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# EFFECTS OF DROUGHT ON RED MAPLE (*ACER RUBRUM*) BRANCH GROWTH

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## ABSTRACT

Red maple branch growth from 2002 and 2001 was measured in millimeters and compared in an attempt to find differences that could be due to the worsening central Pennsylvania drought. Significant differences were found between the 2001 and 2002 growth. A paired sample t-test controlled for most variables, and correlation analysis indicated that tree circumference had no significant impact on branch growth. These data are inconclusive and further research is necessary.

*Keywords:* Acer rubrum*, drought, hardwoods, red maple*

## INTRODUCTION

In the winter of 1998, former Pennsylvania Governor Tom Ridge declared a drought emergency in 12 counties (Pennsylvania DEP 2002). During that year, Huntingdon County was only at warning status, which means residents were asked to voluntarily reduce water use by 10-15% and state officials begin preparing for a coordinated response to protect state water supplies (Pennsylvania DEP 2002). However, on 12 February 2002 Governor Mark Schweiker upgraded Huntingdon's drought status to a drought emergency, meaning that state officials must prepare for a concentrated management phase of operations to marshal all available resources, and that it is possible to impose mandatory restrictions on nonessential water uses that are provided for in 4 PA Code Chapter 119 (Pennsylvania DEP 2002). Figure 1 shows the current status of all Pennsylvania counties.

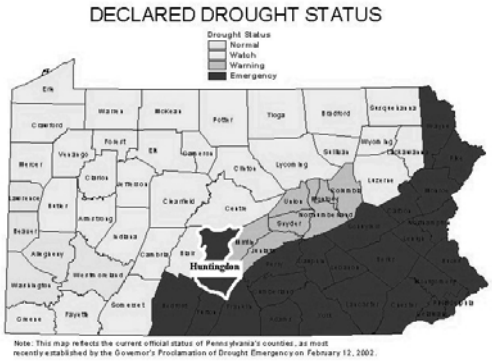


*Figure 1. Drought status of Pennsylvania counties as of 12 February 2002 (Pennsylvania DEP 2002).*

Huntingdon County received more precipitation during 2000 than in 2001. The normal average is 39 inches. Table 1 lists monthly and yearly precipitation values and Table 2 lists the deviation from the norm for each month and year.

*Table 1- Monthly and yearly precipitation totals for Huntingdon County during the years 2000 and 2001 (Pennsylvania DEP 2002).*

**Precipitation of Huntingdon County (Amount in inches)**

| Year | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sep | Oct | Nov | Dec | Year to Date | Year to Date as % of Normal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | 1.3 | 2.9 | 2.9 | 4.6 | 4.6 | 4.1 | 3.5 | 3.1 | 2.6 | 2.4 | 2.5 | 2 | 36.5 | 97.3 |
| **2001** | 1.6 | 1 | 3.8 | 2.9 | 2.5 | 4 | 1.8 | 2.4 | 2.9 | 1.4 | 1.6 | 2.1 | 28 | 74.7 |

*Table 2- Percent deviation from the norm for each month and year during 2000 and 2001 (Pennsylvania DEP 2002).*

**Monthly Precipitation Departure from Normal of Huntingdon County (Amount in inches)**

| Year | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | -1 | 0.3 | -0.3 | 1.4 | 0.9 | 0.2 | 0 | 0 | -0.6 | -0.6 | -0.7 | -0.7 | -1.1 |
| **2001** | -0.7 | -1.5 | 0.6 | -0.3 | -1.2 | 0.1 | -1.7 | -0.7 | -0.3 | -1.6 | -1.6 | -0.6 | -9.5 |

Drought conditions create stressful environments that can negatively impact plant growth (Graves unknown date). Extended periods of time with little or no moisture cause physiological imbalances in trees. Some consequences of low moisture levels include leaf scorching, early fall coloration, susceptibility to insects and tree diseases, and a reduction of twig and foliage growth (Slusher 1998; Cornell University Fact Sheet 1999).

The red maple (*Acer rubrum*), is a common hardwood tree found in deciduous forests in eastern North America. Red maples tolerate drought due to their readiness to stop growing under dry conditions (Walters and Yawney, unknown date) and by producing a second growth flush when conditions improve, even if growth has stopped for two weeks (Walters and Yawney, unknown date). Red maples also have more variation in water content during a dry year than a wet year (Wullschleger et al. 1996). Red maples, like all hardwoods, only grow outward from the apical or lateral meristems, and once growth becomes woody it never lengths further (Ricklefs and Miller 2001). The branch will, however, increase in width.

