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Mapping Timber Harvest in Baker to Bay Image between 1988 and 2011 Using Unsupervised Classification of Landsat Imagery

ABSTRACT

Timber harvest is one of the Pacific Northwest's most abundant natural resources which needs to be sustainably managed. In this study, I used six time sequential Landsat satellite Images with Tassel Cap Transformation on the Thematic Mapper Bands to identify the change in timber regions throughout the Baker to Bay Landsat image in north western Washington State and southern British Columbia. The objective of the study is to identify where, when, and the amount of logging throughout this image. To achieve this, I performed an Iterative Self Organizing Data Analysis on a composite change image and assigned information classes of timber harvest year. Results show a general decline in timber harvest, and private land owners and the department of natural resources harvesting the largest amounts of timber. This approach to mapping timber harvest change is efficient and generally accurate, but without ground truth data, the degree of accuracy cannot be calculated.

METHODS

Original imagery is composed of six Landsat Thematic Mapper (TM) Scenes over the baker to bay image area between 1988 and 2011. Data that are used to analyze the results cover the same baker to bay scene and include a land use change composite map, an ownership map, an elevation map, and the unsupervised classification from previous lab. All scenes have been georectified to the 1995 image and use a spatial resolution of 25 meters by 25 meters (Wallin, 2015). The original imagery all contain the 6 TM bands (1-5, 7) and 1988, 1992, and 1995 contain Tassel Cap indices (Wallin, 2015). The Tassel Cap Transformation involves a conversion and linear combination of bands, usually for a specific purpose (Campbell, 2011). The change map layers are generated by differencing the composite Tassel Cap values of brightness and greenness in each sequential image, which are useful for observing vegetation change over time (Wallin, 2015). These are the imagery produced by Huxley College of the Environment at Western Washington University which I obtained for this project.

Analysis of this lab generally follows the outline set by Dr. Wallin. For the first analysis of data, I initiated an Iterative Self Organizing Data Analysis (ISODATA) unsupervised classification on the change map. ISODATA classifications assign all values to the same class and eliminate spectral variability in classes by creating new classes (Verbyla, 1995). Like the previous lab, 50 spectral classes were assigned from the 10 change layers. With the aide of false color infrared maps between 1988 and 2011, I assigned the 50 spectral classes into 6 information classes of timber harvest between 1988 and 1992, harvest between 1992 and 1995, harvest between 1995 and 2000, harvest between 2000 and 2005, harvest between 2005 and 2011, and finally a no change class (Wallin, 2015). To eliminate erroneous assignment of timber harvest in areas in alpine and agricultural areas, I use the elevation image to mask out pixels below 100 meters and above 1700 meters (Wallin, 2015). To further reduce error, I create a mask of areas identified in the previous lab as clearcut, deciduous, and conifer. Both masks are combined using band math and is applied to the final classification map. I reduce potential error even further by sieving small pixels which are not likely a timber harvest signal, and by clumping pixels with a 3 pixel by 3 pixel smoothing window to remove inclusions of ‘no change’ in the image (Wallin, 2015). Finally, I apply band math with the ownership image and the change image to generate the total forested area, and the number of information class pixels in each ownership area (Wallin, 2015).

RESULTS

The result of this study shows a general trend of decreasing timber harvest for the whole image as progressing through time (Table 1). After the 1988-1992 time interval, harvest percent per year decreases 3.64% and never again rises above 1% land harvested per year (Table 1). Calculating the amount of forest and harvest in each ownership area shows which areas are harvesting the highest percentage their forests. Private Land owners and the Department of Natural Resources both harvest the highest percentage of their lands, with private land owners always harvesting the most with the exception of the 2000-2005 interval (Table 2). Private Land owners also own roughly 11,000 more hectares than the next largest group, which means they also harvest the highest raw amount of timber (Table 2). All the harvest trends roughly fit the overall trend in Table 1, with the highest harvest between 1988 and 1992 with a steep decrease and a gentle rise from 1992-2011.

