The Influences and Implications of Environmental & Ecological Variations on BC's Forest Fires

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Table of Contents

Appendices

Abstract

One of the most prominent headlines that BC residents notice in the summer are our province's battle with forests fires. With an average season's spending tagged at $116 million every year, it is possible to assess a season's severity from the amount spent mitigating and preventing damages. For instance, 2009 was the worst year on record, having cost the government $400 million (BC Wildfire Services, 2016). The yearly costs, and amount of land burnt varies drastically every year, however. For example, 2011 was one of the quietest years on record, having cost only $64 million. Nevertheless, there is still evidence of an overall uphill climb in the average number of hectares burnt every year, as well as with the yearly fire service costs throughout time. Our study evaluates correlations that may exist between this trend and environmental factors. We found that although there have been noticeable changes in the yearly average amounts of precipitation and temperature, the correlation was not always particularly strong for our timeframe and regions of study. This is likely because there are large variations in these factors naturally, which can be difficult to represent well through our methods of GIS analyses. There were, however, indications that fires burnt heavily in regions heavily infested with mountain pine beetles (Dendroctonus ponderosae). With GIS analysis software, were able to provide visual representations of our findings.

Project Synopsis

Our project aims to assess the implications that climate change has had, and will continue to have on our native forests through incidences of wildfire. By analyzing the amount of government spending on wildfire management each year, we are able to deduce the amount of damage each year that wildfires cause. Furthermore, we analyzed the spatial distribution of wildfires and their sizes and rates of occurrence through time. Our study area includes the southern portion of British Columbia, however in some cases more specific analyses were focused on just the Thompson-Okanagan region. In recent decades, wildfires have greatly affected inhabitants in those regions of BC. From substantially altering landscapes, to decreasing air quality and heightening fear; wildfires are major source of concern for the government.

We quantified and compared the extent of damage caused by naturally occurring wildfires versus those that were human caused. Of highest importance however, we looked into environmental factors that may have had a role in influencing the perceived trends. These include but are not limited to: amount of summer precipitation, amount of snowfall over the previous winter, and average summer temperatures. Additionally, we strove to find correlations that may exist between forest fires and the severity of the current mountain pine beetle outbreak, and the ways by which these fires were affecting local communities, such as recreational trails & parks.

To execute our project, we gathered data from a number of sources. The majority of our data was gathered from the government of BC's open access data. From the data descriptions provided, we deduced that theses sources for data would be reliable and useful for our purposes.

Methodology of Analysis

Various methods and GIS techniques were carried out in the analysis of the different elements integrated into our study. We divided the physical areas of study into 3 divisions: the province of BC, the Okanagan region, and the area in BC that has been salvaged by Mountain Pine Beetles. From there we took into account fire incidents in 2015, clipping these points to each area we studied. For BC and Okanagan maps we isolated human caused fires via select by attribute, and to visualize the scope of impact, used quantitative symbologies (manual breaks) to show the distribution of various sizes of fires (in hectares).

To see historic changes in climate, temperature and precipitation data over roughly the last century (1900-2013) were utilized to scope the region's susceptibility to wildfires by drastic climate change. The temperature and precipitation tabular data required a data join with ecoprovinces, which are regional divisions of BC based on similar ecosystems contained within the areas. The temperature change map follow a quantitative symbology with a classification of natural breaks, while the precipitation change map follow a classification of manual breaks, however, the values differing not very far from the natural breaks divisions.

In associating the spread of wildfires with human activity, we looked at roads in BC and the Okanagan, as well as recreational trails in the Okanagan. A buffer was performed around all of the roads and the trails shape files, with a 2km buffer around the roads, and a 1km buffer around the trails, as we wanted to look at if direct human activity had any strong correlation. The human caused fire were then intersected with the buffer, or by using select by location, to see if many person caused fires were within pathways of human activity and if the distribution of these fires closely followed those pathways.

We also looked at species conservation areas that are at high risk and if last year's wildfire spread had threatened these conservation at risk areas. The shapefile downloaded from dataBC, however, contained many intricate polygons covering the entire Okanagan region, and for this reason we only extracted and looked at conservation areas that are at very high risk for analysis. We then intersected the human caused fire points with the conservation areas at high risk, as well as placing a 500m buffer on these polygons to see the extent of potential risk they were in. Since we were looking at Mountain Pine Beetle Salvage areas throughout BC and their associations with the spread of BC wildfires, we took into account elevation by including raster DEM files. A hillshade was placed at a z factor of 3 to clearly see at what elevations were more susceptible to be occupied by mountain pine beetle colonies.

Overall, the methods used in our study were, for the most part, consisting of data extraction, mining, and intersects. In deciding on which techniques to use, we based our considerations around our focus of studying 2015 wildfire spread, especially those resulting from human activity, and visualization to easily compare and contrast the scope of impact of wildfires.

Discussion & Results

Mountain Pine Beetle - Map: Appendix A

As can be seen in our map, "2015 Wildfire Occurrences in Mountain Pine Beetle (MPB) Salvage Areas in BC", there are an abundance of fires that take place within the MPB salvage areas, with the most occurring in the southern half of the province within the salvage area.

Many scientists attribute the severity of current forest fires in BC to be caused by the mountain pine beetle (D. ponderosae). This is because once a tree dies from an attack, it loses most of its moisture and catches fires much more readily (Harvey et al. 2014) than a living tree. When thousands of hectares of forests are covered with dead and dry pine trees, the landscape is much more susceptible to larger fires that travel faster, and that are significantly harder to put out. The spread of D. ponderosae has gained momentum in the last couple decades, becoming the largest insect outbreak in recorded history in the world (Keeling et al., 2013). The most influential contributor to this is climate change. Without the cold (- 40 C) winters we once had that would kill off most of the population, their populations are no longer maintained.

