MAMMAL CACHING OF OAK ACORNS IN A RED PINE AND A MIXED-OAK STAND

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Abstract: Small mammal caching of oak (*Quercus* spp.) acorns in adjacent red pine (*Pinus resinosa*) and mixed-oak stands was investigated at The Penn State Experimental Forest, Huntingdon Co., Pennsylvania. Gray squirrels (*Sciurus carolinensis*) and mice (*Peromyscus* spp.) were the most common acorn-caching species. Acorn production was estimated at 104,200 red oak group acorns/ha and 80,250 white oak group acorns/ha. Acorn caches in the red pine stand were estimated at 900 red oak acorns/ha and 650 white oak acorns/ha. In contrast, in the mixed-oak stand 45,350 red oak acorns/ha and 24,150 white oak acorns/ha were cached. Gray squirrels cached 38% of the acorns produced; 98% of the acorns were cached in the mixed-oak stand. Gray squirrels cached 38% of the acorns produced; 98% of the acorns were cached in the mixed-oak stand.

INTRODUCTION

In the northeastern United States, foresters and wildlife managers consider oaks (*Quercus* spp.) to be the most important tree species (Martin et al. 1951, Shaw 1971). Cahalane (1942), Janzen (1971) and Potter (1978) reported dispersal and planting of acorns by mammals and birds are beneficial for oak regeneration. However, the role of small mammals in oak regeneration is unclear; Marquis et al. (1976) and Gottschalk (1983) reported mammal predation of acorns and small seedlings has a serious negative effect on oak regeneration and contributes to regeneration failure.

Size and frequency of acorn crops vary yearly and are unpredictable (Sharp and Chisman 1961). Size and viability of acorns also differ with geographic location (Marquis et al. 1976). Acorn crops vary from 0 to 250,000+ acorns/acre (Olson and Boyce 1971). Acorns ripen and are dispersed from late August to early December. Acorns of the white oak group mature in one year, whereas acorns of the red oak group require two years (Olson 1974). In autumn white oak acorns germinate immediately upon dropping and the radicle may reach a depth of 8 inches before onset of cold weather (Watt 1979). Red oak acorns do not germinate until spring, as they require 32-41°F and moist stratification for at least 30-60 days (McQuilken

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1983). Byrne (1961) stated when oak is well-established, the next stand will be mostly of seed origin.

Northeastern mammals that cache acorns are the gray squirrel, fox squirrel (*Sciurus niger*), red squirrel (*Tamiasciurus hudsonicus*), southern flying squirrel (*Glaucomys volans*), northern flying squirrel (*Glaucomys sabrinus*), deer mouse (*Peromyscus maniculatus*), white-footed mouse (*Peromyscus leucopus*), and eastern chipmunk (*Tamias striatus*) (Martin et al. 1951). Other small mammals such as voles (*Microtus* spp., *Clethrionomys gapperi*), jumping mice (*Zapus hudsonius*, *Napaeozapus insignis*), and the eastern woodrat (*Neotoma floridana*) may be of minor importance.

Two different strategies of seed-caching exist, larderhoarding and scatterhoarding (Stapanian and Smith 1978). Larderhoarding is the process of gathering seeds into one, or at most a few, large, concentrated, defended caches. Scatterhoarding is the process in which seeds are stored in numerous, widely scattered, small (one to a few seeds) caches. Scatterhoarders, such as the gray squirrel, have potential to benefit oak regeneration. Burying an acorn increases survival and may create ideal conditions for germination (Griffin 1971, Janzen 1971, Barnett 1977). Scattering caches ensures appropriate conditions for survival of some acorns and a good distribution of seedlings (Cahalane 1942). Therefore, scatterhoarders may be of greater benefit to successful oak regeneration than larderhoarders.

Small mammals may be the prime distributors of acorns regardless of stand type. Gray squirrels may be the prime mammalian distributors of acorns in conifer stands. Our objective was to compare acorn dispersal by small mammals between oak and red pine stands. Funding was provided by the School of Forest Resources, The Pennsylvania State University. We thank T. W. Bowersox, G. M. Kelly, R. D. Shipman and L. M. Woebkenberg for advice.

METHODS

Established within a 60-yr-old, 12-ha mixed oak stand located in the Penn State Experimental Forest, Huntingdon Co., Pennsylvania, the study area was a 45-year-old, 1-ha red pine plantation with 3 x 3 m spacing. A 1-ha mixed oak site that shared a 100-m border with the red pine plantation was delineated.

The census and assessment lines technique developed by O'Farrel et al. (1977) provided small mammal abundance estimates. Sherman traps baited with rodent chow were used for live-trapping. Flyger's (1959) time-area count method was used to estimate chipmunk and squirrel abundance.

Acorn production was estimated by the number of caps, and acorn availability was estimated by the number of acorns present on 40 4-m2 plots in the 1-ha oak site. All acorns and acorn caps were counted, by red oak group or white oak group, but not removed. Counts were conducted bi-weekly from the last week of September through November. Each count consisted of 40 plots that were randomly selected each sample period.

