Contribution of Landscape and Local Conditions to Invasion Success of Non-Native Apple Snails in Ranchland Wetlands

Steffan M Pierre [1]

M.S. Student , University of Central Florida
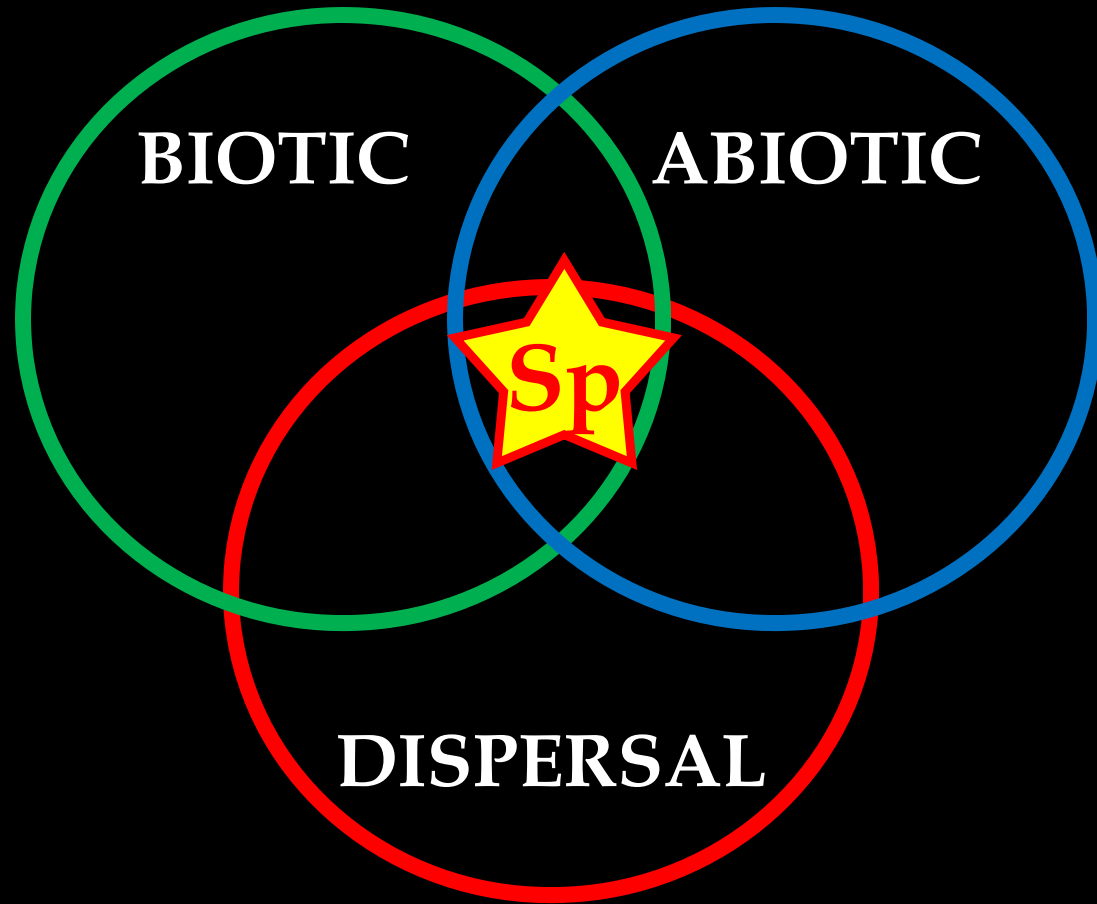**steffanpierre@knights.ucf.edu**

Elizabeth H. Boughton [2], Archbold Biological Station , Lake Placid, Florida, USA
Pedro F. Quintana Ascencio [1], University of Central Florida, Orlando, Florida, USA

Buck Island Ranch ("The Ranch")

- Buck Island Ranch (BIR),
  Lake Placid, Florida
  (lat 27°09"N; long 81°12"W)

- 628 wetlands parcels
  (0.01 to 41.9 ha)

- Ditches & irrigation structures

- Matrix of cattle pasture lands
  - improved (non-native Bahia grass
    (*Paspalum notatum*))
  - semi-native (native and non-native
    grasses and forbs)

Ditches

Semi-Native
Pasture Wetland

Improved Pasture Wetland

Photo Credits: MAERC

- But *P. maculata* isn't observed in every wetland…

- Broad Questions:
  What explains where they are?

- Would these snails survive in any wetland they can disperse to?

- Are there factors that assist or hinder wetland colonization ?

Research Question 1

Where are apple **snails** present …

&

how are they distributed relative to **landscape** and **wetland variables**?

