



**Creating a “Bare-Earth” Digital Terrain Model
From Pixel-Correlated Elevation Data**

Carey Gibson
Mapping and Geomatics Services
Ministry of Natural Resources and Forestry
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Outline

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Objectives

- “Modernize” the Provincial Digital Elevation Model (DEM) for Southern Ontario
 - bare-earth product
 - newer
 - more consistent
 - better resolution and accuracy
 - better quality
- Make use of good quality pixel-correlated elevation data from existing imagery projects

Ontario, Canada

Landmass:

- 1,076,000 sq. km
- 416,000 sq. miles
- 266,000,000 acres
- “2 ½ Californias”



Ontario

“Far North”



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Boreal Forest



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Southern Ontario
(mixed landcover
with urban)



Ontario

“Far North” →

- SRTM elevation

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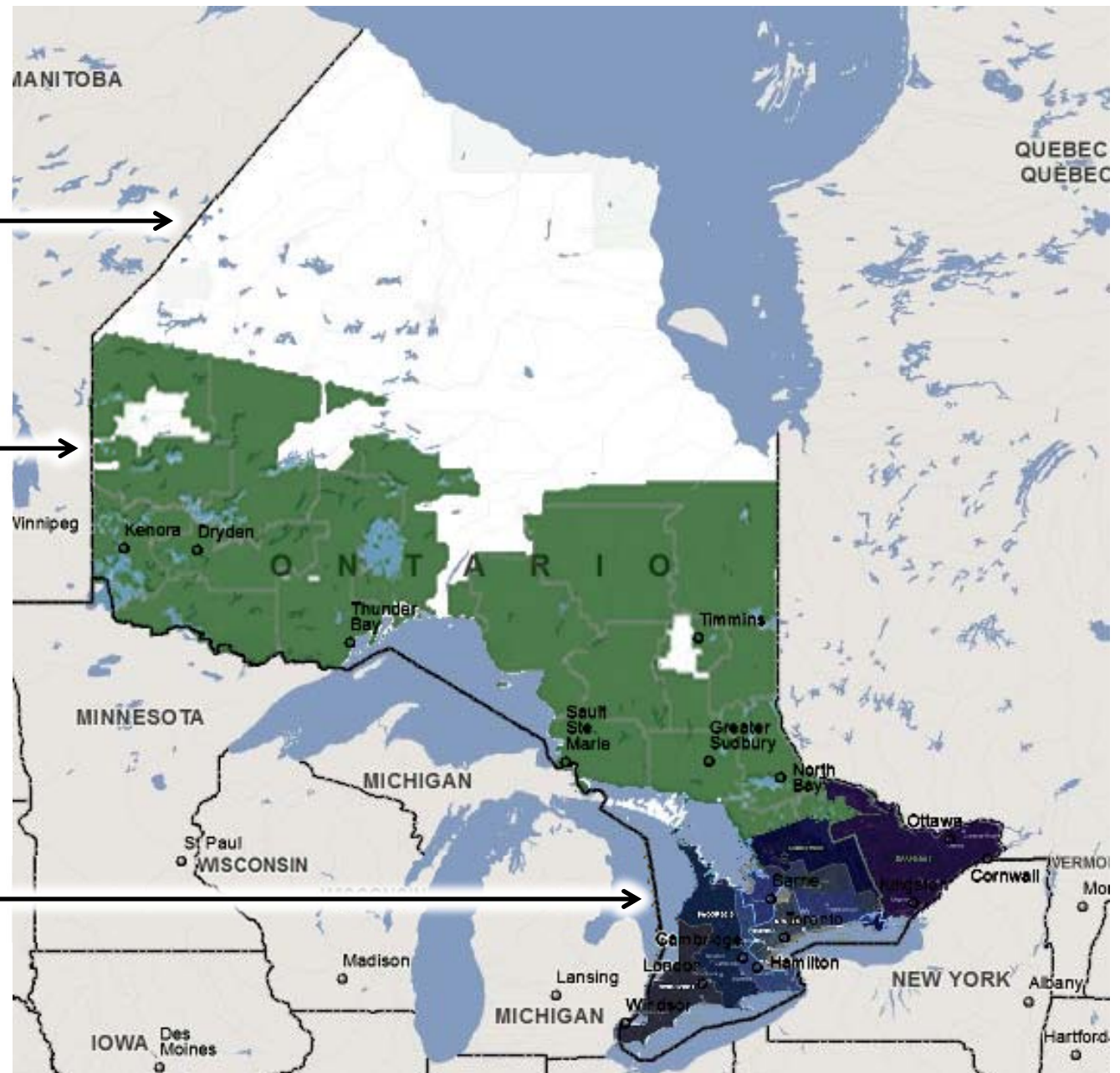
Boreal Forest →

