LANDSCAPE CONTROLS ON SNOW ACCUMULATION IN AN ALPINE CATCHMENT

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ABSTRACT

The central question addressed by this poster is relationship between landscape types and snow accumulation. Of particular interest is the relative amount of snow accumulation in talus areas. Talus areas play an important role in alpine hydrology because these areas have been shown to provide water late into the summer growing season. One reason that talus areas may provide important sources of water late into the growing season is because they accumulate more snow than other landscape types in alpine basins. The roughness of talus areas reduces the redistribution of snow by wind, which may cause an increase in accumulation. Furthermore, talus areas are often located beneath steep rock faces, and these areas may accumulate relatively high amounts of snow due to sluffs and avalanches.

Snow surveys were conducted at maximum accumulation in the Green Lakes Basin in the Colorado Front Range during the years 1997 through 2000. This basin has been extensively studied in the past, and the major landscape types have been mapped and digitized onto a GIS. Using a combination of field measurements and geostatistical techniques we have estimated the distribution of snow water equivalent throughout the basin and compared it to the mapped landscape types.

INTRODUCTION

One of the most challenging problems in snow hydrology is understanding the spatial distribution of snow water equivalence (SWE) in montane catchments. A number of researchers have shown that the spatial distribution of SWE is influenced by a number of factors in a non-linear fashion, including slope, aspect, elevation, wind redistribution, terrain features, and vegetation type and amount. Consequently, understanding the spatial distribution of SWE from first principles has had little success. Here we evaluate the spatial distribution of snow depth in an alpine catchment in the Colorado Front Range, using four years of snow depth measurements at maximum accumulation. Specific questions we sought to answer include:

- Does the distribution of snow depth vary significantly among landscape types?
- Does the distribution of snow depth show spatial organization?
- Are there year-to-year differences in these relationships?

SITE DESCRIPTION

The Green Lakes Valley is an east-facing headwater catchment that abuts the Continental Divide and is located entirely within the Arapaho-Roosevelt National Forest. The Green Lake 4 basin ranges in elevation from 3,575 to 4,000 m, is 224 ha in size, and appears typical of alpine basins in the Colorado Front Range (Figure 1). Bare rock makes up 29% of the basin area, talus 33%, vegetated soils 29%, the Arikaree glacier 4%, and there are two lakes in the basin. The area has a continental climate, receiving about 1000 mm of precipitation annually, 80% as snow [Williams et al., 1996].

METHODS

As part of the Niwot Ridge Long-Term Ecological Research (LTER) program, a snow survey was performed at maximum accumulation in the Green Lakes 4 watershed from 1997 through 2000. Snow depths were measured using hand probes similar to those in Elder et al. [1991]. The spatial density of field measurements varied from year to year as a function of the number and experience of field help. Each data point was registered using a Trimble PathFinder GPS and transferred to a 10-meter Digital Elevation Model.

Landcover classes (lakes, glacier, vegetation, talus, and bare rock) were then overlain on the DEM using the Spatial Analyst extension of ESRI's ArcView GIS. The relationship of snow depth to landscape type was then evaluated for each year using measured snow depths classified by landscape type. Spatial distribution of snow depth for snow-covered area was investigated using a geostatistical approach.

