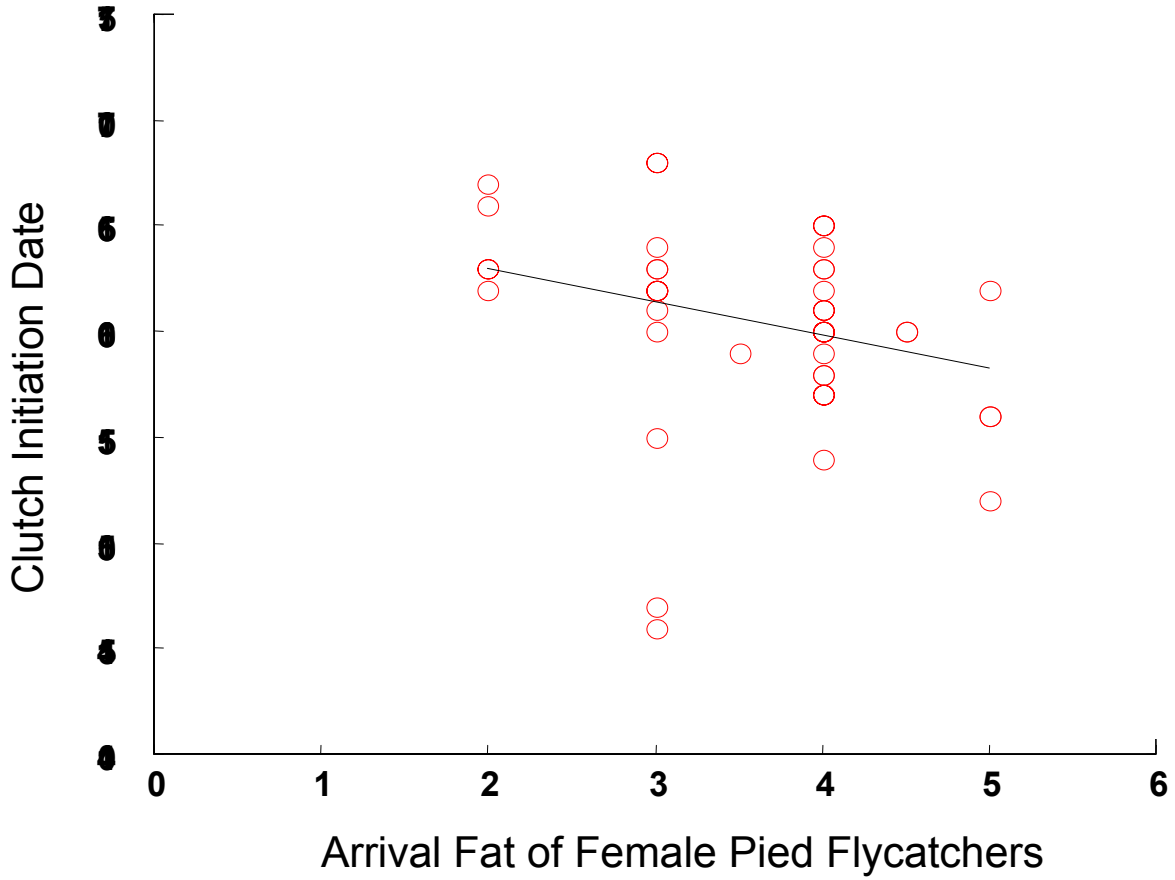
Roland Sandberg

PIED FLYCATCHER
Ficedula hypoleuca

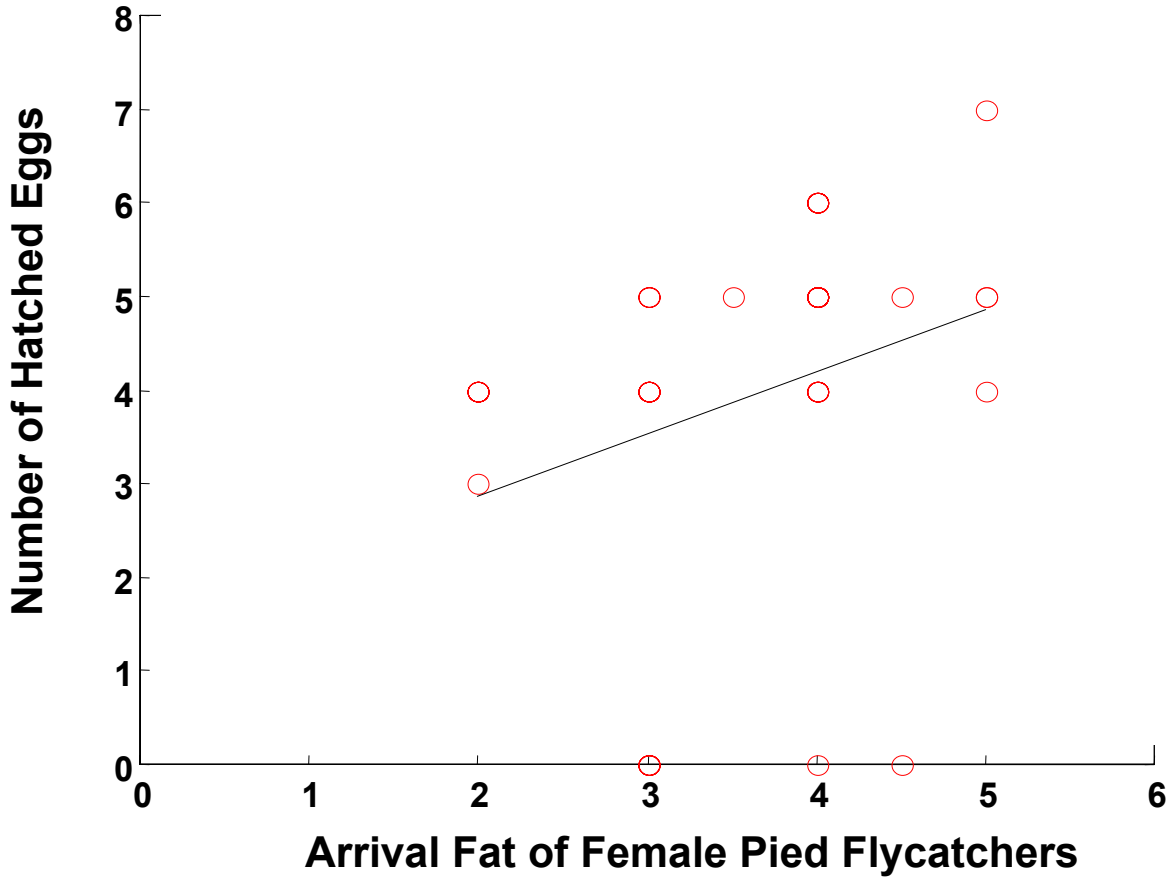
Relationship between spring arrival date and clutch initiation date in Pied Flycatchers, Swedish Lapland



Relationship between arrival fat stores and clutch initiation date in Pied Flycatchers, Swedish Lapland



