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Lab 7: Interpretation and Classification of LandTrendr Disturbance Data

Abstract

This project evaluated disturbances found on the land from 2007 to 2009 within and around the North Cascades National Park, WA. The purpose was to investigate and classify the agents of change for each disturbance using analysis of aerial imagery, and LandTrendr Data in the form of patch centroids and Tasseled Cap Landsat image Chips. The classifications were then cross-referenced with a Random Forest classification model in order find all agents of change and assess accuracy of the results. Findings produced an overall accuracy of 62% and displaying an overall reduction of disturbances over the course of 3 years. It was found that the majority of patches of disturbances were due to progressive defoliation, followed by mass movement. However these while high in numbers were small in area when compared with fire which covered the largest areas of disturbance. Some of the largest areas of confusion were between riparian disturbances and mass movements, while tree topple disturbance was poorly assessed. Overall the process was successful, and could be made more so with additional experience, and the process proved to be much more efficient that field verification.

Methods

Data Used:

The study area for the project was the North Cascades National Park and an area extending 10 miles outside of its border. The visual analysis was performed using Google Earth Aerial Imagery. The imagery was taken from aircraft and specific patches detailing areas and dates of land disturbances and fires was evaluated. In addition LandTrendr data from 1985-2009 was used to evaluate changes in reflectance values for the areas of disturbance. The methods used by the Laboratory for Applications of Remote Sensing in Ecology at Oregon State University condensed Landsat Imagery and transferred the reflectance values into values of wetness which in turn could be evaluated to determine agent of change. (Kennedy et al., 2007)

Analysis:

A combination of visual analysis of aerial photography and LandTrendr data was used to assign 55 sample patches of disturbances. Each of the 55 sites were individually analyzed, first by looking at aerial photography before during and after the event occurred. Then the LandTrendr data was evaluated, and a judgment was made by evaluating the wetness of area before and after the time of disturbance. Using the NCCN Landscape Dynamics Monitoring Protocol's *Description of the Landscape Change Categories* as a guide the patches were then assigned an agent of change of one of the following: Fire, Mass Movement, Riparian, Progressive Defoliation, Tree Topple, and Avalanche. (Antonova, N et al. 2012) Once all 55 sample plots had been assigned an agent, a Random Forest Classification was applied to the classification results. The Random Forest Classification used a statistical model to evaluate and assign its own agents based on the correlation between two trees and the strength of these individual areas. (Brieman, L., & Cutler, A.,2012) Once all of the patches have been assigned by the Random Forest Classification it randomly selected 1000 trees to cross reference with the agents assigned through LandTrendr and aerial photography. Using this model an confusion matrix was derived to assess accuracy. In addition, all of the 412 disturbances were assigned agencies using an supervised classification created from the 55 sample sites. Lastly the process created a table displaying the probability that the assigned agency belonged to another agency. All data and methods are from (Antonova, N. & Wallin, D., 2014)

Results

Using the aerial photography and LandTrendr data each of the sample sites were assigned an agency. The results can be seen in Figure 1.

Patch ID	Year	Agent
5767	*2009*	*Progressive Defoliation*
6308	2007	Progressive Defoliation
6415	2009	Avalanche
6434	2009	Avalanche
6484	2009	Riparian
6588	2008	Riparian
6753	2007	Mass Movement
6822	2007	Mass Movement
6845	2007	Mass Movement
6862	2008	Mass Movement
6863	2007	Mass Movement
6943	2007	Riparian
7004	2007	Riparian
8262	2007	Riparian
8936	2009	Avalanche
8973	2009	Avalanche
9050	2009	Fire
9850	2008	Mass Movement
9935	2008	Mass Movement
10275	2008	Riparian
10276	2008	Tree Topple
6562	2007	Progressive Defoliation
8006	2007	Progressive Defoliation
10490	2008	Progressive Defoliation
10811	2008	Mass Movement
10958	2008	Progressive Defoliation
11008	2008	Mass Movement
11088	2009	Avalanche
11564	2007	Progressive Defoliation
12080	2007	Progressive Defoliation
12154	2007	Fire
12158	2008	Mass Movement
12159	2008	Fire
12199	2007	Progressive Defoliation
12231	2007	Progressive Defoliation
12311	2007	Progressive Defoliation
12625	2007	Progressive Defoliation
12701	2007	Progressive Defoliation
12862	2007	Tree Topple
12872	2008	Mass Movement
12900	2007	Progressive Defoliation
12940	2007	Tree Topple
13356	2009	Mass Movement
13374	2007	Avalanche
13451	2007	Fire
13533	2007	Fire
13603	2007	Fire
13610	2007	Fire
13707	2007	Fire
13723	2007	Progressive Defoliation
13758	2007	Progressive Defoliation
13761	2007	Progressive Defoliation
13772	2007	Progressive Defoliation
12229	2007	Fire
12757	2009	Progressive Defoliation

