

High-resolution Mapping of Vernal Pools using LiDAR and Object-based Image Analysis

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**High Branch Conservation Services



North Atlantic Landscape Conservation Cooperative

✓ Compile and Standardize
Existing Vernal Pools Databases

✓ Demonstrate Utility of High-
resolution Remote-sensing Data
to Vernal Pools Mapping

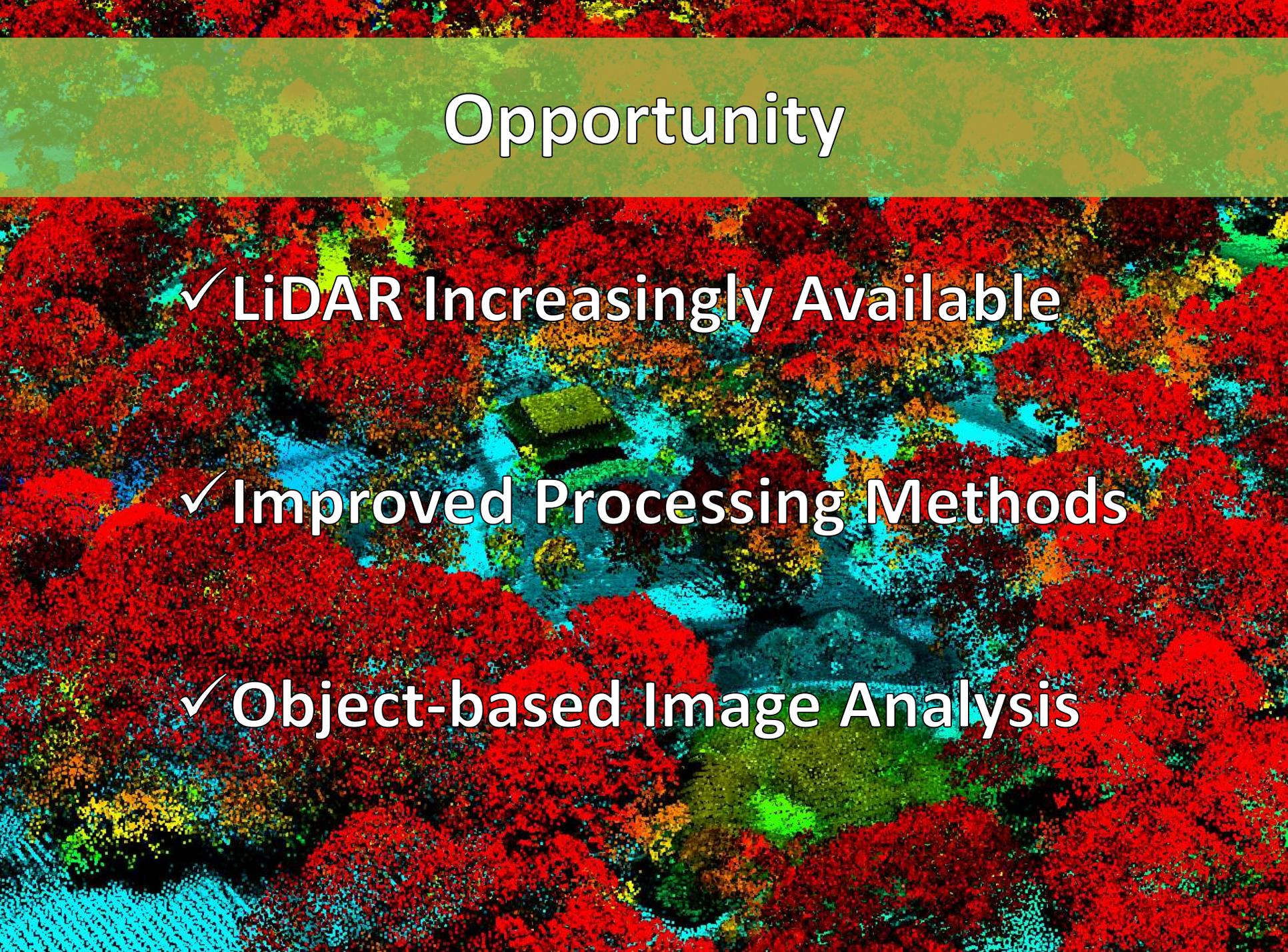
NALCC Project – Modeling Component

- ✓ Develop Tools\Methods that are Effective and Efficient for Broad-scale Analyses
- ✓ Appropriate and Adaptable for North Atlantic Region, Virginia to Nova Scotia

Need

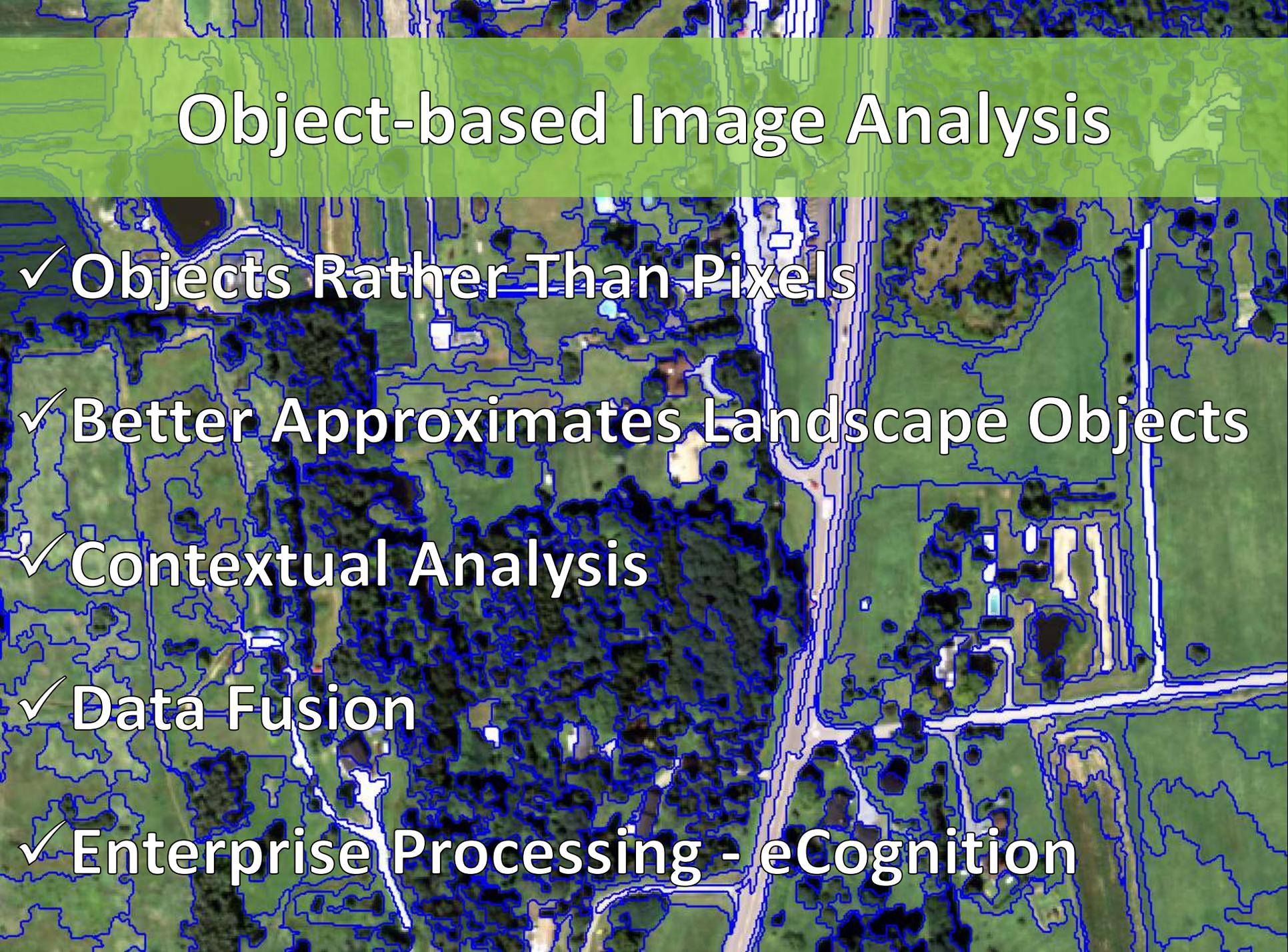
- ✓ Manual Interpretation Effective but Laborious
- ✓ Remote Sensing Methods Improving but Often Limited in Scope
- ✓ Regional Analyses Require Efficient Processing and Data Fusion

Opportunity

An aerial LiDAR point cloud of a forest. The ground is colored in shades of blue and cyan, while the trees are colored in red, orange, and yellow. A small, rectangular building is visible in the center of the image, colored in a dark green.

- ✓ LiDAR Increasingly Available
- ✓ Improved Processing Methods
- ✓ Object-based Image Analysis

Object-based Image Analysis

An aerial photograph of a landscape, possibly a farm or rural area, with various fields, trees, and buildings. The image is overlaid with a complex network of blue lines that represent the boundaries of objects identified by an object-based image analysis algorithm. These lines delineate fields, roads, and structures, showing a more holistic view of the scene compared to pixel-level analysis.

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

On Tiles

- Reset
- Import Other Needed Layers
- Image Processing
 - Slope
 - Aspect
 - Density Layers
 - Distance Maps
 - Tobacoe - Lee Sigma
 - edge extraction lee sigma (5.0, Bright) 'CTE' => 'Lee Sigma CTE'
- Background
 - chest board: 909999 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: chest board: 909999999
 - Streams and Rivers
 - Classify
 - unclassified with 'FTType': HydroPoly = 460 at Level 2: _Temp 1
 - _Temp 1 at Level 2: Large Water Bodies
 - Large Open Water Bodies
 - Classify
 - unclassified with 'FTType': HydroPoly = 390 and 'AreaSqKm': HydroPoly > 0.04 at Level 2: _Temp 1
 - Grow Large Open Waterbodies to Capture All Areas of Water
 - Segmentation
 - unclassified at Level 2: 100 [shape:0.1 compact:0.5]
 - Grow
 - loop: _Temp 1 at Level 2: <- unclassified Mean Ortho_NBR < 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 Pal at Level 2: _Temp 6
 - _Temp 6 with Mean Intensity < 20 at Level 3: _Temp 8

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

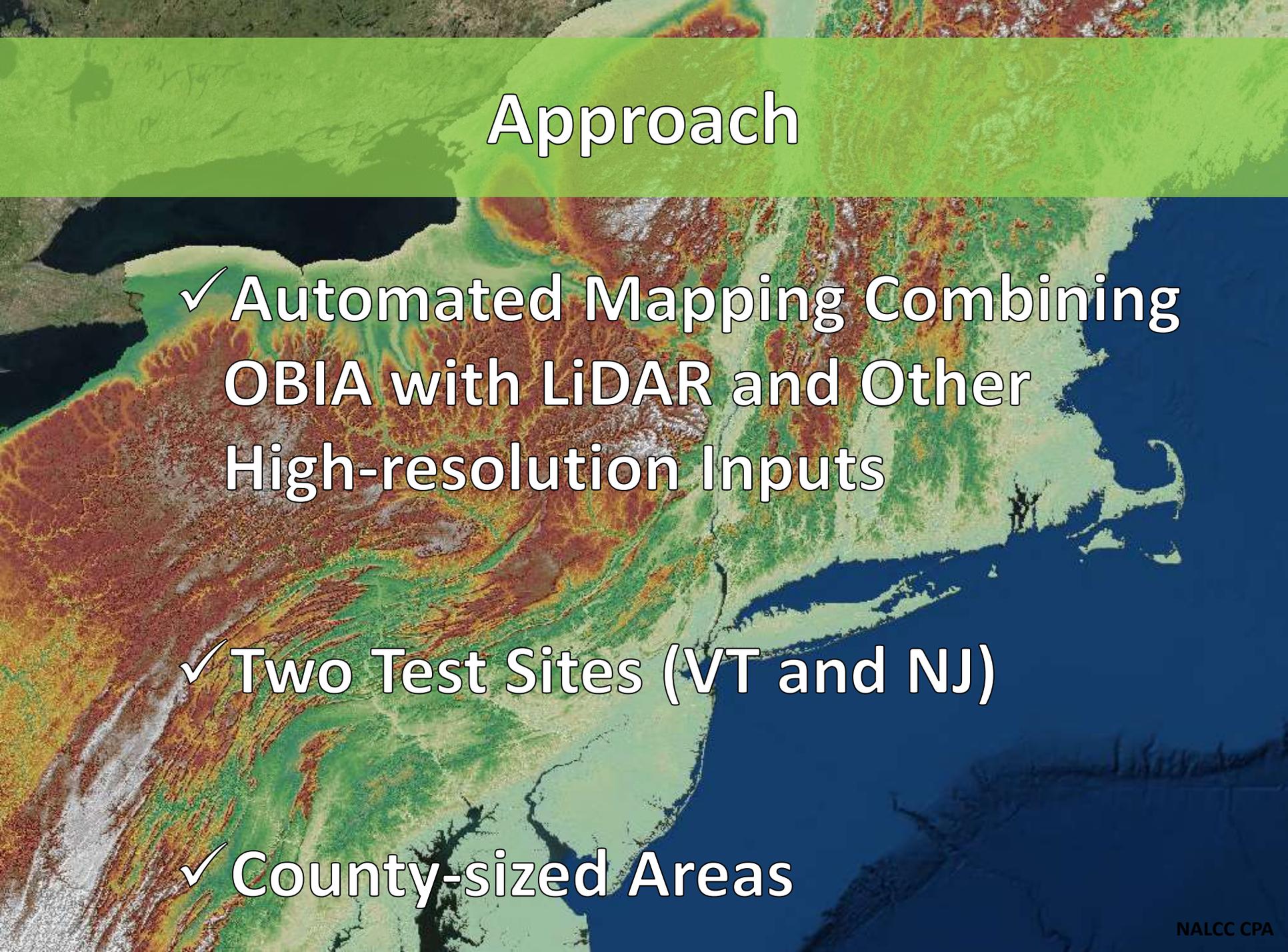
- _Candidate Pools - Physical Features Only
- _Candidate Pools - Rimmed by Steep Slopes
- _Candidate Pools - Developed Features
- Clumped Pools
- Developed Thematic
- Evaluation Buffer
- Flow Accumulation
- Ghost
- Hydrology Thematic
 - Hydrology Lite
 - Hydrology Poly
- _Temp 1
- _Temp 2
- _Temp 3
- _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

Image Object Information

| Feature | Value |
|-------------------------------|-------|
| Scene-Related Features | |
| Scene Features | |
| Loop | 50 |
| MMU | 20 |
| Class-Related | |
| Number of clas... | |
| _AOI | 0 |
| Scene-Related | |
| Existence of in... | |
| Candidate Pools | 0 |
| Developed Features | 0 |
| temporary | 0 |

Features / Classification / Class Evolution

Approach



- ✓ Automated Mapping Combining OBIA with LiDAR and Other High-resolution Inputs
- ✓ Two Test Sites (VT and NJ)
- ✓ County-sized Areas

Constraints and Priorities

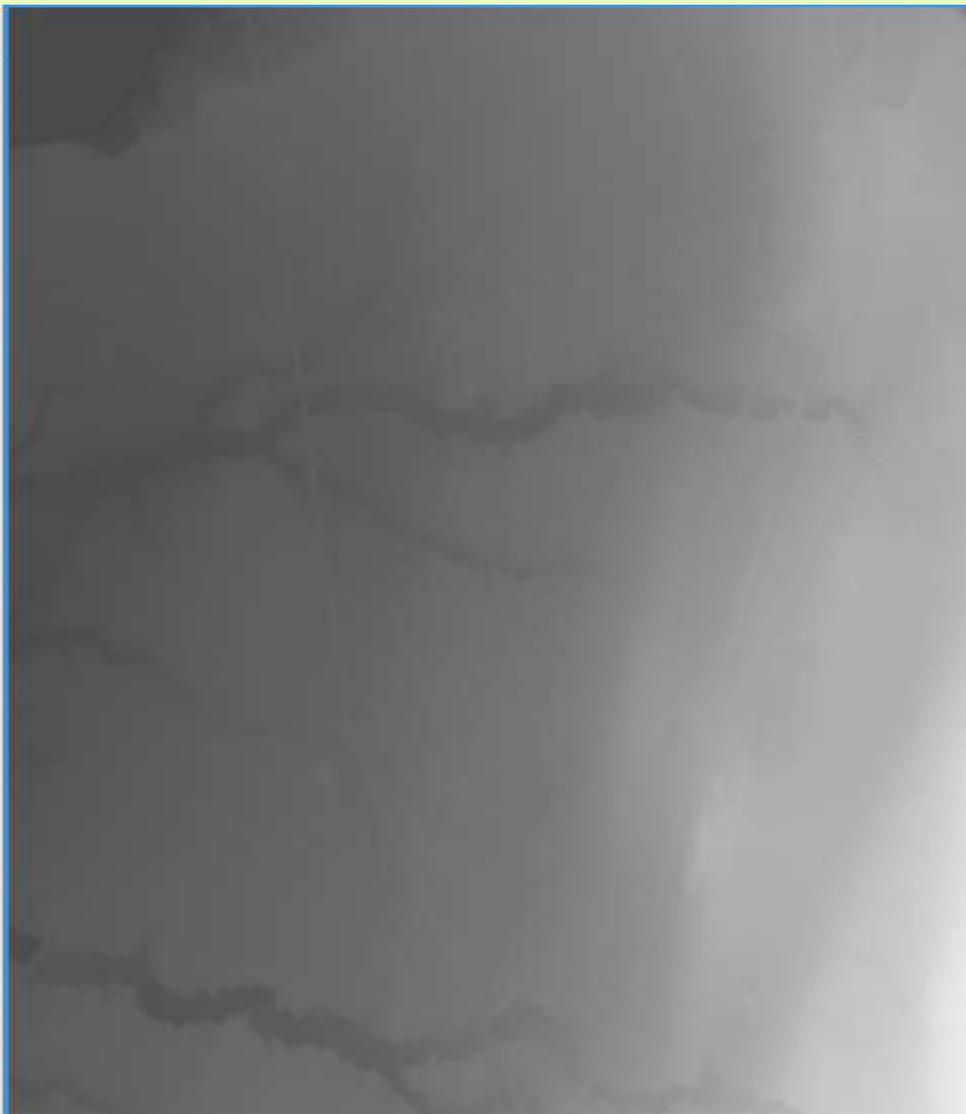
- *Potential Vernal Pools*
- Provide as Much Information as Possible for Stakeholders
- Focus on Avoiding Omission Errors

