Land Cover and Change Accuracy Assessment

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Land Use Work Group

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U.S. Department of the Interior
U.S. Geological Survey

Chesapeake Conservancy

University of Vermont Spatial Analysis Lab

Accuracy Assessment Process

1. Generate points to sample
2. Load in National Agricultural Imagery Program (NAIP) imagery for 2013/14 and 2021/22
3. Two people, individually, classify what the land cover is in both dates

2013/14 2021/22

Challenges

Challenges

Distance to patch edge

The closer the point is to the edge, the more difficult it is to identify.

In this example, the point is in the transition zone between a crop field and the tree line.

Challenges

Subjectivity of land cover

Some land covers are similar and aren’t a cut-and-dry call.

For example, the difference between Low Vegetation, Shrubland, and Tree Canopy is the height of the feature. This point lies where those three classes mix.

Additionally, the height at any given point can’t be seen from the imagery itself.

Challenges

Shadows

Shadows present both classification and validation challenges. Shadows can mask the feature and make them difficult to identify.

The shadows are different in the images due to differences in flight angle and sun angle (time of day and year)

Challenges

Changes in image resolution

The 2013/14 imagery is 1-meter resolution. The 2021/22 imagery is 60-centimeter (0.6-meters).

The features in the 60-cm imagery are clearer and more easily identifiable.

Key Terms

- Overall Accuracy
  - What percentage of the map represents what is actually on the ground
- Producer’s Accuracy
  - What percentage of the actual thing (e.g. tree canopy) is mapped as the thing
- User’s Accuracy
  - How likely the mapped thing (e.g. tree canopy) is actually the thing mapped

What are the Accuracies to be Reported?

Static Land Cover

96% of the mapped region

Overall Accuracy*: 95%

Land Cover	Producer's*	User's*
Water	99%	98%
Herbaceous	94%	95%
Tree Canopy	97%	95%
Impervious	89%	91%
Barren	40%	63%

* Represents fuzzy (3x3-meter window) accuracy between 5 classes

Land Cover Change

4% of the mapped region

Overall Accuracy**: 86%

Producer's: 96%

User's: 77%

** Represents fuzzy (3x3-meter window) accuracy between change and no change

Water
Water

Herbaceous
Low Vegetation
Shrubland
Emergent Wetlands

Tree Canopy
Tree Canopy
Tree Canopy over Structures
Tree Canopy over Other Impervious
Tree Canopy over Roads

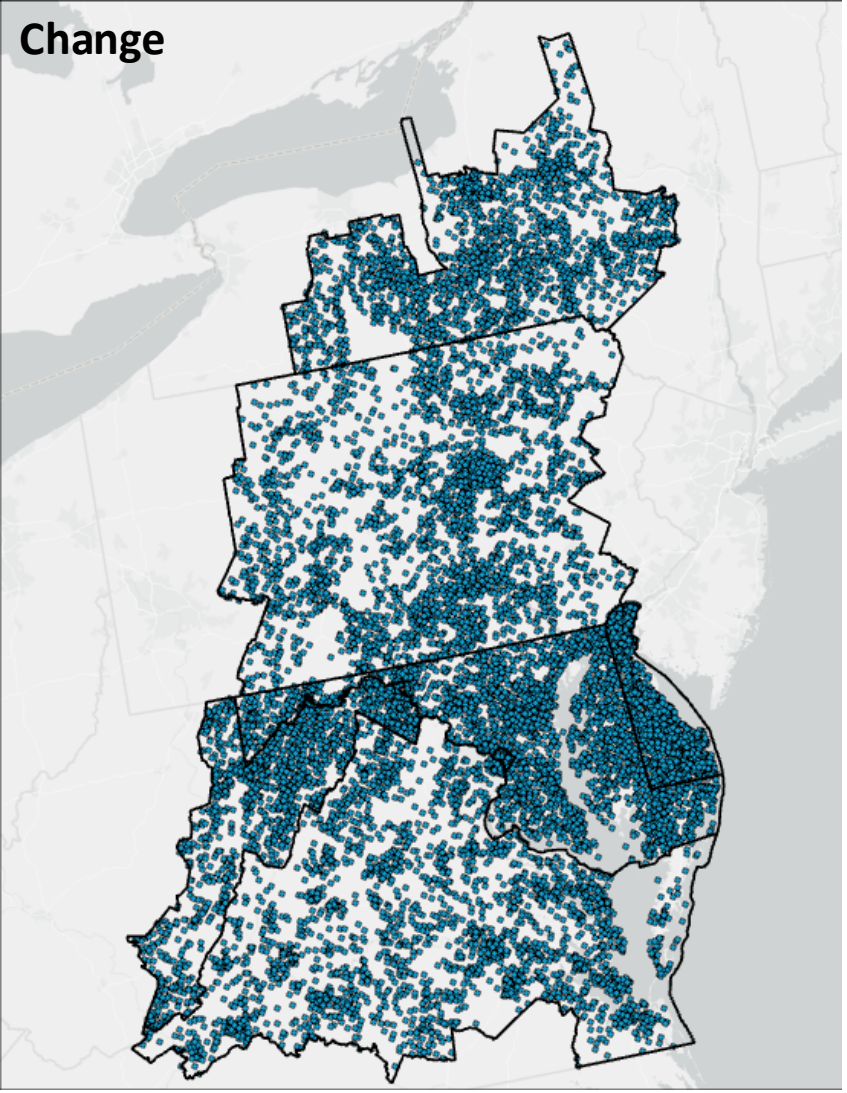
Impervious
Structures
Other Impervious
Roads

