GC43L-2451 The Badger Project: Succession, Patterned Ground, and Restoration at a Mountain Mine

Martha E Apple[1], mapple@mtech.edu, Keith E Moore[1], Xiaobing Zhou[2], Robert Pal[1], Joel Graff[1], Makena Tanko[1], Joe Griffin[1], Nicholas Rasschaert[1], Abby Peltomaa[1] and The Badger Mine Research Team[1], (1)Montana Technological University, Biological Sciences, (2)Montana Technological University, Geological Engineering, Butte, Montana.

The Alpine Plant Processes Lab of Ecology (APPLE) Lab

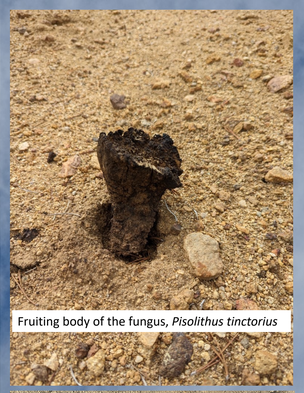
ABSTRACT:

Mountains are integral and important parts of the world that are sometimes mined for their metals and minerals. While lucrative, mines in mountainous regions have not always received proper environmental stewardship. Thus, some mining regions have suffered accordingly, which in turn influences watersheds and their biota. In Butte, Montana, historical mining practices wreaked havoc on the montane/subalpine landscape.

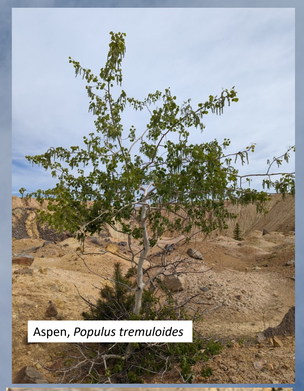
At the Badger Mine, just west of the Continental Divide in the Northern Rockies, and north of Butte, Montana (46.03° N, -112.52° W, 1901 m), artificially patterned ground consists of small hills (≤ 2 m) alternating with valleys. This pattern was formed in the mid-1900s by truckloads of overburden from the adjacent Berkeley Pit copper mine.

The Badger Mine site is now inhabited by a variety of pioneer vascular plant species, most of which arrived voluntarily and are illustrative of early successional stages. The valleys host the filamentous green alga, *Klebsormidium sp.*, in a biological soil crust along with moss, grasses, and herbaceous plants.. The hillslopes are sparsely populated with herbaceous plants and trees, including Mountain Ash, Aspen, Douglas Fir, Engelmann Spruce, and Lodgepole Pine, associated with the early successional mycorrhizal fungus *Pisolithus tinctorius*. Animals spotted at the Badger Mine Site include Mule Deer, Ravens, and Mountain Bluebirds.

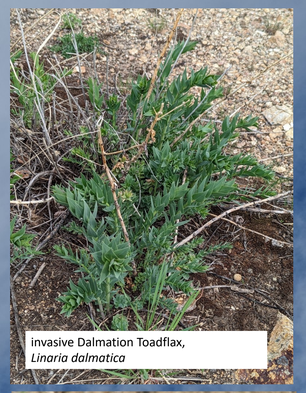
This ongoing research may provide insights for ecological restoration of mined areas in mountainous regions.



