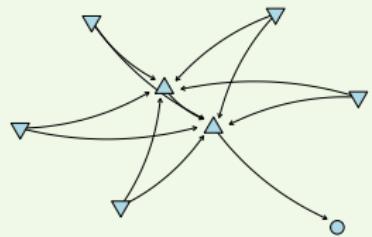
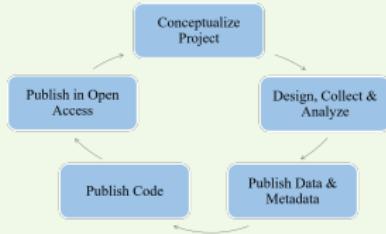


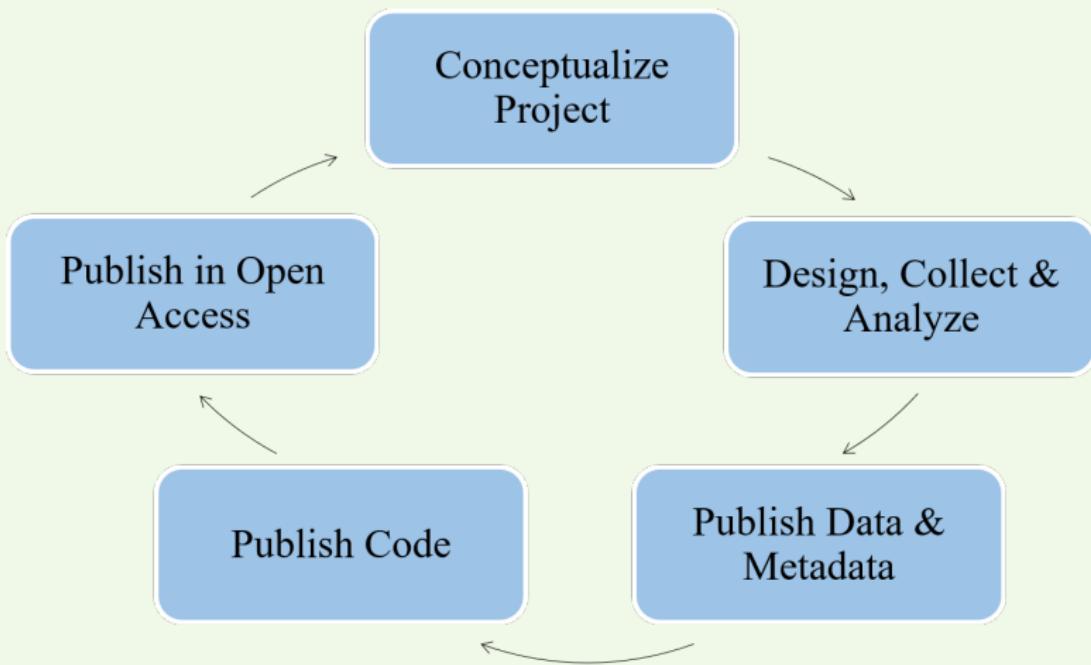
Use of open science to inform restoration projects in estuaries: A Tampa Bay example

Marcus W. Beck¹, Ed Sherwood, Kirsten Dorans, Jessica Renee Henkel, Kathryn Ireland, Patricia Varela

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April 23, 2018





Modified from Hampton et al. 2015. The Tao of open science for ecology. *Ecosphere* 6(7):1-13.

Open science workflow

Open Science for Synthesis: Gulf Research Program

July 10 - July 28, 2017

NCEAS, Santa Barbara, CA





Today's talk

Our experience using the open science workflow to inform restoration projects in estuaries

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Our experience using the open science workflow to inform restoration projects in estuaries

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- *Synthesize* data in space and time to evaluate cumulative effects of restoration projects
- *Develop* a decision support tool with empirical observations to evaluate likelihood of potential outcomes
- *Apply* the tool to guide expectations for future restoration projects

Tampa Bay - from gross to less gross



Past:

- Mid-1970s N load 8.2×10^6 yr^{-1} [Greening and Janicki, 2006]
- Elevated chl-a concentrations
- Increased occurrence of HABs



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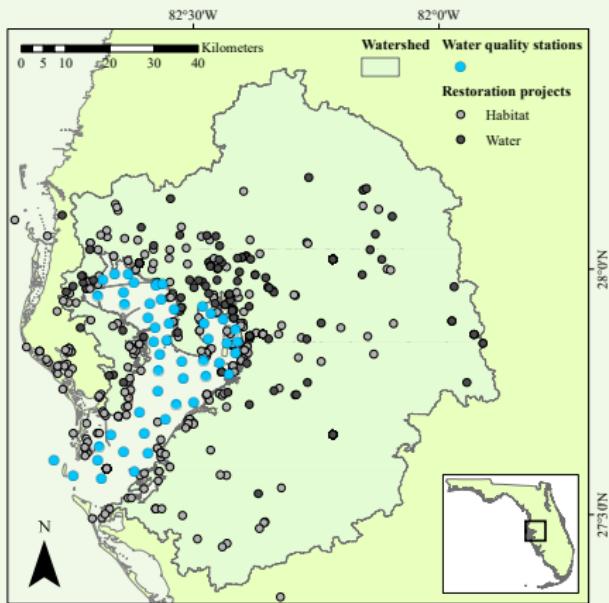
Past:

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Present:

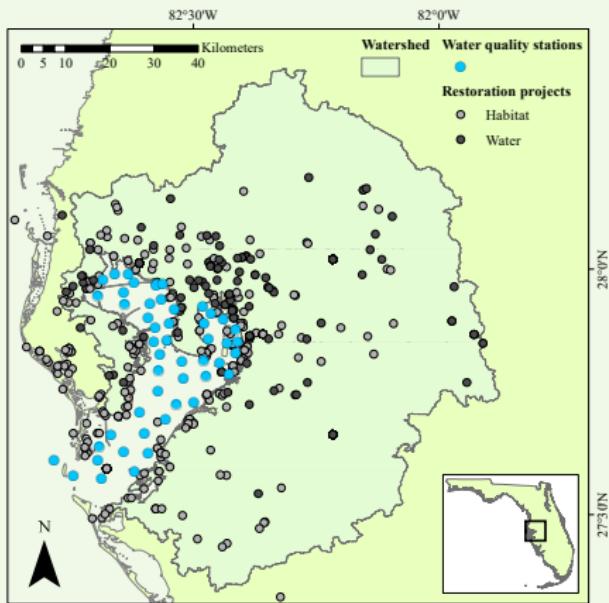
- 2016 seagrass at ~17k ha [Sherwood et al., 2017]
- Reductions in nutrient load, chlorophyll
- Increase in water clarity [Morrison et al., 2006, Beck et al., 2017]

