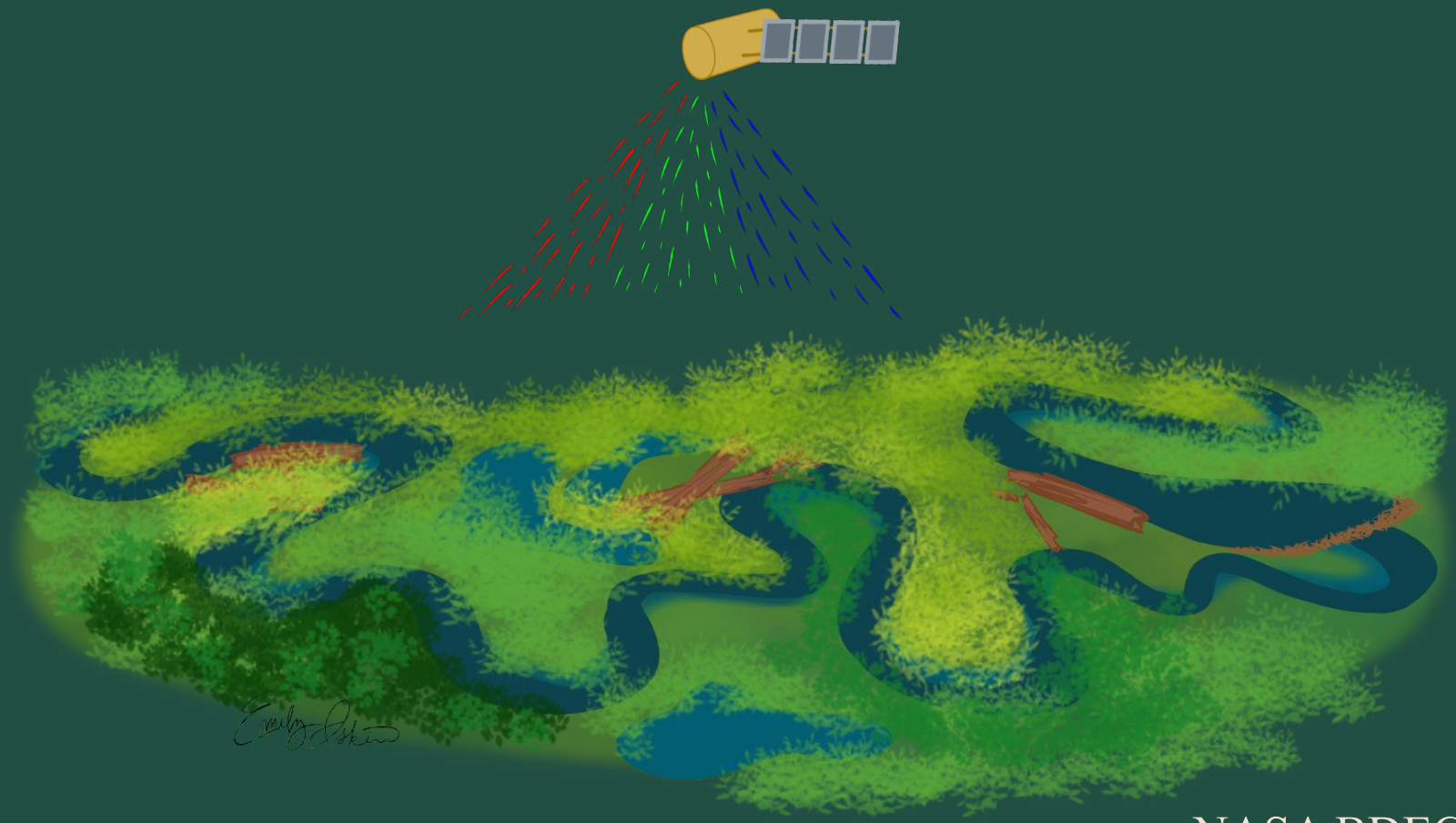
MRRMaid-Change: a decision-support guide for statistical change analysis of beaver rewilding



Jodi Brandt, Boise State University

NASA BDEC 2025 Team Meeting

Tuesday, May 27, 2025

Research Team (Boise State) and End User Partners (Trout Unlimited)

Jodi Brandt

Nick Kolarik

Erik Nati-Johnson

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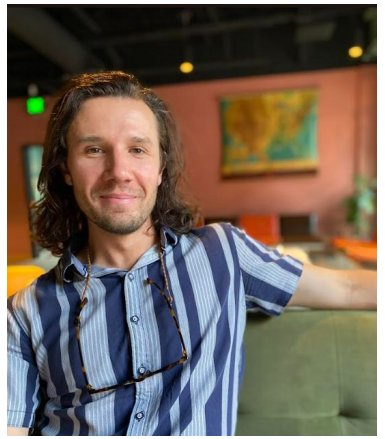

Louis Jochems

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The Project

Develop a satellite-based monitoring system for mesic ecosystems in the sagebrush biome to support adaptive management of beaver rewilding

The Sagebrush Biome

BOISE STATE UNIVERSITY

TROUT UNLIMITED

NASA

Restoration

Mesic Resource

Monitoring

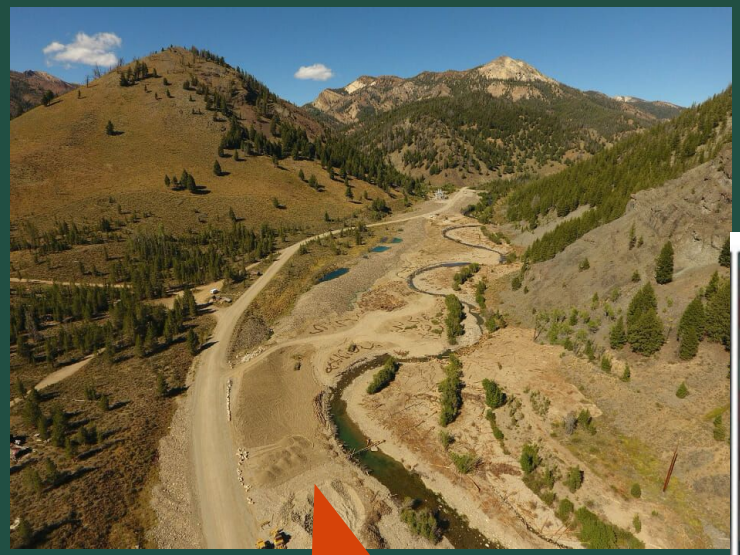
MRRMaid

Indicator of mesic ecosystem condition = proportion of valley bottom that is mesic

