2005 AK-DEP Highpower (#226) / Herron River (#227) FARSITE and FSPro Calibration

Overview

In the absence of available LANDFIRE data in Alaska, a FARSITE landscape file was generated for the Tanana Zone Wildland Fire Decision Support System (WFDSS) prototype by applying a cross-walk to the recently released Alaska National Land Cover Data (NLCD) dataset. In an effort to determine the validity of the NLCD-based Tanana Zone landscape (.lcp) file for use in WFDSS and FPA, FARSITE calibration runs were conducted using a fire that had occurred in Denali National Park and Preserve in 2005. Calibration efforts were focused on the Denali area because of the potential to use a FARSITE .lcp file based on the Denali landcover map. The Denali .lcp was felt to be of higher quality than the Tanana Zone .lcp file because of the enhanced detail and accuracy of the Denali landcover map in comparison to the NLCD data. The 2005 Herron River fire was used for calibration because of the availability of good perimeter data during a time of large fire growth (July 7-12). Initial calibration runs on the Tanana Zone .lcp verified the need for major refinements and modifications. Further calibration should be conducted on historic fires throughout the Tanana Zone.

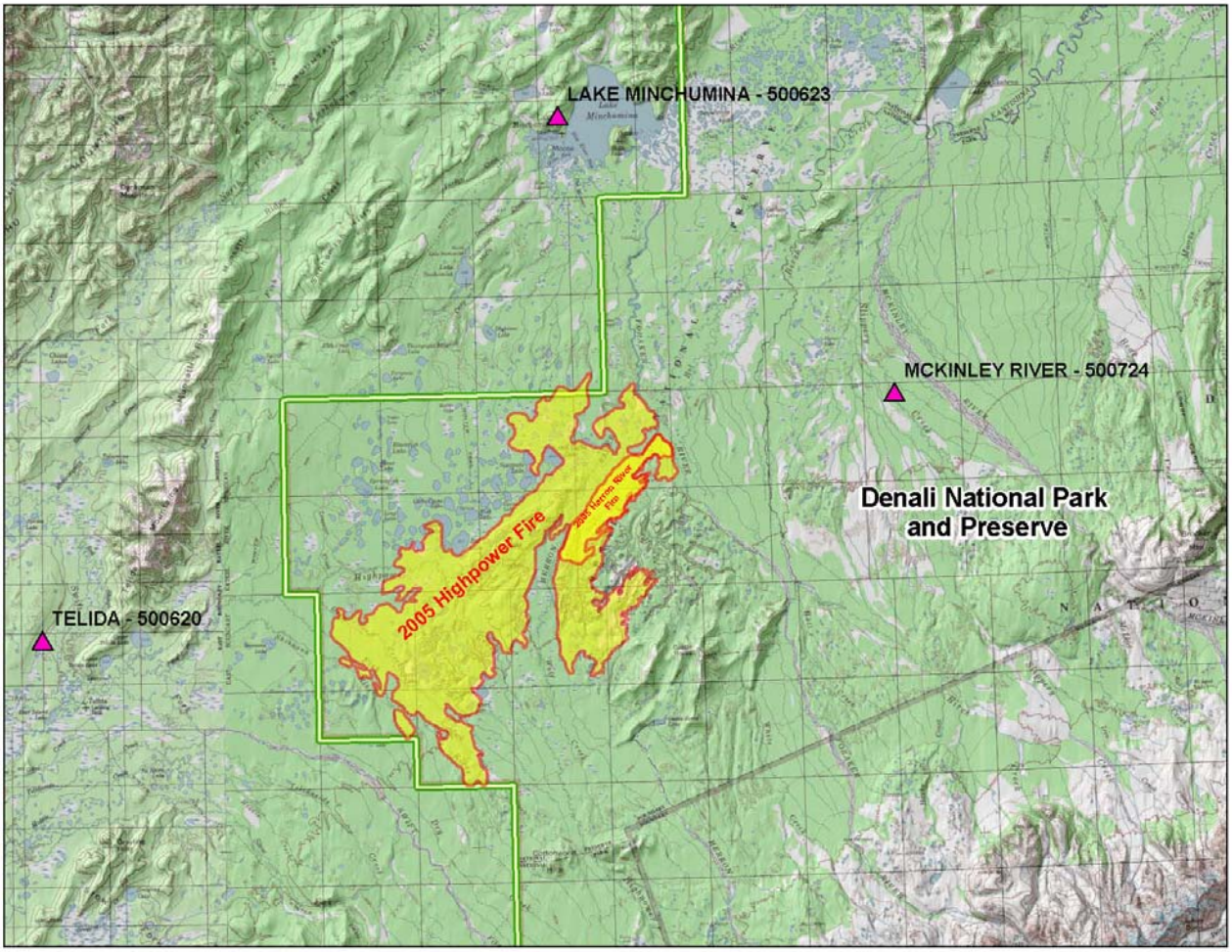
The Herron River fire started on June 14, 2005. The Herron River fire was eventually overtaken by the Highpower fire, which also started on June 14. The final size of the Highpower/Herron River fires was in excess of 118,000 acres.

During the calibration process numerous Scott–Burgan fire behavior fuel models were tested to represent black spruce as well as the NLCD Shrub/Scrub landcover class, including SH2, SH5, GS2 and TU4 .TU4 (timber-understory 4) fuel model was developed by Robert Burgan and Rodney Norum specifically for Alaska black spruce.

Using actual hourly weather observations from nearby weather stations and recommended live fuel moistures and burning period inputs, the best results were achieved by using TU4 as the fuel model for black spruce. As recommended by those familiar with black spruce as well as through the calibration process, it was determined that the canopy base height of TU4 needed to be reduced from 0.3 meters to 0.1 meters in order to allow the model to appropriately transition to crown fire. This modification provided more realistic rates of spread and crown fire activity. During the calibration process various live fuel moistures were tested since this is an important FARSITE and FSPro input when using the Scott-Burgan fire behavior fuel models.

Three weather stations in the vicinity of the Highpower / Herron River fires were examined for use in the calibration process (Map 1). In the end, the Telida RAWS (500620) was used for calibration weather inputs and the Lake Minchumina RAWS (500623) was used for wind inputs.

Map 1 RAWS near the Highpower/Herron fires



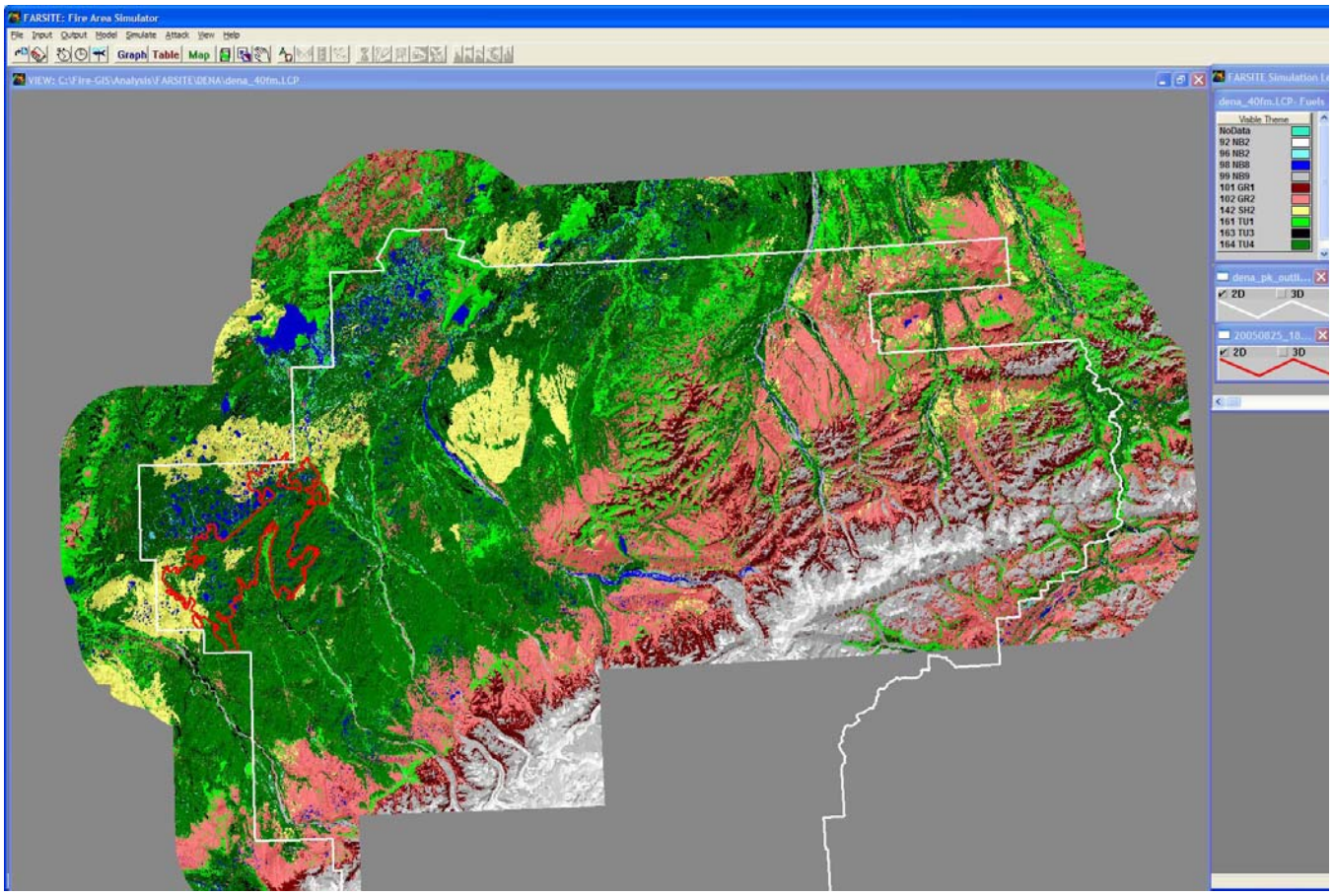
Fuels

A FARSITE landscape file was generated using a subset of the NPS 2001 Denali Landcover Map. The landcover types in the Denali landcover map were cross-walked to a Fuel Type in the Fuel Model Guide to Alaska Vegetation (April 2008). The associated Scott/Burgan fire behavior fuel model for that fuel type was then used for the Denali landcover type. Canopy characteristics were developed using a set of cross-walk tables prepared in February 1999 by Doug Stephen, Brad Cella, Skip Theisen, John See and Larry Vanderlinden as well as ancillary data and observations from the Users Guide to the Denali Landcover Map. The fuel model and canopy characteristic assignments developed for the Denali Landcover Map classification types are shown in Table 3.

