2006

Relationships among arthropods, herbaceous-shrub layer vegetation, and soil in an early succession pine stand.

Brent Burt
Stephen F Austin State University, dbburt@sfasu.edu

Richard N. Conner
Wildlife Habitat and Silviculture Laboratory, Southern Research Station

Saenz Daniel
Wildlife Habitat and Silviculture Laboratory, Southern Research Station

Recommended Citation

Conner, R.N., D. Saenz, and D. B. Burt. 2006. Relationships among arthropods, herbaceous-shrub layer vegetation, and soil in an early succession pine stand. Bulletin of the Texas Ornithological Society 39:3-7.

FOOD FOR EARLY SUCCESSION BIRDS: RELATIONSHIPS AMONG ARTHROPODS, SHRUB VEGETATION, AND SOIL

RICHARD N. CONNER[1,3], DANIEL SAENZ[1], AND D. BRENT BURT[2]

[1]*Wildlife Habitat and Silviculture Laboratory (maintained in cooperation with the Arthur Temple College of Forestry), Southern Research Station, 506 Hayter Street, Nacogdoches, Texas 75965–3556 and*

[2]*Department of Biology, Stephen F. Austin State University Nacogdoches, Texas 75962*

ABSTRACT.—During spring and early summer, shrub- and herbaceous-level vegetation provides nesting and foraging habitat for many shrub-habitat birds. We examined relationships among arthropod biomass and abundance, foliage leaf surface area and weight, vegetation ground cover, soil characteristics, relative humidity, and temperature to evaluate what factors may influence arthropod food resources for birds. Relative humidity was inversely associated with arthropod biomass; as humidity increased biomass decreased (r = -0.44, P = 0.004). We failed to detect any relationships between deciduous foliage (surface area and weight) and arthropod biomass or abundance. However, both arthropod abundance (r = 0.30, P = 0.06) and biomass (r = 0.39, P = 0.01) were positively associated with the percentage of herbaceous ground cover. Arthropod abundance also appeared to be positively associated with the percentage of clay in the soil and negatively associated with the percentage of sand. Herbaceous layer vegetation (forbs and grasses) is known to be positively associated with fire frequency suggesting a possible foraging benefit for birds during spring in habitats that are frequently burned. Management of early and late succession pine forest habitat to produce and maintain a healthy herbaceous layer will likely support more arthropods and provide quality foraging habitat for birds.

Many foliage-gleaning birds are dependent on arthropods as food, particularly during spring and early summer (Berthold 1976, Lewke 1982). In late summer and fall, bird use of plant materials such as fruits generally increases (Baird 1980). Many species of birds breed in early successional habitats created by timber harvesting (Conner and Adkisson 1975, Dickson et al. 1995). Such habitat typically has an abundance of both herbaceous and shrub-level vegetation. Recent research suggests that herbaceous ground cover, which is associated with frequent fire in the south, may be more important for the production of arthropod biomass and abundance than shrub leaf surface area (Hess and James 1998, James et al. 2001, Collins et al. 2002).

We explored the relationships among soil characteristics, vegetation, and arthropods in a 3-year-old pine plantation with deciduous and pine foliage that was present in early successional vegetation in Nacogdoches County, eastern Texas, during June 1982. If soil nutrients were a determinant of leaf nutritional quality, sites with better soil nutrients should produce higher arthropod abundance and biomass. We examine possible relationships between weather, vegetation, and soil characteristics and arthropod biomass and abundance.

STUDY SITE

We selected a 3-year-old loblolly pine *(Pinus taeda)* plantation (20 ha) with pine, deciduous, and herbaceous foliage from ground level to about 1.5 m high on the Angelina National Forest (31° 15′ N, 94° 15′ W) in eastern Texas. The plantation had patchy foliage and ranged from xeric, sandy hilltops to mesic sites along intermittent streams. Loblolly pine, shortleaf pine (*Pinus echinata*), post oak (*Quercus stellata*), winged sumac *(Rhus copallina),* smooth sumac *(R. glabra)*, and sweetgum (*Liquidambar styraciflua*) were the dominant woody plants in the young pine plantation.

