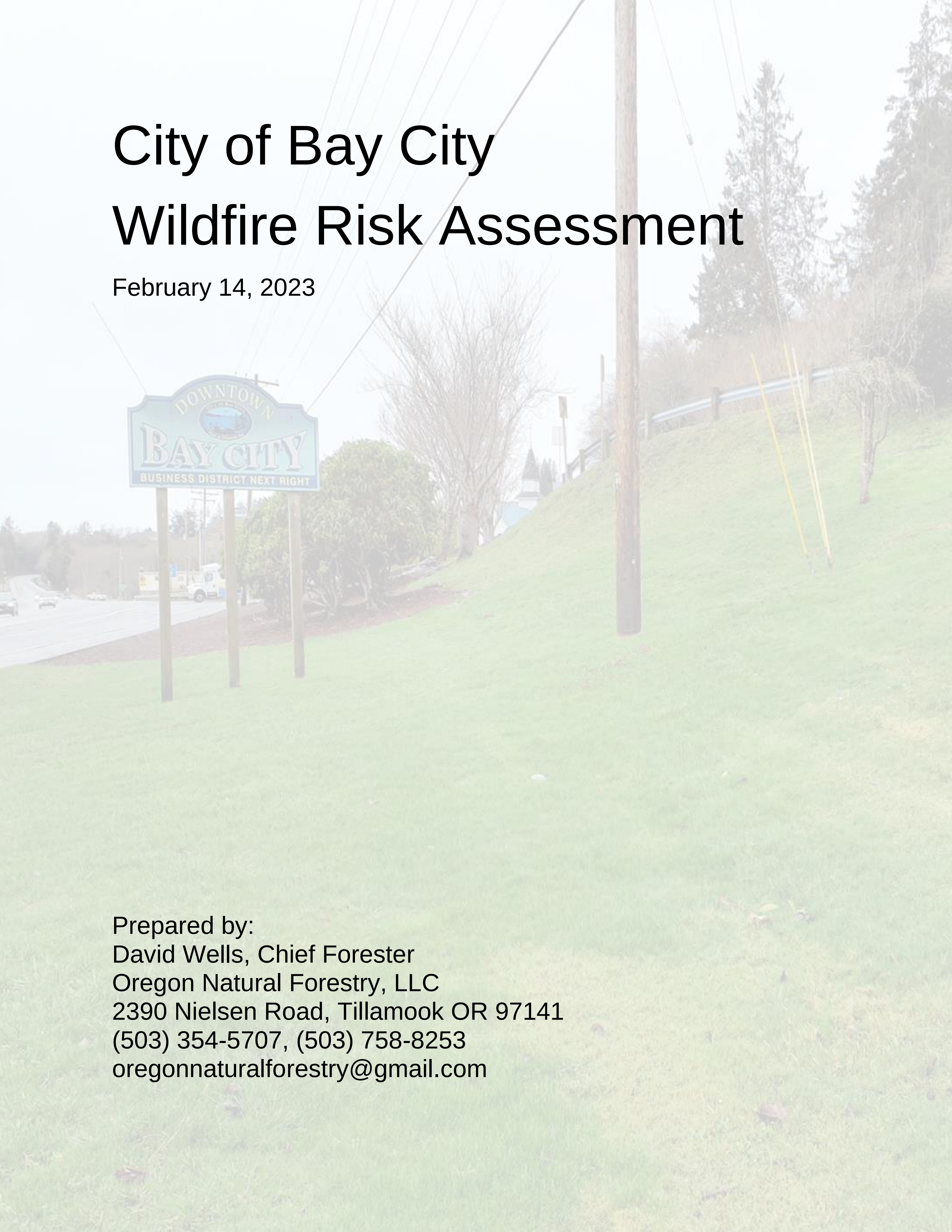
City of Bay City
Wildfire Risk Assessment

February 14, 2023



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City of Bay City Wildfire Risk Assessment

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Executive Summary

The City of Bay City is located in Northwestern Oregon the eastern edge of Tillamook Bay and the western edge of the Tillamook State Forest. To the casual observer the risk to the City and its development and residents from wildfire would appear to be minimal if at all. However repeated reviews assessing the risk of natural hazards to incorporated and un-incorporated areas of Tillamook County (2007, 2017) have listed the City of Bay City as having a high risk of wildfire compared to other areas in the County. This 2023 assessment is specifically evaluating the current wildfire risk.

Both fire intensity and fire frequency need to be considered when thinking of the overall risk. It is interesting that both of the initial assessments, conducted before the Labor Day Fires of 2020, described the greatest threat as being in the southwestern portion of the City. Following the 2020 fires interest in wildfire risk increased after thick smoke covered the area from distant fires and the adjacent Pike Road Fire. Natural fire return intervals are reported for this area as being in the range of 200 years or more. There is historical evidence (Tillamook Fires, 6-year return interval) that given the right conditions and ignition source, fires can return with a higher frequency.

This assessment found areas of fuel loadings that could burn with near un-stoppable intensity under "Red Flag" conditions. Red Flag conditions are those that are most favorable for fire growth, high winds and temperatures and low relative humidity. The highest fuel loadings were in the City's northeast corner adjacent to private, City and State owned forest land. High fuel loadings were also found in the northwest and southern part of the city. Throughout the city vacant lots and vegetation filled draws create a mosaic of fire potential that could ignite and spread fire under the worst fire conditions. Given the fuel loading and mosaic of dense vegetation it is possible that fire could spread from the forest all the way to Tillamook Bay in some locations.

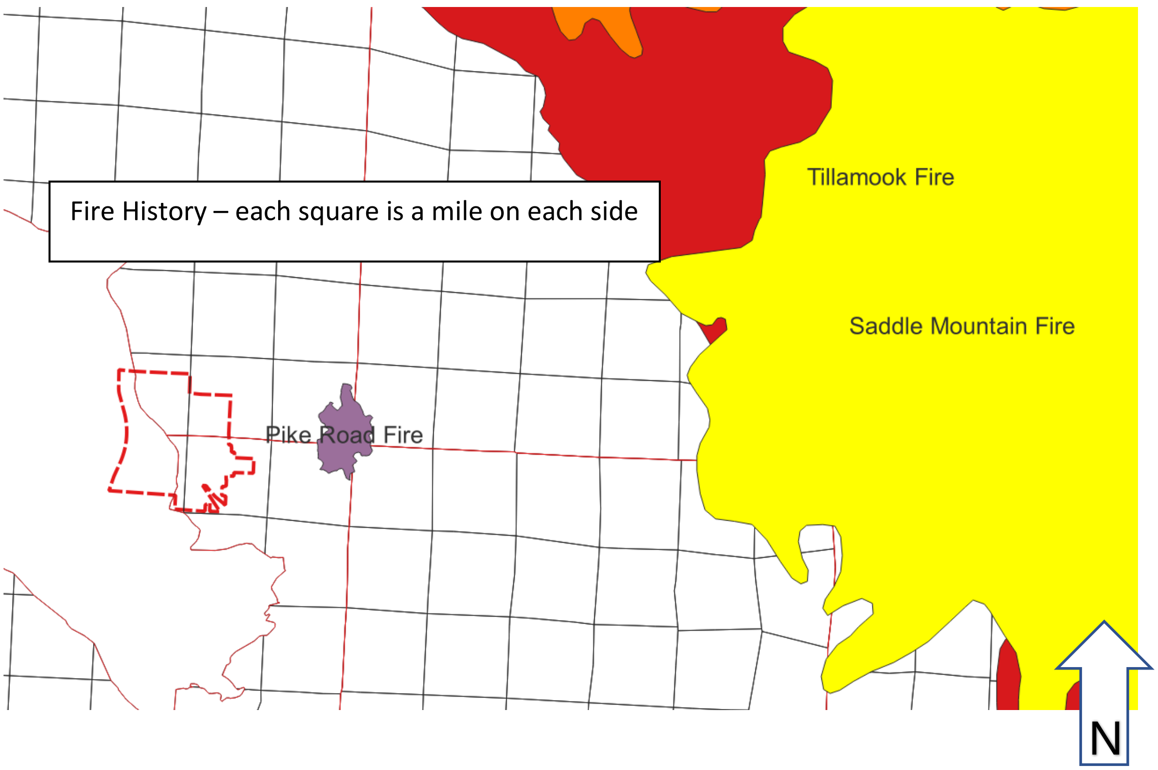
Density of structures within the city combined with wildfire risk suggest similar damage to what happened in Otis and Lincoln City from the Echo Mountain Complex wildfire (September 2020) is possible. Four areas were designated where the fire intensity could make fire control very difficult. The largest of these areas was the larger timber in the northeast corner of the property. Within this area 153 tax lots (not necessarily structures) are located. Overall a total of 710 lots could be impacted in the intense fire zone and zone of potential impact.

Recommendations center on reducing the amount of vegetative fuel available in a wildfire conditions. Structural hardening to minimize ignition should also be considered but specifics are beyond the scope of this assessment.

Historical Perspective

There is a long history of wildfire associated with Coastal towns adjacent to forested areas like Bay City. In September 1936 the Bandon fire burned from the forest and through town forcing people to seek shelter at the beach. Almost every building in Bandon was burned and 10 people lost their lives. That same year a wildfire burned much of Depoe Bay without loss of life but still the report stated that almost every home was somewhat blackened.

The 1933 Tillamook Fire burned within about 5.9 miles of Bay City. This megafire was followed 6 years later by the 1939 Saddle Mountain Fire that inched closer to town, burning within 5.5 miles. Six years later again the Wilson River-Salmonberry Fire came again as close as 5.9 miles to the city limits.



Pat Vining reported that the Bay City central business district was involved in a fire burning it down.

In September 2020 the Pike Road Fire, the largest fire in 40 years to burn in Tillamook County, burned to within 1.1 miles of Bay City. This fire was stopped using logging equipment to make a fireline that did prevent its further spread towards the city. Woody debris remains in certain locations resulting from primary and secondary fire control construction on the Tillamook State Forest. This down wood adds to the fuel loading available during a wildfire event and adds to risk from the forest to the City.

A commonality of these fires, except that of the historic central business district fire, was extremely dry conditions, a remote start somewhere in the forest and then strong east winds that blow the fires westward towards Bay City.

Multi-hazard risk assessments conducted by Tillamook County were completed in 2007 and 2017. In the 2017 Tillamook County Multi-Jurisdictional Natural Hazards Mitigation Plan, Bay City was rated High, on a low, moderate, high scale, for Wildfire Risk.

Tillamook County Multi-Jurisdictional Natural Hazards Mitigation Plan – June 28, 2017

Table 75. Local Risk Assessment: Wildfire

Jurisdiction	History	Vulnerability	Maximum Threat	Probability	Total	Risk Level
Unincorporated Tillamook County	2	25	20	14	61	Low
Neskowin*	-	-	-	-	-	-
Oceanside-Netarts*	-	-	-	-	-	-
Pacific City*	-	-	-	-	-	-
Bay City	0	15	90	21	126	High
Garibaldi	6	15	50	21	92	Low
Manzanita	0	20	40	0	60	Low
Nehalem	2	35	100	14	151	Moderate
Rockaway Beach	2	30	80	35	147	Moderate
Tillamook	0	20	80	7	107	Low
Wheeler	8	5	50	28	91	Low
Port of Tillamook Bay	0	5	10	7	22	Low
Port of Garibaldi	2	5	10	14	31	Low

**Included in Unincorporated Tillamook County*

Source: Tillamook County Multi-Jurisdictional NHMP Update Steering Committee, September-October, 2016

Methodology

The City of Bay City occupies a total area of 1.26 square miles (806 acres) of land which was the area of inquiry for this assessment.

To complete the assessment a square grid of approximately 450' on each side was geographically laid over the city. At each node assessments were made as to aspect, slope, flame length, native vegetation and invasive species vegetation. Aspect*, slope and vegetation are all factors that can influence fire intensity. Flame length was used as a corollary to fire intensity and ability for fire suppression activities to be successful or not. Flame length was estimated under what would be "Red Flag" fire weather conditions, high wind, high temperature and low relative humidity.

Relationship of surface fire flame length and fireline intensity to suppression interpretations

Flame length		Fireline intensity		Interpretation
ft	m	Btu/ft/s	kJ/m/s	
< 4	< 1.2	< 100	<350	• Fires can generally be attacked at the head or flanks by persons using hand tools. • Hand line should hold the fire.
4 – 8	1.2 – 2.4	100 – 500	350 – 1700	• Fires are too intense for direct attack on the head by persons using hand tools. • Hand line cannot be relied on to hold the fire. • Equipment such as dozers, pumpers, and retardant aircraft can be effective.
8 – 11	2.4 – 3.4	500 – 1000	1700 – 3500	• Fires may present serious control problems—torching out, crowning, and spotting. • Control efforts at the fire head will probably be ineffective
> 11	> 3.4	> 1000	> 3500	• Crowning, spotting, and major fire runs are probable. • Control efforts at head of fire are ineffective.

Andrews, Patricia L.; Heinsch, Faith Ann; Schelvan, Luke. 2011. **How to generate and interpret fire characteristics charts for surface and crown fire behavior.** Gen. Tech. Rep. RMRS-GTR-253. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 40 p.

144 points were evaluated. When the point was not visible from the public right-of-way an estimate of fire intensity was made observing the adjacent area and current aerial photos of the area.

* Aspect: a position facing a particular direction, -*note* aspect is usually expressed as a compass direction in degrees or cardinal directions. (Dictionary of Forestry, Dr. Robert Deal editor, 2018)

Photos of areas and their associated with flame length.

Plot 98 example of low fire danger with a flame length of 2’ or less

Plot 109 example of fire danger that could produce a 2-4’ flame length because of a combination of slope, aspect and vegetation

Plot 54 example of fire danger that could produce a 4-6' flame length from the tall grass that would be somewhat mitigated by the shading of red alder trees.

Plot 22 example of fire danger that could produce a 6-8' flame length from down wood, brush, slope and aspect

Plot 28 example of fire danger that could produce an 8-12’ flame length from thicker brush, trees, slope and aspect.

Plot 59 example of 12’+ potential for flame length and rapid fire spread if the fire spread from tree top to tree top under high winds and low relative humidity.

Using a geographical information system (GIS) the flame length at each observation node was entered to see if there were any patterns of where higher flame length could be expected. Using GIS the areas of higher flame lengths, 8 feet and longer, were considered as an area where the effect of a wildfire would be significant on a structure. From the boundary of the area of significant effect a 1/8 mile (660 feet) boundary was extended to reflect what maybe the effect of a fire. The 1/8 mile distance was chosen as being the same distance as the length required by the Oregon Department of Forestry for a Permit to Use Power Driven Machinery adjacent to forest land.

Not specifically measured in this assessment is the frequency of wildfire occurrence. The report "Hazards of Risk: Identifying Plausible Community Wildfire Disasters in Low-Frequency Fire Regimes", prepared by the USDA https://www.fs.usda.gov/pnw/publications/hazards-risk-identifying-plausible-community-wildfire-disasters-low-frequency-fire was reviewed. The return interval of fires in low frequency fire areas like the City of Bay City is not well documented. The primary reason is they naturally happen infrequently which is different than what happens in other areas of Oregon like the Bend in Central Oregon. The return interval for fire on the Coast can be 200 years or more. Historically major fires have happened at much more frequent intervals than that like the series of the four Tillamook Burns that occurred every 6 years beginning in 1933. These fires on the "westside" can be extremely intense and devastating.

Current Conditions/Observations

The City of Bay City is diverse in its areas of wildfire risk. There are areas with little to no risk of wildfire spreading and others where fire suppression activity may be ineffective.

The table below shows the percentage of Bay City and the estimated fire intensity.

Flame length in feet	0	0-2	2-4	4-6	6-8	8-12	12+
Plot Count	5	36	21	28	25	12	17
Percent of Bay City area	3.5	25.0	14.6	19.4	17.4	8.3	11.8
Suppression methods effective to stop fire	Yes	Yes	Yes	Yes	Yes	No*	No

* 8-12 foot flame length stopping at head of fire ineffective

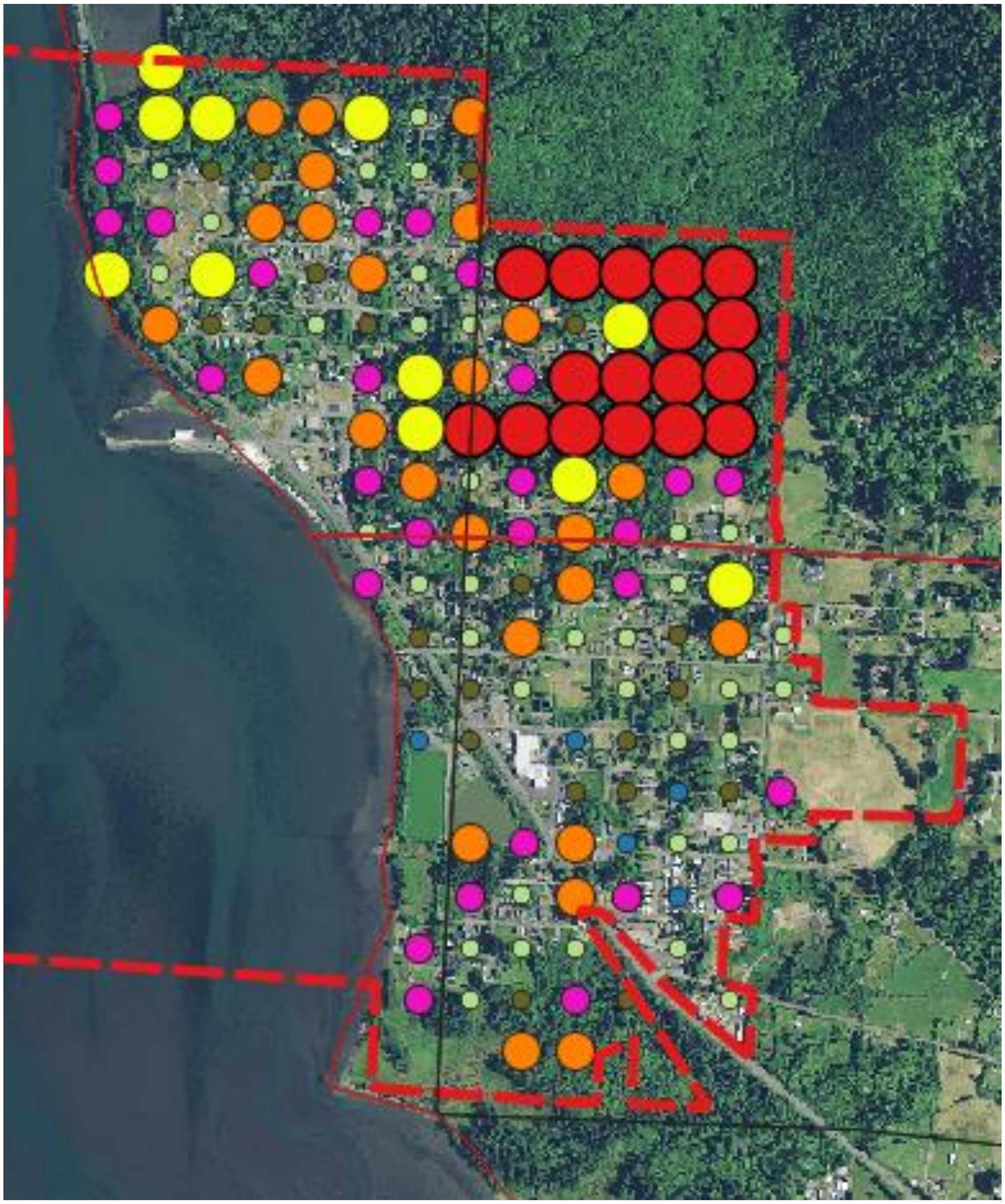
Of the observed sites about 43% could be suppressed with hand tools like a shovel, water from a garden hose or something to swat the flames down like a wet sack. These are the areas with an estimated flame length of less than four feet.

