

Selecting Target Populations for ROPS Retrofit Programs in Pennsylvania and Vermont

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ABSTRACT. *Agriculture has the highest injury and fatality rates when compared with other U.S. industries, and tractor overturns remain the leading cause of agricultural fatalities. Rollover protection structures (ROPS) are the only proven devices to protect a tractor operator in the event of an overturn. These devices are 99% effective when used with a seatbelt. Nearly 49% of tractors in the U.S. are not equipped with a ROPS. Interventions such as social marketing, community awareness campaigns, and financial incentives have been directed at encouraging farmers to install ROPS on their unprotected tractors. The purpose of this study was to conduct similar comparisons of ROPS protection and readiness to retrofit in different segments of the Vermont and Pennsylvania farm communities. A telephone survey was used to collect data on ROPS prevalence, farm demographic characteristics, and farmer's stage of change relative to installing ROPS on farm tractors. Our data provide new and unique information on the prevalence of ROPS-equipped tractors relative to commodity, farm size, and a variety of other demographic variables. Extrapolating from these data, the commodities studied account for roughly 162,072 tractors across the two states. Of these, 85,927 (53%) do not have ROPS. Of these unprotected tractors, 77,203 are in Pennsylvania and 8,724 are in Vermont. Our other two research questions dealt with the farmer's stage of change and possible ways to segment this population. The stage of change portion of our work demonstrates that most Pennsylvania and Vermont farmers are not contemplating ROPS retrofitting in the near future. Since no major differences were found in the stage of change, the number of unprotected tractors was examined for each of the commodity groups. In Pennsylvania, 29% of all unprotected tractors were found on cash crop farms. This trend was even more apparent on smaller farms than large farms. This led to the selection of smaller cash crop farms as the target audience for social marketing messages. In contrast, researchers in Vermont found a bimodal distribution of unprotected tractors. Of all the commodity groups surveyed in Vermont, vegetable and cash crop farmers were least likely to have even one protected tractor to use on the farm. Probably the most encouraging finding from this study is that over 85% of Pennsylvania farms and over 87% of Vermont farms surveyed had at least one tractor available that had ROPS protection. Of those farms, 25.5% of the Pennsylvania farms and 46% of the Vermont farms have ROPS on all of*

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their tractors. Both of these findings were greater than the findings from a 2006 survey of New York State farms, which found that 75% of surveyed New York farms have ROPS on at least one tractor, and 18% have ROPS on all tractors. Even with these encouraging data, the goal of 100% of tractors with ROPS is far from being met. There are still an estimated 90,000 unprotected tractors on Pennsylvania and Vermont farms, and these farm owners are currently unmotivated to install ROPS. However, as demonstrated in New York State, it may be possible to use social marketing that combines persuasive messages and cost-sharing to persuade these farmers that ROPS are indeed important and accessible.

Keywords. *Retrofit, Rollover, ROPS, Safety, Social marketing, Stages of change, Target population, Tractor overturn.*

Agriculture has the highest injury and fatality rates when compared with other U.S. industries. Recent numbers from the Bureau of Labor Statistics indicate the rate of fatal agricultural injuries is 26.8 per 100,000 full-time workers. This work death rate is seven times the all-industry work death rate of 3.5 (BLS, 2011). Although tractor overturns remain the leading cause of agricultural fatalities (Myers and Hendricks, 2010), these events have decreased 28.5% from 1992 to 2007 (Myers, 2010).

Rollover protection structures (ROPS) are the only proven devices to protect a tractor operator in the event of an overturn. These devices are 99% effective when used with a seatbelt (NIOSH, 2004). Fortunately, since 1985, the industry has required that ROPS be provided as standard equipment on all new tractors (*ASABE Standards*, 2009). Even with the advent of this ROPS standard, according to data from the NIOSH Occupational Injury Surveillance of Production Agriculture, about 49% of tractors in the U.S. are not equipped with ROPS (Myers, 2010). Most of these unprotected tractors were manufactured prior to the advent of the 1985 industry decision to make ROPS standard equipment on tractors.

Interventions such as social marketing (Sorensen et al., 2008), community awareness campaigns (Cole et al., 2000), and financial incentives (Hallman, 2005) have been directed at encouraging farmers to install ROPS on their unprotected tractors. Sorensen et al. (2008) defines social marketing as an intervention development framework that is based on the concept of exchange. This framework demands that researchers work to increase the benefits of healthy behaviors and decrease the costs so that healthy behaviors are a more appealing option. In New York State, the New York Center for Agricultural Medicine and Health launched a successful social marketing campaign aimed at increasing the number of ROPS-protected tractors in November 2006. Since the launch of this program, there has been a significant increase in ROPS sales (Sorensen et al., 2008). Research shows that there has also been a shift in farmers' readiness to change subsequent to the intervention (Jenkins et al., 2012). The farmers' readiness to change is measured by standard behavior change models, described below.

Prior to the advent of the New York State program, New York State farm populations were segmented, also known as categorized, to compare differences in risk exposures, readiness to install ROPS, and barriers and motivators to retrofitting (May et al., 2006). Data from this study identified small crop and livestock farms as having the lowest proportion of ROPS-protected tractors. Readiness to install ROPS was based on the "stages of change" model described below and was fairly consistent in the different New York

State farm segments. The transtheoretical model (TTM) of health behavior change is one of several behavior change theories that carefully consider the combination of barriers and motivators to effect behavioral change (Yoder and Murphy, 2012). The TTM assesses an individual's readiness to engage in healthier behaviors and provides strategies, or processes of change, to move the individual through the stages of change to action and maintenance. It is often referred to as the "stages of change" model. Although this information has been helpful for identifying a target segment for the New York State ROPS intervention, little has been published on comparisons of risk exposures and readiness to install ROPS among farming segments in other states.

