COMMUNITY WILDFIRE PROTECTION PLANS: MODELING LANDFIRE, GIS, AND COMMUNITY VALUES

Heather Timmons and Joseph Fluder
SWCA Environmental Consultants

ABSTRACT:

Many geographic information system-based (GIS-based) methods have been used when developing Community Wildfire Protection Plans (CWPPs) since the Healthy Forest Restoration Act was signed into law in 2003. CWPP wildfire risk assessments are flexible and diverse, and are developed by individual communities in a collaborative process involving multiple government agencies, stakeholders, and private landowners. Rather than using only derivations of fuel and topography data, as has been done in prior CWPPs and wildfire risk assessments, SWCA Environmental Consultants has incorporated LANDFIRE data and values at risk defined by individual communities into ArcGIS models. This paper will detail the model inputs, process, and outputs. It will also showcase examples of how communities are using CWPPs and GIS to make risk assessments better reflect the collaborative input intended by the CWPP process.

INTRODUCTION:

In recognition of widespread declining forest health, the Healthy Forest Restoration Act (HFRA) was passed in 2003 to expedite the development and implementation of hazardous fuels reduction projects on federal land. A key component of the HFRA is the development of Community Wildfire Protection Plans (CWPPs) as a mechanism for public input and prioritization of fuel reduction projects. A CWPP provides background information about a project area, a discussion of community values at risk (CVAR), community base maps, a fire risk assessment, and recommendations that identify treatment areas for reducing fuels and promoting education and awareness about wildland fires, as well as monitoring and assessment strategies. Collaboration between federal, state, and local agencies and communities is necessary to develop hazardous fuels reduction projects and place priority on treatment areas identified by communities in a CWPP. In addition, communities that have CWPPs in place will be given priority for funding of hazardous fuels reduction projects carried out under the auspices of the HFRA. SWCA Environmental Consultants (SWCA) has been providing CWPP development services to communities across the western U.S. following the steps detailed in "Preparing a Community Wildfire Protection Plan: A Handbook for Wildland–Urban Interface Communities" (Society of American Foresters [SAF] 2004). The steps are as follows:

1. Step One: Convene Decision Makers. Form a Core Team made up of representatives from the appropriate local governments, local fire authorities, and state agencies responsible for forest management.

2. Step Two: Involve Federal Agencies. Identify and engage local representatives of the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM). Contact and involve other land management agencies as appropriate.

3. <u>Step Three: Engage Interested Parties</u>. Contact and encourage active involvement in plan development from a broad range of interested organizations and stakeholders.

4. <u>Step Four: Establish a Community Base Map(s)</u>. Work with partners to establish a baseline map (or maps) defining the community's Wildland Urban Interface (WUI) and showing inhabited areas at risk, forested areas that contain critical human infrastructure, and forest areas at risk for large-scale fire disturbance.

5. <u>Step Five: Develop a Community Risk Assessment</u>. Work with partners to develop a community risk assessment that considers fuel hazards; risk of wildfire occurrence; homes, businesses, and essential infrastructure at risk; other CVAR; and local preparedness capability. Rate the level of risk for each factor and incorporate this information into the base map(s) as appropriate.

6. <u>Step Six: Establish Community Priorities and Recommendations</u>. Use the base map(s) and the community risk assessment to facilitate a collaborative community discussion that leads to the identification of local priorities for fuel treatment, reducing structural ignitability, and other issues of interest, such as improving fire response capability. Clearly indicate whether priority projects are directly related to the protection of communities and essential infrastructure or to reducing wildfire risks to other community values.

7. <u>Step Seven: Develop an Action Plan and Assessment Strategy</u>. Consider developing a detailed implementation strategy to accompany the CWPP, as well as a monitoring plan that will ensure its long-term success.

8. <u>Step Eight: Finalize Community Wildfire Protection Plan</u>. Finalize the CWPP and communicate the results to community and key partners.

The focus of this paper is the methods used for step five, Developing the Community Risk Assessment. The guidelines for developing the risk assessment are broad and give each community the opportunity to incorporate unique values.