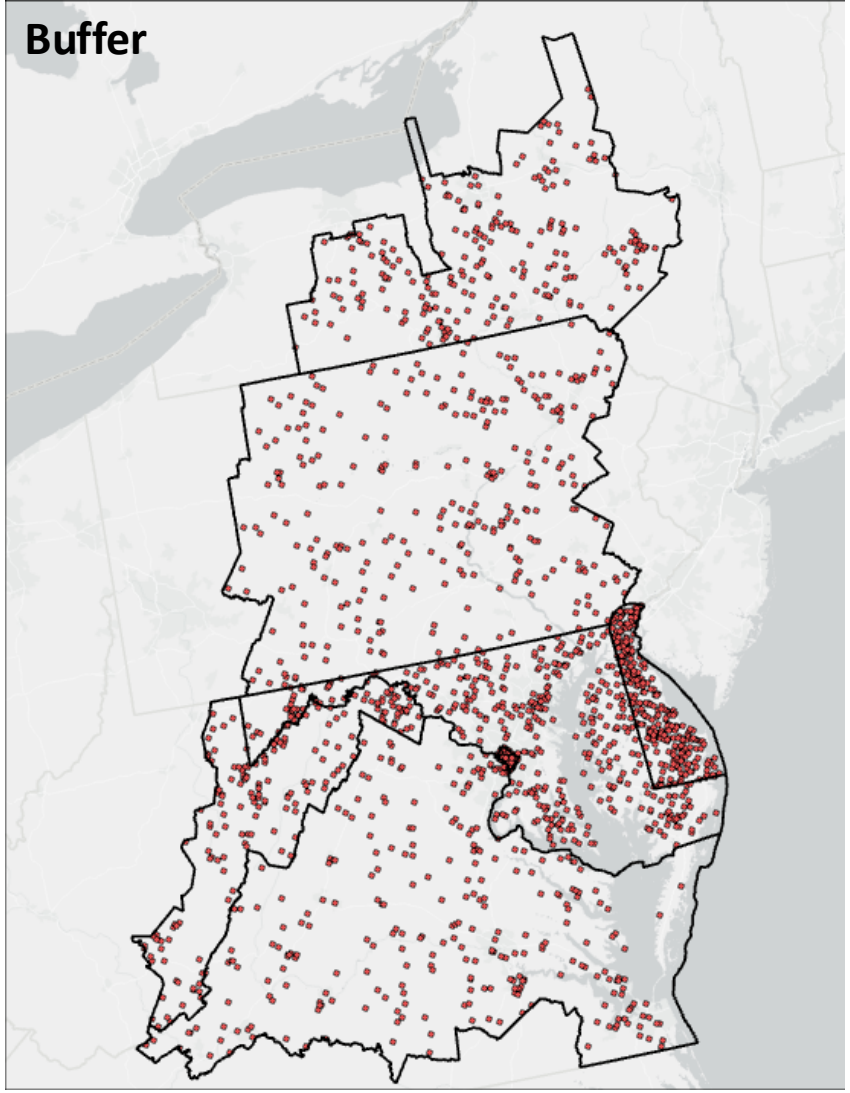
Barren
Barren

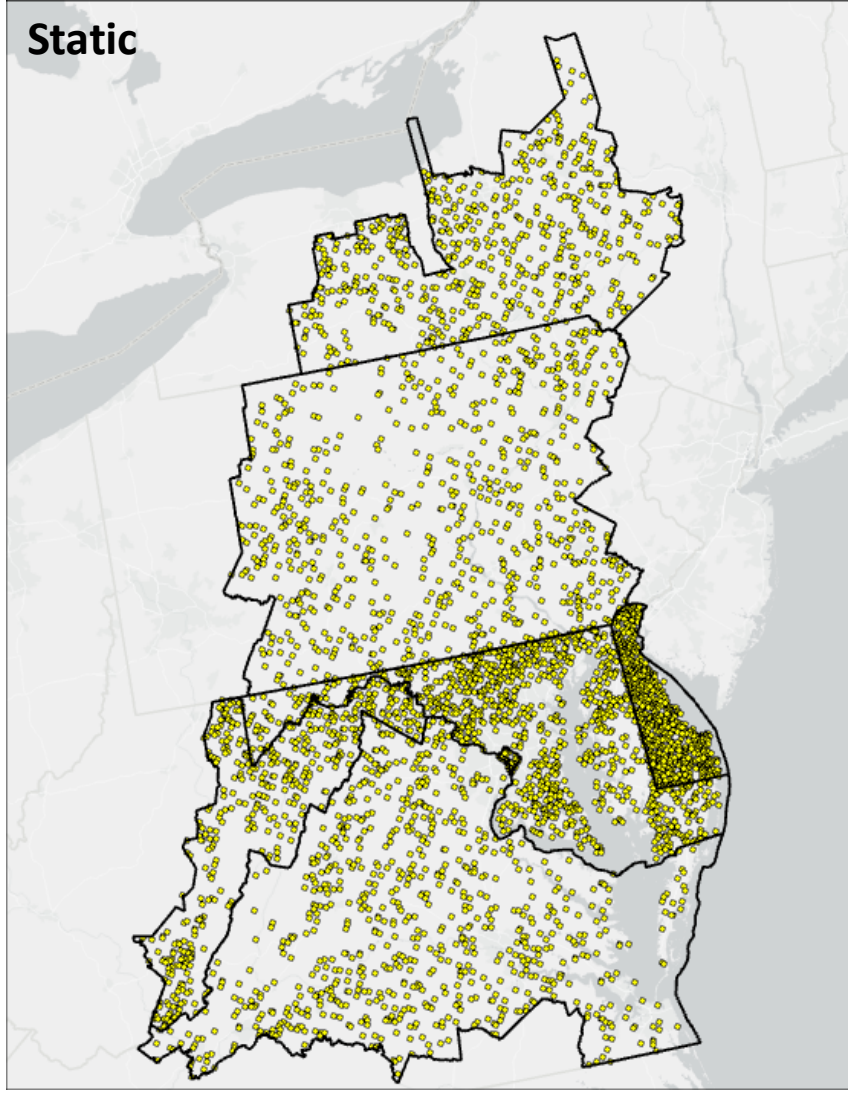
Accuracy Assessment Overview

state	change	static	buffer
DC	3,153	777	298
DE	3,784	924	320
MD	4,154	1,010	381
NY	2,600	573	224
PA	3,375	721	287
VA	3,912	790	292
WV	2,219	476	190
Total	**23,197**	**5,271**	**1,992**

