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WILDLIFE DAMAGE TO AGRICULTURAL CROPS IN PENNSYLVANIA: THE FARMERS' PERSPECTIVE

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Abstract**:** Agricultural damage by wildlife is a major concern for both agricultural and wildlife agencies at the state and federal level. Our objective was to estimate wildlife damage to agricultural crops on a statewide basis. We sent questionnaires to 4,958 farmers and 1,003 were returned after 2 mailings. Twenty-five percent of farmers responding to our survey rated the level of wildlife damage to their crops as severe or very severe, 46% as moderate, and 29% had none or very little. Mean levels of crop loss to wildlife ranged from 6% for wheat to 10% for corn grain, and white-tailed deer (*Odocoileus virginianus*) were the most commonly reported cause of damage for all crops except soybeans. Farmers estimated the economic value of damage caused by wildlife to 6 crops (corn grain, silage, alfalfa, soybeans, oats, and wheat) as > $70 million. Ninety-one percent of Pennsylvania farmers allowed deer hunting on their farms, but 62% of the farms were bordered at least partially by land that was posted (no hunting or limited hunting). Fifty-six percent of farmers whose land was bordered by posted land believed adjacent posted land made it difficult for them to control deer numbers and damage on the land they farmed. Thirty-one percent of farmers responding to the questionnaire reported that they had changed farming practices (i.e., no longer farmed a particular field or raised a particular crop) as a consequence of deer damage. Additional methods used to control deer damage included shooting (28%), chasing (13%), fencing (9.3%), repellents (7%), and noise devices (5%). Fencing and shooting were the only methods rated as being at least moderately effective.

Key Words: agricultural damage, *Odocoileus virginianus*, Pennsylvania, white-tailed deer, wildlife

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Agricultural damage by wildlife is a major concern for both agricultural and wildlife agencies at the state and federal level. In a survey of state wildlife agencies, state agricultural departments, wildlife extension specialists, U. S. Department of Agriculture Animal Damage Control state directors, and state Farm Bureau officials, respondents from many states indicated damage caused by wildlife had increased in the last 30 years and that deer were their worst problem (Conover and Decker 1991). Although deer apparently were responsible for the most damage on a national level, 27 different wildlife species were listed by respondents as causing the worst problem in their respective states. Conover and Decker (1991) suggested 2 factors caused the increase in wildlife damage: changes in agricultural practices (i.e., plowing practices, irrigation, and use of dwarf and semi-dwarf species in orchards) and increasing wildlife populations. White-tailed deer (*Odocoileus virginianus*) populations have increased in the past 50 years in much of the Midwest and Mid-Atlantic states (Gladfelter 1984, Palmer et al. 1985). Unfortunately, updated national estimates of the extent and distribution of corn or other crop losses due to deer damage have been rare (Conover and Decker 1991, but see Wywialowski 1996).

As on the national level, white-tailed deer are thought to cause the most crop damage in Pennsylvania (Wingard et al. 1981, Anon. 1989). Some growers report that farming is no longer profitable because of deer damage, but debate exists regarding the severity and distribution of damage across the state. Disagreement over damage severity arises because estimates of crop losses to deer vary from year to year, with respect to adjacent land uses or habitat types, and with respect to sampling methods (Korschgen 1962, Murphy et al. 1985).

Two methods can be employed to evaluate wildlife damage: 1) indirect, in the form of postal or telephone surveys; and 2) direct, in the form of on-the-ground sampling. Given the magnitude of measuring and documenting wildlife damage on a large scale (state, regional, or national), agriculture and wildlife professionals often rely on surveys administered to farmers to estimate loss (e.g., Wywialowski 1996). Postal questionnaires have been used to evaluate perceptions and estimates of damage, knowledge of wildlife species, and preferred wildlife management options (Craven et al. 1992). The first national survey on wildlife damage was conducted by McDowell and Pillsbury (1959). Conover and Decker (1991) attempted to re-evaluate issues of wildlife damage in 1987 with a similar survey. Since that time, many states or individual agencies have conducted their own surveys to evaluate the magnitude of damage, species responsible, economic impacts, and landowner tolerance to damage without extensive labor costs for field sampling (Craven et al. 1992). We used a questionnaire to estimate the extent, value, and causes of crop damage in Pennsylvania.

