Virginia Department of Recreation and Conservation
Division of Soil and Water Conservation
Presentation to Agriculture Workgroup - 8/17/2023

Virginia Tillage/Residue Survey - Using an Alternative Approach for Verification

Introduction and Background

- Virginia's previous tillage survey was completed in 2015

- A new survey was conducted during 2022 to update the 2015 survey

- For the 2022 survey, DCR followed the guidance of the roadside transect survey method as described in the CBP report "Recommendation Report for the Establishment of Uniform Evaluation Standards for Application of Roadside Transect Surveys to Identify and Inventory Agricultural Conservation Practices for the Chesapeake Bay Program Partnership's Watershed Model" (16 March 2017) with one exception:

  - Due to budget and time constraints, an alternative approach for the verification process was established to prevent the need for in-person visits
  - The alternative approach involved the use of **photographs being captured during the original surveying process** that could then be evaluated to determine residue levels

Purpose of Presentation to Agriculture Workgroup

- Initial presentation was given to Agriculture Workgroup on 7/20/2023

- Today's presentation will give a shortened overview of the methodology used for the 2022 survey to refresh the Workgroup on the project

- A review of the project methodology was conducted by Tetra Tech that resulted in several recommendations

- Answers to questions received and responses to the recommendations from the independent review will also be presented

- **The goal of today's presentation is to seek consensus from this workgroup to accept the methodology and to allow the submission of this survey's results for use in the Chesapeake Bay Model beginning with 2023 Progress.**

2022 Survey Information

Residue Categories

- Less than 15% (Conventional Tillage)
- 15% - 30% (Reduced Tillage)
- 30% - 60% (Conservation Tillage)
- Greater than 60% (High Residue Tillage Management)

- The 2015 results were the *a priori* estimates for the 2022 sample size calculations.
- The survey units were counties or a combination of adjacent counties with similar agricultural characteristics.
- Survey teams were composed primarily of Soil and Water Conservation District staff.
  - DCR provided training for all survey team members to ensure that all teams followed the same procedures.
  - Each survey team consisted of a minimum of 2 members – a driver and a data collector

Data Collection

- Surveyors worked in designated survey units to minimally obtain the specific number of cropland survey points required.

- ESRI's Quick Capture application was used to capture residue observations

- Option to collect photo with each point entered
  - Survey teams were instructed to **capture a photo** for approximately every 5th point observed

- DCR assisted survey teams to determine routes for their survey areas when necessary
  - GIS technology (ESRI's Network Analyst) was used to create the most efficient routes through cropland areas
  - ArcGIS Navigator could be used with routes for turn-by-turn directions
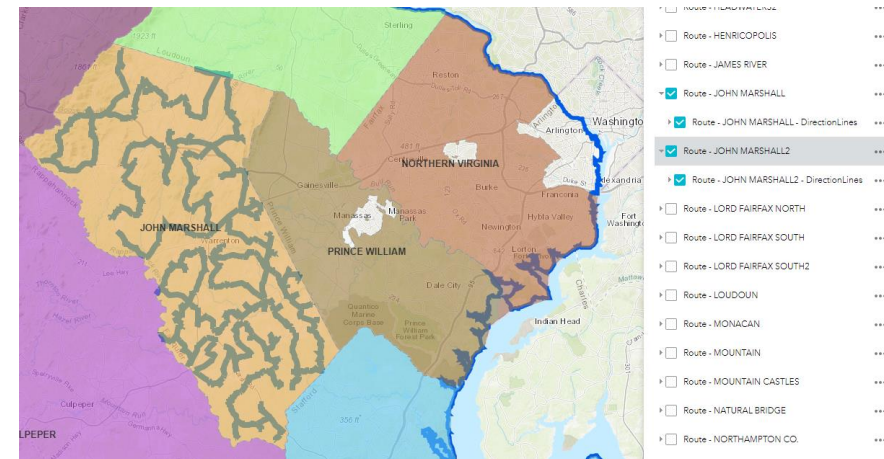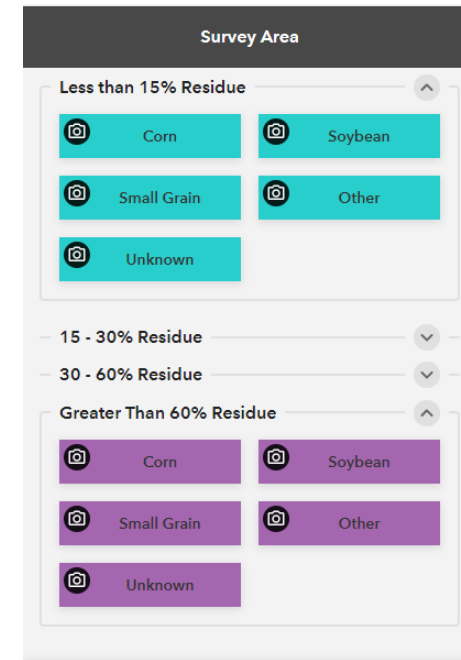
Monitoring Using ESRI Dashboard

