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Building Footprint Extraction: A Land Use Classification Comparison of Satellite Imagery vs. Orthoimagery

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Introduction

The Town of Windham, Maine Proposed Municipal Budget FY 2012-2013 called for $12,750 for professional services to develop a building footprint database. There are several municipal applications for building footprints including, but not limited to: Taxation/valuation of properties; setbacks for code enforcement; public safety planning; historical analysis of building patterns; general planning, where to encourage growth and redevelopment; zoning analysis and recreational planning. Due to the town's in-house GIS (Geographic Information Systems) capabilities, the project will be developed within the Assessor's Office and based on the 2012 Maine Office of GIS 6" Orthoimagery for Windham. The following is an effort to discover if imagery is an efficient resource to complete the project.

Literature Review

Extracting building footprints from remotely sensed imagery can be accomplished using high resolution multispectral data as well as LiDAR (Klinger 2008). While LiDAR can be difficult to acquire, high resolution orthoimagery is often available for towns and cities across the U.S. and can be a suitable substitute. Extensions of the ERDAS image processing software can perform such analyses. Prisloe et al (2001) detail the extraction of impervious surfaces using satellite imagery and ArcGIS. The authors also use the Anderson land classification system to identify impervious surfaces. Similar analyses can be useful for town and city planners interested in mapping building footprints.

Satellite Image Analysis

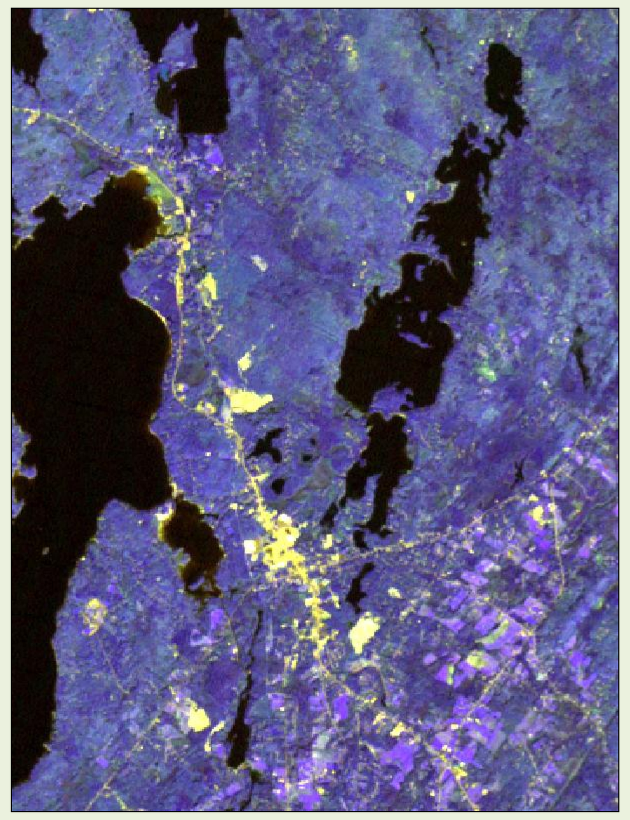


Figure 1: Enhanced Thematic Mapper Plus (EMT+) 2006 image North Windham, Maine

Enhanced Thematic Mapper Plus (EMT+) 2006 data from the University of Maryland and NASAs Global Land Cover Facility was downloaded, clipped and a subset layer stack created. Stretching and high pass filtering techniques were used to preprocess the image. The false color composite (FCC) shown (Fig. 1) uses bands 2, 3 & 4.

