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DEER EXCLUSION EFFORTS TO REDUCE CROP DAMAGE IN MICHIGAN AND NORTHEAST WISCONSIN

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Abstract: A random sample of 93 deer-fenced farms in northern Lower and Upper Michigan and northeast Wisconsin and 250 non-deer-fenced farms in 5 Upper Michigan counties with high white-tailed deer (*Odocoileus virginianus*) populations was surveyed by mail using 2 different questionnaires. High-tensile electric was the most commonly used type of deer exclusion fence. A 1.8 m (6 ft) height apparently provided the best balance between effectiveness, cost, and ease of installation. Fence users perceived that 2.4 m (8 ft) woven wire was most effective. However, the high cost of installation limited widespread use. Other types of fence with inconsistent or low ratings by users were high-tensile non-electric and 1 or 2 wire temporary fencing. Farmers perceived that all non-fencing deer control alternatives were relatively ineffective with the exception of state issued deer shooting permits.

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Key words: crop damage, exclusion, fence, *Odocoileus virginianus*, white-tailed deer.

Commercial agricultural operations in Michigan's Upper and northern Lower Peninsulas face many challenges. On numerous occasions between 1989 and 1993, representative groups of Upper Peninsula (UP) farmers have identified deer (*Odocoileus virginianus*) damage as the most serious production problem they face. In some areas of heavy deer population, farmers no longer attempt to grow field corn. Promising new crops such as canola (*Brassica napus*) and sweet white lupins (*Lupinus albus*) are considered impractical by many farmers because of almost certain loss to deer depredation. Kidney bean yield has been reduced by 24-43% (Long et al. 1990*b*) and quality of dry seed has been reduced as well (Long et al. 1990*a*). Alfalfa yield was reduced 18.7% by deer depredation in Michigan (Long 1987). In general, farm groups estimate annual losses to deer at 25% of all field and forage crops across the UP.

The deer damage problem on farms creates a very serious and potentially confrontational situation between the agricultural community and sportsmen's groups. The Michigan Department of Natural Resources (DNR) administers programs, including the block permit and crop-damage permit programs, which are intended to provide farmers with a legal opportunity to reduce deer numbers on their property. While partially effective, these herd reduction efforts, along with regular deer seasons (archery, firearm, and muzzle-loading) have not been sufficient to prevent a dramatic increase in losses of farm crops to deer feeding.

Fencing to exclude deer from farm crop land is an alternative method to address the problem (Longhurst 1962, Wright 1994). Farmers growing high-value crops, gardeners, airports, and nurseries have used fencing successfully for deer exclusion. An understanding of the various types of fences, exclusion effectiveness, cost of installation, maintenance expenses, and perceptions of success by users may be valuable to farmers considering fencing and researchers interested in further addressing the crop damage problem.

The objectives of this study were to characterize and assess the types of farms using deer exclusion fences and the types of fences used. A secondary objective was to determine perceptions of farmers, both users and non-users, concerning relative success and other aspects of deer exclusion fencing as well as perceptions of alternative methods of reducing deer damage to crops. Appreciation is extented to the Growing UP Agricultural Association for funding this study of deer exclusion fencing.

STUDY POPULATION AND LOCATION

This study was conducted in Michigan's Upper and northern Lower Peninsulas (LP) and 11 northeast Wisconsin counties among farmers with deer exclusion fences. Commercial agricultural producers without deer exclusion fences were surveyed in Iron, Dickinson, Menominee, Delta, and south Marquette counties, Michigan. The study was conducted in areas of known high deer population.

METHODS

A list of 125 deer-fenced farms was developed through contacts with fencing contractors, County Extension Agricultural Agents, Soil Conservation District officials, and others. A list of 678 commercial farmers in the high deer population areas listed above was procured from County Extension Agricultural Agents. A random sample of 94 deer-fenced farm operators and 250 non-deer-fenced farm operators was surveyed by mail. Sample size was determined using the StatPac statistical analysis computer program (Walonick 1985).

Separate questionnaires were used for deer-fenced farm operators and for non-deer-fenced farm operators. Questions were formulated through a review of deer damage litera-

ture. The questionnaire was tested for validity by Michigan State University (MSU) Department of Agricultural and Extension Education faculty members, MSU Extension professional staff, and Growing UP Agricultural Association officers.

