Introduction to Quantitative Wildfire Risk Assessments and Community Exposure

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Objectives of today’s discussion

1. Introduce common terminology in wildfire risk sciences

2. Develop a working knowledge of how quantitative wildfire risk assessments are conducted

3. Understand how climate, fuels, weather and topography are included in wildfire risk assessments
Roadmap

Part I: Introduction
  – background
  – process and terminology

Part II: 2017 PNW QWRA as an example

Part III: Linkages to the WUI
  – Community exposure

Part IV: Conclusions/Questions
Where do we have decision space?

1. How often should we update the fire hazard assessment?
2. Do we assess today’s conditions that reflect recent large fires, like Bootleg, which will show the community of Sycan Estates as having low burn probability for 5 – 10 years, or fuel conditions that will develop as the forest regenerates?
3. Is a structure evaluated at its location only, or within some specified distance around the structure.
4. Research has shown ember showers are a major contributor to structure ignition. Do we want to make an attempt to incorporate this exposure as well, specifically for those structure not directly exposed to a flaming front?
5. How do we handle fuels in areas like the Willamette Valley? There are many grass seed fields that used to be burned by farmers but that practice has diminished. Should we model these at their peak loadings before harvest, or after?
6. Do we determine exposure on burn probability only, or burn probability and fire intensity?
7. Do we want to assess fire intensity at peak levels or with the central tendency of fire intensity across all simulated fires?
2020 Holiday Farm fire
Part I: Introduction
Part I: Introduction
Risk management process
Fundamentals of wildfire risk assessments

Wildfire risk vs. hazard
- Hazard assessment vs. effects analysis/valuation
- Burn probability
- Fire intensity
- Susceptibility
  - Response functions
- Relative importance
- Conditional net value change (cNVC)
- Expected net value change (eNVC)

Home/community exposure
cNVC: a formal system for quantifying fire risk

Wildfire risk vs. hazard
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- Fire intensity
- Susceptibility
  - Response functions
- Relative importance
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- Expected net value change (eNVC)

Home/community exposure

Scott et al. 2013
Part II: A relevant example to reinforce these concepts

Pacific Northwest Quantitative Wildfire Risk Assessment: Methods and Results

Prepared by:
Julie W. Gilbertson-Day, Joe H. Scott, Kevin C. Vogler, and April Brough
Pyrologix LLC
Fire intensity