This project was funded by the Pennsylvania Department of Agriculture. M. Eckhaus and J. Rotz of The Pennsylvania Farm Bureau (formerly Association) provided support, contacts, mailing lists, and personnel to mail the questionnaire. M.B. Forgy entered the questionnaire data, and J.N. Bosco word-processed the final report. We appreciate the cooperation of Pennsylvania farmers who responded to our questionnaire.

METHODS

In Pennsylvania, there are approximately 50,000 farms (Anon. 1996) and, in 1993, 535,013 ha of corn were planted (Anon 1995). We used a comprehensive list of farmers maintained by the Pennsylvania Farm Bureau (PFB), which has 20,097 members distributed across the state, to select farmers who would receive the questionnaire. We identified 4,958 randomly chosen farmers and, to maintain the confidentiality of their list, the PFB mailed our questionnaire to them in April 1995. We allocated sampling among counties proportional to the amount of cropland within each county; the number of questionnaires mailed per county ranged from 31 to 119, except Philadelphia county, which received none.

In August 1995, a second mailing was made to a random sample of 1,000 farmers who did not respond to the initial mailing. Individuals were asked to base their answers on crops they grew during 1994.

Farmers were asked to estimate the amount of wildlife damage to each crop grown in 1994, the species perceived to be causing the damage, and the time of year damage occurred. In addition, respondents were asked the type and size of farm operated, percent income earned from farming, percentage of posted land surrounding their farm, and their perceived trend in white-tailed deer numbers on the land they farm. We also asked farmers to describe abatement methods they used, rank their effectiveness in controlling white-tailed deer and other wildlife damage to crops, and describe level of hunting pressure on their land.

We asked the PFB to randomly select 4 names from each county from the list of farmers who did not respond to either mailing. From that list we randomly selected 2 farmers from each of 61 counties. During August 1996, we attempted to telephone 122 farmers to ask if they recalled receiving the questionnaire, and if they believed wildlife damage was a major problem in their farm operation. In addition, farmers were asked why they did not return the questionnaire and to estimate the percentage of their corn crop that was lost to wildlife damage.

We compared responses from the first mailing with those of the second to gain insight about expected responses from non-respondents (Fowler 1993). All statistical comparisons were done with Statistical Analysis System (SAS Inst. Inc. 1989) and Minitab (Minitab 1993) at α=0.05.

RESULTS

Response Rate

Pennsylvania farmers returned 870 usable questionnaires from the initial mailing. Seventy questionnaires were returned by farmers who were no longer actively farming. These were deducted from the total number of questionnaires mailed. One-hundred thirty-three farmers returned usable questionnaires from the second mailing. Our overall return rates for the first and second mailings were 17.8% and 13.3%, respectively. Subsequently, the two mailings were combined yielding 1,003 usable questionnaires, which yielded overall response rate of 20.5%. In the telephone survey, we successfully contacted 105 farmers.

General Information

Pennsylvania farmers (n=868) had an average of 31$\pm$0.52 (SE) years farming experience. Fifty-seven percent of the respondents derived >75% of their income from farming; 25% derived <25%. Farmers (n=877) described their primary farm operation as being dairy (41%), grain (18%), beef (16%), other (11%), vegetable (5%), fruit (5%), swine (3%), and poultry (1%). Average farm size ($\bar{x}$ ±SE) for Pennsylvania farmers who owned the land they farmed (n=890) was 94$\pm$3.7 ha with an average of 56$\pm$2.4 ha in cropland, 17$\pm$1.1 ha in pasture, 31$\pm$3.6 ha in woodland. Fifty-six percent of farmers (n=1,003) leased land. Average amount of land leased was 75±4.1 ha (68±4.0 ha in cropland, 19±1.8 ha in pasture).

