

## **Abstract**

Leaf turgor loss point (TLP) has been proposed to be a key indicator of drought resistance in plants. Many terrestrial landscapes are facing increased stress with the increase in intensity and duration of drought due to climate change. One of the ecosystems expected to be heavily affected by increased drought are grasslands, which comprise a large majority of terrestrial landscapes. Forb species may be at risk of succumbing to drought than grasses, but forbs contribute to much of the biodiversity in these ecosystems. Identifying differences in leaf turgor loss point among forbs across different grasslands can help to determine their drought resistance. Through use of an osmometer, 61 forb species were collected across 3 different grassland sites in the United States (Flagstaff, Santa Rita, Jornada) to determine their TLP, and leaf dry matter content (LDMC). Sites that experience higher temperature and lower precipitation exhibited lower leaf TLP than sites lower temperature and higher precipitation. TLP is useful for indicating the range of drought resistance in grassland forbs and can be used to predict how a grassland communities respond to a drought. LDMC is strongly correlated with TLP, further identifying why specific survival strategies used by grassland forbs.

# Differences of turgor loss point and leaf dry matter content across grassland forbs

## Introduction

Plants trapped in their sessile lifestyles are faced with countless different stressors that effect their functionality and distribution. One stressor that has increasingly become more prevalent is that of drought; both increased temperatures and reduced water availability effect the survival of plants and the communities they compose. A drought, which can be defined by a prolonged period of time in which there is abnormally low water availability, whether through precipitation, ground, or surface water, affects the environment in a multitude of ways (USGS 2020.) Economic loss, limited aboveground output (Naudts et al. 2010), shifting flora and fauna communities, and reduction in carbon uptake (Delzon 2015) are some of the expected outcomes from a drought (Zwiche et al. 2015, Beck et al. 2007.) Drought occurrence is expected to increase both in intensity and duration in the coming years (Jung et al. 2013, Cook 2019). Predicting how drought will affect plant communities found throughout a diverse range of ecosystems is difficult due to the how abiotic factors such as precipitation, wind, nutrient availability, and water availability affect what plant species form a community within an ecosystem. It can be difficult to accurately identify how a drought will affect plants in local communities and how different communities may have a better chance at overall survival due to community composition. Due to modes of drought resistance survival strategies varying among different plant species, even with plants found within the same ecosystem, it can be difficult to accurately predict how drought will affect plants.

The objective of this study is to determine how leaf turgor loss point and its relation to leafy dry matter content is different across grassland forbs. Identifying the relationship between turgor loss point and leaf dry matter content within forbs can help to identify survival strategies used in grasslands and what type of survival strategy is dominant in a community. Leafy dry matter content and turgor loss point can be beneficial in identifying the physiological reasons for the occurrence of forbs with different survival strategies across grasslands.

A method that can be used to help understand response to drought is leaf turgor loss point (TLP) due to how heavily associated these traits are with drought resistance. Osmolarity is the measure of how concentrated solutes are in a solution and osmotic pressure, which is a function of osmolarity, is the pressure developed from the movement of solutes across a gradient (Caon 2008.) Osmotic pressure influences the opening and closing of stomata in plants to be able to regulate the internal pressure of cells. Another function of osmolarity which plays a key role is osmotic potential which is the potential for water to move across a membrane, such as a leaf, caused by different concentrations of water and solutes in a plant (Caon 2008.) Osmotic potential gives insight how much water can be lost or retained in a plant.

Turgor pressure in a plant is the internal water pressure needed to maintain cell structure and prevent dehydration of the cell; turgor loss point is the point in which the internal pressure that is used to maintain cell structure nears zero. At this point, turgor in cells cannot be

difficult to maintain cellular processes and survival due to the diminishing structural support from cells.

Another trait seen in plants that help with survival is leaf dry matter content (LDMC.) This trait is less varied across plant species because it not dependent on leaf thickness or environmental influences such as soil nutrients and precipitation which can vary greatly across landscapes but instead is dependent on the method of survival that a plant uses (Wilson et al. 1998.). LDMC is useful to predict plant survival strategies not only because of how it is less varied but it is also a great predictor for how much information can be obtained from LDMC values within a plant. A wide range of insights can be gained such as how a plant makes use of resources such as nutrients, allocation of resources for growth, survival strategy used, and indicate the productivity of a community (Wright et al. 1998, Pakeman 2014.)

Lower TLP in a plant can allow water to be retained and moved throughout a plant longer when faced with reduced water availability, characteristic of higher leaf dry matter content (LDMC) in leaves from cell structure being thicker to provide a more rigid cells (Sun et al. 2020.) Cells that are more rigid take longer to collapse from loss of internal pressure, allowing metabolic processes to continue much longer than if the plant had a less rigid cell structure. This method of low TLP and higher LDMC is commonly seen in plants that are drought tolerant as they are able to withstand harsh drought stress. Higher TLP in plants show different modes of survival as early stomata closure to better retain water (Sun et al. 2020). Plants with high TLP tend to have lower LDMC generally do poor in drought environments, characteristic of plants that are drought avoiders. These plants tend to wilt much sooner under reduced water availability because their cell structure is not rigid enough to withstand a loss of internal pressure for long

periods of time. Turgor loss point in a plant is important to understand the mode of survival that may be used under drought.

