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## ABSTRACT

The impact of wildlife damage on the profitability of apple farming in New York's Hudson Valley was determined by use of a Standard Net Present Value (NPV) analysis as a means to measure long-term impact. Data were gathered through questionnaire and interview of a stratified random sample of 39 growers that represented 17% of the regional growers. Data concerning species causing damage, extent of wildlife damage and types of controls used were combined with current and long-range costs including revenue lost through damage and control costs. Limitations of the analysis are discussed along with results that indicate an annual equivalent cost flow for all wildlife damage between \$3.8 and \$3.85 million or \$184 to \$188 per acre. This study shows that a typical grower experienced combined revenue losses and control costs of \$12,500 during 1986. Fifty-two percent of this was associated with wildlife controls, 40% with revenue losses and the remainder with tree replacement costs. Over a 25-year period beginning in 1985, the NPV of control costs and revenue losses is projected to total between \$53 and \$62 million depending upon whether a 3.5% or 5.0% discount rate is used.



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## INTRODUCTION

Wildlife damage a variety of crops produced in the United States such as grains, orchards, vegetables, and ornamentals (Byers, 1984: Caslick and Decker, 1977; Katsma and Rusch, 1979; Tobin, 1986; McDowell and Pillsbury, 1959). The extent of the damage varies by region due to differences in climate terrain, crops, and wildlife. Despite the implementation of numerous control strategies, wildlife continue to be a severe problem in some parts of the country. This is because wildlife are extremely adaptable and in some cases thrive in areas where man has significantly altered the original habitat. For example, deer populations in New York are much larger than in the past because of the creation of fields and meadows while orchards are an ideal habitat for voles (Sauer, 1984; Byers, 1984). Hudson Valley apple orchards are particulary susceptible to damage caused by pine and meadow voles, deer, woodchucks, and a variety of birds.

The primary objective of this study was to estimate the impact of wildlife damage on the profitability of producing apples in four counties of the Hudson Valley, New York. These counties were: Ulster, Columbia, Dutchess, and Orange. The first objective is important for several reasons. First, apple production is an integral part of the agricultural sector of the region. In 1985, 234 farms produced apples which had a total gross revenue ranging between \$35-\$45 million. Second, most fruit growers obtain most of their revenue from the sale of apples since half of the regional fruit farm acreage in the Hudson Valley is planted with apple trees (New York Crop Reporting Service, 1986; see Table 1). This implies that if wildlife cause extensive damage to apple orchards, then individual growers would suffer economic hardship. A secondary objective of the study was to gain insights concerning the cost and effectiveness of wildlife control measures. The control strategy selected hinges on the nature of the wildlife problem, the extent of damage, and the availability of capital, labor, and machinery. Growers attempt to select controls which are best suited to deal with their particular wildlife problem. The study estimated the impact of wildlife damage on Hudson Valley apple production caused by five wildlife species. These species included pine voles (**Microtus pinetorum**), meadow voles (**Microtus pennsylvanicus**), white-tailed deer (**Odocoileus virginianus**), birds (several species), and woodchucks (**Marmota monax**).

## METHODS

### Analytical Framework

Cost and revenue losses associated with wildlife damage in the Hudson Valley were estimated for the current year and over the life of the orchards. A standard net present value analysis (NPV) was selected as the means to measure the long-term impact of wildlife on the profitability of producing apples in the Hudson Valley. Net present value analysis allows for a comparison of streams of income obtained over time from different control strategies. The value of future returns are discounted to equate future dollars with present worth. Miranowski (1984) pointed out that historically the real rate of return on investment opportunities available to farmers has been between 3.5 and 5 percent. Consequently, these were the rates selected to compute the NPV for this study. In standard notation, the net present value of wildlife controls and revenue losses can be written as:

$$(1) \quad NVP = (-)\sum_{i=1}^{n} \frac{C_{ji} + R_{ji}}{(1=r)^{i}}$$

where:

$C_{ji}$ = costs associated with controlling wildlife type j in year i

$R_{ji}$ = revenue losses associated with wildlife type j in year i

$r$ = discount rate

$n$ = total number of time periods

The net present value was calculated assuming that n=25, which corresponds to an orchard lifespan of 25 years. Revenues and costs vary considerably over time reflecting a transition in the average age, density, and composition of the trees.

The results of the net present value analysis were used to compute annual equivalent cash flows, which converts the NPV into annual cash flows that equal the amount a grower would have to pay each year for 25 years to equal the payment of the entire NPV today. To determine the equivalent cash flows the NPV was divided by the present value of one dollar per year for 25 years at the appropriate discount rate (Aplin et al., 1977).

### Questionnaire Design

To measure the extent of wildlife damage, a stratified random sample of 39 apple growers was interviewed in the four county region. This represented 17 percent of the regional apple growers (Table 1). The respondents were asked to indicate the types of wildlife which affect their orchards, the extent of wildlife damage their orchards experience, and the types of wildlife controls they use. This information was then combined with price data obtained from other sources to compute current and long-term costs and revenue losses associated with wildlife controls and damage.

