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

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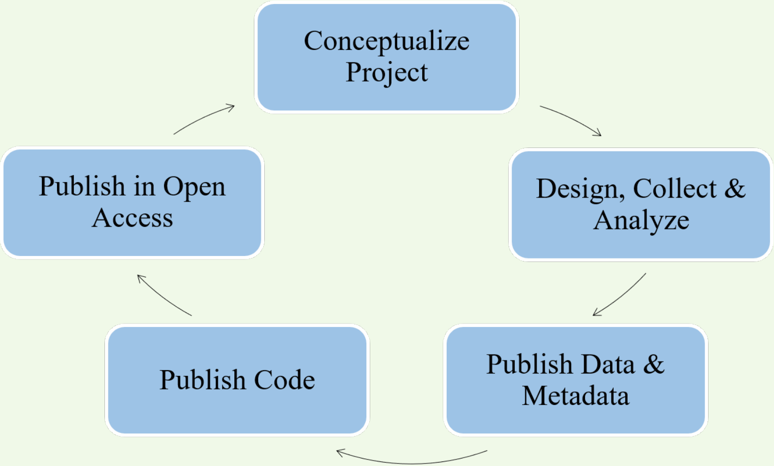
Open science workflow



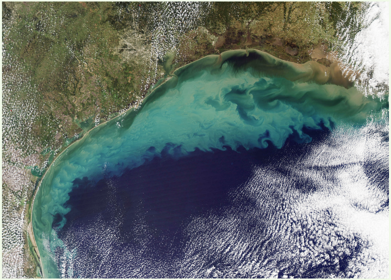
Modified from Hampton et al. 2015. The Tao of open science for ecology. Ecosphere 6(7):1-13.

Final thoughts

Open Science for Synthesis: Gulf Research Program

July 10 - July 28, 2017
NCEAS, Santa Barbara, CA

NCEAS
National Center for Ecological Analysis and Synthesis



Open science workflow

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`https://nceas.github.io/oss-2017/lessons.html`

- Collaboration modes and technologies, virtual collaboration
- Data management, preservation, and sharing
- Data manipulation, integration, and exploration
- Scientific workflows and reproducible research
- Programming using agile and sustainable software practices
- Data analysis and modeling
- Communicating results to broad communities

Today's talk

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- ***Develop*** a decision support tool with empirical observations to evaluate likelihood of potential outcomes

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Can we use disparate data to prioritize future restoration projects aimed at improving water quality?

- ***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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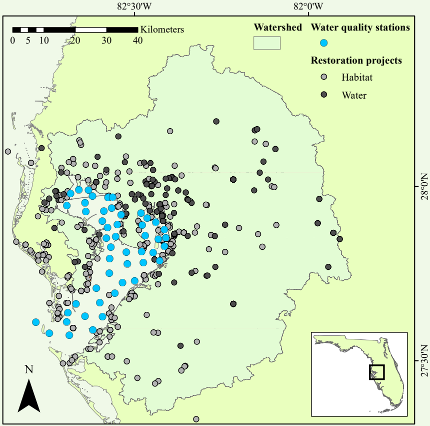
Present:

- 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

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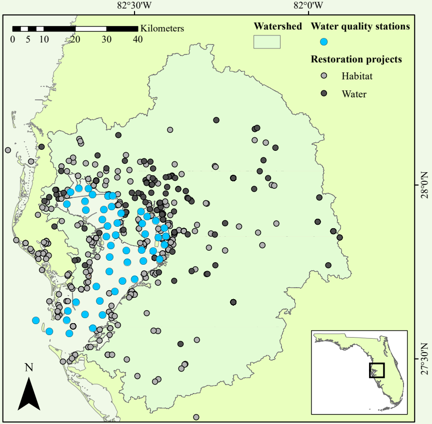

