The National Hazard and Risk Model (No-HARM) is a decision support tool for wildfire hazard and risk assessment. Incorporating the predicted severity (hazard) and the predicted frequency (risk) of wildfire in a given location, No-HARM gives a comprehensive view of the threat context a structure is exposed to.

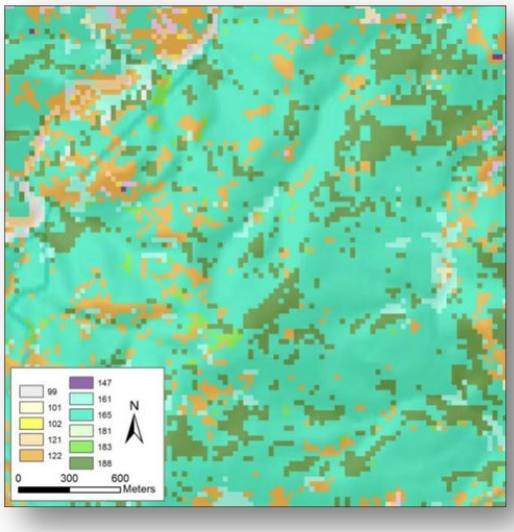

Figure 1: Fuel model data showing the typical pixel-based nature of this type of input data

Many wildfire-related data sets are delivered in a format that breaks the landscape up into squares or pixels (Figure 1). This approach typically allows wide variation from square to square on the landscape. A square (or pixel) has very little to do with how a fire burns and the variation from square to square can be difficult to interpret. No-HARM takes a different approach. All of the data sets which No-HARM uses to create the final analysis (many of which come in the "squares" format) are integrated into shapes on the landscape that actually have something to do with how wildfires burn.

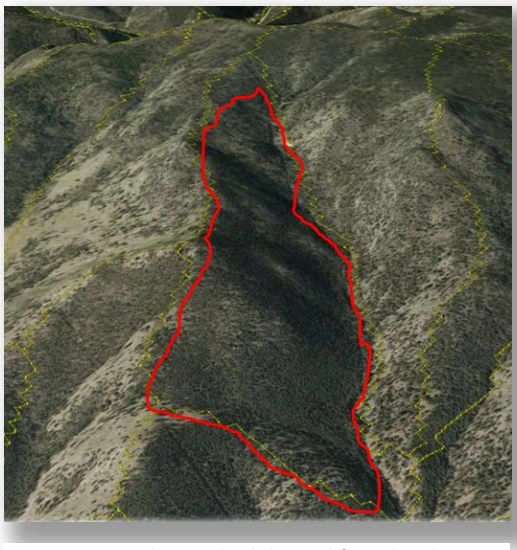

Figure 2: Sample FireShed derived from local topography

No-HARM divides the data up into "FireSheds" (Figure 2) that are based on the topography (hills and valleys) of the landscape. These FireSheds tend to correlate to the vegetation and the directions that fires will burn in the absence of wind. This means that FireSheds divide the landscape up into like planning units. The wildland and intermix modules of No-HARM (see below) use FireSheds to aggregate the landscape.

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No-HARM also accounts for the fact that FireSheds experience wildfire hazard and risk from outside their boundaries (Figure 3). A FireShed may contain mostly grass meadow but be surrounded by dense forest. If a house is built in the meadow, it is not only subject to the threat from the grass fuel in the meadow, it is also subject to the threat from the timber fuel in the surrounding FireSheds. Because of this, No-HARM incorporates the threat from surrounding FireSheds into the threat profile for every adjacent FireShed.

No-HARM uses the concept of dividing the landscape based on the relative amount of built environment (structures, roads and other infrastructure) vs. wildland fuels. The rationale for this distinction is that wildland fires behave differently when burning in pure wildland fuels than when burning through fuel interrupted by structures and roads. Similarly, suppression of wildland fires is conducted differently, and with varying degrees of success, when in remote areas compared with densely-populated areas. These differences are captured in No-HARM by categorizing the landscape into three separate threat types, each of which is modeled with its own individual set of inputs and associated methodology. The three threat types are divided into the following modules of the model: **Wildland**, **Intermix** and **Interface** (Figure 4).

