KANSAS STATE | Applied Aviation
U N I V E R S I T Y | Research Center

Aerial Survey & Classification of Bush Honeysuckle

Project Report
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Project Participants, Authors:
Kurt Carraway, UAS Executive Director
Andi Meyer, UAS Research Program Manager
Travis Balthazor, UAS Flight Operations Manager
Trevor Witt, UAS Data Analyst

Kansas State University Polytechnic Campus
Applied Aviation Research Center (AARC)
2310 Centennial Road
Salina, KS 67401-8196
785-826-2640

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1   Introduction

The Kansas State University (KSU) Applied Aviation Research Center (AARC) conducted flight operations over the Kansas cities of Manhattan, Lawrence, Topeka, Hutchinson, and Wichita during fall 2016. These operations were conducted for a Kansas Forest Service project aimed at the management of bush honeysuckle. The objective of the flight operations was to capture still imagery to produce orthomosaics covering each city. The orthomosaics were then classified using common image classification algorithms and techniques to show concentrations of bush honeysuckle within and around each city.

2   Background

In 2014, the Kansas Forest Service partnered with KSU geography researchers to collect and analyze aerial data to identify concentrations of bush honeysuckle. From these initial efforts, the Kansas Forest Service obtained a rough classification of bush honeysuckle in the City of Manhattan. This progress laid the ground work to identifying if remote sensing, namely data collected with a manned aircraft, has a practical use to influencing management decisions of bush honeysuckle.

In mid-fall 2016, the Kansas Forest Service contacted the AARC to resume the project. The AARC collected aerial imagery with a Cessna 172 over the previously stated cities, processed the imagery to create orthomosaics, and then classified those orthomosaics to highlight bush honeysuckle concentrations. Identification of these concentrations was accomplished by using confirmed locations of bush honeysuckle to train a classification software to find other concentrations.

The deliverables of the project consisted of the source photos, orthomosaics, classified orthomosaics, and this report detailing the equipment, processes used, problems encountered, estimates of bush honeysuckle coverage area in each city, and recommendations to improve results.

3   Equipment

3.1   Manned Aircraft (C172S)

For this project, the AARC selected an aircraft within KSU's fleet of newer Cessna 172S Skyhawks. This aircraft is well suited for mapping missions due to upgraded equipment. The equipage offered by the Cessna 172S includes (1) a Garmin G1000 digital flight display (Figure 1) which increases the pilot's situation awareness through features such as a moving map displaying the aircraft's current position and (2) a two-axis autopilot which reduces pilot workload, allowing more attention to aircraft speed and flight path.

Figure 1. Inside View of the C172S

3.2   Sensor and Mounts

NIR Modified Sony a5100
The Sony a5100 boasts a 24.3 Megapixel APS-C CMOS 23.5mm x 15.6mm sensor. For the aerial surveys, this camera was configured with a 20mm prime lens and a near-infrared (NIR) filter. This filter allows green and blue light to hit the sensor, but it blocks red light. Instead of red light, the filter allows NIR light to be captured by the sensor. Most living vegetation reflects a significant amount of NIR light and varying types of vegetation can be differentiated by the amount of reflected NIR light. The goal with using this sensor was to pick up the unique reflectance signature of bush honeysuckle.

Sensor Mounts
The sensor was installed in a pod mounted on the aircraft's wing strut (Figure 2). This pod mount was used to enable the use of the Cessna 172S, an aircraft that is well-equipped for mapping missions. The only disadvantage to mounting the sensor on the strut was it eliminated the ability to manually adjust sensor settings and view captured images during flight. To accommodate this change, the sensor settings and sample images were accessed during flight via a laptop through a wired connection.

Figure 2. Sensor Pod Mount on the C172S Wing Strut

3.3 Support Equipment

Pixhawk Autopilot
The Pixhawk autopilot is a computer used for autonomous vehicle navigation. It can also execute a variety of other functions. For this project, the autopilot was used for two functions – triggering the sensor by a preprogrammed distance interval and representing aircraft position through Mission Planner's interface. This autopilot was not used to directly control the Cessna 172 aircraft.

Mission Planner
Mission Planner is a software program that synchronizes with the autopilot to build flight plans, adjust the trigger distance interval, and monitor overall status. A flight plan was built within Mission Planner to show the lines the aircraft needed to fly. The pilot viewed these lines on a flight plan display and used them as reference to properly navigate the aircraft.

Flight Plan Display Device
A flight plan display device (Microsoft Surface) was mounted directly in front of the pilot to allow for a quick scan to make sure the aircraft was following the proper path.

Data Processing Computer
Significant computing power is required to generate orthomosaics from the hundreds of images captured during mapping missions. The computer used for data processing was a Falcon Northwest custom-built Mach V desktop with a 6-core Intel i7 3930K 3.2 GHz processor, 32 GB of RAM, and NVIDIA GeForce GTX Titan 6 GB video card.

Photogrammetry Software
Agisoft PhotoScan was the primary software used for processing single images to produce orthomosaics. It is a stand-alone software product that performs photogrammetric processing of digital images and generates 3D spatial data for geographic information systems (GIS) applications. The software is available in standard and professional versions. KSU utilizes the professional version as it is designed for authoring GIS content.

Classification Software
ESRI ArcMap is a software where a variety of GIS tasks can be accomplished. ArcMap also has basic raster manipulation and classification tools. For this project, ArcMap was used to generate vegetation indices. These indices were exported as a GeoTIFF and then imported in ENVI for robust classification.

Harris Geospatial ENVI is a GIS software that is used to conduct image analysis. This task is primarily accomplished through image classification. This allows the user to extract information that may be otherwise hidden in raw imagery. For this project ENVI was used to classify and estimate concentration areas of bush honeysuckle throughout the surveyed cites.

4   Methodology

4.1   Flight Operations Methods

Successful flight operations involve the balance of flight crew coordination, flight parameters, and air traffic control coordination. The successful negotiation of these elements enabled efficient flight operations to collect high-quality images.

Flight Crew Coordination
To collect the data within the planned two-week timeframe, three two-person crews were tasked with completing the surveys. A crew consisted of a pilot and a payload operator where the former would focus on flying the airplane and the latter would focus on operating the sensor. Work instructions for flight and payload operation were developed to ensure consistency between flights and crews. The work instruction for payload operation was especially critical because inconsistency in operation could result in gaps of coverage as seen in the Manhattan orthomosaic.

Flight Parameters
All flights were conducted November 9-19, 2016. The goal was to capture data within two weeks of the leaves falling off the trees. This goal was partially achieved, as some species still had their leaves attached. The following parameters were used for the flights:

- Image overlap: 75%
- Image side-lap: 75%
- Altitude above ground level (AGL): 2000 feet
- Speed: 100 miles per hour

The 75% image overlap and side-lap was chosen to facilitate successful orthomosaic production using PhotoScan. For the manned flight, an altitude of 2000 feet AGL was selected to produce 12 cm/pixel ground resolution. A flight speed of 100 mph was selected to allow for favorable camera shutter speed while optimizing time to complete the city-wide flight.

