Spatial patterns of Lightning-Caused Wildfires in the Okanagan in 2015 and 2017

1.0 Introduction

With the increase in the number of wildfires in the past few years, there is a significant demand from the fire managers in British Columbia to understand the spatial patterns of forest fire occurrence in the Okanagan basin and help them determine the appropriate preventive measures to avoid wildfires. Geographic Information System or GIS is a computer-based system that allows users to create, manage, analyze, and plot data onto a map (ESRI, n.d.). With the right data and GIS processing tools, it is possible to analyze point and spatial patterns of wildfires that happened in a specified area. Being able to understand point and spatial patterns of wildfires allows agencies and related stakeholders of the province to execute informed decisions on measures to prevent wildfires and effectively allocate the appropriate number of resources.

In 2015, a major wildfire attacked British Columbia causing an above-average number of wildfires and areas burned (BC Wildfire Service, 2022). Lightning was responsible for over 65% of the wildfires that occurred in 2015 (BC Wildfire Service, 2022). Just under two years after the start of the 2015 fire season, there was a record-breaking fire season on the summer of 2017 which is still remembered as one of the worst wildfire seasons that ever happened in British Columbia. There was over 1.2 million hectares burned and around 65,000 people were evacuated which prompted the longest Provincial State of Emergency British Columbia has ever had (BC Wildfire Service, 2022). Thus, it is important to understand how these two big fire seasons relate to each other in terms of spatial patterns. The goal of this study is to use point pattern analysis and spatial statistics to identify and analyze the differences in spatial patterns of lightning-caused wildfires that happened in the Okanagan in 2015 and 2017.

2.0 Study Area and Data

According to Dr. David Scott, associate professor of earth, environmental and geographic science at the University of British Columbia Okanagan, the Okanagan region is considered as a semi-desert area with a very small amount of precipitation (Scott, 2019). This means that the region is very dry and vulnerable to wildfires. The high presence of fuel loads due to decades of fire suppression is also a significant factor that makes the Okanagan one of the most wildfire-prone areas in Canada (Scott, 2019). This study will focus on the Okanagan region represented by the dark yellow polygons on the study area map on Figure 1.

There are two main datasets that are used which are the 2008 to 2018 Okanagan fire data and the Okanagan landscape units. The 2008 to 2018 Okanagan fire data is a subset of the fire locations that combines all fire locations in the Okanagan from 2008 to 2018. The dataset is provided by the Government of British Columbia and was clipped based on the boundaries of the Vernon and Penticton Fire Zones area. The confirmed fire locations are mapped using latitude and longitude coordinates and include other information such as the year, cause, zone, id type, and size in hectares. From 2008 to 2018, there are 2051 fires that were recorded in the Okanagan area. The Okanagan landscape units dataset is a subset of the Landscape Units of British Columbia dataset and is provided by the Government of British Columbia. The data was clipped based on the boundaries of the Vernon and Penticton Fire Zones area. There are 34 landscape units that were recorded in the dataset.

3.0 Methods

To identify and analyze the differences in spatial patterns of lightning-caused wildfires in the Okanagan in 2015 and 2017, methods such as attribute query, mean center, kernel density, spatial join, Moran's I, and local Moran's I are used. Since the analysis only focuses on lightning-caused wildfires that happened in 2015 and 2017, the 2008 to 2018 Okanagan fire dataset is filtered using attribute query to create a new dataset with only fires that were caused by lightning and that happened in 2015 or 2017. Using the new dataset, it is now possible to apply mean center to determine the geographic center. Since the size of area burned is an important factor in determining the intensity of a fire, weighted mean center will be used instead of the standard mean center method. The fire year, which is a categorical attribute, is used as the case field to classify the mean center based on the year. With this data, it is now possible to produce a thematic map to highlight the weighted geographic center of fires in different years based on the size of burned area.

To further verify the findings from the previous method, kernel density is used. The kernel density method produces a continuous raster which is essential in identifying localized patterns of high-density clusters or also known as hotspots (Hart & Zandbergen, 2014). Since this study aims to identify the differences between the fires in 2015 and 2017, the dataset is split into two based on the fire year using attribute query. The output density values are classified into nine equal intervals and are smoothed over a 600m resolution grid using a default search radius or bandwidth of 30778.62 meters for the 2015 fire year and 19932.40 for the 2017 fire year. The default bandwidth is chosen using trial and error. It was identified that any bandwidth that is over the default will over-smooth the data and any bandwidth that is under the default will under-smooth the data. With this data, it is possible to produce a thematic heatmap to show the fire hotspots in different years.

