Measuring Wildlife Depredation of Native Pecans

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Abstract: Wildlife depredation of native pecans was evaluated during 1989 and 1990 using ground plots to estimate nut damage, and shuck to pecan ratios to estimate caching in peripheral areas of south-central Oklahoma native pecan groves adjacent to woodland. Total wildlife damage ranged from 28–447 kg/ha, which exceeded harvestable pecans (0–103 kg/ha) from the same areas. Caching comprised 59% (4–381 kg/ha) of the total damage attributable to wildlife. Fox squirrel (*Sciurus niger*) nut damage ranged from 17–67 kg/ha, and exceeded that of all other wildlife combined. Fox squirrel nut damage, bird nut damage, caching, total wildlife damage, and harvested pecans did not differ significantly ($P > 0.05$) between years. However, the ratio of damaged to harvested pecans was higher for all damage categories in the lower pecan production year of 1990. Significant differences were detected in fox squirrel nut damage and caching among groves within years ($P = 0.04$ and $P = 0.02$, respectively).

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Native pecan groves are created through selective clearing of bottomland forest. Where bottomland grades into upland or property boundaries or other limitations prevent clearing, groves are often left immediately adjacent to tracts of undisturbed woodland. This interspersion of an attractive food source among areas of high quality cover creates the opportunity for significant wildlife depredation, though wildlife damage is perhaps the least studied of the factors limiting native pecan production.

Wildlife damage to pecan production can be divided into 3 components: tree injury—damage to the pecan tree itself; nut damage—consumption or spoilage of pecans within the grove; and caching—removal or storage of pecans rendering them unavailable for harvest. Previous estimates of nut damage and caching of native pecans have ranged from 14 to 194 kg/ha, with fox squirrels, blue jays (*Cyanocitta cristata*), American crows (*Corvus brachyrhynchos*), red-bellied (*Melanerpes carolinus*), and red-headed woodpeckers (*M. erythrocephalus*) identified as the major depredators (Leppla 1980, Hall 1984). These studies derived caching estimates using flightline counts of birds flying out of the groves with pecans, an indirect measure which does not account for caching by other species of wildlife.

The objectives of this study were to develop an improved method of measuring

caching and to use it to develop wildlife damage estimates, which would provide an economic basis for evaluating potential damage control methods in native pecans. I thank numerous personnel of the Noble Foundation who assisted with data collection, particularly J.H. Holman, J.L. Kusterer, M.S. Miller, and M.D. Stewart. Data input was provided by L.K. Auld. W.D. Warde provided statistical consultation. B.S. Landgraf contributed suggestions on methodology. K.L. Gee, R.L. Lochmiller, M.D. Porter, M.R. Vaughan, P. Zwank, and 2 anonymous referees provided helpful comments on earlier drafts of this manuscript.

Methods

The Noble Foundation's Red River Demonstration and Research Farm (RRDRF) in Love County, Oklahoma, supports 143 ha of native pecan groves which are being used in a long term study of the cost effectiveness of various control measures on wildlife depredation of pecan production (Fig. 1). A 1988 pilot study indicated that total wildlife nut damage was greatest near the grove-woodland edge.

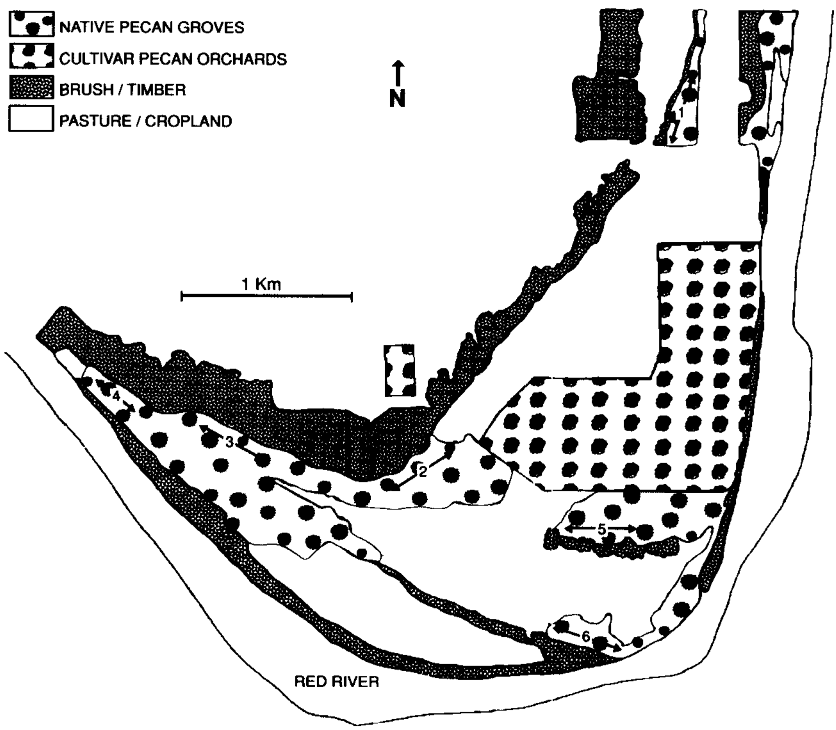

Figure 1. General habitat map of the Noble Foundation's Red River Demonstration and Research Farm in Love County, Oklahoma. Numbers indicate the specific location of study areas.

