Wildland/Urban Interface Fires and Communities at Risk
Joint Fire Modeling Project for Teton County, Idaho
Bureau of Land Management, Upper Snake River District GIS
and
Idaho State University GIS Training and Research Center

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Anthony Crafts, crafanth@isu.edu
Jamen Underwood, undejame@isu.edu
Keith Weber, webekeit@isu.edu

Abstract:

Wildland/Urban Interface (WUI) fires and Communities at Risk (CAR) projects are high priorities to federal land management agencies. It is important that the federal government help educate homeowners, firefighters, local officials, and land managers regarding the risk of wildland fire. The Bureau of Land Management's (BLM) Upper Snake River District (USRD) Geographic Information Systems (GIS) team and the GIS Training and Research Center (GISTReC) at Idaho State University (ISU), have created a model to predict potential wildfire risk areas for Teton County, Idaho. During this project models were created of specific individual risks associated with wildfires: topography, fuel load, and the number of structures at risk. These models were evaluated together to create a final fire risk model for Teton County, Idaho. This report describes each of the WUI fire risk components and what affect each has on the final fire risk model. This final model is an accurate depiction of the spatial distribution of wildfire risk in Teton County and can be used by regional fire managers to manage wildfire risk.

Keywords:

Fire, Wildfire, GIS, Teton County, Idaho, BLM, Fire Regime, Slope, Aspect, Fuel Load

Contents

Introduction:

The Wildland/Urban Interface (WUI) is more than a geographic area. It is anywhere homes and other anthropogenic structures exist among flammable vegetative fuels (Owens and Durland, 2002). Because wildland fire is an essential component of healthy ecosystems, people need to live compatibly with wildland fire (Owens and Durland, 2002). As people move into the Wildland/Urban Interface zones, planners and agencies responsible for fire management and protection are in need of tools to help them assess fire risk and make decisions regarding funding, development, and deployment of suppression resources. One valuable tool used by fire managers is Geographic Information Systems (GIS). GIS allows for spatial analysis of large geographic areas and is easily integrated with remote sensing (satellite imagery). Using both GIS and remote sensing, a Wildland/Urban Interface (WUI) Fire Risk model was created. It is comprised of seven component models that describe various aspects of fire risk. These component models are generally organized as topography, fuel load, and structure density models.

- **Aspect: Sun Position –** takes into account varying fire risks associated with aspect, especially as it relates to desiccation effects.
- **Slope: Rate of Spread –** translates how the steepness of a surface affects the rate of spread of a fire.
- **Slope: Suppression Difficulty –** takes into account how varying slope influences suppression efforts by firefighters and their equipment.
- **Fuel Load: Intensity –** describes how different fuel load classes release heat energy during a fire and thereby affect their environment.
- **Fuel Load: Rate of Spread –** describes how different fuel types spread and affect fire risk.
- **Fuel Load: Vegetation Moisture –** takes into account how different levels of vegetation moisture affect fire risk.
- **Structure at Risk –** includes the density of man-made structures.

Each of the component models are weighted and summed to produce the Final Fire Risk Model. The Teton County, Idaho WUI fire risk assessment is a continuation of WUI projects that have been completed and validated.

Methods:

GIS data sets:

- Digital Elevation Model (DEM) of Teton County
- Landsat 5 TM imagery for Teton County and environs – Path 38, Row 30, acquired May 16, 2006.
- Digital Orthophoto Quarter-Quads (DOQQs) acquired May 18, 2006
- Transportation, place and county boundary datasets for Teton County acquired May 16, 2006
- Structure density raster data was based on census data of population centers within Teton County.

Data Preprocessing:

Elevation Data:

The DEM data for Teton County was obtained from Idaho State University (ISU) GIS Center's Spatial Library. Through the use of ArcMap 9.0 this data was used to produce the aspect and slope fire risk component models. These models were created using pixels with 30 meter spatial resolution.

Landsat Imagery:

Landsat 5 TM multi-spectral imagery was used (Path 038 Row 030, acquired May 18, 2006). The Landsat Imagery was ordered from the USGS website.

Other Datasets:

The Teton county boundaries and roads datasets were downloaded from the Inside Idaho website. The Teton County boundary was selectively saved as a separate shapefile and re-projected to IDTM-83.

The roads dataset was masked to include only the roads within Teton County using the county boundary mentioned above as the mask.

Data Processing:

The WUI fire risk model consists of seven component models that can be categorized as follows:

- Topography
    - Slope
        - *Suppression difficulty*
        - *Rate of spread*
    - Aspect
        - *Sun position*
- Fuel Load
    - *Rate of Spread*
    - *Fire Intensity*
    - *Vegetation Moisture*
- Structure
    - *Structure Density (structures at risk)*

Each component model was treated separately to learn how each affected fire risk. In order to evaluate the fire risk contribution of each component model made, we normalized the value range using a scale from 0 to 1000, where 1000 indicates the highest risk. For each component model (except the Structure Density) we normalized using weightings described in Mattsson *et al*. (2002) and Jansson *et al*. (2002) to complete our analysis. After completing these analyses, we examined the impact each fire model component had on the overall fire risk in Teton County, Idaho.

Topographic Sub-Model Components

Creating the Topographic: Slope: Suppression Difficulty Component Model

Using the Teton County DEM as input, a slope grid can be calculated using the ArcMap (Spatial Analyst → Surface Analysis → Slope). The resultant pixel values equate to the slope of the DEM at that point. The output pixel value unit of the grid was expressed in degrees of slope, the z-factor was 1 and the output cell size was 30 meters.

To create the Slope: Suppression Difficulty Component model, we used the slope model created above and applied weightings for Slope: Supression Difficulty following Mattsson *et al*. (2002) (table B-6 in Appendix B) using ArcMap (Spatial Analyst → Reclassify) shown in figure 1.

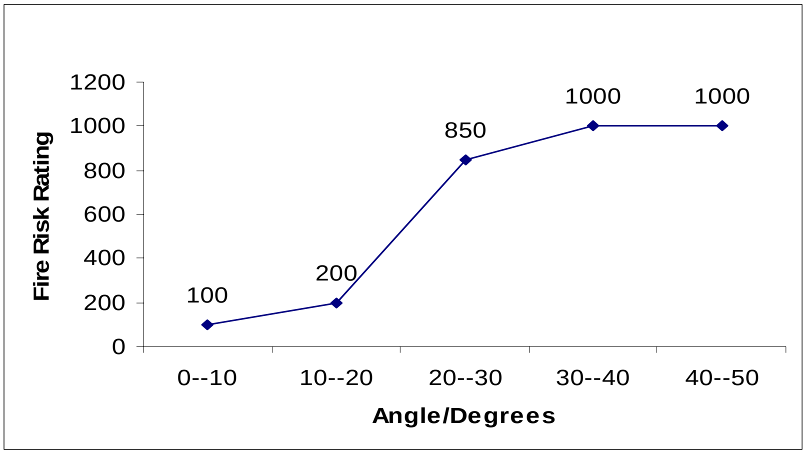

Figure 1. *Weightings for slope/suppression difficulties describe how suppression difficulties are affected by the angle of slope (Mattsson et al, 2002).*

Creating the Topographic: Slope: Rate of Spread Component Model

To make the Slope: Rate of Spread sub-model, we reclassified the Slope based on weightings from Mattsson *et al.* (2002) using ArcMap → Spatial Analysis → Reclassify (fig. 2). These weightings are shown in table B-5 in Appendix B.

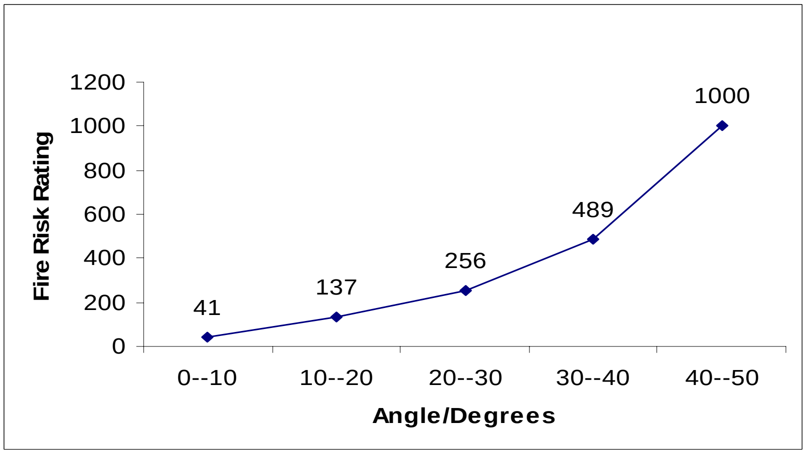

Figure 2. *Weightings describe how spread rate increase with angle of slope. The weight proportion is essentially exponential with slope angle (Mattsson et al., 2002).*

Creating the Topographic: Aspect Sun Position

Aspect indicates the horizontal *direction* of the instantaneous slope face. Using the Teton County area DEM as input, an aspect grid was calculated. The resultant pixel intensity equates to the angular horizontal direction of the DEM slope at that point. The ArcMap processing selection was: Spatial Analyst → Surface Analysis → Aspect. The output units were degrees (where 0 is north, 90 is East, etc.) and the output cell size was set to 30 meters.

To create the Aspect: Orientation to Sunlight we reclassified the aspect grid, following Mattsson *et al.* (2002) (table B-7 in Appendix B) using ArcMap → Spatial Analyst → Reclassify (fig. 3)

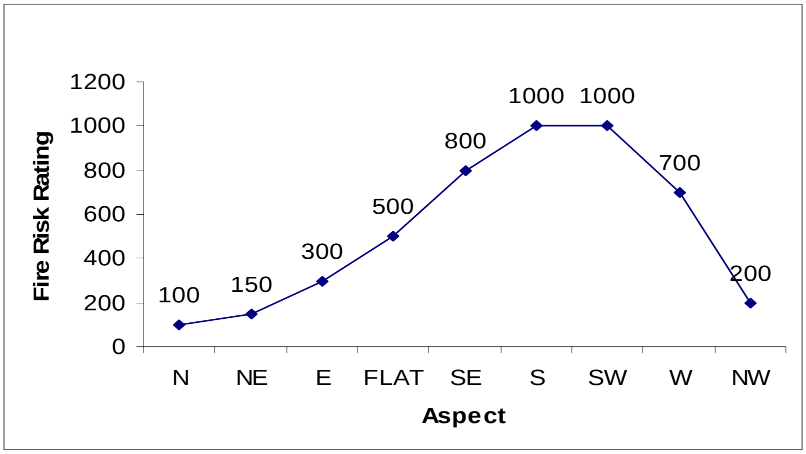

Figure 3. *Weightings for Aspect/Sun position describe how the sun desiccates the ground at different aspects (Mattsson et al, 2002).*

<u>Fuel Load Sub-model Components</u>

Creating the Fuel Load Fire Risk Components

The fuel fire risk components are derived from the fuel load estimates from the Normalized Difference Vegetation Index (NDVI) calculated from the Landsat imagery.