- ▫ **Surveyed wetlands for snail presence**
- ▫ **Characterized wetlands using suite of landscape & localized variables**

Photo Credits:
MAERC, Ryan Chabot

Research Question 2

Does snail absence indicate **unsuitable habitat?**
or **dispersal limitation?**

- ☐ **Conducted field enclosure experiments & monitored survival and growth**

- ☐ **3 late juvenile snails @ wetland; 20 wetlands**

Suite of Potentially Explanatory Variables

- Wetland pH_{H2O}
- Hardness $_{H2O}$ (Calcium)
- Dissolved O_2
- Conductivity $_{H2O}$
- Vegetation cover
- Wetland area

- Ditch presence (surface drainage inlet)
- Ditch number
- Pasture type (improved vs semi native)
- Wetland shape complexity (Perimeter/surface area)
- Euclidean Isolation
- Topological Isolation

**Selected from review of apple snail literature
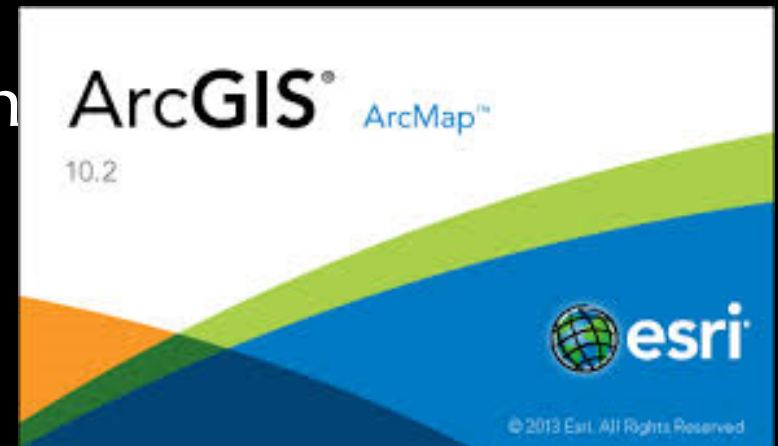 Analyzed using AICc Model Selection Approach

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Tools

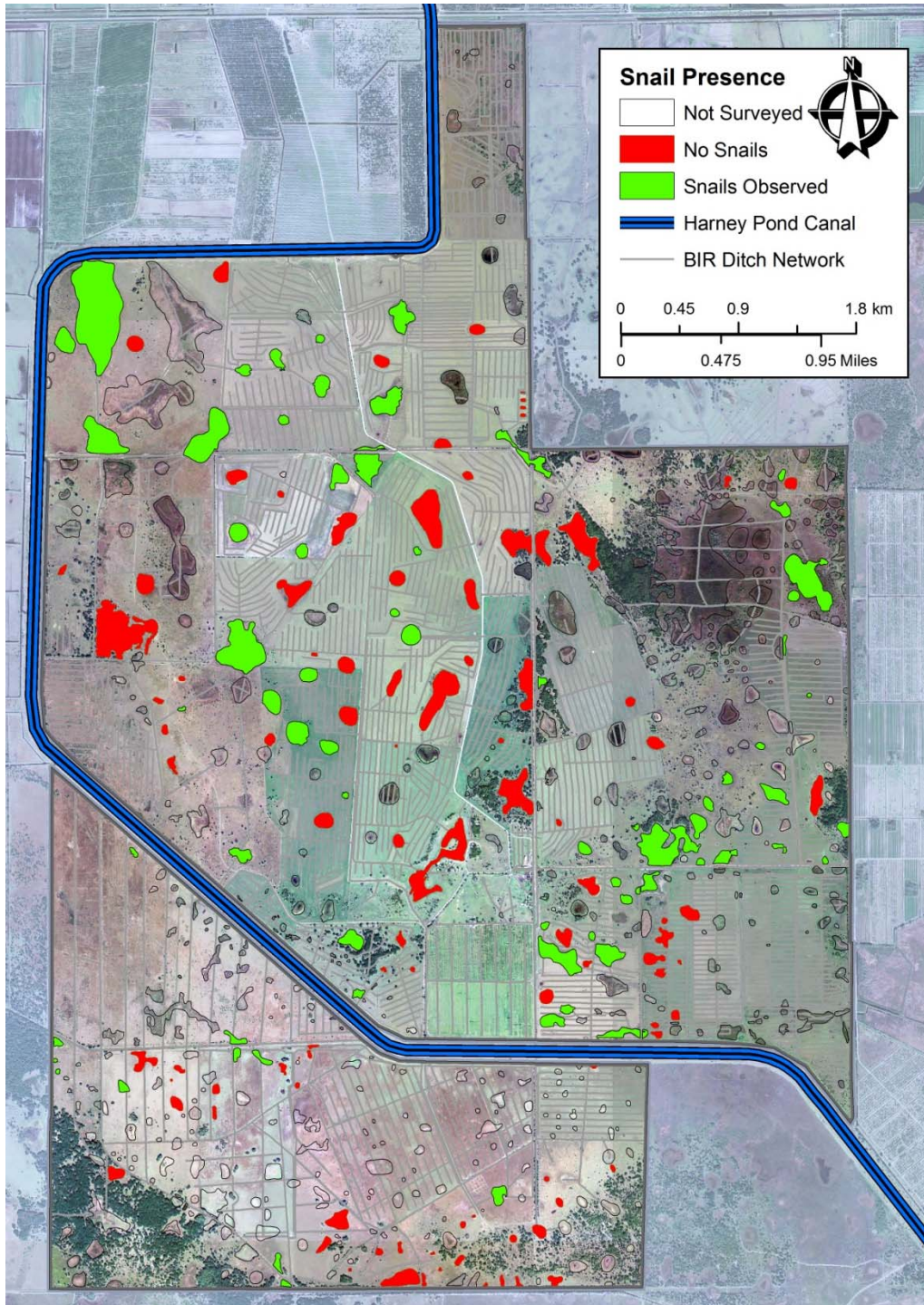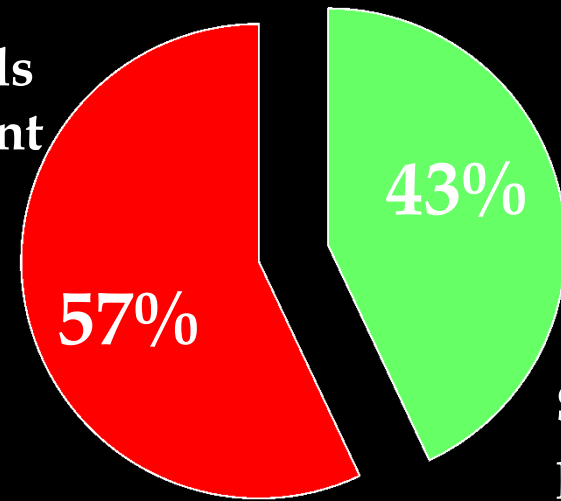- All statistical analyses and graphs were done using packages in **R**

