Regional drought and oak decline/mortality trends in the Ozark Highlands of Arkansas and Missouri

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Introduction

Since the late 1970's oak decline and mortality have plagued Midwestern upland oak-hickory forests, particularly oak species in the red oak group (*Quercus Section Lobatae*) across the Ozark Highlands of Missouri, Arkansas and Okalahoma (Dwyer et al. 1995). Advanced tree age and periodic drought, as well as armillaria root fungi and red oak borer attack are believed to contribute to oak decline and mortality (Starkey et al. 2004). Declining trees first show foliage wilt and browning followed by progressive branch dieback in the middle and/or upper crown. Trees eventually die if crown dieback Continues. We analyzed oak mortality by species (groups) and inventory year to illustrate the general trend of oak decline and mortality by using the 1999-2006 FIA plots measured annually in the Ozark Highlands of Arkansas and Missouri.

Data and Methods

- We calculated the percentage of dead trees in terms of density and basal area (ba) for different species (groups) by inventory year based on the 1999-2006 annual FIA plots in the Ozark Highlands of Arkansas and Missouri.
- We regressed the percentage (transformed) of dead tree density and basal area against inventory year to rank oak species by decline and mortality severity based on the estimated regression coefficient (slope).
- We compared oak decline and mortality trends and palmer drought severity index (PDSI) curves derived from NOAA data using coincidence analysis to illustrate the impact of drought on oak decline and mortality.

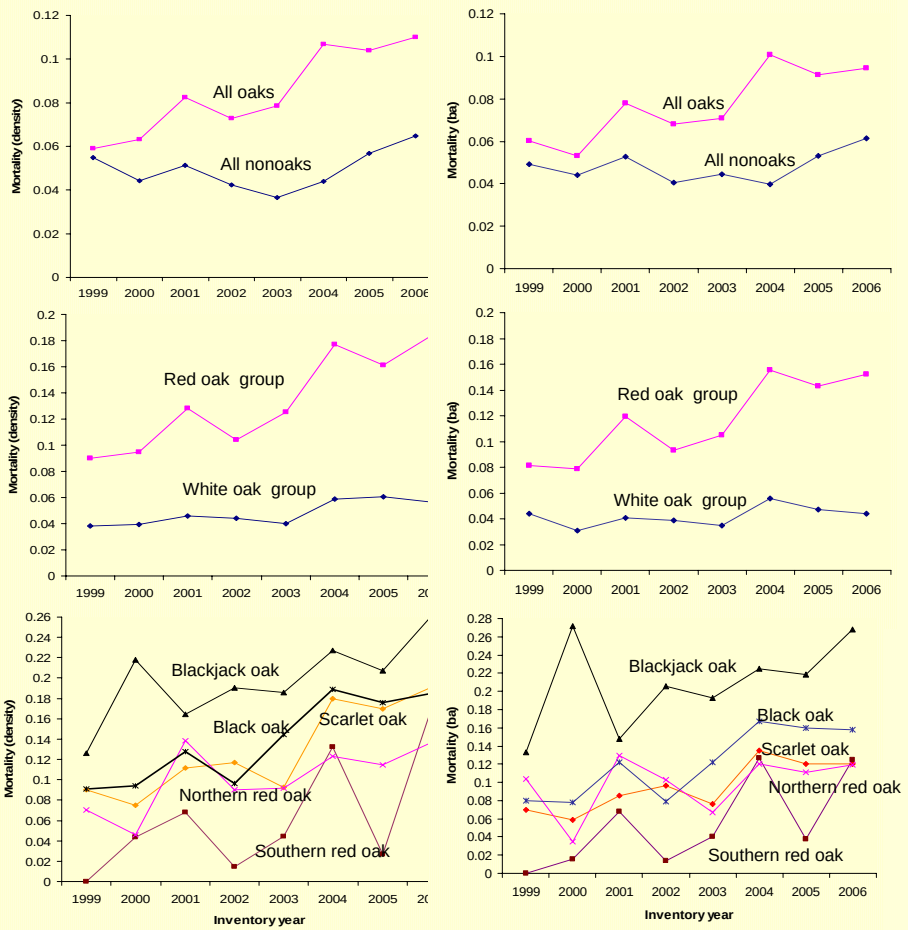

Figure 1. Proportions of dead tree number and basal area (ba) by species and species groups in the Ozark Highlands of Arkansas and Missouri.

