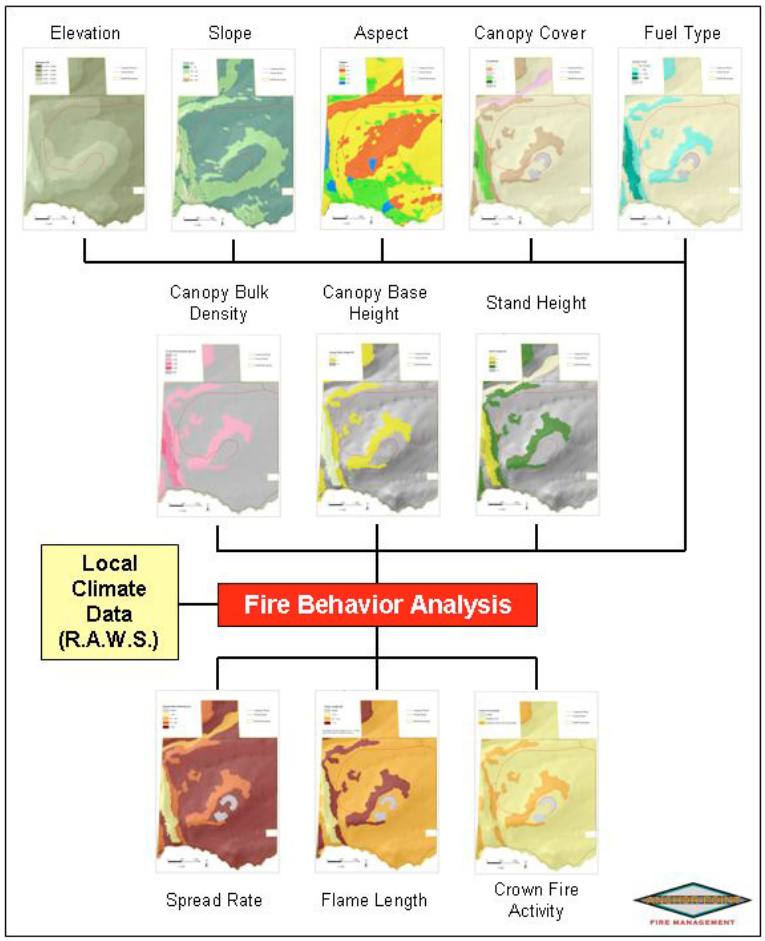
Appendix A

Fire Behavior Potential Analysis Methodology

Purpose

The purpose of this appendix is to describe the methodology used to evaluate the threat to Values at Risk in the study area. These threats—represented by physical hazards such as fuels, weather, and topography—were evaluated by modeling their effects on Fire Behavior Potential.

Figure 1. Flow Chart



Based on a set of inputs significant to fire behavior, the Fire Behavior Potential analysis shows in graphic form the probable range of spread rate, flame length, and crown fire potential for the analysis area. The model inputs include aspect, slope, elevation, canopy cover, fuel type, canopy bulk density, canopy base height, stand height, and climate data. The model outputs are determined

using **FlamMap**[1], which combines surface fire predictions with the potential for crown fire development. Calculations for surface fire predictions (rate of spread and flame length) are based on the USDA Forest Service's **BEHAVE**[2] model.

BEHAVE

The **BEHAVE** fire behavior prediction and fuel modeling system was used to determine surface fire behavior estimates for this study. **BEHAVE** is a nationally recognized set of calculations used to estimate a surface fire's intensity and rate of spread, given certain conditions of topography, fuels, and weather. The **BEHAVE** modeling system has been used for a variety of applications, including prediction of an ongoing fire, prescribed fire planning, fuel hazard assessment, initial attack dispatch, and fire prevention planning and training. Predictions of wildland fire behavior are made for a single point in time and space, given simple user-defined fuels, weather, and topography. Requested values depend on the modeling choices made by the user.

Assumptions of **BEHAVE:**

- Fire is predicted at the flaming front
- Fire is free burning
- Behavior is heavily weighted towards the fine fuels
- Continuous and uniform fuels
- Surface fires

FlamMap

Anchor Point uses **FlamMap** to evaluate the potential fire conditions in the fire behavior study area. The City of Santa Fe encompasses 24,000 acres (37.5 square miles). The study area, for fire behavior analysis, covers approximately 50,993 acres (79.7 square miles). This area includes the fire department response area and a large buffer in all directions. This buffer was included to provide the fire department with an analysis of potential fire behavior on adjacent lands. From both planning and tactical perspectives, it is important to evaluate exposures beyond the jurisdiction. The study area is broken down into grid cells of 10 meters per side (10M). Using existing vector and raster spatial data and field data, **ArcGIS** spatial analysis capabilities are used to calculate model inputs for each 10M cell. These values are input into **FlamMap,** along with reference weather and fuel moisture (long-term weather observations statistically calculated from the Pecos Remote Automated Weather Station information). The outputs of **FlamMap** include the estimated Rate of Spread (from **BEHAVE**), Flame Length (from **BEHAVE**) and Crown Fire Activity for a

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[1] Mark Finney, Stuart Brittain and Rob Seli. Joint Fire Sciences Program of the Rocky Mountain Research Station (USDA Forest Service, Missoula, Montana), Bureau of Land Management, and Systems for Environmental Management (Missoula, Montana).

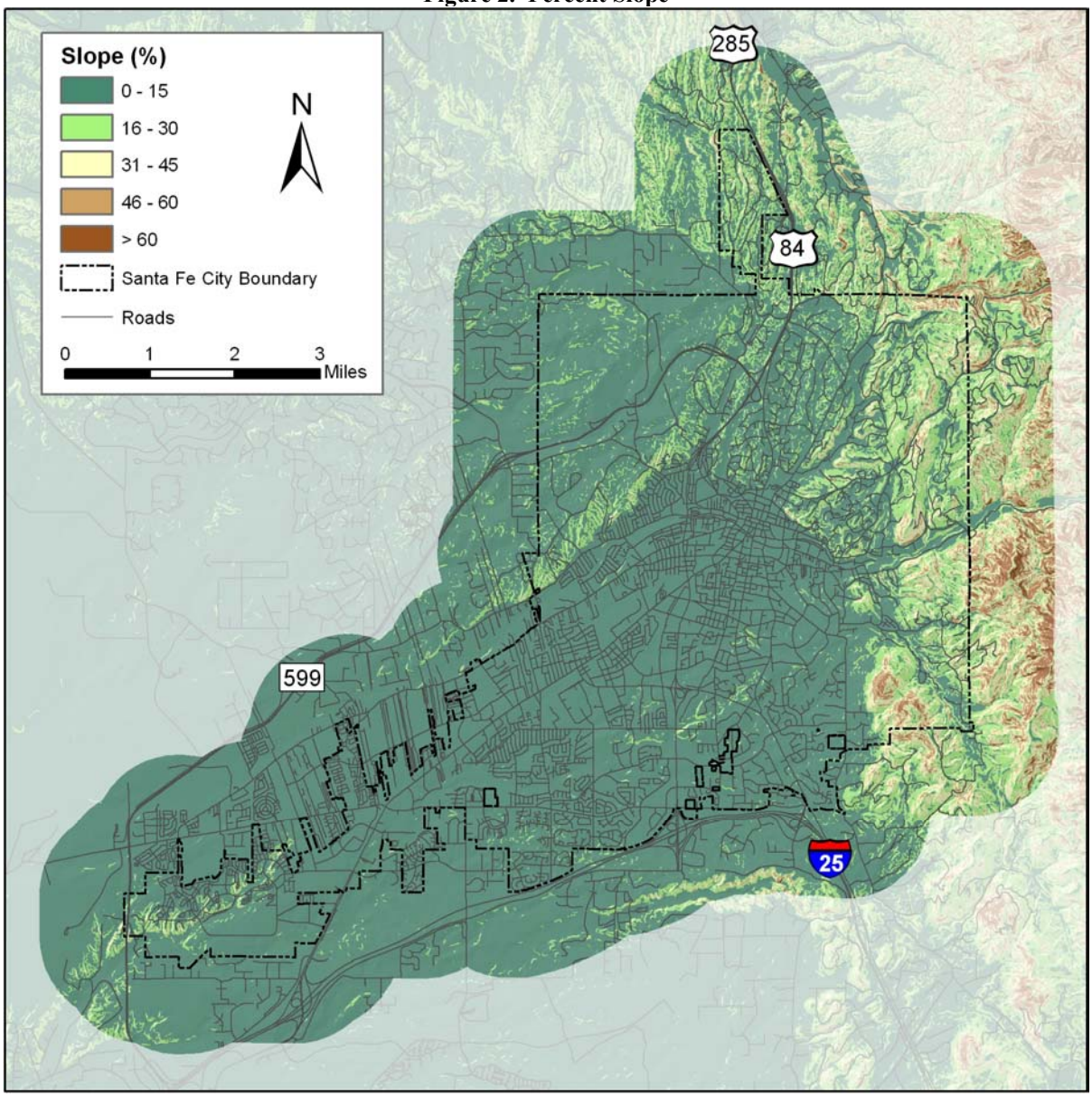
[2] Patricia L. Andrews, producer and designer. Collin D. Bevins, programmer and designer. Joint Fire Sciences Program of the Rocky Mountain Research Station (USDA Forest Service, Missoula, Montana) and Systems for Environmental Management (Missoula, Montana).

fire in that 10M cell. The model computes these values for each cell in the study area independently, so that the data in each cell is unaffected by adjacent cells.