    RStudio
    Version 0.98.507 – © 2009-2013 RStudio, Inc.

- Random wetland selection
  Spatial variables
  Isolation indices
  Map figures

Snail Presence

- Not Surveyed
- No Snails
- Snails Observed
- Harney Pond Canal
- BIR Ditch Network

| 0 | 0.45 | 0.9 | | 1.8 km |
| 0 | | 0.475 | 0.95 Miles |

Snails absent

57%

43%

Snails present

- ▣ 73 wetlands indicated apple snails present (eggs; multiple unclustered shells or whole snails)

- ▣ 98 wetlands had no observed evidence of snail presence

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Potential Explanatory Variables for Snail Presence

- pH_{H2O}
- Hardness (Calcium)$_{H2O}$
- Dissolved O_2
- Conductivity $_{H2O}$
- Vegetation cover
- Wetland area

- Ditch presence (surface drainage inlet)
- Ditch number
- Pasture type (improved vs semi native)
- Wetland shape complexity (Perimeter/surface area)
- Euclidean Isolation
- Topological Isolation

According to AICc Model Selection:

Ditch presence & pH_{H2O}

*predicted to be important to snail presence

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Best Model: Presence ~ (Ditches & pH)

Probability of Snail Presence with pH

y = 0.44 ditch +0.26pH+ -1.2

Rsq = 0.31

P value = 1.93e-08
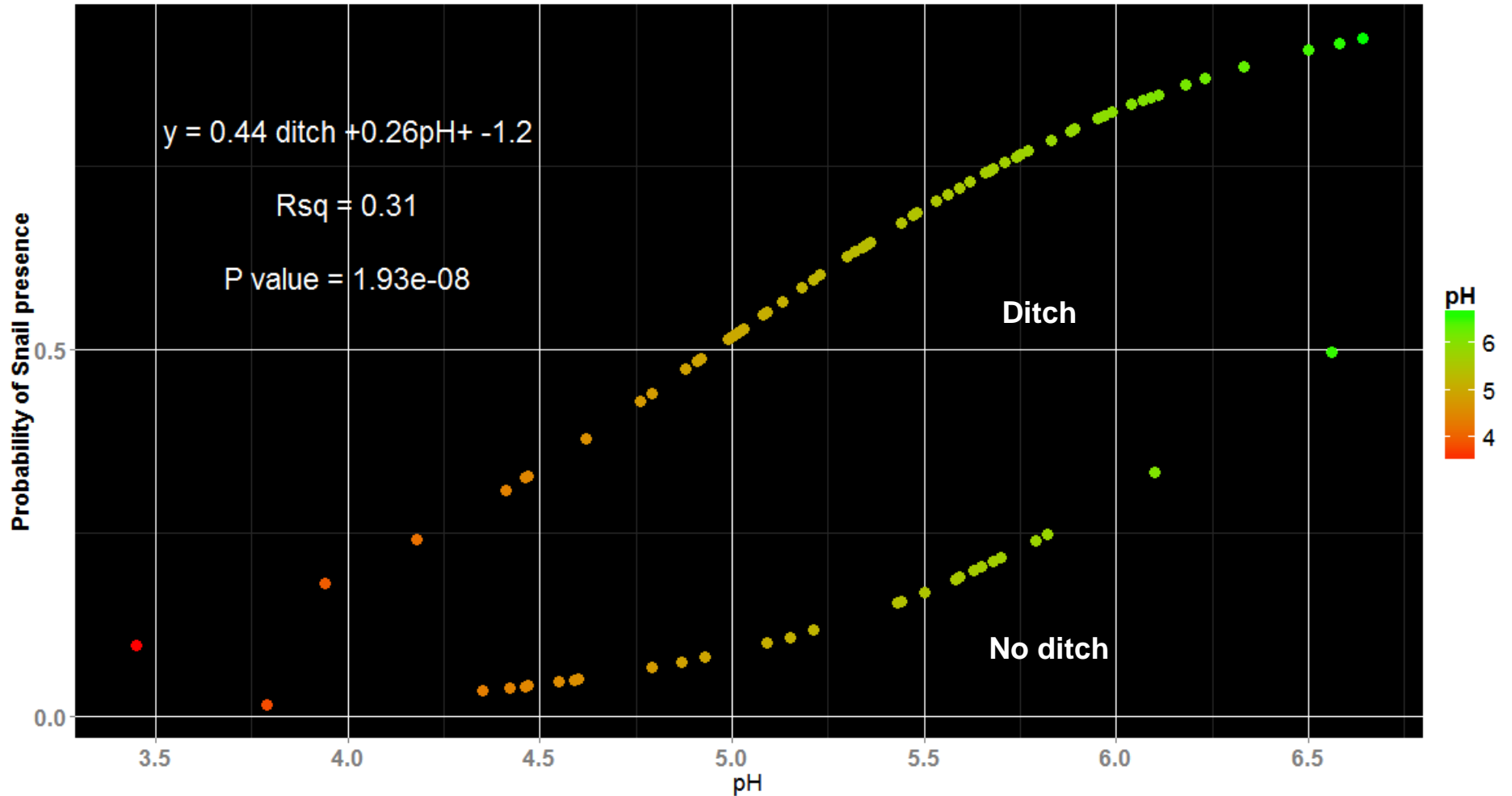
Question 2

Does snail absence indicate **unfavorable habitat?**
(or **dispersal limitation?**)
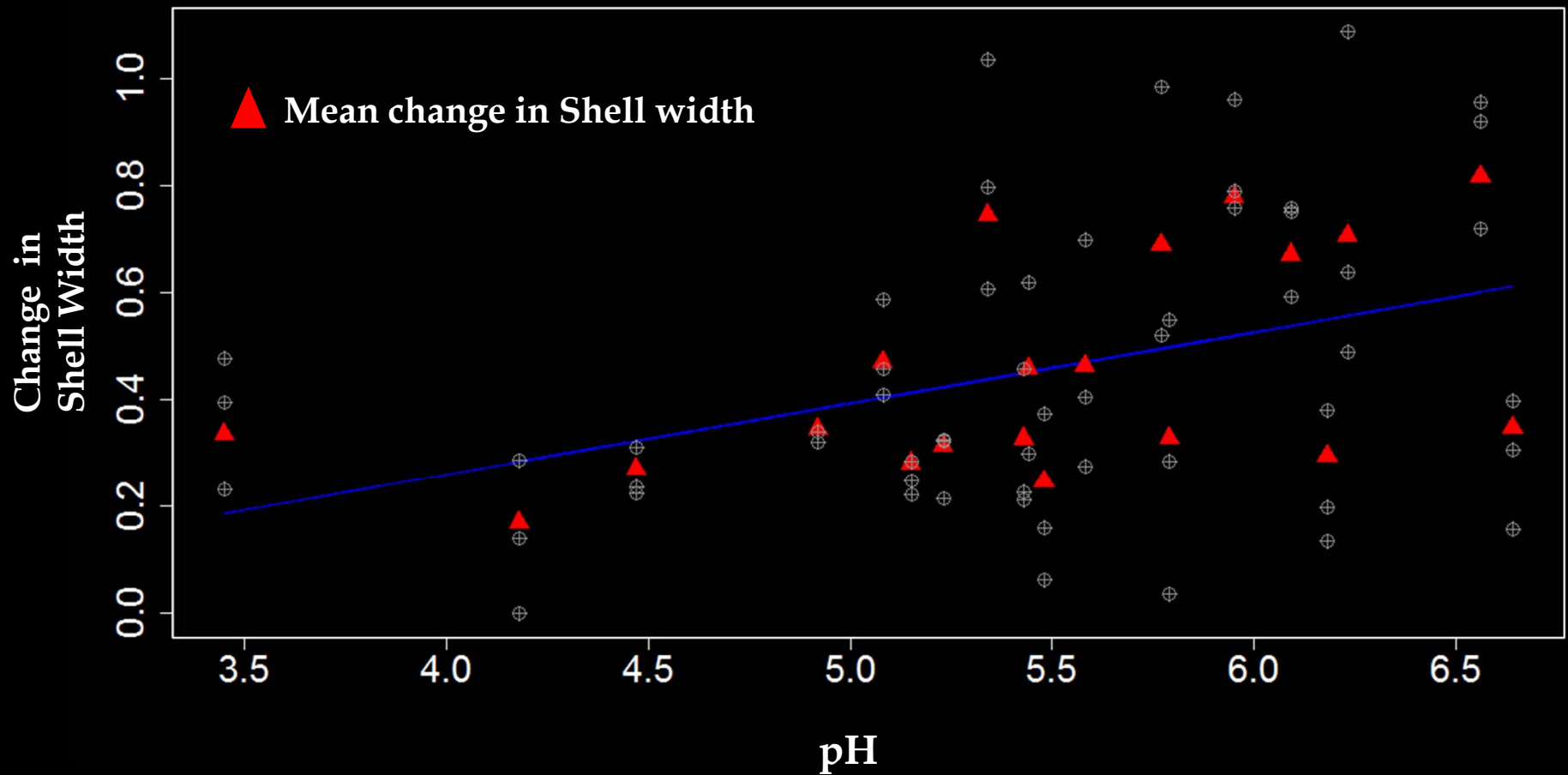
If absence
= less suitable
habitat

