Effect of Time Elapsed after Prescribed Burning in Longleaf Pine Stands on Potential Prey of the Red-Cockaded -Woodpecker

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ABSTRACT. *The effects of dormant and growing season prescribed burns on the potential arthropod prey of the red-cockuded woodpecker* (Picoides borealis) *were studied in longleaf pine* (Pinus palustris *Mill.) stands on the upper Coastal Plain of South Carolina Sampling was conducted 0, 1, 2, or 3 yrpost-burn. Stands were burned once during the winters of 1991, 1992, 1993, and 1994 or in the summer of 1992. Four types of traps sampled arthropods in the litter layer, the herbaceous understory, and on the bole of pine trees. Woodpecker prey abundance and biomass were sampled continuously from June 30, 1993 to June 30, 1994. Overall arthropod diversity was sampled seasonally in June, October, January, and April ofthesameyear. Thedifferent trap types had similar arthropod diversity and evenness, but most had low faunal overlap which indicates that they effectively sampled different parts of the arthropod community. When capturesfrom all trap undprep types were combinedfor each plot no significant differences werefound among winter burnedplots or between winter and summer burned plots. However, certain prey types were effected by burning. Among stands burned in winter, spider abundance was highest in samples from the soil/litter layer of stands burned 3 yr prior to sampling. Comparison of stands burned in winter 1992 to those burned in the summer showed that the winter 1992 burns had higherspiderand ant (Hymenopteru: Formicidue} biomass on the tree boles. Spiders appeared to be the only group affected by winter burning while spiders and ants were affected by the summer burning. In general, time elapsed after the prescribed burns were applied had little effect on the primary arthropodprey of the red-cockaded woodpecker. South. J. Appl. For. 22(3):175–183.*

The red-cockaded woodpecker (RCW), *Picoides borealis,* nests in mature pine stands with little midstory or understory vegetation (Crosby 197 1, Hopkins and Lynn 197 1, Thompson and Baker 197 1, Grimes 1977, USDA Forest Service 1995), and it prefers live pines greater than 23 cm dbh to forage on for arthropods (Baker 197 1, Hooper and Lennartz 198 1). The RCW evolved in pine forests where frequent fires kept the forest relatively open by inhibiting hardwood growth and regeneration (Jackson 197 1). Today, prescribed burns are often used in southern pine forests to control hardwoods, stimulate the development of pines, and reduce the likelihood of wildfire (Boyer 1990). Consequently, prescribed burning is often recommended as a method for creating and maintaining desirable RCW habitat (Costa and Escano 1989, USDA Forest Service 1995). However, while fire may create suitable nesting habitat, it may also have a negative effect on the arthropods that serve as food for RCW. Particularly because 40–70% of the arthropod biomass that is captured crawling on the boles of live longleaf pine *(Pinuspulustris* Mill.) trees crawls onto the tree from the soil/litter layer (Hanula and Franzreb 1998).

Common prey of the RCW include wood roaches, ants, caterpillars, centipedes, spiders, and beetles (Beal 1911, Harlow and Lennartz 1977, Hanula and Franzreb 199.5, Hess and James 1997). Of these prey, roaches, ants, centipedes, and spiders are the most important and most likely to be

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affected by prescribed burning. Recently, Hess and James (1997) found that *Crematogaster ashmeadi*, an ant species that comprised a high proportion of the stomach contents they examined, were lower in abundance in areas on the Apalachicola National Forest that exhibited characteristics of frequent burning.

Limited studies in North American pine forests show that burning decreases arthropod numbers when burned and unburned areas are compared (Heyward and Tissot 1936, Pearse 1943. Buffington 1967, Harris and Whitcomb 1974). However, fire is an integral part of longleaf pine forests (Horton 1995), and an inexpensive and useful tool for managing understory vegetation. For these reasons it is unlikely that its use will be curtailed, so information is needed on whether or not arthropod populations are negatively affected by prescribed burning and, if so, how long it takes them to recover. The objective of our study was to determine the effects of winter and summer burning on the primary arthropod prey of the RCW. Specifically, we wanted to determine if arthropod diversity, abundance, and biomass in the litter layer, in the herbaceous understory, or on the bark of longleaf pine is affected by either type of burning. In addition, we monitored arthropod abundance on winter burns of differing ages (postburn) to determine if arthropod populations increase with increasing lengths of time after the prescribed burns are applied.

Methods and Materials

Study Site and Treatment

The study was conducted on the 80,270 ha Savannah River Site (SRS), a U.S. Department of Energy facility located on the upper Coastal Plain of South Carolina along the Savannah River. Longleaf pine forests are a major component of the landscape. All forested areas on the SRS are managed by the USDA Forest Service. One important management goal for the site is to increase the numbers of red-cockaded woodpeckers.

