WEST WIDE WILDFIRE RISK ASSESSMENT

FINAL REPORT

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Prepared for:

Oregon Department of Forestry

Western Forestry Leadership Coalition

Council of Western State Foresters

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Prepared By: The Sanborn Map Company

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Section 1 Introduction

1.1. Background

The Oregon Department of Forestry (ODF and Agency), on behalf of the Council of Western State Foresters (CWSF) and the Western Forestry Leadership Coalition (WFLC), has conducted a wildfire risk assessment and report for the 17 western states and selected U.S. affiliated Pacific Islands. At the highest level, this assessment is known as the West Wide Wildfire Risk Assessment, or WWA.

Managing wildfire risk in the western United States is becoming an increasingly complex challenge as wildland fuels continue to build, drought conditions persist, human development spreads, and budgets are flat or declining while suppression costs increase. Wildfire Risk Assessments like the Southern Wildfire Risk Assessment (SWRA) have proven valuable for quantifying the magnitude of the current wildfire problem in the South with results comparable across geographic areas. It has allowed for comprehensive comparisons between regional geographic areas and has aided in the mitigation of wildfire risks across the south. It clearly identifies the level of risk to communities or other areas of interest and enhances communication of wildfire risk to the public.

While some Western states have completed wildfire risk assessments that meet their individual needs, a comprehensive and consistent wildfire risk assessment similar to the SWRA was desired in the West. The Council of Western State Foresters and the Western Forestry Leadership Coalition desire to quantify the magnitude of the current wildfire problem and level of risk to communities and resources in the West with results comparable across geographic areas. In addition, they desired a report that:

- Summarized data by state;
- Documented recent accomplishments since the Healthy Forest Restoration Act was implemented;
- Documented future challenges and recommended actions; and
- Enhanced communication of wildfire risk to the public.

To accomplish these tasks ODF contracted with the Sanborn Map Company to conduct a wildfire risk assessment for the west. The project timeframe was October 2007 to February 2013 and the following is the Final Methods Report for the project.

1.2. Project Objectives

Developing this comprehensive wildfire risk assessment for the West accomplished the following objectives:

- ☑ Production of a periodic wildfire risk assessment that quantified the magnitude of the current wildfire problem in the West and provided a baseline for quantifying mitigation activities and monitoring change over time.
- ☑ Implementation of a method that is repeatable, quantifiable, scientifically based, consistent, and provides results comparable across geographic areas by applying uniform criteria across the western states.
- ☑ Development of an assessment and report that allows comprehensive comparisons between regional geographic areas and assists in quantifying risk and fire effects to aid in the mitigation of wildfire risks across the western United States.
- ☑ An assessment similar to the Southern Wildfire Risk Assessment (SWRA) conducted for the 13 Southern states.
- ☑ Provision of the data necessary to clearly identify the level of risk to areas such as counties, communities and resources that is consistent with the SWRA.
- ☑ Provision of risk assessment data needed to support a status report document on the policies, programs and processes in place to mitigate risks
- ☑ Provision of information that will enhance the states' ability to communicate wildfire risk to the public.

The assessment included the 17 western states, including Alaska (AK), Arizona (AZ), California (CA), Colorado(CO), Hawaii(HI), Idaho(ID), Kansas(KS), Montana(MT), North Dakota(ND), Nebraska(NE), New Mexico(NM), Nevada(NV), Oregon(OR), South Dakota(SD), Utah(UT), Washington(WA), and Wyoming(WY). In addition, the assessment included the U.S. affiliated Pacific Islands including the Territory of Guam, Republic of Palau, Yap and Chuuk (Federated States of Micronesia), Territory of American Samoa and the Commonwealth of the Northern Mariana Islands (CNMI). Note that the reference to the Pacific Islands for the purposes of the WWA does not include Hawaii. In addition, while the Marshall Islands were not originally included in the scope of the WWA, we were able to include them in the final summary for the Pacific Islands.

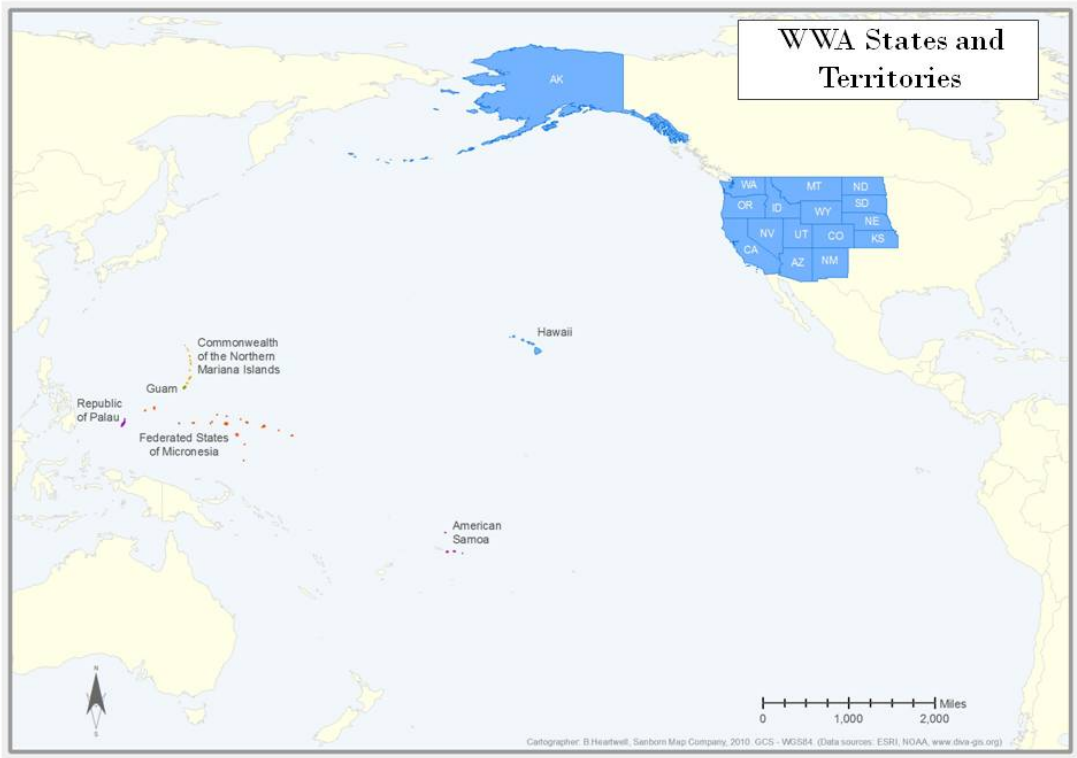


Figure 1-1. West Wide Wildfire Risk Assessment Project Area

1.3. Project Team

Figure 1-2 presents the WWA project team comprised of The Sanborn Map Company, ODF and key project participants. The core technical team consisted of Jim Wolf (ODF), and Janet Hoyt, Don Carlton, and David Buckley (Sanborn Team) who met on a weekly basis throughout the project to review status and technical process. The Project Steering Committee (PSC) met monthly with the technical team to receive status reports and review and approve key decisions in the risk assessment process.

In addition to this core team, primary points of contact (POCs) were identified for each state and territory to facilitate project communication. Representatives were responsible for providing key input datasets in a timely manner as well as providing regular feedback on compiled data inputs, data rule sets and criteria, and assessment outputs. Four groups of technical points of contact (Fuels, Meteorology, Fire Behavior and GIS) were formed to support the primary points of contact and provide guidance and review in the development of several key risk assessment datasets. These state representatives and committee members are identified in Appendix A.

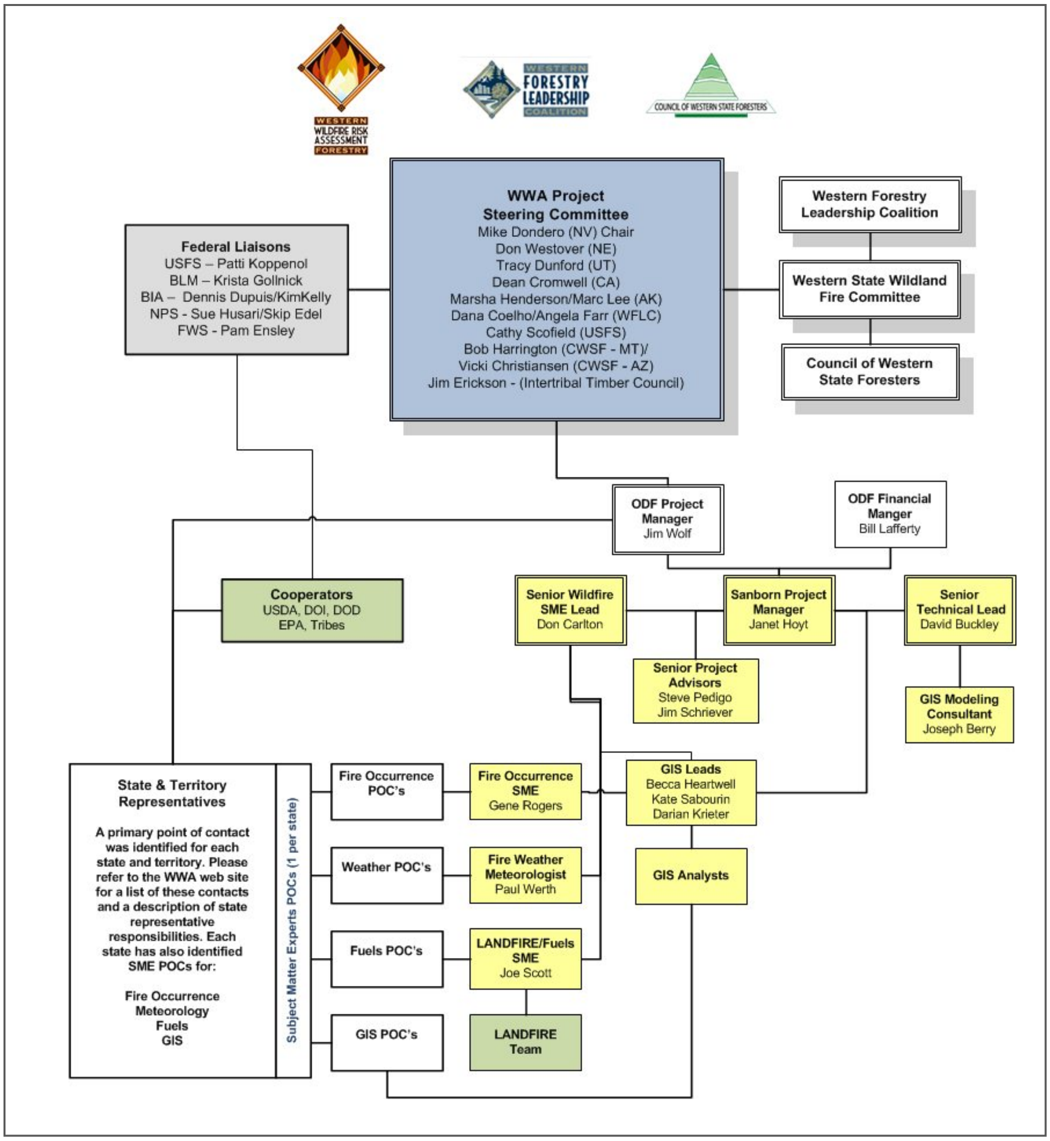


Figure 1-2. WWA Organization Chart

1.4. Content of the Report

This report contains a detailed description of the project methods and results. The report is organized into the following sections;

- Section 1: Introduction
  - Summary of the goals and objectives of the project along with the project study are, team and general structure of the document
- Section 2: Project Overview
  - Overview of the risk assessment and deliverables to introduce the process and datasets. Provides a background for the next section or a high level overview for those interested in a cursory understanding of the process.
- Section 3: WWA Methods and Data Development
  - Describes the wildfire risk assessment process in detail
- Section 4: Final Deliverables
  - Summarizes the final deliverables
- Section 5: Assessment Results and Findings
  - A summary of notable accomplishments and lessons learned during the project

1.5. Related Project Documentation

Throughout the project several reports were developed and provided to appropriate team members to facilitate communication, project progress and review of outputs. These documents set standards, provided technical background for reviewers, and delivered findings during the project. These documents include:

- DATA STANDARDS REPORT
  - This document was developed at the start of the project to identify data standards to be used throughout the project. It includes information on projections, data formats, and methods of data transfer
- TECHNICAL BRIEFS
  - These documents were developed to provide state representatives with an understanding of the processes used to produce datasets they would be reviewing. There were four technical briefs:
    - Fuels Briefing Paper
    - Weather Data Briefing Paper
    - Fire Occurrence Data Briefing Paper
    - Fire Effects Briefing Paper

- DATA GAP ANALYSIS REPORT
  - The Data Gap Analysis Report identified issues that were encountered in the data development process and improvements that could be made in acquiring data in the future.

Because these reports are dated due to their interim delivery timeframes and much of the pertinent information they contain has been captured and updated in this final report, they should be reviewed only as the WWA Project Manager deems appropriate.

In addition to these documents, several other documents were developed as part of the WWA and are being delivered as addendums to this final report as they contain additional information not contained or fully detailed within this report. These include:

- ADDENDUM I: DETAILED TECHNICAL METHODS
  - This document contains detailed methods documentation for the project. It includes processes for developing datasets as well as parameters used in the processes.
- ADDENDUM II: FIRE EFFECTS PROCESS
  - This Excel spreadsheet mathematically defines the process used to calculate fire effects and provides the final regional scores and weights along with the individual state scores and weights for the fire effects process.
- ADDENDUM III: PACIFIC ISLANDS WILDFIRE RISK SUMMARY
  - This document summarizes the Statewide Assessment and Resource Strategies for each of the Pacific Islands with regards to wildfire risk
- ADDENDUM IV: REGIONAL SUMMARY STATISTICS
  - Regional reports summarizing the risk assessment results in pdf format.
- ADDENDUM V: STATE STATISTICAL SUMMARIES
  - Examples of the state wide statistical reports that summarized the risk assessment results.
- ADDENDUM VI: COUNTY RISK REPORTS
  - Examples of the reports developed for each of the counties summarizing the risk assessment results.
- ADDENDUM VII: DELIVERY DATA STRUCTURE
  - This document describes the structure of the final data deliverable to include file structure, tiling structure and brief descriptions of the filenames.
- ADDENDUM VIII: STATE SPECIFIC DATA
  - This document describes what the State Specific Data is, why it's needed, what layers are affected, and the basic process in developing the data.

1.6. Definition of Terms

As with many projects of this size and scope, the WWA comes with its own suite of acronyms and terminology, to confuse the unsuspecting reader. We have tried our best to introduce and define a term as we move along in the report, but have also included a glossary of terms at the end of this document to support the reader in untangling this web.

1.7. Links for Web Resources

The URL for a specific Internet reference may be of value to the reader. A list of these is contained in Appendix B. Within the text when a website is referred to, it will be identified by a reference to Appendix B.

Section 2 Project Overview

2.1. Project Components & Tasks

The WWA involved a series of steps (referred to as components) and tasks that leveraged methods previously established and proven in the Southern Wildfire Risk Assessment (SWRA) project completed in 2005.

The assessment methods used in the WWA are based on a systematic, rational planning process initiated with an assessment of the current situation. Each task in the WWA technical approach builds on information gathered, compiled and analyzed in previous tasks to derive final outputs of wildfire threat and risk. Primary task components included:

- **Component 1**: Data Acquisition, Compilation and Database Development
  - This comprised the acquisition and compilation of existing federal, tribal, state and local data, the conversion and cleaning of data, and development of databases required to conduct the assessment.
- **Component 2:** Model Development and Risk Assessment
  - This comprised the development of the risk assessment model and conducting the assessment to produce results consistent with the SWRA.
- **Component 3:** Reports
  - This comprised the development, review, and presentation of progress reports, draft reports, and final reports.
- **Component 4:** Technology Transfer
  - This comprised the transfer of final data to the states and review of the deliverables with the states to ensure the outputs, databases and model were properly understood.
- **Component 5:** Project Management
  - This comprised the project management necessary to manage a complex project in terms of geographic area and diversity and the large number of participants and stakeholders.

The data compilation and assessment tasks were wrapped around a project management framework that ensured on-going communication and quality assurance throughout the project. The technical assessment tasks were also supplemented with necessary summary reporting, results delivery and technology transfer tasks so that results from the assessment were delivered in a format usable by participating agencies.

2.2. Data Acquisition, Compilation and Database Development

The data acquisition, compilation and development component of the WWA was a significant task in the project. Not only did base datasets and reference datasets need to be gathered for the entire WWA region, several datasets needed to be developed specifically for the assessment. Wherever possible, these datasets needed to be consistent throughout the region and often months were spent researching data sources and reporting findings back to the PSC to ensure the best available and most appropriate data were being used for the project.

The bulk of the data development took place from early 2010 and ended in late summer 2011, although adjustments were made to a couple of datasets after this timeframe when risk assessment production started and it became clear the adjustments were necessary to obtain quality risk assessment results. The Project Steering Committee had final approval on the datasets developed for the project.

The WWA project consists of three general types of datasets:

1. Reference Data - data used as reference only and not used in any of the analytical models. This includes data such as cell towers and congressional districts.

2. Input Data - data compiled and derived as inputs into the analytical models. This includes primary input data, such as Surface Fuel Models, as well as derived input data, such as Fire Occurrence Areas and Wildland Development Areas.

3. Output Data -data output from the analytical models. These datasets are categorized as Indices, Ratings and Scores.

Table 2-1 summarizes the datasets that are part of the West Wide Risk Assessment. Data is listed by category. Methods for datasets that were compiled or developed by the WWA technical team, such as the Infrastructure Assets dataset, are detailed in Section 3 of this report. Methods for datasets that were simply downloaded for input or reference, such as ESRI roads, are not detailed since their development is documented by the data's source and can be located at source websites or in the metadata.

Table 2-1. Datasets associated with the West Wide Wildfire Risk Assessment

Dataset	Description	Feature Type
Indices		
Fire Risk Index (FRI)	Measure of overall wildfire risk.	Raster
Fire Effects Index (FEI)	Identifies areas with important values affected by wildland fire and/or that are costly to suppress. FEI is a weighted combination of the Values Impacted Rating (VIR) and Suppression Difficulty Rating (SDR) layers described below.	Raster
Fire Threat Index (FTI)	Wildfire threat is an index related to the likelihood of an acre burning. The FTI integrates the probability of an acre igniting and the expected final fire size, based on the rate of spread in four weather percentile categories, into a single measure of wildfire threat.	Raster
Ratings		
Values Impacted Rating (VIR)	Reflects areas that have important values affected by wildland fire. This combines all Values Impacted being assessed based on a composite of weights provided by the states. Fire Threat Index is not a component of VIR, so values are conditional, assuming that the probability of being impacted by fire is equal	Raster
Suppression Difficulty Rating (SDR)	Reflects areas with increased difficulty for fire suppression. It is based on fireline production rates and slope and a composite of the scores and weights provided by the states.	Raster
Scores		
Response Function Scores (RFS)	For each individual Value dataset, identifies areas for those values impacted that are at risk to wildland fire. This is based on the scores and weights provided by the states.	Raster
Key Inputs		
Wildland Development Areas (WDA)	Describes where people are living in wildland areas (i.e. urban areas masked out). This dataset is derived from the LandScan population count data and represents the number of housing units per acre.	Raster
Drinking Water Importance Areas (DWIA)	An index that identifies areas that are most crucial to sustaining the quality of drinking water by incorporating data on water supply, surface drinking water consumers at the point of intake, and the flow patterns to the surface water intakes. The U.S. Forest Service's Forests to Faucets (F2F) project is the primary source of this dataset, however, F2F does not exist for Alaska and Hawaii so alternative datasets were used for these two states.	Raster
Forest Assets (FA)	Forested lands categorized by height, cover and susceptibility (response to wildland fire). The LANDFIRE vegetation datasets (existing vegetation type, cover, and height) were the primary inputs to this dataset along with a crosswalk of the existing Vegetation Type dataset to a susceptibility class.	Raster

Dataset	Description	Feature Type
Riparian Assets (RA)	Riparian areas that are important as a suite of ecosystem services, including both terrestrial and aquatic habitat, water quality and quantity, and other ecological functions. The National Hydrography Dataset (NHD), the National Wetlands Inventory (NWI) and LANDFIRE's Existing Vegetation Dataset (EVT) were the primary inputs to this dataset.	Raster
Infrastructure Assets (IA)	Key infrastructure assets that are susceptible to adverse effects from wildfires. Includes Roads (Levels 1-3), Railroads, Airports, Schools and Hospitals (roads and railroads are buffered by 300m and airports, schools and hospitals are buffered by 500m).	Raster
Fire Occurrence Areas (FOA)	Areas within which the probability of each acre igniting is the same. (Based on historical fire occurrence data).	Raster
Fire Behavior Outputs	Rate of Spread, Flame Length, Fire Type (canopy fire potential) by Low, Moderate, High and Extreme percentile weather. Also provided is the Expected Rate of Spread and Flame Length which is the weighted average of using probability of a fire occurring by percentile weather times the output at that percentile weather. The probability of a surface or canopy fire type occurring is also provided.	Raster
Weather Influence Zones (WIZ)	Areas where, for analysis purposes, the weather on any given day is uniform.	Polygon
Where People Live (WPL)	Describes where people are living and includes both urban and rural areas. This dataset is derived from the LandScan population count data and is based on the number of housing units per acre. The WDA dataset (above) is a subset of the WPL dataset.	Raster
Other Input Datasets		
Vegetation Type*	Existing Vegetation Type (from LANDFIRE)	Raster
Vegetation Height*	Existing Vegetation Height (from LANDFIRE)	Raster
Percent Canopy Cover*	Tree Canopy Cover (from LANDFIRE)	Raster
Canopy Base Height* (CBH)	Canopy fuels variable (from LANDFIRE)	Raster
Canopy Bulk Density* (CBD)	Canopy fuels variable (from LANDFIRE)	Raster
Canopy Ceiling Height* (CCH)	Canopy fuels variable (from LANDFIRE Canopy Height)	Raster
Surface Fuels	Derived from the LANDFIRE FBFM40 dataset which uses the 2005 Fire Behavior Prediction System Fuel Model Set	Raster
Historical Fire Ignition Data	Historical fire ignition locations (federal and state sources)	Points and Polygons
Topography*	Slope, Aspect and Elevation (from LANDFIRE)	Raster
Roads*	Roads from the ESRI Data v10	Lines
Airports*	Location of airports from the ESRI Data v10	Points
Schools*	Location of schools from the ESRI Data v10	Points
Hospitals*	Location of hospitals from the ESRI Data v10	Points
Railroads*	Railroads from the ESRI Data v10	Lines
Counties	County boundaries from the ESRI Data v10 except in Alaska where boundaries were compiled from other data sources.	Polygons

Dataset	Description	Feature Type
Land Ownership*	Land ownership – based on the Conservation Biology Institute (CBI) data	Polygons
Congressional Districts*	Congressional District Boundaries (from ESRI and U.S. Census Bureau)	Polygons
Cell Towers*	Location of cell towers. Source is FCC data.	Points

**These datasets were taken directly from their data source. No adjustments or additional modeling of the data was done.*

2.3.Overview of Risk Assessment Data and Process

This section contains a brief description of the analytical process used to quantify wildfire risk. It provides a high level description of the process and introduces several of the datasets used in the assessment in an effort to familiarize the reader with the basics prior to diving into the details. A more detailed explanation of each process and dataset is contained in Section 3.

The basic risk assessment model used in the West Wide Wildfire Risk Assessment is shown in Figure 2-1. The three primary outputs from the risk assessment are the Fire Risk Index, the Fire Threat Index and the Fire Effects Index. Webster's dictionary defines risk as "the possibility of suffering harm or loss." Within the WWA, the data layer that defines wildland fire risk is the Fire Risk Index (FRI), while the "possibility of suffering harm or loss" is represented by the Fire Threat Index (possibility) and the Fire Effects Index (harm or loss). The Fire Risk Index is calculated from the Fire Threat Index (FTI) and the Fire Effects Index (FEI). The following section describes each of these primary outputs and introduces the datasets used in their development, each of which is also identified in the process diagram below.

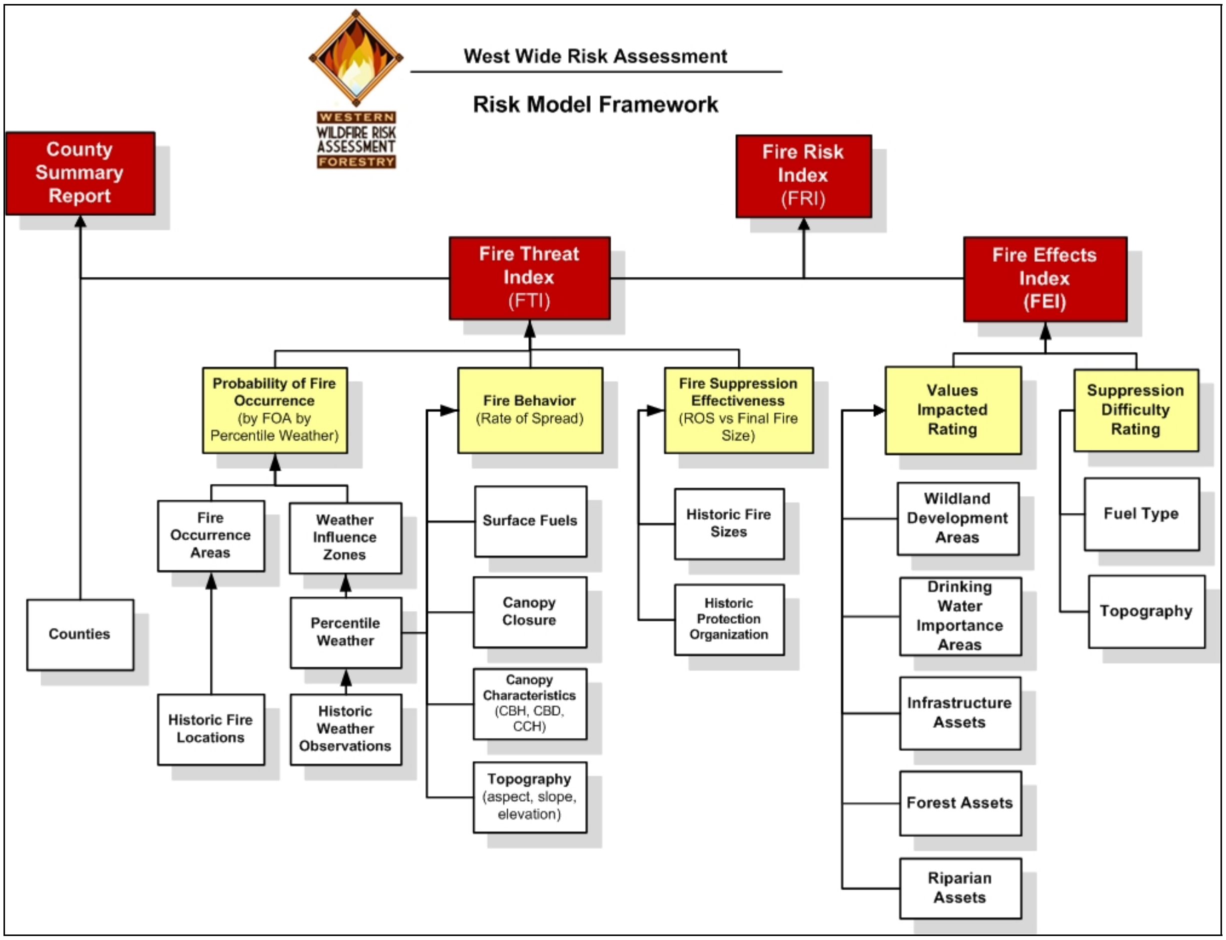


Figure 2-1. Wildfire Risk Assessment Process

2.3.1. Fire Threat

The fire threat component of the fire risk assessment process is called the Fire Threat Index (Figure 2-1). It is calculated as a number greater than zero (0) but less than or equal to one (1). The process used relies on the analytical methods that would be used to calculate the probability of an acre burning. The FTI integrates the probability of an acre igniting and the expected final fire size based on the rate of spread in four weather percentile categories. Due to some necessary assumptions, mainly fuel homogeneity, it is not the true probability. But since all areas within the analysis area have this value determined consistently, it allows for comparison and ordination of areas as to the likelihood of an acre burning. There are three primary components to developing fire threat:

1. Fire Occurrence
2. Fire Behavior and
3. Fire Suppression Effectiveness

Fire Occurrence

To develop the FTI, the first task is to gather past fire occurrence information. The goal is to use this information to define areas of uniform probability of an acre igniting. These areas are called Fire Occurrence Areas (FOA). Within an FOA category, the probability of an acre igniting is the same. Pictorially, if one were to locate the point locations for historic ignitions within a FOA on a map, the points would appear to be equally spaced.

The next step is to examine what the fire behavior might be within an area if a fire occurs in that area.

Fire Behavior

Fire behavior prediction can be estimated using methods defined in the Fire Behavior Prediction System (Rothermel 1983, Scott and Reinhardt 2001, Andrews 2007, Heinsch and Andrews 2010). Fire behavior is predicted for surface and canopy fires. The prediction system requires that data be gathered and mapped for fuels and topography at a local scale. In addition, on a larger but uniform scale, the weather needs to be defined. For the WWA, the mapping scale for fuels and topographic data is a 30-meter by 30-meter resolution or approximately 100 feet by 100 feet. For the WWA, weather is defined by Weather Influence Zones (WIZ).

Fuels and Topography

Fuels data used in the WWA was gathered from the LANDFIRE project (Appendix B). The version of this data is called the Refresh (LF 1.1.0) dataset and maps the data layers to a benchmark year of 2008. Both surface and canopy fire data was used. To predict surface fire behavior, the Fire Behavior Prediction System 2005 fuel model set was used. This LANDFIRE fuels data was used as presented, with the acceptation of modifications in urban areas as described later. To model canopy (crown) fire occurrence and behavior, the canopy base height and canopy bulk density LANDFIRE data layers were used. To assist in the adjustment of weather observations to a ground level reference, the canopy ceiling height (stand height) and canopy cover data layers were used.

Slope, aspect and elevation values were also gathered from the LANDFIRE project Refresh (LF 1.1.0) dataset.

Weather

Weather throughout the project area varies considerably based upon geography. Weather Influence Zones (WIZ) were developed and represent areas of relatively homogenous weather or climatology. Each state provided a fire weather meteorologist contact for coordination with the project staff meteorologist in the development of Weather Influence Zones.

The following criteria were used to determine WIZ boundaries.

- Topographic features: mountain ranges (location, elevation, slope orientation), river basins

- Precipitation climatology (annual, fire season)
- Existing weather forecast areas such as Predictive Service Areas
- Percentile weather at weather stations
- Fire danger ratings that are similar throughout the WIZ
- State boundaries

A search of land management agency fire weather stations (RAWS, manual) and National Oceanographic and Atmospheric Administration (NOAA) surface observations was conducted to establish a quality, long-term weather dataset. The primary sources of this data are: the U.S. Forest Service's Fire and Aviation Management Web Applications (FAMWEB) web site, the Western Regional Climate Center Fire Program Analysis historical weather data delivery system and NOAA's National Climate Data Center.

With the likelihood of a cell igniting known as well as the fire behavior, the next step is estimating what a resultant fire size might be.

Fire Suppression Effectiveness

To calculate Fire Threat, the expected size of a fire needs to be estimated to facilitate estimating the probability of an acre burning. To do this, it was necessary to develop relationships between fire spread rates and the expected final fire size. The inputs to this relationship are the expected fire behavior and a measure of suppression effectiveness of fire protection forces.

For the WWA, the fires are assumed to have initial attack response under a full suppression philosophy. For each Weather Influence Zone, the fire occurrence reports were used to develop initial relationships. Via a calibration process, final relationships were developed. Following calibration for a Weather Influence Zone, the predicted annual acres burned are similar to the historic expected acres burned which were developed from the fire occurrence reports.

Fire Threat Index (FTI)

The Fire Threat Index is calculated for each percentile weather category for each 30-meter by 30-meter cell on burnable area within each state. The four values from the four percentile weather categories are summed to obtain the FTI for a cell. The calculation is done for cells within an FOA and WIZ intersection. Within this intersection, each cell has the same likelihood of igniting (FOA) as well as expected weather (WIZ). When the calculation is done for a cell, it is assumed that all cells in the FOA and WIZ intersection have the attributes of the cell. In essence, one is asking, "What would be the expected probability of an acre burning if all cells in the FOA and WIZ intersection were the same as the selected cell?" A detailed explanation of this calculation is contained in Section 3.