Drought is a common occurrence throughout the world and directly affects water availability in plants and thus their survival. Biomes that most commonly experience droughts are arid and semi-arid biomes such as grasslands, sagebrush steppe, and deserts. Drought prone areas are susceptible to changes such as reduced water availability, increased annual temperatures, warmer winters, that will occur as a result of climate change (Griffin et al. 2019.) Arid and semi-arid regions roughly cover one-third of the Earth's land area. Grassland alone covering more than 30% of land. This makes critical biomes to understand due to the large amount of biodiversity that they host (Griffin et al. 2019). Drought events greatly affect plant growth, leading to plant closures, desiccation, and reduced productivity. Plant species will respond to arid and drought conditions differently due to various survival strategies even if species have similar traits such as life history, leaf hairiness, or leaf thickness (Blum 2005). Within grassland, plants, specifically forbs, tend to be smaller in size, reduced leaf area to prevent rapid desiccation, and early blooming in order to cope with water and temperature stressors that commonly occur. The expected increase in drought occurrence and intensity as a result of climate change, it is important to understand how plants will react regarding their resilience to increased stressors and how that will affect community composition and ultimately ecosystem function (Wright et al. 2015, Hoover et al. 2019, Rooijen 2015).

Plants make use of one of three general strategies when faced with a drought. The first strategy is drought tolerance in which the plant resists dehydration and wilting during a drought. This is accomplished by maintaining turgor pressure through increased LDMC and lower

osmotic potential in order to prevent wilting at the cost of limited growth and production during the drought (Delzon 2015). Many plants in arid environments that face reoccurring droughts have adapted to tolerate the reduced water availability. Other plants may make use of drought avoidance strategies rather than drought tolerance, which are methods of survival that makes use of the water available by managing water loss through stomatal closure, change of metabolic rates, growth of root systems to uptake more water, and maintaining cell turgor (Delzon 2015, Basu et al. 2016). Lastly, the final method that plants use to survive drought is escapism. Categorized by plants that are not productive and instead dormmate during the drought due to a quick lifespan that allows for them not to be present to experience of the drought. (Delzon 2015, Basu et al. 2016).

Plants have adapted to common occurring stressors through a variety of traits that help them to survive the reduced availability of water. Growth is limited by water reduction as the plant is no longer able to properly adjust its osmotic potential, resulting in carbohydrates and inorganic ions to build up within the plant (Claeys & Inzé 2013, Hoover et al. 2019). The buildup of carbohydrates has shown to be correlated with sudden decreased growth rate when water availability is reduced (Claeys & Inzé 2013). With increasing intensity and occurrence of reduced water availability, plants dedicate more of their metabolic processes to survive drought related stress instead of using the same metabolic processes to facilitate growth (Claeys & Inzé 2013.)

Decreasing metabolic rates is not the only method that plants have evolved in order to survive through the stresses that drought may cause. Physiological and morphological adaptations are also in place to further help overall tolerance and survival from stressors. In order to prevent wilting, which happens when plants are unable to retain the pressure in cells causing

the plant to lose pressure and internal structure, plants regulate the opening and closing of their stomata. This prevents water loss due to a change in air humidity or more commonly a change in the water potential in their leaves (Hoover et al. 2019). Stomatal closure helps to minimize water loss but with faced with reduced water availability, the duration of closure is increased with lower water availability. The stomatal closure does not only affect water movement and gas exchange in a plant but causes a cascade of adjustments of the organic solutes and ions within a plant (Chen & Jiang 2010). Adjustment of ions and solutes which increase in concentration occurs in a plant when stomata are closed for prolonged times help to further reduce water loss and continue metabolic processes (Chen & Jiang 2010).

In grasslands, forbs contribute more diversity in the landscape than grasses and other flora, forb species present is upward to four times greater than grass species in many grasslands (Eviner 2016.) Many forbs found in grasslands have evolved adaptations to survive the arid conditions they grow in; reduced growing season, release of seeds earlier in the growing season for better chance of continuation of plant lineage, and increased nutrient uptake from roots are some of the adaptations forbs have evolved in order to survive and thrive in grasslands.

Surviving in the harsh conditions present in grasslands with the common occurrence of drought, which commonly brings forth temperature and water availability extremes, is something forbs are adapted to handling with. Yet the increase of environmental extremes both in duration and intensity is something not all forbs are not equipped to handle. The biodiversity present in grasslands is threatened by extreme drought conditions which can see the loss of rare and uncommon species in local environments. Ecological changes occurring from a shifting plant community due to forbs inability to survive stressors such as drought can give insight on the

likelihood of soil erosion, desertification, fragmentation of a community, and loss of local species within an area (Fang et al. 2015).

There are a variety of ways to predict the possible changes that may occur in an ecosystem as a result of stress. This is primarily done by examining a selection of traits of the plants and how certain stressors act upon the plant traits and at what point does a stressor become life threatening to survival of a plant. Functional traits are measurable traits that can be morphological, physiological, and even phenological which can be examined from a species level up to an ecosystem level (Malézieux et al. 2007.) Being able to understand how specific traits such as metabolite usage, the strength of membrane integrity, and osmolarity, can be stomata (Hoover et al. 2019) can tolerate and survive reduced water availability better than plants with larger and more spread out stomata. Understanding specific traits of a plant can give insight into what will survive certain stressors; the plants with small, densely located stomata are less likely to be affected from drought and be lost locally from the stressor while plants with Nolan et al. 2019).

By understanding the relationship of turgor loss point that forbs possess and water availability within stressful environments, it can give better insight into community-level response to increasing stressors that specifically act on water within the plant. In addition to understanding community response, by looking at the different values of turgor loss point present in grassland forb species, we can understand the types of survival modes that are common within a specific grassland such as drought resistance, drought tolerance, or drought

escape. The relationship of these water bound traits in forbs will be useful to better understand for the future aspects of ecology with rising climate temperature, increased stressors both in duration and intensity, and biodiversity of forbs within grassland communities.

