DAMAGE TO APPLE TREES ASSOCIATED WITH WOODCHUCK BURROWS IN ORCHARDS

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Abstract: Wildlife damage to apple trees causes significant production losses in the United States. To determine whether woodchuck (Marmota monax) activity was associated with reduced apple production, we quantified damage to apple trees growing <1.5 and 12–15 m from 58 active woodchuck burrows in 3 Connecticut orchards. Ninety-six percent of five trees near burrows had been gnawed by woodchucks, whereas no trees 12–15 m away had been gnawed. Incidence of death was 17 and 0% for trees <1.5 and 12–15 m away from burrows, respectively. Height, maximum canopy width, and stem diameter 0.5 m aboveground were less (P ≤ 0.001) for trees adjacent to burrows than for trees of the same age and variety 12–15 m away. Trees 12–15 m from burrows produced 1.8 times as many apples as trees adjacent to burrows. Apples produced near burrows, on average, weighed less (P < 0.05) than apples produced 12–15 m away in 3 of the 7 plantings. Control of woodchucks may be warranted in orchards with burrow densities >3/ha.

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Woodchucks inhabit agricultural areas throughout much of eastern North America, and their activities often conflict with human interests (Swihart and Conover 1988, 1991). Woodchucks cause direct negative impacts by feeding on forage, fruit, and vegetable crops (Grizzell 1955, Merriam and Merriam 1965, Arenalalt and Romig 1985, Swihart 1991a, Swihart and Picone 1991a) and by gnawing on young trees in nurseries or orchards (Swihart 1991b, Swihart and Picone 1991b). They also cause problems indirectly as a consequence of their burrowing activities, which create hazardous conditions for farm machinery and may lead to excessive aeration of plant roots (Swihart and Conover 1988).

Many orchardists perceive woodchucks as significant pests. Apple growers in the Hudson Valley region of New York estimated that woodchucks killed or damaged 3.5% of young (<6 yr old) trees each year, compared with 1.9% for voles (Microtus spp.) and 4.0% for white-tailed deer (Odocoileus virginianus: <5 yr-old trees) (Phillips et al. 1987). However, field verification of negative effects of woodchucks on tree growth, survival, and fruit production has not been conducted. Our objective was to determine whether woodchuck activity in orchards was associated with reduced growth, survival, or fruit production of trees. Because previous studies demonstrated that most of the potentially deleterious activities of woodchucks occur in close proximity to burrows (Ouellet and Ferron 1988, Swihart 1991a), we investigated trees adjacent to burrows for evidence of damage.

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METHODS

We selected active woodchuck burrows for study in August 1989 at 3 commercial apple orchards in Southington (n = 2) and Middlefield (n = 1), Connecticut. We classified all burrows in the study areas as active on the basis of freshly excavated soil, capture or sighting of a woodchuck at the burrow entrance, or use of the burrow by radio-collared individuals (Swihart 1991b, 1992). We included burrows in the study only if they were <1.5 m from an apple tree and if the area within a 1.5-m radius showed
no evidence of meadow vole presence, as determined by inspection for gnawing damage, feces, runways, and burrows. A previous study (Swihart 1991b) of gnawing damage revealed that most gnawed trees occurred within 1.5 m of a burrow.

We categorized trees <1.5 m from burrows as either live or dead. For live trees, we measured height, maximum canopy width, and stem diameter 0.5 m aboveground. We then counted the number of apples occurring on each tree. After counting, we measured from each study tree the maximum height and width of 4–15 randomly selected apples (median = 9). The number of apples that we measured from a tree was roughly proportional to the abundance of apples produced by a tree relative to other trees examined. Finally, we recorded the incidence of gnawing by woodchucks and measured the gnawed surface area of each tree.