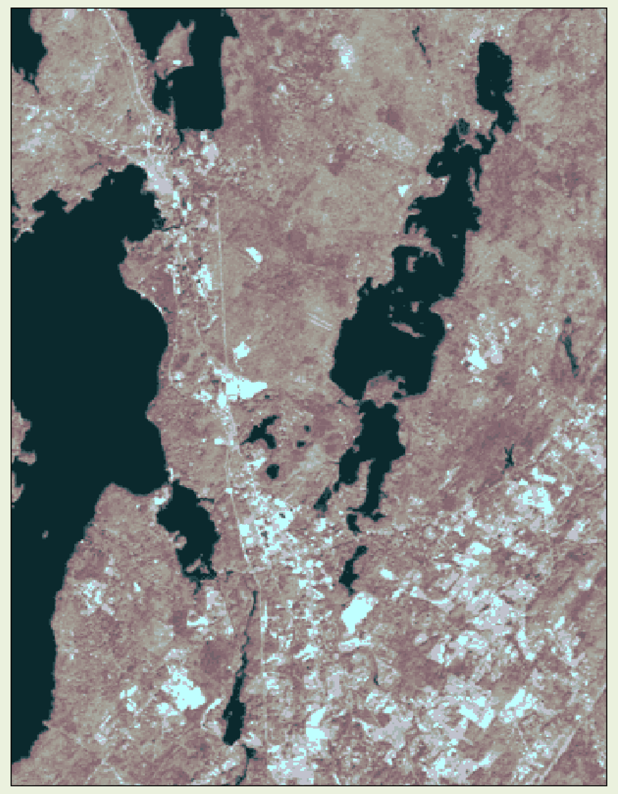


Figure 2: Unsupervised Land Use/Land Cover Classification of North Windham.

An Iterative Self-Organizing Data Analysis Technique (ISODATA) unsupervised land use classification was conducted in ERDAS Imagine to categorize or group the image pixels into15 separate classes (Fig. 2.)

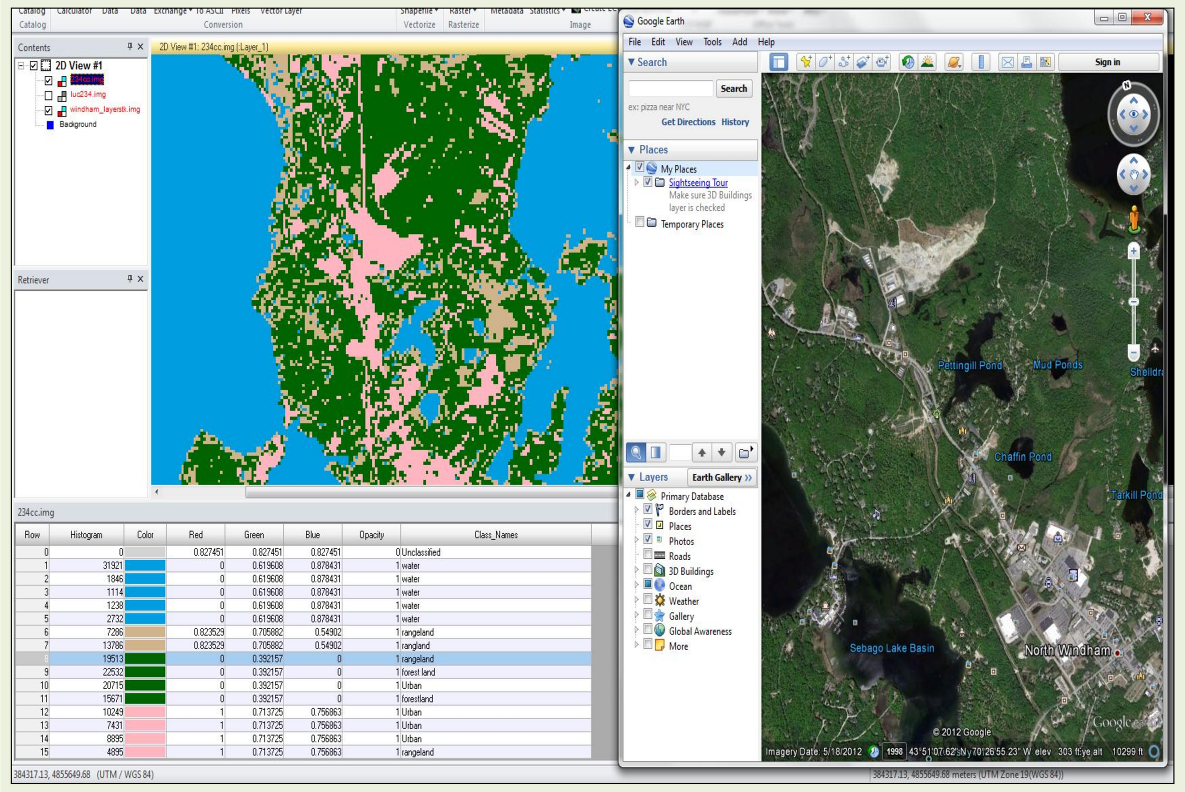
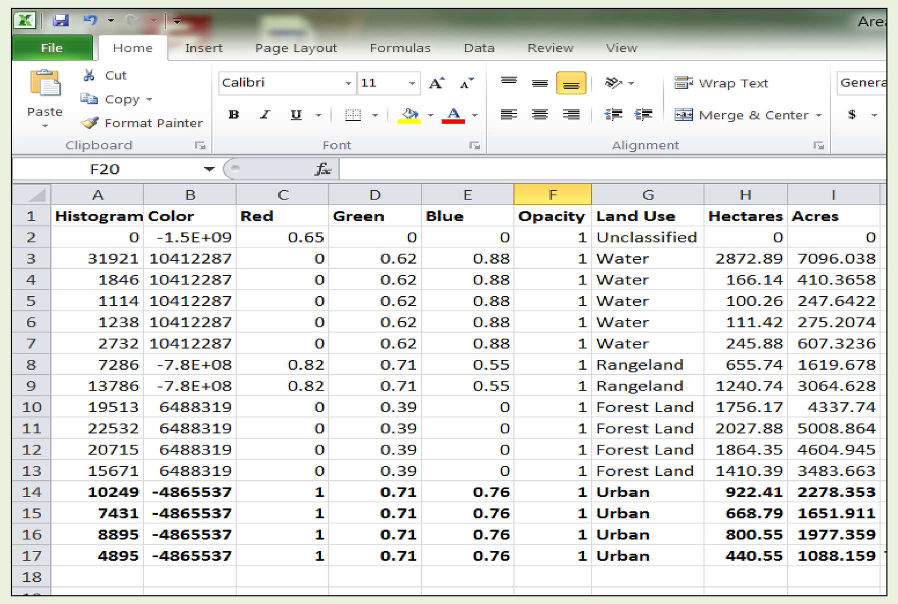