– measured by flame length
<table>
<thead>
<tr>
<th>HVRA &amp; Sub-HVRA</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infrastructure</strong></td>
<td></td>
</tr>
<tr>
<td>Electric transmission lines – high &amp; low voltage</td>
<td>Electric Power Transmission Lines extracted from the Homeland Security Infrastructure Program (HSIP) database.</td>
</tr>
<tr>
<td>Railroads</td>
<td>Railroad features extracted from the Homeland Security Infrastructure Program (HSIP) database.</td>
</tr>
<tr>
<td>Roads – Interstates and State highways</td>
<td>Interstates and highways extracted from the Homeland Security Infrastructure Program (HSIP) database. Removed smaller roads (SHIELD_CL=0) from highways.</td>
</tr>
<tr>
<td>Communication sites and cell towers</td>
<td>Communication sites, towers, and antennas and cell towers extracted from the Homeland Security Infrastructure Program (HSIP) database.</td>
</tr>
<tr>
<td>Seed orchards</td>
<td>Extracted from the Pacific Northwest Region Corporate database to represent seed orchard assets across the Region.</td>
</tr>
<tr>
<td>Sawmills</td>
<td>Wood Product Manufacturing Facilities extracted from the Homeland Security Infrastructure Program (HSIP) database.</td>
</tr>
<tr>
<td>High and low developed rec sites</td>
<td>Recreation sites/structures mapped by USFS, USFWS, NPS, BLM, ODF, and DNR and including state, county, and local parks and campgrounds. High vs. low investment level assigned based on dataset attributes.</td>
</tr>
<tr>
<td>Ski Areas</td>
<td>OR and WA ski area boundaries, digitized outer edge and infrastructure using Google Earth imagery</td>
</tr>
<tr>
<td>Historic buildings</td>
<td>Historic buildings as recorded by the National Register of Historic Places</td>
</tr>
<tr>
<td><strong>People and Property</strong></td>
<td></td>
</tr>
<tr>
<td>Where People Live (WPL) by density class</td>
<td>Housing density classes as developed by the West Wide Wildfire Risk Assessment project.</td>
</tr>
<tr>
<td>USFS Private Inholdings</td>
<td>Private inholdings on USFS lands extracted from the Basic Ownership layer by querying &quot;NON-FS&quot;. NPS lands were removed from the NON-FS lands before including in this dataset. Refined to private ownership using BLM Ownership (OWNERSHIP_POLY) and BLM Surface Management Agency (BLM_SMA_FS_update).</td>
</tr>
<tr>
<td>Timber</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Tribal Owned/Colville Reservation Commercial Timber</td>
<td>American Indian/Alaska Native/Native Hawaiian (AIANHH) Areas Shapefile from U.S. Census Bureau as Tribal ownership overlay along with Colville Reservation Commercial forestland</td>
</tr>
<tr>
<td>Private Industrial</td>
<td>Privately owned, industrial timber lands extracted from the Atterbury Consultants ownership maps for Oregon and Washington (selected attributes containing IFPC, REIT, and TIMO)</td>
</tr>
<tr>
<td>BLM Harvestable/Potential</td>
<td>Harvest Land Base from the ROD for western OR, O&amp;C lands, Coos Bay Wagon Rd, Public Domain lands, and the BLM-owned polygons from the E. WA Resource Management Plan.</td>
</tr>
<tr>
<td>Fire Regime Groups 1,3,4/5</td>
<td>R6 Forest Structure Restoration Needs Update Analysis – (DeMeo et al., In Press)</td>
</tr>
<tr>
<td>Size classes &lt;10in., 10-20in., &gt;20in.</td>
<td>R6 Forest Structure Restoration Needs Update Analysis – (DeMeo et al., In Press)</td>
</tr>
</tbody>
</table>

| Vegetation Condition          |                                                                                       |
| Seral state departure by FRG group | R6 Forest Structure Restoration Needs Update Analysis – (DeMeo et al., In Press) |
Table 4. (Continued) HVRA and sub-HVRA identified for the Pacific Northwest Region wildfire risk assessment and associated data sources.

| Watersheds                                                                 | Washington Drinking Water System Boundaries for watershed boundaries and surface water intake locations  
                                                                                                      | Oregon Surface Drinking Water Source Areas and intake locations from EPA Safe Drinking Water Information System (SDWIS)  
                                                                                                      | Developed by USFS Remote Sensing Applications Center (RSAC)  
| Wildlife                                                                   | U.S. Fish and Wildlife Service, Endangered Species Program, ECOS Joint Development Team  
                                                                                                      | Predicted habitat suitability map (Glenn et al., 2017)  
                                                                                                      | Wildland Fire Decision Support System (WFDSS) - 2015 greater sage grouse (GRSG) Land Use Plan (LUPs) Allocations  
                                                                                                      | USDA - Natural Resources Conservation Service, Index of Relative Ecosystem Resilience and Resistance across Sage-Grouse Management Zones  
                                                                                                      | StreamNet Generalized Fish Distribution, Bull Trout (January 2012)  
                                                                                                      | U.S. Fish and Wildlife Service, Endangered Species Program, ECOS Joint Development Team  
                                                                                                      | U.S. Fish and Wildlife Service, Endangered Species Program, ECOS Joint Development Team  
                                                                                                      | U.S. Fish and Wildlife Service, Endangered Species Program, ECOS Joint Development Team  
                                                                                                      | Non-Anadromous Redband Trout (RBT) Range-wide Database - ODFW  
                                                                                                      | StreamNet Generalized Fish Distribution, Coastal Cutthroat Trout (January 2012) -  
                                                                                                      | StreamNet Generalized Fish Distribution, Lahontan Cutthroat Trout (January 2012)  
| Bull trout                                                                 |  
| Chinook salmon                                                             |  
| Coho salmon                                                                |  
| Steelhead trout                                                            |  
| Redband trout                                                              |  
| Coastal cutthroat trout                                                    |  
| Lahontan cutthroat trout                                                   |  

