Biochar influence on subterranean termites: 36-month evaluation

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Abstract

This first interim research report concerning subterranean termite activity summarizes the 36-month evaluation of a 5-year study-in-progress on the Stanislaus National Forest, Calaveras County, California, within the Sierra Nevada Mountains. The Lakemont timber salvage site was clear-cut during 2017 and received biochar treatments during November 2017. Wood stakes, ground-boards and PVC termite monitoring stations were installed during 2018. Evaluation and sampling began during 2019. Study plots were established across the open field salvage site. Non-disturbed forest tree plots were also established on the open field periphery. Open field and tree plots were randomly assigned one of two biochar amendments to the soil surface or designated as a non-treated control. Wood stakes were placed in plots to monitor decay and changes in wood soundness each year as well as evaluate subterranean termite activity. To gain additional insight into subterranean termite activity, all open field and tree plots also contain in-ground termite monitoring stations and soil-surface ground-boards. Currently, forest tree plots have not exhibited sufficient termite activity to draw conclusions concerning effects of biochar on foraging termites. However, biochar applications to open field soil may have increased termite activity in the high rate open field plots. The highest biochar application rate of 22,417 kg•ha^{-1} (10 tons•acre^{-1}) exhibited the greatest termite foraging activity after 36 months compared with the 6,725 kg•ha^{-1} (3 tons•acre^{-1}) and non-treated control plots. However, another two years or longer evaluations should more clearly identify definitive trends and allow more accurate conclusions concerning effects of biochar soil amendments on subterranean termite foraging activity.

Overview

For the termite part of this biochar amendment field research project, activity of subterranean termites within the open field and tree plots continues to be evaluated. The open field salvage area soil is extensively disturbed, scarified and rutted, and several areas are severely compacted due to heavy equipment operating on wet soil. In addition, within two years after the salvage operation ground-cover was nearly 100%, dominated by the low-growing plant 'mountain misery' (*Chamaebatia foliolosa* Benth., aka bearclover). Widespread amounts of coarse woody debris remain throughout the open field site. Because subterranean termites are beneficial within the natural soil environment and are primary reducer-decomposers of dead wood (Krishna and Weesner 1969, Thorne 1998), evaluating effects of biochar on their repopulating and foraging activities on disturbed salvage sites as well as their activity within non-salvage adjacent tree sites is of interest. This research will provide insight into overall subterranean termite activity within biochar amended and non-amended soil in both natural forest sites and disturbed open field salvage sites.

The Lakemont timber salvage site is located near the town of Arnold, California, on the Sierra Nevada Mountains central western slope. The site encompasses approximately 8 ha (20 acres) with a southeast aspect and 13% slope north-to-south. Site elevation ranges from 1,210- to 1,262-m (3,970 to 4,140 feet) AMSL (38°14.874'N–120°22.697'W). The terrain is rough and littered with limbs and stumps due to logging activities. A severe drought for the past two years has resulted in a hot, dry open field soil surface during summer months.

Objectives

Several factors concerning subterranean termites are being evaluated through at least five years. These factors include:

- Relative frequency of termites within the different biochar treatments – tree plots and open field plots.
- Percent attack by termites on 'surface' and 'mineral soil' wood stakes.
- Percent attack by termites on surface ground-boards, and wood inside PVC monitoring stations.
- Determination of ASTM damage ratings for all stakes, ground-boards, and monitoring station wood.
- Comparison of mass loss from pine and aspen stakes due to termite feeding within and between tree plots and open field plots.
- Comparison of mass loss from ground-boards, and wood billets in PVC monitoring stations, within and between tree plots and open field plots.
- Estimation of relative numbers of termites feeding on stakes, ground-boards, and monitoring wood.
- Identification of different subterranean termite species and colonies.