The Fire Threat Index dataset is the culmination of the Fire Threat analytical process and it is one of the primary outputs of the WWA.

2.3.2. Fire Effects

The Fire Effects component of the risk assessment involves integrating several input datasets to derive a Values Impacted Rating and Suppression Difficulty Rating. The purpose is to identify those areas that have important values that can be affected by fire as well as to identify those areas that are difficult or costly to suppress. These potential effects from a wildfire were defined in two areas, Values Impacted and Fire Suppression Difficulty. These potential effects were measured using a response function score.

Response Function Scores

Response functions translate fire effects into net value change (NVC) to the affected resource. In each response function, NVC is based on the flame length of the fire and represents both beneficial and adverse effects to the resource (Calkin, Ager, and Gilbertson-Day 2010). Although fire outcomes could be related to any fire characteristic, response is typically related to some measure of fire intensity such a flame length. Fire intensity is a robust fire characteristic because it integrates two important fire characteristics, fuel consumption and spread rate. (Ager and others 2007; Finney 2005).

The fire response function scores for the WWA were determined to be measured as a number from -1 to –9. This indicates a negative impact from fire, with -1 representing least negative impacts, and -9 most negative impacts. While response functions are also designed to consider positive effects (values from +1 to +9), only assign negative response function score values were assigned to the WWA values impacted. The number 0 reflects no impact, positive or negative.

Values Impacted

Five separate "values that potentially could be impacted by fire," were defined for inclusion in the Values Impacted Rating for the WWA. These data layers were defined through an iterative process of the technical team researching and developing likely candidates for the values datasets, often assisted by state feedback, and then presenting the findings and recommendations to the PSC for final approval. Many other "values" are present that are important and could be negatively impacted by wildfire but were not used in this assessment (i.e. threatened and endangered species habitat). These layers are:

- Drinking Water Importance Areas
- Forest Assets
- Infrastructure Assets
- Riparian Assets
- Wildland Development Areas (Housing Density)

Each value impacted is briefly described below. More detail on each layer as well as the response function scores developed and used is described in Section 3.

Drinking Water Importance Areas

This layer identifies an index of surface drinking water importance, reflecting a measure of water quality and quantity, characterized by Hydrologic Unit Code 12 (HUC 12) watersheds. The Hydrologic Unit system is a standardized watershed classification system developed by USGS (Appendix B). Areas that are a source of drinking water are of critical importance and adverse effects from fire are a key concern.

Forest Assets

The Forest Assets data layer identifies forestland categorized by its cover, height and susceptibility or response to fire. These characteristics allow for the prioritization of landscapes reflecting forest assets that would be most adversely affected by fire. The LANDFIRE Refresh dataset (Appendix B) was used to map stand height, canopy cover and the existing vegetation type (EVT).

Infrastructure Assets

This layer identifies key infrastructure assets, such as schools, airports, hospitals, roads and railroads that are susceptible to adverse effects from wildfires. These features are combined into a single dataset and buffered to reflect areas of concern surrounding the assets.

Riparian Assets

This layer identifies riparian areas that are important as a suite of ecosystem services, including both terrestrial and aquatic habitat, water quality, water quantity, and other ecological functions. Riparian areas are considered an especially important element of the landscape in the West.

The process for defining these riparian areas was complex. It involved identifying the riparian footprint and then assigning a rating based upon two important riparian functions. These functions are water quantity and quality together as well as ecological significance. The WWA technical team developed the Riparian Assets data layer model with support from state representatives. Input datasets used in the model included the National Hydrography Dataset (NHD) and the National Wetlands Inventory.

Wildland Development Areas (Housing Units per Acre)

The Wildland Development Areas (WDA) data layer was developed to identify "where people live" in wildland areas that are threatened by fire from wildland fuels. Wildland Development Areas were compiled from the Where People Live (WPL) dataset which was developed using advanced modeling techniques based on the LandScan population count data available from the Department of Homeland Security, HSIP Freedom Dataset. The HSIP Freedom dataset is available at no cost to U.S. local, state, territorial, tribal and Federal government agencies (Appendix B).

The process excluded the core urban areas that are not in a neighborhood or area threatened by fire burning in wildland fuels. In the process, care was taken to leave relatively small high-density structure areas, one housing unit on 1/3rd of an acre or more, in the Wildland Development Areas data layer when the area was small enough to be threatened by fire from wildland fuels.

The WPL and WDA datasets have been derived to represent the number of houses per square kilometer, consistent with Federal Register and USFS Silvis datasets. However, to aid in the interpretation and use of this data, the legends are presented in "houses per acre". This was done to adhere to traditional use and understanding of this data by planners.

Value Impacted Rating (VIR)

For each value impacted (previous five datasets), each state completed a matrix showing a defined response function value for each value impacted category and fire intensity class (flame length class). The fire intensity or flame length does vary for each of the four percentile weather classes. The Fire Threat Index (FTI) was used to weight the four response function values to obtain a response function score within a cell for a value impacted. The details of the calculation are contained in Section 3.

Each state also provided a measure for the relative importance of each value impacted in relation to the other values impacted. The average of these importance numbers by value impacted was then developed. It together with the acres in each value impacted category was then used to develop the weight of the Response Function Scores for all value impacted categories. This aggregate score was calculated for the Value Impacted Rating using the relative extent process (Thompson, et. Al. In Press). The relative extent is determined using the west wide state provided relative importance weight for each value impacted and the total burnable acres west wide occupied by each value impacted category. The WWA-wide value impacted weights are: Infrastructure Assets, 46.2%; Wildland Development Areas, 44.7%; Drinking Water Importance Areas, 1.0%; Forest Assets, 3.6%; and Riparian Assets, 4.5%.

Fire Suppression Difficulty

The difficulty and potentially the cost for a wildfire to be suppressed are defined as fire suppression difficulty. Two datasets together are used to develop a Fire Suppression Difficulty Rating; these are Surface Fuel Model and Slope.

Surface Fuel Model

The surface fuels affect the ability of firefighters to construct and hold fireline. Surface fuels data used in the WWA were gathered from the LANDFIRE project, Refresh (LF 1.1.0) (Appendix B). The fuel model set used is defined by Scott and Burgan (2005) and is referred to as the 2005 FBPS fuel model set.

Slope

The Fireline Handbook's (National Wildfire Coordinating Group 2004), Appendix A, page A-34, defines four slope classes as follows: 0-25%, 26-40%, 41-55% and 56-74%. A fifth class of 75% or greater was added for WWA use. LANDFIRE Refresh (LF 1.1.0) was also the source of the slope data.

Fire Suppression Difficulty Rating (SDR)

Based on the hand crew fireline production capability (feet per person per hour), the burnable fuel models in the 2005 FBPS fuel model set were grouped into three categories: slow (0-66 feet), medium (67-165 feet) and fast (greater than 165 feet).

Fireline production capability on the five slope classes was used as the basic reference to obtain the suppression difficulty score. To remain constant with the value impacted response function score values of 0 to –9, this "score" is also defined as the Suppression Difficulty Rating assigned to each combination of fuel model group (slow, medium and fast) and slope category.

Fire Effects Index (FEI)

The Fire Effects Index is developed via a weighted combination of the Values Impacted Rating and the Suppression Difficulty Rating. The VIR weight plus the SDR weight totaled to 100%. The states provided input to these weights. Once the VIR and SDR values were determined and the input from the states was averaged, the final weights for the WWA were VIR, 90%, and SDR, 10%.

$$FEI = [(VIR) * (VIR\ weight) + (SDR) * (SDR\ weight)] / 100$$

Note that the resultant Fire Effects Index is a value theoretically between –0.01 and –9.0.

2.3.3. Fire Risk

As mentioned, the data layer that defines wildland fire risk in the WWA is the Fire Risk Index (FRI). The Fire Risk Index is calculated from the Fire Threat Index (FTI), and the Fire Effects Index (FEI). The initial fire risk calculation is IFRI = FTI * FEI. The Fire Effects Index is a value theoretically between –0.01 and –9.0 while the Fire Threat Index is a value between 0.0 and 1.0. This product results in an "expected fire effects value" less than 0 but greater than or equal to –9.0. An "expected" value is a measure of the likelihood of an effect occurring. Since the initial calculation results in small negative values, the final FRI calculation includes 10,000 as a scalar multiplier:

$$FRI = FTI * FEI * 10{,}000.$$

The scalar is included to make the values a bit larger to enhance understanding.

2.4. Project Deliverables

The project deliverables for the WWA consisted of:

- the datasets compiled and developed for the project,
- data tables and lookup tables identifying parameters used in the risk assessment,
- both interim and final presentations on the project status,
- several reports including this final methods report, and
- project web site and domain name www.WestWideRiskAssessment.com.

In addition to the datasets listed in Section 2.2, the deliverables included:

- Tables
  - Model parameter lookup tables - required to compute Fire Threat Index.
  - Fire Effects Scores and Weightings - State and Regional Response Function Scores and weights used to develop the Fire Effects Index and Fire Risk Index.
  - Percentile weather - Database of percentile weather tables used to develop FTI.
- Reports
  - Summary Statistics – State and County summary statistics by various data categories (i.e. Risk by Fuel Type).
  - Data Gap Analysis Report - Document describing gaps in the input datasets and how they were handled and/or recommendations for future updates.
  - WWA Project Final Report – Documents methods used to develop the risk outputs and a summary of results and findings. (This report)

Section 3 WWA Methods and Data Development

This section contains a detailed description of the analysis process to quantify wildfire risk. It is a more detailed explanation of each process than was contained in Section 2 and consists of the following subsections:

- Risk Assessment Process
- Data Classification Categories
- Fire Threat Index
- Fire Effects Index
- Fire Risk Index

3.1. Risk Assessment Process

Within the WWA, the data layer that defines wildland fire risk is the Fire Risk Index (FRI), (Figure 3-1). The Fire Risk Index is calculated from the Fire Threat Index (FTI), and the Fire Effects Index (FEI).

The FEI is the potential expected effects of the fire as defined via response functions. The final calculation is FRI = FTI * FEI*10,000. The scalar is included to make the data values a bit larger to enhance understanding and presentation of the map data.

The description of the process that follows will describe initially the development of the Fire Threat Index. This is followed by descriptions of the Fire Effects Index and then how these are combined to create the Fire Risk Index.

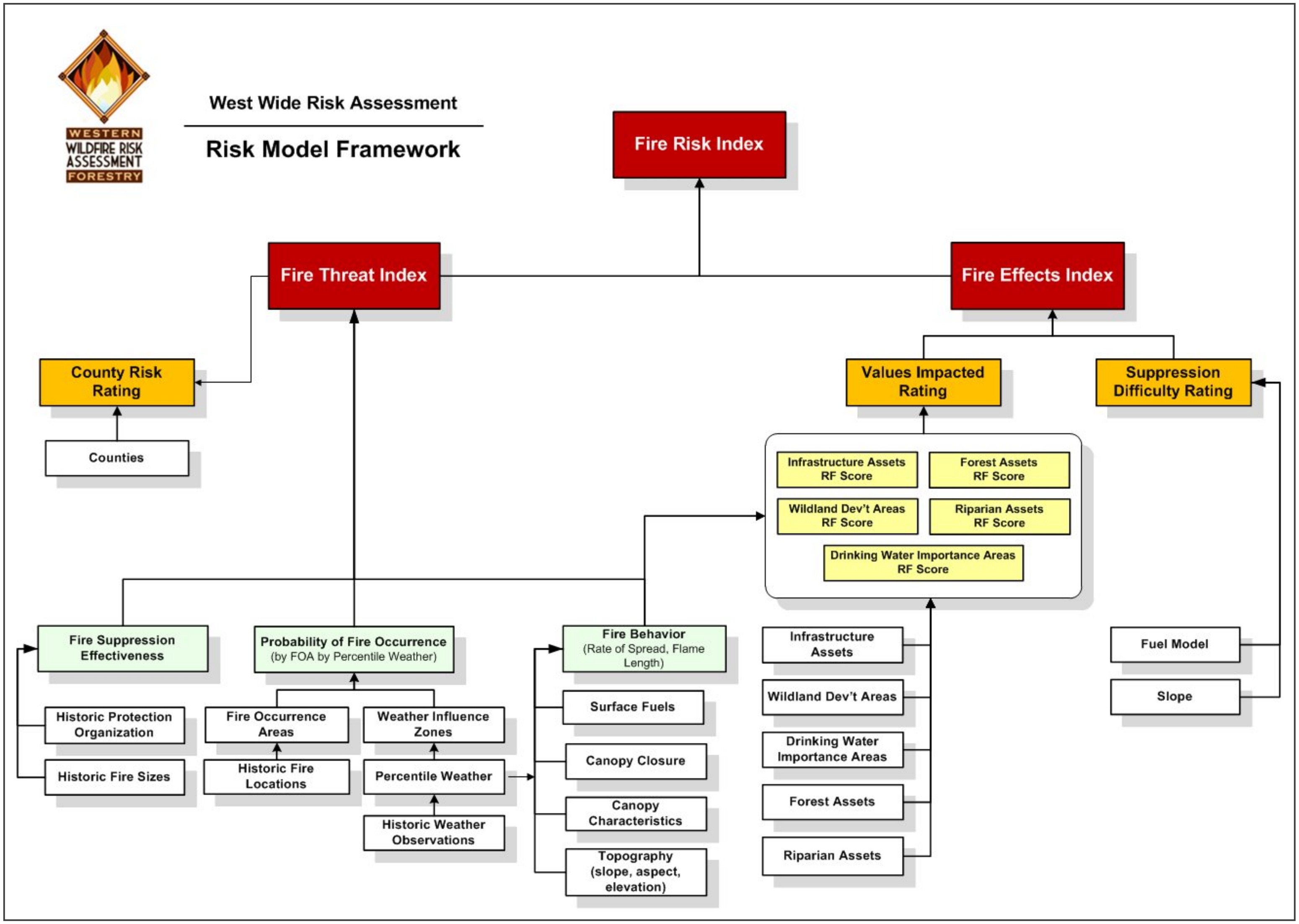


Figure 3-1. WWA Wildfire Risk Assessment Process

3.2. Classification Categories

Prior to reviewing the risk assessment details, it is important to understand the process used to categorize output data for the WWA. Several output data layers, specifically the indices, ratings and scores data layers, as well as the Fire Occurrence Area (FOA) data layer, are comprised of continuous floating point data values. For example, the fire occurrence area data layer has 732,387 unique cellular fire occurrence rate values. Hence, it is necessary to group these values into classes or categories. For consistency, for the output data layers (including FOA), nine categories have been used. The breakpoints between these categories are based on a consistent target cumulative percentile value as shown in Table 3-1.

Table 3-1: Cumulative percent breaks used for class breaks in the WWA

Category	% Range	Cumulative%	Categorical%
1	0 – 32.9%	32.9%	32.9%
2	33.0 - 63.5%	63.5%	30.5%
3	63.5 -70.0%	70.0%	6.5%
4	70.0 - 77.5%	77.5%	7.5%
5	77.5 - 85.5%	85.5%	8.0%
6	85.5 - 92.5%	92.5%	7.0%
7	92.5 - 96.5%	96.5%	4.0%
8	96.5 - 98.5%	98.5%	2.0%
9	98.5 - 100.0%	100.0%	1.5%

By design, the categories were developed to display the highest rated 14.5% of the cells in categories 6-9. The highest rated 22.5% of the cells are in categories 5-9. Notice this places the highest rated cells (areas) into just about half of the categories (5-9) which allows the user to truly locate and distinguish the differences within these highly rated cells (areas).

The class breaks have been defined based on the distribution of data for the 17 western states for each layer. In this regard, the categorical percent represents the percentage of area across the entire west, i.e. Category 9 reflects the top 1.5% of area in the entire west.

A consistent color scheme has been applied to each of the nine categories. The "color ramp" used is shown in Figure 3-2, with the example being from the Fire Occurrence Area (FOA) dataset.

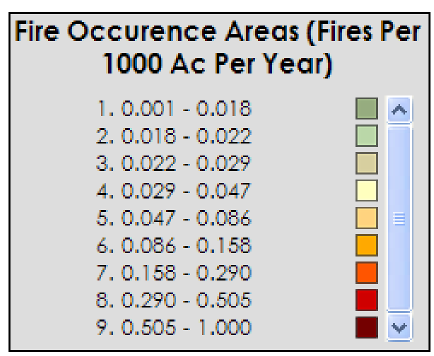


Figure 3-2. Color ramp used for WWA classes. Value breaks shown here are for FOA, specifically.

3.3. Fire Threat

The word "risk" is used with varying definitions by the public. Webster's dictionary though defines risk as "the possibility of suffering harm or loss." The fire threat component of the fire risk assessment process is "the possibility" part of the risk definition and is called the Fire Threat Index (Figure 3-1).

Fire Threat Index is calculated as a number greater than zero (0) but less than or equal to one (1). The process used to calculate fire threat relies on the analytical methods that would be used to calculate the probability of an acre burning. The FTI integrates the probability of an acre igniting and fire suppression effectiveness relationships. Due to some necessary assumptions, mainly fuel homogeneity, it is not the true probability. However, since all areas within the analysis area have this value determined consistently, it allows for comparison and ordination of areas as to the likelihood of an acre burning.

The process of determining fire threat includes three primary components:

- Fire Occurrence
- Fire Behavior, and
- Fire Suppression Effectiveness

3.3.1. Fire Occurrence

To develop the Fire Threat Index, the first task was to gather historical fire occurrence information. Wildland fire occurrence data for the WWA project was required to be spatially referenced fire ignition point locations. In addition, associated fire report attributes such as ignition date and fire control date were valuable to know. The process flowchart in Figure 3-3 shows where this data is used (red outlined boxes) in support of the development of the Fire Threat Index. The goal in gathering this information was to use it to define areas of uniform probability of an acre igniting. These areas are called Fire Occurrence Areas (FOA). Figure 3-4 shows an example of spatial fire occurrence data and Figure 3-5 shows what the Fire Occurrence Area data layer might look like using this spatial fire occurrence data.

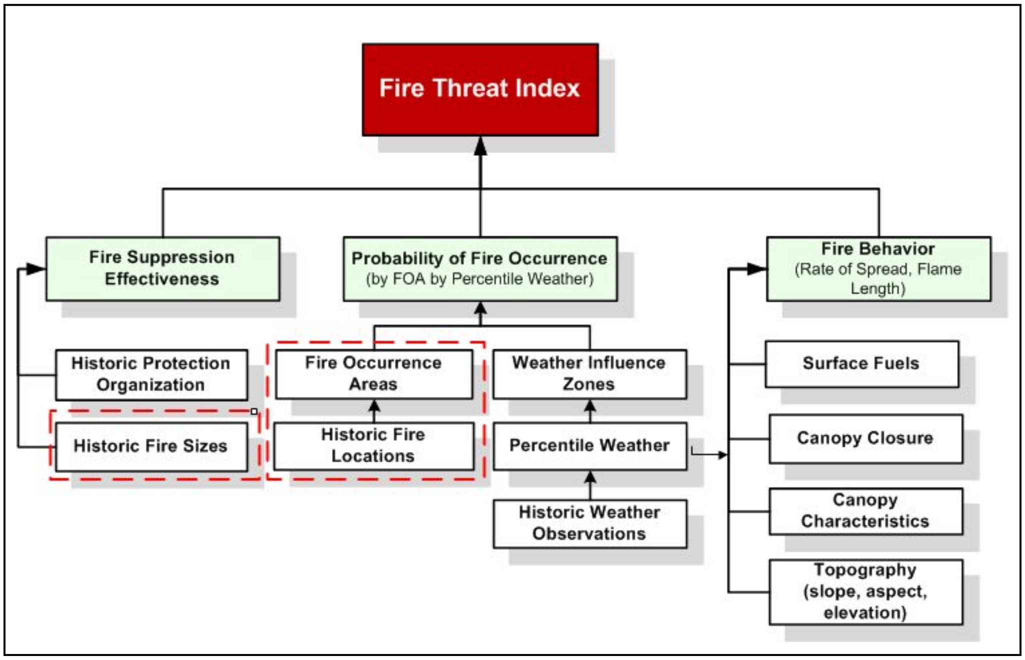


Figure 3-3. Portions of Fire Threat model supported by historical fire occurrence data.

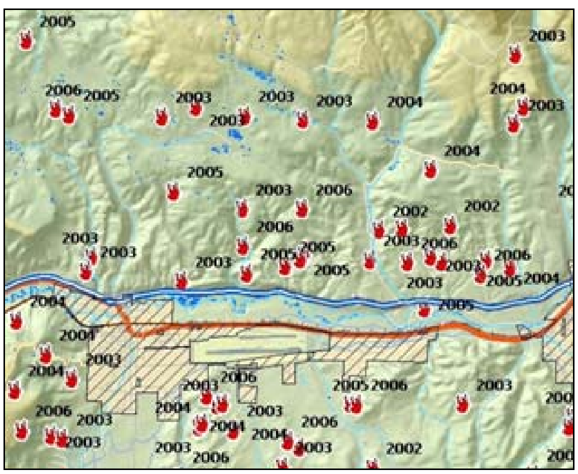


Figure 3-4. Historical Fire Occurrence Points

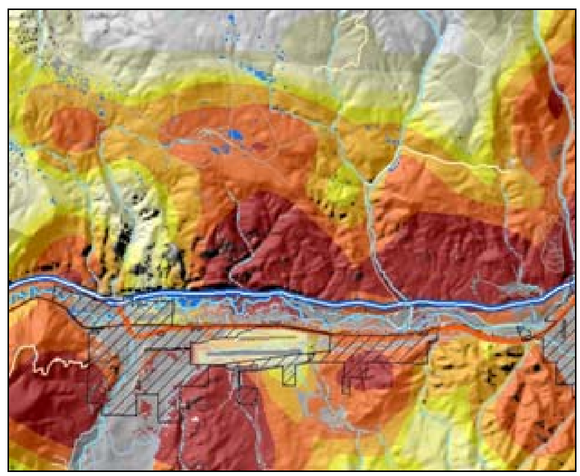


Figure 3-5. Fire Occurrence Areas

Fire occurrence report data was gathered from the states, the federal government and from the National Fire Incident Reporting System (NFIRS). As a standard, the WWA requested fire occurrence fire report data from the agency that has the statutory responsibility for fire protection. In some locations, the agency that has the statutory responsibility for fire protection via agreements has a different agency actually providing the initial attack of fires on their lands. This request was made to minimize the duplicate fire reports that the project might receive.

To support the gathering of fire occurrence data from the states, a Fire Occurrence Data Briefing Paper was developed. The data fields and the format of the data requested were communicated to the states. Conference calls were held to accomplish the transfer of this data request. The data was to be "cleaned" by state representatives in order to remove duplicate fire locations and erroneous fire locations and related report information. Project staff worked with the state representatives and provided guidance and quality control on wildland fire ignition location data. Project staff spent significant time to insure as best as could be determined that duplicate fire reports were identified for fires with a final fire size greater than 100 acres.

For each wildland fire ignition, the following data fields were requested.

- Discovery Date
- Unit Organizational Code
- Fire Number Or ID
- Total Acres Burned
- Fire Cause Code
- DATUM
- Latitude
- Longitude
- Discovery Time
- Contained Date
- Contained Time
- Control Date
- Control Time

Those states that did not collect all of the attributes requested were asked to provide as many of the requested attributes as possible. As a minimum for each wildland fire, the year of the fire and the location of the fire described by latitude/longitude were needed.

These same data fields were also gathered from the federal fire occurrence data on lands protected by the following agencies: USDA U.S. Forest Service, DOI Bureau of Land Management, DOI Bureau of Indian Affairs, DOI U.S. Fish and Wildlife Service and DOI National Park Service. The primary source of fire occurrence reports was from the U.S. Forest Service's Fire and Aviation Management Web Applications (FAMWEB) web site.

Since the state fire occurrence reports are only for lands that the state has the statutory responsibility for fire protection, it was necessary to obtain fire occurrence data for other privately owned lands. Most of these lands have wildland fire protection provided by an urban or rural fire protection district. These fire protection districts have been requested to report all fires including wildland fire to the U.S. Department of Homeland Security National Fire Incident Reporting System (NFIRS).

The project contacted the Department of Homeland Security and obtained the NFIRS fire report databases for the years 1999 through 2009. A custom program was written to extract from these yearly databases the fire report data defined above for all wildland fires (Incident Types 140-143), special outside fires (Incident Type 160) and agriculture fires (Incident Types 170-173).

Almost all of the fire reports from NFIRS did not contain a location defined by latitude/longitude or township/range/section. This requires the reporting fire department to complete the optional locations section of the report. Almost without exception, the fire departments are completing this section with only a field with a street address, town, state and zip code. Hence for all fires reported via NFIRS, the fire was located on the landscape by assigning it to a postal service zip code. All fires within a zip code were then uniformly distributed to the cells within the postal service zip code. This allows for the accounting of these fires in the FOA development process though on a less spatial basis than fires reported by the states and federal agencies. Note due to data issues, NFIRS data was not used in Colorado.

The years for which fire reports were provided varied based on availability. For the five federal agencies, fire reports from 1999 –2008 were used. For the states, the data varied with different year time periods ranging between 1999 and 2009. The maximum period used was 10 years. For the NFIRS data, it became apparent from the number of fire reports by state that, by 2004, implementation of the reporting process was in place. Also, the reporting by fire protection districts is voluntary in most states. Hence, a complete set of reports is not available but the project used what was available. For the reports that were available, the period 2004 – 2009 was used. In all cases, the process annualizes the fire occurrence.

Fire Occurrence Areas (FOA)

A Fire Occurrence Area (FOA) is an area where the probability of each acre igniting is the same. Pictorially, if one were to locate the point location for historic ignitions on a map of an FOA, the points would appear to be equally spaced.

This data layer is a surface grid of calculated mean ignition rates that represent the probability of a wildland fire igniting. It was developed using the historical fire ignition data discussed above. Resultant fire ignition rates are measured in fires per 1,000 acres per year. Figure 3-6 shows Jackson County, Oregon, with fire ignition location points.

Prior to developing the FOAs, the fire locations were reviewed for quality assurance. The first step was to review the data spatially. Fire locations that were outside the jurisdiction of the reporting agency were deleted. The assumption here is that the legal description, latitude/ longitude, is incorrect and there is no reasonable way to find the correct location.

The second step in reviewing the fire reports was to remove any apparent duplicate fire reports. Duplicate fire reports can occur if more than one agency responds to the same fire and each agency submits a report. For this reason, the project staff compiled from each agency only fire reports for fires for which the agency has statutory responsibility.

Duplicates can frequently be recognized by comparing the fire start date, fire size and latitude/longitude. Identifying duplicate fires was done by sorting the data and identifying those fires with the same date and then comparing the fire size and coordinate locations.

All processing was done using grid-based modeling using floating point calculations to facilitate greater numerical precision. The modeling process is designed to distribute the fire frequency across the burnable area within a one mile by one mile grid. Neighborhood modeling functions are applied to derive an ignition rate for every burnable cell in a grid using raster processing techniques. Detailed steps for developing FOA are in Addendum I. As noted previously, Figure 3-6a and 3-6b show Jackson County, Oregon, with fire ignition locations and fire occurrence areas.

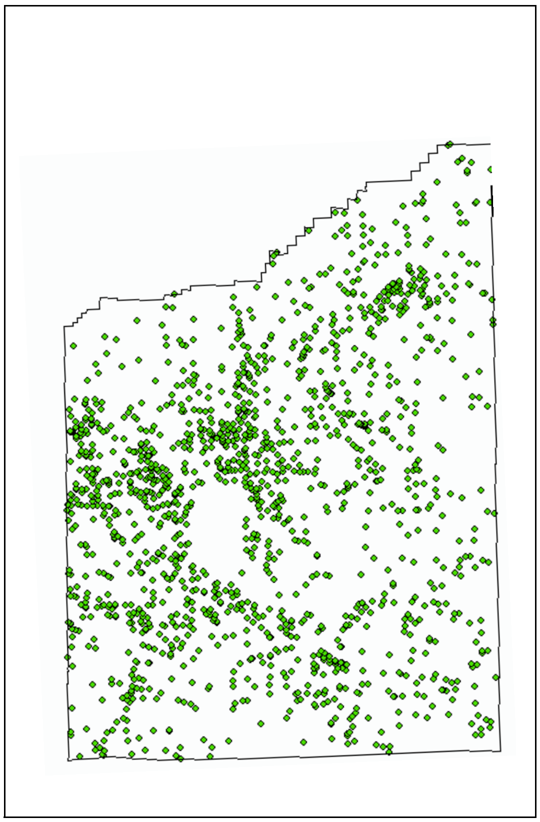


Figure 3-6a. Fire Ignition Locations

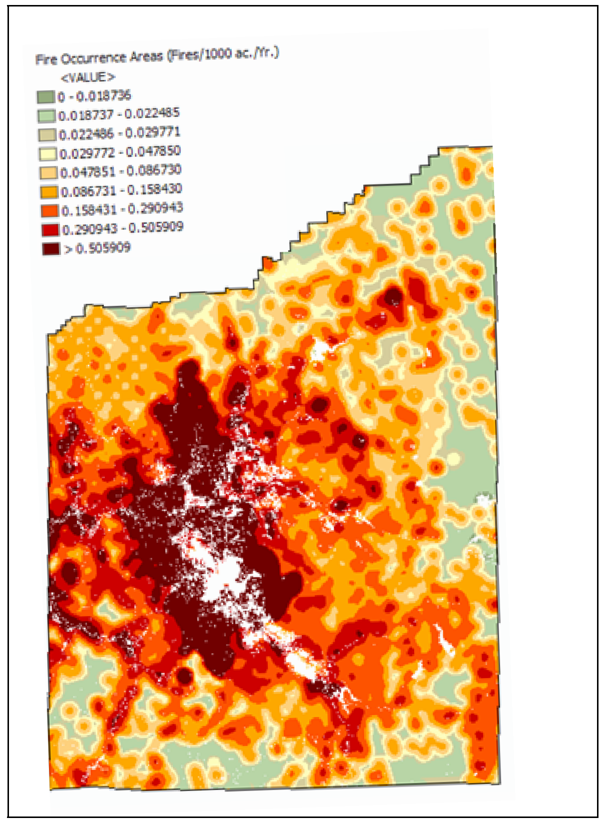


Figure 3-6b. Fire Occurrence Areas

3.3.2. Fire Behavior

Fire behavior prediction was estimated using methods defined in the Fire Behavior Prediction System (Rothermel 1983, Scott and Reinhardt 2001, Andrews 2007, Heinsch and Andrews 2010). Fire behavior was predicted for surface and canopy fire types. The prediction system requires that data be gathered and mapped for fuels and topography at a local scale. For the WWA, the mapping scale for fuels and topographic data is at a 30-meter by 30-meter resolution or approximately 100 feet by 100 feet. On a larger but uniform scale, the weather needs to be defined.

Weather

Weather throughout the project area varies considerably based upon geography. Weather Influence Zones (WIZ) were developed and represent areas of relatively homogenous weather or climatology. Each state provided a fire weather meteorologist contact for coordination with the project staff meteorologist in the development of Weather Influence Zones.

The following criteria were used to determine WIZ boundaries.

- Topographic features: mountain ranges (location, elevation, slope orientation), river basins
- Precipitation climatology (annual, fire season)
- Existing weather forecast areas such as Predictive Service Areas
- Percentile weather at weather stations
- Fire danger ratings that are similar throughout the WIZ
- State boundaries

Figures 3-7 through 3-9 show the Weather Influence Zones for Hawaii, the contiguous 15 western states and Alaska.

A search of land management agency fire weather stations and National Oceanographic and Atmospheric Administration (NOAA) surface observations was conducted to establish a quality, long-term weather dataset. The primary sources of this data are: the U.S. Forest Service's Fire and Aviation Management Web Applications (FAMWEB) web site. In addition, weather stations and daily observations were gathered from the weather data

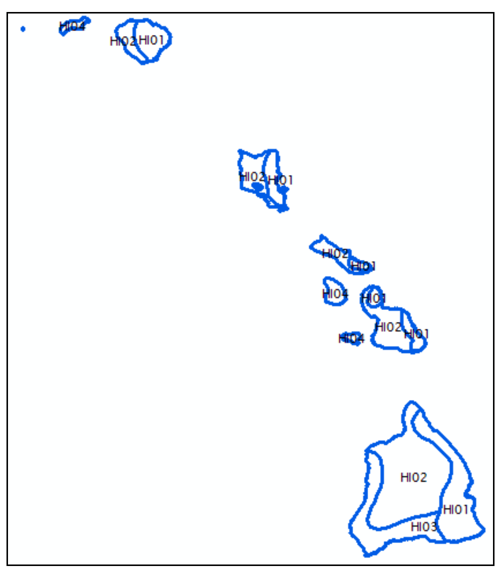


Figure 3-7. Weather Influence Zones for Hawaii

delivery system located at the NOAA's National Climate Data Center (CDC). The preferred length of record for these stations was 20 years, but stations with fewer years were used if necessary.

