Method to Inform Cover Crop Transect Data with Management Actions from Voluntary Producer Survey Data for Annual Cover Crop Implementation Reporting

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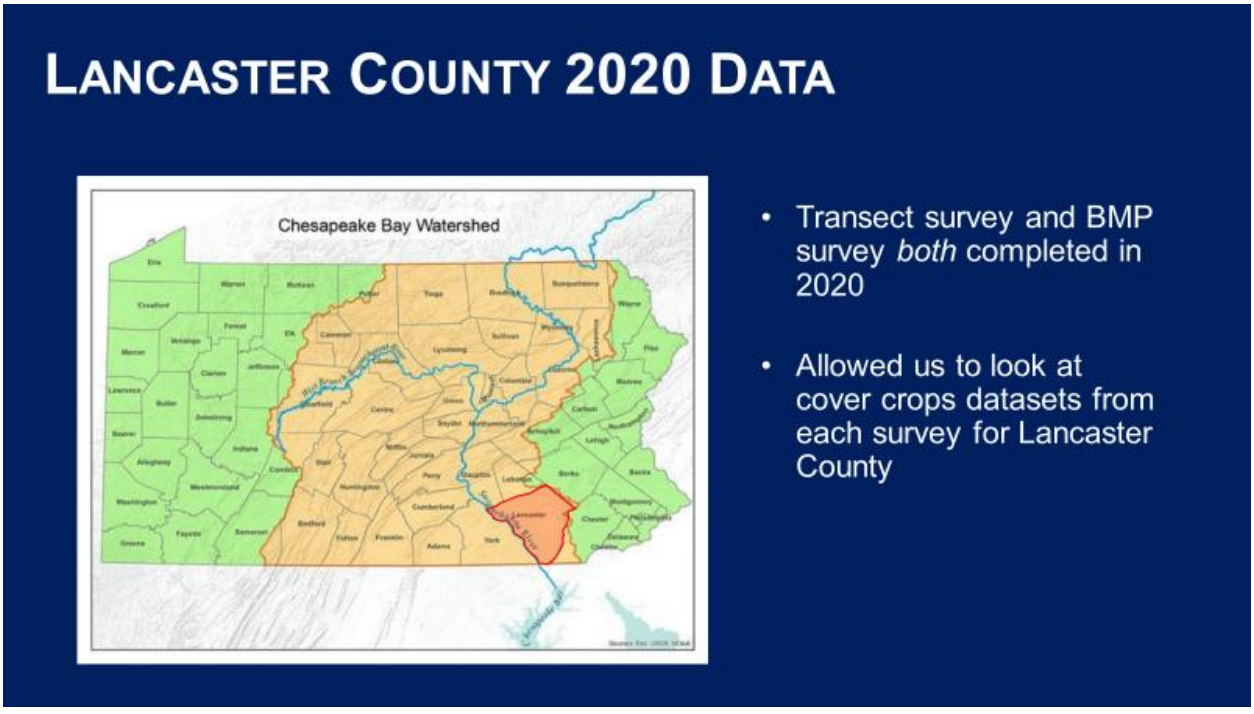
Introduction

The Pennsylvania Department of Environmental Protection (DEP), Pennsylvania State University Agricultural Sciences (PSU), and Capital Resource Conservation & Development (CAP RC&D) have completed a pilot project with assistance from Mark Dubin, Senior Agricultural Advisor with the University of Maryland Extension to investigate an improvement of Pennsylvania's cover crop reporting using multiple data sources. This pilot project has been presented to the Chesapeake Bay Program Partnership's Agriculture Workgroup at its July 21st, August 18th, September 15th, October 20th, and finally for approval at its November 17, 2022, meetings.

The pilot project used a new hybrid data approach of combining several survey data sources, including the PSU Voluntary Producer Survey completed in 2020 in Lancaster County in concert with the 2019-2020 CAP RC&D Transect field observation study for the same County to apply known management actions to contemporaneous field observations to develop an enriched data set that could more fully report the planting species, nutrient application, and other components of the observed plantings from the Transect Survey. The Transect Survey was approved for use for traditional cover crop reporting by the Agriculture Workgroup in November 2016, but was not approved for use in identifying commodity cover crops, and has limitations in being able to identify planted species information given the short growth time following fall planting. This pilot project was developed to investigate the overlap of the two survey datasets, and seeks to provide additional management action information from the PSU Producer Survey to better inform Pennsylvania's Transect Survey data based on matched survey responses and field observations by incorporating both visual and non-visual BMP verification methods.



