Title: Verification Analysis of Red Flag Warnings in the Reno, Nevada County Warning Area

Extended Abstract: Red Flag Warnings (RFWs) are a product issued by the National Weather Service (NWS) to indicate when conditions are conducive to fire development and spread. This product alerts firefighters, emergency managers, and other government officials to a potential increase in fire activity so they can effectively place resources to mitigate the potential threat.

Red Flag Warnings are issued based on set criteria involving a combination of relative humidity and wind speed for a given region. If a warning is issued and the criteria is not met, it is considered "unverified" and if criteria is met but a warning is not issued, it is considered "missed". The purpose of verification analysis is to determine what improvements can be made to the forecasting and communication process of RFWs.

One of the greatest forecasting challenges for fire weather in NWS Reno's County Warning Area (CWA) is the drastic change in elevation across the Sierra range and Great Basin. Across the region, there are multiple minor mountain ranges that independently affect the airflow and humidity of the region. When forecasting for a larger area, it can be challenging at times to take all the minute factors into consideration and occasionally it leads to forecaster error. Wind speed is generally higher and relative humidity is generally lower at higher elevations. This means weather stations relaying data will often show conditions that meet RFW criteria on a regular basis. However, in order for a RFW to verify for a Fire Weather Zone, multiple sites must have verifying conditions. So while the upper elevation sites verify on a regular basis, lower elevation sites may not verify leading to unverified warnings or missed warnings if the forecaster assumes conditions will not meet at lower elevations. This difficulty is amplified by the current size of the Fire Weather Zones which each encompass a diverse landscape that can be difficult to forecast when trying to determine fire weather conditions across changing elevations.

This research project found that borderline and marginal conditions were the primary reason for missed RFWs. Several times the wind speed would verify but humidity would be forecasted just above criteria so a RFW was not issued as a precaution against over-warn. The uncertainty in forecasting was occasionally increased when model forecasts disagreed on the location of wind generating events that could potentially affect the relative humidity of the area. The difficulty with this disagreement in criteria is that when fuels have dried out completely, a slight increase in humidity above criteria will not necessarily denote lesser fire danger. This can be a challenging call for forecasters who do not want to increase the false alarm rate but also know that a fire will spread rapidly despite higher relative humidity.

Another primary reason RFWs were missed was due to overshadow by another event. Sometimes a RFW was missed because a more severe fire weather event was forecasted later in the week and posed a greater threat to the community. As a result, NWS Reno made a command decision to forego warning the lesser event in order to focus on the more severe event and reduce the possibility of over-warn. While this decision led to more missed events in

the verification analysis, it was determined during analysis that the move to miss the event was justified.

Throughout the process of research an important discovery was made regarding verification analysis. While post-analysis is effective at evaluating similarities between weather events, it is not as useful when there is a lack of correlation. In this case, it is critical to view the weather events from the perspective of a weather forecaster instead of only a researcher. This approach was aided by NWS Reno's commitment to writing long and detailed Area Forecast Discussions (AFDs) which allowed us to gain perspective on what influenced the forecasters to issue or forego RFWs. Ultimately this research was considered a success and the reasons behind the missed events were effectively determined because of the AFDs. As a result, the researchers would like to encourage NWS offices to continue to invest in writing a good analysis in their issued products, as it helps not only convey the details of the event to the public but allows for an accurate post-analysis to improve future decisions.