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ESCI-442

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February 19, 2014

Change Detection Using Unsupervised Classification: Whatcom County Forests from 1988 to 1995

Abstract

Using Landsat imagery of the Bay to Baker study area of Whatcom County from 1988, 1992, 1995, a change in forest harvest was detected. The study used unsupervised classification to break the area into three distinct categories of alteration from 1988 to 1995: No Change, Timber Harvested between 1988 and 1992, and Timber Harvested between 1992 and 1995. Results indicated that most of the area remained unchanged, and more timber harvest occurred between 1988-1992 than from 1992-1995. The results evaluated in the realm of forested area only and then evaluated in terms of land ownership. The study was effective in singling out and quantifying areas of change, yet some issues could be taken with the percentages totals of forested land, as the data determined here was cross-referenced with rather inaccurate LULC Classification data.

Methods

Data Used:

This study used 6 Landsat images all of the Bay to Baker study area. All images had been georectified and contained 6 Thematic Mapper spectral bands. The images in UTM zone 10N, datum: NAD27, were taken during the summers of 1988, 1992, and 1995. Another image, the change image (16 bits) included data subtracting brightness and greenness images from 95-92, and 92-88. In addition another Landsat image was used to determine the different ownership values of land for the study area. Lastly a LULC image from a previous study was brought used in order to determine the total amount of forested land in the image.

Analysis:

To begin the analysis, an ISODATA Unsupervised Classification was performed on the "Change" image to classify the image into 50 distinct spectral classes. Each of the 50 spectral classes was then individually evaluated to determine which of the 3 information classes it should be assigned to. The three information classes were as follows: 1. No Change from 1988 to 1995, 2. Timber Harvest occurred from 1988 to 1992, and 3. Timber Harvest occurred from 1992 to 1995. The spectral classes were assigned by cross-referencing spectral classes against infrared images of 1988, 1992, and 1995. The area for each spectral class was evaluated based on a combination of visual analysis and examination of spectral values for each of the years of interest. Once each spectral class was assigned an information class, areas of elevations below 100 meters and above 1500 meters were excluded from the study in order to minimize error in which change had been attributed to either cropland change or snowmelt change. Further narrowing down of the study was done by eliminating any areas of change smaller than 2 hectares, as any areas smaller would most likely have been a result of natural forest disturbance and not harvest. Lastly any areas in which harvest had occurred, yet areas of no change appeared to be present within areas of change were reclassified as an area of harvest.

In addition to further summarize the results, Coniferous, Deciduous, and all Clear Cut areas of the LULC image were combined in order to determine the total amount of forested area within the study area. All methods were taken from: (Antonova and Wallin, 2014)