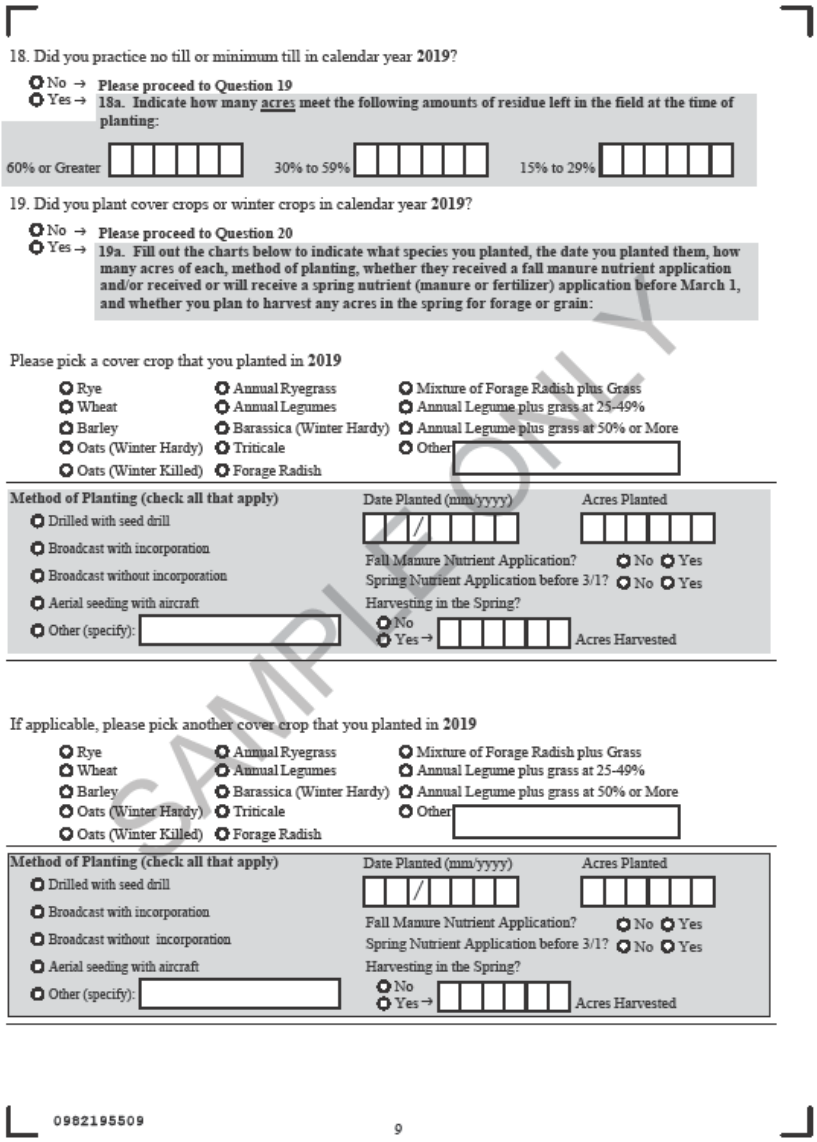
Transect Survey

The CAP RC&D Transect Survey is conducted in two parts (fall planting and spring termination) on a rotational basis of roughly every other year. County transect routes and surveys are pre-established with GPS documented survey points, and are conducted at roughly 13-14 counties per year in counties with greater than 50,000 crop acres. The 2020 Lancaster County Survey included 970 field observations from the transect survey (485 unique latitude/longitude pairs with observations on the left- and right-hand sides of the road on a pre-planned, systematic route developed through Lancaster County. The survey team stops at regular defined GPS intervals, and includes a driver, an observer, and a data recorder who complete the county survey route over 2-3 days. The personnel are typically drawn from retired USDA Natural Resources Conservation Service (NRCS) and experienced County Conservation District employees. Quality assurance and control field inspections are conducted separately following the survey team work to randomly verify a minimum of ten percent of their observations for data QA/QC. The survey begins with a fall survey conducted approximately two weeks following the first average frost date for the county. The fall survey documents planted cover crops at observation points along the transect survey route. The same points are visited again in the spring during the conservation tillage survey and additional information about the previously identified planted cover crop fields are collected to establish whether they were harvested or terminated. Late planted cover crops established after the fall survey are also identified and recorded. If a cover crop is still standing, it is assumed that the crop will be harvested. These point count observations allow the identification of unharvested (spring terminated) crop acres in the county over a given winter. The systematic and unbiased sampling method employed through the survey allows for the extrapolation of the data to the entire county row crop acreage which is eligible for cover crops. The use of the survey approach was approved by the Chesapeake Bay Agriculture Work Group for the collection of Traditional Cover Crops, but not for Traditional Cover Crops with Fall Manure, or Commodity Cover Crops which are harvested. Both cover crop management types include the application of nutrients, which require the use of non-visual verification methods. Additional information on the Transect Survey methodology is available in DEP's Quality Assurance Project Plan (QAPP) here: https://files.dep.state.pa.us/Water/ChesapeakeBayOffice/2021_PA_CBO_QAPP_12.1.2021.pdf

The Transect Survey observation results are extrapolated from the reported unharvested acres of cover crops (a.k.a. traditional cover crops) using the row crop acres reported for the surveyed county as established by the annual base conditions reported in the Chesapeake Bay Program Partnership's Chesapeake Assessment Scenario Tool (CAST), and as developed by trend analyses from the USDA Agriculture Census and NASS Annual Reports. The Base Condition report from each reporting year in CAST is used to establish the annual county Row Crop acres, and these acreages are used to establish the reported county cover crop acres based on the implementation percentages identified by the transect survey report. Because plant species information and nutrient application data are not evident from the survey, only cereal wheat is allowed as a default for reporting as a conservative estimation factor. It is known that other more effective nitrogen-scavenging species such as cereal rye are known to be planted. An alternative data source to the transect survey method alone is needed to better reflect the more specific management actions being implemented with these cover crop practices in the field to enhance the data being reported and used in the Chesapeake Bay Watershed Model (CBWM).

Penn State Survey

The PSU Voluntary Producer Survey was initiated in 2016 on a pilot basis and approved for progress reporting by the Agriculture Workgroup in July 2016. Key data available from the cover crop section of the survey includes; the planted species or mixture, planting date and method, number of planted acres of each type, nutrient applications in the fall or spring before March 1st, and whether the crop was harvested. Surveys are completed voluntarily by producers using standardized survey forms available online or from individually mailed applications, and reflect agricultural production, conservation practices, and management actions implemented for the identified year of the survey. Completed survey forms are submitted back to PSU, and a minimum of ten percent of the responses are selected for quality control field visits conducted by PSU Extension staff. The results of the QA/QC visits are utilized to verify individual surveys and adjust the survey dataset as required to account for the QA/QC findings following the close of the survey and prior to final reporting. A complete copy of the 2020 survey questionnaire is attached in the appendix, and a snapshot of the survey showing Question 19 regarding cover crops is provided below:



18. Did you practice no till or minimum till in calendar year **2019**?

○ No → **Please proceed to Question 19**
○ Yes → **18a. Indicate how many acres meet the following amounts of residue left in the field at the time of planting:**

60% or Greater ☐☐☐☐☐ 30% to 59% ☐☐☐☐☐ 15% to 29% ☐☐☐☐☐

19. Did you plant cover crops or winter crops in calendar year **2019**?

○ No → **Please proceed to Question 20**
○ Yes → **19a. Fill out the charts below to indicate what species you planted, the date you planted them, how many acres of each, method of planting, whether they received a fall manure nutrient application and/or received or will receive a spring nutrient (manure or fertilizer) application before March 1, and whether you plan to harvest any acres in the spring for forage or grain:**

