Welcome to Unit 8 Lesson 3: Application of FSPro in Long-term Geospatial Fire Analysis.

Previous units and lessons focused on the use of geospatial modeling systems to address short- and mid-term analyses using FlamMap and FARSITE, respectively. In this Lesson 3 of Unit 8, we will be covering the use of FSPro in long-term simulations. By the end of this lesson, the student should have a good understanding of why FSPro is suitable for these types of analyses and items to consider. The lesson will take approximately one and a half hours to complete.

It must be stressed that the Wildland Fire Decision Support System (WFDSS) and its components are still a work in progress. As such, as new updates or changes are applied, the appearance and method for acquiring information may be different than presented here. While screen captures of the most current views were used in the development of this lesson, do not be surprised if, when you access the system, there are differences from the material presented here.
Lesson objectives

- Understand the differences between FSPro and RERAP
- Understand why FSPro is appropriate for long-term simulations
- Describe and understand how FSPro settings affect modeling run time and modeling results
- Select the appropriate model settings for an FSPro long-term simulation
- Select the appropriate weather station for ERC and Winds Information

Let’s first go over the lesson objectives. Upon successful completion of this lesson, you should be able to:

1) Understand the differences between FSPro and RERAP
2) Understand why FSPro is appropriate for long-term simulations
3) Describe and understand how FSPro settings affect modeling run time and modeling results
4) Select the appropriate model settings for an FSPro long-term simulation, and
5) Select the appropriate weather station for ERC and Winds Information.
This lesson is divided into the following parts:

1) Introduction,
2) Why use FSPro for long-term simulations,
3) Long-term simulation considerations,
4) FSPro model setup,
5) Issues with 30-day simulations,
6) Selection of appropriate weather stations,
7) FSPro general information,
8) FSPro ERC Classes,
9) FSPro ERC Stream, and
10) FSPro Winds.
Previous Units and Lessons have addressed the limitations and assumptions behind each of the fire modeling systems listed here. To date, the potential uses of each of these models to answer specific management questions have been addressed. In this lesson, we will be focusing on FSPro and its use in answering long-range or long-term modeling questions. Often, these simulations have modeling durations in excess of seven days. While FARSITE can be used to model a fire for a period of seven days, it is for only one weather scenario and for a single fire event. With FSPro, we are interested in estimating the probability that the fire may affect or impact a point of concern from a known perimeter or point over a specified period of time based on historical climatology or under uncertain weather. In this way, FSPro is unlike FARSITE or FlamMap, which use a specific weather scenario to determine whether a fire will spread in a specific direction, arrive at a specific location, or the associated fire behaviors we could encounter in a specified period of time. This is a major difference between FSPro and the current philosophy of fire modeling using geospatial models such as FARSITE and FlamMap.
WHY FSPro for Long-Term Simulations

- FARSITE
- The Rare Event Risk Analysis Process (RERAP)

While FARSITE can be used to simulate fire growth for periods of 7 days or more, it is for a single fire under only one wind-weather scenario and offers no information as to the probability of an area being impacted under multiple wind-weather scenarios. This limitation eliminates the use of this model to answer questions related to probability analysis.

In the past, the Rare Event Risk Analysis Process (RERAP) would have been used to determine the probability of risk associated with a point of concern. While RERAP was appropriate for the time, it did have its limitations. FSPro, while incorporating some of the same ideas in RERAP, is fundamentally different and a much more powerful and appropriate tool for determining fire spread probability.
Why FSPro compared to FARSITE?

- Using FSPro and historical weather info is better than FARSITE if you want to know which points of concern the fire might affect beyond the time that a weather forecast would be reliable.

- Unlike FARSITE, FSPro will simulate a single fire using historical weather to create 1000s of artificial seasons from which a probability surface is developed.

- The simulation duration should be driven by the period of interest as to when a fire could potentially impact a specific point or area.

- Long-term analysis based on probability outcomes lend themselves to dealing with uncertainty in the weather, to risk based assessments, and to strategic decision making.

With simulation durations lasting 7 or more days, we will be outside the reliability of forecasted weather information. FSPro overcomes this by generating hundreds of potential wind and weather scenarios and incorporates this information in simulating 1000s of individual fires. Ultimately, the choice of simulation duration (7 days, 14 days, 21 days, etc.) should be driven by the period of interest as to when a fire could impact a specific point or area. Long-term analysis using FSPro based on probability outcomes lend themselves to dealing with uncertainty in the weather, to risk based assessments, and to strategic decision making.
In a long-term analysis, we are interested in the probability or potential of the fire to reach or impact specific points of concern. In this example, we have multiple points of concern intersected with an FSPPro probability output for a specific time period. Each point of concern has a unique probability of being impacted during the modeled period. The Rare Event Risk Analysis Program (RERAP) would can be used to assess the probability of the fire reaching or impacting each point of concern. However, RERAP could only address the probability of each point of concern being impacted individually, based on the season end, and assumed that fire spread was only in one dimension.
The probability assessed in RERAP is for a particular point based on the season ending event, whereas in FSPro it is specific to the time period analyzed. RERAP assumed that the fire spread was in one direction and under the influence of a specific wind direction; fire spread in FSPro can reach a point from any direction as either a head, flanking, backing, or even a spot fire under the influence of winds from any direction. In most cases, fire spread modeled in only one direction may not be the fastest travel path. To adjust for current seasonal conditions, RERAP merely modified the probabilities of four specific historical averages. FSPro, on the other hand, knows the current seasonal trend and the variation of the current season compared to previous years and incorporates this information in the development of wind/weather scenarios and the artificial seasons it uses. RERAP could not incorporate spotting very easily without some ingenuity on the part of the user. In FSPro, spotting is incorporated into every simulation and can occur if fuels and weather conditions allow it. Finally, in RERAP, non-burnable fuels along any transect ensured a very low probability of the fire reaching a point of concern unless the modeler was creative in dealing with these fuels. In FSPro, because fire spread can reach a point on the landscape as either a head, flanking, backing, or from spotting, it can deal with islands or patches of non-burnable fuels more realistically.
In a long-term analysis we are interested in the probability or potential of the fire to reach or impact specific points of concern. In this example, we have multiple points of concern intersected with an FSPPro probability output for a specific time period. Each point of concern has a unique probability of being impacted during the modeled period. In contrast, the Rare Event Risk Analysis Program (RERAP) assess only the probability of the fire reaching or impacting each point of concern individually, prior to the end of the season.

While RERAP assumes that the fire spread is in one direction and under the influence of only one set of wind conditions, fire spread in FSPPro can reach a point from any direction as either a head, flanking, backing, or even a spot fire under the influence of winds from any direction. In most cases, fire spread in one direction may not be the fastest travel path. FSPPro can address this by its use of the Minimum Travel Time (MTT) fire spread algorithm.
What question do we want answered?

If we want to get an idea as to where and when the fire might spread over a short period of time using forecasted weather or a specific weather scenario, FARSITE or FlamMap are the applications of choice.

If we want a longer range view to get an idea as to the probability that fire might affect a point of concern given climatology, FSPro is the tool to use.

Ultimately, the selected geospatial fire modeling system and simulation duration are driven by the question we want to address. Regardless of the modeling system selected, it must be remembered that model outputs do not provide “the answer” but rather provide information to assist in making an informed decision. Ultimately, the selected choice of action falls to the decision maker and his or her acceptable level of risk. Generally, if we are concerned with how a fire might spread or associated fire behaviors based on forecasted weather or specific weather scenarios, FARSITE or FlamMap are appropriate applications. However, if we are interested in longer-range simulations and information about the potential or probable impacts from a fire under uncertain weather or climatology, then FSPro is the modeling system to use.

