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Use of Confined Dogs for Reducing Deer Damage to Apple Orchards

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Abstract: We assessed the efficacy of free-ranging dogs, confined by buried fences and electronic collars, for reducing deer damage to apple trees in three commercial apple orchards in Oswego County, New York State. During 1995 and 1996, we monitored paired dog-protected and control plots in each orchard. Within dog-protected areas, the percentage of damaged buds was lower, and fruit yield was higher in both 1995 and 1996 than for control plots. Gross economic returns were higher from dog-protected than control plots in both 1995 (by 51%) and 1996 (by 184%). After two seasons of growth, trees planted in May 1995 had nearly three times the cross-sectional area, and were 60% taller if they were in dog-protected rather than control plots. Dogs provided increased economic returns for growers at much lower cost than conventional barrier fencing.

Key words: deer management, dogs, fruit orchard, invisible fence

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INTRODUCTION

White-tailed deer (*Odocoileus virginianus*) damage is a serious problem for fruit growers (Scott and Townsend 1985, Purdy et al. 1987, Phillips et al. 1987). Surveys conducted in 9 northeastern states showed that 20 to 65% of orchard owners suffered moderate or severe losses from deer damage (Caslick and Decker 1979, Scott and Townsend 1985, Purdy et al. 1989). In the Hudson Valley, estimated revenue lost from deer damage and associated preventative measures averaged about $1,500 per apple orchard in 1986 (Phillips et al. 1988). In New York, deer caused losses of $11,000 to $27,000 in a 20-ha orchard (Torrice 1999). Deer damage has increased in recent years (Purdy et al. 1989, Brown et al. 2004), and is likely to continue to do so in the northeast because of the rising deer population (Curtis et al. 2000). In 2003, deer damage to tree fruits in New York State was estimated at $9.4 million (Brown et al. 2004).

Deer cause damage to fruit trees mainly by browsing. In addition, antler rubbing during fall also injures small trees (Harder 1968, Scott and Townsend 1985, Lemieux et al. 2000a). Over winter, deer may browse on leaf and flower buds of apple trees, which can significantly reduce fruit production (Katsma and Rusch 1980, Austin and Urness 1989). Removal of terminal vegetative buds causes excessive branching known as “witch’s broom”, which can reduce yield (Westwood 1993). Young trees are especially vulnerable to damage, as browsing on leader branches can kill trees (Boyce 1950, Phillips et al. 1987), cause them to become misshapen or stunted, or delay their development and yield (Harder 1970, Scott and Townsend 1985). A small increase in the time to first fruit production could have substantial impact on profitability over the life of an orchard (McAninch et al. 1985, Pomerantz et al. 1986). Deer also browse on apple trees during the growing season, feeding on leaves and fruit (Scott and Townsend 1985). The trend toward planting dwarfing rootstocks at high density has increased deer damage by increasing the number of trees and branches within the reach of deer (Caslick and Decker 1979).

Currently, deer damage to agricultural crops is controlled mainly by the use of electric or barrier fencing, and repellents (Porter 1983, Curtis et al. 1994). These methods have been moderately successful for protecting orchards and other crops from deer (Conover and Kania 1987, Hygnstrom and Craven 1988, Swihart and Conover 1988, Lord 1990, Curtis et al. 1994, Mason 1998). However, fencing requires substantial investment in both equipment and labor (Porter 1983, Swihart and Conover 1988, Lord 1997). Also, opening and closing gates when accessing orchards can be frustrating over the long term. Interviews with apple growers indicated they were concerned about fence costs, maintenance, effectiveness, and the economic rate of return for fencing (Purdy et al. 1987).

Some commercial repellents can prevent severe damage under certain conditions for up to 18 weeks (Lemieux et al. 2000b). However, when deer feeding pressure is high, repellents do not always provide adequate protection (Conover 1984). Application costs may also be prohibitive for crops covering large areas (Consumer Reports 1998). Furthermore, re-applications are often necessary (Lord 1990), which increases the labor and material costs.

