# Wildland/Urban Interface Fires and Communities at Risk

## Joint Fire Modeling Project for Bingham County, Idaho
## Bureau of Land Management, Upper Snake River District GIS
## and
## Idaho State University GIS Training and Research Center

December 10, 2004

**Jackie Langille, langjack@isu.edu**

**Richard Neves, neverich@isu.edu**

**Jill Norton, nortjill@isu.edu**

**Francisco M. Garcia Gomez franmigg@fyl.uva.es**

**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 Bingham County, Idaho. Component models were created with specific individual risks associated with wildfire: topography, fuel load, and the structure density. These models were evaluated together to create a final fire risk model for Bingham County, Idaho. This report describes each of the WUI fire risk components and what affect each had on the final fire risk model. The final model is an accurate depiction of the spatial distribution of wildfire risk in Bingham County and can be used by regional fire managers to manage wildfire risk. The Final Fire Risk Model shows that 80% of Bingham County has a medium fire risk rating.

**Keywords:** Wildfire, GIS, Bingham County, Idaho, BLM, Fire Regime Condition Class, Slope, Aspect, Fuel Load.

*Contents*

***Wildland/Urban Interface Fires and Communities at Risk*** ..... ***1***

***Abstract:*** ..... ***1***

***Keywords:*** ..... ***1***

***Introduction:*** ..... ***3***

***Methods:*** ..... ***4***

***GIS data sets:*** ..... ***4***

***Data Preprocessing:*** ..... ***4***
Elevation Data: ..... 4
Landsat Imagery: ..... 4
Other Datasets: ..... 5

***Data Processing:*** ..... ***5***
Topographic Component Models ..... 6
Fuel Load Component Models ..... 8

Fire Regime Condition Class (FRCC) Component Model ..... 12
Structure Component Model ..... 12

***WUI fire risk model*** ..... ***13***

***Results:*** ..... ***13***

***Discussion:*** ..... ***28***

***Assessments of error and bias:*** ..... ***30***

***References cited:*** ..... ***31***

***Acknowledgements:*** ..... ***32***

***Appendices*** ..... ***33***

***Appendix A – Cartographic Model*** ..... ***33***

***Appendix B – Weightings*** ..... ***34***

***Appendix C – Data dictionary*** ..... ***36***

## 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.
- **Structures 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 Bingham County, Idaho WUI fire risk assessment is a continuation of WUI projects that have been completed and validated for the City of Pocatello, Idaho (Mattson *et al*., 2002) the city of

Lava Hot Springs, Idaho (Jansson *et al.,* 2002), Clark County, Idaho (Gentry *et al.*, 2003), Bannock County, Idaho (Gentry *et al.*, 2003), Power County, Idaho (Gentry *et al.*, 2003), Oneida County, Idaho (Frank *et al., 2004),* and Caribou County, Idaho (Bulawa *et al.,* 2004).

# Methods:

## GIS data sets:

- Digital Elevation Model (DEM) of Bingham County
- Landsat 5 TM imagery for Bingham County and environs –Path 039, Row 030, acquired August 25, 2004.
- Digital Orthophoto Quarter-Quads (DOQQs) for Bingham County acquired September 3, 2004.
- Transportation, place and county boundary datasets for Bingham County
- Structure data (Bingham County Driveways) provided by Cheryl Robertson of Bingham County last updates August 13, 2004.
- Fire Regime Condition Class data provided by Lance Brady of the Idaho Bureau of Land Management, Upper Snake River District on July 14, 2004.

## Data Preprocessing:

### ***Elevation Data:***

The DEM data for Bingham County was obtained from the 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. The component models produced with this data set were considered undesirable due to the 90 meter spatial resolution of the original DEM. High resolution Slope and Aspect data was subsequently provided by ISU GIS Director, Keith Weber. These data replaced the DEM originally obtained from the ISU Spatial Library, and new slope and aspect models were created using pixels with 28.5 meter spatial resolution.

### ***Landsat Imagery:***

Landsat 5 TM multispectral imagery was used (Path 039 Row 030, acquired August 25, 2004). The Landsat Imagery was ordered from the USGS website, http://edcsns17.cr.usgs.gov/EarthExplorer/ . We used bands 1, 2, 3, 4, 5, and 7. These bands were converted into ArcInfo grids using the *imagegrid* command of ArcInfo 9.

***Other Datasets:***

The Idaho county boundaries and Idaho places datasets were downloaded from the Spatial Library (located on the ISU GIS Center website, http://giscenter.isu.edu/data/data.html). The Bingham County boundary was selectively saved as a separate shapefile and re-projected to IDTM-83.

The roads dataset was also obtained from the GIS Center's Spatial Library.

## 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
    - *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).

The *Structures at risk* component model was produced using a buffer procedure suggested by Blackfoot Fire Chief Kevin Gray and Pocatello Fire Official Roger Reese and are discussed in detail later in this report.

## ***Topographic Component Models***

### ***Creating the Topographic: Slope: Suppression Difficulty Component Model***

Using the Bingham 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 cellsize was 30 meters.

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

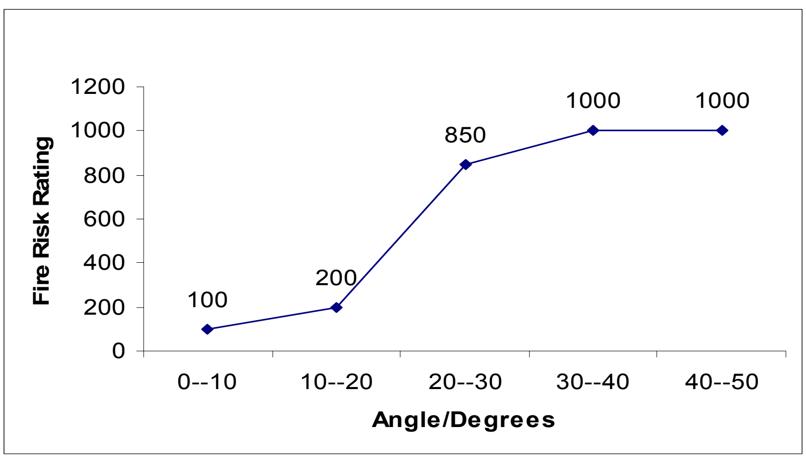



***Figure 1.*** *Weightings for slope/suppression difficulties describe how suppression difficulties are affected by the angle of slope (Mattsson et al, 2002).*

### ***Creating the Topographic: Slope: Rate of Spread Component Model***

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

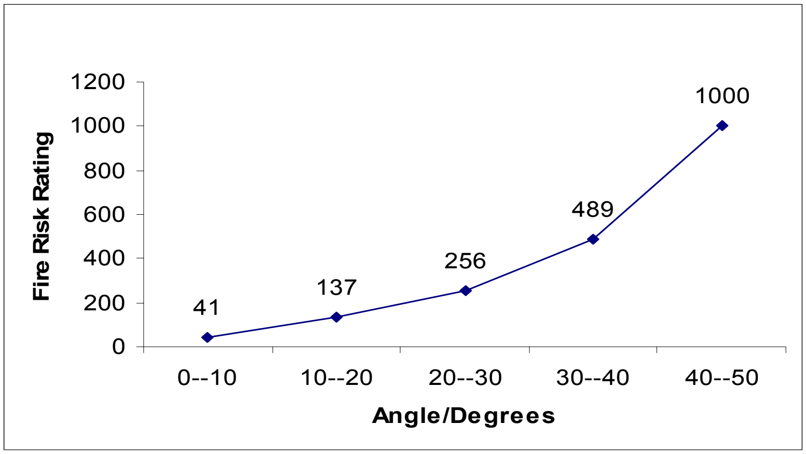



***Figure 2.*** *Weightings describe how spread rate increase with angle of slope. The weight proportion is essentially exponential with slope angle (Mattsson et al., 2002).*

***Creating the Topography: Aspect: Sun Position Component Model***

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

To create the Aspect: Sun Position component model we reclassified the aspect grid, following Mattsson *et al* (2002) (table B-7 in Appendix B) using ArcMap (Spatial Analyst → Reclassify) shown in figure 3.

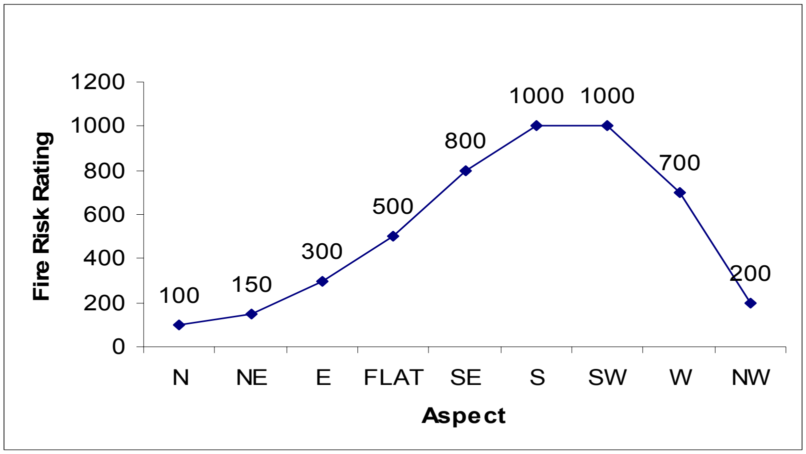



***Figure 3.*** *Weightings for Aspect/Sun position describe how the sun desiccates the ground at different aspects (Mattsson et al, 2002).*

## *Fuel Load Component Models*

### *Creating the Fuel Load Fire Risk Component Model*

The fuel load risk components were derived from fuel load estimates which were in turn determined using the Normalized Difference Vegetation Index (NDVI) that was calculated using the Landsat imagery.