Tampa Bay - open data sources



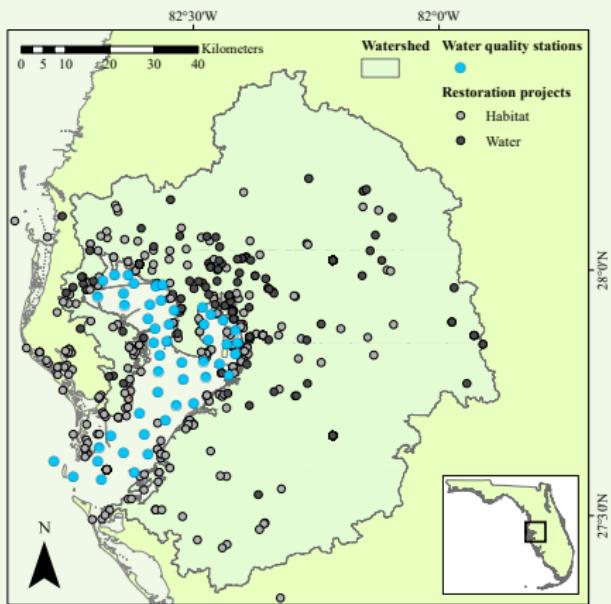
- **Water quality** monitoring dataset: 1974 to present, ~500 obs. per site

Tampa Bay - open data sources



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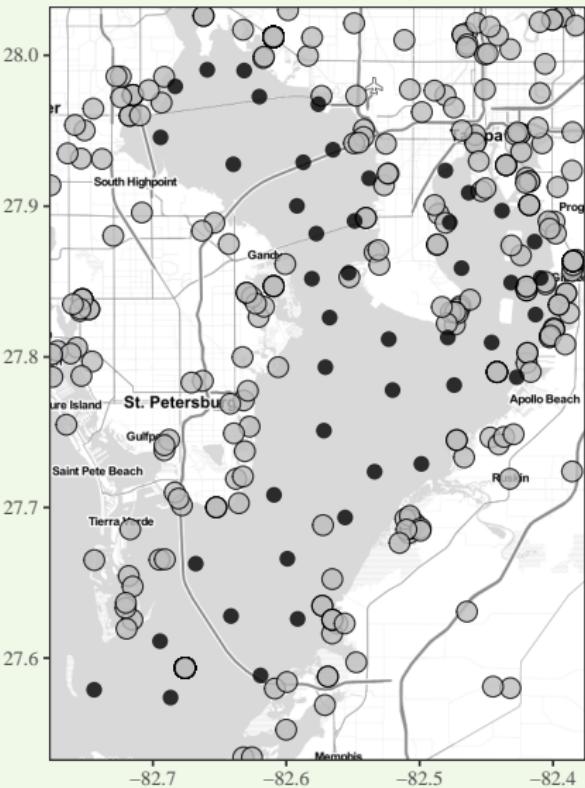
Despite considerable *investments* in restoration, *effectiveness evaluation* continues to elude practitioners at geographic scales

[Diefenderfer et al., 2016]

Task 1: Can we empirically link 500 restoration projects to chlorophyll changes at water quality stations over a forty year period?

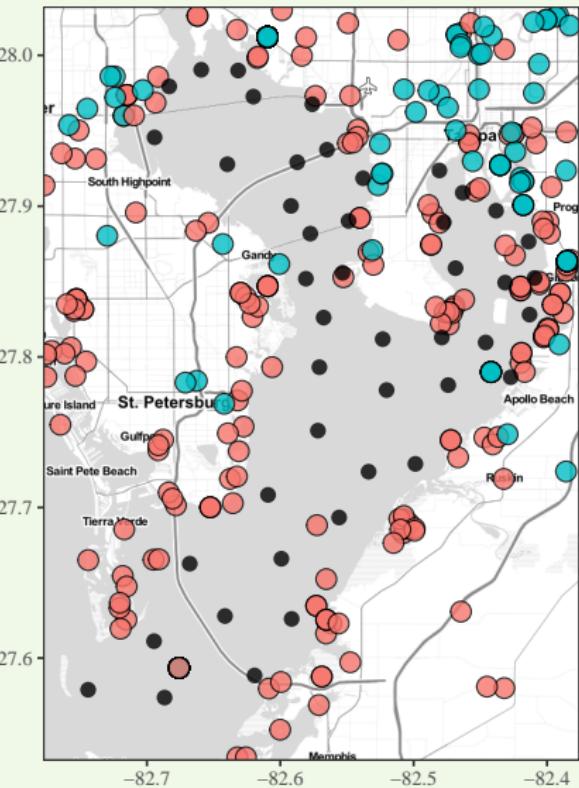


Data munging with open source tools



Can we link 500 restoration projects to chlorophyll changes over a forty year period?

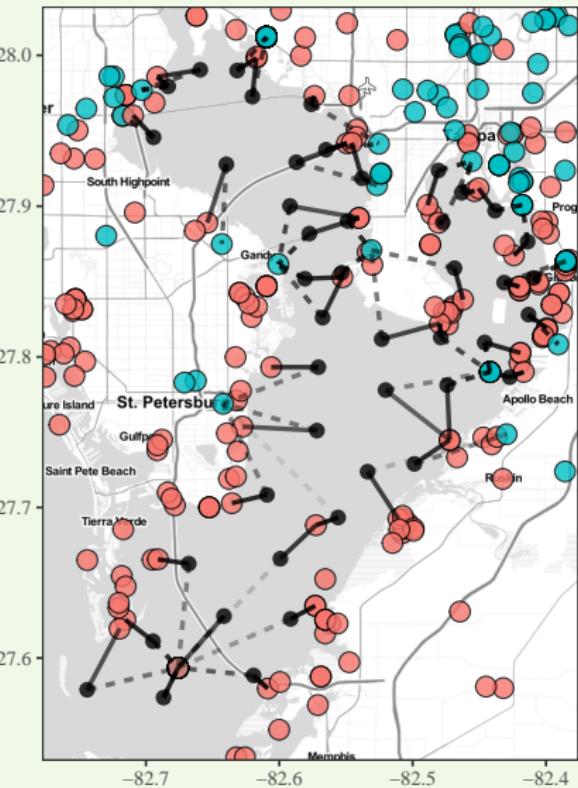
Data munging with open source tools



Can we link 500 restoration projects to chlorophyll changes over a forty year period?