The final classification shows a majority of the map as no change relative to timber harvest (Fig. 1). This comes as a result of masking forest and elevation, as well as sieving and clumping the image. Figure 1 illustrates that a majority of the timber harvest has occurred between 1988 and 1992, since the cyan color is the most dominate (Fig. 1).

Table 1. Sequential Timber Harvest in the Baker to Bay Image. Total forested area in the Baker to Bay image is 121829.81 which is used to find the percentage of area harvested, which is then normalized by the number of years in the time interval.

Time Interval	Area (Hectares)	%Total Forest Area	%Total Forest /Year
1988-1992	19,864.63	16.31	4.08
1992-1995	1,613.00	1.32	0.44
1995-2000	4,556.19	3.74	0.75
2000-2005	5,451.31	4.47	0.89
205-2011	4,803.00	3.94	0.66

Table 2. Sequential Timber Harvests in the Baker to Bay Image in different land ownership areas. Total area of forest in each ownership category is calculated generated from the combination elevation and forest area map. This total area is used in calculating total percentage of harvest, which is then normalized by the number of years in each time interval.

	Wilderness			National Forest			Private Land			Department of Natural Resources		
	Total Forest=6,692.31 Hectare			Total Forest=30,227.38 Hectare			Total Forest=49,733.19 Hectare			Total Forest=35,139.31 Hectare		
Time	Pixels	Area (Hectares)	%Harvest /Year	Pixels	Area (Hectares)	%Harvest /Year	Pixels	Area (Hectares)	%Harvest /Year	Pixels	Area (Hectares)	%Harvest /Year
88-92	5027.00	314.19	1.17	54723.00	3420.19	2.83	163,853.00	10,240.81	5.15	94,076.00	5879.75	4.18
92-95	0.00	0.00	0.00	2375.00	148.44	0.16	16,159.00	1,009.94	0.68	7,274.00	454.63	0.43
95-00	428.00	26.75	0.08	853.00	53.31	0.04	44,939.00	2,808.69	1.13	26,678.00	1667.38	0.95
00-05	267.00	16.69	0.05	2688.00	168.00	0.11	46,944.00	2,934.00	1.18	37,322.00	2332.63	1.33
05-11	3702.00	231.38	0.58	9325.00	582.81	0.32	40,742.00	2,546.38	0.85	23,079.00	1442.44	0.68

