Environmental fluctuations reshape an unexpected diversity-disturbance relationship in a microbial community

Original paper by: Christopher Mancuso, et al (2021)

Re-analysis by: Clay Swackhamer

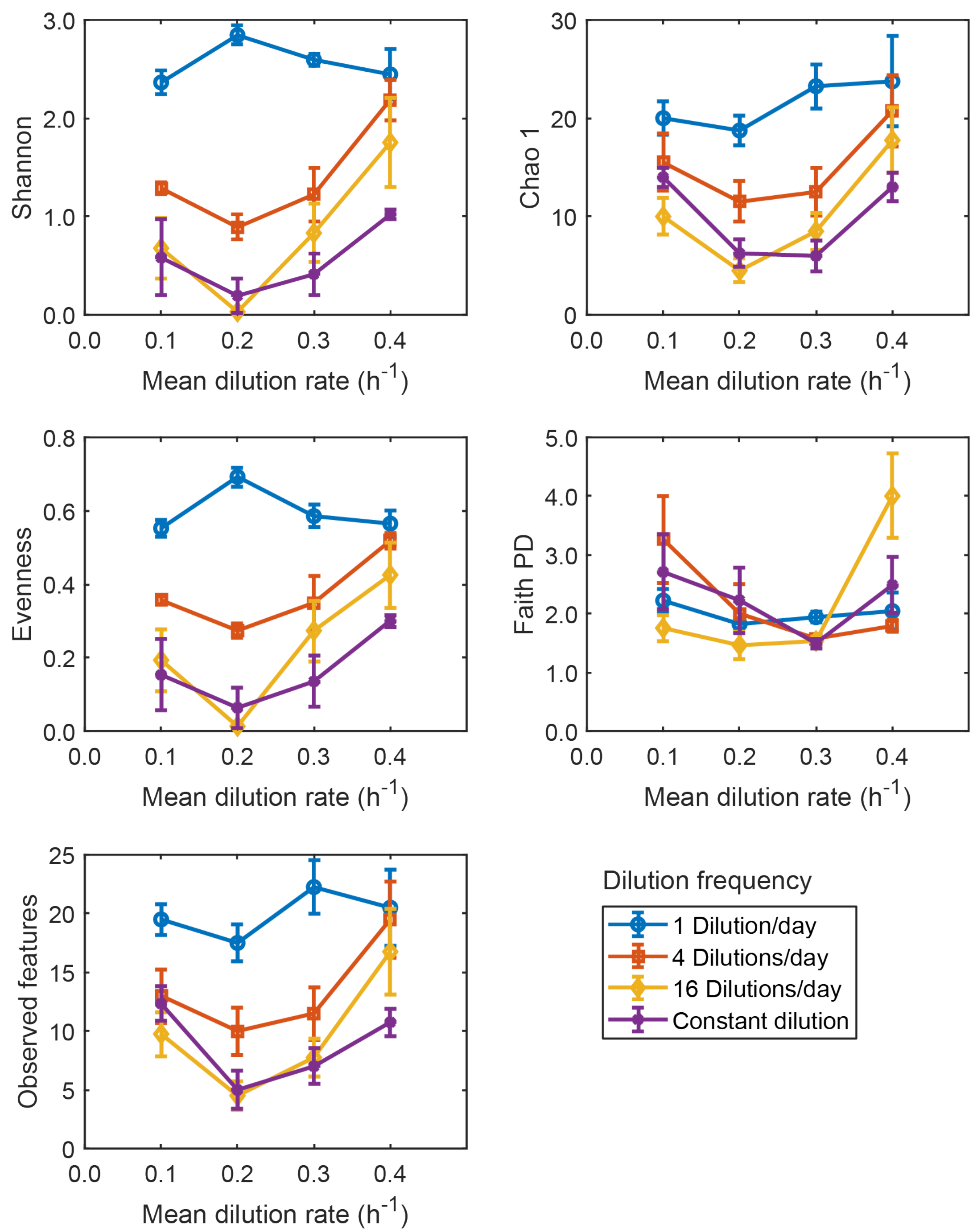
This is a project for ANSC 595 (molecular microbiome analysis) taught by: Tim Johnson

