INITIAL OBSERVATIONS ON TREE MORTALITY FOLLOWING A SEVERE DROUGHT IN 2012 IN TWO INDIANA STATE FORESTS AND IMPLICATIONS FOR LONG-TERM COMPOSITIONAL DYNAMICS

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ABSTRACT

Introduction

Compositional and structural changes in response to silvicultural treatments in forest stands are well documented (e.g., Saunders and Wagner 2008), but the stochastic nature of natural disturbance events often precludes direct observation of their impacts on stand dynamics. Though the current dominance of oak-hickory forest types in the Central Hardwoods Forest region (CHFR) has been largely attributed to anthropogenic disturbance, some have postulated that periodic severe droughts may also have limited the dominance of more vigorous competitors. Morrisey et al. (2008), for example, found in a study of 70 clearcut stands on highly productive sites in the Hoosier National Forest that oak (*Quercus* spp.) persisted, and occasionally increased in dominance, through the stem exclusion phase of stand development; they attributed this to differential mortality among oaks and more site-sensitive yellow-poplar (*Liriodendron tulipifera* L.), particularly on more exposed slope positions and xeric sites (Beck 1990). Several other researchers (e.g., Hilt 1985, Parker and Swank 1982) have made similar observations of yellow-poplar's relative susceptibility to drought events.

Methods

We used a subset of forest inventory data collected as part of the hardwood ecosystem experiment in southern Indiana to assess the immediate impacts of a severe drought in 2012 on tree mortality. Initial sampling of the study area was conducted between 2008 and 2010 (hereafter Inventory 1). All standing living and dead stems were measured and categorized by condition and decay class (1-5) in 1/4-acre overstory (>4.5-inch diameter at breast height [d.b.h.]) and nested 1/20-acre sapling (2- to 5-inch d.b.h.) plots. Remeasurement of two-thirds of these plots was completed in 2013 (hereafter Inventory 2). This presentation is a preliminary report of a partial inventory conducted one year following the drought of 2012.

Proportions of dead trees were summarized by species, size class (sawtimber [>12-inch d.b.h.] or pole [2- to 12-inch d.b.h.]), and ecological land type (ELT, Van Kley and Parker 1993). A binomial proportions test (prop.test) in the R version 2.15.0 statistical software package (R Foundation for Statistical Computing, Vienna, Austria) was used to determine the significance of differences in the proportion of dead to living trees. Due to inconsistencies in data collection in the first inventory, we were unable to directly compare proportions for individual decay classes between Inventory 1 and Inventory 2.

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Results and Discussion

Overall, about 5.2 percent of stems were dead in Inventory 1, which is significantly lower ($p < 0.001$) than in Inventory 2 taken in 2013 when nearly 10 percent of stems were dead. The number of dead trees increased by 2.5 percent for sawtimber-sized trees and by 5.8 percent for poles between Inventories 1 and 2. All species considered in this analysis showed significantly higher proportions of dead trees in 2013, though the magnitude of the increase was greatest for yellow-poplar.

Detailed observations from Inventory 2 showed about 3.2 percent of all trees recorded had a decay class of 1, indicating recent mortality. This was substantially higher than background annual mortality rates (McWilliams et al. 1997). A smaller percentage of sawtimber-sized trees (2.1 percent) compared to poles (3.6 percent) was recorded as decay class 1. Mortality rates of all yellow-poplar stems (11.6 percent) were significantly higher ($p < 0.001$) than that of the main oak (*Quercus*) and hickory (*Carya*) species (2.4 percent). There was some variation by ELT in the number of dead and declining yellow-poplar trees, with mesic slopes (ELT 4) and dry slopes (ELT 2) having the highest proportion of newly dead trees (Figs. 1A and 1B). White oak (*Quercus alba* L.), the most widely distributed oak species on the sites, showed little variation in mortality across the different ELTs (Figs. 1C and 1D).

