

## Technical Memorandum

February 1, 2012

STI-910902-4341-TM

To: John Cissel, Joint Fire Science Program (JFSP)  
From: Stacy A. Drury, Erin M. Banwell, and ShihMing Huang  
Re: **IFTDSS Surface Fire Behavior Output Evaluation**

### Introduction

The Interagency Fuels Treatment Decision Support System (IFTDSS) is a web-based software framework that provides access to fire and fuels software applications. The IFTDSS project is designed to provide managers tasked with planning fuels treatments and prescribed burns with the modeling tools they need in an easy-to-use, intuitive user interface that is consistent across modeling systems. A goal in the IFTDSS development is to reproduce the scientific data output of the original software model, module, or system.

In the IFTDSS, *models* are the scientific algorithms used to estimate the likelihood or magnitude of an event such as a fire occurring or how rapidly a fire may move across the landscape. The Rothermel (1972) rate of spread model is an example of a scientific model in IFTDSS. *Modules* are larger software applications that provide the user with access to the scientific models in a meaningful way. For example, the SURFACE fire behavior module in BehavePlus 5.0.5 couples the Rothermel rate of spread model with other scientific models to provide insight into how a fire might behave in specific environments under user-specified conditions. *Software modeling systems*, such as BehavePlus 5.0.5 and IFTDSS, are larger collections of models and modules that describe fire activity and the fire environment. These larger systems comprise many of the tools needed by fire managers to plan and implement fire management activities including fuels treatments and prescribed burns.

This study was conducted to evaluate and compare module output from select IFTDSS fire behavior modules with output from BehavePlus 5.0.5 and NEXUS 2.0. As of January 2012, the IFTDSS has implemented five modules to estimate fire behavior:

1. **IFT-surface.** a surface fire behavior prediction module constructed from the fire behavior system development kit (FBSDK) code package algorithms ([www.fire.org](http://www.fire.org)) and a set of BehavePlus code libraries provided by Collin Bevins;
2. **FCCS-surface.** a surface fire behavior prediction module designed specifically for the Fuel Characteristics Classification System (FCCS) fuelbeds;
3. **IFT-FlamMap.** a fire behavior prediction module for individual stands that accesses the FlamMap Version 3.0 dll;

4. **IFT-FlamMap Spatial.** a spatial fire behavior prediction module utilizing the FlamMap Version 3.0 dll across a spatial landscape; and
5. **IFT-crown.** a crown fire behavior prediction module constructed from the FBSDK code package and the set of BehavePlus code libraries.

This study presents the fire behavior results from two IFTDSS fire behavior prediction modules, IFT-surface and IFT-FlamMap. The objective of this study was to identify potential differences among the IFTDSS fire behavior prediction modules and the results from two fire behavior prediction systems widely used for modeling fire behavior, BehavePlus 5.0.5 and NEXUS 2.0. Each IFTDSS fire behavior prediction module was compared with the SURFACE fire behavior prediction module in BehavePlus 5.0.5, and the surface fire behavior prediction calculators in NEXUS 2.0, to test whether the modeled results from the IFTDSS fire behavior prediction modules agree with the output from these existing desktop software packages for a common set of environmental inputs.

## Methods

Fuel type, fuel moisture, slope, wind speed and wind direction are all potential influences on modeled fire behavior. In order to test for potential divergences from the widely used modeling systems, BehavePlus and NEXUS, the output from IFT-surface and IFT-FlamMap modules for individual stands were tested with the BehavePlus 5.0.5 SURFACE module output and output from Nexus 2.0. Each IFTDSS fire behavior module and corresponding module in BehavePlus or Nexus received identical input parameters for the original 13 fire behavior fuel models (Anderson 1982) and the relatively new Scott and Burgan standard 40 fuel models (Scott and Burgan 2005) inputs.

Four slope scenarios were tested:

- flat terrain – a no-slope (0%) scenario which tested the model parameters without a slope influence,
- up slope – a 50% slope scenario with the wind blowing upslope,
- down slope – a 50% slope scenario with the wind blowing down slope, and
- cross-slope – a 50% slope scenario where the wind was simulated as blowing perpendicular to the slope (**Table 1**).

**Table 1.** The four slope scenarios used for the fire behavior module comparison.

Scenario	Slope (%)	Aspect (degrees)	Wind Direction (degrees)
Flat terrain	0	0	0
Up Slope	50	90	90
Down Slope	50	270	90
Cross-Slope	50	0	90

Wind speed was modeled as a flat 15 mph, 20-foot wind speed, which was adjusted by fuel model to reflect midflame wind speed. The adjusted wind speeds ranged from 4.1 to 8.2 depending on fire behavior fuel model (Appendix 1). Wind adjustment factors (WAF) vary by fuel model as each fuel type influences the wind differently. Midflame wind speeds were calculated and adjusted internally in the BehavePlus and IFT-FlamMap modules. BehavePlus was used to calculate a WAF and an adjusted wind speed for each fire behavior fuel model (FBFM); these values were manually entered into the IFT-surface and NEXUS modules.

Fuel moisture was held constant for all fire behavior fuel models using the low fuel moisture from Scott and Burgan 2005. The low fuel moisture condition was chosen to reflect common moisture conditions during wildfires and the drier end of most prescribed burn prescriptions (**Table 2**).

**Table 2.** Low fuel moisture scenario from Scott and Burgan 2005 used for the fire behavior module comparison.

Fuel Category	Fuel Moisture (%)
1-hr fuel moisture	6
10-hr fuel moisture	7
100-hr fuel moisture	8
Live herbaceous fuel moisture	60
Live woody fuel moisture	90
Foliar Moisture	100

To ensure that only surface fire behavior potentials were tested in this analysis, all canopy fuel values (canopy cover, canopy height, crown base height, and crown bulk density) were set to zero. All input values are presented in Appendix 1.

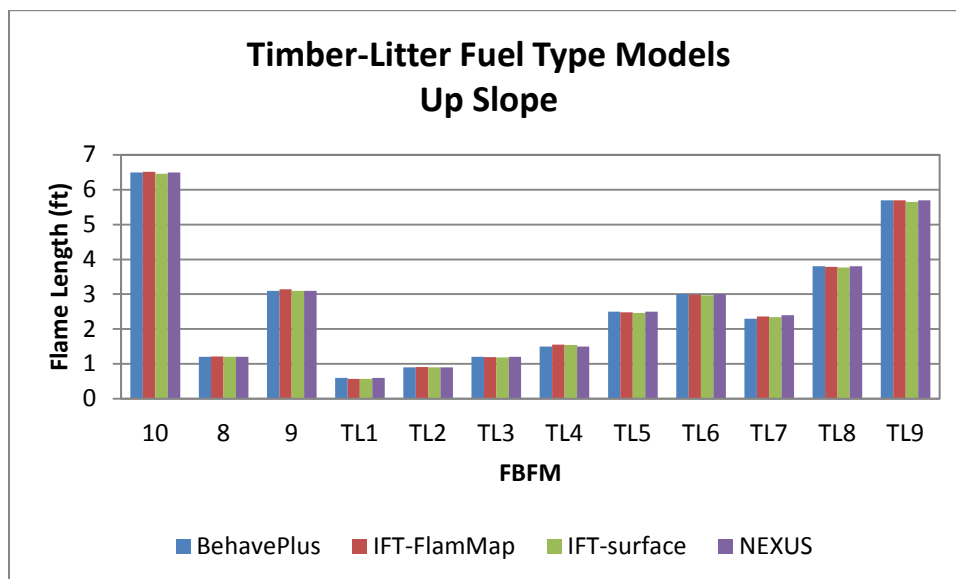
Fire behavior prediction comparison tables were constructed for each slope scenario. Within each slope scenario module results were filtered into six fuel type categories: grass, grass-shrub, shrub, slash-blowdown, timber-litter, and timber-understory. For ease of presentation and direct comparison, only the most commonly used fire behavior outputs of flame length, rate of spread, fireline intensity, and heat per unit area were compared.

## Results

There were no major differences among the output of the IFTDSS fire behavior modules and the output from BehavePlus or NEXUS for the Anderson 13 fire behavior fuel models or the newer Scott and Burgan 40 standard fuel models for the 848 individual fire behavior simulations completed (Table 3; Figure 1; Appendix 2; Appendix 3). For the four slope scenarios tested, the surface fire behavior predictions from IFT-surface and IFT-FlamMap were in agreement (Table 3; Figure 1; Appendix 2; Appendix 3). Moreover, the fire behavior predictions from the IFTDSS fire behavior modules were in agreement with the BehavePlus and NEXUS desktop applications (Table 3; Figure 1; Appendix 2; Appendix 3). A complete fuel model by fuel model listing of the

module output comparisons are presented in Appendix 2 and Appendix 3. Figure 1 is reflective of the general pattern of agreement among the fire behavior prediction results. In this figure, it is clear that the individual fire behavior fuel models are providing similar results for flame length.

Although the fire behavior prediction results of the two IFTDSS modules, BehavePlus 5.0.5 and NEXUS 2.0, were in general agreement, there were small but consistent differences throughout the data. NEXUS often produced slightly lower values for fireline intensity than BehavePlus (41% of simulations) and the two IFTDSS modules (36% of simulations; see Table 3; Appendix 2). Also, the IFT-FlamMap module consistently produced lower values for Fuel Model 2 (Table 3 and Appendix 2). Table 3 shows that the magnitude of this divergence among the IFTDSS fire behavior for individual stands output and the output produced by the other three fire behavior modules tested is low. The flame length estimate from IFT-FlamMap was 6.8 ft, slightly less than the 7.2 ft flame lengths produced by the other systems (Table 3). In addition, rate of spread values for Fuel Model 2 were also slightly lower (42.3 vs. 46.9; Table 3). The Fuel Model 2 fire behavior estimates were the only case in which the IFTDSS implementation of the FlamMap dll differed by more than a few percent (Appendix 2). Moreover, these differences were small, approximately 6% for the flame length difference between BehavePlus and IFT-FlamMap, a 10% difference for rate of spread, and a 12% difference for fireline intensity.



**Figure 1.** Comparison of simulated flame length values for timber litter fire behavior fuel models (FBFM). Each module in BehavePlus 5.0.5, the IFTDSS Version 1.0, and NEXUS 2.0 were provided with identical input data.

## Discussion

Across the range of values tested, output results tended to be identical. In the infrequent cases in which differences were noted, they were approximately 10% or less. The observed differences among module outputs are likely due to rounding or truncating differences that occur during calculations or in unit conversions. For example, in BehavePlus, fireline intensity is

calculated by multiplying the heat per unit area times the rate of spread (Andrews 1986). If one application truncates the values for heat per unit area and rate of spread while the other application rounds them, the differences could be of the magnitude noted here.

## Conclusions

The IFTDSS fire behavior fuel modules tested here produced acceptable results when compared with the outputs for BehavePlus 5.0.5 and NEXUS 2.0. Small differences are to be expected due to rounding and truncating in calculations or in unit conversions.. However, these small differences do not alter the interpretation of the model results.

**Table 3.** Summary table showing the results of two IFTDSS Version 1.0 fire behavior module outputs compared with modeled fire behavior from BehavePlus 5.0.5 and NEXUS 2.0 on flat terrain. Inputs were held constant for each of the Anderson 13 grass fuel models. A complete list of model comparisons is located in Appendix 2.

Fire Behavior Fuel Model	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models - Grass Fuel Types					
1	BehavePlus	5.0	110.7	184.1	90.9
	IFT-surface	4.9	109.4	181.8	90.6
	IFT-FlamMap	5.0	111.0	184.4	90.5
	NEXUS	4.9	109.4	182.1	90.9
2	BehavePlus	7.2	46.9	419.6	487.7
	IFT-surface	7.2	46.5	415.4	487.6
	IFT-FlamMap	6.8	42.3	370.7	477.6
	NEXUS	7.2	46.5	415.3	486.7
3	BehavePlus	15.8	167.3	2278.6	741.5
	IFT-surface	15.8	167.5	2280.0	742.4
	IFT-FlamMap	15.8	167.6	2286.9	743.3
	NEXUS	15.8	164.6	2275.6	739.5

## Further Evaluations

Additional testing of the stand level modeling capacity with FlamMap 3.0 would provide useful information. Testing FlamMap 3.0 is a more complicated process than testing with the other stand-alone modeling systems tested here, as FlamMap requires a special landscape file, or lcp, as input. The current IFTDSS Version 1.0 does not allow users to export lcp files used internally in the IFTDSS for use in other programs, which limits the ability to directly test the implementation of the FlamMap dll in the IFT-FlamMap module. Manual pixel by pixel testing of IFT-FlamMap with output from FlamMap 3.0 conducted at Sonoma Technology yielded identical results for the two systems (data on file at STI). However, the IFTDSS development team plans

to provide additional data export functionality in the near future which will enable more stringent testing to occur.

## References

- Anderson H.E (1982) Aids to determining fuel models for estimating fire behavior. Technical report by the USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT, General Technical Report INT-122, June. Available on the Internet at [http://www.fs.fed.us/rm/pubs\\_int/int\\_gtr122.pdf](http://www.fs.fed.us/rm/pubs_int/int_gtr122.pdf).
- Rothermel, R.C. (1972). A mathematical model for predicting fire spread in wildland fuels. Res. Pap. INT-115. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.
- Scott J.H. and Burgan R.E. (2005) Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model. Technical report by the USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO, General Technical Report RMRS-GTR-15, June. Available on the Internet at [http://www.fs.fed.us/rm/pubs/rmrs\\_gtr153.pdf](http://www.fs.fed.us/rm/pubs/rmrs_gtr153.pdf).

## Appendix 1

### **Complete data input tables for comparing IFTDSS fire behavior module outputs with fire behavior potential results from BehavePlus 5.0.5 and NEXUS 2.0**

For this study, we compared fire potential simulations for the two IFTDSS fire behavior prediction modules with the BehavePlus and NEXUS modeling systems to ensure that the IFTDSS calculators were implemented correctly. This appendix provides all the input values which remained constant for each fire behavior fuel module. We classified fire behavior fuel models into the following six groups: grass, grass-shrub, shrub, slash-blowdown, timber-litter, and timber-understory. Comparisons were made for four scenarios: a flat terrain scenario that tested the model parameters without a slope influence, an upslope condition with the wind, a downslope scenario with an opposing influence of wind, and a cross-slope condition where the wind was simulated as blowing perpendicular to the slope.

The following tables present the intercomparison results by fuel model for each scenario:

- Tables 1 through 6 present the data inputs supplied to each fire behavior prediction module for the flat terrain (no slope) scenario,
- Tables 7 through 12 present the data inputs supplied to each fire behavior prediction module for the upslope scenario,
- Tables 13 through 18 present the data inputs supplied to each fire behavior prediction module for the downslope scenario,
- and Tables 19 through 24 present the data inputs supplied to each fire behavior prediction module for the cross-slope scenario.