Hypothesis

Introduced snails will have <u>lower survival</u>

and

<u>slower growth rates</u> in wetlands where

no snails were observed

Snail Survival and Growth
(AICc Model Selection)

- pH_{H2O}
- Hardness $_{H2O}$ (Calcium)
- **Previous Snail Presence**
- Dissolved O_2
- Conductivity $_{H2O}$
- Vegetation cover
- Pasture type (improved vs semi native)
- Wetland area

Most explan (Calcium):

Previous Snail Presence

pH_{H2O}

*predicted

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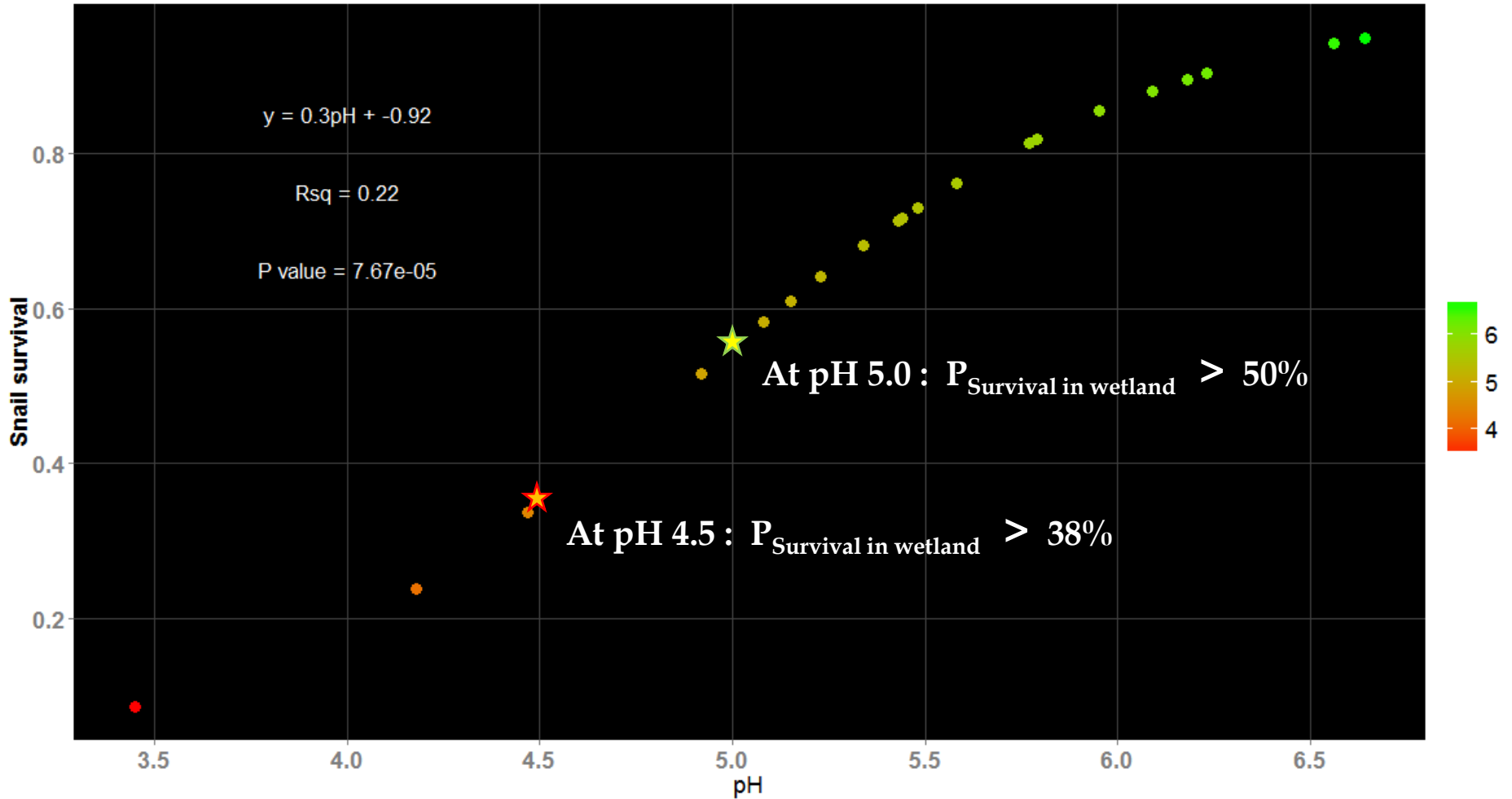# Snail Growth ~ pH

