Trait-based Simulation of Microbiomes across a Climate Gradient

Bin Wang[1], Steven D. Allison[1,2]

[1]Ecology and Evolutionary Biology, [2]Earth System Science
University of California Irvine
Email: bwang7@uci.edu

November 20, 2020

This document serves to detail the parameterization of DEMENTpy across the Southern California climate gradient, and supplement the main manuscript with model formulation, supporting text and results.

1 DEMENTpy

1.1 Dispersal

Dispersal is a key process in microbiome assembly and functioning. DEMENTpy deals with dispersal explicitly with a few assumptions on environmental factors controlling dispersal rate (R_d), which follows:

$$R_d = ?? \tag{1}$$

2 Climate gradient and derivation of forcings

This document details the preparation for DEMENTpy inputs at each of the five sites simulated across the climate gradient (**Figure 1**). In detail, inputs including water potential, soil temperature, and litter chemistry were processed and derived. Water potential was derived from precipitation via an intermediate step of converting the precipitation data. Python code (in the format of Jupyter Notebook, i.e., .ipynb) underlying all of the processing is accessible at a GitHub Repo (`https://github.com/bioatmosphere/microbiome-climate-gradient.git`). With step-by-step demonstrations, those readers who have a keen interest are supposed to be able to easily reproduce these preparations.

2.1 Ecosystems across the Southern California climate gradient

All five sites (**Table 1**) are located on granitic parent material and experience Mediterranean precipitation patterns (cool, wet winters; hot, dry summers). This climate gradient covers a temperature range from ... to...

2.2 Climate Forcing

2.2.1 Precipitation

Longterm daily precipitation data were accessed from various sources for the five sites:

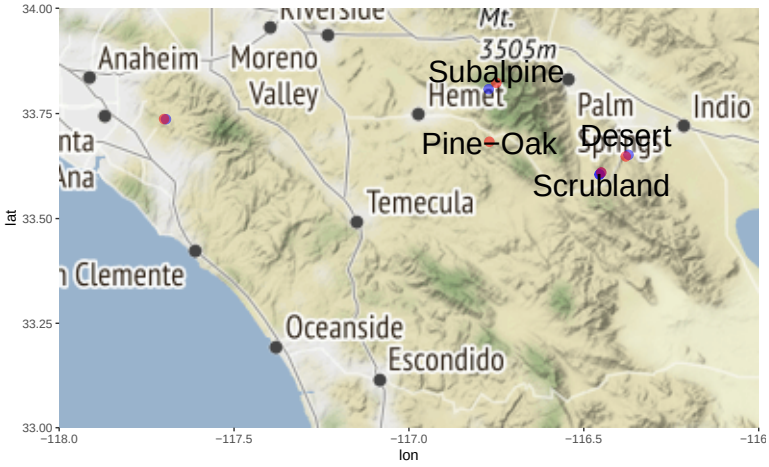

Figure 1: Location of the five sites across the gradient.

Table 1: Five sites across the climate gradient.

Site	Latitude	Longitude	Elevation
Desert	33.648	-116.38	275
Scrubland	33.610	-116.45	1280
Grassland	33.737	-117.70	470
Pine-Oak	33.683	-116.77	1710
Subalpine	33.823	-116.75	2250

Desert: daily precipitation data from Boyd Deep Canyon California accessible at `https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caucde`

Scrubland: daily precipitation data from Burns Pinon Ridge Reserve California accessible at `https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caucbu`

Grassland:

Pine-Oak: daily precipitation data from James Reserve Station, California available at `https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caucja`

Subalpine: Since there was no station directly next to the Subalpine site, the precipitation at this site is likely underestimated. In Glassman et al. (2019), precipitation was averaged from three NOAA weather stations with heated gauges accounting for snow (USC00045091; US1CARV0002; and USC00044211): `https://www.ncdc.noaa.gov/cdo-web/datasets#GHCND`. Instead, daily precipitation data from station Mt. San Jacinto California (`https://raws.dri.edu/cgi-bin/rawMAIN.pl?caCMSJ`) was accessed.