Unburned stands of longleaf pine were not available on the SRS so the study was restricted to burned stands composed of 40- to 60-yr-old longleaf pine. The average dbh of the trees in the stands was 22.5 cm and pine basal area averaged 19 m^2/ha. Prescribed burning was not used extensively on the site until recently. Based on available burn histories the majority of the stands selected for the study were only burned once prior to 199 1. In most cases, the previous burns were conducted 10–20 yr before the study burns. Summer burned plots differed in that all of them were burned in the winter approximately 1.5 yr before the summer burn.

Treatments consisted of prescribed burns applied to stands in the winter of 199 1, 1992, 1993, and 1994, and the summer of 1992 (only one stand was burned on the SRS in the summer of 199 1, and none were burned in the summer of 1993). Plots in stands burned in winter 1994 were established in April 1994. Plots in the remaining stands were established in June 1993. Three stands with similar characteristics were selected for each burn type and year. These stands were selected from areas burned on three different dates (one stand/date) but within the same season and year of burning. One 0.2 ha plot was established in each stand for arthropod sampling.

Arthropod Sampling

Four types of traps were used to sample arthropods in 1993 and 1994. These included crawl traps to capture arthropods crawling on the bark of the trees, flight-intercept traps to capture insects flying to the trees, pan traps placed on the ground to capture hopping and low flying insects, and pitfall traps to capture arthropods that crawl on the soil/litter layer. All trap types had collection containers that were partially filled with 1% formaldehyde in a saturated salt (NaCl) solution. Arthropods (excluding Collembola and mites) captured in the various traps were sorted, placed into vials containing 70% ethanol, and later identified to genus or the lowest taxonomic level possible.

Crawl traps (Figure 1) were constructed in the same manner as those described by Hanula and New (1996). Traps were attached at a height of 2 m to five randomly selected longleaf pine trees per plot. A drift fence. consisting of an aluminum band wrapped around the tree directly below the trap, was added to force arthropods into the trap and collection container.

Flight-intercept traps were used to capture insects flying to the bark of trees. The conventional trap was modified by adding a 5 cm top and 5 cm side to increase the capture of

Figure 1. Crawl trap on the bole of a longleaf pine tree 1.5 m above the ground to catch arthropods crawling up the trees.

insects that hit the large plexiglass plate and fly up or to the side instead of falling down (Figure 2). The top halfofa 1 liter soda bottle was attached to the bottom of the trap as a collection container. Insects flew into the plexiglass and dropped into the soda bottle where they were preserved and later removed. One flight trap was placed at 1 m above ground, mid-bole, and the base of the crown of two trees with similar attributes (e.g.. dbh, height, crown position, and size) per plot.

Pitfall traps captured arthropods crawling on the ground. A small funnel (8.4 cm diam) fitted to the mouth of a 480 ml plastic drinking cup, with drain holes in the bottom, directed arthropods into a 120 ml capacity specimen cup (inside the larger cup) filled with preservative. The trap was placed in the ground so that the lip of the drinking cup was level with the soil surface. A 1.5 x 15 cm sheet metal cover supported 5 to 6 cm above the trap by aluminum nails prevented rain from flooding the specimen cup. Four pitfall traps were placed randomly in each plot.

Pan traps captured low flying or hopping insects. These traps were similar to those described by Hansen (1988) and consisted of a plastic box (approximately 40 x 28.5 x 14 cm) fitted with 2 plexiglass baffles (60.5 x 30.5 cm) in the form of an X (Figure 3). Flying insects hit the panels and fell into the box and preservative solution. Two pan traps were placed on the ground approximately IO m apart near the center of each plot. These traps were only used in the study for estimating arthropod diversity

Relative abundance estimates of the primary prey of RCW were based on samples from crawl, flight-intercept, and pitfall traps. The traps were operated continuously throughout the study. Samples were removed from the traps weekly from June 30, 1993, to November 19, 1993, and April I l, 1994, to June 30, 1994, and biweekly from November 19, 1993, to April I l, 1994. Spiders (Araneae), wood roaches (Dictyoptera: Blattellidae). centipedes (Chilopoda), three genera of ants (Hymenoptera: Formicidae, *Formica* spp., *Camponotus* spp., and *Crematogaster* spp.), and caterpillars (Lepidoptera larvae) were defined as the primary prey of the RCW based on previous studies (Beal 191 l, Baker 1971, Harlow and Lennartz 1977, Hanula and Franzreb 1995). After identification, up to 20 specimens of each taxon were ovendried at 40°C for 72 hr and weighed. The average weight of these specimens was multiplied by the number of individuals within a sample to estimate biomass.

Overall arthropod diversity and faunal similarity was determined by identifying every specimen caught in all traps from one weekly collection in summer, fall, winter, and spring (July 1993, October 1993, January 1994, and April 1994). Specimens that could not be identified to genus, such as immature and rare or damaged individuals, were identified to the lowest possible taxonomic level.