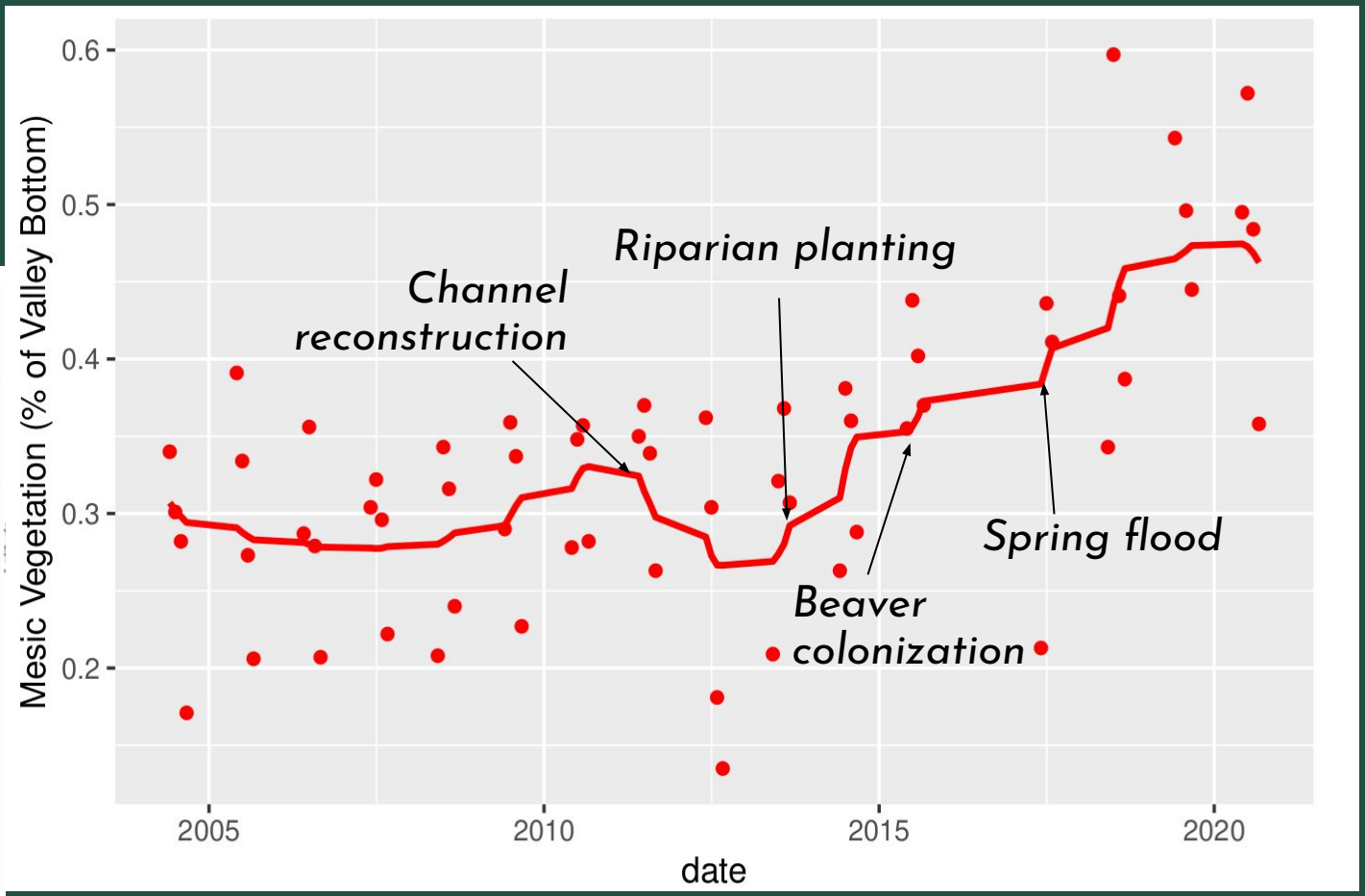
Natural site = ~90% of valley bottom is mesic

Gold mining site - < 30% of valley bottom is mesic

Product development and case study timelines



Gold mining site, severely degraded, restoration start 2012



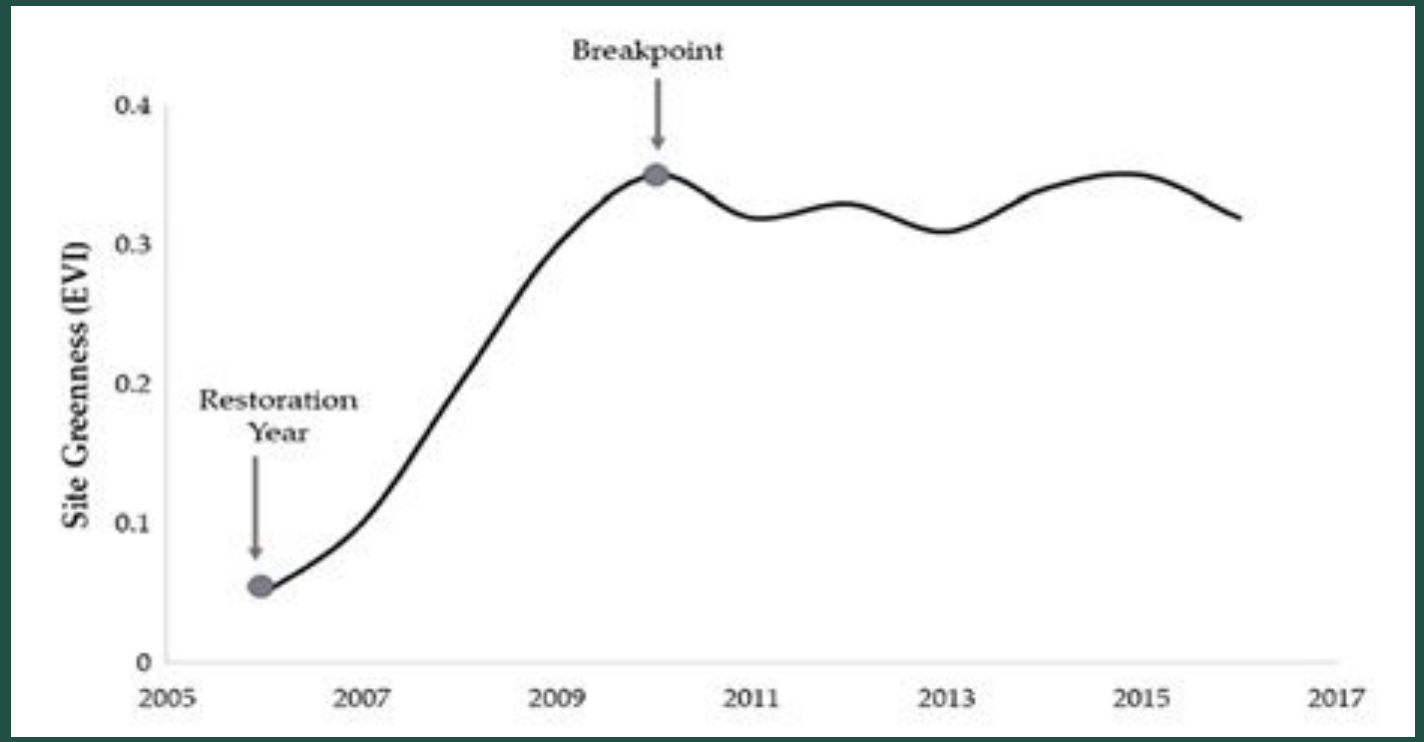
Time series from Monthly MRRMaid, Landsat fractional components with machine learning regression, Kolarik et al., 2024

Statistical change analyses techiques (e.g. breakpoint, change point, counterfactual) can provide insights for adaptive management

Our partners have specific questions and site knowledge.

