Community Wildfire Protection Plan

Municipality of Anchorage

Appendix C: Methodology

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SUPPRESSION PLANNING UNIT HAZARD RATING METHODOLOGY

Purpose

The purpose of this appendix is to provide an overview of the methodology used to determine the hazard ratings for the Suppression Planning Units (SPUs) in the CWPP and includes a brief description of the two tools principally involved – the SPU Hazard Rating (SPUHR) and the Interagency Fuel Treatment Decision Support System (IFTDSS). SPUHR is used to determine the adjective hazard rating class (Low, Moderate, High, Very High, or Extreme) for each of the SPUs in the study area.

Bintel has partnered with Dr. Jen Schmidt of UAA to complete the fire behavior modeling and develop the SPUHR algorithm localized for the unique attributes of the MOA. **This analysis produces ratings and maps that aid in the placement, type, and priority of mitigation recommendations.**

IFTDSS is a product of the U.S. Forest Service Missoula Fire Sciences Laboratory.[1] IFTDSS models several aspects of predicted fire behavior and Landscape Burn Probability (LBP). The IFTDSS modeling outputs are combined with a geographic information system (GIS) spatial analysis of physical factors, such as community topography and distance to fire stations and water supplies, to generate the SPUHR scores.

Introduction

The primary outcome of the hazard study performed for this CWPP is to identify and quantify wildland fire hazards for the Wildland-Urban Interface (WUI) residential areas. WUI areas in the study area have been grouped into 30 Suppression Planning Units (SPUs), listed in Table 1 for hazard analysis and prioritization of mitigation recommendations.

For purposes of this study, SPU boundaries are based on areas of residential development that represent similar dominant wildfire hazards and are geographically contiguous rather than political, HOA, or traditional neighborhood boundaries. Non-residential land, such as large commercial or government-owned tracts, have been excluded. Isolated single properties and small groups of properties are addressed as individual parcel assessments and not considered an SPU for this purpose.

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[1] https://iftdss.firenet.gov/landing_page/about.html

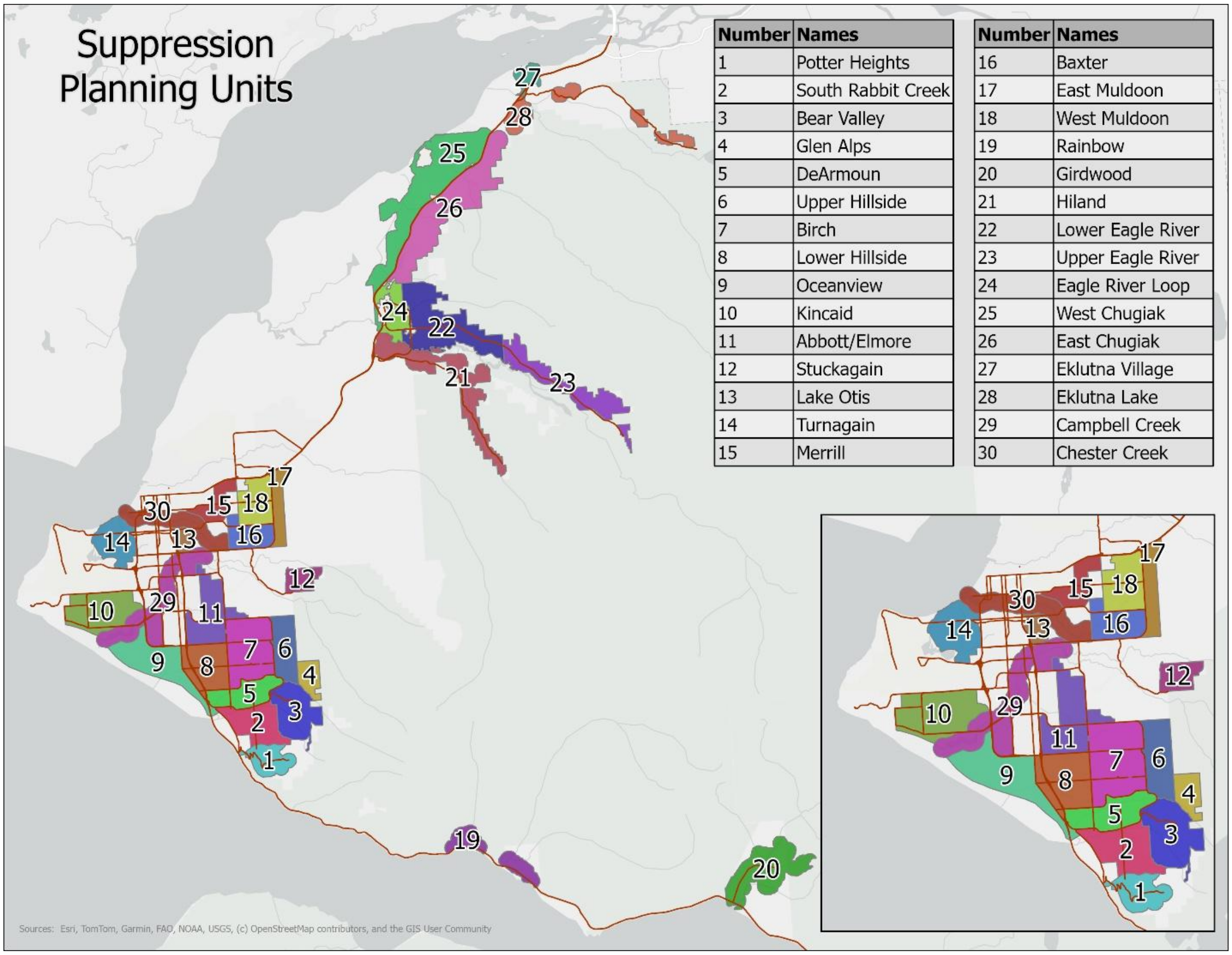

Figure 1 - Suppression Planning Units[2]

The WUI is also known as the area where adjacent natural fuels represent a wildfire hazard to what would be an urban or suburban development in a different setting. The WI consists of communities where wildland fuels surround homes. Several authorities including the U.S. Fire Administration, the International Wildland-Urban Interface Code (IWUIC), and the National Fire Protection Association (NFPA) also recognize an “Occluded” category of interface communities that includes developed areas surrounding wildland fuel islands of less than 1,000 acres.[3] In terms of hazard analysis and mitigation, these communities are treated and defined as SPUs.