- Consider an effect of restoration *site type*?

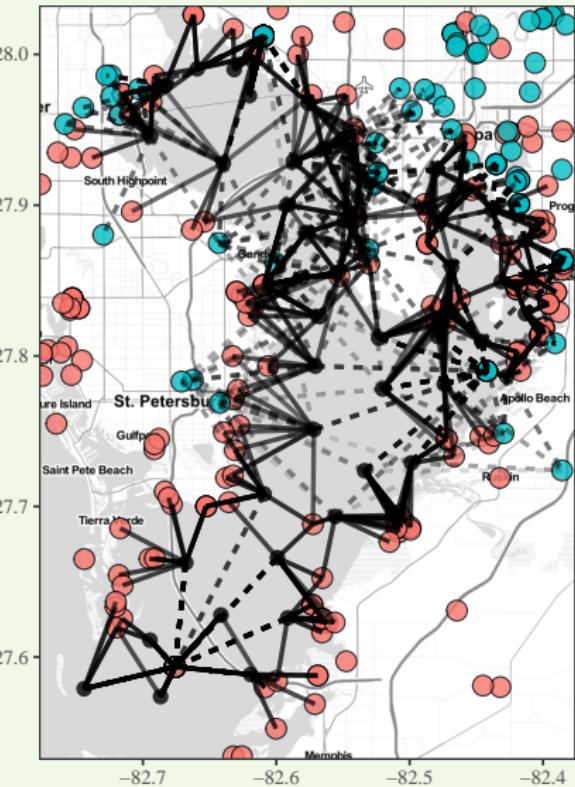
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Can we link 500 restoration projects to chlorophyll changes over a forty year period?

- Consider an effect of restoration *site type*?
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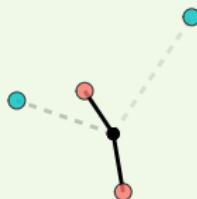
Data munging with open source tools



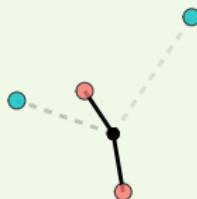
Can we link 500 restoration projects to chlorophyll changes over a forty year period?

- Consider an effect of restoration *site type*?
- Consider *distance* of sites from water quality stations?
- Consider *cumulative effects*?

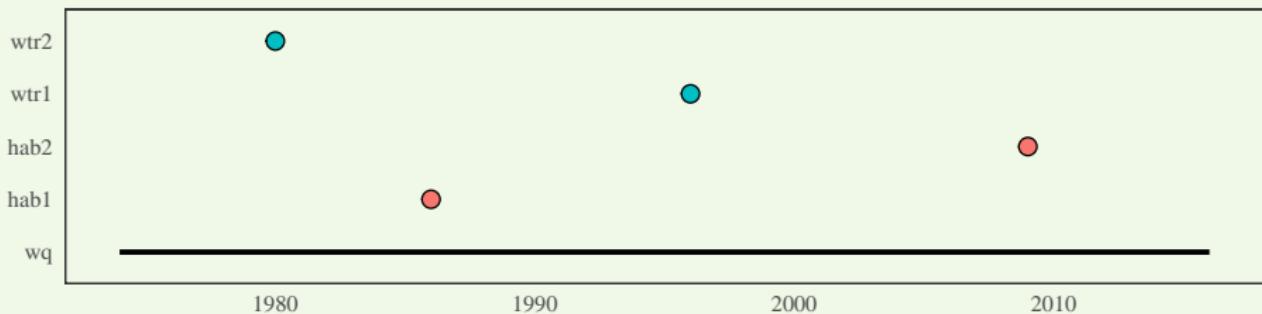
WQ and restoration sites: *spatial join*



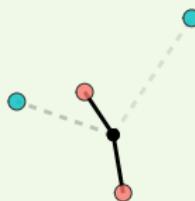
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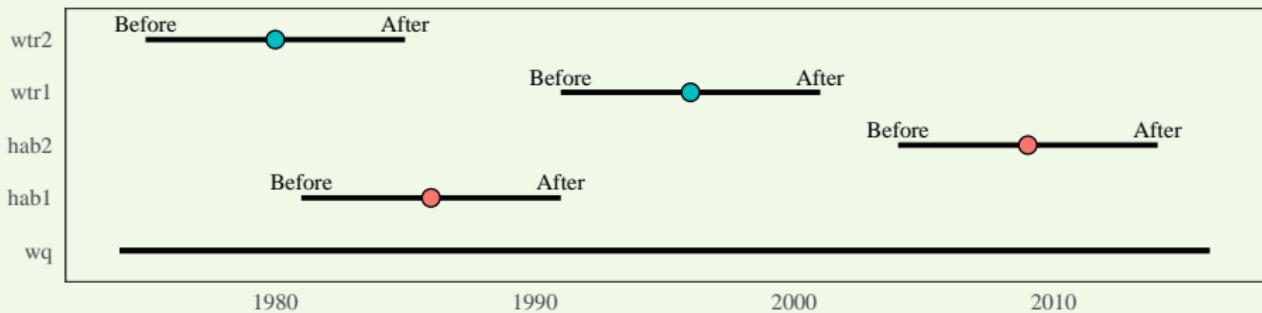
WQ and restoration sites: *temporal join*



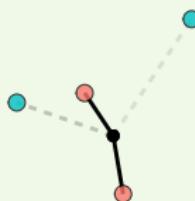
WQ and restoration sites: *spatial join*



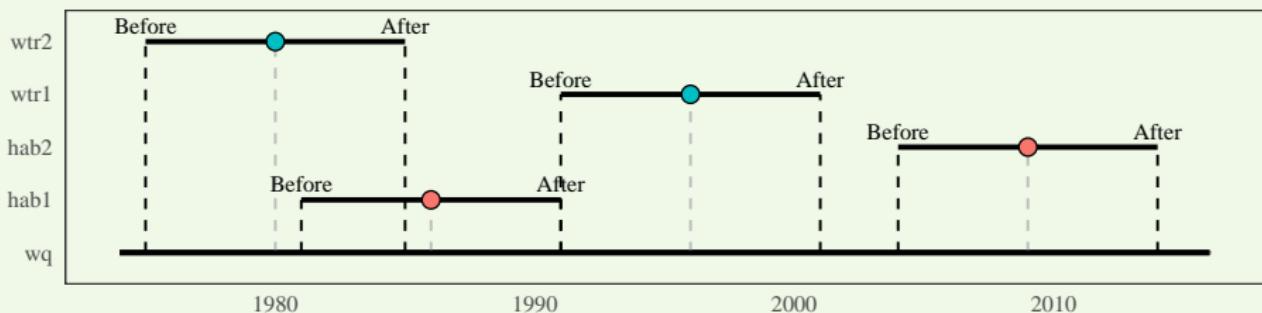
WQ and restoration sites: *temporal join, before/after*