We have statistical/technical expertise.

Together, we built the MRRMaid-Change guide to link these sets of knowledge.

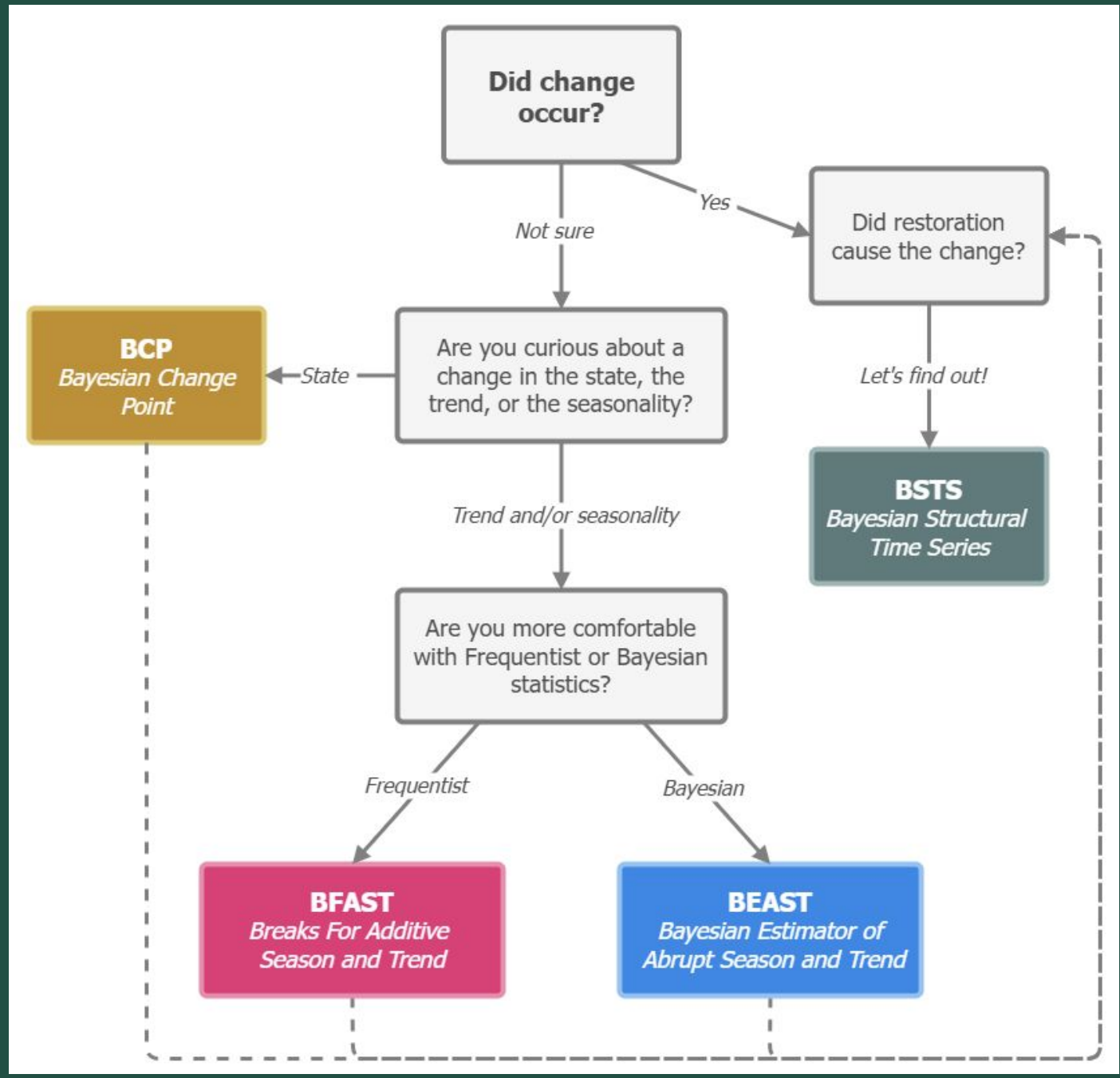


Conceptual diagram of breakpoint analysis, from Taddeo and Dronova, 2020

MRRMaid-Change decision flowchart

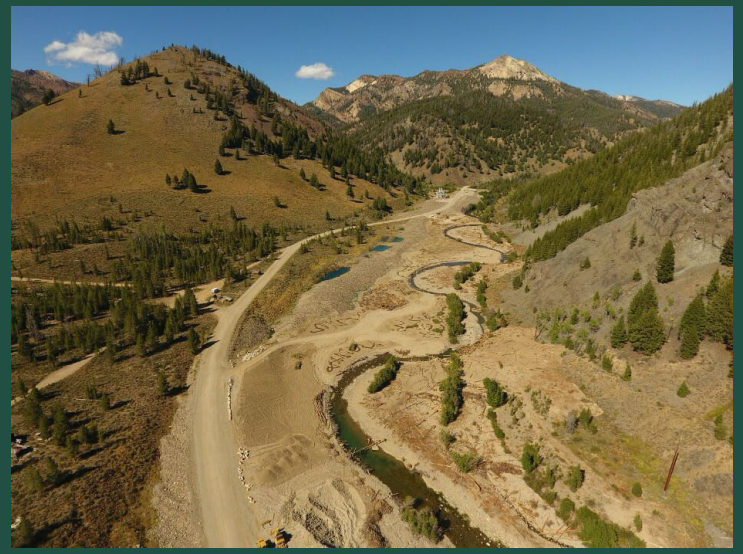
White boxes = End user questions

