Continuous Monitoring of Dynamic Pulse-Driven Phenological Phases in a Semiarid Shrubland

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1. Introduction

Evidence of climate change is becoming ever more apparent, particularly in its effect on phenological events. Green up, flowering, and fruiting are all affected by external triggers such as precipitation, photoperiod, and temperature, which vary between years as a result of climatic changes. However, these interactions are not well understood, especially in water-limited environments. As climate change affects the timing of phenological events, it can have a very large impact on the ecosystem. Changes in phenology can throw off the timing of pollinators and other important processes within the ecosystem, creating numerous potential imbalances that could drastically alter the ecosystem. In order to better understand what changes may be expected, this study monitors creosotebush in an attempt to find what influences blooming and greenup throughout the year.

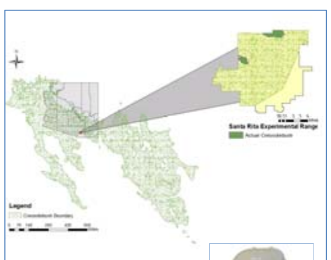
2. Hypotheses

•Spring phenology will be most driven by energy triggers (e.g. temperature, radiation) rather than by precipitation.
•Summer precipitation will be most linked with precipitation events and soil moisture.

3. Study Site

3.1) Site Description

•A creosote-dominated shrubland in the northern Santa Rita Experimental Range, southern Arizona.
•Creosotebush was chosen due to its wide range across the southwestern US and northern Mexico. It has the second highest number of pollinators, including 120 native species of bees.



Range of Creosote
Image courtesy of Michelle Cavanaugh

3.2) Monitoring:

•An eddy covariance tower has been monitoring ecosystem energy, water, and carbon fluxes since February, 2008.
•Three digital cameras within the tower footprint track phenological activity, e.g. greenup and blooming.

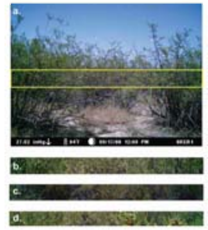
4. Methods

4.1) Blooming Analysis

•Manually determined start/end blooming dates from noon phenocam photos
•Start dates were chosen as the day of first bloom seen in any of the cameras
•End date was chosen as the date of the last open bloom between the cameras

4.2) Greenup Analysis

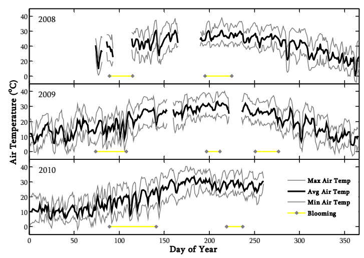
•Greenness index was calculated using the equation $I_g = 2G - (R + B)$, where G, R, and B are the green, red, and blue values, respectively, of the photos.
• These values were then averaged between the three cameras for analysis.



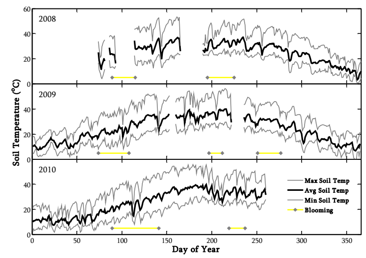
Example of a Region of Interest used in calculating the greenness index

5. Results

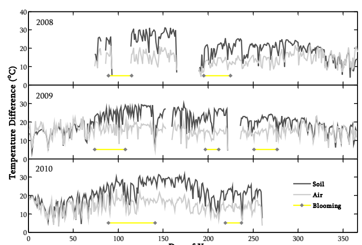
5.1) Possible Blooming Triggers



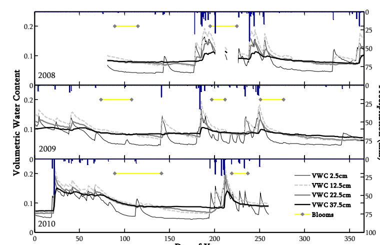
a) Air Temperature:
•Increases in the spring and peaks around day 200
•Mean air temp is not an obvious trigger for blooming, even in spring
•Max and min air temp are also not obvious triggers during the year



b) Soil Temperature:
•Soil temp peaks around day 200
•Mean soil temp is not an obvious blooming trigger
•Divergent max and min temps in the spring may correlate slightly with blooming

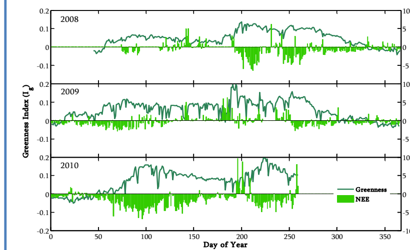


c) Soil and Air Temp Range:
•Temp ranges for both soil and air start to diverge near blooming events
•Temperature ranges for both are similar in the winter, but the range of soil temps begins to increase faster than that of air right before blooming, most notably in the spring
•Differences between ranges usually decrease before blooming events



d) Soil Moisture:
•First bloom of the year seems to occur after winter rains become less frequent
•Repeat blooming occurs shortly after rainfall events that wet at least the top 10cm of soil
•Winter precip may affect duration of blooming during the following spring

5.2) Possible Greenup Triggers



a) Greenness and Net Ecosystem Exchange:

•Correlation between Greenness and NEE in the summer

•Greenness peaks around day 200

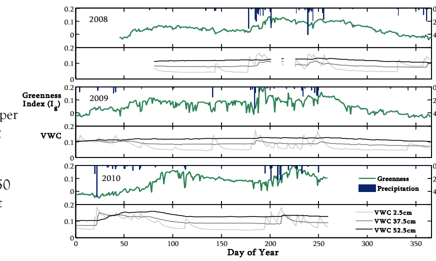
•2008 and 2010 may have 2 main greenup events - 2009 appears to have a third

b) Greenness and Moisture:

•Summer precip may affect greenness, even small events

•Increased soil moisture deeper than 30cm may affect spring greenup

•Soil moisture deeper than 50 cm seems to have little affect during the summer



6. Future Work

Quantitative analysis will be the next step in this study, including such analysis as linear regression. As more data is collected, we will be able to gain a better idea of what triggers phenological events. Analysis will be conducted in the attempt to more definitively link environmental factors with the repeat blooming and greenup events seen in creosotebush. With this understanding, we ultimately hope to create models that can predict when blooming will occur. By being able to predict phenological events, the scientific community can better understand and model the effects climate change will have on dryland ecosystems. With this knowledge, better management practices can be developed to help preserve delicate ecosystems around the world.

7. References

•Kurc, S.A., and Benton, L.M., 2009. Digital image-derived greenness links deep soil moisture to carbon uptake in creosotebush-dominated shrubland. Journal of Arid Environments 74 (5), 585-594.
•Richardson, A.D., et al., 2007. Use of digital webcam images to track spring green-up in a deciduous broadleaf forest. Oecologia 152 (2), 323-334.

8. Acknowledgements

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