Modeling Fire Growth Potential in the Alaskan Taiga

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The Story

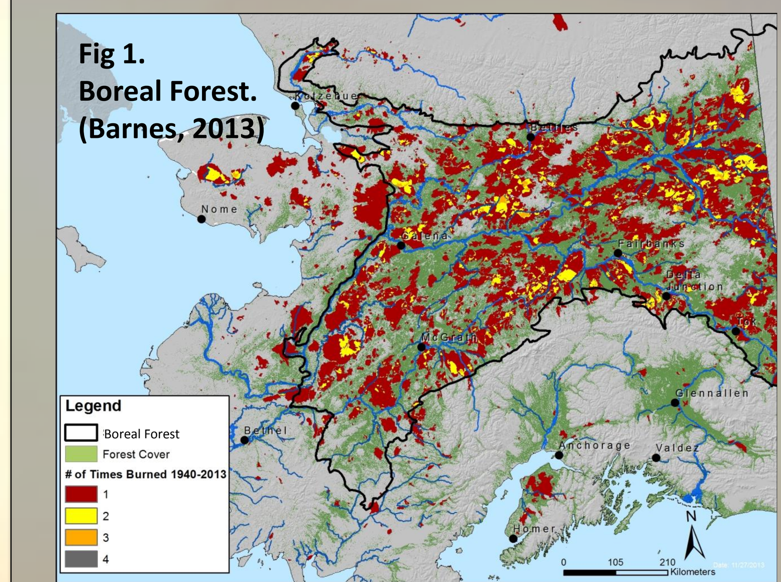


Fig 1. Boreal Forest. (Barnes, 2013)

Fire management in Alaska, owing to its experience with large fire growth on remote wildlands, requires effective fire potential assessment to prioritize resource usage and incident strategies.

With nearest neighbors Yukon Territory and British Columbia having similar problems in the Boreal Forest, Alaska fire protection agencies followed their lead and adopted tools from the Canadian Forest Fire Danger Rating System (CFFDRS) for day-to-day decisions.

Fig 2. Black spruce

Implementation of the Wildland Fire Decision Support System (WFDSS) as the primary manager's resource for incident decisions brought spatial analysis tools that have been employed since 2008. Spatial analyses in the system highlight just how difficult it is to predict growth over days and weeks in the boreal forest.

Almost immediately modeled growth in black spruce became an issue, due to its boom and bust growth pattern. Debates about fuel model selection (tu4 – dwarf conifer or sh5 - fire behavior like FBP C-2) and associated fire environment inputs continue to this day among experienced analysts and firefighters.

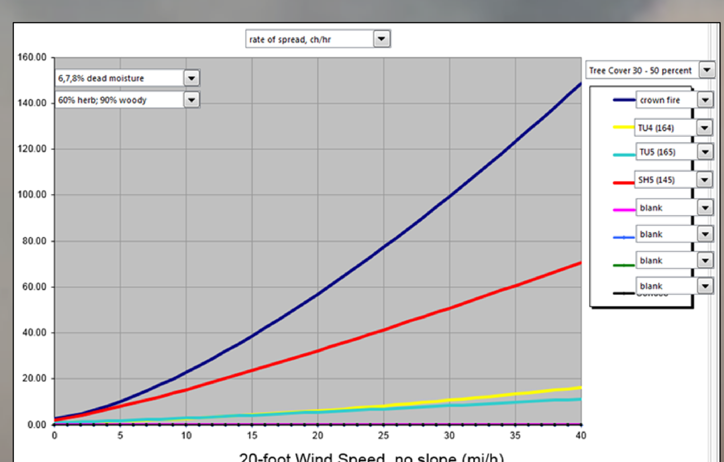


Fig 3. CompareModels495, (Scott, 2009)

The Idea

WFDSS analysis tools utilize US models, such as the National Fire Danger Rating System (NFDRS), LANDFIRE fuel model depictions that cover the landscape, and the Rothermel spread models.