We estimated vegetation cover with satellite imagery using the Normalized Difference Vegetation Index (NDVI) for Landset dated 05-16-2006. The NDVI, which is an estimation of photo-synthetically active vegetation, was calculated from band 3 (visible red) and band 4 (near infrared) of the original uncorrected Landset imagery. The resulting NDVI has an interval of -1 to +1, where -1 is no vegetation and +1 is pure photo-synthetically active vegetation. We created the NDVI using Idrisi after bands 3 and 4 were stretched and then converted to “byte binary”. The following equation was used to create the NDVI grid:

$$NDVI = \frac{Band4 - Band3}{Band4 + Band3}$$

Equation 1: Equation for calculating NDVI.

The PCA (Principal Components Analysis) was created using Idrisi (Image Processing → Transformations → PCA). This produces 4 components. PCA components 1, 2, and 3 were used.

Supervised classification of Landsat imagery through Idrisi Kilimanjaro (ver. 14.02) was used for estimating fuel load in Teton County. To estimate fuel load, we used field sample points (96 sample points) that were collected within the O’Neal site by Jed Gregory, Luke Sander, and Keith Webber in July 2005. Each of the sample points was initially classified into 6 fuel load categories based upon on-site estimates of ground-cover (0.74, 1, 2, 4, 6 and >6 tons per acre). For this project, these categories were reclassified into a fuel load grid with the following 4 fuel load classes:

1. 0 tons/acre (No vegetation)
2. <2 tons/acre (Grassland with some Sagebrush)
3. 2-6 tons/acre (Low and Typical Sagebrush)
4. >6 tons/acre (Forest)

Using Idrisi, we created signature files for the field training sites using an NDVI model produced from Landsat imagery and PCA Components 1, 2, and 3 (Idrisi → Image Processing → Signature Development → MAKESIG). The signature files were then used to create a fuel load raster grid using Idrisi (Hard Classifiers → MAXLIKE). We validated the predictions of this model using techniques described in the next section “Fuel Load Model Validation”.

Fuel Load Model Validation

The fuel load mode was validated using the following methodology:

> A standard error matrix where each predicted (modeled) class was compared against the measured (field) class at all sample point locations. A Kappa statistic was calculated. This statistic serves as an indicator of how much better or worse our classification performed compared to pure random classification.

Fuel Load: Vegetation Moisture

The fuel load grid (described above) was reclassified (to values 0, 1, 4, and 6) using ArcMap → Spatial Analyst → Reclassify as described in table B-1 (Appendix B).

A vegetation moisture grid was created through reclassification of the NDVI grid using ArcMap (Spatial Analyst → Reclassify) to delineate wet vegetation, dry vegetation, and no vegetation. Values of <0.15 were reclassified to 100, 0.15-0.6 were reclassified to 200, and >0.6 were reclassified to 75 where 100 equals no vegetation, 200 equals dry vegetation, and 75 equals moist vegetation as seen in B-1 of Appendix B.

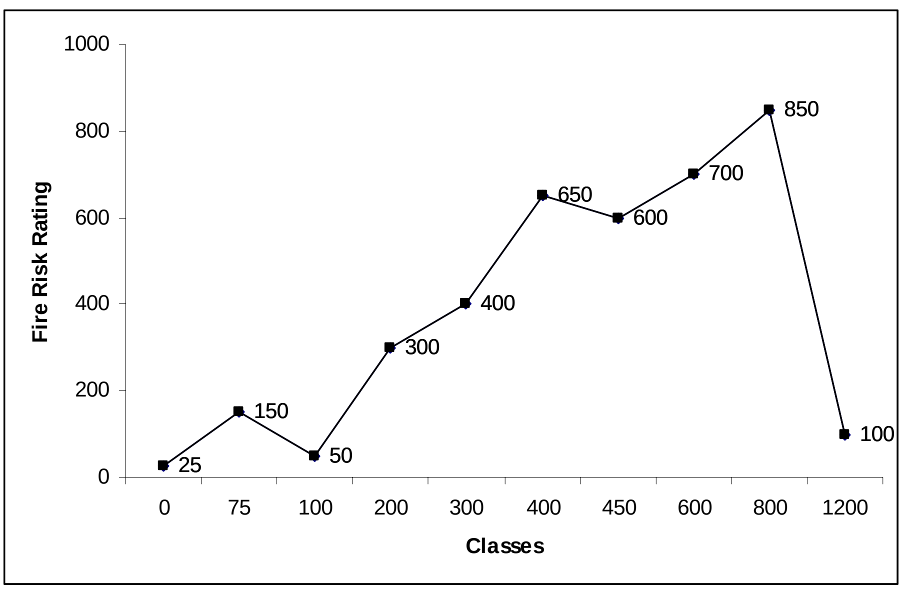

Figure 4. **Weightings for Fuel Load/ Vegetation Moisture (Jansson et al, 2002).**

Fuel load: Rate of Spread Component Model

The fuel load-derived Rate of Spread component model was created by a reclassification of the fuel load grid, following Mattsson *et al*. (2002) (table B-3 in Appendix B), using ArcMap → Spatial Analyst → Reclassify (fig. 5).

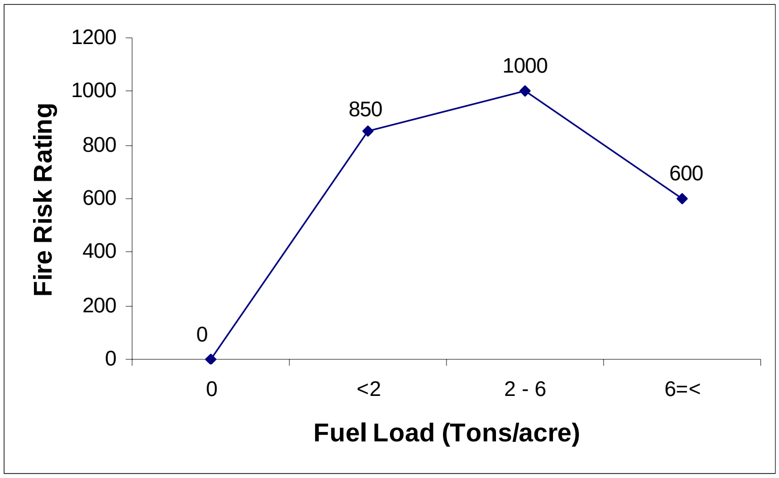

Figure 5. Weightings for Fuel Load/ Rate of Spread (Mattsson et al, 2002).

Fuel load: Fire Intensity Component Model

The fire intensity component model was derived by a reclassification of the fuel load grid, using values following Mattsson *et al*. (2002) (table B-4 in Appendix B) with ArcMap → Spatial Analyst → Reclassify (fig. 6).

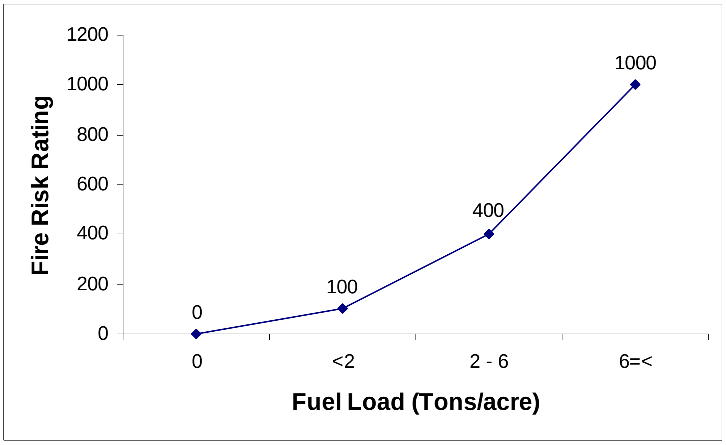

Figure 6. This chart describes all weightings for Fuel Load/ Intensity (Mattsson et al, 2002).

Structure Sub-Model Components

Structures at Risk Component Model

To create the Structures at Risk sub model we used census data for the population centers of Teton County. To make this component consistent with the other sub-models, the range of pixel values was stretched to a range of 0 – 1000.

WUI Fire Risk Model

After completing the above analyses, we examined the impact each fire model component had on the overall fire risk in Teton County, Idaho. The final fire risk model was determined as a weighted average (using ArcMap → Spatial Analyst → Raster Calculator) of the 7 component models. The weight of each component is given in Table 1. The weights were determined through consultation with a regional fire manager, Fred Judd (personal communication).

Component	Description	Percentage
Aspect	Sun position	5%
Slope	Rate of Spread	17%
Slope	Suppression Difficulties	11%
Fuel load	Vegetation Moisture	11%
Fuel load	Rate of Spread	17%
Fuel load	Fire Intensity	17%
Structures	Structures at Risk	22%

Table 1. *Components and weights of the Final Fire Risk Model.*

Results:

The NDVI grid used to classify the fuel load model is shown in Figure 9. The reclassified NDVI grid estimating the location of wet vegetation, dry vegetation and no vegetation is shown in Figure 10. Figure 11 illustrates the Fuel Load model derived from field training sites and Landsat satellite imagery. Table 4 shows the error matrix validation for the fuel load model. The overall Kappa statistic was determined to be 0.8581 indicating that the classification was approximately 90% better than chance.

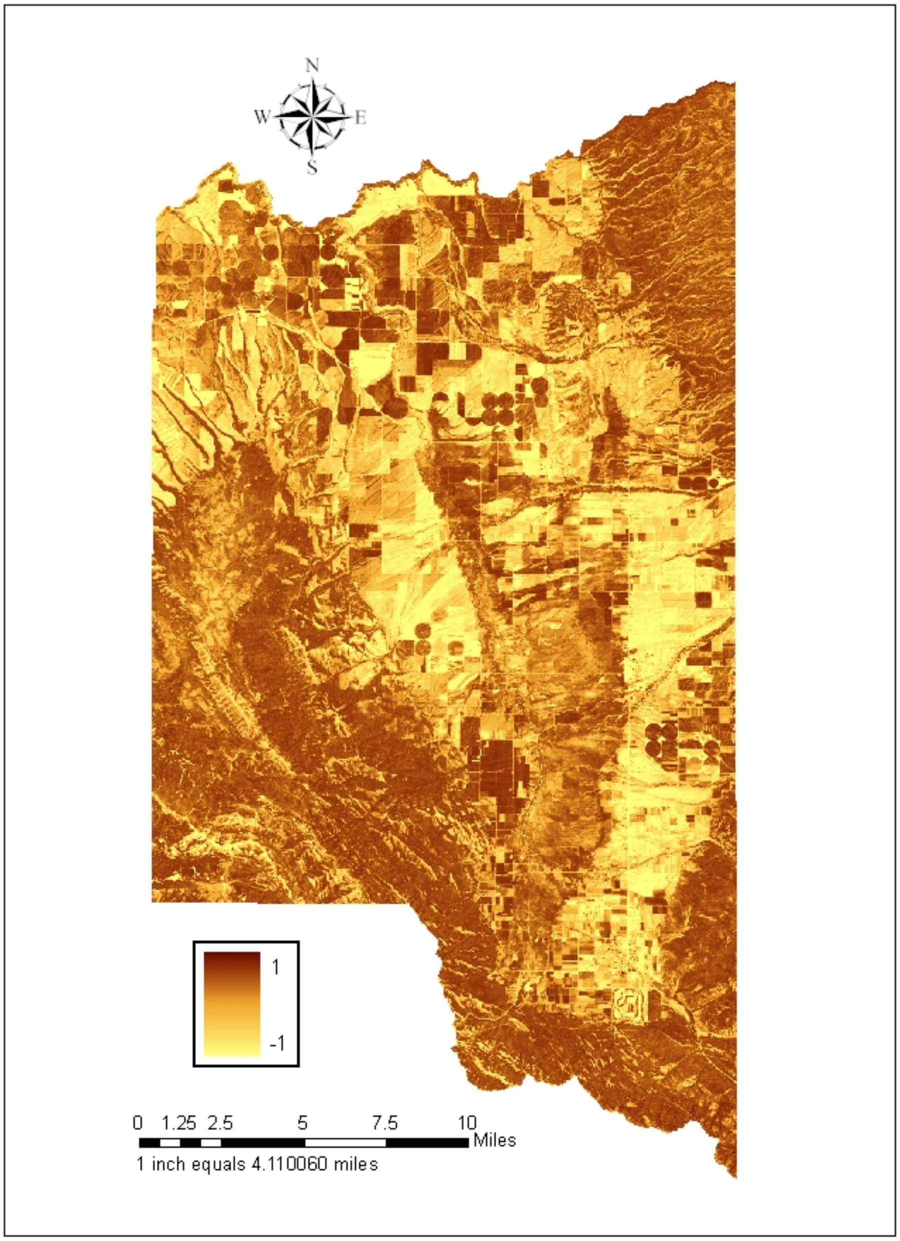

Figure 9. *The NDVI has an interval of -1 to +1, where -1 is no vegetation and +1 is pure vegetation.*