Air Traffic Control Coordination

Air Traffic Control (ATC) coordination was critical to the flight operations. Each city represented unique challenges. Manhattan required working with Manhattan Regional Airport's ATC to coordinate the operation with local air traffic. To make the turns of the flight more efficient, the flight crew also coordinated with Fort Riley's ATC to allow the mapping aircraft to enter restricted airspace. Flights over Lawrence, Topeka, and Hutchinson were more straightforward, only requiring coordination with the local airport's ATC.

The most complicated operation was over Wichita. This city boasted the busiest airspace when compared to the other cities and required constant deviation from the mapping flight plan. Wichita was also the largest area to survey. With the flight deviations, this city's survey mission was extended to three separate days of data collection. This increased mission complexity and lead to issues when the data was processed and classified.

4.2   Data Collection Methods

Quality data collection requires a balance of ambient conditions, flight parameters, and camera settings to acquire images with sufficient exposure (brightness) and detail. Table 1 describes the adjustments of each camera setting and the effect on images.

Table 1. Camera Setting Adjustments

Setting	Increase		Decrease	
	Unique Effect	Image Effect	Unique Effect	Image Effect
Aperture	Shallow depth of field	Brighter	Extended depth of field	Darker
Shutter Speed	Reduce motion blur	Darker	Increase motion blur	Brighter
ISO	More image noise	Brighter	Less image noise	Darker

Ambient conditions proved difficult for many of the flights conducted under this agreement. Ideal conditions for capturing NIR imagery involve flying during a cloudless day and two hours before or after solar noon. Some flights took 6-8 eight hours over multiple days to complete, which put data collection outside the ideal window. Also, longer flights provided more opportunity for conditions to change, specifically clouds. Some flights began during cloudless conditions, but as the flight progressed clouds moved in.

To compensate for the change in ambient conditions, either due to change in solar elevation or clouds, the payload operator would adjust the camera settings during the flight. Capturing data outside of ideal conditions negatively affected the imagery and resulted in a more difficult classification task. Ultimately, the following settings were used:

- Aperture: f/4.0
- Shutter Speed: 1/2000 second
- ISO: 125 - ***

(Note: the ISO was adjusted to compensate for change in ambient light)

4.3 Image Processing Methods

Before processing data, the imagery was backed up using a standardized naming convention to two separate locations as a safeguard against data loss from hardware malfunction or human error. Following the flights, the data was compiled through intensive processing methods, summarized by the following workflow:

- Stitch images together and generate 3D point cloud
- Remove false points and refine point cloud
- Georeference data
- Generate 3D mesh and texture
- Generate orthomosaic and export

Using PhotoScan, the images were stitched together to generate a 3D point cloud. The initial step can generate erroneous points. These points were removed and the point cloud was refined. Next, the data was georeferenced. This was done by identifying distinguishable features in the images, such as sidewalk intersections, and associating these points with satellite locations from Google Earth. This method yielded a spatial accuracy of about 3 meters throughout the model. In the next step, a 3D mesh was generated using the point cloud as reference. A texture was then generated on the 3D mesh.

Finally, an orthomosaic was generated and exported. The orthomosaic was exported as a complete, single map of the city. Full resolution of the orthomosaic was 12 cm/pixel. In addition to full resolution, the orthomosaics where exported at lower resolutions to test in the classification process.

4.4 Orthomosaic Classification Methods

It was not practical to classify the full resolution 12cm/pixel imagery. This created orthomosaics that were too large to view and work with. By testing multiple lower resolutions, it was found that 60 cm/pixel would work for most of the cities as a compromise of resolution and file size. However, to initially identify the proper classification procedure, a subsample tile at full 12cm/pixel resolution was used to try various classification settings. Once a process was established, it was then applied city-wide on each orthomosaic.

Overview

The image classification process followed multiple discrete steps which are described at a high level in this section. A detailed step-by-step workflow for performing the classification using ENVI and ArcGIS is provided in Appendix A.

First, a vegetation index was created to highlight areas of photosynthetic activity. This was done by manipulating the NIR/Green/Blue source imagery with the following algorithm:

$$(NIR-Green-Blue) / (NIR+Green+Blue)$$

The values represented in the vegetation index map ranged from negative one to positive one. The NDVI map was then normalized to a scale of zero to positive one. Lower values represented lower

reflectance and higher values represented more. This resulted in a map with noticeable contrast between vegetation and urban content (Figure 3).
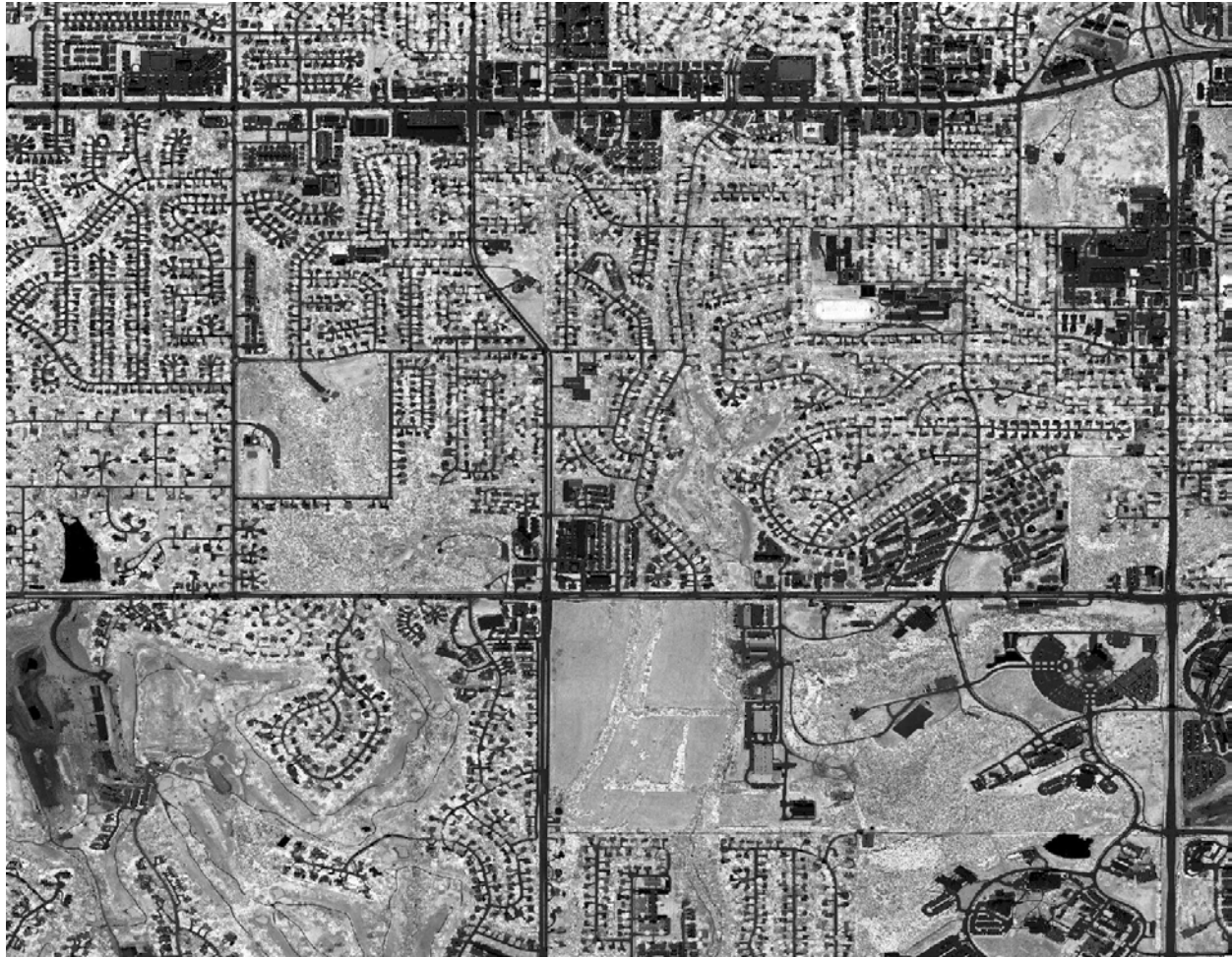

