2007 CARIBOU HILLS FIRE:

Kenai Peninsula Borough
Spruce Bark Beetle
Mitigation Program

Research Paper

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FIRE BEHAVIOR ANALYSIS AND CUSTOM FUEL MODEL DEVELOPMENT FOR THE KENAI PENINSULA

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Introduction:

Over 1.4 million acres of bark beetle insect activity was recorded (Burnside 2001) on the Kenai Peninsula during the 1990's,. This "high intensity" beetle infestation dramatically altered the composition and structure of spruce forests in affected areas. Ever since the beetle attack episode occurred, dynamic change in the fire regime has been experienced within the disturbance area.

This large-scale forest disturbance has created a unique fuel complex. The current fuel bed composition is not well represented by any of the standard "NFFL" fuel models. Nor is this dead jack-straw fuel configuration replicated by models in the Canadian Fire Behavior Prediction System.

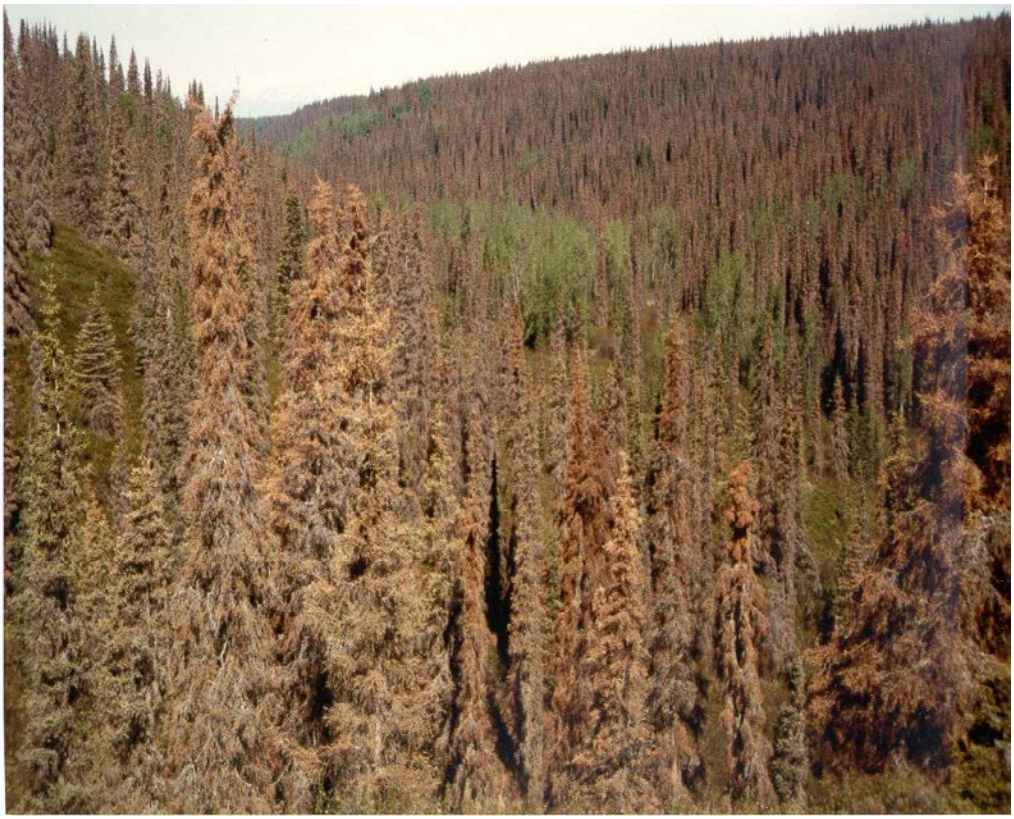

Figure 1. South Fork of Ninilchik River Drainage

The 2007 Caribou Hills Fire burned approximately 55, 438 acres. During part of the fire event, the natural fire growth progression and combustion intensity levels were not altered by suppression efforts to any significant extent. In affect, the fire overshadowed and fully exceeded fire suppression capability available at that period in time.