In the City about 37% of the area was evaluated as having flame lengths between 4 and 8 feet. A fire intensity that generates a flame length of between four and eight feet could be stopped using heavy equipment. Effective methods include bulldozers and other tree clearing equipment used by the logging industry that can quickly create a wide fire line once in place. Aerial suppression methods like air tankers dropping fire retardant and helicopters dropping water are also effective at stopping a fire with these flame lengths.

About 8% of the City would see flame lengths of 8 to 12 feet in a wildfire situation. With flame lengths of over eight (8) and less than twelve (12) feet stopping the fire at its head is generally not possible even with equipment. Suppression methods could be effective on the side of the fire that would eventually stop the fire by working towards the head. Before the fire could be stopped because of an indirect (not at the head of the fire) fire spread could continue burning additional area.

About 12% percent of the City area would experience flame lengths of 12 feet or more. With flame lengths of 12 feet or more suppression methods are not effective and rapid un-checked fire spread could be expected.

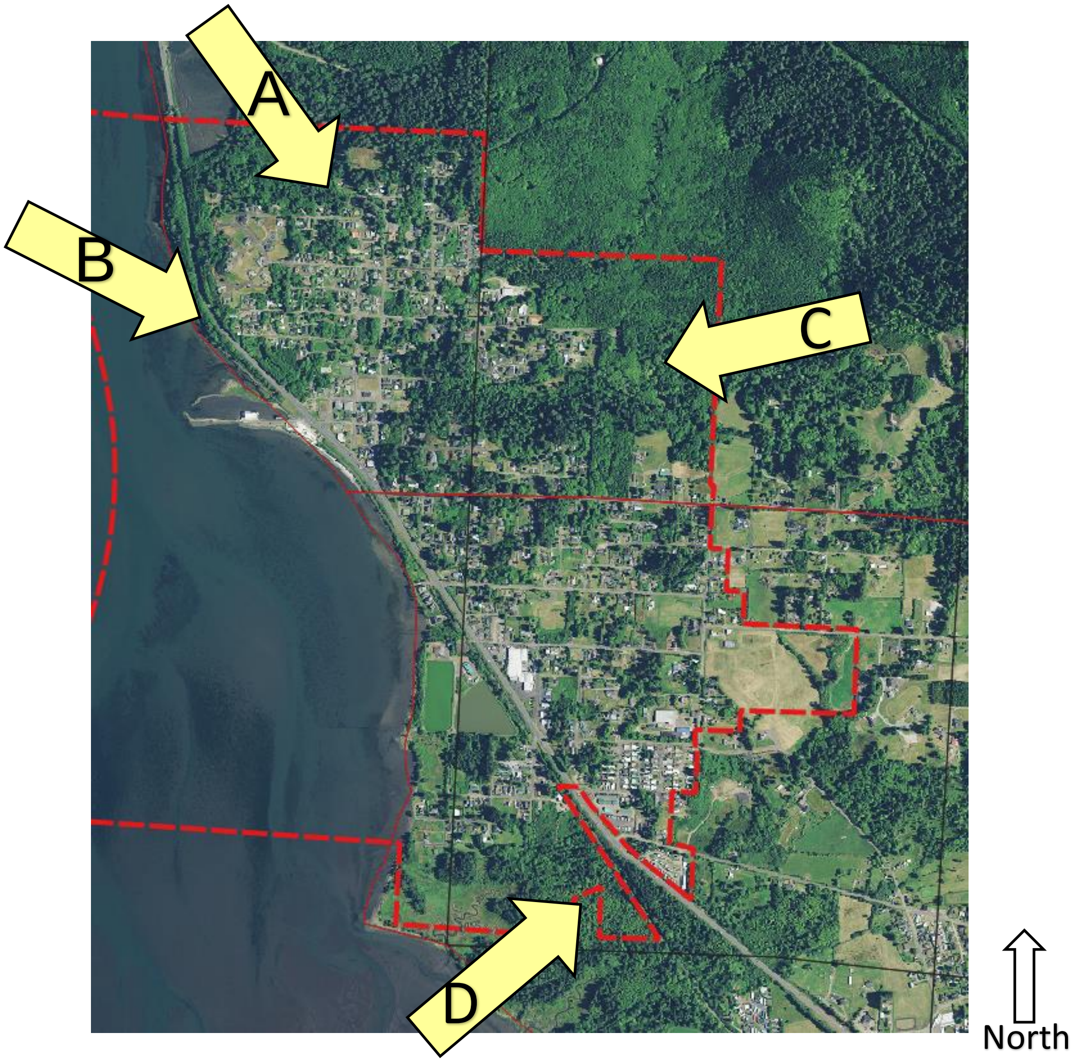
Direct fire suppression methods would be effective in about 80% of the City to stop the wildfire spread. In 20% of the City direct fire suppression methods are predicted to be in-effective.



City of Bay City - Wildfire Risk Assessment
Initial data by fire intensity/ flame length
January 16, 2023

Flame length under extreme fire conditions		
Feet	Color	Size
0	Blue	small
0-2	Light green	small
2-4	Brown	small
4-6	Purple	medium
6-8	Orange	medium larger
8-10	Burnt orange	medium larger
10-12	Yellow	less large
12 +	Red	large

Typical summer winds come from both the northwest and east, each with their own potential to support wildfire growth. The below illustration is an example of how wildfire could blow into the City.



Arrow "A", on a normal summer day the wind blows from the northwest, usually building with intensity in the afternoon. This afternoon wind coincides with solar exposure on south facing slopes that have produced the days maximum drying effect. Arrow "A" is an area that has both vegetation that could support high fire intensity and also the northwest wind that could blow fire into the city. This area is along Highway 101 which has a greater potential for wildfire ignition sources from passing vehicles and people camping out.

Arrow B on the map is an area of vegetation that could support an intense wildfire that is also connected with Highway 101 and campers that may use the area.

Arrow C in the northeast is the route of the most potentially destructive wildfire entry into the city. The reason is the volume of fuel (trees and other vegetation), connection to the State and Private forest and susceptibility to an east wind. East winds are “gravity” winds and not as influenced by the daily warming and cooling of surrounding areas. They are driven by atmospheric pressure gradients that flow from high to low pressures. Typically, East Winds on the coast develop when a high pressure area inland develops and flows to a low pressure area off the Coast. This brings unusually dry and warm air to the Coast that is usually cool and moist. East winds can be of long and sustained duration that blow day and night. Combining sustained dry and warm wind with vegetation at its driest in the late summer and early fall creates a “Red Flag” fire weather condition when a wildfire can burn with unusual intensity. The ignition sources for fires in this area are less obvious than vehicle traffic and campers along Highway 101. All the same, wildfire ignition sources do exist and are sometimes at great distance from the city. The report, referenced in Hazards of Risk: identifying Plausable Community Wildfire Disasters in Low-Frequency Fire Regimes provides some way to quantify the frequency of these fires.

Arrow D at the south end of the city where there is ample vegetation to generate high intensity wildfires. Winds in this area both northwest and East could blow a wildfire into developed areas. An East wind especially could block off evacuation routes for residents leaving this area.

Suggestions to reduce wildfire risk for Areas A, B, C, and D are in the section titled “Recommendations”.

Vacant lots with overgrown vegetation is another wildfire risk factor in Bay City (see below map).

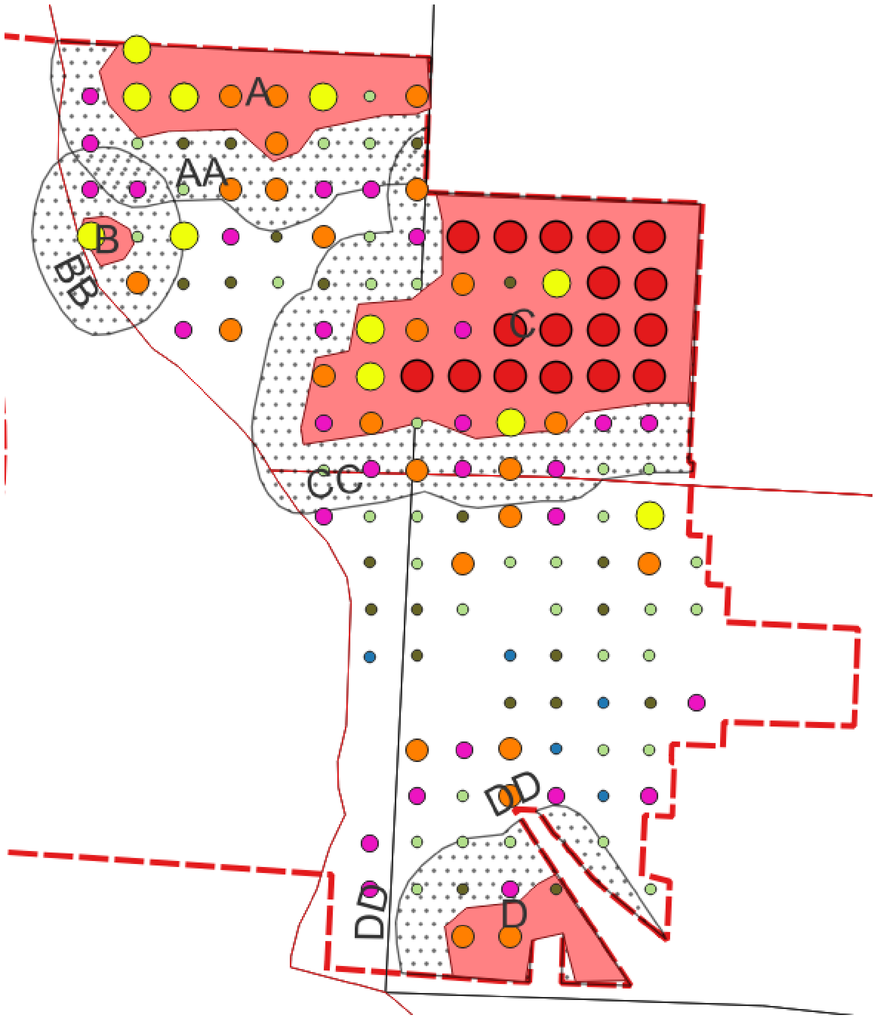
Many of the lots were covered with Himalayan blackberry, an invasive species. Blackberry creates additional fire risk due to the dead canes that dry out in the heat of summer. Other vegetation in the vacant lots included trees, ivy, holly and native species like salal and salmonberry, etc.

Vacant lots with vegetation are the red diamonds.

Plot 40, Vegetation in vacant lot

A primary reason for the wildfire assessment was to identify the city lots where wildfire risk is the greatest. That would be considering slope, aspect, vegetation and likelihood of ignition. Considering these factors general risk areas were identified, shown below as light red. Overlying that and beyond at a distance of 1/8th mile (660 feet) is an area identified with black dots that could also be affected by a wildfire in the primary area. As a total percent of the City's area about 58% is either as the primary or secondary wildfire area.

Size of Each Wildfire Risk					
Primary Area – light red	acres	Secondary Area – black dots	acres	Total Area acres	Percent of city
A	53.2	AA	62.4	115.6	14%
B	3.8	BB	42.0	45.8	6%
C	149.0	CC	107.7	256.7	32%
D	21.7	DD	34.5	56.2	7%



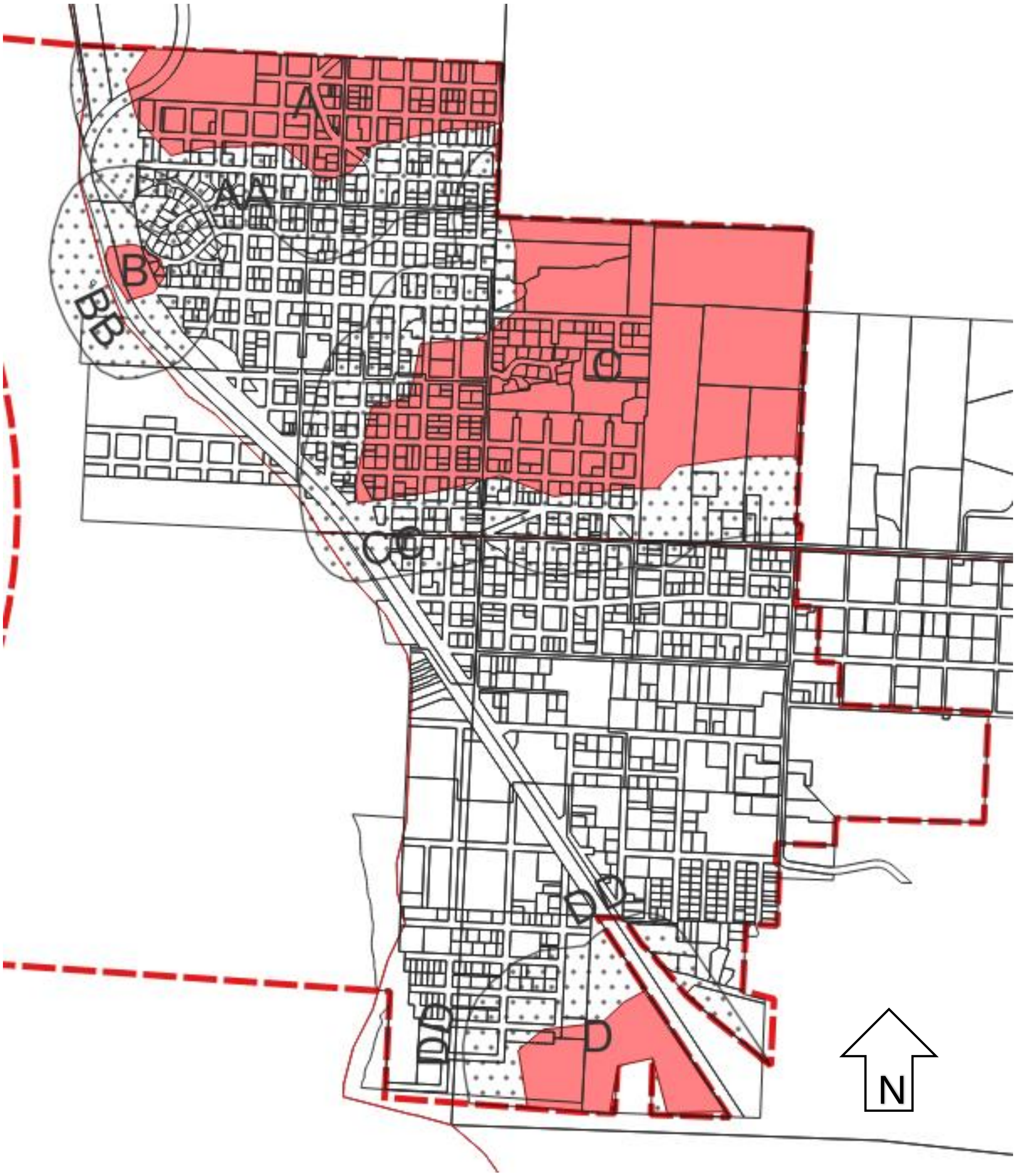
Light red – primary wildfire risk area

Black dots – secondary wildfire risk area

The area of wildfire risk can also be expressed as the number of City lots that could be threatened. Some lots could be threatened by fires from different sources, fires that burn with the typical northwest summer wind or less frequent East wind. The lots listed in the table below include all of the lots, developed, un-developed and un-buildable. The number of individual lot owners totals 406, some of whom own multiple lots. A listing by lot owner is in Appendix 3.

Tillamook County Tax Lots in Each of the Wildfire Risk Areas			
Primary – light red	Number	Secondary – black dots	Number*
A	90	AA	149
B	4	BB	57
C	153	CC	222
D	4	DD	31
Total	251		459

*when secondary wildfire risk zones overlapped, e.g., overlap area AA and BB, lots were counted in both AA and BB



Wildfire risk zones of Bay City over Tillamook County tax lots

Recommendations:

A zoned approach is suggested that considers both the intensity of the wildfire and likelihood of it starting. Areas that have generally more chances of wildfire are those with connections to more people, like Highway 101. The area with the greatest intensity but is less likely to have ignition is the northeastern part of the city.

Wildfire risk moderation – Zoned approach				
Area	Fire intensity	Chance of fire start	Vegetation Management	Defensible Space
A	Moderate - High	Moderate - High	Yes	Yes
B	Moderate - High	Moderate - High	Yes	Yes
C	High	Low - Moderate	Targeted	Yes
D	Moderate - High	Moderate - High	Yes	Yes
Other areas				Yes

Wildfire intensity moderate to high and moderate to high chance of start:

Where wildfire risk is highest, considering both intensity and the likelihood of a fire starting, applying Firewise® principles of defensible space should be considered. These areas could also benefit from vegetation management. The goal would be to reduce the likelihood of the fire reaching the canopy of trees where fire spread rates and intensity would be the highest by applying the principles of fire resilient forests. To do this "ladder fuels", vegetation that creates a bridge between the ground and the tree canopy (treetops), should be removed. Typical ladder fuels are limbs that reach to the ground and small trees and other vegetation that grow in small forest openings and in the forest shade. Ideally the goal would be to manage the fuel (vegetation) to keep the flame length at 2-3 feet. Generally, that would be a ground fuel length of 18 inches or less in height. Wildfire Risk Areas in Bay City A, B and D.

Principles of Fire-Resilient Forests (from Agee 2002)

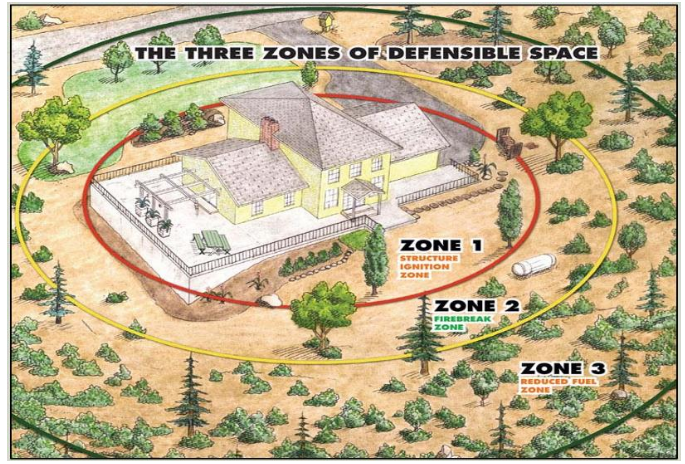
Principle	Effect	Advantage	Concerns
Reduce surface fuels	Reduces potential flame length	Control easier, less torching	Surface disturbance, less with fire than with other techniques
Increase height to live crown	Requires longer flame length to begin torching	Less torching	Opens understory, may allow surface wind to increase
Decrease crown density	Makes tree-to-tree crown fires less probable	Reduces crown fire potential	Surface wind may increase and surface fuels may be drier
Keep larger trees	Thicker bark and taller crowns	Increases tree survivability	Removing smaller trees is economically less profitable

Vegetation management, in high fuel and moderate to high wildfire ignition area, Bay Ridge area

Wildfire intensity high and low to moderate chance of start:

Where fire intensity is high and the probability of ignition low more effort could be made on the application of Firewise® concepts to create defensible space in the structure ignition, fire break and reduced fuel zones. Vegetation management could still be considered beyond the reduced fuel zone however the return frequency of fire maybe so infrequent that maintaining fuel reduction in the area that grows vegetation as vigorously as the Oregon Coast may soon exhaust out the most ardent wildfire reduction practitioner. The wildfire reduction area is in the northeastern corner of Bay City.

In other areas that are not directly in the intensive fire zone the Firewise® concepts of developing defensible space should still be considered. During a wildfire under extreme circumstances burning embers will likely be landing beyond the actual fire area carried by wind. The wind itself can be intense fanning whatever fire is started. It is under these conditions that the structure would need to survive. Hardening the home with fire resistant materials and removing flammable material concentrations near it would all add to its survivability.

Example of Firewise® landscaping in the Goose Point area and an illustration of the concept of the three area of defensible space.

