Predicting the Future Climate Suitability Envelope for *Quercus garryana*

By Skyler Elmstrom

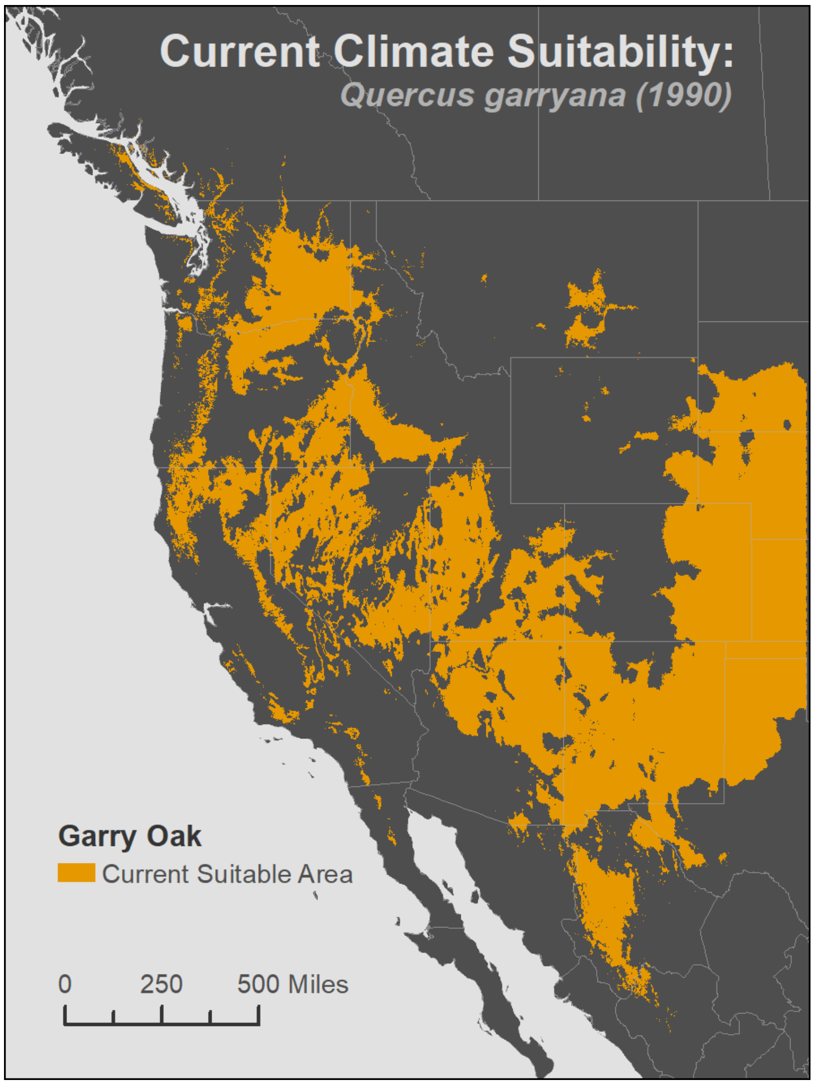

Figure 1. Current Climate Suitability of Quercus garryana based on data from the normal period 1961-1990 as described in the historical climate surfaces for western North America (Hamann, A. et. al. 2013).

Introduction:

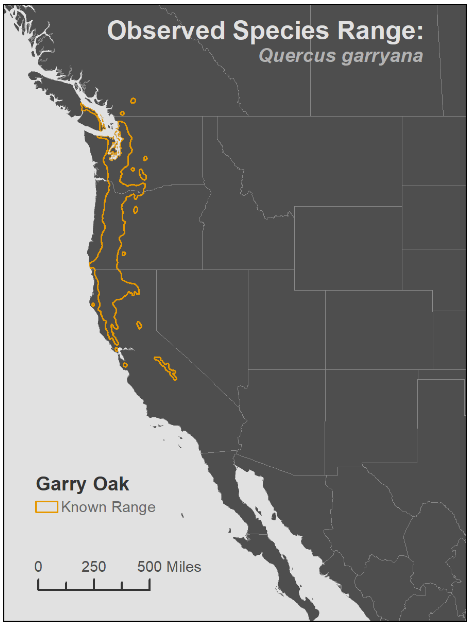

Figure 2. This map depicts the native range of Garry oak as observed during the normal climate period of 1961-1990.