This burn event provided a basis for analyzing rates of fire travel across the landscape and intensity levels. FARSITE was used to develop new custom models so as to forecast probable characteristics of future fire episodes in this type of fuel complex.

Figure 2. Anchor River Drainage – East End Road Area

Background:

The spruce bark beetle outbreak on the Kenai Peninsula was unprecedented, not only in its large size, but intensity level of the infestation. In many stands, tree mortality reached 85% to 98% of all spruce over 6" DBH. The bark beetle episode lasted about 10 years at high intensity levels.

For approximately 5 – 8 years after the beetle attack, the landscape was dominated by the red and brown hues of standing dead spruce (Fig. 1). During this period, a variety of fungus species and other organisms began to affect wood fiber after mortality. Over time, the weakened trees have been subject to stem breakage as decay advances. This evolution of forest structure change is now well progressed on the Kenai Peninsula. Remnant spruce stands are now mostly a jack-straw configuration (Fig 2).

Spruce tree needle loss occurs within two years after beetle attack. The more open canopy layer allows increased direct sunlight to reach the forest floor. The net response is a loss in moss depth and significant increase in fine fuel (1 hr <1/4") volume loading.

The greatest increase in fine fuels is represented by native blue joint grass (calamagrostis candensis). This is the dominant species in most areas. Surface fuels in the 10 hour (1/4" – 1"), 100 hour (1" – 3") and 1000 hour (>3") time lag class have also increased dramatically as stands have unraveled in the past 10 years.

Landscape and Vegetation - Spatial Data:

Following the bark beetle epidemic, staff at the Kenai Peninsula Borough Spruce Bark Beetle Mitigation Program systematically classified vegetation using a photogrammetric interpretation process. The vegetative class polygons were then rendered to GIS format. The protocols for this mapping effort include a total of 434 types of forest and vegetation class combinations.

The original map classifications have been modified in cases where known changes or disturbances have transpired. As example, classifications have been revised to reflect areas that have been logged and the areas consumed by large fires.

The landscape areas that have been mapped for vegetative classification include all of the western Kenai Peninsula from the mountains to Cook Inlet and the Kachemak Bay. A band of area has been mapped on the south side of Kachemak Bay; from the Bradely Lake dam to Nanwalek. A corridor has been mapped through the Chugach Mountains along the Seward and Sterling Highways. As of this draft, preparations are underway to map a new area around Tyonek.

Fuel Model Development:

The event which provided opportunity for developing new custom fuel models was the 2007 Caribou Hills Fire. This fire was initial attacked on June 19, 2007 and had substantial fire size growth through June 24, 2007. The time periods selected for specific analysis and fuel model development include the evening of June 19 and the time period of mid day June 21st through all of June 22nd (Fig. 3).

Weather information for use in FARSITE operations was retrieved from a historic record data source available on the internet (mesowest roman site). Three different weather observation stations were reviewed to evaluate weather attributes. This included "RAWS" stations identified as Ninilchik, Homer (HO2) and Skilak Guard Station. It was determined that the Ninilchik weather data was the "best fit" for this fire event.

Albeit the Ninilchik weather information was deemed the best source, a revision of wind speed and direction data was used in model development. With analysis, it was determined the length-to-width ratio of the actual fire shape on the dates of interest did not coincide well to the RAWS observations. Rather than wind speed average, peak gust data was used in order to produce the elongated shape (length-width ratio) of the actual burn. Wind direction was also modified (to a lesser extent) in order to derive a fire location in FARSITE operations that replicated the actual burn spread across the landscape.

With weather and topographic information set for use, the other principal variable was vegetation. It is the vegetative characteristics that were tested in various volumes, surface area relationships and other attributes that are derivative for new model development.

To begin the process, fuel loading volumes and other attributes were first derived by means of estimation based upon experience. From this point, a series of FARSITE production "runs" were conducted. With each run output, model attributes such as load volume, fuel bed depth, and surface-to-volume ratio were changed to better replicate the actual burn area and intensity levels that occurred during the actual Caribou Hills Fire.