Sound acorns (1,000 white oak (*Quercus alba*) and 1,000 red oak (*Quercus rubra* L.)) were selected to estimate acorn dispersal. A location was randomly selected on the oak-red pine border. On 16 September, blue paint-marked acorns, 500 of each species, were placed in two adjacent piles, in a covered bait station, which was used to discourage birds and mammals larger than squirrels from removing the acorns. The station was monitored daily until all acorns were removed. This procedure was repeated on 12 November with green paint-marked acorns. Yellow fluorescent pigment was used for 3 days to monitor species of mammals removing acorns. For 4 2-week intervals, stands were searched for caches. For each 2-week interval, 50 points were randomly selected in each stand. A 4-m2 area was systematically searched at each point by raking the litter and soil to a depth of approximately 12 cm with a procedure similar to Montgomery et al. (1975). Marked and unmarked acorns, by species and distance from the red pine-oak border, were recorded. Jackson's Positive Method for analyzing capture-recapture data (Begon 1979) was used to determine density of cached acorns.

RESULTS AND DISCUSSION

Mean small mammal abundance in the oak stand, August through November, was 2.02, 0.0, 0.63 and 3.95 (August only) individuals/ha for gray squirrels, red squirrels, chipmunks, and *Peromyscus* spp., respectively. In the red pine stand, gray squirrel, red squirrel, chipmunk and *Peromyscus* mean abundance estimates were 0.31, 0.07, 0.16 and 7.89 (August only) individuals/ha, respectively. Gray squirrel abundance was low to average as compared to estimates of Nixon et al. (1968). Captures of *Peromyscus* in the oak and pine stands were 77 and 66, respectively. M'Closkey (1980) stated capture frequency of live-trapped rodents provides a good estimate of foraging effort. Red oak production peaked at 66,050 acorns/ha (SD=39,425), whereas peak white oak production was 35,325 (SD=33,225) (Table 1).

All acorns marked in September and November were removed from the bait station in 2 and 6 days, respectively. There was no difference (P=0.11) in the disappearance rate between red and white oak acorns. Marked acorn recovery rate was 0.053 and 0.030 in the oak and red pine stand, respectively. Maximum number of acorns cached in the oak stand was 45,350 (SD=27,650) and 24,150 (SD=22,850) for red and white oak, respectively (Table 2). In the red pine stand, maximum number of acorns cached was 900 (SD=1,950) and 650 (SD=1,225) for red and white oak, respectively (Table 2). Gray squirrels, as revealed by tracks of yellow fluorescent pigment, removed all acorns from the bait stations.

Caches containing marked acorns were observed only within 20 m of the oak-pine border in the pine stand; marked caches were within 50 m in oak stand, but were concentrated (85%) within 20 m of the border. The farthest unmarked cache was within 50 m in the pine stand; caches were distributed throughout the oak stand.

Table 1.--Red and white oak acorns/ha and caps/ha on the ground at bi-weekly intervals (n=40 4-m2 plots per interval).

	Red Oak				White Oak			
	Acorns		Caps		Acorns		Caps	
Week	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
21 Sep.	39,550	28,850	8,550	6,250	25,750	27,325	5,575	6,800
5 Oct.	66,050	39,425	46,800	25,650	35,325	33,225	30,375	25,175
19 Oct.	18,300	16,225	72,825	42,950	950	1,750	55,125	48,900
2 Nov.	2,200	3,300	82,200	51,125	450	1,175	61,625	48,450
16 Nov.	500	1,150	104,200	51,400	325	825	80,250	58,000

Table 2.--Red and white acorns cached/ha in the oak and red pine stands per sample period (n = 50 4-m2 plots).

Elasped	Red Pine				Oak			
time	Red Oak		White Oak		Red Oak		White Oak	
(weeks)	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
3	450	1,200	300	825	8,550	7,700	1,350	1,700
5	500	1,125	450	1,075	37,100	22,750	18,550	27,700
7	700	1,425	650	1,225	43,650	28,450	24,150	22,850
9	900	1,950	500	1,125	45,350	27,650	15,400	16,375

Comparison of total acorn production (caps) (184,450/ha) to total peak caches (69,500/ha) indicated 37.7% of total acorn production was reflected in caches. Activity of small mammals in the oak stand resulted in 70,000 well-distributed caches/ha. Gray squirrels were the important species in acorn dispersal. Their style of caching, a single acorn buried approximately 3 cm deep, may be beneficial for acorn storage and germination. Core (1971) reported gray squirrels are so important in dispersal that a diminishing squirrel population could have adverse effects on acorn distribution. Gray squirrels used many of the 70,000 cached acorns/ha, however, nondormancy of white oak may have added seedlings that may not have become established otherwise. Chew (1978:175) stated, "The number of seeds that are consumed can easily be overly impressive . . . If there has been a long evolutionary relationship of plant and predator, the loss of 99% of the plant's seed crop to the granivore is not necessarily of any consequence to the plant's future destiny and productivity. Measurement of this loss per se is not proof of an effect of the seed predator on the plant."

Gray squirrels cached 38% of the acrons produced; the mixed-oak stands was preferred for caching. This information could be used as a basis for intensely managing squirrel

populations in areas where enhancement of oak reproduction is a priority. Some options would be leaving den trees when cutting, altering rotation length to favor squirrels, and manipulating the opening date of squirrel hunting season. Perhaps squirrel hunting season should open after the majority of acorns has fallen and been cached, to enhance oak regeneration potential.

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