POST-FIRE RESPONSE OF BRYOPHYTES IN ASSOCIATION WITH UNDERSTORY VASCULAR PLANTS IN THE LOST PINES ECOSYSTEM OF CENTRAL TEXAS

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Post-fire Response of Bryophytes in Association with Understory Vascular Plants in the Lost Pines Ecosystem of Central Texas. (May 2014)

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Bryophytes, which are usually early-responders to disturbance, have generally not been included in post-fire vascular plant research and may be an important element in the fire-recovery process. This study expands the work of past studies of forest succession after fire by combining vascular and non-vascular community fire-response interactions in a comprehensive evaluation of understory response to the Bastrop Fires of 2011. Approximately two years after the fire, I quantified herbaceous and non-vascular plant cover in both heavily burned and unburned riparian and upland areas in two adjacent watersheds of the unique Bastrop Lost Pines Ecosystem to identify recognizable post-fire plant assemblage patterns. I also measured soil moisture and estimated ground cover percentages of litter, bare ground and rock. Results demonstrate clear differentiation in species presence. Vascular plant species diversity and abundance was higher in burned areas while bryophyte presence in burned areas was primarily restricted to a limited number of early disturbance species. In unburned areas, bryophyte diversity was high while vascular plant diversity and abundance was low. Burned areas had low bryophyte diversity but were dominated by both vascular and non-vascular species commonly associated with disturbance. A significant finding is that soil moisture was higher in burned areas than unburned areas. Litter cover was not found to inhibit groundcover species regeneration, however litter composition and thickness may have an influence. Results of this study offer inferences into interactions between bryophytes and vascular plants and the role these interactions play in ecosystem recovery processes.

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DEDICATION

This thesis is dedicated to Kenneth A. Hanson with love and enduring gratitude for his support and patience during my many months of field work and long hours of word- and data- wrangling.

ACKNOWLEDGEMENTS

This thesis would not have been possible without the invaluable help of two very important people.

Dr. Georgianne Moore guided me through the experimental design and patiently walked me through the steps of the thesis-writing process with critical insights into wording and how best to convey information. She also played a major role in organizing and making sense of the data that I collected.

Over the course of many months at the microscope, S. M. Tracy Herbarium curator Dale A. Kruse taught me to identify bryophytes and later gave critical facilitation in manipulating multivariate species data. His good sense of humor enhanced both tasks. Led Zeppelin will never be the same.

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CHAPTER I

INTRODUCTION

The capacity of species to colonize disturbed sites can determine ensuing vegetation patterns. Disturbance events such as fire dramatically alter ecosystem functioning. However studies on the interactions between fire and understory diversity rarely take bryophytes into account (Ryömä and Laaka-Lindberg 2005). Bryophytes are able to grow on mineral soil and can reproduce as soon as moisture is available. As a result, bryophytes provide much-needed early cover to soil in burned areas (Kayes et al. 2010). The initial dominance of bryophytes may play an important role in the success of forest restoration and successional pathways in mixed, conifer forests, particularly within the first four years after fire (de las Heras-Ibáñez et al. 1991, Ryömä and Laaka-Lindberg 2005, Kayes et al. 2010).

Although bryophytes as a plant group are well-researched in Mediterranean, Australian and western and northern North American ecosystems, bryophytes are rarely included in vascular plant studies (Fensham and Streimann 1997, Heinselman and Wright 1973). Little is known about bryophyte effects on vascular plants (Soudzilovskaia et al. 2011). In 1954, Eula Whitehouse (1954) noted the lack of research on Texas moss ecology. Since that time there have been few studies on bryophyte and vascular plant associations in Texas (Huston 2007). Data on bryophyte/vascular associations is inconclusive with some studies determining that a relationship exists, while others indicate that there is no relationship between bryophytes and vascular plants (McCune and Antos 1981, Söderström 1981, Fensham and Streimann 1997). Söderström (1981) determined that vascular plant and bryophyte diversity in spruce forests of central Sweden was dependent on slope aspect alone. McCune and Antos (1981) found an equal diversity of bryoid and vascular strata in the *Abies grandis* (Douglas ex D. Don) Lindl. dominated forests of Montana based on microclimate heterogeneity. Fensham and Streimann (1997) found a strong correlation between moss species richness and vascular species richness based on moisture, substrate and canopy in a dry rainforest in northern Queensland, Australia.

Two studies of note taking place in *Pinus taeda* L. dominated forests in Texas have emerged in recent years. A 2007 study identified eight bryophyte community types in the east Texas Pineywoods region (Huston 2007). An endangered species study for the Houston toad (*Bufo houstonensis*) was conducted by Texas Parks and Wildlife (TP&W) in some of the same watersheds as my study but did not include bryophytes. TP&W determined vascular plant responses to low, moderate and high severity fires. These fires included both prescribed fires conducted 2009 to 2011 and the 2011 wildfire (Brown et al. 2014). Because loblolly pine ecosystems are adapted to frequent low-intensity fires (Waldrop et al. 1992), the 2011 Bastrop high-intensity fire was a maladapted circumstance providing a unique research opportunity.

One of our most compelling contemporary concerns is climate change and how it affects ecosystem function. Bryophytes are an unexplored source of information on the environmental effects of climate change as the new “canaries in the coal mine” (Tuba et al. 2011) and are good indicators of environmental change (Newmaster et al. 2005). Soudziilovskaia et al (2011) found that climate or anthropogenic driven change effects on bryophyte species composition had direct effects on forest community composition. Given the combined effects of the Bastrop fires of 2011 and the ongoing drought, research on bryophyte and vascular plant species associations in the Lost Pines Ecosystem may provide insight into interactions that may affect fire recovery and functional restoration in ways that are not yet understood. Bryophyte association patterns can be used to determine species that are appropriate for conservation planning (Fensham and Streimann 1997) and hence restoration of damaged or stressed environments.

The first study objective was to identify site conditions impacting vascular and non-vascular species presence and composition, and determining species abundance by percent cover. Site conditions included soil moisture, amount of litter, percent overstory shade cover, and location in riparian or upland areas. Three associated hypotheses were that there would be a) a negative relationship between litter and groundcover species cover that is associated with germination limitation; b) that increasing canopy shade in unburned areas would result in low groundcover species cover; and c) that soil moisture would limit groundcover. The second objective aimed to compare burn responses of bryophytes to vascular plants and determine species predominance in burned or unburned sites. I hypothesized that species predominance would differentiate between burned and unburned areas. The third objective endeavored to identify specific vascular plant and bryophyte community assemblages in burned versus unburned sites and identify indicator species. The hypothesis was that burned and unburned areas would have distinctly different plant and bryophyte communities and indicator species.

