DEER DAMAGE AND DAMAGE CONTROL IN OHIO'S NURSERIES, ORCHARDS AND CHRISTMAS TREE PLANTINGS: THE GROWER'S VIEW[1].

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ABSTRACT

A survey of white-tailed deer (Odocoileus virginianus) damage was conducted among growers (N = 2,236) of fruit, Christmas tree and nursery crops in Ohio; over 81% responded. Damage was reported by 43.1% of Christmas tree growers, 41.3% of orchardists and 32.5% of nurserymen. Most commonly reported by orchardists as damaged were apples (Malus spp.), by Christmas tree growers were white pines (Pinus strobus), and by nurserymen were maples (Acer spp.). Young plants ($\bar{x}$ = 7.5 years) were more commonly damaged than older plants of all species. Seasonal damage was most common in spring and summer for orchard species, and fall and winter for Christmas tree and nursery species. Mean percent of crop damaged ranged from 9.5% in spruces (Picea spp.) to 48.8% in cherries (Prunus spp.). Average reported losses/ha were \$204 by orchardists, \$219 by Christmas tree growers and \$268 by nurserymen. Positive relationships were demonstrated between damage levels and two deer density indices; buck harvest/km^2 and mean maximum deer sighted were significantly ($P < 0.0001$) correlated with damage ($R^2 = 0.571$). Regression equations using these indices should be useful in predicting damage. As percentage of cultivated crops bordering production areas increased, the chance of damage occurring decreased ($P = 0.06$). Growers with damage had significantly ($P < 0.05$) more woods ($\bar{x}$ = 49.7%) bordering crop areas than did growers without damage ($\bar{x}$ = 39.3%). The most popular means of damage control was sport hunting. Significantly more ($P < 0.05$) growers that had damage permitted hunting (70.6%) than growers without damage (41.6%). Other control techniques used by growers included repellents (16.5%), special deer harvest permits (3-10%), deer deterrent fencing (5.8%), and scare devices (4.5%). Human hair, tankage and Hinder were the most commonly used repellents, and 65 to 92% of respondents using repellents thought repellents offered some to complete protection.

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INTRODUCTION

In 1959, McDowell and Pillsbury reported white-tailed deer damage to crops in Ohio as slight. Since then the deer herd in Ohio has increased dramatically (Nielsen et al. 1982, Stoll and Mountz 1983), and deer damage reports from orchardists, nurserymen and Christmas tree growers to Extension Specialists have increased concurrently. Antler rubbing by deer caused >\$30,000 damage in one Ohio nursery, more than all insects and diseases combined (Nielsen et al. 1982). Stoll and Mountz (1983) surveyed rural Ohio landowners about deer and deer damage, and concluded orchardists and green vegetable growers incurred higher losses from deer damage than other farmers; they made no assessment of damage to nurseries or Christmas tree plantings. Damage by deer could have important economic consequences to these commercial tree industries, which gross more than \$200 million annually (R. C. Funt, Horticulture Extension Specialist, Ohio State Univer., pers. commun.).

In 1983, we began a study of deer damage in orchards, nurseries and

Christmas tree plantings. One objective was to determine the statewide distribution and perceived seriousness of deer damage to these crops. We also wanted to discover what growers were doing to combat deer damage.

Before practical and effective control methods can be implemented, characteristics of deer damage must be known (deCalasta and Schwendeman 1978). Most deer damage research has dealt with reforestation problems (Adams 1949, Marquis 1974, Marquis et al. 1976, Marquis and Grisez 1978), deer damage control methods (Carpenter 1966, Denton et al. 1969, Caslick and Decker 1979, Robinette and Causey 1979, Palmer et al. 1983, Porter 1983) or grower attitudes toward deer (Brown et al. 1978, Brown and Decker 1979, Decker and Brown 1982, Stoll and Mountz 1983). Although some research has been done (Crouch 1966, Harder 1970, Nielsen et al. 1982), the nature and extent of deer damage in orchards, nurseries and Christmas tree plantings has not been adequately defined. Therefore we added to our study objectives: determine species/varieties most susceptible to deer, plant parts damaged, proportion of crop damaged and estimated economic losses caused by deer.