The purpose of this study was to conduct similar comparisons of ROPS protection and readiness to retrofit in different segments of the Vermont and Pennsylvania farm communities. The data were then used to compare risk exposures and readiness to change variables between all three states, as well as between different demographic groups. The results of this study are reported here.

Methods

Telephone Survey

To collect the data, researchers for Pennsylvania and Vermont adapted the survey that had been used to compare and select a target segment in the New York State study (May et al., 2006). The entire questionnaire was administered in an approximately five-minute telephone call by the New York National Agricultural Statistics Service (NY-NASS). The survey instrument was pilot-tested in the New York State ROPS Retrofit Program (May et al., 2006) and further revised. This survey permitted the collection of data on ROPS prevalence, farm demographic characteristics, and on a farmer's stage of change relative to installing ROPS on farm tractors.

Previous surveys of the northeast farm community have divided it by major commodity groups: dairy, livestock, fruit, vegetable, and cash crop (May et al., 2006). Similar commodity groups were used for this study. Early in the course of the study, it became apparent that maple farms were likely to represent a distinct segment within the Vermont farm community. These farms were then included in the Vermont surveys. Samples were randomly drawn from each commodity group for Pennsylvania and Vermont farms by NY-NASS. Once randomized, farms were contacted in sequential fashion until 100 or more farms were obtained for each of the commodities. Information was collected on the number of acres worked by cash crop, fruit, vegetable, and maple (Vermont only) farmers and the total number of animals for livestock and dairy farms in order to segment each commodity into large and small strata during the analysis phase. Respondents were farm owners and, when these were not available, the person answering the call was asked whether they were familiar enough with farm operations to answer survey questions. If so, they were asked to identify their affiliation with the farm (e.g., farm wife, farm supervisor, etc.). The Mary Imogene Bassett Hospital Institutional Review Board approved the human subjects aspects of this study.

Inclusion Criteria

Any agricultural operation having membership in one of the statewide commodity groups of interest or listed with the USDA-NASS was included in the study population. Farms found to be no longer in active production (annual sales of more than \$1,000) were excluded from data collection. If a farm had ROPS on all tractors by virtue of purchase

(i.e., the farmer had never retrofitted a tractor with ROPS), we gathered data on the farm. However, since the focus of desired behavior change in the study is retrofitting tractors currently lacking ROPS, these farms did not qualify for the stage of change portion of the analysis. In these situations, we continued recruiting farms until we reached the target numbers described above for each commodity.

Stages of Change

The questionnaire responses allowed the investigators to place a subject in one of seven potential stages of change described in table 1. Figure 1 shows the basic structure of the questionnaire and the logic used in assigning each farmer to a specific stage of change. This strategy reflects modifications of the traditional stages of change that we believe are more suitable for the situation of ROPS retrofitting. Several of the stages have been subdivided to better describe the potential social marketing audiences in the Vermont and Pennsylvania farm communities. The usual “maintenance” stage of change has limited significance for ROPS retrofit social marketing and has been dropped.

Data Management and Analysis

Telephone responses were entered onto hard copy and subsequently reviewed by both the telephone interviewer and the project coordinator. Data forms were double-entered into SAS (SAS Institute, Inc., Cary, N.C.) and corrected after comparisons. For analysis of size, farms were aggregated based on being either below or above the median size of

Table 1. Description of stage of change categories.

Stage of Change	Description
Pre-contemplation knowledge	Not thinking about retrofitting, unaware of necessity of ROPS
Pre-contemplation motivation	Not thinking about retrofitting, aware of necessity of ROPS
Early contemplation	Have thought about retrofitting but haven't talked to a dealer
Late contemplation	Have thought about retrofitting and have talked to a dealer
Decision / Determination	Have set an appointment to retrofit
Action I	Have retrofitted at least one tractor but not all tractors have ROPS
Action II	Have retrofitted at least one tractor and all other tractors have ROPS

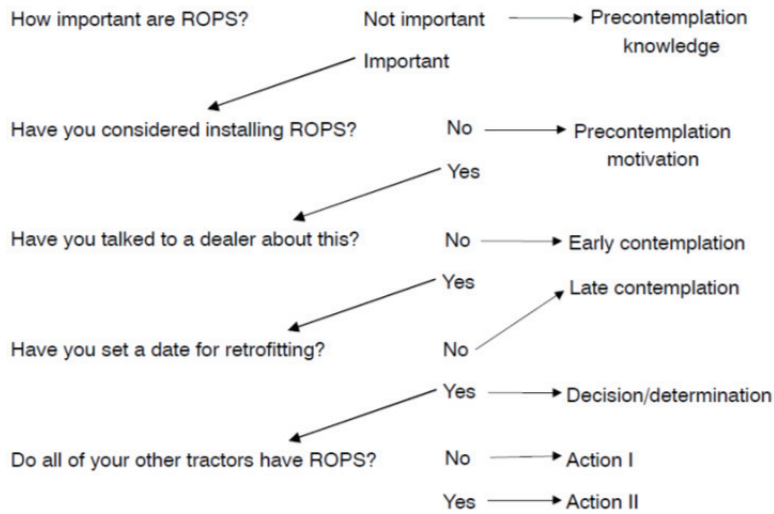


Figure 1. Stage of change assessment.

the farms being sampled for a given commodity. Similarly, farmers were aggregated by age based on the median reported age.