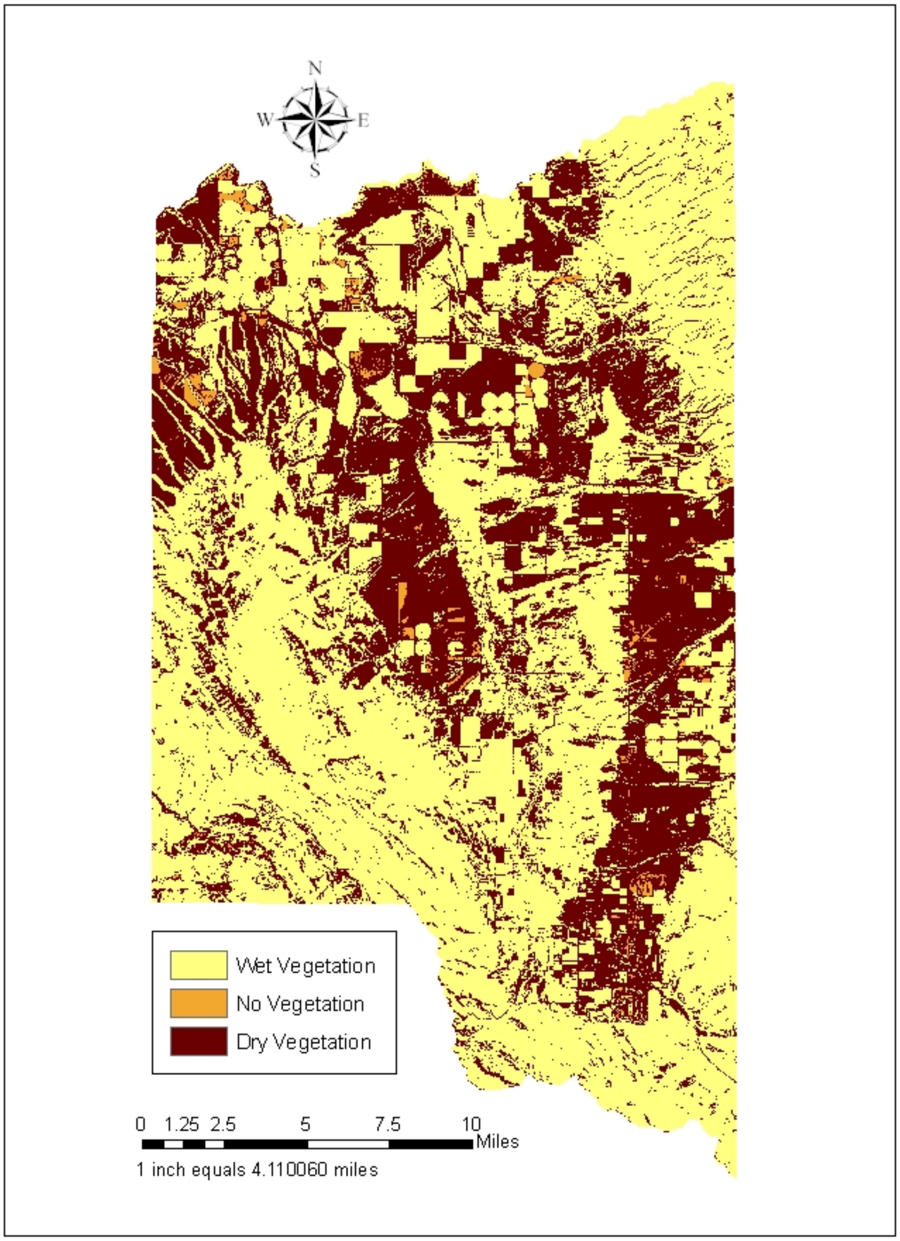

Figure 10. *The results of the reclassification of NDVI into no vegetation (100), dry vegetation (200), and wet vegetation (75).*

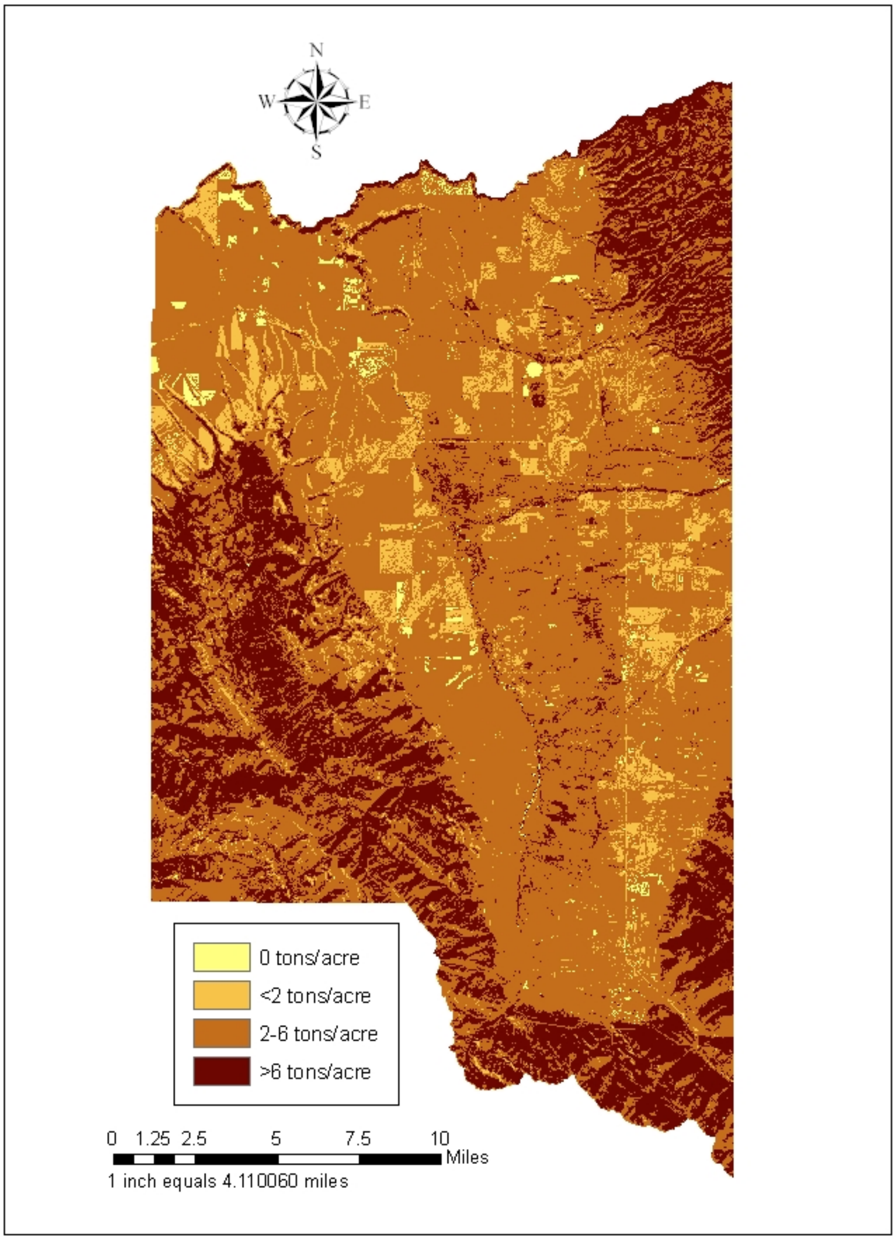

Figure 11. *The fuel load model and the distribution of different fuel load classes for Teton County, Idaho.*

		Field Measurement (tons/acre)					
		0	**<2**	**2 - 6**	**>6**	**Total**	**Commission Accuracy**
Modeled Fuel Load (tons/acre)	**0**	30	0	0	0	**30**	100.00%
	<2	0	67	10	0	**77**	87.01%
	2 - 6	0	5	17	2	**24**	70.83%
	>6	0	0	1	48	**49**	97.96%
	Total	**30**	**72**	**28**	**50**	**180**	**Overall Accuracy**
	Omission Accuracy	100.00%	93.06%	60.71%	96%		**90%**

Table 4. *Error matrix for the fuel load model.*

The three component models derived from the fuel load model are shown in figures 12, 13, and 14. Figure 12 is the vegetation moisture model, irrigated and riparian areas contain the lowest risk values, while the greases, shrubs, and mountainous areas throughout Teton County contain the highest values. The high risk areas are due to the low moisture content associated with sagebrush steppe that dominates the area. The effect of fuel load on fire's spread rate is reported in figure 13. Mountainous areas, with larger fuel loads, contain the lowest values, where grasses and shrubs contain the highest values. The high risk areas are due to the high concentration of 2-6 tons/acre fuels. Finally, figure 14 is the intensity model. Confers in the highlands comprise the highest risk for the most intense fires.