Materials and Methods

Three tree study blocks of non-disturbed forest consisting of three mature trees per block are currently established on natural, non-salvage wooded areas immediately adjacent to the open field salvage site. Each tree per block was randomly assigned one of two biochar treatments or designated as a non-treated control. In addition, three study blocks, each consisting of three 0.4 ha (1 acre) plots are established on the approximately 8 ha (20 acre) Lakemont open field salvage site. One of the two biochar treatments to the soil surface or the non-treated control was randomly assigned to one of the three plots per block for both tree and open field plots. Treatments: No biochar application to the soil surface (control plot); biochar low rate – 6,725 kg•ha^{-1} (3 tons•acre^{-1}); biochar high rate – 22,417 kg•ha^{-1} (10 tons•acre^{-1}).

Within each of the nine non-disturbed single tree plots, four 10.2-cm diameter x 20.3-cm tall (4-inch diameter x 8-inch tall) PVC in-ground monitoring stations that contain pine billets were vertically inserted into the soil approximately 1 m (3 feet) from each tree and spaced 90° apart. Two of these stations have open bottoms to allow entrance by foraging termites. Bottom openings of the other two stations are enclosed with stainless steel mesh to exclude subterranean termites and other soil-dwelling animals. In addition, four 15- x 30- x 2.5-cm (6 x 12 x 1 inch) pine ground-board (GB) monitors were placed on bare mineral soil and equi-spaced around each tree adjacent to the PVC monitoring stations. Two ground-boards are open (non-enclosed) and two ground-boards are completely enclosed in stainless steel mesh (Figure 1). For open field plots, in-ground PVC monitors and surface ground-boards along with two larger, wood-filled centrally located monitoring stations were installed and remain in each of these nine plots. Enclosed monitors and ground-boards allow for wood mass loss comparisons with and without termite feeding activity (Figure 2).