- Forest Resource
Inventory products

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Southern Ontario
(mixed landcover
with urban) →

- stereo imagery



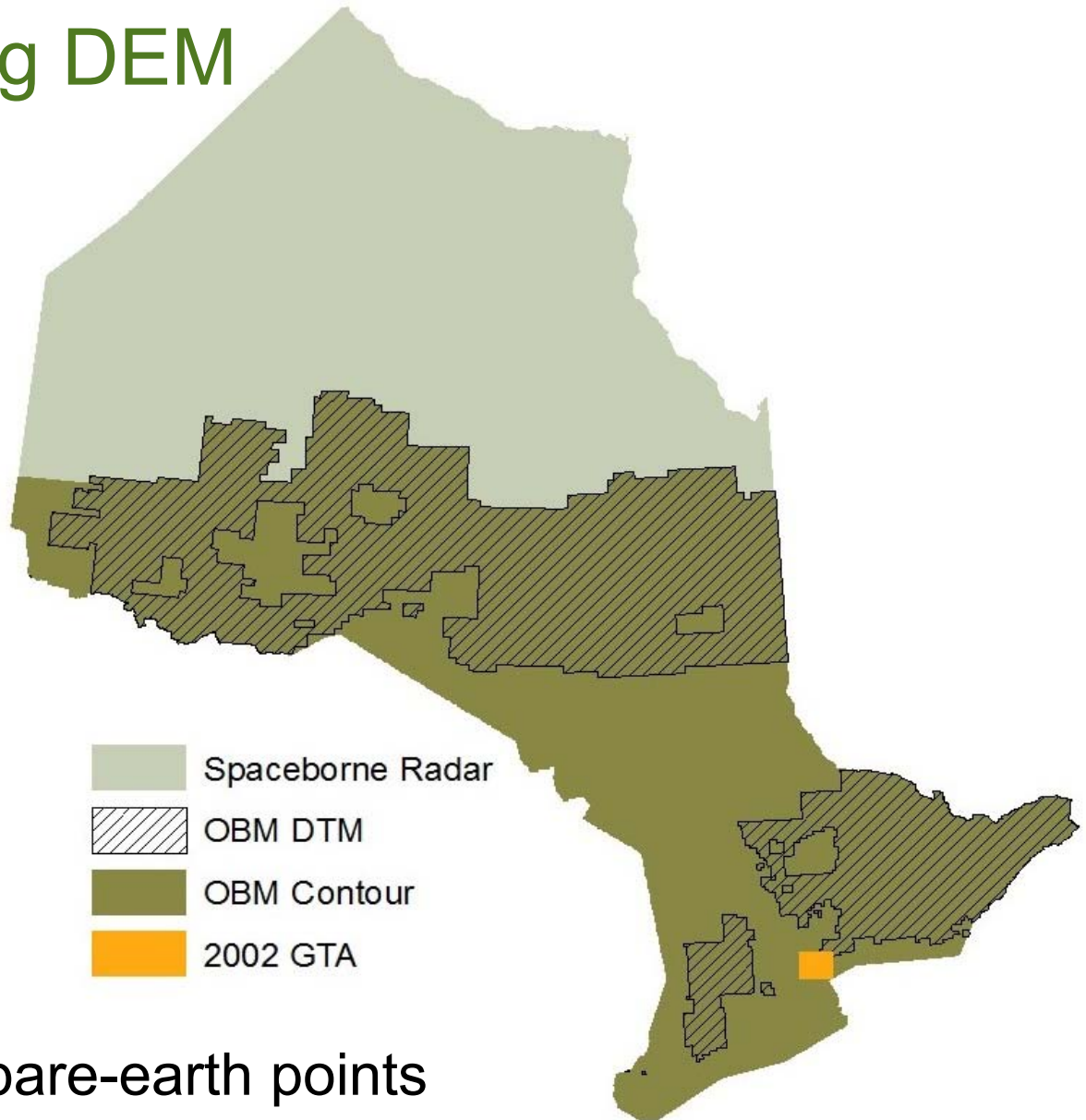
Ontario's Existing DEM

SRTM (Shuttle Radar Topography Mission)
in Far North

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Ontario Base Map
program in south