METHODS

In September 1983, a self-administered, mail-back questionnaire was sent to 2,236 growers of fruit, nursery or Christmas tree crops. The questionnaire was constructed primarily of closed-end and multiple choice questions. The mailing list included members of the Ohio Christmas Tree Growers Association, state licensed nursery operators with >2 ha in production and state licensed pesticide applicators. This list was supplemented with names of growers supplied by Extension Specialists. We attempted to contact all growers of these crops in Ohio. Multiple contacts were used to maximize response (Dillman 1978).

RESULTS

Survey Response

Response after all contacts was >81%. Some questionnaires were not deliverable (N = 36), and some growers returning the survey were not growing crops of interest (N = 324), leaving 1,487 usable questionnaires for analysis. No difference ($P > 0.05$) in question response was noted between respondents to mail contacts and those contacted during the telephone follow-up of non-respondents. Many respondents (N = 555) were growing more than one crop of interest.

Damage Reported

Proportion of growers reporting damage ranged from 7.7% for vineyards to 43.1% in Christmas tree plantings (Table 1). Damage was reported by 41.3% of orchardists and 32.5% of nurserymen.

Most growers with damage (60.4%) described damage levels as slight or very slight. Moderate levels of damage were claimed by 28.7% of the growers with damage, and only 10.9% considered damage incurred to be heavy or very heavy.

Damage Characteristics

We expected to distinguish susceptibility to deer damage of different varieties, but growers rarely differentiated by variety. Apples (*Malus* spp.) were listed as damaged more frequently than any other orchard species (Table 2). White pine (*Pinus strobus*) was reported as the most frequently damaged Christmas tree. Nurserymen reported that deer damaged maples (*Acer* spp.) more than any other nursery species. Young trees ($\bar{x}$ = 7.5 yrs.) of all species were reported more commonly damaged by deer than older trees.

Damage by deer was reported most frequently for apples in spring and summer, pears (*Pyrus communis*) in summer, and peaches in fall. Christmas tree and nursery species were reported as receiving most damage during fall and winter, although some nurserymen

Table 1. Percentage of Ohio growers with deer damage in 1983.

Crop	N	Growers with Damage
Christmas trees	480	43.1
Orchards	723	41.3
Nurseries	296	32.5
Vineyards	233	7.7
Vegetables	416	16.1
Small Fruit	92	10.9

reported damage in summer to some species.

Growers consistently reported damage to buds, twigs and stems; evergreens were exceptions to bud damage as a problem. Damage to leaves/needles was a greater problem in fruit and nursery species than in Christmas trees. Damage to fruit was reported less frequently than damage to buds, leaves, twigs and stems. Pears had reportedly more bark damage than other orchard species, and spruces and pines had more bark damage than firs. Nursery species seemed to have more bark damage than either Christmas tree or orchard species.

Growers with damage reported mean proportions of crops damaged in apples and peaches of 26% and 25%, respectively. Cherries received extensive damage but the number of growers reporting damage to cherries was too small for definitive conclusions (N = 12). Firs were most damaged ($\bar{x}$ = 22.1%) of the Christmas tree species. Nursery species incurred slightly higher damage than orchard and Christmas trees relative to percentage of crop affected. Mean estimated losses per grower were $2,225 for apples, $1,228 for White pine and $214 for maples (Table 2). Some apple growers reported total losses from deer of $50,000. Mean losses were $268/ha for Nursery-only, $219/ha for Christmas tree-only and $204/ha for Orchard-only operations.

Deer Numbers, Cover and Damage

Most growers (52.2%) without deer damage in 1983 reported no occurrence of deer damage during the previous five years (1979-1983). Sixty-nine percent of the growers reporting damage in 1983 reported increases in damage over the 1979-1983 period. Significantly more ($P < 0.05$) growers with deer damage in 1983 reported increases in deer damage from 1979-1983 than growers reporting no damage in 1983, 69.1% vs. 5.9%, respectively.