### Table 6. Response functions for the Infrastructure HVRA to highlight electric transmission lines.

<table>
<thead>
<tr>
<th>Sub-HVRA</th>
<th>FIL1</th>
<th>FIL2</th>
<th>FIL3</th>
<th>FIL4</th>
<th>FIL5</th>
<th>FIL6</th>
<th>Share of RI(^1)</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trans-Line- High voltage</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>-10</td>
<td>-50</td>
<td>-70</td>
<td>40.86%</td>
<td>905,585</td>
</tr>
<tr>
<td>Trans-Line- Low voltage</td>
<td>-10</td>
<td>-20</td>
<td>-50</td>
<td>-70</td>
<td>-80</td>
<td>-90</td>
<td>16.79%</td>
<td>743,972</td>
</tr>
<tr>
<td>Railroads</td>
<td>-10</td>
<td>-20</td>
<td>-30</td>
<td>-40</td>
<td>-50</td>
<td>-50</td>
<td>16.57%</td>
<td>612,073</td>
</tr>
<tr>
<td>Interstates</td>
<td>0</td>
<td>-5</td>
<td>-10</td>
<td>-15</td>
<td>-20</td>
<td>-30</td>
<td>4.74%</td>
<td>175,191</td>
</tr>
<tr>
<td>State Highways</td>
<td>0</td>
<td>-5</td>
<td>-10</td>
<td>-15</td>
<td>-20</td>
<td>-30</td>
<td>12.98%</td>
<td>958,745</td>
</tr>
<tr>
<td>Communication Sites/Cell Towers</td>
<td>-10</td>
<td>-30</td>
<td>-60</td>
<td>-80</td>
<td>-100</td>
<td>-100</td>
<td>3.65%</td>
<td>80,924</td>
</tr>
<tr>
<td>Seed Orchards</td>
<td>-50</td>
<td>-90</td>
<td>-100</td>
<td>-100</td>
<td>-100</td>
<td>-100</td>
<td>0.02%</td>
<td>2,704</td>
</tr>
<tr>
<td>Sawmills</td>
<td>-10</td>
<td>-20</td>
<td>-30</td>
<td>-40</td>
<td>-60</td>
<td>-80</td>
<td>0.10%</td>
<td>1,448</td>
</tr>
<tr>
<td>Ski Areas</td>
<td>0</td>
<td>-10</td>
<td>-20</td>
<td>-40</td>
<td>-60</td>
<td>-80</td>
<td>0.44%</td>
<td>16,175</td>
</tr>
<tr>
<td>Recreation High Developed</td>
<td>-10</td>
<td>-30</td>
<td>-70</td>
<td>-90</td>
<td>-100</td>
<td>-100</td>
<td>1.93%</td>
<td>26,793</td>
</tr>
<tr>
<td>Recreation Low Developed</td>
<td>-10</td>
<td>-30</td>
<td>-70</td>
<td>-90</td>
<td>-100</td>
<td>-100</td>
<td>1.17%</td>
<td>129,886</td>
</tr>
<tr>
<td>Historic Structures</td>
<td>-30</td>
<td>-50</td>
<td>-70</td>
<td>-100</td>
<td>-100</td>
<td>-100</td>
<td>0.73%</td>
<td>8,140</td>
</tr>
</tbody>
</table>

\(^1\) Within-HVRA relative importance.

The share of HVRA importance is based on relative importance per unit area and mapped extent.
Integrating HVRAs with differing units of measure (for example, habitat vs. homes) requires relative importance (RI) values for each HVRA/sub-HVRA. These values were identified in the RI workshop, as discussed in Section 3. The final importance weight used in the risk calculations is a function of overall HVRA importance, sub-HVRA importance, and relative extent (pixel count) of each sub-HVRA. This value is therefore called relative importance per pixel (RIPP).

