Wetland Restoration Trajectories and Long-Term Ecosystem Monitoring: A Tidal Wetland Story

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Discussion Outline

- Large scale monitoring projects
- Data synthesis
- Restoration goals and assumptions
- How do we compare recovery across sites?
- How soon can we except recovery?
- What have we learned so far?
- Moving forward and adapting

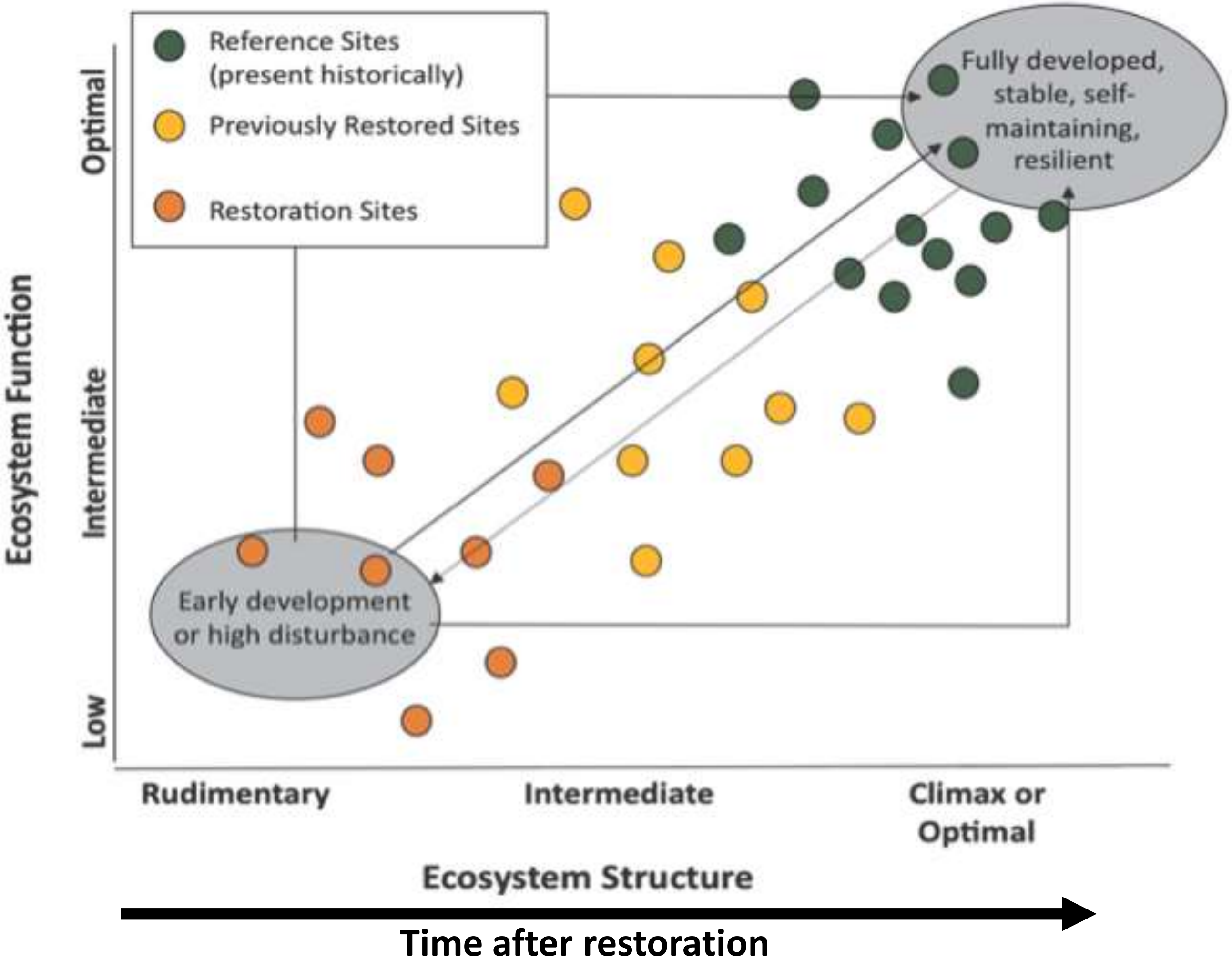
Large Scale Monitoring Projects Lower Columbia River

- Action Effectiveness Monitoring and Research (AEMR, Restoration – Multiple Years of Data)
- EMP (Ecosystem Monitoring Program, Ecological Status and Trends Monitoring)
- Kidd Dissertation (Restoration- Chronosequence)

Are restoration sites following a trajectory?

What is the scientific basis for all of these restoration efforts?