Colored boxes = Statistical analysis technique



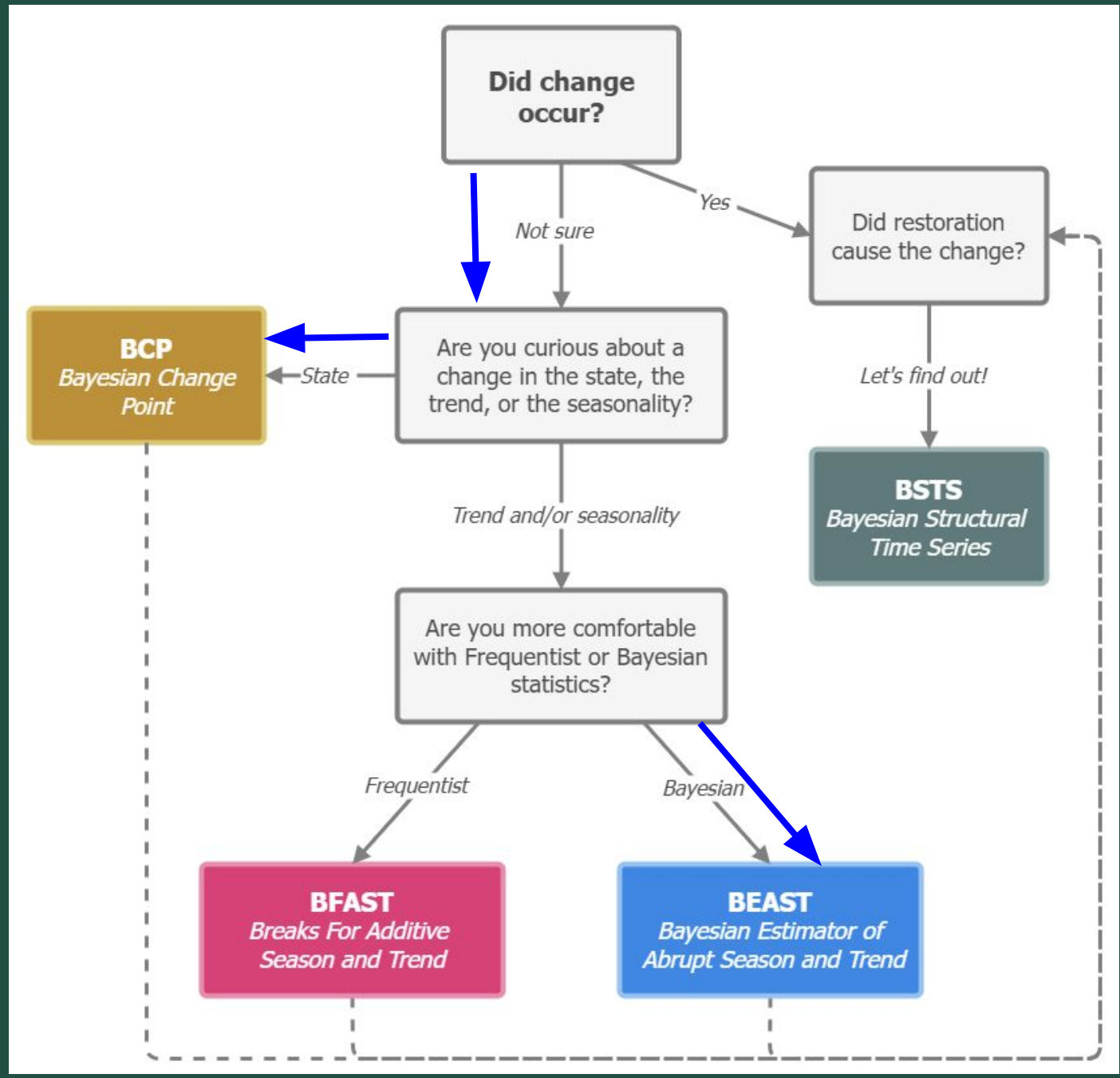
Kolarik et al., in review. Time series analyses provide a low-cost and scalable way to assess restoration outcomes from satellite data.

Example 1

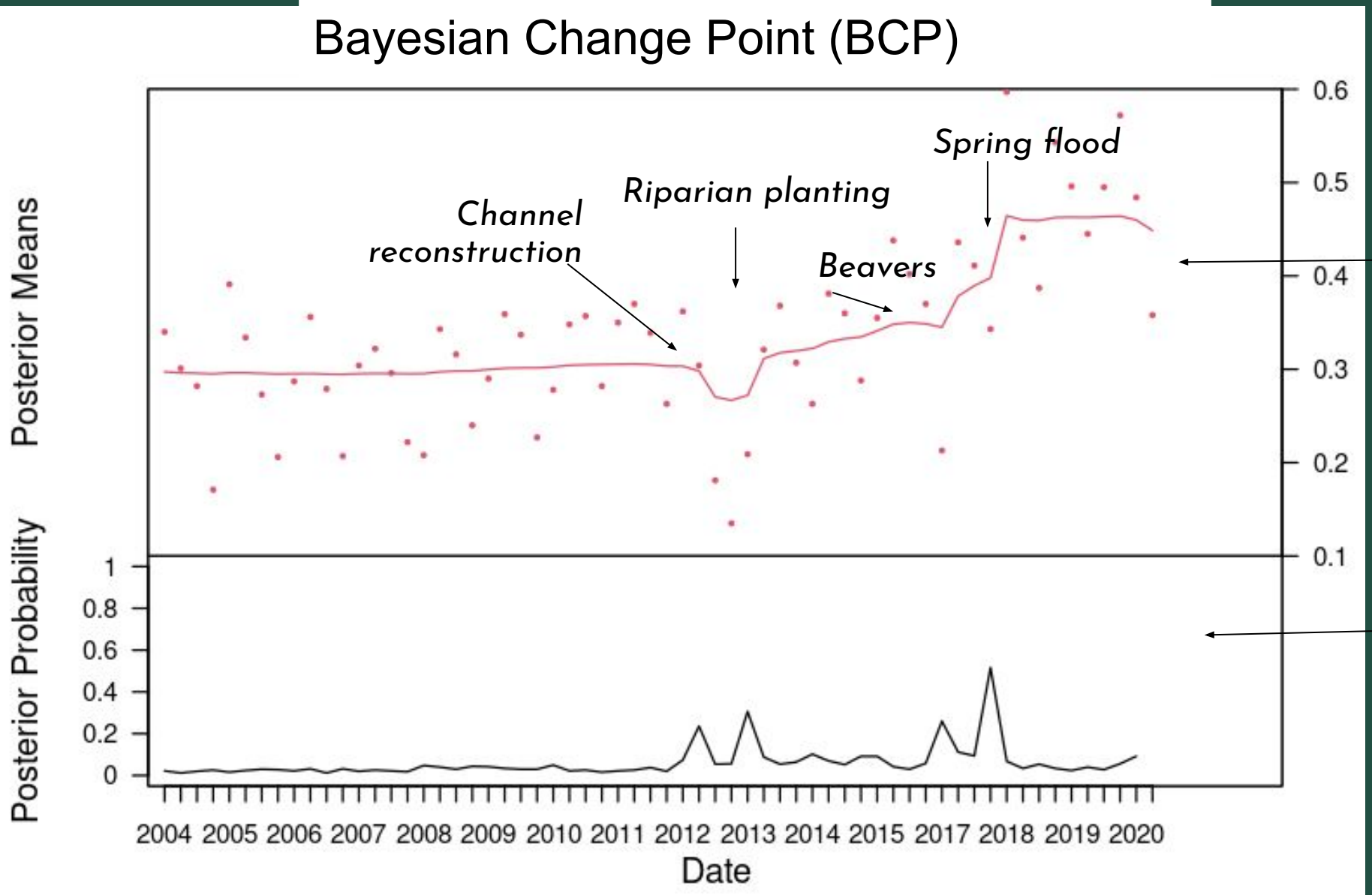


Did an ecosystem state change occur?

