Modeling fish community responses to changes in water flow: predicting aquatic habitat co-benefits from nature-based solution flood resiliency projects in Louisiana

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OBJECTIVE Test flow – fish relationship hypotheses using machine learning models generated from streamflow metrics and fish sampling data and incorporate these modeled relationships into a NBS decision support tool

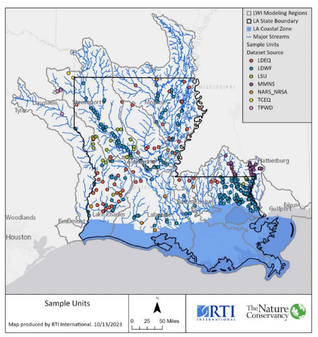
Modeling Fish Response to Changes in Water Flow

- Machine learning techniques can be used to predict individual species or fish community guild responses to changes to flow due to a nature-based solution (NBS) project
- Space-for-time approach uses flow – ecological condition spatial relationships as a proxy for modeling flow alteration – ecological response relationships over time
- This approach requires high resolution streamflow models that accurately represent current flow conditions and can predict changes in flow from an NBS project

RTI International's WaterFALL

- A powerful modeling and decision-support platform that enables comprehensive investigation of flow characteristics and water availability at multiple geographic scales
- Can generate diverse water flow characteristic metrics that describe optimal or required conditions to sustain stream habitat function and health at the National Hydrography Dataset catchment scale

Ecological Data



- We combined multiple state and federal fish sampling datasets from programs in LA, MS, and TX
- Filtered data by catchment to only include most recent sampling event and standardized data to address gear type and sampling method biases
- 351 total sampling units

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Our methodology models ecological responses to stream and river dynamics to identify key flow thresholds where ecological conditions are positively or negatively affected, offering actionable insights to inform nature-based solution (NBS) project planning

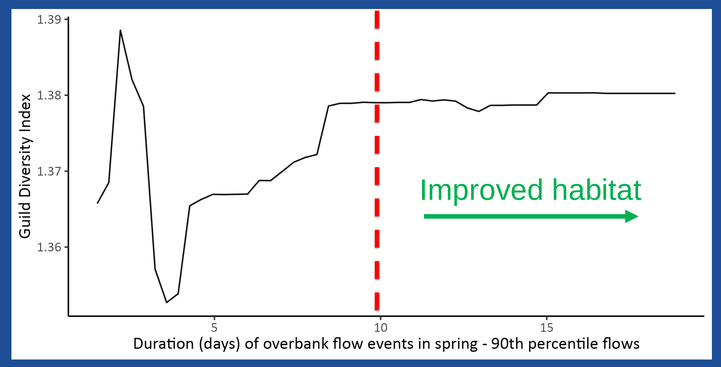

Figure 1. Floodplain spawner guild response curve and threshold value

Habitat is improved or maintained for the floodplain guild if a NBS project changes or maintains ecological conditions so overbank flow events can have a duration of ≥ 10 days in the spring (red line value)

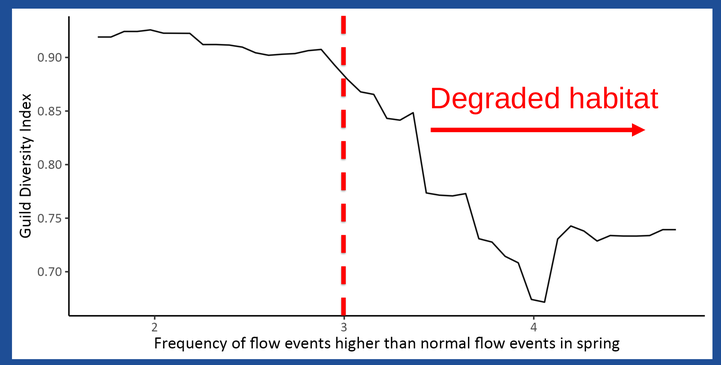

Figure 2. Sucker guild response curve and threshold value

Habitat is improved or maintained for the sucker guild if a NBS project changes or maintains ecological conditions so the duration of higher-than-normal flow events is < 3 days in the spring (red line value)

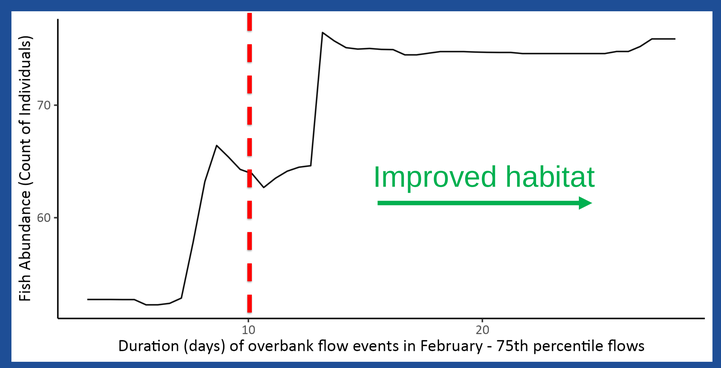

Figure 3. Largemouth bass response curve and threshold value

Habitat is improved or maintained for largemouth bass if a NBS project changes or maintains ecological conditions so overbank flow events in February can have a duration of ≥ 10 days (red line value)

Methodology

- Quantile random forest (QRF) regression was used to model flow-ecological condition spatial relationships for a floodplain spawner guild (N = 198), a sucker guild (N = 71), and largemouth bass (N = 145) as an individual species due to its local cultural importance
- Species chosen based on sample size available and their ecological and cultural importance in Louisiana
- Literature review and expert input used to guide the selection of flow metrics that influence critical periods of a species' life history, and considered how the magnitude, duration, frequency, and seasonal timing of streamflow affects these species
- Used QRF partial dependence plots for the most influential flow metrics (ranked by variable importance) to explore significant threshold effects (where the response variable significantly increased or decreased at a specific flow value)

Results

- The floodplain spawner guild was predicted to benefit from overbank flow events (90th percentile flows) greater than 10 days long between February and June (model goodness of fit = 0.45)
- The sucker guild was predicted to benefit when the average duration of higher-than-normal flows (> 75th percentile flows) are < 3 days during the spring season (February – June) (model goodness of fit = 0.15)
- Largemouth Bass were predicted to benefit from overbank flow events (75th percentile flows) in February that are greater than 10 days (model goodness of fit = 0.62)
- These threshold values will be integrated into the Louisiana Watershed Initiative's NBS Explorer web application to help rank proposed NBS projects by expected aquatic species co-benefit.

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