Please pick a cover crop that you planted in **2019**

○ Rye ○ Annual Ryegrass ○ Mixture of Forage Radish plus Grass
○ Wheat ○ Annual Legumes ○ Annual Legume plus grass at 25-49%
○ Barley ○ Barassica (Winter Hardy) ○ Annual Legume plus grass at 50% or More
○ Oats (Winter Hardy) ○ Triticale ○ Other ☐
○ Oats (Winter Killed) ○ Forage Radish

Method of Planting (check all that apply)
○ Drilled with seed drill
○ Broadcast with incorporation
○ Broadcast without incorporation
○ Aerial seeding with aircraft
○ Other (specify): ☐

Date Planted (mm/yyyy) ☐☐/☐☐☐☐ Acres Planted ☐☐☐☐☐
Fall Manure Nutrient Application? ○ No ○ Yes
Spring Nutrient Application before 3/1? ○ No ○ Yes
Harvesting in the Spring?
○ No
○ Yes → ☐☐☐☐☐ Acres Harvested

If applicable, please pick another cover crop that you planted in **2019**

○ Rye ○ Annual Ryegrass ○ Mixture of Forage Radish plus Grass
○ Wheat ○ Annual Legumes ○ Annual Legume plus grass at 25-49%
○ Barley ○ Barassica (Winter Hardy) ○ Annual Legume plus grass at 50% or More
○ Oats (Winter Hardy) ○ Triticale ○ Other ☐
○ Oats (Winter Killed) ○ Forage Radish

Method of Planting (check all that apply)
○ Drilled with seed drill
○ Broadcast with incorporation
○ Broadcast without incorporation
○ Aerial seeding with aircraft
○ Other (specify): ☐

Date Planted (mm/yyyy) ☐☐/☐☐☐☐ Acres Planted ☐☐☐☐☐
Fall Manure Nutrient Application? ○ No ○ Yes
Spring Nutrient Application before 3/1? ○ No ○ Yes
Harvesting in the Spring?
○ No
○ Yes → ☐☐☐☐☐ Acres Harvested

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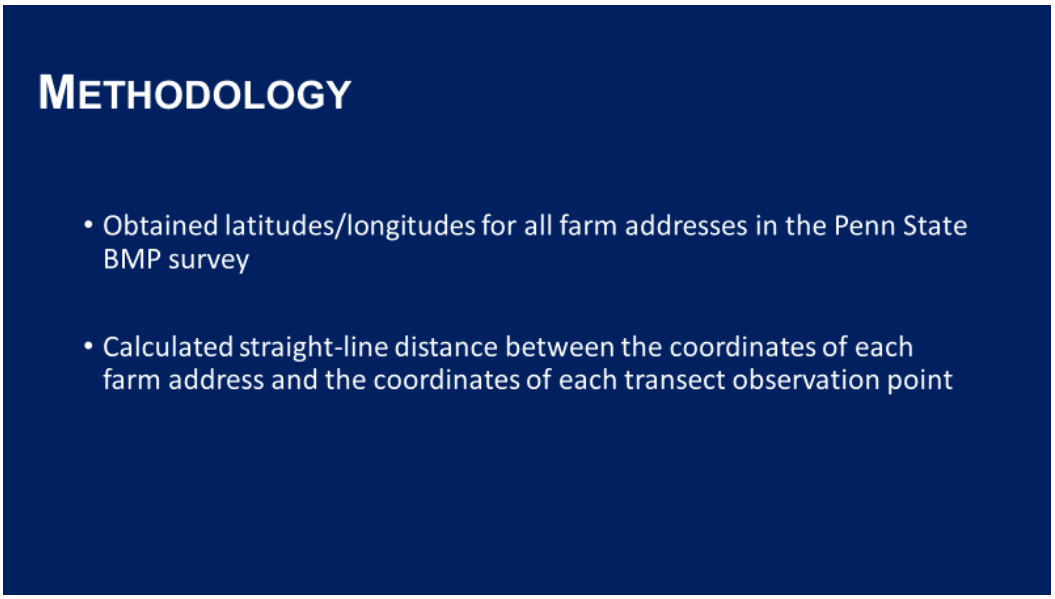
The PSU Producer Survey provides five blank form fields to report cover crop plantings so that multiple cover crop planting and management systems can be reported within the survey response.

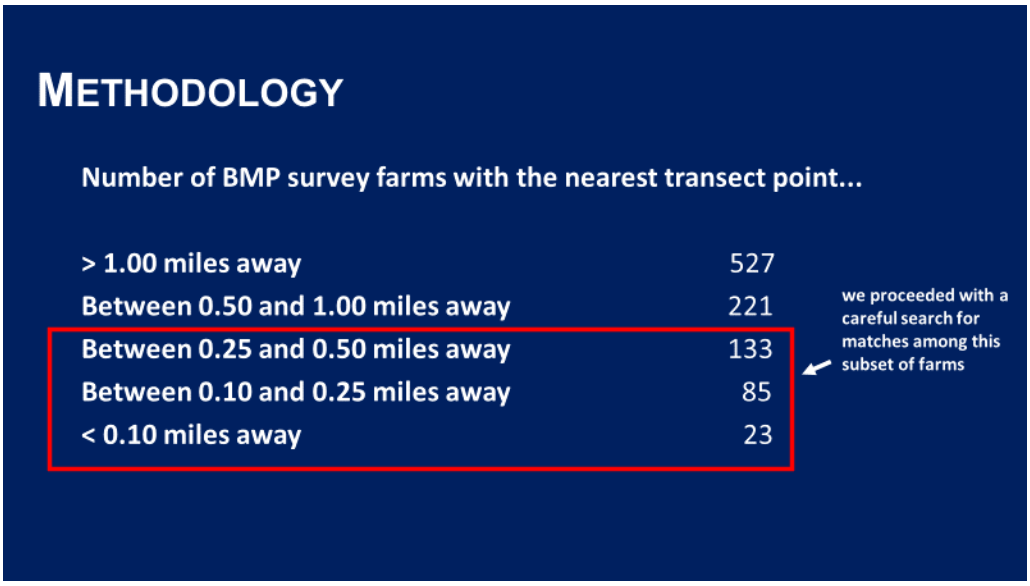
The initial pilot 2016 Producer Survey received nearly 7,000 participants and was repeated in four pilot Watershed Implementation Plan (WIP) counties in 2020 (Lancaster, York, Adams, and Franklin) with nearly 1,800 participants. Additional county surveys were most recently completed in 2022 in Pennsylvania's 14 remaining Tier 2 & 3 counties as identified in Pennsylvania's Phase 3 WIP with just over 1,000 participants. A copy of the 2020 PSU Producer Survey Report is available here: https://files.dep.state.pa.us/Water/ChesapeakeBayOffice/Ag%20page/Farm_Survey_2020_Final_Report_Feb_1_2021.pdf

