FLORIDA WILDLAND FIRE RISK ASSESSMENT

FINAL REPORT

January 31, 2011

Prepared for:

Division of Forestry – State of Florida

By:

Janet Hoyt (Sanborn Map Company)
Don Carlton (Fire Program Solutions)

Table of Contents

List of Tables

List of Figures

Acknowledgments

Sanborn would like to thank the Florida Division of Forestry for their support and dedication in guiding this project to its end. We would also like to acknowledge the financial support of FEMA and the Florida Division of Emergency Management in funding this project.

The contractor team was made up of staff from The Sanborn Map Company including Janet Hoyt, Becca Heartwell, Tyler Bax, Darian Krieter, and Ginger Voyles, along with Don Carlton from Fire Program Solutions.

1.0 Introduction

1.1 Background

To reduce the loss of life and property due to wildfire, communities and fire management organizations should actively manage wildland fire risk. Managing wildland fire risk can be challenging as fuels frequently change across the landscape and through time. Fire behavior can be affected by changes in land development, fuels, weather conditions, and topography. In addition, many social, technical and institutional barriers exist to proactive fire risk management and planning.

In 2002, the State of Florida developed a wildfire risk assessment that took these factors into consideration. This project provided the State with a comprehensive view of wildfire risk throughout their state and supplied wildland fire managers with a means of proactively managing fire. An ArcView[1] tool, Fire Risk Assessment System (FRAS), was developed in 2002 that allowed fire managers to work with these datasets. In 2005, through the coordination of the Southern Group of State Foresters (SGSF), this effort was broadened to a Southern Wildfire Risk Assessment (SWRA) for the 13 Southern states. In addition, the SGSF supported the development of the Southern Wildfire Risk Assessment System (SFRAS), an ArcMap program that provides a set of tools for analyzing and assessing the risk datasets, assisting wildland fire managers with understanding and managing risk in their state. SFRAS was built on the initial work done to develop FRAS.

Through this current project, Florida has undertaken an effort to update their wildfire risk assessment datasets as well as provide a custom version of the SFRAS software. Capitalizing on the recent Florida Wildfire Risk Assessment Canopy Inventory Project (FRACIP), this update incorporates current canopy fuel datasets developed from that project, as well as a 2007 update to Florida's 2005 Surface Fuels dataset. With these and many other improved datasets, the State is keeping with their vision of providing its wildland fire manager's with the most current and up to date information and tools for managing wildland fire risk.

Throughout this document, the original wildfire risk assessment is identified as the '2002' assessment/Published Results/FRA, while this current update is referred to as the '2011', assessment/Published Results/FRA.

[1] ArcView and ArcMap are part of the ArcGIS software developed by ESRI.

1.2 Objectives

The primary intent of this 2011 Florida Risk Assessment project was to:

- Update the original Florida Published Results. The Florida Published Results are the final statewide output datasets for the Fire Risk Assessment System (FRAS) model.
- Have the updated Published Results operate in the SWRA SFRAS application. SFRAS needed to be updated to incorporate the Florida elements of the Fire Effects model, Level of Concern model, Communities-at-Risk model and model parameterization.

These datasets, or Published Results, along with the FLFRAS software will provide state wildland fire managers with an updated baseline dataset identifying the current status of risk in the State as well as a set of tools to assist them with monitoring wildfire risk for proactive fire management planning. These tools will assist them with:

- Identifying those areas that are currently most prone to wildfire
- Identifying areas that may require additional tactical planning
- Providing the information necessary to justify resource, budget and funding requests and allocation
- Increasing communication with local residents and the public to address community priorities and needs
- Planning for response and suppression resource needs
- Planning and prioritizing hazardous fuel treatment programs, and
- Establishing a data repository and a series of software tools to support continued analysis and monitoring of wildfire risk.

To accomplish these objectives, the following three tasks were completed for this project:

- Published Results: Data Acquisition, Creation and Conversion
- Wildland Fire Risk Analysis
- Development of FLFRAS

The following report is organized by these tasks.

2.0 Published Results

This section of the document provides information about the GIS datasets that were either acquired or developed for this risk assessment analysis. These data layers include:

- those that were provided as input to the risk assessment
- those datasets that are created as intermediate outputs from the risk assessment
- and those resulting final outputs from the risk assessment itself.

Metadata describing these datasets were delivered with the 2011 Published Results. The following section discusses these datasets briefly. Please refer to the metadata deliverable for complete information in this regard.

2.1 Initial Input Datasets

The following datasets were supplied at the start of the project, with the majority provided by the Division of Forestry. Those datasets not supplied by the DOF are noted below in parentheses following the data layer.

- Canopy Fuels Datasets
  - Canopy Cover
  - Canopy Base Height
  - Stand Height
  - Canopy Bulk Density
  - Canopy Ceiling Height
- Community Boundaries
- County Boundaries
- Critical Facilities
- Fire Occurrence Area (FOA)
- NOAA Weather Observations (Federal Agency Historical Weather Observations)
- Initial Dispatch Locations
- Infrastructure (Airports, Hospitals, Schools)
- Land Ownership

- Plantations
- Roads
- SSURGO Muck Soils
- Surface Fuels (2007 update to Florida's 2005 vintage dataset)
- Topography:
  - Elevation
  - Slope
  - Aspect
- Utility Corridors
- Vegetation
- Water (Sanborn derived from Surface Fuels dataset)
- Weather Influence Zones (from the 2002 FL FRA, although adjusted slightly for this project)
- Wildland-Urban Interface (WUI)

A brief description of each follows:

Canopy Fuels Datasets

The canopy fuels datasets were provided by the state. These were developed for the Florida Wildfire Risk Assessment Canopy Inventory Project and were based on 2007 vintage species, canopy cover, and height datasets. The fuels datasets included Canopy Base Height, Canopy Bulk Density, Stand Height (Canopy Ceiling Height) [2], and Canopy Cover. Refer to the Florida Wildfire Risk Assessment Canopy Inventory Project for more information on the creation of this dataset.

Communities

Community Polygons represent cities and other populated areas such as suburbs and rural housing communities. This dataset identifies communities and community boundaries (areas of significant population, historical or property value), based primarily on the local knowledge and experience of FDOF field personnel. The data originated from Lat/Long point locations provided by Florida DOF personnel, which were then reconciled with available place name polygons derived from various data sources. In some instances a corresponding polygon was not identifiable and so a temporary 500ft buffer was generated for each unmatched point location. The current FL FRA Communities data consists of all known communities as of 2010.

[2] Note that the Canopy Ceiling Height and Stand Height were derived from the same dataset and are just aggregated into classes differently. Stand Height has 9 thematic classes, while CCH is rounded to the nearest 5 foot height increment.

County Boundaries

Polygon features representing county boundaries. The source scale is 1:24,000 and the original data source is the US Census Bureau. This dataset was used to tile the 2011 Published Results.

Critical Facilities

The Critical Facilities grids represent potential areas impacted by wildfire, particularly by smoke situations. These were created by calculating a 500 meter buffer around major roads and highways; a 500 meter buffer around schools and hospitals; and a 1000 meter buffer around airports and helipad features. After the buffer was created for each of the data layers (roads 1, roads 2, roads 3, schools, airports, and hospitals) they were converted to grids and then merged into one grid with values of 1 and 0, a value of 1 being inside a buffer and 0 being outside. This data is then used as part of the Environmental Effects Rating calculation within the LOC tool.

Fire Occurrence Areas (FOA)

The FOA dataset was developed during the Florida Wildfire Risk Assessment Canopy Inventory Project. 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 2007 update to the 2005 Surface Fuels dataset. Refer to the Florida Wildfire Risk Assessment Canopy Inventory Project for more information on the creation of this dataset.

Historical Weather Observations

Daily weather data was gathered from land management agency maintained weather stations and from National Oceanographic and Atmospheric Administration (NOAA) maintained weather stations. Data was gathered from various starting dates (years) through 2009. The weather data is integrated with the Weather Influence Zones (WIZ) data for use in the WFSI component of the risk model.

Infrastructure (schools, airports, hospitals)

Airports: Polygon features representing airports and some heliports. This dataset contains 2007 information for public and military facilities.

Hospitals: Point features representing primary care and surgical facilities, specifically, ambulatory surgical centers and hospitals, including VA hospitals. This 2006 dataset was generated by the Florida Department of Health.

Schools: Point features representing publicly owned K-12 schools. This data is a subset of a larger 2007 dataset which included adult and vocational technical schools, colleges and universities.

Initial Dispatch Locations

These are locations where firefighting resources are stored and are generally the first sources for response to a wildfire within their jurisdiction. Data was derived from 2009 statewide emergency services facilities data. FDOF district offices and other FDOF facilities were added.

Land Ownership

These are polygon features that represent "Florida Managed Lands", which are public lands that the Florida Natural Areas Inventory (FNAI) has identified as having natural resource value and that are being managed at least partially for conservation purposes. The dataset was generated by the FNAI in 2009 and information in the data layer was provided to the FNAI by individual managing agencies.

Plantations

The primary source for the plantation dataset is an extraction of the Florida Land Use, Cover and Forms Classification System (FLUCFCS) data relevant to natural and human plantation areas. The purpose was to identify high dollar value vegetative land use/land cover characteristics with the potential for loss in the event of wildfire. The FLUCFCS data was produced by the Florida Department of Environmental Protection (FDEP) through the five Water Management District jurisdictions.

Roads

Four distinct levels of roads were compiled for the project. Roads are not only used for reference data but also to define Critical Facilities (for Environmental Effects Rating), and for modeling the Fire Response Accessibility Index (FRAI). The data was extracted from the 2010 NAVTEQ roads dataset and separated into four levels based on the speed class attribute. Ferry routes were eliminated for all road levels.

Roads1: Level 1 Roads represent roadways with expected speed limits of 65-80 mph. This group typically includes the primary or major interstate highways.

Roads2: Level 2 Roads represent roadways with expected speed limits of 41-64 mph. This group typically includes secondary highways and many major streets.

Roads3: Level 3 Roads represent roadways with expected speed limits of 31-40 mph.

Roads4: Level 4 Roads are all other streets with expected speed limits of 0-30 mph.

Soils

In Florida, the soils dataset was derived from the SSURGO soils database and only includes organic soils (muck, peat) that make it difficult for firefighters to access wildfires. SSURGO data was supplemented with STATSGO soils where muck was incomplete or underrepresented.

Surface Fuels

The surface fuel model dataset used in this current FLFRAS is the 2007 update to Florida's 2005 Surface Fuel Layer. Florida uses surface fuel model classes based on the 13 FBPS fuel models (FBPS Model 13, Heavy Slash, does not occur in Florida). In addition, there are four custom non-burnable fuel model classes (water, urban, agriculture, and barren). Numerous additional custom fuel models, developed for the SWRA, were also used to support the fuel profiles and the Fuel Treatment Analysis tool.

Topography

Elevation: Digital Elevation Models (DEMs) were acquired from the U.S. Geological survey National Elevation Dataset (NED) for the state of Florida. Elevation is measured in meters.

Slope: Slope raster datasets were derived from the U.S. Geological survey National Elevation Dataset (NED) for the state of Florida. Grid values are integers and represent percent slope.

Aspect: The aspect raster datasets were derived from the U.S. Geological survey National Elevation Dataset (NED) for the state of Florida. Aspect was calculated in degrees and aggregated into four classes representing the four cardinal directions - 0, 90, 180, and 270. Values of -1 (flat areas) were classified as 180 degrees (south).

Utility Corridors

The utility corridors dataset is a Statewide 500 meter buffer derived from 2006 electrical and oil / natural gas transmission lines. This data was developed solely for use with the 2011 Florida Fire Risk Assessment System (FLFRAS). It is intended as an aid to fire fighters and fire mitigation specialists for the purpose of strategizing risk reduction and the prevention of utility service interruption.

Vegetation

The source for the vegetation dataset was the Species layer from the Division of Forestry's FRACIP project. This dataset was developed using LANDSAT TM data from 2007. Refer to the Florida Wildfire Risk Assessment Canopy Inventory Project for more information on the creation of this dataset.

Water

Sanborn derived the water layer from the surface fuels dataset by extracting the water custom fuel model class (FM 98). For more information refer to the surface fuels dataset description.

Wildland Urban Interface

The Wildland-Urban Interface (WUI) is the area where houses meet or intermingle with undeveloped wildland vegetation. This makes the WUI a focal area for human-environmental conflicts such as wildland fires, habitat fragmentation, invasive species, and biodiversity decline. The WUI data layer was generated by integrating U.S. Census and USGS National Land Cover data to meet the Federal Register definition of WUI (federal Register 66:751, 2001) and then the Florida Managed Areas were excluded (see Land Ownership for more information on Managed Areas). The data is used for the Environmental Effects Rating modeling.

2.2 Intermediate Derived Data Outputs

Several datasets were derived through data processing and analysis using the source input data layers. These datasets are described in this section.

Suppression Costs Rating

Each burnable cell is assigned a Suppression Costs Rating (suppco). This Rating is based on three elements: fuel type, topography, and the presence or absence of organic (peat/muck) soils. An increase in rating reflects an increased difficulty, and therefore an increased cost, of suppression.

In the 2002 FL FRA, slope was not considered in this rating due to the negligible impact that slope has on suppression costs throughout the state. In the current WFRAS model, which is the prototype for the 2011 FLFRAS, slope is included. The slope multipliers used for Florida in the SWRA were therefore used in this project. These are 1.0 for all slope classes. The actual equations for Suppression Costs Rating will be discussed in Section 3, but the end result of setting the default score to 1.0 is to effectively negate any influence of slope on the Suppression Costs Rating. The following figure shows an example of the Suppression Costs Rating for an area in Brevard County, Florida.

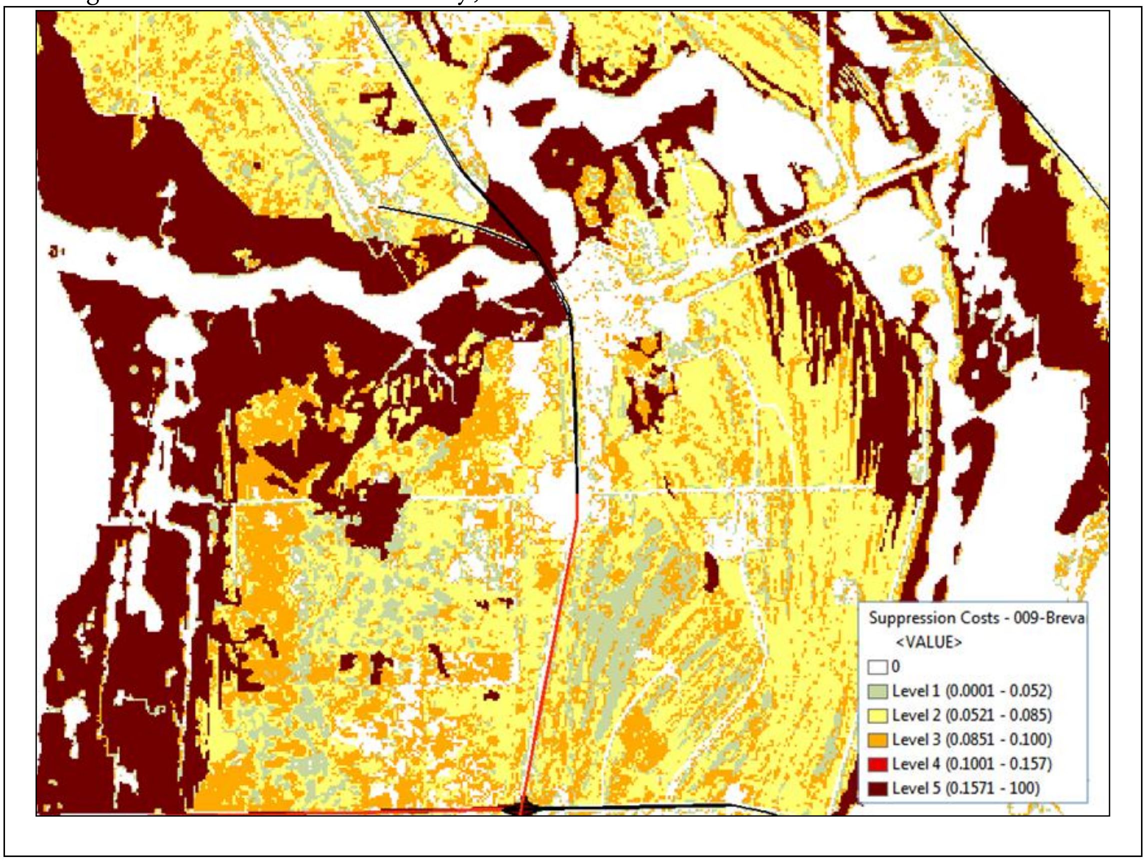


Figure 1. Example of Suppression Costs Rating for Brevard County.

Environmental Effects Rating

The Environmental Effects Rating reflects those areas that have important values at risk to wildland fire. This rating is based on four elements: critical facilities, utility corridors, plantations, and the wildland urban interface. Ratings were assigned by state fire managers, during the 2002 FL FRA, using a matrix process to combine individual ratings for each element into one overall rating for each burnable cell. The following figure shows an example of the Environmental Effects Rating for an area in Alachua County, Florida.

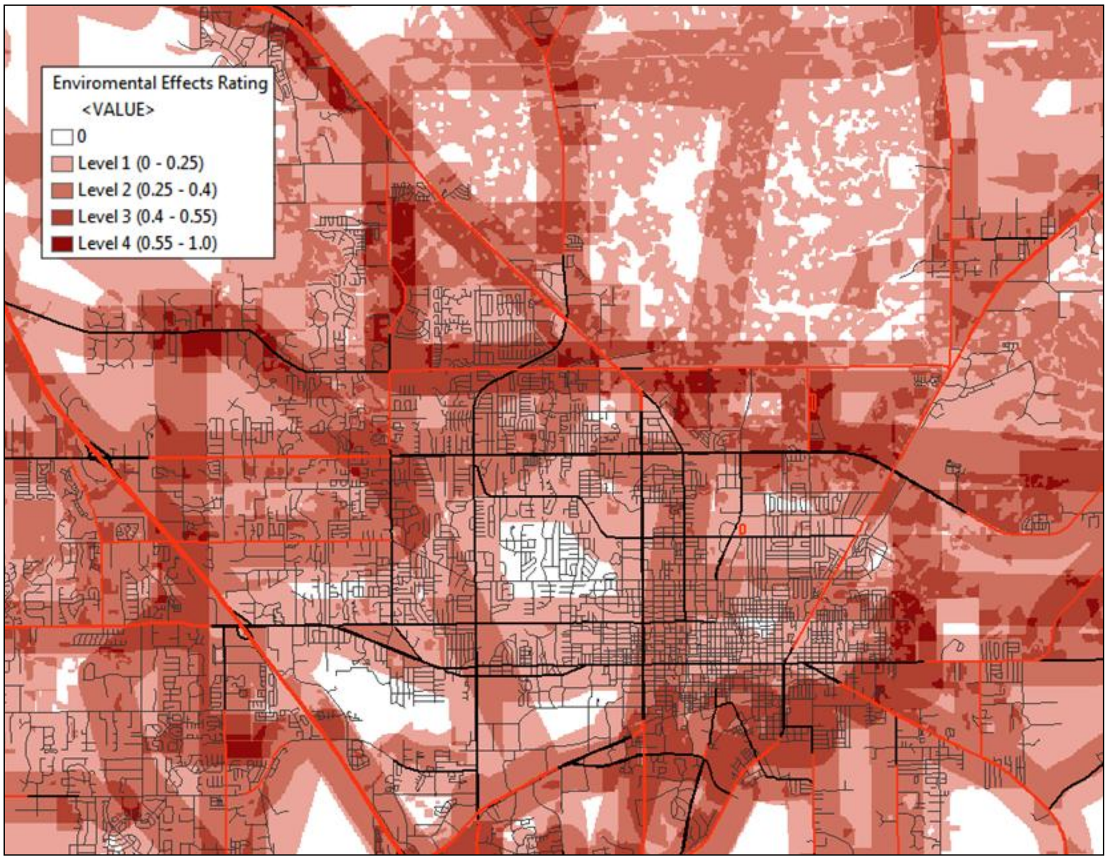


Figure 2. Example of Environmental Effects Rating data for Alachua County.

Weather Influence Zones

Weather in Florida varies geographically. A Weather Influence Zone (WIZ) is an area where, for analysis purposes, the weather on any given day is uniform. WIZs for Florida were initially developed in the 2002 FL FRA project using the expertise of Fire Weather Meteorologists. There are a total of 20 WIZs identified for the state of Florida. All WIZ boundaries remained the same in this project, except for a slight adjustment between WIZs FL13 and FL16 (Figure 3). The East-West boundary between these two zones was shifted to the south, moving Glades County into FL13, to provide the Wildfire Susceptibility Index with a more natural break in this area. This decision was based on discussions with and recommendations from the state Fire Management Administrator and DOF project staff.

Within each WIZ, daily weather observations data was gathered and, through analysis of the data, percentile weather was developed for each WIZ. The compilation, integration and analysis of percentile weather are undertaken as part of the wildfire risk analysis task. Refer to Section 3.4 for more information about this process. The following figure presents the WIZ boundaries defined for the 2011 FL FRA project.

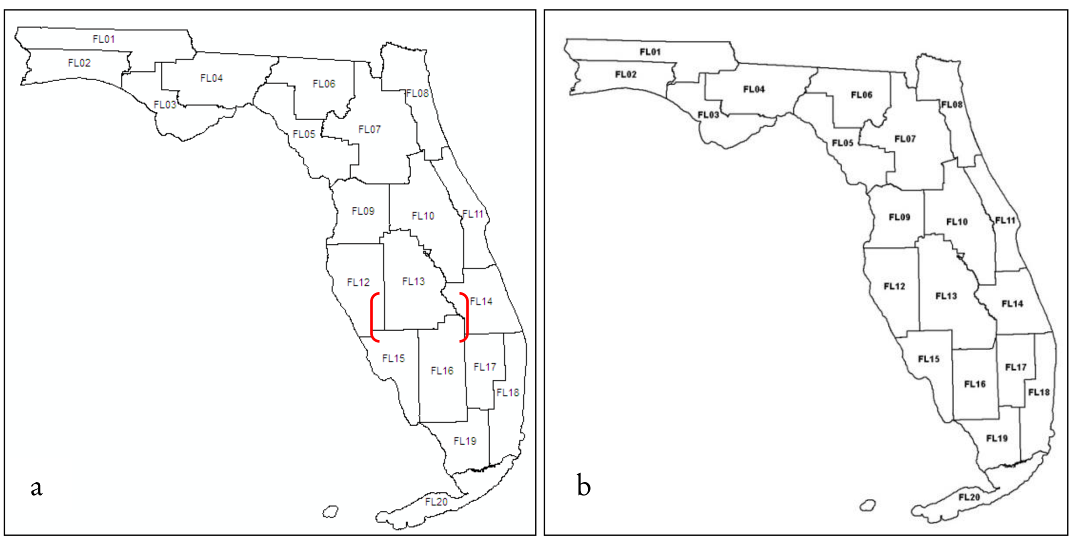


Figure 3. Weather Influence Zone boundaries: a) original WIZ boundaries; b) final WIZ boundaries. Adjusted boundary identified in (a) by red brackets.

2.3 Modeled Data Outputs

This section describes the primary data outputs created from the 2011 FRA risk models.

Community Risk Rating

A risk rating was generated for each community identified in the project. These risk scores are derived by averaging the WFSI value for each community, including a buffer zone around the community. The Communities at Risk (CAR) layer was created by generating a 3-mile buffer around each community polygon and calculating the average WFSI rating within the buffered area. The following figure presents an example of community risk ratings for an area in Alachua County, Florida.