Fire Behavior Inputs

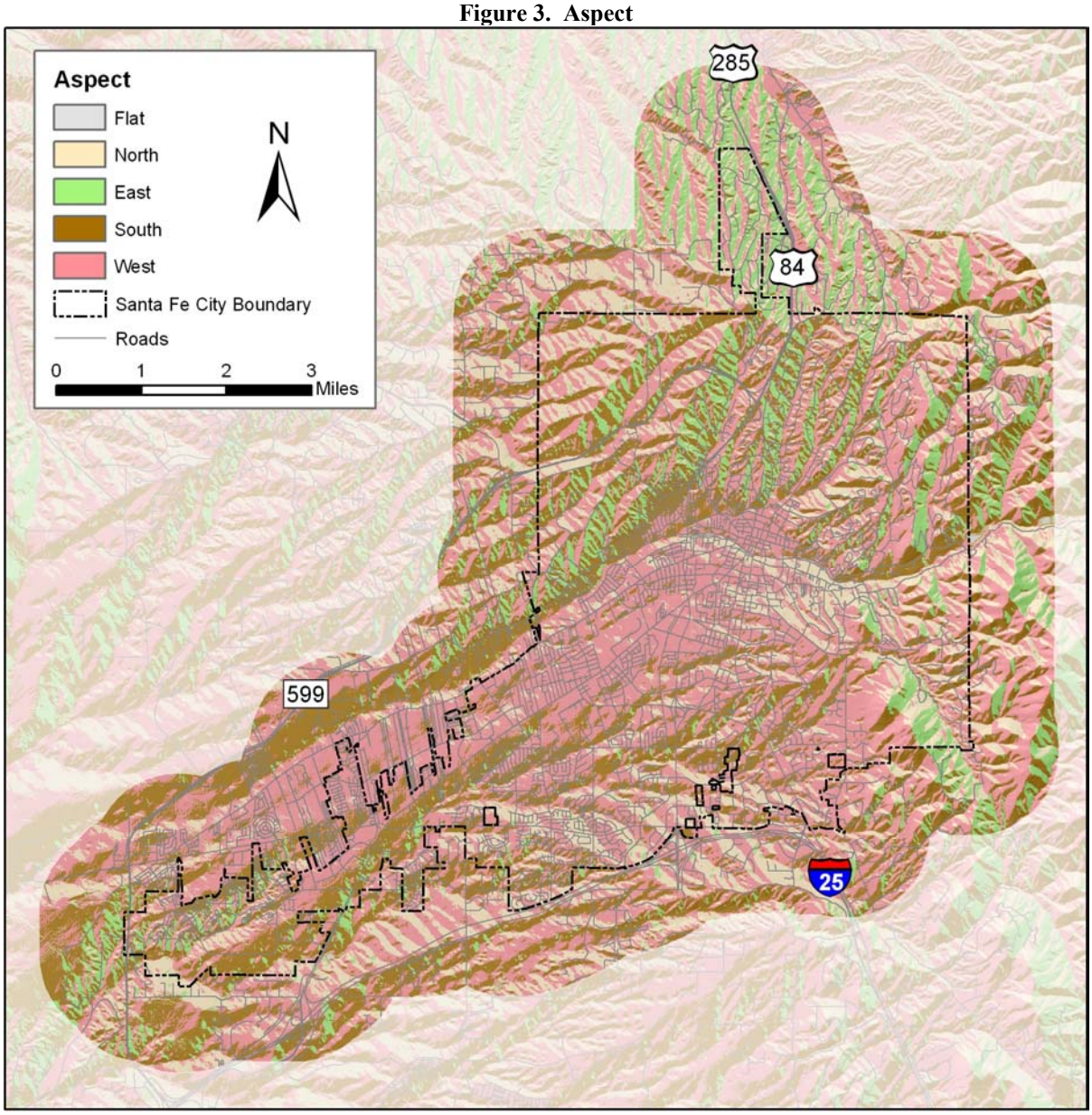
The major factors influencing fire behavior are fuels (type and coverage), weather, and topography (aspect, slope, and elevation). The following pages contain a brief explanation of each.

Figure 2. Percent Slope



Slopes are shown here as percent (rise/run x100). Steeper slopes intensify fire behavior and thus contribute to a higher wildfire hazard rating. Rates of spread for a slope of 30% are typically double those of flat terrain, when all other influences are equal.

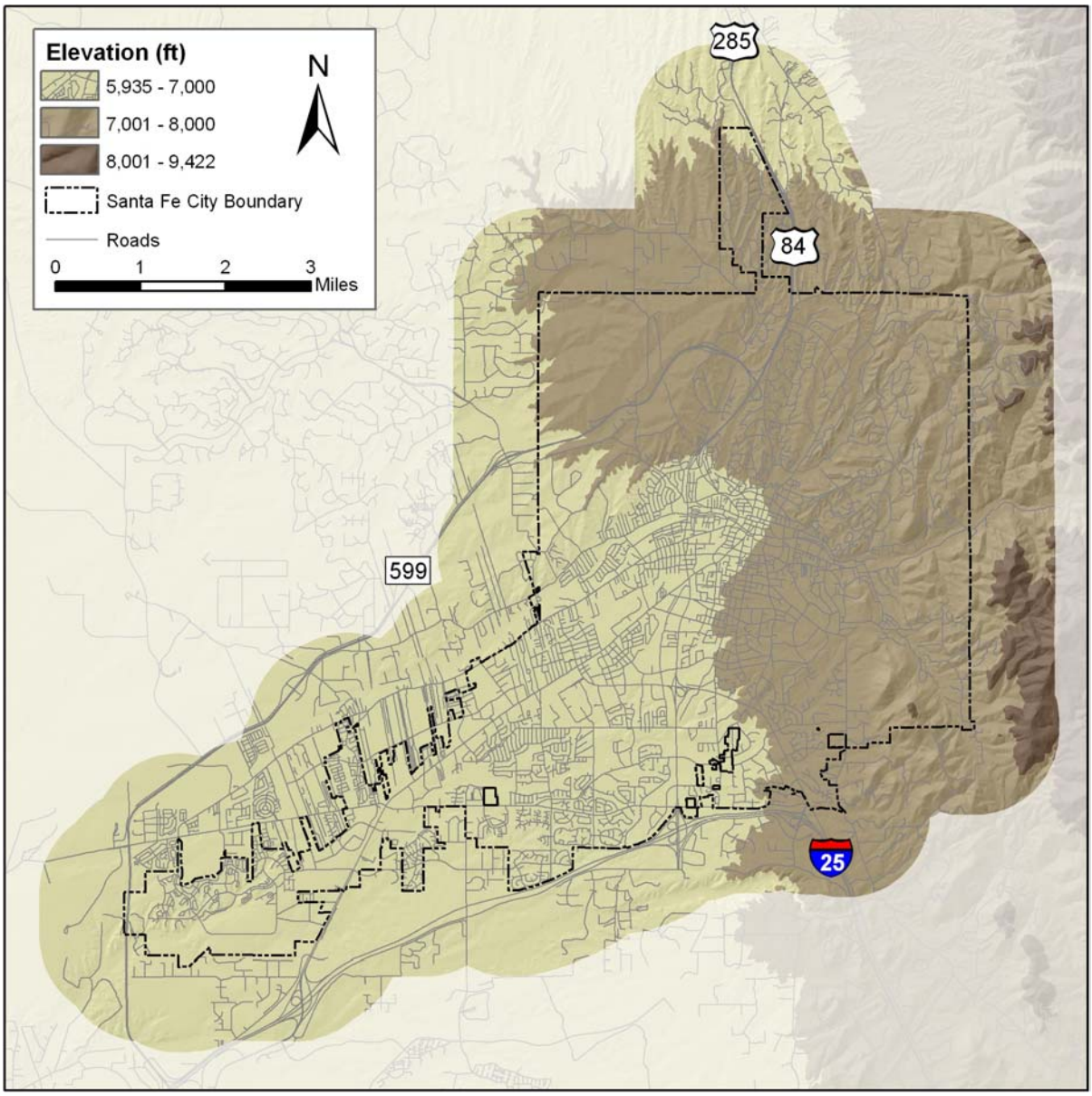
Figure 3. Aspect



Aspects are shown as degrees from north, ranging from 0 to 360 according to their orientation. Aspects are influential in the type and quantity of vegetative fuels. Fuels on south facing slopes tend to be drier and more lightly loaded than fuels on north facing slopes, when all other influences are equal. Aspect also has an influence on plant species dominance.