Other model adjustments made during the development process include revision of canopy characteristics along with the percentage of spot fire ignition probability. FARSITE has the capability to exponentially adjust for rates of spread that can be factored into fire growth run output. The analysis process included testing and revising file adjustment values to gain the desired outputs.

Results:

Through the process of working with FARSITE to replicate propagation of the Caribou Hills Fire, it was determined that three (3) new distinct custom models are needed to reflect real-world conditions and results for fire spread.

The FARSITE fire progression output results were compared to the mapped perimeter of the Caribou Hills Fire. Figure 4 shows the actual Caribou Hills fire perimeter boundary along with the fire intensity outputs generated by FARSITE using the new custom models. Approximately 85% of the FARSITE production is within the identified fire perimeter with the bulk of variation being on the western side. This zone coincides with residential dwellings located around the fire area. Assumption is made that this area did, in fact, receive fire suppression actions at the time that were successful to the decree indicated by the model outputs. Lacking fire suppression intervention, it appears the fire would have burned this additional area.

Figures 5 and 6 also show the fire perimeter boundary location with FARSITE outputs. These two figures provide information with respect to flame lengths that affected the fire area along with rates of fire spread.

An appendix is attached which describes all of the custom fuel model products that the author has produced for Alaskan fire applications. The newest fire models for use with "jackstraw" beetle-kill spruce fuel complexes are labeled as model 21 and model 22. An additional model was generated from this analysis work to replicate post-logging grass fuel beds mixed with residual slash debris.