Results

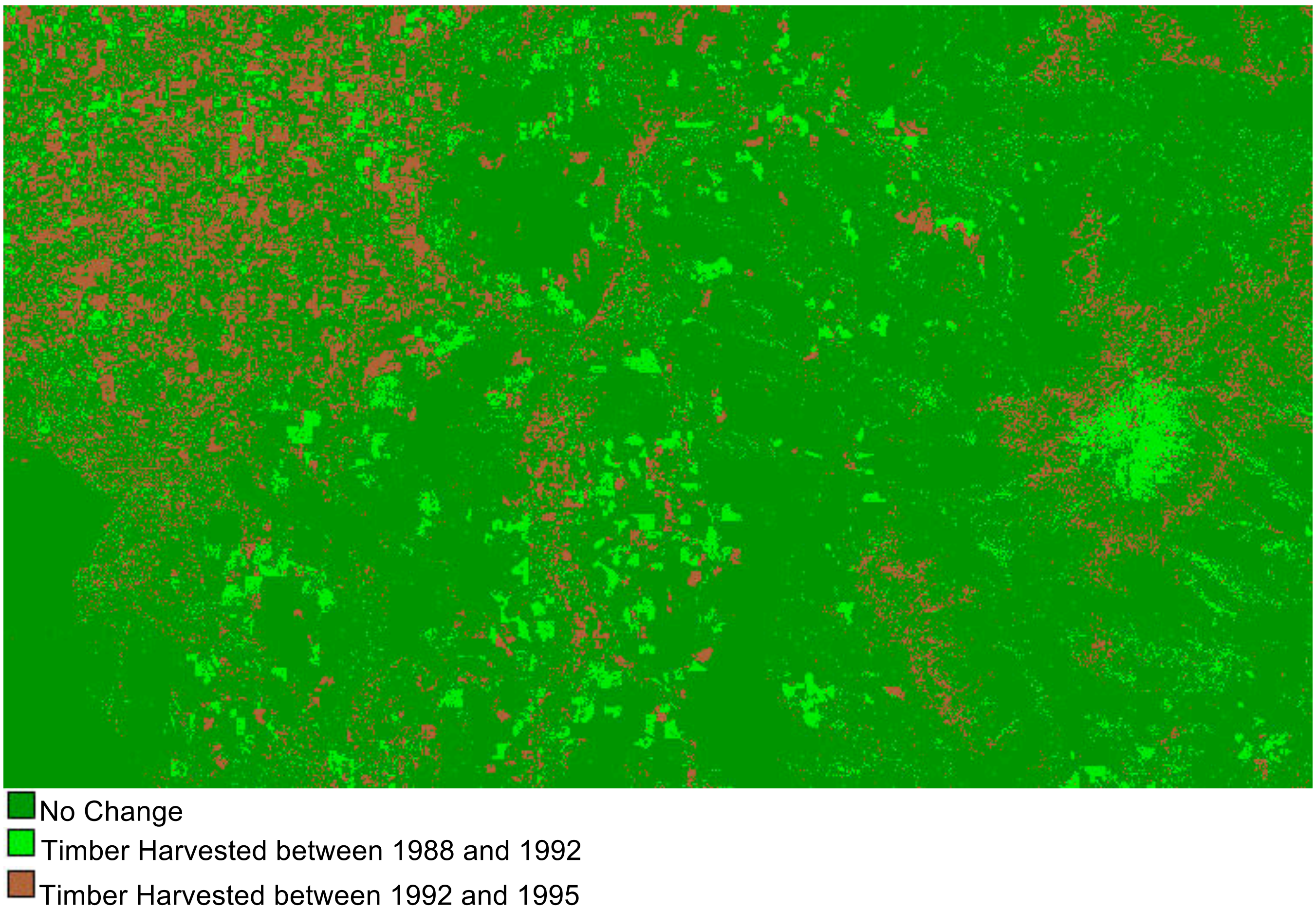

Figure 1: The 3 Change Detection Classes at all Elevations

The above image shows the initial results of the combination of the 50 spectral classes into the 3 information classes representing 3 amounts of change over the years. It is evident through a quick observation that much of the area showing harvest is actually a result of crop modification, urban growth, or snowpack changes. To eliminate as much error as possible an elevation mask was used. The results of which can be seen in Figure 2.