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[2] https://experience.arcgis.com/experience/1170079e0aac464c87a0a5eb280cd6a4
[3] National Institute of Standards and Technology Technical Note 2205, March 2022, page 3 (footnote 1)

SPU Hazard Rating (SPUHR) - Description

The SPUHR methodology was developed specifically for this MOA CWPP by Dr. Schmidt and the AFD Wildfire Division. The SPUHR combines physical infrastructure factors such as structure density, road access, and water supply with social and demographic factors, finally using fire behavior and LBP outputs from IFTDSS. The model was developed through multiple rounds of discussion, and the results were validated by local fire department experts.

Elements of NFPA 1140 have been integrated into this methodology to ensure compatibility with national standards. Aspects of NFPA 1142 regarding water supply for rural and suburban firefighting are also included in the assessment by evaluating proximity and capacity of water for fire suppression.

SPUHR ratings are relative to ratings for other SPUs the same study area. For example, a “High” hazard community in northern Alaska will not look like a “High” hazard community in MOA.

Several factors were used to assess wildfire hazard, risk, and vulnerability (Table 1). Each factor has a range of values, and within each factor the natural distribution of those values was used to assign each SPU a rank score between one and five based on natural breaks in the data (Jenks 1967)[4]. One represents the lowest score (i.e. lowest risk) and five represents the highest score (i.e. highest risk). A total of 19 factors included in the SPUHR approach (Table 1). The factors were grouped into categories (Table 1) to reflect different aspects of hazard, risk, and vulnerability. After each SPU was assigned a score of 1-5 for each factor, the factors were grouped into categories (Table 1).

The SPU factor scores were totaled within each category to provide a cumulative SPU score for that category. Each category contributed equally to the total score, except for vulnerability and values at risk, which represented half a factor. The reason for this is that while socio-economic factors are important, fuel must be present for a wildfire hazard to exist, and a fast response is crucial to limiting the spread of wildfires within an urban environment. So, more weight should be given to those factors. The final numeric total score was then used to sort SPUs into one of five adjective hazard classes: Low, Moderate, High, Very High or Extreme. Table 2 shows the SPUHR ratings for the SPUs of this study area.

[4] Jenks, George F. 1967. "The Data Model Concept in Statistical Mapping", International Yearbook of Cartography 7: 186–190.

Category	Factor within each suppresion planning unit (SPU)	Source
Fire Hazard	Average 2024 wildfire exposure	Dr. Schmidt
	Average integrated hazard	IFTDSS
	Average wildfire structure risk	Dr. Schmidt
Fire Behavior	Terrain Ruggedness 90th percentile	United States Geological Survey (USGS)
	Percent of the area with a south-facing slope	United States Geological Survey (USGS)
Fire History	Density of wildland fire starts (2001-2021)	Municipality of Anchorage
Fuel	Ratio of hazardous fuel area to SPU area	Dr. Schmidt
Suppression	Percent of structures not within a 200m buffer of a fire hydrant	Municipality of Anchorage
	Percent of the area outside of a fire service area	Municipality of Anchorage
	Average response time to parcels from the nearest fire station	Municipality of Anchorage/Dr. Schmidt
Access	Percent of the road length of roads that dead ends	Municipality of Anchorage/Dr. Schmidt
	Percent of the road length with a slope of 6% or more	Municipality of Anchorage/United States Geological Survey (USGS)
	Density of sharp curves	Dr. Schmidt
Vulnerability	Percent of the households that speak English less than "Well"	American Community Survey Data (2019-2023, Block Group)
	Percent of the population under 18 or over 64 years old	American Community Survey Data (2019-2023, Block Group)
	Percent of households with no vehicle	American Community Survey Data (2019-2023, Block Group)
	Percent of civilians with a disability	American Community Survey Data (2019-2023, Block Group)
Values at Risk	Structure density	Municipality of Anchorage
	Total land and building values divided by area	Municipality of Anchorage

Table 1 - Factors, and their sources, used in the SPUHR approach to rate SPUs

The SPUHR ratings, as described above, have been included in the hazard summaries of the SPUs found in *Appendix A: Suppression Planning Units* and in the CWPP section discussing SPUs within the Municipality of Anchorage AOI.

Fire Behavior Analysis

The CWPP hazard analysis begins by modeling wildfire behavior within the study area boundary. This is done using an industry-standard, fire-behavior modeling package known as IFTDSS (v3.11)[5]. IFTDSS uses maps of fuel characteristics and topography, along with information about past weather patterns, to predict the severity of wildfire. The 90th and 97th percentile weather (top 10% and 3% of fire weather days) are used to calculate fuel moisture and wind during a high and extreme fire danger day. Dominant wind directions and speeds are then calculated from the frequency distributions of the Remote Automatic Weather Stations (RAWS) records. That information is used to measure how any given vegetation will burn across the study area under the same weather conditions.

[5] https://iftdss.firenet.gov/iftdss2/#/landing (same as footnote 1)

Landscape Fire Behavior Modeling Inputs:

- Fuel Model
- Canopy Cover
- Stand Height
- Canopy Base Height
- Canopy Bulk Density
- Topographic Position (Aspect, Slope and Elevation)
- Initial Fuel Moisture
- Wind Speed and Direction

Landscape Fire Behavior Simulation Outputs:

- Flame Length
- Rate of Spread
- Crown Fire Activity
- Fireline Intensity
- Heat per Unit Area

Fire Behavior Modeling Procedure

The study area is broken down into grid cells with dimensions of 30 meters × 30 meters; fire behavior is predicted for each cell barographic, fuel, and weather input information. For this study, rather than using the LANDFIRE data integrated into the Interagency Fuel Treatment Decision Support System (IFTDSS) that was used to perform modeling, Dr. Schmidt used a modified landcover layer from the Arctic Boreal Vulnerability Experiment (ABoVE) project that focused on the Arctic.[6] This layer was modified to include impacts from a recent spruce beetle outbreak and identified black and white spruce. This layer was found to more adequately capture vegetation within an urban environment. Dr. Schmidt worked with a fire behavior analysist at the National Park Service (Chris Moore) to develop a crosswalk between the landcover categories and fuel characteristics used in the model (surface fuels, canopy closure [CC], canopy height [CH], canopy base height [CBH], and canopy bulk density [CBD]). IFTDSS provides a topographic dataset (aspect, slope, and elevation).