Most explanatory variable : pH_{H2O}

Snail Survival ~ pH

Probability of Snail Survival with pH

$y = 0.3pH + -0.92$

Rsq = 0.22

P value = 7.67e-05

At pH 5.0 : $P_{Survival\ in\ wetland} > 50\%$

At pH 4.5 : $P_{Survival\ in\ wetland} > 38\%$

Conclusions

- Snail dispersal/distribution is associated with ditches (topological wetland connectivity)

    - Snails appear to be primarily dispersed with flood events

- Snail absence is more likely associated with dispersal limitation than unsuitable habitat in permanent wetlands
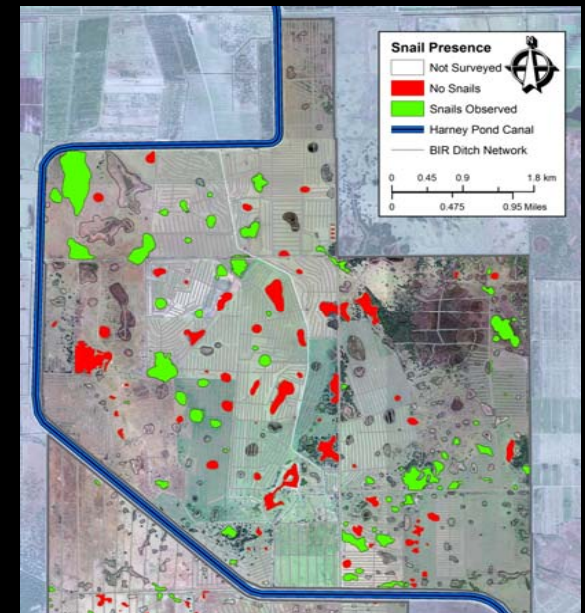
Conclusions

Within wetlands, pH was the best predictor of Snail presence , Survival & Growth

- *P. maculata* does better where wetland pH is more neutral

- But what wetland pH _limits_ them?

  - Unclear, but < pH 5.0

Lack of association with Water Hardness

- Little variation in hardness across BIR landscape

  - Spatial scale too small??

- Role of calcium uptake from macrophyte consumption?

And Finally...

If Buck Island Ranch is indicative of local ranchland wetland habitat

- High probability of dense *P. maculata* populations
- **Although considered "peripheral" habitat...**

