Harvest Analysis of a Maryland Gray Squirrel Population

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Abstract: Gray squirrel (*Sciurus carolinensis*) harvest was investigated on a 2,320-ha Maryland study area from 1976 through 1981 using harvest/recovery estimates (Brownie et al. 1978) of marked squirrels. The minimum percentage removed by hunters was estimated to be 7% of adults and 9% of young and subadults. Hunting pressure, expressed as the number of trips, averaged 1,641 annually over a 17-week season with the majority (95%) occurring in the first 6 weeks. Average annual survival rate estimates were 0.52 for adults and 0.46 for subadults and young. However, survival esimates were variable. Results showed that current harvest levels could be sustained.

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Several studies have suggested that limiting hunting has little effect on gray squirrel populations (Uhlig 1956, Madson 1964, Barkalow and Shorten 1973). Uhlig (1956) and Madson (1964) concluded that a harvest of 50% to 60% was not detrimental, while Mosby (1969) suggested that it may be possible to remove only up to 40% of a fall population without impact. Mosby et al. (1977) suggested that the "law of diminishing returns" intrinsically regulates squirrel harvests to safe levels, especially in extensive forests. However, Nixon et al. (1974) reported an overharvest of a woodlot fox squirrel (*S. niger*) population with average annual mortality of 75.2%. Nixon et al. (1975) found that a combination of heavy hunting pressure, and unstable mast crops caused a squirrel population to depend on immigration to sustain average annual mortality of 80%, with hunting (kills and cripples) accounting for 58.8% of annual mortality.

This study reports results of an investigation of annual harvest of a gray squirrel population on a 2,320-ha study area in Maryland. Results provide a response to hunters' concerns in years of low squirrel populations.

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Methods

The study was conducted on the Indian Springs Wildlife Management Area (ISWMA) near Clear Spring, Washington County, Maryland. The study area, on 4 noncontiguous tracts ranging in size between 323 and 816 ha, was comprised primarily of mixed oak (*Quercus spp.*) and hickory (*Carya spp.*) forests, with associated cove hardwoods. Small stands (<1 to 5 ha) of mixed Virginia-shortleaf Pine (*Pinus virginiana* and *P. echinata*) are scattered over the area with some stands of Table Mountain Pine (*P. pungens*) existing at higher elevations. Roughly 75% of the area is forested with 50- to 70-year-old trees of moderate size (200–350 mm dbh), 17% in trees > 350mm, and 6% < 200 mm dbh. The remainder of the area (2%) was comprised of interspersed clearcuts, permanent openings, and fields.

Squirrel hunting demand at ISWMA is considered moderately high. Prior to 1981, hunter density on the area was limited to 1 hunter/10 ha and was controlled by daily permits. Normally, the opening day and first Saturday of the squirrel season resulted in permit requests that exceeded limits. At all other times hunter densities were less than the maximum. In 1981 the limit was changed to 1 hunter/4 ha. With this change, permit requests never reached the maximum allowed. Hunters were allowed to hunt tract of choice, i.e. density limits applied to the area as a whole. This permit system also required hunters to check on and off the area, thus all squirrels legally harvested and reported could be checked for age, sex, and marks.

Using nest boxes, a study was designed to investigate the proportion of the gray squirrel population harvested, and to determine survival rates (Barkalow et al. 1970). With these procedures, a representative sample of squirrel populations and harvests on the study area was obtained. To mark squirrels, 125 nest boxes were placed each year between 1976 and 1979 for a total of 500 boxes, on selected sites on 3 of the 4 tracts. Nest boxes were examined each April and September (prior to the hunting seasons) except in 1976, when an additional check was made in November. All captured squirrels were aged, sexed, marked and released or, if nestlings, returned to the box. Adult and subadult classes were determined by examination of external genitalia (Taber 1969), by overall size of the animal, and by tail pelage (Sharp 1958). Age of young was determined using criteria described by Uhlig (1955). Animals >12 months were considered adults; between 4 and 12 months, subadults; and <4 months, young. Subadults and young were combined for analysis since these age classes represented an annual recruitment increment to the population. Therefore, during the recovery period, 1 class would have been born in a previous year (adults) and another class born in the current year (subadults and young). For each box checked, we recorded number of squirrels present by sex and age, and number, sex and age of squirrels marked and released. Captured squirrels

Table 1. Gray squirrel harvest, number of marked nestlings recovered, number with unknown status, number of hunting trips and harvest per trip on the Indian Springs Wildlife Management Area, Maryland, 1976–1981.