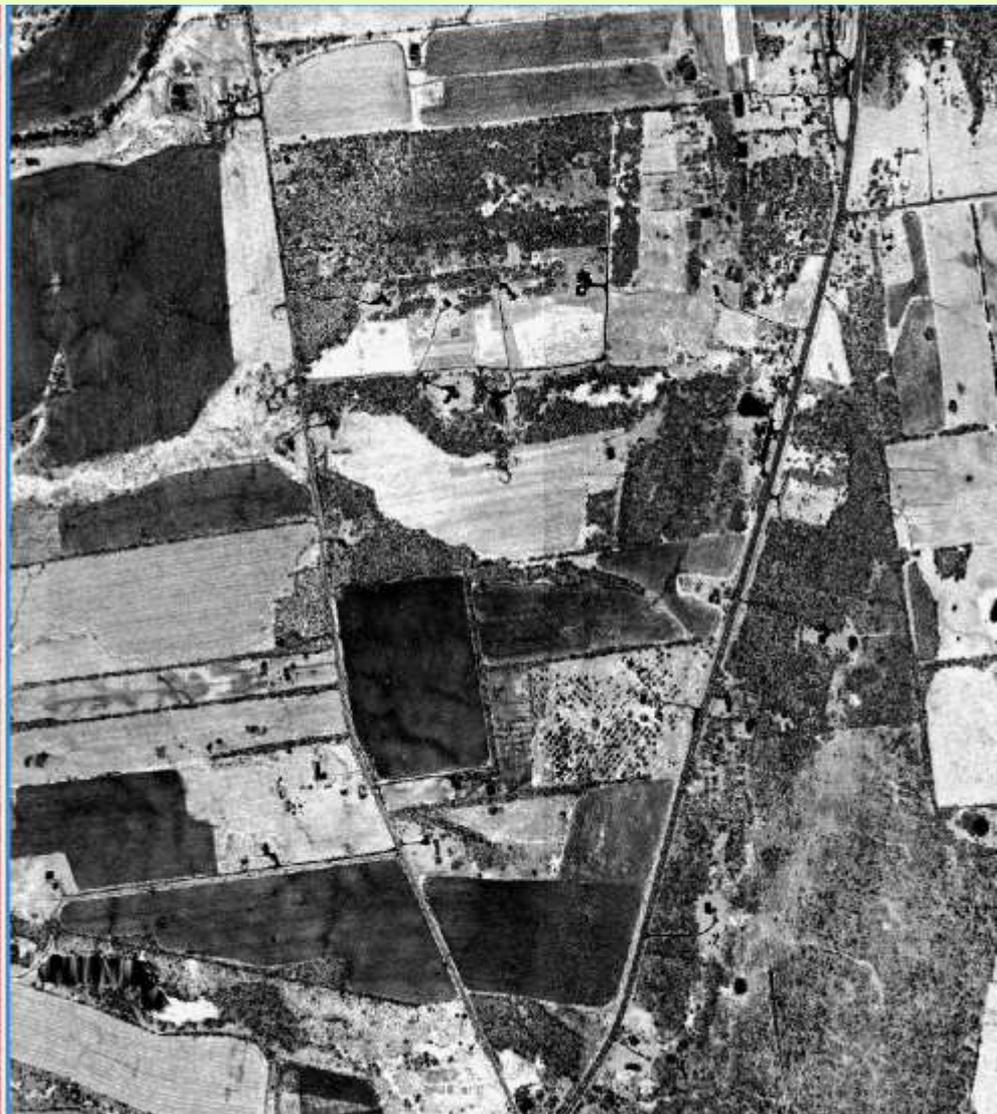


Data Layers







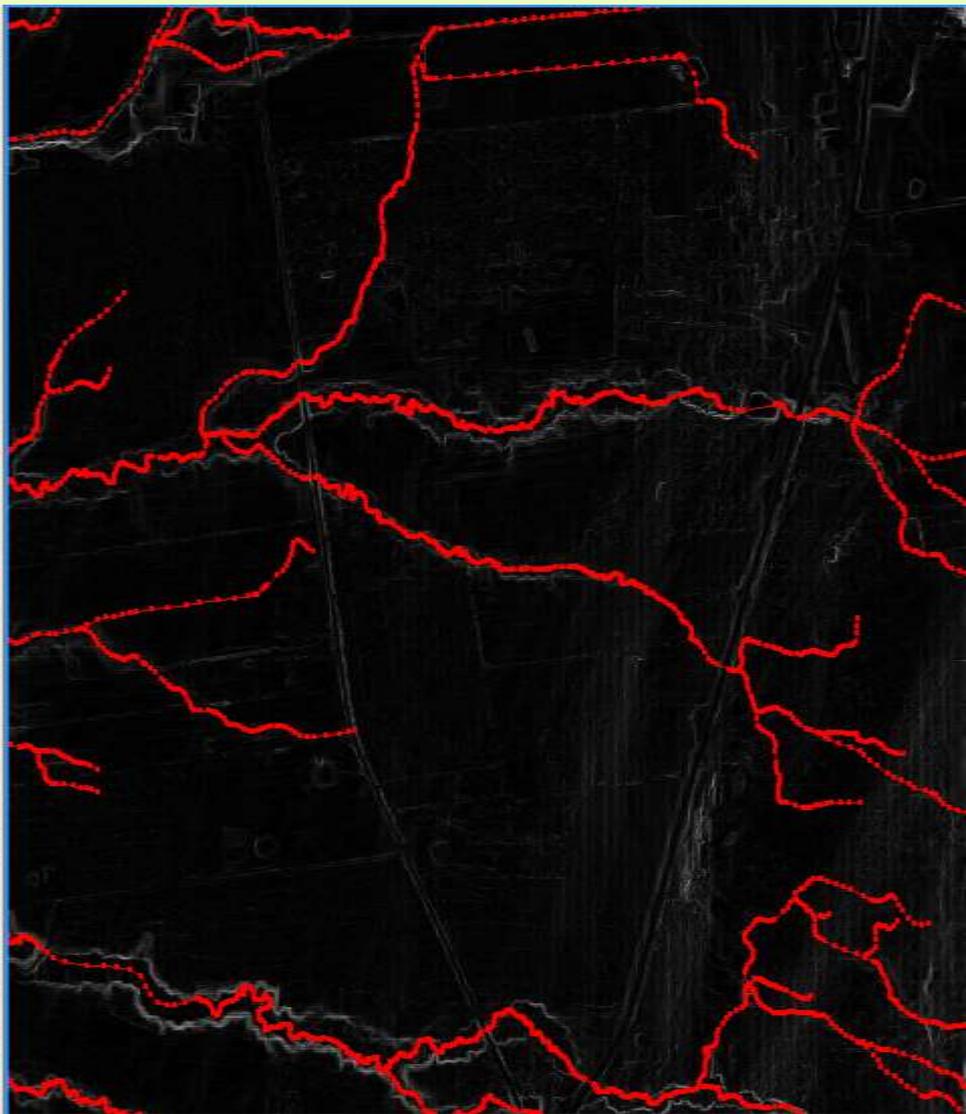
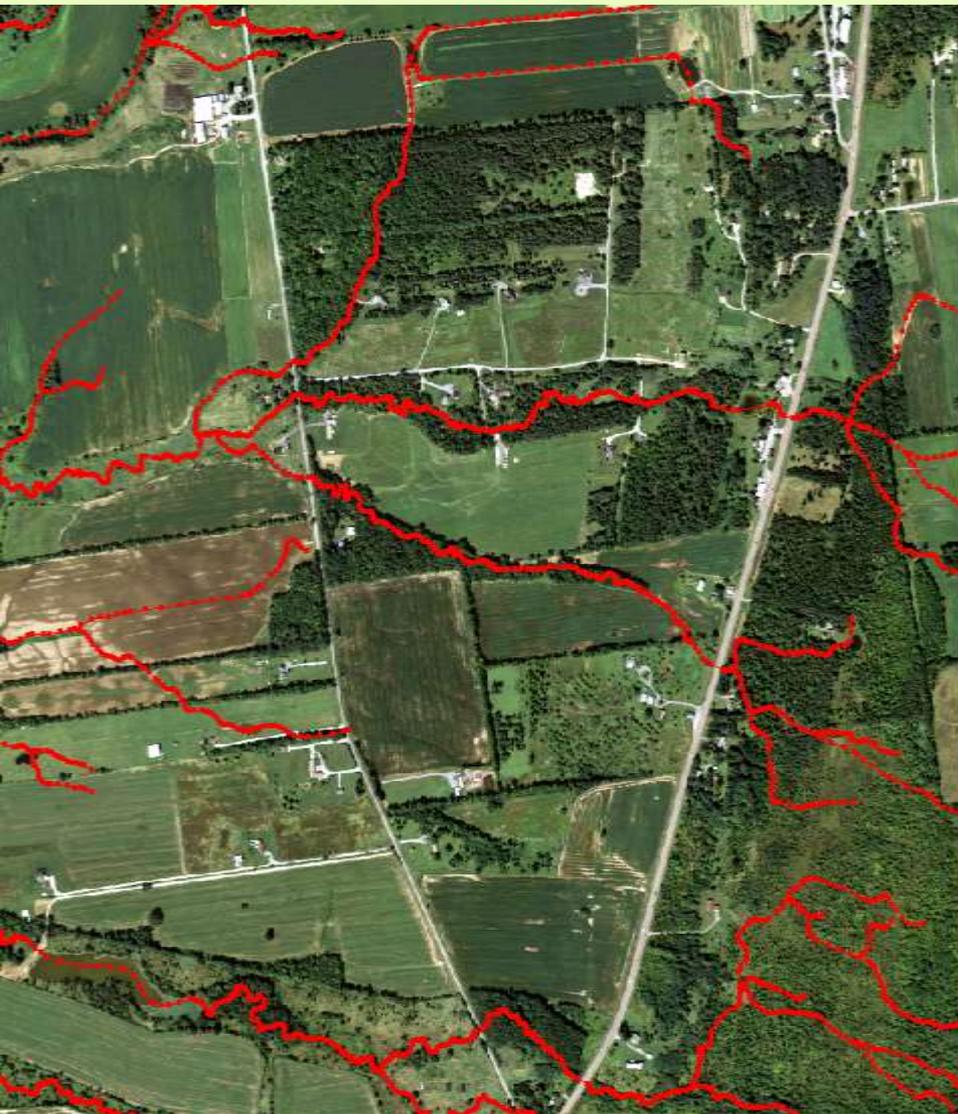














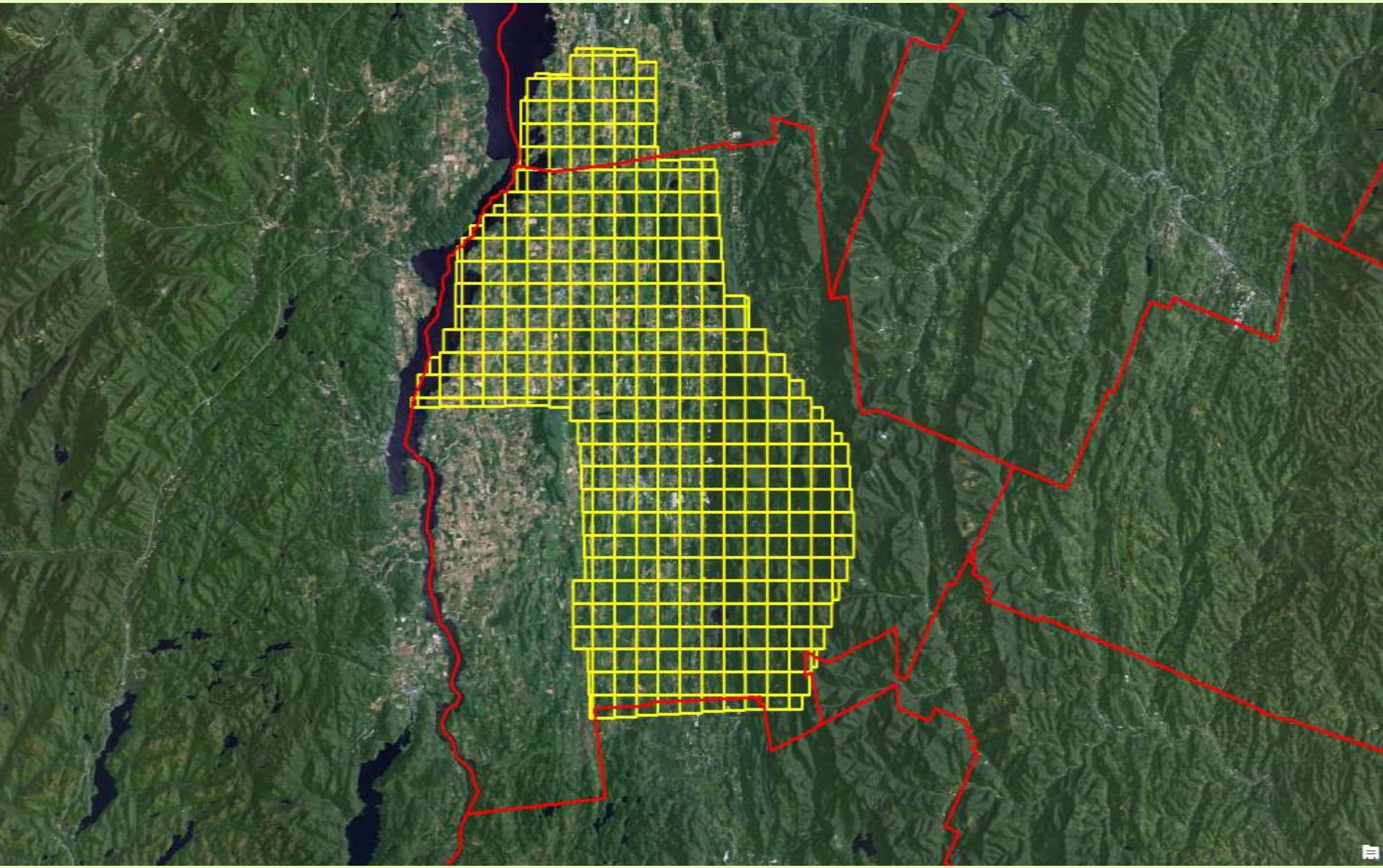


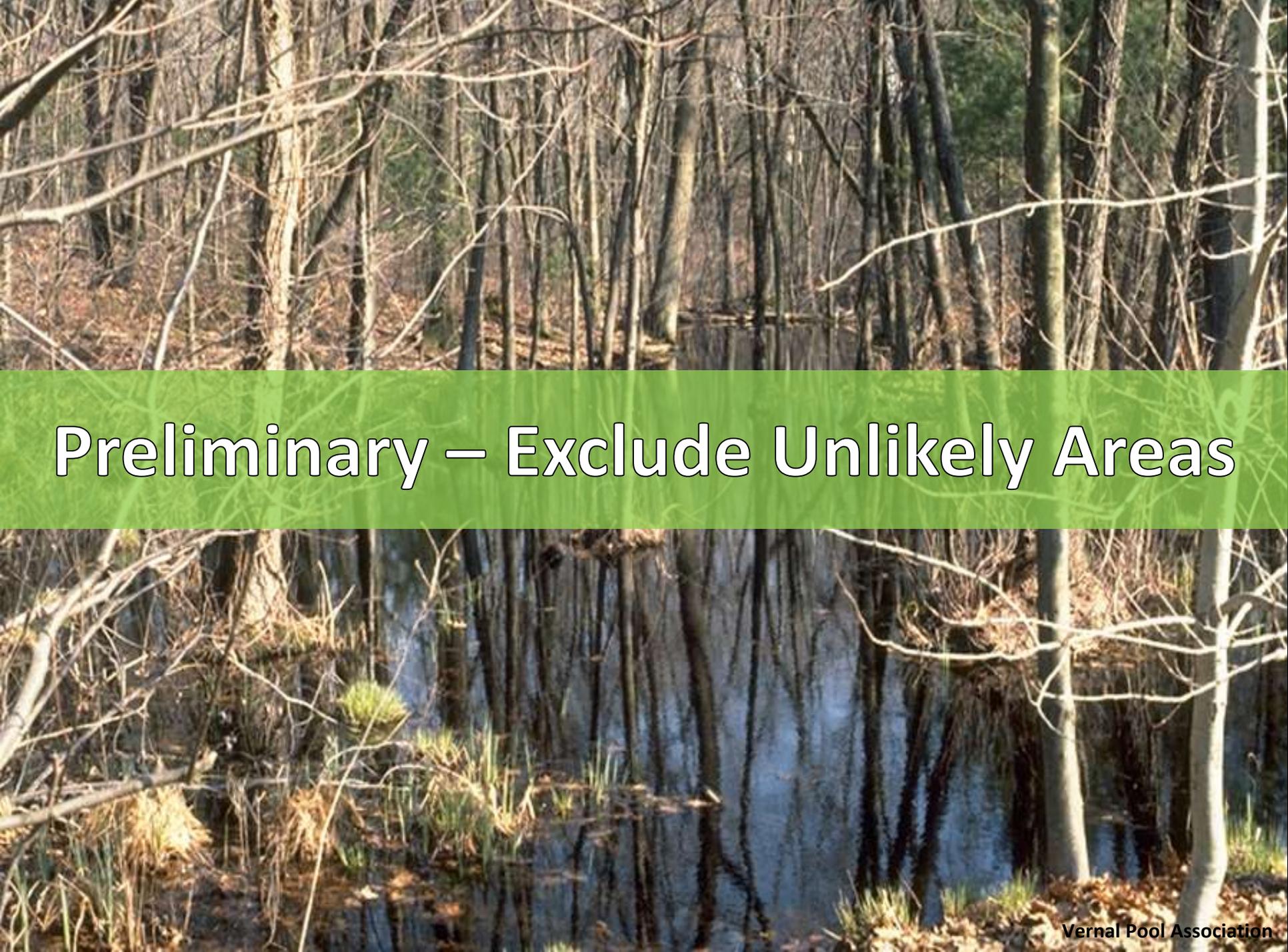
A photograph of a forest stream with a green banner overlay. The stream is in the foreground, reflecting the surrounding trees. The trees are mostly bare, suggesting a late autumn or winter setting. The banner is a solid green color with white text.

Modeling – Addison County, VT

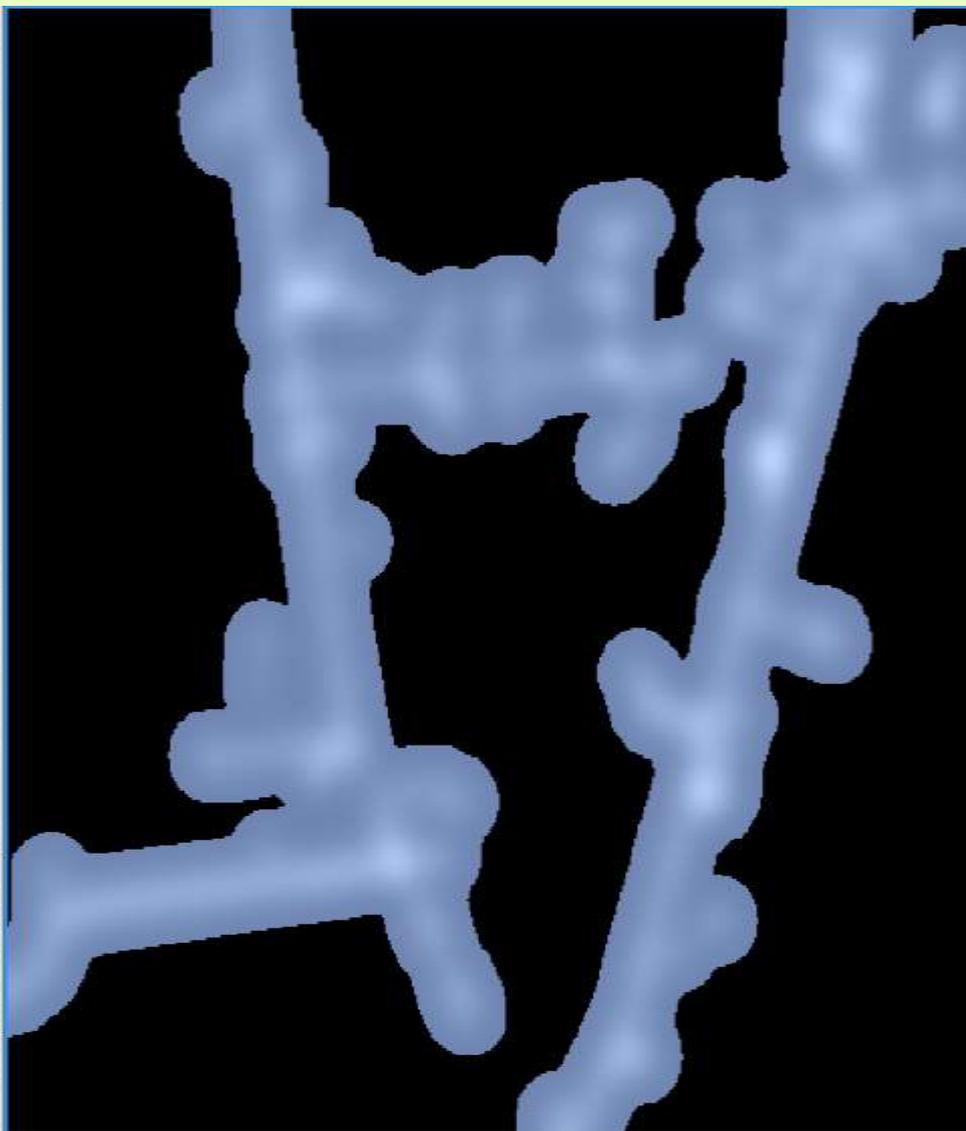
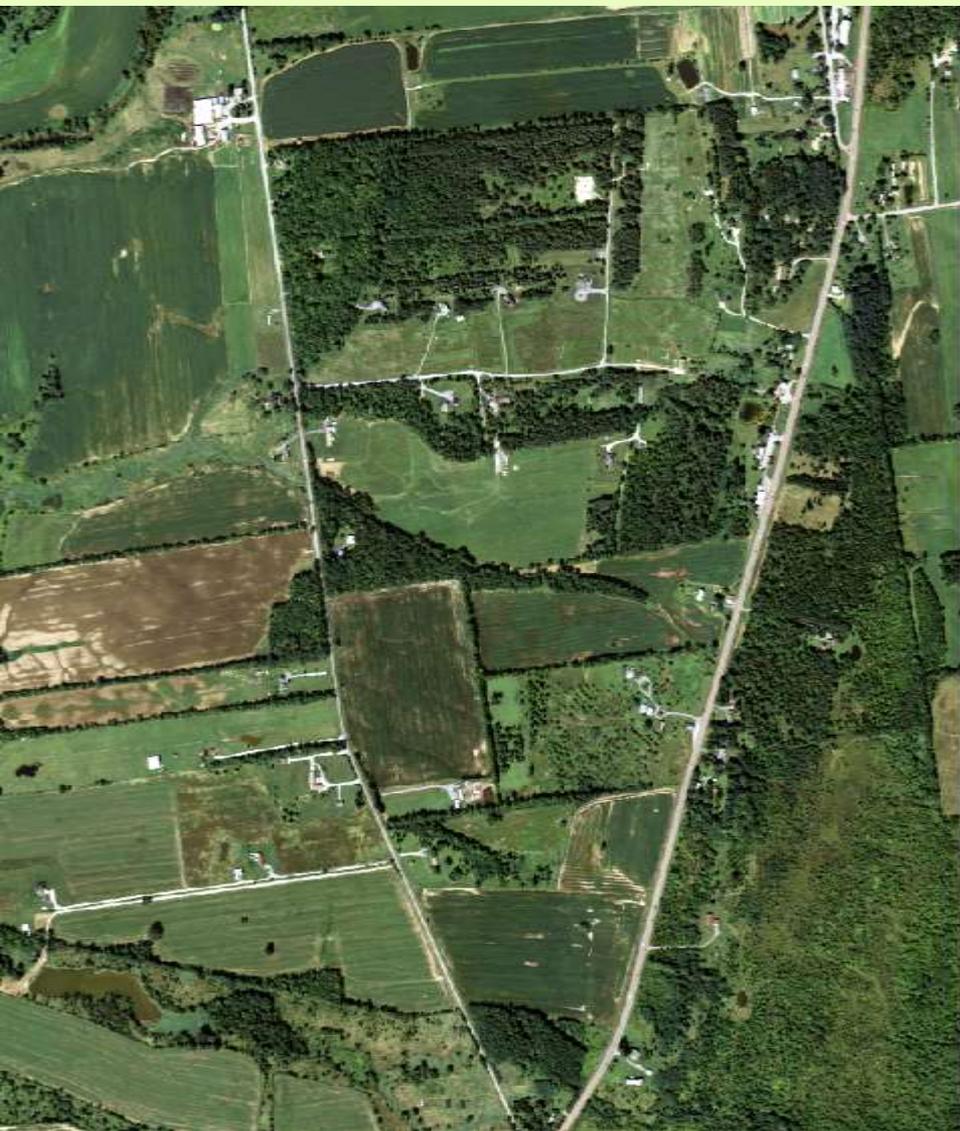
Modeling Approach