Matching Methodology

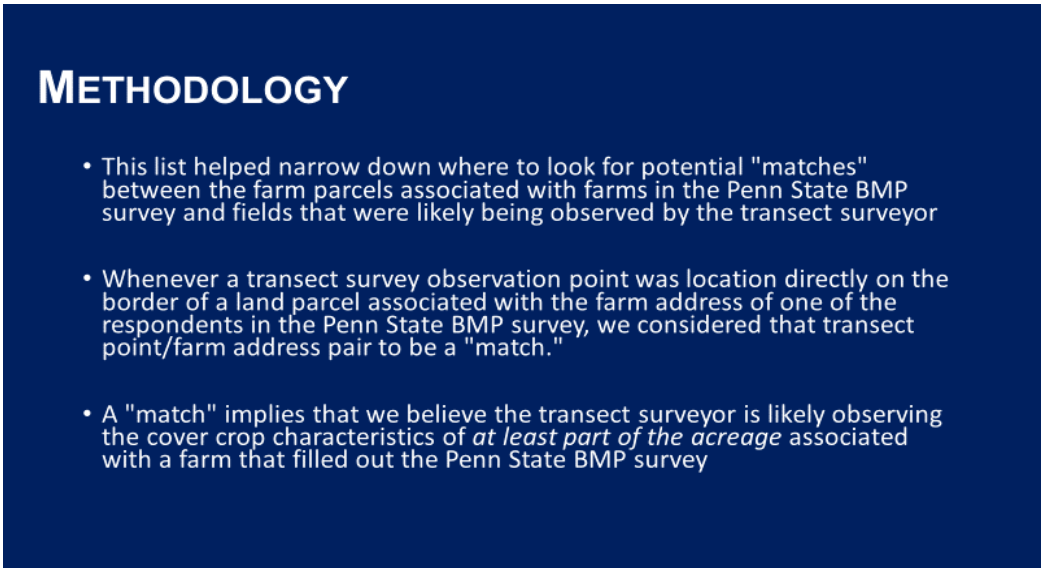
The Lancaster County response to the 2020 PSU Producer Survey included 989 farms, and 970 waypoint observations from the Transect Survey. This pilot study was designed to identify how many Transect Survey observations belong to farm operations represented in the PSU Producer Survey. The response and waypoint matching effort was a large part of the pilot project effort, and because of data privacy assured in the PSU Producer Survey, only PSU could perform this assessment without sharing personally identifiable information.

PSU used the 2020 Lancaster County transect waypoint data and observations provided by Cap RC&D to geospatially locate the transect waypoints and used the Lancaster County Tax Parcel Map to geo-locate PSU respondent addresses and the physical boundaries of property ownership. When a tax parcel identified as a survey respondent was co-located with a transect waypoint, the PSU survey response and transect waypoint(s) were determined to be a match.

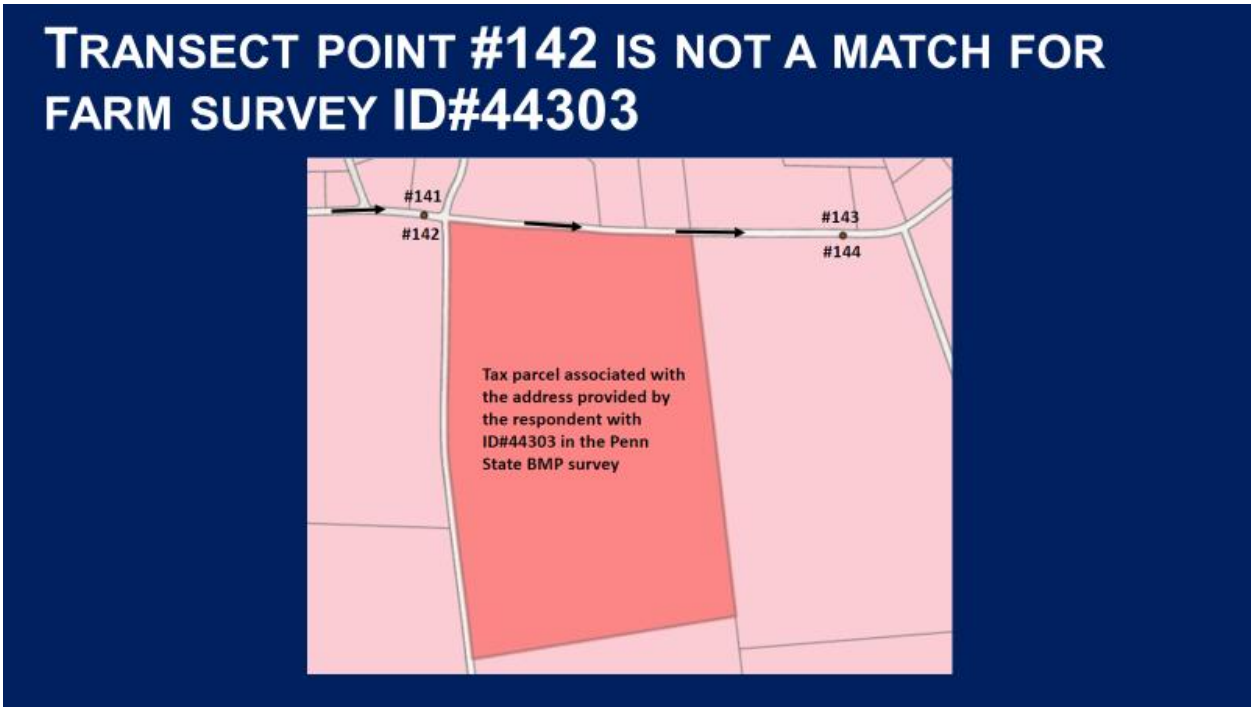




Using a half-mile search radius created a subset of responses with most probable matches.