METHODS

Arthropod biomass and abundance were estimated by sampling 40 rectangular volumes of foliage (1 x 1 x 10 m) with a 38-cm-diameter insect sweep net. The sampled rectangular volumes (our sample unit) were

[3]E-mail: rconner@fs.fed.us

at least 20 m apart to avoid violating independence of observation. Twenty net sweeps were made of the foliage within each of these rectangular volumes between 0830 and 1130 DST from 22 June to 21 July 1982, and captured arthropods were placed in a kill-jar with chloroform. Arthropods in these samples were identified to taxonomic order and oven dried at 85° C for 48 h (to constant weight) and weighed on an analytical balance. Relative humidity was measured with a sling psychrometer and ambient air temperature recorded immediately after arthropods were sampled. Percent ground cover of herbaceous dicots (forbs) and monocots (grasses) was estimated by viewing downward through a 4 cm diameter x 13 cm long hollow PVC tube at three points systematically placed on the 10-m-long rectangle. A soil auger was used to collect a soil sample to a depth of 15 cm for each rectangle at the three points where ground cover was estimated and the samples from each of these three points combined and mixed in a soil sample bag. Soil samples were analyzed for pH, texture, and chemical properties at the Stephen F. Austin State University Department of Agriculture Soil Science Laboratory.

All foliage within each of the 1 x 1 x 10 m rectangular volume (n = 40) where arthropods had been sampled was identified to species, clipped with hand pruning shears, and placed in a separate, large plastic bag for each rectangle and transported back to the laboratory. In the laboratory each leaf was run through a Licor area meter (LI-3000) with a conveyor belt three times, and then averaged to measure total leaf surface area for each rectangular volume. Foliage from each sample unit was then oven dried to constant weight at 85° C to obtain a measure of foliar biomass for each rectangular volume. Foliar surface area and dry weight biomass were divided by 10 to obtain a measure per cubic meter. All variables were evaluated for normality (Kolmogorov-Smirnov one sample test, $P < 0.05$) and transformed with an arcsine transformation, if necessary, and descriptive statistics were calculated (Table 1). Relationships among variables were examined using Pearson correlations. Multiple linear regressions (forward stepwise) were used to determine what subsets of variables were the best predictors of arthropod biomass and abundance.

Table 1. Descriptive statistics for arthropod, foliage, micro climate, and soil characteristics in early succession shrub-level vegetation (n = 40) in eastern Texas.

Habitat characteristic	Mean	SD	Minimum	Maximum
Arthropod biomass (g)	0.09	0.09	0.003	0.386
Arthropod abundance (#)	18.7	12.2	2.0	55.0
Relative humidity (%)	82.7	9.3	58.0	95.0
Temperature (C°)	29.0	3.2	21.5	35.3
Foliage leaf area (cm^2/m^3)	1415.8	538.7	548.7	3310.3
Foliage weight (g/m^3)	143.1	47.9	66.8	281.1
Herbaceous dicot (%)	36.3	17.0	7.0	75.0
Herbaceous monocot (%)	51.2	16.5	10.0	78.0
Sand (%)	73.9	2.9	68.0	80.0
Silt (%)	11.0	2.2	6.0	16.0
Clay (%)	15.2	1.8	12.0	22.0
Soil pH	5.9	0.2	5.3	6.3
Calcium (ppm)	717.5	229.7	300.0	1400.0
Magnesium (ppm)	72.3	22.4	40.0	80.0
Iron (ppm)	15.2	5.0	6.6	20.0
Manganese (ppm)	5.5	2.1	2.2	10.0
Nitrogen (ppm)	726.3	277.6	77.0	1569.0
Phosphorus (ppm)	2.1	1.3	0.5	6.0

RESULTS AND DISCUSSION

Relative humidity was significantly associated with arthropod biomass but not arthropod abundance (Table 2). As humidity increased, arthropod biomass decreased. This may be a function of arthropod size as small arthropods, which tend to be more common than large ones, may have been more affected by morning dew. Temperature variation (21.5 to 35.3° C) during our sampling period (0830–1130 DST) was not related to arthropod biomass or abundance (Table 2). Our sweep net samples collected 742 arthropods representing 10 taxonomic orders (Table 3). Homopterans, arachnids, and orthopterans were the most frequently captured arthropods in the sweep nets.

Soil texture was correlated with arthropod abundance but not arthropod biomass. Increased percentages of clay and decreasing percentages of sand were associated with increasing arthropod abundance (Table 2). Arthropod abundance was negatively associated with manganese in the soil. We detected no relationship between nitrogen or phosphorus and arthropod abundance or biomass (Table 2).