Reference weather and fuel moisture information are obtained from one or more Remote Automated Weather Station (RAWS) sites. This study examined wind roses from the Anchorage Airport (PANC) during fire season (May-August 15th), which suggested 359 and 160. Based on feedback from AFD experts, wind directions of 160 and 290 were used.

6 Wang JA, Sulla-Menashe D, Woodcock CE, Sonnentag O, Keeling RF, Friedl MA (2019) ABoVE: Landsat-derived Annual Dominant Land Cover Across ABoVE Core Domain, 1984-2014. In: ORNL Distributed Active Archive Center. https://daac.ornl.gov/ABOVE/guides/Annual_Landcover_ABoVE.html Accessed May 2023

Predominant wind directions and speeds are calculated from the frequency distributions of the RAWS records. For the flame length, rate of spread, crown fire activity, and fireline intensity model runs, an upslope wind direction is used (i.e., the fire is assumed to burn uphill). This simulates the worst-case scenario (winds aligned with slopes) and is considered the best scenario to run for preplanning. Both live and dead fuel moistures for each landscape cell are calculated by the model based on the topography (slope, aspect, and elevation) and shading from forest canopy and clouds, as well as the recorded weather (precipitation, high and low temperatures, and high and low relative humidity) for the previous three days that lead up to the date chosen to get the best representation of the standard conditions.

Rate of spread values generated by the simulation are classified into four categories based on standard ranges: less than 20, 20.0–40.0, 40.1–60.0, and greater than 60 chains per hour (Ch/h). A chain is a logging measurement that is equal to 66 feet; 1 mile equals 80 chains, 1 Ch/h equals approximately 1 foot/minute, and 80 chains per hour equals 1 mile/hour. A high rate of spread does not necessarily indicate severe fire effects in all portions of the study area. Fire will move very quickly across short grass fields but will not burn very hot and may not cause any major damage to the soil or man-made features.

Crown fire activity values generated by the simulation are classified into four categories based on standard descriptions: active crown fire, passive crown fire (torching), surface fire, and noncombustible. In the surface fire category, little or no tree torching will be expected. During passive crown fire activity, isolated torching of trees or groups of trees will be observed, and fire movement through the canopy will be limited to short distances. During active crown fire, sustained fire movement through the canopy independent of surface fire is probable.

Flame Length is a proxy for the heat generated by the flaming front. Generally, flame lengths of less than 4 feet can be attacked directly at the head or flanks by fire crews. Flame lengths of 4 – 8 feet are too intense for direct attack with hand tools and are usually attacked by machinery or air operations. When flame lengths are greater than 8 feet, any type of direct attack becomes impractical, and the fire is usually attacked by indirect methods such as utilizing natural and man-made barriers and backfiring.

Fireline Intensity and Heat per Unit Area are specific measures of the intensity on the leading edge of the fire versus the heat being released across the area actively burning irrespective of rate of spread.

Spotting and Embers – Embers are a major cause of structure loss. Thousands of embers, or “firebrands”, can be carried by the wind and rain down on structures. These embers can be parts of twigs or branches, pinecones, bark, or wood shingles and other flammable debris torn from burning roofs or debris piles. While any vegetation can create embers, trees are the most problematic since their embers travel the furthest distance. The impact of ember cast on fire spread is dictated by several factors.

- The source, size, and number of firebrands.
- The distance the firebrand is carried downwind.
- The probability of igniting a new fire at the downwind location.

While there is currently no standard model that can predict home to home ignition (urban conflagration), it is well documented that when multiple structures are burning under strong wind conditions, they will continue to generate viable embers that will land on structures ahead of the fire. The distance the fire will penetrate urban/suburban areas will be dictated by the windspeeds and the intensity of the fire. It is safe to say there will probably be ember and smoke impacts beyond where existing fire behavior models show ember cast.

Landscape Burn Probability (LBP) Output

Landscape Burn Probability Model (LBP) evaluates the likelihood an ignition will develop into a wildfire. This model, along with fire severity predictions from fire-behavior modeling, are employed to determine the contextual threat of wildfire to the SPUs of the study area.

Similar but also useful, the Burn Probability output (BP) quantifies the likelihood of a fire occurring under a fixed set of weather and fuel moisture conditions.

In addition to BP, LBP also models Conditional Flame Length (CFL). CFL is an estimate of the average flame length for all fires that burn at a given point on the landscape under a fixed set of weather and fuel moisture conditions. This number is lower than the Landscape Fire Behavior Flame Length output because it averages head, flank, and backing fire for each pixel instead of just the head fire.

The most relevant product of the LBP analysis for hazard mitigation planning is Integrated Hazard. Integrated Hazard combines BP with CFL into a single characteristic that can be mapped.

The outputs of the fire behavior modeling process provide a significant portion of the SPUHR score.

Hazard Rating Factors

A zonal analysis of physical geography affecting wildfire hazard threats to the communities is critical to the SPUHR ratings. ArcGIS Pro (version 3.5.2) was used to create the factors used to rank the SPUs. The zonal statistics tool was used for Average 2024 wildfire exposure

- Average 2024 wildfire exposure – Zonal statistics was used to calculate the average wildfire exposure within each SPU (Schmidt et al. 2024)[7]
- Average Integrated Hazard - Zonal statistics was used to calculate the integrated hazard, which is an output from IFTDSS, within each SPU
- Average wildfire structure risk – Zonal statistics was used to calculate the average wildfire exposure within each SPU https://bit.ly/moawildfireexposure [8]

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7 Schmidt, J.I., Ziel, R.H., Calef, M.P. et al. Spatial distribution of wildfire threat in the far north: exposure assessment in boreal communities. Nat Hazards120, 4901–4924 (2024). https://doi.org/10.1007/s11069-023-06365-4

8 Schmidt, J.I., Ziel, R.H., Calef, M.P. et al. Spatial distribution of wildfire threat in the far north: exposure assessment in boreal communities. Nat Hazards120, 4901–4924 (2024). https://doi.org/10.1007/s11069-023-06365-4