Previous risk assessment methods used in CWPPs and WUI assessments have relied heavily on deriving risk or hazard exclusively from topographic and fuels data, while failing to evaluate issues of scale and data quality, with limited ground-truthing or data verification. These methods have the problem of diluting the CVAR inputs and weakening their impacts on the overall risk assessment, which in turn limits the effectiveness of the risk assessment and subsequent land management implementation. Previous geographic information system-based (GIS-based) methods have been successful in providing a snapshot of hazard or risk within a given area (Caprio et al. 1997; Pratt 2000; Montague 2003; Price 2003) using basic topographic, vegetative, and weather data sets. These methods largely employ a weighted-based approach in Model Builder. Other models use similar methods but largely use Model Builder with the Raster Calculator and reclassification methods (for example, Barz et al. 2004).

Because of the limitations of these previous risk assessment methods and the desire to use data that more accurately predicted fire behavior, SWCA's risk assessment models incorporate data developed by the Landscape Fire and Resource Management Planning Tools Project

(LANDFIRE) and assess fire behavior using well established models including FARSITE fire area simulator (Version 4.1.054), FlamMap (Version 3.0), and FireFamilyPlus (Version 3.0) to generate extreme condition fire behavior models such as flame length, rate of spread, fireline intensity and crown fire behavior. These fire behavior models are then combined with the values at risk defined by individual communities in ArcGIS models to derive the risk assessment.

TOOLS AND DATA:

Risk assessments are created in ArcGIS Desktop 9.2, utilizing Model Builder, the Spatial Analyst extension, as well the LANDFIRE Data Access Tool (Version 1.05) extension for ArcMap.

LANDFIRE is a national remote sensing project that provides land managers a data source for all inputs needed for FARSITE, FlamMap, and other fire behavior models (outlined below). The database is managed by the USFS and is widely used throughout the country for land management planning. More information can be obtained from http://www.landfire.gov.

FARSITE

FARSITE is a computer model based on Rothermel's Spread Equations (Rothermel 1983) and also incorporates crown fire models. FARSITE uses spatial data on fuels, canopy cover, canopy height, crown bulk density, canopy base height, aspect, slope, elevation, wind, and weather to model fire behavior across a landscape. In essence, FARSITE is a spatial and temporal fire behavior model. FARSITE is used to generate fuel moisture and landscape files as inputs for FlamMap. Information on fire behavior models can be obtained from http://www.fire.org.

FlamMap

Like FARSITE, FlamMap uses a spatial component for its inputs, but only provides fire behavior predictions for a single set of weather inputs. In essence, it gives fire behavior predictions across a landscape for a snapshot of time. FlamMap does not predict fire spread across a landscape but can be used to predict fire behavior under extreme (worst case) weather scenarios.

FireFamilyPlus

FireFamilyPlus is a software system for summarizing and analyzing daily weather observations and computing fire danger indices based on the National Fire Danger Rating System.

WORKFLOW:

The following workflow has been followed for creating the risk assessment:

1. Obtain spatial and non-spatial data needed for developing the risk assessment and evaluate the scale and accuracy of all data sets.

2. Generate fire behavior models.

3. Create raster data sets of fire occurrence and CVAR.

4. Determine weights and rankings of individual risk assessment components and create the risk assessment.

Step 4 has been revised based on input from the Core Team and fire behavior specialists until the final risk assessment is reached.

1: Obtain spatial and non-spatial data needed for developing the risk assessment and evaluate the scale and accuracy of all data sets

Spatial data required for fire behavior models is obtained from the LANDFIRE national map using the LANDFIRE data access tool. This data includes Scott and Burgan's (2005) 40 fuel models, slope, aspect, elevation, forest canopy base height, forest canopy bulk density, forest canopy cover, and forest canopy height.

Non-spatial weather data is obtained from "FAMWEB" (http://fam.nwcg.gov/fam-web/famweb/index$.startup), a fire weather database maintained by the National Wildfire Coordinating Group. With guidance from fire and weather experts from the Region 3 Southwest Coordination Center, a remote automated weather (RAW) station is selected and data is downloaded from the website. The RAW station is selected based on period of record, location within the planning area, reliability of the data, and how representative the data would be for weather in the planning area.

Spatial data for determining the community values is obtained from various sources, including data clearinghouses, government agencies, county assessor or rural addressing offices, Core Team participants, and stakeholders. Data needed for each individual risk assessment are unique to each community.

Fire history data can be obtained from federal, state, and local agencies. Due to varying degrees of accuracy between agencies, point locations are used to determine the density of fires.

All data sets are evaluated for project area coverage, usable scale, accuracy, and availability. Data sets that do not meet minimum standards are excluded from the risk assessment.