Figure 2. Flight-intercept trap positioned at the base of a longleaf pine tree bole used to catch arthropods flying to the bark of trees.

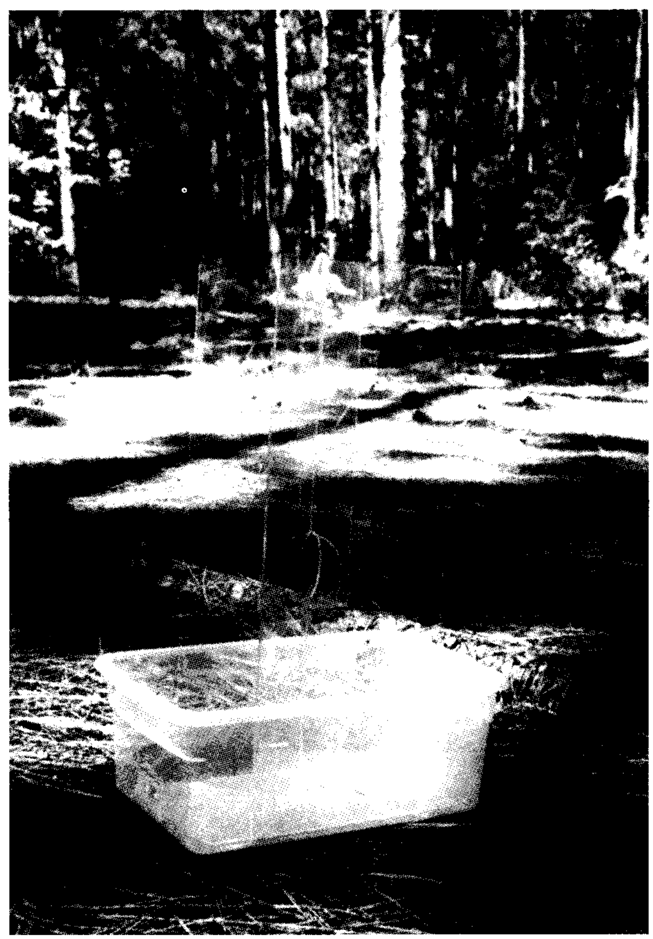

Figure 3. Pan orwatertrap situated in a longleaf pine plot to catch low flying and hopping arthropods.

Habitat Sampling

Leaf litter samples were collected in September 1993 and in July 1994 to compare postfire litter accumulation to the abundance and diversity of arthropods. Three, 1 m^2 random samples were taken per plot. The litter was collected, oven dried (103°C for 72 hr) and weighed.

Midstory and understory vegetation abundance and diversity were measured on July 13, 1994. Herbs and shrubs were measured along four random 25 m long transects radiating out from the plot center. Herbaceous plant genera, number of stems, and percentage of plant cover were recorded in three 1 m^2 samples taken at 8.3 m intervals along each transect for a total of 12 samples per plot. Percentage of herb cover was estimated by using a modification of the Daubenmire cover scale (Mueller-Dombois and Ellenberg 1974).

Overstory tree canopy cover was recorded as present or absent at each sample point along the transects using a cardboard tube to sight the canopy directly above the 1 m^2 herb sample areas (James and Shugart 1970). The genus and dbh of each live tree within the 0.2 ha plot were also recorded. Shrubs (defined as greater than 1 m in height and less than 2.5 cm diameter) within 1 m of either side of the transect lines were recorded by genus and number of stems. The diameter and length of all woody debris greater than 2.5 cm in diameter intercepted by the transects was also recorded.

Statistical Analysis

Arthropod and vegetation diversity and evenness were estimated using the Shannon-Weaver diversity index and the evenness index (Zar 1984). The Shannon-Weaver index,

$$H' = -\sum p_i \log_e (p_i)$$

where p_i is the proportion of individuals of genus i to the total number of individuals of all genera, measures the numbers of different taxonomic classes and relative abundance of those classes. The evenness index ($J' = H'/\log_e S$) relates the observed H' to $\log_e S$, where S = the number of genera. $\log_e$ (S) calculates the maximum possible diversity for the number of taxonomic classes present.

The similarity of arthropod communities was compared among trap types and burn treatments with Raabe's percentage of fauna1 similarity,

$$\%S = \sum \min (P_{ij}, P_{ik})$$

where P_{ij} = percentage of genus i on plot j (j = 1,2) (Southwood 1966). This index takes relative abundance into consideration by comparing taxon from two treatments. It estimates the proportion of each taxon in a sample, compares two samples by individual taxa, and then determines the lowest common percent overlap for each taxon. These are summed to calculate overall percent similarity which ranges from 0% to 100%.

Diversity of arthropods was estimated for each treatment by combining the four seasonal samples. Diversity, prey abundance, and prey biomass were compared among stands burned in winter 1991, 1992, and 1993, and also between stands burned winter and summer 1992. Comparisons of winter 1994 to the other winter burns were limited to the April to June 1994 sampling dates.