Figure 3: Analysis and classification of satellite image.

The swipe function and Google Earth were used to identify features. The USGS Land Use/Land Cover Classification System for Use with Remote Sensing Data (Anderson et al., 1976) was used to code land use classes in both the satellite imagery (Fig. 3) and the orthoimagery (Fig. 8).



	Histogram	Color	Red	Green	Blue	Opacity	Land Use	Hectares	Acres
2	0	-1.5E+09	0.65	0	0	1	Unclassified	0	0
3	31921	10412287	0	0.62	0.88	1	Water	2872.89	7096.038
4	1846	10412287	0	0.62	0.88	1	Water	166.14	410.3658
5	1114	10412287	0	0.62	0.88	1	Water	100.26	247.6422
6	1238	10412287	0	0.62	0.88	1	Water	111.42	275.2074
7	2732	10412287	0	0.62	0.88	1	Water	245.88	607.3236
8	7286	-7.8E+08	0.82	0.71	0.55	1	Rangeland	655.74	1619.678
9	13786	-7.8E+08	0.82	0.71	0.55	1	Rangeland	1240.74	3064.628
10	19513	6488319	0	0.39	0	1	Forest Land	1756.17	4337.74
11	22532	6488319	0	0.39	0	1	Forest Land	2027.88	5008.864
12	20715	6488319	0	0.39	0	1	Forest Land	1864.35	4604.945
13	15671	6488319	0	0.39	0	1	Forest Land	1410.39	3483.663
14	**10249**	**-4865537**	**1**	**0.71**	**0.76**	**1**	**Urban**	**922.41**	**2278.353**
15	**7431**	**-4865537**	**1**	**0.71**	**0.76**	**1**	**Urban**	**668.79**	**1651.911**
16	**8895**	**-4865537**	**1**	**0.71**	**0.76**	**1**	**Urban**	**800.55**	**1977.359**
17	**4895**	**-4865537**	**1**	**0.71**	**0.76**	**1**	**Urban**	**440.55**	**1088.159**

Figure 4: Classification results and calculations.

The classification results and area calculations were exported as a .dat file and imported into an Excel spreadsheet to show classification results and summarized to get total urban area in acres for future reference (Fig. 4).