- ESRI Dashboard allowed for near real time monitoring of survey progress by DCR Division of Soil and Water Conservation Data Services Manager for the following purposes:

  - Photographs could be viewed to ensure that teams were taking them following instructions giving during training sessions.

  - General routes could be observed to determine if survey teams were covering the majority of crop land areas in the survey unit.

  - When a team reported that a survey unit was complete, the Dashboard could be used to determine if the minimum number of points was obtained.
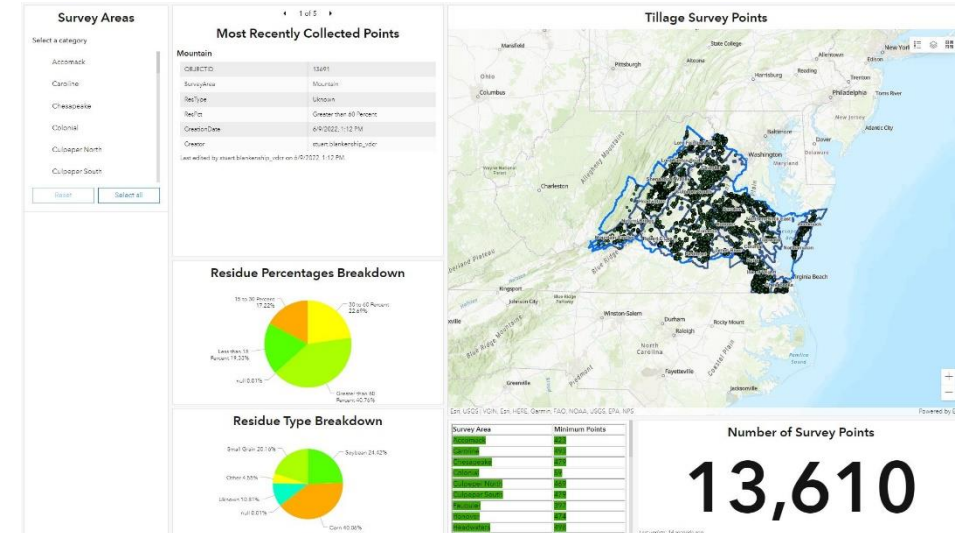
Survey Verification

- Surveyors were instructed to take a picture of the residue cover indicative of their recording of residue occurrence at a set interval.

- Surveyors were also instructed to take photos while standing on the field, if possible, and to take the photo in a way that would allow the photo interpreter to clearly see the residue.

- Approximately 13,600 points were surveyed and over 4,000 pictures were taken and available for review.

- A random sampling of approximately half of the 4,000 photos was selected for review with the knowledge that some photos would not meet the quality needed and would need to be discarded.

Representative Photos for Residue Categories

Less Than 15%   **15% - 30%**   **30% - 60%**   **Greater Than 60%**

Representative Photos of Insufficient Quality

Photo Review Process

- With 2000 photos needing to be reviewed, it was originally decided that multiple photo reviewers would need to be selected to split the workload.

- Several DCR employees with experience classifying residue volunteered to help in the effort.

- A meeting was held to give guidelines on the photo classification process including instructions on the quality of photo that would be needed to accurately classify residue.

- This process was completed with 1,760 photos being classified by the multiple reviewers.

Results of Original Photo Review

- Overall accuracy is around 64% which raised questions as to the accuracy of using photos for verification.

- After investigation, it was found that some of the photo interpreters were determining classifications using photographs that were not of sufficient quality to accurately estimate residue coverage.

- It was decided that the same group of photos would be reviewed by a single photo interpreter to reduce variation and to ensure that only quality photos were being used for estimates.

This is a comparison of the survey classification to the photo (ground) truth classification.