Furthermore, provincial fire suppression policies that are in place have also compounded the increased spread of D. ponderosae. Their populations were also once controlled through smaller, naturally occurring fires. Hence, since so much effort has been put into preventing any fires from developing, this essential environmental process is not longer able to occur. Unfortunately, there are no signs indicating that the MPB outbreak will dissipate anytime soon. Climate change has only been predicted to worsen in the future, and wildfire suppression policies are almost definitely going to remain in place. As a result, the fate of BC's future forests does not seem particularly hopeful.

The following are the statistical results (in hectares) drawn from ArcGIS that pertain to this map:

BC's total landmas	95,136,269.6
Total MPB Salvage Are	50,934,127
Total Old Growth Management Area in MPB	9,513
1507 Fires in MPBSA → Total Fire are	102,911
Largest fire in MBS	25,00

It can be observed that be seen above that over half of BC's total landmass has been categorized as a MPB salvage area. This area is only going to continue to grow. The only way for there to be real change in this regard, is for policy makers around the world to acknowledge the data and to act accordingly. This includes developing policies that will help mitigate climate change, while still allowing natural environmental processes to take place.

Climate Trends in British Columbia - Map: Appendix B and C

Climate change is one of the biggest challenges for mitigating any natural disasters, as the results of climate change seem to be increasing their consistency and strength. Wildfires are no exception; the number and intensity of fires in British Columbia will likely increase "by more than 50 percent or more in the next 40 years", especially the number of fires sparked by lightning strikes (Lee, 2012). In 2010, the land affected by fire was the highest number in two decades (Lee, 2012).

One of the contributing factors causing this to happen is the temperature trend across the province over the last century. As can be seen in the two maps, the entire province has experienced at least some (and in some parts, drastic) increases in both temperature and precipitation. Disturbingly, the most dramatic increase in temperature is farther north in the province, and there is data to support the fact that the northern part of the province has been experiencing a gradually increasing number of wildfires (Government of British Columbia, 2016). The increases in precipitation don't follow the same pattern as temperature; the north experienced only a small increase in precipitation over the past century compared to the southeast corner of the province, which has seen a dramatic increase. Interestingly, as can be seen in our map in Appendix C, the biggest concentration of fires (as well as most of the fires greater than 100 hectares) in British Columbia appear to be in the eco-province that experienced the smallest increase in temperature but the biggest increase in precipitation. However, this map also shows that fires have been occurring in the northern region of the province as well.

Climate change and its resulting effects, especially temperature increase and (to an extent) precipitation increase, are having an undeniable effect on the forests of British Columbia. The Government of British Columbia puts a fairly strong priority on fire fighting and fire management (Government of British Columbia, 2016). However, like most climate related issues that need mitigation, the root of the problem is climate change itself. And until world leaders take a firm stand on global shifts to slow down human causes of climate change, we will continue to see an increase in the temperature and precipitation in BC, and in strength and number of wildfires.

Ecosystems at Risk of Being Affected by wildfire and Okanagan trails - Map: Appendix D and E

Almost half of the forest in British Columbia is over 140 years old, though 15% of all the forest in the province is protected (Council of Forest Industries, 2016). However, this is still a generally high conservation percentage compared to most of the world. It is not only the forests that are the reason these conservation areas in place; BC is the most ecologically diverse province in Canada as well as the most biologically diverse province—more than half of the species of wildlife and fish found in Canada are found in BC (Council of Forest Industries, 2016). So, understandably, conservation in British Columbia is a hot topic of conversation for citizens as well as in politics, and everyone has an opinion in the matter. There are many classes of Protected Areas in BC, ranging from national parks (A, B, and C classes) to conservancies, to recreational areas (BC Ministry of Environment, 2015). Each of these categories have different exact criteria and policies as to what qualifies as an area in need of protection and what exactly is limited in each area. However, all of them include management of resource use and general sustainability of those resources. As can be seen on the map, there are many spots of ecosystem conservation areas at very high risk of being affected by wildfires in the Okanagan area, with many densely pink areas lining up with roads and especially right around the lakes. This is likely because lakes are popular vacation spots and easy to access because of many large roads in the area, and with more human activity comes more danger for damage to conservation areas. When you take into account the whereabouts of trails in the Okanagan (Appendix E), which also invite more concentrated human activity, many denser pink areas also line up with trails. Logically this would occur because hikers with little expertise are likely to start campfires that then get out of control in conservation areas near the trails. Furthermore, almost all of the large >100 hectare fires occur within close reach of roads or trails.

With the information given in these maps, the natural thought for conservationists would likely be to limit access to these areas, or (if not in place already), implement a fire safety program in all these areas to ensure that human caused fire issues are kept to a minimum. Another option is to raise the degree of fire fighting preparation specifically in these areas so as to be prepared to limit the size and severity of fires in the area, as it is not a question of if, but when.

Ignition sites of human caused fires' proximity to major roadways - Map: Appendix F.1 & F.2

It should come as no surprise that the distribution of human caused fires in Canada is heavily concentrated in areas near or adjacent to roadways. Major roadways in particular are especially strongly associated with higher frequency of forest fires; in fact, in the Okanagan in 2015 over 50% of all forest fires were ignited within 2km of major roadways alone (Appendix F.2). This trend is apparent throughout all of BC (Appendix F.1) and can be attributed to the fact that many major highways cut through rural, isolated areas of dense forest, and as such can go unnoticed for much longer periods of time, while also taking longer to receive action to be suppressed (Martell and Sun, 2008). With this in mind, it could certainly be considered that along the path of major roadways can be considered 'high risk' areas for human caused forest fires. In order to more effectively prevent future instances of human caused forest fires in high risk areas, further appropriate precautions should be implemented in these. Commonly used methods include patrols, satellite imagery, wireless sensors, and watch towers (Zhang, Han, & Kan, 2008); implementation of such precautionary measures along the highest risk areas, which we have determined to be areas within ~2km of major roadways, would undoubtedly decrease discovery and response time when dealing with human caused forest fires.