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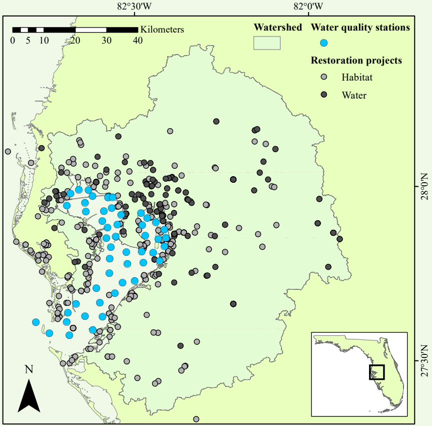

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Despite considerable ***investments*** in restoration, ***effectiveness evaluation*** continues to elude practitioners at geographic scales [Diefenderfer et al., 2016]

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

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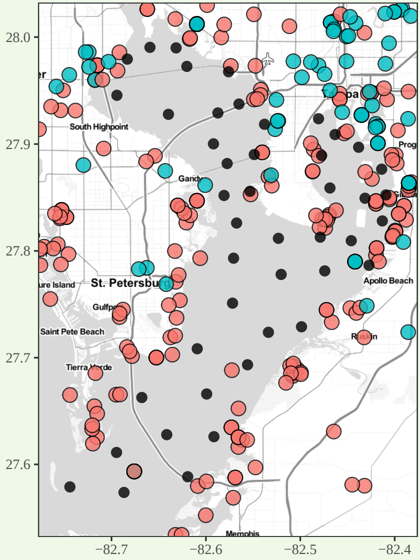
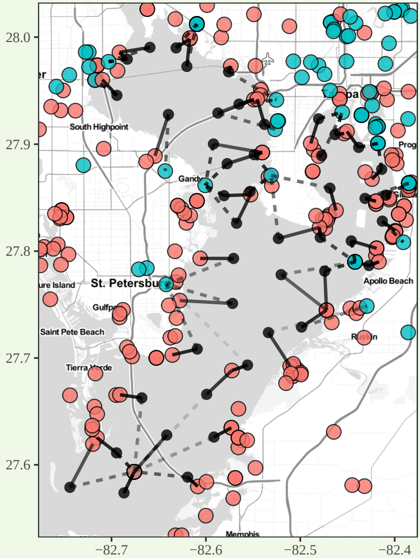
Data munging with open source tools



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

- Consider an effect of restoration ***site type***?



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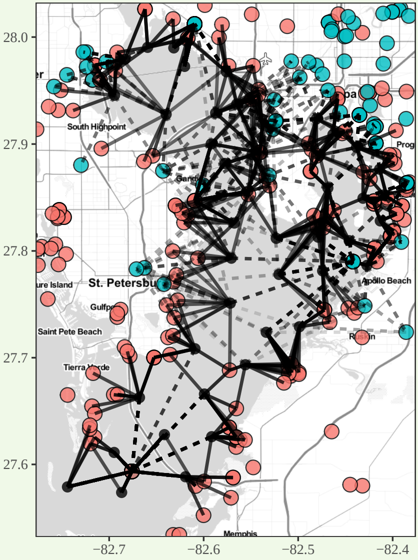
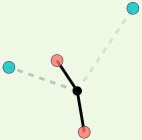


Can we link 500 restoration projects to chlorophyll changes over a forty year period?

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

Data munging with open source tools

WQ and restoration sites: ***spatial join***



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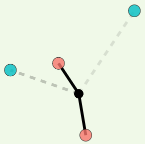
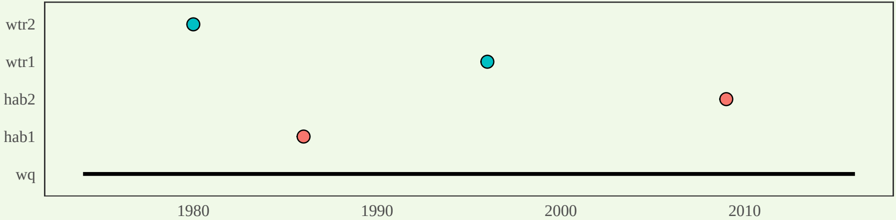
WQ and restoration sites: *spatial join*