Figure 1. 55 Sample Sites and thier corresponding Patch ID numbers, Year of Disturbance and Agents of Change

After running the classified sample sites against the Random Forest Classification a confusion matrix was generated and an overall accuracy was assessed. These results can be seen in Figure 2.

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Call:
 randomForest(formula = Agent ~ ., data = wdat, ntree = 10000)
               Type of random forest: classification
                     Number of trees: 10000
No. of variables tried at each split: 7

        OOB estimate of  error rate: 38.18%
Confusion matrix:
                       Avalanche Fire MassMovement ProgressiveDefoliation Riparian  TreeTopple  class.error
Avalanche                      3    1            0                      2        0           0   0.50000000
Fire                           1    5            1                      1        1           0   0.44444444
MassMovement                   1    1            8                      1        0           1   0.33333333
ProgressiveDefoliation         0    0            1                     18        0           0   0.05263158
Riparian                       0    0            6                      0        0           0   1.00000000
TreeTopple                     0    0            2                      1        0           0   1.00000000
```

Figure 2. Overall Error Rate and Confusion Matrix

As seen above the error rate was 38.18% meaning that the agency assigned was slightly below 62% accurate when evaluating agency of disturbance. The confusion matrix further breaks down the assessment. When viewing it is clear that the largest discrepancies occurred in the Tree Topple and Riparian agencies where none of the patches were consistent when cross-referenced. The largest agency of success was the Progressive Defoliation which was over 94% accurate.

This was in part due to this being the most prevalent agency of disturbance over the three year span. Of the 412 disturbances, nearly half of them were progressive defoliation. The next closest agency of disturbance over that time was Mass Movement with less than half of the total of Progressive Defoliation. Further breakdowns of the totals from 2007 to 2009 can be seen in Figure 3.

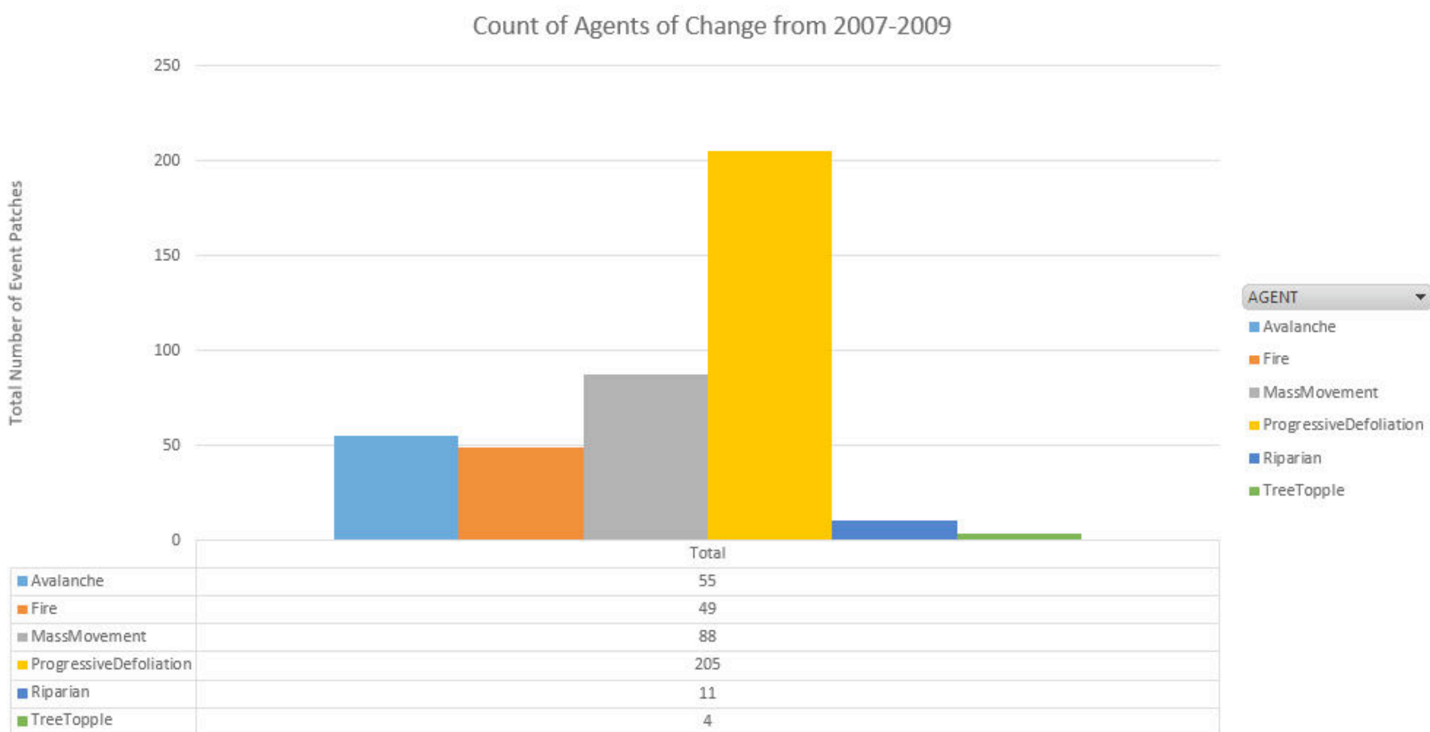
