Use of urban habitats by the threatened Wood Stork may aid in population-level recovery

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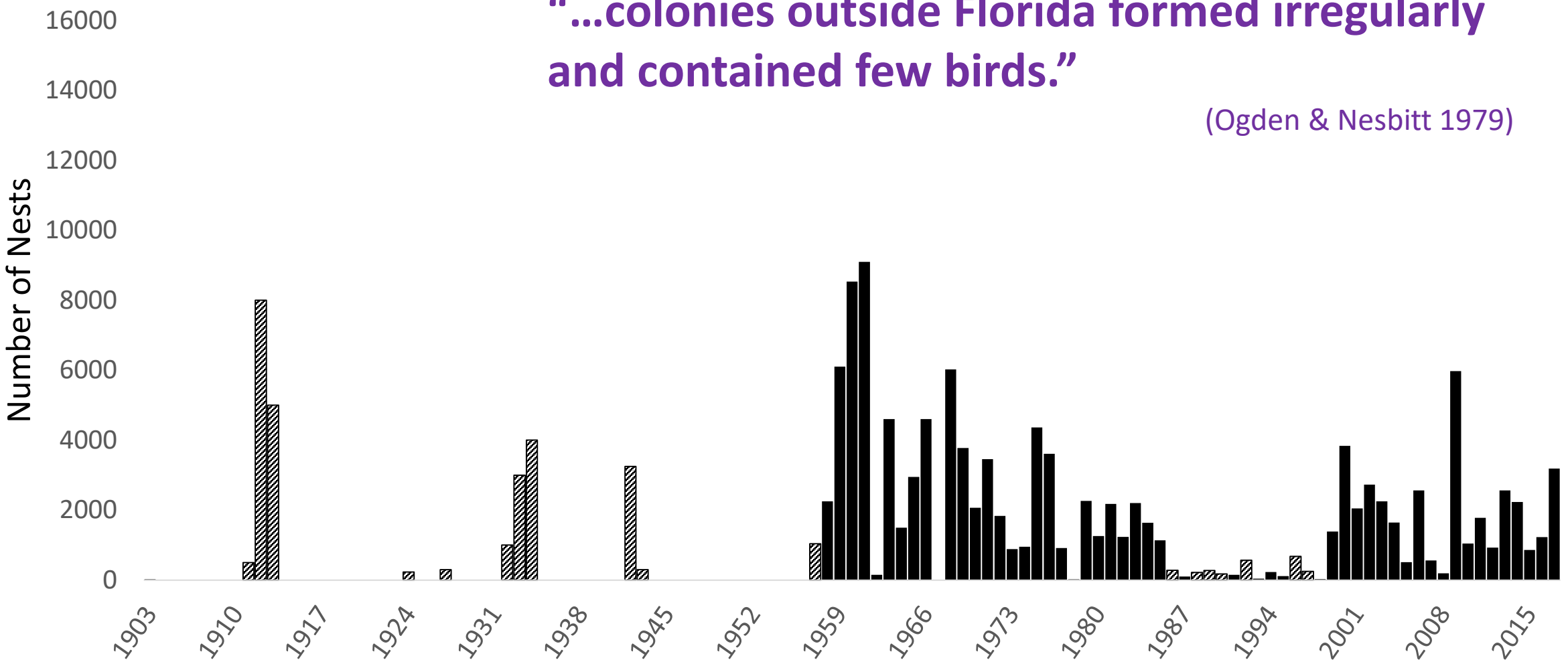
Storks in South Florida, 1903-2017

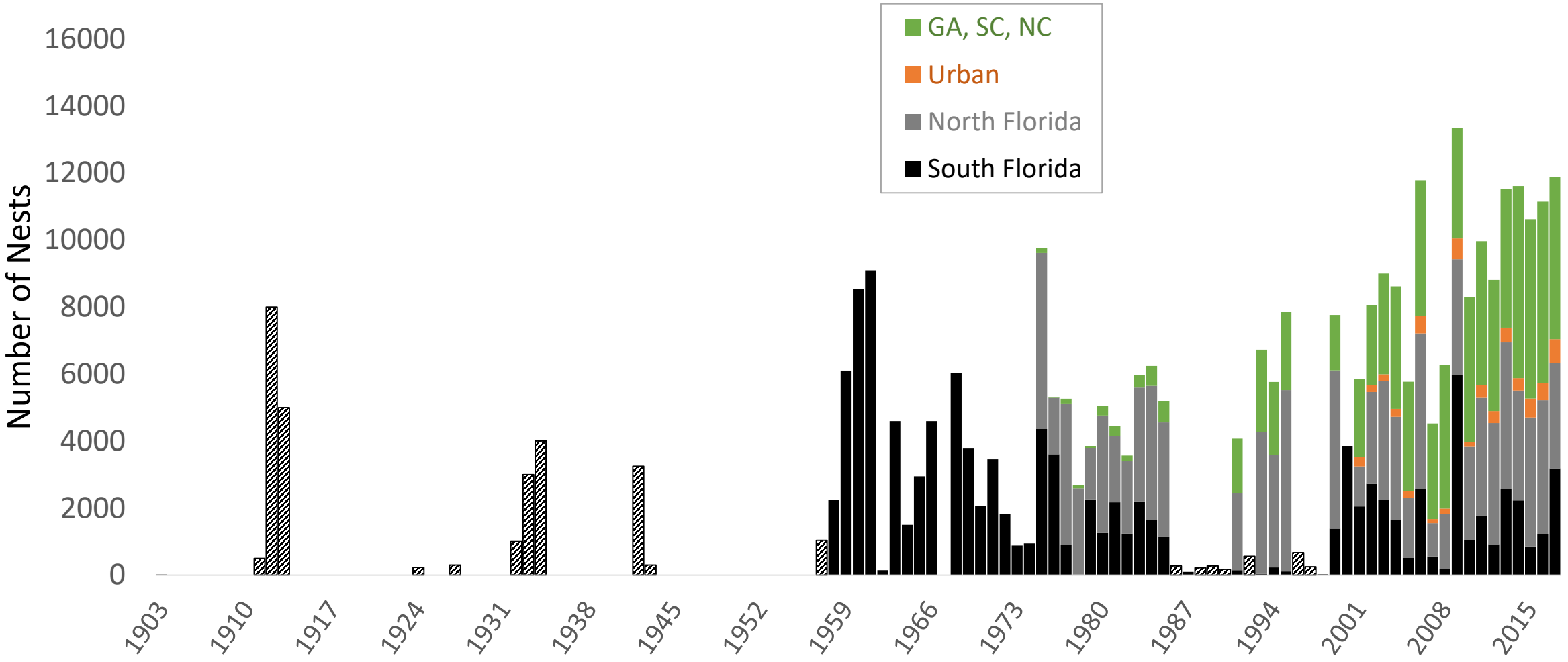
"…colonies outside Florida formed irregularly and contained few birds."

(Ogden & Nesbitt 1979)

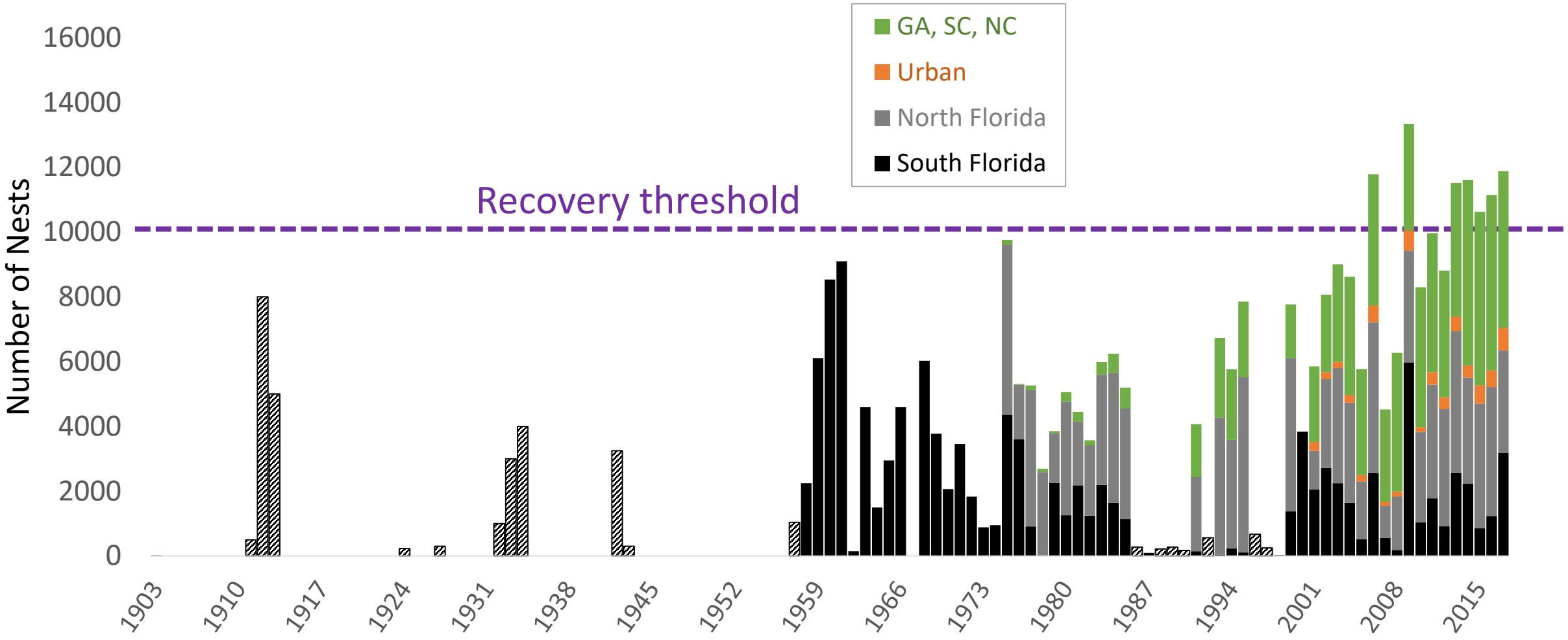


Ogden 1978; Crozier & Gawlik 2003; SFWMD 2002-2018

Stork range expansion, 1970s onward



Stork range expansion, 1970s onward



Q: Is urban habitat now essential to stork recovery?