Figure 3. NDVI Map of Subsample Image Showing Levels of Reflectance

The second step was the creation of a mask. A mask denotes areas that are known to not contain target pixels and can be applied to disregard these areas. For this project, a mask was used to disregard all urban pixels because features such as roads, sidewalks, and buildings will never contain bush honeysuckle. Masking saves processing time because the software ignores these areas. The vegetation index histogram was used to identify which pixels to mask. Each city had a similar histogram with two peaks, as shown in Figure 4. In this figure, the x-axis represents intensity of reflectance and the y-axis represents quantity of pixels. The valley next to the first peak was analyzed and all pixels under this value were masked. The mask was then combined with the vegetation index and source image to create an attribute image.
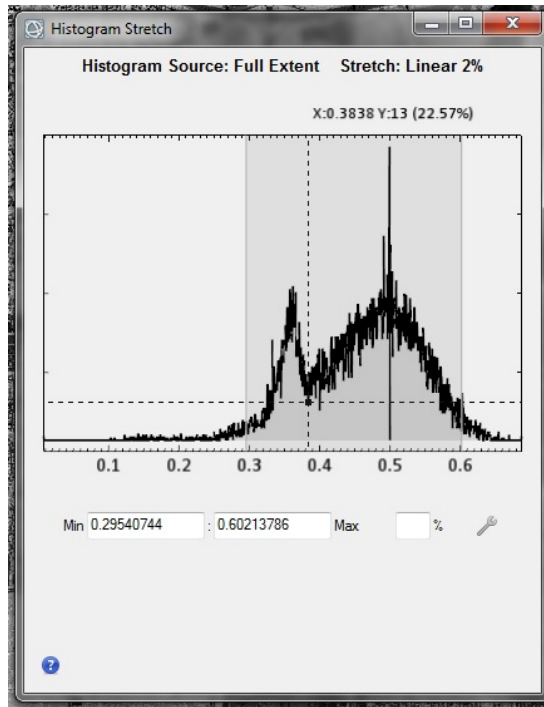
Figure 4. Histogram Showing Pixel Reflectance Distribution

The third step was the creation of an attribute image. Attribute images are core to image classification. Multiple data layers are combined into a single image. For this project, the NIR/Green/Blue source image was combined with the NDVI and mask to create a five-layer attribute image. This way each layer represented its unique signature to influence image classification. Before image classification could occur, areas containing confirmed infestations of bush honeysuckle needed to be annotated.

The fourth step involved annotating confirmed areas of bush honeysuckle and other features such as grass and dirt as needed. Bush honeysuckle was annotated by using the shape files provided by the Kansas Forest Service (Figure 5). The shape files were created by physically identifying areas of bush honeysuckle and recording the location with a GPS receiver. Some cities required the annotation of different features such as grass and dirt. These additional annotations were needed to refine bush honeysuckle classification. The annotations served as training data for the supervised classification process.

Figure 5. Shape Files Showing Confirmed Areas of Bush Honeysuckle

The fifth step was the actual classification of bush honeysuckle. There are two paths to take in image classification, supervised and unsupervised. The former requires training data, and the latter does not but instead classifies based solely on pixel characteristics. The previous work for the project utilized both methods, but the AARC only used supervised classification to take advantage of the availability of known bush honeysuckle locations.