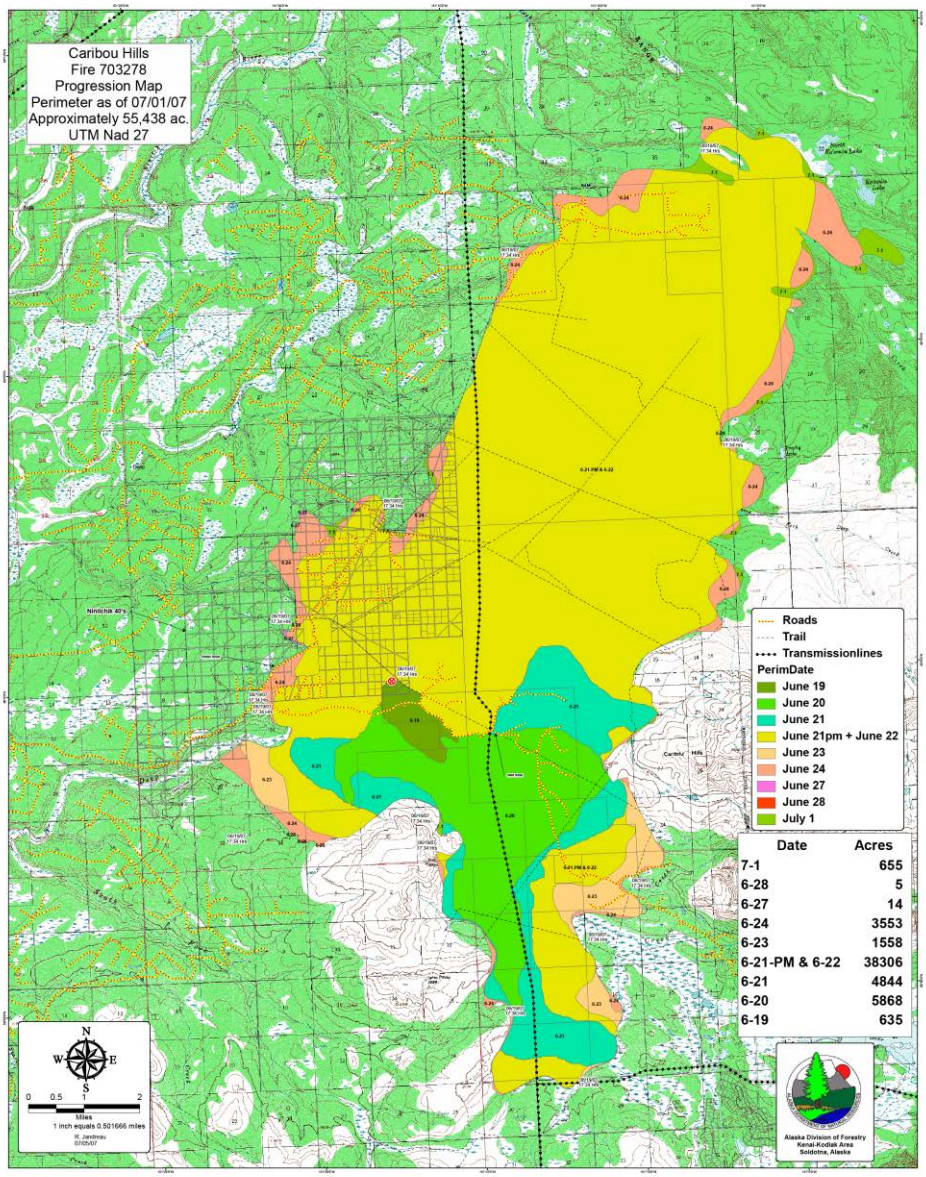

Figure 3. Caribou Hills Fire Chronology Progression Map.

