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ESCI-442
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March 7, 2014

Image Segmentation and Unsupervised Classification of Acme, WA

Abstract

In this study, a WorldView-2 Satellite image of Amce, WA, was segmented using both 8-bands and 4 bands. The resulting images were then classified using an unsupervised Isodata classification. The resulting spectral classes were then assigned information classes for both images. An accuracy assessment and confusion matrix was generated by cross-referencing the resulting classified images with ground truth data. An accuracy of 59.7% was achieved for the 8-band image and an accuracy of 60.4% was achieved for the 4-band image. The classification was successful, and a great deal of efficiency an accuracy was gained through the use of segmentation. Further analysis could be applied in order to achieve more accurate results.

Methods

Data:

For the purposes of this lab, one subset of larger image of the area around Acme, WA was used. The image was taken using a WorldView-2 Satellite. The sensor has 8 bands (Coastal, Blue, Green, Yellow, Red, Red Edge, Near Infrared-1, and Near Infrared-2) ranging in wavelength from 0.40 um to 1.04 um. The image has a spatial resolution of 1.8 meters for the 8 bands and additionally it has a resolution of .46 meters for the panchromatic image. It has a radiometric resolution of 11 bits per pixel. The image this project is working with has 67,113,030 bytes and is 2,048 pixels by 2,048 pixels. The projection of the image is UTM Zone 10 North and is using a WGS 1984 Datum. The image was not resampled (imported using nearest neighbor) for any of the following analysis. (Satellite Image Corporation, 2014)(Wallin, 2014)

Figure 1: WorldView-2 Image of the Study Area near Acme, WA

Analysis:

Image Segmentation was applied to the image in order to group like values of pixels. This process was done two times, first with all 8 bands and then with just 4 bands (WV-2 bands 2: Blue, 3: Green, 5: Red, and 7: Near IR-1). Each time the segmentation was done to the image, specific parameters were given. The same parameters were applied to both segmentations. The first was to limit the segment areas to 25 pixels or 100 m^2. The second was to require the segmentation process to operate in a fashion in which it grew out from a pixel in search of other pixels that had values similar to its own. The value of the surrounding pixels had to be within 10 to be included in the segment. The value was determined by analyzing the Mean and Standard Deviation of "brightness" in each of the bands. After the segmentation had been achieved in the 2 cases (8 bands and 4 bands) the two resulting images were run through an ISODATA classification. The area, mean brightness for each band, and the covariance matrix were calculated for each segment in the images. These results were used to classify the segments. Segments that had a likeness of at least 75% were then assigned to the same spectral classes. From here each of the images then had their respective spectral classes assigned to information classes using the image in true color, and IR form for reference. The information classes were as follows: Water, Pasture, Crops, Farm Buildings, Recent Clearcut, Conifer Forest, and Rock/Gravel/Soil. Additionally, the 8 Band image had a Deciduous Forest information class, whereas the 4 Band Image did not. Once the classes had been assigned the resulting image was cross referenced against ground truth data in order to generate a confusion matrix and assess the accuracy of the classification. All Methods are from: (Anotnova and Wallin, 2014)

