Weather Effects on the Success of Longleaf Pine Crops

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Abstract

Longleaf pine (*Pinus palustris* Mill.) has long been known to have irregular cone crops. It is not known what factors control the bounty of the cone crop. There are three critical stages in cone development: reproductive primordia development in June and July of year 1, pollination in March and April of year 2, and ovule fertilization in April and May of year 3. Using National Weather Service data and historical records of cone crops across the South we attempted to relate the conditions at the above mentioned critical stages to the yield of cones in longleaf pine stands. Weather does have a significant effect on cone crops, but the relationship is complex and cannot be attributed to any small subset of variables.

Methods

Cooperator	State and County
Kisatchie National Forest	Louisiana, Grant
Cedar Creek Company	Alabama, Escambia
Blackwater River State Forest	Florida, Santa Rosa
Eglin Air Force Base	Florida, Okaloosa
Apalachicola National Forest	Florida, Leon
Jones Ecological Research Center	Georgia, Baker
Tall Timbers Research Station	Florida, Leon
Fort Benning Military Base	Georgia, Chattahoochee
Sandhills State Forest	South Carolina, Chesterfield
Bladen Lakes State Forest	North Carolina, Bladen

Table 1. Counts of green cones were made in the Spring at the above locations.

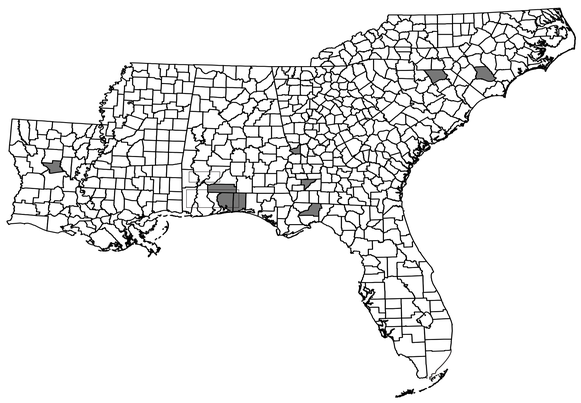

Figure 1. Location of sample trees.

Crop Quality	Cones per Tree
Bumper crop	≥100
Fair to Good crop	25 to 99
Poor to Failed crop	<25

Table 2. The quality of the cone crop was evaluated using the above criteria.

Variables Analyzed

There are three time periods thought to be very important in longleaf pine seed development and they guide our initial variable selection.

Primordia development: conditions in June and July two years before seed crop.

Pollination: conditions in March and April one year before seed crop.

Fertilization: conditions in April and May of the seed year.

To avoid ignoring factors not accounted for by these time periods we also included monthly values for all other time periods from January of two years before the seed crop to June of the seed crop year when the count was done.

Climate variables analyzed include precipitation, Palmer Drought Severity Index (PDSI; + is wet, - is dry), average temperature, maximum temperature, minimum temperature, heating degree days (higher is colder), and cooling degree days (higher is warmer) for all of the time periods mentioned above.

Results

A stepwise linear discriminant analysis selected 17 of the 171 variables as being significant for discrimination. They are:

+ November PDSI 1 year before crop
+ August minimum temperature 1 year before crop
- August temperature 2 years before crop
+ July cooling degree days 1 year before crop
- March and April precipitation 1 year before crop
- August precipitation 2 years before crop
- May PDSI 2 years before crop
- April PDSI 2 years before crop
+ October precipitation 2 years before crop
+ November maximum temperature 2 years before crop
- March and April cooling degree days 1 year before crop
+ September maximum temperature 1 year before crop
- November precipitation 2 years before crop
- April maximum temperature 2 years before crop
+ April cooling degree days 2 years before crop
+ May minimum temperature 2 years before crop
+ October precipitation 1 year before crop

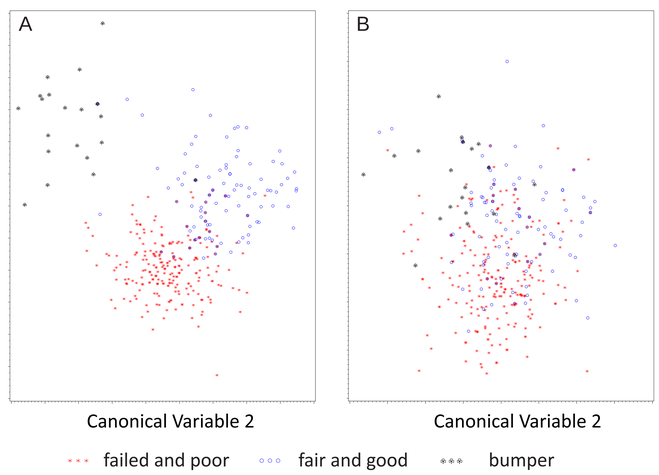

Figure 2. Results of canonical discriminant analysis showing that (A) 171 variables clearly visually delineate cone production classes, but that (B) the 17 significant variables alone so not. They are both significant for discriminating between all classes.

