Environmental Factors of BC Wildfires

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GEOB 270

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December 4, 2017

Table of Contents **Page**

Abstract

British Columbia has experienced a multitude of wildfires throughout history, with 2017 reaching a record burning of 894, 491 hectares of land.[1] In order to understand the factors that contribute to the causes and growth of wildfires in the province, we researched environmental factors as well as natural factors compared to anthropogenic causes of wildfires in BC. The following report outlines the process of researching, extracting, and manipulating the displayed data to evaluate potential features of the province that facilitate the spread of wildfires and track them back to their root causes. Through Geographic Information System (GIS) analysis, we found that the Boreal Ecodivision has the highest rate of historical wildfires in its area at 27%, compared to the five other BC ecodivisions, with Semi-Arid Steppe Highlands following in second with 19% of historical wildfires covering its region. Our findings also revealed that anthropogenic causes were greater than lightning causes of wildfires in BC, meaning that humans have had a large impact on causing wildfire disasters. In combination with human and environmental factors, BC's wildfires hold great concern of destruction of land and homes, especially in dry and hot summer months. The results of this analysis will articulate the specific causes of vulnerability in certain regions of British Columbia.

[1] Michelle Ghoussoub, "B.C. Surpasses Worst Wildfire Season on Record," *CBC News* (August 2017): http://www.cbc.ca/news/canada/british-columbia/b-c-surpasses-worst-wildfire-season-on-record-1.4249435 (accessed December 3, 2017).

Description of Project Area

For this project, our study area focused on the province of British Columbia. British Columbia has been subject to many wildfires in the past due to its abundant coastal forest regions and overall mixed climates which enable wildfires to stay fuelled, especially during hot and dry summer months. To gather data on the environmental causes and enablers of historical wildfires, we first analyzed physical factors of the province that would reveal information on whether different environmental features of ecodivisions influenced the frequency of historical fires within BC. According to British Columbia's Ministry of Environment, an ecodivision is classified as an area of broad climatic and physiographic uniformity.[2] There are seven different ecodivisions in British Columbia: Sub-Arctic Pacific, Boreal, Cool Hypermaritime and Highlands, Humid Continental Highlands, Semi-Arid Steppe Highlands, Sub-Arctic, and Sub-Arctic Highlands. These ecodivisons are separated based on terrestrial and marine ecosystem complexities as well as regions of physiographic uniformity. For this particular analysis, we chose to omit the Sub-Arctic Pacific ecodivison that fell across the entirety of the parts of the Pacific Ocean surrounding the coast of British Columbia. This choice was made because of the nature of wildfires, and their inability to sustain themselves in areas without land coverage. The other components we researched in relation to wildfires in BC were mixed forest land coverage and overall causes of wildfires in BC. We also sought to find correlations between the proximity of major cities to human or lightning caused historical wildfires.

Our data analysis consisted of various layers which gave information on where wildfires have occurred up until the year of 2016 and the environmental, spatial, and

[2] Dennis A. Demarchi, "The British Columbia Ecoregion Classification," *Ecosystem Information Section*, (March 2011): http://www.env.gov.bc.ca/ecology/ecoregions (accessed December 2, 2017)

anthropogenic factors that have impacted these fires. We extracted data from DataBC, which allowed us to gather relevant spatial data of the province. For our first sequence of maps (Figure 8.1 and Figure 8.2), we collected data layers of mixed forest GeoBase Land Coverage areas within BC, ecodivision classifications, and historical fire perimeters. This sequence of maps is significant to draw interpretations on whether various climatic features can affect the frequency of wildfires. For the next sequence of maps (Figures 8.3, 8.4, and 8.5) we added layers of major cities, historical wildfires (up to 2016), and fire causes - categorized into lightning caused or human caused. This data is helpful to reveal relationships between anthropogenic versus environmental factors of the causes of wildfires in BC.

Methodology of Analysis

To research the factors and occurrence of wildfires in British Columbia, we split up our analysis into two different streams. Firstly, to analyse the relationship between wildfires and ecodivisions in BC, 6 shapefiles were obtained from both DataBC and the UBC geodatabase: 1) Old Growth Management Areas, 2) Mixed Forest 1:250,000 GeoBase Land Cover, 3) Ecodivisions, Ecoregion Ecosystem Classification, 4) Historical Fire Perimeters, 5) Map of Canada and 6) Major Cities in Canada. We were able to obtain a map of Canada, and then extracted British Columbia to create a new layer in which we could add our data layers to. We also clipped our major cities layer to our BC layer in order to locate cities that might have been affected by wildfires in the past to determine if those areas were susceptible to wildfires in the future. From this step, our other layers such as the Historical and Current Fire Perimeters could also be clipped onto this layer to focus on British Columbia only. Next, each ecodivision was transformed into a new individual layer by selecting the attribute in the ecodivisions layer. We then used the statistics function to gather the sum for each ecodivision, and then clipped each ecodivision to the historical fires layer. We then were able to divide each clipped historical fires polygon area to its respective ecodivision area to game the total percentage of fire covered within each ecodivision. This analysis gave us insights to whether certain environmental properties of individual ecodivisions made them more vulnerable to wildfires or had features that prolonged wildfires once they occurred, such as vegetation, forest coverage, and climatic factors.

Our second stream of research we did was comparing the frequency of historic fire wildfires around major cities, and whether they were caused by lightning or by people. Using the same British Columbia province layer that we used with our first set of maps, we cleared the ecodivisions layer and combined the BC layer with the Historical Fire Perimeters layer,

major cities, and fire causes. Using the data in the attribute table for the Historical Fire Perimeters layer, we were able to separate the fires caused by humans or by lightning into new layers. We then sought to find the correlation between cities and causes of wildfires, and to do this we created two different buffers, one of 10km from each major city and one of 5km and then exported the selected features as new layers. Afterwards, we used the intersect tool to combine the buffers to the fires caused by lightning and the fires caused by people to compare the frequency of historical occurrence close to cities. This gave us insight into whether the causes of wildfires showed patterns of anthropogenic factors closer to cities.