Approach = BCP



BCP - Change in ecosystem state



Observed

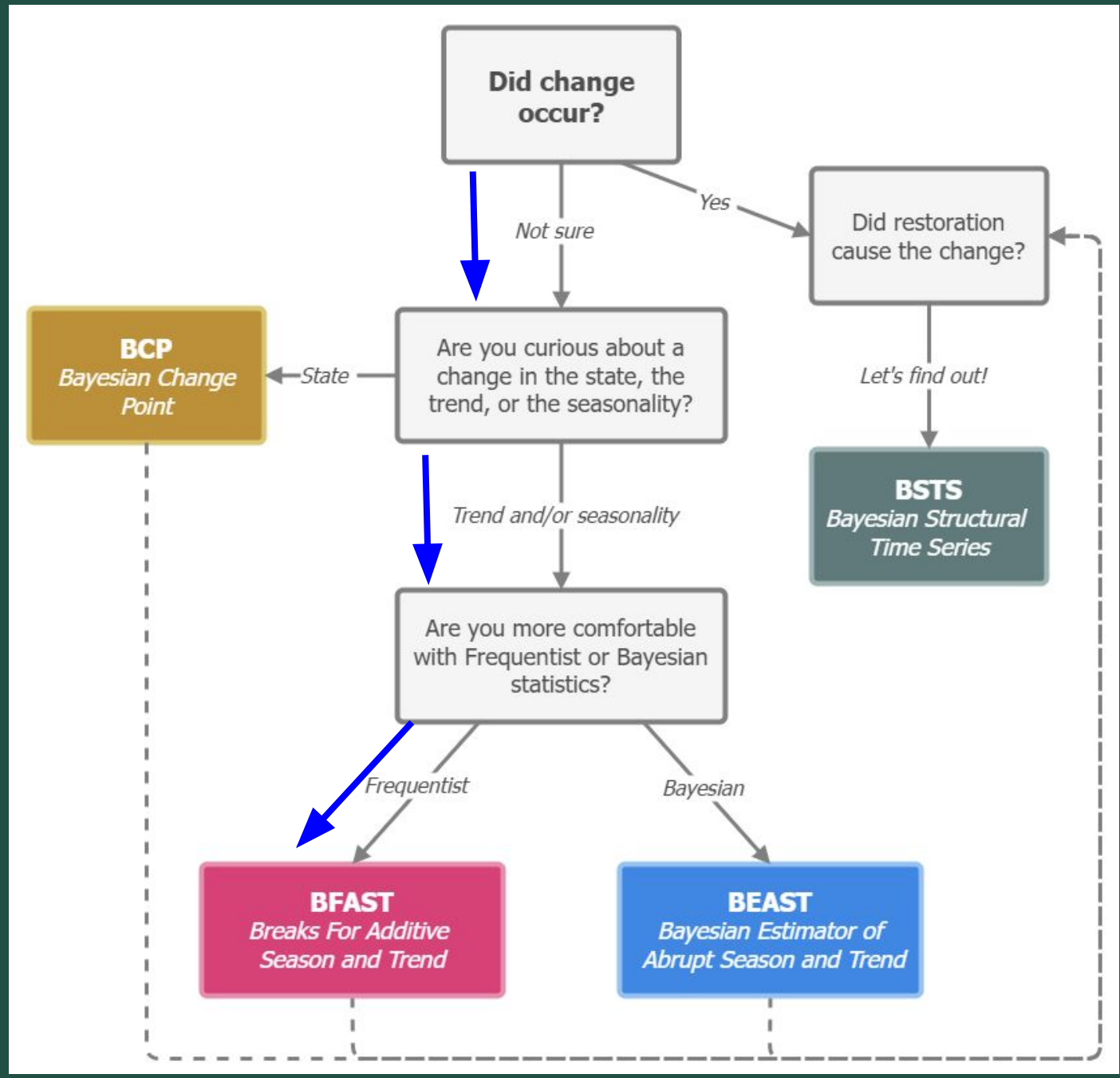
Change point output: probability of shift in mean mesic proportion

Spring flood: 57% probability of ecosystem shift

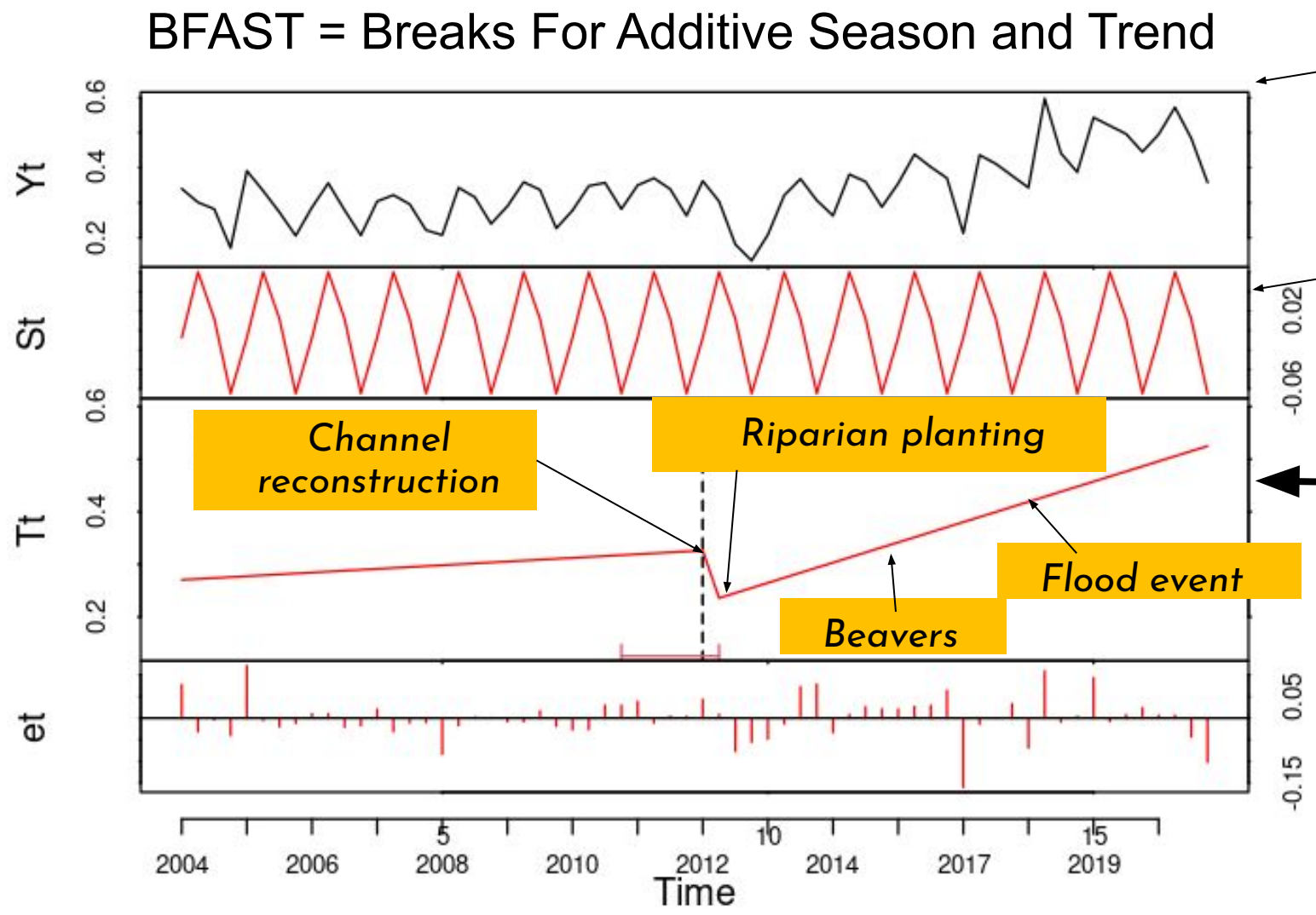
Example 2

a. Did a change in trend and/or seasonality occur?
b. Frequentist approach

Approach = BFAST



BFAST - Did change in trend or seasonality occur? (Frequentist approach; "statistically-significant")