Aside from identifying spatial patterns, it is also essential to identify spatial correlations. In order to measure spatial correlations, it is required join the fire dataset and the landscape units dataset. Using spatial join, the polygons were combined with the attributes of the 2015 and 2017 lightning-caused fire point locations based on an intersect. The fire size attribute was added using a mean merge rule. The fire size attribute of joined datasets represents the mean fire size in each polygon. Now it is possible to conduct the Moran's I method to calculate the global measure of spatial correlations. Similar to the previous method, since this study compares fires between two years, the method will also be applied to each of the fire year which are 2015 and 2017. Contiguity Edges Corners is used for the conceptualization of spatial relationship since it is a simple and reasonable approach for polygon data (Soleimani & Bagheri, 2021). The method is also row standardized since the data is an aggregated polygon data (Ver Hoef et al., 2017). Since it is identified that one of the datasets has significant positive spatial correlation or clustering, it is important to use the local Moran's I method is used to identify where the cluster is. The same conceptualization of spatial relationship and standardization is used with 499 permutations. With this data it is possible to produce a thematic map on which landscape unit is the fire clustered at in different years.

4.0 Results

It is identified that there are significant differences in spatial patterns of lightning-caused wildfires that happened in the Okanagan in 2015 and 2017. It is found that the epicenter of the fire shifted northwards from 2015 to 2017. This finding is supported with Figure 2 which shows the weighted geographic center of fires in 2015 and 2017 based on the size of burned area. Furthermore, it is found that the fire hotspots also shifted northwards from 2015 to 2017. This finding is supported with Figure 3 and Figure 4 which shows the location of fire hotspots in 2015 and 2017. In addition to that, it is also identified that the lightning-caused fire in the Okanagan in 2015 tends to be more spread out and random with local patterns of low-low clusters and low-high outliers. On the other hand, the lightning-caused fire in the Okanagan in 2017 is significantly clustered with local patterns of significant low-low, high-high clusters, and with low-high outliers. These findings are supported with Figure 5 and Figure 6 which shows the spatial autocorrelation report of the lightning caused fires in the Okanagan in 2015 and 2017 respectively. Furthermore, the findings are also supported with Figure 7 and Figure 8 which shows the locations of clustered lightning caused fire locations in the Okanagan in 2015 and 2017 respectively. Through point pattern analysis and spatial statistics, it is possible to conclude that there is a shift in the epicenter of wildfires caused by lightning in the Okanagan area from the south to the north in 2015 and 2017. It is also possible to conclude that the lightning-caused fire in 2015 is more dispersed while the lightning-caused fire in 2017 is more clustered.

5.0 Discussion

The northward shift in the epicenter of wildfires caused by lightning in the Okanagan area from 2015 to 2017 may be closely related with the biogeoclimatic zone transformation caused by climate change. This claim is supported by a report written by Eric Taylor and Bill Taylor about potential impacts of climate change on natural ecosystems of British Columbia and Yukon. The report states that interior steppe and pine savanna, which are fire-prone vegetations, may expand upslope northwards (Taylor & Taylor, 1997). With this transformation, northern regions of Canada that usually have a low chance of wildfires due to its vegetation and forest characteristics needs to brace for future possibilities of an increase in wildfires.

Analyzing point patterns and spatial statistics allows agencies to understand the wildfire behaviours and predict the locations of future wildfires. By knowing which areas that are vulnerable to future wildfires, agencies could optimize its resources by increasing its wildfire preventive measures on those areas. Stakeholders such as residents of the affected area may increase their awareness of possible wildfires around their area while other stakeholders such as insurance companies may increase their premium on affected areas due to the high possibilities of the area being exposed to wildfires. Using the available data, it is possible to extend this investigation by investigating other types of fires or even increase the year range to further validate the claim of the northward shift in the epicenter of wildfires. All in all, from this investigation, it is identified that there is a northward shift in the epicenter of wildfires caused by lightning in the Okanagan area from 2015 to 2017. It is also identified that in the Okanagan area, lightning-caused fire locations in 2015 are more dispersed while the lightning-caused fire locations in 2017 are more clustered.