Discussion and Results

Through our analysis, we discovered that Boreal ecosystems were most susceptible to wildfires, with 27% of its area being affected by wildfires historically. The ecosystems least susceptible to wildfires were the Cool Hypermaritime and Highlands, with only 2% of its area being affected by wildfires. The remaining four ecosystems, Semi-Arid Steppe Highlands, Sub-Arctic, Humid Continental Highlands, and Sub-Arctic Highlands had values that fell in between, them being 19%, 14%, 14% and 11%, respectively.

A boreal ecosystem refers to "cool or cold temperate regions at high latitudes in the Northern Hemisphere."[3] These ecosystems are characterised by its vast species of trees that make up the forests, and are adapted to long, cold winters. Though drastic, wildfires also play two important roles within boreal ecosystem ecology - the maintenance of the vegetation mosaic in the landscape, and the variety of tree and ecological species found in these ecosystems.[4] Without the occurrence of these wildfires, we wouldn't be able to stimulate new growth with wildfires opening up the forest canopy, allowing for new species a chance to thrive within our forests. The occurrence of wildfires has changed over time and space because of climate change. Wildfires are more frequent when the weather conditions are warm, dry, and windy. Since the 1970s, the warming trend in the Northern Hemisphere has accelerated, and the most probable cause for this warming would be the enhanced greenhouse effect that is noticeable in these ecosystems.[5] Over the past century, British Columbia has warmed an average of 1.4°C, and if broken down into the six terrestrial ecodivisions, data shows that areas with Boreal ecosystems have warmed more significantly than in other areas,

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[3] Chris Park and Michael Allaby, *A Dictionary of Environment and Conservation* (Oxford: Oxford University Press, 2013).
[4] Michael G. Weber and Brian J. Stocks, "Forest Fires and Sustainability in the Boreal Forests of Canada," *Royal Swedish Academy of Sciences* 27 (1998): 546.
[5] Martin P. Girardin and Manfred Mudelsee, "Past and Future Changes in Canadian Boreal Wildfire Activity," *Ecological Applications* 18 (2008): 392.

which could suggest a higher percentage of wildfires occurring here.[6] In contrast, Cool Hypermaritime and Highlands ecosystems are more damp and warm, and encompass areas such as Vancouver Island or Haida Gwaii. Because the air is more humid in these areas, occurrence of wildfires is lower. Also, the surface area of vegetation and land cover is much less in comparison to the Boreal region, as shown in Figure 8.2, and therefore could also contribute the smaller number of wildfires. Also, the elevation within this area is generally higher as this particular area contains the Coast Mountains, and therefore causes the temperatures to drop because of higher elevations. Precipitation is also a lot more common with higher elevations, as the atmosphere cannot hold in as much condensation, and contributes to higher rainfall and less frequency of wildfires.

In the second sequence of maps, we mapped out the causes of historical fires to observe whether there was a discrepancy in the amount caused by people as compared to lightning. As shown in Figure 8.3, there is a variegated spatial distribution of lightning caused incidents as well as human caused incidents of wildfires. The causes of wildfire incidents are very integrated with each other. However, a large concentration of smaller fires does occur in the south of British Columbia, whereas larger but more spread out wildfires occur closer to the north. This could be attributed to smaller population density and less major cities in the north, therefore, slower response time, and larger areas of land coverage that fuel wildfires. However, comparing between causes, our data showed that overall, more fires were human caused, but lightning incidents overlapped with many of the areas that were human caused.

[6] Government of BC, "Climate Change," *Environmental Reporting BC* (2015): http://www.env.gov.bc.ca/soe/indicators/climate-change/temp/html (accessed December 2, 2017)

To gain a deeper understanding of the correlation between cities' proximities to causes of fires, we created a buffer of 10km to each major city to investigate whether more lightning or human caused fire incidents occurred within that buffer. This tool gave us information on the distribution of causes and whether urban developments could have influenced the causes of wildfires. Within the 10km buffer we found that out of the 42 major cities in our data layer, 25 cities were associated with lightning causes, while 42 were associated with person causes. It is important to note that all 42 cities also encompassed human caused incidents, noted by the orange outlined green dots in Figure 8.4 which represents cities that had lightning and human caused wildfires within their 10km buffer. To narrow down our results we also performed a 5km buffer analysis as shown in Figure 8.5 to show fire causes closer to the major cities. This evaluation revealed that the number of cities with lightning caused wildfires within 5km of cities was reduced to 11, and cities that had wildfires that were person caused within 5km was reduced to 20. The overall wildfires decreased closer to the major cities, but a consistent pattern with both buffers showed that within all the cities with lightning caused wildfires, human caused factors were also present. Therefore, all major cities displayed human caused wildfires, and some of those cities encompassed both person causes and lightning causes. This data therefore expresses that most of the causes of wildfires in BC are due to anthropogenic factors, whether intentional or accidental. According to the Government of BC,[7] causes of wildfires includes:

- Fuel in the form of live or dead trees, vegetation and other organic matter
- Oxygen in the air around us
- Heat to ignite and burn, from lightning or human sources

[7] Government of BC, "Wildfire Causes," *Forest Stewardship*: http://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/wildfire-management/wildfire-response/fire-characteristics/causes (accessed December 3, 2017)

A variety of both environmental and anthropogenic factors can be attributed to causes and facilitators of wildfires in British Columbia. Increasing climates, specifically in the Boreal ecodivision, wind and dryness intensity, as well as human factors such as unregulated campfires and lit cigarette butts could all play a factor into the increase of wildfires over the years. A correlation between cities proximities to the human caused wildfires provides us with the possible conclusion that people have had a large impact on causing wildfires which has led to a large devastation of land coverage. "Humans were responsible to causing over half (or 566) of the 1,050 wildfires that started in 2016".[8] Subsequently, our data communicates that anthropogenic causes have superseded lightning caused wildfire events, and in combination with environmental elements of various ecodivisions, historical wildfires have affected many regions of the province and will continue to do so if the climate, winds, forest coverage, and carelessness of human activities pursue.