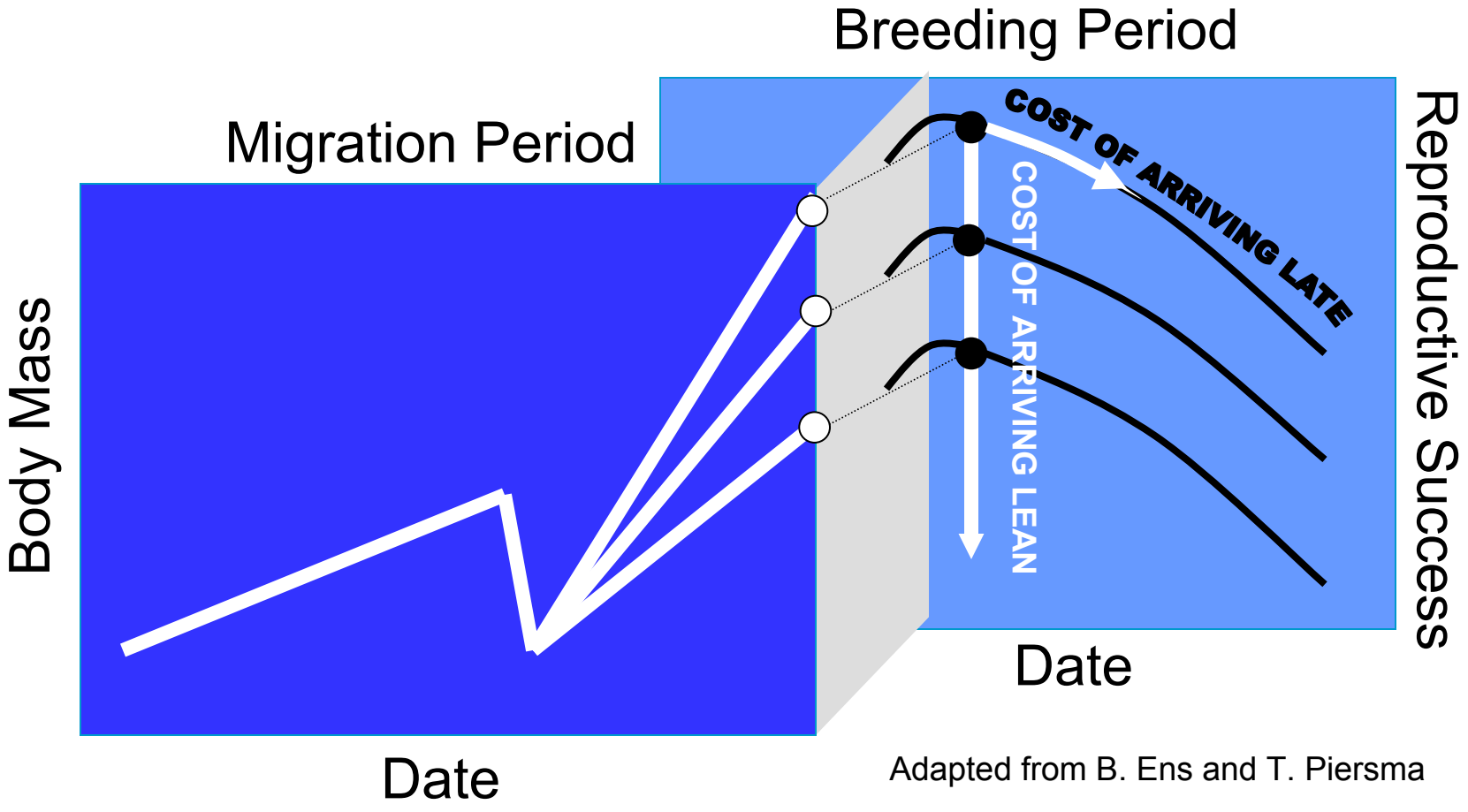
Relationship between arrival fat stores and number of hatched eggs in Pied Flycatchers, Swedish Lapland



Solutions to Problems & Consequences for Reproductive Performance

- Clutch initiation correlated with arrival date
- Migrants arrive with surplus fat stores
- Female reproductive performance correlated with fat stores upon arrival

