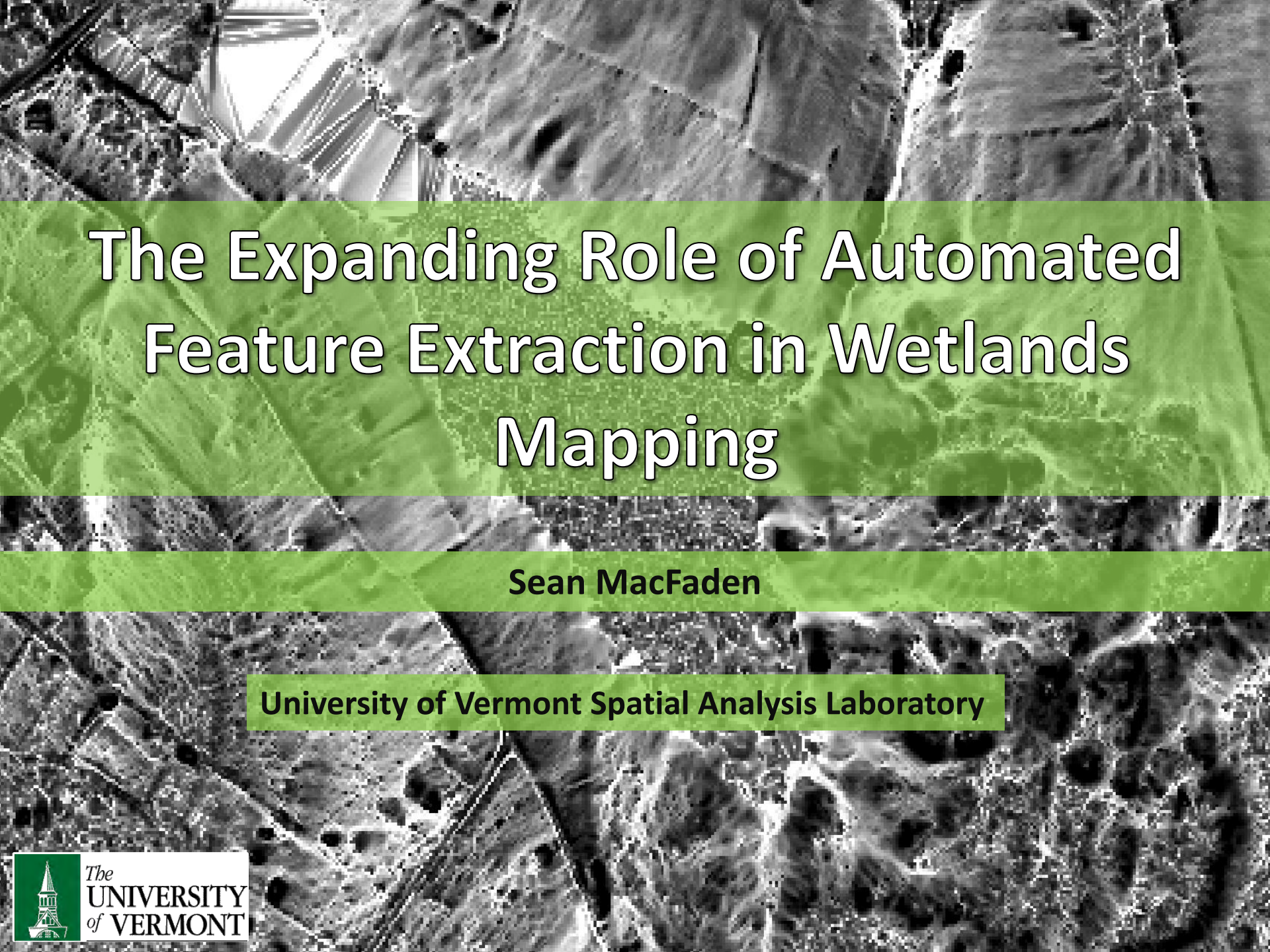


The Expanding Role of Automated Feature Extraction in Wetlands Mapping

Sean MacFaden

University of Vermont Spatial Analysis Laboratory

The UNIVERSITY of VERMONT

Need

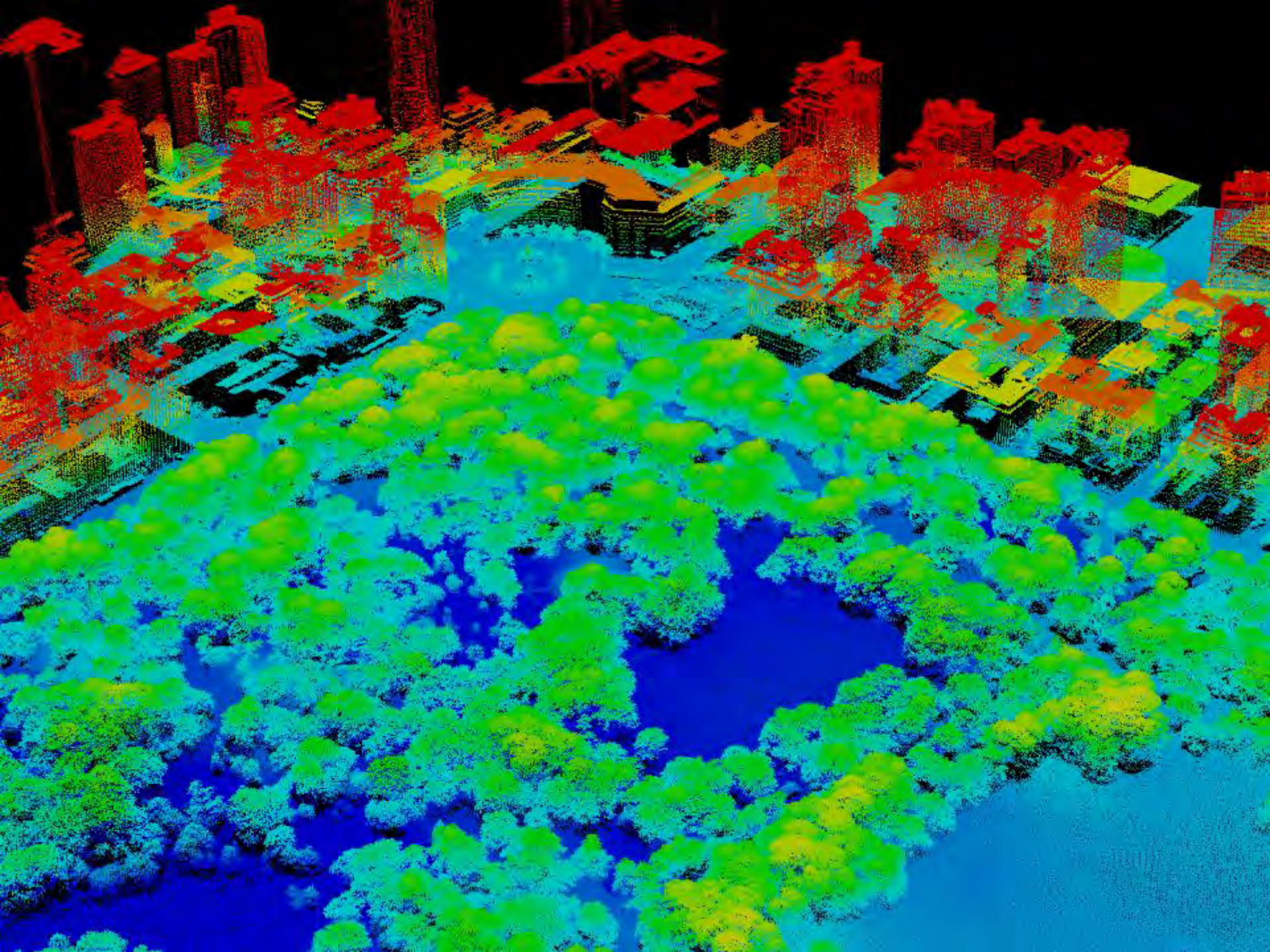
- ✓ Manual Interpretation Effective but Laborious
- ✓ Existing Datasets Outdated
- ✓ Omissions and Locational Errors

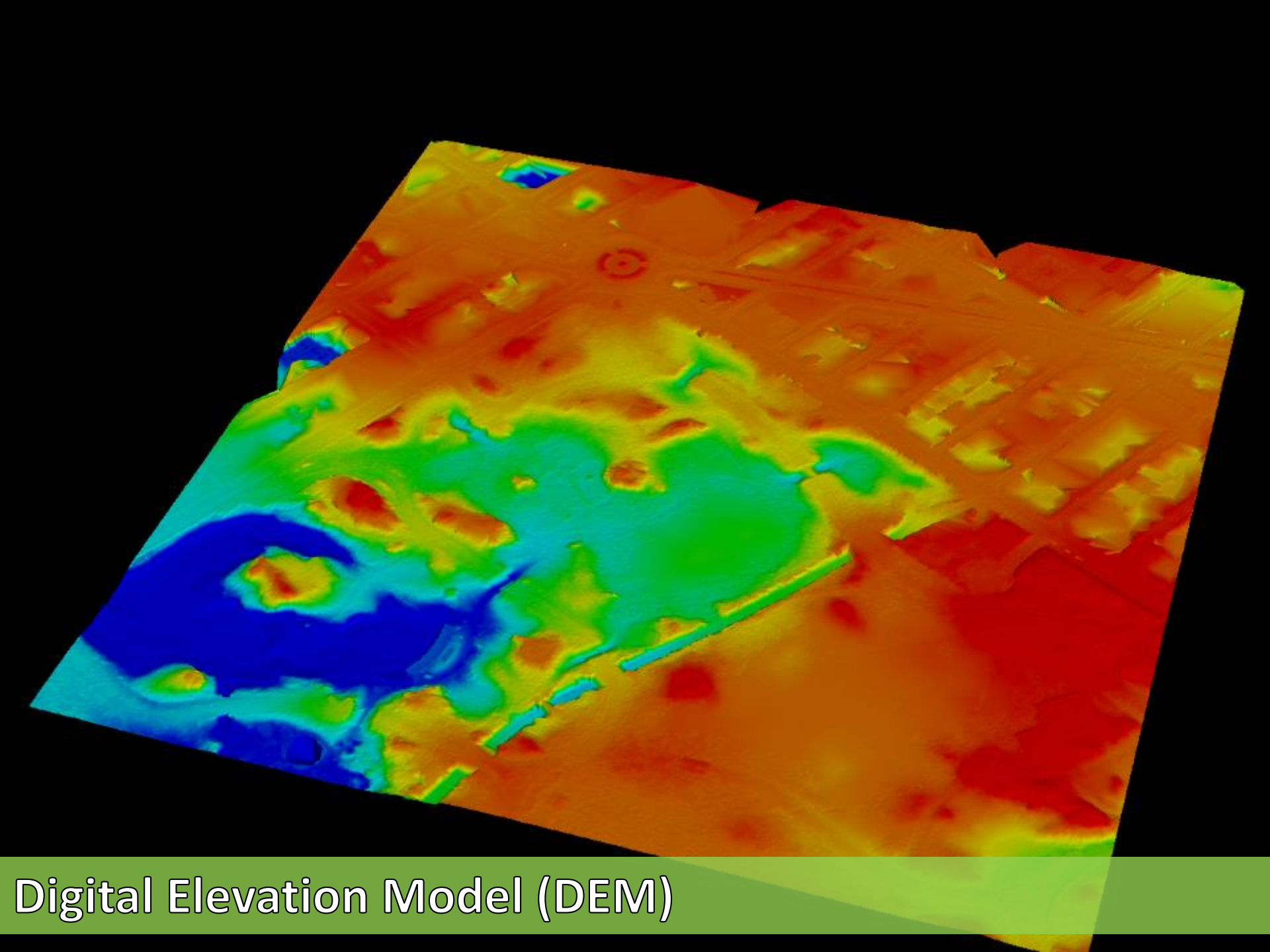
Opportunity

- ✓ LiDAR Increasingly Available
- ✓ High-resolution Imagery
- ✓ Usually FREE!
- ✓ Improved Processing Methods

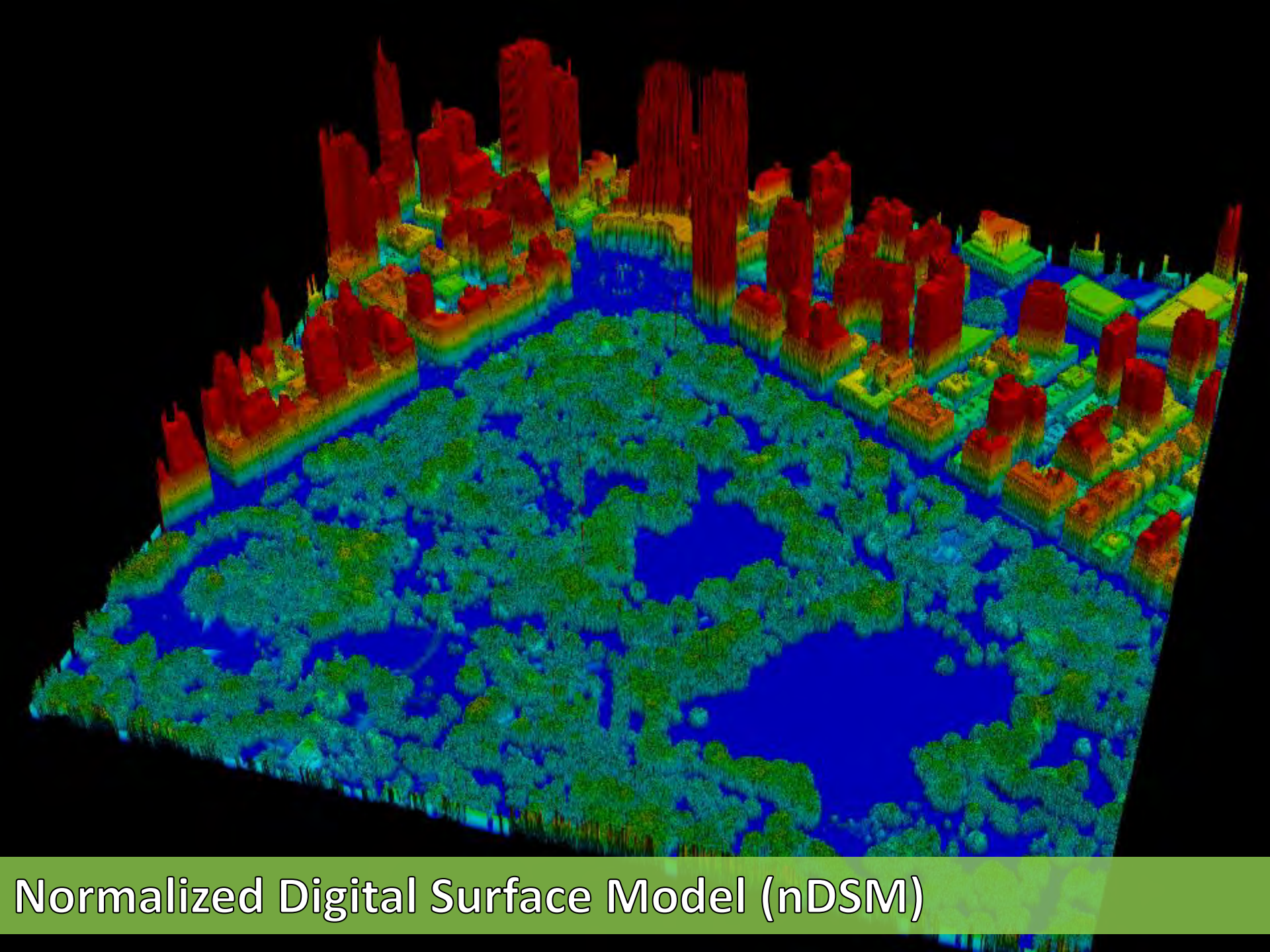
LiDAR

Light Detection And Ranging

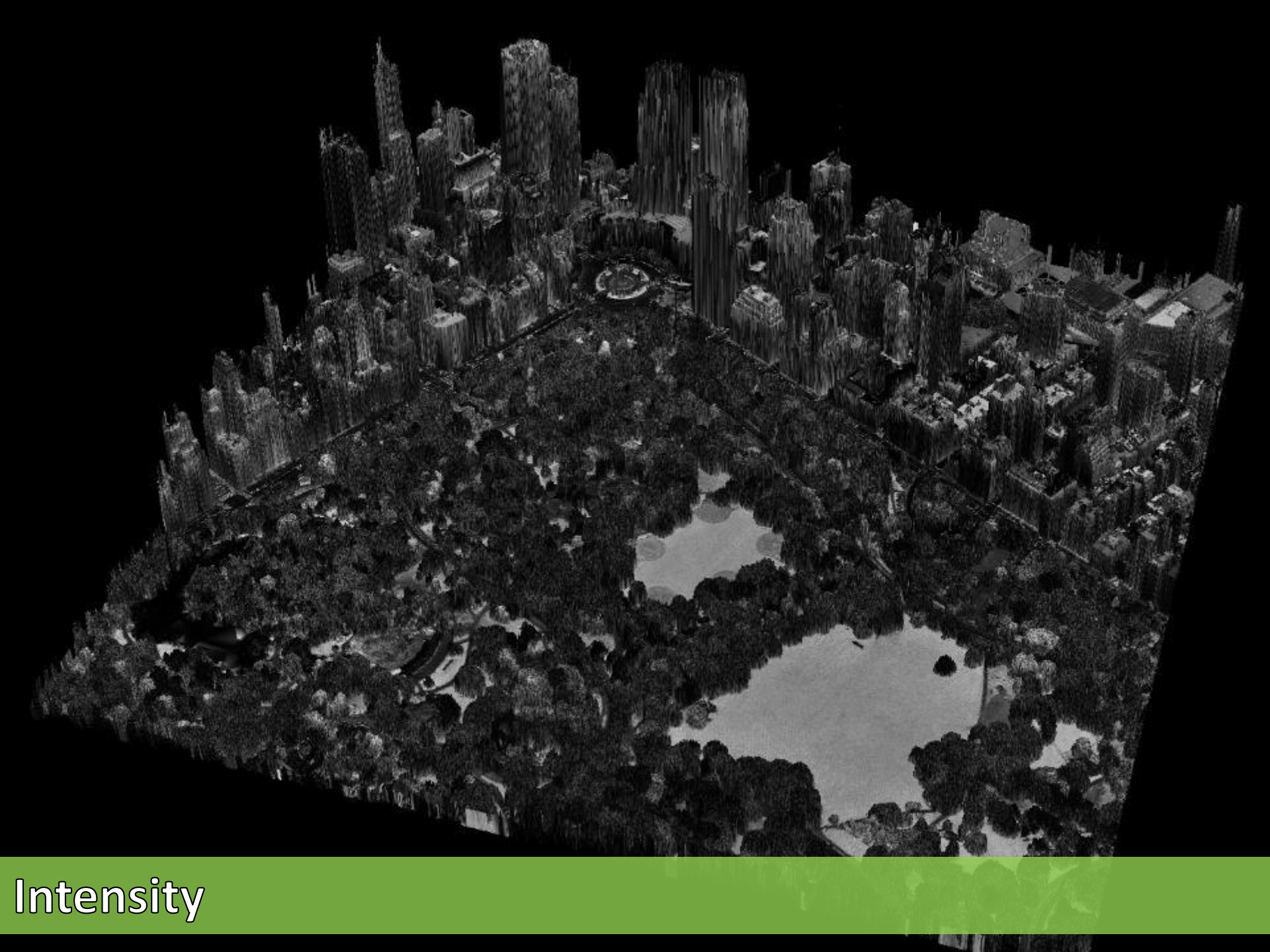




Digital Elevation Model (DEM)