Theory of ecological restoration-recovery



Thom et al. (2010) describing a restoration trajectory

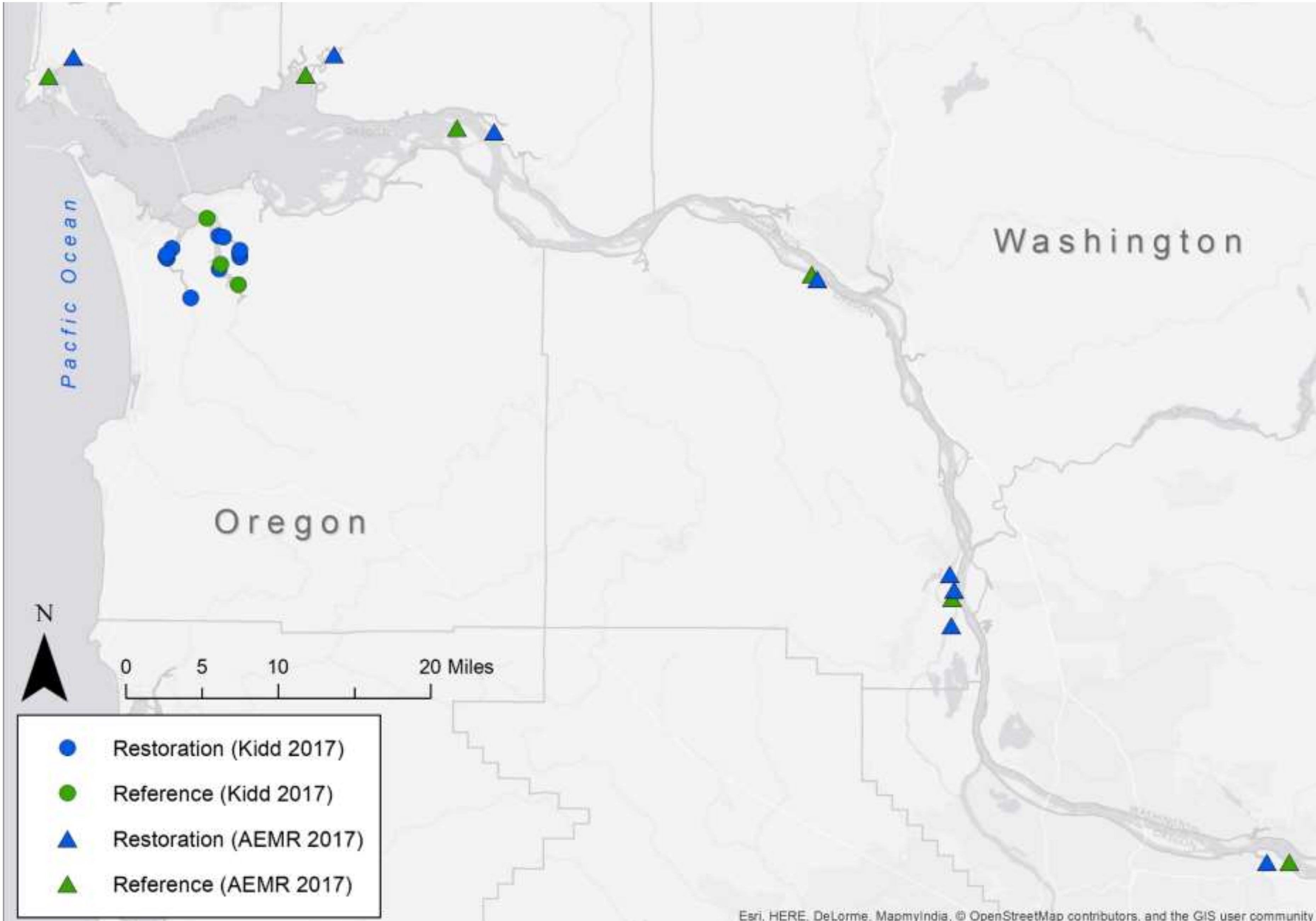
Further Citations: van der Valk 1981, Keddy 1992, SER 2004, Wilcox 2004, Apostol et al. 2006, Hilderbrand et al. 2005

Methods

- Restoration Type: Hydrologic Reconnection
- Sites and Years of Data
  - **Youngs Bay Study (2013-14'):** 11 restoration sites ages ranging from 1-54 years post-restoration, 3 reference sites, 2 pre-restoration
  - **AEMR (2013-17'):** 9 restoration sites with paired reference sites, data from pre-restoration (8 sites) to 1 year post (9 sites), 3 years post (7 sites), and 5 years (1 site) post-restoration

Monitored Restoration and Reference Wetlands in the Lower Columbia River

used in this analysis



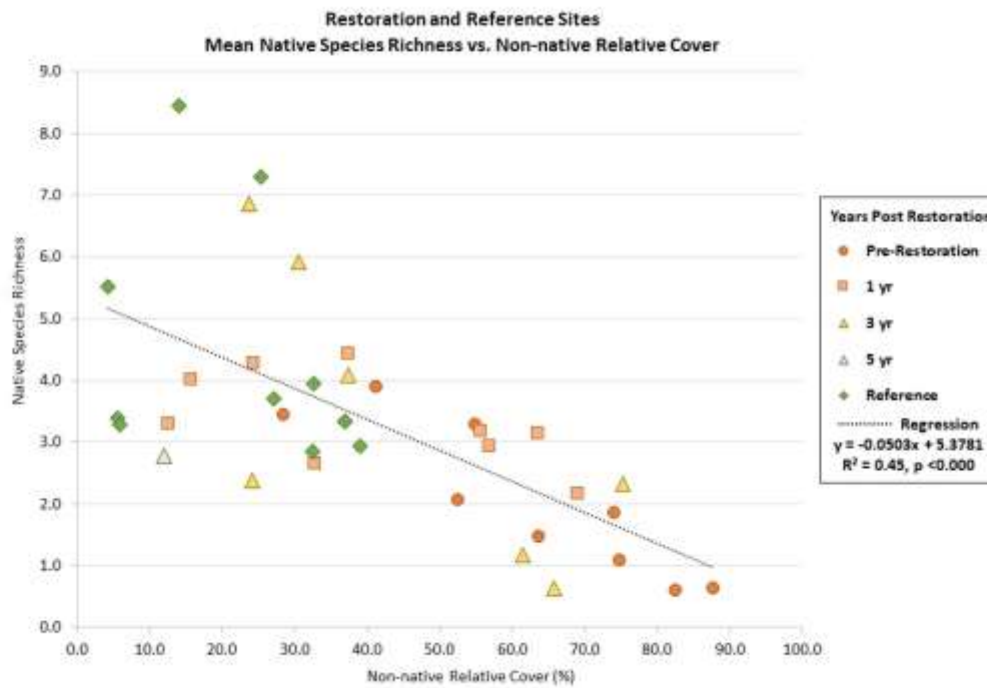
Methods

- Combining data across studies
  - Vegetation data collected at all the restoration and reference sites using similar methods (Roegner 2009)
- Summarized by native vs. non-native species using USDA species status classifications
- Native and Non-native Relative Cover

Plant Community Native and Non-native Species Dominance

Impacts to restoration trajectories

Invasive species
Phalaris arundinacea, reed canarygrass



Grow at the exclusion of natives – reduces native species richness

Plant Community Native and Non-native Species Dominance

Impacts to restoration trajectories

Invasive species
Phalaris arundinacea, reed canarygrass

Non-natives limit/impact:

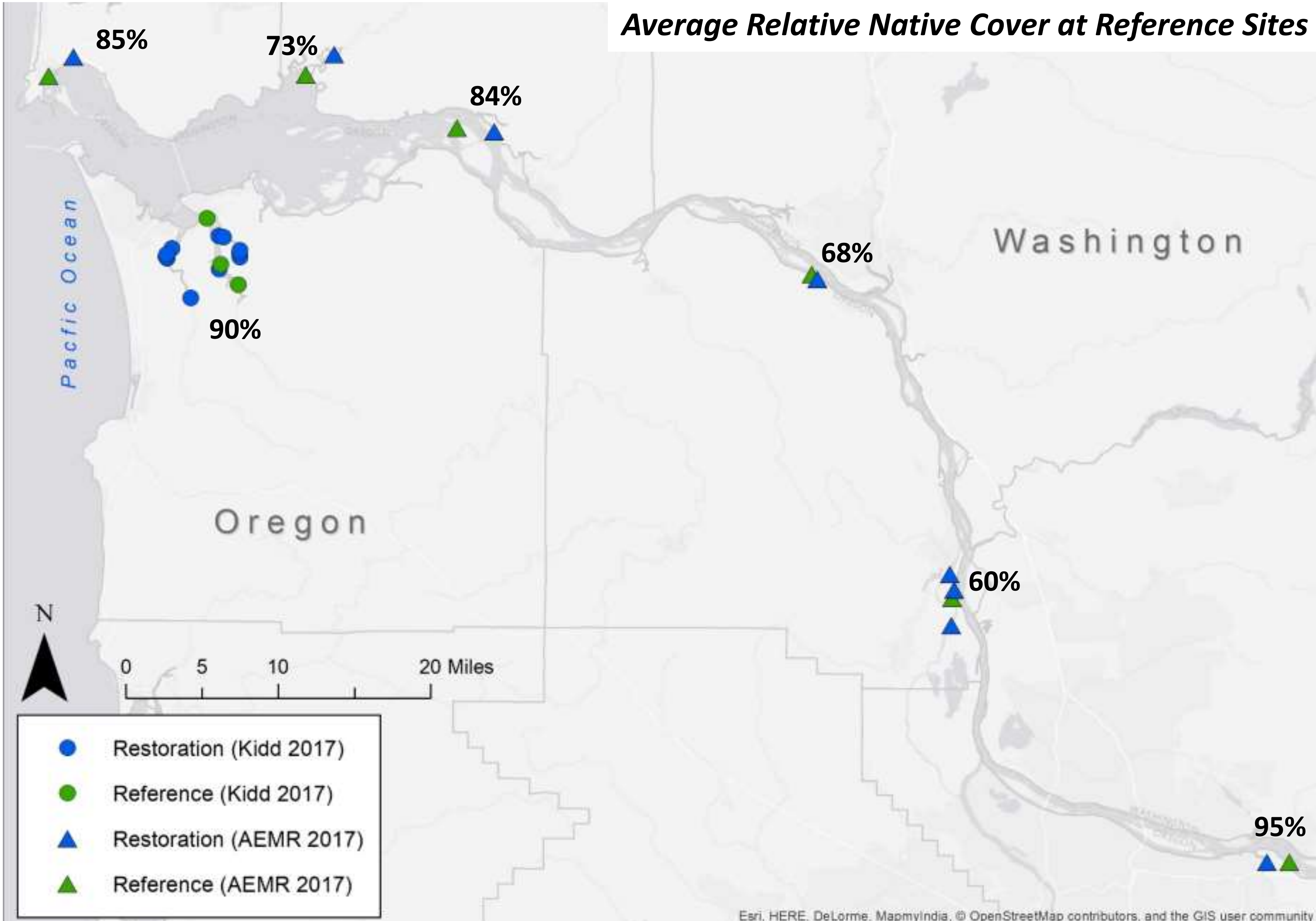
- Habitat Complexity & Diversity
- Detritus Quality – Nutrient Cycling
- Macroinvertebrate Communities

(e.g. Mabry and Dettman 2010, Lavergne & Molofsky 2010, Kidd & Yeakley 2015, Hanson et al. 2016, Klopfenstein 2016)

Grow at the exclusion of natives – reduces native species richness

Monitored Restoration and Reference Wetlands in the Lower Columbia River

used in this analysis



Relativized Response Ratio (RR)

$$RR = \ln\left(\frac{Mean\ Restoration\ Site\ Value}{Mean\ Reference\ Site\ Value}\right)$$

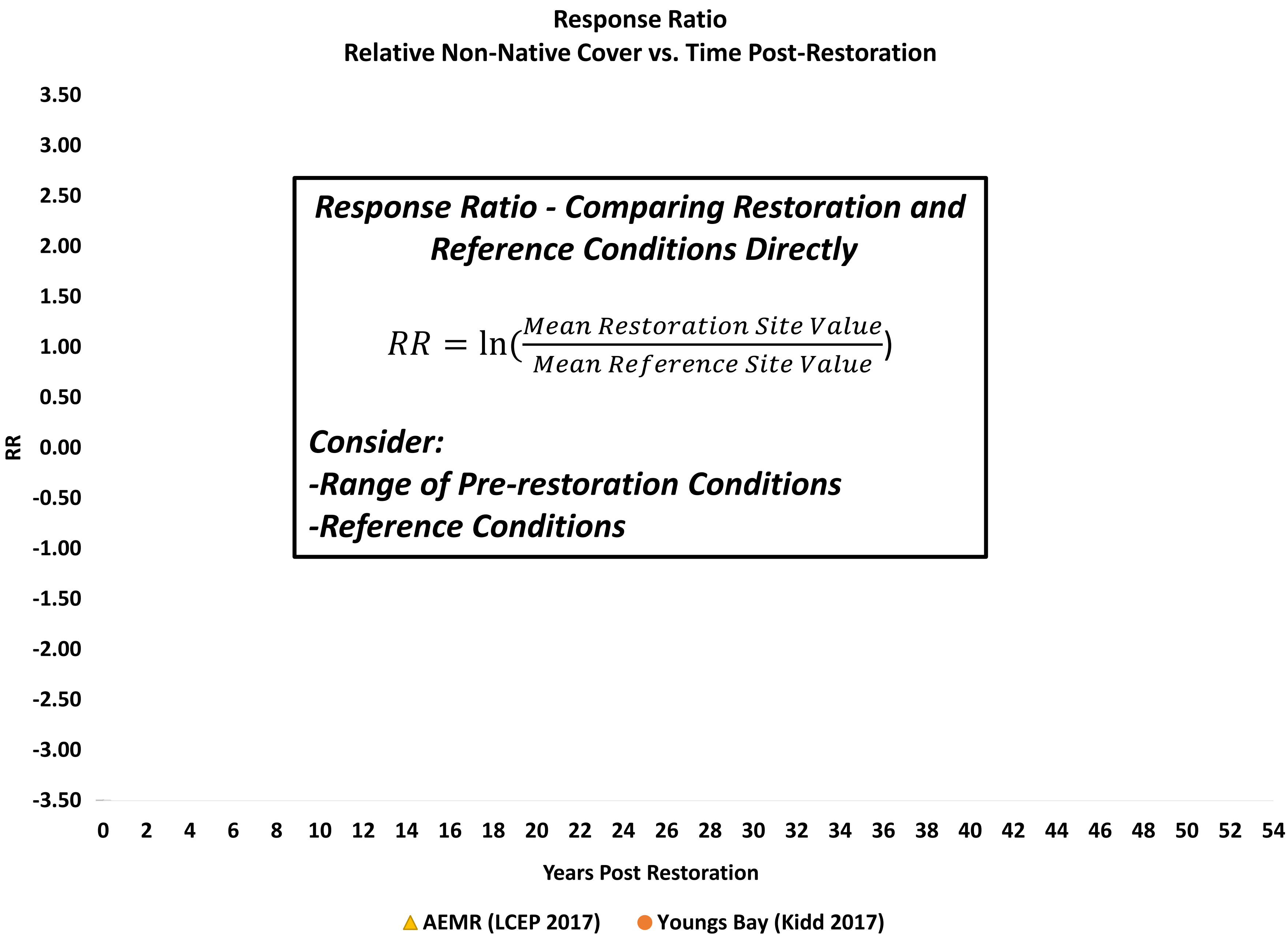
- Values close to 0 = most similar to Reference Site
- Calculate for each year data is collected
- Graph RR values vs. Restoration Year
- See *Meli et al. 2014* and *Lajeunesse 2015* for details
- **Allows for meaningful comparisons of recovery across wetlands throughout the estuary**
  - **Across vegetation zones, - i.e. RCG has a much wider elevation band as you move up river (see zones outlined by *Diefenderfer, Borde, and Cullinan 2013*)**