- Terrain Ruggedness 90th percentile – Terrain ruggedness captures the amount of elevation difference between adjacent cells. The United States Geological Survey digital elevation model (DEM, 7.64 m resolution). Zonal statistics was used to calculate 90^{th} percentile within each SPU. This is the value below which 90% of the cells within its zone fall. Higher values indicate increased ruggedness.
- Percent of the area with a south-facing slope – The same USGS DEM was used to calculate aspect. Then the south, southwest, and southeast aspects were identified and the percent of the SPU with these aspects was calculated.
- Density of wildland fire starts (2001-2021) -The number of callouts from AFD related to non-structure fire event totaled for each SPU and then divided by the area of the SPU (km2).
- Ratio of hazardous fuel area to SPU area – The hazardous fuel layer (2024) associated with the previous wildfire exposure layer (Schmidt et al. 2024)[9] was reclassified to identify areas with hazardous vegetation. Then the area within each SPU covered by hazardous vegetation was calculated and then divided by the area of the SPU (km2).
- Percent of structures not within a 200m buffer of a fire hydrant – The fire hydrant layer from the MOA was used and 200m buffers around each hydrant were identified. The MOA building extent layer was used to calculate the total number of buildings within an SPU and the total number of buildings not within 200m of a fire hydrant. The total number of buildings outside of the 200m fire hydrant buffer within an SPU was then divided by the total number of buildings within an SPU.
- Percent of the area outside of a fire service area – The fire service area (FSA) boundaries from the MOA were used to calculate how much area outside of a FSA within a SPU. This area was then divided by the total area of the SPU.
- Average response time from nearest fire station to parcels – The road network database maintained by the MOA was used along with the Network Analysis Closest Facilities tool in ArcGIS Pro. With this tool we used the MOA parcel database to identify the closest fire station based on travel time. Then it calculated the travel time for each parcel to the nearest fire station. The average parcel travel time was calculated within each SPU.
- Percent of the road length of roads that dead ends – Dead end roads were identified with a previous project (Schmidt and See 2023).[10] The length (km) of the dead end only roads was calculated within each SPU. Then this value was divided by the total length of roads within an SPU.

9 Schmidt, J.I., Ziel, R.H., Calef, M.P. et al. Spatial distribution of wildfire threat in the far north: exposure assessment in boreal communities. Nat Hazards120, 4901–4924 (2024). https://doi.org/10.1007/s11069-023-06365-4

10 Schmidt J.I., See J. (2023) Advancing Wildfire Preparedness and Planning in Anchorage Wildfire Exposure and Egress Study

- Percent of the road length with a slope of 6% or more - The previous DEM was used to calculate slope. Then the roads were clipped by a mask where the slope was 6% or more. The length (km) of clipped roads was recalculated. The total length of roads within the area of 6% or more was totaled within each SPU. This value was then divided by the total length of roads within an SPU.[11]
- Density of sharp curves – Dr. Schmidt visually inspected the MOA road database and identified curves sharper than 90 degrees. The total number of these sharp curves within the SPU was then divided by the area of the SPU.
- Percent of the households that speak English less than "Well" - Used the 5-year average American Community Survey data (2019-2023) at the block group level to determine the total number of households that speak English “Not Well” or “Not at all” within each SPU. Then divide this number by the total number of households within an SPU.
- Percent of the population under 18 or over 64 years old - Used the 5-year average American Community Survey data (2019-2023) at the block group level to determine the number of people younger than 18 and over 64 years old within each SPU. Then divide this number by the total number of households within an SPU.
- Percent of households with no vehicle - Used the 5-year average American Community Survey data (2019-2023) at the block group level to determine the number of households with no vehicle access within each SPU. Then divide this number by the total number of households within an SPU.
- Percent of civilians with a disability - Used the 5-year average American Community Survey data (2019-2023) at the block group level to calculate the total civilian noninstitutionalized population with a disability. Then divide this number by the total civilian noninstitutionalized population within an SPU.
- Structure density – The previously mentioned MOA building dataset was used to calculate the total number of structures within an SPU. This was then divided by the total area of the SPU (km2).
- Total land and building values divided by area – Used the total land and building value from the MOA appraisal database to total the value within an SPU. This was then divided by the total area of the SPU (km2).

The Fire Behavior outputs and the GIS Zonal Analysis described above were adjusted by the on-the-ground field survey of HIZ hazard factors to generate an adjective rating of the SPUs. The SPUHR ratings are used to recommend and prioritize mitigation actions presented in the CWPP report. For a narrative of the fire-related characteristics and hazards for each of these SPUs see *Appendix A: Suppression Planning Units*.

11 Schmidt J.I., See J. (2023) Advancing Wildfire Preparedness and Planning in Anchorage Wildfire Exposure and Egress Study

Appendix C: Methodology

The SPUHR Ratings for the 30 SPUs in the MOA are shown in the Table and Map below.

