DELAYING SNOWPACK ABLATION

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ABSTRACT

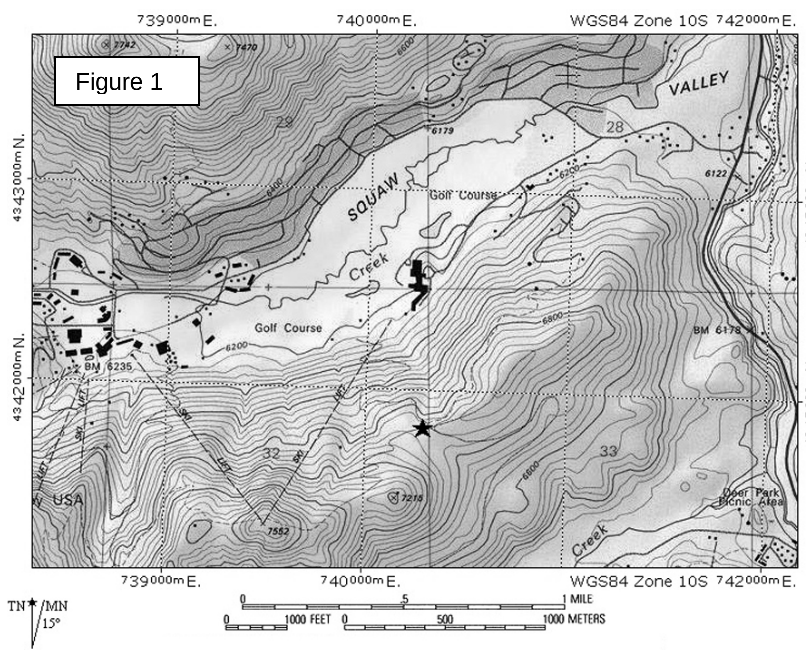
Just north of Lake Tahoe in California's Sierra Nevada, three 9 m^2 areas of the melting spring snowpack were covered with layers of wood chips, 2, 5, and 10 cm thick. This was an investigative exercise to determine if snowmelt rates could be significantly altered during soil restoration projects. Snowmelt under the wood chips was found to be exponentially slower than the surrounding snowpack, while melting at a highly linear rate. Melt rate corresponded to the thickness of the wood chip layer. The snow plot covered with 10 cm of chips was found to melt slowest, losing on average 0.87 cm of water equivalent per day. The snow under the thickest layer of wood chips persisted 23 days longer than the surrounding snow cover.

Keywords: snowmelt, albedo, snowmelt rates

INTRODUCTION

Real estate development in many mountain communities has put excessive pressure on watershed health. Springtime in mountain environments is characterized by high snowmelt rates delivering large water volumes to soils and stream channels. Excessive surface runoff can result, causing slope and channel erosion, and increased stream sedimentation. These effects tend to be magnified in ski areas where steep topography and deep snowpacks conspire with construction activities, removal of vegetation, road building, and the resultant soil disturbance.

Various sizes, grades, and species of wood chips have been used as soil amendments in a wide variety of agricultural and restoration applications. Wood chips spread over and tilled into soils have been shown to increase surface water infiltration rates thereby decreasing surface runoff and erosion. Wood chips also add structure and nutrients to lacking soils. Our working hypothesis is that if soil conditions are such that infiltration rates are significantly lower than spring snowmelt rates, surface runoff will be excessive. To either increase soil infiltration rates and/or decrease snowmelt rates would therefore be advantageous.



On May 15, 2006, work crews from Integrated Environmental Restoration Services, a Tahoe City, California based erosion control and restoration firm, spread a layer of tub-ground wood chips over the snowpack surface on a mid-slope bench ("Juniper Saddle" UTM 10S 0740290 E, 4341809 N, 2091 m elevation, Figure 1) within the Squaw Valley ski area. Three plots, each 3 x 3 meters in size, were covered with wood chips; a fourth plot, also 3 x 3 meters, was left untreated as a control plot. The four plots were set in a 2 x 2 grid one meter apart. Plot A, the NW corner of the grid, was