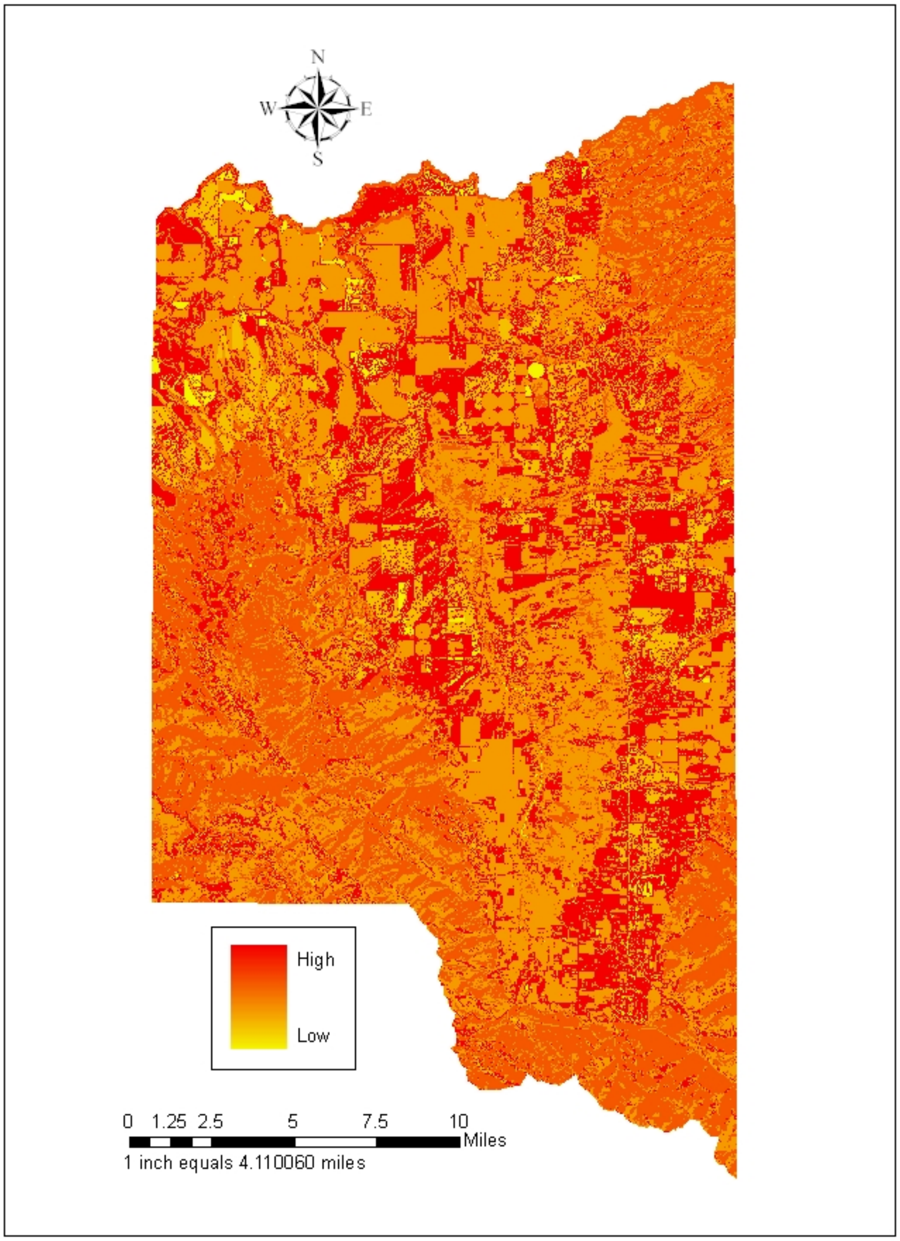

Figure 12. *Fuel Load/Vegetation Moisture model. This model expresses how low vegetation moisture and the combination of different fuel load classes affect fire risk. This model was given an overall weighting of 11% of the final model.*

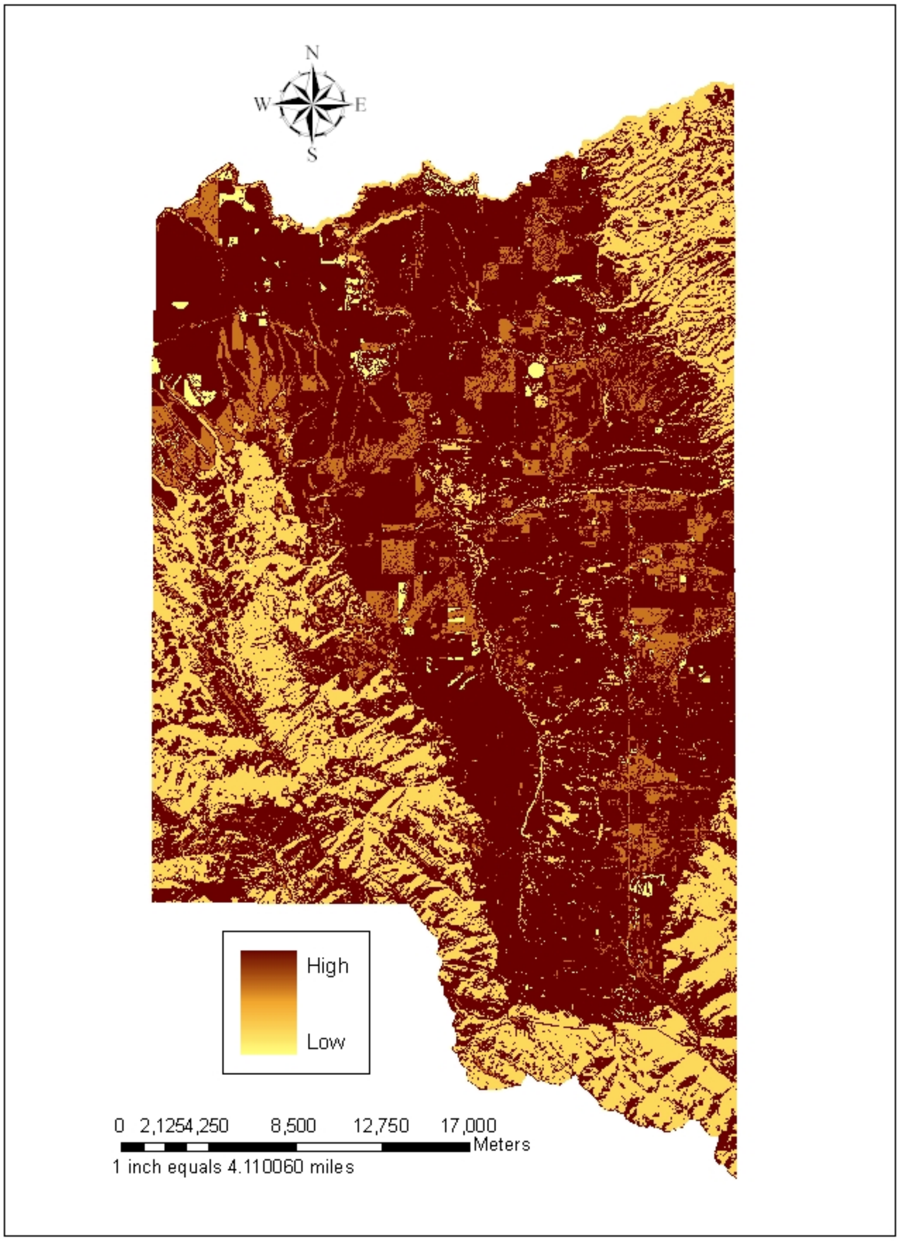

Figure 13. *The Fuel Load/Rate of Spread model. This model expresses the fire risk associated with the spread rate of different load classes. This model was given an overall weighting of 17% of the final model.*

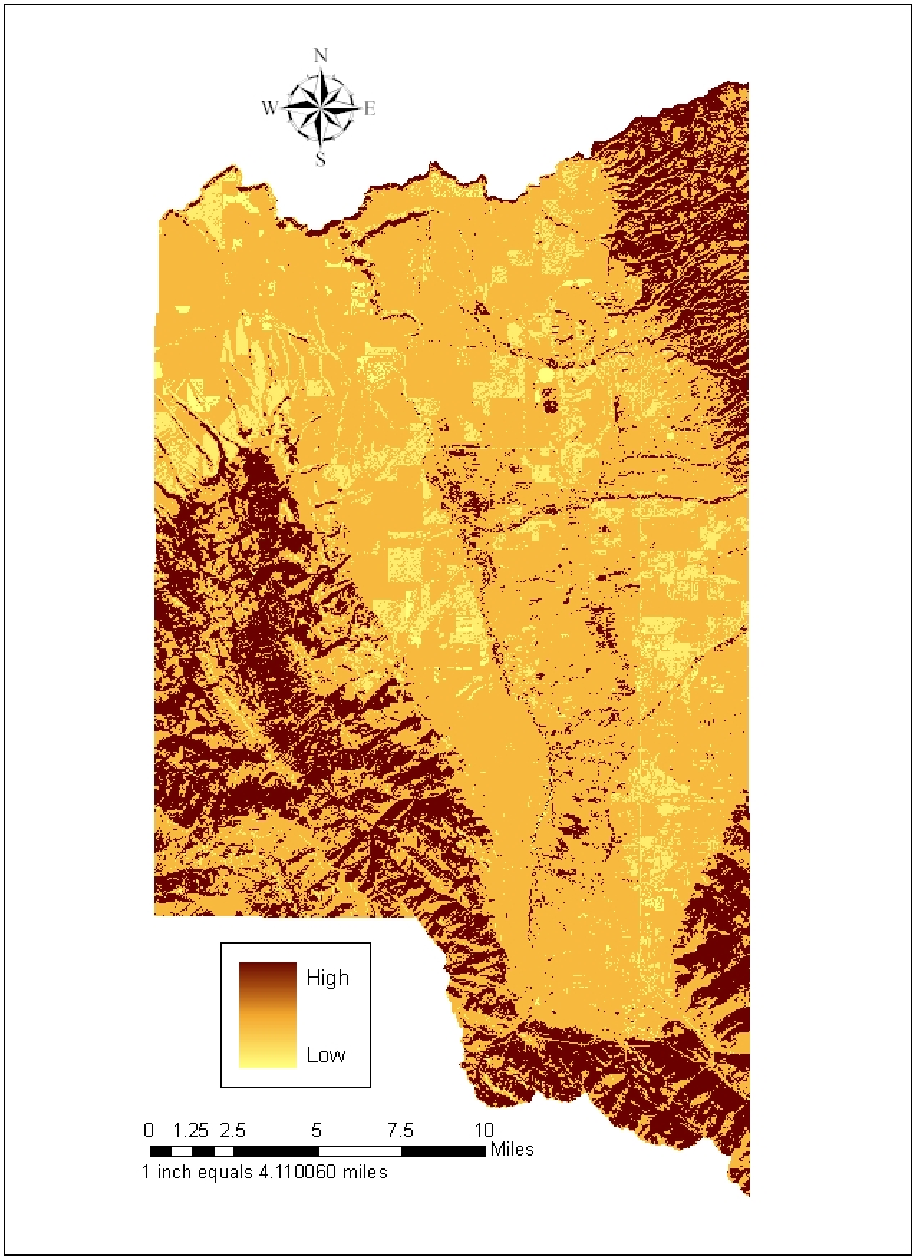

Figure 14. *The Fuel Load/Intensity model. This model expresses the fire risk associated with the amount of heat energy (intensity) each fuel load class gives off. This model was given an overall weighting of 17% of the final model.*

Figures 15-17 are the component models generated using the Teton County DEM. Figure 15 assesses the risk of fires spreading quickly due to steep slopes. Here, the highlands throughout the county received the highest values and the lowlands received the lowest values. Next is the suppression difficulty model (figure 16), where steeper slopes pose increasingly greater problems to fire fighters attempting to access fires in order to suppress them. The steeper terrain is weighted the highest risk. Figure 17 is the Aspect: Sun Position component model. South and southwest aspects contain the highest fire risk, due to the intense sunlight and prevailing wind exposure. North and east facing slopes, which are sheltered from intense sunlight and prevailing wind through much of the day, contain the lowest fire risk.