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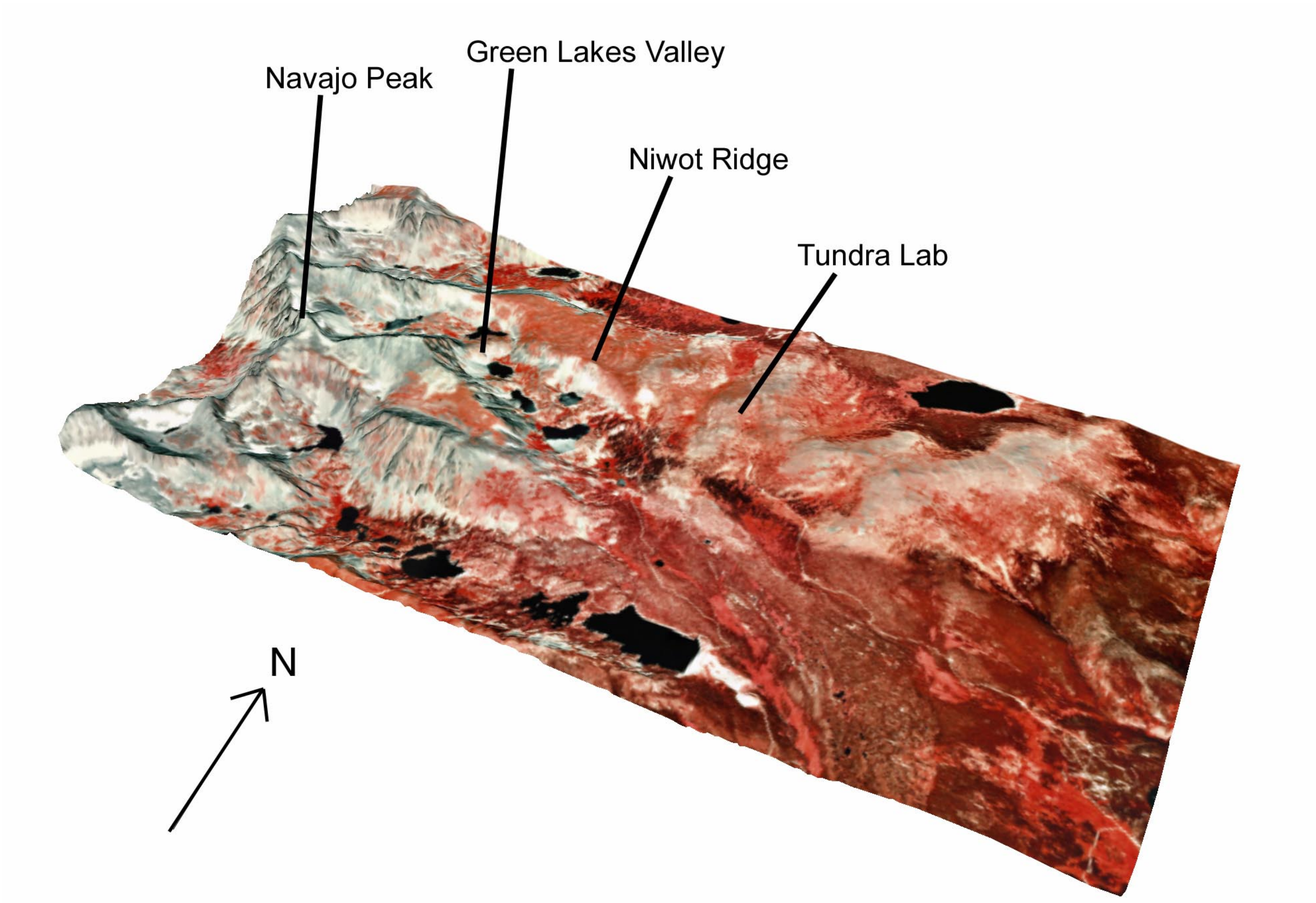

Figure 1. Site map showing location of the Green Lakes Valley in the Colorado Front Range. The study site lies upcanyon from the Green Lakes Valley marker.

RESULTS

The number of snow depth measurements ranged from 193 measurements in 1997 to 751 in 2000 (Figure 2). We also added zero snow depths on about a 50-meter grid for non-snow covered area that was too steep to sample.

In all years, snow depth was greatest on the Arikaree glacier and then on talus (Figure 3). Snow depth was generally similar on bedrock, vegetation, and lakes, and always less than on the Arikaree Glacier and on talus. To illustrate, in 2000 (Figure 3) mean snow depth was 5.11 meters on the Arikaree glacier, 2.17 meters on talus, 1.47 meters on rock, and 1.40 meters on vegetation. Over the four years, talus fields generally had about 50% deeper snow than vegetation, rock, or lakes.