- With all 171 variables included, all of the cone production classes are significantly different.
- With only the 17 significant variables obtained from a stepwise discriminant analysis, all classes are still significantly different even though this is not obvious from the graph.
- Other subsets of the input variables like just moisture variables or variables from the time periods of primordia formation, pollination, and fertilization did not provide a significant discriminant function.
- Of the significant variables, 8 were related to moisture and 9 were related to temperature.
- Of the significant variables, 7 are from condition 1 year ago and 10 are from conditions 2 years ago.
- A linear discriminant function fails to correctly classify the cone production class 29% of the time.

Discussion

This research is not the first attempt that has ever been made on relating climate to cone production of longleaf pine. Shoulders (1967) looked at rainfall effects on flowering and Pederson and others (1999) looked at precipitation and temperature on cone production. Both of these papers looked only at a single location whereas we have included 10 locations and more years of data.

Shoulders (1967) found that low rainfall in April, May and June of the primordia year reduced the flowering ability of trees and high rainfall increased it. We found only rainfall in June and July was significantly related to cone production.

Pederson and others (1999) found that warmer temperatures in the winter and spring of the primordia year were positively correlated to cone yield and that July, August, and September temperature was negatively correlated with July being the only significant month. Our results basically agree with this except we found a warm winter was more important than a warm spring and that higher temperatures in August was our significant month for negative correlation. Similarly we agree with their findings that warm temperatures from October of the primordia year until pollination is positive; and then negative during pollination, but our significant months differ slightly. We fully agree that April temperatures in the seed year are significantly negatively correlated.

Pederson and others (1999) also found that precipitation during primordia development and also during October and November of the pollination year was positively correlated with cone crops and that exactly matches our results.

In addition to average temperature and rainfall, we also analyzed correlations using PDSI. This smoothed out the trends so that it appears that it is good to be dry before primordia formation and wet afterwards.

Maximum temperature correlations basically mirror average temperature but have stronger negative correlations when they are present. Minimum temperature correlations have stronger positive correlations when they are present. This suggests too hot and too cold are negative and there is some moderate temperature that is best.

Heating degree days is another measure of deviations from an average and the correlations show that it is better to be warm until pollination and mostly cooler afterwards. Cooling degree days help to reveal that it is also good to have a warm Summer after pollination which isn't shown as strongly by heating degree days which go to zero in the summer months.

The discriminant analysis primarily shows that it is possible to predict cone crops based solely on weather data. However, it is a complex function requiring many inputs that might not be easy to obtain. Many of the variables that were significant in the discriminant function are also significant in the analysis of correlation coefficients, but several were not. At this time it is not possible to determine if the inclusion of these variables is the result of a complex interaction or a statistical artifact.

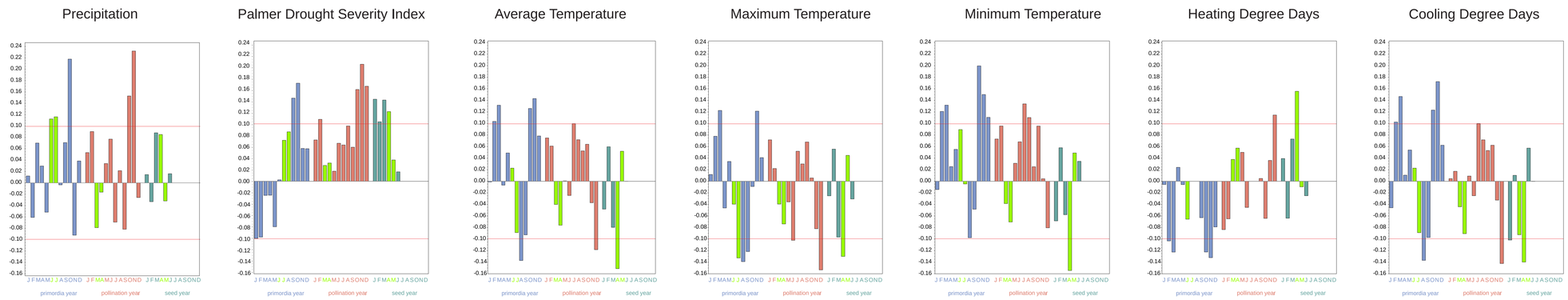

Figure 3. Pearson correlation coefficients are plotted for each of the weather variables analyzed. The red line in each graph marks the approximate limit for significance of the correlations. The bars colored light green are the important stages in seed development (primordia development, pollination, and ovule fertilization).

References

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Pederson, Neil; Kush, John S.; Meldahl, Ralph S.; Boyer, William D. 2000. Longleaf pine cone crops and climate: A possible link. In: Haywood, James D., ed. Proceedings of the tenth biennial southern silvicultural research conference: 199 February 16-18, Shreveport, LA. Gen. Tech. Rep. SRS-30. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 255-258.

Shoulders, Eugene. 1967. Fertilizer application, inherent fruitfulness, and rainfall affect flowering of longleaf pine. For. Sci. 13(4):376-383.