- The primary purpose of the assessment is to evaluate the accuracy of land cover change from 2013/14 – 2021/22.
- The University of Vermont Spatial Analysis Lab (UVM-SAL) and the Chesapeake Conservancy Conservation Innovation Center (CC-CIC) ground truthed over 30,000 points from imagery.
- The points are stratified by state and the three criteria below.
    1. Change – mapped land cover change
    2. Buffer – no mapped land cover change within a 100-meter buffer of mapped change
    3. Static – no mapped change outside of 100-meter buffer of mapped change







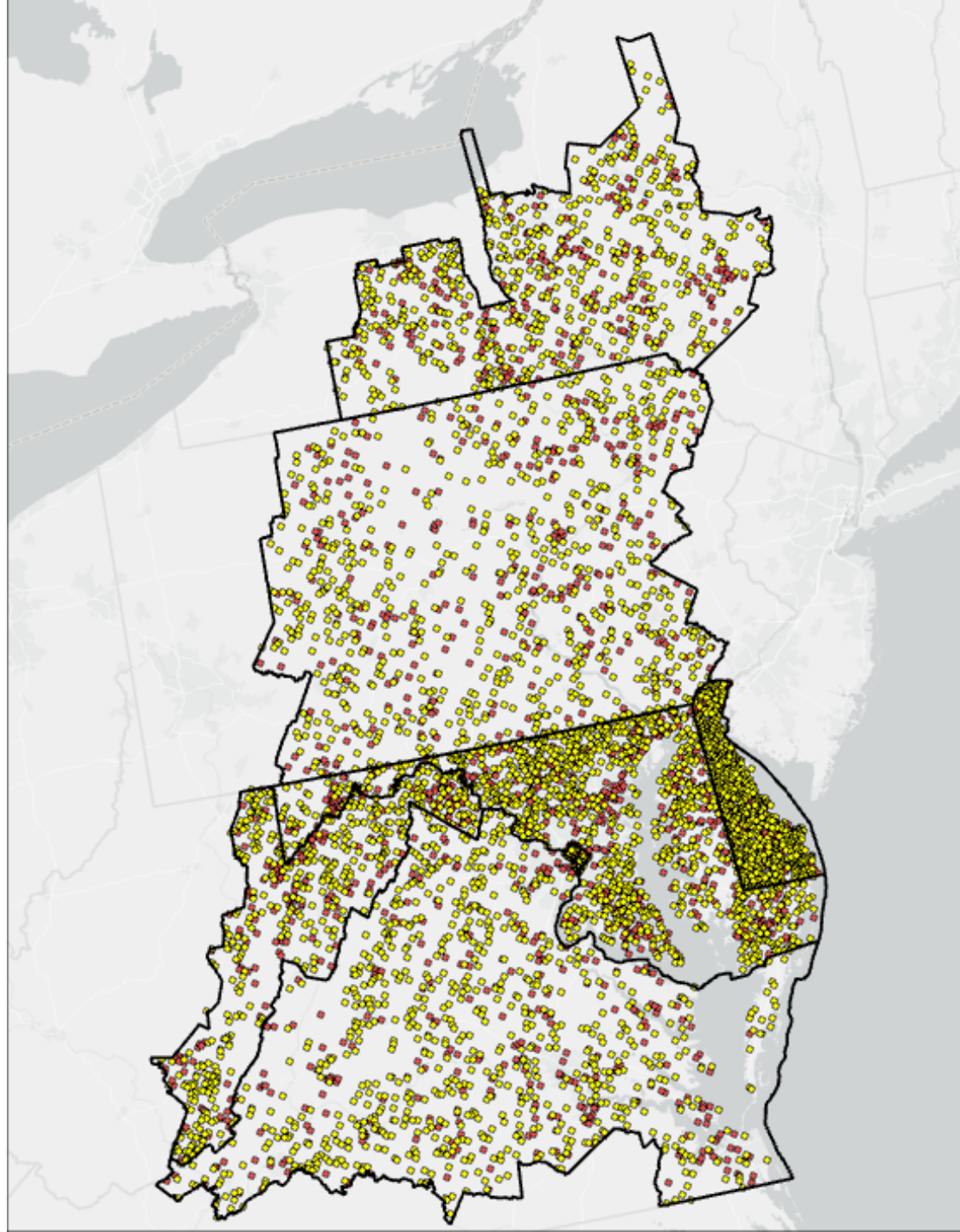
Point Distribution by Type

Static Accuracy

- Points from the Static and Buffer types represent areas where no change is mapped in 2021/22

- Change points are excluded for static accuracy because:
  - Static accuracy is most likely to be incorrect where change occurred AND
  - Mapped change makes up only 3.8% of the total mapped area.

- Including change points in static accuracy assessment disproportionately skews the results that is not representative of the data.
  - Change accuracy is evaluated separately.



Static Accuracy (Outside of mapped change)

Ground Truth Land Cover

Mapped Land Cover	WATR	EMWT	TREE	SHRB	LOWV	BARR	STRC	IMPO	ROAD	TCST	TCOI	TCRO	Frequency	UA
WATR	768	4	2	-	5	-	-	1	-	-	-	-	780	98%
EMWT	7	76	2	-	1	-	-	-	-	-	-	-	86	88%
TREE	2	2	3,103	39	69	-	-	3	2	1	5	8	3,234	96%
SHRB	1	5	96	40	78	-	-	1	-	-	-	-	221	18%
LOWV	4	14	71	23	2,348	6	3	11	2	-	-	1	2,483	95%
BARR	3	-	8	-	32	31	-	7	1	-	-	-	82	38%
STRC	-	-	2	-	4	-	95	6	1	-	-	-	108	88%
IMPO	-	-	2	1	20	11	1	88	10	-	2	-	135	65%
ROAD	-	-	1	-	2	3	-	8	89	-	-	2	105	85%
TCST	-	-	3	-	-	-	3	-	-	-	-	-	6	0%
TCOI	-	-	5	-	2	-	-	2	1	-	2	1	13	15%
TCRO	-	-	-	-	2	-	-	-	3	-	-	5	10	50%
Frequency	785	101	3,295	103	2,563	51	102	127	109	1	9	17	7,263	
PA	98%	75%	94%	39%	92%	61%	93%	69%	82%	0%	22%	29%		**91%**