Different species of bryophytes depend on varying types of substrates (Newmaster et al. 2005). Because of the sampling issues that can arise from different substrates (rocks, soil, fallen branches, and trees) and the difficulty in correlating that data with vascular understory plants, this study will focus on soil and decaying wood substrate bryophytes growing in direct contact with the soil. These bryophytes are the most likely to have impact on vascular plant assemblages.

CHAPTER II

METHODS

The study area consisted of two adjacent watersheds in the Bastrop Lost Pines Ecosystem in a loblolly pine-dominated forest. The Price Creek watershed study area was moderately to heavily burned in the 2011 Bastrop County Complex Fire. The Spicer Creek watershed was unburned, but displayed evidence of pine beetle damage. Price Creek watershed dominant vegetation consisted of understory and groundcover disturbance species such as *Heterotheca subaxillaris* (Lam.) Britton & Rusby, disturbance mosses such as *Funaria hygrometrica* Hedw. and *Ditrichum pallidum* (Hedw.) Hampe, and the grass species *Dichanthelium* (Hitchc. & Chase) Gould. The Spicer Creek watershed was dominated by canopy species such as *P. taeda* where pine beetles were not present, *Juniperus virginiana* L., *Ilex vomitoria* Aiton and exhibited very little understory and groundcover diversity. Both areas had *Quercus stellata* Wangenh. present; those in the burned Price Creek watershed were resprouting from burned trees.

Both watersheds have very similar elevations. The elevation for the Price Creek watershed ranged from 557 to 604 feet, averaging 579 feet and the Spicer Creek watershed elevation ranged from 544 to 671 feet, averaging 572 feet.

Although the soils in the two watersheds have different classifications, they are both acidic thermic paleustalfs and are similar. Soils in the burned watershed are Silstid loamy fine sand with 1 - 5 percent slopes. The unburned watershed soils are Padina fine sand with a slightly steeper slope at 1 - 12 percent and have a thicker epipedon (Soil Survey Staff 2013). Both have deep sandy surface layers. (See figure 1).

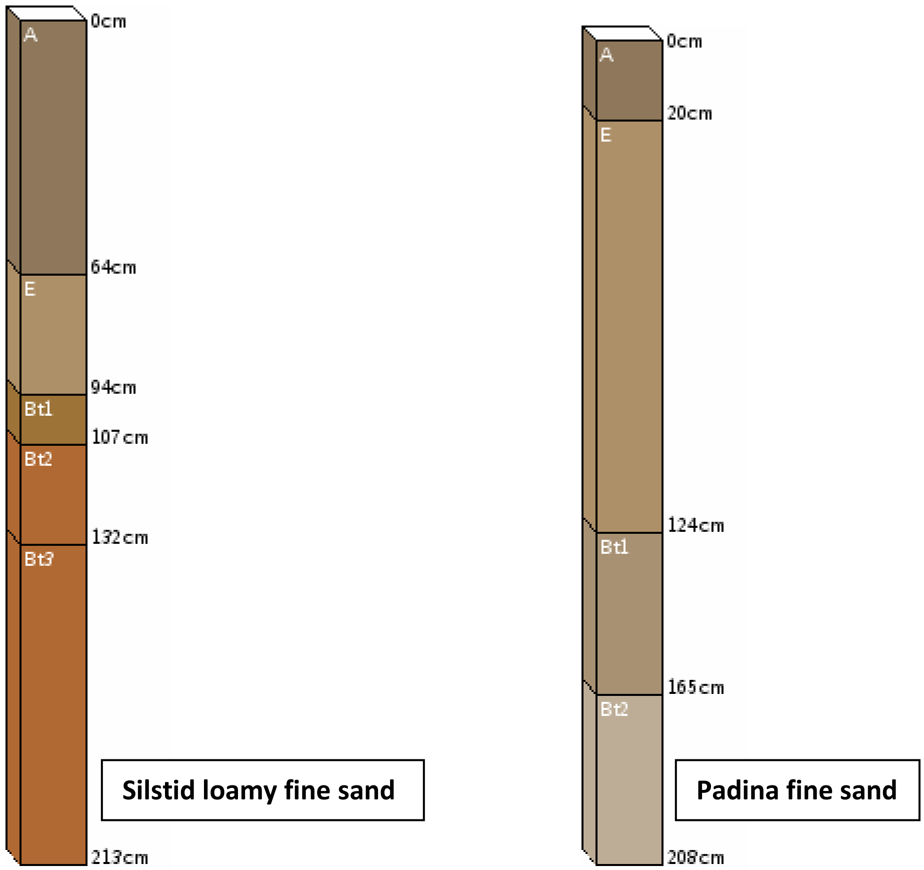

Figure 1. Soil profile of the burned watershed soil Silstid loamy fine sand (left) and the unburned watershed soil Padina fine sand (right) (Soil Survey Staff 2013).

This study used a stratified random sampling method with 1 m^2 permanent plots in riparian and upland strata along 80 meter transects. Transects were perpendicular from stream beds at regular 20 meter intervals with a random start point. Five riparian quadrats were placed at 5 meter intervals along each transect, the first starting just above the active channel. A 20 meter gap was established, followed by five upland 1 m^2 quadrats placed at 5 meter intervals. Each transect had ten quadrats, five each per study area. Two watersheds were identified: one heavily to moderately burned, one unburned. Five transects were set up in each of these two watersheds for a total of ten transects and one hundred quadrats.

Data collected included soil moisture, soil texture, plant cover percent, non-vegetative groundcover percent, burn severity, and type of soil cover. Soil moisture was measured with a FieldScout TDR 100 Soil Moisture Meter at a depth of 20 cm with three replicates per quadrat. Soil was textured by feel. Plant cover was determined by percent cover estimates in three strata: canopy – above 15 feet, understory – between 1.5 and 15 feet, and groundcover – below 1.5 feet. Plant cover often exceeded 100 percent due to the stratified nature of vegetative growth. Non-vegetative soil cover was estimated by percent bare ground, litter and rock on the soil surface. Soil cover percentages always equaled 100 percent. Plants were identified to the species level when possible. Because of the complexity of moss communities, percent cover for all present bryophytes was estimated as a whole for all present species. Individual bryophyte species were then identified by frequency only. Burn severity was classed as heavily burned, moderately burned or unburned. Soil cover class was identified using FIREMON cover/frequency code protocol (Lutes 2006).

