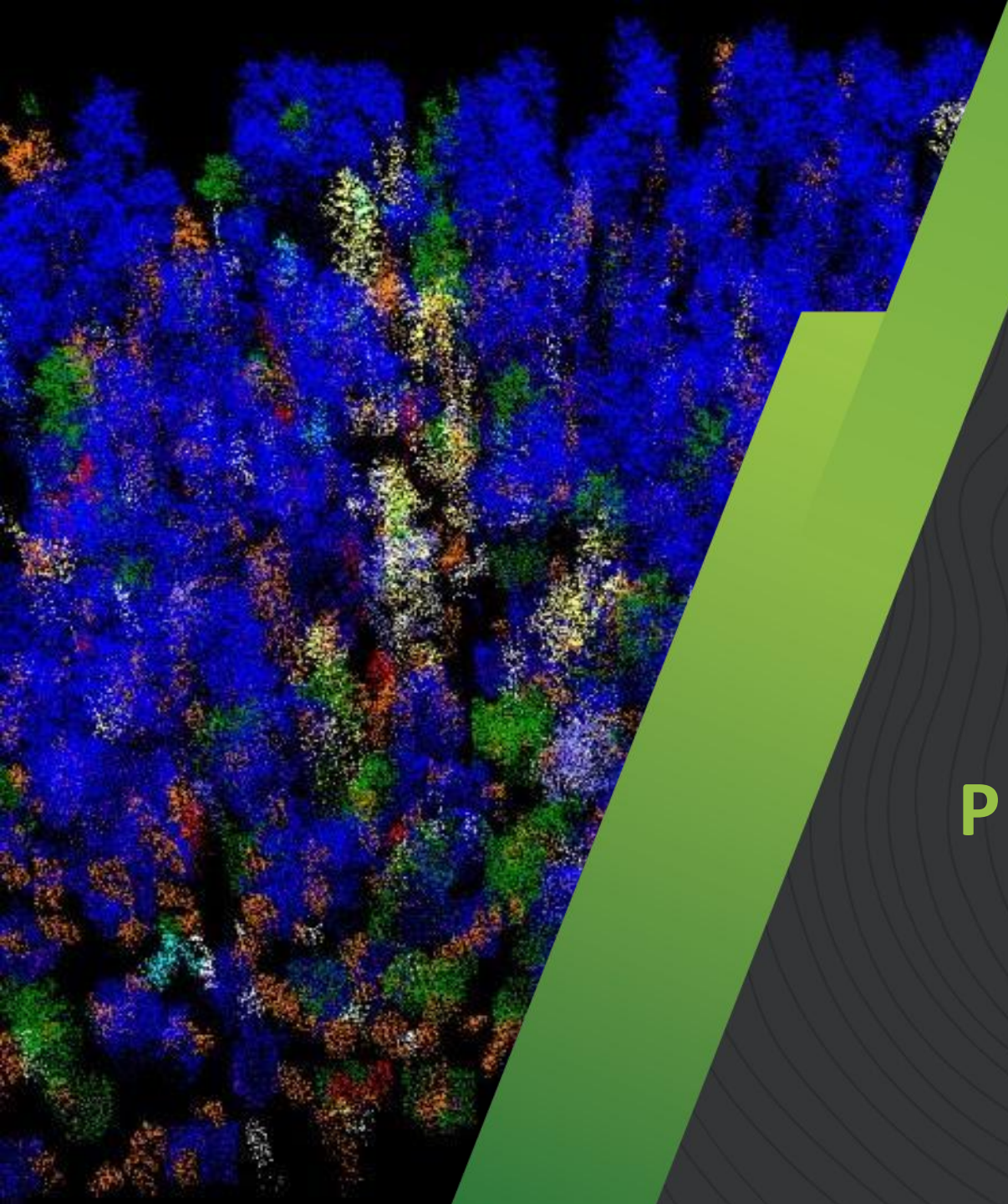

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OLI Workshop - 2025

PP FMA – Inventory Photo Interp to Data Science

April 15, 2025

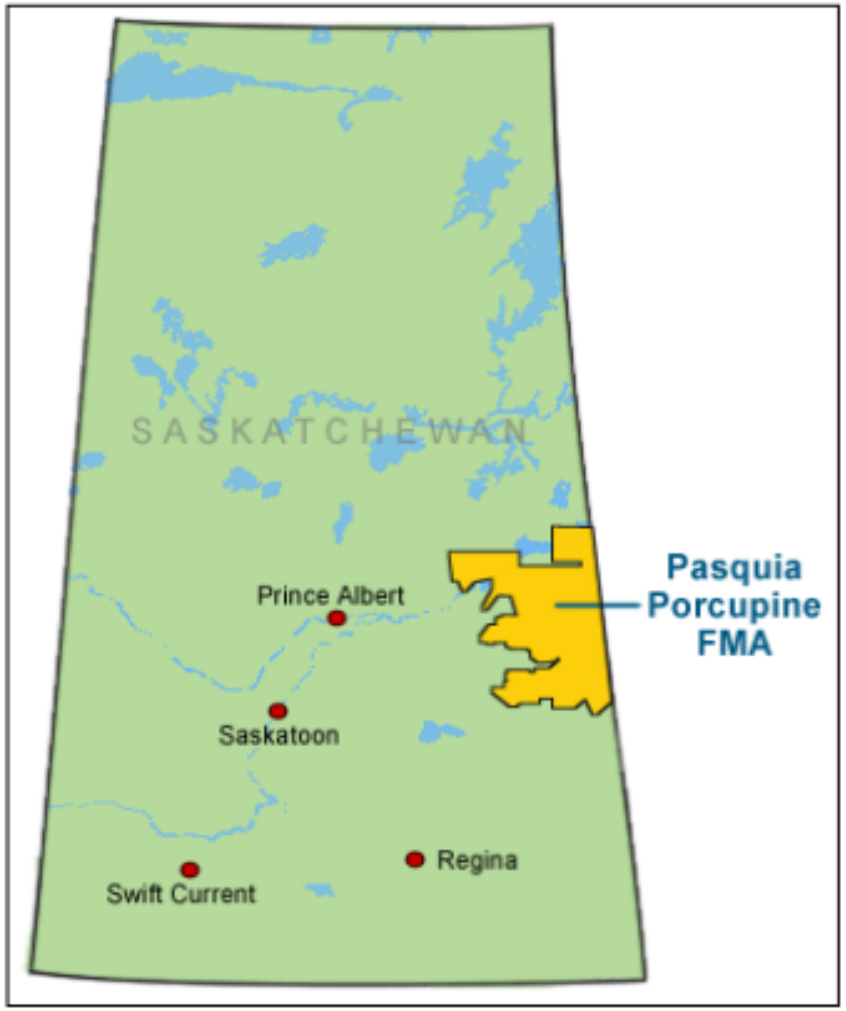
Introduction

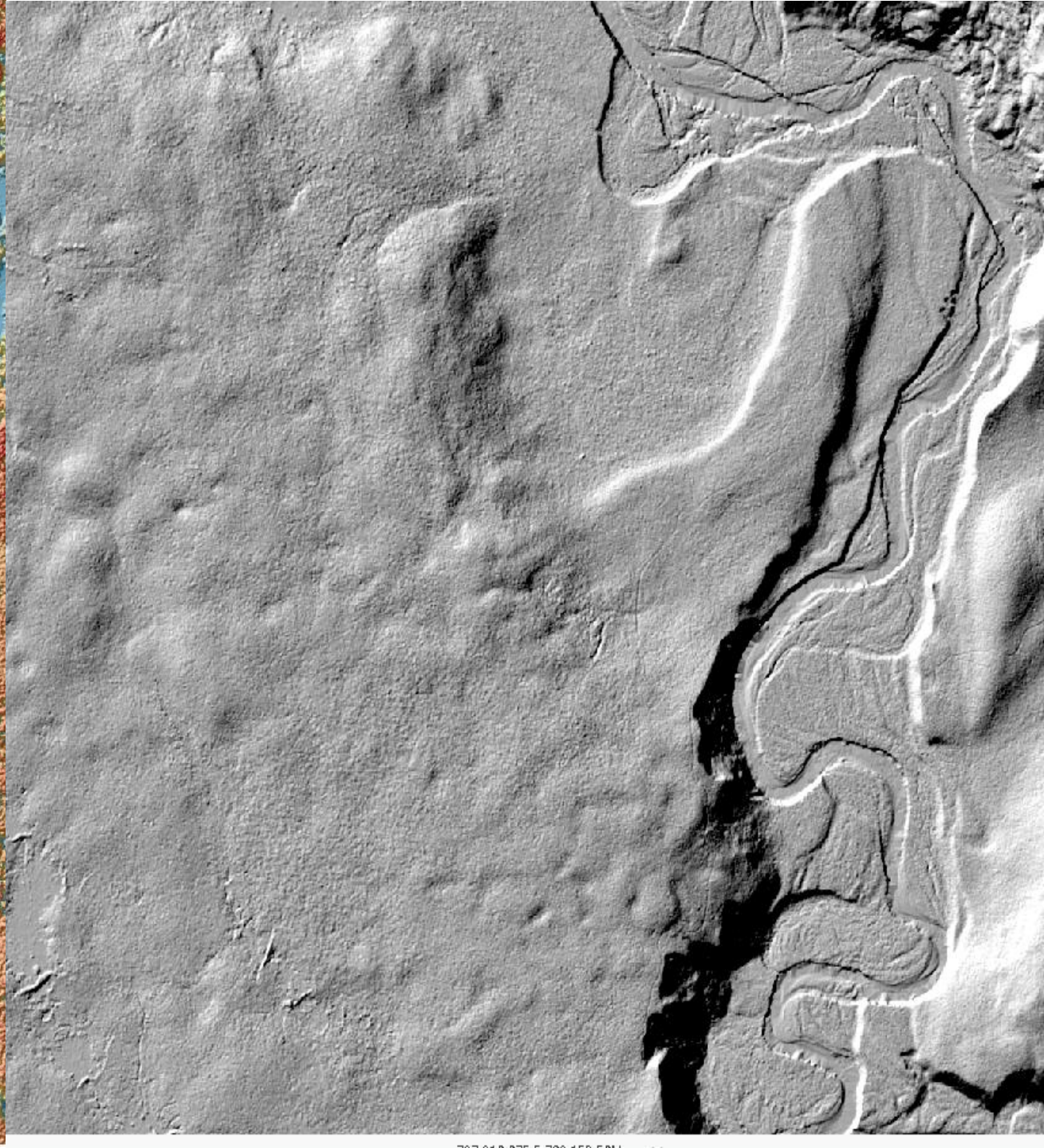
PP FMA Forest Inventory

- New Provincial Inventory Standard (2020)
- Moving from photo interpretation toward remote sensing and data science.
- More detailed inventory data created faster. Better link strategic and operational forest planning.

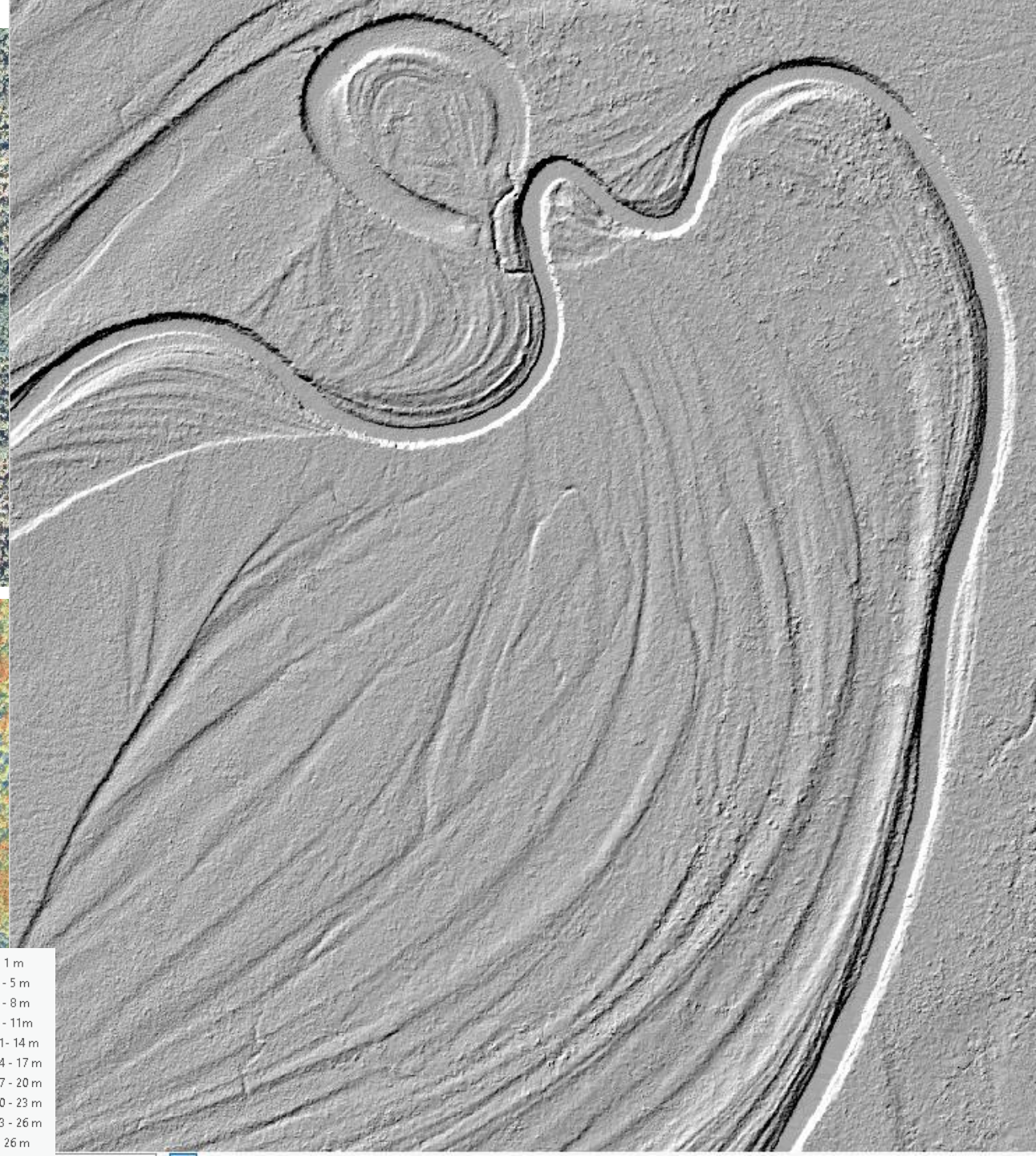
- 20cm RGBI Imagery, 2 PPM Lidar, Sentinel 2 Imagery, MODIS, 230 ground Plots (400m2)

~2 Million hectares (4.9 M acres)



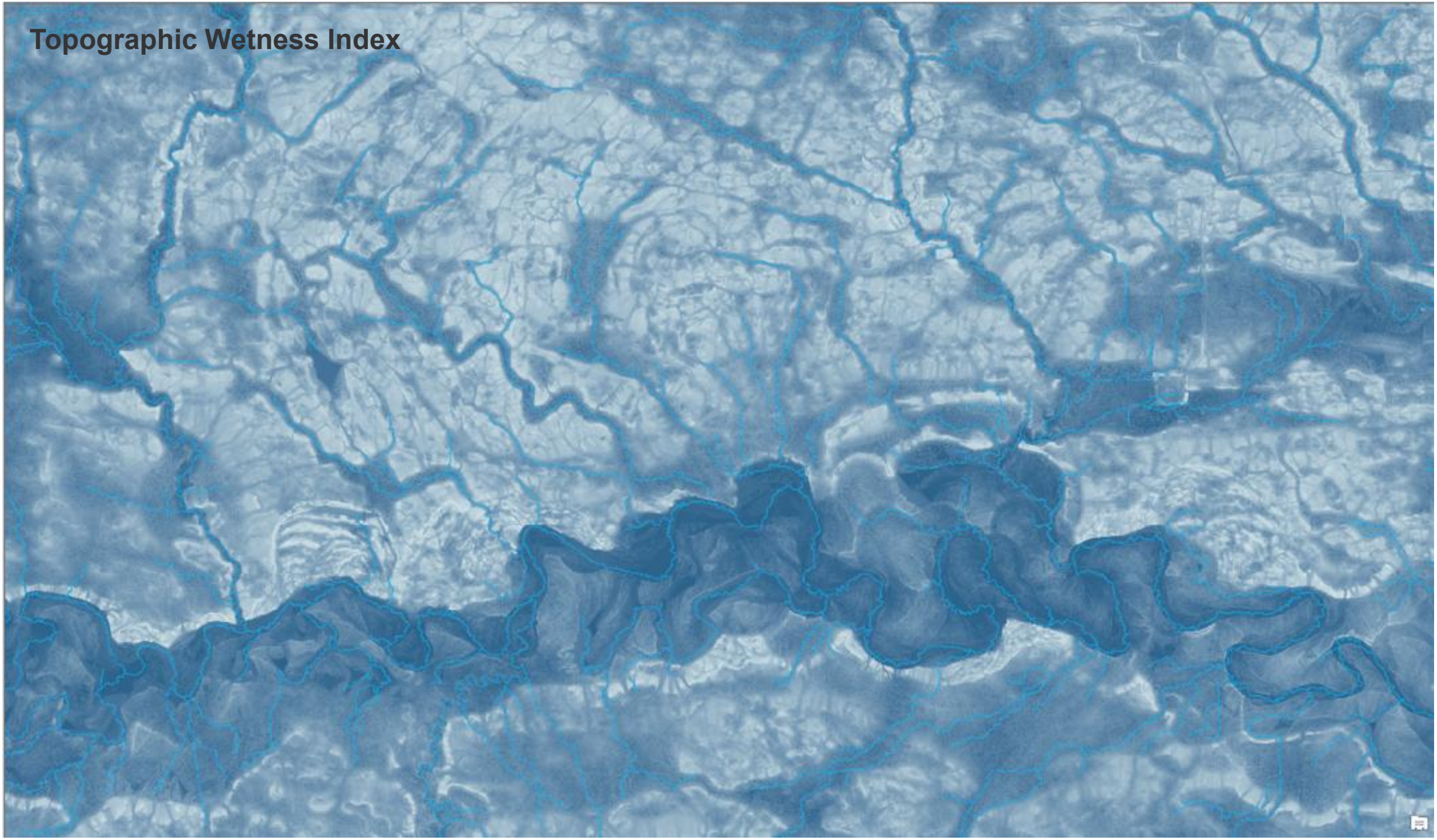



< 1 m
1 - 5 m
5 - 8 m
8 - 11m
11- 14 m
14 - 17 m
17 - 20 m
20 - 23 m
23 - 26 m
> 26 m