The weather station catalog was obtained from the U.S. Forest Service's Fire and Aviation Management Web Applications (FAMWEB) web site. Except for the assigned fuel model, the catalog information was used as stated by the station's maintaining agency.

WWA staff gathered weather observations from weather stations. These weather observations were used to select a weather station that best represented the weather in the Weather Influence Zone. Using the weather observation for the best fit station, fuel moisture values and wind speed values were determined for four percentile weather categories, Low (15% of days), Moderate (75% of days), High (7% of days) and Extreme (3% of days).

Weather observation data was gathered for 2,144 weather stations. The fire season was defined by Weather Influence Zone and is shown in Addendum I. This data was checked for errors and then imported into a custom built program named WRISK which is based on the USDA-Forest Service's FireFamilyPlus program. The WRISK program was specifically tailored to the needs of the WWA and uses the same equations as the FireFamilyPlus program.

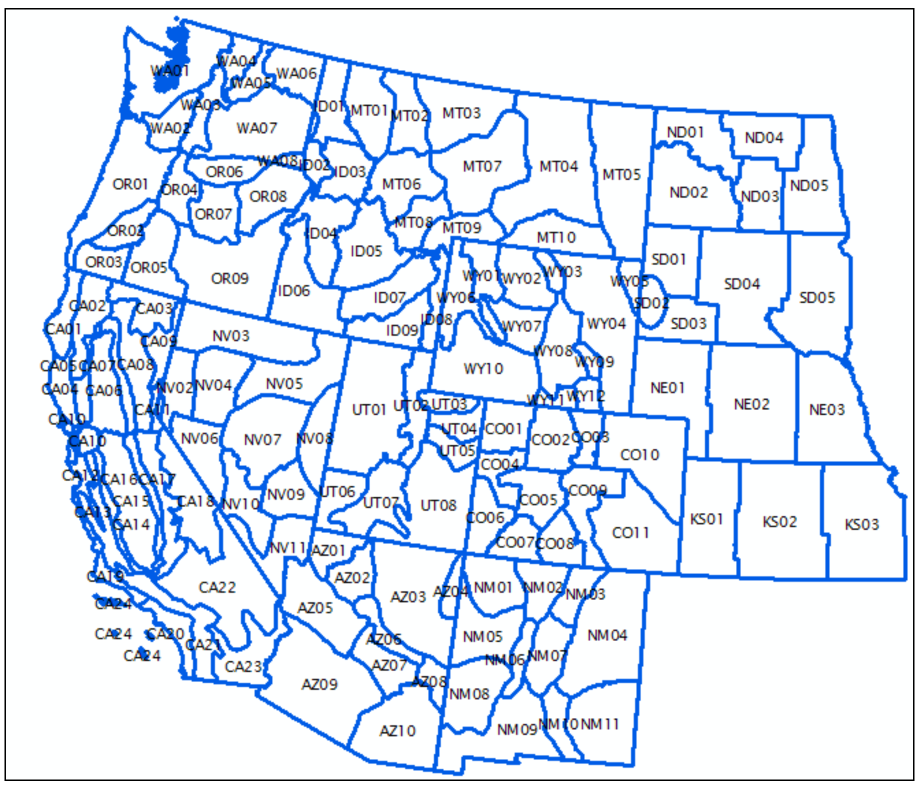


Figure 3-8. Weather Influence Zones for the Contiguous 15 Western States

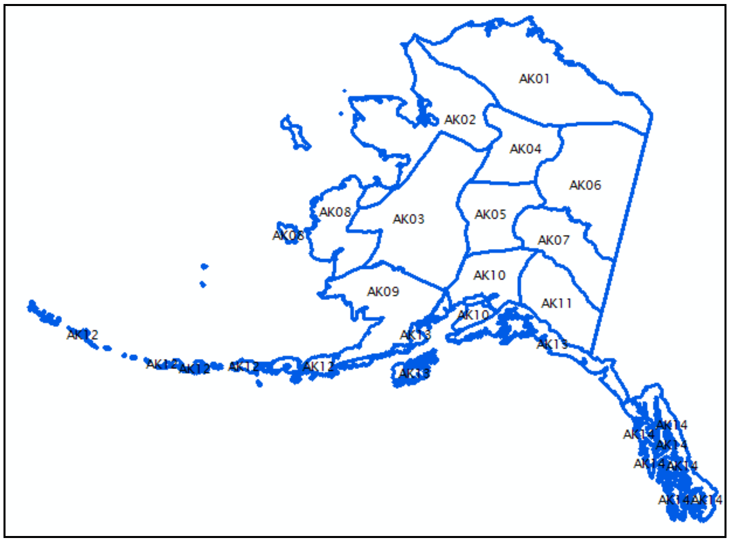


Figure 3-9. Weather Influence Zones for Alaska

The National Fire Danger Rating System (NFDRS) index Spread Component (SC) was calculated for each day. For each weather station, the Spread Component was calculated using the NFDRS fuel model G. Fuel model G contains fuel loading values in all of the dead (1-h, 10-h and 100-h) and live (herbaceous and woody) fuel categories. This allows for the influence in the Spread Component calculation of the fuel moisture values in all of the fuel categories. In this calculation, the climate class and slope class defined in the station catalog were used. The grass type was assumed to be perennial.

The Spread Component was then divided into four commutative percentile categories Low (0-15%), Moderate (16-90%), High (91-97%) and Extreme (98-100%). The median Spread Component was determined for each category. The environmental values for 1-h, 10-h, 100-h timelag fuel moisture, live herbaceous fuel moisture, live woody fuel moisture and the 20 foot 10 minute average wind speed were determined as the average of the respective values on days when the Spread Component was equal to the median Spread Component. This allowed for the determination of four percentile weather categories with the percent of occurrence of each category and with environmental values to define the weather conditions within each category.

An example printout and screen capture of percentile weather values from the FireFamilyPlus program for a weather station is shown in Figure 3-10. This example weather station named Pine Hills Fire Station is shown for reference to the program outputs of percentile weather. The WRISK program does not have these printouts or screens. Showing the screens from the FireFamilyPlus program is done for explanation purposes.

Percentile Weather Report from FireFamilyPlus

```
FireFamily Plus Percentile Weather Report for RERAP

 Station: 045711: PINE HILLS FIRE STA    Variable: SC
 Model: 7G3PE2
         Data Years: 1980 - 2009
         Date Range: May 1 - December 15
Wind Directions: N, NE, E, SE, S, SW, W, NW

Percentiles, Probabilities, and Mid-Points
    Variable/Component Range      Low       Mod       High      Ext
            Percentile Range     0 - 15   16 - 89   90 - 97   98 - 100
         Climatol. Probability     15        75         7         3
            Mid-Point     SC     4 -   4   8 -   8   14 -  14   22 -  99
            Num Observations      309      1013       242        60
       Calculated Spread Comp.      4         8        14        27
                Calculated ERC     28        50        64        59

Fuel Moistures
        1 Hour Fuel Moisture     10.27      5.73      3.50      3.25
       10 Hour Fuel Moisture     13.37      7.54      5.35      6.06
      100 Hour Fuel Moisture     16.68     11.39      8.37      8.96
    Herbaceous Fuel Moisture     95.59     64.60     50.32     46.85
         Woody Fuel Moisture    135.07     98.45     81.82     90.46
              20' Wind Speed      3.78      5.57      8.22     16.12
     1000 Hour Fuel Moisture     17.14     12.56     10.44     11.64

 4287 Weather Records Used, 4287 Days With Wind (100.00%)
```

Percentile Weather Decision Screen from FireFamilyPlus

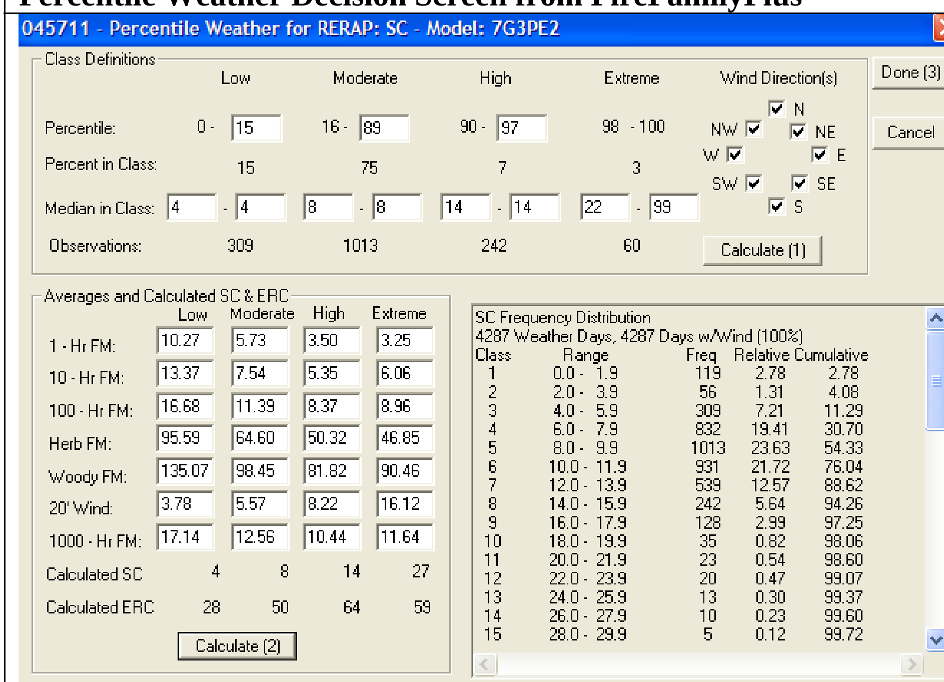


Figure 3-10. Example screens from Fire Family Plus for demonstration purposes.

For each WIZ, one weather dataset needed to be developed with a weather observation for each day. To do this, the most representative station within each WIZ was determined. The weather stations selected for each WIZ with the years of record are shown in Addendum I.

For the live herbaceous fuel moisture, the values are based on the expected rate of curing of grasses in the climate class assigned to the representative weather station in each WIZ. Consistency is needed here as the grass fuel models in the 2005 FBPS Fuel Model Set are dynamic where grass loading is transferred from the herb to the 1-hr dead category based on the herb fuel moisture (Table 3-2).

Table 3-2. Herbaceous Curing and Fuel Moisture Assumptions

Climate Class	Percentile Weather							
	Low		Moderate		High		Extreme	
	Prop. Cured	Herb Moisture	Prop. Cured	Herb Moisture	Prop. Cured	Herb Moisture	Prop. Cured	Herb Moisture
1, 2	0.2	102%	0.6	66%	0.9	39%	1.0	30%
3, 4	0.1	111%	0.5	75%	0.8	48%	0.9	39%

An example set of percentile fuel moisture values for a weather station with the 1-h, 10-h, 100-h timelag fuel moisture, live woody fuel moisture and wind speed are shown in Figure 3-11. The percentile weather fuel moistures and wind speeds for the representative weather stations selected for all WIZs are listed in Addendum I.

	1-hr Timelag				10-hr Timelag				100-hr Timelag			
WIZ	L	M	H	E	L	M	H	E	L	M	H	E
3504	6.8	4.5	5.2	4.5	8.5	6.2	6.8	5.2	11.5	8.6	7.5	6.9
	Herbaceous				Woody				20 foot Wind Speed			
WIZ	L	M	H	E	L	M	H	E	L	M	H	E
3504	102	66	39	30	96	76	71	70	2.6	4.5	8.8	11.0

Figure 3-11. Example Percentile Fuel Moisture and Wind Speed Values

If 15 percent of the days during the fire season are in the Low Percentile Weather Category, one cannot assume that 15 percent of the fires during the fire season will occur on the days in this Weather Category. The Low, Moderate, High and Extreme weather categories contain 15%, 75%, 7% and 3% of the days respectively. Notice that the proportion of fires that occur can vary from this nominal percentage of days by category. Hence the next task is to determine the probability of a fire occurring under each percentile weather category.

For each day within the fire season, the NFDRS Spread Component was calculated using the WRISK program. Each historic fire was assigned a Spread Component based on the fire's start date. The four percentile weather categories were also developed using the same assumptions for spread component and the four percentile weather categories have spread component ranges. Hence, a correlation was made assigning each historic fire to one of the four percentile weather categories.

From these assignments, the proportion of fires that occurred in each percentile weather category by WIZ was determined for the project area. An example is shown in Figure 3-12. The values for each Weather Influence Zone are shown in Addendum I.

	Percentile Weather			
WIZ	Low	Mod	High	Ext
3504	0.188	0.696	0.093	0.023

Figure 3-12. Example Proportion of Fires by Percentile Weather Category

To assist in the adjustment of weather observations to a ground level reference for fire behavior calculations, the canopy ceiling height (stand height) and canopy cover data layers were used. Together with the canopy base height data layer, this allowed for the prediction of canopy fire occurrence within a percentile weather category in a cell.

In the canopy fire calculation, the foliar moisture content for all percentile weather categories was set at 100%.

Fuels and Topography

Software is used to generate fire behavior data that is comparable across the landscape for a given set of weather, fuels and fuel moisture data inputs. Fire behavior data can be generated by programs like FARSITE (Fire Area Simulator) (Finney 1998) and FlamMap Finney (2004). To facilitate these calculations, custom fire behavior prediction software was built that has equations consistent to those developed and used in FARSITE and FlamMap Finney. This custom software was built to provide a seamless access by GIS software to fire behavior values for a cell.

GIS data is required for five data themes; elevation, slope, aspect, surface fuel model and canopy cover (Figure 3-13). Three additional optional data themes are as follows: canopy height, canopy base height and canopy bulk density.

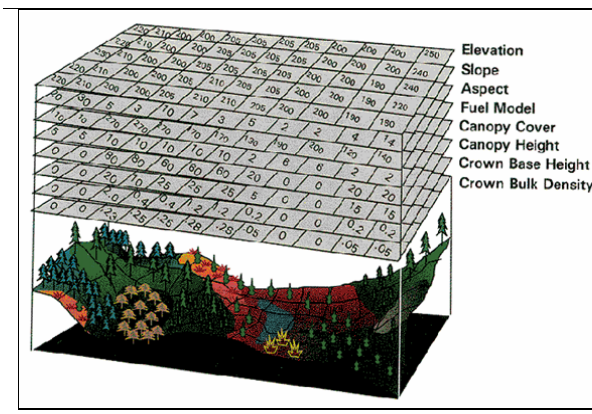


Figure 3-13. Diagram with GIS Data Layers for Fire Behavior Prediction

All fuels and topographic data used in the WWA were gathered from the LANDFIRE project. The version of this data is called the Refresh (LF 1.1.0) dataset and maps the data layers to a benchmark year of 2008.

Surface Fuels

To predict surface fire behavior, the 2005 Fire Behavior Prediction System fuel model set was used (Addendum I). This fuel model set includes 40 fuel models as defined by Scott and Burgan (2005). The source of this data was LANDFIRE Refresh. The LANDFIRE surface fuel model data also includes four fuel models which are non-burnable; urban, agriculture, barren and water. The 1982 Fire Behavior Prediction System fuel model set (Anderson 1982) is also included in Addendum I since a fuel model map using this fuel model set was a deliverable for this project.

For the areas mapped with a burnable fuel model by the LANDFIRE project, it was determined by the WWA staff that some of these areas were actually in core urban areas. Figure 3-14 shows an example of fuel model TL-6 (light blue) assigned to urban areas between the non-burnable streets (true urban).

The WWA staff, in coordination with some state representatives and the WWA project manager, developed rule sets and a process to reassign some of these burnable areas to the non-burnable fuel model urban (91). This process utilized the Where People Live dataset to help refine the urban areas based on housing units per acre. A single rule set was not appropriate for all states; therefore each state was individually analyzed to determine the combination of housing units per acre threshold and size of housing density (rule set) that best refined urban. In several states, a handful of polygons were manually adjusted either to urban or back to burnable when the model simply did not work to the technical team's satisfaction. These rule sets for all states are listed in Addendum I.

Figure 3-15 shows the result for the area that was defined as urban in the Boulder, Colorado, area (Figure 3-14). For Colorado, the threshold used was 6.2 household units per acre (247.4 – 370.6 people/sq km). This corresponds to the dark pink to dark maroon areas shown on the left side of the figure. That selection was used to generate the urban mask seen on the right (maroon polygons).

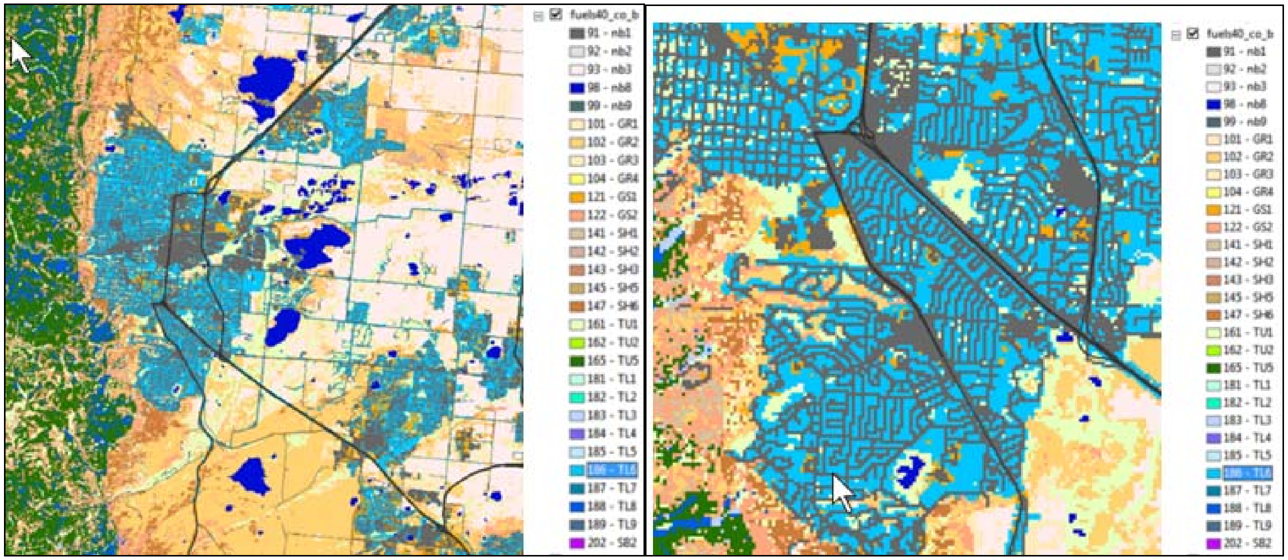


Figure 3-14. Burnable Fuel Model Inside Urban Area near Boulder, Colorado.

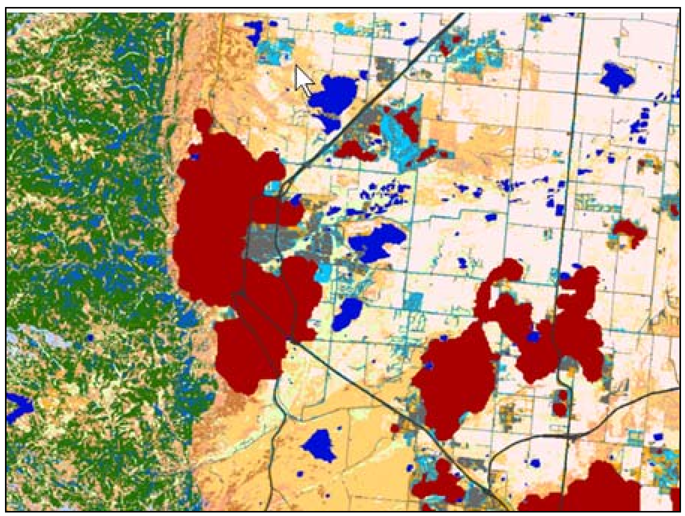


Figure 3-15. Urban Area Defined for Boulder.

This effort allowed for additional area to be added to the LANDFIRE Refresh surface fuel model Urban (91) to better reflect the urban areas. A deliverable for the project was a data layer with the 1982 FBPS fuel model set (Anderson 1982). This dataset was provided but not used in the analysis work. The urban fuel model in the 1982 FBPS fuel model set was also modified as described. The definition of the fuel models in the 1982 FBPS fuel model set is contained in Addendum I.

In Figure 3-16, an area of Jackson, County, Oregon, has the surface fuels mapped using the 2005 FBPS fuel model set. The area in the lower right is Medford. Note the uniform definition of this area as an urban fuel model (91).

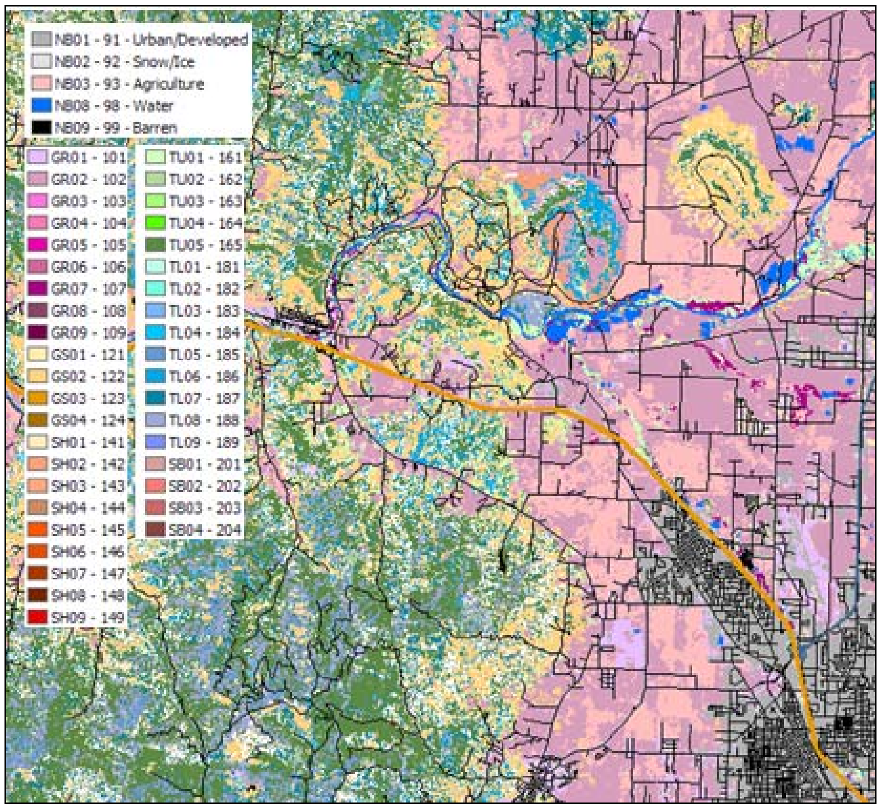


Figure 3-16. Area of Jackson County OR with Surface Fuels Mapped

Topography

The slope, aspect and elevation values were also gathered from the LANDFIRE project Refresh (LF 1.1.0) dataset.

For each 30-meter by 30-meter cell in the LANDFIRE data, the rate of spread, flame length and fire type (surface or canopy) was calculated using the equations in the Fire Behavior Prediction System. This calculation was done for all four percentile weather categories.

Canopy

To model canopy (crown) fire occurrence and behavior, the canopy base height and canopy bulk density datasets from LANDFIRE were used. Examples for canopy base height and canopy bulk density are shown for a section of Jackson County, Oregon, in Figures 3-17 and 3-18. Canopy base height is shown in the units of feet times 10. In Figure 3-17, divide the unit shown in the legend by 10 to get units in feet. For example, 3 in the legend represents 0.3 feet on the ground. The units for canopy bulk density are in kilograms per cubic meter (kg/m3) times 100. For example, 10 in the legend means 0.10 kg/m3 on the ground. The use of the metric units here is common. To convert to pounds per cubic foot (lbs/ft3) multiply the kilograms per cubic meter by 0.062427885.

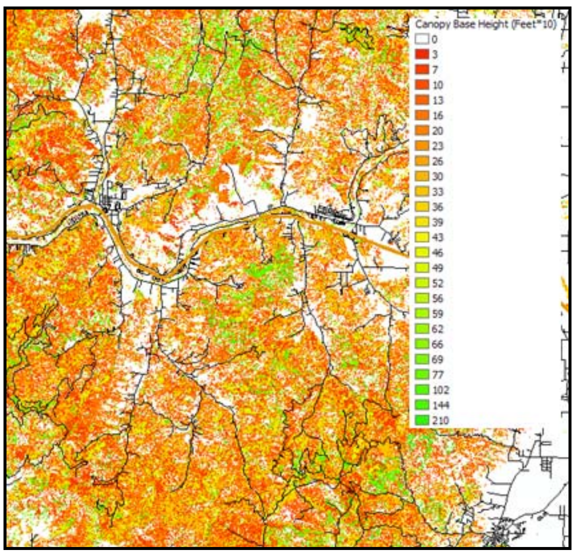


Figure 3-17. Canopy Base Height (ft * 10)

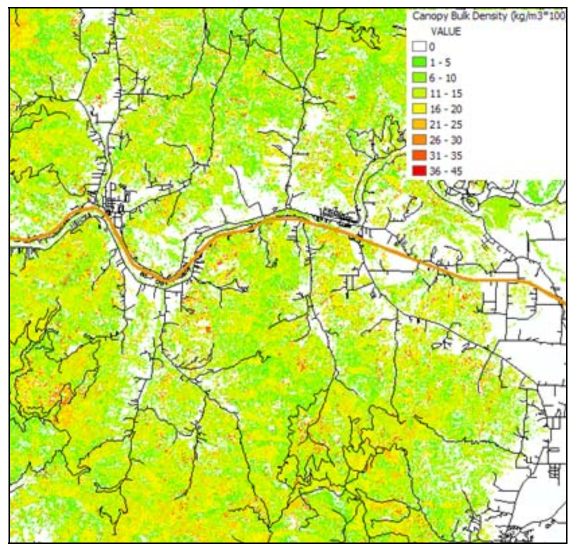


Figure 3-18. Canopy Bulk Density (kg/m3)

There are three fire types: surface, passive and active. A surface fire is one that is spreading in the surface fuels or in the surface fuel model

In areas where there is a tree canopy and where the needles or leaves of the trees can support fire movement vertically into the crowns of these trees, canopy fire occurrence can occur. The word canopy is used here as it refers to stands of trees which have canopies, whereas individual trees have crowns.

If a fire spreads vertically into the crown of a tree or a group of tree crowns, this is called a passive fire type.

When a fire does spread vertically and, due to the conditions present, generally high wind speeds or steep slopes or both, the fire then actually spreads laterally primarily through the canopy of the tree stand but with the support of the surface fire intensity, this is called an active fire type.

Figure 3-19 shows the predicted fire type (surface, passive or active) for an area of Jackson County, Oregon, under the high percentile weather category. The high percentile weather category is the 90-97% percentile condition. The fire type is predicted for all four percentile weather categories and data layers for each are provided in the published results (Figure 3-19).

In practical terms, what is important is whether passive or active fire types are likely. Hence, these two fire types will be collectively referred to as canopy fire. Figure 3-20 shows the same area of Jackson County, Oregon, as Figure 3-19 but displays the probability of canopy fire occurrence under all four percentile weather conditions. As shown canopy fire can occur and in the example, it is predicted to occur at greater than a 0.75 probability based on all four percentile weather conditions on many areas. A comparison shows almost the entire canopy fire occurrence is of the passive fire type.

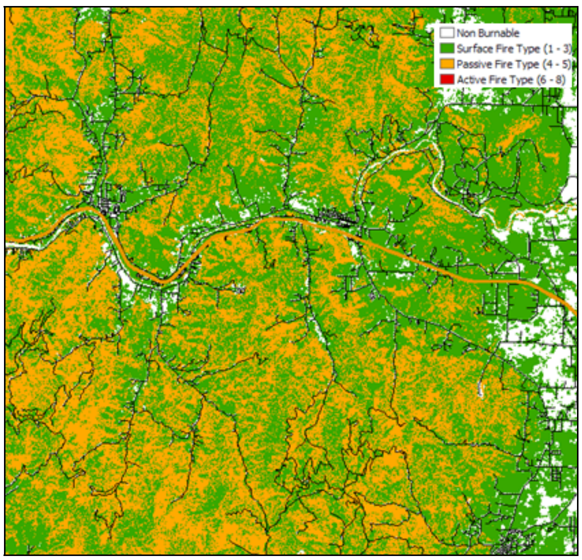


Figure 3-19. Fire Type, High Percentile Weather Category

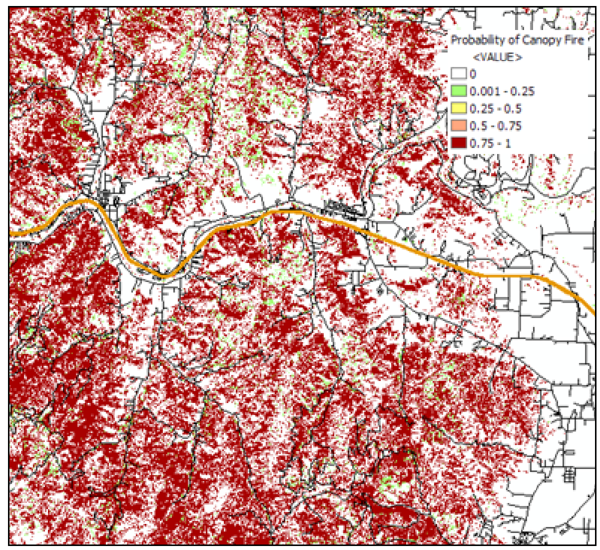


Figure 3-20. Probability of Canopy Fire Based on All Percentile Categories

Resultant Fire Behavior

For each of the four percentile weather categories, the key fire behavior outputs of rate of spread (chains/hr) and flame length (feet) were calculated and mapped by cell. Note a chain is a forestry unit of measure and is equal to 66 feet. For reference, feet per minute is equal to 1.1 times chains per hour. The resultant fire behavior includes the occurrence of canopy fire and its effect on the rate of spread and flame length.

For each percentile weather category, the rate of spread, flame length and fire type are provided in published results data layers. Fire type was described above and an example was displayed in Figure 3-19.

For the same area of Jackson County, Oregon, Figure 3-21 shows the rate of spread under the high percentile weather category, and Figure 3-22 shows the flame length.

Using all four percentile weather category outputs and doing a weighted average of these outputs using the probability of a fire occurring in each percentile weather category, the "expected" values for each can be calculated. These are displayed in Figures 3-23 and 3-24.

Now that the likelihood of a cell igniting is known as well as the fire behavior, the next step in calculating Fire Threat Index is estimating what a resultant fire size might be.