Restoration Trajectories

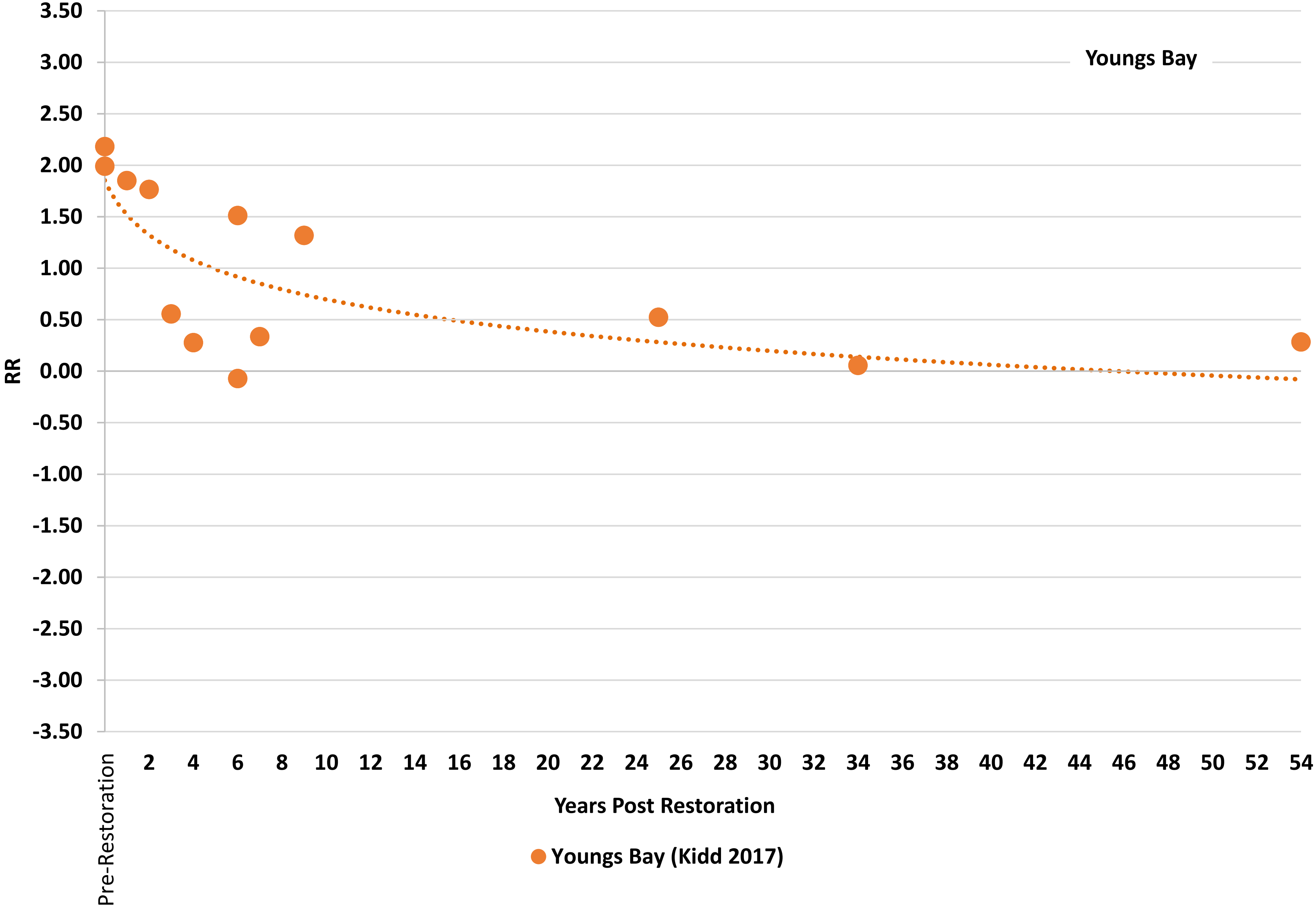
Native/Non-native Cover ……………………… Predicted 5-10 yr