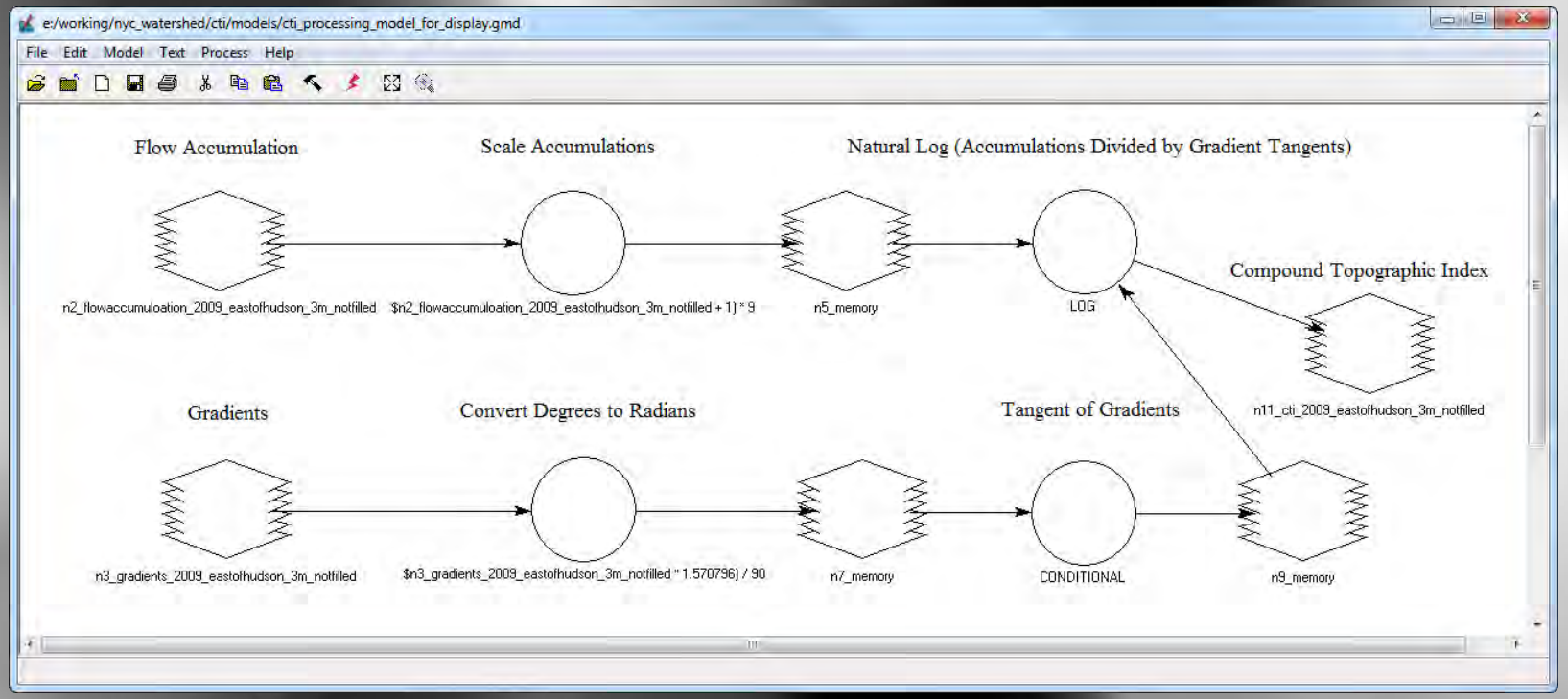


Normalized Digital Surface Model (nDSM)

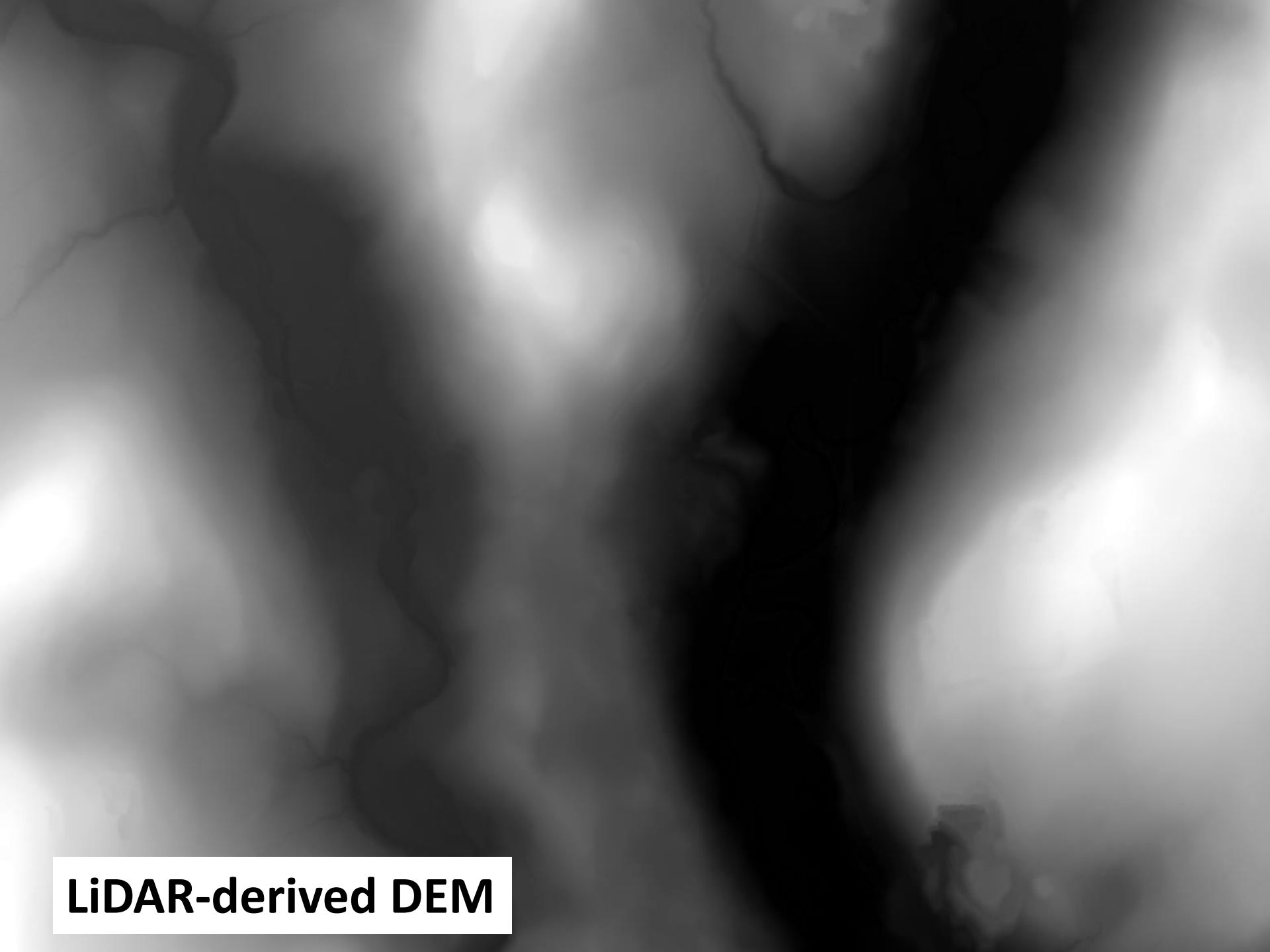


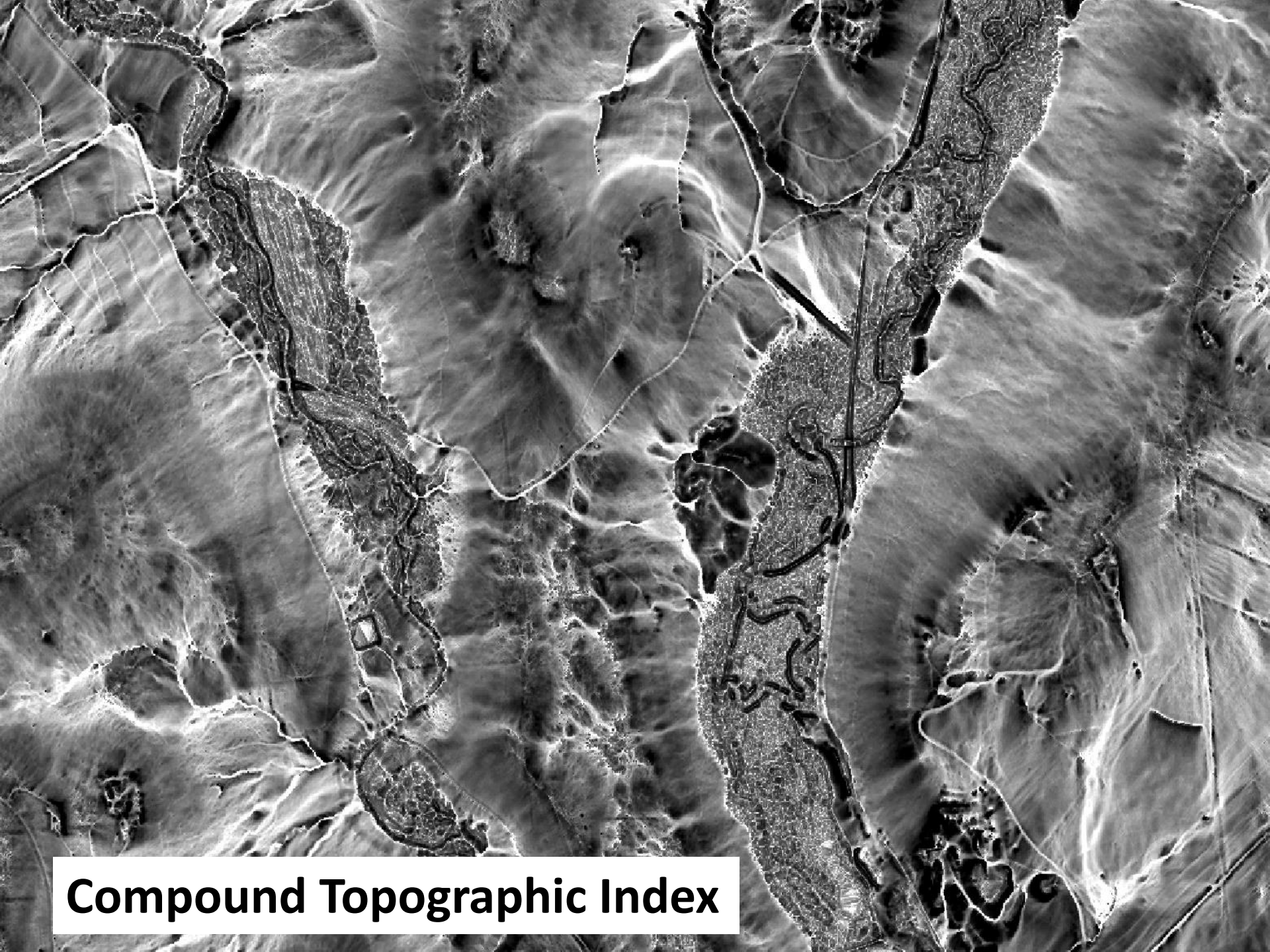
Intensity

Key Derivative: Compound Topographic Index

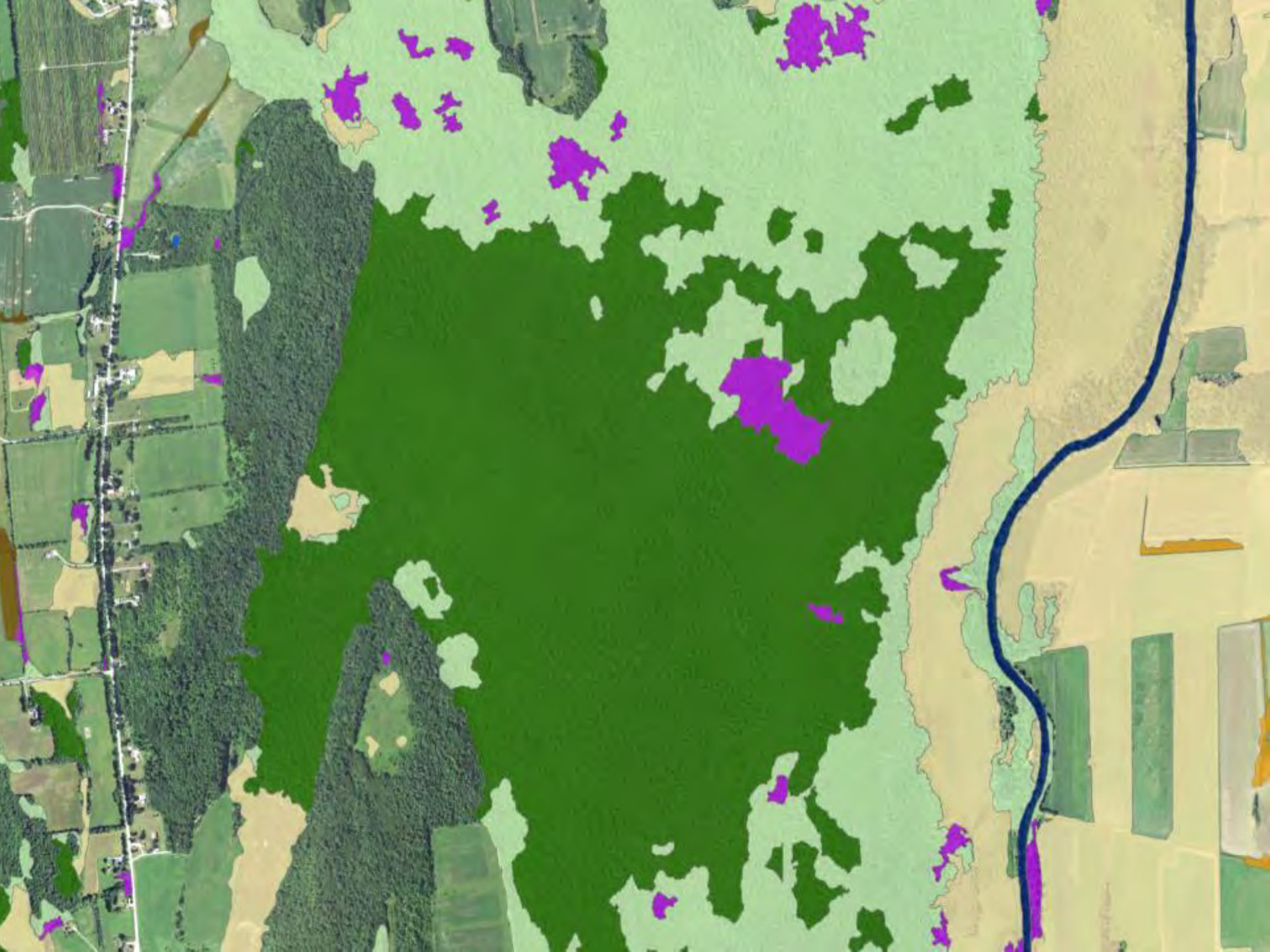


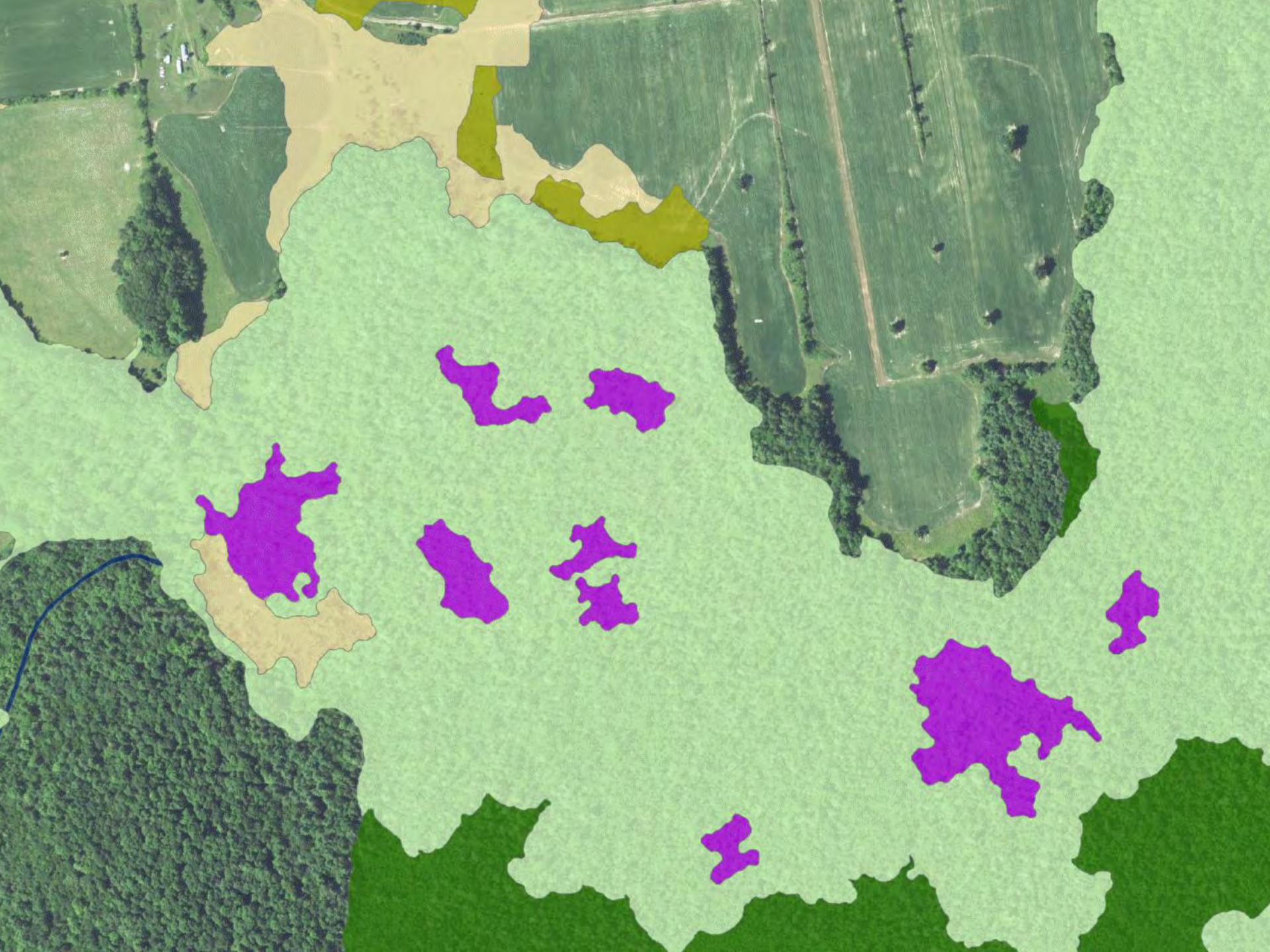
Bevan and Kirby (1979), as described by Rampi et al. (2014)

