

SEED TOOLKIT USER GUIDE

<https://www.usgs.gov/apps/seed-toolkit/>

GENERAL NOTES ON USE:

- You must reload the application (refresh the page) for each independent inquiry.
- Large datasets may take considerably longer to process so please be patient and commit to the seed analysis you are running.

The **Seed Selection Tool** allows users to visualize the similarity of climates between a restoration material's (RM's) location of origin and a defined geographic area. We use "restoration material" to refer to any type of seed (e.g., germplasms, cultivars, wild-collected, source-identified, etc.) used in a restoration treatment. This tool can help users 1) prioritize which RMs are best matched to a restoration site based on climate and 2) identify locations to prioritize for seed collection and RM development. Users upload RM origins as a text (.txt) file or they can be selected from a table of commonly used RMs across the Intermountain West. When multiple RMs are selected, this tool can either 1) display a map identifying RMs that surpass the user-defined climate similarity threshold (e.g., how similar or dissimilar origin sites are from potential restoration sites), or 2) split climate space within the defined region into as many partitions as there are RMs, with each partition showing the geographic area over which one RM is most closely matched (e.g., areas as suitable or unsuitable based on user-defined thresholds).



Step 1: Choose application

- Select the first option: **Seed Selection Tool**.



Step 2: Define a geographic area

- From the drop-down menu, choose from the following: **Lat/Long Slider Bars** or **Spatial Polygon**
 - **Lat/Long Slider Bars** allow you to create a rectangular bounding box around an area for which you plan to rank RMs based on the best climate match between a restoration site and RM origins.
 - **Spatial Polygon option** will prompt you to upload a shapefile of the area you wish to investigate. Shapefiles must be uploaded as a zipped folder including the following components: **.shp, .shx, .dbf, prj**.



Step 3: Select a seed source

- Either **upload a .csv document** of the location of the seed source(s) you wish to investigate or **select sources from a table of restoration materials**.

- If you choose to upload your own seed source location, the .csv document must be formatted as the example below (including the exact column labels as lowercase letters):

id	x	y
MACA_Amethyst	-111.815	44.006

- If you choose to select one or more seed sources from the table of restoration materials, a multi-page menu will appear with a list of currently available RMs for common restoration species across the American West. You may choose more than one RM as well as more than one species.

