Insights on Ecohydrological Controls of Phenological Events in *Larrea tridentata* through Continuous Monitoring using Digital Cameras

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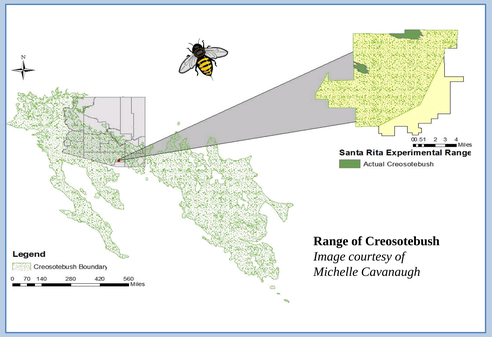
1. Introduction

An increasingly earlier onset of spring phenological activity has been well established, with elevated springtime temperatures as the primary culprit. Studies highlighting this change in ecosystem functioning have generally been conducted where energy is the primary limiting factor for plant activity. Importantly, phenological studies in semiarid ecosystems where water is the major limiting factor are rare. Unlike in energy-limited ecosystems, the timing of phenological events in semiarid ecosystems tends to be strongly linked to discrete pulse-like precipitation events. Most of these precipitation events are small, wetting only the top few centimeters of the soil and then quickly lost to evapotranspiration. Only rare large precipitation events are capable of wetting the root zone beyond the depth of evaporative demand providing moisture for plant phenological activity. The main objective of this study is to identify the triggers of phenological activity in a water-limited *Larrea tridentata* ecosystem of the southwestern United States.

2. Hypotheses

- Spring flowering will be strongly driven by energy triggers (e.g. temperature, radiation) rather than by precipitation.
- While shallow soil moisture may play a role in some phenological activity, summer flowering will be will be strongly linked with large precipitation events wetting the root zone beyond the depth of evaporative demand.

3. Study Site and Description



- Creosotebush was chosen for this research (1) due to its prevalence across the southwestern US and northern Mexico, (2) because it is a repeat flowering species enabling multiple flowering events in a single year, and (3) because it supports numerous pollinators, including over 100 native bee species.
- Our study site is located near the northern boundary of the Santa Rita Experimental Range, southern Arizona. It has a semiarid climate with bimodal precipitation pattern averaging about 330 mm annually.
- Soil at the site is sandy loam up to depths of at least 1 m. Root densities are greatest between 20 and 40 cm.
- Percent cover at the site is ~ 24%, with 14% of that as creosotebush and the other a mix of grasses, cactus, and other herbaceous cover. The average height of the creosotebush is 1.7 m.

An eddy covariance tower at the site has been monitoring ecosystem energy, water, and carbon fluxes in addition to meteorological variables and soil moisture since February 2008.

Three digital cameras (referred to as 'phenocams') within the tower footprint capture daily images with 6 MP resolution to monitor phenological activity, e.g. greenup and blooming.

4. Methods

Flowering Analysis

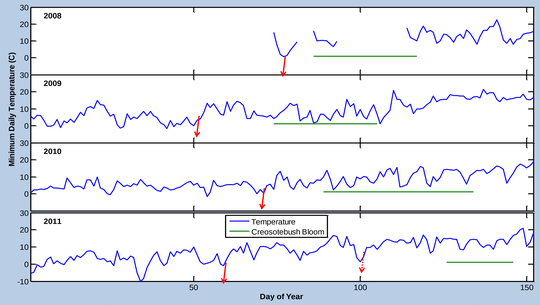
- Manually determined start and end flowering dates for each flowering period from noon-time phenocam photos
- The start date was defined as the day of first flower seen in any of the camera images
- The end date was chosen as the date of the last open flower seen in any of the camera images

Growing Degree Day (GDD) Calculation

- GDDs are a measure of heat accumulation derived from local weather conditions that are used to predict phenological activity.
- GDDs were calculated by taking the average of the daily maximum and minimum temperatures compared to a base temperature (10° C): $\frac{T_{max}+T_{min}}{2}-T_{base}$

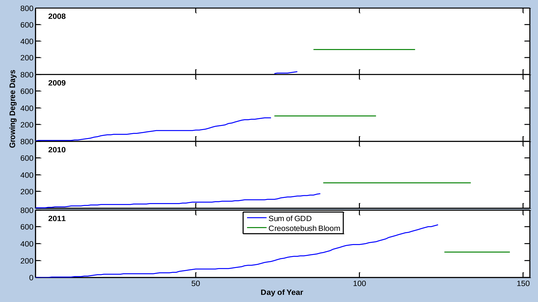
5. Results

5.1 Spring Minimum Temperatures



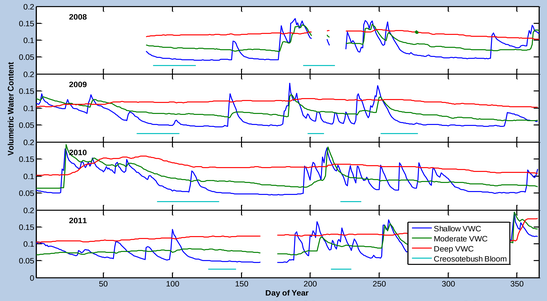
- Spring flowering tends to occur approximately 10 – 30 days after the final [normal] spring freeze.
- However, 2011 data suggests that the ecosystem will flower 10 – 30 days after "near" freezing temperatures.

5.2 Growing Degree Days



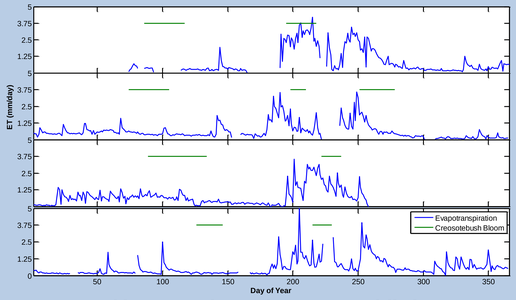
- The mean for annual growing degree days that lead to flowering in creosotebush was 355.
- This is much smaller from earlier studies (e.g. Bowers and Dimmitt 1994) that suggested a mean of closer to 440.
- However, this seems to vary from year to year.

5.3 Soil Moisture



- Spring blooms occur at periods of high deep VWC and low shallow VWC.
- Summer blooms occur after a high at shallow and moderate depths VWC and during a high in deep VWC.

5.4 Evapotranspiration



- Summer blooms are shorter than spring or fall, during a time of high ET.
- A lack of large spikes in spring ET, may lead to a longer spring flowering period.

6. Conclusions

- Spring flowering events are consistent and tend to be associated with a temperature-related energy trigger.
- Summer flowering events are dependent on the timing and amount of monsoon precipitation and the distribution of moisture in the soil profile.
- Summer flowering periods tends be shorter in duration than spring flowering periods, suggesting either a resource limitation or a season-specific plant reproductive strategy in these ecosystems.

7. Future Work

Analysis will be continued in the attempt to more definitively link environmental factors with the repeat flowering events. Using this understanding, we can create models that can predict when flowering will occur, enabling the scientific community to better predict the effects climate change will have on dryland ecosystems. With this knowledge, better management practices can be developed to help preserve delicate dryland ecosystems around the world.

8. Acknowledgements

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