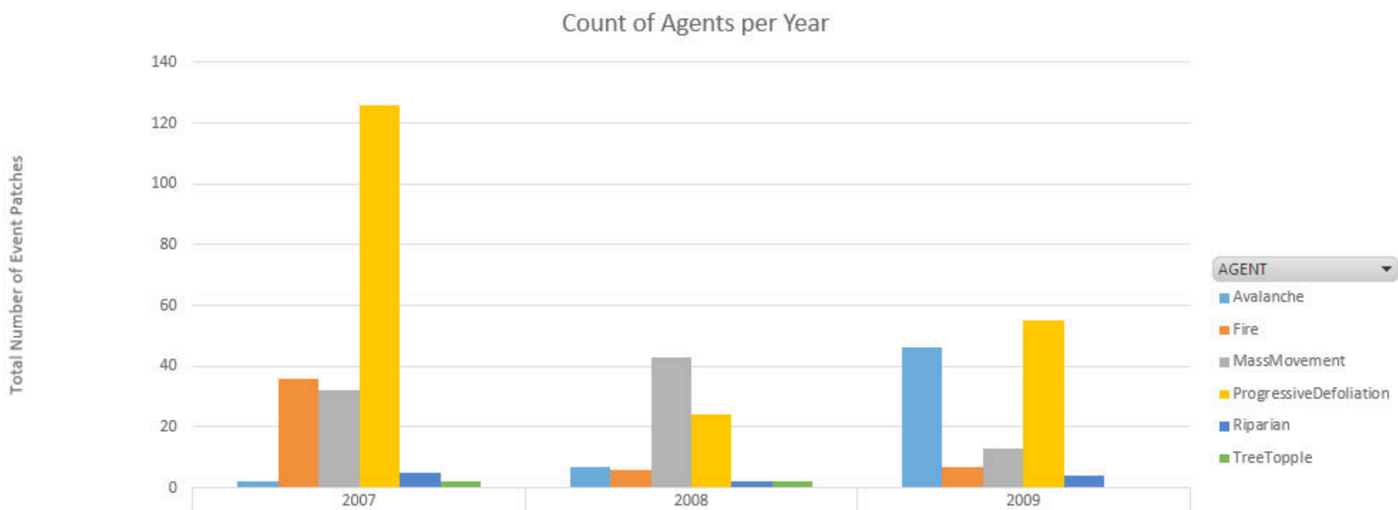


Figure 3. Disturbances from 2007 to 2009 by agency of change type.

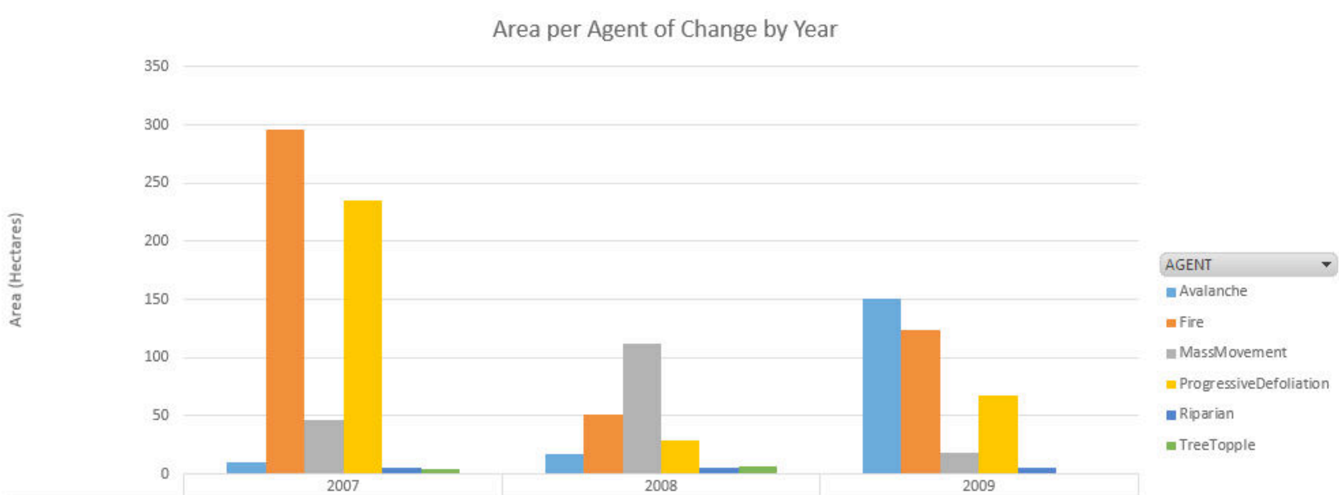
When evaluating the data in specific years, it can be seen that the majority of the Progressive Defoliation occurred in 2007. The same is true of Fire, however the opposite is true for Avalanche. Mass Movement is unique in that it peaked in 2008, whereas both Riparian and Tree Topple remain more or less consistent over the years.



	2007	2008	2009
Avalanche	2	7	46
Fire	36	6	7
MassMovement	32	43	13
ProgressiveDefoliation	126	24	55
Riparian	5	2	4
TreeTopple	2	2	

Figure 4. Disturbance count per year for each of the agency types.

Although the Progressive Defoliation had the most patches within the park, the largest area of disturbance was Fire. The other agencies were largely consistent when evaluating increases and decreases in both number and area. Avalanches for instance had corresponding upward values in both number of patches and area.



	2007	2008	2009
Avalanche	9.9	17.64	151.2
Fire	296.37	51.21	123.93
MassMovement	46.62	111.6	18.45
ProgressiveDefoliation	235.53	28.89	67.86
Riparian	5.67	5.31	4.86
TreeTopple	4.14	6.66	

Figure 5. Area of Disturbance

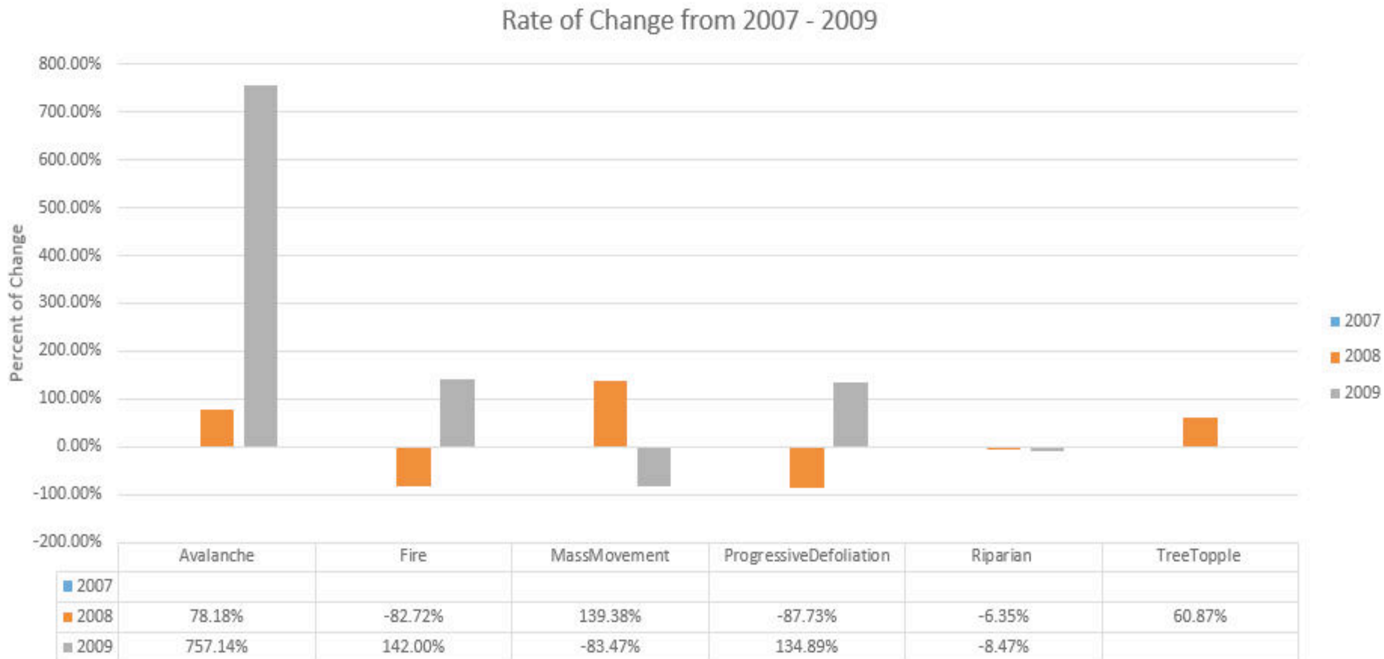


Figure 6. Rate of Change from 2007 -2009 for each agent

Disturbance Type	Avalanche	Fire	MassMovement	ProgressiveDefoliation	Riparian	TreeTopple	Grand Total
Hectares from 07-09	178.74	471.51	176.67	332.28	15.84	10.8	1185.84
Average Hectares per year	59.58	157.17	58.89	110.76	5.28	3.6	395.28
Percentage of North Cascades NP affected per year	0.0216%	0.0570%	0.0214%	0.0402%	0.0019%	0.0013%	0.1434%

Figure 7. Annual Rate of Change for each agent

When observing the data in Figure 6, no specific trends can be seen when looking at all the agents. When narrowing it down to the specific agent the one that is most noticeable is the drastic increase in Avalanche over the 3 years. This would most likely have to do with the winter snow totals, but it can also be seen that this trend does not carry over into Fire, Mass Movement and Riparian, which many times are also associated with precipitation totals.