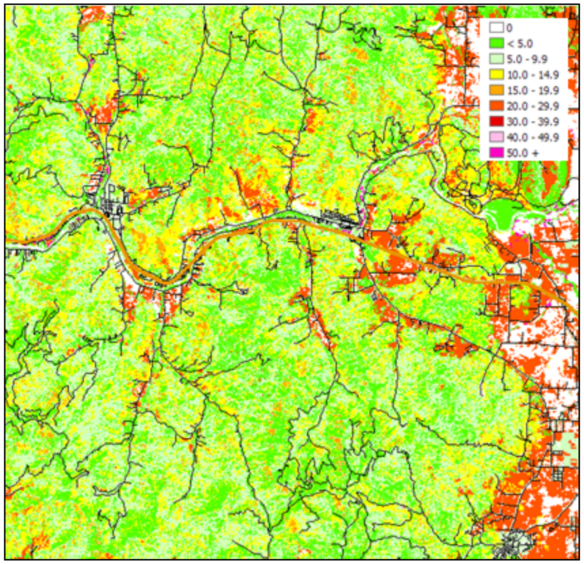


Figure 3-21. Surface Rate of Spread, High Percentile Weather

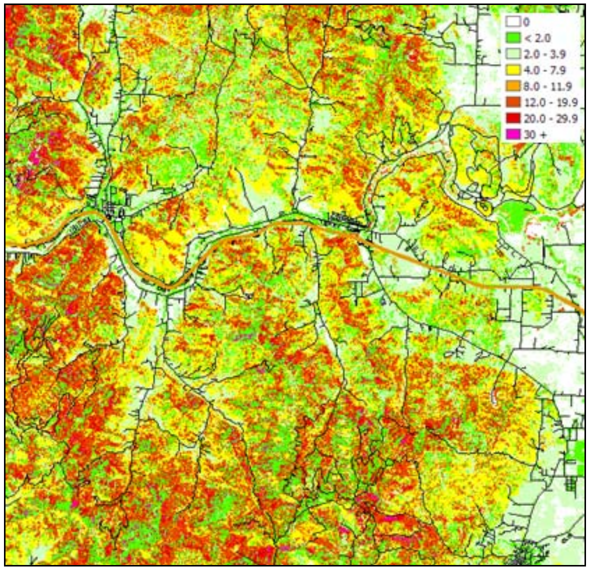


Figure 3-22. Flame Length, High Percentile Weather

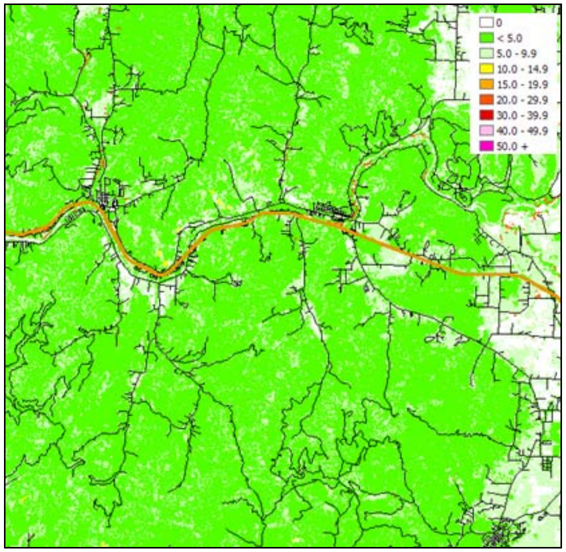


Figure 3-23. Surface Rate of Spread, Expected

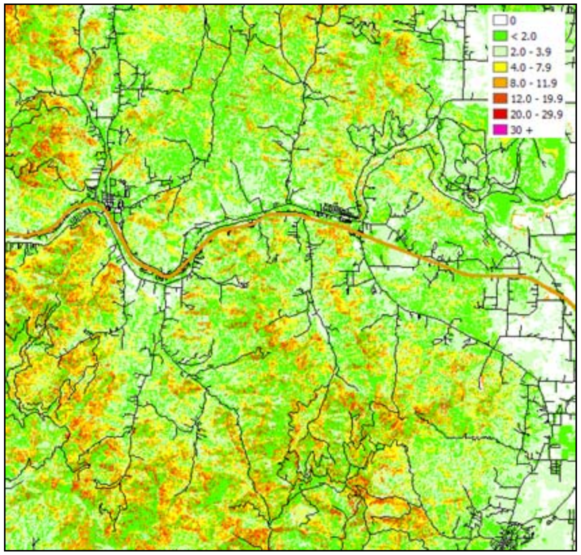


Figure 3-24. Flame Length, Expected

3.3.3 Fire Suppression Effectiveness

To calculate the Fire Threat, the expected size of a fire needs to be estimated to facilitate estimating a measure of the probability of an acre burning. To do this, it was necessary to develop relationships between fire spread rates and the potential expected final fire size. The inputs to this relationship are the expected fire behavior and a measure of suppression effectiveness of fire protection forces.

The fires occurring are assumed to be attacked under a full suppression philosophy. For each Weather Influence Zone, the fire occurrence reports were used to develop initial relationships. Via a calibration process, final relationships were developed. Following calibration for a Weather Influence Zone, the predicted annual acres burned are similar to the historic expected acres burned developed from the fire occurrence reports.

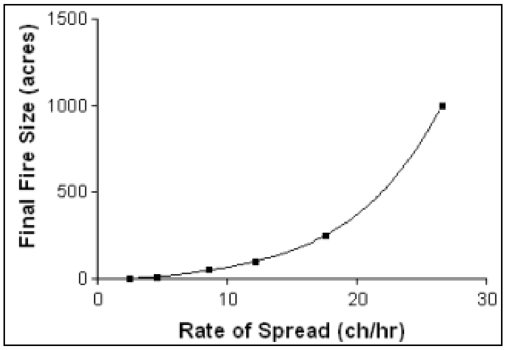


Figure 3-25. Generic Relationship Between Rate of Spread and Final Fire Size

For each Weather Influence Zone, a relationship between the rate of spread and final fire size was developed using the fire report data from the states and federal agencies for the period where a final fire size was recorded on the fire report (Figure 3-25). For NFIRS fire reports, final fire size was only entered on a small number of reports and hence this data was not used here. This relationship is applied to each Weather Influence Zone but the development was done over multiple zones based on the primary fire protection responsibility.

Several fire size classes were used to estimate the amount of time from fire start to fire containment. The average fire rate of spread for each benchmark fire size was estimated by using the double ellipse area model developed by Fons (1946) as documented by Anderson (1983). The model calculates fire size (Area) as a constant based on the midflame wind speed (K) times the distance the fire as traveled in a given time squared (D2). The variable D is equal to rate of spread multiplied by the time in hours to obtain fire containment. Mid-flame wind speed categories were defined for benchmark sizes.

A relationship between the fire size and average rate of spread values for the benchmark fire sizes was developed using multi-variable regression. A power function was determined to be the best equation form to use:

$$Y = A + B*X^{C} + D*X^{E}$$

where X = rate of spread, Y is the expected fire size and A-E are the regression coefficients.

A maximum expected fire size was set for each Weather Influence Zone to account for physical conditions that would limit fire spread. These values were based on historic fire sizes.

3.3.4 Fire Threat Index (FTI)

The Fire Threat Index is calculated for each percentile weather category for each 30-meter by 30-meter cell of burnable area within each state. The four values from the four percentile weather categories are summed to obtain the FTI for a cell. The calculation is done for cells within an FOA and WIZ intersection. Within this intersection, each cell has the same likelihood of igniting (FOA) as well as the expected weather (WIZ). When the calculation is done for a cell, it is assumed that all cells in the FOA and WIZ intersection have the attributes of the cell. In essence, one is asking, "What would be the expected probability of an acre burning if all cells in the FOA and WIZ intersection were the same at the selected cell?"

To assist in the understanding of the calculation, an example is presented. Assume that the calculation is being done for a cell in FOA 1, WIZ 1 (Figure 3-26). The data flow is shown via the example table below (Table 3-3). For the example, assume that the fire occurrence rate in FOA 1 is 0.1 fires / 1000 acres / year and assume there are 1,000,000 acres in the FOA 1, WIZ 1 intersection. This yields 100 fires per year in FOA 1.

Row 1 gives the proportion of fires that have historically occurred within each of the percentile weather categories.

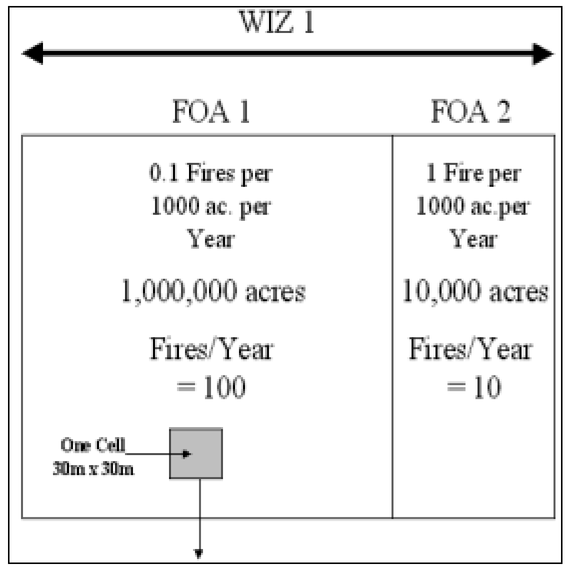


Figure 3-26. Example WIZ and FOAs

Table 3-3 Example Fire Threat Index Calculation

Row	Item	Percentile Weather				Total
		Low	Moderate	High	Extreme	
1	Proportion of Fires	0.10	0.80	0.08	0.02	1.00
2	Number of Fires	10	80	8	2	100
3	Rate of Spread (chains/hr)	2	5	12	24	N/A
4	Final Fire Size (acres)	1	6	98	900	N/A
5	Annual Acres Burned	10	480	784	1800	3074
6	FTI	0.00001	0.00048	0.000784	0.00180	0.003074

Multiplying the proportion of fires in each percentile weather category by the total number of fires in the FOA 1 and WIZ 1 intersection (100 fires) allows for determination of the number of fires in each percentile weather category, row 2.

Assume that the custom-built fire behavior calculations program has calculated a rate of spread for each percentile weather category (row 3). Assume there are fire suppression effectiveness relationships built for use in the Weather Influence Zone; hence a final fire size (row 4) can be determined from the rate of spread (row 3).

Multiplying the number of fires per year in each percentile weather category (row 2) by the expected final fire size (row 4) yields the annual expected acres burned for each percentile weather category (Row 5).

Dividing the annual expected acres burned for each percentile weather category by the total acres within the FOA1 and WIZ 1 intersection (1,000,000 acres) yields the nominal probability of an acre burning and the Fire Threat Index (FTI) within each percentile weather category (Row 6). The FTI for the cell is the sum of the four percentile weather category FTI values.

The calculation described results in the calculation of a cell-based FTI (Figure 3-27). To consider the flammability of cells in the area of a given cell, a roving window is used to calculate an average cell value by incorporating the values of cells around each cell. The "average" FTI for all of the cells within a roving window is determined resulting in the "smoothed FTI" (Figure 3-28). The radius of the roving window circle is eight 30-meter cells. This is a radius of 787 feet and the circle contains 44 acres. This is the FTI value assigned to each burnable cell in the project area.

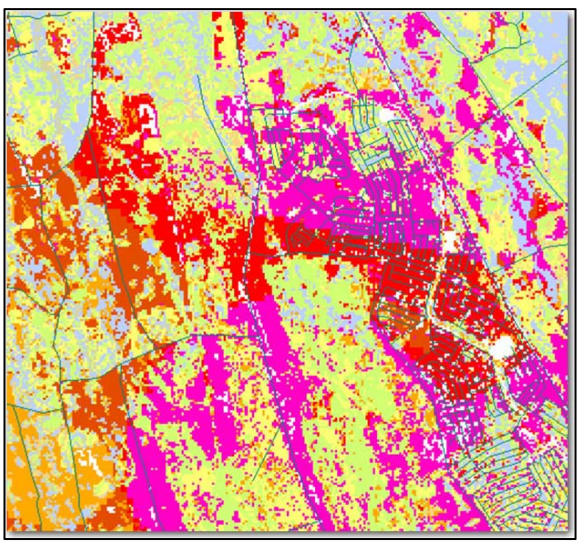


Figure 3-27. Cellular FTI

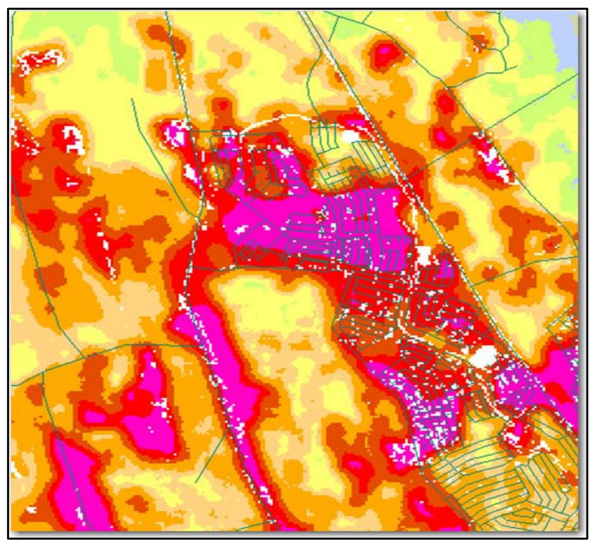


Figure 3-28. Roving Window FTI

Figure 3-29 shows an example of the Fire Threat Index data layer for an area of Jackson County, Oregon.

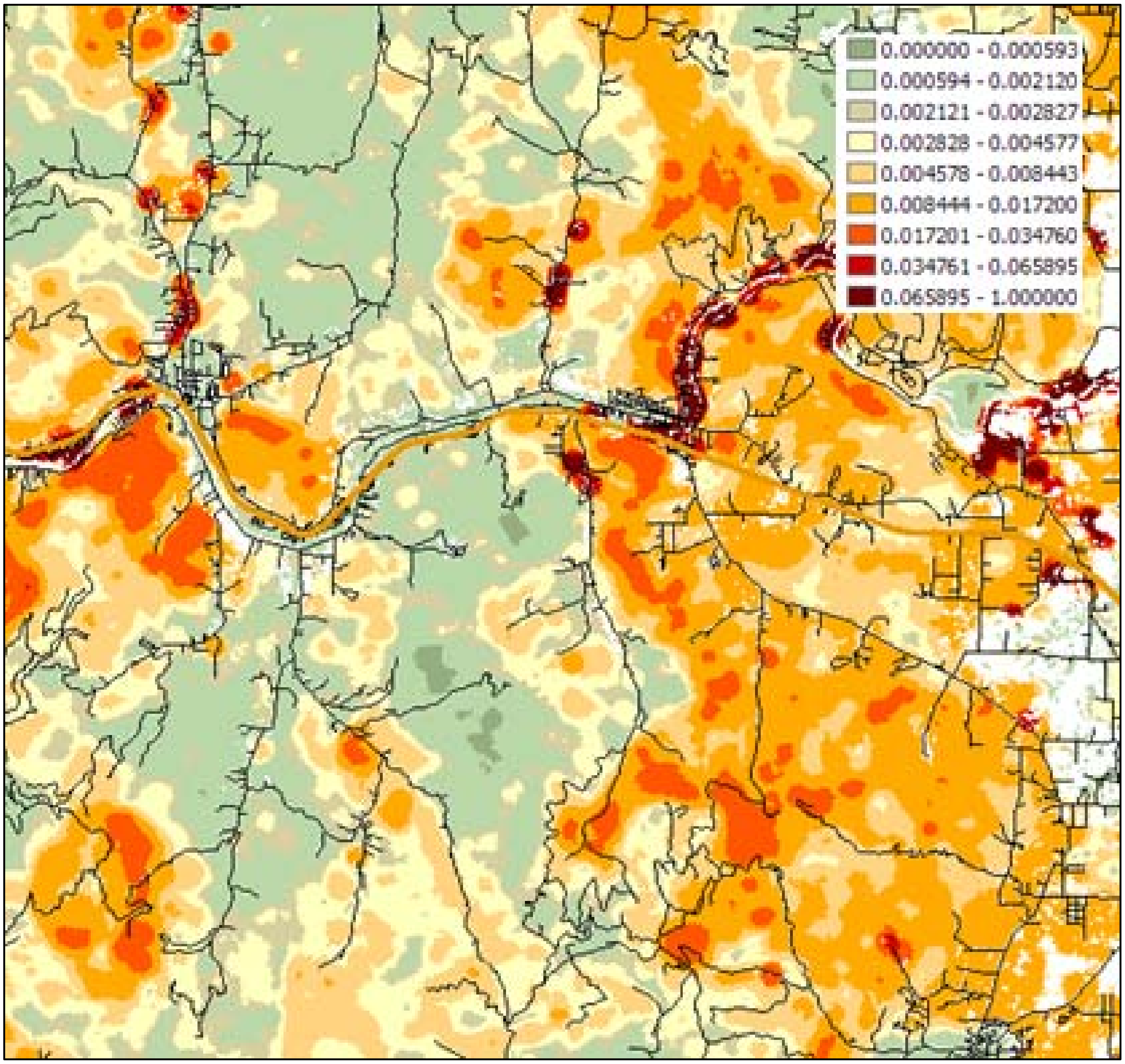


Figure 3-29 Example of the Fire Threat Index

3.4. Fire Effects

The Fire Effects component of the risk assessment involves integrating several input datasets to derive a Values Impacted Rating (VIR) and Suppression Difficulty Rating (SDR). The purpose is to identify those areas that have important values that can be affected by fire. The purpose is also to identify those areas that are difficult or costly to suppress. The Values Impacted Rating and the Suppression Difficulty Rating are weighted to calculate the Fire Effects Index (FEI).

$$FEI = \frac{(VIR) * (VIR\ weight) + (SDR) * (SDR\ weight)}{100}$$

The VIR and SDR weights in this formula are integers that sum to 100, hence the reason for the denominator of 100. In short, the FEI is the weighted average of the VIR and SDR.

Five separate "values that potentially could be impacted by fire," were defined for inclusion in the Values Impacted Rating for the WWA. These data layers were defined through an iterative process of the technical team researching and developing likely candidates for the values datasets, often assisted by state feedback, and then presenting the findings and recommendations to the PSC for final approval. Many other "values" are present that are important and could be negatively impacted by wildfire but were not used in this assessment (i.e. threaten and endangered species). These data layers are called Values Impacted and they are:

- Infrastructure Assets
- Drinking Water Importance Areas
- Forest Assets
- Riparian Assets
- Wildland Development Areas (Housing Units per Acre)

The potential effects on these Values Impacted were measured using a *response function* score (Calkin, Ager, and Gilbertson-Day 2010). This methodology is different than what was initially proposed for the WWA, which was to use the Southern Wildfire Risk Assessment methods. After reviewing the progress that the First Approximation (Appendix B) had made in the use of response functions, the technical team determined that it would be beneficial to implement the response function methodology, as it would provide better results. This caused a slight delay in the project in order to adjust the methods, but the more robust and flexible means of determining potential effects was determined to warrant the adjustment.

The remainder of this section details the process for developing each of the datasets that are used to calculate the Fire Effects Index. The section first discusses response function scores and how they were determined. The Values Impacted datasets are described next along with the response function scores that were used for each of these datasets. Next the process of combining these scores into a single Values Impacted Rating is detailed along with the Suppression Difficulty Rating development. The final discussion is on the development of the Fire Effects Index.

3.4.1. Values Impacted Response Function Scores

Calculating effects at a given location requires estimating the effects of a fire burning with a known intensity in the identified resource category. Based on investigations conducted by the WWA technical team, a response function approach was selected to define the effects. This is used to determine an aggregate Values Impacted Rating for all values impacted that might reside within a cell. For consistency, the same scoring system was used to develop the Suppression Difficulty Rating.

Response functions translate fire effects into a net value change to the described resource. Although fire outcomes can be related to any fire characteristic, response is typically related to some measure of fire intensity such as flame length. Fire intensity is a robust fire characteristic because it integrates two important fire characteristics: fuel consumption and spread rate (Ager and others 2007; Finney 2005). For the WWA, in each response function, net value change is based on the flame length (intensity) of the fire and can represent both beneficial and adverse effects to the resource (Calkin, Ager, and Gilbertson-Day 2010).

The fire response function scores for the WWA are measured as a number from 0 to –9. This indicates a negative impact from fire. In applying the concept of response functions, the design is to also use positive values from +9 to 0 to define when and to what extent there is a positive effect from fire. After review of the initial state input, it was decided to only assign negative response function score values to the WWA Values Impacted.

Following a series of webinars, each state completed a matrix showing for each Value Impacted layer a defined response function value for each value impacted category and fire intensity class (flame length class). An example of this matrix for the Drinking Water Importance Area Value Impacted is shown in Figure 3-30.

Value Impacted	FIL	Flame length/FIL class 1	2	3	4	5	6	RI
	Class	0-2	2-4	4-6	6-8	8-12	12+	
	Category							
Drinking Water	1	0.00	-0.30	-0.50	-0.70	-0.90	-0.90	10
	2	0.00	-0.60	-1.00	-1.40	-1.80	-1.80	20
	3	0.00	-0.90	-1.50	-2.10	-2.70	-2.70	30
	4	0.00	-1.20	-2.00	-2.80	-3.60	-3.60	40
	5	0.00	-1.50	-2.50	-3.50	-4.50	-4.50	50
	6	0.00	-1.80	-3.00	-4.20	-5.40	-5.40	60
	7	0.00	-2.10	-3.50	-4.90	-6.30	-6.30	70
	8	0.00	-2.40	-4.00	-5.60	-7.20	-7.20	80
	9	0.00	-2.70	-4.50	-6.30	-8.10	-8.10	90
	10	0.00	-3.00	-5.00	-7.00	-9.00	-9.00	100

Figure 3-30. Response Function Values for Drinking Water Importance Areas

The format shown in Figure 3-30 was provided to each state for each of the five Values Impacted. The states completed the entry of the response function scores in one of two ways.

The first way was to enter the values directly as desired.

The second was to enter the response function scores for the most affected value impacted category and then to assign a value impacted relative importance value for each of the other value impacted categories. In the example in Figure 3-30, the most affected value category is category 10. For this category, the response function scores assigned by flame length category are shown in the yellow highlighted cells. The value impacted relative importance values for each of the other Value Impacted categories are shown in the orange highlighted cells (RI titled column). Note that the value impacted relative importance value for category 10 is 100 and the others are defined from 0 to 100 based on the benchmark value of 100. The resultant response function score is the product of the response function score for the most affected category (category 10 in Figure 3-30) and the relative importance value for a Value Impacted category divided by 100. For example using Figure 3-30, the response function score for Value Impacted category 5 and flame length category 3 is –2.50, which is –5.00 times 50 divided by100 (-5.00*50/100).

The final response function scores used for calculating the outputs were determined by averaging the individual state response functions scores, creating a west wide average. This average was used to create the Fire Effects outputs. As an example, Figure 3-31 contains the resultant and used project area's response function score matrix for the value impacted Drinking Water Importance Areas.

Value Impacted		Flame length/FIL class					
	FIL	1	2	3	4	5	6
	Class	0-2	2-4	4-6	6-8	8-12	12+
	Category						
Drinking Water	1	-0.01	-0.20	-0.45	-0.66	-0.80	-0.86
	2	-0.08	-0.42	-0.84	-1.21	-1.50	-1.61
	3	-0.18	-0.63	-1.20	-1.76	-2.19	-2.35
	4	-0.38	-1.04	-1.84	-2.61	-3.19	-3.43
	5	-0.48	-1.34	-2.20	-3.14	-3.86	-4.15
	6	-0.67	-1.57	-2.55	-3.68	-4.53	-4.87
	7	-0.77	-1.79	-2.89	-4.19	-5.18	-5.57
	8	-0.90	-2.13	-3.48	-4.96	-6.10	-6.54
	9	-1.00	-2.36	-3.84	-5.51	-6.79	-7.28
	10	-1.11	-2.59	-4.20	-6.06	-7.48	-8.03

Figure 3-31. Response Function Scores for Drinking Water Importance Areas

The next task was to develop the Values Impacted "score" for each of the Values Impacted that occurred in a cell. Figure 3-32 shows an example of this calculation and will be used to walk the reader through the process. As a first step to this process, the flame length at each cell needed to be calculated for each of the 4 percentile weather categories. These values were then used as part of the process.

In the example shown in Figure 3-32, the flame lengths are 2.2 feet, 6.2 feet, 11.0 feet and 51.6 feet for the low, moderate, high and extreme percentile weather categories. The cell is overlapped by a Drinking Water Importance Area only, as indicated by the values of the other Values Impacted Categories being 0 (i.e. in this example no other layers overlap this particular area/cell). Based on the flame length under each percentile weather category, the response function values would be –2.36, -5.51, -6.79 and –7.28 (Figure 3-31), respectively for the low, moderate, high and extreme percentile weather categories.

Variable		Percentile Weather				
		Low	Mod	High	Ext	FTI
Fire Threat Index		0.00001	0.04800	0.00780	0.00100	0.0568
FL (ft) (CFL)		2.2	6.2	11.0	51.6	
FL class (FIL)		2	4	5	6	
	VI Category					
Infrastructure Assets	0	1 = near road, railroad, school, airport, hospital				
Wildland Development Areas	0	1-7: density classes from low to high				
Drinking Water Importance Areas	9	1-10: classes based on population served				
Forest Assets	0	Example is 1= Sensitive, 0-10 m., closed;				
Riparian Assets	0	1 = less important; 2 = moderately important; 3 = important				
	(FTI Wted)	Response Function Values				
	RF Scores	Low	Mod	High	Ext	
Infrastructure Assets	0.000	0.00	0.00	0.00	0.00	
Wildland Development Areas	0.000	0.00	0.00	0.00	0.00	
Drinking Water Importance Areas	-5.719	-2.36	-5.51	-6.79	-7.28	
Forest Assets	0.000	0.00	0.00	0.00	0.00	
Riparian Assets	0.000	0.00	0.00	0.00	0.00	

Figure 3-32. Example of Calculation of Value Impacted Score

The Fire Threat Index, the previously calculated measure of the probability of an acre burning, for the low, moderate, high and extreme percentile weather categories is 0.00001, 0.04800, 0.00780 and 0.0010 respectively.

To obtain the Drinking Water Importance Areas Response Function Score for the cell, the Fire Threat Index values for each percentile weather category are multiplied by the response function scores in the respective category. The reason the Fire Threat Index value is used is that it represents the likelihood of an area burning, and therefore the likelihood of the fire response function "effect" occurring at a given percentile weather category.

$$\text{DWIA Score} = [(0.00001)*(-2.36) + (0.048)*(-5.51) + (0.0078)*(-6.79) + (0.001)*(-7.28)]/ [0.0568] = -5.719$$

In this example, the final DWIA RFS is -5.719 for the cell.

Values Impacted

As mentioned, five separate "values that potentially could be impacted by fire," are defined and called Values Impacted. These Values Impacted are:

- Drinking Water Importance Areas
- Forest Assets
- Infrastructure Assets
- Riparian Assets

- Wildland Development Areas (Housing Units per Acre)

Each Value Impacted is described together with the project area response function values.

Drinking Water Importance Areas

This layer identifies an index that identifies areas that are most crucial to sustaining the quality of drinking water by incorporating data on water supply, surface drinking water consumers at the point of intake, and the flow patterns to the surface water intakes. It is characterized by Hydrologic Unit Code 12 (HUC 12) watersheds. The Hydrologic Unit system is a standardized watershed classification system developed by United States Geological Survey (Appendix B). Areas that are a source of drinking water are of critical importance and adverse effects from fire are a key concern. The U.S. Forest Service's Forests to Faucets (F2F) project is the primary source of this dataset, however, F2F does not exist for Alaska and Hawaii so alternative datasets were used for these two states.

The U.S. Forest Service Forests to Faucets (F2F) project is the primary source of the drinking water dataset (Appendix B). This project used geo-spatial (GIS) modeling to develop an index of importance for supplying drinking water using HUC 12 watersheds as the spatial resolution. Watersheds are ranked from 1 to 100 reflecting relative level of importance, with 100 being the most important and 1 the least important.

Several criteria were used in the F2F project to derive the importance rating including water supply, flow analysis, and downstream drinking water demand. The final model of surface drinking water importance used in the F2F project combines the drinking water protection model, capturing the flow of water and water demand, with a model of mean annual water supply. The values generated by the drinking water protection model are simply multiplied by the results of the model of mean annual water supply to create the final surface drinking water importance index (Weidner 2011). The WWA project reclassed F2F data from 100 to 10 categories. An example of Drinking Water Importance categories for an area of Jackson County, Oregon, is shown in Figure 3-33.

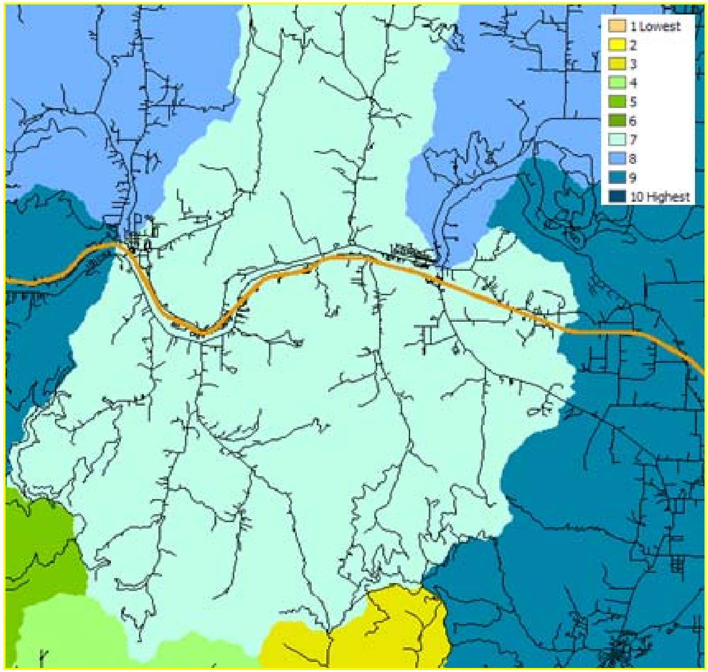


Figure 3-33. Drinking Water Importance Areas Mapping

The F2F data was not produced for Alaska and Hawaii. A U.S. Environmental Protection Agency Municipal Watersheds dataset and a State of Hawaii Department of Land and Natural Resources Watershed Protection Areas dataset were therefore used to develop the Drinking Water layer in Hawaii. A dataset from the State of Alaska, Department of Environmental Conservation Drinking Water Program, Environmental Conservation was used for Alaska.

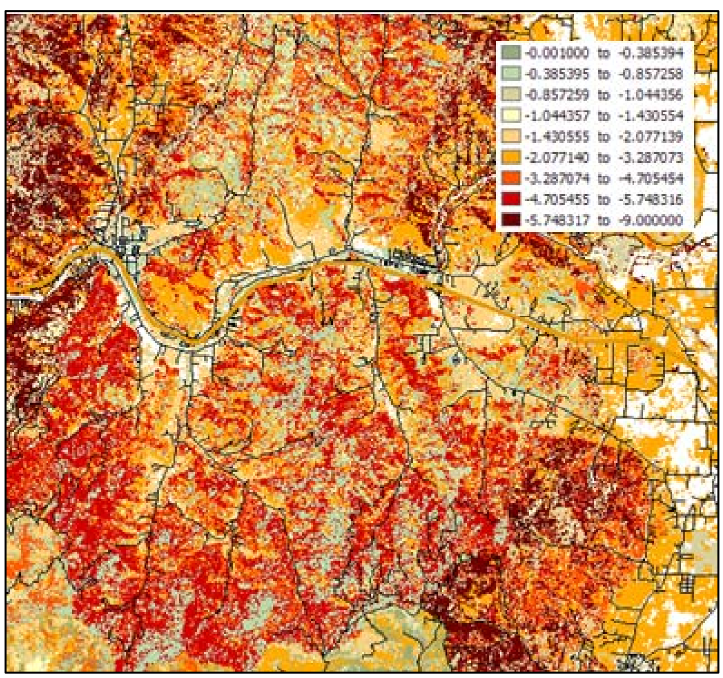


Figure 3-34. Drinking Water Importance Areas response function scores for a portion of Jackson County, OR.

The project area response function scores were then determined by averaging the individual state response functions scores. Figure 3-31 contains the project area's response function score matrix for the value impacted Drinking Water Importance Areas. Figure 3-34 presents an example of the Drinking Water Importance Area response function scores for an area of Jackson County, Oregon. Fire behavior from fuels is the main reason for differences seen within a Drinking Water Importance Area category (Figure 3-33 and 3-34).

Infrastructure Assets

This layer identifies key infrastructure assets, such as schools, airports, hospitals, roads and railroads that are susceptible to adverse effects from wildfires. These features are combined into a single dataset and buffered to reflect areas of concern surrounding the assets. Roads and railroads use a 300-meter buffer while schools, airports and hospitals use a 500-meter buffer. These buffer distances were determined by professional judgment from the Project Steering Committee while using the Southern Fire Risk Assessment as guidelines initially. Figure 3-35 presents an example of the Infrastructure data layer for an area of Jackson County, Oregon.

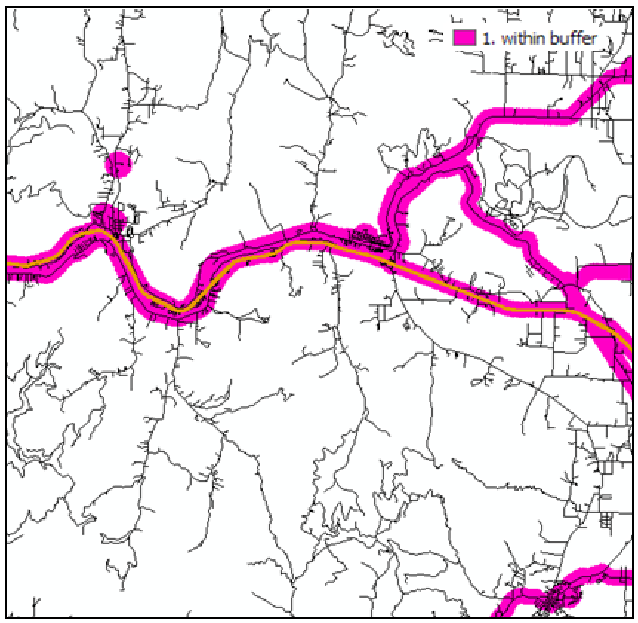


Figure 3-35. Infrastructure Assets for an area in Jackson County, OR.