A personalized cover letter was prepared for each questionnaire explaining the importance of the study and requesting assistance. A self-addressed, stamped, and encoded envelope was included with the cover letter and questionaire. A follow-up letter was sent to non-respondents 10 days after the first mailing. A second follow-up request, consisting of an additional copy of the questionnaire and a stamped envelope was sent to non-respondents after 21 days.

Descriptive statistics were used for analysis and presentation. Frequency distributions, percentages, means, and standard deviations were based on location, crops grown, perceived deer population pressure, and other variables.

RESULTS

Of the deer-fenced farms surveyed, 52.8% were located in 16 northern Wisconsin counties and the remaining 47.2% were located in 19 Michigan UP and LP counties. Deer-fenced farms were more difficult to identify and more sparse in Michigan, perhaps due to the Wisconsin DNR crop protection program which subsidizes the construction of deer exclusion fences on Wisconsin farms. The response rate of 77.7% (73 returned out of 94 mailed) for all surveyed deer-fenced farms was adequate for this study. Of these, 20.5% were from the UP, 27.4% from the LP and 52.1% were from 11 counties in northern Wisconsin. No UP county exceeded 3 returned questionnaires.

Of the 250 non-deer-fenced farms surveyed, the response of 156 constituted a return rate of 62.4%. Commercial farms not currently known to be using deer exclusion fences in 5 UP counties with high deer populations were targeted.

Farm Characteristics

The most common enterprise found on deer-fenced farms in this study was high value fruit and vegetables, followed by beef, potatoes, Christmas trees, dairy, commercial deer feed, grain, tree nursery, and specialty crops. Several farms indicated multiple enterprises (Table 1). Of responding farms, 50.8% indicated that fruits and vegetables were enclosed. Christmas trees, nursery ornamentals, deer bait, and other specialty crops, when added, bring this total to 87.1%. In comparison, agronomic crops including corn, potatoes, beans, alfalfa, and small grains were enclosed by 66.2% of responding deer-fenced farms. Dairy and beef operators predominated on non-deer-fenced farms (Table 1).

Gross annual sales reported by deer-fenced and non-deer-fenced farms ranged from $1,000 to over $150,000. Annual sales of deer-fenced farms was evenly distributed among categories. However, non-deer-fenced had generally lower gross annual sales (Table 2).

The total cropland available on deer-fenced farms ranged from 0.8-2023.5 ha. The distribution of total acreage size was multi-modal among respondents with a median of 80.9 ha and mean of 162.7 ha (SE = 37.1). This indicated a wide variance among deer-fenced farm respondents in terms of farm size.

The total acreage on farms without deer exclusion fencing averaged 122.1 ha with a range of 0.4-566.3 ha, a median of 84.7 ha, and a mode of 202.3 ha. Farm size did not differ greatly from deer-fenced farms.

The total deer-fence enclosed cropland indicated by deer-fenced farms ranged from 0.4-463.2 ha. The mean was 42.5 ha (SE = 9.1), median was 16.2 ha, and the mode was 16.2 ha. The low standard error of the mean indicated much more conformity of total enclosed acreage than for total cropland on deer-fenced farms. Most respondents only had 1 deer-

Table 1. Various farm enterprises reported on deer-fenced and non-deer-fenced farms from northern Michigan and northern Wisconsin.

	% of Respondents	
Type of crop	**Deer-fenced** *n*=73	**Non-deer-fenced** *n*=144
Dairy	11	68
Beef	15	43
Hay	0	10
Potato	13	10
High value fruit or vegetable	43	5
Commercial deer feed	8	2
Christmas trees	12	2
Tree nursery	4	0
Grain	7	8
Sheep	0	4
Other specialty[a]	13	11

[a]Includes crop research, forestry research, hog, sunflower, horse, cranberry, ginseng, and hay.

Table 2. Annual gross farm sales of deer-fenced and non-deer-fenced farm respondents in Michigan and northern Wisconsin.

Gross farm sales	% of Respondents	
	Deer-fenced	Non-deer-fenced
$	*n*=73	*n*=125
1,000 - 10,000	22.6	42.4
10,001 - 50,000	27.4	24.8
50,001 - 150,000	25.8	20.8
150,000+	24.2	12.0

fenced area, but up to 20 were reported.

