

# Turbidity and Timber Harvest in the Forest Grove Watershed

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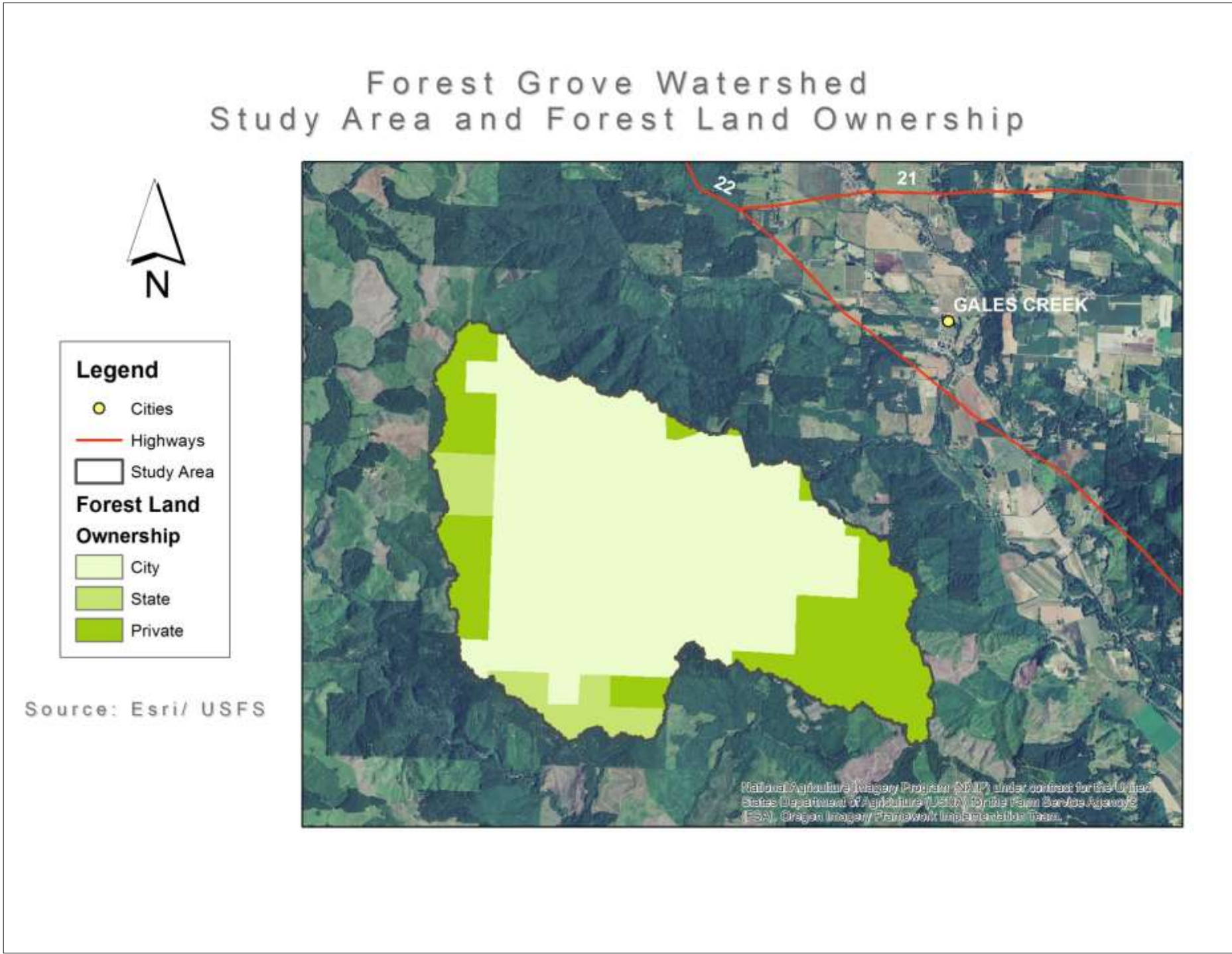
## INTRODUCTION