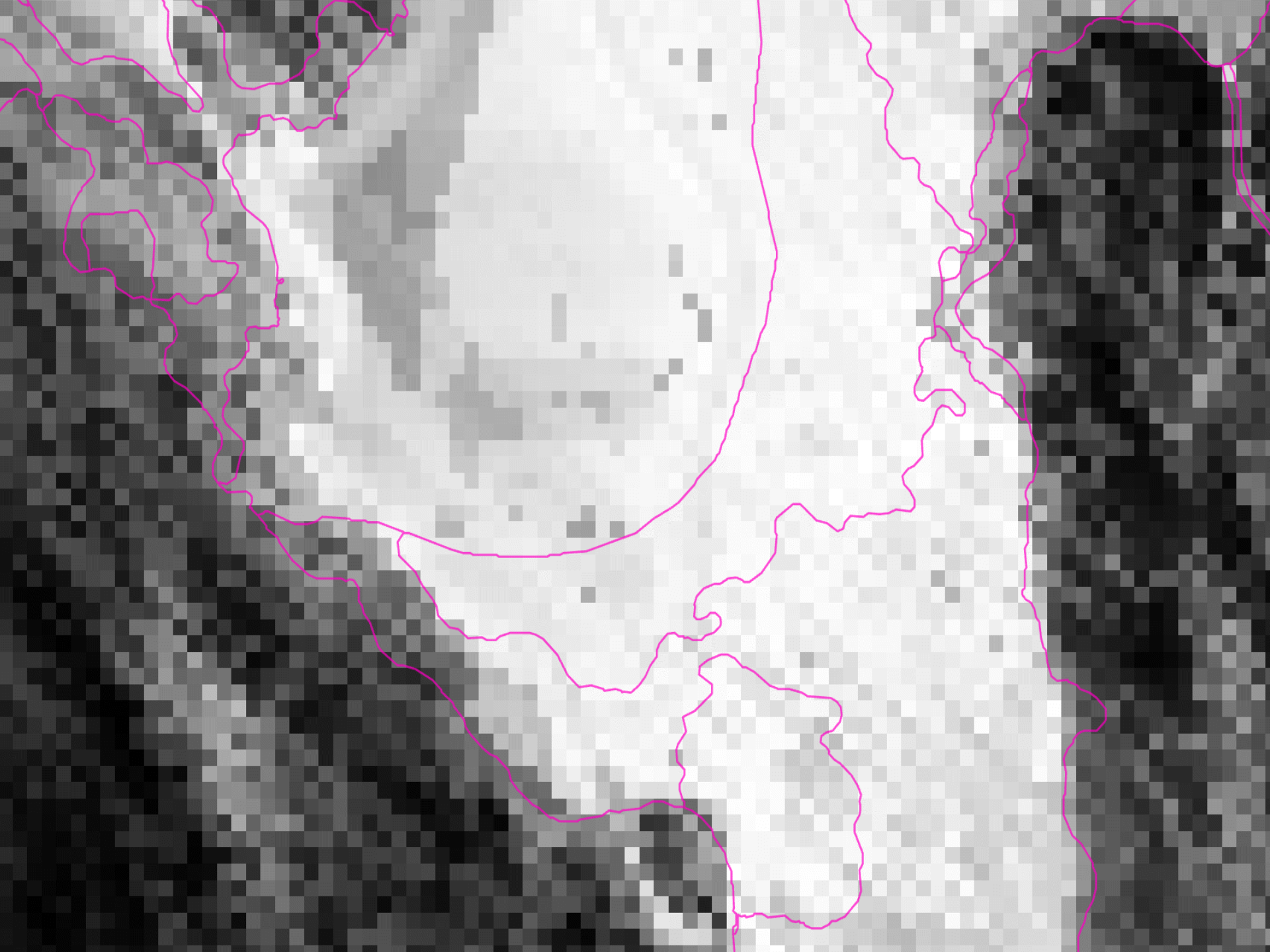

LiDAR-derived DEM


Compound Topographic Index

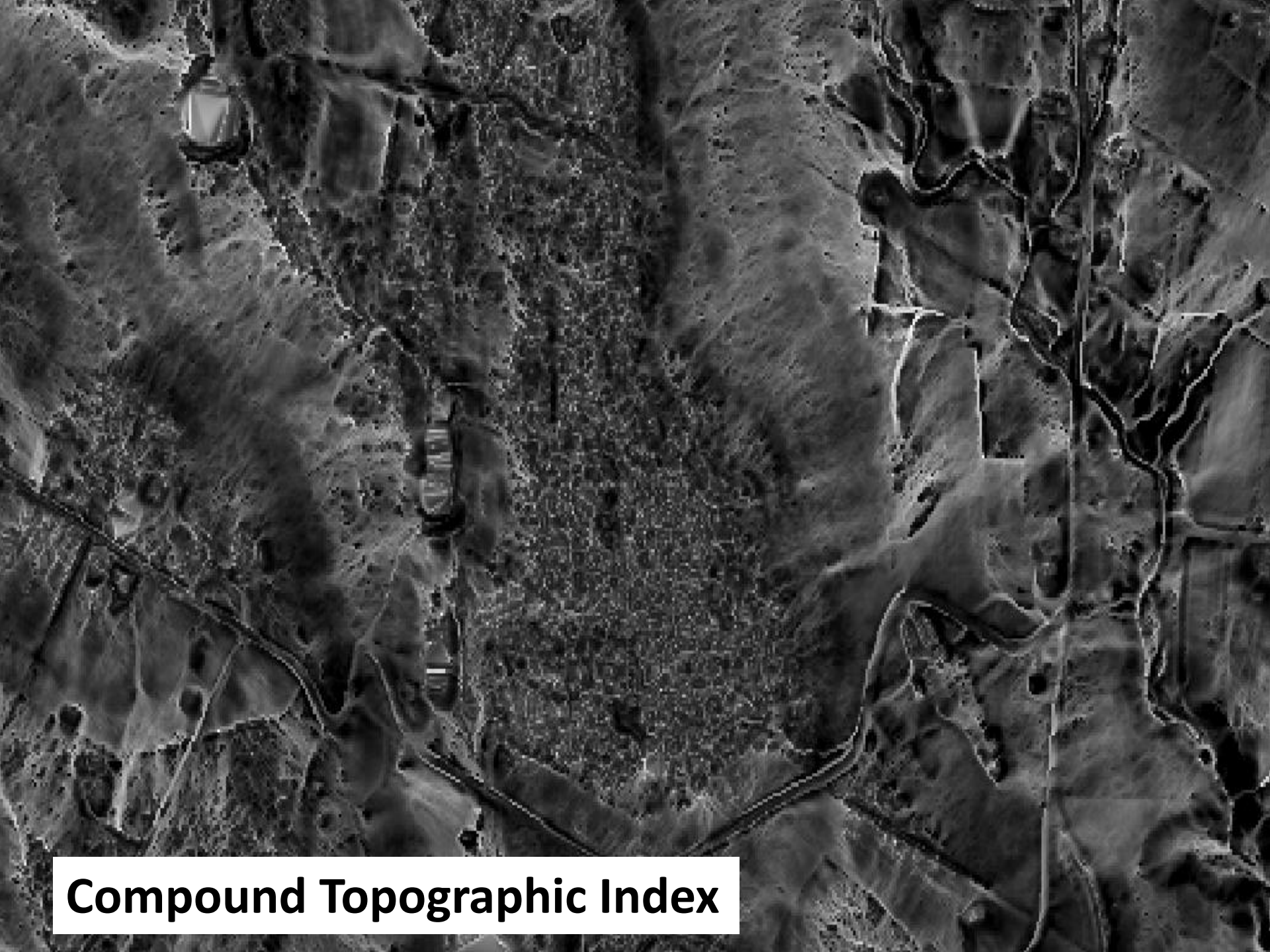

Object-based Image Analysis
✓Objects Rather Than Pixels
✓Better Approximates Landscape Objects
✓Contextual Analysis
✓Data Fusion
✓Enterprise Processing - eCognition

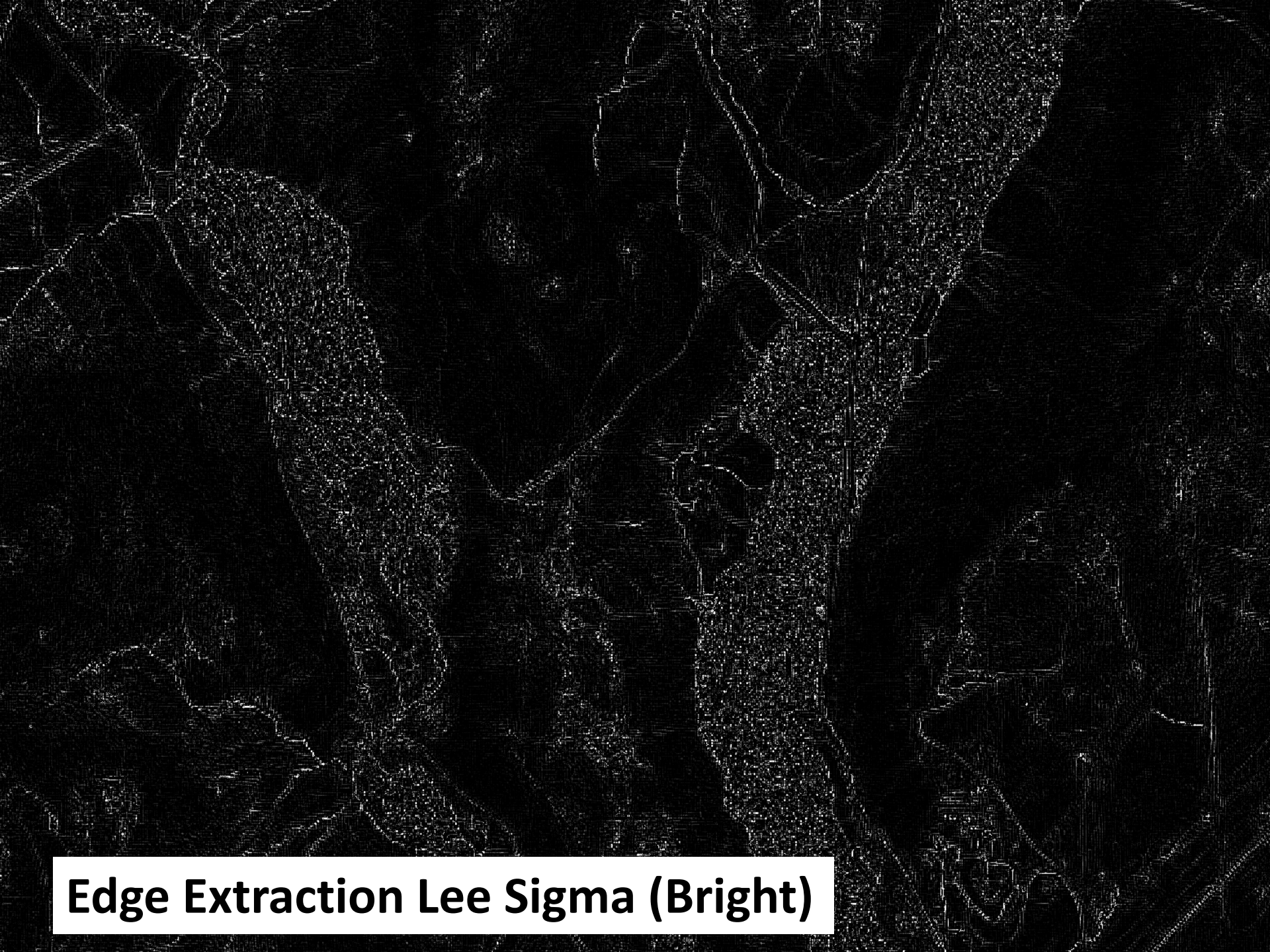


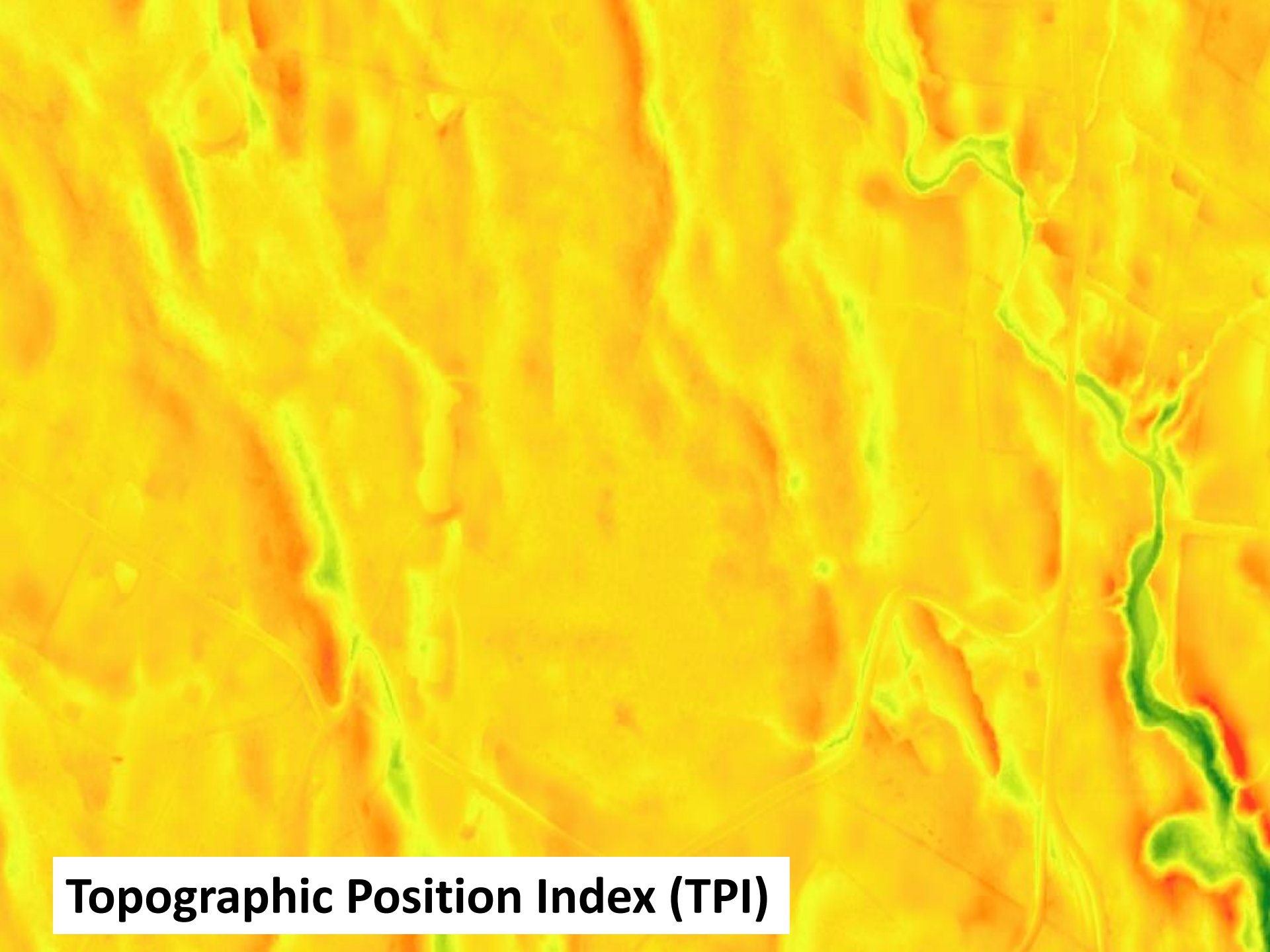




Data Fusion

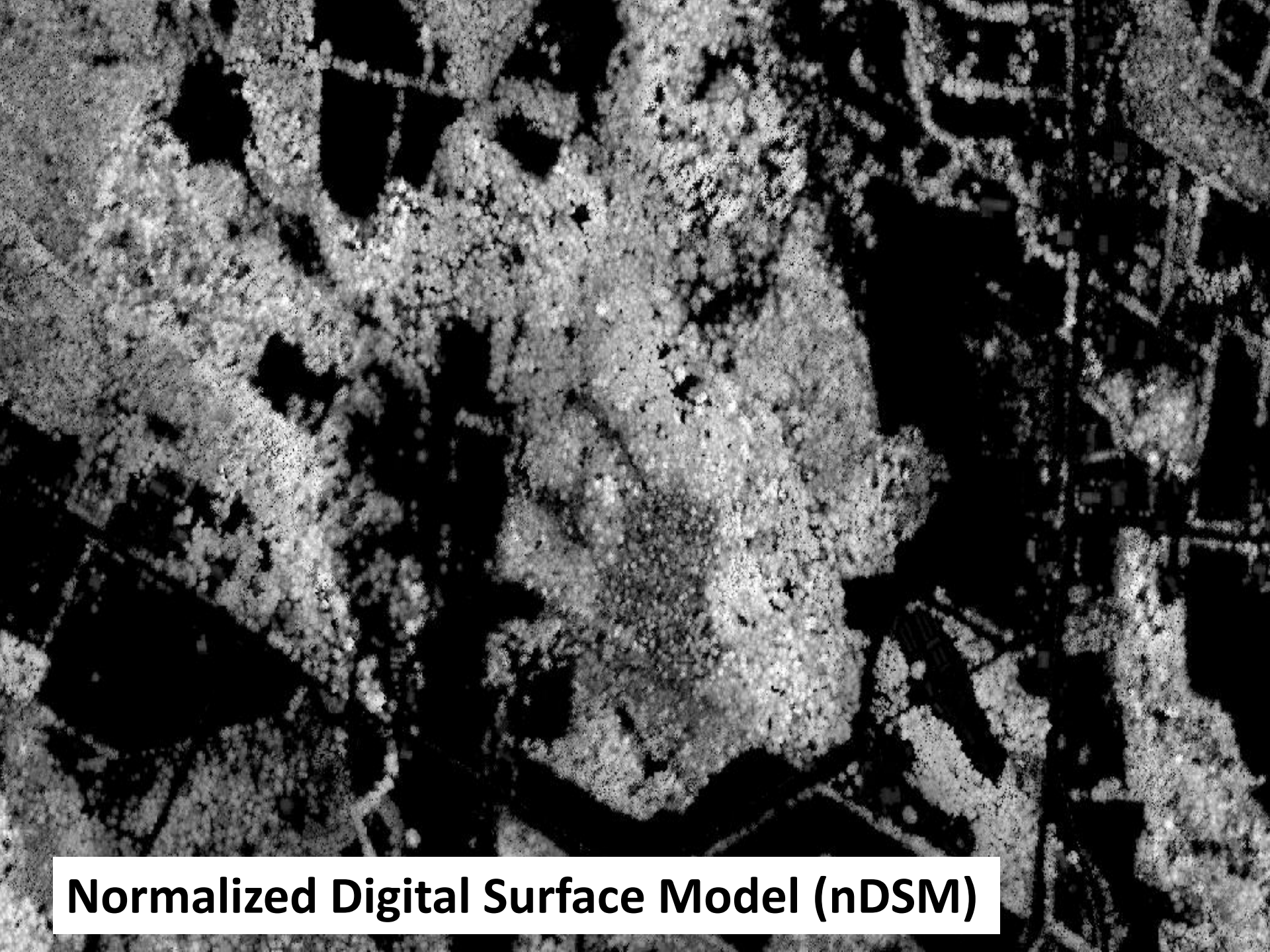

Compound Topographic Index

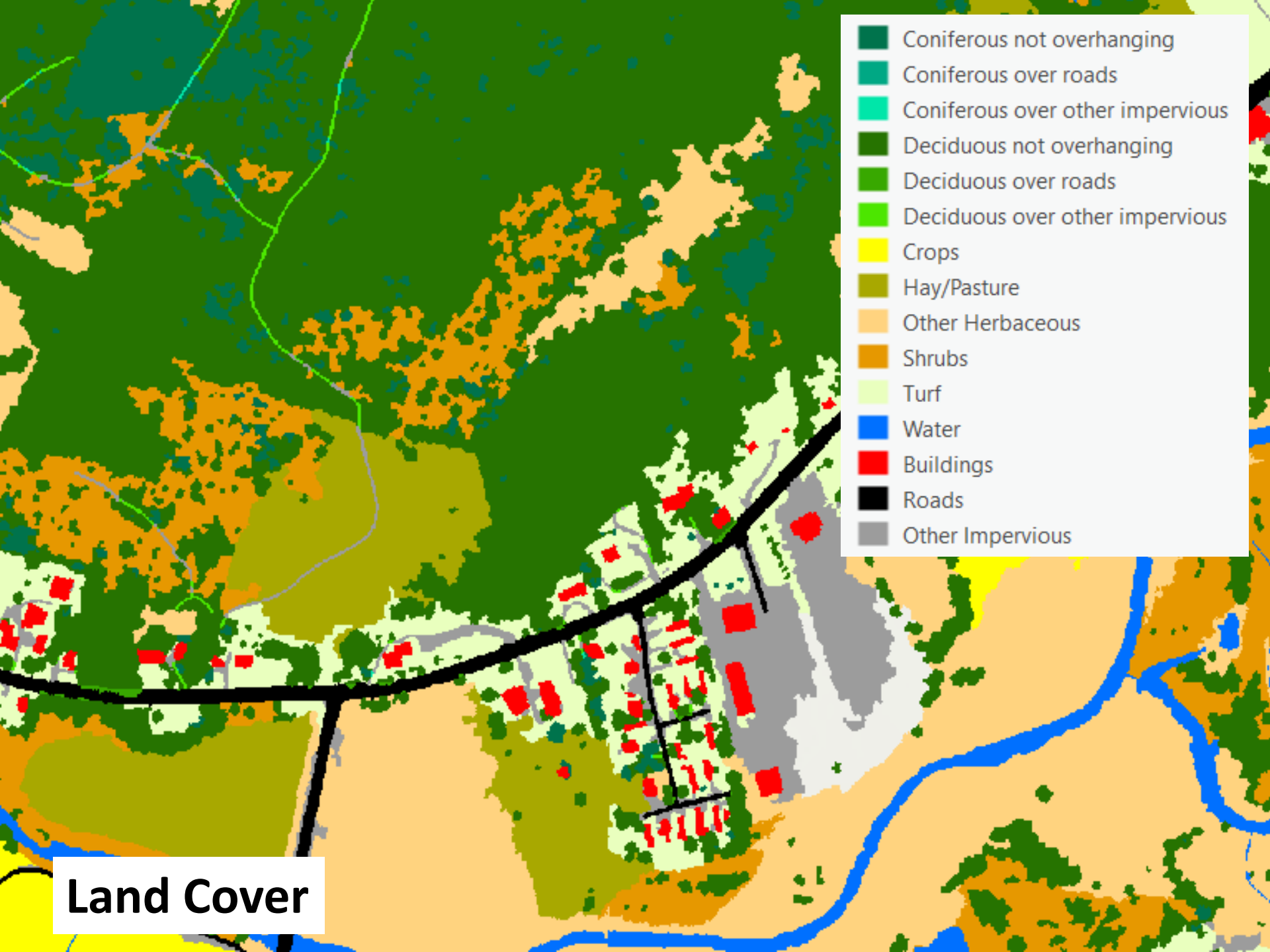

Edge Extraction Lee Sigma (Bright)