Analysis of variance (ANOVA) was used to measure univariate responses (SAS 1985). Means separation was determined by Tukey's studentized range test. Within the ANOVA, specific contrasts were run for a summer 1992 versus winter 1992 comparison and a winter linear time effect. Linear time effect was used to determine if abundance and biomass changed with time (years postburn) for winter burns.

Results

Abundance and Biomass

A total of 23,662 specimens of the various RCW prey were collected during the study. Overall abundance and biomass of the primary RCW prey were compared for winter 199 1, 1992, 1993, and summer 1992, burns. Total prey abundance and biomass were not affected by the type of burn or the length of time postburn. Separate analyses of collections from traps on the bark and in the soil/litter layer also showed no differences among burns (Table 1). Flight intercept traps caught very few RCW prey so they were not included in other analyses. The stands burned during winter 1994 were sampled from April to June, 1994. Comparisons of overall prey captures for that period showed no significant differences (F = 0.53; df = 4, 10) among any of the burn treatments.

Prey items were also separated into classes, orders, or families to see if burning affected some groups more than others. Spider biomass was higher (F = 4.49, df = 3,8; P < 0.04) in traps on the bark in winter 1992 burns than in plots burned in winter 199 1 (Figure 4) and spider abundance (F = 5.81, df = 3,8; P < 0.02) was higher on the soil/litter layer of

Table 1. Mean number (standard error) and biomass (g) per plot of all red-cockaded woodpecker prey captured flying to trees, crawling up them, or crawling on the soil/litter surface by type of burn and year conducted. Samples were collected continuously from June 30, 1993, to June 30.1994, on the Savannah River Site, SC.

Prescribed bum			Flight traps [1]		Bark [1]		Soil/litter'	
Tyye	Year	N	No.	Biomass	No.	Biomass	No.	Biomass
Winter	1991	3	3 (0.)a	0.1 (0.10)a	861 (131.6)a	2.5 (0.43)a	855 (174.1)a	3.8 (0.44)a
	1992	3	9 (2.0)a	0.6 (0.30)a	2,187 (1,285.7)a	4.3 (1.20)a	600 (83.1)a	3.0 (0.90)a
	1993	3	3 (0.6)a	0.2 (0.10)a	1,314 (382.1)a	3.4 (0.47)a	618 (159.6)a	3.2 (0.16)a
Summer	1992	3	4 (0.6)a	0.1 (0.01)a	877 (142.7)a	3.1 (0.05)a	465 (134.7)a	2.6 (0.20)a

1 Means followed by the same letter within columns are not significantly different according to Tukey's studentized range test (P < 0.05).