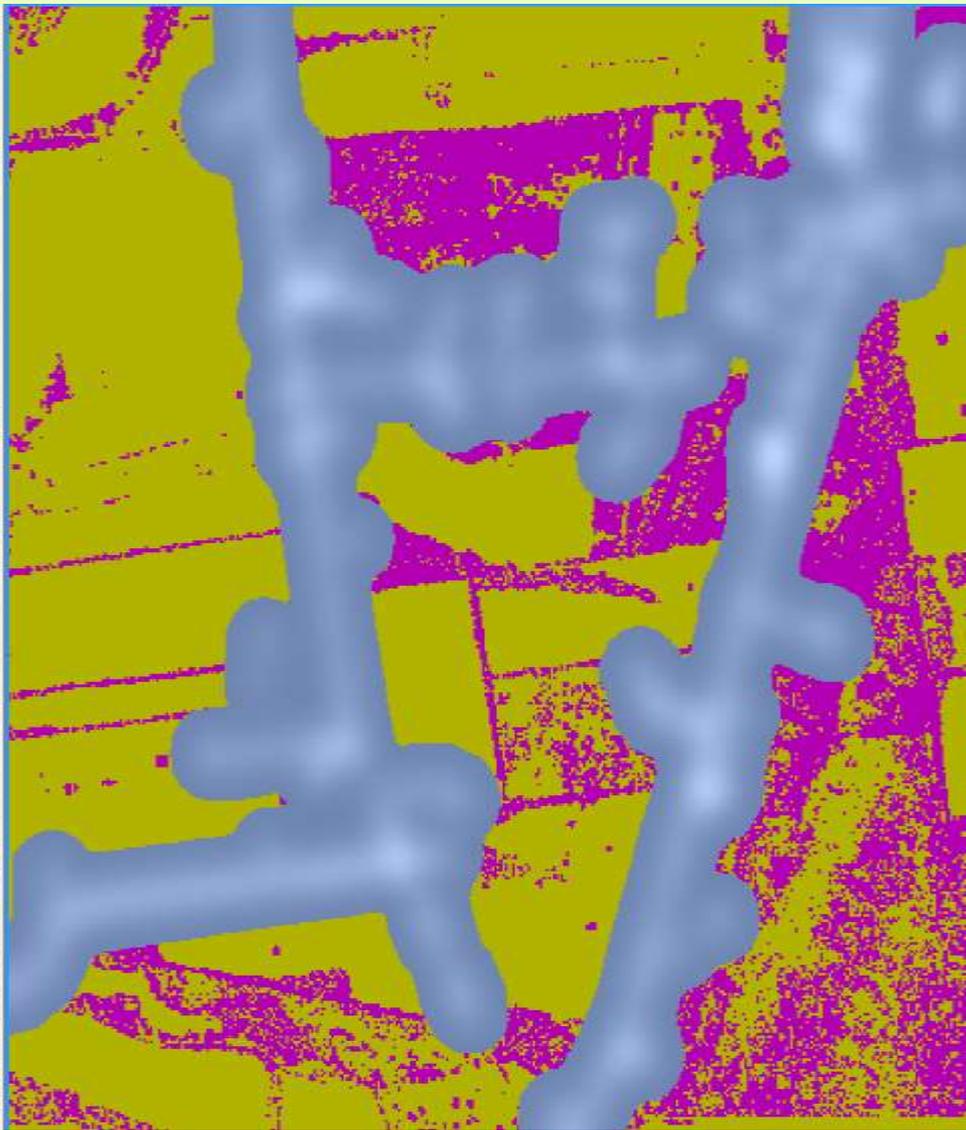
- ✓ Step 1: Identify Depressions (DEM)
- ✓ Step 2: Eliminate Outliers
- ✓ Step 3: Rank Remaining Pools by Evaluating Site Characteristics and Landscape Context



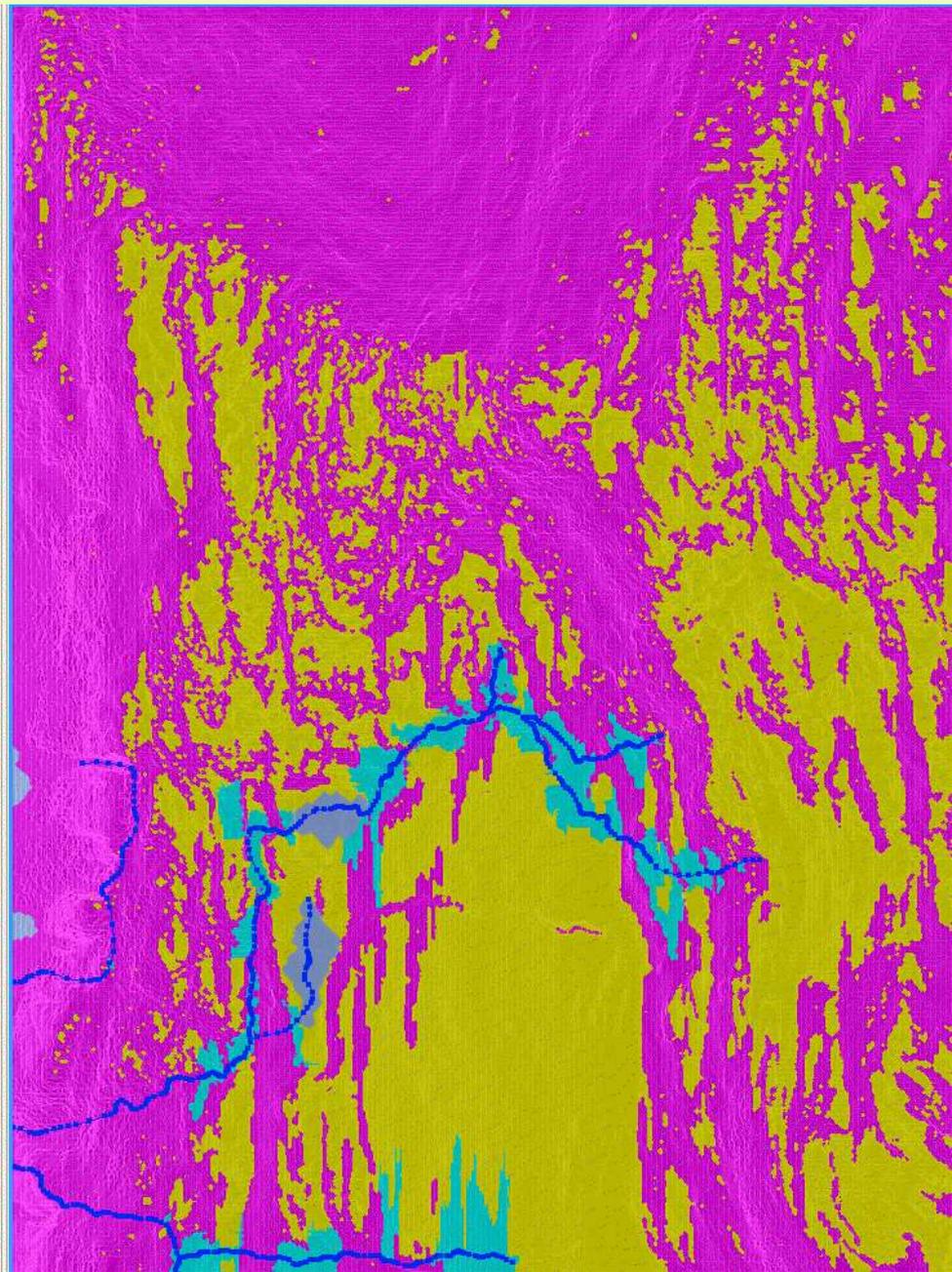
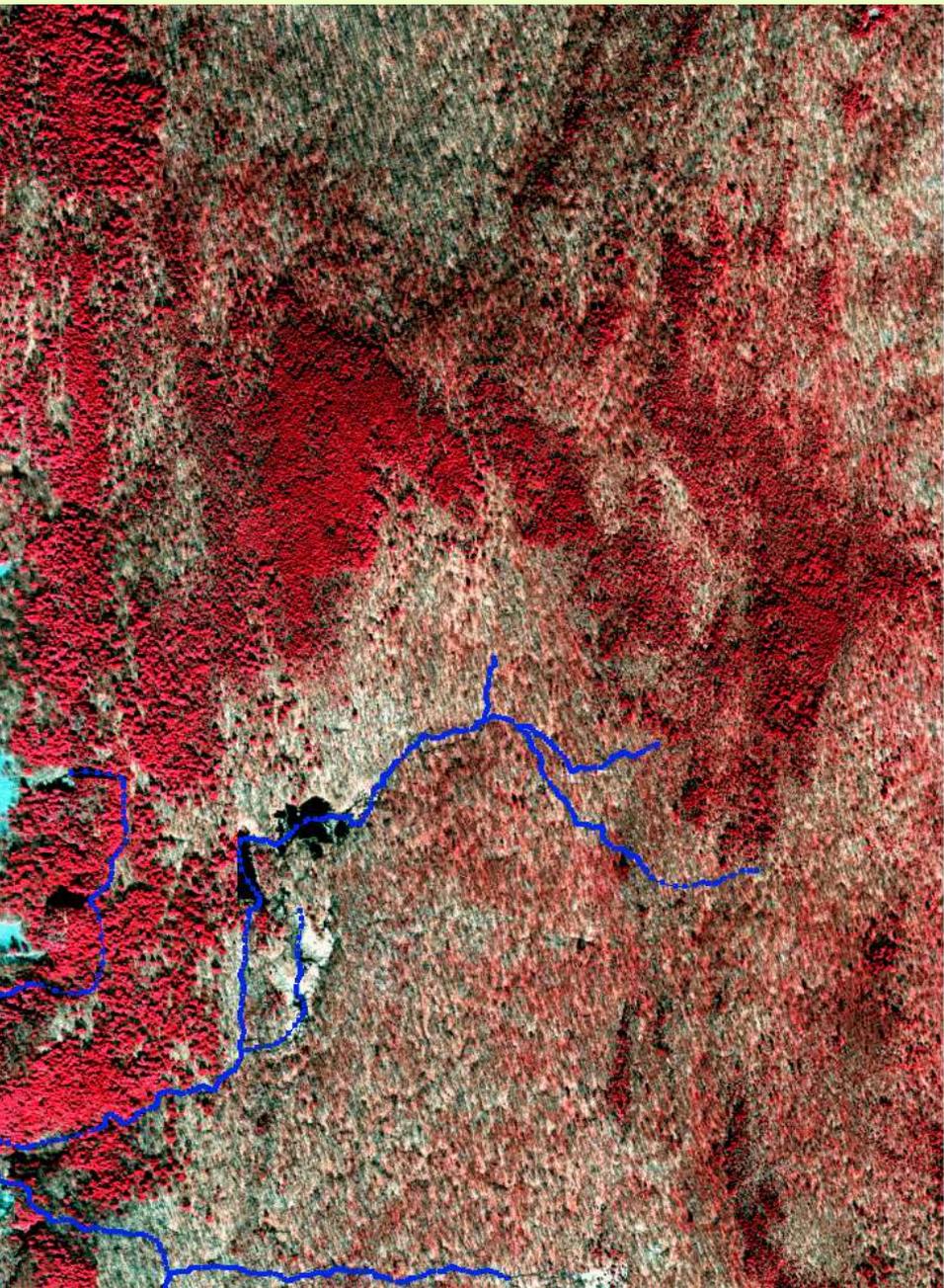
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Preliminary – Exclude Unlikely Areas



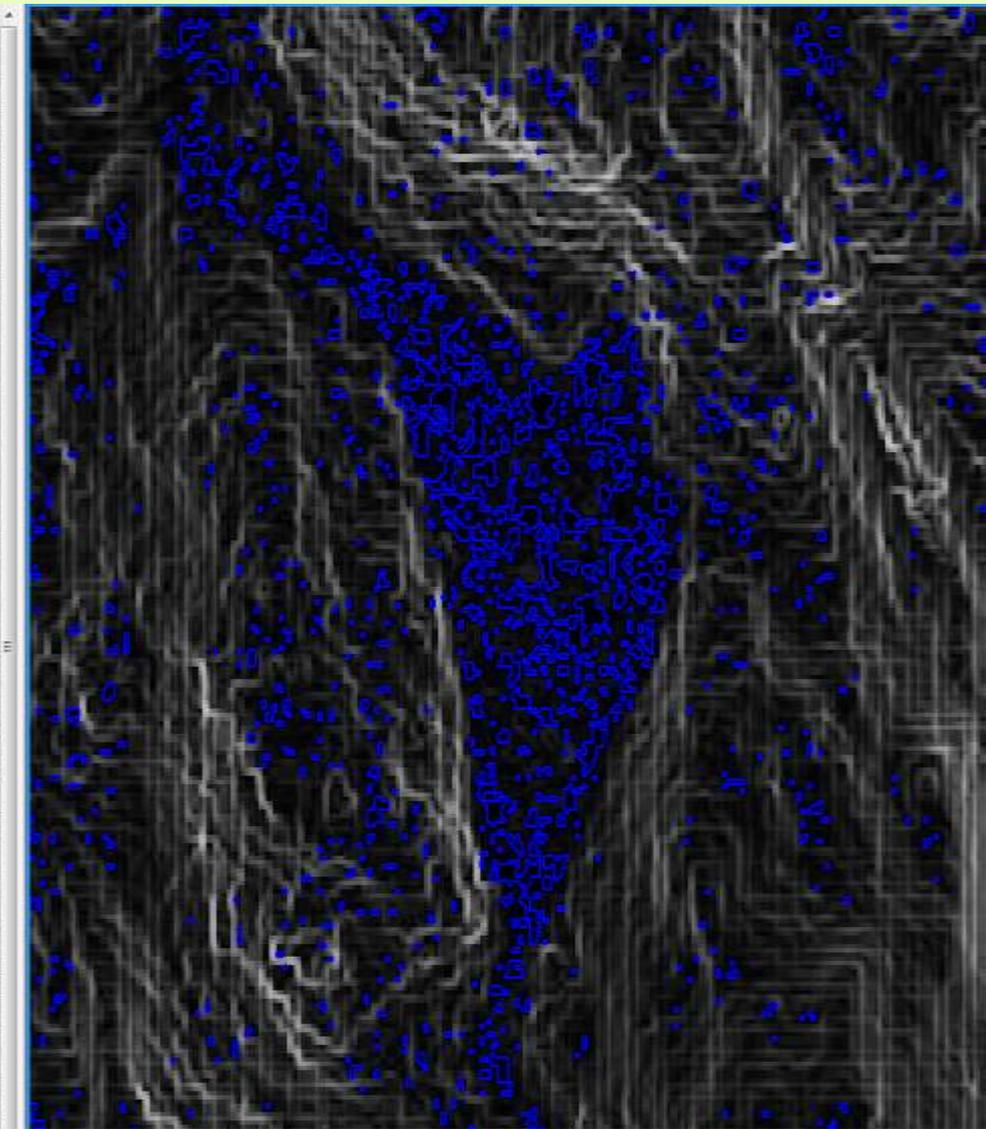
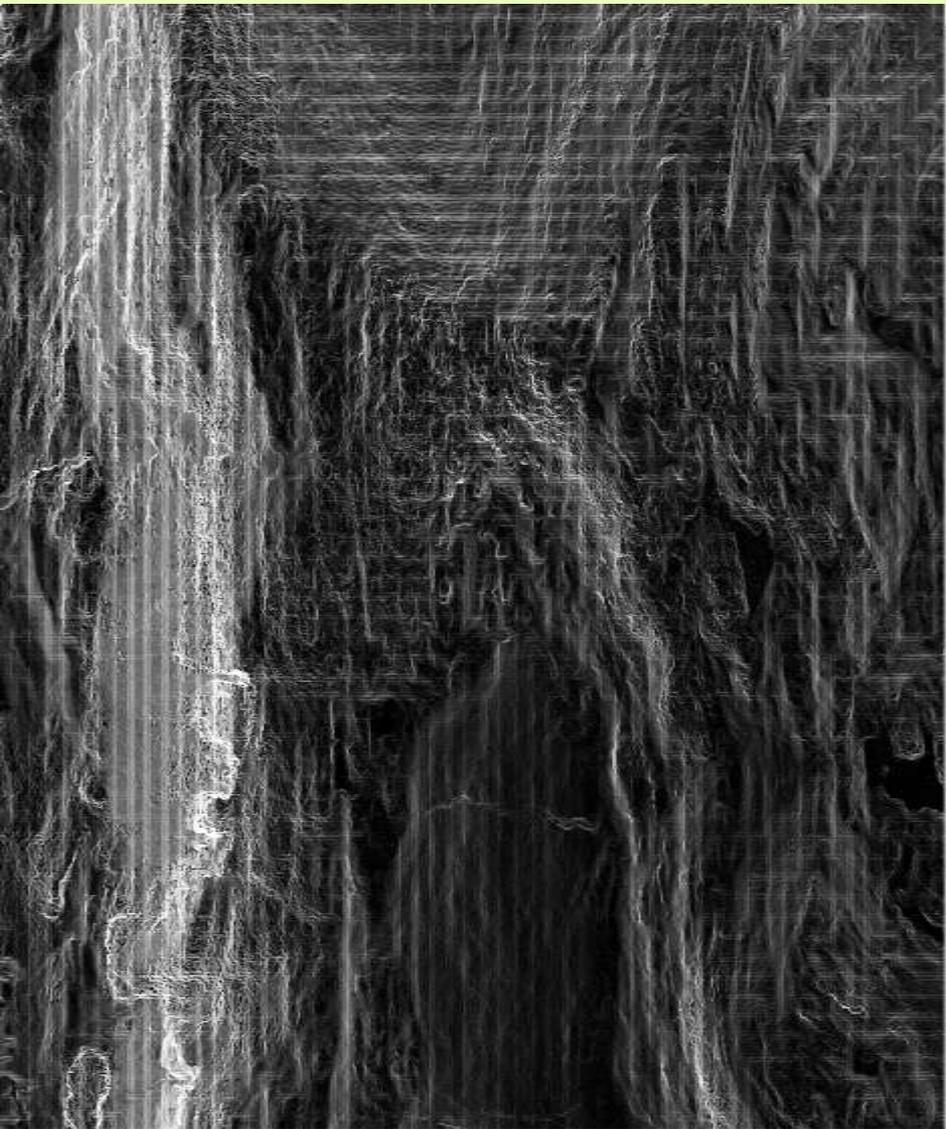