Table 1. FARSITE Assignments made to Denali Landcover Map

VALUE	COUNT	Landcover Type	Alaska Fuel Model Guide Fuel Type	Fuel Model	Fuel Model #	% Canopy Cover	Crown Base Height (m)	Stand Height (m)	Crown Bulk Density ((kg/m^3)*100)
1	669,622	Dense-Open Spruce Forest	(3) Closed Black Spruce Forest	TU3	163.00000	60	0.3	10.0	0.20
2	4,736,608	Open-Woodland Spruce Forest	(6) Open Black Spruce Forest	TU4	164.00000	40	0.3	8.0	0.20
3	6,703,454	Open-Woodland Stunted Spruce	(22) Dwarf Tree Black Spruce Scrub	TU4	164.00000	30	0.3	4.0	0.20
4	992,255	Broadleaf Forest	(14) Closed Paper Birch-Quaking Aspen Forest	TU1	161.00000	75	3.5	8.0	0.05
5	1,185,006	Mixed Spruce-Broadleaf Forest	(20) White Spruce-Paper Birch-Balsam Poplar	TU1	161.00000	50	1.5	8.0	0.15
6	1,049,249	Alder Shrub	(23) Closed Tall Alder-Willow Shrub	TU1	161.00000	0	0.0	0.0	0.00
7	569,367	Willow Shrub	(23) Closed Tall Alder-Willow Shrub	TU1	161.00000	0	0.0	0.0	0.00
8	424,549	Closed Low Shrub Birch	(28) Closed Low Birch/Birch-Willow/Ericaceous Shrub	SH2	142.00000	0	0.0	0.0	0.00
9	4,169,732	Low Shrub Birch-Ericaceous-Willow	(32) Open Low Birch-Willow/Ericaceous Shrub Bog	GR2	102.00000	0	0.0	0.0	0.00
10	1,899,647	Low Shrub-Sedge	(30) Open Low Mixed Shrub-Sedge Tussock Tundra/Bog	GR2	102.00000	0	0.0	0.0	0.00
11	0	Peatland	(22) Dwarf Tree Black Spruce Scrub	TU4	164.00000	0	0.0	0.0	0.00
12	655	Herbaceous-Shrub	(37) Dwarf Shrub Tundra	GR1	101.00000	0	0.0	0.0	0.00
13	1,618,175	Dwarf Shrub	(37) Dwarf Shrub Tundra	GR1	101.00000	0	0.0	0.0	0.00
14	336,273	Dwarf Shrub-Rock	(37) Dwarf Shrub Tundra	GR1	101.00000	0	0.0	0.0	0.00
15	187,540	Dry-Mesic Herbaceous	(44) Mesic Sedge-Grass-Herb Meadow Tundra	GR2	102.00000	0	0.0	0.0	0.00
16	272,258	Wet Herbaceous	(51) Wet Species - Non Burnable	NB6	96.00000	0	0.0	0.0	0.00
17	2,987	Aquatic Herbaceous	(55) Aquatic Herbaceous	NB8	98.00000	0	0.0	0.0	0.00
18	988,934	Sparse Ground		NB9	99.00000	0	0.0	0.0	0.00
19	1,068,480	Bare Ground		NB9	99.00000	0	0.0	0.0	0.00
20	870,971	Snow-Ice		NB2	92.00000	0	0.0	0.0	0.00
21	1,341,793	Shadow-Indeterminate		NB9	99.00000	0	0.0	0.0	0.00
22	204,580	Silty Water		NB8	98.00000	0	0.0	0.0	0.00
23	462,179	Clear Water		NB8	98.00000	0	0.0	0.0	0.00
24	1,553,264	Burn	(28) Closed Low Birch/Birch-Willow/Ericaceous Shrub	SH2	142.00000	0	0.0	0.0	0.00
25	14,898	Cloud	(37) Dwarf Shrub Tundra	GR1	101.00000	0	0.0	0.0	0.00

Map 2 Denali Landcover FARSITE landscape showing fire behavior fuel models



Topography inputs were derived using a 60 meter USGS National Elevation Dataset (NED) of the area. The 60 meter NED dataset was re-sampled using cubic convolution to a 30 meter resolution to coincide with the resolution of the Denali landcover map.

After the .lcp file was created, the Crown Base Height values for TU4 and TU3 were changed from 0.3 meters to 0.1 meters to allow for adequate transition to crownfire.

Updating Fuels Inputs to Reflect for Recent Fires

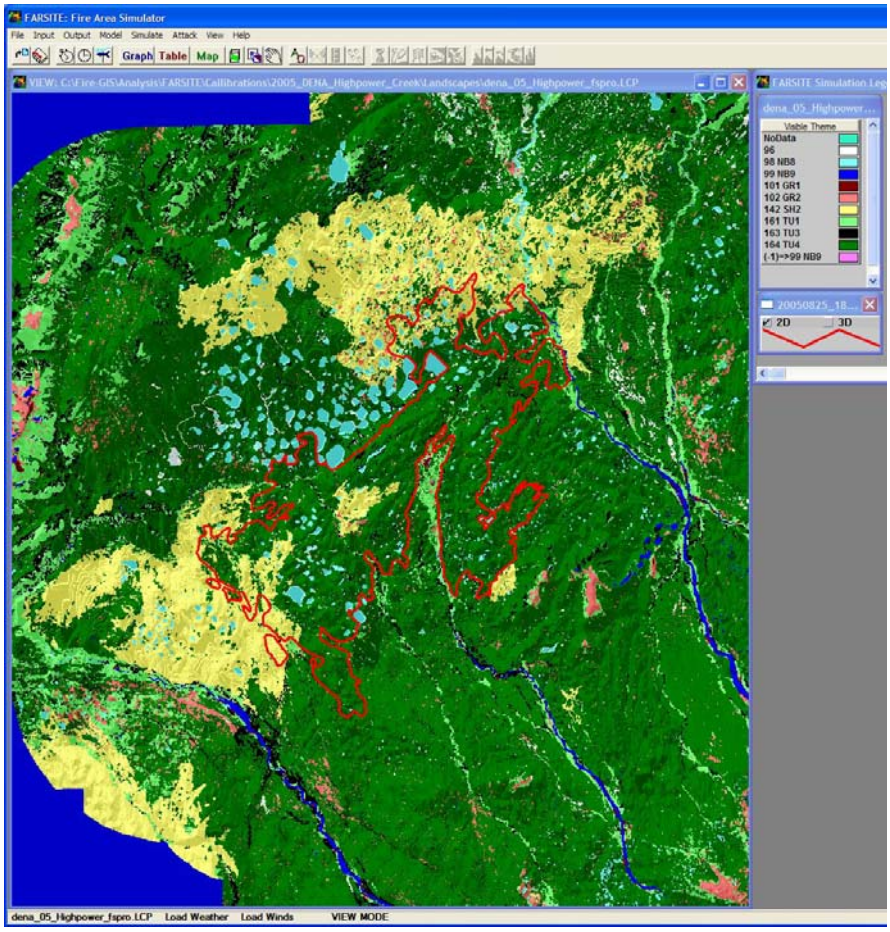
The Denali landcover map was published in 2001 but was derived from imagery collected between 1985 and 2000. The effects of fires since 2000 are not captured in the Denali landcover map and several fires from the 1990's also did not appear in the portion of the Denali landcover map around the Highpower fire. A set of update decision rules were developed by Pat Stephen, Jennifer Allen, Larry Weddle and Brian Sorbel to allow for updating the Denali .lcp file to reflect recent fire activity. Based upon time since fire, the entire area within a fire perimeter was updated to a corresponding fuel model using the following table:

Time Since Fire	Resulting Fuel Model
1 - 3 years	TL1
4 – 5 years	TU1
6 – 15 years	SH2

The fire behavior fuel models in the vicinity of the Highpower / Herron River fires are shown before the update and after the update in maps 3 and 4.