Differences between continuous or interval-scale measures with respect to two classification levels, for example, mean age of farm owner with respect to size of respective farm (large or small), were analyzed using Student's t-test. Differences among continuous measures with respect to three or more classification levels, for example, mean annual hours of tractor usage with respect to no ROPS, some ROPS, or all ROPS on farm tractors, were determined using Student's t-test.

Relationships between pairs of continuous or interval-scale measures, for example, age of farm owner and respective percentage of farm tractors with ROPS, were explored with Pearson's correlation (r) and, when warranted, further developed using linear least squares regression analysis.

Differences in proportion with respect to nominal categorical measures, for example, proportion of tractors with or without ROPS with respect to farm commodity, were analyzed using the χ^2 test. Two-way contingency tables employing at least one ordinal categorical measure, for example, minors operating tractors (yes or no), and stage of change (1, 2, 3, 4, 5, 6, and 7), were analyzed using the Cochran-Mantel-Haenszel χ^2 test.

When deemed appropriate, continuous measures were recast as categorical measures per their median or quartile cutoff points and then subjected to analytic methods as described above. Such an approach was used, for example, to determine large or small farm size from median acreage or number of livestock, or to determine a four-level classification from the quartile ages of farm owners. In addition, the stage of change scale was sometimes used as either a categorical or an interval-scale measure, such that results garnered in one analytic venue were corroborated with results from another. For example, when comparing scales of readiness to change between large and small farms, the Cochran-Mantel-Haenszel χ^2 test was used while treating stage of change as a categorical measure, and Student's t-test was used while treating stage of change as an interval-scale measure. Continuous and categorical analyses, as previously described, were typically carried out within each distinct farm commodity group: dairy, livestock, cash crops, vegetables, fruit, and maple (Vermont only).

Estimation of Tractors in Pennsylvania and Vermont without ROPS

To improve efficiency and still ensure adequate numbers for analysis of each commodity, this survey did not sample commodities in proportion to their actual distribution within Pennsylvania and Vermont agriculture. Therefore, to estimate the actual numbers of tractors (with and without ROPS) in each state, the most current data on the number of tractors in each state were obtained from the USDA-NASS. To estimate the number of tractors with and without ROPS, the number of tractors in each state was multiplied by the percentage of tractors without ROPS identified in the sample populations by the telephone surveys in each state.

Pennsylvania Results

A total of 1620 randomly selected Pennsylvania farmers were contacted by telephone. Of these, 537 farmers agreed to participate. However, of the 537 who participated, 90 did not provide complete information (some values were missing) or did not have a primary farming commodity that fell within the five groups that were eligible for the study. As a result, only 447 surveys (27.6%) were suitable for data analysis. The characteristics of the

Table 2. Characteristics of the Pennsylvania tractor cohort.

Commodity (No. of Farms)	Farmer Age ^[a] (years)	Farm Size ^[a] (acres)	No. of Live- stock ^[a]	Tractor Hours ^[a]	Percent with Minors Operating Tractors	Tractors			
						Total	Non- ROPS Total	No. per Farm ^[a]	Non- ROPS per Farm ^[a]
All (447)	54.66 ±0.66	93.52 ±10.97	1473.75 ±730.63	723.96 ±71.58	24.66	1716	901	3.83 ±0.15	2.02 ±0.11
Dairy (109)	49.1 ±1.22	-	1065.51 ±934.29	1428.72 ±215.78	44.95	514	202	4.71 ±0.24	1.85 ±0.17
Livestock (112)	53.94 ±1.2	-	1885.83 ±1128.31	528.89 ±69.98	16.96	350	185	3.12 ±0.24	1.65 ±0.17
Cash crop (100)	58.36 ±1.42	127.57 ±19.22	-	512.61 ±92.7	15.15	414	262	4.14 ±0.38	2.62 ±0.29
Fruit (69)	56.32 ±1.71	73.56 ±19.73	-	704.39 ±249.26	18.84	254	126	3.68 ±0.42	1.83 ±0.3
Vegetable (57)	58.26 ±1.14	56.93 ±10.53	-	535.77 ±79.9	24.56	184	126	3.23 ±0.18	2.21 ±0.15

^[a] Mean ± standard error of the mean.

Table 3. Distribution of ROPS in Pennsylvania.

ROPS Use	Farms		ROPS Use	Tractors	
	Number	Percent		Number	Percent
No ROPS	217	48.55	No ROPS	901	52.51
Some ROPS	117	26.17	ROPS	815	47.49
All ROPS	113	25.28	Total	1716	100
Total	447	100			

respondents are listed in table 2. For dairy and livestock farmers, farm size was determined by the number of animals, not the number of acres, which seemed the most appropriate method of classifying farm size for these commodities.

Percentage of Tractors with ROPS

Participating farms had a total of 1716 tractors. A suitable cab or ROPS structure (as indicated by an engraved ASAE designation) was present on 815 (47.49%) of these tractors. The majority of the study farms (51.45%) had some, if not all, tractors equipped with ROPS (table 3). Comparisons between large and small farms in regard to percentage of ROPS-protected tractors revealed significant differences ($p < 0.0001$), with large farms having higher percentages of ROPS protection (56%) than small farms (39%).