Within the supervised classification method, there are multiple different algorithms that can be used to accomplish a classification task. Maximum likelihood was used for this project because of its simplicity. This algorithm assumes the statistics of each class in each band are normally distributed and calculates the probability a given pixel belongs to a specific class. The probability threshold can be left unset which will classify every pixel; this results in many false classifications. Other features were annotated and probability thresholds settings were adjusted to optimize accurate bush honeysuckle detection. Figure 6 shows the classification step, in which green represents grass, blue is bush honeysuckle, black pixels are unclassified, and gray pixels are masked. Ultimately, large areas of probable bush honeysuckle infestation were identified, but individual trees, and at times other vegetation, were falsely classified as bush honeysuckle. These false areas needed to be disregarded as much as possible by smoothing the classification.
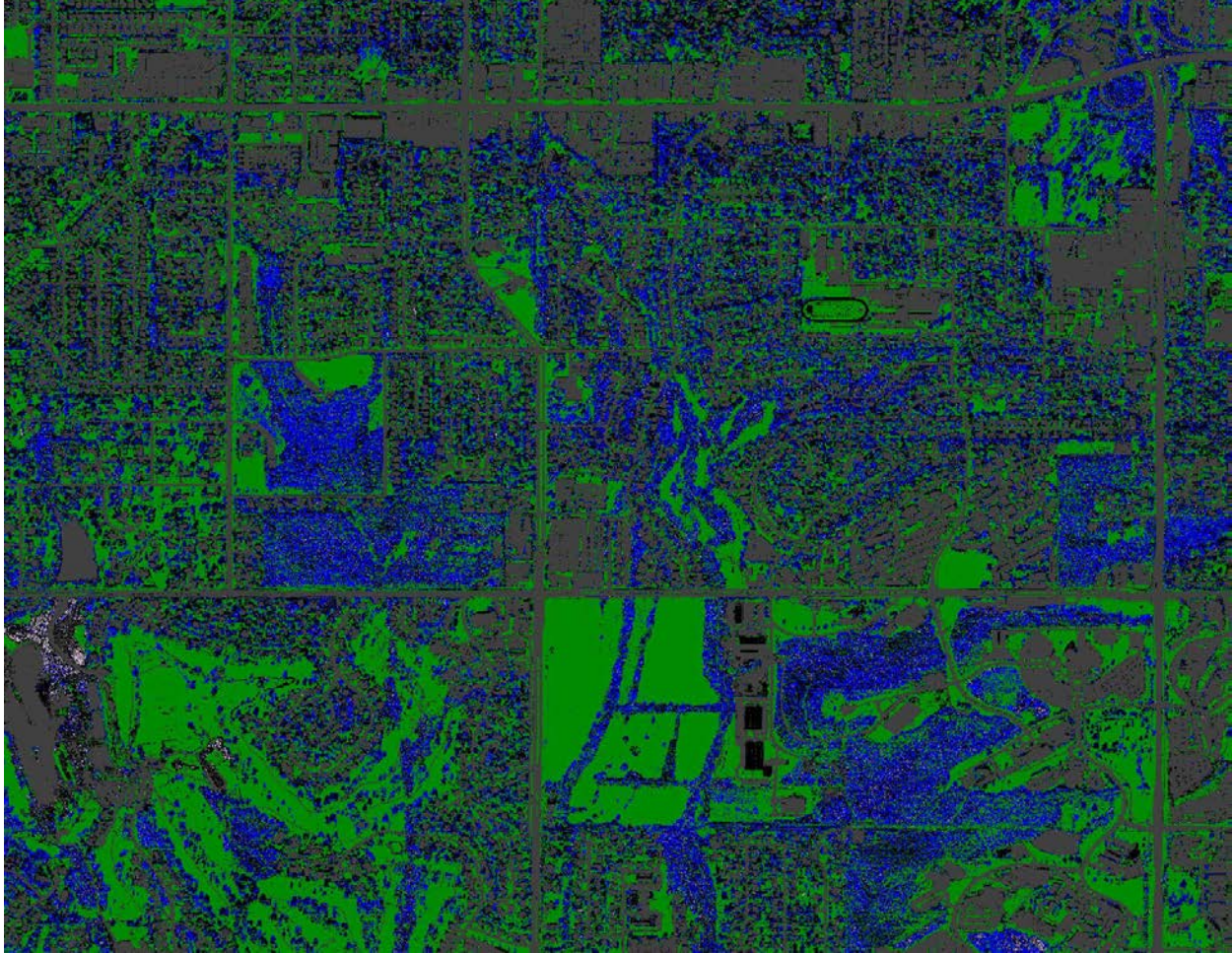
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Figure 6. Subsample Image Classification Map

The sixth and final step involved smoothing the classification to highlight and estimate coverage areas of bush honeysuckle. The first tool used in classification smoothing was "Sieve Classes." This tool looks at a center pixel's neighboring pixels and will set the center pixel to unclassified if enough neighboring pixels do not share the same original classification of the center pixel. This effectively removes small isolated pixel classifications. Converting isolated pixels to unclassified cleans up the classification by leaving only larger groupings of pixels. To highlight these areas better, the "Clump Classes" tool was then used. "Clump Classes" fills in the holes of large pixel groupings. This gives better contrast to the classified areas. By using this tool, predicted concentrations of bush honey suckle are easier to identify.

The classification process sought to make the most out of the aerial data. Through multiple classification iterations some cities garnered ideal results that clearly highlighted likely areas of bush honeysuckle. Some cities produced less favorable results, likely due to the challenges associated with leaf cover and image brightness.

Challenges

Before beginning the classification phase of this project, the AARC identified multiple challenges to properly classify bush honeysuckle. The most significant challenge was caused by trees within areas of known bush honeysuckle and the variation in leaf cover for these trees (Figure 7). The shape file locations of confirmed bush honeysuckle contained not only bush honeysuckle but also tree leaves and branches. The presence of these extra features prevented the discrete detection of bush honeysuckle pixels. Instead, anything with similar reflectance properties to the areas identified in the training areas were classified as bush honeysuckle. This produced bush honeysuckle classification in areas that were likely false.

Figure 7. Variation in Leaf Cover (Yellow: Trees with leaves; Blue: Trees without leaves)

The presence of shadows and clouds also had a significant effect on accurate classification of the imagery (Figure 8). Shadows blocked out areas that were left either unclassified, masked, or falsely classified. Camera settings were adjusted to compensate for the change in ambient light, but this still produced undesirable results. Eventually through classification refinement and smoothing, the classification maps in each of the cities produced results that made the best of undesirable source imagery.

Figure 8. Brightness Variation Caused by Cloud Cover

5   Results

The following sections provide the classification results for Lawrence, Hutchinson, Manhattan, Topeka, and Wichita. This includes a high-level, city-wide map showing areas of predicted concentrations of bush honeysuckle, as well as estimates of percent coverage area in each city. Full resolution TIFF files are provided with this report to help identify these locations. The following legend applies to the following images:

- Red = Bush honeysuckle
- Green = Grass and/or farmland
- Blue = Soil
- Black = Unclassified
- Gray = Masked

5.1   Lawrence

The Lawrence classification (Figure 9) is likely to be the most accurate due to fewer image artifacts such as lighting inconsistency and leaf variation. Of all the cities evaluated, the Lawrence orthomosaic maintained the most consistent image brightness throughout the city. This was due to the absence of clouds and a smaller city size (which avoids major changes in solar elevation). The second factor that contributed to a good image classification was good coverage of training shape file polygons which covered multiple large areas within the city. This facilitated better classification predictions within the software. Ultimately, 7.5% of the mapped area was identified as likely to contain bush honeysuckle.
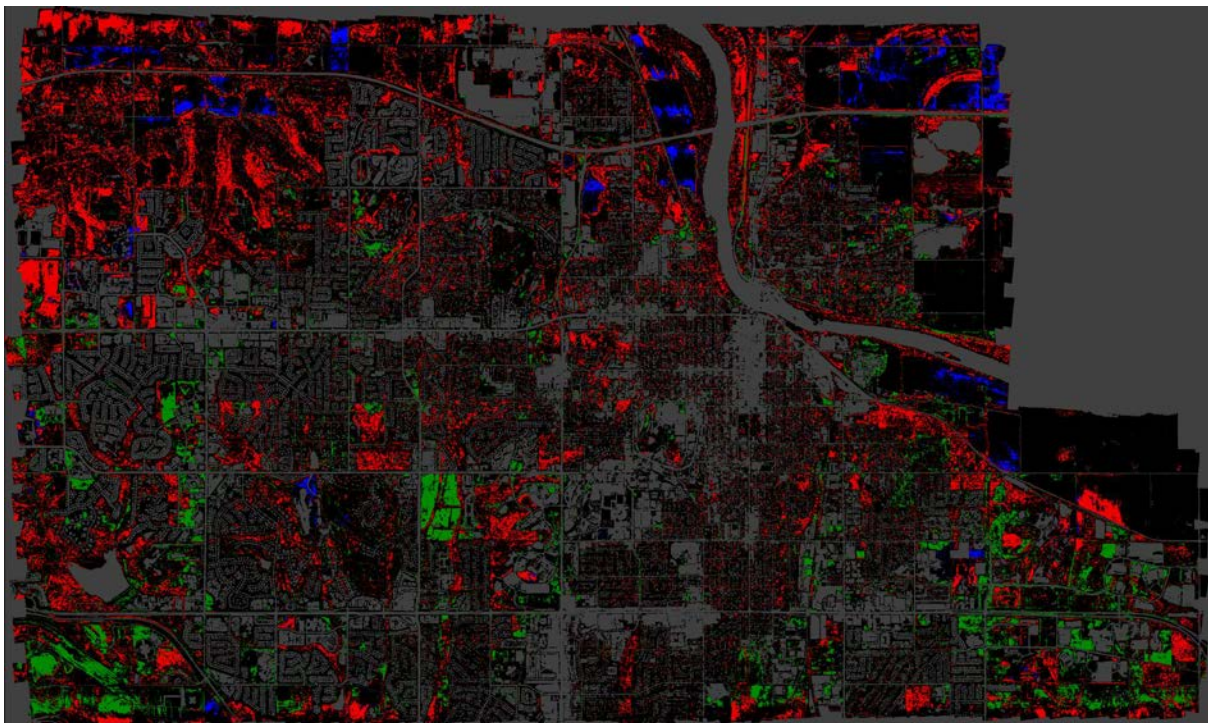