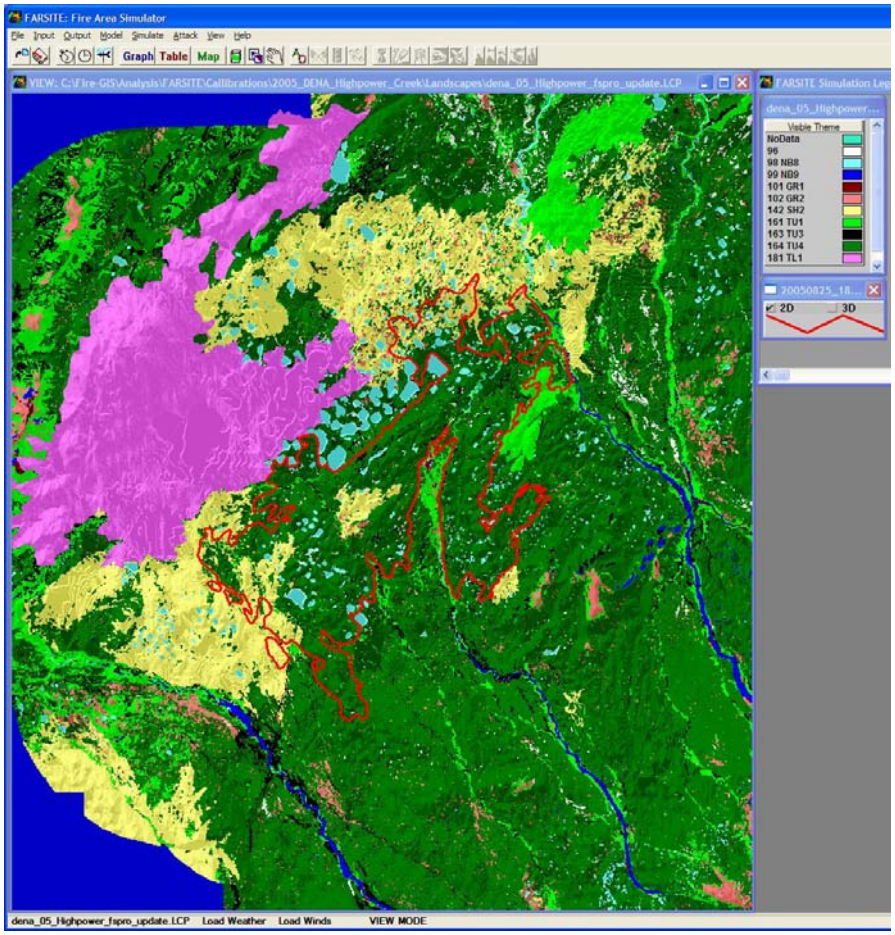
Map 3

FARSITE landscape before updating for recent fire



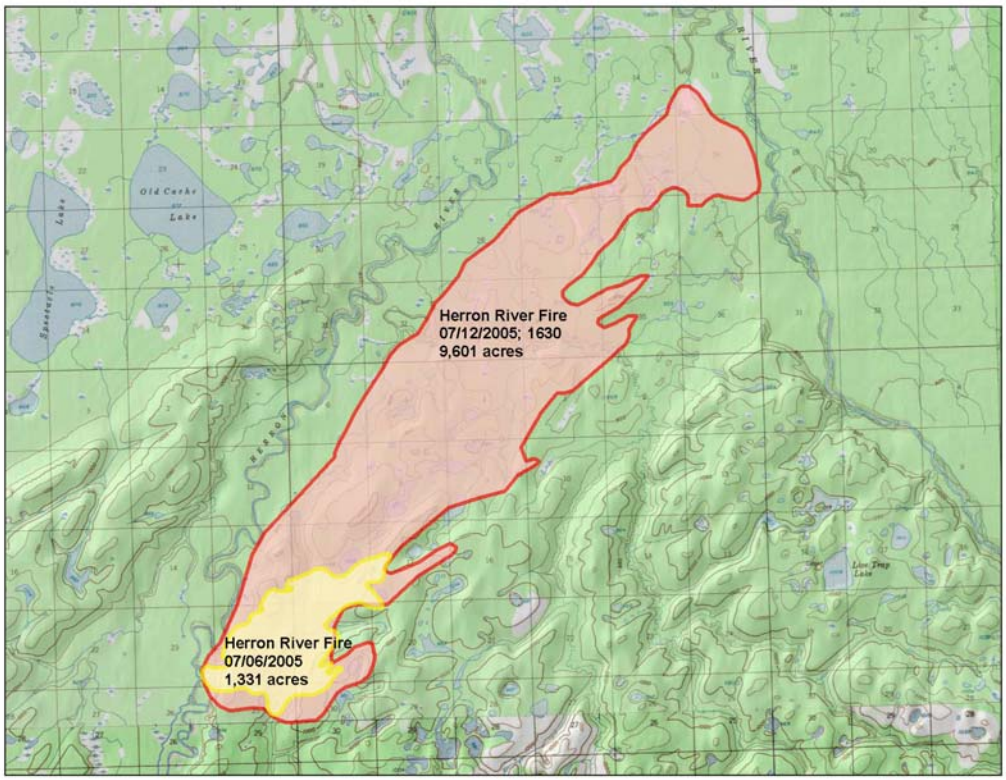
Map 4

FARSITE landscape showing updates for recent fire activity



FARSITE Calibration

Calibration exercises were completed on the Herron River fire during the period between July 7 and July 12, 2005. The extents of the Herron River fire on July 6 and July 12 are shown in Map 5.



Map 5

FARSITE Calibration Runs

Calibration Run #1: Herron River Fire – Denali Landscape

Intent: Match modeled fire spread to observed fire spread using the Denali .lcp file.

Duration: 1200 July 7 – 2300 July 12

Ignition Source: July 6 Herron River Fire Perimeter

Landscape File: Denali .lcp w/ recent fire updates

Weather File Source: Telida RAWS

Wind File Source: Lake Minchumina RAWS; hourly observations (GUSTS)

Model Parameters:
Perimeter Resolution: 90 meters
Distance Resolution: 90 meters
Time Step: 1 hour

Fire Behavior Options:
Crownfire enabled (Scott and Reinhardt method left unchecked)
No ignition delay
Spotting Frequency = 0.9%

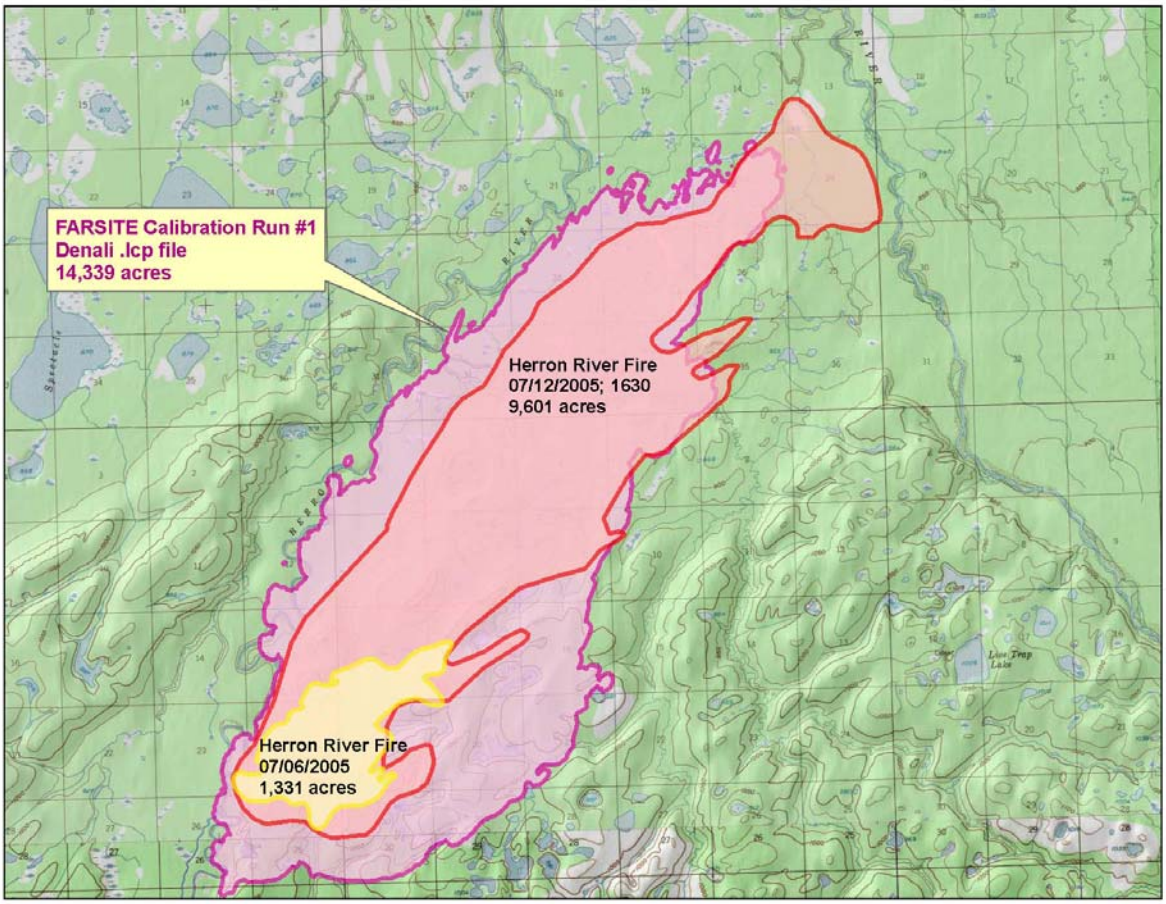
Project Canopy Characteristics:
Foliar MC = 90%
Diameter = 10 cm
Tolerance = Medium
Species = Subalpine Fir (best representation for black spruce)

Burn Period: 1100 – 2300 (12 hours)

Fuel Moistures:
Live Herbaceous = 90% (determined by Pat Stephen and Jennifer Allen)
Live Woody = 80% (determined by Pat Stephen through calibration)
Dead fuels - A three day fuels “conditioning period” was used to allow appropriate fuel moisture calculations based on elevation, slope and aspect.