Topographic Position Index (TPI)


Leaf-off Orthoimagery


Leaf-on Orthoimagery

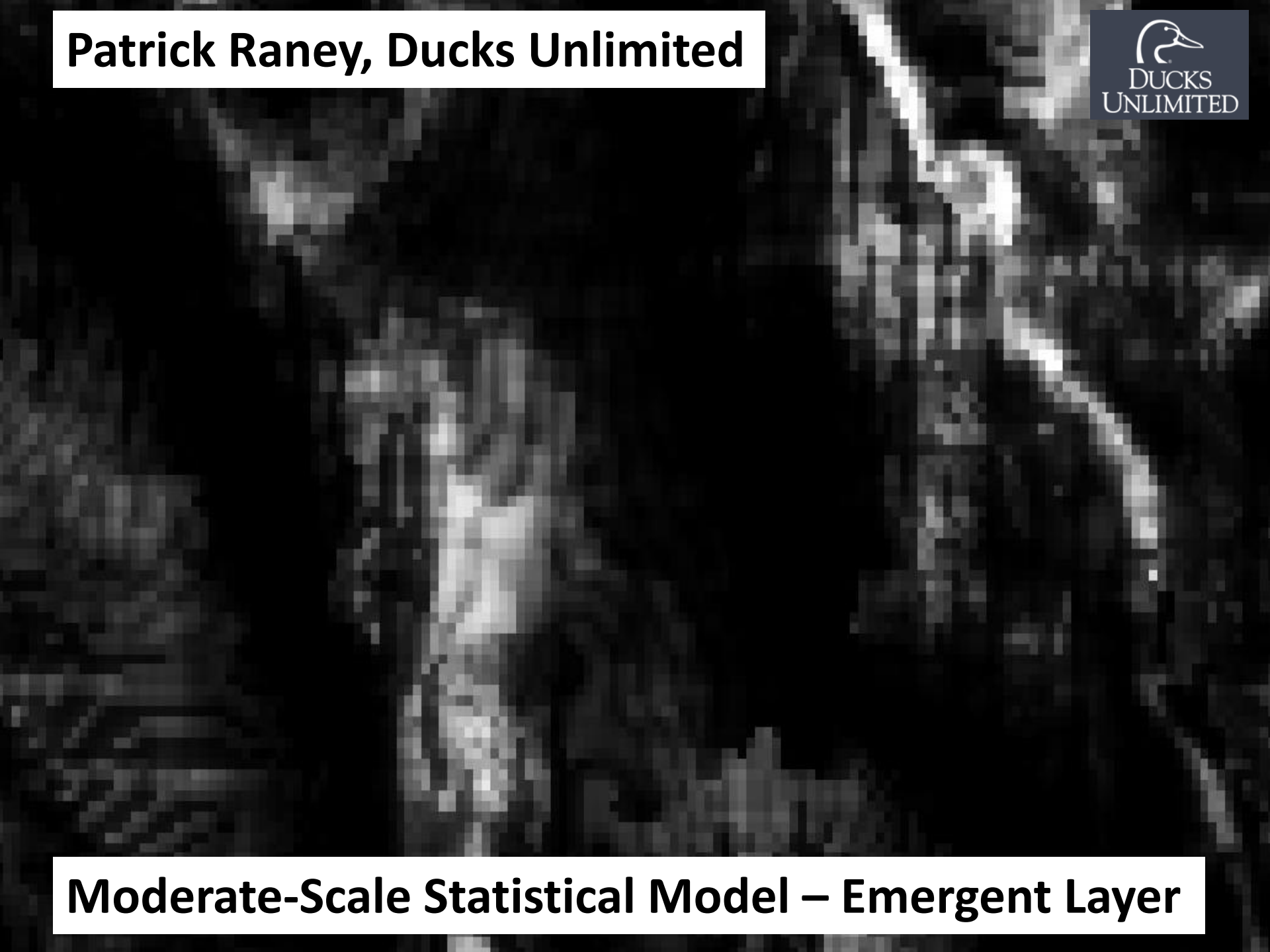

Normalized Digital Surface Model (nDSM)


Coniferous not overhanging
Coniferous over roads
Coniferous over other impervious
Deciduous not overhanging
Deciduous over roads
Deciduous over other impervious
Crops
Hay/Pasture
Other Herbaceous
Shrubs
Turf
Water
Buildings
Roads
Other Impervious

Land Cover

Road Centerlines

NHD Hydrology

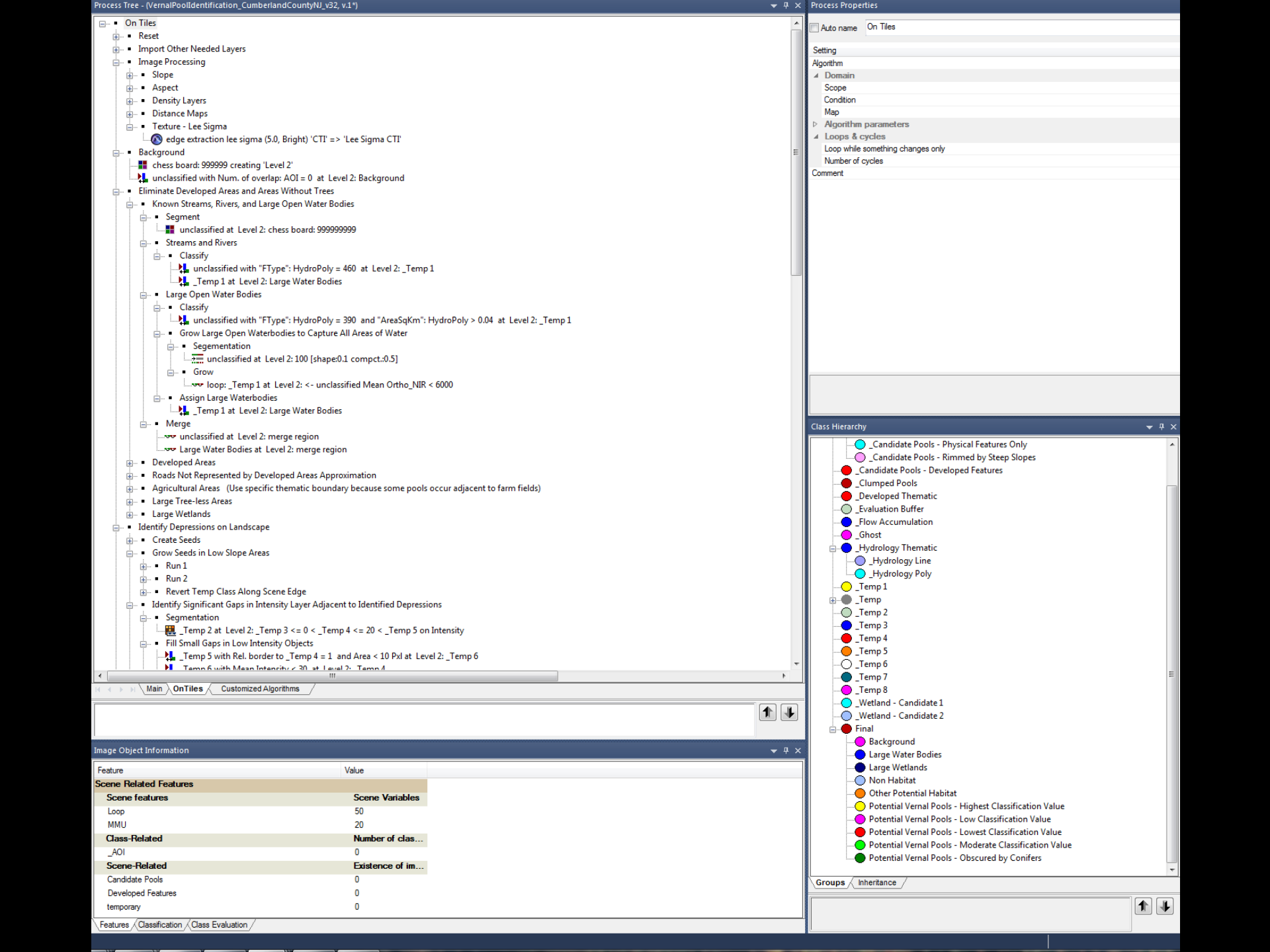

Patrick Raney, Ducks Unlimited
DUCKS UNLIMITED
Moderate-Scale Statistical Model – Emergent Layer

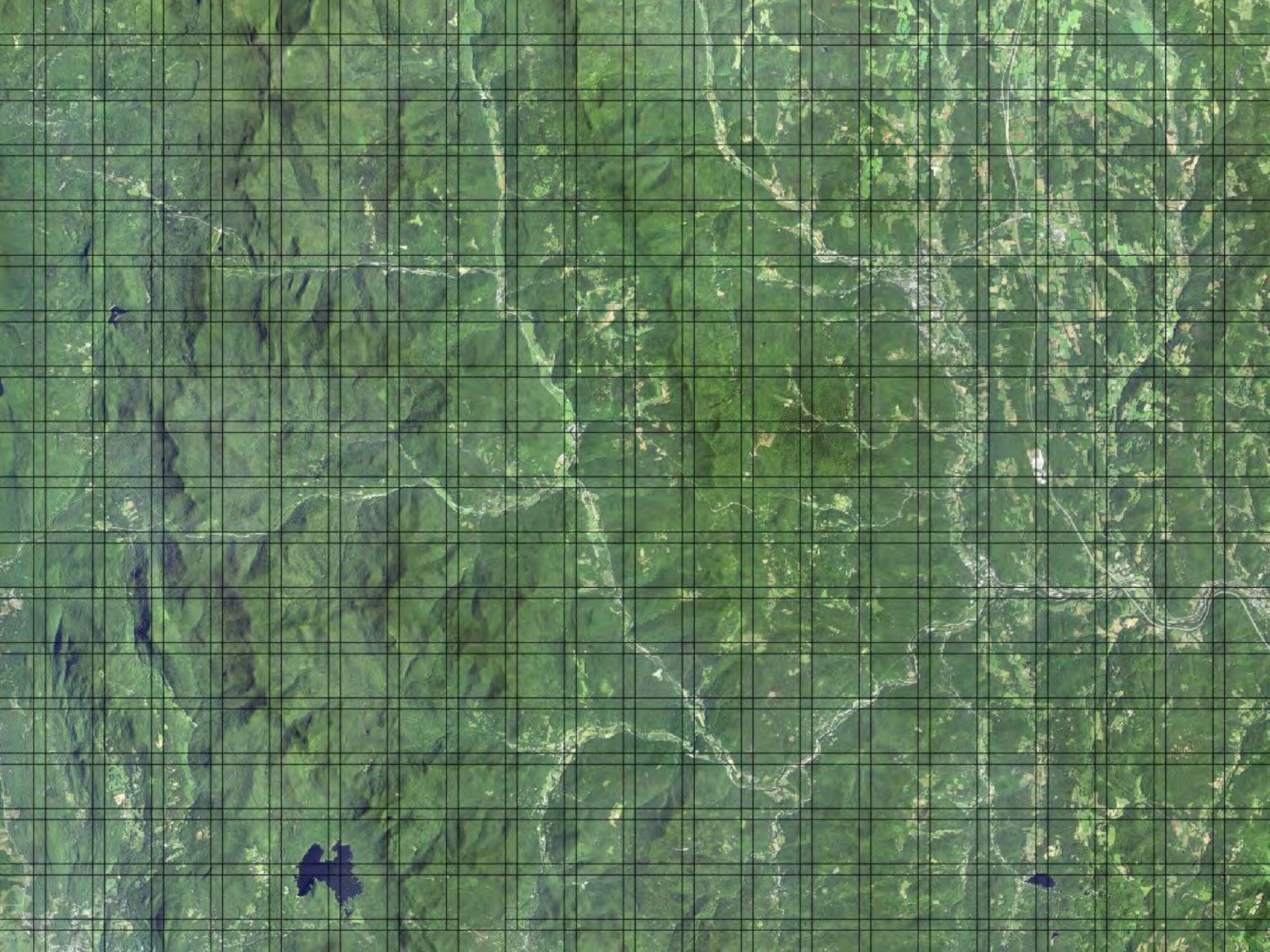
Moderate-Scale Statistical Model – Woody Layer

