Modeling Distributed Snowpack Properties as a Mechanism for Identifying Elk Distribution Patterns in the Northern Elk Winter Range, Yellowstone National Park

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Abstract. Winter mortality is the primary control on elk populations in the Northern Elk Winter Range of the Greater Yellowstone Ecosystem. Yet to date, little is known about snow-elk interactions and how the heterogeneous distribution of snowpack properties may affect migration, predation avoidance, forage utilization and habitat selection. This study developed an approach to model the spatial and temporal distribution of snowpack properties for two basins within the Northern Elk Winter Range at a spatial resolution compatible with the energetic expenditures and herd distribution patterns of elk, while using parsimonious field measurements. Our spatial model was based on a combination of field measurements, a well-instrumented met station sampling at 10 minute intervals, and SNTHERM, a 1-d process based energy and mass balance model. ANOVA tests based on 1200 measurements of snow depth and 120 snow pits showed that snow properties were significantly different as a function of forest cover type, elevation and aspect. We spatially distributed the model by classifying the study area into regions of similar physical characteristics and running the model for each classification zone. Initial snowpack properties were from field measurements, and energy balance parameters were spatially distributed. For example, radiation was spatially distributed for the winter season of 2004 at 1-hr intervals over a 30-m DEM using TOPORAD. The model captured the spatial distribution of snow depth, density, and SWE well, with an R^2 of 0.91 for measured vs. modeled SWE at 30 snowpits sampled monthly. Comparison of our model to the existing NREL snow model developed for the Northern Elk Winter Range showed an improvement of 58%. Comparison of daily SWE measurements at our site with SNOTEL measurements had an R^2 of 0.95, suggesting that we may be able to retroactively spatially distribute the long-term SNOTEL records.

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