## Appendix C: Using Science and Technology to Inform Decisions

As wildfires become increasingly complex, the use of science-based tools to evaluate and understand risks and potential impacts becomes increasingly important. The wildfire community has been using fire behavior models since the early 1980s, although the computer interface has advanced from punch cards and significant delays in obtaining predictions to laptop programs, such as BEHAVE+ that allow for near-instantaneous predictions. Advancing tools have taken us from simple tables of output to maps and graphs of outputs and from not incorporating any resource values to incorporating a host of natural, cultural, and infrastructure resource values. The advent of LANDFIRE, a series of data layers for vegetation, greatly facilitated the development of a number of fire behavior, smoke dispersion, and fire effects tools used to support decisions made during and after a wildfire. Many of the current science-based productions are most useful for long duration fires in forests.

### Wildland Fire Decision Support System (WFDSS)

The Wildland Fire Decision Support System (WFDSS, pronounced woof’-dis) represents the current state-of-the-art with respect to estimating fire behavior, such as rate-of-spread and flame length, as well as the probabilities that a given fire or group of fires will spread in different directions and potentially impact various resources such as homes, commercial timber, and endangered species habitat. WFDSS also serves to document the incident goals and objectives for a fire or complex of fires and the decisions made about how to manage a fire or complex of fires.

WFDSS provides four levels of geospatial fire behavior projections:

* Basic Fire Behavior – estimates fire behavior for every cell in the analysis area based on simple weather and fuel moisture inputs. Answers questions about potential fire behavior such as expected flame lengths, whether any crown fire would be active or passive, and how will fine fuel moisture vary across the area.
* Short-Term Fire Behavior – uses one set of wind and fuel moisture inputs, estimates fire spread pathways and arrival time of a fire over a period of hours. Answers such questions as how far will the fire travel over x hours with a stready y mph windspeed.
* Near-Term Fire Behavior – Uses weather and wind inputs that change over the analysis period to estimate fire spread and fire behavior, such as flame length. The analysis period is limited to a maximum of seven days, but most runs are for three days. Answers such questions as how far might the fire spread over the next three days given the weather forecast for that period.
* Fire Spread Probability, or FSPro – uses weather and long-term climate records to produce multiple simulations of fire spread. The analyst controls many aspects of the fire such as emplacing barriers to fire spread, adjusting spotting potential, using or not using terrain to modify windspeed and direction, and adjusting fuel models to better reflect actual conditions. Projections can be set for any length of time but are most commonly run for 7 to 14 days using three days of forecasted weather to start the run and then historical climate data for the remainder of the analysis period. Answers questions such as the probability that a given cell will burn and the probability that the fire will reach designated points of concern over the analysis period, as well as probabilities of the fire reaching various sizes.

In all cases, the fire behavior projections assume no suppression actions are taken. These simulations help the firefighting team establish location or weather thresholds for initiating certain types of actions, ranging from evacuations to wrapping small, isolated structures to allow them to survive passage of the fire. In addition to fire behavior, WFDSS allows users to analyze historical weather and determine the probability of when the season may end.

WFDSS also includes a relative risk rating that evaluates how high or low the overall risk of the fire is given values at risk and their proximity to the fire along with other social and political concerns; the hazards posed by fuel conditions, expected fire behavior, and the potential for fire growth; and the probability based on the time of year, barriers to fire spread, and current seasonal severity relative to a “normal” fire season. Each time WFDSS is updated, a new risk assessment can be prepared, allowing the decision-maker and the firefighting team to see how risk is changing over time on a given fire.

Lastly, WDFSS creates a recommended incident organization based on the relative risk rating, the difficulty in implementing the course of action described, and social-political concerns related to the fire, such as mixed ownerships potentially or actually involved. The result is a recommended incident organization, such as a type 2 or type 1 incident management team.

### Smoke Forecasting

Wildfire smoke is a significant concern for air quality regulators and the public. The fire management community and air quality regulators now have access to a number of smoke modeling tools to assess expected smoke production, transport, and dispersion in near-real time.

### Risk Management and Assistance Teams (RMAT)

In 2017, the Forest Service began testing the use of Risk Management Assistance Teams to help managers, cooperators, and the public better understand the risks posed by large and complex fires. RMATs evaluate alternative management strategies for a fire to better display tradeoffs, risks to highly valued assets, and opportunities for fire benefits. The primary areas covered by RMATs include fire behavior and weather, tradeoffs of alternative courses of action with respect to firefighter safety and incident objectives, and aviation effectiveness and suppression difficulty.

RMATs help determine priorities when dealing with multiple fires through the development of exceedance probability curves. Using a risk assessment, the team identifies the locations and lists of values that warrant protection from fire and then uses FSPro in WFDSS to estimate the probability that the fire will reach the locations of those values. Exceedence probability curves can be used by a local unit, area command, multiagency command, geographic coordination center, or agency to establish which fires should receive scarce firefighting resources.