Geostatistics provided a consistent pattern of snow distribution over the four years (Figure 4). For all four years, the spatial distribution of snow depths fit an exponential model. Lag distances at the sill ranged from 180 meters (2000, the lowest snow year) to 375 meters (1997, the highest snow year). The semivariance over the four years was reasonably constrained, ranging from about 2.5 to 3.5.

SUMMARY AND CONCLUSIONS

- Snow depth differed consistently by landscape type.
- Talus areas always had greater snow depths than vegetated, rock, and lake landscape types.
- Geostatistics showed that there was spatial organization to the distribution of snow depths.
- Moreover, these relationships were consistent:
  --- over a four-year period,
  --- with a variable number of measurements by year, and
  --- with different field personnel each year.

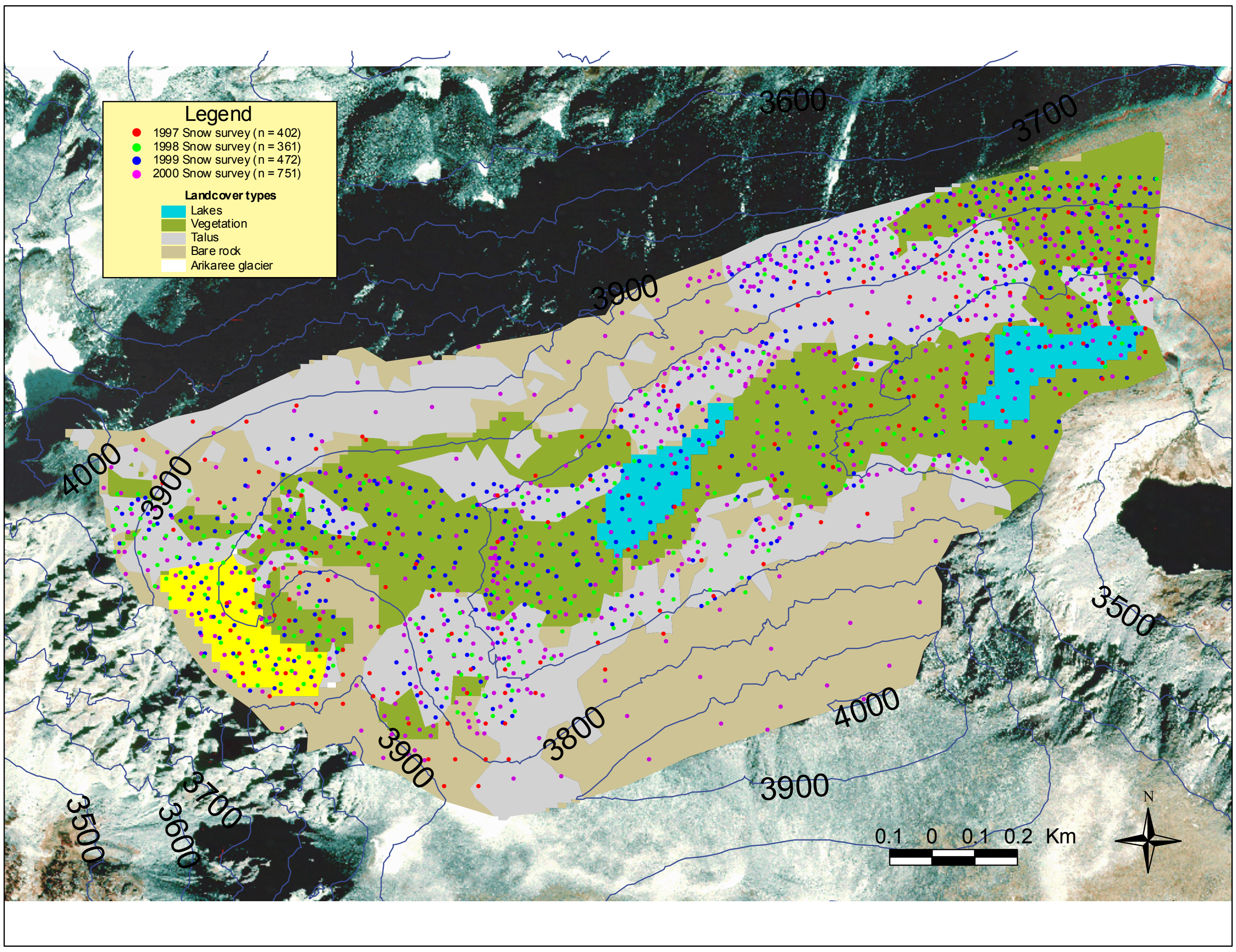

Figure 2. Landscape types and location of measurements of snow depths in the Green Lakes Valley from 1997-2000.