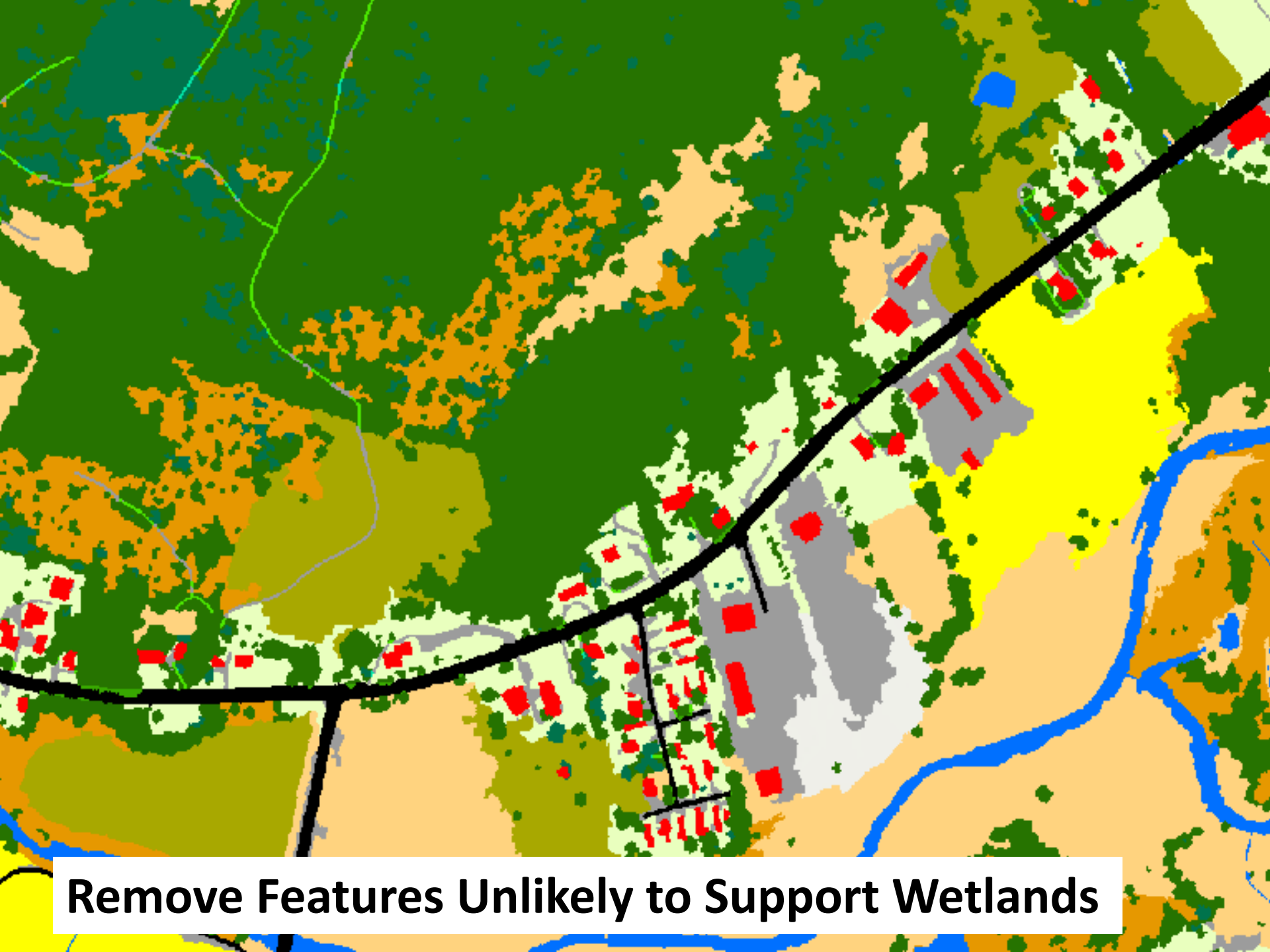

Automated Feature Extraction

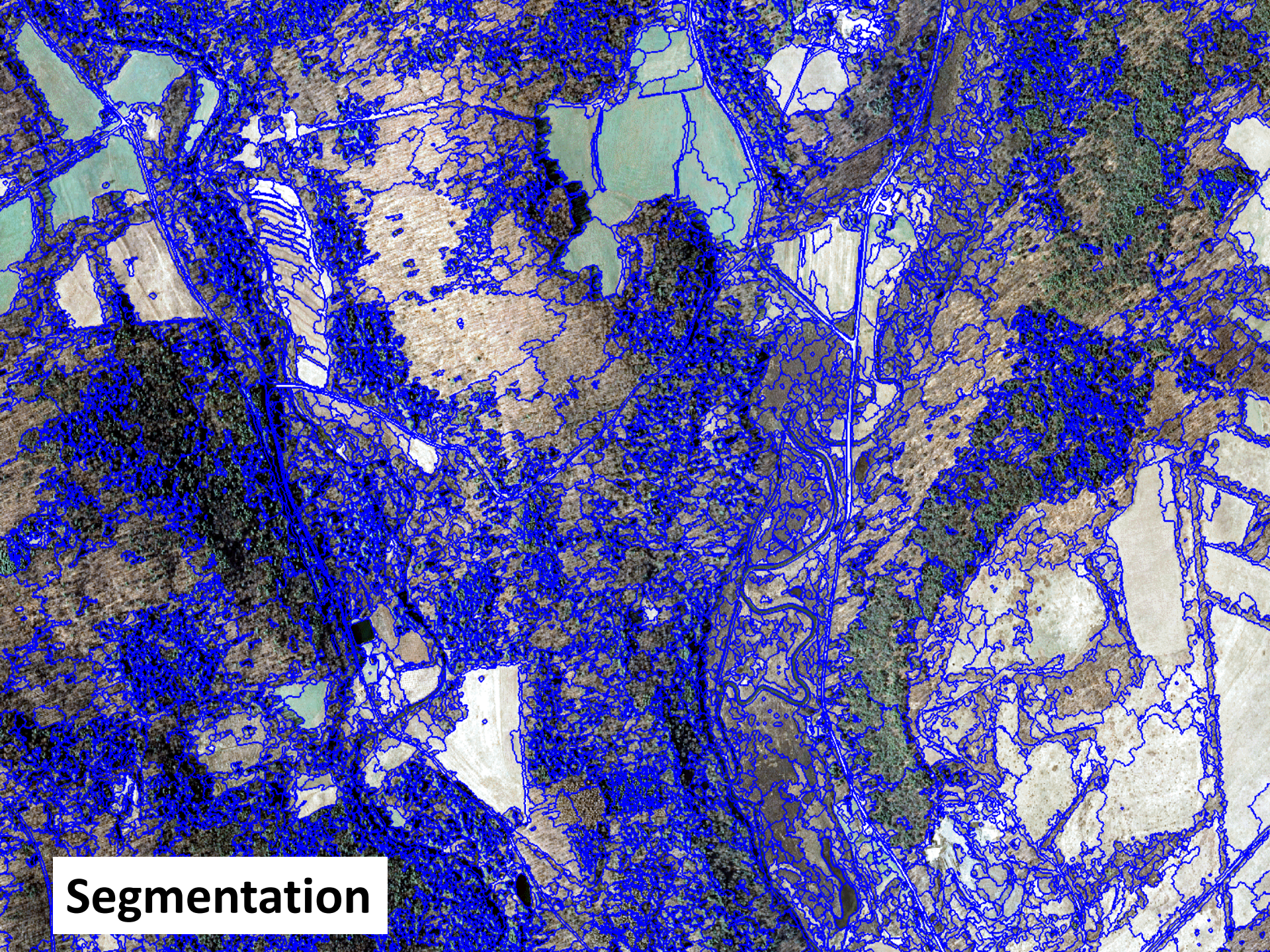
Workflow

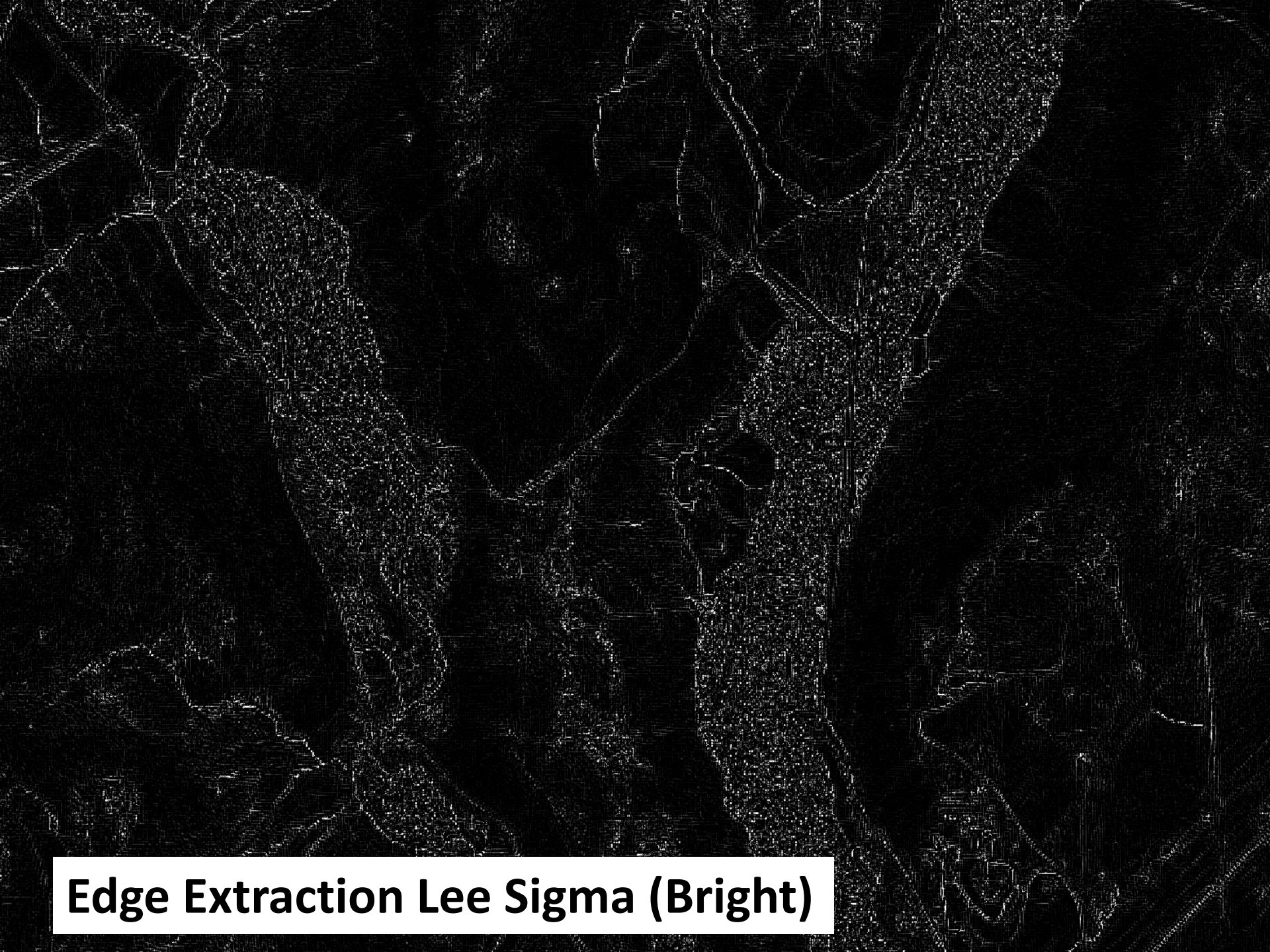
- Rule-set Based (Expert System)
- Iterative, Experimental
- Field Data\Review Points Help Identify Systematic Problems

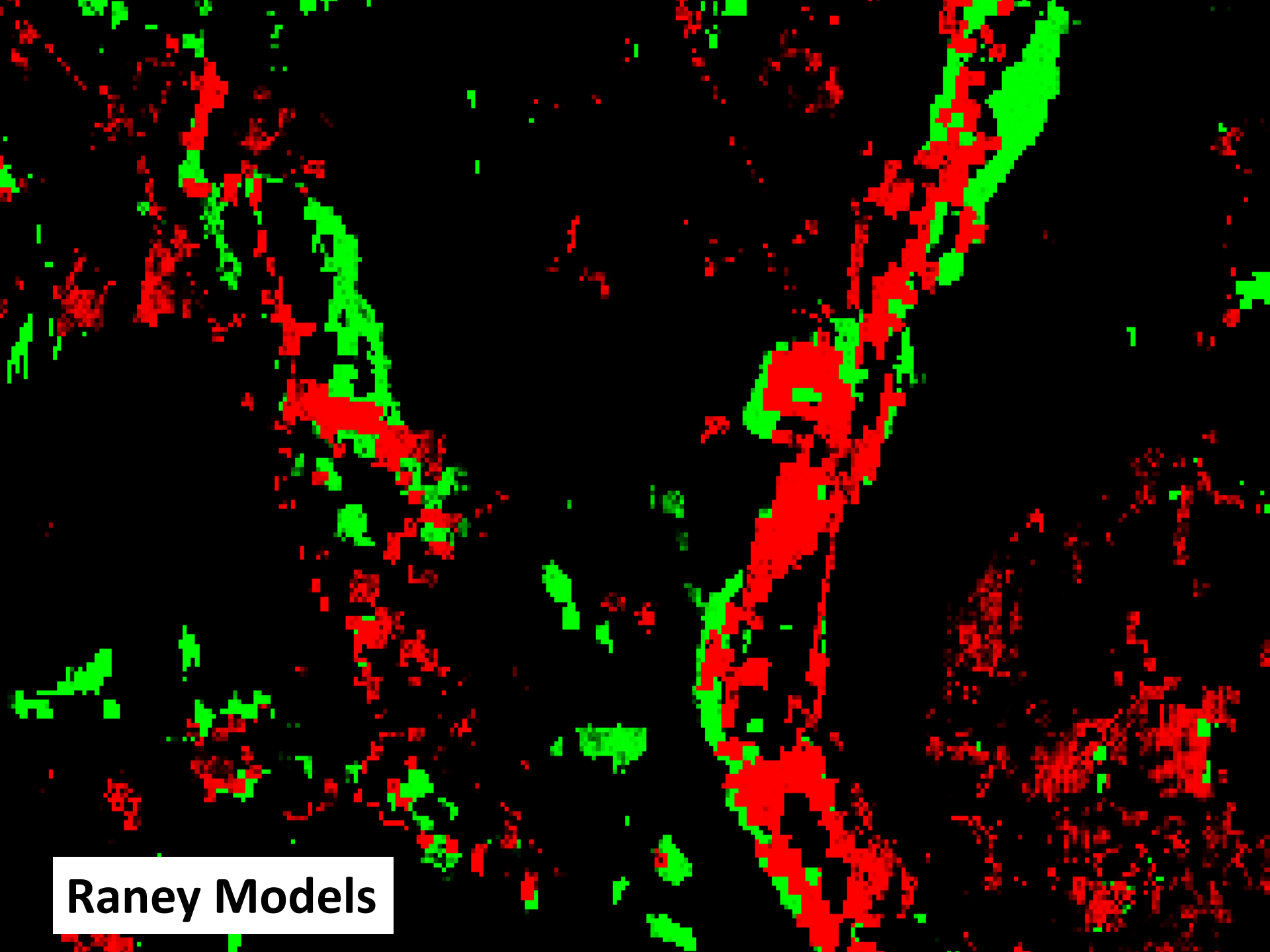

Process Tree - (VernalPoolIdentification_CumberlandCountyNJ_v32, v.1*)
On Tiles
Reset
Import Other Needed Layers
Image Processing
Slope
Aspect
Density Layers
Distance Maps
Texture - Lee Sigma
edge extraction lee sigma (5.0, Bright) 'CTI' => 'Lee Sigma CTI'
Background
chess board: 999999 creating 'Level 2'
unclassified with Num. of overlap: AOI = 0 at Level 2: Background
Eliminate Developed Areas and Areas Without Trees
Known Streams, Rivers, and Large Open Water Bodies
Segment
unclassified at Level 2: chess board: 999999999
Streams and Rivers
Classify
unclassified with "FType": HydroPoly = 460 at Level 2: _Temp 1
_Temp 1 at Level 2: Large Water Bodies
Large Open Water Bodies
Classify
unclassified with "FType": HydroPoly = 390 and "AreaSqKm": HydroPoly > 0.04 at Level 2: _Temp 1
Grow Large Open Waterbodies to Capture All Areas of Water
Segementation
unclassified at Level 2: 100 [shape:0.1 compct.:0.5]
Grow
loop: _Temp 1 at Level 2: <- unclassified Mean Ortho_NIR < 6000
Assign Large Waterbodies
_Temp 1 at Level 2: Large Water Bodies
Merge
unclassified at Level 2: merge region
Large Water Bodies at Level 2: merge region
Developed Areas
Roads Not Represented by Developed Areas Approximation
Agricultural Areas (Use specific thematic boundary because some pools occur adjacent to farm fields)
Large Tree-less Areas
Large Wetlands
Identify Depressions on Landscape
Create Seeds
Grow Seeds in Low Slope Areas
Run 1
Run 2
Revert Temp Class Along Scene Edge
Identify Significant Gaps in Intensity Layer Adjacent to Identified Depressions
Segmentation
_Temp 2 at Level 2: _Temp 3 <= 0 < _Temp 4 <= 20 < _Temp 5 on Intensity
Fill Small Gaps in Low Intensity Objects
_Temp 5 with Rel. border to _Temp 4 = 1 and Area < 10 Pxl at Level 2: _Temp 6
Main
OnTiles
Customized Algorithms
Process Properties
Auto name
On Tiles
Setting
Algorithm
Domain
Scope
Condition
Map
Algorithm parameters
Loops & cycles
Loop while something changes only
Number of cycles
Comment
Class Hierarchy
_Candidate Pools - Physical Features Only
_Candidate Pools - Rimmed by Steep Slopes
_Candidate Pools - Developed Features
_Clumped Pools
_Developed Thematic
_Evaluation Buffer
_Flow Accumulation
_Ghost
_Hydrology Thematic
_Hydrology Line
_Hydrology Poly
_Temp 1
_Temp
_Temp 2
_Temp 3
_Temp 4
_Temp 5
_Temp 6
_Temp 7
_Temp 8
_Wetland - Candidate 1
_Wetland - Candidate 2
Final
Background
Large Water Bodies
Large Wetlands
Non Habitat
Other Potential Habitat
Potential Vernal Pools - Highest Classification Value
Potential Vernal Pools - Low Classification Value
Potential Vernal Pools - Lowest Classification Value
Potential Vernal Pools - Moderate Classification Value
Potential Vernal Pools - Obscured by Conifers
Groups
Inheritance
Image Object Information
Feature
Value
Scene Related Features
Scene features
Scene Variables
Loop
50
MMU
20
Class-Related
Number of clas...
_AOI
0
Scene-Related
Existence of im...
Candidate Pools
0
Developed Features
0
temporary
0
Features
Classification
Class Evaluation



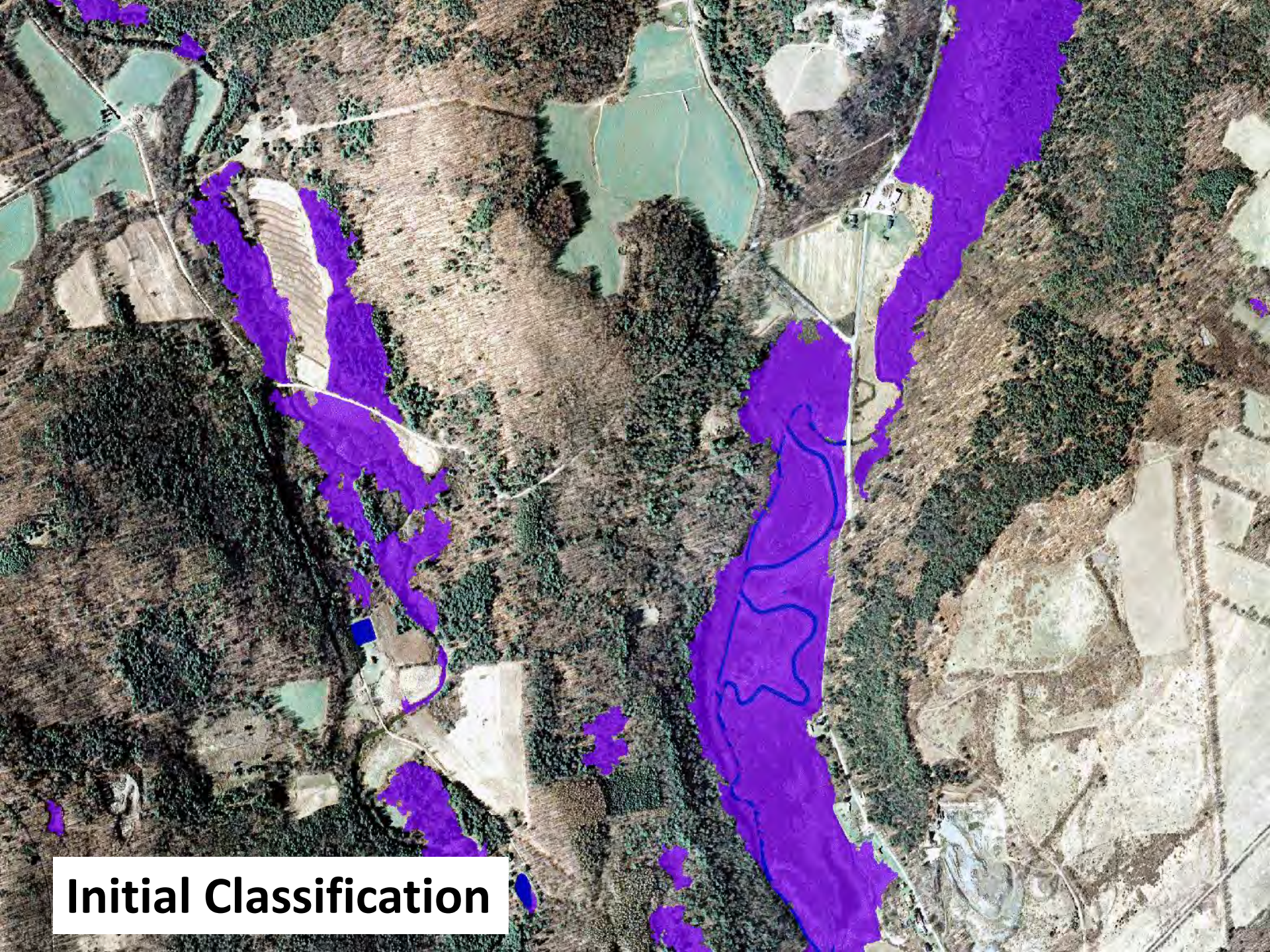

Remove Features Unlikely to Support Wetlands


Segmentation

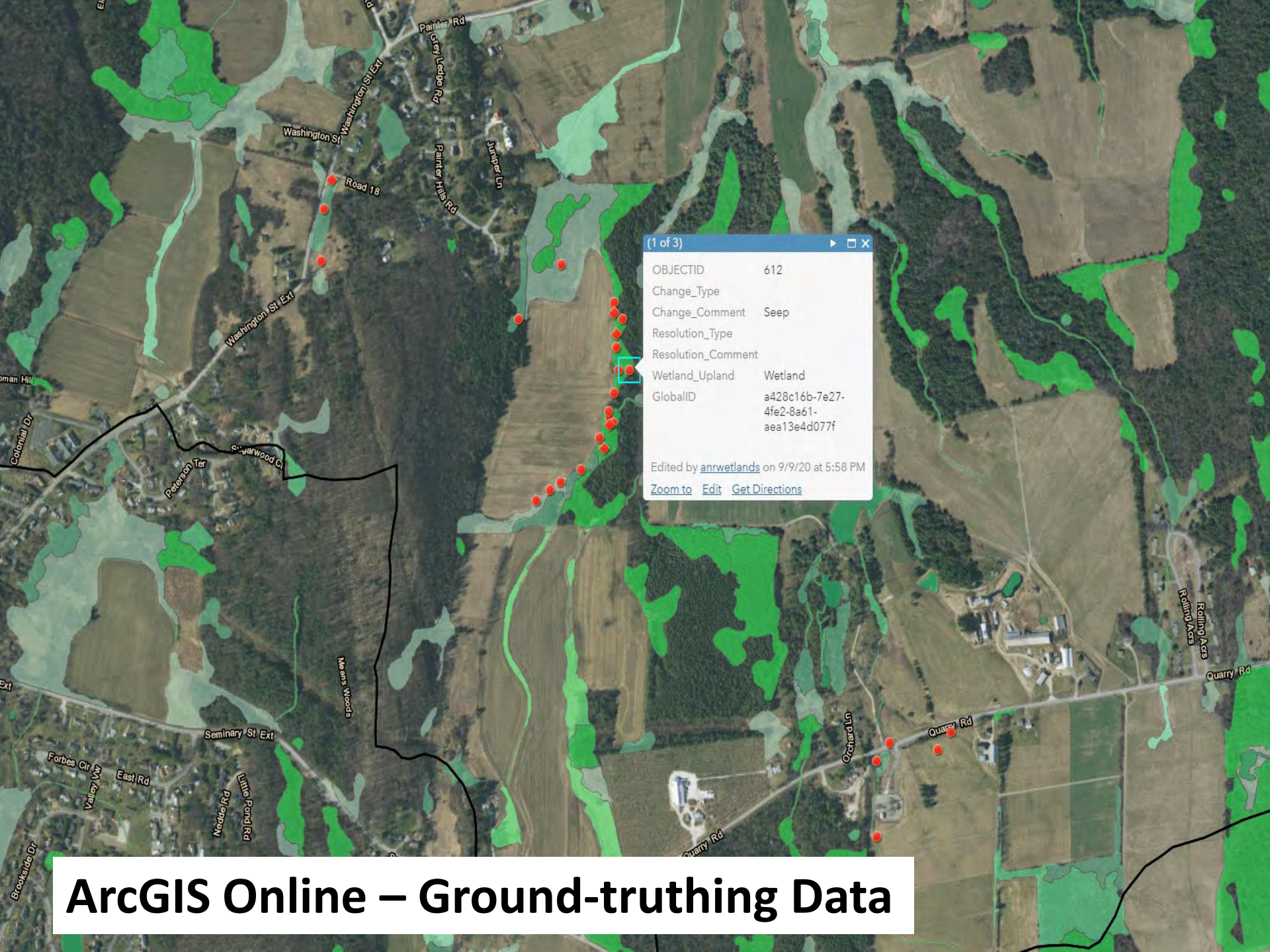

Edge Extraction Lee Sigma (Bright)


