SQUIRREL DENSITIES IN PINE-HARDWOOD FORESTS AND STREAMSIDE MANAGEMENT ZONES

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Abstract: Time-area counts in east-central Mississippi revealed squirrel *(Sciurus* spp.) fall densities of 3.06/ha in pine-hardwood forests (PH), 3.14/ha in pine-hardwood forests next to streamside management zones (PH-SMZ), and 6.55/ha in streamside management zones (SMZ) in 1974. In 1975 squirrel densities were 1.48/ha (PH) and 2.55/ha (SMZ). Densities were also higher in SMZ (3.38/ha) than in PH (2.32/ha) and in PH-SMZ (1.95/ha) in 1978. PH had a slightly higher squirrel density (3.41/ha) than SMZ (3.36/ha) in 1979. Average detection distance was 31.4 m and average time for detection was 13 minutes. SMZ with an average width of 100 m in bottomland sites, provided higher (averaging 4.08 squirrels/ha) gray squirrel *(S. carolinensis)* populations.

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Southern forests are expected to produce the majority of the nation's wood products by the year 2000 and hopefully will also produce an abundance of wildlife (Ripley 1974). The conversion of some 20 million ha of pine-hardwood forests to pine plantations in the South will increase pine timber and pulpwood production (Walstad 1976), but the effects on gray and fox squirrel *(S. niger)* populations and hunting are a major concern among sportsmen and wildlife agencies. Squirrel hunting is very popular in the southern states (Jacobson et al. 1979).

To protect the riparian system and to provide wildlife habitat not found in pine plantations, some forest owners leave a strip (streamside management zone) of mature timber along creeks and rivers (Buckner and Landers 1980). This paper compares squirrel densities in these zones to densities in pine-hardwood forests and to pine-hardwood forests next to streamside management zones. Squirrel densities in the bordering pine plantations of various ages were not determined.

METHODS

Squirrel densities were sampled in three mature pine-hardwood forests (PH), two PH forests adjacent to streamside management zones (PH-SMZ), and in two streamside management zones (SMZ) in the Interior Flatwoods of Kemper County, Mississippi. PH forests (averaging 55 ha) consisted of stands usually isolated by pine plantations of various ages (1-9 years) from other forested areas. The PH and PH-SMZ forests ranged from 44-65 ha. The PH portion of PH-SMZ was bordered by a SMZ at least on one side. The SMZ were bordered on both sides by young loblolly pine *(Pinus taeda)* plantations. The SMZ extended several miles along permanent creeks and varied in width from 40-141 m, averaging 100 m.

PH and PH-SMZ stands averaged 76-years-old, and SMZ forests were 91-years-old. PH and PH-SMZ both contained about 43 percent pine and 57 percent hardwood basal area. Most of the merchantable pine had been removed from the SMZ. PH and PH-SMZ stands averaged 9.6 m^2/ha pine and 12.6 m^2/ha hardwood basal area. Oaks *(Quercus* spp.) and hickories *(Carya* spp.) comprised most of the hardwood basal area. SMZ had a total hardwood basal area of 18.4 m^2/ha and contained mostly oaks of different species than found in PH or PH-SMZ (Warren 1980).

The flatwood soils were acid, poorly-drained, and clayey. The climate was mild and moist, with an average annual temperature of 17°C and an annual rainfall of 140 cm (Pettry 1977).

Time-area counts of squirrels were conducted from late September to mid-October in 1974, 1975, 1978, and 1979 with at least four counts in each study area prior to the opening of the squirrel hunting season. The counts were conducted from 0630-0930 hrs (Uhlig 1955) when cloud cover was less than 25 percent, temperature was above 4°C, and wind was less than 8 kmph. Initially, two observers counted squirrels in an area, and then, several days later, two different observers counted squirrels in the same area. The two observers in PH and PH-SMZ were about 400 m apart and counted squirrels along compass lines at five plots about 100 m apart. The two observers in each SMZ counted squirrels by either starting at the same point where a road traversed the SMZ, each observer moving in opposite directions, or from different roads crossing the SMZ. In these SMZ observers traveled the center of the hardwood strips transecting streams for plot determination. Squirrels in each SMZ were counted by the two observers at five plots about 100 m apart also. Each observer counted squirrels for 30 minutes and then quietly walked to the next plot. Each observer noted the method of initial detection for each squirrel, either aural or visual, the distance to each squirrel seen, the time required to detect each squirrel after arriving at the plot, and other data. Only squirrels that were seen were counted.