LINKAGE/TRANSITION BETWEEN SEASONS

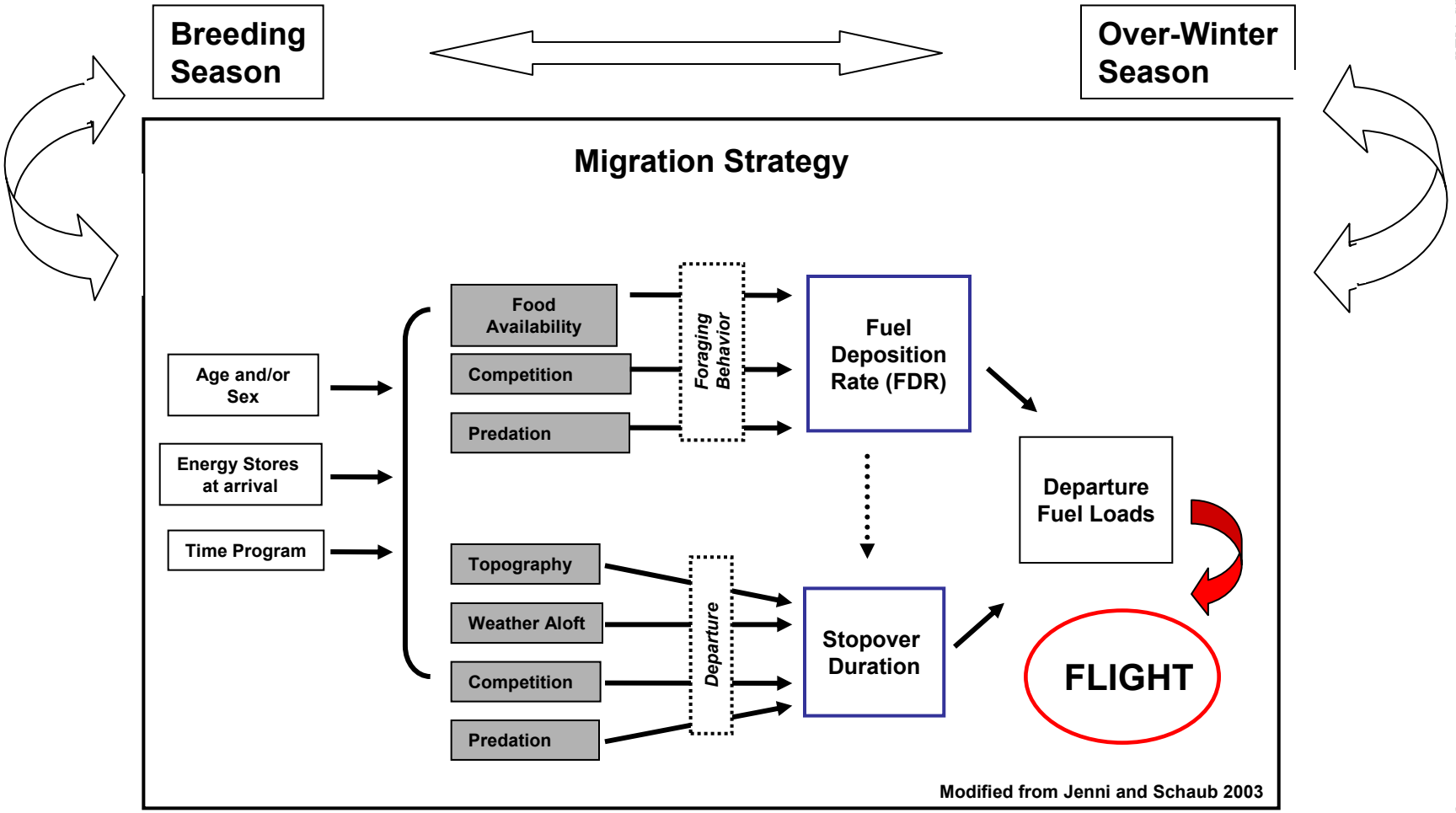


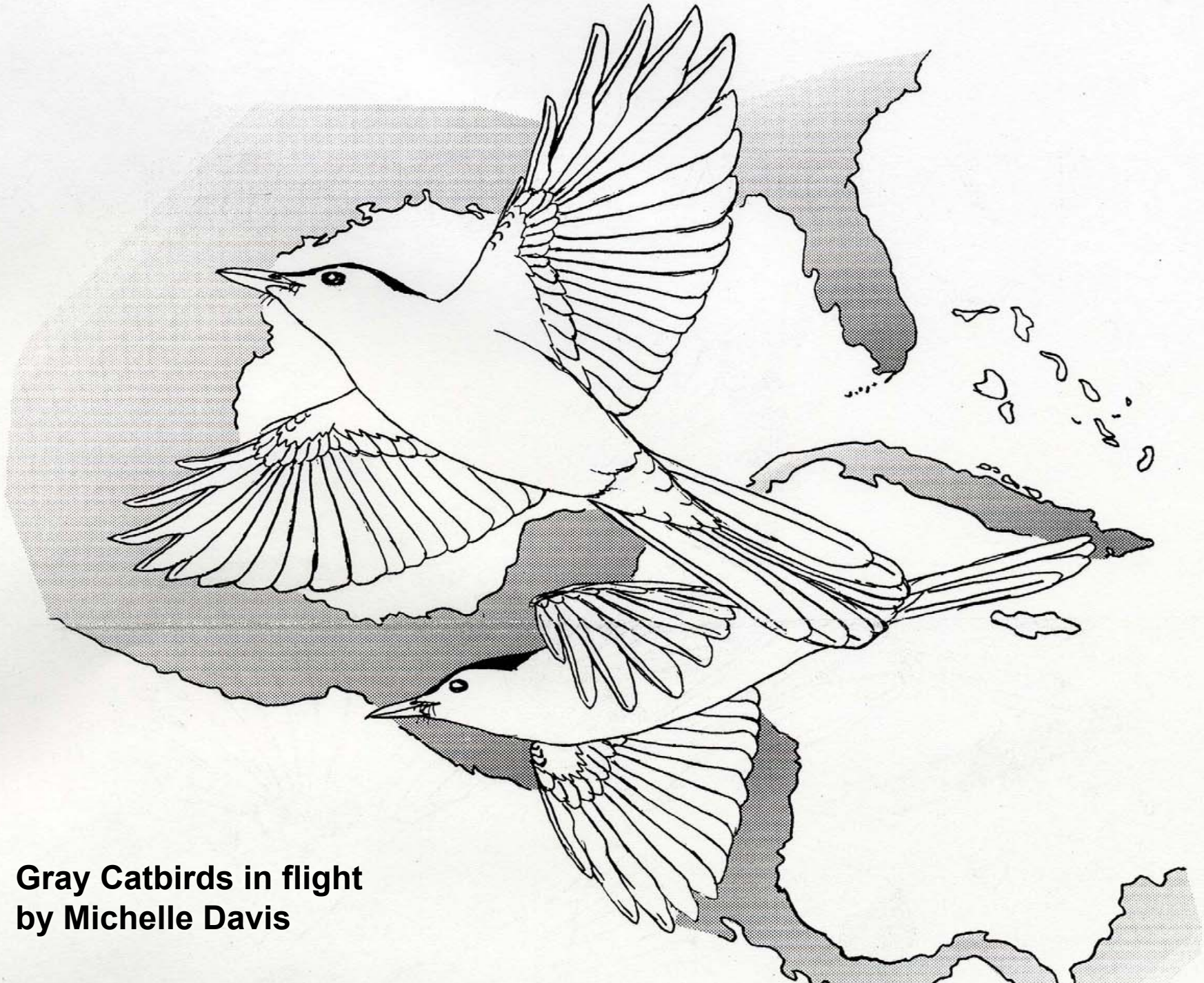
Adapted from B. Ens and T. Piersma

Connectivity: If we knew the destination, then … .

THANK YOU!

Conceptual Model





Gray Catbirds in flight
by Michelle Davis

EN ROUTE PROBLEMS

Adjust to unfamiliar habitats