6.0 Figures

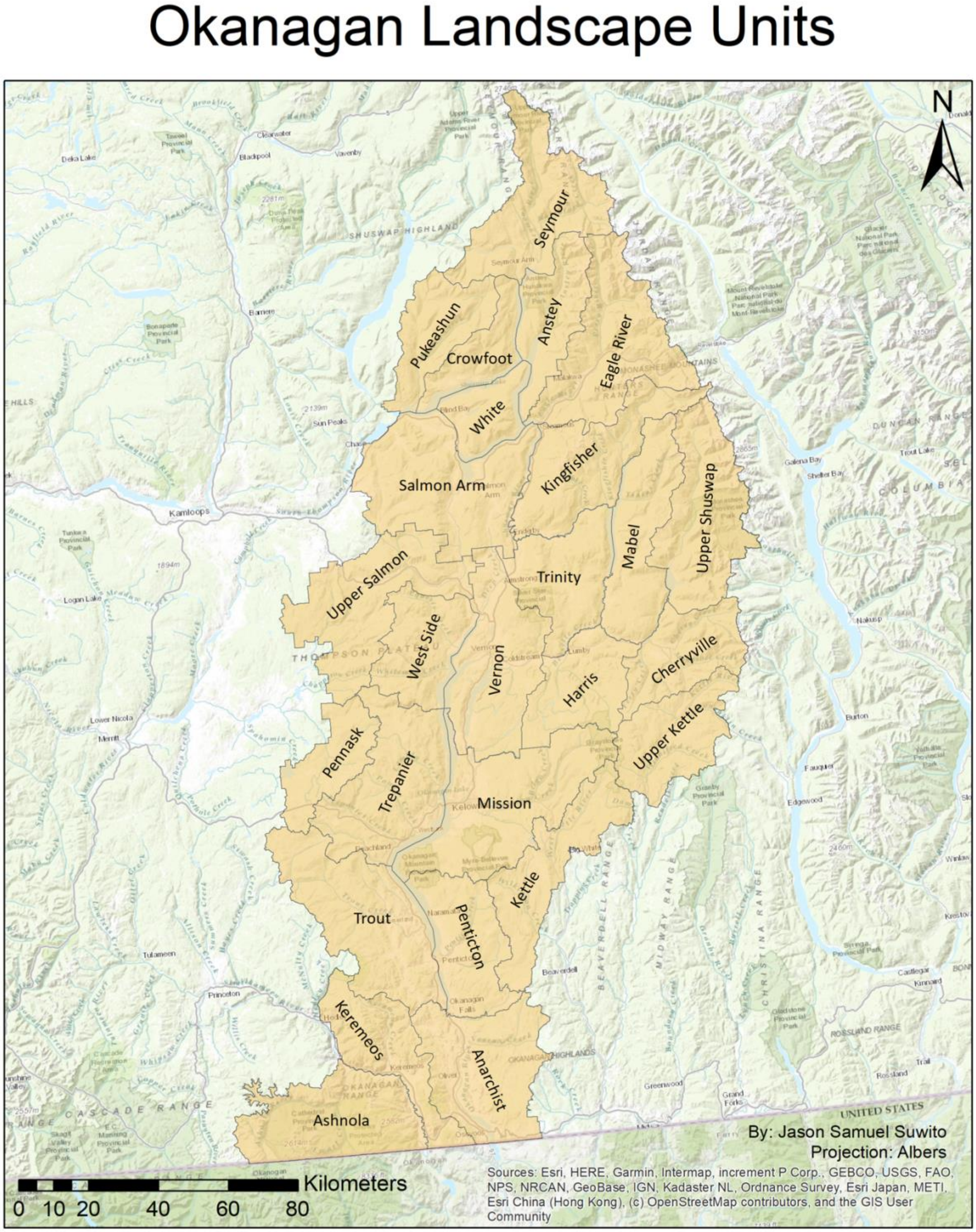


Figure 1. Study area map showing the landscape units in the Okanagan represented with labeled dark yellow polygons