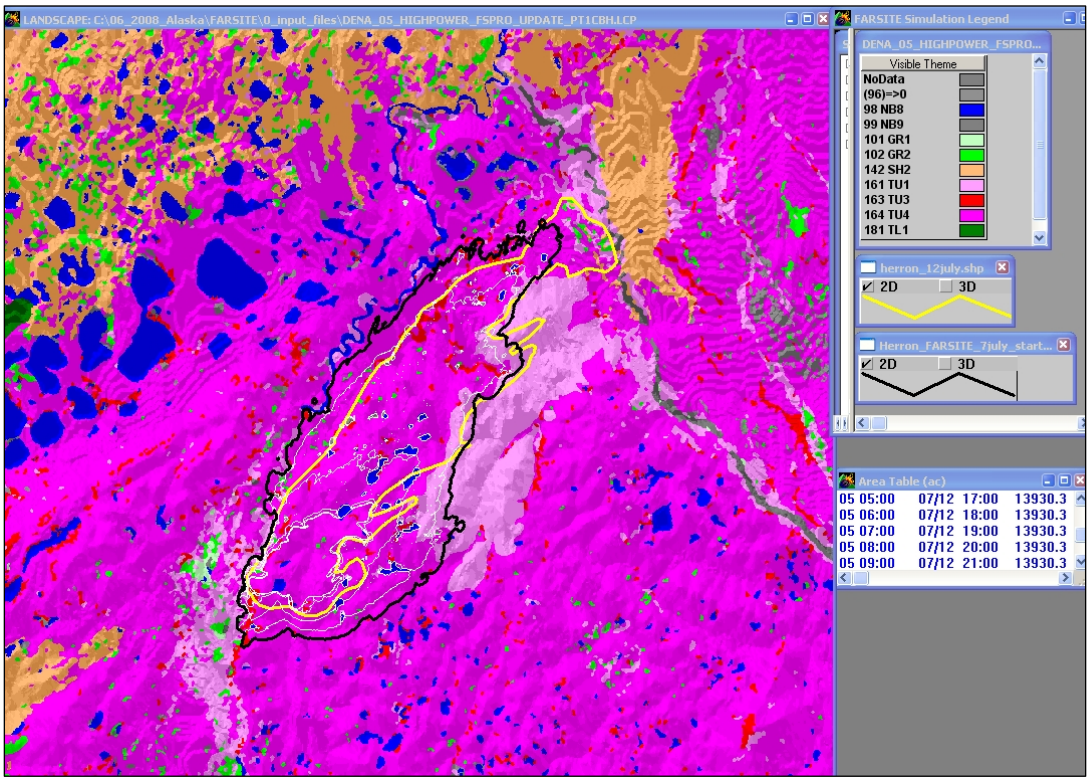
The results of Calibration Run #1 are shown in Maps 6 and 7.

Map 6 FARSITE calibration – Denali Landscape



Map 7

FARSITE calibration screen capture using Denali .lcp



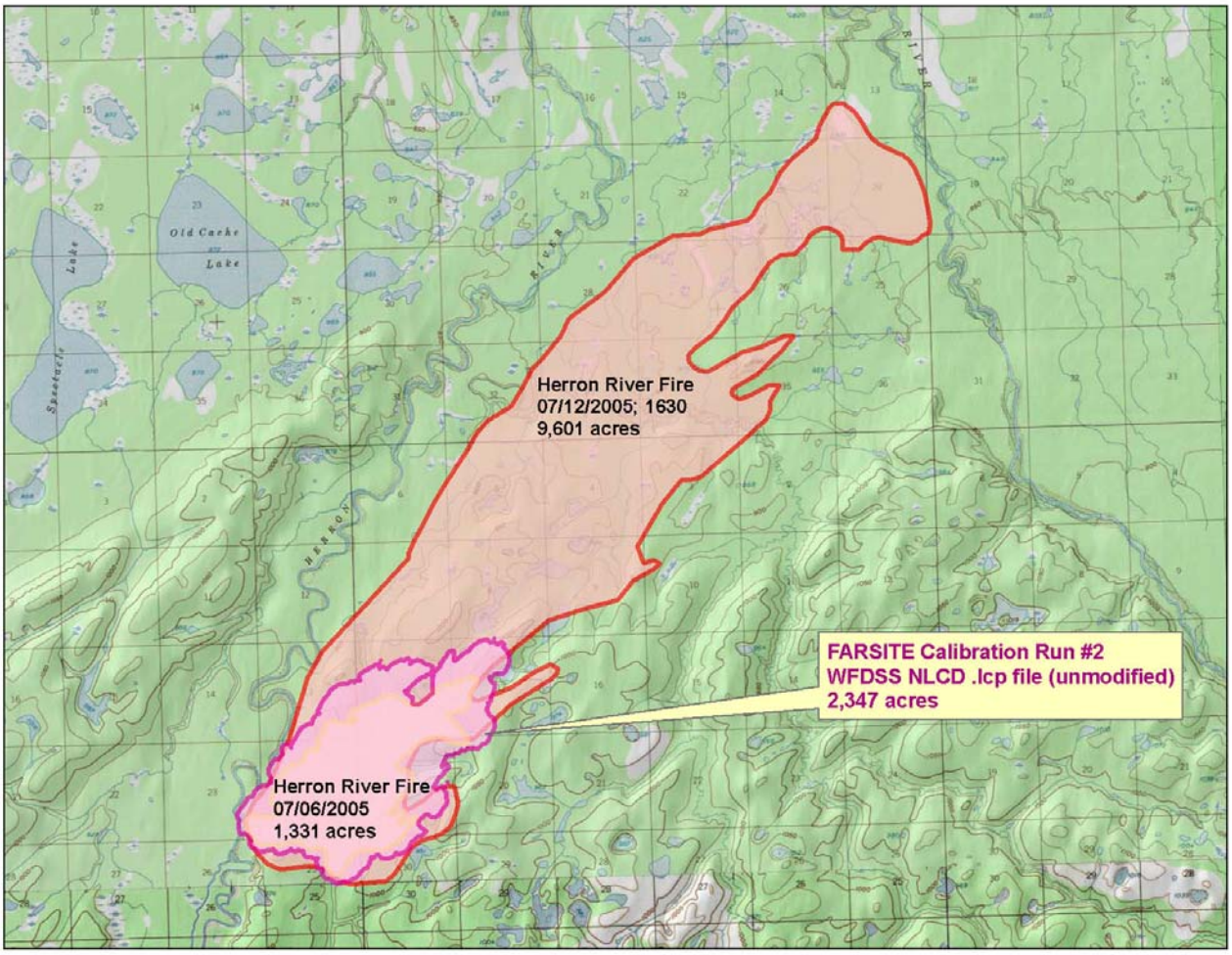
<u>Calibration Run #2</u>: Herron River Fire – WFDSS Landscape (NLCD data)

Intent: Assess modeled output using the unedited Tanana Zone .lcp file for comparison with calibration using the DENA .lcp file.

<u>Landscape File</u>: WFDSS NLCD with recent fire updates; Note the canopy base height for TU4 in this calibration run was not changed from 0.3 meters to 0.1 meters to allow for testing of the Tanana Zone .lcp file as it exists within WFDSS.

All other inputs were the same as Calibration Run #1. The results of Calibration Run #2 are shown in Map 8.