In a long-term analysis using FSPro, the question should be thought of as “What is the probability of a fire reaching or impacting a specific point in the proscribed simulation duration?” For example, what is the probability that point X will be impacted by the fire in the next Y number of days? The number of days is the simulation duration and can be 7, 14, 21 days or longer. While simulation durations of 30 days or longer can be run, other issues start to creep into the analysis that can confound or complicate these types of analyses. Simulations lasting 30 days should be the exception rather than the rule and rarely if ever should simulation durations exceed 30 days.
In this section, we will discuss items to consider in relation to long-term simulations.
Analysis (Simulation) Duration

- **Short-term 1-3 days or hours (8-16 hours)**
  - Specific weather forecast & likely outcome

- **Mid-term 3-7 days**
  - Less specific & less accurate weather forecasts. Interest in multiple weather scenarios.

- **Long-term 7 days or greater**
  - No specific or accurate weather forecasts

When we speak to short-, mid-, or long-term, we are addressing the simulation duration; and regardless of the duration, a common issue is the weather. Typically, as the analysis duration lengthens, the accuracy and reliability of the weather forecast decreases. The degrading forecast and selected simulation duration lend themselves to addressing specific management questions and thus the appropriate geospatial fire model. In a short-term analysis, we are typically interested in specific outcomes related to specific weather conditions or forecasts. FARSITE and the Minimum Travel Time (MTT) function within FlamMap lend themselves to these type analyses. With mid-term analyses, the interest is over a longer time period, but the management questions are often similar to those considered in a short-term analysis. However, the reliance on forecasted weather decreases and we become more concerned with multiple weather scenarios or localized known problem weather scenarios of concern, such as Santa Ana wind conditions, for which, again, FARSITE is appropriate. Previous units have addressed the use of FARSITE and FlamMap to address short- and mid-term analysis and the appropriate management questions. In this unit, we focus on long-term analysis using FSPro with simulation durations of 7-days or greater.

While FSPro can incorporate forecasted information, this should only account for approximately 25% of the total number of days in a simulation duration. Remember, we will typically have simulation durations in excess of seven days with 14-21 days the norm, all of which are outside the forecast reliability. With long-term simulations (our current focus) we are no longer concerned with a specific forecast because we will normally be outside their level of reliability for the period of interest. We become more concerned with making risk-based decisions (potential or probable impacts, expected impacts-loss), strategic operational decisions (point protection vs. perimeter control), and the probable or potential impacts from a known perimeter or point using historical climatology or uncertain weather conditions.
Long-term Simulation - Considerations

- Where are you in the fire season?
- What type of fire season are you experiencing?
- Where are you in the life-cycle of the individual fire or incident?
- These questions and the simulation duration length all have implications on model settings

Once the decision has been made to use FSPro to look at the burn probability associated with a long-duration simulation, there are other critical elements related to the simulation duration. First, where are you in the fire season and what type of season are you experiencing? Secondly, where are you in the life cycle of the individual fire or incident in relation to the simulation duration. These have implications on model settings and parameters associated with the selected simulation duration.
Where are you in the fire season? Early, mid, or late in the season, affects:
- Live fuel moisture settings
- Burn period settings
- Spotting
- ERC Classes

What type of fire season are you experiencing?
- Above or below average in terms of:
  - Fire danger (ERC)
  - Fire occurrence
  - Fire environment
  - Fire behavior
- These affect:
  - ERC Classes
  - Live fuel moisture settings
  - Burn period settings
  - Spotting percentage

As the FSPPro Fire Behavior Specialist, all the decisions you make surrounding model settings, decisions concerning adjusting landscapes, and the interpretation of model outputs need to be made for what is appropriate in the context of place for that fire (geographically, elevation, fuel type, etc.) and temporally in the fire season.

Where are you in the fire season? Early, mid, or late? Where you are temporally in the fire season needs to be considered when applying model values and settings to live fuel moistures, burn periods, and spotting. If it is early in the season or late in the season, additional lower bins for ERC classes or manually changing the ERC range values by ERC bin may be required. For the area you are working, what type of fire season are you experiencing? Is it above or below normal for where you are in the season in terms of fire danger as measured by ERC? How is ERC relating to fire occurrence, the current fire environment, and observed fire behavior? Considering all this is important in relation to individual ERC Classes and other model settings such as live fuel moistures, burn period settings, and controlling spotting.

We will go into more detail on these subjects later in the lesson…
Where you are in the life cycle of the individual fire or incident can have major bearing on the amount of information available to you, such as known fire perimeter and its location, where contained-controlled fire line exists, available information on current or past fire behavior, and having a local contact to discuss model settings and output. Searching out this information and making these local contacts are critical for the setting of model parameters, communicating results, obtaining model feedback, and critiquing of the fuels information. These become even more critical when conducting these analyses from a remote location.

If you are working remotely, obtaining local contacts can be difficult, but is important for verifying current fire behavior that can be used to inform model settings, your assumptions, as well as verifying the fuels layer for the area. A local contact may also provide information on appropriate RAWS stations to use for ERC and wind information.

Realize that at the start of an incident, initial information can be less than accurate. Often times, you may have to create the current fire perimeter within FSPro based on verbal descriptions, a faxed copy of a map, or by using the Active MODIS detects within FSPro. Later in the incident, GPS or infrared-interpreted mapped perimeters may become available. The mapping functions within FSPro can be used to create fire perimeters, barriers, and landscape masks as needed.

Information on contained-controlled areas of the fire while, sometimes difficult to obtain early-on, will have an affect on resultant fire probabilities. Past fires may have an affect on controlling fire spread as well. These areas can be accounted for in FSPro by the use of barriers to represent controlled line or using landscape masks to alter surface fuels in the case of past fires.
Long-term Simulation -

Considerations

- Where are you in the life-cycle of the individual fire or incident?
  - Early in the incident modeling management questions are less specific – but more critical in the first 48 hours before a course of action is determined that can be hard to pull back from
  - Middle of the incident modeling complexity and the types of management questions become more focused

FSPro analyses in the first 48 hours of an incident may be able to inform and influence management decisions from a broad strategic standpoint – for example, potential points of concern and prioritization of fires in a multiple start scenario.

Later on in the life of an incident, information on fire perimeters is more accurate and readily available, and knowledge on completed fireline becomes available. Management questions are more focused and directed to specific locations on a perimeter.
All of the following contribute to the overall run time for any FSPro simulation:

- Landscape extent
- Landscape raster resolution
- Number of fires
- Simulation duration
- Number of wind/weather scenarios
- Burn period settings

The landscape extent, landscape raster resolution, number of fires, simulation duration, number of wind/weather scenarios, and burn period settings all contribute to the overall run time for any FSPro simulation. The modeler has direct control over all of these settings. Some are relatively straightforward, while others take some experimentation to determine the interactions of model settings on model run time and model outputs. There are no specific “cut in stone” guidelines on these values as they will change in relation to each specific incident's needs and modeling objectives. In the following section, we will briefly touch on each of these, building on information on these subjects presented in Lesson 1 of this unit.
The default Landscape Extent for any FSPro analysis is a 40-mile square box centered on the latitude and longitude of the incident. The landscape extent is important because it represents the modeling domain for FSPro. For every pixel within the modeling domain, fire behavior will be calculated. This can account for a significant amount of time, especially if the area is larger than required. The art is in selecting a landscape extent large enough to account for the FSPro output but not so large that time is spent calculating fire behavior for areas not needed. Often, early in the incident, the default landscape extent may be too large and reducing the size may improve calculation efficiency, depending on the selected landscape raster resolution. Later in the life cycle of the fire, increasing the landscape extent will be required to account for the increased footprint of the fire and ensure that the potential FSPro results are captured. When determining the landscape extent, a general rule is to extend the landscape extent in the likely fire spread direction, accounting for the fuel type and corresponding spread rates and the number of days each simulated fire will last, for example, 14 days or 30 days (simulation duration).
The default landscape raster resolution in FSPro is 90 meters. The raster resolution determines the size of individual pixels and, in conjunction with the landscape extent, determines the total number of landscape pixels contained within the FSPro modeling domain. A landscape at 60 meter resolution contains 2.25 times as many pixels compared to the same landscape at a 90 meter resolution. For example, a landscape of 640 acres will have 720 pixels at a 60 meter resolution and only 320 pixels at 90 meter resolution. The interaction of the landscape extent and landscape resolutions contributing to modeling run time cannot be discounted. Continuing with this example, with all other modeling parameters the same, the 60 meter resolution landscape will take approximately 3 and a half hours to complete, compared to 1 and a quarter hours for the 90 meter resolution landscape.
Long-term Simulations –

