LONG-TERM PRESCRIBED BURNING REGIME HAS LITTLE EFFECT ON SPRINGTAILS IN PINE STANDS OF SOUTHERN ARKANSAS

Michele L. Renschin, Lynne C. Thompson, and Michael G. Shelton[1]

Abstract—Concerns regarding the impacts of prescribed fires on faunal communities in pine stands have led to numerous studies. One soil/litter insect that may be influenced by fire is springtails, an important member of the forest floor community. A study was conducted in burned and unburned loblolly/shortleaf pine stands in southeastern Arkansas to examine whether springtail abundance, composition, and diversity were different between areas burned every 2 to 3 years over the past 20 years and areas not burned at all. Litterbags were used to collect springtails periodically over a 10-month period. Comparisons of springtail populations for the two treatments were analyzed by abundance, diversity, and similarity. A total of 5,528 individuals were collected, but only 92 percent could be identified to family; identified specimens represented 24 genera and 10 families. The prescribed fires significantly affected only one genus, *Orchesella*, which occurred in burned areas more frequently than in unburned areas. Springtail diversity was not affected by burning. Dendrograms based on Jaccard and Sorenson (Bray-Curtis) similarity indices showed no distinct grouping of the treatments. These results indicate that springtail populations on the sites are influenced more by other environmental factors than by prescribed fire.

INTRODUCTION

The health and productivity of an ecosystem can often be evaluated by quantifying the amount and diversity of organisms living in it. One group of organisms that is often used to evaluate ecosystem health and productivity is microarthropods. Microarthropods make significant contributions to processes such as decomposition, nutrient cycling, and soil formation; these processes help maintain and sustain forest productivity. Consequently, disturbances such as fire may affect these organisms and alter the processes they mediate, thus influencing forest productivity (Fritze and others 1993). Soil faunal populations are of particular importance in forest soils because they are highly important in the breakdown of forest litter (Fisher and Binkley 2000, Heyward and Tissot 1936, Weaver and Heyman 1997). One important group of soil fauna that are often studied is the collembolans or "springtails". Although very common and abundant, springtails are seldom observed because of their small size and habit of living in concealed situations. They are most commonly found in or near soil, bark, logs, fungi, and leaf litter and have populations of up to 100,000 individuals per m^2 or more (Christianson and Bellinger 1998). Although the functional contribution of collembolans in a soil community is difficult to assess, inferences can be made from their populations and species diversity. Because Collembola can be a good indicator of ecosystem health (Weaver and Heyman 1997), it may be possible to use their sensitivity to prescribed fire as a gauge of the mesofauna population as a whole. Although information is available on the impact of fire on fungi and bacteria (Fritze and others 1993), the impacts of fire on soil fauna are not well documented. There have been relatively few studies relating prescribed fire use with forest floor collembolan communities in southern pine stands (Johnston and Crossley 2002). Although intense fires affect microorganisms most dramatically, less intensive fires, as typified by prescribed burning in the South, usually have little impact, because only minor changes in soil properties are associated with fire (Wade and Lunsford 1989). A better understanding of how fire alters soil faunal populations is essential to fine-tune forest management. The following study was initiated to evaluate the effects of long-term use of prescribed fire on collembolan populations. The objective of the study was to examine whether collembolan abundance, composition, and diversity are different between burned and unburned treatments.

METHODS

Study Area and Treatments

The study was located in three compartments of the Crossett Experimental Forest in southern Ashley County, AR. Stands consisted of loblolly (*Pinus taeda*) and shortleaf pine (*P. echinata*) and are managed using uneven-aged management (Cain and Shelton 2002). Two burn treatments, established in January of 1981, were used: (1) an unburned control, and (2) an irregular interval winter burn (2 to 3 years). Six 1-ha plots were used, one unburned control, and one irregularly burned plot in each of the three compartments. Within each measurement plot, three subplots were installed for placement of litterbags.