Non-native

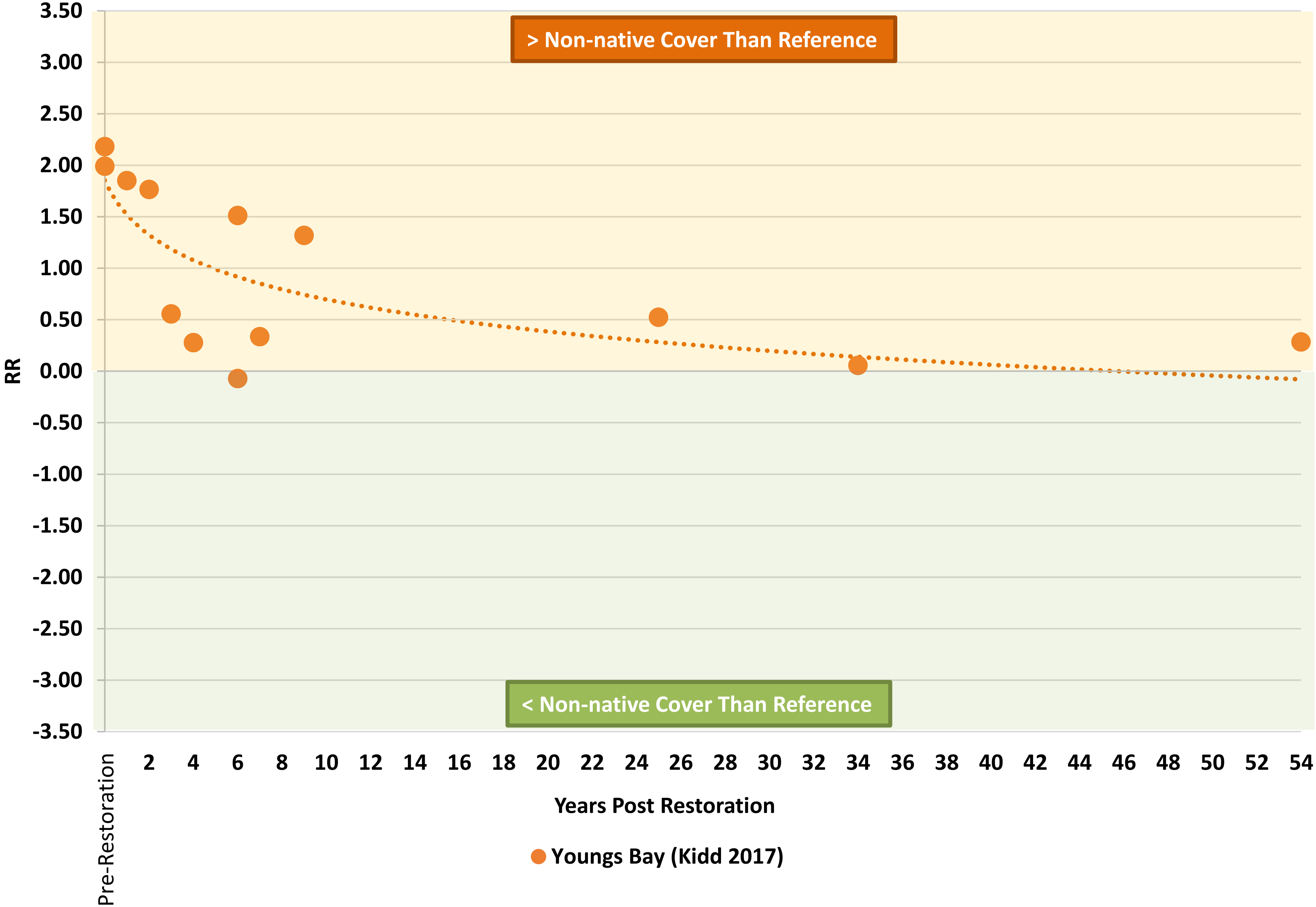
Native

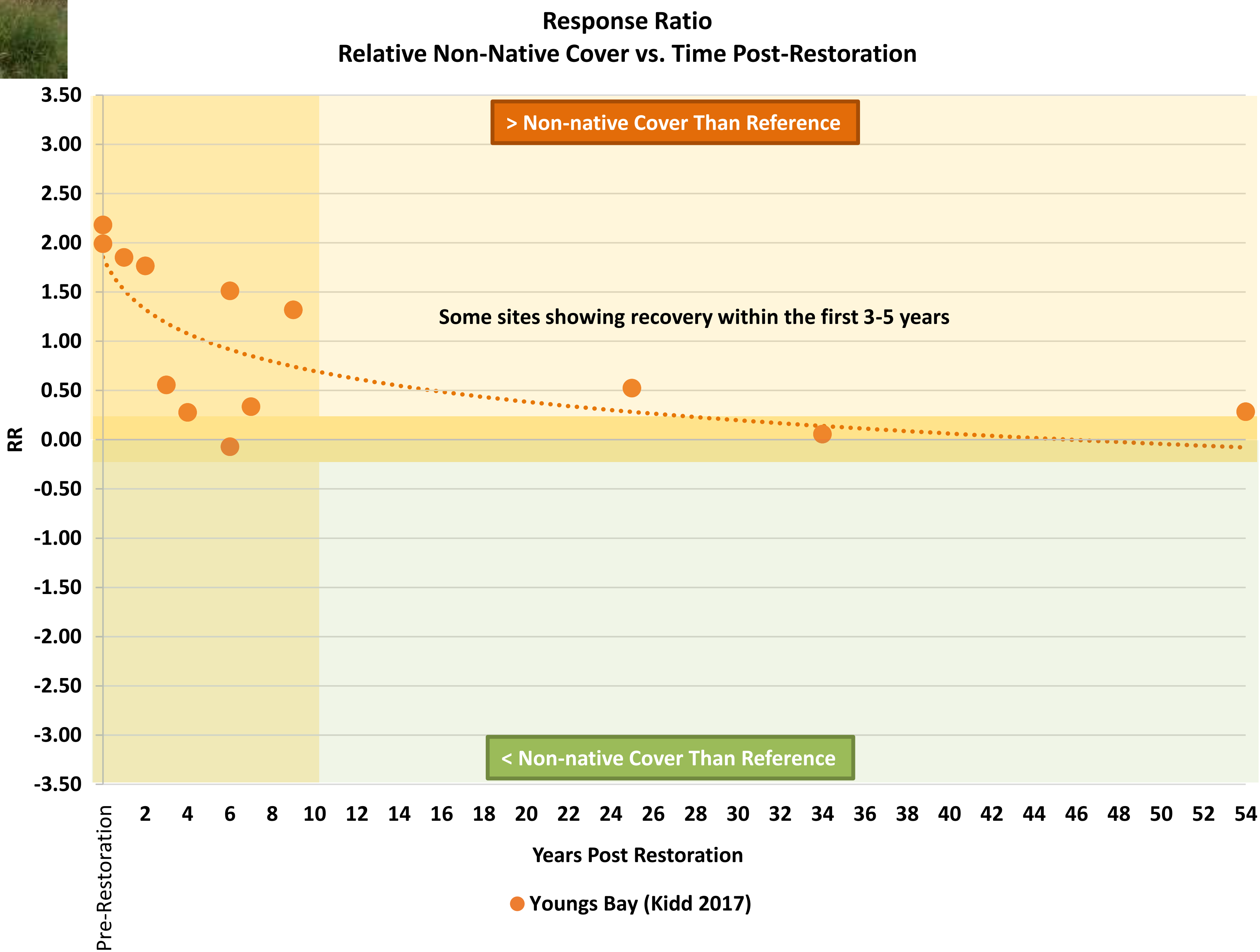

Response Ratio
Relative Non-Native Cover vs. Time Post-Restoration
Response Ratio - Comparing Restoration and Reference Conditions Directly
$RR = \ln(\frac{Mean\ Restoration\ Site\ Value}{Mean\ Reference\ Site\ Value})$
Consider:
-Range of Pre-restoration Conditions
-Reference Conditions
RR
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54
Years Post Restoration
AEMR (LCEP 2017)
Youngs Bay (Kidd 2017)