Map 8 FARSITE calibration run using WFDSS Tanana Zone landscape



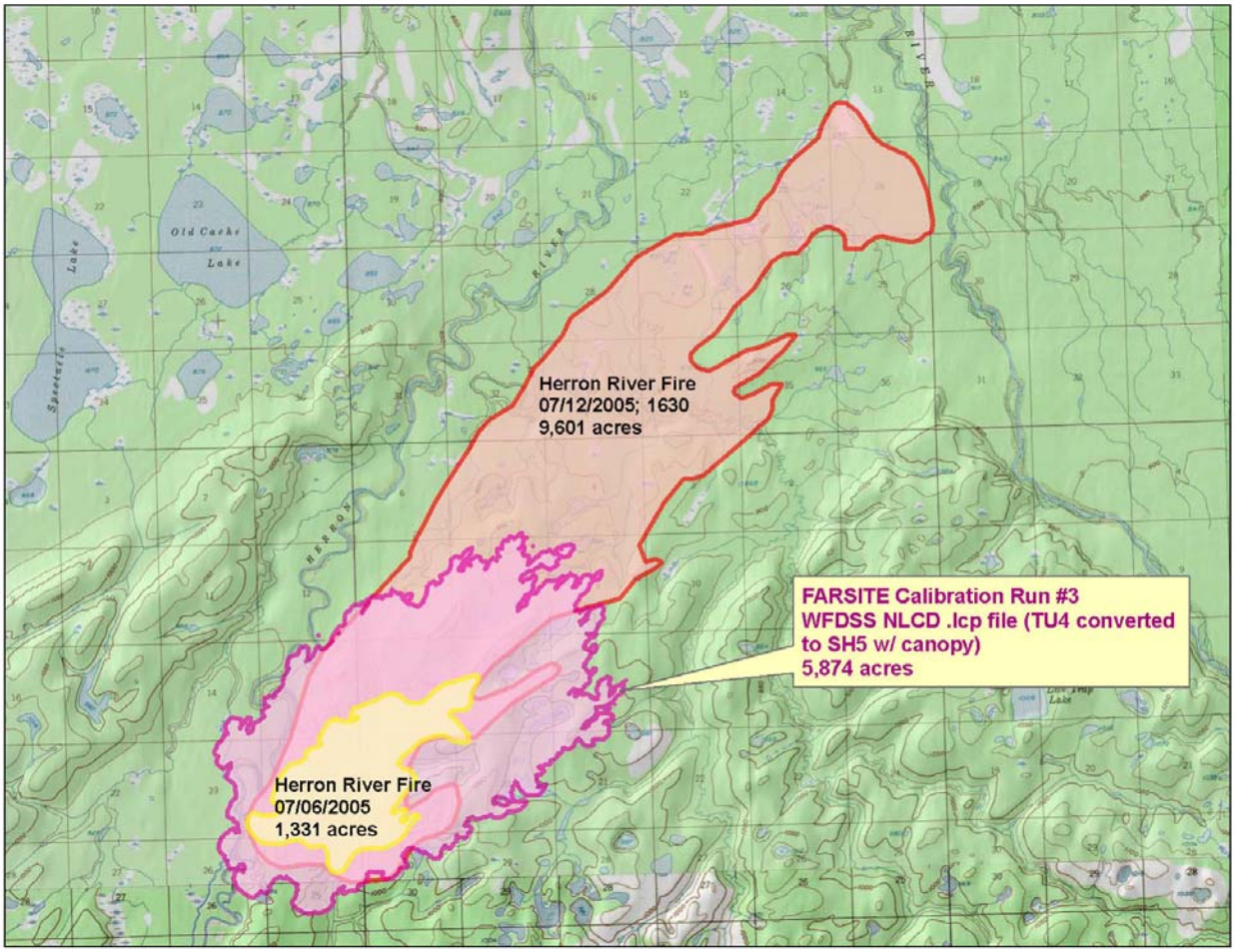
<u>Calibration Run #3</u>: Herron River Fire – Tanana Zone WFDSS landscape – TU4 to SH5

<u>Intent</u>: Assess modeled fire growth on the original Tanana Zone .lcp file with TU4 converted to SH5 as suggested by Robert Ziel (Zeke).

<u>Landscape File</u>: WFDSS NLCD with recent fire updates and TU4 converted to SH5 with canopy.

All other inputs were the same as Calibration Runs #1 and #2. The results of Calibration Run #3 are shown in Map 9.

Map 9 FARSITE calibration run using WFDSS Tanana Zone landscape and SH5

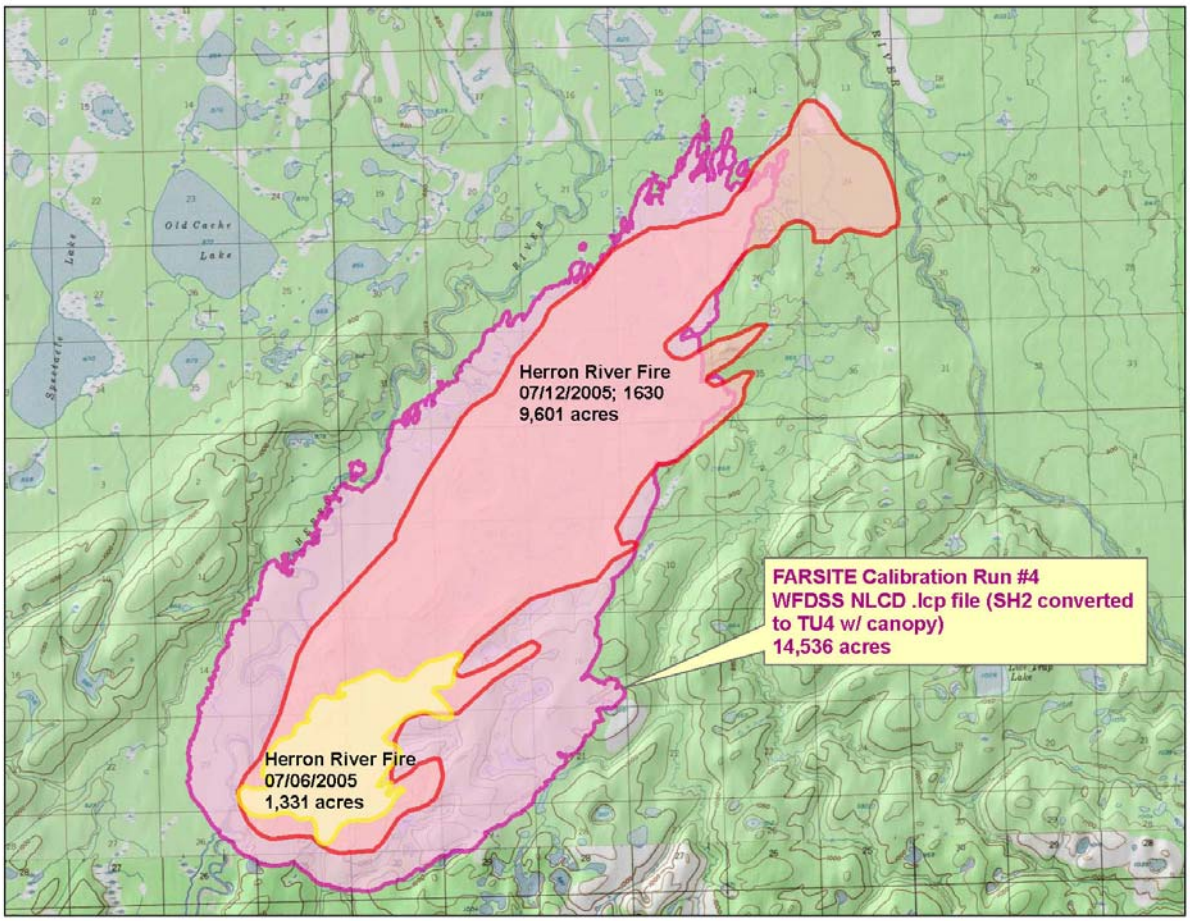


<u>Calibration Run #4</u>: Herron River Fire - Tanana Zone WFDSS modified landscape

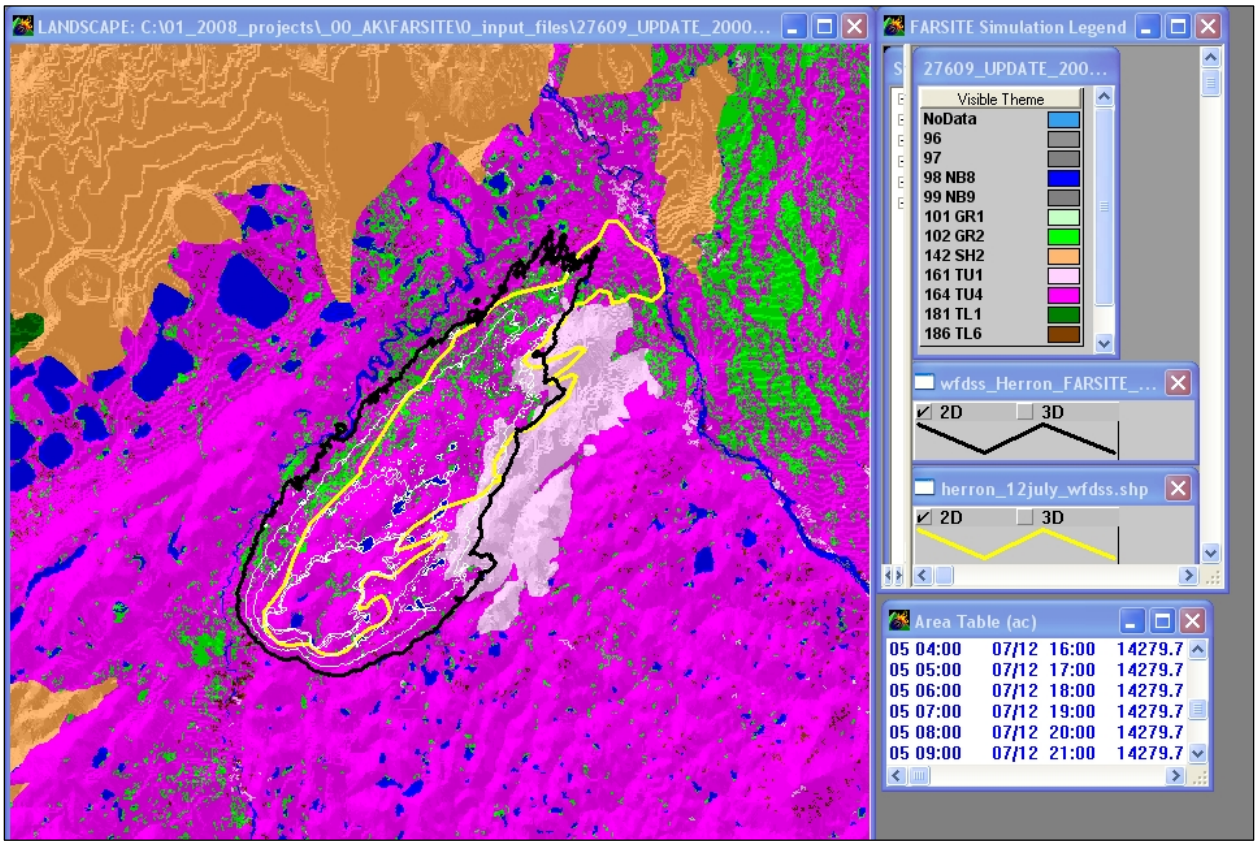
<u>Intent</u>: Develop a fix to the Tanana Zone .lcp which allows for fire growth modeling comparable to that obtained using the NPS DENA .lcp file.

