Assessing Risk of Mountain Pine Beetle Attack in Northern BC

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Abstract

BC's central interior forests have recently become the subject of a widespread mountain pine beetle infestation, which now dates back to the year 1993. The mountain pine beetles, which primarily target lodgepole pine trees, are able to severely damage or kill large stands of trees by damaging the phloem layer within a tree, effectively eliminating its water and nutrient supply. Due to the extent and severity of BC's latest beetle infestation, our pine forests have experienced particular devastation. Several factors have been identified as responsible for the beetle infestation, including, warm winter temperatures, hot, dry summers, and the maturation of lodgepole pine stands. This project attempted to use a GIS to identify areas which are at risk of further pine beetle infestation. Several calculable variables were used to determine susceptibility to attack. These variables were combined into a final calculation, which produced a susceptibility rating for the landscape on a scale of 0-10. Areas exhibiting low numbers were termed low risk, while areas with high number values were deemed high risk to future pine beetle attack.

Introduction

- Mountain pine beetle infestation has become a major problem to the forests of BC, specifically to mature stands of lodgepole pine
- Pine beetle attacks are destroying large stands of forest, which in turn has had negative impacts on the BC forest industry, especially in terms of sustainable harvesting for the future
- The study area lies between Prince George and Mackenzie, in Northern British Columbia
- The objective of this project is to create a final output which will rate the landscape within the study area in terms of susceptibility to future pine beetle attack

Study Area and Data Source

- The study area for this project was a northern BC forest area in between Prince George and Mackenzie. Originally, the study area encompassed a square section of the TRIM Map Sheet 93J, including subsections 54-56, 64-66 and 74-76. This area was significantly clipped however, in order to improve slow loading and processing times.

- The TRIM data used for this project were contained within the files: 93j054.saf, 93j055.saf, 93j056.saf, 93j064.saf, 93j065.saf, 93j066.saf, 93j074.saf, 93j075.saf, and 93j076.saf. Forest cover data were contained in the file vri93j.zip, and mountain pine beetle attack data came from the files beetle99.zip, ply2000.shp, and ply.shp.
- All data were obtained from the UNBC GIS Lab database, located at N:\data\. TRIM data were obtained in .saf file format from N:\data\gisdata\trim1. Forest cover data were in .zip file format, copied from N:\data\gisdata\bc_vri. Finally, pine beetle attack data were obtained in .zip and .shp file format from N:\data\gisdata\mount_pine_beetle \raw\years.
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Data Manipulation

- All data were copied to N:\truantk\geog413\finalproject\
- Once obtained, the TRIM data needed to be converted from .saf to ArcInfo .e00 file format. This was done using the FME Universal Translator, which combined all of the .saf files and translated them. The forest cover and pine beetle attack data in .zip format needed to be unzipped for use in ArcMap. Once all data were converted to a useful format, they were displayed in ArcMap. The data were then clipped to a more manageable size by the shapefile studyarea.shp, which was created in ArcCatalog and edited in ArcMap.

Methods / Procedure

- Model (the procedure for solving the problem)
- With the data displayed and clipped to the desired size, comparison of layers was the next step. Pine beetle attack data from each of the three years (1999, 2000, 2001) were joined together using the UNION tool in ArcToolbox, to provide an overview of recent attacks. The forest cover layer was classified according to leading species. From the TRIM data, the contour layer was used to generate a TIN. This TIN was further used to generate an elevation layer and an aspect layer.
- At this point, the forest cover layer was compared to the pine beetle attack layer, to determine which forest factors were most commonly found within infested areas, and their general value ranges. Based upon this visual determination, the following query was entered in ArcMap's Select by Attributes application, to select forest cover areas that displayed similar characteristics: [SP1= PL OR SP1 = SXW AND SP1_PERC > 70 AND AGE > 150 AND HEIGHT >= 25 AND HEIGHT <= 30]. This selection was exported as a new layer, which represented areas of forest susceptible to pine beetle attack due to biotic characteristics.
- In a similar manner, the elevation and aspect layers were visually analyzed to determine the most frequent ranges of values in which pine beetle attacks were found to occur. Using the Raster Calculator, a new layer was created which highlighted areas determined to be susceptible to pine beetle attack due to elevation and aspect. The calculation for this layer combined areas with an elevation range of 850-1000m and areas with an aspect range of 0-180^{o}.
- Three distance maps were then created, using Distance -> Straight Line within the Spatial Analyst tool. These maps displayed the distances from already infested areas, susceptible forest areas, and areas susceptible due to elevation and aspect.
- Each distance map was reclassified, with the closest class receiving a '10' value, the next closest receiving a '9' and so on, with the furthest class being labeled as '0'. The elevation and aspect susceptibility map was reclassified so that susceptible areas were labeled '10' and non-susceptible areas were labeled '1'.
- Finally, the risk factor calculation was run, which took each observed variable into account. The three reclassified layers created in the previous steps were used in this calculation. The final calculation ran as follows: Risk = [Distance from Infested Areas] * 0.5 + [Distance from Susceptible Forest] * 0.3 + [Elevation and Aspect Susceptible] * 0.2. This calculation created a final output, which rated the entire study area in terms of susceptibility to pine beetle attack. Areas exhibiting a '10' value were at highest risk, and areas with '0' values had the lowest risk of being attacked.