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another by using TLP and what are the underlying environmental influences for the differences of TLP. In addition to understanding how TLP is different across grasslands forbs, understanding the relationship between TLP and LDMC is important for identifying forb survival strategies within different grasslands.

## **Methodology**

### *Field collection*

The forb samples were collected in three different locations within the United States during the summer growing season of 2019. The first location is the Jornada experiment range in New Mexico in the Chihuahuan Desert. The Jornada Experiment Range sits at an elevation of 1260 m with an annual mean precipitation of 246 mm and annual mean temperature is 14 C °. Santa Rita Experimental Range in Arizona, found within the Sonoran Desert. The experiment is at an elevation of 1150 m with an annual mean precipitation of 373.11 mm and an annual mean temperature of 9.07 C °. The final site in which samples were collected is from ponderosa pine woodland in Flagstaff, Arizona; the area is at an elevation of 2,130 m, experiencing annual mean precipitation of 555 mm and annual mean temperature of 7.9 C °.

A total of 61 different species of forbs collected had five replicates with a few exceptions due to rarity. All traits measured were done at species levels rather than at ecosystem level. Each

species had the above ground tissue collected and placed immediately into a cooler to later be rehydrated to full turgor over 12 hours. Any damaged or wilting leaves were removed as they may not be able to represent the true osmotic potential and turgor loss point due to the trauma. After being rehydrated, the samples are then placed in a freezer at  $-18^{\circ}\text{C}$  or lower until the samples can be measured using an osmometer.

### *Data collection*

Samples were then placed within a freezer until they were ready to have their osmotic potential sampled within the lab. To measure osmotic potential, first a single leaf that has no signs of cuts, decay, or any damage is taken from a sample bag. The forb leaf is then punched approximately 15 times, avoiding puncturing the midvein of the leaf when possible. Avoidance of the midvein of the leaf was to ensure accurate osmolarity measurement across samples. The punctured area was then removed using a biopsy punch immediately after being punctured then placed within the osmometer.

Samples were measured using a VAPRO<sup>®</sup> Vapor Pressure Osmometer 5600 in different set time intervals. Repeated measurements were taken from samples until osmolarity values stabilized after reaching the lowest osmolarity value. An overall range of 0-5 minutes were used throughout the forb samples, but a majority of samples were measured in the 2-3-minute range using trial and error. While some species had exhibited trends allowing for duration of sample reading and time interval to be easy to determine after a few samples, other species duration of sample reading and time interval varied, causing difficulty in determining appropriate time to be

used for the osmometer. Overall time for the osmolarity value to stabilize varied greatly between species, ranging from 20 minutes upwards to 1.5 hours. A full reading from the osmometer included osmolarity readings that decreased until they hit the lowest reading from the recorded output sequence; the sample was considered finished once the osmotic potential readings increased two consecutive times. Any readings that increased from the first value, stopped reading due to drying, or suddenly dropped to a continuous reading of 0 mmol/kg were not used in analysis.

In addition to collecting osmolarity readings from each sample, leaf dry-matter content that was already collected and measured was used in addition to leaf osmotic potential and turgor loss point to explain some of the trends seen from analysis.

#### *Data analysis*

In order to get the most accurate osmolarity reading through the osmometer, the lowest value from the forb samples were used as they were the most representative of real-world osmolarity of the forb. The osmolarity data was then converted into osmotic potential for each sample, this was then converted into turgor loss point. All samples were then compiled into species averages of turgor loss point to be used for analysis.

Statistical analyses of data were all performed using R software. We used histograms and linear models to understand the relationship between turgor loss point, leaf dry-matter content, precipitation, temperature, and site location. The histograms were used to compare turgor loss point across sites in order to identify any significant differences in turgor loss point between sites. Linear models were used to plot leaf turgor loss point against other environmental and plant traits in R. The environmental traits used to determine possible effects on turgor loss point

were mean annual precipitation (mm) and mean annual temperature (°C). Leaf dry matter content (LDMC) was used to determine if this plant trait had any possible correlation with turgor loss point seen throughout the site. Each histogram and linear model was graphed with a 95% confidence interval.

## **Results and Discussion**

### *Turgor Loss Point (TLP)*

Analysis of the turgor loss point in forbs shows that there is a significant difference between the range and average of TLP of the overall grassland for each of three sites used (Fig. 1). The differences between the average TLP of a site across each grasslands shows that the forb communities found utilize different water management strategies and survival strategies in order to survive within the harsh, semi-arid environments they reside in. Each site presents different ranges of the calculated TLP, demonstrating turgor loss point is not consistent for forb communities across semi-arid grasslands.