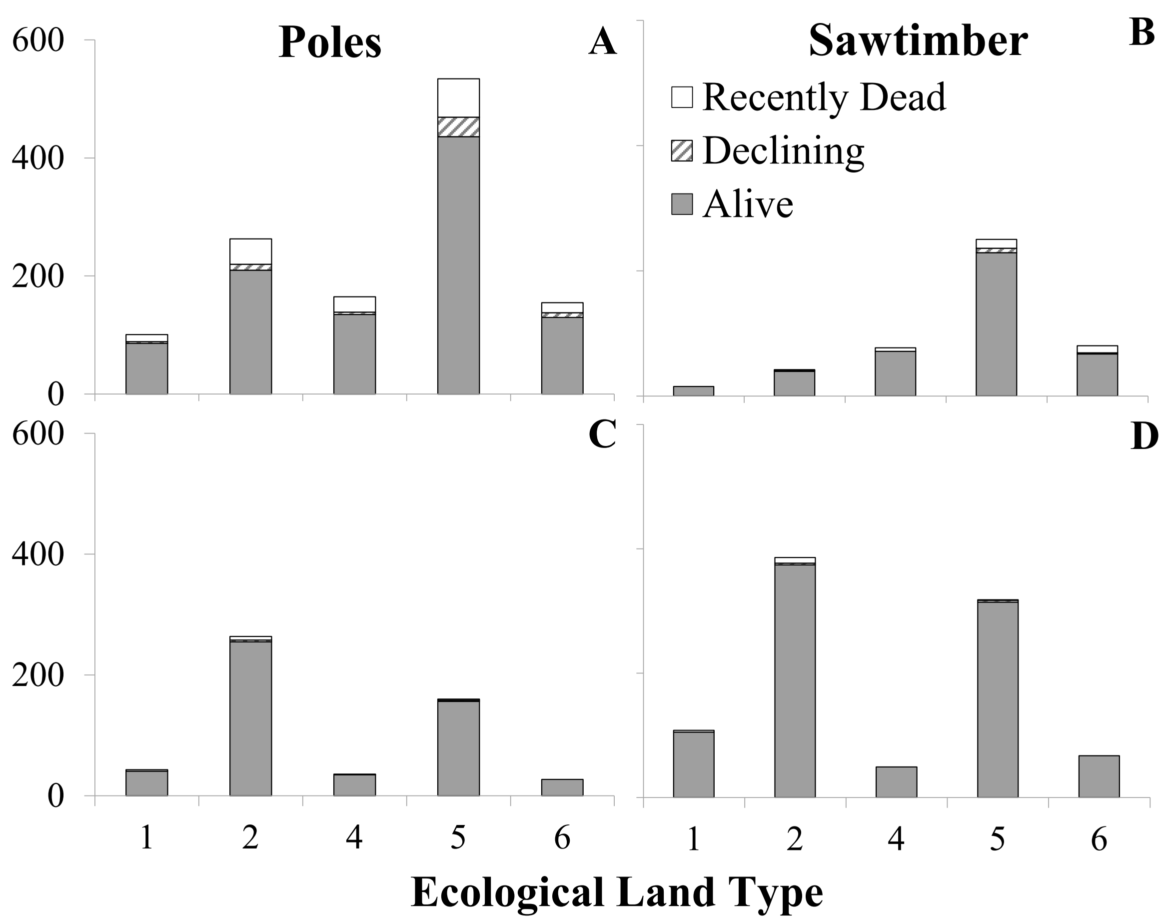

Figure 1.—Relative proportion of recently dead (decay class 1) and declining trees by size class for yellow-poplar (A, B) and white oak (C, D). Ecological land types (ELTs) are: dry ridges (1), dry slopes (2), mesic broad summits (4), mesic slopes (5), and bottomlands (6).

These preliminary results provided limited quantitative evidence that mortality rates for yellow-poplar immediately following a severe drought event were significantly higher than those for co-occurring oaks of the same size class, thus supporting the supposition that drought promotes shifts in species dominance in even-aged stands in the central hardwoods. Since drought-related mortality often occurs over a period of several years, we expect that overall mortality from the 2012 drought will be higher than the estimates in this analysis. It was evident from this data that pole-sized yellow-poplar stands were particularly susceptible to drought. However, if oak species are to capitalize on the growing space vacated by drought-killed yellow-poplar, it is imperative that oaks persist in a competitive state until a severe drought occurs. Given the growing evidence that noncompetitive oaks in pole-sized stands likely require release as early as 10 years of age (Zenner et al. 2012), it seems doubtful that managers can rely exclusively on stochastic drought events to maintain oak in even-aged central hardwood stands.

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