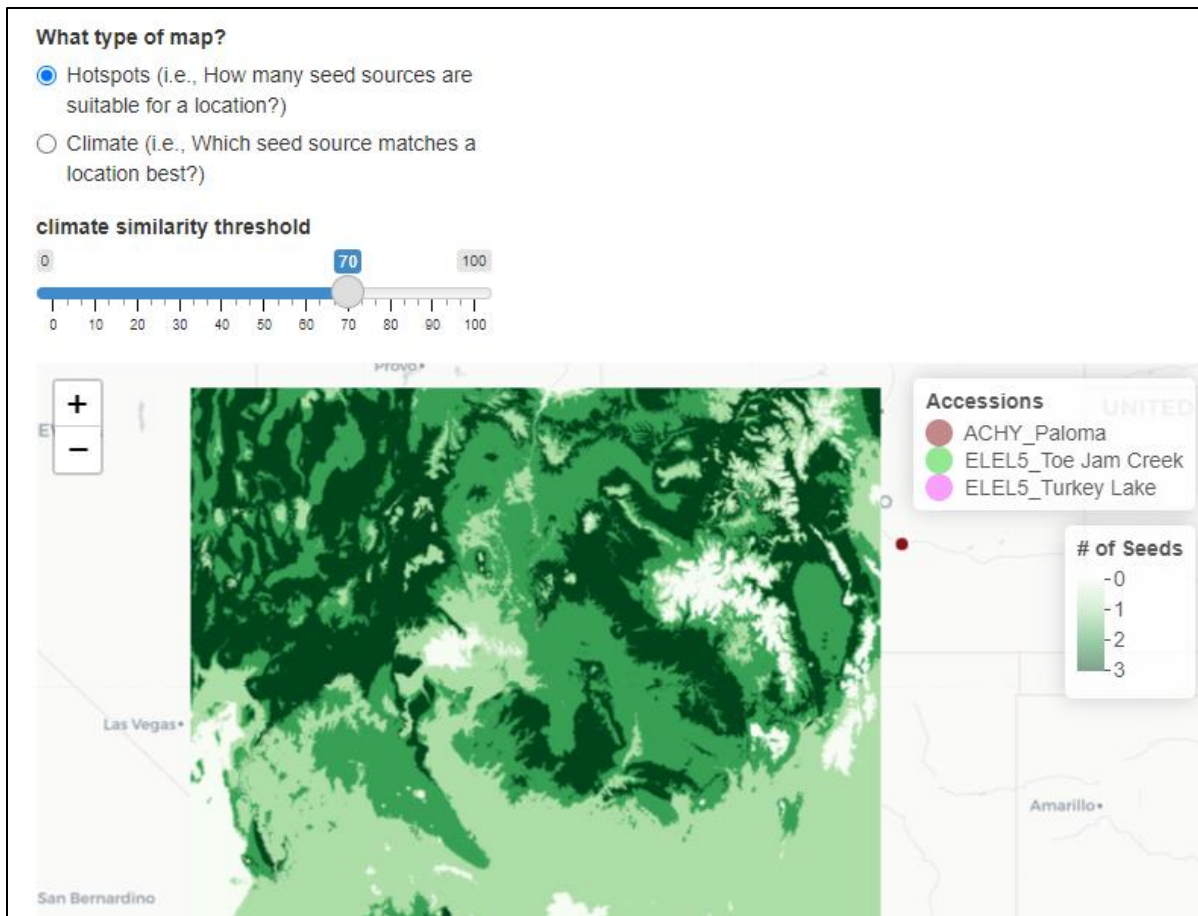


Step 4: Weight climate variables

- As species growth and establishment is often correlated with one or many environmental variables, assigning more weight to a certain variable could create climate similarity models specifically tailored to the species of interest. Note that incorporating this type of information (as may be inferred from common garden experiments, landscape genomic analyses, or species distribution models) necessitates that the user consider one species at a time, given that species often respond to climate space uniquely.
- You may choose to alter the weight of the following climate variables:
 - Mean annual temperature (°C), diurnal temperature range (°C), temperature seasonality (°C), temperature in the wettest quarter (°C), mean annual precipitation (mm), precipitation seasonality (mm), and precipitation of the warmest quarter (mm)