High turbidity in public water systems affects the effectiveness of treatment process, and therefore requires an increase in operational cost. It is known that precipitation has the natural effect to increase turbidity, but human factors such as agricultural practices also contribute highly to turbidity in rivers and streams. The City of Forest Grove is located to the West of Portland in Washington County. The Drinking Water Source Area of Forest Grove it is located in the Upper Tualatin basin, in North West Oregon (Map 1), where the land is owned by different types of owners (City, State and Private Forest Land), and its use is mainly Forestry. This watershed experienced a decreasing trend in turbidity over the period of 1994 to 2008 (ODEQ 2010). This project intended to find if there is a correlation with the Timber Harvest activities in the watershed and the levels of turbidity registered in the Intake of the Drinking Water Plant.

## DATASET

The data used for this project were:

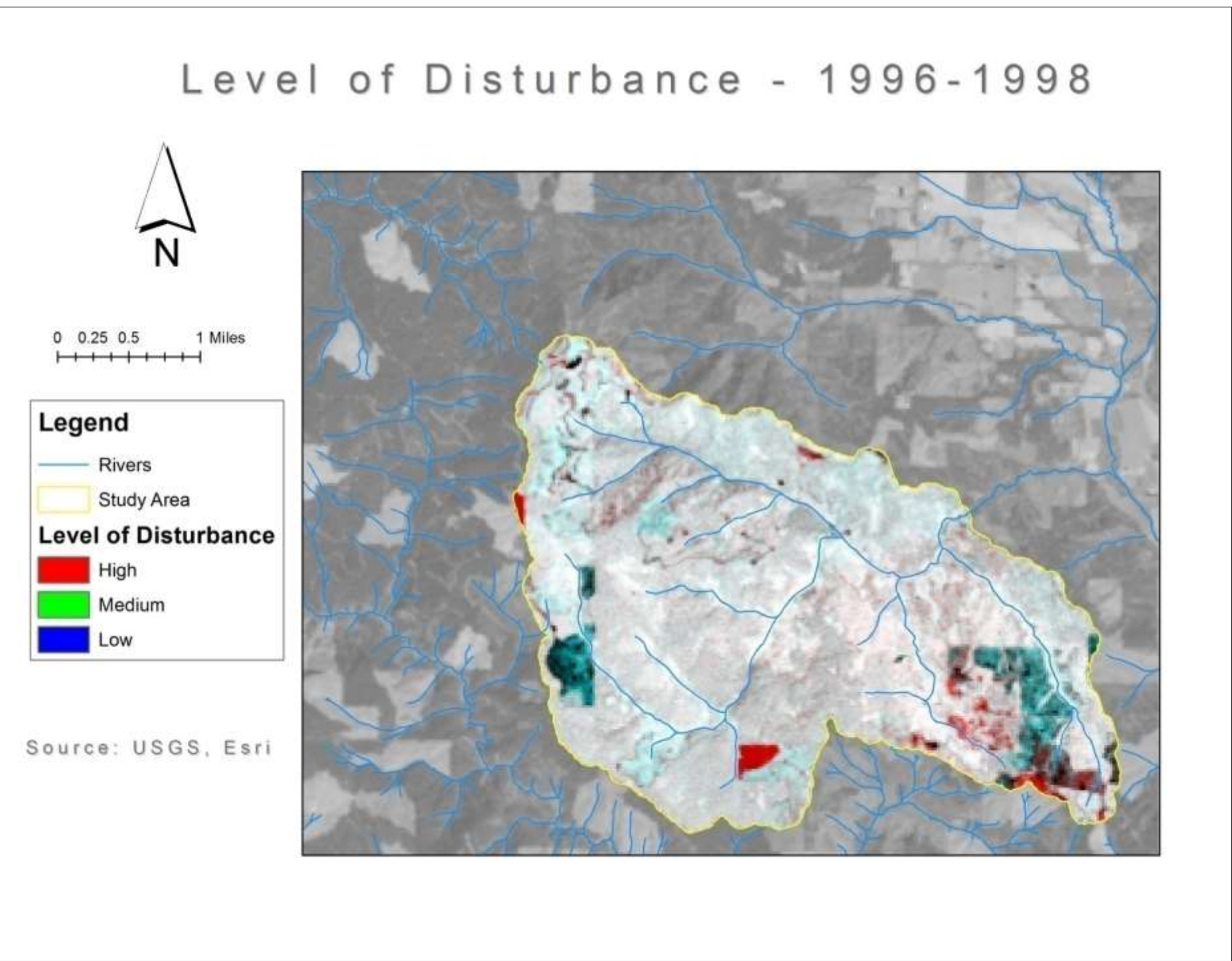
- Daily Turbidity data. Turbidity data was collected by the Forest Grove Public Water System at their intake from November 1994 through September 2008. This monitoring station is located at the lowest part of the watershed.
- Daily Precipitation data (from November 1994 to September 2008)was obtained from RAWS weather stations.
- Landsat 5 Imagery from (June/July 1994 to June/July 2008), downloaded from USGS website.
- Drinking Water Source Area (.shp), obtained from the ODEQ.
- Forest Grove Forest Land Ownership (.shp), obtained from the ODEQ.