WQ and restoration sites: *spatial join*

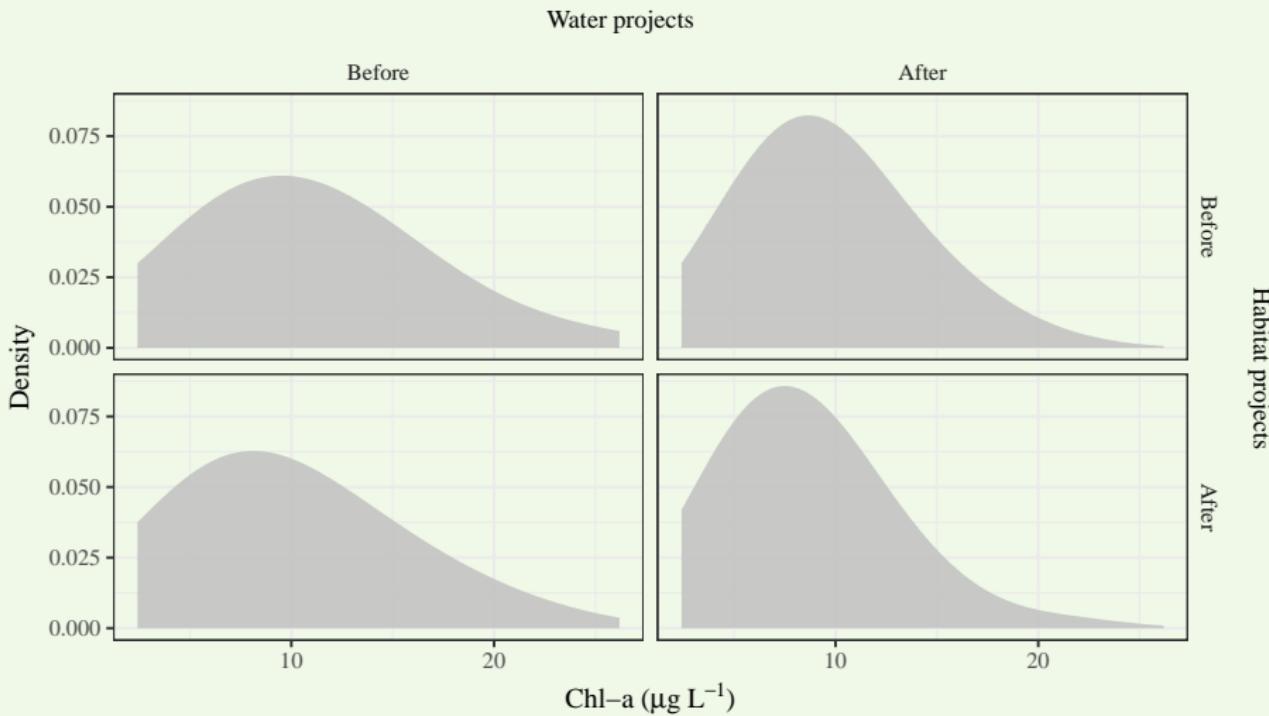


WQ and restoration sites: *temporal join, before/after, slice*



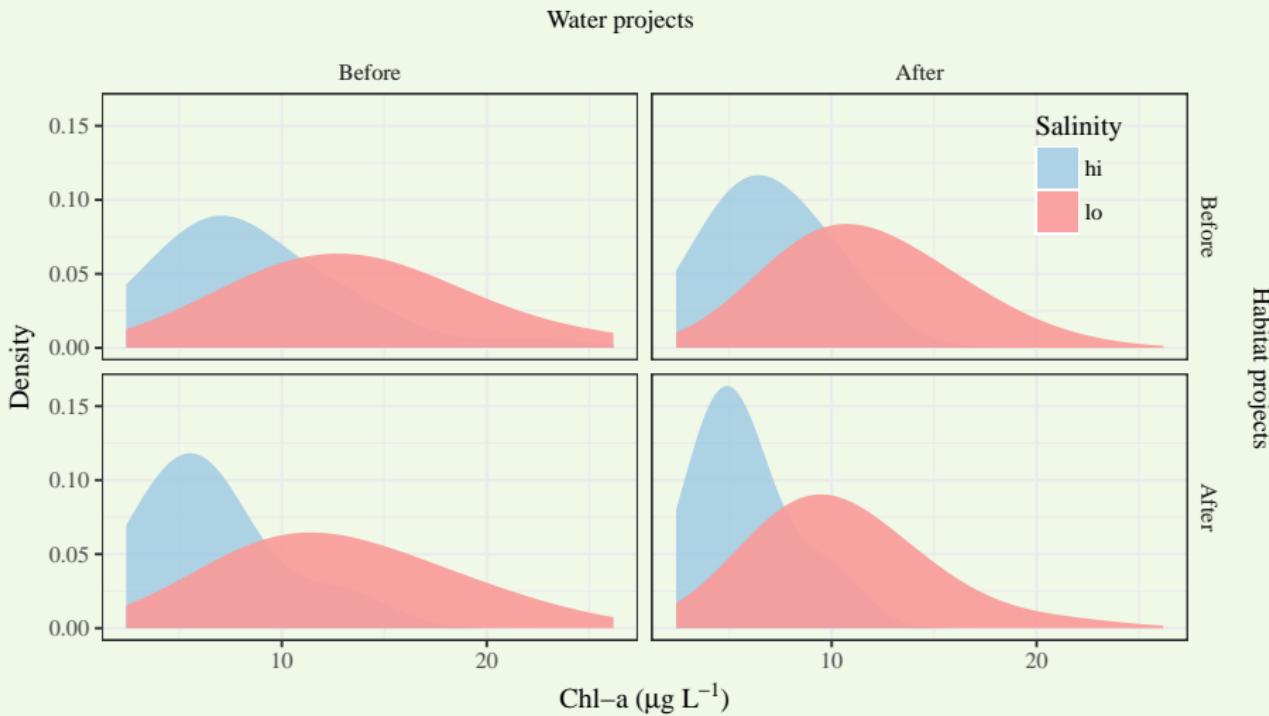
Data munging with open source tools

For *many* water quality stations matched to *many* restoration sites...