- Landscape Raster Resolution
  - Coarsening the raster resolution will generalize the fuels information used during the simulation
  - Coarsening the raster resolution may eliminate critical pathways for fire spread in heterogeneous landscapes

There are ramifications associated with increasing the raster resolution to a coarser resolution (90m to 120m). In a landscape that is fairly homogeneous, this may not cause any problems. However, in heterogeneous landscapes, coarsening the raster resolution will generalize the fuels information. In some instances, generalizing the fuels information may eliminate critical fire travel paths in areas containing a mix of burnable and non-burnable fuels. Under these circumstances, you may need to “bite-the-bullet” and use a finer resolution and endure the longer computational times associated with using a finer raster resolution. During the testing and calibration phase, you will want to evaluate the effect of increasing or decreasing the raster resolution of your landscape on model results. The effect of raster resolution on generalizing landscape information can be viewed in WFDSS at the View Landscape and changing the Raster Resolution.
Long-term Simulations –

Simulation Duration

- Potential number of days each simulated fire can spread
- Increasing the simulation duration increases FSPro run time
- As the simulation duration increases, may need to increase the landscape extent and coarsen the raster resolution
- Selected simulation duration should be based on the interest of the probability of a fire reaching or impacting a specific point in the prescribed simulation duration

Run Time

Simulation Duration is the number of days each simulated fire can potentially spread. For example, if we set the simulation duration to 7-days and the selected ERC value for each day is equal to or above the minimum ERC value, the fire will spread every day of the simulation for the number of minutes in the burn period for that corresponding ERC. As we increase the simulation duration, each fire will have the potential to spread for more days and thus have a greater potential reach across the landscape.

As the simulation duration increases, a corresponding increase in the landscape extent will be required to ensure the potential FSPro output is covered. As the simulation duration increases to periods of 20-30 days, a coarsening of the raster resolution, for example 90m to 120m, may also be required to reduce the simulation run-time.
Number of fires is the number of fires that will be simulated during the FSPro run. As the number of fires increases, the simulation run-time will also increase.

Where you are in the analysis (calibration and evaluation, a final FSPro simulation) and your selected simulation duration will all influence the number of fires you simulate at any point in the process.

The critical element the number of simulated fires influences is the potential to account for the rare event. Experience over the last several years has indicated that, to account for the rare events in a simulation, a minimum of 1000 simulated fires is required. The only time fewer than 1000 fires should be considered is during the initial testing and calibration for an incident.
Long-term Simulations –

Model Setup

- Simulation Duration straight forward – selected based on desired time frame of interest
- Raster resolution and landscape extent more difficult and influenced by:
  - How soon need a model result
  - Heterogeneity of the fuels data
  - Size of the current fire footprint
  - Selected simulation duration
  - Other users system demands

While the simulation duration is fairly straight forward, determining the appropriate raster resolution and landscape extent can be more difficult and is the art and science of geospatial modeling. It will likely take several attempts during the calibration process to determine the appropriate settings for an FSPro analysis for any one incident.

The determination of an appropriate landscape extent and raster resolution, at a minimum, will be influenced by: 1) the amount of time you have to provide an answer; 2) the heterogeneity of the fuels. Increasing the raster resolution to a coarser resolution (90m to 120m) will generalize the fuels information and may eliminate critical fire travel paths in areas containing a mix of burnable and non-burnable fuels; 3) the size of the current fire footprint you are starting with and whether you are using the entire fire perimeter or focusing on selected areas of the perimeter; 5) the selected simulation duration (remember the simulation duration sets how many days each simulated fire will last – for simulation durations of 30 days or longer, you will need to coarsen the raster resolution of the landscape); and 5) the number of fires to simulate, of which a minimum number of simulated fires to run is 1,000. Experience to date has shown that, in most instances, this will include some of the rare events, the less than 0.2% of probability zones.
It should be evident by now that many factors need to be considered when determining the appropriate landscape extent, raster resolution, and number of simulated fires. Every incident and fire will have unique combinations of fuels, topography, weather, modeling questions, and objectives, which need to be evaluated in the context of place for the respective fire. Thus, it is difficult to offer cut-and-dry recommendations that will be appropriate in every instance. The one exception to this is the minimum number of fires, which generally should not fall below 1000 for a final model run.

The table on this slide offers some general ranges of values to consider based on the simulation duration. However, you may find that for your specific situation, these values will be different. The bottom line is that you, the modeler, will need to critically evaluate the various trade-offs on model results and computation time based on your experience and fire behavior knowledge. As you make use of the model over time, these subtle and various interactions will become more familiar to you. There is an ancient modeling proverb that is appropriate here: “Don’t set ‘em fine if you can’t do the time.”
For a simulation duration of 7 days, you can often get by with a finer raster resolution as long as the existing fire footprint is small (< 3,000 acres) or you are interested only in smaller portions of a larger fire and the landscape extent is not too large. You can also experiment with increasing the number of fires to simulate. In general, with a simulation duration of 7 days, you can often use finer raster resolutions and simulate more fires without suffering too much of a computation penalty.

For a simulation duration of 14 days, you will likely need a larger landscape extent because each simulated fire will have a longer time to experience fire growth. This larger landscape extent will, to a certain amount, drive your selection of raster resolution and simulated number of fires. Again, the existing fire footprint and whether you are modeling the entire perimeter or just portions of the fire will influence these selections. You may find that a coarsening of the raster resolution is needed to meet time-frames imposed on you for modeling results. Remember, coarsening the raster resolution comes with a cost on the information the model uses as it will generalize the landscape information. The cost of generalizing the landscape needs to be tempered with how the model uses the information to model fire growth across the landscape and model results.
Often times, an agency administrator will ask what is the probability of the fire impacting an area within 30 days or longer. Simulation durations of these lengths introduce other issues and concerns. However, before addressing these, let us continue our discussion on raster resolutions and number of fires.

Simulation durations in this range will require a very large landscape extent to ensure enough area to capture the FSPro probability output. This large landscape extent will have a direct impact on modeling time. Remember, the raster resolution and landscape extent will determine the number of pixels in the FSPro modeling domain for which fire behavior will be calculated. Again, the existing fire footprint and whether you are modeling the entire perimeter or just portions of the fire will also influence these selections. Determining the needed landscape extent will likely require several attempts to define the appropriate landscape extent. In the calibration and testing phase, it is recommended to use a very coarse raster resolution (270 meters) and very few numbers of fires (somewhere between 500-800). This should provide insight to the needed landscape extent. Even after this preliminary work, it may take you several additional attempts using your final raster resolutions and number of simulated fires to get the final landscape extent.
For simulation durations of these lengths, you will need to coarsen the raster resolution to obtain results in a timely fashion. Remember, by coarsening the raster resolution, the underlying landscape information will be generalized. Because of this, not as much information will be used when determining the resultant fire behavior and FSPro probability outputs. As mentioned previously, this may not be a critical issue on relatively homogeneous landscapes. However, on heterogeneous landscapes, the generalization of fuels information can be an issue. Depending on the mix of burnable to non-burnable fuels, the amount of fire growth could be greatly over- or under-predicted. Because of the generalizing of the landscape information and its affect on model outputs, it becomes even more critical to evaluate the interaction of raster resolution and model results.