Response Ratio
Relative Non-Native Cover vs. Time Post-Restoration



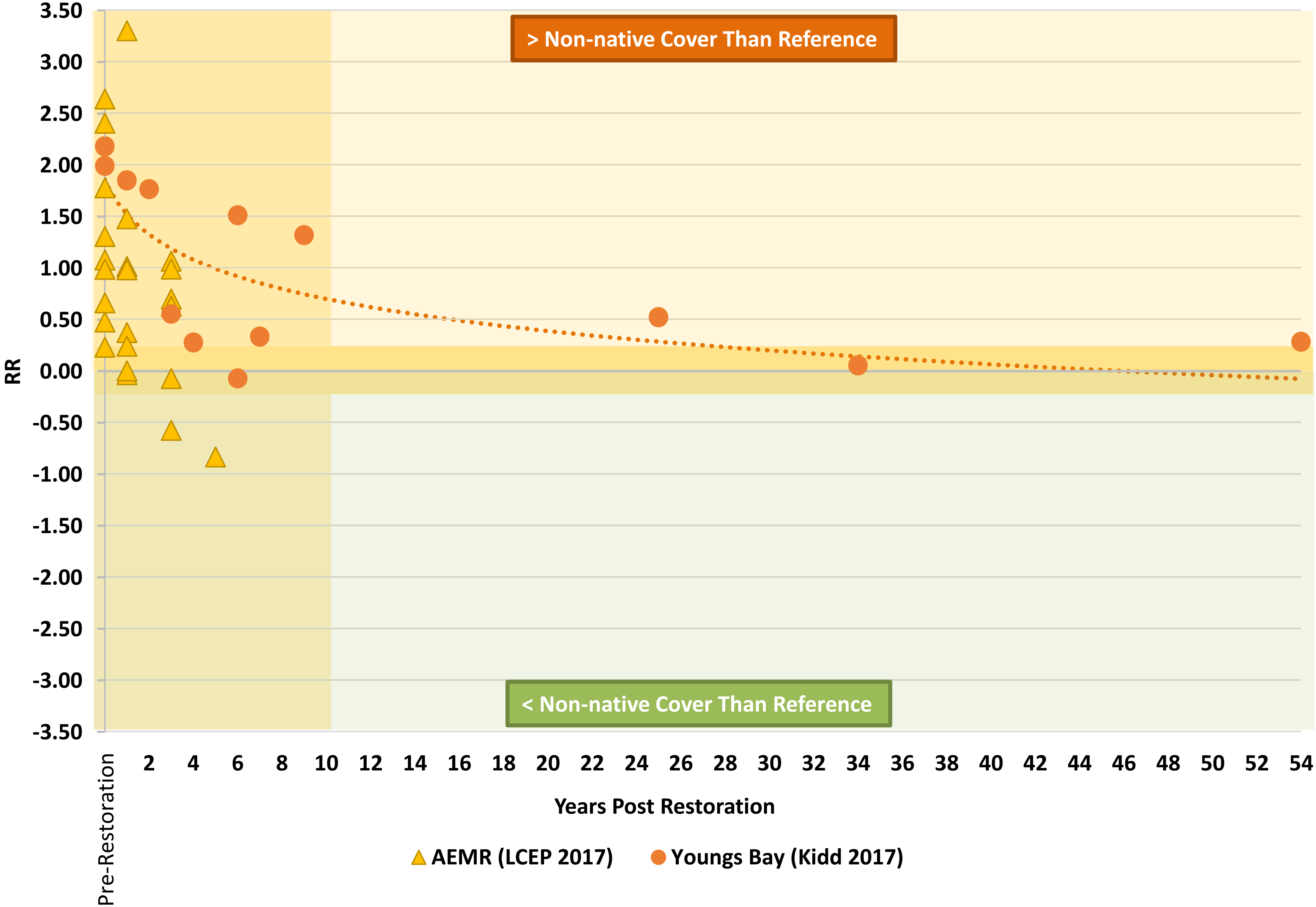
Response Ratio
Relative Non-Native Cover vs. Time Post-Restoration





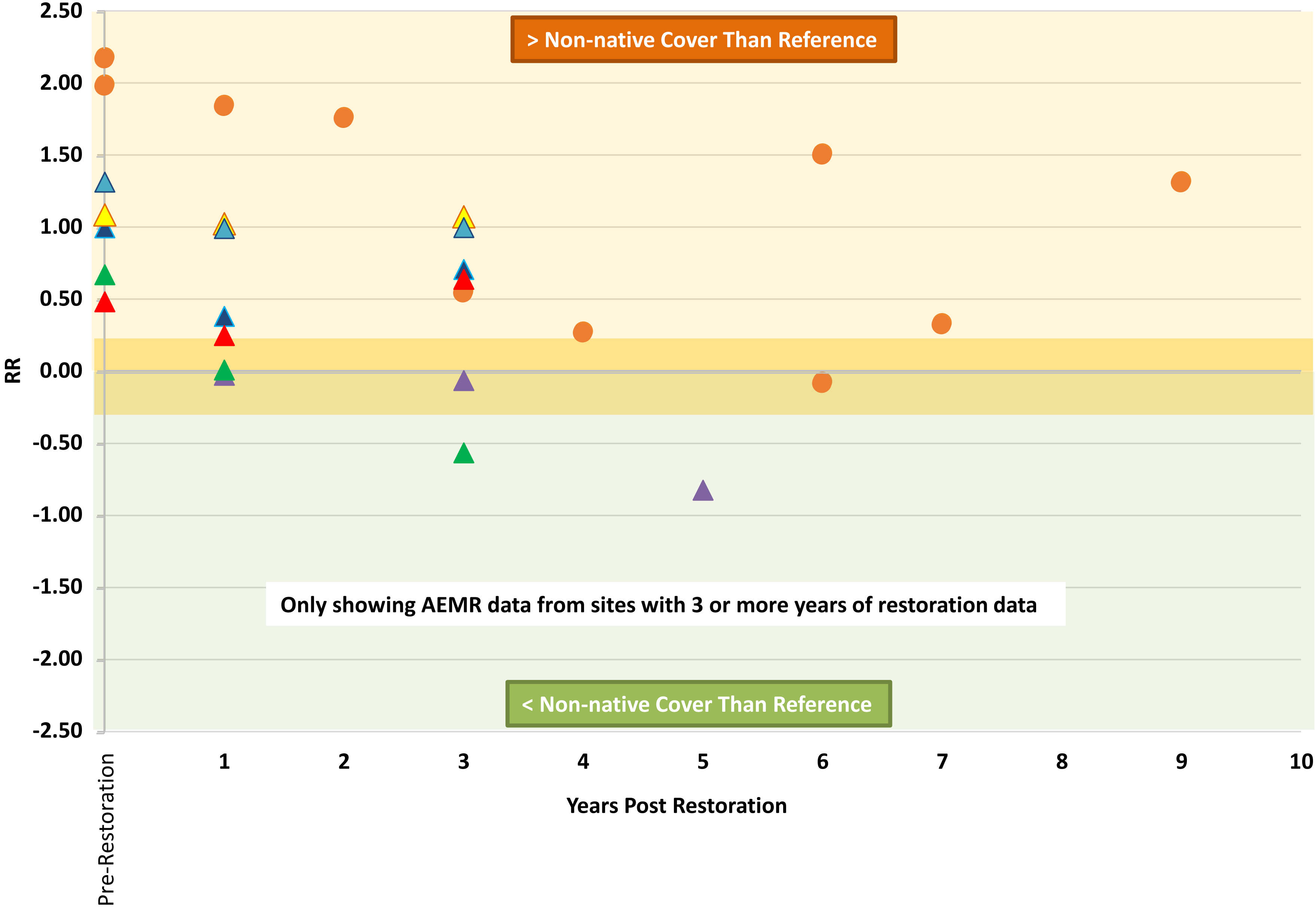
Response Ratio
Relative Non-Native Cover vs. Time Post-Restoration
> Non-native Cover Than Reference
Some sites showing recovery within the first 3-5 years
< Non-native Cover Than Reference
RR
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
Pre-Restoration
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54
Years Post Restoration
Youngs Bay (Kidd 2017)