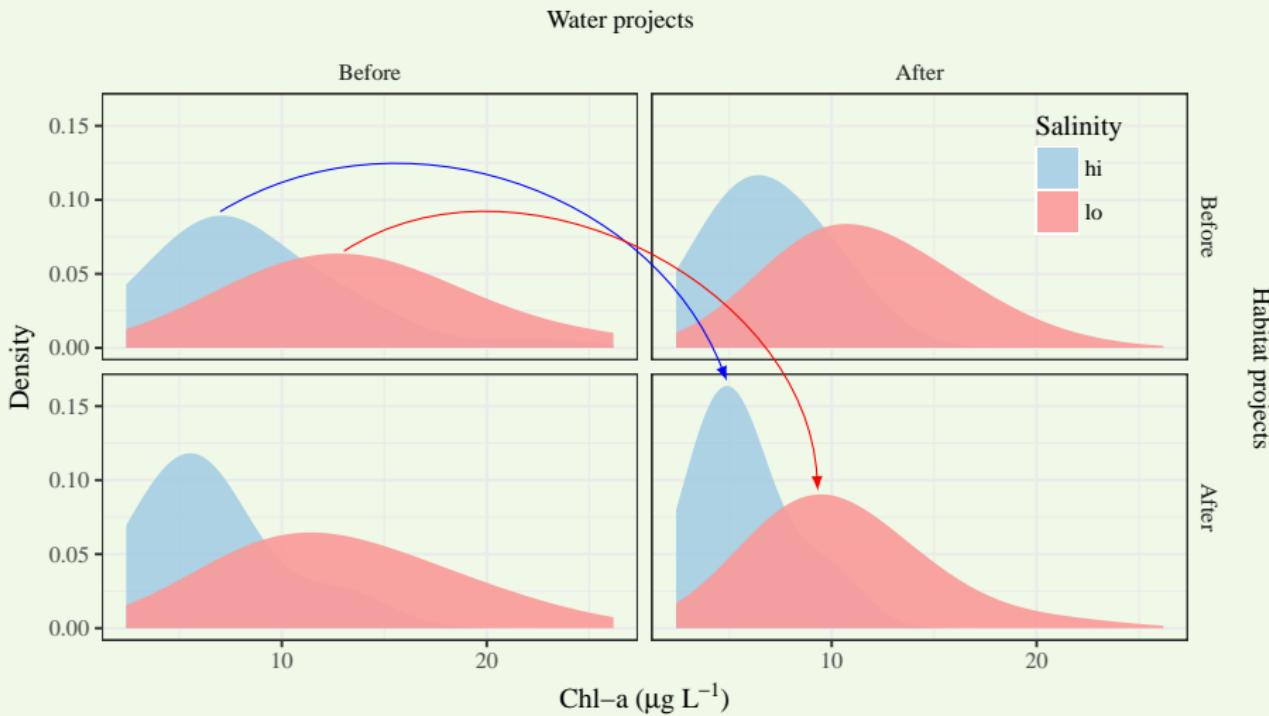
Data munging with open source tools

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Data munging with open source tools

For *many* water quality stations matched to *many* restoration sites...



What is the probability of low/high chlorophyll given other events?

$$P(Chl \mid Event) = \frac{P(Event|Chl) \cdot P(Chl)}{P(Event)}$$

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- Do water quality conditions differ by *restoration type*?
- Does it differ by low/high *salinity* as a natural covariate?

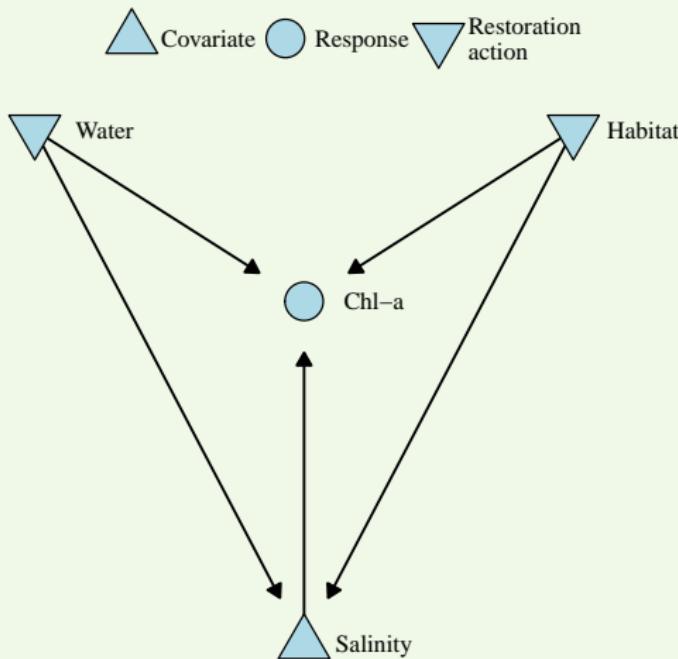
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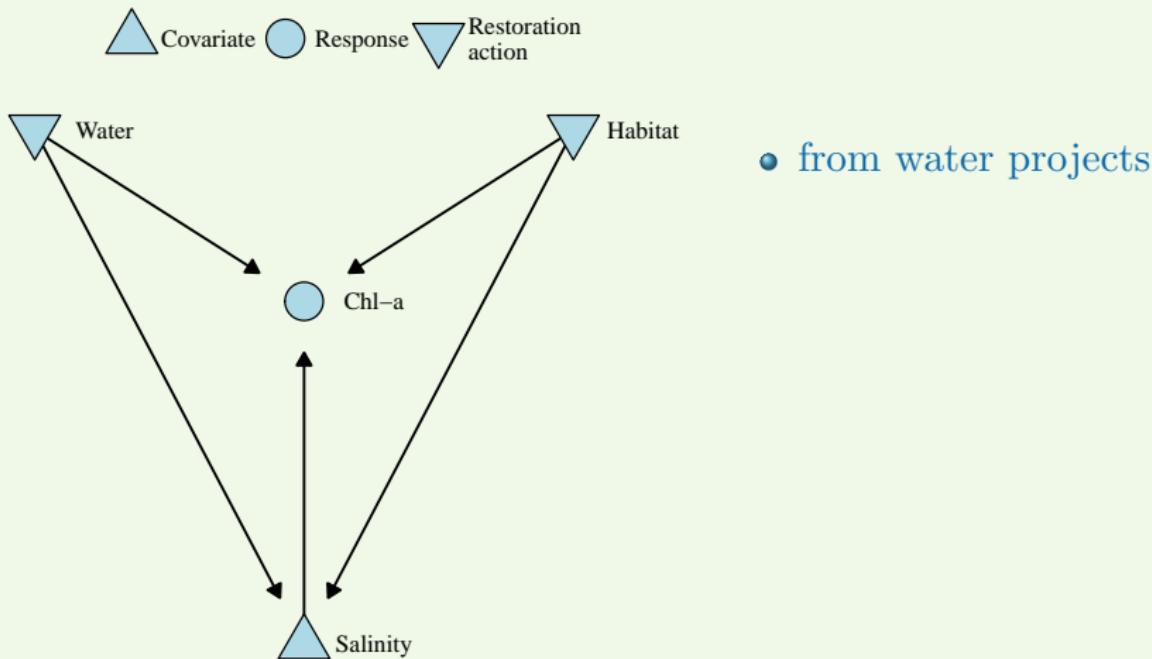
Bayesian models let us evaluate likelihood of potential outcomes given conditional distributions