Species: Quantify the importance of urban nesting habitat to long-term health of Wood Storks in the US

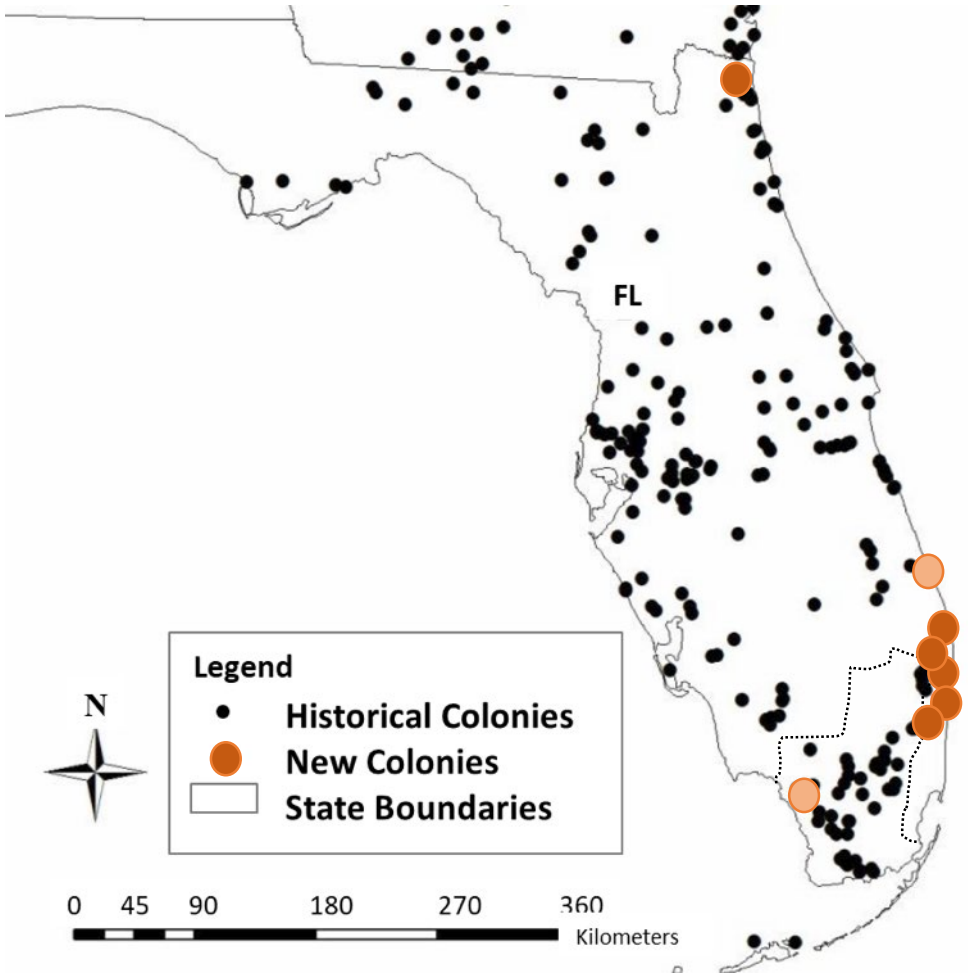
CERP: Incorporate observed changes (3) in the ecosystem interactions of an indicator species into recovery models

Ecology/Conservation Biology: Framework for recovery planning of other ESA-listed species with high adaptive capacities

Observed shifts in…

1. Breeding locations

Stork expansion from marsh into urban areas



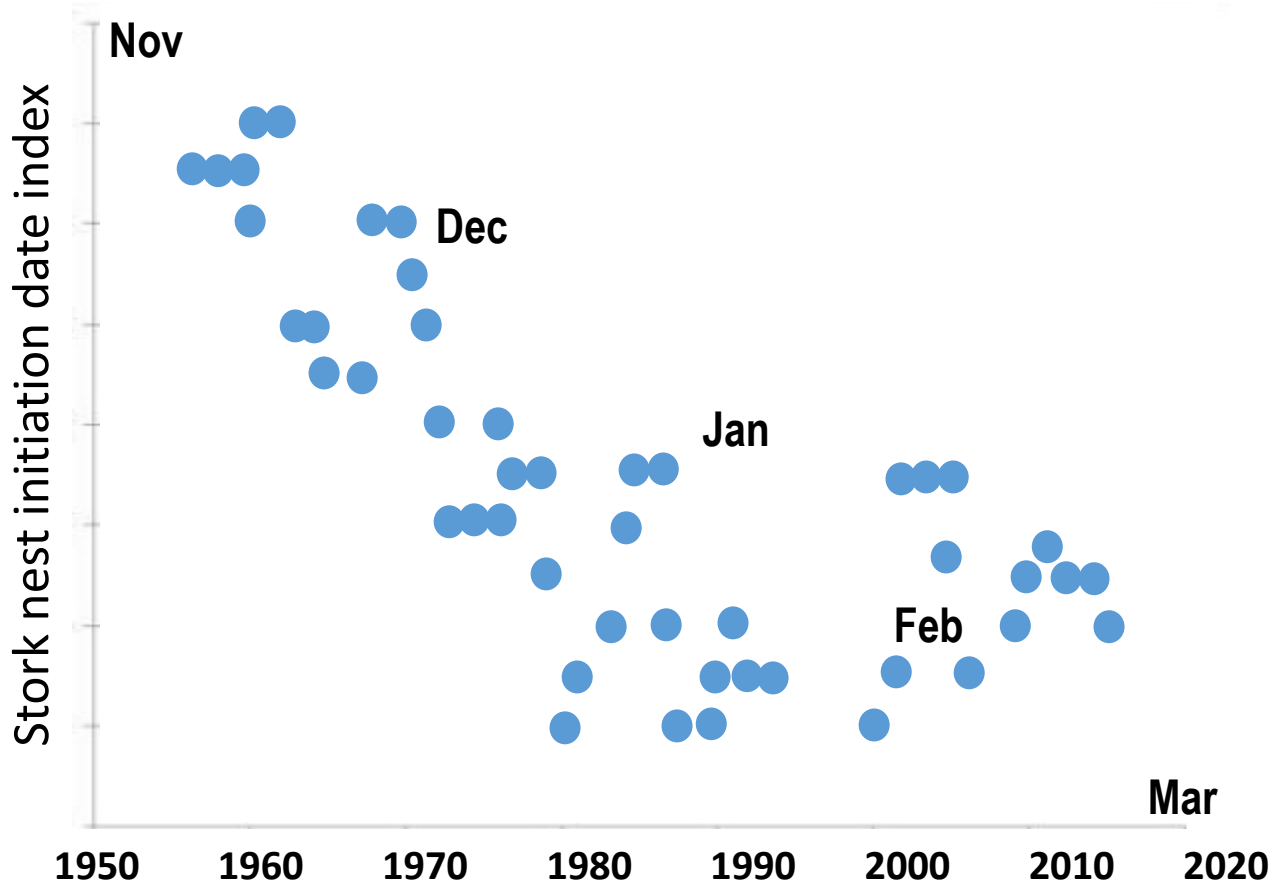
6+ urban colonies established post-2000

Adapted from Tsai et al. (2011). Report for Felburn Foundation. 67pp.

Observed shifts in…

1. Breeding locations
2. Timing of nest initiation

Everglades storks now initiate nesting later

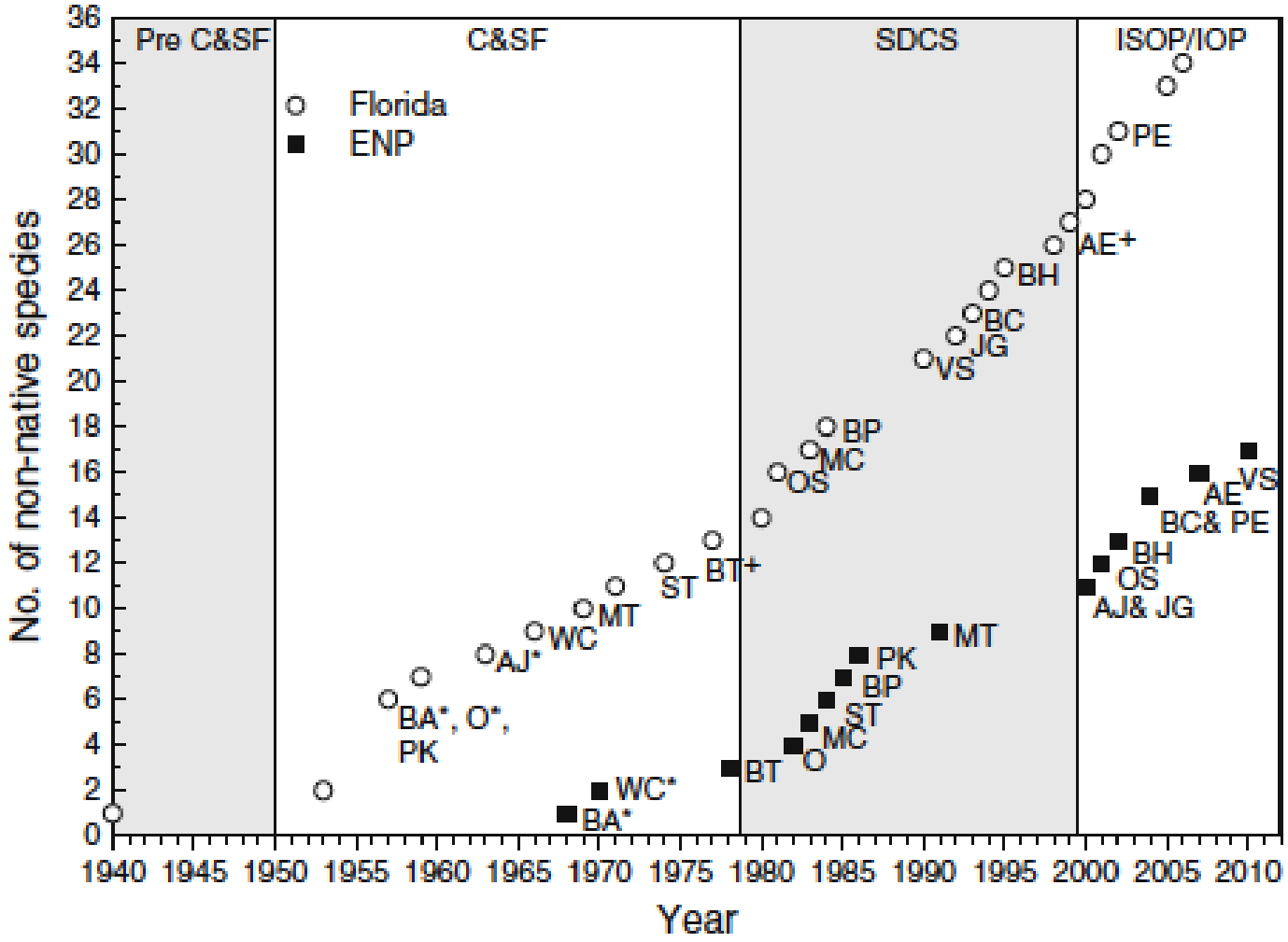


Cook, M. I. (2016). South Florida Wading Bird Report, West Palm Beach, FL. 45pp.