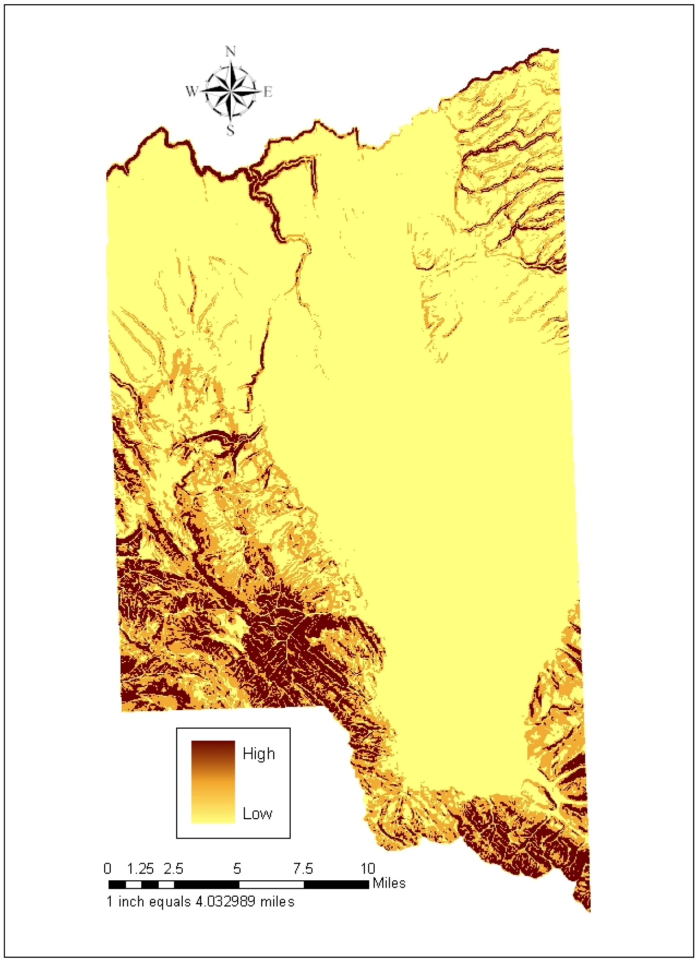

Figure 15. *The Slope/Rate of Spread model. This model expresses how different angles of slope affect the spread rate of fire. Steeper slopes are given the highest fire risk. This model was given an overall weighting of 17% of the final model.*

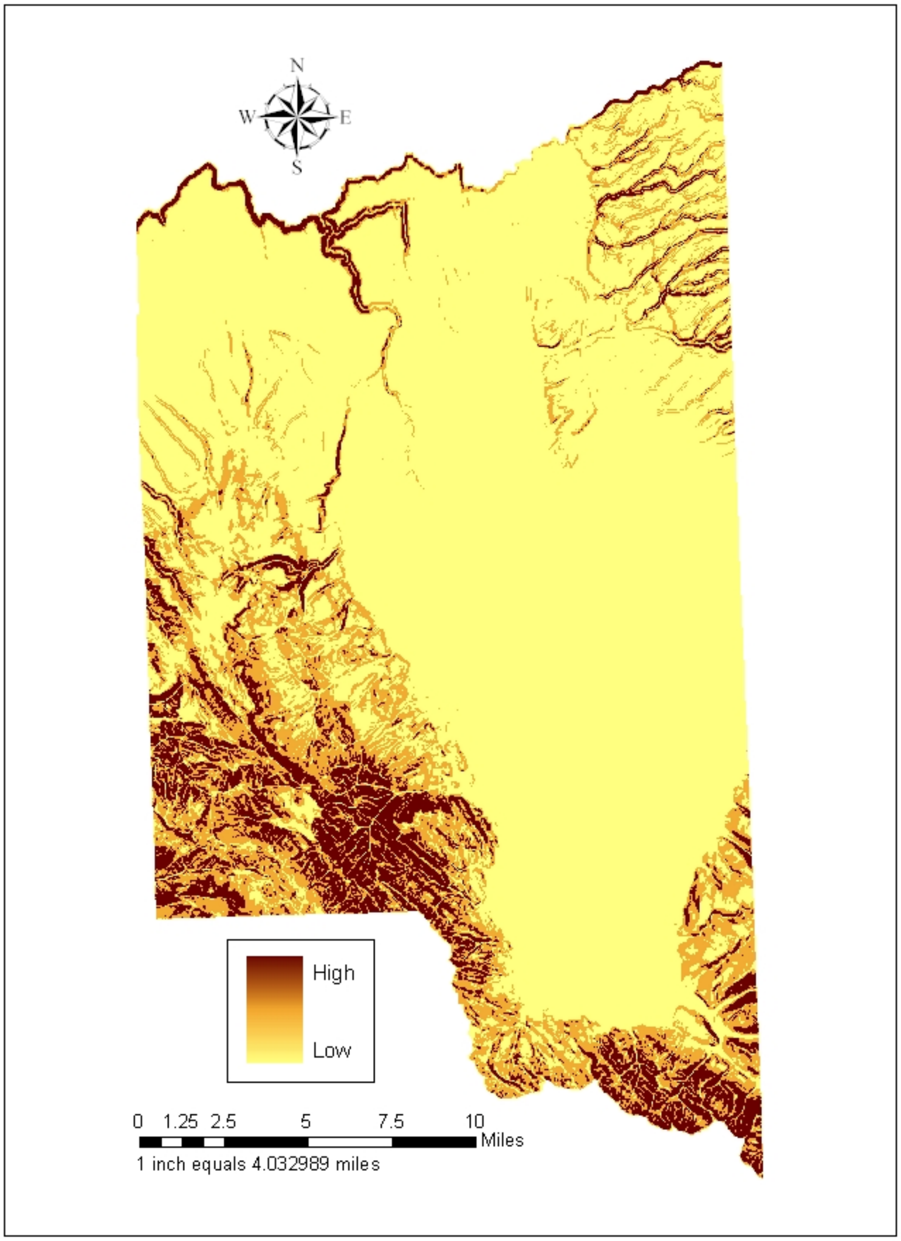

Figure 16. *The slope/Suppression Difficulty model. This model expresses how different slope angles affect suppression efforts of firefighters. This model was given an overall weighting of 11% of the final model.*

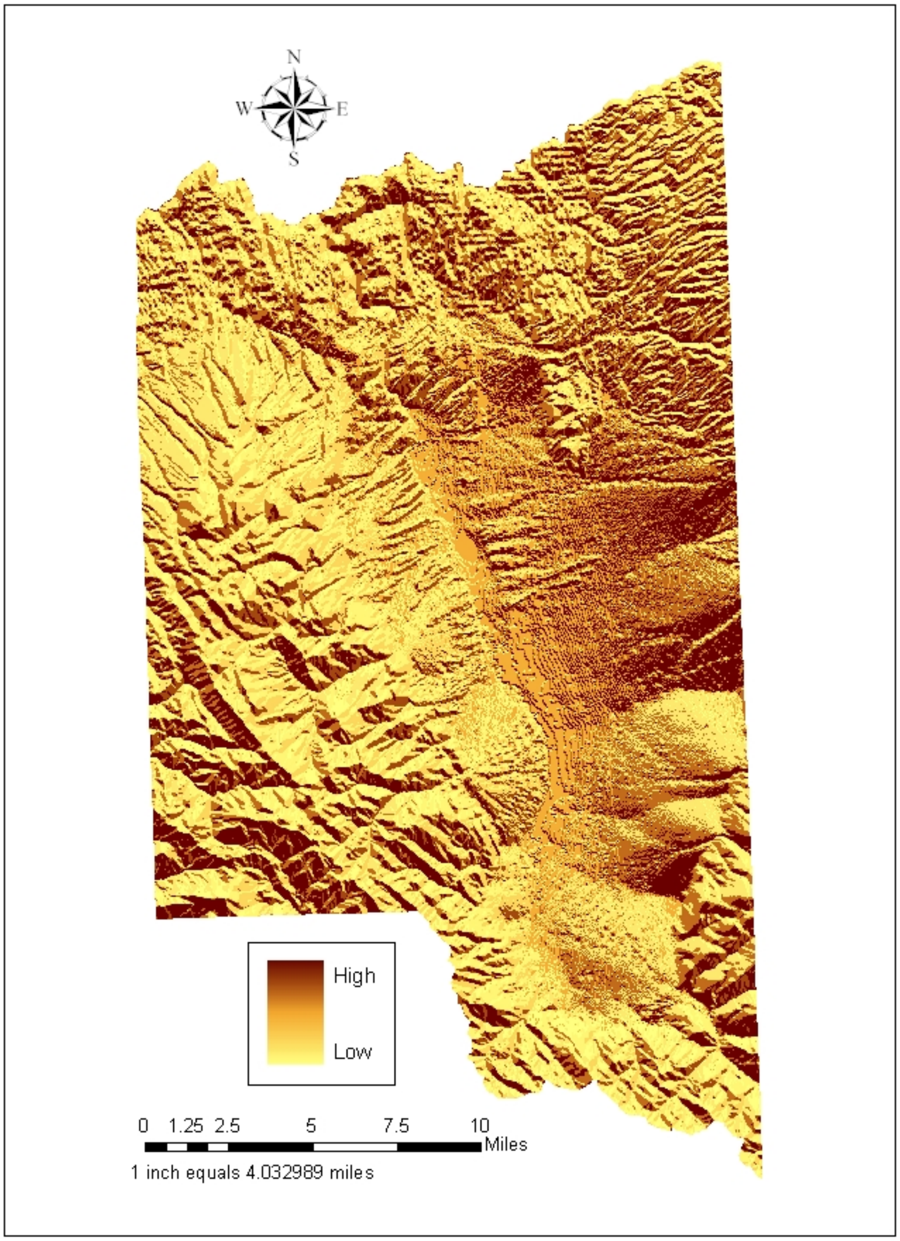

Figure 17. *The Aspect: Sun Position. This model expresses how different aspects affect fire risk. Southern aspects have the highest fire risk. This model was given an overall weighting of 5% of the final model.*

Figure 18 shows the Structures at Risk Component model. Here, of course, the population centers of Teton County; Driggs, Victor, Tetonia, Felt, Darby, Fox Creek, Bates, and Clawson contain the structure density and the highest fire risk.