**Table 1.** Data inputs used in modeling surface fire behavior on a flat terrain for the grass fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
GRASS FUEL TYPE MODELS									
1	6	7	8	60	90	5.4	0	0	0
2	6	7	8	60	90	5.4	0	0	0
3	6	7	8	60	90	6.6	0	0	0
GR1	6	7	8	60	90	4.6	0	0	0
GR2	6	7	8	60	90	5.4	0	0	0
GR3	6	7	8	60	90	6.3	0	0	0
GR4	6	7	8	60	90	6.3	0	0	0
GR5	6	7	8	60	90	5.9	0	0	0
GR6	6	7	8	60	90	5.9	0	0	0
GR7	6	7	8	60	90	6.9	0	0	0
GR8	6	7	8	60	90	7.4	0	0	0
GR9	6	7	8	60	90	7.8	0	0	0



**Table 2.** Data inputs used in modeling surface fire behavior on a flat terrain for the grass-shrub fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
GRASS-SHRUB FUEL TYPE MODELS									
4	6	7	8	60	90	8.2	0	0	0
5	6	7	8	60	90	6.3	0	0	0
6	6	7	8	60	90	6.6	0	0	0
7	6	7	8	60	90	6.6	0	0	0
GS1	6	7	8	60	90	5.3	0	0	0
GS2	6	7	8	60	90	5.9	0	0	0
GS3	6	7	8	60	90	6.1	0	0	0
GS4	6	7	8	60	90	6.3	0	0	0

**Table 3.** Data inputs used in modeling surface fire behavior on a flat terrain for the shrub fire behavior fuel models (Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
SHRUB FUEL TYPE MODELS									
SH1	6	7	8	60	90	5.4	0	0	0
SH2	6	7	8	60	90	5.4	0	0	0
SH3	6	7	8	60	90	6.5	0	0	0
SH4	6	7	8	60	90	6.9	0	0	0
SH5	6	7	8	60	90	8.2	0	0	0
SH6	6	7	8	60	90	6.3	0	0	0
SH7	6	7	8	60	90	8.2	0	0	0
SH8	6	7	8	60	90	6.9	0	0	0
SH9	6	7	8	60	90	7.6	0	0	0

**Table 4.** Data inputs used in modeling surface fire behavior on a flat terrain for the slash-blowdown fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
SLASH-BLOWDOWN FUEL TYPE MODELS									
11	6	7	8	60	90	5.4	0	0	0
12	6	7	8	60	90	6.5	0	0	0
13	6	7	8	60	90	6.9	0	0	0
SB1	6	7	8	60	90	5.4	0	0	0
SB2	6	7	8	60	90	5.4	0	0	0
SB3	6	7	8	60	90	5.6	0	0	0
SB4	6	7	8	60	90	6.7	0	0	0

**Table 5.** Data inputs used in modeling surface fire behavior on a flat terrain for the timber-litter fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
TIMBER-LITTER FUEL TYPE MODELS									
8	6	7	8	60	90	4.1	0	0	0
9	6	7	8	60	90	4.1	0	0	0
10	6	7	8	60	90	5.4	0	0	0
TL1	6	7	8	60	90	4.1	0	0	0
TL2	6	7	8	60	90	4.1	0	0	0
TL3	6	7	8	60	90	4.4	0	0	0
TL4	6	7	8	60	90	4.6	0	0	0
TL5	6	7	8	60	90	4.9	0	0	0
TL6	6	7	8	60	90	4.4	0	0	0
TL7	6	7	8	60	90	4.6	0	0	0
TL8	6	7	8	60	90	4.4	0	0	0
TL9	6	7	8	60	90	4.9	0	0	0

**Table 6.** Data inputs used in modeling surface fire behavior on a flat terrain for the timber-understory fire behavior fuel models (Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
TIMBER-UNDERSTORY FUEL TYPE MODELS									
TU1	6	7	8	60	90	4.9	0	0	0
TU2	6	7	8	60	90	5.4	0	0	0
TU3	6	7	8	60	90	5.7	0	0	0
TU4	6	7	8	60	90	4.8	0	0	0
TU5	6	7	8	60	90	5.4	0	0	0

**Table 7.** Data inputs used in modeling upslope surface fire behavior for the grass fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
GRASS FUEL TYPE MODELS									
1	6	7	8	60	90	5.4	90	50	90
2	6	7	8	60	90	5.4	90	50	90
3	6	7	8	60	90	6.6	90	50	90
GR1	6	7	8	60	90	4.6	90	50	90
GR2	6	7	8	60	90	5.4	90	50	90
GR3	6	7	8	60	90	6.3	90	50	90
GR4	6	7	8	60	90	6.3	90	50	90
GR5	6	7	8	60	90	5.9	90	50	90
GR6	6	7	8	60	90	5.9	90	50	90
GR7	6	7	8	60	90	6.9	90	50	90
GR8	6	7	8	60	90	7.4	90	50	90
GR9	6	7	8	60	90	7.8	90	50	90

**Table 8.** Data inputs used in modeling upslope surface fire behavior for the grass-shrub fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
GRASS-SHRUB FUEL TYPE MODELS									
4	6	7	8	60	90	8.2	90	50	90
5	6	7	8	60	90	6.3	90	50	90
6	6	7	8	60	90	6.6	90	50	90
7	6	7	8	60	90	6.6	90	50	90
GS1	6	7	8	60	90	5.3	90	50	90
GS2	6	7	8	60	90	5.9	90	50	90
GS3	6	7	8	60	90	6.1	90	50	90
GS4	6	7	8	60	90	6.3	90	50	90

**Table 9.** Data inputs used in modeling upslope surface fire behavior for the shrub fire behavior fuel models (Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
SHRUB FUEL TYPE MODELS									
SH1	6	7	8	60	90	5.4	90	50	90
SH2	6	7	8	60	90	5.4	90	50	90
SH3	6	7	8	60	90	6.5	90	50	90
SH4	6	7	8	60	90	6.9	90	50	90
SH5	6	7	8	60	90	8.2	90	50	90
SH6	6	7	8	60	90	6.3	90	50	90
SH7	6	7	8	60	90	8.2	90	50	90
SH8	6	7	8	60	90	6.9	90	50	90
SH9	6	7	8	60	90	7.6	90	50	90



**Table 10.** Data inputs used in modeling upslope surface fire behavior for the slash-blowdown fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
SLASH-BLOWDOWN FUEL TYPE MODELS									
11	6	7	8	60	90	5.4	90	50	90
12	6	7	8	60	90	6.5	90	50	90
13	6	7	8	60	90	6.9	90	50	90
SB1	6	7	8	60	90	5.4	90	50	90
SB2	6	7	8	60	90	5.4	90	50	90
SB3	6	7	8	60	90	5.6	90	50	90
SB4	6	7	8	60	90	6.7	90	50	90

**Table 11.** Data inputs used in modeling upslope surface fire behavior for the timber-litter fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
TIMBER-LITTER FUEL TYPE MODELS									
8	6	7	8	60	90	4.1	90	50	90
9	6	7	8	60	90	4.1	90	50	90
10	6	7	8	60	90	5.4	90	50	90
TL1	6	7	8	60	90	4.1	90	50	90
TL2	6	7	8	60	90	4.1	90	50	90
TL3	6	7	8	60	90	4.4	90	50	90
TL4	6	7	8	60	90	4.6	90	50	90
TL5	6	7	8	60	90	4.9	90	50	90
TL6	6	7	8	60	90	4.4	90	50	90
TL7	6	7	8	60	90	4.6	90	50	90
TL8	6	7	8	60	90	4.4	90	50	90
TL9	6	7	8	60	90	4.9	90	50	90

**Table 12.** Data inputs used in modeling upslope surface fire behavior for the timber-understory fire behavior fuel models (Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
TIMBER-UNDERSTORY FUEL TYPE MODELS									
TU1	6	7	8	60	90	4.9	90	50	90
TU2	6	7	8	60	90	5.4	90	50	90
TU3	6	7	8	60	90	5.7	90	50	90
TU4	6	7	8	60	90	4.8	90	50	90
TU5	6	7	8	60	90	5.4	90	50	90

**Table 13.** Data inputs used in modeling downslope surface fire behavior for the grass fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
GRASS FUEL TYPE MODELS									
1	6	7	8	60	90	5.4	90	50	270
2	6	7	8	60	90	5.4	90	50	270
3	6	7	8	60	90	6.6	90	50	270
GR1	6	7	8	60	90	4.6	90	50	270
GR2	6	7	8	60	90	5.4	90	50	270
GR3	6	7	8	60	90	6.3	90	50	270
GR4	6	7	8	60	90	6.3	90	50	270
GR5	6	7	8	60	90	5.9	90	50	270
GR6	6	7	8	60	90	5.9	90	50	270
GR7	6	7	8	60	90	6.9	90	50	270
GR8	6	7	8	60	90	7.4	90	50	270
GR9	6	7	8	60	90	7.8	90	50	270

**Table 14.** Data inputs used in modeling downslope surface fire behavior for the grass-shrub fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
GRASS-SHRUB FUEL TYPE MODELS									
4	6	7	8	60	90	8.2	90	50	270
5	6	7	8	60	90	6.3	90	50	270
6	6	7	8	60	90	6.6	90	50	270
7	6	7	8	60	90	6.6	90	50	270
GS1	6	7	8	60	90	5.3	90	50	270
GS2	6	7	8	60	90	5.9	90	50	270
GS3	6	7	8	60	90	6.1	90	50	270
GS4	6	7	8	60	90	6.3	90	50	270

**Table 15.** Data inputs used in modeling downslope surface fire behavior for the shrub fire behavior fuel models (Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
SHRUB FUEL TYPE MODELS									
SH1	6	7	8	60	90	5.4	90	50	270
SH2	6	7	8	60	90	5.4	90	50	270
SH3	6	7	8	60	90	6.5	90	50	270
SH4	6	7	8	60	90	6.9	90	50	270
SH5	6	7	8	60	90	8.2	90	50	270
SH6	6	7	8	60	90	6.3	90	50	270
SH7	6	7	8	60	90	8.2	90	50	270
SH8	6	7	8	60	90	6.9	90	50	270
SH9	6	7	8	60	90	7.6	90	50	270

**Table 16.** Data inputs used in modeling downslope surface fire behavior for the slash-blowdown fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
SLASH-BLOWDOWN FUEL TYPE MODELS									
11	6	7	8	60	90	5.4	90	50	270
12	6	7	8	60	90	6.5	90	50	270
13	6	7	8	60	90	6.9	90	50	270
SB1	6	7	8	60	90	5.4	90	50	270
SB2	6	7	8	60	90	5.4	90	50	270
SB3	6	7	8	60	90	5.6	90	50	270
SB4	6	7	8	60	90	6.7	90	50	270

**Table 17.** Data inputs used in modeling downslope surface fire behavior for the timber-litter fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
TIMBER-LITTER FUEL TYPE MODELS									
8	6	7	8	60	90	4.1	90	50	270
9	6	7	8	60	90	4.1	90	50	270
10	6	7	8	60	90	5.4	90	50	270
TL1	6	7	8	60	90	4.1	90	50	270
TL2	6	7	8	60	90	4.1	90	50	270
TL3	6	7	8	60	90	4.4	90	50	270
TL4	6	7	8	60	90	4.6	90	50	270
TL5	6	7	8	60	90	4.9	90	50	270
TL6	6	7	8	60	90	4.4	90	50	270
TL7	6	7	8	60	90	4.6	90	50	270
TL8	6	7	8	60	90	4.4	90	50	270
TL9	6	7	8	60	90	4.9	90	50	270



**Table 18.** Data inputs used in modeling downslope surface fire behavior for the timber-understory fire behavior fuel models (Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
TIMBER-UNDERSTORY FUEL TYPE MODELS									
TU1	6	7	8	60	90	4.9	90	50	270
TU2	6	7	8	60	90	5.4	90	50	270
TU3	6	7	8	60	90	5.7	90	50	270
TU4	6	7	8	60	90	4.8	90	50	270
TU5	6	7	8	60	90	5.4	90	50	270

**Table 19.** Data inputs used in modeling down cross-slope (wind blowing perpendicular to slope) surface fire behavior for the grass fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
GRASS FUEL TYPE MODELS									
1	6	7	8	60	90	5.4	90	50	0
2	6	7	8	60	90	5.4	90	50	0
3	6	7	8	60	90	6.6	90	50	0
GR1	6	7	8	60	90	4.6	90	50	0
GR2	6	7	8	60	90	5.4	90	50	0
GR3	6	7	8	60	90	6.3	90	50	0
GR4	6	7	8	60	90	6.3	90	50	0
GR5	6	7	8	60	90	5.9	90	50	0
GR6	6	7	8	60	90	5.9	90	50	0
GR7	6	7	8	60	90	6.9	90	50	0
GR8	6	7	8	60	90	7.4	90	50	0
GR9	6	7	8	60	90	7.8	90	50	0

**Table 20.** Data inputs used in modeling cross-slope surface fire behavior for the grass-shrub fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
GRASS-SHRUB FUEL TYPE MODELS									
4	6	7	8	60	90	8.2	90	50	0
5	6	7	8	60	90	6.3	90	50	0
6	6	7	8	60	90	6.6	90	50	0
7	6	7	8	60	90	6.6	90	50	0
GS1	6	7	8	60	90	5.3	90	50	0
GS2	6	7	8	60	90	5.9	90	50	0
GS3	6	7	8	60	90	6.1	90	50	0
GS4	6	7	8	60	90	6.3	90	50	0

**Table 21.** Data inputs used in modeling cross-slope surface fire behavior for the shrub fire behavior fuel models (Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
SHRUB FUEL TYPE MODELS									
SH1	6	7	8	60	90	5.4	90	50	0
SH2	6	7	8	60	90	5.4	90	50	0
SH3	6	7	8	60	90	6.5	90	50	0
SH4	6	7	8	60	90	6.9	90	50	0
SH5	6	7	8	60	90	8.2	90	50	0
SH6	6	7	8	60	90	6.3	90	50	0
SH7	6	7	8	60	90	8.2	90	50	0
SH8	6	7	8	60	90	6.9	90	50	0
SH9	6	7	8	60	90	7.6	90	50	0

**Table 22.** Data inputs used in modeling cross-slope surface fire behavior for the slash-blowdown fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
SLASH-BLOWDOWN FUEL TYPE MODELS									
11	6	7	8	60	90	5.4	90	50	0
12	6	7	8	60	90	6.5	90	50	0
13	6	7	8	60	90	6.9	90	50	0
SB1	6	7	8	60	90	5.4	90	50	0
SB2	6	7	8	60	90	5.4	90	50	0
SB3	6	7	8	60	90	5.6	90	50	0
SB4	6	7	8	60	90	6.7	90	50	0

**Table 23.** Data inputs used in modeling cross-slope surface fire behavior for the timber-litter fire behavior fuel models (Anderson 13 and Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
TIMBER-LITTER FUEL TYPE MODELS									
8	6	7	8	60	90	4.1	90	50	0
9	6	7	8	60	90	4.1	90	50	0
10	6	7	8	60	90	5.4	90	50	0
TL1	6	7	8	60	90	4.1	90	50	0
TL2	6	7	8	60	90	4.1	90	50	0
TL3	6	7	8	60	90	4.4	90	50	0
TL4	6	7	8	60	90	4.6	90	50	0
TL5	6	7	8	60	90	4.9	90	50	0
TL6	6	7	8	60	90	4.4	90	50	0
TL7	6	7	8	60	90	4.6	90	50	0
TL8	6	7	8	60	90	4.4	90	50	0
TL9	6	7	8	60	90	4.9	90	50	0

**Table 24.** Data inputs used in modeling cross-slope surface fire behavior for the timber-understory fire behavior fuel models (Scott and Burgan 40).