We estimated vegetation cover with satellite imagery using the Normalized Difference Vegetation Index (NDVI) for Landsat 5 TM (August 25, 2004). 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 Landsat 5 TM imagery. The resulting NDVI has an interval of –1 to +1, where pixels with –1 were no vegetation and pixels with +1 were theoretically filled with photo synthetically active vegetation. Idrisi (Image Processing→ Transformation→ VEGINDEX) was used to calculate the NDVI grid using equation 1:

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

***Equation 1****: Equation for calculating NDVI.*

The PCA, Principal Components Analysis was creating using Idrisi (Image Processing→ Transormation→PCA). This produces 7 components. PCA components 1, 2 and 3 were used.

Supervised classification of Landsat 5 TM imagery through Idrisi Kilimanjaro (ver. 14.02) was used for estimating fuel load in Bingham County. To estimate fuel load, we used field sample points (231 sample points) that were collected in July of 2004 within the Big Desert area of Western Bingham County. 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:

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

Using Idrisi, we created signature files for the field training sites using an NDVI model produced from Landsat 5 TM 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 model was validated using the following methodology:

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

The fuel load grid (with values 0, 1, 4, and 6) was then multiplied by the vegetation moisture grid (ArcMap → Spatial Analyst → Raster Calculator) to produce an intermediate raster grid. The intermediate grid was then reclassified using weights based on Jansson *et al.* (2002) shown in B-2 of Appendix B.

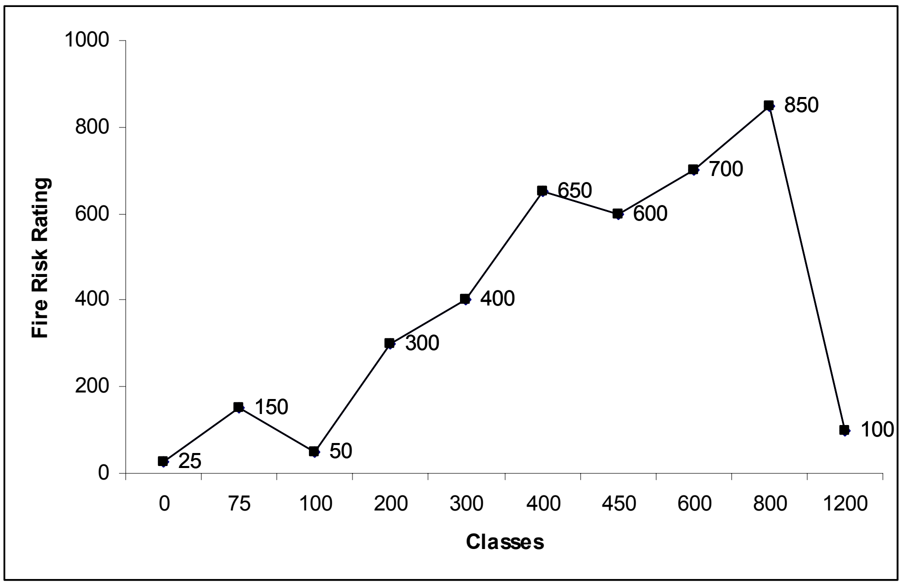



***Figure 4.*** *Weightings for Fuel Load/ Vegetation Moisture (Jansson et al, 2002).*

### *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).

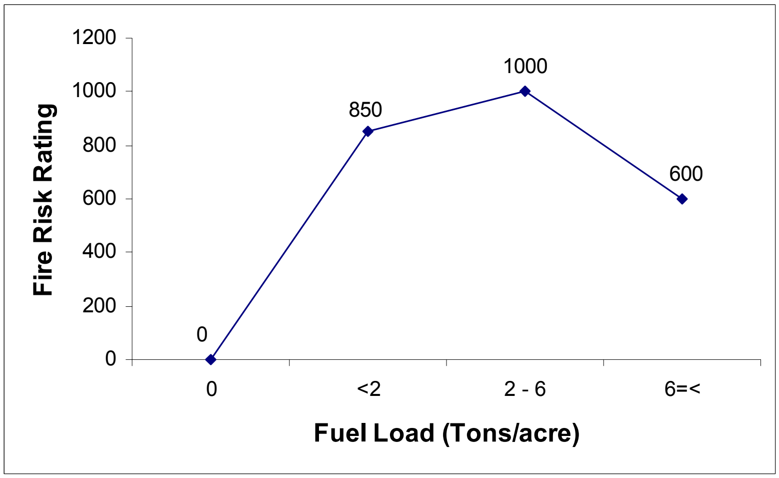



***Figure 5***. *Weightings for Fuel Load/ Rate of Spread (Mattsson et al, 2002).*

### *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).

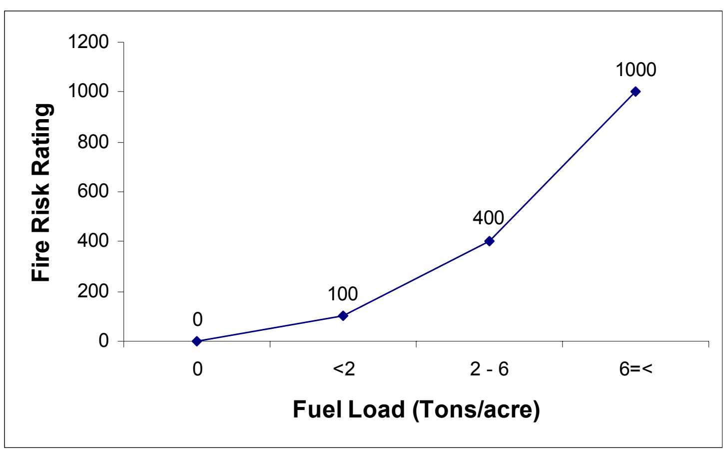



***Figure 6.*** *This chart describes all weightings for Fuel Load/ Intensity (Mattsson et al, 2002).*

## ***Fire Regime Condition Class (FRCC) Component Model***

To create an Alternative Fire Regime Condition Class Fire Risk Model, we substituted the Fire Regime Condition Class (FRCC) Component Model for the Fire Intensity Component Model.

There are 3 condition classes used in this study. The 3 condition classes are used with 5 fire regimes. The 5 fire regimes are essentially fuel models. The condition classes indicate the condition of the area relative to its historic fire regime as it relates to fire return interval (*Conran,* personal communication).

The 5 fire regimes are based on a vegetation community's historic fire return interval and historic fire severity (stand-replacing or not). The fire regimes resemble fuel models because fire frequency and severity directly affect fuel loading. An FRCC of 3 can also indicate a fire regime that is out of whack due to too much fire (too many acres burned). The sagebrush steppe in the Snake River Plain is a good example of a vegetation community that has had a dramatically increased fire return interval compared to the historic fire interval, due to a continuous bed of cheat grass (*Heide,* personal communication).

The Fire Regime Condition Class data provided by Lance Brady of the Idaho Bureau of Land management (figure 22) was converted to raster format using ArcMap (Spatial Analyst→Convert→Feature to Raster). It was then reclassified (Spatial Analyst→Reclassify) to create the Normalized Fire Regime Condition Class Component Model (figure 24). Agriculture and Condition Class 1 were reclassified to 300, Cheat Grass and Condition Class 2 were reclassified to 700, Condition Class 3 was reclassifed to 1000, and all others were reclassified to 0.

## ***Structure Component Model***

### ***Structures at Risk Component Model***

To create the Structures at Risk component model we used a "driveways" shapefile provided by Cheryl Robertson of Bingham County. From these data a *Structure Density* model was created using ArcMap 9.0 (ArcMap→ Spatial Analyst → Density).

In order to produce the *Structures at Risk* model from the *Structure Density Model*, we consulted with Blackfoot Fire Chief Kevin Gray and Pocatello Fire Official Roger Reese. They suggested the use of a buffer procedure to identify those structures on the margin of organized communities. Only those structures found outside the buffer would be used to produce the *Structures at Risk* component model.

After analyzing Bingham County Fire Risk maps provided by Kevin Gray, and various buffer dimensions, we selected a buffer of 200 meters as appropriate for Bingham County communities. These communities are Blackfoot, Firth, Basalt, Shelley, and Aberdeen. To make this component consistent with the other models, pixel values were reclassified 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 Bingham 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 5 TM satellite imagery. Table 4 shows the error matrix validation for the fuel load model. The overall Kappa statistic was determined to be 0.7083 indicating that the classification was approximately 70.8% better than chance.