Using the *conditional probabilities* from the *empirical response*, what's the probability of low chlorophyll...



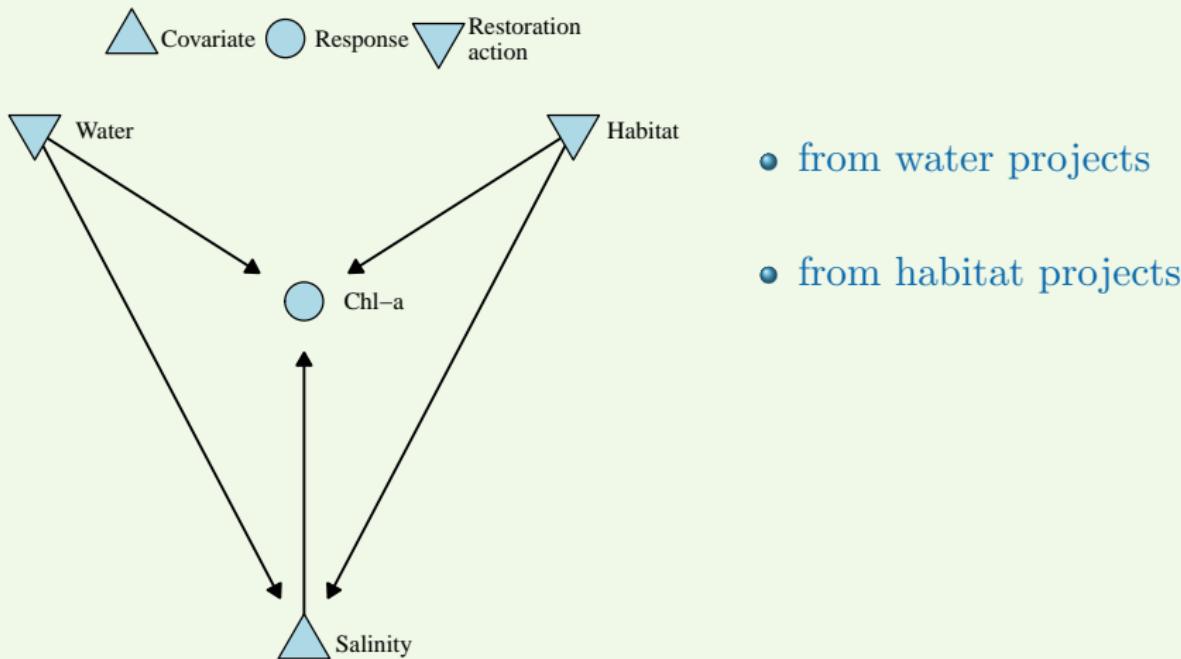
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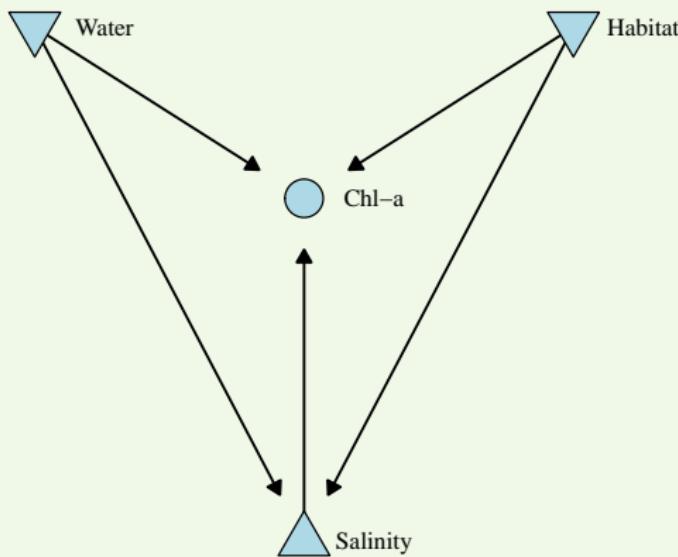
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△ Covariate ○ Response ▼ Restoration action

