ECOLOGICAL DRIVERS OF MAMMALIAN TREE ISLAND USE

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MICCOSUKEE TRIBE OF INDIANS OF FLORIDA

Tree Islands as Habitat

- Wildlife relies heavily on tree island habitat
  - Forage, dry refugia, forested cover, breeding/nesting/rearing sites

- Mammals especially reliant because of terrestrial affinity

- Quality mediated by tree island characteristics (e.g., size, elevation, plants)

1. Diversity
2. Composition
3. Distributions (Zarnetske et al., 2017; Hamer et al., 2021; Ferreira Neto et al., 2021)

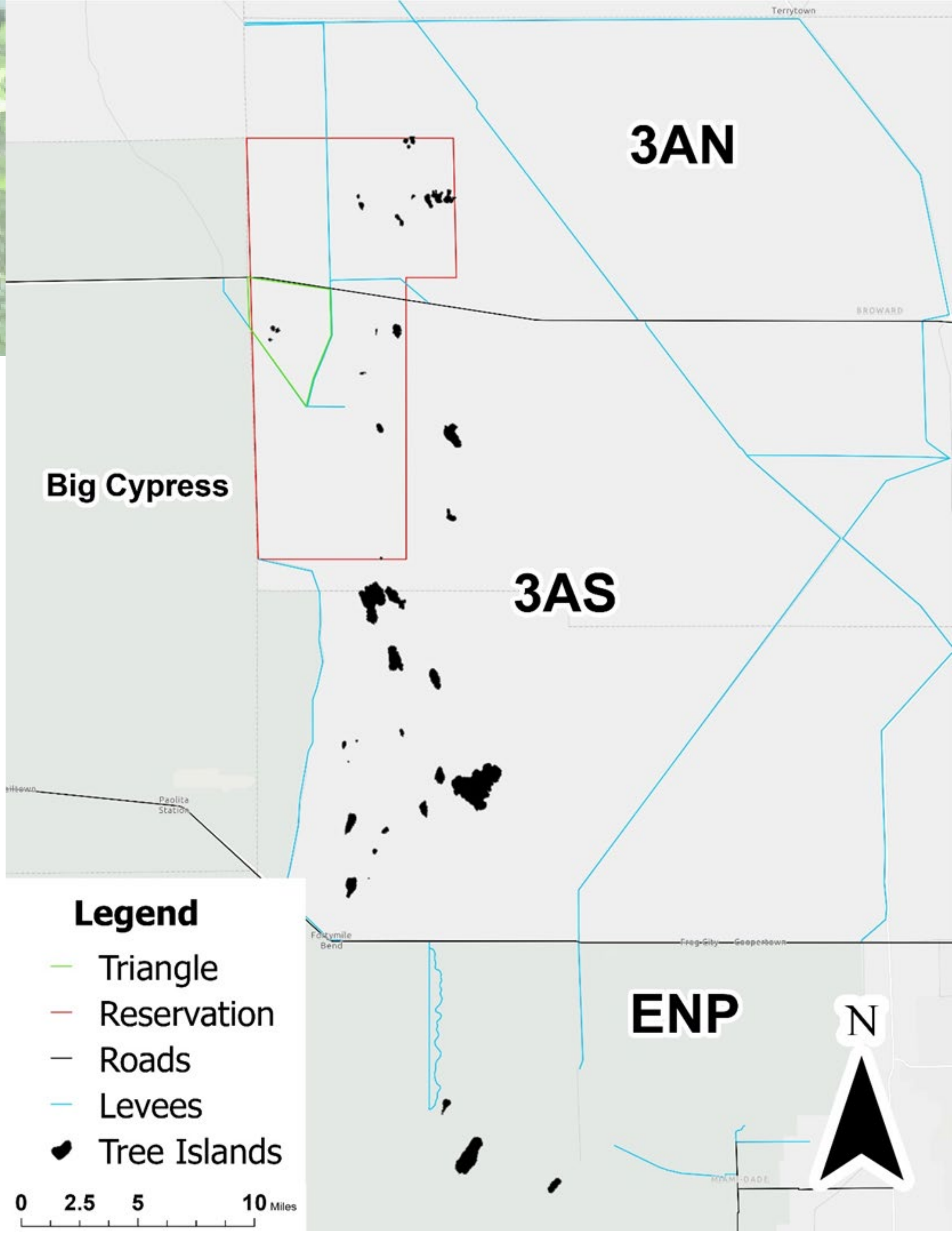
- Limited mammal research in Everglades
  - Multidecadal decline

Methods

- **Site Selection**

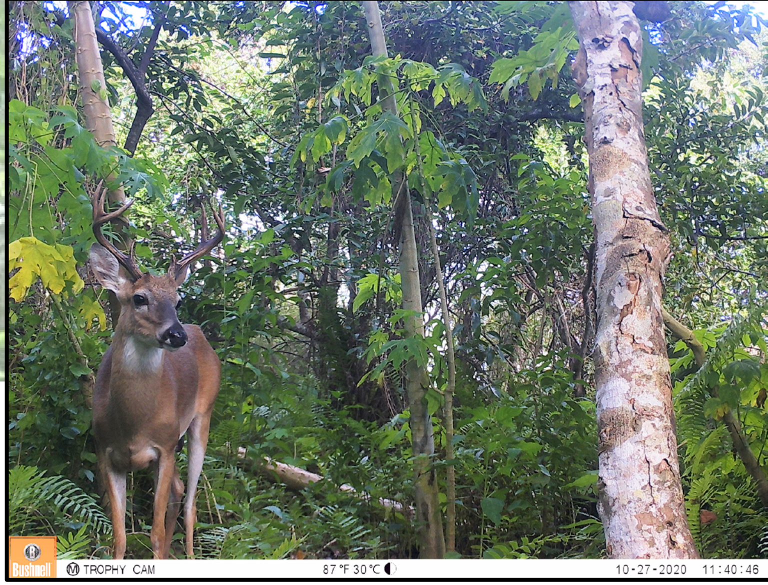
- Areas of interest (distinct hydrologically)
    1. **3AN** (10 TIs)
    2. **TRI** (3 TIs)
    3. **3AS** (24 TIs)
    4. **ENP** (3 TIs)