Results

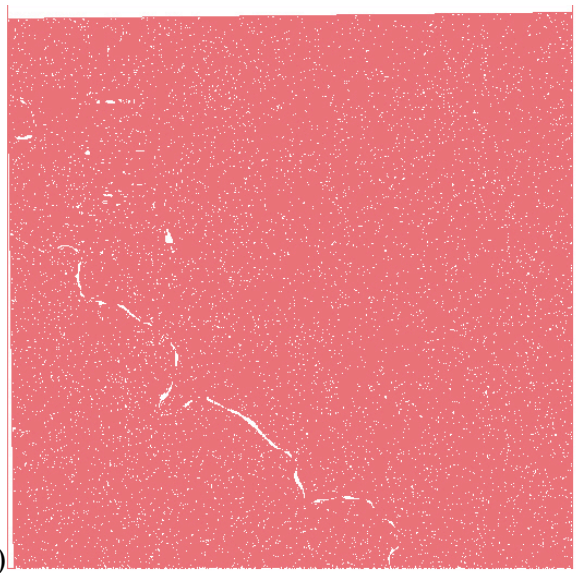
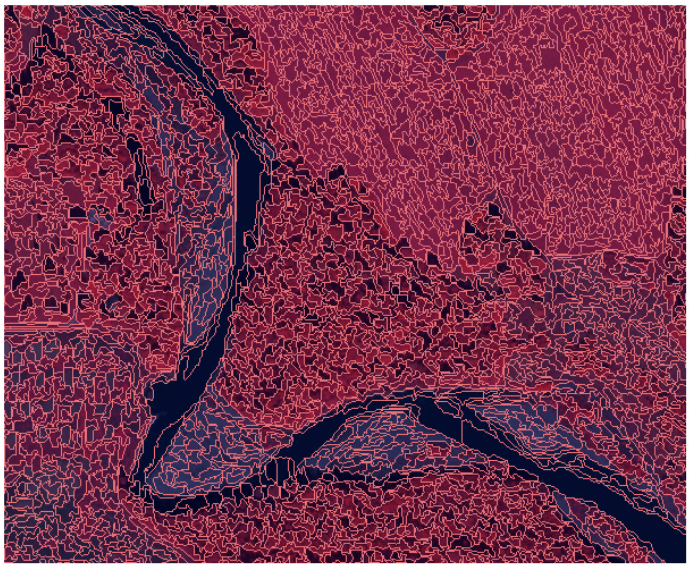
a)  b) 

Figure 2: The 8 band WV-2 Image Segmentation: a) The full extent of the image. b) The image zoomed in on the Nooksack River, displaying individual segments.

The image in Figure 2 is the area surrounding Acme, WA segmented by the 8 bands of the image. Section a) of Figure 2 is the full extent of the image and thus not much can be deciphered from it. The individual segments seen in section b) were analyzed and classified based on the segments spectral values.

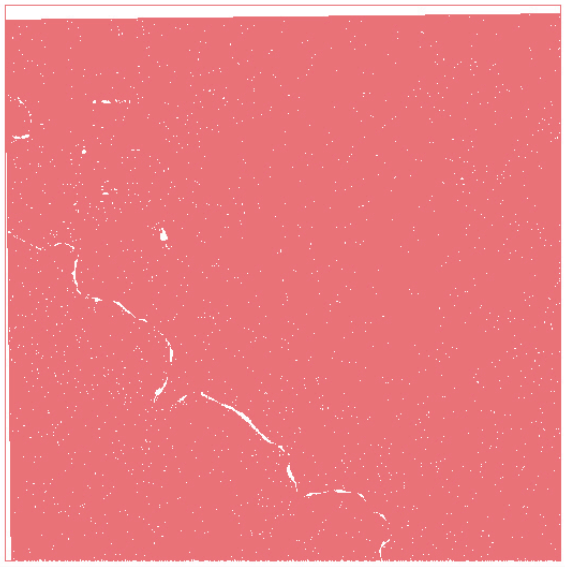
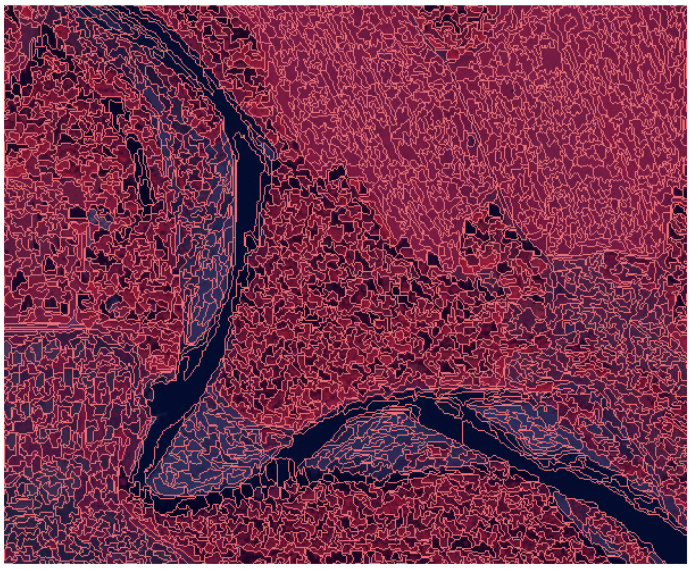
a)  b) 

Figure 3: The 4 Band WV-2 Image Segmentation: a) The full extent of the image. b) The image zoomed in on the Nooksack River, displaying individual segments.