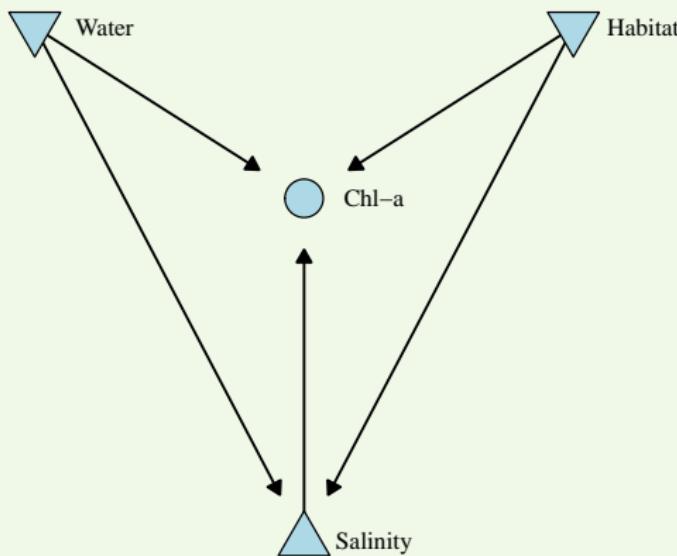


- from water projects
- from habitat projects
- from all projects

Data munging with open source tools

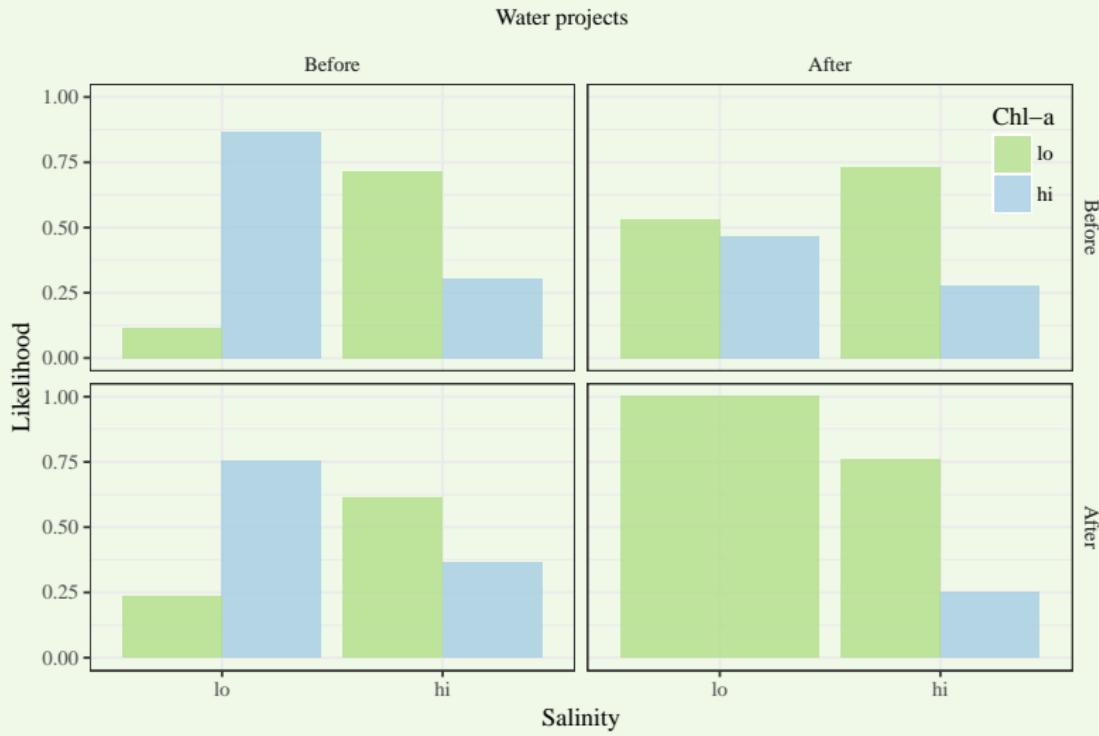
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△ Covariate ○ Response ▼ Restoration action



- from water projects
- from habitat projects
- from all projects
- by salinity regime

All possible scenarios:



Individual scenarios: Probability of high chlorophyll

Water projects:

- Before: 53%
- After: 26%

Habitat projects:

- Before: 50%
- After: 50%

Invidividual scenarios: Probability of **high** chlorophyll

Water projects:

- Before: 53%
- After: 26%

Habitat projects:

- Before: 50%
- After: 50%

Invidividual scenarios: Probability of **low** chlorophyll

Water projects:

- Before: 46%
- After: 77%

Habitat projects:

- Before: 49%
- After: 51%

Where is the sweet spot?

Probability of low chlorophyll before/after **both project types** by
low/high salinity

Where is the sweet spot?

Probability of low chlorophyll before/after **both project types** by
low/high salinity

Low salinity:

- Before both projects: 13%
- After both projects: 100%

High salinity:

- Before both projects: 69%
- After both projects: 75%

Take home:

- Water infrastructure projects had the largest effect

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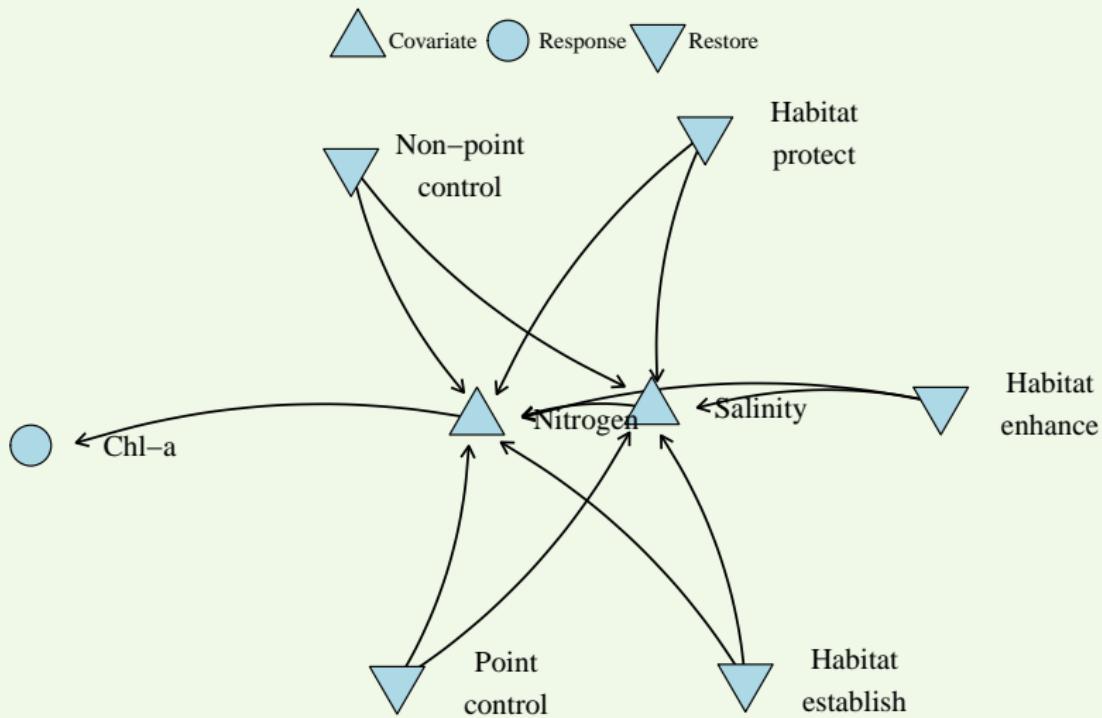
- Depends on year, distance combinations