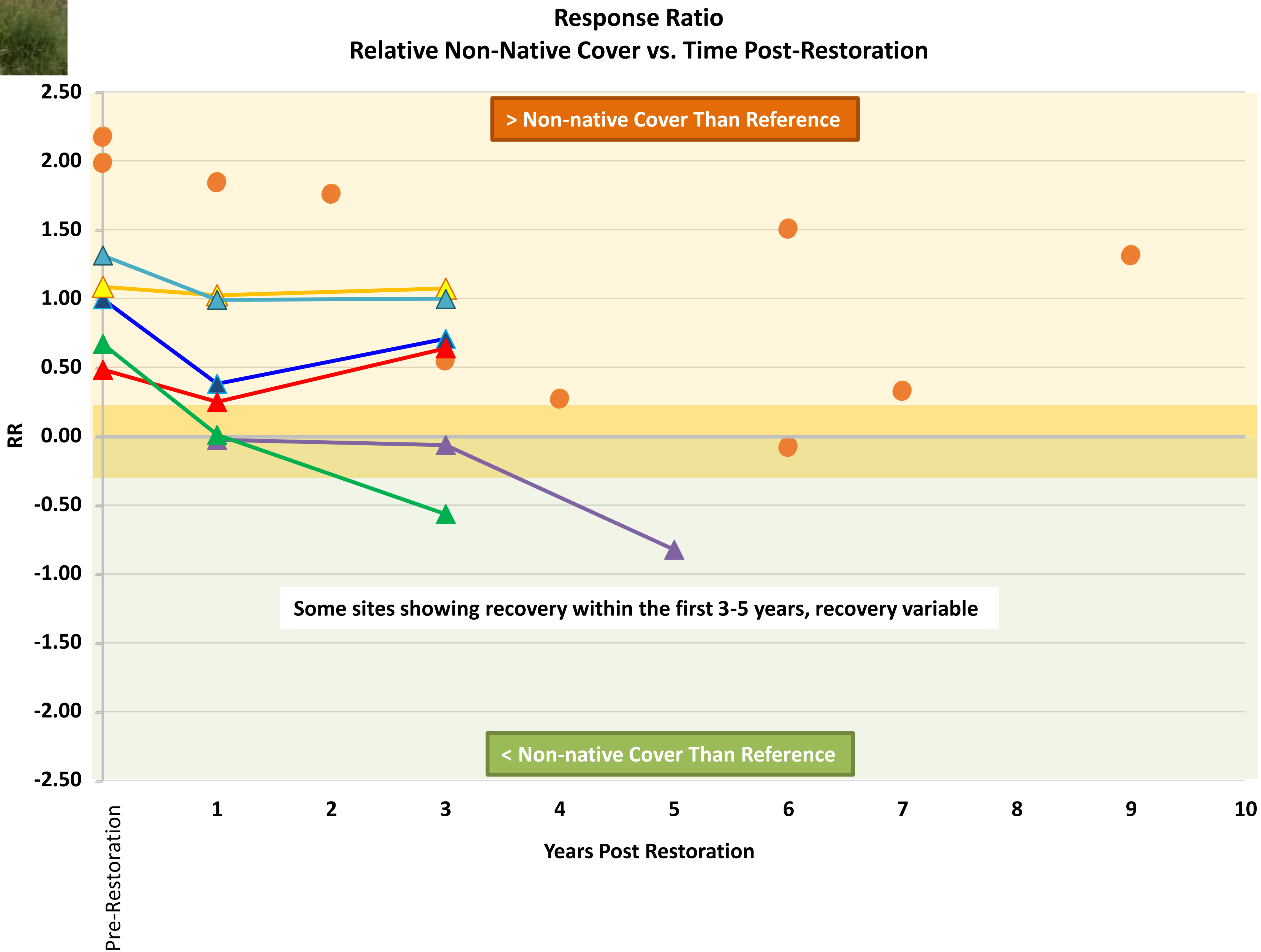
Response Ratio
Relative Non-Native Cover vs. Time Post-Restoration