2: Generate fire behavior models

In order to create fire behavior models, data need to be developed and converted into the correct formats. The LANDFIRE data provided displays 30-meter resolution ESRI Grid (GRID) format. For future steps, the LANDFIRE data is then reprojected from Albers to Universal Transverse Mercator (UTM) and is also converted to American Standard Code for Information Interchange (ASCII) text files for use in the FARSITE and FlamMap models. The reprojecting and conversions are performed using Model Builder to increase efficiency (Figure 1Figure 1).

These ASCII files are input into FARSITE to generate a landscape file (LCP), which is a composite grid all the topography and fuel inputs.
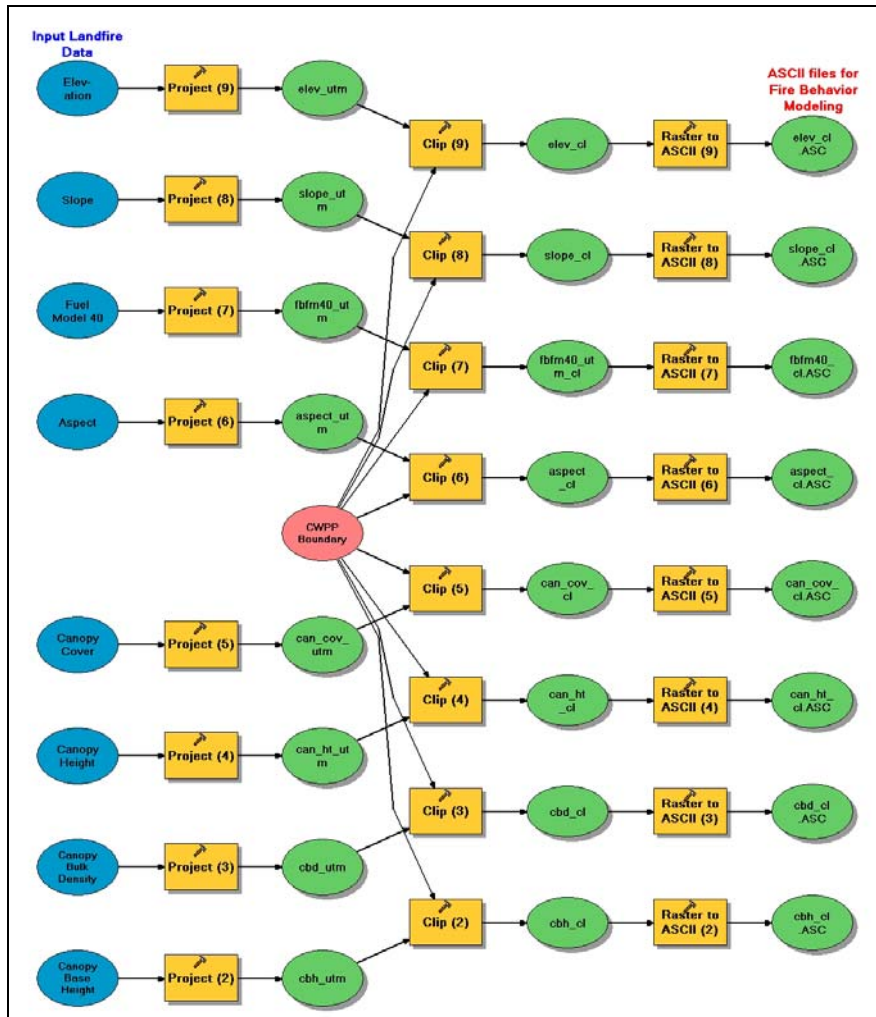
Figure 1.   ArcGIS model converting LANDFIRE GRIDs into ASCII format
for use in FARSITE and FlamMap.

Another critical input for the fire behavior models is the fuel moisture file (FMS). To create the FMS weather files obtained from FAMWEB, they are processed in FireFamilyPlus to generate 90th percentile or higher weather files that included prevailing wind direction, 20-foot wind speed, and FMS for downed (1-hour, 10-hour, and 100-hour) and live herbaceous and live woody fuels between the months of April and August (fire season). These outputs are loaded into FARSITE and used to generate the FMS for use in FlamMap.