Fruiting body of the fungus, *Pisolithus tinctorius*



Aspen, *Populus tremuloides*

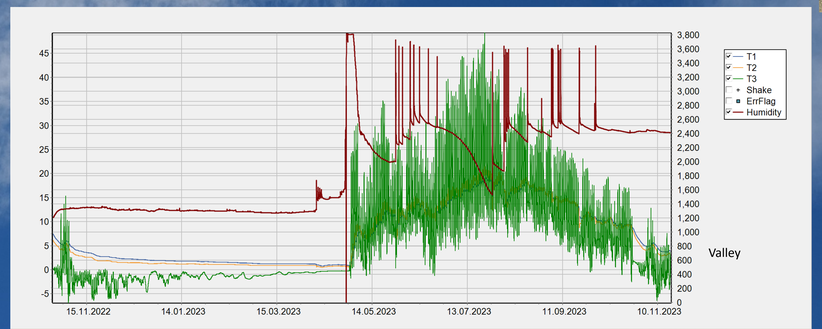


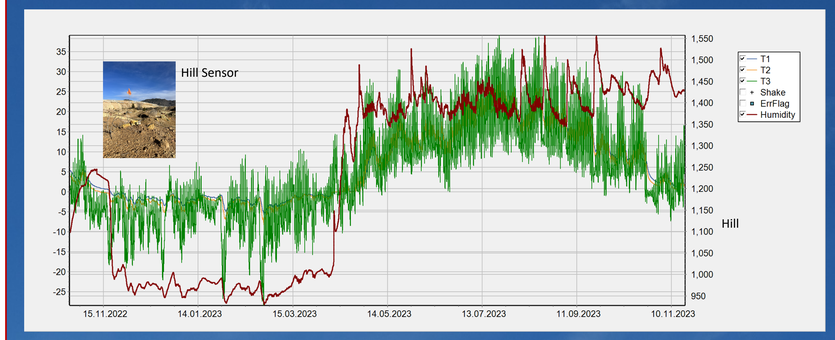
invasive Dalmation Toadflax, *Linaria dalmatica*

Deer hoof prints in clay, and *Klebsormidium sp.*

Copper

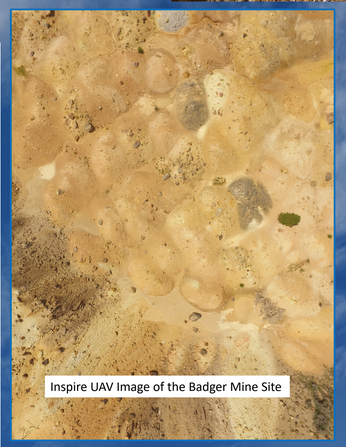
Native Rockcress, *Boechera lemmonii*





Soil (T1 and T2) and air (T3) temperature and humidity profiles from valley and hill *in-situ* TMS-4 TOMST sensors, 10/25/22 – 11/18/23, hourly readings. Temperature profiles exhibit a zero-curtain established by apparent snow accumulation in the valleys and soil humidity decreased during the summer. The sensors were placed in unshaded areas of the Badger Mine Site and were therefore subject to intense solar radiation and high summer temperatures.

Pentecost, Allan [Artist] (2016), Freshwater Biological Association.



Inspire UAV Image of the Badger Mine Site

An unmined area south of Butte and the Highland Mountains.

Makena Tanko, Keith Moore, and Nicholas Rasschaert Installing sensors, October 2022

METHODS:

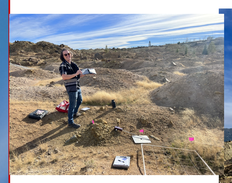
To investigate the Badger Mine as a model for succession on heterogeneous patterned ground in areas with post-mining restoration efforts, we are mapping plant and microbial functional type distribution of the contrasting hill and valley topography. Plant functional traits will be quantified, and Simpson's diversity index will determine the relative density of native and invasive plants.

eDNA will be collected and purified from soil samples along the transects and soil microbial 16S and 18S rRNA and ITS markers will be amplified. and high-throughput sequenced for the prokaryotic and eukaryotic taxonomic groups of the microbial community.

In October 2022, five pairs of TMS-4 (TOMST) soil temperature and moisture sensors were installed on hill summits and valleys, with hourly recordings of surface, 5cm underground, and air temperatures, with the first year's data collected in November 2023.

In July 2023, we flew Inspire UAVs over the Badger Mine to visualize topography and plant distribution, and established 30m sinusoidal transects across hills and valleys and at an adjacent, flat, control site to record ground surface characteristics, species distributions, epilithic lichens, bryophytes, biological soil crusts and soil pH. Metal content will be determined with a hand-held Energy-dispersive X-Ray Spectroscopy (EDX) device..

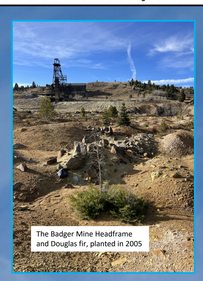
Keith Moore



At the Site

Transects

The sinusoidal transect



The Badger Mine Headframe and Douglas fir, planted in 2005

Standing water in the valleys

SUMMARY:

The Badger Mine Site represents revegetation after massive degradation from mining.

Vascular plants include native and nonnative species which readily invade disturbed ground.

Soil and air temperature sensors remain *in-situ*, and temperature and humidity profiles differ markedly between hills and valleys.

Microbial and botanical investigations are scheduled for Spring, 2024.

This ongoing study has the goals of understanding the dynamics of pioneer species arrival on newly colonized land and the roles of microbes in succession and environmental restoration.

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