Fire Behavior Fuel Model	1-hr fuel moisture (percent)	10-hr fuel moisture (percent)	100-hr fuel moisture (percent)	Live herbaceous fuel moisture (percent)	Live woody fuel moisture (percent)	Midflame Wind Speed (miles/hour)	Wind Direction (from North) (degrees)	Slope (percent)	Aspect (degrees)
TIMBER-UNDERSTORY FUEL TYPE MODELS									
TU1	6	7	8	60	90	4.9	90	50	0
TU2	6	7	8	60	90	5.4	90	50	0
TU3	6	7	8	60	90	5.7	90	50	0
TU4	6	7	8	60	90	4.8	90	50	0
TU5	6	7	8	60	90	5.4	90	50	0

## Appendix 2.

### Summary result tables comparing fire behavior module outputs from IFTDSS with fire behavior potential results from BehavePlus 5.0.5 and NEXUS 2.0.

For this study, we compared fire potential simulations for two IFTDSS fire behavior calculators (IFT-surface and IFT-FlamMap) with the BehavePlus and NEXUS modeling systems to ensure that the IFTDSS calculators were implemented correctly. All input values remained constant for each comparison (see Appendix 1). We classified fire behavior fuel models into the following six groups: grass, grass-shrub, shrub, slash-blowdown, timber-litter, and timber-understory. Four scenarios were compared: a flat terrain scenario that tested the model parameters without a slope influence, an upslope condition with the wind, a downslope scenario with an opposing influence of wind, and a cross-slope condition where the wind was simulated as blowing perpendicular to the slope.

The following tables present the intercomparison results by fuel model for each scenario:

- Tables 1 through 12 present the fire behavior simulation results for the grass fire behavior fuel models (FM 1 through 3, Anderson 13; FM GR1 through GR9, Scott and Burgan 40).
- Tables 13 through 20 present the fire behavior simulation results for the grass-shrub fire behavior fuel models (FM 4 through 7, Anderson 13; FM GS1 through GS4, Scott and Burgan 40).
- Tables 21 through 29 present the results for the shrub fuel models (Anderson 13 fuel models; SH1 through SH9, Scott and Burgan).
- Tables 30 through 36 present the fire behavior simulation results for the slash-blowdown fire behavior fuel models (FM 11 through 13, Anderson 13; FM SB1 through SB4, Scott and Burgan 40).
- Tables 37 through 48 present the fire behavior simulation results for the timber-litter fire behavior fuel models (FM 8 through 10, Anderson 13; FM TL1 through TL9, Scott and Burgan 40).
- Tables 49 through 53 present the fire behavior simulation results for the timber understory fire behavior fuel models (FM TU1 through TU5, Scott and Burgan 40—no Anderson 13 fuel models were classified as exclusively timber understory fuel models)..



Table 1. Fuel Model 1. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft2)
Anderson 13 Fire Behavior Fuel Models - Grass Fuel Types						
1	Flat Terrain (no slope)	BehavePlus	5.0	110.7	184.1	90.9
		IFT-surface	4.9	109.4	181.8	90.6
		IFT-FlamMap	5.0	111.0	184.4	90.5
		NEXUS	4.9	109.4	182.1	90.9
	Up Slope	BehavePlus	5.8	153.7	255.0	91.0
		IFT-surface	5.7	152.5	253.3	90.6
		IFT-FlamMap	5.8	156.0	258.6	90.6
		NEXUS	5.7	152.5	253.0	91.0
	Down Slope	BehavePlus	3.9	67.6	112.0	91.0
		IFT-surface	3.9	66.3	110.2	90.6
		IFT-FlamMap	3.9	66.4	110.1	90.6
		NEXUS	3.9	66.3	110.0	91.0
	Across Slope	BehavePlus	5.1	119.0	198.0	91.0
		IFT-surface	5.1	117.9	195.9	90.6
		IFT-FlamMap	5.1	120.0	199.1	90.6
		NEXUS	5.1	117.9	196.0	91.0

Table 2. Fuel Model 2. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models - Grass Fuel Types						
2	Flat Terrain (no slope)	BehavePlus	7.2	46.9	419.6	487.7
		IFT-surface	7.2	46.5	415.4	487.6
		IFT-FlamMap	6.8	42.3	370.7	477.6
		NEXUS	7.2	46.5	415.3	486.7
	Up Slope	BehavePlus	8.3	63.0	564.0	488.2
		IFT-surface	8.3	62.6	559.4	487.6
		IFT-FlamMap	7.9	57.6	502.1	478.1
		NEXUS	8.3	62.6	558.0	487.2
	Down Slope	BehavePlus	6.0	30.8	276.0	488.2
		IFT-surface	5.9	30.4	271.4	487.6
		IFT-FlamMap	5.6	27.2	238.8	478.1
		NEXUS	5.9	30.4	271.0	487.2
	Across Slope	BehavePlus	7.4	49.8	445.0	488.2
		IFT-surface	7.4	49.3	441.0	487.6
		IFT-FlamMap	7.0	44.8	394.2	478.1
		NEXUS	7.4	49.3	440.0	487.2

Table 3. Fuel Model 3. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models - Grass Fuel Types						
3	Flat Terrain (no slope)	BehavePlus	15.8	167.3	2276.8	742.4
		IFT-surface	15.8	167.5	2280.0	742.4
		IFT-FlamMap	15.8	167.6	2286.9	743.3
		NEXUS	15.8	164.6	2275.6	739.5
	Up Slope	BehavePlus	17.4	207.4	2822.1	742.4
		IFT-surface	17.4	207.6	2825.6	742.4
		IFT-FlamMap	17.5	209.6	2853.0	744.1
		NEXUS	17.4	207.6	2818.1	740.4
	Down Slope	BehavePlus	13.9	127.2	1731.0	742.4
		IFT-surface	13.9	127.4	1734.4	742.4
		IFT-FlamMap	13.9	125.6	1717.7	744.1
		NEXUS	13.9	127.4	1730.0	740.4
	Across Slope	BehavePlus	16.0	172.1	2343.0	742.4
		IFT-surface	16.0	172.4	2346.1	742.4
		IFT-FlamMap	16.0	172.8	2356.0	744.1
		NEXUS	16.0	172.4	2340.0	740.4

Table 4. Fuel Model GR1. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft2)
Scott and Burgan 40 Fire Behavior Fuel Models - Grass Fuel Types						
GR1	Flat Terrain (no slope)	BehavePlus	1.8	14.1	21.0	81.9
		IFT-surface	1.8	14.1	21.0	81.5
		IFT-FlamMap	1.8	14.1	21.0	81.5
		NEXUS	1.8	14.1	21.0	81.9
	Up Slope	BehavePlus	1.8	14.1	21.0	82.0
		IFT-surface	1.8	14.1	21.0	81.5
		IFT-FlamMap	1.8	14.1	21.0	81.6
		NEXUS	2.2	20.5	31.0	82.0
	Down Slope	BehavePlus	1.4	8.3	12.0	82.0
		IFT-surface	1.4	8.3	12.4	81.5
		IFT-FlamMap	1.4	8.1	12.2	81.6
		NEXUS	1.4	7.7	11.0	82.0
	Across Slope	BehavePlus	1.8	14.1	21.0	82.0
		IFT-surface	1.8	14.1	21.0	81.5
		IFT-FlamMap	1.8	14.1	21.0	81.6
		NEXUS	1.9	15.5	23.0	82.0

Table 5. Fuel Model GR2. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models - Grass Fuel Types						
GR2	Flat Terrain (no slope)	BehavePlus	4.8	39.1	174.1	241.8
		IFT-surface	4.8	38.7	172.2	242.4
		IFT-FlamMap	4.8	39.1	174.0	242.2
		NEXUS	4.8	38.7	172.1	241.8
	Up Slope	BehavePlus	5.5	51.8	230.0	242.1
		IFT-surface	5.5	51.5	229.0	242.4
		IFT-FlamMap	5.5	52.4	232.9	242.5
		NEXUS	5.5	51.5	229.0	242.1
	Down Slope	BehavePlus	4.0	26.3	117.0	242.1
		IFT-surface	4.0	26.0	115.4	242.4
		IFT-FlamMap	4.0	25.9	114.9	242.5
		NEXUS	4.0	26.0	115.0	242.1
	Across Slope	BehavePlus	4.9	41.2	183.0	242.1
		IFT-surface	4.9	40.9	181.7	242.4
		IFT-FlamMap	5.0	41.4	183.9	242.5
		NEXUS	4.9	40.9	182.0	242.1

Table 6. Fuel Model GR3. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft2)
Scott and Burgan 40 Fire Behavior Fuel Models - Grass Fuel Types						
GR3	Flat Terrain (no slope)	BehavePlus	7.7	62.1	486.3	426.7
		IFT-surface	7.8	62.5	488.4	426.6
		IFT-FlamMap	7.8	62.2	486.6	426.2
		NEXUS	7.8	62.5	488.3	426.7
	Up Slope	BehavePlus	6.8	47.4	371.0	427.2
		IFT-surface	8.6	77.2	603.4	426.6
		IFT-FlamMap	8.6	77.5	605.7	426.7
		NEXUS	8.6	77.2	603.0	427.2
	Down Slope	BehavePlus	6.8	47.4	371.0	427.2
		IFT-surface	6.9	47.7	373.3	426.6
		IFT-FlamMap	6.8	46.9	366.8	426.7
		NEXUS	6.9	47.7	373.0	427.2
	Across Slope	BehavePlus	7.8	63.9	499.0	427.2
		IFT-surface	7.9	64.2	502.1	426.6
		IFT-FlamMap	7.9	64.1	500.9	426.7
		NEXUS	7.9	64.2	502.0	427.2

Table 7. Fuel Model GR4. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models - Grass Fuel Types						
GR4	Flat Terrain (no slope)	BehavePlus	10.0	97.2	839.6	470.7
		IFT-surface	10.0	97.9	844.7	470.8
		IFT-FlamMap	10.0	97.4	840.9	470.5
		NEXUS	10.0	97.9	845.6	470.7
	Up Slope	BehavePlus	11.1	123.2	1063.0	471.2
		IFT-surface	11.1	123.8	1069.0	470.8
		IFT-FlamMap	11.2	124.3	1073.1	471.0
		NEXUS	11.1	123.8	1069.0	471.2
	Down Slope	BehavePlus	8.6	71.2	615.0	471.2
		IFT-surface	8.7	71.9	620.4	470.8
		IFT-FlamMap	8.6	70.4	607.6	471.0
		NEXUS	8.7	71.9	620.0	471.2
	Across Slope	BehavePlus	10.1	100.7	869.0	471.2
		IFT-surface	10.2	101.3	874.8	470.8
		IFT-FlamMap	10.1	101.1	872.6	471.0
		NEXUS	10.2	101.3	875.0	471.2

Table 8. Fuel Model GR5. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft2)
Scott and Burgan 40 Fire Behavior Fuel Models - Grass Fuel Types						
GR5	Flat Terrain (no slope)	BehavePlus	11.9	71.6	1246.9	948.4
		IFT-surface	12.0	71.7	1247.4	948.6
		IFT-FlamMap	12.0	71.8	1248.6	947.9
		NEXUS	11.9	70.9	1233.9	948.4
	Up Slope	BehavePlus	13.5	92.8	1614.0	949.5
		IFT-surface	13.5	92.9	1615.8	948.6
		IFT-FlamMap	13.5	93.7	1630.0	948.9
		NEXUS	13.4	92.1	1602.0	949.5
	Down Slope	BehavePlus	10.2	50.5	877.0	949.5
		IFT-surface	10.2	50.5	879.1	948.6
		IFT-FlamMap	10.1	49.8	865.4	948.9
		NEXUS	10.1	49.7	965.0	949.5
	Across Slope	BehavePlus	12.2	74.8	1301.0	949.5
		IFT-surface	12.2	74.9	1302.7	948.6
		IFT-FlamMap	12.2	75.1	1306.7	948.9
		NEXUS	12.1	74.1	1289.0	949.5



Table 9. Fuel Model GR6. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models - Grass Fuel Types						
GR6	Flat Terrain (no slope)	BehavePlus	14.7	91.6	1962.4	1167.3
		IFT-surface	14.7	91.7	1963.7	1168.0
		IFT-FlamMap	14.7	91.7	1965.5	1167.0
		NEXUS	14.6	90.6	1940.4	1167.3
	Up Slope	BehavePlus	16.6	119.7	2564.0	1168.6
		IFT-surface	16.7	119.9	2567.1	1168.0
		IFT-FlamMap	16.7	121.0	2590.2	1168.3
		NEXUS	16.6	118.7	2542.0	1168.6
	Down Slope	BehavePlus	12.4	63.4	1358.0	1168.6
		IFT-surface	12.4	63.5	1360.4	1168.0
		IFT-FlamMap	12.4	62.5	1338.0	1168.3
		NEXUS	12.3	62.4	1336.0	1168.6
	Across Slope	BehavePlus	15.0	96.0	2055.0	1168.6
		IFT-surface	15.1	96.1	2058.1	1168.0
		IFT-FlamMap	15.1	96.5	2064.8	1168.3
		NEXUS	15.0	95.0	2035.0	1168.6

Table 10. Fuel Model GR7. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models - Grass Fuel Types						
GR7	Flat Terrain (no slope)	BehavePlus	22.6	164.3	4975.5	1650.0
		IFT-surface	22.6	165.0	4992.2	1650.8
		IFT-FlamMap	22.6	164.6	4983.6	1649.4
		NEXUS	22.6	165.0	4995.6	1650.0
	Up Slope	BehavePlus	25.0	204.4	6186.1	1651.8
		IFT-surface	25.0	205.1	6206.8	1650.8
		IFT-FlamMap	25.1	206.2	6240.8	1651.3
		NEXUS	25.0	205.1	6206.1	1651.8
	Down Slope	BehavePlus	19.8	124.1	3757.1	1651.8
		IFT-surface	19.9	124.8	3777.7	1650.8
		IFT-FlamMap	19.8	122.9	3719.5	1651.3
		NEXUS	19.9	124.8	3777.1	1651.8
	Across Slope	BehavePlus	22.9	169.3	5123.1	1651.8
		IFT-surface	22.9	169.9	5142.6	1650.8
		IFT-FlamMap	22.9	169.9	5141.0	1651.3
		IFT-FlamMap	22.9	169.9	5141.0	1651.3