A cell is considered as being in the Infrastructure Asset layer if it falls in at least one of the buffers noted above. Value Impacted Category 1represents a cell that is within one or more buffers of defined infrastructure.

If a cell was inside of a buffer area, it was assigned a response function value by flame length class by each state. The average of the state values was used to define the project area response function value. Figure 3-36 contains the project area's response function score matrix for the value impacted, Infrastructure. Figure 3-37 presents an example of the Infrastructure Assets response function scores for an area of Jackson County, Oregon.

Value Impacted	FIL Class	Flame length/FIL class 1	2	3	4	5	6
		0-2	2-4	4-6	6-8	8-12	12+
	Category						
Infrastucture	0	0.00	0.00	0.00	0.00	0.00	0.00
	1	-3.48	-4.97	-6.33	-7.31	-8.23	-8.41

Figure 3-36. Response function scores for Infrastructure Assets

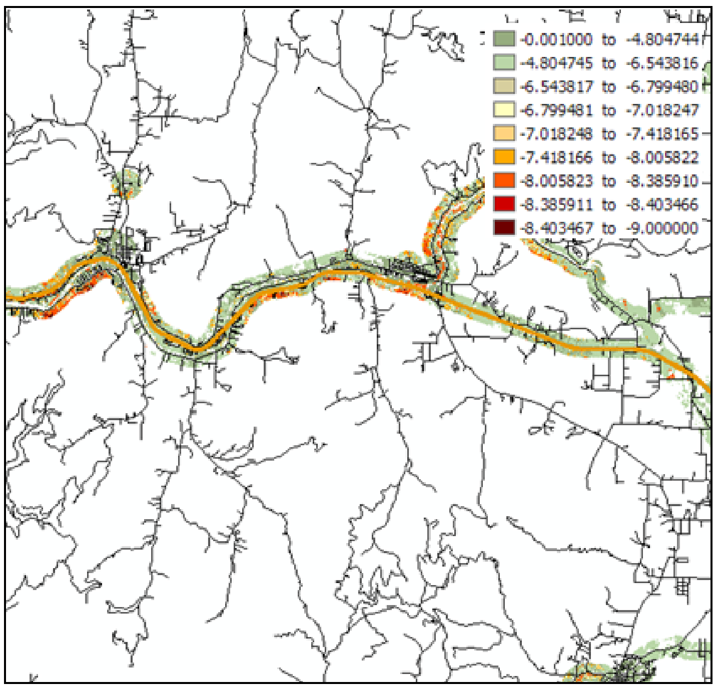


Figure 3-37. Infrastructure Asset Response Function Scores for an area in Jackson County, OR.

Forest Assets

The Forest Assets data layer identifies forestland categorized by its cover, height and susceptibility, or response, to fire. These characteristics allow for the prioritization of landscapes reflecting forest assets that would be most adversely affected by fire. The LANDFIRE Refresh dataset (Appendix B) was used to map stand height, canopy cover and the existing vegetation type (EVT).

Canopy cover from LANDFIRE was re-classified into two categories, open or sparse and closed. Areas classified as open or sparse have a canopy cover less than 60%. Areas classified as closed have a canopy cover greater than 60%. An example of canopy cover for an area of Jackson County, Oregon, is shown in Figure 3-38.

Canopy height from LANDFIRE was classified into two categories, 0-10 meters and greater than 10 meters. An example of canopy height for an area of Jackson County, Oregon, is shown in Figure 3-38.

Response to fire was developed from the LANDFIRE existing vegetation type (EVT) dataset. There are over 1,000 existing vegetation types in the project area. Using a crosswalk defined by project ecologists, a classification of susceptibility and response to fire was defined and documented by fire ecologists into the three fire response classes. These three classes are sensitive, resilient and adaptive.

- Sensitive - These are tree species that are intolerant or sensitive to damage from fire with low intensity.
- Resilient - These are tree species that have characteristics that help the tree resist damage from fire and whose adult stages can survive low intensity fires.
- Adaptive – These are tree species adapted with the ability to regenerate following fire by sprouting or serotinous cones.

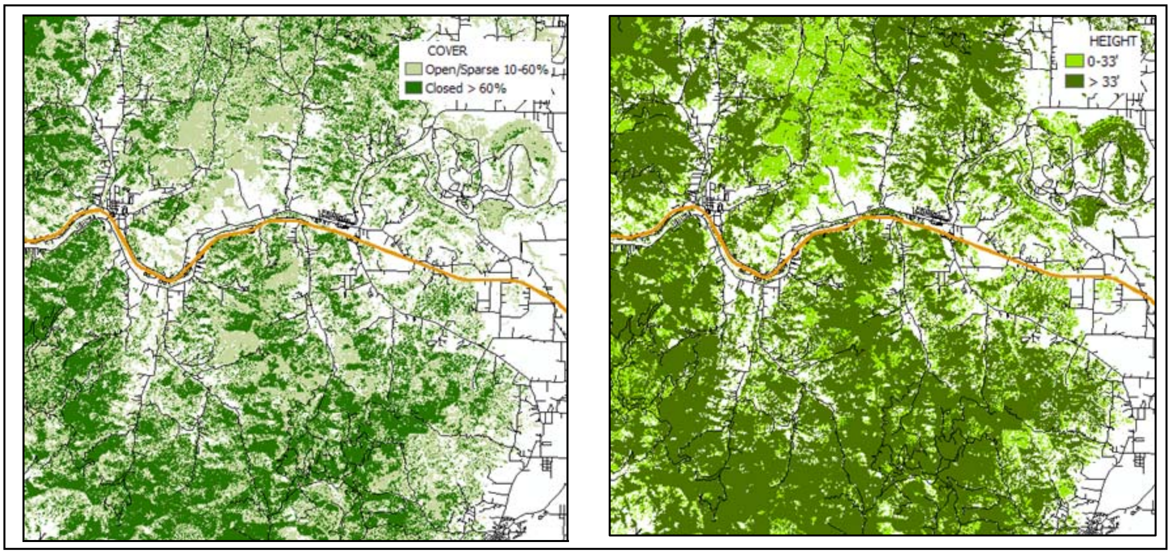


Figure 3-38. Canopy Cover and Canopy Height Mapping Jackson County OR

An example of response to fire for an area of Jackson County, Oregon, is shown in Figure 3-39. Figure 3-40 contains the project area's response function score matrix for the value impacted Forest Assets.

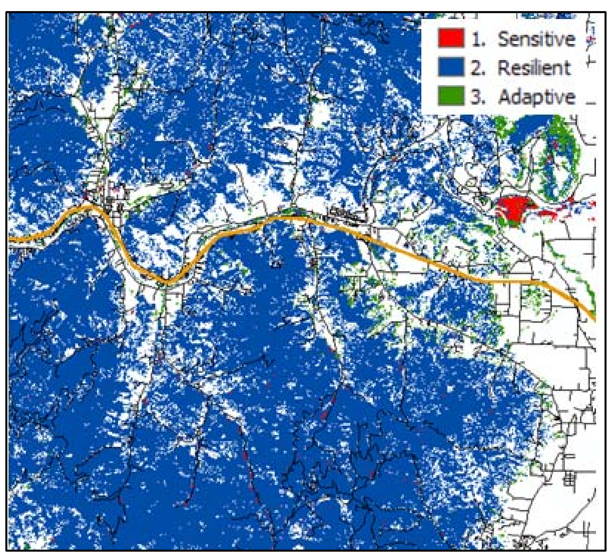


Figure 3-39. Response to fire for Jackson County, OR

Value Impacted				FIL Class / Category	Flame length/FIL class 1 (0-2)	2 (2-4)	3 (4-6)	4 (6-8)	5 (8-12)	6 (12+)
Forest Assets	Sensitive	Closed	0-10 m	1	-2.61	-3.84	-5.52	-7.13	-8.11	-8.34
Forest Assets	Sensitive	Closed	10+m	2	-1.93	-2.96	-4.45	-6.01	-7.05	-7.35
Forest Assets	Sensitive	Open/Sp	0-10 m	3	-1.20	-1.77	-2.54	-3.29	-3.73	-3.82
Forest Assets	Sensitive	Open/Sp	10+m	4	-0.89	-1.36	-2.05	-2.77	-3.24	-3.36
Forest Assets	Resilient	Closed	0-10 m	5	-1.23	-2.00	-3.33	-4.94	-6.48	-7.22
Forest Assets	Resilient	Closed	10+m	6	-0.60	-1.17	-1.99	-2.93	-4.10	-4.65
Forest Assets	Resilient	Open/Sp	0-10 m	7	-0.56	-0.92	-1.54	-2.29	-3.00	-3.34
Forest Assets	Resilient	Open/Sp	10+m	8	-0.27	-0.53	-0.90	-1.33	-1.87	-2.12
Forest Assets	Adaptive	Closed	0-10 m	9	-0.98	-1.75	-2.95	-4.00	-5.67	-6.66
Forest Assets	Adaptive	Closed	10+m	10	-0.43	-1.03	-1.96	-2.53	-3.68	-4.33
Forest Assets	Adaptive	Open/Sp	0-10 m	11	-0.45	-0.78	-1.33	-1.81	-2.59	-3.04
Forest Assets	Adaptive	Open/Sp	10+m	12	-0.19	-0.46	-0.88	-1.13	-1.66	-1.96

Figure 3-40. Project area Response Function Scores for Forest Assets

Figure 3-41 presents an example of the Forest Assets data layer categories for an area of Jackson County, Oregon and an example of the Forest Assets Response Function Scores results for the same area.

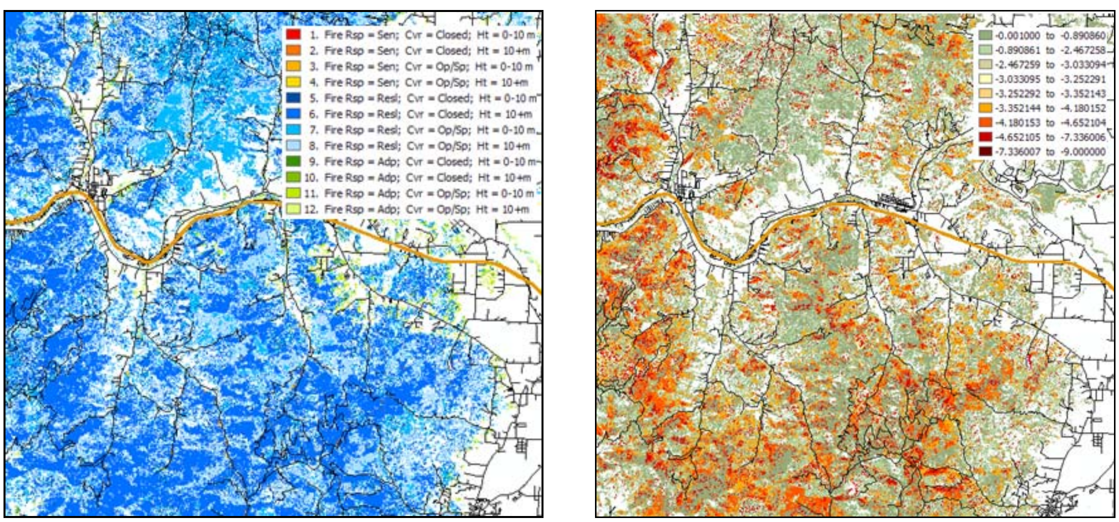


Figure 3-41. Forest Asset Categories (left) and Forest Asset Response Function Scores (right) (area in Jackson County, OR)

Riparian Assets

This layer identifies riparian areas that are important as a suite of ecosystem services, including both terrestrial and aquatic habitat, water quality, water quantity, and other ecological functions. Riparian areas are considered an especially important element of the landscape in the West. Accordingly, a separate dataset has been compiled to provide state representatives the opportunity to consider the impact from fire in riparian areas.

The process for defining these riparian areas was complex. It involved identifying the riparian footprint and then assigning a rating based upon two important riparian functions. These functions are water quantity and quality together as well as ecological significance. The WWA technical team developed the Riparian Assets data layer model with in-kind support from state representatives. Input datasets used in the model included the National Hydrography Dataset (NHD) and the National Wetlands Inventory (NWI).

The National Hydrography Dataset (NHD) was used to represent hydrology. A subset of streams and water bodies, which represents perennial, intermittent, and wetlands, was created. The NHD water bodies' dataset was used to determine the location of lakes, ponds, swamps, and marshes (wetlands).

The U.S. Fish and Wildlife Service have posted the National Wetlands Inventory (NWI) to the Internet (Appendix B). This is a comprehensive dataset covering the entire United States that explicitly maps wetland areas. This dataset was used in two ways. The first way was to establish a wetland riparian footprint. The second way was to provide value information about the condition of the wetland riparian area. The NWI contains five categories: marine, estuarine, riverine, lacustrine, and palustrine. To avoid overlap with the wetland areas already identified, the only system used from the NWI was palustrine.

There was one exception to the use of the NWI dataset and this was for Alaska. The Alaska NWI data was incomplete, and as a result left large seam lines and missing data areas in a tiled patchwork. As a surrogate to identifying palustrine wetlands, we used a wetlands dataset that was developed by NASA's Jet Propulsion Laboratory (JPL) (Appendix B). The JPL wetlands dataset is based off of training and testing data compiled from NWI as well as the Alaska Geospatial Data Clearinghouse. While this dataset lacked a few of the classes that were in NWI (aquatic beds and unconsolidated shore) and did not provide modifiers for eliminating constructed features, such as reservoirs and impoundments, it provided a good alternative that was much more comprehensive and consistent than NWI throughout Alaska.

After selecting the correct features from the NHD and NWI, they were buffered to create the riparian footprint. Buffering these spatial features approximately 150 feet created footprints for perennial streams and wetlands. Seasonal watercourse extent was created based on 75-foot buffers. Development of a rating of impact for Riparian Assets was then done by initially considering water quality and quantity as measured by erosion potential, annual average precipitation[1] and slope. In addition, ecological significance was included as measured by LANDFIRE vegetation classification to depict habitat quality and susceptibility to fire.

[1] Slight variations in source data for precipitation and erosion were used for Alaska and Hawaii. For a detailed description of the RA process see Addendum III

The model created values impacted categories 1, 2 and 3 represent a range of increasing importance of the riparian area as well as sensitivity to fire-related impacts on the suite of ecosystem services. A Value Impacted Category 3 generally represents riparian areas with the highest importance, such as conifer, hardwood, or riparian vegetation on steeper slopes, erodible soils and areas of higher annual rainfall. A Value Impacted Category 1 generally represents riparian areas the lowest importance, such as exotic or grass vegetation types, on flatter slopes, in areas of low annual rainfall. Category 2 represents moderately importance riparian areas.

Figure 3-42 presents an example of the Riparian Assets data layer categories for an area of Jackson County, Oregon. Figure 3-43 shows the project area's response function score matrix.

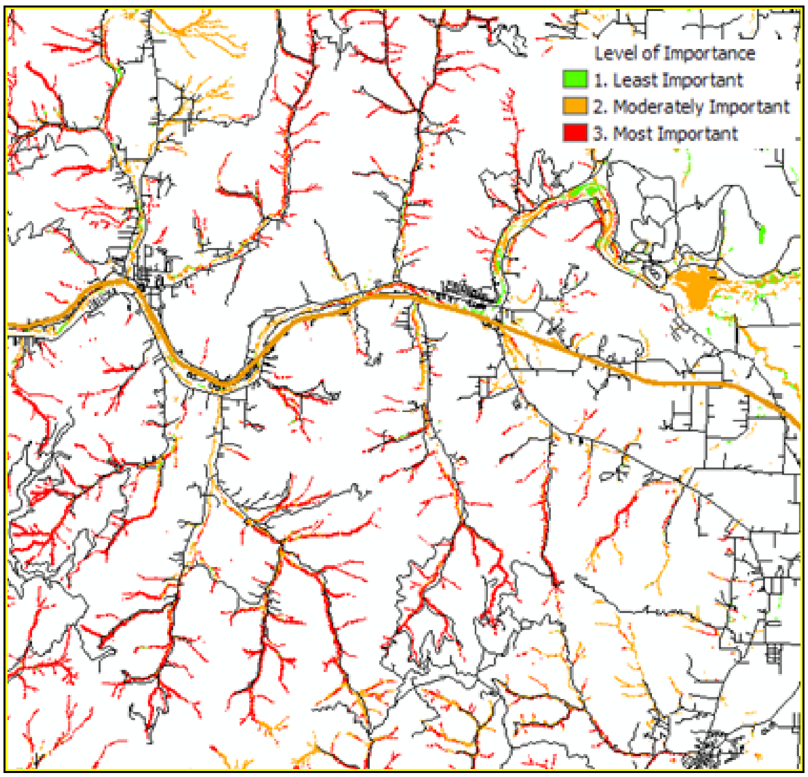


Figure 3-42. Riparian Assets example from Jackson County, OR

Value Impacted	FIL Class	Flame length/FIL class 1	2	3	4	5	6
	Class	0-2	2-4	4-6	6-8	8-12	12+
	Category						
Riparian Assets	1	-0.30	-0.88	-1.53	-2.23	-2.91	-3.20
	2	-0.25	-1.09	-2.05	-3.13	-4.24	-4.78
	3	-0.17	-1.41	-2.83	-4.63	-6.67	-7.66

Figure 3-43. WWA response function scores for Riparian Assets

Figure 3-44 is a more detailed view of one of the drainages from Figure 3-42 for a more detailed display of the categories. Figure 3-45 shows the Riparian Assets Response Function Score results for this area.

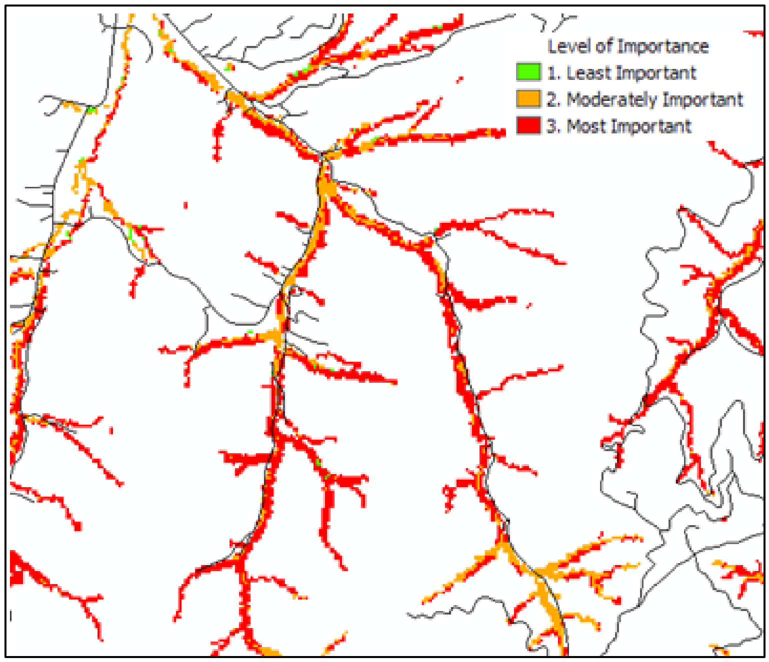


Figure 3-44. Detail of drainage showing Riparian Assets categories

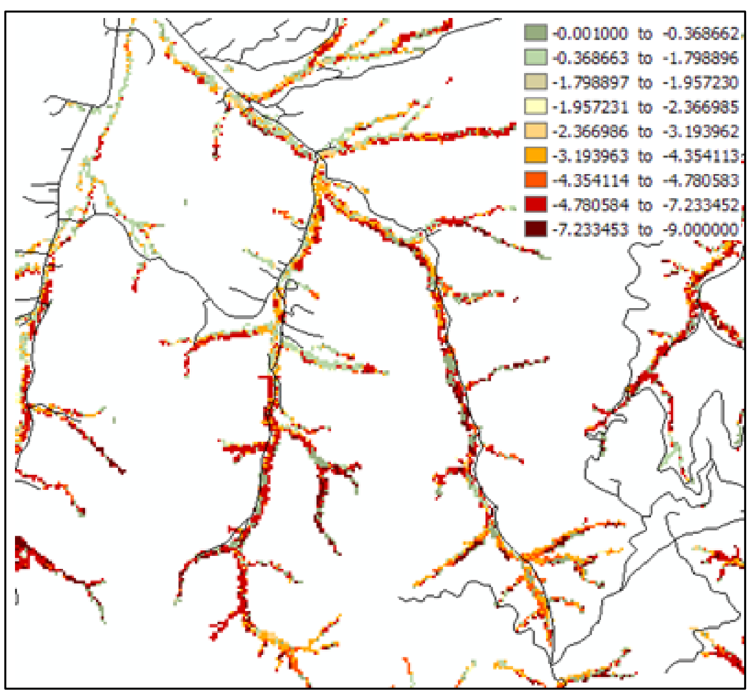


Figure 3-45. Riparian Assets Response Function Scores Results

Wildland Development Areas (Housing Units per Acre)

The location of people living in Wildland Urban Interface and rural areas is key information for defining potential impacts to people and homes from fire. The data layer used to represent this value was called Wildland Development Areas (WDA) and to develop this data layer, there was a need to develop the Where People Live (WPL) data layer first.

Where People Live (Housing Units per Acre)

The Where People Live (WPL) dataset was developed using advanced modeling techniques based on the LandScan population count data available from the Department of Homeland Security, HSIP Freedom Dataset. The HSIP Freedom dataset was available at no cost to U.S. local, state, territorial, tribal and Federal government agencies (refer to the web link in Appendix B to obtain more information about the LandScan data).

Developed by the Oak Ridge National Laboratory, LandScan has been developed using sophisticated algorithms that integrate high-resolution imagery, nighttime lights imagery and other local spatial data to identify daytime and nighttime population distributions. The Oak Ridge National Laboratory LandScan web site has a more detailed description of the dataset (Appendix B).

The WPL and WDA datasets have been derived to represent the number of houses per square kilometer, consistent with Federal Register and USFS Silvis datasets. However, to aid in the interpretation and use of this data, the legends are presented in "houses per acre". This was done to adhere to traditional use and understanding of this data by planners.

The Where People Live data layer includes categories up to or greater than three housing units per acre (Table 3-4). This is greater than one housing unit on 1/3rd of an acre. This, in many cases, includes dense urban areas. Figure 3-46 presents an example of the Where People Live data layer categories for an area of Jackson County, Oregon.

Table 3-4 Housing Density

Category	From Houses/sq. km.	To Houses/sq.km.	Houses per acre	General Name
1	0.000001	6.177635	Less than 1 HU / 40 acres	Below Density Rating
2	6.177635	12.355269	1 HU / 40 acres to 1 HU / 20 acres	Very Low
3	12.355269	24.710538	1 HU / 20 acres to 1 HU / 10 acres	Low
4	24.710538	49.42	1 HU / 10 acres to 1 HU / 5 acres	Medium
5	49.42	123.55269	1 HU / 5 acres to 1 HU / 2 acres	Medium-High
6	123.55269	741.31614	1 HU / 2 acres to 3 HU / acre	High
7	741.31614	100,000	More than 3 HU / acre	Very High

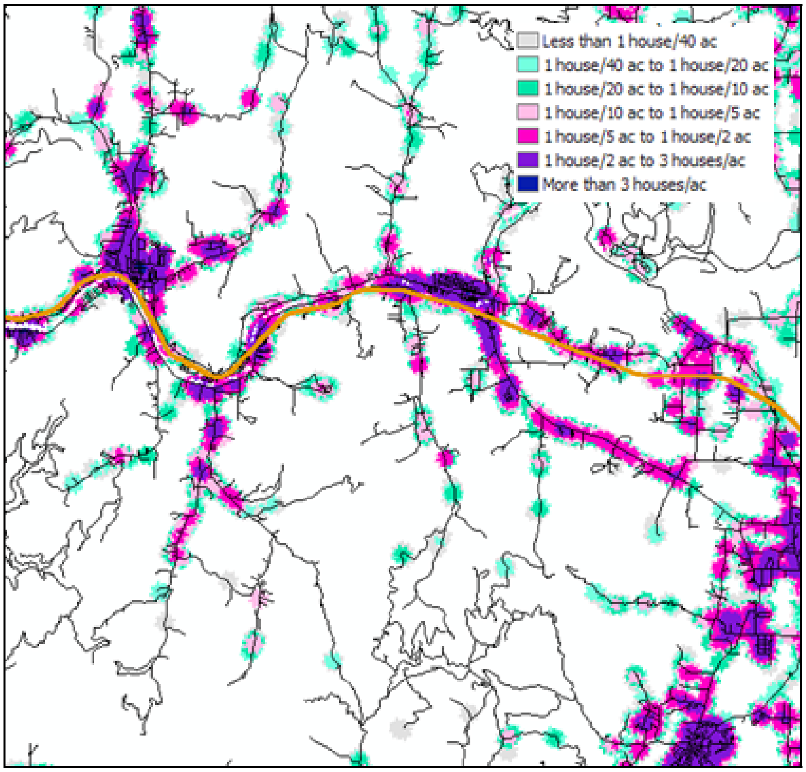


Figure 3-46. Where People Live dataset for area in Jackson County, OR.

Wildland Development Areas(Housing Units per Acre)

Using the Where People Live dataset, the WWA staff, in coordination with state representatives and the project manager, developed rule sets and a process to define areas where people and homes are threatened by fire from wildland fuels. This process coincided with the one described in Section 3.3.2 regarding refinement of the surface fuels burnable area. While the thresholds in each state varied, the process was the same and allowed for the consideration of unique urban patterns within the states. The result was the Wildland Development Areas dataset.

Figure 3-47a shows an area near Boulder, Colorado. The maroon coloring in Figure 3-47b shows the result of the area near Boulder that was defined as urban during the surface fuel refinement process. These core urban areas were masked out of the WPL data layer in order to develop the Wildland Development Areas data layer. An example of this masking is shown in Figure 3-48 for an area in Portland, OR. The colored areas in Figure 3-48b are the areas remaining from the WPL dataset (Figure 3-48a) that are in the WDA dataset, where people and homes are threatened by fire from wildland fuels.

Figure 3-49 shows an example of the Wildland Development Areas data layer categories for an area of Jackson County, Oregon as well as the Response Functions Score results for this dataset in this area. Figure 3-50 shows the project area's response function score matrix.

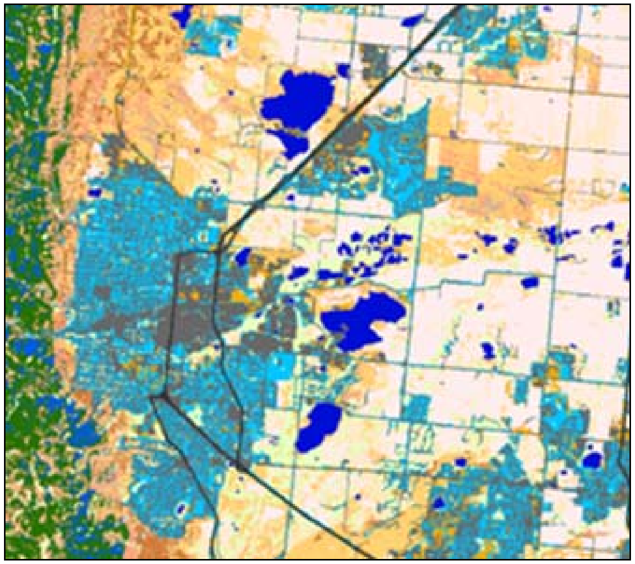


Figure 3-47a. Boulder CO example area

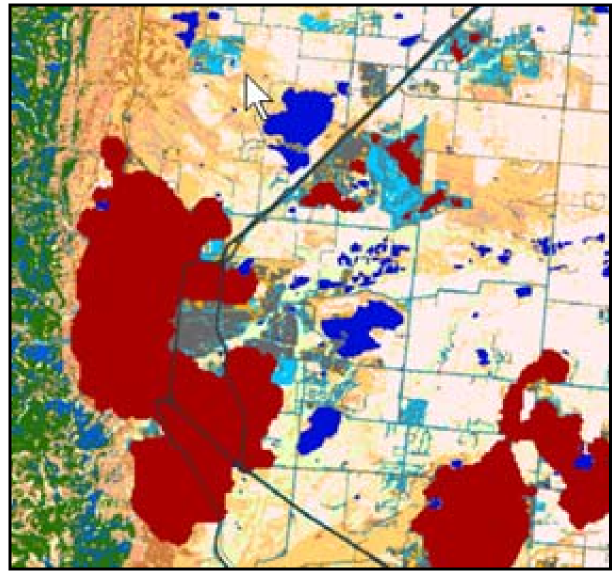


Figure 3-47b. Areas defined as urban

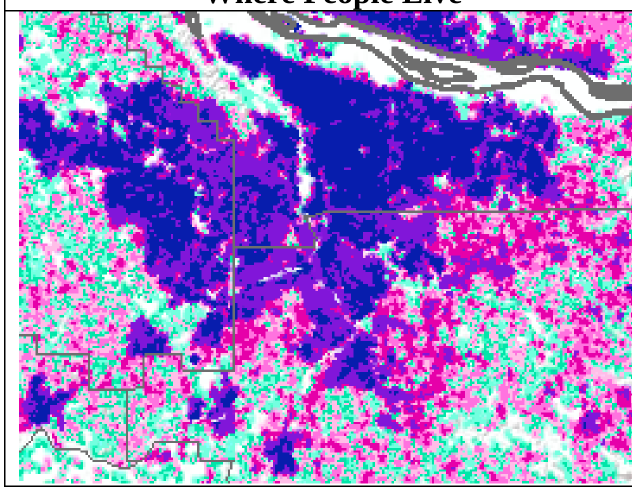
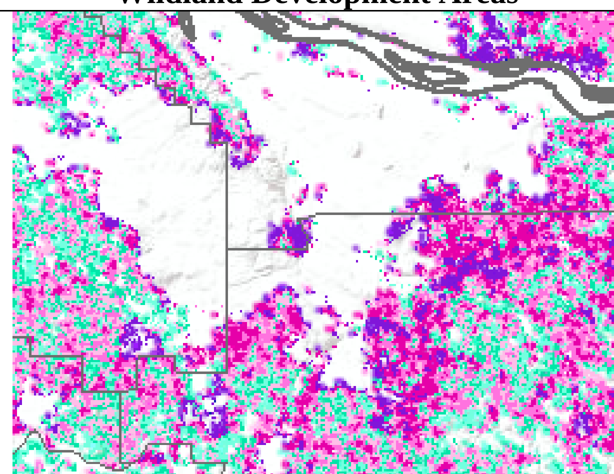
Where People Live	Wildland Development Areas	Categories
		**Where People Live and Wildland Development Areas** (housing density) Less than 1 house/40 ac 1 house/40 ac to 1 house/20 ac 1 house/20 ac to 1 house/10 ac 1 house/10 ac to 1 house/5 ac 1 house/5 ac to 1 house/2 ac 1 house/2 ac to 3 houses/ac More than 3 houses/ac

Figure 3-48a. WPL data layer near Portland OR

Figure 3-48b. WDA data layer near Portland OR

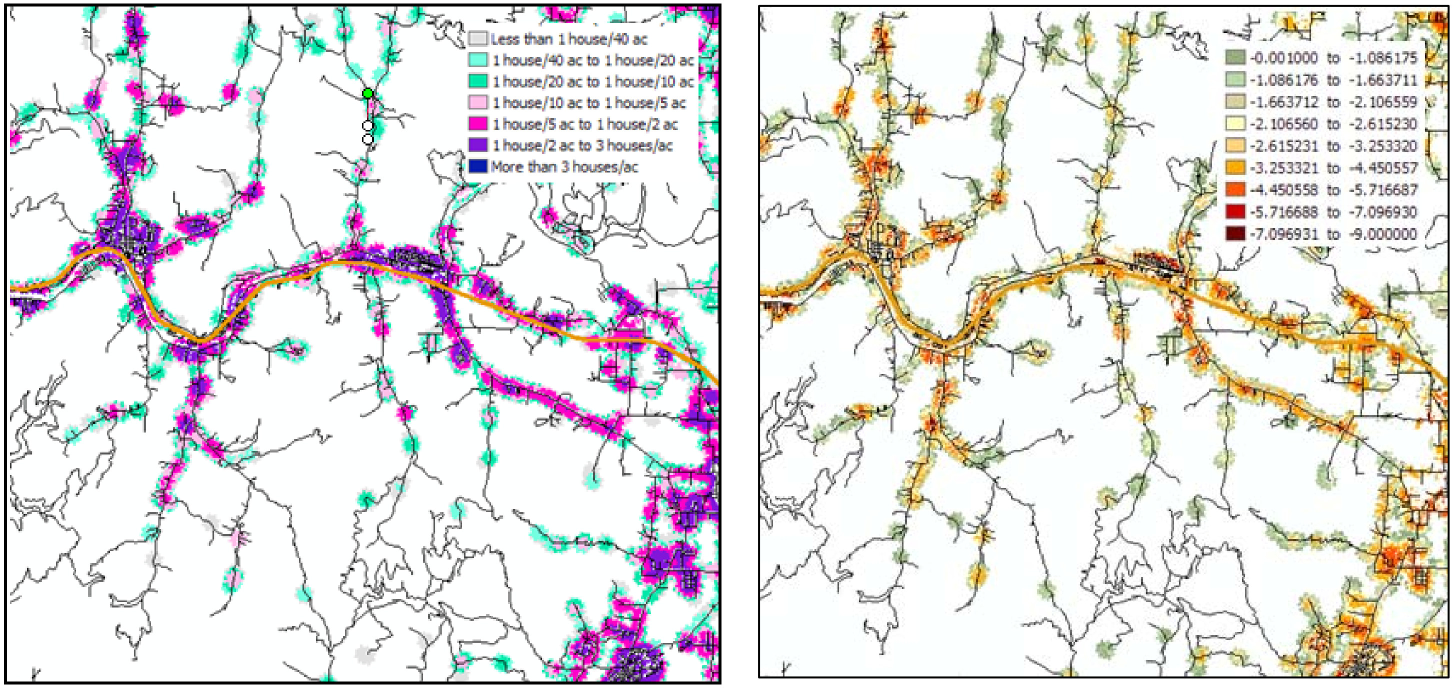


Figure 3-49. Wildland Development Areas (left) and WDA Response Function Scores (Jackson County, OR)

Value Impacted	FIL Class	Flame length/FIL class 1 0-2	2 2-4	3 4-6	4 6-8	5 8-12	6 12+
	Category						
Wildland Development Areas	1	-0.60	-0.88	-1.03	-1.16	-1.21	-1.22
	2	-0.80	-1.15	-1.38	-1.57	-1.66	-1.68
	3	-1.12	-1.70	-2.13	-2.49	-2.68	-2.71
	4	-1.52	-2.41	-3.06	-3.56	-3.91	-3.94
	5	-2.11	-3.28	-4.23	-5.04	-5.64	-5.72
	6	-3.16	-4.88	-6.34	-7.75	-8.84	-9.00
	7	-3.16	-4.88	-6.34	-7.75	-8.84	-9.00

Figure 3-50. WWA response function scores for Wildland Development Areas

Value Impacted Rating (VIR)

For a cell on the landscape, a Value Impacted Score for a Value Impacted dataset was developed and described earlier. These values are displayed in the RF Scores column for another example shown in Figure 3-51.