2.2.2 Dead Fuel Moisture

Dead Fuel moisture `https://www.wfas.net/index.php/dead-fuel-moisture-moisture--drought-38`

2.2.3 Water Potential (ψ)

As there are no direct measurements of water potential (ψ; unit: MPa) across the gradient, an approximation was applied. This approximation is based on the only available, indirectly derived water potential data at the grassland site. With available measurements of water content (θ; unit: g H_2O g^{-1} wood), daily water potential was derived by Allison & Goulden (2017) at the grassland site for a record of ?????. This derivation of water potential followed a conversion from water content to water potential as per the equation [Dix (1985), referenced in Allison & Goulden (2017)]:

$$\psi_{grassland} = -10^{0.118-0.114\log_{10}\theta} \tag{2}$$

Water potential of all the other four sites (ψ_{site}) were then derived by linearly scaling grassland site water potential ($\psi_{grassland}$) based on the Total Annual Precipitation(**TAP**; unit: mm) at each site following:

$$\psi_{site} = \frac{TAP_{site}}{TAP_{grassland}}\psi_{grassland} \tag{3}$$

One condition that makes this approximate scaling legitimate is the same Mediterranean precipitation patterns across the climate gradient (cool, wet winters and hot, dry summers).

2.2.4 Temperature (°C)

DEMENTpy is conceived using litter temperature at a daily resolution in principle. In practice, soil temperature is used instead to approximate the litter temperature. Soil temperature data at a sub-daily time step across the gradient at each of five sites were measured. Details with regards to the measurement method, pre-, and post-processing are documented in Glassman et al. (2018). These data are openly accesible at `https://github.com/stevenallison/UCIClimateExperiment/tree/master/updatednames`. From these field measurements, daily soil temperature was derived by averaging all measurements in each day. A step-by-step demonstration of this derivation is presented in the Jupyter Notebook `soil_temperature.ipynb`.

2.3 Litter Chemistry and Input

DEMENTpy requires substrate-specific inputs in terms of C, N, and P (**Table xx**). **Phospholipids** (i.e.,OrgP1 in the model) are a key component of all cell membranes(`https://en.wikipedia.org/wiki/Phospholipid`). Though compound-specific stoichiometry is clear for determining concentration by element, substrate-specific concentration ((Sub_i); unit: mg cm^{-3}) needs to be determined. This derivation followed:

$$Sub_{s,i} = Fraction_{s,i}Total_s \tag{4}$$

where s is one of the five sites, i is one of the 10 substrates, $Fraction_{s,i}$ is the percentage of substrate i in site s, and $Total_s$ is the total concentration of initial substrates (C+N+P) in site s. $Fraction$ was informed by field measurements of litter chemistry at each site as presented in Baker & Allison (2017). $Total$ was approximated by NPP at each site. As per the observation by Baker & Allison

(2017), standing litter pools are largest in the grassland and pine-oak site, reduced in the subalpine site, significantly reduced in the scrubland site, and negligible in the desert site. A detailed script implementing these processes is presented in the Jupyter Notebook `litter_chemistry_v1.ipynb`.

References

Allison, Steven D, & Goulden, Michael L. 2017. Consequences of drought tolerance traits for microbial decomposition in the DEMENT model. Soil Biology and Biochemistry, **107**, 104–113.

Baker, Nameer R, & Allison, Steven D. 2017. Extracellular enzyme kinetics and thermodynamics along a climate gradient in southern California. Soil Biology and Biochemistry, **114**, 82–92.

Dix, NJ. 1985. Changes in relationship between water content and water potential after decay and its significance for fungal successions. Transactions of the British Mycological Society, **85**, 649–653.

Glassman, Sydney I, Weihe, Claudia, Li, Junhui, Albright, Michaeline BN, Looby, Caitlin I, Martiny, Adam C, Treseder, Kathleen K, Allison, Steven D, & Martiny, Jennifer BH. 2018. Decomposition responses to climate depend on microbial community composition. Proceedings of the National Academy of Sciences, **115**, 11994–11999.