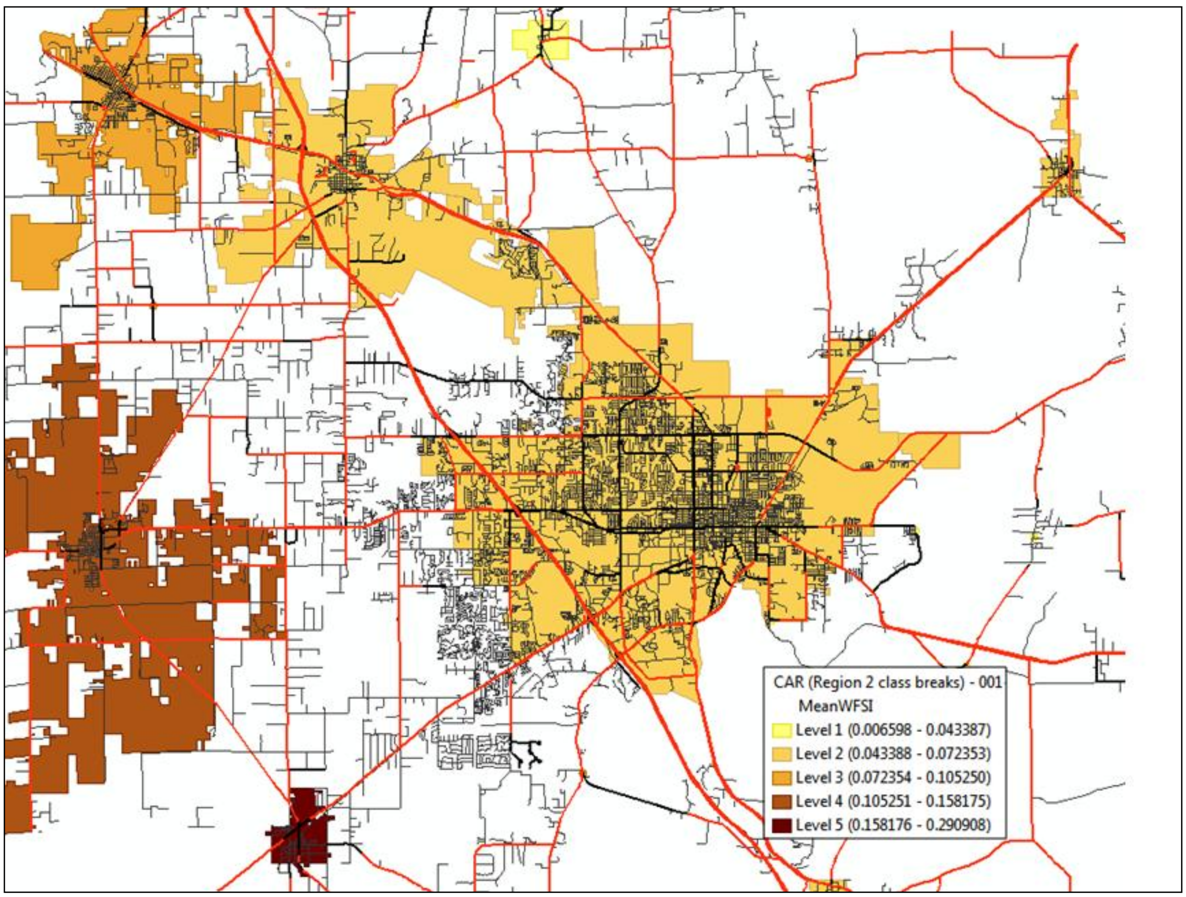


Figure 4. Example of Communities at Risk rating output data for Alachua County.

Fire Effects Index

The Fire Effects Index (FEI) is combined with the WFSI to calculate the Level of Concern. The FEI is comprised of two inputs: Environmental Effects Rating and Suppression Costs Rating. The purpose of the index is to identify those areas that have important values at risk to wildland fire and/or are costly to suppress.

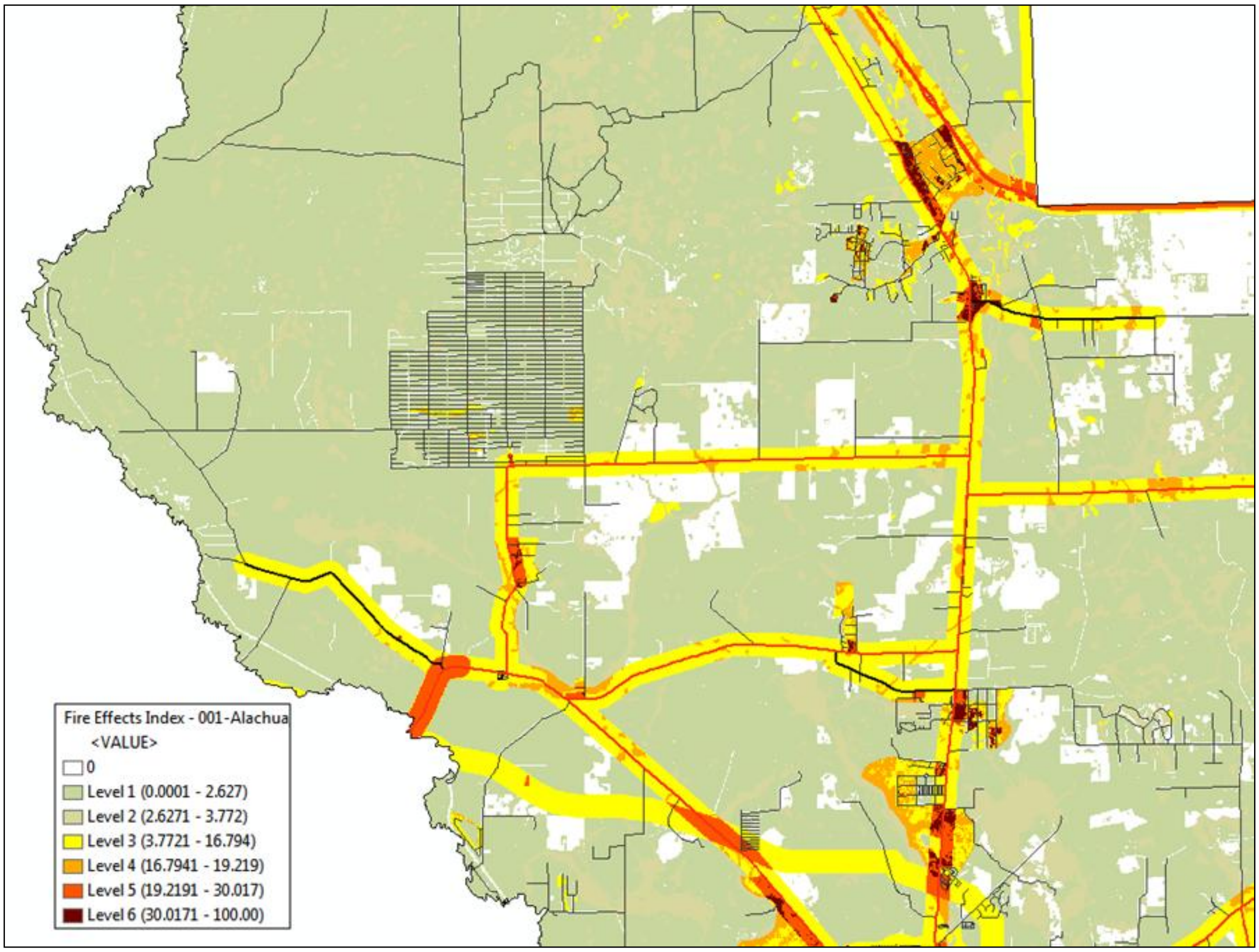


Figure 5. Example Fire Effects Index output data

Fire Response Accessibility Index

The Fire Response Accessibility Index (FRAI) is a relative measure of how long it would take initial attack resources to drive from their resource location to each point on the map. The FRAI is calculated based on the distance from resource locations. The speed traveled on roads was estimated based on the class of road. Travel off of roads was assumed to be at 5 mph. Water was coded as "No Data", meaning that travel across water could not be done unless there was a road crossing. The analysis therefore does not account for islands that are accessible only by water or aircraft. A cost distance analysis was run to assign an approximate time to reach each cell (i.e. any location on the map) from an existing Initial Dispatch Location.

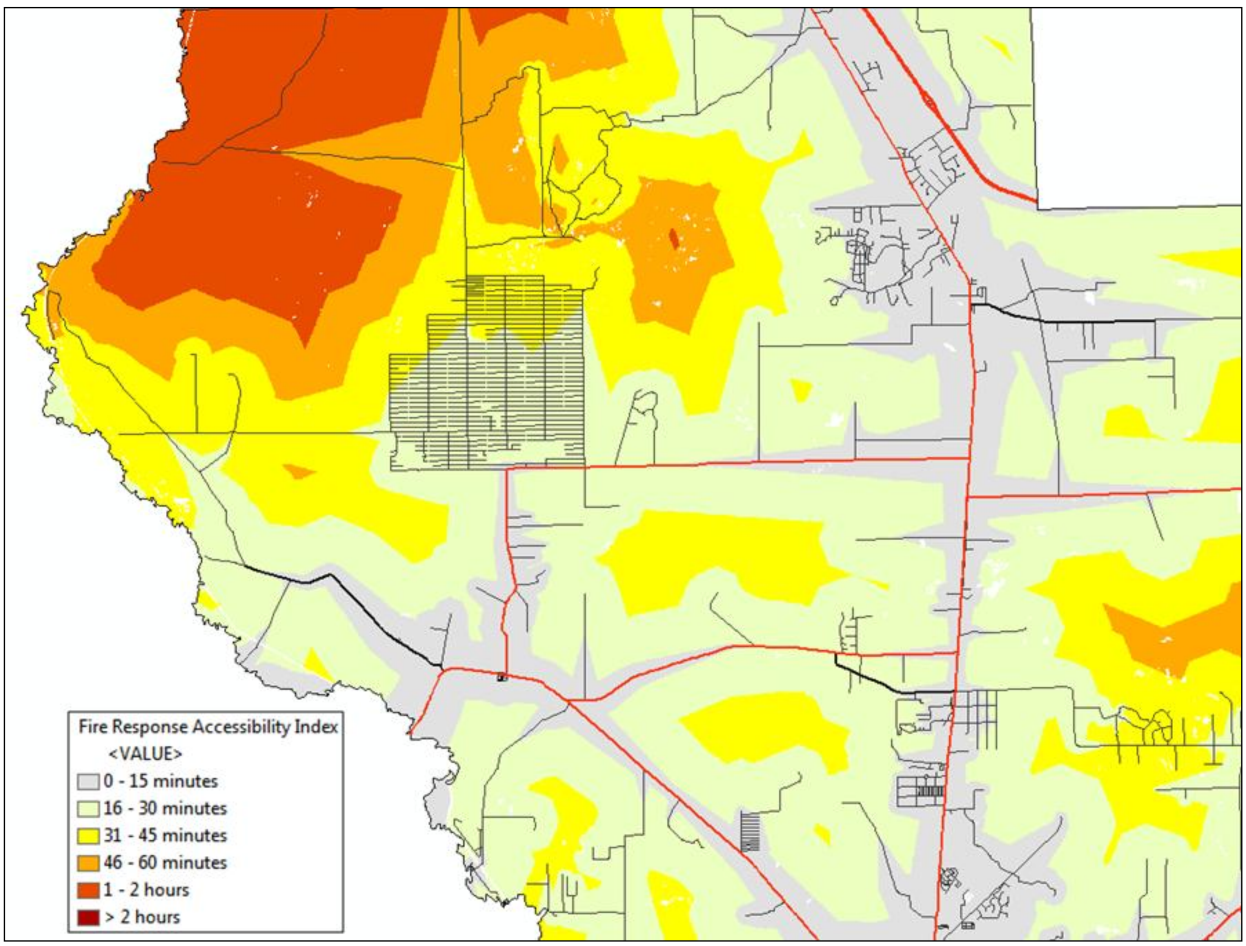


Figure 6. Example Fire Response Accessibility Index output data

Level of Concern Index

The Level of Concern (LOC) is a value between 0 and 100. It is calculated as the Wildland Fire Susceptibility Index (WFSI) times the Fire Effects Index (FEI). It is one of the two primary outputs of the Florida Fire Risk Assessment System and is a measure of wildfire risk.

The LOC can be used to:

- identify areas where mitigation options may be of value;
- allow agencies to work together and better define priorities;
- develop a refined analysis of a complex landscape and fire situations using GIS, and;
- increase communication with local residents to address community priorities and needs.

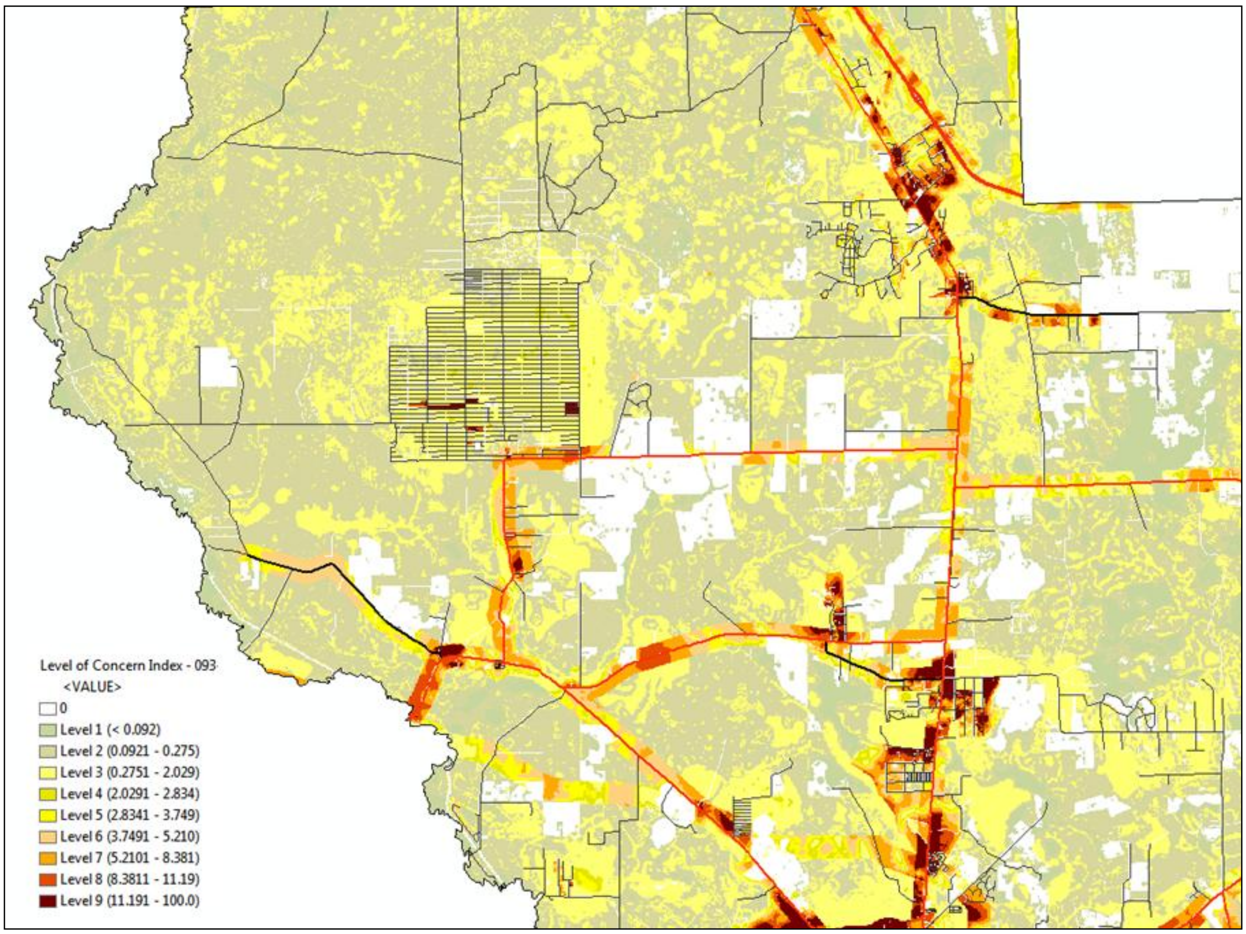


Figure 7. Example of Level of Concern Index output data

Wildland Fire Susceptibility Index

The Wildland Fire Susceptibility Index (WFSI) is a value between 0 and 1. It was developed consistent with the mathematical calculation process for determining the probability of an acre burning[3]. The WFSI integrates the a measure related to 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 wildland fire susceptibility, or threat. Each cell resides within an intersection of a fire occurrence are (FOA) and a weather influence zone (WIZ). Due to some necessary assumptions, mainly fuel homogeneity, it is not the true probability. But since all cells in the State have this index determined using a consistent process, comparison and ordination of areas across a defined study area can occur.

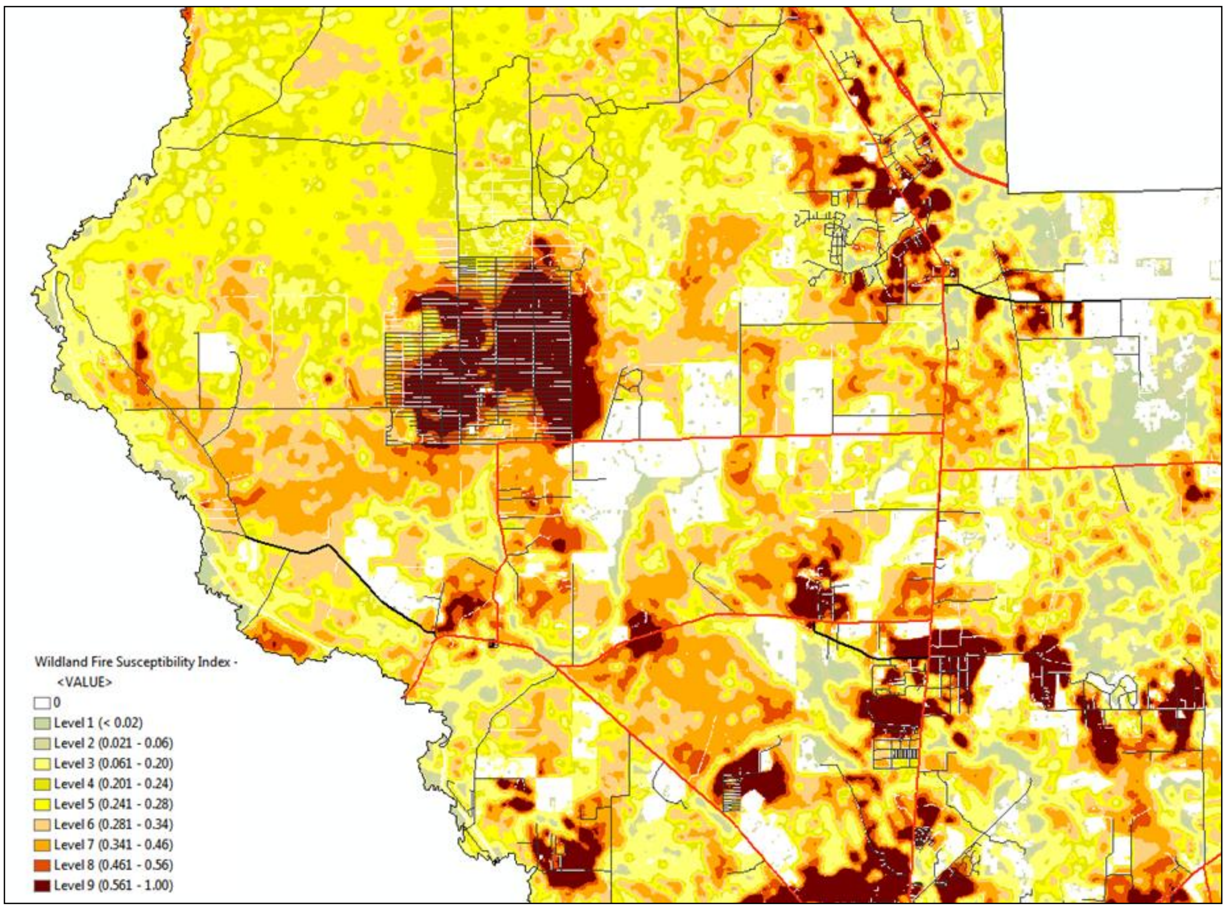


Figure 8. Example Wildland Fire Susceptibility Index output data

[3] See Example of the Calculation of WFSI for more on the calculation of WFSI

2.4 Data Projection System

All data in the Published Results was provided in the following map projection:

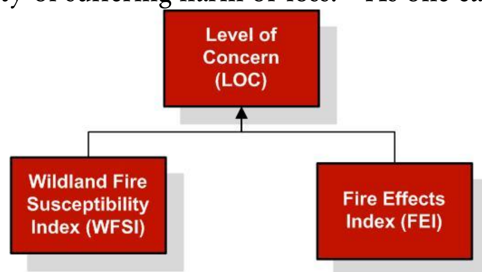
Map Projection: NAD_1983_HARN_Florida_GDL_Albers

- Projection: Albers
- False_Easting: 400000.000000
- False_Northing: 0.000000
- Central_Meridian: -84.000000
- Standard_Parallel_1: 24.000000
- Standard_Parallel_2: 31.500000
- Latitude_Of_Origin: 24.000000
- Linear Unit: Meter
- Angular Unit: Degree
- GCS_North_American_1983_HARN
- Datum: D_North_American_1983_HARN

3.0 Wildland Fire Risk Assessment Methods

3.1 Overview of the Risk Model

Webster's dictionary defines risk as "The possibility of suffering harm or loss." As one can see, there needs to be an "effect of an action" before one can incur a risk from an action. Traditionally, fire management personnel have used the term "risk" to refer to "what starts wildland fires." Within the risk assessment, the Level of Concern Index (LOC) is the best measure of wildland fire risk.



The Level of Concern is calculated from Wildland Fire Susceptibility Index (WFSI) and the Fire Effects Index. The Level of Concern is discussed in detail in Section 3.2.

FL FRA Process Flow

The following figure presents the process flow for the 2011 FL FRA and identifies all key assessment models and datasets. A description of the primary risk assessment model components follows for the key 2011 FL FRA outputs:

- Level of Concern Index (Section 3.2)
- Fire Effects Index (Section 3.3)
- Wildland Fire Susceptibility Index (Section 3.4)
- Fire Response Accessibility Index (Section 3.5)
- Community at Risk Analysis (Section 3.6)

Note that the same models are used to create the Published Results as are provided with the FLFRAS application.

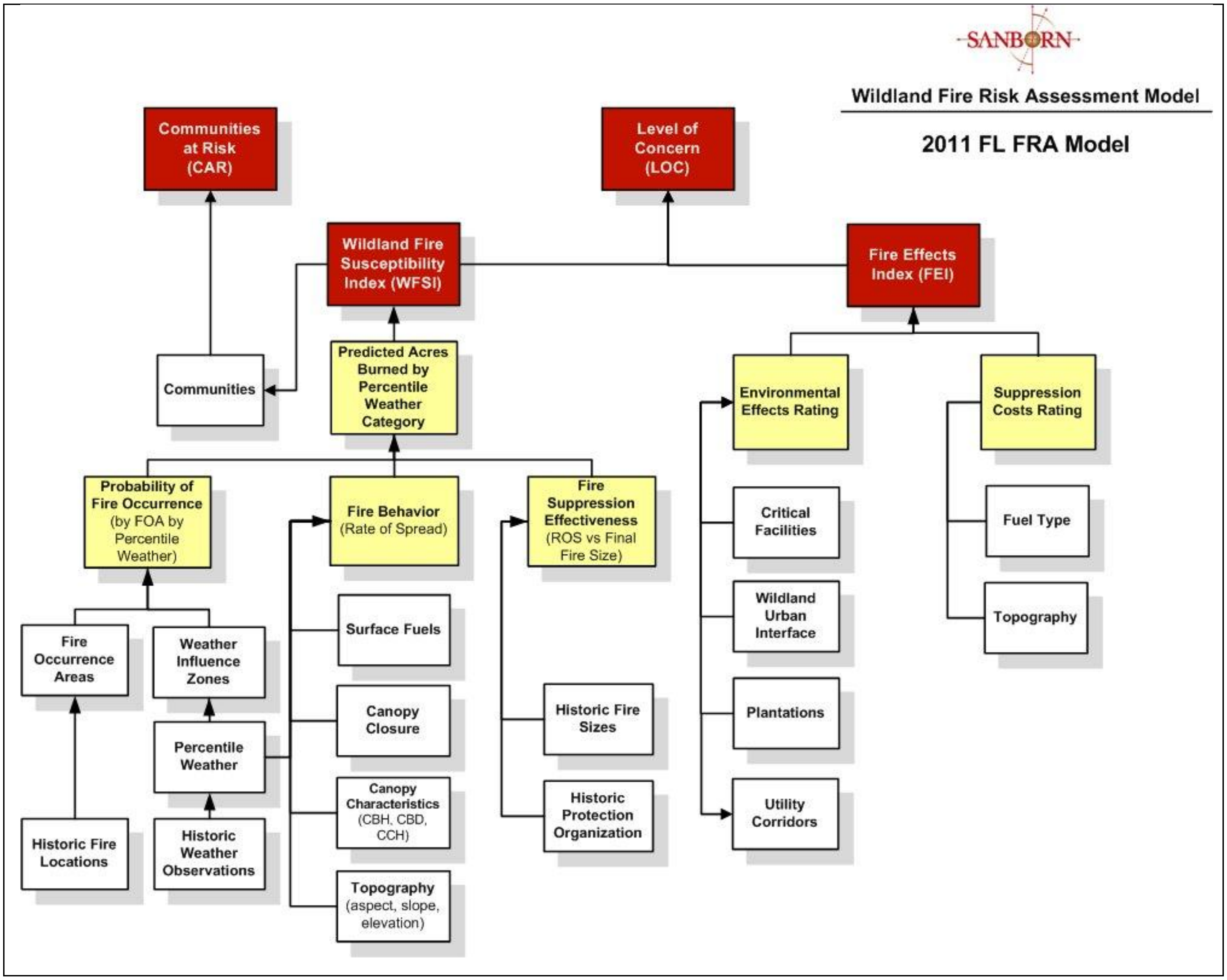


Figure 9. 2011 FL FRA model process flow

Refer to Appendix E for a description of data classification schemes (value ranges and symbology) for all key output data layers.