Perceived Trends in Deer Numbers and Hunting Pressure

Pennsylvania farmers (n=982) believed that the number of white-tailed deer over the past 5 years had decreased greatly (6%), decreased (15%), had not changed (32%), increased (36%) or increased greatly (11%). Farmers (n=823) perceived that hunting for white-tailed deer hunting over the past 5 years had increased greatly (5%), increased (24%), had not changed (47%), decreased (20%), or decreased greatly (4%). Responses between the first and second mailings differed for perceived trend in white-tailed deer numbers (χ^2=15.41, p=0.004), but did not differ in perceived trend in white-tailed deer hunting pressure (χ^2=1.91, p=0.7523). Forty-eight percent of respondents to the first mailing (n=853) thought deer numbers had increased over the past 5 years, whereas only 37% of those responding to the second mailing (n=129) believed deer numbers had increased.

Hunting Pressure on Adjacent Land and on Farmland

Sixty-two percent of the individuals who owned land and 63% of the individuals who leased land (n=923) farmed areas that bordered lands that were posted. There was no difference between first and second mailings in the number of farmers who owned (χ^2=0.58, p>0.4) or leased land (χ^2=2.28, p=0.13) bordered by posted land. Fifty-six percent of farmers (n=646) whose land was bordered by posted land believed that posting made it difficult to control white-tailed deer numbers on land they farmed. Perceptions about the effect of adjacent land posting on control of deer numbers differed between first and second mailings (χ^2=5.08, p=0.024). Fifty-eight percent of respondents to the first mailing believed adjacent posted land made it difficult for them to control deer numbers, whereas 46% of second mailing respondents believed similarly.

Among farmers who owned their farmland, 49% indicated that their land was bordered by private land where hunting was permitted, 36% by private land that was posted, 12% by public land where hunting was permitted, and 3% by public land where hunting was not permitted. For leased farm land, the respective percentages were 50%, 36%, 10%, and 4%.

Ninety-one percent of Pennsylvania farmers allowed deer hunting on their farms. Respondents to the first mailing were more likely (χ^2=5.21, p=0.02) to allow deer hunting (92%) than respondents to the second mailing (85%). Pennsylvania farmers (n=725) reported the level of hunting for antlered deer on owned farmland was very light (11%), light (17%), moderate

(36%), heavy (27%), or very heavy (9%). For farmers who leased farmland (n=395), the respective percentages were 13%, 23%, 38%, 19%, or 7%. Response (n=711) regarding level of hunting for antlerless deer on owned farmland was very light (25%), light (3%), moderate (50%), heavy (3%), or very heavy (19%). For farmers who leased farmland (n=383), the respective percentages were 24%, 8%, 50%, 2%, or 15%. There was no difference between the first and second mailing responses for the level of antlered deer hunting on owned land (χ^2=0.44, p=0.50) or on leased land (χ^2=3.0, p=0.25). Likewise, no difference was detected between first and second mailing responses for the level of antlerless deer hunting on owned land (χ^2=4.3, p=0.367) and on leased land (χ^2=3.7, p=0.448).

Wildlife Damage Estimates

Farmers rated damage to crops by wildlife as none (5%), very little (24%), moderate (46%), severe (19%), or very severe (6%). Farmers perceptions about level of damage differed between the first and second mailings (χ^2=9.5, p=0.05). Twenty-seven percent of respondents to the first mailing estimated damage as severe or very severe, whereas only 17% of respondents to the second mailing ranked damage levels this high.

In addition to providing an overall estimate of damage, farmers were asked to report specific crops grown, to estimate the percentage of each crop lost to wildlife damage, and to identify the species causing the damage and time of year that damage occurred. Farmers were asked to list any wildlife species that caused damage and the primary species causing damage. For seven crops, we had sufficient responses to calculate mean area (ha) planted (Table 1) and to examine attributes of damage.

The mean percent crop loss due to wildlife damage ranged from 6% for wheat to 10% for corn grain (Table 1). In all cases except for soybeans, respondents to the first mailing reported higher levels of damage, but these differences were not significant.