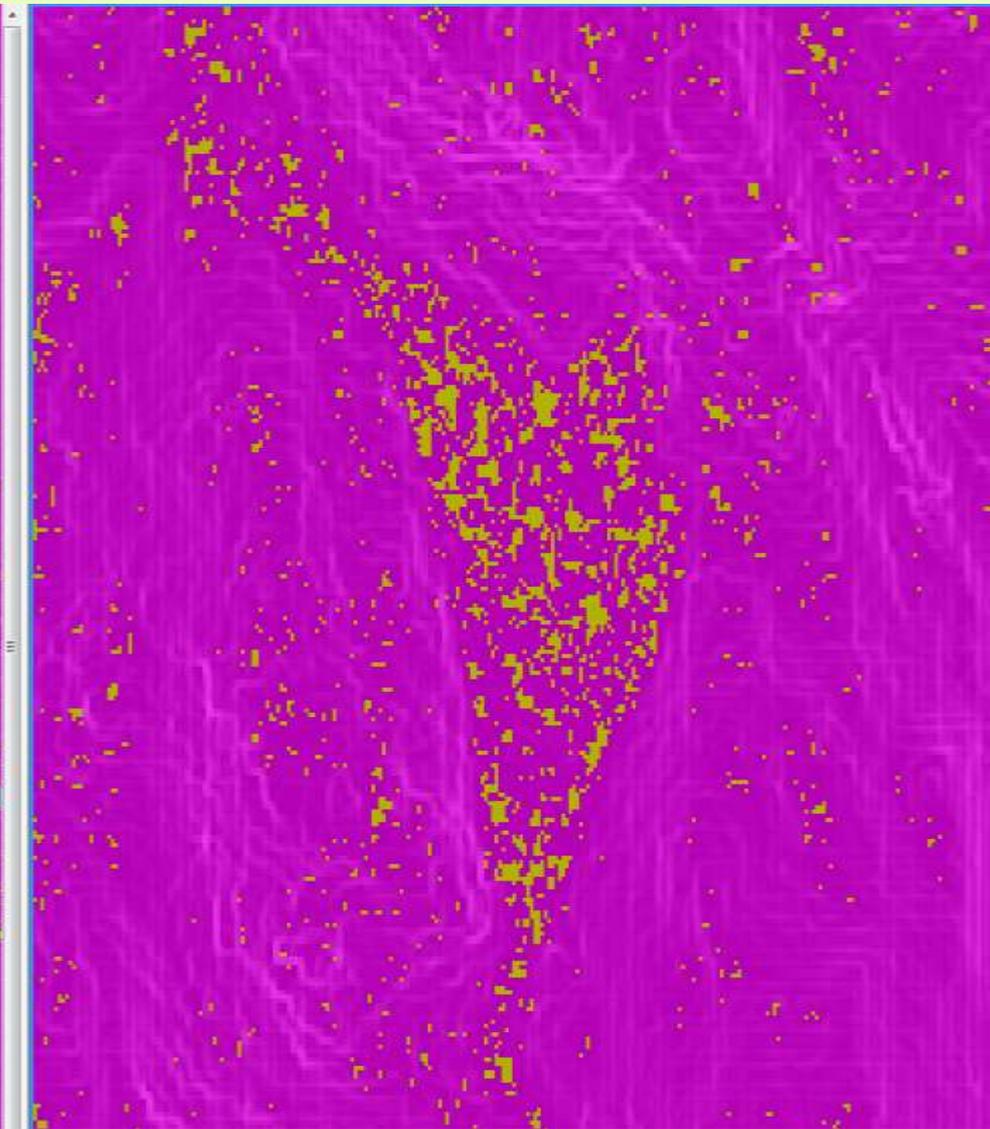
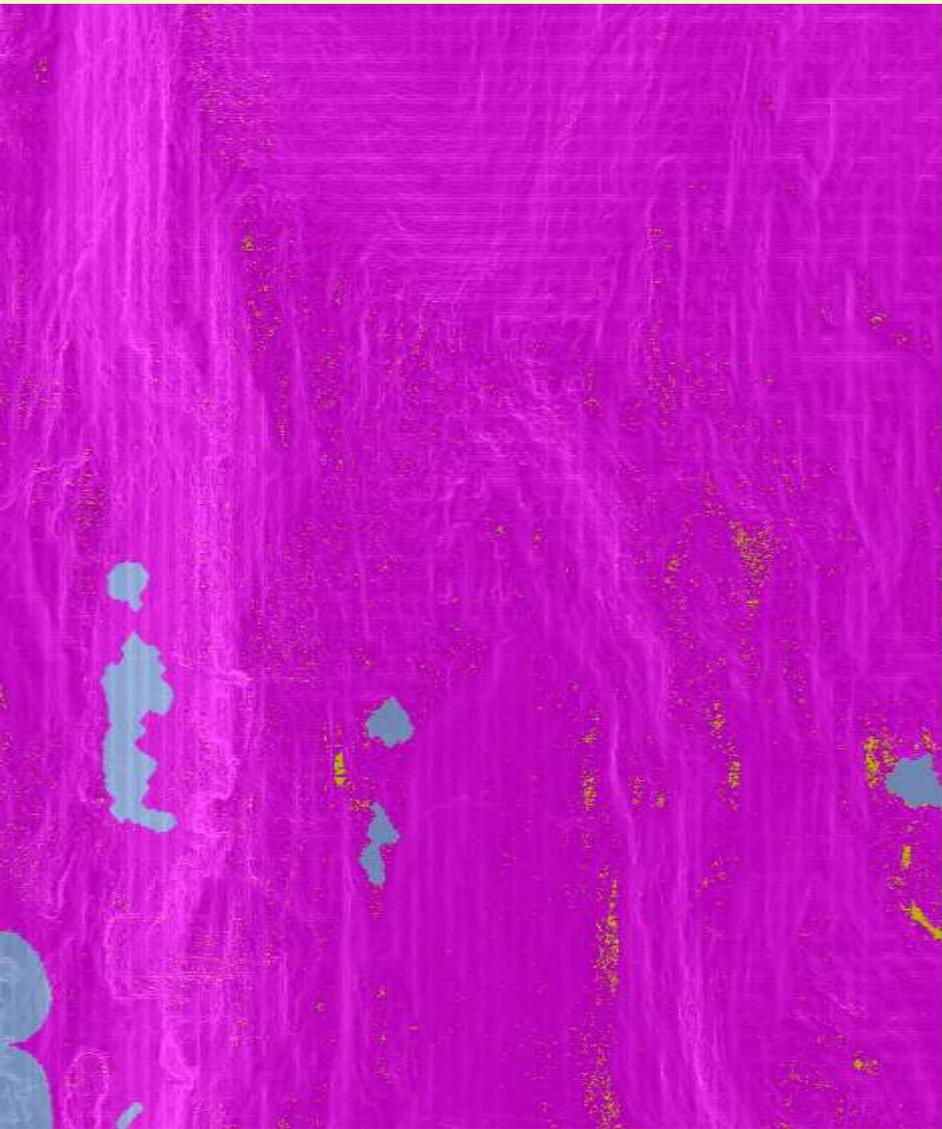


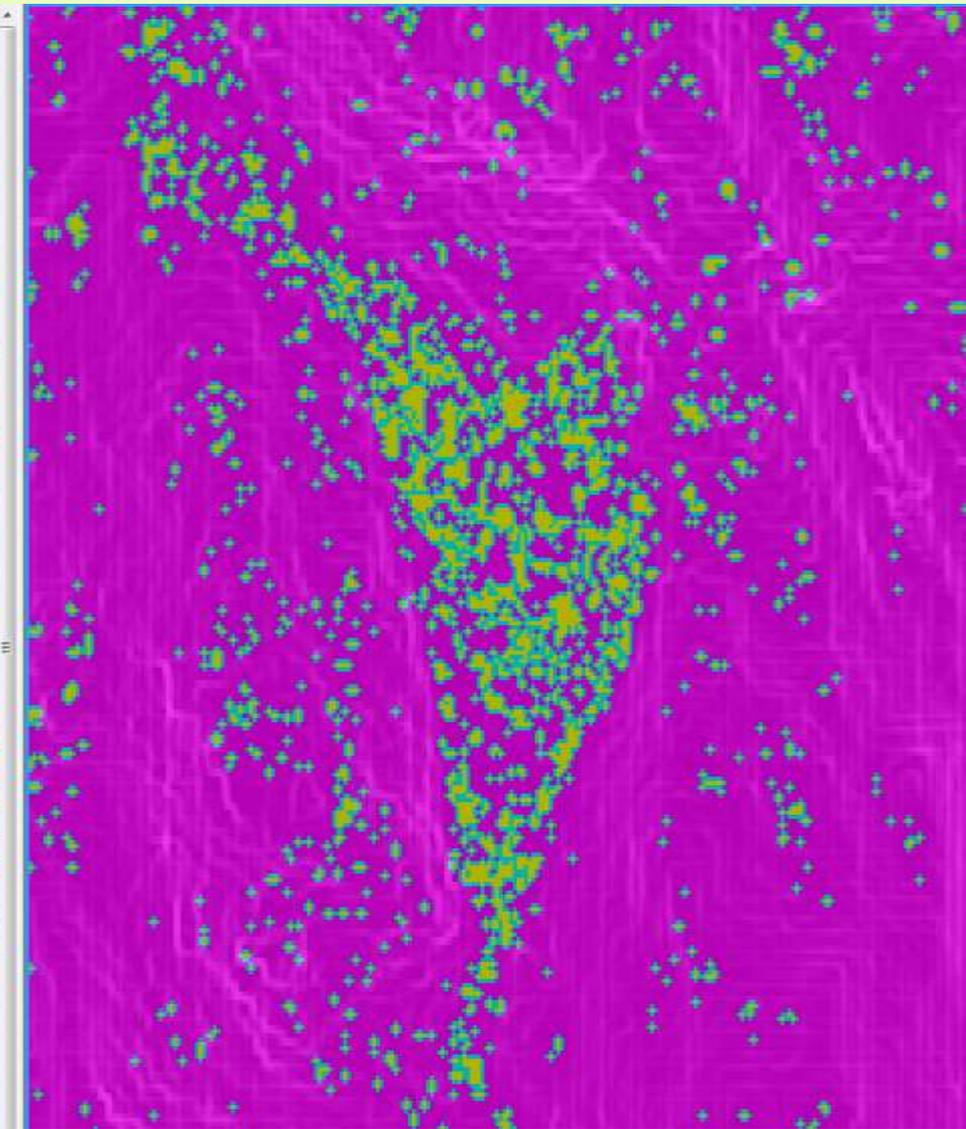


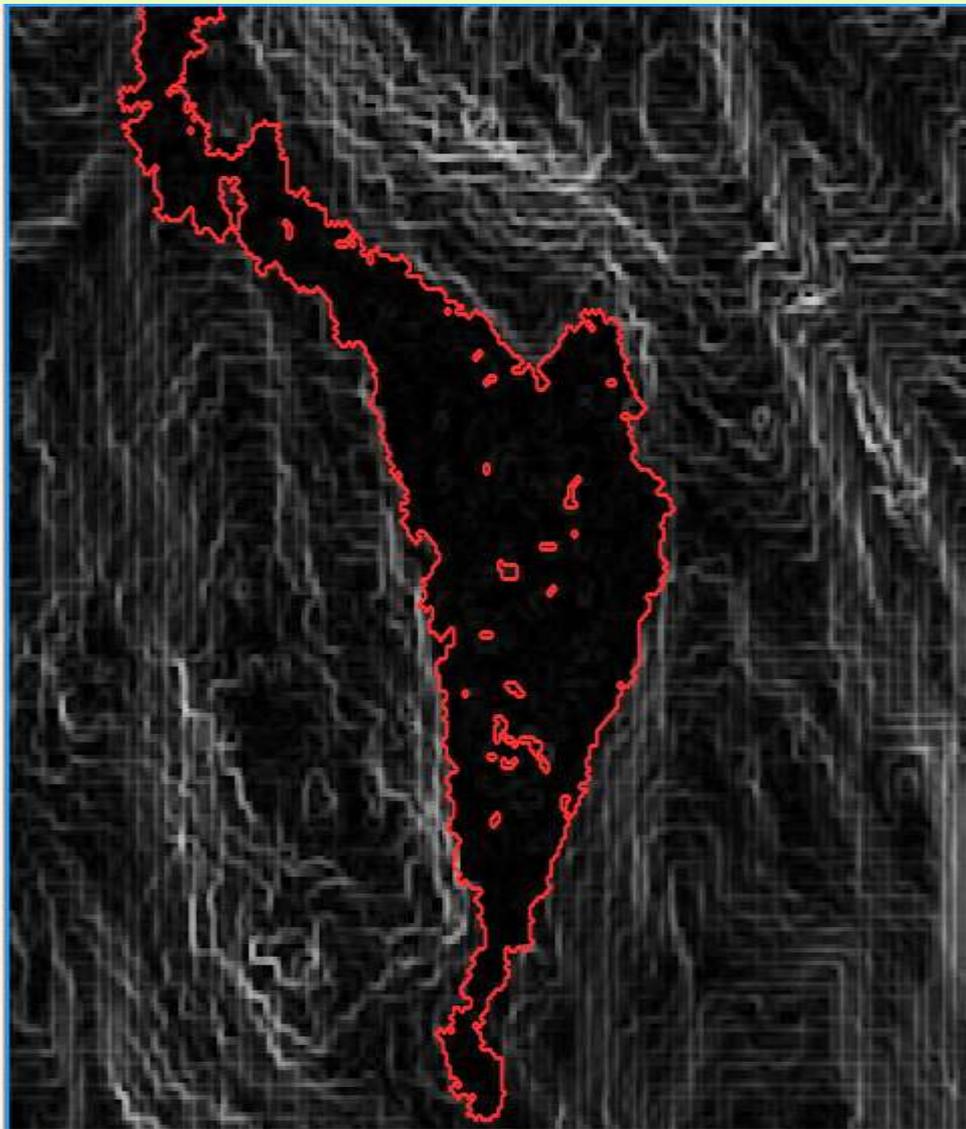
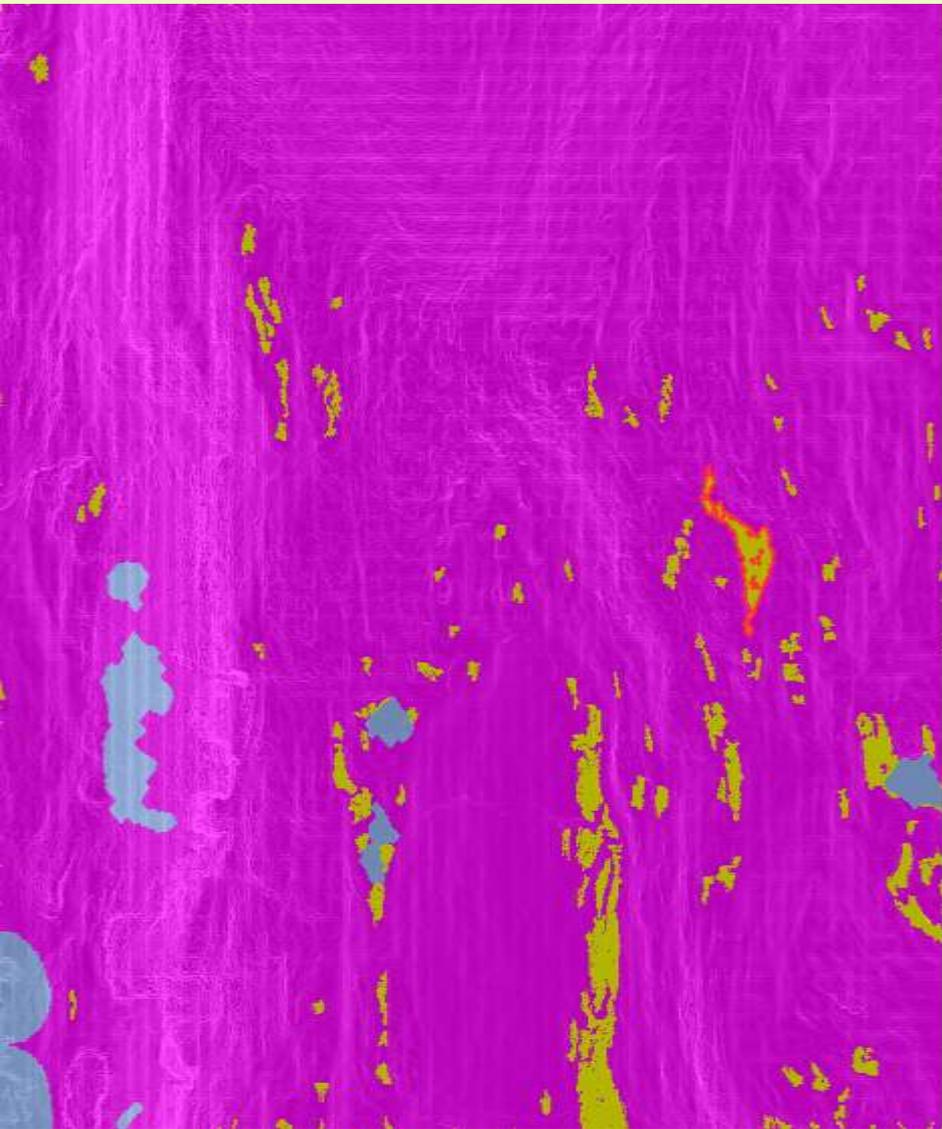


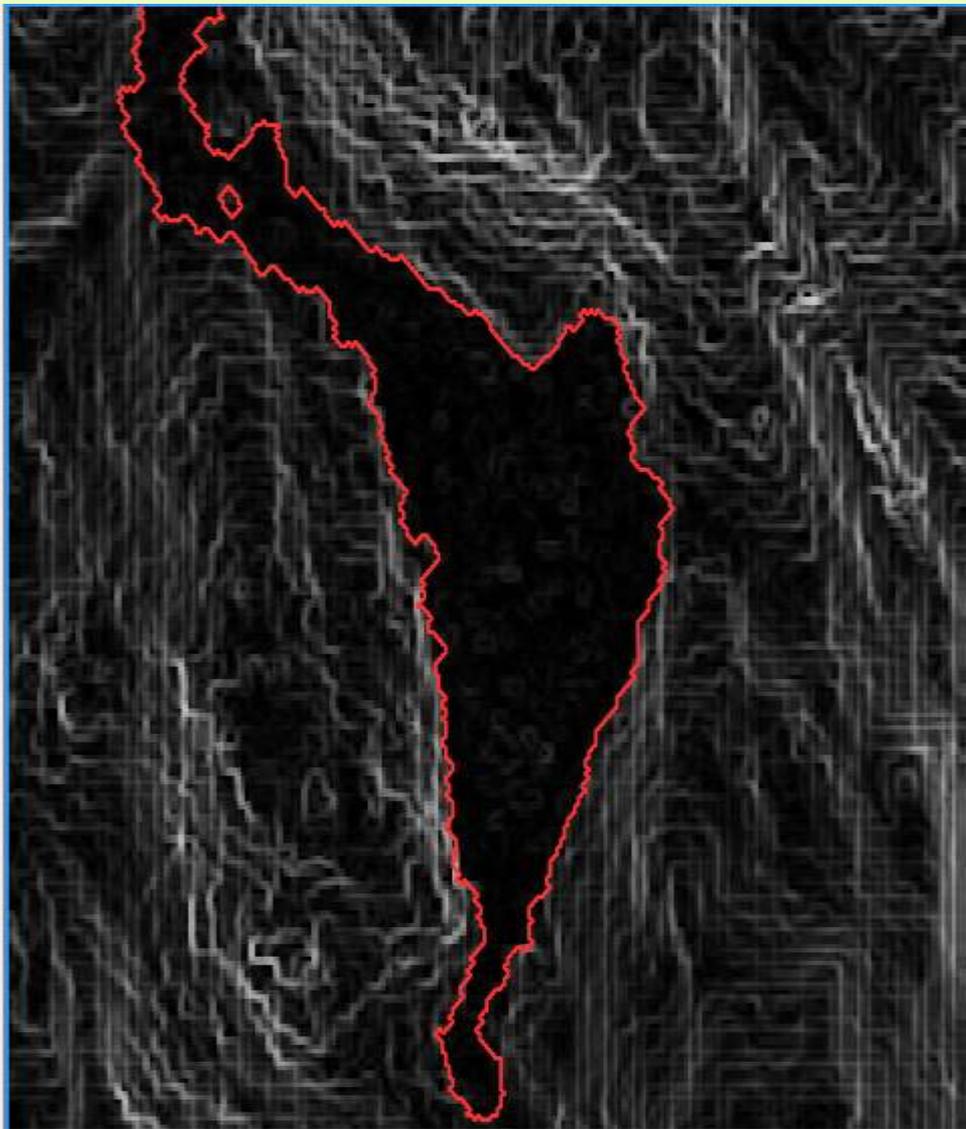
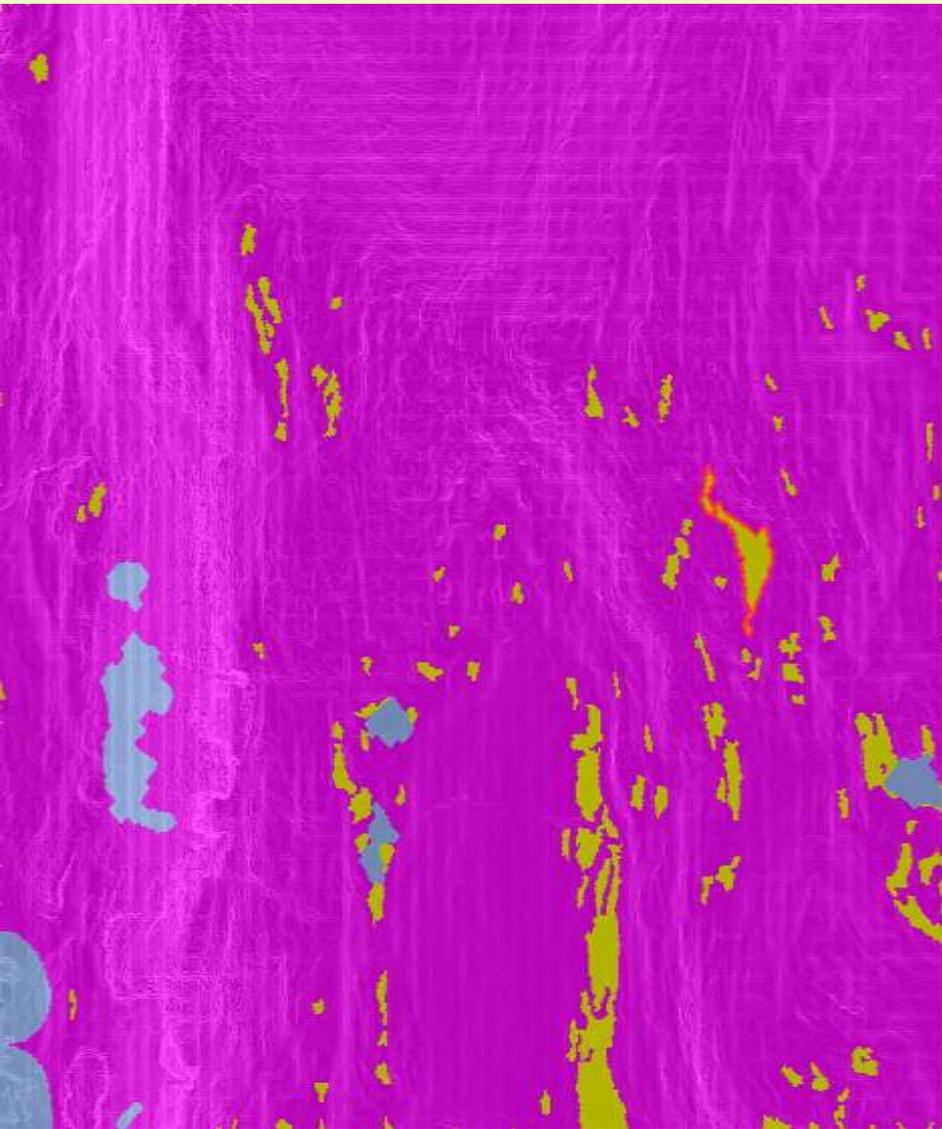
Step 1 – Depression Mapping

