How Can the Measurement of Fluorescence Help with Eastern Red Cedar Disaster?

Authors: Christian Roopnarinesingh, Jeff Dudek*, and Dr. Henry D. Adams†

Abstract: *Juniperus virginiana,* more commonly known as the Eastern Red Cedar, has caused excess economic damage due to its dynamic flammability in the Great Plains. Research on the variables in which Eastern Red Cedars are flammable have been proven useful in combating these tragic events. Recording live fuel moisture (LFM) and water potential are accurate when a researcher wants to know the flammability of the plant. However, fluorescence can be used as a more convenient way of measuring water potential, and therefore flammability due to its user-friendly and less costly fluorometer instrument.

Keywords: Fluorescence, Water Potential, Live Fuel Moisture, Eastern Red Cedars, Flammability

Introduction

The Eastern Red Cedar is a species native to riparian areas in Great Plains of North America but currently acts as an invasive species outside of riparian systems. The Eastern Red Cedar encroaches in land that is home to native species and changes the environment that the species is specifically well suited for. More importantly, Eastern Red Cedars are one of the primary reasons for wildfires in all of Oklahoma, yet can be surprisingly fire tolerant under certain conditions. How fire tolerant an Eastern Red Cedar is heavily dependent on a multitude of factors, including foliar and soil moisture. Environments that have low moisture are typical in Midwest US, meaning that the Eastern Red Cedars are extremely combustible in this area and can cause serious economic loss. This includes - but is not exclusive to - loss of forage for cattle and uncontrollable wildfires (Engle et al. 1996).

As previously mentioned, there are an excessive amount of variables that determine how flammable Eastern Red Cedars are. One of the most important factors is called live fuel moisture content, or the amount of moisture present in live plant leaves. Live fuel moisture (LFM) is measured by weighing leaf clippings while wet and storing them in a drying oven before re-weighing while dry.

If a Juniper is using excessive energy to store water, then it has little or no water to work with. Another way to measure the amount of water stored in a plant's leaves is to measure it's water potential which is a measure of how much energy is being used by the plant to store water. When an Eastern Red Cedar is forced to hold small amounts of water in its leaves, it becomes more combustible since water is a heat sink (Pyne 1996). Water potential is measured by a machine called a Scholander pressure chamber, which uses pressurized gas to force a plant leaf clipping to push its held water out of its stomata.

The research that I'm assisting with aims to correlate LFM with plant leaf water potential to build a fire risk prediction model. Additionally, it aims to correlate soil moisture, the amount of water contained in the soil that is available for usage by the Eastern Red Cedar (Hoff et al. 2018) with LFM. Soil moisture data is collected using the Oklahoma Mesonet. These factors are signals of a plant's water stress. While these measurements give accurate results, they can be inconvenient and costly when used to measure Eastern Red Cedars. However, one factor that can be used to

* Graduate Student Mentor, Department of Plant Biology, Ecology, and Evolution
† Faculty Mentor, Department of Plant Biology, Ecology, and Evolution

measure overall flammability of Junipers that avoids this is fluorescence through remote sensing.

When plants are absorbing light, they emit the wavelengths they are not absorbing which ultimately gives their specific colors (Bowyer and Danson 2004). Fluorescence is the measurement of how much of each wavelength is being emitted by plants, showing how effectively their photosynthetic systems are working. The effectiveness of the photosynthetic systems depends on how much water is available for use and therefore will correlate with water potential, LFM, and soil moisture. We hypothesize as signs of water stress increase, fluorescence will decrease along with LFM (Jacquemoud et al. 1995). This information can help future research by giving researchers an economically affordable measurement of plant physiological stress, allows for widespread measurement of multiple Red Cedars rapidly, and is much more convenient relative to other ways of measuring plant physiological stress. With a more efficient way of collecting flammability data, fire prediction models can become even more accurate since the sample size will grow larger due to effective widespread use of remote sensing techniques like fluorometry.

Methods

Samples were taken at sites with varying data: Boiling Springs State park in Woodward to have a dry site, Cross Timbers Experimental Range (Called Marina) for a wet site, and Cooksen for a site that is neither dry or wet relative to the other sites.