Error & Uncertainty

Due to the limited availability and nature of data that is relevant to us, there will always exist facets of uncertainty and error. One of the most prevalent recurring concerns we encountered regarded the varying time frames of the available data; in that different data sets did not alway encompass the same period. For example, the temperature and precipitation tables, which allowed us to identify trends in annual rates of rainfall and temperature, were only available from 1900 to 2013, meanwhile our data on fires was for the year 2015; as such we are relying on extrapolating the trends which we have seen in the 1900 - 2013 period when making comparisons. Similarly, lack of detail in data can result in less precise results; which thereby potentially inhibits the full extent of given correlation from being accurately represented in a map. An example of this may be the extent of the data for BC roads; as the data used only contains polylines for major roads and highways, and does not include any other types roadways such as city streets or forest service roads. As such, the complete correlation between a human caused fire's site of ignition and proximity to a roadway cannot fully be examined.

Another area of uncertainty arises when isolating the data which we considered to be 'relevant'. An example of this can be found when discussing ecosystems at risk by human caused fires (Appendix D), where we decided to focus only on areas at 'very high risk', in order to isolate only the highest risk areas and ease data management to create a clear and concise map. This may challenge ethics as different parties may have different views regarding what it means for an area and/or species to be considered at 'very high risk'. Although the focus of our maps was aimed towards exclusively human caused fires, there was certainly a clear correlation between naturally caused fires (i.e. lightning), and larger areas affected. As such, it is possible that naturally caused fires may have shown a stronger correlation with the climatic features that we investigated.

In order to create an easily legible visualization of the data, different classifications and breaks were used when presenting the data. For example, when presenting temperature data, natural breaks were used, meanwhile manual breaks were used when presenting the precipitation data. While this does allow the data of interest to be more easily isolated it also creates issues of possible bias to show certain characteristics of the data, while potentially not accurately representing other facets.