Observed

Seasonal pattern

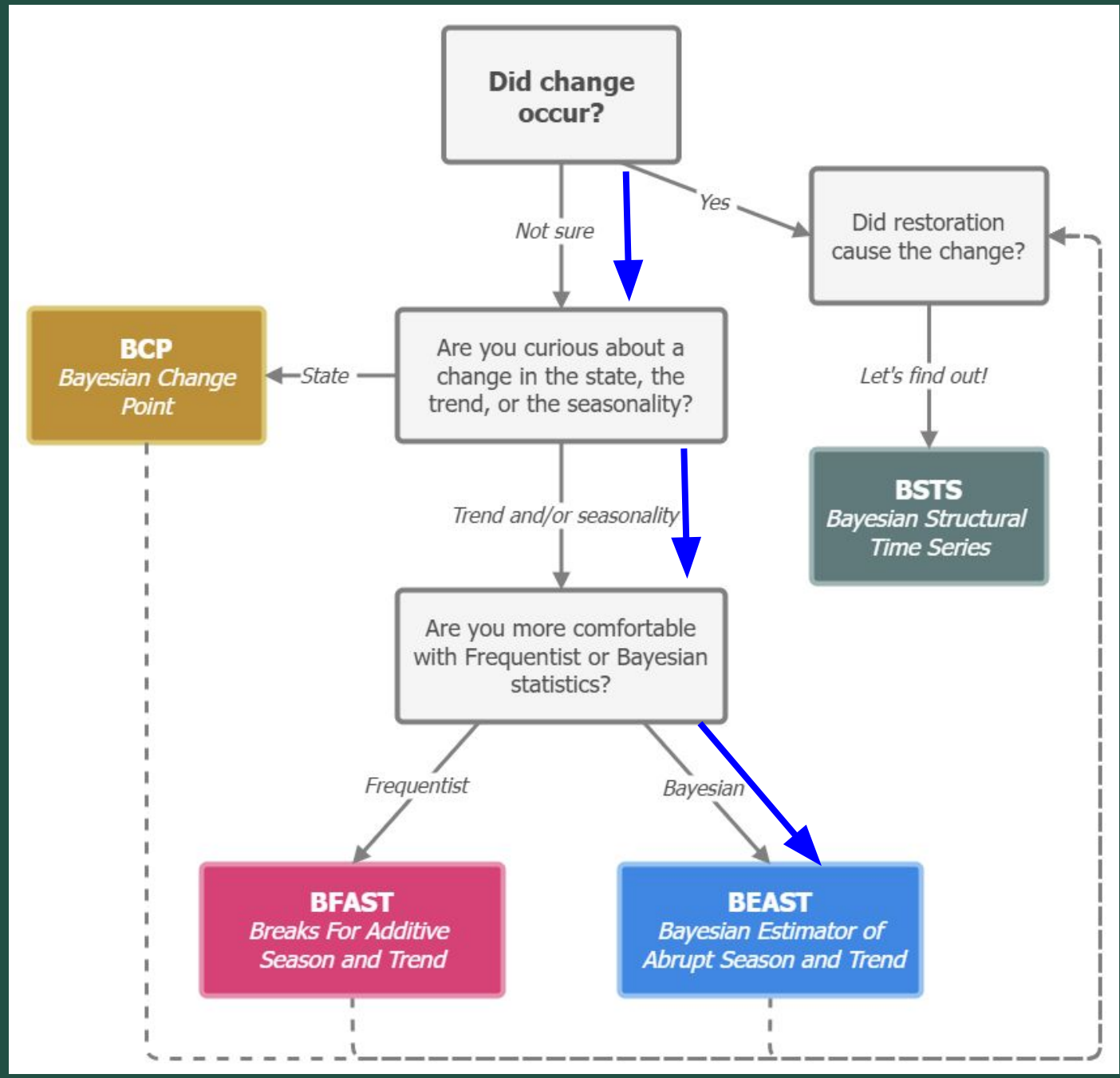
Change point = dotted vertical line

- **1 detected ($p<0.05$)**
- **pre-restoration trend = 0.7%.**
- **post-restoration trend = 3.9%**