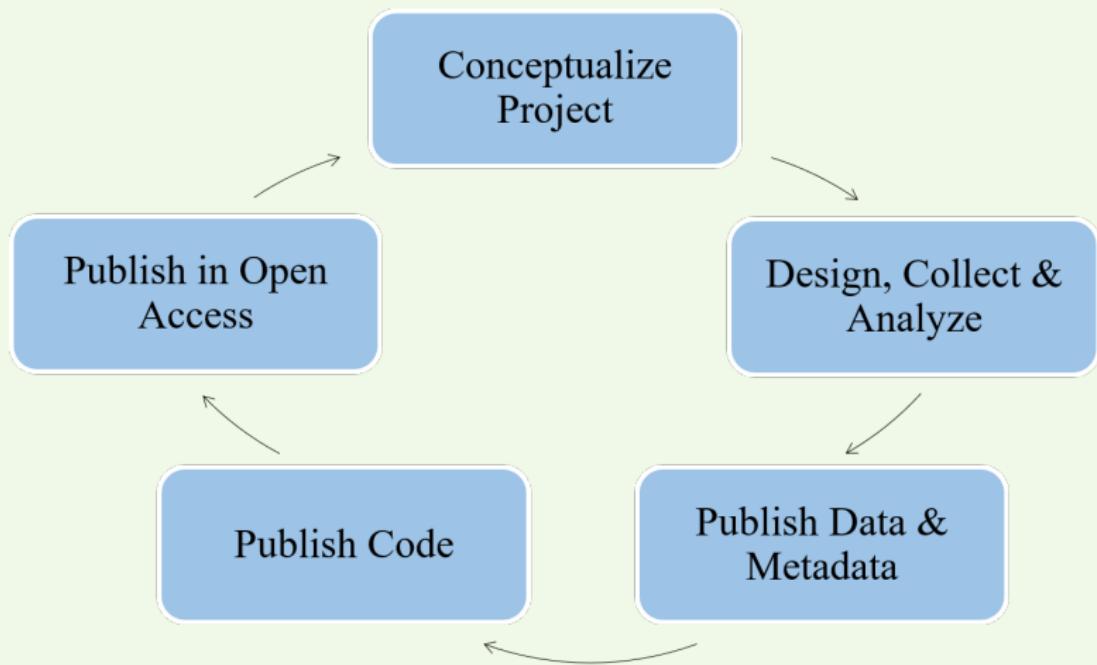
Take home:

- Water infrastructure projects had the largest effect
- Habitat projects had an effect but less so
- Effects most noticeable in low salinity zone

But...

- Depends on year, distance combinations
- This is a simple model

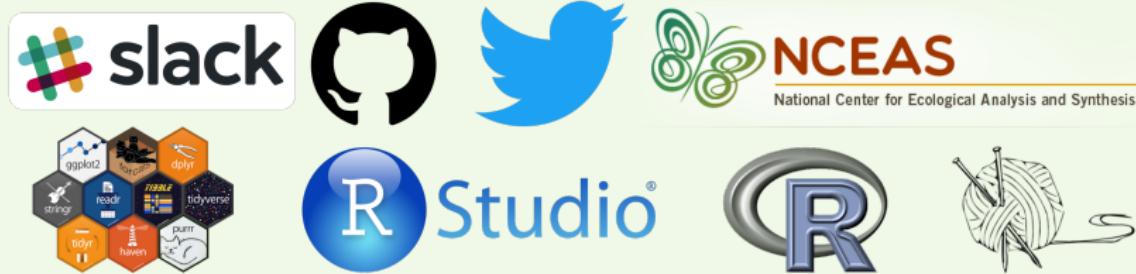
The holy grail:



Modified from [Hampton et al., 2015]

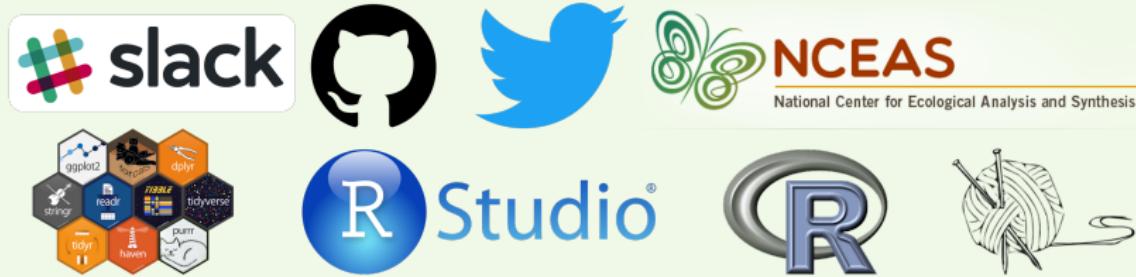
What aspects of our project used and benefitted from open science?

- Early idea conception
- Long distance collaboration
- Transparent and reproducible analysis



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... but the circle is not complete

Acknowledgments:

Research staff and employees at NCEAS: M. B. Jones, A. Budden, T. Neal, B. Mecum, C. Lortie, L. Wasser, J. Brun

The Gulf Research Program

Field staff and data managers at Hillsborough County Environmental Protection Commission

Funding sources and contact:



marcusb@sccwrp.org, 7147553217

GitHub (project):
<https://github.com/fawda123/restorebayes>

GitHub (presentation):
https://github.com/fawda123/AWRA_2018

Twitter: @fawda123

References

- Beck MW, Hagy III JD, Le C. 2017.
Quantifying seagrass light requirements using an algorithm to spatially resolve depth of colonization.
Estuaries and Coasts, pages 1–17.
- Diefenderfer HL, Johnson GE, Thom RM, Buenau KE, Weitkamp LA, Woodley CM, Borde AB, Kropp RK. 2016.
Evidence-based evaluation of the cumulative effects of ecosystem restoration.
Ecosphere, 7(3):e01242.
- Greening H, Janicki A. 2006.
Toward reversal of eutrophic conditions in a subtropical estuary: Water quality and seagrass response to nitrogen loading reductions in Tampa Bay, Florida, USA.
Environmental Management, 38(2):163–178.
- Hampton SE, Anderson SS, Bagby SC, Gries C, Han X, Hart EM, Jones MB, Lenhardt WC, MacDonald A, Michener WK, Mudge J, Pourmokhtarian A, Schildhauer MP, Woo KH, Zimmerman N. 2015.
The tao of open science for ecology.
Ecosphere, 6(7):1–13.
- Morrison G, Sherwood ET, Boler R, Barron J. 2006.
Variations in water clarity and chlorophylla in Tampa Bay, Florida, in response to annual rainfall, 1985–2004.
Estuaries and Coasts, 29(6):926–931.
- Sherwood ET, Greening HS, Johansson JOR, Kaufman K, Raulerson G. 2017.
Tampa Bay (Florida, USA): Documenting seagrass recovery since the 1980s and reviewing the benefits.
Southeastern Geographer, 57(3):294–319.