Table 11. Fuel Model GR8. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models - Grass Fuel Types						
GR8	Flat Terrain (no slope)	BehavePlus	28.5	163.7	8236.9	2741.3
		IFT-surface	28.5	164.2	8256.3	2742.5
		IFT-FlamMap	28.5	163.9	8247.2	2740.3
		NEXUS	28.4	162.9	8195.8	2740.3
	Up Slope	BehavePlus	31.2	199.4	10028.2	2744.4
		IFT-surface	31.2	200.0	10053.4	2742.5
		IFT-FlamMap	31.3	201.0	10106.6	2743.4
		NEXUS	31.1	198.6	9987.2	2743.4
	Down Slope	BehavePlus	25.4	128.0	6434.1	2744.4
		IFT-surface	25.5	128.5	6459.2	2742.5
		IFT-FlamMap	25.3	126.8	6376.4	2743.4
		NEXUS	25.3	127.2	6393.1	2743.4
	Across Slope	BehavePlus	28.8	167.7	8430.2	2744.4
		IFT-surface	28.8	168.2	8455.3	2742.5
		IFT-FlamMap	28.8	168.2	8454.2	2743.4
		NEXUS	28.7	166.9	8390.2	2743.4

Table 12. Fuel Model GR9. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models - Grass Fuel Types						
GR9	Flat Terrain (no slope)	BehavePlus	41.6	303.7	18812.4	3374.9
		IFT-surface	41.6	302.9	18752.7	3376.8
		IFT-FlamMap	41.7	304.2	18840.5	3374.0
		NEXUS	41.6	302.9	18764.4	3373.9
	Up Slope	BehavePlus	45.4	366.1	22666.4	3378.7
		IFT-surface	45.3	365.4	22619.9	3376.8
		IFT-FlamMap	45.5	369.0	22841.0	3377.8
		NEXUS	45.3	365.4	22618.4	3377.7
	Down Slope	BehavePlus	37.4	241.2	14932.3	3378.7
		IFT-surface	37.4	240.5	14885.5	3376.8
		IFT-FlamMap	37.3	239.3	14813.7	3377.8
		NEXUS	37.4	240.4	14884.3	3377.7
	Across Slope	BehavePlus	42.0	310.2	19204.4	3378.7
		IFT-surface	42.0	309.5	19158.3	3376.8
		IFT-FlamMap	42.1	311.1	19258.5	3377.8
		NEXUS	42.0	309.5	19157.4	3377.7

Table 13. Fuel Model 4. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models – Grass-Shrub Fuel Types						
4	Flat Terrain (no slope)	BehavePlus	27.7	160.1	7783.6	2647.3
		IFT-surface	27.7	160.1	7775.2	2649.3
		IFT-FlamMap	27.8	160.5	7801.4	2647.7
		NEXUS	27.8	161.4	7847.6	2647.3
	Up Slope	BehavePlus	30.1	191.3	9291.2	2650.3
		IFT-surface	30.1	191.2	9288.6	2649.3
		IFT-FlamMap	30.2	192.8	9367.8	2650.7
		NEXUS	30.2	192.6	9356.2	2650.3
	Down Slope	BehavePlus	25.1	129.0	6264.1	2650.3
		IFT-surface	25.1	128.9	6261.7	2649.3
		IFT-FlamMap	25.0	128.0	6224.0	2650.7
		NEXUS	25.2	130.3	6328.1	2650.3
	Across Slope	BehavePlus	28.0	163.2	7928.1	2650.3
		IFT-surface	28.0	163.2	7925.2	2649.3
		IFT-FlamMap	28.0	164.0	7955.8	2650.7
		NEXUS	28.1	164.5	7991.1	2650.3

Table 14. Fuel Model 5. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models – Grass-Shrub Fuel Types						
5	Flat Terrain (no slope)	BehavePlus	7.3	35.8	427.3	651.6
		IFT-surface	7.3	36.0	429.9	651.6
		IFT-FlamMap	7.3	35.8	427.3	649.6
		NEXUS	7.3	36.0	429.3	649.6
	Up Slope	BehavePlus	8.2	45.5	543.0	652.3
		IFT-surface	8.2	45.7	546.0	651.6
		IFT-FlamMap	8.2	45.6	547.3	650.3
		NEXUS	8.2	45.7	545.0	650.3
	Down Slope	BehavePlus	6.3	26.0	311.0	652.3
		IFT-surface	6.3	26.3	313.8	651.6
		IFT-FlamMap	6.3	25.6	306.7	650.3
		NEXUS	6.3	26.3	313.0	650.3
	Across Slope	BehavePlus	7.4	37.1	443.0	652.3
		IFT-surface	7.4	37.3	445.8	651.6
		IFT-FlamMap	7.4	37.6	444.0	650.3
		NEXUS	7.4	37.3	445.0	650.3

Table 15. Fuel Model 6. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models – Grass-Shrub Fuel Types						
6	Flat Terrain (no slope)	BehavePlus	7.2	48.3	416.3	469.7
		IFT-surface	7.2	48.3	416.6	470.2
		IFT-FlamMap	7.2	48.4	416.2	468.7
		NEXUS	7.2	48.3	416.3	468.7
	Up Slope	BehavePlus	8.0	60.7	524.0	470.2
		IFT-surface	8.0	60.8	524.2	470.2
		IFT-FlamMap	8.0	61.6	527.4	469.3
		NEXUS	8.0	60.8	523.0	469.2
	Down Slope	BehavePlus	6.3	35.8	308.0	470.2
		IFT-surface	6.3	35.8	308.9	470.2
		IFT-FlamMap	6.3	35.2	304.4	469.3
		NEXUS	6.3	35.9	308.0	469.2
	Across Slope	BehavePlus	7.3	49.9	430.0	470.2
		IFT-surface	7.3	50.0	430.8	470.2
		IFT-FlamMap	7.3	50.4	431.0	469.3
		NEXUS	7.3	50.0	430.0	469.2

Table 16. Fuel Model 7. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models – Grass-Shrub Fuel Types						
7	Flat Terrain (no slope)	BehavePlus	7.2	42.8	415.3	529.7
		IFT-surface	7.2	42.8	415.8	529.5
		IFT-FlamMap	6.9	37.5	381.9	555.0
		NEXUS	7.2	42.8	415.3	527.7
	Up Slope	BehavePlus	8.0	53.6	520.0	530.3
		IFT-surface	8.0	53.7	521.0	529.5
		IFT-FlamMap	7.7	47.2	480.1	555.6
		NEXUS	8.0	53.6	520.0	528.3
	Down Slope	BehavePlus	6.3	31.9	310.0	530.3
		IFT-surface	6.3	32.0	310.5	529.5
		IFT-FlamMap	6.0	28.0	283.2	555.6
		NEXUS	6.3	32.0	310.0	528.3
	Across Slope	BehavePlus	7.3	44.2	429.0	530.3
		IFT-surface	7.3	44.2	429.3	529.5
		IFT-FlamMap	7.0	38.4	394.4	555.6
		NEXUS	7.3	44.2	428.0	528.3



Table 17. Fuel Model GS1. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Grass-Shrub Fuel Types						
GS1	Flat Terrain (no slope)	BehavePlus	3.4	16.7	81.1	264.8
		IFT-surface	3.4	16.6	80.5	264.7
		IFT-FlamMap	3.4	16.7	81.1	264.4
		NEXUS	3.4	16.4	79.1	264.8
	Up Slope	BehavePlus	3.9	22.4	109.0	265.1
		IFT-surface	3.9	22.3	108.3	264.7
		IFT-FlamMap	3.9	22.7	109.9	264.7
		NEXUS	3.9	22.1	107.0	265.1
	Down Slope	BehavePlus	2.8	10.9	53.0	265.1
		IFT-surface	2.8	10.9	52.6	264.7
		IFT-FlamMap	2.8	10.8	52.2	264.7
		NEXUS	2.8	10.6	52.0	265.1
	Across Slope	BehavePlus	3.5	17.7	86.0	265.1
		IFT-surface	3.5	17.6	85.3	264.7
		IFT-FlamMap	3.5	17.8	86.2	264.7
		NEXUS	3.5	17.4	84.0	265.1

Table 18. Fuel Model GS2. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Grass-Shrub Fuel Types						
GS2	Flat Terrain (no slope)	BehavePlus	5.6	28.8	242.2	458.7
		IFT-surface	5.6	28.9	242.6	458.7
		IFT-FlamMap	5.6	28.9	242.9	458.4
		NEXUS	5.6	28.5	240.2	458.7
	Up Slope	BehavePlus	6.3	37.5	315.0	459.2
		IFT-surface	6.4	37.5	315.3	458.7
		IFT-FlamMap	6.4	37.8	318.2	458.9
		NEXUS	6.3	37.2	312.0	459.2
	Down Slope	BehavePlus	4.8	20.2	170.0	459.2
		IFT-surface	4.8	20.2	169.9	458.7
		IFT-FlamMap	4.7	19.9	167.3	458.9
		NEXUS	4.7	19.9	164.0	459.2
	Across Slope	BehavePlus	5.7	30.1	253.0	459.2
		IFT-surface	5.7	30.2	253.7	458.7
		IFT-FlamMap	5.8	30.3	254.5	458.9
		NEXUS	5.7	29.8	251.0	459.2

Table 19. Fuel Model GS3. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Grass-Shrub Fuel Types						
GS3	Flat Terrain (no slope)	BehavePlus	8.7	42.5	631.5	809.5
		IFT-surface	8.7	42.2	627.1	809.8
		IFT-FlamMap	8.7	42.6	632.2	809.1
		NEXUS	8.8	42.7	634.5	809.5
	Up Slope	BehavePlus	9.8	54.3	807.0	810.4
		IFT-surface	9.8	54.1	802.9	809.8
		IFT-FlamMap	9.8	54.9	814.3	810.0
		NEXUS	9.8	54.5	810.0	810.4
	Down Slope	BehavePlus	7.5	30.6	455.0	810.4
		IFT-surface	7.5	30.4	451.2	809.8
		IFT-FlamMap	7.5	30.3	449.3	810.0
		NEXUS	7.5	30.9	458.0	810.4
	Across Slope	BehavePlus	8.9	44.2	656.0	810.4
		IFT-surface	8.9	43.9	652.1	809.8
		IFT-FlamMap	8.9	44.4	658.3	810.0
		NEXUS	8.9	44.4	659.0	810.4

Table 20. Fuel Model GS4. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Grass-Shrub Fuel Types						
GS4	Flat Terrain (no slope)	BehavePlus	17.1	40.3	2719.9	3674.7
		IFT-surface	17.0	40.0	2697.1	3676.9
		IFT-FlamMap	17.1	40.4	2724.4	3673.6
		NEXUS	17.0	40.0	2698.9	3674.7
	Up Slope	BehavePlus	19.3	52.2	3519.1	3678.9
		IFT-surface	19.2	51.9	3498.2	3676.9
		IFT-FlamMap	19.4	52.7	3554.2	3677.8
		NEXUS	19.2	51.9	3498.1	3678.9
	Down Slope	BehavePlus	14.6	28.4	1917.0	3678.9
		IFT-surface	14.5	28.1	1895.9	3676.9
		IFT-FlamMap	14.5	28.1	1890.9	3677.8
		NEXUS	14.5	28.1	1896.0	3678.9
	Across Slope	BehavePlus	17.4	42.1	2840.1	3678.9
		IFT-surface	17.4	41.8	2819.9	3676.9
		IFT-FlamMap	17.5	42.3	2852.4	3677.8
		NEXUS	17.4	41.8	2820.1	3678.9

Table 21. Fuel Model SH1. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Shrub Fuel Types						
SH1	Flat Terrain (no slope)	BehavePlus	0.7	1.7	3.0	82.9
		IFT-surface	0.7	1.7	2.6	83.4
		IFT-FlamMap	0.7	1.7	3.0	82.9
		NEXUS	0.7	1.7	3.0	82.9
	Up Slope	BehavePlus	0.7	1.7	3.0	83.0
		IFT-surface	0.7	1.7	2.6	83.4
		IFT-FlamMap	0.7	1.7	2.6	83.4
		NEXUS	0.9	2.6	4.0	83.0
	Down Slope	BehavePlus	0.7	1.7	3.0	83.0
		IFT-surface	0.7	1.7	2.6	83.4
		IFT-FlamMap	0.7	1.7	2.6	83.4
		NEXUS	0.5	0.8	1.0	83.0
	Across Slope	BehavePlus	0.7	1.7	3.0	83.0
		IFT-surface	0.7	1.7	2.6	83.4
		IFT-FlamMap	0.7	1.7	2.6	83.4
		NEXUS	0.7	2.0	3.0	83.0

Table 22. Fuel Model SH2. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Shrub Fuel Types						
SH2	Flat Terrain (no slope)	BehavePlus	2.3	3.4	33.0	532.7
		IFT-surface	2.3	3.4	32.9	532.8
		IFT-FlamMap	2.3	3.4	33.0	532.7
		NEXUS	2.2	3.4	33.0	532.7
	Up Slope	BehavePlus	2.6	4.6	45.0	533.3
		IFT-surface	2.6	4.6	45.1	532.8
		IFT-FlamMap	2.6	4.7	45.9	533.0
		NEXUS	2.6	4.6	45.0	533.3
	Down Slope	BehavePlus	1.8	2.2	21.0	533.3
		IFT-surface	1.8	2.1	20.8	532.8
		IFT-FlamMap	1.8	2.1	20.6	533.0
		NEXUS	1.8	2.1	21.0	533.3
	Across Slope	BehavePlus	2.3	3.6	36.0	533.3
		IFT-surface	2.3	3.6	35.3	532.8
		IFT-FlamMap	2.3	3.7	35.7	533.0
		NEXUS	2.3	3.6	35.0	533.3

Table 23. Fuel Model SH3. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Shrub Fuel Types						
SH3	Flat Terrain (no slope)	BehavePlus	2.7	5.4	49.0	495.7
		IFT-surface	2.7	5.4	49.1	495.8
		IFT-FlamMap	2.7	5.4	49.0	495.7
		NEXUS	2.7	5.5	50.0	495.7
	Up Slope	BehavePlus	3.0	6.9	63.0	496.3
		IFT-surface	3.0	6.9	62.6	495.8
		IFT-FlamMap	3.0	7.0	63.4	496.0
		NEXUS	3.0	7.0	63.0	496.3
	Down Slope	BehavePlus	2.3	3.9	36.0	496.3
		IFT-surface	2.3	3.9	35.6	495.8
		IFT-FlamMap	2.3	3.9	35.4	496.0
		NEXUS	2.4	4.0	36.0	496.3
	Across Slope	BehavePlus	2.8	5.6	51.0	496.3
		IFT-surface	2.7	5.6	51.0	495.8
		IFT-FlamMap	2.8	5.7	51.4	496.0
		NEXUS	2.8	5.7	52.0	496.3