Along with scores for each value class and flame length combination, each state also provided a measure for the relative importance of each Value Impacted in relation to the other Values Impacted. It together with the acres in each value impacted category was then used to develop the weight the Response Function Scores for all value impacted categories. This aggregate score was calculated for the Value Impacted Rating using the relative extent process (Thompson, et. Al. In Press). The relative extent is determined using the west wide state provided relative importance weight for each value impacted and the total burnable acres west wide occupied by each value impacted category. The WWA-wide value impacted weights are: Infrastructure Assets, 46.2%; Wildland Development Areas, 44.7%; Drinking Water Importance Areas, 1.0%; Forest Assets, 3.6%; and Riparian Assets, 4.5%.

Figure 3-51 shows an example of the calculation of the Value Impacted Rating. It does show that each value impacted occurs within the example cell. This is very unlikely on the landscape and is shown here for descriptive purposes only.

Variable		Percentile Weather				
		Low	Mod	High	Ext	FTI
Fire Threat Index		0.00001	0.04800	0.00780	0.00100	0.0568
FL (ft) (CFL)		2.2	6.2	11.0	51.6	
FL class (FIL)		2	4	5	6	
	VI Category					
Infrastructure Assets	1	1 = near road, railroad, school, airport, hospital				
Wildland Development Areas	7	1-7: density classes from low to high				
Drinking Water Importance Areas	9	1-10: classes based on population served				
Forest Assets	1	Example is 1= Sensitive, 0-10 m., closed;				
Riparian Assets	3	1 = less important; 2 = moderately important; 3 = important				
	(FTI Wted)	Response Function Values				Weighting
	RF Scores	Low	Mod	High	Ext	Factor
Infrastructure Assets	-7.458	-4.97	-7.31	-8.23	-8.41	46.2%
Wildland Development Areas	-7.922	-4.88	-7.75	-8.84	-9.00	44.7%
Drinking Water Importance Areas	-5.719	-2.36	-5.51	-6.79	-7.28	1.0%
Forest Assets	-7.281	-3.84	-7.13	-8.11	-8.34	3.6%
Riparian Assets	-4.959	-1.41	-4.63	-6.67	-7.66	4.5%
Values Impacted Rating	-7.529					

Figure 3-51. Example of Values Impacted Rating Calculation

The Value Impacted Rating calculation in the example is shown below:

VIR= [(0.462)*(-7.458) + (0.447)*(-7.922) + (0.01)*(-5.719) + (0.036)*(-7.281) + (0.045)*(-4.959) ~ -7.529

3.4.2 Fire Suppression Difficulty

The difficulty and potential cost for a wildfire to be suppressed is defined as fire suppression difficulty. Two datasets together are used to develop a Fire Suppression Difficulty Rating, surface model and slope.

Surface Fuel Model

The surface fuels affect the ability of firefighters to construct and hold fireline. Surface fuels data used in the WWA were gathered from the LANDFIRE project, Refresh (LF 1.1.0) (Appendix B). The fuel model set used is defined by Scott and Burgan (2005) and is referred to as the 2005 FBPS fuel model set.

The fireline production rates from the NWCG Fireline Handbook (National Wildfire Coordinating Group 2004) as well as the Fire Program Analysis (FPA) project (Appendix B) were used to group the surface fuel models from the 2005 Fire Behavior Prediction System fuel model set (Scott and Burgan 2005) into three fireline production rate categories: Slow, Medium and Fast (Figure 3-52).

Grass		Grass/ Shrub	Shrub	Timber Litter/ Understory	Timber Litter	Slash
gr1		gs1	sh1	tu1	tl1	sb1
gr2		gs2	sh2	tu2	tl2	sb2
gr3		gs3	sh3	tu3	tl3	sb3
gr4		gs4	sh4	tu4	tl4	sb4
gr5			sh5	tu5	tl5	
gr6			sh6		tl6	
gr7			sh7		tl7	
gr8			sh8		tl8	
gr9			sh9		tl9	
	Key	Fast				
		Medium				
		Slow				

Figure 3-52. Fireline Production Rate Categories

Slope

The Fireline Handbook's Appendix A, page A-34, defines four slope classes as follows: 0-25%, 26-40%, 41-55% and 56-74%. A fifth class of 75% or greater was added to the WWA for completeness.

Fire Suppression Difficulty Rating (SDR)

Based on the fireline production rate categories and slope category combinations, a suggested rating scale was developed. It uses the same range of numeric values as is used for the response function scores for values impacted. This range is from -1 to -9. The suppression difficulty rating was calculated for each combination of fireline and slope steepness categories as the average of the state provided ratings (Figure 3-53).

Suppression Difficulty	Production Rate	Code	Slope Steepness				
			0-25	26-40	41-55	56-74	75+
			1	2	3	4	5
	Fast	1	-1.50	-3.96	-7.04	-8.74	-9.00
	Medium	2	-3.19	-5.19	-7.64	-8.54	-8.88
	Slow	3	-4.49	-6.16	-8.06	-8.91	-9.00

Figure 3-53. Fireline Production Rate Categories

Figure 3-54 shows an example of the Value Impacted Rating data layer for an area of Jackson County, Oregon as well as an example of the Suppression Difficulty Rating data layer for the same area. The final Suppression Difficulty classes were developed as a combination of the fireline production rate (slow, medium, fast) and the slope class. The response function scores were then ordinated from quickest fireline production rate (-1.5) to the slowest fireline production rate (-9).

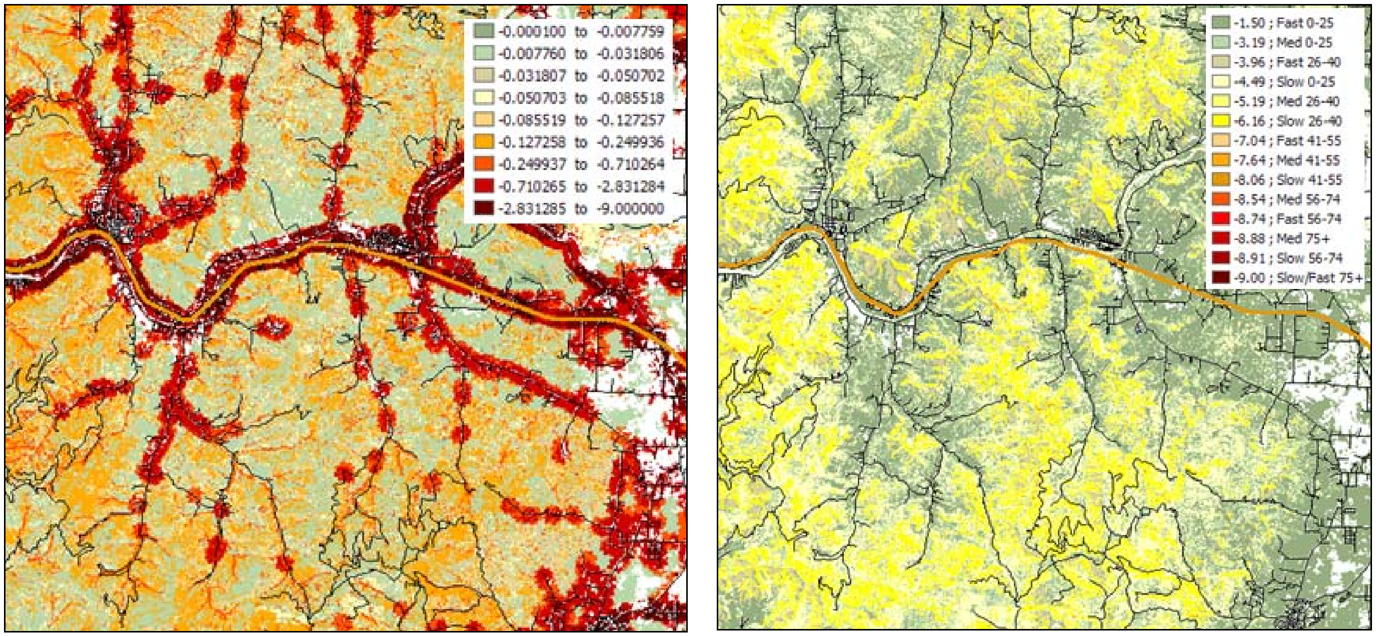


Figure 3-54 Value Impacted Rating (left) and Suppression Difficulty Rating for an area in Jackson County, OR.

Fire Effects Index (FEI)

The final step of the fire effects process is to calculate the Fire Effects Index. As noted earlier, the Fire Effects component of the risk assessment involves integrating the Values Impacted Rating and Suppression Difficulty Rating using the following equation

$$FEI = [(VIR) * (VIR\ weight) + (SDR) * (SDR\ weight)] / 100$$

The VIR weight plus the SDR weight total to 100%. The states provided input to these weights. Once the VIR and SDR values were determined and the input from the states was averaged, the final weights were VIR, 90%, and SDR, 10%. The resultant Fire Effects Index is a value theoretically between –0.01 and –9.0. Figure 3-55 shows an example of the calculation of the Fire Effects Index. The spreadsheet containing these calculations is also provided as Addendum II to this report.

$$FEI = [(-7.529) * (0.9) + (-4.49) * (0.1)] / 100= -7.225$$

Variable		Percentile Weather				
		Low	Mod	High	Ext	FTI
Fire Threat Index		0.00001	0.04800	0.00780	0.00100	0.0568
FL (ft) (CFL)		2.2	6.2	11.0	51.6	
FL class (FIL)		2	4	5	6	
	VI Category					
Infrastructure Assets	1	1 = near road, railroad, school, airport, hospital				
Wildland Development Areas	7	1-7: density classes from low to high				
Drinking Water Importance Areas	9	1-10: classes based on population served				
Forest Assets	1	Example is 1= Sensitive, 0-10 m., closed;				
Riparian Assets	3	1 = less important; 2 = moderately important; 3 = important				
	(FTI Wted)	Response Function Values				Weighting
	RF Scores	Low	Mod	High	Ext	Factor
Infrastructure Assets	-7.458	-4.97	-7.31	-8.23	-8.41	46.2%
Wildland Development Areas	-7.922	-4.88	-7.75	-8.84	-9.00	44.7%
Drinking Water Importance Areas	-5.719	-2.36	-5.51	-6.79	-7.28	1.0%
Forest Assets	-7.281	-3.84	-7.13	-8.11	-8.34	3.6%
Riparian Assets	-4.959	-1.41	-4.63	-6.67	-7.66	4.5%
Values Impacted Rating	-7.529					
Slope Class	1	1 = flat; 5 = steepest				
Fuel Type	3	1=Grass; 2 = Timber Litter; 3=Brush;				
Suppression Difficulty Rating	-4.49					
Suppression Difficulty Weight	10					
Values Impacted Weight	90					
Fire Effects Index	-7.225					

Figure 3-55. Final calculations for Fire Effects Index

Figure 3-56 shows an example of the final Fire Effects Index data layer for an area of Jackson County, Oregon.

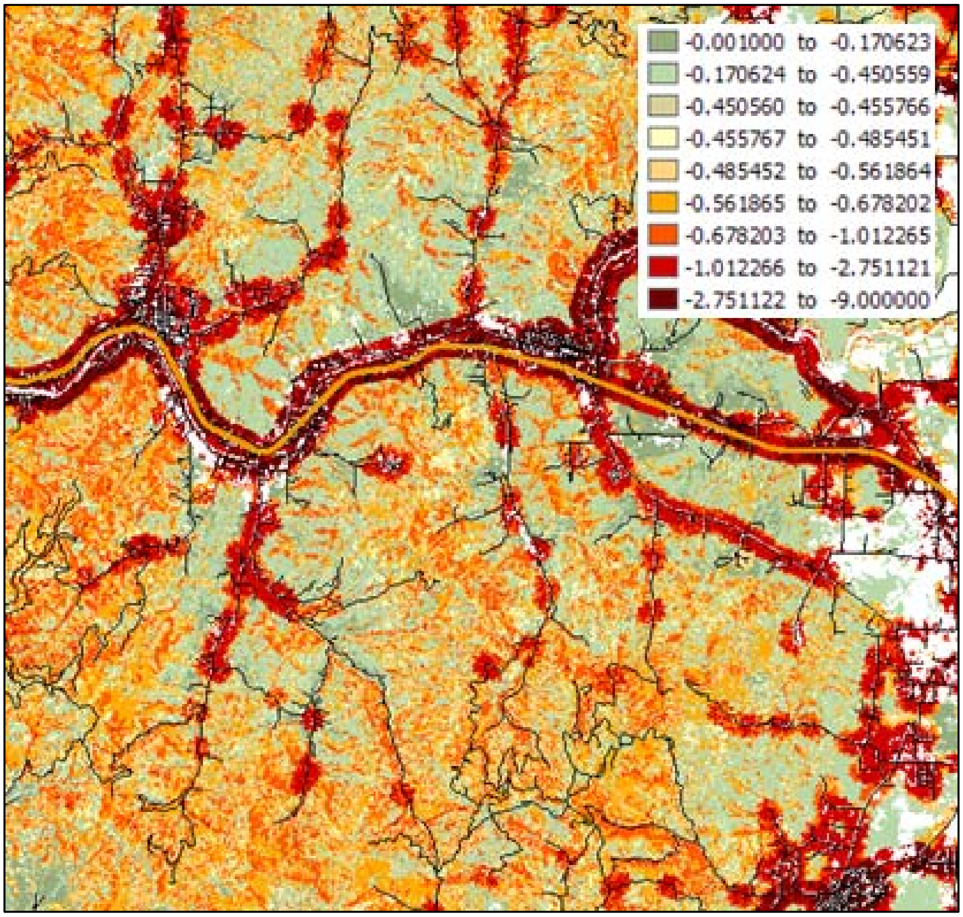


Figure 3-56. Final Fire Effects Index for an area in Jackson County, OR

3.5. Fire Risk

As mentioned, the data layer that defines wildland fire risk is the Fire Risk Index (FRI), (Figure 3-1).

3.5.1 Fire Risk Index (FRI)

The Fire Risk Index is calculated from the Fire Threat Index (FTI) and the Fire Effects Index (FEI). The FEI is the potential expected effects of the fire as defined via response functions. The initial calculation is IFRI = FTI * FEI. The Fire Effects Index is a value theoretically between –0.01 and –9.0 while the Fire Threat Index is a value between 0.0 and 1.0. This product results in an "expected fire effects value" less than 0 but greater than or equal to –9.0. An "expected" value is a measure of the likelihood of an effect occurring. Since the initial calculation frequently results in a small negative value, the final FRI calculation includes 10,000 as a scalar multiplier:

FRI = IFTI * FEI * 10,000.

The scalar is included to make the values a bit larger to enhance understanding. Figure 3-57 shows an example of the calculation of the Fire Risk Index.

Variable		Percentile Weather				
		Low	Mod	High	Ext	FTI
Fire Threat Index		0.00001	0.04800	0.00780	0.00100	0.0568
FL (ft) (CFL)		2.2	6.2	11.0	51.6	
FL class (FIL)		2	4	5	6	
	VI Category					
Infrastructure Assets	1	1 = near road, railroad, school, airport, hospital				
Wildland Development Areas	7	1-7: density classes from low to high				
Drinking Water Importance Areas	9	1-10: classes based on population served				
Forest Assets	1	Example is 1= Sensitive, 0-10 m., closed;				
Riparian Assets	3	1 = less important; 2 = moderately important; 3 = important				
	(FTI Wted)	Response Function Values				Weighting
	RF Scores	Low	Mod	High	Ext	Factor
Infrastructure Assets	-7.458	-4.97	-7.31	-8.23	-8.41	46.2%
Wildland Development Areas	-7.922	-4.88	-7.75	-8.84	-9.00	44.7%
Drinking Water Importance Areas	-5.719	-2.36	-5.51	-6.79	-7.28	1.0%
Forest Assets	-7.281	-3.84	-7.13	-8.11	-8.34	3.6%
Riparian Assets	-4.959	-1.41	-4.63	-6.67	-7.66	4.5%
Values Impacted Rating	-7.529					
Slope Class	1	1 = flat; 5 = steepest				
Fuel Type	3	1=Grass; 2 = Timber Litter; 3=Brush;				
Suppression Difficulty Rating	-4.49					
Suppression Difficulty Weight	10					
Values Impacted Weight	90					
Fire Effects Index	-7.225					
Initial Fire Risk Index	-0.410					
Fire Risk Index	-4104.4					

Figure 3-57. Calculation of Fire Risk Index. Note that it is the Initial Fire Risk Index multiplied by 10,000.

Figure 3-58 shows an example of the Fire Risk Index data layer for an area of Jackson County, Oregon.

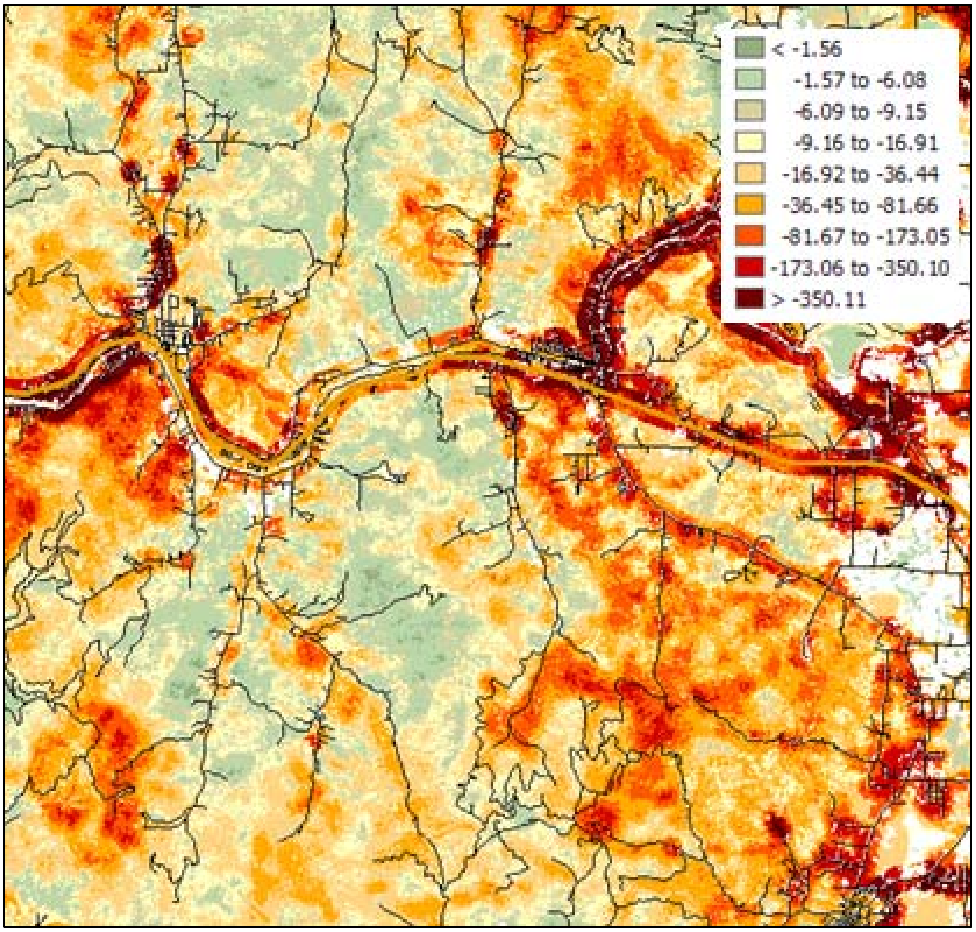


Figure 3-58. Final Fire Risk Index layer for an area in Jackson County, OR

Understanding the Risk Assessment Results

Many data layers are included in the risk assessment process. These input datasets need to be reviewed along with the final risk values to truly understand their interactions and determine why risks may be high or low. When the inputs for results are defined and compared, the relationship between input and output data layer values can answer questions. As an example, Figures 3-59 through 3-62 show the Fire Occurrence Area, Fire Threat Index, Fire Effects Index and Fire Risk Index for an area of Jackson County, Oregon. One should use multiple layers like these to determine the reasons why a cell might have a particular fire risk value defined.

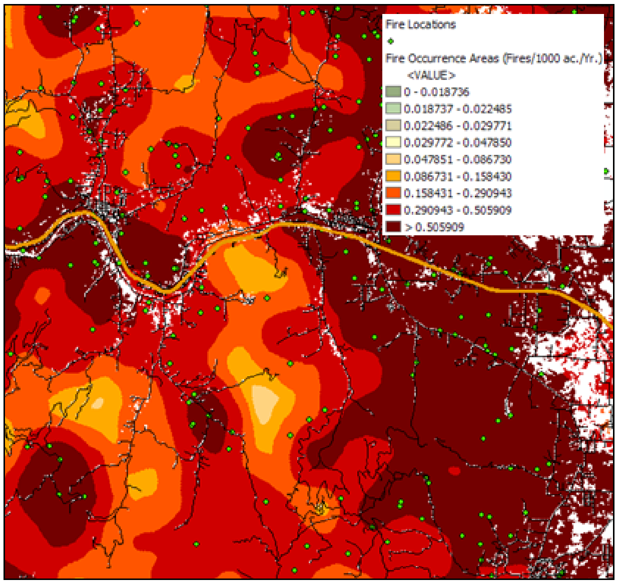


Figure 3-59 Fire Occurrence Areas

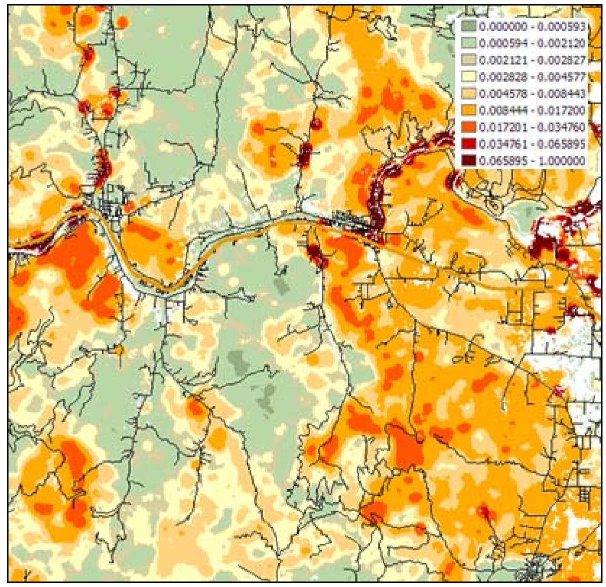


Figure 3-60. Fire Threat Index

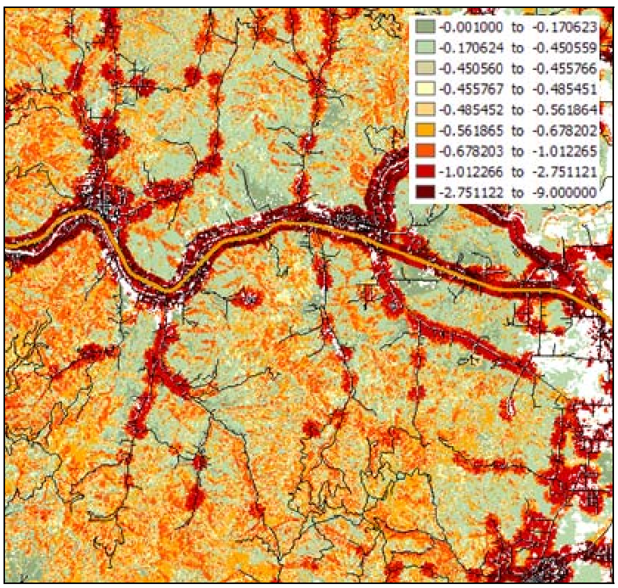


Figure 3-61 Fire Effects Index

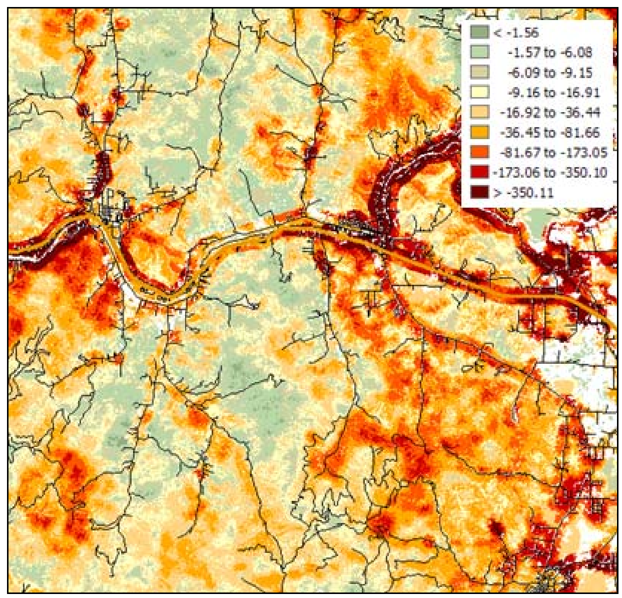


Figure 3-62. Fire Risk Index

3.6. Pacific Islands

The Pacific Islands lack some of the basic datasets required to complete a quantitative wildfire risk assessment. In particular, the lack of fire ignition and report data is a deficiency and this limits the analysis of historical fire occurrence. The ability to assign fuel models to vegetation was not possible uniformly across the island groups. While this may change in the near future, with LANDFIRE scheduled to release datasets for the Pacific Islands in their next update, in the meantime, we have reviewed the Pacific Islands State Forest Resource Assessment documents and identified several key factors relating to wildfire risk. We've summarized these items in a document for the WWA project and are providing it as Addendum III to this final report.

Dialogue and collaboration with the Pacific Islands for data compilation and delivery was challenging. The WWA was unable to complete a quantitative wildfire risk assessment for the Pacific Islands due to lack of complete fuels data, fire occurrence reports and values impacted data. The Pacific Islands lack some of the basic data sets required to produce a complete risk assessment.

In particular, the lack of fire ignition and report data limits the analysis of historical fire occurrence. The ability to assign fuel models to vegetation was not possible uniformly across the island groups. The U.S Forest Service, Region 5, State and Private Forestry, should be supported in an effort to implement a common fire reporting system in the Pacific Islands. The circa 2010 version of LANDFIRE is due to be released in March, 2013 and is scheduled to include fuels data for of the Pacific Islands. The circa 2010 data sets will afford analysis of fire behavior potential and a basic hazard assessment in the future. In addition, if fire occurrence data can be gathered with an attribute of a fire ignition location, then a fire threat layer could be developed after the LANDFIRE program releases the circa 2010 update in March 2013. These accomplishments could be completed in Phase 2 if desired.

While a quantitative assessment was not possible the following is a brief summary of general trends pertaining to wildfire risk in the Pacific Islands.

In general though, due to the high precipitation rates on the Pacific Islands, the surface fuel model in forested areas is a Fire Behavior Prediction System (FBPS) 1982 Fuel Model Set fuel model 8 (Nelson 2009). The FBPS 2005 Fuel Model Set fuel model would be timber litter (TL1, TL2, TL3, TL6 or TL9) or timber litter/understory (TU02 or TU03) (Carlton and Wolf 2010). Most wildland fires that are of concern burn in the more open grass or shrub fuel types. Representative fuel models in these fuel types are FBPS 1982 Fuel Model Set fuel models 2, 3 and 7 (Neill and Rea 2004). A custom fuel model has also been developed to represent taller grass (Neill and Rea 2004). For the FBPS 2005 Fuel Model Set fuel models, representative fuel model are GR3, GR6, GR8 and GS4 (Carlton and Wolf 2010).

El Niño-Southern Oscillation (ENSO) and Wildfire

During El Niño-Southern Oscillation, rainfall increases over a distance of several thousand kilometers along the equator from the central to the eastern Pacific in response to the warming of the underlying sea surface temperatures. The opposite effect tends to be experienced during La Nina, although the west-east scale of rainfall anomalies over the equatorial Pacific is somewhat reduced compared to warm events (NOAA 2012a).

During El Niño-Southern Oscillation events, there has been shown to be an increased occurrence of wildfire and acres burned in Western Micronesia, specifically the Territory of Guam, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia and Republic of Palau (Falanruw and other, 2009). Information for Guam shows approximately a six fold increase in acres burned in 1983, 1987, 1988, 1992 and 1998 than normal. Of if these years were during El Niño-Southern Oscillation events (NOAA 2012b).

During El Niño-Southern Oscillation events, particular attention should be paid to fire prevention and fire suppression preparedness.

Statewide Assessment and Resource Strategy (SWARS)

The Statewide Assessment and Resource Strategy (SWARS) was developed to identify the highest priorities within a State for forest resource management and needs. It is needed to define areas where assistance is desired from the United States Department of Agriculture, U.S. Forest Service's State and Private Forestry (S&PF) Redesign program. The SWARS are required based on an amendment to the Cooperative Forestry Assistance Act (CFAA), as enacted in the 2008 Farm Bill. Each State is required to complete a State Assessment and Resource Strategy within two years after enactment of the 2008 Farm Bill (June 18, 2008) to receive funds under CFAA.

The National Themes and Objectives for the SWARS include a theme titled "Protect Forests from Harm and an objective to Restore Fire-Adapted Lands and Reduce Risk of Wildfire Impacts." Within this theme and objective, the occurrence and use of fire was included in the definition of issues and strategies.

As the WWA was unable to complete a quantitative wildfire risk assessment for the Pacific Islands, a review of the SWARS for the Pacific Islands was provided. This summary is included as Addendum III to this report. The information is taken from each of the SWARS and provides as overview of wildland fire issues and strategies for the Pacific Islands.

Section 4 Final Deliverables

This section provides a description of the final project deliverables.

4.1. Published Results

The outputs from the West Wide Wildfire Risk Assessment that define the current fire situation in the WWA project area are referred to as the Published Results. These outputs provide a data platform for use by operational staff, as well as other fire management collaborators, in mitigation planning and communication activities. These results can be used for identifying areas where more localized analysis may be appropriate, for summarizing the relative risk between areas, for community wildfire reporting, etc..