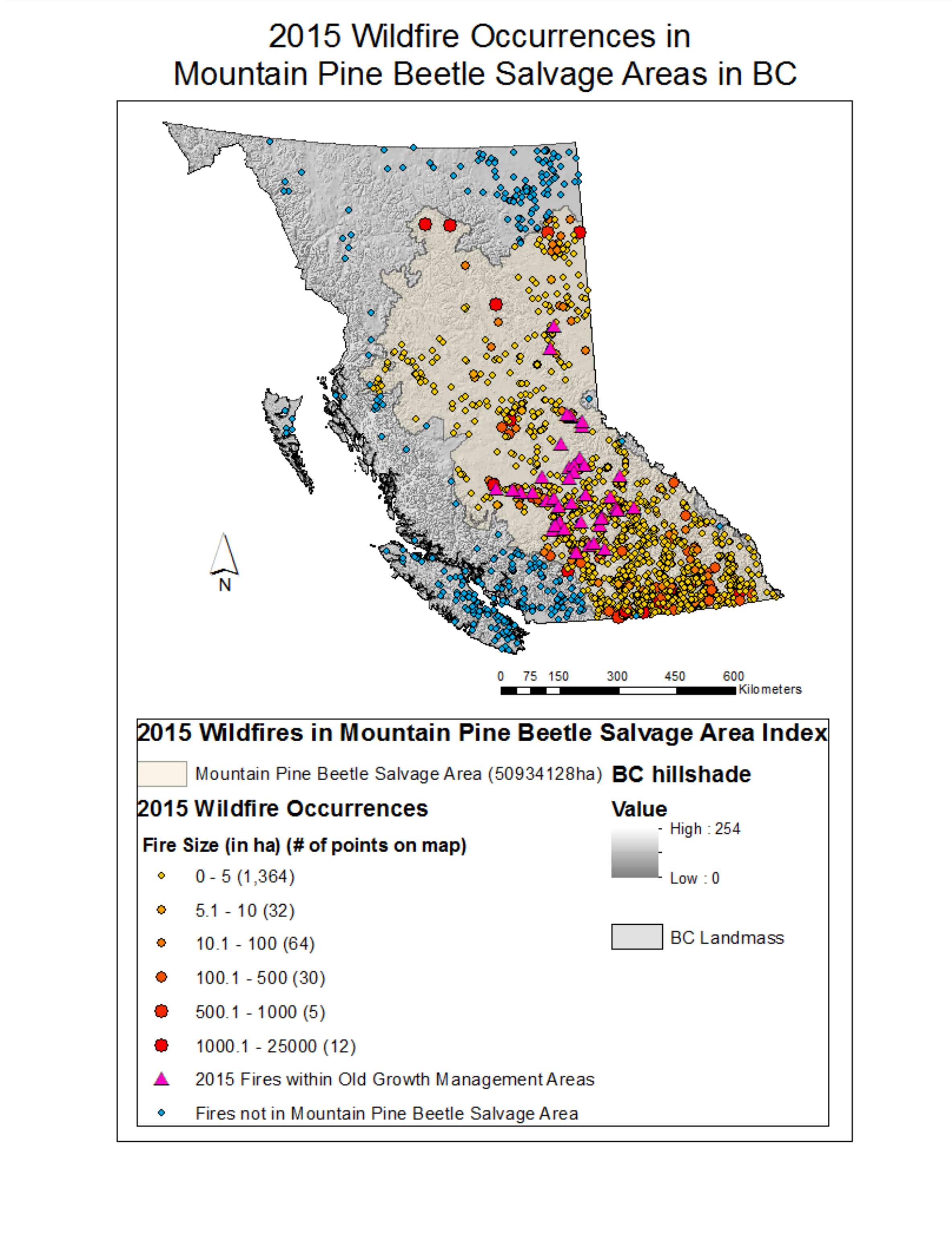
Future Research & Recommendations

The main focus in our study was aimed towards investigating correlations between human caused forest fires and a variety of socio-environmental factors. However, many of these factors would undoubtedly be highly applicable should the study be extended to include naturally caused fires. Therefore, there is potential for us to include naturally caused forest fires in future investigations, in order to create a variety of more comprehensive maps that examine a wider range of correlation/causation factors, and provide a more accurate representation of BC's forest fires and the effects they have. Furthermore, the issue of forest fires is by no means isolated to BC, as forest fires remain a prevalent cause for concern across Canada (Stocks et al., 2002), therefor, future research could extend the study to other provinces within Canada.

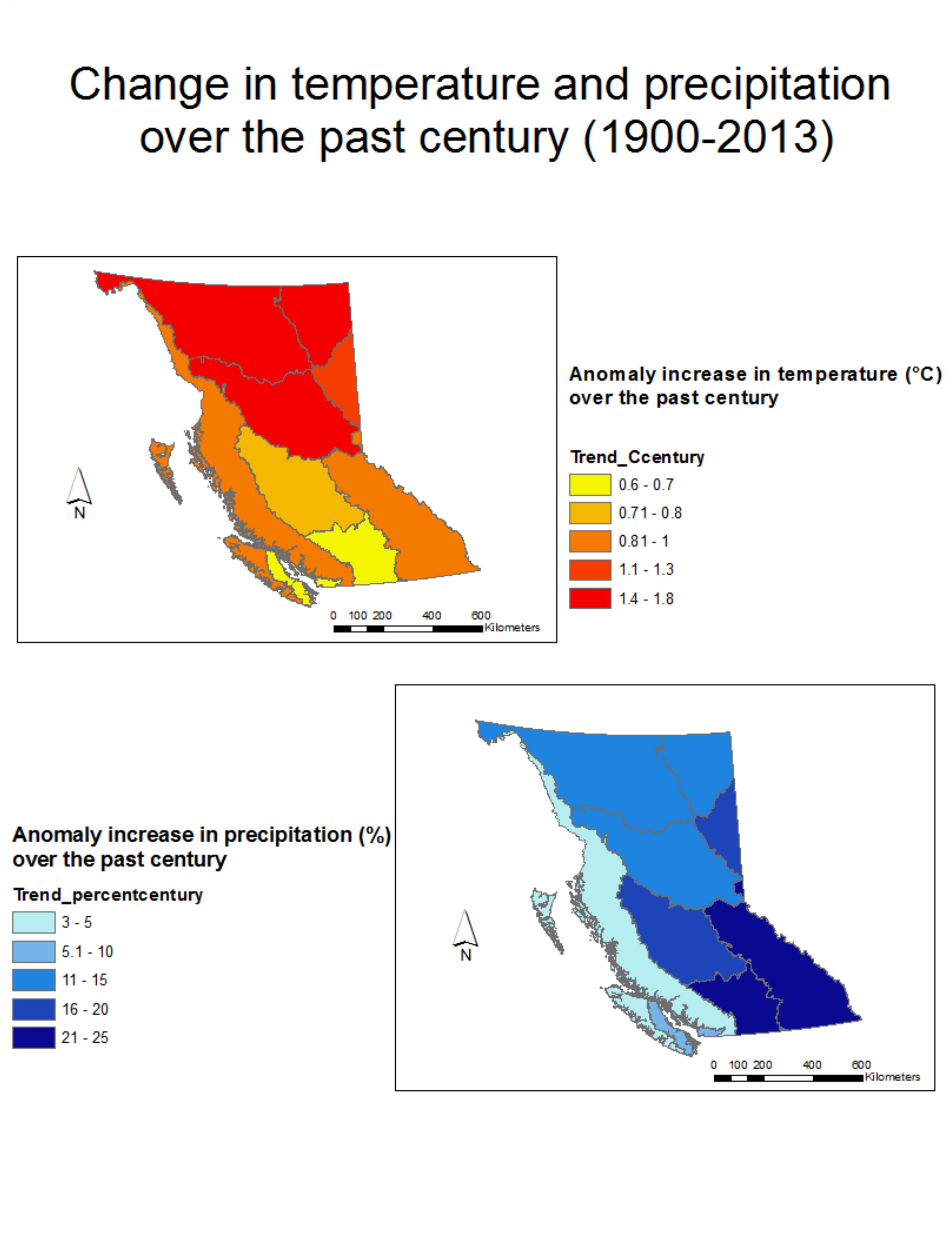
Fire projections from the Hadley Centre GCM predict an increase in forest fire frequency of up to 140% by the end of the 21st century based on current climate trends (Wotton, Nock, & Flannigan, 2010). As such, it is important that research into forest fire trends, such as ours, is able to yield findings that are actionable, and would allow appropriate precautions to be made in the future, whereby decreasing the risk of further harm to humans and ecosystems. In regard to human caused fires and their prevention, we could identify what the specific human involvement in the fire ignition was, and thereby implement further preventative measures that are specific to the most common human causes of fires. However, the problem is of course larger than each specific instance, and our role in climate change is a hugely influential constituent contributing to fire frequency, and represents a multi-faceted wicked problem for humans to tackle as a collective.