Sample Count Error Matrix		Photo Truthing				Row Totals	Marginal Proportions
Class		1	2	3	4		
	1	179	53	18	5	255	0.16
Classified	2	36	88	61	32	217	0.15
Data	3	13	92	167	86	358	0.21
	4	3	33	187	707	930	0.48
Column Totals		231	266	433	830	1760	

Area Proportion Error Matrix		Photo Truthing				Row Totals	
Class		1	2	3	4		
	1	0.111	0.033	0.011	0.003	0.16	0.102
Classified	2	0.025	0.061	0.043	0.022	0.15	0.020
Data	3	0.008	0.053	0.097	0.050	0.21	0.007
	4	0.002	0.017	0.097	0.367	0.48	0.002
Column Totals		0.146	0.165	0.247	0.442		
Adjusted 90% CI	+/-	0.010	0.014	0.016	0.015		
Producer's Accuracy		0.765	0.373	0.390	0.830		
User's Accuracy		0.702	0.406	0.466	0.760		
Overall Accuracy						0.636	
Var(Producer's Acc.)		0.00052	0.00054	0.00035	0.00013		
Var(User's Acc.)		0.00012	0.00014	0.00014	0.00010		
Var(Overall Acc.)						0.00012	

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Results of Final Photo Review

- 1,561 photos were classified by one photo reviewer, DCR's Data Services Manager for the Division of Soil and Water Conservation, to ensure consistency in the photo review process.

- Overall accuracy improved to just over 85%.

- Supports the conclusion that photo reviewers were interpreting photos of insufficient quality.

This is a comparison of the survey classification to the photo (ground) truth classification.

Sample Count Error Matrix		Photo Truthing				Row Totals	Marginal Proportions
Class		1	2	3	4		
	1	197	28	1	1	227	0.15
Classified	2	18	132	25	5	180	0.12
Data	3	4	44	213	25	286	0.18
	4	2	1	77	788	868	0.56
Column Totals		221	205	316	819	1561	

Area Proportion Error Matrix		Photo Truthing				Row Totals
Class		1	2	3	4	
	1	0.126201	0.017937	0.000641	0.000641	0.15
Classified	2	0.011531	0.084561	0.016015	0.003203	0.12
Data	3	0.002562	0.028187	0.136451	0.016015	0.18
	4	0.001281	0.000641	0.049327	0.504805	0.56
Column Totals		0.141576	0.131326	0.202434	0.524664	
Adjusted 90% CI	+/-	0.007331	0.010454	0.012797	0.010617	
Producer's Accuracy		0.891403	0.643902	0.674051	0.962149	
User's Accuracy		0.867841	0.733333	0.744755	0.907834	
Overall Accuracy						0.852
Var(Producer's Acc.)		0.00037	0.00073	0.00048	0.00004	
Var(User's Acc.)		0.00007	0.00013	0.00012	0.00005	
Var(Overall Acc.)						7.7247E-05

Sample In Field Verification

- 189 originally observed points were revisited in person.

- Accuracy was roughly 63% versus the 85% metric for the final photo verification
  - Possibly attributed to small sample size and/or to the specific smaller are revisited not having highly accurate original residue interpretations
  - In addition, this variability could also be attributed to differences in "ocular calibration" between the different surveyors across the survey teams.

This is a comparison of the original classification of a field to the field checkers classification of that field.

Sample Count Error Matrix		Ground Truth				Row Totals	Marginal Proportions
Class		1	2	3	4		
	1	11	10	2	6	29	0.1534
Original	2	3	7	8	16	34	0.1799
Classification	3	1	3	17	18	39	0.2063
	4	0	0	3	84	87	0.4603
Column Totals		15	20	30	124	189	

Area Proportion Error Matrix		Ground Truth				Row Totals	
Class		1	2	3	4		
	1	0.058201	0.05291	0.010582	0.031746	0.1534	
Classified	2	0.015873	0.037037	0.042328	0.084656	0.1799	
Data	3	0.005291	0.015873	0.089947	0.095238	0.2063	
	4	0	0	0.015873	0.444444	0.4603	
Column Totals		0.079365	0.10582	0.15873	0.656085		
Adjusted 90% CI	+/-	0.028722	0.034106	0.039889	0.044833		
Producer's Accuracy		0.733333	0.35	0.566667	0.677419		
User's Accuracy		0.37931	0.205882	0.435897	0.965517		
Overall Accuracy						0.62963	
Var(Producer's Acc.)		0.011024	0.008726	0.005881	0.000704		
Var(User's Acc.)		0.001246	0.000865	0.001301	0.000176		
Var(Overall Acc.)						0.000696	

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Photo Interpretation Compared to In Field Verification

- 95 of the 189 points revisited in person contained photos from the original survey team

- Residue classification of the 95 points revisited in person were then compared to classifications from photos

- Result was roughly an 84% match

This is a comparison of the photo classification of a field to the field checkers classification of that field.

