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EVALUATING SUSCEPTIBILITY OF RED-COCKADED WOODPECKER CAVITY TREES TO SOUTHERN PINE BEETLE IN TEXAS ¹

William G. Ross, David L. Kulhavy and Richard N. Conner ²

Abstract. Characteristics of loblolly (*Pinus taeda* L.) and shortleaf (*Pinus echinutu* Mill.) pine trees favored by the endangered red-cockaded woodpecker, *Picoides borealis* (Vieillot) for nesting and roosting cavities over much of eastern Texas, tend to make these trees highly vulnerable to mortality from bark beetle attack. Resin flow and xylem moisture potential, often used as indicators of pine susceptibility to bark beetle mortality, were measured in several red-cockaded woodpecker cavity tree clusters in the Angelina and Davy Crockett National Forests. No differences in xylem moisture potential were found, while resin flow varied by site, tree species, and cavity tree type. With over half of cavity tree mortality in Texas caused by southern pine beetle, *Dendroctonus frontalis* Zimmerman, pro-active management to reduce bark beetle hazard in southern pine stands is imperative.

Introduction

The red-cockaded woodpecker, *Picoides borealis* (Vieillot) (**RCW**), has been federally listed as an endangered species since 1970. With populations occurring in a variety of pine and pine-hardwood ecosystems of the South and Southeastern U.S., the RCW is unique in that it excavates roosting and nesting cavities exclusively in living pine. Old-growth longleaf pine (*Pinus palustris* Mill.) appears to be favored when available (U.S. Fish and Wildlife Service, 1985), but shortleaf (*P. echinutu* Mill.), loblolly (*P. taeda* L.) slash (*P. elliotii* Engelm.), Virginia (*P. virginianu* Mill.) and pitch (*P. rigida* Mill.) pines are readily utilized (Hooper et al. 1980; Kalisz and Boettcher, 1991). RCW populations in Texas (Conner and Rudolph, 1989) and southwide (Costa and Escano, 1989) are generally declining due to loss and fragmentation of old-growth southern pine habitat (U.S. Fish and Wildlife Service, 1985; Conner and Rudolph, 1991a).

In addition to excavating its cavities in living pines, **RCWs** peck small holes, called resin wells, around cavity entrances that cause a copious flow of resin down and around the boles of their cavity trees. The resin serves as a barrier against rat snakes, *Elaphe obsoleta* (Say), a major RCW predator (Rudolph et al. 1990a), but has little effect on cavity competitors (Rudolph et al. 1990b). Attack by southern pine beetle (*Dendroctonus frontalis* Zimm.) is the major cause of RCW cavity tree loss in Texas

loblolly and shortleaf pine stands in Texas (Conner et al. 1991a, Kulhavy et al. 1992). Trees favored by the RCW for nesting and roosting cavities tend to be old, ranging from approximately 60 to 130 years of age in loblolly and shortleaf pine, with slow radial growth, and infection with red-heart rot (*Phellinus pini*) (Conner and Locke 1982, Conner and O'Halloran 1987, Rudolph and Conner 1991). Such characteristics tend to place pine trees at high risk of attack by southern pine beetles and other phloem-boring beetles, even when bark beetle populations are generally at endemic levels.

A primary host defense against bark beetles is preformed resin flow (Hodges et al. 1979, Paine et al. 1985). Preformed resin is resin present in the resin ducts at the time of wounding or insect attack, rather than resin produced as a response to these stimuli. Bark beetles, particularly during endemic population levels, are often unable to colonize and kill pines with high resin flow. An important factor in predisposing trees to insect attack is moisture stress. Lorio and Hodges (1977) found that stressed pines were much less able to resist southern pine beetle attack than unstressed trees.

The purpose of this study is to examine the effects of RCW cavity tree excavation and resin-well pecking on preformed resin flow and tree moisture stress. Implications for management based on these and other characteristics of RCW cavity trees and cavity tree clusters will be explored.