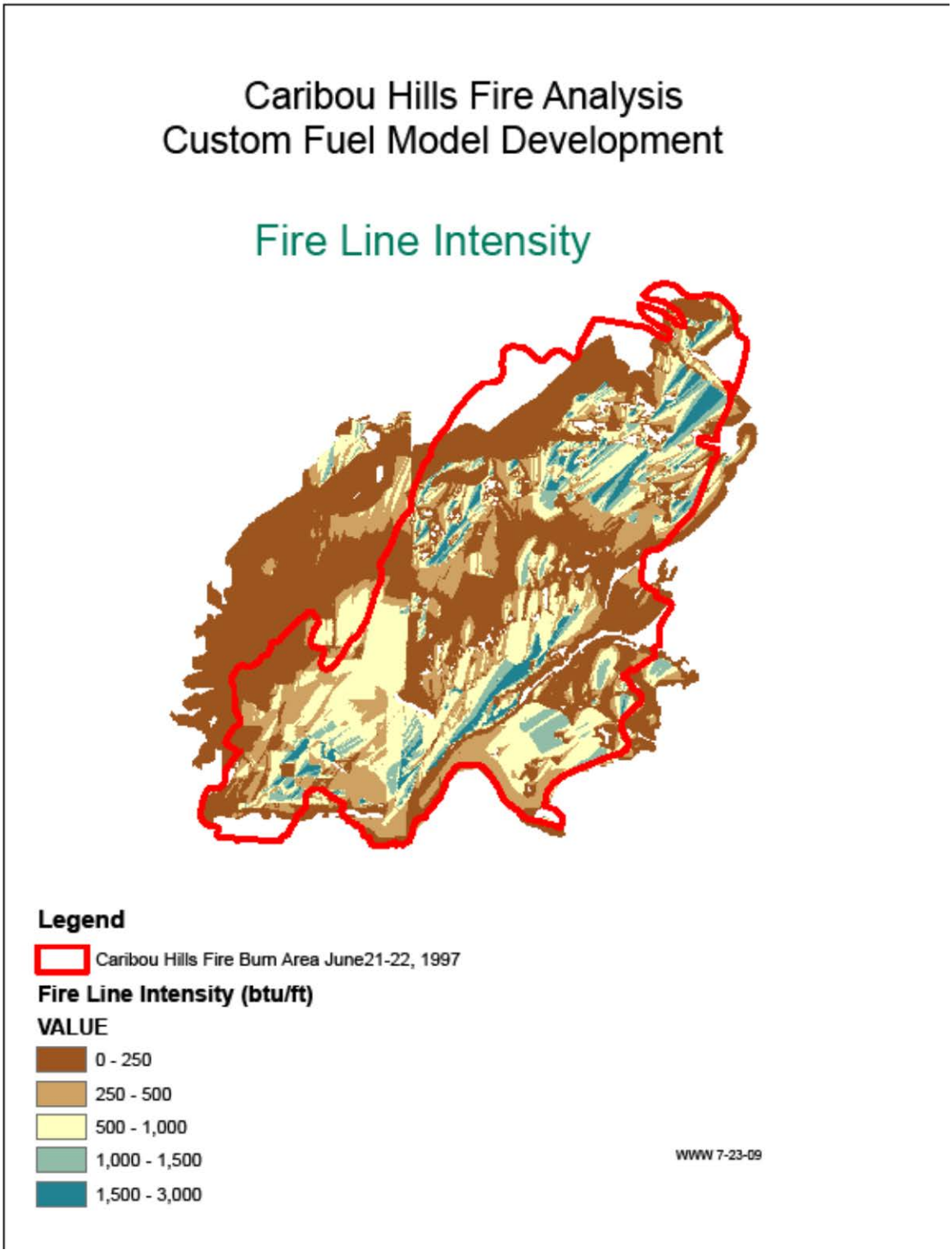

Figure 4. The fire shape derived from FARSITE is compared to the actual Caribou Hills Fire perimeter for the June 21st PM and all of June 22nd burn period.