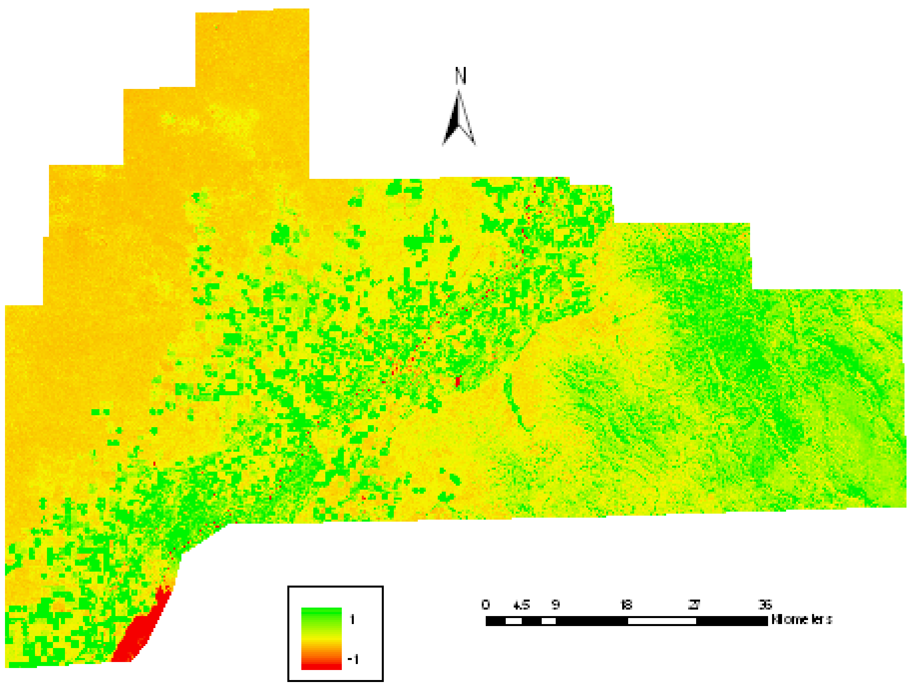



***Figure 9.*** *The NDVI has an interval of –1 to +1, where –1 is no vegetation and +1 is pure vegetation.*

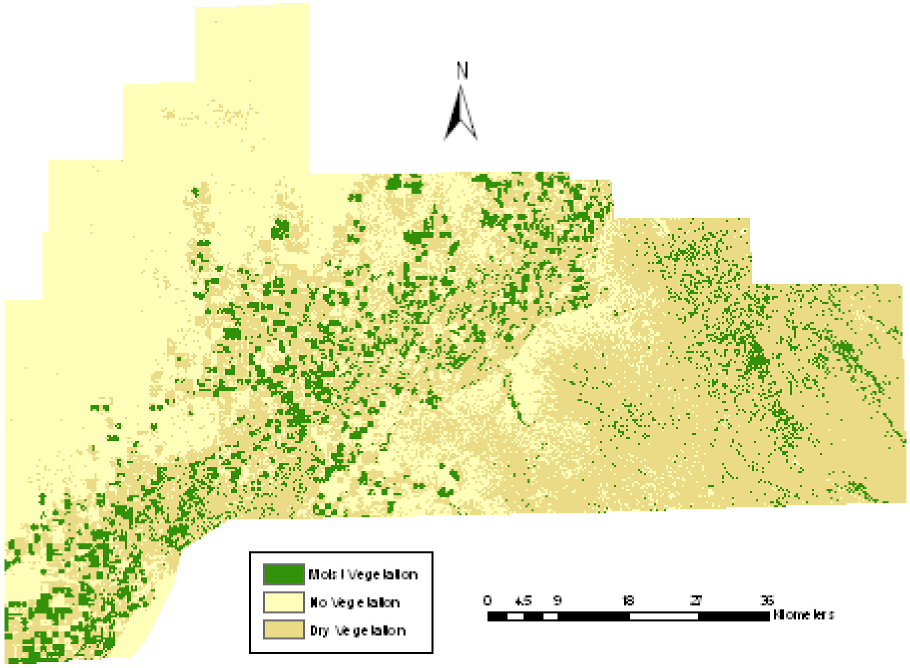



***Figure 10.*** *The results of the reclassification of NDVI into no vegetation (100), dry vegetation (200) and wet vegetation (75).*

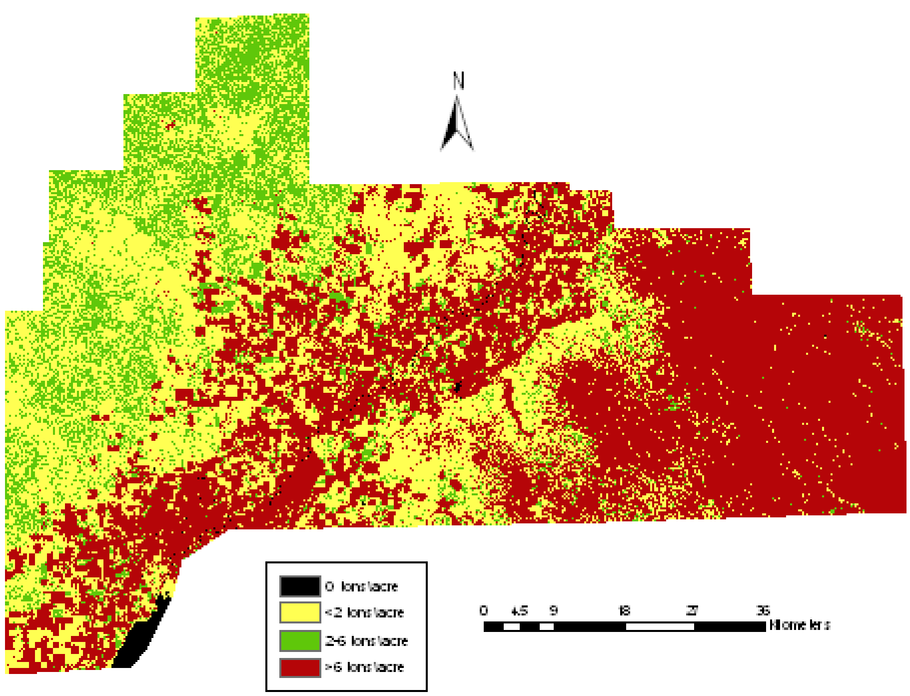



***Figure 11.*** *The fuel load model and the distribution of different fuel load classes for Bingham County, ID.*

**Field Measurement (tons/acre)**

| | | 0 | <2 | 2 - 6 | >6 | Total | Commission Accuracy |
|---|---|---|---|---|---|---|---|
| **Modeled Fuel Load (tons/acre)** | **0** | 7 | 0 | 0 | 0 | **7** | 100.00% |
| | **<2** | 0 | 52 | 3 | 0 | **55** | 94.55% |
| | **2 - 6** | 0 | 20 | 13 | 0 | **33** | 39.39% |
| | **>6** | 0 | 0 | 0 | 27 | **27** | 100% |
| | **Total** | **7** | **72** | **16** | **27** | **122** | **Overall Accuracy** |
| | **Ommission Accuracy** | 100.00% | 72.22% | 81.25% | 100.00% | | **81.15%** |

***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 grasses, shrubs, and mountainous areas throughout Bingham 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 in the western portion of Bingham County contain the highest values. The high risk areas are due to the high concentration of 0-4 tons/acre fuels. Finally, figure 14 is the intensity model. Conifers in the highlands comprise the highest risks for the most intense fires.

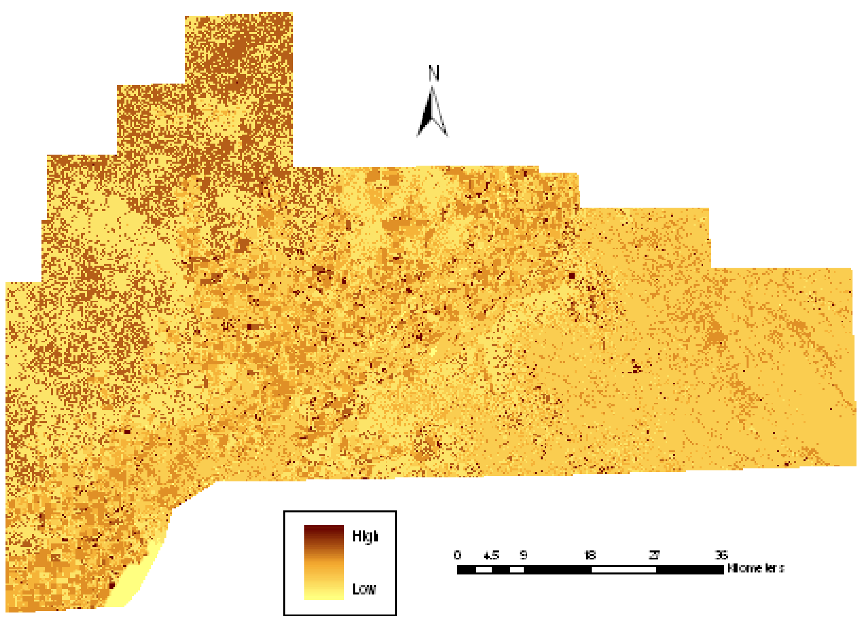



***Figure 12.*** *Fuel Load/ Vegetation Moisture model. This model expresses how low vegetation moisture and the combination of different fuel load classes affect fire risk. This model was given an overall weighting of 11% of the final model.*

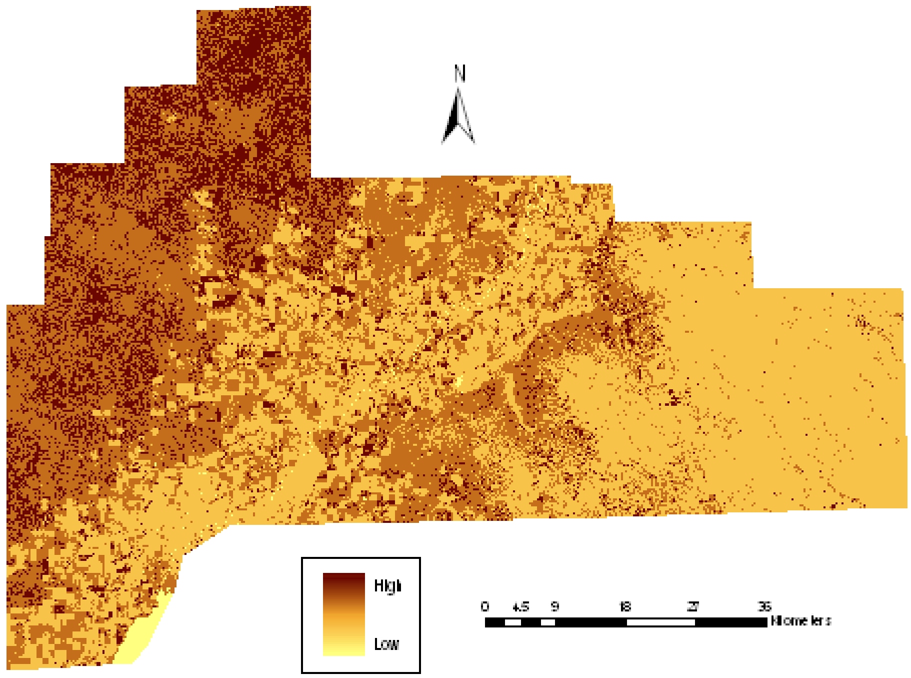



***Figure 13.*** *The Fuel Load/ Rate of Spread model. This model expresses the fire risk associated with the spread rate of different fuel load classes. This model was given an overall weighting of 17% of the final model.*