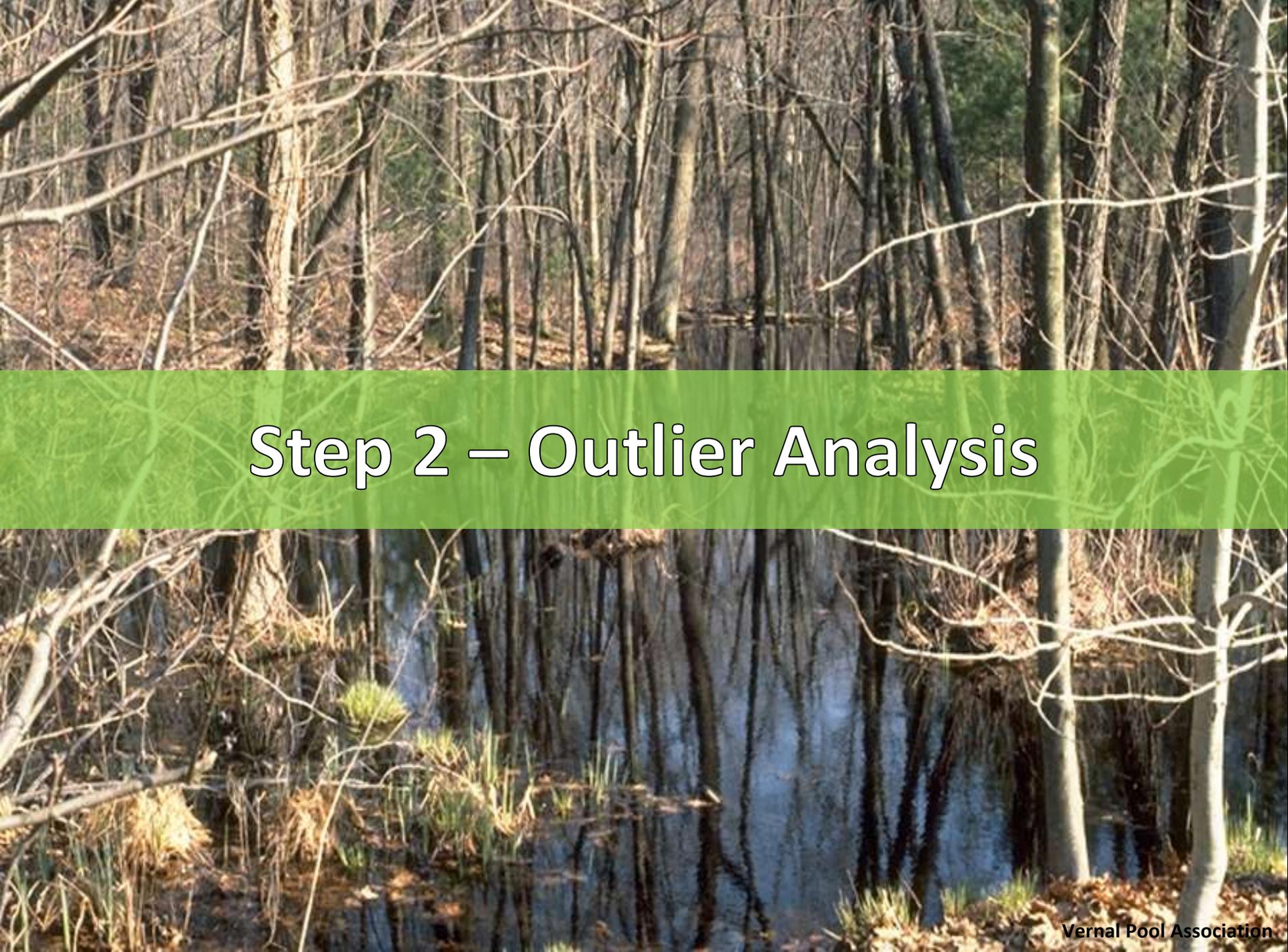




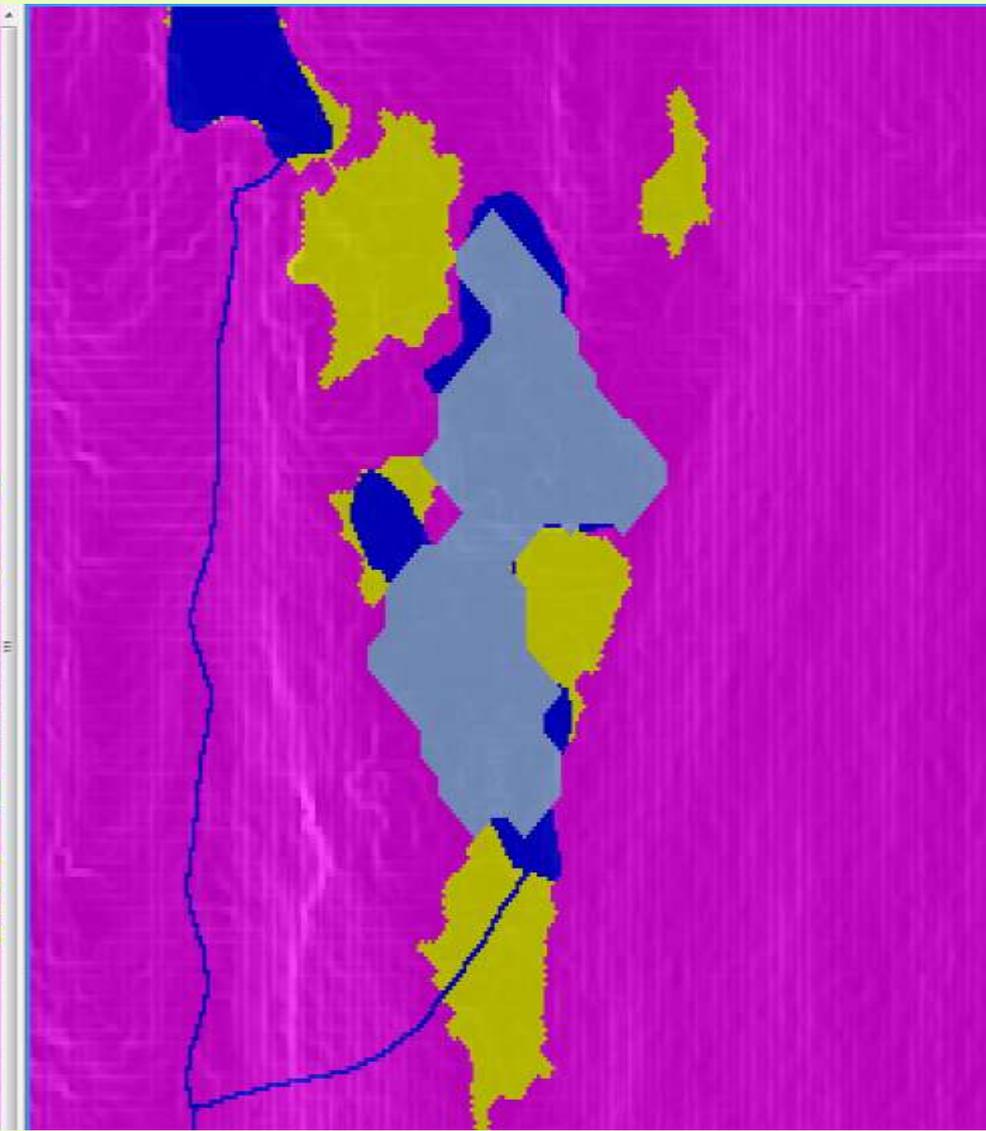


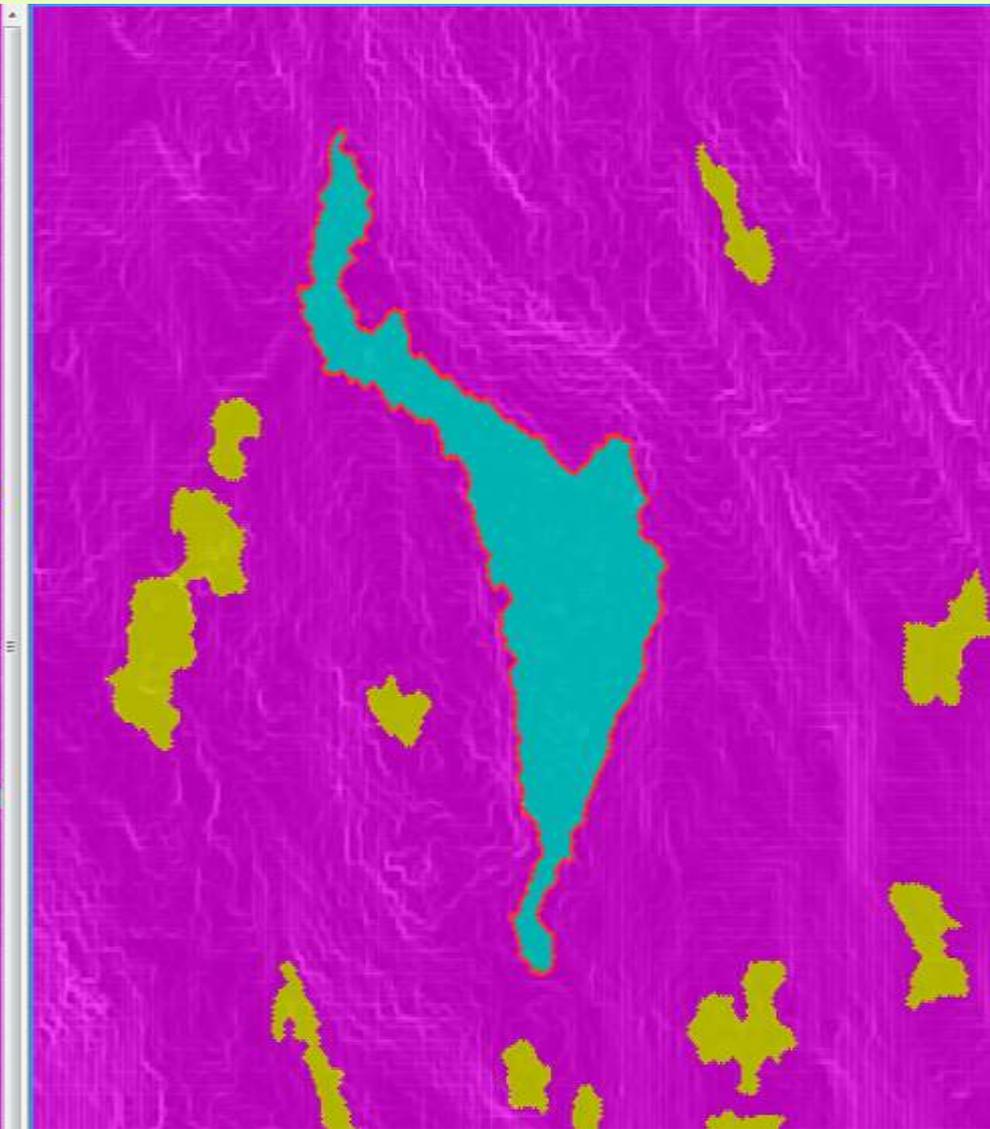
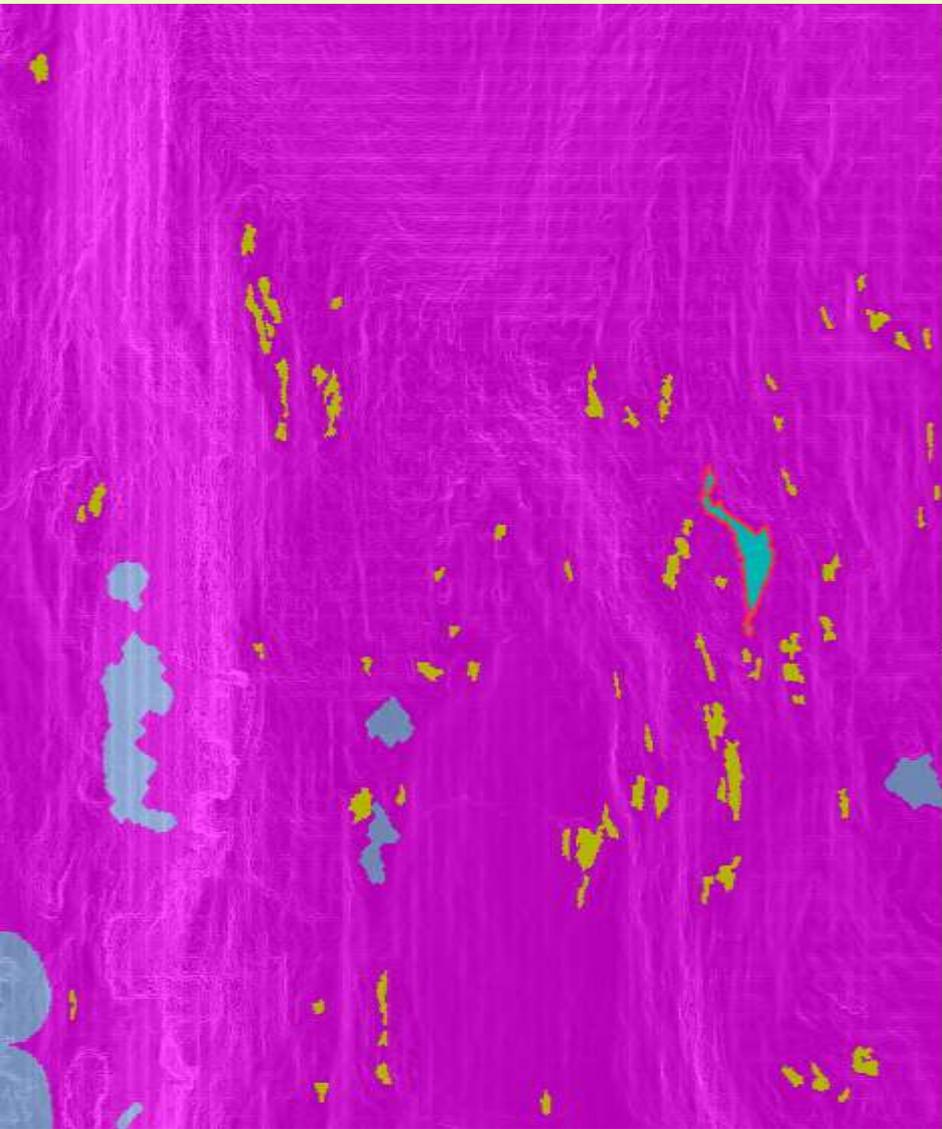


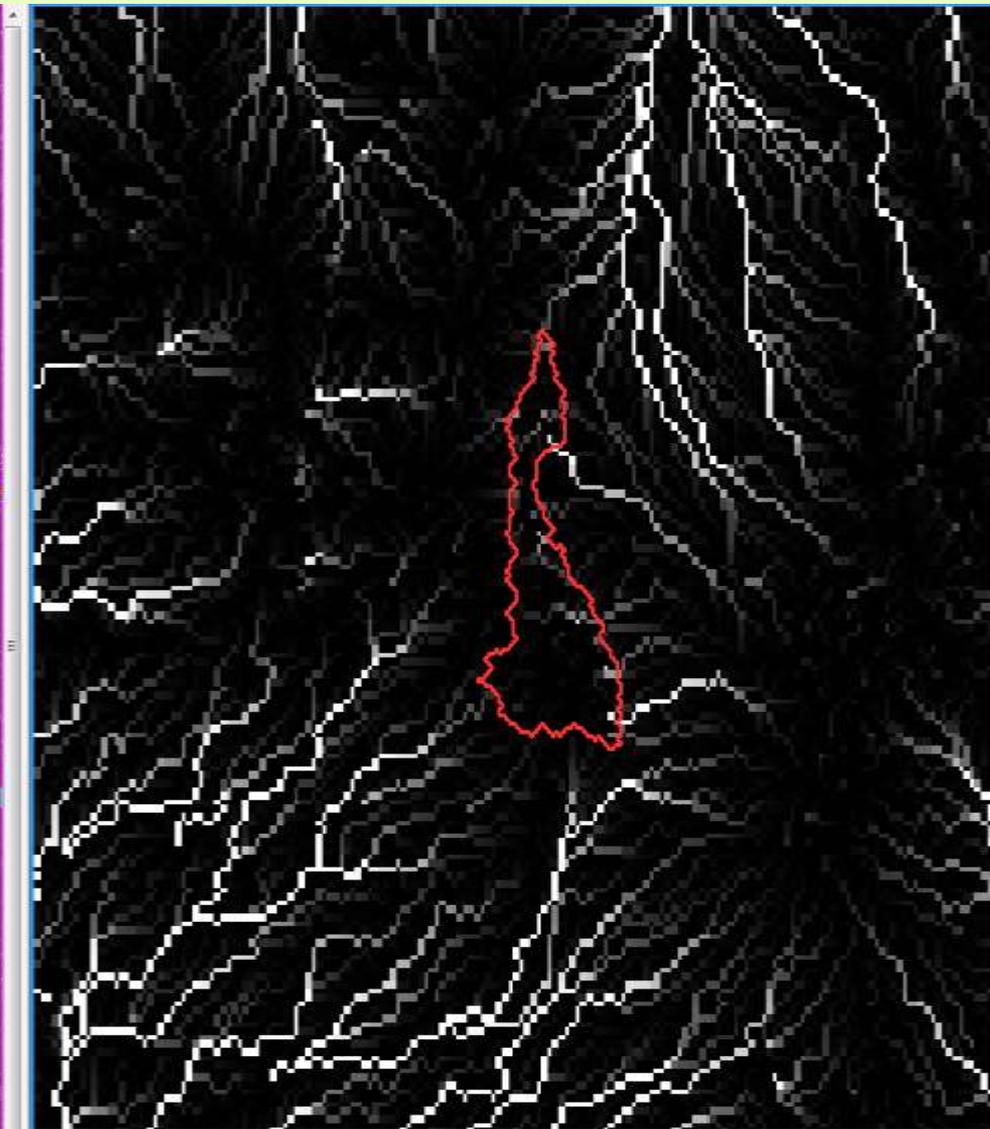
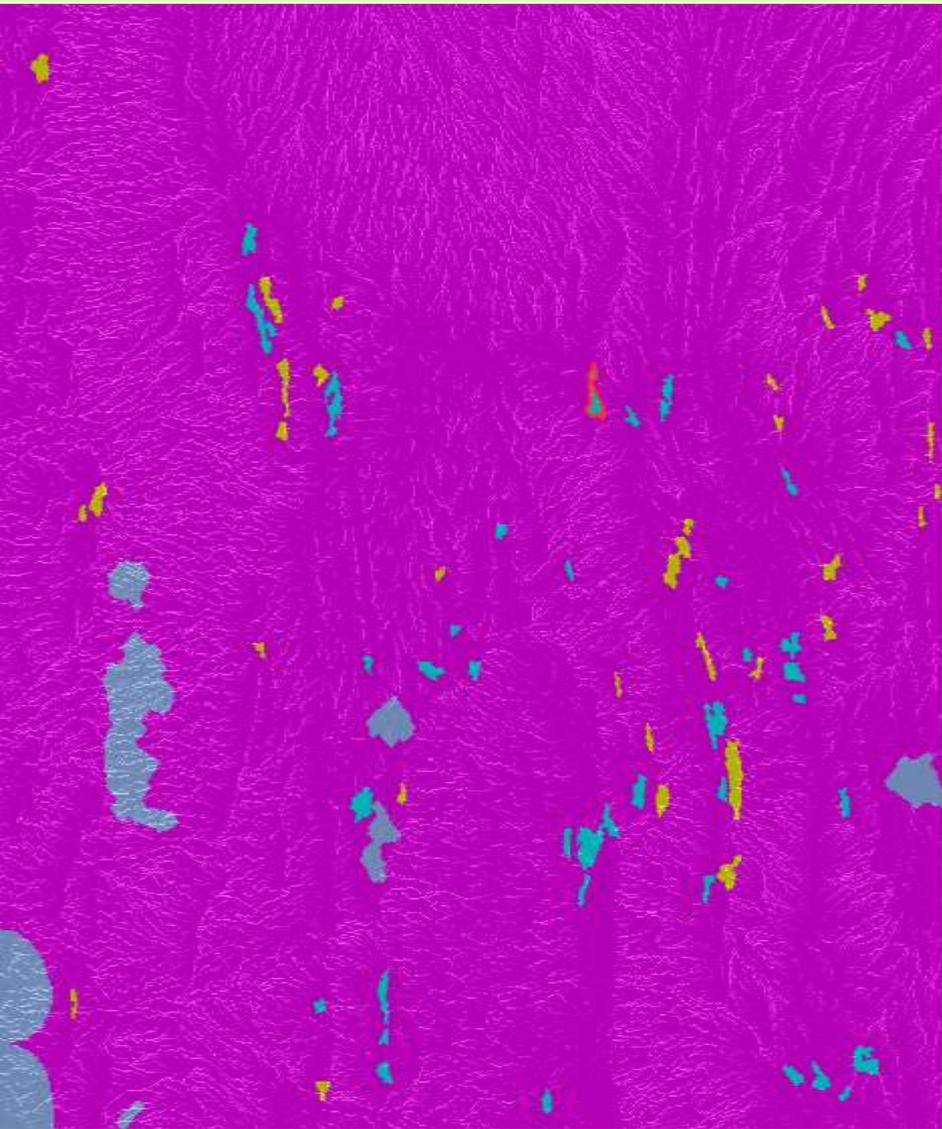