WQ and restoration sites: *temporal join*



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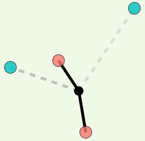
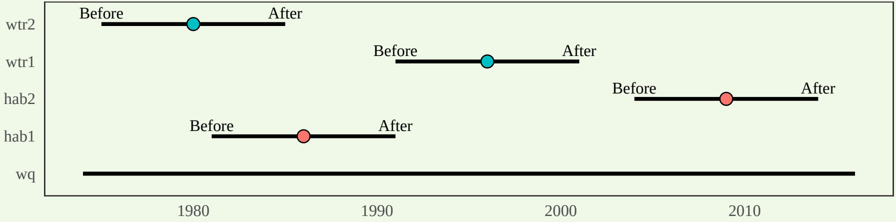
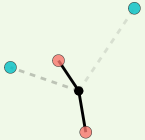


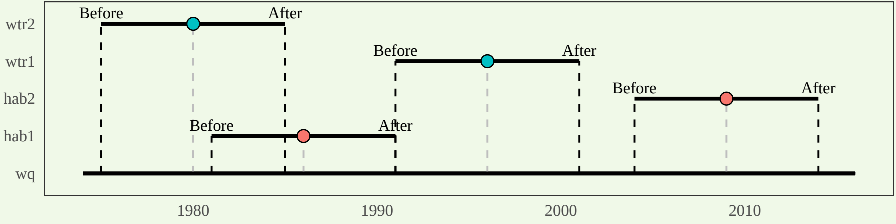
WQ and restoration sites: *temporal join, before/after*



WQ and restoration sites: *spatial join*

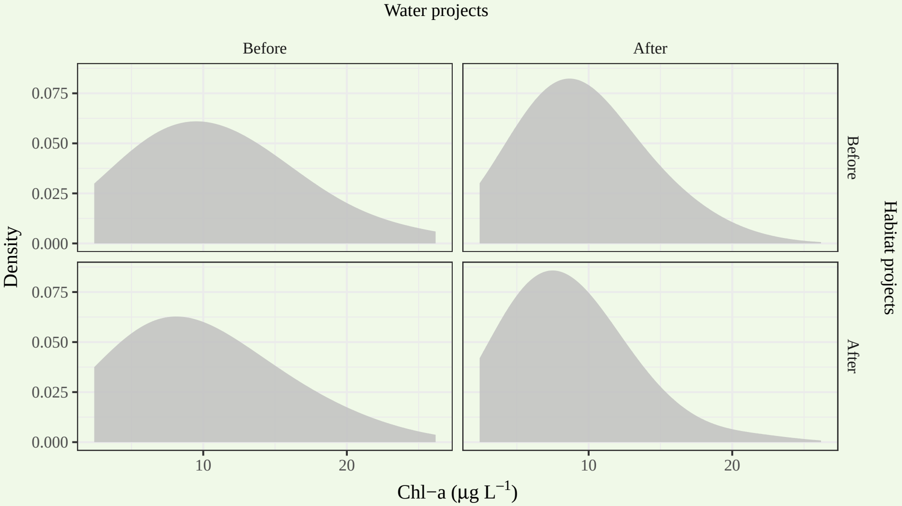


WQ and restoration sites: *temporal join, before/after, slice*



Data munging with open source tools

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



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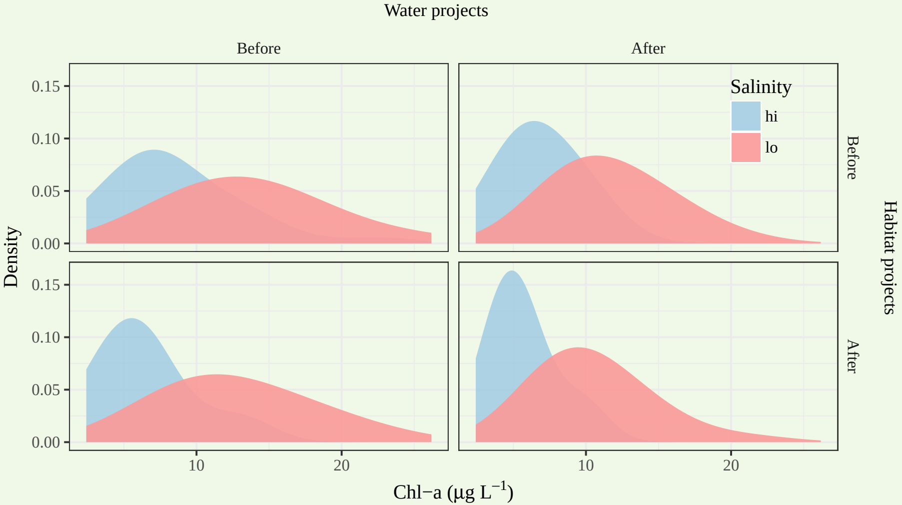