Observed shifts in…

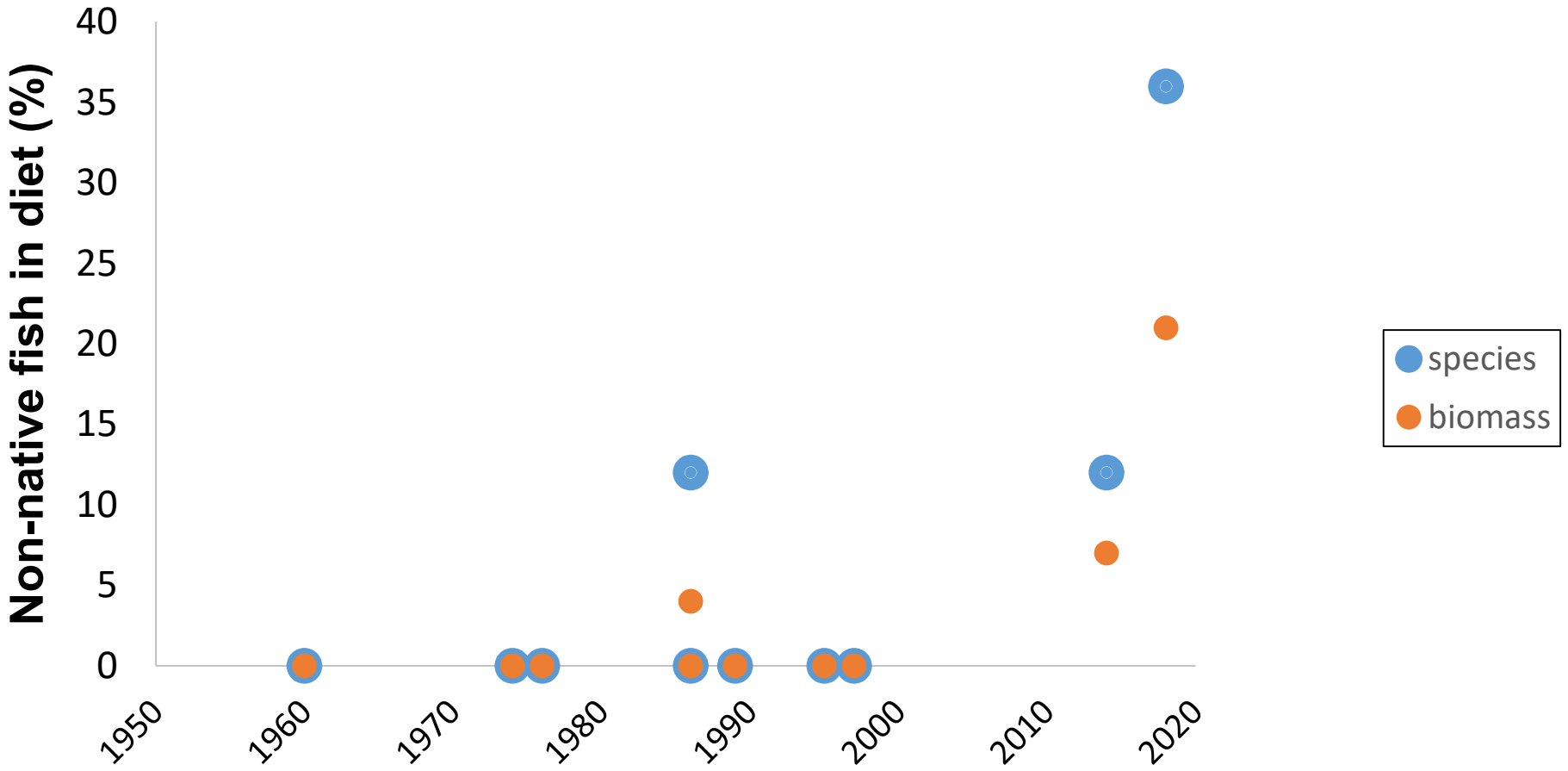
1. Breeding locations
2. Timing of nest initiation
3. Diet
    - Presence of non-native fishes
    - Shift in prey types
    - Shift in foraging locations?

Non-native fish establish in ENP in 1960s

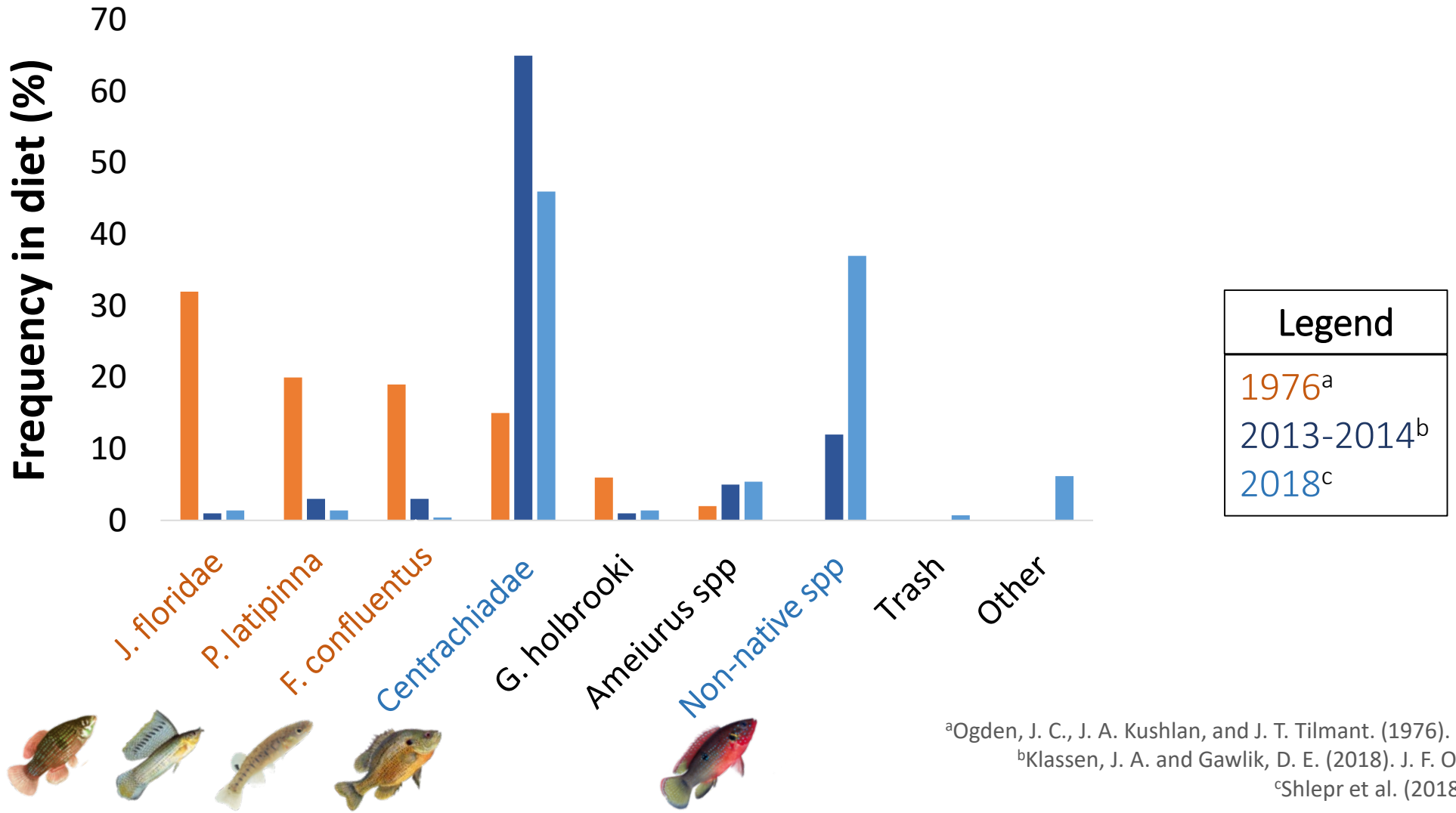


Kline et al. 2014. Wetlands 34 (Supp 1): S175-S187.

Non-natives are now common prey to storks

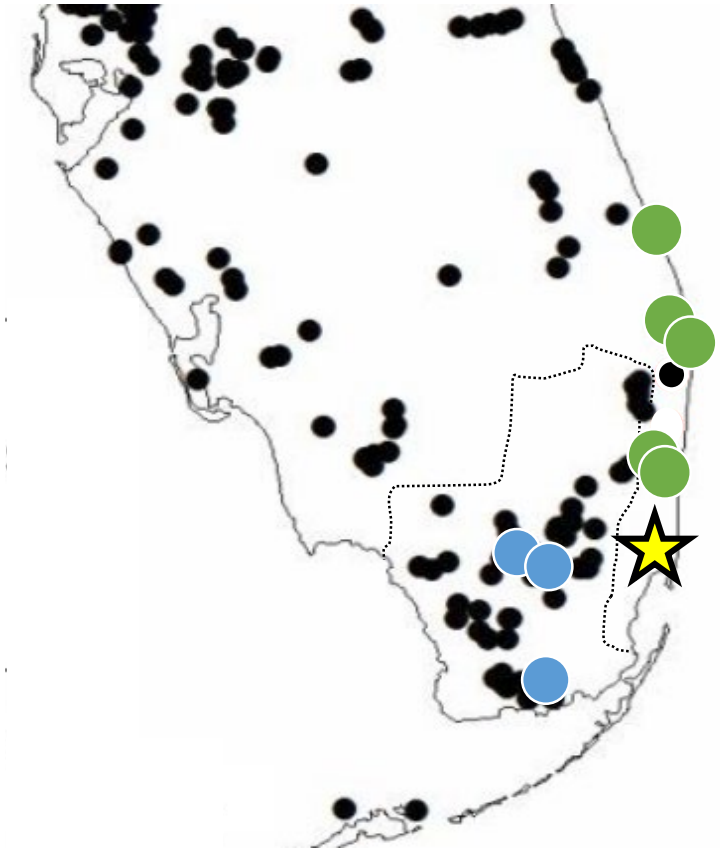


Primary prey has shifted since the 1970s



[a]Ogden, J. C., J. A. Kushlan, and J. T. Tilmant. (1976). Condor 78: 324-330.
[b]Klassen, J. A. and Gawlik, D. E. (2018). J. F. Ornithol. 89: 126-139.
[c]Shlepr et al. (2018). Unpublished data.