The LCP and FMS files are then used in FlamMap to generate extreme fire behavior model outputs. These models include rate of spread, flame length, crown fire activity, and fireline intensity (Figure 2Figure 2). Finally, the model outputs are then exported in ASCII format and converted to GRID using ArcMap and Model Builder (Figure 3Figure 3).
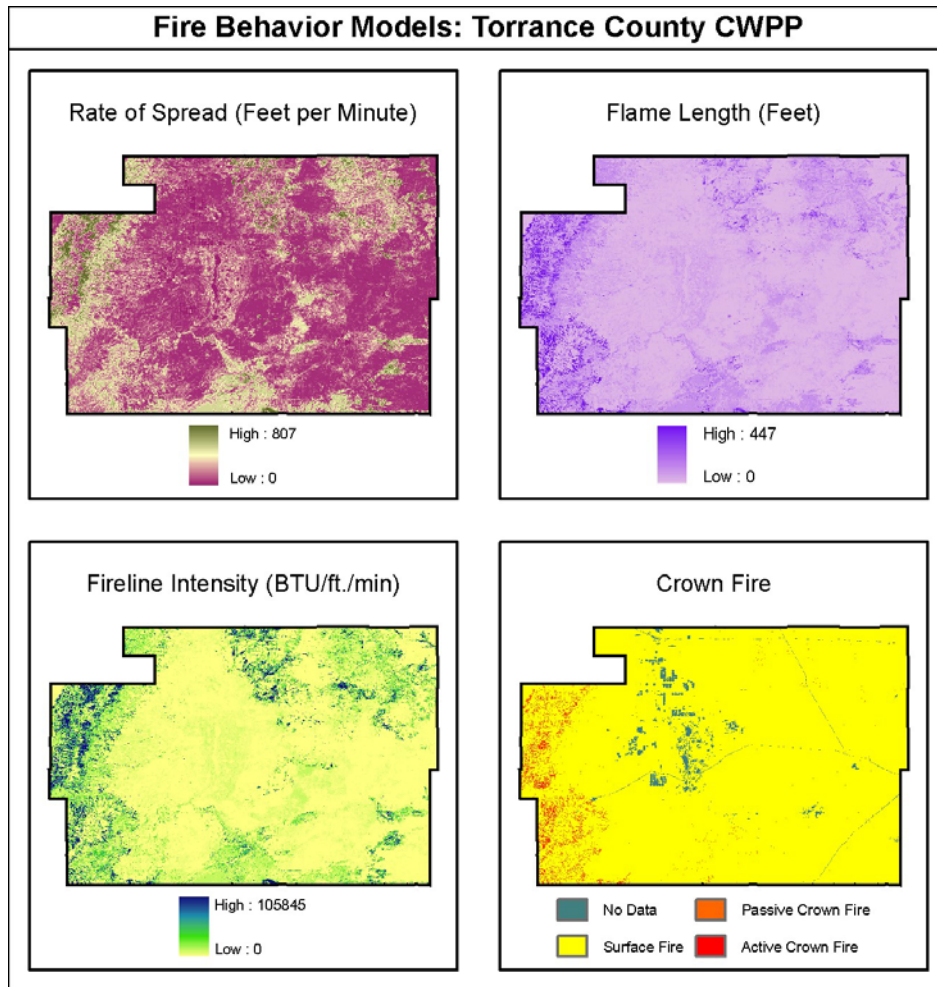
Figure 2. Fire behavior models generated in FlamMap.
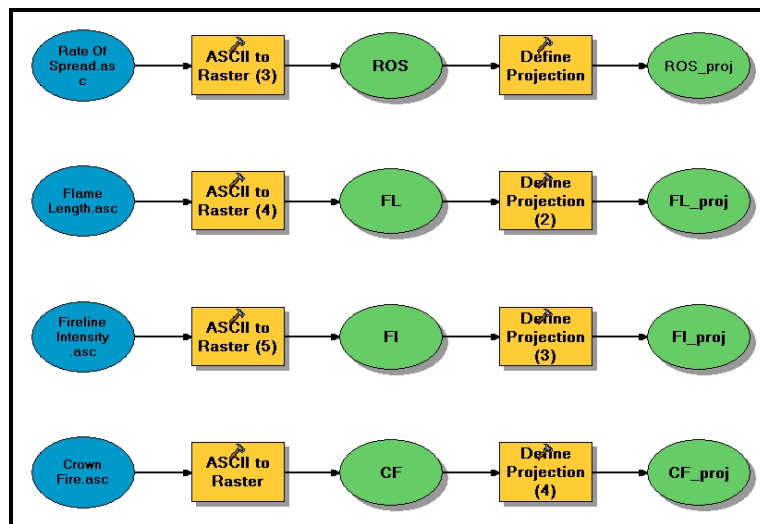

Figure 3. ArcGIS model converting fire behavior ASCII files to GRIDs

3:   Create raster data sets of fire occurrence and CVAR.