Two sets of data were collected to ensure record of plants that may be seasonally dormant. One test data set was collected as transects were being set up over the course of five months (August to December) but was not used. The second data set was collected during the course of one week in December and formed the basis of study results (See Table 1). This time of year coincides with bryophyte activity.

Table 1. Transect coordinates, dates of collection, soil type, and burn condition.

Transect	Sampling date	N coordinates	W coordinates	Soil Type	Burn condition
GLT1	12/16/2013	30.19086˚	97.22485˚	Silstid loamy fine sand	Heavy
GLT2	12/16/2013	30.19224˚	97.22781˚	Silstid loamy fine sand	Heavy to moderate
GLT3	12/17/2013	30.19240˚	97.22719˚	Silstid loamy fine sand	Heavy to moderate
GLT4	12/17/2013	30.19255˚	97.22763˚	Silstid loamy fine sand	Heavy to scorched
GLT5	12/18/2013	30.19427˚	97.22863˚	Silstid loamy fine sand	Heavy
GLT6	12/18/2013	30.19613˚	97.22562˚	Padina fine sand	Unburned
GLT7	12/19/2013	30.19621˚	97.23578˚	Padina fine sand	Unburned
GLT8	12/19/2013	30.19620˚	97.23602˚	Padina fine sand	Unburned
GLT9	12/20/2013	30.19624°	97.23623˚	Padina fine sand	Unburned
GLT10	12/20/2013	30.19544°	97.23230°	Padina fine sand	Unburned to scorched

Analysis

To identify site conditions impacting species presence, abundance and composition, I compared soil moisture, amount and thickness of litter, percent overstory shade cover, and quadrat location between riparian and upland areas using univariate and multivariate regression. I then compared the burn responses of bryophytes and vascular plants, determining species predominance in burned or unburned sites by ranking the ten most common vascular and non-vascular plants in heavily burned and unburned conditions. Species community data was determined with PC-ORD in a multivariate analysis of ecological communities. Vascular plant and bryophyte associations and indicator species were identified.

CHAPTER III

RESULTS

As a whole, soil moisture levels were extremely low at the time of sampling. Overall soil moisture was higher in burned quadrats than unburned quadrats (See figure 2). Soil moisture was generally higher in riparian quadrats than in uplands.

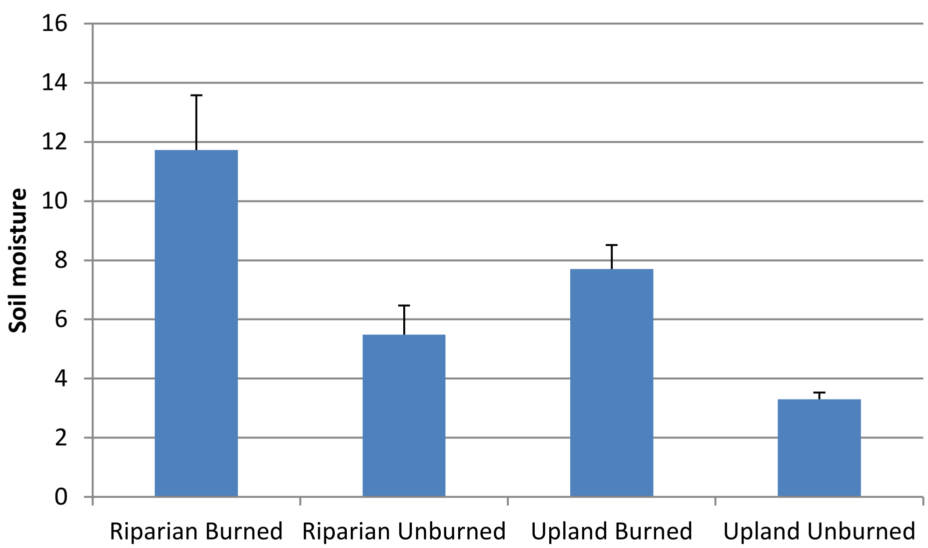

Figure 2. Soil moisture in burned and unburned riparian and upland quadrats.
Error bars are standard errors (n = 25 quadrats per category).

In comparing groundcover species cover with soil moisture in burned areas, there was a mixed trend among transects with no generalizable relationship ($p > 0.05$). When comparing groundcover species cover with soil moisture, there was also no relationship ($p > 0.05$). There was no evidence to support the hypothesis that surface soil moisture limited ground cover abundance within unburned areas.

Soil conditions in burned areas were very poor, consisting of bare ground and ash in most quadrats. Litter cover in burned areas exceeded 90 percent, but averaged only 50 percent in burned riparian areas and 74 percent in burned upland areas (See figure 3).

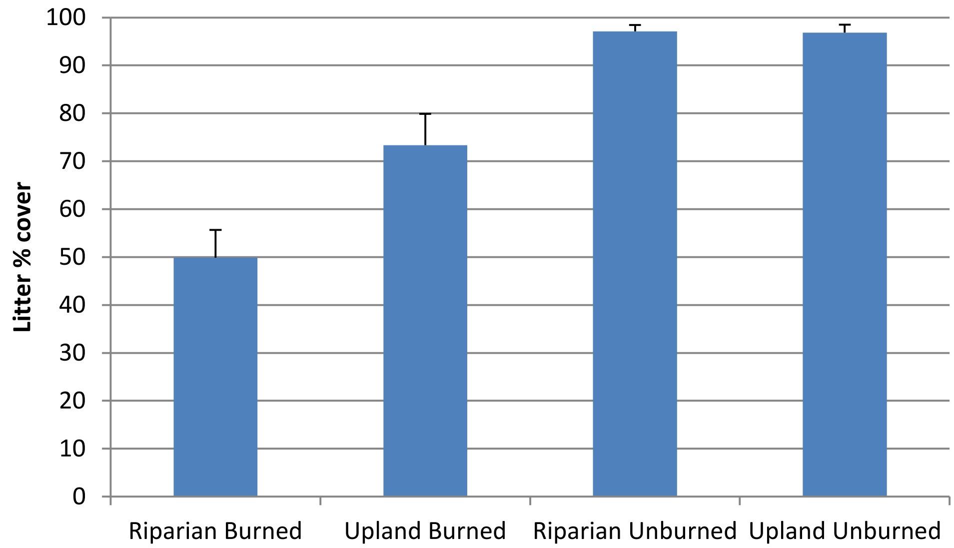

Figure 3. Litter percent cover in burned and unburned riparian and upland quadrats. Error bars are standard errors (n = 25 quadrats per category).

