Virginia Department of Recreation and Conservation

Division of Soil and Water Conservation

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

Introduction

- Virginia's previous tillage survey was completed in 2015
- A new survey needed to occur to update the 2015 survey
- Planning for an update survey began during the Fall of 2020 for a 2021 survey
  - Postponed due to COVID concerns and the requirement for multiple staff to be in vehicles performing the operations
- Planning resumed during the Fall of 2021 for a rescheduled 2022 survey as COVID exposure concerns began to ease

Purpose of Presentation to Agriculture Workgroup

- 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

Survey Methodology

2015 Residue Categories

- Less than 30%
- 30% - 60%
- Greater than 60%

2022 Residue Categories

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

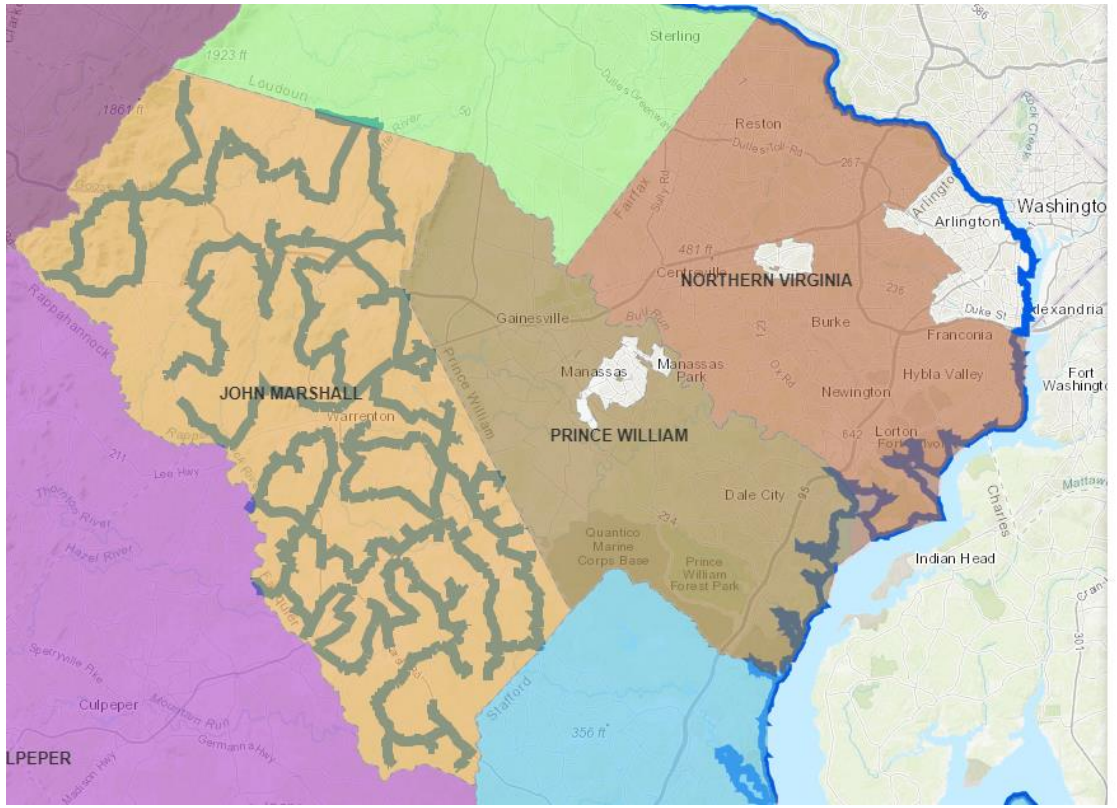
- The *a priori* estimate for the 2015 survey was the latest CTIC survey results
- The 2015 results were the *a priori* estimates for the 2022 sample size calculations.
- The survey units, with few exceptions, were the same for the two surveys.

Survey Teams

- Survey teams for both the 2015 and 2022 surveys were composed primarily of Soil and Water Conservation District staff.
  - Many with previous experience estimating crop residue
  - Familiar with areas they are surveying
- DCR provided training for all survey team members to ensure that all teams followed the same procedures.
  - Training materials available through links in appendix of document provided along with this presentation
- Each survey team consisted of a minimum of 2 members – a driver and a data collector

Survey Routes

- DCR assisted survey teams to determine routes for the 2015 and 2022 surveys when necessary
  - Routes for 2015 and 2022 surveys were not necessarily the same
- For the 2022 survey, 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