Shooting deer under the authority of crop depredation permits is another method used by some orchard owners to reduce damage (Purdy et al. 1987). Two advantages to this are the relatively low cost, and the obvious and immediate reduction in deer numbers. However, disadvantages are that culling deer is time consuming, reductions are short-term (Purdy et al. 1987), and assessment of efficacy is difficult (Erickson and Giessman 1989). Apple growers are therefore still seeking information about new, more effective methods for controlling deer damage (Purdy et al. 1987). Fruit growers tend to select techniques that have low initial costs, and give immediate rewards in time, money, and/or effort.

We explored the use of dogs for reducing deer damage to fruit orchards. Restrained dogs failed to keep deer out of agricultural crops because deer became accustomed to the dogs and their barking (DeGarmo and Gill 1958). However, Beringer et al. (1994) found that free-ranging dogs, confined by a buried fence and electronic collars, were effective in reducing deer damage to a white pine (*Pinus strobus*) plantation. Browse rates were significantly lower in dog-protected plots during the 3-year study. We tested the efficacy of confined dogs for protecting apple orchards in New York.

METHODS

Three commercial apple orchards in central New York were selected: (1) Behling Orchards in the town of Mexico; (2) Fruit Valley Orchards in Oswego; and (3) Fowler's Orchard in Fair Haven. During the fall of 1994, an invisible fence system (Off Limits® Crop Protection System, Invisible Fence Co., Inc., Berwyn, PA) was installed at each of these orchards, following the manufacturer's instructions. This system used two free-ranging dogs, and a 12-gauge insulated copper wire that was buried 6 cm deep, and was electrified using a 110-volt power source. The dogs were conditioned to remain within the fenced area through the use of shock collars activated by radio-waves transmitted along the buried wire.

Areas protected by the invisible fences ranged from 4.8 to 6.1 ha, with an adjacent control plot of least 1.6 ha at each location. At Behling Orchards, we enclosed 13- and 15-year-old 'Cortland' trees, planted at a density of 325 trees per hectare. At Fruit Valley Orchards, 5-year-old 'Jonamac' and 'Marshall McIntosh' trees, planted at a density of 850 trees per hectare, were protected. Finally at Fowler's Orchard, the fence enclosed 15- and 20-year-old 'McIntosh' trees, planted at a density of 250 trees per hectare.

We obtained dogs from a local animal shelter, selecting ones that were large, with a heavy coat so they could withstand winter conditions (Beringer et al. 1994), and exhibited a propensity to bark and chase. We selected one Labrador and one Labrador-cross for Behling's, two husky/collie crosses for Fruit Valley, and two German shepherd crosses for Fowler's orchard. The dogs were moved to the treated plots during the fall of 1994, where they were provided with a two-dog kennel, and each dog was fitted with a battery-powered collar that gave the dog a shock if it approached within 2 to 5 m of the buried electronic fence. The dogs were trained to learn the location of the fence boundary over a 1 to 2 week period following the manufacturer's protocols (Beringer et al. 1994).

We randomly selected and marked 50 trees that were located approximately 40 m inside the fence in the treated plots, and 50 that were in the control plots 40 m outside of the fence. The severity of over-winter deer browsing was quantified in April 1995 and 1996 by recording the number of damaged and intact buds on two limbs below 2 m in height on each marked tree in each plot. In both years, twigs that were damaged by deer were counted and cut with pruning shears so that new and prior damage could be distinguished both during and between sampling sessions. Pruned branch tips could be readily distinguished from the more ragged mastication damage to browsed twigs and buds caused by deer.

We assessed the effect of dog-protection on yield by weighing all fruit within deer browsing zone (up to 2 m high) from 20 randomly-selected control trees, and 20 dog-protected trees in September each year. We controlled for the effect of tree size on yield by dividing yield by trunk diameter (Katsma and Rusch 1980). Fruit yield (kg per hectare) was calculated with the formula: trees/ha x mean kg/tree. Gross returns per hectare were determined by multiplying kg/ha x $/kg.