I found no evidence to support the hypothesis that litter cover inhibited groundcover establishment. To the contrary, in burned areas, there was a weak positive relationship between litter cover and ground cover (See figure 4).

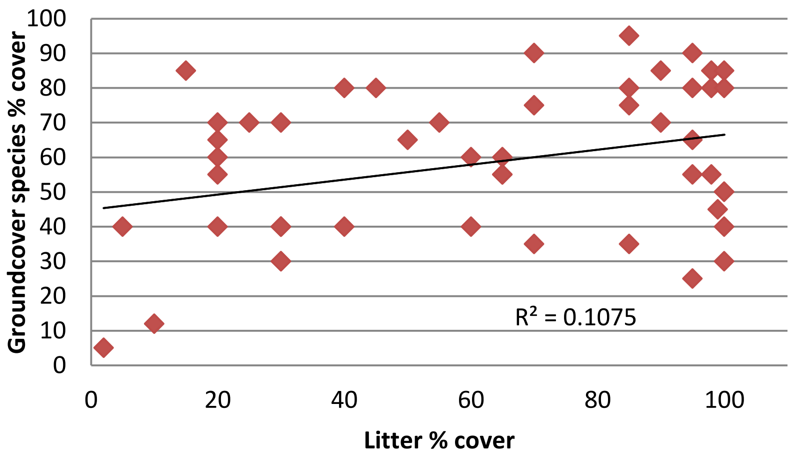

Figure 4. Litter percent cover compared to groundcover species cover in burned quadrats.

Groundcover species found in burned and unburned areas were distinctly different. In general, vascular plant species diversity and abundance was higher in burned areas. Bryophyte abundance was also higher in burned areas, particularly in riparian areas. Bryophyte abundance overall rivaled that of the dominant vascular plants (See figure 5). Burned areas were dominated by *Polypremum procumbens* L., unburned areas by *I. vomitoria* and *J. virginiana*. *Dichanthelium* sp. was also common in burned riparian quadrats, but also occurred frequently in unburned upland quadrats. Resprouts of *Q. stellata* were commonly found in burned upland quadrats. Other common species were *Baccharis* L., and *Vaccinium arboretum* Marshall.

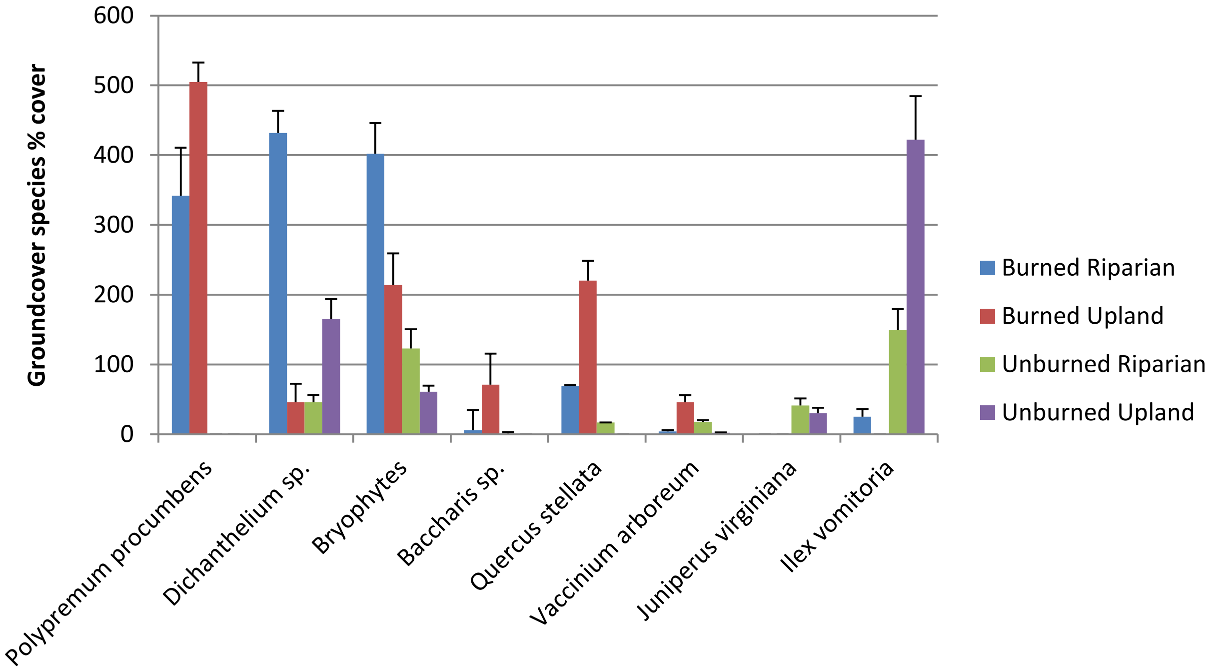

Figure 5. Total percent groundcover of bryophytes and most abundant vascular plant species.

Two bryophytes known to be disturbance species, *F. hygrometrica* and *D. pallidum* were most abundant in burned areas (See figure 6) with ten and twenty four occurrences, respectively. *F. hygrometrica* had nearly twice as many occurrences in riparian quadrats than upland quadrats, whereas *D. pallidum* was evenly distributed between both riparian and upland areas. Four bryophyte species were only present in riparian quadrats with highest frequency closest to the active channel of the creek.

