Curriculum Module: LTER Snowpack Dust Experiment

The Niwot Ridge Long-Term Ecological Research (LTER) site located in the Colorado Front Range is an interdisciplinary research program with the long-term goals of building a predictive understanding of ecological processes in high-elevation mountain ecosystems and contributing to broad conceptual advances in ecology. Niwot Ridge LTER also provides education, outreach, and knowledge to inform alpine resource management and conservation. As a SnowSchool site, Niwot Ridge LTER provides a unique opportunity to better integrate cutting-edge snow science into the SnowSchool curriculum and activity guides. Winter Wildlands Alliance developed the following educational activity at the National Flagship SnowSchool site near Boise ID after an interview with Niwot Ridge PhD student Cliff Bueno de Mesquita about his ongoing snowpack and climate science research.

Background Science: Snow scientists have determined that the global snowpack is melting on average a few weeks earlier due to climate change. This trend carries with it many implications for our water supply, soil moisture, plant phenology and wildlife habitat. To better understand the effect of an earlier snowpack melt, scientists at Niwot Ridge designed an experiment using black sand spread over the surface of the snow. The black sand significantly reduces the snow's albedo (reflectiveness) and, depending on weather, melts the snowpack up to a week early. This provides scientists with a unique opportunity to study the effects of climate change on high mountain ecosystems. Additionally, dust settling on the surface of the mountain snowpack is itself an increasingly frequent phenomenon and a research topic of interest to snow scientists. Thus, this experiment makes for an ideal SnowSchool activity with the potential to provoke rich science-based discussions among student participants.

Materials: Depth probe or measuring stick, shovel, 2-4 pieces of cardboard (at least 3 feet long), various natural debris such as dust, sand, dirt or duff, flagging

Setting it up: This activity requires very little equipment, but it does necessitate a bit of preparation. Depending on the time available, you could opt to either set this up yourself, or have your students help you. The first step is to identify an undisturbed patch of snow to do the experiment. This should be in an exposed spot free of shade. The next step is to create 1 meter x 1 meter plots covered with dust, duff and/or sand (also, be sure to leave a control plot that is just snow). In the example below, we made two plots using dark colored duff and a greyer granitic sand. Both were found on site and collected using a metal shovel. Using the same amount of each element, we created the plots by using recycled cardboard for borders and sprinkling the two elements over the snow.

The cardboard was a simple but critical component that created the square shape and well-defined snow/sand border that later helped capture the students' attention visually. We used a probe to measure the snowpack depth in the center of each of the three plots (sand, control and duff) and took notes in order to make accurate comparisons later.

Wait and let the sun work: Keep in mind this experiment is best done in spring, and depending on the amount of sun it may take a couple of days to see significant changes. In this example, we waited approximately 1 week before inviting the students to make observations.

Exploring the results with the students: A week after making the plots we came back and measured the changes, which you can see recorded in the chart below. This activity reminded us of investigating animal tracks in the snow with students- it's a fascinating but very fragile phenomenon! In order to avoid your experiment getting trampled in the first 10 seconds of the activity it's important to set-up a border. We used irrigation system flagging, which worked well. We explored two approaches to framing the activity with students:

As a Science Experiment: When the students arrived at the site, we informed them that we were doing a science experiment and asked them if they would like to help. After capturing their interest we spread out around the plots and asked a series of questions:

- *Based on what you see, what do you think I am studying here?*
- *What has happened so far in this experiment?*
- *What are the differences between the three plots?* (Note: We had the total loss/melt for each plot written on large pieces of cardboard)
- *Why did the darker plot melt faster than the other two?*
- *Why would we care to study this?*
- *What or who would this affect?*

Plots=	**Sand**	**Snow**	**Duff**
Depth Before	64cm	70cm	56cm
Depth After 1 Week	36cm	58cm	21cm
Total Loss (Melt)	**-28cm**	**-21cm**	**-35cm**

As a Snow Mystery: Sometimes it is simpler and less contrived to just ask a curious group of kids to describe what they see and invite them to solve a natural mystery. In this case, you may be able to explore the science of snowpack albedo without actually having to frame the activity as a science experiment. In some cases the absence of a science-based agenda may provoke a richer and more authentic analysis of the plots.

Extending involvement: The most impactful activities are both science-based AND hands-on for the students. To further engage your students one possibility may be to have some large plots ready for them to conduct their own experiment. Invite them to take even handfuls of sand/duff and spread them as evenly as possible over the plots (you will notice some less-than-even sprinkling in the photo below). Make sure to have a control plot for comparison. Lastly, ask them to make a hypothesis about how many days it will take for them to melt all the way to the ground.

Conclusions: What happened? If the plot is near the kids' school or they will be coming back soon, then you can plan to have them make observations. But if your SnowSchool site is far away you may need to post or send the students a digital picture of the survey site.

References:

Blankinship, J. C., M. W. Meadows, R. G, Lucas, and S. C. Hart (2014), Snowmelt timing alters shallow but not deep soil moisture in the Sierra Nevada, Water Resour. Res., 50, doi:10.1002/2013WR014541

Painter, T. H., S. M. Skiles, J. S. Deems, W. T. Brandt, and J. Dozier (2018), Variation in rising limb of Colorado River snowmelt runoff hydrograph controlled by dust radiative forcing in snow. *Geophysical Research Letters*, 45: 797-808. https://doi.org/10.1002/2017GL075826

Curriculum Connection:

National Science Education Standards (Earth Science) - Students should develop an understanding of the structure of the earth system

Next Generation Science Standards (5-E SS2-1) - Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

National Science Education Standards (Science as Inquiry) - Students should develop abilities necessary to do scientific inquiry.

Next Generation Science Standards (3-ESS2-S) - Obtain and combine information to describe climates in different regions of the world

Common Core State Standard MP.2: Reason abstractly and quantitatively