I felt that impacts of control measures were best tested in areas receiving high wildlife damage. Therefore, I established 6 4.3-ha (91- × 466-m) study areas, separated by a minimum of 368 m, adjacent to the woodland habitat in 1989. Area 1 was frequently flooded in September of 1989 and 1990 making sampling impossible; therefore, it is not included in further discussion. Fox squirrel trapping was conducted in areas 2 and 3 in 1989 and in areas 2, 3, and 5 in 1990.

Prior to 1988, damage control efforts in the RRDRF groves were limited to sport hunting of fox squirrels and American crows and shooting of blue jays under a U.S. Fish and Wildlife Service depredation permit. No wildlife damage control efforts, including hunting, were applied to any groves in 1988; to areas 4, 5, and 6 in 1989; and to areas 4 and 6 in 1990. This paper reports wildlife depredation estimated in each of the 1989 and 1990 untreated study areas.

Nut Damage Estimates

Fifteen trees were randomly selected within each study area and 2 permanent 1-m^2 circular ground plots established magnetic east and west midway between the trunk and the outer canopy of each tree. Consistent rather than random directions were used in order to facilitate locating the plots during each sampling period. Ground plots were sampled biweekly from mid-August through harvest in December 1989 and 1990. Pecan shucks and damaged pecans were removed from all plots and counted at each sampling period but undamaged pecans were left in place until the final sampling period. All trees were shaken with a Savage® model 4200 pecan shaker prior to final sampling.

Pecans were classified as either damaged by fox squirrels, birds, other wildlife, nonwildlife causes, or undamaged. Fox squirrels in caged feeding trials either left pecan shells in pieces or created a jagged, chipped shell entrance hole which could be distinguished from the damage of the other rodents present on the RRDRF (J.G. Huggins, unpubl. data). Bird damage was identified by characteristic beak indention marks and the lack of gnaw marks. Bird damage was not differentiated by species. The number of damaged pecans represented in a sample was derived by dividing the number of identified pecan end pieces by 2.

Caching Estimates

Each pecan matures inside its protective 4-valve shuck or husk (Brison 1974). Upon maturity, the shuck splits longitudinally and separates from the pecan. An unknown but probably minor amount of caching occurs prior to shuck split. After shuck split, wildlife usually remove only the pecan leaving the shuck behind. Therefore, the ratio of pecans to shucks could be used as a conservative measure of caching. Similarly, Darley-Hill and Johnson (1981) used the ratio of acorns to acorn caps remaining beneath pin oaks (*Quercus palustris*) to estimate blue jay caching of acorns.

In 1989, caching was estimated by subtracting the number of pecans from the number of shucks found in the individual ground plots. However, since the shaking procedure shook a much larger percentage of the pecans off of the tree than the shucks, more pecans than shucks were actually found in some plots. Therefore it was necessary to derive a correction factor to adjust for this bias. During the 2 days prior to the mechanical shaking operation in 1990 an average of 99 shucks and 66 pecans were randomly marked on each of 10 trees. All pecans and shucks were then removed from the ground plots, the trees were shaken, and then the plots were sampled again. The number of marked shucks and pecans remaining in the trees was then counted. The following formula was used to estimate caching (number of pecans) per plot.

$$SGB + SGA/(1-STA/STB) - (PGB + PGA/(1-PTA/PTB))$$ where:

SGB = cumulative total number of shucks found in ground plot before shaking

SGA = number of shucks found in ground plot after shaking

STA = total number of marked shucks remaining in trees after shaking

STB = total number of marked shucks in trees before shaking

PGB = cumulative total number of pecans found in ground plot before shaking

PGA = number of pecans found in ground plot after shaking

PTA = total number of marked pecans remaining in trees after shaking

PTB = total number of marked pecans in trees before shaking.

This correction factor also was applied to the 1989 data, though any difference in the shuck and nut fall characteristics between the 2 years is unknown. Since it was impossible to have a negative caching total, a negative total for any particular tree's 2 plots combined was counted as 0. Estimates of damage and harvest in kg/ha for each year were calculated by extrapolating from pecans/plot to each tree's canopy area, multiplying by the average weight of pecans for that year, and then extrapolating to each area's number of trees/ha.