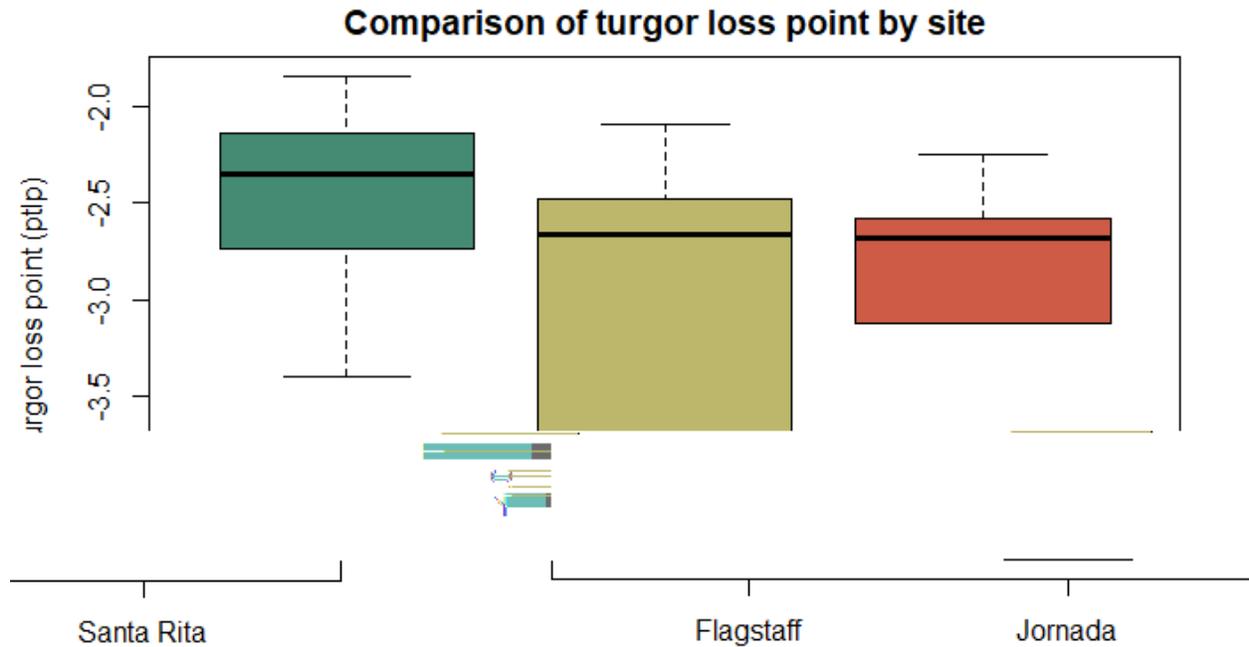


Figure 1: Comparison of turgor loss point between grasslands. Each boxplot represents a different site which is significantly greater than the other two sites, Jornada mean TLP of -2.9 and Santa Rita mean TLP of -2.93, with  $P < 0.0001$

Despite average TLP being vastly different across the grassland sites, the differences in the average TLP in the sites is most likely due to the different forb species and their specific environmental requirements to grow, survive, and reproduce in. Mean annual temperature, mean annual precipitation, and occurrence and intensity of drought are varied across the grasslands. Difference in turgor loss point is most likely due to the composition of different species which make use of different survival strategies which affect osmotic rates. This is seen the significant differences between the average TLP and ranges seen with each site with a  $P < 0.001$  (Fig. 1). Forb species that had a mean TLP value that are less negative indicate that the species are able to tolerate milder environments on average. These milder grasslands such as Flagstaff experience



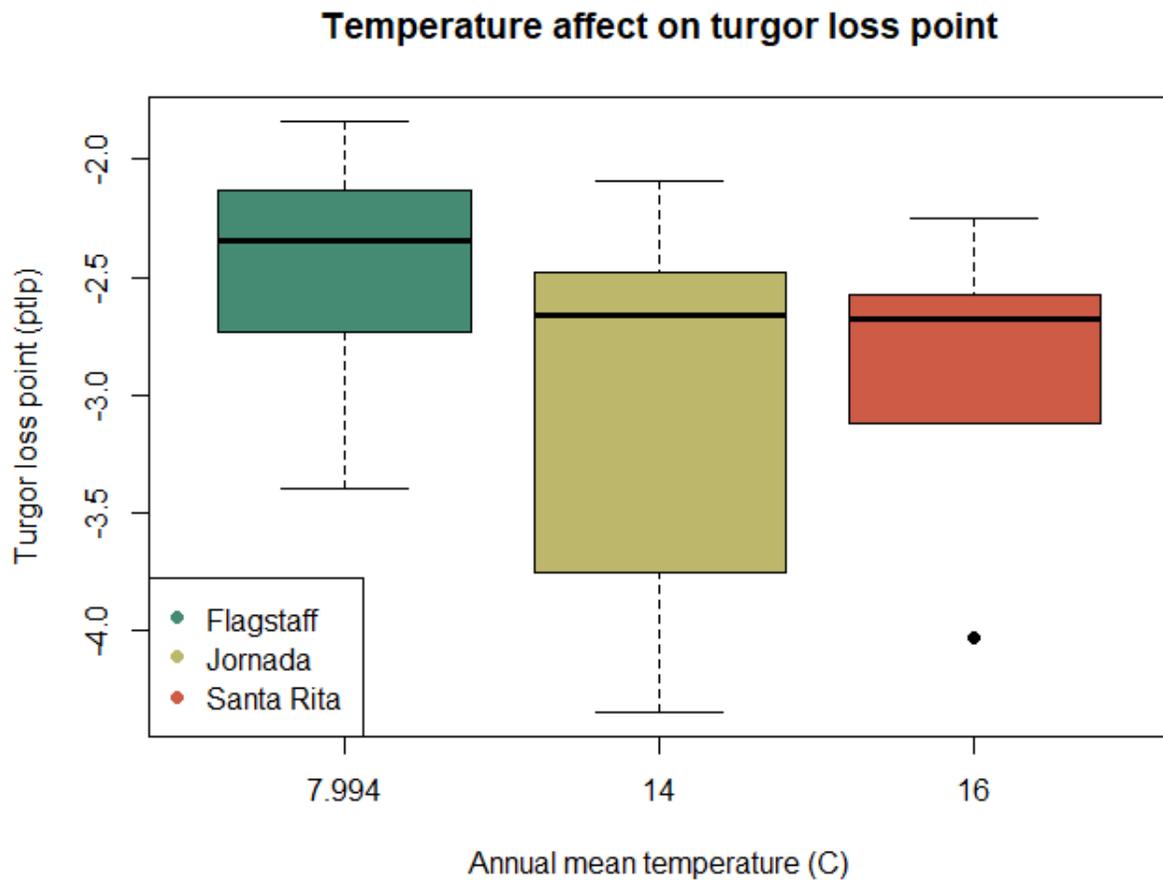


Figure 2: Temperature effect on turgor loss point. Each site was significantly different from each other by  $P < 0.001$ . There is one outlier for the Santa Rita site due to reduced forb species used in comparison to Flagstaff and Jornada.