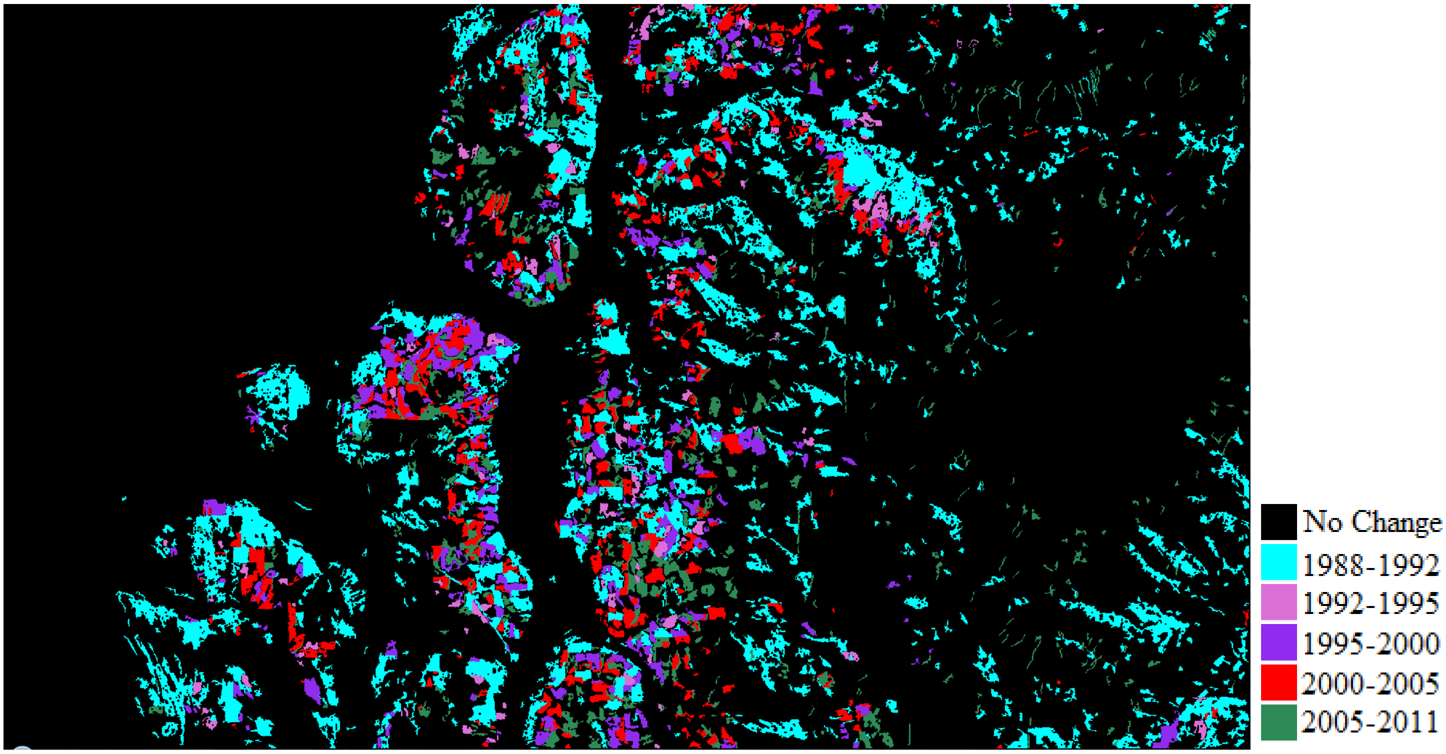

Figure 1. Final timber harvests classification for the Baker to Bay Image. A majority of the image indicates no change has occurred in relation to timber harvest. This classification is a result of elevation and forest masking, as well as sieving and clumping of pixels.

DISCUSSION

This project generally followed the procedure of simultaneous image differencing outline by Cohen et al., 1998 however my procedure did not include and form of ground truth data or accuracy assessment. The unique spectral changes after logging periods, especially with a Tassel Cap Transformation to emphasize vegetation, justifies the methods of using the spectral signature to identify date of logging. Room for improvement includes gathering ground truth data which would allow me to more subjectively assign information classes from the ISODATA classification, as well as operate an accuracy assessment on this classification.

This type of study is important for managing limited earth resources like timber. By accurately monitoring timber harvests, we can more actively use sustainable forestry techniques.

In the report for example, I show the locations and dates of timber harvest (Fig. 1). This allows land owners to select more sustainable or potentially profitable plots of land.

Generally, this study was a successful at quantifying timber harvest from 1988-2011, but without a way of validating this study the results can only be taken at face value and success is difficult to determine. In comparison to original imagery in false and true color, the final classification does a reasonable job from a visual standpoint. The forest and elevation masks retain only middle elevation forest lands and relies in part of the accuracy of the original forest classification. Certain biases in the method, such as the elevation window for harvesting, the sieving parameter to eliminate noise, and the smoothing window for clumping, likely reduce the accuracy of the final classification. Assigning spectral classes to information classes was difficult in some places for example, alpine areas around Mt. Baker have a similar signature as logging 2000-2005. This specific example was resolved using masks, but others may have not been resolved.

Despite the problems of accuracy assessments, biases involved in classification, and difficulties of more than one information class in a spectral class, the study overall was successful. The study by Cohen et al., 1998 validates the methods. This method works well both as a reasonably accurate and efficient means of mapping clearcuts in the Baker to Bay image.

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