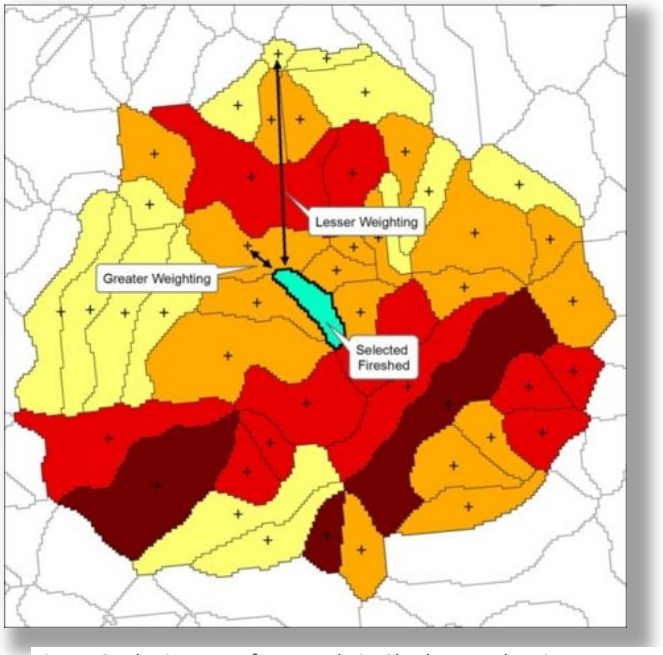

Figure 3: The impact of external FireSheds are taken into account in assigning the overall rating.

The **Wildland** module (Figure 4) operates in areas that are best represented by relatively continuous fuel with limited presence of structures, roads and other human-caused disturbances. Relatively few people live in these areas which limits one type of ignition source (anthropogenic) but any structures that are

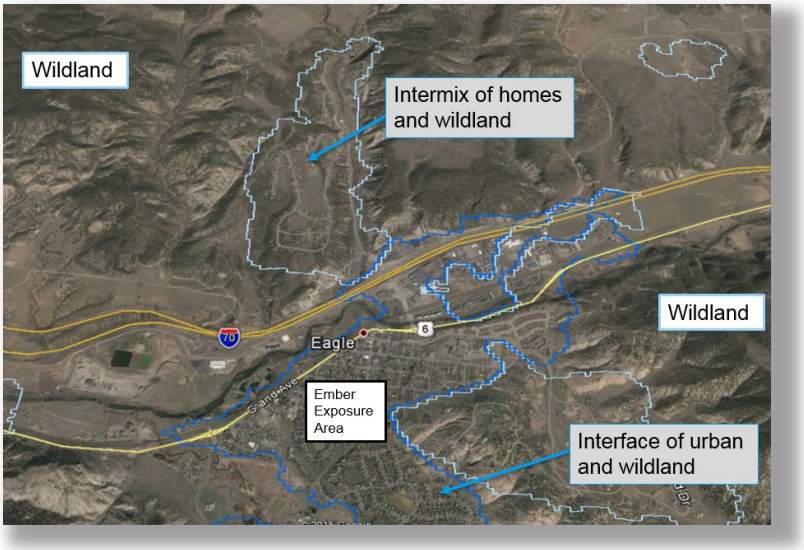

Figure 4: Landscape divided into Wildland, Intermix and Interface areas

located in these areas are surrounded by fuel. Depending on weather and topography (both accounted for in No-HARM), this can make suppression difficult or impossible. Potential mitigation measures are typically focused on treatment of the vegetation immediately surrounding a structure and hardening of the structure itself. Fires occurring in the **Wildland** will typically burn uninterrupted until conditions are no longer favorable or until the fire moves into less volatile fuel.

The relative absence of the built environment in the **Wildland** module means that the factors included are mostly related to the fuel, topography and typical weather patterns along with the history of wildfires experienced in a given area. The one nod to the influence of suppression capabilities in this module is the distance to the nearest fire station.

Primary Wildfire Risk Measures:

- RISKDESC – This is a measure of threat due to wildfire that is broken up into 4 descriptive categories: Wildland Low, Wildland Moderate, Wildland High and Wildland Very High. This category is appropriate when the data are being used for a general overview or when the audience is not familiar with No-HARM or wildfire hazard and risk rating in general.
- RISK50 – This field is for displaying more detail in the data or when greater refinement is desired. In this field, the wildfire threat is broken into 50 values (1-50). This field is good for mapping patterns when it is not necessary to know the exact value based on the color (human eyes can't differentiate 50 colors effectively).