WATR = Water
EMWT = Emergent Wetlands
TREE = Tree Canopy
SHRB = Shrubland
LOWV = Low Vegetation
BARR = Barren
STRC = Structures
IMPO = Impervious Other
ROAD = Roads
TCST = Tree Canopy over Structures
TCOI = Tree Canopy over Other Impervious
TCRO = Tree Canopy over Roads

Static Accuracy (Outside of mapped change)

Ground Truth Land Cover

Mapped Land Cover

LC	WATR	EMWT	TREE	SHRB	LOWV	BARR	STRC	IMPO	ROAD	TCST	TCOI	TCRO	Frequency	UA
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EMWT	7	76	2	-	1	-	-	-					86	88%
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STRC	-	-	2	-	4	-	95	6	1	-	-	-	108	88%
IMPO						11	1	88	10	-	2	-	135	65%
ROAD						3	-	8	89	-	-	2	105	85%
TCST						-	3	-	-	-	-	-	6	0%
TCOI						-	-	2	1	-	2	1	13	15%
TCRO	-	-	-	-	2	-	-	-	3	-	-	5	10	50%
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PA	98%	75%	94%	39%	92%	61%	93%	69%	82%	0%	22%	29%		91%

Off-Diagonal (White cells)
Represents the number of incorrectly mapped points

Diagonal (Green cells)
Represents the number of correctly mapped points

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ROAD = Roads
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Static Accuracy (Outside of mapped change)

Ground Truth Land Cover

Mapped Land Cover

LC	WATR	EMWT	TREE	SHRB	LOWV	BARR	STRC	IMPO	ROAD	TCST	TCOI	TCRO	Frequency	UA
WATR	768	4	2	-	5	-	-	1	-	-	-	-	780	98%
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LOWV	4	14	71	23	2,348	6	3	11	2	-	-	1	2,483	95%
BARR	3	-	8	-	32	31						-	82	38%
STRC	-	-	2	-	4	-						-	108	88%
IMPO	-	-	2	1	20	11						-	135	65%
ROAD	-	-	1	-	2	3						2	105	85%
TCST	-	-	3	-	-	-	3	-	-	-	-	-	6	0%
TCOI	-	-	5	-	2	-	-	2	1	-	2	1	13	15%
TCRO	-	-	-	-	2	-	-	-	3	-	-	5	10	50%
Frequency	785	101	3,295	103	2,563	51	102	127	109	1	9	17	7,263	
PA	98%	75%	94%	39%	92%	61%	93%	69%	82%	0%	22%	29%		91%

Total Frequency
Represents the total number of points evaluated

WATR = Water
EMWT = Emergent Wetlands
TREE = Tree Canopy
SHRB = Shrubland
LOWV = Low Vegetation
BARR = Barren
STRC = Structures
IMPO = Impervious Other
ROAD = Roads
TCST = Tree Canopy over Structures
TCOI = Tree Canopy over Other Impervious
TCRO = Tree Canopy over Roads

Static Accuracy (Outside of mapped change)

Ground Truth Land Cover

Mapped Land Cover	WATR	EMWT	TREE	SHRB	LOWV	BARR	STRC	IMPO	ROAD	TCST	TCOI	TCRO	Frequency	UA
WATR	768	4	2	-	5	-	-	1	-	-	-	-	780	98%
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TCST	-	-	3	-	-	-						-	6	0%
TCOI	-	-	5	-	2	-	-	2	1	-	2	1	13	15%
TCRO	-	-	-	-	2	-	-	-	3	-	-	5	10	50%
Frequency	785	101	3,295	103	2,563	51	102	127	109	1	9	17	7,263	
PA	98%	75%	94%	39%	92%	61%	93%	69%	82%	0%	22%	29%		91%

Overall Accuracy (91%)
Represents the total number of correctly mapped points out of all points evaluated

WATR = Water
EMWT = Emergent Wetlands
TREE = Tree Canopy
SHRB = Shrubland
LOWV = Low Vegetation
BARR = Barren
STRC = Structures
IMPO = Impervious Other
ROAD = Roads
TCST = Tree Canopy over Structures
TCOI = Tree Canopy over Other Impervious
TCRO = Tree Canopy over Roads

Static Accuracy (Outside of mapped change)

Ground Truth Land Cover

Mapped Land Cover

LC	WATR	EMWT	TREE	SHRB	LOWV	BARR	STRC	IMPO	ROAD	TCST	TCOI	TCRO	Frequency	UA
WATR	768	4	2	-	5	-	-	1	-	-	-	-	780	98%
EMWT	7	76	2	-	1	-	-	-	-	-	-	-	86	88%
TREE	2	2	3,103	39	69	-						8	3,234	96%
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STRC	-	-	2	-	4	-						-	108	88%
IMPO	-	-	2	1	20	11						-	135	65%
ROAD	-	-	1	-	2	3						2	105	85%
TCST	-	-	3	-	-	-						-	6	0%
TCOI	-	-	5	-	2	-	-	2	1	-	2	1	13	15%
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Frequency	785	101	3,295	103	2,563	51	102	127	109	1	9	17	7,263	
PA	98%	75%	94%	39%	92%	61%	93%	69%	82%	0%	22%	29%		**91%**

Producer's Accuracy (PA)
Represents the percent of the truth data that are mapped correctly, per class.

For example, 94% of the Tree Canopy ground truth points (3,103 / 3,295) are mapped correctly.