Year	Gray squirrel harvest	Marked squirrels		Unknown status[a]		Number of hunting trips	Squirrel harvest per trip
		Number recovered	Percent of total harvest	Number	Percent of total harvest		
1976	607	10	1.6	48	7.9	1,568	0.39
1977	755	14	1.9	34	4.5	1,496	0.50
1978	953	26	2.7	43	4.5	1,532	0.62
1979	629	19	3.0	38	6.0	1,651	0.38
1980	554	18	3.2	44	7.9	1,613	0.34
1981	955	30	3.1	60	6.3	1,983	0.48
TOTAL	4,453	117	2.6	267	5.9		
Average	742.2	19.5		44.5		1,640.5	0.45

[a]Squirrels here were skinned, cleaned or discarded by hunters prior to arriving at check station; therefore, mark status could not be determined.

were marked by toe clipping and ear notching so age class and year marked could be determined by a bag check (individuals could not be identified).

Marked squirrels, recovered through hunter harvest, were examined for age, sex, reproductive status and weight. Age was determined as previously described, and weight, accurately determined to the nearest gram, was used as an aid (Flyger, pers. commun.). All squirrels reported as harvested were checked or accounted for. Mark status could not be determined for 5.9% of the total harvest (Table 1). We believe some animals were removed by illegal hunters or not reported. Recovery rate is considered to be synonymous with harvest rate for this study since any error from this source is small. Hunting pressure was expressed as number of squirrel hunter trips. A trip was defined as a squirrel hunter on the area for any part of a day.

Recovery data were analyzed using procedures described by Brownie et al. (1978). These procedures allowed estimation of 2 parameters: (1) survival rate - S - the probability that a marked animal alive at the start of the year (time of marking) survives until the following year; (2) recovery rate - f - the probability that a marked animal alive at the start of the year is killed and retrieved by a hunter and its mark is recorded. Brownie et al. (1978) described procedures to determine which model bests fits a data set. Using these procedures it was determined that the H1 model of Brownie et al. (1978) best fit the data.

All marked animals were subject to harvest (recovery) in the year marked but survival from time of marking to potential recovery varied, resulting in heterogenity in S and f. This problem is discussed by Pollock and Raveling (1982) and by Nichols et al. (1982). As these studies point out, 1 annual marking period reduces heterogenity and subsequent biases. However, combining data from 2 different marking periods (April and September) was essential because of the small numbers marked and recovered. It should be emphasized that combining the 2 marking pe-

riods will induce heterogenity of survival and recovery rates which could mean the estimates are somewhat biased.

The complement of survival rate, mortality rate (1-S), includes hunter harvest as well as other causes of death such as predation, disease, etc. Assuming harvest rates are approximated by recovery rates, this property provides a method to determine the hunter harvest component of total mortality.

Results

Over the 6-year period, 831 gray squirrels of all classes were marked and released (Table 2). Overall, the spring box check yielded more animals for marking (59.3%) than did the fall check. Because box checks were timed to coincide with peak nesting periods, the majority (74.2%) of squirrels marked were nestlings. Sex ratio of nestlings was 1:0.93 in favor of males. More adult females than males were captured (1:1.42), as females with young were frequently captured together.

A gross rate of recovery of 14.1% (117 recoveries from 831 marked squirrels) was realized over the 6-year study. A total harvest of 4,453 gray squirrels contained 117 marked individuals (2.6%). Since 267 squirrels were classified as unknown, about 7 (267 × .026 = 6.9) unknown squirrels potentially could have been marked (Table 1). Marked and recovered animals (Table 2) were arranged by class so that year of marking and year of recovery of marked animals could be analyzed (Table

Table 2. Number of gray squirrel marked by sex and age at Indian Springs Wildlife Management Area, Maryland, 1976–1981.

		Number of squirrels marked by sex and age							
Year	Season marked	Adult males	Adult females	Subadult males	Subadult females	Young males	Young females	Total	
1976	S[a]	1	3			7	13	24	
	F	1	3			26	26	56	
	W	3	1	4		3	3	14	94
1977	S	6	7		1	33	28	75	
	F		2	1	1	9	5	18	93
1978	S	9	13	4	1	27	21	75	
	F	1	11	1	1	52	33	99	174
1979	S	12	7	4	4	24	28	79	
	F	1	5			27	33	66	145
1980	S	15	16	18	8	26	33	116	
	F		5		1	24	23	53	169
1981	S	13	15	5	3	54	38	128	
	F	3	4			7	14	28	156
TOTAL		65	92	37	20	319	298	831	

[a]S = Spring marked (April).
F = Early fall marked (September).
W = Winter marked (November).