Estimated Number of Tractors without ROPS

The most recent number of tractors reported by the USDA-NASS was 147,025 (USDA, 2007). The percentage of tractors found in this study was 52.51%. Multiplying these two numbers gives an estimate of 77,203 tractors without ROPS in Pennsylvania.

Farmer Age Comparison

Large farms: No significant differences in mean age were seen between farms with no ROPS (53.8), some ROPS (55.6), and all ROPS (53.8).

Small farms: No significant differences in mean age were seen between farms with no ROPS (55.9), some ROPS (52.9), and all ROPS (52.5).

Minors Operating Tractors

Large farms: No significant differences were seen in the percentage of farms with mi-

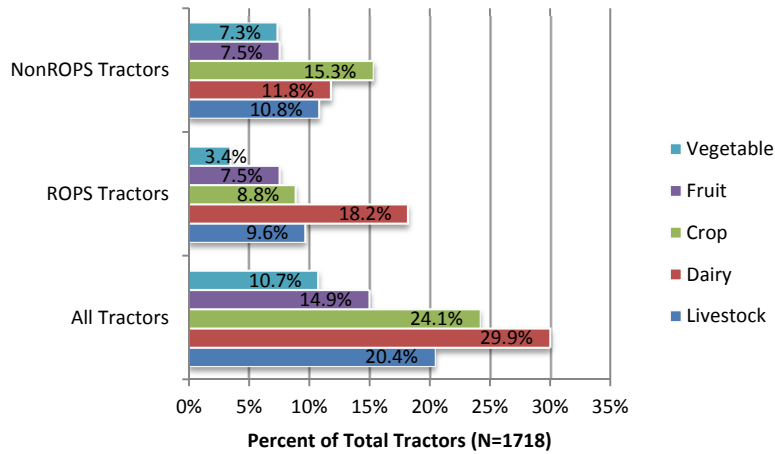


Figure 2. Prevalence of ROPS relative to commodity in Pennsylvania.

nors operating tractors between the no ROPS, some ROPS, and all ROPS groups. However, there were higher percentages of minors operating tractors on farms with all ROPS (24.6%) and some ROPS (30.5%) versus those with no ROPS (19.4%).

Small farms: Significant differences ($p = 0.019$) were seen in the percentage of farms with minors operating tractors between the no ROPS, some ROPS, and all ROPS groups. This was primarily due to the much higher percentage of farms with minors operating tractors in the some ROPS group (33.8%) than either all ROPS (15.2%) or no ROPS (16.7%).

ROPS Use Relative to Commodity

Because there was no farm size by commodity interaction in this ANOVA model, the commodity results were pooled across both large and small farms. Figure 2 shows the distribution of non-ROPS, ROPS, and total tractors by commodity. The test of the difference in the percentage of ROPS-protected tractors between commodity groups was significant ($p = 0.016$). Post-hoc comparisons showed that the only significant pairwise difference was between crops (39% with ROPS) and dairy (57% with ROPS).

ROPS Use Relative to Farm Size

Large farms: Figure 3 shows the distribution of large farms with some, all, or no ROPS present on their tractors. Although a majority of the farms had at least some ROPS (58.5%). There were still 14.9% of the farms that had no ROPS. Although there were no significant differences between commodity groups in the percentage of farms with no ROPS, there were some differences in these percentages that were deemed noteworthy. For example, only 7.7% of dairy farms were observed to have no ROPS versus 23.8% of farms in the livestock commodity group.

Small farms: Figure 4 shows the distribution of small farms with some, all, or no ROPS present on their tractors. The percentage of small farms with no ROPS (40.7%) is much greater than that of large farms (14.9%). For small farms, highly significant differences were seen between commodity groups in the percentage with no ROPS. The most striking difference was the low percentage of dairy farms with no ROPS (11.9%) versus the much higher levels seen for livestock (51.2%), crops (50.0%), and vegetables (55.6%).

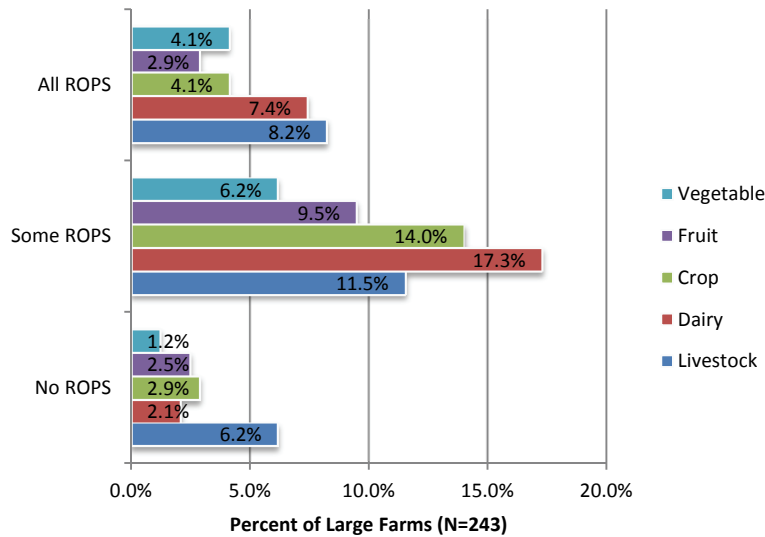


Figure 3. Distribution of ROPS by commodity on large farms in Pennsylvania.