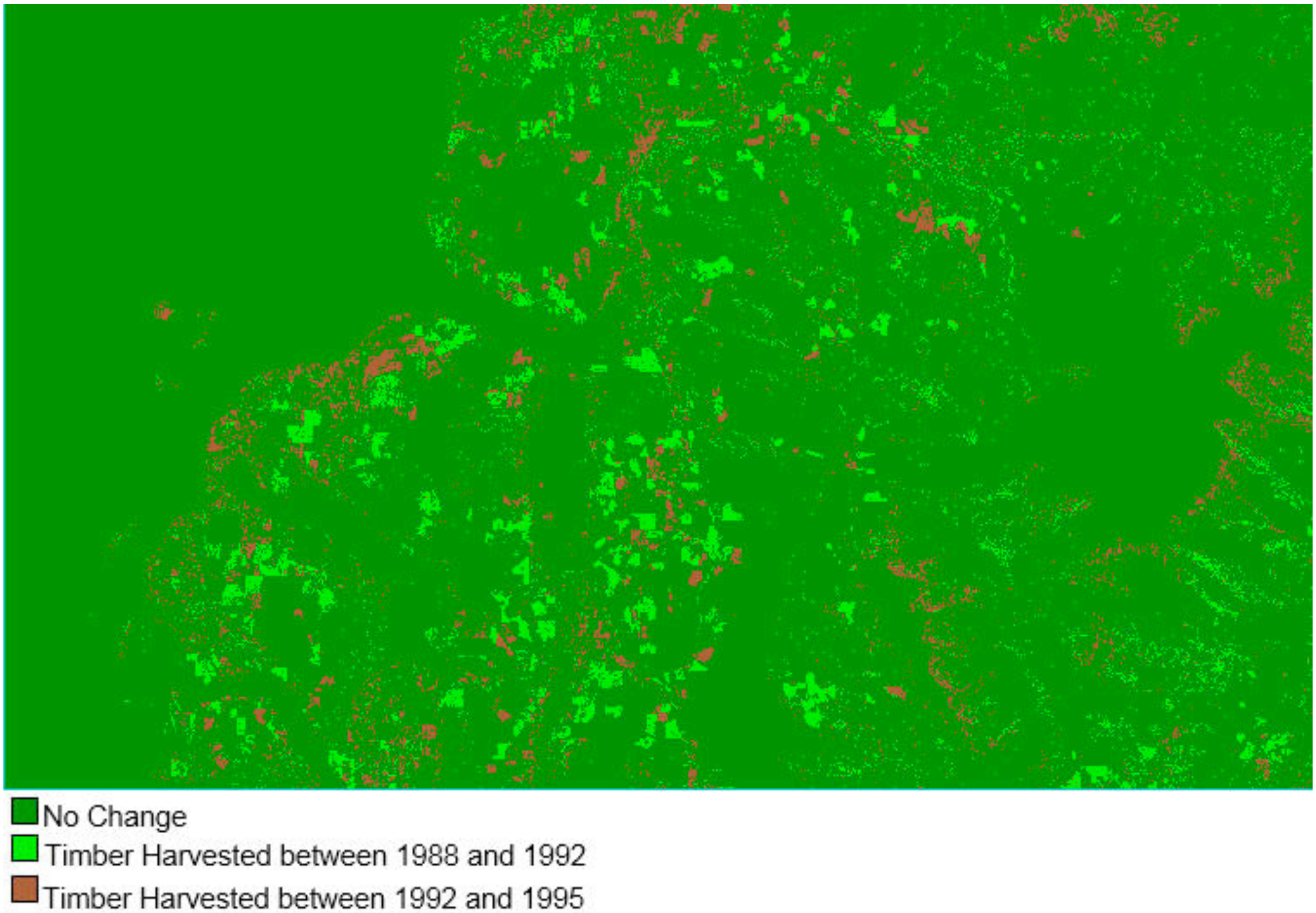

Figure 2: The 3 information classes excluding elevations of below 100 meters and above 1500 meters

The output of the elevation mask achieved the desired results and should have eliminated much of the areas in which change other than forest removal had been attributed to harvest. This image shows a truer representation in which much of the study area is not effected by timber harvest. There are however various small areas (mostly attributed to timber harvest: 88-92) which are most likely, due to their small size, small forest disturbances rather than harvest. To eliminate this error, the harvest areas smaller than 2 hectares were eliminated, and any areas of harvest or no change inside an area of harvest were absorbed by the larger harvest area. The results and final classification of change can be seen in Figure 3.

