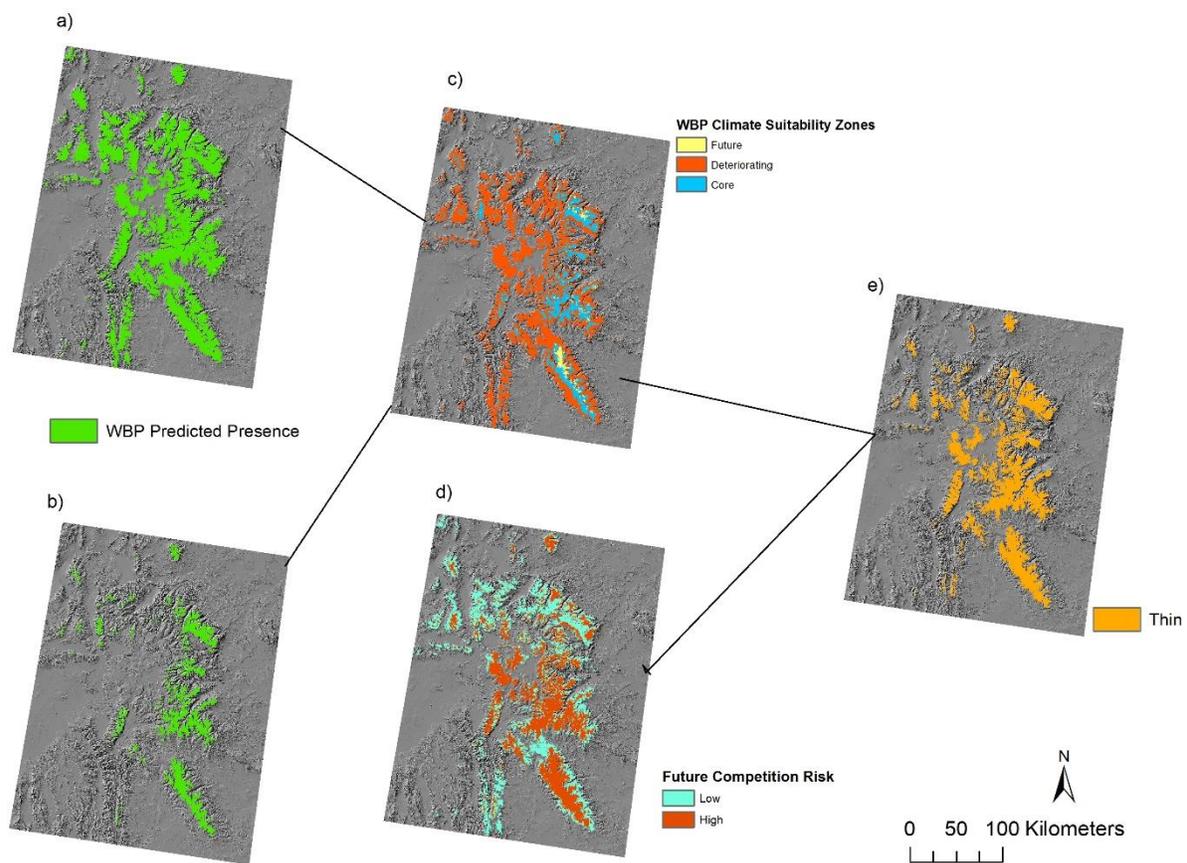


Online Resource 1: Mapping climate suitability zones and zones of potential competition risk for whitebark pine.

We mapped core, deteriorating, and future zones of climate suitability for WBP based on historical and future climate suitability from species distribution models (SDMs) (Fig. 1). Historical climate suitability was modeled from PRISM climate data for each year from 1980 to 2010. The projected climate suitability included annual projections from 2010 through 2099 for each of three selected future climate scenarios. Historical climate suitability and projected climate suitability were represented by the probability (0-1) for each 30-arcsecond (~800 m) pixel that the climate conditions were suitable for WBP, based upon a random forest model (Chang et al. 2014). We first calculated the average climate suitability for the 30 year historical climate period (1950-1980). For each GCM, we then calculated the average climate suitability for each of three future time periods of interest: (2010-2040, 2040-2070, and 2069-2099). For each climate scenario (historical and each future GCM and time period), we created binary maps of climate suitability for WBP, using the threshold where the random forest model sensitivity was equal to specificity ($P = 0.421$) (Chang et al. 2014). By comparing the binary historical suitability maps to the projected climate suitability maps, we classified the GYE study area into the core, deteriorating, and future climate zones for each future climate scenario.

The three future climate scenarios used in this study were selected to bracket the range of potential future climate suitability for WBP. Differences among GCMs and emissions scenarios, or Representative Concentration Pathways (RCPs) lead to uncertainty in the future climate conditions (Beaumont et al. 2008). This uncertainty argues for the use of multiple climate scenarios in adaptation planning (Cross et al. 2012b). Using the nine GCMs which best simulated historical climate in the U.S. Pacific Northwest (Rupp et al. 2013), Chang et al. (2014) modeled future climate suitability for WBP in the GYE. Based on these projections, we selected the GCMs that predict the lowest (HadGEM2-ES), mid-range (CESM1-CAM5), and highest (CNRM-CM5) area of future suitable habitat for WBP (Chang et al. 2014). Because current emissions align with higher emission scenarios (IPCC 2014), we used projections from the RCP 8.5 scenario for each GCM to develop our climate-informed management plans.

We then developed maps of future competition risk to further refine spatial prioritization of management actions. Future competition risk was based on SDMs for Douglas-fir, Engelmann spruce, subalpine fir, and lodgepole pine in the GYE (Fig 1; Piekielek et al. 2015). With the assumption that if any or all of the competitor species could be present that raised the risk to WBP, for each future scenario, we summed the probabilities of future climate suitability. Thus, the summed competition maps could exceed a probability of 1 if multiple species were predicted to have high future suitability. Then, for each future scenario, we used the median probability value to reclassify the maps into “high competition” and “low competition” risk.



Supplementary Figure 1 The climate-informed management strategies were based upon zones of climate suitability for WBP and future competition risk. Projections of (a) historical climate suitability for WBP and (b) future climate suitability for WBP were overlaid to develop (c) WBP climate suitability zones.

Historical and future WBP climate suitability were based on projections from Chang et al. (2014). WBP climate suitability was then overlaid with (d) future competition risk. Future competition risk was determined by summing future projected probabilities for Douglas-fir, Engelmann spruce, subalpine fir, and lodgepole pine from Piekielek et al. (2015) and dividing into low or high risk based on the median value of future probability. WBP climate suitability zones were overlaid with future competition risk to map (e) management actions, such as thinning, based on the criteria shown in Table 3