20cm Orthophoto (1:1500 scale)

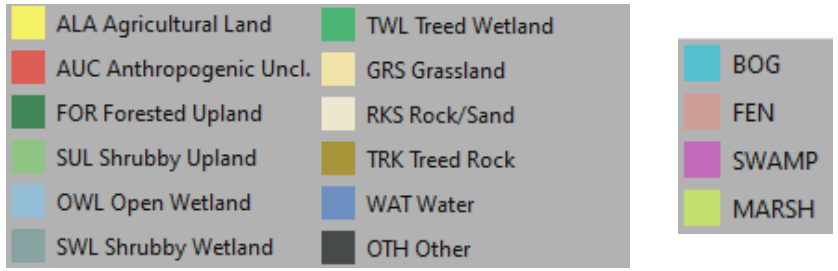
Topographic Wetness Index



Approach

Data Science Supported by Photo Interpretation

- 2023 Lidar and Imagery Collected
- 2023 Ground Plots Collected (230)
  - Plus ~50 validation plots early (Jan/Feb 2024)
- Land Class is assigned (10m pixels, > 0.25 ha polygons) with supporting wetland class
- Forested Land Base given additional attributes



Height (HEIGHT)
Basal Area (BA)
Quadratic Mean Diameter (QMD)
Merchantable Stems per Hectare (MSTEMS)
Total Stems per Hectare (TSTEMS)
Gross Biological Volume (GBVOL)
Gross Merchantable Volume (GMVOL8)
Gross Merchantable Volume (GMVOLX)

Canopy Leading Species and Percent (SP1, SP1_PER)
Canopy 2nd Species and Percent (SP2, SPC2_PER)
Canopy 3rd Species and Percent (SP3, SPC3_PER)
Canopy 4th Species and Percent (SP4, SPC4_PER)
Canopy 5th Species and Percent (SP5, SPC5_PER)
Canopy 6th Species and Percent (SP6, SPC6_PER)

Elevation
Avg Slope
Aspect
Topo Class
Soil Moisture Regime

Photo Interpretation As Training (4770 samples)

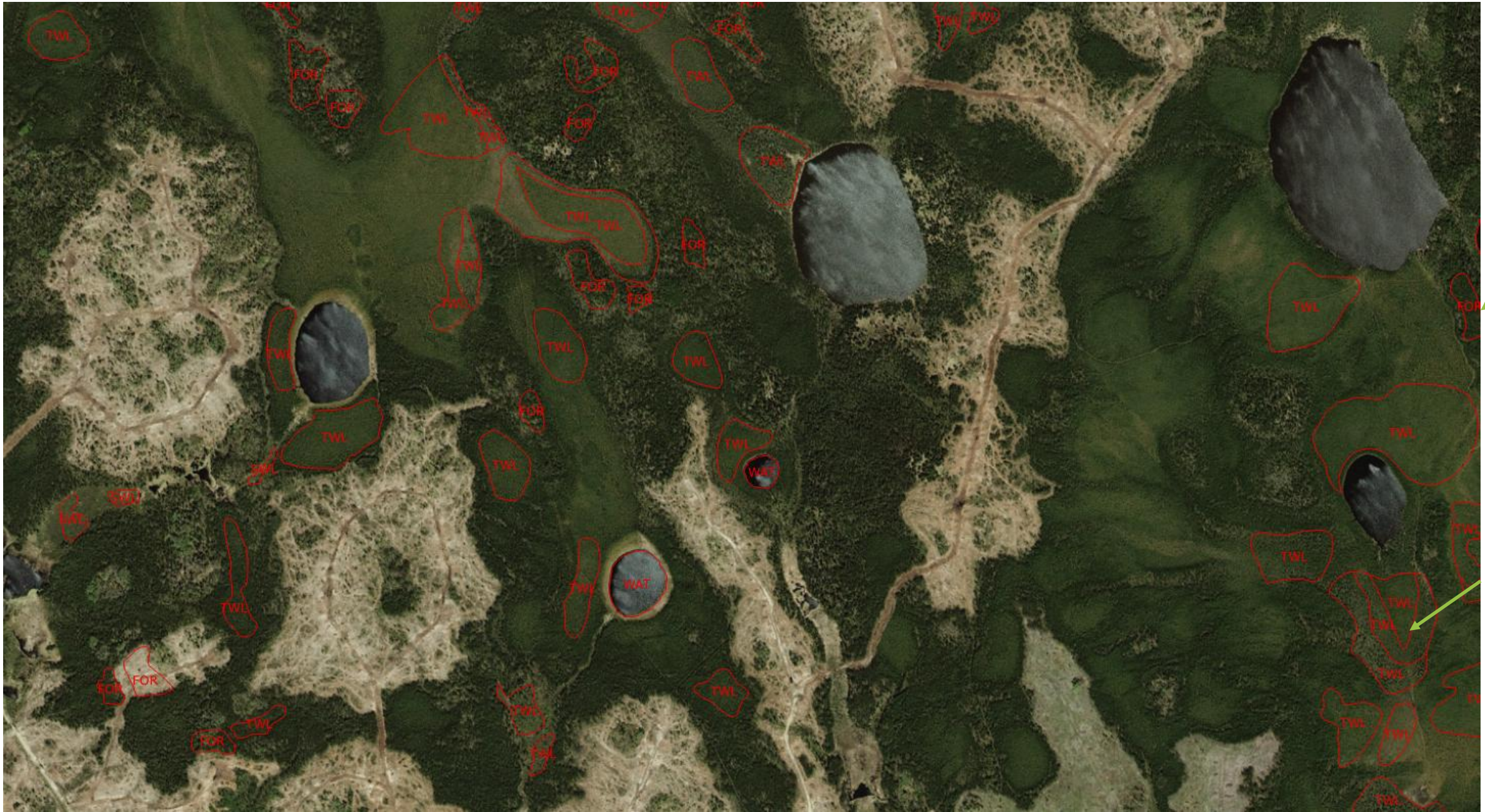
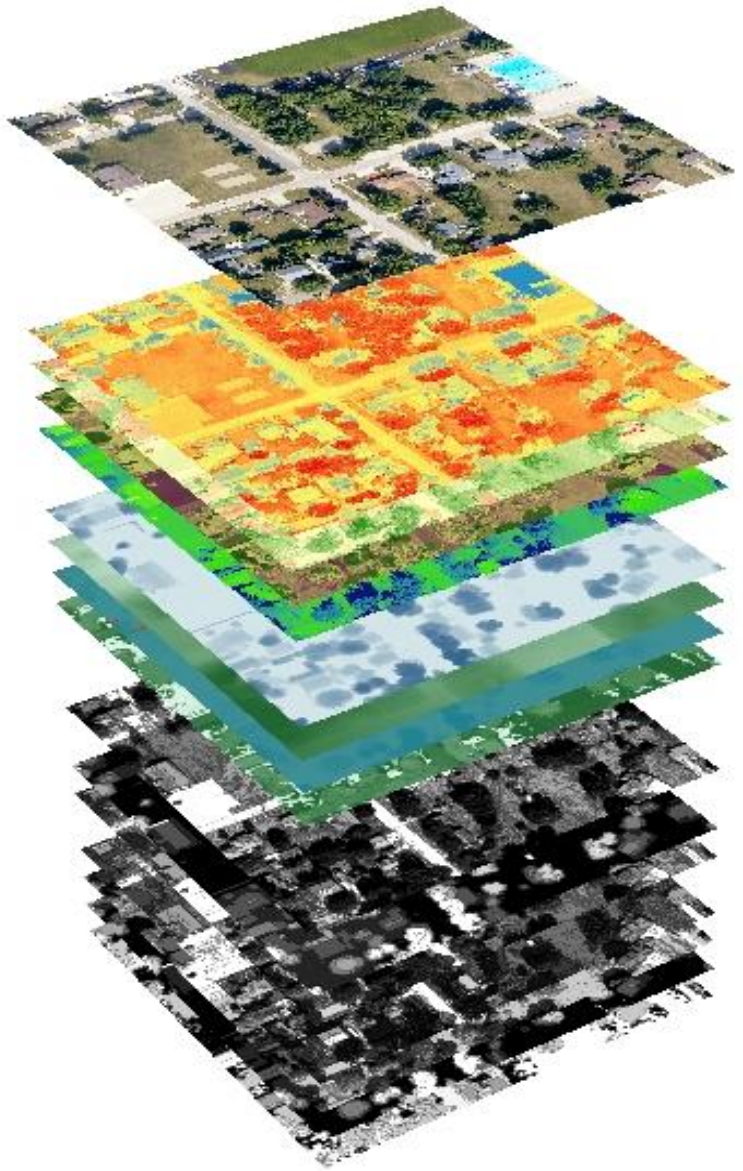


Photo Interpretation As Training (Variety of each Type)