- 1979-1998
- photogrammetry
- mixture of ground contours and manually digitized bare-earth points

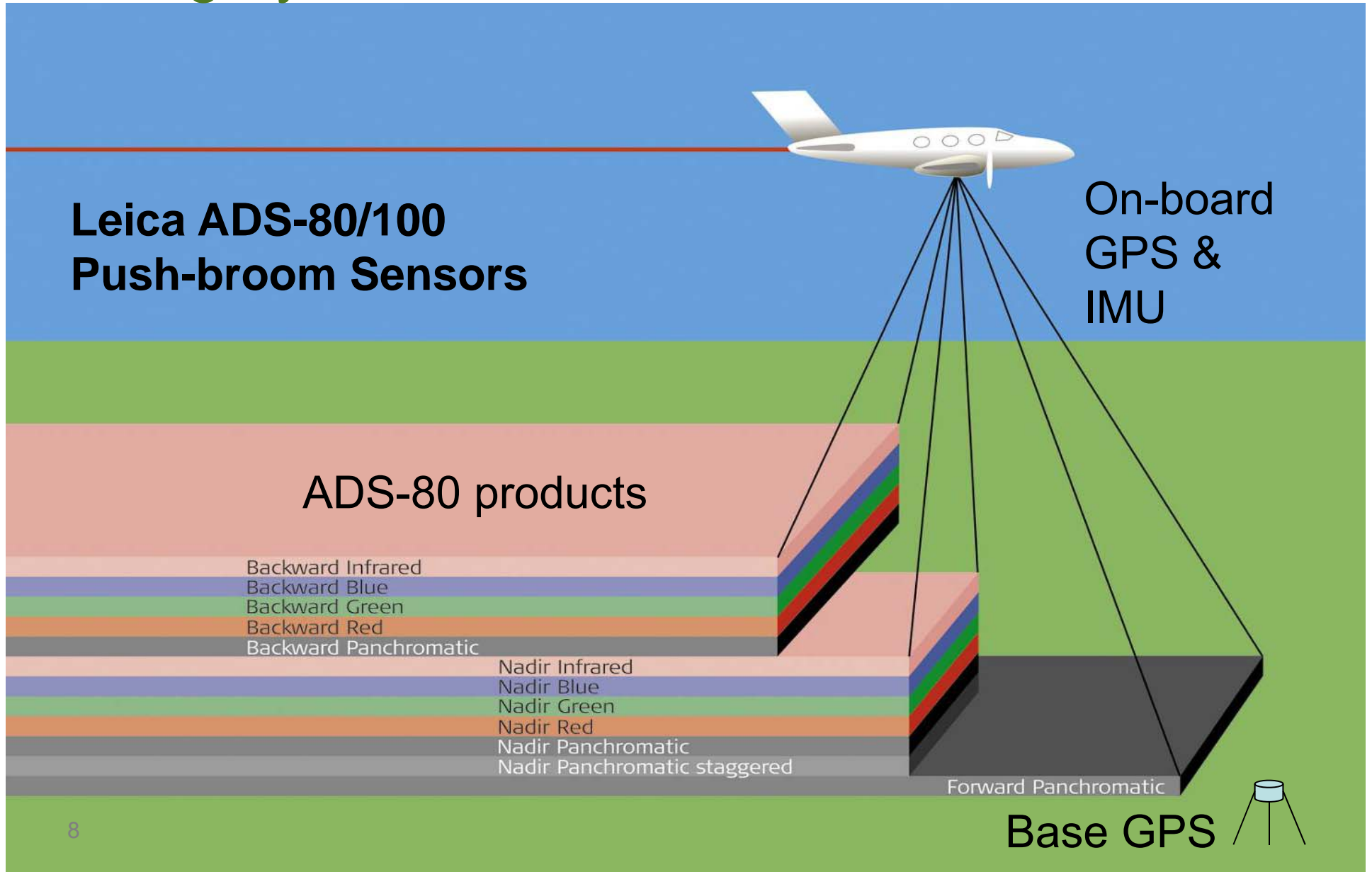


Imagery Derived Products (Southern Ontario)