    - 34 islands randomly along depth transect
    - TRI and ENP added to ensure full range of combinations



* Polygons are 5x the scale of their true areal extent

Methods



▪ Camera Trapping

- Deployed using consistent protocol (i.e., height, angle, settings)
- Cams on “head” of TIs
  - More diverse than downstream areas (All species use head, not subset)
  - Last place to flood. During high-water, wildlife congregate here
  - Methodological consistency. ‘Head’ is not ‘habitat’

- Cameras positioned to optimize data collection

- Hourly occurrences → Relative abundance index (RAI)

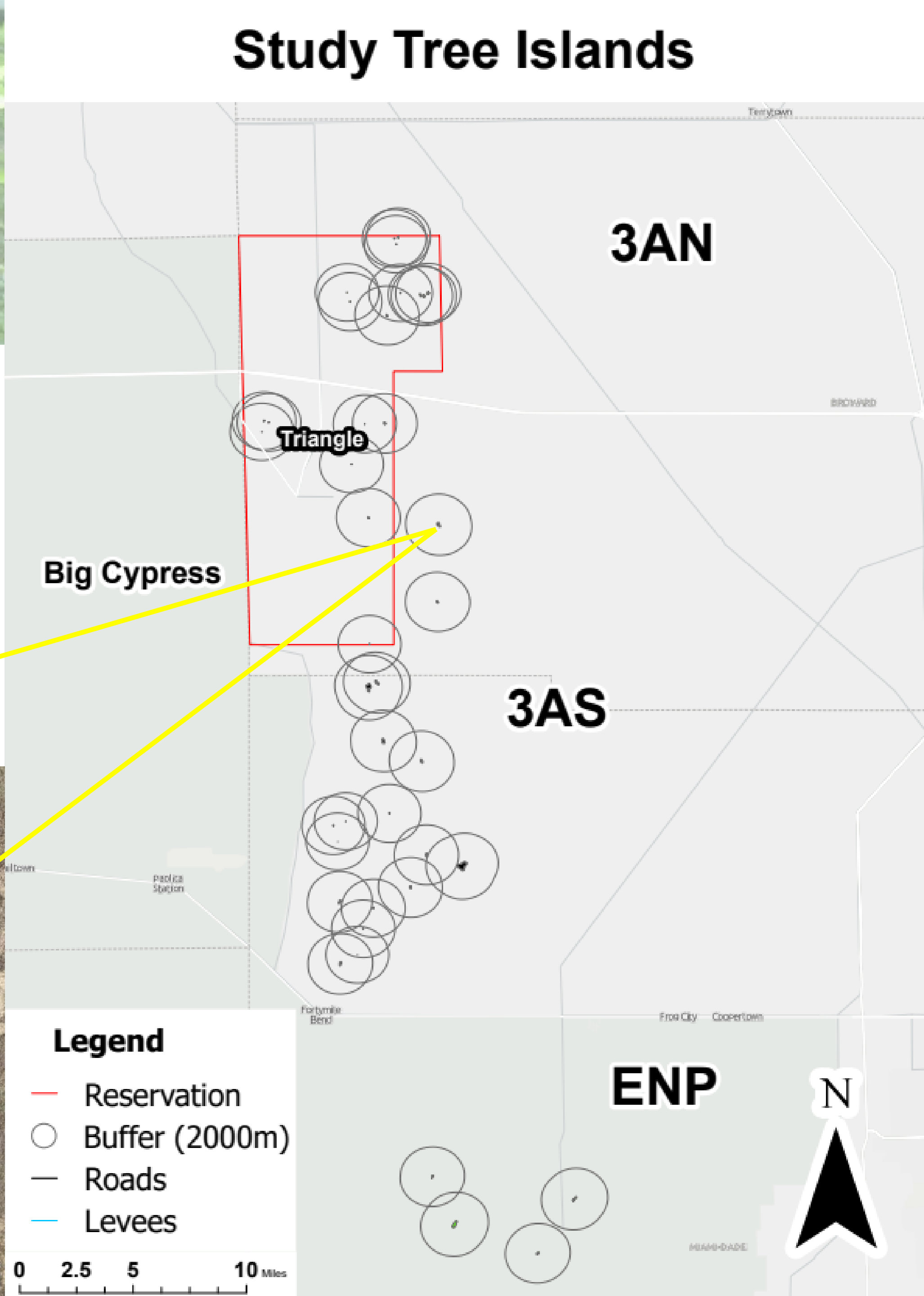
  RAI spp1 =(Number of occurrences) / (Number of trap days)