Raney Models

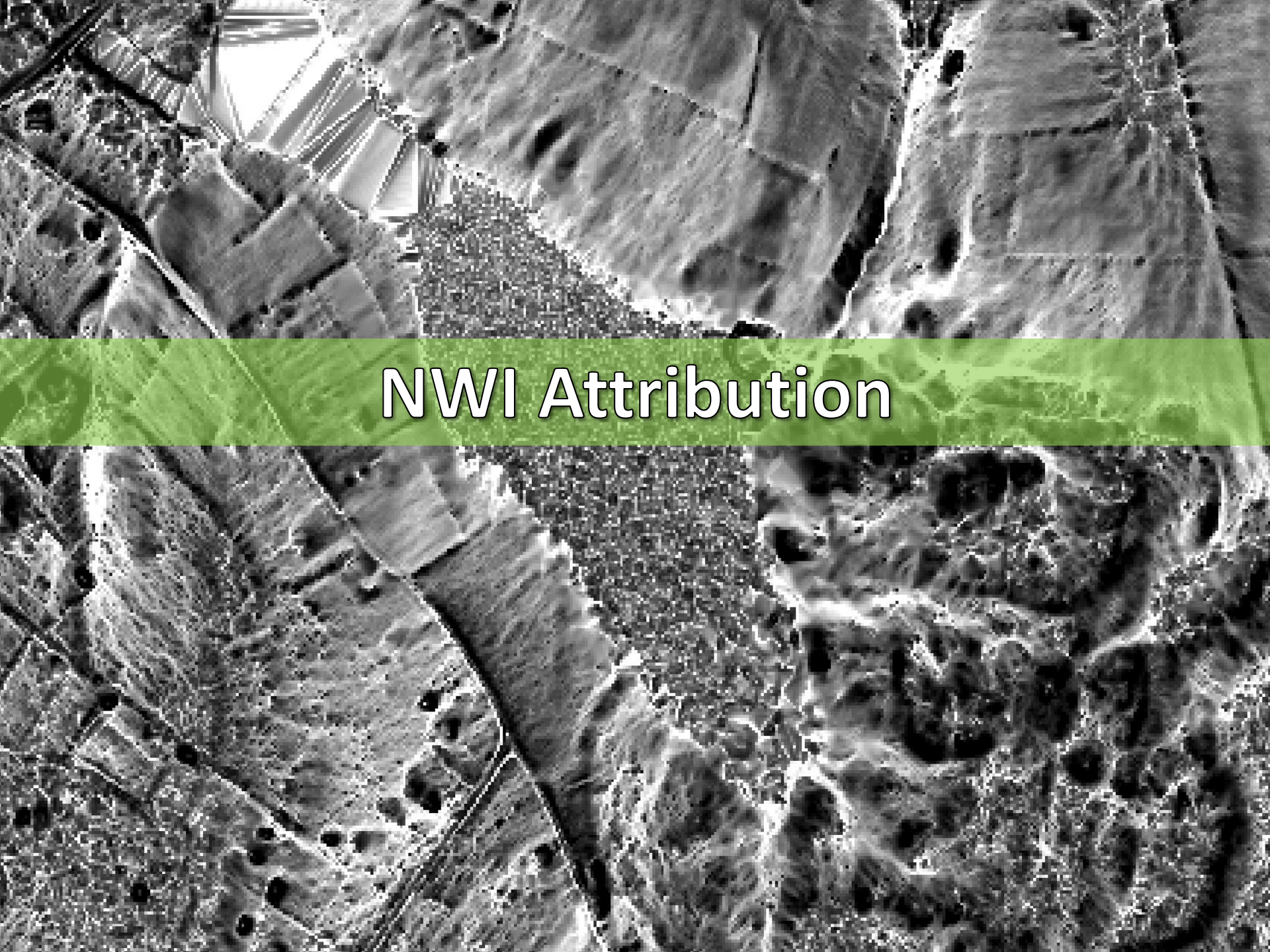

Leaf-off Orthoimagery


Initial Classification

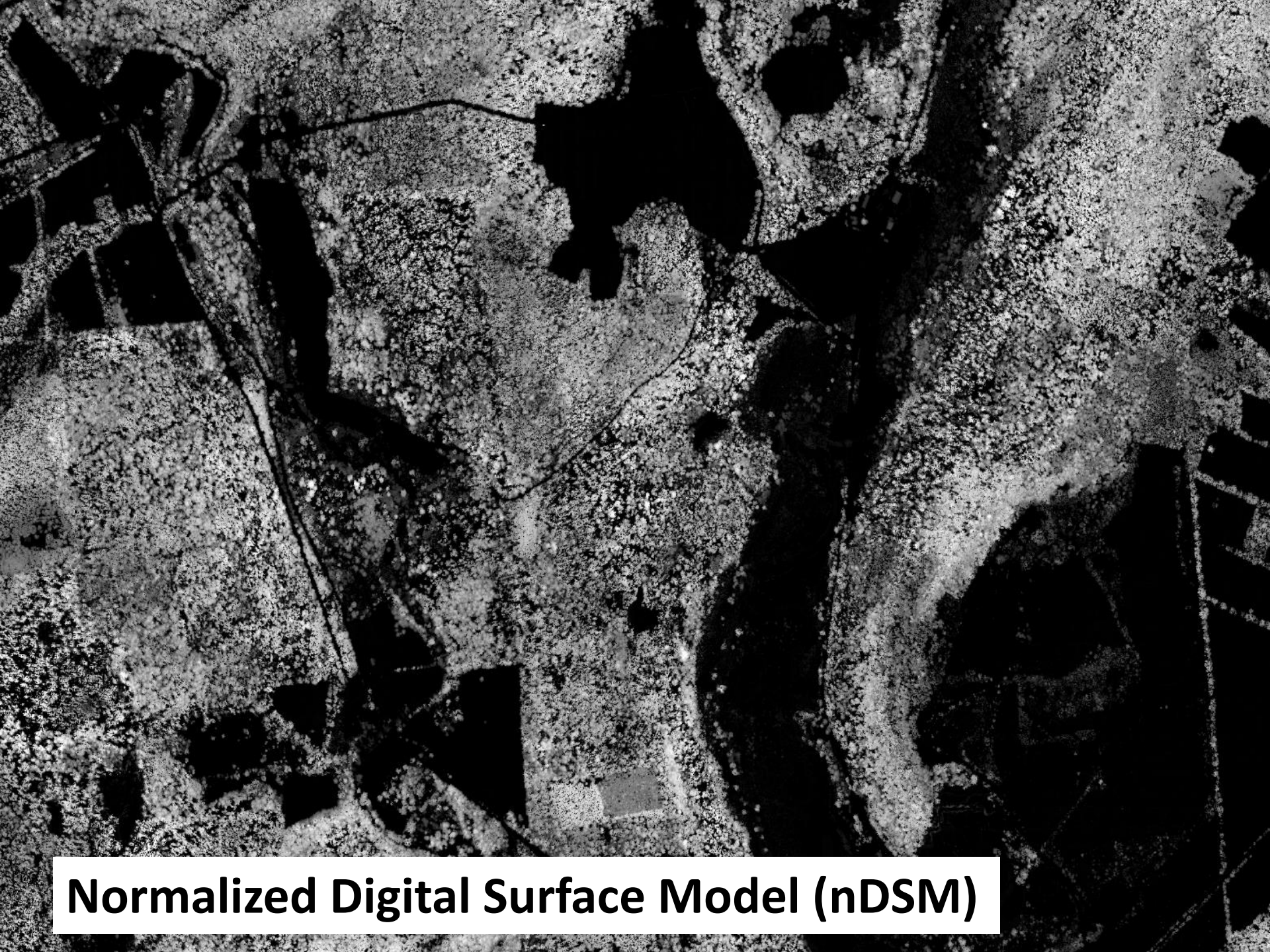
- EXPERT SYSTEM
- ITERATIVE

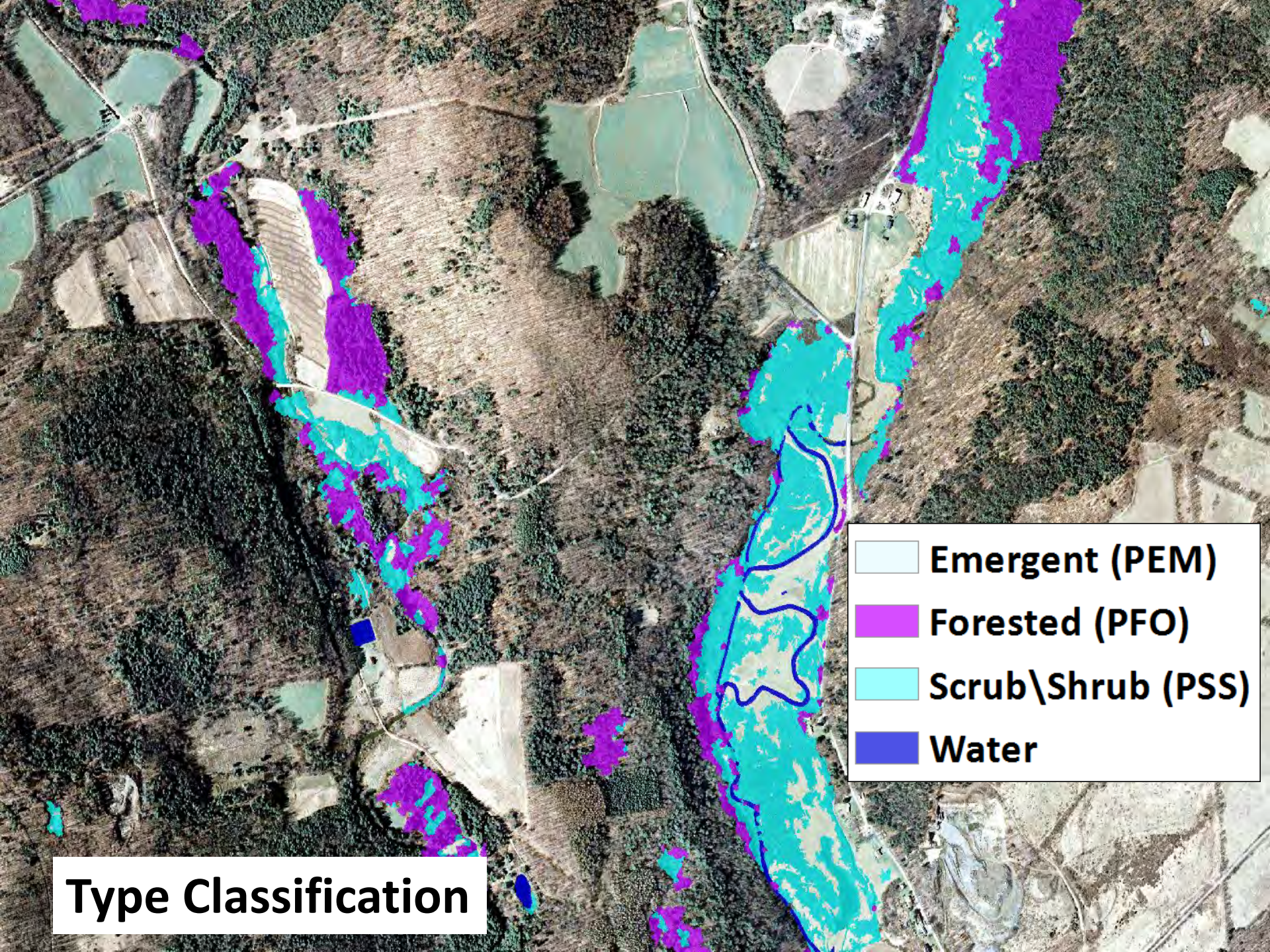


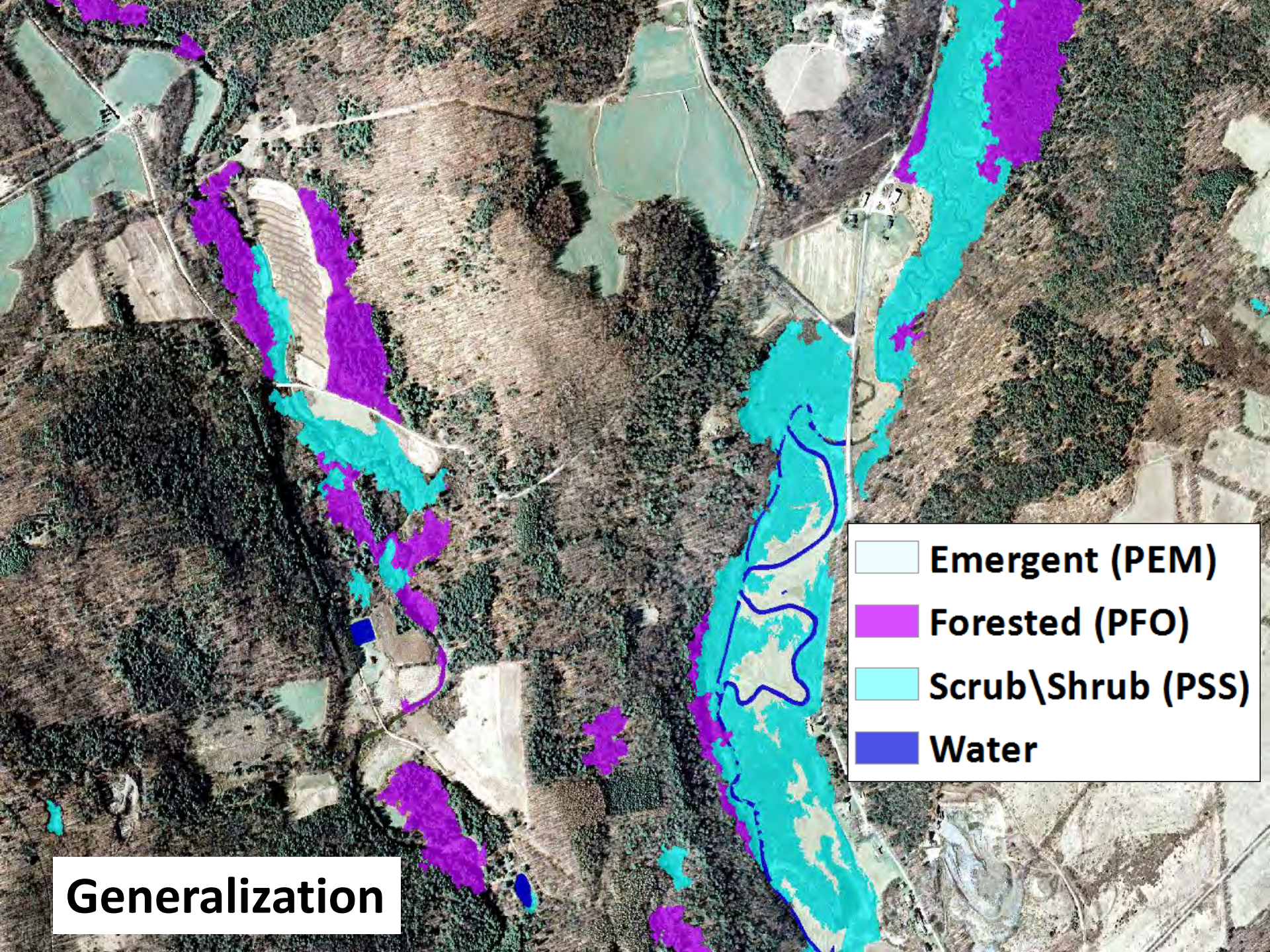
ArcGIS Online – Ground-truthing Data



NWI Attribution


Normalized Digital Surface Model (nDSM)


Emergent (PEM)
Forested (PFO)
Scrub\Shrub (PSS)
Water
Type Classification


Emergent (PEM)
Forested (PFO)
Scrub\Shrub (PSS)
Water
Generalization

Expanded Classification

- “Default” Cowardin Classification
- Modeling
- Thematic Datasets (if available)

Cowardin Class	Cowardin Description	Modeling Workflow
L1UB	Lacustrine, Limnetic, Unconsolidated Bottom	National Hydrography Dataset (NHD) Waterbody ≥ 20 ac
PUB	Palustrine, Unconsolidated Bottom	NHD Waterbody < 20 ac (if not already mapped as wetlands)
R3UB	Riverine, Upper Perennial, Unconsolidated Bottom	NHD Area (if not already mapped as wetlands)
R4SB	Riverine, Intermittent, Streambed	NHD Flowlines buffered 5’ on each side (if not already mapped as wetlands)
PEM2	Palustrine, Emergent, Non-persistent	All remaining water (mapped using multispectral imagery)
PEM1	Palustrine, Emergent, Persistent	All emergent features identified by vegetation height
PFO1	Palustrine, Forested, Broad-Leaved Deciduous	Forested features identified by vegetation height and then divided into deciduous and coniferous classes using multispectral imagery; features with >50% deciduous cover assigned to this class
PFO4	Palustrine, Forested, Needle-Leaved Evergreen	Forested features identified by vegetation height and then divided into deciduous and coniferous classes using multispectral imagery; features with >50% coniferous cover assigned to this class
PSS1	Palustrine, Scrub-Shrub, Broad-Leaved Deciduous	Remaining wetland features divided into deciduous and coniferous classes using multispectral imagery; features with >50% deciduous cover assigned to this class
PSS4	Palustrine, Scrub-Shrub, Needle-Leaved Evergreen	Remaining wetland features divided into deciduous and coniferous classes using multispectral imagery; features with >50% coniferous cover assigned to this class

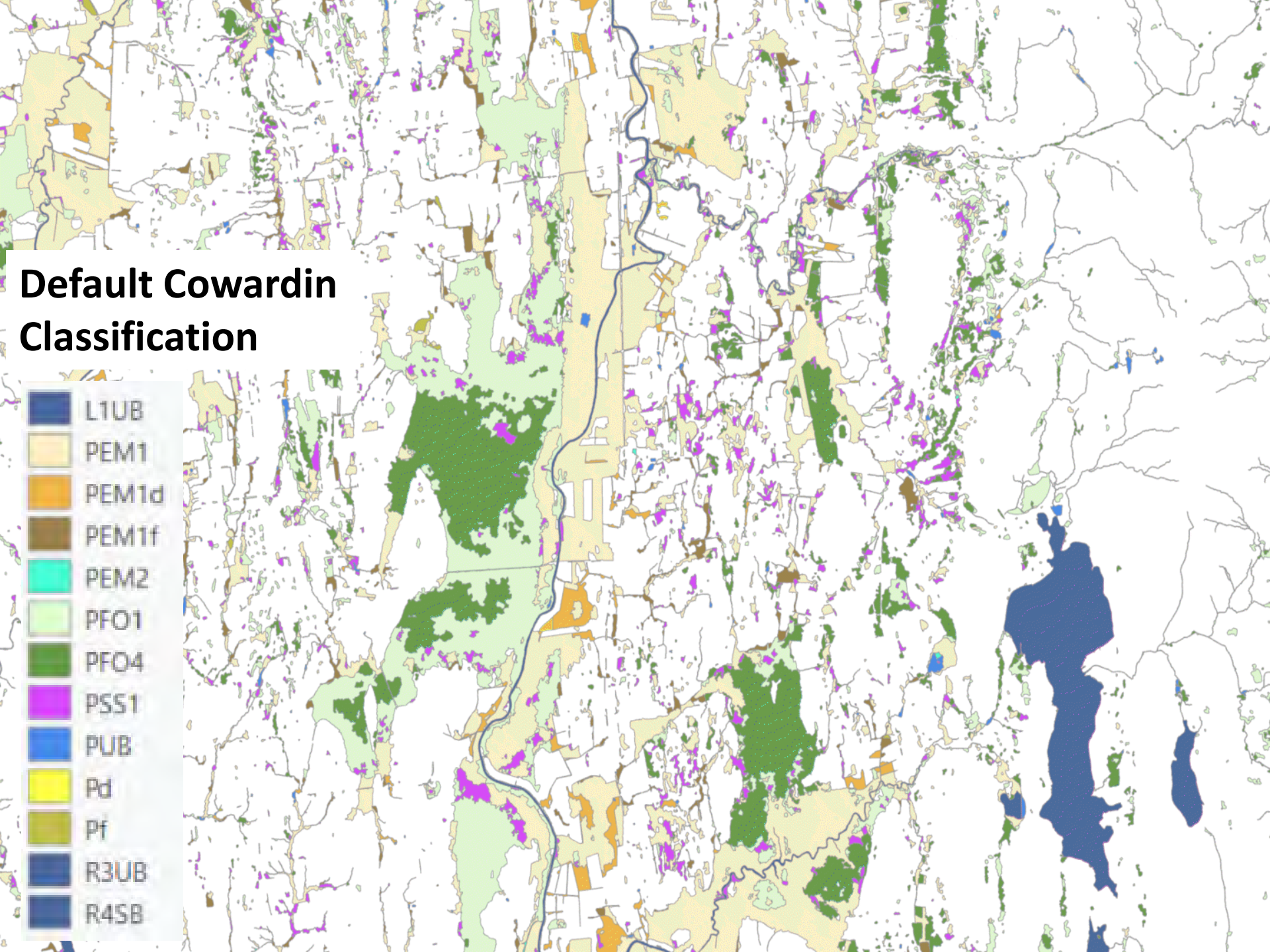
Cowardin Class	Cowardin Description	Modeling Workflow
PEM1d	Palustrine, Emergent, Persistent, Ditched (Hay\Pasture)	Coincides with Hay\Pasture and NHD Ditches
PEM1f	Palustrine, Emergent, Persistent, Farmed (Hay\Pasture)	Coincides with Hay\Pasture
Pd	Palustrine, Ditched (Crops)	Coincides with Crops and NHD Ditches
Pf	Palustrine, Farmed (Crops)	Coincides with Crops