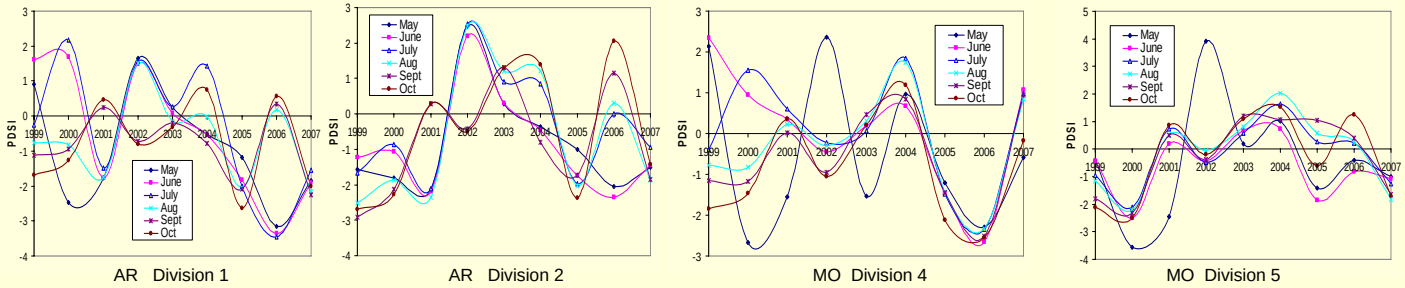

Figure 2. Palmer drought severity index (PDSI) in the divisions of the Ozark Highlands of Arkansas and Missouri from May to October.

Results and Discussion

Compared with nonoak species, oak species overall showed an escalating mortality trend in terms of proportion of dead tree number and basal area (Figure 1 top). Red oak group species decline and resultant mortality are the major determinant of this trend, for white oak group species maintained a relatively stable mortality rate in the sequence (Figure 1 middle). Mortality varied significantly among major red oak group species with blackjack oak having the highest mortality rate and southern red oak the lowest mortality rate. The mortality rank (from high to low) were blackjack oak, black oak, scarlet oak, northern red oak and southern red oak (Figure 1 bottom).

Dead tree number and basal area for nonoak and white oak group species fluctuated around 4% during the sequence, while for red oak group species as a whole the percentage increased jaggedly from around 8% in 1999 up to 16-18 % by 2006. Based on the magnitude of regression coefficient (slope), southern red oak had the greatest increase in mortality during the sequence, most possibly indicating it was most susceptible to decline. Next were black oak, blackjack oak, scarlet oak and northern red oak. This species susceptibility order conformed to the above mortality rate rank to a certain extent.

As shown by published dendrochronological studies, tree growth (e.g., ring width) was moderately correlated with drought. Oak decline and mortality trend coincided closely with regional drought pattern (Figure 2). Drought pattern varied by divisions in the Ozark Highlands. Contiguous divisions (MO Division 5 and AR Division 2, MO Division 4 and AR Division 1) shared similar drought pattern. An coincidence analysis of drought patterns and oak decline and mortality trends indicated that drought was a major determinant of oak decline and mortality regionally. Drought condition from May to October (growing season) of both the current and previous years contributed to oak decline and mortality. The 2001 and 2004 mortality peaks corresponded with the severe drought from 1999 to 2000 and from 2002 to 2003.

As shown, tree characteristics (crown class and dbh) and competition condition were most important to oak decline and mortality at stand or small scales (Fan et al. 2006, Shifley et al. 2006). We will use a hierarchical approach to explore how regional climate patterns like drought interact with local factors to affect oak decline and mortality.

Major references

Fan, Z., J. M. Kabrick, and S. R. Shifley. 2006. Classification and regression tree based survival analysis in oak-dominated forests of Missouri's Ozark highlands. Can. J. For. Res. 36: 1740-1748.

Shifley, S. R., Z. Fan, J. M. Kabrick, and R. G. Jensen. 2006. Oak mortality risk factors and mortality estimation. For. Eco. Manage. 229:16-26.