MATCH SEED TO CLIMATE

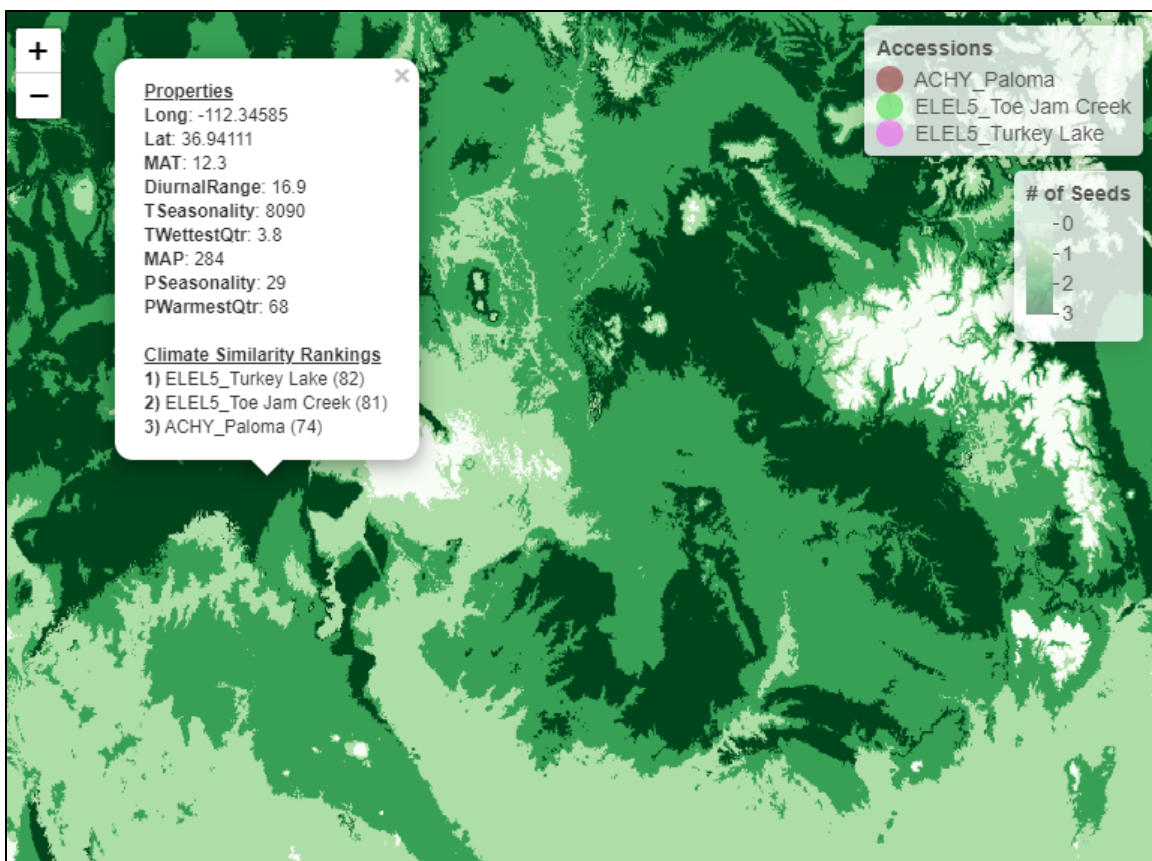
- Example of a **Hotspot** map using a 70% climate similarity threshold with the ACHY_Paloma, ELEL5_Toe Jam Creek, and ELEL5_Turkey Lake restoration materials selected:



How to interpret results:

- After you click the *Match Seed to Climate* button, a map will appear. You may choose to view these results as either a **Hotspots** or **Climate** map by toggling the radio buttons above the map.
- For each species included in the analysis, each pixel (approximately 1 km) is given a rank based on how similar it is to the RM's origin location based on the 8 climatic variables. These ranks are used to create the hotspot polygons and climate maps described below.
 - **Hotspots map:** *Before interpreting this map, use the sliding bar at the top of the page to select a climate similarity threshold between 1 and 100.* The thresholds indicate how similar the climate is to the seed source location with a 100% match meaning the climate is the exact same as the location from which the RM was originally collected. A 50% climate similarity threshold would highlight cells where RMs have a >50% match.

- The **Hotspots** map illustrates how many of the selected RMs surpass the defined threshold at every location within the bounding box. Darker colors correspond with more RMs having a climate match at a location. For example, in the image below, the dark green areas represent locations where all three of the selected RMs surpass the defined similarity threshold (set at 70%). The pop-up box (upper left side of image) shows the latitude and longitude of the location selected with the cursor, the climate variables at the location, and a ranked list of the RMs in terms of climate match. In the list, ELEL5_Turkey Lake has an 82% match, while ELEL5_Toe Jam Creek has an 81% match, which may indicate that these materials will perform equally well if the climate characteristics of the sites from which these RMs were collected affects their performance at the intended restoration site.