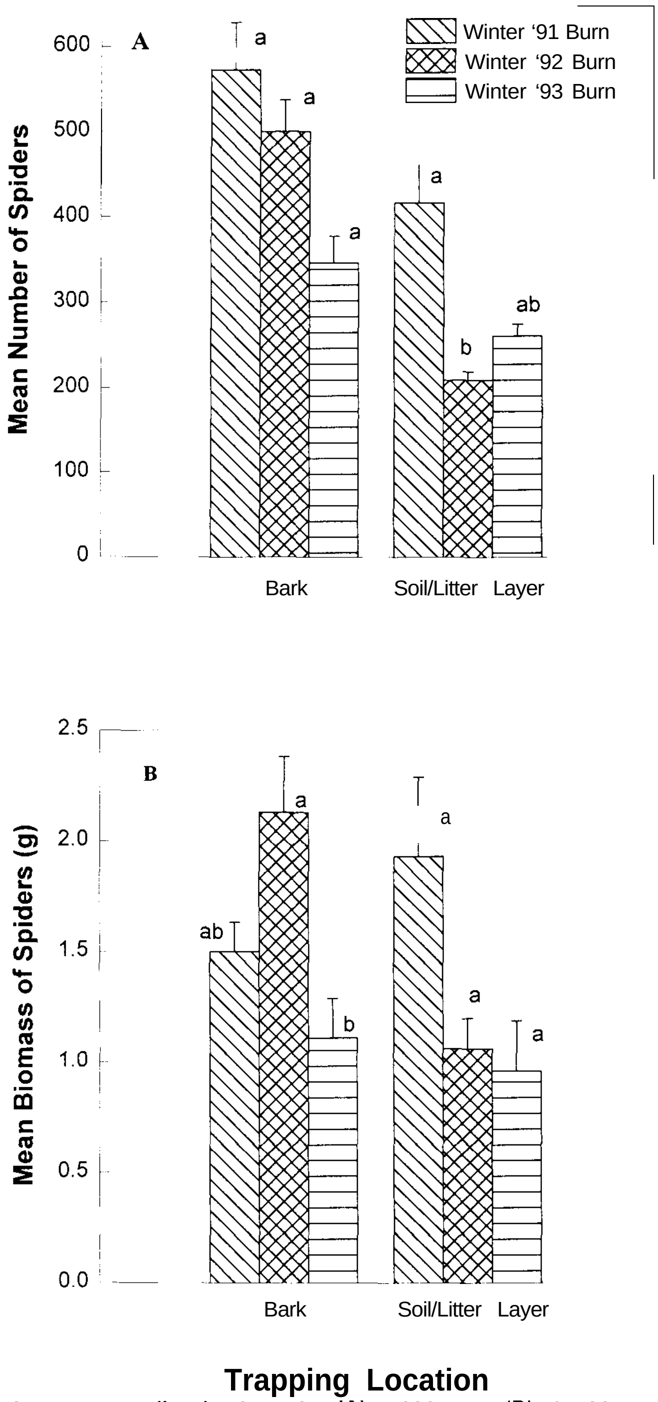

Figure 4. Mean (I——I SE) number (A) and biomass (B) of spiders (Araneae) captured on the bark of longleaf pine trees or the soil/ litter layer of stands burned in winter 1991, 1992, or 1993 on the Savannah River Site, SC. Columns with the same letter above them within graphs and trapping locations are not significantly different according to Tukey's studentized range test ($P < 0.05$).

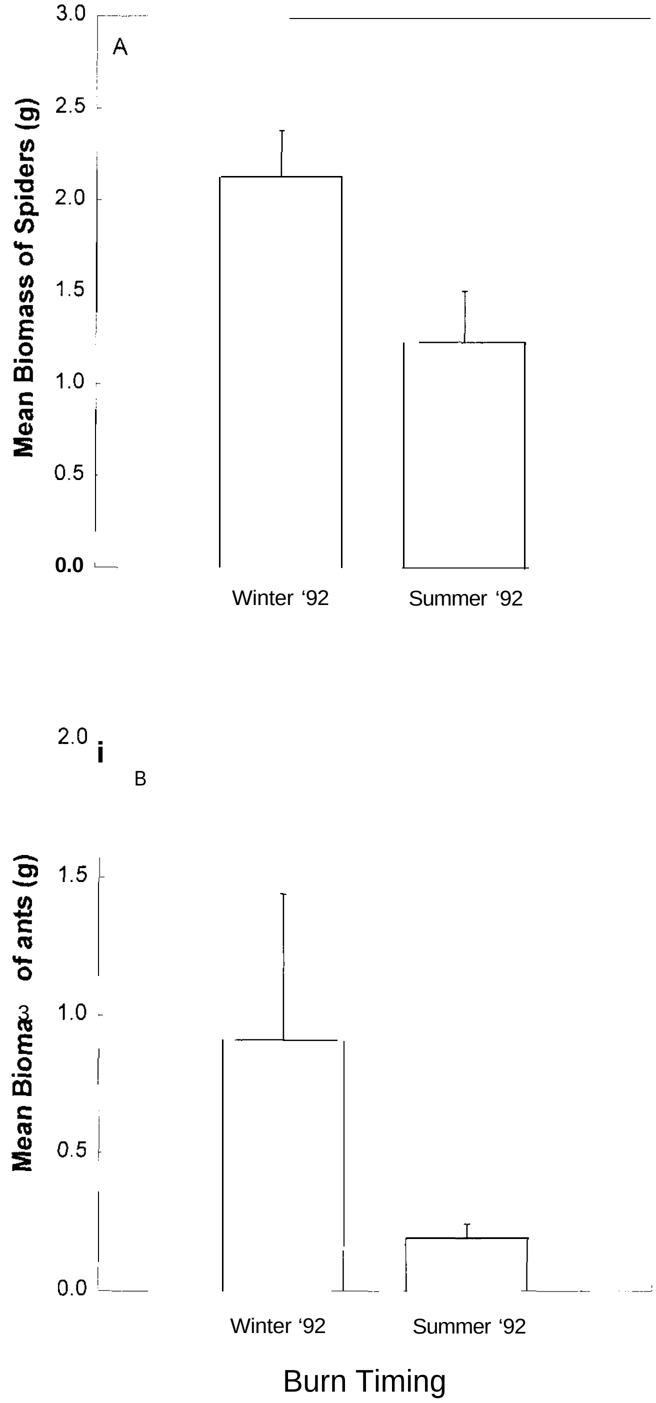

Figure 5. Mean (I-I SE) biomass of spiders (A) (Araneae) and mean biomass of ants (B) (Hymenoptera: Formicidae) captured on the bark of longleaf pine trees in stands burned in the winter WV') or summer (S') 1992. Means within graphs are significantly different by ANOVA using specific contrasts of summer 1992 versuswinter 1992 burns (for spiders $F = 8.79$, $df = 1{,}8$ and $P < 0.02$; for ants $F = 3.36$, $df = 1{,}8$ and $P < 0.10$).

winter 199 1 burned stands than winter 1992. The abundance and biomass of roaches, centipedes, ants, or caterpillars were not significantly different among the various winter burn treatments when these groups were examined separately.