Appendices

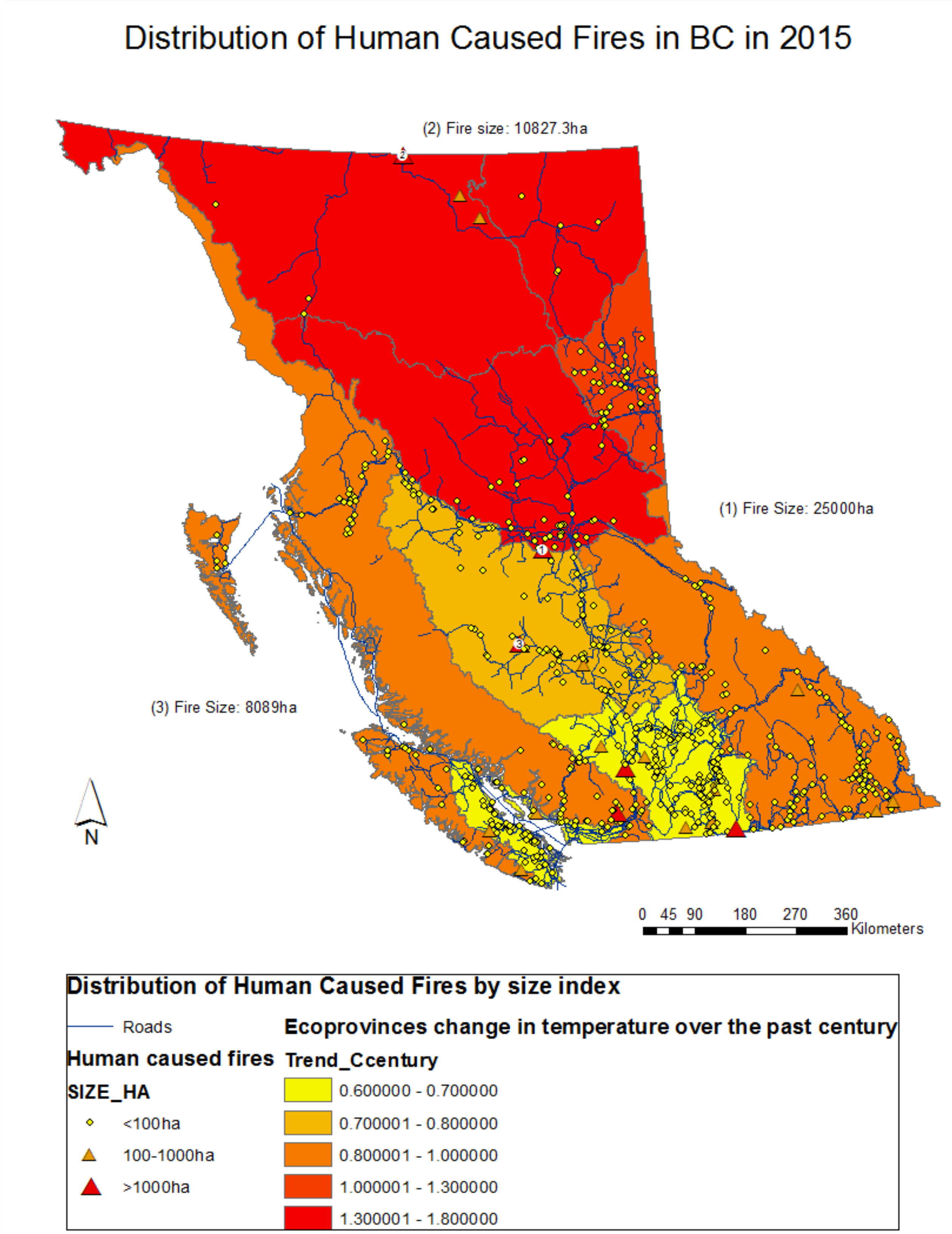
Appendix A



Appendix B

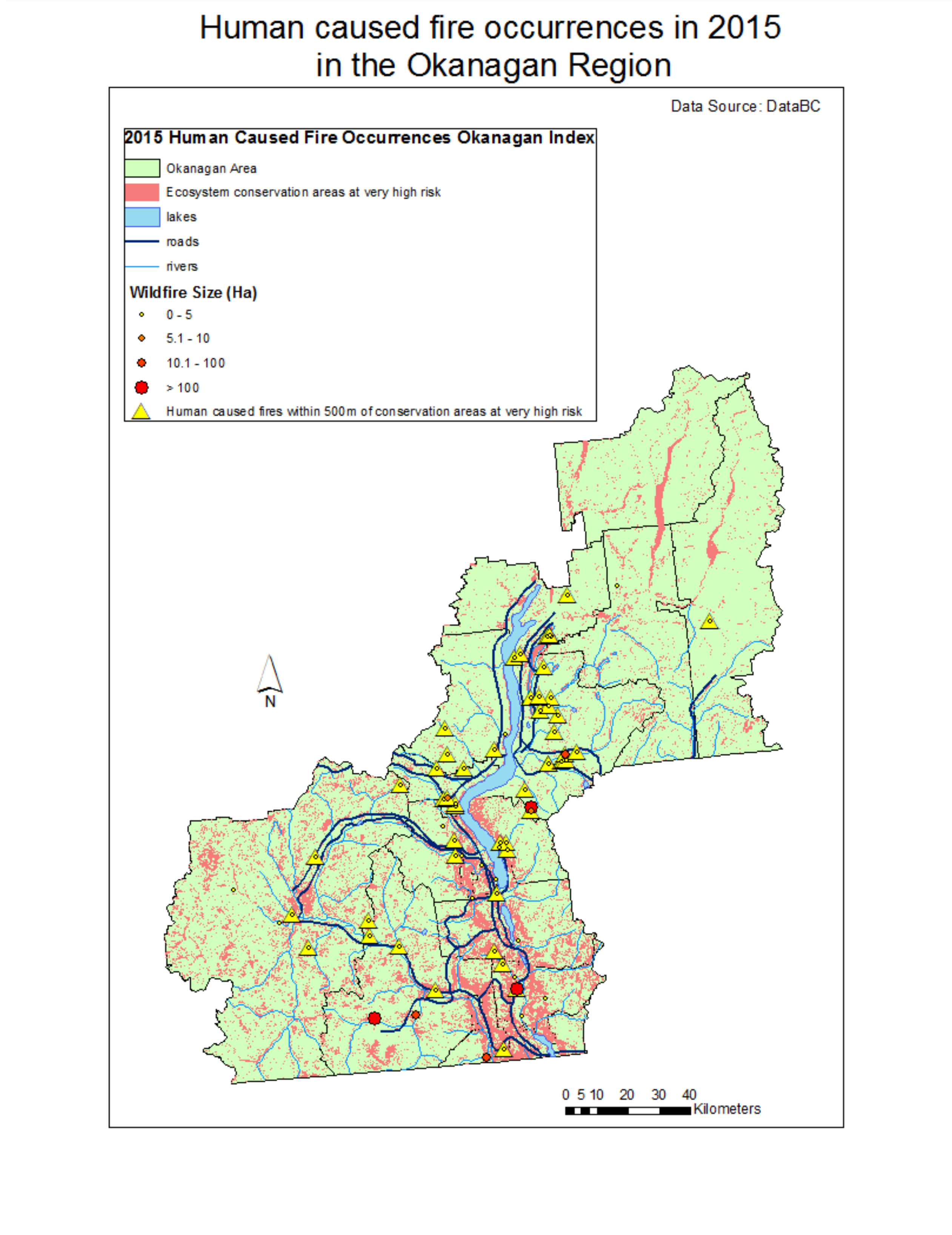

Change in temperature and precipitation over the past century (1900-2013)
Anomaly increase in temperature (°C) over the past century
Trend_Ccentury
0.6 - 0.7
0.71 - 0.8
0.81 - 1
1.1 - 1.3
1.4 - 1.8
N
0 100 200 400 600 Kilometers
Anomaly increase in precipitation (%) over the past century
Trend_percentcentury
3 - 5
5.1 - 10
11 - 15
16 - 20
21 - 25
N
0 100 200 400 600 Kilometers