3.2 Level of Concern Index (LOC)

The LOC model integrates the WFSI with the Fire Effects Index (FEI) to derive an overall index of Level of Concern. LOC represents the overall wildfire risk. This reflects the possibility of suffering loss. LOC is calculated by simply multiplying the WFSI value by the FEI value for every 30m by 30m cell. The equation is:

Level of Concern = WFSI * FEI   Equation 1

The WFSI is a value between 0 and 1. The Fire Effects Index is a value between 0 and 100. Hence, the LOC is a value between 0 and 100.

The LOC output values are assigned to nine categories ranging from Level 1 to Level 9, based on analysis of the frequency distribution of layer values for Florida. Based on this distribution optimum class breaks were defined by Sanborn's fire behavior expert to ensure that the results are properly represented. Appendix E provides a description of the LOC class ranges.

3.3 Fire Effects Index

The Fire Effects Index is comprised of two inputs:

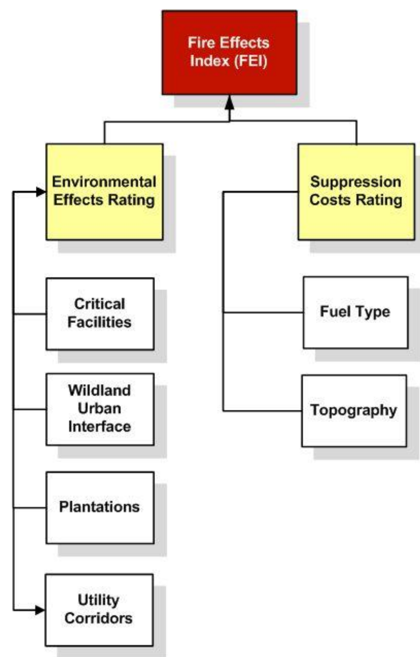
1. Environmental Effects Rating
2. Suppression Costs Rating

The purpose of the index is to identify those areas that have important values at risk to wildland fire and/or are costly to suppress.

The Fire Effects Index is calculated by combining the Environmental Effects Rating and the Suppression Costs Rating using the following equation:

Fire Effects = (0.80 * Environmental Effects Rating) + (0.20 * Suppression Costs Rating) * 100

(Equation 2)



The final Fire Effects Values can range from 0 – 100. The weighting values of 0.80 for the Environmental Effects Rating and 0.20 for the Suppression Costs Rating were defined by State fire planning specialists during a workshop conducted during the 2002 FRA project.

Tools are provided in the 2011 FLFRAS to facilitate analysis that allows users to change these values to reflect different local scenarios and recreate FEI and LOC. Figure 10 presents an example of the FEI output and the two primary input layers, Environmental Effects Rating and Suppression Costs Rating.

The FEI process (Figure 11) involves the following steps:

1. Defining scores (Flame Length versus Final Fire Size) for each layer in the two ratings
2. Defining weightings for the layers in each rating (i.e. WUI vs. Plantations vs. Utility Corridors etc.)
3. Defining multipliers for slope class
4. Defining the weights for Suppression Costs Rating versus Environmental Effects Rating

The scores and weightings used in this risk assessment were the same as those used in Florida's 2002 FRA, except for slope and slash which were not considered in 2002. These steps are summarized below.

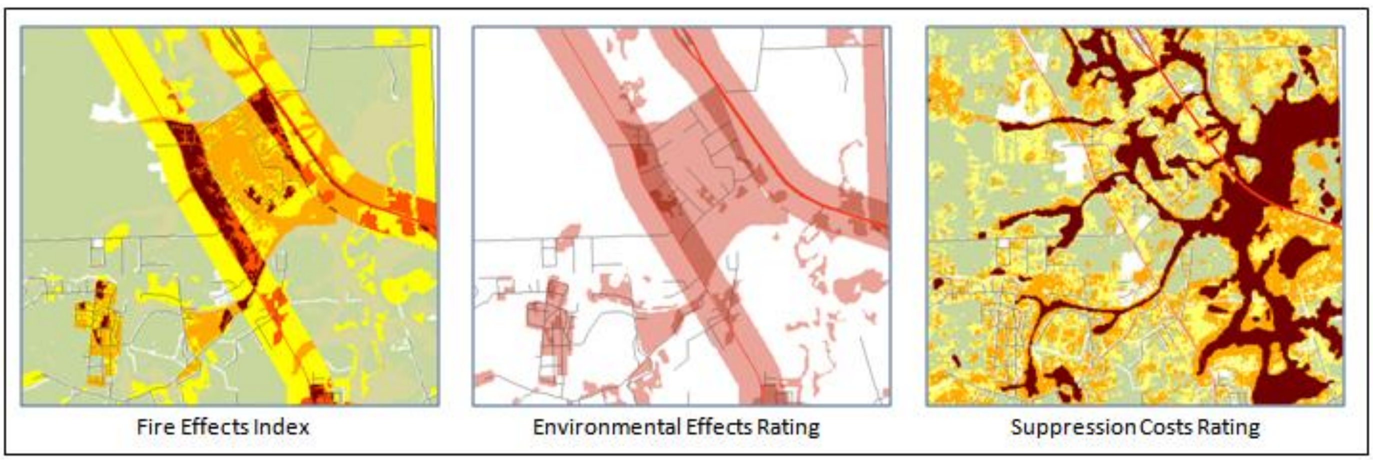


Figure 10. Example FEI map at left with input layers shown at right

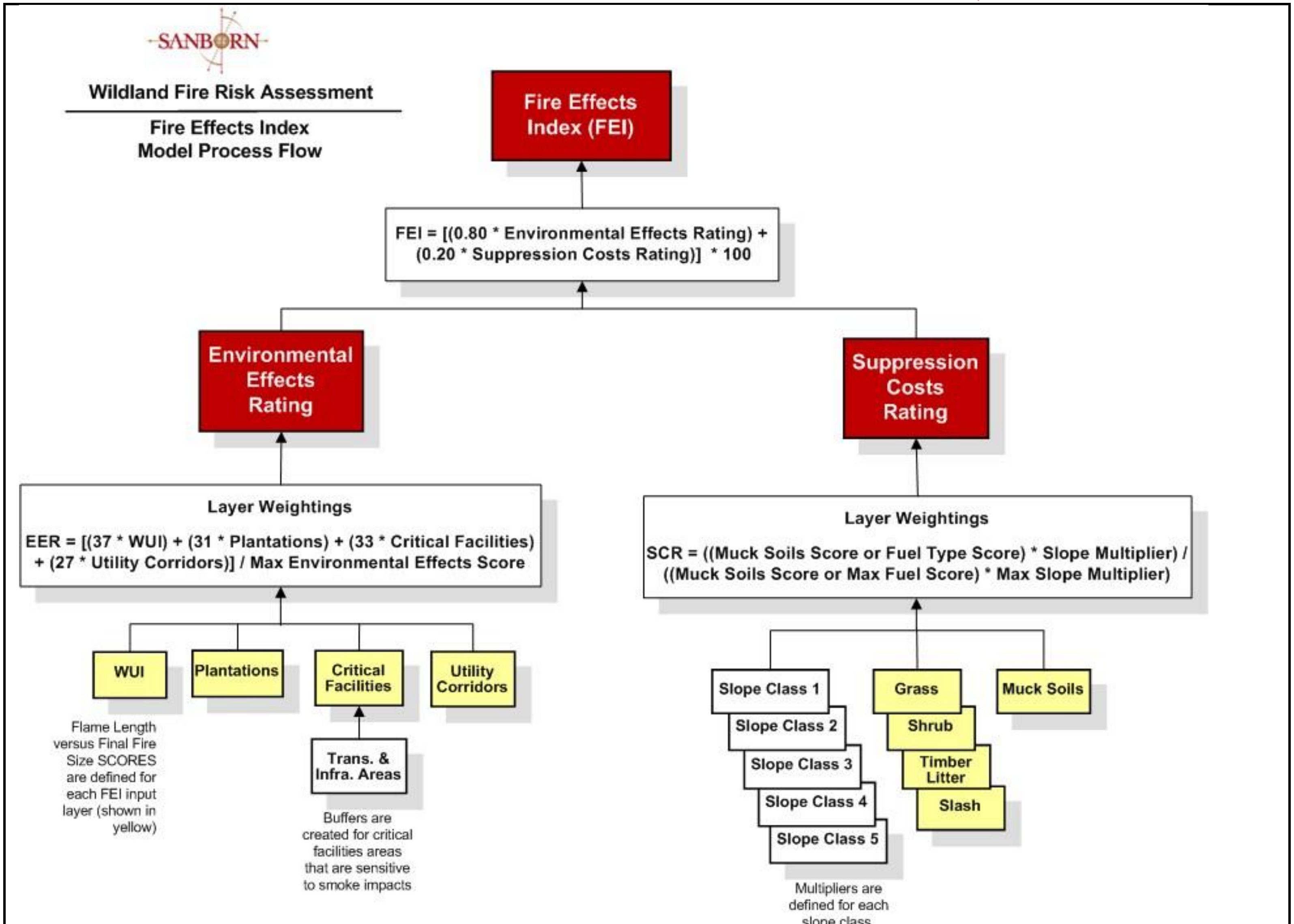
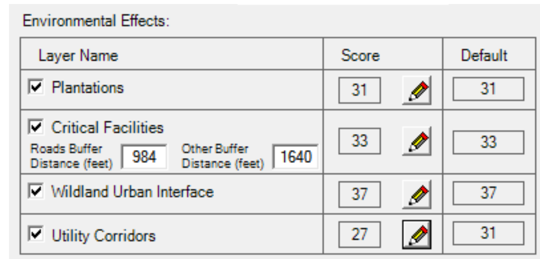


Figure 11. The Fire Effects Index model process flow

Environmental Effects Rating

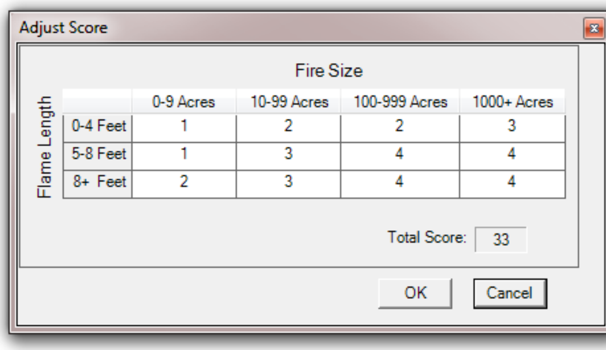
The environmental effects data included in the assessment are:

- Plantations (natural and planted)
- Critical Facilities (smoke sensitive areas)
- Wildland Urban Interface
- Utility Corridors



By combining these four layers with different weightings that reflect importance, an environmental effects rating can be calculated. Figure 12 shows examples of the four key effects layers and the resultant Environmental Effects Rating layer.

Each input data layer was assigned an *impact score* by State fire managers during the 2002 Florida risk assessment. These same scores were used in this assessment[4]. The scores were defined using a matrix to assign a value of 1 to 4 (1 being low effect, 4 being high) for each flame length vs. fire size scenario for each effects layer. To arrive at a final score for an Environmental Effects layer, the individual values in the matrix were summed (e.g. 33 shown in this example). The matrices for each of the Environmental Effects layers are identified in Appendix G.



The Environmental Effects Rating is determined by summing the Environmental Effects Scores for a cell and dividing that total by the total possible score of 192 (48 = the maximum score * 4 potential environmental effects).

[4] Documentation of the wildland urban interface score from the 2002 FRA project was found showing values of both 36 and 37. From the documentation it is not clear which one was developed during the workshop in 2001. Hence, for consistency, the value (37) that appears in the 2002 FRA and the SWRA was used in this project.

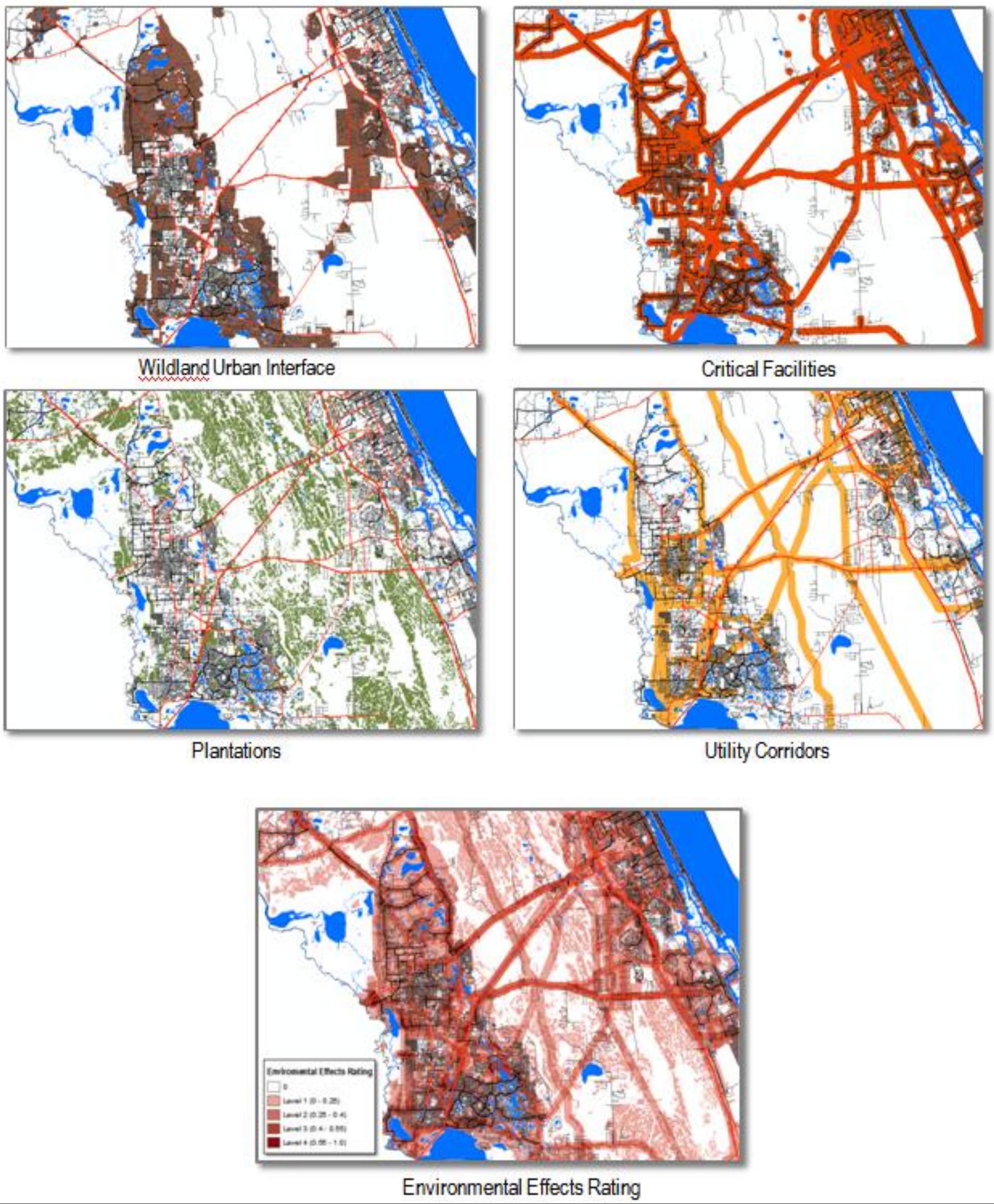


Figure 12. Examples of Environmental Effects Rating map and input layers

Suppression Costs Rating

The layers that are included in the development of the Suppression Costs Rating are:

- Fuel Type (grass, shrub, timber litter, slash)
- Slope
- Muck Soils

The logic for calculating suppression costs rating involves a combination of scores for the individual fuels and multipliers for slope.

Suppression Cost:

Layer Name	Score	Default
Base Suppression Score:	32	32
Fuel Types: Fuels		
- Grass Score	9	9
- Shrub Score	33	33
- Timber Litter Score	40	40
- Slash Score	38	38
☑ Organic / Peat Soils	60	60
Layer Name	**Multiplier**	**Default**
Topography (slope)		
- Class 1 (0 - 25%)	1.00	1.00
- Class 2 (26 - 40%)	1.00	1.00
- Class 3 (41 - 55%)	1.00	1.00
- Class 4 (56 - 75%)	1.00	1.00
- Class 5 (76+ %)	1.00	1.00

Fuel Type

The surface fuels layer was used to assign each cell in the state a fuel type of grass, shrub, timber litter or slash. A score was defined for each layer using the same values as the 2002 FL FRA. While slash is considered to be a rare occurrence in Florida[5], the default score was still developed in case the state ever has need to consider this fuel type. Because slash was not used in the 2002 FL FRA, the score being used for slash is the one developed for Florida during the SWRA project.

Topography (slope)

In the 2002 FL FRA, slope was not included in the model. However, the current WFRAS model, which is the prototype for this FLFRAS project, includes slope. Therefore, the slope multiplier values for Florida that were determined by state fire managers during the SWRA project were used in this project. For Florida, because slope is expected to have little impact on suppression costs, this multiplier was set at a default of 1.0. This has the effect of removing any slope impact from the calculation for Suppression Costs Rating because the equations just get multiplied by a factor of 1.

The topography multiplier was assigned to each of the following slope classes:

- Slope Class 1 – 0 to 25%
- Slope Class 2 – 26 to 40%
- Slope Class 3 – 41 to 55%
- Slope Class 4 – 56 to 75%
- Slope Class 5 – 76+%

[5] The current Florida Surface Fuels dataset used in this assessment had less than 15 acres of slash for the entire state.

Organic / Peat Soils

Organic/Peat (muck) soils were extracted from SSURGO data by the state. These soils are associated with environmental characteristics that are challenging for firefighting efforts, as fires within these areas tend to be expensive and difficult to extinguish. Both wheeled and even tracked vehicle mobility can be constrained by the instability of these soils. Areas with muck soils also present a risk of ground fire during extreme drought conditions.

The suppression costs are evaluated by fuel type and topography. Each burnable cell in the state was assigned a Suppression Costs score using a similar matrix process used for the Environmental Effects scoring. The grass, shrub, and timber litter fuel type scores from the 2002 FL FRA were used. The slash fuel type was added in 2011 with the score assigned from the SWRA project. This was done to provide completeness and for potential future analysis of fuel type changes from natural events or human activities. The slope scores also came from the SWRA project as mentioned above.

For organic / peat soils, or muck soils, the score was assigned to be 60 which is 1.25 times the maximum score of 48. This higher value for Muck soils was implemented during the SWRA to reflect the increased suppression costs in this situation. The Suppression Costs Rating for each cell was then calculated by dividing the product of the Fuel Type Score (or Muck score if Muck is present) and the Topography Multiplier by the product of the maximum fuel type score (or Muck soils score) and the maximum slope multiplier. Again, because the effect of slope on suppression costs in Florida is considered to be negligible, the topography multiplier is set to 1 for all slope classes. Any slope impact is therefore effectively removed from the equation (i.e. multiplication by 1).

The following figure (Figure 13) presents an example of the Suppression Costs Rating output and its primary input layers.

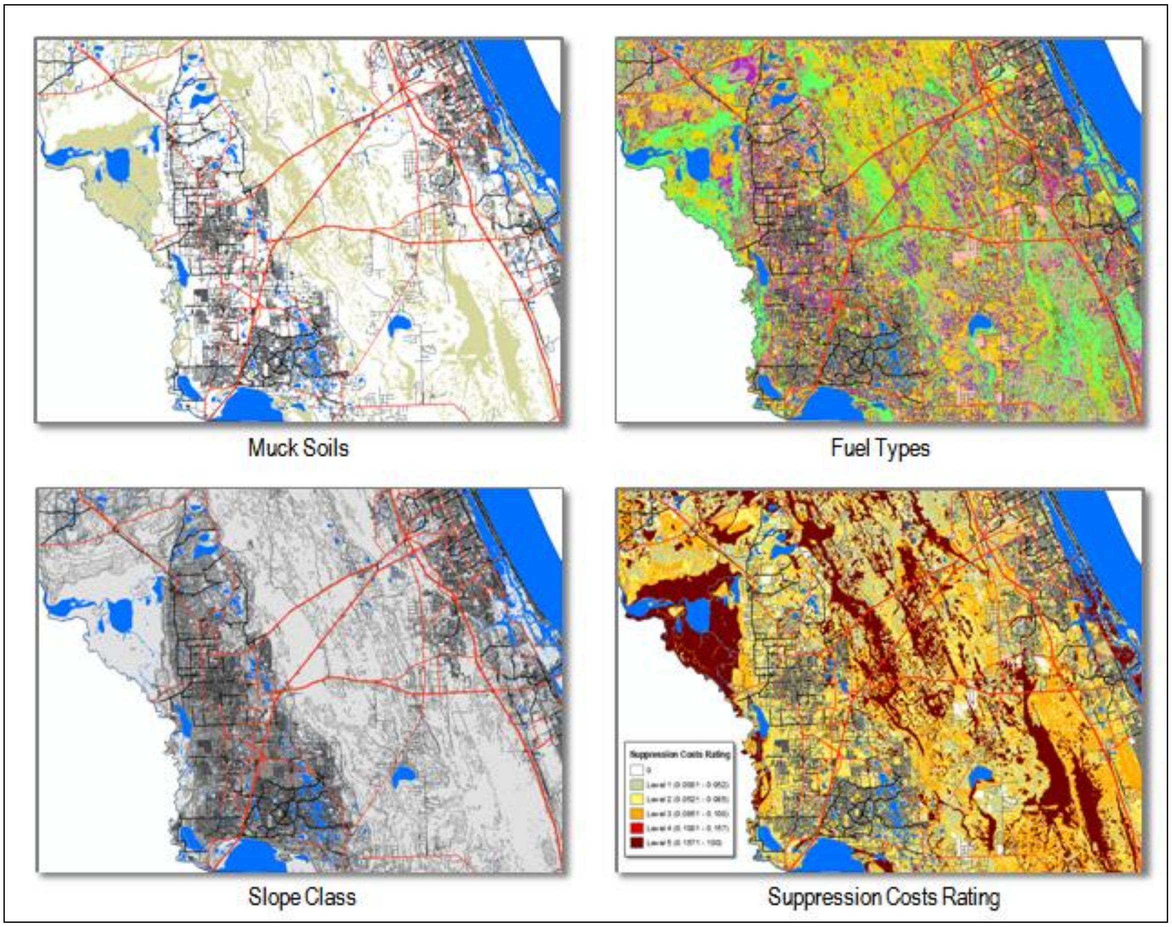


Figure 13. Example Suppression Costs Rating map and input layers

3.4 Wildland Fire Susceptibility Index (WFSI)

The key index from the risk assessment that can support current fire planning needs in Florida is the Wildland Fire Susceptibility Index (WFSI). The WFSI is a value between 0 and 1 that is related to the likelihood of an acre burning. The following figure describes the WFSI model.