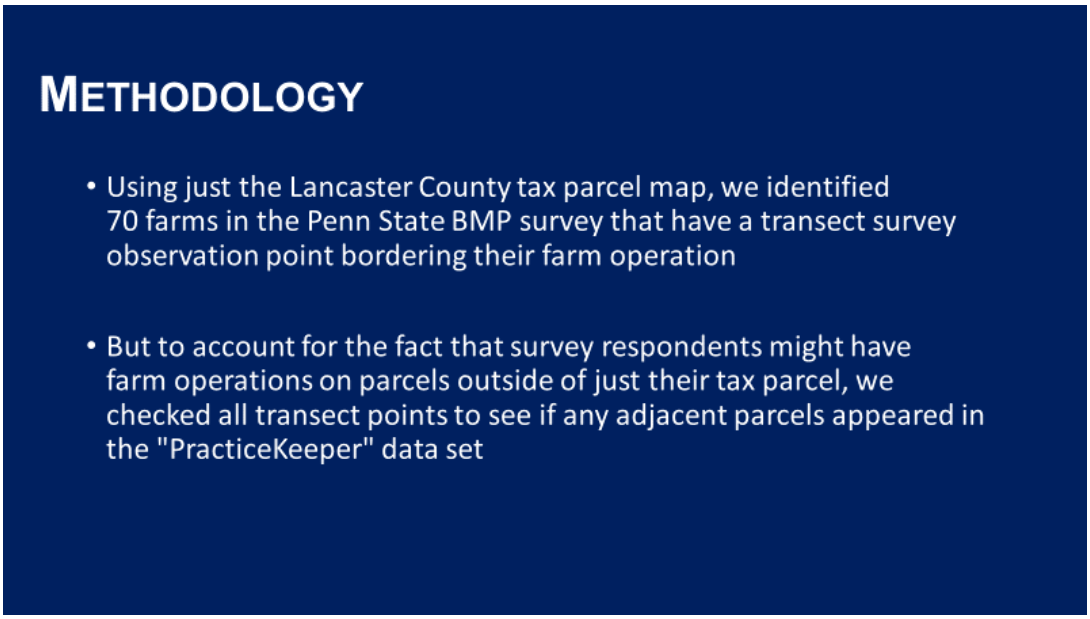


The figure below illustrates a non-matching situation:

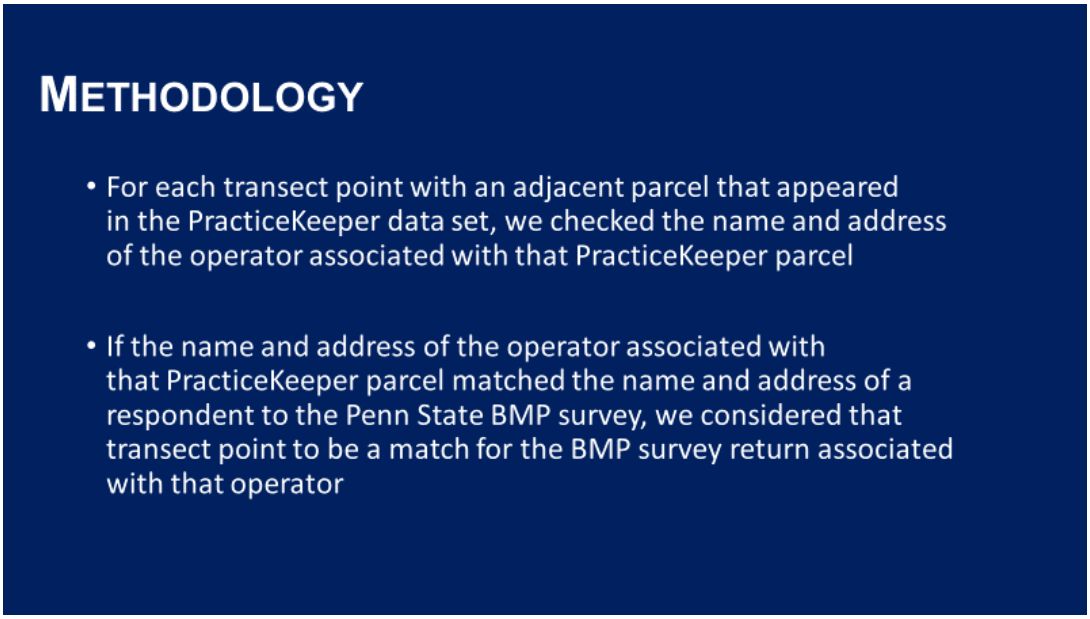


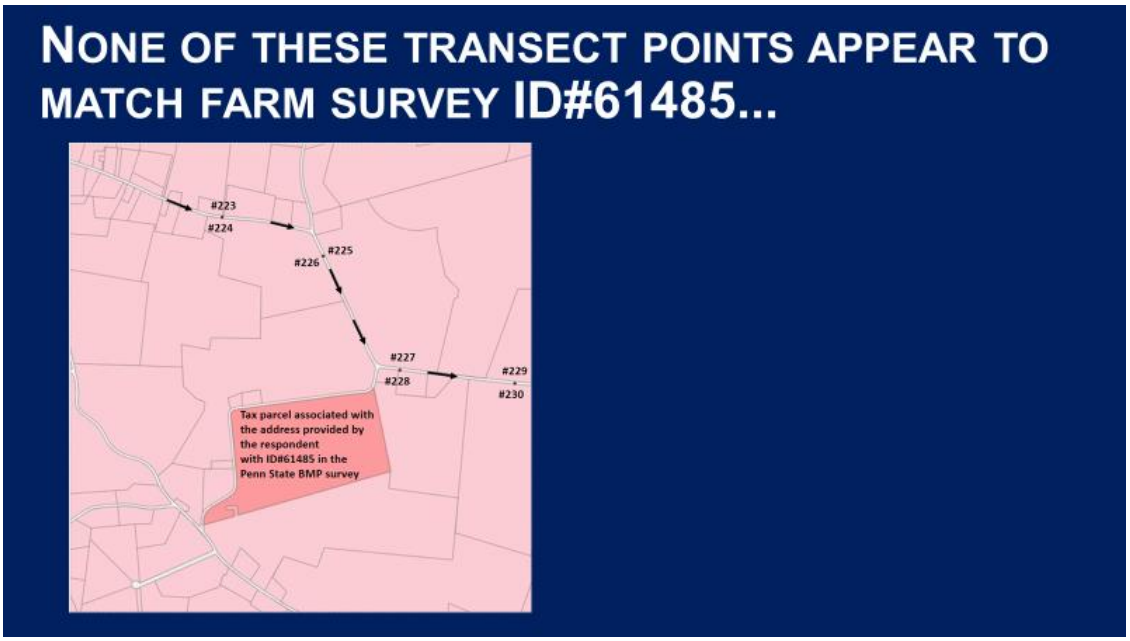
While the figure below shows where a waypoint observation could be matched to a PSU survey response parcel:

After an initial effort using the Tax Parcel Map, additional mapping from Nutrient Management Plans logged in PracticeKeeper helped expand the number of other nearby parcels associated with the farming operation and other additional waypoints that could potentially be associated with the PSU Producer Survey response.

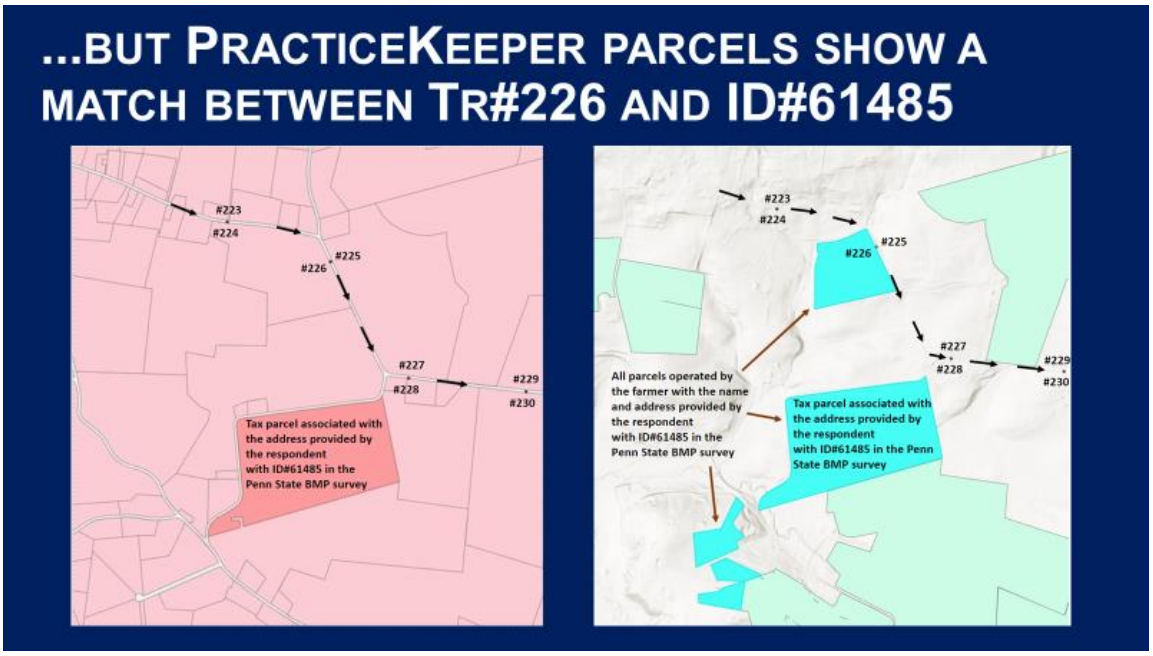


PracticeKeeper software is used by County Conservation Districts to inventory active BMPs and plan implementation areas, including farm tracts and fields which are incorporated in the agricultural operation but not owned by the producer, such as leased or rented properties. PSU employed the following methodology in expanding the parcel footprint for survey participants.





The illustration below shows how nearby adjacent parcels could be picked up as matches using the expanded operator footprint information.



METHODOLOGY

- Using the combination of the Lancaster County tax parcel map and the map of PracticeKeeper parcels, we identified 94 farms in the Penn State BMP survey that have a transect survey observation point bordering their farm operation (as compared to 70 farms using just the Lancaster County tax parcels)

Based on the additional parcel information provided in the PracticeKeeper NMP Dataset, 24 additional matches were identified to expand the total matched population to 94 farming operations. With this population identified, additional comparisons were made between the Transect and PSU Survey responses.

RESULTS

- The degree of correspondence between the cover crop information reported by farmers in the Penn State BMP survey and the cover crop information collected in the transect survey can be compared in terms of:

1. the presence of any cover crop reported
2. the type of cover crop reported
3. whether the cover crop was reported to be harvested

PRESENCE OF A COVER CROP

		Were cover crops reported at the transect point?	
		Yes	No
Were cover crops reported by the farm in the Penn State BMP survey that borders the transect point?	Yes	51 (54.3%)	30 (31.9%)
	No	2 (2.1%)	11 (11.7%)

The numbers in each cell denote the number of farm-transect point pairs where cover crops were reported in one or the other survey, both surveys, or neither survey

The presence of a cover crop alone could potentially be misleading if crop acres reported are not located along the roadside at the Transect Survey waypoint, or are located away from operation's headquarters, or if not observed at the time of the transect survey (planting date).