Other Factors:

- SEVERITY – This module input is an estimate of how severe fire behavior would be in the event of an ignition. Factored into this estimate is the topography (slope, aspect and

elevation), the prevailing weather patterns in the area (based on readings at weather stations located nation-wide) and the fuel type present (40 different subsets of grass, shrub and timber vegetation types). (1 is the lowest severity, 50 is the highest)

- FREQUENCY – The Frequency input is designed to indicate the relative likelihood that a fire requiring suppression will occur on the landscape. To map this likelihood a combination of Probability of Ignition and Rate of Spread predictions were used. Probability of Ignition refers to how likely it is that an ember will ignite in each location. It is based on historic weather patterns along with topographic factors such as slope, aspect, and elevation. Higher Probability of Ignition means that a fire is more likely to start.

  Probability of Ignition, by itself, doesn't tell the whole story, however. The probability of an ignition causing a wildfire that requires suppression is also dependent on how fast a fire will grow once an ignition has started. This growth rate is captured in No-HARM by with the addition of Rate of Spread predictions. Higher Rates of Spread make it more likely that a fire grows to a problem size before fire fighters can arrive to put it fire out. Combining Probability of Ignition patterns with those of Rate of Spread allows No-HARM to map where fires are more or less likely on the landscape. (1 is the least likely, 50 is the most likely)

- FSTATPROX – The only human-related variable in the **Wildland** module is the distance to the nearest fire station. Structures located nearer to fire stations may have a greater probability of a successful wildfire suppression or structure protection effort. (1 is closer to a fire station and 50 is farther away)
- CROWNFIRE – Crown fire activity, whether in the form of isolated trees or clumps of trees or the complete involvement of the canopy, represents a worst-case scenario in terms of fire behavior. (Low, Moderate and High)
- NONBURN – The amount of non-burnable area (mostly agricultural and urban) in the fireshed. Greater percentages of non-burnable area have a mitigating impact on the overall risk rating. (Low, Moderate and High) Note: "High" in this field refers to the magnitude of non-burnable area which, for this factor, represents a mitigating impact on wildfire risk. This is the opposite of the CROWNFIRE factor above where "High" refers to a greater magnitude of Crown Fire, which would be an aggravating effect on wildfire risk.
- VEG_MODS – Modification of vegetation through purposeful fuel treatment, as a by-product of a particular land use (eg. golf courses) or as a natural element (bare ground or open water) should be reflected in the overall risk rating of an area. VEG_MODS is an effort to capture these factors in the landscape. Included in this layer are manually digitized human-disturbed areas (golf courses, mines, other industrial areas) and

lakes/rivers and bare ground (from the fuel data set used for fire behavior analysis). Each of these polygons is assigned a maximum point value based on the amount of disturbance (a golf course or lake gets more points than a timber thinning project). Each FireShed in No-HARM is then assigned a composite vegetation modification (VEG_MODS) rating based on the number, point value and distance away from these "treated" polygons. (Present, Absent)

- MOD_POINTS – This field, along with MOD_NOTES (see below) is an effort to give the client the opportunity to modify the data over time. These modifications may arise from a disagreement with No-HARM's ratings or from a change in status of ratings in FireSheds. Regardless, these two columns are provided so that No-HARM ratings can be altered by authorized personnel to document changes. More detailed instructions for how to use this field will be given below, however, the purpose of MOD_POINTS is to record the number of points (positive or negative) that should be added to or subtracted from the overall risk rating (RISK50). (This field is set to zero to start, but is intended to be altered by the user as the need arises.)
- MOD_NOTES – While the MOD_POINTS field is used to record a number of points, the VEG_NOTES field is for recording the reason that the points in VEG_POINTS were added or subtracted from the RISK50 rating. This is so that the user can go back and look at the field in the future to determine what changes have been made to a particular FireShed. (Blank to start, populated by user, 254 text character limit)

The **Intermix** module is characterized by a higher density of structures, roads and other infrastructure breaking up the continuity of natural fuel on the landscape. Threats to values-at-risk in this module focus not only on fuels, but also on the complexity of suppression in this environment. Higher road densities allow better access for suppression resources, but they also introduce an element of potential confusion for access and egress. Suppression strategies in **Intermix** areas must account for groups of houses as opposed to single structures as might be encountered in the **Wildland**. Along with suppression complexities, the presence of greater numbers of people in the **Intermix** also can mean a higher risk of ignitions due to barbecues, fireworks, matches, etc. The **Intermix** module accounts for this added complexity and added built environment by adding a greater number of appropriate input data sets. The inclusion of these added input data sets in conjunction with the wildland data sets (mentioned above) as a "baseline" threat profile, captures the threat to structures in areas represented by this fuel/structure mixture.