The proximity of neighboring farms was thought by many farmers to affect severity of deer damage to crops. An isolated farm in an area of high deer population was thought to suffer most severely. Of non-deer-fenced farm respondents, 45% had a neighboring farm within 0.40 km and 12.9% had a neighboring farm within 0.40-0.80 km. Of responding deer-fenced farms, 60.6% reported a neighboring commercial farmer either adjacent or within 0.40 km and 22.5% reported the nearest commercial farmer at over 3.22 km distance. The remaining 16.9% reported the nearest commercial farm at 0.40-3.22 km distance.

Of responding deer-fenced farmers, 75.3% reported severe to very severe crop loss before fencing was installed. Only 24.6% of these farmers reported not severe to somewhat severe crop loss before fencing.

User Perceptions Of Deer Exclusion Fencing

The types of deer exclusion fences in use among respondents fell into 4 main categories: high-tensile electric (65.3%), high-tensile non-electric (8.3%), woven wire (19.7%), and temporary (12.5%). Other types of fencing included barbed wire, wood and combinations of barbed wire, and woven wire with electric.

High-tensile fences, both electric and non-electric ranged in height from 1.5-2.4 m with 1.8 m the most common height. The total number of wires used in high-tensile fences ranged from 5-16. Of deer-fenced farm respondents, 67% indicated that wire spacing was the same between all wires, most were spaced 25.4 cm apart. The rest of the high-tensile fences had closer wire spacing on the lower part of the fence. Generally, the lower portion of the fence was about 1.2 m high with 15.2 cm wire spacing. The upper wire spacing was generally 25.4 cm and the upper portion of the fence varied in height from 0.6-1.5 m. Among high-tensile electric fences, 4 or 5 was the most frequent number of electrified wires. Two types of post systems were used. Wood posts were indicated by 50% of respondents. Fiberglass spacer posts in combination with wood were indicated by 42%. Post spacing in high-tensile systems was commonly 9.1 m.

Woven wire fence was in use by 19.7% of respondents. Woven wire fences were generally 2.4 m high with wood posts spaced at 6.1 m. Temporary fencing was in use by 12.5% of respondents, all from northern Wisconsin. This fencing consisted of 1 (40%) or 2 (60%) electrified tapes spaced generally at 61 cm on fiberglass posts. Temporary fencing sometimes did not fully enclose crops but was placed to discourage wildlife entry from a known direction. Temporary electric tapes were sometimes baited with peanut butter or another material attractive to wildlife, causing them to lick the electrified wire.

The cost-effectiveness of woven wire deer exclusion fencing was most favorably rated by users. High-tensile electric fencing was also rated very favorably with high-tensile non-electric and temporary fencing rated much lower (Table 3).

Woven wire fencing was clearly perceived to be superior to the design-effectiveness of other fencing types (Table 3). High-tensile electric fencing received a relatively equal distribution of ratings through the scale. High-tensile non-electric fencing was perceived very well by some users and poorly by others. Temporary fencing was perceived by its users as least design-effective.

Woven-wire deer exclusion fencing was perceived as most practical by users. High-tensile electric fencing received somewhat less favorable ratings. High-tensile non-electric fencing received either very favorable ratings or poor to moderate ratings. Temporary fencing had the poorest ratings of all fencing types (Table 3).

The success rating of deer-fencing types referred to the respondents' rating of the ability of a fence to exclude deer (Table 3). This rating provided an overall impression by fence users of their deer-fencing efforts. Woven wire fencing was perceived as most successful by its users. High-tensile electric fence was also highly rated by respondents, though less highly than woven wire. High-tensile and temporary fencing were perceived as third and fourth in terms of success, respectively.

Perceptions of deer-fenced farm operators using all reported types of permanent deer exclusion fencing were compared with those using temporary deer exclusion fencing. Permanent fencing was perceived more favorably than temporary fencing in all cases. However, 2-wire temporary fencing was perceived to perform better than 1-wire temporary fencing in cost and design effectiveness, practicality, and success (Table 4).

Several heights of high-tensile electric deer exclusion fence were reported by deer-fenced farms. The 1.8 m high-tensile electric fence received more favorable ratings than other heights in every category except design effectiveness, where the 2.1 m height was perceived as more favorable.

Farmer responses indicate that cost effectiveness and practicality was greater for 2.4 m woven wire fences than for those >2.4 m tall. However, the design effectiveness and success of woven wire fences >2.4 m tall were greater than for those 2.4 m tall.