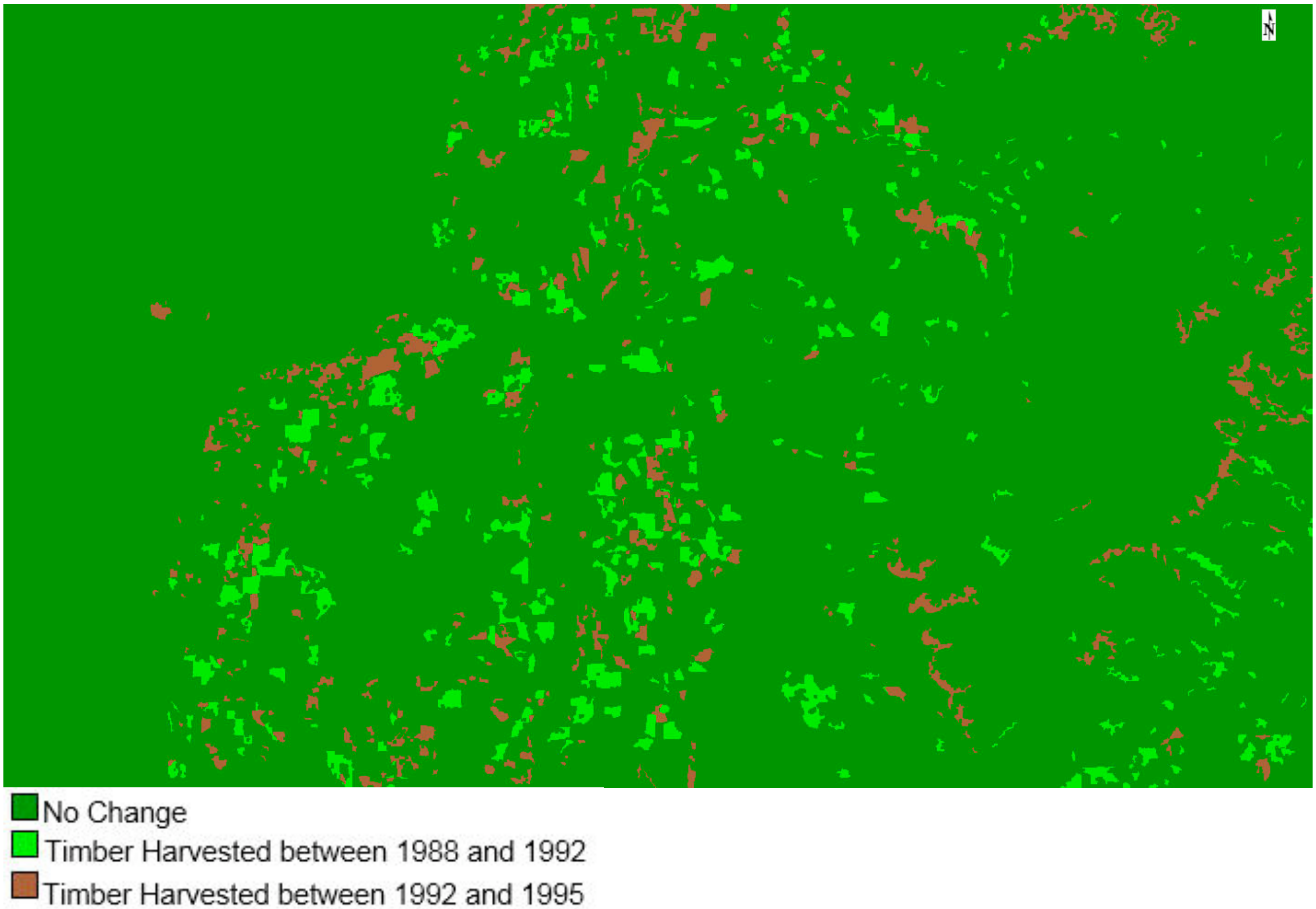

Figure 3: The 3 information classes with desired elevations excluded and only areas larger than 2 hectares remaining.

	No Change between 1988-1992	Timber Harvested between 1988-1992	Timber Harvested between 1992-1995
Total Number of Cells	3,557,582	138,143	109,475
Total Area in Hectares	222,348.8750	8,633.9375	6,842.1875

Table 1: Total number of cells (of the total image) and the total area for each change detection class. The data is for the time period stated, not per year.

As seen in the table, the results indicate that while most of the area remained unchanged during the period, there was an overall reduction of timber harvest in the latter period of time. This data is relatively in keeping with what is known about the logging industry and how it has modified over time.

	Timber Harvested between 1988-1992	Timber Harvested between 1992-1995
Percentage of Study Area	0.726%	0.719%
Percentage of Forested Area	1.095%	1.085%
Percentage of Wilderness Area	0.096%	1.100%
Percentage of National Forest	0.413%	0.435%
Percentage of Private Lands	0.882%	0.759%
Percentage of DNR Lands	1.021%	0.647%

Table 2: Percentages of the total area as well as various sub-areas within the study area. All percentages are of a per year basis

As indicated by the tables above, there was a slight overall decrease in timber harvest in the latter period, although the reduction is very slight when viewed on a per year basis. When further broken down it is very evident that much of the reduction took place on DNR land and to a lesser extent Private Lands. There actually was an increase in logging of both National Forest (although the increase is so slight it may be viewed as consistent) and in particularly Wilderness Areas.