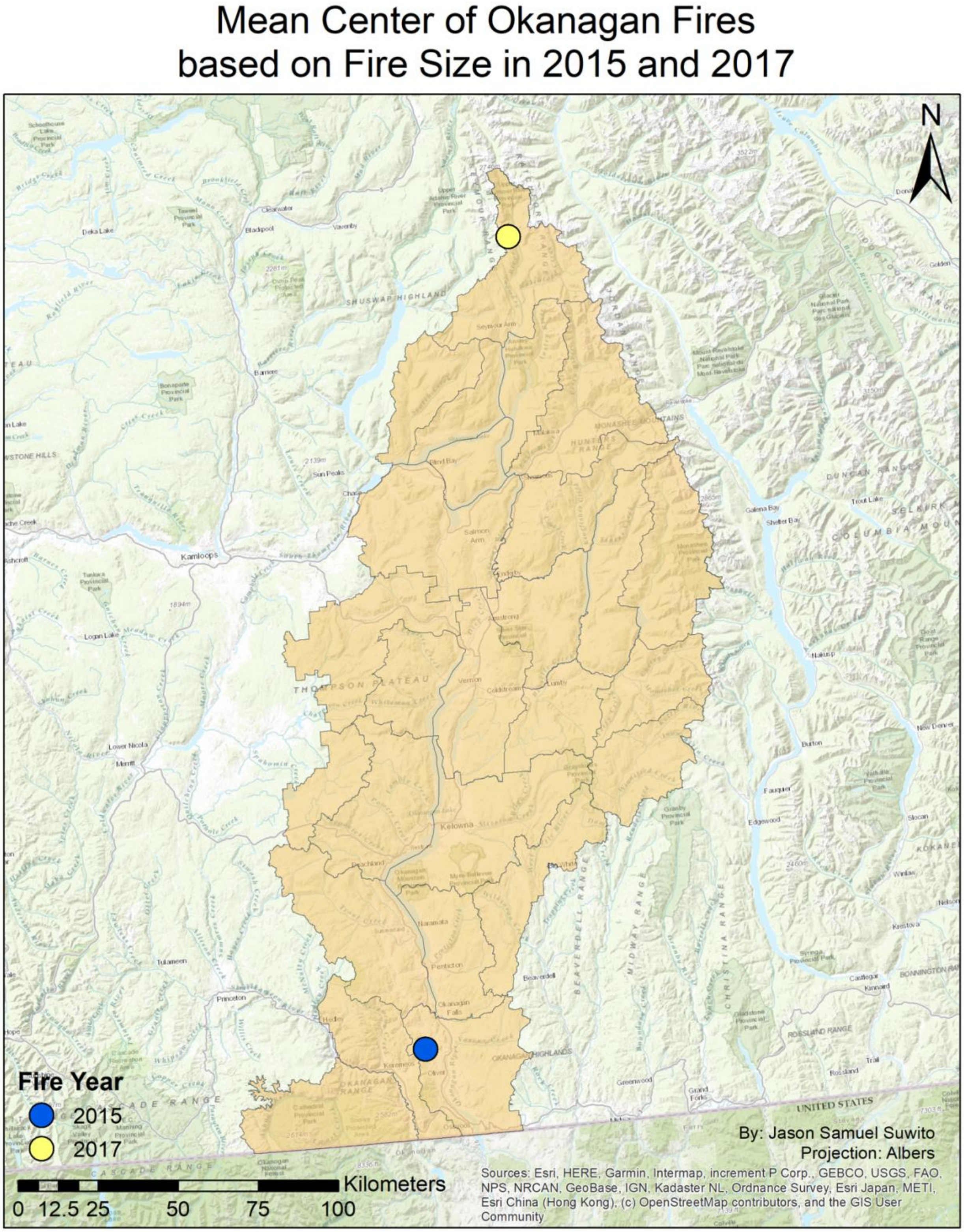


Figure 2. Geographic mean center of lightning-caused fires in the Okanagan weighted based on its fire size for the year of 2015 and 2017.