Quercus garryana – more commonly known as Garry oak or Oregon white oak— is a hardwood native to the Pacific Coast which boasts impressive physiological tolerance to drought, freezing temperatures, and flooding and can grow in a variety of conditions ranging from cool and moist to hot and dry. The United States Forest Service (USFS) provides the following climatologic ranges Q. *garryana* can survive in (Stein 2017):

- Extreme Temperatures -34°C to 47°C
- Average Annual Temperatures 8°C to 18°C
- Coldest Month Temperatures -11°C to 10°C
- Warmest Month Temperatures 16°C to 29°C
- Annual Precipitation of 170mm to 2630mm
- Snowfall of up to 4170mm
- Frost-Free Seasons of as Little as 63 Days

Despite garryana's ability to survive in harsh conditions, it is heavily outcompeted by other faster growing, taller trees such as Douglas Fir (Stein 2017). As with most species, climate change is also significantly impacting the range of where Q. *garryana* live and be found. In order to assess future trends in the distribution of *Q. garryana*, it is important to understand how changes in climate, soils and topology, and the distribution of other species may factor into that trend. In this report, six climate variables are explored and compared between the last period of normal observation from 1961 to 1990 and future climate predictions based on the ensemble average of 14 climate models to assess how climate will affect *Q. garryana* distribution trends (Hamann, A. et. al. 2013).

Data:

Three climate datasets were used in this analysis and were generated with the ClimateWNA v4.62 software package, available at http://tinyurl.com/ClimateWNA, based on methodology described by Hamann et al. 2013:

- 24 Bioclimate Variables (1961-1990 normal period)
  - 1km Resolution Raster Dataset
  - Lambert Conformal Conic projection
- Ensemble of all 23 CMIP3 AOGCMs, Emission Scenario A1B (Moderate), 2080's
  - Lambert Conformal Conic projection
- Ensemble of all 23 CMIP3 AOGCMs, Emission Scenario A2 (High), 2080's
  - Lambert Conformal Conic projection

Additionally, the observed native range vector dataset of *Q. garryana* was obtained for comparison from the *Atlas of United States Trees* (Little, Elbert L., Jr. 1971) at http://databasin.org/datasets/967ab76d207c4d00ae4503a54945cc2a. For the purposes of this analysis, all vector and raster datasets were reprojected into Lambert Conformal Conic with a central meridian of -105.0°.

Methods:

Six bioclimate variables were selected for use in this climate analysis based on the climate range descriptions detailed by the USFS (USFS 2017). The variables selected are Mean Annual Temperature (MAT), Mean Coldest Month Temperature (MCMT), Mean Warmest Month Temperature (MWMT), Mean Annual Precipitaton (MAP), Snowfall (PAS), and Number of Frost Free Days (NFFD). Analyses for each scenario and the normal period were completed using ArcGIS Spatial Analyst Raster Calculator to create a combined raster that returned a binary output of 0 or 1 based on the suitability of each cells climate variable values for *Q. garryana* survival. The range of values used for each variable can be found in the list of ranges in the introduction of this report. An additional analysis was made to determine what change in suitability occurred between the normal period raster and the future climate prediction rasters using the Spatial Analyst Minus tool. The values of each cell in our normal period raster was subtracted from the future climate rasters to ascertain areas in which suitability was lost or gained.

Results:

Our analyses show that climate suitability area for *Q. garryana* will expand eastward and northward while most of the previous native range will become unsuitable, particularly among the North Cascade range and California inland-coastal area (Fig. 3).