Mornings at ~10:30 AM is when the samples were taken for optimal measurements of photosynthesis. The equipment brought included a Optiscence 30p fluorometer, Scholander water pressure chamber for water potentials, a 20 cm soil probe, a pole pruning saw for clippings, and a balance scale for weighing samples. A dry oven was used to measure but was not brought with us.. LFM can then be calculated using the formula [100 * (wet weight - dry weight) / (dry weight)].

We took a total of 50 samples per site; we chose to have such a large sample size since there are various amounts of confounding factors that could skew our data in this study, including weather and amount of recent rain. The samples were small snippets that were cut off from the tree. Each sample was measured for original weight immediately, and dry weight later to calculate LFM. First, the samples were measured with the fluorometer and then the pressure chamber for later comparisons. All samples were taken from the same spot of an Eastern Red Cedar to ensure accurate results and cut out confounding factors. The samples were cut to fit the Scholander water pressure's hole conveniently. Preliminary results do not suggest a linear relationship between fluorescence and live fuel moisture.

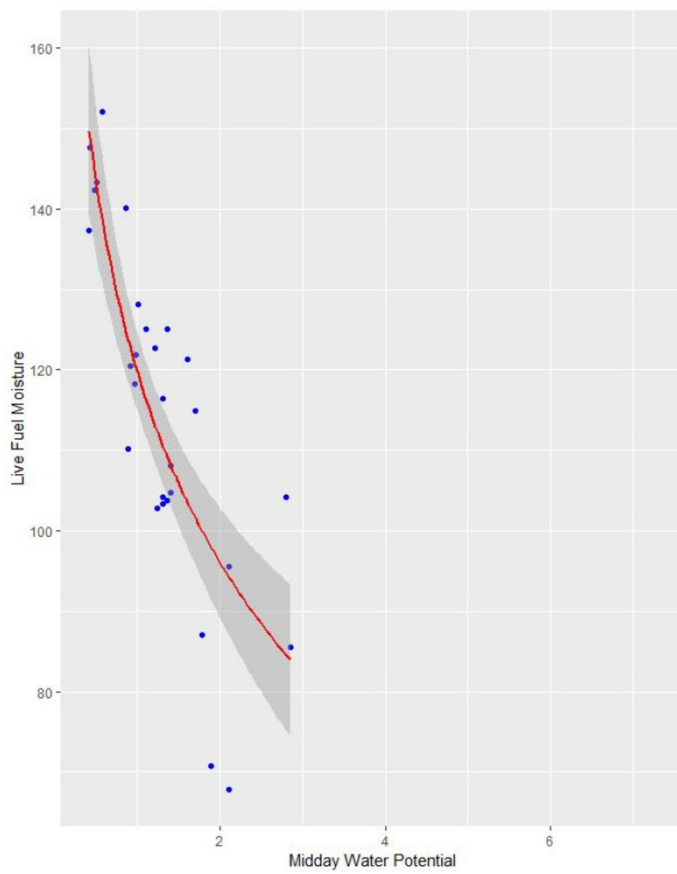

Figure 1: LFM and water potential. This figure is present to emphasize the strong correlation between LFM and water potential. Therefore, if fluorescence strongly correlates with LFM, it can be deducted that fluorescence also correlates with water potential.

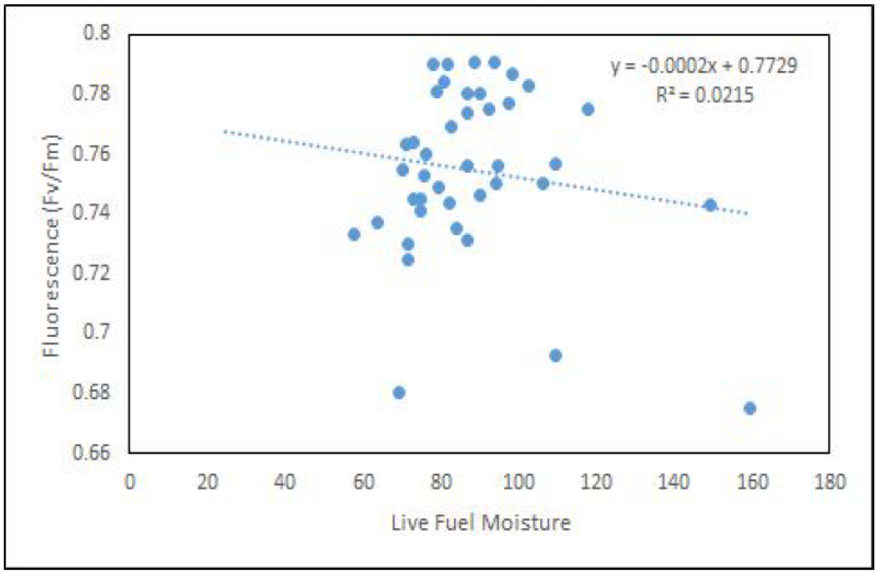

Figure 2: Preliminary data over the correlation of fluorescence and water potential.