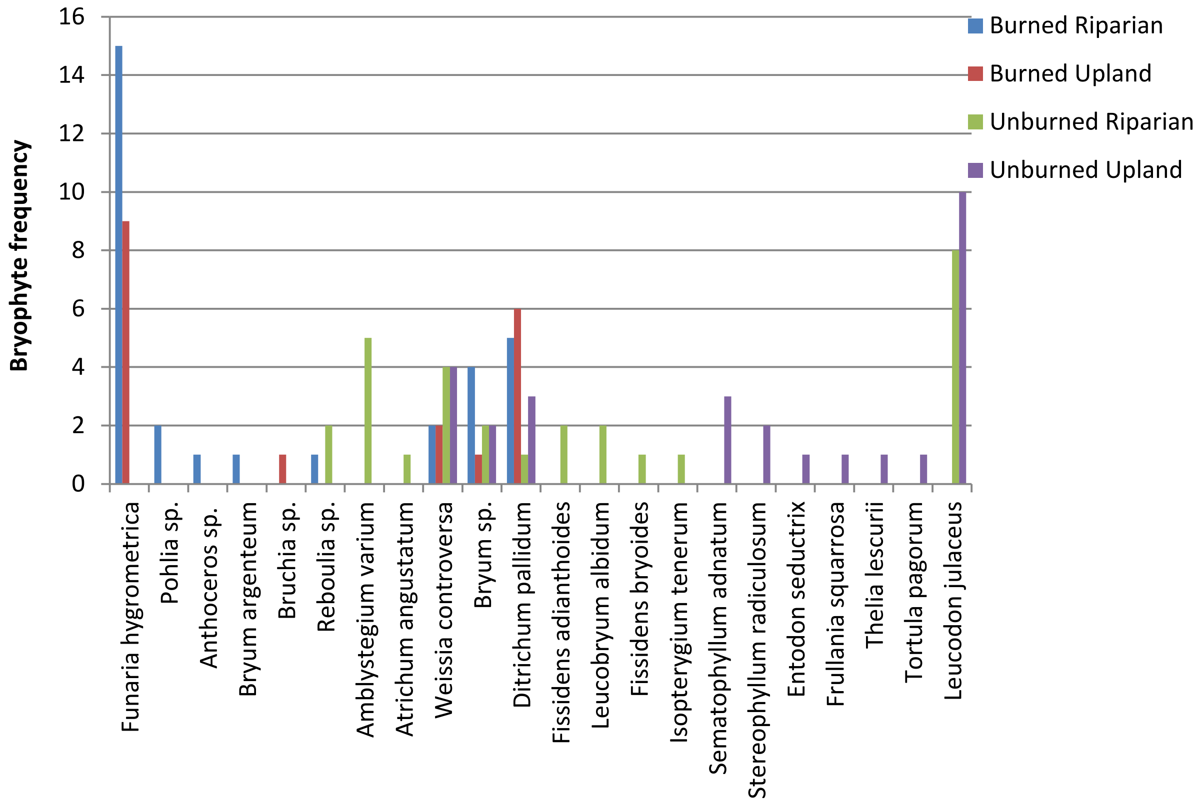

Figure 6. Bryophyte frequency in all quadrats.

Unburned areas had seventeen bryophyte species (See figure 6). Species richness was dominated by *Leucodon julaceus* (Hedw.) Sull. and *Weissia controversa* Hedw. with an almost equal representation of approximately nine occurrences in either riparian or upland quadrats. *L. julaceus* is typically corticolous (Reese 1984) and its presence can be accounted for by the large amounts of decaying bark in the soil surface of unburned quadrats. Seven bryophyte species occurred only in riparian quadrats. Of these, *Amblystegium varium* (Hedw.) Lindb. is commonly found in damp areas (Reese 1984). Fourteen mosses were present in quadrats closest to the active channel, with numbers quickly dropping off with increased distance from the creek. Hornworts and liverworts (*Anthoceros* L. emend. Prosk. and *Reboulia* Raddi, nom. cons.) were restricted to riparian areas.

The understory in unburned quadrats was dominated by *I. vomitoria*, followed by *J. virginiana*. *Q. stellata* and *Baccharis* sp. dominated the burned understory. *Q. stellata* and *Baccharis* sp. were the two dominant species in burned understory (See figure 7).

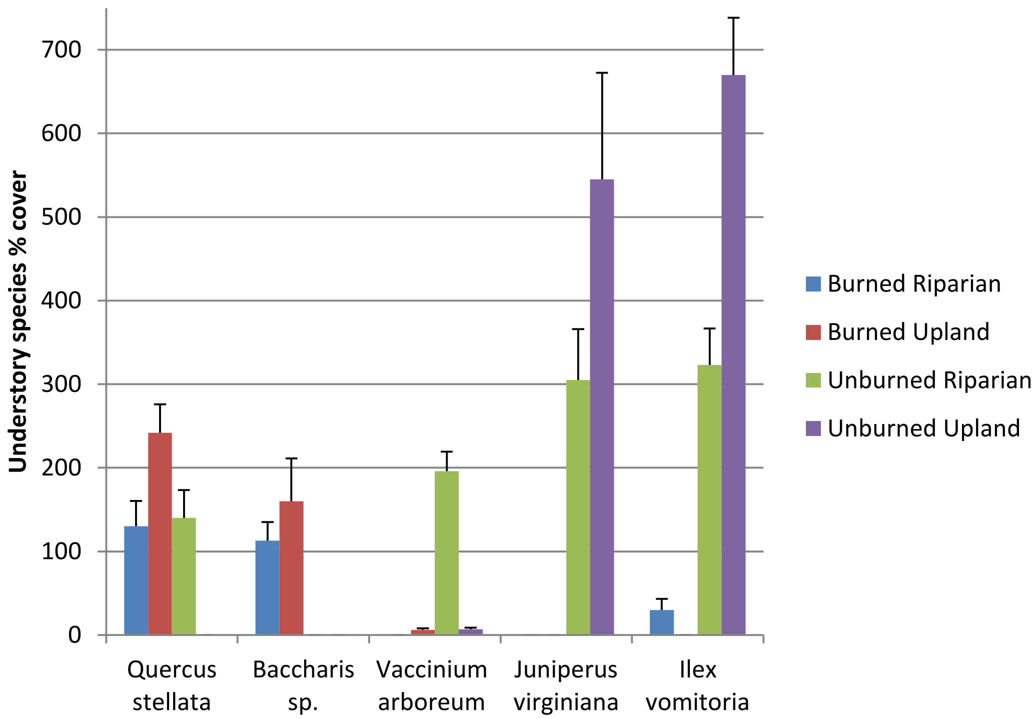

Figure 7. Total percent cover of understory species in all quadrats with standard error bars.

Canopy species (growing taller than fifteen feet) were virtually non-existent in burned areas. Three species occupied the unburned canopy strata. Of these, *J. virginiana* dominated in upland areas whereas *P. taeda* dominated in unburned riparia (See figure 8). A comparison of canopy cover in unburned areas to groundcover species cover showed a weakly negative relationship that was not significant.