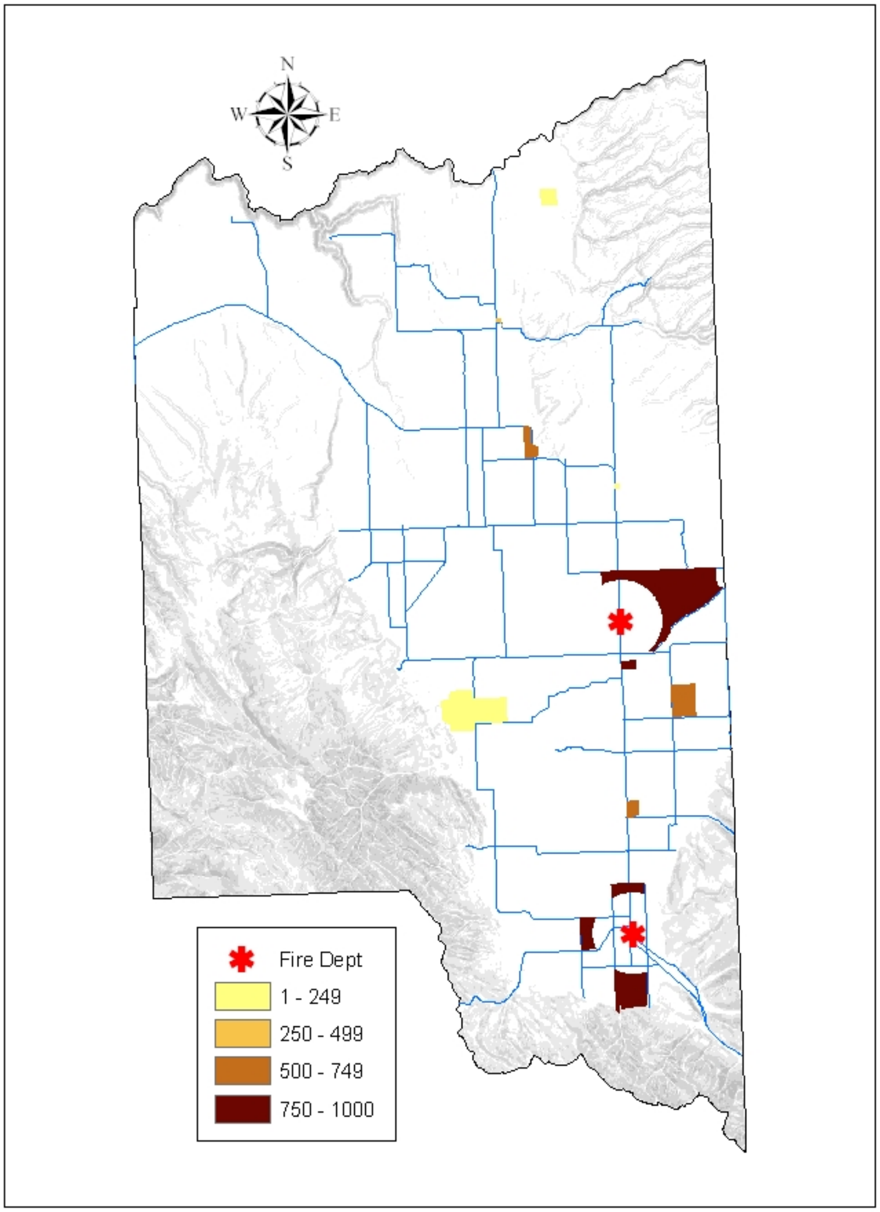

Figure 18. *The Structures at Risk model. This model expresses areas that are high risk due to high structure density and is given an overall weighting of 22% of the final model.*

The Final Fire Risk Model for Teton County is shown in Figure 19. Figure 20 shows the Fire History on public lands within Teton County from 1939 – 2003. This was constructed from data available in the ISU GIS Center's Spatial Library. km^2