Figure 3 represents the same results depicted in Figure 2, however the segmentation was applied only using 4 Bands. (The only reason for inclusion of Figures 2 & 3 are for the purposes of demonstrating the analysis done in Spring before using previously classified images for the remainder of the analysis.)

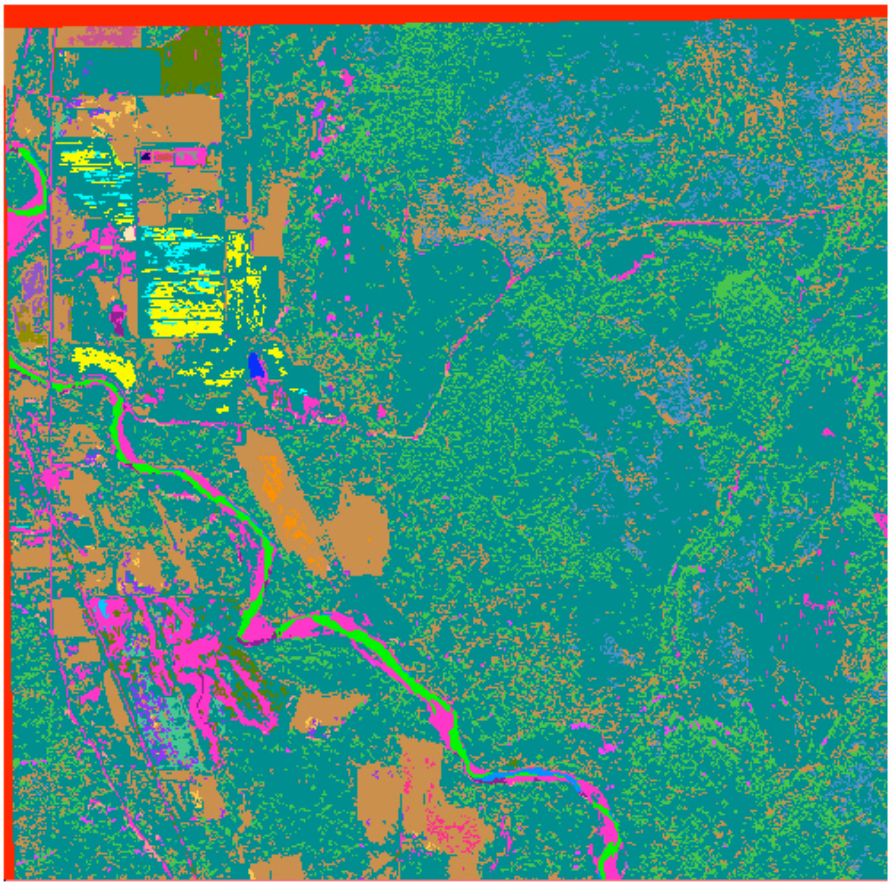


Figure 4: Isodata Classification of a World View -2 satellite image of Acme, WA using 8 bands. Isodata Classification was done in SPRING.

The image seen in Figure 4 is the result of the original WV-2 Satellite Image segmented and then classified, resulting in the 30 spectral classes.