For comparison, we repeated the measurements described above using a tree 12–15 m away from each burrow but within the same row. Direction within a row was determined by flipping a coin, subject to the constraint that the control tree was >12 m from all burrows. One exception to this design occurred because no tree was planted 12–15 m from the burrow in the same row; consequently, we chose a tree from an adjacent row. We verified with orchard managers that selected trees were the same age and variety as trees <1.5 m from burrows. If paired trees from the 2 distances differed in age (due to replacement of a dead or injured tree), we excluded the pair from analyses comparing physical characteristics and fruit yield. We collected height and width measurements for 6–18 apples (median = 11) from each paired tree 12–15 m from burrows.

To reduce temporal variation in results, we collected all data for fruit yield and physical measurements during the last week of August 1989. Height and width measurements of apples were taken to avoid the destructive sampling inherent in picking unripe apples for determination of mass. As an alternative, we picked and recorded fresh mass for a small (n = 10–55), random subsample of apples from each of 7 plantings containing several apple varieties (1 Mcintosh, 2 red delicious, 1 matsu, and 1 empire planting, as well as 1 planting containing rows of rome, cortland, and red delicious and 1 planting containing rows of melrose, matsu, and rome Smith). We used data from these apples to construct models specific to each planting for predicting fresh mass as a function of height and width using multiple linear regression.

Within each planting, fresh mass was estimated for each apple for which we had collected height and width data.

Physical characteristics and fruit yield (no. of apples) of paired trees <1.5 and 12–15 m from a burrow were compared using Wilcoxon matched-pairs tests (Conover 1980). We compared mean estimated fresh mass of apples for paired trees using 2-sample t-tests for each of the 7 plantings.

Differences in apple production near versus far from woodchuck burrows could result if burrowing sites were selected because they exhibited a particular set of topographic or edaphic characteristics. To determine whether differences existed, we measured slope, as well as moisture and texture (Lunt et al. 1950) of soil collected with a hand auger to a depth of 25 cm, at 43 active burrows in the Middlefield orchard and at 110 burrows in 1 Southington orchard. We collected these data in August 1987 (Southington) and July 1988 (Middlefield). At the same time, we collected data on slope and soil moisture and texture at 45 random points in the Middlefield orchard and 53 random points in the Southington orchard. We determined soil pH in August 1988 for 20 burrows at the Southington orchard, and compared these values with pH values obtained from samples collected 10–20 m from each burrow in microsites similar to those in which burrows were located (e.g., in the same row of trees and the same distance from a tree). We made pH determinations for soil samples collected 0.0, 2.5, and 5.0 m from a burrow. We used 2-tailed t-tests to compare slope and soil moisture at each orchard, whereas differences in soil pH among burrows and paired microsites were examined using analysis of covariance, with distance as the covariate. We compared differences in soil texture classes using Chi-square goodness-of-fit tests.

RESULTS

Seventeen percent (10) of the 58 trees <1.5 m from a burrow were either dead or were live trees that had been planted to replace dead ones. No dead or replacement trees were observed at paired sites 12–15 m from burrows (χ² = 10.94, 1 df, P < 0.001). Of the 48 live trees <1.5 m from burrows, 46 (96%) had been gnawed by woodchucks. None of the trees at paired sites
12-15 m from burrows had been gnawed ($\chi^2 = 88.95, 1 \text{ df, } P < 0.001$). Mean ($\pm 1 \text{ SE}$) surface area gnawed was 191 $\pm$ 20 cm$^2$ on trees <1.5 m from burrows.

All 3 measures of physical size were less ($P \leq 0.001$) for live trees <1.5 m from burrows relative to trees of the same age and variety 12-15 m away. Height ($\bar{x} \pm 1 \text{ SE}$) of trees <1.5 and 12-15 m from burrows was 3.1 $\pm$ 0.1 and 3.6 $\pm$ 0.1 m, respectively. Maximal canopy width of trees <1.5 and 12-15 m from burrows was 3.0 $\pm$ 0.1 and 5.5 $\pm$ 0.1 m, respectively. Stem diameter 0.5 m aboveground was 7.0 $\pm$ 0.4 cm for trees <1.5 m from burrows and 8.2 $\pm$ 0.3 cm for paired trees 12-15 m away.