Table 24. Fuel Model SH4. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Shrub Fuel Types						
SH4	Flat Terrain (no slope)	BehavePlus	8.0	42.9	526.4	667.6
		IFT-surface	8.1	43.1	528.2	668.4
		IFT-FlamMap	8.0	42.9	526.4	667.6
		NEXUS	8.0	43.1	528.4	667.6
	Up Slope	BehavePlus	8.9	53.1	651.0	668.3
		IFT-surface	8.9	53.3	653.3	668.4
		IFT-FlamMap	8.9	53.6	657.0	668.6
		NEXUS	8.9	53.3	653.0	668.3
	Down Slope	BehavePlus	7.1	32.7	401.0	668.3
		IFT-surface	7.1	32.9	403.0	668.4
		IFT-FlamMap	7.1	32.4	397.2	668.6
		NEXUS	7.1	32.9	403.0	668.3
	Across Slope	BehavePlus	8.1	44.2	541.0	668.3
		IFT-surface	8.2	44.3	543.2	668.4
		IFT-FlamMap	8.2	44.3	543.2	668.6
		NEXUS	8.2	44.3	543.0	668.3



Table 25. Fuel Model SH5. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Shrub Fuel Types						
SH5	Flat Terrain (no slope)	BehavePlus	8.0	42.9	526.4	667.6
		IFT-surface	8.1	43.1	528.2	668.4
		IFT-FlamMap	8.0	42.9	526.4	667.6
		NEXUS	8.0	43.1	528.4	667.6
	Up Slope	BehavePlus	8.9	53.1	651.0	668.3
		IFT-surface	8.9	53.3	653.3	668.4
		IFT-FlamMap	8.9	53.6	657.0	668.6
		NEXUS	8.9	53.3	653.0	668.3
	Down Slope	BehavePlus	7.1	32.7	401.0	668.3
		IFT-surface	7.1	32.9	403.0	668.4
		IFT-FlamMap	7.1	32.4	397.2	668.6
		NEXUS	7.1	32.9	403.0	668.3
	Across Slope	BehavePlus	8.1	44.2	541.0	668.3
		IFT-surface	8.2	44.3	543.2	668.4
		IFT-FlamMap	8.2	44.3	543.2	668.6
		NEXUS	8.2	44.3	543.0	668.3

Table 26. Fuel Model SH6. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Shrub Fuel Types						
SH6	Flat Terrain (no slope)	BehavePlus	17.7	101.4	2935.1	1577.0
		IFT-surface	17.7	101.4	2932.6	1577.5
		IFT-FlamMap	17.7	101.4	2935.1	1577.0
		NEXUS	17.8	102.1	2955.1	1576.0
	Up Slope	BehavePlus	11.5	38.2	1139.0	1624.8
		IFT-surface	11.5	38.4	1143.2	1624.1
		IFT-FlamMap	11.5	38.6	1149.1	1624.6
		NEXUS	11.5	38.4	1143.0	1624.8
	Down Slope	BehavePlus	8.9	22.1	659.0	1624.8
		IFT-surface	8.9	22.3	663.3	1624.1
		IFT-FlamMap	8.9	21.9	650.8	1624.6
		NEXUS	8.9	22.3	663.0	1624.8
	Across Slope	BehavePlus	10.4	31.3	931.0	1624.8
		IFT-surface	10.5	31.4	935.8	1624.1
		IFT-FlamMap	10.5	31.4	934.9	1624.6
		NEXUS	10.5	31.4	936.0	1624.8

Table 27. Fuel Model SH7. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Shrub Fuel Types						
SH7	Flat Terrain (no slope)	BehavePlus	16.7	65.7	2574.8	2133.7
		IFT-surface	16.7	65.7	2572.3	2135.2
		IFT-FlamMap	16.7	65.7	2574.8	2133.7
		NEXUS	16.7	66.2	2591.8	2133.7
	Up Slope	BehavePlus	18.1	78.5	3073.1	2136.1
		IFT-surface	18.1	78.5	3072.7	2135.2
		IFT-FlamMap	18.2	79.1	3096.9	2136.0
		NEXUS	18.1	79.0	3090.1	2136.1
	Down Slope	BehavePlus	15.1	52.9	2072.0	2136.1
		IFT-surface	15.1	52.9	2071.8	2135.2
		IFT-FlamMap	15.1	52.6	2057.6	2136.0
		NEXUS	15.2	53.4	2090.0	2136.1
	Across Slope	BehavePlus	16.8	67.0	2622.0	2136.1
		IFT-surface	16.8	67.0	2621.8	2135.2
		IFT-FlamMap	16.9	67.2	2630.1	2136.0
		NEXUS	16.9	67.4	2639.0	2136.1

Table 28. Fuel Model SH8. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Shrub Fuel Types						
SH8	Flat Terrain (no slope)	BehavePlus	12.3	33.3	1335.0	2185.6
		IFT-surface	12.3	33.4	1338.3	2187.1
		IFT-FlamMap	12.3	33.3	1335.0	2185.6
		NEXUS	12.3	33.4	1339.0	2185.6
	Up Slope	BehavePlus	13.7	41.7	1672.0	2188.1
		IFT-surface	13.7	41.8	1676.4	2187.1
		IFT-FlamMap	13.7	42.1	1687.0	2187.9
		NEXUS	13.7	41.8	1676.0	2188.1
	Down Slope	BehavePlus	10.8	24.8	995.0	2188.1
		IFT-surface	10.8	24.9	1000.2	2187.1
		IFT-FlamMap	10.7	24.6	984.9	2187.9
		NEXUS	10.8	24.9	1000.0	2188.1
	Across Slope	BehavePlus	12.5	34.4	1377.0	2188.1
		IFT-surface	12.5	34.5	1382.0	2187.1
		IFT-FlamMap	12.5	34.5	1382.7	2187.9
		NEXUS	12.5	34.5	1382.0	2188.1

Table 29. Fuel Model SH9. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Shrub Fuel Types						
SH9	Flat Terrain (no slope)	BehavePlus	21.5	68.6	4493.2	3567.8
		IFT-surface	21.6	69.0	4518.0	3570.4
		IFT-FlamMap	21.5	68.6	4493.2	3567.8
		NEXUS	21.4	67.9	4449.2	3567.8
	Up Slope	BehavePlus	23.7	84.1	5505.1	3571.8
		IFT-surface	23.7	84.5	5532.6	3570.4
		IFT-FlamMap	23.8	84.8	5551.8	3571.9
		NEXUS	23.6	83.4	5460.1	3571.8
	Down Slope	BehavePlus	19.1	53.1	3475.1	3571.8
		IFT-surface	19.2	53.5	3503.3	3570.4
		IFT-FlamMap	19.1	52.6	3444.5	3571.9
		NEXUS	19.0	52.4	3431.1	3571.8
	Across Slope	BehavePlus	21.8	70.4	4607.1	3571.8
		IFT-surface	21.9	70.8	4634.5	3570.4
		IFT-FlamMap	21.8	70.6	4623.1	3571.9
		NEXUS	21.7	69.7	4564.1	3571.8

Table 30. Fuel Model 11. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models – Slash-Blowdown Fuel Types						
11	Flat Terrain (no slope)	BehavePlus	3.6	6.7	93.1	759.5
		IFT-surface	3.6	6.6	92.5	760.1
		IFT-FlamMap	3.6	6.7	93.3	759.6
		NEXUS	3.6	6.6	92.1	759.5
	Up Slope	BehavePlus	4.2	9.2	129.0	760.4
		IFT-surface	4.2	9.2	128.0	760.1
		IFT-FlamMap	4.2	9.6	130.1	760.5
		NEXUS	4.2	9.2	128.0	760.4
	Down Slope	BehavePlus	2.9	4.1	58.0	760.4
		IFT-surface	2.9	4.1	57.0	760.1
		IFT-FlamMap	2.9	4.0	56.3	760.5
		NEXUS	2.9	7.1	57.0	760.4
	Across Slope	BehavePlus	3.7	7.2	100.0	760.4
		IFT-surface	3.7	7.2	99.6	760.1
		IFT-FlamMap	3.8	7.2	100.8	760.5
		NEXUS	3.7	7.2	100.0	760.4

Table 31. Fuel Model 12. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models – Slash-Blowdown Fuel Types						
12	Flat Terrain (no slope)	BehavePlus	9.2	17.3	701.5	2203.6
		IFT-surface	9.2	17.4	704.7	2205.0
		IFT-FlamMap	9.2	17.4	702.9	2203.5
		NEXUS	9.2	17.3	699.5	2203.6
	Up Slope	BehavePlus	10.5	23.1	932.0	2206.1
		IFT-surface	10.5	23.2	935.8	2204.9
		IFT-FlamMap	10.5	23.2	942.3	2205.7
		NEXUS	10.4	23.0	930.0	2206.1
	Down Slope	BehavePlus	7.6	11.6	470.0	2206.1
		IFT-surface	7.7	11.7	473.7	2204.9
		IFT-FlamMap	7.6	11.2	462.4	2206.0
		NEXUS	7.6	11.6	468.0	2206.1
	Across Slope	BehavePlus	9.4	18.3	741.0	2206.1
		IFT-surface	9.4	18.4	744.6	2204.9
		IFT-FlamMap	9.4	18.4	745.1	2206.0
		NEXUS	9.4	18.3	739.0	2206.1

Table 32. Fuel Model 13. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models – Slash-Blowdown Fuel Types						
13	Flat Terrain (no slope)	BehavePlus	12.3	22.3	1326.9	3242.0
		IFT-surface	12.3	22.4	1330.3	3244.4
		IFT-FlamMap	12.3	22.3	1329.4	3242.2
		NEXUS	12.3	22.4	1330.9	3242.0
	Up Slope	BehavePlus	14.0	29.4	1749.0	3245.7
		IFT-surface	14.0	29.5	1753.5	3244.4
		IFT-FlamMap	14.0	29.6	1768.0	3245.9
		NEXUS	14.0	29.5	1754.0	3245.7
	Down Slope	BehavePlus	10.3	15.2	903.0	3245.7
		IFT-surface	10.3	15.3	907.1	3244.4
		IFT-FlamMap	10.2	15.2	889.0	3245.9
		NEXUS	10.3	15.3	907.0	3245.7
	Across Slope	BehavePlus	12.6	23.5	1398.0	3245.7
		IFT-surface	12.6	23.6	1401.6	3244.4
		IFT-FlamMap	12.6	24.0	1404.7	3245.9
		NEXUS	12.6	23.6	1402.0	3245.7



Table 33. Fuel Model SB1. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Slash-Blowdown Fuel Types						
SB1	Flat Terrain (no slope)	BehavePlus	3.2	7.0	73.1	568.6
		IFT-surface	3.2	7.0	72.9	568.5
		IFT-FlamMap	3.3	7.1	73.6	568.1
		NEXUS	3.2	7.0	73.1	568.6
	Up Slope	BehavePlus	3.8	9.7	101.0	569.3
		IFT-surface	3.8	9.7	101.0	568.5
		IFT-FlamMap	3.8	9.9	102.7	568.8
		NEXUS	3.8	9.7	101.0	569.3
	Down Slope	BehavePlus	2.6	4.4	45.0	569.3
		IFT-surface	2.6	4.3	44.9	568.5
		IFT-FlamMap	2.6	4.3	44.5	568.8
		NEXUS	2.6	4.3	45.0	569.3
	Across Slope	BehavePlus	3.4	7.6	79.0	569.3
		IFT-surface	3.4	7.5	78.6	568.5
		IFT-FlamMap	3.4	7.6	79.6	568.8
		NEXUS	3.4	7.5	79.0	569.3

Table 34. Fuel Model SB2. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Slash-Blowdown Fuel Types						
SB2	Flat Terrain (no slope)	BehavePlus	6.4	17.2	316.2	1002.4
		IFT-surface	6.3	17.0	313.1	1003.4
		IFT-FlamMap	6.4	17.2	316.4	1002.7
		NEXUS	6.3	17.0	313.2	1002.4
	Up Slope	BehavePlus	7.3	23.5	432.0	1003.5
		IFT-surface	7.3	23.3	429.2	1003.4
		IFT-FlamMap	7.4	23.8	436.8	1003.8
		NEXUS	7.3	23.3	429.0	1003.5
	Down Slope	BehavePlus	5.1	10.8	199.0	1003.5
		IFT-surface	5.1	10.7	196.9	1003.4
		IFT-FlamMap	5.1	10.6	195.6	1003.8
		NEXUS	5.0	10.7	197.0	1003.5
	Across Slope	BehavePlus	6.6	18.4	338.0	1003.5
		IFT-surface	6.5	18.3	335.7	1003.4
		IFT-FlamMap	6.6	18.5	340.1	1003.8
		NEXUS	6.5	18.3	336.0	1003.5

Table 35. Fuel Model SB3. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Slash-Blowdown Fuel Types						
SB3	Flat Terrain (no slope)	BehavePlus	9.8	32.6	805.6	1345.2
		IFT-surface	9.7	32.4	799.2	1345.7
		IFT-FlamMap	9.8	32.7	807.6	1344.7
		NEXUS	9.8	33.2	819.6	1345.2
	Up Slope	BehavePlus	7.3	23.5	432.0	1003.5
		IFT-surface	7.3	23.3	429.2	1003.4
		IFT-FlamMap	7.4	23.8	436.8	1003.8
		NEXUS	7.3	23.3	429.0	1003.5
	Down Slope	BehavePlus	8.0	21.4	528.0	1346.7
		IFT-surface	8.0	21.1	521.6	1345.7
		IFT-FlamMap	8.0	21.0	518.8	1346.3
		NEXUS	8.1	22.0	542.0	1346.7
	Across Slope	BehavePlus	10.0	34.7	855.0	1346.7
		IFT-surface	10.0	34.4	849.5	1345.7
		IFT-FlamMap	10.1	34.9	860.2	1346.3
		NEXUS	10.1	35.2	868.0	1346.7

Table 36. Fuel Model SB4. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Slash-Blowdown Fuel Types						
SB4	Flat Terrain (no slope)	BehavePlus	15.3	80.7	2130.5	1439.1
		IFT-surface	15.3	80.5	2124.1	1439.7
		IFT-FlamMap	15.3	80.9	2135.3	1438.6
		NEXUS	15.3	81.3	2148.5	1439.1
	Up Slope	BehavePlus	17.0	102.0	2691.0	1440.7
		IFT-surface	17.0	101.8	2686.0	1439.7
		IFT-FlamMap	17.1	103.0	2717.2	1440.3
		NEXUS	17.1	102.6	2708.1	1440.7
	Down Slope	BehavePlus	13.3	59.4	1567.0	1440.7
		IFT-surface	13.3	59.2	1562.3	1439.7
		IFT-FlamMap	13.2	58.7	1550.3	1440.3
		NEXUS	13.3	60.0	1585.0	1440.7
	Across Slope	BehavePlus	15.5	83.6	2205.0	1440.7
		IFT-surface	15.5	83.4	2200.6	1439.7
		IFT-FlamMap	15.6	83.9	2215.1	1440.3
		NEXUS	15.6	84.2	2222.0	1440.7