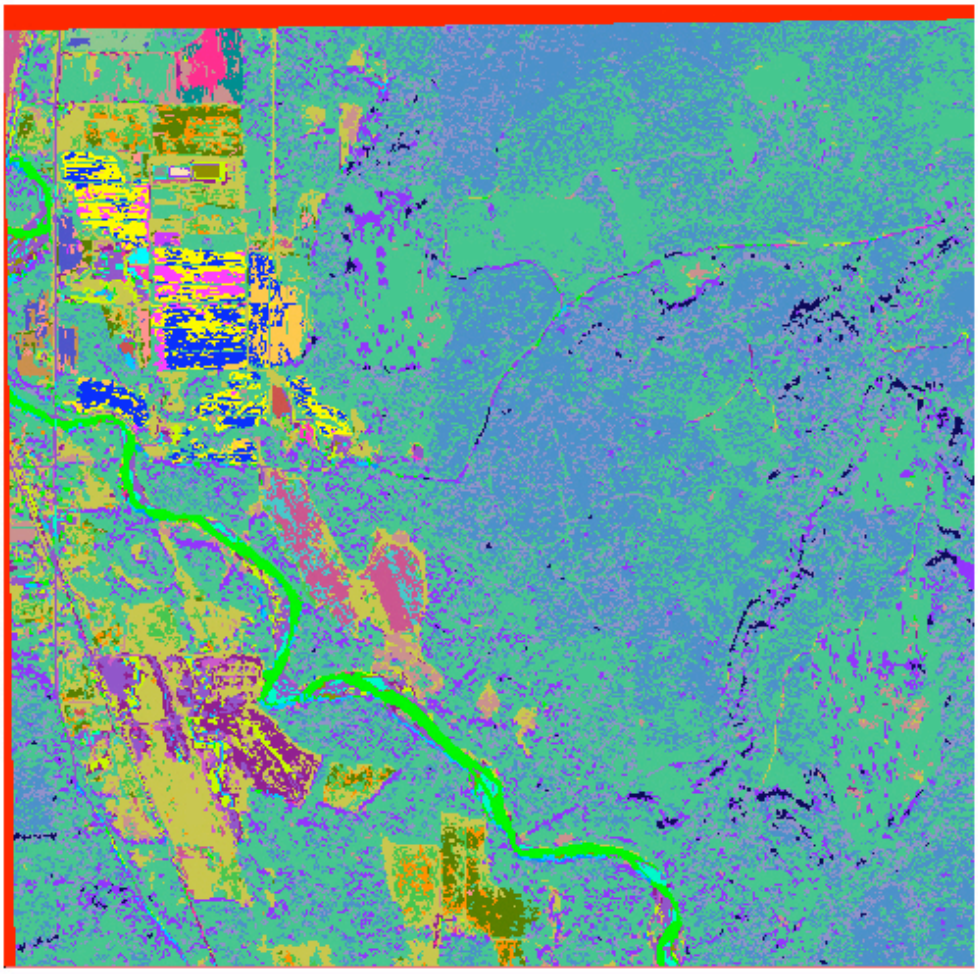


Figure 5: Isodata Classification of a World View -2 satellite image of Acme, WA using 4 bands. Isodata Classification was done in SPRING.

The image seen in Figure 4 is the result of the original WV-2 Satellite Image segmented and then classified, resulting in the 37 spectral classes.