Results

* The clipped study area with forest cover layer and pine beetle infestation layer can be seen in Fig.1, with Lodgepole Pine stands displayed in Lime Green, White Spruce in Dark Green, and all other stands in Brown.

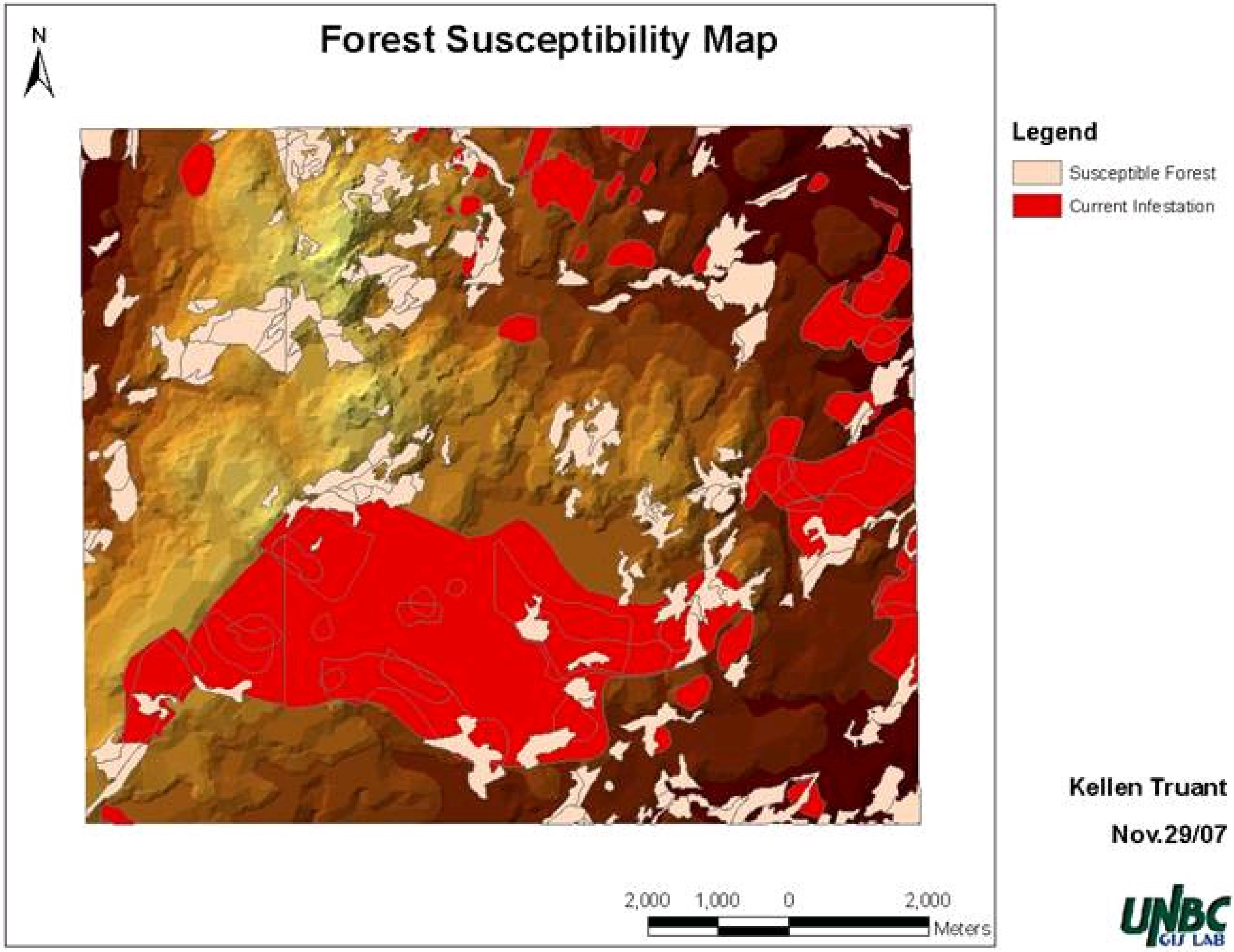

Fig.2 – Forest Susceptibility Output with Pine Beetle Infestation and TIN layers

- Areas determined to be susceptible to pine beetle attack due to elevation and aspect are displayed in Fig.3 over top of the TIN layer.