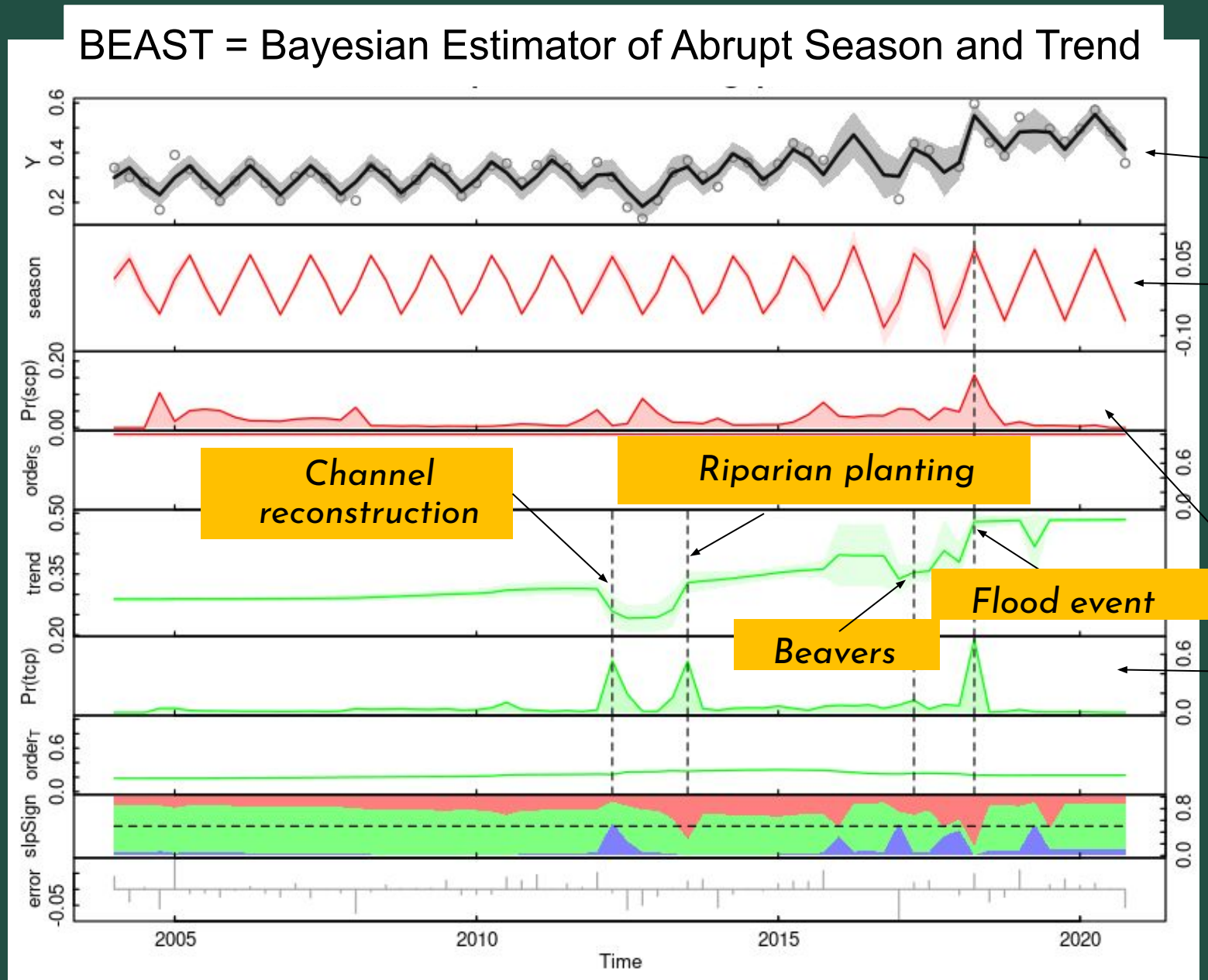
Example 3

a. Did change occur in trend/seasonality?
b. Bayesian approach

Approach = BEAST



BEAST - Bayesian; Probability that change occurred



Observed

Seasonal pattern

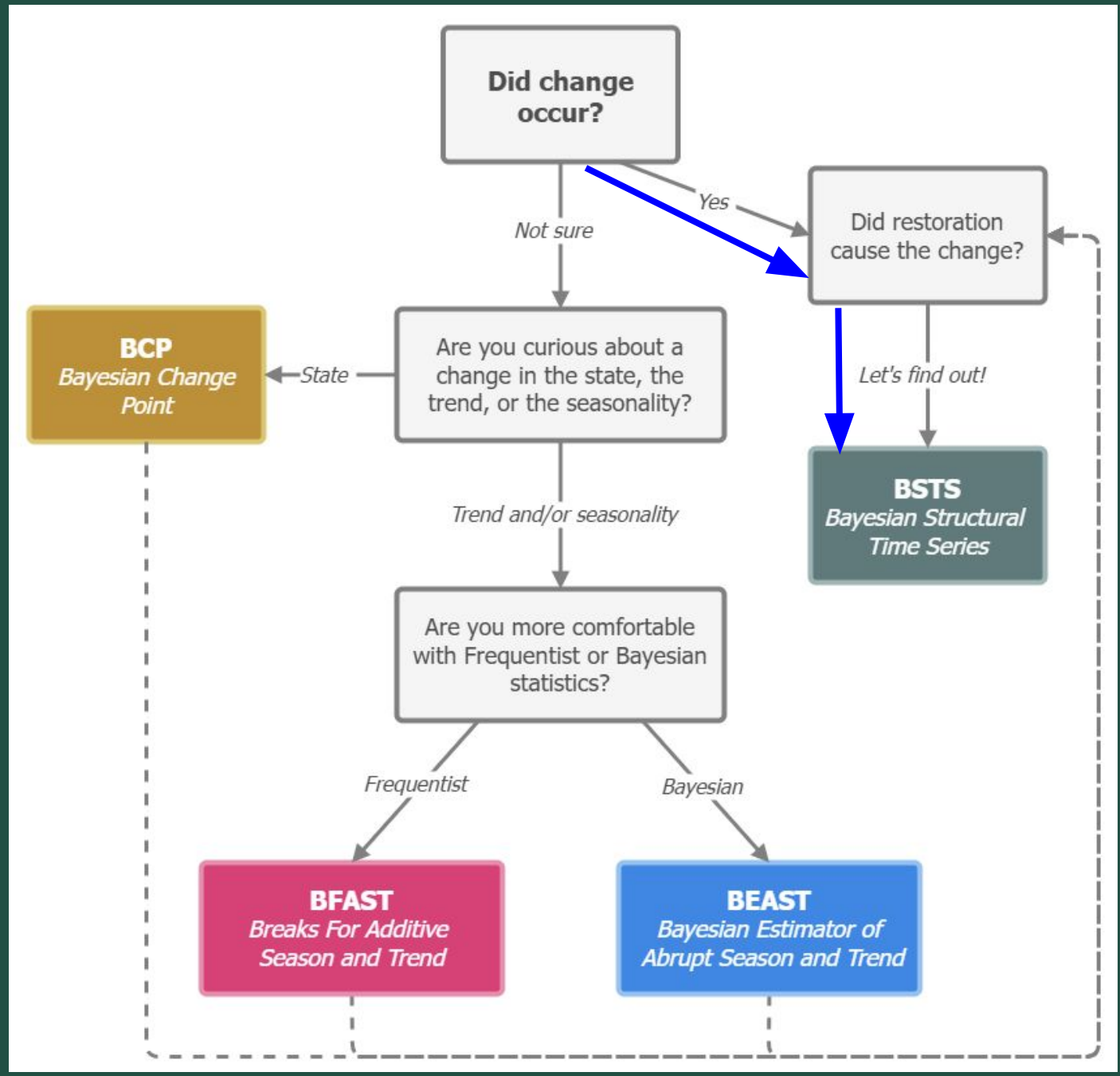
Dotted line = change point

- **4 detected**
- **Flood event: 87% probability of a trend change; seasonal component contributed**

Example 4

Did restoration CAUSE the change?