Comparison of dormant to growing season burns (winter 1992 to summer 1992) revealed no significant differences in total prey abundance or biomass in the stands regardless of sampling location (Table 1). However, when the prey were separated by taxonomic groupings, differences were found in the biomass of spiders ($F = 8.79$, df = 1,8; $P < 0.02$) and ants ($F = 3.36$, $df = 1{,}8$; $P < 0.10$) captured on the bark (Figure 5). In both cases, biomass was higher on the bark of trees in stands burned in the winter 1992 than on those burned in summer 1992.

Diversity, Equitability, and Fauna1 Overlap

A total of 10,935 arthropod specimens were collected and identified in the four seasonal samples used to mea-

Table 2. Summary of arthropods collected in diversity samples after prescribed burning in longleaf pine stands on the Savannah River Site, SC.

Class	Order	No. of families	No. of genera
Arachnida	Araneae	17	40
	Chelonethida	NI[1]	NI
	Phalangida	NI	NI
Chilopoda	Geophilomorpha	NI	NI
	Scolopendromorpha	NI	NI
Diplopoda	NI	NI	NI
Insecta	Coleoptera	52	156
	Diptera	29	61
	Ephemeroptera	1	1
	Hemiptera	21	35
	Hymenoptera	28	88
	Isoptera	1	NI
	Lepidoptera	13	NI
	Mecoptera	1	1
	Neuroptera	3	2
	Odonata	1	NI
	Orthoptera	5	10
	Plecoptera	1	1
	Psocoptera	1	NI
	Thysanura	2	2
	Trichoptera	2	NI

[1]NI= Not identified

sure overall arthropod diversity. Table 2 shows the number of orders. families, and genera collected. Stands burned in winter I99 1, 1992. 1993, and summer 1992 burns had very similar arthropod diversity and evenness. Diversity (H') ranged from 4.05 (summer 1992) to 3.41 (winter 1992) and evenness (J') ranged from 0.8 1 (summer 1992) to 0.69 (winter 1992) for all taxa combined. Arthropod diversity and evenness of stands burned in 1994 were also similar to other burn dates. When the seven most abundant orders (Araneae, Coleoptera, Diptera, Hymenoptera, Hemiptera, Homoptera. and Orthoptera) were examined individually, diversity and evenness were similar within orders regardless of burning dates.

Raabe's percentage of faunal overlap for paired burn treatments was similar for all possible pairs ranging from 46 to 52% similarity of arthropod communities. The faunal overlap for arthropod communities in winter and summer 1992 burned stands was 49%, which was similar to the overlap among the winter burned stands. Fauna1 overlap among different types of traps (Table 3) was low, which shows that the traps provided a broad assessment of the arthropod fauna on the plots.

Habitat Samples

The treatments were similar in terms of tree size, basal area, shrub numbers, and diversity, and the amount of woody debris present on them. However, they did differ in the amount of litter biomass. the percentage of herbaceous cover. and the numbers of herb stems.

Litter biomass was highest in stands burned in winter 199 1 and lowest in those burned in winter 1994 and summer 1992,

Table3. Comparisonofthesimilarityofarthropodfaunasampled by various types of traps.

Trap comparison	% similarity[1]
Crawl–Pan	5.0
Pitfall-Pan	11.1
Crawl-Pitfall	24.2
Pitfall–Flight	26.2
Crawl–Flight	40.8
Pan Flight	51.9
Flight (1m)– Flight (mid-bole)	43.3
Flight (1m)– Flight (base of crown)	41.4
Flight (mid-bole)– Flight (base of crown)	64.2

1 Calculated using Raabe's percentage of faunalsimilarity (Southwood 1966).

although the latter two did not differ significantly from stands burned in winter 1992 and 1993 (Table 4). On the other hand, the numbers of herb stems were highest on the summer burned plots ($F = 6.38$. $df = 4,10$; $P < 0.01$) while winter burned stands had lower and relatively equal numbers of herbaceous stems regardless of the time elapsed since the burns were conducted (Table 4).

When canopy cover was compared with herb cover, the stands burned in summer and winter 1992 had similar low canopy cover, but the summer 1992 plots had much higher herb cover (Figure 6). Since winter 1992 and summer 1992 burned stands had similarcanopy cover. it is unlikely that low canopy cover was the reason for the greater number of herbaceous plants in the summer burned stands. All winter burn plots had similar low herb cover regardless of canopy cover. No significant relationships were found between litter biomass, amount of woody debris, vegetation diversity or vegetation abundance, and arthropod diversity, abundance, or biomass.