The key output datasets and maps delivered were:

- Fire Risk Index (FRI) – Figure 4-1
- Fire Threat Index (FTI) - Figure 4-2
- Fire Effects Index (FEI) - Figure 4-3
- Values Impacted Rating (VIR)
- Suppression Difficulty Rating (SDR)
- Surface Fuels
- Fire Occurrence Areas (FOA)
- Response Function Scores (RFSs) – for each values dataset (WDA, RA, FA, DWIA, IA)

Numerous other datasets were also delivered with these as indicated in Section 2.0.

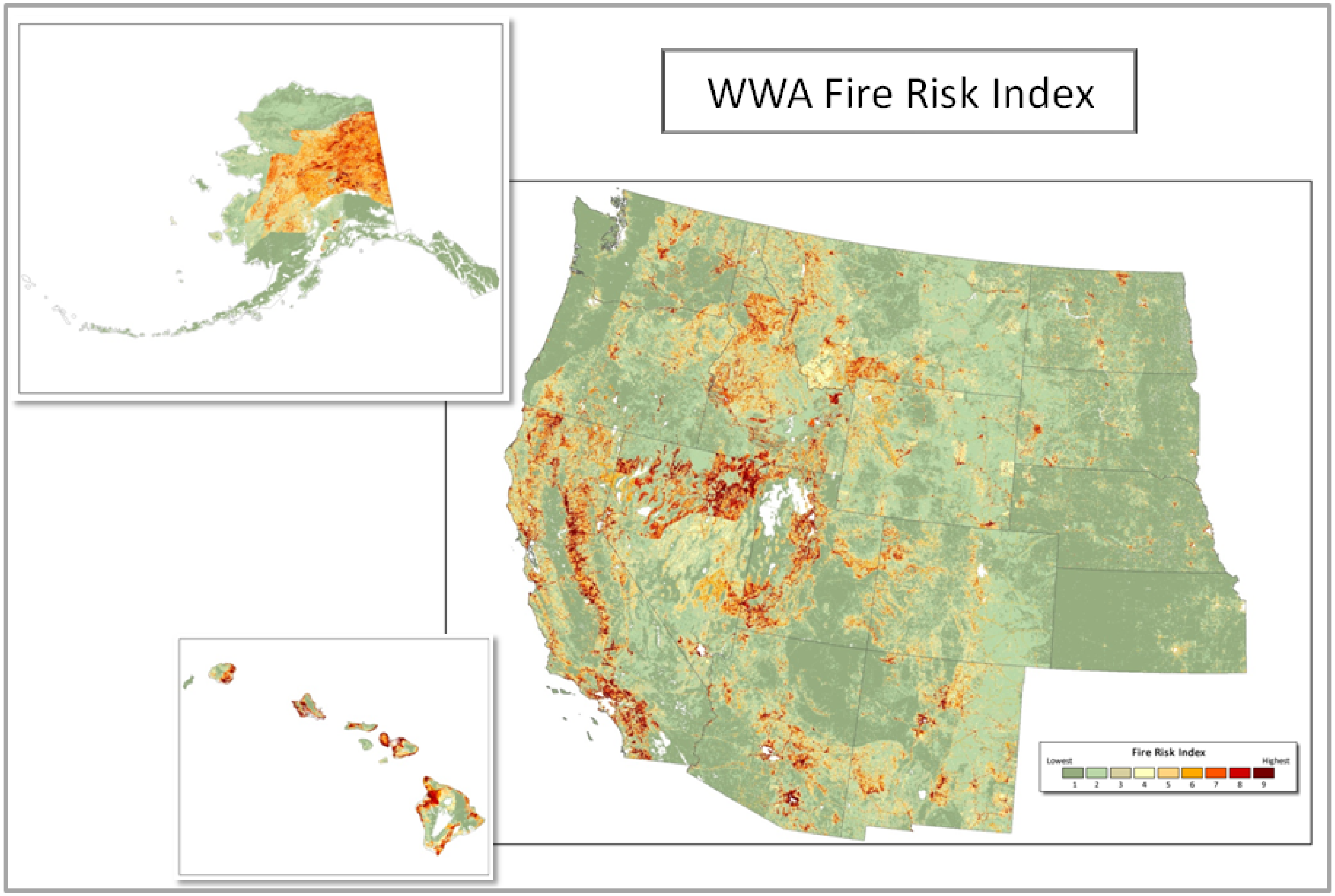


Figure 4-1. Final Fire Risk Index layer for the 17 western states.

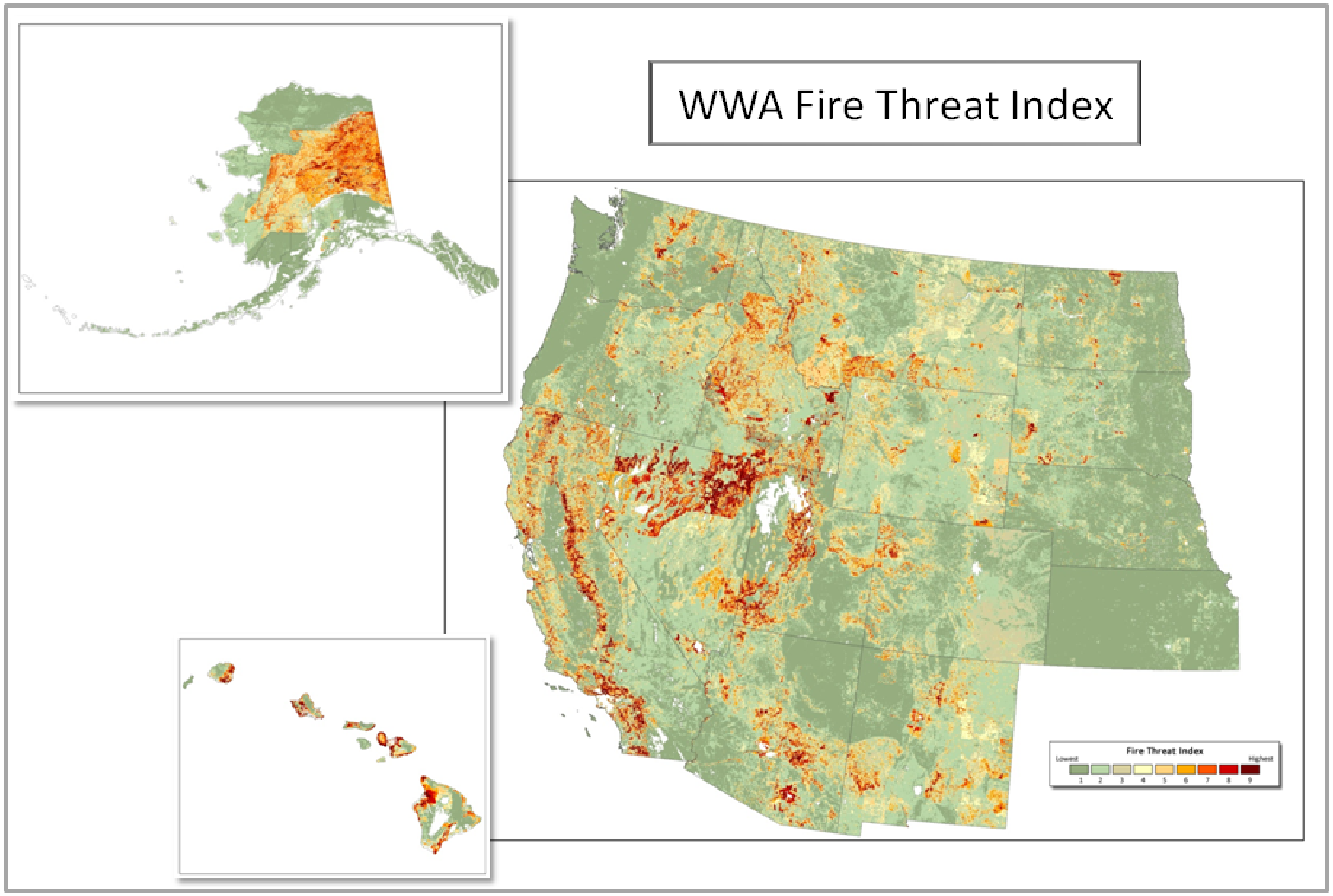


Figure 4-2. Final Fire Threat Index layer for the 17 western states.

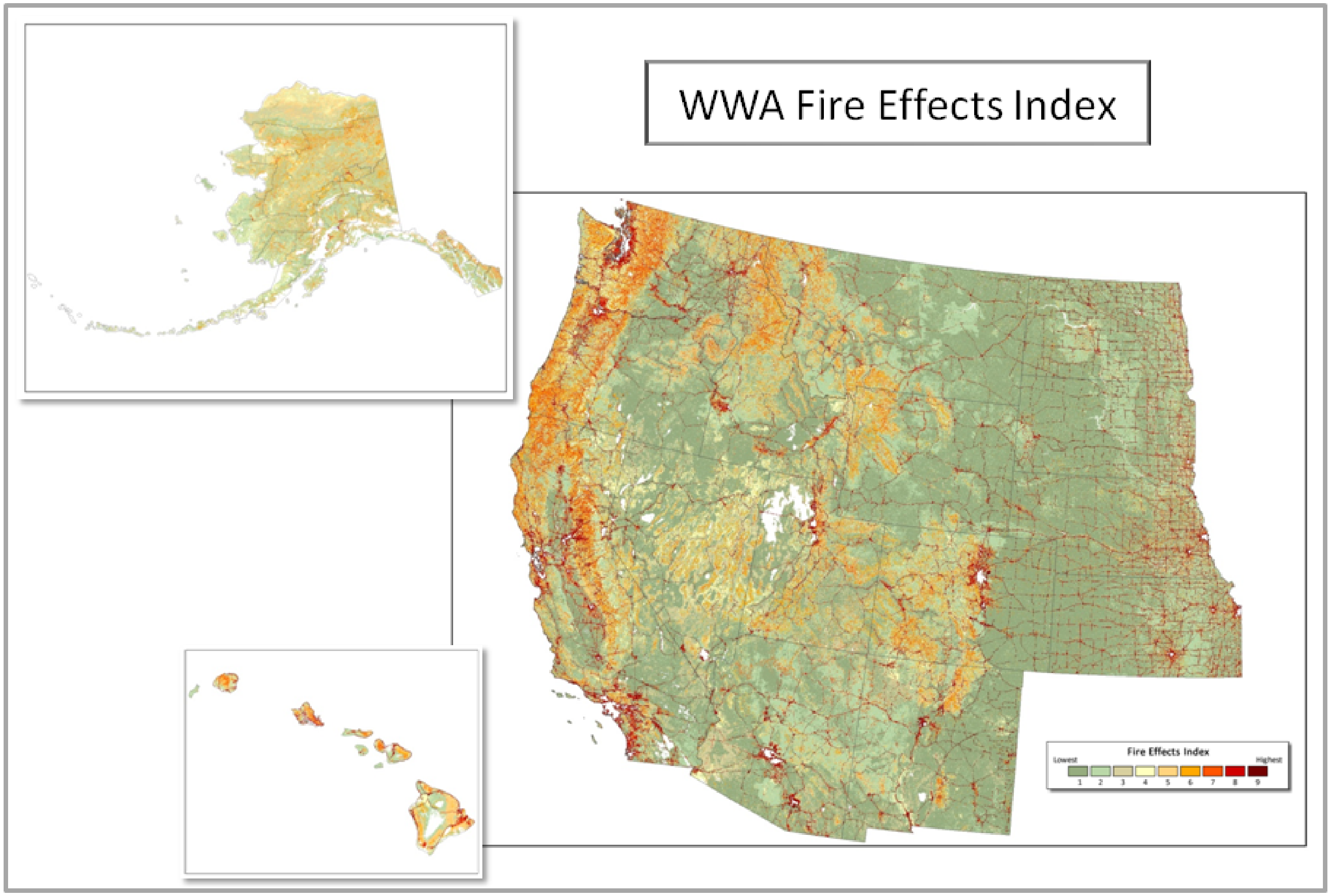


Figure 4-3. Final Fire Effects Index layer for the 17 western states.

4.2. Data Formats and Delivery

All data developed for the WWA project was delivered in both a single regional WWA map projection as well as individual state projections, as defined in the Data Standards document developed at the start of the project (Appendix C). Each state received the WWA Regional Level data for their state in both the WWA regional projection and their state's projection. The Oregon Department of Forestry, on behalf of the WFLC and the CWSF, received a complete set of all state data.

The Published Results were delivered to each state and the ODF on hard drives which contained the following:

- All datasets tiled by county in a uniform geodatabase file structure (Addendum VII)
- A folder of Layer Files to assist with viewing the datasets in ArcMap
- A sample ArcMap project document (.mxd) for one example county in each state for the state's to use as a guide for viewing the data.
- A README.txt file describing the contents of the hard drive and the data structure of the drive.

The final report was delivered in both MS WORD and PDF format and included the Addendums noted in Section 1.5.

Data was delivered in the fall of 2012 to each state. The list of initial mailing contacts is provided in Appendix D.

4.3. Project Reports

Several documents were developed and provided as project deliverables throughout the life of the project. These documents supported the project with communicating key steps along the way and documenting lessons learned as the project progressed. These included:

- **WWA Final Report (this document)**: The final report (this document) provides a summary of all project activities. This includes a description of the risk assessment methods, algorithms and technologies utilized.
- **WWA Data Standards Report:** This document was developed at the start of the project to identify data standards to be used throughout the project. It includes information on projections, data formats, and methods of data transfer
- **WWA Data Gap Analysis Report:** The Data Gap Analysis Report identified issues that were encountered in the data development process and improvements that could be made in acquiring data in the future.
- **WWA Technical Briefs:** These documents were developed to provide state representatives with an understanding of their involvement in the project and the processes used to produce datasets they would be reviewing.

- State Representative Roles & Responsibilities
- Federal Liaisons Roles & Responsibilities
- Summary of Project Milestones
- Fuels Mapping
- Fire Occurrence
- Weather Influence Zones
- Fire Effects

- **WWA Summary Statistics (Regional & State):** The Summary Statistics provide a first look at the results on a regional and state level.
- **WWA County Risk Reports** The County Risk Reports provide a first look at the risk assessment results within each state.

Section 5 Assessment Results and Findings

5.1.Results and Use of Data

Key data used in the assessment varies with respect to accuracy and date of compilation. For example, ignition data of federal fire occurrence was utilized for the period 1999-2008, while occurrence data used from National Fire Incident Reporting System (NFIRS) to supplement state data ranged for the period 2004-2009. Some states were not able to provide occurrence data for the same period. The fuels data represents 2008. Population data represents 2010. Other data is more up to date. All raster data was compiled at a scale consistent with 30 meters.

With the exceptions noted in the Data Gap Analysis Report, the assessment was conducted using consistent data across all 17 Western states. Accordingly, the output data that was derived and the assessment Published Results that were created are largely comparable across the entire West. The models utilized ensure that the assessment results are consistent, comparable and repeatable.

Please note that the WWA Published Results may not match other assessments conducted that use different data, technical methods, or scale of analysis. Having two assessments that do not match does not mean that either one of them is incorrect. The use of different data sources, often from different collection dates and with spatial accuracy and resolutions, combined with different modeling assumptions or definitions will result in different results and can have different interpretations and uses. The WWA results are not intended to replace local and state products as a decision-making tool. The WWA is meant to serve as a regional policy analysis tool that provides results comparable across geographic areas in the West, and to supplement existing products for state and local fire protection planning.

5.2.Summary Statistics

Three sets of summary statistics were developed using the results of the WWA. These are:

1. Regional Summary Statistics,
2. State Summary Statistics, and
3. County Risk Reports

The WWA technical team developed initial statistical summaries and then vetted them with the WWA Project Manager as well as some individual state representatives to develop an initial set of draft statistics. These were then presented to and reviewed by the Project Steering Committee and their feedback was incorporated into the final statistical summaries.

The Regional Summary Statistics include comparisons of several of the risk assessment outputs for the states on a region wide basis. This dataset consists of the summary statistics identified below. An example is shown in Figure 5-1, and the full set of regional statistics is included in an Adobe PDF document provided as Addendum IV to this report.

- **Fire Risk**: Total Acres
- **Fire Risk**: Percent Acres
- **Fire Threat**: Total Acres
- **Fire Threat**: Percent Acres
- **Fire Effects**: Total Acres
- **Fire Effects**: Percent Acres
- **Values Impacted Rating**: Total Acres
- **Values Impacted Scores**: Percent Acres
- **Values**: Moderate-High Response Function Score Acres VS Total Acres
- **Wildland Development Areas**: Population
- **WDA Response Function Scores**: Population
- **Surface Fuels**: Total Acres
- **Number of Fires**: State & Federal Reported VS NFIRS
- **Acres Burned**: State & Federal Reported Fires
- **Riparian Assets**: Total Acres
- **Wildland Development Areas**: Total Acres
- **Pacific Islands** (excluding Hawaii)

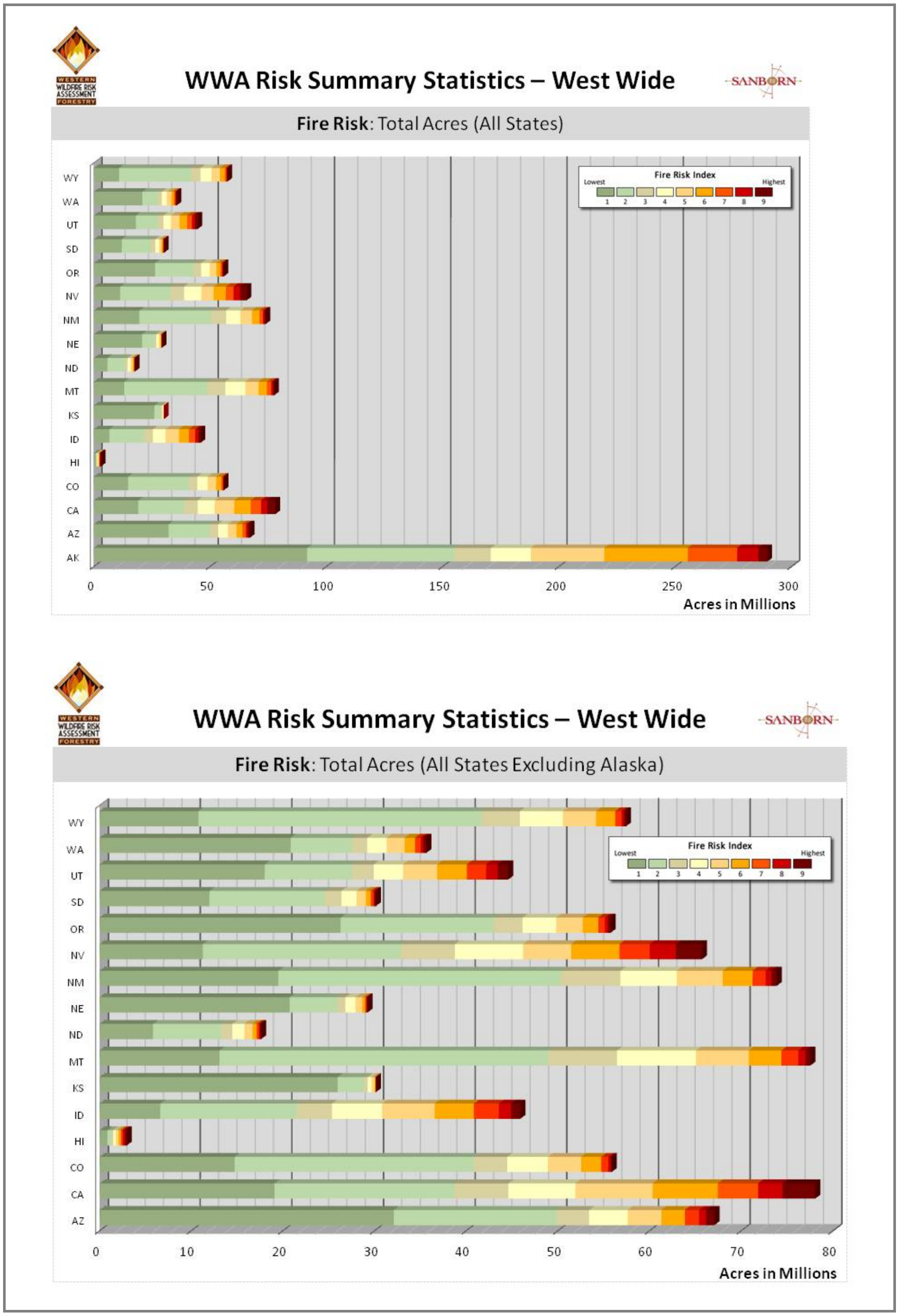


Figure 5-1. Example of the Regional Summary Statistic for Fire Risk Index

The State Summary Statistics summarize the same key outputs as the regional statistics, but on a statewide basis for all Western states. The specific statistics are listed below, and Figures 5-2 and 5-3 show examples of two of the statewide statistics. The full set of statewide statistical summaries can be found in Addendum V of this report.

- **Fire Risk**: Total Acres
- **Fire Threat**: Total Acres
- **Fire Effects**: Total Acres
- **Values Impacted Scores**: Percent Acres
- **Values**: Moderate-High Response Function Score Acres VS Total Acres
- **Wildland Development Areas**: Population
- **WDA Response Function Scores**: Population
- **Surface Fuels**: Total Acres
- **Number of Fires**: State & Federal Reported VS NFIRS
- **Acres Burned**: State & Federal Reported Fires
- **Riparian Assets**: Total Acres
- **Wildland Development Areas**: Total Acres

The final statistics reports are the County Risk Summary Reports that provide a breakdown of the primary outputs by county for each state. Counties provide a consistent geography for summarizing risk outputs within a state and across the west. Counties are also a standard administrative area used for mitigation planning and risk reporting. The County Summaries include Fire Risk Index, Fire Threat Index and Fire Effects Index, as well as Wildland Development Areas.

An example of the County Summaries for the State of Arizona is shown in Figure 5-4 and the remaining County Summaries are provided in Addendum VI too this report.

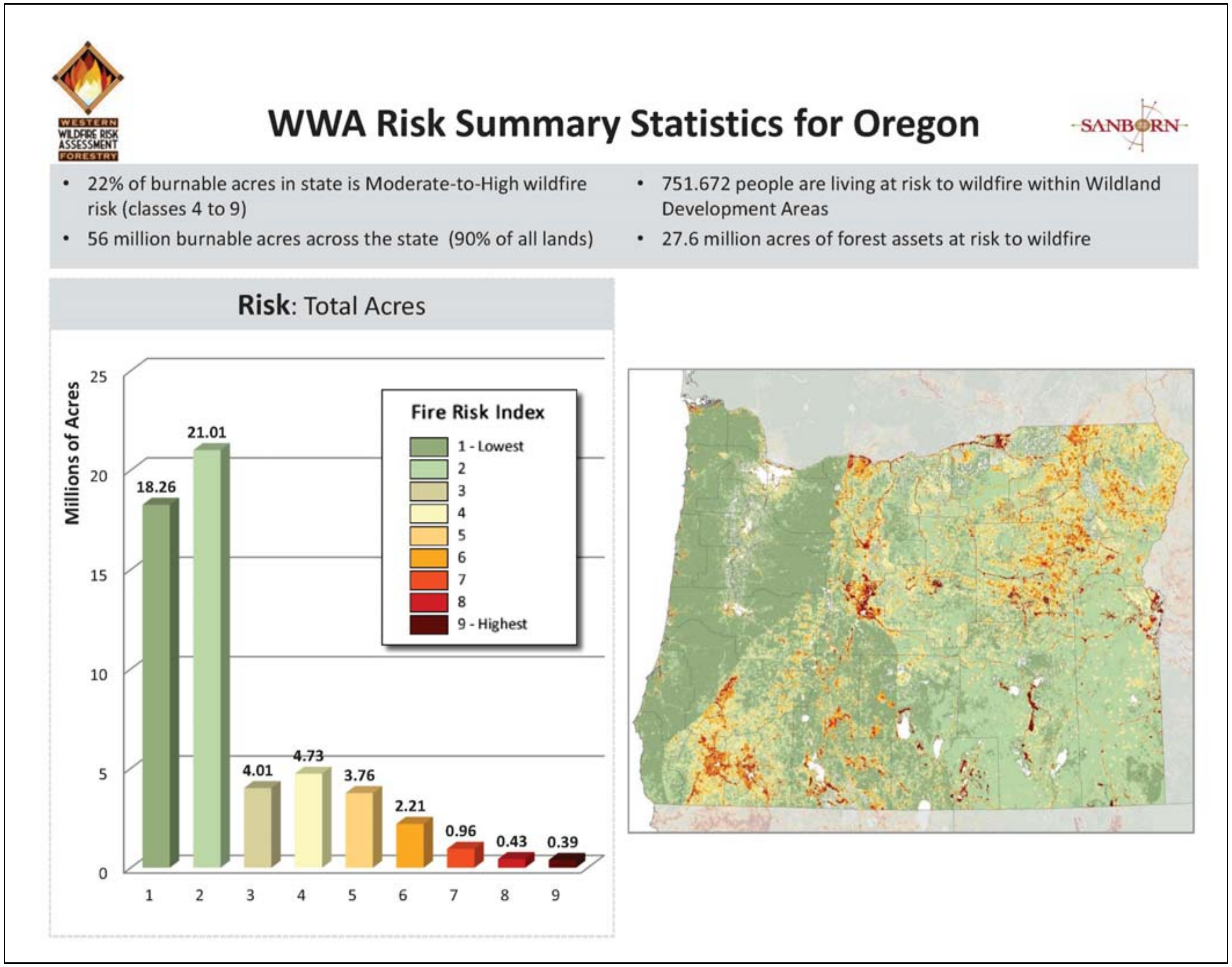


Figure 5-2. Example of the Statewide Summary Statistic for Fire Risk

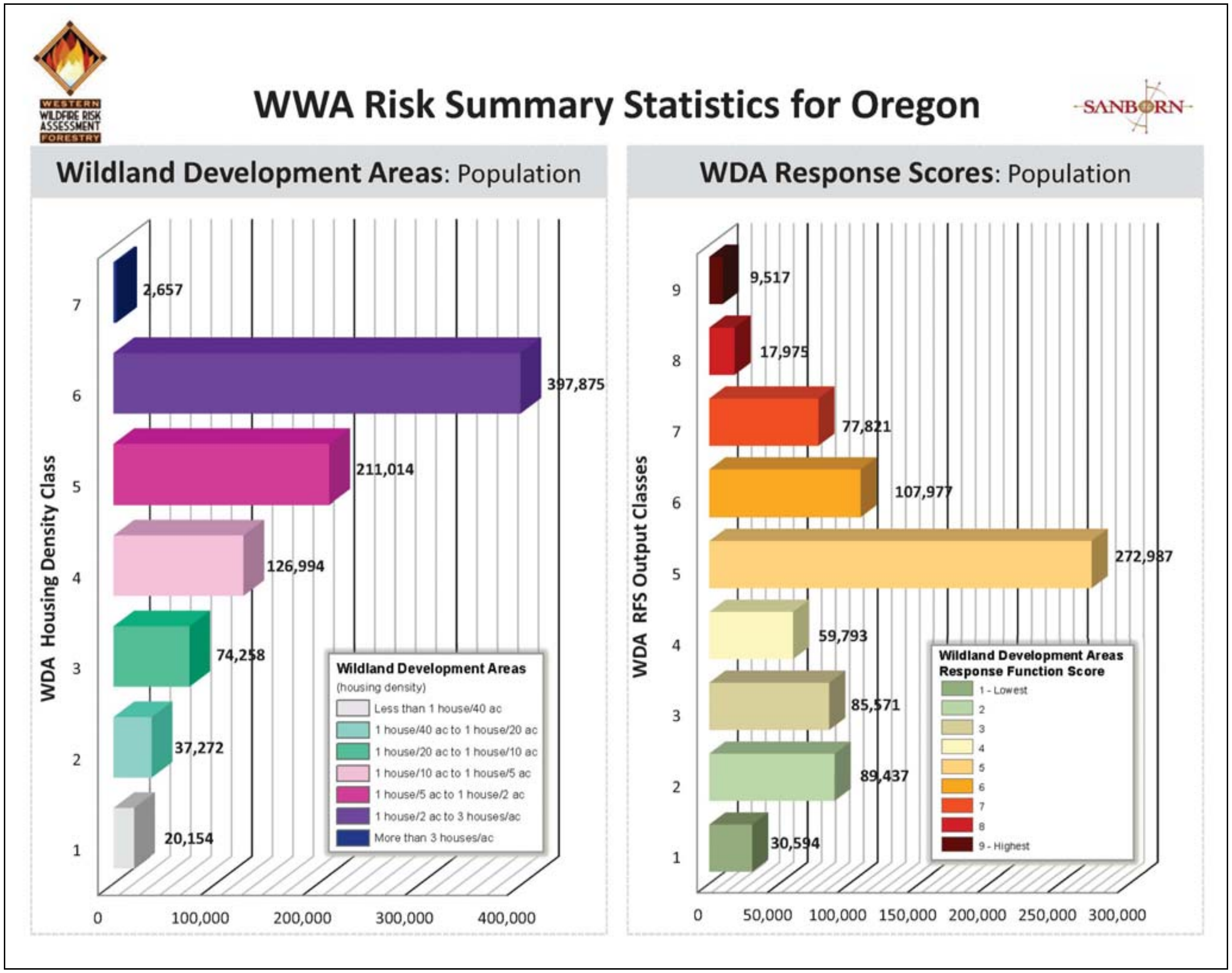


Figure 5-3. Example of the Statewide Summary Statistic for Wildland Development Areas and their Response Function Scores

ARIZONA - County Risk Summary Report

Fire Risk Index (FRI) - Acres by County

COUNTY	FIPS	FRI 1	FRI 2	FRI 3	FRI 4	FRI 5	FRI 6	FRI 7	FRI 8	FRI 9
Apache	04001	4,721,376	1,043,290	209,312	231,399	167,428	77,491	28,113	9,971	7,092
Cochise	04003	1,458,261	1,356,075	218,149	247,241	213,815	143,080	90,478	39,787	35,918
Coconino	04005	6,595,575	2,492,057	529,999	510,320	330,187	179,482	83,642	33,448	17,596
Gila	04007	139,101	603,687	258,276	423,667	511,852	435,489	311,896	160,798	173,888
Graham	04009	725,086	956,503	223,773	312,801	318,404	199,475	107,618	34,694	17,653
Greenlee	04011	219,883	407,905	129,252	171,280	130,911	60,165	26,564	7,822	2,858
La Paz	04012	2,011,975	561,093	35,877	35,061	30,461	22,913	12,465	6,347	5,909
Maricopa	04013	2,366,296	1,355,374	194,630	281,090	307,034	235,260	134,018	90,558	99,202
Mohave	04015	2,546,464	3,039,129	582,982	618,296	497,936	373,217	192,359	99,119	75,139
Navajo	04017	4,397,070	752,385	148,608	182,263	139,033	66,380	34,652	16,886	21,750
Pima	04019	2,444,335	1,492,631	265,845	327,472	276,045	232,656	225,485	101,830	270,917
Pinal	04021	948,111	1,053,832	207,138	232,139	177,598	155,312	102,997	60,365	64,618
Santa Cruz	04023	149,144	295,571	72,292	86,537	74,859	51,631	27,721	12,696	9,195
Yavapai	04025	1,165,371	1,883,973	442,590	525,569	460,513	309,030	176,909	78,039	85,826
Yuma	04027	2,214,780	446,493	36,499	37,039	35,281	21,799	8,564	5,820	7,158
	Totals	32,102,828	17,739,999	3,555,223	4,222,173	3,671,358	2,563,381	1,563,482	758,179	894,721

Figure 5-4. Example of a County Summary for the State of Arizona

5.3. Accomplishments

The WWA project was the first of its kind in the West and emphasizes the States' commitment to better understand wildfire risk in the west and to continue working towards improving fire protection planning and mitigation efforts. The project has numerous accomplishments worth noting:

1. **Delivery of a Comprehensive Wildfire GIS Database** - A key accomplishment of the WWA project is the rich and comprehensive database of wildfire risk information developed and delivered to the states. This provides a consistent baseline of GIS data that can be utilized for on-going assessments and analysis.
2. **Regional application of LANDFIRE** - The WWA is one of the first region-wide applications of the LANDFIRE datasets. Without this readily available source of consistent fuels and vegetation data for the entire west this project would have been much more complicated and costly to complete. Our appreciation goes out to the LANDFIRE team for keeping us up to speed on changes that were occurring to the LANDFIRE datasets and the schedule for these updates. Based on this communication, the WWA made a key decision to wait for the LANDFIRE REFRESH datasets for use in this assessment. While this decision included timeline delays, it resulted in a much more consistent and up to date product for the western states.
3. **Integration of Response Function Methods** - The decision to implement the response function methods for Fire Effects analysis resulted in considerably better outputs that adhere to Cohesive Strategy future directions and methods. This was a significant achievement to accommodate these methods enhancements, and results in consistent results that provide great utility across the west to evaluate values-at-risk.