Ranchland wetlands → high utility to apple snail predators

Photo Credits: David Hemmings, Greg Matthews, Mia McPherson

Species Distribution & Dispersal

BIOTIC ABIOTIC

Sp

DISPERSAL

DISPERSAL into SUITABLE HABITAT ≠ SPECIES PRESENCE
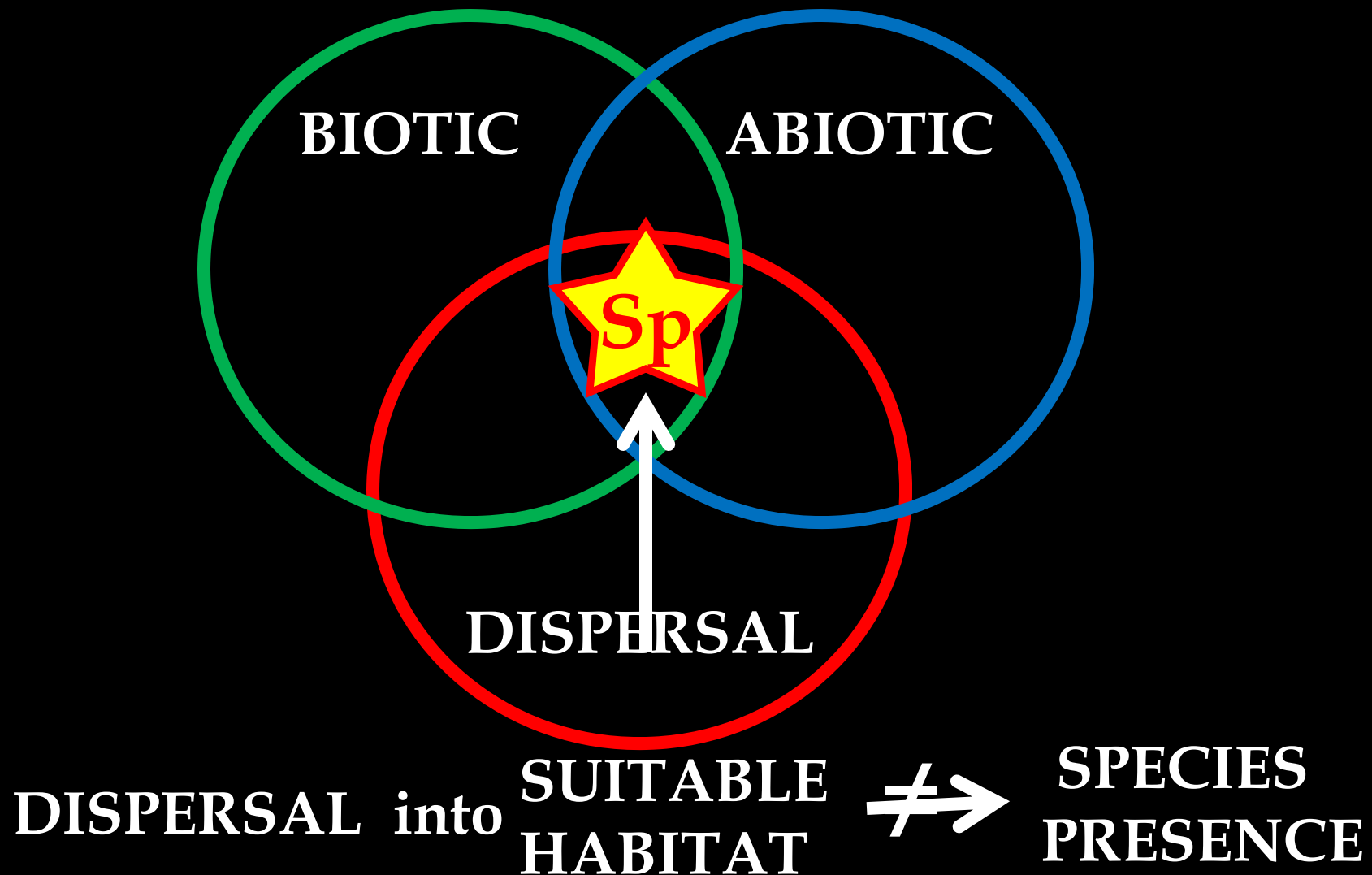
Modified from Soberon (2007)

Fig. 1 Operculum width (a), shell height (b), and shell length (c) measurements for P. ...esent ...n from ...ail.net
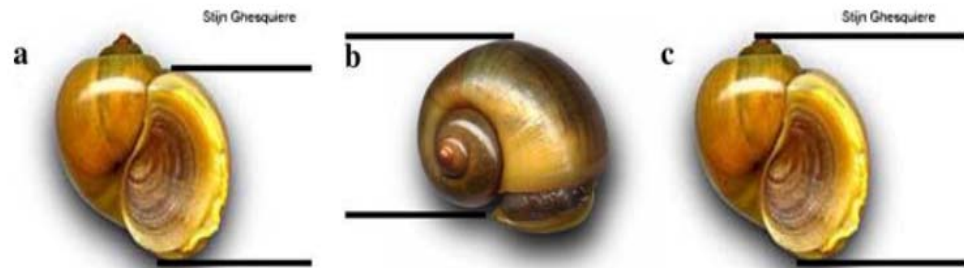
Wetland Selection