Field methods (2014-*2020*)

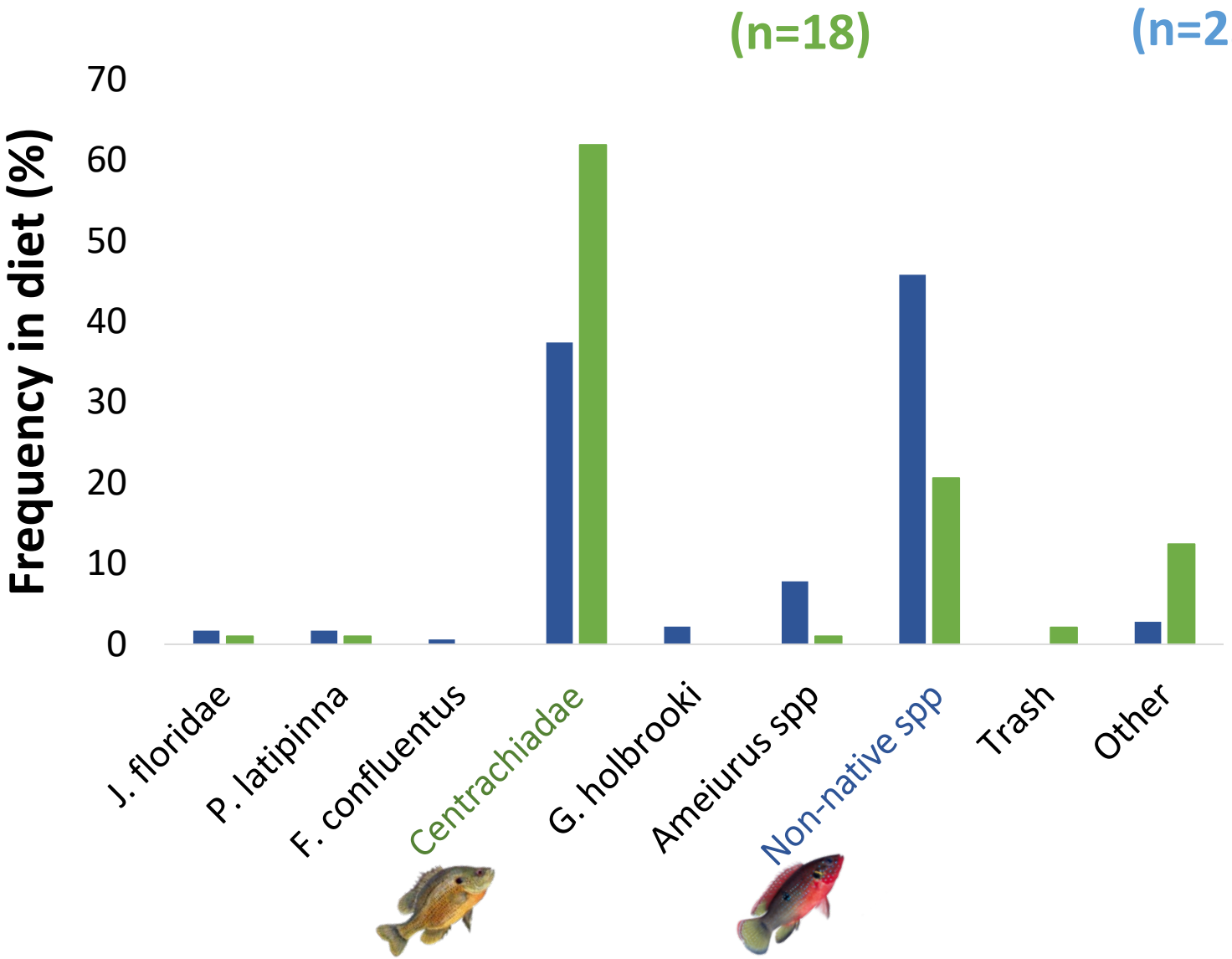


Urban colonies

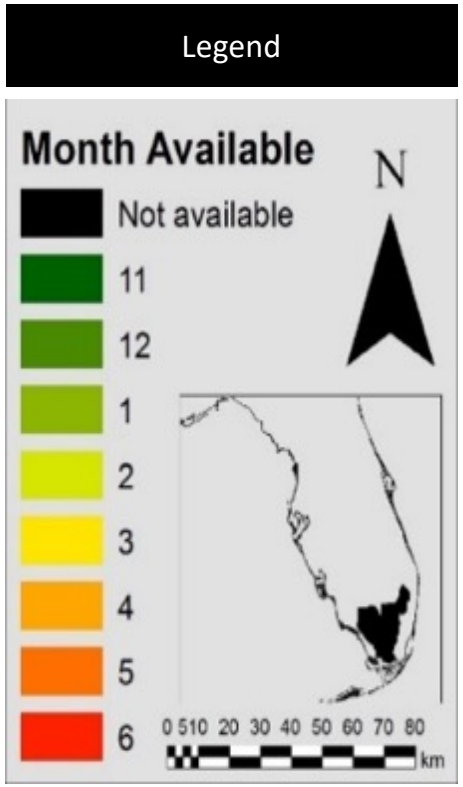
Miami, Florida

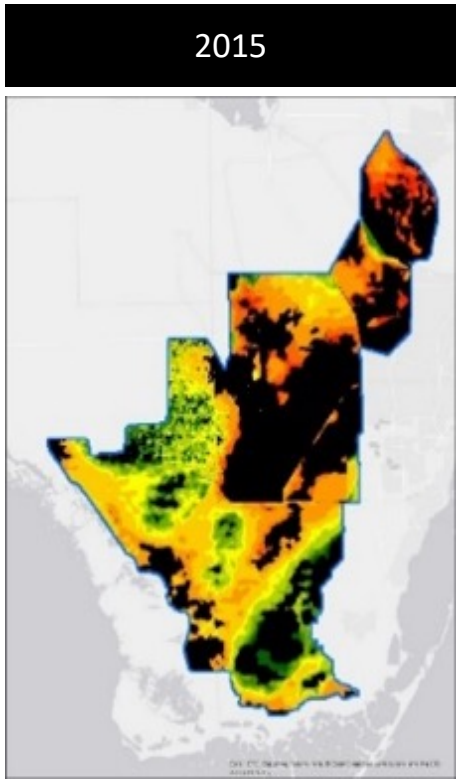
Marsh colonies

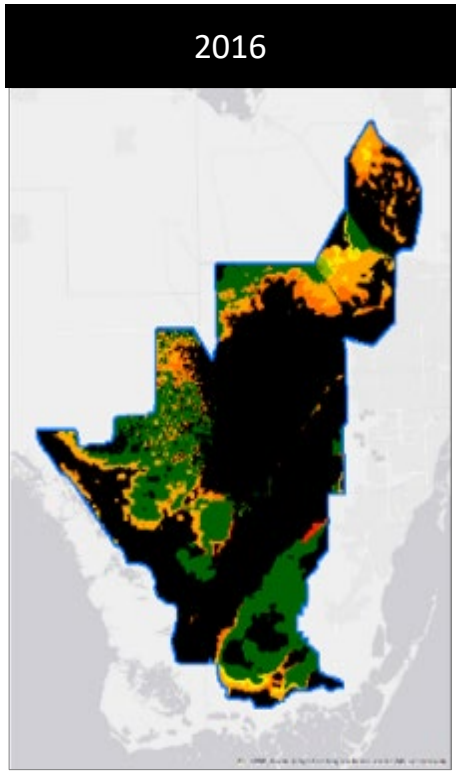
Diet differs between urban and marsh storks

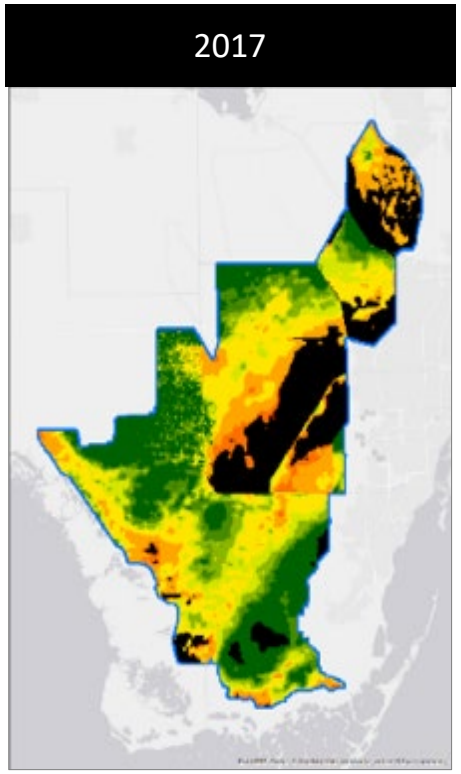


Habitat models currently ignore urban spaces









Maps prepared by Gawlik Lab (unpublished data).

Hypothesis

H_0: No correlation between the amount of non-native fishes consumed by Wood Stork chicks and nest productivity.