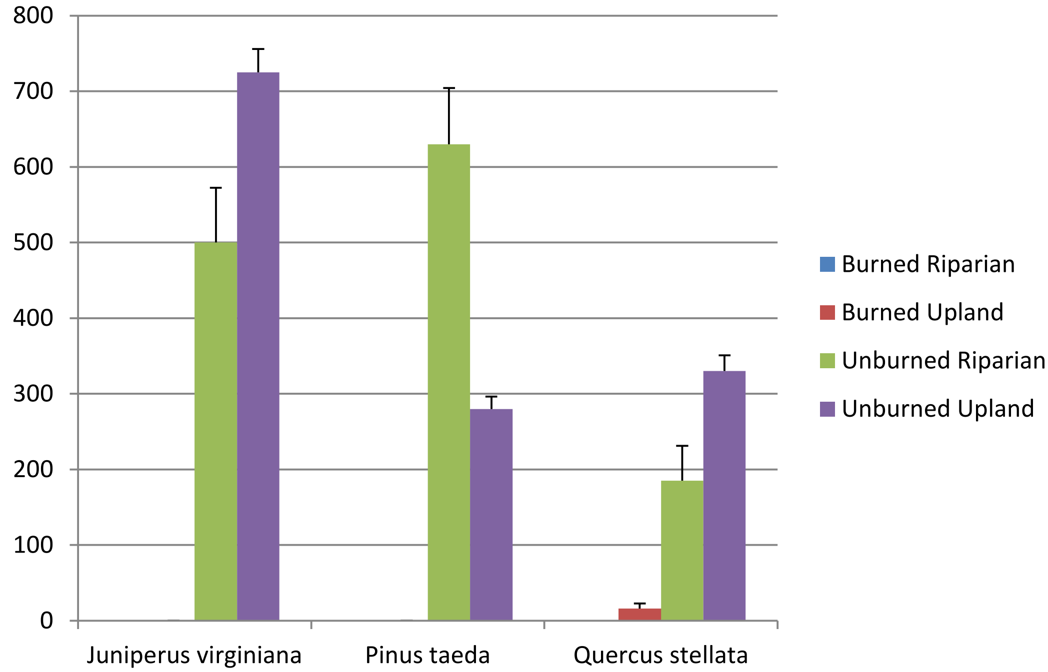

Figure 8. Total percent cover of canopy species with standard error bars. Burned areas had virtually no canopy cover.

PC-ORD analysis, based on frequency for all three strata, identified eleven indicator species using the Monte Carlo test of significance of observed maximum indicator value for a species. Species identified as indicator species had an indicator value (Brown et al. 2014) greater than 30 and p-value less than 0.05. An indicator species represents a "group based on constancy and distribution of abundance" (Peck 2010). The identified indicator species were *F. hygrometrica*, *D. pallidum*, *L. julaceus*, *W. controversa*., *Baccharis* sp., *Dichanthelium* sp., *I. vomitoria*, *J. virginiana*, *P. procumbens* and *V. arboreum*. The first four of these species are bryophytes. Three species were strong indicators with indicator values greater than 50 and a p-value of less than 0.05. Two were the predominant disturbance bryophyte species *D. pallidum,* and *F. hygrometrica*. The third was *J. virginiana.*

Frequency cluster analysis sorted four species communities fairly neatly between burned and unburned quadrats. A few anomalies occurred in a generalized or homogeneous species composition dominated by individual indicator species that appeared in both burned and unburned areas (See figure 9). The presence of indicator species *Dichanthelium* sp. and *D. pallidum* most frequently caused this anomaly.