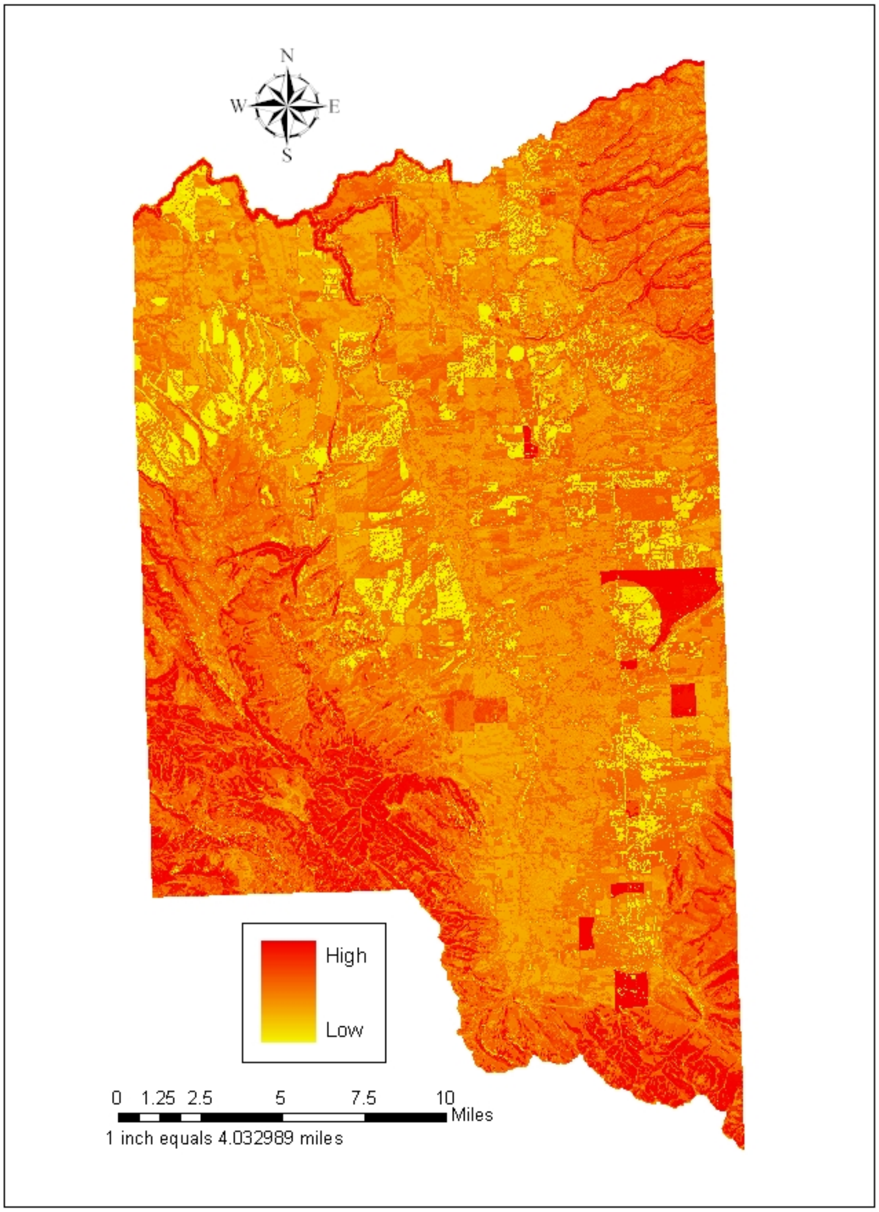

Figure 19. *The Final Fire Risk Model for Teton County, Idaho.*

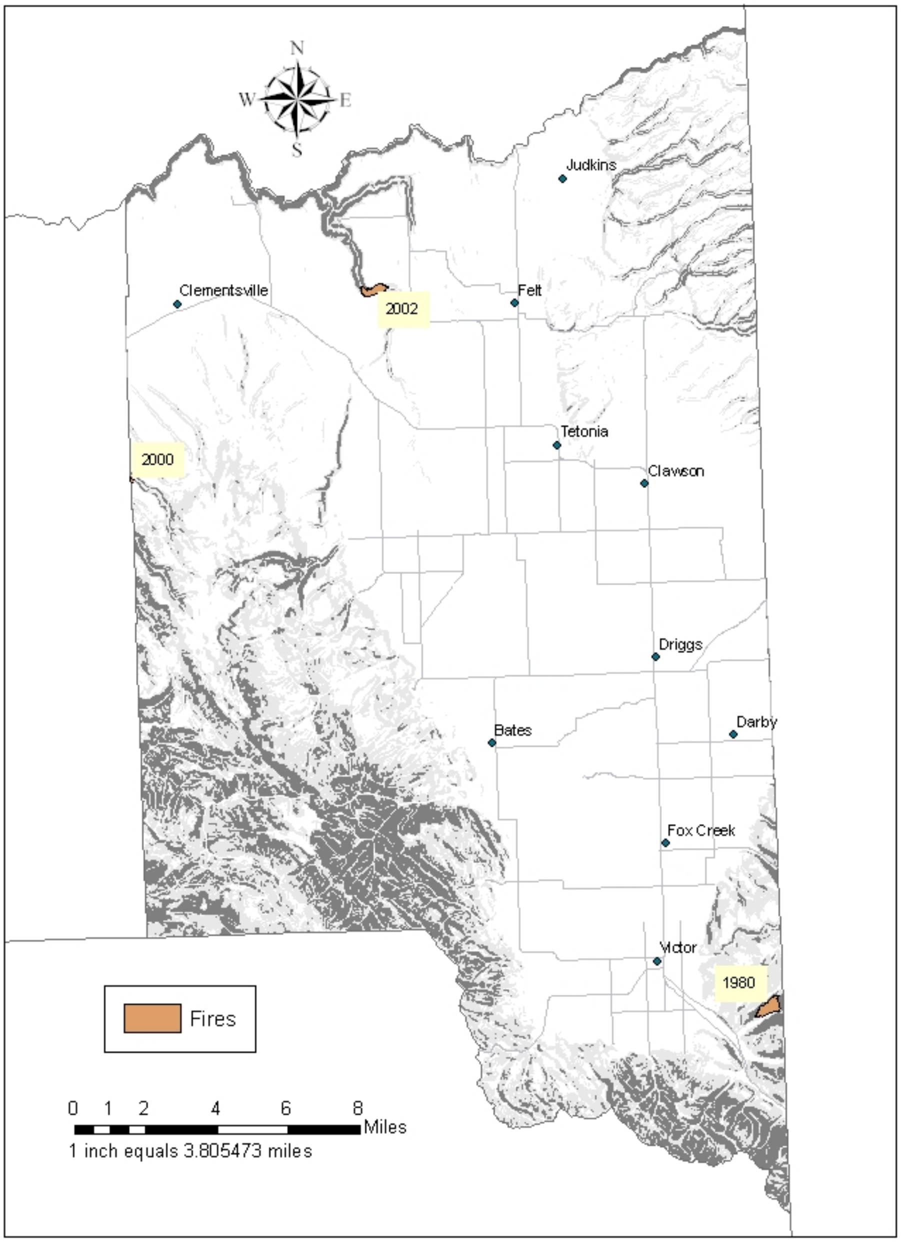

Figure 20. *Fire history for Teton County, 1939-2003.*

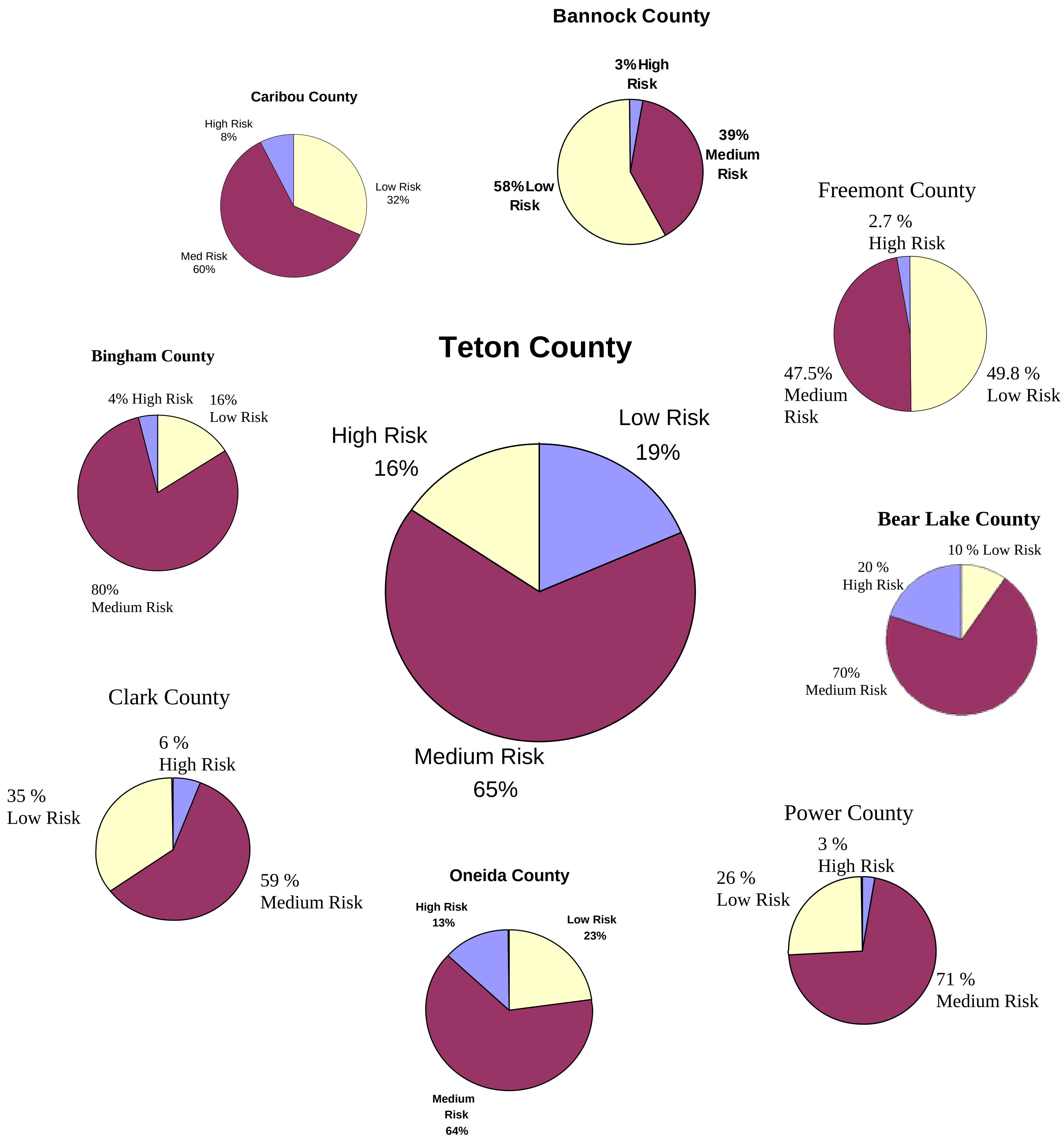

Figure 8: *Percent of Caribou, Bannock, Freemont, Bear Lake, Power, Oneida, Clark, Bingham and Teton counties considered low, medium and high fire susceptibility based on the standard fire susceptibility model.*

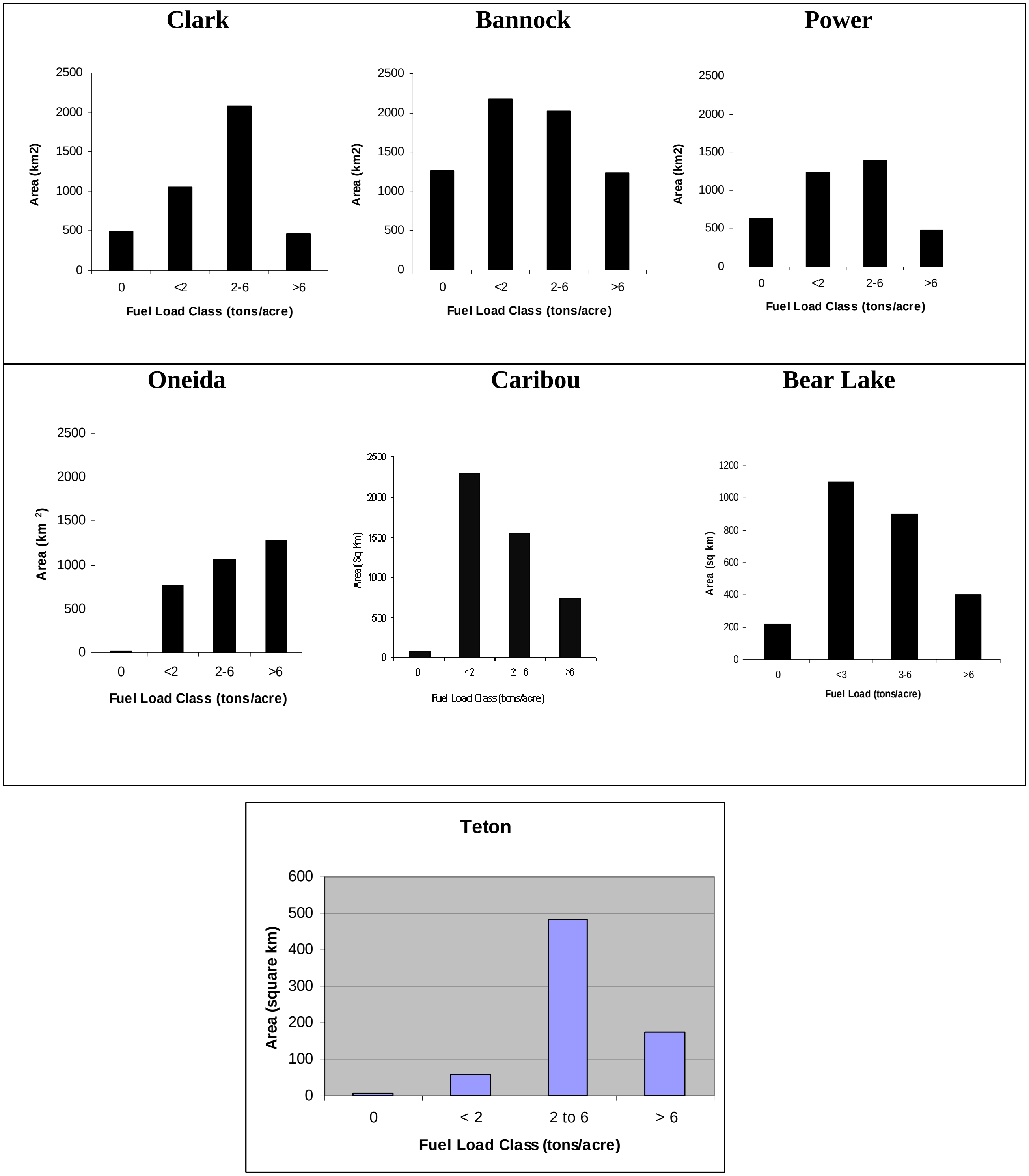

***Figure 9**: Comparison of fuel load distribution for Clark County, Bannock County, Power County, Oneida County, Caribou County, Bear Lake County, and Teton County.*

Total Acres Classified as Low, Medium and High Fire Susceptibility								
	Fremont County	**Bear Lake County**	**Clark County**	**Bannock County**	**Power County**	**Oneida County**	**Caribou County**	**Teton County**
Low	570,608	62,080	395,360	413,146	233,958	175,761	356,923	46,094
Medium	598,237.4	435,008	666,464	277,805	638,886	495,089	688,575	187,261
High	32,434.6	124,288	67,776	21,370	26,996	97,599	84,806	54,737
Total	**1,201,280**	**621,376**	**1,129,600**	**712,321**	**899,840**	**768,449**	**1,130,304**	**288,092**

Table 2: *Total acres classified as low, medium, and high fire susceptibility for Fremont, Bear Lake, Clark, Bannock, Power, Oneida, Caribou and Teton counties.*

Discussion:

Teton, Fremont, Bear Lake, Clark, Bannock, Power, and Oneida counties all contain high desert sagebrush steppe ecosystems.

Of these counties, Teton County has the smallest area with 450 square miles. Bear Lake County has the second-smallest area, with 971 square miles. In order of size Fremont has the largest area, with 1,877 square miles, Clark County with 1,765 square miles, Power County with 1,406 square miles, Oneida County with 1,200 square miles and Bannock County with an area of 1,113 square miles.

Bear Lake County has the highest total acres classified as high fire susceptibility with 124,288 acres. Oneida County has the second largest area classified as high susceptibility with 97,599 acres. Caribou County follows with 84,806 acres classified as high susceptibility, followed by Clark County with 67,776 acres, Teton County with 54,737; Fremont County with 32,434.6 acres and Power County with 26,996 acres. Bannock County has the least acres as high susceptibility at 21,370 acres. The high fire susceptibility classification for all six counties is concentrated in the mountainous areas. This is due to the influence of the topography component models Aspect/ Sun Position, Slope/ Suppression Difficulty, and Slope/ Rate of Spread, as well as the fuel load >6 tons/acre.

Caribou County has the largest area classified as medium fire susceptibility with 688,575 acres. Clark County and Power County (66,464 acres and 638,886acres respectively) have the next highest medium susceptibility classification. This is followed by Fremont, Oneida, Bear Lake, Bannock County, Teton Counties (598,237.4 acres, 495,089 acres, 435,008 acres, and 277,805, 187,261 acres respectively). The southern portion of Clark County and the northern portion of Power County are located within the Snake River Plain which consists of primarily < 2 and 2-6 tons/acre fuels.

NDVI values vary with absorption of red light by plant chlorophyll and the reflection of infrared radiation by water-filled leaf cells. It is correlated with Intercepted Photo-synthetically Active Radiation (IPAR) (Land Management Monitoring, 2003). In most cases (but not all) IPAR and hence NDVI is correlated with photosynthesis. Because photosynthesis occurs in the green parts of plant material the NDVI is normally used to estimate green vegetation. The NDVI is a nonlinear function which varies between -1 and +1 but is undefined when RED and NIR are zero (Land Management Monitoring, 2003). Early in this project we determined thresholds for no-vegetation, dry-vegetation, and moist vegetation using NDVI. We chose the value 0.15 as a threshold between no vegetation and general vegetation based on where and how well the NDVI values matched a DOQQ. We chose the second threshold (separating dry vegetation from moisture vegetation) using similar methods. The NDVI value of 0.6 was the threshold limit between dry vegetation and moist vegetation.

The Structure Vulnerability component was weighted most heavily (22%). Due to the nature of this project, we were most interested in quantifying susceptibility for the Wildland/ Urban Interface. This model allowed us to emphasize the interface areas. Areas of high structure density received the highest fire susceptibility values and areas of low or no structure got the lowest fire susceptibility values. Bannock, by far, has the largest population with 75,323. The next largest by population is Fremont County with 12,263 people. Teton has a population of 7,467 and Bingham has a population of 7,397. Bear Lake County has a population of 6,409. Oneida County's population is 4,131 and Clark County has 971 (U.S. Census Bureau Quick Facts 2003). Though each county has a relatively large area, the Structure Vulnerability component model for Bannock County shows the highest risk to structures (U.S. Census Bureau Quick Facts 2003) because of the number of urban areas within the county.