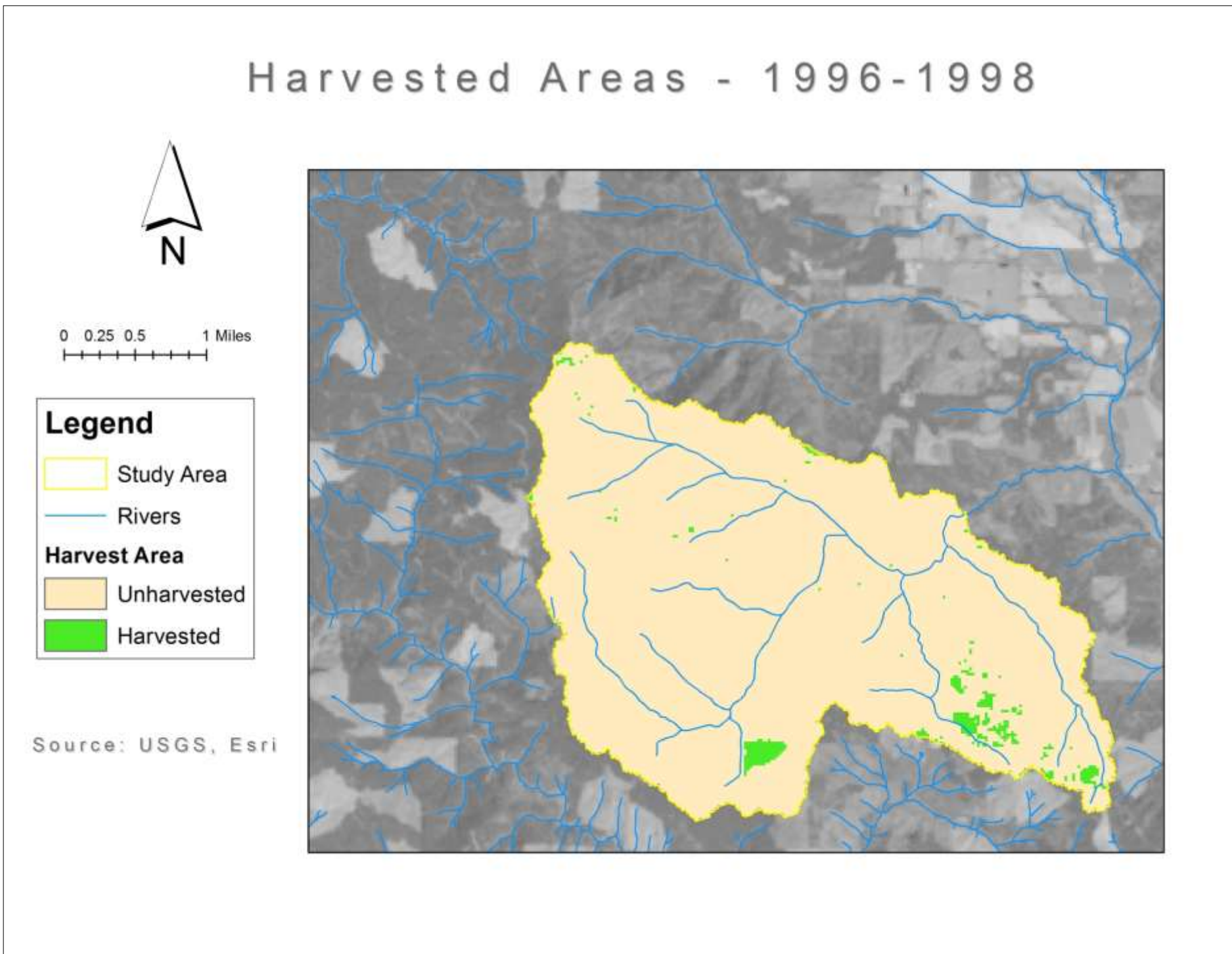
Map 1. Forest Grove Watershed: Study Area and Forest Land Ownership