Growers were asked what trends in deer sightings on production areas they had noticed over the 1979-1983 period. Growers with damage in 1983 reported significantly ($P < 0.001$) different trends than growers without damage; more growers with damage in 1983 noticed increases in deer sightings (60.1% vs. 27.5%) than growers with no damage. Conversely, more growers without damage in 1983 reported approximately the same number of deer sightings than did growers with damage (41.1% vs. 29.6%). Only 9.1% and 18.4% of the growers with and without damage, respectively, noticed decreases in deer sightings over the 1979-1983 period.

The proportion of growers by county with damage was used as the dependent variable (Y) with buck harvest/km^2 (BH/km^2) by county as the independent variable (X) in regression analysis. The model $Y = 0.438 + 0.69X$ was highly significant ($P < 0.0001$, $r^2 = 0.419$). Hence, BH/km^2 accounted for about 42% of the variation in proportion of growers with damage.

Growers were asked the maximum number of deer sighted in production areas at one time. The mean for all respondents was 5.2 deer. Growers with damage reported a significantly ($P < 0.05$) higher mean maximum number of deer (MMD) seen ($\bar{x}$ = 7.3) than growers without damage ($\bar{x}$ = 2.9). Proportion of growers with damage by county (Y) was regressed on MMD (X), and the resulting equation, $Y = 0.195 + 0.064X$, was highly significant ($P < 0.0001$, $r^2 = 0.475$).

Both deer density indices were used in multiple regression analysis to predict proportion of growers with damage (Y). The equation $Y = 0.2384 + 0.4027 * BH/km^2 + 0.0442 * MMD$ was also highly significant ($P < 0.0001$, $R^2 = 0.571$).

Table 2. Plant species and summary of damage characteristics of plants most commonly listed by growers as incurring deer damage.

Species	Ages of Plant (yrs) $\bar{x}$	Ages of Plant (yrs) SD	Most Common Seasons of Damage[a]	Most Commonly Damaged Plant Parts[b]	% of Crop Damaged $\bar{x}$	% of Crop Damaged SD	Mean Estimated Damage Costs ($) $\bar{x}$	Mean Estimated Damage Costs ($) SD
Apples (*Malus* spp.)	5.14	7.62	Spr, Sum	Twg, Bud, Lvs	26.1	29.4	2,226	7,038
Peaches (*Prunus persica*)	4.74	10.8	Fal, Spr	Stm, Twg, Bud, Brk	24.7	30.4	1,064	1,792
Fruit trees	2.97	7.62	Fal, Win, Spr	Twg, Lvs, Stm	23.9	26.3	214	250
Pears (*Pyrus* spp.)	5.86	9.25	Sum	Twg, Brk, Lvs	19.8	25.9	1,287	3,276
Cherries (*Prunus* spp.)	3.16	1.45	Spr, Fal	Twg, Stm, Lvs, Bud	48.8	35.0	229	326
White pine (*Pinus strobus*)	3.60	1.84	Win	Stm, Bud	18.1	26.7	1,228	2,262
Scotch pine (*Pinus sylvestris*)	4.24	2.46	Win	Stm, Bud	13.8	19.5	1,106	3,305
Spruce (*Picea* spp.)	5.57	2.75	Fal, Win	Stm, Twg, Brk	9.5	13.2	588	1,001
Christmas trees	4.08	2.29	Win, Fal	Stm, Twg, Bud	17.4	25.3	373	802
Pine (*Pinus* spp.)	5.52	6.71	Win	Stm, Brk	10.4	13.9	261	265
Fir (*Abies* spp. and *Pseudotsuga* spp.)	6.26	5.92	Fal, Win	Bud, Stm, Brk	22.1	27.8	531	631
Maples (*Acer* spp.)	6.02	8.37	Fal, Win	Stm, Brk, Twg	15.6	19.2	214	522
Shade trees	4.92	2.29	Win	Brk, Stm, Twg	27.9	32.2	1,107	2,263
Ornamental trees	3.82	1.96	Fal, Sum	Brk, Stm, Twg, Bud	20.7	20.2	664	764
Crabapples (*Malus* spp.)	3.56	2.66	Win, Fal	Stm, Twg, Brk	28.8	28.9	1,011	1,324
Yews (*Taxus* spp.)	5.12	3.25	Win	Stm, Lvs, Twg, Bud	45.8	41.1	990	1,199
Arborvitae (*Thujopsis* spp.)	3.17	2.62	Win, Fal	Twg, Stm	43.7	46.4	220	194
Evergreens	7.25	3.29	Fal	Brk, Stm, Twg	12.7	19.6	957	1,795

