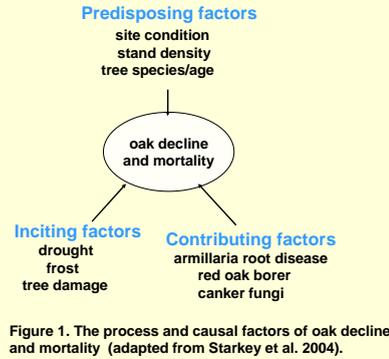


Survival analysis of declining black and scarlet oaks in the Ozark Highlands, Missouri

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Introduction

Among oaks, black oak (*Quercus velutina* Lam.) and scarlet oak (*Quercus coccinea* Muenchh.) are the two major species that have suffered "oak decline syndrome" in Missouri forests (Dwyer et al. 1995). Oak decline results from the interaction of predisposing stress factors (e.g., poor site quality, unfavorable stand condition, advanced tree age) and secondary disease and insect pests (e.g., root fungi, insect borers) (Figure 1). It has been a top priority in forest health management to identify potential oak decline risk factors and predict declining tree's survival time. According to a set of published study results, the major predisposing factors of oak decline include tree species, crown class, dbh, and bal (basal area in larger trees). Survival analyses of declining oak trees by these risk factors will help stand level decline evaluation and prescription of silvicultural treatments to mitigate oak decline and mortality.



Data and Methods

- We used crown class, dbh and bal to classify black and scarlet oaks into 7 and 9 risk groups based on the 1999-2006 Missouri Ozark Forest Ecosystem Project (MOFEP) data (Shifley et al. 2006).
- We used the product-limit method to evaluate the survival rate of black and scarlet oaks within each risk group (Fan et al. 2006).

Results and Discussion

Compared to white oak (92% of survival), only 65 and 73 % of black oak and scarlet oak, respectively, survived after sixteen years (Fig. 2). The difference in survival time between black and scarlet oaks was statistically significant ($p < 0.0001$). As shown by the estimated survival curves, there was no evident difference between black and scarlet oaks for the first eight years (1990-1998). But after then black oak mortality escalated quickly so that only about 65% of black oak trees tagged in 1990 were alive by year 2006.

Black and scarlet oaks were classified into seven and nine risk groups, respectively (Figure 3). Crown class was the most significant factor to survival for both species. Sixteen-year survival rates of dominant and codominant black oak varied from 50 to 85 percent depending on tree size (dbh) and competition condition (bal). While less than half of intermediate and suppressed trees survived. Competition condition (bal) was more important than tree size (dbh) to the survival of black oaks (Figure 3).

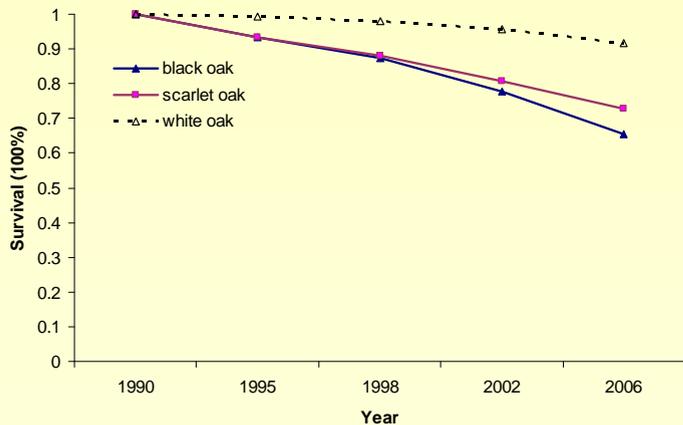


Figure 2. Survival of black and scarlet oaks versus white oak (reference) in unmanaged mature forest from 1990 to 2006.

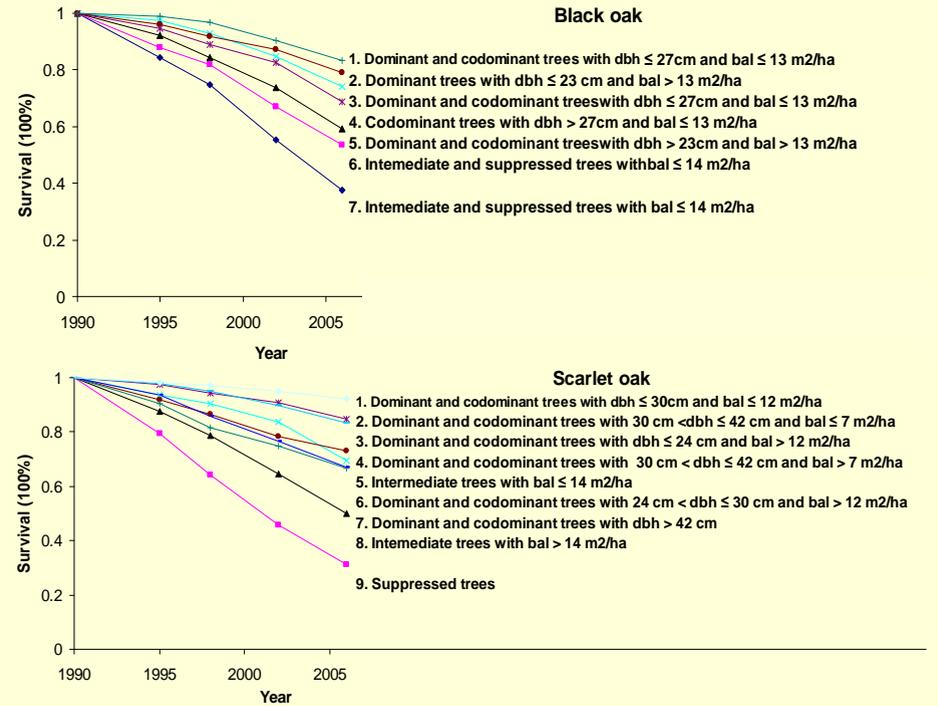


Figure 3. Survival of black and scarlet oaks by survival groups from 1990 - 2006.

There was a wide discrepancy in survival (from 64 to 91%) among the six risk groups of dominant and codominant scarlet oaks. Unlike black oak, tree size (dbh) had more influence than competition (bal) on scarlet oak survival. With same or similar competition condition, for example, trees ≤ 30 cm dbh had nearly 15% higher survival than trees > 30 cm. Survival of suppressed scarlet oaks was very low (37%), but intermediate scarlet oak survival changed significantly. Compared to trees with bal > 14 sq meters/ha (50% of survival), intermediate scarlet oak with bal < 14 sq meters/ha had a survival rate of 70% which was even higher than certain dominant and codominant tree groups (survival of 66%).

Conclusion

In the Ozark Highlands, large-scale oak decline has caused precipitous mortality, reaching 2.3% annually among red oak species. Black and scarlet oaks can be classified into different risk groups based on the well known predisposing factors including crown class, dbh and bal (basal area in larger trees, a measure of competition from above). Survival of each risk group can be estimated based on monitoring data like MOFEP or FIA and be used to prescribe treatments to mitigate oak decline and mortality.

Major references

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