Defining Land Class



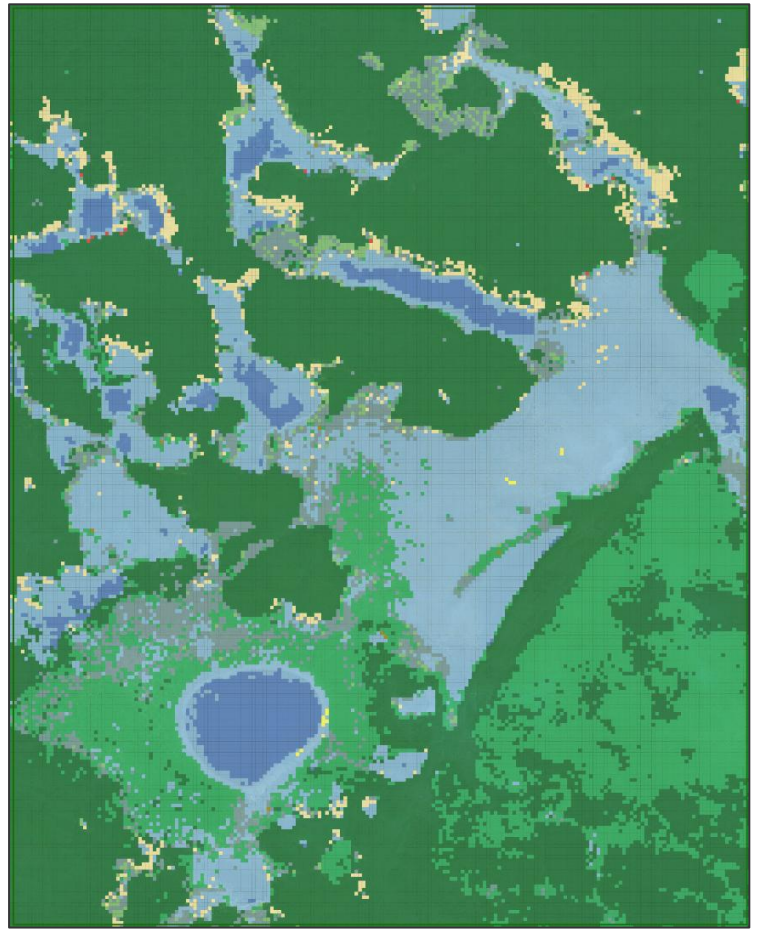
HiRes Orthos

Spectral Indices

LiDAR-Derived

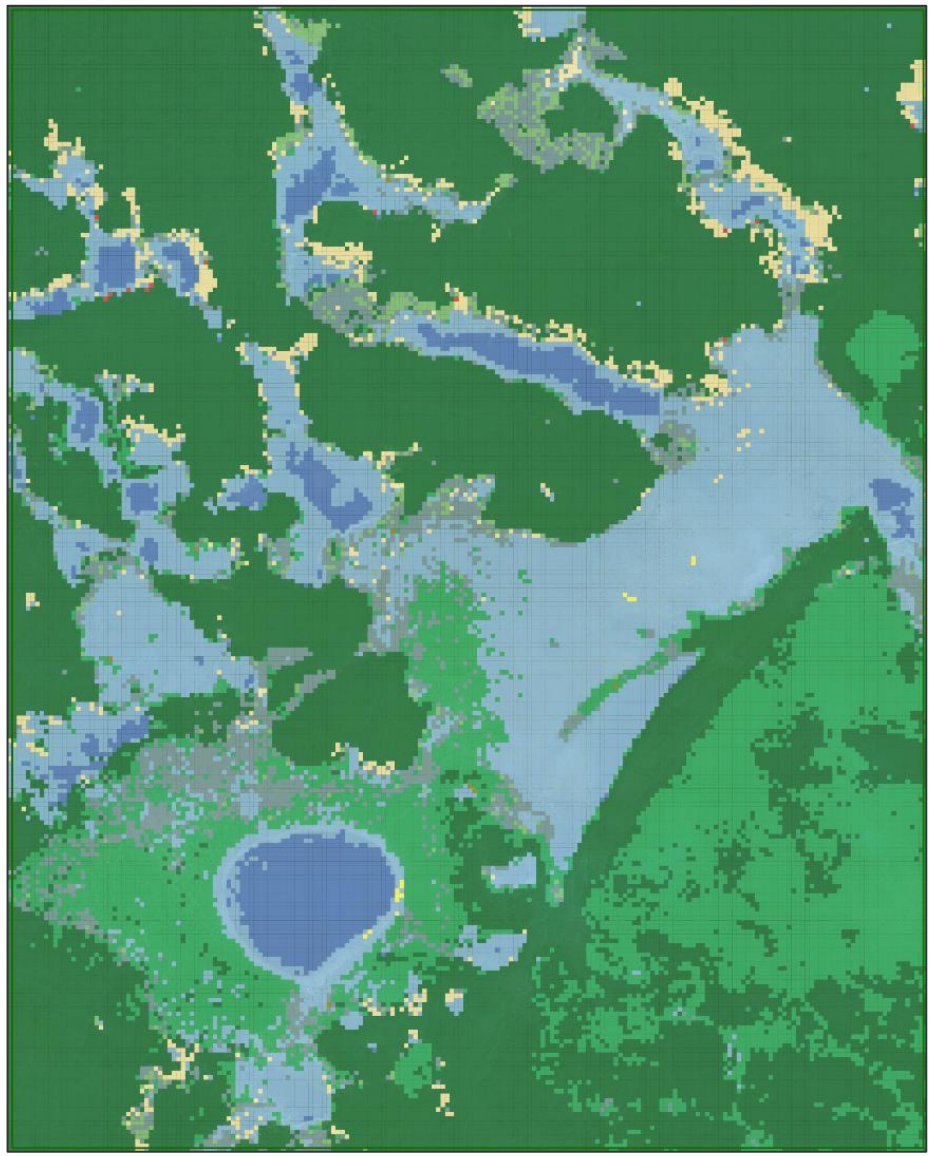
Texture Analysis

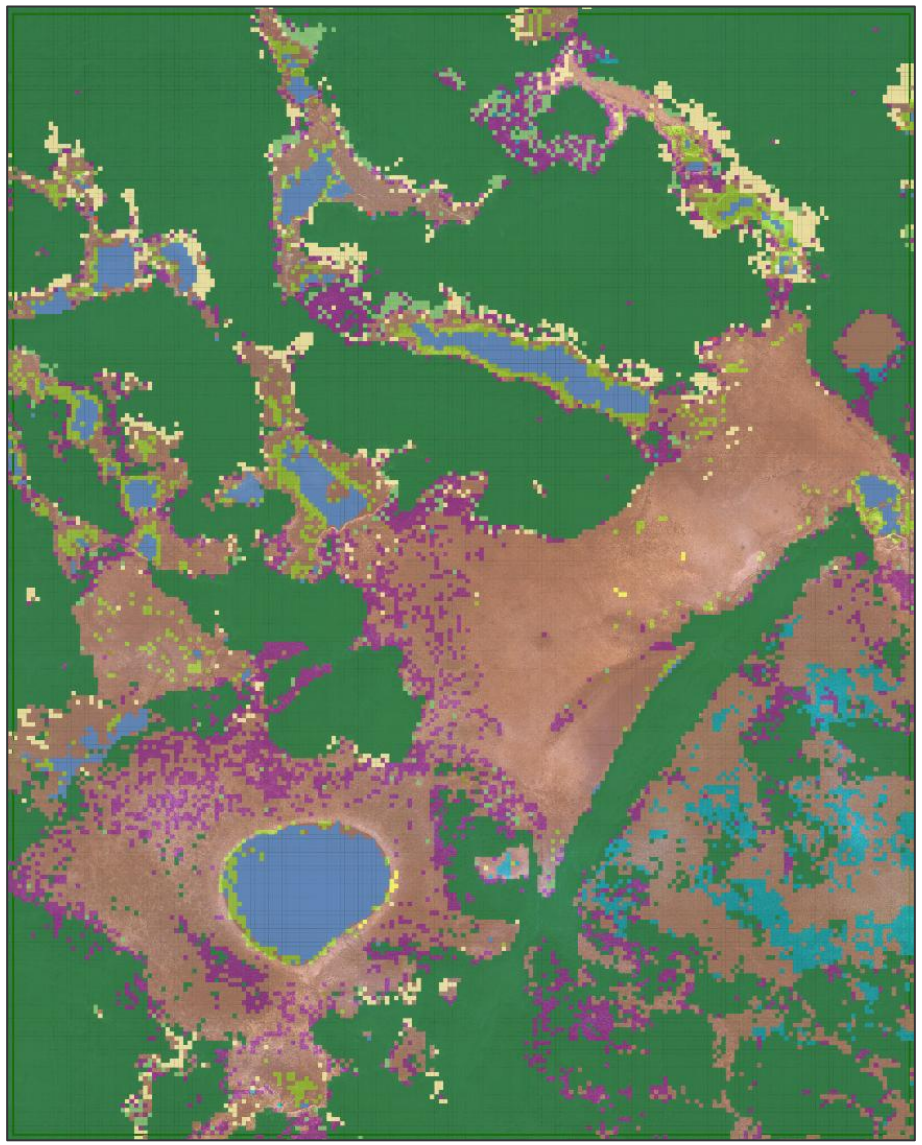
Land Class Predicted



Land/ Wetland Classes Assigned

- 10m pixel scale
- Then smoothed to polygons

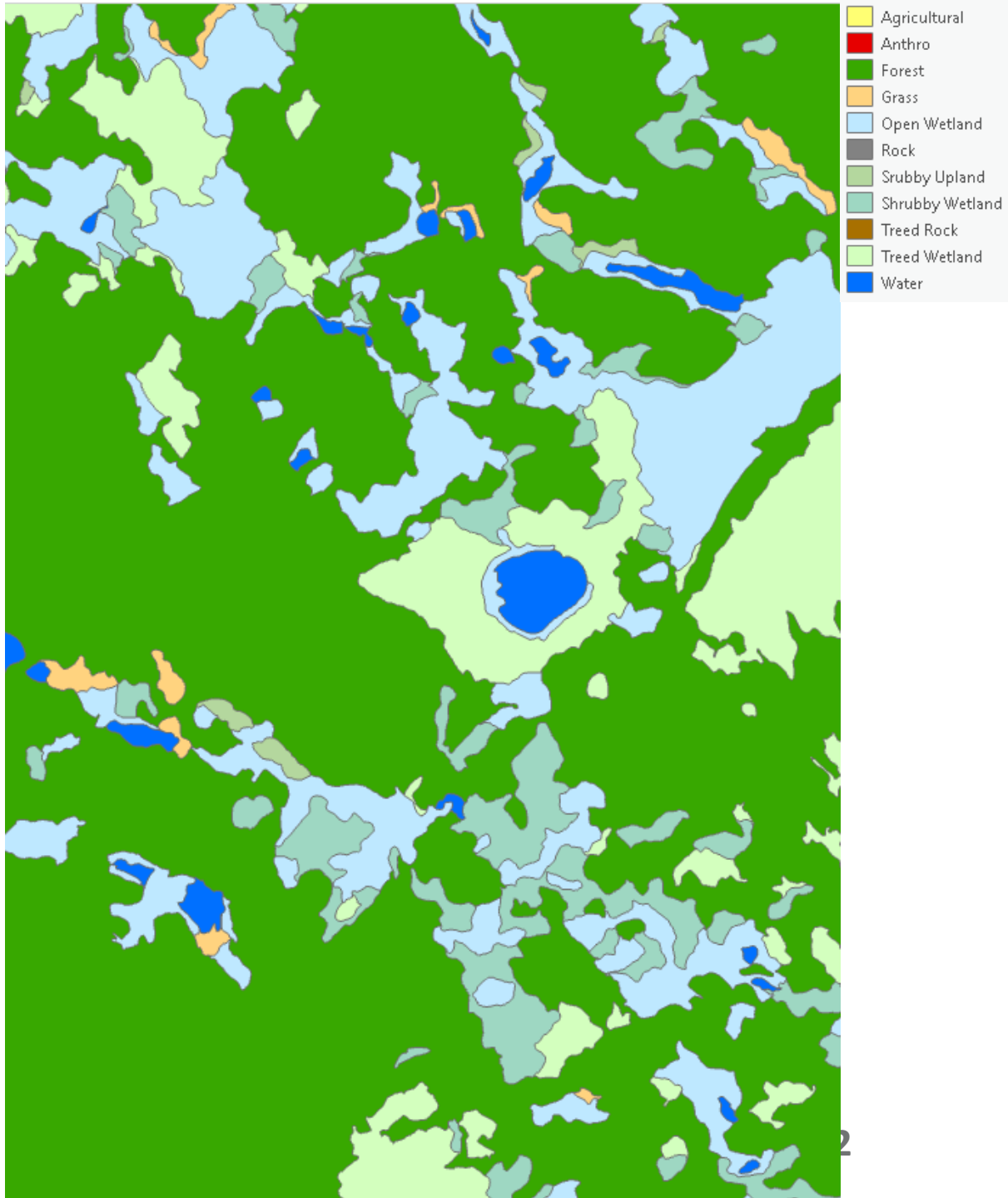




Land Class

–

Smoothed to Polygons



Land Class – Unweighted Accuracy Test

Unweighted Accuracy Test:

The WAT was created by randomly selecting 60 tiles from each of the predicted classes and then each were reviewed by a stereo interpreter and assigned a class. The results show agreement between the predicted and interpreted classes – and assumes all classes are equally important (not really the case).

		Prediction												
		WA	TW	SW	OW	FO	SU	TR	GR	RK	AL	AU	Total	Hit rate (Correct/ Photo Interp)
Photo Interpreter	WA	**58**	0	0	1	0	0	0	0	0	0	0	59	98%
	TW	0	**57**	5	2	0	1	13	0	3	0	1	82	70%
	SW	0	1	**45**	1	0	3	2	0	0	0	0	52	87%
	OW	1	0	0	**53**	0	0	8	3	16	36	13	130	41%
	FO	1	0	0	3	**60**	3	5	4	4	3	4	87	69%
	SU	0	2	9	0	0	**53**	11	4	1	0	1	81	65%
	TR	0	0	0	0	0	0	**12**	0	0	0	0	12	100%
	GR	0	0	1	0	0	0	4	**49**	9	13	15	91	54%
	RK	0	0	0	0	0	0	0	0	**12**	2	7	21	57%
	AL	0	0	0	0	0	0	0	0	2	**6**	0	8	75%
	AU	0	0	0	0	0	0	5	0	13	0	**19**	37	51%
Total		60	60	60	60	60	60	60	60	60	60	60	660	64.2%
Precision (Correct/ TSI)		97%	95%	75%	88%	100%	88%	20%	82%	20%	10%	32%		
Average correct % (Hit rate and precision combined)		97%	80%	80%	56%	82%	75%	33%	65%	30%	18%	39%		

	Accuracy	Precision
Treed	81.2%	81.7%
Treed & Shrubby	89.8%	94.0%
Wetlands	62.1%	91.1%
Anthro/Agriculture	55.6%	20.8%

Land Class – Weighted Accuracy Test

Weighted Accuracy Test:

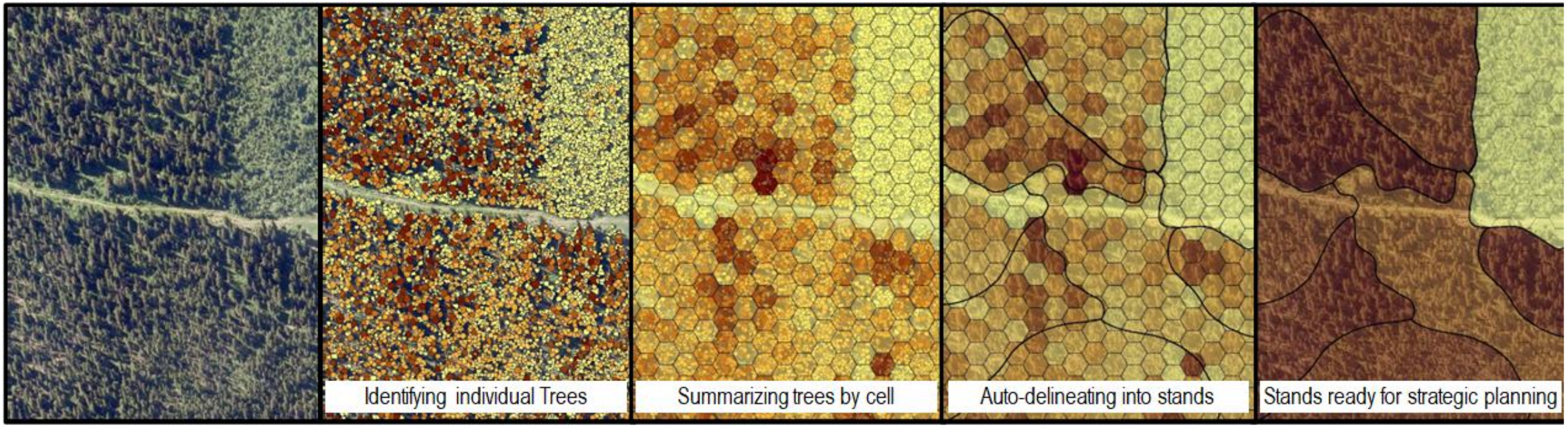
The WAT was created by randomly selecting 60 tiles from each of the predicted classes and then each were reviewed by a stereo interpreter. The results were then weighted by the frequency of the predicted classification across the land base (e.g. the 60 FOR sample were expanded to 869).

		Prediction												
		WA	TW	SW	OW	FO	SU	TR	GR	RK	AL	AU	Total	Hit rate (Correct/ Photo Interp)
Photo Interpreter	WA	**87**	0	0	4	0	0	0	0	0	0	0	90	96%
	TW	0	**495**	5	7	0	0	0	0	0	0	0	509	97%
	SW	0	9	**49**	4	0	1	0	0	0	0	0	63	78%
	OW	1	0	0	**198**	0	0	0	2	0	1	1	204	97%
	FO	1	0	0	11	**869**	1	0	3	0	0	0	886	98%
	SU	0	17	10	0	0	**18**	0	3	0	0	0	49	37%
	TR	0	0	0	0	0	0	**0**	0	0	0	0	0	100%
	GR	0	0	1	0	0	0	0	**36**	0	0	1	39	94%
	RK	0	0	0	0	0	0	0	0	**0**	0	0	1	34%
	AL	0	0	0	0	0	0	0	0	0	**0**	0	0	84%
	AU	0	0	0	0	0	0	0	0	0	0	**1**	1	72%
Total		90	521	66	224	869	21	2	45	1	2	3	1841	95.2%
Precision (Correct/ TSI)		97%	95%	75%	88%	100%	88%	20%	82%	20%	10%	32%		
Average correct % (Hit rate and precision combined)		96%	96%	77%	93%	99%	52%	33%	87%	25%	18%	44%		

	Accuracy	Precision
Treed	97.8%	98.1%
Treed & Shrubby	98.0%	99.9%
Wetlands	99.0%	94.7%
Anthro/Agriculture	73.4%	23.5%

Predicting Forest Attributes
Species at Tree Level, Other Attributes at Tile Level

Trees… to Area Based Cells…. to Stand Polygons



Overview of Species Prediction

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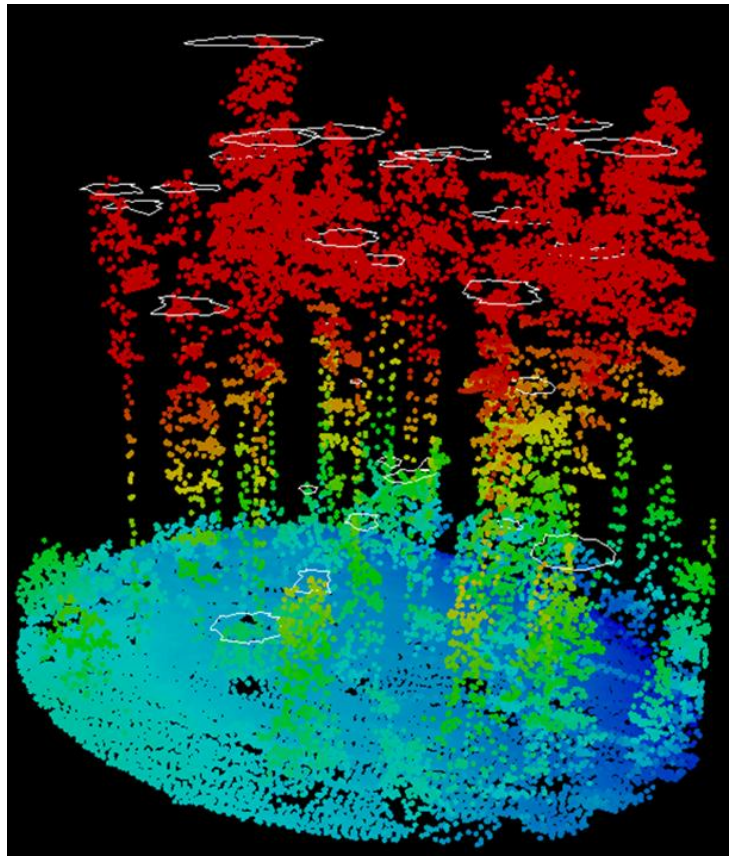
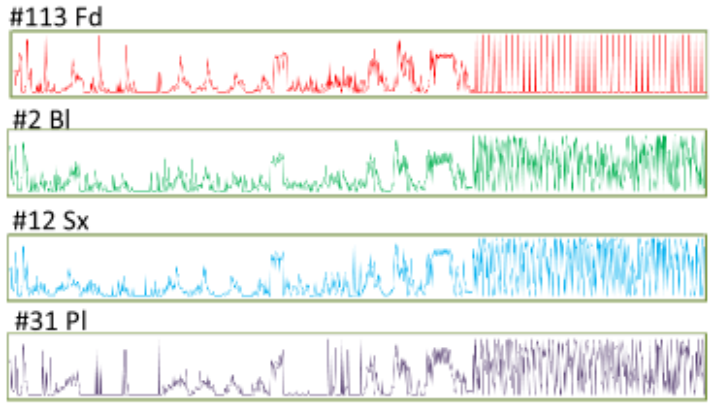
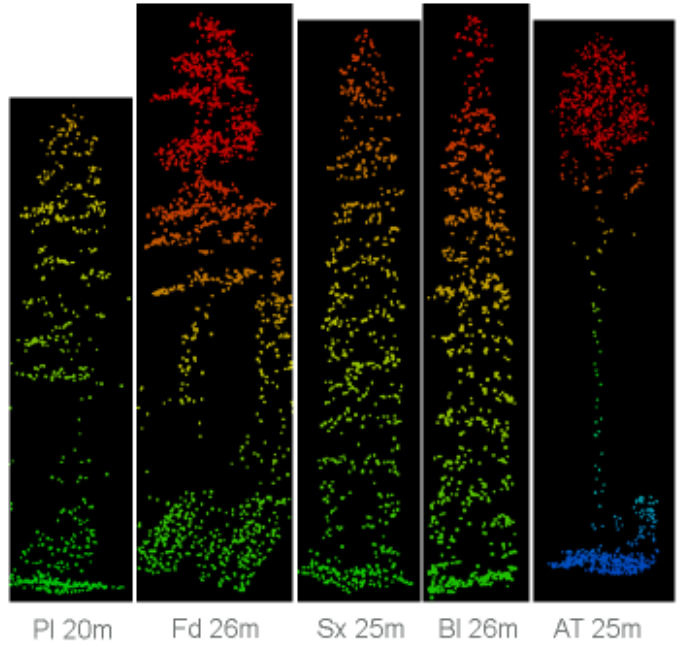
Basic Voxel Seg Completed to get approximate crown polys (2 ppm Lidar), High Resolution photo interpretation to assign species to training data. Support Vector Machine – likelihood of each species predicted.