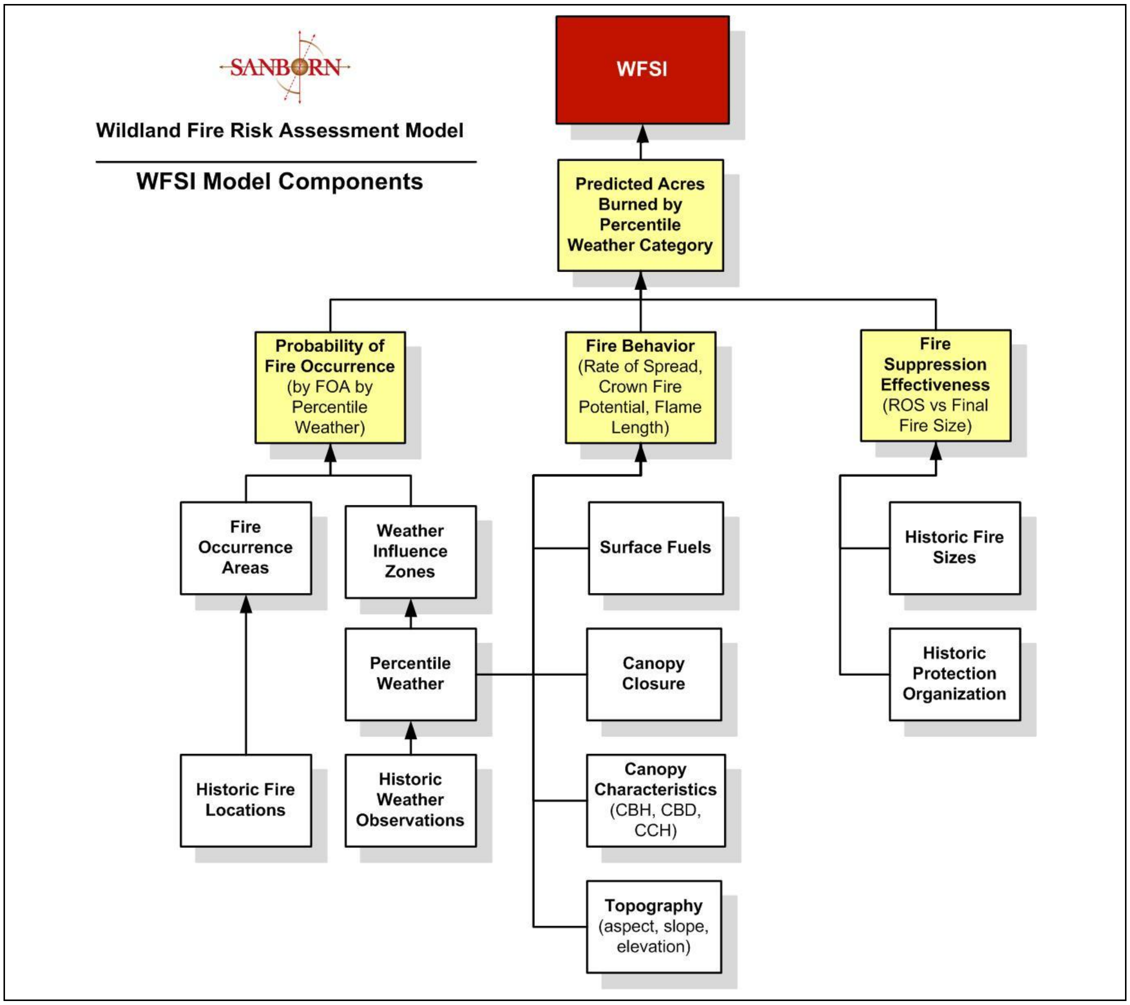


Figure 14. 2011 FL FRA WFSI Model

WFSI 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 wildland fire susceptibility, or threat. Each cell resides within an intersection of a fire occurrence area (FOA) and a weather influence zone (WIZ). Due to some necessary assumptions, as described in the section titled Example of the Calculation of WFSI, the value calculated is not the true probability of an acre burning but an index related to the probability of an acre burning. Since all cells have this index determined using a consistent process, comparison and ordination of areas across a defined study area can occur.

WFSI is comprised of three key data streams:

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

A description of these key elements is presented below.

Fire Occurrence Areas

A Fire Occurrence Area (FOA) is an area where the probability of each acre igniting is the same. The historical fire locations compiled from fire history reports were used to calculate the FOA map. FOAs reflect the mean ignition rates, quantified as the number of fires per year per 1000 acres. The following figure presents an example of source fire ignitions and the resultant FOA map created using the FOA model. For more information on the development of FOAs, refer to the final report from the FRACIP project.

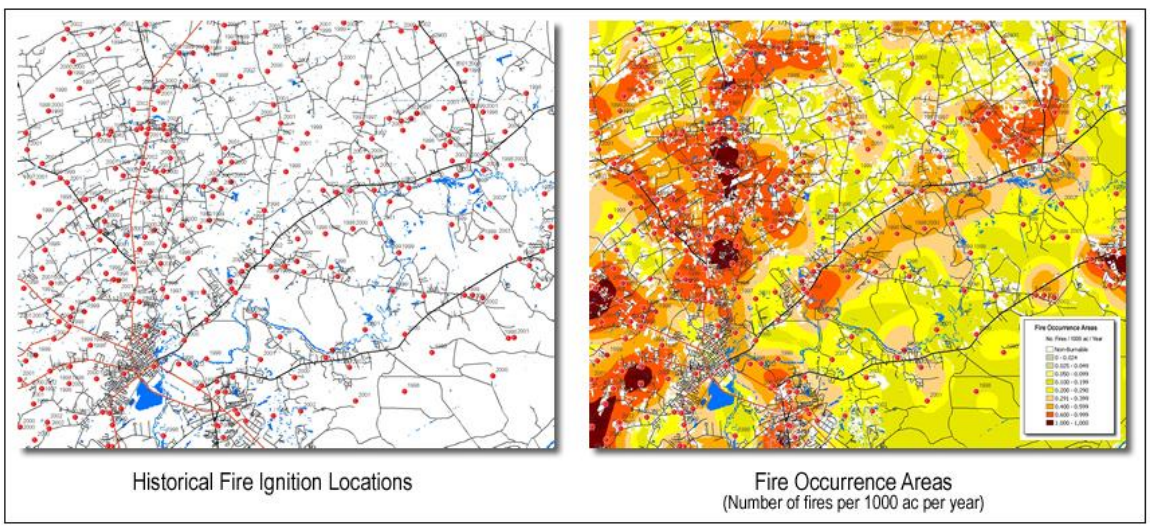
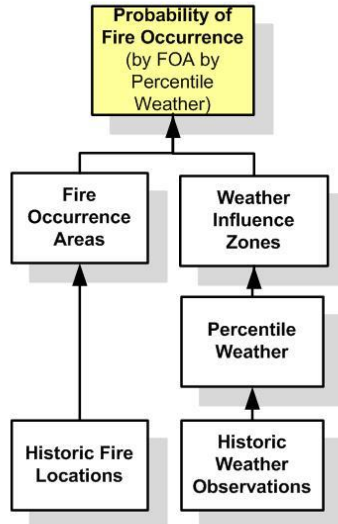


Figure 15. Example fire ignitions and resultant FOA

Weather Influence Zones and Percentile Weather Values



As discussed previously, a Weather Influence Zone (WIZ) is an area where weather is considered to be uniform. Within each WIZ, daily weather data from weather stations is gathered and percentile weather is developed for each WIZ using the USDA Forest Service's FireFamily Plus program.

Weather Observation Data

Within each WIZ, daily weather data was gathered from 1994 – 2009, if available, from land management agency maintained weather stations and from the National Oceanographic and Atmospheric Administration (NOAA) maintained weather stations. Weather observations are taken at 2pm each day based upon data standards defined in the National Fire Weather Observers Handbook. This weather observation data was checked for errors and then imported into the FireFamily Plus software program. In several WIZs the only weather station available was a federal RAWS station. The state indicated they were uncomfortable with the weather observations from these stations. Hence, weather stations from adjoining WIZs were used in the WIZs where the RAWS stations were located.

The National Fire Danger Rating System (NFDRS) index Spread Component (SC) was calculated for each day. The fire season was set from October 1 through May 31, based on the dates used in the 2002 FL FRA, and the SC was calculated using the NFDRS fuel model G. Though little fuel model G exists throughout Florida, fuel model G contains fuel loading 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 SC calculation of the fuel moisture values in all of the fuel categories. In addition, climate class 3 (sub-humid / humid) and slope class 1 (0-25%) were used.

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 SC 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 SC was equal to the median SC. 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.

This was done for each weather station in a WIZ using the FireFamily Plus program. The average SC for each percentile weather category was then determined. The fire weather meteorologist for the project, Paul Werth, then selected the one weather station in the WIZ that best represented the average SC values. This weather station was selected to represent the weather data for the WIZ as well as the percentile fuel moisture and wind speed values for the WIZ. An example printout of percentile weather values from FireFamily Plus for WIZ 1 in Florida is shown in Figure 16.

```
1- FireFamily Plus Percentile Weather Report for RERAP

 Station: 722215: Crestview              Variable: SC
 Model: 7G1PE3
         Data Years: 2000 - 2009
         Date Range: October 1 - May 31
Wind Directions: N, NE, E, SE, S, SW, 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      1 -   1   5 -   5   16 -  16   26 -  99
            Num Observations      109       209        35        26
     Calculated Spread Comp.        1         5        16        32
              Calculated ERC       18        23        22        23

Fuel Moistures
        1 Hour Fuel Moisture      8.89      6.98      7.63      6.80
       10 Hour Fuel Moisture     10.80      9.09      9.75      8.96
      100 Hour Fuel Moisture     18.45     17.55     18.23     17.57
    Herbaceous Fuel Moisture    163.82     61.29     16.78     22.56
         Woody Fuel Moisture    165.13    104.53     75.60     78.32
              20' Wind Speed      0.64      5.88     14.29     23.31
     1000 Hour Fuel Moisture     22.35     21.20     21.39     21.38

 2411 Weather Records Used, 2202 Days with Wind (91.33%)
```

Figure 16. Example of Percentile weather data

Proportion (Percent) of Fires That Occur Within Each Percentile Weather Category

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. As an example, Table 1 shows the proportion of fires by percentile weather category for the 20 WIZs in Florida. 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 significantly from this nominal percentage of days by category.

For each day with weather at the WIZ weather station from January 1, 1999 through December 31, 2007, the NFDRS Spread Component was calculated using the FireFamily Plus program. Each fire within the fire occurrence database for all agencies within a Weather Influence Zone has a fire start date. 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 SC and the four categories have SC ranges. Hence, a correlation could be 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 (Table 1). This data is used as input into the WFSI model.

Table 1. Proportion of Fire by Percentile Weather for Florida

WIZ	Percentile Weather Category			
	Low	Mod	High	Extreme
1	10.6%	73.7%	13.6%	2.0%
2	18.8%	67.1%	12.1%	2.0%
3	15.1%	73.9%	8.3%	2.8%
4	15.5%	70.1%	8.4%	6.1%
5	17.9%	70.0%	7.5%	4.6%
6	8.9%	75.8%	8.0%	7.3%
7	15.6%	73.6%	6.5%	4.2%
8	12.3%	78.6%	6.6%	2.6%
9	9.8%	78.9%	9.0%	2.3%
10	19.5%	67.4%	5.8%	7.3%
11	19.1%	69.3%	8.9%	2.7%
12	13.6%	75.2%	7.6%	3.5%
13	19.9%	69.8%	7.0%	3.3%
14	16.1%	72.8%	6.6%	4.6%
15	15.7%	74.7%	6.5%	3.1%
16	17.5%	72.2%	7.9%	2.4%
17	17.9%	74.1%	6.7%	1.3%
18	12.3%	80.5%	5.7%	1.6%
19	12.3%	80.5%	5.7%	1.6%
20	23.5%	68.7%	5.2%	2.6%

Fire Behavior Prediction

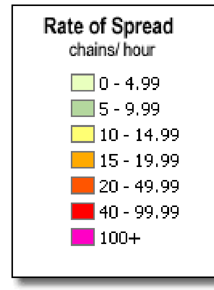
Fire behavior outputs are a key component of the FLFRAS model. Potential fire behavior is evaluated using a fire behavior prediction program, FB3. The FB3 DLL fire behavior program uses topographic information, fuel characteristics, and weather to calculate rate-of-spread, flame length, fire type, and other into the fire behavior characteristics of fire behavior.

The FB3 DLL is used within FLFRAS to generate fire behavior outputs that are comparable across the landscape for a given set of weather, fuels and fuel moisture data inputs. The following minimum data layers are required and used as input to the program:

- Elevation
- Slope
- Aspect
- Surface Fuel Model, and
- Canopy Cover.

Three additional data layers - Canopy Height, Canopy Base Height and Canopy Bulk Density – can be and were used to calculate crown fire potential.

Rate of Spread



The main fire behavior output calculated for the 2011 FL FRA is rate of spread (ROS). ROS is calculated since it can be used to estimate a fire's expected size. Final Fire Size is a key intermediate dataset used in the WFSI model. Additional fire behavior outputs, such as fire intensities and flame length, are available as outputs of the FLFRAS application. Refer to Appendix E of the 2011 FLFRAS User Guide for information on how to calculate and use other outputs in ArcGIS.

The 2011 FL FRA calculates the behavior of a fire occurring in each 30x30 meter cell under defined weather conditions. Fire behavior is described independently for each individual cell. This fire behavior calculation does not account for contagious processes that may affect fire behavior in an adjacent cell.

Fire behavior output data, such as rate of spread and flame length, are valuable information for fire specialists in assessing risk and analyzing mitigation options. In the 2011 FL FRA model, ROS is automatically calculated each time WFSI is calculated. ROS (chains per hour) is calculated for each of the four percentile weather scenarios (low, moderate, high and extreme). Each weather scenario output is combined in the WFSI model as a component in calculating the final WFSI values. The following figure presents an example of the four percentile weather ROS outputs for a specific area of interest. A proposed fuels treatment boundary is shown in black as reference.

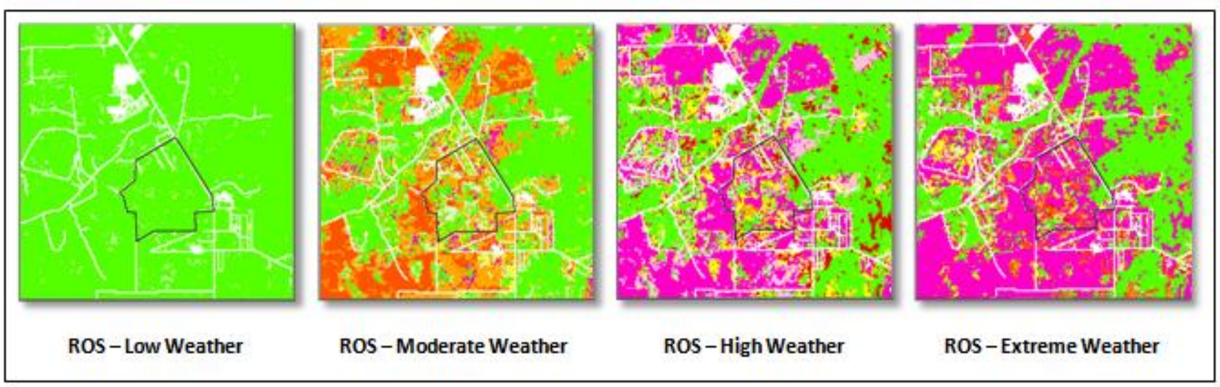


Figure 17. Example ROS outputs for the four percentile weather categories

Surface Fuel Models

The description of surface fuel models is a key element of the FL FRA model. Surface fuels are a key input for fire behavior analysis and the WFSI calculations. Fuels were described using the 1982 FBPS Fuel Models (Table 2). Descriptions of these models are found in Appendix C. As noted in the data input section, the surface fuels data for this project came from the State's 2007 update to their 2005 surface fuels dataset (Figure 18). Note that FBPS 13, Heavy Slash, does not exist in Florida.

Table 2. 1982 FBPS surface fuels used in the FL FRA

FBPS Fuel Model	Description
1	Short Grass (1 ft.)
2	Timber (grass and understory)
3	Tall Grass (2.5 ft.)
4	Chaparral
5	Brush
6	Dormant Brush, hardwood Slash
7	Southern Rough
8	Closed Timber Litter
9	Hardwood Litter (long-needle pine)
10	Timber (litter and understory)
11	Light Slash
12	Medium Slash
13	Heavy Slash

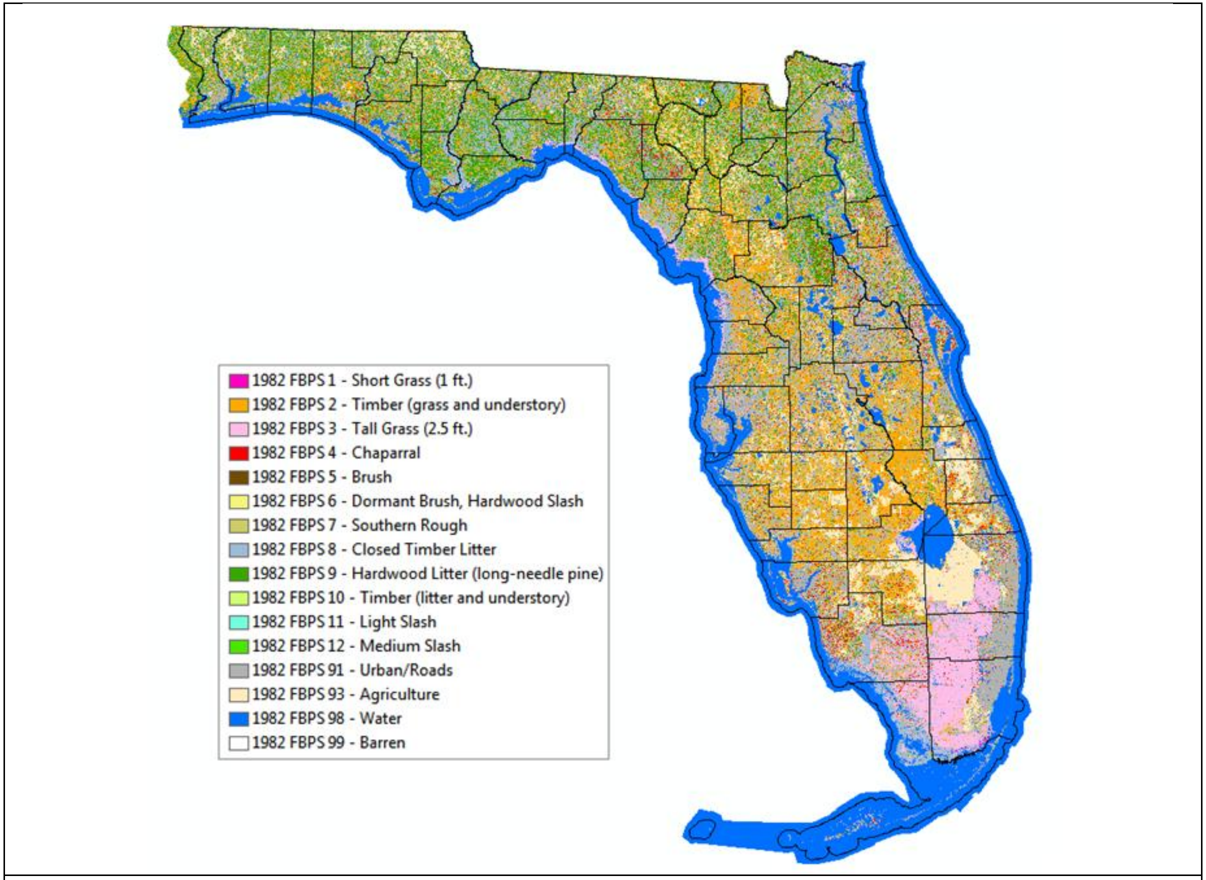


Figure 18. Surface fuels map of Florida

Canopy Fuel Characteristics

Canopy data is also a requirement for the WFSI model. These datasets are required to conduct the fire behavior analysis. The canopy datasets for this project came from the Florida Wildland Fire Risk Assessment Canopy Inventory Project and consisted of Canopy Bulk Density, Canopy Base Height, Stand Height (Canopy Ceiling Height), and Canopy Cover.

Fire Suppression Effectiveness

The final component to the WFSI model is the analysis of fire suppression effectiveness. This data represents key parameters and thresholds utilized in the WFSI model. A description of the key elements is presented below.

Rate of Spread vs. Final Fire Size Relationships

For a cell, the FOA provides an estimate of the likelihood of a given cell igniting. To calculate the WFSI, the expected size of a fire needs to be determined to facilitate estimating the probability of an acre burning. To do this, it was necessary to develop relationships between fire spread rates (ROS) and the expected final fire size (FFS) (see adjacent figure for an example). The inputs to this relationship are the expected fire behavior, which depends on fuels, weather and topography and a measure of suppression effectiveness of fire protection forces.

A description of the processing logic to define the fire rate of spread follows.

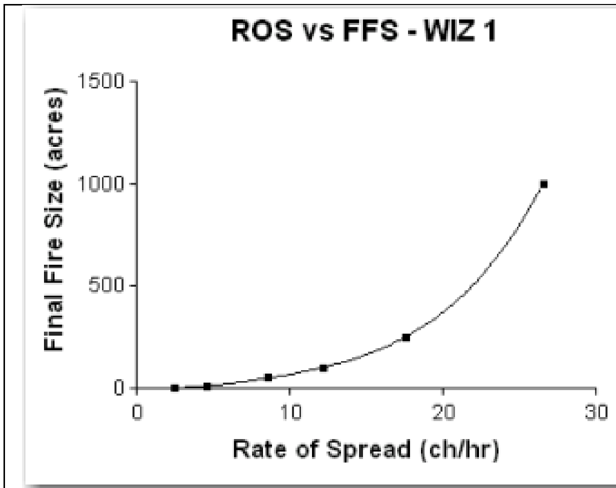


Figure 19. ROS versus FFS relationships

For each Weather Influence Zone, a relationship between the rate of spread and final fire size was developed during the FRA1 in 2002 and was used here. Several fire size classes were used to estimate the amount of time from fire start to fire containment. For all WIZs, the time from fire start to fire containment for the benchmark fire sizes of 0.5, 2, 10, 50, 100, 500 and 1,000 acres was determined. Additional fire sizes greater than 1,000 acres were used when fires of these sizes occurred historically within a WIZ.

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:

$$\text{Area} = K * D^2 \qquad \text{Equation 3}$$

where K is a constant dependent solely on mid-flame wind speed and D is the distance the fire has traveled from its point of origin (D = rate of spread times containment time). Mid-flame wind speed was set at 1, 2, 3, 5, 7, 9, and 12 mph for each of the benchmark sizes of 0.5, 2, 10, 50, 100, 500 and 1,000-acre fires. The mid-flame wind speed was set at a value of 12 mph or larger for fires with final fire sizes greater than 1,000 acres.

A relationship between the fire size and average rate of spread values for the benchmark fire sizes was developed using multi-variable regression.

In Florida, a fourth order polynomial was determined to be the best equation form to use except for fuel models 1 and 3:

$$Y = A + B*X + C*X^2 + D*X^3 + E*X^4 \qquad \text{Equation 4}$$

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

For fuel models 1 and 3, a power function was determined to be the best equation form to use:

$$Y = A + B*X^C + D*X^E \qquad \text{Equation 5}$$

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

In some cases, A was changed so that a 0.5 acre fire was expected when the rate of spread was 1 chain per hour (1.1 feet per minute).

A maximum expected fire size was set for all WIZs to account for physical conditions that would limit fire spread. These values were based on historic fire sizes. **Error! Reference source not found.** provides an example of these types of relationships. The equation developed was:

$$FFS = 2.0 - 2.995*X + 1.589*X^2 - 0.09751*X^3 + 0.003605*X^4$$

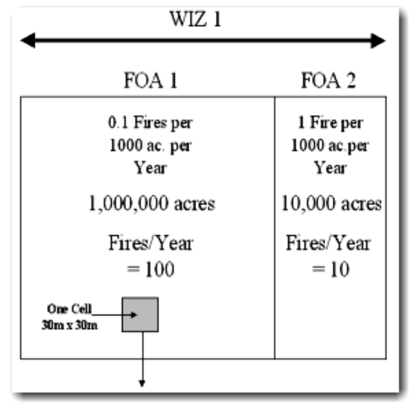
with a maximum fire size of 2,000 acres. Note that for spread rates greater than 35 ch/hr, the final fire size remains at 2,000 acres.

Table 3. Example of FFS relationships table

A			2.0000000
B			-2.9950000
C			1.5890000
D			-0.0975100
E			0.0036050
Max Size			2000
Largest Fire			1080
WIZ-->			1
ROS	Avg	Std Dev	Acres
1	0.5	0.2	0.5
2	1.3	0.4	1.6
3	3.1	1.3	5.0
4	6.6	2.8	10.1
5	12.1	5.0	16.8
6	20.0	8.0	24.8
7	30.8	12.0	34.1
8	45.0	17.2	44.6
9	62.9	24.0	56.3
10	85.1	32.6	69.5
15	276.8	112.3	168.0
20	649.2	278.8	374.4
25	1269.0	569.3	804.9
30	2207.6	1027.5	1629.5
35	3427.5	1770.2	2000.0
40	5003.6	2879.1	2000.0
45	6991.7	4425.4	2000.0
50	9492.6	6459.7	2000.0
55	12570.3	9058.9	2000.0
60	16290.5	12310.7	2000.0
65	19212.3	14298.3	2000.0
70	21849.3	16655.9	2000.0
75	24442.1	19915.0	2000.0
80	27347.0	24205.3	2000.0
85	29947.6	29126.7	2000.0
90	32620.6	34923.8	2000.0
100	36124.3	38901.0	2000.0
120	40031.6	42376.1	2000.0

Example of the Calculation of WFSI

The WFSI is calculated for each percentile weather category for each 30-meter by 30-meter cell on burnable area within the state. The four WFSI values from the four Percentile Weather Categories are summed to obtain the WFSI for a cell. The calculation is done for cells within a FOA and WIZ intersection. 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?"