[8] Government of BC, "Wildfire Season Summary," *Wildfire Statistics:* http://www2.gov.bc.ca/gov/content/safety/wildfire-status/wildfire-statistics/wildfire-season-summary (accessed December 3, 2017)

Error and Uncertainty

Some of the most prominent setbacks that we faced during the initial stages of our project occurred as we were gathering data for our map. Many of the arcMap layers that we attempted to find and download for our map had restricted access, such as the layer for BC Wildfire Fuel Management Locations. This layer would provide information on BC's management of forest and range fuels to mitigate and prevent larger wildfire occurrences, with processes involving the thinning out of trees, pruning branches, prescribed fire use and other best practices. Our group feels that these files would have greatly benefitted our project analysis for wildfire management, as this additional layer adds the dimensions of human/governmental intervention and prevention methods into the evaluation.

Another aspect of uncertainty that we encountered was during the extraction of BC from the overall map of Canada. Our group felt that using this method as opposed to a layer that focused just on the details of the BC coastlines and borders may have affected the overall shape area that we used to calculate our percentages. This is in part because a map layer that is created to encompass a greater overall shape of Canada, may fail to be more accurate when it comes to the detail of smaller portions of land. This can be made apparent if one zooms into the Greater Vancouver Area on the map to see that the shape of the city appears slightly skewed. Our group only resorted to extracting this particular outline of BC because we could not locate another shapefile with just BC.

Finally, we encountered this last uncertainty in calculation as our group was extracting the wildfire layer to fit each of the climate ecodivisions in the 'ERC_ECODIV_polygon' layer. Because we encountered errors while trying to clip the historical fires layer (H_FIRE_PLY_polygon) to each extracted ecodivision layer, we chose

instead to apply the select by location method. For the option of spatial selection method, we chose to only include wildfire polygons that fall completely within the source layer of our climate ecodivision. Our other potential option was to choose wildfires that contain the source layer feature. Because of this selection, we did not account for wildfires that had a section of their area within each ecodivision, as many of the polygons lay on the borders of two ecodivisions. As a result, we may have underestimated the total area of wildfires that were within each ecodivision layer.

If we were able to improve upon or fix any aspects of our project in the future, we would have liked to conduct more research to see if there were ways in which we could access the restricted files on the DataBC database. We would also like to locate a more accurate shapefile of BC for analysis and look into other methods of extracting the overlap for the wildfires layer that allows for us to take into account the portions of the wildfires that are near or intersecting with the borders of the ecodivisions.