<u>Landscape File</u>: WFDSS NLCD w/ recent fire updates and SH2 (shrub/scrub) converted to TU4 with canopy. In addition, areas previously designated as SH2 were given the following canopy characteristics: stand height = 4 meters; canopy base height = 0.1 meters; crown bulk density = 0.1 kg/m^3. The lower stand height and crown bulk density values (relative to other areas designated as TU4 by default) were meant to capture the more woodland/open nature of these likely-spruce dominated areas which were lumped into the Shrub/Scrub class in the NLCD dataset. Spotting frequency was set to 2.0% instead of 0.9% but all other inputs were the same as Calibration Runs #1, #2 and #3. See Maps 10 and 11.

Map 10 FARSITE calibration using WFDSS landscape changed to make Shrub/Scrub TU4



Map 11 Five day FARSITE calibration screen capture of the Herron Fire with Shrub/Scrub as TU4



<u>Calibration Run #5</u>: Herron River Fire – WFDSS modified landscape with TU4 changed to FM15

<u>Intent</u>: To test custom fuel model 15 and compare results to TU4. This calibration utilized FARSITE custom fuel model (FM15) which was based on Rodney Norum's research for predicting fire behavior in Alaska black spruce. FM15 was developed several years ago by Alaska Fire Behavior Analysts (FBANs) to have flame lengths similar to standard fuel model 5 and the rate of spread of fuel model 9 with an adjustment factor of 1.2. This custom model was created before the 2005 Scott-Burgan standard fuel models were developed. Custom fuel models cannot be used in WFDSS.

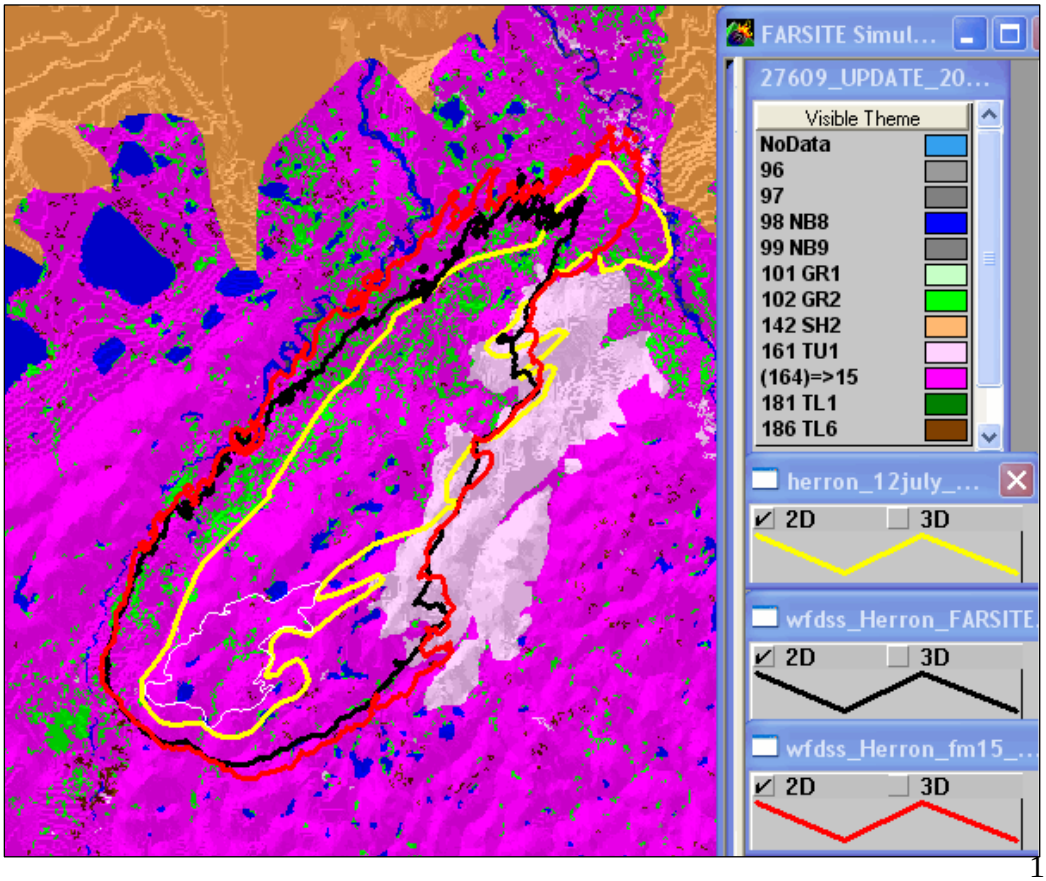
<u>Inputs</u>: All the exact same inputs were used for this calibration run as were used for Run #4 except that a custom fuel model file (.fmd) consisting of FM15 was used. TU4 was then converted to FM15. Map 12 below shows FARSITE calibration results of both TU4 (black perimeter) and custom FM15 (red perimeter).

Table 4 Parameters for custom fuel model 15 assigned to black spruce land cover

Category	Value	Units
1 hour fuel loading	2.46	Tons/Acre
10 hour fuel loading	5.44	Tons/Acre
100 hour fuel loading	2.87	Tons/Acre
Live Herbaceous	1.00	Tons/Acre
Live Woody	3.00	Tons/Acre
1 hour surface to volume ratio	3500	/Ft
Live herbaceous surface to volume ratio	1500	/Ft
Live woody surface to volume ratio	1500	/Ft
Fuel bed depth	1.5	Ft
Heat Content (dead and live)	8000	Btu/lb
Moisture of extinction	15	%

Map 12

FARSITE calibration with TU4 converted to custom FM15 shown in red. The black line is the perimeter from the TU4 calibration



Discussion

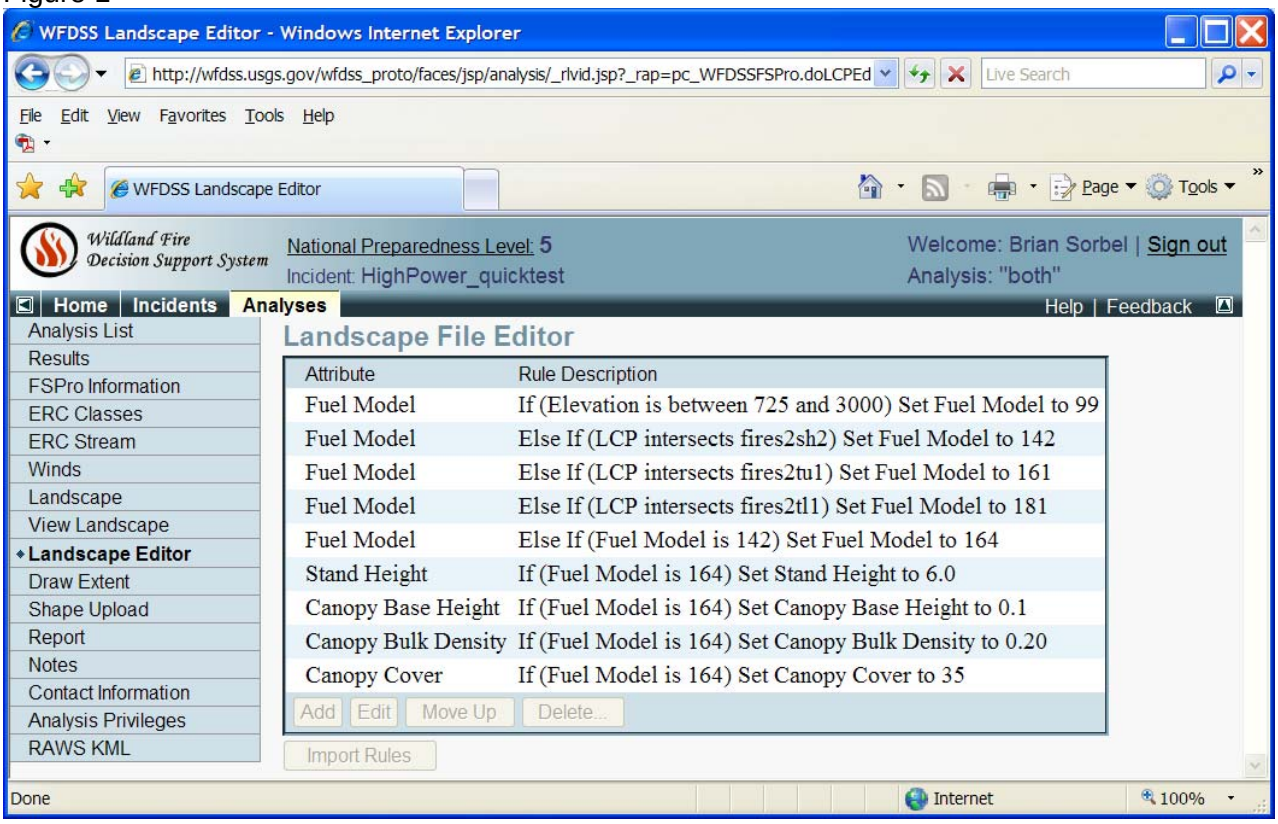
Good results were obtained with calibration using the Denali .lcp file. However, this was not the case when using an unmodified version of the NLCD Tanana Zone .lcp file that resides in WFDSS. A primary weakness of the NLCD dataset for Alaska, and of any .lcp files derived from it, is that the Shrub/Scrub class appears to have been significantly over-mapped. On a statewide level, and, more specifically, within the extent of the Tanana Zone .lcp file, the shrub/scrub class is the dominant landcover class in the NLCD dataset.