The names and addresses of the growers interviewed were obtained from the New York Crop Reporting Board. The stratification criteria was that each farm must contain at least 50 acres of apple orchards. The reasons for doing this were twofold. First, the study was primarily concerned with the effects of wildlife damage on commercial growers. Many orchards smaller than 50 acres may not be as profit-oriented as large farms since the owners of small farms frequently supplement their income from outside sources. Secondly, by surveying large farms, a much higher percentage of the regional apple acreage was included in the sample which increased the likelihood of accurately portraying the scope of the wildlife problem. Thirty-four percent of the regional acreage was included in the Hudson Valley Wildlife Damage Survey.

The questionnaire was divided into six sections. The first section was designed to obtain background information from the growers regarding their farming operation. Growers were asked to indicate how much land they rent and/or own, the types of fruit they produce, the number of bearing and nonbearing acres of each fruit type, tree density, and the number of acres of farmland used for other purposes by land use type. Information concerning tree age was also requested since yields vary by tree age and since wildlife affect young trees in different ways than old trees. Since each farm has trees of many different ages, growers were asked to estimate the mean tree ages for each tree type. Additional background information concerning each farm included in the survey was obtained from the individual responses to the 1985 Orchard and Vineyard Survey. The survey contained information on the varieties, rootstocks, number of trees for each rootstock, and the ages of the trees planted.

Sections 2-6 were concerned with the impact of wildlife damage on apple production. In these sections of the questionnaire, data were collected regarding the types of controls used including baits, cultural practices, deterrents, tree guards, and fences. Growers were first asked to estimate the amount of each control applied per acre, the number of applications per season, age of the trees and the percentage of apple acreage receiving treatment, and the method of application. For cultural practices such as mowing and herbicide applications, which often are routinely conducted regardless of wildlife damage, information was elicited regarding the number of applications that were applied solely for wildlife control. Only the additional applications were used in the computation of wildlife control costs. This information, when combined with price information, permitted the calculation of the total cost of applying each form of control.

Growers were then asked to estimate the amount of wildlife related damage their orchards experience or would experience with and without controls. Respondents predicted the extent of wildlife damage their orchards would experience with controls, without controls for one year, and assuming that controls were permanently removed. Damage was expressed in terms of the total number of trees damaged, seriously damaged, or killed.

Growers were asked to predict the level of damage for both young and old trees. Young trees damaged by voles and woodchucks were defined as being six years and younger while young trees damaged by deer were defined as being five years or younger. Damage was measured in this way since the impact of wildlife damage is more severe for young trees than for older trees. Damage was also estimated separately for semi-dwarf, dwarf, and standard trees. Deer damage dwarf and semi-dwarf trees more than standard trees because the former are smaller and, therefore, a greater proportion of the total bearing surface is accessible. Dwarf and semi-dwarf trees are not damaged more than standard trees by voles, but because they have weaker root systems, the impact of the damage is greater.

The degree of damage was expressed in terms of loss of yield potential. This refers to the ability of a tree to produce now and into the future. Growers estimated the percentage of yield potential lost during the current year and the percentage of lost potential which could be regained over time. Although deer and voles may both cause equivalent losses of yield potential, the ability of a damaged tree to recover from vole damage is generally less than recovery from deer damage. Hence, the long-term impact of vole damage will be greater than deer damage although in the short run they may be the same.

Although birds cause damage to the fruit, growers rarely use any type of control to minimize this damage. Hence, when making comparisons of current year bird damage with damage caused by other types of wildlife, it must be remembered that the latter are being controlled while the former are not. If controls on voles, deer, and woodchucks were removed, the damage caused by these types of wildlife would far exceed that caused by birds (Table 2).

Yield, Packout, and Prices

To predict the economic impact of wildlife damage it was necessary to estimate the yield curves for semi-dwarf, dwarf, and standard trees. Forshey (1987) estimated these curves assuming that growers follow average management practices and that yields are not severely affected by disease, weather, or insects. The yield curves were used to estimate production during the current year and over an orchard life cycle of 25 years. Yield during any particular year is a function of the age of the tree and tree type while production is a function of yield and acreage planted.

Since apple yields follow a nonlinear growth path and since there are trees of many ages, yield is characterized by the average yield which is attainable along a particular section of the yield curve. Production was estimated by multiplying the yield attained in this fashion by the number of acres of the particular tree type in question.

In addition to estimating production, it was also important to estimate apple packout. Packout, which refers to the quality of the harvested fruit was assumed to be 90 percent fancy and extra fancy and 10 percent juice for semi-dwarf and dwarf trees. Only 65 percent of the packout of standard trees was assumed to be fancy and extra fancy while 35 percent was assumed to be used for juice. This is because standard trees in the Hudson Valley are generally past their prime. Eighty percent of the nonjuice packout was assumed to be extra fancy and 20 percent fancy.