Appendix C

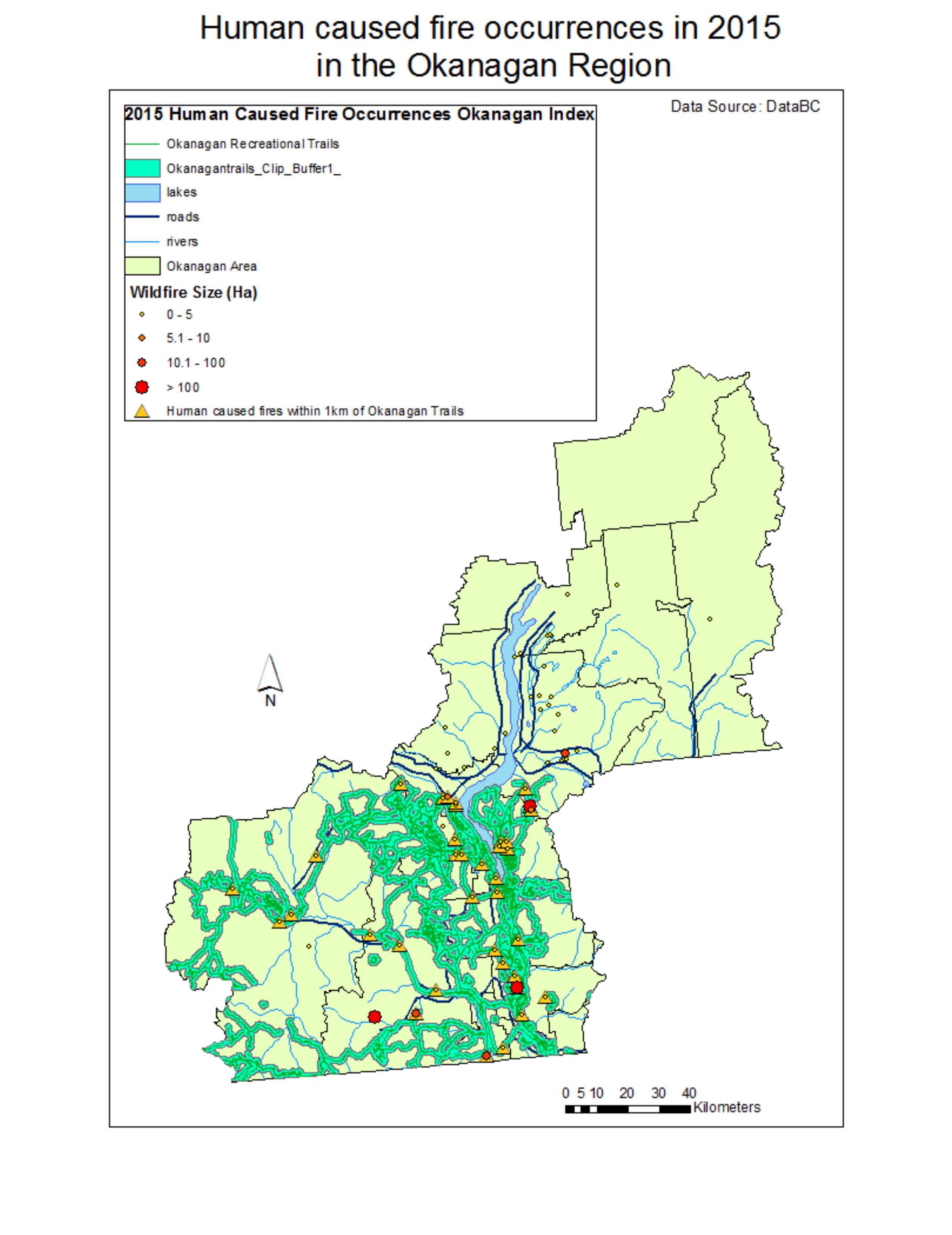


Distribution of Human Caused Fires in BC in 2015
(2) Fire size: 10827.3ha
(1) Fire Size: 25000ha
(3) Fire Size: 8089ha
N
0 45 90 180 270 360
Kilometers
Distribution of Human Caused Fires by size index
Roads
Human caused fires
SIZE_HA
<100ha
100-1000ha
>1000ha
Ecoprovinces change in temperature over the past century
Trend_Ccentury
0.600000 - 0.700000
0.700001 - 0.800000
0.800001 - 1.000000
1.000001 - 1.300000
1.300001 - 1.800000

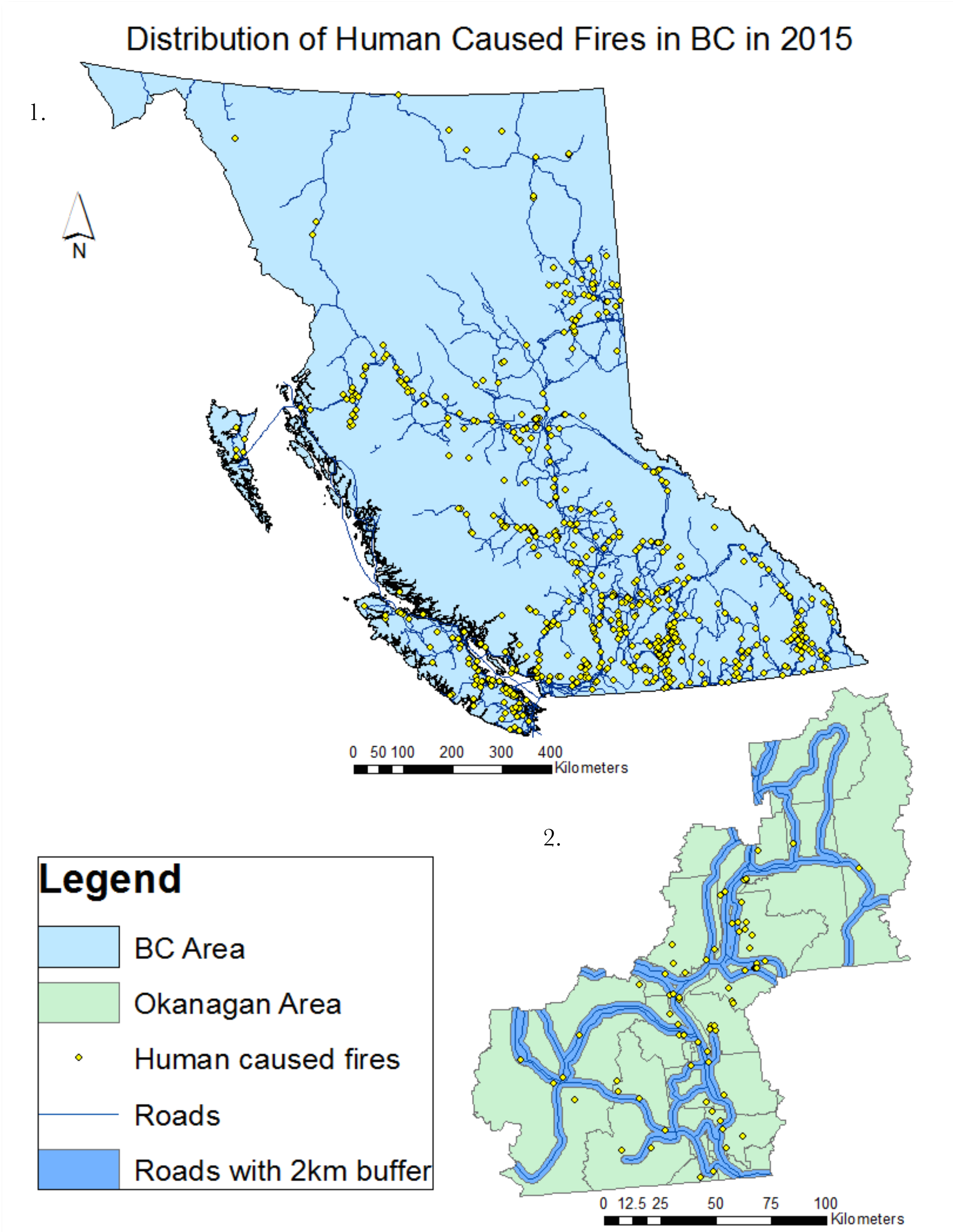
Appendix D


Human caused fire occurrences in 2015
in the Okanagan Region
Data Source: DataBC
2015 Human Caused Fire Occurrences Okanagan Index
Okanagan Area
Ecosystem conservation areas at very high risk
lakes
roads
rivers
Wildfire Size (Ha)
0 - 5
5.1 - 10
10.1 - 100
> 100
Human caused fires within 500m of conservation areas at very high risk
N
0 5 10 20 30 40
Kilometers

