Seed Movement with Soil Erosion in southwestern Ponderosa Pine Forests

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TREE

Abstract

Anthropogenic activities have altered the structure of southwestern Ponderosa pine forests from open forest with diverse herbaceous understories to closed forests with more homogenous understories. The objectives of this study are to: (1) analyze how fire severity and hillslope gradient affects the soil seed bank, (2) quantify post fire erosion and associated seed displacement, and (3) understand the impacts on regeneration after fire in a ponderosa pine forest in New Mexico. Seed movement due to erosion will be assessed using sediment traps, survey techniques, and seed tracers. Four sites were selected based on fire severity and hillslope gradient with two replicate erosion plots per site. For each 3 x 10 m plot, three sediment traps were installed at the bottom of the slope. Net erosion will be quantified by repeated high resolution survey of plots. Two seed tracer sizes were deployed. Initial slope gradients for steep slopes average 0.22 ± 0.09, whereas the gentle slopes average 0.13 ± 0.01. Hillslope shape is rectilinear but steeper slopes show some shape departures, which suggests more complex erosion patterns. Higher erosion rates are expected in severely burned sites where the soil is more prone to erosion.

Purpose

The objectives of this study are to: (1) analyze how fire severity and hill slope gradient affects the soil seed bank over time, (2) to quantify post fire erosion and associated seed displacement, and (3) understand the impacts on regeneration of vegetation after fire in a ponderosa pine forest in New Mexico.

Introduction and Site Description

Human activities have greatly altered the historical structure and fire regime of southwestern Ponderosa pine forests. Their historical open forest structures with large trees and diverse herbaceous understories have transformed into forests that are denser with smaller, stressed trees and more homogenous understories. Historically, these ecosystems evolved with frequent moderate fires, which promoted forest health. However, current conditions have resulted in larger fuel loads and the enhanced presence of fuel ladders, which increases the risk for stand-replacing fires (Cooper 1960). There have been many studies conducted which focus on the restoration of these ecosystems to their natural conditions. However, the role of the seed bank in restoring understory plant life and diversity in these ecosystems is not well known (Carr 2012). Further, while seed movement due to erosion can be negligible under normal conditions, the extent of erosion-driven seed movement after fire when soils are increasingly prone to erosion is not well known.

The study site is located in the Valles Caldera National Preserve in the heart of the Jemez Mountains in north-central New Mexico (Fig. 1). On May 31, 2013, the Thompson ridge fire was initiated in the area due to a downed power line. The fire burned in a mosaic pattern of varying severities (Fig. 2) until it was contained on July 23.