RMATs in the Pacific Northwest have been using the 2017 draft Quantitative Risk Assessment product to inform a variety of analyses concerning long-duration fires and multiple fires. The Quantitative Risk Assessment product was developed last winter and spring by refining the LANDFIRE fuels layer, identifying the high value resources and assets, developing expected changes in value should a fire reach the identified resource or asset, and ranking the relative importance of the results.

Typical assets include items such as homes, communication sites, transmission and distribution lines, railroads, major roads such as interstates and state highways, developed and dispersed recreation sites, ski areas, historical structures, seed orchards, and mills. Typical high-valued resources include elements such as commercial timber, municipal watersheds, federally threatened or endangered species habitat, and sensitive species habitat such as greater sage-grouse. Assets and resources typically respond differently to fires of different intensity, with some resources benefitting from some fire intensities, generally lower intensities, but harmed by other fire intensities, generally higher intensities. The final product is a risk map that displays an overall expected net change in the value of assets and resources, integrating the expected change across all fire intensities and all values in a given map pixel.

For example, an RMAT evaluated 65 fires on the Umpqua, Willamette, Deschutes, and Ochoco National Forests in mid-August. This analysis used a 7-day FSPro run that included 3 days of forecasted weather, 3,000 runs, and the effects of previous fires and containment lines (figure x). It assumed no suppression actions were taken on the 30 fires simulated.



Seven-day FSPro results for several fires on the Umpqua National Forest

The team grouped the fires into seven clusters to evaluate the expected net loss or benefit (figure x). This analysis indicates that the northern Umpqua (UPF North) and the Willamette (WIF North and WIF South) are most likely to see the highest net loss over the next seven days in the absence of any suppression action. The southern Umpqua (UPF South) and southern Rogue River-Siskiyou (RSF South) were expected to see mild to moderate loss, while the northern Rogue River-Siskiyou (RSF North) could see a mild loss in the absence of any suppression action. Further, the expected loss on the northern Rogue River-Siskiyou expected losses were half those expected for the southern Umpqua and southern Rogue River-Siskiyou. Conversely, the Deschutes and Ochoco National Forests (DEF/OCF) were expected to see a net resource benefit from the two fires assessed (Milli and Belknap). As a result, the recommended priority for firefighting resources was:

1. UPF North
2. WIF South
3. WIF North
4. UPF South/RSF South
5. RSF North
6. DEF/OCF



### Rapid Assessment of Vegetation Condition after Wildfire (RAVG)

To inform the short-term management needs post-fire, fires that occur in forests can take advantage of RAVG. The Geospatial Technology and Applications Center produces estimates of tree mortality within 45 days of fire containment for all fires that burned at least 1,000 acres of National Forest System lands. RAVG estimates the change in tree basal area, grouping the change into seven categories and then mapping it into four categories (0-24.9% loss, 25-49.9% loss, 50-74.9% loss, and 75-100% loss). Forest managers use this information to support assessments of reforestation needs, and whether and where salvage of burned trees might be appropriate.

### Infrared Mapping

Infrared, or thermal, mapping is widely used to track wildfire growth and identify hotspots, otherwise undetected spot fires, and the hottest part of the fire. Infrared technology has advanced greatly in recent years. The National Interagency Fire Center in Boise staffs and maintains the National Infrared Operations Unit. The unit consists of aircraft, thermal imaging cameras, infrared interpreters, and geographic information systems. The aircraft fly over several fires, usually at night, and download the imagery to the interpreters who convert the splotches, sqiggles, and dots into the fire edge, hotspots, rocks, roads, streams, and other terrain features into maps firefighting teams can use to develop or update daily plans for managing the fire as well as tracking the size of the fire.

### Drones

Drones can be both a blessing and a curse on wildfires. Recreational use of drones has increased tremendously and when these drones stray into the closed airspace over a fire, they present a significant collision risk to the firefighting aircraft. Drones are hard to see and operate at the same level as air tankers, helicopters, and other aircraft working on the fire. Those aircraft have to cease operations immediately, and must leave the airspace or land. If the firefighting aircraft are conducting critical operations, such as retardant or water drops, crew shuttles, and relaying critical information about the fire to firefighters, intruding drones can hurt those efforts, potentially allow the fire to spread farther than it might have otherwise, placing people, resources, structures, and infrastructure at unnecessary risk.

However, drone use on wildfires is starting to increase. In these cases, use of the drone is well-communicated with other aircraft, allowing them to stay clear of the airspace where a drone is operating. The timing of drone use can also occur outside of critical air operations. In particular, infrared detection equipment and even simple video cameras allow the firefighting team to map the fire edge and hotspots as well as provide valuable imagery of the current fire edge and what lies in the path of the fire. In extreme cases, drones can be used to locate firefighting crews that have lost communications with the main fire, as occurred in Yosemite National Park in 2013.