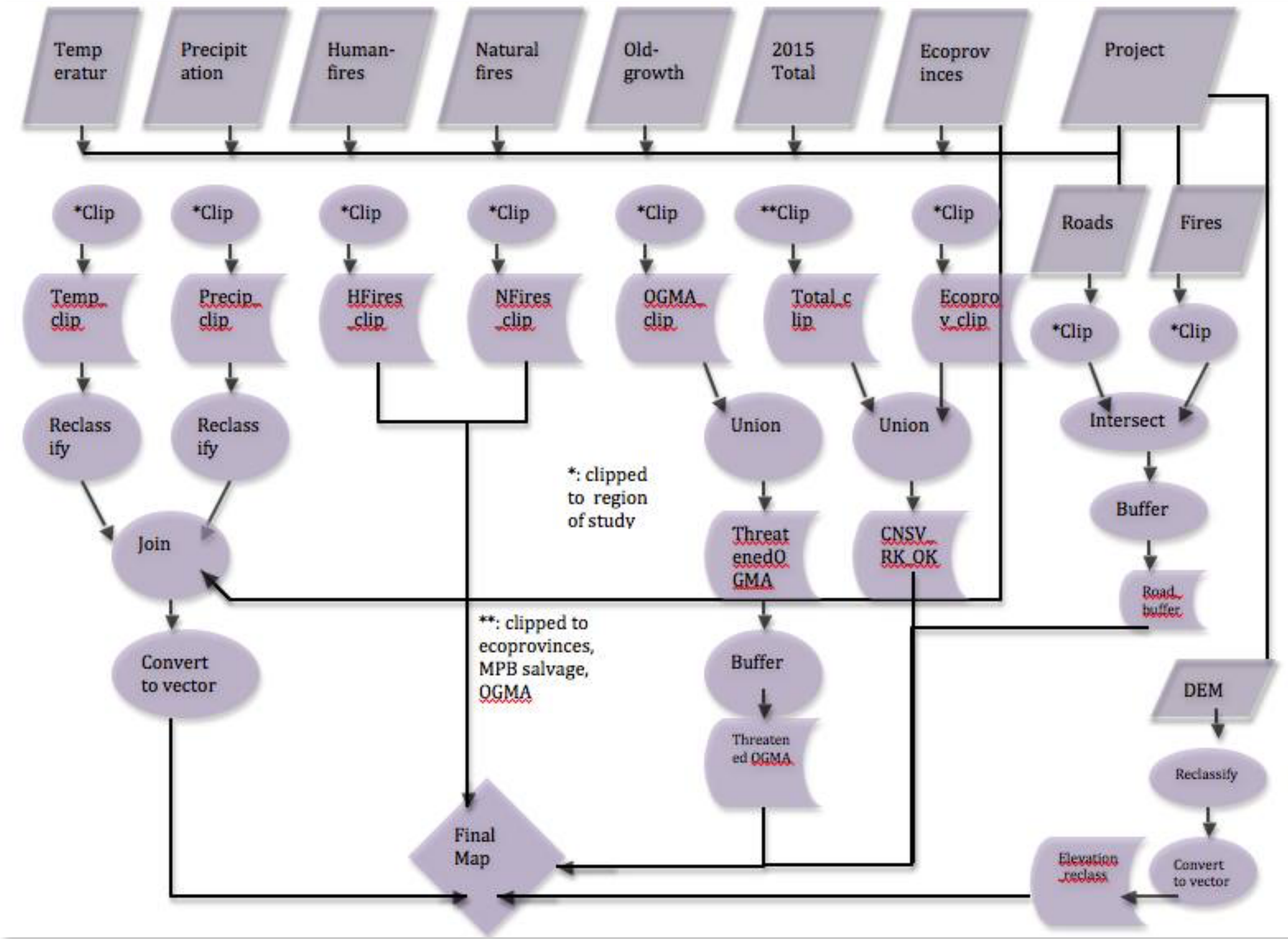
Appendix E


Human caused fire occurrences in 2015
in the Okanagan Region
2015 Human Caused Fire Occurrences Okanagan Index
Okanagan Recreational Trails
Okanagantrails_Clip_Buffer1_
lakes
roads
rivers
Okanagan Area
Wildfire Size (Ha)
0 - 5
5.1 - 10
10.1 - 100
> 100
Human caused fires within 1km of Okanagan Trails
Data Source: DataBC
N
0 5 10 20 30 40
Kilometers

Appendix F.1 & F.2



Appendix G



Temp eratur
Precipit ation
Human-fires
Natural fires
Old-growth
2015 Total
Ecoprov inces
Project
*Clip
*Clip
*Clip
*Clip
*Clip
**Clip
*Clip
Roads
Fires
Temp clip
Precip clip
HFires clip
NFires clip
OGMA clip
Total_c lip
Ecopro v_clip
*Clip
*Clip
Reclass ify
Reclass ify
Union
Union
Intersect
*: clipped to region of study
Join
Threat enedO GMA
CNSV RK_OK
Buffer
Road buffer
**: clipped to ecoprovinces, MPB salvage, OGMA
Convert to vector
Buffer
DEM
Threaten ed OGMA
Reclassify
Final Map
Elevation reclass
Convert to vector

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Picture References

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