Sampling

Litterbags (Berg and others 1998) were 30 cm by 30 cm with a mesh size of 5 mm on the top and 2 mm on the bottom. Six litterbags, each filled with 20 g of pine foliage litter collected in the fall of 1999, were placed into the field on February 24, 2000, and collected after 1, 2, 5, 7, and 10 months. A Berlese funnel was used for collembolan extraction. Collembola were sorted from the rest of the

[1]Former Graduate Research Assistant and Professor, Arkansas Forest Resources Center, School of Forest Resources, University of Arkansas at Monticello, Monticello, AR 71656-3469; and Research Forester, USDA Forest Service, Southern Research Station, Monticello, AR 71656-3516, respectively.

Citation for proceedings: Connor, Kristina F., ed. 2004. Proceedings of the 12th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–71. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 594 p.

extracted organisms, stored in 75 percent ethyl alcohol, and later identified. Except for the families Hypogastruridae and Neanuridae, identification was done to genus using several established collembolan keys (Bellinger and others 2003, Christianson and Bellinger 1998). Dr. Richard Snider, Department of Zoology, Michigan State University, identified voucher specimens. Additional genera and one family, which were not identified as vouchers at the date of this paper, were labeled as Morphogenus 1 - 5 and Morphofamily 1.

Statistics

Abundance of individuals occurring within treatments was compared using an analysis of variance with a split plot design (SAS Institute Inc. 1990). Diversity was measured using the Shannon-Weiner index (Colwell 1997). Cluster analysis (McCune and Medford 1999) used resemblance coefficients to evaluate the similarity of burned and unburned treatments. The unweighted pair-group method was used because it produces less distortion in transforming similarities into a dendrogram (Romesburg 1984). The Jaccard index uses presence-absence or binary (0 or 1) data, whereas the Sorenson (Bray-Curtis) index uses abundance information. The Sorenson and Jaccard indices are two of the most useful and widely-used indices (Magurran 1988).

RESULTS

A total of 5,528 individuals were collected, but only 92 percent could be accurately identified to family because some specimens were damaged or otherwise rendered unidentifiable. The 5,062 specimens identified represented 10 families and 24 genera (table 1). The overall abundance of collembolans was slightly, but nonsignificantly, greater on the burned versus unburned areas. Of the 24 genera collected, 17 had greater abundance in the burned areas. The number of specimens collected by genus ranged from 4 (*Katianna*) to 533 (*Orchesella*). Only one genus, *Orchesella*, was significantly more abundant in the burned treatments than the unburned treatments ($P = 0.022$). The burned treatments were slightly, but not significantly ($P = 0.119$), more diverse than the unburned areas. The mean Shannon diversity index was 2.21 for the burned areas and 2.08 for the unburned areas. The unburned sites exhibited higher variation in diversity across subplots than the burned sites.

Using the Jaccard index (fig. 1), both treatments of compartment 11 are the same, and those for compartments 24 and 55 are dissimilar. Using the Sorenson index, the burned area of compartment 24 separates out as very different. This result is not surprising, because the burned areas of compartment 24 exhibited high numbers of collembola (particularly *Hydroisotoma*), which would influence the Sorenson index. The Jaccard index would be more influenced by the presence of genera not found elsewhere, which occurred on the unburned areas of compartment 24.

Table 1—Treatment totals for collembolan genera extracted from 108 litterbags from February 2000 to January 2001 in burned and unburned areas of uneven-aged loblolly-shortleaf pine stands in southern Arkansas