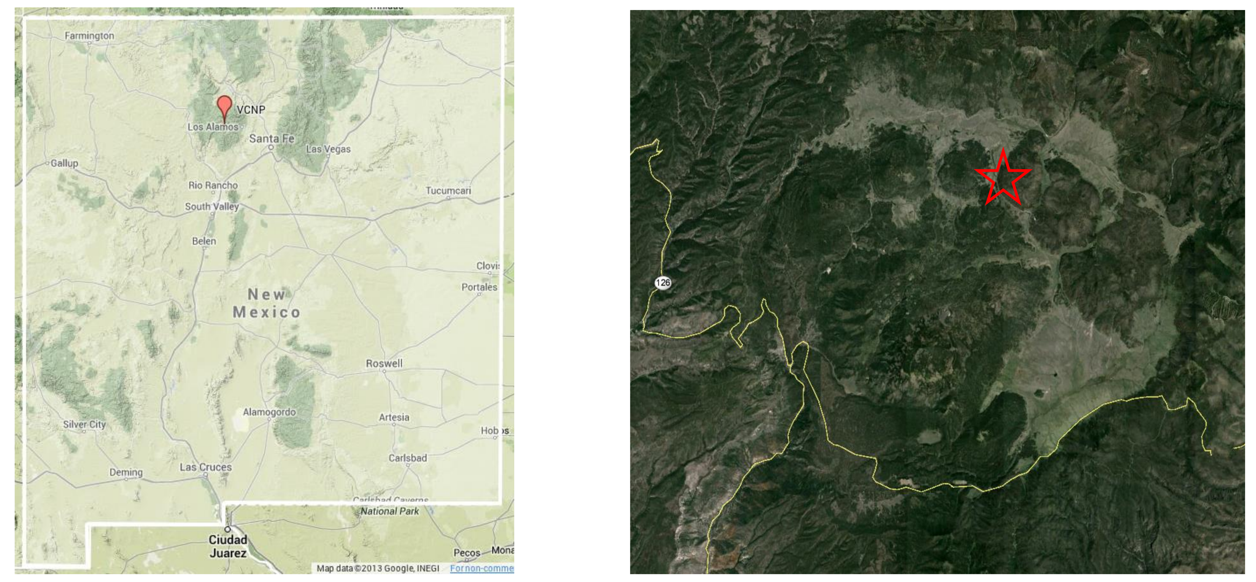

Fig 1. Left: Map of the Valles Caldera National Preserve within New Mexico. Right: Topographical map of the caldera with a star indicating the study site location.

Fig 2. An example of a high severity site (Left) compared with a low severity site (Right).

Methods

To study the effects of fire and slope on erosion and seed movement, 4 sites were selected based on fire severity (high or low) and hillslope gradient (steep or gentle) with 2 replicate erosion plots per site. One control plot was constructed in an un-burned area so that pre-fire conditions could be assessed. Plots were established between July 28 and August 6, 2013.

Seed movement due to erosion is assessed using sediment traps, survey techniques and seed tracers. For each 3 x 10 m erosion plot, three sediment traps were installed at the bottom of the slope (Fig 4). Trapped material is removed from the traps at different intervals and analyzed for the amount of sediment trapped, the species and number of viable and unviable seeds, and the presence of seed tracers. Net erosion will be quantified by repeated survey of the plots taking height measurements every 35 cm (Fig 3).

Two different seed tracers, one cylindrical and the other spherical, which mimic the size and density of some grass-like seeds were used. These color-coded tracers documented starting position every 2 meters downslope with tracers placed across the entire plot (Fig. 4). Their movement is monitored over time using photography and the sediment traps.

Fig 3. Survey of a plot using a laser distance meter. Measurements are taken every 40 cm downslope and every 30 cm across slope.

Fig 4. A high severity erosion plot after seed tracers had been dispersed. Three sediment traps measuring approximately 40 x 30 x 20 cm, were installed downslope of each erosion plot.

Preliminary Results

Survey data were used to generate a profile and compute the gradient for each erosion plot. Analysis of the field data show that the initial slope gradients for the four gentle slopes range from 0.11 to 0.13 with a mean gradient of 0.13 ± 0.01 (Fig. 5A). The four steep slope gradients range from 0.13 to 0.31 with a mean gradient of 0.22 ± 0.091(Fig. 5B).

Hillslope gradients for gentle slopes are very similar showing a rectilinear shape (Figure 5A). The steeper slopes show some departures from the rectilinear shape (Figure 5B), which suggests that more complex erosion processes have occurred and will occur due to the higher hillslope gradients. These gradients may change over time, as larger gradients will most likely result in higher rates of erosion particularly in severely burned sites where the soil is more prone to being eroded. Two months after plot establishment, the material from each sediment trap was collected. Between visits, the area experienced about 31 cm of precipitation. The material collected from the two high severity steep slope plots was approximately 200 kg. In contrast, the material collected from the low severity plots was only about 0.1 kg.