The accuracy being over 50% for Progressive Defoliation, Mass Movement, Fire, and Avalanche corresponded with the higher total values. It seems clear that the higher number of occurrences of disturbances, results in a better accuracy. The Tree Topple and Riparian agencies had the lowest accuracy, however they also had the smallest number of occurrences and the lowest total area. The data does however depict certain trends than did occur over the 3 years.

Discussion

The results above pose a few questions that are in need of discussion. The table representing the disturbance patches and their corresponding years of event and agent of change is relatively straight forward and does not warrant further analysis. The accuracy of these classifications and the classification of the other 357 patches classified based off the assignments of agents is in need of further evaluation. The overall accuracy of 61.82% is to be expected considering the lack of experience in assessing agents of change on both a visual level, and a level of interpretation of tassel cap formations. A higher accuracy would surely be seen if the agents had been assigned through an individual with greater experience who would be aware of specific clues to look for in the disturbance. In the confusion matrix, it is clear that the largest inconsistency between the users' classification and the random forest classification occurred between Riparian and Mass Movement. The discrepancy between the Riparian and Mass Movement is most likely due to a difference of classification based on stream size. In my classification, most disturbances alongside a stream or river were classified as Riparian. The Random Forest Classification determined the same events (6 of them) were actually Mass Movement. In all actuality the cause of the mass movement was likely a debris flow of some sort. Debris Flows being a hydrological disturbance, were incorrectly classified as Riparian, due to the assumption that the stream channel qualified as a riparian area. The spectral characteristics of a stream, as seen by satellites through Landsat imagery, would perhaps not be large enough to register as riparian. Through the aerial photography in the visual analysis (with a much higher spatial resolution) the disturbance was classified as Riparian, when the Satellite may not have had the capability to view.