## ANALYSIS

Daily Turbidity data was organized in values above 10 NTU (Klein 2001) which corresponded to the months of November to May of each year. These months are coincident with the beginning of the rainy season. Daily Precipitation data for the same period was also selected for each year. The DWSA was used to localize the study area, and helped with the delineation of the Watershed. The Ownership shapefile was converted to raster and reclassified into 3 categories: City, State and Private, with the reclassify tool (Map 1). The amount of timber harvested areas (clearcuts) in the watershed was quantified every 2 years in the period of 1994 to 2008, giving 7 samples of clearcut areas (1994-1996; 1996-1998; 1998-2000; 2000-2002; 2002-2004; 2004-2006; 2006-2008). NVDI was applied to the images using data from the red and near-infrared bands (Band 3 and Band 4 in TM) to show vegetation status, represented in different colors. Clearcuts were identified as red areas (Map 2). The outputs of the NVDI served as reference areas. Band 2 represents the status of vegetation in one year, and Band 1 the status after 2 years. Raster calculator was used to subtract Band1- Band2, being the output of it the disturbed areas between the two years. A threshold was selected for each sample (pixel values between >0,05- >0.123) for determining what was considered clearcut areas, based on the index values generated from the Band’s subtracts. A Conditional Function was then applied excluding all values under the threshold (Map 3). The cell counts for the clearcut areas where converted to area values, and the Zonal Tabulate Area was used to calculate the areas for each Forest land type (City, State and Private). The results were expressed as Total percentage (%) of watershed harvested, and percentage of watershed harvested by type of ownership. A linear regression model was performed using the EXCEL spreadsheet to analyze the correlation between turbidity and % of watershed harvested. The same relationship was analyzed for turbidity and precipitation. Many different ways to express turbidity have been tried in order to find the one that gives the strongest relationship with the independent variables.



