Fitchburg Land Cover Model and Ash Identification Report

2011 Urban Forestry Grant Project

The City of Fitchburg was awarded an Urban Forestry grant in 2011 by the Wisconsin Department of Natural Resources (DNR). The primary goal of the grant was to take available high resolution aerial imagery and Light Distancing and Ranging (LiDAR) data to create a higher accuracy land cover model then has been traditionally available. The secondary goal was to attempt to identify ash trees from their Near Infra-Red (IR) wavelength signature by using multiple aerial images across two months that were flown when ashes usually undergo phenological changes. Prior experience has shown that the Near IR signatures of trees, from species to species are too similar to allow species identification. This project would allow us to determine if Near IR signatures would be unique enough at a certain time of year and to allow ash trees to be identified from surrounding tree cover.

In addition we are attempting to determine if an analysis of this kind can be performed using readily available software and data sets, to reduce the cost of the analysis. The City of Fitchburg partnered with Ayres Associates and the University of Wisconsin-Madison's Forestry Department to obtain imagery and for their experience with remote sensing.

The long term goal for this project is to take the data generated from the land cover model and plug it into iTree. This software allows the user to determine the environmental and economic impact the urban forest has in Fitchburg. iTree models air quality, carbon storage and storm water runoff mitigation. If the ash identification proves successful it will allow for city staff to prepare for the impact of the emerald ash borer that is likely to be infecting trees in the Dane county area in the next 3 to 5 years.

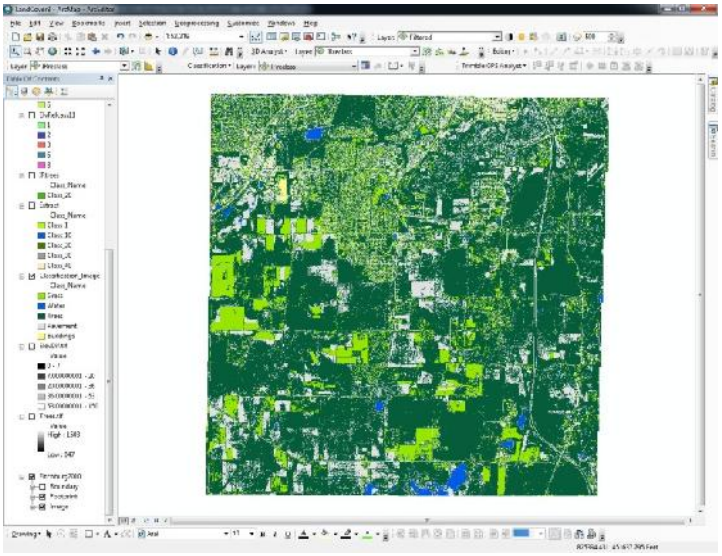
Land Cover Modeling

Most land cover models used in forestry management are based on 30 meter resolution LANDSAT satellite imagery. While this is a quality data source for state wide analysis, it has shown to be too coarse for smaller areas of study.

The City of Fitchburg is a member of the Fly Dane consortium, which is an organization of cities, towns, the county and private companies that need high resolution and up to date aerial imagery of Dane County, Wisconsin. By joining together the costs for obtaining imagery is significantly reduced for the members. Ayres Associates was awarded the contract to provide the 1 foot (30 cm) resolution, leaf off imagery in 2009. Ayres was also able to offer 6 inch (15 cm) imagery, Near IR imagery and LiDAR data sets for an additional cost. Fitchburg acquired 1 foot (30 cm) Near IR and 2 foot (60 cm) LiDAR across the entire city for use in the Public Works Department.