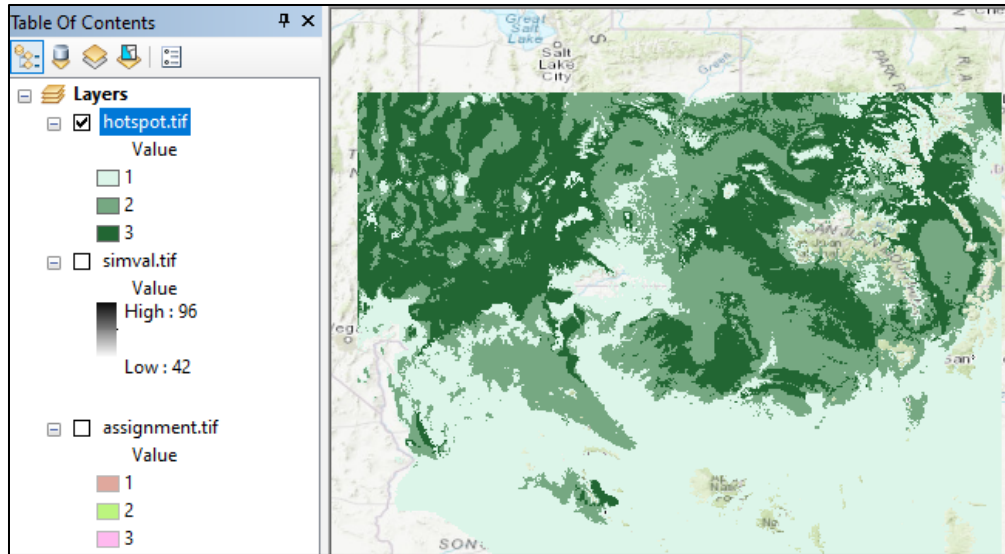


- **Climate map:** This map splits the designated geographic space into as many groups (i.e., colors) as there are RMs selected or uploaded. Each color is used to display where the associated RM has the best climatic match. Furthermore, within colors, a lighter to darker gradient indicates where the RM is least and best climatically matched, respectively. If you select any point on the map, a pop-up box will appear with the coordinates of that point, properties of each climate variable, and climate similarity rankings for all the selected RMs. See image below:

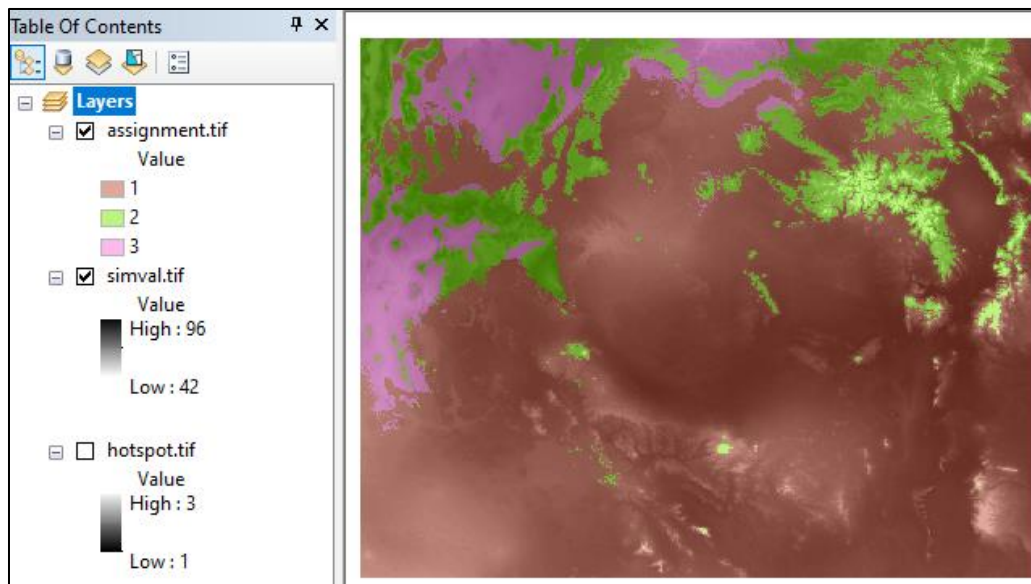


- Choosing to download results for an analysis will save a zipped folder containing the following files:
 - *simval.tif*: this raster contains the climate similarity values for the region of interest. It reports how climatically close each cell is to its accession assignment
 - *assignment.tif*: this raster contains values of accession assignments for all cells within the extent of interest
 - *hotspot.tif*: this raster contains values of the number of suitable seed sources per cell for all cells within the extent of interest (70% is automatically populated)
 - *accession.data.csv*: this file contains coordinates and climate values for all accessions analyzed
 - *assignment.val.key.csv*: this file contains the integer value associated with each accession in the *accession.assignment.tif*
 - *assignments.boxplot.pdf*: this plot displays the distribution of climate data for the cells within each accession assignment
- To view the **Hotspots** map after downloading the results from the Seed Selector, open the *hotspot.tif* using GIS software. This allows you to display the raster as categorical data using unique values and a single-color gradient as shown below. This raster will illustrate which areas have a similar climate (at a default 70% threshold unless

otherwise specified) for the chosen restoration materials with values representing the number of restoration materials with a 70% or higher climate similarity. Pixel values in the *hotspot.tif* illustrate the # of seed accessions suitable under the climate similarity threshold. Hotspot assignments are found in the *assignment.val.key.csv*. The example below is displayed in ArcMap using the ACHY_Paloma, ELEL5_Turkey Lake, and ELEL5_Toe Jam Creek RMs at a 70% climate similarity threshold:



- To view the **climate** map you downloaded using GIS software, set high values of the *simval.tif* as black and low values as white, then overlay *assignment.tif* and set it to 50% opacity with values as categorical, each a unique color. Pixel values in the *simval.tif* represent how climatically similar each pixel is to the center of its accession assignment. The climatic center environmental variable data for each accession is found in the *accession.data.csv*. The example below is in ArcMap with the ACHY_Paloma, ELEL5_Turkey Lake, and ELEL5_Toe Jam Creek restoration materials:



The Climate Partitioning Tool allows users to split climate variation into a selected number of groups, or partitions, across a defined geographic area. Users may also upload geographic points that are displayed on top of the climate partitions; these points may represent, for example, wildland seed collections. As such, the tool allows users to 1) visualize the geographic distribution of environmental gradients across a region, 2) investigate how seed collections represent environmental variation across a geographic area, and 3) identify collection gaps to prioritize future seed collection. Climate and partition data can be downloaded for geographic points, which may assist in downstream activities like choosing seed sources for composite native plant materials development strategies (e.g., Bucharova et al. 2019).



Step 1: Choose application

- Select the first option: **Climate partitioning tool**



Step 2: Define a geographic area

- From the drop-down menu, choose from the following: **Lat/Long Slider Bars** or **Spatial Polygon**
 - **Lat/Long Slider Bars** allows you to create a rectangular bounding box around the area desired to create climate partitions.
 - **Spatial Polygon option** will prompt you to upload a shapefile of the area you wish to investigate. Shapefiles must be uploaded as a zipped folder including the following components: **.shp, .shx, .dbf, .prj**.



Step 3: Select a seed source

- Upload points that you wish to display on top of the climate partitions you will create with this tool. Unlike with the Seed Selection Tool, the points do not influence the calculations to determine partitions (i.e., Step 4). These points could represent wildland seed collections or restoration site locations. You may leave this field blank. If you choose to upload your own seed source location, the .csv document must be formatted as the example below (including the exact column labels):

id	x	y
SOS_collection_1	-111.815	44.006



Step 4: Select number of partitions

- Use sliding bars to choose between 1 and 50 climate partitions.