Methods

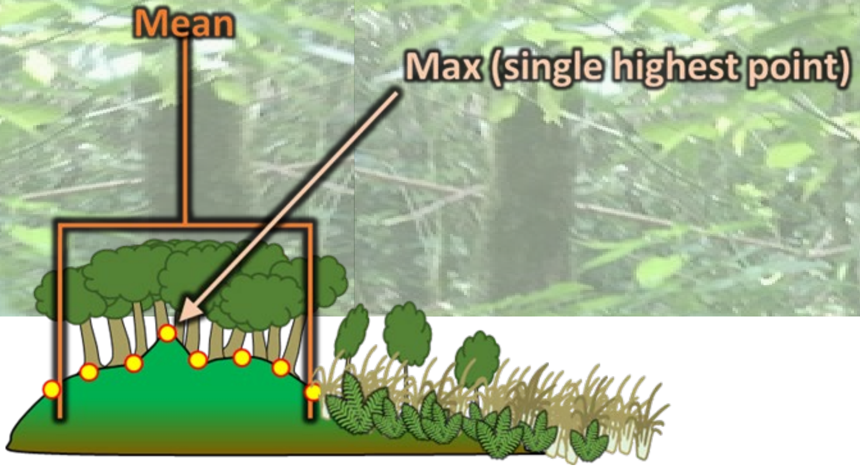
- **Landscape Characteristics**

  - ArcGIS Pro to digitize heads
  - Measure head area
  - Spatial Rings

    100/250/500/1000/2000m
    - # of Neighbors
    - Area of Neighbors



Methods



- **Elev./Hydrology**

- Head elevations surveyed (post-Eta in Nov. 20)
  - Transect -10m (marsh), through head (not tail)
  - Measured 3x every 5 – 10 m; Hammock vs Bayhead/swamp, respectively
    - 3AS   Triangle   3AN
    - ENP (SOFTEL)

- (EDEN water level) – (Survey Depth) = (Plot Elevation)
  - Derive tree island & marsh (rings) hydrologic variables

    Max. elev., Relative water, Hydroperiod, etc.

Methods

▪ Vegetation

- Same transect as the elevation survey

<u>4x4 m square plot</u>

- Ground cover/Vines/Saplings/Trees
  - DBH
  - Crown cover
  - Canopy height
  - Canopy structure

<u>2x2 m subplot</u>

- Herbs/Vines
  - Stem density
  - % Crown cover

Table 2. Stratification and defining criteria of plants in vegetation surveys.

Strata	*Criteria*
Herbs	Plants, including vines and seedlings, with a maximum height <1 m.
Shrubs	Plants, excluding vines, with a maximum height >1 m; woody species must have a DBH <1 cm.
Vines	Vines with a maximum height >1 m.
Saplings	Woody species with a maximum height >1 m and DBH of 1-5 cm.
Trees	Woody species with a maximum height >1 m and DBH ≥5 cm.

(Sah, 2004)

Species Diversity

▪ Coverage

- Occurrence data used to calculate **coverage**
  (How completely sample represents population)

  Mean **coverage** = 99% (min. = 86%)

- Standardize to **asymptotic estimate** of **coverage** (100%)
  - Minimal extrapolation
    (only 6 increased) (Roswell et al., 2021)

$$C = 1 - \frac{f_1}{n}\left[\frac{(n-1)f_1}{(n-1)f_1 + 2f_2}\right]$$

Asymptotic Estimate

	Richness	Hill-Shannon
Gamma	12	3.2
Alpha	1 – 12	1 – 6
Mean alpha	5	2.4
Beta	2.4	1.3

Common Name		Scientific Name
Black bear		*Ursus americanus floridanus*
Bobcat		*Lynx rufus*
Coyote		*Canis latrans*
Eastern gray squirrel		*Sciurus carolinensis*
Feral hog		*Sus scrofa*
Florida panther		*Felis concolor coryi*
Marsh rabbit		*Sylvilagus palustris*
Raccoon		*Procyon lotor*
River otter		*Lutra canadensis*
Virginia opossum		*Dideplphis virginiana*
Whitetail deer		*Odocoileus virginianus seminolus*
Rat	Cotton mouse	*Peromyscus gossypinus*
	Marsh rice rat	*Oryzomys palustris*
	Hispid cotton rat	*Sigmodon hispidus*
	Norway rat	*Rattus norvegicus*
	Roof rat	*Rattus rattus*

Species Diversity

▪ Generalized Linear Mixed Models (GLMMs)

- GLMMs modelled variables as fixed effects
  - o Site as random effect
  - o AIC identified parsimonious models

❖**Ave. marsh depth** best explained

Species Richness (R^2_{marg} = 0.34)
Hill-Shannon (R^2_{marg} = 0.49)

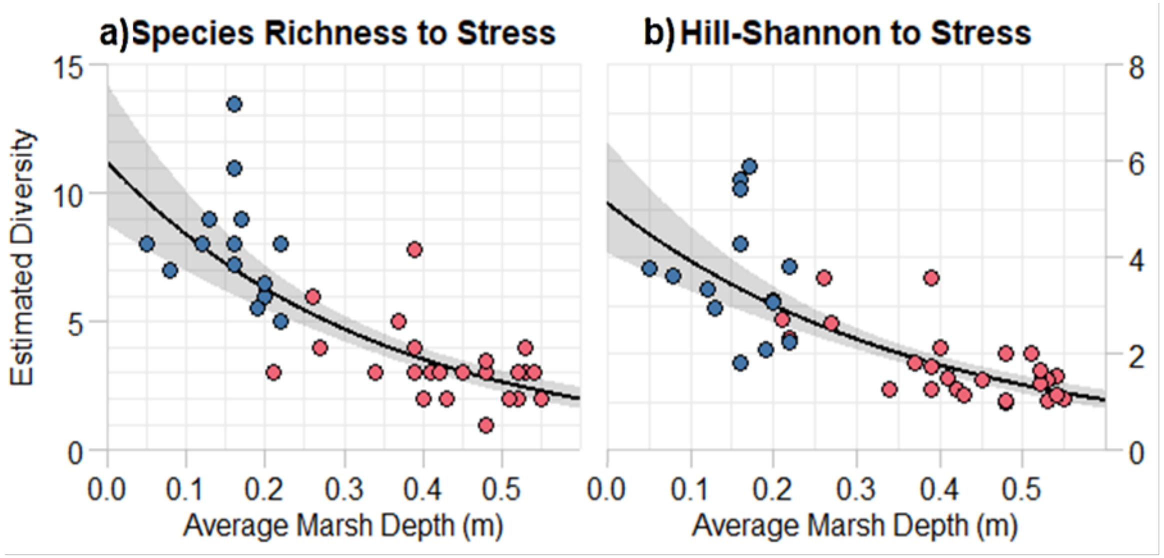
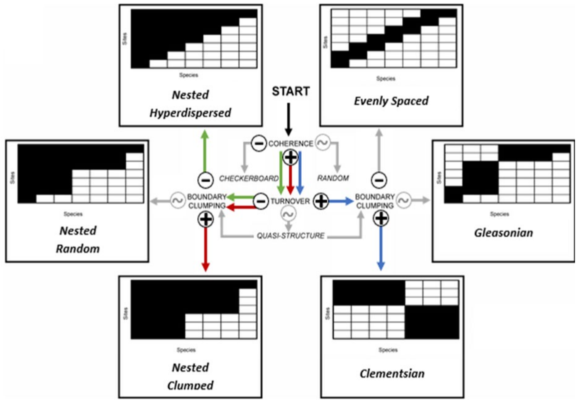