Figure 9. Lawrence Classification

5.2   Hutchinson

The Hutchinson classification (Figure 10) resulted in the smallest percentage of likely bush honeysuckle coverage, estimated as only 0.92% of the mapped area. This might be caused by the genuine absence of bush honeysuckle and/or relatively small sample of shape file polygons to train the classification.
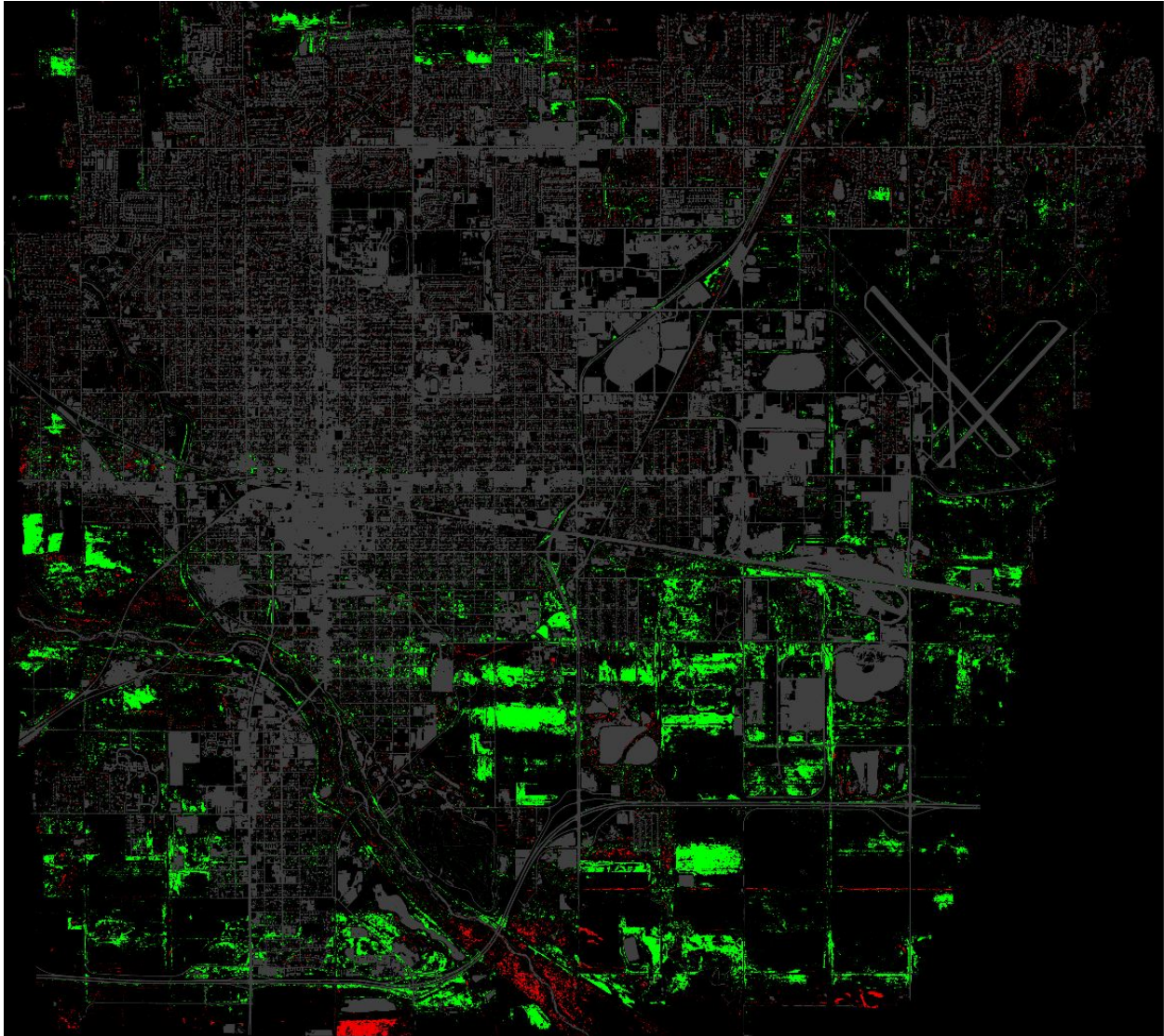

