Key scientific questions of this study:
- How are species such as the wolverine (Gulo gulo luscus) that rely on snowpack for habitat and denning to changes in snowpack?
- What is the expected influence of climate change on the retention of snowpack in the foreseeable future?
- How do fine-scale topographical features like terrain, slope, and aspect influence the depth and extent of snowpack in montane regions?

Methods for High-Resolution Simulation in DHSVM

The Distributed Hydrology Soil Vegetation Model explicitly represents the effects of topography and vegetation on water fluxes through a domain. It was run for the historic period from water year 1998-2013 and for five scenarios of future change. The results for the historic period were validated against SNOTEL observing stations and against MODIS snow cover. Key points:

1. Significant Snow Depth: A value of 0.5m snow depth (equivalent to 0.2m of SWE) was used as a proxy for "significant snow depth" usable by the wolverine. A snow depth:SWE ratio of 2.5 was assumed from SNOTEL data.

2. Delta Method: The future climate model scenarios were downscaled using the "delta method", which applies change factors from the climate models to the historic temperature and precipitation forcings used by DHSVM.

3. Extreme Years: Wet, dry, and near-normal representative case study years were identified and analyzed for their response to future climate perturbations.

Results: Climate Change Bearings on Snowpack

Results show a decrease in SWE across all 5 climate scenarios (selected to encompass CMIP5 GCMs range in precipitation and temperature) in both regions, as compared to the historical simulation. Greatest losses in snowpack appear in scenarios with the greatest temperature increase (HadGEM2, scenario 4 below). Patterns of snow retention on north-facing slopes in the Glacier National Park area and on north-northwest-facing slopes in the Rocky Mountain National Park area become exacerbated in warm/dry years. Wet/snowy years are likely to retain snow in similar amounts in the near- and above-treeline zones simulated in this study.

Major Conclusions and Next Steps

- Results show a decrease in wolverine habitat (snowpack depth greater than 0.5m) universally across all future climate scenarios, accompanied by noticeable fragmentation of habitable area.
- Sensitivity to climate change increases in drought years.
- Snow sensitivity to climate change is greater in south-facing steep slopes at high elevation.
- Applying the data relating SWE sensitivity to predictors such as elevation, slope, aspect, temperature, and precipitation from this study to other areas of the western U.S. will provide a broader picture of the changing landscape within the next 50-100 years.
- The next step is to construct a statistical model using the relationship between SWE sensitivity and these predictors to the wider western United States to identify broad, spatial patterns.

References: 1. McKelvey et al., 2011 (USDA), 2. Copeland et al., 2010 (USGS), 3. Littell et al., 2011 (USDA), 4. McKelvey et al., 2014 (CIRES), Schwartz et al., 2009, (USDA), Li et al., 2016 (USGS)

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