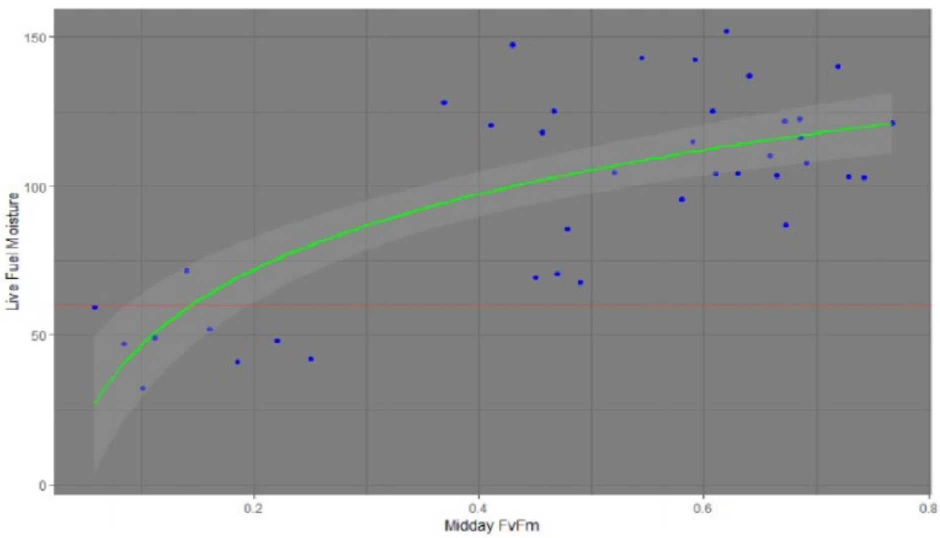

Figure 3: There was a strong r squared value of .75 between fluorescence and water potential, making fluorescence a reliable tool for measuring water potential.

However, more data collection is necessary. All preliminary information was created on Excel.

This research project is to find a correlation between fluorescence and LFM for the sake of obtaining data quickly in future research projects that would help create a more accurate fire prediction model.

Discussion

The data (Figure 1) show a slight correlation between LFM and fluorescence, but that is due to the inefficient amount of sampling. As sample amounts grew, the correlation between LFM and fluorescence became more significant with an r squared value of ~.75. Figure 2 is present to help understand the significant correlation between water potential and LFM, and what the correlation between LFM and fluorescence should look like (Figure 3). With the high sample rates, it is possible that our preliminary data has not suggested the same results as our authentic data; fluorescence does correlate with LFM with more samples. "LFM is important because there's a 60 percent threshold where cedars get more flammable (Weir and Scasta). However LFM is difficult and time consuming to measure. Our results show that leaf water potential, which is a measure of tension within the xylem of plants (Paul et al. 98), is a good predictor of LFM. Additionally, we were able to show that chlorophyll fluorescence taken at midday is a strong predictor of LFM. This is important because chlorophyll fluorescence is quicker and easier to measure than either LFM or leaf water potential. There are limitations on this project. The most efficient way of obtaining fluorescence based data is using a drone-based scanner. The drone based scanner is a drone that can measure multiple fluorescence activity of all types of plants in an area. Oklahoma State University did not have a drone available, so the possibility of using this method of measurement is absent.

Conclusion

As stated in the discussion, a strong correlation can be found between fluorescence and LFM. This is undoubtedly pleasant for scientists in both user-friendly and economic perspectives. The fluorometer is much less expensive than water potential instruments that are orthodoxically used for water potential measurements. Eastern Red Cedar is a threat to the Great Plains of North America, and can be combated through readings of LFM, but more conveniently fluorescence.

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