Trees <1.5 m from burrows produced an average of 43% fewer apples than did trees 12-15 m away ($Z = 4.0, P = 0.0001$). Regression models for predicting fresh mass of apples on the basis of height and width measurements were significant for all plantings, explaining from 84 to 98% of the variation in mass (Table 1). Estimated mean mass of apples from trees <1.5 m from burrows was lower ($P < 0.05$) than the estimated mean mass of apples growing 12-15 m away for 3 of the plantings; no differences occurred for the remaining plantings (Table 1).

Sites at which burrows were located did not differ from randomly chosen sites in either slope (Southington: $t = 1.44, 161 \text{ df, } P = 0.14$; Middlefield: $t = 0.19, 86 \text{ df, } P = 0.85$) or soil moisture (Southington: $t = -1.52, 161 \text{ df, } P = 0.13$; Middlefield: $t = 1.01, 86 \text{ df, } P = 0.31$). Soil pH did not differ between burrows and paired microsites ($F = 0.40; 1, 79 \text{ df, } P = 0.50$). Two soil texture classes occurred at Middlefield (sandy loam and fine sandy loam), whereas 4 texture classes occurred at Southington (loamy sand, sandy loam, fine sandy loam, silt). A higher proportion of burrows (0.86) was found in sandy loam soils than at random points (0.43) at Middlefield ($\chi^2 = 17.3, 1 \text{ df, } P < 0.001$). No differences were evident at Southington ($\chi^2 = 5.49, 3 \text{ df, } P > 0.10$), but a lower proportion of burrows (0.34) were found in sandy loam soils than at random points (0.46).

**DISCUSSION**

Trees adjacent to woodchuck burrows were smaller, suffered greater gnawing and mortality, and produced fewer apples than did trees 12-15 m away from burrows. Although our study was not designed to differentiate among the possible causes of these differences, gnawing likely was responsible for at least a portion of the damage we observed. Gnawing often precedes scent marking by woodchucks, and 96% of all scent marking occurs <6 m from a burrow (Ouellet and Ferron 1988). Strong correlations have been documented between gnawing near burrows and mortality of naturally occurring woody plants (Swihart and Picone 1991b). Gnawing can be particularly detrimental to young plants, commonly resulting in complete girdling. Negative effects of root exposure also could have contributed to observed results.

We doubt that topographic or edaphic differences were primary causes of reduced apple production at burrows. No differences in slope, soil moisture, or soil pH were evident, and soil texture at burrows varied in only one of the orchards studied. Moreover, it is unclear whether differences in soil characteristics reflect inherent site differences upon which woodchucks...
cure when selecting burrow sites, or whether differences might reflect alteration of these characteristics during establishment and maintenance of burrows.

MANAGEMENT IMPLICATIONS

Our study was of short duration, and thus it was impossible to determine the extent to which the pattern of fruit production we observed was repeated annually. In addition, because our study was conducted before apples had completely ripened, we do not know the extent to which differential rates of premature fruit drop or mass gain at the 2 distances might have altered final estimates of yield. Nonetheless, a 43% reduction in number of apples produced is severe, and this reduction was exacerbated by the lower mass of apples from 3 of the plantings (Table 1). Fortunately, woodchuck burrows occur at fairly low densities. The orchards in which we worked contained 3–5 burrows/ha (cf. Swihart 1991a), and the orchards contained approximately 330 semidwarf trees/ha. Hence, 0.9–1.1% of trees were affected by woodchucks, resulting in an overall reduction in yield of roughly 0.4–0.6%. This value is an underestimate, however, because the 17% of trees killed at woodchuck burrows were not incorporated into the calculations. In perennial crops such as apples, the loss of a tree impacts future as well as present production, and even sporadic losses of <1% of trees can cause substantial losses in apple yield (Byers 1985). Hence, densities of active burrows exceeding 3/ha may warrant control measures aimed at reducing woodchuck numbers, at least in young plantings.

LITERATURE CITED


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