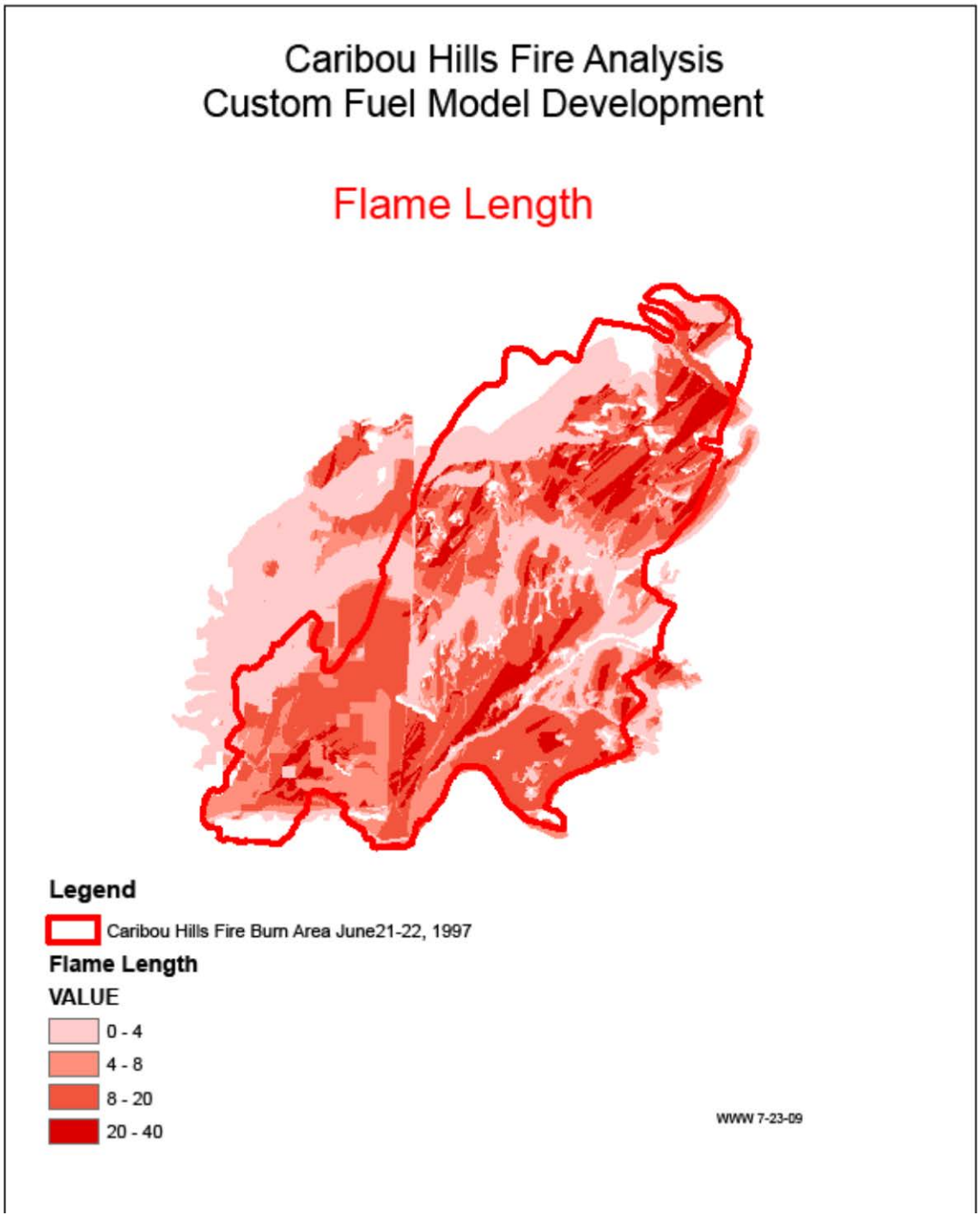

Figure 5. This figure shows the flame lengths generated by FARSITE for theJune 21st PM and all of June 22nd burn period. Flame lengths are derived frompotential heat production of fuel bed along with weather and topographic influences.