[a] Spr = Spring, Sum = Summer, Fal = Fall, Win = Winter

[b] Stm = Stems, Twg = Twigs, Brk = Bark, Lvs = Leaves, Bud = Buds

Growers were asked to estimate percentages of their production areas bordered with cover types used by deer. Cultivated crops and woodlands were the most frequent border types. The mean percentage of bordering cultivated crops ranged from 49.9% in northwest Ohio to 32.9% in southeast Ohio. As percentage of bordering cultivated crops decreased, the chance of deer damage to tree crops increased ($P = 0.06$). Growers with deer damage reported significantly higher ($P < 0.05$) averages of bordering woodlands than growers without damage (49.7% vs. 39.3%). Average percentages of woodlands bordering production areas ranged from 23.2% in northwest Ohio to 47.1% in southeast Ohio.

Damage Control Methods

Most growers were not using deer damage control methods except to allow hunting (Table 3). Scare devices were used by only 4.5% ($N = 66$) of growers. Generally, growers rated scare devices as less effective than repellents (Scott and Townsend 1985b), but sample sizes were too small for reliable conclusions. The most frequently used devices were guns and exploders; other devices included dogs, scarecrows and objects hung in or around trees. Only 5.8% of the 1487 respondents had deer-deterrent fencing.

Two types of deer kill permits are issued to landowners for deer damage control by the Ohio Department of Natural Resources, Division of Wildlife (ODW). One permit type is a landowner doe tag used to tag legally harvested deer during the hunting season. These permits are transferable to any hunter with a valid deer license and allow hunters to harvest does even if they had not received a doe permit through the usual method of computer allocation. Only 10.3% ($N = 151$) of all growers applied for landowner doe permits; 17.2% ($N = 130$) of the growers with damage in 1983 and 3.0% ($N = 21$) of the growers with no damage applied for doe permits.

The out-of-season deer kill permit was rarely utilized (3.1%, $N = 45$) by growers. This permit allows landowners or their agents to kill any deer found in production areas.

Chemical repellents were the second most common damage control method but were only used by 16.5% of all respondents. Over 27% ($N = 206$) of the 745 respondents with damage used chemical repellents for damage control; only 34 growers without damage were using repellents. Human hair was the most commonly used repellent (Scott and Townsend 1985b). Other common repellents included tankage, Hinder, Hot Sauce and thiram products. All repellents used were rated as having some effectiveness in controlling deer damage, although some growers using each repellent rated them as no help at all (Scott and Townsend 1985b).

Of the growers with damage, 70.6% allowed deer hunting on production areas. Only 41.6% of growers without damage allowed hunting. Among all crop types, growers with damage were significantly ($P < 0.05$) more likely to allow hunting than growers without damage.

DISCUSSION AND MANAGEMENT IMPLICATIONS

The excellent survey response indicates a strong interest in deer and deer damage among growers. Our data show deer damage has clearly become more than the localized problem reported by McDowell and Pillsbury (1959). Most growers were willing to accept some damage, as implied by the 60.4% of growers with damage who described that damage as slight or very slight. Brown et al. (1978) reported similar acceptance of some damage by farmers in New York. Growers with moderate to very heavy damage are still a minority in Ohio, but we believe that wildlife managers should strive to ease the very real damage problems of these growers.