Discussion

Previous studies have shown that a large portion of the arthropod biomass that occurs on the bark of live longleaf pine trees crawls there from the soil/litter layer (Hanula and Franrreb 1998). Despite the obvious impacts that burning has on the forest floor, this study suggests that time elapsed after winter burning had little effect on the

Table 4. Mean (standard error) biomass of litter and number of herbs, and median percentage of herbaceous cover in various prescribed burn treatments ($n = 3$) applied to longleaf pine stands on the Savannah River Site, SC. Vegetation was sampled on July 13, 1994.

Bum	Litter biomass (g)[1]	Herbaceous vegetation Mean no.	Median % cover[2]
Winter '9 1	1,410 (201) a'	147 (27.7) b	2.5
Winter '92	533 (89) b	163 (13.0) b	2.5
Winter '93	736 (131) b	69 (41.2) b	0.5
Winter '94	384 (46) b	106 (25.5) b	0.5
Summer '92	312 (60) b	400 (99.6) a	37.0

1 Based on ovendried weight at 103°C for 72 hr.
2 Determined using a modification of the Daubenmire cover scale (Mueller-Dombois and Ellenberg 1974).
3 Valueswithincolumnsfollowed bysameletterdo not differ significantly according to Tukey's Studentized range test ($P < 0.05$).

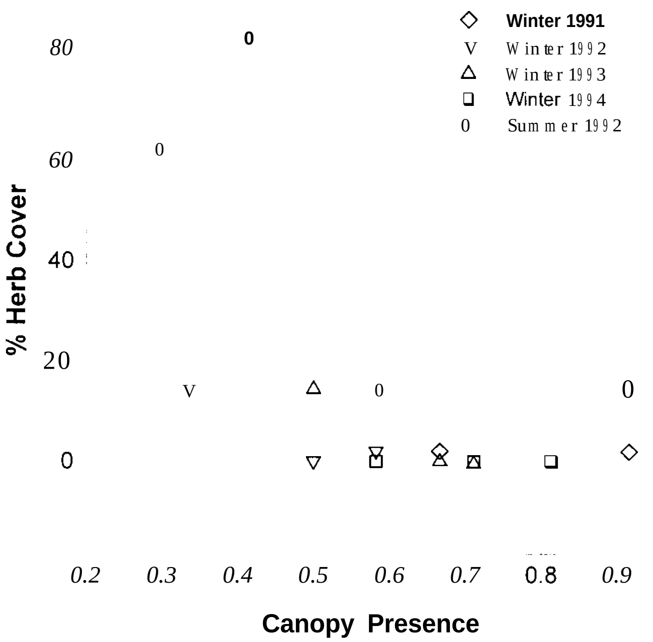

Figure 6. Comparison of canopy cover and percent herb cover for stands of longleaf pine burned in the winter 1991, 1992, 1993, 1994, or summer 1992 on the Savannah River Site, S.C. Canopy cover is equal to the number of times the canopy was observed above a sample point divided by the number of sample points. Both canopy cover and percent herb cover were measured on July 13, 1994.

number of prey or the prey biomass available for RCW. This was demonstrated by the fact that stands burned in winter 1991 had similar prey populations to those burned in 1993 and 1994. In addition. burns conducted in winter 1994 had similar diversity and evenness to those burned in previous years suggesting that winter prescribed burning had little effect on the overall arthropod community. Although it is possible that burning affected the arthropod populations. but the time elapsed from the first burns in 1991 to the time of the study was insufficient for them to increase. this seems unlikely. Particularly because stands treated in winter 1994 were burned only 2 months before our sampling began. If winter burning had a significant effect on the prey. those stands should have had lower prey abundance.

On the other hand, the season that a prescribed burn was conducted did affect some prey types. Summer burns in 1992 reduced both ant and spider biomass on the boles of trees when compared to stands burned in the winter 1992. Beal (1911) reported that ants made up over 50% of adult RCW diet and, recently, Hess and James (1997) reported that ants made up 58% of adult and 15% of nestling stomach contents on the Apalachicola National Forest in Florida. Hess and James (1997) also reported that spiders made up 15% of the nestling stomach contents. However, other studies found ants and spiders to be a small portion of the diet of nestlings (Harlow and Lennartz 1977, Hanula and Franzreb 1995). Studies of the diet of RCW on the Savannah River Site showed that wood roaches were an important part of the diet of nestlings comprising 50–80% of the prey at that location (Hanula and Franzreb 1995). Additional studies have confirmed these findings in subsequent years on the SRS and at other locations (Hanula et al. unpublished data). RCW are probably opportunists that take advantage of whatever arthropods are readily available on the bark (Hanula and Franzreb 1995). Since prey availability may vary over time at a given location, it is important to understand how burning affects all of the major prey groups.