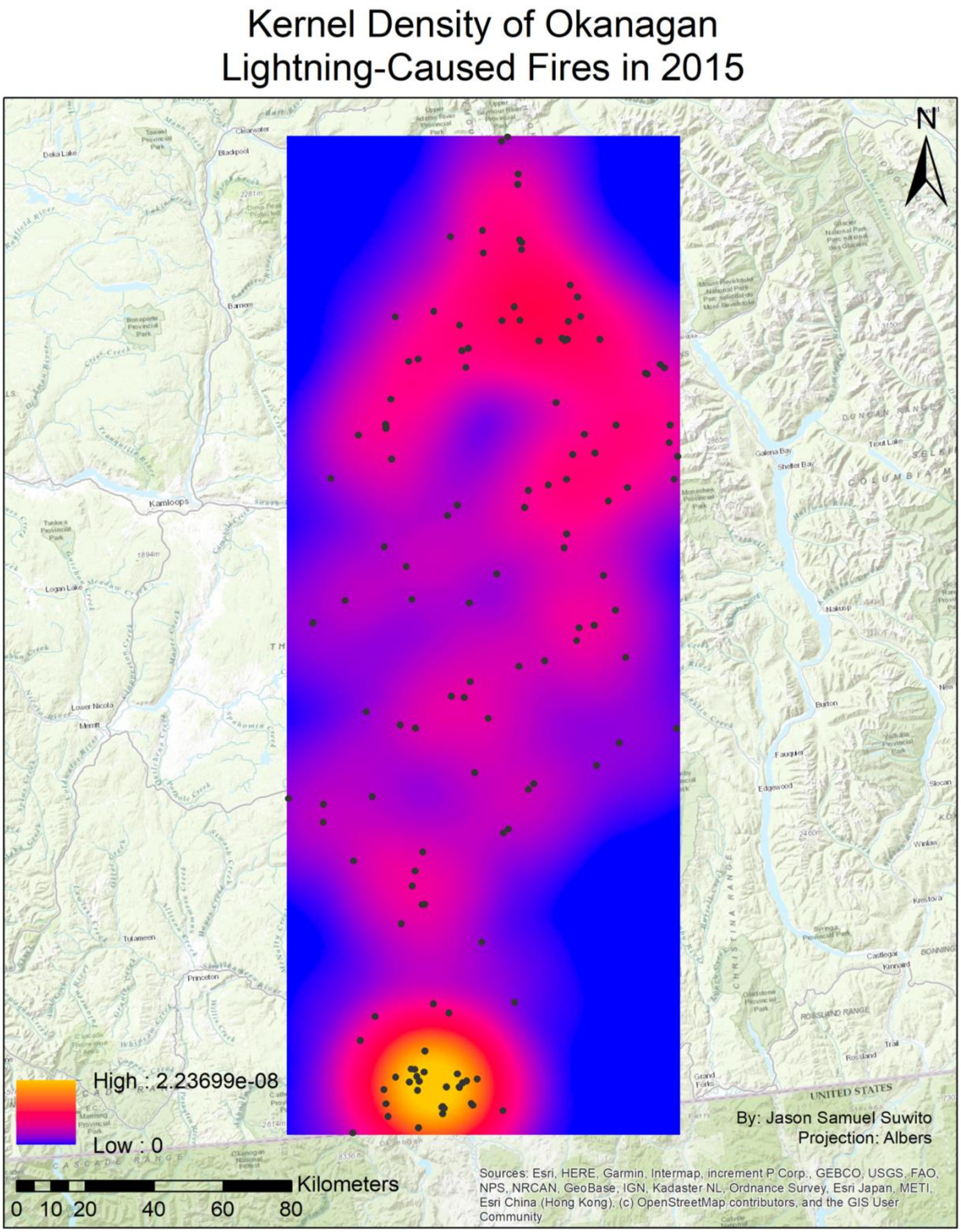


Figure 3. Heat map of lightning-caused fire in the Okanagan in 2015

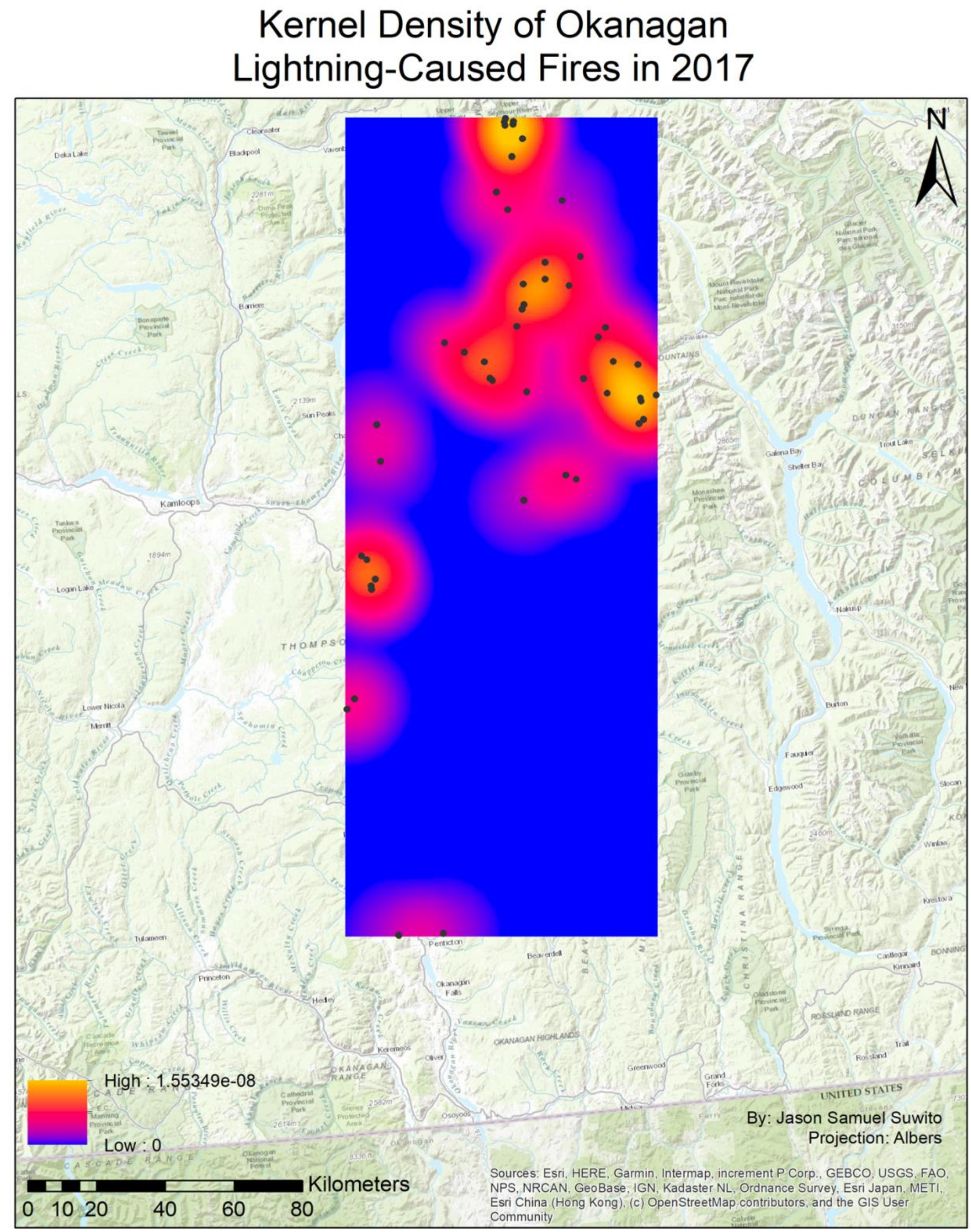
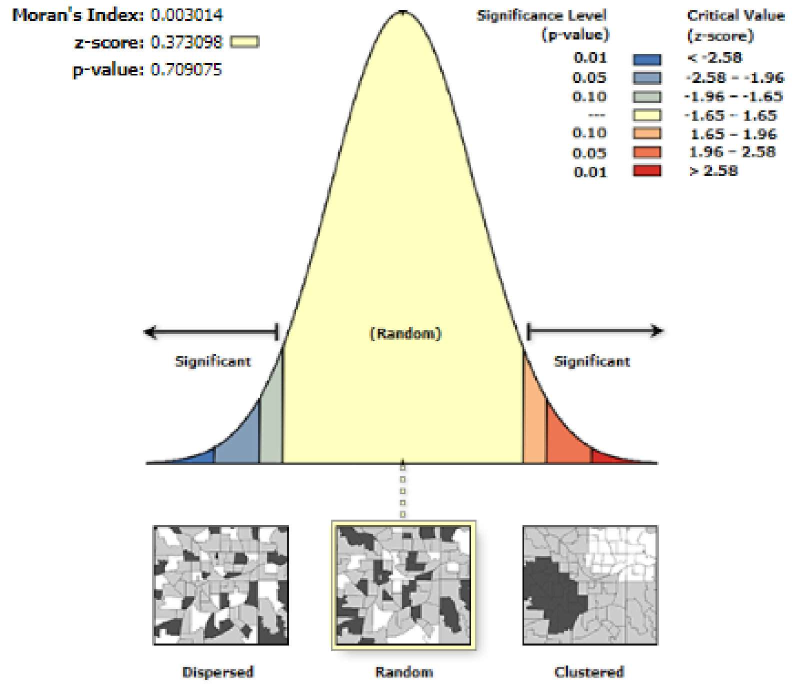