Information concerning the costs of wildlife control measures and apple prices were obtained from a variety of sources. Some of the data concerned with the costs of wildlife control were obtained by sending a brief survey to three agricultural supply companies in the Hudson Valley. A large portion of the cost data was also obtained from budgets prepared by Castaldi (1987) which estimated the costs of establishing apple orchards in the Hudson Valley.

Apple prices were obtained from several sources. The prices for fancy and extra fancy apples were obtained by taking a monthly average of F.O.B. prices during 1985-1986. F.O.B. (Freight on Board) prices do not include storage, dipping, and other costs associated with apple harvesting. The prices were obtained from the New York Crop Reporting Service. The extra fancy and fancy prices per bushel obtained in this fashion were $11.57 and $8.17, respectively. When these prices were multiplied by the percentage shares of nonjuice packout and total packout, the combined extra fancy and fancy prices became $9.80 for semi-dwarf and dwarf trees and $7.08 for standard trees. The total price was found by adding to the above prices the percentage share of price contributed by juice. The juice price represents a simple average of the prices a select group of growers provided. This price was 5.04¢ per pound or $2.02 per bushel. The total weighted price for semi-dwarf and dwarf tree production was $10.00 per bushel while the price for standard tree production was $7.79 per bushel.

Since apples not harvested due to wildlife damage will not incur packing or harvesting costs, these handling costs must be subtracted from the total weighted prices. Packing and harvesting costs were estimated by Castaldi (1987) to equal $2.00 and 65¢ per bushel (for picking labor), respectively. Because harvesting costs other than labor are fixed, they were not relevant to this analysis. Thus, the per bushel prices for semi-dwarf and dwarf trees and standard trees used to compute revenue losses were $7.35 and $5.14, respectively.

Limitations of the Analysis

There are several caveats associated with the analysis presented in this paper. One of the primary limitations concerns the manner in which yield and packout were selected. Since the yields were estimated without the benefit of extensive field data and since damage of one type or another usually affects production, there may exist wide variations between potential and predicted production levels. This is further constrained by the assumption that apple acreage will remain constant over time. In reality, the apple acreage in the Hudson Valley has been decreasing over the past few years and there is reason to believe that this trend will continue (New York Orchard and Vineyard Survey, 1980-1985).

A second limitation concerns the selection of apple prices, input prices, inflation rates, and interest rates. These were assumed to be constant over the 25 year time period. Thus, the analysis did not allow for fluctuations in demand due to changing tastes and preferences. Prices may be influenced by the availability of substitutes and the quantity produced while growers may plant alternative crops which are less susceptible to wildlife damage. In addition, the selection of discount rates is somewhat arbitrary since it is difficult to put a value on future returns and investment opportunities.

A third limitation concerns the speculative nature of many of the responses provided by apple growers. Growers usually had to approximate the level of wildlife damage their farm currently experiences. Their responses were very speculative when they were asked to predict the level of damage assuming that controls are removed for various lengths of time. Thus, caution must be exercised in interpreting the estimates of revenue losses. In general, estimates of costs can be expected to be much more accurate than estimates of revenue losses.

## RESULTS

Damage

Respondents estimated that voles annually kill 0.7 percent of the young trees and 0.5 percent of the older trees. They also estimated that voles damage 1.2 percent of young trees and 0.9 percent of older trees. These results are very similar to those estimated by Ferguson (1980), Brooks and Struger (1983), and Sullivan et al. (1980). Two-thirds of all the damage was attributed to meadow voles. Young damaged trees were estimated to lose 86 percent of their yield potential, very little of which could be recovered. Older damaged trees were estimated to lose nearly 50 percent of their yield potential over half of which could be recovered (Table 2).

The most widely used bait was zinc phosphide cracked corn ($Zn_3P_2$) which was used on over 85 percent of the apple acreage to prevent large buildups of meadow voles. Rozol , (chlorophacinone: .005 lbs. a.i./acre/application applied as a bait) which was used primarily to control pine voles, and ZPRB-AG (zinc phosphide rodent bait AG formulated by Bell Laboratories, Inc. as a 2% $Zn_3P_2$ active ingredient grain-based pellet) were applied to only 16 and 18 percent of the regional acreage, respectively. They were usually applied by hand to areas which have a serious vole problem. Part of the reason that little of these baits were applied is that they cost twice as much per pound as zinc phosphide cracked corn. Also, it is more difficult to apply them with a fertilizer spreader. Fifty percent of the orchards received additional herbicides while the entire apple acreage was mowed one additional time as a precaution against vole damage. Nearly three times as many machine and labor hours were used for mowing than for applying herbicides to control voles. In contrast to the two cultural practices discussed above, tree base clearing was done solely to prevent vole damage. Only 21 percent of the regional acreage was tree base cleared although the number of labor hours required was similar to that used for mowing (Table 3).