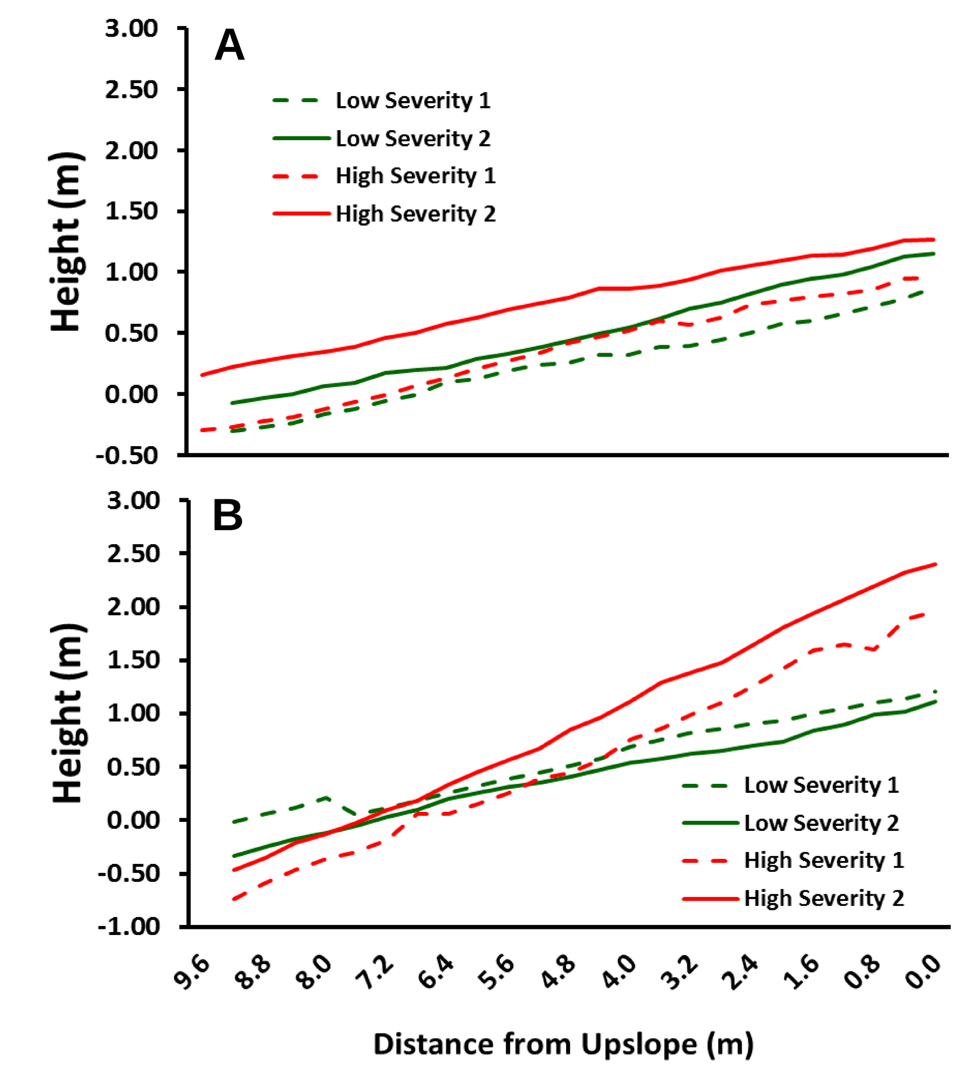

Fig 5. Slope profiles for A) gentle and B) steep slope treatments. Gradients were generated by taking the heights of the ground surface down the middle of the plot.

On the high severity-steep slopes seed tracers had moved an excess of 50 m downslope while there was little to no movement on the low fire-severity plots regardless of slope. High severity, gentle slopes showed an intermediate movement distance with tracers being found as far as 23 m downslope. This suggests that seed movement can be relatively substantial and dependent on fire and slope gradient.

Concluding Remarks

Initial slope profiles suggest there are more complex erosional processes occurring on steep slope plots relative to gentle slope plots. Further, initial observations of seed tracer movement indicate grass-like seeds are more prone to erosion-driven movement on high severity steep slope plots than any other treatment .

References

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Acknowledgements

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