Table 37. Fuel Model 8. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
8	Flat Terrain (no slope)	BehavePlus	1.0	1.6	5.0	187.9
		IFT-surface	1.0	1.6	5.4	188.5
		IFT-FlamMap	1.0	1.6	5.5	188.5
		NEXUS	1.0	1.6	6.0	188.9
	Up Slope	BehavePlus	1.2	2.4	8.0	188.1
		IFT-surface	1.2	2.4	8.4	188.5
		IFT-FlamMap	1.2	2.4	8.5	188.7
		NEXUS	1.2	2.5	9.0	189.1
	Down Slope	BehavePlus	0.7	0.7	3.0	188.1
		IFT-surface	0.7	0.7	2.5	188.5
		IFT-FlamMap	0.7	0.8	2.4	188.7
		NEXUS	0.7	0.8	3.0	189.1
	Across Slope	BehavePlus	1.1	1.8	6.0	188.1
		IFT-surface	1.1	1.8	6.3	188.5
		IFT-FlamMap	1.1	1.6	6.4	188.7
		NEXUS	1.1	1.9	6.0	189.1

Table 38. Fuel Model 9. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
9	Flat Terrain (no slope)	BehavePlus	2.6	6.5	44.0	369.8
		IFT-surface	2.6	6.5	43.8	370.0
		IFT-FlamMap	2.6	6.6	44.6	370.4
		NEXUS	2.6	6.7	46.0	370.8
	Up Slope	BehavePlus	3.1	9.9	67.0	370.2
		IFT-surface	3.1	9.8	66.5	370.0
		IFT-FlamMap	3.1	10.4	68.2	370.8
		NEXUS	3.1	10.1	68.0	371.2
	Down Slope	BehavePlus	1.9	3.2	22.0	370.2
		IFT-surface	1.8	3.1	21.2	370.0
		IFT-FlamMap	1.8	3.2	21.0	370.8
		NEXUS	1.9	3.4	23.0	371.2
	Across Slope	BehavePlus	2.7	7.4	50.0	370.2
		IFT-surface	2.7	7.4	50.0	370.0
		IFT-FlamMap	2.8	7.2	51.1	370.8
		NEXUS	2.8	7.6	52.0	371.2

Table 39. Fuel Model 10. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Anderson 13 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
10	Flat Terrain (no slope)	BehavePlus	5.6	10.1	240.2	1291.2
		IFT-surface	5.6	10.1	238.4	1292.0
		IFT-FlamMap	5.6	10.8	241.4	1291.3
		NEXUS	5.6	10.1	239.2	1291.2
	Up Slope	BehavePlus	6.5	13.9	330.0	1292.7
		IFT-surface	6.5	13.8	327.8	1292.0
		IFT-FlamMap	6.5	14.4	334.2	1292.8
		NEXUS	6.5	13.9	328.0	1292.7
	Down Slope	BehavePlus	4.5	6.4	151.0	1292.7
		IFT-surface	4.5	6.3	149.0	1292.0
		IFT-FlamMap	4.5	6.4	148.2	1292.8
		NEXUS	4.5	6.3	149.0	1292.7
	Across Slope	BehavePlus	5.8	10.9	258.0	1292.7
		IFT-surface	5.8	10.8	256.0	1292.0
		IFT-FlamMap	5.8	11.2	259.8	1292.8
		NEXUS	5.8	10.8	257.0	1292.7

Table 40. Fuel Model TL1. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
TL1	Flat Terrain (no slope)	BehavePlus	0.5	0.7	1.0	104.9
		IFT-surface	0.5	0.7	1.4	104.8
		IFT-FlamMap	0.5	0.7	1.4	104.8
		NEXUS	0.5	0.8	1.0	104.9
	Up Slope	BehavePlus	0.6	0.9	2.0	105.1
		IFT-surface	0.6	0.9	1.7	104.8
		IFT-FlamMap	0.6	0.9	1.7	104.9
		NEXUS	0.6	1.2	2.0	105.1
	Down Slope	BehavePlus	0.4	0.3	1.0	105.1
		IFT-surface	0.4	0.3	0.6	104.8
		IFT-FlamMap	0.4	0.3	0.6	104.9
		NEXUS	0.4	0.4	1.0	105.1
	Across Slope	BehavePlus	0.6	0.9	2.0	105.1
		IFT-surface	0.6	0.9	1.6	104.8
		IFT-FlamMap	0.6	0.9	1.7	104.9
		NEXUS	0.6	0.9	2.0	105.1



Table 41. Fuel Model TL2. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
TL2	Flat Terrain (no slope)	BehavePlus	0.7	1.1	3.0	144.9
		IFT-surface	0.7	1.1	2.9	144.9
		IFT-FlamMap	0.7	1.1	2.9	144.8
		NEXUS	0.7	1.1	3.0	144.9
	Up Slope	BehavePlus	0.9	1.7	4.0	145.1
		IFT-surface	0.9	1.7	4.5	144.9
		IFT-FlamMap	0.9	1.7	4.6	145.0
		NEXUS	0.9	1.7	5.0	145.1
	Down Slope	BehavePlus	0.5	0.5	1.0	145.1
		IFT-surface	0.5	0.5	1.3	144.9
		IFT-FlamMap	0.5	0.5	1.3	145.0
		NEXUS	0.5	0.5	1.0	145.1
	Across Slope	BehavePlus	0.8	1.3	3.0	145.1
		IFT-surface	0.8	1.3	3.4	144.9
		IFT-FlamMap	0.8	1.3	3.4	145.0
		NEXUS	0.8	1.3	3.0	145.1

Table 42. Fuel Model TL3. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
TL3	Flat Terrain (no slope)	BehavePlus	1.0	1.5	5.0	196.9
		IFT-surface	1.0	1.5	5.4	196.7
		IFT-FlamMap	1.0	1.5	5.4	196.5
		NEXUS	1.0	1.5	5.0	196.9
	Up Slope	BehavePlus	1.2	2.3	8.0	197.1
		IFT-surface	1.2	2.3	8.1	196.7
		IFT-FlamMap	1.2	2.3	8.2	196.8
		NEXUS	1.2	2.2	8.0	197.1
	Down Slope	BehavePlus	0.7	0.7	3.0	197.1
		IFT-surface	0.7	0.8	2.7	196.7
		IFT-FlamMap	0.7	0.7	2.6	196.8
		NEXUS	0.7	0.7	3.0	197.1
	Across Slope	BehavePlus	1.0	1.7	6.0	197.1
		IFT-surface	1.0	1.7	6.1	196.7
		IFT-FlamMap	1.0	1.7	6.2	196.8
		NEXUS	1.0	1.7	6.0	197.1

Table 43. Fuel Model TL4. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
TL4	Flat Terrain (no slope)	BehavePlus	1.3	2.3	10.0	238.9
		IFT-surface	1.3	2.3	9.9	239.3
		IFT-FlamMap	1.3	2.3	9.9	239.2
		NEXUS	1.3	2.3	10.0	238.9
	Up Slope	BehavePlus	1.5	3.3	15.0	239.1
		IFT-surface	1.5	3.3	14.5	239.3
		IFT-FlamMap	1.6	3.4	14.8	239.4
		NEXUS	1.5	3.3	15.0	239.1
	Down Slope	BehavePlus	1.0	1.2	5.0	239.1
		IFT-surface	1.0	1.2	5.2	239.3
		IFT-FlamMap	1.0	1.2	5.1	239.4
		NEXUS	1.0	1.2	5.0	239.1
	Across Slope	BehavePlus	1.4	2.5	11.0	239.1
		IFT-surface	1.4	2.5	11.0	239.3
		IFT-FlamMap	1.4	2.5	11.2	239.4
		NEXUS	1.4	2.5	11.0	239.1

Table 44. Fuel Model TL5. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
TL5	Flat Terrain (no slope)	BehavePlus	2.1	4.4	28.0	347.8
		IFT-surface	2.1	4.4	28.0	348.0
		IFT-FlamMap	2.1	4.5	28.4	347.7
		NEXUS	2.1	4.5	28.0	347.8
	Up Slope	BehavePlus	2.5	6.3	40.0	348.2
		IFT-surface	2.5	6.3	40.0	348.0
		IFT-FlamMap	2.5	6.4	40.9	348.1
		NEXUS	2.5	6.3	40.0	348.2
	Down Slope	BehavePlus	1.6	2.6	16.0	348.2
		IFT-surface	1.6	2.5	16.0	348.0
		IFT-FlamMap	1.6	2.5	15.9	348.1
		NEXUS	1.6	2.5	16.0	348.2
	Across Slope	BehavePlus	2.2	4.9	31.0	348.2
		IFT-surface	2.2	4.8	30.7	348.0
		IFT-FlamMap	2.2	4.9	31.2	348.1
		NEXUS	2.2	4.9	32.0	348.2

Table 45. Fuel Model TL6. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
TL6	Flat Terrain (no slope)	BehavePlus	2.5	5.0	41.0	439.7
		IFT-surface	2.5	5.0	40.7	440.4
		IFT-FlamMap	2.5	5.1	40.8	440.1
		NEXUS	2.5	5.0	40.0	439.7
	Up Slope	BehavePlus	3.0	7.5	61.0	440.2
		IFT-surface	3.0	7.5	60.6	440.4
		IFT-FlamMap	3.0	7.6	61.4	440.6
		NEXUS	3.0	7.4	60.0	440.2
	Down Slope	BehavePlus	1.8	2.6	21.0	440.2
		IFT-surface	1.8	2.6	20.8	440.4
		IFT-FlamMap	1.8	2.5	20.1	440.6
		NEXUS	1.8	2.5	20.0	440.2
	Across Slope	BehavePlus	2.6	5.7	46.0	440.2
		IFT-surface	2.6	5.7	45.9	440.4
		IFT-FlamMap	2.6	5.7	46.2	440.6
		NEXUS	2.6	5.6	45.0	440.2

Table 46. Fuel Model TL7. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
TL7	Flat Terrain (no slope)	BehavePlus	1.9	2.7	24.0	495.7
		IFT-surface	2.0	2.7	24.2	496.1
		IFT-FlamMap	2.0	2.7	24.3	495.8
		NEXUS	2.0	2.7	24.0	495.7
	Up Slope	BehavePlus	2.3	4.0	36.0	496.3
		IFT-surface	2.3	4.0	36.1	496.1
		IFT-FlamMap	2.4	4.0	36.6	496.3
		NEXUS	2.4	4.0	36.0	496.3
	Down Slope	BehavePlus	1.4	1.3	12.0	496.3
		IFT-surface	1.4	1.4	12.2	496.1
		IFT-FlamMap	1.4	1.3	11.9	496.3
		NEXUS	1.4	1.4	13.0	496.3
	Across Slope	BehavePlus	2.1	3.0	27.0	496.3
		IFT-surface	2.1	3.0	27.4	496.1
		IFT-FlamMap	2.1	3.0	27.6	496.3
		NEXUS	2.1	3.0	28.0	496.3

Table 47. Fuel Model TL8. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
TL8	Flat Terrain (no slope)	BehavePlus	3.1	5.2	67.0	704.6
		IFT-surface	3.1	5.2	67.5	705.3
		IFT-FlamMap	3.1	5.2	67.6	704.8
		NEXUS	3.1	5.2	67.0	704.6
	Up Slope	BehavePlus	3.8	7.8	101.0	705.4
		IFT-surface	3.8	7.8	101.3	705.3
		IFT-FlamMap	3.8	7.9	102.7	705.6
		NEXUS	3.8	7.8	100.0	705.4
	Down Slope	BehavePlus	2.3	2.6	34.0	705.4
		IFT-surface	2.3	2.6	33.7	705.3
		IFT-FlamMap	2.2	2.5	32.4	705.6
		NEXUS	2.2	2.5	33.0	705.4
	Across Slope	BehavePlus	3.3	5.9	77.0	705.4
		IFT-surface	3.3	5.9	76.7	705.3
		IFT-FlamMap	3.3	6.0	77.3	705.6
		NEXUS	3.3	5.9	76.0	705.4

Table 48. Fuel Model TL9. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Litter Fuel Types						
TL9	Flat Terrain (no slope)	BehavePlus	4.8	9.0	172.1	1042.3
		IFT-surface	4.8	8.9	170.0	1043.3
		IFT-FlamMap	4.8	9.0	172.2	1042.6
		NEXUS	4.8	9.0	172.1	1042.3
	Up Slope	BehavePlus	5.7	12.9	246.0	1043.5
		IFT-surface	5.7	12.8	244.6	1043.3
		IFT-FlamMap	5.7	13.0	249.5	1043.8
		NEXUS	5.7	12.9	247.0	1043.5
	Down Slope	BehavePlus	3.7	5.1	97.0	1043.5
		IFT-surface	3.7	5.0	95.5	1043.3
		IFT-FlamMap	3.7	5.0	94.6	1043.8
		NEXUS	3.7	5.1	98.0	1043.5
	Across Slope	BehavePlus	5.0	9.9	189.0	1043.5
		IFT-surface	5.0	9.8	187.6	1043.3
		IFT-FlamMap	5.0	10.0	190.6	1043.8
		NEXUS	5.0	9.9	190.0	1043.5



Table 49. Fuel Model TU1. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Understory Fuel Types						
TU1	Flat Terrain (no slope)	BehavePlus	1.9	3.0	22.0	396.8
		IFT-surface	1.9	3.0	21.5	396.7
		IFT-FlamMap	1.9	3.0	21.8	396.4
		NEXUS	1.9	3.0	22.0	396.8
	Up Slope	BehavePlus	2.2	4.2	31.0	397.2
		IFT-surface	2.2	4.2	30.4	396.7
		IFT-FlamMap	2.2	4.3	31.0	396.9
		NEXUS	2.2	4.2	31.0	397.2
	Down Slope	BehavePlus	1.5	1.8	13.0	397.2
		IFT-surface	1.5	1.8	12.7	396.7
		IFT-FlamMap	1.5	1.7	12.6	396.9
		NEXUS	1.5	1.8	13.0	394.2
	Across Slope	BehavePlus	1.9	3.2	24.0	397.2
		IFT-surface	1.9	3.2	23.4	396.7
		IFT-FlamMap	1.9	3.3	23.8	396.9
		NEXUS	1.9	3.3	24.0	397.2