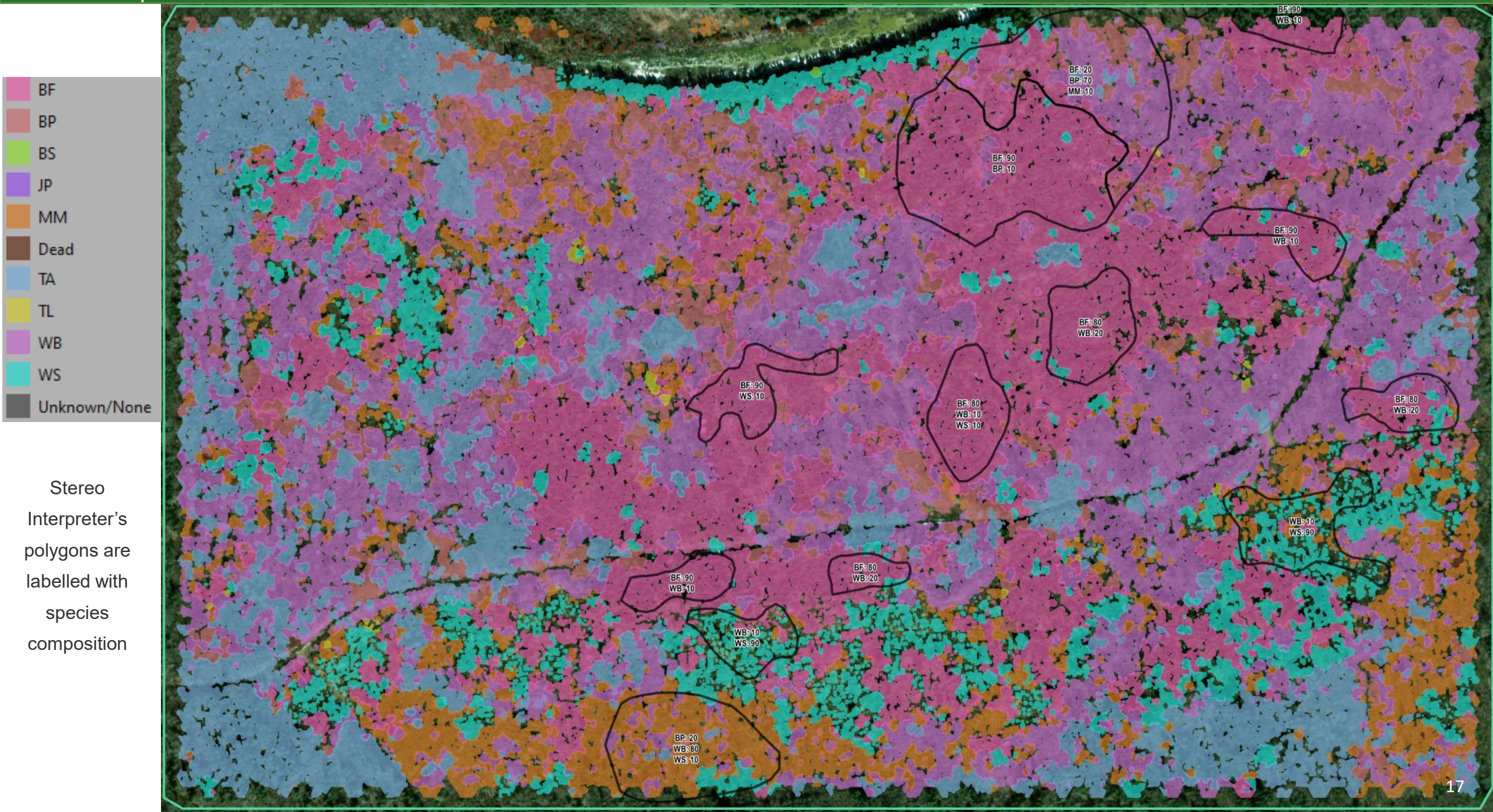
Assigning Species (Tree by Tree)

- Crown metrics taken from the point cloud - crown shape, size, and density, and colour (intensity)
- Species assigned using machine learning algorithm and photo interpretation tree library.





TSI Lead Species with Stereo Interpreter Polygons Overlaid



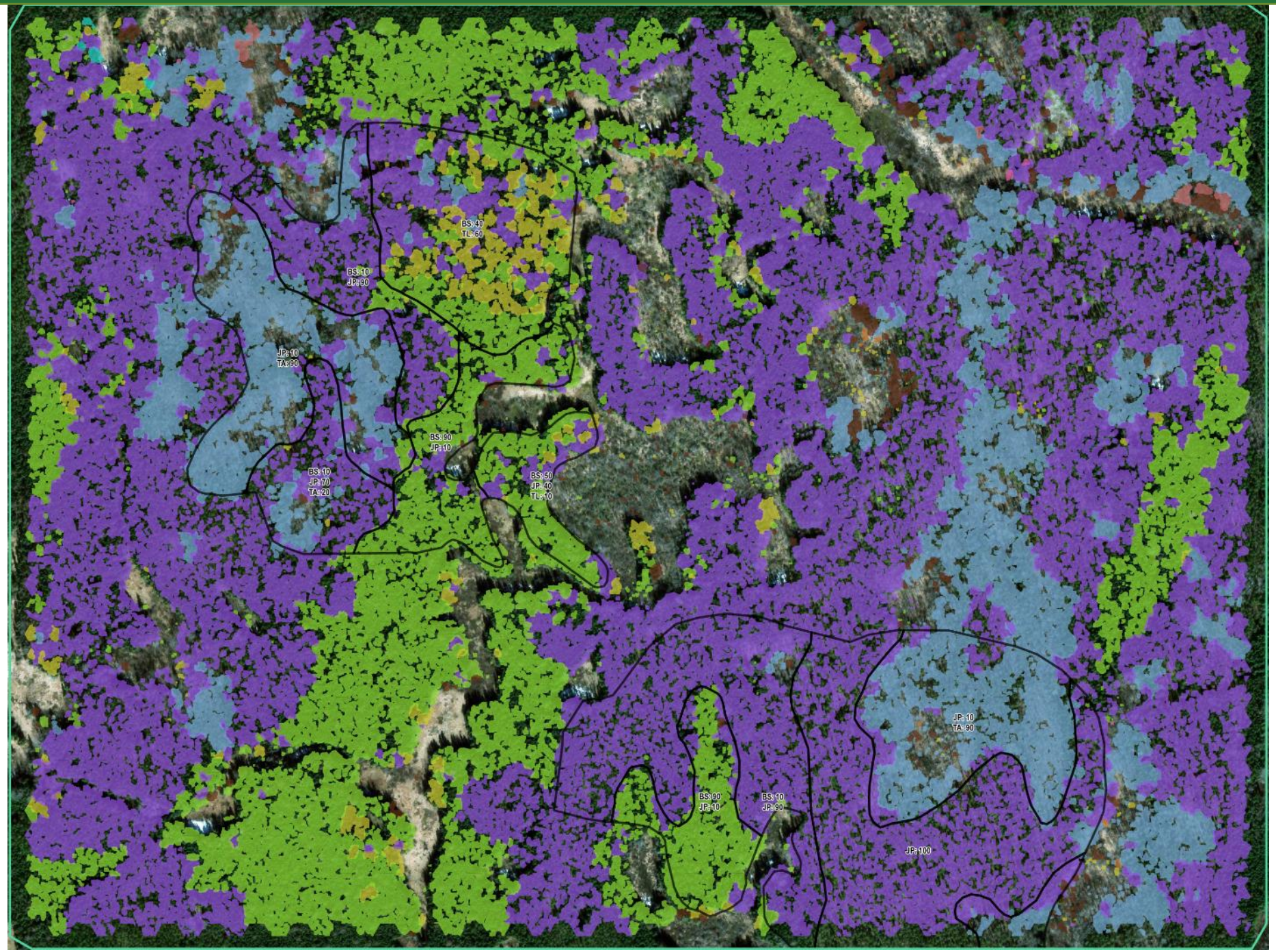
Stereo Interpreter's polygons are labelled with species composition

PPFMA – Species (3)

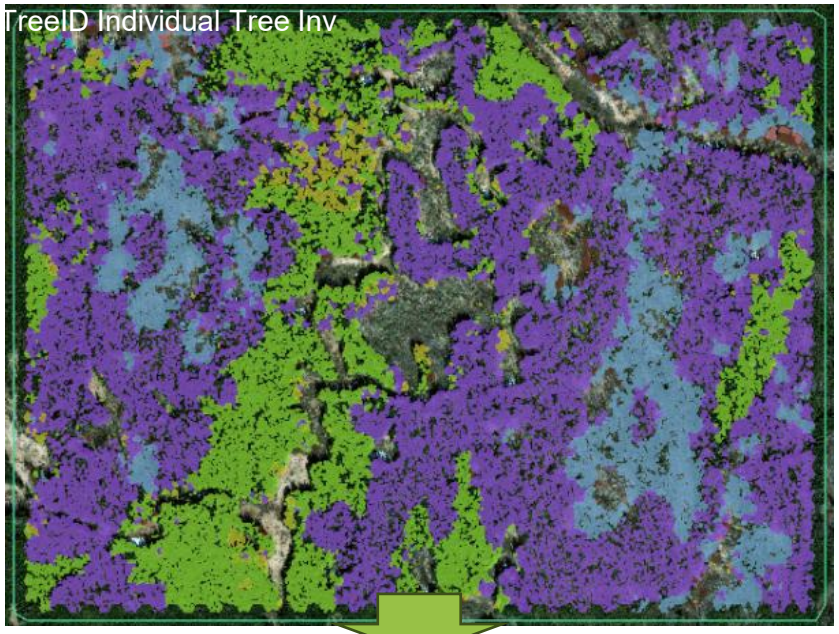
TSI Lead Species Hex with Stereo Interpreter Polygons Overlaid

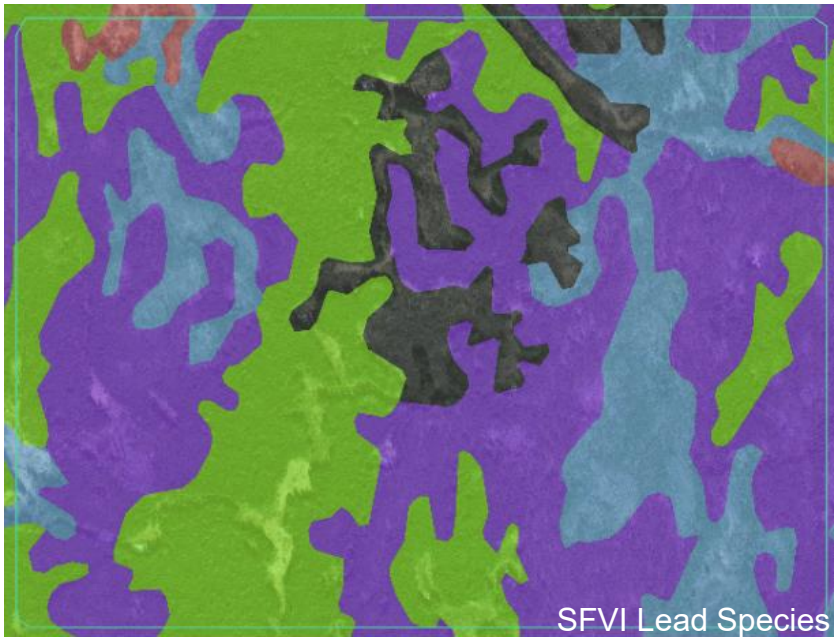
BF
BP
BS
JP
MM
Dead
TA
TL
WB
WS
Unknown/None

Stereo Interpreter's polygons are labelled with species composition



PPFMA – Species (3)



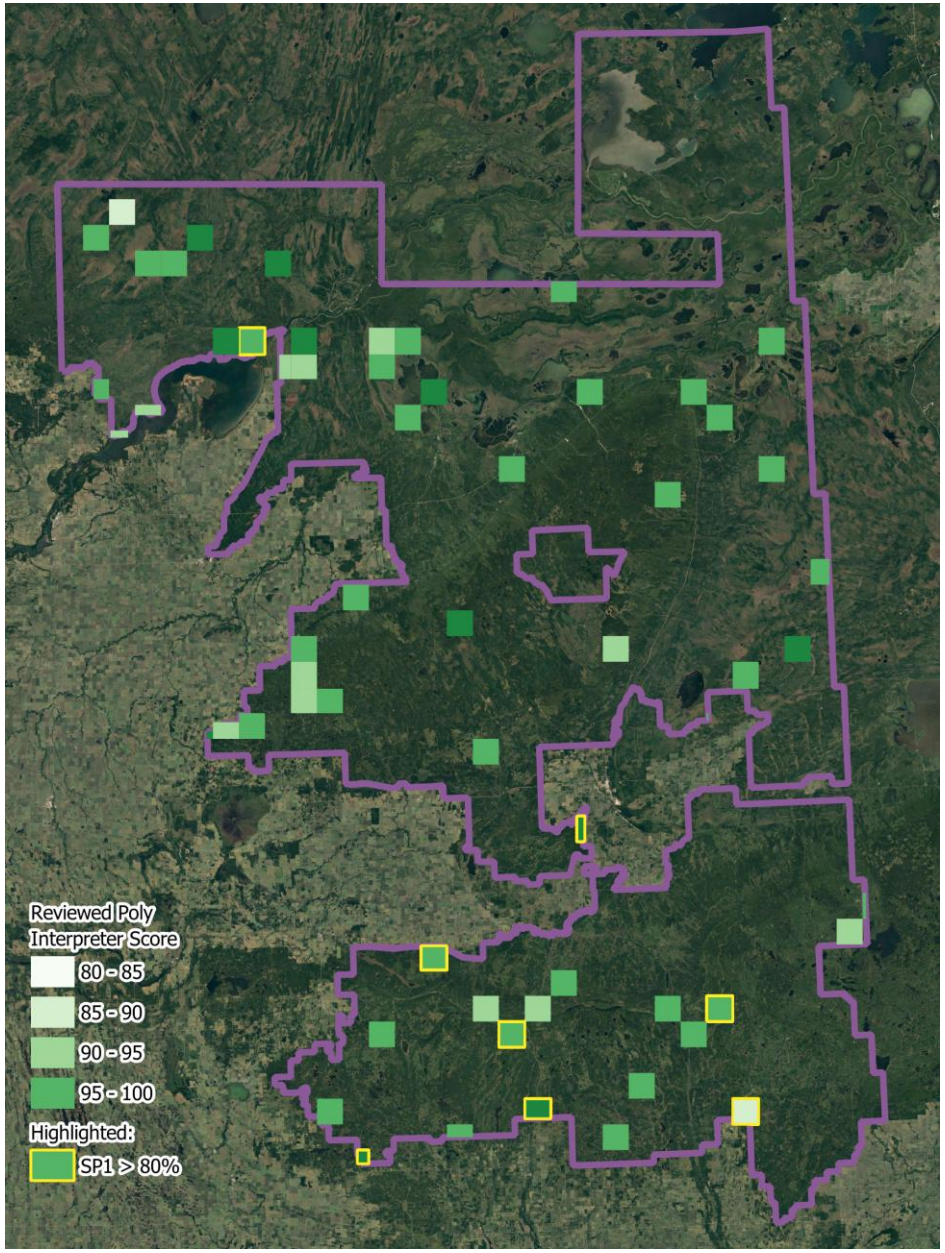


TreeID and SFVI both have similar results for this area.

TreeID better delineates smaller clumps of alternative species, including Dead.

*Dead stems may be removed from final species composition and recorded as “% Dead” field in final vector layer

PPFMA – Species Accuracy



Accuracy of species across 4x4 km areas as determined by photo interpreter review.

Interpreter made a subjective % call on how well the tree crown species assignment aligned with their view of the species present. Ranged from 80-100% (Avg 94.5%)

Grid ID	Composition	Score		Grid ID	Composition	Score
C_8	BS52TL47WS0	80		N_13	TA32BP24BS16	95
AA_43	TA82BS6WS3	85		N_16	TA65BP19SN9	95
AE_36	TA56JP24BS11	90		O_37	TA89BP7WS2	95
C_17	TA45WS14JP14	90		P_44	TA79SN6BP5	95
D_16	JP32TA24MM21	90		Q_29	TA73BP10WS6	95
G_28	TA46BP38BS6	90		R_18	BS40TA27TL15	95
I_14	TA28MM25BS20	90		R_40	TA88BP6WS2	95
J_14	BS67TL29MM1	90		T_11	TA40BP29SN16	95
J_26	TA80WB9BP8	90		T_38	TA69BP20BS5	95
J_27	TA65BP25WB4	90		U_15	TA43TL18BS13	95
M_13	TA53BP20BS9	90		V_44	TA75WS9SN8	95
Q_39	TA57BP11WB8	90		W_42	BS40TA22WS17	95
S_39	TA69BP12WS4	90		X_19	BS55TA29TL6	95
V_25	TA45BS16WB14	90		X_39	TA70BP9WB6	95
AA_26	BS51TA32TL11	95		Y_15	WB33TA26BF11	95
AB_13	TA78BP10SN4	95		Y_40	TA71WS10WB8	95
AB_18	BS80TL14TA1	95		Z_16	TL32TA19BS15	95
AD_22	BS74TL19WS2	95		Z_28	BS77TL12SN11	95
AF_35	BS44JP39TL13	95		Z_39	TA90WS4BP3	95
B_15	TA57MM16BP8	95		AC_25	BS78JP12TL9	100
B_9	TL55BS39SN2	95		F_28	TA73BP21WS2	100
D_10	BS72TL27SN0	95		F_9	BS60JP30TL10	100
E_10	BS40TA31TL14	95		G_13	TA56BS21TL8	100
H_13	TA82BS6BP4	95		I_10	TA36BS25TL23	100
H_28	TA50BP28BS9	95		J_13	BS38TA27TL20	100
J_25	TA65BP21WB6	95		L_45	TA84SN8WB3	100
K_27	TA73BP14BS4	95		O_15	TA39SN18WB14	100
K_43	TA73BS10SN6	95		P_24	SN43BS32TL9	100
L_23	TA61BP24SN4	95		S_43	TA82BS6BP4	100
M_14	TA80BP11SN3	95		U_32	TA82BP10WS3	100
M_40	TA79BP7SN7	95		Average (All)		94.5

