Estimating Numbers of Red Oak Borer (Coleoptera; Cerambycidae) From Xylem Galleries in Dead Oak Trees

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Introduction and Methods

An outbreak of red oak borer, *Enaphalodes rufulus* (Haldeman) is being considered the major contributing mortality factor to red oaks in an oak decline event occurring in the Ozark National Forests of Northern Arkansas, Fig. 1. Red oak borer is a native long horned beetle historically not known to cause tree mortality. Currently, red oaks in the *Quercus* subgenus, *Erythrobalanus*, are experiencing widespread mortality and evidence suggests that it is due to this unprecedented outbreak. Two question arise: how many red oak borers are necessary for tree death, does the number necessary vary with topographic landforms?

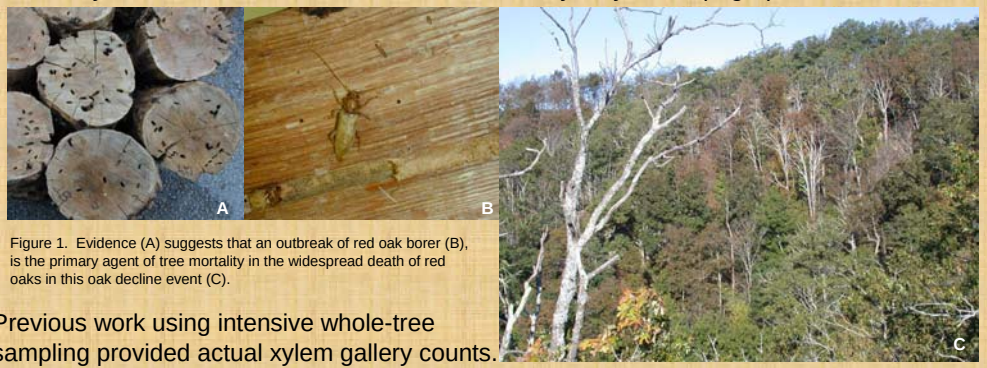

Figure 1. Evidence (A) suggests that an outbreak of red oak borer (B), is the primary agent of tree mortality in the widespread death of red oaks in this oak decline event (C).

Previous work using intensive whole-tree sampling provided actual xylem gallery counts. These, in conjunction with cross sectional xylem hole counts, served as a basis for developing a model to predict the number of red oak borer inhabiting a tree until it's death. First, we determined average length of xylem gallery. This average length, 0.1875 m, is based on 162 samples. We then used the proportion represented by this average length to extrapolate the number of holes present in the entire sample unit. A model was developed using linear regression analysis ($y = 1.2771x + 0.6437$, $R2=0.93$) based on estimated number of xylem holes (y) and actual number of xylem galleries (x). This model can be used with cross-sectional hole counts to estimate number of red oak borer xylem galleries in each sample unit. Paired t-tests revealed no significant difference between estimated and actual densities (df =11, P=0.83).

Field sampling was conducted in six 3000 m² field plots previously identified as experiencing high levels of *E. rufulus* induced tree mortality. These plots were located on three topographic landforms (ridge, south and west-facing benches) in two different areas (Fly Gap and White Rock) of the Ozark National Forest. Within each plot, five dead northern red oaks, (*Quercus rubra* L.), were arbitrarily chosen, felled and cut into 0.5 m sections from 1.0 m to the top of the infested bole, Fig. 2. Diameter and number of red oak borer xylem gallery holes on top of each sample were recorded for each sample.

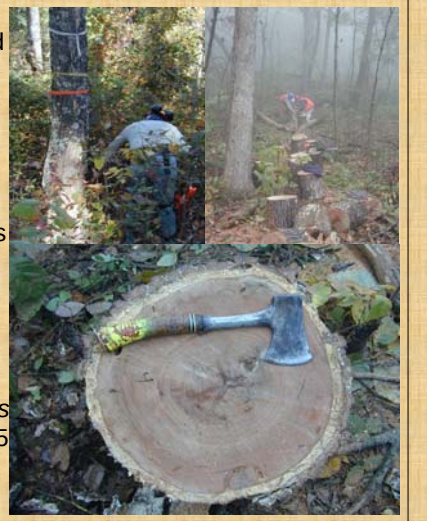

Figure 2. Sampling methods for determining red oak borer xylem holes on cross sections

Results

There was no difference in densities of red oak borer needed for tree death by area (P=0.62), Table 1. At Fly Gap there were more xylem galleries in ridge trees compared to trees on south and west benches (P=0.002). At White Rock there were significantly more xylem galleries in ridge trees compared to west benches (P=0.05), but not significantly more than those on south benches (P=0.19). Combining trees from both areas, there were significantly more red oak borers needed for tree death on ridges than on either south or west benches (P=0.0004), Fig. 5.

Area	Topographic Position	Mean (±SE)
	Ridge	42.7 (1.9) A
Fly Gap	South	22.4 (4.0) B
(n=15)	West	25.0 (3.8) B
		30.0 (3.0)
	Ridge	37.7 (6.8) A
White Rock	South	26.3 (4.2) AB
(n=15)	West	19.1 (4.3) B
		27.7 (3.5)

Table 1. Mean xylem gallery densities in two regions of the Ozark National Forest. Letters indicate significant differences between topographic positions at α0.05 using Tukey-Kramer means comparison. There was no significant difference between areas.

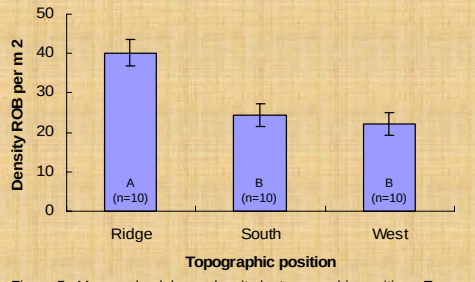

Figure 5. Mean red oak borer density by topographic position. Error bars indicate standard error and different letters indicate significant differences at α0.05 using Tukey-Kramer means comparison.

Discussion

Trees located on ridge plots had the highest densities of red oak borer xylem galleries. This could indicate that more successful red oak borer are necessary for tree death on these topographic positions. Previous lab studies on these sites have also shown that ridges have significantly more dead trees, and condition of standing dead trees indicate that many have been dead >4 years. On ridge plots, red oak borer may experienced greater survival in a given generation, resulting in fewer generations necessary for tree death.

At Fly Gap, both south and west study plots were significantly different from the ridge, as was the case between west and ridge study plots at White Rock. An explanation for fewer red oak borer in trees on these sites could be that there are other contributing factors to tree mortality on these topographic positions. One such contributing factor could be presence/ absence of *Armillaria*, a root rot fungus. *Armillaria* is known to occur on south and west sites in the Ozarks, and if present, tree defense may be weakened. If *Armillaria* is present on a tree, red oak borer might stress trees enough for the fungus to take advantage of the tree's weakened state. Unpublished data show that *Armillaria* is less common on ridges, suggesting red oak borer as the sole contributor to tree mortality on these sites.

Acknowledgements

Thanks to Mike Chain, Jim Guldin, Rose Barnhill, Vanessa Ware, Tracy Dahl, Leah Lucio and John Riggins; i.e, the tree feller, Forest Service contact and Forest Entomology lab.