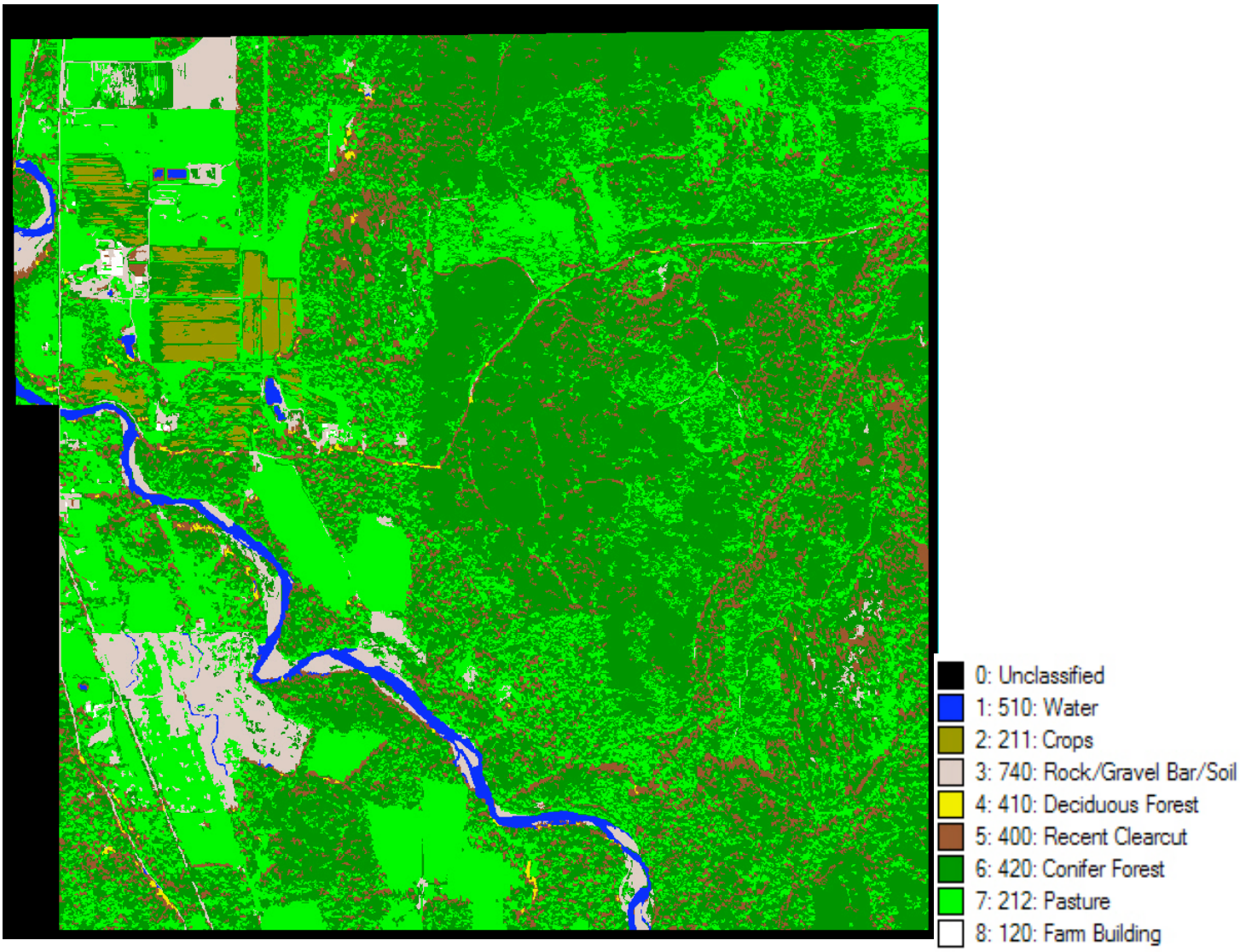


Figure 6: 8 Band Isodata Classification of Acme, Wa

Acme Classification Confusion Matrix - 8 Band Image

redicted lass	Ground Truth (Reference Data) Farm Building	Crops	Pasture	Clearcut	Deciduous	Conifer	Water	Rock/Gravel/Soil	Row Total	User's Acc (%)	
arm Building	8	0	0	0	0	0	0	0	8	100.0	Farm Building
rops	0	7	0	0	0	0	0	0	7	100.0	Crops
asture	0	0	16	6	3	1	2	0	28	57.1	Pasture
learcut	0	0	0	1	1	0	0	0	2	50.0	Clearcut
eciduous	0	0	0	0	0	0	0	0	0	0.0	Deciduous
onifer	0	8	0	13	14	29	0	1	65	44.6	Conifer
/ater	0	0	0	0	0	0	7	0	7	100.0	Water
ock/Gravel/Soil	0	1	0	0	0	0	0	6	7	85.7	Rock/Gravel/S
olumn Total	8	16	16	20	18	30	9	7	124	Total Samples	
									74	Total # Correct	
rod Acc (%)	100.0	43.8	100.0	5.0	0.0	96.7	77.8	85.7	**59.7**	**Overall Accuracy**	

Table 1: 8 Band Isodata Classification Confusion Matrix for Image of Acme, WA

In Figure 6, the Image, segmented and classified with 8 bands has had each of the 30 spectral classes assigned to the above information classes. In Table 1, the accuracy of 59.7% can be viewed. The strongest User's accuracy occurred in the assigning of Water, Farm Buildings, and Crops, whereas Deciduous and Conifer Forest achieved the lowest accuracy scores. The results differed however when looking at the Producer's Accuracy, where both Pasture and Conifer (both of which below 60% in the User's Accuracy) achieved accuracies of over 90%.