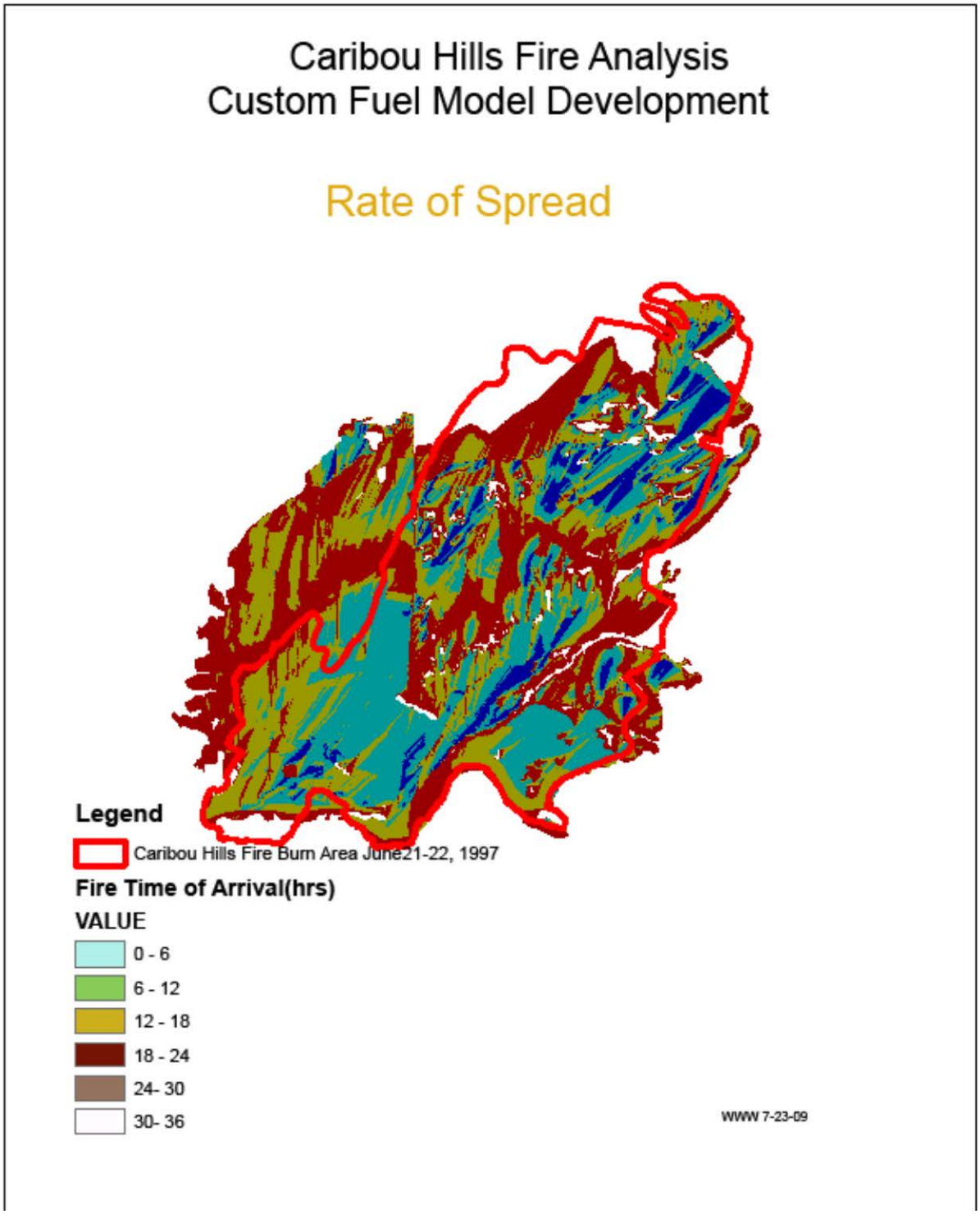

Figure 6. This figure shows the rate of fire spread through vegetation for the period of June 21st PM through all of June 22nd.

APPENDIX A

CUSTOM MODEL DESCRIPTION & DATA SET

This Appendix provides a brief description of each custom fuel model developed by the author for use with Alaska wildland and prescribed fire applications. This includes previously developed fuel models along with the three new custom models (#21, #22 & #23) generated as a result of the Caribou Hills Fire analysis work The model attribute information is provided in a file format protocol to facilitate direct "copy & paste" as a Custom Fuel Model input into FARSITE.

Model 15 – Alaska Black Spruce:

This model represents black spruce forest composition where the stand is approximately 40 years or older since past fire disturbance event. The forest area is upland, permafrost or relatively dry site and is moderate to fully stocked.

FM#	1HR	10HR	100HR	LiveH	LiveW	FM Type	1HSAV	LivHSAV	LivWSAV	Depth	XtMoist	D-Heat	L-Heat
15	2.500	3.300	1.700	1.100	2.500	static	2900	1400	1400	2.500	20	8000	8000

Model 16 – Standing Dead Spruce - Closed Canopy

This model represents Sitka, white or lutz spruce forest with moderate to heavy stocking levels. The stand has little hardwood species component. The stand has beetle-kill rates of 60% or greater mortality proportion and is mostly upright vertical stem structure.

FM#	1HR	10HR	100HR	LiveH	LiveW	FM Type	1HSAV	LivHSAV	LivWSAV	Depth	XtMoist	D-Heat	L-Heat
16	3.000	2.500	0.800	1.100	1.200	static	2800	1000	1000	2.000	20	8000	8000

Model 17 – Standing Dead Spruce - Open Canopy

This model represents Sitka, white or lutz spruce forest with open grown or woodland structure. The spruce is predominantly beetle kill with 60% or greater mortality proportion.

FM#	1HR	10HR	100HR	LiveH	LiveW	FM Type	1HSAV	LivHSAV	LivWSAV	Depth	XtMoist	D-Heat	L-Heat
17	2.000	2.000	0.800	1.100	1.2000	static	2700	1000	1000	2.200	22	8000	8000

Model 18 – Alder and Riparian (wet site) Willow

This model represents brush species such as alder and willow that grows on wet sites and in large patches. The fuel bed has little dead fine fuel component such as grass and may contain open water areas. Depth of the fuel bed is minimal.