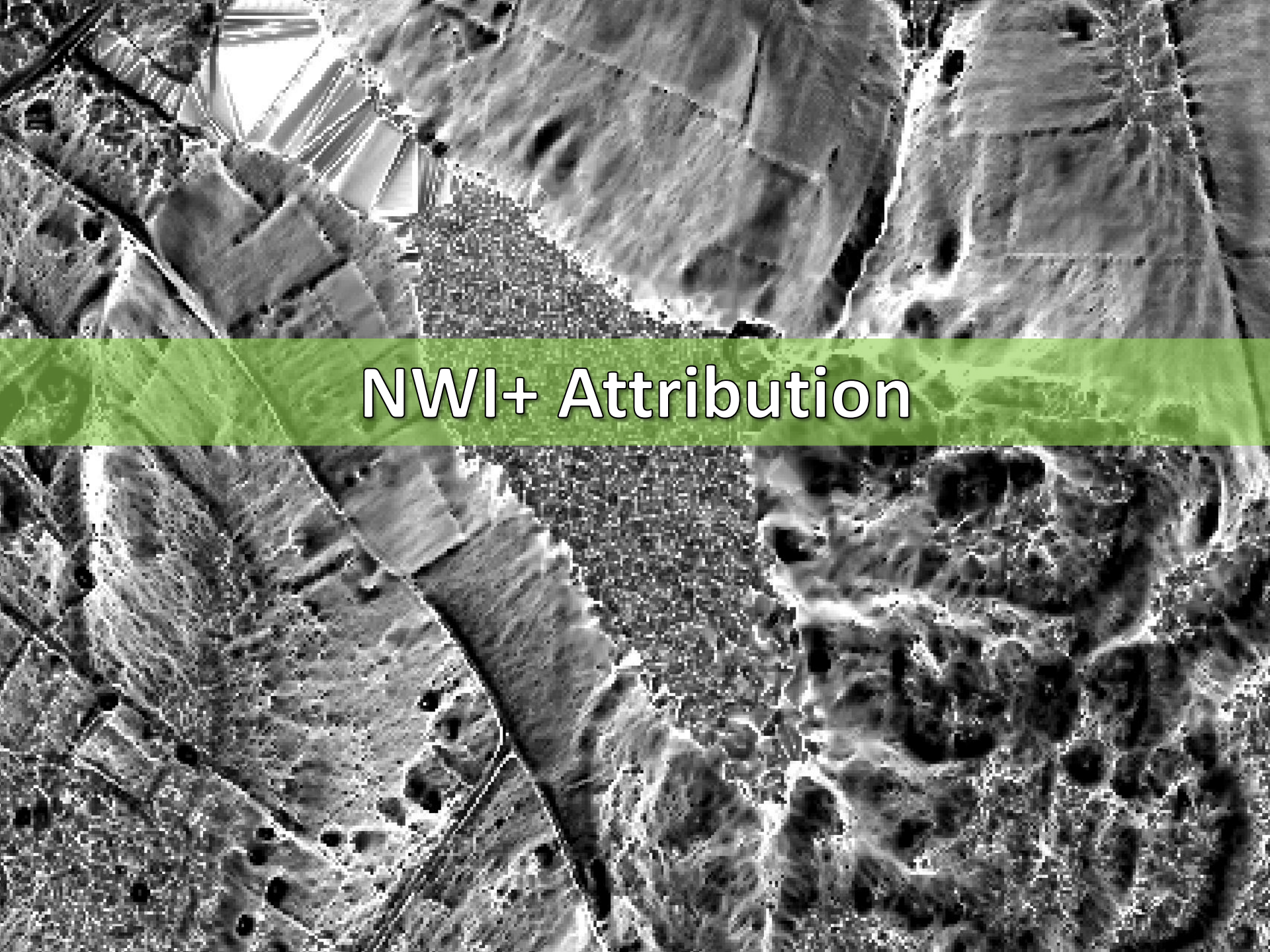
Default Classification will vary by:

Study-area Location

Data Availability

Default Cowardin Classification



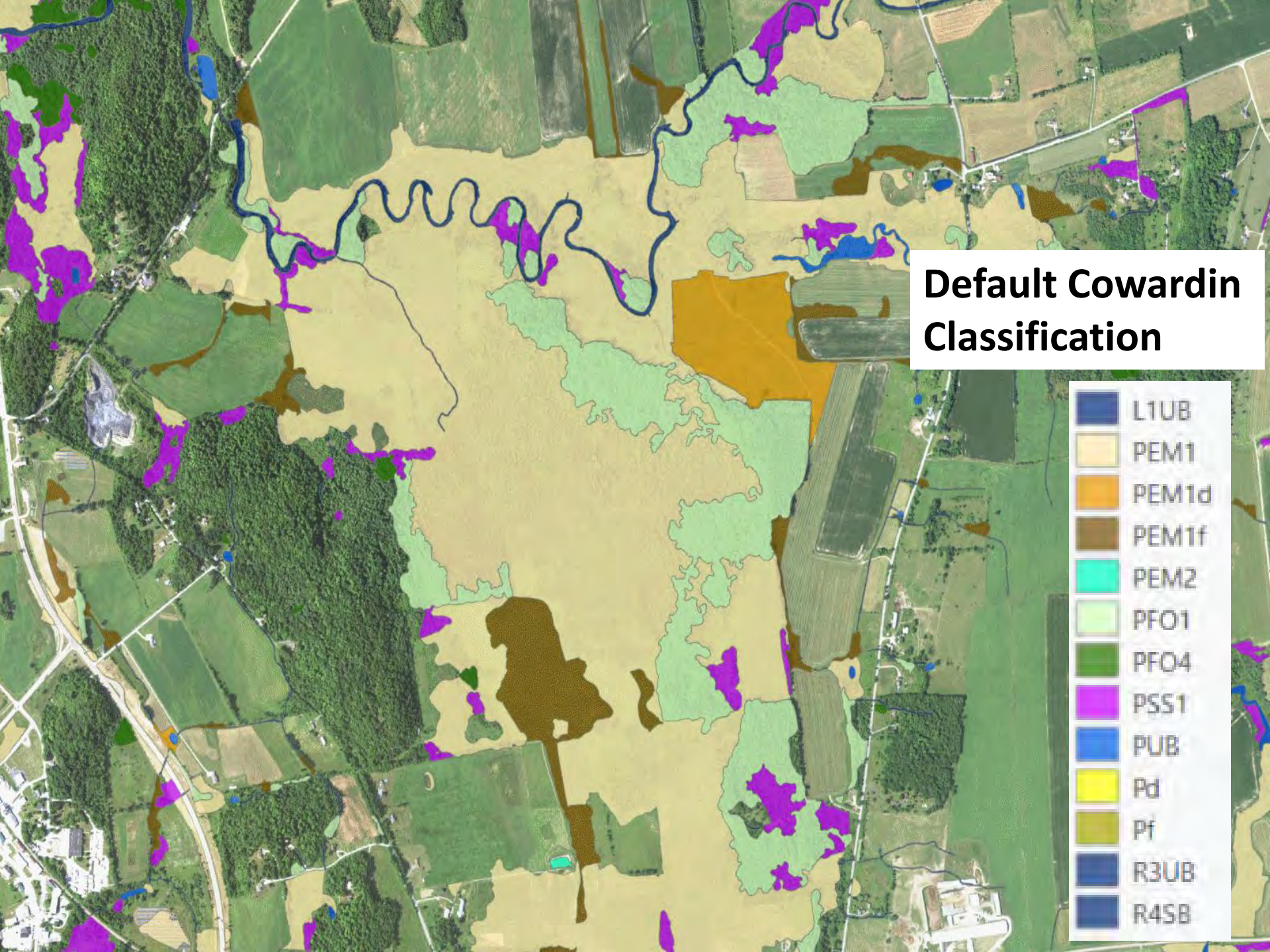

NWI+ Attribution

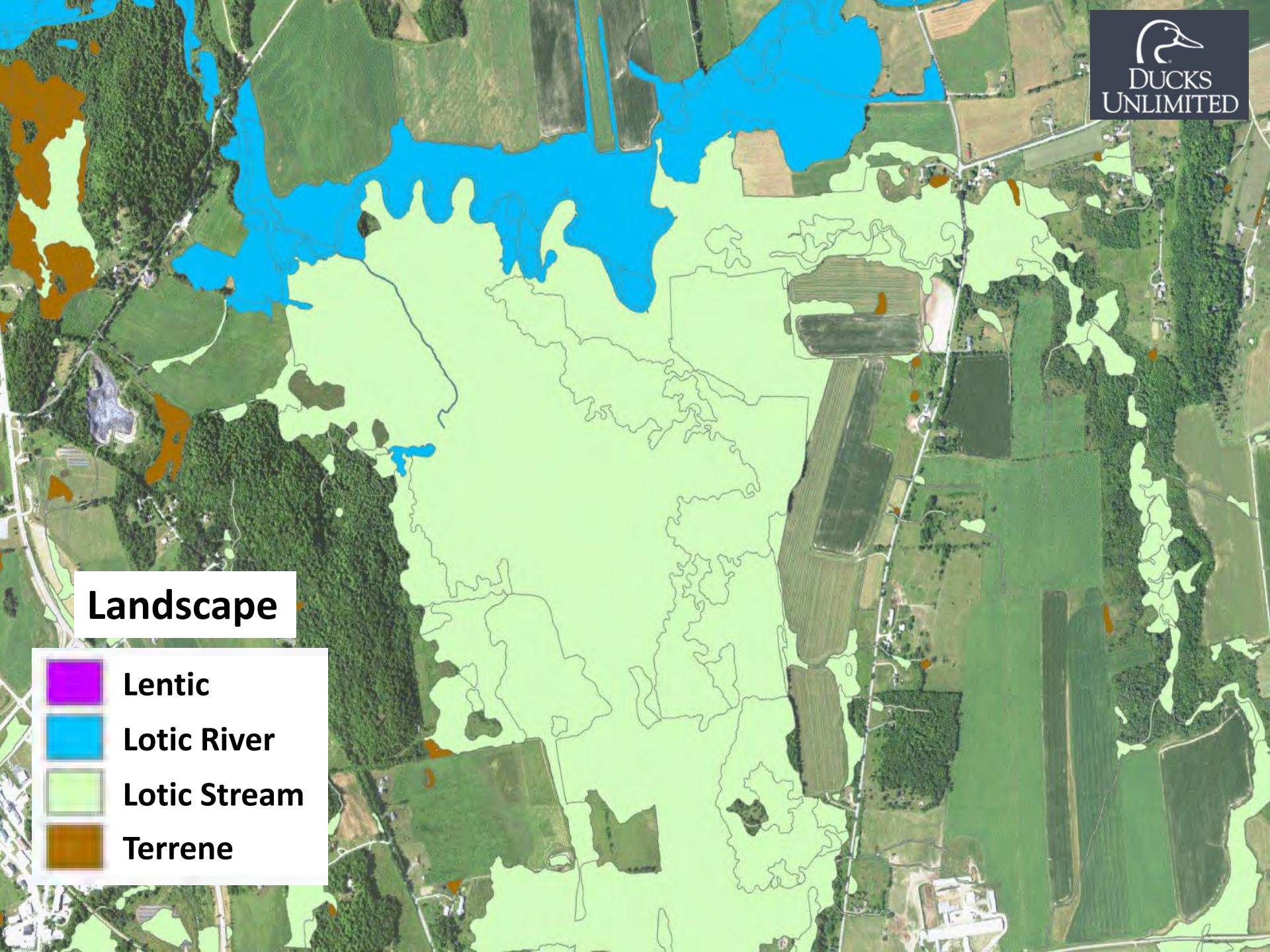
Hydrogeomorphic Classification (LLWW)

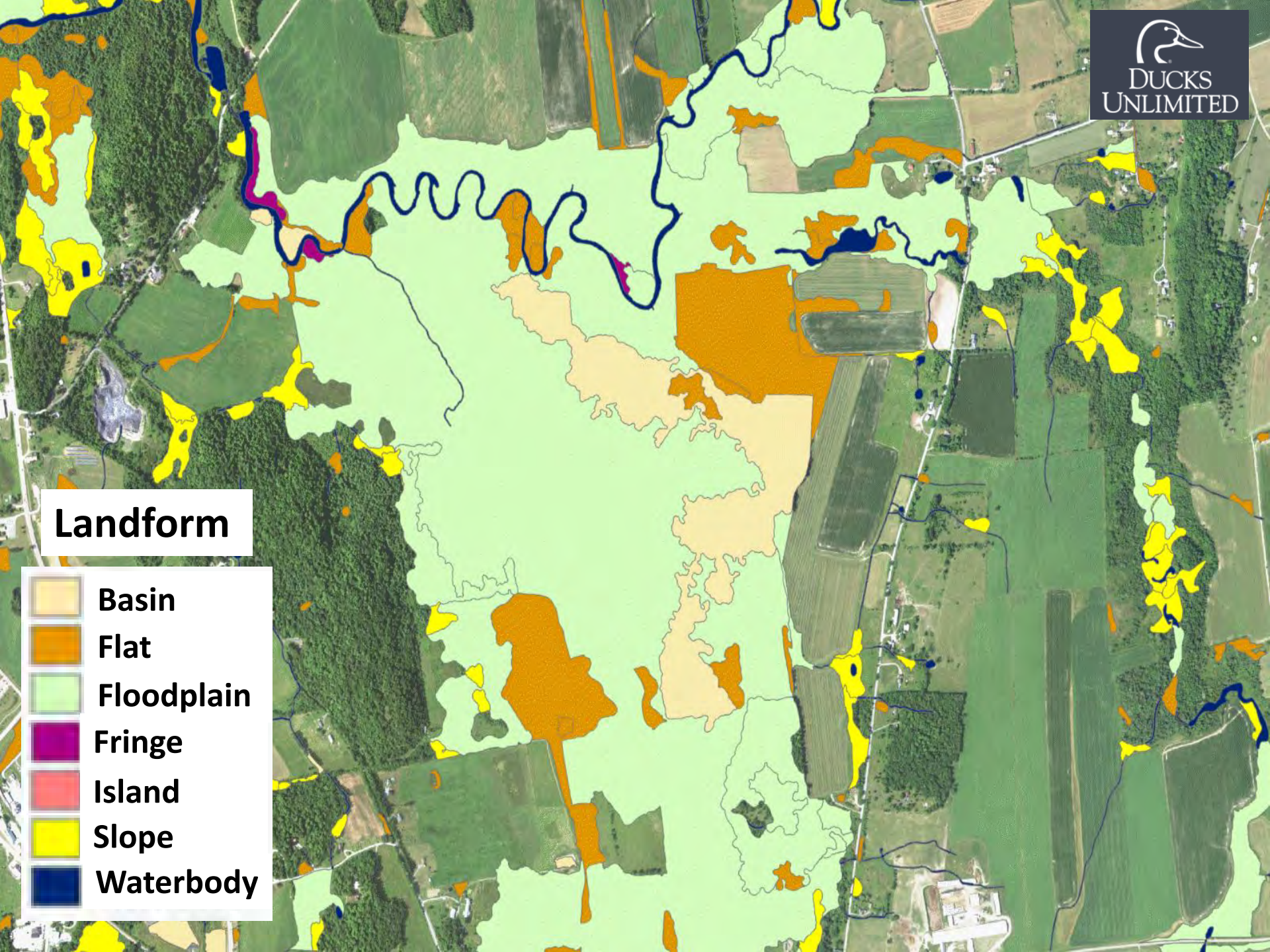
- Ducks Unlimited (Alek Kreiger, Robb Macleod)
- Modeling
- Thematic Datasets (e.g., floodplains)
- Assumed from Cowardin

LLWW

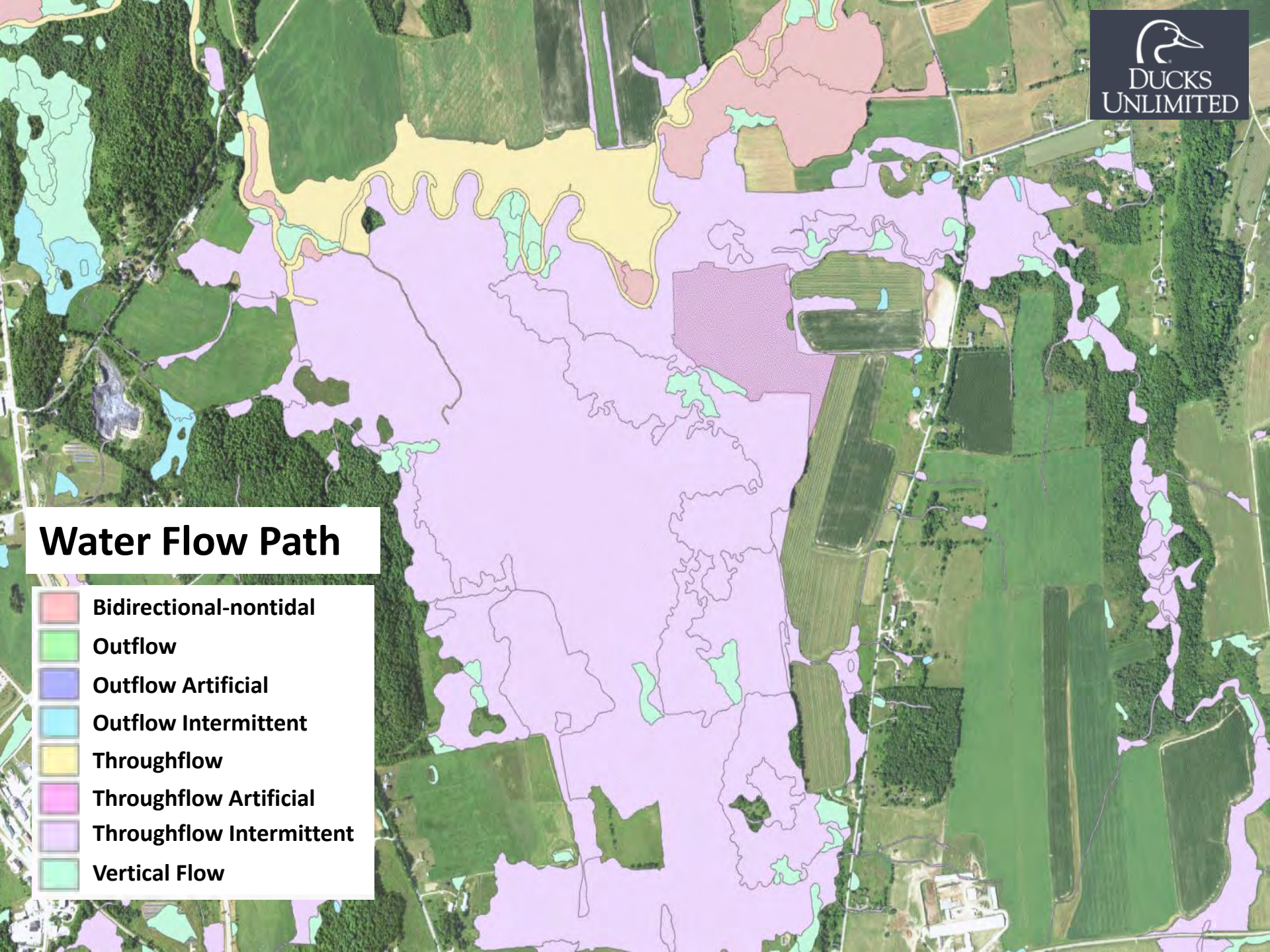
- Landscape
- Landform
- Waterbody
- Water Flow Path