Family/*Genus*	Burned	Unburned	Total
Family Dicyrtomidae			
Ptenothrix	7	5	12
Family Sminthurididae			
Sminthurides	35	23	58
Family Katiannidae			
Katianna	3	1	4
Sminthurinus	82	29	111
Family Sminthuridae			
Sminthurus	97	32	129
Neosminthurus	79	193	272
Family Tomoceridae			
Tomocerus	22	10	32
Family Neanuridae[a]	157	214	371
Family Entomobryidae			
Entomobrya	82	61	143
Lepidocyrtus	276	194	470
Pseudosinella	207	273	480
Orchesella	384	149	533
Family Isotomidae			
Cryptopygus	10	4	14
Isotoma	71	52	123
Isotomurus	31	24	55
Isotomiella	27	40	67
Hydroisotoma	399	11	410
Isotomid Morphogenus 1	17	3	20
Isotomid Morphogenus 2	43	48	91
Isotomid Morphogenus 3	49	28	77
Isotomid Morphogenus 4	6	0	6
Isotomid Morphogenus 5	49	24	73
Family Hypogastruridae[a]	644	822	1,466
Morphofamily 1			
Purple Morphogenus	3	45	48
Total	2,780	2,285	5,065

[a] Individuals were not identified to genus.

DISCUSSION

There is growing interest in using prescribed fire to restore habitat for threatened species. One concern with its use is that by promoting habitat for one species, habitat may be lost for others. Modifications of environmental conditions beyond the capacity of a species to adapt result in the loss of certain species and the addition of others (Paquin and Corderre 1997). Many of the studies occurring in the southeast have focused on groups of species that are more mobile (e.g., butterflies, flies) and less labor intensive to study. Prescriptions developed for these more mobile species may be harmful to less recognizable groups, such as the forest floor fauna, that cannot escape flames. This study began by asking the question: Does long-term prescribed fire influence collembolan populations in these stands and, if so, how? Results from other studies investigating fire effects on collembolan populations have been variable (Dindal and Metz 1976, Henig-Sever and others 2001). Many studies revealing reductions in collembolan populations are done short-term (e.g., Dindal and Metz 1976), whereas studies investigating the effects of fire after a longer period of time (such as this study) have shown rapid recovery (Kalisz and Powell 2000, Wikars and Schimmel 2001).

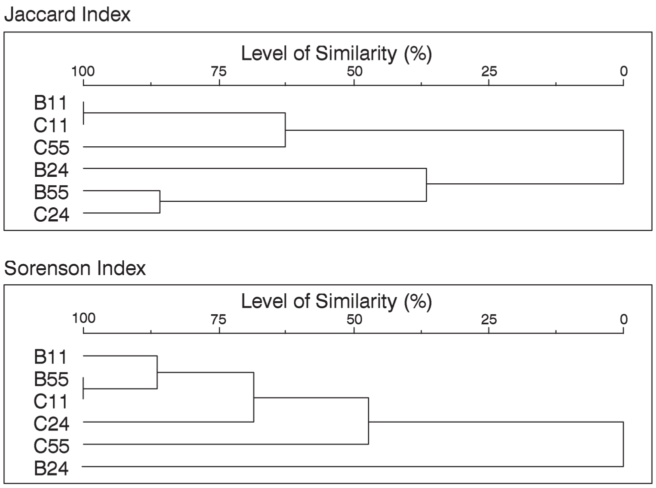

Figure 1—Dendrograms using the Jaccard and Sorenson indices to depict the relationships between collembolan genera from three burned and three unburned stands. The letter is treatment (B = Burn or C = Unburned Control), and the number identifies study site compartment [or replicate] (11, 24, and 55).

Numerically, this study shows a trend for higher abundance and diversity in burned stands than unburned stands. Although this trend was not statistically significant, it is unknown whether or not it is biologically significant. It is not apparent that there were large shifts in collembolan composition as a result of the fires. The only genus that showed significant differences between treatments was *Orchesella*. Some studies have shown certain species or families to be positively correlated with fire conditions. This study observed increases in some genera and decreases in others. In conclusion, it seems that 20 years of prescribed fire have not affected overall collembolan populations in these stands. Apparently, the collembolan populations in this study are more sensitive to environmental factors other than burning.

ACKNOWLEDGMENTS

This work was jointly supported by the USDA Forest Service and the Arkansas Forest Resources Center. We thank Dr. Hal Leichty, Dr. Richard Snider, and Dr. Paul Doruska for their technical assistance, and Kenny Davis, Steve Tackett, Adrian Grell, Rhona Jitta, Issac Foote, Ruthann Chapman, and Sam Clark for their help with work in the field and laboratory.