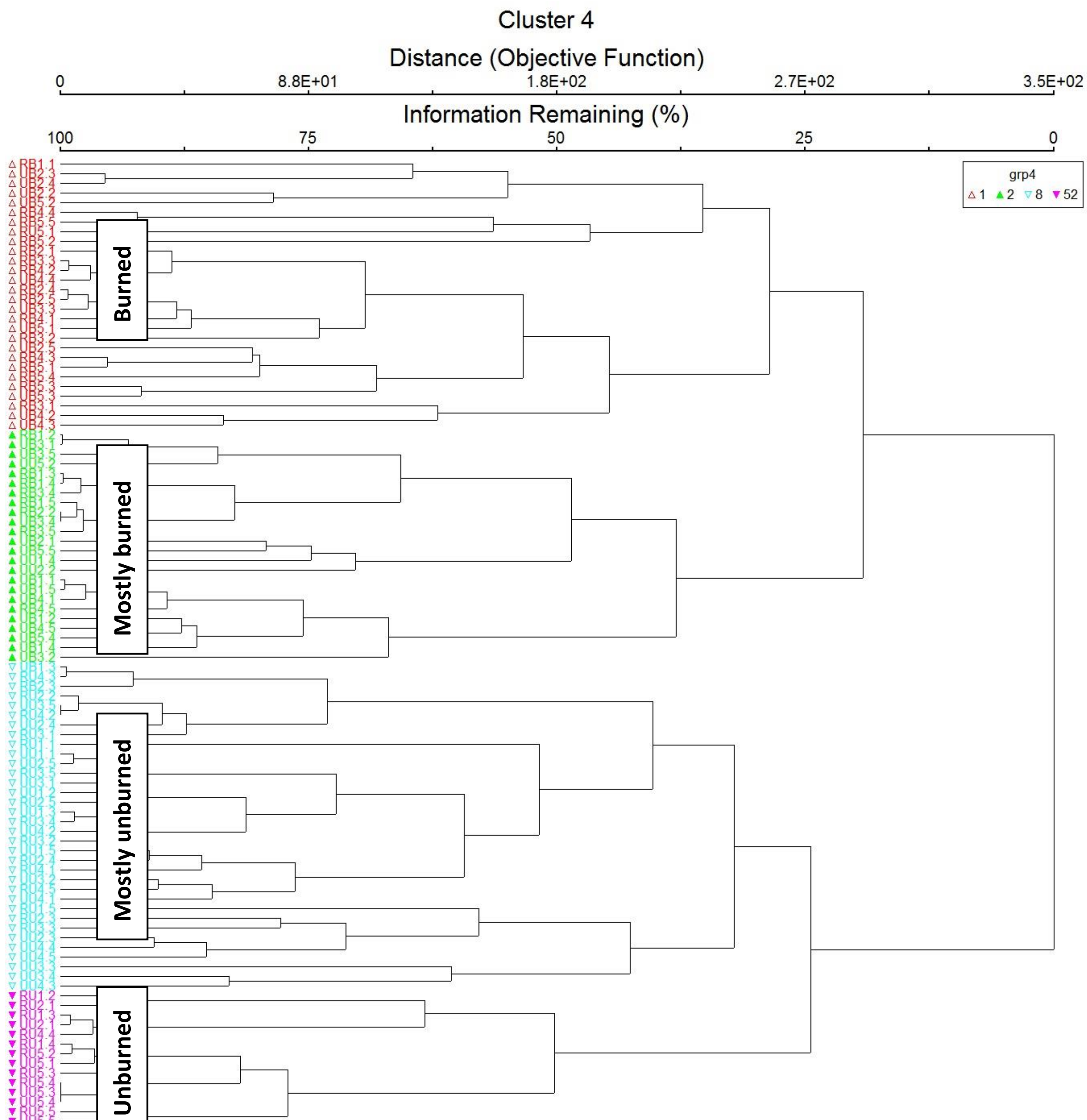

Figure 9.   PC-ORD Classification dendrogram showing four distinct species communities.

CHAPTER IV

DISCUSSION

Non-vascular plants have long been overlooked in their role as early-responders to disturbance and "setting the stage" for subsequent plant species succession. Pioneer mosses such as *F. hygrometrica* provide the ecosystem function of soil stabilization through rapid colonization which reduces wind and water erosion (Hardman and McCune 2010).

As early responders to disturbance, bryophytes are clearly part of ecosystem recovery processes. Pioneer primary producers, bryophytes have the ability to retain water, cycle nutrients and adapt to various habitats. These characteristics allow bryophytes to act as nurse plants that facilitate the reintroduction of vascular plants in disturbed ecosystems (Ren et al. 2010). Bryophytes also serve as good indicator species of riparian health (Hylander et al. 2002). Two of the four bryophytes identified as indicator species in this study (*F. hygrometrica* and *D. pallidum*), are early seral disturbance species, which pave the way for post-disturbance vascular succession.

Surface soil moisture on the dates of observation was low in all quadrats, averaging below ten percent (See figure 2), given that the last significant rain event of less than 1 inch occurred twenty days prior. This is stressful to plants and can limit their growth, although a total of 19 inches of rain fell in the previous twelve months (52 percent of normal) (Weather Underground 2014). Interestingly, burned plots were wetter than unburned plots. It is possible that canopy and understory species had increased transpiration and intercepted rainfall which reduced soil moisture.

I did not find evidence that litter inhibits regeneration (See figure 4). While litter cover was present in varying degrees throughout all transects (50 to 74 percent in burned areas and up to 100 percent in unburned areas), it is important to note that types and depth of litter in burned and unburned quadrats differed by my observation. Burned area litter was visibly thinner and consisted primarily of very fine grass residue. Unburned area litter consisted of a mix of oak, juniper and pine litter. In some quadrats, pine needle litter was as much as an estimated six inches deep.

I also did not find any evidence that lower groundcover in unburned areas was related to shading by the canopy. The fact that soil moisture was higher in burned areas suggests water availability may have been an important factor stimulating regrowth.

The two watersheds were only between 550 and 1,150 meters apart, yet plant species were dramatically different, indicative of the effect of fire and species response. Lower strata in burned areas were dominated by r-selected type species that are aggressive colonizers with a high incidence of annual species (During 1979). Overall diversity was higher in the burned watershed; however bryophyte diversity was somewhat higher in the unburned watershed (See figure 6). The overall trend is that groundcover vegetation diversity increased after the high-severity Bastrop fires of 2011.

Canopy species (growing taller than fifteen feet) were virtually non-existent in burned areas, as expected given the study area was heavily burned. Only three species occupied the unburned canopy strata. Of these, *J. virginiana* predominated in upland areas whereas *P. taeda* dominated in unburned riparia (See figure 8).

Resprouting *Q. stellata* dominated the understory in burned areas (See figure 7). In contrast, I did not find any *P. taeda* in any quadrats, burned or unburned. These results may inform Lost Pines restoration efforts and suggests a *P. taeda* introduction strategy. Some areas throughout the burn complex do have seedlings appearing, while many areas have been replanted with seedlings.

Groundcover species dominance was dramatically different between burned and unburned areas (See figure 10). Burned areas were fairly consistently dominated by *Dichanthelium* sp., *P. procumbens*, and bryophytes. *Dichanthelium* and bryophytes were the only species that were present in significant amounts in both burned and unburned areas. *Dichanthelium* is a species that readily reproduces readily from seed banks after disturbance (Mou et al. 2005). *P. procumbens* (juniper leaf) is a forb in the Buddlejaceae family. *Polyprenum* and has been shown to form a part of the soil seed bank in loblolly pine forests (Andreu et al. 2009). Overall, burned areas were dominated by both vascular and non-vascular species commonly associated with disturbance. Despite that fire prompted the appearance of some less common species like *P. procumbens*, none of the plants found were non-native invaders.