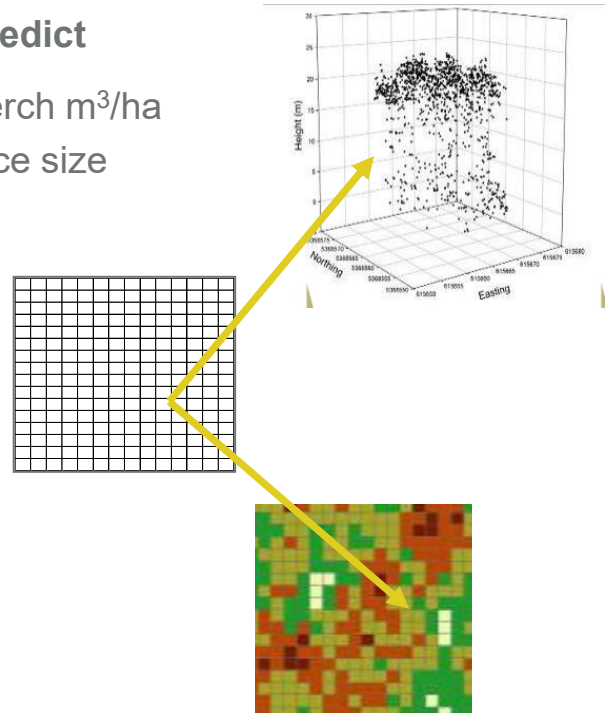
Other Forest Attributes - Hex Tiles

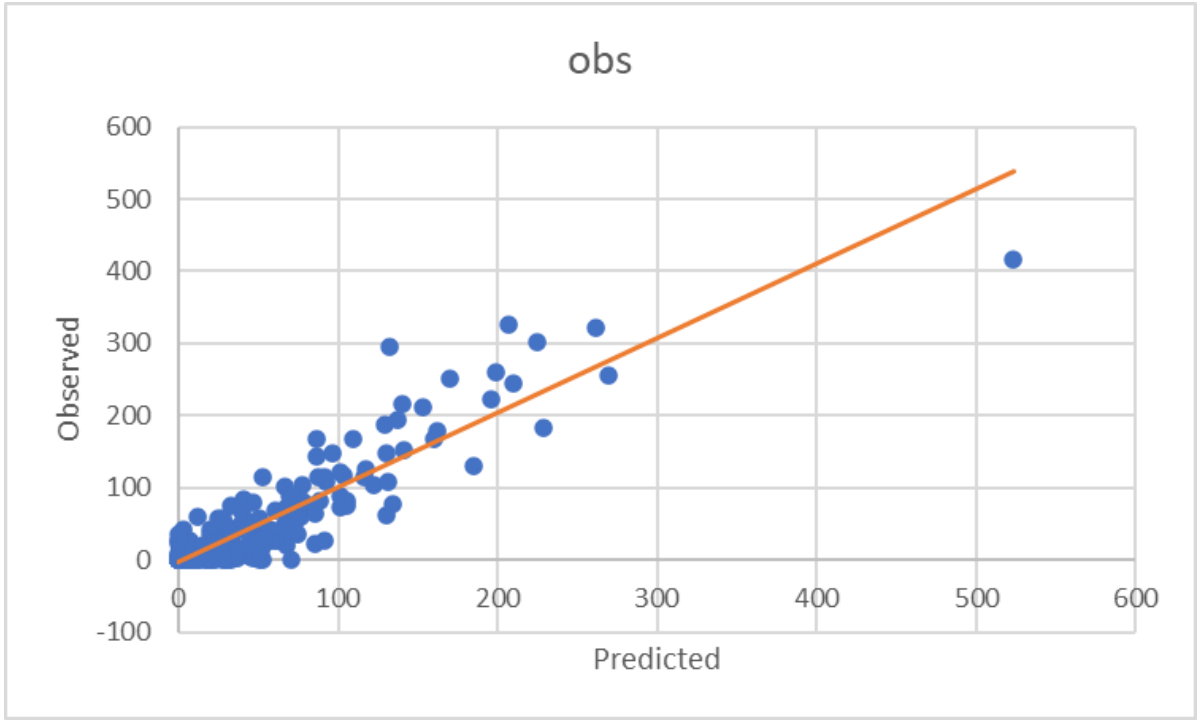
LiDAR metrics on 400m grid cells (Hexs)

+ **Ground Plots** (spatially linked to cells)

= **Models to Predict**

- Gross and Merch m^3/ha
- Products, Piece size
- Diameters
- Basal Area
- Biomass

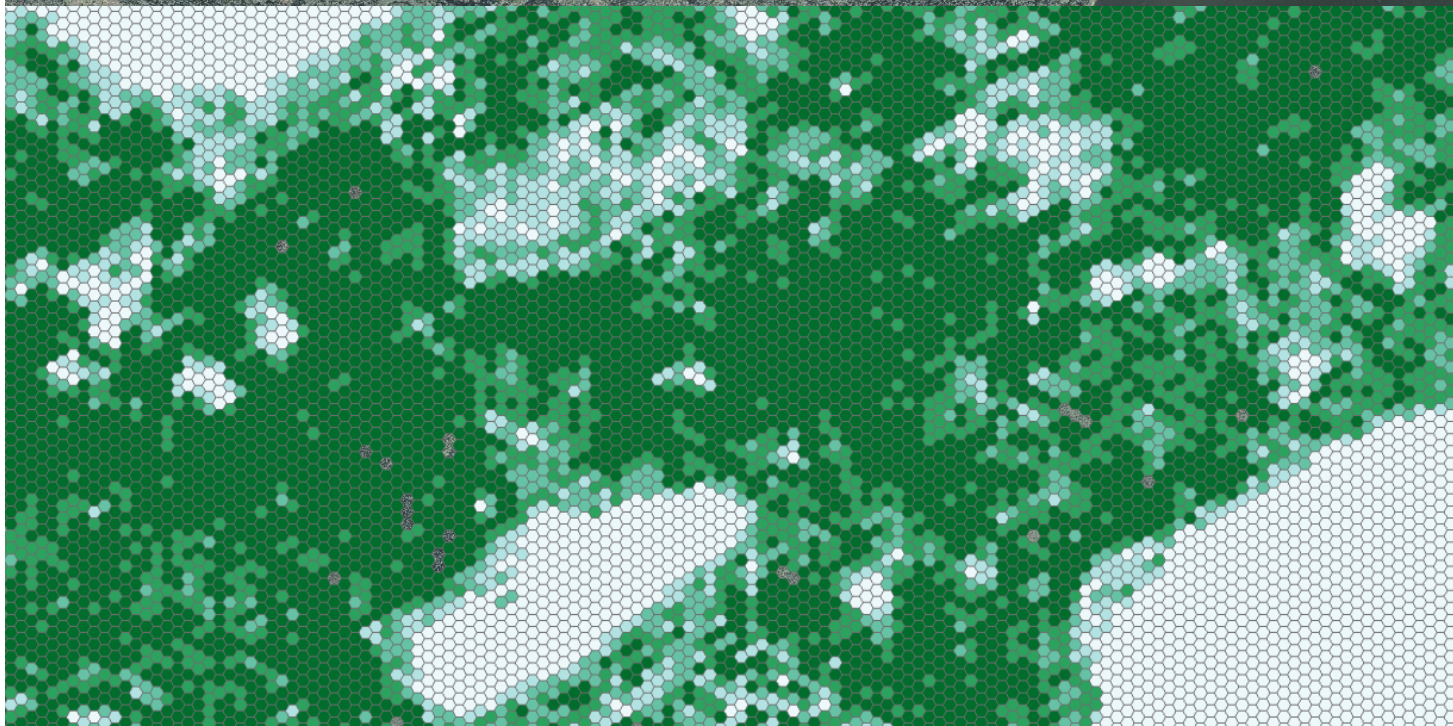


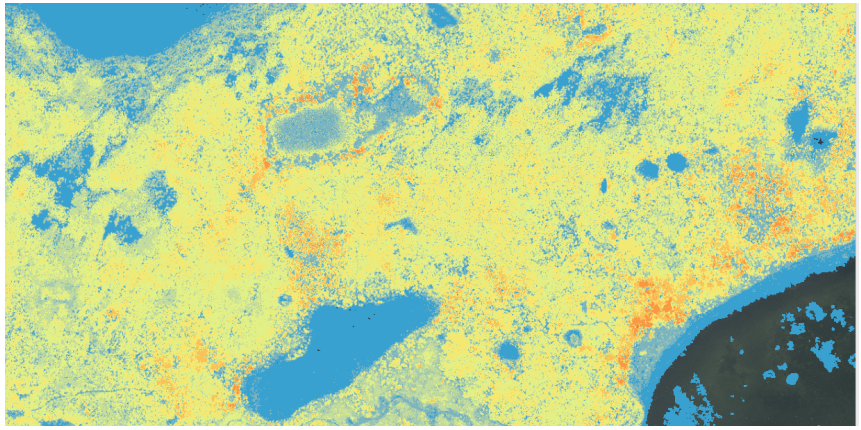


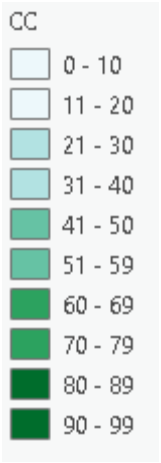
Crown Closure (%)

Derived directly from LiDAR dataset

% CHM cells >60% of Top Height



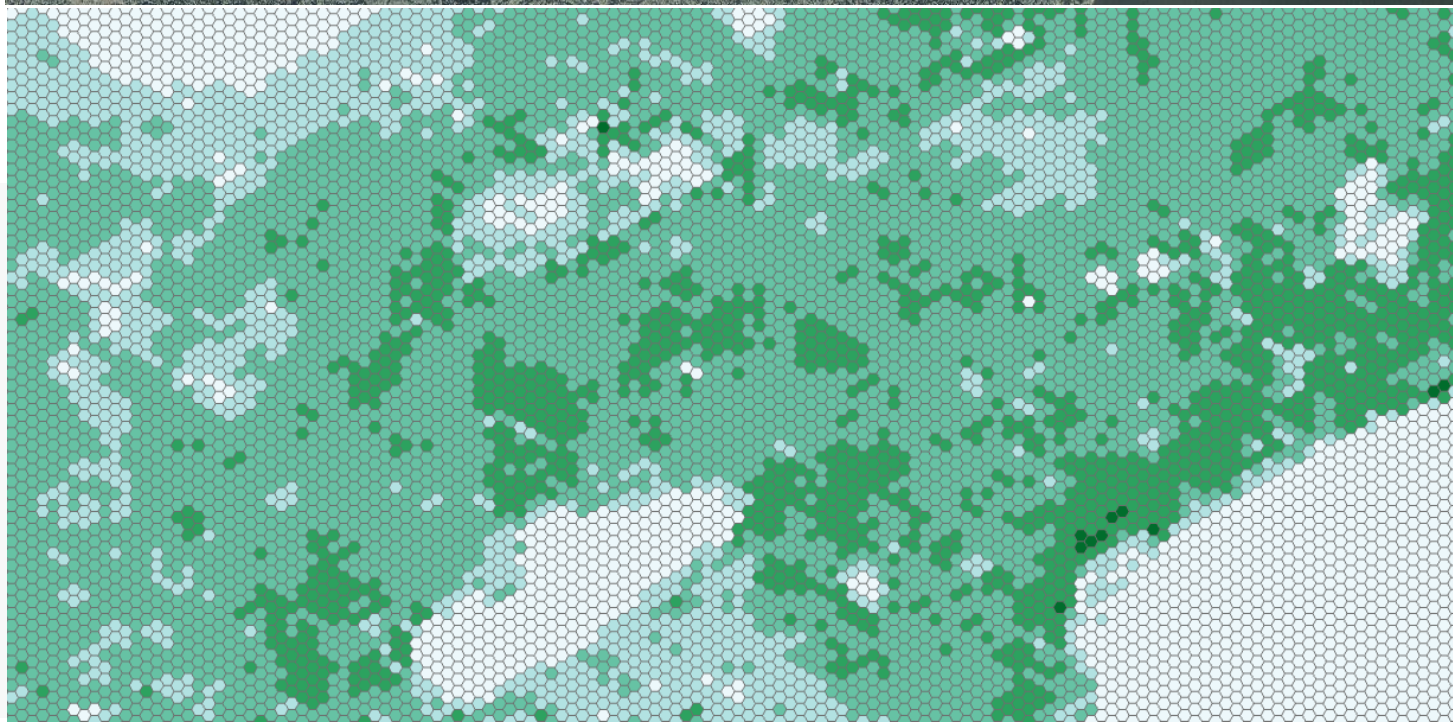




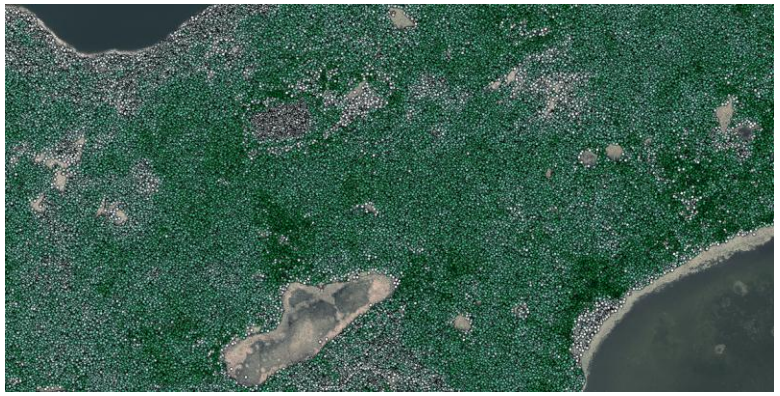
Top Height

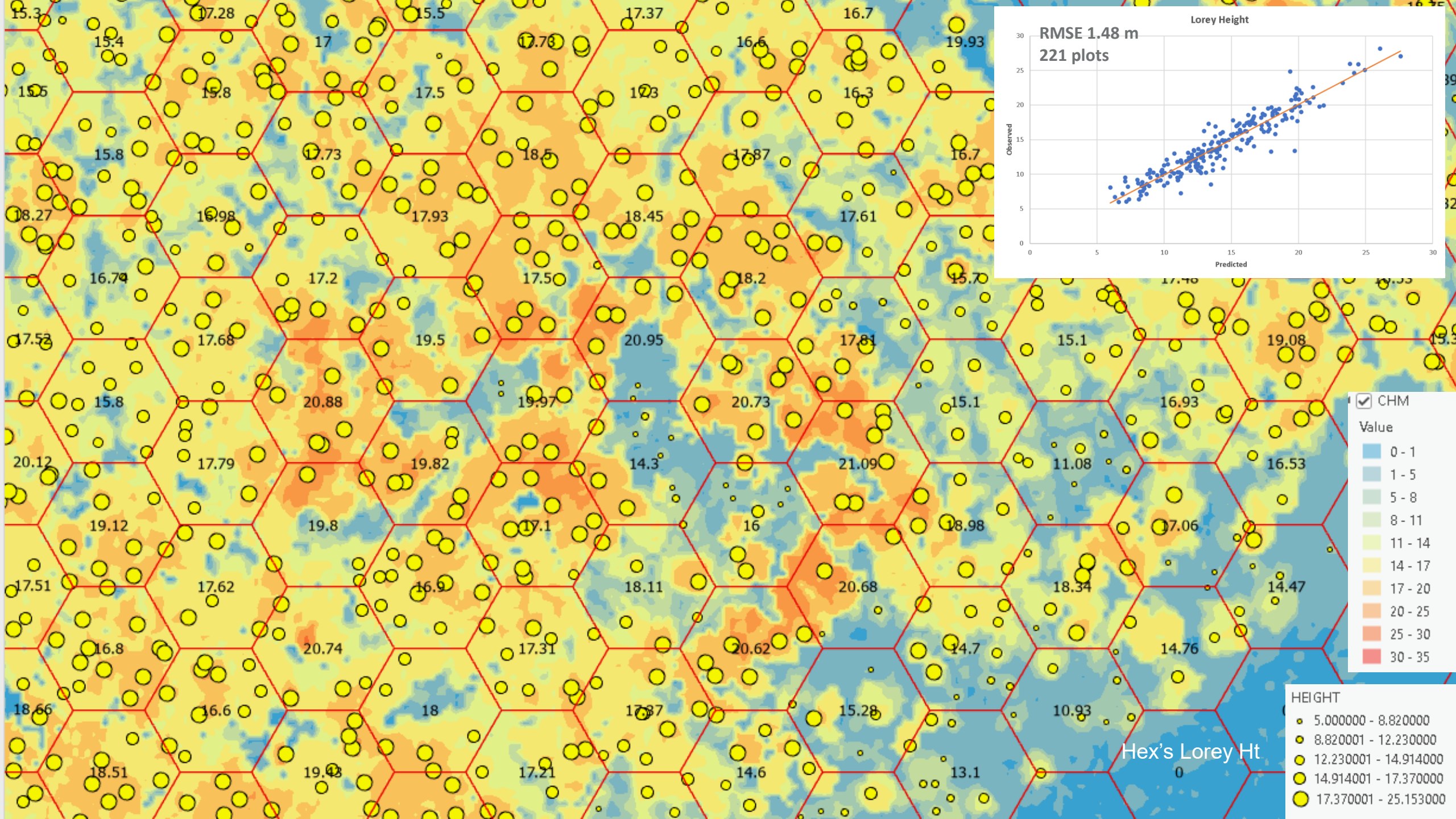
Derived directly from LiDAR dataset

Average of 4 tallest trees in a tile



Individual Tree Heights




Lorey Height
RMSE 1.48 m
221 plots
Observed
Predicted
0
5
10
15
20
25
30
CHM
Value
0 - 1
1 - 5
5 - 8
8 - 11
11 - 14
14 - 17
17 - 20
20 - 25
25 - 30
30 - 35
HEIGHT
5.000000 - 8.820000
8.820001 - 12.230000
12.230001 - 14.914000
14.914001 - 17.370000
17.370001 - 25.153000
Hex's Lorey Ht