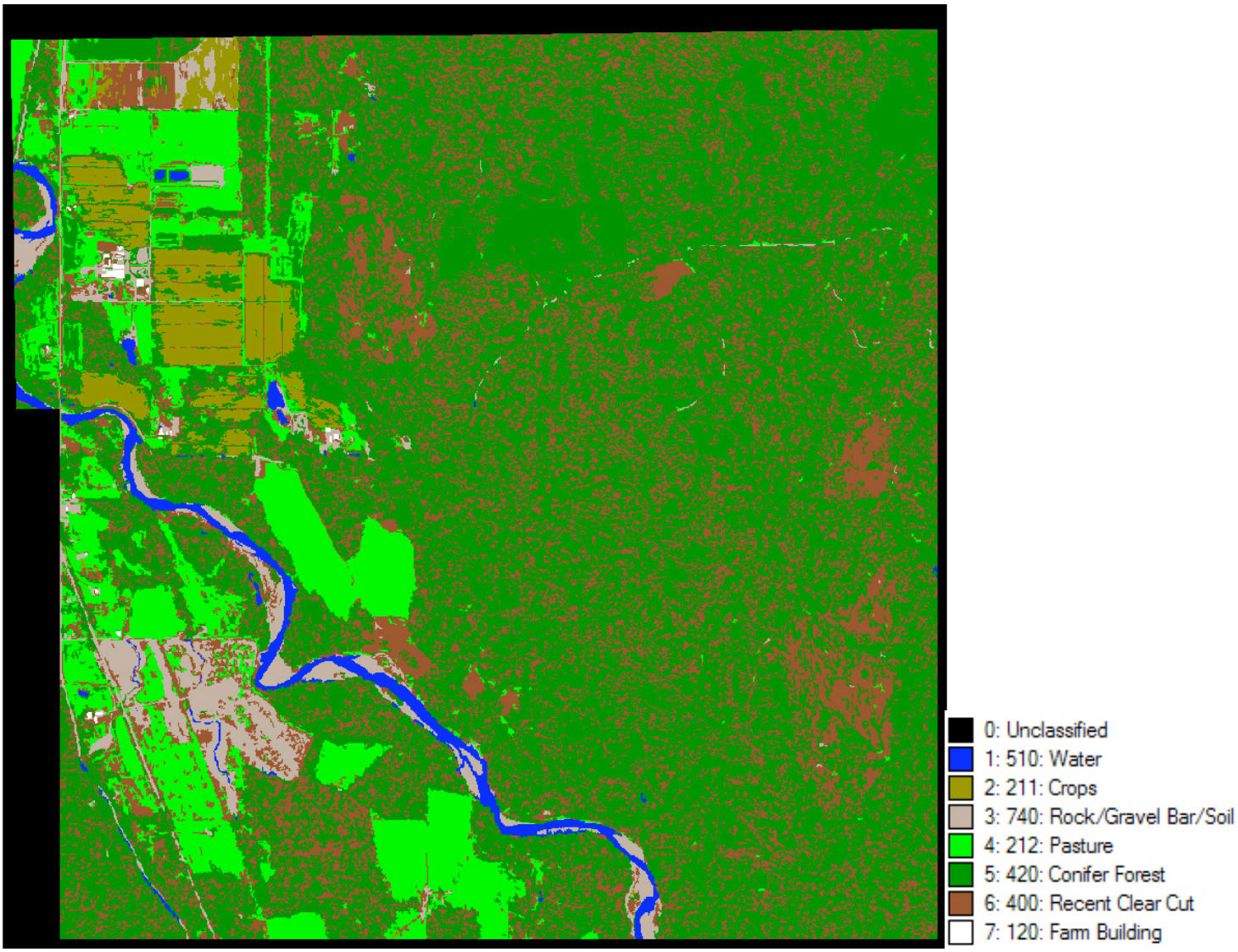


Figure 7: 4 Band Isodata Classification of Acme, WA

Acme Confusion Matrix - 4 Band Image

edicted	Ground Truth (Reference Data)							Row		User's	
ass	Farm Building	Crops	Pasture	Clearcut	Conifer	Water	Rock/Gravel/Soil	Total		Acc (%)	
rm Building	5	0	0	0	0	0	0	5		100.0	Farm Building
ops	0	9	0	0	0	0	0	9		100.0	Crops
sture	0	0	8	0	0	1	0	9		88.9	Pasture
earcut	2	1	0	8	9	0	0	20		40.0	Clearcut
nifer	0	6	8	12	21	1	1	49		42.9	Conifer
ater	0	0	0	0	0	7	0	7		100.0	Water
ck/Gravel/Soil	1	0	0	0	0	0	6	7		85.7	Rock/Gravel/So
lumn Total	8	16	16	20	30	9	7	106	Total Samples		
								64	Total # Correct		
od Acc (%)	62.5	56.3	50.0	40.0	70.0	77.8	85.7	**60.4**	**Overall Accuracy**		

Table 2: 4 Band Isodata Classification Confusion Matrix for Image of Acme, WA

In Figure 7, the image is seen with the 37 spectral classes assigned to information classes. The results of the image are similar to what is seen in Figure 6, however much of what was assigned as Pasture has been assigned as either Conifer Forest or Clearcut. Additionally the class of Deciduous Forest is seen in Figure 7. In Table 2, a higher accuracy was achieved with 4 bands as opposed to 8. The increase was slight only by .7%, but an increase nonetheless. When looking at the individual classes, the Farm Building, Crops, and Water remain perfect in the User's Accuracy, however the much of the Producer's Accuracy is more evenly dispersed, with a notable absence of either 100% or 0%.