Approach = BSTS



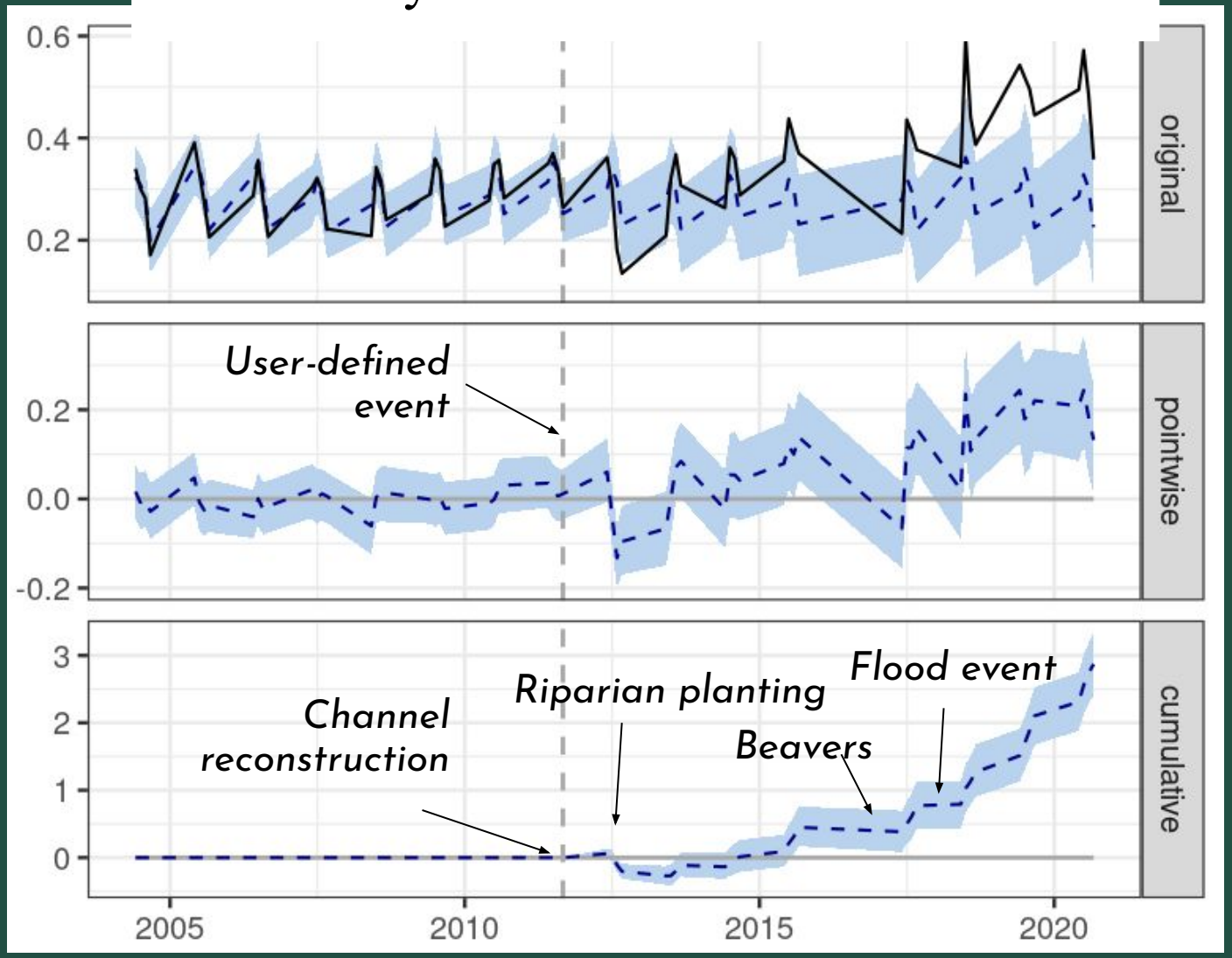
BSTS - Cumulative causal impact of restoration

BSTS = Bayesian Structural Time Series

Additional inputs needed:

-a single date of restoration

-Covariates that influence the outcome



Black = Observed
Blue = counterfactual, with credibility intervals

Cumulative: The restoration led to a 31% (25%-38%) increase in mesic resources

Insights from MRRMaid-Change at this site

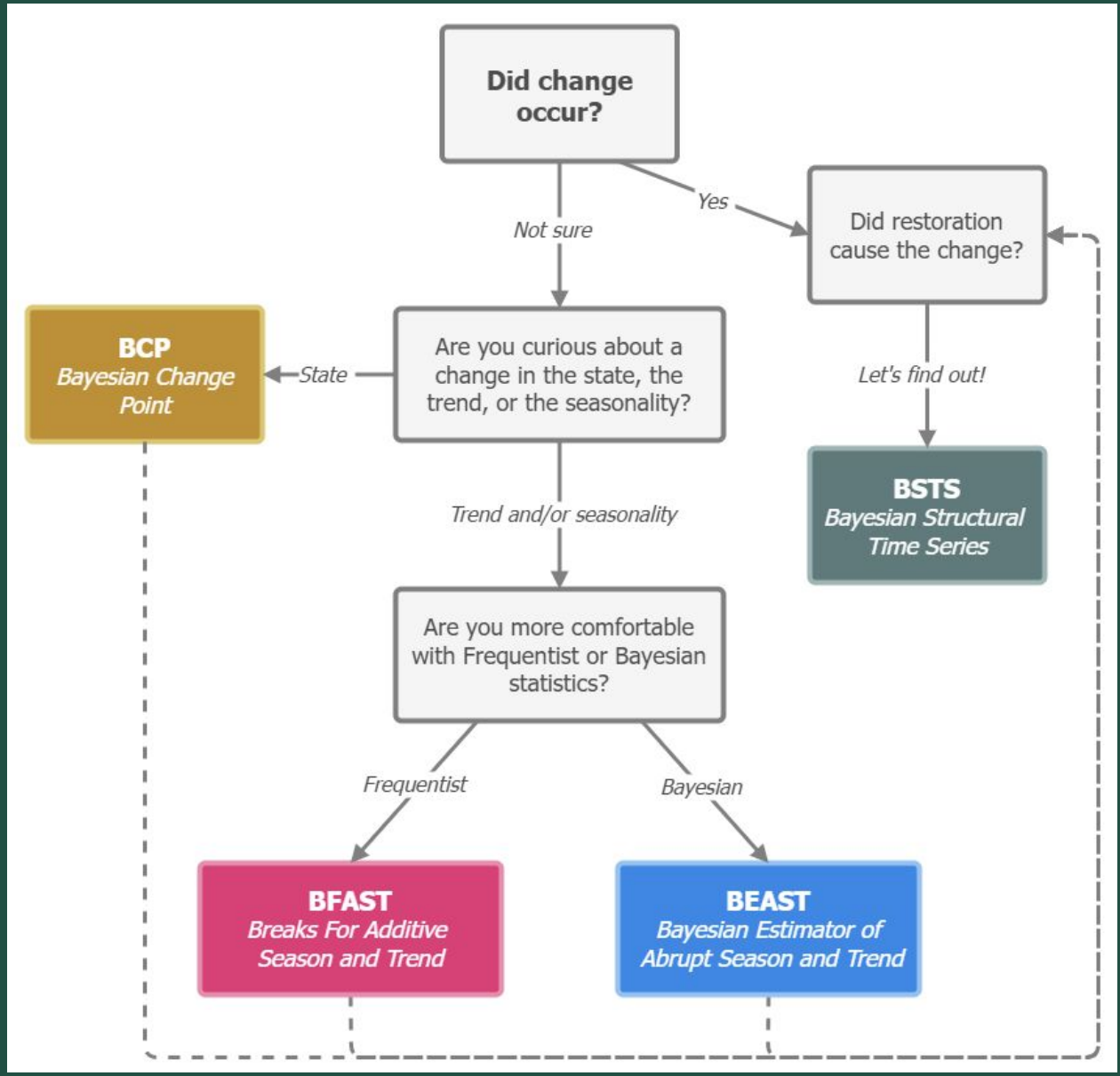
- Increase in the mesic resource was statistically significant (BEAST)
- Restoration CAUSED a 31% increase (BSTS)
- Strong evidence for state change (BCP)
- Strong evidence for the importance of multiple restoration activities/natural events (BFAST, BCP).
- **Take home**: Severely degraded sites can be restored in <10 years. Multiple restoration activities, and some help from nature (e.g. beavers, spring flood), were likely critical to achieve this success.

MRRMaid-Change: Summary

-Common end-user questions can be answered with each statistical method

-Together, the outputs can be interpreted to provide a more complete assessment of the restoration process at a given site.

-Can provide quantitative evidence of restoration success as well as insights for future restoration projects.



Thank you! Questions?

Kolarik et al., in review. Restoration Ecology. Time series analyses provide a low-cost and scalable way to assess restoration outcomes from satellite data.

Come visit our poster to learn about MRRMaid expansion plans!