Spring 2017 Patrick Lab Stream Surveys Manuscript Outline

Title: Precipitation Constrains Communities in Coastal Streams

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**Introduction:**

Theoretical Context (Environmental Filters)

* Community is driven by biotic and abiotic filters.
* Biotic filters take the form of interspecific interactions such as competition.
* Abiotic filters include temperature, precipitation, and disturbance regimes for which species have limited physiological tolerances.
* Community assembly models remain system-specific and cannot be broadly applied without a more comprehensive understanding of the fine-scale mechanisms of these filters.
* Studying linking processes between abiotic filters and assembly processes enhance our ability to predict community assembly.

Broad Impacts (Climate Change)

* Climate dictates many abiotic filters.
* Climate determines precipitation, temperature, and disturbance regimes.
* The Climate is changing.
* It is important to understand the climate-driven mechanisms of community assembly.

Predictive Science (Space-for-time)

* There are 2 strategies for improving our ability to understand and predict the impacts of climate change on biological processes.
* Experimental studies
* Space-for-time substitutions
* Gradient-based research is large in scale and cannot provide evidence for fine-scale mechanisms that link climate to community assembly.
* Furthering climate gradient research needs to control confounding environmental variables including geology, temperature, elevation, and human land-use practices.

Iconic Study System (Stream Ecology)

* Stream communities are sensitive to precipitation.
* Stream communities are commonly used to develop ecological paradigms.
* There are no existing stream data sets that include a climate gradient that controls for confounding abiotic variables including geology, elevation, temperature, and land-use practices.
* There is a demand for identifying a suitable geographic region that has a significant climate gradient which excludes changes in confounding abiotic variables.
* Fish communities are well suited for this ecological study because entire communities can be easily surveyed.
* There is rich diversity in form and function in freshwater fishes.
* Fish have well-documented environmental tolerance profiles.

Study Objectives

* South Texas spans a wind-driven precipitation gradient without accompanying changes in geology, elevation, temperature, and land-use practices.
* There are perennial streams with long-standing USGS gages that record long-term climate and a flow data.
* These streams are not biologically sampled for existing biomonitoring programs.
* This study’s objectives hypotheses include:
  + Objective 1. Identify patterns in diversity and composition of fish and macroinvertebrate communities that correspond to changes in precipitation.
    - Hypothesis 1: Annual Precipitation is positively correlated with community diversity.
    - Rationale 1: Humid precipitation regimes create more stable environment by creating habitat heterogeneity and predictable flow regimes which promotes the development of greater biodiversity
  + Objective 2: Identify precipitation-driven shifts in community composition.
    - Hypothesis 2: Semi-arid communities will be composed of species that tolerate extreme environmental conditions and have short life-cycles.
    - Rationale 2: As climate becomes arid, drought frequency and duration increase separated by flash-flood events. Thus, organisms either need the ability to tolerate drought and floods or to be able to disperse and establish quickly in between disturbance events.

**Methods**

Sample Locations

* Texas Coastal Prairie
* Precipitation Gradient
* Stream Selection
* Reach Selection

Biological Sampling

* Fish collection
  + Electrofishing
  + Identification to species
  + Vouchers
* Macroinvertebrate collection
  + Kicknet
  + Picking to 300 count
  + Identification to genus

Habitat Sampling

* Water samples
* Water quality
* Stream morphology
* Substrate
* Canopy density

Data Sourcing

* USGS gauges II data set

Data Analysis

* Diversity
  + Calculated metrics (SI and RR)
  + Linear Regression
  + Reducing variable pool (UVR & PCA)
  + multivariate linear regressions
* Composition
  + NMDS
    - Heirarchical clustering
    - Vegan (metaMDS)
  + Fitting previously identified environmental variables

**Results**

Diversity

* Fish:
  + Precip (+) correlate to SI and RR
  + (-) correlate to SI and RR: Low Flow Pulse Percentage (LFPP), salinity, Canopy, Outfall Density, Ammonia
* Macroinvertebrate
  + In progress. Problem losing 2 sites during merge of dataframes

Composition

* Fish NMDS
  + Semi-arid stream communities are dominated by cyprinids and poecilids
  + Mesic streams are dominated Lepomis
  + Sub-humid stream communities are include ictalurids and unique taxa
  + Environmental drivers:
    - Ammonia drives NMDS1
    - PPT, PO4 and Land use drive NMDS2
* Macroinvertebrate NMDS
  + Semi-arid stream communities are dominated by Gast and Dipt
  + Mesic and sub humid streams contain unique taxa of Eph, Odo, Tricho, and Arthro
  + Environmental drivers:
    - NMDS1: Conductivity and PO4
    - NMDS2: Precip and land-use

**Discussion**

Diversity

* We expected Shannon Index to correlate positively with annual precipitation through hydrological regime and riparian-mediated effects.
  + Indicated drivers: AP, cnd, cpy, and NH4
* Macroinvertebrate community diversity did not correlate with annual precipitation.
  + Static species diversity could reflect a deep regional pool of species.
  + Environmental drivers: conductivity and phosphates
  + Evapotranspiration may drive ion concentrations that filter species in semi-arid streams.
  + Phosphate inputs may stimulate autochthonous production which may be a more important driver of SI in macroinvertebrate communities (primary consumers).

Composition

* We expected a compositional shift within the gradient with semi-arid communities consisting of species capable of resisting hydrological disturbances or short life cycles and ample dispersal capabilities.
* Fish community assemblages in semi-arid regions contain short-lived species with high tolerance to salinity and low DO, while sub-humid communities contain longer-lived species with lower tolerances and different breeding strategies.
* Macroinvertebrate communities transition from gastropoda and diptera dominated communities in semi-arid streams to assemblages of Ephemeroptera, odonata, trichoptera, and arthropoda in mesic and sub-humid streams.
* Thus, fish community composition appears to be driven by drought-resistance, while macroinvertebrate community composition is driven by flood resistance.
* Both fish and macroinvertebrate communities indicate a shift from shorter-lived taxa in semi-arid streams to longer-lived generation times in sub-humid streams.

Purpose

* Improving community assembly predictions requires a better understanding of fine-scale environmental drivers.
* Space-for-time substitutions identify environmental drivers, but are currently hindered by spatial scale and the accompanying confounding variables.
* Here, we present the patterns of community diversity and composition in fish and macroinvertebrate communities spanning a steep precipitation gradient to identify fine-scale drivers of community assembly while minimizing differences in typical confounding environmental variables.

Extending Concepts

* Precipitation drives hydrological regimes which constrains fish communities (via drought effects) and macroinvertebrate communities (via flood effects). (Supported)
* Precipitation-driven landscape biogeochemistry may regulate nutrient inputs to streams which have implications for macroinvertebrate diversity and composition. (Intimated)
* Bottom-up vs. top-down Precipitation-driven shifts in macroinvertebrate communities can drive changes in fish communities through trophic interactions and vice versa. (Intimated)

Future Goals

* Incorporate temporal variation in community to enhance the accuracy of our community analyses.
* Compare and contrast the role of resistance and resilience in communities spanning the precipitation gradient to drought and flood events.
* Continue to clarify the fine scale mechanisms of precipitation control on stream communities: riparian zone, biogeochemistry, and water chemistry, trophic interactions.