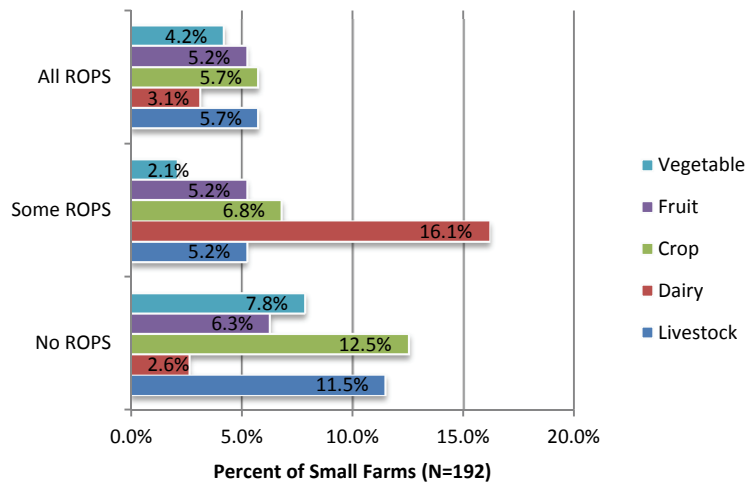


Figure 4. Distribution of ROPS by commodity on small farms in Pennsylvania.

Stage of Change Relative to Commodity

Figure 5 shows that a majority of the farmers in every commodity group were in the pre-contemplation stage of change (as described in table 1). There was no significant interaction between farm size and commodity in the ANOVA model for stage of change. The test of the difference between large and small farms had no significant difference in this outcome when compared across commodity groups.

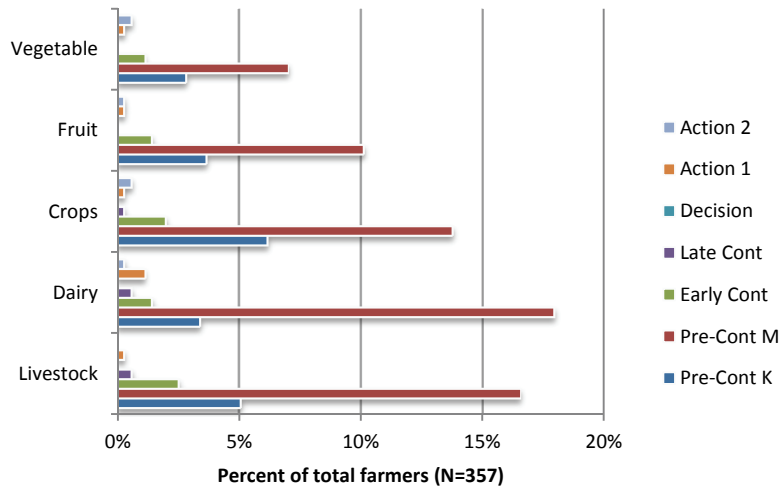


Figure 5. Distribution of Pennsylvania farmers by stage of change.

Vermont Results

A total of 1741 randomly selected Vermont farmers were contacted by telephone. Of these, 669 (38.4%) agreed to participate in the study by answering the questionnaire. However, of the 669 who participated, 128 did not provide complete information (some values were missing) or did not have a primary farming commodity that fell within the five group that were eligible for the study. As a result, only 541 (31.1%) surveys were suitable for data analysis. The characteristics of the respondents are listed in table 4. For dairy and livestock farmers, farm size was determined by the number of animals, not the number of acres, which seemed the most appropriate method of classifying farm size for these commodities.

Percentage of Tractors with ROPS

Participating farms had a total of 1504 tractors. A suitable cab or ROPS structure (as indicated by an engraved ASAE designation) was present on 632 (42.02%) of these tractors. The majority of the study farms (82.07%) had some, if not all, tractors equipped with ROPS (table 5). Comparisons between large and small farms in regard to percentage of ROPS-protected tractors revealed no significant differences, with large farms having ROPS protection on 64% of tractors and small farms having ROPS protection on 63%.

Estimated Number of Tractors without ROPS

The most recent number of tractors reported by the USDA-NASS was 15,047 (USDA, 2007). The percentage of tractors found in this study was 57.98%. Multiplying these two numbers gives an estimate of 8,724 tractors without ROPS in Vermont.

Farmer Age Comparison

Large farms: There was a significant ($p = 0.06$) effect for ROPS protection as related to age. This was primarily driven by the mean age of farmers with all ROPS (54.8) being

Table 4. Characteristics of the Vermont tractor cohort.

Commodity (No. of Farms)	Farmer Age ^[a] (years)	Farm Size ^[a] (acres)	No. of Live- stock ^[a]	Tractor Hours ^[a]	Percentage with Minors Operating Tractors	Tractors			
						Total	Non- ROPS Total	No. per Farm ^[a]	Non- ROPS per Farm ^[a]
All (541)	57.19 ±0.56	93.52 ±10.97	85.09 ±7.21	611 ±67.38	8.96	1504	632	2.8 ±0.1	1.17 ±0.07
Dairy (112)	55.88 ±1.19	-	124.05 ±7.43	1021.49 ±209.54	16.96	477	185	4.26 ±0.2	1.65 ±0.18
Livestock (129)	57.62 ±1.14	-	50.77 ±11.03	459.26 ±79.91	4.72	303	144	2.35 ±0.18	1.12 ±0.15
Cash crop (64)	59.57 ±1.55	165.41 ±22.2	-	723.71 ±310.06	9.38	183	81	2.86 ±0.22	1.27 ±0.18
Fruit (83)	58.52 ±1.37	49.78 ±8.22	-	391.86 ±87.83	6.02	198	84	2.39 ±0.31	1.01 ±0.18
Vegetable (56)	53.11 ±1.71	48.69 ±11.53	-	555.21 ±148.48	5.45	161	75	2.88 ±0.31	1.34 ±0.22
Maple (97)	57.68 ±1.39	165.95 ±19.73	-	479.92 ±75.82	9.47	182	63	1.88 ±0.16	0.65 ±0.14

^[a] Mean ± standard error of the mean

Table 5. Distribution of ROPS in Vermont.