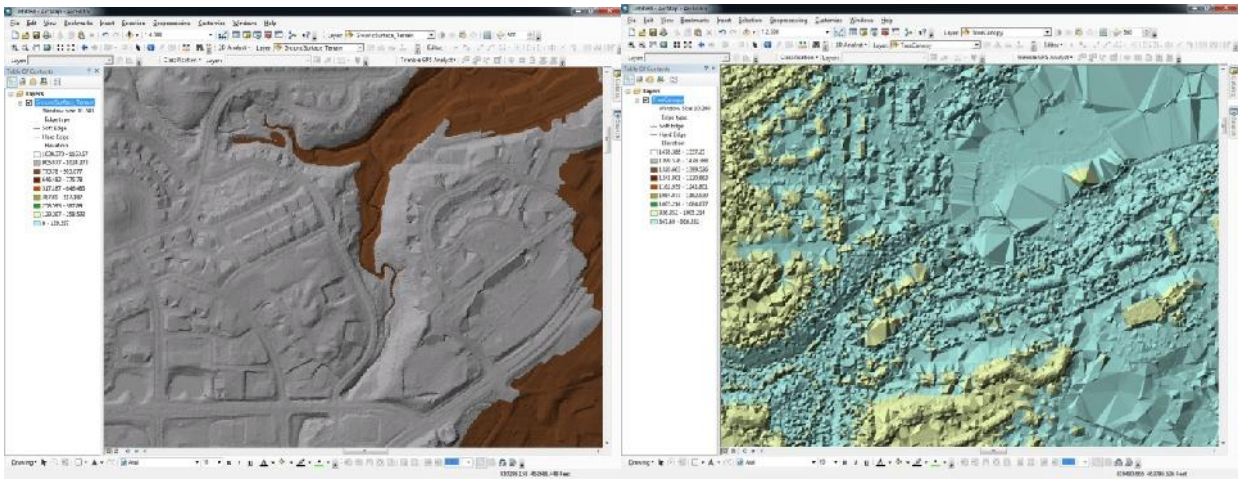
For the 2011 grant we took the Near IR and LiDAR data sets and ran them through ESRI's ArcGIS 10 with the Spatial Analyst extension to create a high accuracy land cover model. Normally leaf off imagery would be of marginal value when trying to perform a land cover analysis but when combined with LiDAR data we were able build the model.

Using Spatial Analyst we first identified and extracted the four land types we were interested in: trees, grass, water and impervious based on the Near IR imagery the result was stored as a raster image. A raster image is a grid of pixels with each pixel having a set value, similar to a digital camera photo.



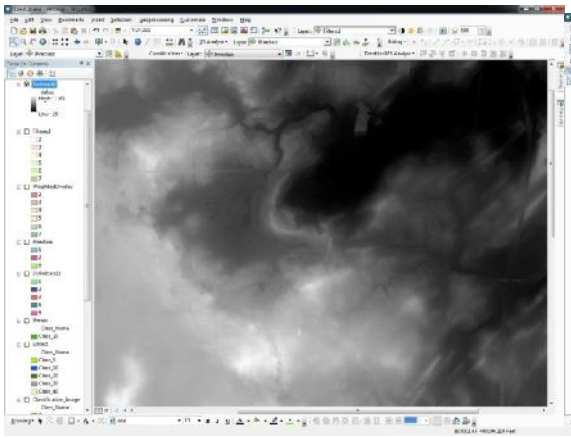
Near IR Raster output

Next we used the LiDAR data to create the tree canopy and bare earth models.

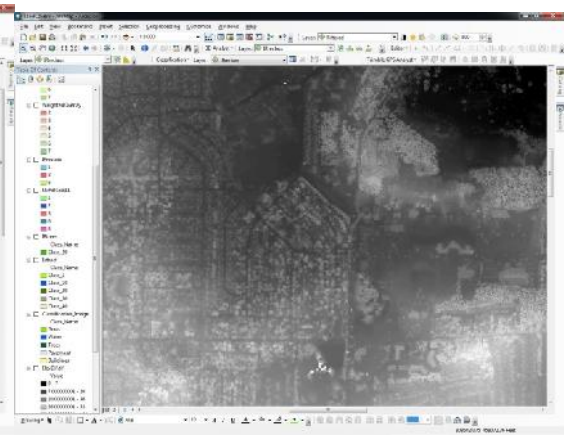


Bare Earth Model *Tree Canopy Model*

The models were converted to raster images.