LITERATURE CITED

Bellinger, P.F.; Christiansen, K.A.; Janssens, F. 2003. Checklist of the Collembola of the world. http://www.collembola.org. [Accessed February 5, 2003].

Berg, M.P.; Kniese, J.P.; Bedaux, J.J.M.; Verhoef, H.A. 1998. Dynamics and stratification of functional groups of micro- and mesoarthropods in the organic layer of a Scots pine forest. Biology and Fertility of Soils. 26: 268-284.

Cain, M.D.; Shelton, M.G. 2002. Does fire have a place in regenerating uneven-aged loblolly and shortleaf pine stands? Southern Journal of Applied Forestry. 23: 117-123.

Christianson, K.; Bellinger, P. 1998. The Collembola of North America: North of the Rio Grande. Grinnell, IA: Grinnell College Publishing. 1520 p.

Colwell, R.K. 1997. EstimateS: Statistical estimation of species richness and shared species from samples. Version 5. http://viceroy.eeb.uconn.edu/estimates. [Accessed June 18, 2001].

Dindal, D.L.; Metz, L.J. 1976. Community structure of Collembola affected by fire frequency. In: Mattson, W.J., ed. The role of arthropods in forest ecosystems. New York, NY: Springer-Verlag: 88-95.

Fisher F.F.; Binkley, D. 2000. Ecology and management of soils, 3rd edition. New York, NY: John Wiley and Sons Inc. 489 p.

Fritze, H.; Pennanen, T.; Pietikainen, J. 1993. Recovery of soil microbial biomass and activity from prescribed burning. Canadian Journal of Forest Research. 23: 1286-1290.

Henig-Sever, N.; Poliakov D.; Broza M. 2001. A novel method for estimation of wildfire intensity based on ash pH and soil microarthropod community. Pedobiologia. 45: 98-106.

Heyward, F.; Tissot, A.N. 1936. Some changes in the soil fauna associated with forest fires in the longleaf pine region. Ecology. 17: 659-666.

Johnston, J.M.; Crossley, D.A. 2002. Forest ecosystem recovery in the southeast US: soil ecology as an essential component of ecosystem management. Forest Ecology and Management. 155: 187-203.

Kalisz, P.J.; Powell, J.E. 2000. Effects of prescribed fire on soil invertebrates in upland forests on the Cumberland Plateau of Kentucky, USA. Natural Areas Journal. 20: 336-341.

Magurran, A.E. 1988. Ecological diversity and its measurement. Princeton, NJ: Princeton University Press. 179 p.

McCune, B.; Medford, M.J. 1999. PC-ORD: Multivariate analysis of ecological data. Version 4.17. Glendon Beach, OR: MjM Software. 237 p.

Paquin, P.; Corderre, D. 1997. Changes in soil macroarthropod communities in relation to forest maturation through three successional stages in the Canadian boreal forest. Oecologia. 112: 104-111.

Romesburg, C.H. 1984. Cluster analysis for researchers. Belmont, CA: Lifetime Learning Publications. 334 p.

SAS Institute Inc. 1990. SAS/STAT users guide, version 6, 4th edition. Cary, NC: SAS Institute Inc. 1686 p.

Wade, D.D.; Lansford, J.D. 1989. A guide for prescribed fire in southern forests. Tech. Pub. R8-TP 11. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. 56 p.

Weaver, J.; Heyman S. 1997. The distribution and abundance of leaf litter arthropods in MOFEP sites 1,2,3. In: Brookshire, B.L.; Shifly, S.R., eds. Proceedings of the Missouri Ozark forest ecosystem project symposium: An experimental approach to landscape research. Gen. Tech. Rep. NC-193. Saint Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 318-331.

Wikars, L.O.; Schimmel, J. 2001. Immediate effects of fire-severity on soil invertebrates in cut and uncut pine forests. Forest Ecology and Management. 141: 189-200.