SOUTHWEST FIRE SCIENCE CONSORTIUM
JFSP FIRE SCIENCE EXCHANGE NETWORK

Fire Moss: natural colonization and post-fire rehabilitation trials

Fire moss natural colonization and contribution to ecosystem function:

Fire mosses consist of three species of early successional bryophytes, *Ceratodon purpureus* (Redshank), *Funaria hygrometrica* (Cord moss), and *Bryum argenteum* (Silvergreen moss), that can quickly recolonize after high severity wildfire in the southwestern US (**Fig 1**). Fire mosses have global distributions and can be found in many ecosystem types, providing ground cover and stabilizing soils quickly after fire. We conducted a survey of post-fire moss colonization around Flagstaff and the White Mountains of Arizona and in the Jemez Mountains of New Mexico. This survey was restricted to patches of high canopy burn severity and Ponderosa pine to wet mixed-conifer forest types. Moss cover was highest two years post fire, but this result is not conclusive as we were unable to test a wide range of forests types one-year post fire. By seven years post fire moss cover had decreased, likely due to competition from vascular plants. Moss cover was highest on shady north facing slopes that had been wet mixed conifer forests pre-fire. Mosses were less abundant on south facing slopes that receive more sunlight and locations where pre-fire organic carbon was low such as dry mixed conifer and ponderosa pine forests.

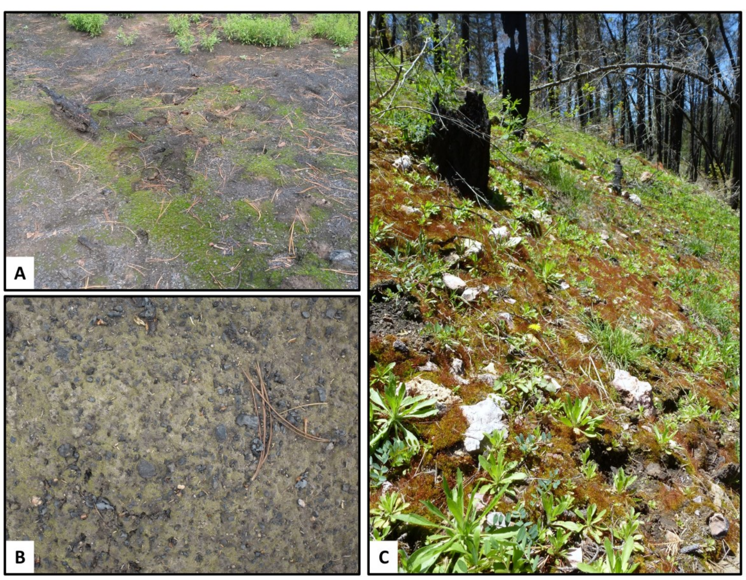

Fig 1: Fire moss four months after (A) the Boundary Fire, AZ with *F. hygrometrica* dominating, (B) the Cajete Fire, NM with *B. argenteum* dominating, and (C) two years after the Slide Fire, AZ with *C. purpureus* dominating.

In brief:

- Fire mosses colonize conifer forests in the southwestern US after severe wildfires
- They achieve the highest cover on shady slopes two years after fire that were wet mixed-conifer forests before the fire.
- Fire moss covered soils resist erosion and increase infiltration when compared to bare soils.
- Fire moss can be grown in the greenhouse with times to harvest of ~2 months using an organic substrate, constant hydration via wicking from below, and a shade cloth to increase humidity.
- Field trials of greenhouse grown fire moss on burned soils had partial success. Pelletization of moss and diatomaceous earth decreased predation by ants allowing for establishment however cover remained low due to drought.

Fig 2: Example of a moss covered and a bare soil microsite. Moss cover increased function for all measurements, 56% for infiltration, 105% for shear strength, 159% for compressive strength, and 192% for aggregate stability.

During this survey, we tested for moss-associated changes in function using paired microsites and found a increase in erosion resistance and infiltration when compared to bare soil (**Fig 2**). These results suggest that managers should monitor for and try to promote moss cover on burned hillslopes and avoid disturbances that could inhibit its growth after fire.

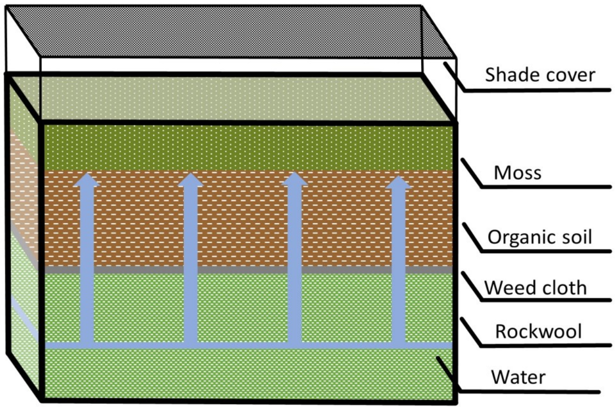

Fig 3: Greenhouse cultivation system, water is ponded in bottoms of basin and wicks from below to keep mosses fully hydrated throughout cultivation. All equipment can be reused in successive cultivation runs.

Fire moss can be grown quickly in the greenhouse

One way to increase the rate of moss colonization post-fire is by growing and adding propagules in the form of clonal vegetative fragments. To achieve this goal, we focused on greenhouse cultivation of fire moss. We found that fire moss achieved high cover in two months when 2mm fragments were sprinkled on commercially available garden soil with constant wicking hydration provided by rockwool hydroponic slabs and a protective shade covering, but growth was not favored by addition of burned materials (**Fig 3**). To grow enough moss for field trials, this technique was deployed on 120 x 55 cm trays. Rotation times were shortened by adding weed cloth below the substrate so mosses could be removed and dried separately at the end of each growth period. Slow drying is necessary to prevent tissue damage.

Fire moss can be established on severely burned soils, but cover remains low

In a series of three experiments we tested the effectiveness of adding moss fragments to recently severely burned soils. Study locations were largely dictated by availability of recently severely burned soils but results from the natural survey were used to verify that moss restoration was feasible. Directly after a fire on Kendrick Peak, AZ, we added moss tissue passed through a 2mm sieve, which was immediately collected by ants. In a second experiment, we added sieved moss alongside moss rolled into pellets. Pellets were a mixture of equal parts sieved moss with substrate and diatomaceous earth. Pelletization increased *B. argenteum* establishment, but cover remained low (~1%) throughout monitoring, which concluded 2 years after inoculation. The third experiment was started 4 months after a fire in the Jemez Mountains of NM (**Fig 4**). Pelletized moss, and pelletized moss at high (5×) application rate was added to a burned forest. Pelletized moss at the high rate increased cover to 10% after 1.5 years; however, treatments largely converged afterward. At both study sites, an exceptional drought during the winter of 2017/2018 reduced success. We believe pelletization was an effective ant deterrent with added benefits of attaching moss propagules to the soil and could assist in mechanized delivery of moss fragments. Other researchers have recently developed a low-cost bicycle powered pelletization machine which could be helpful in scaling up future restoration trials. However, we do not yet suggest this as a viable postfire rehabilitation technique.

In future research, if funded, we plan to refine greenhouse growing and pelletization techniques, test field establishment under non-drought conditions, and examine fire mosses' roll in the recovery of soil bacteria and fungi after fire.

Fig 4: Fire moss addition trials in a dry mixed conifer forest four months after the Cajete fire in the Jemez Mountains, New Mexico. White squares are mosses pelletized with diatomaceous earth at two different cover amounts.

Questions? See high moss cover post-fire? Contact Henry Grover: Email: henrygrover@nau.edu, Phone: 8027340249