Between year comparisons of the variables fox squirrel nut damage, bird nut damage, caching, total wildlife damage, and harvested pecans were made using data from areas 4 and 6 only. Comparisons between areas within years included the 1989 data from area 5. All data were analyzed as a nested ANOVA design (2 plots per tree, 15 trees per area).

Time-area Counts

Time-area counts were conducted one morning each week from September through December harvest each year. A 2.6-ha semicircular plot was centered within each study area with its straight boundary along the woodland edge. Plot boundaries were marked with steel fence posts. An observer sat at the radial center of the plot and recorded the number of fox squirrels, blue jays, American crows, and red-bellied and red-headed woodpeckers observed entering the plot area during a 15-minute observation period. No precount waiting periods were observed because Flyger (1959) and Batcheller (1980) found that precount waiting periods were unnecessary for tree squirrels and blue jays, respectively. Three other areas were counted as part of another study so that a series of 6 counts were made each day.

A count began at the first study area at sunrise and all counts were completed within 3 hours after sunrise. The order of each count was rotated weekly so that each area was counted first every sixth week.

Results and Discussion

Pecan production was higher in 1989 than in 1990 (Table 1), but differences between years ($P = 0.33$) and between areas within years ($P = 0.33$) were not significant. Total wildlife damage of pecans far exceeded undamaged (harvested) pecans on all areas in both years. Though total wildlife damage did not differ significantly between years ($P = 0.15$), availability of pecans probably limited wildlife damage in 1990. The ratio of total wildlife damaged to harvested pecans was much higher in 1990 than in the higher pecan production year of 1989. Total wildlife damage did not differ between areas within years ($P = 0.37$).

Caching was the most significant component of wildlife damage, accounting for 59% of the total wildlife damage estimate over the 2 years. The caching estimates should be considered conservative; a negative sampling bias likely existed because

Table 1. Estimated number of pecans/m^2, kg/ha, and $/ha of pecans by damage type in peripheral areas of south-central Oklahoma native pecan groves adjacent to woodland.

	Area 4		Area 5	Area 6	
Type of damage	1989	1990	1989	1989	1990
Undamaged					
N/m^2	8.6	0.4	6.6	1.3	0.1
kg/ha	103	5	32	3	0
$/ha[a]	72	6	22	2	0
Total wildlife damage[b]					
N/m^2	42.7	15.2	28.2	25.9	12.6
kg/ha	447	168	146	57	28
$/ha	313	193	102	40	32
Cached					
N/m^2	37.0	7.5	13.0	15.0	1.5
kg/ha	381	80	72	32	4
$/ha	267	92	50	22	5
Fox squirrel nut damage					
N/m^2	3.6	5.9	11.9	7.5	10.3
kg/ha	42	67	57	17	22
$/ha	29	77	40	12	25
Bird nut damage					
N/m^2	1.9	1.4	3.2	3.2	0.7
kg/ha	22	16	16	7	1
$/ha[a]	15	18	11	5	1

[a]Value based on price received for native pecans of $1.54/kg and $2.54/kg in 1989 and 1990, respectively.
[b]Includes caching and fox squirrel, bird, and other wildlife nut damage.

it was much easier to find a pecan in the ground plots than the 4 shuck valves necessary to comprise a whole shuck. In addition, any pecans cached prior to shuck split were not counted by this method. Caching did not differ significantly between years ($P = 0.22$) but did differ between areas within years ($P = 0.02$).

Blue jays comprised 81% of the time-area count observations of the major pecan depredators over the 2 years of this study (Table 2), most often observed in presumed caching flights in and out of the groves. Leppla (1980) and Hall (1984) estimated that blue jays were responsible for >90% of the caching in native groves, but they did not measure mammalian caching. Batcheller (1980) estimated the mean rate of blue jay caching of pecans in 2 native grove flight lines at 0.35 pecans/minute. Darley-Hill and Johnson (1981) reported that blue jays cached 54% of the total acorn crop in a pin oak stand and Johnson and Adkisson (1985) calculated that blue jays dispersed approximately 150,000 beech nuts (*Fagus grandifolia*) from a 44-ha woodlot over a 27-day period. Stapanian and Smith (1978) reported that 5 resident fox squirrels cached only 20% (77) of available black walnuts within 160 hours of observation (0.1 cached walnuts/squirrel-hour).

Fox squirrels caused more nut damage than all other wildlife species combined each year and damaged more pecans than were harvested in 4 of the 5 areas over the 2 years. Fox squirrel nut damage peaked in early September of both years and 43% of the combined 2-year total occurred during September (Fig. 2). Fox squirrel nut damage did not differ between years ($P = 0.47$) but did differ between areas within years ($P = 0.04$).