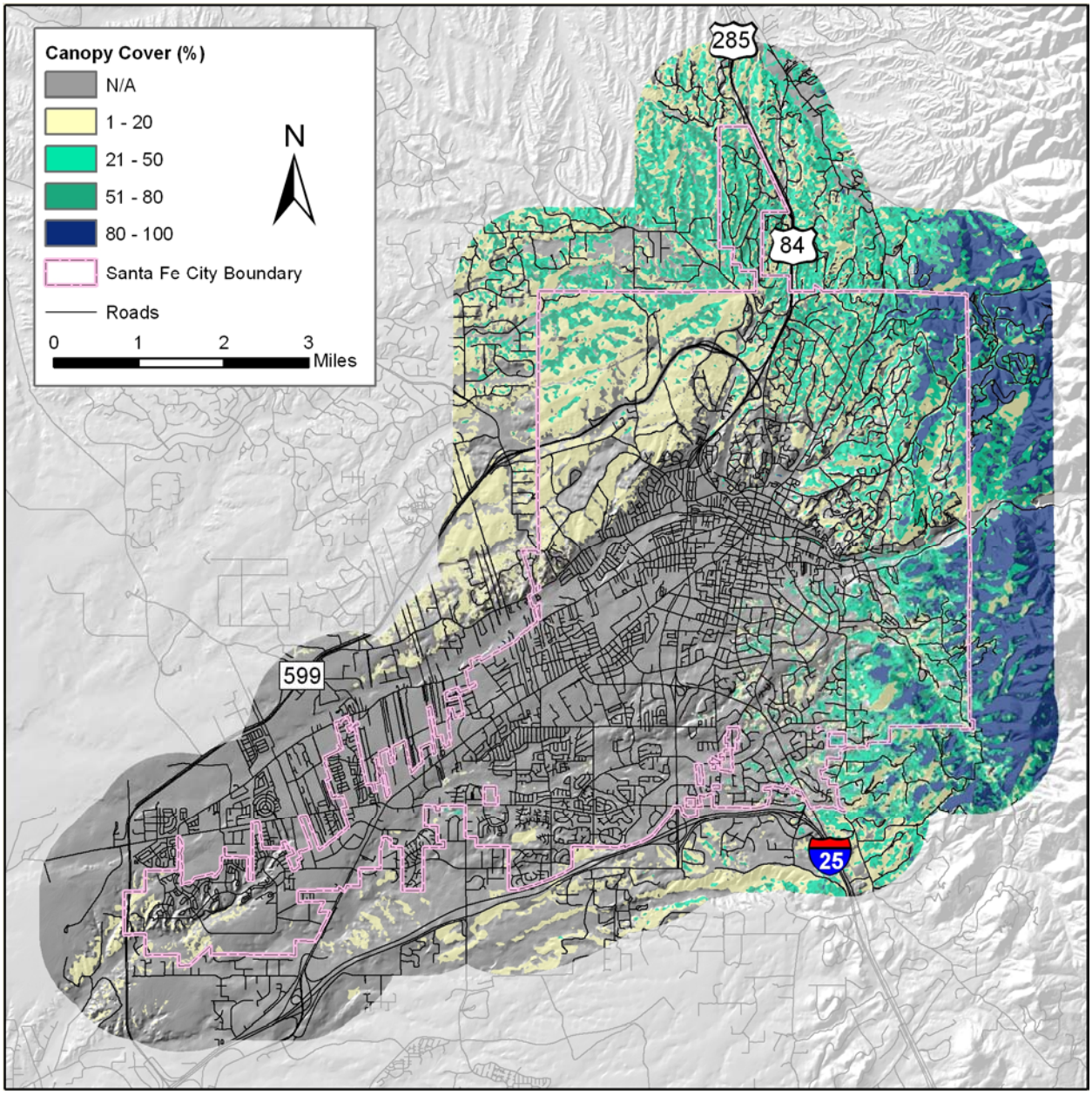
Classification	North	East	South	West
Range	315-45	45-135	135-225	225-315

Figure 4. Elevation



Elevations within the SFFPD range from 5,935 feet to approximately 9,422 feet. As elevation increases, environmental conditions, fuel species, and characteristics change.

Figure 5. Canopy Cover



Canopy cover is the percentage of the ground surface that is shaded by or covered by tree crowns.. Coverage units are in four categories: 1=1-20%, 2=21-50%, 3=51-80%, 4=81-100%. Coverage has a direct effect on the type and amount of surface fuels available for burning through shading. Canopy cover is also a measure of the horizontal continuity of aerial fuels. Heavier canopy cover allows for an easier transmission of fire from crown to crown.

Fuel Models and Fire Behavior

Fuel models are a set of numbers that describe fuels in terms that a fire behavior model can use.[3]

There are seven characteristics that are used to categorize fuel models.

1. Fuel Loading
2. Size and Shape
3. Compactness
4. Horizontal Continuity
5. Vertical Arrangement
6. Moisture Content
7. Chemical Content

Each of the major fuel types present in the study area are described below in terms of the characteristics that coincide with that fuel model. Fuel model descriptions are taken from Anderson's *Aids to Determining Fuel Models for Estimating Fire Behavior*[4], a national standard guide to fuel modeling. **Vegetation for the project area may or may not be specifically listed in the description**. Plant species are only an aid to help visualize the characteristics of the model. The photos are taken from the project area and show where the local vegetation fits in. A table showing a range of surface fire behavior based on the **BEHAVE** system is also included.

The study area is represented primarily by seven fuel models (FM): FM 1, 2, 3, 6, 8, 10, and 14 (a custom fuel model). Other fuel models may exist, but not in quantities that could significantly influence fire behavior in the Wildland Urban Interface. Figure 6 displays the fuel types graphically for the study area.

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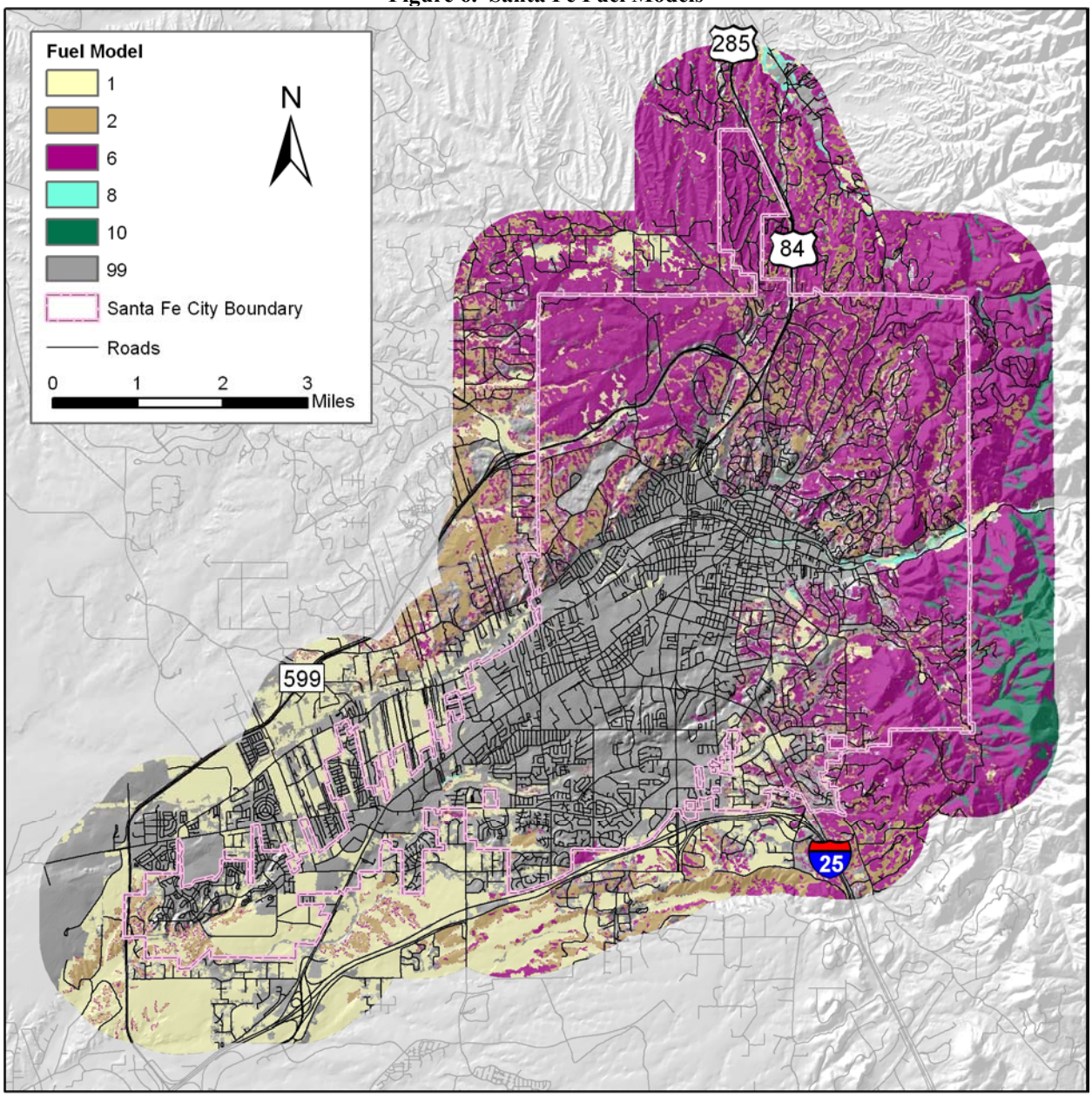
[3] Anderson, Hal E. *Aids to Determining Fuel Models for Estimating Fire Behavior*. National Wildfire Coordinating Group. NFES 1574. April 1982.

Figure 6. Santa Fe Fuel Models



Fuel models 97, 98, and 99 in the map legend indicate areas of insignificant combustibility such as water, rock, sand, etc.

FUEL MODEL 1

Figure 7. Grass/forbs

General Fuel Model Characteristics

Grasslands and savanna are represented along with stubble, grass-tundra, and grass-shrub combinations.