The ISODATA image classification procedure categorizes pixels in an image based on similar pixel values and groups the results into land use and land cover classes. As an example, water bodies in an image would have the similar spectral properties and would be grouped together. This procedure was developed by Tou and Gonzalez (1974) and is based on the K-means clustering approach.

The ERDAS Land Use Classification image was uploaded into ArcMap 10.1 and overlayed at 60% transparency over the Maine GeoLibrary 2012 6" Orthoimagery. The urban areas, including building and gravel pits are visible through the pink urban layer (Fig. 5).

Figure 5: ERDAS Imagine land use classification image overlayed on 2012 ortho imagery.

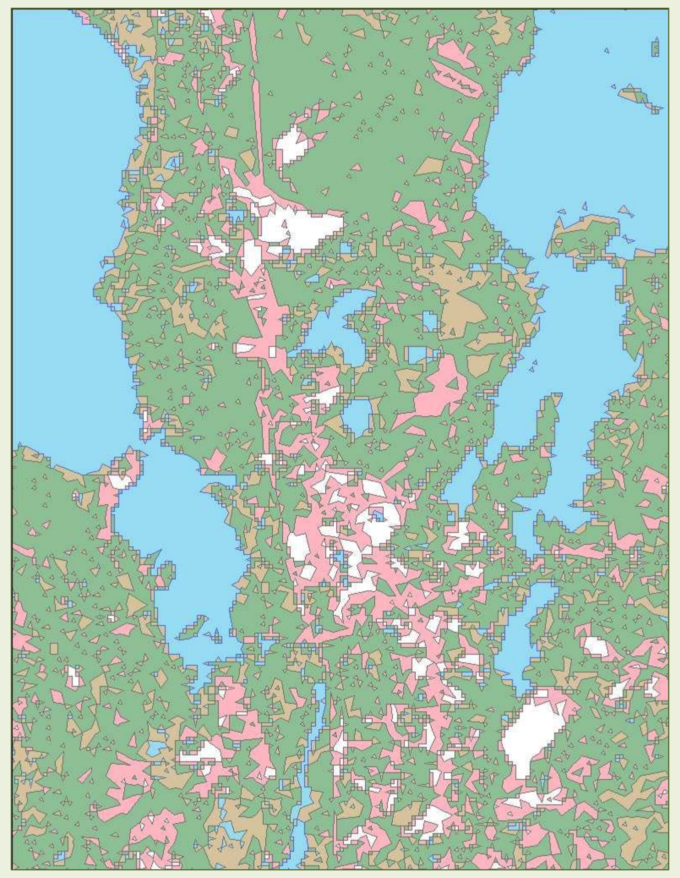


Figure 6: Raster image converted to polygon .shp file.

In ArcMap the ERDAS raster image was converted into a polygon .shp file using the following process:

In ArcMap 10.1 - 1. Open ArcToolbox; 2. Conversion Tools; 3. From Raster; 4. Raster to Polygon; 5. Input Raster; 6. Field Value = Class_Names; 7. Output Polygon Feature.

Although the results are not adequately detailed for developing a building footprint layer they may be of an accuracy level useful for developing an impervious surface analysis. (Fig. 6).

Orthophoto Image Analysis

Figure 7: 2001 Orthophoto of a portion of the North Windham Commercial District.

The Maine GeoLibrary 2012 6" orthophotos were not yet available in a tiff format at the time of this project and as a result, the 2001 Maine GeoLibrary orthophotos were used. This particular tile appeared to have the most development and was used to run the ISODATA (Fig. 7). The results are shown in Figure 8.