WATR = Water
EMWT = Emergent Wetlands
TREE = Tree Canopy
SHRB = Shrubland
LOWV = Low Vegetation
BARR = Barren
STRC = Structures
IMPO = Impervious Other
ROAD = Roads
TCST = Tree Canopy over Structures
TCOI = Tree Canopy over Other Impervious
TCRO = Tree Canopy over Roads

Static Accuracy (Outside of mapped change)

Ground Truth Land Cover

Mapped Land Cover	WATR	EMWT	TREE	SHRB	LOWV	BARR	STRC	IMPO	ROAD	TCST	TCOI	TCRO	Frequency	UA
WATR	768	4	2	-	5	-	-	1	-	-	-	-	780	98%
EMWT	7	76	2	-	1	-						-	86	88%
TREE	2	2	3,103	39	69	-						8	3,234	96%
SHRB	1	5	96	40	78	-						-	221	18%
LOWV	4	14	71	23	2,348	6						1	2,483	95%
BARR	3	-	8	-	32	31						-	82	38%
STRC	-	-	2	-	4	-						-	108	88%
IMPO	-	-	2	1	20	11						-	135	65%
ROAD	-	-	1	-	2	3						2	105	85%
TCST	-	-	3	-	-	-						-	6	0%
TCOI	-	-	5	-	2	-	-	2	1	-	2	1	13	15%
TCRO	-	-	-	-	2	-	-	-	3	-	-	5	10	50%
Frequency	785	101	3,295	103	2,563	51	102	127	109	1	9	17	7,263	
PA	98%	75%	94%	39%	92%	61%	93%	69%	82%	0%	22%	29%		**91%**

User's Accuracy (UA)
Represents the percent of the mapped data that are mapped correctly, per class.

For example, 96% of the mapped Tree Canopy points (3,103 / 3,234) are mapped correctly.

WATR = Water
EMWT = Emergent Wetlands
TREE = Tree Canopy
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LOWV = Low Vegetation
BARR = Barren
STRC = Structures
IMPO = Impervious Other
ROAD = Roads
TCST = Tree Canopy over Structures
TCOI = Tree Canopy over Other Impervious
TCRO = Tree Canopy over Roads

Static Accuracy (Outside of mapped change)

Ground Truth Land Cover

Mapped Land Cover

LC	WATR	EMWT	TREE	SHRB	LOWV	BARR	STRC	IMPO	ROAD	TCST	TCOI	TCRO	Frequency	UA
WATR	768	4	2	-	5	-	-	1	-	-	-	-	780	98%
EMWT	7	76	2	-	1	-	-	-	-	-	-	-	86	88%
TREE	2	2	3,103	39	69	-						8	3,234	96%
SHRB	1	5	96	40	78	-						-	221	18%
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STRC	-	-	2	-	4	-						-	108	88%
IMPO	-	-	2	1	20	11						-	135	65%
ROAD	-	-	1	-	2	3						2	105	85%
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TCOI	-	-	5	-	2	-	-	2	1	-	2	1	13	15%
TCRO	-	-	-	-	2	-	-	-	3	-	-	5	10	50%
Frequency	785	101	3,295	103	2,563	51	102	127	109	1	9	17	7,263	
PA	98%	75%	94%	39%	92%	61%	93%	69%	82%	0%	22%	29%		**91%**

What Classes are Confused?
Shrubland is largely confused with Tree Canopy (TC) and Low Vegetation (LV).

This is likely due to shrubland being subjective (when does LV become shrubland and shrubland/LV become TC?).

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BARR = Barren
STRC = Structures
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ROAD = Roads
TCST = Tree Canopy over Structures
TCOI = Tree Canopy over Other Impervious
TCRO = Tree Canopy over Roads

Static Accuracy: Allowing Confusion Between Classes

Ground Truth Land Cover

Mapped Land Cover

Map_static	WAT	HERB	TREE	BARE	IMP	frequency	UA
WAT	768	9	2	-	1	780	98%
HERB	12	2,585	170	6	17	2,790	93%
TREE	2	114	3,133	-	14	3,263	96%
BARE	3	32	8	31	8	82	38%
IMP	-	27	9	14	298	348	86%
frequency	785	2,767	3,322	51	338	7,263	
PA	98%	93%	94%	61%	88%		94%

Why allow confusion?

1. Address subjective classes
2. Increase sample size (static classes not used as strata)
3. Say something meaningful about the most used metrics derived from the data (e.g. tree canopy and impervious)

WAT (Water)
Water

HERB (Herbaceous)
Low Vegetation
Shrubland
Emergent Wetlands

TREE (Tree Canopy)
Tree Canopy
Tree Canopy over Structures
Tree Canopy over Other Impervious
Tree Canopy over Roads

BARE (Barren)
Barren

IMP (Impervious)
Structures
Other Impervious
Roads

Static Accuracy: Allowing Confusion Between Classes

Ground Truth Land Cover

Mapped Land Cover

Map_static	WAT	HERB	TREE	BARE	IMP	frequency	UA
WAT	768	9	2	-	1	780	98%
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frequency	785	2,767	3,322	51	338	7,263	
PA	98%	93%	94%	61%	88%		94%

Overall Accuracy
Increase from 91% to 94%

WAT (Water)
Water

HERB (Herbaceous)
Low Vegetation
Shrubland
Emergent Wetlands

TREE (Tree Canopy)
Tree Canopy
Tree Canopy over Structures
Tree Canopy over Other Impervious
Tree Canopy over Roads