Study Area Specific Fuel Model Characteristics

Open grasslands and small forbs are found primarily on the western areas of the projects, and mostly at lower elevations.

Common Types/Species

Annual and perennial grasses are included in this fuel model.

Fire Behavior

Fire spread is governed by the fine, very porous, and continuous herbaceous fuels that have cured or are nearly cured. Fires in this fuel model are surface fires that move rapidly through the cured grass and associated material. Very little shrub or timber is present—generally less than one-third of the area.

FUEL MODEL 1

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	**4.0**	**6.0**	**8.0**	**10.0**	**12.0**
2.0	28.8	92.9	203.6	362.4	570.1	665.6
4.0	22.0	71.1	155.7	277.0	345.1	345.1
6.0	19.4	62.4	136.8	243.4	270.1	270.1
8.0	16.7	53.9	118.1	198.7	198.7	198.7
10.0	11.0	35.6	64.8	64.8	64.8	64.8

10-hr fuel = 5%, 100-hr fuel = 6%, herbaceous fuel moisture = 100%, slope = 10%

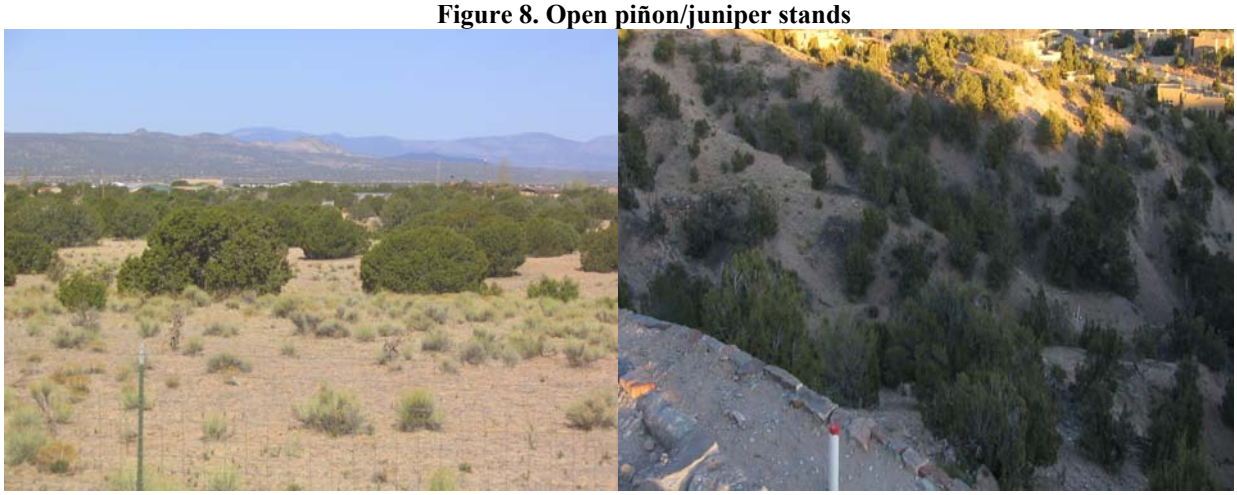
Flame Length in Feet

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	**4.0**	**6.0**	**8.0**	**10.0**	**12.0**
2.0	3.0	5.1	7.3	9.6	11.8	12.7
4.0	2.4	4.1	5.9	7.8	8.6	8.6
6.0	2.2	3.8	5.5	7.1	7.5	7.5
8.0	2.0	3.4	4.9	6.3	6.3	6.3
10.0	1.4	2.4	3.2	3.2	3.2	3.2

10-hr fuel = 5%, 100-hr fuel = 6%, herbaceous fuel moisture = 100%, slope = 10%

FUEL MODEL 2

Figure 8. Open piñon/juniper stands



General Fuel Model Characteristics

This type consists of open shrub lands and pine stands or scrub oak stands that cover one-third to two-thirds of the area. Trees are widely spaced with few understory shrubs or regeneration. Ground cover consists of mountain grasses/and or needles and small woody litter.

Study Area Specific Fuel Model Characteristics

Open piñon/juniper stands with 10%-20% canopy cover and some understory vegetation.

Common Types/Species

Open grown pine stands, sagebrush and scrub oak stands. There may be some piñon-juniper in this model. Ground cover consists of mountain grasses/and or needles and small woody litter.

Fire Behavior

Surface fires that spread primarily through the fine herbaceous fuels, either curing or dead. Clumps of fuel may generate higher fire intensities, which can in turn produce firebrands. Fire is carried by grasses and/or woody litter.

FUEL MODEL 2

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

		Mid-flame Wind Speed					
		2.0	**4.0**	**6.0**	**8.0**	**10.0**	**12.0**
Fine Dead Fuel Moisture %	**2.0**	12.4	34.2	67.5	111.6	166.0	230.2
	4.0	10.2	28.0	55.3	91.4	135.9	188.5
	6.0	9.0	24.9	49.1	81.2	120.8	167.6
	8.0	8.3	22.9	45.3	74.9	111.3	154.4
	10.0	7.4	20.5	40.5	67.0	99.7	138.3
	12.0	5.9	16.3	32.3	53.3	79.3	110.0

10-hr fuel 5%, 100 = 6%, woody fuel moisture = 100%, slope 10%

Flame Length in Feet

		Mid-flame Wind Speed					
		2.0	**4.0**	**6.0**	**8.0**	**10.0**	**12.0**
Fine Dead Fuel Moisture %	**2.0**	4.3	6.9	9.4	11.8	14.2	16.5
	4.0	3.7	5.8	8.0	10.1	12.1	14.0
	6.0	3.4	5.4	7.3	9.2	11.1	12.9
	8.0	3.2	5.1	6.9	8.7	10.5	12.2
	10.0	2.9	4.7	6.4	8.1	9.7	11.2
	12.0	2.4	3.9	5.3	6.7	8.0	9.3

10-hr fuel = 5%, 100-hr fuel = 6%, herbaceous fuel moisture = 100%, slope = 10%

FUEL MODEL 3

Figure 9. Riparian bosques (Extreme Conditions)

General Fuel Model Characteristics

Stands are tall, averaging about 3 feet (1 m) but there may be considerable variation. Approximately one-third or more of the stand is considered dead or cured and maintains the fire .

Study Area Specific Fuel Model Characteristics

(Extreme Conditions) In the Riparian Bosques (FM 8), understory grasses, forbs, and leaf litter will be the primary contributor to more intense burning. The overstory trees may burn but rarely transition to a crown fire.

Common Types/Species

Wild or cultivated grains that have not been harvested—can be considered similar to tall prairie and marshland grasses.

Fire Behavior

Fires in this fuel are the most intense of the grass group and display high rates of spread under the influence of wind. Wind may drive fire into the upper heights of the grass and across standing water.

FUEL MODEL 3

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	**4.0**	**6.0**	**8.0**	**10.0**	**12.0**
2.0	61.7	139.3	230.4	331.6	441.1	557.6
4.0	48.6	109.7	181.5	261.2	347.4	439.2
6.0	40.2	90.7	150.0	215.9	287.1	363
8.0	34.8	78.6	130.0	187.1	248.9	314.7
10.0	31.4	70.8	117.2	168.7	224.4	283.6
12.0	61.7	139.3	230.4	331.6	441.1	557.6

10-hr fuel 5%, 100 = 6%, herbaceous fuel moisture = 100%, slope 10%

Flame Length in Feet

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	**4.0**	**6.0**	**8.0**	**10.0**	**12.0**
2.0	3.0	5.1	7.3	9.6	11.8	12.7
4.0	2.4	4.1	5.9	7.8	8.6	8.6
6.0	2.2	3.8	5.5	7.1	7.5	7.5
8.0	2.0	3.4	4.9	6.3	6.3	6.3
10.0	1.4	2.4	3.2	3.2	3.2	3.2
12.0	3.0	5.1	7.3	9.6	11.8	12.7

10-hr fuel = 5%, 100-hr fuel = 6%, herbaceous fuel moisture = 100%, slope = 10%

FUEL MODEL 6

Figure 10. Piñon/juniper stands

General Fuel Model Characteristics

A broad range of shrub conditions is covered by this model.

Study Area Specific Fuel Model Characteristics

Piñon/juniper stands with >20% canopy cover and very little understory. Low to moderate dead and down fuel loadings.

Common Types/Species

Fuel situations to be considered include intermediate stands of chamisa, chaparral, oak brush, low pocosin, Alaskan spruce taiga, and shrub tundra. Even hardwood slash that has cured can be considered. Piñon/juniper shrub lands may be represented but may over-predict the rate of spread, except at high winds, such as 20 mi/h (32 km/h), at the 20-foot level.

Fire Behavior

Fires carry through the shrub layer where the foliage is flammable, but this requires moderate winds—greater than 8 mi/h (13 km/h)—at mid-flame height. Fire will drop to the ground at low wind speeds or at openings in the stand.