Figure 4. Heat map of lightning-caused fire in the Okanagan in 2017

Spatial Autocorrelation Report



Given the z-score of 0.37309825283, the pattern does not appear to be significantly different than random.

Global Moran's I Summary

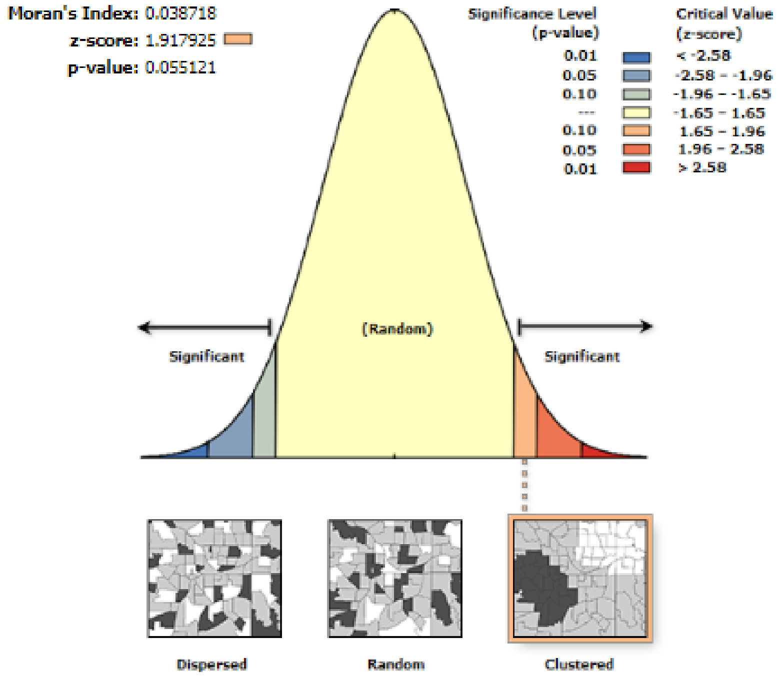
Moran's Index:	0.003014
Expected Index:	-0.030303
Variance:	0.007974
z-score:	0.373098
p-value:	0.709075

Dataset Information

Input Feature Class:	ok_lu_fire_light_15
Input Field:	SIZE_HA
Conceptualization:	CONTIGUITY_EDGES_CORNERS
Distance Method:	EUCLIDEAN
Row Standardization:	True
Distance Threshold:	None
Weights Matrix File:	None
Selection Set:	False

Figure 5. Spatial autocorrelation report using Global Moran's I method of the lightning-caused fire in the Okanagan in 2015.