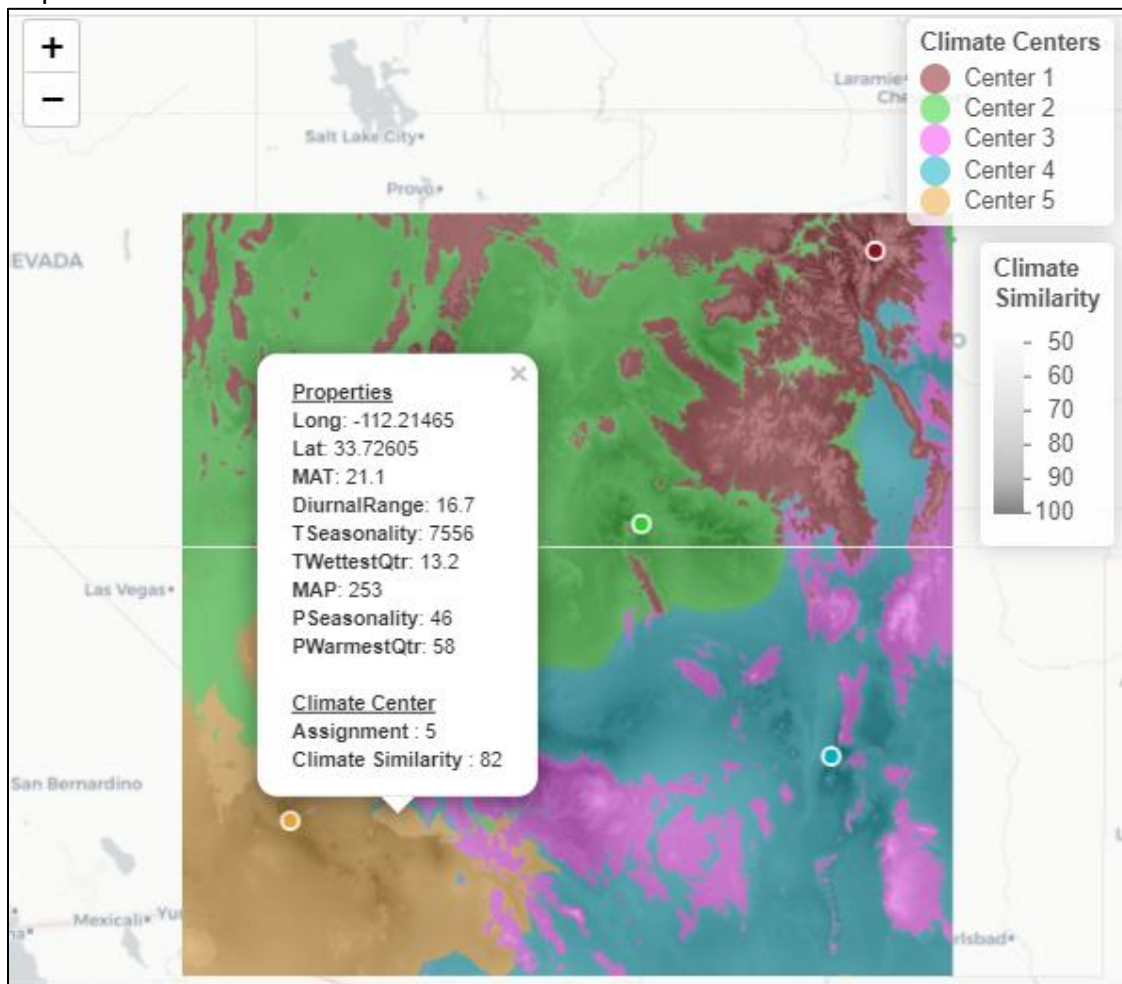


Step 5: Weight climate variables

- As climate similarity models are created using climatic variables, giving more weight to a certain variable could create partitions specifically tailored to a climate study scenario you may be interested in. Leaving all the climate variables with the standard weight of 1 will provide robust results for climate partitions.
- You may choose to give more weight to the following climate variables:
 - Mean annual temperature (°C), diurnal temperature range (°C), temperature seasonality (°C), temperature in the wettest quarter (°C), mean annual precipitation (mm), precipitation seasonality (mm), and precipitation of the warmest quarter (mm)