Deer damaged species at roughly the frequency of occurrence in orchard and Christmas tree plantings. Apples were reported damaged more frequently than other orchard crops; in 1982, 3,885 ha

Table 3. Number (and %) of Ohio growers using chemical repellents, scare devices, special doe permits, special kill permits, and in-season hunting for deer damage control.

	Reported Damage	Reported No Damage	Total
Using scare devices			
YES	59 (7.8)	7 (1.0)	66 (4.5)
NO	697 (92.2)	707 (99.0)	1404 (95.5)
Applied for doe permits			
YES	130 (17.2)	21 (3.0)	151 (10.3)
NO	624 (82.8)	691 (97.0)	1615 (89.7)
Using out-of-season permits			
YES	45 (6.0)	0 (0.0)	45 (3.1)
NO	709 (94.0)	706 (100)	1415 (96.9)
Using repellents			
YES	206 (27.6)	34 (4.8)	240 (16.5)
NO	539 (72.4)	677 (95.2)	1246 (83.5)
Allowed hunting			
YES	532 (70.6)	293 (41.6)	825 (56.6)
NO	222 (29.4)	412 (58.4)	634 (43.4)

in 485 orchards were in apple production and only 726 ha were in production of all other orchard species (Ohio Crop Reporting Service 1984). Within the Christmas tree crop, only white pine was damaged more frequently than its relative occurrence. White pine was the second most abundantly planted Christmas tree species after Scotch pine (*Pinus sylvestris*) (Brown 1983). Scotch pine may be less desirable to deer, or white pine may be a preferred species.

Relative abundances of nursery species were unobtainable, but we expected crabapples to be frequently damaged because Nixon et al. (1970) reported crabapples as the most important deer food plant in Ohio. Red and sugar maples were heavily browsed in Pennsylvania (Marquis 1981) and were reported by Ohio growers as frequently browsed.

Young plants of these tree crops were strongly preferred by deer, therefore managers should adopt primary control strategies for protection of young plants. Most young trees are within browsing range of deer, and trees 16-25mm in diameter are preferred for antler rubbing (Nielsen et al. 1982). Nurserymen and Christmas tree growers may have increased problems due to deer preference for young trees because their products are young plants with relatively short crop rotations.

Most orchard species incurred damage in spring and summer. Ellingwood et al. (1983) also reported apples received more damage in summer than in fall and winter. Frequent summer use of orchard crops indicates deer prefer these species over natural foods abundant at this time. Frequent damage to the Christmas tree species in fall and winter implies deer are using these species when other food sources are less available.

Plant parts damaged determine effects on the plant. Alteration of plant growth patterns is usually the result of bud damage (Westwood 1978:117-128). Removal of terminal buds may cause stunting of growth, resulting in unsalable plants or death (Westwood 1978:117-128; Nielsen et al. 1982). Nursery and Christmas tree growers are especially sensitive to bud damage in their products because tree shape and size determine price. Bud damage to orchard species may be less critical unless the terminal bud is affected. Simulated browsing of winter buds on mature trees did not affect apple production except during the next season (Katsuma and Rusch 1980), but repeated winter bud damage may keep fruit yields below potential yield and affect grower profits. Harder (1970) found that the major effect of browsing was alteration of scafold (large fruit bearing limbs) training.

Leaf and fruit consumption by deer may not seriously affect plants. Fruit damage results in no lasting effects to trees, but severe fruit damage may have serious economic consequences. Young trees may be more affected by leaf damage than mature trees because they have fewer leaves and more of their photosynthetic potential is affected. Excessive pruning reduces leaf potential, resulting in a loss of root growth and fruitfulness (Westwood 1978:157-158).

Bark removal and limb breakage were the major effects of antler rubbing on orchard trees; trunks or limbs of trees with >50% of their bark circumference removed were likely to die (Harder 1970). Damaged bark and broken limbs also affect scafold training in young trees and fruit production in mature trees (Harder 1970; Westwood 1978). Such damage may alter growth patterns of Christmas tree and nursery species, resulting in unsalable plants (Nielsen et al. 1982).