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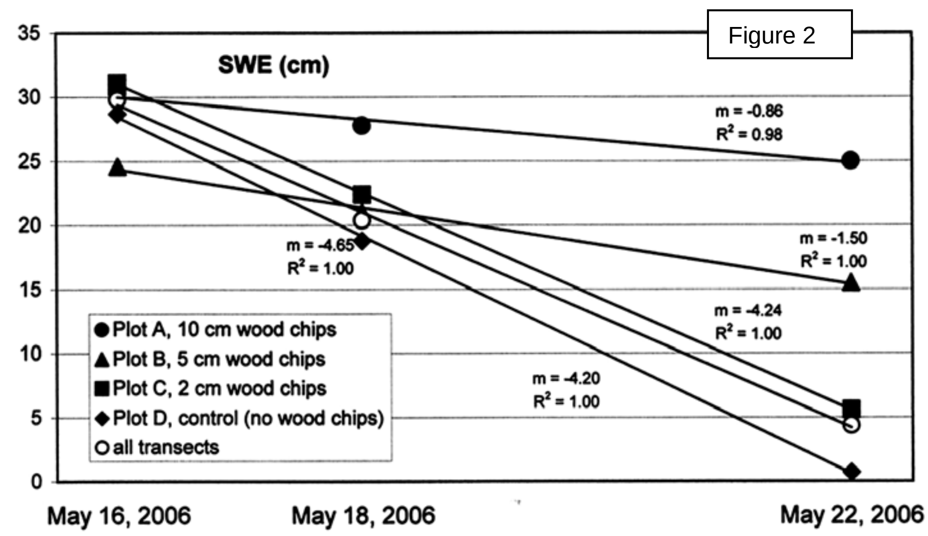
covered with 10 cm of wood chips; Plot B, the NE corner of the grid, was covered with 5 cm of wood chips, and Plot C, in the SW corner, was covered with 2 cm of wood chips. Plot D, in the SE corner, was left untouched to serve as the control plot. The wood chips on Plots A and B entirely occluded the snowpack surface while those on Plot C visually occluded approximately 90 percent of the underlying snow surface. Snow depths in the area averaged just over 60 cm. The square plots were oriented 9 degrees off true north on a local slope of 6 percent (north facing). This part of the ski area had been closed for two weeks, and was a regularly machine-groomed ski run throughout the winter season.

METHODS

On May 16, 2006, four snow measurement transects were laid out in an east/west orientation 20 meters to each side of the plots. Snow depth, average snowpack density, and snow water equivalent (SWE) were measured at 2 meter intervals along the transects. Each transect had 22 measurement points. Snow depth, density, and water content were also measured at the plot centers and 50 cm in from the four corners. Transect measurements were completed on May 16, May 18, and May 22. When the site was next visited on May 25, all measurement points along the transects had melted free of snow.

ANALYSIS

Figure 2 is a plot of the assembled (324) SWE values for each plot and the surrounding snowpack (represented by the four measurement transects and Plot D). The high R^2 values describe a very linear rate of melt (m) for all plots and transects, but the melt rate of the surrounding snowpack was 4.9 times that of the snows under 10 cm of wood chips and 2.8 times that of the snow under 5 cm of wood chips. The snowpack covered with 2 cm of wood chips (Plot C) showed no significant difference in snow water loss than the surrounding, untreated snow. Over this six-day melt period, Plot A averaged .86 cm of melt per day; Plot B, 1.50 cm melt per day; and Plot C, 4.24 cm per day. The control plot, Plot D, lost 4.65 cm per day while the transects averaged 4.20 cm per day melt. It should be noted that during this period the SWE melt rate at the Central Sierra Snow Laboratory's (CSSL) main study plot, 18 km to the northwest of Squaw Valley (and, at 2098 m elevation, a similar altitude), averaged 3.54 cm/day. The higher melt rate near the wood chip treated plots can be attributed to the more modest snow depths causing a decrease in local surface albedo as the amount of nearby snow-free ground expanded. (Snow depth at CSSL on May 16 was 135 cm; on May 22, 88 cm.)