Figure 10. Hutchinson Classification

5.3   Manhattan

The percentage of bush honeysuckle classification was also small for Manhattan, with a coverage area of 1.66% of the total mapped area (Figure 11). Despite the false detection of two agriculture fields as bush honeysuckle, this estimate may be low. This is most likely due to the southern strip of the city being brighter than the rest of the source orthomosaic, and as a result, few pixels in the southern strip were identified as containing bush honeysuckle.
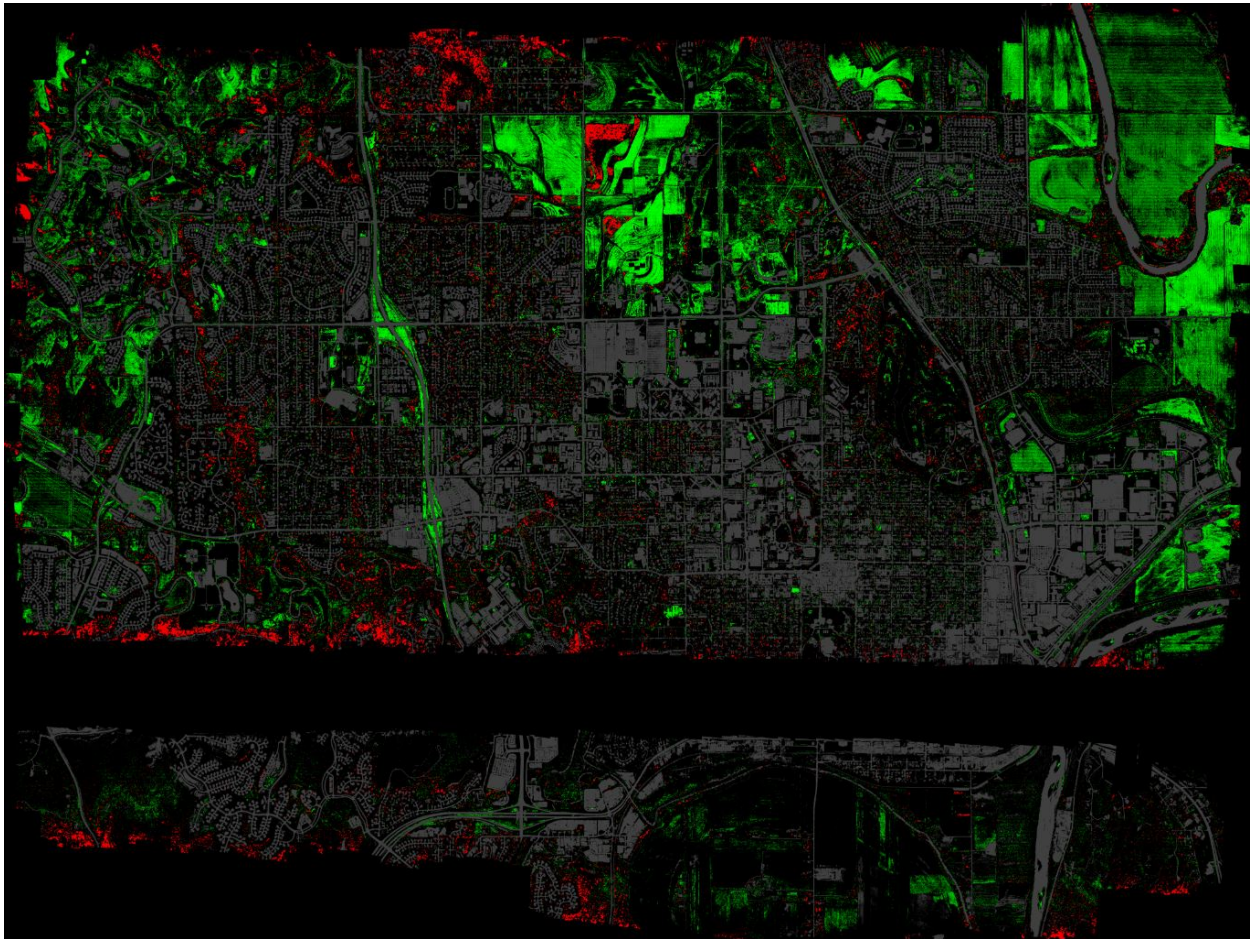

Figure 11. Manhattan Classification

5.4   Topeka

The image classification of Topeka (Figure 12) is expected to be less accurate than other cities. The source orthomosaic had extreme variety in brightness levels due to variable cloud cover on the days it was flown. Darker areas tended to contain more pixels of bush honeysuckle while lighter areas contained less. Most of the source orthomosaic was dark and this resulted in a potential overestimation of bush honeysuckle. The estimated bush honeysuckle coverage area was just under 10% of the total mapped area.
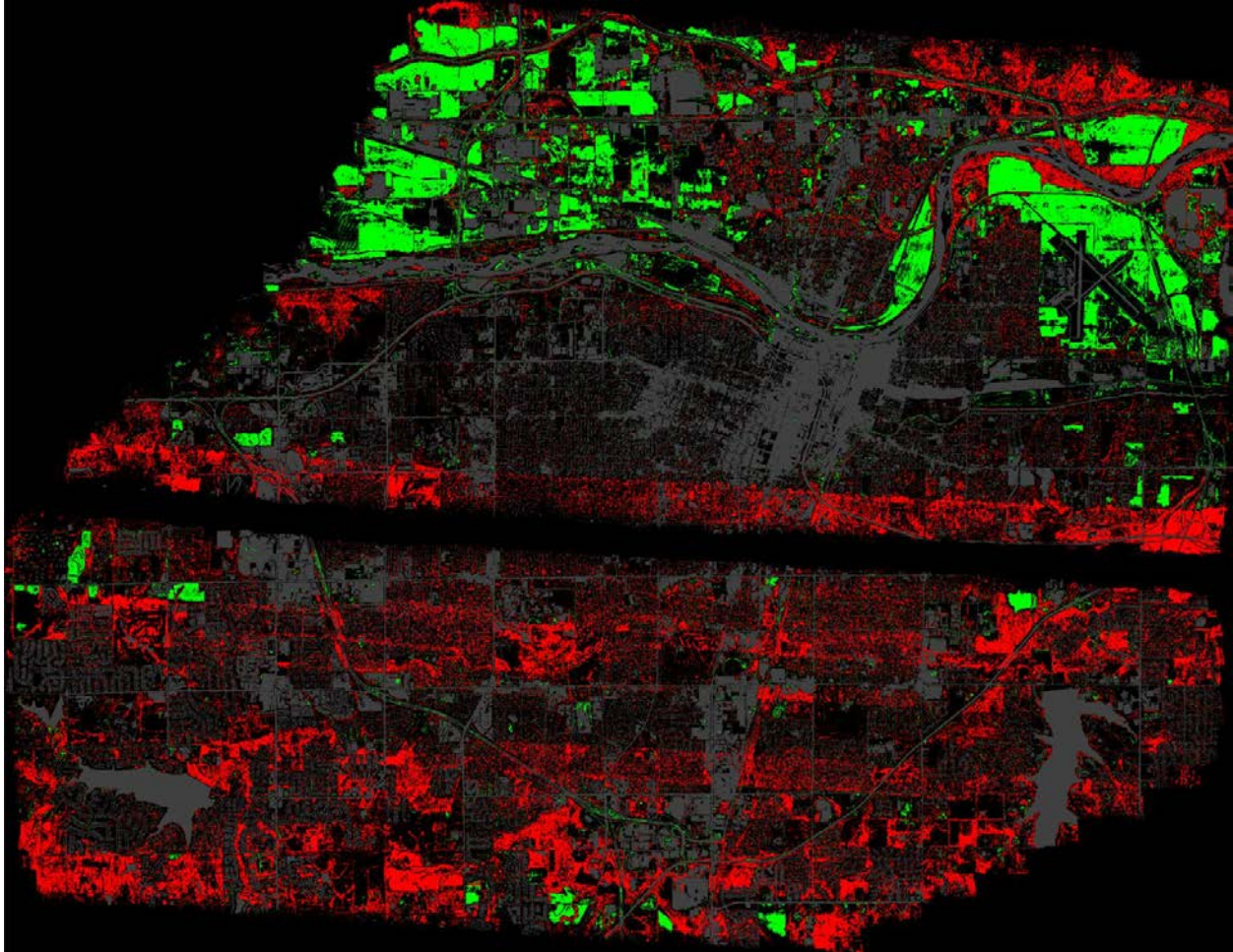
Figure 12. Topeka Classification

5.5   **Wichita**

Wichita was the largest classification task. The other four cities were resampled to 60cm per pixel, but Wichita needed to be resampled to 1m per pixel because of its geographical size. This is because the file format for exporting orthomosaics is limited to four gigabytes and exporting Wichita at 60cm per pixel would exceed that limit. Resampling reduces the amount of information used to classify the concentration areas. Although this may have negatively affected the results, other environmental factors had a more detrimental effect.