Respondents predicted that if controls were removed for one year 47 percent of the young trees would be killed and 50 percent would be damaged. Twenty-one percent of the older trees were predicted to be killed and 39 percent damaged. Thus, all of the young trees would be killed within three years and nearly 100 percent of the older trees would be killed within six years if controls were permanently removed (Table 2).

Respondents estimated that deer currently kill one percent of young trees and damage another three percent. Both of these figures are somewhat higher than those estimated for vole related damage. Young trees damaged by deer were estimated to lose 42 percent of their yield potential of which growers indicated they can regain 70 percent. In contrast, 8 percent of the older trees were estimated to be damaged by deer and to lose 18 percent of their yield potential of which 90 percent can be regained. Unlike older trees damaged by voles, no older trees are killed by deer (Table 2).

Small bars of toilet soap or mesh bags of hair are hung in trees as repellents. Thirteen percent of the regional acreage received soap while only 2 percent of the acreage received hair bags (Table 3). Far more acreage received soap than hair bags since deer have grown accustomed to the latter repellent. Over 83 percent of the trees one to three years of age received one or both of these repellents while wire mesh or electric fences have been constructed on only three percent of the regional apple acreage.

Respondents predicted that 17 percent of young trees would be killed and 36 percent damaged if deer controls (including hunting) were removed for one year. They also predicted that 9 percent of the older trees would be damaged although no older trees would be killed. It was predicted that 87 percent of the yield potential of young trees would be destroyed within three years and that 34 percent of the yield potential of older trees would be destroyed within five years if controls were permanently removed. These estimates indicate that vole damage to young trees in the short-run is much more severe than deer damage but that in the long-run the damage is similar. The potential of voles to damage older trees is much greater than the potential damage caused by deer over any length of time (Table 2).

Respondents estimated that birds affect the production of 38 percent of the young trees and 19 percent of the older trees. Birds damage more young trees mainly because most young trees are earlier coloring and more highly colored. Also, a higher percentage of these trees produce early red varieties. Only 2 percent of the production from the trees affected by birds is damaged of which 80 percent is thrown away while the rest is used for processing (Table 2).

Respondents estimated that woodchucks kill one-half of one percent of young trees and damage three percent. Two-tenths of one percent of older trees were estimated to be killed by woodchucks and one percent damaged. Bombs and phostoxin were applied to 43 and 16 percent of the regional acreage, respectively, to control woodchuck damage.

It was predicted that if woodchuck controls were removed for one year, 9 percent of the young trees would be killed and 11 percent damaged. One percent of the older trees were predicted to be killed and 3 percent damaged (Table 2). These results indicate that the threat posed by woodchucks to the physical well-being of trees is far less than that posed by voles and deer.

Current Costs and Revenue Losses

It was estimated, based on the results of our survey, that growers spent over $1.5 million, or $75 per acre to prevent wildlife from damaging Hudson Valley apple production (Table 4). Over 90 percent of the money was spent to prevent vole damage, 37 percent of which was spent on additional mowing, 22 percent on additional herbicides, 6 percent each on tree base clearing and tree guards, 18 percent on zinc phosphide cracked corn, and the remainder on Rozol and ZPRB-AG. Expenses on cultural practices represented two-thirds of the vole control costs of which machinery use represented 50 percent. In contrast, Pearson (1976) estimated that the average grower in the Hudson Valley annually spent only $6 per acre to control pine voles.

Only 5 percent, or $3.50 per acre, of the total control costs was spent to control deer damage, of which 80 percent was spent to apply soap, 8 percent was used to apply hair bags, while the remainder was used to build and maintain deer fences. Close to 80 percent of the costs were for labor while the rest was for materials. This compares favorably with the results of a study by Tatro (1986) who estimated that New York growers annually spent $3.70 per acre on deer control costs. Three percent of the total control costs were spent to contain woodchuck damage, 80 percent of which was used to apply bombs, 11 percent was used to apply phostoxin, and the remainder was spent on applying water and cyanide. Eighty-one percent of the money was spent on labor and the rest on materials (Table 4).

In addition to control costs, growers spent $250,000, or $12 per acre, to replace trees killed by wildlife. Over 40 percent of the expenditure was to replace trees killed by voles while the remainder was equally divided between replacing trees killed by deer and woodchucks (Tables 5 and 6).

Growers suffered revenue losses amounting to $1.15 million or $56 per acre in 1986 (Tables 5 and 6). Thirty-five percent of the revenue losses were caused by vole damage, 33 percent by birds, 23 percent by deer, and 9 percent by woodchucks. Only 20 percent of the revenue losses were associated with damage to young trees of which over 30 percent was associated with vole damage and 30 percent with deer damage.