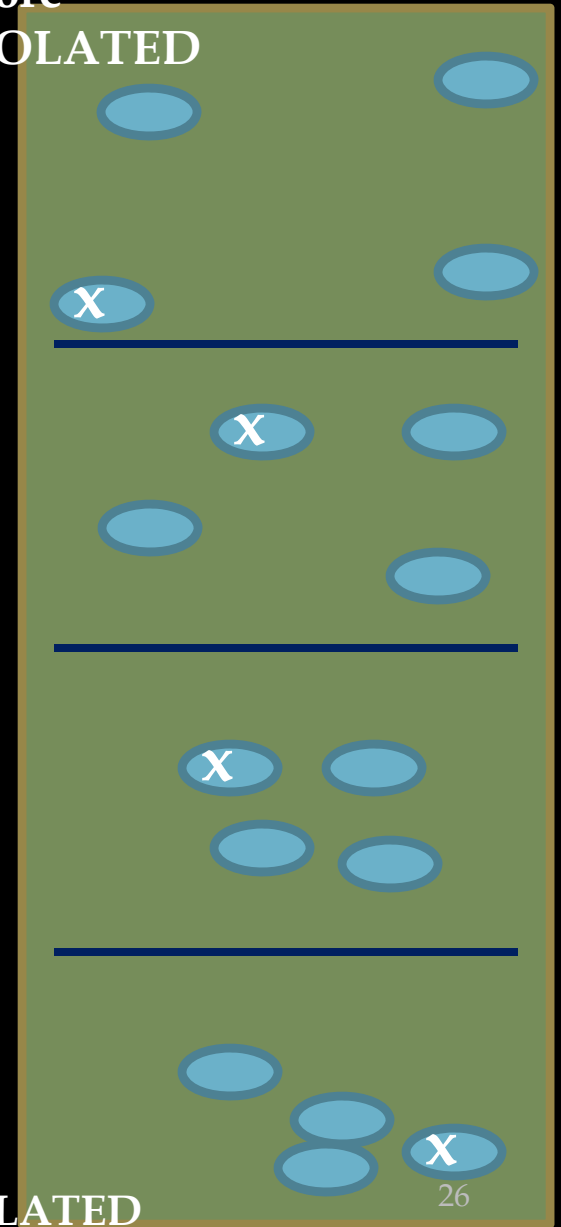- 200 wetlands were randomly selected for survey (stratified random)

- Wetlands were ranked according to isolation indices

- Split into quartiles.

- 30* wetlands randomly selected per quartile, from each isolation index
  * accounting for potential overlap in indices

**More
ISOLATED**

**Less
ISOLATED**

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AICc Table for Snail Presence

Modnames	K	AICc	Delta_AICc	ModelLik	AICcWt	LL	Cum.Wt
Presence ~ Xinflo+pH	3	102.56	0.0000	1.0000e+00	6.0930e-01	-48.146	0.60930
Presence ~ Xinflo*pH	4	104.16	1.6048	4.4826e-01	2.7312e-01	-47.858	0.88242
Presence ~ Xinflo+MinEucWet+Xinflo*pH	5	106.28	3.7212	1.5558e-01	9.4794e-02	-47.802	0.97721
Presence ~ Xinflo+MinEucWet+Xinflo:MinDitchDist	4	110.62	8.0652	1.7729e-02	1.0802e-02	-51.088	0.98802
Presence ~ Xinflo + log(MinEucWet+1)+ Xinflo:log(MinDitchDist+1)	4	112.36	9.8043	7.4307e-03	4.5275e-03	-51.958	0.99254
Presence ~ Xinflo	2	113.28	10.7281	4.6818e-03	2.8526e-03	-54.577	0.99540
Presence ~ Xinflo+ Xinflo:log(MinDitchDist+1)	3	114.08	11.5278	3.1388e-03	1.9124e-03	-53.910	0.99731
Presence ~ Xinflo + Xinflo:log(MyIsoIndex+1)	3	115.17	12.6135	1.8239e-03	1.1113e-03	-54.453	0.99842
Presence ~ MyIsoIndex*Xinflo	3	115.41	12.8558	1.6159e-03	9.8454e-04	-54.574	0.99940
Presence ~ Xinflo + log(MinEucWet+1)+ Xinflo:log(MyIsoIndex+1)	4	117.23	14.6694	6.5251e-04	3.9757e-04	-54.391	0.99980
Presence ~ pH	2	118.87	16.3166	2.8635e-04	1.7447e-04	-57.371	0.99998
Presence ~ WetInfloCount	12	123.07	20.5090	3.5198e-05	2.1446e-05	-47.630	1.00000
Presence ~ Cdty	2	129.84	27.2860	1.1883e-06	7.2403e-07	-62.856	1.00000
Presence ~ Hanski	2	130.24	27.6810	9.7532e-07	5.9426e-07	-63.053	1.00000
Presence ~ PERIMETER	2	132.52	29.9600	3.1208e-07	1.9015e-07	-64.193	1.00000
Presence ~ AreaHA	2	132.72	30.1631	2.8194e-07	1.7179e-07	-64.294	1.00000
Presence ~ 1	1	133.73	31.1743	1.7006e-07	1.0362e-07	-65.844	1.00000
Presence ~ MinEucWet	2	135.81	33.2505	6.0220e-08	3.6692e-08	-65.838	1.00000
Presence ~ DOmg	2	135.82	33.2610	5.9905e-08	3.6500e-08	-65.843	1.00000