We hypothesized that there should be a correlation between the level of precipitation and stem growth of the red maple. The growth during 2001 was influenced by the precipitation during 2000, while the growth during 2002 was influenced by the precipitation during 2001. Therefore, based on the above Huntingdon County precipitation information, we hypothesized that the 2002 growth should be significantly less than the 2001 growth due to a lower amount of rainfall.

## FIELD SITE

On 28 March and 2 April 2002 we measured red maple branch growth at two sites south and north of the New Access Road at the Raystown Field Station (Fig. 2). The section south of the road was a hardwood forest, while the site north of the road was composed almost solely of red maple. Both sites were on the northern side of the ridge that runs along ridge road.

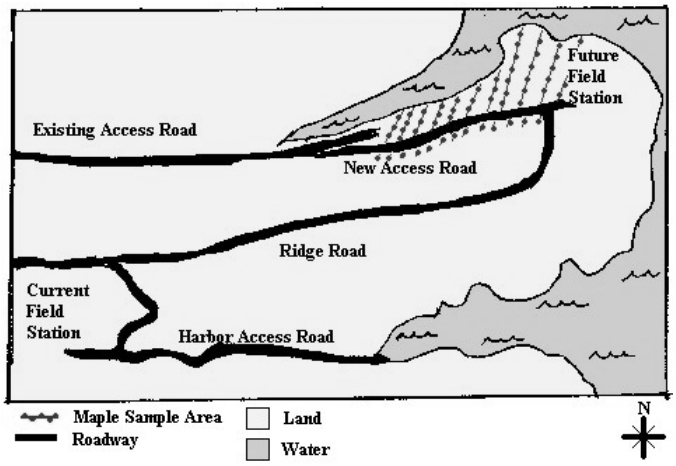


*Figure 2. Map of sample area at Raystown Field Station.*

## METHODS AND MATERIALS

The southern site was surveyed on 28 March 2002 and the northern site was sampled on 2 April 2002. Twenty trees were measured on the southern site and thirty trees were measured on the northern site. The first branch with at least five living branch ends was determined and then five random branches were measured for both 2002 growth and 2001 growth. Trees that forked at the base of their trunks were not measured because the first branch could not be determined. Growth measurements for 2002 were taken from the base of the bud to the 2002 apical meristem (Fig 3). Growth measurements for the 2001 season were taken from 2002 apical meristem to the 2001 apical meristem scar (2001 meristem), which indicates last year's growth base. In all, we measured a total of 50 trees and obtained 250 pairs of data. Trunk circumference measurements were taken at diameter breast height. Circumference was measured because diameter tape was not available. All measurements were taken in millimeters. MS Excel was used to organize and average the data, while Minitab was used for statistical analysis.

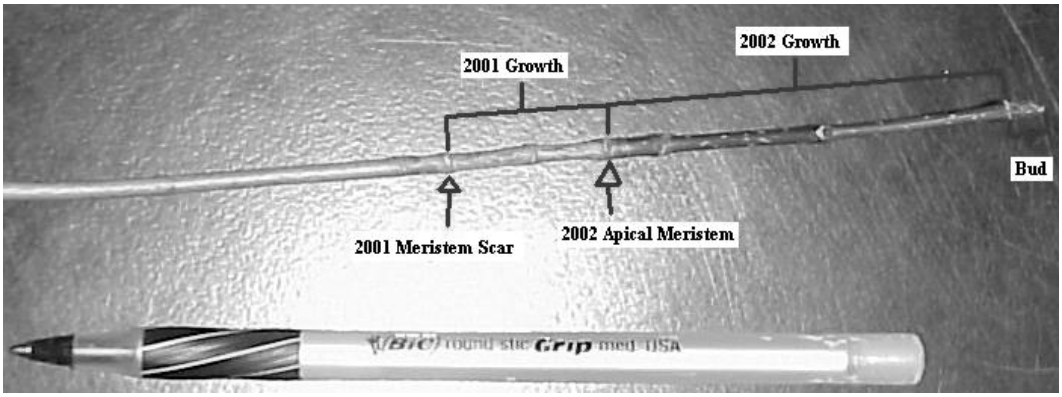


*Figure 3. Red maple branch growth pattern and standard ball point pen for size reference.*

# RESULTS

We measured five different branches on fifty separate trees. The average measurements are given in Table 3 and represented along with the average difference between 2002 and 2001 growth in Fig. 4. A paired t-test indicated that there was a significant difference between 2001 and 2002 growth ($t$ = -13.11; $P$ < 0.001). However, the growth data were not normal, as indicated in Figs. 5 & 6), thus invalidating the paired t-test. Therefore, a nonparametric sign test, which is similar to a t-test, was used. Again there was a significant difference in growth between years. The resulting 2002 median equaled 25 $\pm$ 2.99 (95% Confidence Interval) and the 2001 median equaled 51 $\pm$ 4.99 (95% Confidence Interval). This indicates there is a less than 5 % chance that the different means arose solely by chance ($P$ < 0.05).