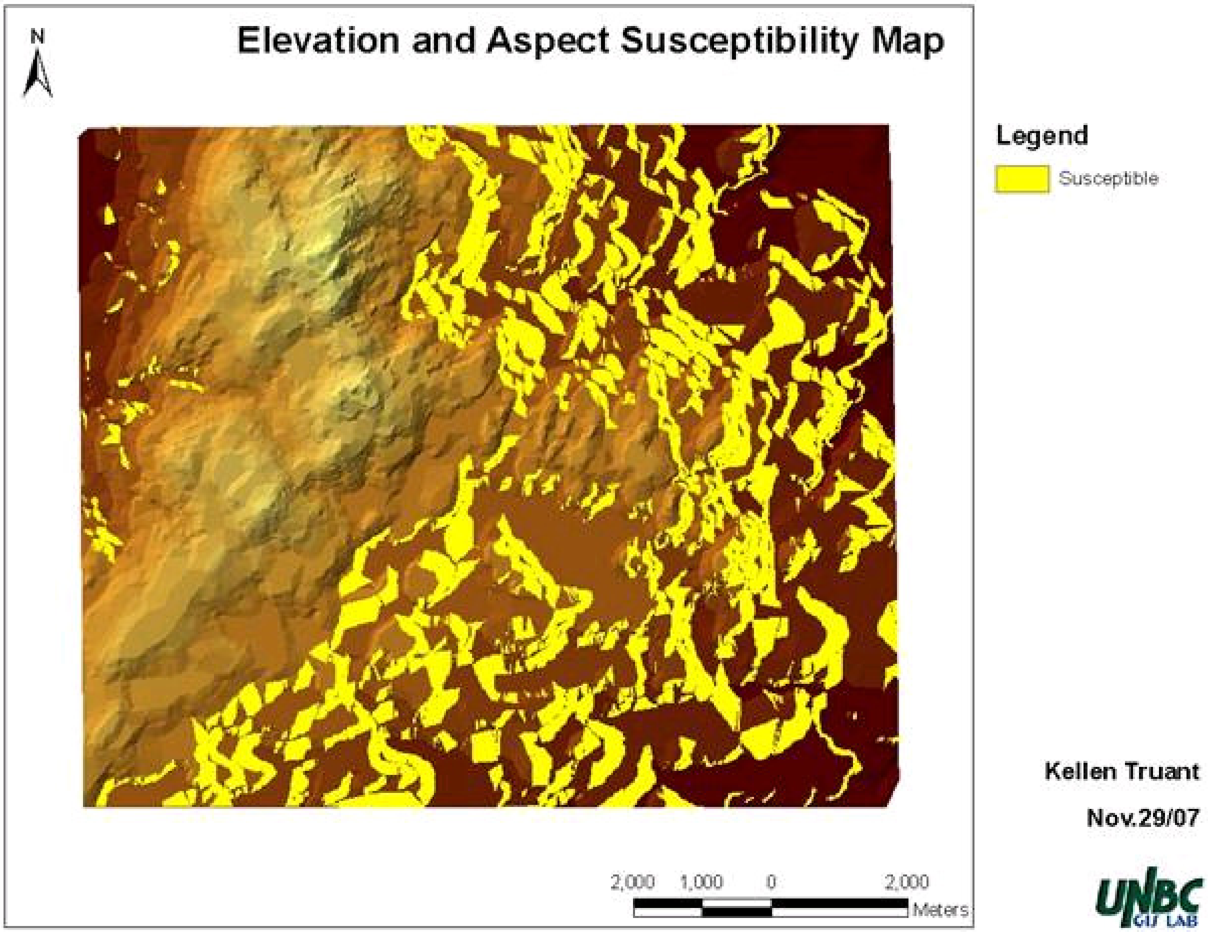

Fig.3 – Elevation and Aspect Susceptibility Output and TIN layer

- The distances from current infestation areas as calculated by Spatial Analyst -> Distance -> Straight Line are shown in Fig.4.

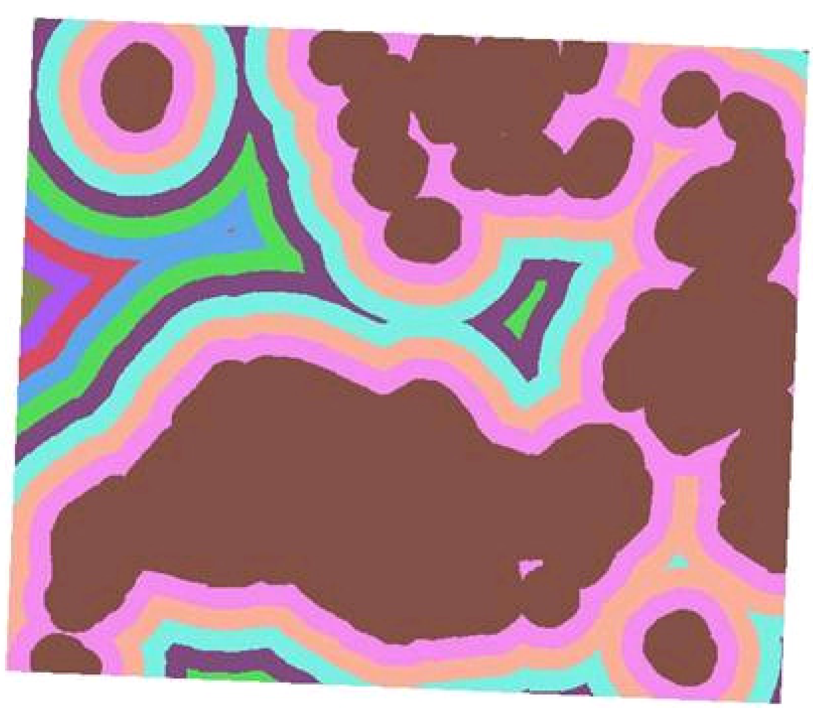

Fig.4 – Distance Map from Current Pine Beetle Infestation

- The final output is displayed in Fig.5, which shows the overall risk factor for the entire study area, with 0 corresponding to least susceptible, and 10 corresponding to most susceptible areas.