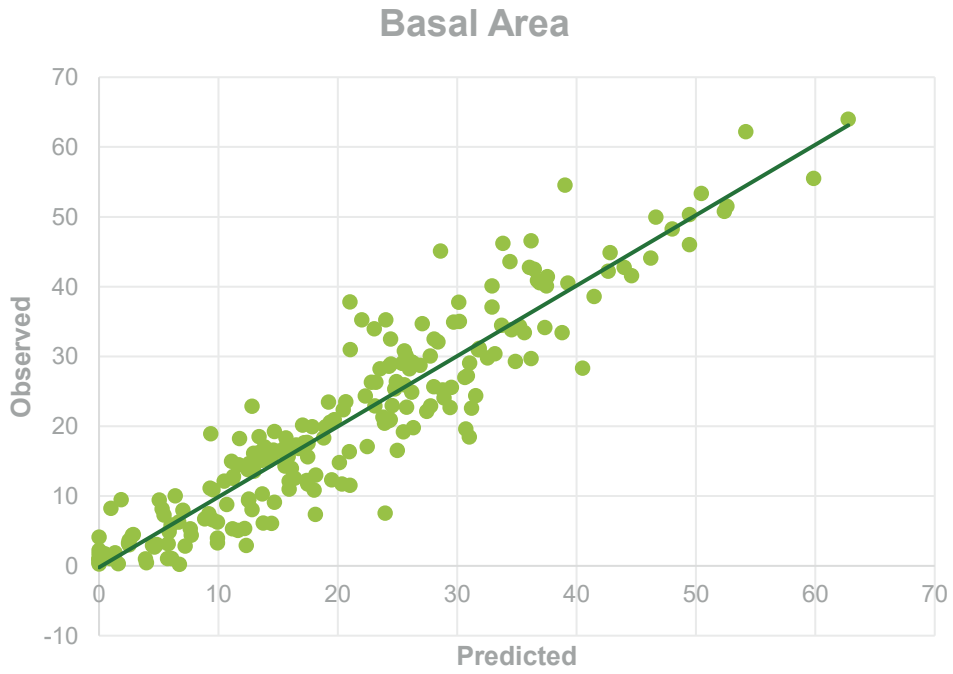
Basal Area / Ha

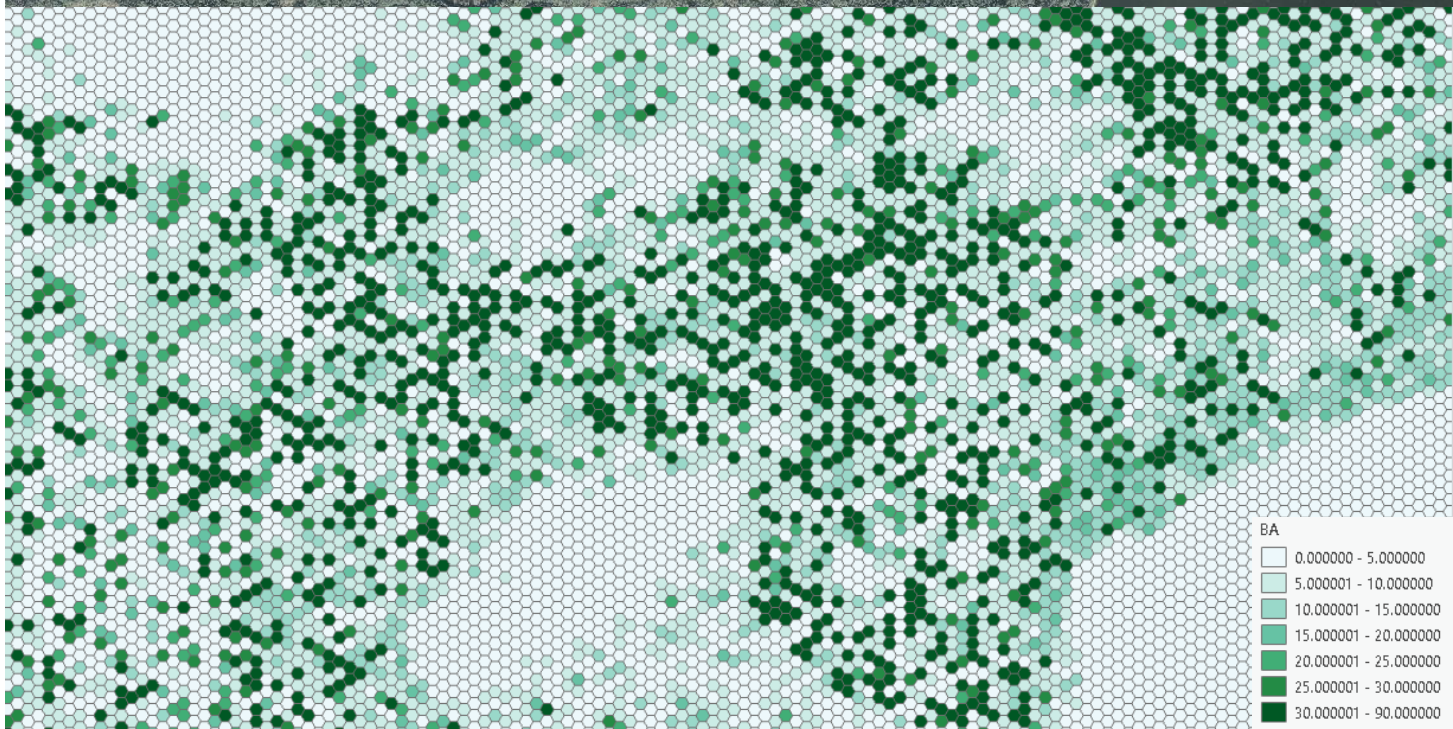
Predicted from Plot Data

Elasticnet with KFold validation (10%)

RMSE: 5.1m²/ha

221 plots





Total Stems / Ha

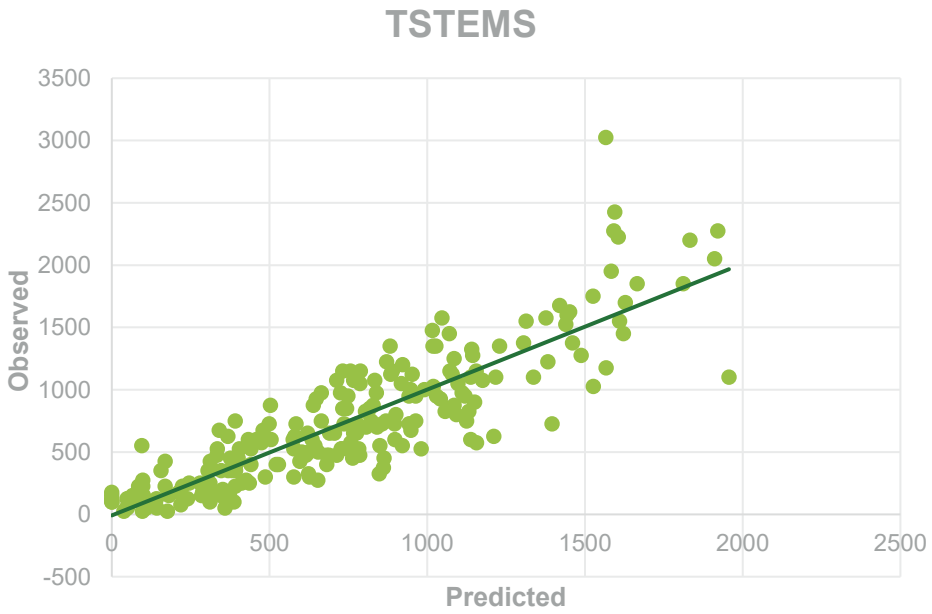
Trees > 1.3 m tall

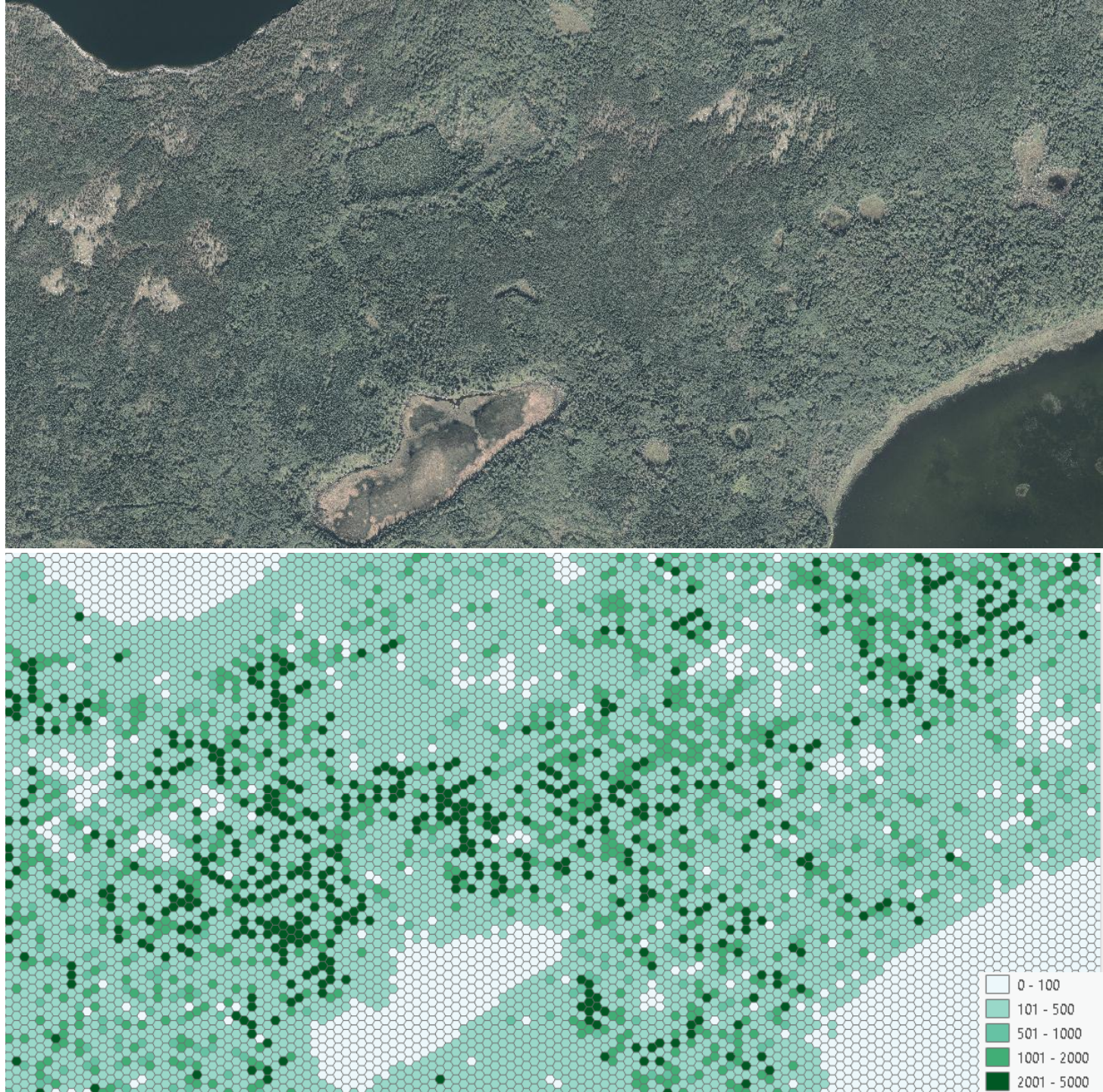
Predicted from Plot Data

Elasticnet with KFold validation (10%)

RMSE: 261 sph

221 plots





Merch SPH

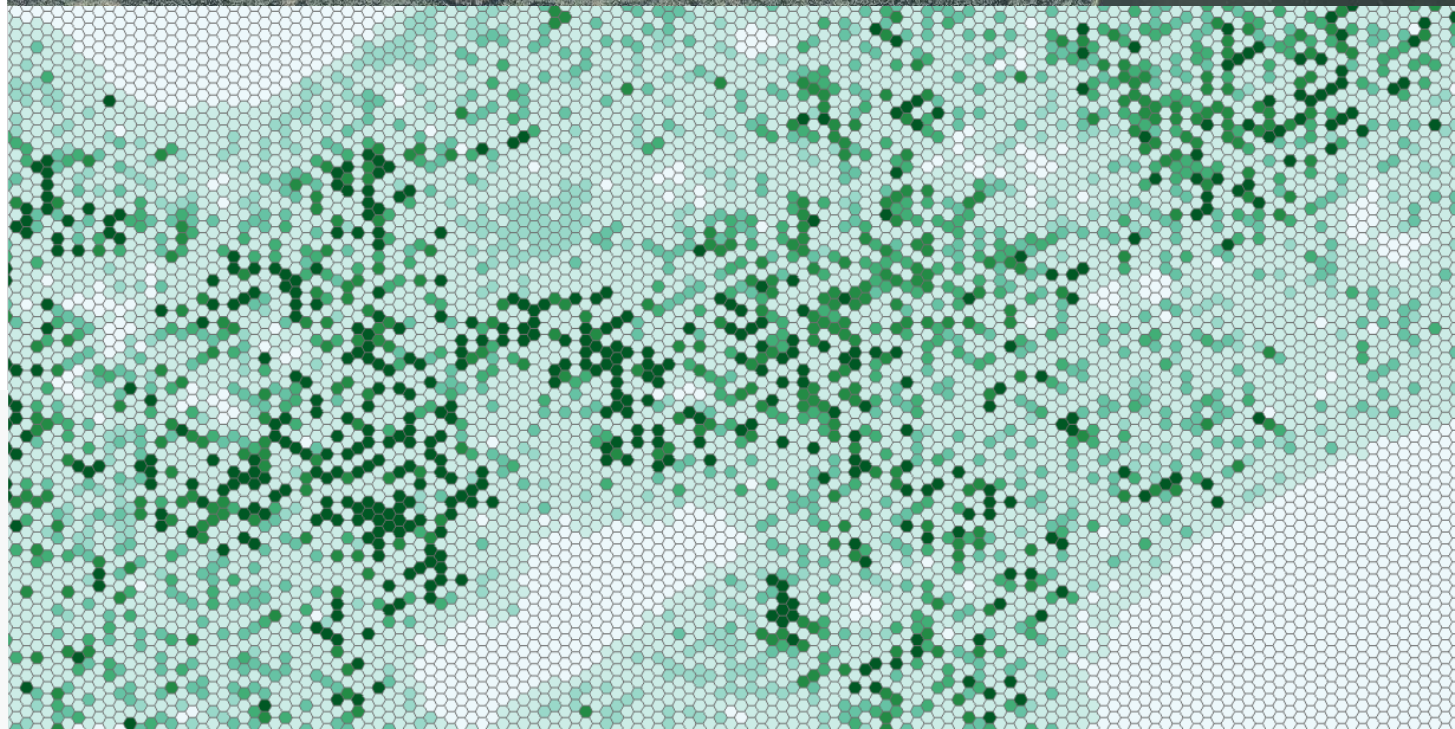
Trees with Merch Volume

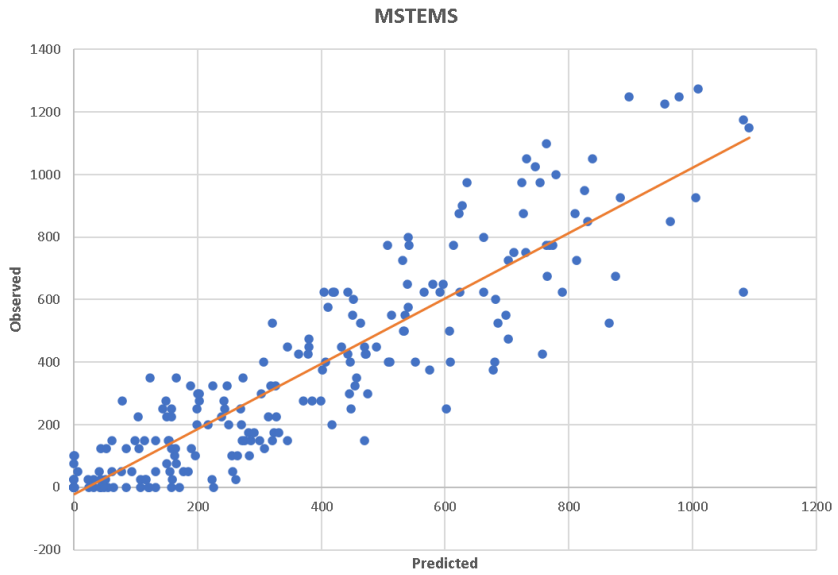
Predicted from Plot Data

Elasticnet with KFold validation (10%)

RMSE: 139 trees

221 plots





Gross Bio m^3 / Ha

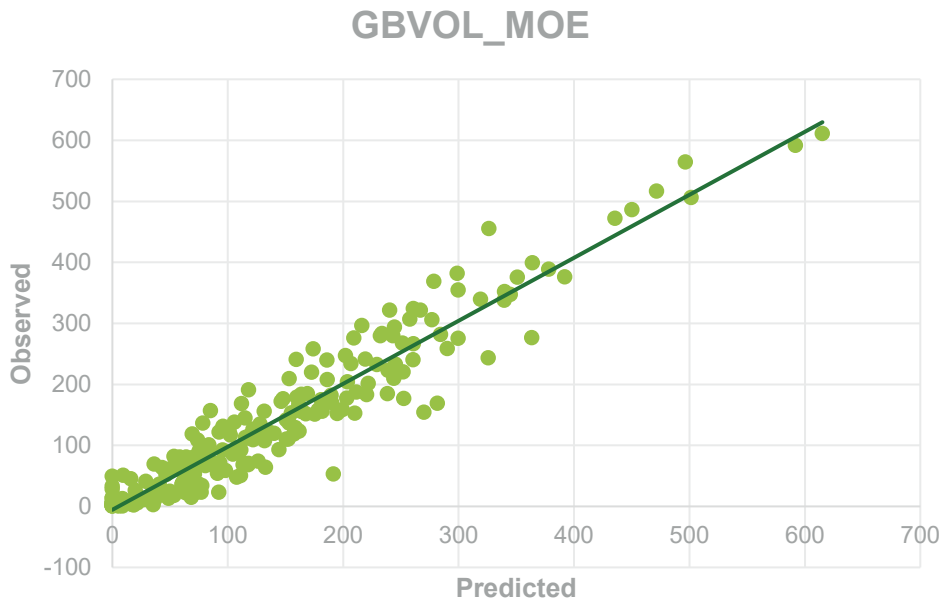
Trees > 1.3m tall (ground to tip)