Table 2. Numbers of blue jays, fox squirrels, American crows, and red-bellied and red-headed woodpeckers counted per 15-minute time-area count in south-central Oklahoma native pecan groves, September–December 1989–1990. 1990 sampling dates are depicted; counts in 1989 were made 2 days later than each 1990 date.

Date	Blue jays	Fox squirrels	American crows	Red-bellied woodpeckers	Red-headed woodpeckers
04 Sep	0.0	0.0	0.0	0.0	0.0
11 Sep	0.0	0.0	0.2	0.0	0.0
18 Sep	0.0	0.6	0.2	0.0	0.0
25 Sep	0.6	0.4	0.8	0.0	0.2
02 Oct	2.0	0.0	0.2	0.4	0.0
09 Oct	2.8	0.2	0.0	0.2	0.0
16 Oct	15.0	0.0	0.0	0.0	0.0
23 Oct	11.2	0.2	0.4	0.2	0.0
30 Oct	8.8	0.4	0.2	0.4	0.0
06 Nov	4.4	0.8	0.6	0.4	0.2
13 Nov	3.2	1.2	0.0	0.2	0.0
20 Nov	1.8	0.0	0.0	0.2	0.0
28 Nov	0.8	0.0	0.2	0.6	0.0
04 Dec	3.2	0.0	1.2	0.6	0.2
11 Dec	0.2	0.0	1.0	0.2	0.0

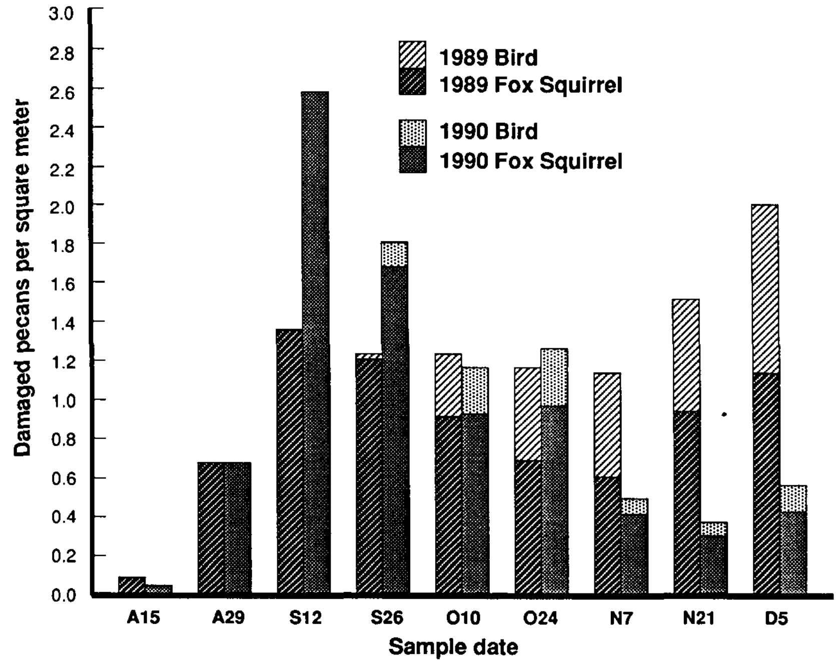

Figure 2. Chronology of pecan nut damage by fox squirrels and birds, August–December 1989 and 1990, in south-central Oklahoma. 1990 sampling dates are depicted; sampling in 1989 was conducted 1 day earlier than each 1990 date.

Bird nut damage did not differ significantly between years ($P = 0.17$) or between areas within years ($P = 0.81$). Bird nut damage did not begin until the initiation of shuck split in late September which coincided with an influx of migratory blue jays in October of each year. Bird nut damage grew steadily and peaked prior to harvest in 1989. In 1990, bird nut damage peaked in October and then declined, probably due to decreasing availability of pecans.

The estimated dollar value of native pecan damage by wildlife represents only the peripheral 91 m of the sampled groves, but such habitats make up 38% (54 ha) of the RRDRF's groves. Informed management decisions regarding the application of damage control measures are based on the perceived value of the crop (a function of production and price) and expected benefits of the control measure. Research results regarding the cost effectiveness of various control measures for pecan depredators are generally lacking. The variability of the economic losses between areas illustrates the need for pecan growers to evaluate the potential benefits of various damage control practices separately for each management unit.

The damage estimation method used in this study should be improved. The categorizing of nut damage by species requires the identification of specific nut damage characteristics for the major depredators of a region. I found it difficult to differentiate the damage of avian depredators. The method used to estimate caching is cumbersome and should be considered conservative, yet is a more complete, direct measure than those employed previously. Further refinement of these measures is needed.

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