The Wichita source orthomosaic also contained darkened strips due to intermittent clouds like the Topeka orthomosaic. This adversely effected classification, especially when combined with a low number of shape file polygon training areas. Ultimately the Wichita classification showed that 1.56% of the mapped area consisted of pixels likely to represent bush honeysuckle (Figure 13).
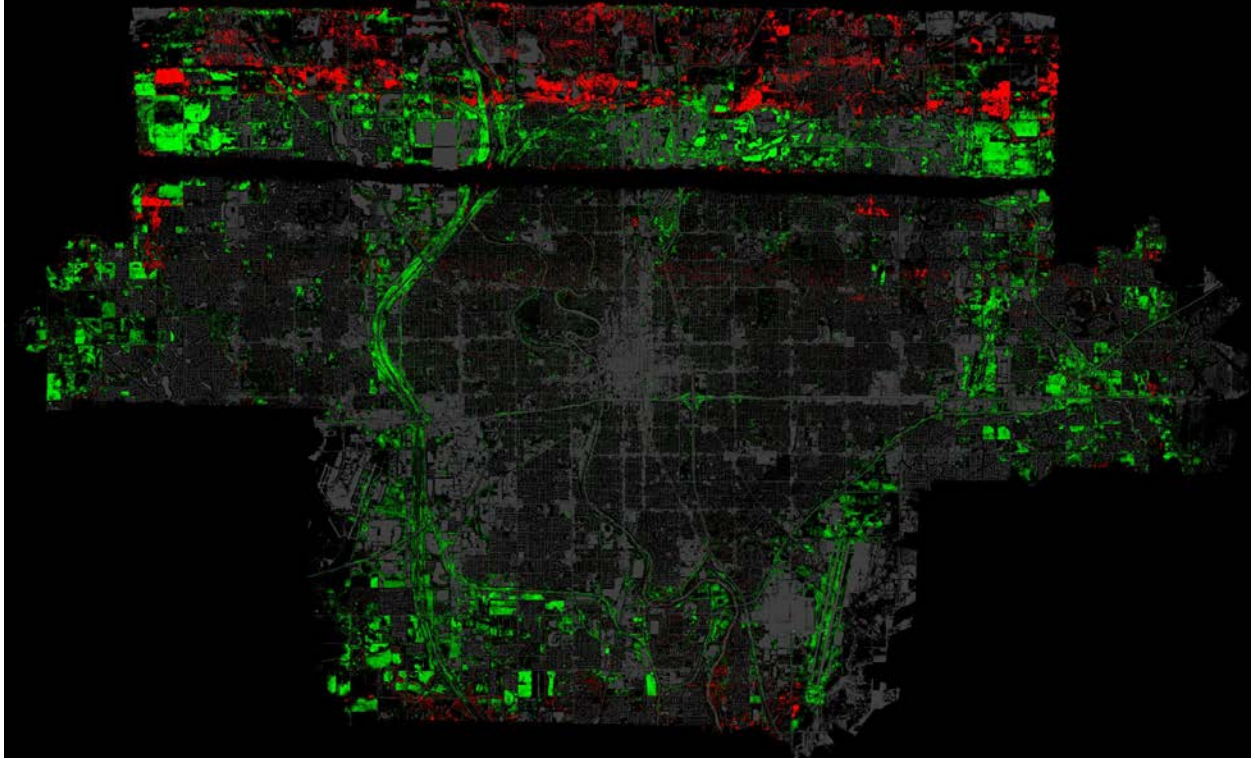
Figure 13. Wichita Classification

6   Recommendations

The main factors that negatively impacted image classification were the presence of leaves on trees and brightness variation in the source orthomosaic. These factors could potentially be mitigated by implementing these first two recommendations.

Use of a multispectral sensor could provide better source imagery than the imagery provided by the converted NIR sensor used for this project. Higher spectral resolution using multiple discrete band sensors could improve classification results by adding additional data layers. This potentially would help better distinguish between honeysuckle and other photosynthetic plant matter.

Variation in orthomosaic brightness could be minimized by spending less time in the air mapping. This would reduce the effect of solar variation and improve the chance of flying during cloud-free conditions. To spend less time flying, the mapping aircraft would need to fly higher. The consequence to flying higher is it decreases the spatial resolution of images (if the same sensor is used). If this project is further pursued, minimum spatial resolution should be determined so that the flights take less time thereby reducing variation in environmental lighting. Minimum spatial resolution could be determined by flying a sample area at multiple altitudes to collect images at multiple resolutions. It could then be determined when the resolution becomes too coarse to be usable for identifying bush honeysuckle concentrations.

An additional recommendation pertains improvement of flight operations. On the 172S Skyhawk used for this project, the two-axis autopilot and external flight plan display allowed the pilot to trace the flight tracks shown on an external display. This technique works most of the time, but it provides a large opportunity for pilot error. The biggest error that occurred was missed flight lines, which resulted in gaps in map coverage. This problem could be reduced and potentially eliminated with mapping mission software. This software can be loaded directly to the aircraft and used to control the aircraft during the mapping mission. The purchase of this software would further improve the pilot's situational awareness and ensure consistent and complete data sets.

It is recommended that the Kansas Forest Service validate the classification maps produced by the AARC. This would be accomplished by physically traveling to identified concentration areas and either confirming or disproving the classified area of bush honeysuckle. The AARC could then use this information to potentially improve classification techniques to improve detection accuracy. Ultimately, the ability to apply the classification techniques to publicly available satellite imagery needs to be tested. This way decision makers can have a method to help guide bush honeysuckle management regardless of the available budget for high resolution imagery.

Appendix A

Bush Honeysuckle Image Classification Workflow

Tip: Take good notes when classifying an image. Also, be sure to keep a consistent file naming convention, as this will help organize the process.

