Wood Storks
From Everglades birds to urban dwellers

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Why move?

- Find resources
- Find mates
- Maintain gene flow
- Establish territories
Migration

Track environmental heterogeneity over broad spatio-temporal scales
Thomson's (1926) definition of migration:

"Changes of habitat, **periodically recurring** and **alternating** in direction, which tend to **secure optimal environmental conditions** at all times."
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But actually...
Seasonality → "Classic" round-trip
Seasonality $\rightarrow$ "Classic" round-trip

Resource breakouts $\rightarrow$ Erratic migration
Seasonality → "Classic" round-trip

Resource breakouts → Erratic migration

Resource trade-offs → Partial migration
Seasonality → "Classic" round-trip

Resource breakouts → Erratic migration

Resource trade-offs → Partial migration

Unpredictability → Facultative migration
Pattern of resource heterogeneity

Migration pattern
Wetlands
Wetlands
Wetlands

Heterogeneity + Unpredictability
Wood Storks
Wood Storks
Wood Storks
Tactile foragers

↓

Prey need to be concentrated!
Tactile foragers

Prey need to be concentrated!
Tactile foragers

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Tactile foragers

Prey need to be concentrated!
Hydrological Dynamics in the Everglades

Wet season

Fish production

Dry season

Fish concentration
Hydrological Dynamics in the Everglades

[Graph showing water depth changes over time with wet season from July to November and dry season from December to June.]
Hydrological Dynamics in the Everglades

Wet season

Dry season

2005
Hydrological Dynamics in the Everglades

Wet season

Dry season

2006

Water depth (ft.)

Jul Sep Nov Jan Mar May Jul
Hydrological Dynamics in the Everglades

Wet season

Dry season

2007

Water depth (ft.)

Jul  Sep  Nov  Jan  Mar  May  Jul
Hydrological Dynamics in the Everglades

Wet season

Dry season

2008
Hydrological Dynamics in the Everglades

Wet season

Dry season

2009
Birds of North America Species Account: "Not a true migrant"
(Coulter et al. 1992)
Seasonality + Unpredictability
Seasonality + Unpredictability

Partial or facultative migration
GPS-Tracking Data Collection

Captures performed in 2004-2012 by Rena Borkhataria et al.
Migration Patterns of Wood Storks in the Southeastern U.S.
Classification of migratory behavior

Migratory choice: y/n (each year)

Net Squared Displacement
Classification of migratory behavior

Migratory choice: y/n (each year)

Net Squared Displacement
Classification of migratory behavior

Fit set of alternative non-linear models to NSD data

Migratory choice: y/n (each year)

Net Squared Displacement

Package 'migrateR'

Final dataset: 200 individual years from 64 individuals

Model selection by AIC
Results
121 migrations (60%)

79 residencies (40%)
Residents, Year-round

Number of overlapping ranges
Seasonality + Unpredictability → Partial or facultative migration
• Are different migratory choices associated with trade-offs in resource acquisition?

• Does this result in different fitness consequences?
Fitness Consequences of Individual Migratory Behavior in Wood Storks
Adaptive value of behavioral heterogeneity in changing environments?

- Barriers to movement
- Phenological shifts
- Anthropogenic food supplementation
Anthropogenic food supplementation

Migration

Residency↑
Anthropogenic food supplementation

↓ Migration

Resource use

↑ Residency

Migratory behavior

Fitness
Anthropogenic alteration of natural food sources

Historic and current flow of the Kissimmee, Okeechobee, Everglades watershed.

Graphic: U.S. Army Corps of Engineers, Jacksonville District
Novel anthropogenic food sources

Photo: Tessie Offner
Focus on breeding season

- Resource use
- Migratory behavior
- Fitness
Focus on breeding season

- Resource use
- Migratory choice prior to breeding
- Fitness
Focus on breeding season

- Foraging-site selection during breeding
- Migratory choice prior to breeding
- Fitness
Focus on breeding season

- Foraging-site selection during breeding
- Migratory choice prior to breeding
- Nest survival
Nest survival analysis

\[ \begin{align*}
Y_1 & = \phi_1 z_1 + p_1 Y_0 \\
Y_2 & = \phi_2 z_2 + p_2 Y_1 \\
& \vdots \\
Y_{T-1} & = \phi_{T-1} z_{T-1} + p_{T-1} Y_{T-2} \\
Y_T & = \phi_T z_T + p_T Y_{T-1}
\end{align*} \]
Foraging-site selection analysis
Foraging-site selection analysis

Used foraging locations
Foraging-site selection analysis

Generated available locations around the nest

Used foraging locations

(A) Observed

(B) Simulated
Foraging-site selection analysis

Generated available locations around the nest

(A) Observed

(B) Simulated

Distance to urban development

Proxy for anthropogenic resources
Results
Foraging-site selection

Strength of selection

Distance to urban development (km)

Choice
- Migrant
- Resident
Nest survival

Distance to urban development (km)

Daily nest survival rate
• Foraging-site selection mediates link between migratory behavior and fitness

• If migratory behavior is inheritable, anthropogenic pressure may promote shift towards residency
• Caveat 1: we could not demonstrate heritability; some individuals show plasticity

• Caveat 2: how does individual fitness scale up to the population level?
Thank you!

Questions?