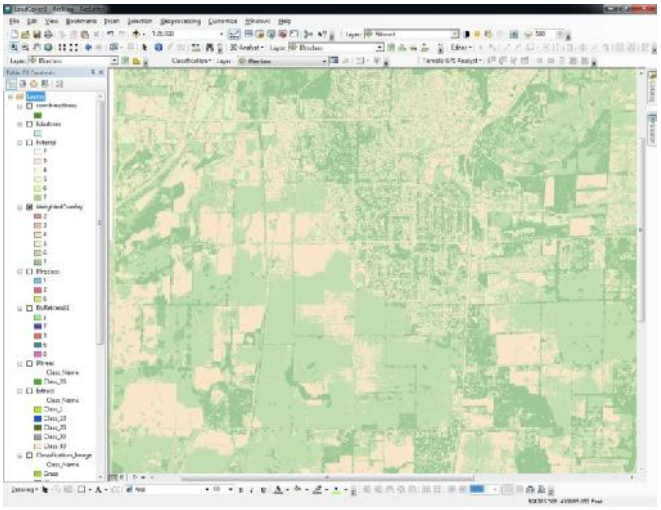
Ground Surface Raster



Tree Canopy Raster

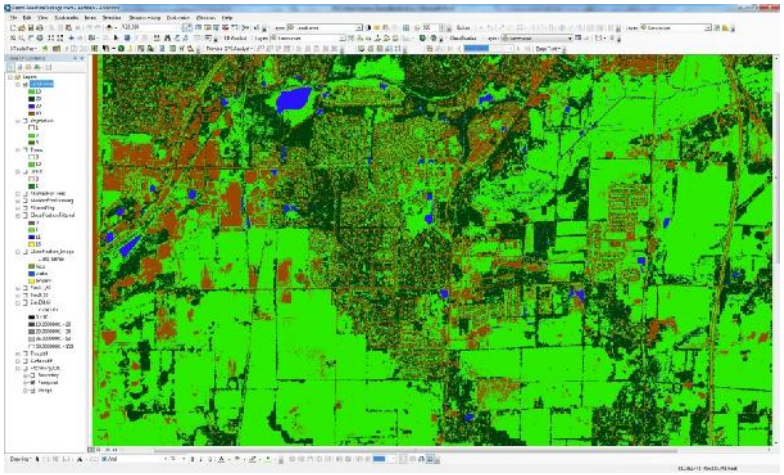
A process called Raster Math was used to extract the areas that had an elevation between 10 and 80 feet (3 – 24 m) which are typical tree height ranges in Fitchburg. At this point we had two competing models the Near IR based and LiDAR based models.

The classification values from the two models were modified for analysis, and a weighted overlay was run. An overlay is a process that places the two models on top of each other and looks for areas where both models agree. In this case we wanted to find areas where both models said a pixel is a tree. Because the Near IR imagery was leaf off when we ran a weighted overlay, we gave more credence to the LiDAR model. If there was a pixel that LiDAR said was a tree and the Near IR said was grass we would classify it as a tree. The LiDAR is more likely to be correct in this study. The results of the overlay were returned as a new raster image.