In the area around the 2005 Highpower / Herron River fires, several areas that were called Open-Woodland Spruce Forest or Open-Woodland Stunted Spruce in the Denali Landcover map were assigned the Shrub/Scrub class in the NLCD dataset. It appears that the NLCD Shrub/Scrub class encompasses both areas that are truly shrubs as well as more open spruce and stunted spruce forests. Within the Tanana Zone .lcp file, the Shrub/Scrub class has been assigned to the SH2 fuel model. Due to errors in mapping of the Shrub/Scrub class, it appears that more appropriate fuels inputs and better fire behavior modeling outputs can be achieved by assigning the Shrub/Scrub class to the TU4 fuel model and incorporating a set of woodland/open black spruce canopy characteristics as described in Calibration #4.

Fire Spread Probability (SPro) Calibration

FSPro calibration runs were completed on the Herron River fire during the same time period: July 7 – 12, 2005. The Tanana Zone .lcp file within WFDSS was edited so that areas previously assigned a SH2 fuel model were given a TU4 model with canopy characteristics similar to the edits made to the .lcp file in FARSITE Calibration Run #4. Figure 1 shows the edits that were made to the Tanana Zone .lcp file within WFDSS.

Figure 1



Three calibration runs were completed for the Herron River fire. The primary difference between the calibration runs was in the type of winds that were used in the weather forecast inputs: Ten Minute Average, Gusts or Both. The first run was completed using Ten Minute Average wind inputs. The wind input values were obtained from the Western Regional Climate Center. The weather forecast inputs for the six day period July 7-12 and resulting FSPro calibration run are shown in Figures 2 and 3.

Figure 2 Forecasted weather stream using 10 minute average winds

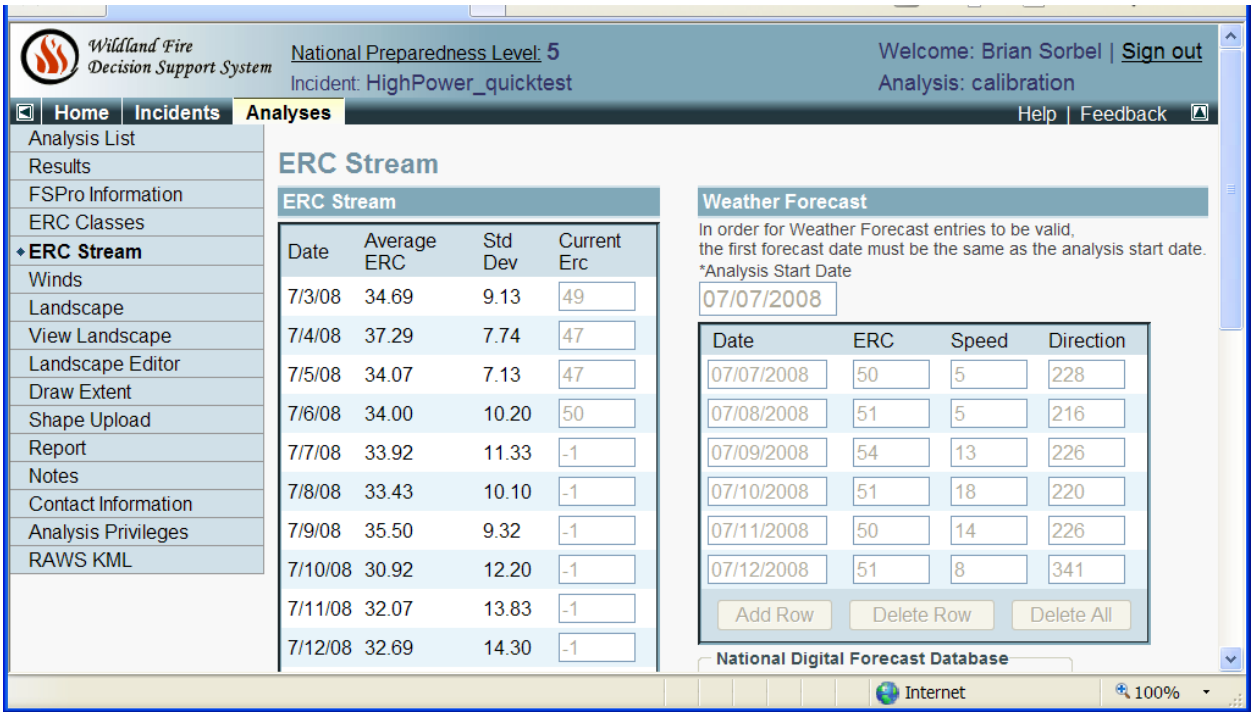
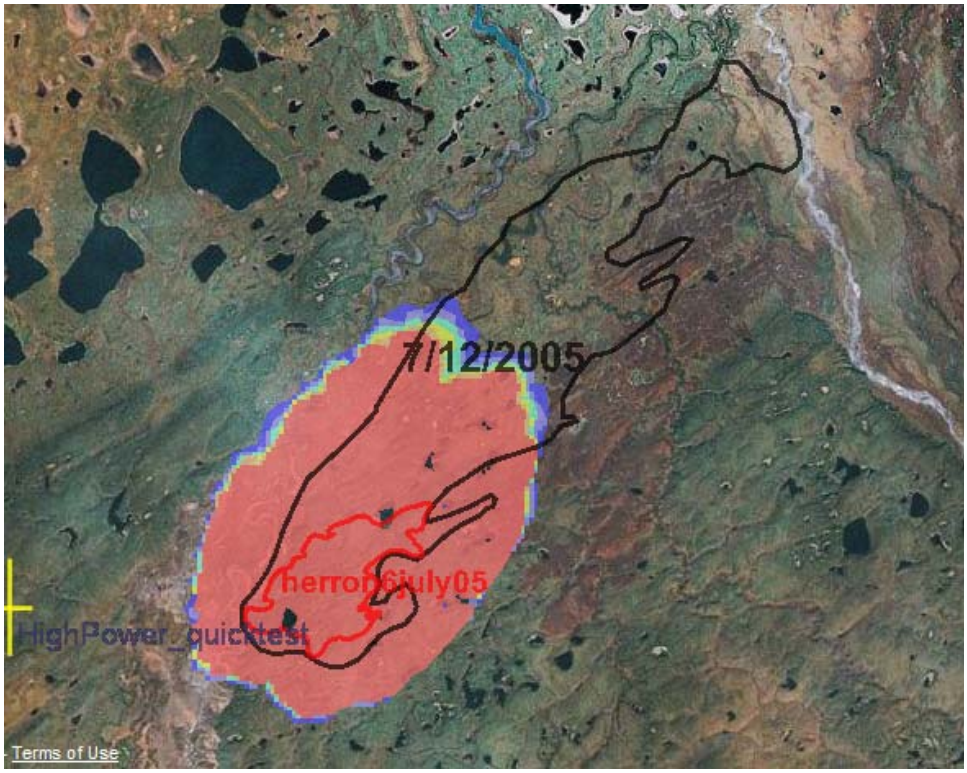


Figure 3

FSPro calibration run using 10 minute average windspeeds



The second run was completed using “Gusts” as the wind input. The weather forecast inputs with gusts and resulting FSPro calibration run are shown in Figures 4 and 5.