Total revenue losses and control costs equaled $2.9 million or $143 per acre (Table 7). Since the average farm in the four county region had 88 acres of apples, the typical grower suffered combined revenue losses and control costs of $12,500 during the past year. Fifty-two percent of this amount was associated with wildlife controls, 40 percent with revenue losses, and the remainder with tree replacement expenses. Farm revenues would have increased between 5 and 8 percent if wildlife problems did not exist.

Revenue losses assuming that

controls were removed for various lengths of time were not computed for several reasons. First, although growers have a fairly good idea of the amount of damage they currently experience, their predictions concerning damage without controls were highly speculative. Second, the amount of damage predicted to occur without vole and deer controls would force virtually all of the growers out of business within several years. Third, the loss of revenues associated with bird damage would change very little since very few growers use bird controls.

In Table 2 it is interesting to note that growers estimate that birds do a modest amount of damage to the fruit in 38% of the young trees and 19% of the older trees. However, in both tree age categories, the yield is reduced only slightly (2%) and, in contrast with vole and deer damage, complete recovery from such damage is predicted. Although birds may damage only 2% of the apples on these trees, this is equivalent to losing the production from 72 acres or 0.3% of all the acreage in the four-county region. Because birds cause no damage to the trees thus negating tree replacements costs and, because their negative impact is subject to 100% recovery in the following year, growers appear to recognize but tolerate a rather substantial amount of fruit loss to birds. In fact, Tables 5 and 6 which extrapolate grower responses to the proportions of total annual revenue lost due to voles, deer, birds, and woodchucks, it is notable that the percentage share of the total revenue losses are 35%, 23%, 33%, and 9%, respectively. Thus growers are experiencing and accepting a degree of damage from uncontrolled bird populations that is nearly equal to that inflicted by voles which are subjected to control efforts. One should be mindful that grower estimates of damage are exactly that. Nevertheless, even a 50% reduction in the estimate for the percent of the crop damaged would still suggest a rather high and heretofore unreported annual revenue loss due to birds. The losses of fruit may be significantly reduced if bird controls were used, although the cost of such controls may far exceed the benefits derived.

Net Present Value Analysis

The total net present value of control costs and revenue losses was estimated to range between $53 million and $62 million for the 25-year period beginning in 1985 (Table 7). Nearly 60 percent of the NPV was associated with vole damage and controls of which 60 percent was contributed by control costs, 31 percent by revenue losses, and the rest by tree replacement (Table 5). The share of revenue losses was predicted to increase over time since more young semi-dwarf trees, which are prone to suffer greater damage than are large standard trees, will be planted. Fourteen percent of the NPV was associated with deer costs and revenue losses, of which 70 percent was associated with a loss of revenue which is a somewhat higher percentage than current revenue losses for the same reasons cited above. Twenty-one percent of the NPV was associated with revenue losses caused by bird damage which represents a much higher share of current losses since the proportion of early coloring and more highly colored varieties will increase considerably over time (New York Orchard and Vineyard Survey, 1980-1985). Six percent of the NPV was associated with woodchuck damage and controls of which 60 percent was contributed by revenue losses.

The annualized NPV, or annual equivalent cost flow, for all wildlife ranged between $3.8 million and $3.85 million or between $184 and $188 per acre. These figures are 23 percent higher than the current revenue losses and control costs which reflects the fact that greater damage is expected to occur in the future. The annualized net present value of revenue losses for older trees were generally twice that experienced during the past year while the losses for young trees remained about the same.

## CONCLUSIONS

The results of this study indicate that the typical grower suffered combined revenue losses and control costs of $12,500 during 1986. Fifty-two percent of this amount was associated with wildlife controls, 40 percent with revenue losses, and the remainder with tree replacement expenses. In interpreting these statistics, it should be remembered that estimates of control costs are reasonably accurate while estimates of revenue losses are somewhat speculative because the revenue loss computation depended more upon growers' perceptions about wildlife damage.

As the proportion of dwarf, semi-dwarf, and standard trees changes, and as the age profile of orchards changes, control costs and revenue losses will be different from those experienced during the past year. Over a 25-year period beginning in 1985, the NPV of control costs and revenue losses was projected to total between $53 million and $62 million, depending upon whether a 5.0 percent or a 3.5 percent discount rate was used. The average annual value of costs and revenue losses ranged between $3.8 and $3.85 million, or approximately $185 per acre.

The above figures indicate that wildlife have a very significant impact on the profitability of producing apples in the Hudson Valley. Research is needed to establish the functional relationship between production and wildlife damage, and to help select optimal control strategies. Despite these limitations, the results of the study provide important insights concerning growers' perceptions of the extent of damage and the costs of control measures and revenue losses. Moreover, these results lay the groundwork for future studies by pinpointing deficiencies in our current knowledge of wildlife damage. Research must focus on these areas to ensure that wildlife will be controlled in a cost-effective manner in future years.