Another fire control possibility is working with the Oregon Department of Forestry to limit access to the forest east of Bay City during periods of highest fire danger. Currently there are gates maintained to restrict motorized access to Hobsonville Point and Larson Creek. A gate at the primary entry into the State Forest at the junction of Patterson Creek and Patterson Ridge Roads that could be closed would help to minimize the potential for a fire start.

Resources

Oregon Department of Forestry, Tillamook District
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edward.h.wallmark@odf.oregon.gov
5005 Third Street, Tillamook OR 97141

Oregon State University Extension Service
Forestry and Natural Resources Extension Fire Program
Aaron Groth, Coastal Oregon Regional Fire Specialist
(503) 325-8573, Extension 259
aaron.groth@oregonstate.edu
2001 Marine Drive, Room 210
Astoria, OR 97103

Tillamook County Emergency Management
Randy Thorpe, Director
(503) 842-3412
201 Laurel Avenue
Tillamook, OR 97141

National Fire Protection Association
Firewise® USA
(800) 344-3555
1 Batterymarch Park
Qunicy, MA 02169

Appendixes

Appendix 1: Plot maps

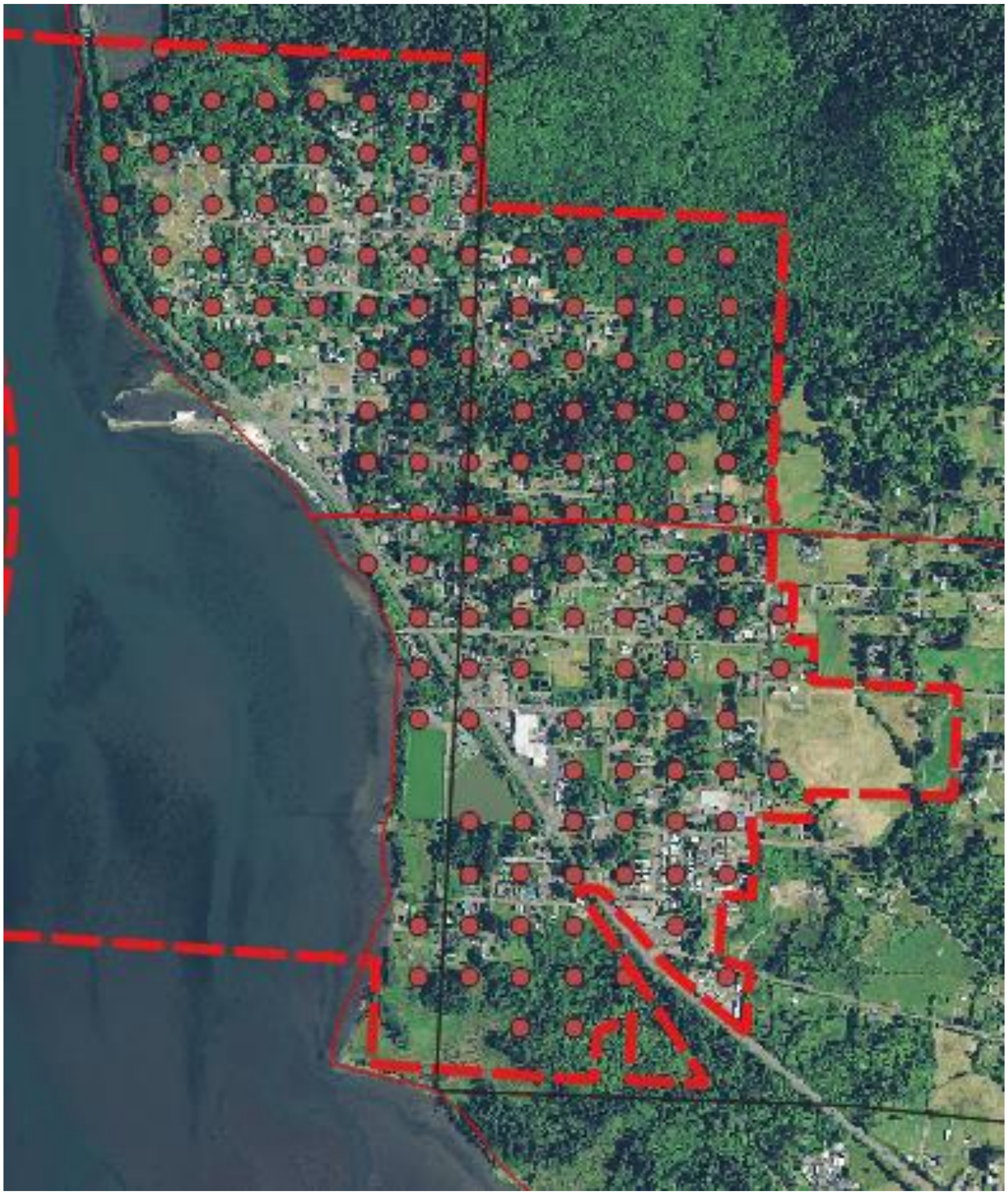
Appendix 2: Plot data

Appendix 3: Lots and lot owners by wildfire risk area

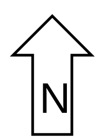
Appendix 4: Hazards of Risk: Identifying Plausible Community Wildfire Disasters in Low-Frequency Fire Regimes

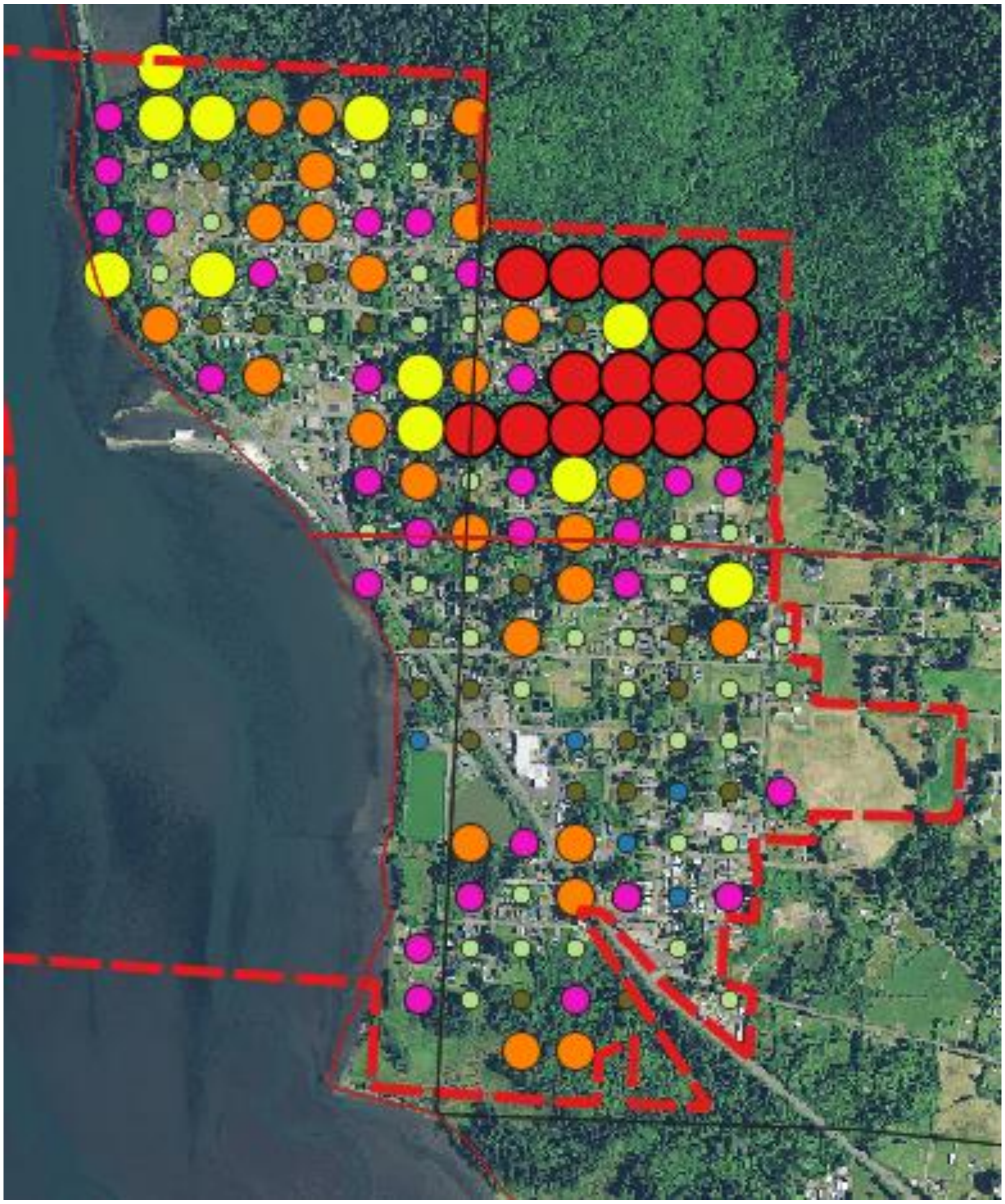
Appendix 5: What is Firewise USA®? – Oregon.gov

Appendix 1: Plot maps



Bay City Wildfire Assessment Plots – rust red

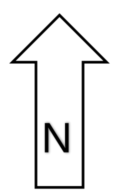




City of Bay City - Wildfire Risk Assessment

Initial data by fire intensity/ flame length

January 16, 2023



Flame length under extreme fire conditions		
Feet	Color	Size
0	Blue	small
0-2	Light green	small
2-4	Brown	small
4-6	Purple	medium
6-8	Orange	medium larger
8-10	Burnt orange	medium larger
10-12	Yellow	less large
12 +	Red	large

Appendix 2: Plot data

Bay City Firewise							
Plot	Average Fire Intensity (Flame length)						
	0	0-2	2-4	4-6	6-8	8-12	12+
1						Y	
2				Y			
3						Y	
4						Y	
5					Y		
6					Y		
7						Y	
8						Y	
9		Y					
10					Y		
11			Y				
12		Y					
13		Y					
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139				Y			
140			Y				
141		Y					
142				Y			
143					Y		
144					Y		

Appendix 3: Lots and lot owners by wildfire risk area

Zone (A)	Zone 2 (AA)	Tax Lot	First	Last	Twp	Range	Section
A	AA	600	Ann	Harper	1N	10W	34B
A	AA	901	James	McCain	1N	10W	34AC
A	AA	800	James	McCain	1N	10W	34AC
A	AA	100	Gary	Oldencamp	1N	10W	34AC
A	AA	500	Gary	Oldencamp	1N	10W	34AD
A	AA	400	Gary	Oldencamp	1N	10W	34AD
A	AA	300	Randall	Dongo-Olsen	1N	10W	34AD
A	AA	200	Susan	Morrow	1N	10W	34AD
A	AA	202	Kathryn	Annus	1N	10W	34AD
A	AA	100	Julie	Manly	1N	10W	34AD
A	AA	600	Gary	Oldencamp	1N	10W	34AC
A	AA	500	Gary	Oldencamp	1N	10W	34AC
A	AA	400	Gary	Oldencamp	1N	10W	34AC
A	AA	300	Gary	Oldencamp	1N	10W	34AC
A	AA	701	Gary	Oldencamp	1N	10W	34AC
A	AA	700	Gary	Oldencamp	1N	10W	34AC
A	AA	700	Gary	Oldencamp	1N	10W	34AD
A	AA	800	Gary	Oldencamp	1N	10W	34AD
A	AA	600	Gary	Oldencamp	1N	10W	34AD
A	AA	601	Gary	Oldencamp	1N	10W	34AD
A	AA	801	Gary	Oldencamp	1N	10W	34AD
A	AA	900	Gary	Oldencamp	1N	10W	34AD
A	AA	1001	Gary	Oldencamp	1N	10W	34AD
A	AA	1000	Gary	Oldencamp	1N	10W	34AD
A	AA	1100	Lee	Klingler	1N	10W	34AD
A	AA	1200	Angela	Maris	1N	10W	34AD
A	AA	1203	Angela	Maris	1N	10W	34AD
A	AA	1202	Anna	Gamble	1N	10W	34AD
A	AA	1201	Mary Jo	Bradley	1N	10W	34AD
A	AA	1204	Keith	Thompson	1N	10W	34AD
A	AA	1304	Nathan	Lindsey	1N	10W	34AD
A	AA	1306	Nathan	Lindsey	1N	10W	34AD
A	AA	1300	Equity	Trust	1N	10W	34AD
A	AA	1305	Kenneth	Greenfield	1N	10W	34AD
A	AA	1301	Gregory	Sweeney	1N	10W	34AD
A	AA	1303	USA	Coast Guard	1N	10W	34AD
A	AA	1302	Kenneth	Greenfield	1N	10W	34AD
A	AA	1401	Julie	Manly	1N	10W	34AD
A	AA	1400	Glenn	Kingsley	1N	10W	34AD

A	AA	1403	Julie	Manly	1N	10W	34AD
A	AA	1402	Bradley	Lepley	1N	10W	34AD
A	AA	900	Rowena	Kohler	1N	10W	34AC
A	AA	1000	Elizabeth	Yingling	1N	10W	34AC
A	AA	1100	Helen	Gienger	1N	10W	34AC
A	AA	1200	Helen	Gienger	1N	10W	34AC
A	AA	1300	Harold	Bennett	1N	10W	34AC
A	AA	1400	Helen	Gienger	1N	10W	34AC
A	AA	1500	Helen	Gienger	1N	10W	34AC
A	AA	1600	Yosef	Yacob	1N	10W	34AC
A	AA	1700	Helen	Gienger	1N	10W	34AC
A	AA	1900	Diane	VanDerkin	1N	10W	34AC
A	AA	1901	Brent	Kirk	1N	10W	34AC
A	AA	2000	Gary	Oldencamp	1N	10W	34AC
A	AA	1800	Robert	Cissna	1N	10W	34AC
A	AA	2100	Gary	Oldencamp	1N	10W	34AC
A	AA	2200	Preston	Wismer	1N	10W	34AD
A	AA	2100	Sue	Walker	1N	10W	34AD
A	AA	2000	Dan	Phillips	1N	10W	34AD
A	AA	1901	Lee	Klingler	1N	10W	34AD
A	AA	1900	Judy	Sours	1N	10W	34AD
A	AA	1800	Lee	Klingler	1N	10W	34AD
A	AA	1801	April	Hoisington-Kite	1N	10W	34AD
A	AA	1802	Daniel	Bentley	1N	10W	34AD
A	AA	1601	Roland	Mayle	1N	10W	34AD
A	AA	1604	Sandra	Mattson	1N	10W	34AD
A	AA	1502	Judith	Lang	1N	10W	34AD
A	AA	1501	Joseph	Zimmerman	1N	10W	34AD
A	AA	1503	Howard	Vanderzanden	1N	10W	34AD
A	AA	1504	Randy	Lepper	1N	10W	34AD
A	AA	4200	Elizabeth	Yingling	1N	10W	34AC
A	AA	3900	Helen	Gienger	1N	10W	34AC
A	AA	3700	Harold	Bennett	1N	10W	34AC
A	AA	3600	Helen	Gienger	1N	10W	34AC
A	AA	3200	Daniel	McQuade	1N	10W	34AC
A	AA	3100	Keith	Pingel	1N	10W	34AC
A	AA	2900	William	Frame	1N	10W	34AC
A	AA	2800	Gary	Ponder	1N	10W	34AC
A	AA	2500	James	Cox	1N	10W	34AC
A	AA	2200	James	Cox	1N	10W	34AC
A	AA	2600	Roger	Ross	1N	10W	34AC
A	AA	2700	Paula	Mills	1N	10W	34AC
A	AA	2701	Elizabeth	Davy	1N	10W	34AC
A	AA	2501	Larry	Klingler	1N	10W	34AD
A	AA	2400	Francis	Stiener	1N	10W	34AD

A	AA	2300	Sue	Walker	1N	10W	34AD
A	AA	2500	Janmarie	Shipley	1N	10W	34AD
A	AA	5502	Nicholas	Johnson	1N	10W	34AC
A	AA	5501	Joseph	Nugent	1N	10W	34AC
A	AA	5401	Bryan	Gibson	1N	10W	34AC
A	AA	5400	Charles	Merritt	1N	10W	34AC
	AA	1700	Glenn	Aspinall	1N	10W	34AD
	AA	1600	Kenneth	Gwyn	1N	10W	34AD
	AA	4300	Robert	Pollock	1N	10W	34AC
	AA	4000	Elizabeth	Yingling	1N	10W	34AC
	AA	4100	Glenn	Wadley	1N	10W	34AC
	AA	3800	Richard	Diamond	1N	10W	34AC
	AA	3300	Daniel	McQuade	1N	10W	34AC
	AA	3400	Daniel	McQuade	1N	10W	34AC
	AA	3500	Daniel	McQuade	1N	10W	34AC
	AA	2600	Alexandria	Pilkington	1N	10W	34AD
	AA	2700	Fouad	Elgharabli	1N	10W	34AD
	AA	2900	Resonant	Properties	1N	10W	34AD
	AA	2800	Larry	Dixon	1N	10W	34AD
	AA	2801	John	Honts	1N	10W	34AD
	AA	2901	George	Brasky	1N	10W	34AD
	AA	3000	George	Brasky	1N	10W	34AD
	AA	3100	Robert	Cissna	1N	10W	34AD
	AA	3300	George	Brasky	1N	10W	34AD
	AA	3400	Bridget	Sigman	1N	10W	34AD
	AA	3701	Cheryl	Knotts	1N	10W	34AD
	AA	3700	Monica	Herinckx	1N	10W	34AD
	AA	3900	Paul	Olsen	1N	10W	34AD
	AA	7800	Helen	Gienger	1N	10W	34AC
	AA	7000	OSU	Foundation	1N	10W	34AC
	AA	7100	OSU	Foundation	1N	10W	34AC
	AA	7200	OSU	Foundation	1N	10W	34AC
	AA	6900	Sona	Yacoubian	1N	10W	34AC
	AA	7300	OSU	Foundation	1N	10W	34AC
	AA	6800	Bay Ridge	Homeowners	1N	10W	34AC
	AA	7400	OSU	Foundation	1N	10W	34AC
	AA	6700	Helen	Gienger	1N	10W	34AC
	AA	7500	OSU	Foundation	1N	10W	34AC
	AA	6600	Helen	Gienger	1N	10W	34AC
	AA	6500	Renee	Nguyen	1N	10W	34AC
	AA	6400	OSU	Foundation	1N	10W	34AC
	AA	6300	Eric	Klein	1N	10W	34AC
	AA	6200	Harriet	Steinberg	1N	10W	34AC
	AA	6100	Michael	Noble	1N	10W	34AC
	AA	6000	Fred	Fine	1N	10W	34AC