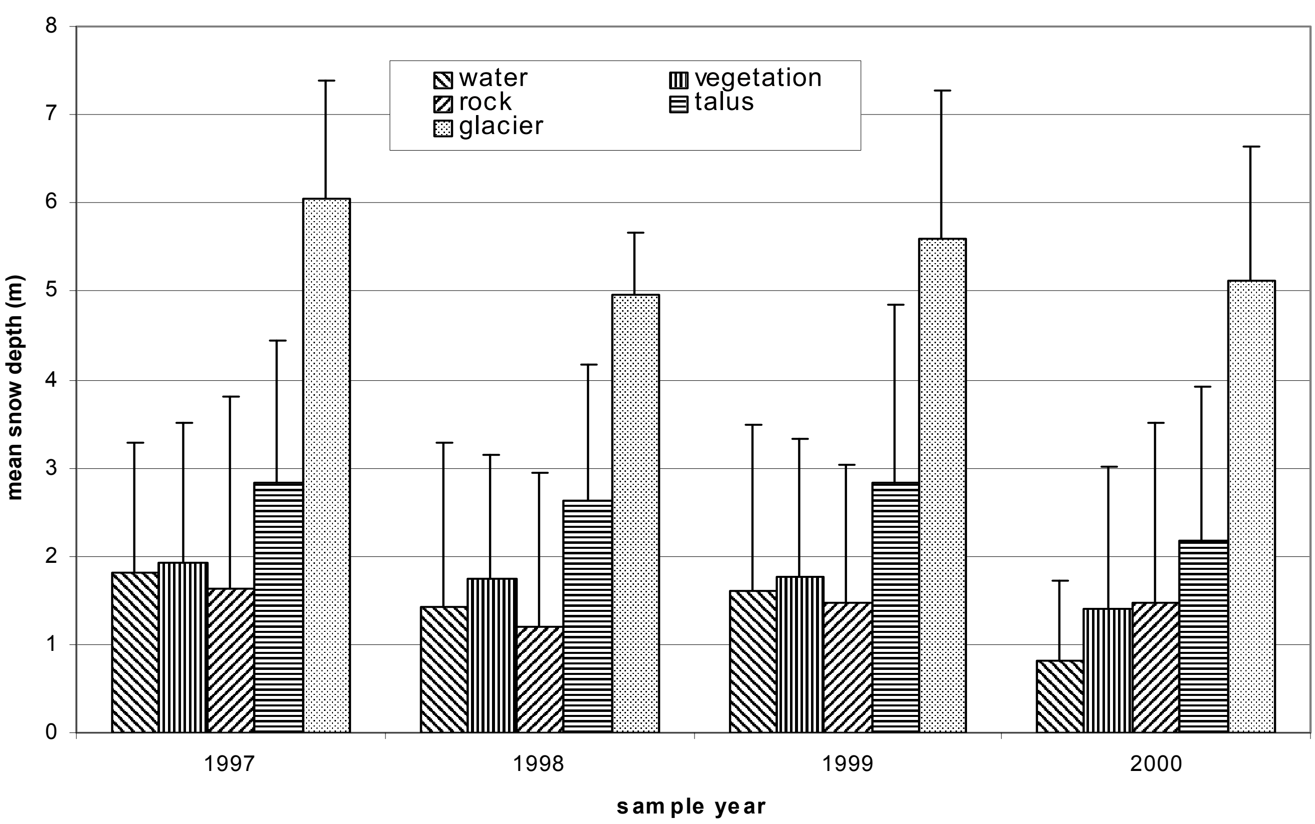

Figure 3. Distribution of snow depth by landscape type, 1997-2000.