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Table 1. Total apple farms, apple farm acreage, apple acreage, and the disposition of acreage on representative apple farms[1/].

| County | Total number of farms producing apples | Total acreage of farms producing apples | Total apple Acreage | Disposition of Acreage on Representative Apple Farms | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Apples | Other Fruit[2/] | Other Crops[3/] | Forest | Other Uses[4/] | All Uses |
| | | ----------------------- | acres | ----------------------- | | | | | |
| Ulster | 104 | 14,901 | 11,629 | 112 | 5 | 1 | 20 | 6 | 144 |
| Columbia | 74 | 17,904 | 5,117 | 69 | 25 | 4 | 92 | 52 | 242 |
| Dutchess | 28 | 5,521 | 2,090 | 75 | 2 | 42 | 14 | 65 | 197 |
| Orange | 28 | 3,553 | 1,720 | 61 | 10 | 7 | 20 | 28 | 127 |
| All Counties | 234 | 41,879 | 20,556 | 88 | 11 | 8 | 42 | 30 | 179 |

1/From New York Crop Reporting Service, 1983-85. New York Agricultural Statistics, Albany, New York; and from New York Crop Reporting Service, 1986. New York Orchard and Vineyard Survey, 1985, Albany, New York.

2/Including pears, peaches, and cherries.

3/Including corn, wheat, buckwheat, etc.

4/Including abandoned orchard, pasture, wetland, buildings, lots, etc.

Table 2. Percentages of Hudson Valley apple acreage damaged annually by wildlife with and without controls[1].

| Wildlife Type | With Controls | | | | No Controls One Year[4] | | Controls Permanently Removed | |
|---|---|---|---|---|---|---|---|---|
| | Trees Killed | Trees Damaged | Reduction of Yield Potential[2] | Yield Potential Recovery[3] | Trees Killed | Trees Damaged | Lost Yield Potential | Damage Time Period |
| | percent | | | | | | | years |
| Young Trees | | | | | | | | |
| Voles | 0.7 | 1.2 | 86.0 | 11.0 | 47.0 | 50.0 | 100.0 | 3 |
| Deer | 1.0 | 3.0 | 42.0 | 68.0 | 17.0 | 36.0 | 87.0 | 3 |
| Birds | 0 | 38.0 | 2.0 | 100.0 | 0 | 38.0 | 2.0 | NA |
| Woodchucks | 0.5 | 3.0 | NA | NA | 9.0 | 11.0 | NA | NA |
| Older Trees | | | | | | | | |
| Voles | 0.5 | 0.9 | 47.0 | 57.0 | 21.0 | 39.0 | 97.0 | 6 |
| Deer | 0 | 8.0 | 18.0 | 93.0 | 0 | 9.0 | 34.0 | 5 |
| Birds | 0 | 19.0 | 2.0 | 100.0 | 0 | 19.0 | 2.0 | NA |
| Woodchucks | 0.2 | 1.0 | NA | NA | 1.0 | 3.0 | NA | NA |

1/Information concerning wildlife damage was obtained from grower responses to the Hudson Valley Wildlife Damage Survey.
2/Yield potential refers to the ability of an apple tree to produce now and into the future.
3/Yield potential recovery refers to the ability of an apple tree to recover from damage over time. This assumes that the tree will not continue to be damaged in future years.
4/Includes any and all materials and or practices intended to act solely as control measures.

Table 3. Quantity and types of wildlife control measures, applications per season, acres receiving treatment, and labor and machine hours required to apply controls to prevent damage by voles, deer, and woodchucks[1/].

| | Control Use and Inputs | | | | |
|---|---|---|---|---|---|
| Control & Wildlife Type | Acres Receiving Treatment[2/] | Applications Per Season | Labor Hours | Machine Hours | Quantity (1,000 lbs.) |
| Voles | | | | | |
| Zinc Phosphide | 17,735 (86) | 1.5 | 5,091 | 3,695 | 289 |
| Rozol | 3,290 (16) | 1.3 | 3,637 | 1,201 | 26 |
| ZP Rodent Bait-AG | 3,762 (18) | 1.4 | 2,974 | 817 | 30 |
| Tree guards | 959 | 1.0 | 2,499 | 0 | 0 |
| Mowing | 20,556 | 1.1 | 16,936 | 16,936 | NA |
| Herbicide | 18,292 | 0.5 | 5,824 | 5,824 | NA |
| Tree base clear | 4,318 (21) | 1.0 | 16,170 | 0 | NA |
| Subtotal | NA | NA | 53,131 | 28,473 | NA |
| Deer | | | | | |
| Soap | 2,656 (13) | 1.1 | 8,553 | 0 | NA |
| Hair bags | 481 (2) | 1.2 | 1,155 | 0 | NA |
| Fence | 653 (3) | NA | 914 | 0 | NA |
| Subtotal | NA | NA | 10,622 | 0 | NA |
| Woodchucks | | | | | |
| Bombs | 8,873 (43) | NA | 5,339 | 0 | NA |
| Phostoxin | 3,368 (16) | NA | 512 | 0 | NA |
| Cyanide | 1,419 | NA | 75 | 0 | 0.04 |
| Water | 614 | NA | 270 | 0 | NA |
| Subtotal | NA | NA | 6,196 | 0 | NA |
| TOTAL | NA | NA | 69,949 | 28,473 | NA |

1/Data concerning the use of wildlife controls was obtained from the results of the Hudson Valley Wildlife Damage Survey.
2/Numbers in parentheses refer to percentages of the total apple acreage.