	AA	5900	OSU	Foundation	1N	10W	34AC
	AA	5800	Joseph	Kranhold	1N	10W	34AC
	AA	5700	Joseph	Kranhold	1N	10W	34AC
	AA	4600	Scott	Olson	1N	10W	34AC
	AA	4500	John	Stringham	1N	10W	34AC
	AA	4502	Neal	Sommerset	1N	10W	34AC
	AA	4800	Liane	Welch	1N	10W	34AC
	AA	5000	Kathleen	Seelye	1N	10W	34AC
	AA	5100	Victor	Cervantes	1N	10W	34AC
	AA	5200	Victor	Cervantes	1N	10W	34AC
	AA	5300	Mark	Ordway	1N	10W	34AC
	AA	5504	Nicholas	Johnson	1N	10W	34AC
	AA	5500	Joseph	Nugent	1N	10W	34AC
	AA	5503	Jerry	Griboski	1N	10W	34AC
	AA	5201	Richard	Anderson	1N	10W	34AD
	AA	5200	Daniel	Paris	1N	10W	34AD
	AA	5100	Richard	Anderson	1N	10W	34AD
	AA	5300	Mark	Henderson	1N	10W	34AD
	AA	5401	Thomas	Imhoff	1N	10W	34AD
	AA	5400	Thomas	Imhoff	1N	10W	34AD
	AA	4800	Darin	Holm	1N	10W	34AD
	AA	4700	Eric	Lessor	1N	10W	34AD
	AA	5000	Trina	Lessor	1N	10W	34AD
	AA	4502	Sean	McRae	1N	10W	34AD
	AA	4400	Steven	Warneke	1N	10W	34AD
	AA	4501	Shawn	Scott	1N	10W	34AD
	AA	4600	Sang Hun	Lee	1N	10W	34AD
	AA	4500	Michael	Blair	1N	10W	34AD
	AA	4601	Sang Hun	Lee	1N	10W	34AD
	AA	4301	Brian	Seaholm	1N	10W	34AD
	AA	4302	Rik	Flynn	1N	10W	34AD
	AA	4305	Helmick	Bay City	1N	10W	34AD
	AA	4304	Bradley	Evers	1N	10W	34AD
	AA	4303	Daniel	Titus	1N	10W	34AD
	AA	4300	Helmick	Bay City	1N	10W	34AD
	AA	4204	Lisa	Tompkins	1N	10W	34AD
	AA	4205	Tereasa	Shipman	1N	10W	34AD
	AA	4206	Angelica	Perez	1N	10W	34AD
	AA	4207	Joel	Bohnke	1N	10W	34AD
	AA	4200	Tillamook	Habitat	1N	10W	34AD
	AA	4201	Tammy	Gregory	1N	10W	34AD
	AA	4202	Michael	Talerico	1N	10W	34AD
	AA	4203	Brandi	Pierson	1N	10W	34AD
	AA	300	Elise	Blaser	1N	10W	34DA
	AA	700	Marrsan	Harrison	1N	10W	34DA

	AA	600	Mark	Killion	1N	10W	34DA
	AA	800	Debra	Starkweather	1N	10W	34DA
	AA	900	Robert	Woldt	1N	10W	34DA
	AA	1200	Hai	Do	1N	10W	34DA
	AA	1100	Gail	Markillie	1N	10W	34DA
	AA	1000	Gail	Markillie	1N	10W	34DA
	AA	1390	Lynda	Goodwin	1N	10W	34DA
	AA	1301	Jason	Elkins	1N	10W	34DA
	AA	1300	Helen	Wright	1N	10W	34DA
	AA	1590	Barbara	Stearns	1N	10W	34DA
	AA	1500	Charles	Stearns	1N	10W	34DA
	AA	1501	Charles	Stearns	1N	10W	34DA
	AA	1400	Charles	Stearns	1N	10W	34DA
	AA	1800	Alan	Brandt	1N	10W	34DA
	AA	1602	Timothy	Weaver	1N	10W	34DA
	AA	1701	Sydney	Elliott	1N	10W	34DA
	AA	1700	Timothy	Weaver	1N	10W	34DA
	AA	101	Barbara	Snell	1N	10W	34DB
	AA	400	Barbara	Snell	1N	10W	34DB
	AA	100	Phuc	Nguyen	1N	10W	34DB
	AA	300	Allen	Dial	1N	10W	34DB
	AA	200	Phuc	Nguyen	1N	10W	34DB
	AA	201	Brent	Lackey	1N	10W	34DB
	AA	500	David	Olson	1N	10W	34DB
	AA	1000	Vance	Rodrigues	1N	10W	34DB
	AA	600	Audrey	Liddicoat	1N	10W	34DB
	AA	900	Carolyn	Zacher	1N	10W	34DB
	AA	700	Chuck	Lumpkin	1N	10W	34DB
	AA	903	Gary	Frunz	1N	10W	34DB
	AA	800	Chuck	Lumpkin	1N	10W	34DB
	AA	901	John	Bender	1N	10W	34DB
	AA	8000	OSU	Foundation	1N	10W	34DB
	AA	8500	OSU	Foundation	1N	10W	34DB
	AA	8100	Richard	Steinberg	1N	10W	34DB
	AA	8400	OSU	Foundation	1N	10W	34DB
	AA	8200	Verl	Wolf	1N	10W	34DB
	AA	8300	OSU	Foundation	1N	10W	34DB
	AA	7600	OSU	Foundation	1N	10W	34AC
	AA	7700	Laurie	Gienger	1N	10W	34AC
	AA	9600	Barry	Meiseles	1N	10W	34DB
	AA	9500	OSU	Foundation	1N	10W	34DB
	AA	9400	Shane	Stutzman	1N	10W	34DB
	AA	9300	OSU	Foundation	1N	10W	34DB
	AA	9200	OSU	Foundation	1N	10W	34DB
	AA	9700	Bay Ridge	Homeowners	1N	10W	34DB

	AA	8600	OSU	Foundation	1N	10W	34DB
	AA	8700	Tra Huy	Boi Ha	1N	10W	34DB
	AA	8800	David	Bauer	1N	10W	34DB
	AA	8900	Huong	Arms	1N	10W	34DB
	AA	9000	David	Blanchard	1N	10W	34DB
	AA	9100	Steven	Reeves	1N	10W	34DB
	AA	10600	Larissa	Faw	1N	10W	34DB
	AA	2000	Valerie	Folkema	1N	10W	34DB
	AA	1900	Kenneth	Lommen	1N	10W	34DB
	AA	2200	Kenneth	Lommen	1N	10W	34DB
	AA	1901	Charles	Smith	1N	10W	34DA
	AA	2000	Charles	Smith	1N	10W	34DA
	AA	1900	Mark	Lengele	1N	10W	34DA
	AA	1902	Taylor	Delanoy	1N	10W	34DA
	AA	2001	Donita	Clothier	1N	10W	34DA
	AA	2100	Patricia	Penney	1N	10W	34DA
	AA	2600	James	Devine	1N	10W	34DA
	AA	2500	Gregory	Kent	1N	10W	34DA
	AA	2200	Robert	Briley	1N	10W	34DA
	AA	3200	Perry	Melson	1N	10W	34DA

Zone 3 (B)	Zone 4 (BB)	Tax Lot	First	Last	Twp	Range	Section
B	BB	12500	OSU	Foundation	1N	10W	34DB
B	BB	12400	Anita	Blaum	1N	10W	34DB
B	BB	12300	OSU	Foundation	1N	10W	34DB
B	BB	12200	Susan	Way	1N	10W	34DB
	BB	7800	Helen	Gienger	1N	10W	34AC
	BB	7000	OSU	Foundation	1N	10W	34AC
	BB	7100	OSU	Foundation	1N	10W	34AC
	BB	7200	OSU	Foundation	1N	10W	34AC
	BB	6900	Sona	Yacoubian	1N	10W	34AC
	BB	7300	OSU	Foundation	1N	10W	34AC
	BB	6800	Bay Ridge	Homeowners	1N	10W	34AC
	BB	7400	OSU	Foundation	1N	10W	34AC
	BB	7500	OSU	Foundation	1N	10W	34AC
	BB	7600	OSU	Foundation	1N	10W	34AC
	BB	7700	Laurie	Gienger	1N	10W	34AC
	BB	9600	Barry	Meiseles	1N	10W	34DB
	BB	9500	OSU	Foundation	1N	10W	34DB
	BB	9400	Shane	Stutzman	1N	10W	34DB
	BB	9300	OSU	Foundation	1N	10W	34DB
	BB	9200	OSU	Foundation	1N	10W	34DB
	BB	9700	Bay Ridge	Homeowners	1N	10W	34DB
	BB	8600	OSU	Foundation	1N	10W	34DB
	BB	8700	Tra Huy	Boi Ha	1N	10W	34DB
	BB	8800	David	Bauer	1N	10W	34DB
	BB	8900	Huong	Arms	1N	10W	34DB
	BB	9000	David	Blanchard	1N	10W	34DB
	BB	9100	Steven	Reeves	1N	10W	34DB
	BB	10600	Larissa	Faw	1N	10W	34DB
	BB	10500	OSU	Foundation	1N	10W	34DB
	BB	10400	Michael	Dressler	1N	10W	34DB
	BB	10300	OSU	Foundation	1N	10W	34DB
	BB	10200	OSU	Foundation	1N	10W	34DB
	BB	10100	OSU	Foundation	1N	10W	34DB
	BB	10000	OSU	Foundation	1N	10W	34DB
	BB	9900	OSU	Foundation	1N	10W	34DB
	BB	9800	OSU	Foundation	1N	10W	34DB
	BB	12100	Bay Ridge	Homeowners	1N	10W	34DB
	BB	11900	Kevin	Penberthy	1N	10W	34DB
	BB	12000	Kevin	Penberthy	1N	10W	34DB

	BB	11800	OSU	Foundation	1N	10W	34DB
	BB	3801	Edwin	Vining	1N	10W	34DB
	BB	11700	OSU	Foundation	1N	10W	34DB
	BB	3803	Connie	Susanka	1N	10W	34DB
	BB	11600	OSU	Foundation	1N	10W	34DB
	BB	3800	Connie	Susanka	1N	10W	34DB
	BB	11500	OSU	Foundation	1N	10W	34DB
	BB	11400	OSU	Foundation	1N	10W	34DB
	BB	3600	Richard	Persons	1N	10W	34DB
	BB	11200	OSU	Foundation	1N	10W	34DB
	BB	11100	OSU	Foundation	1N	10W	34DB
	BB	11000	Richard	Knode	1N	10W	34DB
	BB	10900	OSU	Foundation	1N	10W	34DB

Zone 5 (C)	Zone 6 (CC)	Tax Lot	First	Last	Twp	Range	Section
C	CC	9300	Wesley	Curry	1N	10W	34DA
C	CC	9101	Long	Mua	1N	10W	34DA
C	CC	8900	Robyn	Lampa	1N	10W	34DA
C	CC	8700	Robyn	Lampa	1N	10W	34DA
C	CC	1800	Doris	Clark	1N	10W	34DD
C	CC	1700	W W Bay	Properties	1N	10W	34DD
C	CC	1300	Jean	Erceg	1N	10W	34DD
C	CC	1200	Norman	Schwisow	1N	10W	34DD
C	CC	1100	Jean	Erceg	1N	10W	34DD
C	CC	700	Geraldine	Graham	1N	10W	34DD
C	CC	600	Raymond	Conklin	1N	10W	34DD
C	CC	501	Harvey	Wyss	1N	10W	34DD
C	CC	500	Harvey	Wyss	1N	10W	34DD
C	CC	200	Oregon Land	Group	1N	10W	34DD
C	CC	300	Harvey	Wyss	1N	10W	34DD
C	CC	401	Harvey	Wyss	1N	10W	34DD
C	CC	400	Harvey	Wyss	1N	10W	34DD
C	CC	4701	Andrew	Debois	1N	10W	34DD
C	CC	4700	Donald	Teninity	1N	10W	34DD
C	CC	4800	DB Steel		1N	10W	34DD
C	CC	4500	Carol	Maxhimer	1N	10W	34DD
C	CC	4900	Brian	Oakes	1N	10W	34DD
C	CC	5100	DB Steel		1N	10W	34DD
C	CC	5000	EMJ Properties		1N	10W	34DD
C	CC	5200	Thomas	Anderson	1N	10W	34DD
C	CC	5700	Colleen	Mahoney	1N	10W	34DD
C	CC	5800	Marian	Stacks	1N	10W	34DD
C	CC	5600	Marilou	Sandberg	1N	10W	34DD
C	CC	5500	Robert	Brown	1N	10W	34DD
C	CC	5900	Gregory	Karpstein	1N	10W	34DD
C	CC	5400	Ronald	Kay	1N	10W	34DD
C	CC	6200	Harvey	Wyss	1N	10W	34DD
C	CC	6201	Harvey	Wyss	1N	10W	34DD
C	CC	6101	Richard	Freeman	1N	10W	34DD
C	CC	6100	Harvey	Wyss	1N	10W	34DD
C	CC	6000	John	Masselli	1N	10W	34DD
C	CC	6001	Kakishta Properties		1N	10W	34DD
C	CC	6300	Devary	Howe	1N	10W	34DD
C	CC	8101	Clarity Investments		1N	10W	34DD

C	CC	7800	Arlo	Goodwin	1N	10W	34DD
C	CC	8100	Shirley	Peters	1N	10W	34DD
C	CC	8000	Tyson	Rasor	1N	10W	34DD
C	CC	7900	Arlo	Goodwin	1N	10W	34DD
C	CC	7700	Verleta	Dupuis	1N	10W	34DD
C	CC	7600	Donald	Caspell	1N	10W	34DD
C	CC	7501	Ronald	Gallegos	1N	10W	34DD
C	CC	7500	Edgar	Eaton	1N	10W	34DD
C	CC	7400	Harvey	Wyss	1N	10W	34DD
C	CC	7000	Harvey	Wyss	1N	10W	34DD
C	CC	7300	Cecil	Zebra	1N	10W	34DD
C	CC	7100	Steven	Crossley	1N	10W	34DD
C	CC	7200	Steven	Crossley	1N	10W	34DD
C	CC	6900	Cheryl	Agee	1N	10W	34DD
C	CC	6800	Raymond	Neubig	1N	10W	34DD
C	CC	6400	Gary	Frey	1N	10W	34DD
C	CC	6700	Michael	McCarthy	1N	10W	34DD
C	CC	6500	Johannes	VanDermolen	1N	10W	34DD
C	CC	6601	Jack	Weller	1N	10W	34DD
C	CC	10300	EMJ Properties		1N	10W	34DD
C	CC	10400	EMJ Properties		1N	10W	34DD
C	CC	10200	EMJ Properties		1N	10W	34DD
C	CC	10100	EMJ Properties		1N	10W	34DD
C	CC	10500	EMJ Properties		1N	10W	34DD
C	CC	10800	Eric	Mash	1N	10W	34DD
C	CC	10700	Kristina	Heusser	1N	10W	34DD
C	CC	10900	Eric	Mash	1N	10W	34DD
C	CC	10600	Robert	Miles	1N	10W	34DD
C	CC	11000	Robert	Miles	1N	10W	34DD
C	CC	11100	Judith	Irwin	1N	10W	34DD
C	CC	11200	Larry	Slawson	1N	10W	34DD
C	CC	11300	Justin	Crump	1N	10W	34DD
C	CC	11500	Ronald	Archer	1N	10W	34DD
C	CC	11600	Mark	Anderson	1N	10W	34DD
C	CC	11700	Arndt	Johnson	1N	10W	34DD
C	CC	103	Robert	Watt	1N	10W	35CB
C	CC	200	Robert	Watt	1N	10W	35CB
C	CC	100	Mark	Wustenberg	1N	10W	35CB
C	CC	300	MW Bay Properties		1N	10W	35CB
C	CC	400	Mark	Wustenberg	1N	10W	35CB
C	CC	105	Phyllis	Wustenberg	1N	10W	35CB
C	CC	800	Mark	Wustenberg	1N	10W	35
C	CC	900	Thomas	Imhoff	1N	10W	35
C	CC	1001	Richard	Crossley	1N	10W	35
C	CC	200	Richard	Crossley	1N	10W	35CD

C	CC	100	John	Mills	1N	10W	35CD
C	CC	900	Issiah	Griffin	1N	10W	35CB
C	CC	903	Janet	Stringer	1N	10W	35CB
C	CC	902	Kimberly	Armitage	1N	10W	35CB
C	CC	901	Eleazar	Hernandez	1N	10W	35CB
C	CC	800	Leo	Gabriel	1N	10W	35CB
C	CC	700	Alyssa	Miller	1N	10W	35CB
C	CC	1000	Teresa	Aman	1N	10W	35CB
C	CC	600	Teresa	Aman	1N	10W	35CB
C	CC	1100	Teresa	Aman	1N	10W	35CB
C	CC	500	Mark	Wustenberg	1N	10W	35CB
C	CC	1200	MW Bay Properties		1N	10W	35CB
C	CC	1300	David	Imholt	1N	10W	35CB
C	CC	1302	Jan	Hoddle	1N	10W	35CB
C	CC	1301	Steven	Baertlein	1N	10W	35CB
C	CC	1403	Melyssa	Graeper	1N	10W	35CB
C	CC	1402	Gillian	Smith	1N	10W	35CB
C	CC	1401	Cheryl	Spellman	1N	10W	35CB
C	CC	1404	Cheryl	Spellman	1N	10W	35CB
C	CC	1400	Daniel	Overholser	1N	10W	35CB
C	CC	1500	Chris	Norris	1N	10W	35CB
C	CC	1506	Michael	Faller	1N	10W	35CB
C	CC	1502	Michael	Faller	1N	10W	35CB
C	CC	1505	Chris	Norris	1N	10W	35CB
C	CC	1507	Greg	Spence	1N	10W	35CB
C	CC	1600	Denis	Olson	1N	10W	35CB
C	CC	101	Gary	Oldencamp	1N	10W	35CC
C	CC	102	Gary	Oldencamp	1N	10W	35CC
C	CC	103	Larz	Stewart	1N	10W	35CC
C	CC	1701	David	Olson	1N	10W	35CB
C	CC	1700	David	Olson	1N	10W	35CB
C	CC	100	Jason	Arnold	1N	10W	35CC
C	CC	1916	Kent	Campbell	1N	10W	35CB
C	CC	1915	Maryan	Fauver	1N	10W	35CB
C	CC	1914	Kathleen	Clyde	1N	10W	35CB
C	CC	1913	Kent	Campbell	1N	10W	35CB
C	CC	1912	Joseph	Schriber	1N	10W	35CB
C	CC	1911	Michael	Calhoun	1N	10W	35CB
C	CC	1910	James	Johansen	1N	10W	35CB
C	CC	1917	Bryan	Areneson	1N	10W	35CB
C	CC	1909	Christian	Mata	1N	10W	35CB
C	CC	1908	Sharon	Bakki	1N	10W	35CB
C	CC	1907	Megan	Sanders	1N	10W	35CB
C	CC	1906	Kent	Campbell	1N	10W	35CB
C	CC	1905	Kelly	Ceder	1N	10W	35CB

C	CC	1904	Deborah	Van Wickle	1N	10W	35CB
C	CC	2001	Raymond	Casper	1N	10W	35CB
C	CC	2000	John	Pohs	1N	10W	35CB
C	CC	1900	Kent	Campbell	1N	10W	35CB
C	CC	1803	Charles	Hildebrand	1N	10W	35CB
C	CC	1802	Michael	Purcell	1N	10W	35CB
C	CC	1801	John	Armitage	1N	10W	35CB
C	CC	1600	Kasey	McNutt	1N	10W	35CC
C	CC	1400	George	Koenig	1N	10W	35CC
C	CC	1000	Ernst	Laemmert	1N	10W	35CC
C	CC	1001	Scott	Megy	1N	10W	35CC
C	CC	901	Roger	Nelson	1N	10W	35CC
C	CC	900	Jennifer	Nelson	1N	10W	35CC
C	CC	800	Eric	Hanson	1N	10W	35CC
C	CC	3300	Lorraine	Hollowell	1N	10W	35CC
C	CC	3000	Lorraine	Hollowell	1N	10W	35CC
C	CC	2800	Mary	Rose	1N	10W	35CC
C	CC	2700	Ronald	Otte	1N	10W	35CC
C	CC	2701	Joe	Zabala	1N	10W	35CC
C	CC	2600	Jarrid	Hunter	1N	10W	35CC
C	CC	2300	George	Koenig	1N	10W	35CC
C	CC	2200	Steven	Fournier	1N	10W	35CC
C	CC	1700	Chris	Norris	1N	10W	35CC
C	CC	1800	Chris	Norris	1N	10W	35CC
	CC	3900	Paul	Olsen	1N	10W	34AD
	CC	4304	Bradley	Evers	1N	10W	34AD
	CC	4303	Daniel	Titus	1N	10W	34AD
	CC	4300	Helmick	Bay City	1N	10W	34AD
	CC	4204	Lisa	Tompkins	1N	10W	34AD
	CC	4205	Tereasa	Shipman	1N	10W	34AD
	CC	4206	Angelica	Perez	1N	10W	34AD
	CC	4207	Joel	Bohnke	1N	10W	34AD
	CC	4200	Tillamook	Habitat	1N	10W	34AD
	CC	4201	Tammy	Gregory	1N	10W	34AD
	CC	4202	Michael	Talerico	1N	10W	34AD
	CC	4203	Brandi	Pierson	1N	10W	34AD
	CC	101	Steven	Rheinberger	1N	10W	34DA
	CC	100	Scott	Motsinger	1N	10W	34DA
	CC	106	Tillamook	Habitat	1N	10W	34DA
	CC	107	Israel	Pozos-Leon	1N	10W	34DA
	CC	105	Deborah	Dixon-Krause	1N	10W	34DA
	CC	104	Tillamook	Habitat	1N	10W	34DA
	CC	103	Brain	Shultz	1N	10W	34DA
	CC	102	Georgina	McVay	1N	10W	34DA
	CC	200	Georgina	McVay	1N	10W	34DA