5.4. Lessons Learned

As with any project, there is always room for improvement. There were many lessons that were learned as we moved through the process of developing the risk assessment for the western states. Some of the data issues were documented in the Data Gap Analysis Report, which was delivered midway through the project. Many others were just noted as the project progressed or were based on reviewing the final results. These items are summarized below along with recommendations for future improvements, where appropriate, in the hope that they may benefit other data collection efforts as well as future updates to the WWA.

Technical Data Issues

A more detailed description of data issues can be found in the project Data Gap Analysis report.

1. **Inconsistent Fire Reporting Data** - The compilation of fire report and ignition data in the project identified that the data collection process for fire reporting is inconsistent and often incomplete across much of the west. In addition, there are

multiple data collection processes administered by various agencies. For many states in the west, collecting fire report data on non-federal lands is the responsibility of the state fire marshal and many cases volunteer fire departments. This limited the ability for some states to compile data and to develop a historical fire occurrence. The fire reports gathered from the National Fire Incident Reporting System (NFIRS) consistently did not have a legal description (latitude and longitude) for the fire origin and also did not have a fire size.

2. **Lack of regionally consistent data at an appropriate scale** - There is generally a lack of consistent scale GIS data for many fire effects categories across the west. Much of the data investigated for the fire effects inputs was either incomplete (i.e. not available for some states/areas), or only available at a coarse resolution not consistent with the 30 meter scale of the assessment analysis.

3. **Wildfire Risk to a Community** - Due to the lack of consistently available community boundary data from the states, it was not possible to generate a consistent analysis of the wildfire risk to communities. Accordingly, a county risk rating deliverable was substituted in its place. In the future, methods could be developed to leverage the Wildland Development Areas data to derive draft community boundaries. This could be based on housing density thresholds, which the states could then refine to produce a consistent community boundary dataset. This approach is being implemented by the Southern Group of State Foresters and should be investigated as a future enhancement.

4. **Pacific Islands Data** - The Pacific Islands lack some of the basic datasets required to complete a quantitative wildfire risk assessment. In particular, the lack of fire ignition and report data is a deficiency and this limits the analysis of historical fire occurrence. The ability to assign fuel models to vegetation was not possible uniformly across the island groups. The 2010 version of LANDFIRE is anticipated within the next year and is slated to include fuels data for the Pacific Islands. That will afford analysis of fire behavior potential and a basic hazard assessment in the future. If fire occurrence data can be gathered with an attribute identifying the fire ignition location, then a fire threat layer could possibly be developed. These accomplishments could be completed in Phase 2. Region 5 Forest Service (S & P) should be supported in effort to implement a fire reporting system in the Pacific Islands.

Technical Approach and Methods

1. **Regionally consistent vs. state appropriate analysis** - The analytical methods can be used to derive regionally calibrated results or individual state calibrated results. While the original project scope focused on developing a west wide regional assessment, there was a desire to develop results to meet individual state priorities and data distribution. It was generally agreed that the states desired results calibrated for individual states. This product was added on to the work at the end of the original contract. Methods are identical to the regional methods detailed in this report, except that calibration was done at a state level using FOA class breaks based on state. The product resulting from this process is known as state specific data.

2. **Variation between western states "values" and priorities** - Due to the extensive range of landscapes characteristics, it was difficult to define a set of consistent "values" and "priorities" for the fire effects layers that satisfied all states. Defining meaningful values impacted for all states was a challenge.

3. **Data Review** - There were technical challenges with reviewing the key input and output datasets with state representatives. The volume of data layers and file sizes restricted the methods for sharing and communicating the data. A web mapping and feedback tool was deployed to simplify data review by eliminating the need for a GIS technical specialist to download and manage large GIS data for each state. In future, the cost/benefits of web mapping and feedback tools should be considered when scoping the project and, if implemented, should be employed earlier in the assessment to provide a consistent and well understood procedure for state reps to review the data.

4. **Determining how to "Value" forests assets** - The Project Steering Committee stressed the need to assess the effect of wildfire on forests in the West. It was important to include federal forests, given their social, ecological, and economic value to states and communities. The extensive range of forest types, associated values across all ownerships, and the role of fire to benefit or harm these values made it difficult to determine how to value forest assets. A review of 17 draft state Forest Action Plans and interviews with the state leads was conducted. No consistent method or data was found to assess forest values. Rather than attempt to "value" a forest, the WWA assessed the forest's potential mortality and response to fire. It is important for users of the WWA assessment to understand that it does not specifically address economic, social, or ecological values commonly related to a forest. It does not measure the potential benefit of fire particularly on publically owned lands.

5. **Suppression Management Strategy and it's affect on Fire Threat Index** – A key input to the Fire Threat Index (FTI) is historic acres burned within a particular Weather Influence Zone. Landscapes with a history of frequent large fires generate very high FTI values which can heavily influence the Fire Risk Index. Landscapes where the suppression management strategy has included fire as a benefit often resulted in high threat (related to the likelihood of an acre burning) and risk indices, even though there may be little perceived concern. If these areas can be identified spatially, the response function approach used by the WWA to assign fire effects could be enhanced in the future to accommodate where modified suppression is being used.

6. **Summarizing county results vs. ratings and rankings** – A key feature of the WWA is the use of consistent data and methods across the entire assessment area to provide a means at the regional level to understand level of risk across the West. It was not intended to rate or rank counties across state lines. As such, the County Summary Report was designed to allow user to understand the level of threat, fire effect and risk by using a suite of data.

Coordination & Communication

1. **The WWA project can be viewed as 20% technical and 80% project management** - While the development and compilation of input data as well as the

risk assessment itself required significant effort, it is agreed that the critical effort and success of the project involved on-going project management and participant coordination. Technical methods were well understood and data gaps and issues were overcome for the most part.

2. **Variation between western state "agencies" is vast** - The role of state forestry organizations in fire suppression, the ability to access data, the availability of funding, etc varies widely from state to state. It is important to understand these differences when coordinating with these agencies on decision points or data review and in developing recommendations geared towards benefitting the participants as a whole. The broad background and experiences of the technical team with these agencies supported this effort well.

3. **Partnerships with federal land management agencies were very important** - The need to integrate key data from federal agency projects and programs became essential to the project. This included LANDFIRE, First Approximation for Fire Risk for the Nation, Forests to Faucets, etc. Accordingly, it was key to develop and maintain good working relationships with these agency liaisons to ensure best publicly available data was used. This increased the quality of the results and greatly reduced the level of effort for potential custom data development.

4. **Potential "conflicts" with other state, local and federal assessments** - Some states and federal liaisons perceive a conflict of the WWA results with existing state assessments and pending federal initiatives, like Cohesive Strategy. These concerns are understandable as there has not been much coordination to date among these projects. As the WWA results are rolled out, the level of conflict and utility will be evaluated and integration of future efforts can be determined.

5. **Confusion and potential lack of coordination between the WWA, State Forest Resource Assessments and Strategies, Western Regional Assessment for Cohesive Strategy** - There was a general confusion among participants and state representatives about the coordination and integration of the WWA with other state and federal initiatives. In particular, the relationship between the SFRA (Forest Action Plans) and the WWA was not well understood. The WWA provides an ideal source of data for the Harm from Threats theme of the SFRA and efforts should be made to clarify this with an example for the states in the near future.

6. **Engagement of State Representatives** - Unfortunately, despite initial intentions and best efforts, the individual state representatives were not able to play the active role originally envisioned. This limits their understanding of the methods and results and requires more effort in the future for the states to properly evaluate the utility of the assessment results. In this regard the delivery of efficient technology transfer tools becomes key to aid in early use and adoption for many states.

7. **Pacific Islands** - Despite best efforts of agency partners and liaisons consistent dialogue and collaboration with the Pacific Islands for data compilation and delivery was challenging. The differences in time zones and cultural activities made communication and coordination difficult at times.

General Project Management

1. **Delays in availability of source data affected schedule** - Delays in the availability of source input data ultimately impacted the project schedule and resulted in delays for completion. In particular, this included the ability of the states to provide fire report data, and the processing and delivery of LANDFIRE program data. These were the two most critical input datasets.
2. **Lack of long term support and funding to maintain and update the WWA** - Currently there is no funding or program in place to keep the WWA results up to date as key input datasets change in future. While updates are not immediately required, the value and utility of the assessment declines over time, and state leadership should prioritize support and maintenance as the use and utility of the results is better understood. Opportunities to coordinate with other agencies and efforts should be identified, such as coordination with the Cohesive Strategy effort which is producing a wealth of data that could potentially be used to improve or supplement the WWA. An example is utilizing the Management Response data when completed to assign separate response function scores to forests being managed to benefit from fire.
3. **LANDFIRE.** The 2010 version LANDFIRE data is scheduled to be released in spring 2013. The new version(s) will include updated in fuels to disturbances caused by large fires, insect and disease, and mechanical treatments. It will also include data for the Pacific Islands.

5.5. Fire in the West Publication

With the completion of the WWA, efforts are underway to develop and publish a Fire in the West report. This report will complement the WFLC True Cost of Wildfire report, the Cohesive Strategy for Wildland Fire Management work and other related documents by quantifying the fire situation providing up to date findings, solutions and recommendations for addressing the fire problem in the West.

Section 6 References

Ager, AA, Finney, MA, Kerns, BK, Maffei, H. 2007. Modeling wildfire risk to northern spotted owl (Strix occidentalis cuariana) habitat in Central Oregon, USA. Forest Ecology and Management 246: 45-56.

Anderson, Hal E. 1982. Aids to determining fuel models for estimating fire behavior. USDA For. Serv. Gen. Tech. Rep. INT-122, 20 p.

Anderson, Hal E. 1983. Predicting wind-driven wild land fire size and shape. Research Paper INT-305. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 26 p.

Andrews, Patricia L.; Bevins, Collin D.; Seli, Robert C. 2005. BehavePlus fire modeling system, version 4.0: User's Guide. Gen. Tech. Rep. RMRS-GTR-106WWW Revised. Ogden, UT: Department of Agriculture, Forest Service, Rocky Mountain Research Station. 132p.

Andrews, P. L. 2007. BehavePlus fire modeling system: past, present, and future. In: Proceedings of 7th Symposium on Fire and Forest Meteorological Society. 2007 October 23-25; Bar Harbor, ME. (647 KB; 13 pages)

Buckley, D., D. Carlton, D. Krieter, and. K. Sabourin. 2006. *Southern WildfireRisk Assessment Final Report,* http://www.southernwildfirerisk.com/reports/

Buckley, D., and K. Sabourin. 2006. *Southern Wildfire Risk Assessment Summary Statistics of Published Results by State and District,* http://www.southernwildfirerisk.com/reports/

Buckley, D., and K. Sabourin. 2006. *Southern Wildfire Risk Assessment Southwide Summary Statistics of Published Results,* http://www.southernwildfirerisk.com/reports/

Calkin, David E.; Ager, Alan A.; Gilbertson-Day, Julie, eds. 2010. Wildfire risk and hazard: procedures for the first approximation. Gen. Tech. Rep. RMRS-GTR-235. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 62 p.

Carlton, Donald W. and James Wolf. 2010. Workshop to Assign Surface Fuels Models for Guam, American Samoa and Palau. Conducted at the California-Nevada-Hawaii Fire Council Conference, April, 2010. Spreadsheet titled Fuel_Model_Wksp-Pacific_Islands.xls.

Cohesive Strategy. *A National Cohesive Wildland Fire Management Strategy, Phase II National Report.* May 2012. 74 p. http://www.forestsandrangelands.gov/strategy/documents/reports/phase2/CSPhaseIIReport_FINAL20120524.pdf

Falanruw, Dr. Margie, Dennis Orbus, Trudy Mahony, John Runpong and Ronnie Ngirachereang. 2009. California-Nevada Fire Council.

Finney, Mark A. 1998. *FARSITE*: Fire Area Simulator -- model development and evaluation. USDA Forest Service, Research Paper RMRS-4, Rocky Mountain Research Station, Ft. Collins, CO. 45p.

Finney, Mark A. 2004. FARSITE: Fire Area Simulator-model development and evaluation. Res. Pap. RMRS-RP-4, Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 47 p.

Finney, M.A. 2005.The challenge of quantitative risk analysis for wildland fire. Forest

Ecology and Management. 211: 97-108.

Fons, Wallace T. 1946. Analysis of fire spread in light forest fuels. J. Agri. Res. 72(3): 93-121.

Heinsch, F. A.; Andrews, P. L. 2010. BehavePlus fire modeling system, version 5.0: Design and Features. General Technical Report RMRS-GTR-249. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. (10,487 KB; 111 pages)

National Wildfire Coordinating Group. 2004. Fireline Handbook. NWCG Handbook 3. PMS 410-1. NFES 0065. National Interagency Fire Center. Boise, Idaho 83705.

Neill, Christie and Janice Rea. 2004. Territory of Guam Fire Assessment. Developed by U.S. Forest Service, Region 5, Vallejo, CA.

NOAA. 2012a. http://www.esrl.noaa.gov/psd/enso/enso.description.html

NOAA. 2012b. http://www.esrl.noaa.gov/psd/enso/compare/

Rothermel, R. C. 1972. A mathematical model for predicting fire spread in wildland fuels. USDA For. Serv. Res. Pap. INT-115, 40 p., illus.

Rothermel, Richard C. 1983. How to Predict the Spread and Intensity of Forest and Range Fires. USDA For. Serv. GTR INT-143, 161 p.

Scott, Joe H. and Elizabeth D. Reinhardt. 2001. Assessing the Crown Fire Potential by Linking Models of Surface and Crown Fire Behavior. USDA Forest Service, Research Paper RMRS-RP-29, Rocky Mountain Research Station, Ft. Collins, CO. 59p.

Scott, Joe H. and Robert E. Burgan. 2005. Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model. USDA Forest Service, Gen. Tech. Rpt. RMRS-GTR-153, Rocky Mountain Research Station, Ft. Collins, CO. 72p.

Scott, Joe and Don Helmbrecht. 2010. Wildfire threat to key resources on the Beaverhead-Deerlodge National Forest. Unpublished Report to the National Forest. 44 pp.

U.S. Forest Service. 2010. Wildfire Risk and Hazard: Procedures for the First Approximation. USDA Forest Service. Rocky Mountain Research Station. General Technical Report RMRS-GTR-235. 62 pp.

Weidner, E., Todd, A. 2011. From the Forest to the Faucet: Drinking Water and Forests in the US, Methods Paper. USDA Forest Service.

Section 7 Glossary of Terms

1-h - The one-hour (1-h) timelag dead fuel category includes fuels from 0 to 0.24 inches (0.64 cm) in diameter. This includes needles, leaves, cured herbaceous plants and fine dead stems of plants.

10-h - The ten-hour (10-h) timelag dead fuel category includes fuels from 0.25 to 0.99 inch (0.64 to 2.54 cm) in diameter.

100-h - The hundred-hour (100-h) timelag fuel category includes fuels from 1 to 2.99 inches (2.54 to 7.62 cm) in diameter.

20-foot Wind Speed - The wind speed is frequently taken at a National Fire Danger Rating System weather station. The National Fire Weathers Observers Handbook provides the standards for the gathering of weather at stations designated to provide data for the National Fire Danger Rating System (Deeming et. al, 1972). The wind speed measurement is taken at 20 feet above the vegetation and is measured based on a 10-minute average. Wind speed values used should be average expected values that can be expected to occur during the period of time the projection is for. Enter the 20-foot wind speed in the cell.

Burn Probability (BP) – The likelihood an acre will burn. In the WWA, this is defined as the Fire Threat Index (FTI). The methods used to develop the FTI result in this index being related to the actual probability of an acre burning.

Commonwealth of the Northern Marianas

Council of Western State Foresters – Established in 1967, the Council of Western State Foresters is a nonpartisan organization of state, territorial, and commonwealth foresters of the Western United States and Pacific Islands. They are one of the contributing members to the WWA.

DOD – Abbreviation for Department of Defense.

DWIA – Abbreviation for Drinking Water Importance Areas.

Drinking Water Importance Areas - A Values Impacted dataset that provides information on surface drinking water importance, reflecting a measure of water quality and quantity, characterized by Hydrologic Unit Code 12 (HUC 12) watersheds.

EVC - Abbreviation for Existing Vegetation Cover.

EVH- Abbreviation for Existing Vegetation Height.

EVT- Abbreviation for Existing VegetationType.

Existing Vegetation Cover – LANDFIRE dataset that identifies the percent vegetation cover at each raster cell.

Existing Vegetation Height - LANDFIRE dataset that identifies the percent vegetation height at each raster cell.

Existing Vegetation Type - LANDFIRE dataset that identifies the percent vegetation type at each raster cell.

FA – Abbreviation for Forest Assets.

Farsite – A computer program that predicts wildland fire behavior and growth using the models in the Fire Behavior Prediction System applied on 3-dimentional GIS data layers.

FBPS - Abbreviation for the Fire Behavior Prediction System.

FFS – Abbreviation for Final Fire Size.

Final Fire Size – The size of a fire in acres upon containment.

Fire Behavior Prediction System – The Fire Behavior Prediction System includes all of the mathematical models and fuel models that are included in the Behave and BehavePlus computer systems.

Fire Effects Index (FEI) – This is a number between +9 and –9 which is the weights average of the Values Impacted Rating and the Suppression Difficulty Rating.

Fire Occurrence Area - A Fire Occurrence Area (FOA) is an area where the probability of each acre igniting is the same.

Fire Threat Index - The Fire Threat Index (FTI) is a value between 0 and 1. It was developed to be consistent with the mathematical calculation process for determining the probability of an acre burning. The FTI integrates the probability of an acre igniting and the expected final fire size based on the rate of spread in four weather percentile categories into a single measure of fire threat. Due to some necessary assumptions, mainly fuel homogeneity, it is not the true probability. But since all areas of the counties have this value determined consistently, it allows for comparison and ordination of areas of the county as to the likelihood of an acre burning.

FireFamilyPlus – A computer program that utilizes historic daily weather observations and historic fire occurrence information to support analysis of fire danger and staffing requirements.

FlamMap - FlamMap is a computer program that generates fire behavior data across the landscape for a given set of weather, fuels and fuel moisture data inputs.

Flame Length - This is the length of the flame in a spreading surface fire within the flaming front. Flame length is measured from midway in the combustion zone to the average tip of the flames.

FOA - Abbreviation for Fire Occurrence Area.

Forest Assets – A Values Impacted dataset that provides information on the effects of fire on forested areas.

FRI – Abbreviation for Fire Risk Index (previously called Level of Concern).

FTI- Abbreviation for Fire Threat Index (previously called Wildland Fire Susceptibility Index).

Fuel Model – A surface fuel model is a set of attributes that define fuel bed characteristics. The attributes such as fuel loading, depth and surface area to volume ratio support the fuel inputs to the Rothermel Fire Spread Model.

Fuel Type – Fuel types are based on the primary carrier of fire, which are grass, brush, timber litter and slash.

Herbaceous - Live herbaceous fuels are grasses and forbs that are living. Herbaceous fuels can be either annual or perennial.

HUC – Abbreviation for Hydrologic unit Code.

Hydrologic Unit Code

IA – Infrastructure Assets

Infrastructure Assets – A Values Impacted dataset that identifies key infrastructure assets, such as schools, airports, hospitals, roads and railroads that are susceptible to adverse effects from wildfires.

Net Value Change (NVC) – The net relative change in the affect of fire on a Value Impacted as measured using response functions.

National Fire Danger Rating System – Refers to the 1972, 1978 and 1988 versions of the fire danger rating systems developed for the United States.

Percentile Weather – A set of weather conditions that represent the average conditions that would occur during a defined percent of the fire season.

Published Results - The primary output from the West Wide Wildfire Risk Assessment developed to describe fire risk across the project area. These outputs provide a data platform for use by operational staff, as well as other fire management collaborators, in mitigation planning and communication activities. These results can be used for identifying areas where more localized analysis (Project Areas) may be appropriate.

RA – Abbreviation for Riparian Assets.

Rate of Spread - Rate of spread is the "speed" the fire travels through the surface fuels. The rate of spread is the spread rate of the head fire spreading uphill with the wind blowing straight uphill. The rate of spread prediction uses the Rothermel (1972) surface fire spread model, which assumes the weather, topography and fuels remain uniform for the elapsed time of the projection.

Relative Importance (RI) – The relative difference in change between Value Impacted categories.

Response Function Score (RFS) - This is a number between +9 and –9, which describes the effect of fire on a Value Impacted. It is assigned for each Value Impacted Category by fire intensity level or flame length class. For the WWA, only negative responses were considered.

Riparian Assets – A Values Impacted dataset that provides information on the effects of fire on riparian areas.

Risk - The possibility of suffering harm or loss.

ROS - Abbreviation for rate of spread.

SC – Abbreviation for Spread Component.

Spread Component – The Spread Component is an index in the National Fire Danger Rating System. It is calculated using the Rothermel Spread Model with a few minor modifications to the model used in the Fire Behavior Prediction System. It is the rate of spread measured in feet per minute assuming a defined fuel model, slope class, climate class and herbaceous vegetation type with weather conditions from a NFDRS weather station.

SDR Weight - The suppression difficulty rating weight is the relative proportion of the fire effects index attributed to Fire Suppression Difficulty. In the WWA, the Fire Effects Index is a weighted average of the Values Impacted Rating and the Suppression Difficulty Rating.

Suppression Difficulty Rating (SDR) – This is a number between – 1 and –9 that represents the difficulty to suppress a wildfire given the combination of fuel type and slope class. It is a relative value in contrast to other combinations of fuel type and slope class. Frequently, the cost to suppress wildfires is in direct proportion to suppression difficulty and can also be used to determine the suppression difficulty value for a combination of fuel type and slope class.

Value Impacted (VI) – This is a dataset that defines a value that can be affected by fire. In the WWA, there are five values impacted defined. These are Infrastructure, Wildland Development Areas, Drinking Water, Forest Assets and Riparian Assets.

Value Impacted Category (VIC) – A values impacted dataset is usually comprised of many individual numeric or alphanumeric values.

Values Impacted Rating (VIR) - Values Impacted Rating is developed from the FTI which is a value related to the burn probability (BP) and fire Response Function Score (RFS) for each Value Impacted for each fire intensity levels (FILs) (flame lengths).

VIR Weight – The values impacted rating weight is the relative proportion of the fire effects index attributed to values impacted. In the WWA, the Fire Effects Index is a weighted average of the Values Impacted Rating and the Suppression Difficulty Rating.

WDA – Abbreviation for Wildland Development Areas.

Western Forestry Leadership Coalition - Formally established in 2000, The Western Forestry Leadership Coalition represents a unique partnership between state and federal government forestry leaders. The Coalition is comprised of 34 members including: 23 State members, also known as the Council of Western State Foresters, and 11 USDA Forest Service members, which include: 7 western Regional Foresters, 3 western USFS Research Station Directors, and 1 USFS Forest Products Lab Director.

Weather Influence Zone – A Weather Influence Zone (WIZ) is an area where the weather conditions are uniform on a given day.

Wildland Development Areas – A Values Impacted dataset that identifies the location of people living in Wildland Urban Interface and rural areas.

WIZ - Abbreviation for Weather Influence Zone.

Woody - Live woody fuels are shrubs that are living.

Appendix A: Project Team

In addition to the core project team identified in Section 1.3, the following representatives were key to the WWA process providing guidance throughout the project with regards to development of datasets, review of outputs and general guidance with regards to their particular area of expertise. The West Wide Wildfire Risk Assessment would not have been a success without the collaborative effort of these team members.

State and Territory - Primary Points of Contact	
State	**Name**
AK	Marc Lee/Marsha Henderson
AZ	Glen Buettner
CA	Dean Cromwell
CO	Rich Homann
HI	Wayne Ching
ID	Don Wagner
KS	Ross Hauck
MT	Will Wood
ND	David Geyer/Sarah Tunge
NE	Don Westover
NM	Don Greigo
NV	Mike Dondero
OR	Teresa Vonn
SD	Steve Hasenohrl
UT	Tracy Dunford
WA	Darrel Johnston
WY	Ron Graham
Territory of Guam	Joe Mafnas
Republic of Palau	Ron R Ngirachereang
Federated States of Micronesia	John Runpong

State and Territory - Primary Points of Contact	
State	**Name**
(Yap,Chuuk)	
American Samoa	Junior F.U.Tuiasosopo
Commonwealth of Northern Mariana Islands	Daniel Repeki Suel

State and Territory – Specialty Points of Contact				
State	**GIS**	**Fire Occurence**	**Meteorology**	**Fuels**
AK	Hans Bucholdt	Sue Christensen	Heidi Strader/Sharon Alden	Robert Schmoll Frank Cole
AZ	Glen Buettner	Glen Buettner	Chuck Maxwell	Scott Hunt
CA	Mark Rosenberg	Dave Sapsis Carl Palmer	John Snook	Dave Sapsis
CO	Matt Tansey	Clair Brown	Rich Homann	Boyd Lebeda
HI	Ron Cannarella	Jesse Acosta	Derek Wroe	
ID	Andrew Mock	Andrew Mock	Don Wagner	Don Wagner
KS	Ross Hauck	Ross Hauck	Russ Mann	Ross Hauck
MT	Liz Hert	Will Wood	Bryan Henry	Don Copple
		Elaine Huseby	Michael Kreyenhagen	Will Wood
ND	Peter Oduor	Geremy Olson	Janine Vining	David Geyer
NE	Joe Stansberry	Don Westover	Russ Mann	Joe Stansberry/ Don Westover
NM	Trent Botkin/ Don Greigo	Don Greigo	Chuck Maxwell	Don Greigo
NV	John Watermolen	Mike Klug	Rhett Milne	Mark Blankensop
OR	Emmor Nile	Teresa Vonn	John Saltenberger	Leanne Mruzik
SD	Doug Haugan	Megan Jaros	Tim Mathewson	Jim Strain
UT	Kevin Well	Kevin Wells	Ed Delgado	
WA	Nicholene Eisfeldt	Albert Kassel	Greg Sinnett Dave Grant	Dave Grant
WY	Ron Graham	Bill Haagenson	Russ Mann	
Territory of Guam		David Q. Peredo/ Mike Aguon		
Republic of Palau		Ron R Ngirachereang		

State and Territory – Specialty Points of Contact				
State	**GIS**	**Fire Occurence**	**Meteorology**	**Fuels**
Federated States of Micronesia (Yap,Chuuk)		John Runpong		
American Samoa		Agavaa Afalava		
Commonwealth of Northern Mariana Islands		Daniel Repeki Suel		

Appendix B: Web Links

- Fire Program Analysis (FPA) - http://www.fpa.nifc.gov/
- First Approximation - http://www.fs.fed.us/rm/pubs/rmrs_gtr235.pdf
- Forests to Faucets - http://www.fs.fed.us/ecosystemservices/FS_Efforts/forests2faucets.shtml
- HSIP Freedom - http://www.dhs.gov/files/programs/gc_1156888108137.shtm
- NASA JPL Wetlands Data - http://wetlands.jpl.nasa.gov/products/alaska_wetland.html
- LANDFIRE - http://www.landfire.gov/
- LANDFIRE data - http://www.landfire.gov/data_overviews.php
- Oak Ridge National Laboratory LandScan - http://www.ornl.gov/sci/landscan/
- U.S.G.S. Hydrologic Unit System - http://nwis.waterdata.usgs.gov/tutorial/huc_def.html
- National Cohesive Wildland Fire Management Strategy - http://www.forestsandrangelands.gov/strategy/index.shtml
- National Wetlands Inventory (NWI) http://www.fws.gov/wetlands/index.html
- West Wide Wildfire Risk Assessment - http://www.westwideriskassessment.com/
- Western Forestry Leadership Coalition – http://www.wflcweb.org

Appendix C: State Projections

Table C-1. Map projections used by states

State	Coordinate System	Datum
Alaska	Alaska Albers Equal Area Conic	NAD83
Arizona	UTM Zone 12N	NAD83
California	California Teale Albers	NAD83
Colorado	UTM Zone 13N	NAD83
Hawaii	UTM Zone 4N	NAD83
Idaho	IDTM	NAD83
Kansas	UTM Zone 14N	NAD83
Montana	State Plane Montana FIPS 2500	NAD83
North Dakota	UTM Zone 14N	NAD83
Nebraska	UTM Zone 14N	NAD83
New Mexico	UTM Zone 13N	NAD83
Nevada	UTM Zone 11N	NAD83
Oregon	Oregon Lambert Feet International (EPSG 2992)	NAD83
South Dakota	UTM Zone 14N	NAD83
Utah	UTM Zone 12N	NAD83
Washington	State Plane Washington South FIPS 4602	NAD83 HARN
Wyoming	UTM Zone 13N	NAD83
FSM (Chuuk)	UTM Zone 56N	WGS84
FSM (Yap)	UTM Zone 54N	WGS84
Northern Mariana Islands	UTM Zone 55N	WGS84
Palau	UTM Zone 53N	WGS84
Guam	UTM Zone 55N	WGS84
American Samoa	UTM Zone 2S	NAD83

Appendix D: Initial Data Stewards

State Mailing Addresses for Final Data Delivery			
State	**Mailing Address**	**State**	**Mailing Address**
AK	Marsha Henderson 3700 Airport Way Fairbanks, AK 99709 907-356-5858	**NM**	Donald J.Griego Resource Protection Bureau NM State Forestry Division 1220 South St. Francis Dr. Santa Fe NM 87504 505-476-3200
AZ	Glen Buettner Arizona State Forestry Division 1110 West Washington, Suite 100 Phoenix, Arizona 85007 602-771-1400	**NV**	Mike Dondero 2478 Fairview Dr Carson City, NV 89701 775-684-2500
CA	Dave Sapsis Senior Fir Scientist CAL FIRE 1300 U St Sacramento, CA 95818 PO Box 944246 Sacramento, CA 94244-2460 916.445.5369	**OR**	Emmor Nile Oregon Department of Forestry 2600 State Street, Salem, OR 97310 503-945-7200
CO	Data Transfer Solutions c/o Dave Bouwman #127, 409 Mason Court Fort Collins, CO 80524 970 472 0807	**SD**	Stephen J. Hasenohrl Assistant Chief for Administration SD Department of Agriculture Wildland Fire Suppression Division 4250 Fire Station RD, STE#2 Rapid City, SD 57703-8722 605-393-8011
HI	Wayne F. Ching Fire Management Officer Division of Forestry & Wildlife 1151 Punchbowl St., Rm. 325 Honolulu, HI 96813 808-587-0166	**UT**	Tracy Dunford Utah Division of Forestry, Fire & State Lands 1594 West North Temple, Suite 3520 SLC, UT 84114-5703 801-538-5555
ID	Don Wagner Idaho Department of Lands 3284 W. Industrial Loop	**WA**	Darrel Johnston Department of Natural Resources Resource Protection Division

State Mailing Addresses for Final Data Delivery			
State	**Mailing Address**	**State**	**Mailing Address**
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KS	Ross Hauck Fire Management Coordinator Kansas Forest Service 2610 Claflin Rd. Manhattan, KS 66502-2798 785-532-3300	**WY**	Ron Graham Fire Management Officer Wyoming State Forestry Division 5500 Bishop Blvd. Cheyenne, WY 82002 307-777-7586
MT	State of Montana Department of Natural Resources and Conservation Attn: Will Wood 2705 Spurgin Road Missoula, MT 59804-3199 406-542-4300	**ODF**	Jim Wolf 3614 Ross Lane Central Point, OR 97501 (541) 324-3446
ND	Sarah Tunge Fire Manager NDSU-ND Forest Service 916 E. Interstate Ave Ste #4 Bismarck, ND 58503 701-328-9985	**WFLC**	TBD
NE	Joe Stansberry GIS Specialist Nebraska Forest Service 202b Forestry Hall, UNL-EC Lincoln, NE 68583-0815 402-472-2944		

Revision log

Date	Revision
March 5, 2016	On page 43, typographical error found. Change “This is a radius of 787 feet and the circle contains 14.23 acres.” TO “This is a radius of 787 feet and the circle contains 44 acres.” This is a documentation issue only and all work was performed correctly.