The $/kg return was ascertained by grading a 36 kg sub-sample of fruit from each control and treatment plot for color and size. Apples with > 50% red color and weighing 141 to 223 g were tray-packed U.S. Extra Fancy; fruit with at least 33 to 50% red color and weighing 88 -140 g were bagged U.S. Fancy; and fruit with < 33% red color and/or weighing < 88 g were classified as juice apples. These color and size data were converted to $/kg return to the grower by a commercial apple-packing house (Apple Acre, Lafayette, NY). The prices varied from 0.16 – 0.54 $/kg.

To determine the effect of deer on newly planted apple orchards, 20 'Empire' trees on M.9/111 rootstock were planted in the control and treatment plots at each of the 3 orchards during May 1995. In August of 1995 and 1996, these trees were photographed against a density board with a 5 x 5-cm^2 grid marking. Based on visual examination of these photographs, we calculated canopy size (canopy cross-sectional area in cm^2) by recording the number of grid cells that were blocked by foliage or branches, and tree height.

All data sets were analyzed with the SuperANOVA (Abacus Concepts 1989) computer program. Means were compared between treatment and control plots in each orchard, and differences were considered significant at $P < 0.05$.

RESULTS

Winter Deer Browsing

The dogs and invisible fence system was effective for reducing deer browsing during winter. Bud loss in April 1995 was 85% less for dog-protected than control trees (1.5% and 10.1%, $P < 0.001$; Table 1). The dogs were less effective during the second winter, however, bud loss on protected trees was still 38% less than that for controls (15.7% and 25.2%, respectively, $P < 0.0001$; Table 1) in April 1996.

Table 1. Mean percent bud loss, at three orchards with dog-protected and control areas (*N*= 2 limbs/tree for 50 trees in each area within an orchard), Oswego County, NY, 1995 and 1996.

	Mean percent bud loss					
	1995			1996		
Orchard	Dog-protected	Control	P	Dog-protected	Control	P
Behling	1.0	6.5	< 0.001	13.8	25.5	< 0.0001
Fruit Valley	0.0	10.4	< 0.001	20.0	18.9	*NS*
Fowler	3.3	13.4	< 0.001	13.5	31.3	< 0.0001
All orchards	1.5	10.1	< 0.001	15.7	25.2	< 0.0001

Yield and Returns per Acre

The dogs were also effective in reducing fruit losses caused by deer damage. The mean yield per mm trunk diameter was higher in dog-protected than control plots by 21% ($P = 0.065$) in 1995, and by 115% ($P < 0.0001$) in 1996 (Table 2). Similarly, mean yield per hectare for dog-protected areas was higher than control plots by 37% in 1995, and 128% in 1996 (Table 3).

Economic benefits varied among study orchards and between years within each orchard (Table 3). Fruit Valley experienced the most pronounced difference between dog-protected blocks and control plots. Here, the gross returns per ha were 348% higher in protected than control plots in 1995 and 404% higher in 1996. In other orchards, gross returns from protected plots were between 14% less and 215% more than from control plots. Fowler's Orchard showed the greatest difference in gross returns between years. In 1995, the dog-protected trees were slightly less profitable (14% lower \$/ha gross return) than the control block. However, in 1996, protected trees yielded 253% more kg fruit per ha than control trees, and the gross return was 215% higher from protected trees. The increase in yield realized from using the invisible fencing system at Behling Orchards was lower in 1996 (1,080 kg/ha) than 1995 (5,805 kg/ha). With higher apple prices in 1996, this translated into an additional \$973/ha in returns for dog-protected plots (Table 3).

Growth of Young Trees

Dog-protection had a profound effect on the growth of young trees that were planted during May 1995. Protected trees were 21% taller than controls by August 1995, and 61% taller in August 1996 (Table 4). Canopy size was also significantly greater for protected than control trees (Table 4). By August 1995, the canopy cross-sectional area was 72% larger ($P < 0.0001$) in protected trees (2,448 cm^2) than in control trees (1,422 cm^2; Table 4). By August 1996, the canopy area of protected trees was 169 % ($P < 0.0001$) larger than that of control trees (3,582 versus 1,332 cm^2, Table 4).

Table 2. Mean fruit yield (kg) per tree, and mean yield per mm trunk diameter for three apple orchards, each with one dog-protected and one control plot, Oswego County, NY, 1995 and 1996. *N* = 20 trees in each plot.