BARE (Barren)
Barren

IMP (Impervious)
Structures
Other Impervious
Roads

Feature Shift

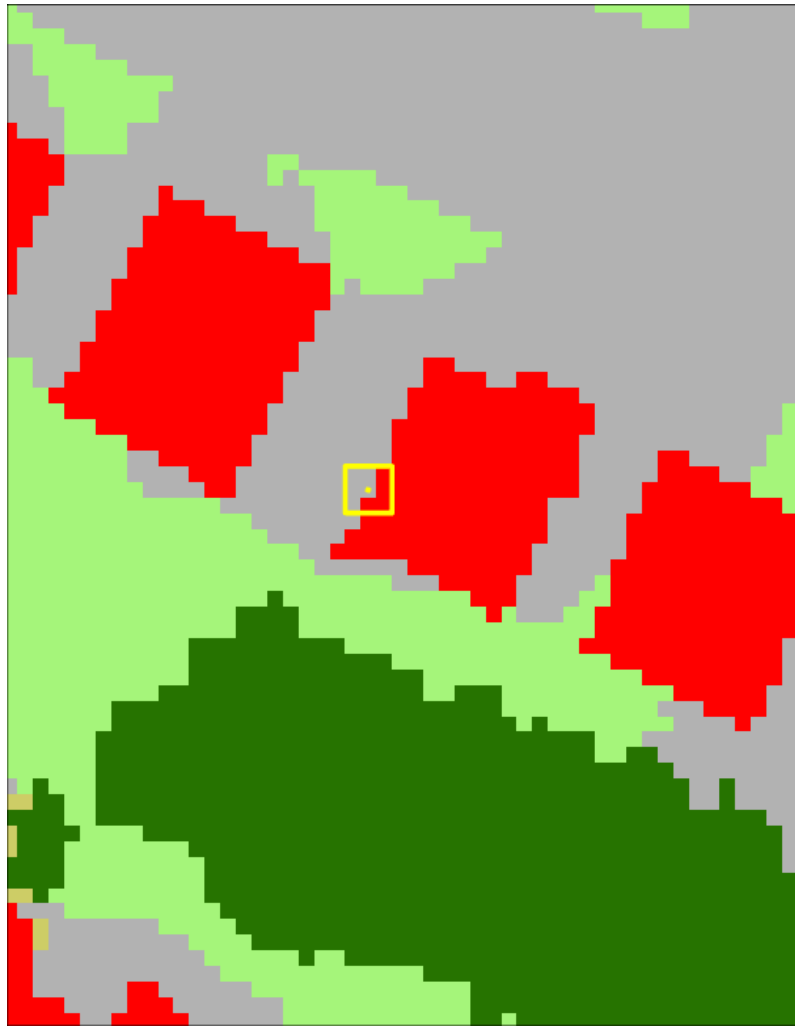
Feature Shift

Why are they different?
The flight angles are different in the images, which can cause shifts for tall features (buildings, trees, etc.)

You cannot see the front of the building

You can see the front of the building

Fuzzy Accuracy – Address Feature Shift



- Assess land cover with 3x3 meter window of each point (one-meter in all directions)
- For example, the point on the left is mapped as other impervious. The ground truth is structure. Since structure is mapped within its 3x3 window, the fuzzy assessment marks this point as correct.

Static Fuzzy Accuracy (Reported)

Ground Truth Land Cover

Mapped Land Cover

Map_static	WAT	HERB	TREE	BARE	IMP	frequency	UA
WAT	770	11	1	3	-	785	98%
HERB	7	2,615	84	32	19	2,757	95%
TREE	2	146	3,162	7	7	3,324	95%
BARE	-	6	-	32	13	51	63%
IMP	1	11	13	7	308	340	91%
frequency	780	2,789	3,260	81	347	7,257	
PA	99%	94%	97%	40%	89%		95%

Overall Accuracy (95%)
Increase from 91% (12 classes)

Increase from 93% (5-classes)

WAT (Water)
Water

HERB (Herbaceous)
Low Vegetation
Shrubland
Emergent Wetlands

TREE (Tree Canopy)
Tree Canopy
Tree Canopy over Structures
Tree Canopy over Other Impervious
Tree Canopy over Roads

BARE (Barren)
Barren

IMP (Impervious)
Structures
Other Impervious
Roads

Static Fuzzy Accuracy (Reported)

Ground Truth Land Cover

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PA	99%	94%	97%	40%	89%		95%

Producer ‘s Accuracy
Water, herbaceous, and tree canopy over 90%

Impervious at 89%

Barren only 40% (difficult to map as it is spectrally similar to impervious).

WAT (Water)
Water

HERB (Herbaceous)
Low Vegetation
Shrubland
Emergent Wetlands

TREE (Tree Canopy)
Tree Canopy
Tree Canopy over Structures
Tree Canopy over Other Impervious
Tree Canopy over Roads

BARE (Barren)
Barren

IMP (Impervious)
Structures
Other Impervious
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Static Fuzzy Accuracy (Reported)

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User's Accuracy
Water, herbaceous, and tree canopy and impervious over 90%

Barren only 63% (difficult to map as it is spectrally similar to impervious).

WAT (Water)
Water

HERB (Herbaceous)
Low Vegetation
Shrubland
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TREE (Tree Canopy)
Tree Canopy
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BARE (Barren)
Barren

IMP (Impervious)
Structures
Other Impervious
Roads

Static Fuzzy Accuracy (Reported)

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Mapped Land Cover: Map_static	WAT	HERB	TREE	BARE	IMP	frequency	UA
WAT	770	11	1	3	-	785	98%
HERB	7	2,615	84	32	19	2,757	95%
TREE	2	146	3,162	7	7	3,324	95%
BARE	-	6	-	32	13	51	63%
IMP	1	11	13	7	308	340	91%
frequency	780	2,789	3,260	81	347	7,257	
PA	99%	94%	97%	40%	89%		95%

