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

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Reference:

McGarigal K, Compton BW, Plunkett EB, DeLuca WV, and Grand J. 2018. Designing sustainable landscapes: temperature settings variables. Report to the North Atlantic Conservation Cooperative, 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
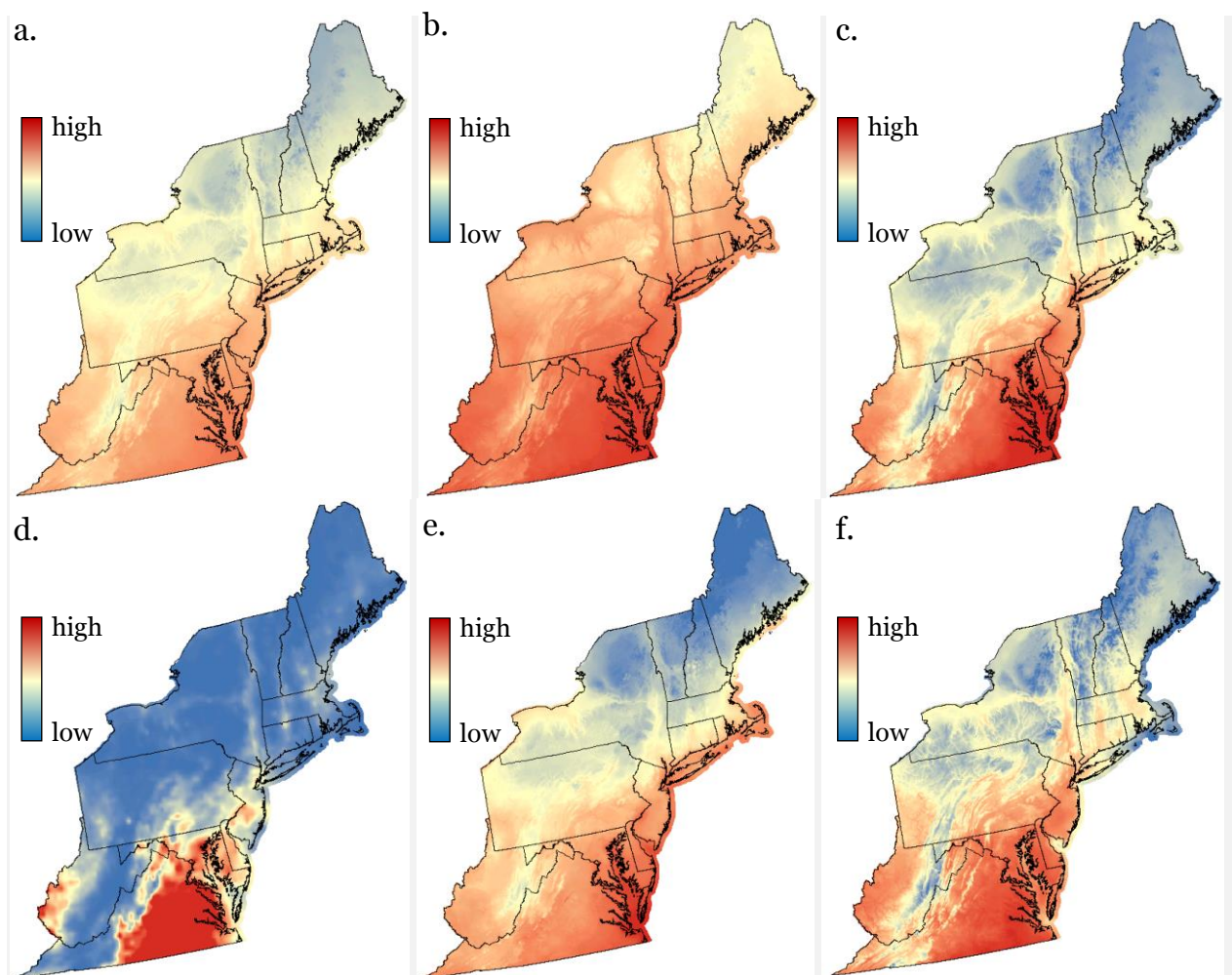

Figure 1. Temperature settings variables for the northeast: (a) mean annual temperature in 2010, (b) mean annual temperature in 2080 under RCP 8.5, (c) growing season degree days, (d) heat index, (e) minimum winter temperature, and (f) maximum summer temperature.

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.

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 two Representative Concentration Pathways, RCP 4.5 and RCP 8.5.

Algorithm

All five variables are based on a 30-year normal centered on the date of interest (2010 or 2080). For 2010, temperatures are from downscaled PRISM data. For 2080, temperatures are based on an ensemble of 14 GCMs downscaled to 800 m PRISM data using the delta method, calculated separately for RCP 4.5 and 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) 2010, (2) 2080 under RCP 4.5, and (3) 2080 under RCP 8.5.

Mean annual temperature (TEMP; units: degrees C $\times$ 100).

Growing season degree days (GDD; units: degrees C $\times$ days).

Heat index (HEAT35; units: degrees C $\times$ days).

Minimum winter temperature (TMIN; units: degrees C $\times$ 100).

Maximum summer temperature (TMAX; units: degrees C $\times$ 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