Used for the production of ortho-photos

- 1) Stereo 4-band imagery (plus pan for 3rd look angle)
- 2) 40 cm elevation point cloud
 - produced from stereo by Semi-Global Matching
- 3) “Steam-rolled” 2 m elevation raster
- 4) 20 cm 4-band (R, G, B, NIR) orthophotos

Imagery Derived Products



Imagery Derived Products

**20 cm
RGB
Orthophotos**

large buildings
circled in red

forested areas
outlined in
black



Imagery Derived Products

**40 cm
elevation
product**

(shaded relief)



Imagery Derived Products

**2 m
Steam-rolled
elevation
raster**

(shaded relief)



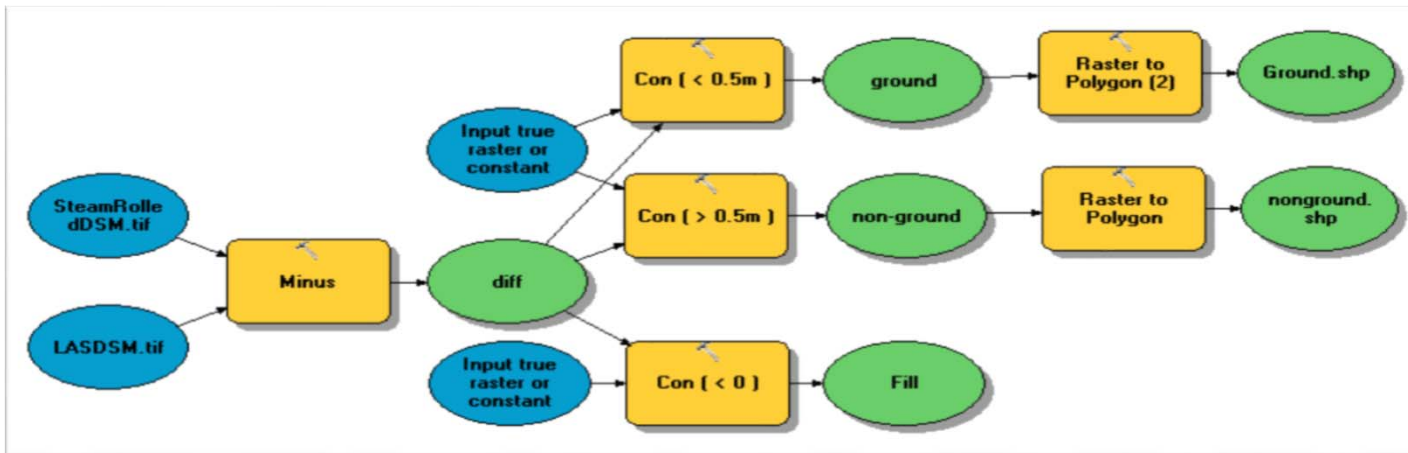
Research Conducted

- Acquired independent ground survey data for accuracy assessment
- Acquired other datasets including Lidar and existing DEM products
- Tested various commercial elevation software packages
- Developed in-house methodology using ArcGIS
 - *chosen as preferred solution*
- Conducted extensive accuracy analysis using LP360 and other statistical tools

Methodology Developed

- Re-tile and thin point-cloud data
- Map and classify waterbodies
- Automated classification of ground/no-ground using 2 m “steam-rolled” product
- Identification of voids
- Classification of dense vegetation, buildings, bridges, etc.
- Additional editing and clean-up
- Production of final products:
 - classified point cloud, raster bare-earth and surface models