Table 3. Recovery of nest box marked adult and young squirrels at Indian Springs Wildlife Management Area, Maryland, 1976–1981 (sexes combined).

Year marked	Number marked	Year of recovery					
		1976	1977	1978	1979	1980	1981
Adults							
1976	12	0	2	0	0	0	0
1977	15		3	1	1	0	0
1978	34			0	2	1	0
1979	25				1	1	0
1980	36					0	1
1981	35						4
Young and subadults							
1976	82	10	3	2	1	1	0
1977	78		6	0	1	0	0
1978	140			23	6	2	2
1979	120				7	7	5
1980	133					6	6
1981	121						12

Table 4. Annual survival and recovery rates of nest-box marked gray squirrels at Indian Springs Wildlife Management Area, Maryland, 1976–1981.

Year	Survival rates				Recovery rates			
	Adults		Young and subadults		Adults		Young and subadults	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
1976	0.44	0.33	0.23	0.12	0.0	–	0.12	0.04
1977	1.00[a]	0.91	0.11	0.13	0.19	0.08	0.08	0.03
1978	0.54	0.48	0.62	0.46	0.03	0.02	0.16	0.03
1979	0.55	0.67	1.0[a]	–	0.05	0.04	0.06	0.02
1980	0.08	0.09	0.32	0.20	0.02	0.02	0.05	0.02
1981					0.11	0.05	0.10	0.03
Average	0.52	0.17	0.46	0.39	0.07	0.02	0.09	0.01

[a]Computed estimates outside 0–1 due to small sample size.

3). Recovery rates for adults were estimated to be 7.0% (3.0%–11.0%, 95% confidence interval, CI) and for young 9.0% (7.0%–12.0%, 95% CI) of the squirrel population (Table 4). Adult gray squirrel survival rates were estimated at 0.52 (0.19–0.85, 95% CI) and young survival rate at 0.46 (0.0–1.0, 95% CI, Table 4). Survival estimates are inconclusive because of wide confidence interval.

Hunting pressure for squirrels remained relatively stable, averaging 1,641 (range 1,496–1,983) trips annually between 1976 and 1981. The high year, 1981, was a result of liberalizing hunter density controls. Squirrel harvest averaged 742 (range 554–955) for the study, with annual oscillations ranging 25.4% below and 28.7% above the 6-year mean. More indicative is the number of squirrels harvested per trip, which ranged from a high (more successful hunting) of 0.61 to a low of 0.34 (Table 1). Squirrel harvest was more closely correlated ($r = 0.84$, $P = 0.05$) with the number marked, i.e. population density, than with the number of trips, i.e. hunting pressure ($r = 0.40$, $P = 0.05$).

Discussion

An average of 7% of the adult and 9% of the young squirrel population was removed annually by hunters. Estimates represent minimum mortality because some losses (crippling, non-reporting, etc.) could not be estimated in this study. Also, mortality between April and October on spring marks will lower the harvest rate. Assuming mortality estimates (1-S) of 0.48 for adults and 0.54 for young are reasonable, and that recoveries are a segment of mortality, then hunter harvest was 14.6% (.07 / 0.48 × 100) of adult mortality and 16.7% (0.09 / 0.54 × 100) of young mortality. Uhlig (1956) estimated about 13% of the statewide squirrel population was removed by hunting in West Virginia. Moran (1953) estimated hunting mortality on gray squirrels to be about 14% in Illinois. Barkalow and Shorten (1973) felt that hunters, nationally, rarely take more than 10% of the fall population. Considering unestimated hunting mortality (crippling, poaching, etc.) the results of this study appear to agree with those cited above. Nixon et al. (1975) found hunting mortality accounted for 58.2% of an average annual mortality of 80%. Because immigration sustained that population, his results suggest that harvest may have exceeded safe limits. Mosby (1969) suggested removals of 40% of the fall population were accomplished without harming the population. The 7% and 9% recovery rates found, in this study, were well below those noted above, suggesting that the study population could sustain higher harvest rates.

Summarizing, it appears that the study area squirrel population could support additional consumptive recreation. Also, most studies have shown that overharvest of squirrel populations is restricted to those cases where heavy hunting pressure and mast crop failures occur together.

Most squirrel hunting (95%) occurs in the first 6 weeks of a 17-week season in Maryland. Since squirrel hunting traditionally decreases by the second week of November, an alternative would be to open the season earlier, thus increasing recreational time. However, advancing the opening date may increase the harvest of lactating females who may have dependent litters. Problem associated with harvesting lactating females appears to be more a sociological than a biological problem and is beyond the scope of this paper.

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