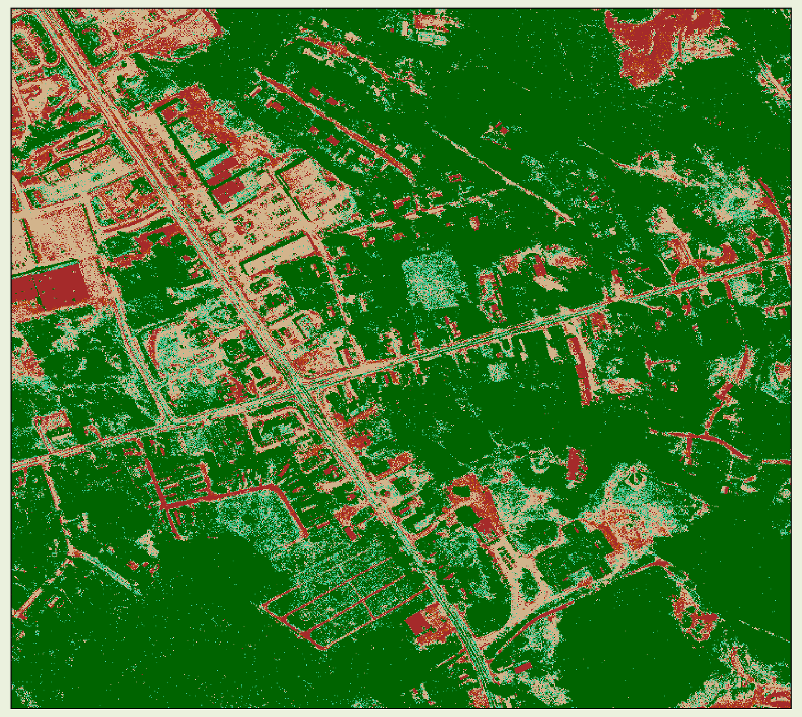


Figure 8: Resulting land use/land cover classification image of North Windham.

A land use classification using the default of 36 classes was performed on the 2001 ortho image. The resulting image was analyzed and class names assigned to differentiate roads, parking lots and buildings from green space (Fig. 8).

Figure 9: Polygon .shp file of North Windham.

This raster image was brought into ArcMap and converted into a polygon .shp file (Fig. 9). The resulting .shp file can be edited and used to create building footprints (Fig. 10).

Results

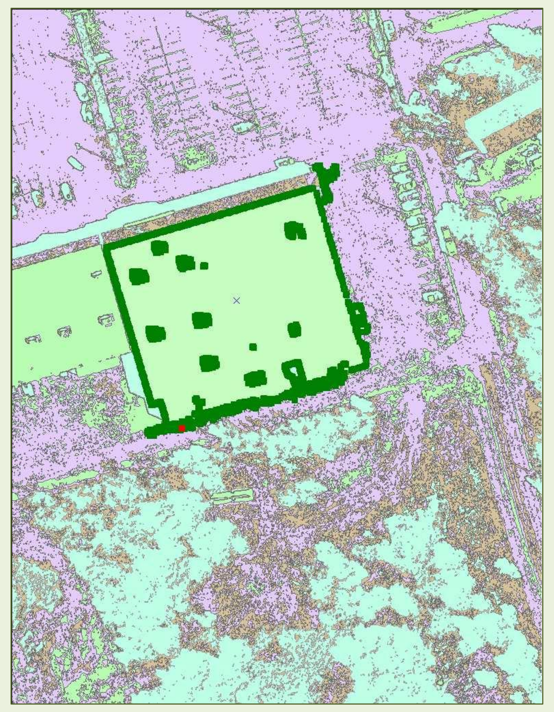


Figure 10: Validation of editing properties of converted image.

The results of using the 2001 images proved to be useable for the application, however, it is expected that the quality of the 2012 6" images will be superior and will produce a .shp file of greater accuracy. The data was verified in ArcMap as a valid polygon with editing properties. The classes can be sorted and selected for export from the attribute table to create a layer of classes that are coded as Urban. From this new Urban layer, polygons will be edited to remove excess vertexes and eliminate any extraneous Urban data.

The quality of the polygon derived from satellite imagery did not have the detail needed for the project but would be useful in future projects such as impervious surface analysis.

Conclusions/Next Steps

- Run land use classification on new 2012 aerials when they become available from the Maine Office of GIS in .tiff format;
- Edit urban classified polygons;
- Develop town-wide building footprint coverage for approximately 7,900 parcels;
- Edit urban polygons to estimate the total impervious surface area of subject commercial zone for future planning projects.

References

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- Griffiths, P. et al. (2010) Mapping mega city growth with multi-sensor data. Remote Sensing of Environment 114(2) pp. 426-439
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- University of Maryland and NASA's Global Land Cover Facility (http://glcf.umiacs.umd.edu/index.shtml)
- Maine Office of GIS Cumberland County Orthophotos 2001 (http://www.maine.gov/megis/)
- Woolpert (http://maps.woolpert.com/ogc/wms)

Acknowledgements

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