The boxplots shows how the temperature of an environment is a good indicator of what TLP values will be seen within an environment. Forbs that have more negative TLP values are more commonly seen within grasslands that experience higher mean annual temperature while forbs with less negative TLP values are populate environments with cooler mean annual temperatures (Fig. 2). Turgor loss point is negatively correlated with annual mean temperature (Fig. 2). At sites with higher mean annual temperatures there are more forb species that have more negative TLP, indicating a possible shift towards more negative TLP as a more effective

survival method to survive arid and stressful environments. Forb species with more negative TLP can survive in the stressful grasslands because of the ability continue moving water throughout increased resistance to desiccation and continuation of metabolic processes, even when the plant is water-stressed.

Sites that experience lower annual mean temperatures are populated with more plant species that have less negative TLP values and very few species that have notably more negative TLP values (Fig. 2). Sites that experience lower temperatures on average having species with less negative TLP values can indicate the temperature acting within the environment is not as significantly impactful at sites with higher temperatures. The less stressful environment in regard to temperature means that desiccation rate is not as severe. Plants species with more negative TLP would be less commonly seen cooler grasslands due to the decreased stressors that can cause leaf desiccation.

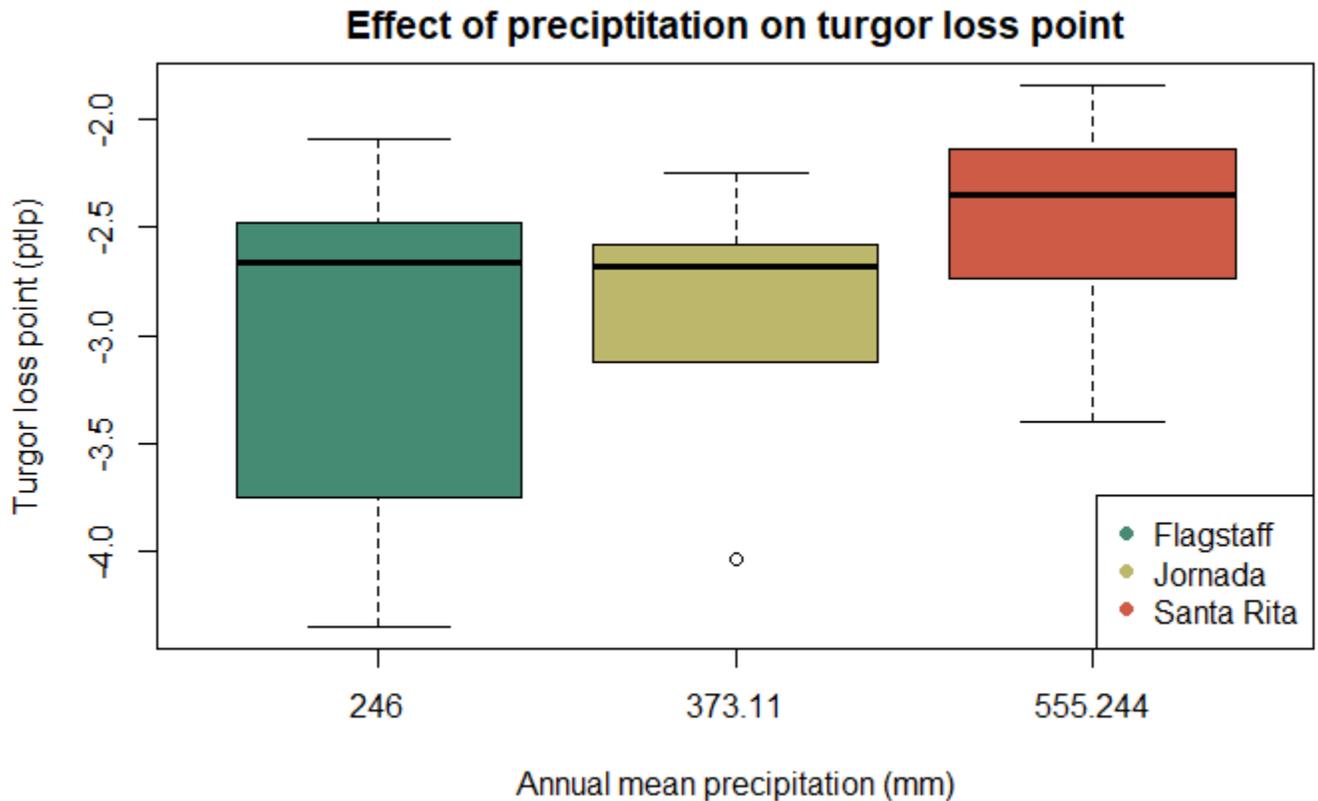


Figure 3: Effect of precipitation on turgor loss point. Flagstaff experienced a significant difference in TLP at  $P < 0.001$  in regard to annual mean precipitation than the two other sites of Jornada and Santa Rita.