Table 4. Wildlife control costs expressed in terms of labor, machine, and material expenses required to prevent damage by voles, deer, and woodchucks[1].

| Control & Wildlife Type | Control Costs: Labor | Machine | Materials | Total[2] |
|---|---|---|---|---|
| | ----- | ----- $1,000 | ----- | ----- |
| **Voles** | | | | |
| Zinc phosphide | 31.4 | 105.0 | 121.5 | 257.9 (18) |
| Rozol | 20.7 | 34.1 | 23.4 | 78.3 |
| ZP Rodent Bait-AG | 16.8 | 23.3 | 29.3 | 69.4 |
| Tree guards | 13.7 | 0 | 70.2 | 83.9 (6) |
| Mowing | 110.0 | 413.4 | 0 | 523.4 (37) |
| Herbicide | 37.8 | 122.7 | 150.9 | 311.4 (22) |
| Tree base clear | 88.9 | 0 | 0 | 88.9 (6) |
| Subtotal | 319.5 | 698.4 | 395.3 | 1,413.2 (92)[3] |
| **Deer** | | | | |
| Soap | 47.1 | 0 | 14.3 | 61.4 (80) |
| Hair bags | 6.4 | 0 | 0 | 6.4 (8) |
| Fence | 4.9 | 0 | 3.5 | 8.4 |
| Subtotal | 58.4 (77)[4] | 0 | 17.8 | 76.2 (5)[3] |
| **Woodchucks** | | | | |
| Bombs | 29.4 | 0 | 6.3 | 35.70 (80) |
| Phostoxin | 3.1 | 0 | 2.0 | 5.1 (11) |
| Cyanide | 0.4 | 0 | 0.3 | 0.7 |
| Water | 3.4 | 0 | 0 | 3.4 |
| Subtotal | 36.3 (81)[4] | 0 | 8.6 | 44.9 (3)[3] |
| TOTAL | 414.2 | 698.4 | 421.7 | 1,534.3 |

[1] Price information from M. Castaldi 1987 and this survey.
[2] Numbers in parentheses in the total column above the subtotals represent the percentage share of the subtotal control costs contributed by each control measure for each wildlife species.
[3] Numbers in parentheses in the total column below the subtotals refer to the percentage share each subtotal contributes to the total costs.
[4] Numbers in parentheses under the labor column refer to the percent of total deer or woodchuck control costs contributed by labor expenses.

Table 5. Vole and deer control costs, tree replacement costs and the associated revenue losses projected over a 25-year period.[1/]

| Components | Current Year | Net Present Value 3.5% Discount | Annualized Net Present Value Assuming a Discount of 3.5% Total | Annualized Net Present Value Assuming a Discount of 3.5% Per Acre | Net Present Value 5% Discount | Annualized Net Present Value Assuming a Discount of 5% Total | Annualized Net Present Value Assuming a Discount of 5% Per Acre |
|---|---|---|---|---|---|---|---|
| | ----million dollars----- | | | $ | -million dollars- | | $ |
| Voles | | | | | | | |
| Control costs | 1.41 | 22.07 | 1.34 | 65 | 19.15 | 1.36 | 68 |
| Tree replacement | 0.11 (44)[3/] | 3.09 | 0.19 | 9 | 2.68 | 0.19 | 10 |
| Revenue losses[2/] (young trees) | 0.08 (35)[4/] | 1.25 | 0.08 | 4 | 1.13 | 0.08 | 4 |
| Revenue losses (old trees) | 0.32 | 10.07 | 0.61 | 30 | 8.26 | 0.58 | 29 |
| Subtotal | 1.92 | 36.48 (58)[5/] | 2.22 | 108 | 31.20 | 2.21 | 111 |
| Deer | | | | | | | |
| Control costs | 0.07 | 0.94 | 0.06 | 3 | 1.08 | 0.07 | 3 |
| Tree replacement | 0.07 | 1.25 | 0.08 | 4 | 1.11 | 0.09 | 4 |
| Revenue losses (young trees) | 0.07 (23)[4/] | 1.16 (70)[6/] | 0.07 | 3 | 1.02 | 0.08 | 4 |
| Revenue losses (old trees) | 0.19 | 5.31 | 0.32 | 16 | 4.45 | 0.38 | 18 |
| Subtotal | 0.40 | 8.94 (14)[5/] | 0.53 | 26 | 7.66 | 0.62 | 29 |
| TOTAL | 2.32 | 45.42 | 2.75 | 134 | 38.86 | 2.83 | 140 |

1/ Based upon data obtained from the Hudson Valley Wildlife Damage Survey, supply companies, and budgets prepared by Castaldi (1987).