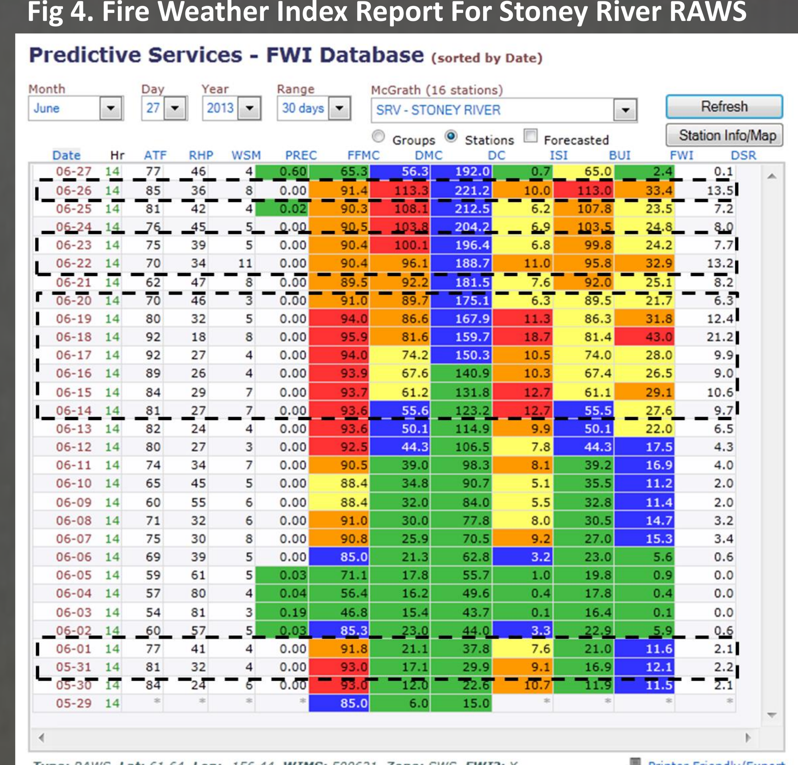
At the same time, Alaska fire managers are quite satisfied with what CFFDRS models tell them about daily fire potential.

This table is an example of many reviewed during 2013. Including daily FWI codes for the Stoney River RAWS, it also highlights growth days (marked with black dash boxes) on the Lime Hills fire nearby. It shows a clear correlation.

Figure 5 highlights an approach to modeling growth that accounts for this boom and bust growth pattern by limiting growth to certain days based on FWI criteria.

Could this approach, using FWI data from Alaska to identify growth days, be applied to WFDSS analysis tools?

Fig 4. Fire Weather Index Report For Stoney River RAWS



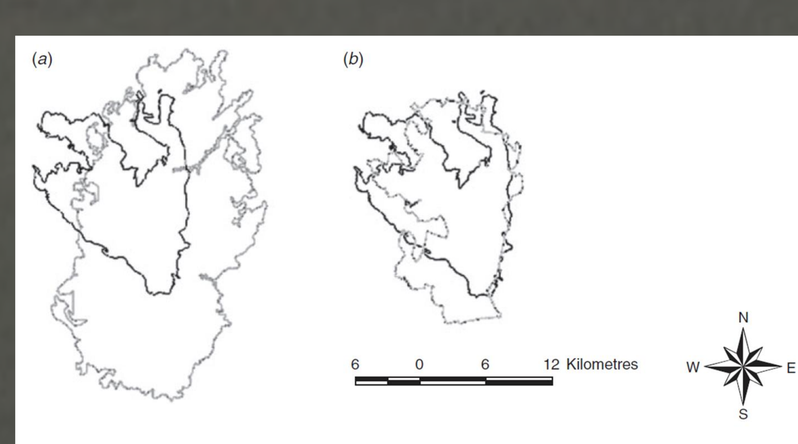


Fig. 1. The actual burn perimeter for Chapleau-1-1999 (19 745 ha) is shown in (a) as a black outline. Superimposed (in grey) is the PROMETHEUS-predicted perimeter where the fire was allowed to grow without spread-event considerations from ignition to being under control (53 154 ha). The PROMETHEUS-predicted perimeter (grey) in (b) where a spread event Initial Spread Index (ISI) threshold of >7.5 (22 180 ha) is used is closer to the real fire perimeter (black) that is superimposed.

Fig 5. From *"Podur Justin, Wotton B. Mike (2011) Defining fire spread event days for fire-growth modeling. International Journal of Wildland Fire **20**, 497–507."*

The "Facts"

Since 2001, Moderate Resolution Imaging Spectroradiometer (MODIS) data has been used to detect active fires. With over 160,000 detects in Interior Alaska, it presents one data source that is identified both spatially and temporally. As shown in Fig. 6, the distribution of MODIS detects seems to correlate well with acres burned.