The relationship annual mean precipitation within an environment and its effect on the turgor loss point values seen in forb species, reveals another trend (Fig. 3). The boxplots that show TLP values against annual mean precipitation show a positive correlation; lower precipitation is correlated to more negative TLP values for forb species, while higher precipitation correlated to less negative TLP values been seen in forb species (Fig. 3). The trend is mostly likely due to the fact that plant species that are able to live within areas with increased precipitation will not have traits associated with withstanding drought; traits such TLP can be expected to be less negative in such areas. Sites that experience lower precipitation annually are

more prone to reduced water availability and drought, thus the occurrence of forb species with more negative TLP can be expected.

### *Leaf dry-matter content (LDMC)*

By plotting LDMC and its relationship to TLP it is seen to have a strong, negative relationship with the functional trait TLP (Fig. 6). This relationship is reinforced by Griffin-Nolan et al (2019) in which they also found that LDMC is strongly correlated with osmotic potential at full turgor in herbaceous plants (Griffin-Nolan et al. 2019). Leaf dry-matter content and its association with turgor loss point show a better indicator for the overall survival in stressful conditions when both are taken into consideration together in conjunction to environment the forb species reside in.

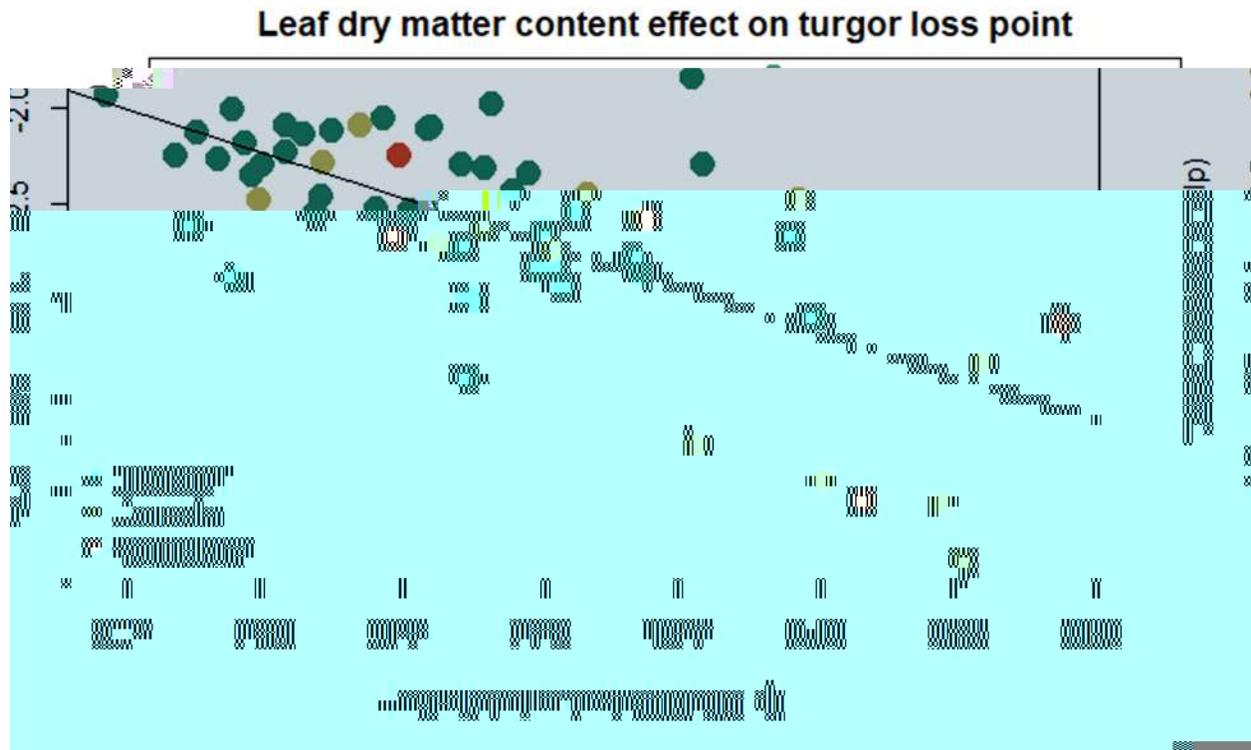


Figure 4: Leaf dry matter content effect on turgor loss point. Relationship between TLP and LDMC of forb species is significantly correlated as noted with a  $P < 0.0001$  across all 3 grassland sites.

Comparison of leaf dry-matter content against turgor loss point is more useful for

4). Looking at the trend of a

fails to fully explain the

overarching ranges TLP values of forb species that exist within a site. LDMC and TLP are strongly correlated with one another and this relationship further reinforces the trend of different survival strategies being dominant within grasslands. The strong relationship of the two plant traits helps to identify how important structure, nutrient acquisition and usage, and water usage are to live within a certain environment whether that be a less stressful environment or a harsher environment. Though plant traits tend to dictate which environment it grows in, an environment is not dictated by what plant survival strategy solely grows within it, plants with varying survival strategies are seen in each of the three grasslands but it is clear that some survival strategies are favored over others (Fig. 4.)

Grassland sites that experience more intense stressors are composed of hardier forbs that are able to survive such conditions through a means of physical and biochemical processes that allow not only continued survival in drought conditions and maintain productivity longer. Forbs that have higher LDMC and more negative TLP to have a drought tolerant lifestyle compose a higher majority of forb species within arid grasslands; they are more likely to survive drought conditions due to their drought tolerance strategy (Fig. 4). This would allow for plant communities in more arid grasslands to maintain their biodiversity longer due to an increased number of forb species having drought tolerance as a mode of survival.