	1995			1996		
Orchard	Dog-protected	Control	P	Dog-protected	Control	P
Behling						
mean fruit yield/tree	56.1	38.1		41.3	38.0	
mean kg yield/mm trunk diam.	3.7	2.5	< 0.001	2.7	2.5	*NS*
Fruit Valley						
mean fruit yield/tree	12.2	2.8		27.4	5.4	
mean kg yield/mm trunk diam.	2.0	0.6	< 0.001	4.0	1.1	< 0.0001
Fowler						
mean fruit yield/tree	42.3	55.2		19.3	5.4	
mean kg yield/mm trunk diam.	3.0	4.1	< 0.001	1.8	0.4	< 0.0001
All orchards						
mean fruit yield/tree	36.9	32.0		29.3	16.3	
mean kg yield/mm trunk diam.	2.9	2.4	< 0.0653	2.8	1.3	< 0.0001

Table 3. Mean fruit yield and economic return for three orchards, each with one dog-protected and one control plot, Oswego County, NY, 1995 and 1996. *N* = 20 trees for each area within an orchard.

	1995		1996	
Orchard	Dog-protected	Control	Dog-protected	Control
Behling				
mean fruit yield (kg/ha)	18,045	12,240	13,275	12,195
mean $/kg	0.17	0.16	0.26	0.21
mean $/ha	3,098	1,988	3,513	2,540
Fruit Valley				
mean fruit yield (kg/ha)	10,260	2,340	23,085	4,500
mean $/kg	0.32	0.32	0.35	0.35
mean $/ha	3,325	743	7,978	1,583
Fowler				
mean fruit yield (kg/ha)	10,485	13,680	4,770	1,350
mean $/kg	0.29	0.26	0.48	0.54
mean $/ha	3,060	3,538	2,283	725
All orchards				
mean fruit yield (kg/ha)	12,915	9,405	13,725	6,030
mean $/kg	0.26	0.25	0.36	0.36
mean $/ha	3,160	2,090	4,590	1,615

Table 4. Mean tree height and canopy cross sectional area for newly-planted trees in three orchards, each with one dog-protected and one control plot, Oswego County, NY 1995 and 1996. *N* = 20 trees in each plot.

1995	1996

Orchard	Dog-protected	Control	P	Dog-protected	Control	P
Behling						
mean tree height (cm)	113.4	84.0		138.2	73.4	
mean canopy size (cm^2)	1836	1062	<5 0.0001	3024	1098	<5 0.0001
Fruit Valley						
mean tree height (cm)	121.7	107.2		171.1	118.3	
mean canopy size (cm^2)	3168	2250	<5 0.0003	5166	2178	<5 0.0001
Fowler						
mean tree height (cm)	131.2	122.2		136.2	85.4	
mean canopy size (cm^2)	2322	936	<5 0.0001	2538	738	<5 0.0001
All orchards						
mean tree height (cm)	122.1	101.1		148.5	92.3	
mean canopy size (cm^2)	2448	1422	< 0.0001	3582	1332	< 0.0001

DISCUSSION

The invisible fence system significantly reduced bud loss during both winters of the study. However, the system was less effective during the second winter (reduction in bud loss of 85% and 38% in 1995 and 1996, respectively). The first winter was relatively mild in central New York State, but the second was more severe. Annual snowfall was 253 cm during the winter of 1994-1995, and 584 cm during 1995-1996. Mean monthly temperatures during winter (November to March) were 0.9ºC and –2.6ºC for the first and second winters, respectively (Oswego East weather station, Northeast Regional Climate Center). Consequently, feeding pressure by deer was considerably higher during the second winter, as shown by the higher mean percentage of buds lost in control plots (25.2% in 1996 vs. 10.1% in 1995). When feeding pressure from deer is higher, crop protection strategies tend to be less effective (Byers et al. 1990, Andelt et al. 1991, Andelt et al. 1992). Thus, the lower efficacy of the dog-protection system during the second winter was partly due to increased feeding pressure from deer. Also, because of the deeper snow during the second winter, the dogs were less able to run easily and therefore less able to chase deer from protected blocks. With milder weather, the dog and invisible fence system was more effective during the first winter (86% reduction in bud loss).