ROPS Use	Farms		ROPS Use	Tractors	
	Number	Percent		Number	Percent
No ROPS	97	17.93	No ROPS	872	57.98
Some ROPS	195	36.04	ROPS	632	42.02
All ROPS	249	46.03	Total	1504	100
Total	541	100			

approximately five years less than the mean age of farmers with no ROPS (59.9). The mean age of farmers with some ROPS (57.9) fell in between these two values.

Small farms: No significant differences in mean age were seen between farms with no ROPS, some ROPS, and all ROPS

Minors Operating Tractors

Large farms: Significant differences ($p = 0.085$) in the percentage of farms with minors operating tractors between the no ROPS, some ROPS, and all ROPS groups were seen. The highest percentage of minors operating tractors was on the farms with some ROPS (15.5%). The no ROPS group had the lowest percentage of minors operating tractors (2.9%). The all ROPS group (9.6%) fell in between these two values.

Small farms: No significant differences were seen in the percentage of farms with minors operating tractors in the no ROPS (6.9%), some ROPS (7.4%), and all ROPS (6.1%) groups.

ROPS Use Relative to Commodity

Because there was no farm size by commodity interaction in this ANOVA model, the commodity results were pooled across both large and small farms. Figure 6 shows the distribution of non-ROPS, ROPS, and total tractors by commodity. The test of the difference in the percentage of ROPS-protected tractors between commodity groups was significant ($p = 0.027$). Despite this significant overall test, there were no significant post-hoc pairwise comparisons.

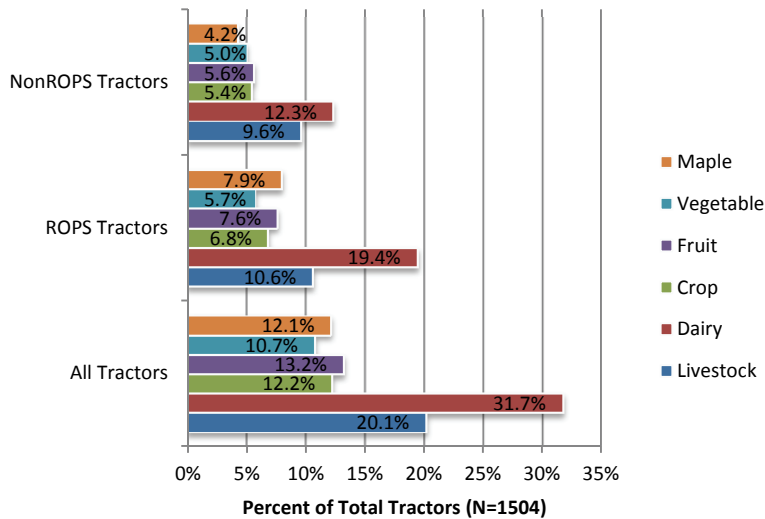


Figure 6. Prevalence of ROPS relative to commodity in Vermont.

ROPS Use Relative to Farm Size

Large farms: Figure 7 shows the distribution of large farms with some ROPS, all ROPS, or no ROPS present on their tractors. Although a majority of the farms had some ROPS (45.2%) or all ROPS (41.9%), there were still 12.9% of the farms that had no ROPS. Highly significant differences ($p < 0.0001$) were found between commodity groups in percentage of farms with no ROPS, some ROPS, and all ROPS. Among the commodities with a low percentage of farms with no ROPS were dairy (0) and maple (4.3). At the higher end were vegetable (24.1) and crops (22.6).

Small farms: Figure 8 shows the distribution of small farms with some ROPS, all ROPS, or no ROPS present on their tractors. The percentage of small farms with no ROPS (23%) is much greater than for large farms (12.8%). No significant differences were found between commodity groups in the percentage of farms with no ROPS, some ROPS, and all ROPS. However, a higher percentage of farms with no ROPS were reported for fruit (30%) and vegetable (29%) farms versus dairy (18.2%) and crops (18.8%).

Stage of Change Relative to Commodity

Figure 9 shows that a majority of the farmers in every commodity group were in the pre-contemplation stage of change (as described in table 3). There were no significant main or interaction effects in this ANOVA model.