Perceptions Of Farmers Without Deer-fencing

Of responding non-deer-fenced farmers, 48.1% felt deer damage on their farms was "not severe" to "somewhat

Table 3. Farmer perceptions of the cost effectiveness, design effectiveness, practicality, and success of 4 major fencing types in northern Michigan.

	Rating of types of fencing[a]																					
	High-tensile electric						High-tensile non-electric						Woven wire						Temporary			
	n	1	2	3	4	5	*n*	1	2	3	4	5	*n*	1	2	3	4	5	*n*	1	2	3	4	5
Cost effectiveness	45	4	11	27	16	42	5	0	60	20	0	20	13	0	15	15	23	46	9	56	11	0	22	11
Design effectiveness	42	5	21	21	24	29	5	20	40	0	0	40	13	8	14	0	15	62	9	56	11	0	33	0
Practicality	45	4	13	27	18	38	6	17	17	16	0	50	14	0	14	29	7	50	10	60	10	0	20	10
Success	45	4	24	20	20	31	6	17	33	17	0	33	14	7	14	7	21	50	9	44	22	0	11	11

[a]Rating is the % of *n* (number of respondents) in a given category. Response categories were: 1 = not cost effective, design effective, practical, or successful, 2 = somewhat cost effective, design effective, practical, or successful, 3 = cost effective, design effective, practical, or successful, and 4 = quite cost effective, design effective, practical, or successful, 5 = very cost effective, design effective, practical, or successful.

severe" and 51.8% felt damage was "severe" to "very severe". Each non-deer-fenced respondent was asked why they chose not to use deer exclusion fencing on their farms. Expense and insufficient deer damage were the predominate reasons given. Seventy-eight percent of the respondents stated they did not experience enough damage to justify fence construction, while 70% recorded that fence costs were too high. High labor requirements ranked third as the most common reason given for not using fencing.

About 17% of non-deer-fenced farms had a neighboring farm which used deer exclusion fencing. Of these, 10 felt that the neighbor's fencing had increased their own deer damage and 11 felt that it had not. Generally, there was only 1 deer-fenced farm within 3.22 km of these farms.

When asked about their willingness to install deer-fencing, only 31.3% of respondents indicated a willingness to install deer exclusion fencing if the government payed 75% of the installation. When asked if they would install deer exclusion fencing if it were more affordable, the response to this more general question was equally split among respondents. Of those non-deer-fenced farm operators who indicated that they would install deer exclusion fencing if it were more affordable, 22.4% said they would enclose all crops.

Each non-deer-fenced farm questionnaire included space for general comments on crop damage due to deer and deer exclusion fencing. Comments common to 10% or more

Table 4. Farmer perceptions of the cost effectiveness, design effectiveness, practicality, and success of all major fencing types used in northern Michigan.

	Fencing attribute ratings[a]																					
	Cost effectiveness						Design effectiveness						Practicality						Success			
Fencing type	*n*	1	2	3	4	5	*n*	1	2	3	4	5	*n*	1	2	3	4	5	*n*	1	2	3	4	5
Permanent - all types	63	3	16	24	16	41	60	7	22	15	20	36	65	5	14	26	14	41	65	6	23	17	18	36
Temporary	9	56	11	0	22	11	9	56	11	0	33	0	10	60	10	0	20	10	9	44	22	0	11	11
High-tensile electric, 1.5 m	8	0	13	50	12	25	8	0	38	25	25	12	8	0	0	63	25	12	8	0	37	12	38	13
High-tensile electric, 1.8 m	13	0	0	15	0	85	13	0	8	8	25	58	13	0	0	23	0	77	12	0	8	8	17	67
High-tensile electric, 2.2 m	4	0	0	25	25	50	3	0	0	33	0	67	4	0	0	50	0	50	4	0	0	50	0	50
High-tensile electric, 2.4 m	7	14	14	14	29	29	7	14	29	29	14	14	7	0	29	29	14	29	7	14	29	29	0	29
Temporary 1-wire	4	75	0	0	25	0	4	75	0	0	25	0	4	75	0	0	25	0	4	75	0	0	25	0
Temporary 2-wire	5	40	20	0	20	20	5	40	20	0	0	0	6	50	17	0	17	16	5	40	40	0	0	2
Woven wire - 2.4 m	4	0	0	0	25	75	4	0	20	0	20	60	5	0	20	20	0	60	6	0	17	0	33	50
Woven wire - >2.4 m	5	0	0	20	40	40	5	0	0	0	20	80	5	0	0	40	20	40	4	0	0	0	25	75