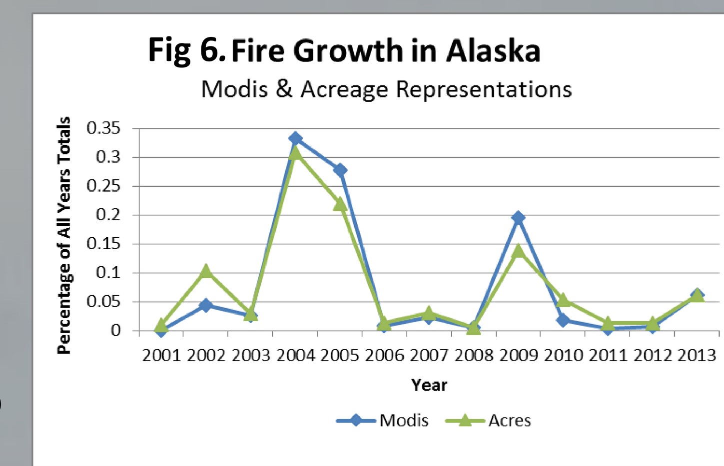


Fig 6. Fire Growth in Alaska

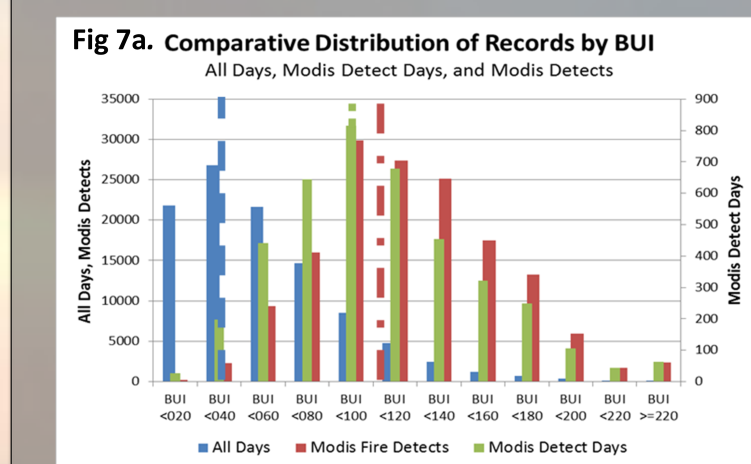


Fig 7a. Comparative Distribution of Records by BUI

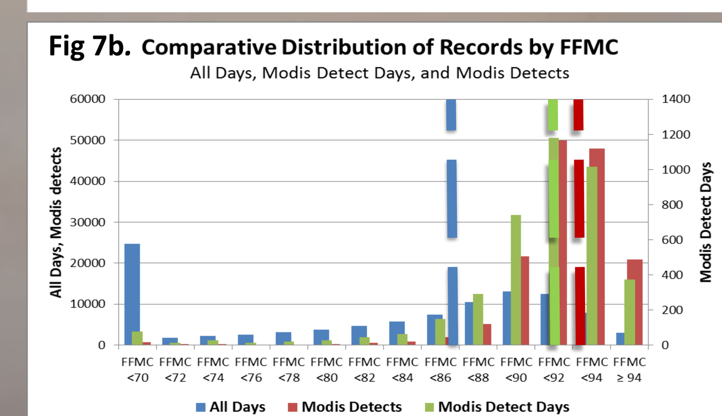


Fig 7b. Comparative Distribution of Records by FFMC

Linking these MODIS detect points with the daily Fire Weather Index (FWI) codes and indices for the nearest weather station based on date and time allows for correlation between the two data sets.

Comparative distribution graphs in Fig. 7a and 7b highlight the utility of both the Buildup Index (BUI) and Fine Fuel Moisture Code (FFMC) in predicting increased potential for active fire as represented by MODIS detects.

Other factors (wind, temperature, Initial Spread Index/ISI) were considered less predictive based on the widely spaced weather observing locations and temporal variability.

Figure 8 shows the frequency of Modis fire detection according to different FFMC and BUI combinations in Interior Alaska from 2001 to 2013.

From this graph, a "Fire Growth Day" could be predicted as any day with an FFMC of at least 88 and a BUI of at least 80. This criteria can be used to develop a climatology of growth days as shown below.