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. The data flow is shown via the example in Table 4 below. 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.

Table 4. Example of WFSI calculation

Row	Item	Percentile Weather				Total
		Low	Moderate	High	Extreme	
1	Percent of Fires	10%	80%	8%	2%	100%
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	**WFSI**	0.00001	0.00048	0.000784	0.00180	0.003074

Note there are 100 fires per year ((0.1 fires / 1000 acres) * 1,000,000 acres). Row 1 gives the Percent of Fires that have historically occurred within each of the Percentile Weather Categories.

Multiplying the Proportion of Fires in each Percentile Weather Category by the total number of fires in the FOA 1 / WIZ 1 intersection (100 fires) allows for determination of the Number of Fires in each Percentile Weather Category, Row 2.

Using FLFRAS the FB3 program has calculated a Rate of Spread for each Percentile Weather Category (Row 3) and a Rate of Spread versus expected Final Fire Size Relationship (Row 4) has been determined. This allows for the determination of the expected Final Fire Size within each Percentile Weather Category.

Multiplying the Number of Fires per year in each Percentile Weather Category by the expected Final Fire Size 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, WIZ 1 intersection (1,000,000 acres) yields the WFSI within each Percentile Weather Category (Row 6). The WFSI for the cell is the sum of the four Percentile Weather Category WFSI values. This is referred to as the "calculated WFSI".

In the 2002 FL FRA, the WFSI was displayed by 30m pixels using its calculated WFSI value. This resulted in a map with a large variety of WFSI value differences in adjacent cells. In other words, the map looked very pixilated. In addition, this did not account for the fire threat to a cell from adjacent cells. To help mitigate both of these issues, a GIS smoothing operation (roving window with 240 m radius) was used to assign a "smoothed WFSI" value to each cell. This value was calculated as the average of the cellular WFSI values within the roving window.

The "smoothed WFSI" values provide a better relative value of WFSI since the value considers the probability of cells around it. A cell with lots of cells around it with higher WFSI will have its value increased because there is a greater probability that it will burn since many of the cells around it may burn; while a cell with lots of cells around it with lower WFSI values will have its WFSI value reduced. Figure 20 presents an example of "calculated" and "smoothed" WFSI. The 2011 FL FRA uses the "smoothed" WFSI.

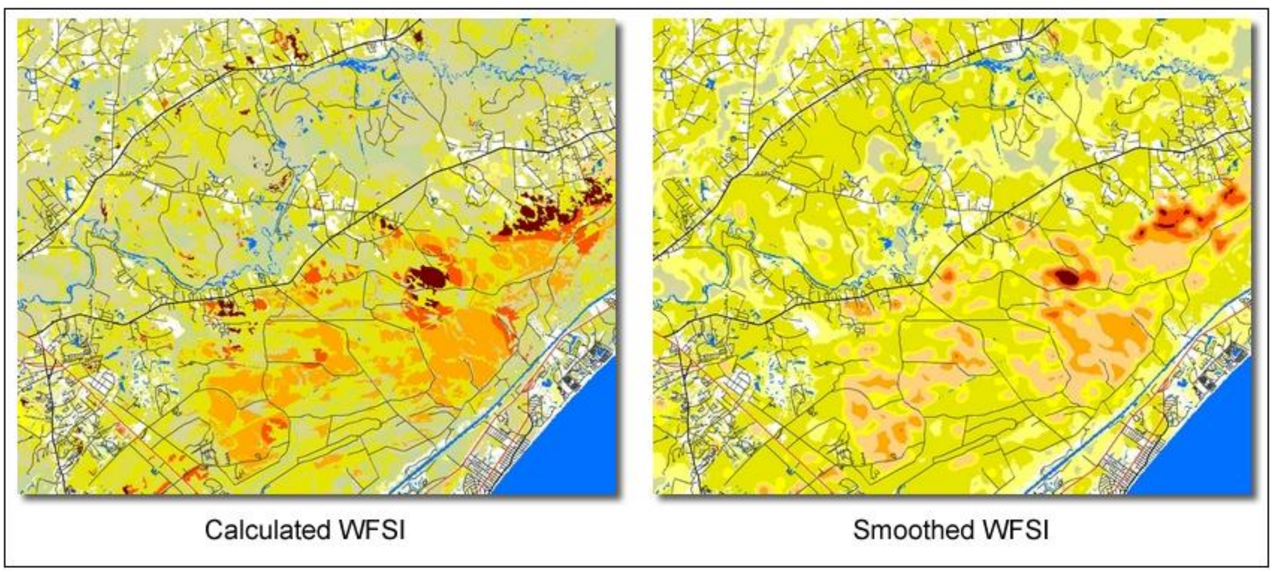
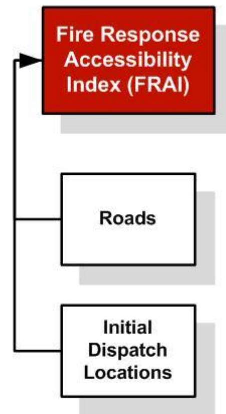


Figure 20. Examples of calculated and smoothed WFSI

3.5 Fire Response Accessibility Index (FRAI)

The Fire Response Accessibility Index (FRAI) is a relative measure of how long it would take initial attack resources to drive from their resource location to any cell (location) on the map. This metric has no association with Level of Concern, WFSI or Fire Effects Index.



FRAI is calculated based on the distance from initial dispatch locations. The speed traveled on roads was estimated based on the class of road. Four classes were used (See Roads data description). Travel off of roads was assumed to be at 5 mph. Water was coded as "No Data," meaning that travel across water could not be done unless there was a road crossing. An approximate time to reach each cell is calculated using spatial cost distance analysis algorithms.

FRAI allows users to identify areas of low accessibility from their dispatch locations. Coupled with the Level of Concern data, this information will highlight areas where accessibility is low and the level of concern is high, providing valuable information for those concerned with the impacts of wildland fire.

The FRAI is divided into six categories as shown at the right.

An example of the FRAI is presented in Figure 21. Initial dispatch locations are shown as a blue circle with a white center on the map. Note that travel time increases for those areas farthest removed from transportation routes and initial dispatch locations.

Table 5. FRAI categories

FRAI Class	Estimated Travel Time from Resource Location to Cell
1	0 – 15 Minutes
2	16 - 30 Minutes
3	31 – 45 Minutes
4	46 – 60 Minutes
5	61-120 Minutes
6	> 120 Minutes

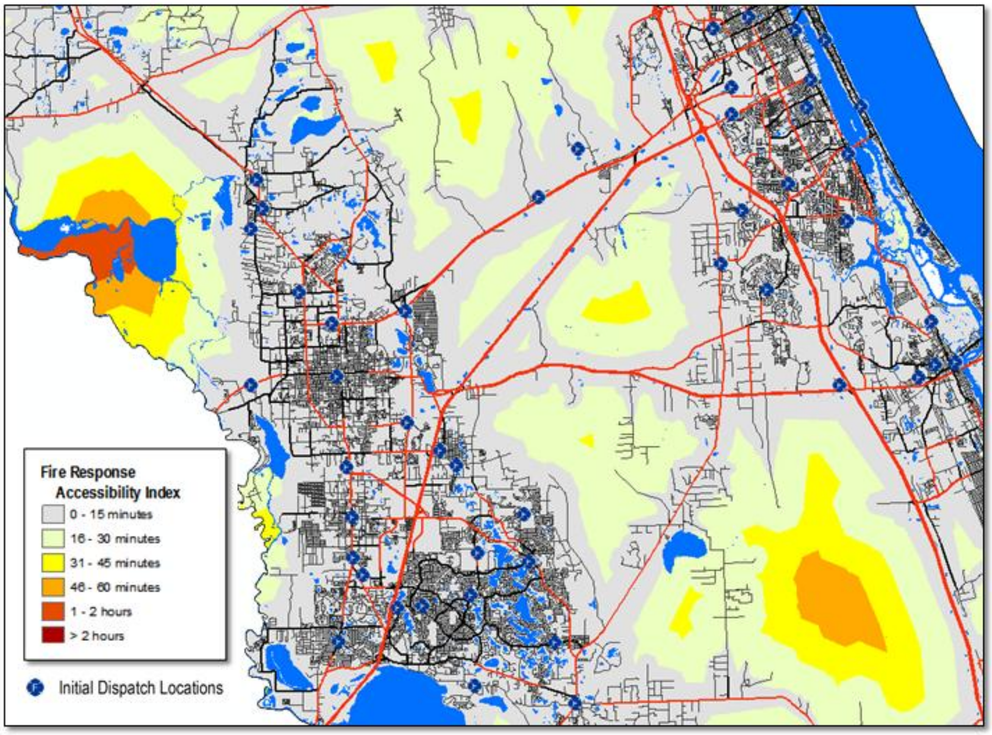


Figure 21. Example FRAI map

Initial Dispatch Locations

Initial dispatch locations data represents where firefighting resources are stored and are generally the first to respond to a wildfire within their jurisdiction. Data was derived from 2009 statewide emergency services facilities data. FDOF district offices and other FDOF facilities were added. Tools are provided in the 2011 FLFRAS application to edit dispatch locations by removing, adding or moving points. The user can then rerun the analysis to determine the impact of these changes.

Road Detail and Travel Speeds

Capabilities are also provided in the 2011 FLFRAS application that allow the user to select the road layers and define the average speed for the layer, as well as change the off road travel speed. By changing the input layer, particularly if Florida acquires more detailed roads data, the user can analyze the impact on accessibility. The tool is designed to support on-going analysis as resources, priorities and budgets change over time.

3.6 Communities at Risk Analysis

Analyzing the wildfire risk to communities is addressed in the 2011 FL FRA by providing a baseline communities dataset as part of the 2011 Published Results, and also, by providing an Area of Concern (AOC) analysis tool in 2011 FLFRAS. By applying the tool with the communities dataset (or subset of the data), a risk rating can be defined for each community. This analysis differs from all other analyses undertaken in the FL FRA as it applies the wildfire risk outputs for a specific purpose – assessing the impact on communities. This provides immediate utility for mitigation planning. The AOC tool is discussed further in Section 4.1 of this document.

Rating Communities for Wildfire Risk

As part of the 2011 FL FRA, communities were rated by the Communities at Risk (CAR) analysis, using a process called Areas of Concern (AOC). AOC averages WFSI for a buffered polygon. We refer to this as the "polygon zone". For the 2011 FL FRA Published Results CAR dataset, a three mile buffer was used around communities (Figure 22). The mean WFSI calculated for each polygon zone was then applied to each polygon. The mean WFSI values were categorized into five values: Level 1 thru Level 5.

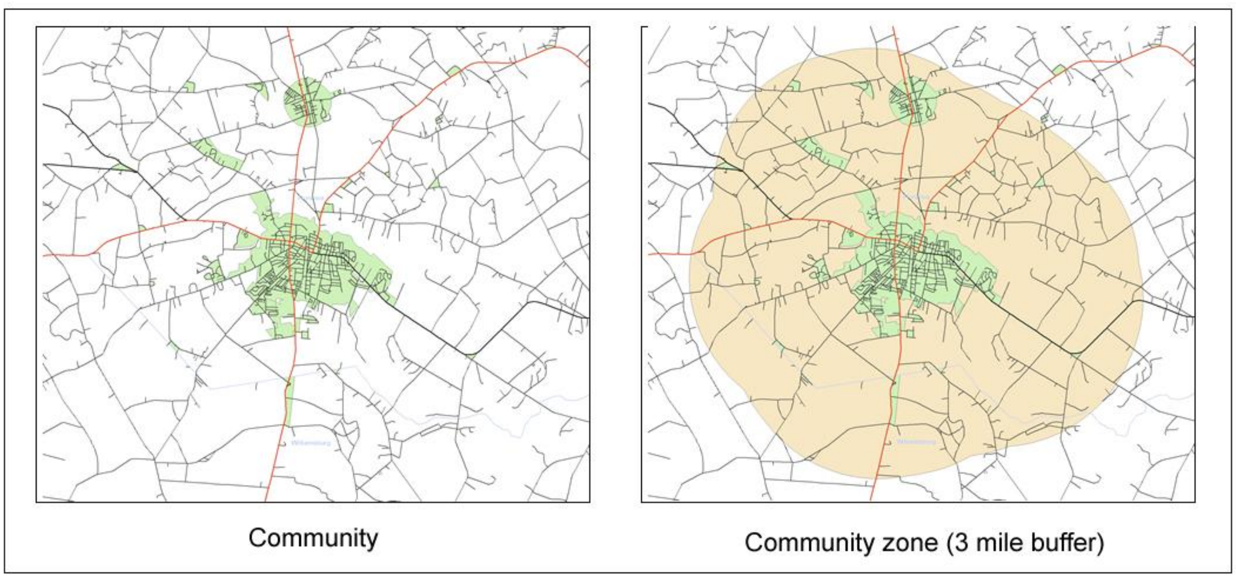


Figure 22. Example community and buffer zone

For the 2011 FL FRA Published Results, the calculation of CAR values was customized to allow calculation on both a statewide and regional basis, with the regions being the four, Florida Division of Forestry Regions. For both the statewide and regional CAR results, the Florida Division of Forestry opted to use Natural Breaks (Jenks, 1967) to define class thresholds, or breaks, for CAR. Natural Breaks divides a range of values, in this case mean WFSI, by minimizing the variance within each class and maximizing the variance between classes. Within the state and within each Region, the CAR class breaks (Levels) can be compared relative to one another. However, CAR class breaks should not be compared between regions or between regions and the state. That is, Level 2 in Region 1 should not be considered the same as Level 2 in Region 4 because they cover different ranges of mean WFSI values. The class breaks are shown below in Table 6.

Table 6. Class breaks used for the CAR analysis

Class Description	CAR Class	Class Values (Mean WFSI)				
		Statewide	Region 1	Region 2	Region 3	Region 4
Level 1	1	0.000032 - 0.038791	0.001224 - 0.015338	0.006598 - 0.043387	0.000050 - 0.047767	0.000032 - 0.027765
Level 2	2	0.038792 - 0.082976	0.015339 - 0.032565	0.043388 - 0.072353	0.047768 - 0.092675	0.027766 - 0.069616
Level 3	3	0.082977 - 0.136591	0.032566 - 0.058047	0.072354 - 0.105250	0.092676 - 0.140288	0.069617 - 0.133760
Level 4	4	0.136592 - 0.206911	0.058048 - 0.100877	0.105251 - 0.158175	0.140289 - 0.206911	0.133761 - 0.212510
Level 5	5	0.206912 - 0.368438	0.100878 - 0.197753	0.158176 - 0.290908	0.206912 - 0.368438	0.212511 - 0.320526

4.0 Florida Wildfire Risk Assessment System (FLFRAS)

The primary technology transfer method used in the 2011 FL FRA project involved the development and provision of the 2011 Florida Fire Risk Assessment System (FLFRAS)[6] to the State. The FLFRAS software encapsulates the assessment results and provides capabilities to create maps and reports using the assessment Published Results[7]. FLFRAS also provides modeling capabilities to allow users to utilize the assessment results for evaluating differing mitigation options, such as fuel treatments, and analyzing the wildfire risk to communities.

1. FLFRAS provides a computer program for personnel to access and use the Published Results.
2. FLFRAS provides a communication method to display the existing wildland fire risk situation within each state to managers, officials and legislators, and operational staff.
3. FLFRAS provides modeling capabilities that support staff in modifying key inputs to reflect local knowledge and situations, to derive custom outputs for Wildland Fire Susceptibility Index, Level of Concern, Fire Response Accessibility Index, and Communities at Risk.

FLFRAS has been developed using the ArcGIS v9.3 software platform and licensed to all FL FRA project participants.

4.1 Overview of FLFRAS

Design and Architecture

FLFRAS was developed as a standalone extension that operates on the ArcGIS v9.3 software.[8] FLFRAS was designed to leverage the capabilities found in the ArcGIS software using the standard ArcMap interface as the framework for the FLFRAS interface.[9] FLFRAS is accessed via a series of custom pull-down menu options within ArcMap that provides custom functionality. Data is managed within FLFRAS using standard ArcGIS Personal Geodatabases and raster files.

[6] For the remainder of this section, FLFRAS will mean the 2011 FLFRAS. If the 2002 FLFRAS is referred to, it will be specifically stated as such.
[7] The models in FLFRAS are the same models used to develop the Published Results.
[8] FLFRAS was specifically designed to operate on the 9.3 version of ArcGIS ArcView. The application will not operate on the ArcView 3.x platform.
[9] ArcMap is the primary interface for the ArcGIS software.

All other standard ArcGIS functions are available while the FLFRAS tools are also available. In several instances, custom tools have been developed to facilitate analysis and review of data. However, none of the core capabilities found within ArcGIS have been removed. The ArcGIS platform provides a robust and extensive framework for growth of FLFRAS and further analysis by operational staff.

This is a key design principle of FLFRAS – to leverage the rich functionality already available within ArcMap so that all FLFRAS data is available for use within ArcMap and ArcToolbox.

The data model employed with FLFRAS utilizes a predefined directory structure that uses ArcGIS Personal Geodatabases and raster files as the key data elements. Numerous attribute lookup tables are stored in the Geodatabases to manage the operation of the application and store data references and preferences for the user.

A detailed review of FLFRAS and its capabilities can be found in the FLFRAS User Guide.[10]

ArcGIS Spatial Analyst

The ArcGIS Spatial Analyst extension is required to facilitate all the modeling, raster data manipulations, and analysis capabilities within FLFRAS.

ArcGIS Extension and FLFRAS MXD

In order to facilitate use of FLFRAS within the existing use of ArcMap documents (.mxd), FLFRAS was designed as an extension. ArcGIS *extensions* can operate in any ArcMap document. This allows users to gain access to FLFRAS capabilities when using their own custom ArcMap documents.

A default ArcMap document (FLFRAS.mxd) is provided as an ideal starting point for learning FLFRAS. The default ArcMap document has predefined layers and has the extension already loaded. The project file is **FLFRAS.mxd** and can be found in the "**FLFRAS**" installation data folder. Double click on the .mxd file to open the project.

It is recommended that users utilize this document until they are familiar with FLFRAS capabilities. The document has been designed so it can satisfy all requirements. The use of other ArcMap documents is not required, but accommodated.

FB3 DLL Integration

FLFRAS has seamlessly integrated the FB3 DLL fire behavior program.[11] The FB3 DLL program provides fire behavior analysis capabilities required to derive outputs for use in the WFSI model. A custom GIS software wrapper has been developed by Sanborn to ensure

[10] FLFRAS User Guide, Version 9.3. Sanborn Map Company, January 2011.

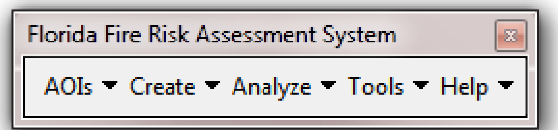
[11] FB3 DLL is commercially licensed software from Fire Program Solutions. FB3 provides fire behavior analysis capabilities for FLFRAS and is licensed solely for use within the FLFRAS interface to SWRA participants.

seamless integration between ArcGIS raster data processing methods and the DLL. This integration is required for the program to operate with GIS data sources with the ArcGIS platform. The integration provides transparent calculation of fire behavior metrics, such as Rate of Spread, without any interaction required by the FLFRAS user. This approach provides significant operating advantages over other fire behavior programs with respect to performance and ease of use.

An overview of the capabilities of FLFRAS is provided below. Please refer to the FLFRAS User Guide for detailed descriptions of FLFRAS capabilities and how to use FLFRAS.

Capabilities

The FLFRAS extension has been designed as a series of pull-down menu options that operate in the ArcMap interface.

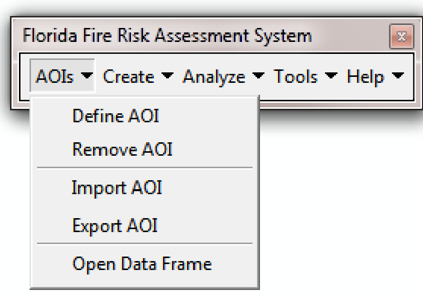


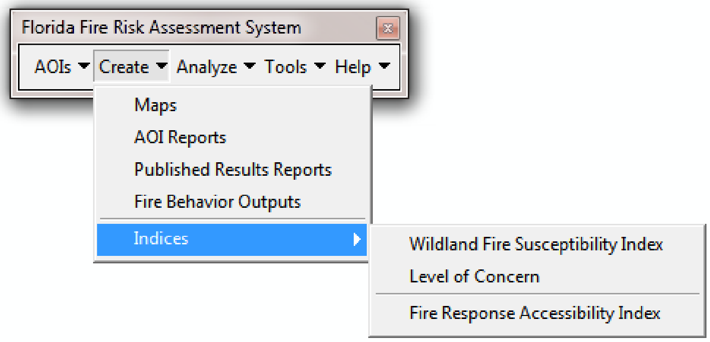
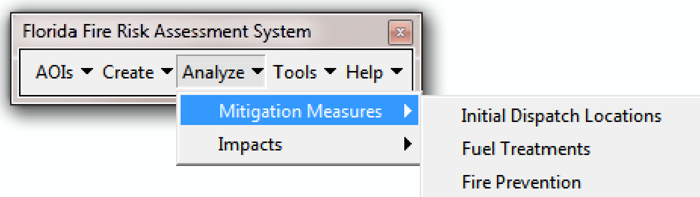
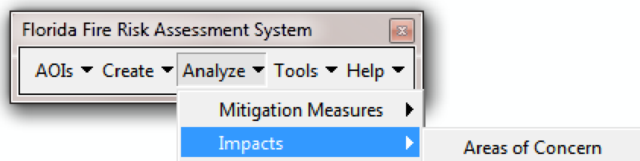
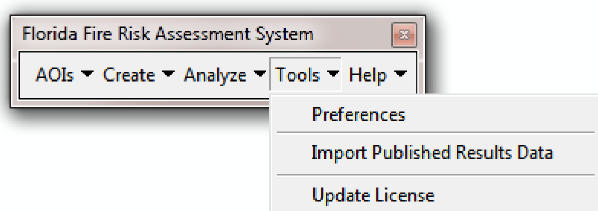
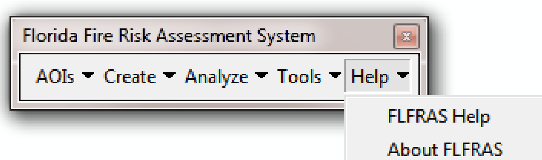
The FLFRAS menu is organized with the following menu options:

AOIs	Tools for creating AOIs to support analysis and modeling of specific user defined areas
Create	Tools for creating output maps and reports of Published Results, and for creating output indices for AOIs
Analyze	Tools for analyzing mitigation measures and impacts
Tools	Tools to support data loading and preferences
Help	Access to the on-line help

The following table (Table 7) presents the complete list of FLFRAS menu options.

Table 7. FLFRAS Menu Options

Menu Option	Description
	**Tools to manage user defined areas of interest** • Define a new AOI • Remove an existing AOI • Import a saved AOI from zip file • Export an existing AOI to a zip file • Open an existing data frame

Menu Option	Description
	**Tools to create outputs** Maps • Create predefined maps in different scales/sizes Reports • Create AOI Reports • Create Published Results Reports Fire Behavior Outputs Indices • Recreate the WFSI • Recreate LOC • Recreate FRAI
 	**Tools to analyze data and results** Analyze mitigation measures by modifying core data • Modify initial dispatch locations • Simulate fuel treatments over time • Analyze Fire Prevention Evaluate assets impacted by potential fire • Categorize Areas of Concern
	**Tools to support data loading and user preferences** • Define application preferences • Load Published Results data from standard delivery format • Update license file
	**On-line help** • On-line procedural help (user guide) • Standard 'About' info

Using the 2011 FL FRA Published Results

As previously noted, the primary deliverable from the 2011 FL FRA project is the updated Published Results. These outputs provide a data platform for use by operational fire staff, fire managers, and decision makers, in mitigation planning and communication activities.

FLFRAS has been designed to clearly distinguish between review of the Published Results, and tools to support deriving new results for user defined areas of interest (AOIs). The Published Results data cannot be modified directly with FLFRAS. However, they can be used as inputs for modeling smaller areas of interest defined by the user. In this regard, FLFRAS will support the user in analyzing management options for fire risk mitigation. AOI data is maintained separately so that it does not change the Published Results data.