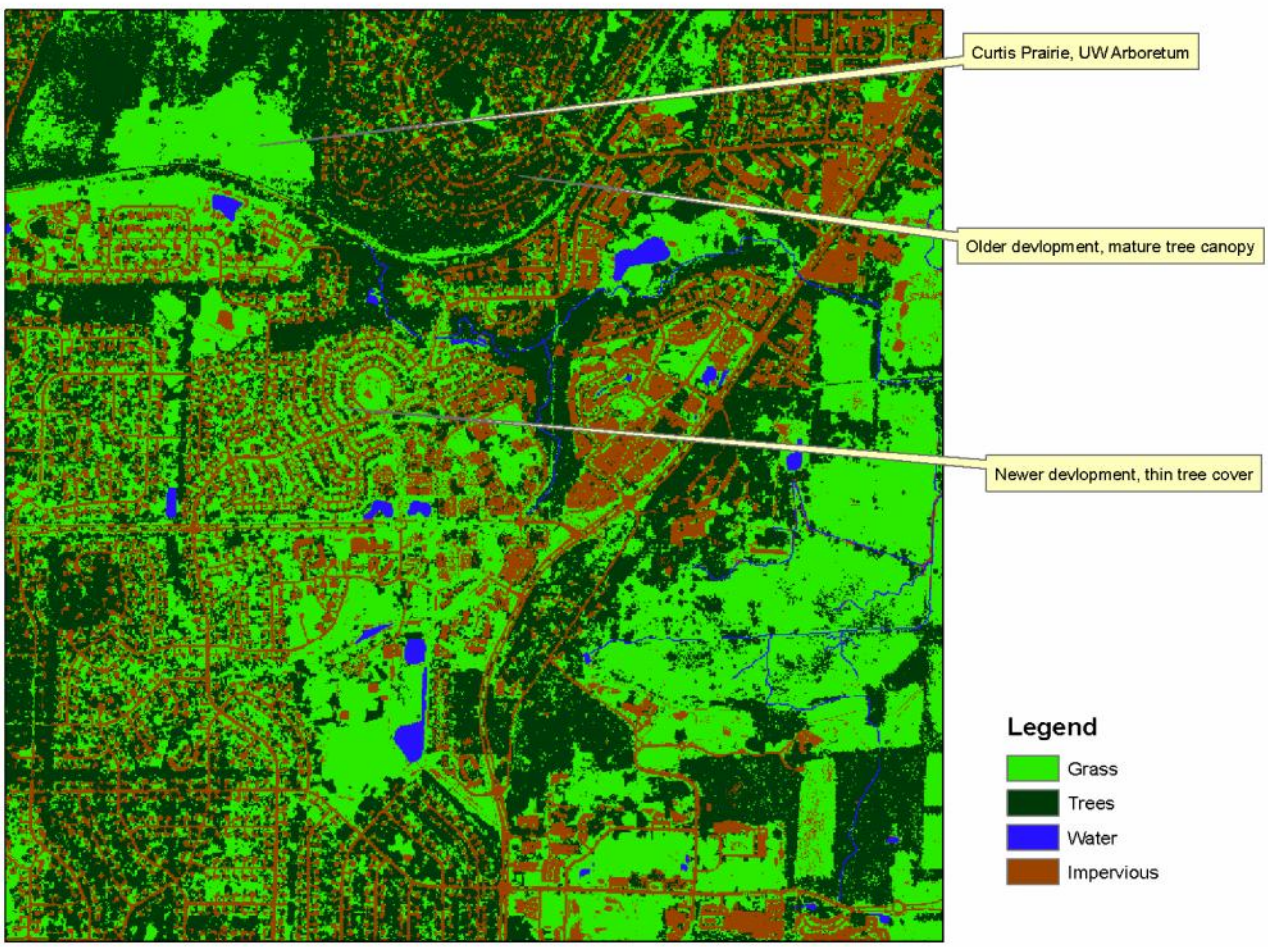


Overlay output

The results were fine-tuned and we also were able to refine our land cover model at the same time.



Final Land Cover Model



The end result was a 12 foot (3.6 m) land cover model for the city that provides much more relevant data when running an analysis on geographically smaller areas. Refer to Table 1 for the land cover types and percent cover for the entire city and the urban service area.