FUEL MODEL 6

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	**4.0**	**6.0**	**8.0**	**10.0**	**12.0**
2.0	17.2	38.5	63.9	92.4	123.5	156.8
4.0	13.9	31.1	51.7	74.8	99.9	126.9
6.0	11.7	26.2	43.5	62.9	84.1	106.8
8.0	10.2	22.9	38.1	55.0	73.6	93.4
10.0	9.2	20.7	34.4	49.7	66.5	84.4
12.0	8.5	19.1	31.7	45.9	61.4	77.9

10-hr fuel = 5%, 100-hr fuel = 6%, herbaceous fuel moisture = 100%, slope = 10%,

Flame Length in Feet

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	**4.0**	**6.0**	**8.0**	**10.0**	**12.0**
2.0	5.0	7.3	9.2	10.9	12.4	13.9
4.0	4.3	6.2	7.8	9.3	10.6	11.8
6.0	3.8	5.5	6.9	8.2	9.3	10.4
8.0	3.4	5.0	6.3	7.4	8.5	9.5
10.0	3.2	4.7	5.9	7.0	8.0	8.9
12.0	3.1	4.4	5.6	6.7	7.6	8.5

10-hr fuel = 5%, 100-hr fuel = 6%, herbaceous fuel moisture = 100%, slope = 10%,

FUEL MODEL 8

Figure 11. Riparian bosque made up of cottonwoods, Siberian elm and other broadleaf species

General Fuel Model Characteristics

Hardwoods that have leafed out support fire in the compact litter layer. This layer is mainly needles, leaves, and occasionally twigs, because little undergrowth is present in the stand. Needle and woody litter are also present in low quantities.

Study Area Specific Fuel Model Characteristics

Riparian Bosque made up of cottonwoods, Siberian elm and other broadleaf species that do not readily burn. Typically, only the leaf litter will be receptive to burning.

Common Types/Species

Several species of hardwood trees such as cottonwoods and willows along riparian areas are represented here. There are mostly streamside understory plants that do not contribute to the fire intensity.

Fire Behavior

Fires in this fuel model are slow burning, low intensity fires that burn through surface fuels. Fuels are mainly needles and woody litter. Heavier fuel loadings from old dead and down trees or branches can cause flare-ups. Heavier fuel loads have the potential to develop crown fires in extreme burning conditions.

FUEL MODEL 8

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	4.0	6.0	8.0	10.0	12.0
2.0	1.1	2.3	3.9	5.7	7.8	10.1
4.0	0.9	1.9	3.2	4.7	6.4	6.9
6.0	0.7	1.6	2.6	3.9	4.9	4.9
8.0	0.6	1.4	2.3	3.4	3.8	3.8
10.0	0.6	1.2	2.0	3.0	3.1	3.1
12.0	0.5	1.1	1.8	2.7	2.7	2.7

10-hr fuel = 5%, 100-hr fuel = 6%, herbaceous fuel moisture = 100%, slope = 10%

Flame Length in Feet

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	4.0	6.0	8.0	10.0	12.0
2.0	0.9	1.3	1.7	2.0	2.3	2.6
4.0	0.8	1.1	1.4	1.7	2.0	2.0
6.0	0.7	1.0	1.2	1.5	1.7	1.7
8.0	0.6	0.9	1.1	1.3	1.4	1.4
10.0	0.6	0.8	1.0	1.2	1.3	1.3
12.0	0.6	0.8	1.0	1.2	1.3	1.3

10-hr fuel = 5%, 100-hr fuel = 6%, herbaceous fuel moisture = 100%, slope = 10%

FUEL MODEL 10

Figure 12. Stringers of ponderosa pine with piñon/juniper understory throughout the higher elevations.

General Fuel Model Characteristics

This model is represented by dense stands of over-mature ponderosa pine, lodgepole pine, mixed-conifer and continuous stands of Douglas-fir. In all stand types, heavy down material is present. There is also a large amount of dead, down, woody fuels. Reproduction may be present, acting as ladder fuels. This model includes stands of budworm-killed Douglas-fir, closed stands of ponderosa pine with large amounts of ladder and surface fuels, and stands of lodgepole pine with heavy loadings of downed trees. This model can occur from the foothills through the sub-alpine zone.

Study Area Specific Fuel Model Characteristics

Stringers of ponderosa pine throughout the higher elevations. Most stands are intermixed with piñon/juniper and are more likely to burn intensely and crown due to the piñon/juniper understory acting as ladder fuels.

Common Types/Species

All types of vegetation can occur in this model, but primary species are Douglas-fir, ponderosa pine and lodgepole pine.

Fire Behavior

Fire intensities can be moderate to extreme. Fire moves through dead, down woody material. Torching and spotting are more frequent. Crown fires are quite possible.

FUEL MODEL 10

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	4.0	6.0	8.0	10.0	12.0
2.0	3.8	8.2	13.7	20.1	27.3	35.1
4.0	3.3	7.2	12.1	17.8	24.1	31.0
6.0	3.0	6.6	11.0	16.1	21.8	28.0
8.0	2.8	6.1	10.2	14.9	20.2	26.0
10.0	2.6	5.7	9.6	14.1	19.1	24.5
12.0	2.5	5.5	9.2	13.4	18.2	23.4

10-hr fuel 5%, 100 = 6%, woody fuel moisture = 100%, slope 10%

Flame Length in Feet

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	4.0	6.0	8.0	10.0	12.0
2.0	3.8	5.5	7.0	8.3	9.5	10.7
4.0	3.5	5.0	6.3	7.5	8.6	9.7
6.0	3.2	4.6	5.8	6.9	7.9	8.9
8.0	3.0	4.3	5.5	6.5	7.5	8.4
10.0	2.9	4.1	5.2	6.2	7.2	8.0
12.0	2.8	4.0	5.1	6.0	6.9	7.8

10-hr fuel 5%, 100 = 6%, woody fuel moisture = 100%, slope 10%

FUEL MODEL 14 (Custom Model for Santa Fe Fire Protection District, Santa Fe NM)

Figure 13. Bug-killed piñon/juniper stands with no needles

Study Area Specific Fuel Model Characteristics

Dead piñon/juniper stands with >20% canopy cover with very little understory and some dead and down fuels.

Fire Behavior

Initially, it was thought that bug-killed piñon/juniper stands would be modeled differently than healthy stands. However, discussions with several fuels and fire behavior specialists have not revealed any evidence of fire behavior differences between the bug-killed and live piñon/juniper stands that was great enough to warrant a different fuel model.

The following stages represent the cycle of bug-infected trees as it relates to fire behavior:

Infected tree: Similar burning to green trees but lower fuel moisture makes it crown a bit faster. **Fuel model 6**

Red needle tree (year 1): Burning is more intense, crowning and spotting is more common, as trees and needles are dried out and more receptive. **Fuel model 6**

Dead tree with no needles (year 1-5) - tree is completely dead and is very receptive to burning. Needles have fallen off so there is not as much fine fuels to help carry the fire into the crowns. The trees burn well, but do not sustain fire without adjacent live crowns. **Fuel model 6**

Dead tree with broken tops and limbs (years 5-10) – the tree is drying out and rotting. The limbs and trunks are breaking off and falling to the ground as a result of wind and snow events. The stands are similar to slash piles and could be considered jackpots of dead and down material. More intense surface burning is common but spotting is less likely. **Fuel model 11** (if there is a large enough area to warrant it). Model 11 will likely over-predict the fire behavior because the fuel loading is far less then a typical fuel model 11 stand.

Decomposed tree (year 10+) - the tree has disintegrated and is now a pile of decomposed wood. Fire behavior is minimal with mostly smoldering. **No fuel model** is needed.

FUEL MODEL 6

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	**4.0**	**6.0**	**8.0**	**10.0**	**12.0**
2.0	17.2	38.5	63.9	92.4	123.5	156.8
4.0	13.9	31.1	51.7	74.8	99.9	126.9
6.0	11.7	26.2	43.5	62.9	84.1	106.8
8.0	10.2	22.9	38.1	55.0	73.6	93.4
10.0	9.2	20.7	34.4	49.7	66.5	84.4
12.0	8.5	19.1	31.7	45.9	61.4	77.9

10-hr fuel = 5%, 100-hr fuel = 6%, herbaceous fuel moisture = 100%, slope = 10%,

Flame Length in Feet

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	**4.0**	**6.0**	**8.0**	**10.0**	**12.0**
2.0	5.0	7.3	9.2	10.9	12.4	13.9
4.0	4.3	6.2	7.8	9.3	10.6	11.8
6.0	3.8	5.5	6.9	8.2	9.3	10.4
8.0	3.4	5.0	6.3	7.4	8.5	9.5
10.0	3.2	4.7	5.9	7.0	8.0	8.9
12.0	3.1	4.4	5.6	6.7	7.6	8.5

10-hr fuel = 5%, 100-hr fuel = 6%, herbaceous fuel moisture = 100%, slope = 10%,

FUEL MODEL 11

Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	4.0	6.0	8.0	10.0	12.0
2.0	3.7	7	10.6	14.5	18.4	22.5
4.0	3	5.7	8.7	11.8	15.1	18.4
6.0	2.6	5	7.6	10.4	13.2	16.1
8.0	2.4	4.6	7	9.5	12.1	14.7
10.0	2.2	4.2	6.4	8.6	11	13.4
12.0	1.9	3.6	5.5	7.5	9.6	11.7

10-hr fuel 5%, 100 = 6%, woody fuel moisture = 100%, slope 10%

Flame Length in Feet

Fine Dead Fuel Moisture %	Mid-flame Wind Speed					
	2.0	4.0	6.0	8.0	10.0	12.0
2.0	3	4.1	4.9	5.7	6.3	6.9
4.0	2.6	3.5	4.2	4.9	5.4	6
6.0	2.4	3.2	3.9	4.5	5	5.5
8.0	2.2	3	3.7	4.2	4.7	5.2
10.0	2.1	2.9	3.5	4	4.5	4.9
12.0	1.9	2.6	3.1	3.6	4	4.4

10-hr fuel 5%, 100 = 6%, woody fuel moisture = 100%, slope 10%

Reference Weather Used in the Fire Behavior Potential Evaluation

The weather inputs for **FlamMap** were created by using weather data collected at the Pecos Remote Automated Weather Station (RAWS).