COVER CROP TYPE

		Cover crop type reported in the transect survey			
		Small grains	Mixture	Hay	Unknown
Cover crop type reported in the Penn State BMP survey	Small grains	43 (84.31%)		1 (1.96%)	2 (3.92%)
	Mixture	1 (1.96%)	2 (3.92%)		
	Legume	1 (1.96%)			
	Other				1 (1.96%)

Each cell denotes the number of farm-transect point pairs for which a particular combination of cover crop types were found across the two survey

Green indicates that the crop type reported in the transect survey matches the type reported in the Penn State BMP survey

Good agreement was observed in the cover crop type between the data sets, which would be expected based on the limited categories established within each survey and types of crops planted.

COVER CROP HARVESTING

		Harvesting regime observed in the transect survey	
		Harvest	No Harvest
Harvesting regime reported in the Penn State BMP survey	Harvest	16* (31.4%)	12 (23.5%)
	No Harvest	3 (5.9%)	20** (39.2%)

*This number includes farms where *at least one* of the matching transect points found a harvested cover crop and *at least one* of the cover crop plots reported by the matching farm in the Penn State BMP survey reported a harvested cover crop

**This number includes farm-transect pairs where *at least one* of the matching transect points found no cover crop harvest and *at least one* of the cover crop plots reported by the matching farm in the BMP survey reported no cover crop harvest

The PSU Survey does not specially ask producers the type of cover crop harvesting, such as if for grain or forage. Consequently, there is the possibility that some producers may have had different understandings of what constituted "harvesting", being understood to mean grain harvesting over a "harvested" use for forage. The amount of this potential confusion is unquantified in the pilot project but will similarly exist in any survey response data set such as the UDSA Agriculture Census and NASS survey data. While not entirely avoidable, the amount of these misclassified acres is thought to be small across the domain of multiple reporters. The findings of the pilot project will be considered in developing future PSU Producer Survey questionnaires.

KEY FINDINGS

- 66% (62 of 94) of the matching farm-transect point pairs reported consistent results in terms of cover crop presence
- 88% (45 of 51) of the cases where a cover crop was present in both the BMP farm survey and the transect survey reported the same category of cover crop type
- The harvesting regime matched in 70% (36 of 51) of the cases

Quality Assurance and Quality Control

Field verification methods previously approved by the Agriculture Workgroup are completed within both the Transect Survey and Penn State Producer Surveys and are used to correct and assure accuracy of the reported final data. Similarly, the matched survey pairs were reviewed in this pilot hybrid approach to correct results from the initial survey responses and to use the field-verified data developed by the PSU Extension staff for those randomly sampled QA/QC operations when available. Two of the 51 matched pairs of were corrected to reflect field-verified data from the PSU Producer Survey. PSU responses SRCID 37377 and 66908 were corrected based on the in-field follow-up visits.

The initially reported SRCID 37377 response reported 1,500 acres of Legume and Grass. The field verification of this response found that this should have been reported as 910 acres of Rye-Oats and 300 acres of Oats-Rye/Wheat-Radish/Rapeseed, which was matched to Forage Radish Plus as a mixture. The planted species and acreages reported from SRCID 37377 were corrected to reflect the field-verified species and acreage amounts of these cover crops.

PSU response SRCID 66908 was corrected based on field verification to indicate that these acres did receive a fall nutrient application, and that the amount of non-harvested wheat planted was reduced by 30 acres from 480 to 450. These changes are highlighted in the PSU Producer Survey response data presented later in this document.

These data were corrected through incorporation of the field verifications within the 51 matched pairs of cover crops. Future surveys should ensure all available field verification data are incorporated prior to analysis, and that each successive county analysis benefit from the lessons learned from this pilot and other prior work, focusing especially on unusual and unexpected results and responses with large reported acreages.

Results from the Matched Data Set

Using the cover crop data reported from the matched PSU Producer Survey respondents, a subset of the responses could be used to characterize the management actions associated with cover crops documented in the survey responses. Additional filtering of the matched set population by removing incongruent harvesting data between the two surveys was investigated but not pursued as the acreage of the matched data pool became concerning small (appx. 2.4%) relative to the overall county row crop acreage. Using all the matched survey data points (representing 9,265 acres) allowed a 4.4% coverage rate for the entire county crop acreage (210,691 acres) which was viewed as a better choice given the scales of each data set.

The planted species data categories reported in the PSU Survey matched well with those provided in the Phase 6 Cover Crop Expert Panel Report here: Phase_6_CC_EP_Final_Report_12-16-2016-NEW_TEMPLATE_FINAL.pdf (d18lev1ok5leia.cloudfront.net) The data from the PSU responses were classified to a corresponding cover crop type as listed in Appendix A, Figure 1 of the Expert Panel Report. For simplicity, planting method and timing were not considered within the pilot project's scope of work to focus on plant species, nutrient applications, and harvesting, but this information could be incorporated in future analysis. Matched survey responses were identified as fitting in Double Crop, Traditional, Traditional w/ Fall Nutrients, and Commodity Cover Crop definitions based on reported harvesting and nutrient application. Only matched survey responses were included in the evaluated response data. The identified Double Crop acres (fertilized and harvested) are not used in cover crop reporting, although the small percentage of identified Commodity Cover Crop acres (63 acres/9,265 matched acres, or 0.7%) would reside within the identified harvested acres of the Transect Survey.

The existing Transect Survey methodology reports three classes of cover crop acres as a percentage of the crop observations made along the transect route and extrapolates point count observations from a systematic, non-biased sample data collection. No harvested acres are reported, and the approved methodology does not allow the reporting of Commodity Cover Crops through the Transect Survey alone. Lancaster County's 2020 Cover Crop results using the Transect Survey calculation is shown below:

Table 1. Current Reporting of Traditional Cover Crops from Transect Survey Results

County	2020 Row Crop Acres (CAST)	Hrvstd Cov %	Hrvstd Cov Acres	TradCovCrop %	TradCovCrop Acres	Trad w/Nut %	Trad w/Nut Acres	Late CC%	Late CC Acres
Lancaster	210,691	49.650%	104,608	15.060%	31,730	1.360%	2,865	0.700%	1,475
		Not Reported							

The existing approach reports each crop type as Normal or Late-planted Wheat Other (not drilled) as a conservative approved default estimation of planting information without additional management action details. A small amount of known nutrient application to non-harvested acres was field documented through Transect observations. A total of 36,070 acres of non-harvested cover crops were identified in 2020 by the Transect Survey.