Primary Wildfire Threat Measures:

- RISKDESC – This is a measure of threat due to wildfire that is broken up into 4 descriptive categories: Intermix Low, Intermix Moderate, Intermix High and Intermix Very High. (see above for further description).

- RISK50 – see above

Other Factors:

- SEVERITY – see above
- FREQUENCY – see above
- FSTATPROX – see above
- TOTPTS – This is the total number of points, aggregated from all of the following fields. The total point value is added to or subtracted from (depending on the sign of the value) the baseline risk value (calculated using SEVERITY, FREQUENCY and FSTATPROX).
- ASPECT – The direction a slope faces can influence how wet or dry it is both daily and seasonally. In the northern hemisphere, south-facing slopes will typically be drier than north-facing slopes. This can have a large impact on the density of fuel and how severe the fire behavior will likely be in the event of a wildfire. (Low, Moderate and High)
- CONTINUITY – Fuel continuity refers to how broken up the fuel in the area is. discontinuous fuel is a mitigating factor for wildfire risk. CONTINUITY captures coarser-scale interruptions in fuels than the VEGCOVER component listed below. (Low, Moderate and High)
- CROWNFIRE – see above
- FOEHN – Some areas are subject to strong, relatively-warm and dry winds that can increase fire behavior, and therefore, risk. Examples of FOEHN winds are the Chinooks of the Rocky Mountains and Santa Anas of southern California. Usually this rating is uniform across the entire area. (All polygons in No-HARM for this project study area are "High.")
- ROADDIST – The distance to the nearest larger road will impact access by suppression resources and ease of evacuation. (Low, Moderate and High)
- SLOPE – Higher slopes make suppression operations more complex/less effective and will also increase fire behavior. (Low, Moderate and High)
- VEGCOVER – Vegetation Cover, a measure of the continuity of fuel, is important because fire will, all other things being equal, burn with more severity and speed through a continuous fuel bed than one that is interrupted by patches of bare ground. VEGCOVER represents fuel at a finer scale than CONTINUITY above. (Low, Moderate and High)
- VEG_MODS – see above
- WATERDIST – Having a rural water source (river, lake, reservoir) closer to a given area will make suppression operations more effective. These water features allow suppression apparatus to be filled more frequently due to shorter drive times and

potential dip sites for helicopters. Hydrant systems are not considered in No-HARM. (Low, Moderate and High)

- MOD_POINTS – see above
- MOD_NOTES – see above

Interface: When structures and roads become the defining elements of a landscape, these areas are assigned to the interface module of No-HARM. Unlike wildland and intermix areas, structures in the interface are primarily threatened by flame impingement on one or two sides, ember cast and smoke from adjacent areas. Fuel does not surround structures and, therefore, the risk to houses is very different. (Note: Individual structures are not assessed directly for flammability.)

Primary Wildfire Threat Measures:

- RISKDESC – This is a measure of threat due to wildfire that is broken up into 3 descriptive categories: Interface Low, Interface Moderate and Interface High (see above for further description).
- RISK50 – This is an attempt to designate values that are on the same 1-50 scale as the Intermix and Wildland RISK50 for interface buffers. Because these values are not modeled explicitly, but are cross-walked from a combination of the TIER and RISK fields, they do not have the same grain (smooth and even distribution of values) that is present in the Intermix and Wildland components.

Factors Considered:

- Adjacent FireShed severity and frequency – see above, not included as fields in the data
- TIER – This refers to the type of threat present (1 (flame impingement/embers/smoke) or 2 (just embers and smoke).
- MOD_POINTS – see above
- MOD_NOTES – see above

Use of the MOD_POINTS and MOD_NOTES Fields

NOTE: Before attempting to edit any fields in the No-HARM shapefiles, we recommend storing an altered version of the data in case anything unintended happens during the editing process and for future comparison.