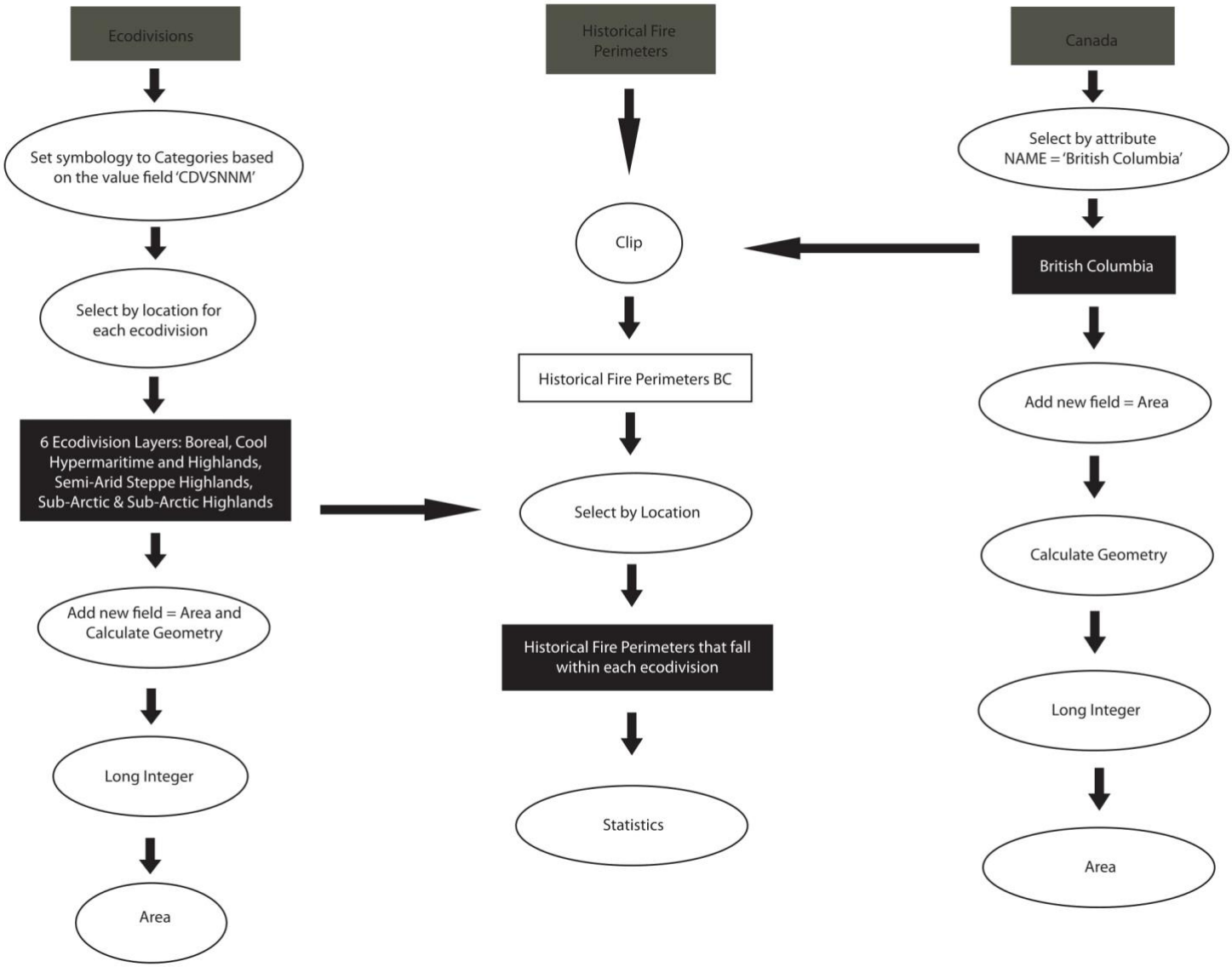
Further Research and Recommendations

With this research, we could have also obtained additional data and considered other factors that contribute to wildfires in BC, such as weather and humidity patterns across BC. Increasingly drier weather patterns could be a potential cause to BC's wildfires, and therefore data showing the change in humidity patterns in comparison to frequency of wildfires by date could be another supportive perspective to analysing environmental impacts of BC wildfires.

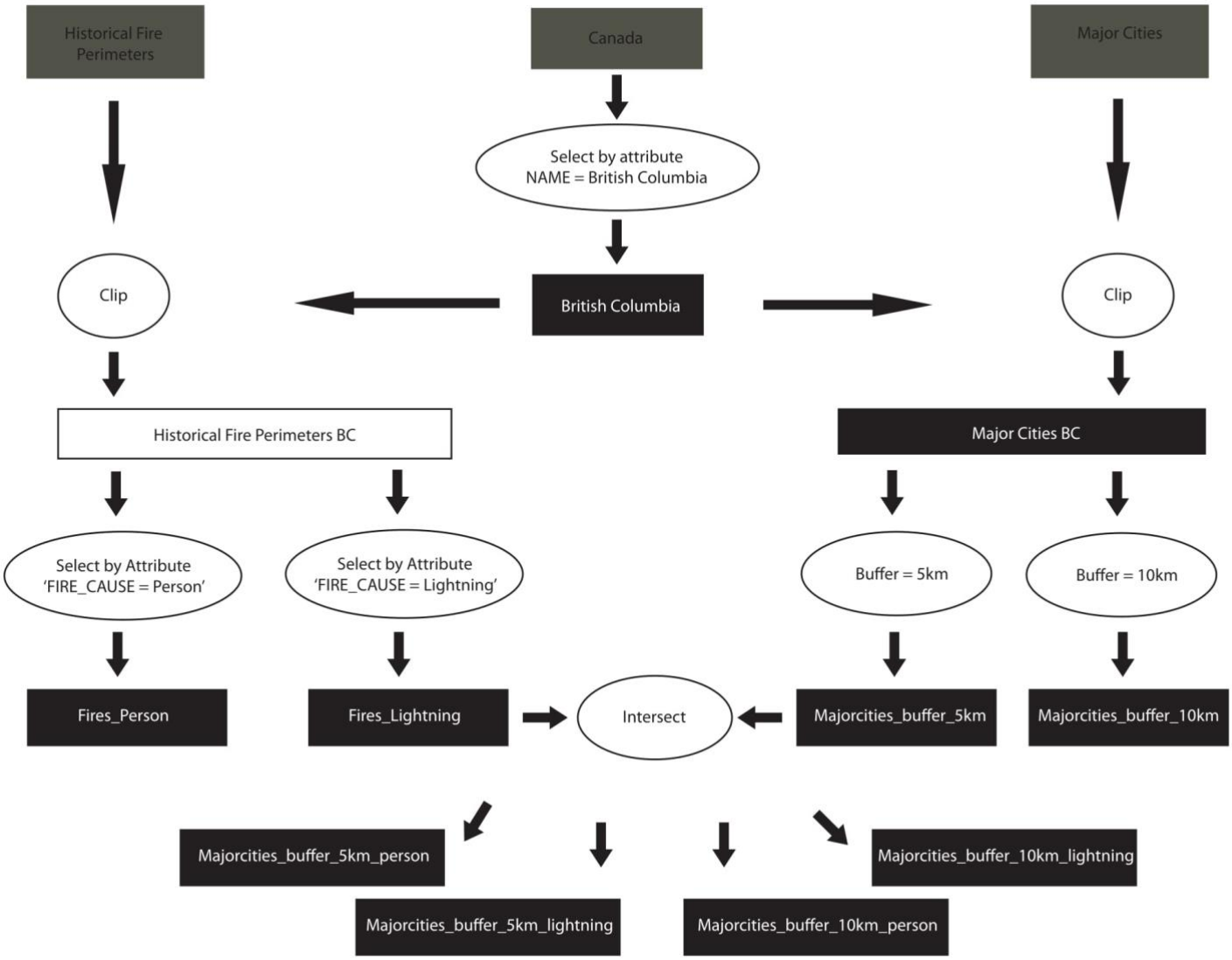
To further research on this topic, we could also compare wildfires with the rest of Canada to see if wildfires occurred within similar ecodivisions throughout other provinces, and whether the frequency of human and natural caused wildfires showed similar patterns near other Canadian major cities. We'd would then be able to see if each province has unique factors that affect the frequency of wildfires, how the dispersion of the ecodivisions look like in Canada, and what environmental and geographic features contribute to the different ecodivisions in the rest of the country.