White-tailed deer were reported most commonly as the cause of damage in all crops except soybeans, where the woodchuck (*Marmota monax*) was reported most frequently. For all crops, white-tailed deer were reported most frequently as the primary wildlife species causing damage. Pennsylvania farmers reported white-tailed deer damage to all crops was heaviest from June through September. Most farmers (70.5%) reported woodchucks caused the most damage to soybeans. Woodchucks were the second most often reported cause of damage to alfalfa (39.7%) and other forage (32.2%). Raccoon (*Procyon lotor*) and blackbirds were the second and third most reported cause of damage to corn grain and corn silage. Blackbirds were the second most reported cause of damage to oats. Among Pennsylvania farmers who reported damage to corn grain and corn silage, 11% and 13.5%, respectively, blamed black bears (*Ursus americanus*). Twelve percent of Pennsylvania farmers who reported damage to wheat attributed that damage to Canada geese (*Branta canadensis*).

Fifty-five percent of farmers (n=105) contacted by telephone were farming actively. Sixty-two percent of them (n=58) believed wildlife damage was not a major problem in their farming operation and estimated that only 4.5% of their corn crop was lost to wildlife. Thirty-eight percent (n=58) believed wildlife damage was a major problem and estimated that 12.9% of their corn crop was lost to wildlife. Farmers who believed wildlife damage was a major problem had higher average loss (%) estimates than farmers who believed wildlife damage was not a major problem (t=3.56, p<0.0005).

The economic cost of wildlife damage to 6 crops was estimated based on farmers' average loss (%) estimates and crop values for 1994 (Anon. 1995). The estimated value of loss to corn (grain and silage combined) and alfalfa was $40,348,000 and $25,582,000, respectively. The total estimated value of loss for the 6 crops was $74,509,000 (Table 2).

Methods Used to Control Wildlife Damage

Thirty-one percent of respondents (n=978) changed farming practices as a result of white-tailed deer damage. Responses differed between

the first and second mailing (χ^2=7.67, p=0.006). Thirty-three percent of respondents to the first mailing changed farming practices as a result of deer damage, whereas only 20% of respondents to the second mailing reported making a change.

Farmers were asked what methods they used to control white-tailed deer and other wildlife damage to crops and to rate the effectiveness of each method (where 1=very effective to 5=not effective). Twenty-eight percent of farmers (n=1,003) used shooting to control crop damage by white-tailed deer. Farmers who reported shooting deer (n=282) believed shooting was moderately effective ($\bar{x}$=2.80). Only 7% of farmers used chemical repellents to control crop damage by deer, which was rated as being somewhat effective ($\bar{x}$=3.74). Nine percent of farmers constructed fences to exclude deer from their fields, and rated this method as being moderately effective ($\bar{x}$=2.85). Five percent of farmers used noise devices to deter deer from their fields, whereas 13% physically chased deer from their fields. These methods were rated as being somewhat to not effective ($\bar{x}$=4.09 and 4.29, respectively).

Thirty-three percent of farmers (n=1,003) used shooting to control crop damage by wildlife other than white-tailed deer and rated it moderately effective ($\bar{x}$=2.92). Eight percent of farmers used chemical repellents, stating that they were moderately effective ($\bar{x}$=3.10). Only 5% of farmers constructed fences to keep wildlife from their fields, but this practice was rated only moderately effective ($\bar{x}$=2.85). Six percent of farmers used noise devices and 8% physically chased wildlife from their fields, both of which were rated somewhat effective ($\bar{x}$=3.68, 3.97, respectively). Eleven percent of farmers reported that they enrolled in the Pennsylvania Game Commission's (PGC) "hot spot" program.

DISCUSSION

Surveys are useful for documenting the extent of a suspected wildlife damage problem, the timing of the problem, and, in some cases, the particular species responsible for the problem (Craven et al. 1992). They also can be used to compare trends among geographic regions or between time periods. In our study, 95% of farmers reported some level of wildlife damage, a value higher than ones reported from other states (e.g., Conover 1994, Wywialowski 1994). Consistent with reports from other states, the white-tailed deer was the primary cause of damage (Conover and Decker 1991, Conover 1997).