African Jewelfish
(*Hemichromis letourneuxi*)

Black Acara
(*Cichlasoma bimaculatum*)

Mayan Cichlid
(*C. urophthalmus*)

In lab:

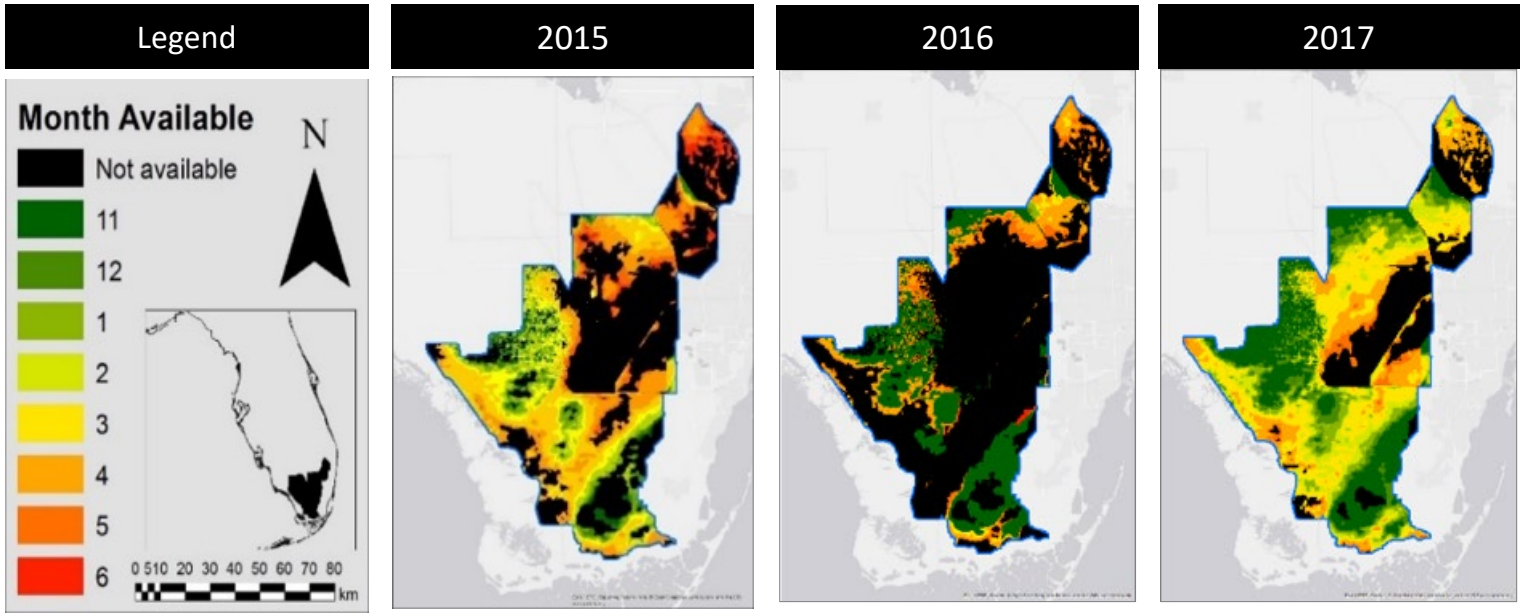
- Identify prey items
  - Species
  - Biomass

Test: nest productivity ~ non-native fishes consumed

Rationale

Non-native prey may affect stork fitness by:

- Altering fish community dynamics (Schofield et al. 2007; Kline et al. 2014)
  - Changed concentration of prey in landscape (Faunce & Lorenz 2000; Gawlik Lab unpubl. data)



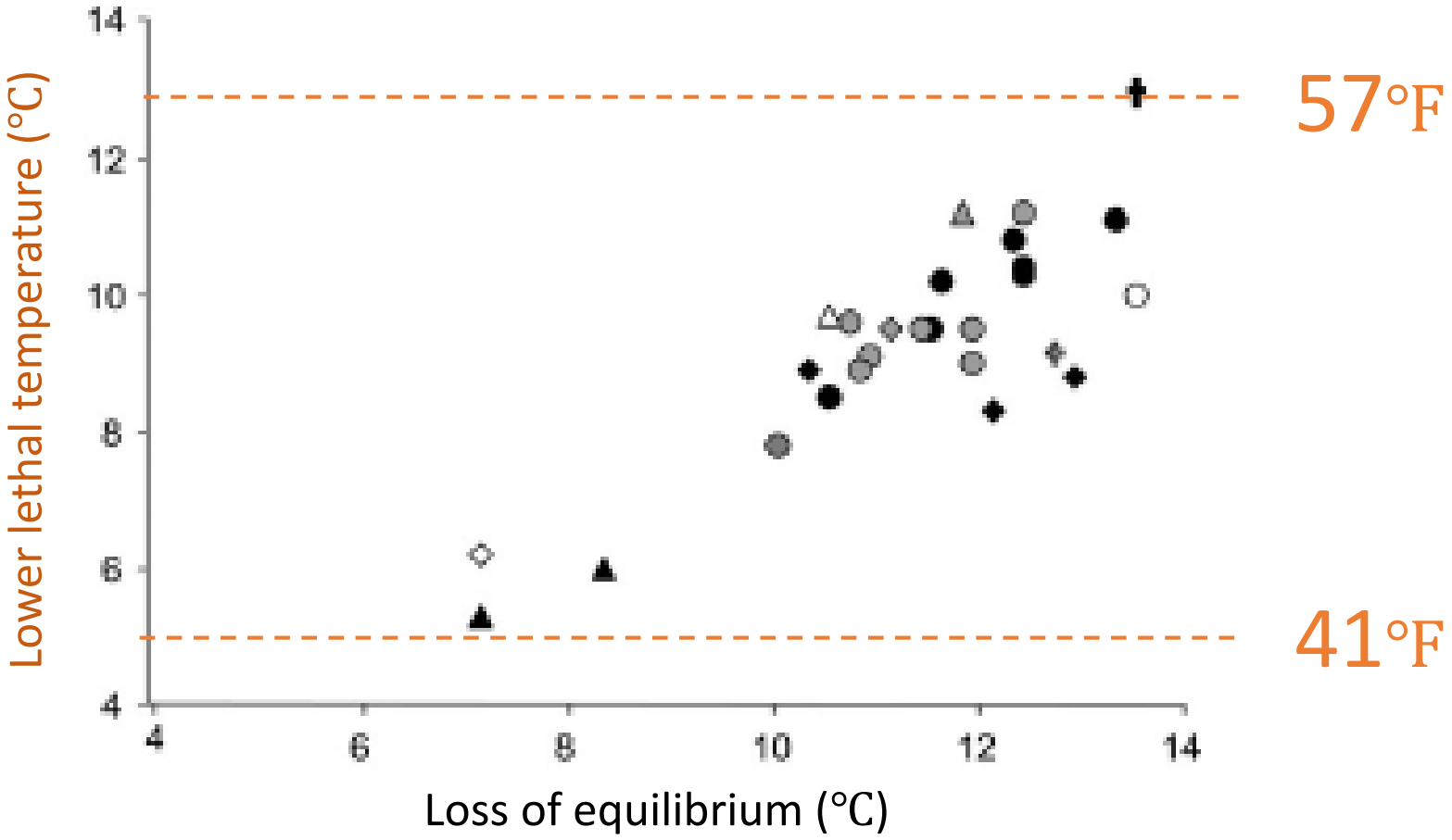
Rationale

Non-native prey may affect stork fitness by:

- Altering fish community dynamics
  - Changed concentration of prey in landscape

- Increased vulnerability of prey base during cold spells (Schofield et al. 2018)

Non-native fish are intolerant to cold



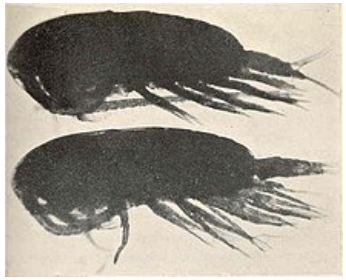
P. J. Schofield and J. L. Kline. (2018) North American Journal of Fisheries Management 38: 706-717.

Rationale

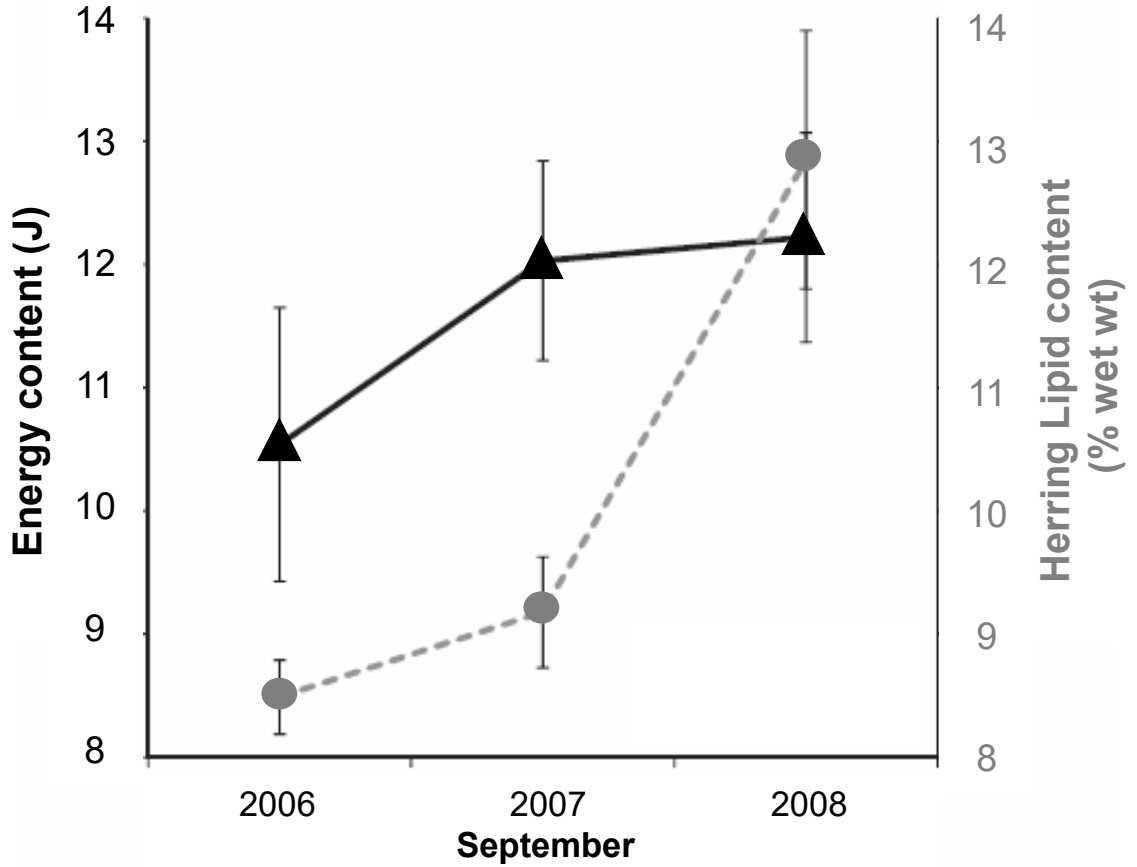
Non-native prey may affect stork fitness by:

- Altering fish community dynamics
  - Changed concentration of prey in landscape
- Increased vulnerability of prey base during cold spells
- Offer different nutritional value than historical diet
  (Kushlan 1979; McKinstry et al. 2013; Lamb et al. 2017)

Nutritional value of prey can vary widely



Copepod
(Calanus finmarchicus)



Atlantic Herring
(Clupea harengus)

McKinstry et al. 2013. Endangered Species Research 20: 195-204.