Figure 5. GLMMs of the effect of matrix-derived hydrologic stress on tree island site's estimated alpha species diversity. Species richness (a) and Hill-Shannon diversity (b). Cluster 1 is blue; Cluster 2 is pink. Gray band depicts the 95% confidence interval.

Metacommunity

- EMS Framework



Modified from Eden et al. (2022)

  - Reciprocal Averaging ordination of RAI

Coherence = + ; Turnover = − ; Clumping = +

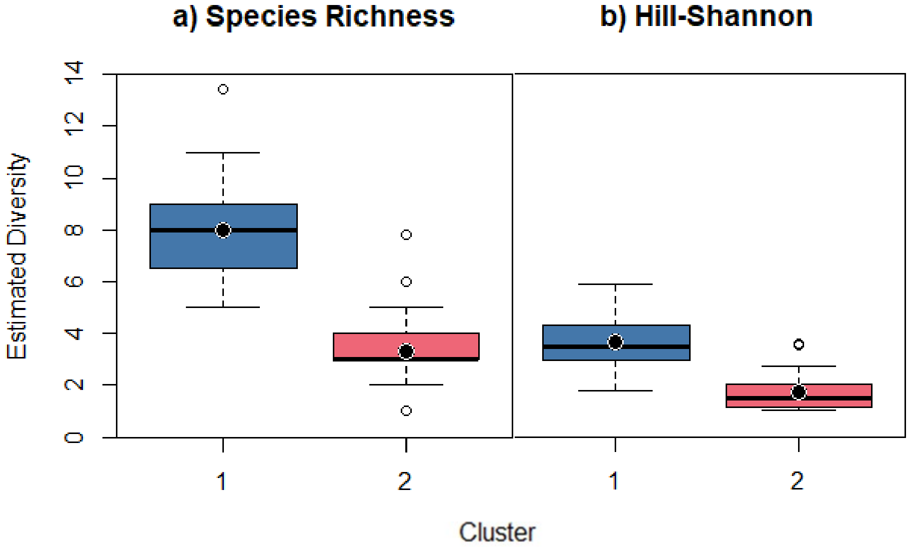


Figure 6. Boxplots of clusters' estimated alpha species diversities. Species richness (a) and Hill-Shannon diversity (b) were estimated from coverage-based asymptotes.