Throughout this lesson, the minimum number of fires to simulate of 1000 has been stressed. This has been found to be critical in modeling fires with short simulation durations, 14 days or less, to account for the rare events. This is a function of the historical occurrence and the probability of these events occurring and the number of days each simulated fire lasts, and thus the potential for these events to be selected. While the minimum number of fires to simulate is still suggested to be 1000 under simulation durations of these lengths (30 days >), you may be able to relax the number of simulated fires to 800. In simulation durations of these lengths, there is a greater chance of these rare events being selected because of the length of each simulated fire when compared to a simulation duration of 7 to 14 days.
Issues with 30-day Simulations

- Large probability footprint
- Short shelf life
- Fuel moisture settings
- Early vs. late in the fire season

Often, Agency Administrators and Line Officers will want an idea as to the probability of a fire reaching various points of concern over very long time periods, and while simulation durations of 30 days or longer can be run, other issues start to creep into the analysis that can confound or complicate these types of analyses. Simulations lasting 30 days should be the exception rather than the rule and rarely, if ever, should simulation durations exceed 30 days. Additionally, because of the generalization of the landscape information, these longer analyses should be viewed with a certain skepticism and have EXTENSIVE explanation provided. The following are just some of the potential issues and concerns related to simulation durations of 30 days or longer:
Issues with 30-day Simulations

- Large probability footprint
- Short shelf life

1) **Large probability footprint**: Because each simulated fire has such a long potential fire growth period, the FSPro probability footprint can be quite large. Because consumers of FSPro information often mistake the probability zones as fire perimeters or fire progression, these results will often intimidate a decision maker. It is imperative that extensive interpretation and explanation be provided. For long duration simulations, it is critical to communicate that the displayed results do not reflect suppression effects in limiting fire spread during the simulation duration.

2) **Short shelf life**: Rarely will these results last for their intended lifespan. Because of the dynamic nature of fire growth, weather events, fire spread events, suppression actions taken on the fire will alter or change fire spread during the simulation; rarely will these simulations remain valid for the modeling period they cover. Often, some type of significant event (weather or fire spread) or suppression action occur, requiring that a new FSPro simulation be done to account for the change in position of the fire on the landscape.
3) **Fuel moisture settings**: Currently, fuel moistures for dead, live woody, and live herbaceous do not adjust temporally during the simulation. Thus, we cannot account for the seasonal changes in these values in simulation durations of 30-days or more. This forces the modeler to select one value by ERC class by fuel type and the assumption that this value will remain unchanged during the life of the simulation duration. One example where this might cause difficulties is in the southwest. For example, if it is mid to late June and the area is experiencing the typical pre-monsoonal drought with a simulation duration of 30 days or longer, you could cross over into the monsoon season. Assuming that the monsoon season follows its historical timing and precipitation patterns, this could trigger green-up in the live herbaceous component and crossing of phenological development stages of live vegetation. This will have a dampening effect on real-time fire behavior that cannot be accounted for in the FSPr0 model.

4) **Early vs. late in the fire season**: Similarly, where you are temporally in the fire season, given the context of place for the fire, influences the fire environment, fire behavior, and burn periods for that fire location. Again, within FSPr0, we cannot account for these temporal/seasonal changes that will influence the assignment of burn period durations and spotting probability during a simulation.

In both cases, you may be required to use settings for these parameters that are outside what you would use for a shorter simulation duration given where you are temporally in the fire season.
In the next section, we will work through each of the FSPro setup screens, incorporating the information presented earlier in this lesson. There are basically five screens for which you will need to provide information. We will again rely on your fire behavior knowledge and understanding of FSPro concepts introduced in previous units and lessons.
At this screen, you assign the **Analysis Name**, input the **Number of Fires** to simulate, the **Number of Days** that each fire will be simulated and the **Analysis Start Date**. The **Number of Days** should be driven by the question of what is the probability that the fire will impact points of concern in the desired time frame. The **Number of Fires** should be enough to account for rare events that could impact fire growth and burn probabilities as influenced by the landscape extent and landscape raster resolution. Remember the interaction of landscape extent, landscape raster resolution, number of fires, and number of days on the overall model simulation time. The **Start Date** should be for the beginning of the period you wish to simulate. While it may seem obvious, when you are in a hurry it is sometimes easily overlooked, especially if you copied a previous analysis.

You can select any shapefile that has been uploaded or created within the WFDSS system. Shapefiles can be either an **Ignition** or **Barrier** file at this location. You can upload additional shapefiles for the incident by selecting the **Shape Upload** option located on the left. Remember, you can only use one barrier file at a time for an analysis. However, the barrier file itself can contain multiple barriers. The same holds true for the **Ignition File**. You can have only one ignition file selected for an analysis, but it can have multiple ignitions within it.

Remember to select the **Save** button anytime changes are made to this screen to make them permanent.

Any of the options located on the left on this page view can be accessed anytime during the setup of the FSPro Run. The **Notes** options allows you to add notes to the incident as you work through the analysis. Use this often to document decisions made during the analysis. This information will be useful to analysts who follow you and help provide documentation on modeling decisions you made.
Before we can discuss ERC classes and Winds specifically, we need to address some general information about weather stations, weather station networks, and station selection. FSPro is dependent on remote weather stations for information to calculate ERC Classes and winds information used by the model. These stations can be either automatic or manual stations for ERCs. However, FSPro is dependent on automatic stations only for its winds information. In some instances, the station density and available station types may limit selection options. The data extent and data quality will be station dependent and reflect the local areas commitment to their weather station network. In most cases, stations available for ERC classes will have a longer record length covering the entire historical record length for that station. Wind information will not be as extensive in record length and limited to the period when the station was converted to an automatic station type. However, the winds information will be hourly and include the ten minute average as well as the peak hourly gust data.
Weather Station Networks

- Important
- Density
- Data control and quality, station maintenance
- Updating observations in WIMS
  - Use wet flags early on when fuels are under snow becomes very important for early season fires
  - Converting observation types, state of weather
- Station selection: closest is not always best. Use most representative station

FSPro is dependant on remote weather stations for the determination of ERC classes and wind information, thus station density becomes important. Opportunities to fill gaps in the existing weather station network or convert the remaining manual stations to automatic reporting stations should be taken advantage of. Reliable FSPro modeling results are also dependent on the quality of data associated with these stations, thus making data quality and control as well as station maintenance important. Throughout the fire season, review of collected data, conversion of observation types, and assignment of proper state of the weather codes by the station owner become critical. The use of wet flags when fuels are under snow or completely saturated is important for fires early in the season; otherwise, ERC Classes may be higher than reality, leading to more fire growth and thus higher probabilities. Because of station density, there may not be a relatively close station to choose from and, in some instances, the closest station may not be the best choice. Always use the most representative station for the fire and situation.
As of August 23, 2008, there were 2,173 weather stations active in the Weather Information Management System (WIMS). Looking at the distribution of stations across the United States, we can see the density of stations varies. We can also see there are some problems with station locations. Notice some stations are located in Canada as well as in the Atlantic Ocean.
Weather Station Networks