Forb species in less arid grasslands notably have a higher concentration of forbs with less negative TLP and lower LDMC (Fig. 4). These forb species that utilize a more drought avoidant strategy may be more susceptible to increasing drought conditions, compromising the overall

biodiversity seen in the plant community due to inability to survive increasing drought stressors. Forbs in these sites are at a higher risk of local extinction due to mode of survival many utilize such as in Flagstaff where a large majority of forb species do not possess more negative TLP or higher LDMC content.

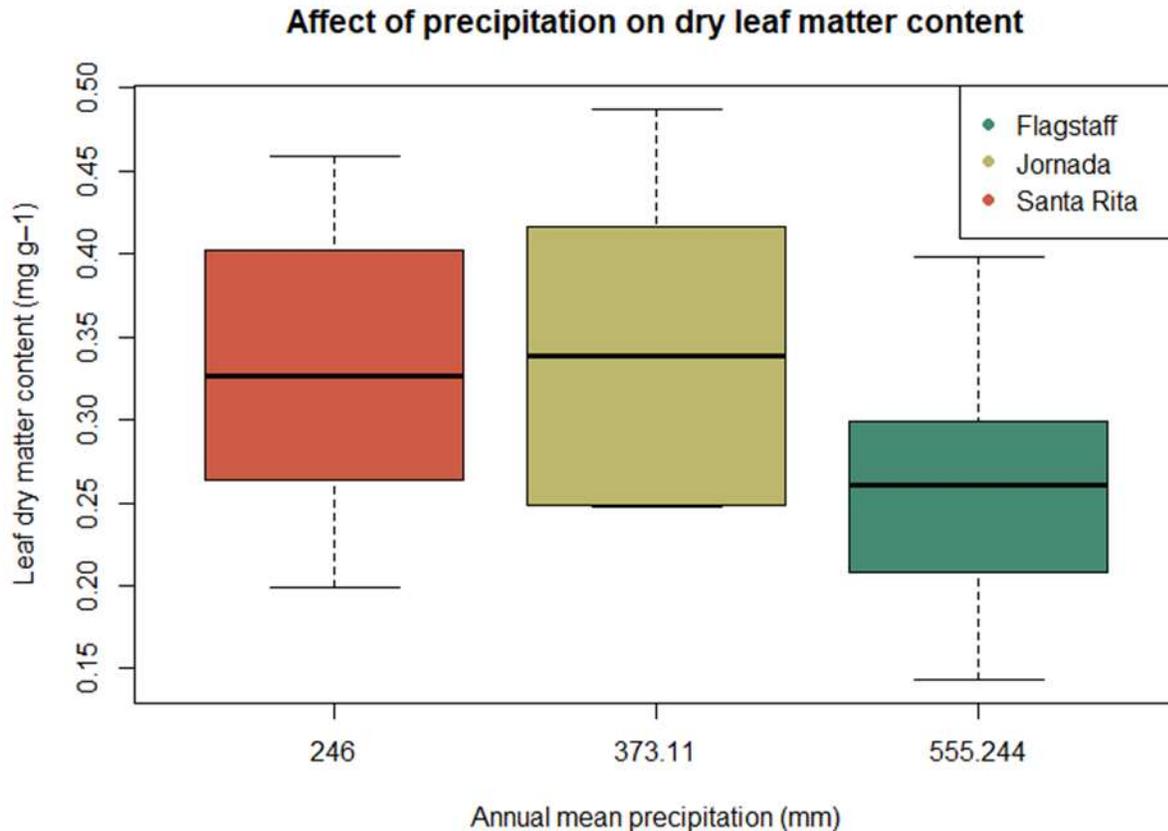


Figure 5 Effect of precipitation on dry leaf matter content. Sites that experience higher annual mean precipitation have higher occurrence of forb species with lower LDMC. Sites with lower LDMC experience lower annual mean precipitation.

The relationship of LDMC seen in grassland forbs can be explained by looking at environmental factors and their relationship to LDMC, giving insight into which strategies forbs use to survive drought stress. Annual mean precipitation is negatively correlated with LDMC. Higher LDMC is seen in sites that receive lower water overall (Fig. 5). The reduced water availability within their environment favors plants species that have the dense internal structure

in order to delay turgor loss point in plants and begin wilting. Lower LDMC is seen in sites that experience wetter environments overall and where plants have more access to water (Fig. 5). In order to sustain metabolic processes without sacrificing nutrients to build more rigid membranes in order to better survive desiccation.