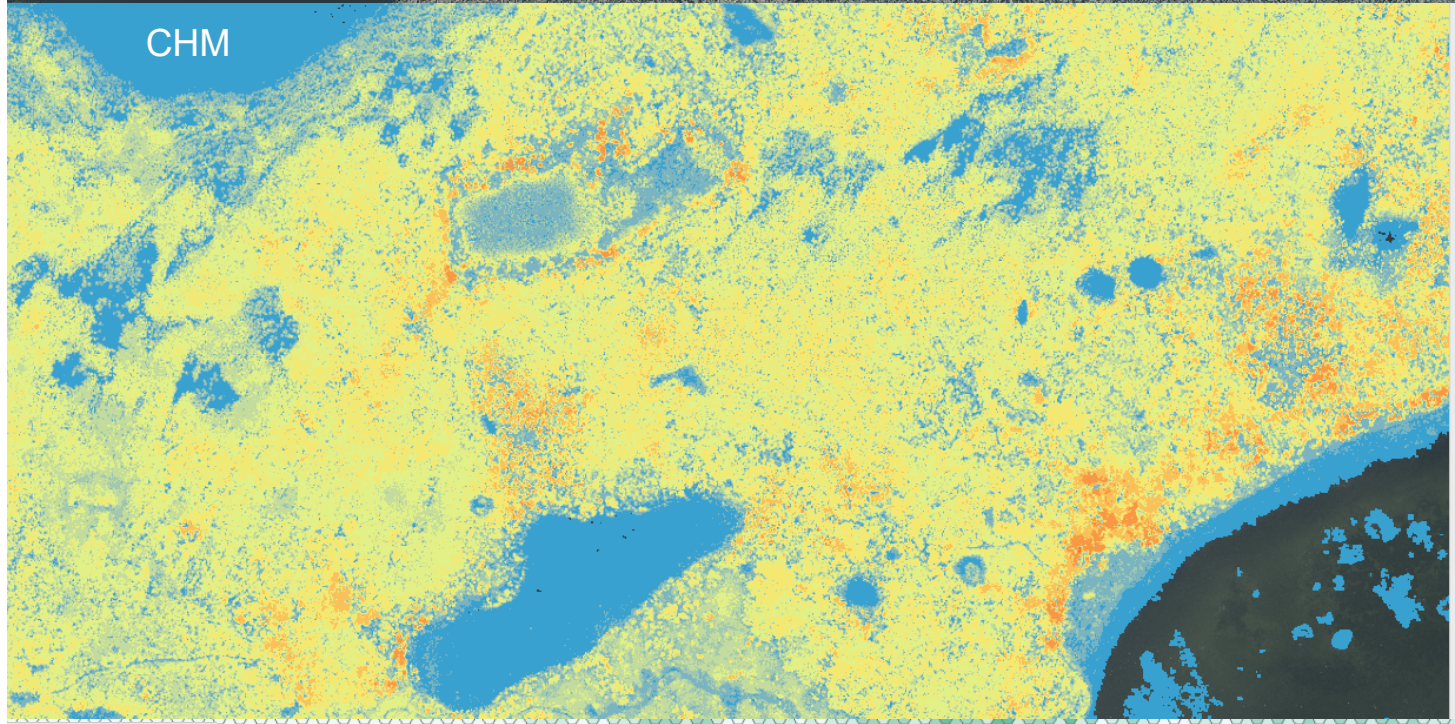
Predicted from Plot Data

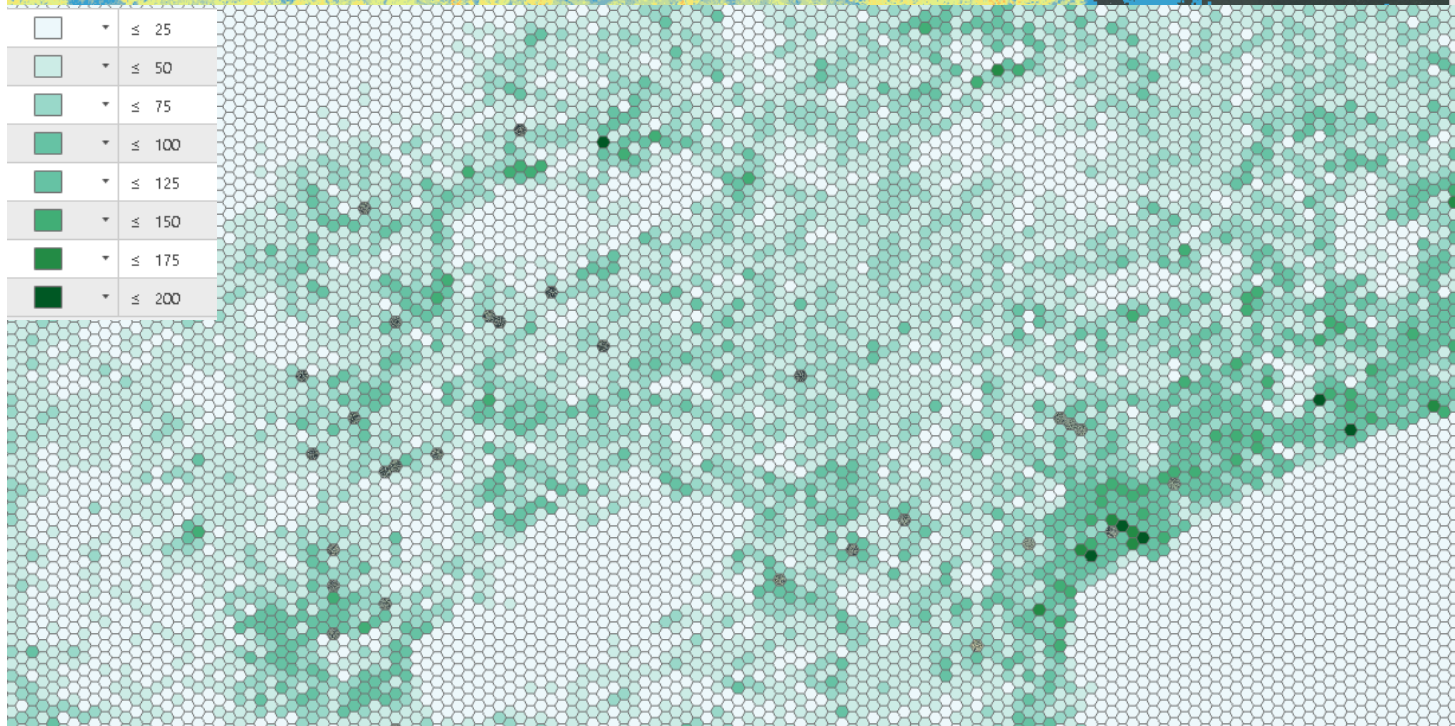
Elasticnet with KFold validation (10%)

RMSE: 37 m3/ha

221 plots





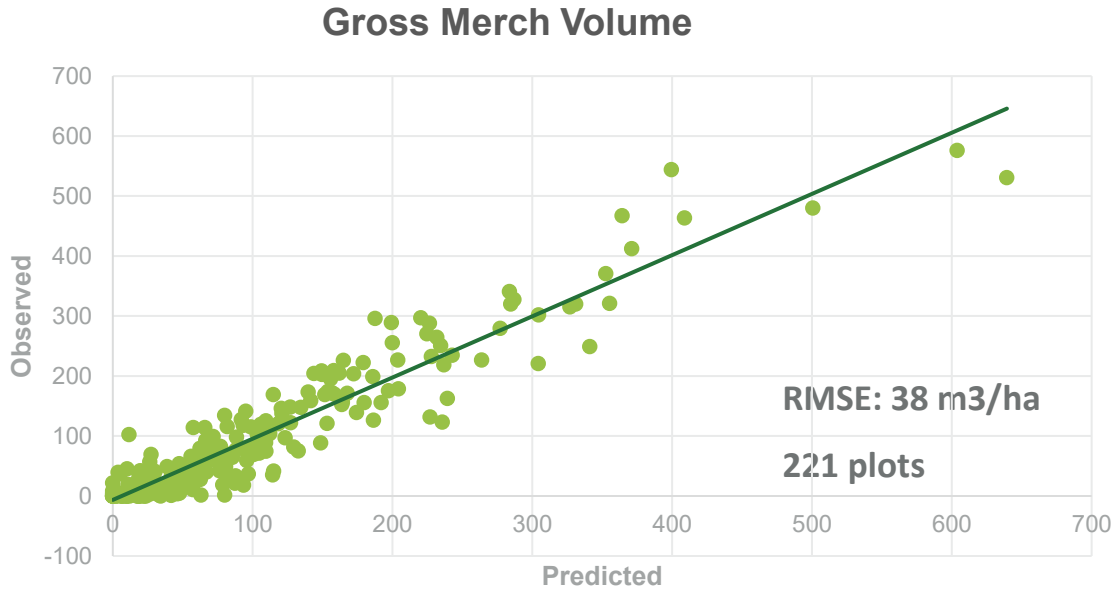


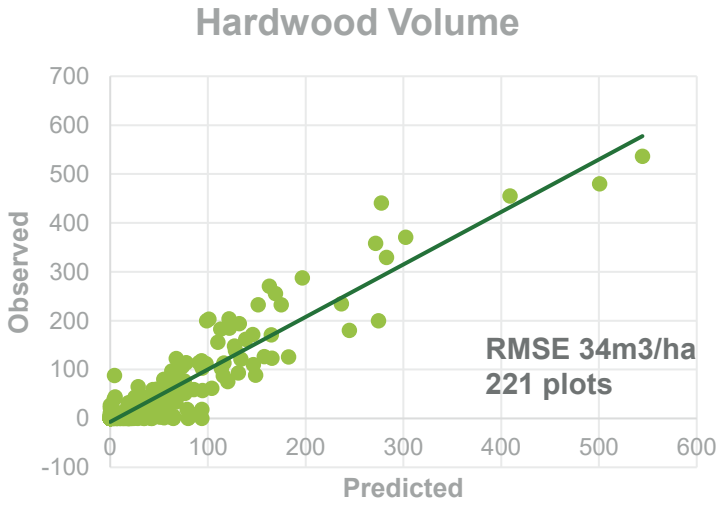
Merch Vol/ha

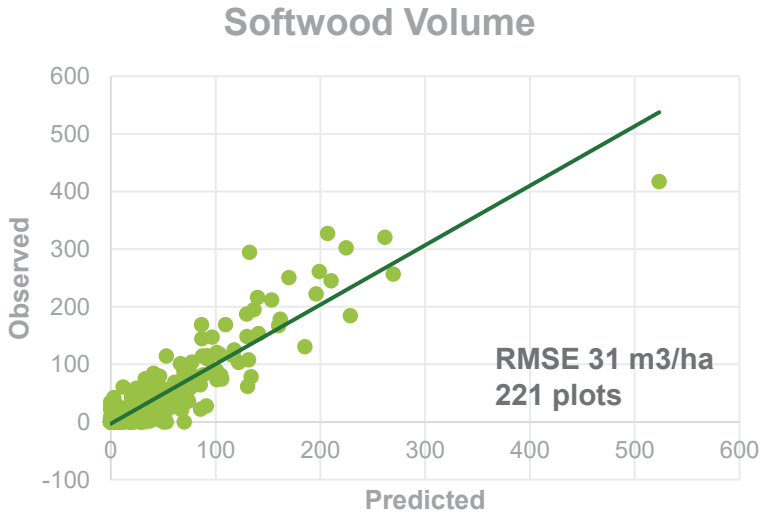
Stump 30cm, 8cm min top diameter

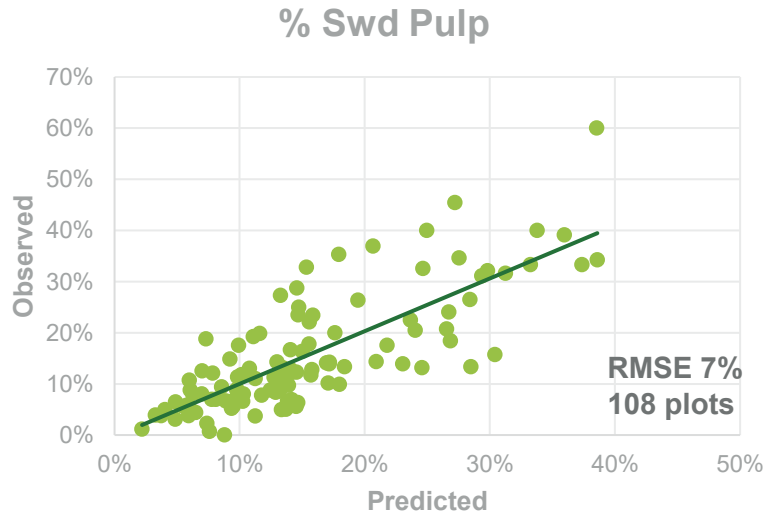
Predicted from Plot Data

Elasticnet with KFold validation (10%)









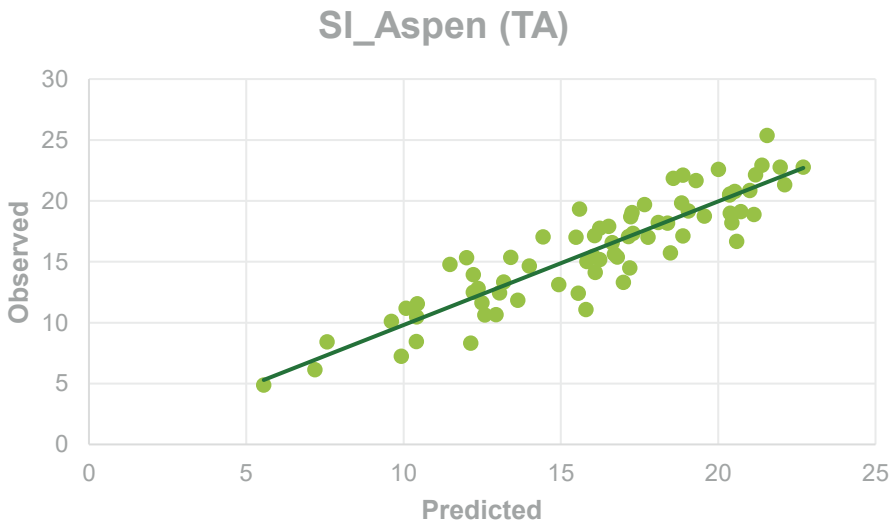
Site Index

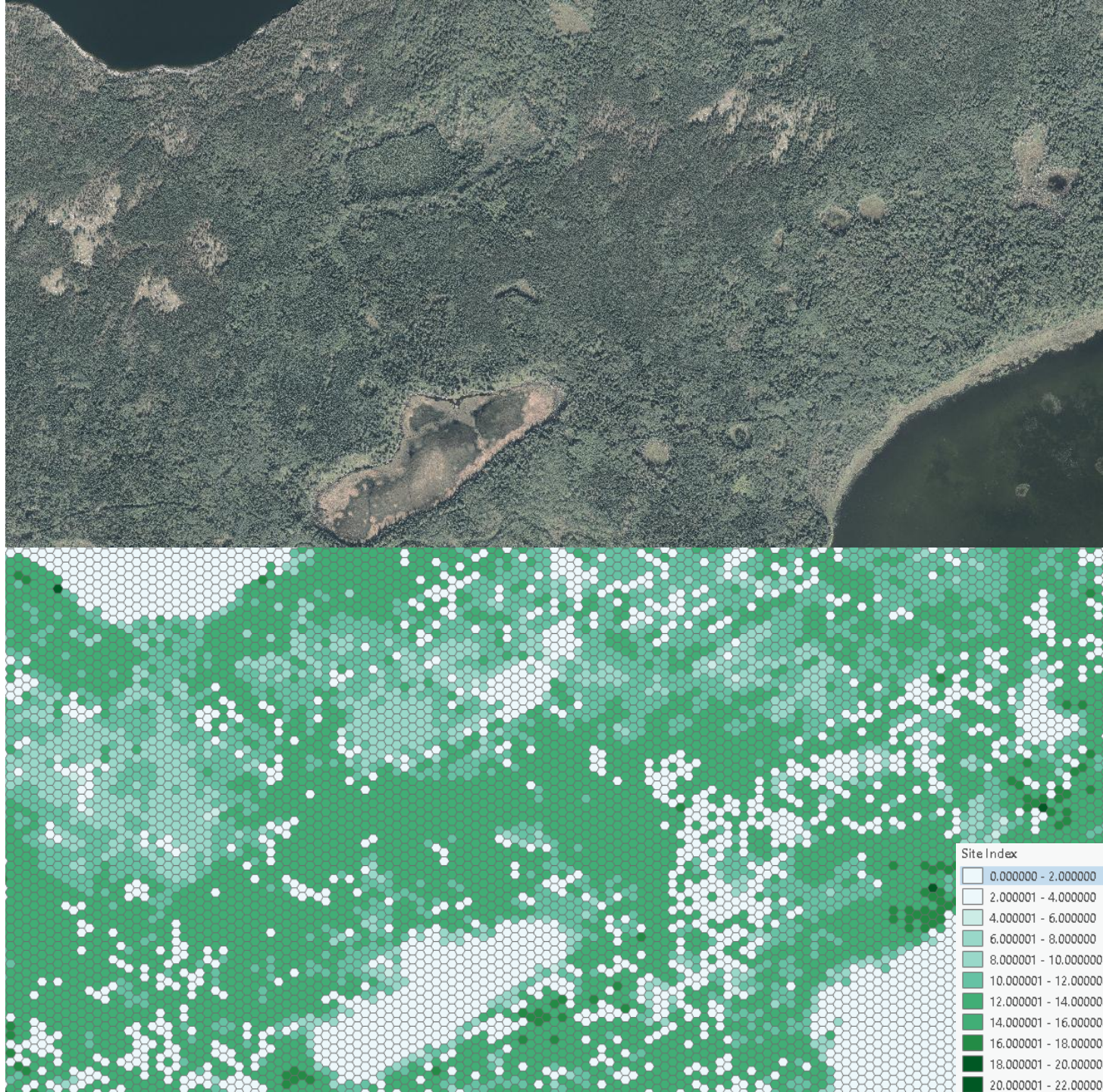
Predicted from Plot Data

Elasticnet with KFold validation (10%)