FM#	1HR	10HR	100HR	LiveH	LiveW	FM Type	1HSAV	LivHSAV	LivWSAV	Depth	XtMoist	D-Heat	L-Heat
18	0.500	1.000	0.500	0.500	0.500	static	2200	1700	1000	0.200	22	8000	8000

Model 19 – Alpine Tundra & Upland Brush

This model represents vegetation that is typically found in higher elevations above timber line. A variety of prostate plant berry species are found in this area with brush species such as blueberry. Fires in this zone typically burn faster backing into the wind.

FM#	1HR	10HR	100HR	LiveH	LiveW	FM Type	1HSAV	LivHSAV	LivWSAV	Depth	XtMoist	D-Heat	L-Heat
19	0.500	0.000	0.000	0.650	0.000	static	2650	1700	1500	0.230	23	8000	8000

Model 20 – Standing Dead Spruce & Hardwood Mix

This model represents upland spruce stands with a significant component of hardwood species such as birch or aspen. The spruce in these stands is predominately dead with about 40% to 70% hardwoods mix.

FM#	1HR	10HR	100HR	LiveH	LiveW	FM Type	1HSAV	LivHSAV	LivWSAV	Depth	XtMoist	D-Heat	L-Heat
20	1.600	1.800	0.800	0.000	0.000	static	2300	1000	1000	1.200	22	8000	8000

Model 21 – Heavy Downed/Jackstraw Dead Spruce

This model represents Sitka, white and lutz spruce stands that are predominately dead. These stands are usually 10 years or more post-beetle attack. Typically 50% or more of the spruce is horizontally arrangement with dead grass fine fuels growing in the downed trees.

FM#	1HR	10HR	100HR	LiveH	LiveW	FM Type	1HSAV	LivHSAV	LivWSAV	Depth	XtMoist	D-Heat	L-Heat
21	4.800	4.900	8.400	1.500	2.200	static	2200	1000	1000	5.200	19	7000	7000

Model 22 – Light Downed/Jackstraw Dead Spruce

This model represents Sitka, white and lutz spruce that is more open grown and lesser stand density than model 21. The spruce component is predominately dead and 10 years or longer since beetle attack. This model can be used with stands that have a moderate (< 40%) proportion of hardwood mix.

FM#	1HR	10HR	100HR	LiveH	LiveW	FM Type	1HSAV	LivHSAV	LivWSAV	Depth	XtMoist	D-Heat	L-Heat
22	3.200	2.400	4.500	1.500	1.800	static	2000	1000	1000	3.300	19	7000	7000

Model 23 – Old Timber Harvest Units with Grass – Regen

This model represents areas that have been logged and have grown back with grass as the primary surface fuel. The areas have a concentration of slash limb debris that was derived through the mechanical harvest process and burn hotter/faster than upland grass patches.

FM#	1HR	10HR	100HR	LiveH	LiveW	FM Type	1HSAV	LivHSAV	LivWSAV	Depth	XtMoist	D-Heat	L-Heat
23	2.300	1.000	0.000	1.050	2.230	static	1600	1600	1000	3.100	19	8000	8000

APPENDEX B

FARSITE DATA INPUT VALUES

Adjustment File Attributes

Model No.	Value
1	1.000000
2	1.000000
3	1.00000
4	1.000000
5	1.000000
6	1.000000
7	1.000000
8	1.000000
9	1.000000
10	1.000000
11	1.000000
12	1.000000
13	1.000000
14	1.000000
15	1.000000
16	1.100000
17	1.100000
18	1.000000
19	0.900000
20	1.000000
21	1.250000
22	1.350000
23	1.350000

Canopy Characteristics Attributes

Item	Value
Tree Height	66 Feet
Crown Base	1.2 Feet
Bulk Density	0.0106 lb/ft3
Foliar MC	50%
Diameter	11 Inch
Tolerance	Medium
Species	Englemann Spruce

Fire Behavior Options

Item	Value
Enable Crownfire	Yes
Link Density&Cover	Yes
Ember Torch Trees	Yes
Enable Spot Fire	Yes
Ignite Freq.	9%
NWNS Backing	No