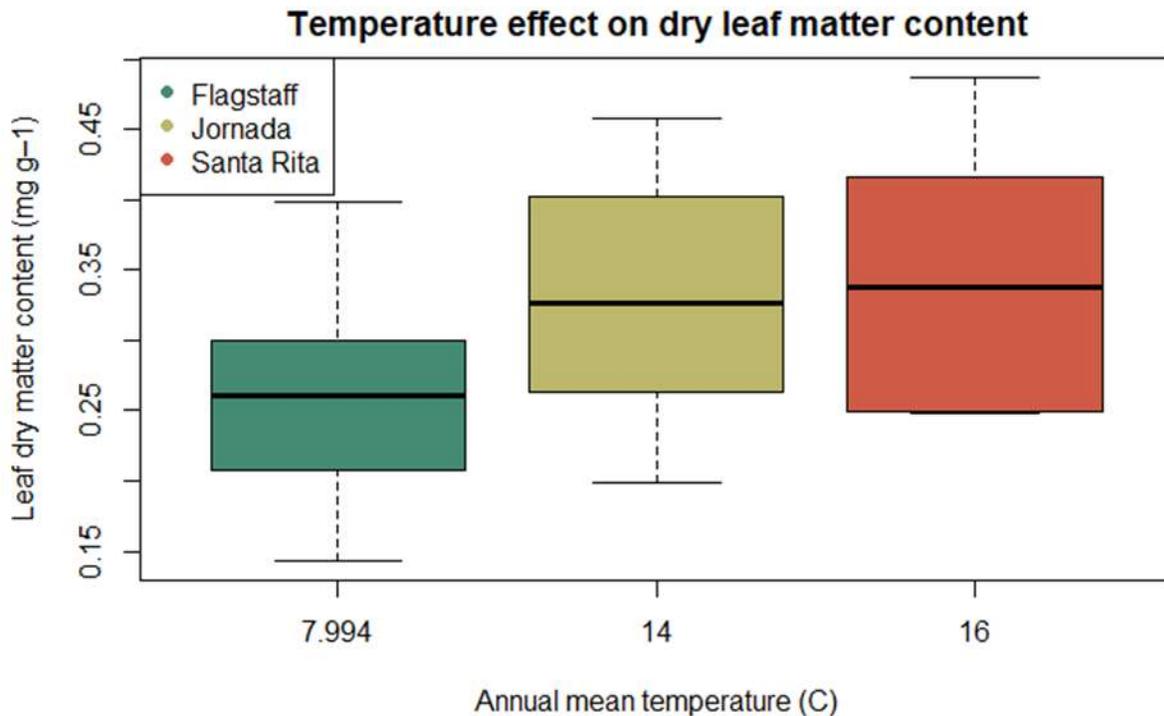


Figure 6 Temperature effect on dry leaf matter content. Grassland sites that experience higher mean annual temperature have more forb species present with high LDMC than sites that experience lower annual mean temperatures.

Mean annual temperature effects the overall range of LDMC seen in grassland forbs by site. LDMC is positively correlated with mean annual temperature. Forbs in sites with lower mean annual temperature tend to have lower LDMC (Fig. 6). This could be due to the reduced need for forbs in environments to survive the wilt causing stressors; reduced water availability is not as strong of a stressors as seen in lower temperature sites as in environments with higher temperature, so the risk of wilting is reduced. The opposite can be said for higher LDMC in grassland forbs which occur more often in sites that experience higher temperature. Increased

LDMC can help to reduce the point at which turgor loss occurs, thus preventing wilting and allowing for survival in more stressful environments.

The specific environment forb species exist in does have an impact on the plant traits that are seen in a community. Comparing TLP and LDMC against each other by site shows how environmental factors such as precipitation and temperature allow for certain forb species to survive within more stressful conditions brought on from drought in environments than others due to their traits (Fig. 5). Forb species that reside in sites that experience more precipitation and less extreme temperature throughout the year will show species that have less negative TLP and lower LDMC due to the less strenuous conditions experienced (Fig. 5). Increased water availability and reduced desiccation rates due to both increased precipitation and decreased temperature allows for forbs with traits less suited to survive recurring drought conditions in less stressful sites such as Flagstaff.

The other two sites, Jordana and Santa Rita, both showed an increase in forb species that had traits that allowed for better survival in the harsher conditions and stressors brought on by higher temperature and less precipitation. Traits such as increased rigidity of internal leaf membranes (higher LDMC) and more negative turgor loss point found in forbs were commonly found in higher abundance than in Flagstaff (Fig. 5.) Forb species that use these traits are more often found in these sites with increased drought stressors and decreased annual mean precipitation. The the different survival strategies implemented by plants in these habitats. Forb species with survival strategies that differ from the dominant survival strategy still exist within these communities but are much less common (Fig. 4.)

All three of these methods that plants use in order to survive drought and the countless stressors it brings are important to understand, as plant communities are not solely comprised of plant species that make use of a single method. A grassland community is not filled completely with forb species that make use of only one survival strategies. However, communities can be composed of forbs that make use of all strategies but strongly favors one mode of survival more than others such, as drought tolerance in more arid environments and drought avoidance in less arid environments.

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Forb species in less arid grasslands notably have a higher concentration of forbs with less negative TLP and lower LDMC (Fig. 6). These forb species that utilize a more drought avoidant strategy may be more susceptible to increasing drought conditions, compromising the overall biodiversity seen in the plant community due to inability to survive increasing drought stressors. Forbs in these sites are at a higher risk of local extinction due to mode of survival many utilize such as in Flagstaff where a large majority of forb species do not possess more negative TLP or higher LDMC content.

In future studies to better understand the differences of drought res

community, a group of plants that contribute to a majority of the biodiversity seen within grassland ecosystems, through leaf dry matter content and turgor loss to understand how forbs handle drought stress. Both traits are good predictors of function, productivity, and survival strategy of a plant which can be used to explain the trends of where forb species are found within an environment and the physiological reasons as to why.

The use of both turgor loss point and leaf dry matter content to identify common plant survival strategies within a community is important because it can be used to identify the potential risks a forb community may face with the expected rise of climate warming. Identification of forb survival strategies through TLP and LDMC can be used to identify species that are at risk of having notable population loss or even local extinction by knowing what species cannot handle increased intensity and occurrence of drought stress. With grasslands occupying a large portion of the landscape and expected to be the most affected environments from climate warming, it is important to be able to use reliable functional traits to identify plant species that are at risk.

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