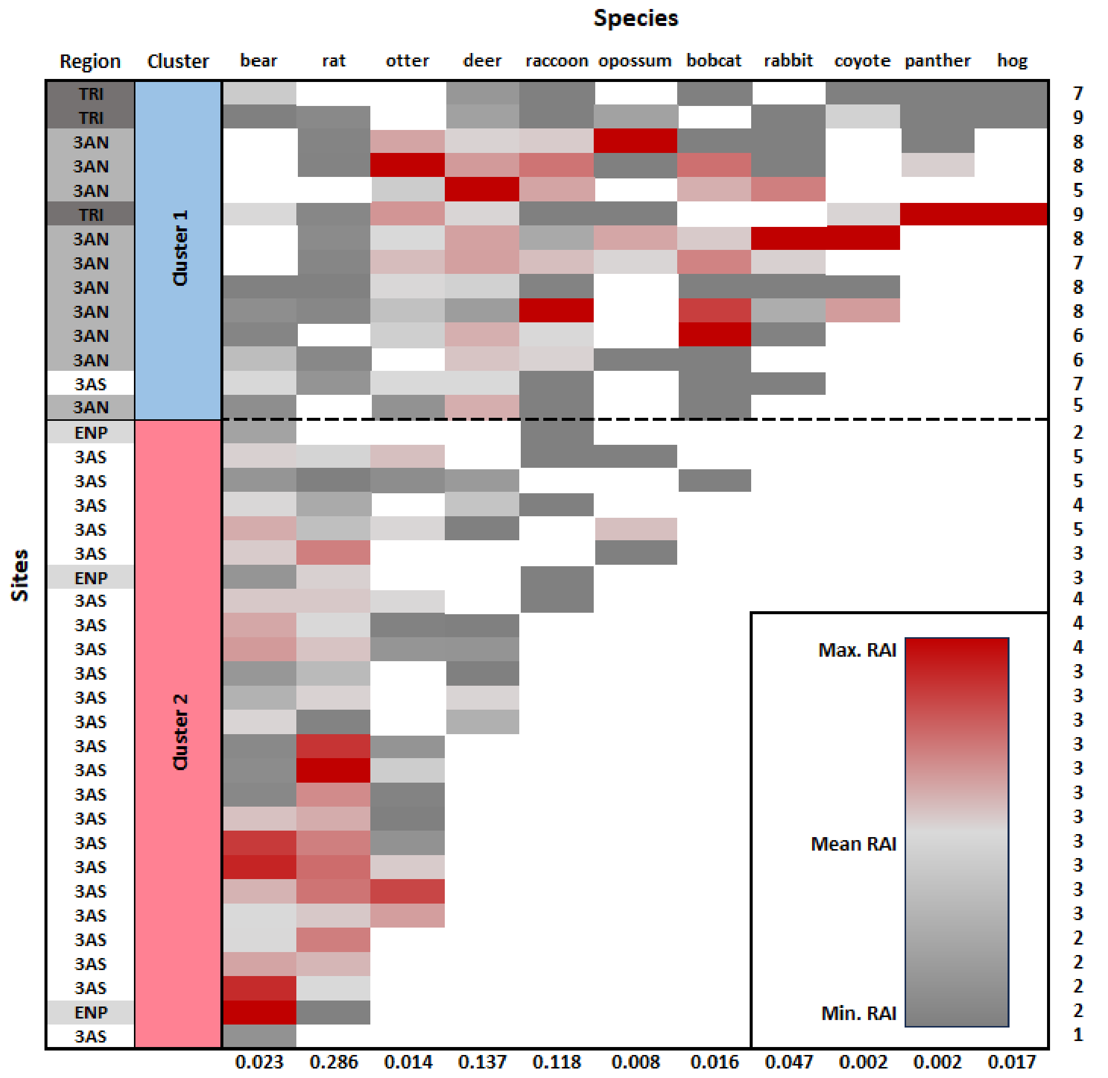


Figure 3. Ordinated sites-species matrix of all tree island sites and mammals detected during camera trapping. Sites and species' relative abundances (RAI) were organized according to their reciprocal averaging Axis-1 score. The right y-axis displays row counts (i.e., number of species at each site) and the bottom x-axis displays column means (i.e., the mean RAI for each species across).

Metacommunity

- **Distance-Based Redundancy Analysis**

  (1) ordinate BC dissimilarity (2) Multiple regression

  - Species in Euclidean space (Angle = Correlation)

    (**spp.** ~ **spp.**) (**var.** ~ **var.**) (**spp.** ~ **var.**)

  - Parsimonious dbRDA reduced to 4 variables
    - Explained 44% total variation

❖**DEEP** = (high-water depth) = 23% of var. (x6)

❖**MRSH** = (marsh amplitude)

❖**AREA** = (log area of head)

❖**NBR%** = (area of neighbors in 1000 m)