Table 50. Fuel Model TU2. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Understory Fuel Types						
TU2	Flat Terrain (no slope)	BehavePlus	3.8	13.7	102.1	404.7
		IFT-surface	3.8	13.6	101.2	405.3
		IFT-FlamMap	3.8	13.8	102.3	405.0
		NEXUS	3.8	13.6	101.1	404.7
	Up Slope	BehavePlus	4.3	18.6	138.0	405.2
		IFT-surface	4.3	18.5	137.1	405.3
		IFT-FlamMap	4.4	18.8	139.5	405.5
		NEXUS	4.3	18.5	137.0	405.2
	Down Slope	BehavePlus	3.1	8.9	66.0	405.2
		IFT-surface	3.1	8.8	65.3	405.3
		IFT-FlamMap	3.1	8.7	65.0	405.5
		NEXUS	3.1	8.8	65.0	405.2
	Across Slope	BehavePlus	3.9	14.6	109.0	405.2
		IFT-surface	3.9	14.5	107.8	405.3
		IFT-FlamMap	3.9	14.7	109.2	405.5
		NEXUS	3.9	14.5	108.0	405.2

Table 51. Fuel Model TU3. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Understory Fuel Types						
TU3	Flat Terrain (no slope)	BehavePlus	7.8	31.5	492.4	850.5
		IFT-surface	7.8	31.4	489.3	850.5
		IFT-FlamMap	7.8	31.6	493.1	849.8
		NEXUS	7.8	31.4	489.3	849.5
	Up Slope	BehavePlus	8.8	41.4	646.0	851.4
		IFT-surface	8.8	41.3	643.4	850.5
		IFT-FlamMap	8.9	41.9	652.7	850.8
		NEXUS	8.8	41.3	643.0	850.4
	Down Slope	BehavePlus	6.6	21.7	338.0	851.4
		IFT-surface	6.5	21.5	335.2	850.5
		IFT-FlamMap	6.5	21.3	332.8	850.8
		NEXUS	6.5	21.5	335.0	850.4
	Across Slope	BehavePlus	8.0	33.1	516.0	851.4
		IFT-surface	8.0	33.0	514.1	850.5
		IFT-FlamMap	8.0	33.3	518.9	850.8
		NEXUS	7.9	33.0	514.0	850.4

Table 52. Fuel Model TU4. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Understory Fuel Types						
TU4	Flat Terrain (no slope)	BehavePlus	5.5	11.6	232.2	1087.3
		IFT-surface	5.5	11.7	233.2	1087.6
		IFT-FlamMap	5.5	11.7	232.8	1086.8
		NEXUS	5.5	11.7	233.2	1087.3
	Up Slope	BehavePlus	6.5	16.6	331.0	1088.6
		IFT-surface	6.5	16.6	331.7	1087.6
		IFT-FlamMap	6.5	16.8	334.9	1088.0
		NEXUS	6.5	16.6	332.0	1088.6
	Down Slope	BehavePlus	4.3	6.7	134.0	1088.6
		IFT-surface	4.3	6.8	134.7	1087.6
		IFT-FlamMap	4.2	6.5	130.3	1088.0
		NEXUS	4.3	6.8	135.0	1088.6
	Across Slope	BehavePlus	5.7	12.7	254.0	1088.6
		IFT-surface	5.8	12.8	255.1	1087.6
		IFT-FlamMap	5.8	12.8	256.0	1088.0
		NEXUS	5.8	12.8	255.0	1088.6

Table 53. Fuel Model TU5. IFTDSS, BehavePlus, NEXUS fire behavior module output comparisons.

Fire Behavior Fuel Model	Slope Scenario	Module	Flame Length (ft)	Rate of Spread (chains per hour)	Fireline Intensity (BTU/ft/s)	Heat Per unit Area (BTU/ft <sup>2</sup> )
Scott and Burgan 40 Fire Behavior Fuel Models – Timber-Understory Fuel Types						
TU5	Flat Terrain (no slope)	BehavePlus	7.7	10.1	475.3	2565.4
		IFT-surface	7.7	10.1	473.0	2566.8
		IFT-FlamMap	7.7	10.1	477.1	2564.9
		NEXUS	7.6	10.1	473.3	2565.4
	Up Slope	BehavePlus	8.9	14.1	662.0	2568.3
		IFT-surface	8.9	14.0	659.1	2566.8
		IFT-FlamMap	9.0	14.2	669.9	2567.8
		NEXUS	8.9	14.0	659.0	2568.3
	Down Slope	BehavePlus	6.1	6.2	290.0	2568.3
		IFT-surface	6.1	6.1	286.9	2566.8
		IFT-FlamMap	6.1	6.0	283.5	2567.8
		NEXUS	6.1	6.1	287.0	2568.3
	Across Slope	BehavePlus	7.9	10.9	514.0	2568.3
		IFT-surface	7.9	10.9	511.6	2566.8
		IFT-FlamMap	8.0	11.0	517.6	2567.8
		NEXUS	7.9	10.9	512.0	2568.3

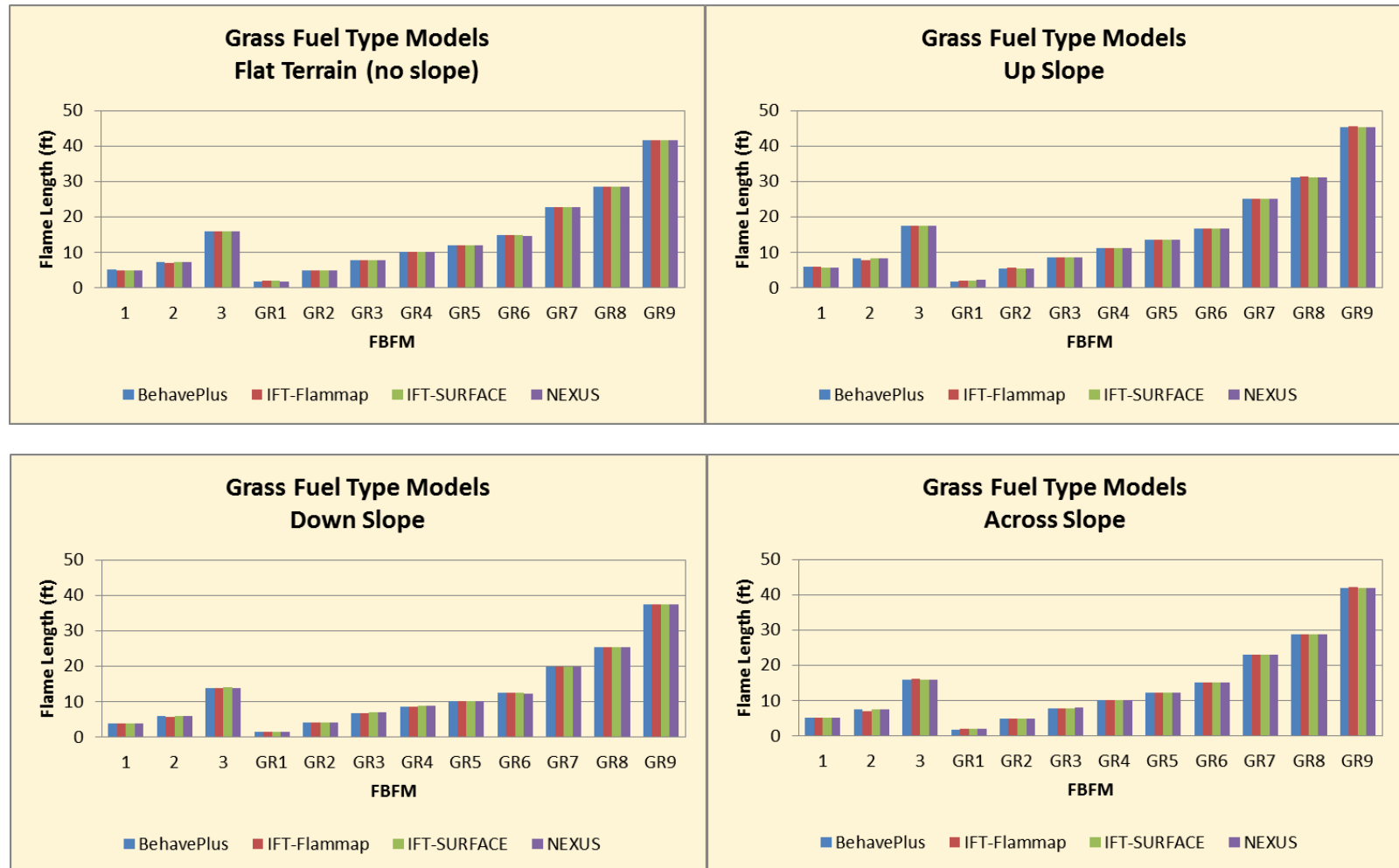
## Appendix 3

### **Summary result figures comparing IFTDSS fire behavior module outputs for flame length with flame length results from BehavePlus 5.0.5 and NEXUS 2.0.**

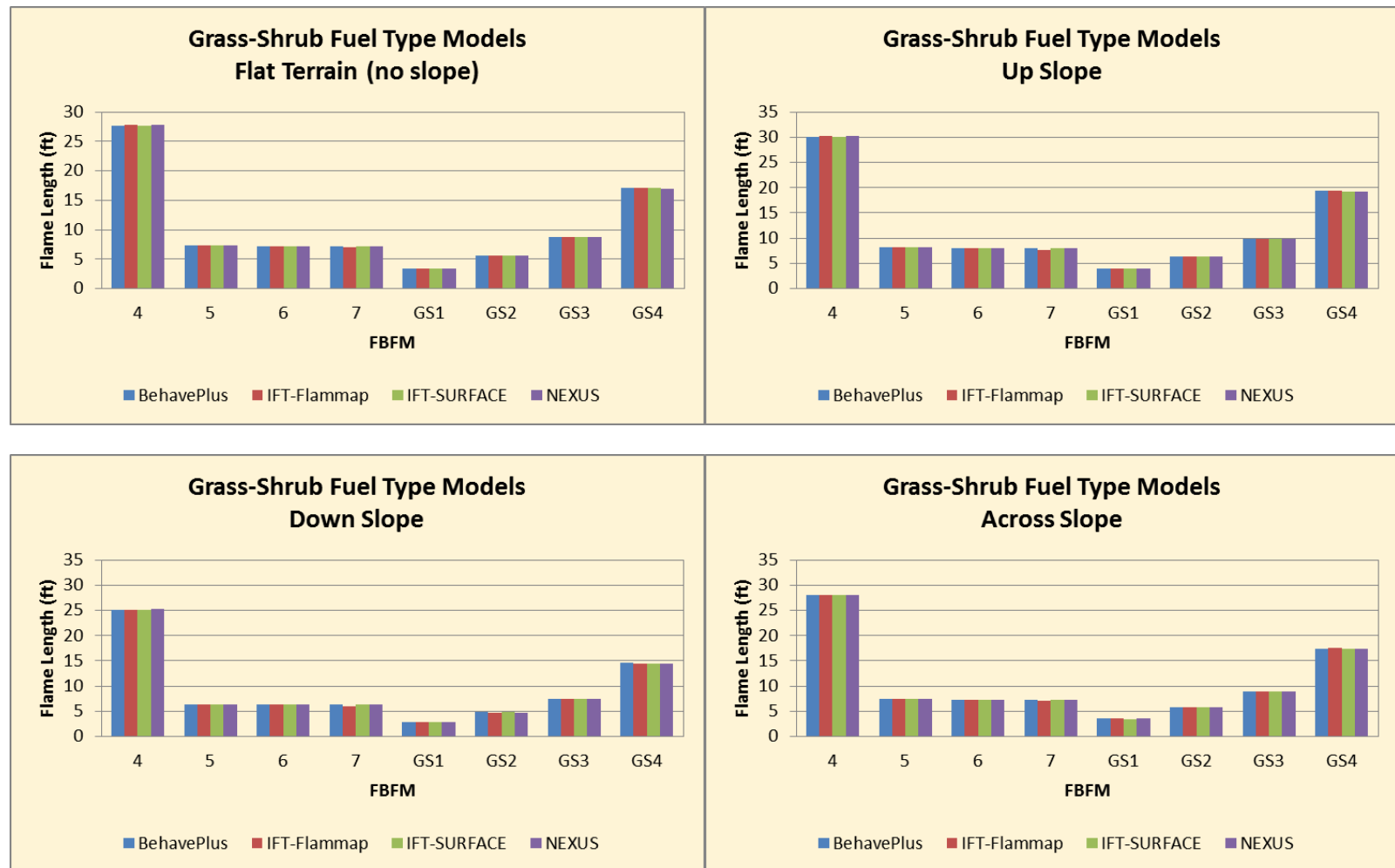
For this study, we compared the flame length estimates for IFT-surface and IFT-FlamMap with the BehavePlus and NEXUS modeling systems to ensure that the IFTDSS calculators were implemented correctly. All input values remained constant for each comparison (see Appendix 1). We classified fire behavior fuel models into the following six groups: grass, grass-shrub, shrub, slash-blowdown, timber-litter, and timber-understory. Comparisons were made for four scenarios: a flat terrain scenario that tested the model parameters without a slope influence, an upslope condition with the wind, a downslope scenario with an opposing influence of wind, and a cross-slope condition where the wind was simulated as blowing perpendicular to the slope.

- Figure 1 presents the grass fuel type fire behavior models results,
- Figure 2 presents the grass-shrub fuel type fire behavior results,
- Figure 3 presents the shrub fuel types,
- Figure 4 presents the slash-blowdown fuel type results,
- Figure 5 presents the timber-litter fuel types results,
- and Figure 6 presents timber-understory fuel type results.

Figures by fire behavior fuel model group for rate of spread, fireline intensity, and heat per unit area are on file at Sonoma Technology, Inc.