While the PSU Survey generates a biased dataset based on those operators voluntarily choosing to participate, we are using the previously discussed matching of systematic Transect Survey waypoints to individual PSU Producer Survey respondents to develop a subset that can cross-inform the data in both surveys. In this way, the pilot project is identifying a population of PSU respondents that correspond with Transect observation points and that those matches

can report additional management actions to better report cover crops being planted in Lancaster County.

Using the species information from the matched pairs, the following distribution of plant species was identified for each cover crop type:

Table 2. Distribution of Plant Species Cover Crop Types Based on Matched Survey Pairs

Traditional with Fall Nutrients Applied Total 4,182 Ac. (50.0%)	**Acres**	**Percent of Share**
Rye Normal Other	1,388	30.0%
Wheat Normal Other	1,671	36.1%
Forage Radish Plus Normal Other	895	19.3%
Triticale Normal Other	604	13.0%
Annual Ryegrass Normal Other	72	1.6%
Oats Normal Other	2	0.04%
Double Crop Acres Total 3,507 Ac. (37.8%)		
Traditional Cover Crops Total 1,543 Ac. (11.5%)	**Acres**	**Percent of Share**
Rye Normal Other	703	66.1%
Wheat Normal Other	127	11.9%
Legume Plus Grass 50% Normal Other	75	7.1%
Annual Ryegrass Normal Other	70	6.6%
Forage Radish Plus Normal Other	60	5.6%
Legume Plus Grass 25-50% Normal Other	20	1.9%
Barley Normal Other	8	0.8%
Commodity Cover Crops Normal Total 63 Ac. (0.7%)	63	100.0%

Based on the cover crop type and species distribution from the matched pairs, an equivalent distribution extrapolated to the known non-harvested area of 36,070 acres is shown below including how these are reported currently (Transect alone) as shown along the right side of the table:

Table 3. Existing and Proposed Reporting of Traditional and Commodity Cover Crops

Extrapolated Results of PSU Survey Responses From Transect Matched Points (9,265 Ac.)

Cover Crop Type		Proposed Extrapolated Result (Ac)			Current Transect Reporting
Traditional with Fall Nutrients Applied Total 4,182 Ac. (50.0%)	**Acres**	**Percent of Share**	29,337		
Rye Normal Other	1,388	30.0%	**8,791**		
Wheat Normal Other	1,671	36.1%	**10,583**		2,865
Forage Radish Plus Normal Other	895	19.3%	**5,669**		
Triticale Normal Other	604	13.0%	**3,826**		
Annual Ryegrass Normal Other	72	1.6%	**456**		
Oats Normal Other	2	0.04%	**13**		
Double Crop Acres Total 3,507 Ac. (37.8%)					
Traditional Cover Crops Total 1,543 Ac. (11.5%)	**Acres**	**Percent of Share**	6,733		
Rye Normal Other	703	66.1%	**4,453**		
Wheat Normal Other	127	11.9%	**804**		31,730
Legume Plus Grass 50% Normal Other	75	7.1%	**475**		
Annual Ryegrass Normal Other	70	6.6%	**443**		
Forage Radish Plus Normal Other	60	5.6%	**380**		
Legume Plus Grass 25-50% Normal Other	20	1.9%	**127**		
Barley Normal Other	8	0.8%	**51**		
		Cover Crop Late Other Wheat			1,475
Commodity Cover Crops Normal Total 63 Ac. (0.7%)	63	100.0%	**1,433**		0
		Total Traditional:	**36,070**		**36,070**
		Total Commodity:	**1,433**		

Proposed New Reporting (Acres) **Existing Transect Only Reporting (Acres)**

Below is an attached link to the excel file created through the matching process and used to calculate the distributed cover crop types based on the data from the PSU survey responses:

https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Copy-of-Final-CC-Table-11-17-22-v2.xlsx

Reporting Calculation Process

The existing Transect reporting process extrapolates the percentages of observed non-harvested cover crop types reported from the annual Transect Survey Report across the county row crop acreage from CAST. These are shown in Table 1 and in Table 3 in green highlighting for Lancaster County in 2020. This new hybrid approach would use the matched pair crop distribution shown in Table 2 which would yield the extrapolated acreages in Table 3 shown in blue highlighting. The total amount of non-harvested row crop acres as established from the Transect Survey extrapolation serves as the total amount of available Traditional Cover Crops which are then refined using the county cover crop fingerprint to report the planted species from the matched pairs between the surveys.

In future reporting, it is expected the county row crop acres will change annually with changing CAST Base Conditions and the Transect Survey and county fingerprint will change less frequently as these surveys and analyses are updated. Future development of the finer-scale fingerprint analyses must use data from the same winter planting and are only valid for the county analyzed due to variability across climate, soils, topography, and regional planting characteristics.

Conclusions

This project has demonstrated that it is possible to integrate management action information from the PSU Producer Survey data with the systematic data collection performed in the approved Transect Survey. The matched dataset including the PSU Producer Survey indicates that more cover crop acres are receiving nutrients and with greater planting diversity than is currently understood through the Transect Survey alone. Additionally, the planting of Commodity Cover Crops does not appear to be a significant (<1%) relative to the PSU Survey planted acres in Lancaster County. These are characteristics thought to be unique to Lancaster County, and as similar data analyses are performed for other counties, the percentages of cover crop types are expected to change, thus Commodity Cover Crops may become more significant.

The pilot project may be accepted as a means of annual verification to improve the quality of data being reported for the implementation of this practice, which is dependent on periodic updates, like the existing Transect Surveys. The surveys can only speak to conditions identified within the county investigated and quality controls used within each survey must be maintained to ensure overall data accuracy. Like the current Transect Survey, the PSU Survey informed cover crop “fingerprint” for the county could be carried forward into the next reporting year until a subsequent county analysis is performed. If approved, this method could be available for reporting cover crops in Lancaster County for the 2022 Chesapeake Bay Program Progress reporting period and subsequent years as modifications are made to improve this process.