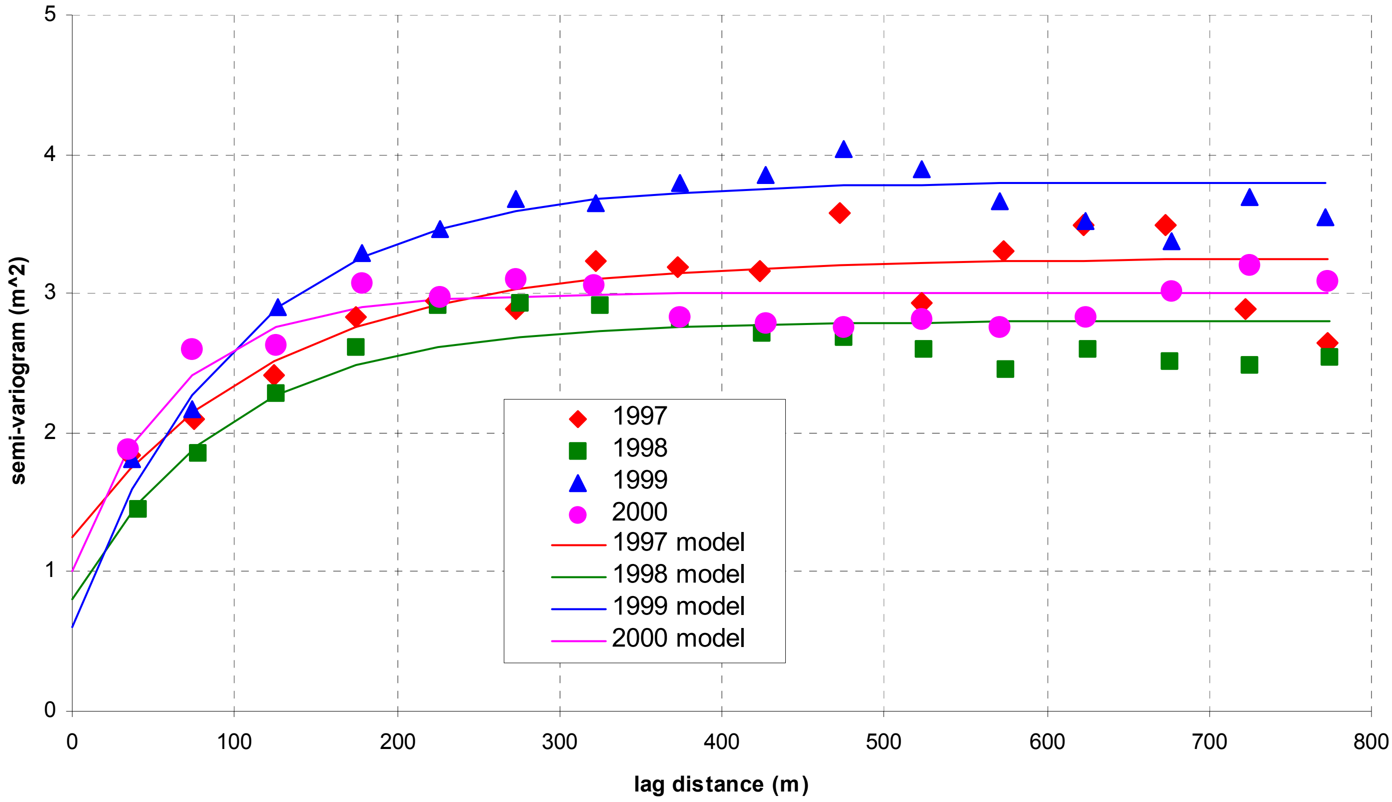

Figure 4. Variograms of snow depth measurements for the four years. Experimental variogram measurements are denoted by the solid symbols. The model variograms are denoted by lines.

ACKNOWLEDGEMENTS

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