Some orchard, Christmas tree and nursery operations are incurring substantial economic losses. Estimates of damage cost and percentage of crops damaged often could not be supplied by growers (Scott and Townsend 1985a). Many growers commented on the difficulty of making such estimates, citing inability to determine long-term effects of deer damage and variability of crop prices. Researchers must devise standardized methods of measuring damage and losses to determine cost effectiveness of damage control measures.

Damage trends reported by growers indicate recent increases in deer problems among growers. Developments within these industries will probably exacerbate deer damage problems. Orchardists are converting to more dwarf and semi-dwarf rootstocks (Caslick and Decker 1979, R.C. Funt pers. commun.) that may never grow out of deer reach. Ohio's Christmas tree industry is expanding and planted approximately 1.5 million trees each year from 1978-1983 (Brown 1983). Deer managers must be prepared to deal with expected increases in damage complaints due to changing or expanding industries, increased value of crops and growing deer populations.

The regression equations we developed should assist deer managers in estimating current and future deer damage. Deer managers can randomly sample growers about number of deer seen in production areas and combine that information with deer density indices to identify probable areas of high deer damage. Problem areas can then be targeted for damage control assistance. Managers could also use these regression equations in adjusting deer harvest to control deer damage after policy decisions concerning acceptable levels of deer damage have been made.

The amount of woodlands and agricultural crops bordering production areas of these tree crops affects deer damage levels. Although manipulation of deer cover surrounding production areas appears to be a possible damage control method, the effects on other wildlife species may be unacceptable to wildlife managers (Craven 1983:D30). Some growers have already begun to clear woodland surrounding production areas to reduce deer damage. Wildlife managers should carefully consider the value to all wildlife species of woodlands that might be removed by growers; in many cases, incipient woodland losses would justify intensive efforts by wildlife agencies to reduce deer damage.

Fencing was infrequently used for deer damage control. Growers in regions of high human populations where shooting is prohibited and where high deer numbers exist may have no alternative for crop protection other than fencing. Many growers complained of the high cost of fences, and most do not seem to be thinking of loans on fencing as legitimate business expense. Development of new, less expensive fences (Caslick and Decker 1979, Porter 1983) may alleviate some of these complaints.

Many of the growers requested information from us on the special kill permits, indicating a general lack of knowledge. Increased awareness and flexibility of these special permit programs offer growers another valuable tool for deer damage control.

Repellents and scare devices were used by some growers, but many complained of the cost and lack of effectiveness. Other growers reported complete effectiveness with some repellents and scare devices (Scott and Townsend 1985b). Inconsistent effectiveness of repellents also has been reported by Harris et al. (1983). Increasing grower awareness of the strengths and limitations of repellents and scare devices for deer damage control may increase the effective use of these methods. Incorporating several repellents and scare devices with other damage control methods into a planned program similar to an integrated pest management system for insects may increase the overall effectiveness of deer damage control.

Local herd reduction through sport hunting remains the least costly method of damage control. Growers reported favorable attitudes toward deer hunting and deer hunters, but often complained of vandalism and hunters' poor behavior (Scott 1984). Deer managers should continue to promote good landowner/hunter relations. If hunting fails to control deer damage, other more expensive or less effective methods may be necessary.

Growers of commercial tree crops in Ohio were surveyed about deer damage. A response rate of >81% indicates an acute interest. Responses of growers also suggest a need for closer communication between growers, deer managers and researchers about deer damage problems. Grower responses provided insight into problem areas and specific plant types prone to damage by deer; apples, white pine and maples were the most commonly damaged of the three types of commercial tree crops. Young trees ($\bar{x}$ = 7.5 yrs) were damaged more commonly than older trees of all crop types. Growers reported spring and summer damage in orchards, and fall and winter damage in Christmas trees and nurseries. Managers could use regression equations based on deer harvested and/or deer seen on production areas to predict areas of deer damage. Growers currently are not using the full arsenal of damage control methods, nor are they using methods in tandem within a system. We expect such a system to make deer damage control far more effective than reported to us by growers.

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