Discussion

The classification was successful, and overall the segmentation led to a higher accuracy than any previous classification performed in any previous studies. Albeit this study was done on a smaller study area and the image had a much higher spatial resolution, which no doubt led to a higher accuracy. While the study did achieve relatively high accuracy, it does indeed have room for improvement. A further step to improve the results could be to run the classification of the eight band again and drop the deciduous category. One spectral class was assigned as deciduous and it failed to match any of the ground truth data. The points of ground truth data that were deciduous were mainly misclassified as conifer, however it seems likely that if some of the spectral classes that were originally classified as conifer, were reclassified as deciduous, there would likely be a large misclassification of conifers. The spectral classes that were forest were usually large, significant areas, and the area had to be classified as what constituted as the majority of the area, in this case conifer. However when observing the image in true color or IR there are many deciduous trees interspersed in the conifer forest (it is evident due to the September date of the image), and while these are classified by ground truth as deciduous, any assignment of these spectral classes in these areas would result in an error in some fashion. To best minimize the error, conifer should be selected and deciduous would be omitted completely.

To further improve results, the study could be rerun on another image of the same area at a different time and date. The image used in the study had multiple spectral classes that were shadow and not any features actually on the ground. In both cases of the 4-band image and the 8-band image, the

shadow spectral classes were classified as conifer forest as the majority of these shadows were due to differences in canopy height. This being said, many of the shadows fell on areas right outside of the forest which were in fact clear cut, water, pasture, or crops; or in many cases the objects casting the shadows where not forest but rather buildings, or other land features. To reduce the shadows on the image, an image could be used that is closer to the equinox and taken closer to noon when the shadows are at a minimum.

Another tool that could be used to better the accuracy would be to take the classification images and run additional GIS to further set parameters for information classes. In the 4-band image, which had the higher accuracy, the least accurate information class was clearcut. When observing Figure 7, it is evident that many of the pixels of the clearcut were located in the western part of the image, near areas of development and agricultural use. Setting parameters such as clearcuts must be a set distance away from agricultural land, development, or a specific distance near an existing forest would improve the accuracy of this class. Similar processes could be applied to other classes.

The methods applied did achieve the desired results. Segmentation improved classification and the clustering of like pixels do help with the grouping of like features on the ground. There was limited difference between the 8-band and the 4 band image, however the 4-band segmentation did result in the production of more spectral classes, which could cause the higher accuracy. It stands to reason that the more spectral classes there are, the smaller the areas, and therefore the lower the chances an area would consist of more individual information classes resulting in inaccuracy. Considering this notion it may be beneficial, to decrease the similarity value of 10, or the area of 25 pixels. This would result in a more intensive process of classification, but may result in a higher accuracy.

In addition to having slightly better accuracy, the 4-band image, provides a better visual (seen in Figure 7) of how the study area is broken up. Figure 6, in comparison would lead the viewer to believe that much of the eastern part of the image consists of pasture, rather than the forest or cleared forest of which it actually is. If the process were to be repeated, this study could serve as a model for repetition, although perhaps a recommendation of only using high spatial resolution data (a LandSat image may ruin into issues during segmentation) and only using 4 bands.

Literature Cited

Antonova, N. & Wallin, D. 2014 *Lab 8: Image Segmentation with Spring and ENVI: WorldView-2, 8-band image of Acme, WA.* ESCI 442/542: Introduction into Remote Sensing < http://staff.wwu.edu/antonon/envr442/ENVI/442_segmentation_ENVI_acme2.htm>

Satellite Imaging Corporation. 2014 *Worldview-2 satellite sensor*. <http://www.satimagingcorp.com/satellite-sensors/worldview-2.html>

Wallin, D. 2014 *Partial Listing of Similar Sensors* ESCI 442/542: Introduction into Remote Sensing <http://faculty.wwu.edu/wallin/envr442/442_highres_sat_info.htm>