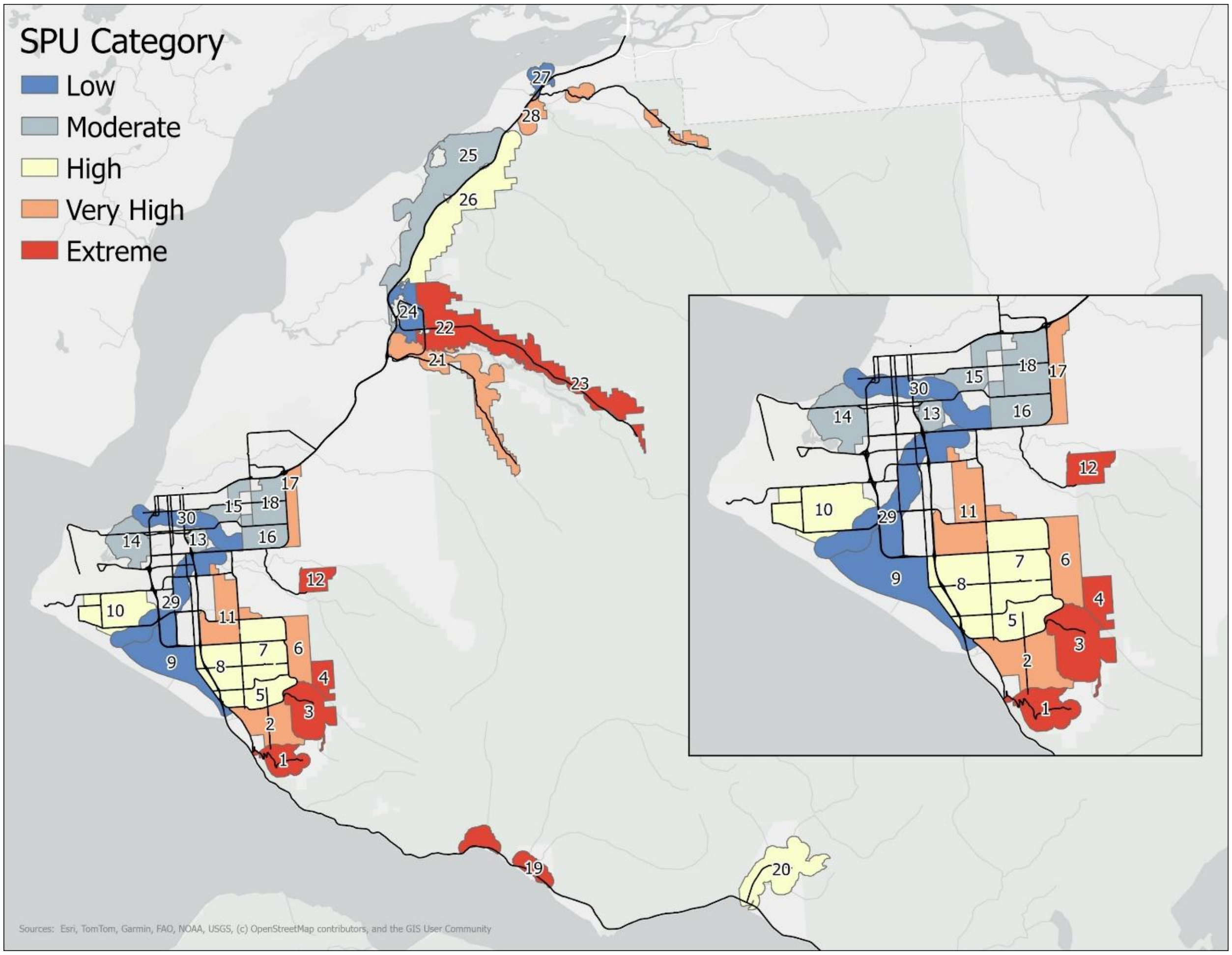


Figure 2 - SPU Hazard Rating Map & Table

SPU No.	Name	Rating
1	Potter Heights	Extreme
2	South Rabbit Creek	Very High
3	Bear Valley	Extreme
4	Glen Alps	Extreme
5	DeArmoun	High
6	Upper Hillside	Very High
7	Birch	High
8	Lower Hillside	High
9	Oceanview	Low
10	Kincaid	High
11	Abbott/Elmore	Very High
12	Stuckagain	Extreme
13	Lake Otis	Moderate
14	Turnagain	Moderate
15	Merrill	Moderate

SPU No.	Name	Rating
16	Baxter	Moderate
17	East Muldoon	Very High
18	West Muldoon	Moderate
19	Rainbow	Extreme
20	Girdwood	High
21	Hiland	Very High
22	Lower Eagle River	Extreme
23	Upper Eagle River	Extreme
24	Eagle River Loop	Low
25	West Chugiak	Moderate
26	East Chugiak	High
27	Eklutna Village	Low
28	Eklutna Lake	Very High
29	Campbell Creek	Low
30	Chester Creek	Low

More maps and visual representations of the rating factors used in the analysis are presented below to further clarify the consistency of results across the different factors used.[12]

Summary

Fire history, the IFTDSS LBP analysis, and in-person expert assessment demonstrate that a high potential for wildfire will continue to threaten WUI SPUs in the Municipality of Anchorage. That said, the analysis also points to a concentration of risk that can be significantly reduced through collaborative efforts by residents and MOA agencies at reasonable cost if pursued now.