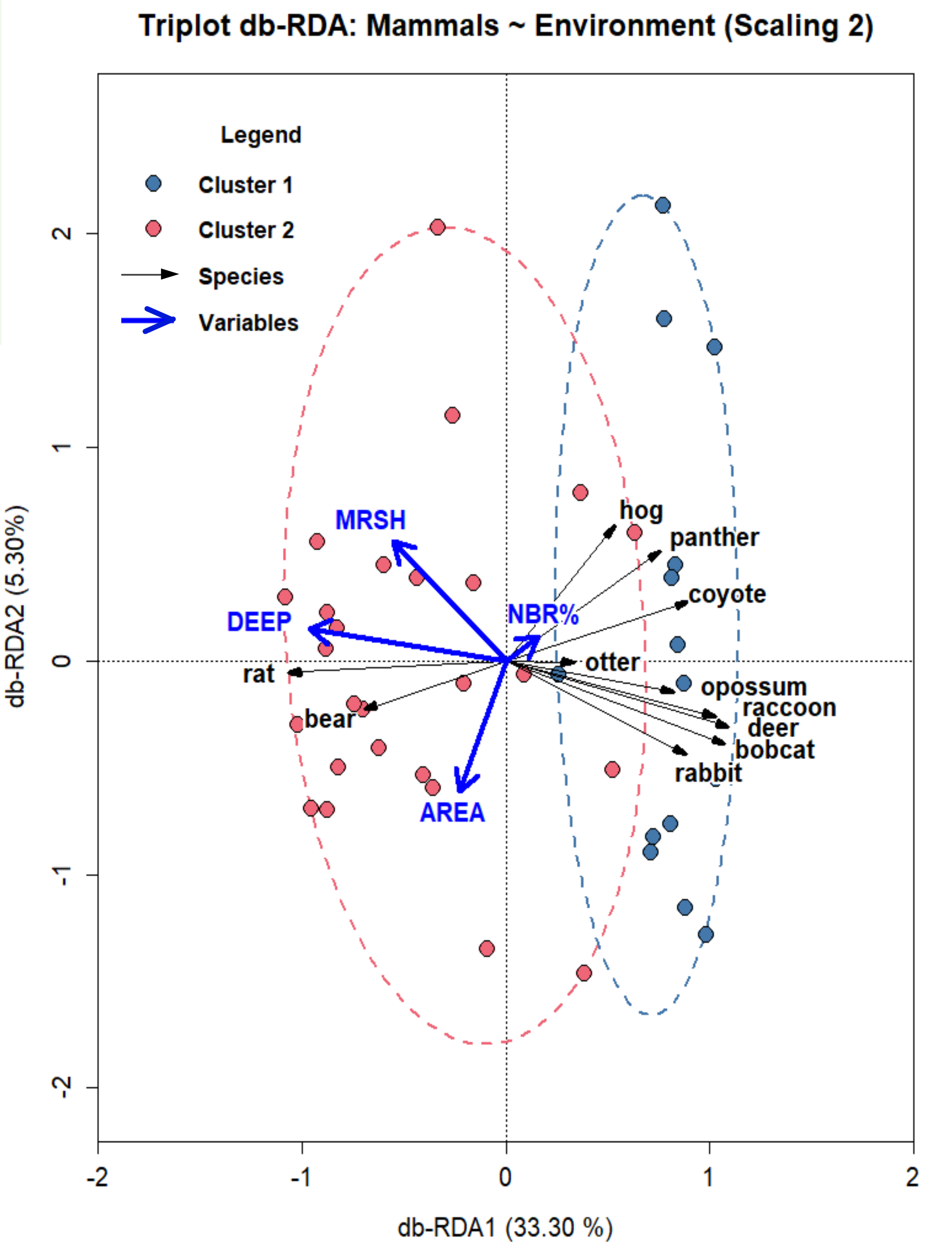


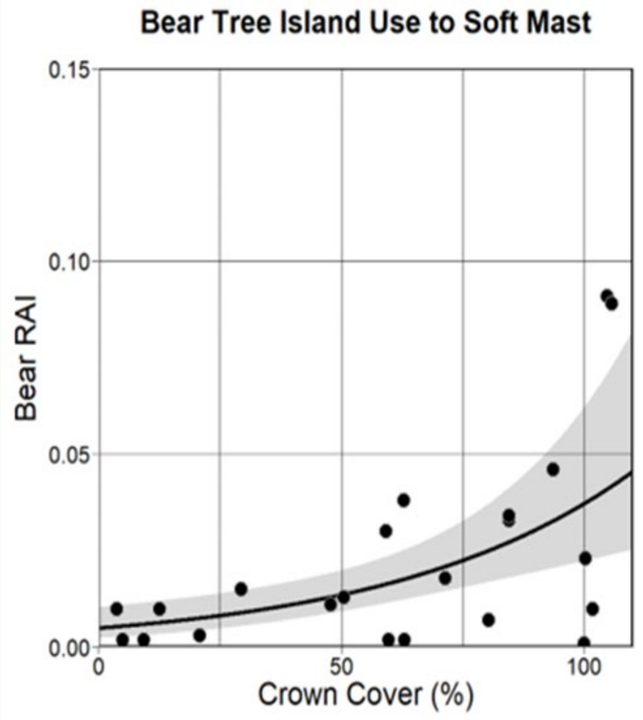
Figure 7. Distance-based redundancy analysis correlation triplot of constraining variables, Hellinger transformed species, and sites scores fitted as orthogonal linear combinations of constraining variables (*i.e.,* linear combination (lc) scores).

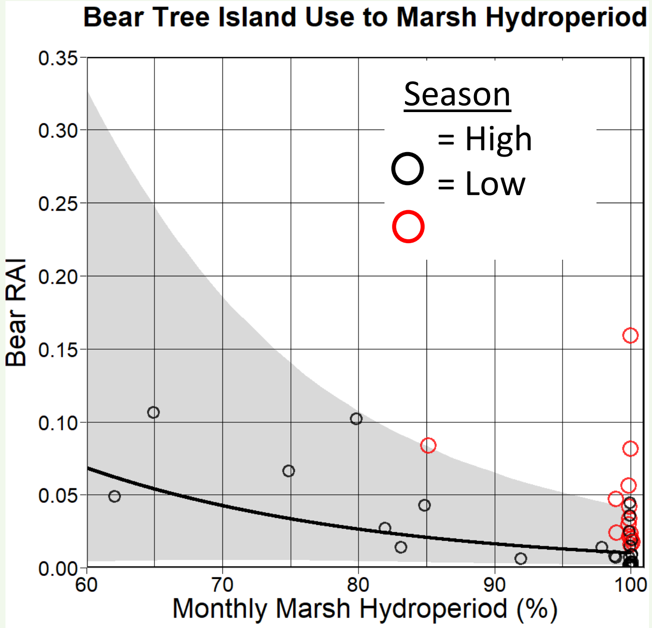
▪ Distance-Based Redundancy Analysis

- Multiple regions & species omits temporal & blurs species-specific trends

Ex. Bears in WCA 3A

- **Bears** on all 24 TIs
  - RAI +10x higher on most used than least used
  - Availability of fruit mast is vital
    - Pond apple, cocoplum, strangler fig
  - +10% hydroperiod → -50% likelihood of use





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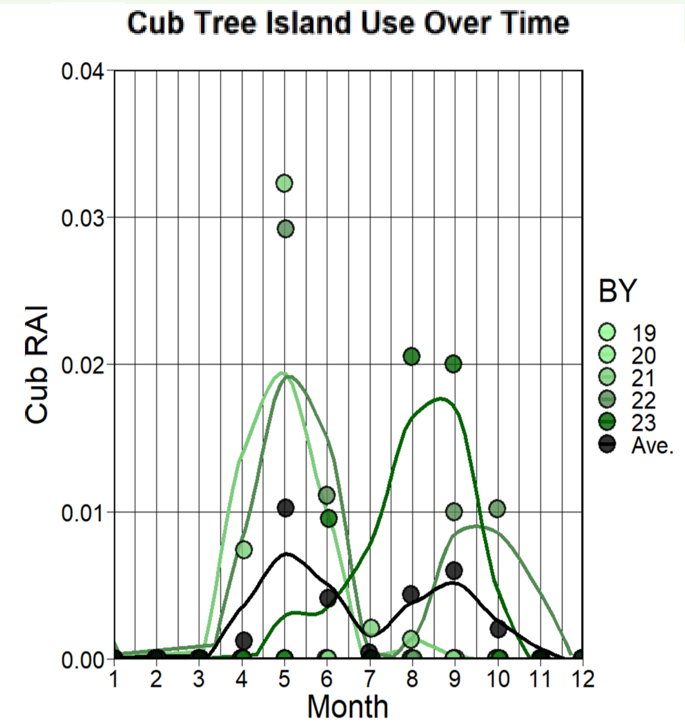