Data Collection

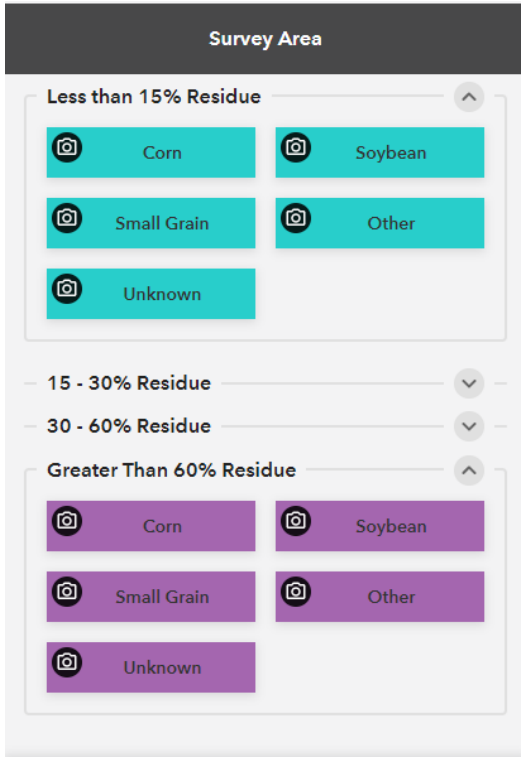
- Surveyors worked in designated survey units to minimally obtain the specific number of cropland survey points required.
- The 2015 survey utilized a hard copy data collection form while the 2022 utilized a digital data collection application

2015 Data Collection Form

Survey Unit: JR – Lower Survey Team: Jim Askew, Mert Lambeer Date: 5/2/15

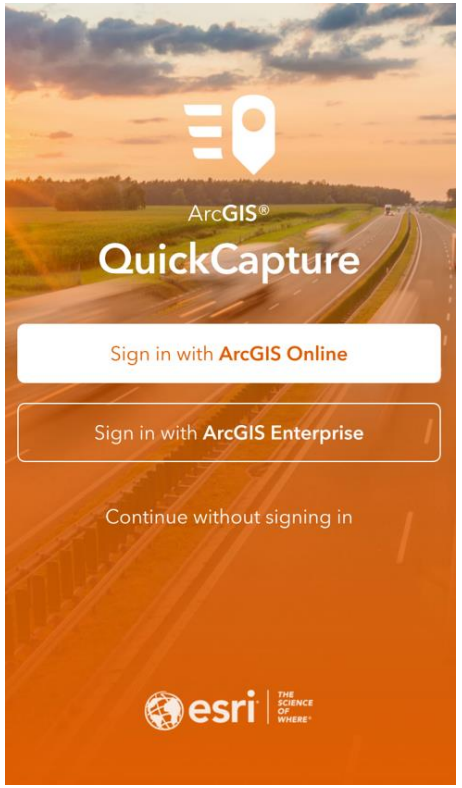
CROP RESIDUE	< 30 %	30 – 60 %	> 60 %
CORN			
SOYBEAN			
SMALL GRAIN			
COTTON			
OTHER			
UNKNOWN			

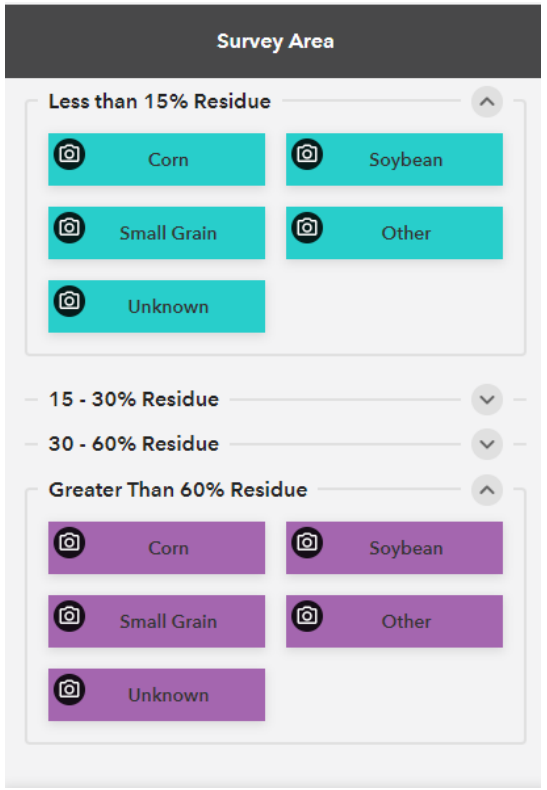
2022 Data Collection Form



2022 Survey Mobile Data Collection

- ESRI's Quick Capture application was used to capture residue observations
- Easy to use, straightforward interface
- Option to collect photo with each point entered
  - Survey teams were instructed to capture a photo for approximately every 5th point observed
- Runs on any Android or iOS (Apple) devices (phones and tablets)
- Data collected is synched with feature class in ArcGIS Online