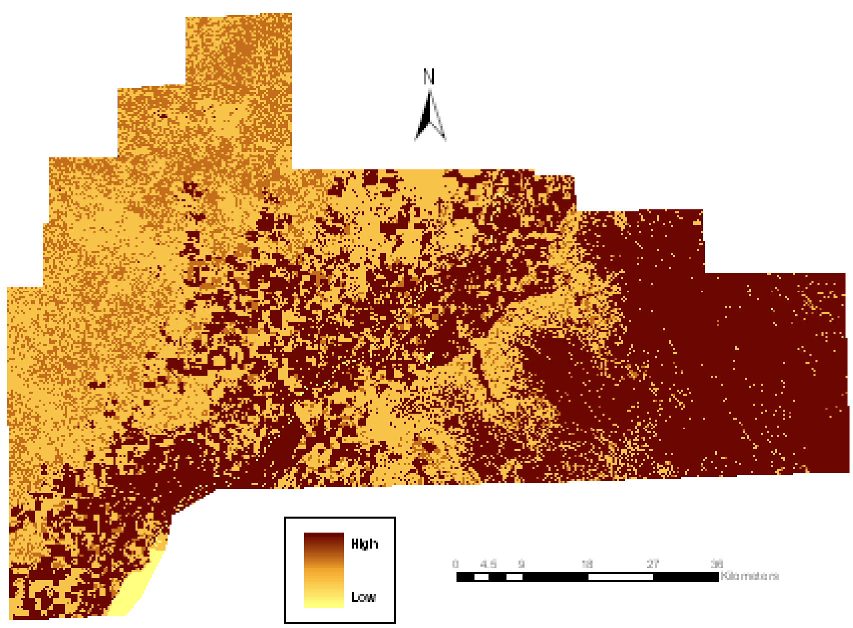



***Figure 14.*** *The Fuel Load/ Intensity model. This model expresses the fire risk associated with the amount of heat energy (intensity) each fuel load class gives off. This model was given an overall weighting of 17% of the final model.*

Figures 15-17 are the component models generated using the Bingham 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 in the eastern part of the county 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.

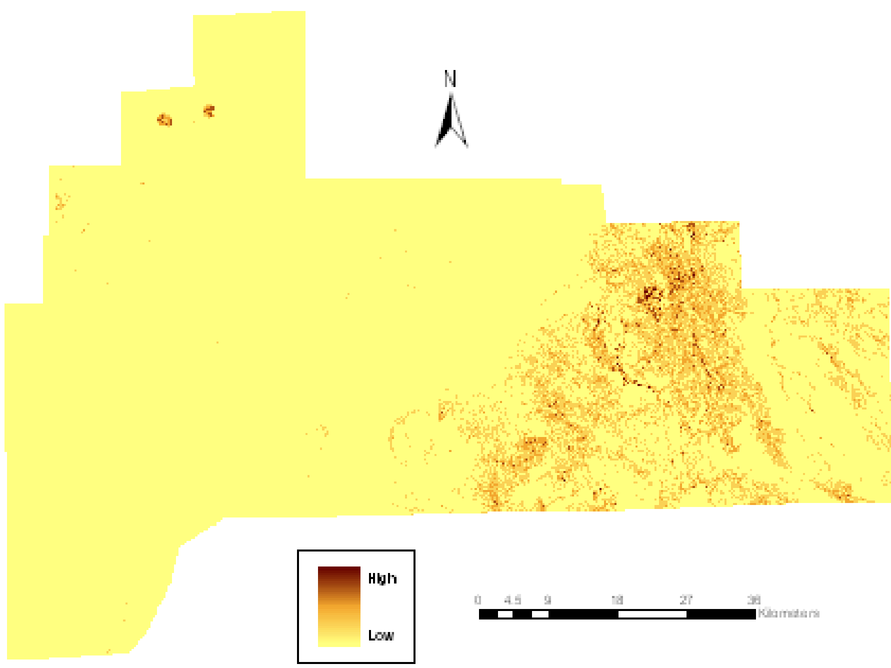



***Figure 15.*** *The Slope/ Rate of spread model. This model expresses how different angles of slope affect the spread rate of fire. Steeper slopes are given the highest fire risk. This model was given an overall weighting of 17% of the final model.*

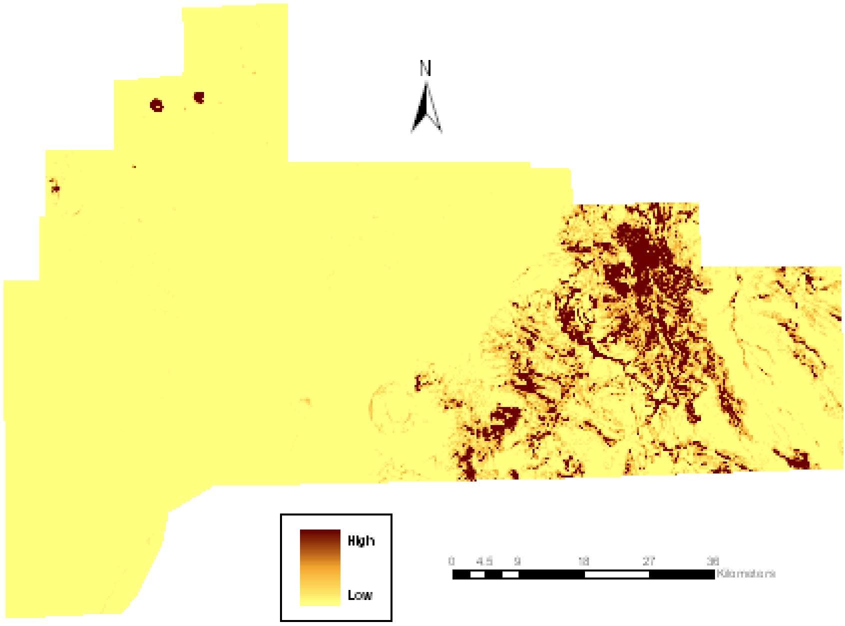



***Figure 16.*** *The Slope/ Suppression Difficulty model. This model expresses how different slope angles affect suppression efforts of firefighters. This model was given an overall weighting of 11% of the final model.*

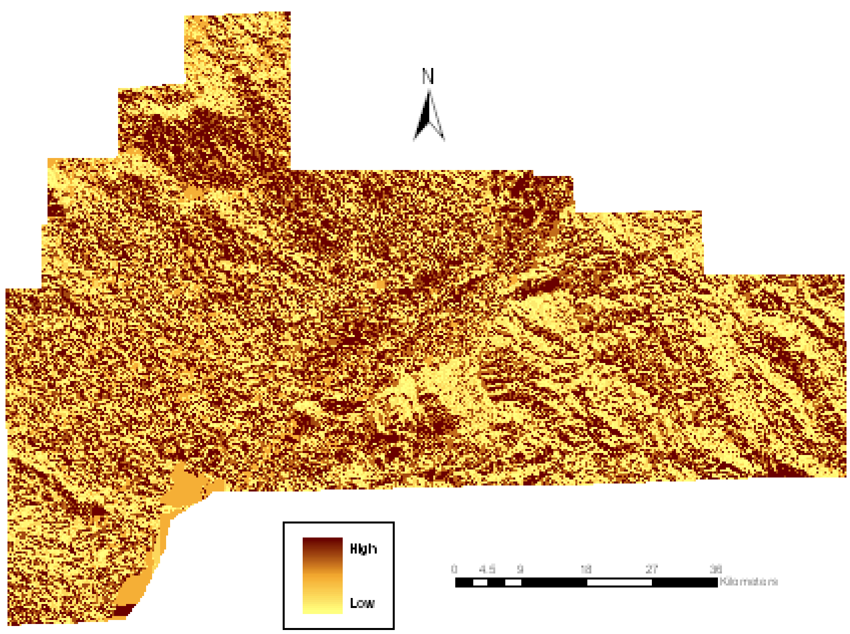



***Figure 17****. The Aspect: Sun Position. This model expresses how different aspects affect fire risk. Southern aspects have the highest fire risk. This model was given an overall weighting of 5% of the final model.*

Figure 18 shows the Structures at Risk Component model. Areas directly outside or within 200 meters inside the city limits that have the highest density (per $Km^2$) have been assigned the highest values. Those with low structure density have been assigned low values.