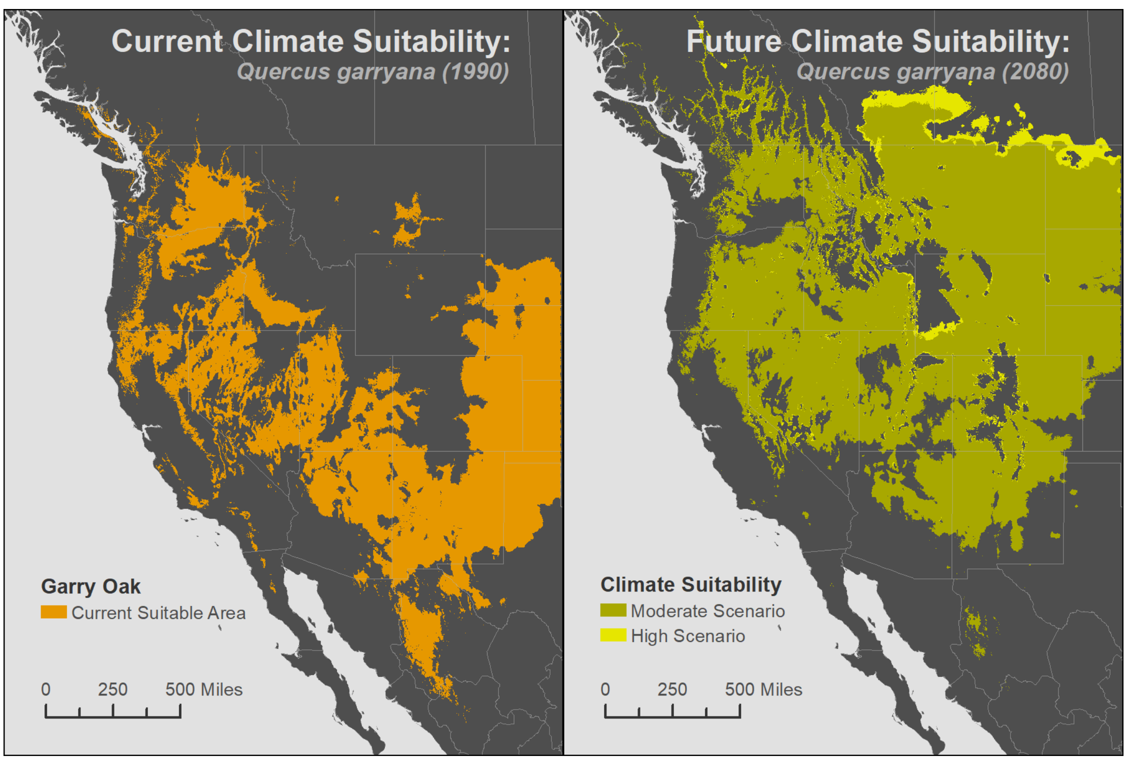

Figure 3. Current Climate Suitability and Future Climate Suitability of Quercus garryana based on data from the normal period 1961-1990 as described in the historical climate surfaces and the projected climate based on moderate and high emission scenarios for western North America (Hamann, A. et. al. 2013).

The unsuitability of the native range by 2080 is clear in the calculated change in suitability raster (Fig. 4); lost suitability dominates the native range. The expanse of gained suitability reinforces our earlier observations that climate is becoming more suitable more northward and eastward (Fig. 4).