Figure 4

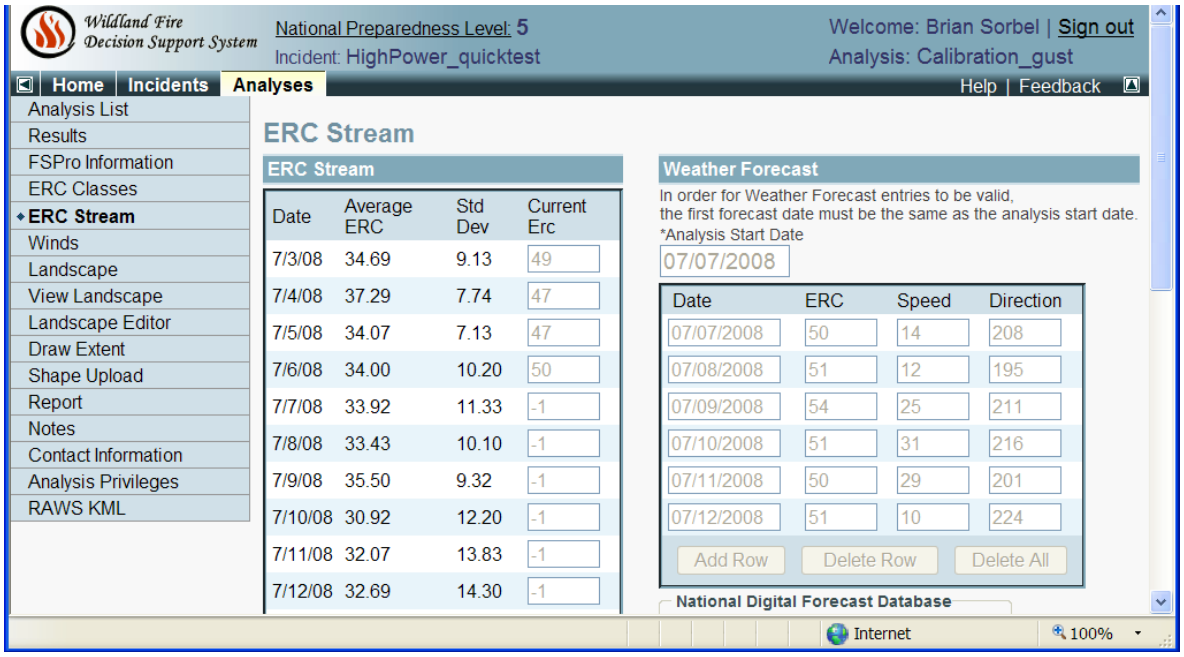
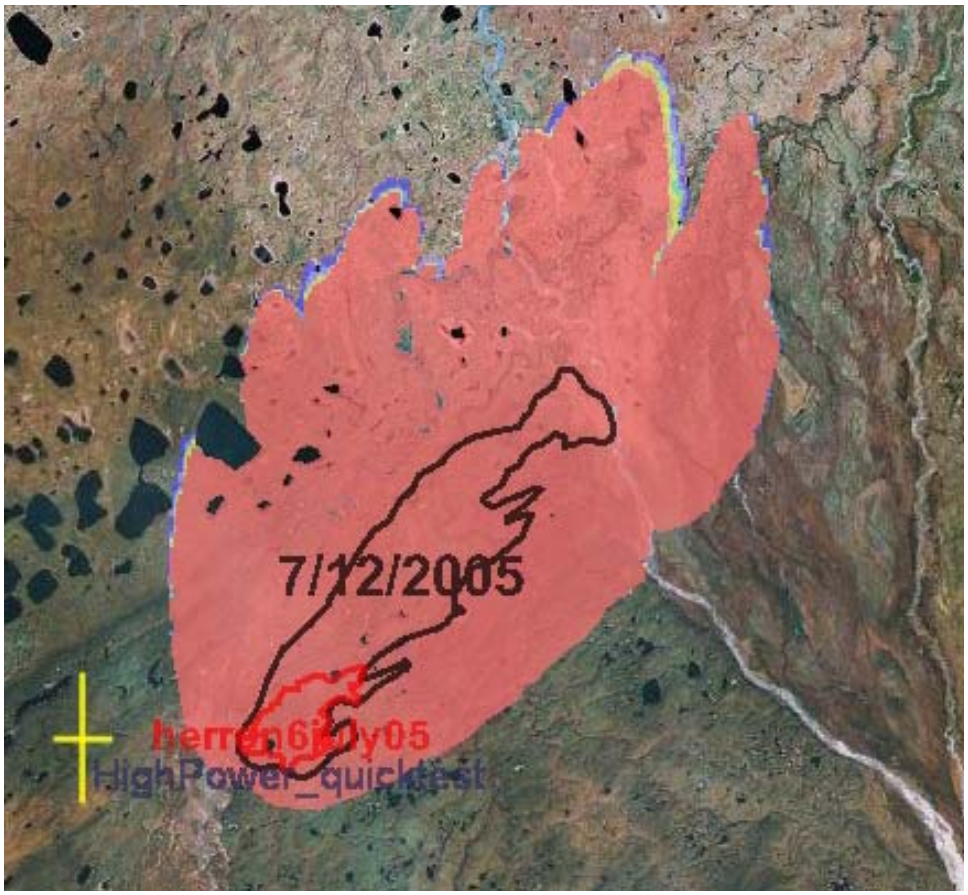


Figure 5

FSPro calibration run using wind gusts



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The third run was completed using wind inputs that were an average of the 10-minute average value and the gusts value (denoted as 'Both' in FSPro). The weather forecast inputs with "both" and resulting FSPro calibration run are shown in Figures 6 and 7.

Figure 6

Forecasted winds utilized an average of the gusts and 10 minute average winds.

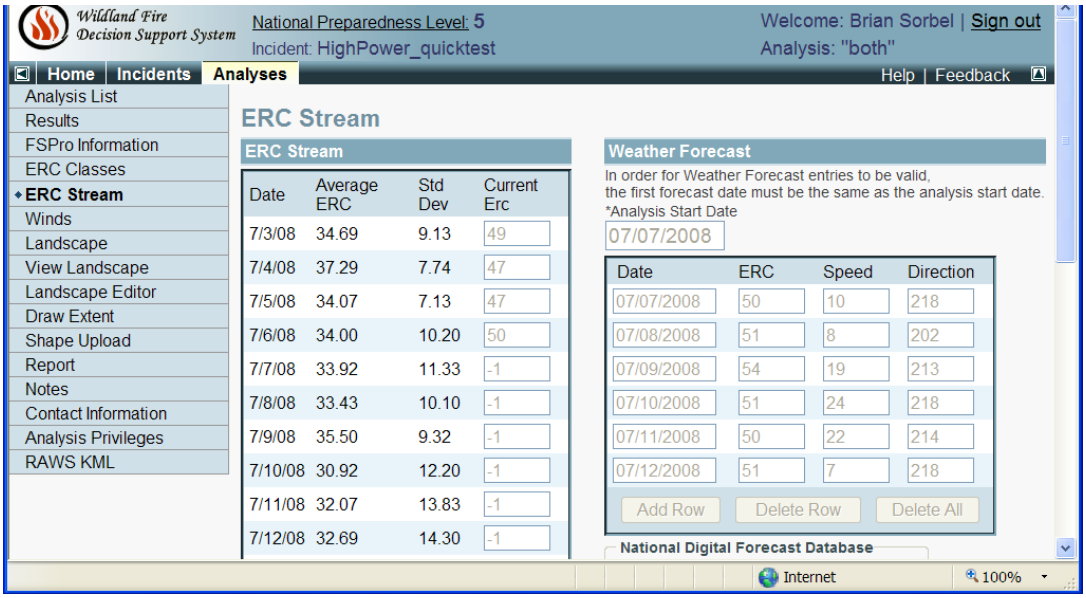
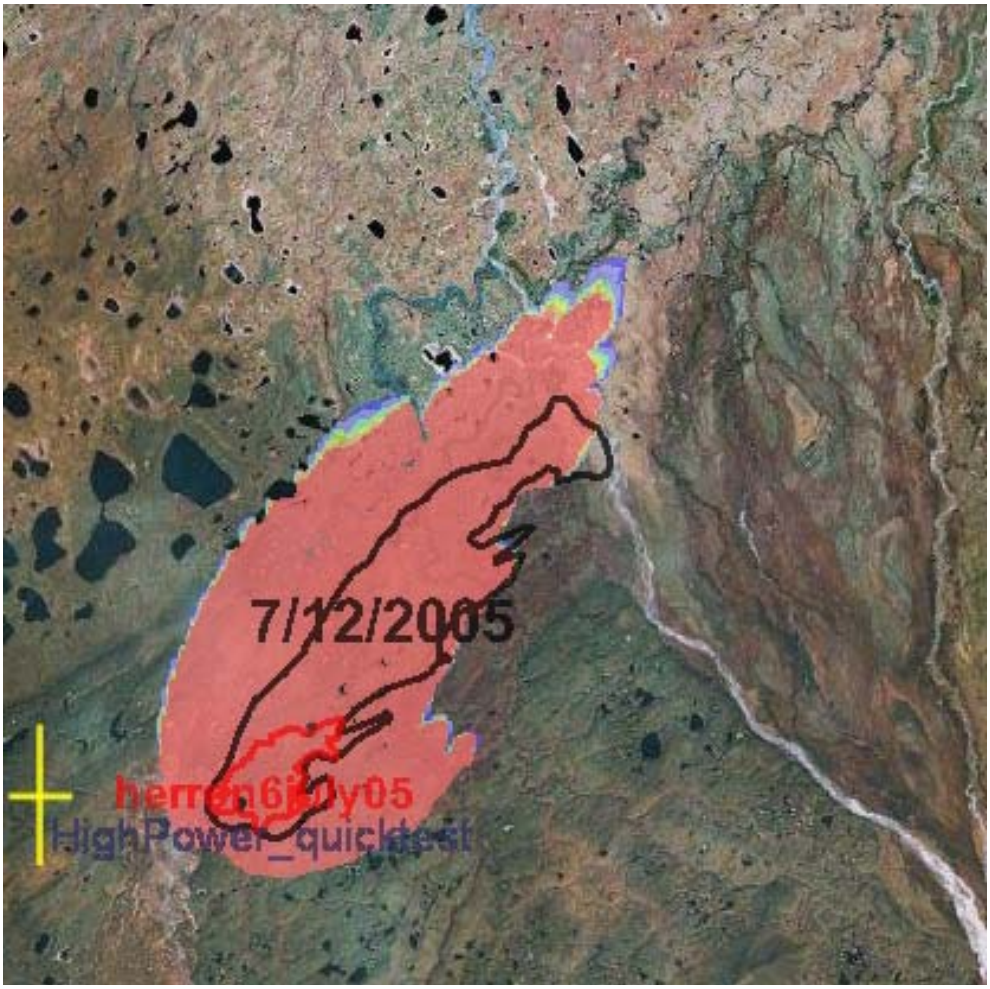


Figure 7

FSPro calibration run using "both" winds



Discussion

The landscape edits to the Tanana Zone .lcp file combined with a wind option of "Both" produced satisfactory FSPro calibration results. Based on these results, it appears that the SH2 to TU4 landscape file modification for the Shrub/Scrub type, which produced positive results in FARSITE also yields positive results in FSPro. In addition, it would appear that the default wind option for FSPro analyses in black spruce should likely be "Both" rather than Ten Minute Average.

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