Other data used in the risk assessment include fire occurrence (fire history) and the CVAR. For inclusion in the risk assessment, all data sets must be continuous over the entire project area and must be represented by a 30-meter resolution GRID in the same projection as the fire behavior model GRIDs. The CVAR data that is included in the risk assessment are very dependent on the needs of the community and the direction of the Core Team, but any data that can be represented spatially can be potentially included. Typical data sets include distance from roads, fire station response time, important water resources, important wildlife and cultural resources, population density, etc. (Figure 4Figure 4). Original data sets for the CVAR are typically provided in ESRI shapefile or feature class format, although occasionally text files and hardcopy maps are used to generate the data sets. Each CVAR is treated uniquely depending on how the Core Team decides to include it in the risk assessment. Densities and buffers are used as necessary on the data sets and then converted to GRID files using the Spatial Analyst extension.

For fire occurrence, the data provided varies significantly depending on the agency that records the fire data. Various federal, state, and local agencies record the data with multiple levels of sophistication and complexity. Because the data must be continuous over the entire project area, SWCA's risk assessments use the simplest data available: point locations, which are typically fire starts or fire centers. To make these point locations suitable for the risk assessment, a simple density GRID is generated in ArcMap using the Spatial Analyst extension. Density is generated in fires per square mile over a 5-mile search radius (Figure 4Figures 4 and Figure 55).
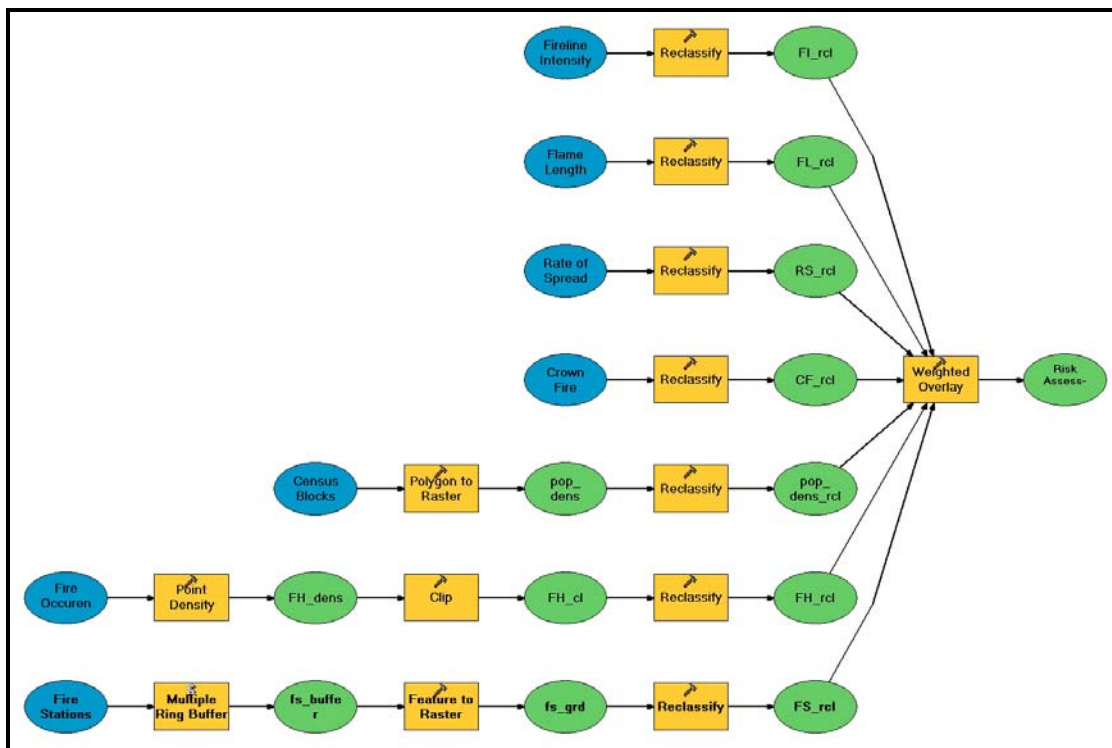