Discussion

Overall the approach used was quite effective. Using ISODATA classification seemed to be a very good way to go about in order to detect change. The classification process easily separated the values, which in turn were easily placed into each of the three categories. While there may have been some variation in classification of the placement of spectral values into information classes, using a combination of true color images and especially infrared images allowed for relatively easy assignments of the spectral classes. It was interesting to see that in addition to an overall reduction of logging, a spatial trend in a Northward direction was present. Also the harvested areas appeared to be less concentrated, and rather than have fewer larger swaths, the data indicates more, smaller areas logging. This would also be in keeping with the perception of the logging industry moving away from large clear cuts to a slightly more selective harvesting approach. The advantages of using these methods are that the land is easily classified and the results can been seen clearly. I would venture to say that after eliminating the high and low elevations, and after allowing only areas larger than two hectares, that the resulting areas of change should be of decent accuracy. The elimination of high areas was needed in order to not have any change in snowpack be misconstrued as forest harvest. Also low areas were taken out of the equation in order to eliminate any urban growth and/or crop change. Most of the farming in Whatcom County is done in the eastern and northern portions of the state and it is evident that these areas were eliminated from the sample area due to the exclusion of areas below 100 meters. The one drawback that does come to mind is the subjectiveness of the classification of spectral classes to information classes. This was attempted to be minimized through the evaluation of spectral values for each class to determine if an increase in brightness of greenness occurred, but still some of the closer values sometimes came down to an educated guess of whether there was change or not. Some areas that could have been harvested in for example early September of 1992 (right after the image was taken) could potentially have been re-vegetated nearly to the point of where they were in the 1992 image. Specifically, if the 1988 image had shown a recent clear cut. It is for this reason, a re-vegetation classification should be added to the study in order to evaluate areas which had been logged shortly prior to 1988 and then re-vegetated. These areas could even have been potentially logged during the 1988-1992 period, but all have similar brightness values as each image could have shown around 4 to 5 years of growth.

The addition of the LULC Classification image to the study, while effective did have its drawbacks. The LULC classification had an overall accuracy of 45.5% which would indicate that it would not be entirely reliable, however the 5 classes combined to determine the forested area of the study area (Deciduous, Conifer, and 3 Clear Cuts) had a much higher producer's accuracy which hovered around the 50%-60% range. In addition the only real low producer accuracy would be the deciduous category, which made up a very miniscule part of the area, so when all is evaluated, the current LULC classification seemed warranted for use. A forested area mask was created in order to determine the full amount of hectares of the area, but band math was not applied to the this image and the change classification image, based on the assumption that the totals for areas of change should not change, as all areas of change should already lie within forested areas due to prior processing. Instead the totals of harvested areas were then taken from the total forested area instead of the total area. There is a slight possibility that an area classified as change could lie outside a forested area, but chances of this should have been reduced through elevation masking. In addition any small outlier could would not upset the accuracy of this study more so than the accuracy levels of the LULC classification map.

To further improve this study, more calculations could be done. One such idea would be to calculate the amount of wilderness forests (or nation forests, or private forests, ect.) were harvested from the total forested area, to determine which area was harvested the most. The totals produced now only tell what proportion of these areas was harvested. In addition more classification could be added such as the re-vegetation class and other classes closer to present day to determine if the perceived downward trend of the logging industry is indeed verified. The results should look to be verified further and an accuracy test could be applied. Clearly either field verification or other LULC maps from these time periods would be needed to further investigate.

The data used was cost efficient, and given the lack of resources needed to classify change in a large area, the approach the study used was warranted and needed. It is imperative to monitor the state of our forests and how they are altered, not just through natural events, but through human impacts. To detect change is to quantify and evaluate the trends in the change so that lessons may be learned to further protect and manage the forests as a resource.

<u>Literature Cited</u>

Antonova, N. & Wallin, D. 2014 *Lab 6: Change Detection Using Unsupervised Classification with ENVI.* ESCI 442/542: Introduction into Remote Sensing < http://staff.wwu.edu/antonon/envr442/ENVI/442_change_lab_ENVI.htm>