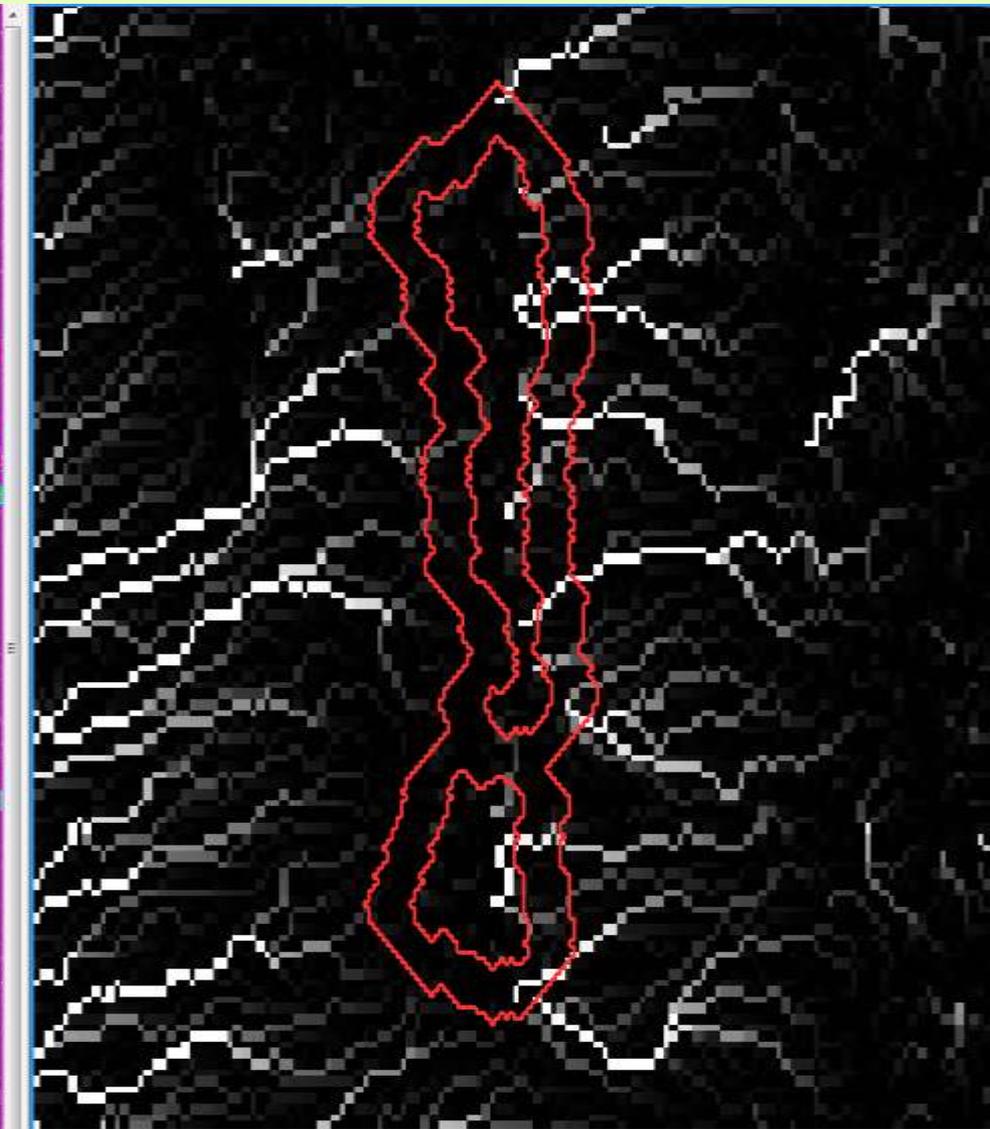
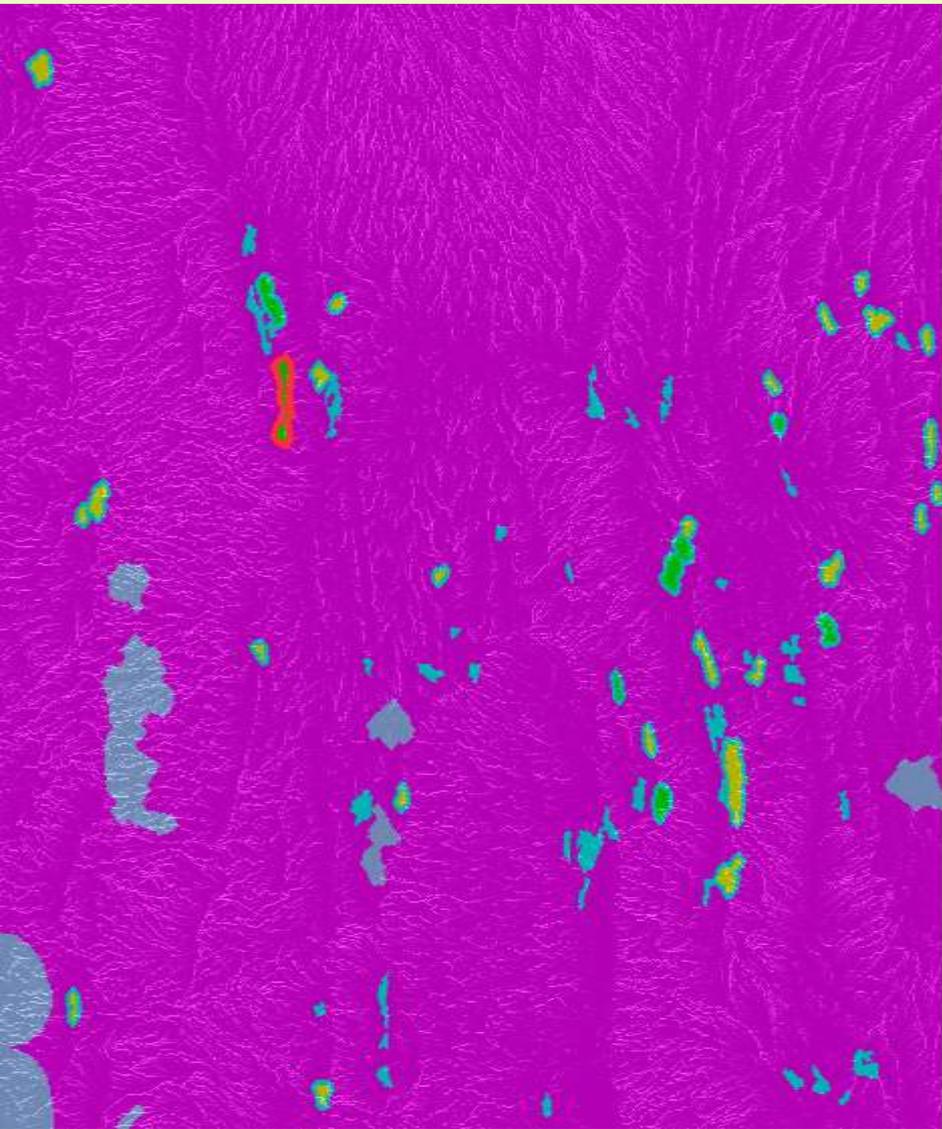


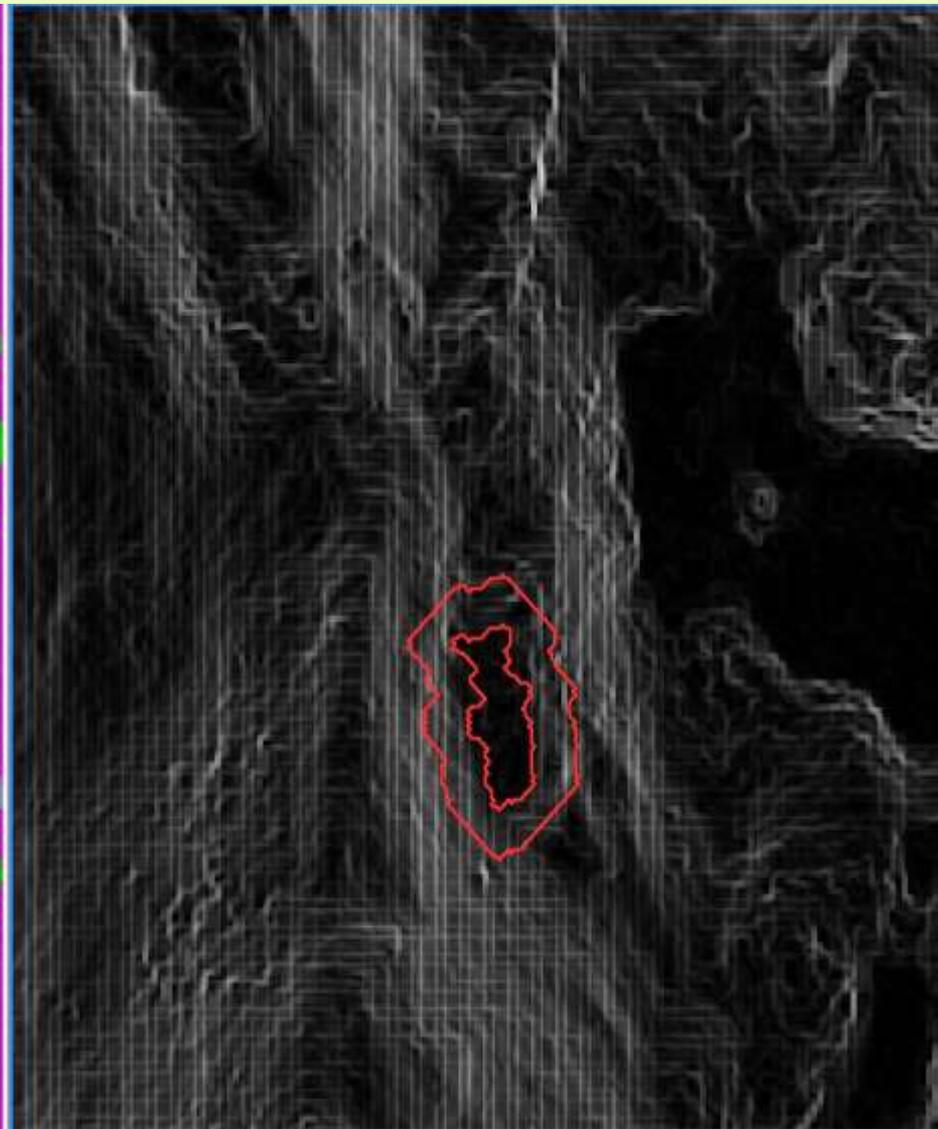
Step 2 – Outlier Analysis





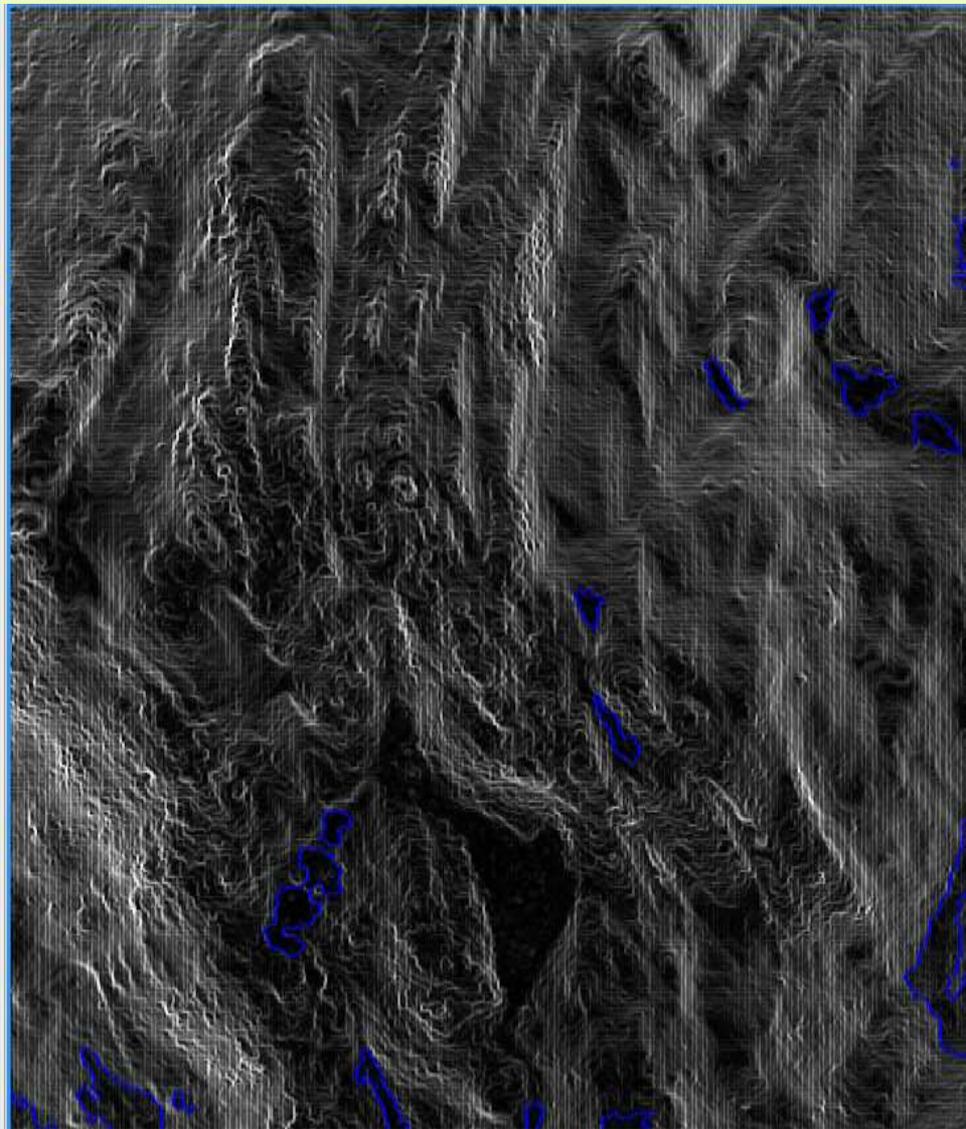
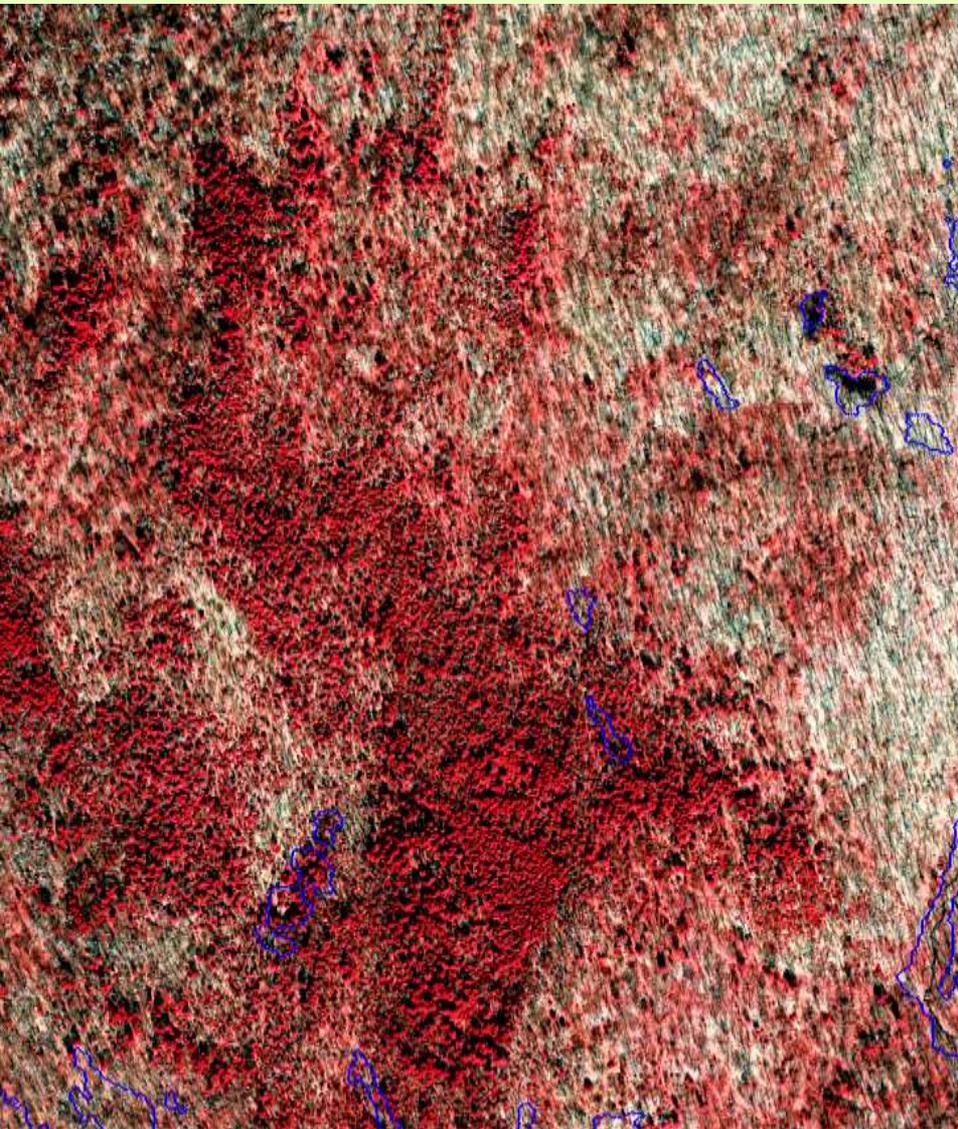