	CC	204	USA	Coast Guard	1N	10W	34DA
	CC	3600	Henry	Davidson	1N	10W	34DA
	CC	3802	Berit	Funnemark	1N	10W	34DA
	CC	3805	Tillamook	Habitat	1N	10W	34DA
	CC	3806	Louis	Demartino	1N	10W	34DA
	CC	3804	Tillamook	Habitat	1N	10W	34DA
	CC	3903	Christopher	Gant	1N	10W	34DA
	CC	3902	Tillamook	Habitat	1N	10W	34DA
	CC	3900	Tillamook	Habitat	1N	10W	34DA
	CC	3904	Tillamook	Habitat	1N	10W	34DA
	CC	4900	Oregon	Properties	1N	10W	34DA
	CC	4700	Melinda	Simon	1N	10W	34DA
	CC	4600	Emma	Greenawald	1N	10W	34DA
	CC	4500	Joseph	Carr	1N	10W	34DA
	CC	4300	Jim	Kidder	1N	10W	34DA
	CC	4400	James	Kidder	1N	10W	34DA
	CC	4203	James	Wakefield	1N	10W	34DA
	CC	4200	Tillamook	Habitat	1N	10W	34DA
	CC	4202	Gerald	Kimball	1N	10W	34DA
	CC	4201	Richard	Redman	1N	10W	34DA
	CC	4100	Christopher	Redpath	1N	10W	34DA
	CC	4000	David	Pace	1N	10W	34DA
	CC	4002	Arnold	Reeder	1N	10W	34DA
	CC	4001	Arnold	Reeder	1N	10W	34DA
	CC	10603	Nathan	Coltrane	1N	10W	34DA
	CC	10602	Jack	Scoval	1N	10W	34DA
	CC	2501	Brenda	Talso	1N	10W	34DD
	CC	2500	Charles	Wooldridge	1N	10W	34DD
	CC	2300	Bay City	Arts Center	1N	10W	34DD
	CC	2400	Jose	Vega	1N	10W	34DD
	CC	10600	Anthony	Troyer	1N	10W	34DA
	CC	10604	Anthony	Troyer	1N	10W	34DA
	CC	6800	Jesse	Hayes	1N	10W	34DA
	CC	7500	Karen	Viehoever	1N	10W	34DA
	CC	7400	James	Fullan	1N	10W	34DA
	CC	10500	Ada	Harris	1N	10W	34DA
	CC	10400	Ada	Harris	1N	10W	34DA
	CC	10300	Katherine	Cogswell	1N	10W	34DA
	CC	10200	Michael	Spencer	1N	10W	34DA
	CC	10100	Ashley	Ladd	1N	10W	34DA
	CC	9901	Lorilee	Torrey	1N	10W	34DA
	CC	9800	Robert	Motsinger	1N	10W	34DA
	CC	9700	John	Buchler	1N	10W	34DA
	CC	9600	Long	Mua	1N	10W	34DA
	CC	9601	Long	Mua	1N	10W	34DA

	CC	9400	Doris	Harris	1N	10W	34DA
	CC	7300	Travis	Barlow	1N	10W	34DA
	CC	7200	Travis	Barlow	1N	10W	34DA
	CC	7700	Dean	Buxton	1N	10W	34DA
	CC	7800	Thomas	Petit	1N	10W	34DA
	CC	9200	David	Caldwell	1N	10W	34DA
	CC	9102	Long	Mua	1N	10W	34DA
	CC	9100	Long	Mua	1N	10W	34DA
	CC	8200	Thomas	Petit	1N	10W	34DA
	CC	8100	Rik Kari	Gutzke	1N	10W	34DA
	CC	8000	Francis	Stubenrauch	1N	10W	34DA
	CC	8400	Fredric	Giannecchini	1N	10W	34DA
	CC	8500	Seward	Whitfield	1N	10W	34DA
	CC	8501	Kathie	Reames	1N	10W	34DA
	CC	8600	Eric	Mallery	1N	10W	34DA
	CC	3300	Francis	Moran	1N	10W	34DD
	CC	2800	Myra	McDonald	1N	10W	34DD
	CC	3200	Jacob	Hilger	1N	10W	34DD
	CC	3000	Leo	Molash	1N	10W	34DD
	CC	2100	Robert	Trost	1N	10W	34DD
	CC	2101	Landing	Enterprise	1N	10W	34DD
	CC	2000	W W Bay	Properties	1N	10W	34DD
	CC	1600	Eric	Clausen	1N	10W	34DD
	CC	1900	W W Bay	Properties	1N	10W	34DD
	CC	1500	Danny	Balmer	1N	10W	34DD
	CC	1400	Deborah	Jamieson	1N	10W	34DD
	CC	3500	Debrah	Downie	1N	10W	34DD
	CC	3600	Debrah	Downie	1N	10W	34DD
	CC	3700	Pacific Lodge #105		1N	10W	34DD
	CC	4200	Erin	Ostensen	1N	10W	34DD
	CC	4300	Mike	Hannah	1N	10W	34DD
	CC	4100	Stephen	Taylor	1N	10W	34DD
	CC	4400	Bahadur	Singh	1N	10W	34DD
	CC	9000	Amanda	Stanaway	1N	10W	34DD
	CC	8800	Verleta	Dupuis	1N	10W	34DD
	CC	9100	Mary	Olson	1N	10W	34DD
	CC	9101	Mary	Olson	1N	10W	34DD
	CC	8700	Sally	Goodwin	1N	10W	34DD
	CC	8601	Loretta	McFarland	1N	10W	34DD
	CC	8200	Larry	Christensen	1N	10W	34DD
	CC	8600	Loretta	McFarland	1N	10W	34DD
	CC	8300	Catherine	Manis	1N	10W	34DD
	CC	8301	Rhonda	Lane	1N	10W	34DD
	CC	8500	Brian	Clark	1N	10W	34DD
	CC	8400	Brian	Clark	1N	10W	34DD

	CC	9300	Steven	Wilkinson	1N	10W	34DD
	CC	9700	John	Smits	1N	10W	34DD
	CC	9800	Methodist Church		1N	10W	34DD
	CC	9900	1St Methodist Church		1N	10W	34DD
	CC	9600	Carla	Gannaway	1N	10W	34DD
	CC	10000	1St Methodist Church		1N	10W	34DD
	CC	9500	Trisha	Kauffman	1N	10W	34DD
	CC	9400	Craig	Kauffman	1N	10W	34DD
	CC	11400	Daniel	Seeman	1N	10W	34DD
	CC	11800	Justin	Crump	1N	10W	34DD
	CC	11902	Kathryn	Crump	1N	10W	34DD
	CC	11904	Kurt	Victor	1N	10W	34DD
	CC	11901	Heidi	Evans	1N	10W	34DD
	CC	11903	Dean	Evans	1N	10W	34DD
	CC	11900	David	Bunnell	1N	10W	34DD
	CC	12001	John	Papineau	1N	10W	34DD
	CC	12100	Kurt	Victor	1N	10W	34DD
	CC	12200	James	Oliver	1N	10W	34DD
	CC	12401	Judith	Irwin	1N	10W	34DD
	CC	12400	Judith	Irwin	1N	10W	34DD
	CC	12300	Santosh	Verghese	1N	10W	34DD
	CC	12500	Robert	Miles	1N	10W	34DD
	CC	12501	Warren	Beaman	1N	10W	34DD
	CC	12600	JoAnne	Schaeffer	1N	10W	34DD
	CC	201	Robert	Watt	1N	10W	35CB
	CC	1100	Jasper	Lind	1N	10W	35CD
	CC	1000	Johnny	Mills	1N	10W	35CD
	CC	900	Johnny	Mills	1N	10W	35CD
	CC	800	Richard	Crossley	1N	10W	35CD
	CC	700	Richard	Crossley	1N	10W	35CD
	CC	500	Adam	Stocton	1N	10W	35CD
	CC	300	Steven	Neal	1N	10W	35CD
	CC	400	Timothy	Josi	1N	10W	35CD
	CC	3200	Harvey	Hollowell	1N	10W	35CC
	CC	3100	Harvey	Hollowell	1N	10W	35CC
	CC	2900	Erin	Tucker	1N	10W	35CC
	CC	2802	Mary	Rose	1N	10W	35CC
	CC	2803	Mary	Rose	1N	10W	35CC
	CC	2801	Brandon	Vachter	1N	10W	35CC
	CC	2000	Gary	Oldencamp	1N	10W	35CC
	CC	2100	Thomas	Tobin	1N	10W	35CC
	CC	2400	Paula	Wende	1N	10W	35CC
	CC	2500	Laurie	Johnson	1N	10W	35CC
	CC	3400	Kurt	Victor	1N	10W	35CC
	CC	3600	Raymond	Prohaska	1N	10W	35CC

	CC	3700	Servohydrolux Holdings		1N	10W	35CC
	CC	3800	Jerry	Crist	1N	10W	35CC
	CC	3900	Michael	Schneider	1N	10W	35CC
	CC	4200	Jerry	Crist	1N	10W	35CC
	CC	4000	Michael	Schneider	1N	10W	35CC
	CC	4100	Sally	Gienger	1N	10W	35CC
	CC	4300	Haakon	Smith	1N	10W	35CC
	CC	4302	Haakon	Smith	1N	10W	35CC
	CC	4400	Hugh	Ragle	1N	10W	35CC
	CC	4301	Marilyn	Filosi	1N	10W	35CC
	CC	4303	Cynthia	Kurtz	1N	10W	35CC
	CC	4600	Pamela	Colby	1N	10W	35CC
	CC	4500	Pamela	Colby	1N	10W	35CC
	CC	4806	Michael	Watkins	1N	10W	35CC
	CC	4900	Michael	Watkins	1N	10W	35CC
	CC	1501	Jill Ann	Princehouse	1S	10W	3AA
	CC	1500	Mathew	Foottit	1S	10W	3AA
	CC	1400	Mathew	Foottit	1S	10W	3AA
	CC	1600	Brian	Gibson	1S	10W	3AA
	CC	1900	Daniel	Howard	1S	10W	3AA
	CC	1700	Keith	Thompson	1S	10W	3AA
	CC	1800	Roberta	Gundersen	1S	10W	3AA
	CC	1300	John	Kerby	1S	10W	3AA
	CC	1100	Shirley	Williams	1S	10W	3AA
	CC	1301	John	Hunter	1S	10W	3AA
	CC	1200	Daniel	Rost	1S	10W	3AA
	CC	1000	Corinne	Cumming	1S	10W	3AA
	CC	100	Karel	Beuer	1S	10W	3AA
	CC	900	Timothy	Bright	1S	10W	3AA
	CC	300	Rosemary	Setterlund	1S	10W	3AA
	CC	800	James	Garrigues	1S	10W	3AA
	CC	2800	Gorjean	Armen	1S	10W	2BB
	CC	3200	Michael	Hays	1S	10W	2BB
	CC	3400	Benjamin	Hunziker	1S	10W	2BB
	CC	2701	Dane	Crossley	1S	10W	2BB
	CC	2100	Dane	Crossley	1S	10W	2BB
	CC	2102	William	Raglione	1S	10W	2BB
	CC	2000	Joel	Haugen	1S	10W	2BB
	CC	2001	Joel	Haugen	1S	10W	2BB
	CC	1600	David	Young	1S	10W	2BB
	CC	1704	Elroy	Thompson	1S	10W	2BB
	CC	1702	John	Witham	1S	10W	2BB
	CC	1705	John	Witham	1S	10W	2BB
	CC	1700	John	Witham	1S	10W	2BB
	CC	1701	Martha	Rook	1S	10W	2BB

	CC	1102	Troy	Jewell	1S	10W	2BB
	CC	1000	WW Bay Properties		1S	10W	2BB
	CC	1101	Henry	Davidson	1S	10W	2BB
	CC	1100	Gordon	Robertson	1S	10W	2BB
	CC	1500	William	Davidson	1S	10W	2BB
	CC	1200	Hugh	Ragle	1S	10W	2BB
	CC	1400	Hugh	Ragle	1S	10W	2BB
	CC	1300	Kathleen	Orr	1S	10W	2BB
	CC	201	Mark	Creamer	1S	10W	2BB
	CC	300	Marina	Ballenger	1S	10W	2BB
	CC	400	Carl	Ballenger	1S	10W	2BB
	CC	100	Ray	Amirkhanian	1S	10W	2BB
	CC	1300	Ray	Amirkhanian	1S	10W	2BA
	CC	1301	Dylan	Hayes	1S	10W	2BA
	CC	1302	Richard	Reid	1S	10W	2BA
	CC	1400	Ray	Amirkhanian	1S	10W	2BA
	CC	1500	Melinda	Kintz	1S	10W	2BA
	CC	1100	Michael	Rawson	1S	10W	2BA
	CC	900	Mark	Anderson	1S	10W	2BA
	CC	1201	James	Henry	1S	10W	2BA
	CC	1200	George	McKay	1N	10W	35

Zone 7 (D)	Zone 8 (DD)	Tax Lot	First	Last	Twp	Range	Section
D	DD	1100	Tillamook County	Pioneer Museum	1S	10W	2CD
D	DD	4500	Tillamook County	Pioneer Museum	1S	10W	2CC
D	DD	4600	Tillamook County	Pioneer Museum	1S	10W	2CC
D	DD	5000	Tillamook County	Pioneer Museum	1S	10W	2CC
	DD	2900	Nehalem Valley	Naturals LLC	1S	10W	2CA
	DD	3000	Robert	Doty	1S	10W	2CA
	DD	3001	Edward	Schmunk	1S	10W	2CA
	DD	1000	F.E.	Morgan	1S	10W	2CD
	DD	700	Robert	Craig	1S	10W	2CD
	DD	600	Linden	Perrine	1S	10W	2CD
	DD	900	F.E.	Morgan	1S	10W	2CD
	DD	400	F.E.	Morgan	1S	10W	2CD
	DD	300	Franke	Brothers	1S	10W	2CD
	DD	200	April	Buckmeier	1S	10W	2CD
	DD	1200	Kilchis	River LLC	1S	10W	2CD
	DD	2000	Peggy	Weber	1S	10W	2CC
	DD	2300	Erma	James	1S	10W	2CC
	DD	2400	Gerald	Wyatt	1S	10W	2CC
	DD	4200	Tillamook County	Pioneer Museum	1S	10W	2CC
	DD	2508	Aaron	Cutts	1S	10W	2CC
	DD	2502	Dale	Ludolph	1S	10W	2CC
	DD	2503	Dale	Ludolph	1S	10W	2CC
	DD	2504	Dale	Ludolph	1S	10W	2CC
	DD	2500	Dale	Ludolph	1S	10W	2CC
	DD	2507	Dale	Ludolph	1S	10W	2CC
	DD	2506	Dale	Ludolph	1S	10W	2CC
	DD	2505	Dale	Ludolph	1S	10W	2CC
	DD	2600	Tommy	Reed	1S	10W	2CC
	DD	2901	Deborah	Hanson	1S	10W	2CC
	DD	4000	Deborah	Hanson	1S	10W	2CC
	DD	3700	Ted	Arthur	1S	10W	2CC
	DD	3800	Weston	McCarter	1S	10W	2CC
	DD	3900	Tillamook County	Pioneer Museum	1S	10W	2CC
	DD	4100	Tillamook County	Pioneer Museum	1S	10W	2CC
	DD	4700	Gary	Foster	1S	10W	2CC

Appendix 4: Hazards of Risk: Identifying Plausible Community Wildfire Disasters in Low-Frequency Fire Regimes

forests MDPI

Article

Hazards of Risk: Identifying Plausible Community Wildfire Disasters in Low-Frequency Fire Regimes

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Abstract: Optimized wildfire risk reduction strategies are generally not resilient in the event of unanticipated, or very rare events, presenting a hazard in risk assessments which otherwise rely on actuarial, mean-based statistics to characterize risk. This hazard of actuarial approaches to wildfire risk is perhaps particularly evident for infrequent fire regimes such as those in the temperate forests west of the Cascade Range crest in Oregon and Washington, USA ("Westside"), where fire return intervals often exceed 200 years but where fires can be extremely intense and devastating. In this study, we used wildfire simulations and building location data to evaluate community wildfire exposure and identify plausible disasters that are not based on typical mean-based statistical approaches. We compared the location and magnitude of simulated disasters to historical disasters (1984–2020) in order to characterize plausible surprises which could inform future wildfire risk reduction planning. Results indicate that nearly half of communities are vulnerable to a future disaster, that the magnitude of plausible disasters exceeds any recent historical events, and that ignitions on private land are most likely to result in very high community exposure. Our methods, in combination with more typical actuarial characterizations, provide a way to support investment in and communication with communities exposed to low-probability, high-consequence wildfires.

Keywords: wildfire risk; risk assessment; community exposure; FSim; surprise; wildfire disaster

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1. Introduction

> *"A single number is not a big enough concept to communicate the idea of risk. It takes a whole curve."* [1]

Across the United States, the scale of wildfire-related losses annually outpaces available resources at the disposal of federal, state, and local actors to mitigate future losses. Driven by federal policy, wildfire risk science has advanced rapidly over the past decade to inform mitigation and adaptation strategies and to support strategic allocation of resources across space and time [2–8]. In the United States, wildfire risk sciences have coalesced around an actuarial definition of risk, where risk is defined as both the probability of wildfire occurrence and the consequence of wildfire given that it occurs [6]. Building on that definition, quantitative wildfire risk assessments simulate wildfire occurrence, assess both negative and positive socioecological consequences, and report risk using integrated metrics that can be combined across diverse resources and values and across diverse landscapes [9]. In both wildfire response and pre-season planning settings, quantitative wildfire risk assessment outputs are used to develop optimized strategies that minimize net negative and maximize net positive impacts from wildfire [5,7,10].

While wildfire risk scientists have necessarily agreed upon shared definitions of risk, it is important to recognize that the public at large does not adhere so strictly to actuarial definitions of risk [1,11,12]. For instance, a homeowner might ask 'what is the risk of a wildfire in my community,' when what they are really asking is 'what is the *probability* of a wildfire in my community?' In this case, the homeowner is using the word risk to ask about what risk scientists actually call "hazard," or the probability of a threat, but the homeowner is not asking about consequences. Divergent definitions of risk may complicate communication, but as quantitative risk assessment outputs are used in more and more decision settings by diverse audiences (i.e., emergency managers, non-fire resource professionals, community planners, etc.), it is essential to continually review and refine how we communicate risk to support decision making in different contexts [13].

Communicating and characterizing risk in the context of low-probability, high-consequence events is particularly challenging [14]. While other disciplines from financial planning to national security and even other natural hazards have developed strategies for explicitly characterizing low-probability, high-consequence events, wildfire risk assessments generally rely on mean-based statistics [13,15–20]. Mean-based statistics are inadequate for communicating the plausibility of extreme events let alone communicating the magnitude of risk [21]. Explicitly characterizing outlier events is particularly important with respect to wildfires because it is precisely those fires which have disproportionate socioecological consequences [22–26]. Not only do outlier events have disproportionate impacts, they are also society's most fecund opportunity for novel learning in complex systems and subsequent adaptation planning [27–29].