[12] https://experience.arcgis.com/experience/53c5785ac0644842b4fe45da002fa339

MAPS OF SELECTED HAZARD RATING FACTORS

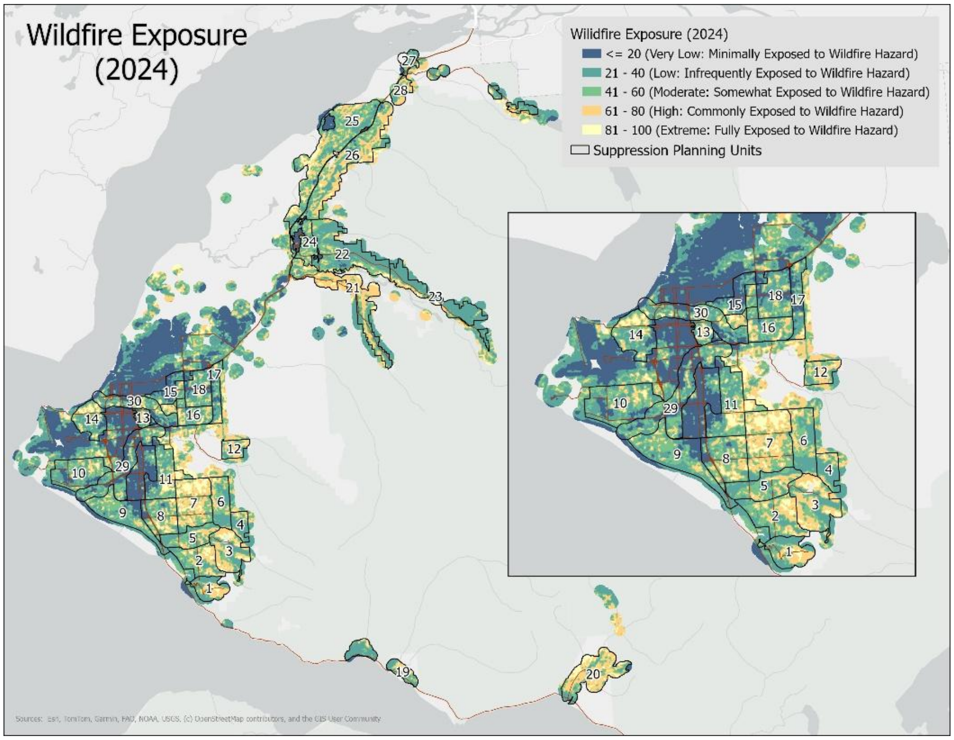


Figure 3 - Average Wildfire Exposure

Average Wildfire Exposure Analysis

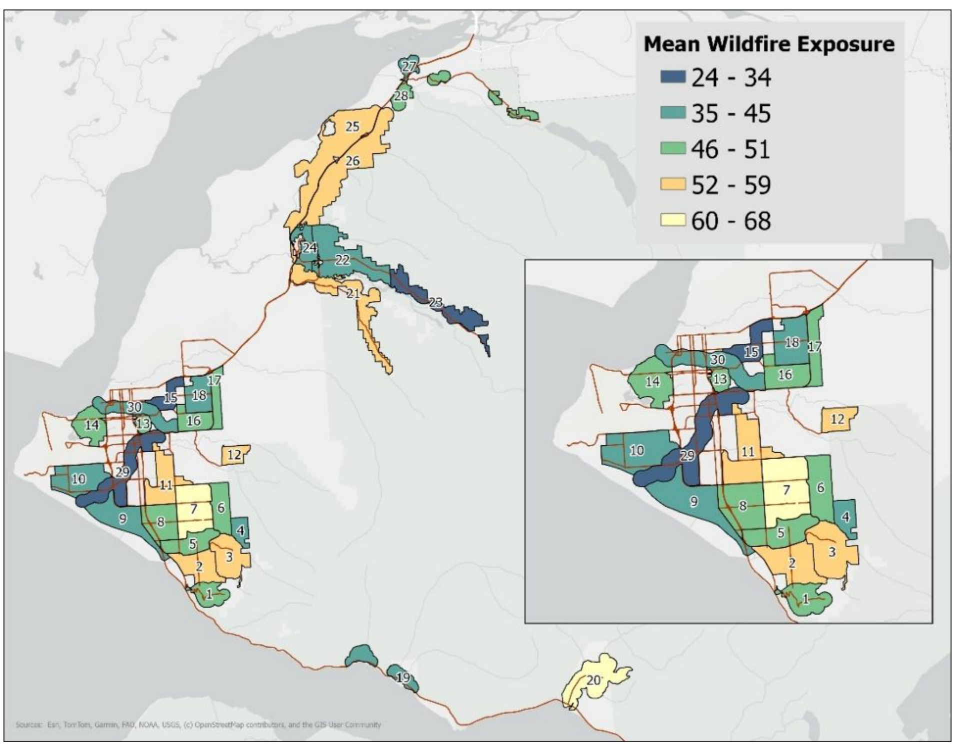
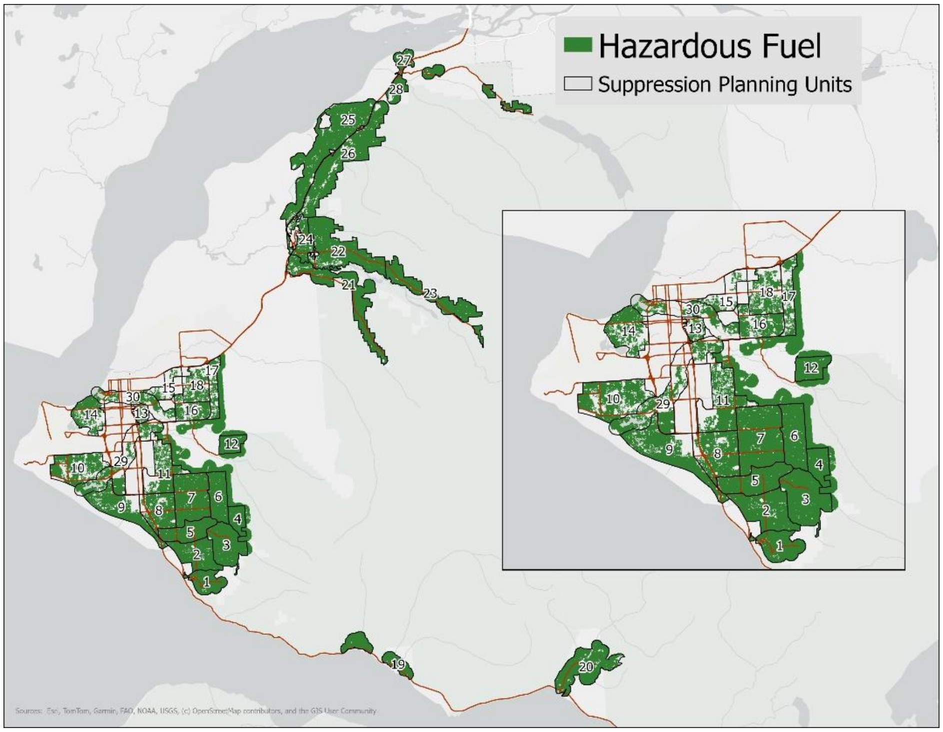


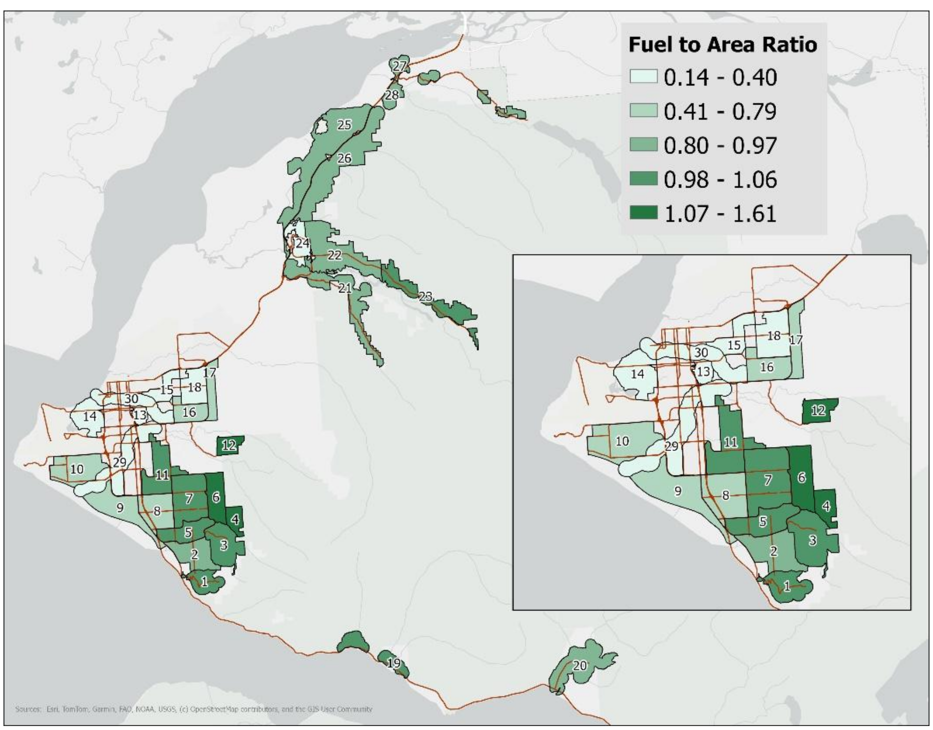
Figure 4 - Mean Wildfire Exposure (Average by SPU)