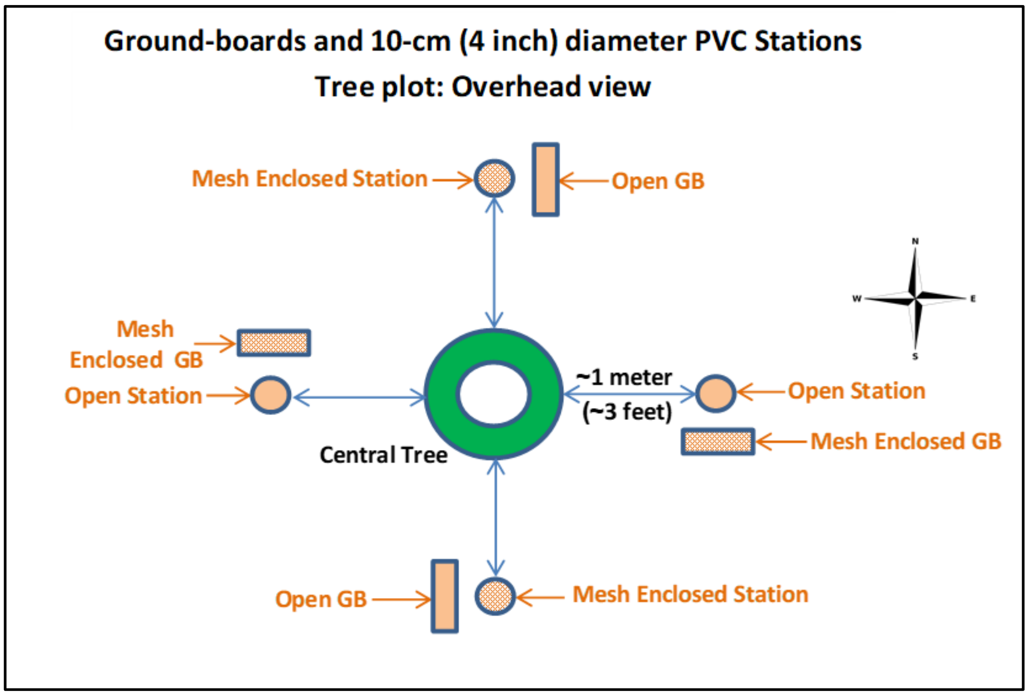
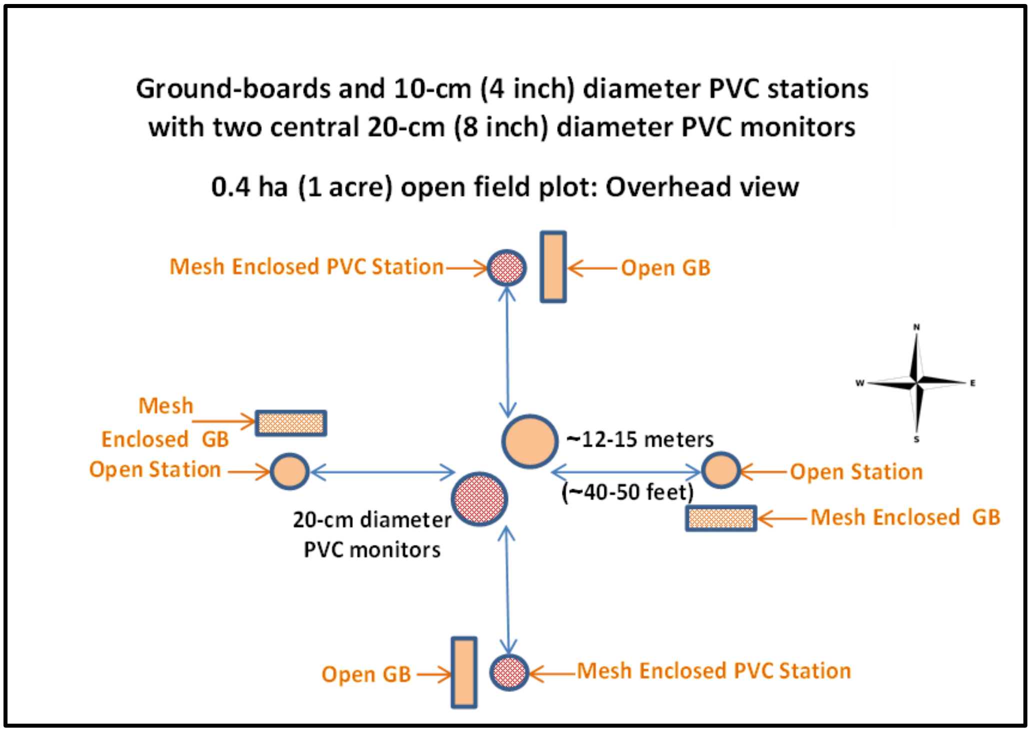


Figure 1. Tree plot monitoring station and ground-board (GB) configuration.