This data has also revealed that anthropogenic causes account for over half of the historical wildfires up to 2016, therefore, recommendations for the BC government would be to enforce strict bans on fires, especially in ecodivisions that are more vulnerable to wildfires such as the Boreal region. We would also recommend establishing and preparing response teams and mitigative measures for the northern regions of BC, as the polygons of historical fires show that these fires have covered a large area of the province. It would be extremely beneficial to further research the data layer for BC Wildfire Fuel Management Locations to assess whether more measures need to be taken in certain ecodivisions to prevent mass and unruly wildfires in the future.

Flow Chart – Sequence 1



Flow Chart – Sequence 2



Appendices

Figure 8.1

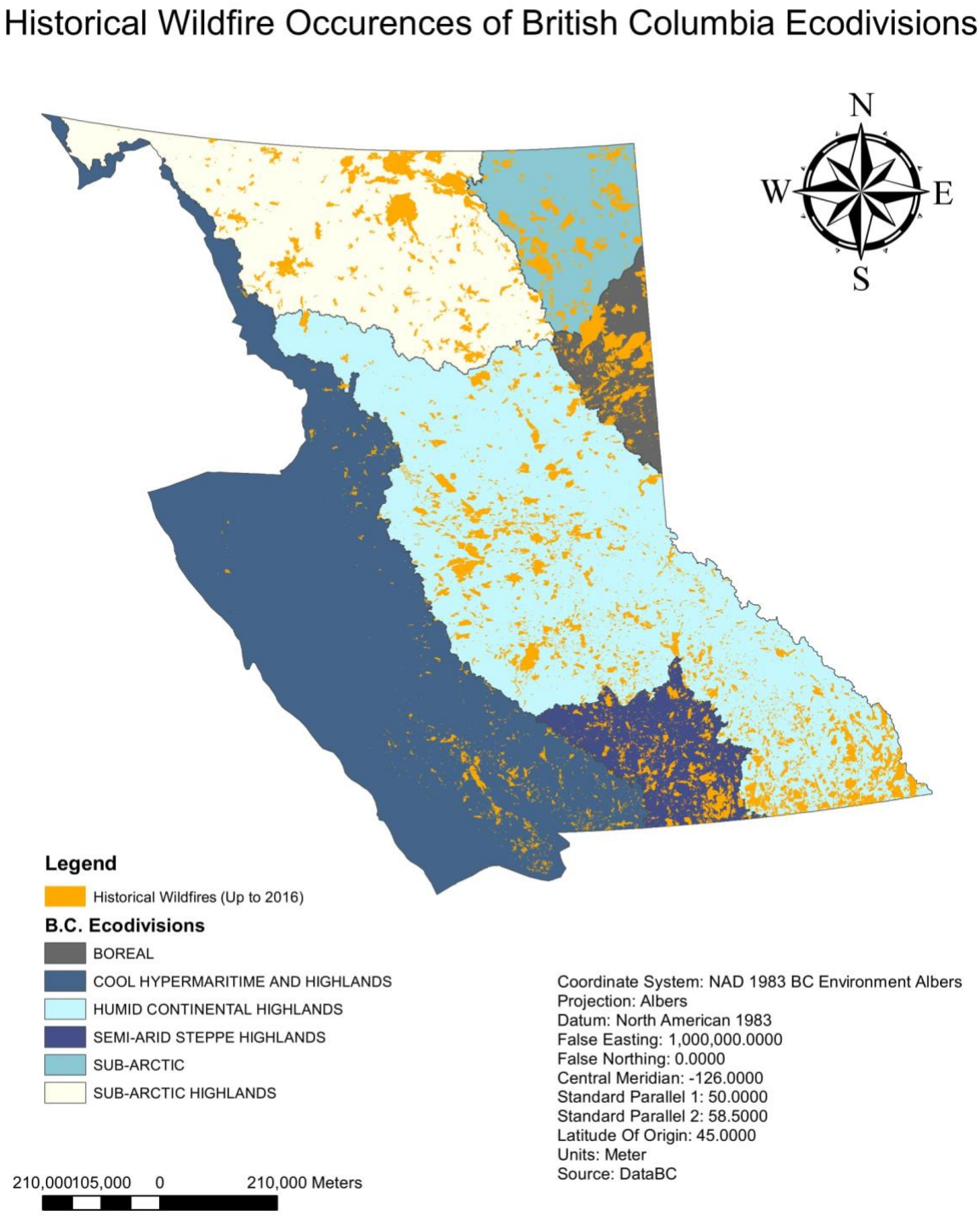


Figure 8.2

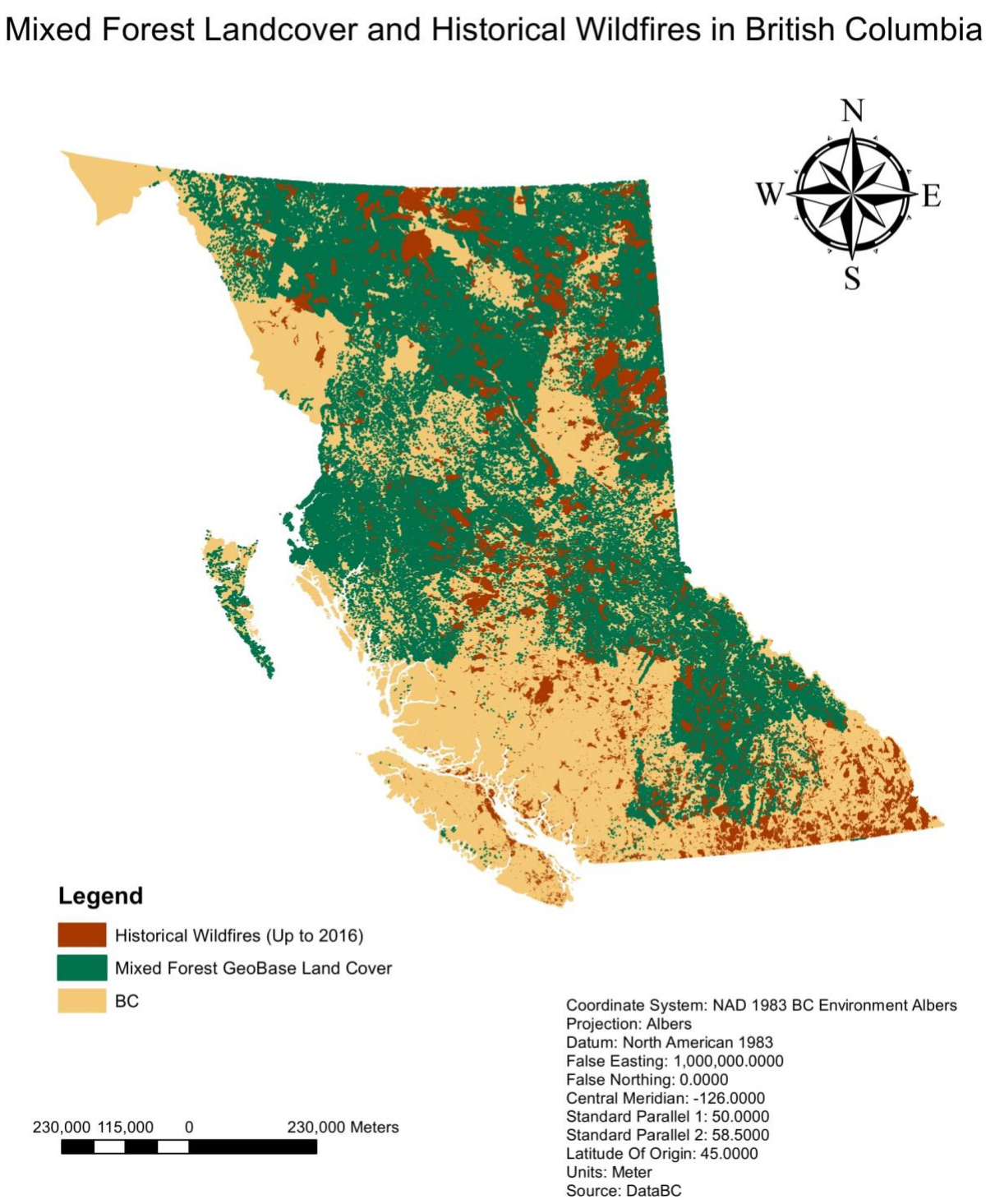

Mixed Forest Landcover and Historical Wildfires in British Columbia
N
W
E
S
Legend
Historical Wildfires (Up to 2016)
Mixed Forest GeoBase Land Cover
BC
230,000 115,000 0 230,000 Meters
Coordinate System: NAD 1983 BC Environment Albers
Projection: Albers
Datum: North American 1983
False Easting: 1,000,000.0000
False Northing: 0.0000
Central Meridian: -126.0000
Standard Parallel 1: 50.0000
Standard Parallel 2: 58.5000
Latitude Of Origin: 45.0000
Units: Meter
Source: DataBC