The MOD_POINTS and MOD_NOTES fields are designed to be used by GIS and wildfire planning personnel to modify the fields supplied in the No-HARM model. The need to change the values in the fields may arise based on a correction to the model using local knowledge or field observation or because the condition within a FireShed polygon has changed since the model was run. It is important to note that, since the data were delivered as data sets without an interface to display and interact with them, they will need to be updated using GIS software and by personnel with a beginning to moderate level of knowledge of how to operate it. Because of the need for knowledgeable GIS personnel to perform this task, detailed explanations of the "button-pushing" aspect of this operation will not be included in this write-up.

There are two fields that will need to be edited in the three (interface, intermix and wildland) No-HARM shapefiles delivered to the client. The MOD_POINTS field will need to be edited with the number of points that will either be added to or subtracted from the RISK50 field to modify the overall hazard rating. The MOD_NOTES field is for recording a memo of why the points were added or subtracted. MOD_POINTS is designed to hold a signed (positive or negative) integer since RISK50 is also an integer field. MOD_NOTES can hold up to 254 characters of text. The procedure, then, would be to determine the number of points that need to be added (positive integer) or subtracted (negative integer). Once the points are entered into the MOD_POINTS field, the reasoning for the adjustment should then be edited into the MOD_NOTES field. In the event that multiple reasons for adjusting the points is found, the two point values should be added together and the sum entered into the MOD_POINTS field. The multiple reasons (and probably their individual integer values) should be stored in the MOD_NOTES field for future reference.

Just editing the MOD_POINTS field will not be enough to change the rating of a given FireShed or interface buffer. The MOD_POINTS value must be added or subtracted from (We suggest storing positive integers for factors that increase the overall risk and negative integers for mitigating factors. This allows the user to add the MOD_POINTS to the RISK50 column rather than have to keep track of whether to add or subtract.) the RISK50 column. Be sure to keep track of which FireSheds have had their MOD_POINTS values added/subtracted from RISK50 – you don't want to do this operation more than once and there is nothing to indicate that it has already been done.

Once the MOD_POINTS values have been added/subtracted from RISK50, there is one final step that has to be taken to ensure that the data base is updated properly. Since RISK50 values are used directly to assign the RISKDESC adjective ratings, it is necessary to also update the RISKDESC field to ensure that any point modifications have not changed an adjective rating. The following table can be used to update the RISKDESC ratings:

RISK50 0-9 : Low

RISK50 10-23 : Moderate

RISK50 24-35 : High

RISK50 >35 : Very High

Note that these ratings are generic descriptions that can used for both wildland and intermix (and technically interface). In order to get the correct value in the RISKDESC field, “Interface,” “Intermix” or “Wildland” should be placed before the ratings in the table above. Editing the RISKDESC field completes the modification process.

The following example is provided to capture the work flow of the steps above. It is hypothetical, but is designed to represent a real-life example. Let’s say that wildfire planning personnel decide that an intermix No-HARM FireShed, currently assigned a RISK50 value of 20 and a RISKDESC value of “Intermix Moderate,” is underestimated based on their knowledge of the community in that FireShed. The wildfire planning personnel have decided that, because most of the houses in the FireShed have older cedar shake roofs/combustible siding AND most of the houses are exposed to overhead power lines, the rating in this FireShed ought to be higher. The wildfire planning personnel go to the GIS department and ask a GIS tech for help in modifying the ratings. The GIS tech, wisely, makes a copy of the three shapefiles that were delivered to the client. She then starts to edit the shapefile. The wildfire planners have decided that the lack of ignition-resistant construction should add 4 points to the rating while the above-ground propane tanks is worthy of a 2 point increase. The tech, having read the above instructions, knows that the first step is to add the two point values (construction and propane tank) together to get 6 points. This number is then entered into the MOD_POINTS field (if the points had been mitigating factors such as abundant turn-around and pullouts for engines or the presence of defensible space around homes, the values would have been negative). The MOD_NOTES field is then updated with something like “4 points were added for construction type and 2 points were added for above-ground propane tanks.” Next, the RISK50 field contents are added to the MOD_POINTS field contents to get a new rating of 26 (20 + 6 = 26 points). The GIS tech checks the table above and notices that the transition from 20 to 26 crosses a boundary for adjective ratings shifting the FireShed from an “Intermix Moderate” to an “Intermix High.” The GIS tech then edits the RISKDESC field to update the adjective description. The above example is for a single FireShed. If multiple FireSheds are being edited simultaneously, the process can be made more efficient by performing some of the operations above at the end of the procedure rather than individually.