Rationale

Non-native prey may affect stork fitness by:

- Altering fish community dynamics ↑/↓
  - Changed concentration of prey in landscape
- Increased vulnerability of prey base during cold spells ↓
- Offer different nutritional value than historical diet ↑/↓

Are non-native prey a net ↑ or ↓ for Stork productivity?

Evidence of potential *adaptation

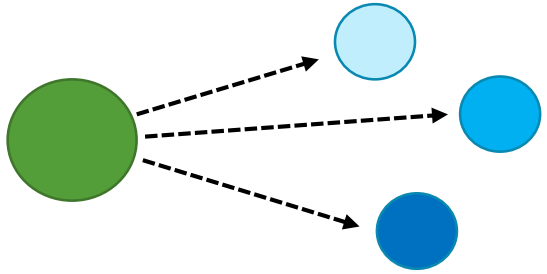
Observed shifts in…

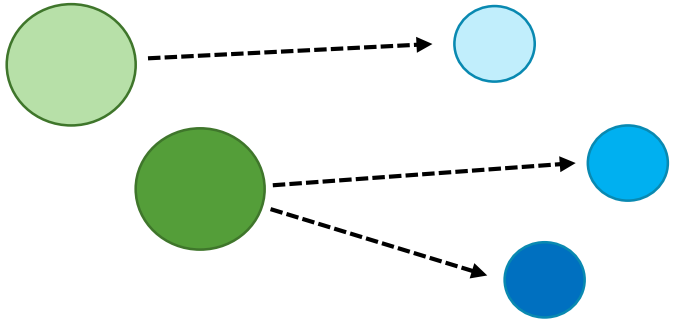
1. Breeding locations
2. Timing of nest initiation
3. Diet (& foraging locations?)

“Adaptation”

Observed shifts in behavior could be evidence of:

Phenotypic plasticity **or** Genetic variability

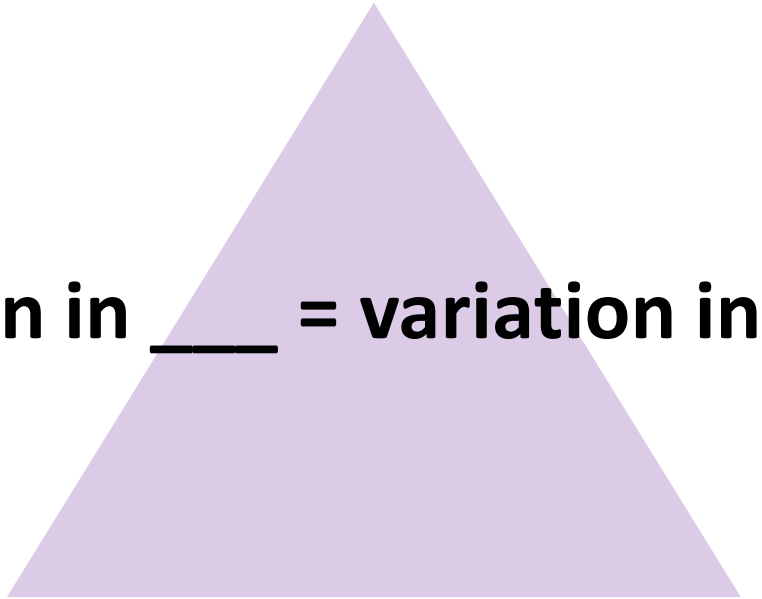




So, are the observed shifts adaptive? Test it!

Diet

(non-native vs. native prey)



Does variation in ___ = variation in productivity?

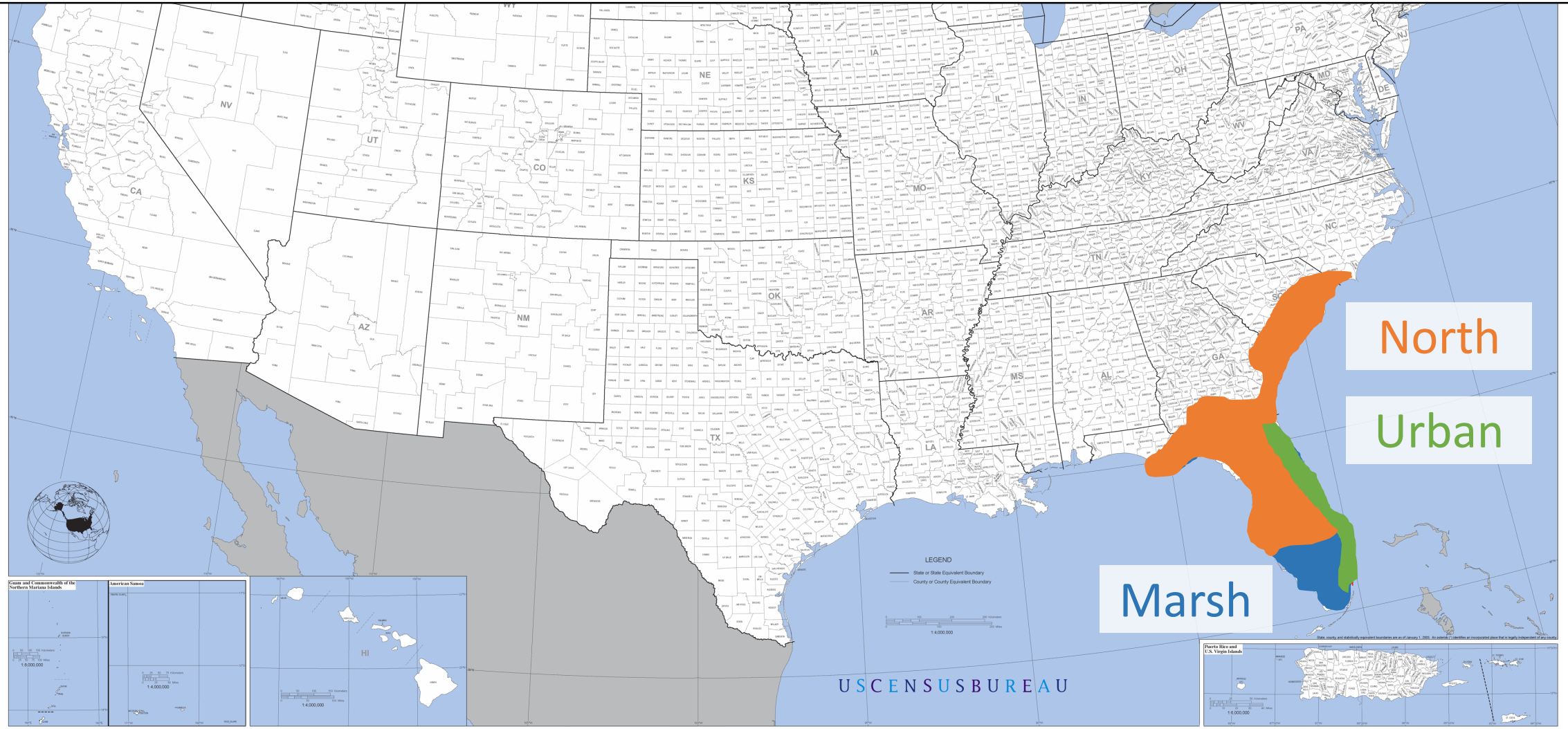
Habitat

(urban vs. marsh nesting)

Genetics

(urban vs. marsh personalities)

Q: Is urban habitat now essential to stock recovery?



Acknowledgements

Research assistance

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Dr. Peter Frederick's lab (UF)

Lori Oberhofer (NPS)

FFWCC and FAU volunteers

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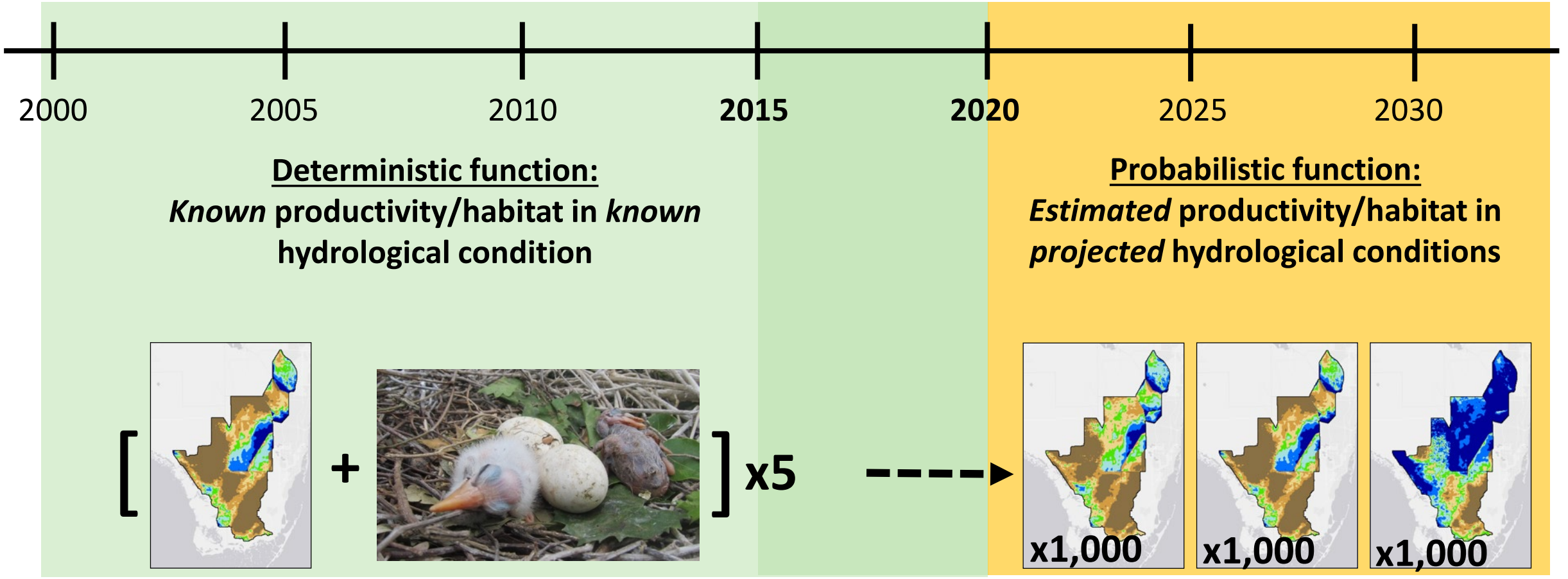
FAU Everglades Environmental Science Fellowship (NPS)