Spatial Autocorrelation Report



Given the z-score of 1.91792515166, there is a less than 10% likelihood that this clustered pattern could be the result of random chance.

Global Moran's I Summary

Moran's Index:	0.038718
Expected Index:	-0.030303
Variance:	0.001295
z-score:	1.917925
p-value:	0.055121

Dataset Information

Input Feature Class:	ok_lu_fire_light_17
Input Field:	SIZE_HA
Conceptualization:	CONTIGUITY_EDGES_CORNERS
Distance Method:	EUCLIDEAN
Row Standardization:	True
Distance Threshold:	None
Weights Matrix File:	None
Selection Set:	False

Figure 6. Spatial autocorrelation report using Global Moran's I method of the lightning-caused fire in the Okanagan in 2017.

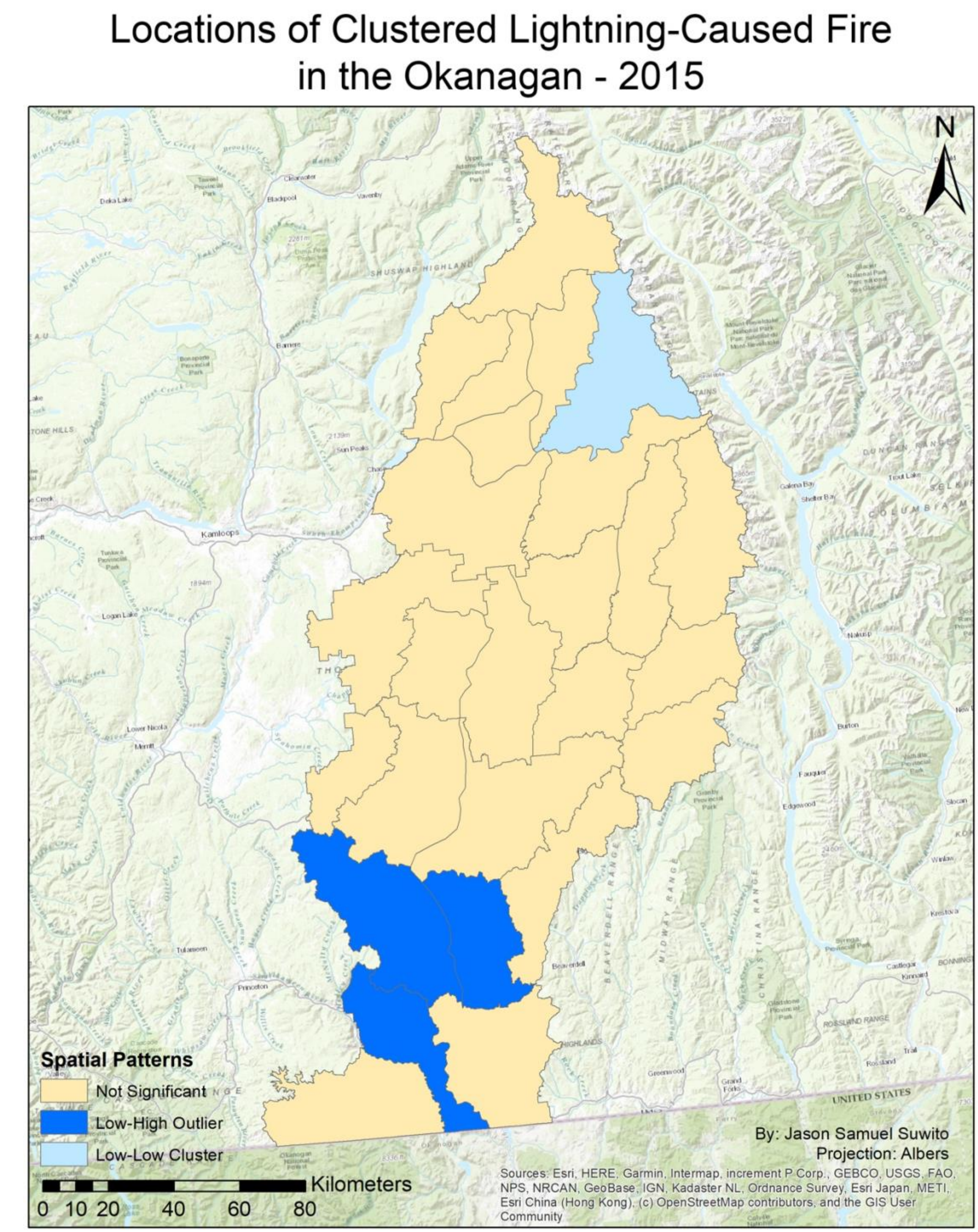


Figure 7. Locations of clusters of the lightning-caused fire in the Okanagan in 2015 identified using the Local Moran's I method.