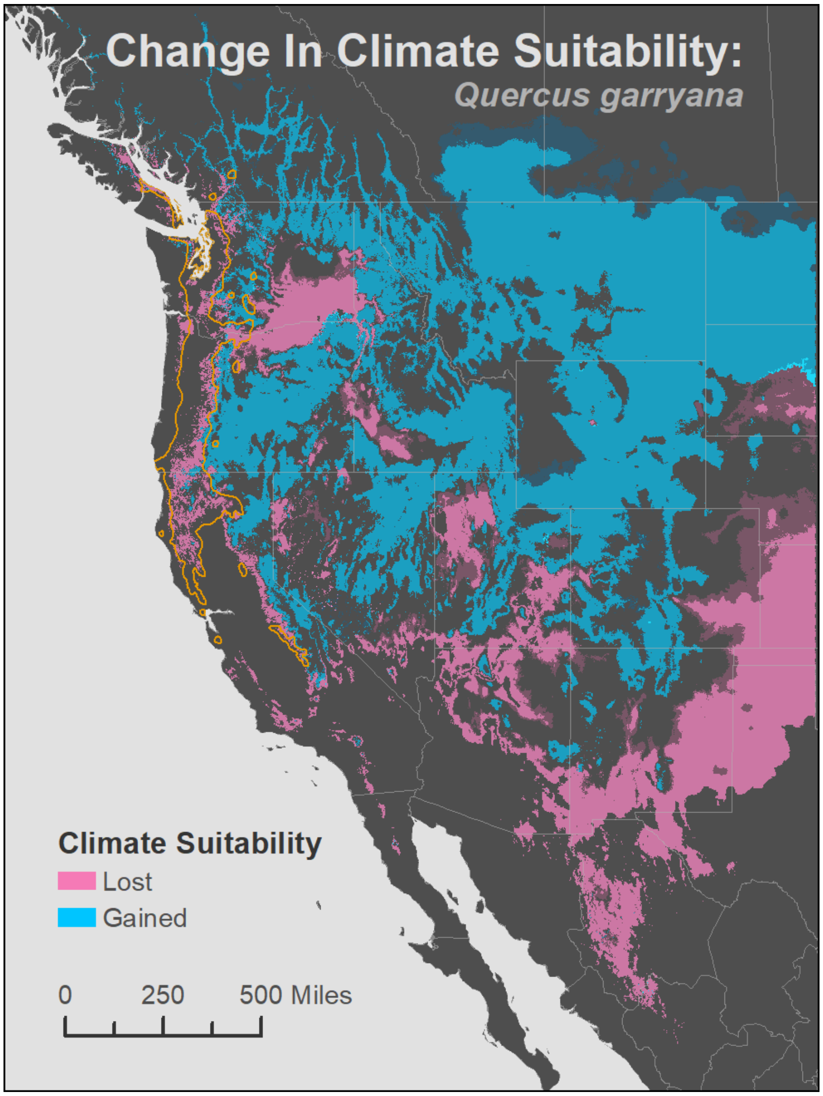

Figure 4. This map depicts the net loss or gain in climate suitability for an area by the 2080's as compared to the normal period of 1961-1990 for *Q. garryana. Pink regions demarcate loss in climate suitability while blue demarcates a gain in climate suitability. Darker shades of either color indicate the high emission scenario expanse while the brighter shades indicate the moderate emissions scenario expanse.*

While these analyses may be useful for looking at general trends in habitat suitability for *Q. garryana* due to climate change, a more holistic approach would provide a more reasonable expectation of how much and where habitat suitability will change.

Conclusion:

Even moderate emission expectations do not bode well for the native range of *Q. garryana*. According to our analyses of 2080's moderate and high emissions scenarios and the subsequent impact on global climates, the climate suitability for this species will be drastically altered, potentially threatening the entire species' population and other organisms that depend on it for food, shelter, and resources. Despite the potential compromise of *Q. garryana's* native range, there is substantial potential for new suitable habitat north and eastward of the original native range. Some key factors that still need to be addressed to make these analyses more comprehensive include soil suitability, interspecies competition, barriers to reproduction and gene flow, disturbance regimes, and anthropogenic impacts including urbanization, fragmentation, and forestry practice. Finding a better fit for the most suitable range of climate conditions this species can regularly tolerate would benefit the analyses as well.

Sources:

Hamann, A. and Wang, T., Spittlehouse, D.L., and Murdock, T.Q. 2013. A comprehensive, high-resolution database of historical and projected climate surfaces for western North America. Bulletin of the American Meteorological Society 94: 1307–1309.

Little, Elbert L., Jr. 1971. Atlas of United States trees. Volume 1. Conifers and important hardwoods. Miscellaneous Publication 1146. Washington, DC: U.S. Department of Agriculture, Forest Service. 9 p., illus. [313 maps, folio].

Stein, William I. Agriculture Handbook 654. Silvics of North America: Oregon White Oak. United States Forest Service, accessed on 12/14/2017. https://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/garryana.htm