Arguably, most if not all wildfire impacts are the result of a disproportionately small number of fires, but this is perhaps especially true in landscapes vulnerable to infrequent, but very intense wildfires. For instance, fire return intervals in forests west of the Cascade Range crest in Oregon and Washington, USA ("Westside"), regularly exceed 200 years and annual burn probabilities are commonly estimated to be less than 0.0001 [30–33]. At the same time, a handful of fires over the past 120 years have demonstrated that when fires eventually occur, the consequences can be extreme [23,34]. Most notably, a spate of synchronous Westside fires in 2020 burned over 300,000 ha, causing the evacuation of nearly 100,000 people, killing five, and resulting in several billion dollars of damage. The 2020 wildfires were often described as "unprecedented" when in fact they were generally characteristic of fires that have impacted the region during the past several centuries, thereby demonstrating the challenge of communicating risk in a landscape driven by very rare events [30,35,36].

One hazard of risk, then, is that depending on the definition and methods used to communicate risk, risk assessments may point end-users towards supposedly rational solutions that might not be so rational under a different definition of risk [37]. On the Westside specifically, risk assessments may point decision makers towards optimized risk reduction strategies that are highly vulnerable to the types of infrequent, extreme events that are characteristic of the region. Westside communities are rarely represented, named, or ranked in community wildfire risk and exposure reports and papers drawing on mean-based metrics, giving the impression that Westside communities are either not at risk at all, or that the risk is miniscule, and resources should be allocated elsewhere. Typically communities within higher-frequency fire regimes are emphasized in reports and maps [38,39]. Yet, 75% of the population in Oregon and Washington live in Westside communities along with all of the associated essential infrastructure and services. While wildfire may be an unlikely annual occurrence, the potential consequences and concerns around wildfire in these areas demands a more nuanced approach to understanding and communicating risk.

A second hazard of risk as it is so often presented in risk assessments is that integrated, unitless metrics are not easily translated outside the context of the risk assessment itself. Unitless metrics are designed to compare and integrate risk across diverse resources and assets so that, for example, the risk to communities and the risk to wildlife are expressed on the same unitless scale (−100–100) and can be combined to calculate a single, comprehensive risk value [6,9]. When operating with an optimization mindset, integrated risk is useful, but to the community planner who wants to know how many homes might be lost during an extreme event, a risk of −75 is not insightful. Risk assessments are used in increasingly diverse decision settings and methods are needed to tailor output to communicate risk for audiences that are using a non-actuarial lens. Wildfire exposure analysis, instead of risk analysis, does not require integrated metrics and therefore may be an effective way to communicate the plausibility of rare events to broad audiences [40].

Rather than rely solely on mean-based and integrated metrics, risk communication in low-frequency fire regimes would benefit from surprise analysis [41]. Surprises are unforeseen, rare, and highly impactful events, and surprise analysis strives to identify potential events that have not otherwise been characterized and to communicate their potential consequences. Surprises are not always calamitous events, but in the case of Westside fire, there is an obvious interest in anticipating potential future disasters in terms of damage to communities. The potential benefit of surprise analysis is that by identifying these events before they happen, we have an opportunity to identify vulnerabilities and adapt without actually having to experience the negative consequences of a disaster. Incorporating surprise analysis into the risk assessment process is particularly useful in low-frequency fire regimes, but may also be useful in socioecologically similar settings such as Patagonia and New Zealand, or even in temperate and boreal forests, where extreme fires are becoming more common [42,43].

Often, potential surprises are identified using statistical analyses of rare event distributions, but in Westside landscapes, where the empirical fire record is limited by the very nature of the fire regime, statistical methods may be insufficient [21,25,44,45]. In which case, simulations provide an opportunity to investigate plausible surprises. In particular, Monte Carlo-style wildfire simulators produce thousands of iterations of plausible event scenarios and hundreds of thousands of simulated wildfires, many of which presumably illustrate plausible Westside surprises [46,47]. The authors in [41] used simulations to investigate plausible future surprises in western Oregon that might arise as a result of climate change, but to the authors' knowledge, no studies have investigated plausible contemporary surprises.

In order to demonstrate the utility of surprise analyses in low-frequency fire regimes we used wildfire simulation outputs that were from an existing assessment and building location footprint dataset to identify plausible wildfire disasters in Westside communities [31,48]. We also compared simulated disasters to historical Westside fires to evaluate the relevance of the simulation data when characterizing infrequent fires, as well as to extract lessons from the simulated results. Specifically, we addressed the following questions: (1) what were the magnitudes and sizes of simulated disasters and how did they compare to historical events; (2) Which communities have experienced historical exposure, and which communities are vulnerable to plausible future disasters; (3) What is the source of simulated community disaster exposure; and (4) How does maximum simulated exposure compare to mean annual building exposure and worst-case scenario-integrated risk metrics? We anticipated that the simulations would illustrate novel disasters in terms of location and magnitude compared to historical events. Further, we anticipated that using maximum community exposure would illustrate unique spatial risk distributions among Westside communities compared to either mean annual exposure, or integrated worst-case scenario risk. Our aim is to demonstrate that non-actuarial characterizations of risk provide additional information that is useful to managers and planners in any fire prone landscape, but particularly so in low-frequency fire regimes.

2. Materials and Methods

2.1. Study Area

The study area (Figure 1) is predominantly the region west of the Cascade Range crest ("Westside") in Oregon and Washington, USA, covering approximately 12.6 million hectares. The Cascade Range crest, running north to south from Washington to Oregon, and in many places rising above 3000 m, plays an enormous role in shaping PNW climate, generally separating temperate maritime conditions on its west side from the arid, high desert to its east. The study area comprises multiple pyrome given in the national pyrome dataset, also used by the Pacific Northwest Quantitative Wildfire Risk Assessment [31,49]. Pyromes are ecoregion polygons closely aligned with Level III ecoregions [50] but adjusted to reflect fire regimes and, in some cases, fire management jurisdictions. The study area extends to forested areas east side of Cascade Range crest in some cases, to account for fires that ignite east of the crest but are transmitted across the crest. Ecoregions of southwestern Oregon were not included owing to their different climate and fire characteristics, which are typically aligned with more frequent fire regimes.

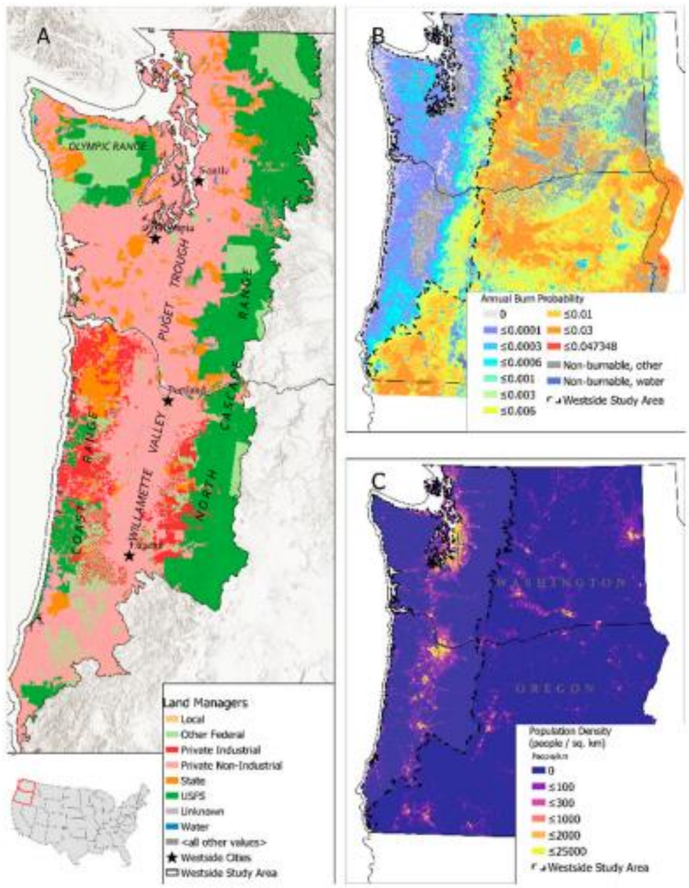

Figure 1. (**A**) Major Westside land manager types and landscape features; (**B**) annual burn probabilities for the PNW adapted from Gilbertson-Day et al. (2018) and historical wildfire perimeters (1984–2020); (**C**) population density.

The region is characterized by a temperate maritime climate influenced strongly by topography. Annual precipitation ranges between approx. 150–500 cm, the highest amounts falling in temperate rain forests in the Olympic Peninsula and along the coast. Most precipitation falls between October and April as snow at higher elevations and rain below. Summers are generally very dry, although fog is common in on the coast [51] and rainstorms occur in the west Cascades [33]. Maximum summer temperatures range between approx. 20–38 °C. Historic Westside fire occurrence has been closely linked to periods of short-term drought in late summer and fall [52]. Particularly disastrous Westside fires appear to be the result of drought, synoptic east winds, and ignition location [53].

Due to the mild and wet climate, Westside forests are exceptionally productive. While generally characterized by mixed-moist conifer forests, potential vegetation types follow approximate elevation gradients. Much of the region between the Coast Range and Cascade Range below ~ 1000 m is in the western hemlock (*Tsuga heterophylla*) vegetation zone, but Douglas fir (*Pseudotsuga menziesii* var. *menziesii*), is the most common extant species [23,33,54]. Higher elevations in the Cascades are in the Pacific silver fir (Abies amabilis) and mountain hemlock (*Tsuga mertensiana*), zones. Coastal forests in Oregon and in the Olympic Peninsula are temperate rainforests dominated by Sitka spruce (*Picea sitchensis*) zone. Forest structure and composition have been heavily influenced by a legacy of and ongoing intensive forest management [55]. National Forests cover approximately 3.5 million hectares, nearly 30% of the study area, mostly at higher elevations in the west Cascades but also including much of the Olympic Peninsula. National Forests are managed for multiple use objectives, but commercial timber harvests have been significantly reduced over the past three decades. Private industrial timber management is common at mid-elevations in the west Cascades and throughout the Coast Range, where silvicultural prescriptions are dominated by clear cut methods. Lower elevations in the Willamette Valley and Puget Trough are dominated by private, non-industrial management including agriculture. Approximately 70% of the PNW population live in the Westside, predominantly in the Seattle, WA (3.8 million people) and Portland, OR (2.7 million people) metro areas.

2.2. Historical Wildfire Data

Historical building exposure was calculated using two historical fire datasets, collectively representing 1984–2020. We used fire perimeters from Monitoring Trends in Burn Severity (MTBS) for fires in the period 1984–2018 [56]. MTBS includes all incidents ≥405 hectares; we excluded prescribed fires from our analysis. In addition, we included fire perimeters from 2019 to 2020 available from the National Interagency Fire Center (NIFC) [57,58]. NIFC records are not limited by size like the MTBS records. NIFC archives include multiple features for each fire representing the fire over time; for each fire we used the most recent feature, assuming that doing so would be the best estimate of final fire size. Fires from both MTBS and NIFC were included in the historic dataset if any portion of the fire intersected the Westside study area (n = 66, Figure 1B). We assume that collectively this historic dataset includes nearly all exposure events from 1984 to 2020 but recognize that because of limitations in each of the data sources, we may not have accounted for all historical exposure.

2.3. Simulated Wildfire Data

We analyzed output from wildfire simulations that were conducted as part of the 2018 Pacific Northwest Quantitative Wildfire Risk Assessment (QWRA) [31]. Simulations were performed using the FSim Large Fire Simulator which has been widely used for local, state, regional, and national fire planning [46,59–62]. FSim has been described in detail elsewhere [46]. Therefore, we provide only its key features. FSim is a Monte Carlo simulation that produces tens of thousands of iterations of a statistically plausible fire season [46]. FSim is calibrated based on relationships between Energy Release Component (ERC) and historical large fire occurrence [63]. Using modules for weather generation, ignition, fire growth and suppression, FSim simulates daily fire scenarios across tens of thousands of fire seasons with statistically plausible but variable daily weather scenarios, and stores spatially explicit final perimeters for each fire as well as the ignition location [64]. QWRA simulations were based on contemporary climate from 1992 to 2012; vegetation and fuel conditions were based on 2014 LANDFIRE data layers but were updated to account for post-2014 disturbances and based on local knowledge from fire and natural resource managers; and recent historic fire occurrence data were primarily drawn from the national Fire Occurrence Dataset which includes all ignitions 1992–2015 but again updated to include fires in the period 2015–2017 [31,65–73]. QWRA simulations were conducted for 23 contiguous model domains across all of Oregon and Washington at 120 m resolution. Our simulated fire dataset includes all fires that intersected the Westside study area (n = 507,539). We elected to use simulations from the QWRA because the model was carefully updated and calibrated with insight from regional fire personnel and because it is the most recent, available risk assessment for the area. The information and data in the QWRA are also referenced and used widely among planners and managers across Oregon and Washington and our analysis will provide a useful complement to those applications.

2.4. Building Exposure

Exposure was looked at in two related ways. First, we determined the per-fire exposure for each simulated and historical fire by intersecting fire perimeters with building footprint data which represents building locations identified using satellite imagery from 2015 [48]. We used only building centroids that fell within the study area, so for fires that burned across the study area boundary and may have exposed buildings both inside and outside of the study area, we counted only buildings exposed within the study area. We further classified any historical or simulated wildfire that exposed more ≥100 buildings as a "disaster." The threshold is based on literature related to empirical building loss analyses, but our methods measure wildfire exposure only rather than consequences (i.e., extent of building damage) [3,74]. For that reason, "disasters" identified in this study are best interpreted as potential disasters in this study. We visually evaluated the relationship between fire size and exposure magnitude in order to determine how many exposure events were disasters and how many disasters were the result of very large fires (≥20,234 ha).

Second, we identified the maximum simulated and historical community exposure events for each of 646 communities. We used community definitions and boundaries developed by which are based on census-designated communities but which are also expanded to include rural, often unincorporated, development based on GIS-determined drive-time analysis [75]. The authors in [39] also used this community dataset in an exposure analysis, allowing us to compare results. We excluded communities along the southern and eastern edges of the study area when ≤50% of the buildings within that community were outside the Westside study area. For each community, we intersected all the historic and simulated wildfires and then, using the intersected perimeters, calculated the resulting building exposure within the community resulting from each fire. This allowed us to assign a list of simulated fires to each community and to then use exceedance probability curves to compare the likelihood of exposure magnitudes across communities [76]. At the community level, we also plotted the relationship between average annual burn probability (averaged across all burnable pixels for each community) and the maximum simulated exposure for that community.

2.5. Exposure Source

We evaluated the source of simulated community exposure in several ways. First, we calculated ignition exposure potential as a way to visually evaluate where the most consequential wildfires ignite. Using the per-fire exposure calculations described above, we added building exposure as an attribute to each simulated ignition point and then interpolated the surface using inverse distance weighting with a power of 0.5, 90 m cell size, and a 7.5 km search radius. Maximum exposure values were binned and mapped using a quantile method.

Second, we evaluated the source of community exposure by assessing where exposure events ignited with respect to land management types and the wildland urban interface (WUI). Land management types were classified into six categories: US Forest Service, Other Federal, State, Local, Private Non-Industrial, and Private Industrial [77]. For all fires that resulted in any exposure within a community, we calculated the number of buildings and proportion of total exposed buildings that resulted from ignitions in each major land management type. Similarly, for WUI classes, we calculated the number of exposed buildings and proportion of total exposure that resulted from ignitions in each of four classes based on 2010 population and vegetation conditions [78]. The four WUI classes include intermix, interface, forest, and urban.

We did not evaluate exposure source for historical buildings because at the time of writing, ignition locations for the 2020 fires had not been confirmed and these fires comprise an overwhelming majority of historical exposure.

2.6. Exposure Metric Comparison

Community vulnerability can be characterized and communicated in multiple ways depending on the context and audience. Our aim was to visually compare community maximum simulated building exposure (our analysis) with two other common metrics: (1) mean annual building exposure and (2) worst-case scenario conditional net value change ($cNVC_{worst}$) for communities. We calculated mean annual building exposure for each Westside community by multiplying the community-wide annual burn probability reported in [39] by the total number of buildings within the Westside study area within each community. $cNVC_{worst}$ was calculated following methods presented by Thompson et al. (2016) and using data layers from [31]. Conditional net value change (cNVC) is a risk metric that reports the expected consequences, given that a fire occurs. cNVC is calculated using pixel-level wildfire intensity values derived from simulations, pixel-based maps of highly valued resources and assets ("HVRA", i.e., buildings), and expert-derived response functions that indicate how HVRAs respond to fires of a given intensity on a scale of −100 to 100. Pixel-based calculations were summed within simulated fire perimeters to calculate per-fire cNVC. For our purposes, we were interested in comparing per-fire worst-case scenarios to maximum building exposure so we calculated $cNVC_{worst}$ for each simulated fire using the Where People Live HVRA (WPL) and associated response functions described in [31]. $cNVC_{worst}$ is interpreted as the worst-case scenario simulated consequences given that a fire of the highest intensity occurs.

3. Results

3.1. What Were the Magnitudes and Sizes of Simulated Disasters and How Did They Compare to Historical Events?

Simulations produced 507,539 fires that intersected the Westside study area, of which 21% (n = 108,114) exposed at least one building within the study area. Per-fire building exposure ranged between one and 2340 buildings (Figure 2A). The maximum simulated event exposed more than twice as many buildings as the largest historical exposure event which exposed 1120 buildings (Figure 2A). In fact, the simulations included 22 fires that resulted in exposure equal to or greater than the worst historical exposure, and 2526 examples of plausible disasters (Figure 2B). The historical fire dataset includes only eight Westside disasters, and of those, six occurred simultaneously in September 2020 and account for 75% of all exposure in the historical dataset. Furthermore, the 2020 Beachie Creek Fire alone accounts for 37% of all historical building exposure from 1984 to 2020 (Table 1).

The most disastrous simulated wildfires were not necessarily the largest simulated wildfires (Figure 3). The median size of simulated exposure events was 159 ha (mean = 961 ha) and the median size of simulated disasters was 1041 ha (mean = 2677 ha). Simulations did include 173 very large wildfires (≥20,234 ha), but only 32 of those were also disasters based on our definitions (Figure 3). However, simulated very large wildfires made up approximately 11% of all simulated exposure despite comprising just 0.03% of simulated fires. In contrast, the largest historical fires were also the greatest exposure events (Figure 3). Historical exposure events ranged in size between approximately 20 and 80,000 ha, and the median size of historical exposure events was 3248 ha (mean = 10,650 ha). In contrast to simulations, very large fires accounted for 74% of all historical Westside building exposure, most of which was the result of five fires that occurred in 2020 (Table 1). Notably, not all historical disasters were the result of very large fires; the Echo Mountain Complex (2020) burned just 996 hectares but exposed 363 buildings, the third greatest exposure event since 1984 (Table 1).

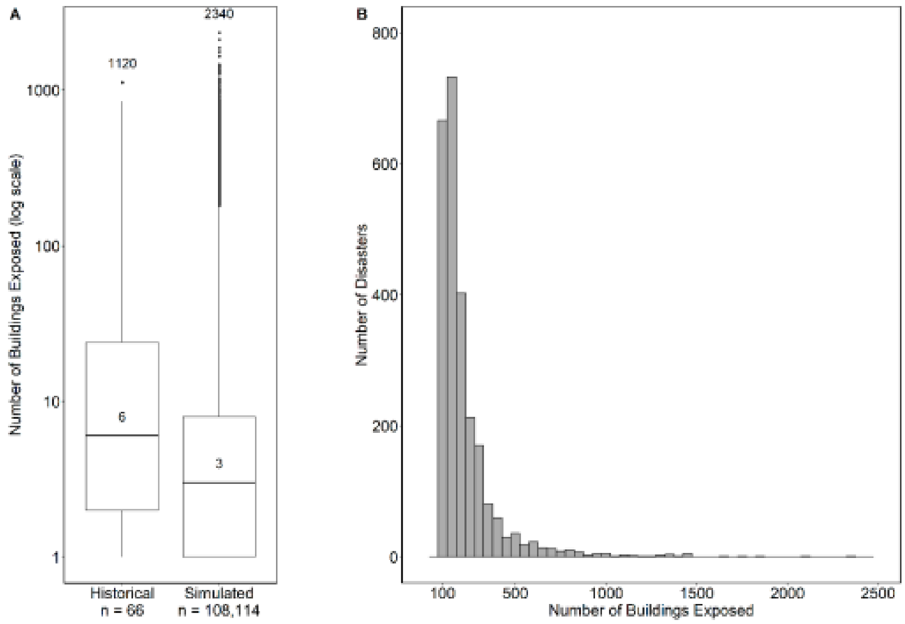

Figure 2. (**A**) Boxplot of historical and simulated exposure magnitudes plotted on log scale. Labels indicate median and maximum number of buildings exposed. (**B**) Frequency distribution of simulated disasters (n = 2526). Historical disasters were not included because there were only eight historical disasters (see Table 1).