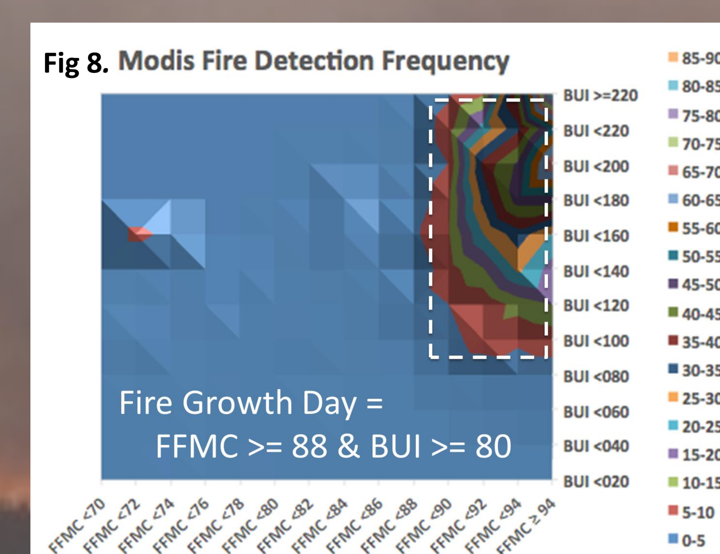


Fig 8. Modis Fire Detection Frequency

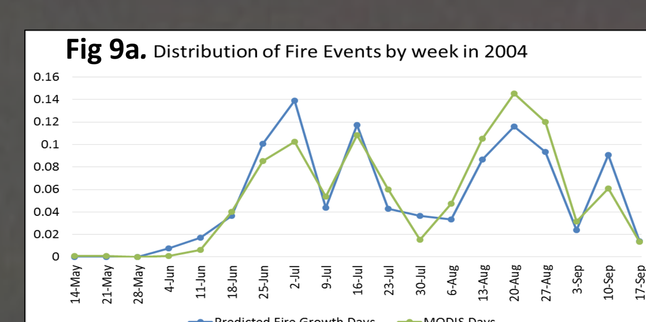


Fig 9a. Distribution of Fire Events by week in 2004

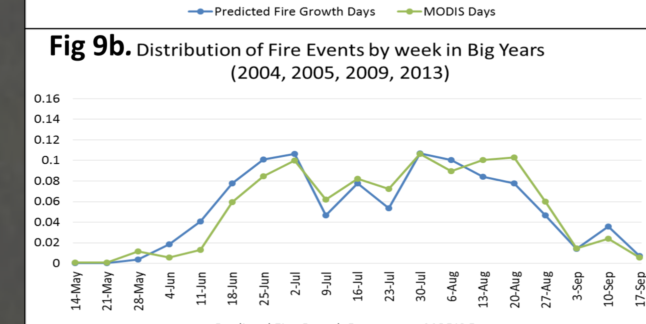


Fig 9b. Distribution of Fire Events by week in Big Years (2004, 2005, 2009, 2013)

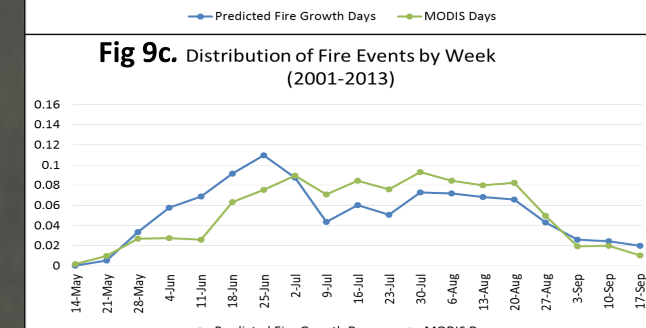


Fig 9c. Distribution of Fire Events by Week (2001-2013)

To test the validity of this definition of a predicted "Fire Growth Day", independent distributions of MODIS fire detections and Predicted Growth Days were sorted by week and year and summarized for Interior Alaska Predictive Service Areas (PSAs). The graphs in Figure 9 show the agreement between the two distributions; this time substituting days of MODIS detects for the total of MODIS hits themselves.

It must be said that the total number of MODIS detect days (4,027) is less than the total number of Predicted Growth Days (10,848). This can be attributed to a number of factors, such as the duplicate sources of MODIS data and distribution of RAWS stations.