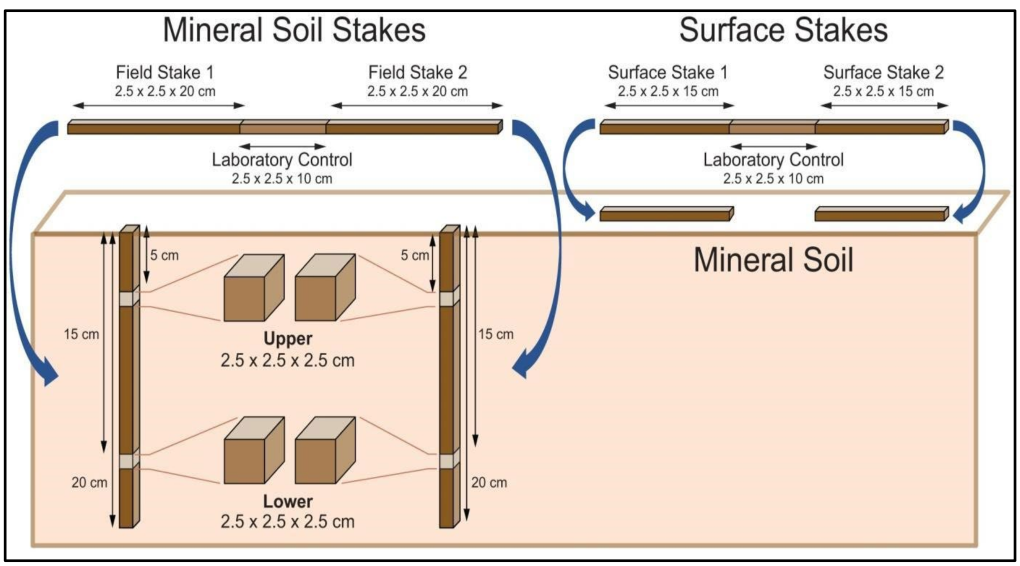


Figure 3. USDA Forest Service and Michigan Technological University vertical Mineral Soil Stakes and Surface Stakes configuration (used by permission–Jurgensen et al. 2020).

In addition to the PVC monitors and ground-boards, two sets of stakes consisting of five aspen plus five southern yellow pine stakes per set were emplaced in the nine open field plots. These sets of 10 stakes each are referred to as "surface stakes" because they are placed on the bare mineral soil surface. The second identical set of 10 stakes is vertically inserted into the soil and referred to as "mineral soil stakes" (Figure 3). These two sets of ten stakes each were replicated five times in each open field plot. Two sets per plot (one set each of 10 surface stakes and 10 mineral soil stakes) are removed and evaluated for decay and changes in wood soundness plus termite damage each year. For tree plots, the same arrangement of two sets of 10 stakes each (five aspen plus five pine stakes per set) were placed in one low biochar, one high biochar, and one control tree plot with all stake sets replicated five times (Page-Dumroese and Tirocke 2021).

Interim findings and discussion (36-months post-biochar applications)

To evaluate subterranean termite activity, all field and tree plot surface and mineral stakes, ground-boards, and PVC monitoring station wood billets were evaluated for termite activity and rated for termite damage using the ASTM rating scale (ASTM 1999). Currently, single tree plots have not shown sufficient termite activity to draw definitive conclusions. However, in the open field salvage plots, the plots with the high biochar application rate exhibited greater termite activity and feeding damage to mineral soil stakes compared with the low rate and control plots (Figure 4). To date, surface stakes have not been contacted by termites. This is possibly due to the hot, dry soil surface during a continuing long-lasting drought over the past two years. Over the next two years, clearer termite activity trends may emerge. Therefore, at this time it is somewhat early in the study to identify and validate definitive trends or draw accurate long-term conclusions concerning overall termite activity within the open field plots although the high biochar plots currently show the greatest termite activity.

Termites fed on a total of 10 pine and 12 aspen mineral soil stakes across all field plots, currently showing no definitive feeding preference for either wood. In the high biochar plots termites damaged a total of 17 mineral soil stakes, compared with four soil mineral stakes in the low biochar plots and one mineral soil stake in control plots. However, only two pine mineral soil stakes contained active termites, plot 1 (high rate; ASTM 7) and plot 8 (control; ASTM 9) (Figure 4).

The large 20-cm (8 inch) diameter central PVC monitors in the open field plots have yet to be located by subterranean termites. These monitors should eventually collect termites for taxonomic identification and delineation of termite activity and foraging distances within the field plots. Presence of different termite colonies within a plot can be determined by genetically comparing specimens from stakes, ground-boards and PVC monitors, providing insight into species diversity and colony density. Wood in the large monitors was pre-weighed for comparison of wood mass loss between open and mesh-enclosed configurations

Many downed logs in natural areas surrounding the salvage site are populated with carpenter ants and dampwood termites as well as subterranean termites. These logs are a source of subterranean termite dispersal flights into open field plots. Numerous stumps and woody debris on the salvage site will serve as nesting and food resources. The study is three years old. This is a short period for termites to re-populate such a severely disturbed field site. Evaluations during the next two years will increase our knowledge of effects of biochar applications to soil on termite foraging and feeding behavior and evaluate if biochar amendments are beneficial or detrimental to termite activity.