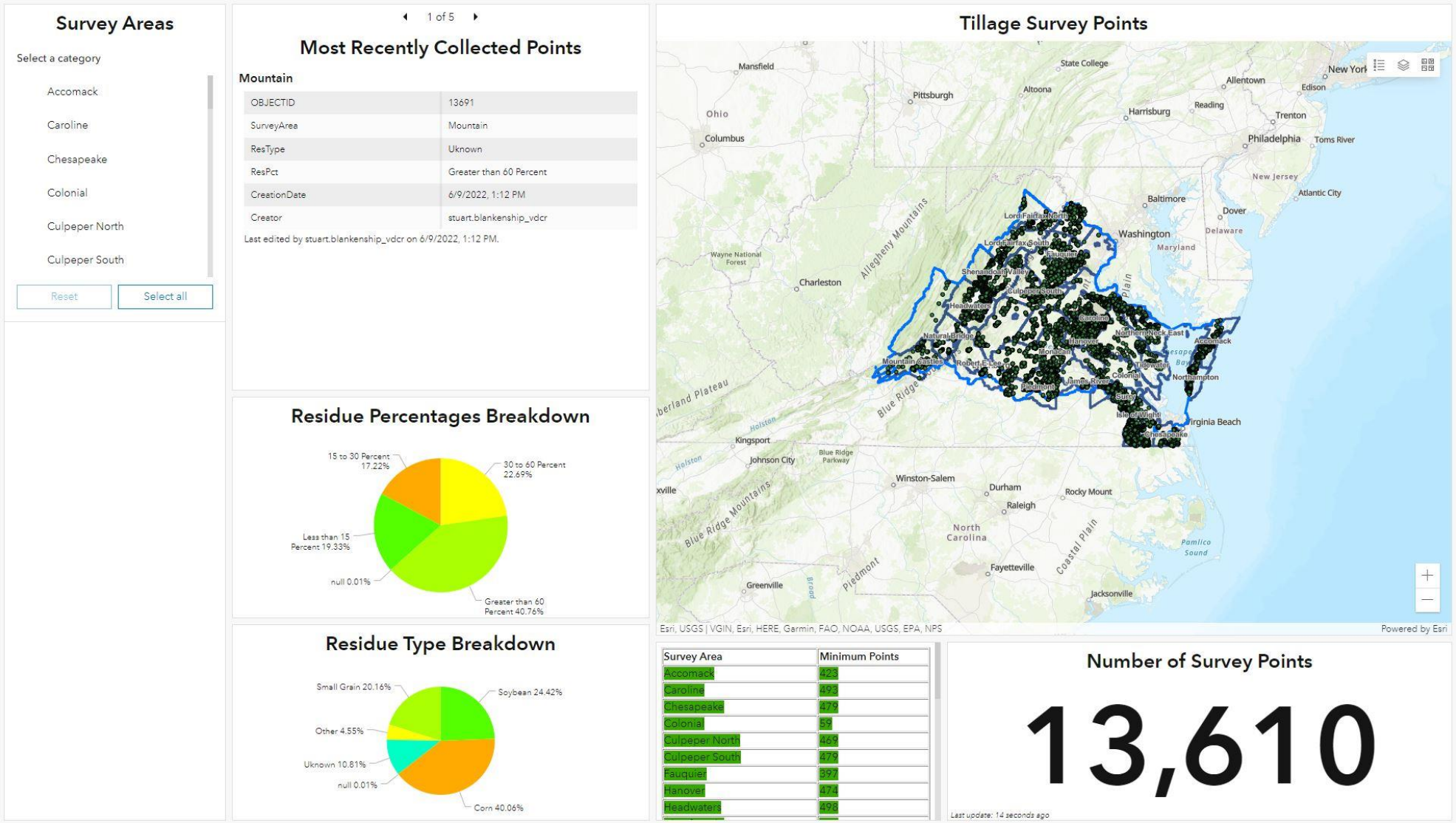




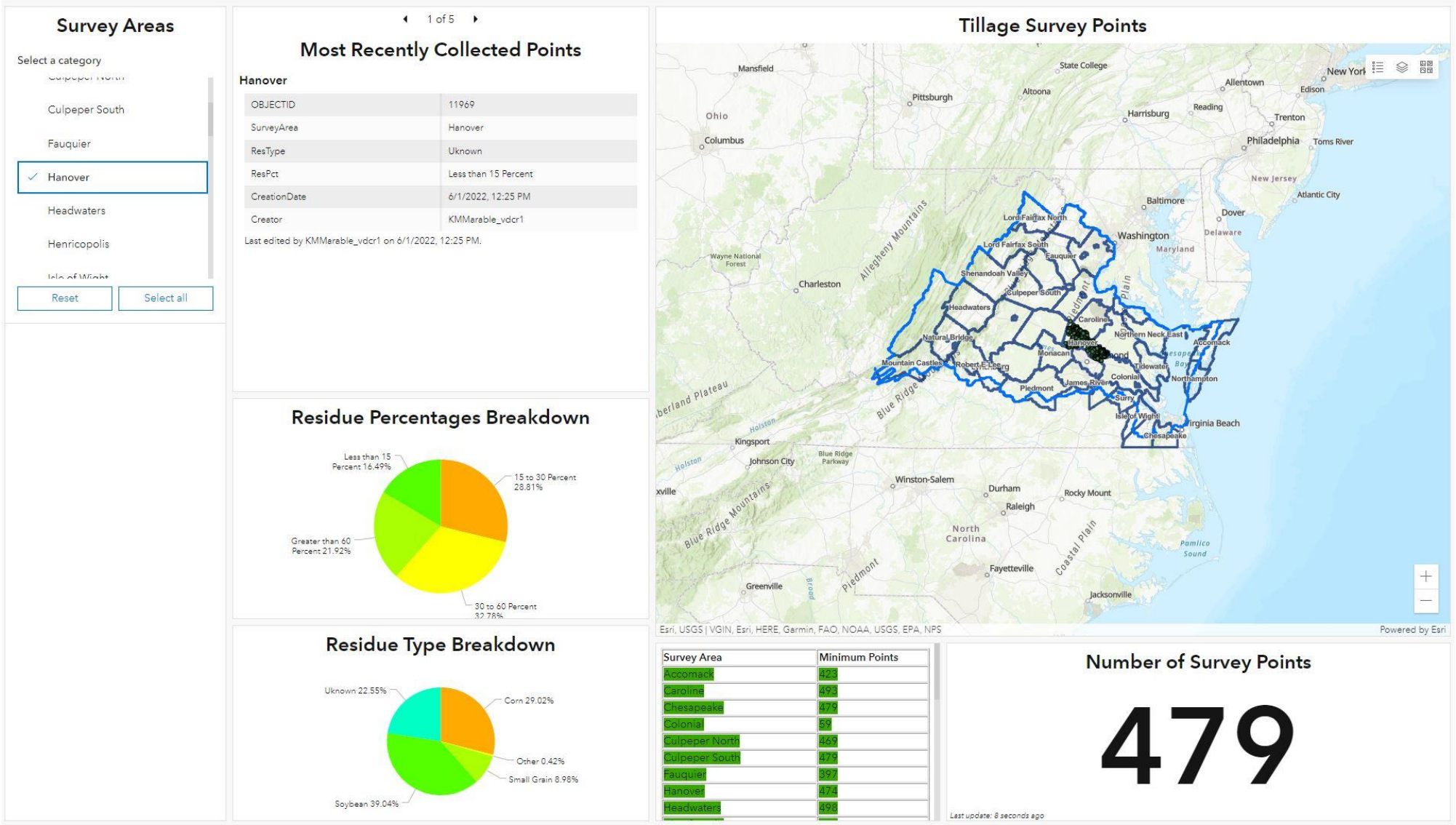
Monitoring Using ESRI Dashboard

- 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.

ESRI Dashboard



ESRI Dashboard (filtered)



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		

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

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	

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

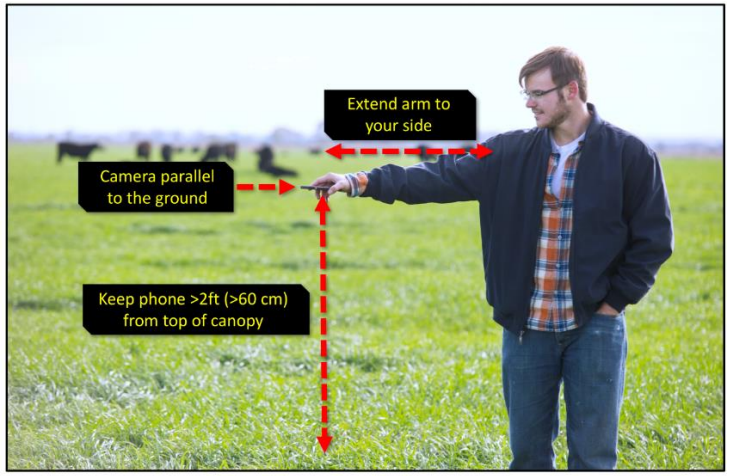
Lessons Learned

- 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.
  - While it was possible to determine residue coverage, DCR will investigate methods to overlay a “virtual ruler” on photographs to allow for more accurate residue determinations.
  - 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.

Lessons Learned - Continued

- 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.

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.
- The Agriculture Workgroup approved the methodology used in the 2022 survey during the August 2023 meeting.

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