This close-up view of the 11 western states shows the distribution of cataloged NFDRS stations in WIMS as of August 23, 2008. Nationally, 88% of the cataloged stations are RAWS (n=1918) with the remaining 12% listed as Manual (n=255) stations. In this view across the 11 western states, we can see there are holes within the distribution of stations. Because of this, you will often need to make some difficult choices on station selection.
Station Selection

- Which station use?
  - Local knowledge
  - GACC website
  - Station evaluations
- Station density and location - reflection of reality
- Examine the data quality, extent, relevance

So how do you select an appropriate station? Use all the tools available to you for evaluating and selecting the appropriate weather station including FireFamily Plus. Previous units and lessons in the course have shown techniques and demonstrated approaches to evaluate weather station data quality, data extent and station relevance. All these techniques and skills are applicable here as well. Ask local fire managers for their input on station selection. Check the local GACC site for information regarding stations as well as contacting the GACC meteorologist for information regarding weather station applicability. You may find after talking to the GACC meteorologist that station evaluations for the GACC have been completed along with recommendations on the use of certain stations. In some instances, station density and station location will not always be optimal – this is reality. Thus, you may be required to use a station that is not the best possible choice. When evaluating a station, examine the data quality, extent, and relevance to the specific incident and analysis you are conducting.
Station Selection

- FSPro assumes fuel moistures and winds are independent
- Can use a different station for each
  - Use the “best” station that reflects ERC (fuel moistures)
  - Winds of influence for that fire
- Examine proximity to fire & elevation (ERC and fuel moistures)
- Examine how the station captures winds of influence for the fire area

FSPro assumes that fuel moistures and winds are independent of each other. Because of this, a different station can be used for each data type. The objective is to select the “best” station reflecting ERC and thus fuel moistures and winds for the fire and specific analysis. Again, previous units have discussed how to evaluate stations and climatology and all of the same concepts and techniques apply here. Because FSPro uses ERC as a surrogate for fuel moistures, you want to select a station that will capture this information based on its elevation and proximity to the fire location. When evaluating a station for wind information you want to examine the station siting in relation to the local topography and how that influences the recorded winds. You want to use a station that has captured the winds of influence for the fire area over its historical record for the period of interest. For example, is it located on a ridge top or valley bottom? Typically, stations located in valley bottoms will be dominated by up-valley down-valley winds, while ridge-top stations will typically capture winds from 360 degrees, but they will generally be of higher speeds. A station located in a north-south oriented valley bottom which captures only up-valley and down-valley winds will not be appropriate if the winds of concern are primarily from the west-southwest.
In the WFDSS system, you can use the RAWS KML option to create a KML file of all the weather stations selected surrounding the latitude and longitude for the incident. This can be a powerful tool for evaluating how the station is sited and the topographical influence on winds for that station, as well as for identifying whether the station location information is entered correctly. The latitude and longitude to create this file uses the location information in the station catalog in WIMS; thus, the accuracy of station locations in the KML is dependent on this information being correctly entered. In the past year, discrepancies in the entered station latitude and longitude for several stations have been discovered by using this file.
The list of weather stations available for calculating ERC Classes are generally within 1 degree of latitude and longitude of the entered incident latitude and longitude. The closest station in terms of its distance from the incident latitude and longitude will be the initial displayed station. The populated list of available stations can contain manual or remote (RAWS) weather stations. The criteria for selection is they must be a cataloged NFDRS weather station, be active and collecting data in WIMS, and have a minimum of 10-years of weather data when FSPro is accessed.

Weather station data extent in terms of the number of years and the months actively collected will be station-dependent. In FSPro we cannot determine the actual length of years a station has collected data and we cannot determine the actual months or how many months within a specific year actual data exists. The months a station actively collects information is best determined outside the WFDSS system. Knowing this is important when setting the date filter’s years and start and end months. As stated previously, the quality, extent, and relevance of each station’s information will vary greatly, and because you may be working outside an area you are familiar with, it is imperative that you learn as much about the available weather stations as you can prior to selecting a station.
When you first select the ERC Classes, your view should look similar to this. Whether the Month/Day fields or the ERC Classes are populated is dependent on whether you copied an existing analysis or whether it is the initial analysis for an incident. Regardless, it should look similar to that shown here.
Clicking on the drop-down box for the Station ID will show a list of available weather stations to use for the analysis. The populated list is based on the criteria mentioned previously. Remember, these are only a list of available stations. It is up to you, the fire behavior specialist, to evaluate and select the most appropriate station for use. When evaluating the weather station, be sure to review the other associated station information, such as Greenup Date, Climate Class, Slope Class, etc. The displayed information reflects the current entries for these data elements in WIMS for the selected station. If you find errors, be sure to note these and pass them on to the station owner so they can be addressed.
In setting the Date Filter, the appropriate **Start** and **End Year**, and the **Start** and **End Month/Day** need to be determined. The criteria established here determines the values in the table below, and changing these parameters will change the values in the table.

An individual station’s weather data coverage in terms of the number of years and the months and days actively collected will be station-dependent. Currently, the length of years for which a station has data available, the actual months and days or how many months and days within a specific year actual weather data exist for cannot be determined in WFDSS. Because of this, determining the appropriate **Date Filter** values may be better accomplished outside the WFDSS system. Knowing this information is important when setting the **Date Filters** for the ERC Classes. The quality, extent, and relevance of each station’s weather information will vary greatly, and because you may be working outside an area you are familiar with, it is imperative that you learn as much about the available weather stations as you can prior to selecting a weather station. Using the **Download FWX** button will download the entire record length of data for the selected station. This data can then be brought into FireFamily Plus and used to assist in evaluating these settings.
The potential record length of the available individual years for the selected station can be viewed by clicking on the **Start Year** drop-down box. In this example, the earliest available year is 1984, with the most recent being 1998. Remember, while the displayed years are consecutive with no interruptions, at this point, whether data exist for every year cannot be determined. So what about the years 1999-2008? Why don’t they show in the drop-down list? The WFDSS system has hard-wired the **Start Year** so that the minimum number of years you can use is 10, making the most recent available start year 1998 in this example. This station is a relatively new station, having data only from 1984 to the present. However, some stations will have longer record lengths with some extending back into the 1950s. So how many years of data should you use? This is where your evaluation of the station and its data comes into play. However, because the system is hard-wired, the minimum number of years you can use is ten. Most recommendations for these types of analyses focus on using a minimum of 20 years. If the station has data extending into the 70s or later, you should consider limiting your data years to sometime in the 1980s to the present. Whatever the selected record length, it should be made based on a proper evaluation of the station and its data in terms of the climatology and current fire environment for the incident. Experiment with various ranges of start years and month/days to see how these alter the information in the table. The determination of these values should be tempered by your knowledge of fire behavior, the current fire environment, and observations or feedback on fire behavior for the fire you are analyzing.
So how about the **Start and End Month/Day**? These parameters should also be influenced by your evaluation of the station data. Remember, in WFDSS, you cannot tell whether all the months for a station have actual data associated with the range of available years. Most stations have consistent data around the fire season, generally from April to late October or November. You will find that manual stations will be limited to the fire season as they are typically only active for these short periods. Again, this will vary by individual station and will need to be verified prior to selecting the starting and ending month/day. Other items influencing your selection are where you are temporally in the fire season, the fire Analysis **Start date**, and the **Simulation Duration**. It is critical to include the **Start Date** and **Simulation Duration** period within your selected **Start** and **End Month/Day** range. Typically, using a **Start Month/Day** corresponding to the beginning of the local fire season will be appropriate as long as it is at least 30 days prior to the Analysis **Start Date**. The **End Month/Day** should extend one to two weeks past the end of the simulation duration. You will need to adjust the ending month/day throughout the life cycle of the fire. Anytime during an analysis that you change any of the parameters on this page, you will need to **Generate ERC Classes** and **Save** the information to make them permanent.