Figure 8.3

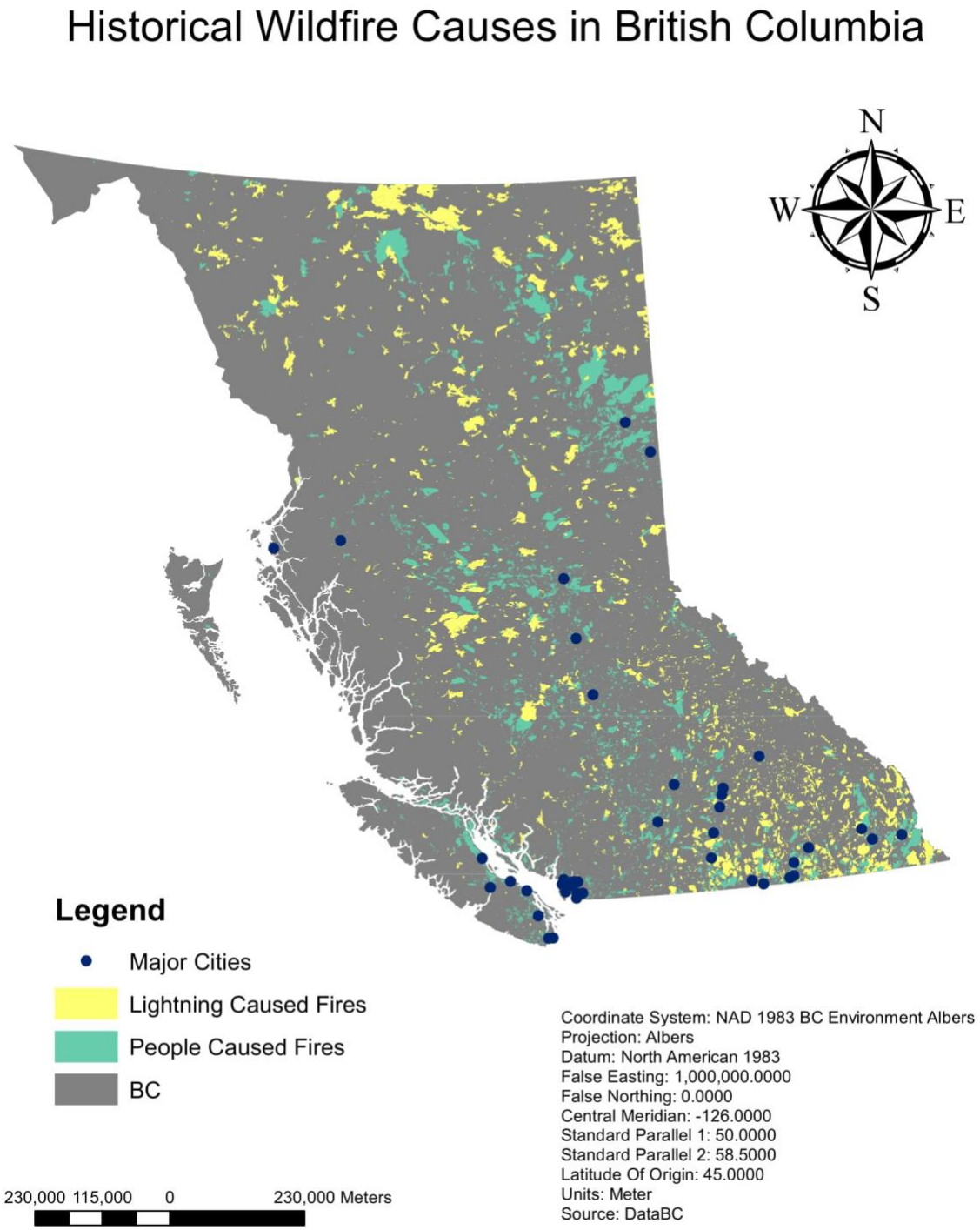

Historical Wildfire Causes in British Columbia
N
W
E
S
Legend
Major Cities
Lightning Caused Fires
People Caused Fires
BC
230,000 115,000 0 230,000 Meters
Coordinate System: NAD 1983 BC Environment Albers
Projection: Albers
Datum: North American 1983
False Easting: 1,000,000.0000
False Northing: 0.0000
Central Meridian: -126.0000
Standard Parallel 1: 50.0000
Standard Parallel 2: 58.5000
Latitude Of Origin: 45.0000
Units: Meter
Source: DataBC