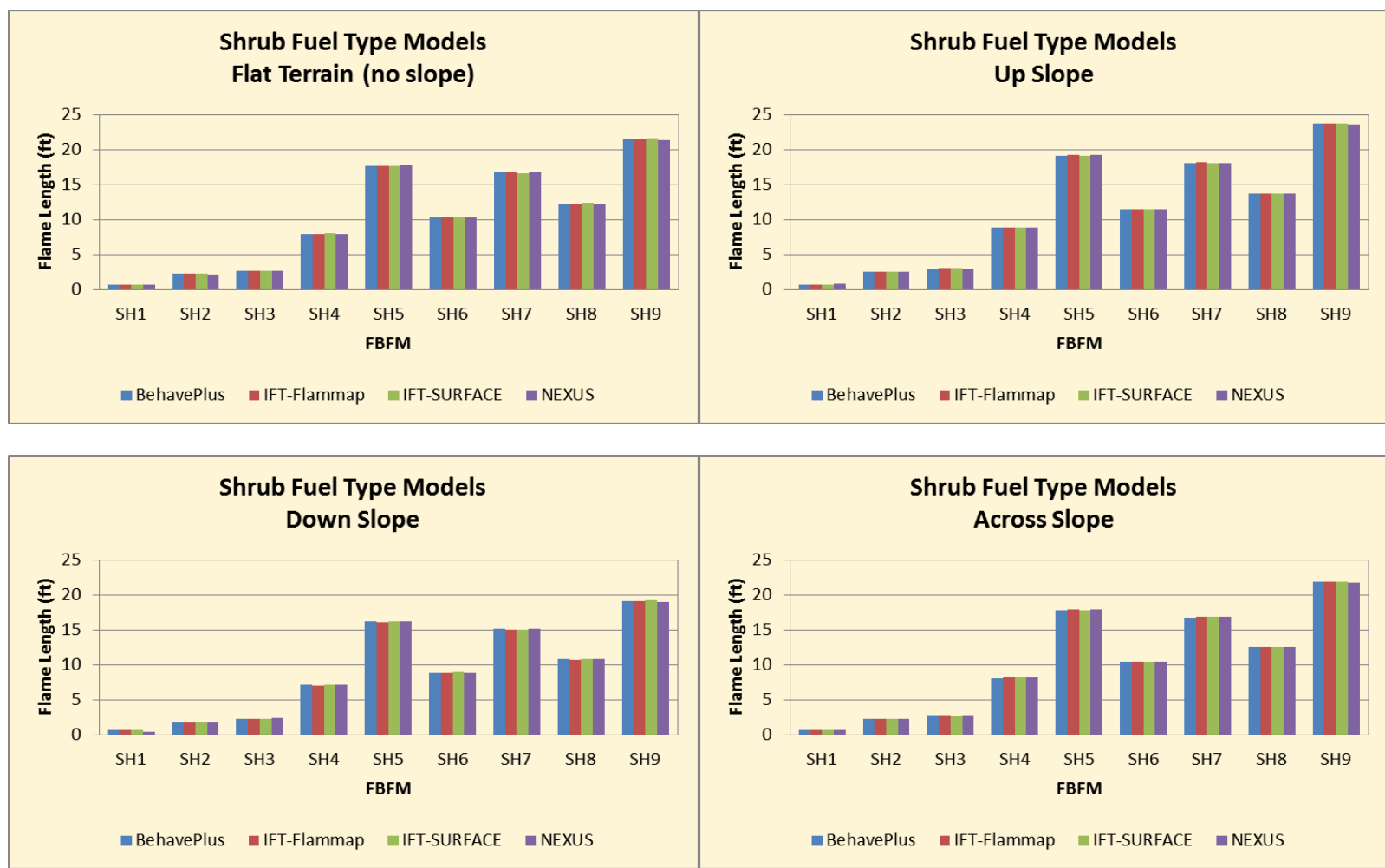


**Figure 1.** Flame Length estimates calculated for grass fire behavior fuel models using BehavePlus 5.0.5, IFT-surface, IFT-FlamMap, and NEXUS 2.0.

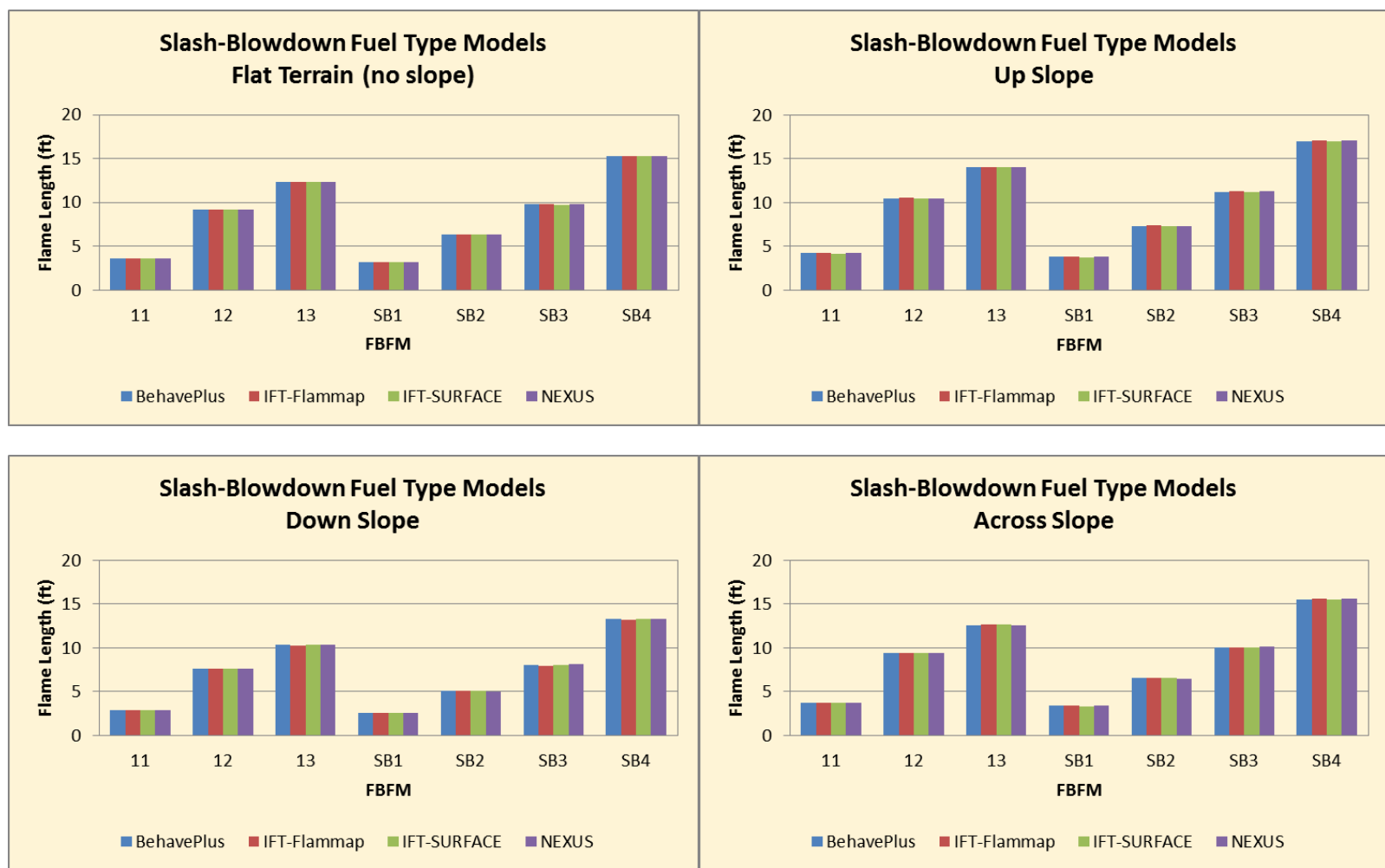


**Figure 2.** Flame Length estimates calculated for grass-shrub fire behavior fuel models using BehavePlus 5.0.5, IFT-surface, IFT-FlamMap, and NEXUS 2.0.

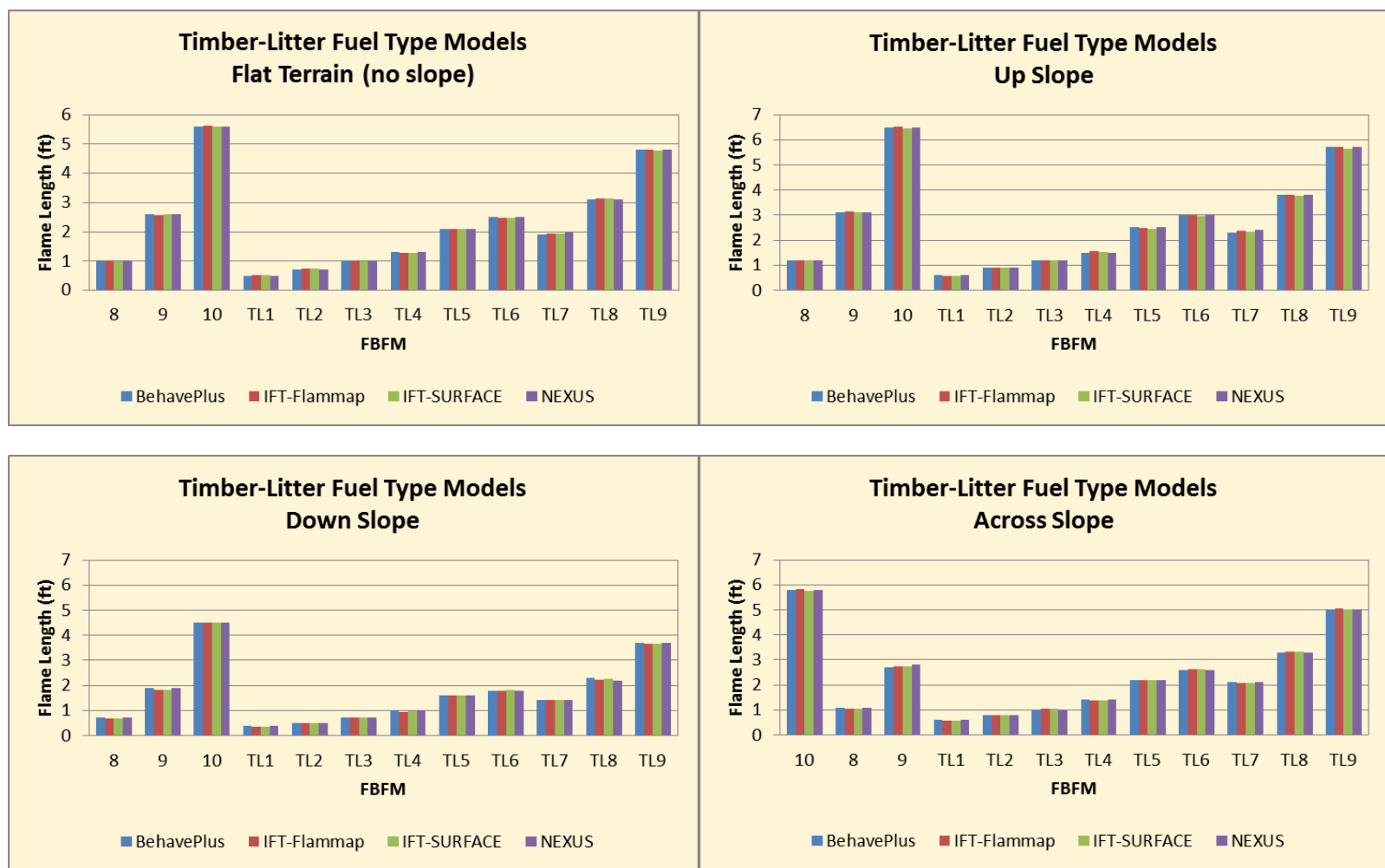




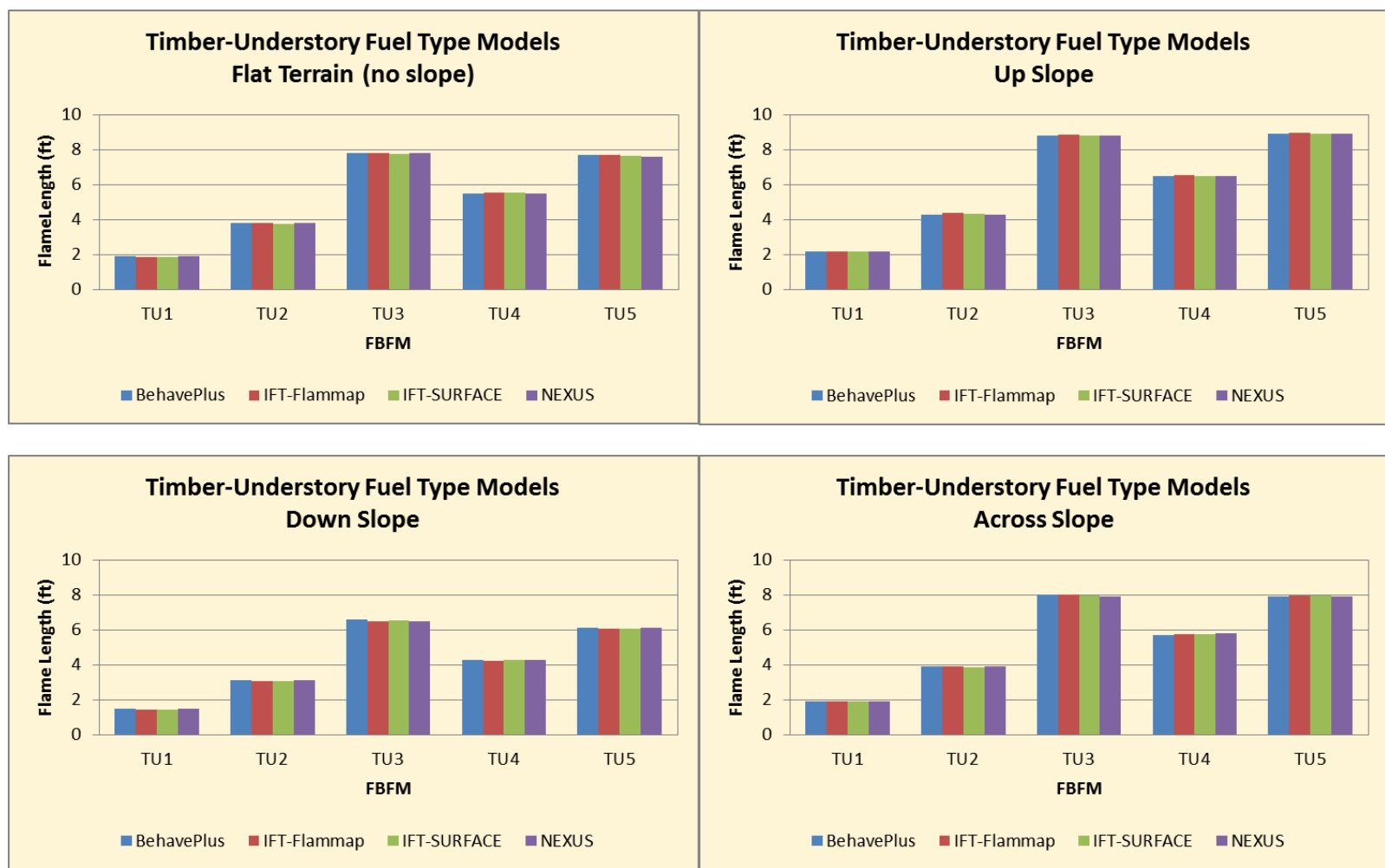
**Figure 3.** Flame Length estimates calculated for shrub fire behavior fuel models using BehavePlus 5.0.5, IFT-surface, IFT-FlamMap, and NEXUS 2.0.



**Figure 4.** Flame Length estimates calculated for slash-blowdown fire behavior fuel models using BehavePlus 5.0.5, IFT-surface, IFT-FlamMap, and NEXUS 2.0.



**Figure 5.** Flame Length estimates calculated for timber-litter fire behavior fuel models using BehavePlus 5.0.5, IFT-surface, IFT-FlamMap, and NEXUS 2.0.



**Figure 6.** Flame Length estimates calculated for timber-understory fire behavior fuel models using BehavePlus 5.0.5, IFT-surface, IFT-FlamMap, and NEXUS 2.0.