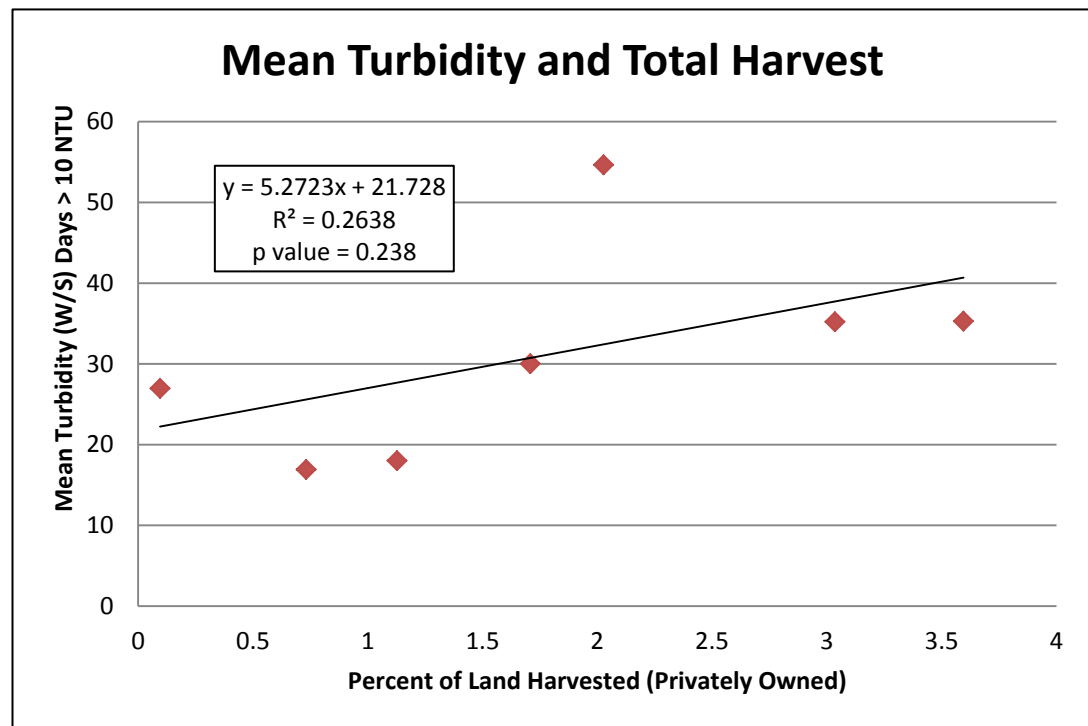
Map 2. Level of disturbance Output obtained with the NVDI tool.



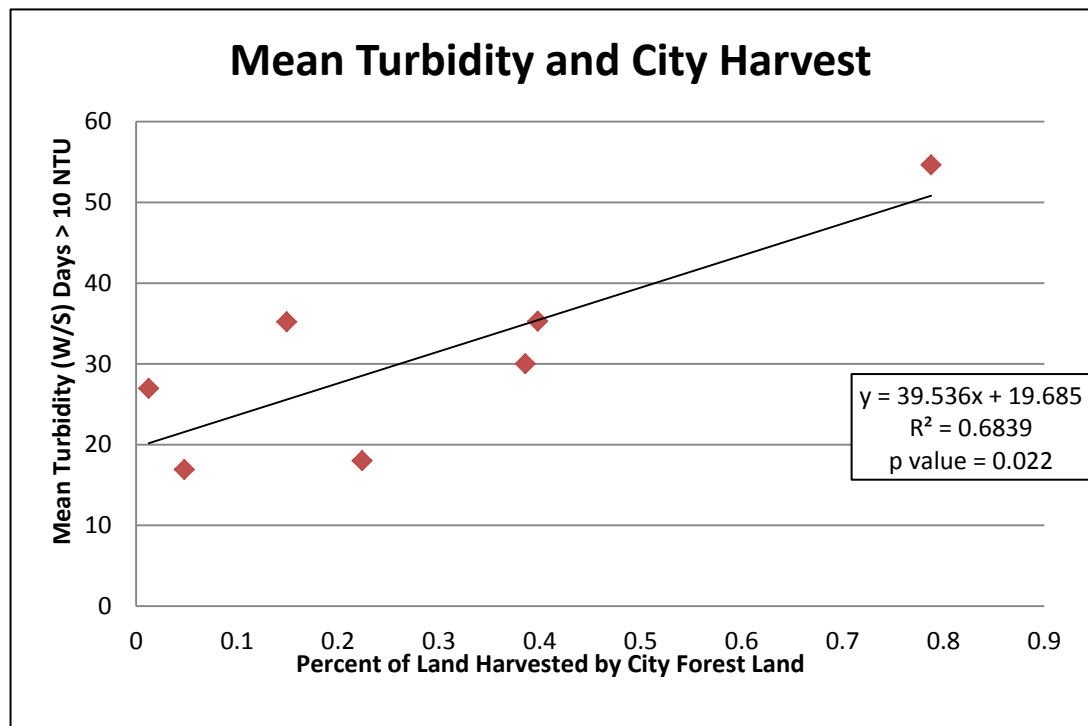
Map 3. Harvested Areas Output from 1996 to 1998 period.