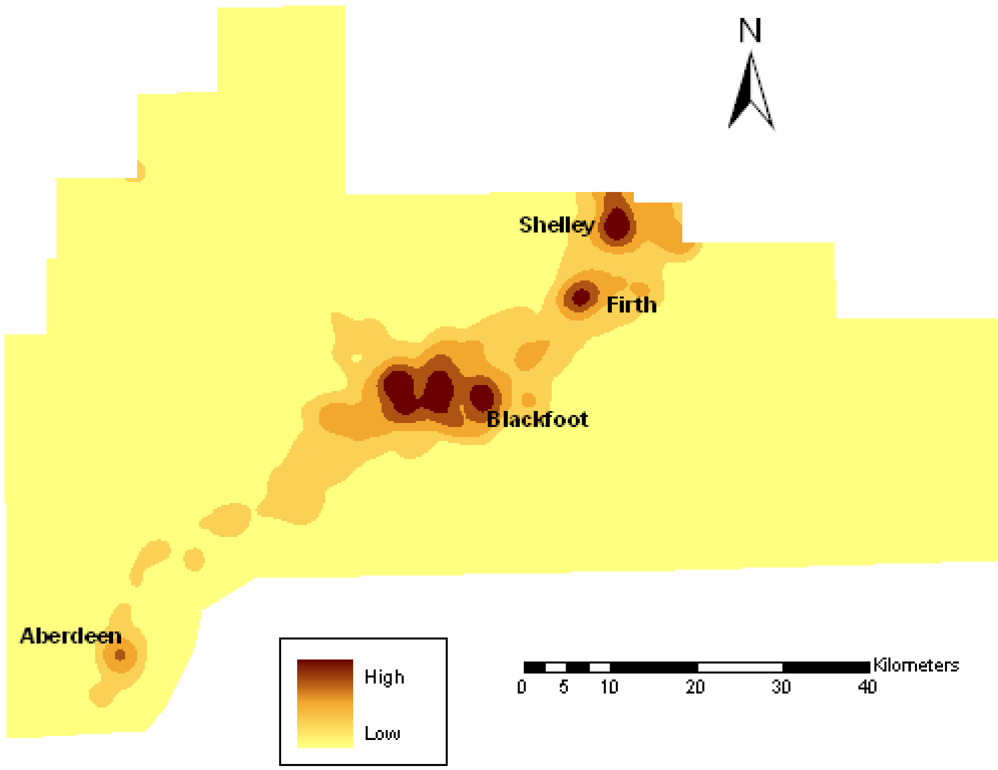



***Figure 18.*** *The Structures at Risk model. This model expresses areas that are high risk to structures and is given an overall weighting of 22% of the final model.*

The Final Fire Risk Model for Bingham County is shown in Figure 19 and the fire risk model with BLM lands superimposed is in Figure 20. Figure 21 shows the Fire History on public lands within Bingham County from 1939 – 2003. This was constructed from data available in the ISU GIS Center's Spatial Library.

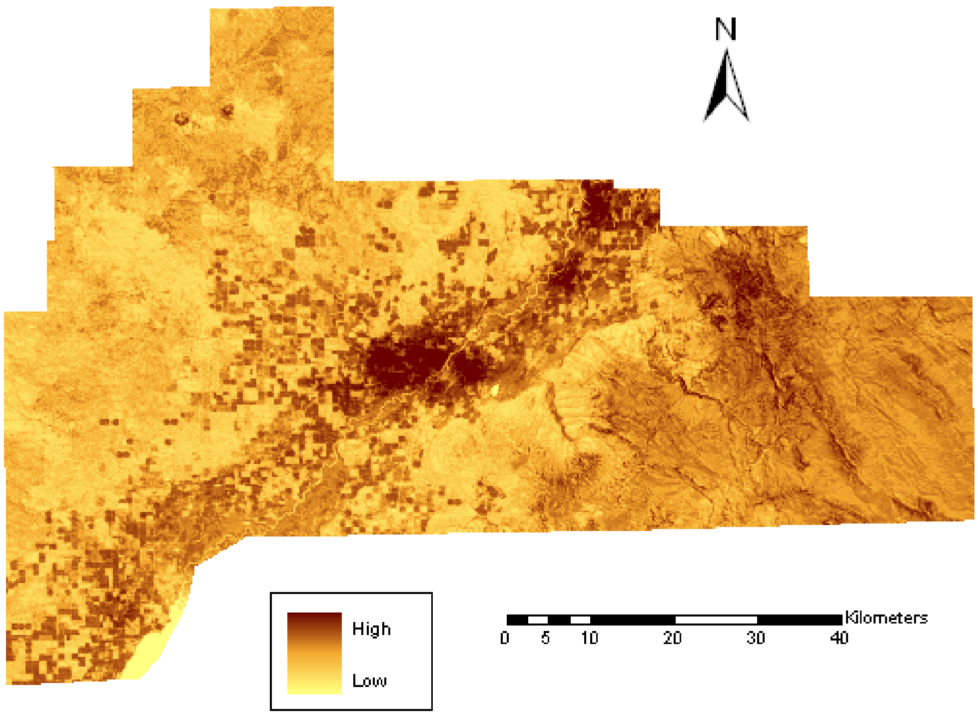



***Figure 19.*** *The Final Fire Risk Model for Bingham County, Idaho.*

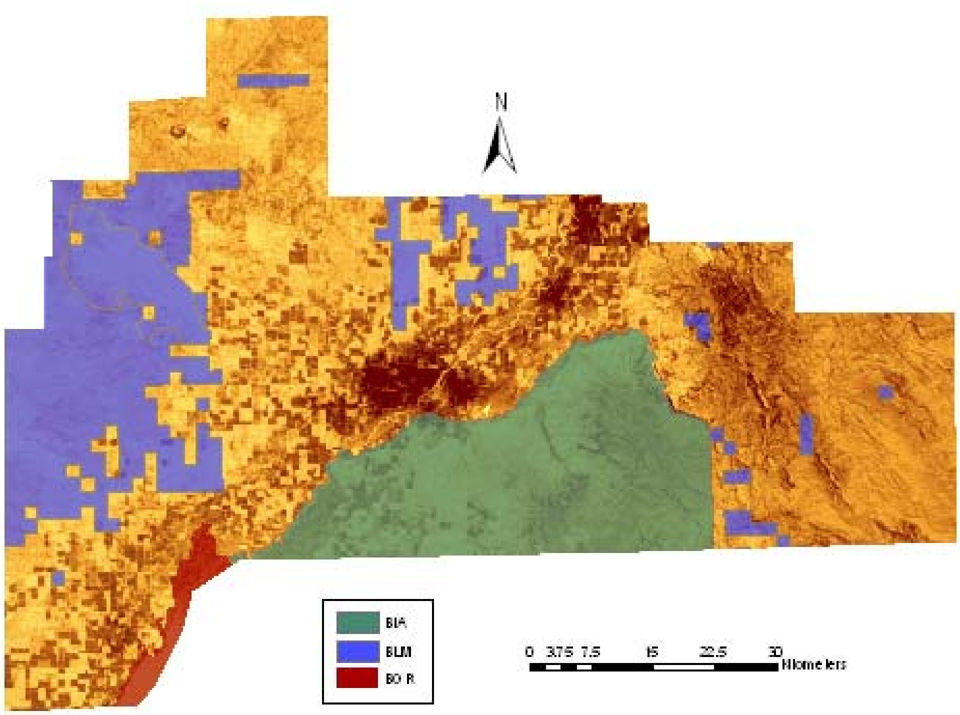



***Figure 20.*** *Federal lands within Bingham County.*

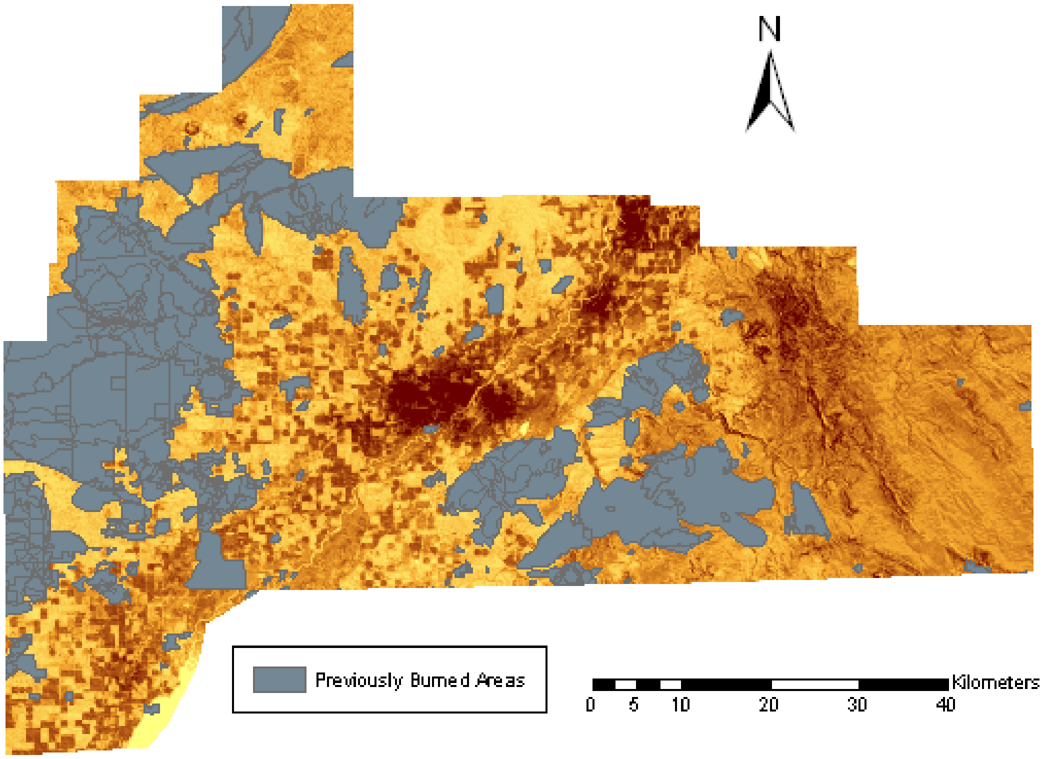



***Figure 21.*** *Fire history for Bingham County, 1939-2003.*

## ***Alternate Fire Risk Model***

An Alternate Fire Risk Model was created by substituting the Fire Regime Condition Class component model in place of Fuel Load: Fire Intensity. The component models and weights comprising the Alternate Fire Risk model were multiplied by their own weighting percentage *(Table 5*). The resulting values were then added to produce the Alternate Fire Risk Model (Figure 25).