The PFB estimated that 74% of all farmers incurred damage to farm crops from white-tailed deer, which amounted to $96,530,000 in losses during 1988 (Anon. 1989). Wingard et al. (1981) reported that 42% of respondents had deer-caused damage on their Pennsylvania farms. When asked to specify the amount ($) of damage caused by deer to all crops on their farms, respondents (62%) placed that loss, when extrapolated to a state-wide basis, at $30,683,879. Losses to all wildlife for 6 crops in 1994, as estimated by farmers, totaled $74,042,000. Wingard et al. (1981) reported perceived trends in white-tailed deer numbers over the past years as decreased (18%), no change (51%), and increased (31%). Thirteen years later, respective percentages from our questionnaire were 22%, 30%, and 48%.

Surveys also are useful to detect changes in tolerance to wildlife damage (Pomerantz et al. 1986, Craven et at. 1992). We did not measure farmers' tolerance to deer and other wildlife damage directly, but instead asked farmers to rank damage on a scale from none to very severe. In an indirect way, this also serves as a measure of tolerance. Most farmers ranked damage as moderate to very little, suggesting that they have accepted the current level of damage as one of the costs of raising crops. However, a third of all respondents altered their farming practices as a result of damage.

Surveys can be used to identify current methods used to control wildlife damage and to design management programs that address stakeholder needs (Craven et al. 1992). In our study, over 90% of farmers allowed deer hunting on their farms, which is one of the primary methods available to them to control deer numbers. However, over 60% of the farms were bordered at least partially by posted lands (i.e., no hunting or limited hunting), a practice which many

farmers believed contributed to their difficulty in controlling deer. This is an extremely difficult problem because agencies have no control over the posting of private lands adjacent to farmlands.

Results from surveys on wildlife damage are useful in developing management plans that will be acceptable to farmers and address their problems and concerns (Craven et al. 1992). In Pennsylvania, in addition to hunting, the primary avenues available to farmers to reduce deer damage include shooting permits, financial assistance with fencing, and the "hot spot" program. Participation in most of these programs generally is low. Although shooting deer outside the hunting season was reported to be moderately effective in reducing damage, less than one-third of farmers reported using this method. It is possible that use of this method was under-reported, but research from other parts of the country suggest that farmers are reluctant to shoot deer for crop damage, possibly because of negative social consequences or desirability (Craven et al. 1992).

Fencing was rated moderately effective in controlling wildlife damage, but was used by <10% of the participants, even though financial assistance was available to them through the PGC. We did not question farmers directly as to why they did not use the method, but conversations with farmers suggest that fencing is not desirable because it is time consuming to install and maintain and needs to be moved on a regular basis when crops are rotated.

The PGC initiated the "hot spot" program in the early 1990s. The program allowed farmers with documented damage from deer to open their land to hunters for a special additional hunting season in early January. The low percentage of farmers participating in this program suggests that it is not an effective form of assistance and, in fact, was highly modified in 1996 in response to farmer concerns. Lack of publicity may have hampered initial efforts to get individuals signed up in the program. However, the perceived or real problem of adjacent posted lands still was a deterrent to some farmers. They commented that deer left the farm when hunters arrived and returned when hunters departed.

Postal surveys have been used widely to estimate damage because they enable researchers to sample a large number of individuals at a relatively low cost. However, there are several disadvantages to using postal questionnaires. For example, accuracy and precision of survey results often are questioned because surveys are not conducted using statistically valid sampling methods, and non-response bias can cloud interpretation of results (Filion 1981, Fowler 1993).

Most wildlife damage surveys have had very high response rates (>70%) (Craven et al. 1992), attributed in part to the great personal interest respondents have in the topic. We do not think the low response rate in our survey reflected a low interest in the topic. A variety of factors have been shown to influence response rates (Heberlein and Baumgartner 1978). In our case, we think the low response rate resulted from (1) a mailing list that included many individuals who no longer farmed, (2) survey length or detail, and (3) using only 1 follow-up mailing. From phone calls to non-respondents, we found that 45% of the individuals who did not respond to either the first or second mailing no longer farmed. This result suggested that our actual return rate based on individuals who were actively farming was much higher than reported. Our survey was only 4 pages long, but we asked a number of very specific questions about amount of damage and species causing damage. The length of time needed or the inability of farmers to accurately answer these questions may have dissuaded some individuals from completing the questionnaire. Finally, we had only 1 follow-up mailing. Repeated mailings have been shown to increase response rates (Heberlein and Baumgartner 1978).