Figure 4.   ArcGIS model for CVAR, reclassification, and Weighted Overlay Analysis.
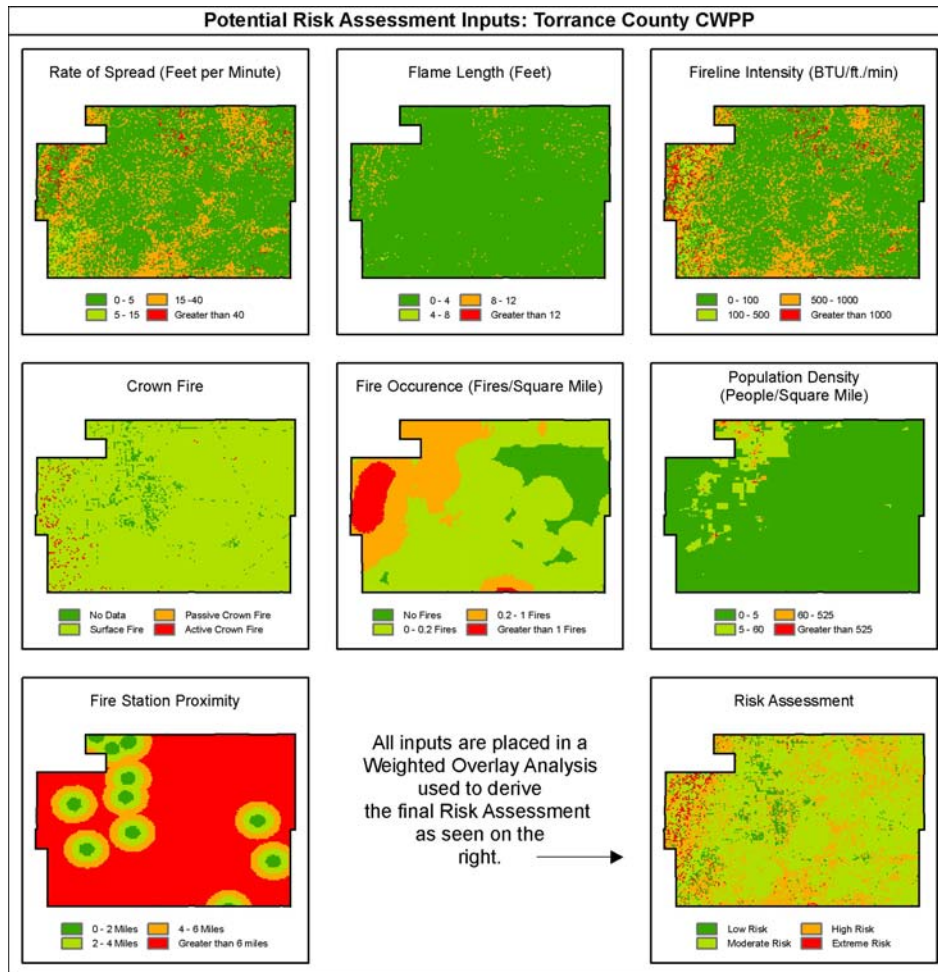
Figure 5.   Reclassified risk assessment inputs and the final risk assessment.

4:   Determine weights and rankings of individual risk assessment components and create the risk assessment

All GRIDs that are parameters in the risk assessment require a common cell size and projection. SWCA uses 30-meter resolution GRIDs to stay consistent with the LANDFIRE data and a common UTM projection. Any data that were not reprojected or converted to GRIDs at the correct resolution in previous steps must be addressed before reclassifying or modeling.

All data are reclassified with the Reclassify tool in ArcMap with a new value between 1 and 4, based on the significance of the data (1=lowest risk, 4=highest risk).   The reclassification of the fire behavior models is modified from risk values in the 40 fuel models (Scott and Burgan 2005) and widely utlized agency fire suppression measures. Reclassification of the CVAR is based on input from fire specialists and from Core Team participants. Once each parameter is reclassified, the Core Team assigns rankings and percentages to each. This allows the Core Team to have maximum input on how much each parameter should affect the risk assessment. These rankings and percentages are then pulled into a Weighted Overlay Analysis in ArcMap. The Weighted Overlay Analysis "stacks" each geographically aligned data set and evaluates an output value derived from each cell value of the overlaid data set in combination with the weighted

assessment. The resulting data set contains only values 1 through 4 (1=Low, 2=Medium, 3=High, 4=Extreme), denoting fire risk (Figure 4Figures 4 and Figure 55). This ranking shows the relative fire risk of each cell based on the input parameters. Table 1Table 1 lists the individual data sets, the classes assigned to the data, and the relative weights assigned within the modeling framework as an example from the Torrance County risk assessment.