Data munging with open source tools

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

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

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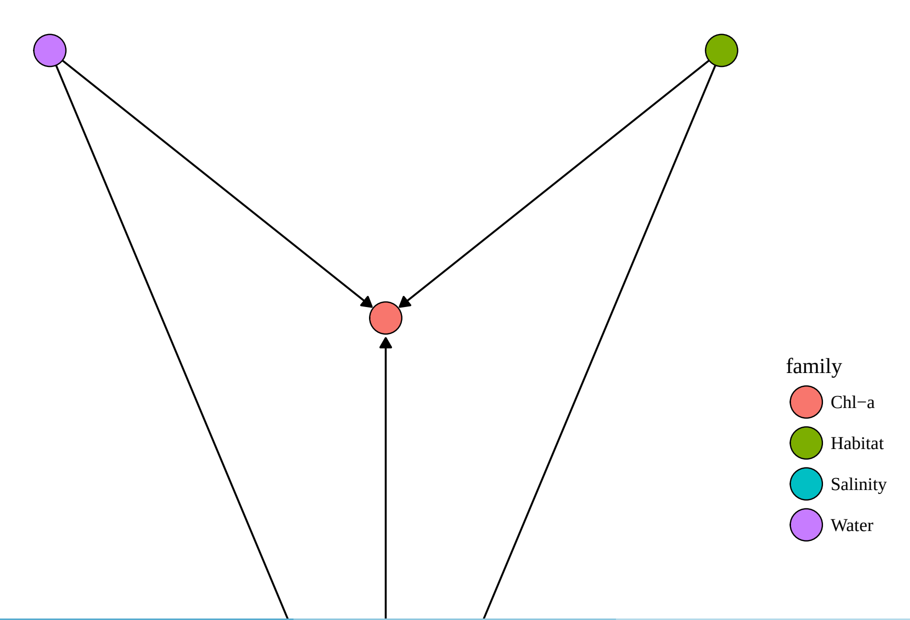
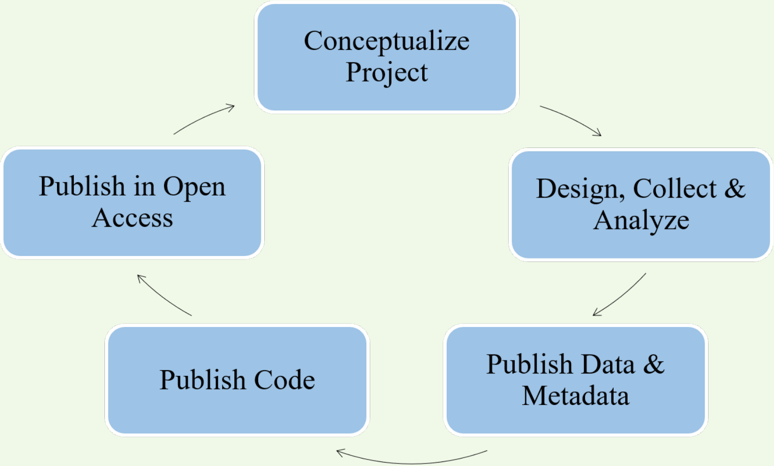
Bayesian models let us evaluate likelihood of potential outcomes given conditional distributions

Data munging with open source tools



Open science workflow



Modified from [Hampton et al., 2015]

Open science workflow

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

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

Teach a scientist to fish...

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 subtrophical 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 chlorophyll *a* 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.