Differences between the first and second mailings can be used to speculate about the expected responses from individuals who did not respond to either mailing (Fowler 1993). In general, respondents to the second mailing perceived damage to be less of a problem than those who had responded initially. They also were much less likely to have changed farming practices as a result of deer damage. Fowler (1993) reported people who have a particular interest in the

subject matter or in the research itself are more likely to return mail questionnaires than those with less interest. Mail surveys with low response rates may be biased in ways that directly are related to the purpose of the research (Donald 1960, Fillion 1975). Consequently, we speculate that individuals who did not respond to either mailing probably perceived damage to be less of a problem than those who took the time to respond. If true, these 1994 estimates of the amount of damage and the effect of wildlife on causing farmers to change farming practices may be overestimated.

Other concerns with surveys include the ability of respondents to accurately identify individual species causing the damage or to correctly estimate the dollar amount of wildlife-related losses (Flyger and Thoerig 1962, Wakeley and Mitchell 1981, Gabrey et al. 1993). As part of a larger study (Tzilkowski et al. 1997), we compared wildlife damage estimates to corn as reported by farmers to our questionnaire with on-the-ground (field) estimates. Although there was a low correlation between farmer and field estimates, there was no pattern of bias, and overall estimates reported by farmers did not differ significantly from field estimates. Wywialowski (1994) concluded producer-derived estimates of wildlife-caused losses often were conservative, and she believed that producers offered useful predictions of wildlife-cause corn losses.

In summary, our results documented the widespread and ubiquitous nature of wildlife damage to crops across Pennsylvania and identified the white-tailed deer as the primary cause of that damage. As long as there is wildlife, there will be some level of damage. The question is how much are farmers willing and able to tolerate. High numbers of farmers ranking damage levels as moderate to very little suggest that many have already accepted current levels of damage. However, survey results also identified the perceived inadequacy of most control measures currently available to farmers and the problem of posted land adjacent to farmland. These issues will need to be addressed by management agencies in the future.

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Table 1. Area (ha) of crops grown during the 1994 growing season and estimated levels of crop loss (%) to wildlife as reported by Pennsylvania farmers (n=1,003) responding to a questionnaire mailed April (mailing 1) and August (mailing 2) 1995.

	Area (ha)			Loss (%)		
Crop	n[a]	$\bar{x}$	SE	n[b]	$\bar{x}$	SE
Alfalfa	529	25.45	1.14	511	9.35	0.50
Corn grain	591	35.74	2.40	575	9.90	0.54
Corn silage	386	17.68	0.99	384	7.53	0.53
Oats	289	11.54	0.85	273	7.27	0.68
Other forage	211	23.64	1.73	200	6.10	0.50
Soybeans	210	35.48	3.54	199	8.78	0.62
Wheat	198	19.28	2.29	184	5.85	0.94

[a] n = number of respondents who grew a particular crop.
[b] n = number of respondents who estimated loss.

Table 2. Approximate economic value (x 1,000 dollars) of damage to 6 crops by wildlife based on combined responses of Pennsylvania farmers (*n* = 1,003) to a questionnaire mailed April (mailing 1) and August (mailing 2) 1995.

Crop	1994 value[a]	loss (%)	Potential value[b]	Estimated value of loss[c]
Corn grain	302,820	9.90	332,799	29,979
Alfalfa	273,600	9.35	299,182	25,582
Soybeans	69,757	8.78	75,882	6,125
Corn silage	137,700	7.53	148,069	10,369
Oats	12,720	7.27	13,645	925
Wheat	26,136	5.85	27,665	1,529
Total	822,733		897,242	74,509

[a] Anon. 1995
[b] Potential value = 1994 value x (1 + (% loss ÷ 100))
[c] Estimated value of loss = Potential value - 1994 value