Table 1. Top ten historical fires (1984–2020) that resulted in the greatest building exposure.

Fire Name	Year	Area Burned (ha)	Buildings Exposed
Beachie Creek	2020	78,218	1120
Holiday Farm	2020	40,031	845
Echo Mountain Complex	2020	996	363
Riverside	2020	55,905	357
Lionshead	2020	74,402	309
Archie Creek	2020	40,581	292
Hatchery Complex	1994	11,033	258
B & B Complex	2003	36,938	209
Norse Peak	2017	20,645	96
Chetco Bar	2017	78,860	68

3.2. Which Communities Have Experienced Historical Exposure, and Which Communities Are Vulnerable to Plausible Future Disasters?

Historically, only 1.5% (n = 10) of Westside communities experienced any building exposure between 1984 and 2020. However, when communities did experience exposure, 70% of instances were of disaster proportions. The greatest historical exposure events were the result of the 2020 wildfires affecting communities in the Oregon west Cascades (i.e., Gates, Estacada, and Springfield) and Oregon coastal communities such as Rose Lodge (Figure 4). The greatest historical community exposure event was 684 buildings, a result of the Holiday Farm Fire (2020) outside Springfield, Oregon (Figure 4). It is important to look at disasters as absolute exposure and also a percent of the total community. For instance, 684 buildings exposed in Springfield makes up just 3% of all buildings in the community. In contrast, 513 buildings in Detroit, Oregon accounted for 97% of all community buildings.

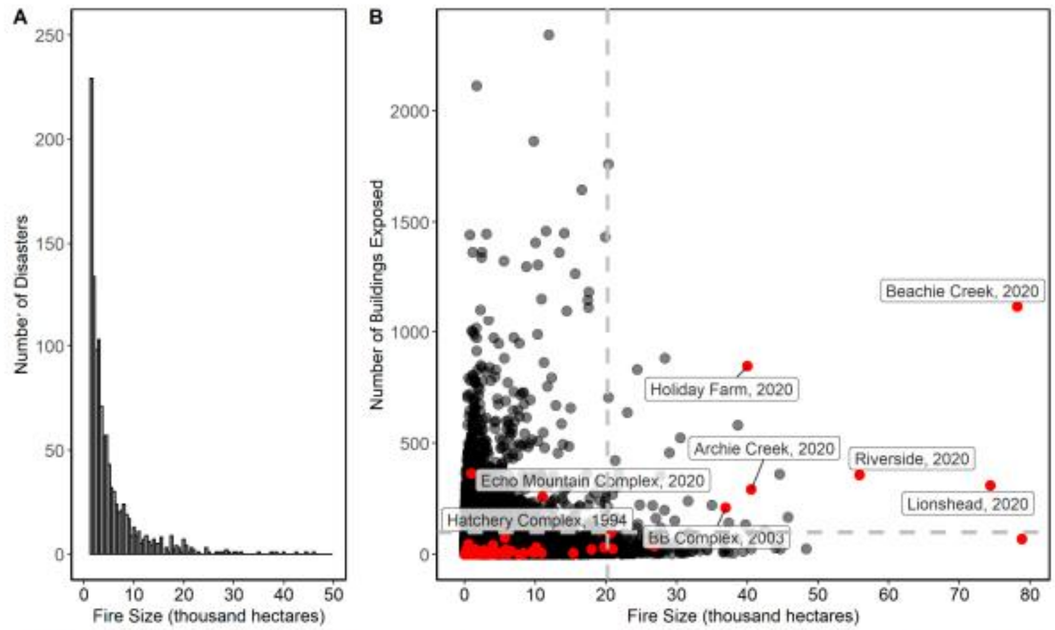

Figure 3. (**A**) Frequency of simulated disasters resulting from fires of a specific size. There were only eight historical disasters, see Table 1. (**B**) Per-fire building exposure as a function of fire size for simulated (black) and historical fires (red). Vertical dashed line is the threshold for very large fires (20,234 ha) and horizontal dashed line is threshold for a disaster (100 buildings).

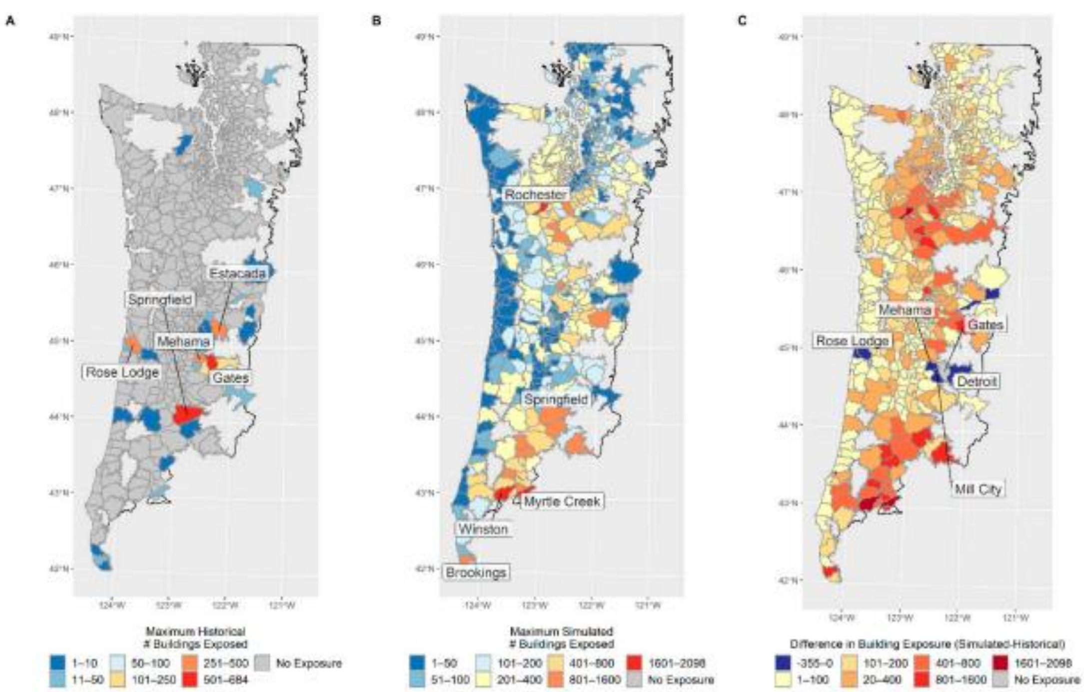

Figure 4. (**A**) Maximum historical community exposure; (**B**) Maximum simulated community exposure; and (**C**) The difference between simulated and historical maximum community exposure events. In panels A and B, labeled communities are the five communities with the greatest maximum exposure values. In panel C, labels corresponding to areas mapped as blue indicate the communities where historical exposure exceeded simulated maximum exposure.

Simulations revealed that plausible disasters are widespread, occurring across the Westside. Ninety-six percent (n = 617) of communities experienced simulated exposure, and 43% (n = 275) of communities experienced a simulated disaster (Figure 4). Simulated community maximum exposure ranged between one and 2098 buildings. The highest simulated exposure event occurred in Rochester, Washington, a town with no historical exposure and very limited fire occurrence in general. The Rochester simulated fire burned 2098 structures which is approximately 39% of all structures within the community. In almost all cases, simulated community maximum exposure greatly exceeded historical exposure. Notable exceptions are in several of the communities affected by the 2020 wildfires, where historical fires exposed more structures than simulations (Figure 4).

Simulations also reveal that some communities are more vulnerable than others to plausible disasters and that the communities with the most simulated disasters or the highest maximum exposure are not necessarily the communities with highest annual burn probabilities (Figure 5). Many communities experienced more than one simulated disaster and, in some cases, the communities that experienced the most disasters were also communities with the highest annual burn probabilities such as Myrtle Creek, Oregon (Figure 5). In many other cases, a high number of disasters were simulated in communities with comparatively low annual burn probabilities, as in Yelm, Washington, where the annual burn probability is an order of magnitude lower than Myrtle Creek, Oregon (Figure 5). Exceedance probabilities in Figure 6 help to illustrate the range of community vulnerability to disasters. Communities with comparatively high annual burn probability such as Brookings, Oregon have elevated likelihood of disasters that expose 500–1000 buildings, whereas communities with comparatively low annual burn probabilities have shallow exceedance probability curves with very long tails (Figure 6).

3.3. *What Is the Source of Simulated Community Disaster Exposure?*

Approximately half of all simulated community exposure was the result of fires that ignited within the community where the exposure occurred. Simulated community disasters were particularly likely to be the result of an intracommunity fire; 86% of disaster-caused exposure was the result of an ignition inside the community where the exposure occurred. This is a somewhat different picture of the source of risk compared to historical exposure, 97% of which was the result of fires that exposed buildings in multiple communities.

Across the Westside, ignitions in forest-type WUI classes were the source of approximately 50% of all simulated exposure (Table 2). However, the majority of all the simulated disaster exposure in communities was the result of ignitions on land managed by private, non-industrial owners (Table 2) and ignitions in close proximity to population centers (Figure 7). Despite comprising 26% of the Westside study area, fires originating on national forests accounted for just 8% of exposure incurred during a disaster. For individual communities, the composition of exposure sources varied (Figure 8). For instance, there were eight simulated disasters in Duluth, WA, all of which ignited in urban WUI classes whereas the 20 simulated disasters in Toledo, WA ignited in all major WUI classes (Figure 8).

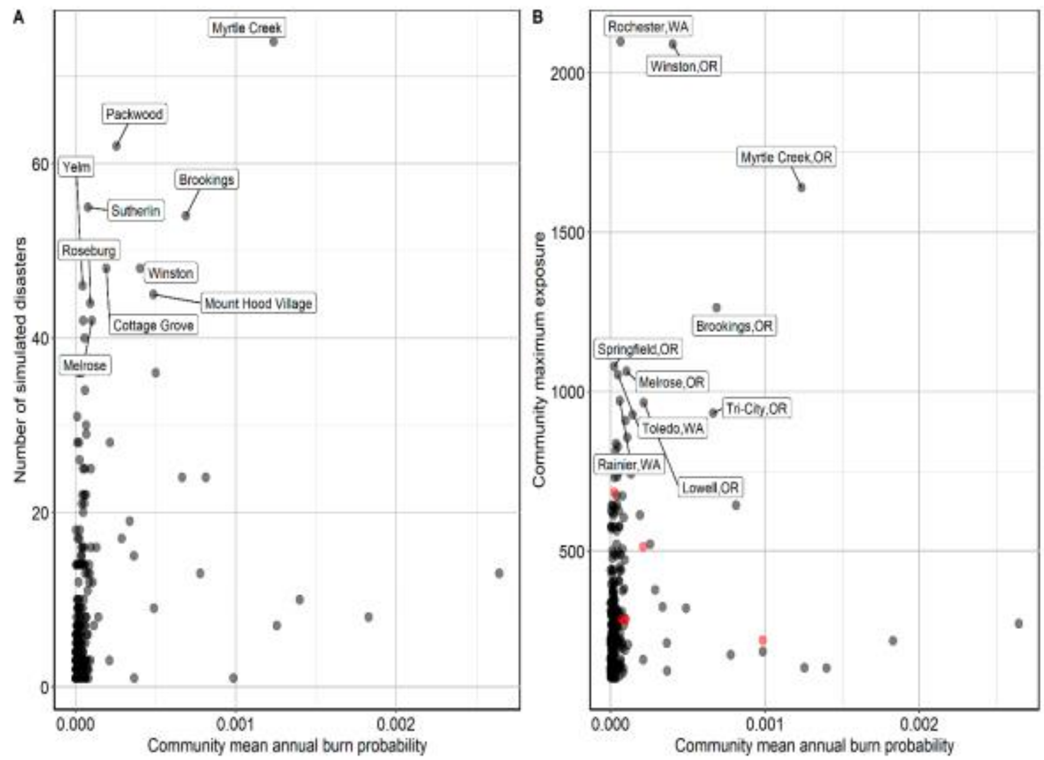

Figure 5. (**A**) The number of simulated community disasters as a function of annual burn probability. (**B**) Magnitude of community maximum simulated (black) and historical (red) exposure events as a function of average annual burn probability. Labels in both panels identify the ten communities with the greatest simulated maximum exposure.

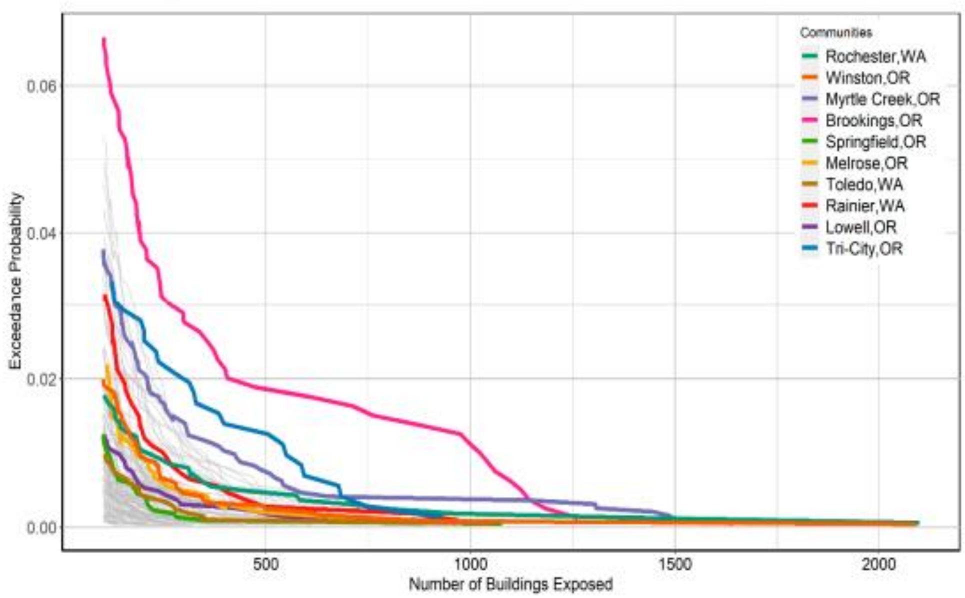

Figure 6. Exceedance probabilities developed from the simulated dataset illustrating the likelihood that, given a disaster occurs in the community, exposure will exceed a certain number of buildings. The lines in color correspond with the ten communities that had the highest simulated maximum exposure while all other communities are shown in gray in the background.

Table 2. Percent of simulated exposure that resulted from ignitions occurring in each WUI and land manager classes. Disaster exposure includes only exposure from simulated fires that exposed ≥ 100 buildings.

Source	Portion of Study Area	Total Exposure	Disaster Exposure
WUI Class			
Forest	77%	51%	43%
Intermix	9%	35%	41%
Interface	3%	8%	10%
Non-Vegetated	10%	5%	5%
Land Manager			
Private Non-Industrial	57%	82%	89%
USFS	26%	11%	2%
Other Federal	8%	2%	1%
Local	<1%	<1%	<1%
Private Industrial	3%	<1%	<1%
State	4%	<1%	<1%

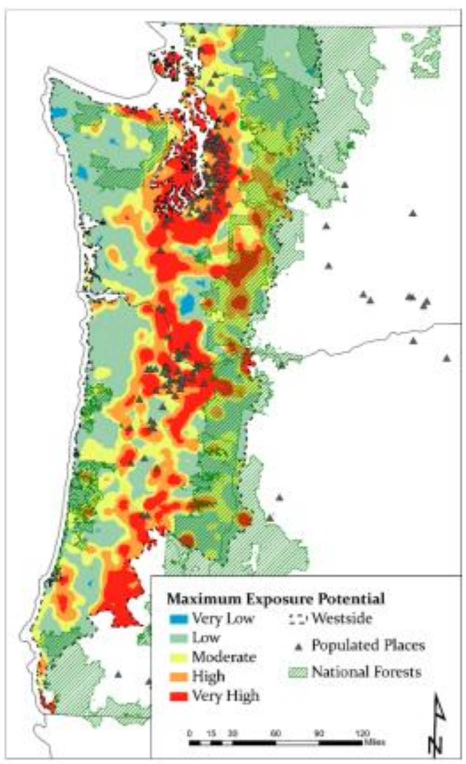

Figure 7. Maximum exposure potential illustrates the relative magnitude of maximum building exposure that could result from an ignition at the given location. Exposure values binned in quantiles so the "Very Low" category accounts for pixels with the bottom 20% of exposure values and the "Very High" category includes all pixels with the top 20% of exposure values.

Figure 8. Relative proportion of each community's disaster exposure that results from unique landowners (**A**) and unique WUI classes (**B**). The top 25 communities with the greatest simulated maximum exposure values are shown.

3.4. How Does Maximum Simulated Exposure Compare to Other More Common Risk Assessment Metrics Derived from Simulations?

Mean annual exposure and $cNVC_{worst}$ each illustrate unique spatial distributions of community wildfire risk (Figure 9). Westside community mean annual building exposure ranges from $\leq$0.01 across much of the region to 16.2 buildings in Trout Lake, Washington and, in general communities with the highest mean annual exposure are communities on the eastern and southern edge of the study area (Figure 9A). Notably, many of the communities that had the highest maximum simulated exposure (Figure 4B) have some of the lowest mean annual exposure values (Figure 9A). Like maximum simulated exposure (Figure 4B) and distinct from mean annual exposure (Figure 9A), $cNVC_{worst}$ appears to highlight communities in more populous parts of the Westside (Figure 9B). $cNVC_{worst}$ values ranged from −23,374 to zero and communities in and around the Portland and Seattle metro areas have some of the most negative $cNVC_{worst}$ values, as do communities in coastal Oregon (Figure 9B).

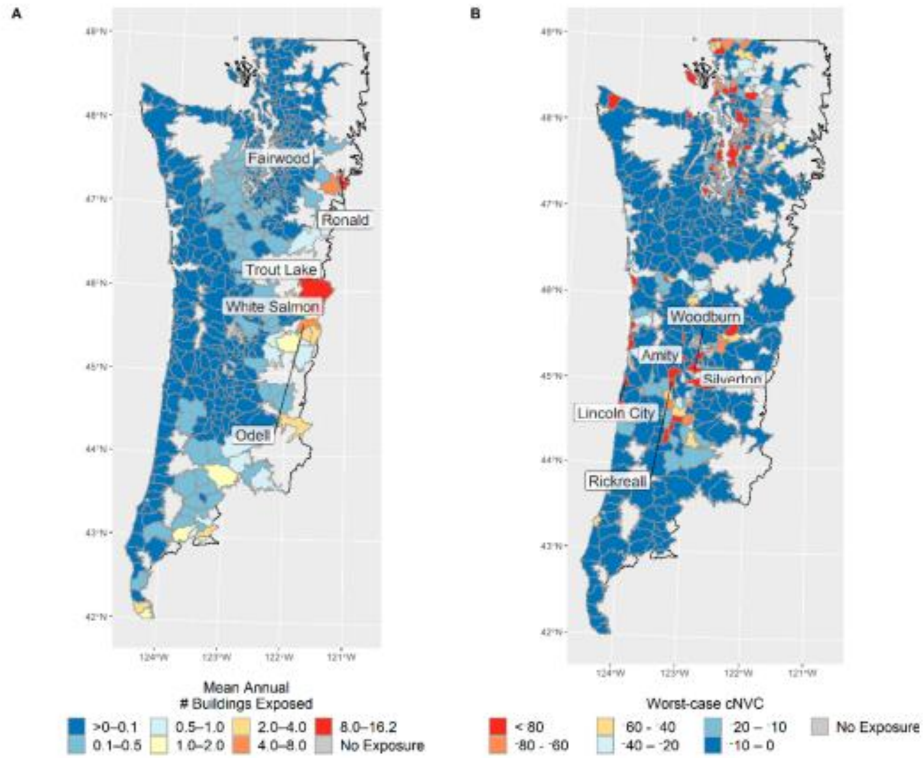

Figure 9. (**A**) mean annual community building exposure; and (**B**) community $cNVC_{worst}$.