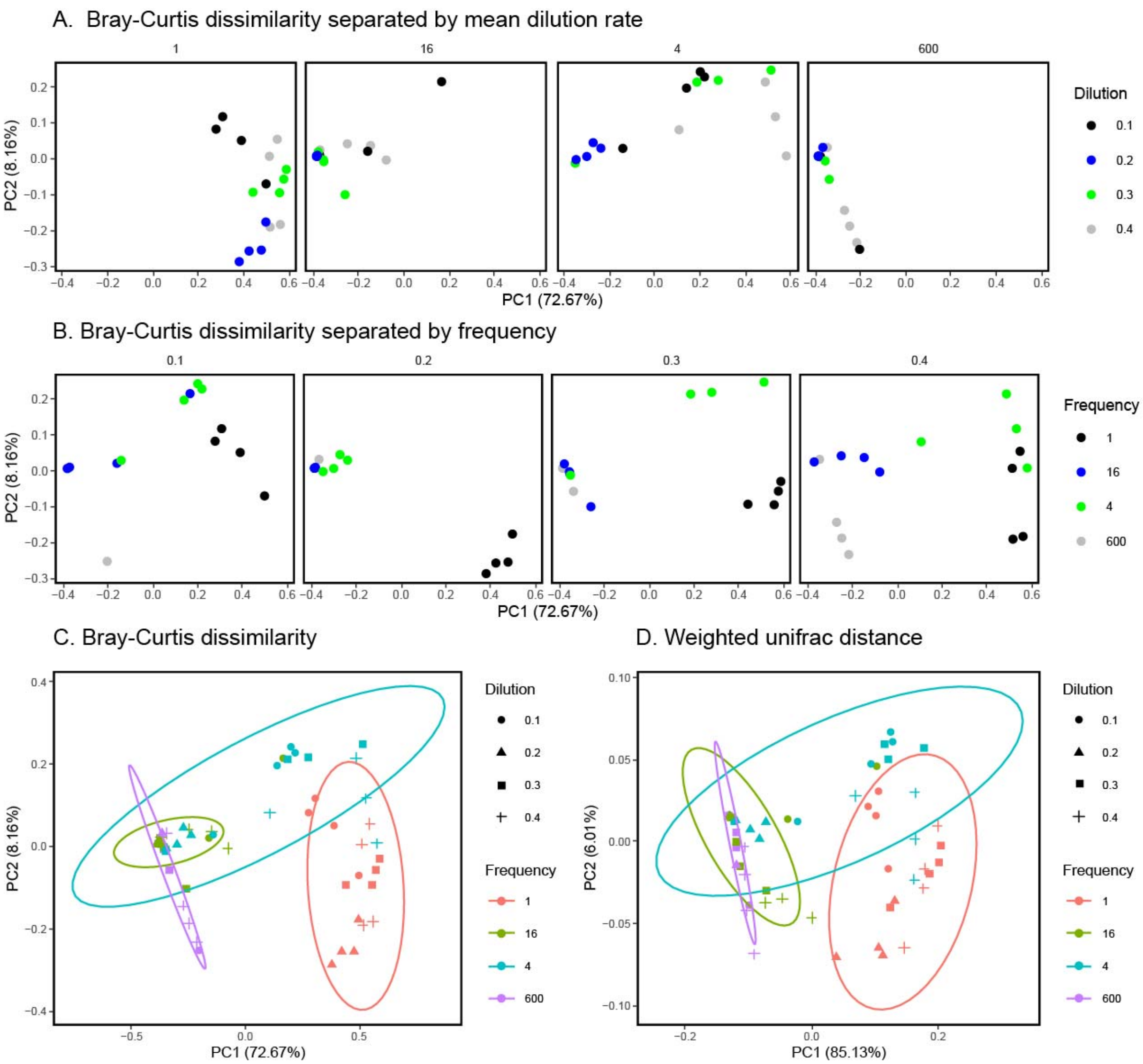
Abstract

The relationships between the diversity of species in an environment and the disturbances which can be experienced by the environment are not fully understood. In this paper,

1 Introduction

Consider a piece of pie with the following dimensions: radius: 5”, angle 40°, and thickness: 1.5”.


Shannon
Chao 1
Evenness
Faith PD
Observed features
Mean dilution rate (h-1)
Dilution frequency
1 Dilution/day
4 Dilutions/day
16 Dilutions/day
Constant dilution



Assume the pie came out of the oven with a homogeneous initial temperature 375°F, and rests on a slab of ice cream with constant temperature 32°F. The room temperature is 70°F. The objective is to determine how long it will take the pie to reach an average internal temperature of 85°F. Assume the temperature of the outer surface of the pie is equal to the temperature of the room. The first step is to solve the problem analytically. To do this, the problem will be modified, but in a way so that a re-useable Green's function can be generated. Then, the Green's function will be used to solve the original problem.

2 Analytic solution

The heat equation is

$$\frac{\partial T}{\partial t} = \alpha \triangle T$$

Where
T = temperature, $°C$
t = time, s

α = thermal diffusivity = $\frac{k}{\rho c_p}$, $\frac{m^2}{s}$
k = thermal conductivity, $\frac{J}{m°C}$
ρ = density, $\frac{kg}{m^3}$
c_p = specific heat capacity, $\frac{J}{kg°C}$

The problem was changed into the international system of units. Using this change, the objective was to solve for time at which the average internal temperature of the pie reaches 29.4 °C. The thermal diffusivity of custard was measured by Betta, et. al (2009), and found to be $\mathbf{1.34x10^{-7} \pm 0.03 \frac{m^2}{s}}$ [2]. This was used for the thermal diffusivity of the pie.

In cylindrical coordinates, the heat equation is

$$\frac{\partial T}{\partial t} = \alpha \left[\frac{1}{r} \frac{\partial}{\partial r} \left(r \frac{\partial T}{\partial r} \right) + \frac{1}{r^2} \frac{\partial^2 T}{\partial \theta^2} + \frac{\partial^2 T}{\partial z^2} \right]$$

References

[1] Greg Miller. *ECH 259 Course Notes*. UC Davis, 2017.

3 Appendix: code for plotting