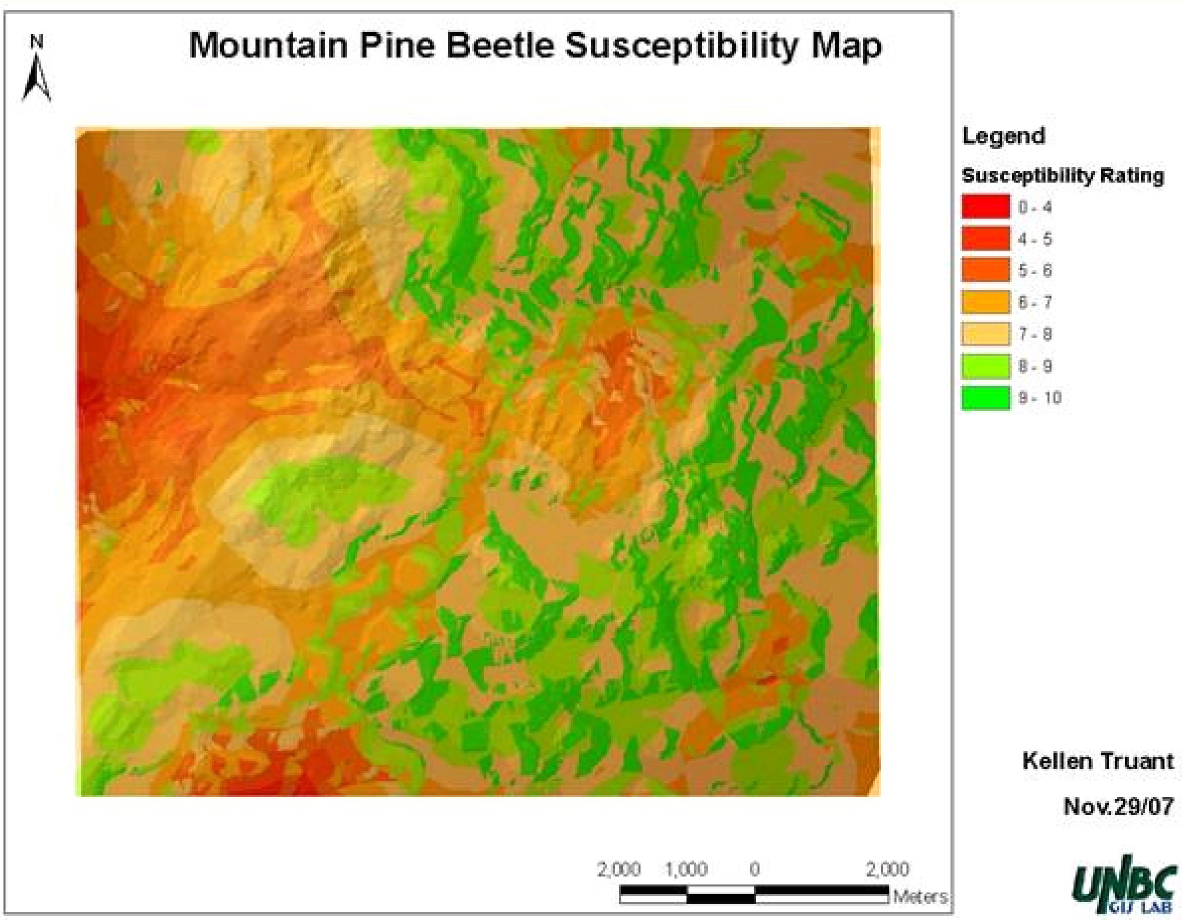

Fig.5 – Final Output Susceptibility Map

Conclusions / Discussion

- The final output provided a visually understandable map, detailing the level of risk of further mountain pine beetle attack in the study area. The susceptibility rating combined a number of factors, including forest characteristics, elevation and aspect, and proximity to infested areas.
- The factor that appears to contribute the most towards susceptibility is distance from already infested stands, which would make sense as this would govern the ability of mountain pine beetle to travel directly from their habitat to new resource areas. It must also be kept in mind that the final calculation was most heavily weighted towards the distance from already infested stands component, which would affect the final output.
- According to the final output, a significant portion of this study area is susceptible to future pine beetle attack. This information may be of interest to the Ministry of Forests in future considerations of management strategies.

Future Works / Developments

- My work on this project is complete
- Other projects could attempt, depending on the capability of the GIS lab in future, to analyze larger areas, or incorporate more updated beetle infestation data
- For future expansion of this type of project, I would recommend incorporating additional value fields into the overall susceptibility rating, in order to achieve a more accurate result. These fields could include factors such as stand DBH (Diameter Breast Height), Tree Density, Wind, and Slope.

References

- All data for this project were made available by the UNBC GIS lab, under the N:\data\gisdata directory
- General information on the mountain pine beetle was obtained from the Ministry of Forests website, at www.gov.bc.ca/for/
- I would like to thank Ping Bai and Darren Janzen for all their help in completing this project
- Data for this project is located at N:\truantk\geog413\finalproject\
- Files for which metadata is included:
- N:\truantk\geog413\finalproject\webpage\fc_susc
- N:\truantk\geog413\finalproject\webpage\finalcalc
- N:\truantk\geog413\finalproject\webpage\elevasp_r

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