Generating Output Maps and Reports

Tools are provided within FLFRAS to generate maps and reports for the Published Results and AOI data. The same suite of tools can be used on either data.

Standard Maps

A series of standard maps are provided in FLFRAS. Users can generate maps quickly and easily using either Published Results data or newly created custom AOI data in either landscape or portrait mode ranging from 8.5 x 11 up to E-size plots. There are 10 standard maps provided with FLFRAS:

- Areas of Concern Category
- Environmental Effects Rating
- Fire Behavior
- Fire Effects Category
- Fire Occurrence Areas
- Fire Response Accessibility
- Level of Concern
- Suppression Costs Rating
- Surface Fuels
- Wildland Fire Susceptibility Index

Standard Reports

A series of standard reports are provided in FLFRAS. Users can generate reports using either Published Results or custom AOI data.

There are 17 standard reports provided with FLFRAS, of which 11 are dynamic reports to reflect the current information within the AOI and 6 are static reports that reflect the Published Results information for the FL FRA project.

Published Results Reports

- Fire History
- Fire Occurrence Area
- Surface Fuel Models
- Wildland Fire Susceptibility Index
- Level of Concern
- Communities at Risk

AOI Reports

- Fuel Model Acres by FOA category
- Fuel Model Acres by WFSI category
- Fuel Model Acres by Effects category
- Fuel Model Acres by LOC category
- Fire Behavior Acres
- FOA acres by WFSI category
- FOA acres by Effects category
- FOA acres by LOC category
- WFSI acres by LOC category
- Effects acres by LOC category
- LOC acres by FRAI category

Using FLFRAS for Fire Management Planning

The analysis and modeling functions provided within FLFRAS are intended to provide information to be analyzed when developing options to mitigate effects and analyze impacts of a wildland fire. Areas where the FOA, WFSI or LOC are high are candidates for mitigation projects. The alternatives are to:

1. Change fuel loading (fuel treatments),
2. Change fire suppression capability (change initial dispatch locations), and/or
3. Create defensible space (location specific survivability).

FLFRAS allows for the definition of project areas (referred to as AOIs) with the ability to recreate outputs such as WFSI, LOC and CAR based on changes in fuel model. Changes in accessibility (FRAI) can also be modeled by editing initial dispatch locations. Analysis and modeling capabilities only operate on AOIs, not on the Published Results data.

Deriving New Indices and Values to Assess Mitigation Measures

In order to effectively utilize FLFRAS for fuels management and mitigation, a fuels modification tool was developed. This tool allows the user to modify fuel models for a user defined Project Area (treatment area), generate updated fuels over a 10 year profile (i.e. the fuels planning horizon), and then use the updated fuel layers to recreate the Wildland Fire Susceptibility Index (WFSI) or Level of Concern (LOC). Outputs can then be used to analyze the change in risk to communities.

Because fuels do not immediately return to their pre-treatment state, it was determined that the expected FBPS fuel model or custom FBPS derivative fuel models would be determined for each of 10 years following a fuel treatment. We refer to this as the fuels planning horizon. Parameters for these horizons were defined by fuel specialists during the SWRA project. These included:

1. Fuel treatment types, (i.e.: broadcast prescribed fire, pile and burn, etc.)
2. Characteristics of the fuel profile following fuel treatment
3. Assignment of a FBPS fuel model or custom FBPS derivative fuel model to the post-treatment fuel profiles, and
4. Identification of the expected FBPS fuel model or a custom FBPS derivative fuel model for 10 years following treatment for each post-treatment fuel profile.

The FLFRAS fuel treatments tool provides fire specialists the capability to simulate numerous fuel treatments over a 10 year planning horizon. Once all treatments are defined, the user can simulate the effect of the treatments on fuels for the entire 10 year period (or selected years). The following figure presents an example of a prescribed burn fuel treatment and the subsequent surface fuels derived immediately following treatment, and in 2014. The output fuels were derived by applying the temporal fuel profiles in the treatment area. Note that custom fuel models with different loading characteristics have been defined for each standard FBPS fuel model to facilitate this modeling capability (Appendix D). Fuel model legends are shown.

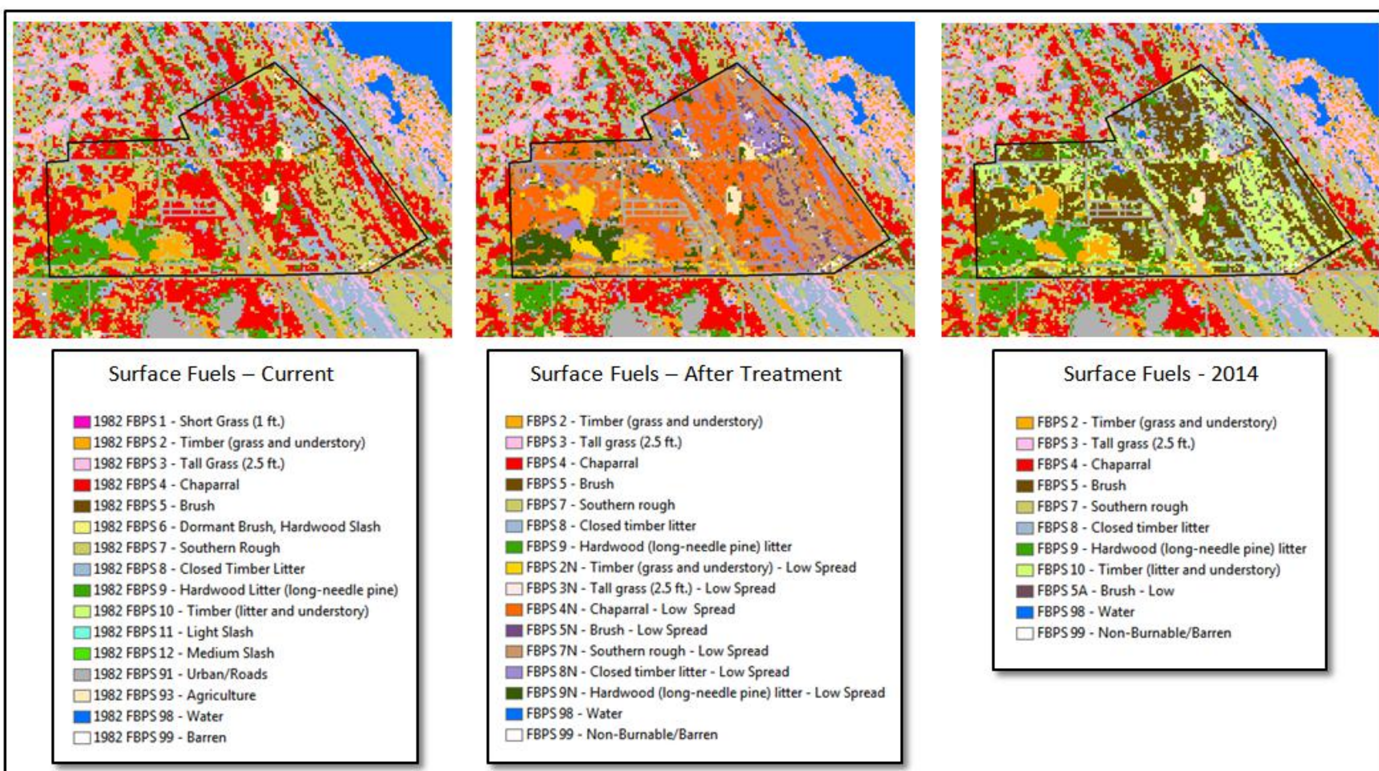


Figure 23. Example of fuel treatment modeling outputs

Once the fuels have been derived for the years of interest, WFSI and/or LOC can then be calculated for those new fuels. The following figure presents the WFSI derived using the output fuel layers for current conditions, immediately following treatment (2010), and in 2014. Note that the risk (WFSI) has been significantly reduced within the treatment area for both time periods (2010 and 2014).

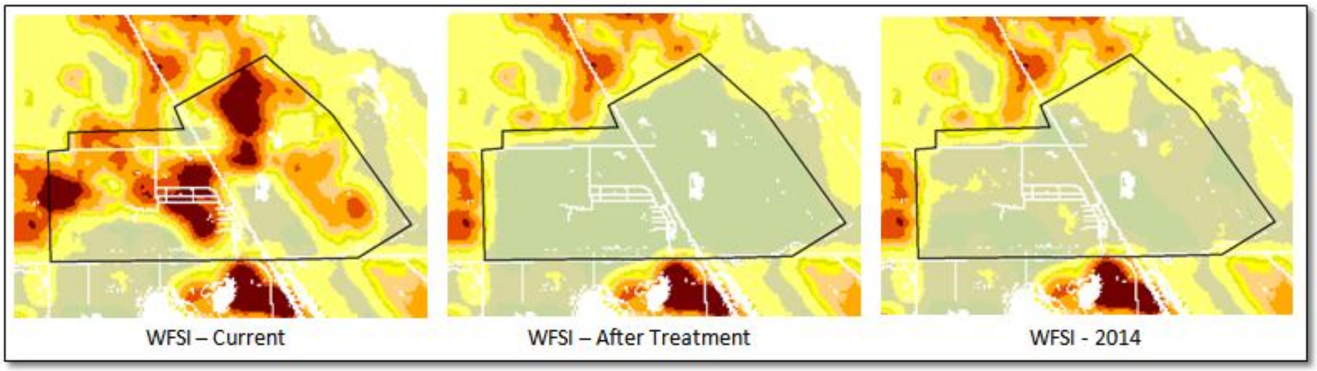


Figure 24. Example of WFSI outputs for fuel treatment AOI

Assessing Risk for Communities

Analyzing wildfire risk to communities is addressed in the FL FRA by providing a baseline communities dataset and an initial communities at risk (CAR) assessment as part of the Published Results, and secondly, by providing an area of concern (AOC) analysis tool in the FLFRAS. By applying the tool with the communities dataset (or subset of the data), a risk rating can be defined for each community.

This tool is useful in two ways. First, within the State, County, or AOI, communities can be categorized based on their level of risk, which can aid in identifying the location where more detailed fire planning may be needed. Second, users are able to identify, categorize and prioritize those areas (not communities necessarily) where tactical analyses and community interaction may be necessary to reduce risk from wildfire. The AOC analysis tool provides a starting point for prioritizing mitigation plans including the development of Community Wildfire Protection Plans (CWPP) for those communities most at risk. The FLFRAS AOC tool has been designed to meet the guidelines identified by the National Association of State Foresters Field Guide for Identifying and Prioritizing Communities at Risk.[12]

[12] Field Guide: Identifying and Prioritizing Communities at Risk, National Association of State Foresters, June 27, 2003. Please refer to this document for more details on the guidelines. Only a summary of the basic approach is provided above.

The AOC tool provided in FLFRAS can be used to calculate mean WFSI ranges for any input polygon dataset. The class thresholds used by the AOC tool are the standard WFRAS[13] class breaks (Table 8).

These class breaks are used to display all AOC results. Because of the different methods used for displaying Published Results CAR and AOC results, the user must ensure they are using the same layer file when making comparisons across datasets. We also recommend displaying Mean WFSI as a label when comparing changes across datasets.

Table 8. Standard class breaks for the WFRAS AOC tool

Class Description	AOC Class	Value Ranges (mean WFSI)
Level 1	1	0.000 to 0.000999
Level 2	2	0.0001 to 0.009999
Level 3	3	0.010 to 0.199999
Level 4	4	0.200 to 0.599999
Level 5	5	0.600 to 1.00000

Using AOC to Compare WFSI for Different Time Periods

AOC should be rerun each time the WFSI layer is modified. This frequently occurs when changes are made to the surface fuels or fire occurrence layer. Since these changes will result in a different WFSI output, the AOC ratings may also be subject to change. An example is provided below.

WFSI will change whenever fuel treatments are applied in an area. AOC ratings will typically change when these treatments are adjacent to a community, especially if volatile fuels and high WFSI values exist. If the fuel treatments are within the buffer zone for a community, the WFSI value will definitely change, and the AOC rating may (or may not) be affected.

Figure 25 shows an AOI and community with a single fuel treatment focused on the highest WFSI values (left). A map is shown for 2009 (right) where the WFSI has been significantly reduced by the fuel treatment activity.

[13] WFRAS is the base component of the FLFRAS software. The Florida custom component is built on top of WFRAS.

Figure 26 shows the Communities at Risk ratings for the initial 2007 Published Results conditions (left - prior to the fuel treatment) and the Area of Concern ratings in 2009 (right) after the fuel treatment. Note how the AOC rating has been reduced for several small communities due to the change in WFSI caused by the fuel treatment. Refer to the AOC classes described above to see the change from Level 5 to Level 2.

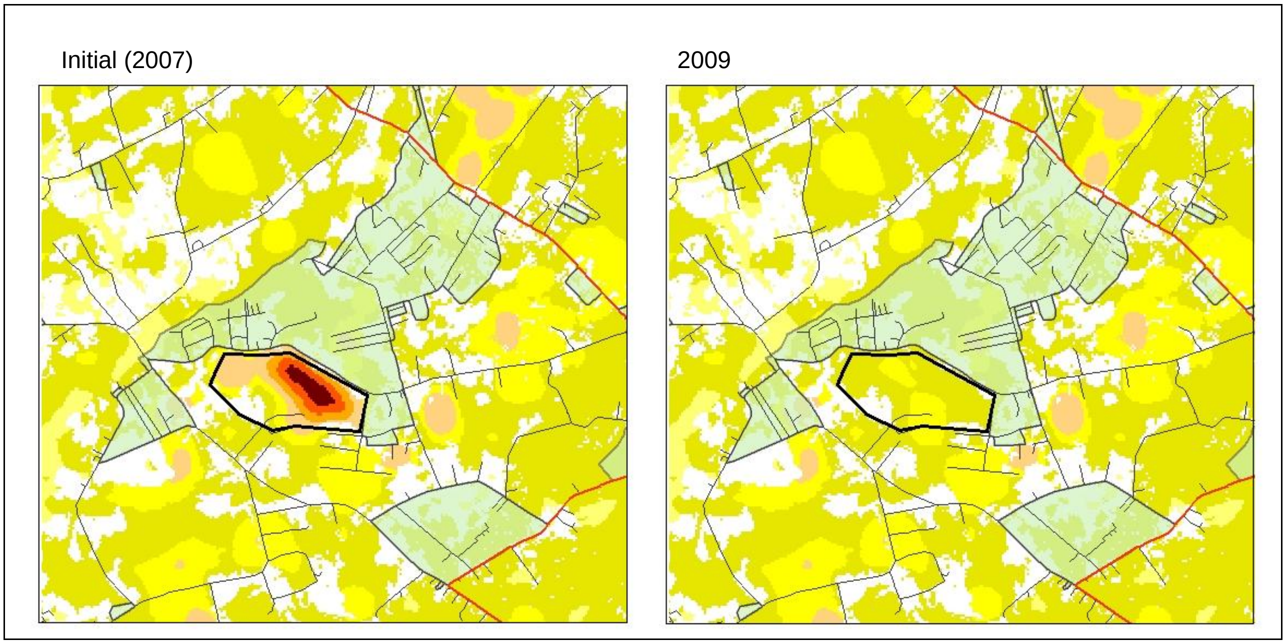


Figure 25. WFSI: Initial (2007) and 2009 showing fuel treatment area

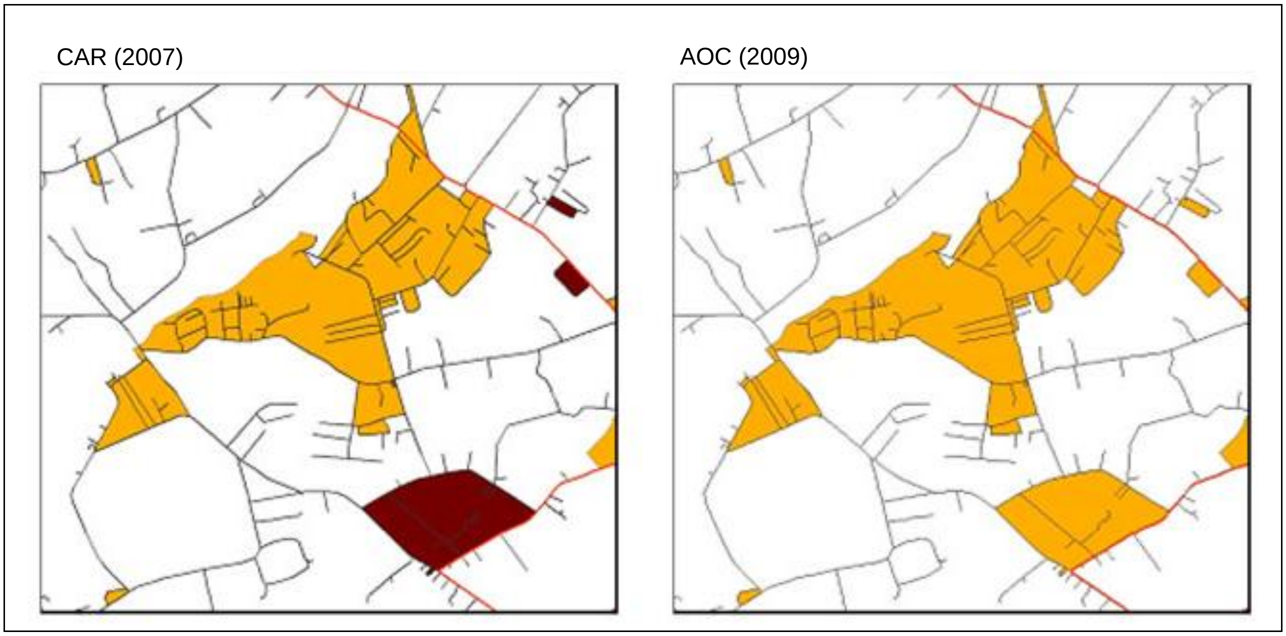


Figure 26. CAR Ratings (2007) and AOC Ratings (2009)

4.2 FLFRAS Licensing

FLFRAS is licensed software available at no charge to participants of the SWRA project. The Sanborn Map Company (Colorado Springs, CO) retains ownership of the software programs and manages user licenses through a software product web site. Evaluation copies of FLFRAS are available for free download from the product web site. Software licenses must be obtained from Sanborn for continued use of the software. An SFRAS license request form is located on the website for this purpose.

For more information on support and maintenance see Section 5.4.

5.0 Final Deliverables

This section provides a description of the final project deliverables.

5.1 Published Results

The outputs from the Florida Wildfire Risk Assessment that define the current fire situation in Florida 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. Published Results were delivered as GIS data partitioned and zipped by County (ESRI data formats).

The primary output datasets and maps delivered were:

1. Level of Concern Index (LOC)
2. Wildland Fire Susceptibility Index (WFSI)
3. Fire Effects Index (FEI)
4. Fire Response Accessibility Index (FRAI)
5. Communities at Risk (CAR)
6. Environmental Effects Rating
7. Suppression Costs Rating

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

5.2 Data Formats and Delivery

All data acquired and compiled for the FL FRA project was delivered with the following format and specifications:

1. Data was received from the State of Florida and then partitioned by County. All data was delivered in ZIP format that included embedded ArcGIS raster data and a Personal Geodatabase containing all vector layers for the County. One ZIP file was delivered for each County.

2. Raster data was delivered in ArcGIS grid coverage format. Vector data was provided in a Personal Geodatabase (one per County). All data was clipped to County boundaries.

The Published Results were delivered to the state on DVD. The FLFRAS software was delivered via DVD as well as through the product website.

5.3 Documentation

Several documents were developed and provided as project deliverables. These include:

- FLFRAS project web site – http://gis.sanborn.com/SFRAS
- FL FRA Final Report (this document)
- FLFRAS User Guide

Project Web Site

A project web site was created that provides summary information about the FL FRA project. Some project deliverables are available for download from the site. The site is hosted by Sanborn as part of the SWRA Maintenance project. The following diagram (Figure 27) presents the FL FRA project's web site home page.

FL FRA Project Final Report

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.

FLFRAS Software User Guide

A detailed FLFRAS User Guide has been released with the final version (9.3) of the FLFRAS software. This document provides a procedural description of how to use the FLFRAS software. The complete content of the user guide is available as on-line help in the FLFRAS application.

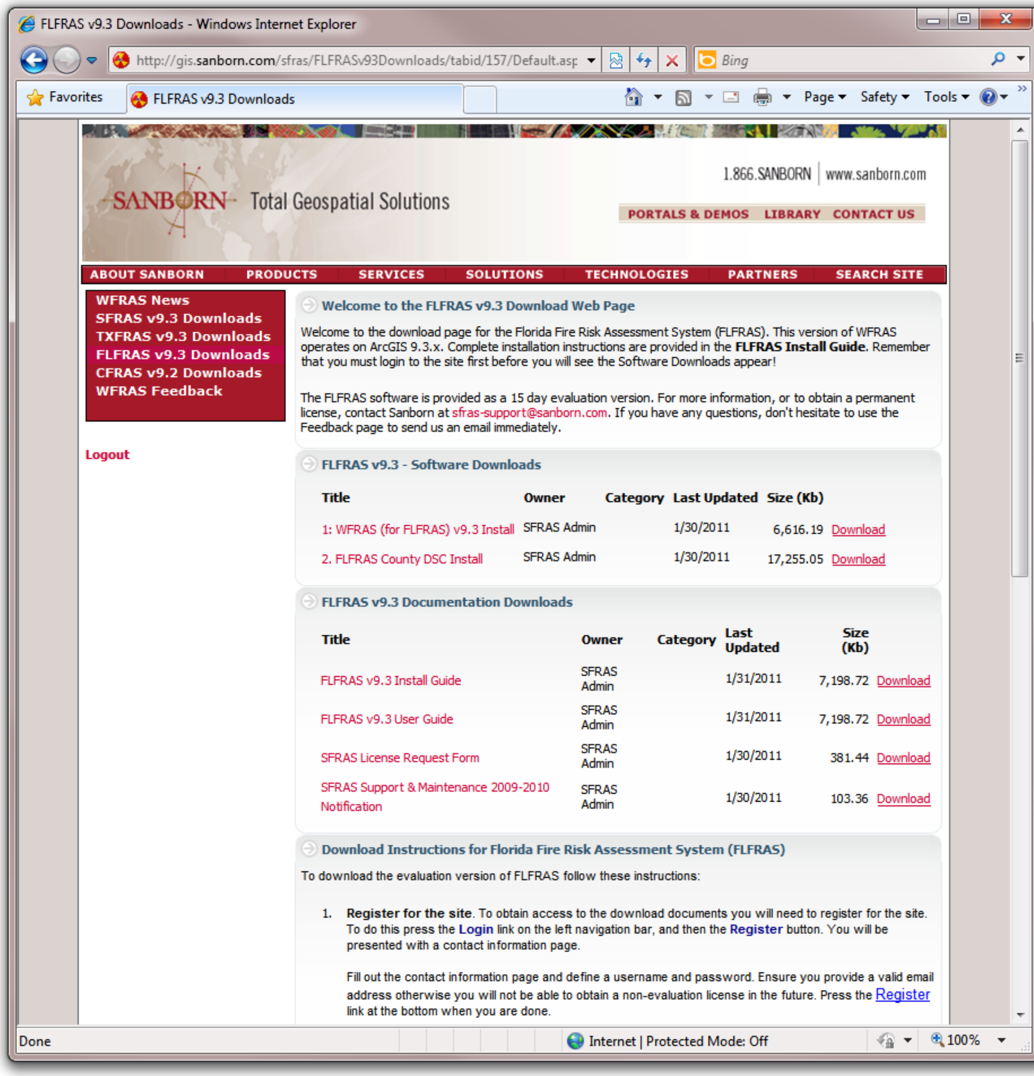


Figure 27. FL FRA project web site

5.4 On-going Support and Maintenance

The FLFRAS County DSC is a customized version of the SFRAS application. As with SFRAS, support and maintenance for FLFRAS is facilitated through an on-going software support and maintenance agreement coordinated through the Southern Group of State Foresters (SGSF). Users can send inquiries directly to the SFRAS Support email address at SFRAS-support@sanborn.com or access the software, license and other documentation via the software product website http://gis.sanborn.com/SFRAS.

To assist the user with understanding the appropriate contact for questions, we are providing the following summary:

- For more information about the FL FRA project contact Jim Brenner, FL FRA Project Manager, Florida Division of Forestry at: Jim.Brenner@freshfromflorida.com.
- For more information about FLFRAS licensing contact The Sanborn Map Company at SFRAS-support@sanborn.com or visit the SFRAS website at: http://gis.sanborn.com/SFRAS.
- Technical Support questions about application functionality, performance, etc. should be made to the SFRAS Support email address at SFRAS-support@sanborn.com.
- Academic questions regarding modeling, fire behavior, etc. should be directed to the Florida Division of Forestry Fire Management Administrator.

