Designing Sustainable Landscapes:

Mean annual temperature, Growing season degree days, Heat index, Minimum winter temperature, and Maximum summer temperature settings variables

A project of the University of Massachusetts Landscape Ecology Lab

Principals:

- Kevin McGarigal, Professor
- Brad Compton, Research Associate
- Ethan Plunkett, Research Associate
- Bill DeLuca, Research Associate
- Joanna Grand, Research Associate

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- North Atlantic Landscape Conservation Cooperative (US Fish and Wildlife Service, Northeast Region)
- Northeast Climate Science Center (USGS)
- University of Massachusetts, Amherst

Reference:

McGarigal K, Compton BW, Plunkett EB, DeLuca WV, and Grand J. 2022. Designing sustainable landscapes: temperature settings variables. Report to US Fish and Wildlife Service, Northeast Region.

General description

These five temperture variables are among several ecological settings variables that collectively characterize the biophysical setting of each 30 m cell at a given point in time (McGarigal et al 2017). The temperature regime strongly affects species composition, as well as rates of ecological processes such as nutrient cycling. We've chosen five variables to represent different aspects of temperature. All five variables have future versions that incorporate climate change via General Circulation Models (GCMs) (as described in the technical document on climate, McGarigal et al 2017).

Mean annual temperature (**Fig. 1a** and **1b**) is a general indicator of climate.

Growing season degree days (**Fig. 1c**) integrates the total heat available throughout the season. In general, growth of plants and ectotherms can be roughly estimated by a

