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Effects of wind disturbance and salvage harvesting on macrofungal communities in a *Pinus* woodland

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ABSTRACT

Natural disturbances alter the biophysical conditions of ecosystems, influencing patterns of structure, composition, and successional dynamics. Following high severity natural disturbance in forest ecosystems, land-managers sometimes employ salvage harvesting to harvest trees killed or damaged by the disturbance agent. Despite its widespread practice, the effects of salvage harvesting on many ecosystem functions and species assemblages are still poorly understood. This study presents the first attempt to document and analyze the effects of salvage harvesting on macrofungal communities following catastrophic wind disturbance. On 27 April 2011, an EF3 tornado damaged forest stands within the Oakmulgee Ranger District of the Talladega National Forest in west-central Alabama, USA. Following the event, portions of some stands were subject to salvage harvesting. In 2016, we established three treatments, undisturbed, tornado disturbed, and salvage harvested, in stands that were dominated by *Pinus palustris* P. Miller prior to the 2011 disturbance events. Throughout the sample period, 546 occurrences of 84 macrofungal species were recorded. Tornado disturbed areas hosted the highest macrofungal species richness overall. Undisturbed areas hosted the highest species richness for ectomycorrhizal macrofungi. Salvage harvested areas had reduced species richness for both saprotrophic and ectomycorrhizal macrofungi compared to tornado disturbed plots. Non-metric multidimensional scaling ordination and permutational multivariate analysis of variance indicated that all three treatments differed in macrofungal community composition. The results indicated that salvage harvesting following catastrophic wind disturbance has the capacity to reduce macrofungal species richness and fruiting abundance. The reduction in deadwood volume and alterations to the ectomycorrhizal-associating plant community documented at salvage harvested sites is likely responsible for the observed differences in macrofungal fruiting patterns. The implications of reduced macrofungal richness in the early stages of forest development following catastrophic disturbance should be subject to long-term studies.

1. Introduction

Natural disturbances are discrete events that alter the biophysical conditions of an ecosystem (Pickett and White, 1985). These events play key roles in regulating ecosystem functions, structures, and species assemblages (White and Jentsch, 2001). Because of their ability to create structural legacies and increase niche space, natural disturbances are often considered important for maintaining biodiversity (Hansen et al., 1991; Franklin et al., 2000). Following high severity natural disturbance events in forest ecosystems, land managers sometimes employ salvage harvesting to reclaim economic losses and reduce fuel loads. Although natural disturbances may be necessary for maintaining healthy ecosystems, researchers have expressed concern about the impact of salvage harvesting on ecosystem resiliency and biodiversity (Karr et al., 2004; Lindenmayer, 2006; Lindenmayer and Noss, 2006; Waldron et al., 2013). Multiple disturbances in quick succession (i.e. compound disturbance), such as those represented by an initial disturbance and salvage harvesting, can have cumulative effects that are beyond the coping ability of native species (Paine et al., 1998, Peterson and Leach, 2008a). Salvage harvesting may also decrease habitat heterogeneity and niche space by removing structural legacies (e.g. deadwood), and altering the biophysical environment in ways not analogous to natural disturbances (e.g. soil compaction). Despite these concerns, some studies show that moderate intensity salvage harvesting does not have undesirable effects on long-term ecosystem function (Peterson and Leach, 2008a, Peterson and Leach, 2008b, Lang et al., 2009, Royo et al., 2016), thus much controversy remains concerning the use of salvage harvesting.

Understanding the impacts of disturbance events may be crucial to future forest management and conservation efforts as global climate