Areas having high variation between observer counts were sampled until the variability was reduced. Count data were compiled for each area from which a total number of squirrels, and total sampling area were calculated. The distance to the farthest squirrel according to Uhlig's (1955) method was used to determine censused area. However, a count of zero squirrels at a plot indicated that no area or plot was sampled. Likewise, a count of 1, a squirrel tallied at 7.6 m from plot center did not accurately reveal total area sampled by the observer. Therefore, it seemed imperative that an average detection distance should be assigned to such plots to prevent an overestimation of squirrel density. More often than not the longest distance a squirrel was detected did not indicate the maximum area the observer had sampled regardless of understory vegetation at the plot. To compensate for this overestimation of squirrel density, an average maximum detectablility distance of 38.1 m, a distance based on 4 years of sampling, was assigned to a plot that had a 0 or 1 count of squirrels to determine the area sampled from plot center. Distance to the farthest squirrel at each plot was used to compute the area sampled when the plot had 2 or more squirrel count. On occasions there were plots with a count of 2 squirrels having the same detection distances for each squirrel. To reveal the area sampled by the observer, which would not be indicated by the distance to the squirrels if it were less than 38.1 m, the average maximum detectability distance was assigned. These plot areas were combined for all counts in each study area to calculate a total area sampled.

The determination of squirrels per hectare calculated from total number of squirrels and total area sampled represented densities for each area which did not show variability that could be analyzed statistically according to Steel and Torrie (1960). To arrive at a statistically valid squirrel density estimate, plot data (number of squirrels and area sampled) were used to calculate a squirrel density for each plot within an area. For example, an area (a SMZ) with 20 plots of data had 20 estimates of squirrel density. Therefore, each plot's data was calculated to represent a squirrel density, testing the variability of these densities within the SMZ, which was based upon the variability between the number of squirrels counted and the area sampled at each plot in the SMZ. Statistical analyses were then used to test the variation among squirrel densities for plots in the area. Averaging these plot densities for an area provided an overestimation of the population, because the means ($\bar{x}$s) of the individual plots taken separately and averaged to arrive at an area density were excessively higher than the mean density figure for the area which was calculated by using total number of squirrels and area sampled for all plots. Each area's density estimate should be calculated using the total number of squirrels counted and total area sampled for all plots in the area. Therefore, these higher density figures represented squirrels per hectare based upon an average of all individual plot area densities, instead of calculating a density for total squirrels tallied and total area sampled for all plots sampled in each area.

Statistical analyses, one-way analysis of variance, and Duncan's New Multiple Range Test were performed at the 0.05 level of probability. Variability among total number of squirrels and total sampling area on individual plots within areas was tested each year and all years combined.

RESULTS

A total of 587 squirrels, 558 (95%) gray and 29 (5%) fox were counted. For all years combined, SMZ had the highest squirrel densities, averaging 4.08/ha, followed by PH-SMZ with 3.56/ha and PH with 3.30/ha (Table 1). The average squirrel density by year and forest situation is presented in Table 2.

The analyses of the plot data revealed that significant variation existed between the PH and SMZ in 1974 and 1978 (Table 3). Also significant variation occurred between two of the three PH forests in 1978. Variation among all plots in the forests in 1975 and 1979 was not significant. The only area having significant plot variation from other areas for any year of the study was the PH forest number 3 in 1975.

Average time required for all squirrel detections in all areas during 1974-1975 and 1978-1979 ranged from 12 to 14 minutes with a four year average detection time of 13 minutes. Detection times varied from less than one minute to 30 minutes. Detection time averaged 3 minutes longer per squirrel in the SMZ, probably due to the skylighting effect the adjacent clearcuts and young pine plantations created. This increased light intensity from skylighting impaired the ability of some observers to census squirrels for two reasons. Glare from the rising sun entering these hardwood strips was great enough at times to retard detectability. Secondly, the increased lighting often made it more difficult for an observer to adequately hide in areas where cover was frequently already sparse, and the observer became more exposed to squirrels. Mean detection distance from plot center in all areas ranged from 26.2 to 33.2 m for the four years with an average detection distance of 31.4 m. Detection distances averaged 1.5 m farther in PH forests than either the SMZ or PH-SMZ. About 58 percent of all squirrels were initially detected visually; the remainder were noticed aurally and then located visually. Initial visual detection went from 50-65 percent of all squirrels recorded in 1975, 1978, and 1979, with a three year average of 59 percent.