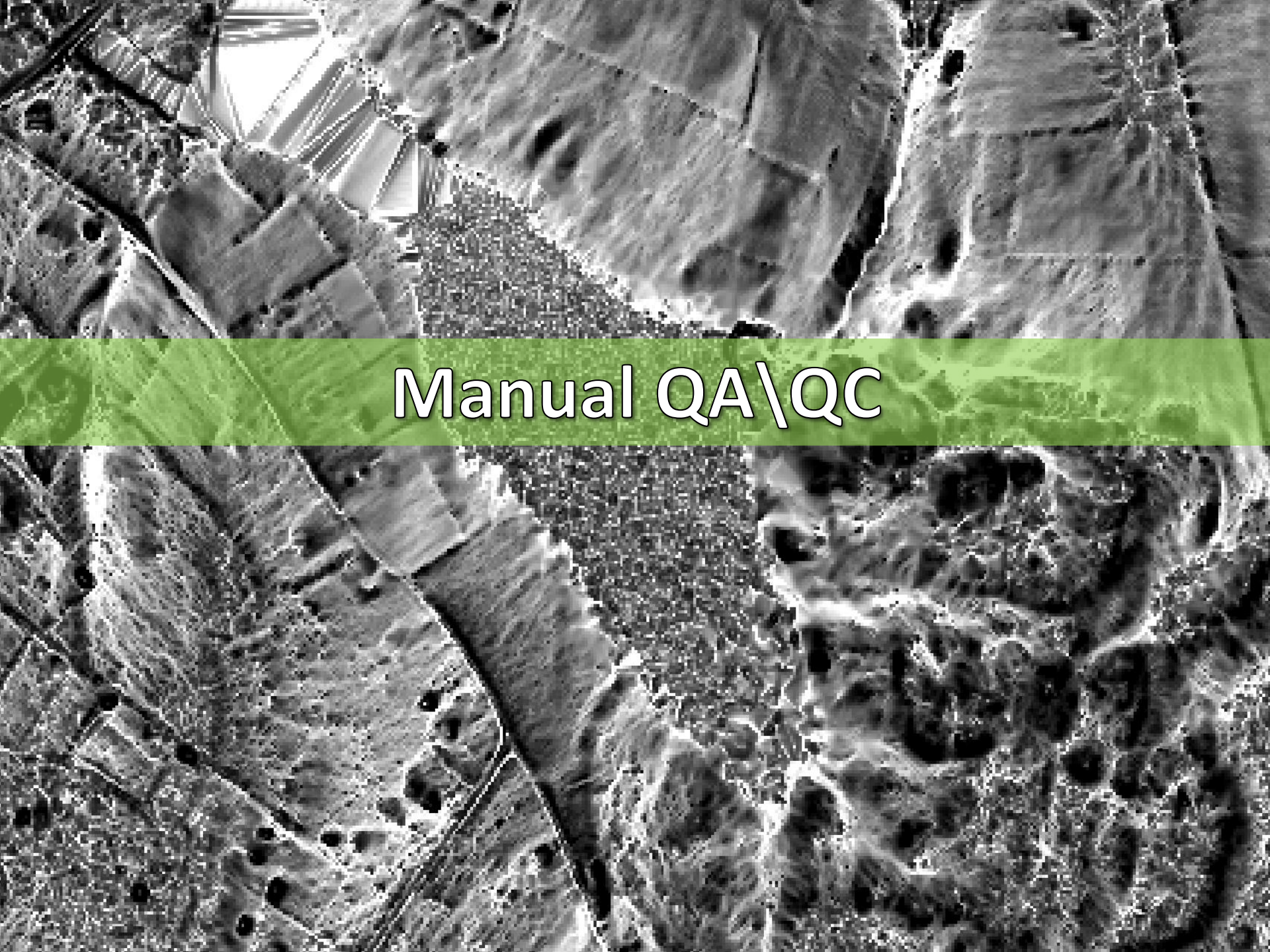

Default Cowardin Classification
L1UB
PEM1
PEM1d
PEM1f
PEM2
PFO1
PFO4
PSS1
PUB
Pd
Pf
R3UB
R4SB


Landscape
Lentic
Lotic River
Lotic Stream
Terrene
DUCKS UNLIMITED


Landform
Basin
Flat
Floodplain
Fringe
Island
Slope
Waterbody
DUCKS UNLIMITED


DUCKS UNLIMITED
Waterbody
Lake
Pond
River

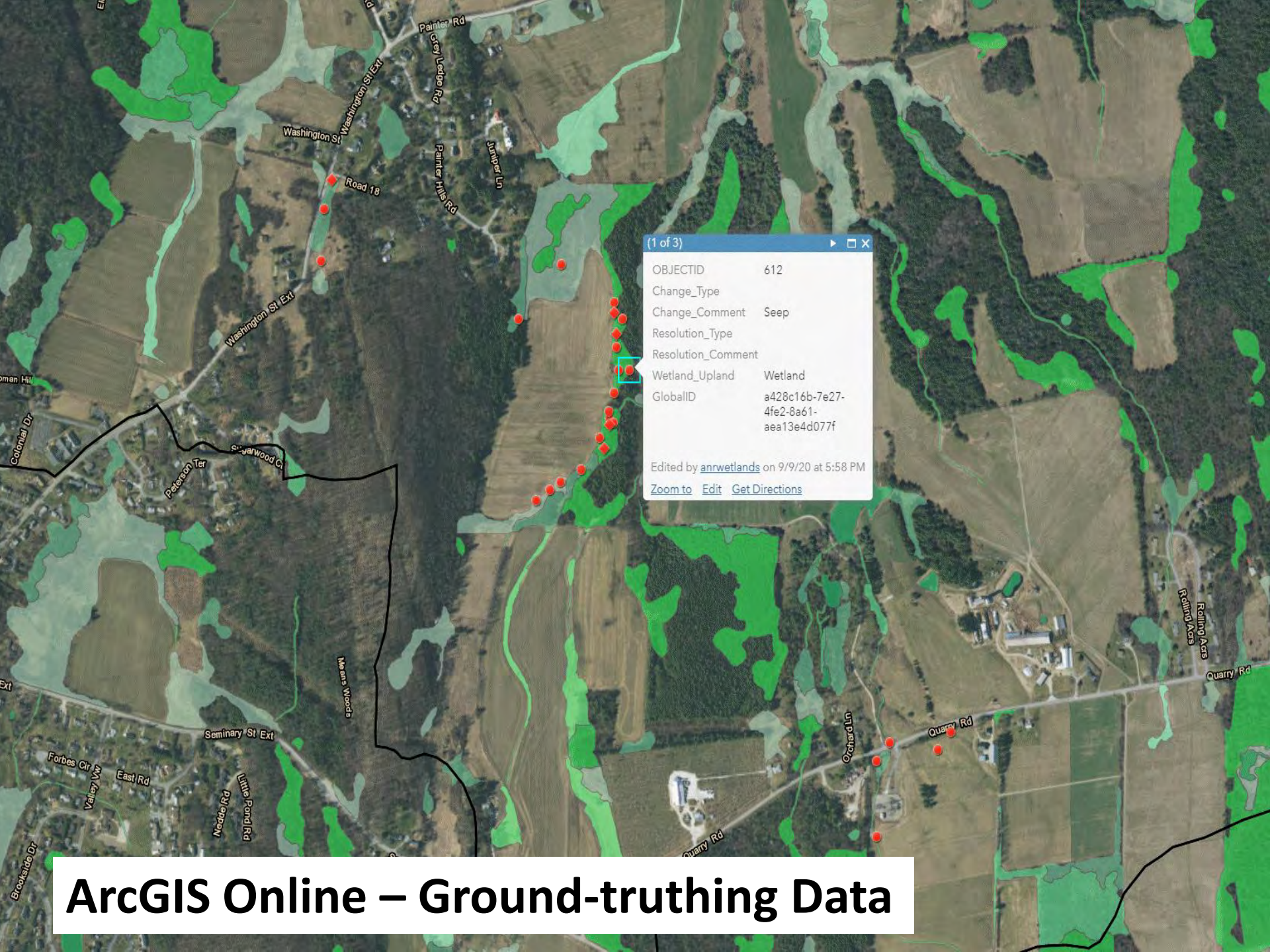

Water Flow Path
Bidirectional-nontidal
Outflow
Outflow Artificial
Outflow Intermittent
Throughflow
Throughflow Artificial
Throughflow Intermittent
Vertical Flow
DUCKS UNLIMITED



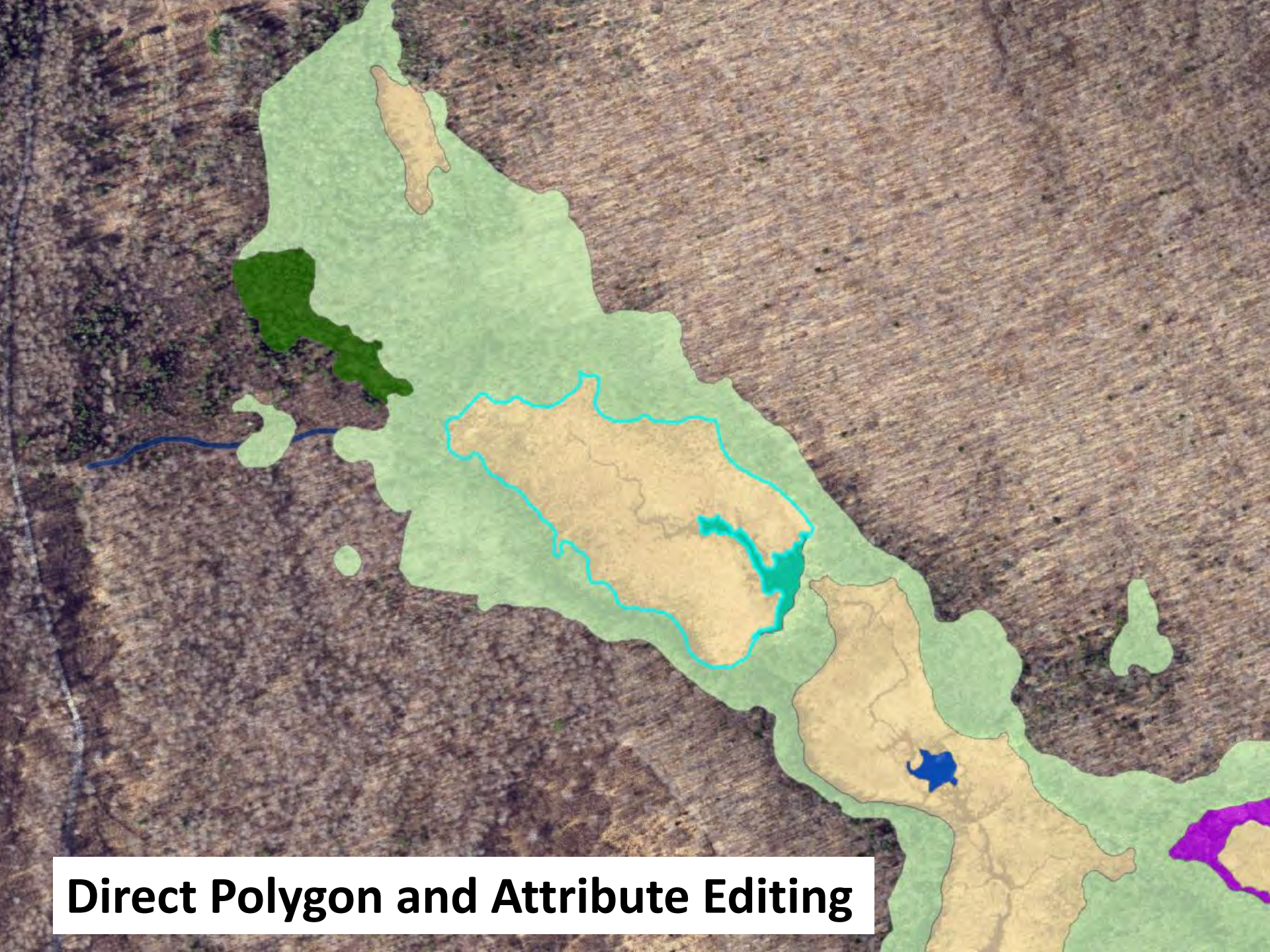
Manual QA\QC

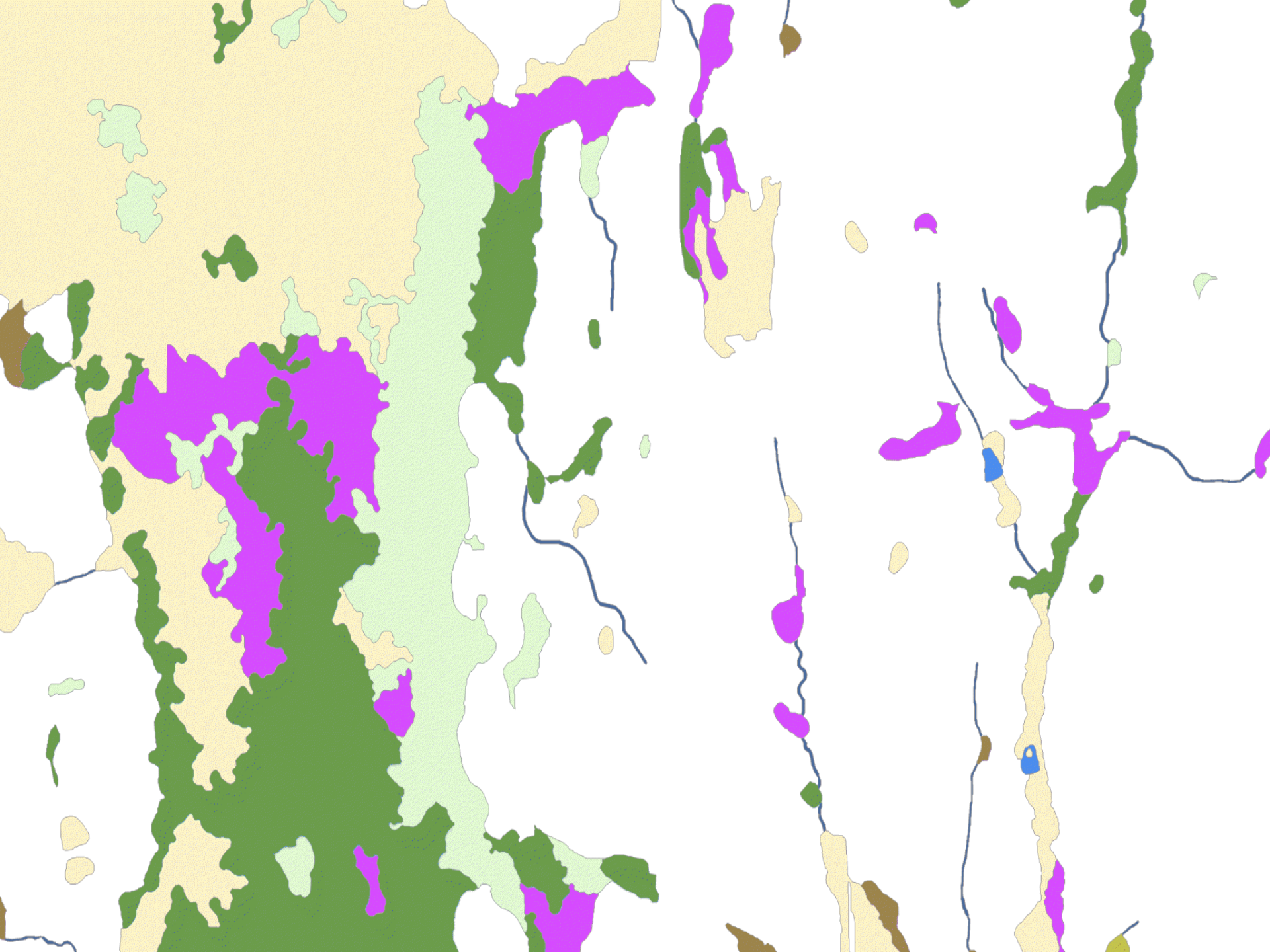
QA\QC Workflow

- Review Presence\Absence
- Attribution
- Field Data\Review Points



ArcGIS Online – Ground-truthing Data


Direct Polygon and Attribute Editing



Automated Feature Extraction

- Data Fusion Essential
- Facilitates Large-area Mapping
- Manual QA\QC Adds Final Margin of Quality
- Hybrid Approach Most Effective

Is it Better, Faster?

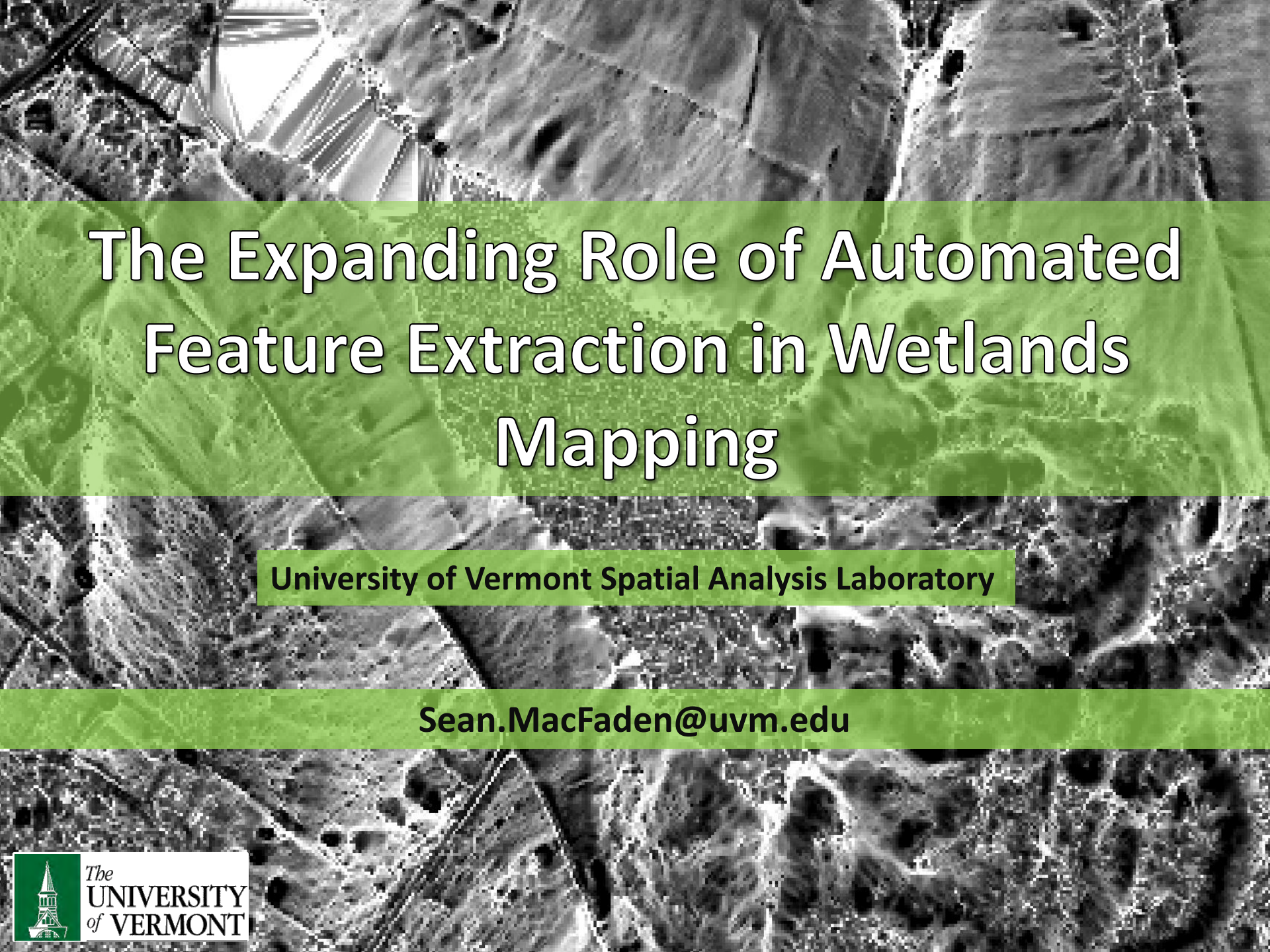
- Nothing Beats Human Cognition! BUT:
- Modeling Definitely Faster
- Helps Capture Features Easily Missed During Manual Mapping
- Equal or Better Map Accuracy
- More Cost Effective?

Future Work

- Deep Learning (AI) – Data Fusion
- Separate (e.g., ArcHydro WIM) or Integral
- Expanded Use of LiDAR Intensity (e.g., Lang et al. 2020)
- Change Detection

Acknowledgments

- Ducks Unlimited
- Vermont Dept. of Environmental Conservation
- VHB
- Bear Creek Environmental
- NYC Department of Environmental Protection
- GroundPoint Engineering
- Pennsylvania Dept. of Environmental Protection
- U.S. EPA Chesapeake Bay Program
- Chesapeake Conservancy
- Upper Susquehanna Coalition



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University of Vermont Spatial Analysis Laboratory

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