For early spring fires that start in April or May, you will not be able to use the start of the typical fire season. These types of analyses can become complicated because knowing the months with data becomes even more critical and may also require that you change the number of days in the **Max Lag** field located in the **ERC Correlation Parameters**.
In most cases, you will not need to change the **Max Lag** and likely never the **Max Degrees of Fit** for the model. The exception to this as mentioned previously is for early spring fires that start in April or May. In these instances, you may not have 30-days of valid weather information prior to the analysis start date. In these circumstances, you would need to change the **Max lag** value. These types of analyses can become complicated because knowing the months with data becomes even more critical, and changing the max lag requires you evaluate the ERC Stream to determine the month and day the selected station started to calculate a daily ERC. This is an advanced topic that requires a more in-depth discussion than allowed for here and will be discussed in the resident portion of the class.
Unit 5 Lesson 3 went into great detail about how the fuel moistures in FSPro are calculated and used. Lesson 1 of this unit discussed information concerning the settings of these values as well. Here we will cover some additional information. Remember that all the ERC values used in FSPro will always be based on NFDRS Fuel Model G, based on the selected stations data and station information. The live and dead fuel moisture values will also be calculated using the standard NFDRS algorithms as implemented in WIMS and FireFamily Plus. The current year will not be used in the calculation of fuel moistures displayed here nor in the calculation of the daily historical average and standard deviation displayed in the ERC Stream.

In most instances you will not need to make changes to the dead fuel moistures within the respective ERC bins (review Unit 5 lesson 3). However, they should always be verified and adjusted if needed or another station investigated for use. Because the live fuel moisture calculations are the weakest model in the NFDRS system, the live fuel moisture values should not be expected to exactly reflect specific species for the geographic area you are working in. Because of this, you will likely need to change the live herbaceous and live woody fuel moistures. One approach to setting these values is to determine the current ERC value for the selected station and determine the specific ERC bin that value corresponds to. Live fuel moisture information can be based on actual field-sampled information, information on greenness as determined in the WFAS system, or based on any other of the appropriate techniques and sources discussed in previous units. Enter the corresponding live fuel moisture in the appropriate ERC bin and adjust the remaining bins up or down from this initial value.
It is important to remember that live fuel moisture content changes throughout the fire season as plant development changes. Actual live fuel moisture changes are a result of natural biological processes responding to climatic influences on plant species characteristics and daily weather and seasonal patterns that act to speed up or slow down plant phenology within limits specific to each species. The take home message for you, the modeler, is that you need to account for the stages of plant development and select an appropriate fuel moisture value to use. These values must be determined within the context of place (location), species, where you are seasonally and current plant phenology, and in relation to the observed fire environment and fire behavior for the specific fire. Live fuel moisture values used in early summer will need to be changed later on in the fire’s life-cycle (late-summer, early fall) as additional FSPro simulations are performed.

For FSPro simulations lasting 7-14 days, live fuel moisture values are not likely to substantially change during the simulation period to have an immediate effect on model outputs. However, FSPro simulations lasting in excess of 30-days can potentially cross stages of plant development. This will complicate the determination of appropriate live fuel moisture values and force the use of a more conservative or average value than you might for a shorter duration simulation. Fires with a simulation duration of 60 days will likely cross different stages of plant development.
Fire Behavior Parameters refer to the Burn Period, Spot Prob, and Delay, and were defined and discussed in Lesson 1 of this unit. What is important here is these values must be determined within the context of place (location), where you are seasonally, and in relation to the current and expected observed fire environment and fire behavior for the current incident and analysis. Similar to live fuel moisture values, settings for these parameters will also change as you move throughout the fire season and the life-cycle of the fire itself. Forecasted weather and/or seasonal weather patterns will require that you change these settings throughout the life-cycle and subsequent modeling of the fire. Fire behavior parameters will need to be adjusted as you temporally move through the fire season. Values used early on in modeling (early summer) will need to be changed later on in the fire’s life-cycle (late-summer, early fall) as dictated by your observations of fire behavior for the incident.
After setting the ERC classes for the analysis, the next screen to address is the ERC Stream. At this point, you can view the daily historical average, the standard deviation, and the current calculated ERC. You can also enter forecasted information for wind speed and direction as well as ERC. Forecast information for the entered days will be used rather than historical climatology and probabilities of historical occurrence. Forecast information can be developed automatically within the system based on the National Weather Service (NWS) National Digital Forecast Database (NDFD) or be manually entered by the user based on information from outside sources.
A view similar to this should appear after you generate and save the ERC classes for an incident. A value of -1 in the ERC stream indicates that a current day’s ERC value has not been calculated and that all the subsequent days’ ERCs will be based on the time series and auto correlation analysis to develop this information. A value of -1 can also occur if you access the system prior to the established reporting time for the selected station or if the weather station owner has not gone into WIMS and changed the observation type and entered a valid state of the weather code for that day. This circumstance can often occur when fire activity is very high and attention is not being given to these duties or following a weekend when perhaps a relief person is on duty who does not have access to edit these parameters in WIMS. You can verify this for a station by accessing WIMS and examining the station data for the days with a -1 and see if this is the case.
At this point, a weather forecast can be entered. Any forecasted weather entered will be used in the simulation rather than the historical climatology. **Forecasted Weather** allows for the accounting in the simulation of a unique or significant weather event that can influence or drive fire growth in the near short-term. This forecast can be for any number of days from 1-10 in the drop-down selection box under the **Days** option. The user can obtain this information “automagically” using the NWS National Digital Forecast Database (NDFD) based on the incident latitude and longitude, in which case all three required data elements will be populated. The user can also enter this information independently based on information obtained from a general fire weather zone forecast, incident-specific spot weather forecast, the local fire weather forecaster, the incident IMET, or the fire behavior analyst. In this case, you will likely get only a forecasted wind speed and direction and you will need to calculate the ERC value. Using the NFDRS calculator in FireFamily Plus based on the forecasted weather is the easiest way to do this.

While the system will allow you to select a forecast period lasting from 1-10 days, it is recommended that a forecast account for no more than 25% of the total number of days of the simulation duration. The typical forecast duration should fall between 3-5 days and no more than 3 days for a 7-day simulation duration. Remember, for periods lasting longer than 5-7 days, the reliability of the forecast starts to degrade. For FSPro simulations with durations of 20 days or longer, not using a forecast period and using straight climatology is appropriate. The exception to this is when there is a unique or credible weather concern that will directly affect fire growth in the short-term, in which case this information should be included as it will directly affect the resultant probabilities.
The list of available weather stations used for wind information will generally be within 1 degree of latitude and longitude of the entered incident latitude and longitude. The closest station in terms of its distance from the incident latitude and longitude will be the initially displayed station. The populated list of available stations consists only of cataloged NFDRS RAWS (satellite and non-satellite) reporting stations that are currently active, collecting data, and transmitting data when FSPro is accessed. The hourly wind information has data for both the ten-minute average and gusts. In all cases, wind speeds of 90 mph are filtered out and not used in developing the winds distribution tables and wind roses. Winds data through 2006 was initially provided by the Desert Research Institute (DRI) and are the same data that are stored and available at the Western Regional Climate Center (WRCC). Wind information from 2007 to the present is obtained from WIMS.