DISCUSSION

The time area count, a direct time-lapse census method, produces variable but assurable results (Uhlig 1955). The annual fluctuations in squirrel densities could have been caused by differences in mast production and/or observer bias, and other variables (Warren 1980). A comparison of squirrel densities among different areas in the same year should be valid. The streamside management zones had the highest squirrel densities; they were older than the pine-hardwood forests and had more and larger mast producers (oaks, hickories) and probably more den trees (cavities). Squirrels could have also obtained some food (e.g. mushrooms, berries) from adjacent young pine plantations.

When PH forests adjacent to and near hardwood strips along streams were clearcut, some squirrels were probably forced into the remaining forest (SMZ). This movement would account for initially high squirrel densities in SMZ. However, squirrel densities remained higher than in PH forests years after clear-cutting, indicating the squirrel

Table 1. Mean squirrel densities (number/ha) based on total number of squirrels and total area sampled on all plots in each study area during time area counts in Kemper County, Mississippi.[1]

Year	Pine-Hardwood Forest			Streamside Management Zone		Pine-Hardwood Forest next to Streamside Management Zone	
	1	2	3	1	2	1	2
1974	1.95	1.73	5.49	8.10	4.97	3.16	3.09
1975	2.79	0.25	1.41	2.82	2.27	--	--
1978	1.21	1.51	4.23	4.77	2.89	1.95	--
1979	3.31	4.87	2.05	3.06	3.66	--	--
Mean	2.3	2.1	3.3	4.7	3.5	2.6	3.1

[1]Average maximum detectability distance not used.

Table 2. Mean squirrel densities (number/ha) by year and study area from time area counts in Kemper County, Mississippi.[1]

Year	Pine-Hardwood Forest	Streamside Management Zone	Pine-Hardwood Forest next to Streamside Management Zone
1974	3.06	6.55	3.14
1975	1.48	2.55	--
1978	2.32	3.83	1.95
1979	3.41	3.36	--
Mean	2.6	4.1	2.5

[1]Average maximum detectability distance not used.

Table 3. Mean squirrel densities (number/ha) using the average of all plot density estimates of each censused study area from time area counts in Kemper County, Mississippi.

Year	Pine-Hardwood Forest			Streamside Management Zone		Pine-Hardwood Forest next to Streamside Management Zone	
	1	2	3	1	2	1	2
1974	5.36 ab[2]	3.68 a	17.57 ac	10.58 bc	8.72 ac	12.50 ac	6.92 ac
1975	32.52 a	7.76 a	1.68 a	10.35 a	5.58 a	--	--
1978	1.53 a	1.66 ab	8.92 b	7.59 b	5.49 ab	3.39 ab	--
1979	5.81 a	16.56 a	3.78 a	5.61 a	20.11 a	--	--
Mean	8.67 a	7.22 a	8.55 a	8.28 a	10.30 a	10.67 a	6.92 a

[1]Average maximum detectability distance used.
[2]Means followed (horizontally) by the same letter are not significantly different ($P < 0.05$).

habitat in SMZ was more favorable than in PH. Nixon et al. (1980) reported that gray squirrel estimated densities declined in southeastern Ohio after clear-cutting.

The SMZ used in this study averaged 100 m wide, which were much wider than hardwood strips left in most intensively managed pine plantations. The squirrel densities estimated for these SMZ should not be expected on upland sites or in much narrower hardwood strips.

The PH, PH-SMZ, and SMZ all had huntable squirrel populations. The SMZ provided travel lanes and better habitat for gray squirrels and many other wildlife species (Hurst and Warren 1980, Nixon et al. 1980). Travel lanes have proved beneficial to wild turkeys *(Meleagris gallopavo)* in the Southeast (Gehrken 1975). Yields of both timber and squirrels can be maintained by long-term planning of cuts on large forest tracts (Roach 1974). Now wildlife managers need to utilize such management opportunities as the SMZ and determine the restrictions necessary on timber harvesting to insure the stability of wildlife species that would be adversely affected by clear-cutting large tracts.

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