Figure 8.4

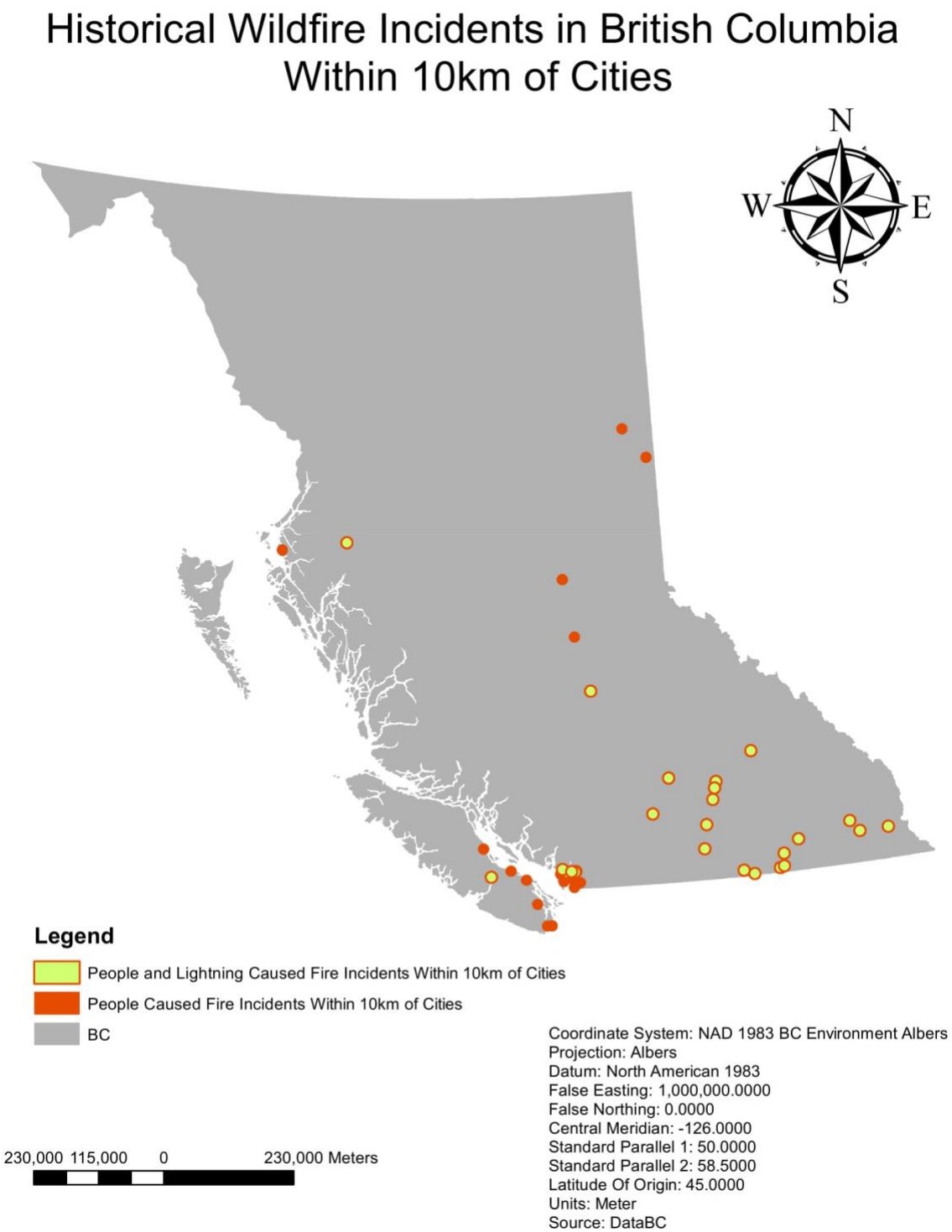
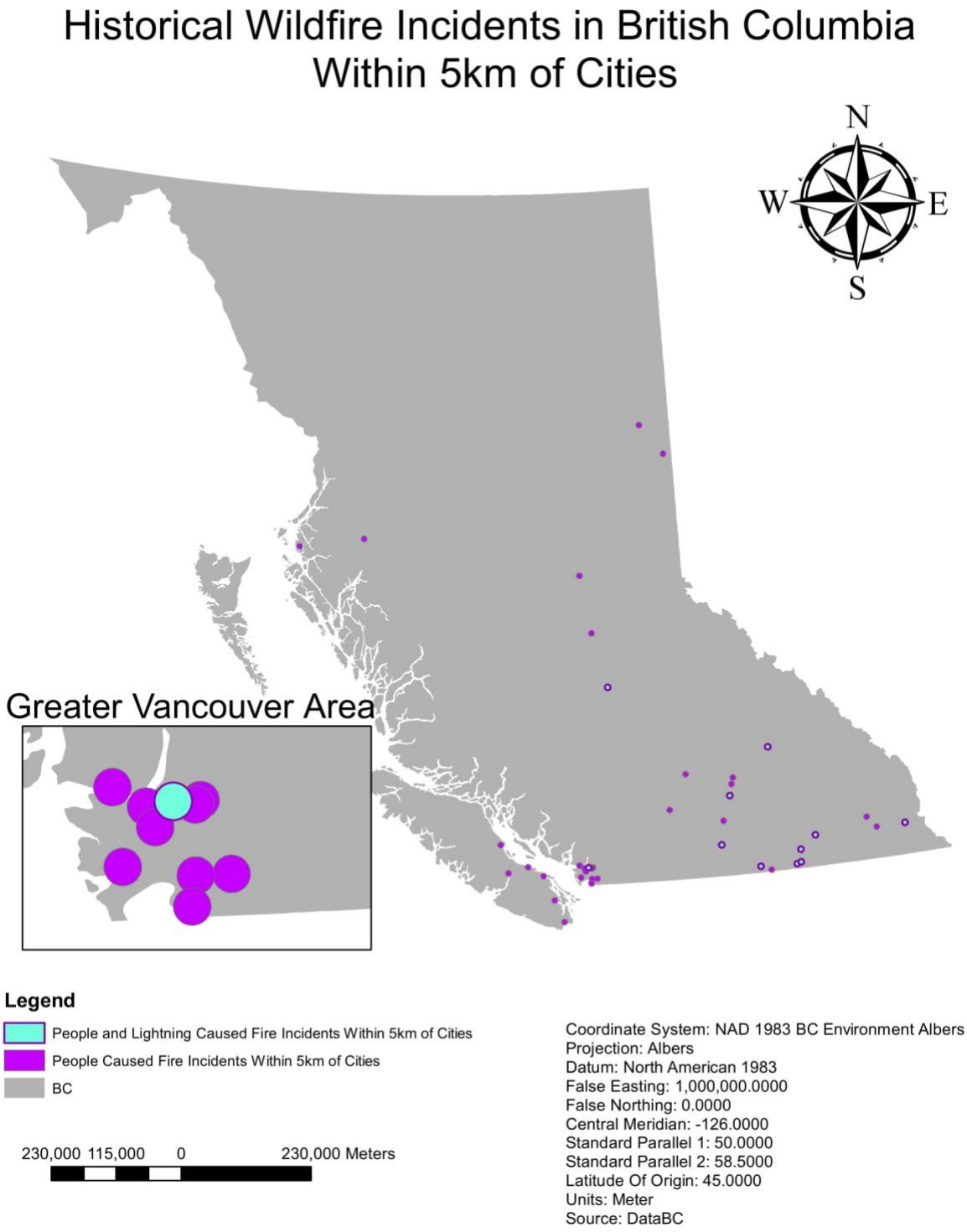

Historical Wildfire Incidents in British Columbia
Within 10km of Cities
N
W
E
S
Legend
People and Lightning Caused Fire Incidents Within 10km of Cities
People Caused Fire Incidents Within 10km of Cities
BC
230,000 115,000 0 230,000 Meters
Coordinate System: NAD 1983 BC Environment Albers
Projection: Albers
Datum: North American 1983
False Easting: 1,000,000.0000
False Northing: 0.0000
Central Meridian: -126.0000
Standard Parallel 1: 50.0000
Standard Parallel 2: 58.5000
Latitude Of Origin: 45.0000
Units: Meter
Source: DataBC

Figure 8.5


Historical Wildfire Incidents in British Columbia
Within 5km of Cities
N
W
E
S
Greater Vancouver Area
Legend
People and Lightning Caused Fire Incidents Within 5km of Cities
People Caused Fire Incidents Within 5km of Cities
BC
230,000 115,000 0 230,000 Meters
Coordinate System: NAD 1983 BC Environment Albers
Projection: Albers
Datum: North American 1983
False Easting: 1,000,000.0000
False Northing: 0.0000
Central Meridian: -126.0000
Standard Parallel 1: 50.0000
Standard Parallel 2: 58.5000
Latitude Of Origin: 45.0000
Units: Meter
Source: DataBC

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