Finally, it is possible to convert this into a "climatology" for the number of growth days per week based on the criteria identified earlier. Figure 10 shows the number of days for each week of the peak season; "predicted" for 2004 itself, the 4 big years, and all 13 years. The 40% threshold superimposed suggests peak potential for active fire years.

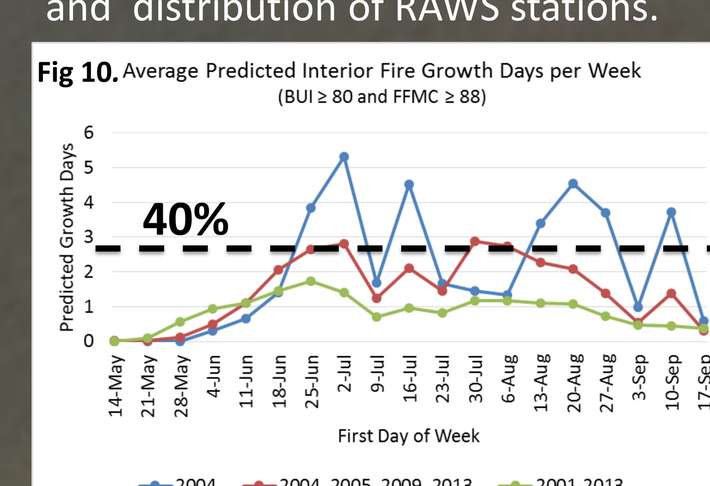


Fig 10. Average Predicted Interior Fire Growth Days per Week (BUI ≥ 80 and FFMC ≥ 88)

The Payoff

Modeling fire spread ultimately requires a basic understanding of the growth events that drive spread in a given landscape and the factors that influence those events.

In Alaska, the history of acreage burned highlights the importance of drought, where precipitation shortfalls combine with long, hot/dry days and wind events to produce large fire growth. Unlike many western US forests, the Boreal Forest of Interior Alaska includes significant hardwood and mixedwood types that slow or stop the spread of even active crown fires.

The recommendations here are intended to capture real factors of the fire environment as model inputs, minimize the need for calibration through user interpretation, and produce timely fire growth and behavior information for decision-makers.

Time of Year/Season Severity

- "Growth" or "Burnable" days are limited by editing the number of rows in Energy Release Component (ERC) Classes and the forecasted ERC values in the ERC Stream. In this Lime Hills Fire example, the top 2 bins actually include 40% of all days in the climatology for the analysis period. This needs to be evaluated in the Event Coverage Report from a preliminary scoping analysis and then revised in subsequent analyses for same date & duration.