We did not detect any relationship of woody foliage surface area or biomass with arthropod biomass and abundance (Table 2). We may have been able to detect a relationship had we taken our samples in early spring (late April and May) when new leaves were succulent and tender. By mid June and July, new leaf growth had diminished and the cuticle on existing leaves was hardening. Arthropod measures were not associated with the amount of herbaceous monocots; however, both arthropod biomass and abundance increased as herbaceous dicots in the ground cover increased (Table 2). Our results from an early succession pine plantation are similar to observations in mature pine forests. Hess and James (1998) and James et al. (2001) reported that herbaceous layer vegetation was the most important habitat characteristic affecting arthropod communities foraged on by Red-cockaded Woodpeckers (*Picoides borealis*) in open, mature longleaf pine (*Pinus palustris*) communities in northern Florida. Collins et al. (2002) observed that abundance of herbaceous dicots was positively associated with the abundance and biomass of pine bole arthropod communities in a mature loblolly-shortleaf pine stand in eastern Texas. In mature pine forests, Collins et al. (2002) and James et al. (2001) noted that the arthropods in the herbaceous layer were particularly important as a foraging resource for the endangered Red-cockaded Woodpecker.

In longleaf and loblolly-shortleaf pine communities, fire is the disturbance factor that typically maintains a well-developed herbaceous layer (Platt et al. 1988, Frost 1993, Conner et al. 2001). In the absence of fire, mechanical

Table 2. Pearson correlations (n = 40) among arthropod biomass, arthropod abundance and foliage and soil characteristics in early succession shrub-level vegetation in eastern Texas.

	Arthropod biomass		**Arthropod abundance**	
Habitat characteristic	***r***	***P***	***r***	***P***
Relative humidity (%)	-0.44	0.004	0.10	0.553
Temperature (° C)	0.22	0.173	-0.07	0.654
Foliage leaf area (cm²/m³)	0.02	0.915	0.14	0.400
Foliage weight (g/m³)	0.09	0.575	0.22	0.181
Herbaceous dicot (%)	0.30	0.060	0.39	0.012
Herbaceous monocot (%)	-0.18	0.277	-0.18	0.262
Sand (%)	-0.07	0.690	-0.44	0.004
Silt (%)	0.20	0.227	0.29	0.071
Clay (%)	-0.14	0.404	0.36	0.021
Soil pH	0.21	0.192	-0.24	0.142
Calcium (ppm)	0.01	0.960	-0.05	0.766
Magnesium (ppm)	-0.07	0.670	-0.01	0.984
Iron (ppm)	0.16	0.320	-0.27	0.094
Manganese (ppm)	0.02	0.926	-0.33	0.040
Nitrogen (ppm)	-0.04	0.824	0.00	0.996
Phosphorus (ppm)	-0.24	0.140	0.04	0.803

Table 3. Arthropod orders collected in sweep net samples (n = 20) of shrub and herbaceous-level vegetation at 40 sites a pine plantation during 1984 in eastern Texas.

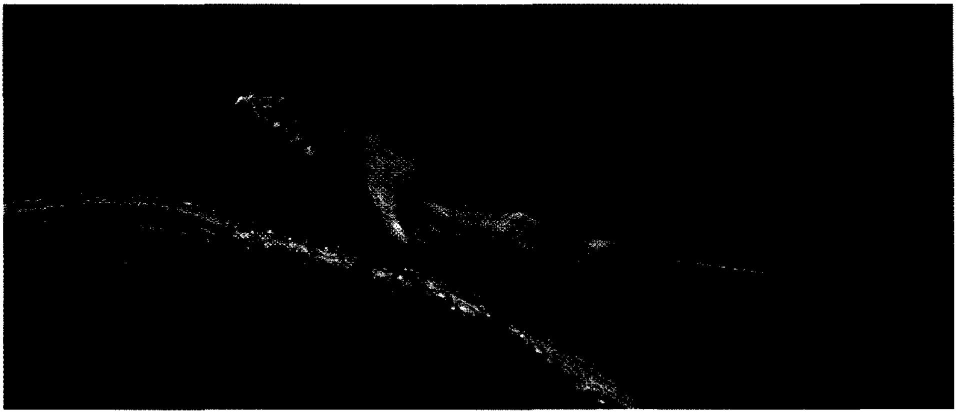
Taxon	Abundance (#)	Frequency (%)
Arachnida	122	16.44
Coleoptera	18	2.43
Diptera	66	8.89
Hemiptera	22	2.96
Homoptera	319	42.99
Hymenoptera	31	4.18
Lepidoptera	17	2.29
Odonata	3	0.40
Orthoptera	143	19.27
Siphonoptera	1	0.13
Total	742	100.00

control of midstory and understory woody vegetation will help maintain some level of herbaceous vegetation for short time periods (Conner and Rudolph 1991, Conner et al. 2001). Clear-cutting, as observed in the present study, can produce an herbaceous layer that is associated with arthropod abundance and biomass. But, this herbaceous vegetation and the arthropods it provides for birds may be short-lived as the developing pine canopy can quickly close and eliminate sunlight that permits an herbaceous layer to grow (Dickson et al. 1984, 1993).