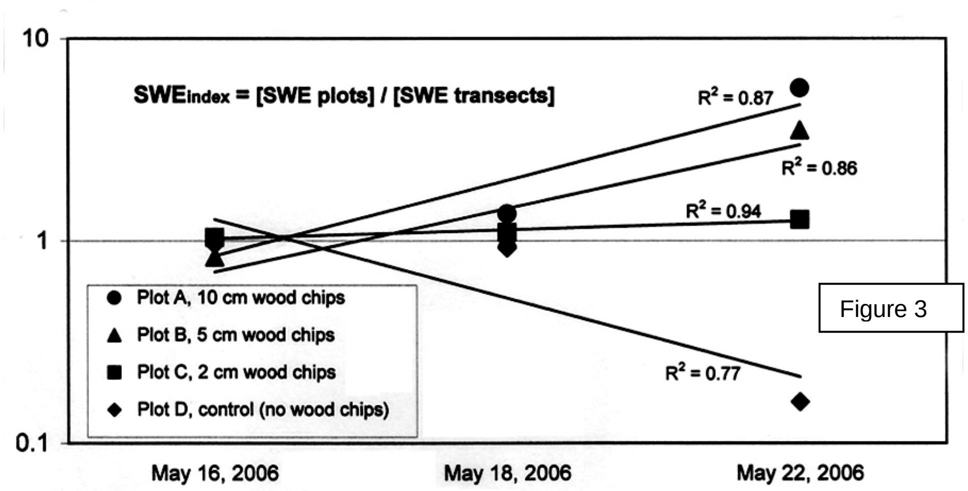


Figure 3 shows the data plotted as a ratio of SWE within the plots to the transect-measured SWE. With these indices plotted against a logarithmic ordinate, the ratios are near-linear, suggesting an exponential difference between rates of snowmelt in and out of the plots. While the SWE_{index} for Plot D was nearly 1 on May 16 and May 18, it diverged strongly on May 22. Several measurement points on the transects held snow later than Plot D, thereby driving the ratio below 1.

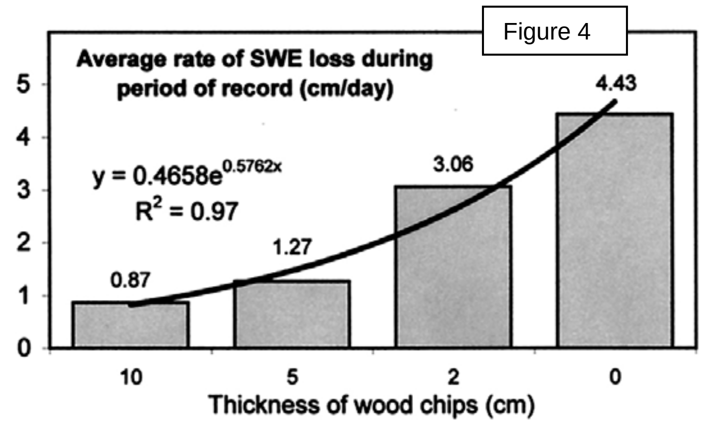
Looking SW at the three wood chip covered plots, May 16, 2006. Average snow depth in the area is just over 60 cm.

The same view June 2, 2006. The highlighted portion shows Plots A, B, C, and D, their snow depths 37, 3, 0, and 0 cm, respectively.

After May 22, 2006

As mentioned previously, when the study plots were visited on May 25 all the transect measurement points were snow-free. The snow under the wood chips, however, persisted. SWE was measured within the plots until they became snow-free. Plot D was snow-free by May 25; Plot C by May 31; Plot B on June 4; and Plot A on June 16. Snowmelt rates from Plots A, B, and C remained strongly linear throughout their periods of record with R^2 values of .98, .98, and .94 respectively. Figure 4 compares the average melt rates from the three wood chip covered plots and the control plot (the average of Plot D and the surrounding snow cover) throughout the entire period of record.

Figure 4



DISCUSSION AND CONCLUSION

Higuchi and Nagoshi showed that a two order of magnitude increase in solid material in the top 1 cm of a perennial snow cover—at very small concentrations (from 10^{-6} to 10^{-4} g/cm^3)—increased the melt rate and decreased the snow cover's duration. Their albedo measurements suggest an increase in the radiative heat flux (and possibly the sensible heat flux) at the snowpack surface, thereby increasing melt. More recently Painter et al have shown that deposits of dust concentrated on the snowpack surface during spring ablation leads to earlier melt through increased melt rates. And though much work has been done explaining differences in the melting snow cover under a forest canopy from that in the open, little research has addressed melting snow under a cover of relatively large amounts of organic debris.

As this preliminary research shows, there is a threshold amount of material, that, when exceeded on the snowpack surface, acts as thermal insulator instead of a conductor. For the past six summers a hospital in Sweden has been cooled in part by using a large reservoir of stored snow as its cooling source. The snow is kept insulated under a thick layer of ground wood chips. Though the surface of wood chips certainly has a lower albedo than the snow surface, and therefore absorbs much more radiant energy, a thick layer of wood poorly conducts that heat to the underlying snow.

Future restoration work within many ski areas of the Lake Tahoe Basin will include applying and tilling wood chips into disturbed soils to increase infiltration and reduce surface runoff. Since most ski areas close to skiing long before ski runs are melted free of snow, covering large areas of the spring snowpack with wood chips can be both operationally feasible and yield results that are ecologically beneficial. Benefits include:

- increasing water yield from the snowpack by decreasing loss to evaporation and sublimation;
- delaying snowmelt to later in the spring or early summer;
- reducing the rate of snowmelt thereby decreasing hillslope and stream channel erosion and stream sedimentation;
- providing a (future) surface mulch to capture sediment in surface runoff;
- adding a long-term source of soil nutrients.

Generation of wood chips on-site can occur simultaneously with other forest practices such as tree cutting or thinning, boosting project efficiency.

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