Tree Toppling, like Riparian was also completely miss classified. User classification assigned 3 disturbances as Tree Topple that according to Random Forests were 2 Mass Movements and 1 Progressive Defoliation. The one Tree Topple in the random selection was classified as Mass Movement by the user. Tree Topple is a very localized event that can be difficult to assess from above due to thick canopy. Gaps in the canopy can easily be confused with gaps in the canopy due to Progressive Defoliation. This would be the most likely reason for the confusion. To improve the results, more experience would be required to work with LandTrendr data.

Additional attributes for the disturbances could vary depending on which agent is being evaluated. One that could be useful is soil type of the area. The soil type could indicate whether events such as tree topple, or specific mass movements would more or less likely. Also vegetation type would be useful in determining which species would be more suspect to agents of progressive defoliation such as specific beetle infestations, either spruce or pine. Other GIS layers could be added such as average wind direction and wind speed to help better diagnose tree topple, an agent that is in need of improved classification. Also precipitation totals would be useful in evaluating avalanches (snowpack totals), fire, riparian and mass movements (flooding events).

When evaluating the tables, much of the park is likely to stay the same. The most likely of all the change is progressive defoliation, meaning it is likely that the park is under the threat of a beetle outbreak or other disturbance. Avalanche totals had the largest increase over the 3 years, possibly indicating that the winter of 2008/2009 had variable climatic conditions combined with large snow precipitation totals. Fire had the largest area in 2007, possibly meaning that the summer for that year was the driest of the 3. Another correlation can be seen in the link between fire and mass movement. In 2008, the national park experienced its lowest fire area totals for the 3 years, yet the highest area of mass movements. This might suggest that 2008 the wettest of the years considering the forest may have held been too saturated to burn, yet the ground may have been saturated enough to cause mass movements. It seems likely that this year would also have the highest totals for riparian disturbances, however this is not the case as 2007 had a slightly larger area disturbed by riparian causes, and there was very little change over the 3 years.