The number of years and the months for which data are actively collected will be station-dependent. Currently, in the WFDSS system, we cannot determine the actual years for which a station has wind data available, the actual months or how many months within a specific year actual wind data exist. The actual years, months, and dates for which wind information exists can only be determined outside the WFDSS system. Knowing this is important when setting the Time Filters for the winds. The quality, extent, and relevance of each station’s wind information will vary greatly, and because you may be working outside an area you are familiar with, it is imperative to learn as much as you can about the available weather stations prior to selecting a weather station.
The station information section for the FSPro Winds is very similar to the ERC Classes page. However, there are two differences. First, there is no information regarding green-up dates, climate class, etc. For the winds, this is not a required element, but you should still review the displayed station catalog information for accuracy. Secondly, it is quite likely that the list of stations that appear in the drop-down list will be different than the list from the ERC Classes. This difference will be due to the station types that each data type will draw from. The available list of stations in the ERC Classes is compiled from RAWS and manual stations, while the winds will use only RAWS stations. So do not be surprised if the lists are not identical. Regardless, it is okay to use different stations for each data type.

Remember, you want to select the most appropriate station for the respective data type (ERC and winds) for the incident.

From the list of stations, you will need to select the appropriate station to use. Your choice of the appropriate station at a minimum should be driven by how well the station captures the winds of influence or concern for the specific fire and modeling objectives for the incident you are modeling, the extent (years and day/months), and quality of the station’s data. It does no good to select a station for a period in October if that station has little to no data for that month.
The Time Filter section, while similar to the ERC Classes Date Filter, is different in that you have more control over some model settings. In addition to the number of years and the month/days used, you can also control the hours of data used. Remember, we have hourly information for both the ten minute average and gusts and, unlike the ERC Classes where we are trying to capture the seasonal influence on fuel moistures, we want to be more focused on the winds and how they relate to the hours of the day when active burning occurs for that incident.

Clicking on the drop-down box for either the Start or End Year will show the potential record length available for use. Remember, while the displayed years are consecutive with no interruptions, at this point whether data exist for every year cannot be determined. Due to the relatively short length of hourly data for most stations, it is common to use the entire record length available. The exception to this would be if during your station analysis you determined that certain years should be excluded because of limited data, poor quality data, or the combination of years and months does not correspond with your analysis period. Unfortunately, you can only exclude years at the start and end, not within the range of years. Again, your station evaluation and station selection should be driven by this consideration.
The choice of months to use should be focused around your analysis start date and simulation duration. In most modeling scenarios, at a minimum, you will want to have the start date at least two-weeks prior to the analysis date and the ending date two weeks past the end of the simulation duration. The key is to select the time periods around your simulation that will capture the winds of concern or influence for the fire, modeling objectives and scenario. You may find that you need to extend these dates to adequately capture the winds for the area you are working in.

The starting and ending hour should be driven by the hours of active burning for the incident you are working with. In general, using a starting hour around 900-1000 hours and an ending hour around 2100-2300 hours will work for most incidents. This is only a general guideline; the actual hours used should be driven by the actual hours of fire activity for the specific incident that you are working on.
This example shows a **Time Filter** for which no wind information existed was set.
In this example, a **Time Filter** for which very little wind information existed was set. Even using both gusts and the ten-minute average information, only three wind speeds were recorded. This example and the previous illustrate the need to determine the number of years and months that data exist during station evaluation prior to setting the **Time Filter** criteria.
There are two ways to evaluate a station’s extent and coverage of wind data. One way is to download the available winds data and evaluate the data in FireFamily Plus. A second method is to access the Western Regional Climate Center (WRCC) database (http://www.raws.dri.edu/index.html) and examine the available data for the station of interest. In examining the Spotted Bear station, we can see that there was no information for the month of March for the entire record length. In fact, the only months for which data may be available consistently for the record length are the months of July through September. The months of June and October are spotty at best.
**Calm Weight** is the percentage of time that values meeting the defined **Calm Threshold** were met. The **Calm Threshold** default value is 1 and is exclusive. This means that for a value of 1, only days with a wind speed of 0 will be used to determine the **Calm Weight** percentage. For the **Winds Type**, three options exist; Ten Minute Average, Gusts, or Both. By selecting Both, information for the Ten Minute Average and Gusts will be used to develop the wind distribution table.

The wind distribution table displays the percentage of time that the displayed combinations of speed and direction have occurred in the past for the selected station and defined **Time Filter**. The displayed speed is the 20-foot wind speed in miles per hour for the selected station while the directions are in degrees. The values displayed here are the same information used to create the Wind Rose, just in a tabular format.

At this point, you can develop a **Wind Rose** based on the established criteria. Wind roses are very useful for evaluating stations and visually inspecting their unique distributions of speed and direction. Selecting the **Download Winds** will download all the wind information for the selected station in a .csv file format. This information can be reviewed in Excel or imported into FireFamily Plus for further evaluation. This will be useful for determining for which months wind information exists. In this example, the wind distribution table is based on only the Ten Minute Average winds. The next two examples will show the wind distribution table using the Gusts, and then Both (Ten minute average and Gusts). Notice how the distributions and range of wind speed values change compared to this example.

Typically, using the Ten minute average wind speeds will work well when the area you are in is experiencing an average fire season or is just below the average. You may find that it even performs well when just above average. As always, you need to evaluate the selected wind types given your observations of the current fire environment, observed fire behavior, and the expected and forecasted weather for the area you are working in.
Here is a wind distribution table based on the **Gust** information only. Notice how the range of wind speeds and the distribution of wind speeds at the lower ranges have changed compared to the previous slide using only the Ten Minute Average winds. Remember, **Gust** information is the peak recorded wind speed and its associated direction within the observation hour. As we would expect, when using only the **Gust** information, the range of wind speeds has increased. Also, notice how the frequencies in the lower wind speed categories have changed as well.

Using the **Gust** information only as a selection should be used judiciously as you are submitting the modeled fire to the potential for higher winds throughout the entire simulation period. Use of the **Gusts** only option may be appropriate for short simulation durations such as 7 days as long as there are high forecasted winds or reason to believe the fire will be under an extended influence of high winds during the simulation period. For longer simulation durations, those lasting 14 days or longer, the use of gusts only is not recommended. If you find that you are having to use the **Gusts** only to get any type of fire spread and fire probabilities, there is likely a more relevant fundamental issue affecting your results. In these instances you should evaluate the fuels data and fuel moistures you are using as well as fire behavior model settings. Additionally, where are you in the fire season? Is it early in the season and you are at ERC values in the 60-70\(^{th}\) percentile range? If this is the case, you would likely not expect much fire spread at this time.
This wind distribution table is based on wind information from the Ten Minute Average and the Gusts (Both). Notice how the range of wind speeds and distributions have changed compared to the previous slides using only the Ten Minute Average winds and only the Gusts. When Winds Type of Both are selected, the calculated distributions are based on both wind types.

When you are in a more severe fire season or in extreme conditions using Winds Type Both may be beneficial. Using Winds Type Both is also appropriate if you need to include the probability of encountering higher wind speeds during a simulation. For simulation durations lasting 7-14 days, selecting Winds Type Both will be appropriate under these conditions. When you get into longer durations – 30 days or longer – then incorporating higher wind speeds may lead to over predictions and the use of Both types will need to be critically evaluated.