RMSE: 1.92 m

73 plots



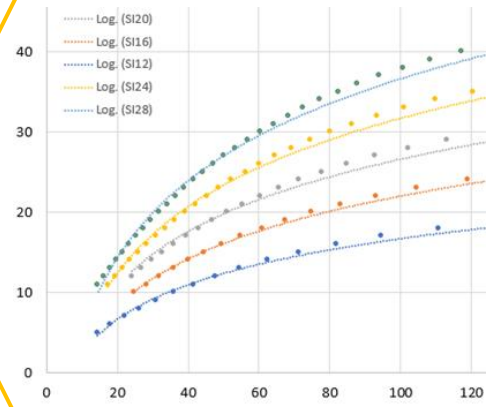


Tree Age Prediction Using LiDAR based ITI

Top Height of Leading Species in HEX

+

Predicted SI In HEX



=

Age of Hex is Calculated

Inverted SI allometric equations (Maltman et al, 2023):

For white spruce:

$$A = \frac{ln\left(1 - \left(\frac{H}{a \cdot S^{b}}\right)^{\frac{1}{d \cdot S^{e}}}\right)}{c}$$

Other species:

$$A = \frac{ln\left(1 - \frac{H^{\frac{1}{c}}}{a \cdot S}\right)}{b}$$

=> Equations coefficients were localized to project using the Site Trees in the plots (Regression fitted)

=>

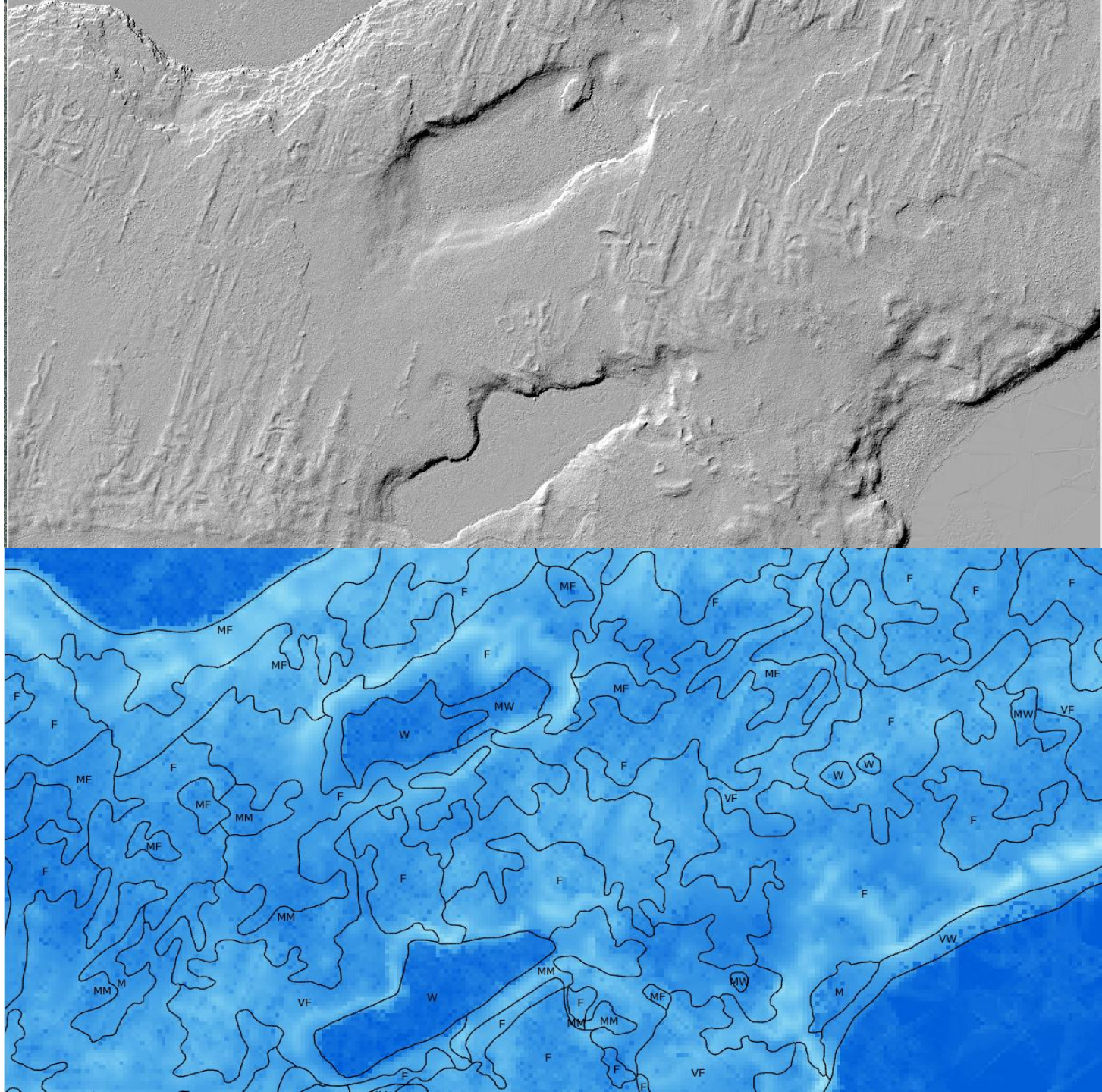
```
##   MODEL SPECIES ECOREGION n_total n_train n_valid    b1     b2    b3 rmse
## 1     1      bp        ALL      18      14       4 3.509 -0.010 0.877 3.43
## 2     2      bs        ALL      56      44      12 6.043 -0.006 0.848 3.29
## 3     3      jp        ALL      20      16       4 2.260 -0.013 0.968 1.38
## 4     4      ta        ALL      53      42      11 2.426 -0.016 0.911 1.94
##   rmse_pct rmse_pct_valid   r2 r2_valid
## 1     0.05           0.07 0.98     0.98
## 2     0.05           0.09 0.99     0.98
## 3     0.03           0.03 0.99     1.00
## 4     0.04           0.04 0.99     0.99
```

Moisture Regime

Predicted from Topographic Wetness Index

Threshold values selected using previous SVFI

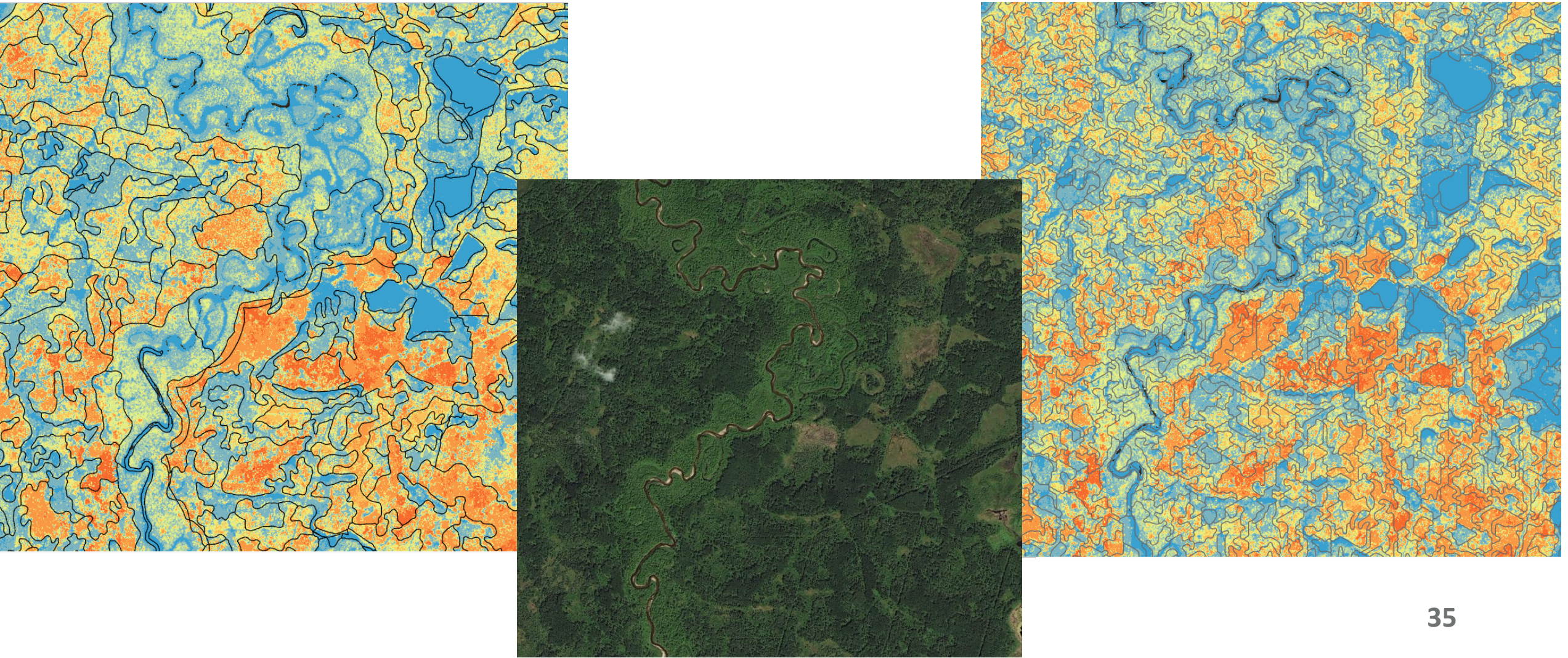
Code	Label	Definition
VD	Very Dry	Soil retains moisture for a negligible period following precipitation and water infiltration is extremely rapid. Indicates an upland stand.
D	Dry	Soil retains moisture for brief periods following precipitation and water infiltration is very rapid. Indicates an upland stand.
MF	Moderately Fresh	Soil retains moisture for short periods following precipitation and water infiltration is rapid. Indicates an upland stand.
F	Fresh	Soil retains moisture for moderately short periods following precipitation and water infiltration is moderate. Indicates an upland stand.
VF	Very Fresh	Soil retains moisture for substantial periods following precipitation or in some cases seepage. Water infiltration is somewhat slow. Indicates an upland stand.
MM	Moderately Moist	Soil retains abundant moisture for most of the growing season. Water infiltration following precipitation and periodic seepage is slow. Mottling may occur below 20 cm. Indicates an upland stand.
M	Moist	Soil is wet for a substantial part of the growing season. Seepage is common with mottling below 20 cm. Indicates an upland stand.
VM	Very Moist	Soil is wet for most of the growing season. Permanent seepage and mottling are present and weak gleying may occur. May occur in wetland or upland stands.
MW	Moderately Wet	Soil is wet for nearly all of the growing season. Permanent seepage and mottling is present, gleying in mineral soils, organic soils are also common. Indicates a wetland.
W	Wet	Water table is at or near the surface (surface seepage) for most of the year. Gleying is common in mineral substrates and organic soils are also common. Indicates a wetland.
VW	Very Wet	The water table is at or above the soil surface all year. Soils are organic or gleyed mineral. Indicates a wetland.



Inventory Polygons (Ecog)

Old SFVI Polygons

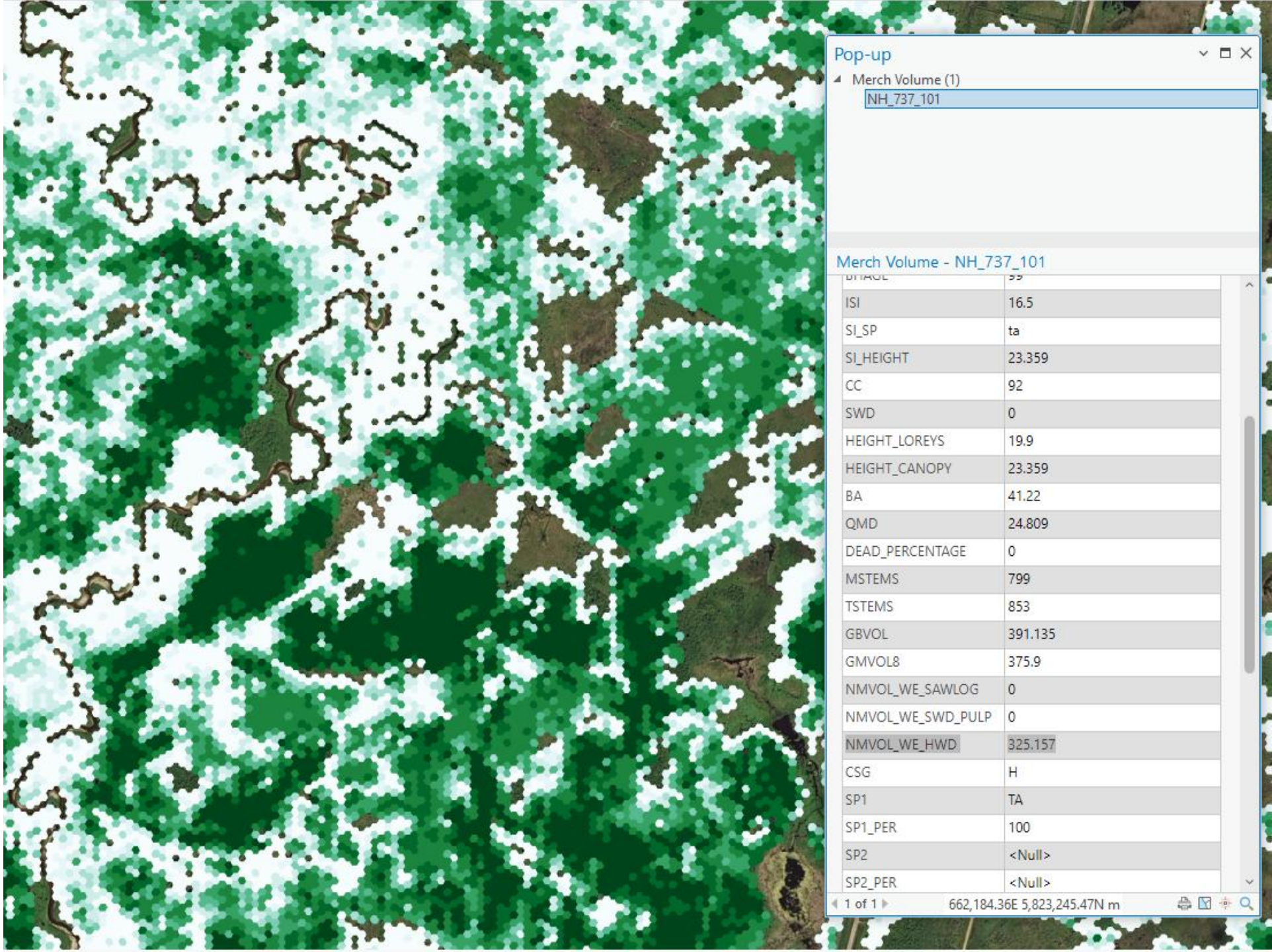
New FMI Polygons

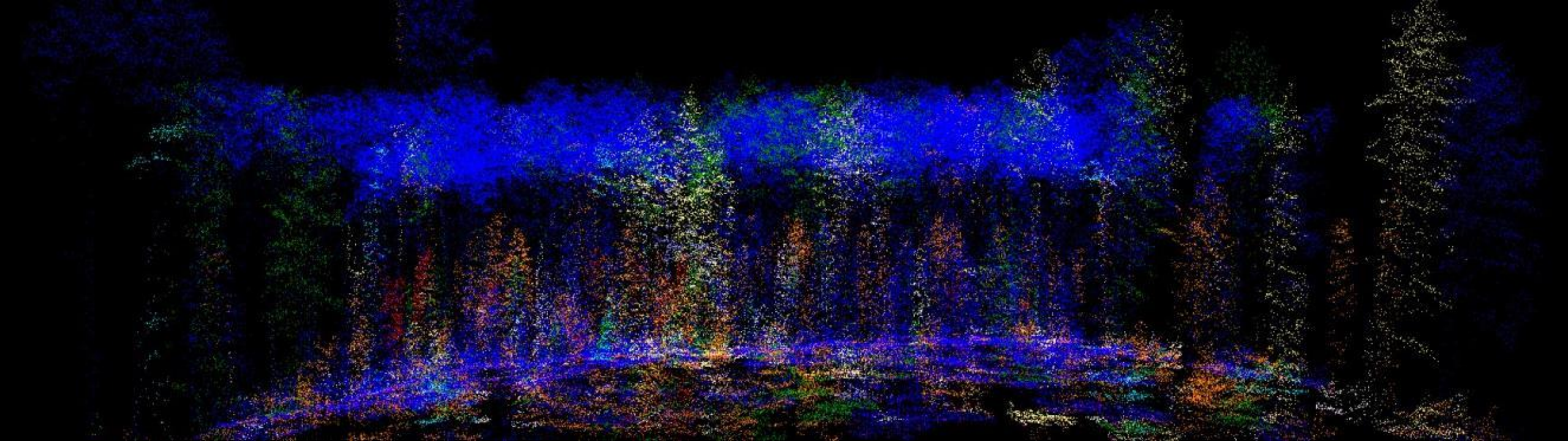


G&Y Link

PP TSA Inventory

- Each 400m2 hex has volume and age.
- All Hex's used as TSP's to build Empirical Yield Curves (many strata)
- Tree lists used to define shape of curves (MGM)





Thank you!

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