[a]Rating is the % of *n* (number of respondents) in a given category. Response categories were: 1 = not cost effective, design effective, practical, or successful, 2 = somewhat cost effective, design effective, practical, or successful, 3 = cost effective, design effective, practical, or successful, and 4 = quite cost effective, design effective, practical, or successful, 5 = very cost effective, design effective, practical, or successful.

of the respondents referenced better herd management (killing more deer), deer fencing as impractical or too expensive, general complaints about deer damage, or statements that deer were not really a significant problem.

Non-fence Deer Control Methods

Both deer-fenced and non-deer-fenced farms were asked identical questions regarding their use and perceptions of the effectiveness of non-fence deer control methods. The various deer killing permits issued by state agencies were perceived as reasonably effective by deer-fenced farm respondents, however, not nearly as effective as deer exclusion fencing (Table 5). Table 6 indicates the use and perceived effectiveness of non-fence deer control methods by commercial farmers not currently using deer exclusion fencing. Deer killing permits and hunting are perceived as more effective by this group than by deer-fence users. However, the perceived effectiveness of non-fence control methods does not compare favorably to the perceived effectiveness of deer exclusion fencing.

When both deer-fence users and non-users were combined, 77% indicated they or their families deer hunt on their farms. Of combined respondents, 70% indicated that other people deer hunt on their farm at no cost. Effectiveness ratings for both of these hunting practices were very similar. Of these, 68% indicated that such hunting was ineffective to somewhat effective in controlling crop damage caused by deer. About 17% indicated that such hunting was effective and about 15% indicated such hunting was quite or very effective.

Fee hunting for deer was a much less prevalent practice among combined respondents but was rated slightly higher in effectiveness by those who used it. Of those using fee hunting, 54% indicated such hunting was ineffective to somewhat effective. Eighteen percent indicated that fee hunting was effective and 27% indicated fee hunting was quite or very effective.

Of combined deer-fenced and non-deer-fenced Michigan and Wisconsin respondents, 11% indicated use of chemical or natural repellants. Of repellant users, 80% indicated their use to be ineffective to somewhat effective, 5% indicated their use to be effective, and 15% indicated their use to be quite to very effective.

Of combined deer-fenced and non-deer-fenced Michigan and Wisconsin respondents, 12% indicated the use of various other non-fence methods to control crop damage caused by deer. These included noise (propane cannon, radio, tapes), chasing with vehicles, placement of unfamiliar objects (cars, scarecrows, ribbons), lure crops, deer feeding stations outside of deer-fenced fields, protection of individual trees and use of soap, human urine, lysol, and dogs to repel deer. Of this group, 65% rated their practice(s) as ineffective to somewhat effective, 25% rated their practice(s) as effective, and 10% rated their practice(s) as quite effective.

In order to compare the use and perceived effectiveness of state-issued special deer killing permits, Wisconsin and Michigan respondents were separated (Table 7). Of combined Michigan respondents, 45% indicated use of block permits and 50% indicated use of crop damage permits. Effectiveness ratings among this group were similar for both types of permit. Of Michigan permit users, 43% indicated them to be ineffective or somewhat effective. About 35% indicated that the permits were effective and 23% indicated permits were quite to very effective.

Of Wisconsin deer-fenced respondents, 29% indicated use of DNR shooting permits. Of these, 47% indicated permits to be ineffective or somewhat effective, 18% indicated permits to be effective, and 36% indicated permits were quite to very effective.

DISCUSSION

Deer fencing was a more common practice in northern Wisconsin than in northern Michigan. This can be explained in part by the Wisconsin state-funded program which subsi-

Table 5. Use and effectiveness of non-fence deer control methods as indicated by deer-fence farm respondents in Michigan's northern Lower and Upper Peninsulas and northeast Wisconsin.

