Over the course of this century, average global temperature is expected to rise somewhere between 1.7°C and 4.9°C if no steps to mitigate climate change are taken (Karl and Trenberth, 2003). Evidence such as shrinking glaciers and upslope shifts of plant and animal ranges have identified mountain regions as some of the most sensitive areas on the planet to climate change (Kohler et al., 2010). Across large regions of North America, warming global temperatures are expected to detrimentally reduce snowpack accumulation and duration despite the cooling of the winters (Karl et al., 2000, 2002), with lower elevation slopes facing the sun expected to be impacted the most (Karmalkar and Bradley, 2017). Mountain resorts are reliant on the winter months to generate a significant portion of their income through the ski industry (Thompson, 2012). In order for snow to form and accumulate, air and surface temperatures must be at or below freezing, and atmospheric and water vapor content were downloaded from the University Corporation for Atmospheric Research (UCAR) at a resolution of 1 degree (Kohler et al., 2010). These models can be run in any number of variables associated with climate change. Six different scenarios were run on snowpack and the cumulative effect of these scenarios were run on snowpack. The model generated in this study can be used to identify areas where clean snowmaking efforts should be maximized.

The model generated by this study is one possible depiction of how climate change may impact the ski industry. Many variables are used, and climate data itself is already an estimation of a possible outcome, signifying that the final models presented here are only an approximation with a high amount of inherent variability.

### Results and Discussion

Areas subject to climate changes from 2017 to 2070 that fall completely out of favor for the ski industry can be seen in Figure 1. Final model outputs of potential climate change impact can be observed in Figure 2. Even though the climate change impact magnitude negative scores indicate an increase in the risk of unfavorable snowpack, every location in the contiguous US generated a positive score by normalization (Table 2). Across large regions of North America, warming global temperatures are expected to detrimentally reduce snowpack accumulation and duration despite the cooling of the winters (Karl et al., 2000, 2002), with lower elevation slopes facing the sun expected to be impacted the most (Karmalkar and Bradley, 2017). Therefore, every ski resort across the contiguous US may face increasingly adverse conditions in the years to come due to climate change.

The average potential climate change impact scores for each full model run were strikingly similar, with scores of 34.3, 35.7, and 36.2 for the low, medium, and high impact models respectively (Fig. 3). Snowmaking efforts have been identified as leading causes for reduced snowpack in a warming world, the impacts and weights of each variable were estimated in these models. Varying the importance of each variable in any model can lead to changed outcomes, leading to the conclusion that further studies are needed in order to hone the accuracy of these models. Some of the variables in this study may have been correlated, sun and air temperature, leading to an overrepresentation of temperature’s importance to the impact models, potentially yielding inaccurate representations of how climate change is affecting snowpack. Another limitation of this study was the availability of high-resolution climate data for both present day and future conditions. Low resolution climate data hides aggregate representation of local conditions, especially along the borders of pixels. Nevertheless, the climate change models that generated the data used in this studies are estimates of climate themselves, and represent only one possible change scenario.

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### References