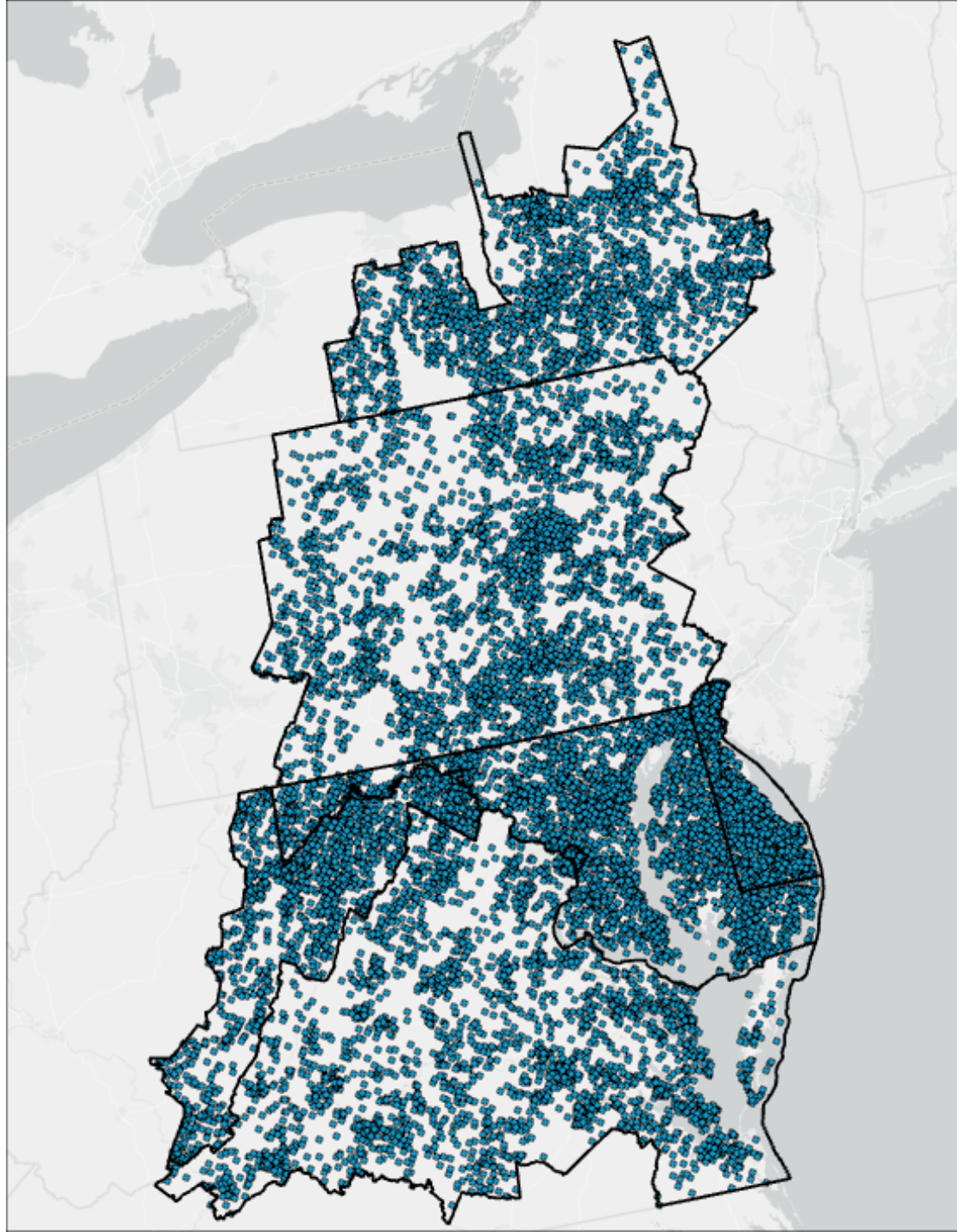
What does this mean?

The static land cover represents where the land cover did not change between 2013/14 and 2021/22. The static land cover makes up 96% of the total mapped area. Of that mapped area, the land cover is highly accurate.

Change Accuracy

- Sampled over 23,000 points of mapped land cover change
  - Stratified by the most mapped change transitions per state

- Sampled almost 2,000 points within a 100-meter buffer of mapped change – where we are most likely to miss change



Change versus No Change Accuracy

Truth

Mapped Change

Map_all	Change	Static	frequency	UA
Change	9,985	5,046	15,031	66%
Static	3,481	11,948	15,429	77%
frequency	13,466	16,994	30,460	
PA	74%	70%		72%

Overall Accuracy (72%)

Of all 30,460 samples, 72% were correctly identified as land cover change or no land cover change

Change versus No Change Accuracy

Truth

Mapped Change

Map_all	Change	Static	frequency	UA
Change	9,985	5,046	15,031	66%
Static	3,481	11,948	15,429	77%
frequency	13,466	16,994	30,460	
PA	74%	70%		72%

Producer's Accuracy Change (74%)

Of the 13,466 points that are change in the truth data, 74% are correctly mapped as change

Change versus No Change Accuracy

Truth

Mapped Change

Map_all	Change	Static	frequency	UA
Change	9,985	5,046	15,031	66%
Static	3,481	11,948	15,429	77%
frequency	13,466	16,994	30,460	
PA	74%	70%		72%

User's Accuracy Change (66%)

Of the 15,031 points that are mapped as change, 74% are change in the truth data

Change versus No Change Fuzzy Accuracy

Truth

Mapped Change

Map_all_fuzzy	Change	Static	frequency	UA
Change	12,980	3,839	16,819	77%
Static	486	13,155	13,641	96%
frequency	13,466	16,994	30,460	
PA	96%	77%		86%

Overall Accuracy (86%)

Of all 30,460 samples, 86% were correctly identified as land cover change or no land cover change within a 3x3 meter window

Change versus No Change Fuzzy Accuracy

Truth

Mapped Change

Map_all_fuzzy	Change	Static	frequency	UA
Change	12,980	3,839	16,819	77%
Static	486	13,155	13,641	96%
frequency	13,466	16,994	30,460	
PA	96%	77%		86%

Producer's Accuracy Change (96%)

Of the 13,466 points that are change in the truth data, 96% are correctly mapped as change within a 3x3 meter window

Change versus No Change Fuzzy Accuracy

Truth

Mapped Change

Map_all_fuzzy	Change	Static	frequency	UA
Change	12,980	3,839	16,819	77%
Static	486	13,155	13,641	96%
frequency	13,466	16,994	30,460	
PA	96%	77%		86%

Producer's Accuracy Change (96%)

Of the 16,819 points that are mapped as change, 77% are change in the truth data within a 3x3 meter window

Change versus No Change Fuzzy Accuracy

Truth

Mapped Change

Map_all_fuzzy	Change	Static	frequency	UA
Change	12,980	3,839	16,819	77%
Static	486	13,155	13,641	96%
frequency	13,466	16,994	30,460	
PA	96%	77%		86%

What does this mean?