Regardless of the Winds Type selected, it is conditional upon the user having conducted a proper evaluation of the selected station, examining the resultant fire probability output in combination with the current fire environment and fire behavior during the selection and evaluation process.
The Wind Roses generated by the WFDSS system are a visual representation of the winds distribution table. Using the Wind Rose is an excellent way to evaluate wind patterns associated with a selected RAWS and may be easier to decipher and interpret than the tabular information. Wind Roses will quickly illuminate distinct patterns of wind for a station and allow you to easily compare and contrast RAWS stations to determine their suitability for use in the FSPro simulation.
In this example, we have three different RAWS stations associated with an incident. For each wind rose, the parameters were the same. They all are for the daily period (24 hours), for the months June through September, and based on wind types Both (Ten min. ave. and Gusts). By doing this, the general wind patterns for each RAWS are easily determined and evaluated. The Benchmark RAWS appears to be located in a fairly open area and captures winds from all directions, although it is primarily from the NW to Eastern quadrants. The Spotted Bear LO RAWS, while located on a ridge-top, primarily captures winds only from the south-southwest, but is dominated by a southwesterly flow. The Condon station pattern is one suggestive of a station located in a valley bottom, which captures only the up-valley, down-valley wind patterns. You may also see the same pattern when a station has a major sheltering effect that limits the winds on the station from any one direction. Another interesting item is the percent of time the winds are calm at each station. At the Condon station the winds are calm almost 12% of the time, which is almost three times greater than the other stations experience.

So here we can see the general wind patterns captured for three different stations. In this case, if we were interested or concerned with winds out of the south-southwest, we definitely would not want to use the Condon station. The Benchmark station may be appropriate, but the winds would still be dominated out of the northwest to eastern quadrants. The Spotted Bear LO seems to capture the winds the majority of the time out of the south-southwest and may be the best station for this analysis. At this point, we would want to narrow our time frames down to the specific hours and month/days of interest for our analysis and see if any major differences occur that would sway our decision to one station or another.
This example shows the same three RAWS stations as the previous example. The difference between the wind roses in the two figures are that here the hours were restricted to a burn period of interest (1000 – 2200 hours) and for the month of August. Assume that the simulation start date and simulation duration is adequately covered within these specified time frames. The same general patterns as the previous figure are still visible; however, there are some notable differences, especially with the Condon station. For the specified burn period and time frame, we have lost the winds in the southeastern quadrant, and the station appears to capture only down-valley winds at its location. While the percentage of calm winds has also decreased for the station, the winds are still calm for a much greater percentage of time compared to the other two stations. For the Benchmark station, the percentages have changed to be almost an equal chance of occurrence from any direction, and for the Spotted Bear LO, the winds are still dominated by the south-southwest quadrant.

In this example, if winds primarily out of the south-southwest are of interest or concern and the expected fire growth is to the north-northeast, it is likely that the Spotted Bear LO RAWS would be the more appropriate station to use based on the analysis conducted here. In reality, on the actual incident the Spotted Bear LO station was used for winds information while the Benchmark RAWS was used for the ERC Classes.
Summary

- FSPro more appropriate for long-term analysis under uncertain weather than FARSITE
- FSPro more appropriate for probability analysis than REPAP
- Long-term simulations need to consider:
  - Where you are in the fire season
  - What type of fire season you are experiencing
  - Where you are in the life-cycle of the individual fire or incident

We'll now summarize what's been covered in this lesson.

FARSITE can be used to simulate fire growth for a single fire under only one wind-weather scenario and offers no information as to the probability of an area being impacted under multiple wind-weather scenarios. This limitation eliminates the use of FARSITE to answer questions related to probability analysis.

RERAP assumes that the fire spread is in one direction and under the influence of a specific wind direction and the average historical climatology. However, fire spread in FSPro can reach a point from any direction as either a head, flanking, backing, or even a spot fire under the influence of winds from any direction. Because FSPro can simulate fire growth more realistically and account for fire spread in 2-dimensions under uncertain weather, it is a much better tool for probability impact analysis than RERAP.

Long-term simulations need to consider at a minimum: Where you are in the fire season, what type of fire season you are experiencing, appropriate live fuel moisture settings, and where you are in the life-cycle of the individual fire or incident. All of these will influence model settings in FSPro.
Summary

- All of the following contribute to the overall run time for any FSPro simulation:
  - Landscape extent
  - Landscape raster resolution
  - Number of fires
  - Simulation duration
  - Number of wind/weather scenarios
  - Burn period settings

- Determination of the appropriate raster resolution and landscape extent are influenced by:
  - How soon need a model result
  - Heterogeneity of the fuels data
  - Size of the current fire footprint
  - Selected simulation duration
  - Other users system demands

Model settings for landscape extent, landscape raster resolution, number of fires, simulation duration, number of wind/weather scenarios, and burn period settings all affect the overall run time of the FSPro model.

Determining the appropriate raster resolution and landscape extent are influenced by: how soon a model result is needed, heterogeneity of the fuels data and how generalizing this information affects model results, size of the current fire footprint, the selected simulation duration, as well as other users demands on the system.
Summary

- **Number of Fires.**
  - The minimum number of fires to simulate should be 1000

- **Simulation Duration**
  - Selected simulation duration should be driven by the interest in knowing the probability of a fire reaching or impacting a specific point in during simulation duration
  - As the simulation duration increases, a corresponding increase in the landscape extent and coarsening of the raster resolution of the landscape information may be required

In order to account for capturing the rare event the minimum number of fires to simulate for a final FSPro simulation should be 1000. Numbers fewer than this may not include rare events in the FSPro modeling results.

The selected simulation duration should be driven by the interest in knowing the probability of a fire reaching or impacting a specific point during the simulation duration.

As the simulation duration increases, a corresponding increase in the landscape extent will be required to insure the potential FSPro output is covered. As the simulation duration increases to periods of 20-30 days, a coarsening of the raster resolution, for example 90m to 120m, may also be required to reduce the simulation run-time.
Summary

- Issues with 30-day Simulations
  - Suppression activities or weather events
  - Large probability footprint
  - Short shelf life
  - Fuel moisture settings
  - Early vs. late in the fire season
  - Require extensive communication and interpretation of model results

- Weather Station Selection Should Consider
  - Local knowledge
  - GACC websites
  - Station evaluations
  - Station density and location
  - Station data quality, extent, relevance

Simulation durations of 30-days or longer need to consider the effect of suppression activities or weather events changing the existing fires location on the landscape which will contribute to the short shelf life of such a simulation; their large probability footprint; how simulations of this duration can cross plant development stages and the effect it has on determining live fuel moisture settings; and early vs. late in the fire season. Simulation durations lasting 30-days or more will require extensive communication and interpretation of model results to the end user.

When evaluating and selecting the appropriate weather station to generate ERC Classes and wind distributions for an FSPPro simulation, take advantage of local knowledge, GACC websites, and GACC meteorologists for suggestions on the appropriate stations to consider. Existing station density, station data quality, data extent, and relevance may limit opportunities for station selection.
Summary

- Within WFDSS can determine the length of years a station has data available, but cannot determine the actual months or how many months within a specific year actual data exist
- Wind Roses beneficial to quickly evaluate wind patterns of RAWS for use in FSPro simulations

When evaluating a weather station to generate ERC Classes or winds distributions, you must determine the actual available years, available months and the available months by year outside the WFDSS System. This is critical when establishing the Date Filters for ERC Classes and the Time Filter for the winds distribution. This will require using tools such as FireFamily Plus to appropriately evaluate this station and determine these criteria.

Wind Roses generated by WFDSS offer a visual representation of the winds distribution table. The Wind Rose option is an excellent way to quickly evaluate wind patterns associated with a selected RAWS. Wind Roses will quickly illuminate distinct patterns of wind for a station and allow you to easily compare and contrast RAWS stations to determine their suitability for use in the FSPro simulation.
You’ve reached the end of this lesson. Please now proceed to Unit 8 Lesson 4: Assessing Values at Risk of Wildfire within the Wildland Fire Decision Support System (WFDSS)…