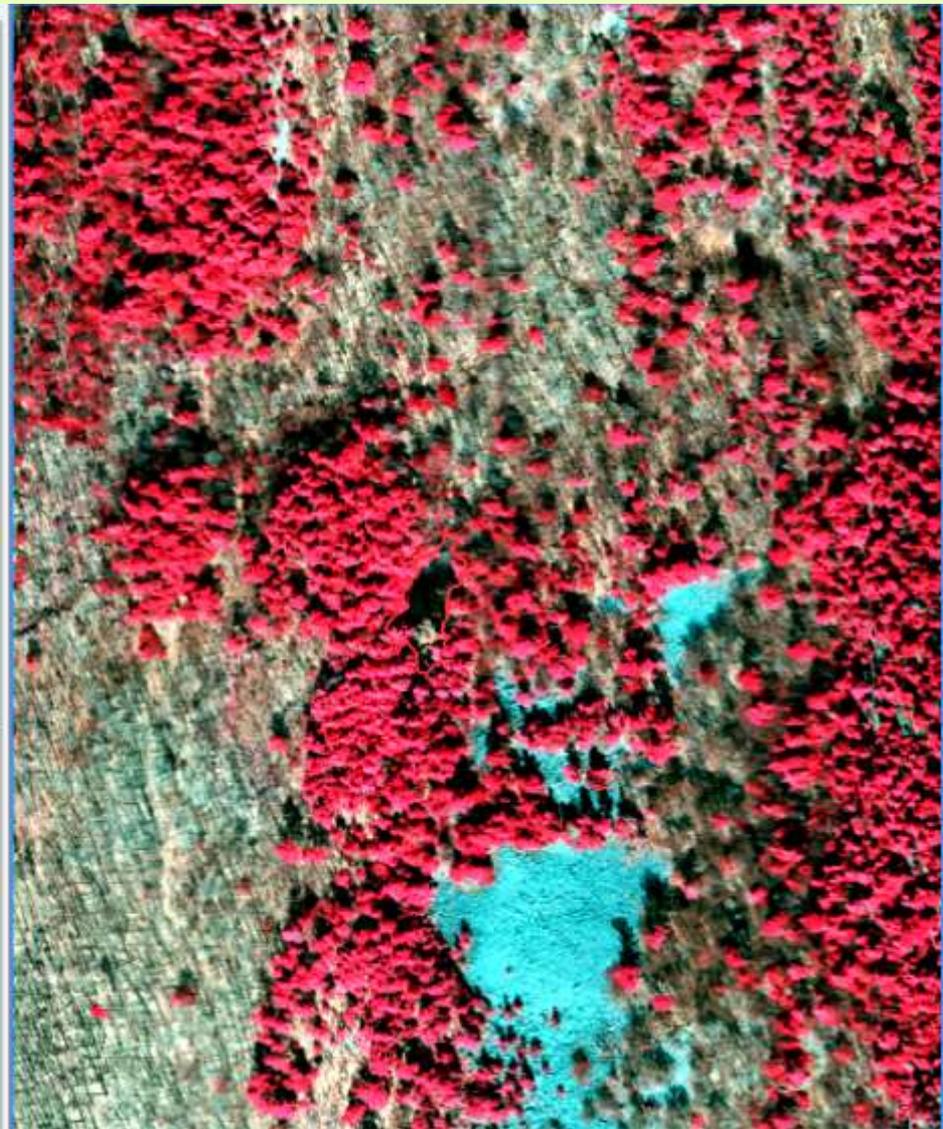




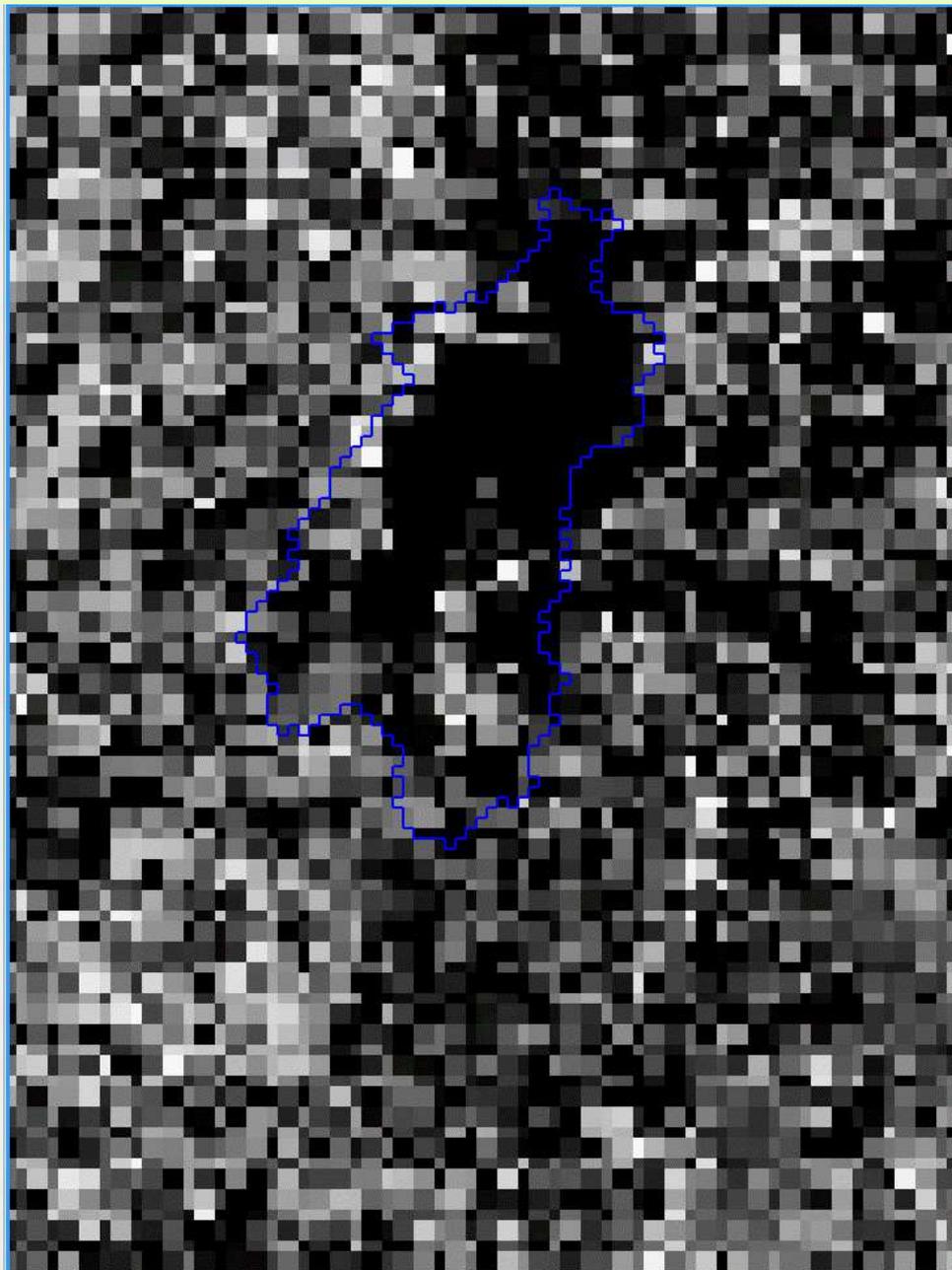
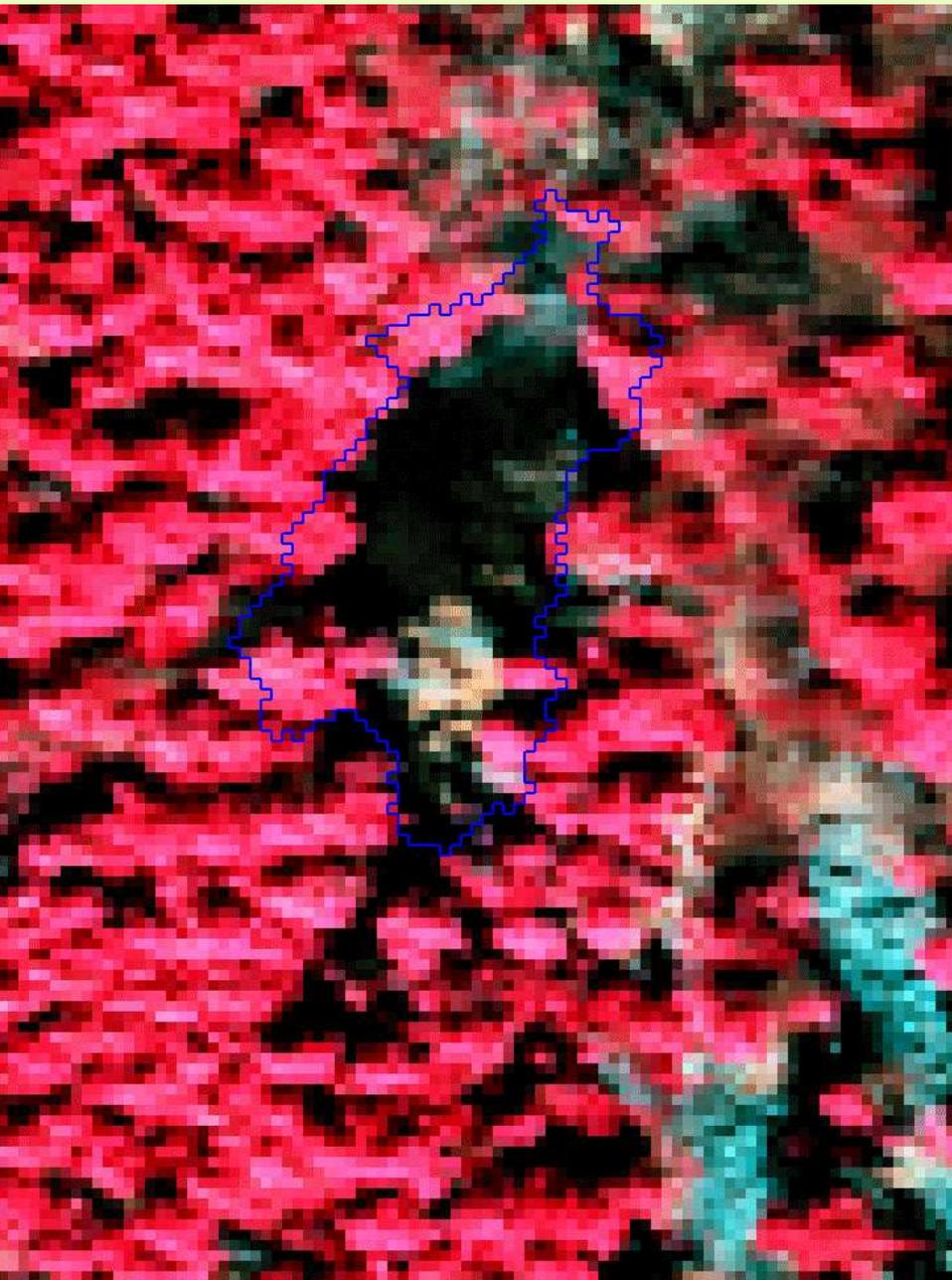
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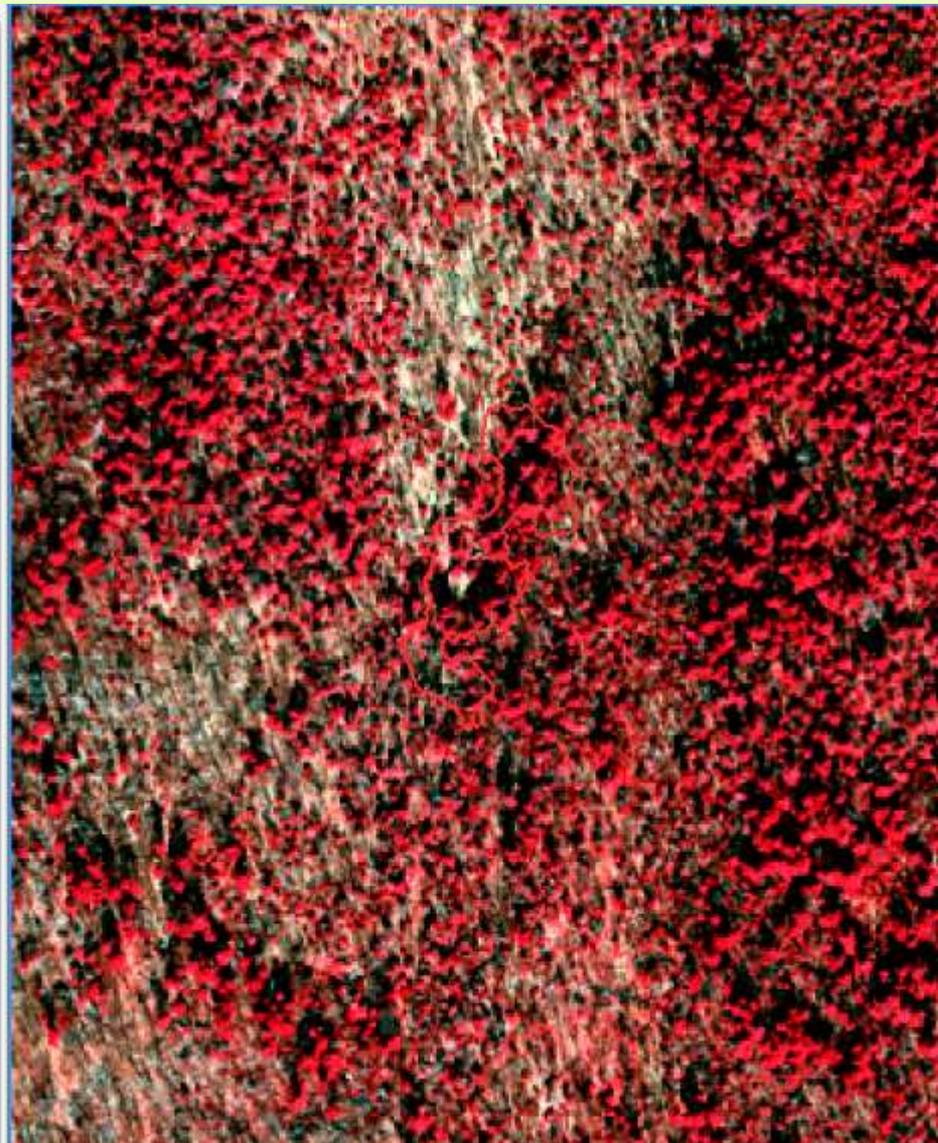
Step 3 – Final Classification











Classification of Depressions

- High Value – Low NIR and low Intensity (or very low Intensity)
- Moderate Value – Low NIR/Intensity combination (or low values of one)
- Low Value – Some evidence of low NIR, clumped, relatively deep

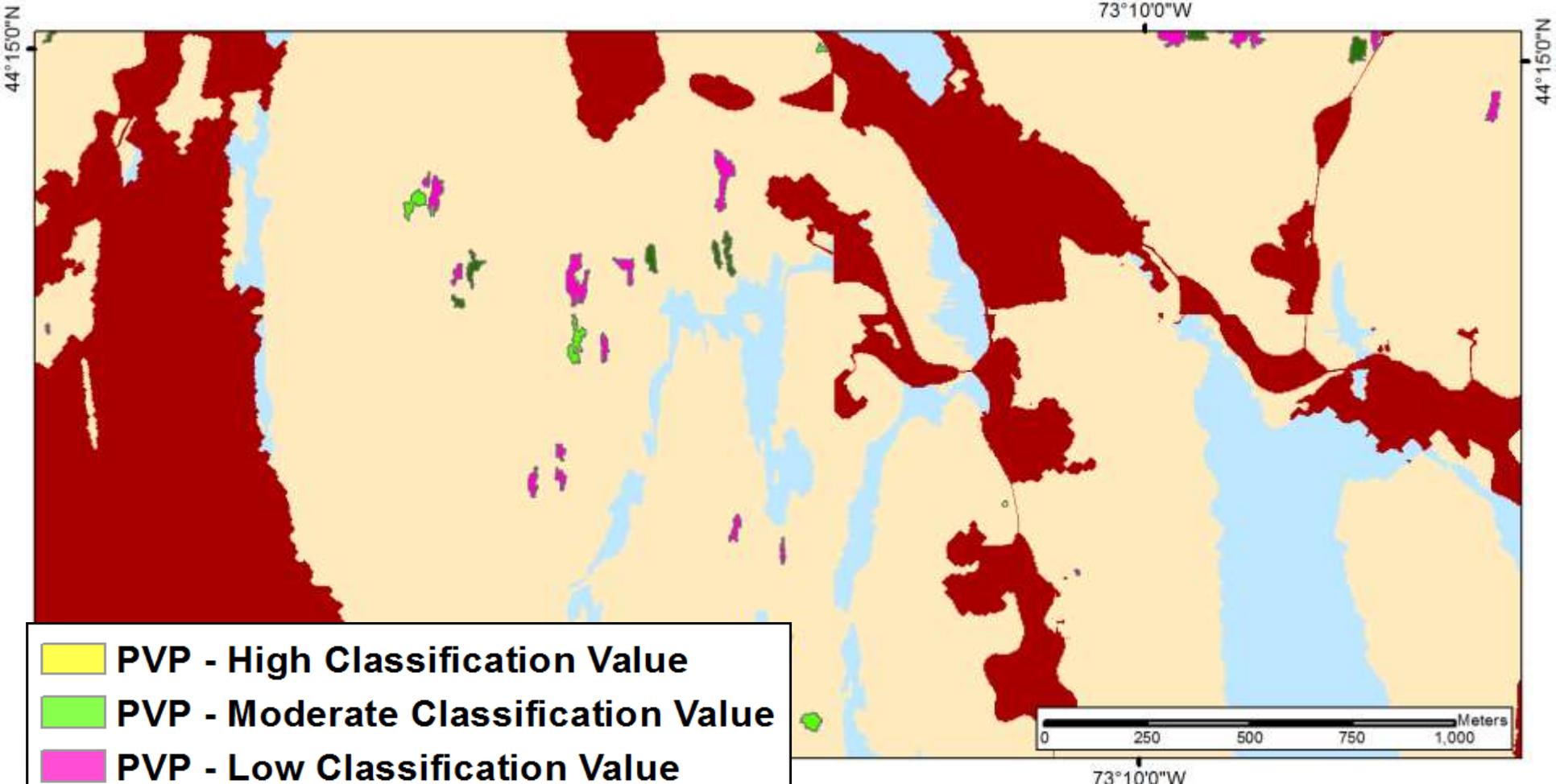
Classification of Depressions

- Obscured by Conifers – Too Little Information to Provide Specific Classification (compare leaf-on vs. leaf-off imagery)



Output





- PVP - High Classification Value**
- PVP - Moderate Classification Value**
- PVP - Low Classification Value**
- PVP - Obscured by Conifers**
- Large Water Bodies**
- Connected Wetlands**
- Non Habitat**
- Other Potential Habitat**

An aerial photograph of a field with a green banner overlaid in the center. The banner contains the text 'Accuracy Assessment'. The field is divided into two sections by the banner. The top section shows several yellow circular markers placed on the ground. The bottom section shows a single yellow circular marker. The field is a mix of green and brown, suggesting different vegetation or soil types.

Accuracy Assessment

2-part Accuracy Assessment

- Compare Modeled Output to Existing Vernal Pools Database
- Evaluate All Other Potential Pools to Reference Imagery

| A. Modeled Potential Pools Relative to Existing Vernal Pools Database, Orthoimagery, and LiDAR Intensity | | | | | | |
|--|---------------------------|-------------------------------|--------------------------|----------------------|----------|-----------|
| Modeled PVPs | | | | | | |
| Reference | High Classification Value | Moderate Classification Value | Low Classification Value | Obscured by Conifers | Omitted | Totals |
| Potential Pool - Evidence | 52 of 85 captured (61%) | | | 0 | 3 | 42 (49%) |
| Potential Pool - Limited Evidence | 0 | 3 | 8 | 2 | 2 | 15 (18%) |
| Not Pool - Agriculture | 0 | 0 | 0 | 0 | 0 | 0 |
| Not Pool - Developed | 0 | 52 of 57 captured (91%) | | | 0 | 0 |
| Not Pool - Upland | 0 | | | | | 0 (24%) |
| Not Pool - Water Body | 0 | 0 | 0 | 0 | 8 | 8 (9%) |
| Not Pool - Wetland | 0 | 0 | 0 | 0 | 0 | 0 |
| Totals | 19 (22%) | 16 (19%) | 15 (18%) | 2 (2%) | 33 (39%) | 85 (100%) |

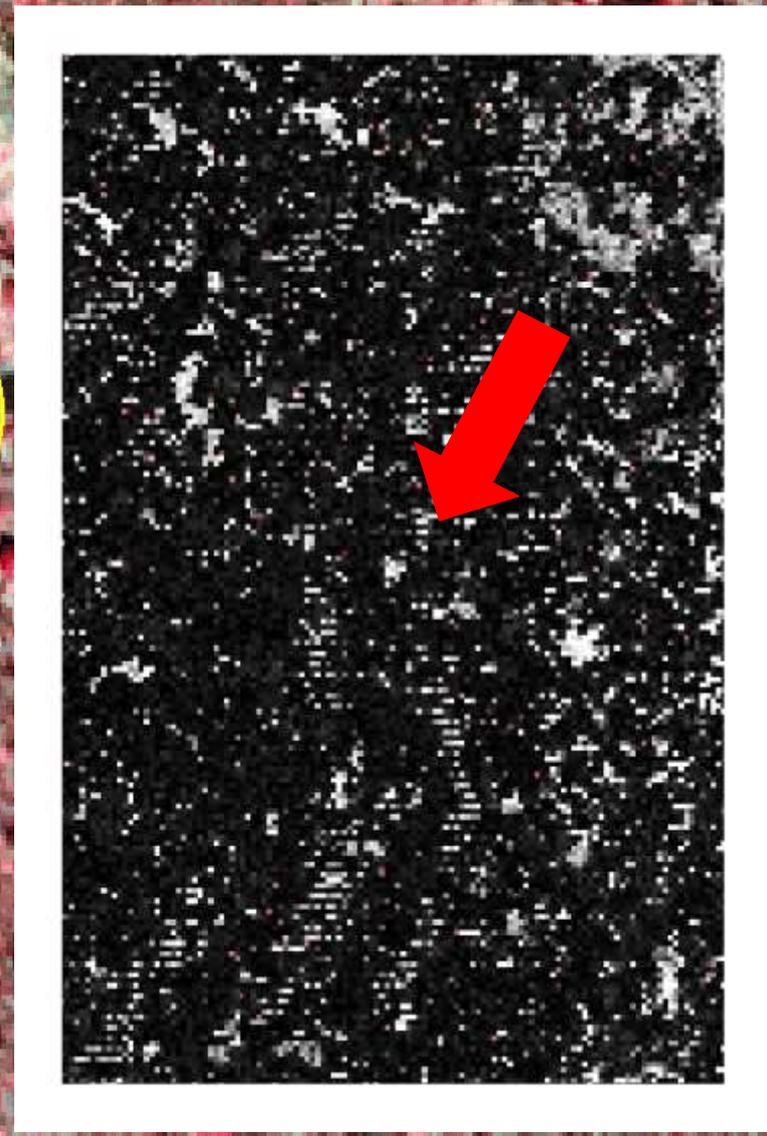
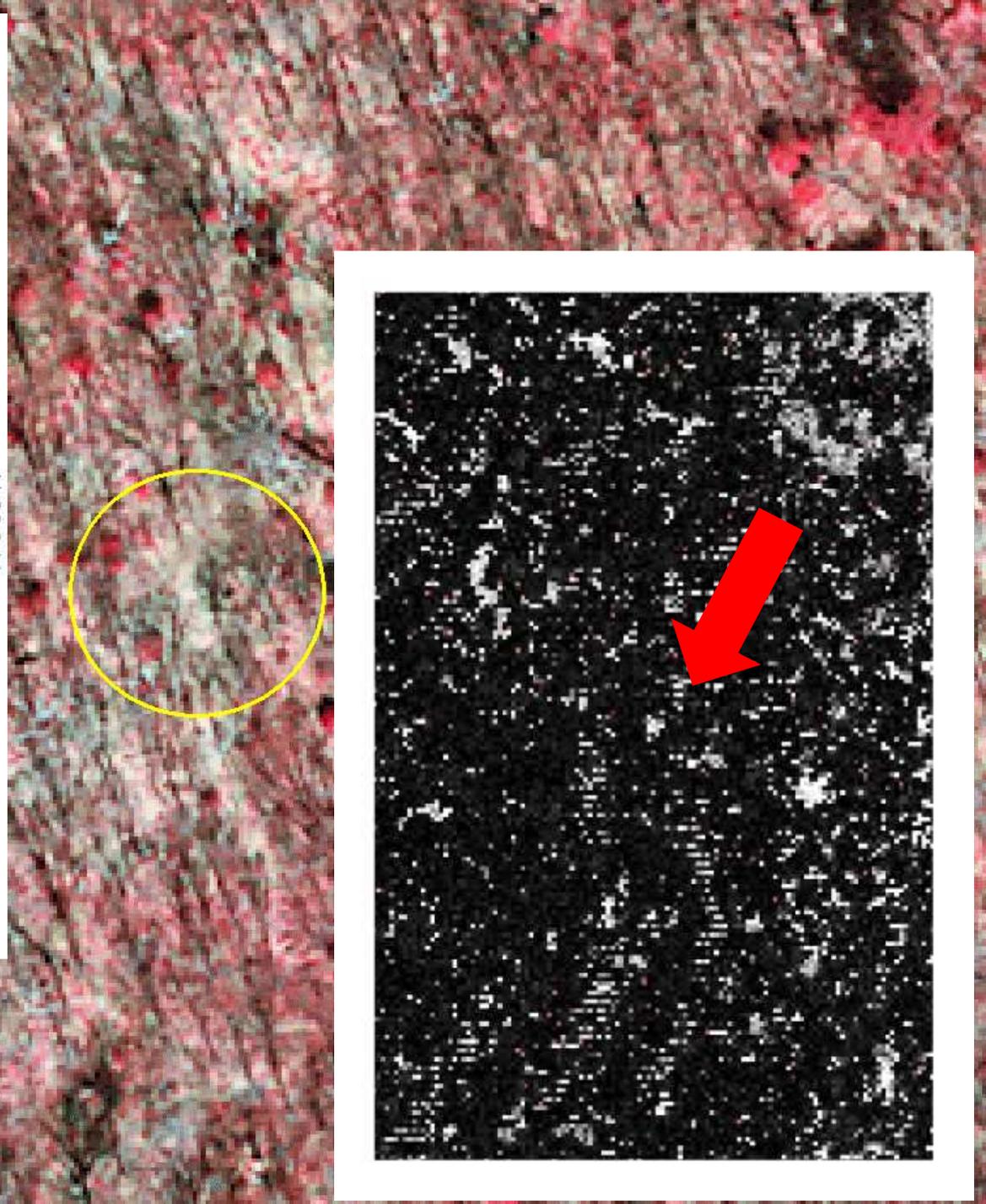
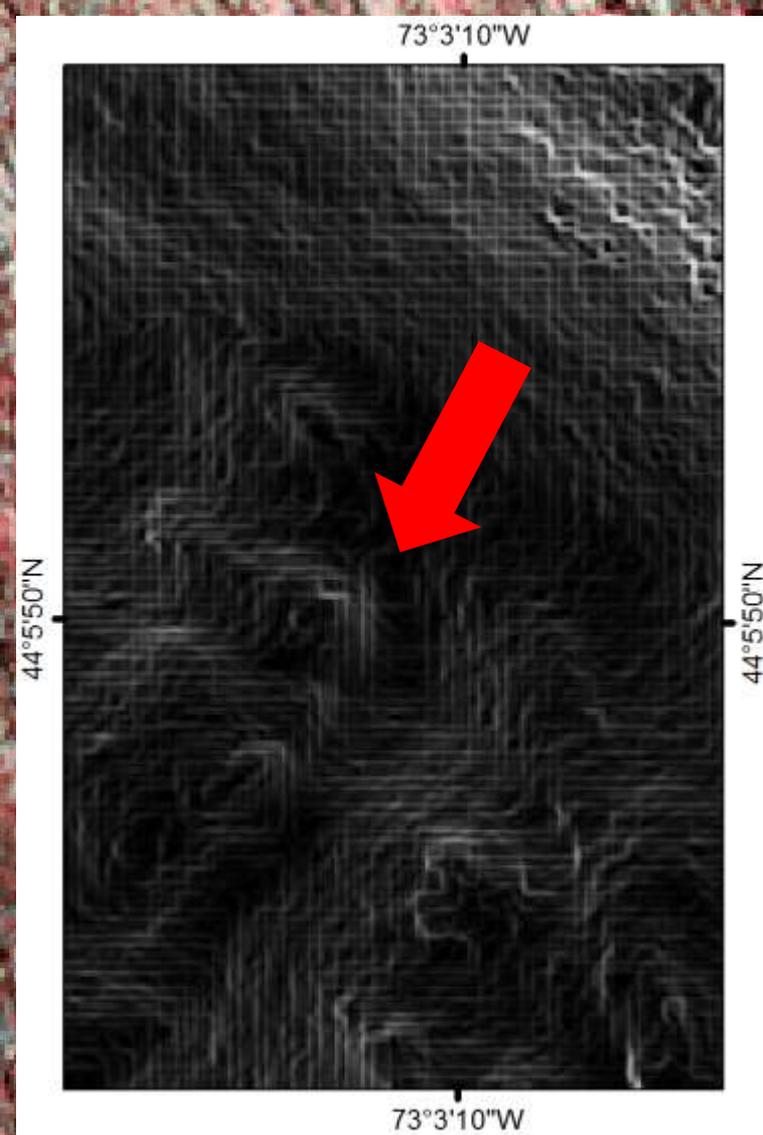
B. All Remaining Modeled Potential Pools Relative to Orthoimagery and LiDAR Intensity