Methodology: Auto-Ground Classification

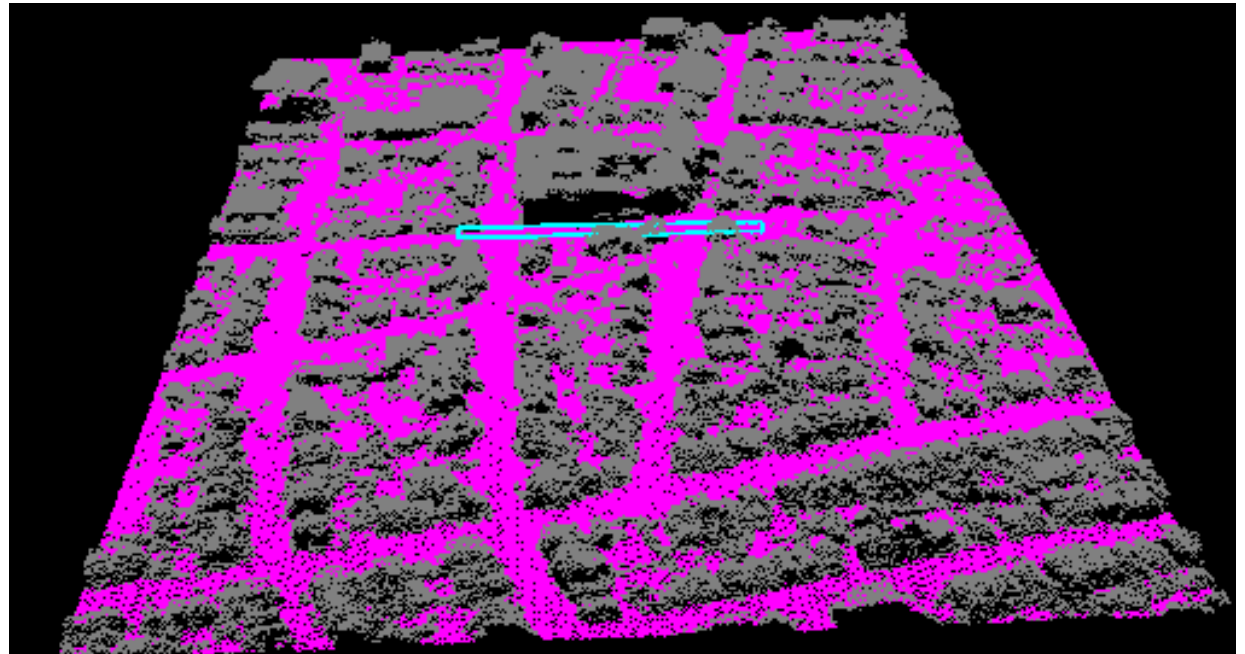


- Developed model to classify ground and non-ground points for creating 'bare-earth' product
- Elevation differences $\leq 50\text{cm}$ of 'steam-rolled' DEM classified as ground
- Ground/non-ground mask produced to classify points

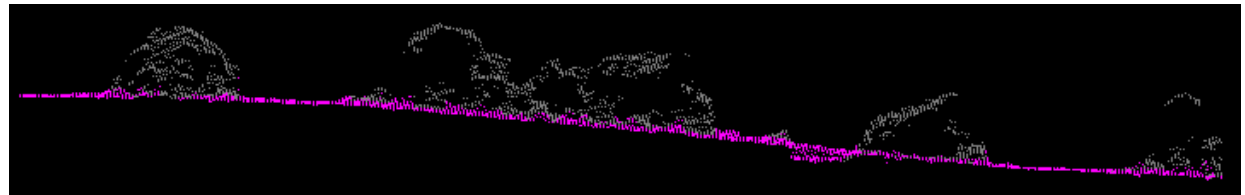
Methodology: Ground Classified Point Cloud

Example of ground classified elevation point cloud

purple = ground
grey = unclassified



cross-section



Methodology: Void Areas Polygons

- Void areas mapped using criteria where ground classified points $\geq 20\text{m}$
- Conifer vegetation largest factor influencing void feature