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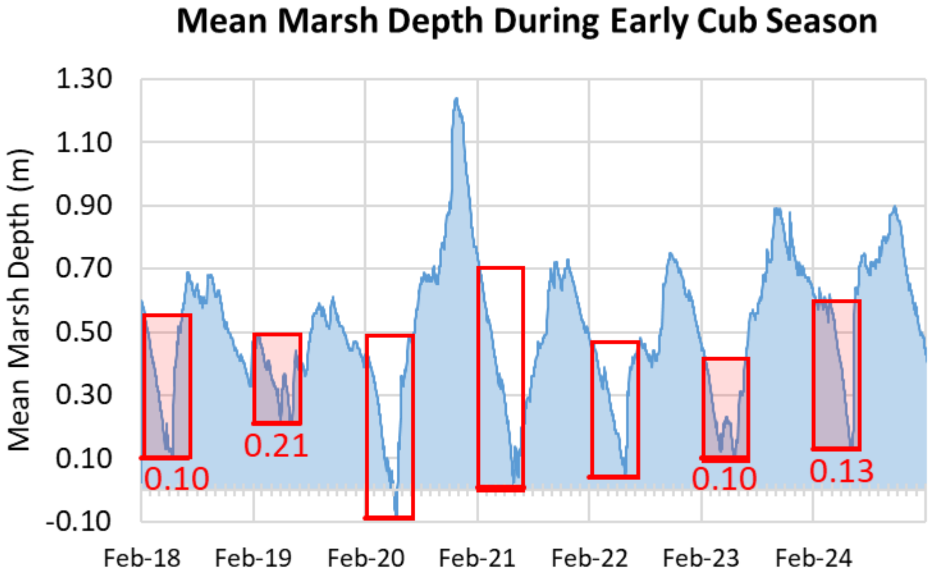
- **Cubs** on 9 TIs
  - 8x more likely on TI with hammock
  - Born in February, emerge April, disperse June
  - Need drydown (<4" = 0.1m) for recruitment
    Very sensitive to pre- & post-denning conditions

(Elowe & Dodge, 1989; Garrison, 2004)



Implications





- **Depth** (wet-season) drive diversity, distributions, habitat use, abundance
  - Patch size and connectivity important but secondary to hydrology

- Multicollinear = islands with >0.4 m are same with regular, prolonged flooding of hammocks
  - Flooding hammocks → loss of forage, habitat, reproductive failure, mortality
  - Marsh drydowns → May – June timing to facilitate dispersal & recruitment

- Is multidecadal decline of mammals MOSTLY due to flooding? pythons?





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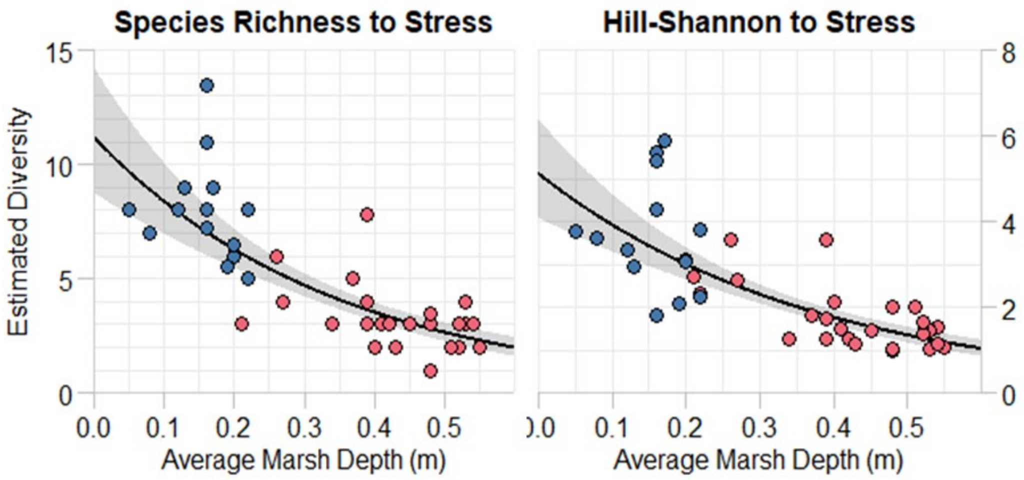
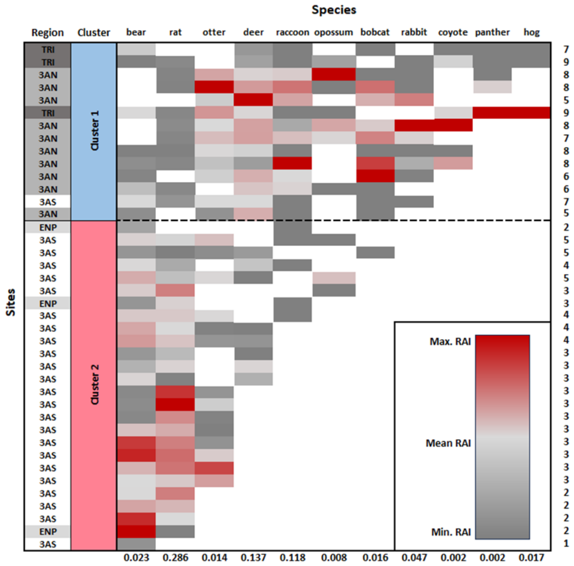
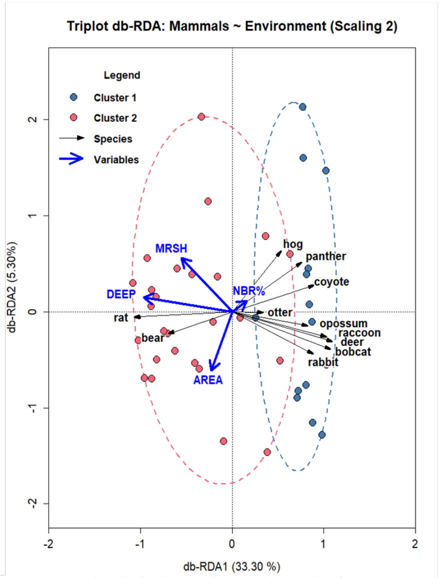
  a) Metacommunity – strong environmental filter; structured by water-depth







