Application of Remote Sensing to Identify and Inventory Agricultural Conservation Practices for the Bay Model

Jon Harcum

Steve Dressing

Tetra Tech, Inc.

Agriculture Workgroup Meeting

January 26, 2017

Tetra Tech Assessment

An assessment of remote sensing accuracy was performed to determine the suitability of remote sensing to identify agricultural conservation practices for credit in the Chesapeake Bay Program (CBP) partnership's watershed model. The assessment combined the findings from a literature search and a detailed evaluation of the strengths and weaknesses of selected metrics.

Literature

- One publication yielded applicable information regarding levels of remote sensing accuracy and the extent of ground-truthing needed in the identification of conservation tillage (Sullivan et al. 2008)
- In short:
  - Sample Size: *n* = 20 seems acceptable although larger n increased accuracy (*n* = 20 and 44 assessed)
  - Overall accuracy of 71% to 78% seems acceptable
  - FAR of 15% to 20% seems acceptable

Possible Outcomes for Remote Sensing

BMP Observed Remotely and Confirmed on Ground (a)	BMP Observed Remotely but not Confirmed on Ground (b)	BMP Not Observed Remotely but Found on Ground (c)	BMP Not Observed Remotely and Not Found on Ground (d)

Data Elements Used in Metrics

		Field Observed		
		Yes	No	Row Total
Remote Sensing	Yes	a	b	a+b
	No	c	d	c+d
	Column Total	a+c	b+d	a+b+c+d=n

Metric	Formula
Critical Success Index (CSI)	a/(a+b+c)
False Alarm Rate (FAR)	b/(a+b)
Hit Rate (HR)	a/(a+c)
Post Agreement Rate (PAG)	a/(a+b)
Proportion Correct (PC)	(a+d)/(a+b+c+d)
Frequency Bias (FB)	(a+b)/(a+c)

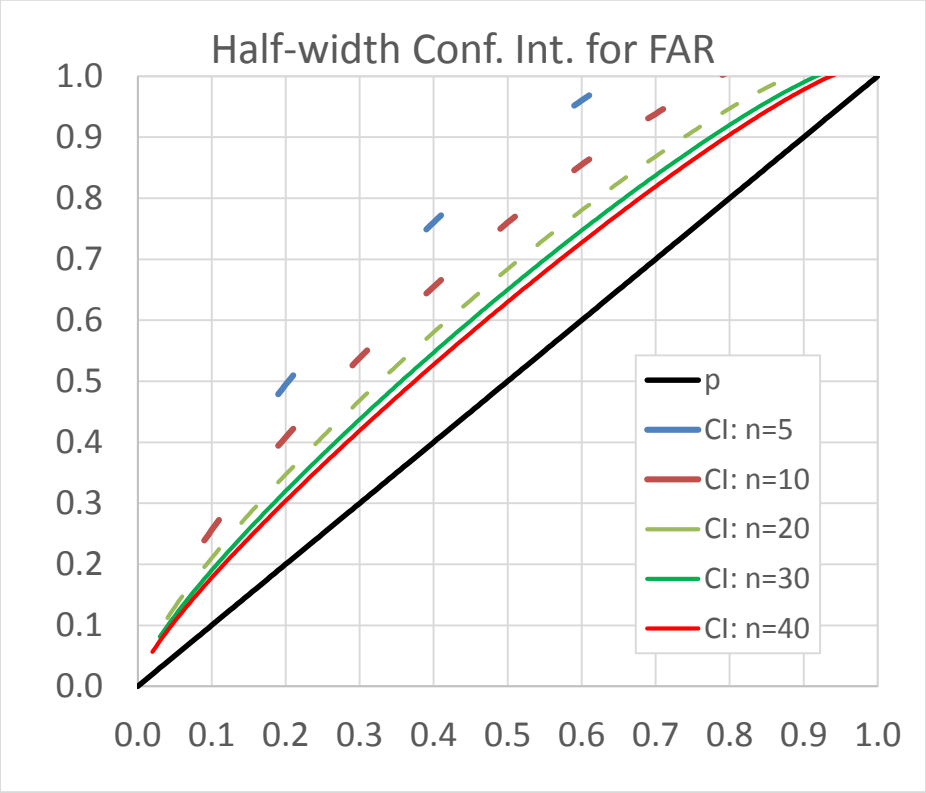
Metrics

- Metrics chosen for assessment are
  - FAR (False Alarm Rate, 0-1)
    - 0 → all found BMPs confirmed
  - PAG (Post-Agreement Rate = 1-FAR, 0-1)
    - user accuracy → probability that BMP found remotely is confirmed
  - HR (Hit Rate, 0-1)
    - 1 → all BMPs found
  - FB (Frequency Bias, 0-∞):
    - 1 → unbiased result
    - >1 → BMPs are over-identified
    - <1 → BMPs under-identified