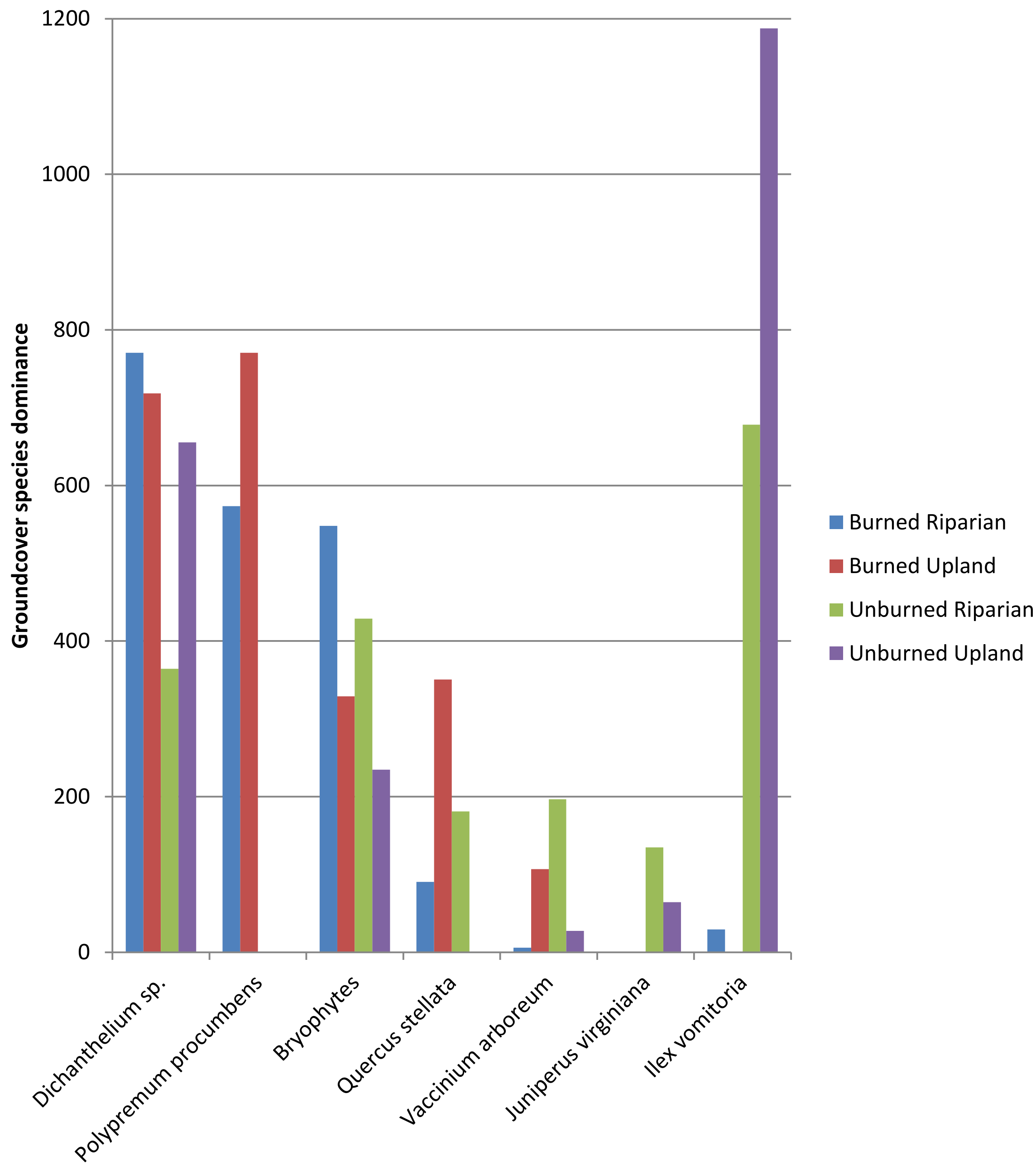

Figure 10. Groundcover species dominance in all quadrats.

Bryophyte species clearly differed between in burned and unburned areas (See figure 6). Both burned and unburned areas demonstrated highest bryophyte diversity closest to the creek channel. *F. hygrometrica*, the dominant bryophyte in burned areas, is considered a weedy, colonizing species (Dietert 1979) well known as a "fire moss" that is a post-fire early succession species (Dietert 1979, Shaw and Goffinet 2000). *Funaria* prefers an alkaline substrate with high nitrogen and potassium concentrations which is typical of post-fire soils (Dietert 1979, Duncan and Dalton 1982). An annual plant, it is considered a good environmental condition indicator (Dietert 1979). Durig (1979) classes *F. hygrometrica* as a "fugitive strategy species" with persistent, long-lived spores. *D. pallidum,* also dominant in burned areas is a bryophyte species common to disturbed areas (Reese 1984).

Funaria's counterpart in unburned areas is *L. julaceus* which has no presence in burned areas. Because *L. julaceus* typically grows on bark substrates (Reese 1984) it grew in areas where bark had not been burned away. Notably, all corticolous mosses were growing on *Juniperus*, *Quercus*, or *Ilex* bark but never on *P. taeda*.

W. controversa, along with *Bryum* spp., did not differentiate between both burned and unburned areas. *W. controversa* is another r-selected pioneer species with high reproductive frequencies but with a perennial life cycle (Dietert 1979, Hutsemekers et al. 2008). *Weissia* is easily identified in the field by the presence of yellow sporophyte seta.

Additional mosses including *Leucobryum albidum* (Brid. ex P. Beauv.) Lindb. and *Thelia lescurii* Sull. were observed in the unburned area outside the quadrats, but were not recorded.

Ten indicator species were identified as associated with plants found in either burned, unburned, or intermediate conditions (*F. hygrometrica*, *D. pallidum*, *L. julaceus*, *W. controversa Baccharis* sp., *Dichanthelium* sp., *I. vomitoria*, *J. virginiana*, *P. procumbens* and *V. arboreum).* Of note also is that major canopy species such as *P. taeda* and *Q. stellata* were not identified as indicator species.

The third community of species in mostly unburned quadrats resembles the *Leucodon-Frullania* mixed forest bryophyte community type identified by Huston (2007) in east Texas. In Huston's *Leucodon-Frullania* community, bryophytes mainly grew on bark substrates and *L. julaceus* was most abundant. In this community, bryophytes were inhibited from growing on soil substrates due to thick litter.

Brown et al. (2014) identified many of the same vascular plants in their Lost Pines burned areas. Of note is shared recognition of the dominance of *Dichanthelium* sp. throughout. They also found that *I. vomitoria* has a negative response to fire which is confirmed in my study by its near-absence in burned quadrats.

It should be noted that a number the loblolly pines in unburned upland areas were dead, presumably from beetle damage. Brown et al. (2014) identified an infestation of the pine engraver beetle (*Ips* spp.) in the Lost Pines *P. taeda* ecosystem. Further research may be able to establish a connection between loblolly beetle damage stress and high fire severity. These fallen trees and their bark and branches contributed significantly to ground surface litter depths.

More seasonally-specific work is needed as a follow-up to this study. The *H. subaxillaris* growing season occurs during the summer when most bryophytes are dormant. *H. subaxillaris* dominated study area quadrats as transects were being set up in the summer and fall but was virtually gone by the time data was collected in December. Summer and fall research could identify interactions of *H. subaxillaris* with the plant community. Additional research conducted during the spring rainy season when both bryophytes and vascular plants are dominant would also favorably augment the data from this study conducted in December.

Conclusion

This study demonstrates that bryophyte and vascular plant interactions have an important role in the post-fire Bastrop Lost Pines Ecosystem recovery process. Burned communities clearly differed in vascular plant species diversity and abundance. Groundcover species diversity was higher in burned areas, but bryophyte abundance was clearly lower and dominated by the pioneer moss *F. hygrometrica.* Higher surface soil moisture may have contributed to the differences observed in burned communities

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