Hess and James (1997) found that longleaf pine stands that exhibited characteristics consistent with frequent burning had fewer trees that contained C. *ashmeadi* ants. the ant they recovered most frequently from RCW stomach flushings. However, James et al. (1997) found that the highest densities of RCW social groups were in areas with evidence of frequent burning. suggesting that reducing ant populations does not adversely affect RCW.

We found no evidence that prescribed burning affected wood roach abundance. Wood roaches are primarily found in decaying wood or hiding in the bark of live trees. They are rarely found in the leaf litter during the daytime (Hanula, unpublished data). In addition, Cantrell (1943) suggested that wood roaches may be more subterranean than previously thought. Therefore, the natural hiding places of wood roaches are likely to be protected from low intensity fires that do not consume the larger woody debris or heat the bark far up the tree bole. Roaches are also agile and may be able to move away from fire, possibly by escaping up the boles of trees.

In contrast to our study, previous studies in North American pine forests demonstrated that burning affected arthropod abundance (Heyward and Tissot 1936, Pearse 1943. Buffington 1967. Harris and Whitcomb 1974). However, these studies compared burned to unburned plots while we investigated burns of different ages. Different study designs, particularly the use of unburned controls, and the lack of replication and statistical analysis in some of the previous studies, may have caused the discrepancies among studies.

Although the use of unburned controls may have revealed other effects of fire in our study, no unburned longleaf pine stands were available on the Savannah River Site. This is not uncommon in most longleaf forests. Longleaf pine is a fire-adapted species and prescribed burning is generally considered to be important in the restoration and maintenance of the diverse herbaceous understory that is often associated with this tree species (Horton 1995). In addition, findings such as James et al. (1997) that show that RCW appear to do better in frequently burned areas increase the likelihood that burning will be widely used in RCW management areas. Evaluating prey populations in relation to the time elapsed after the burn provides information useful to forest and wildlife managers committed to a burning program.

Our study was similar to others (Rice 1932. Heyward and Tissot 1936, Buffington 1967) in showing that spider abundance was reduced by fire. Winter burning affected spider numbers in the litter but had no effect on the spider captures on the bark. Spider populations were highest in the winter 1991 burn areas where they had the longest time to recover. More spiders were captured on the bark in winter 1991 burn areas, but spider biomass was higher in the winter 1992 burn.

Fire has the short-term effect of destroying the understory vegetation and, therefore, the food sources of many arthropods. However, our results showed that arthropod diversity and evenness were similar regardless of time elapsed since winter burning or the type of burn.

We found that summer burned areas had a high percentage of herbaceous cover, a possible result of fire destroying apical meristems and stimulating dormant buds (Platt et al. 1988). The greater percentage of herbaceous cover on the forest floor in summer burned plots may have also resulted from reduced canopy cover. However, the plots burned in winter 1992 had canopy cover almost identical to those burned in summer 1992 but much lower herbaceous understory cover. This result differs from another study in loblolly pine flatwoods, where herbaceous cover was higher in winter burns when compared to summer burns or no burns (Gilliam and Christensen 1986) but agrees with the findings of Platt et al. (1988). We found no relationship between herbaceous cover condition and overall arthropod diversity. Arthropod diversity may not be important to RCW since previous studies have demonstrated that they rely on relatively few common arthropods (Beal 1911, Harlow and Lennartz 1977, Hanula and Franzreb 1995, Hess and James 1997). However, public land managers are increasingly being called on to maintain or increase overall diversity within forests.

Buffington (1967) suggested that a loss of incorporated and unincorporated organic matter through fire may decrease food for smaller organisms (microarthropods, bacteria, fungi, etc.) and ultimately reduce their predators. We found no evidence, however, that litter accumulation influenced overall RCW prey abundance. Although ground-dwelling spider abundance was higher on the winter 199 1 burned areas, it is unclear whether this was a result of greater litter accumulation, and the resulting increase in microarthropods, or simply longer population recovery time.

Woody debris volume was similar on all burned stands regardless of time elapsed since burning or the type of burn. Many arthropods may protect themselves from fire by hiding in or under dead trees. For example, Rice (1932) found that a single 3 x 8 in. piece of wood protected 19 chinch bugs, 2 cut-worm larvae, 1 ground beetle, 1 slug, and 2 centipedes during a fire. Likewise, Riechert and Reeder (1972) suggested that spiders in burrows, under rocks, and in clumps of vegetation may escape fire.

Conclusion

Summer burning reduced both spider and ant biomass on tree boles in longleaf pine stands used by RCW for foraging habitat, so it appears to have a greater impact on RCW prey availability than winter burning. In contrast, overall prey abundance was approximately the same in winter burned areas regardless of how long ago they had been burned. Despite the impact that summer burning has on some RCW prey, insufficient data are available, on how these prey reductions affect RCW, to justify limiting its use. At this time, it appears that the benefits of prescribed burning for RCW habitat management outweigh the negative impacts on their primary prey.

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