		Field Observed		
		Yes	No	Total
Remote Sensing	Yes	a	b	a+b
	No	c	d	c+d
	Tot.	a+c	b+d	n

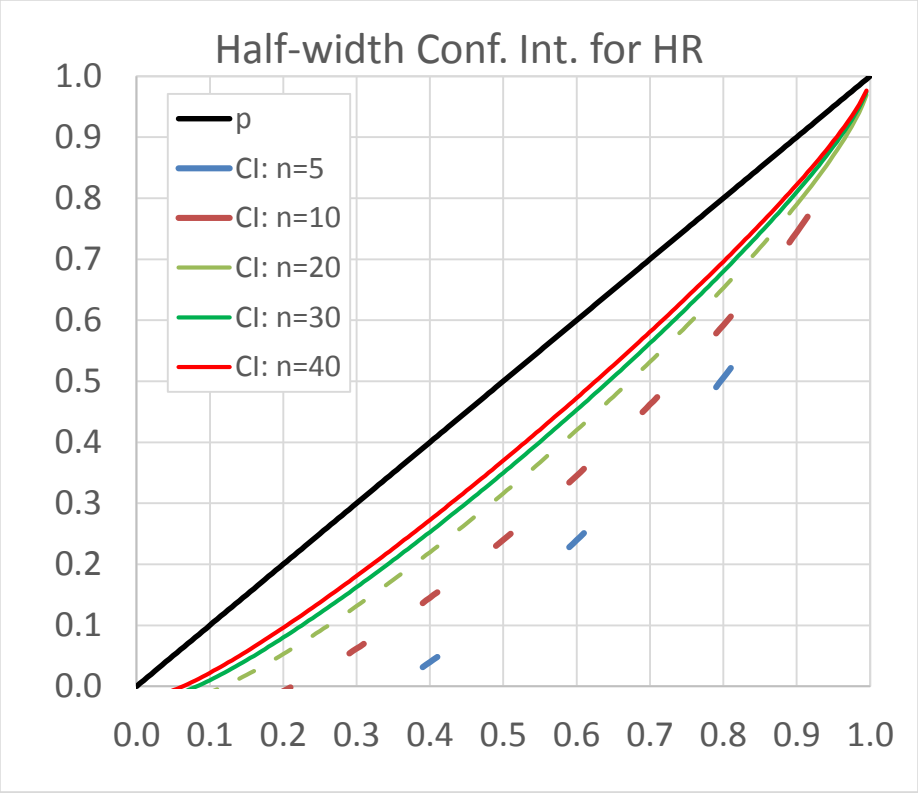
Metric	Formula
False Alarm Rate (FAR)	b/(a+b)
Hit Rate (HR)	a/(a+c)
Post Agreement Rate (PAG)	a/(a+b)
Frequency Bias (FB)	(a+b)/(a+c)

Results



Half-Width Confidence Intervals for FAR with Large N

Results



Half-Width Confidence Intervals for HR with Large N

Scaling Results

- Dividing the total number of remote-sensing detected BMPs by FB could be used to scale the remote sensing results to correct for bias. Is equivalent to multiplying by the ratio of PAG/HR.
- Confidence interval for the ratio PAG/HR can also be calculated.

Example Bias Correction

Practice Name	BMP Observed Remotely and Confirmed on Ground (a)	BMP Observed Remotely but Not Confirmed on Ground (b)	BMP Not Observed Remotely but Found on Ground (c)	Total Field Verification Sample Size (d)	Population Size (N)	
Strip cropping	110	22	40	172	1371	
	FAR	HR	CSI	PC	PAG	
Estimate	0.17	0.73	0.64	0.64	0.83	
UCL90	0.22					
LCL90		0.68	0.58	0.58	0.78	
	FB	PAG / HR	Overall Remotely Sensed BMPs	Bias Corrected Estimate of BMPs		
Estimate	0.88	1.14	1,371	1,558		
LCL90		1.02		1,405		
UCL90		1.26		1,727		

Recommendations

- Two-step process may be appropriate where the first step requires that the following conditions be met:
  - Sample size ≥20
  - FAR (upper 90% confidence limit value is recommended) is at or below the threshold value
    - perhaps 0.2 or 0.3
  - HR (lower 90% confidence limit value is recommended) is at or above the threshold value
    - perhaps 0.7 or 0.8 (NOTE: Example on slide 10 was 0.68)

Recommendations (cont.)

- If first step conditions are met, the estimate of BMP quantity would then be corrected for bias using the ratio of PAG/HR
  - Lower confidence limit value is recommended for a conservative estimate

Discussion