Software: ArcMap

Step 1: Create NDVI

- Right click "Layers" within the Table of Contents.
- Navigate to the source orthomosaic Tiff file.
- Import first three layers of tiff file (source orthomosaic). Double click the file, and select the first 3 bands.
- Toolbox→spatial analyst→map algebra→raster calculator
- Use algorithm (Float (Band1-Band2-Band3)) / (Float (Band1+Band2+Band3)).
- NOTE: Parenthesis are critical.
- Save under file naming format: [Location]e3ndvi[resolution]

Step 2: Normalize NDVI (scaling 0-1 instead of -1-1)

- Back to raster calculator
- Use algorithm ("file.name" - "file.name".minimum) / ("file.name".maximum-"file.name".minimum).
- Save under file naming format: [Location]e3n[resolution]
- Right click on layer and select "data-export data" ([location]e3n[resolution]1) – Make sure to select correct export location.
- Save ArcMap file under file naming format: Forestry [Date] [Location]

Software: ENVI

Step 3: Load and Visualize Files

- Open source orthomosaic (Naming convention varies)
  - This will open blue, need to select the first three bands in order (right click on layer—select "Change RGB Bands"—select band 1, 2, and 3 in that order)
- Open NDVI ([location]e3n[resolution]1)
- Location Shape file (typically named: [Location]_Locations.shp)

Step 4: Create Mask

- For reference, view Histogram using the toolbar at the top (example below). Find minimum mask value using the bottom of the first peak.
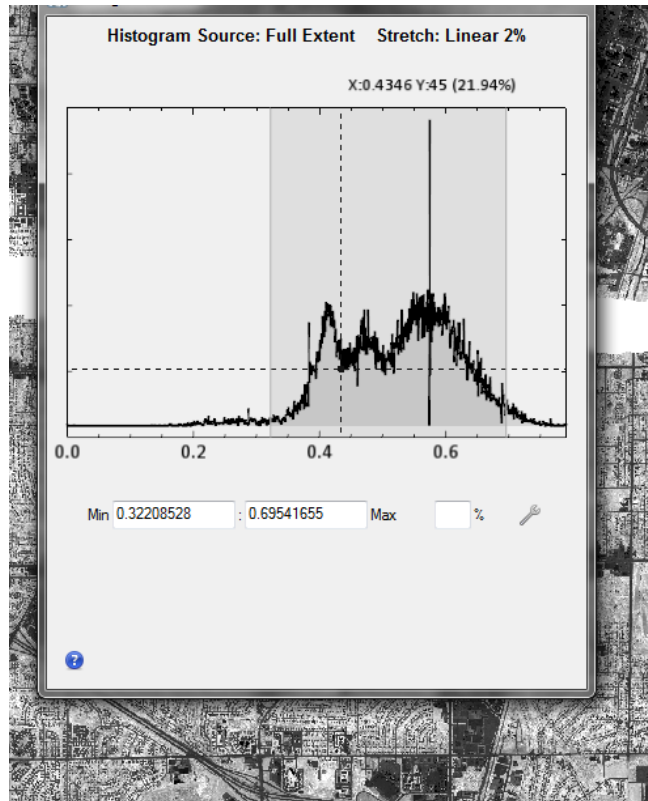
- Type in toolbox: "mask" select "build mask"
- Select NDVI file, select "OK"
- Options→Import Data Range→Select file again→input the X coordinate of the low value after the peak for minimum (for this example it would be 0.4346- see arrow above) —set maximum to 1
- Select Output destination and filename (naming convention: "[Location][resolution]mask"

Step 5: Stack Layers

- Type into toolbox "Stack" select "Layer Stacking"
- Select "Import File"
- First import the NIR, G, B tiff, but only select the first three bands (do this by clicking on the file once, selecting at the bottom the "Spectral Subset" box and select Band 1, 2, and 3) Select OK. Import this file first then go back and import the NDVI, and mask ENVI.
- Once all 5 bands are imported, enter the Output Filename (and location) (typical name convention: [location]stack).

- NOTE: Once this is complete. it only displays one band, but the others are in there.

Step 6: Annotate Bush Honeysuckle (and other Regions of Interest (ROI))

- NOTE: The Locations shape file must be layered on top of the stack in the Layer Manager toolbar to be able to see where those shape files are (you can drag it to the top).
- If the shape files are hard to see, change the color by right clicking on the layer and select "Properties" Select the first "Line Color" tab to change it, and to fill in the shapes, select "Fill Interior" and select "True." This color can also be changed in the tab right below it "Fill Color."
- Select "Region of Interest (ROI) Tool" at the top of the toolbar.
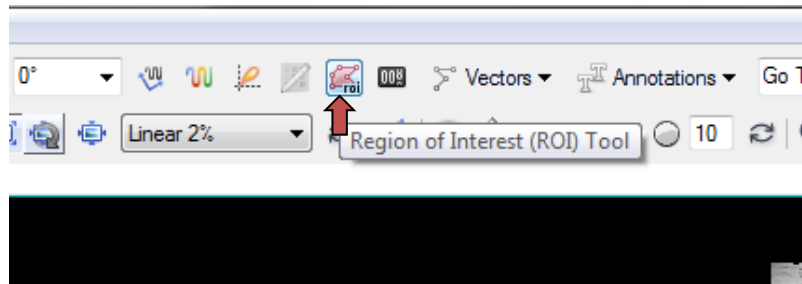
- Select "New ROI" in the window that comes up.
- Name it Bush Honeysuckle and change the color if applicable (Probably want a different color than the shape file color)
- Use the shape files and RGB, G, B tiff to create the ROIs.
- NOTE: I found it easier to un-fill the location shape files during this process (right click on file – "Properties" – "Fill Interior" – "False")
- Make sure to save ROIs (File—Save as—enter output file (Naming convention: [Location]roiBushHoneysuckle)
- Repeat for Grass ROIs if applicable.

Step 7: Classification

- Click Toolbox→Classification→Supervised Classification→Maximum Likelihood Classification
- Click on the mask file and at the bottom click "Select Mask Band," select the mask file, and hit "OK"
- Select "OK"
- Select the stack file under "Select Input File:" and hit OK
- Select "Bush Honeysuckle" and "Grass" (or other ROI(s)) under "Select Classes from Regions:"

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- Set the Probability Threshold between 0 and 1 (how certain do you want the software to be that the pixel it is classifying is correct?)
- Beside "Enter Output Class Filename" click "Choose" and select your file saving location and name using the convention [location]class[number of attempt]

Step 8: Classification Smoothing

- Toolbox→ Classification→ Post Classification → Sieve Classes → Select Classified file → Select Pixel Connectivity (as needed), Class Order, Minimum Size → Save as using the classification file name and "Sieve" at the end.
- Toolbox → Majority/Minority Analysis (Clump Classes) →Select the recently created "Sieve" file → Select classes, set to Majority, adjust the kernel size and pixel weight as needed → Save as using the classification file name and "Major" at the end.
- Analyze the classification map to see if it fits desired results
- If it does not fit desired results, adjust settings within "Sieve" and "Majority/Minority Analysis" and try again.