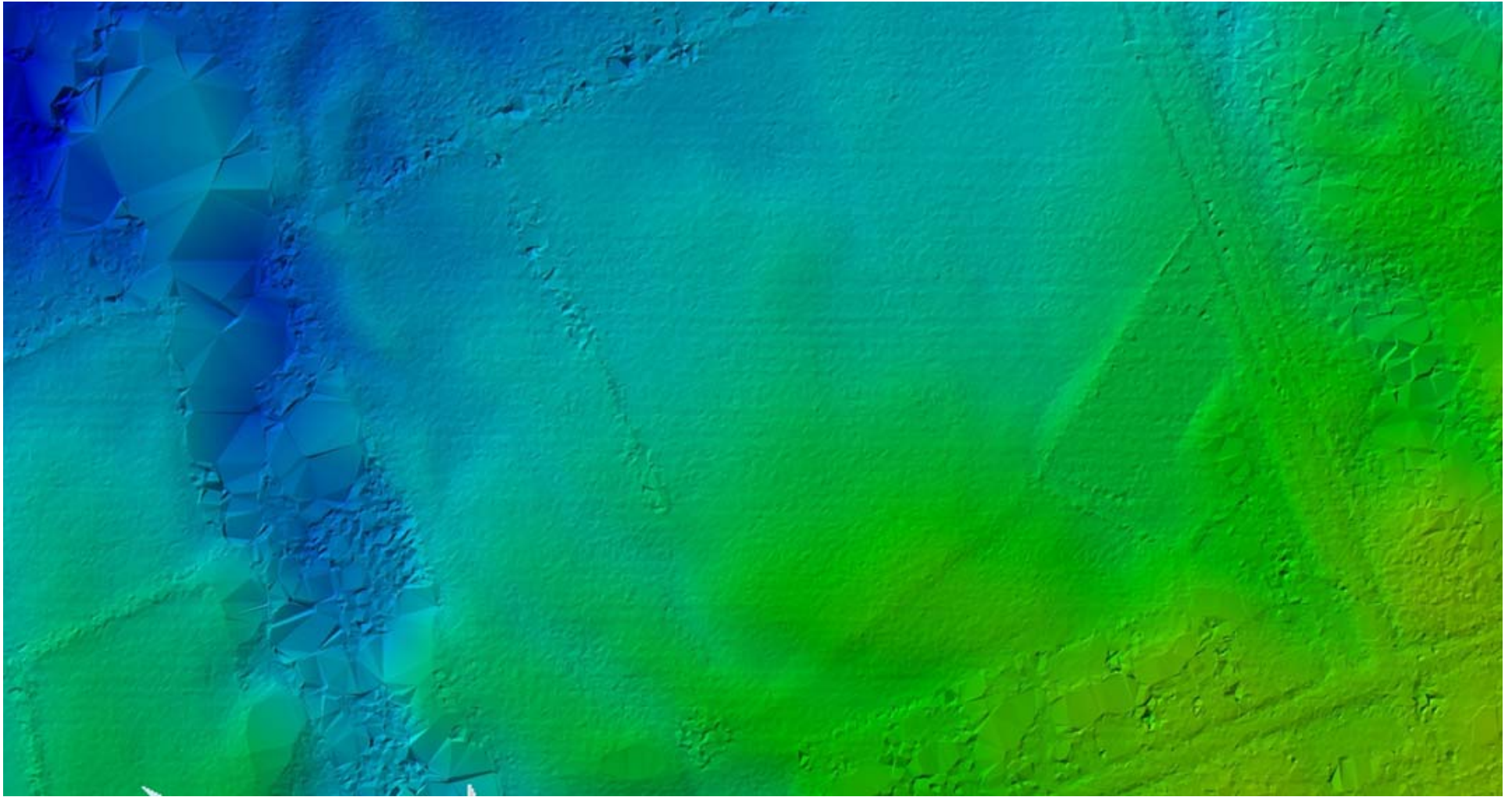
Site Example: 20cm Leaf-off Imagery



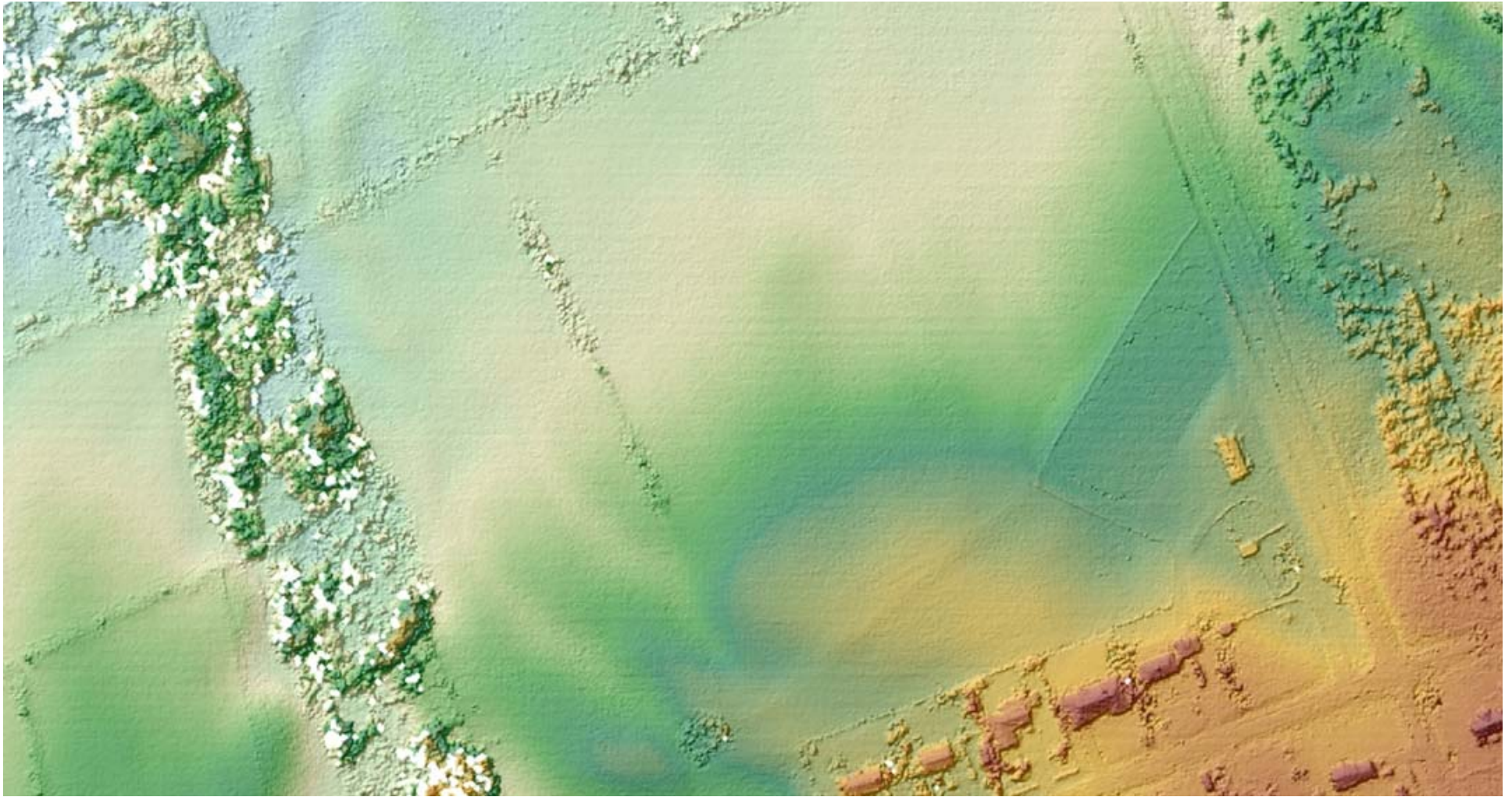
Site Example: Ground Voids



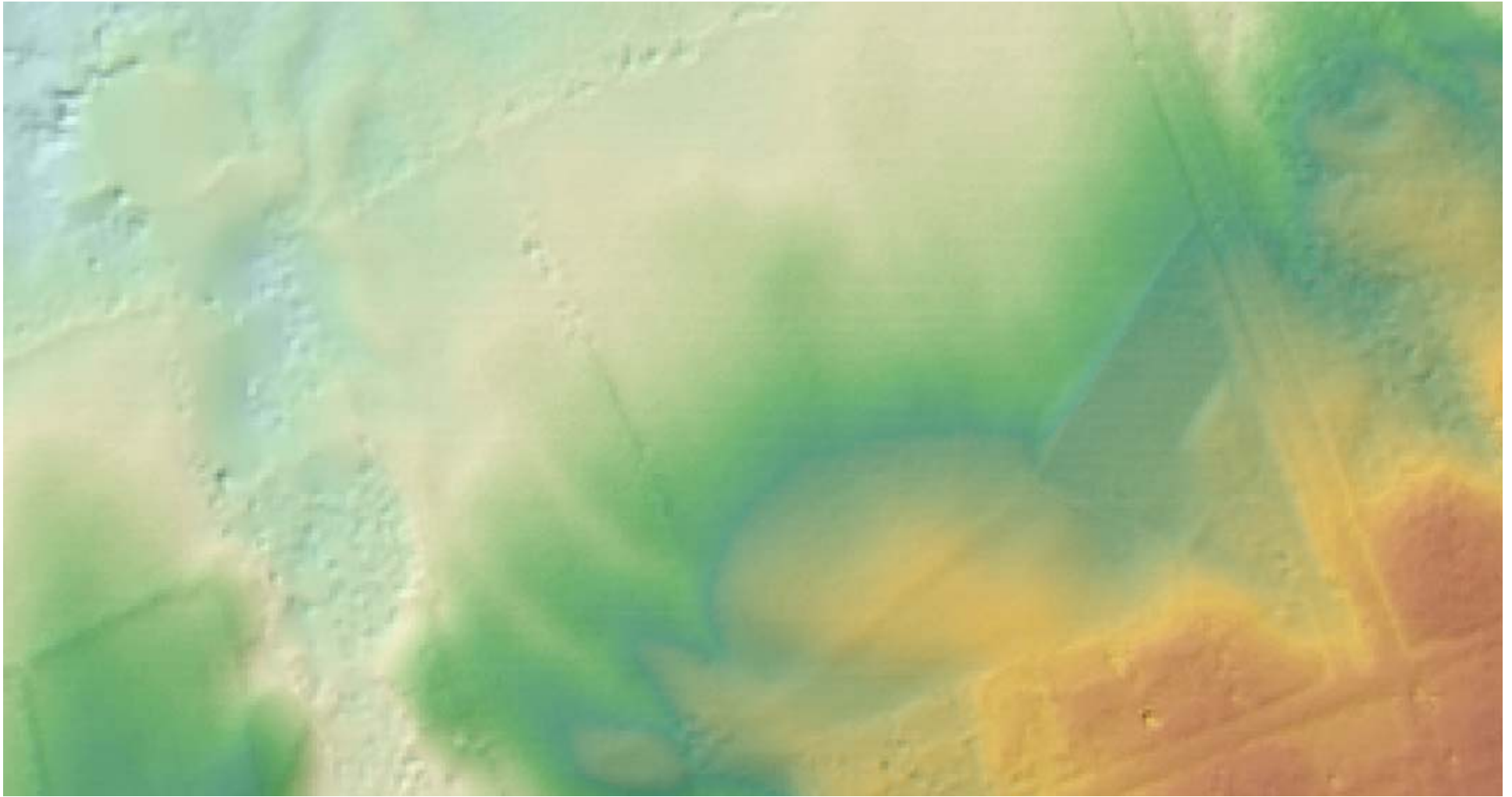
Site Example: Raw TIN – Ground Points



Site Example: Surface Elevation Raster



Site Example: Bare-earth Raster



Accomplishments

- Researched available applications for extracting ground points from imagery-derived elevation
- Developed automated ground classification procedure
- Developed automated void identification / delineation
- Performed extensive accuracy analysis
- Developed production-oriented workflow
 - minimizing manual editing

Next Steps

- Publish and report accuracy statistics to clarify capabilities and limitations of the data
- Exploring other elevation classification filters or algorithms to potentially improve the automatic classification of ground elevation points
- Identify solution for capturing large-scale hydrographic features (watercourse/waterbody) to add breaklines as a surface constraint when constructing the DTM
- Testing entire workflow and start of production

Questions?

For further information, contact:

Carey Gibson or Kent Todd

Mapping and Geomatics Services

Ontario Ministry of Natural Resources and Forestry

pmu@ontario.ca