| 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% |
| Fire Regime | Condition Class | 17% |
| Structures | Structures at Risk | 22% |

***Table 5.*** *Sub model components of the Fire Regime Condition Class Alternate Fire Risk Model*

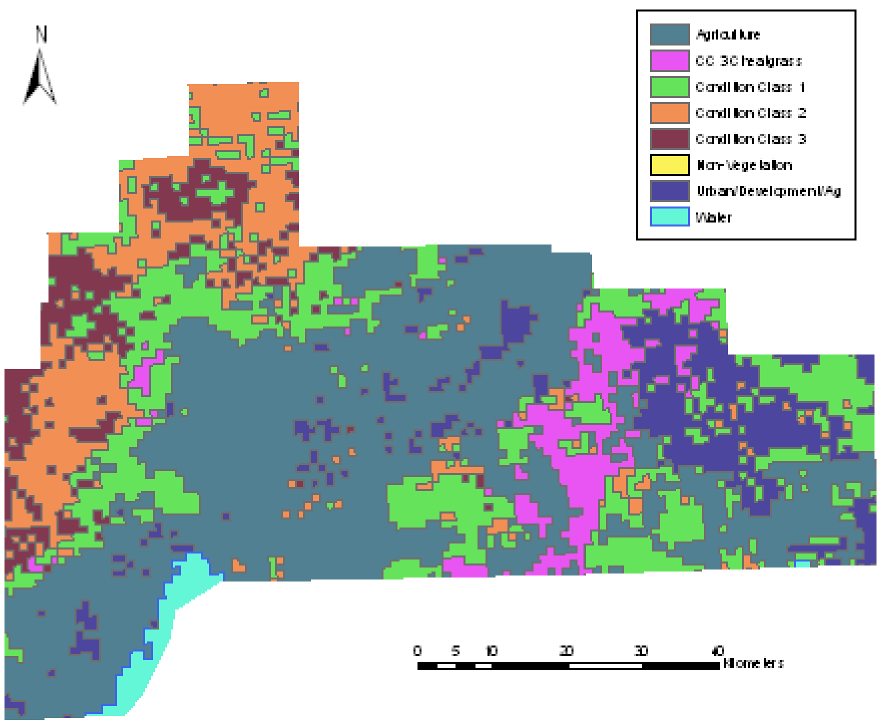



***Figure 22.*** *Condition Classes of Bingham County from data provided by Lance Brady of the Bureau of Land Management*

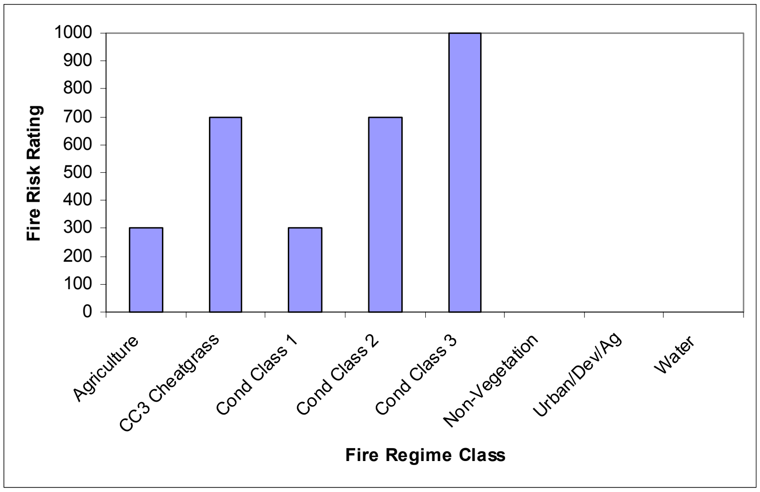



***Figure 23.*** *Fire risk ratings of Fire Regime Class components*

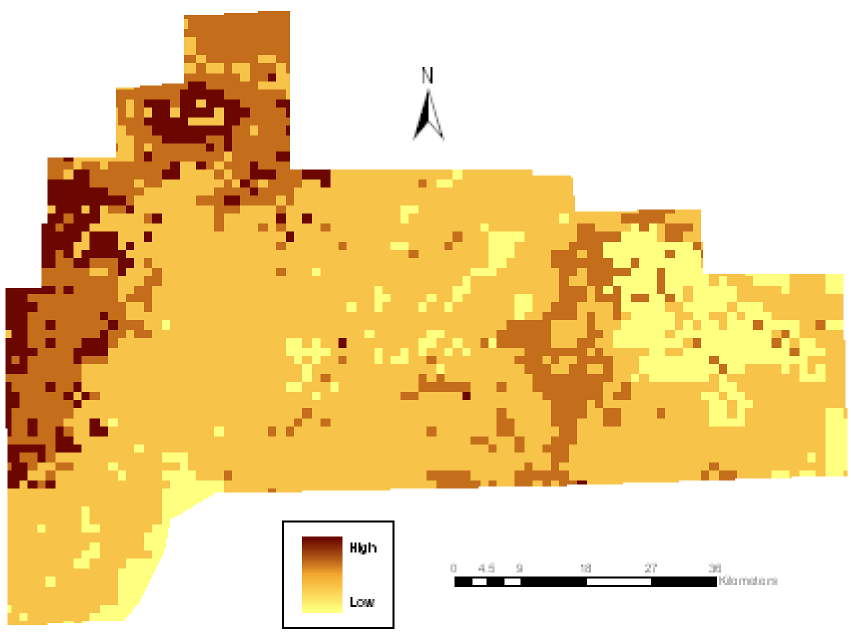



***Figure 24.*** *Normalized Fire Regime Condition Class sub model component*

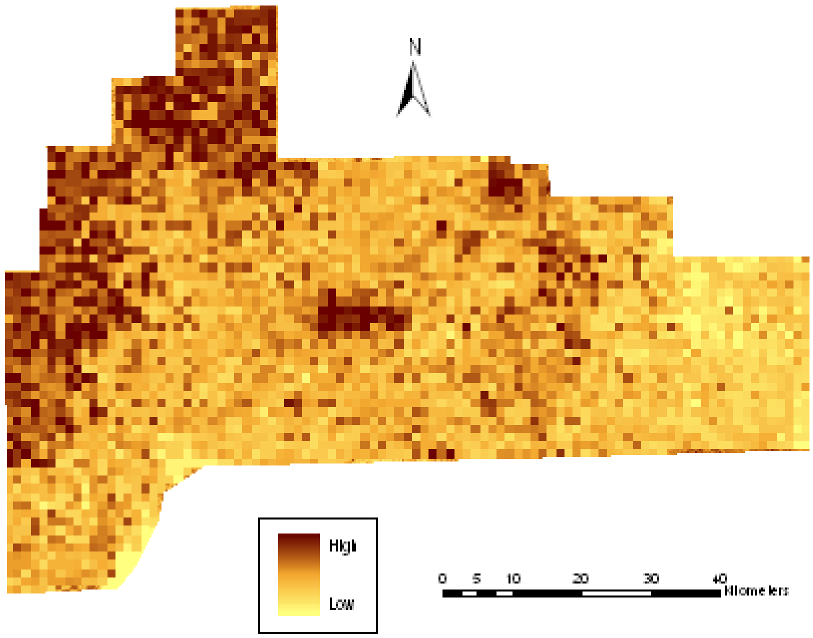



***Figure 25.*** *Alternate Fire Risk Model for Bingham County using the Fire Regime Condition Class sub model in place of the Fuel Load: Fire Intensity sub model.*

We compared the WUI fire risk models for Clark County, Bannock County, Power County, Oneida County, Caribou County, and Bingham County, Idaho. Figure 7 shows portions of each county classified as low, medium, and high risk relative to individual areas. We did this by reclassifying the final fire risk model into three distinct classes (0-222 = low risk; 222-444 = medium risk; 444-668 = high risk). The Fire Risk Model has values from 0 – 668. Comparison between total acres classified as low, medium, and high fire risk is shown in table 2. Figure 8 describes the fuel load distribution for each county. Table 3 shows total acres of BLM Land classified as low, medium, and high fire risk.