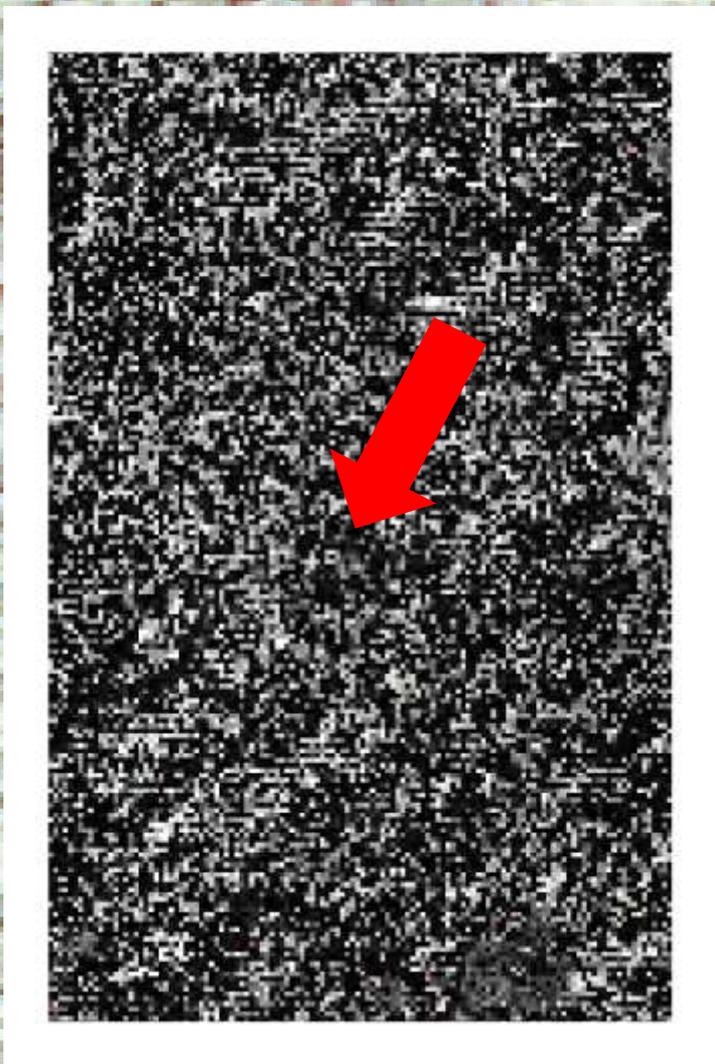
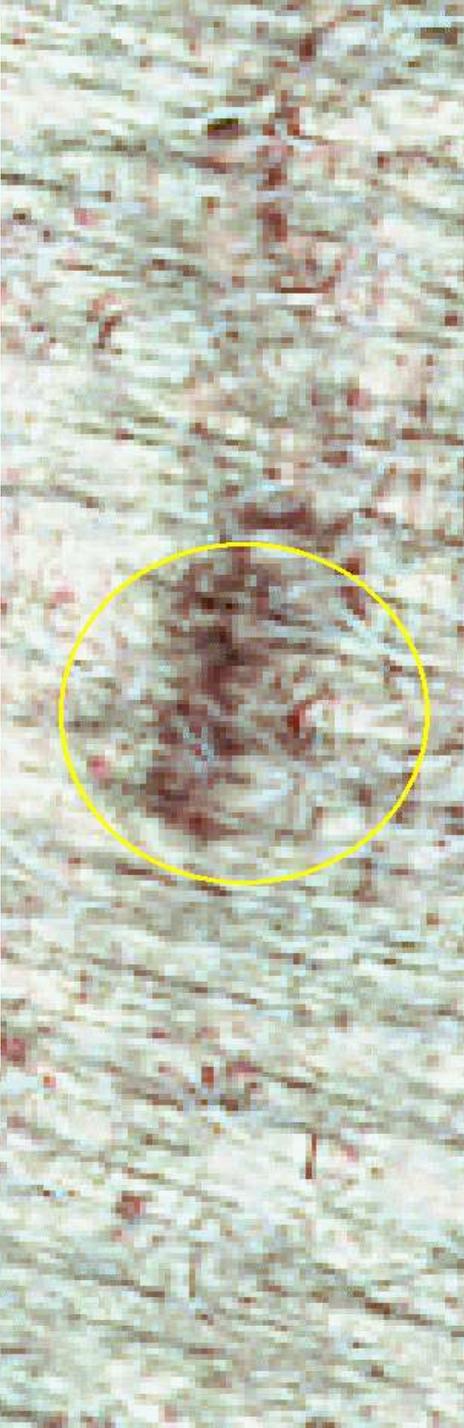
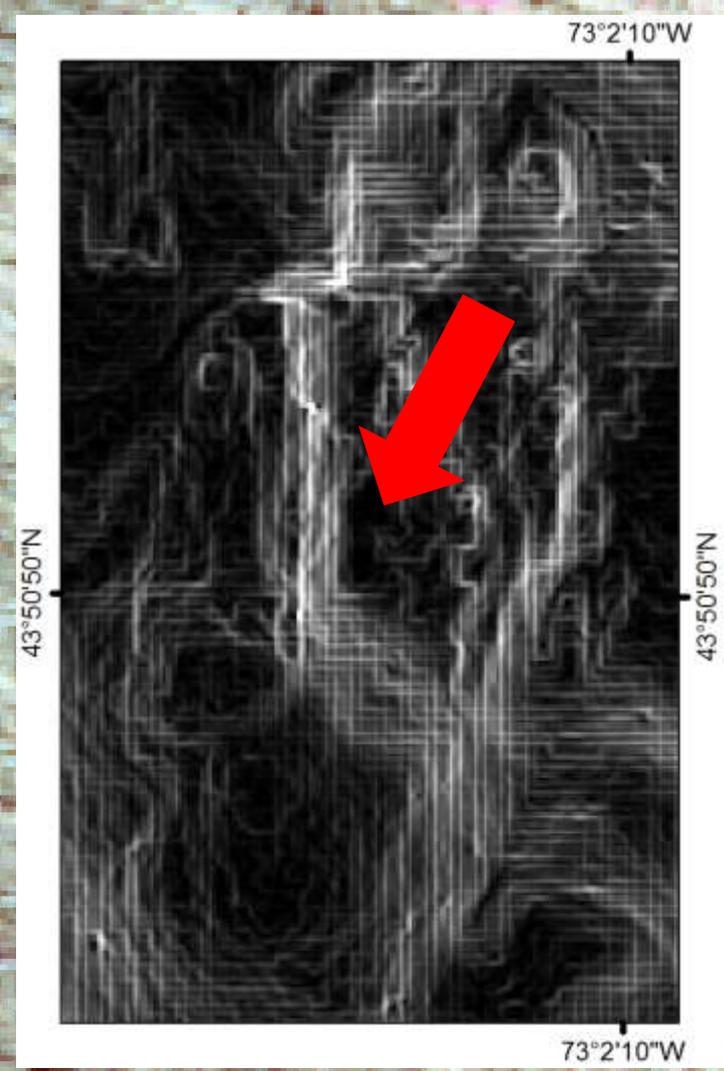
Modeled PVPs

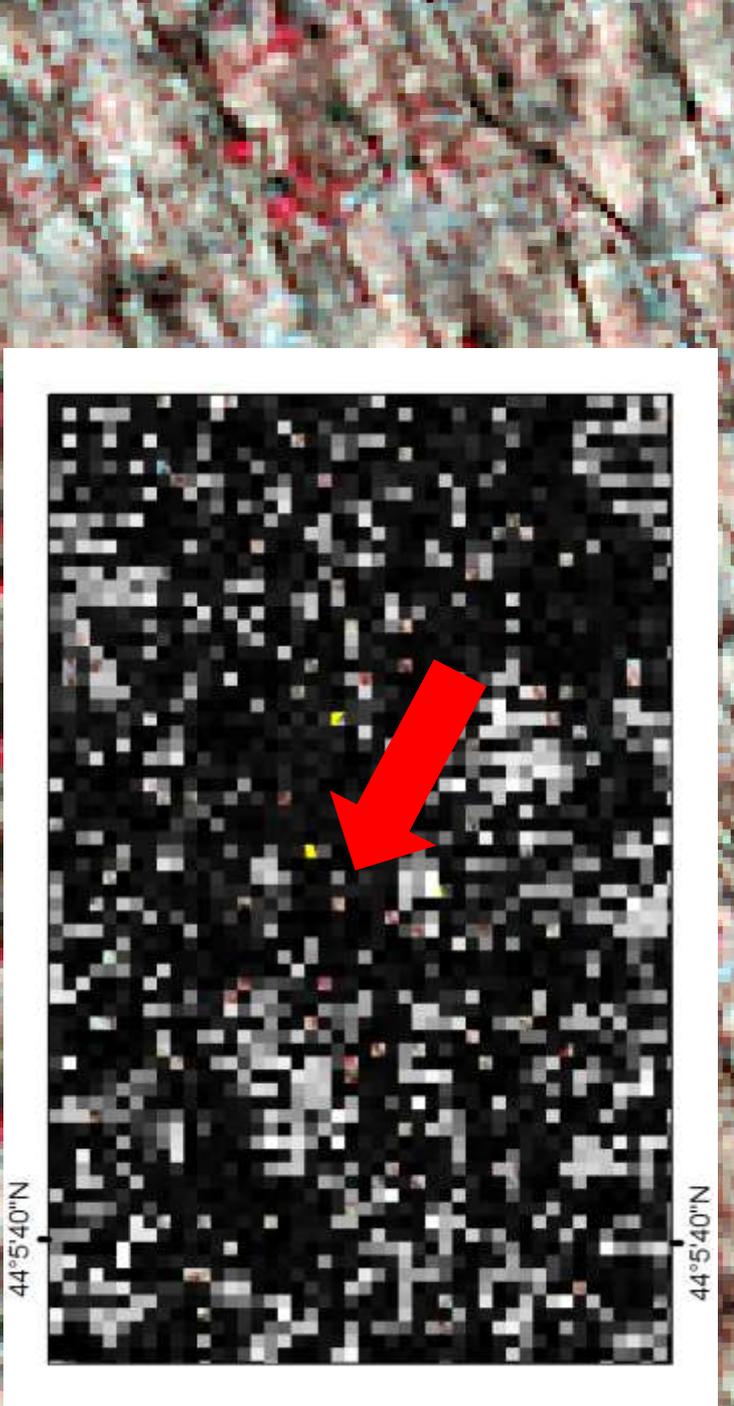
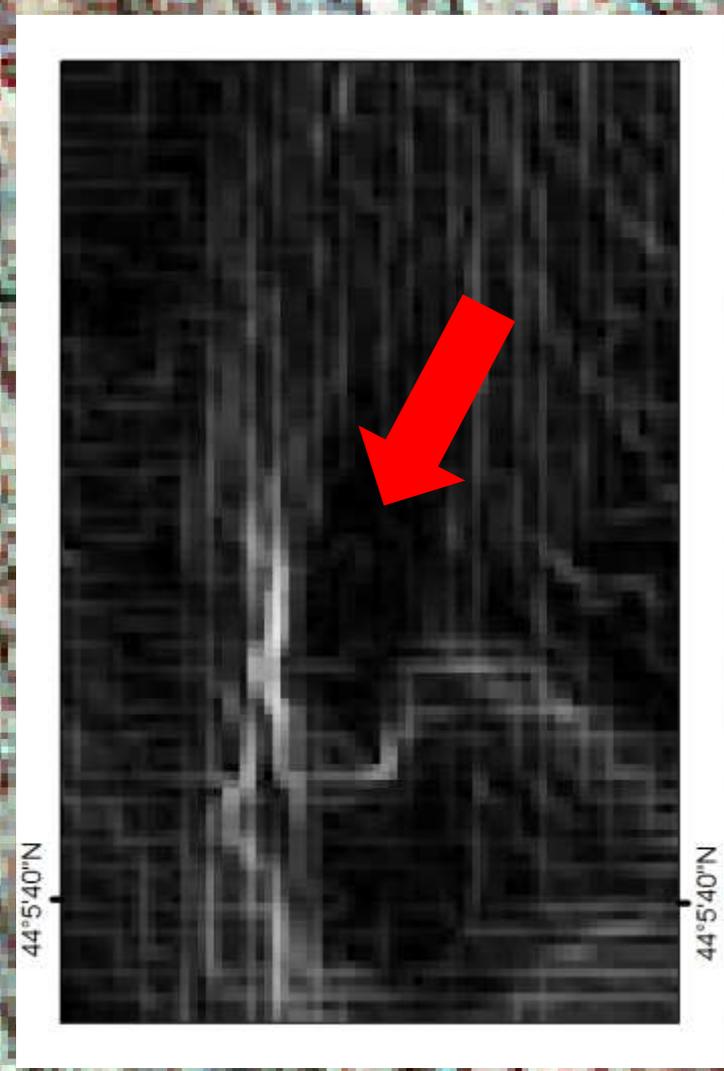
| Reference | High Classification Value | Moderate Classification Value | Low Classification Value | Obscured by Conifers | Totals | |
|-----------------------------------|-----------------------------------|-------------------------------|--------------------------|----------------------|-----------|--|
| Potential Pool – Strong Evidence | 33% with Evidence of Water | | | | | |
| Potential Pool – Limited Evidence | 61 | 248 | 313 | 71 | 693 (29%) | |
| Not Pool – Agriculture | 0 | 2 | 1 | 1 | 4 (<1%) | |
| Not Pool - Developed | 23 | 40 | 26 | 4 | 93 (4%) | |

Streamline: 40% with Evidence of Water

| | | | | | | |
|-----------------------|-----------|-----------|-------------|-----------|--------------|--|
| Not Pool – Water Body | 81 | 27 | 2 | 0 | 110 (5%) | |
| Not Pool - Wetland | 46 | 81 | 91 | 24 | 242 (10%) | |
| Totals | 297 (12%) | 643 (27%) | 1,062 (45%) | 381 (16%) | 2,383 (100%) | |







Modeling Summary

- LiDAR-derived DEM Essential to Identification of Depressions
- Classification: LiDAR Intensity and Leaf-off Imagery Best Combination
- Current Model Errs Toward Over-prediction

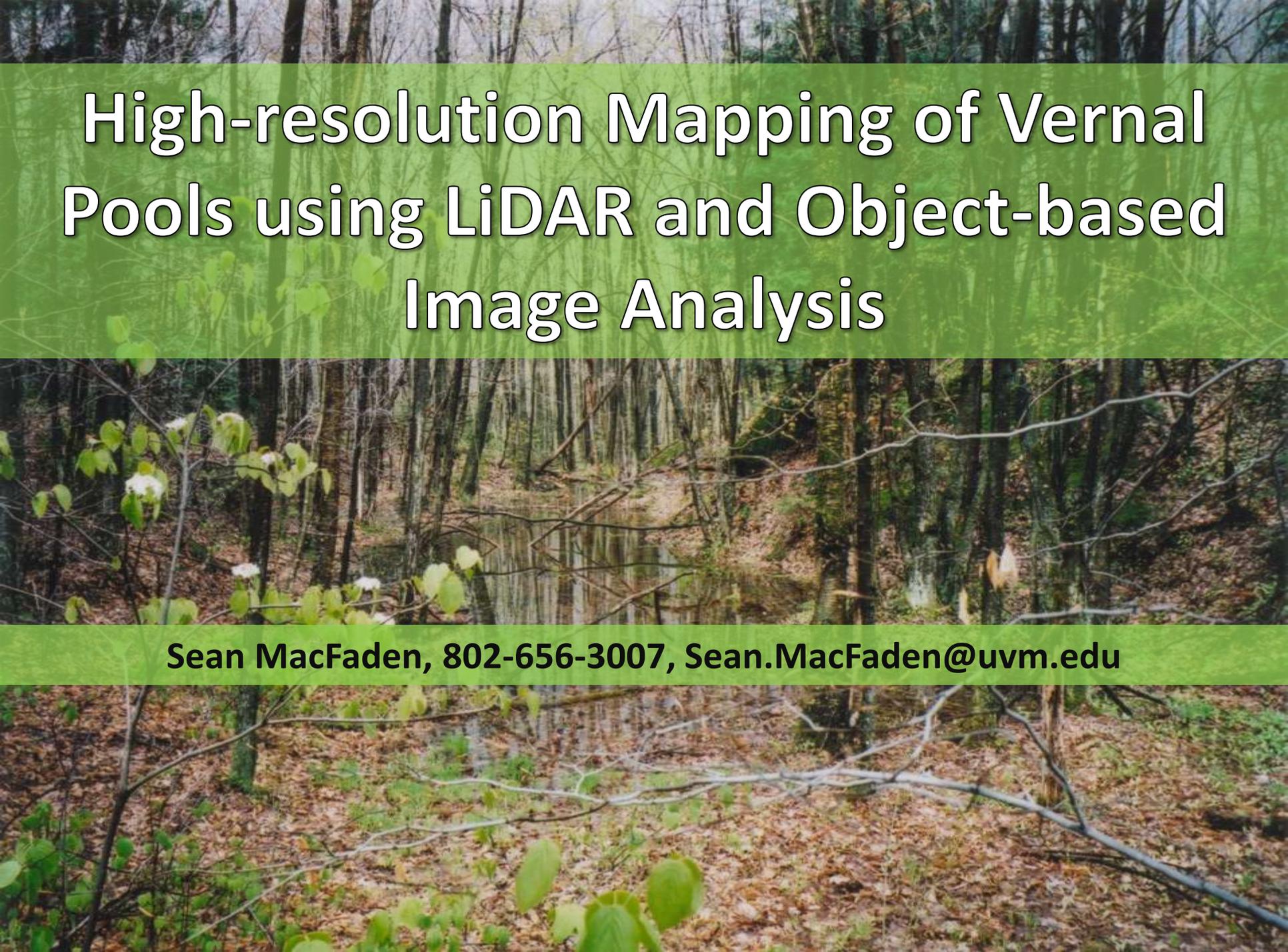
Possible Refinements

- Strengthen Classification Criteria for Evidence of Water
- Incorporate Pool Depth into High and Moderate Classes
- Calibrate Model in Study Areas with Larger Number of Known Pools

Products

- ✓ Template Rule Sets Can Now be Adapted for Other Parts of Region

- ✓ Export GIS-ready Data that Direct\Inform Field Validation

A photograph of a forest stream with a green overlay at the top containing the title text. The stream is surrounded by trees and fallen leaves, and the water reflects the surrounding environment. The green overlay at the top contains the title text in white with a black outline.

High-resolution Mapping of Vernal Pools using LiDAR and Object-based Image Analysis

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