Pecos Site Information (Station ID # 291202)

Latitude (dd mm ss)	35° 32' 44.88" N
Longitude (dd mm ss)	105° 29' 39.84" W
Elevation (ft.)	8,600

Weather observations from the Pecos RAWS were averaged for an eleven-year period (1994-2005) to calculate these conditions. The average conditions class (16th to 89th percentile) was calculated for each variable (1 hour, 10 hour, and 100 hour fuel moisture, woody fuel moisture, herbaceous fuel moisture, and wind speed) using Fire Family Plus. This weather condition class most closely represents an average fire season day.

The extreme conditions class was calculated using ninety-seventh percentile weather data. In other words, the weather conditions existing on the four most severe fire weather days (sorted by Spread Component) in each season for the eleven-year period were averaged together. It is reasonable to assume that similar conditions may exist for at least four days of the fire season during an average year. During extreme years, such conditions may exist for significantly longer periods. These calculations may actually be conservative compared to observed fire behavior. The following values were used in **FlamMap**:

Average Weather Conditions	
Variable	**Value**
20 ft Wind speed up slope	17 mph
Herbaceous fuel moisture	54%
Woody fuel moisture	102%
100-hr fuel moisture	11%
10-hr fuel moisture	7%
1-hr fuel moisture	6%

Extreme Weather Conditions	
Variable	**Value**
20 ft Wind speed up slope	30 mph
Herbaceous fuel moisture	15%
Woody fuel moisture	60%
100-hr fuel moisture	4%
10-hr fuel moisture	3%
1-hr fuel moisture	2%

(Note: Winds at 20 ft will be significantly less noticeable at ground level. Therefore, a "gentle breeze" may actually constitute an 11 MPH 20-foot wind, adding one of the components necessary for extreme weather conditions.)

Fire Behavior Interpretation and Limitations

This evaluation is a prediction of likely fire behavior given a standardized set of conditions and a single point source ignition at every point. It does not consider cumulative impacts of increased fire intensity over time and space. The model does not calculate the probability that a wildfire will occur. It assumes an ignition occurrence for every cell (each 10 x 10 meter area).

Weather conditions are extremely variable, and not all combinations are accounted for. These outputs are best used for pre-planning and not as a stand-alone product for tactical planning. It is recommended that whenever possible, fire behavior calculations be made with actual weather observations during the fire. It is also recommended that the most current ERC values be calculated and distributed during the fire season, to be used as a guideline for fire behavior potential.

Fire Behavior Analysis Outputs

From the fire behavior predictions, crown fire activity, rate of spread and flame length are derived. The following maps graphically display the outputs of **FlamMap** for both average and extreme weather conditions.

Figure 14. Predictions of Crown Fire Activity (Average Weather Conditions)

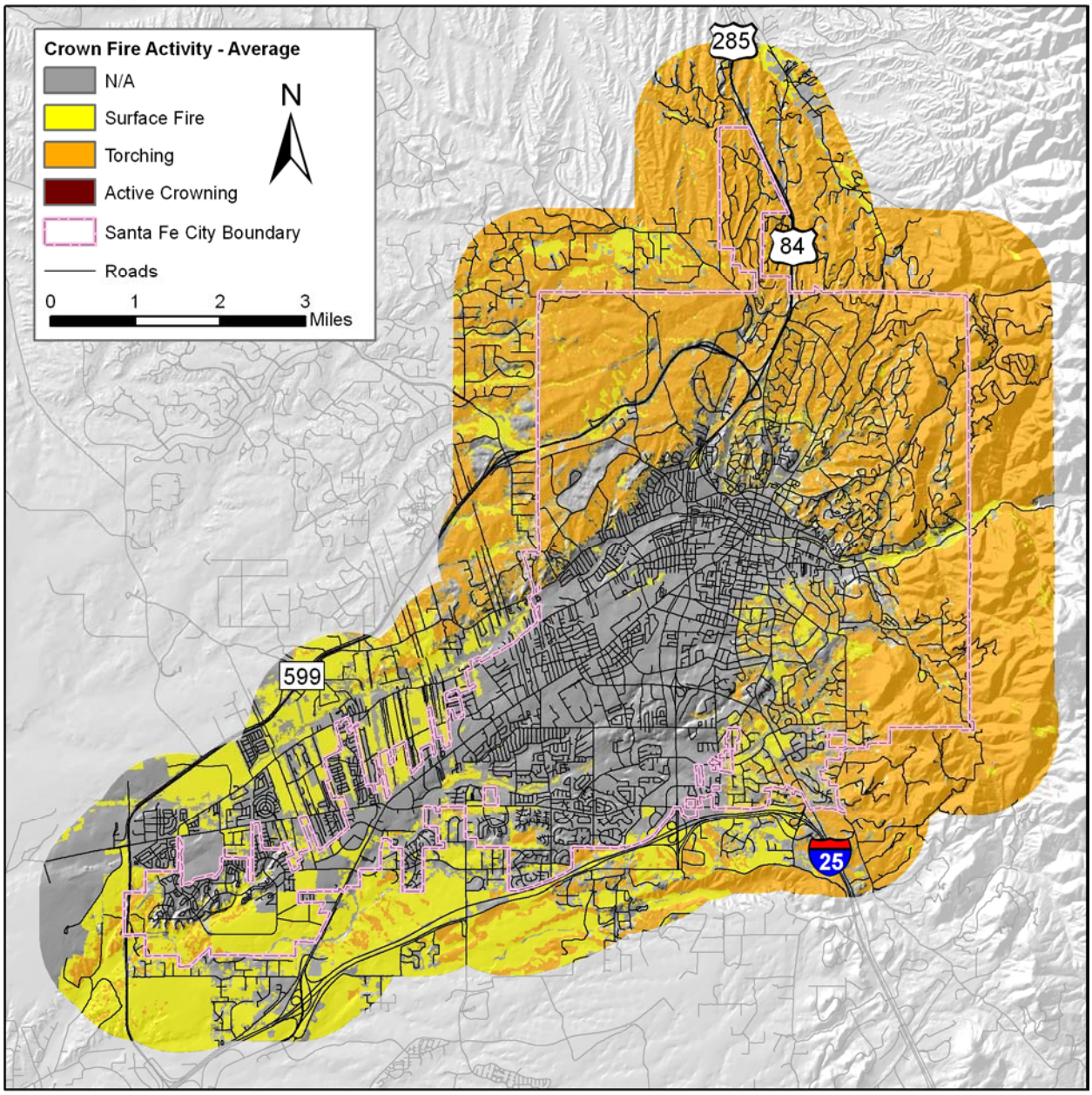
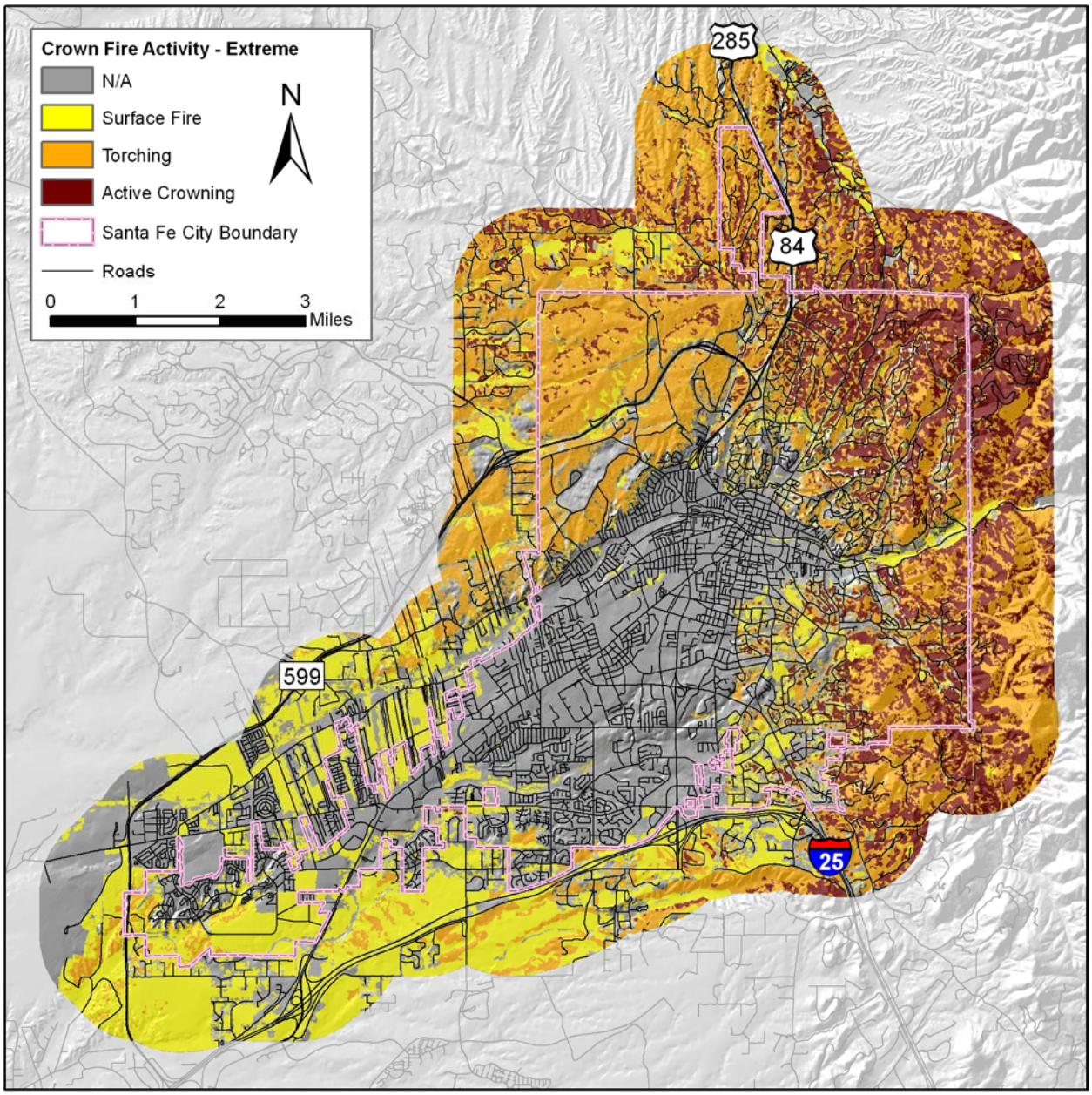
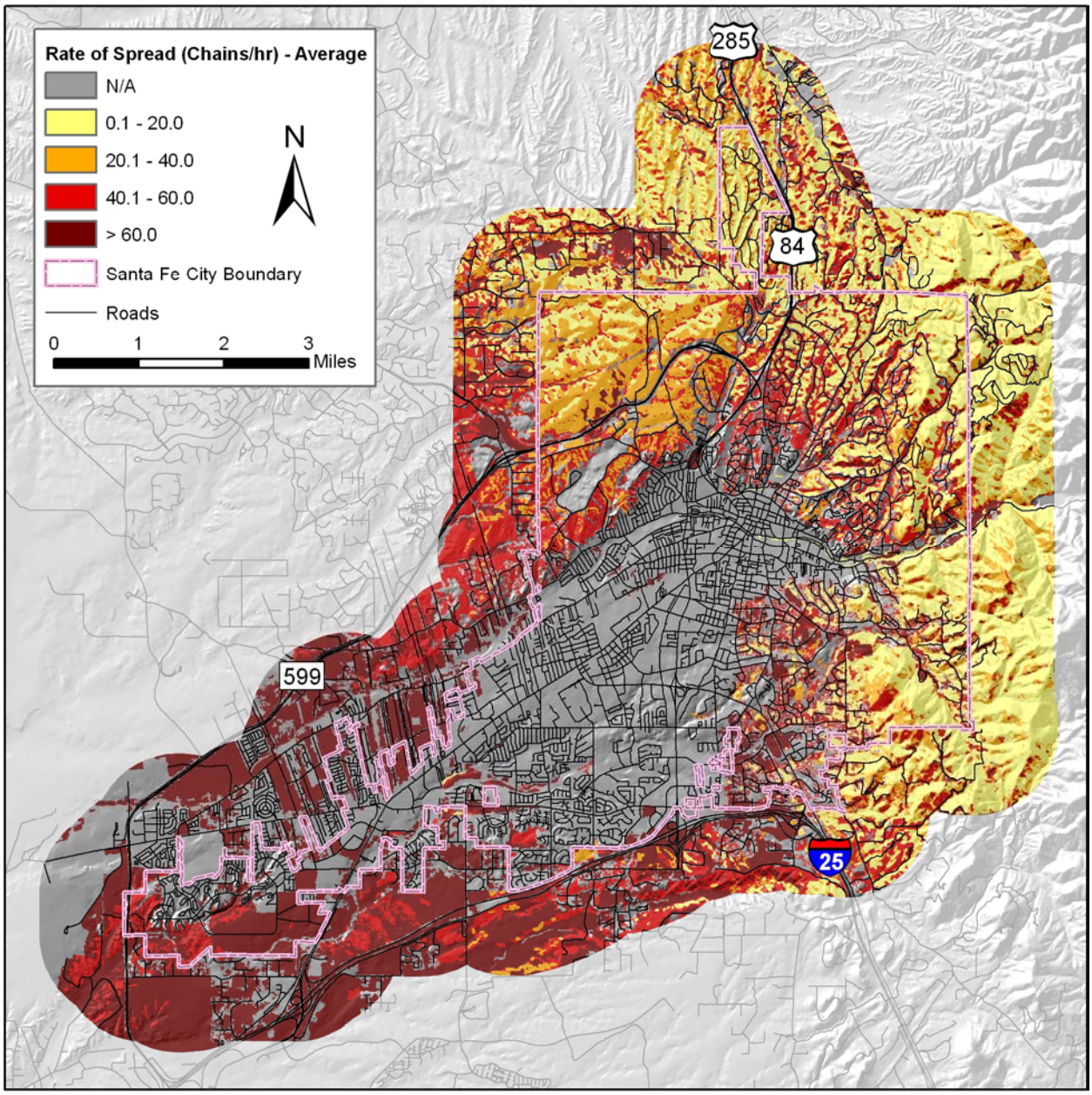