Table 1.   Torrance County risk assessment Inputs, Weights, and Reclassifications

Layer	Source	Year	Weight (%)	Ranks
Flame Length	LANDFIRE: Elevation, Aspect, Slope, Scott and Burgan (2005) 40 Fuel Model, Forest Canopy Base Height, Forest Canopy Bulk Density, Forest Canopy Cover, Forest Canopy Height	2007	20	1: 0–4 feet
				2: 4–8 feet
				3: 8–12 feet
				4: Greater than 12 feet
	Mountainair RAW Stations (Weather)	1992–2006		
Fire Occurrence	New Mexico State Forestry	1987–2007	15	1: No fires/mile squared
				2: 0.0–0.2 fire/mile squared
				3: 0.2–1.0 fire/mile squared
				4: Greater than 1 fire/mile squared
Rate of Spread	LANDFIRE: Elevation, Aspect, Slope, Scott and Burgan (2005) 40 Fuel Model, Forest Canopy Base Height, Forest Canopy Bulk Density, Forest Canopy Cover, Forest Canopy Height	2007	15	1: 0–5 feet/minute
				2: 5–15 feet/minute
				3: 15–40 feet/minute
				4: Greater than 40 feet/minute
	Mountainair RAW Stations (Weather)	1992–2006		
Crown Fire Activity	LANDFIRE: Elevation, Aspect, Slope, Scott and Burgan (2005) 40 Fuel Model, Forest Canopy Base Height, Forest Canopy Bulk Density, Forest Canopy Cover, Forest Canopy Height	2007	15	1: No data
	Mountainair RAW Stations (Weather)	1992–2006		
				2: Surface fire
				3: Passive crown fire
				4: active crown fire
Population Density	U.S. 2000 Census Block Population	2000	15	1: 0–5 people/mile squared
				2: 5–60 people/mile squared
				3: 60–525 people/mile squared
				4: Greater than 525 people/mile squared
Fireline Intensity	LANDFIRE: Elevation, Aspect, Slope, Scott and Burgan (2005) 40 Fuel Model, Forest Canopy Base Height, Forest Canopy Bulk Density, Forest Canopy Cover, Forest Canopy Height	2007	10	1: 0–100 BTU/feet/sec
				2: 100–500 BTU/feet/sec
				3: 500–1,000 BTU/feet/sec
				4: Greater than 1,000 BTU/feet/sec
	Mountainair RAW Stations (Weather)	1992–2006		
Proximity to Fire Station	New Mexico State Fire Marshall, USFS, BLM, and Torrance County	2007	10	1: 0.0–0.5 miles
				2: 0.5–1.0 miles
				3: 1.0–1.5 miles
				4: Greater than 1.5 miles

Weights and input parameters are modified based on the needs and input of the Core Team. The use of Model Builder for the reclassification and weighted overlay allow for speedy updates and revisions throughout the entire process (Figure 4Figures 4 and Figure 55). Once the risk assessment is finalized, it is then used as an aid to develop treatment recommendations by the Core Team.