The current capabilities of FLFRAS are not intended to satisfy all fire management or fuels management requirements. Capabilities were developed to meet the specific needs as defined for the FL FRA project. Suggestions for improvement should be directed to the SFRAS support email address.

Technical Appendices

A. 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.

AOI – Abbreviation for Area of Interest.

Area of Interest – Generally a subset area inside a County or Counties that one wishes to define. An entire County can be defined as an Area of Interest. Within an Area of Interest, Project Areas can be defined for analysis of mitigation measures.

Broadcast Rx fire – The application of fire to the entire Project Area.

Broadcast Rx fire followed by chopping – The application of fire to the entire Project Area followed by the mechanical application of equipment that chops vegetation into smaller pieces.

Broadcast Rx fire followed by herbicide – The application of fire to the entire Project Area – followed by the application of herbicide to the entire Project Area.

Chopping and harrowing – Chopping of wildland fuels followed by harrowing.

Chopping followed by Rx Fire – Chopping of wildland fuels followed by fire.

Critical Facilities – These areas includes a buffered distance from specified roads together with schools, hospitals and designated airports.

Defensible Space – The area around a structure that when cleared of flammable vegetation increases the ability of firefighters to protect the structure from a wildland fire.

Environmental Effects Rating – This rating is the sum of the individual effects scores for critical facilities, urban interface, utility corridors and plantations adjusted based on the total maximum value.

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.

Fb3.dll – The fb3.dll is a dynamic link language program that generates fire behavior data across the landscape for a given set of weather, fuels and fuel moisture data inputs.

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 BehavePlus computer systems.

Fire Effects Index - The Fire Effects Index was calculated by adding 80% of the Environmental Effects Rating to 20% of the Suppression Costs Rating. The Fire Effects Index can range from 0 – 100.

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

Fire Response Accessibility Index - The Fire Response Accessibility Index (FRAI) is a relative measure of how long it would take initial attack resources to drive from their resource location to the cell.

FireFamily Plus – 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.

Florida Fire Risk Assessment System – A computer application which is an extension to the ArcGIS 9.3 software that allows for the viewing and printing of information from the Published Results as well as the ability to analyze the effectiveness of some mitigation measures.

Florida Wildfire Risk Assessment – The Florida Wildfire Risk Assessment includes all of the data layers, indices, outputs and reports of the Published Results from the Florida Wildfire Risk Assessment Project along with the FLFRAS software.

FOA - Abbreviation for Fire Occurrence Area.

FRAI - Abbreviation for Fire Response Accessibility Index.

FLFRAS - Abbreviation for Florida Fire Risk Assessment System.

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 Profile – A description of the fuels in a wildland area over time.

Fuel Situation - A fuel situation is a specific vegetative and physical condition in Florida that identifies a condition where a specific FBPS fuel model would occur. Within the Florida Fuel Model Dichotomous Key, fuel situations were defined. The same FBPS fuel model can result from different fuel situations. As fuels mitigation measures are defined, the appropriate fuel situation will need to be defined for the fuel models that exist within the Project Area.

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.

Herbicide Only – The application of herbicide as the sole fuel treatment method.

Initial Dispatch Locations – Locations where firefighting equipment is located or stationed.

Level of Concern - The Level of Concern is calculated as the Wildland Fire Susceptibility Index (WFSI) times the Fire Effects Index (FEI). The WFSI is a value between 0 and 1. The Fire Effects Index is a value between 0 and 100. Hence the LOC is a value between 0 and 100.

LOC - Abbreviation for Level of Concern.

Mastication – Use of machinery that uses powered rotary mechanical action to change wildland fuels.

Mitigation Options – Methods and projects proposed to reduce the effects of the current situation. In FLFRAS, analysis of the effectiveness of fuels treatment projects and fire prevention activities to reduce the effects of wildland fires is stressed.

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

Organic / Peat (Muck Soils) - Muck soils are organic soils that constitute areas of concern for firefighting efforts as fires within these areas tend to be expensive and difficult to extinguish.

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

Piling and burning (or chipping) with machine – A fuel treatment method where fuels are arranged by hand or mechanical means into piles which are then burned or chipped.

Plantations – A data layer intended to identify high dollar value vegetative land use/land cover characteristics with the potential for loss in the event of wildfire.

Project Area - A Project Area is defined as the area where fire prevention and/or fuels treatment measures are to be analyzed.

Published Results - The primary output from the Florida Wildfire Risk Assessment developed to describe fire risk across the state. 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.

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 Packing Ratio - This is the fuel model's packing ratio divided by the optimum packing ratio for the fuel model. Vertically oriented fuel beds like grass and brush generally have a relative packing ratio less than one while horizontally oriented fuel beds such as timber litter and slash have a relative packing ratio greater than one.

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.

Suppression Costs Rating – The suppression costs rating is a measure of how difficult it is to suppress a fire. The higher the rating the more difficult the fire is to suppress.

Surface Area to Volume - The 1-h surface-area-to-volume ratio (1-h SA/V) is the amount of area on the outside of the fuel (surface area) divided by the volume of the fuel. A way to visualize the surface-area-to-volume ratio is the square feet of wrapping paper in would take to wrap a box divided by the volume of the box in cubic feet. The 10-h and 100-h SA/V are set at 109 ft2/ft (358 m2/m3) and 30 (98 m2/m3) for all fire behavior fuel models.

Thinning – The cutting of trees generally in diameter classes that are smaller than the average stand diameter for a timber stand. Thinning reduces the number of trees per acre.

Urban Interface – The area between wildland fuels and defined urban communities and areas.

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

WFSI - Abbreviation for Wildland Fire Susceptibility Index.

Wildland Fire Susceptibility Index - The Wildland Fire Susceptibility Index (WFSI) 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 WFSI 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 wildland fire susceptibility. Due to some necessary assumptions, mainly fuel homogeneity, it is not the true probability. But since all areas of the State have this value determined consistently, it allows for comparison and ordination of areas of the state as to the likelihood of an acre burning.

WIZ - Abbreviation for Weather Influence Zone.

Woody - Live woody fuels are shrubs that are living.

B. Literature Cited and References

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

Andrews, Patricia L. 1986. BEHAVE: fire behavior prediction and fuel modeling system-BURN subsystem, Part 1. USDA For. Serv. Gen. Tech. Rep. INT-194. 130 p.

Andrews, Patricia L. 1989. BEHAVE: fire behavior prediction and fuel modeling system-BURN subsystem, Part 2. USDA For. Serv. Gen. Tech. Rep. INT-260. 93 p.

Burgan, Robert E. and Richard C. Rothermel. 1984. BEHAVE: fire behavior prediction and fuel modeling system-FUEL subsystem. USDA For. Serv. Gen. Tech. Rep. INT-167. 126 p.

Carlton, Donald W. and Michael Calvin. 2006. Users' Guide to CrownMass©, Fire Program Solutions and Acacia Services. 112 p.

Florida Fire Risk Assessment Final Report. Dec 2002. Sanborn on behalf of Florida Division of Forestry. Primary authors Don Carlton, Julie Coen.

Florida Fire Risk Assessment System User Guide. Dec 2002. Sanborn on behalf of Florida Division of Forestry. Primary authors David Buckley, Don Carlton, Julie Coen.

Florida Fire Risk Assessment Training Guide. Dec 2002. Sanborn on behalf of Florida Division of Forestry. Primary authors Don Carlton, Julie Coen.

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.

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

Jenks, George F. 1967. "The Data Model Concept in Statistical Mapping", International Yearbook of Cartography 7: 186-190.

Keane, R. E; Elizabeth Reinhardt; Joe H. Scott; Kathy Gray; James A. Reardon. In press.

Estimating forest canopy bulk density using six indirect methods. Can. J. For. Res. In press.

Scott, Joe H.; R. E. Burgan. In press. A comprehensive set of standard fire behavior fuel models for use with Rothermel's surface fire spread model. Rocky Mountain Research Station General Technical Report.

Scott, Joe H.; E. D. Reinhardt. 2005. Stereo Photo Guide for Estimating Canopy Fuel Characteristics. Rocky Mountain Research Station General Technical Report RMRS GTR-145. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 49p.

Scott, Joe H. 2003. Canopy fuel treatment standards for the wildland-urban interface. In: " Fire, fuel treatments, and ecological restoration: conference proceedings; 2002 April 16-18; Fort Collins, CO. Omi, Philip N.; Joyce, Linda A., tech. eds. 2003. Proceedings RMRS-P-29. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, p. 29-37.

Scott, Joe H. and Elizabeth D. Reinhardt. 2002. Estimating canopy fuels in conifer forests. Fire Management Today. 62(4): 45-50.

Scott, Joe H. and Elizabeth D. Reinhardt. 2001. Assessing crown fire potential by linking models of surface and crown fire behavior. Res. Pap. RMRS-RP-29. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 59 p.

C. FBPS Fuel Model Descriptions

Fuel Model Descriptions

Fuel Model 1 Grass– Fire spread is governed by the very fine, porous, and continuous herbaceous fuels that have cured or are nearly cured. Fires are surface fires that move rapidly through cured grass. Very little timber or shrubs is present, generally less than one-third of the area.

Grasslands and savanna are represented along with stubble, grass-tundra, and grass-shrub combinations that met the above area constraint. Annual and perennial grasses are included in this fuel model.

Fuel Model 2 Grass– Fire spread is primarily through the fine herbaceous fuels, either curing or dead. These are surface fires where the herbaceous material, in addition to litter and dead down stemwood from open shrub or timber overstory, contribute to the fire intensity. Open shrub lands and pine stands that cover 1/3 to 2/3 of the area.

Fuel Model 3 Grass– Fire in this grass group displays the highest rate of spread and fire intensity under the influence of wind.

Fuel Model 4 Shrub– Fire intensity and fast spreading fires involve the foliage and live and dead fine woody fuels with continuous secondary overstory involvement. Stands are nearly mature shrubs six feet tall or more. Conifer plantations can be included in this fuel model.

Fuel Model 5 Shrub– Fire is generally carried by the surface fuels that are made up of litter cast by the shrubs and grasses in the understory. Fires are generally not very intense because the fuels are light.

Fuel Model 6 Shrub– Fires carry through the shrub layer were the foliage is more flammable than fuel model 5 but requires moderate winds, greater than eight miles per hour.

Fuel Model 7 Shrub– Fires burn through the shrub strata and surface with equal ease and can occur at higher dead fuel moisture because of the flammability of live foliage and other live material.

Fuel Model 8 Timber– Slow burning ground fuels with low flame lengths are generally the case, although the fire may encounter small jackpots of heavier concentrations of fuels that can flare up. Only under severe weather conditions do the fuels pose a threat. Closed-canopy stands of short-needled conifers or hardwoods that have leafed out support fire in the compact litter layer.

Fuel Model 9 Timber– Fires run through the surface faster than in fuel model 8 and have a longer flame length. Both long-needle pine and hardwood stands are typical. Concentrations of dead down woody material will cause possible torching, spotting, and crowning of trees.

Fuel Model 10 Timber– Fires burn in the surface and ground fuels with greater intensity than the other timber liter types. A result of over maturing and natural events creates a large load of heavy down, dead material on the forest floor. Crowning out spotting and torching of individual tress is more likely to occur, leading to potential fire control difficulties.

Fuel Model 11 Slash– Fire is fairly active in the slash and herbaceous material. Fuel loads are light and shaded. Light partial cuts or thinning operations in conifer stand are representative of the model.

Fuel Model 12 Slash– Rapidly spreading fire with high intensities capable of generating firebrands can occur. When fire starts it is generally sustained until a change in conditions or fuel occurs. Fuels generally total less than 35 tons per acre and are well distributed. Heavily thinned conifer stands, clearcuts, and medium to heavy partial cuts are this model.

Fuel Model 13 Slash– A continuous layer of slash generally carries fire. Large quantities of material three inches and greater are present. Fires spread quickly. Active flaming is present for a sustained period of time and firebrands may be generated. This contributes to spotting. This fuel model is not present inFlorida.

Fuel Model 91 – Urban

Fuel Model 93 – Agriculture

Fuel Model 98 – Water

Fuel Model 99–Barren

D. Custom Fuel Model Definitions

A description of the custom FBPS derivative fuel models is provided in this appendix.

Low Derivatives of the FBPS Fuel Models 1-12

For each FBPS fuel model, a low version was developed by reducing the fuel loading in each category by 30% and by reducing the fuel bed bulk depth by 30%. The consistent reduction in depth and loading maintains the fuel bed bulk density and characteristic (average) surface area to volume ratio for the fuel bed. The low derivative fuel models are designated with the letter 'A' following the standard fuel model number. For example, a 1A is the low loading version of a FBPS fuel model 1.

High Derivatives of the FBPS Fuel Models 1-12

For each FBPS fuel model, a high version was developed by increasing the fuel loading in each category by 30% and by increasing the fuel bed bulk depth by 30%. The high derivative fuel models are designated with the letter 'Z' following the standard fuel model number. For example, a 1Z is the high loading version of a FBPS fuel model 1.

Low Spread Derivatives of the FBPS Fuel Models 1-12

For each FBPS fuel model a low spread version was developed by reducing the fuel loading and fuel bed depth in each category to a very low level. The rate of spread in these models is approximately 1 chain per hour using the Extreme Weather Percentile conditions. It is meant to simulate the expected fire behavior in some fuel bed immediately post-treatment. The low spread fuel models are designated with the letter 'N' following the standard fuel model number. For example, a 1N is the low spread version of a FBPS fuel model 1.

Fuel Model Parameters

Fuel Model ID and Description	Total Loading (t/ac)	Fuelbed Depth (ft)	Fuel Loading (tons/ac)					Surface Area to Volume Ratio			Mc Content of Extinction	Heat Content
			1 hr	10 hr	100 hr	Herb	Woody	1 hr	Herb	Woody		
1A Short grass (1 ft.) - Low	0.52	0.70	0.52	0.00	0.00	0.00	0.00	3500	N/A	N/A	0.12	8000
1M Short grass (1 ft.) - FBPS	0.74	1.00	0.74	0.00	0.00	0.00	0.00	3500	N/A	N/A	0.12	8000
1Z Short grass (1 ft.) - High	0.96	1.30	0.96	0.00	0.00	0.00	0.00	3500	N/A	N/A	0.12	8000
2A Timber (grass and understory) - Low	2.81	0.70	1.40	0.70	0.35	0.35	0.00	3000	1500	N/A	0.15	8000
2M Timber (grass and understory) - FBPS	4.01	1.00	2.00	1.00	0.50	0.50	0.00	3000	1500	N/A	0.15	8000
2Z Timber (grass and understory) - High	5.21	1.30	2.60	1.30	0.65	0.65	0.00	3000	1500	N/A	0.15	8000
3A Tall grass (2.5 ft.) - Low	2.10	1.75	2.10	0.00	0.00	0.00	0.00	1500	N/A	N/A	0.25	8000
3M Tall grass (2.5 ft.) - FBPS	3.01	2.50	3.01	0.00	0.00	0.00	0.00	1500	N/A	N/A	0.25	8000
3Z Tall grass (2.5 ft.) - High	3.91	3.25	3.91	0.00	0.00	0.00	0.00	1500	N/A	N/A	0.25	8000
4A Chaparral - Low	11.22	4.20	3.51	2.81	1.40	0.00	3.51	2000	N/A	1500	0.20	8000
4M Chaparral -FBPS	16.03	6.00	5.01	4.01	2.00	0.00	5.01	2000	N/A	1500	0.20	8000

Fuel Model ID and Description	Total Loading (t/ac)	Fuelbed Depth (ft)	Fuel Loading (tons/ac)					Surface Area to Volume Ratio			Mc Content of Extinction	Heat Content
			1 hr	10 hr	100 hr	Herb	Woody	1 hr	Herb	Woody		
4Z Chaparral - High	20.84	7.80	6.51	5.21	2.60	0.00	6.51	2000	N/A	1500	0.20	8000
5A Brush - Low	2.45	1.40	0.70	0.35	0.00	0.00	1.40	2000	N/A	1500	0.20	8000
5M Brush - FBPS	3.50	2.00	1.00	0.50	0.00	0.00	2.00	2000	N/A	1500	0.20	8000
5Z Brush - High	4.55	2.60	1.30	0.65	0.00	0.00	2.60	2000	N/A	1500	0.20	8000
6A Dormant brush, hardwood slash - Low	4.21	1.75	1.05	1.75	1.40	0.00	0.00	1750	N/A	N/A	0.25	8000
6M Dormant brush, hardwood slash - FBPS	6.01	2.50	1.50	2.50	2.00	0.00	0.00	1750	N/A	N/A	0.25	8000
6Z Dormant brush, hardwood slash - High	7.81	3.25	1.95	3.26	2.60	0.00	0.00	1750	N/A	N/A	0.25	8000
7A Southern rough - Low	3.42	1.75	0.79	1.31	1.05	0.00	0.26	1750	N/A	1550	0.40	8000
7M Southern rough - FBPS	4.88	2.50	1.13	1.87	1.50	0.00	0.37	1750	N/A	1550	0.40	8000
7Z Southern rough - High	6.34	3.25	1.47	2.44	1.95	0.00	0.48	1750	N/A	1550	0.40	8000
8A Closed timber litter - Low	3.51	0.14	1.05	0.70	1.75	0.00	0.00	2000	N/A	N/A	0.30	8000
8M Closed timber litter - FBPS	5.01	0.20	1.50	1.00	2.50	0.00	0.00	2000	N/A	N/A	0.30	8000
8Z Closed timber litter - High	6.51	0.26	1.95	1.30	3.26	0.00	0.00	2000	N/A	N/A	0.30	8000
9A Hardwood (long-needle pine) litter - Low	2.44	0.14	2.04	0.29	0.11	0.00	0.00	2500	N/A	N/A	0.25	8000
9M Hardwood (long-needle pine) litter - FBPS	3.48	0.20	2.92	0.41	0.15	0.00	0.00	2500	N/A	N/A	0.25	8000
9Z Hardwood (long-needle pine) litter - High	4.53	0.26	3.79	0.54	0.20	0.00	0.00	2500	N/A	N/A	0.25	8000
10A Timber (litter and understory) - Low	8.41	0.70	2.10	1.40	3.51	0.00	1.40	2000	N/A	1500	0.25	8000
10B Timber (litter and understory) - FBPS	12.02	1.00	3.01	2.00	5.01	0.00	2.00	2000	N/A	1500	0.25	8000
10C Timber (litter and understory) - High	15.62	1.30	3.91	2.60	6.51	0.00	2.60	2000	N/A	1500	0.25	8000
11AA Light slash - Low-A-Low Depth	2.00	0.12	0.26	0.78	0.96	0.00	0.00	1500	N/A	N/A	0.15	8000
11AB Light slash - Low-A-Avg Depth	2.00	0.17	0.26	0.78	0.96	0.00	0.00	1500	N/A	N/A	0.15	8000
11AC Light slash - Low-A-High Depth	2.00	0.23	0.26	0.78	0.96	0.00	0.00	1500	N/A	N/A	0.15	8000
11BA Light slash - Low-B-Low Depth	4.00	0.24	0.52	1.57	1.91	0.00	0.00	1500	N/A	N/A	0.15	8000
11BB Light slash - Low-B-Avg Depth	4.00	0.35	0.52	1.57	1.91	0.00	0.00	1500	N/A	N/A	0.15	8000
11BC Light slash - Low-B-High Depth	4.00	0.45	0.52	1.57	1.91	0.00	0.00	1500	N/A	N/A	0.15	8000
11CA Light slash - Low-C-Low Depth	6.50	0.39	0.85	2.54	3.11	0.00	0.00	1500	N/A	N/A	0.15	8000
11CB Light slash - Low-C-Avg Depth	6.50	0.56	0.85	2.54	3.11	0.00	0.00	1500	N/A	N/A	0.15	8000
11CC Light slash - Low-C-High Depth	6.50	0.73	0.85	2.54	3.11	0.00	0.00	1500	N/A	N/A	0.15	8000
11DA Light slash - FBPS-D-Low Depth	9.00	0.55	1.17	3.52	4.30	0.00	0.00	1500	N/A	N/A	0.15	8000
11DB Light slash - FBPS-D-Avg Depth	9.00	0.78	1.17	3.52	4.30	0.00	0.00	1500	N/A	N/A	0.15	8000
11DC Light slash - FBPS-D-High Depth	9.00	1.02	1.17	3.52	4.30	0.00	0.00	1500	N/A	N/A	0.15	8000
11MA Light slash - FBPS-M-Low Depth	11.52	0.70	1.50	4.51	5.51	0.00	0.00	1500	N/A	N/A	0.15	8000
11MB Light slash - FBPS-M-Avg Depth	11.52	1.00	1.50	4.51	5.51	0.00	0.00	1500	N/A	N/A	0.15	8000
11MC Light slash - FBPS-M-High Depth	11.52	1.30	1.50	4.51	5.51	0.00	0.00	1500	N/A	N/A	0.15	8000
11XA Light slash - FBPS-X-Low Depth	14.00	0.85	1.83	5.48	6.70	0.00	0.00	1500	N/A	N/A	0.15	8000
11XB Light slash - FBPS-X-Avg Depth	14.00	1.22	1.83	5.48	6.70	0.00	0.00	1500	N/A	N/A	0.15	8000
11XC Light slash - FBPS-X-High Depth	14.00	1.58	1.83	5.48	6.70	0.00	0.00	1500	N/A	N/A	0.15	8000
11YA Light slash - High-Y-Low Depth	17.00	1.03	2.22	6.65	8.13	0.00	0.00	1500	N/A	N/A	0.15	8000
11YB Light slash - High-Y-Avg Depth	17.00	1.48	2.22	6.65	8.13	0.00	0.00	1500	N/A	N/A	0.15	8000
11YC Light slash - High-Y-High Depth	17.00	1.92	2.22	6.65	8.13	0.00	0.00	1500	N/A	N/A	0.15	8000
11ZA Light slash - High-Z-Low Depth	20.00	1.22	2.61	7.83	9.57	0.00	0.00	1500	N/A	N/A	0.15	8000
11ZB Light slash - High-Z-Avg Depth	20.00	1.74	2.61	7.83	9.57	0.00	0.00	1500	N/A	N/A	0.15	8000
11ZC Light slash - High-Z-High Depth	20.00	2.26	2.61	7.83	9.57	0.00	0.00	1500	N/A	N/A	0.15	8000
12AA Medium slash - Low-A-Low Depth	23.00	1.07	2.67	9.33	11.00	0.00	0.00	1500	N/A	N/A	0.20	8000
12AB Medium slash - Low-A-Avg Depth	23.00	1.53	2.67	9.33	11.00	0.00	0.00	1500	N/A	N/A	0.20	8000
12AC Medium slash - Low-A-High Depth	23.00	1.99	2.67	9.33	11.00	0.00	0.00	1500	N/A	N/A	0.20	8000
12BA Medium slash - Low-B-Low Depth	26.00	1.21	3.01	10.55	12.43	0.00	0.00	1500	N/A	N/A	0.20	8000
12BB Medium slash - Low-B-Avg Depth	26.00	1.73	3.01	10.55	12.43	0.00	0.00	1500	N/A	N/A	0.20	8000