Non-deer fence control method	*n*	Used	Not used	Perceived effectiveness[a] 1	2	3	4	5
MDNR block permits	70	22.9	77.1	29.4	23.5	41.2	0.0	5.9
MDNR crop damage permits	69	27.5	72.5	19.0	33.3	38.1	9.5	0.0
WI-DNR shooting permits	68	16.2	83.8	28.6	14.3	14.3	28.6	14.3
Deer hunting (myself & family)	68	70.6	29.4	37.2	32.6	14.0	7.0	9.3
Deer hunting (others - no charge)	69	71.0	29.0	38.1	35.7	11.9	0.0	9.5
Deer hunting (others - fee hunt)	68	10.3	89.7	22.2	44.4	11.1	0.0	11.1
Chemical or natural repellants	69	30.4	69.6	45.0	35.0	5.0	10.0	5.0
Other methods[b]	68	16.2	83.8	9.1	36.4	36.4	9.1	9.1

[a]Rating is the % of *n* (number of respondents) in a given category. Response categories were: 1 = not effective, 2 = somewhat effective, 3 = effective, 4 = quite effective, and 5 = very effective.

[b]Including: human urine, noise devices, deer feeding station outside fence, lysol-soaked cotton on stakes, bar soap hung on trees, and individual tree protection.

Table 6. Use and effectiveness of non-fence deer control methods as indicated by non-deer fence farm respondents in 5 Michigan Upper Peninsula counties.

Non-deer fence control method	*n*	Used	Not used	Perceived effectiveness[a] 1	2	3	4	5
MDNR block permits	136	43.4	56.6	10.2	32.2	33.9	16.9	6.8
MDNR crop damage permits	138	47.1	52.9	9.7	29.0	30.6	21.0	9.7
WI-DNR shooting permits	133	0.0	100.0	—	—	—	—	—
Deer hunting (myself & family)	137	79.6	20.4	34.1	34.1	17.6	11.8	2.4
Deer hunting (others - no charge)	138	68.8	31.2	27.5	36.3	22.5	10.0	3.8
Deer hunting (others - fee hunt)	136	16.2	83.8	15.0	30.0	20.0	30.0	5.0
Chemical or natural repellants	138	1.4	98.6	—	—	—	—	—
Other methods[b]	136	10.3	89.7	10.0	70.0	10.0	10.0	0.0

[a]Rating is the % of *n* (number of respondents) in a given category. Response categories were: 1 = not effective, 2 = somewhat effective, 3 = effective, 4 = quite effective, 5 = very effective.

[b]Including: noise and chasing, scarecrows, ribbons, cars, lure crops, individual tree protection, and dogs.

dizes the cost for wildlife exclusion practices on farms. Predictably, high value crops such as small fruits, vegetables, Christmas trees, orchards, tree nurseries, and deer bait were more commonly fenced than agronomic crops. The benefits of using deer exclusion fence were very apparent to the farmers using them. Many commented that they would not be able to continue operations without fencing.

Deer-fenced Farms

Although the overall size of farms using deer exclusion fence varied widely, most deer-fenced farms enclosed only 1 area. Potential reasons included the smaller scale of most commercial farm operations in the areas surveyed and the expense involved in deer exclusion fencing. Sixteen hectares was the most commonly reported enclosure size. Gross annual sales on deer-fenced farms also varied. Farms with gross annual sales over $150,000 were the most common. However, small farm income did not preclude the use of deer exclusion fencing.

The difference in farms using deer exclusion fencing versus those not using deer exclusion fencing, centered on types of crops grown and farmer perceptions of acceptable deer damage to crops. Users of deer fence tended to be growing high value crops. Agronomic crops were also grown in rotation. Non-deer-fenced farms surveyed were mostly livestock-based, particularly dairy and beef. These farms produce forage as a major crop. Forage crops, including alfalfa, clover, mixed grass/legume, and grass were perceived as lower value crops and did not show deer damage in an obvious, visual way.

Deer Fence Designs

Four basic types of deer exclusion fences were identified by the farmers surveyed. These included high-tensile electric, woven wire, high-tensile non-electric, and temporary 1- and 2-wire fences. Woven wire fencing was perceived most favorably by deer-fenced farm respondents. It was very successful in excluding deer and required very little maintenance once installed. This type of fencing was less common than high-tensile electric, probably due to the cost of installation. The 2.4 m woven wire fence received more favorable ratings than taller woven wire fencing. Cost effectiveness and practicality decline on woven wire fencing over 2.4 m tall. However, the design effectiveness and success of woven wire fencing over 2.4 m tall was perceived more favorably.