Figure 15. Predictions of Crown Fire Activity (Extreme Weather Conditions)



Crown fire activity values are generated by the **FlamMap** model and are classified into four categories based on standard ranges: Active, Passive, Surface and Not Applicable. In the surface fire category, little or no tree torching will be expected. During passive crown fire activity, isolated torching of trees or groups of trees will be observed and canopy runs will be limited to short distances. During active crown fire activity, sustained runs through the canopy will be observed that may be independent of surface fire activity.

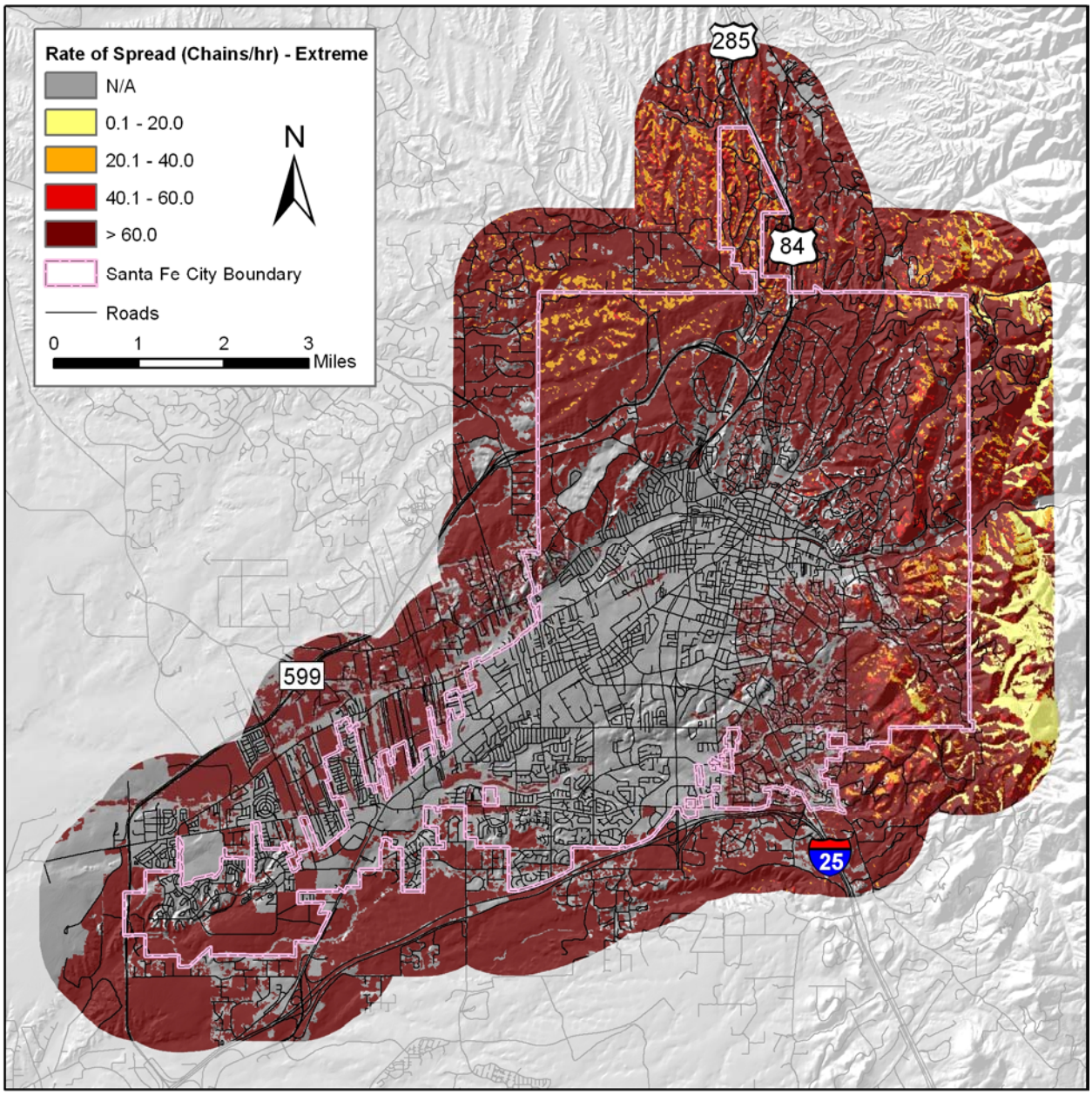
Figure 16. Rate of Spread Predictions (Average Weather Conditions)



Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

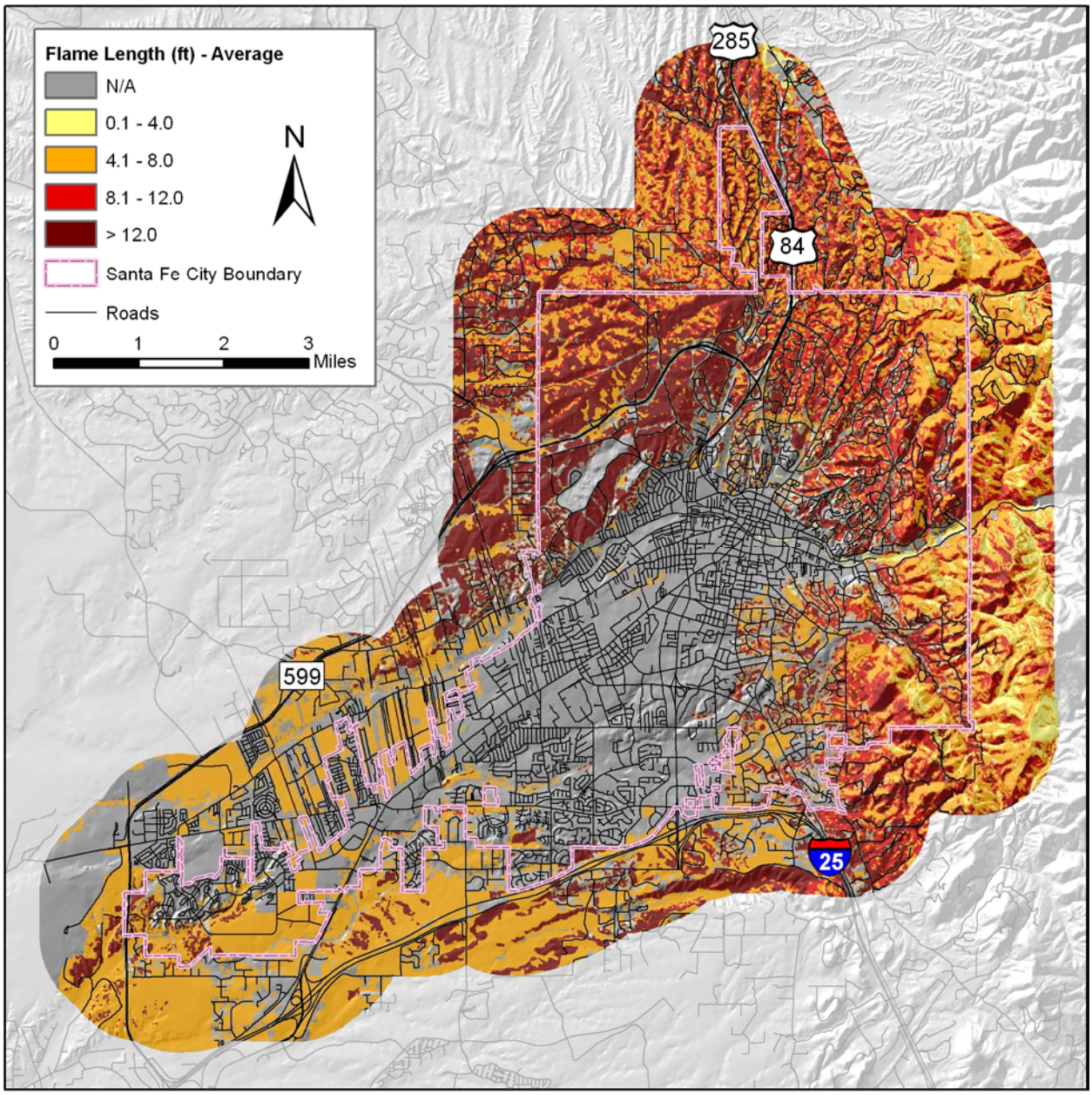
Spread rate values are generated by the **FlamMap** model and are classified into four categories based on standard ranges: 0-20 ch/h (chains/hour), 20.1-40 ch/h, 40.1-60 ch/h, and >60 ch/h. A chain is a logging measurement that is equal to 66 feet. One mile equals 80 chains. 1 ch/h equals approximately 1 foot/minute, 80 chains per hour equals 1 mile per hour.

Figure 17. Rate of Spread Predictions (Extreme Weather Conditions)



Rate of spread in chains/hour
(1 chain=66 ft) (80 chains/HR = 1 MPH)

Figure 18. Flame Length Predictions (Average Weather Conditions)



Flame length values are generated by the **FlamMap** model and classified in the four categories based on standard ranges: 0-4 feet, 4.1-8 feet, 8.1-12 feet and 12.1-60 feet. Flame lengths of 4 feet and less are acceptable for direct attack by hand crews. Flame lengths of 4-8 feet are suitable for direct attack by machinery. With flame lengths of greater than 8 feet, indirect and aerial attacks are the preferred methods.

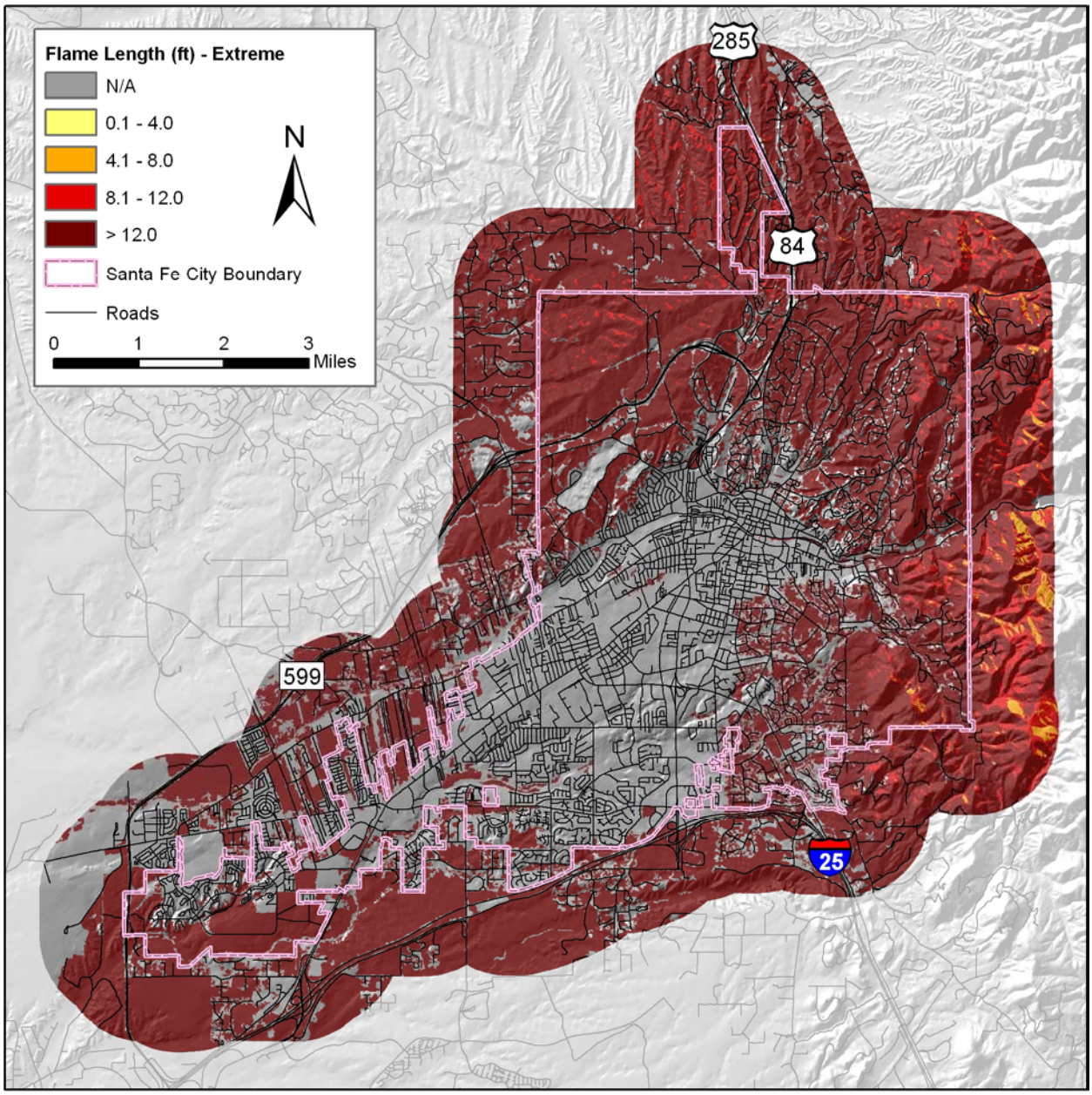



Figure 19. Flame Length Predictions (Extreme Weather Conditions)