Army Corps of Engineers research grant

Kushlan Research Grant (Waterbird Society)

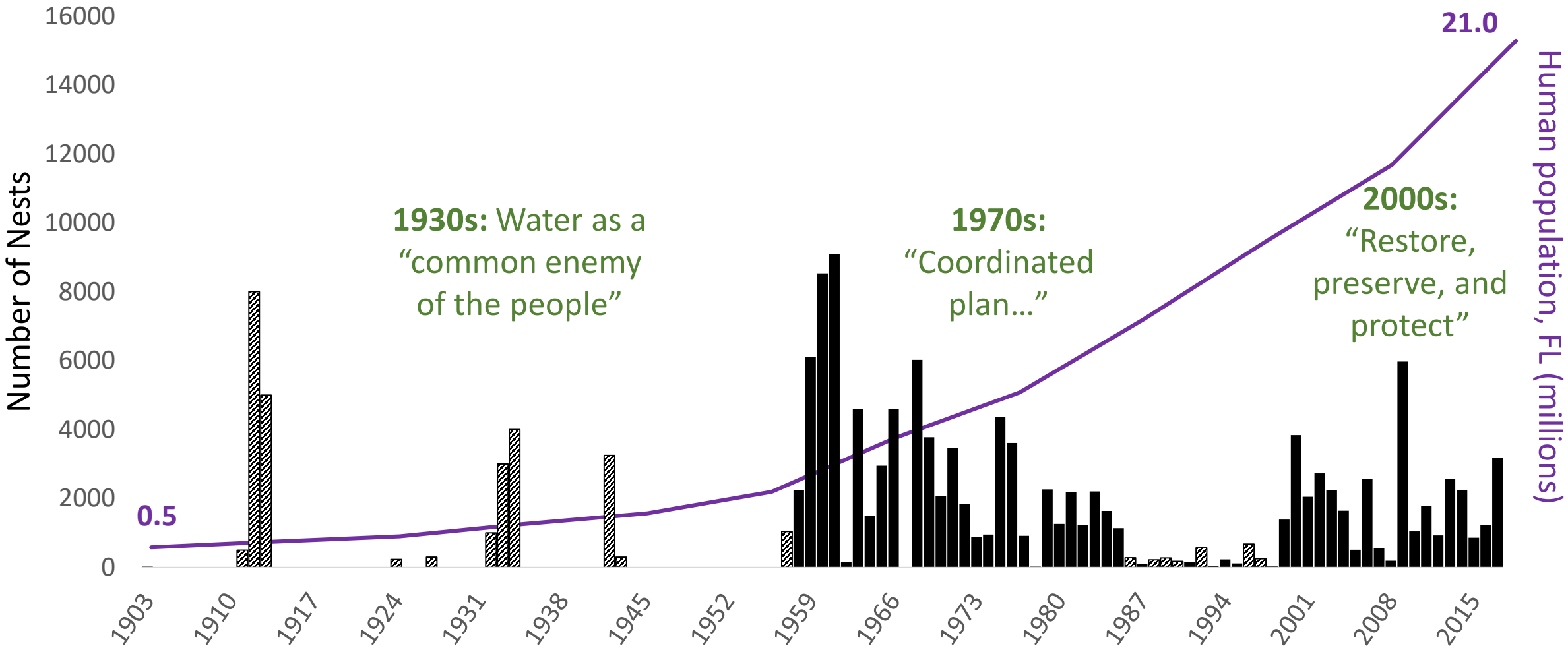
Stochastic simulation in R

Which nesting habitat will be favored in the future given various hydrological scenarios?



Have storks adapted to the urbanized U.S.?

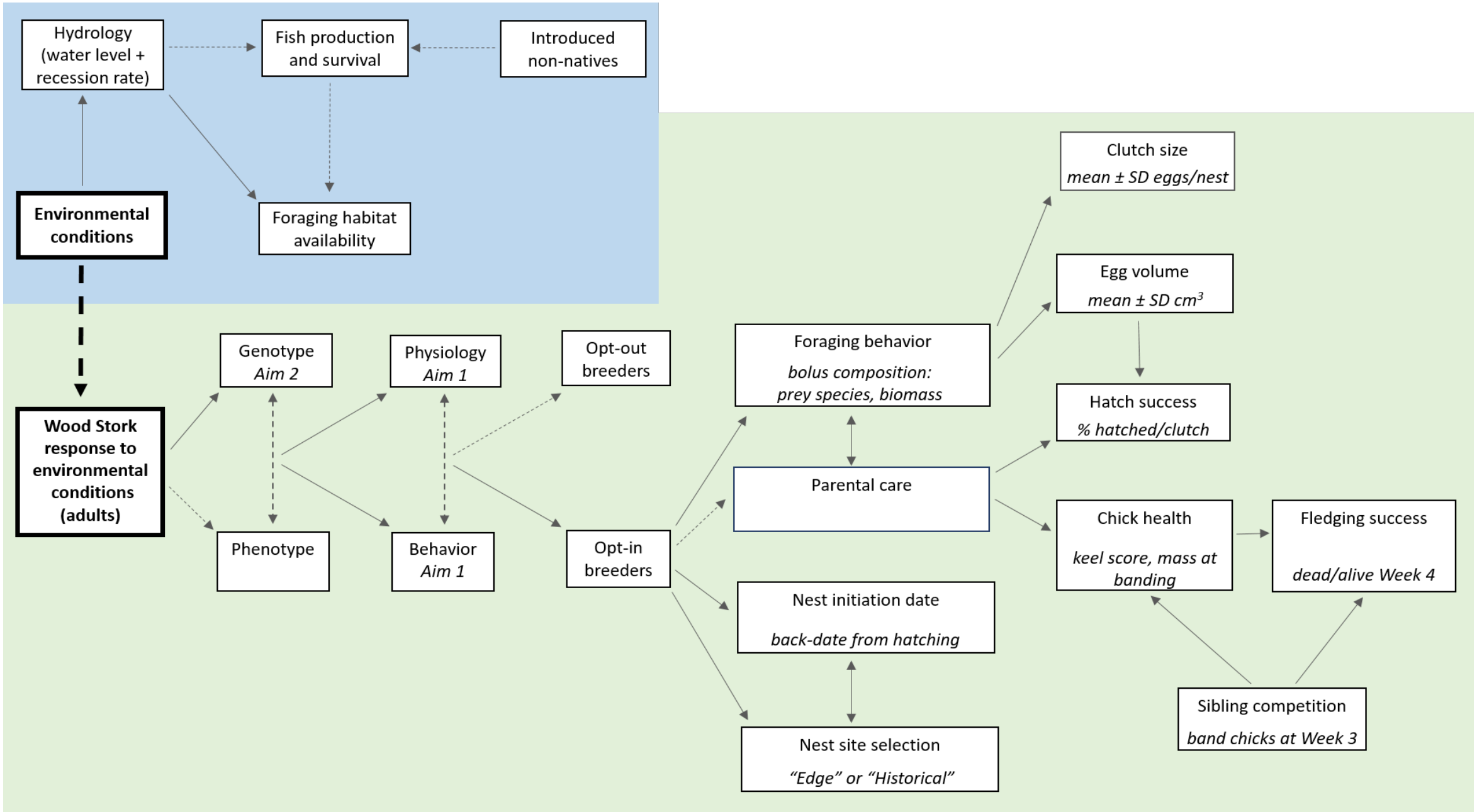
Human-ecosystem interactions, 1903-2017



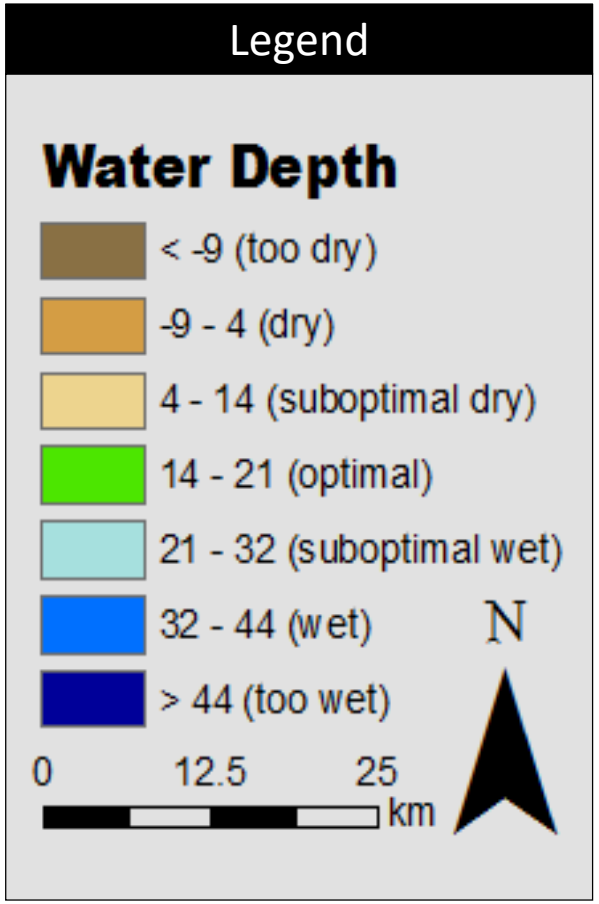
Ogden 1978; Crozier & Gawlik 2003; SFWMD 2002-2018

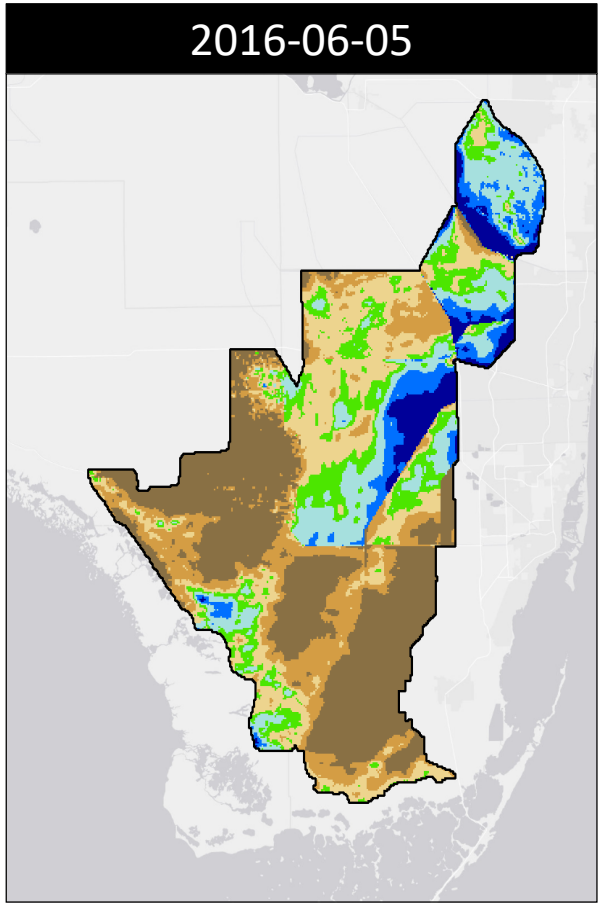
In lab:

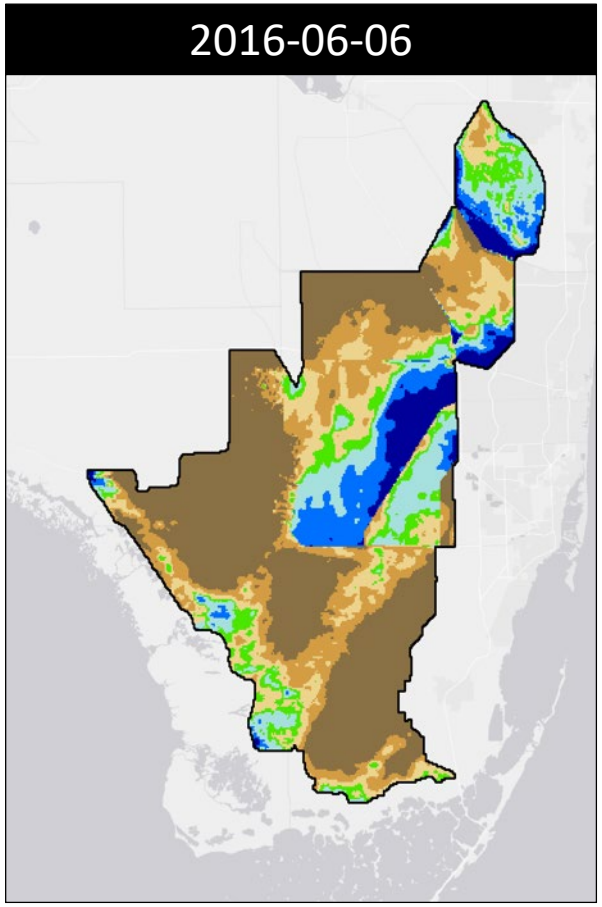
- Identify prey items
  - Species
  - Biomass

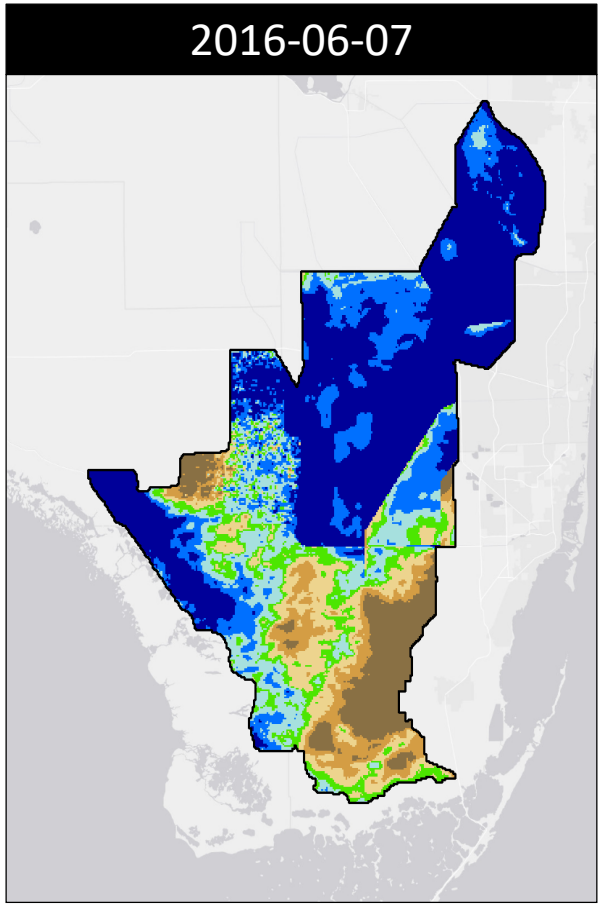

Hydrology (water level + recession rate)
Fish production and survival
Introduced non-natives
Environmental conditions
Foraging habitat availability
Wood Stork response to environmental conditions (adults)
Genotype Aim 2
Physiology Aim 1
Opt-out breeders
Phenotype
Behavior Aim 1
Opt-in breeders
Foraging behavior
bolus composition: prey species, biomass
Parental care
Nest initiation date
back-date from hatching
Nest site selection
"Edge" or "Historical"
Clutch size
mean ± SD eggs/nest
Egg volume
mean ± SD cm3
Hatch success
% hatched/clutch
Chick health
keel score, mass at banding
Fledging success
dead/alive Week 4
Sibling competition
band chicks at Week 3

Foraging habitat availability by day

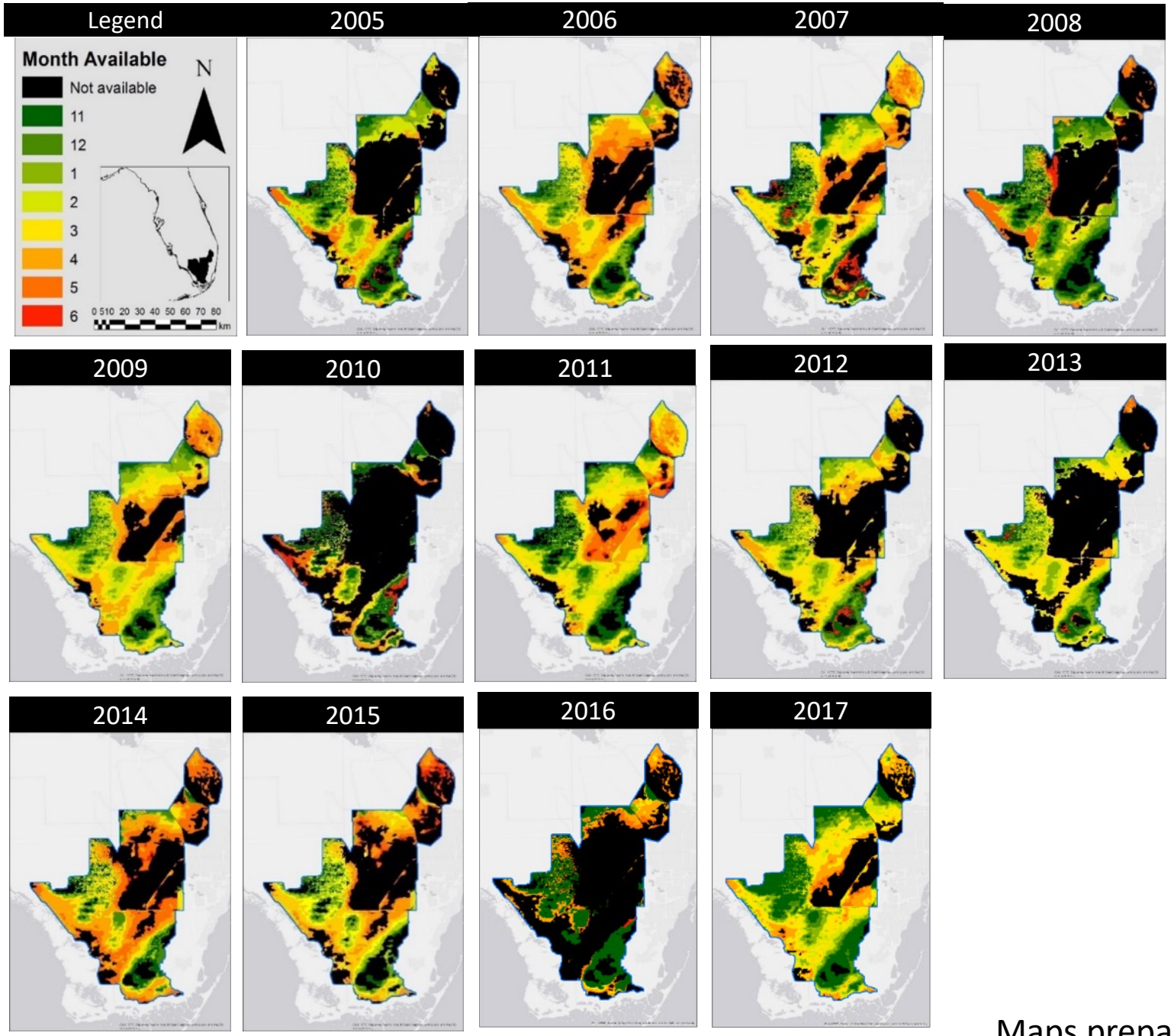








Maps prepared by Gawlik Lab



Maps prepared by Avian Ecology Lab (FAU)

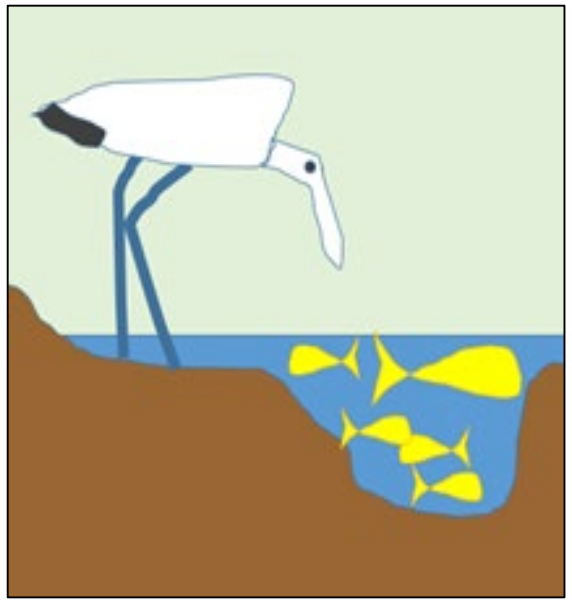
Significance

Urban-influenced shifts in nesting and foraging behaviors are not built into current Stork—Fish—Hydrology models.

Wading bird populations

Fish communities

Water conditions



Wading bird populations

Native fish

Non-native fish

Water Condition X

Water Condition Y

Water Condition Z