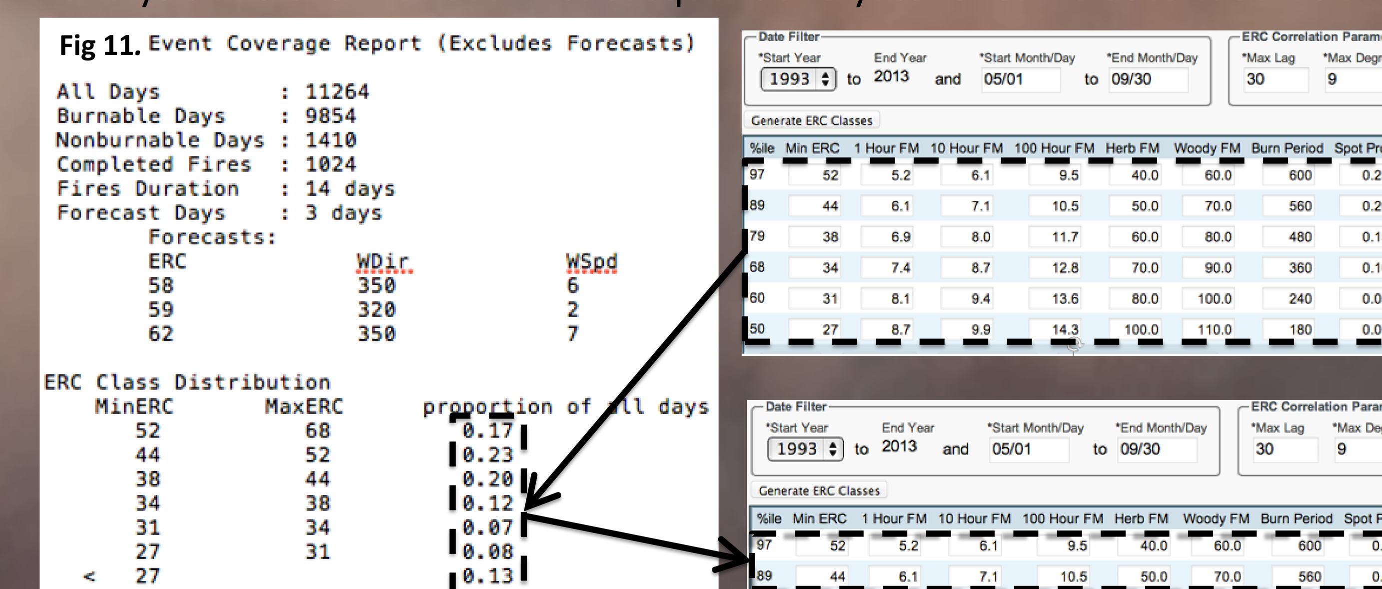


Fig 11.

With 2 bins, less variance needed here

- Burn Period should reflect day length factors, important in Alaska.
- Herb FM should reflect current curing
- Woody FM should reflect known trends in either spruce or broadleaf shrubs, based on which is driving fire spread. With sh5, the shrub is spruce.

Fuels & Barriers to Spread

Fuels & Barriers to Spread are critical drivers of modeling in the boreal landscape. Black spruce exhibits explosive growth while hardwoods serve as fire slowing barriers. Burn scars are everywhere. And cured/curing tussock can carry fire under lighter winds

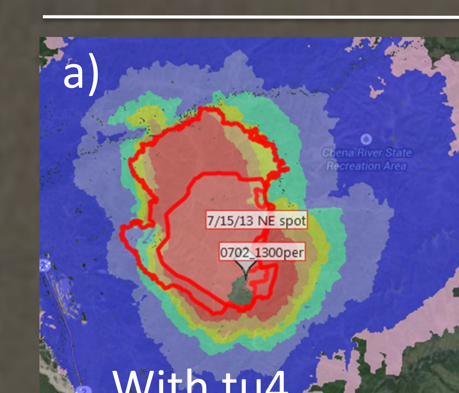
- Use sh5 (145), which matches FBP C-2 behavior, instead of tu4 (164)
- Evaluate representations of hardwood/mixedwood types on the landscape to insure reasonability
- Map Rivers and streams as barriers

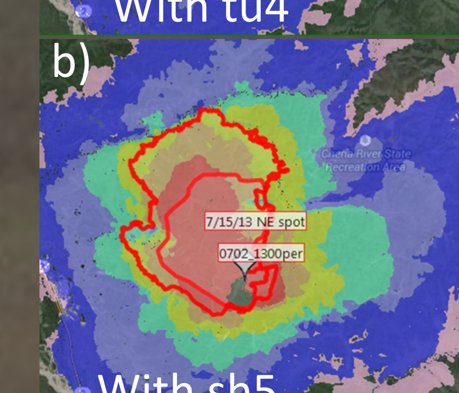
Day to Day Fire Environment

Day to Day Fire Environment changes with the ERC Stream and wind rose frequencies. Use FWI growth day criteria to set ERC in forecast

- Winds have the largest impact on the spread models. Insure forecast speed and direction and the Wind Rose are the best they can be.
- Dead Fuel Moistures, along with winds, can be drivers of day to day variation. Use the two bins to differentiate good from great days

Spotting Probability for fine tuning





Stuart Creek 2 - 14day FSPro from June 30th

These two depictions compare analyses a) using conventional calibrations with tu4 (164) and b) limiting burnable days/burn periods with sh5 (145).

- Smaller high probability contour (red) in b) reflects growth due to 3-day forecast more clearly than a).
- Unburned area in NE corner of b) reflects stronger influence of burn scar than a) due primarily herbaceous fuel moisture settings, fuel model selection and burnable days.
- Wind rose plays a larger role in b) with increased probabilities to the east due to SW and W winds.
- Stuart Creek 2 actually experienced intermittent growth events on 6/30, 7/1, 7/6, 7/7, and 7/13 .