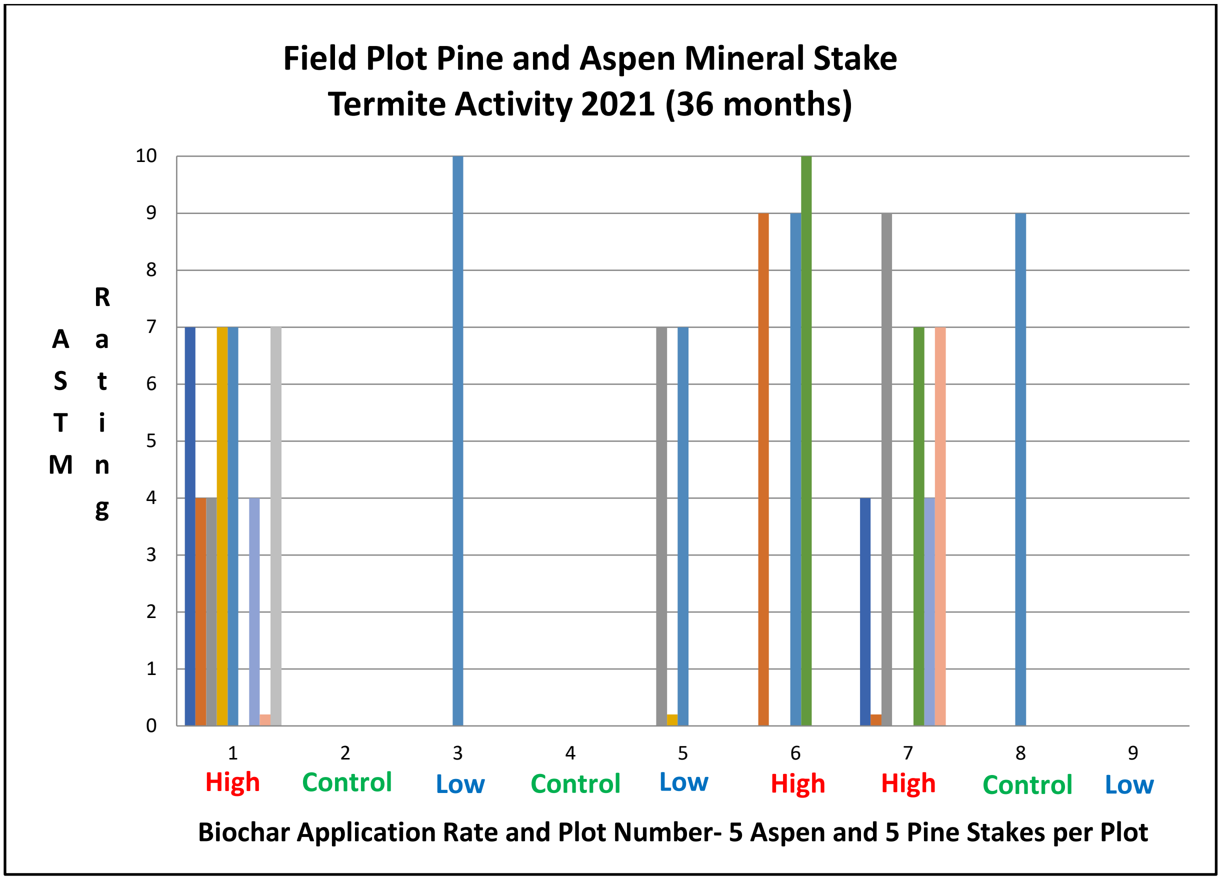


Figure 4. ASTM damage ratings to mineral aspen and mineral pine stakes by plot and biochar application. Five aspen stakes and five pine stakes per open field plot.

Keywords: biochar, carbon soil amendment, subterranean termites, timber salvage restoration

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