Response Ratio
Relative Non-Native Cover vs. Time Post-Restoration

Response Ratio
Relative Non-Native Cover vs. Time Post-Restoration





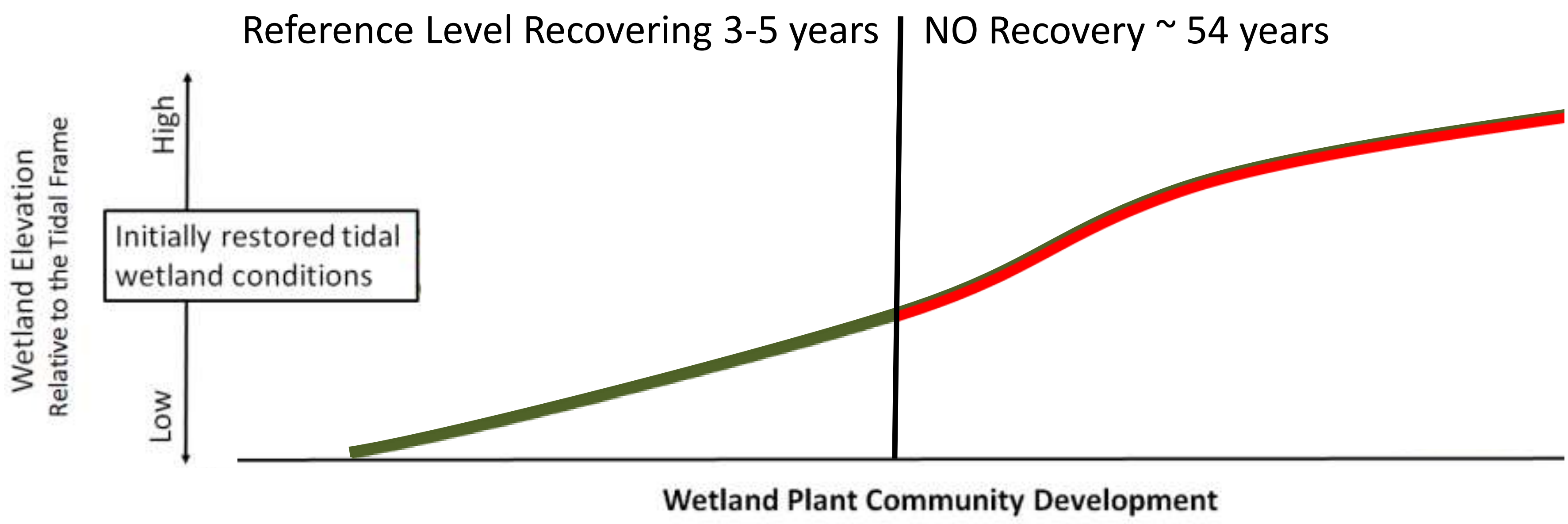
Response Ratio
Relative Non-Native Cover vs. Time Post-Restoration
> Non-native Cover Than Reference
Some sites showing recovery within the first 3-5 years, recovery variable
< Non-native Cover Than Reference
RR
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
Pre-Restoration
1
2
3
4
5
6
7
8
9
10
Years Post Restoration

Native vs. Non-native Plant Community Recovery

- **Question site recovery when native and non-native sp. cover are <u>*not within ±25% (± 0.25 RR)*</u> of reference conditions by years 3-5 post restoration**
  - **Are reference conditions a reasonable expectation?**
  - **Did the restored site hit the <u>target hydrology</u> to reduce invasive species (i.e. Reed canarygrass)?**
  - **<u>Scrape down</u> soil conditions can make plant recovery slow**
    - **Low soil organic content**
    - **Low nutrient retention**
    - **High bulk density (compaction)**
    - **Seed bank**

Restored low elevation marsh areas have higher similarity to reference marshes and less non-native species than higher elevation marsh areas.

Plant Community Recovery



Youngs Bay Examples

Youngs Bay Restoration Sites

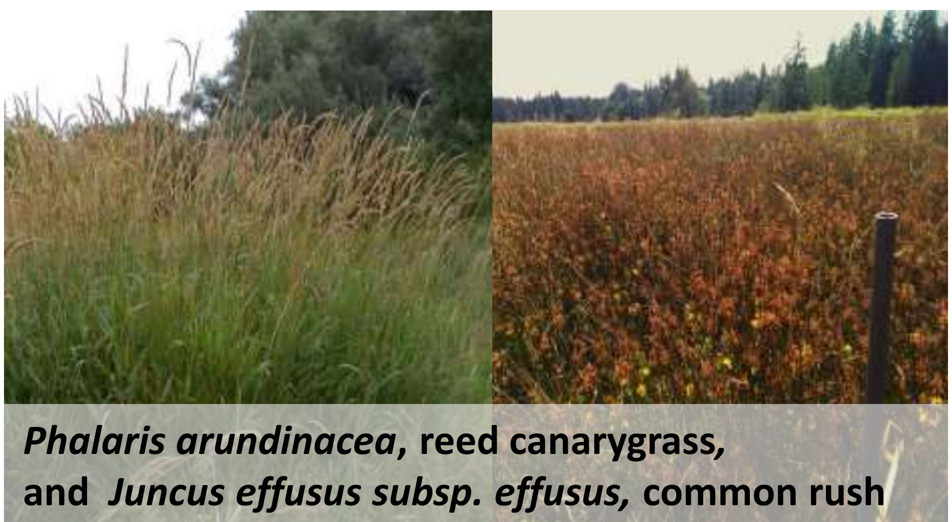
Non-native Dominant High Marsh

Locations above mean high water

- Higher soil ORP (hydrologic indicator)
- Lower soil pH
- Lower soil Organic Matter
- Higher soil Bulk Density
- Lower soil Salinities

Significant Differences Compared to Reference Wetlands

All characteristic of pre-restoration wet pasture conditions



***Phalaris arundinacea*, reed canarygrass,**
and *Juncus effusus subsp. effusus,* common rush

Soil conditions need to be considered

- -Pre-restoration conditions
- -Impacts of soil scrape down
- -Recovery timelines

Phalaris arundinacea, reed canarygrass, and *Juncus effusus subsp. effusus,* common rush

Moving Towards Understanding Recovery

- **Does the site have similar restored hydrology to the reference site?**
  - **Restored/Reference condition comparisons should focus on matching wetland hydrologic zones *based on duration, frequency, and timing of inundation***
  - **Monitoring and comparing hydrologically similar areas within reference and restored sites for tracking recovery**
    - **Different trajectories of recovery can be expected and adaptive management will likely be needed**

Future Planning and Monitoring

- Consider
  - Wetland hydrologic zones being restored
    - Mud flat, low marsh, high marsh, shrub
  - Impact of scrape down
    - Removing soil organic matter
    - Compacting soil
    - Soil texture
  - Seed banks (native & non-native)
    - Local native seed dispersal?
  - Creating goals that are measurable
    - Such as within a +/- 0.25 Response Ratio in 5 yrs.

HOW? – use hydrologic modeling to predict inundation and recovery

HOW? - Evaluate soil conditions and adjust plans and/or expectations accordingly

HOW? - Evaluate seed bank conditions and local seed sources, plan to seed or control non-natives as needed

HOW? - Monitor Plant Communities and Soil Conditions

Next Steps

- Compare wetland recovery within hydrologic zones
  - Identify if/why restoration targets aren't being met
  - Evaluate soil conditions
- Use monitoring data to help adaptively manage recovery
- Response Ratios can be helpful to compare the recovery of multiple ecological indicators across sites

Questions?

THANK YOU FOR LISTENING!

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Thank you!

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Lower Columbia Estuary Partnership