## RESULTS

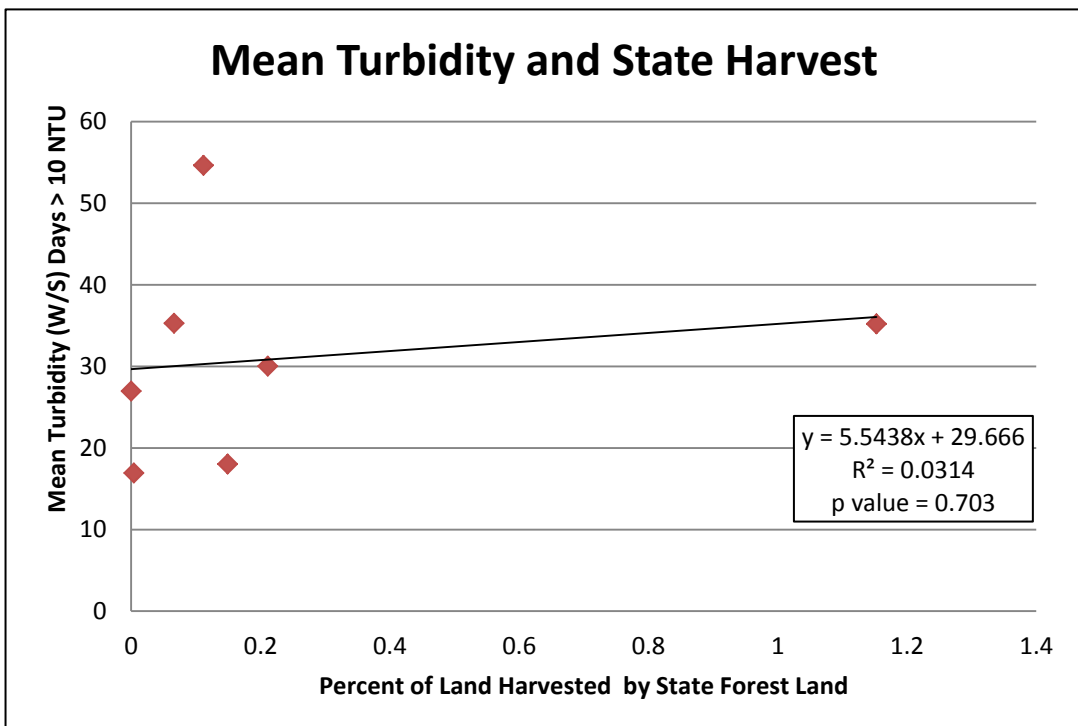
There is a positive, week ( $R^2$ : 0.24) and not significant ( $p$ : 0.26) relationship between Mean Turbidity and the Percentage of the Watershed Harvested (Graph 1). For the individual harvest, Mean Turbidity and City Forest Harvested area (Graph 2) have a positive, significant ( $p$ : 0.02) and more strong relationship ( $R^2$ : 0.68). Mean Turbidity and Harvested Area of State Forest and Private forest land (Graph 3 and 4) seem to have almost no relationship ( $R^2$ : 0.03 and  $R^2$ : 0.12). On the other hand, Mean Turbidity and Total Precipitation (graph 5) presents a negative, week, and insignificant relationship ( $R^2$ : 0.31,  $p$ : 0.19).