GENERATE PARTITIONS

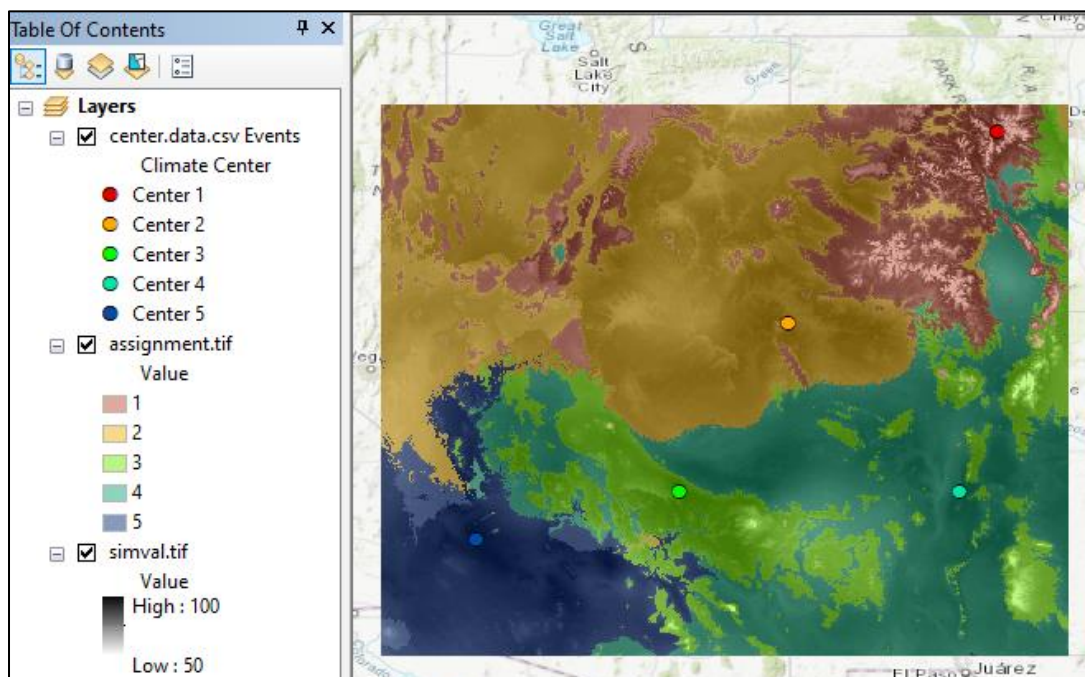
- An example of results using the Climate Partition tool and selecting 5 partitions is provided below:





How to interpret results:

- After you click the *Generate Partitions* button, a map will appear with the number of climate partitions you indicated in Step 4, as well as a point within each partition indicating its *Climate Center*. The Climate Center represents the average climate value of each partition.
- Each pixel (approximately 1km²) is given a rank based on how similar it is to the *Climate Center* of the partition in which it resides.
- If you choose to download this dataset, each download will be a zipped folder containing the following files:
 - *simval.tif*: this raster contains the climate similarity values for the extent of interest. It reports how climatically close each cell is to its climate center assignment
 - *assignment.tif*: this raster contains values for climate center assignments for all cells within the extent of interest
 - *center.data.csv*: this file contains coordinates and climate variate values for all climate centers generated in these analyses
 - *bestpartition.data.csv*: this file contains coordinates, the best partition, the climate similarity between coordinates and the center of the best partition, and climate variate values for any seed sources uploaded in these analyses
 - *assignments.boxplot.pdf*: this plot displays the distribution of climate data for the cells within each center assignment
- To view the climate partitions you downloaded, set high values of the *simval.tif* as black and low values as white, then overlay *center.assignment.tif* and set it to 50% opacity with values as categorical, each a unique color. Finally, import the *center.data.csv* and display as x,y coordinates. The example below is in ArcMap with 5 climate partitions:



LITERATURE CITED

Bucharova, A., Bossdorf, O., Hölzel, N. *et al.* Mix and match: regional admixture provenancing strikes a balance among different seed-sourcing strategies for ecological restoration. *Conservation Genetics* **20**, 7–17 (2019). <https://rdcu.be/cBgxQ>