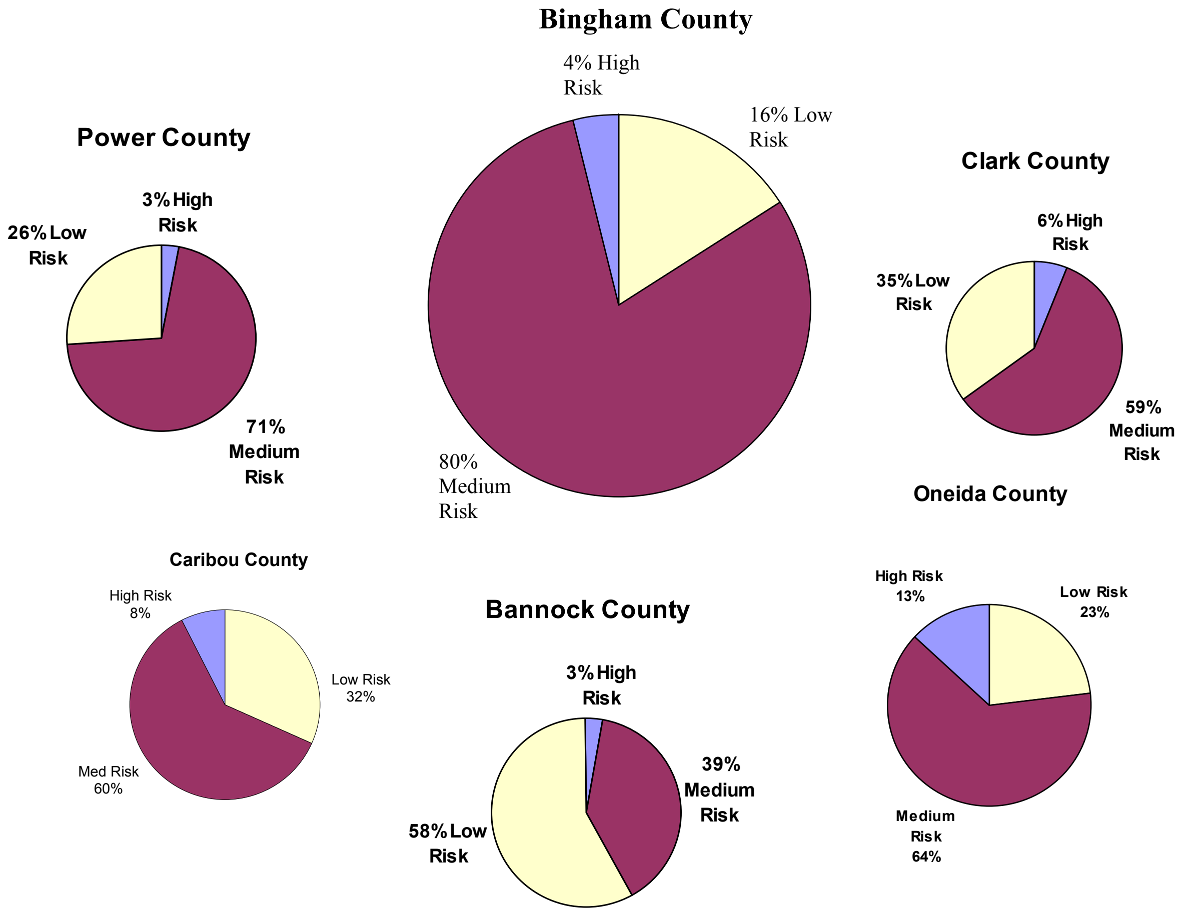



***Figure 7.*** *Percent of Clark County, Bannock County, Power County, Oneida County, Caribou County and Bingham County considered low, medium, and high fire risk*

| Total Acres Classified as low, medium and high fire risk | | | | | | |
|---|---|---|---|---|---|---|
| | Bingham County | Clark County | Bannock County | Power County | Oneida County | Caribou County |
| Low | 214,528 | 395,360 | 413,146 | 233,958 | 175,761 | 356,9263 |
| Medium | 1,072,640 | 666,464 | 277,805 | 638,886 | 495,089 | 688,575 |
| High | 53,632 | 67,776 | 21,370 | 26,996 | 97,599 | 84,806 |
| **Total** | **1,340,800** | **1,129,600** | **712,321** | **899,840** | **768,449** | **1,130,304** |

***Table 2.*** *Fire Risk Ratings for each county.*

| BLM Land | | |
|---|---|---|
| Fire Risk | Acres | Percent |
| Low | 83,429 | 35% |
| Medium | 11,918 | 5% |
| High | 143,021 | 60% |
| Total | 238,368 | |

***Table 3.*** *BLM lands classified to low, medium and high fire risk.*

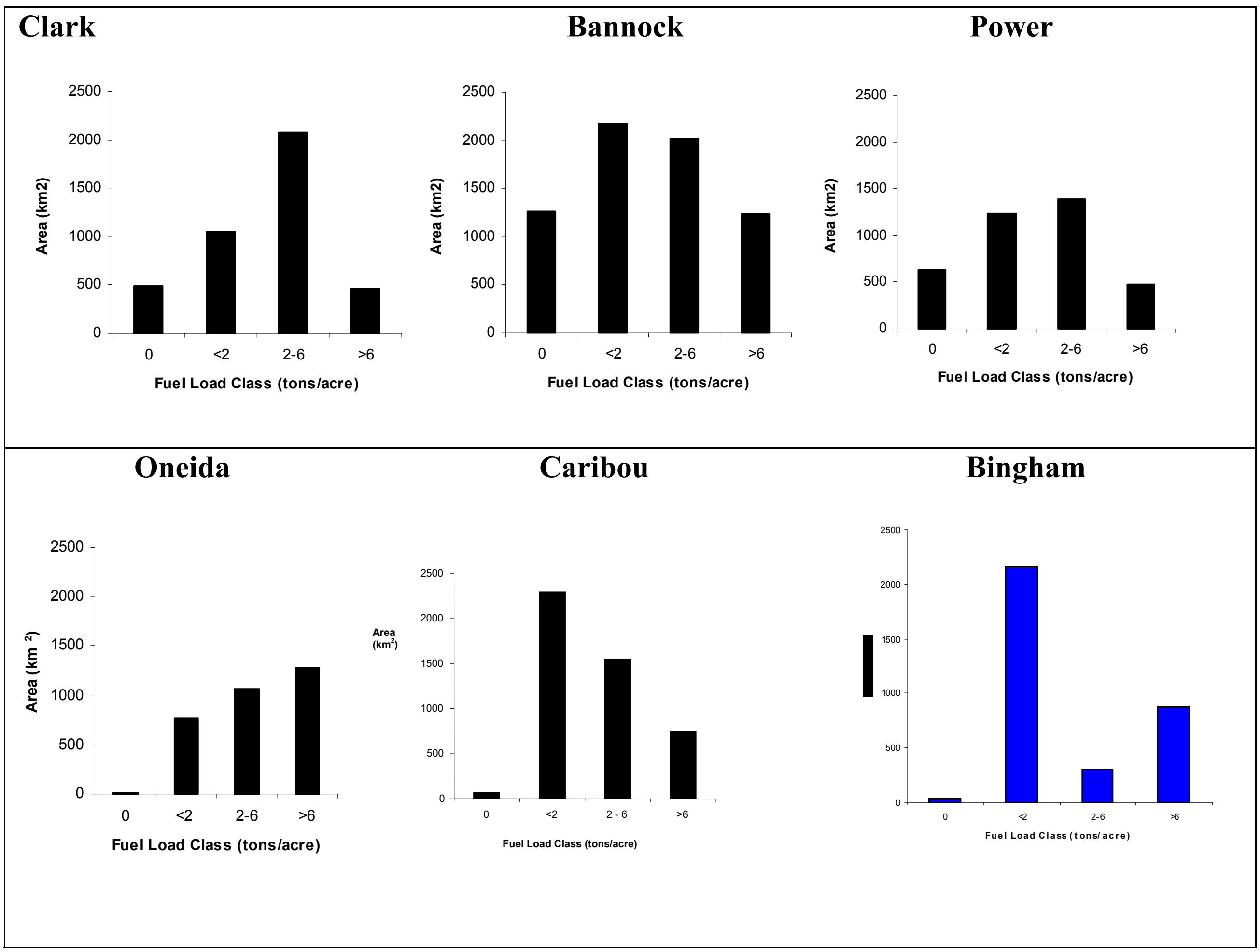



***Figure 8.*** *Comparison of fuel load distribution for Clark County (A), Bannock County (B), Power County (C), and Bingham County (D).*

## **Discussion:**

Bingham, Caribou, Clark, Bannock, Power, and Oneida counties all contain high desert sagebrush-steppe ecosystems.

Of these counties, Bingham has the largest area with 2,095 $mi^2$ or 5426 $km^2$ (1,340,800 acres). In order of size Caribou County has the next largest area with 1,799 $mi^2$ (1,151,360 acres). Clark County is next with 1,765 $mi^2$ (1,129,600 acres). Next is Power County with 1,406 $mi^2$ (899,840 acres), Oneida County with 1,200 $mi^2$ (768,000 acres) and Bannock County with 1,113 $mi^2$ (712,321 acres).

Oneida County has the highest total acres classified as high fire risk with 97,599 acres. Caribou County has the second largest area classified as high fire risk with 84,806 acres. Clark County follows with 67,776 acres classified as high fire risk, followed by Bingham County with 53,632 acres. Power County follows with 26,996 acres and Bannock County with 21,370 acres. The high fire risk classification for all four 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.

Bingham County has the largest area classified as medium fire risk with 1,072,640 acres. Caribou has the second largest area classified as medium risk with 688,575 acres. Clark County with 666,464 acres and Power County with 638,886 have the next highest medium risk classification, followed by Caribou and Bannock County (495,089 and 277,805 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 fuel loads.