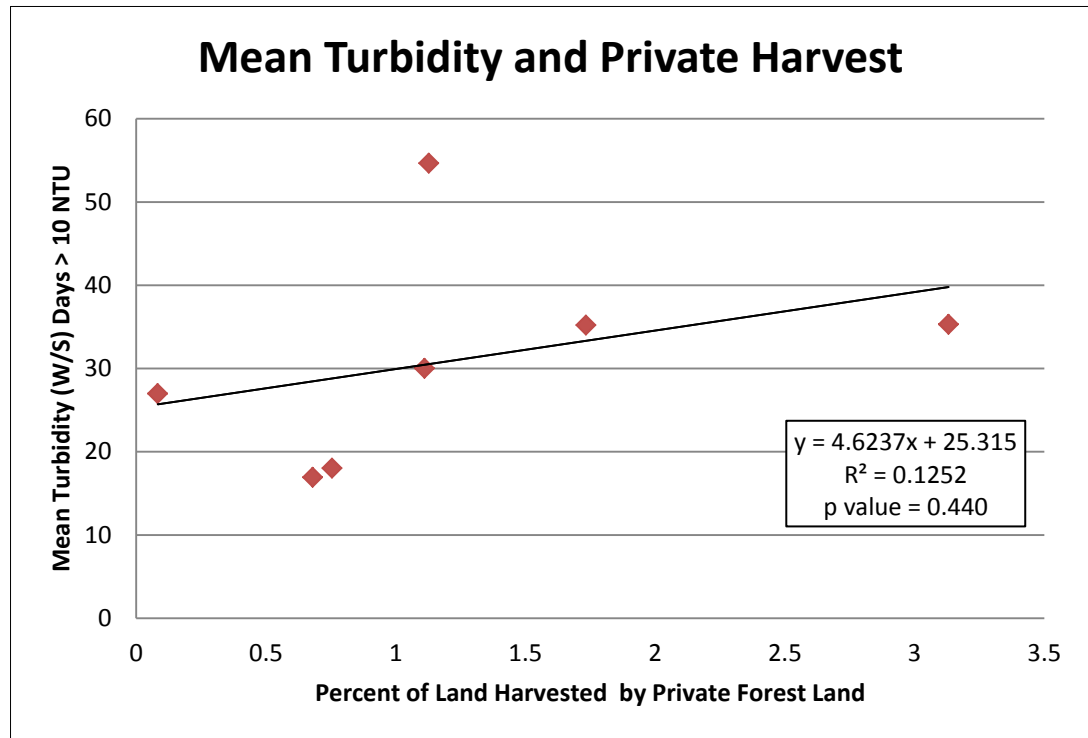
Graph 1. Linear regression analysis of Mean Turbidity and Total Harvest.



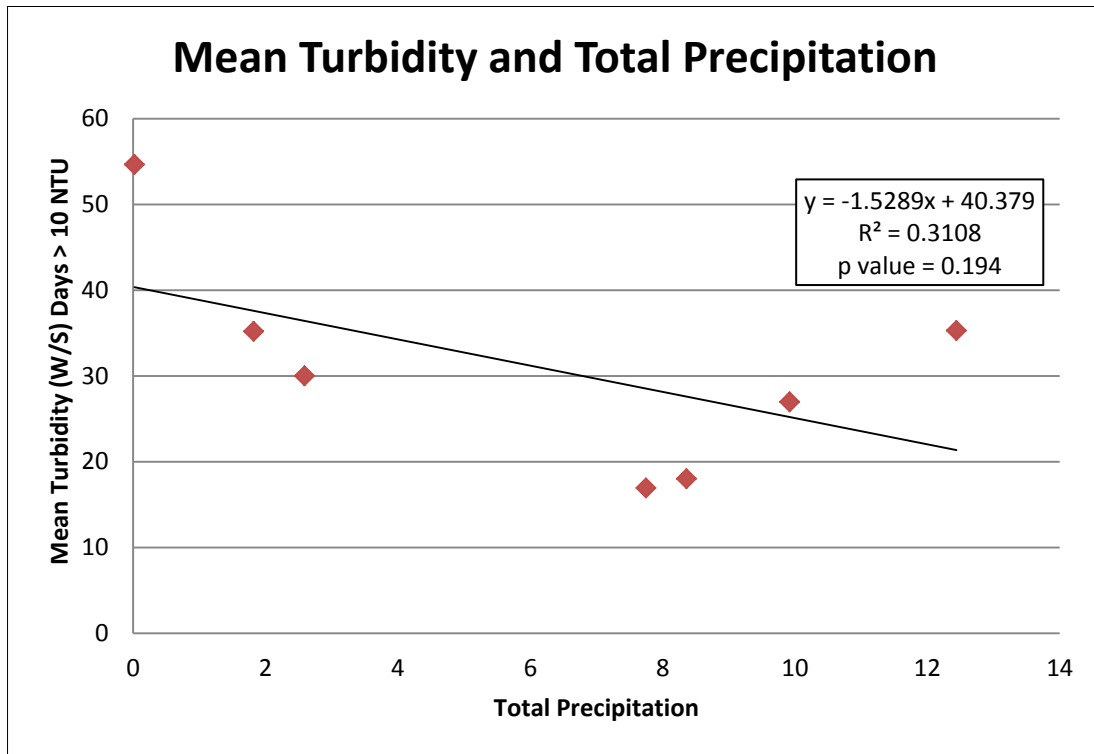
Graph 2. Linear regression analysis of Mean Turbidity and City Forest Land Harvest.