The mapped land cover change does well differentiating change versus no change, erring on the side of mapping more change than seen in the truth data.

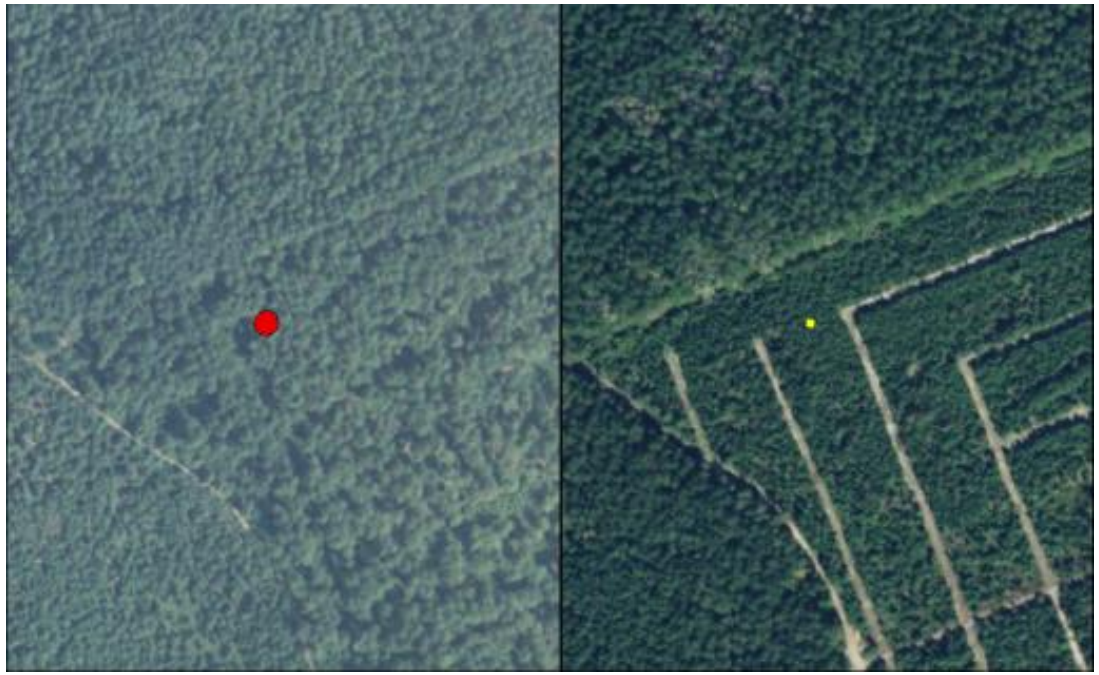
Tree Canopy Change Accuracy

- Where the truth data is tree canopy change (Producer's accuracy), 75% of the mapped tree canopy gains and losses are correct between 2013/14 and 2021/22 in a 3x3-meter window
  - Loss has a higher accuracy at 84%
  - 84% of tree canopy change truth data is tree canopy in either or both mapped dates

Mapped no change in tree canopy at the point (likely lack of LiDAR in two dates
Truth data show Tree Canopy to Low Vegetation

Tree Canopy Change Accuracy

- Where tree canopy change is mapped (User's accuracy), 56% is correctly identified as gain or loss between 2013/14 and 2021/22
  - Loss has a higher accuracy at 64%
  - 77% of mapped tree canopy change is tree canopy in either or both dates in the truth data
  - Note: Unable to compute fuzzy (3x3m) user's accuracy. We could be mapping this correctly, in the neighboring cells.



Mapped change in tree canopy at the point (likely due to presence of LiDAR in two dates)
Truth data show no change in Tree Canopy

Tree Canopy Change Accuracy

- Doing a good job capturing tree canopy change seen in the truth data.
- Mapping more tree canopy change than is seen in the truth data.

- The truth data are derived from the imagery. Tree canopy is mapped using the imagery and height maps from Light Detection and Ranging (LiDAR). The LiDAR are independent from the imagery and do not represent the exact date of the imagery. The LiDAR used is +/- a few years from the date of the imagery. This mismatch in dates causes the detection of tree canopy change that is not seen in the imagery, and the potential for missed change.

Impervious Change Accuracy

- Where the truth data is impervious change (Producer's accuracy), 76% of the mapped impervious gains and losses are correct between 2013/14 and 2021/22 in a 3x3-meter window
  - Gains and losses are 78% and 70% accurate, respectively
  - 87% of impervious change truth data is impervious in either or both mapped dates

- Where impervious change is mapped (User's accuracy), 57% is correctly identified as gain or loss between 2013/14 and 2021/22
  - Gain has a higher accuracy at 68%
  - 75% of mapped impervious change is impervious in either or both dates in the truth data
  - Note: Unable to compute fuzzy (3x3m) user's accuracy. We could be mapping this correctly, in the neighboring cells.

Impervious Change Accuracy

- Doing a good job capturing impervious change seen in the truth data.
- Mapping more impervious change than seen in the truth data.

- Shadows in one date's image and not the other is likely a part of why the map show more impervious change than the ground truth
  - Shadows can cause non-impervious features to be classified as such. Given the angle of imagery and the time of day and year the imagery is taken varies between the images, the shadows between dates are often different.

Ongoing Work

- More analyses are underway to continue to better understand the accuracy of the data. Some of those analyses are:
  - Evaluating static and change accuracy by distance to patch edge
  - Evaluating static and change accuracy by patch size
  - Evaluating static and change accuracy by landscape heterogeneity
    - Level of heterogeneity and dominant land covers to determine accuracies across an urban to rural gradient

Questions or Feedback?

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