Annual Variability was not taken into consideration in this study, but should be considered if further investigation is undertaken. The seasonal change could have significant impacts on the extent of canopy cover, wetness values for the tassel caps, and snowpack variability, all which could affect the evaluation of agent types. Overall the use of Google Earth and the Time Sync application was effective. Being able to have increased resolution in the Google Earth imagery combined with the multiple images over the years enabled the user to carefully assess the plot. Also being able to look at the area outside the plot was essential in evaluating any clues towards the cause of the disturbance. While the overall accuracy was slightly above 60%, this low value is not a result of either Google Earth or the Time Sync Application, but rather due to inexperience. The Time Sync app specifically is not a system that can be mastered in a short time, but rather learned through repeated practice. The programs made it much easier to assess the agents of change than through field verification. Field verification of all 412 plots would have been near impossible given the amount of plots, size of the area, and inaccessibility of the locations. If attempted the process would be incredibly time consuming, and given the terrain and other factors, the results would still not be entirely accurate. Through the process used for this project, levels of accuracy of upwards of 80% can be achieved in a matter of hours using free or inexpensive data and applications. (Antonova, N. & Wallin, D. 2014) The same would not be true for field verification.

The methods used for this project could be improved with more practice and an increased number of attributes associated with the disturbance plots. Also as technology increases, Google Earth imagery will improve in both resolution and the frequency, the agency of change will be easier to assess through visual interpretation. Though occasional field verification could be helpful, given the relative ease (in time and money) of this process makes it ideal to further classify disturbances in other times and in other areas of the earth.

Literature Cited

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