Furthermore, average growth per tree in 2001 and 2002 were unrelated to tree circumference ($P$ = 0.632; $P$ = 0.112).

*Table 3. Total and average measurements for red maple branch growth, circumference and absolute value of difference.*

| | Circum. | 2002 | 2001 | Difference of Absolute Value |
|---|---|---|---|---|
| **Total** | 8643 | 8331 | 14735 | 7728 |
| **Average** | 172.86 | 33.32 | 58.94 | 30.912 |

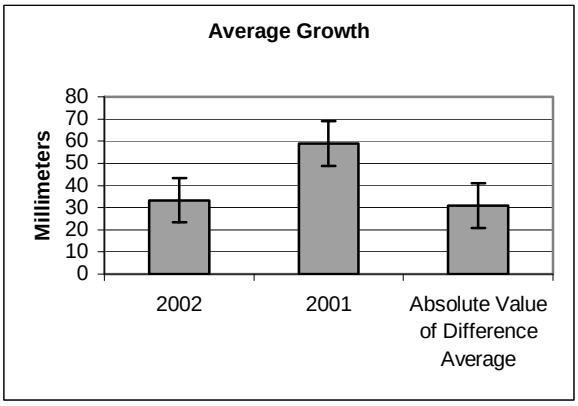


*Figure 4. Average red maple branch growth in 2001 and 2002 and the absolute value of the difference in growth between years.*

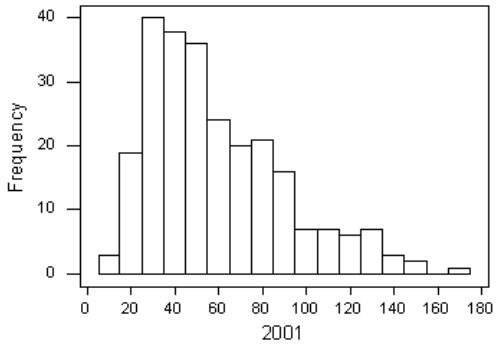


*Figure 5. Frequency histogram of 2001 red maple branch growth*

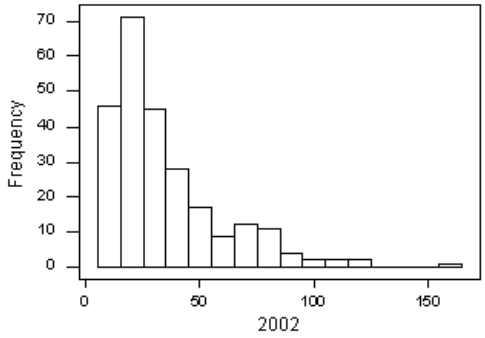


*Figure 6. Frequency histogram of 2002 red maple branch growth.*

## DISCUSSION

We hypothesized that red maple branches would show lower growth in 2002 than in 2001 due to the worsening drought in 2002 in Huntingdon County. The data that we have collected indeed shows that the 2002 branches have, on average, grown 30.9 mm less than the 2001 branches, a significant difference (Fig. 4). Very small growth increments were also more frequent in 2002 than in 2001 (Figs. 5 & 6), and the longest 2002 meristems were shorter than the longest meristems in the 2001 growth year.

Having paired samples controlled for the effects of many other variables because each branch experienced the same environmental and climatic factors, such as nutrients, sunlight, disease, etc. Furthermore, by obtaining 250 pairs of data our sample was large enough to allow small differences in growth to be detected.

Another consideration that influenced our study was the area from which we sampled. All of our data came from the northern slope of a hill at the Raystown Field Station. Northern slopes typically receive more precipitation and thus vegetation can be expected to experience a healthier habitat than similar vegetation on a southern slope. The south facing slope data were excluded to eliminate an extra variable.

Another variable that we found to be inconsequential was tree circumference. Concerned that larger trees would have larger and deeper root systems, which could more readily access water, we examined tree-branch growth in relation to trunk circumference. No effect was observed.

Although we have not conclusively shown that drought has affected the growth of red maple, previous studies have shown a significant relationship between precipitation and yearly growth of hardwood forest species. For example, Hanson et al. (2001) have shown that many tree species, including *Acer rubrum*, not only grow faster but also show a lower mortality rate under relatively moist conditions.

Our research provides an excellent basis for future work. Provided the drought continues, subsequent data could be added to determine if a significant trend exists. The sample area could be broadened or compared to a new area. Southern slope red maples or additional tree species could also be studied.

## ACKNOWLEDGEMENTS

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