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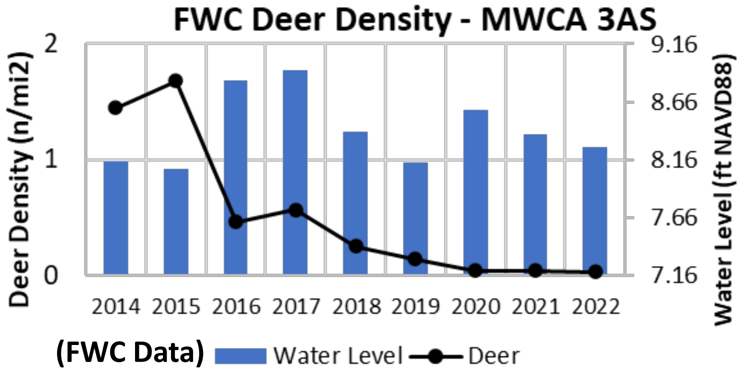

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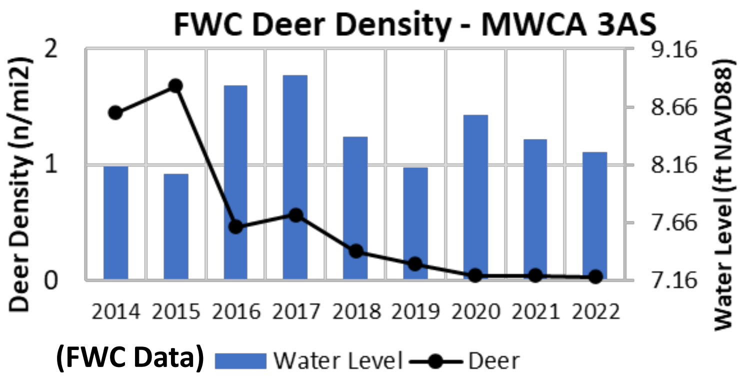
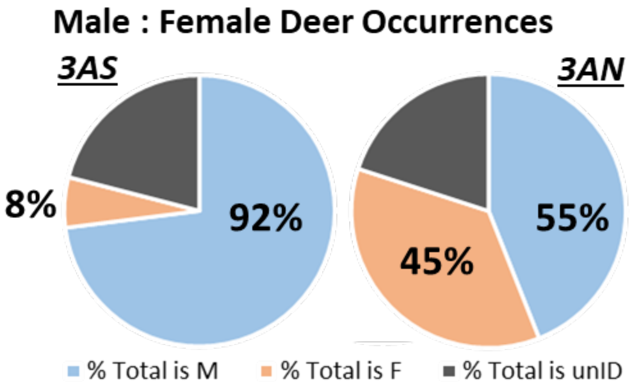
  c) Mass mortality (~50%) during high-water; demographics

(MacDonald-Beyers, & Labisky, 2005)
(Cherry et al., 2019)





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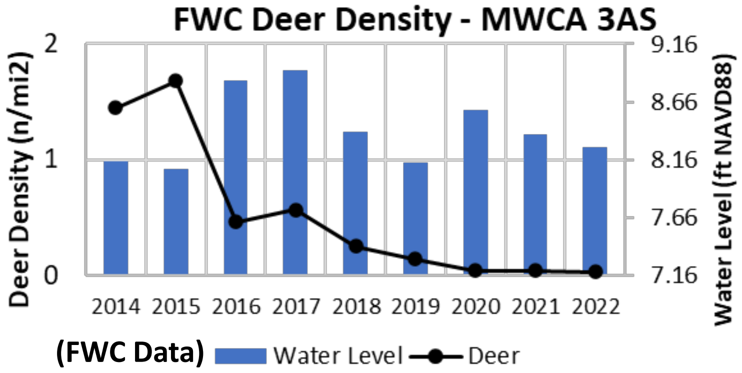
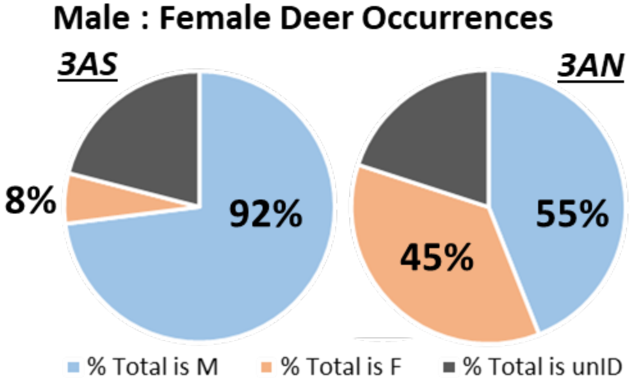
  - c) Mass mortality (~50%) during high-water; demographics (MacDonald-Beyers, & Labisky, 2005)
  - d) Diversity & occurrences higher where drier (Cherry et al., 2019)





RAI of 3AS to	3AN	TRI
▪ Coyote	✓	✓
▪ Panther	✓	✓
▪ Bobcat	27x	11x
▪ Deer	13x	15x
▪ Opossum	2x	7x
▪ Marsh rabbit	76x	2x

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- Is multidecadal decline of mammals MOSTLY due to flooding? pythons?
    - Multiple lines of evidence suggest high-water may be leading driver, at least regionally (3AS)

  * Need direct species interaction data (e.g., python predation or density)
  * Need species-specific studies to refine understandings (e.g., raccoons sensitive to 500m scale)

- **Restore** Quantity suitable habitat (TI Area and Number)
  Quality (Forage + Hydrologic stress)

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