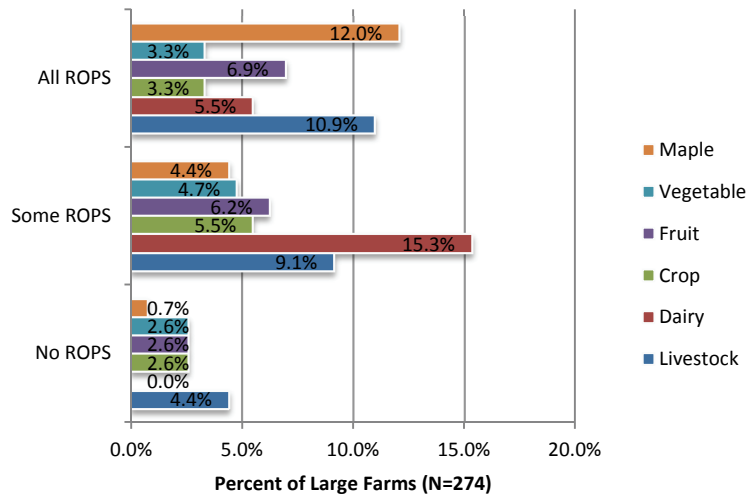


Figure 7. Distribution of ROPS farms by commodity on large farms in Vermont.

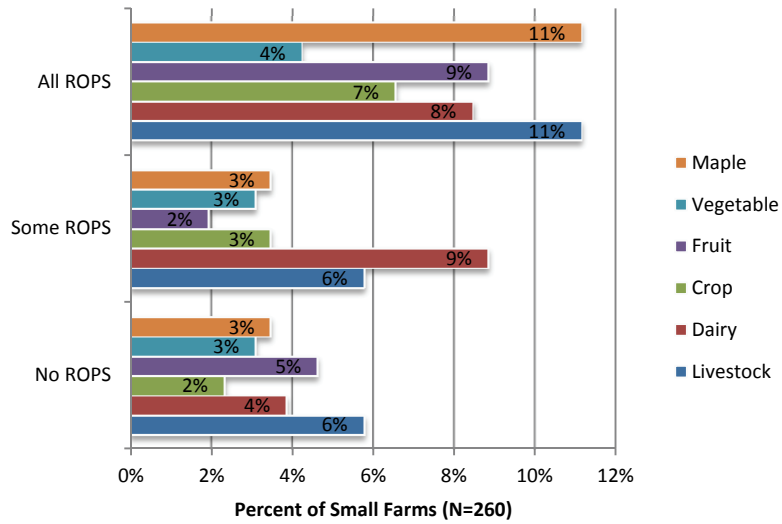


Figure 8. Distribution of ROPS farms by commodity on small farms in Vermont.

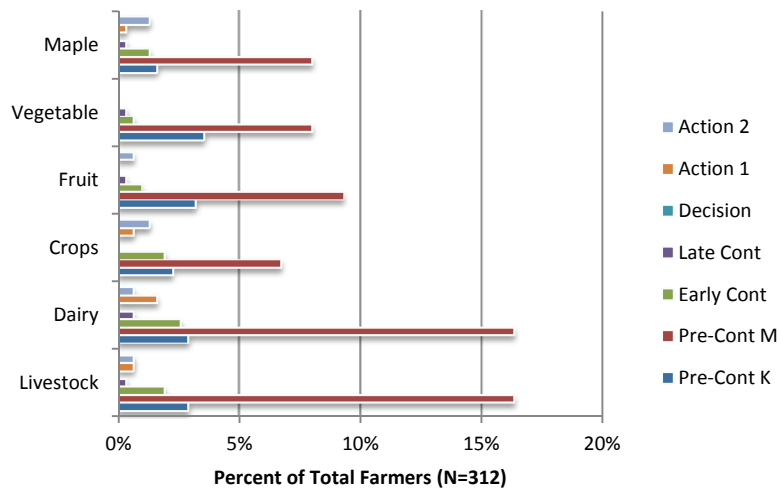


Figure 9. Distribution of Vermont farmers by stage of change.

Discussion

Two of the goals of this study were defining the number and distribution of unprotected tractors in Pennsylvania and Vermont and defining characteristics associated with this. Some of this information is available in previous publications from NIOSH and other sources (cited below) or in the USDA Census of Agriculture (USDA, 2007). However, our data provide new and unique information on the prevalence of ROPS-equipped tractors relative to commodity, farm size, and a variety of other demographic variables. Extrapolating from these data, the commodities studied account for roughly 162,072 tractors across the two states. Of these, 85,927 (53%) do not have ROPS. Of these unprotected tractors, 77,203 are in Pennsylvania and 8,724 are in Vermont. This percentage of unprotected tractors is very similar to what was also found in the state of New York. The absence of ROPS was more notable on smaller farms, farms owned by older farmers, and farms with fewer overall hours of tractor operation (which correlated closely with size). This is similar to the findings of Loring and Myers (2008). The presence of at least one child operator on a farm did not seem to influence the likelihood of having ROPS protection.

The tractor figures cited above are estimates. However, it is more likely that our calculations represent an underestimation of both total tractors and total unprotected tractors. The commodities studied in this survey do not account for all farms in each state. The remaining farms likely represent a heterogeneous group of generally smaller farms. It is impossible to speculate about these with any hint of accuracy, other than to acknowledge that there are more protected and unprotected tractors in Pennsylvania and Vermont than has been calculated. In light of this, 90,000 unprotected tractors appear to be a conservative estimate for both states.