The RF and RIPP values were combined with estimates of the flame-length probability (FLP) in each of the six flame-length classes to estimate conditional NVC (cNVC) as the sum-product of flame-length probability (FLP) and response function value (RF) over all the six flame-length classes, with a weighting factor adjustment for the relative importance per unit area of each HVRA, as follows:

\[ cNVC_j = \sum_{i}^{n} FLP_i \times RF_{ij} \times RIPP_j \]

where i refers to flame length class (n = 6), j refers to each HVRA, and RIPP is the weighting factor based on the relative importance and relative extent (number of pixels) of each HVRA. The cNVC calculation shown above places each pixel of each resource on a common scale (relative importance), allowing them to be summed across all resources to produce the total cNVC at a given pixel:

\[ cNVC = \sum_{j}^{m} cNVC_j \]

where cNVC is calculated for each pixel in the analysis area. Finally, eNVC for each pixel is calculated as the product of cNVC and annual BP:

\[ eNVC = cNVC \times BP \]
Part II: Ex. Relative importance

PP = people and property
INFRA = infrastructure
WATER = H₂O
TIMBER = timber
WILD = wildlife habitat
VC = vegetation condition

Figure 8. Overall HVRA Relative Importance for the primary HVRAs included in PNRA
Part III: Linkages to the wildland-urban interface
Exposure to wildfire

Any structure/community with a greater than zero burn probability has exposure

Can stratify exposure based on burn probability and fire intensity

Can stratify communities based on number of exposed homes and burn probability, or burn probability integrated with fire intensity

2018 Camp Fire
### Generalized Susceptibility

<table>
<thead>
<tr>
<th>Wildfire intensity (flame length)</th>
<th>Assumed damage to homes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 2 feet</td>
<td>25%</td>
</tr>
<tr>
<td>2 - 4 feet</td>
<td>40%</td>
</tr>
<tr>
<td>4 - 6 feet</td>
<td>55%</td>
</tr>
<tr>
<td>6 - 8 feet</td>
<td>70%</td>
</tr>
<tr>
<td>8 - 12 feet</td>
<td>85%</td>
</tr>
<tr>
<td>&gt;12 feet</td>
<td>100%</td>
</tr>
</tbody>
</table>

[https://wildfirerisk.org](https://wildfirerisk.org)
Community exposure

![Graph showing estimated housing units exposed to wildfire versus burn probability.](image)

Map of California showing top 25 ranked NCRP Communities and other NCRP Communities with total potential housing units exposed. Burn Probability is indicated by color:

- 0
- 0 - 0.01
- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.04
- 0.04 - 0.05
- 0.05 - 0.06
- 0.06 - 0.07
- 0.07 - 0.08
- 0.08 - 0.105417304
Community exposure

Estimated # Housing Units Exposed to Wildfire

Burn probability

Part III: Structure/community exposure

Top 25 Ranked NCRP Communities
- Total potential housing units exposed
  - > 0 - 1000
  - >1000 - 2500
  - >2500 - 5000
  - >5000 - 10000
  - >10000 - 25000
  - >25000 - 66394

Other NCRP Communities
- Total potential housing units exposed
  - > 0 - 1000
  - > 1000 - 2500
  - > 2500 - 5000
  - > 5000 - 10000
  - > 10000 - 25000
  - > 25000

Source of Exposure
- Total housing units exposed in simulated fires
  - 0
  - > 0 - 10
  - > 10 - 50
  - > 50 - 100
  - > 100 - 500
  - > 500 - 1000
  - > 1000 - 2500
  - > 2500

Forest Service Administrated Lands
Where do we have decision space?

1. How often should we update the fire hazard assessment?
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Our decision space

State of California adopted new codes in 2007, took effect on new construction in 2008

Contemporary climate
Initial attack (IA) “Success” & Implications

IA Efficiency largely unchanged, but:
- Fire are more expensive
- Fires now cause more damage
- Fuel conditions dramatically changed (stand-landscape)

IA success never be 100%. We will always have big fires.