Locations of Clustered Lightning-Caused Fire in the Okanagan - 2017

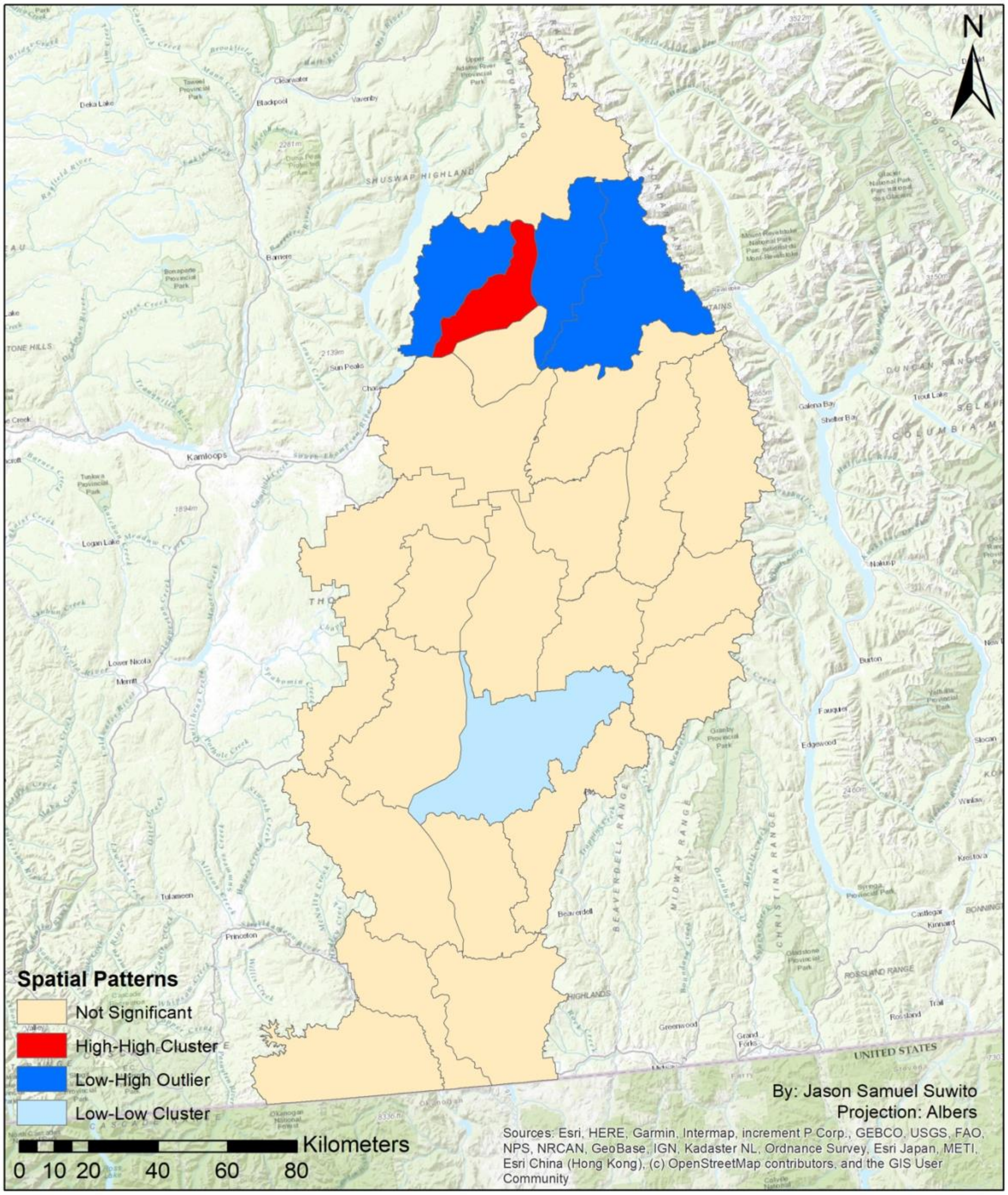


Figure 8. Locations of clusters of the lightning-caused fire in the Okanagan in 2017 identified using the Local Moran's I method.

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