Acquire food in short time

Avoid predators

Contend with competitors

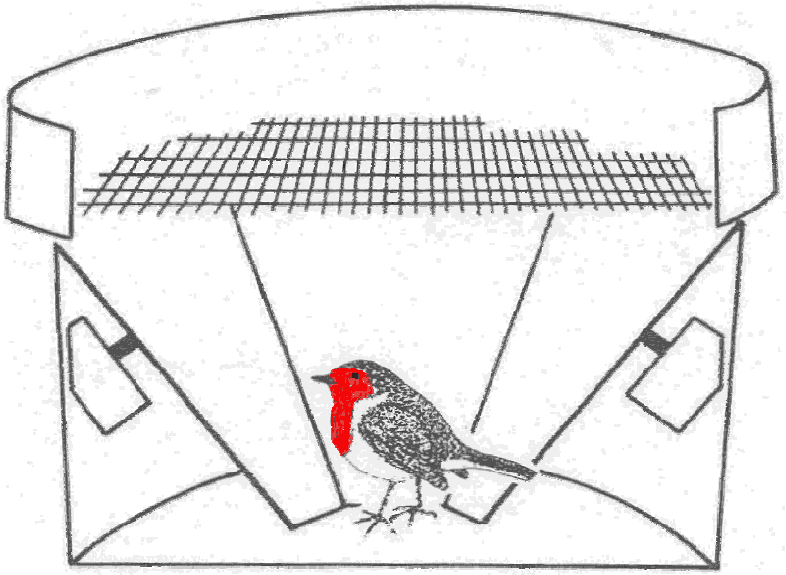
Resolve conflicting demands

Maintain health

Gain adequate sleep

Find/maintain the right direction

Cope with adverse weather



Migratory activity and orientation of activity displayed in cage setting