Sample Count Error Matrix		Ground Truth				Row Totals	Marginal Proportions
Class		1	2	3	4		
	1	8	2	0	0	10	0.1053
Photo	2	3	8	4	0	15	0.1579
Classification	3	0	1	15	3	19	0.2000
	4	0	0	2	49	51	0.5368
Column Totals		11	11	21	52	95	

| Area Proportion Error Matrix		Ground Truth				Row Totals
Class		1	2	3	4	
	1	0.084211	0.021053	0	0	0.1053
Classified	2	0.031579	0.084211	0.042105	0	0.1579
Data	3	0	0.010526	0.157895	0.031579	0.2000
	4	0	0	0.021053	0.515789	0.5368
Column Totals		0.115789	0.115789	0.221053	0.547368	
Adjusted 90% CI	+/-	0.036112	0.04508	0.050294	0.037246	
Producer's Accuracy		0.727273	0.727273	0.714286	0.942308	
User's Accuracy		0.8	0.533333	0.789474	0.960784	
Overall Accuracy						0.8421
Var(Producer's Acc.)		0.011475	0.01343	0.006201	0.000832	
Var(User's Acc.)		0.001684	0.00262	0.00175	0.000397	
Var(Overall Acc.)						0.0012

Lessons Learned

- Many lessons were learned during the 2022 survey process that can be applied to future surveys.
  - DCR would strongly recommend that survey teams use tablets versus cell phones with the Quick Capture application to make it easier to see the various buttons.
    - Colors of buttons could also be adjusted to better distinguish categories.
  - Quick Capture default settings should be changed to allow for manual upload of data versus automatic upload which resulted in duplicate points that had to be removed during post processing.
  - To allow for more accurate identification of fields that were surveyed, a left/right designation should be added to points collected using the Quick Capture application.

Response to Recommendations

- General instructions on how to capture photos of the residue on fields was given during training, but it was found that photos were being captured at different heights and angles by different survey teams.

  - For future surveys, more specific instructions and procedures should be given to ensure that photographs are being taken from consistent heights and angles.

An example could be created like the one below, created by Canopeo (https://canopeoapp.com), to show how to properly take a photograph.
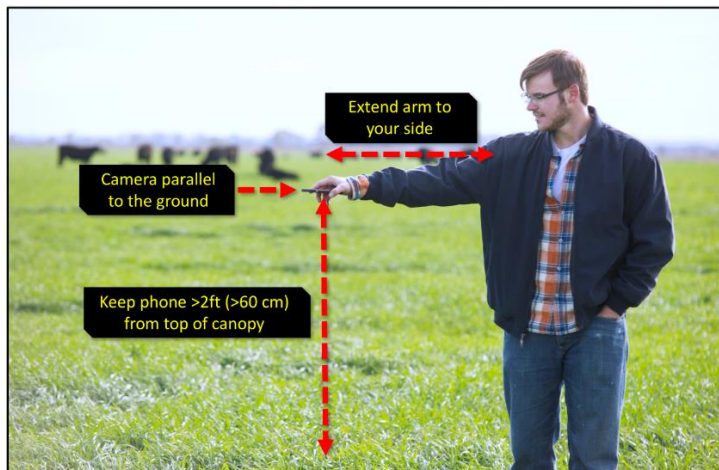
A tripod could also be used to ensure consistent heights and angles although this could still be a challenge due to concerns with accessing private land.

Extend arm to your side

Camera parallel to the ground

Keep phone >2ft (>60 cm) from top of canopy

Response to Recommendations

- The variability observed between the in-field verification and the original survey observations could be attributed to differences in "ocular calibration" between the different surveyors across the survey teams. DCR recognizes that additional guidance should be given on data collections methods and photos of residue amounts to allow for better calibration across the survey teams.

- Report has been updated to clarify that the 95 sites that were compared to the original 189 in-field ground truthed sites were a subset of the 189 sites where images were taken.

- DCR acknowledges the reminder of the recommendations in the 2017 Recommendations Report

- Location information has been removed from the photos available through the link in the report appendix.

Conclusions

- With the final error matrix for verification using photographs being approximately 85%, this process has shown that photos can be used to achieve accurate residue determinations without the need for revisiting points in person.

- **DCR seeks consensus from this workgroup to accept the methodology and to allow the submission of this survey's results for use in the Chesapeake Bay Model beginning with 2023 Progress.**

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