Our study adds to a growing literature on the positive association of herbaceous-level vegetation with arthropod communities (James et al. 2001, Collins et al. 2002). The importance of arthropods as a foraging resource for birds is well established (Lewke 1982, Ramsay and Houston 2003, Yard et al. 2004). Our results also emphasize the importance of herbaceous layer plants, which are known to be associated with fire, in early succession pine forests. Management activities that promote herbaceous-level vegetation, such as fire, should be an important option for forest managers to consider at all stages of forest succession in southern pine forests.

ACKNOWLEDGMENTS

We thank K. A. Baum, W. B. Godwin, N. E. Koerth, and J. A. Neal for constructive comments on an early draft of the paper and A. E. Snow for help with field data collection and laboratory analyses. The use of trade, equipment, or firm names in this publication is for reader information only and does not imply endorsement by the U.S. Department of Agriculture of any product or service.



Brown-crested Flycatcher. ©Rolf Nussbaumer/VIREO

LITERATURE CITED

Baird, J. W. 1980. The selection and use of fruit by birds in an eastern forest. Wilson Bull. 92:63–73.

Berthold, P. 1976. Animalische und vegetabilische Ernährung omnivorer Singvogelarten: Nahrungsbevorzugung, Jahresperiodik der Nahrungswahl, physiologische und ökologische Bedeutung. J. für Ornithologie 117:145–209.

Collins, C. S., R. N. Conner and D. Saenz. 2002. Influence of hardwood midstory and pine species on pine bole arthropods. For. Ecol. Manage. 164:211–220.

Conner, R. N. and C. S. Adkisson. 1975. The effects of clearcutting on the diversity of breeding birds. J. For. 73:781–785.

Conner, R. N. and D. C. Rudolph. 1991. Effects of midstory reduction and thinning in Red-cockaded Woodpecker cavity tree clusters. Wildl. Soc. Bull. 19:63–66.

Conner, R. N., D. C. Rudolph and J. R. Walters. 2001. The red-cockaded woodpecker, surviving in a fire-maintained ecosystem. Univ. Texas Press, Austin.

Dickson, J. G., R. N. Conner and J. H. Williamson. 1984. Bird community changes in a young pine plantation in east Texas. So. J. Appl. For. 8:47–51.

Dickson, J. G., R. N. Conner and J. H. Williamson. 1993. Breeding bird community changes in a developing pine plantation. Bird Populations 1:28–35.

Dickson, J. G., F. R. Thompson, R. N. Conner, and K. E. Franzreb. 1995. Silviculture in central and southeastern oak-pine forests. pp. 245–266 In T. E. Martin and D. M. Finch, eds., Ecology and management of Neotropical migratory birds, Oxford University Press, New York.

Frost, C. C. 1993. Four centuries of changing landscape patterns in the longleaf pine ecosystem. Proc. Tall Timbers Fire Ecol. Conf. 18:17–43.

Hess, C. A. and F. C. James. 1998. Diet of the Red-cockaded Woodpecker in the Apalachicola National Forest. J. Wildl. Manage. 62:509–517.

James, F. C., C. A. Hess, B. C. Kicklighter, and R. A. Thum. 2001. Ecosystem management and the niche gestalt of the Red-cockaded Woodpecker in longleaf pine forests. Ecol. Appl. 11:854–870.

Lewke, R. E. 1982. A comparison of foraging behavior among permanent, summer, and winter resident bird groups. Condor 84:84–90.

Platt, W. J., G. W. Evans, and S. L. Rathburn. 1988. The population dynamics of a long-lived conifer. Am. Nat. 131:491–525.

Ramsay, S. L. and D. C. Houston. 2003. Amino acid composition of some woodland arthropods and its implications for breeding tits and other passerines. Ibis 145:227–232.

Yard, H. K., C. Van Riper iii, B. T. Brown, and M. J. Kearsley. 2004. Diets of insectivorous birds along the Colorado River in Grand Canyon, Arizona. Condor 106:106–115.