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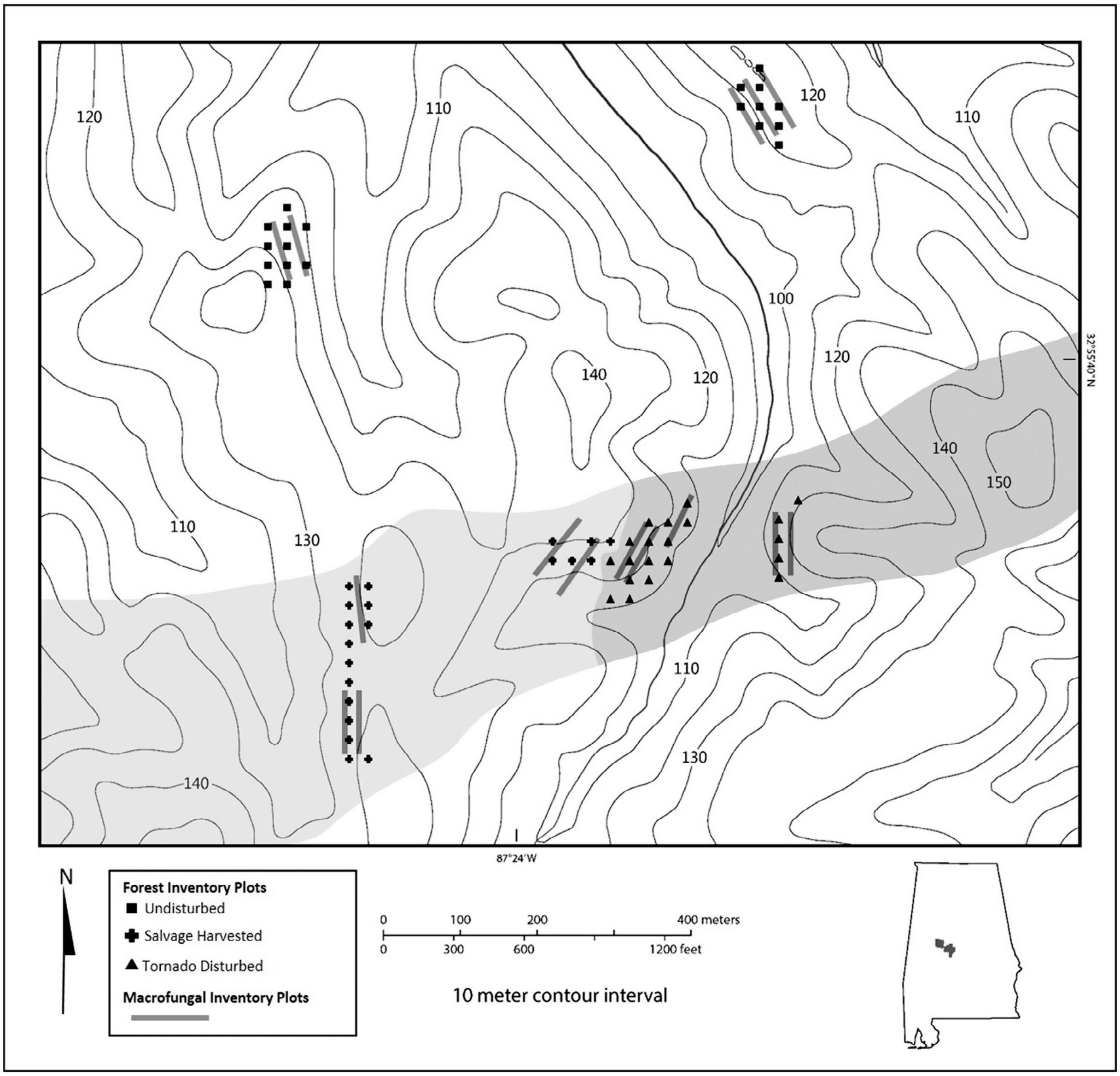

Fig. 1. Map of the study site within the Oakmulgee Ranger District, Talladega National Forest, Alabama, USA. Shaded region indicates areas disturbed by an EF3 tornado on 27 April 2011. Light grey shaded region indicates areas subsequently salvage harvested following the tornado. Squares represent undisturbed forest inventory plots, triangles represent tornado disturbed forest inventory plots, and plus signs indicate salvage harvested forest inventory plots. Grey bars indicate macrofungal inventory plots. Shaded area on the Alabama inset map indicates the Oakmulgee Ranger District.

change threatens to increase the frequency and intensity of disturbance agents such as tornados, hurricanes, and wildfires (Dale et al., 2001). Additionally, the practice of salvage harvesting following disturbance in forest ecosystems remains prevalent throughout the world, despite the dearth of information regarding its long-term ecosystem impacts (Royo et al., 2016). The majority of forest disturbance studies, including those on salvage harvesting, have focused on the alteration of woody plant composition and forest structural attributes (Peterson and Leach, 2008a; Lang et al., 2009; Waldron et al., 2013; White et al., 2014; Royo et al., 2016; Fraver et al., 2017). Few studies have considered the impacts of disturbance events on fungal communities, and a paucity of information on fungal ecology and biogeography exists for many geographic regions and ecosystem types. The differential impacts of various disturbance agents, magnitudes, and severities on fungal communities must be subject to further study to optimize conservation and management efforts concerned with protecting fungal biodiversity and associated ecosystem function.

Ectomycorrhizal (ECM) and saprotrophic fungi are two distinct fungal groups prevalent in forest ecosystems. ECM fungi derive their carbon from living plant roots, typically those of woody species, while saprotrophic fungi derive carbon from dead organic material. Studies considering the successional patterns of ECM fungi have often found higher species richness in older forests (Visser, 1995; Fernandez-Toiran et al., 2006; Twieg et al., 2007), suggesting that many ECM fungi may not be able to persist through or establish soon after stand initiating disturbance events. These phenomena are likely caused by removal of the host plant community (e.g. mature trees) and alterations to the abiotic environment such as increased light exposure, which can raise soil temperatures and hinder ECM fungal growth (Parke et al., 1983; Bruns, 1995). Compositional shifts in ECM communities have also been reported following disturbances such as fires (Taylor and Bruns, 1999) and tornadoes (Craig et al., 2016), however the lack of species-specific life history data makes it difficult to assess these shifts. Harvesting operations can create impacts distinct from those of natural disturbance agents, and thus may have unique effects on ECM fungi. For example, soil compaction and mixing is often a consequence of timber harvesting that can impact soil inhabiting organisms. These disruptions in the soil environment can cause physical damage to fungal hyphae and