Fuel Model ID and Description	Total Loading (t/ac)	Fuelbed Depth (ft)	Fuel Loading (tons/ac)					Surface Area to Volume Ratio			Mc Content of Extinction	Heat Content
			1 hr	10 hr	100 hr	Herb	Woody	1 hr	Herb	Woody		
12BC Medium slash - Low-B-High Depth	26.00	2.25	3.01	10.55	12.43	0.00	0.00	1500	N/A	N/A	0.20	8000
12CA Medium slash - Low-C-Low Depth	29.00	1.35	3.36	11.77	13.87	0.00	0.00	1500	N/A	N/A	0.20	8000
12CB Medium slash - Low-C-Avg Depth	29.00	1.93	3.36	11.77	13.87	0.00	0.00	1500	N/A	N/A	0.20	8000
12CC Medium slash - Low-C-High Depth	29.00	2.51	3.36	11.77	13.87	0.00	0.00	1500	N/A	N/A	0.20	8000
12DA Medium slash - FBPS-D-Low Depth	32.00	1.49	3.71	12.99	15.30	0.00	0.00	1500	N/A	N/A	0.20	8000
12DB Medium slash - FBPS-D-Avg Depth	32.00	2.13	3.71	12.99	15.30	0.00	0.00	1500	N/A	N/A	0.20	8000
12DC Medium slash - FBPS-D-High Depth	32.00	2.77	3.71	12.99	15.30	0.00	0.00	1500	N/A	N/A	0.20	8000
12MA Medium slash - FBPS-M-Low Depth	34.56	1.61	4.01	14.03	16.53	0.00	0.00	1500	N/A	N/A	0.20	8000
12MB Medium slash - FBPS-M-Avg Depth	34.56	2.30	4.01	14.03	16.53	0.00	0.00	1500	N/A	N/A	0.20	8000
12MC Medium slash - FBPS-M-High Depth	34.56	2.99	4.01	14.03	16.53	0.00	0.00	1500	N/A	N/A	0.20	8000
12XA Medium slash - FBPS-X-Low Depth	37.00	1.72	4.29	15.01	17.70	0.00	0.00	1500	N/A	N/A	0.20	8000
12XB Medium slash - FBPS-X-Avg Depth	37.00	2.46	4.29	15.01	17.70	0.00	0.00	1500	N/A	N/A	0.20	8000
12XC Medium slash - FBPS-X-High Depth	37.00	3.20	4.29	15.01	17.70	0.00	0.00	1500	N/A	N/A	0.20	8000
12YA Medium slash - High-Y-Low Depth	40.00	1.86	4.64	16.23	19.13	0.00	0.00	1500	N/A	N/A	0.20	8000
12YB Medium slash - High-Y-Avg Depth	40.00	2.66	4.64	16.23	19.13	0.00	0.00	1500	N/A	N/A	0.20	8000
12YC Medium slash - High-Y-High Depth	40.00	3.46	4.64	16.23	19.13	0.00	0.00	1500	N/A	N/A	0.20	8000
12ZA Medium slash - High-Z-Low Depth	43.00	2.00	4.99	17.45	20.57	0.00	0.00	1500	N/A	N/A	0.20	8000
12ZB Medium slash - High-Z-Avg Depth	43.00	2.86	4.99	17.45	20.57	0.00	0.00	1500	N/A	N/A	0.20	8000
12ZC Medium slash - High-Z-High Depth	43.00	3.72	4.99	17.45	20.57	0.00	0.00	1500	N/A	N/A	0.20	8000
13AA Heavy slash - Low-A-Low Depth	46.00	1.66	5.55	18.24	22.21	0.00	0.00	1500	N/A	N/A	0.25	8000
13AB Heavy slash - Low-A-Avg Depth	46.00	2.37	5.55	18.24	22.21	0.00	0.00	1500	N/A	N/A	0.25	8000
13AC Heavy slash - Low-A-High Depth	46.00	3.09	5.55	18.24	22.21	0.00	0.00	1500	N/A	N/A	0.25	8000
13BA Heavy slash - Low-B-Low Depth	49.00	1.77	5.91	19.43	23.66	0.00	0.00	1500	N/A	N/A	0.25	8000
13BB Heavy slash - Low-B-Avg Depth	49.00	2.53	5.91	19.43	23.66	0.00	0.00	1500	N/A	N/A	0.25	8000
13BC Heavy slash - Low-B-High Depth	49.00	3.29	5.91	19.43	23.66	0.00	0.00	1500	N/A	N/A	0.25	8000
13CA Heavy slash - Low-C-Low Depth	52.00	1.88	6.28	20.62	25.10	0.00	0.00	1500	N/A	N/A	0.25	8000
13CB Heavy slash - Low-C-Avg Depth	52.00	2.68	6.28	20.62	25.10	0.00	0.00	1500	N/A	N/A	0.25	8000
13CC Heavy slash - Low-C-High Depth	52.00	3.49	6.28	20.62	25.10	0.00	0.00	1500	N/A	N/A	0.25	8000
13DA Heavy slash - FBPS-D-Low Depth	55.00	1.99	6.64	21.81	26.55	0.00	0.00	1500	N/A	N/A	0.25	8000
13DB Heavy slash - FBPS-D-Avg Depth	55.00	2.84	6.64	21.81	26.55	0.00	0.00	1500	N/A	N/A	0.25	8000
13DC Heavy slash - FBPS-D-High Depth	55.00	3.69	6.64	21.81	26.55	0.00	0.00	1500	N/A	N/A	0.25	8000
13MA Heavy slash - FBPS-M-Low Depth	58.11	2.10	7.01	23.04	28.05	0.00	0.00	1500	N/A	N/A	0.25	8000
13MB Heavy slash - FBPS-M-Avg Depth	58.11	3.00	7.01	23.04	28.05	0.00	0.00	1500	N/A	N/A	0.25	8000
13MC Heavy slash - FBPS-M-High Depth	58.11	3.90	7.01	23.04	28.05	0.00	0.00	1500	N/A	N/A	0.25	8000
13XA Heavy slash - FBPS-X-Low Depth	61.00	2.20	7.36	24.19	29.45	0.00	0.00	1500	N/A	N/A	0.25	8000
13XB Heavy slash - FBPS-X-Avg Depth	61.00	3.15	7.36	24.19	29.45	0.00	0.00	1500	N/A	N/A	0.25	8000
13XC Heavy slash - FBPS-X-High Depth	61.00	4.09	7.36	24.19	29.45	0.00	0.00	1500	N/A	N/A	0.25	8000
13YA Heavy slash - High-Y-Low Depth	64.00	2.31	7.72	25.38	30.90	0.00	0.00	1500	N/A	N/A	0.25	8000
13YB Heavy slash - High-Y-Avg Depth	64.00	3.30	7.72	25.38	30.90	0.00	0.00	1500	N/A	N/A	0.25	8000
13YC Heavy slash - High-Y-High Depth	64.00	4.30	7.72	25.38	30.90	0.00	0.00	1500	N/A	N/A	0.25	8000
13ZA Heavy slash - High-Z-Low Depth	66.00	2.39	7.97	26.17	31.86	0.00	0.00	1500	N/A	N/A	0.25	8000
13ZB Heavy slash - High-Z-Avg Depth	66.00	3.41	7.97	26.17	31.86	0.00	0.00	1500	N/A	N/A	0.25	8000
13ZC Heavy slash - High-Z-High Depth	66.00	4.43	7.97	26.17	31.86	0.00	0.00	1500	N/A	N/A	0.25	8000
95 Snow/Ice	0	0	0	0	0	0	0	0	0	0	0	0
92 Urban	0	0	0	0	0	0	0	0	0	0	0	0
93 Agriculture	0	0	0	0	0	0	0	0	0	0	0	0
98 Water	0	0	0	0	0	0	0	0	0	0	0	0
99 Rock/Dirt	0	0	0	0	0	0	0	0	0	0	0	0

Fuel Model ID and Description	Total Loading (t/ac)	Fuelbed Depth (ft)	Fuel Loading (tons/ac)					Surface Area to Volume Ratio			Mc Content of Extinction	Heat Content
			1 hr	10 hr	100 hr	Herb	Woody	1 hr	Herb	Woody		
Low Spread Fuel Models												
1N Short grass (1 ft.) – Low Spread	0.10	0.12	0.10	0.00	0.00	0.00	0.00	3500	N/A	N/A	0.12	8000
2N Timber (grass and understory) - Low	0.25	0.07	0.14	0.07	0.04	0.04	0.00	3000	1500	N/A	0.15	8000
3N Tall grass (2.5 ft.) - Low Spread	0.12	0.10	0.12	0.00	0.00	0.00	0.00	1500	N/A	N/A	0.25	8000
4N Chaparral - Low Spread	0.33	0.18	0.15	0.12	0.06	0.00	0.15	2000	N/A	1500	0.20	8000
5N Brush – Low Spread	0.14	0.18	0.09	0.05	0.00	0.00	0.18	2000	N/A	1500	0l20	8000
6N Dormant brush, hdwd slash – Low spread	0.60	0.23	0.14	0.23	0.23	0.00	0.00	1750	N/A	N/A	0.25	8000
7N Southern rough – Low Spread	0.41	0.23	0.10	0.17	0.14	0.00	0.03	1750	N/A	1550	0.40	8000
8N Closed timber litter – Low Spread	2.50	0.10	0.75	0.50	1.25	0.00	0.00	2000	N/A	N/A	0.30	8000
9N Hardwood (long-needle pine) litter – Low	0.56	0.05	0.47	0.07	0.02	0.00	0.00	2500	N/A	N/A	0.25	8000
10N Timber (litter and understory) – Low	1.00	0.10	0.30	0.20	0.50	0.00	0.20	2000	N/A	1500	0.25	8000
11N Light Slash – Low Spread	2.20	0.19	0.29	0.86	1.05	0.00	0.00	1500	N/A	N/A	0.15	8000
12N Medium Slash – Low Spread	2.42	0.16	0.28	0.98	1.16	0.00	0.00	1500	N/A	N/A	0.20	8000
13N Heavy Slash – High Spread	2.42	0.16	0.28	0.98	1.16	0.00	0.00	1500	N/A	N/A	0.20	8000

E. Output Data Classification Schemes

This appendix provides a description of the map classification schemes (value ranges and symbology) applied to all primary output maps. Since many 2011 FL FRA outputs represent quantitative, continuous data values, the maps are presented with predefined thematic classes. Rather than reclassifying output data into discrete classes (i.e. such as 1 to 9 for WFSI, etc), the outputs are provided with their raw output values and are classified using ArcMap layer files. The layer files, provided with the data and the 2011 FLFRAS software, define the class thresholds and the symbology for the output layers. This approach ensures that the data can be used for further analysis if desired by project participants. Classification breaks were often determined based on analysis of the frequency distribution of layer values for Florida. Based on this distribution, optimum class breaks were defined to ensure that the results are properly represented. Some classification schemes, such as Communities at Risk, were reviewed and approved by the Division of Forestry. The following figures illustrate the output data classifications used in the 2011 FL FRA project.

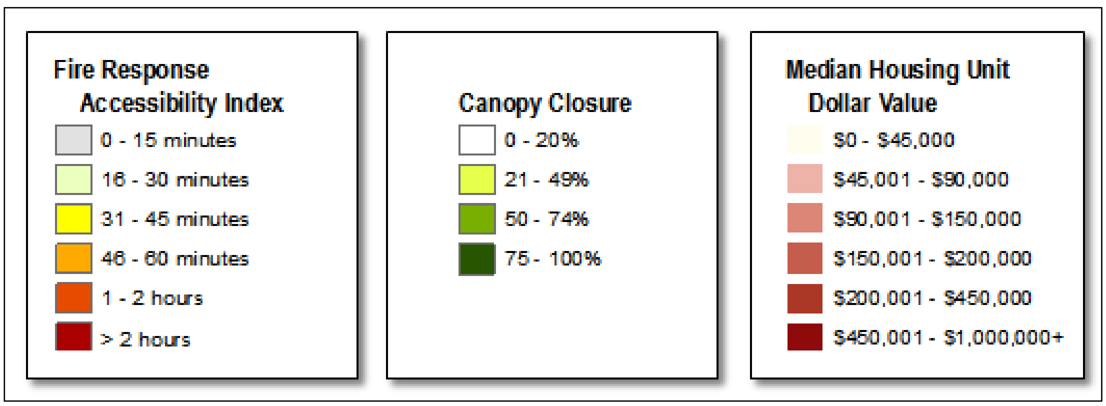


Figure 28. Legends for miscellaneous output data

FOA

Fire Occurrence Areas (fires/1000 acres/year)
<VALUE>
- 0
- Level 1 (0 - 0.024)
- Level 2 (0.025 - 0.049)
- Level 3 (0.050 - 0.099)
- Level 4 (0.100 - 0.199)
- Level 5 (0.200 - 0.290)
- Level 6 (0.291 - 0.399)
- Level 7 (0.400 - 0.599)
- Level 8 (0.600 - 0.999)
- Level 9 (1.000 - 1,000)

WFSI

Wildland Fire Susceptibility Index
<VALUE>
- 0
- Level 1 (< 0.02)
- Level 2 (0.021 - 0.06)
- Level 3 (0.061 - 0.20)
- Level 4 (0.201 - 0.24)
- Level 5 (0.241 - 0.28)
- Level 6 (0.281 - 0.34)
- Level 7 (0.341 - 0.46)
- Level 8 (0.461 - 0.56)
- Level 9 (0.561 - 1.00)

LOC

Level of Concern Index
<VALUE>
- 0
- Level 1 (< 0.092)
- Level 2 (0.0921 - 0.275)
- Level 3 (0.2751 - 2.029)
- Level 4 (2.0291 - 2.834)
- Level 5 (2.8341 - 3.749)
- Level 6 (3.7491 - 5.210)
- Level 7 (5.2101 - 8.381)
- Level 8 (8.3811 - 11.19)
- Level 9 (11.191 - 100.0)

Surface Fuels

Surface Fuels
- 1982 FBPS 1 - Short Grass (1 ft.)
- 1982 FBPS 2 - Timber (grass and understory)
- 1982 FBPS 3 - Tall Grass (2.5 ft.)
- 1982 FBPS 4 - Chaparral
- 1982 FBPS 5 - Brush
- 1982 FBPS 6 - Dormant Brush, Hardwood Slash
- 1982 FBPS 7 - Southern Rough
- 1982 FBPS 8 - Closed Timber Litter
- 1982 FBPS 9 - Hardwood Litter (long-needle pine)
- 1982 FBPS 10 - Timber (litter and understory)
- 1982 FBPS 11 - Light Slash
- 1982 FBPS 12 - Medium Slash
- 1982 FBPS 91 - Urban/Roads
- 1982 FBPS 93 - Agriculture
- 1982 FBPS 98 - Water
- 1982 FBPS 99 - Barren

Communities at Risk (statewide)

CAR_Statewide
MeanWFSI
- Level 1 (0.000032 - 0.038791)
- Level 2 (0.038792 - 0.082976)
- Level 3 (0.082977 - 0.136591)
- Level 4 (0.136592 - 0.206911)
- Level 5 (0.206912 - 0.368438)

Communities at Risk (regions 1 and 2)

CAR_region_1
MeanWFSI
- Level 1 (0.001224 - 0.015338)
- Level 2 (0.015339 - 0.032565)
- Level 3 (0.032566 - 0.058047)
- Level 4 (0.058048 - 0.100877)
- Level 5 (0.100878 - 0.197753)

CAR_region_2
MeanWFSI
- Level 1 (0.006598 - 0.043387)
- Level 2 (0.043388 - 0.072353)
- Level 3 (0.072354 - 0.105250)
- Level 4 (0.105251 - 0.158175)
- Level 5 (0.158176 - 0.290908)

Communities at Risk (regions 3 and 4)

CAR_region_3
MeanWFSI
- Level 1 (0.000050 - 0.047767)
- Level 2 (0.047768 - 0.092675)
- Level 3 (0.092676 - 0.140288)
- Level 4 (0.140289 - 0.206911)
- Level 5 (0.206912 - 0.368438)

CAR_region_4
MeanWFSI
- Level 1 (0.000032 - 0.027765)
- Level 2 (0.027766 - 0.069616)
- Level 3 (0.069617 - 0.133760)
- Level 4 (0.133761 - 0.212510)
- Level 5 (0.212511 - 0.320526)

Areas of Concern

Area of Concern
MeanWFSI
- 0
- Level 1 (0.000 - 0.000999)
- Level 2 (0.0001 - 0.009999)
- Level 3 (0.010 - 0.199999)
- Level 4 (0.200 - 0.599999)
- Level 5 (0.600 - 1.00000)

Figure 29. Legends for WFSI and LOC related outputs layers

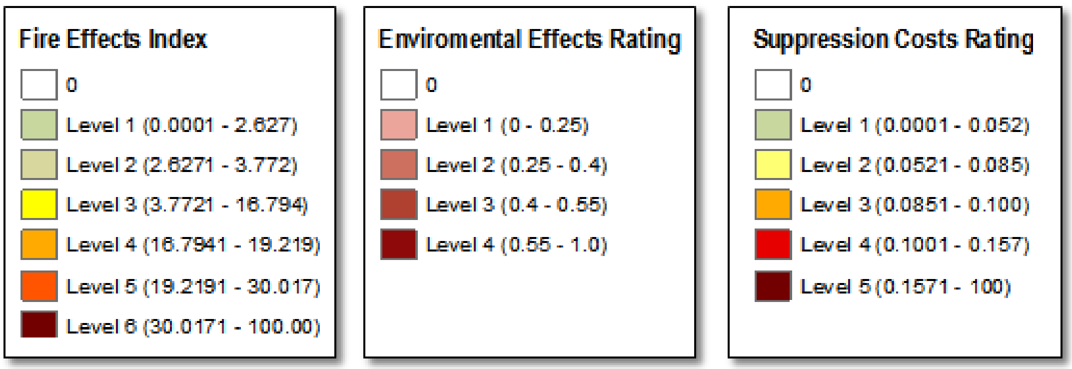


Figure 30. Legends for the Fire Effects Index related output layers

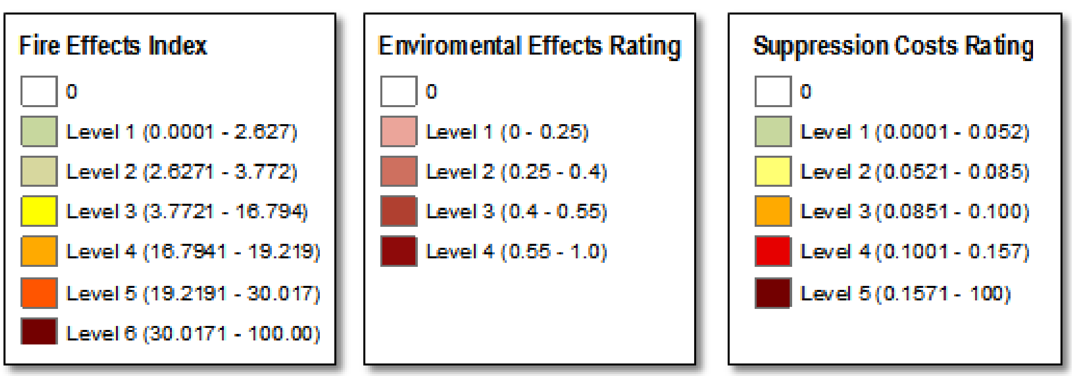


Figure 31. Legends for the Fire Effects Index related output layers

F. Percentile Weather by Weather Influence Zone

Percentile weather is provided in the following tables.

	20-ft. Wind Speed				1-hr Fuel Moisture				10-hr Fuel Moisture			
WIZ	Low	Mod	High	Ext	Low	Mod	High	Ext	Low	Mod	High	Ext
1	0.6	5.9	14.3	23.3	8.9	7.0	7.6	6.8	10.8	9.1	9.8	9.0
2	1.3	5.8	15.2	23.9	11.6	8.1	7.2	6.8	12.4	9.6	8.6	8.5
3	4.2	5.8	15.3	21.6	12.9	7.5	6.7	6.3	14.4	9.3	8.4	8.4
4	2.9	5.5	16.0	23.4	10.8	7.0	6.1	6.2	12.5	9.0	8.2	8.5
5	3.6	5.5	14.7	26.3	13.0	6.9	7.1	7.6	14.7	9.0	9.1	9.6
6	0.7	4.6	11.5	17.5	8.8	6.8	6.0	6.4	10.7	8.7	7.7	8.3
7	3.4	5.7	15.9	24.3	10.8	7.0	6.1	6.2	12.5	9.0	8.2	8.4
8	3.4	5.2	15.5	25.7	11.6	7.5	6.2	6.4	13.2	9.5	8.1	8.5
9	3.3	6.0	15.8	24.8	9.0	7.0	6.9	7.2	11.0	9.0	8.8	9.2
10	3.6	13.0	18.9	26.2	9.0	8.0	7.4	6.6	10.7	9.4	8.6	8.1
11	0.2	8.6	17.8	30.0	8.1	7.1	6.4	6.2	10.2	9.0	8.1	8.1
12	4.4	9.0	19.2	26.3	12.7	7.7	7.4	7.4	14.3	9.5	9.0	9.2
13	1.0	8.9	17.4	25.8	8.1	6.9	6.3	6.7	9.6	8.5	7.9	8.4
14	0.7	8.6	18.1	25.1	9.4	7.7	7.5	7.3	11.4	9.6	9.1	9.0
15	1.0	8.9	17.4	24.8	7.8	7.1	6.8	6.7	9.7	8.9	8.5	8.6
16	1.0	8.9	17.4	24.8	7.8	7.1	6.8	6.7	9.7	8.9	8.5	8.6
17	3.7	12.0	20.3	28.6	8.2	7.9	7.4	7.2	10.1	9.6	8.8	8.8
18	4.9	9.0	17.8	26.5	14.3	7.5	6.5	6.7	15.7	9.4	8.2	8.7
19	3.6	13.0	18.9	26.2	9.0	8.0	7.4	6.6	10.7	9.4	8.6	8.1
20	2.0	8.0	16.3	23.7	9.1	8.7	7.5	7.7	10.5	10.0	9.2	9.2

WIZ	100-hr Fuel Moisture				Herb Fuel Moisture				Woody Fuel Moisture			
	Low	Mod	High	Ext	Low	Mod	High	Ext	Low	Mod	High	Ext
1	18.5	17.6	18.2	17.6	163.8	61.3	30.0	30.0	165.1	104.5	75.6	78.3
2	15.8	15.5	14.0	15.3	68.5	56.3	36.5	30.0	112.7	102.0	83.0	79.4
3	17.8	16.5	15.5	16.7	97.4	78.2	43.8	30.6	141.0	125.1	99.5	89.1
4	17.5	17.0	17.0	17.8	87.8	73.8	34.8	30.0	126.5	116.1	86.2	76.2
5	18.5	17.4	17.4	17.5	101.6	73.1	30.0	30.0	132.9	114.2	80.9	74.4
6	18.6	16.4	14.5	15.9	138.9	69.1	46.7	15.1	163.6	113.8	95.5	75.2
7	17.7	17.0	16.5	17.2	100.2	78.6	34.9	30.0	139.5	122.8	88.5	75.7
8	17.7	17.3	15.7	16.7	91.2	60.7	31.2	30.0	119.9	100.2	81.1	77.2
9	17.8	17.2	16.5	17.1	110.5	91.0	47.1	30.0	139.3	127.1	95.8	81.4
10	17.8	15.3	13.4	14.0	95.9	83.9	55.2	40.5	145.8	128.9	104.8	96.4
11	18.2	16.9	15.1	15.7	127.2	102.0	61.1	46.4	162.2	143.7	112.6	96.3
12	17.9	16.5	15.7	16.5	107.5	94.1	78.4	46.9	150.0	138.4	127.0	91.1
13	15.9	14.9	14.0	15.0	77.8	63.4	54.2	44.5	110.6	101.4	93.9	90.9
14	19.0	17.2	15.4	15.9	137.7	100.4	73.8	58.1	164.9	135.9	119.6	101.9
15	17.2	15.8	15.1	15.9	121.8	84.7	78.3	65.3	159.6	129.1	117.5	114.5
16	17.2	15.8	15.1	15.9	121.8	84.7	78.3	65.3	159.6	129.1	117.5	114.5
17	17.7	16.3	14.2	15.0	109.2	105.1	73.0	60.8	155.4	143.1	116.8	116.8
18	18.0	16.8	14.7	16.8	110.4	93.7	65.6	37.4	152.7	137.6	114.2	93.6
19	17.8	15.3	13.4	14.0	95.9	83.9	55.2	40.5	145.8	128.9	104.8	96.4
20	16.3	15.4	14.5	15.5	93.7	79.8	61.7	53.4	130.5	121.5	111.7	111.5

G. Environmental Effects and Suppression Costs Score Matrices

.

Utility Corridors

Flame Length	Fire Size:	0-9 Acres	10-99 Acres	100-999 Acres	1000+ Acres
	0-4 Feet	1	1	1	2
	5-8 Feet	1	2	3	3
	8+ Feet	2	3	4	4

WUI

Flame Length	Fire Size:	0-9 Acres	10-99 Acres	100-999 Acres	1000+ Acres
	0-4 Feet	1	2	3	3
	5-8 Feet	2	3	4	4
	8+ Feet	3	4	4	4

Plantations

Flame Length	Fire Size:	0-9 Acres	10-99 Acres	100-999 Acres	1000+ Acres
	0-4 Feet	1	1	2	2
	5-8 Feet	2	2	3	4
	8+ Feet	3	3	4	4

Critical Facilities

Flame Length		Fire Size			
		0-9 Acres	10-99 Acres	100-999 Acres	1000+ Acres
	0-4 Feet	1	2	2	3
	5-8 Feet	1	3	4	4
	8+ Feet	2	3	4	4

Base Suppression

Flame Length		Fire Size			
		0-9 Acres	10-99 Acres	100-999 Acres	1000+ Acres
	0-4 Feet	1	2	2	3
	5-8 Feet	2	2	3	4
	8+ Feet	2	3	4	4