Dog-protected trees also produced a higher yield (kg fruit/mm trunk diameter) than control trees both years. The difference was less pronounced for the 1995 harvest (21% greater) than in 1996 (115% greater). However, overall bud loss was greater in 1996 than in 1995, and the dogs were less effective in 1996 (85% and 37% less on dog-protected than for control trees during winter 1995 and 1996, respectively). Bud losses of less than 20% had little effect on yield (Katsma and Rusch 1980, Austin and Urness 1989). In our study, bud loss for both control and protected trees was less than 10.5% during the first year, and yield was similar in both plot types (2.4 and 2.9 kg/mm trunk diameter on control and protected trees, respectively). During the second winter, despite higher foraging pressure from deer, the dogs succeeded in keeping bud loss below 20% in the fenced plots, and the yield from these trees was the same in the second year (2.8 kg/mm trunk diameter) as in the first. However, control trees lost 25.1% of their buds during the second winter and their fruit yield was considerably lower in the second year than the first (1.3 versus 2.4 kg/mm trunk diameter). Our results therefore support the findings that bud losses of less than 20% have little effect on yield (Katsma and Rusch 1980, Austin and Urness 1989), and that bud losses greater than 20% may reduce yield (Austin and Urness 1989). However, the threshold at which bud loss affects apple yield may vary with tree variety, because some varieties may partially compensate for loss of fruit buds on one branch by retaining more fruit per blossom cluster on another (Katsma and Rusch 1980).

The invisible fence system was installed at Fruit Valley Orchard approximately three years before the start of this trial. Hence the higher financial gain there, as compared with the other orchards, indicated that growers may see increased benefits from using this system over time as deer behavior and foraging patterns change.

We attributed the 14% reduction in gross return from employing the dog-protection system at Fowler's Orchard in 1995 to the fact that this orchard had not been uniformly pruned that year. In 1996, we pruned these trees to correct for canopy size and the results were more favorable, with protected trees yielding 253% more kg fruit per ha than control trees, and an increase in gross return ($/ha) of 215%.

We confirmed that deer browsing may reduce the growth potential for young trees, both in terms of their height and canopy area (Mower et al. 1997). This can be serious for growers because establishing good tree structure during the early years is critical for economic returns from high-density orchards (Westwood 1993). With investments ranging from approximately $7,500 to $19,500 per ha, depending on the planting system and area (White and DeMarree 1992), profitability depends on bringing an orchard into production as soon as possible. The invisible fence system protected the young trees we planted. These trees presumably will achieve their projected break-even date (approximately 8 to 10 years), and thereafter will result in potential annual gross returns of $7,000 to $8,000 per ha (White and DeMarree 1992). Thus, invisible fencing with dogs can be an effective way to protect the substantial investment for high-density orchards and help ensure future profitability. Furthermore, costing approximately $5,700 to protect a 20-ha block, the invisible fence system is considerably less expensive to install than woven-wire or conventional electric fencing ($48,000 and $28,000, respectively for the same area; Curtis et al. 1994).

Our results indicate that the maximum benefit from using the dog-protection system may be experienced several years after the system is installed. Also, growers must use proper pruning and orchard management practices. Less impressive results can be expected in situations where attention is not given to the entire orchard management system.

Apple growers must realize that the invisible fence system acts more as a deer repellent rather than a physical barrier. Some damage to trees must be expected even in years with relatively light deer-foraging pressure. Also, in addition to deer damage, other factors may affect yield and gross return, such as weather conditions, apple variety, and disease prevalence. At a specific site, the availability of alternative forage, population densities and movement patterns of deer, location of winter cover, and weather conditions (e.g., deep snowfall) may influence the success of the invisible fence system, or any other deer deterrent. Despite the inherent variability between years, we were able to demonstrate significant economic benefits from using this system to control deer damage to orchards in both years of this study. In addition to protecting orchards and pine plantations (Beringer et al. 1994), this control technique may be useful for protecting other crops from deer damage.

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