Graph 3. Linear regression analysis of Mean Turbidity and State Forest Land Harvest.



Graph 4. Linear regression analysis of Mean Turbidity and Private Forest Land Harvest.



Graph 5. Linear regression analysis of Mean Turbidity and Total Precipitation.

## CONCLUSION

Mean Turbidity and Total Percentage of Watershed harvested show a positive but very weak correlation. It can be assumed that the sum of the clearcuts in the watershed cannot be directly used to predict turbidity values in the lower part of the watershed. In the case of Mean Turbidity and City Forest Land harvested, the positive, strong and significant correlation indicates that with the increase in harvest area in this land, turbidity also increases. The City Forest Land covers more than 67% of total area, and is located in the medium and lower watershed. Therefore, it is more likely that the turbidity will be easily driven by the harvest activities in this area. Moreover, ODEQ (2010) reported a decrease in turbidity in the late 90’s, which was attributed to the change in timber harvest practices by City Forest Land to Forest Stewardship Council (FSC)-certified management plan. Thus, it can be assumed that the decrease in turbidity over the years has to do with the change in Harvest practices in this portion of the watershed. On the other hand, Mean Turbidity and State Forest land, as well as Private Forest land seem to be inconsistent to explain high turbidity values. This can be explained in different ways. First, these lands are in the upper watershed, which means that is unlikely to correlate their harvest activities to the turbidity registered in the lowest watershed. However, Mean turbidity and Total precipitation shows a negative, very weak, and insignificant relationship. It seems like values turbidity above 10NTU are unlikely to be explained by precipitation values. In this regard, this result is in concordance with ODEQ (2010) findings about turbidity and whether patterns for this watershed, where they mentioned that turbidity patterns are not likely to be explained by weather.

There were a number of limitations regarding this project that mostly have to do with the data available. First, having just one monitoring station did not make possible the study of individual harvest practices and their impacts on turbidity in different parts of the watershed. Second, the Daily turbidity data have no records for a some days. Finally, the small research time window (1994-2008, broken down in 7 periods-samples) limited the extent of variables that could be combined, and therefore, restricted the analysis of the relationship to a simpler model. These years were selected for the turbidity data available, and it was broken down that way by expert’s recommendation. For further studies on this same case, it is suggested that additional variables be considered in the analysis. These variables would include; the distance, slope and soil type between the harvest areas and the streams that they drain to, and how to calculate the effect of the gradual regrowth of the disturbed area and its effect on soil erosion versus fully regrown areas of land. If possible, additional monitoring stations would provide more data to compare turbidity levels along each waterway and the harvest areas that drain to them. All of this will require dedicated resources in time and funding to be able to collect adequate data and perform the analysis on it.

## REFERENCES

1. Department of Environmental Quality. June 2010. Turbidity Analysis for Oregon Public Water Systems Water Quality in Coast Range Drinking Water Source Areas (Report). Portland, Oregon: 23-26.
2. Klein, R. Lewis, J. Buffleben, W. 2011. Logging and Turbidity in the Coastal Watershed of Northen California. Geomorphology 139, 140 (2012): 136-144.