The most common type of deer exclusion fence reported was high-tensile electric. This type was perceived very favorably by farmers, although somewhat less favorably than woven wire fence. The most favorably perceived height among respondents using high-tensile electric fencing was 1.8 m. The cost and ease of installation made high-tensile electric the fence of choice. The 1.8 m height appears to strike a good balance between effectiveness, cost, and ease of installation.

High-tensile non-electric fencing was not commonly used and received inconsistent ratings from users. Temporary fencing was reported only among Wisconsin farms. Although inexpensive and readily available through government-subsidized programs, this fencing is not perceived as effective by the majority of users.

Non-deer-fenced Farms

The non-deer-fenced sample population was a more homogeneous group than the deer-fenced sample. The prevailing enterprise among this group was dairy. Farm size and proximity to neighbors was similar to the deer-fenced sample. However, this group perceived less severe crop losses due to deer than the deer-fenced farm sample prior to fencing. Non-deer fenced respondents indicated that deer fencing is too expensive and deer damage not severe enough to warrant fencing. About one-third of non-fenced farm operators perceived an increase in deer damage when neighbors within 3.22 km (2 mi) used deer exclusion fencing. However, this increase was quite moderate. Only a minority of non-fenced farm operators would install fencing if the expense was lowered by govern-

Table 7. Use and effectiveness of special DNR deer shooting permits as indicated by combined deer-fenced and non-deer-fenced Michigan respondents and deer-fenced Wisconsin respondents.

Non-deer fence control method	*n*	Used	Not used	Perceived effectiveness[a] 1	2	3	4	5
MDNR block permits[b]	168	45	55	14	30	36	13	7
MDNR crop damage permits[b]	169	50	50	12	30	33	18	7
WI-DNR shooting permits[c]	38	29	71	29	18	18	24	12

[a]Rating is the % of *n* (number of respondents) in a given category. Response categories were: 1 = not effective, 2 = somewhat effective, 3 = effective, 4 = quite effective, 5 = very effective.

[b]Michigan residents only.

[c]Wisconsin residents only.

ment cost-share or other means. Agronomic crops including corn, small grains, potatoes, and forage were the primary crops which would be enclosed by these operators if fencing were more affordable.

Other Deer Damage Control Methods

Deer-fenced farms use fewer DNR shooting permits and more chemical and natural repellants than non-deer-fenced farms. However, regular deer hunting and other deer control methods are used by a similar majority of respondents from both groups. Generally, non-deer-fence control methods are rated much less favorably than fencing. Michigan and Wisconsin block and crop damage permits are rated as the best of non-deer-fence control methods.

Farmer-Deer Hunter Relationship

The relationship between sportsmen and farmers is in transition in areas of the UP containing significant agricultural land. Farmers increasingly sell hunting privileges in the form of "fee hunting," to the chagrin of many hunters unaccustomed to such practices. Many deer hunters have little sympathy for farmers who claim to suffer economic hardship due to crop damage by deer. These hunters feel that farmers are excluding deer hunters from prime hunting areas and are only getting what they deserve. Other hunters are very concerned about farmers' deer damage problems and they try to work with them cooperatively. The farmer-deer hunter relationship is very dynamic and unpredictable. This study has not uncovered any evidence that the use of deer exclusion fencing is objectionable to deer hunters.

CONCLUSIONS

Fencing is perceived as the only effective method to control deer damage to crops. Farmers must perceive significant damage to high value crops before a decision to fence is made. Small, scattered fields discourage farmers from installing deer exclusion fencing.

Only those farmers whose operations are located in areas of high deer population and who grow high value crops which cannot tolerate deer damage should consider investing in deer exclusion fencing. Most Michigan UP commercial farms do not fit this profile. However, the potential exists for development of orchards, nurseries, vegetable, Christmas tree, and other types of operations which could benefit economically from deer exclusion fencing.

The most viable alternative to fencing is special, state-issued deer killing permits. The numbers of these permits issued varies from year to year at the discretion of the state Department of Natural Resources. Farmers, therefore, have little or no control over the numbers of deer they may legally kill regardless of their perceived need of relief from deer depredation. Fencing is the only dependable alternative if predictable results are needed.

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