2/ Revenue losses for young trees damaged by voles includes trees 6 years and younger. Revenue losses for young trees damaged by deer includes trees 5 years and younger.

3/ Number in parentheses below current year column beside tree replacement refers to the percentage of total tree replacement costs associated with wildlife which is contributed by vole damage.

4/ Number in parentheses beside revenue loss figures in column one refers to the percentage shares of the total revenue losses associated with each wildlife type.

5/ Percentage of total NPV control costs and revenue losses associated with each type of wildlife.

6/ Percentage of share of total NPV for each wildlife type which is contributed by revenue losses.

Table 6. Bird and woodchuck control costs, tree replacement costs and the associated revenue losses projected over a 25-year period.[1]

| Components | Current Year | Net Present Value 3.5% Discount | Annualized Net Present Value Assuming a Discount of 3.5%: Total | Annualized Net Present Value Assuming a Discount of 3.5%: Per Acre | Net Present Value 5% Discount | Annualized Net Present Value Assuming a Discount of 5%: Total | Annualized Net Present Value Assuming a Discount of 5%: Per Acre |
|---|---|---|---|---|---|---|---|
| | ----million dollars----- | | | $ | -million dollars- | | $ |
| Birds | | | | | | | |
| Revenue losses[2] (young trees) | 0.05 | 0.95 | 0.06 | 3 | 0.84 | 0.06 | 3 |
| Revenue losses (old trees) | (33)[4] 0.33 | 12.31 | 0.75 | 37 | 10.21 | 0.72 | 35 |
| Subtotal | 0.38 | 13.26 (21)[5] | 0.81 | 40 | 11.05 | 0.78 | 38 |
| Woodchucks | | | | | | | |
| Control costs[3] | 0.05 | 0.76 | 0.05 | 2 | 0.66 | 0.05 | 2 |
| Tree replacement | 0.07 | 0.88 | 0.05 | 2 | 0.76 | 0.05 | 2 |
| Revenue losses (young trees) | 0.03 | 0.48 | 0.03 | 1 | 0.43 | 0.03 | 1 |
| Revenue losses (old trees) | (9)[4] 0.08 | (60)[6] 1.79 | 0.11 | 5 | 1.49 | 0.11 | 5 |
| Subtotal | 0.23 | 3.91 (6) | 0.24 | 10 | 3.34 | 0.24 | 10 |
| TOTAL | 0.61 | 17.17 | 1.05 | 50 | 14.39 | 1.02 | 48 |

[1] Based upon data obtained from the Hudson Valley Wildlife Damage Survey, supply companies, and budgets prepared by Castaldi (1987).

[2] No bird control costs were reported by respondents included in the Wildlife Damage Survey. In reality some growers do spend money to protect their orchards against bird damage.

[3] Revenue losses for young trees damaged by woodchucks and birds included trees 6 years and younger.

[4] Number in parentheses beside revenue loss figures in column one refers to the percentage shares of the total revenue losses associated with each wildlife type.

[5] Percentage of total NPV control costs and revenue losses associated with each type of wildlife.

[6] Percentage share of total NPV for each wildlife type which is contributed by revenue losses.

Table 7. Aggregated wildlife control costs and tree replacement costs and the associated revenue losses projected over a 25-year period.[1/]

| Wildlife | Current Year | NPV 3.5% Discount | Annualized NPV Assuming a Discount of 3.5%: Total | Annualized NPV Assuming a Discount of 3.5%: Per Acre | NPV 5% Discount | Annualized NPV Assuming a Discount of 5%: Total | Annualized NPV Assuming a Discount of 5%: Per Acre |
|---|---|---|---|---|---|---|---|
| | ----million dollars----- | | | $ | -million dollars- | | $ |
| Voles | 1.92 | 36.48 | 2.22 | 108 | 31.20 | 2.21 | 111 |
| Deer | 0.40 | 8.94 | 0.53 | 26 | 7.66 | 0.62 | 29 |
| Birds | 0.38 | 13.26 | 0.81 | 40 | 11.05 | 0.78 | 38 |
| Woodchucks | 0.23 | 3.91 | 0.24 | 10 | 3.34 | 0.24 | 10 |
| All Wildlife | 2.93 | 62.59 | 3.80 | 184 | 53.25 | 3.85 | 188 |

[1/]Based upon data obtained from the Hudson Valley Wildlife Damage Survey, supply companies, and budgets prepared by Castaldi (1987).