Our figures appear to be generally consistent with data gathered in New York State. The calculated frequency of unprotected tractors on New York farms has declined somewhat from the rates noted a decade or more ago. A decline in unprotected tractors (no

ROPS) was also found by Hard and Meyers (2011). Data from NYCAMH/Cornell University tracking of New York farm fatalities from 1985 to 1989 showed that 52 (55%) of fatalities were related to farm tractors (May et al., 2006). Of these tractor fatalities, 27 (52%) were due to tractor overturns. In response to these findings, investigators undertook a series of studies in the 1990s to better define the problem. Three of these studies involved physical inspections of tractors. Initially, a systematic on-farm inspection of all (605) tractors on 136 randomly selected dairy farms across New York State was performed. This survey, which was linked with a concurrent one-on-one training session with each farmer, found appropriate ROPS on 33% of the tractors inspected (Hill et al., 1992). In subsequent work, all tractors offered at a series of farm auctions across the state, a total of 233 tractors, were systematically evaluated against published ASABE Standards. Findings included the presence of ROPS on 32% of tractors inspected (West and May, 1998). The most recent and most extensive study of tractors in New York was in the NIOSH-sponsored New York Farm Family Health and Hazard Survey (FFHHS), which concluded data gathering in the mid-1990s (Hallman et al., 1997). In that study, a research team from the New York State Department of Health, Cornell University, and NYCAMH linked extensive health, safety, and attitudinal data collected by telephone interviews with actual on-farm hazard surveys and health screening data. Systematic inspections of the mechanical equipment were done by the Cornell team on a cohort of 580 farms that were selected to reflect the size and commodity distribution of all New York farms. The FFHHS project described a fleet of 2,513 tractors with significant safety defects. This included ROPS being absent on 61.4% tractors and seatbelts absent on 28% of the tractors that had ROPS. Some improvement in the rate of ROPS use is suggested by these data, with rates of 33% ROPS in the early 1990s rising to 48% of tractors having ROPS in the most recent data.

Our other two research questions dealt with the farmers' stage of change and possible ways to segment this population. The stage of change portion of our work demonstrates that most Pennsylvania and Vermont farmers are not contemplating ROPS retrofitting in the near future. Stage of change appeared to be fairly evenly distributed across most of the commodities and nearly all other farm characteristics. The lack of statistical difference in stage of change noted in figures 5 and 9 mainly reflects the fact that no commodity group is notably more or less progressed on the change continuum than other commodities. The stage of change data suggest that a majority of the farmers from all of the commodity groups are aware of the necessity of ROPS; however, they are not thinking about retrofitting, hence the need for social marketing and possibly other incentives.

Since no major differences were found in the stage of change, the number of unprotected tractors was examined for each of the commodity groups. In Pennsylvania, 29% of all unprotected tractors were found on cash crop farms. This trend was even more apparent on smaller farms than on large farms. This led to the selection of smaller cash crop farms as the target audience for the social marketing messages. In contrast, researchers in Vermont found a bimodal split in the distribution of unprotected tractors. Of all the commodity groups surveyed in Vermont, vegetable and cash crop farmers were least likely to have even one protected tractor to use on the farm. Fruit farmers also had increased exposures to unprotected tractors, but because of the significant barrier fruit farmers have to using roll bars (i.e., the need to drive under low-hanging tree branches, which can damage the tree), the decision was made to focus on vegetable and hay farmers for intervention.

Limitations

There are several sources of potential error in this study. All surveyed farms were randomly selected, and the usable response rate (27.6% in Pennsylvania and 31.1% in Vermont) may not be high enough to suggest that the results are representative of all farms. To the extent that these lists are not representative of the farms in each commodity group, these data may be biased. The survey was telephone-based, and farmers' responses were not validated by visual inspection. Farmers could have misrepresented their tractor fleet, although this seems unlikely. Somewhat more problematic is ensuring that the cabs and non-cab structures on these tractors actually meet ASABE Standards and thus should be counted as ROPS. On occasion, farmers indicated some uncertainty about this.

Some assumptions were made in the design of this research. The decision to define farmer age and farm size relative to commodity medians reflects an inability to determine generally accepted criteria regarding when a farm is "large" or when a farmer is "old." Evaluation of our findings would be easier for readers if there were generally accepted criteria to which we could refer for these comparisons. A decision was made to exclude from the stage of change analyses any farms that had all tractors protected with ROPS, unless at least one of these tractors had been ROPS retrofitted by the farmer. This resulted in farms being excluded. These farmers were excluded because we believed them to be outside of the stage of change spectrum. It is possible that some of those excluded may have actually bought a tractor specifically to obtain ROPS protection and thus should have been included in the stage of change analyses. Based on our interactions with farmers, we believe that this would represent a very small fraction of the farmers excluded.

Conclusions

Probably the most encouraging finding from this study is that over 85% of Pennsylvania farms and over 87% of Vermont farms surveyed had at least one tractor available that had ROPS protection. Of those farms, 25.5% of the Pennsylvania farms and 46% Vermont farms have ROPS on all of their tractors. Both of these findings were greater than the findings from a 2006 survey of New York State farms, which found that 75% have ROPS on at least one tractor, and 18% have ROPS on all tractors.

Even with this encouraging fact, the goal of 100% of tractors with ROPS is far from being met. There are still an estimated 90,000 unprotected tractors on Pennsylvania and Vermont farms, and these farm owners are unmotivated to install ROPS. However, as demonstrated in New York State, it may be possible to use social marketing that combines persuasive messages and cost-sharing to persuade these farmers that ROPS are indeed important and accessible.

Many of the processes and procedures, like the modification of the stages of change model, used in this and previous studies will be valuable to future research and applications of social marketing in ROPS retrofitting and other agricultural safety and health interventions.

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