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 Structures at Risk component was weighted most heavily (22%). Due to the nature of this project, we were most interested in quantifying risk for the Wildland/ Urban Interface. This model allowed us to emphasize the interface areas. Areas of high structure density received the highest fire risk values and areas of low or no structure got the lowest fire risk values. The Structures at Risk component shows that of all six counties, Bannock, by far, has the largest population with 75,323, while Caribou County has a population of 7,397. Bingham County has a population of 42,926 (2003 estimate). 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 (Clark- 1,765 $mi^2$; Power- 1,406 $mi^2$; Oneida- 1,200 $mi^2$; Bannock- 1,113 $mi^2$, and Bingham County- 2095 $mi^2$), the structure density component model for Bannock County shows the highest risk to structure (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 2-6 tons/acre received the highest fire risk value, because of its high load of fine, low-standing fuels. Fuel Load class >6 tons/acre received the lowest fire risk 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 risk values, because fire increases exponentially with slope. Correspondingly, shallower angles have lower fire risk 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 risk value. Areas that had wet vegetation and lower fuel load had the lowest fire risk values.

The Fuel Load/ Intensity component takes into account how intense a fire of different fuel load classes affects fire risk. 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 risk 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 risk 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 risk values and shallow slopes received the lowest fire risk 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 risk 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, Kevin Grey, Roger Sears, Paul Muirbrook, Errol Covington and Cheryl Robertson. 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 risk in our study area and that it is easy to understand. Because the model is easy to understand, it should be applied by 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, felt were more important.

Lastly, the date (August 25, 2004) on which the Landsat 5 TM data was acquired plays a significant role in the outcome of the Fuel Load-based components of the final model. At this time of year the vegetation is dryer and some of the farmlands are drying also.

## References cited:


Amdahl, G. 2001. *Disaster Response: GIS for Public Safety* United States of America: ESRI PRESS.

Anderson Hal E. 1982. Aids to Determining Fuel Models for Estimating Fire Behavior. National Wildfire Coordinating Group.

Bulawa, Walt, Neves R., Garcia Gomez F.M., Weber K.T., Conran K. and Burkhardt F. 2003. Wildland/Urban Interface and Communities at Risk: Caribou County, Idaho

Congalton R.G and Green K. 1999. Assessing the Accuracy of Remotely Sensed Data: Principles and Practices. Lewis Publishers, Boca Raton.

Conran, Kevin; and Brady, Lance; Idaho Bureau of Land Management, Upper Snake River District, *Personal communications.*

Covington, Errol; Emergency Services Coordinator, Bingham County, *Personal Communication*.

Gentry C., Narsavage D., Weber K.T., and Burkhardt F. 2003. Wildland/Urban Interface and Communities at Risk: Power County, Idaho

Grey, Kevin; Fire Chief of Blackfoot, *personal communication.*

Heide, Sarah Crocker; Idaho Bureau of Land Management

Jansson, C., Pettersson, O., Weber K.T., and Burkhardt F. 2002. Wildland/Urban Interface and Communities at Risk: Lava Hot Springs, Idaho

Land Management Monitoring. 2003. http://www.ea.gov.au/land/monitoring/ndvi.html

Mattsson, D.,Thoren, F., Weber K.T., and Burkhardt F. 2002. Wildland/Urban Interface and Communities at Risk: Pocatello, Idaho.

Muirbrook, Paul; Weed Specialist, Bingham County, *Personal Communication.*

Owens J. and Durland P. 2002. Wild Fire Primer/ A Guide for Educators. United States Government Printing Office.

Reese, Roger; Pocatello Fire Official, *Personal Communication*.

Robertson, Cheryl; Bingham County, *Personal Communications*.

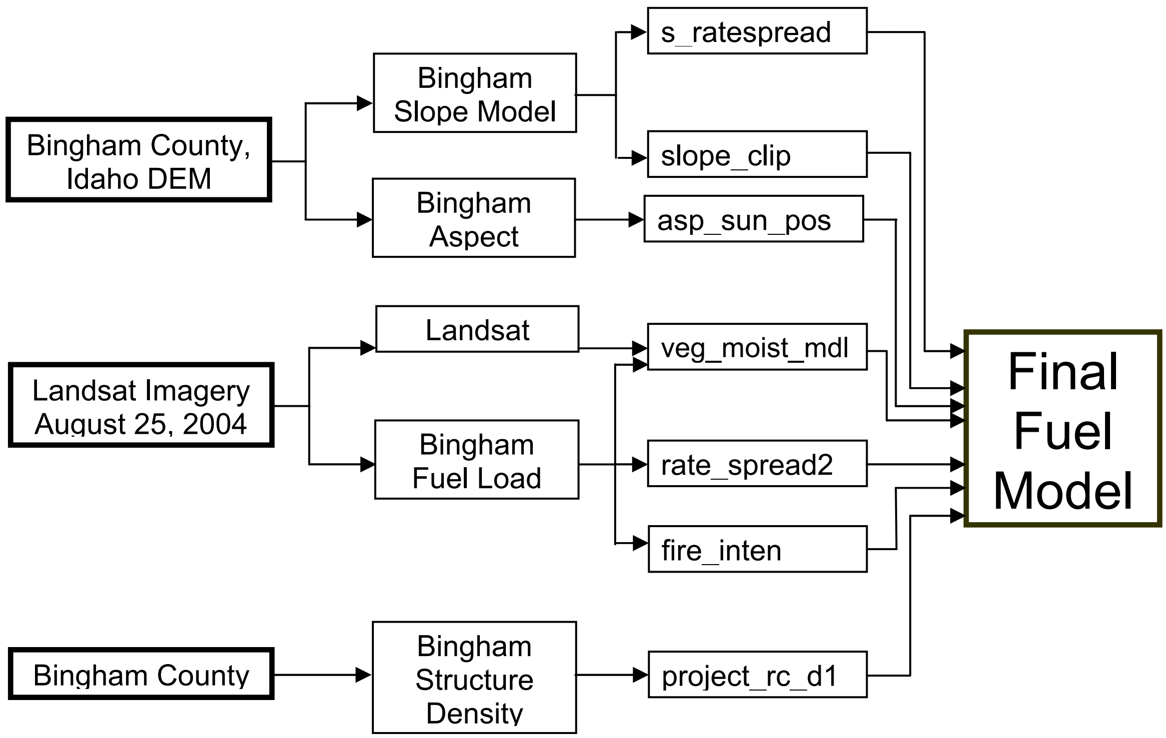
Snider, Paul; GPS Technician, Bingham County, *Personal Communication*.

## Acknowledgements:

At Kevin Conran's (Idaho Bureau of Land Management) suggestion we incorporated Vegetation Condition Classes into our Fire Risk model. Shortly thereafter Lance Brady (Idaho Bureau of Land Management) supplied the ISU GIS Center with Condition Class Data. This data has been used to develop an alternate Fire Risk Model for Bingham County, Caribou County, Oneida County, and Bannock County. The same criteria used in the original model were used to construct this alternate Fire Risk Model with one exception. In the alternate model the Fire Regime Condition Class component model was used in place of the Fuel load/ Fire intensity component model.

<u>**Appendices**</u>

## Appendix A – Cartographic Model



## Appendix B – Weightings

These tables show the weightings we used to weight our fire risk component models.

*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 = <2 tons/acre | 200 = Dry Vegetation |
| 4 = 2-6 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 | | Full path to dataset | | Description | | Format |
|---|---|---|---|---|---|---|---|---|
| **County boundary** | | B_cty_outline_new.shp | | C:\Data\BinghamWUI\Final Data | | Boundary of Bingham county | | Shapefile |
| **Roads** | | roads_new_clip.shp | | C:\Data\BinghamWUI\Final Data | | Roads in Bingham County | | line shapefile |
| **Fuel Load** | | fuel_ld_mdl1.tif | | C:\Data\BinghamWUI\Final Data | | Fuel Load model for Bingham County. Classes are 1= no fuel load, 2= <2 tons/acre, 3= 2-6 tons/acre, and4=>6 tons/acre | | TIFF -30m pixels |
| **Component models** | | asp_sun_pos1.tif | | \C:\Data\BinghamWUI\Final Data | | Risk associated with aspect angle **i.e**. North, East,……. | | TIFF -30m pixels |
| | | s_ratespread1.tif | | \C:\Data\BinghamWUI\Final Data | | Risk associated with how fire spreads with angle of slope. | | TIFF -30m pixels |
| | | slope_clip1.tif | | C:\Data\BinghamWUI\Final Data | | Risk associated with how suppression efforts are affected by angle of slope. | | TIFF - 30m pixels |
| | | fl_rt_spread1.tif | | C:\Data\BinghamWUI\Final Data | | Risk associated with how quickly different fuel load classes spread during a fire. | | TIFF - 30m pixels |
| | | fire_inten1.tif | | C:\Data\BinghamWUI\Final Data | | Risk associated with how intense (release of heat energy) different fuel load classes burn. | | TIFF - 30m pixels |
| | | veg_moist_mdl1.tif | | C:\Data\BinghamWUI\Final Data | | Risk associated with vegetation moisture. | | TIFF - 30m pixels |
| | | strctr_risk1.tif | | C:\Data\BinghamWUI\Final Data | | Risk associated with structure density. | | TIFF - 30m pixels |
| **Fire Regime Condition Class model** | | Project_cond61.tif | | C:\Data\BinghamWUI\Final Data | | | | TIFF- 1223m pixels |
| **Final Models** | | Final_model1.tif | | C:\Data\BinghamWUI\Final Data | | Final risk model | | TIFF - 30m pixels |
| | | Frcc_fnl_mdl1.tif | | C:\Data\BinghamWUI\Final Data | | Final risk model using condition classes | | TIFF - 1223 m pixels |
| **Reports** | | Bingham_WUI_Report | | C:\Data\BinghamWUI\Final Data | | Report covering methods, results, & conclusions of WUI modeling | | Word Document |

* These models had been generated in grid format. They have been converted to TIFF format. This was done with ArcMap 9.0 → Export Data.