Mean Wildfire Exposure by SPU



MOA Hazardous Fuels

Figure 4 - Hazardous Fuels



Fuel to SPU Area Ratio

Figure 5 - SPU Fuel to Area Ratio

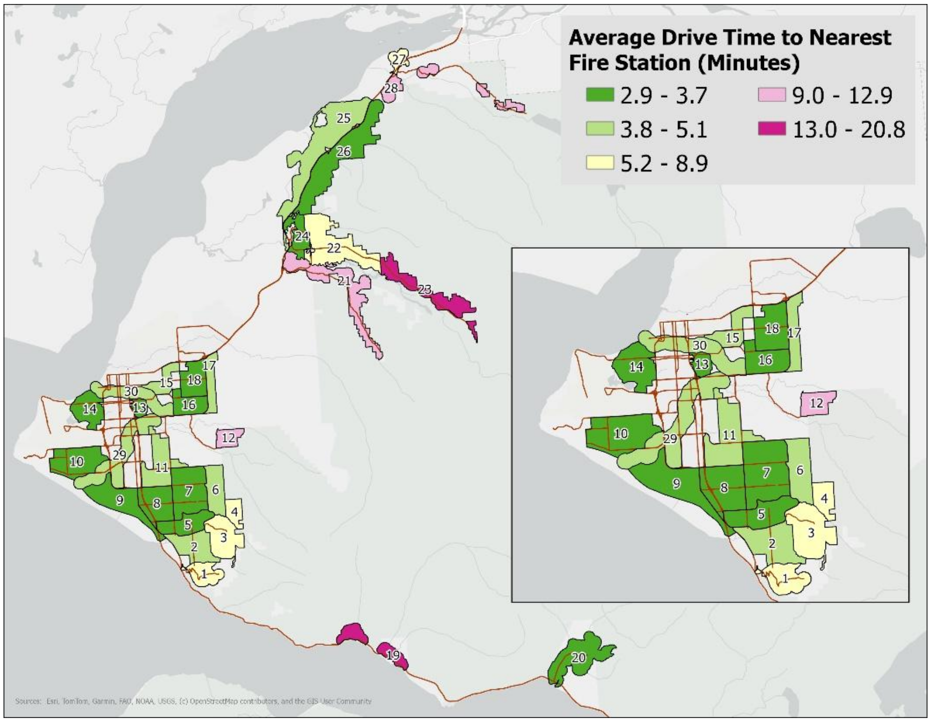


Figure 6 - Suppression Factors

Suppression Factors

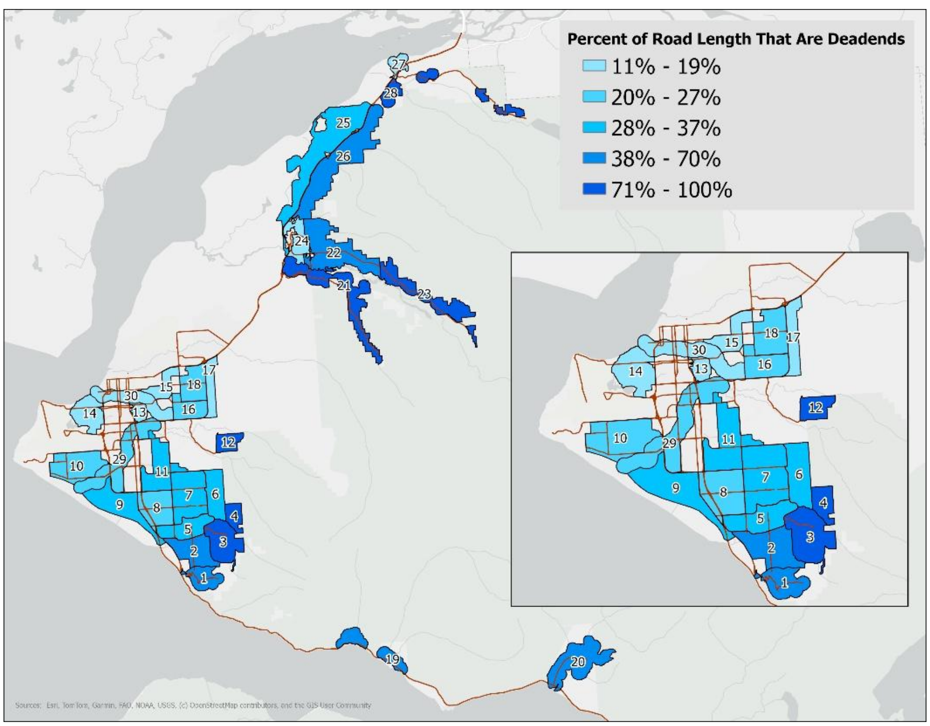


Figure 7 - Percentage of Dead-End Roads in SPU

Access

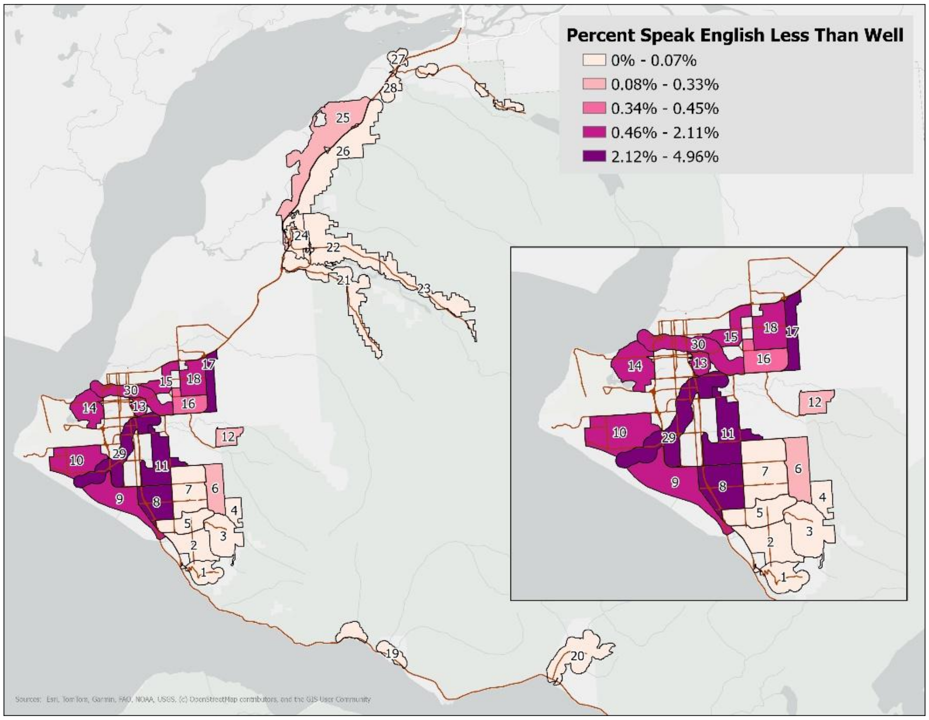


Figure 8 - Social Vulnerability Factors

Social Vulnerability Factors

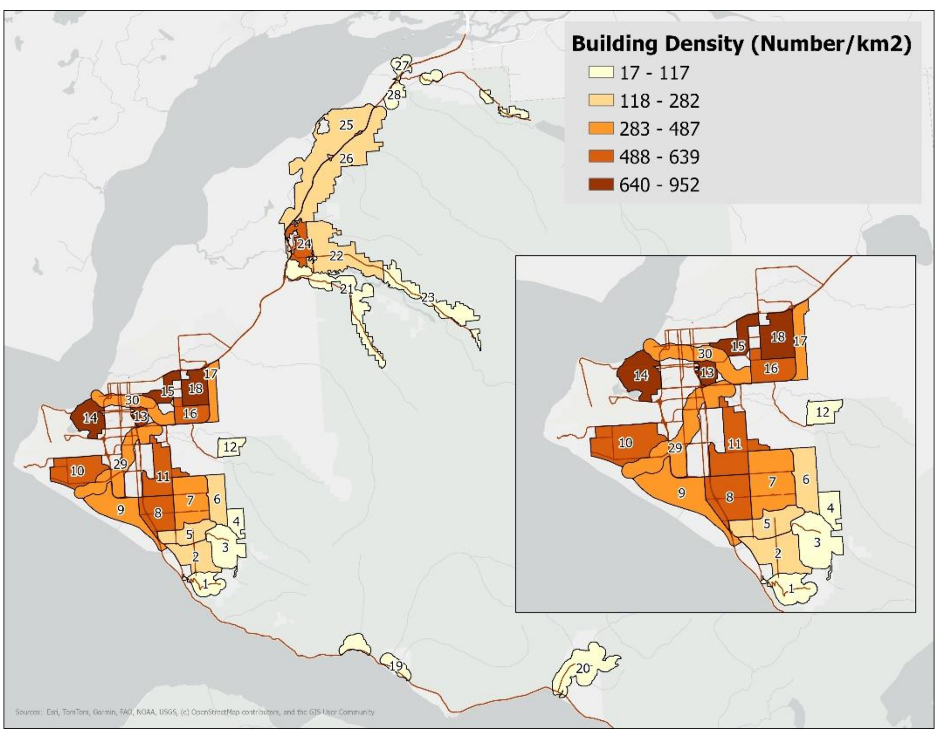


Figure 9 - Building Density, Values at Risk

Values at Risk

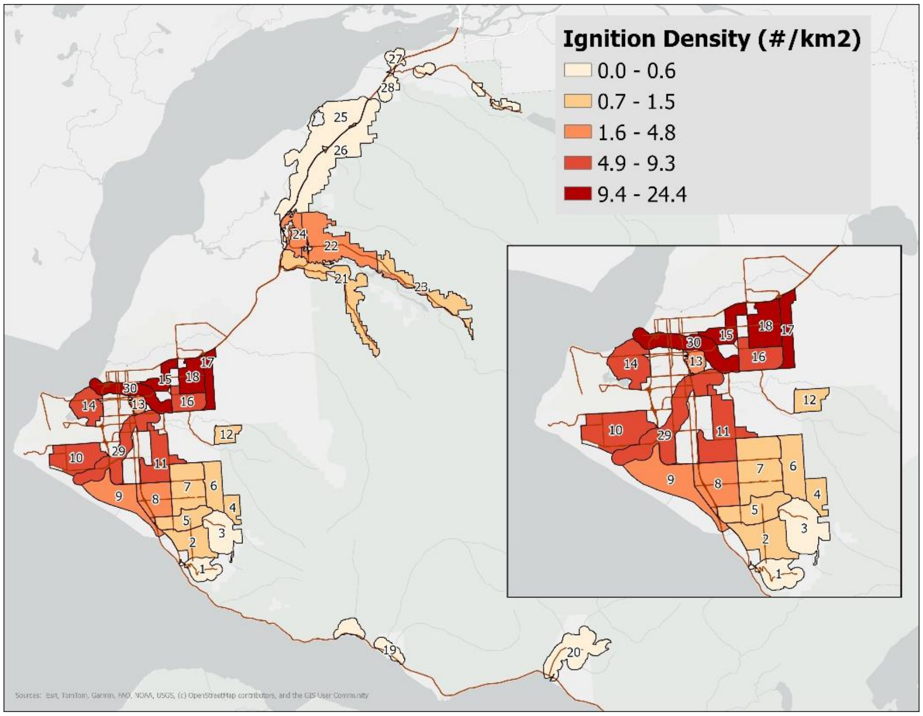


Figure 10 - Ignition Map 2001 to 2021 (courtesy Dr. Jen Schmidt)

Fire Ignition Patterns and Frequency

Special Credit

Dr. Jen Schmidt of the University of Alaska collaborated closely with the AFD Wildfire Division and Bintel to co-develop the rating methodology explained in this appendix and conducted a majority of the analysis. This approach helped to recognize the unique characteristics of the MOA topography, vegetation, and wildfire risk.[13]

Any omissions or errors in the summary of the methodology contained herein unintentional and is the responsibility of Bintel Inc.

[13] https://experience.arcgis.com/experience/53c5785ac0644842b4fe45da002fa339