Table 1. Land Cover Model Results for City

Land Type	Percent Cover Citywide	Percent Cover Urban Service Area
Trees	24	31
Grass/Agriculture	64	43
Water	1	2
Impervious	11	20

Ash Identification

In the Near IR band it is fairly easy to separate tree cover from grass cover using leaf on imagery. However previous experience with land cover extraction produced an unexpected result. The software was sensitive enough to separate different building materials on roof tops and roads. Older construction used different materials on roof tops, and unless the algorithms were specifically told what to look for it would split off older and more recent construction into different land covers. If the software is able to identify building materials then it may be possible to identify tree species as well.

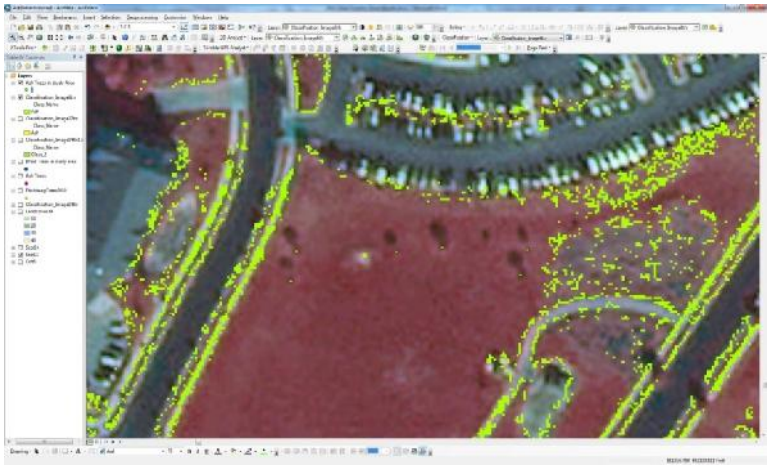
The City of Milwaukee has had some success in identifying tree species using hyper spectral imagery, but the cost associated with this process made it impractical for smaller communities. Using the experience of the roof top problem, Fitchburg decided to try something similar using low cost or free imagery.

In this previous study Fitchburg attempted to identify tree species using 1 meter leaf on Near IR imagery obtained from the USDA. We first collected the coordinates of known ash trees with a Trimble Geo XT GPS receiver. We then took a sample of the ash trees (10% of known ashes in Fitchburg) and digitized the crown to create a training set to run the extraction algorithms on. After running the program the results were field checked. Unfortunately the software was not able to accurately identify Ash trees using this method. We had a roughly 30% accuracy rate which was not good enough for what we required.

After discussions with faculty at the UW –Madison, Ayres Associates and DNR Urban Forestry staff, it was determined that this method may prove successful if the imagery was obtained in the fall when the trees are undergoing phenological changes in reaction to the changing weather. To this end Ayres agreed to make four flights in the fall over a sample area and provide the imagery at a reduced cost for this grant.

Using the land cover model that was created as a part of the grant we were looking to take the fall imagery, and extract the area that has known tree cover. We would then digitize crowns from the known ash tree locations that are going through the seasonal changes and run the extraction process to identify ash trees.

The results proved to be similar to the previous study. The software had difficulty picking out known ashes and misidentified other trees as ashes



Near IR Ash Identification Output

It appears that we are running into a similar problem to the land cover model. The Near IR band is too coarse for analysis on a smaller geographic area. With larger areas where there are tens or hundreds of acres of contiguous trees of the same species, tree identification may be possible, but in urbanized areas with a fragmented forest with a mix of species and sizes this method is not successful at this time. As technology advances and the cost comes down for hyper spectral imaging it may be possible for smaller communities to create the data needed for an analysis of this kind.

This grant enabled the City of Fitchburg to create a process for land cover extraction using significantly higher resolution imagery while reducing costs by using commonly available software and readily available data. This process is able to be replicated by other communities interested in emulating the work. For the next phase of the grant we hope to use the data created to run a comprehensive analysis of the Fitchburg Urban Forest.

It should also be noted that these models are intended to provide a broad over view of the makeup of the landscape. They are not accurate to the point where they can be considered a replacement for boots on the ground, field verifying actual conditions. When used as a planning and public information tool they can provide a powerful visual and data rich representation of the state of the urban forest.

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