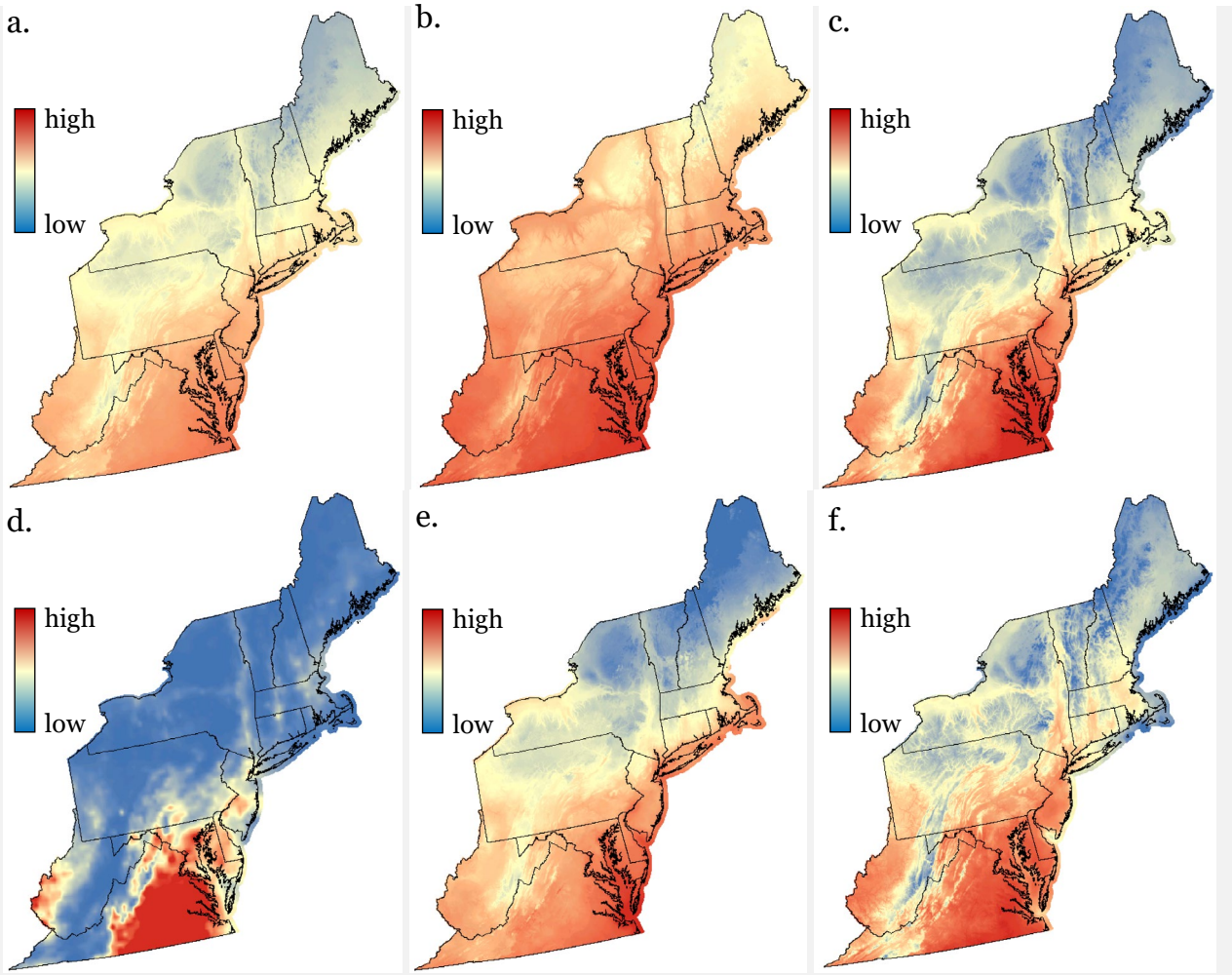

Figure 1. Temperature settings variables for the northeast: (a) mean annual temperature in 2010, (b) mean annual temperature in 2080 under RCP 8.5, (c) growing season degree days, (d) heat index, (e) minimum winter temperature, and (f) maximum summer temperature.

degree-day model, thus the sum of degree-days over the season indicates which species may be within their northern range limits. Degree-days are the sum of the exceedance of daily mean temperatures above a threshold of 10 C.

The **Heat index** (**Fig. 1d**), like growing season degree days, integrates heat throughout the season, but it focuses on high temperatures. It takes a sum of maximum daily temperatures above a lower threshold of 35 C, resulting in an index of likely heat stress to plants. This variable is an index to the southern range limits of many species.

The **Minimum winter temperature** (**Fig. 1e**) can determine the northern range limits for many species.

The **Maximum summer temperature** (**Fig. 1f**) determines the southern range limits of a number of species.

Version 5 Update

Version 5 climate variables exclude several model runs that were considered to perform poorly in the Northeast Region (Karmalkar et al. 2019) reducing the set to 13. The new package is based solely on RCP 8.5 (dropping RCP4.5). Version 3 of the package included the climate data for years 2010 and 2080; the update includes 2020 (the new "current" year), 2040 and 2080.

Use and interpretation of these layers

Three of these ecological settings variables (growing season degree days, heat index, and minimum winter temperature) are used for the similarity and connectedness ecological integrity metrics, and all but the heat index are used for some of the representative species models. These layers carry the following assumptions:

- PRISM temperature data (used for downscaling the GCM data) are accurate.
- GCM predictions for 2080 are correct.
- Geographical downscaling (from 800 m for PRISM data, and from 12 km for GCM data) don't introduce errors.
- Source data are monthly means, and thus give coarse estimates of these variables.
- Data are based on 30-year normals, and thus remove annual temperature variation.

See the DSL climate document referenced above for a more complete list of assumptions and limitations of these data.

Derivation of these layers

Data source

- DSL climate grids, based on 800 m PRISM data, as modified by an ensemble of GCMs for future timesteps under Representative Concentration Pathways (RCP) 8.5.

Algorithm

All five variables are based on a 30-year normal centered on the date of interest (2020, 2040, or 2080). For 2080, temperatures are based on an ensemble of 13 GCMs downscaled to 800 m PRISM data using the delta method, calculated for RCP 8.5. These five variables are calculated as follows:

Mean annual temperature: mean of daily minimum and daily maximum temperature for all days in the year.

Growing season degree days: sum of daily mean temperatures above 10 C.

Heat index: sum of daily maximum temperatures above 35 C.

Minimum winter temperature: mean of the daily minimum temperatures in December, January, and February.

Maximum summer temperature: mean of the daily maximum temperatures in June, July, and August.

For details on how these data were derived, see the DSL climate document referenced above.

GIS metadata

These data products are distributed as geoTIFF rasters (30 m cells) and can be found at McGarigal et al (2017). Each raster is distributed in three versions: (1) 2020, (2) 2040 and (3) 2080 all under RCP 8.5.

Mean annual temperature (TEMP; units: degrees C × 100).

Growing season degree days (GDD; units: degrees C × days).

Heat index (HEAT35; units: degrees C × days).

Minimum winter temperature (TMIN; units: degrees C × 100).

Maximum summer temperature (TMAX; units: degrees C × 100).

Literature Cited

McGarigal K, Compton BW, Plunkett EB, DeLuca WV, and Grand J. 2017. Designing sustainable landscapes products, including technical documentation and data products. https://scholarworks.umass.edu/designing_sustainable_landscapes

Karmalkar AV, Thibeault JM, Bryan AM, and Seth A. 2019. Identifying credible and diverse GCMs for regional climate change studies—case study: Northeastern United States. Climatic Change. 154. 10.1007/s10584-019-02411-y.