The Fuel Load/ Rate of Spread takes into account how fast a fire will spread depending on different fuel load classes. The lower fuel load classes were considered to be the primary carrier of fire (e.g. grasses) and have the fastest spread rate. Fuel Load class 3-6 tons/acre received the highest fire susceptibility value, because of its high load of fine, low-standing fuels. Fuel Load class >6 tons/acre received the lowest fire susceptibility value since these fuels are of a larger size and higher moisture content, so they will not ignite as quickly.

The Slope/ Rate of Spread component model takes into account how different angles of slope affect the rate of spread of a fire. When fire moves across flat land it moves more slowly than fire moving up a mountainside (Amdahl, 2001). The steeper angles in this model have the highest fire susceptibility values, because fire increases exponentially with slope. Correspondingly, shallower angles have lower fire susceptibility values.

The Fuel Load/ Vegetation component accounts for moist vegetation and different fuel load classes that may be abundant but not readily flammable. Areas with dry vegetation and high fuel load (>6 tons/acre) had the highest fire susceptibility value. Areas that had wet vegetation and lower fuel load had the lowest fire susceptibility values.

The Fuel Load/ Intensity component takes into account how intense a fire of different fuel load classes affects fire susceptibility. Intensity is considered the amount of energy a fire produces. The more energy the fire produces, the more difficult it is for the firefighters to suppress it. Intense fires create their own wind system, drying out fuel ahead of the fire. This intensity depends on fuel load and other factors such as wind and ground conditions at the time of the fire. Thus, if firefighters do not suppress the fire, it will keep spreading. The fuel load class >6 tons/acre had the highest fire susceptibility value, due to the high intensity fires associated with these larger fuels.

The Slope/Suppression Difficulties component describes how difficult it is for firefighters to suppress fire based on slope/terrain steepness. If firefighters cannot reach the fire, it will keep burning even though it may be a low susceptibility area according to other criteria. Slopes that are > 20 degrees affect wheeled vehicle support and slopes > 30 degrees affect tracked vehicle support. Without the aid of motorized equipment support suppression efforts are slowed, allowing the fire to spread. Slopes with the greatest degree of inclination had the highest fire susceptibility values and shallow slopes received the lowest fire susceptibility values.

The Aspect/ Sun position component models the direction each slope faces and the extent to which the sun desiccates the ground/vegetation. The sun will desiccate the ground/vegetation more on southern aspects and least on northern aspects. Southern aspects received the highest fire susceptibility values and northern aspects received the lowest.

Assessments of error and bias:

All estimations in this report are made based upon our knowledge of the criteria and the expert knowledge of Keith T. Weber, Felicia Burkhardt, Fred Judd, Lance Brady, Kevin Conran, Sarah Heide, and Josse Allen. We have discussed our analyses and results with these people and believe our results to be valid.

The goal for our model is to be a tool to assist fire managers and decision-makers. As we treated each analysis separately, we believe the results have accuracy adequate to fit this purpose. We further believe our model gives a good overview of the fire susceptibility in our study area and that it is easy to understand. Because the model is easy to understand, it should be applied to other users, which was a primary objective with this study.

Not all conditions affecting wildfire could be accurately modeled in this study. Factors not taken into account, such as wind direction and wind speed, are difficult to model without building many assumptions into the model (e.g., yearly weather patterns). Since the scope of this study is broad, we felt that removing these factors from the final model helped its overall effectiveness as a management tool. This also allowed us to place more emphasis on the factors we, Fred Judd, and Kevin Conran (personal communication) felt were more important.

Lastly, the date (Path 38, Row 30, was taken on May 16, 2006) on which the Landsat 5 data was acquired plays a significant role in the outcome of the Fuel Load-based components of the final model.

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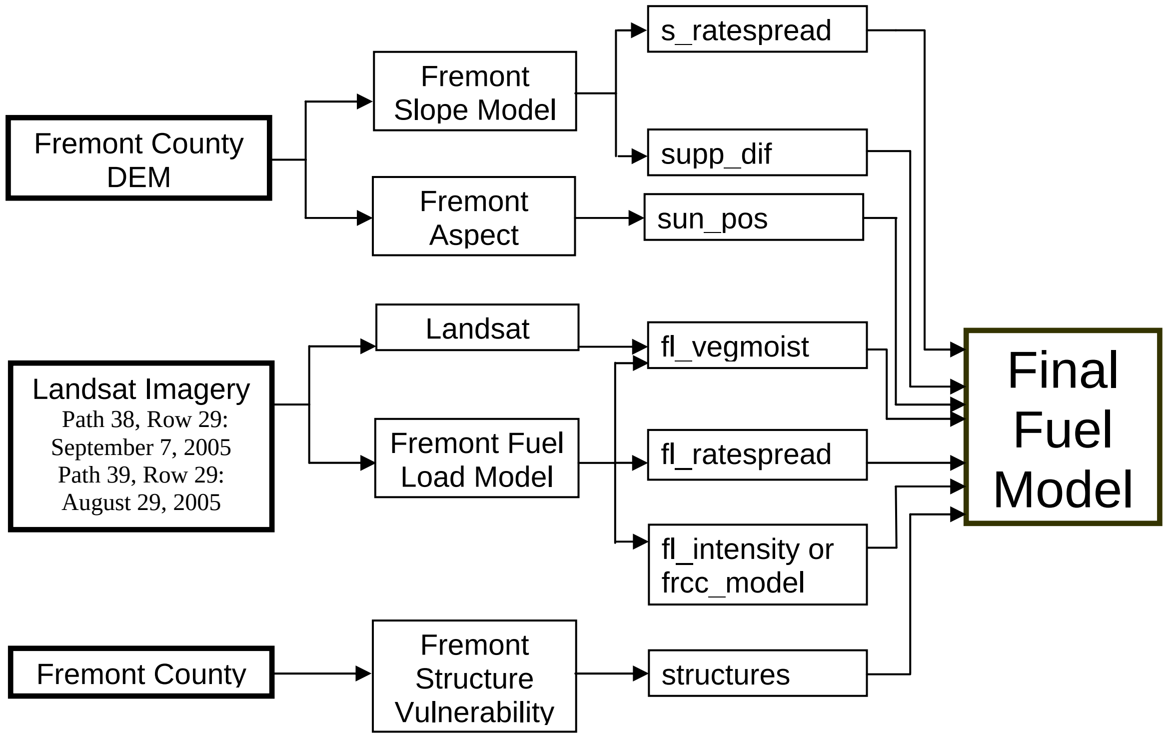
Acknowledgements:

Kevin Conran from the Idaho Bureau of Land Management suggested that we incorporate Vegetation Condition Classes into our Fire Susceptibility model. Shortly thereafter Lance Brady, also from the Idaho Bureau of Land Management, supplied the ISU GIS Center with Condition Class Data. This data has been used to develop an alternate Fire Susceptibility Model for Fremont County and for previous counties where WUI studies were conducted, and where appropriate data was available. The same criteria used in the original model were used to construct this alternate Fire Susceptibility Model with one exception. In the alternate model the Fire Regime Condition Class sub model was used in place of the Fuel load/ Fire Intensity sub model.

Appendices

Appendix A – Cartographic Model



Appendix B – Weightings

These tables show the weightings we used to weight our fire risk model components.

Table B-1: Reclassification system of the *Fuel Load and NDVI grids. Compare with figure1.*

Fuel Load	NDVI
0 = 0 tons/acre	100 = No Vegetation
1 = <3 tons/acre	200 = Dry Vegetation
4 = 3-6 tons/acre	75 = Moist Vegetation
6 = >6 tons/acre	

Table B-2: Weighting data for Fuel Load/ Vegetation Moisture component model (Jansson et al. 2002). Compare with figure 1.

Fuel Load *	Vegetation =	Class	Weights
1	100	100	50
1	200	200	300
1	75	75	150
4	100	400	650
4	200	800	850
4	75	300	400
6	100	600	700
6	200	1200	100
6	75	450	600
0	*	0	25

Table B-3: Weighting data for Fuel Load/ Rate of Spread. Compare with figure 2.

Classes (Tons/acres)	Weights
0	0
1	850
4	1000
6	600

Table B-4: Weighting data for Fuel Load/ Intensity. Compare with figure 3.

Classes (Tons/acres)	Weights
0	0
1	100
4	400
6	1000

Table B-5: Weighting data for Slope/ Rate of Spread. Compare with figure 4.

Angle/degree Intervals	Weights
0—10	41
10—20	137
20—30	256
30—40	489
40—50	1000

Table B-6: Weighting data for Slope/ Suppression Difficulties. Compare with figure 5.

Angle/degree Intervals	Weights
0--10	100
10--20	200
20--30	850
30--40	1000
40--50	1000

Table B-7: Weighting data for Aspect/ Sun Position. Compare with figure 6.

Degree Interval	Aspect	Weight
337.5--22.5	N	100
22.5--67.5	NE	150
67.5--112.5	E	300
112.5--157.5	SE	800
157.5--202.5	S	1000
202.5--247.5	SW	1000
247.5--292.5	W	700
292.5--337.5	NW	200

Appendix C – Data dictionary

Data	File name	Description	Format
County boundary	TetonCntyBoundClip	Boundary of Teton county	polygon coverage
County Roads	TetonRds	Roads of Teton County	Shapefile
Structures Model	Structur	Data set of structures	Shapefile
Bands used for NDVI	Band_3	Landsat Band 3 for Teton County	Grid - 28.5m pixels
	Band_4	Landsat Band 4 for Teton County	Grid - 28.5m pixels
NDVI	NDVI	NDVI for Teton County	Grid - 28.5 pixels
Fuel Load Model	FuelLoad	Fuel Load model for Teton County. Classes are 0 tons/acre, <3 tons/acre, 3-4 tons/acre, and 6> tons/acre	Grid - 28.5m pixels
DEM	Demclip	Digital Elevation Model of Teton County	Grid - 28.5m pixels
Component models	...\ Teton_WUI\FinalFuelModel\Aspect\sunpos\sunpos	Susceptibility associated with aspect angle **i.e**. North, East, ...	Grid - 28.5m pixels
	...\Teton_WUI\FinalFuelModel\Slope\s_ratespread\TetnRSCM	Susceptibility associated with how fire spreads with angle of slope.	Grid - 28.5m pixels
	...\Teton_WUI\FinalFuelModel\Slope\slope_clip\TetnSDCM	Susceptibility associated with how suppression efforts are affected by angle of slope.	Grid - 28.5m pixels
	...\Teton_WUI\FinalFuelModel\FuelLoad\ratespread\ratesprd	Susceptibility associated with how quickly different fuel load classes spread during a fire.	Grid - 28.5m pixels
	...\Teton_WUI\FinalFuelModel\FuelLoad\fire_inten\intensity	Susceptibility associated with how intense (release of heat energy) different fuel load classes burn.	Grid - 28.5m pixels
	...\Teton_WUI\FinalFuelModel\FuelLoad\veg_moist_model\stretch\multiply	Susceptibility associated with vegetation moisture.	Grid - 28.5m pixels
	...\Teton_WUI\FinalFuelModel\Structures\structur	Susceptibility associated with structure density.	Grid - 28.5m pixels
Final Model	...\Teton_WUI\FinalFuelModel\FinalFireRisk\finals	Final susceptibility model	Grid - 28.5m pixels
Reports	Teton_WUI_Report_final.doc	Report covering methods, results, & conclusions of WUI modeling	Word Document