4. Discussion

It may seem obvious that Westside communities are, in fact, exposed to wildfire disasters. The 2020 wildfire season and periodic events over the last century have demonstrated the capacity of Westside forests to produce large, intense, and destructive wildfires. Yet, Westside communities are rarely if ever explicitly included in risk and exposure reports that rank communities across the PNW [38,39]; and, when annual burn probability-based wildfire risk is mapped across the PNW, there is little to no visual complexity across Westside landscapes, leaving Westside planners and managers curious about how to characterize their risk [31,79]. The hazard of adhering strictly to actuarial definitions of risk is that the plausibility of surprising fires, the very fires that inevitably have the greatest consequences, is not adequately communicated. So, while the plausibility of Westside disasters is not inconceivable in and of itself, our aim here was to demonstrate the value of specific and intentional methods for characterizing community wildfire risk in low-frequency fire regimes [14,16,20,26]. The concept of anticipating surprises has been applied to Westside wildfire risk when considering the potential impacts of climate change, but here we demonstrated the utility of surprise analysis for contemporary risk, showing that in low-frequency fire regimes with limited empirical records, past fires are by no means a complete projection of plausible disasters in the near future [41]. Planners and managers can use our results, or re-create the analysis for other resources (i.e., water provision infrastructure), to build narrative scenarios and further explore community vulnerability [80,81].

Interestingly, by comparing simulated and historical events in our analysis, we observed that many Westside communities are vulnerable to disasters which are unlike any historical events. Simulated disasters were novel with respect to the specific communities affected and the magnitude of per-fire exposure. Such results might be expected given the paucity of empirical information from areas with low-frequency fire regimes. Over 40% of Westside communities are vulnerable to plausible disasters, including communities in and around the most populous parts of the region and communities with no historical exposure record. For instance, Rochester, WA, which experienced the greatest disaster in the simulations, is listed in [39] as having zero annual residential exposure and which we illustrated in Figure 7 in the lowest category of annual building exposure. Consistent with previous observations that simulated annual building exposure commonly exceeds empirical annual exposure across the western United States, we found that simulated disasters greatly exceeded any historical fire in terms of number of buildings exposed [82].

Our results indicated that future disasters are most likely to be the result of fires that ignite on private land in relatively close proximity to community infrastructure. Despite the fact that this finding is consistent with similarly modeled exposure analyses simulations, it is still somewhat unanticipated for two reasons [38,39,83,84]. First, ignitions in interface or intermix WUI, in close proximity to structures, are generally discovered quickly, agencies can respond efficiently, and, historically, suppression reactions have been particularly strong [85,86]. One explanation for our finding is that FSim uses a perimeter trimming algorithm to simulate the effect of suppression on fire size but it is agnostic of suppression concerns such as proximity to high-value resources or suppression difficulty [46]. A second reason that our results are unanticipated is that they do not obviously align with historical precedent. The majority of historical exposure in our analysis was the result of a handful of fires in 2020 that appear to have ignited on U.S. Forest Service land, although at the time of this writing ignition locations have not been confirmed. Regardless of the land manager associated with their ignition, those few fires (i.e., Beachie Creek and Holiday Farm, Table 1) were very large fires that ignited remote from the communities where they eventually caused enormous exposure (i.e., Springfield and Gates, Figure 4). Given the historical record and the limitations we noted regarding FSim's suppression module, readers might choose to downplay the plausibility of simulated disasters, but we caution against doing so. While the simulated disasters are without obvious precedent in the historical record, they are similar to the Alameda Drive Fire which burned approximately 1200 hectares in southwest Oregon, just outside our study area, but exposed over 1600 buildings, destroyed 700 and claimed four lives. Similar events have not taken place in Westside communities in the historical record, but our results demonstrate that many Westside communities have combinations of fuel continuity and building density capable of facilitating a disaster [74,82,87].

In order to specifically characterize Westside community wildfire risk, we combined probabilistic and surprise analysis techniques. Similar to previous studies, we avoided the limitations of mean-based rankings by using exceedance probabilities help to clearly illustrate plausible outlier events as well as to communicate the likelihood of outlier events [76,82,84,88]. In the instance of Westside community exposure, exceedance probability curves help reinforce the idea that disasters are exceedingly unlikely especially on an annual basis, but are possible and could have extreme consequences. In contrast to mean-based statistics which distill exposure down to a single number, exceedance probabilities illustrate an entire spectrum of exposure for each community [1]. Further, by comparing community annual burn probability with community exposure exceedance probabilities, we demonstrated that the former does not accurately predict or adequately communicate the magnitude of plausible disasters.

Similarly, we included a visual comparison of our exposure metric with $cNVC_{worst}$ which uses methods outlined in [76] to characterize per-fire worst-case scenarios with respect to communities. Even though $cNVC_{worst}$ is intended to communicate wildfire consequences, which exposure does not, our results demonstrate by comparison how $cNVC_{worst}$ is relatively intractable outside the context of a risk assessment, arguably limiting opportunities for effective risk communication. Integrated metrics have gained favor to facilitate prioritization across diverse resources and assets, but other studies have demonstrated examples of ways that simple exposure metrics, as opposed to integrated risk, can be used to prioritize risk reduction activities [40,88].

One limitation of our method that deserves attention is that the simulations we used were performed in 2017, prior to the record-setting fire season of 2020. FSim is a Monte Carlo-style model and generates tens of thousands of versions of a plausible fire season based on recent-historical fire occurrence and climate. Across all those iterations the simulations did produce fires that were novel in terms of size compared to empirical fires in the period 1984–2017 but did not produce any fires as large or synchronous as the four largest in 2020. This could reflect the paucity of historical fire data and extreme weather information available to calibrate FSim. Inclusion of the 2020 fires and their associated weather conditions would most likely have some impacts on future simulations. The weather that fueled Westside wildfires in 2020 was anomalous and does not appear in the weather records used to calibrate the simulations we used [88]. Accordingly, the simulations and our subsequent analysis should not be interpreted as true worst-case scenarios. While downslope winds such as those that fueled the 2020 wildfires in western Oregon are generally considered to have fueled many of the region's most significant historical fires spanning the last century or more, there is no clear linkage with human-caused climate change and no agreement on whether or not similar meteorological events and their consequent fires could become more common [89]. Nonetheless, climate change is expected to increase fuel aridity and susceptibility in the event of future fires, and across the western United states, highly synchronous fire events are increasingly likely and could facilitate disasters not simply because there are more simultaneous fires, but by depleting available national suppression resources [90–92].

Following on the limitation described above, ongoing future research is aimed at developing methods to incorporate rare, historical fires into the FSim calibration process. Generally, large fire size and frequency are calibrated in FSim using a comprehensive dataset of ignition locations and fire sizes for fires in the period 1992–2015 because it is the most complete and spatially explicit dataset that is available [93]. Planned work is aimed at modifying the calibration process to also include pre-1992 fires in the calibration dataset so very rare fires are included in the range of plausible events. Additional future, related research could aim to describe the myriad ways and settings in which risk assessments are designed and outputs are being used. We chose to focus our analysis on a low-frequency fire regime, where risk characterization is particularly challenging. However, the importance of audience-tailored risk communication is important in any natural hazard setting [20,94,95]. As simulated, burn probability-based quantitative risk assessments are increasingly common and the outputs are widely distributed to broad audiences, not just fire managers, for use in diverse planning settings, it is important that wildfire risk scientists continue to deliver information in equally diverse formats to meet broad audience interests [96]. To that end, future work might also seek to describe how different audiences respond to the differences between integrated risk metrics and exposure analyses. Finally, as simulated outputs become increasingly useful in decision support settings and as we learn more about Westside fire regimes, there is an opportunity to update model calibration techniques to include more than just the past 30 years of fire history and to, hopefully, better account for rare events.

5. Conclusions

Characterizing wildfire risk in low-frequency fire regimes is particularly challenging because common mean-based risk assessments do not explicitly communicate the plausibility of low-probability, high-consequence wildfires. In addition, empirical information relied upon to simulate risk that may only cover a few decades of historical records may poorly describe plausible wildfire events. Combining surprise analysis with probabilistic techniques provides an opportunity to anticipate future wildfire disasters while still informing resource prioritization schemes. In this study, we demonstrated the utility of simulations with respect to identifying plausible future Westside community wildfire disasters and found that simulations illustrated exposure events nearly twice as great as any single historical event, and also that nearly 50% of communities are vulnerable to future disasters even though few have experienced exposure in the past four decades. We found that simulated exposure was most commonly the result of ignitions that occurred on private land in forest and intermix WUI types. Finally, comparison of our results with other approaches to risk characterization demonstrated that surprise analysis is complementary and key, and highlighting Westside communities which are otherwise absent from mean-based analyses.

As wildfire risk assessment output applications become increasingly diverse, our results provide one method for adapting them for improved risk communication in landscapes where wildfire is an infrequent threat. Future work could aim to better understand and characterize other forms of empirical information to calibrate models, as well as the myriad applications of wildfire risk assessment outputs and, further, could aim to better understand how diverse audiences respond to different risk characterization methods.

6. Patents

This section is not mandatory but may be added if there are patents resulting from the work reported in this manuscript.

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Appendix 5: What is Firewise USA®? – Oregon.gov

https://www.oregon.gov/osp/Docs/Firewise-the%20program.pdf

NFPA

FIREWISE USA®

RESIDENTS REDUCING WILDFIRE RISKS

A framework to help residents get organized, find direction, and take action to increase the ignition resistance of their homes and community.

- Started in 2002
- 12 original pilot sites, 9 are still active
- Partnership between NFPA, USFS, DOI, and NASF.

Goal:

Preventing the destruction of homes during a wildfire event

Program based in science

- Research by Dr. Jack Cohen (USFS, retired)
  - Fire does not engulf everything in its path
  - Fire only advances to locations that meet requirements of combustion
  - Altering the type, size, quantity, and spacing of vegetation and other fuels will reduce likelihood of combustion

- Research by the Insurance Institute for Business and Home Safety (embers)
  - https://disastersafety.org/wildfire/protect-your-home-from-wildfire/

- Individual responsibility
- Encourages neighbors to work together
- Voluntary participation
- A means to decrease risk for residents and first responders

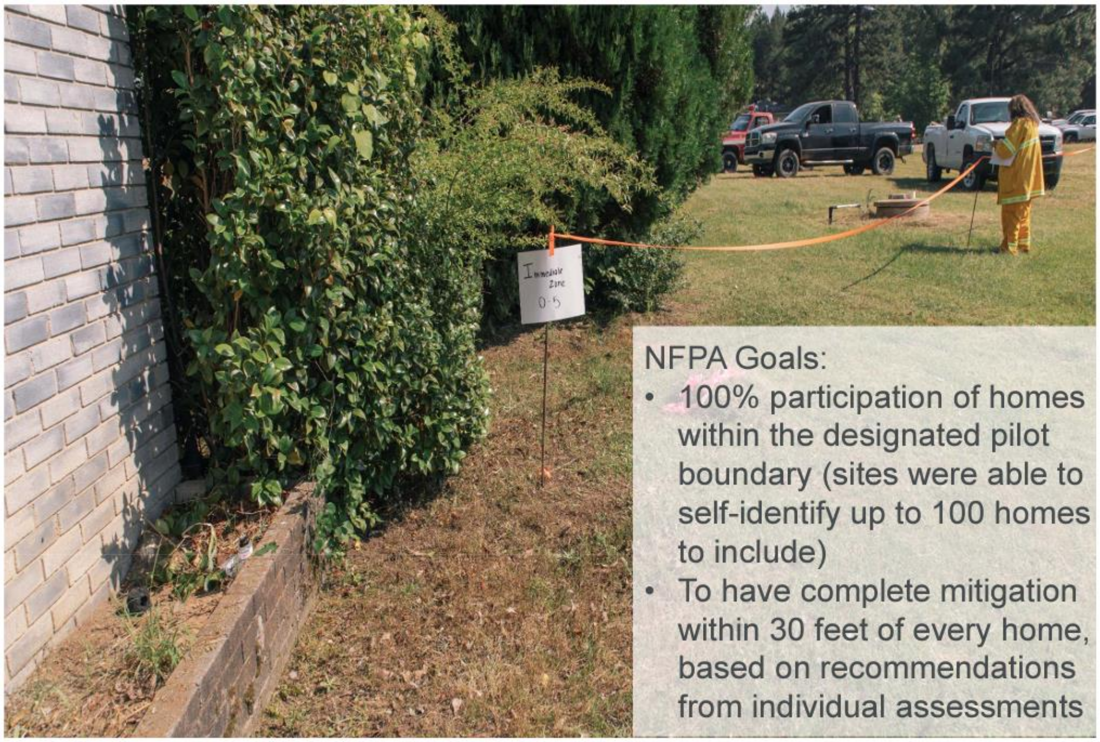
What does the program look like today?

- Active in 42 states, 1,659 sites at the close of 2019
- Emphasis on the importance of the home and work done 0-5 feet from the base
  - Post-fire research tells us these are the critical areas to address
- Quality over quantity

New 24-month pilot program

2019 & 2020, partnering with 7 sites from 7 states

Increase resident participation in active wildfire risk reduction through a focused approach.



 9

Firewise Success

- Blogs – examples of communities that have face wildfires and survived, largely in thanks to their efforts
  - www.community.nfpa.org/community/fire-break/blog
  - Always looks for stories to share
- Video - Falls Creek, Durango, CO

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Thank you!!!

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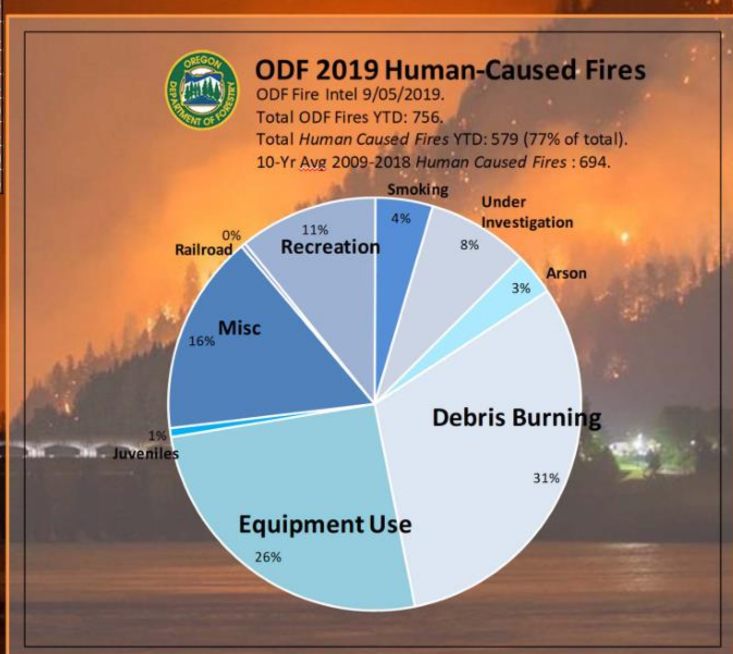
11

Arson	19	4.93
Debris Burning	180	628.21
Equipment Use	148	407.7
Juveniles	4	1.22
Lightning	177	1438.87
Miscellaneous	91	171.04
Railroad	2	.01
Recreation	63	13219.74
Smoking	26	2.89
Under Invest	44	614.14
Other	2	0
Grand Total	**756**	**16488.75**



This can happen when wildfire comes your way.....

Remember: Fires are naturally occurring part of forest ecosystems and retain forest health.

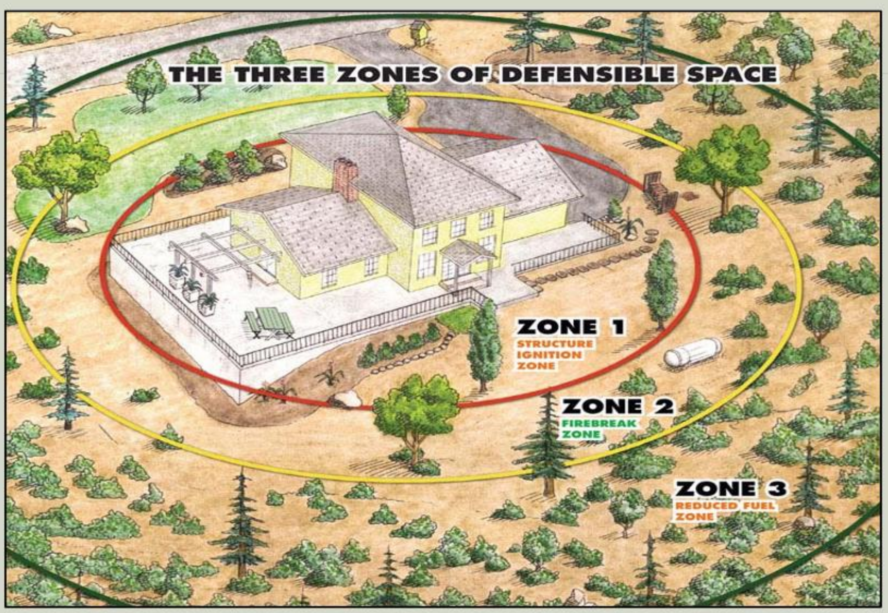
Or with Defensible Space...

What is Firewise Community?

- A community taking initiative.
- Positive collaboration: take action <u>before</u> a fire.
- Action plan and fire planning.
- Enhances prevention, response, and recovery from fire.
- Education and awareness.
- Access to Resources.

Things to do on your property to be more fire safe.

- Create Defensible Space- 30-100 foot of fire resistant space around the home.




The USAA insurance has recognized Firewise Communities through insurance discounts!
USAA gives homeowners insurance discounts to communities recognized by the Firewise Communities/USA® program. Evaluates risk through assessment tools and WSDProapp available on usaa.com and applies premium discounts to USAA policy holders.
USAA
USAA


Firewise Benefits?
1. Creates a Framework for Action
Action Plan/ CWPP
Ready, Set, Go
2. Learning About Wildfire:
Assessments
Education
3. Peace of Mind
Organization vs. Panic
Safer/ Knowledgeable
4. Community-Building
Firewise education
Cleanup day
Common Goals

Firewise Benefits?

5. Citizen Pride
Self-accountability
Plaque/Annual Renewals

6. Publicity
Firewise USA Nationally
Plaque/Recognized
Signage

7. Access to future Funding and Assistance
Wildfire Preparedness
Day Grant Funding

Requirements for Firewise USA

- **Community Assessment** done by Fire Experts (local Fire Department or ODF) and community leaders. (updated every 5 yrs.)
- **Create a Board** or Committee that includes residents.
- **Action plan** developed as a multi-year plan (that needs to be updated every 3 years).
- **Firewise Day:** Minimum of one wildfire risk reduction educational outreach event or fuels reduction event annually.
- **Minimum of 8 dwelling units** with a max of 2,500.
- **Minimum of one volunteer hour** ($25.43) per each participating dwelling unit annually.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Questions?
FIREWISE USA
Residents reducing wildfire risks