EXAMPLES AND CONCLUSIONS

Our example project used in this paper is Torrance County, New Mexico. This risk assessment was developed during 2007 and revised in 2008. The Torrance County risk assessment gives us the opportunity to compare our results with actual wildfires that occurred after the risk assessment was developed (Figure 6Figure 6).
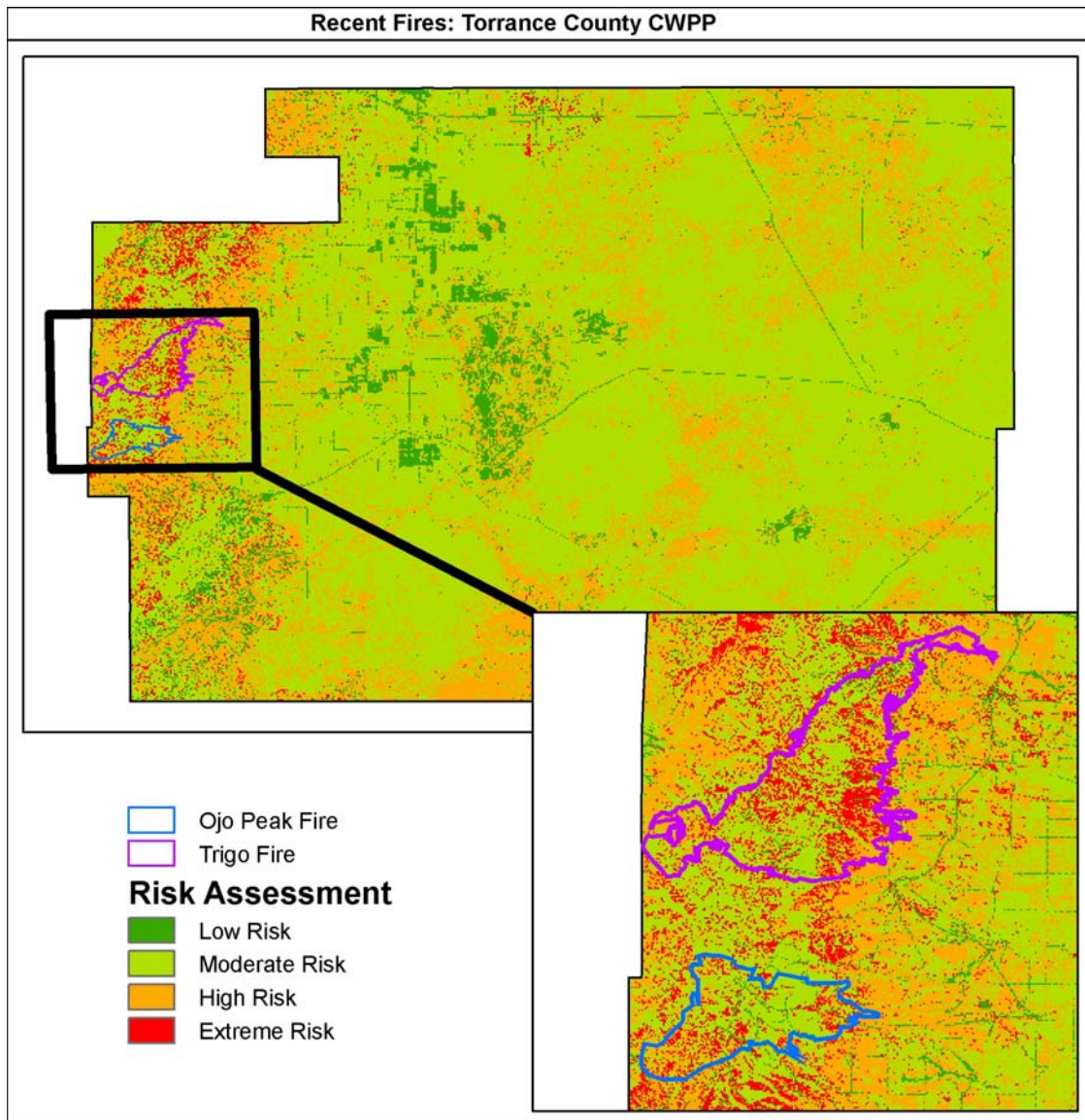

Figure 6. Recent fires in Torrance County compared to the risk assessment.

The Ojo Peak fire burned approximately 7,500 acres in late November 2007, and the Trigo fire burned over 13,000 acres through April and May 2008. These fires both started in areas our models determined to be high or extreme risk and spread into the other areas.

As with all CWPPs, once the risk assessment was developed fuel reduction treatments and community outreach recommendations were developed (Step 6 from SAF 2004). Beyond that, the risk assessment can be used by land managers for planning purposes; wildfire response teams can use the risk assessment to determine which areas need priority response during a wildfire, and homeowners can gain assistance with implementing private treatments.

The CWPP guidelines also require regular updates to CWPPs. By using LANDFIRE data and the ArcGIS tools outlined above, updating the risk assessment a simple task: download the updated LANDFIRE data and update any other spatial data sets, then run the same models in ArcGIS. These methods are easily available to anyone that has the correct software and knowledge.

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