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Methods and Materials

Data were collected in the Bannister Wildlife Management Area of the Angelina National Forest (ANF) of Texas periodically during the growing seasons of 1988 and 1989. Data were also collected in 1989 and 1990 from the **Neches** district in the Davy Crockett National Forest of Texas, approximately 100 km west of the ANF.

Red-cockaded woodpecker cavity trees evaluated in this study were either loblolly or shortleaf pines. Sample trees in the **ANF** were divided into four categories:

1. Trees currently used for RCW nesting and roosting that had been established prior to 1987 (old active),
2. Trees previously used for nesting and roosting, but currently not used by RCW (inactive),
3. Trees having external characteristics associated with RCW trees, such as age, evidence of heart-rot, etc., but no history of RCW utilization (potential) and
4. Cavity trees excavated after 1987 (new active).

In the DCNF, only the first three categories were sampled. Approximately **60** trees, divided into appropriate categories, were sampled in each forest. The same trees were used in each sampling interval.

Resin flow was measured by driving a 2.54 cm diameter circular arch punch to the interface of xylem and phloem at approximately 1.4 m (diameter at breast height) on the bole following the method of **Lorio et al. 1990**. All holes were punched between 0700 and 1000 hours to minimize effects of diurnal variation in resin flow (**Nebeker et al. 1988**). Triangular metal funnels were then placed under the wounds to divert exuded oleoresin into a clear plastic graduated tube. Resin flow was recorded at 8 and 24 hours after wounding. After recording twenty-four hour values, funnels and tubes were removed, and the bark plug replaced. To avoid placing undue additional stress on the trees, only one sample per tree was taken during any one sampling period.

Xylem moisture potential was evaluated using the pressure chamber technique (**Scholander et al. 1965**). Twig samples were taken from the upper crowns of cavity and non-cavity trees selected from among the tree samples for resin flow. Sampling took place during peak stress **times** of 1300 to 1500 hours at the same times as resin sampling. Only established active RCW trees, inactive trees, and potential trees

were evaluated. Newly excavated cavity trees were too few in number to provide valid comparisons. Sample collection was accomplished with a shotgun, and moisture status evaluated within sixty seconds of removal.

Data were analyzed using the **SPSS^x** statistical **software** package (**Norusis 1985**). Resin flow at 8 and 24 hours was analyzed separately for each species and by each forest. Resin flow by species was analyzed using the Mann-Whitney U-Wilcoxon Rank Sum test (**Norusis 1985**). **Kruskal-Wallis** non-parametric rank analysis was used to evaluate resin flow by cavity tree type. When differences were significant at **$P \leq 0.05$** , ranked means were separated using the non-parametric multiple comparison procedure described by **Daniel (1990)** using an experimentwise error rate of 0.20. The same procedures were used to analyze xylem moisture potential.

Results

Overall 8 and 24 hour resin flow, combining all cavity tree types, showed significant differences in resin flow by species (Figures 1 and **2**), but with the species exhibiting highest resin flow differing by forest. In the Angelina National Forest, shortleaf pine had higher resin flow, while loblolly pine had the highest resin flow in the DCNF.

Analysis of sample trees by cavity tree type showed similar difference by species. In the ANF there were no significant differences in resin flow by cavity tree type in loblolly pine (Figures 3 and 4). In shortleaf pine however, newly activated cavity trees had much higher resin flow than old active, inactive or potential.

Results from the Davy Crockett National Forest were different (Figures 5 and 6). Active loblolly pine cavity-trees had significantly higher resin flow than the potential trees. For shortleaf cavity trees, resin flow was highest in the potential trees and lowest in inactive trees.

No significant differences were found in xylem moisture potential between cavity tree types in either forest. It should be emphasized, however, that these are results taken only during hours of peak stress and do not include newly excavated cavity trees.

Discussion

Cavity excavation and continual resin-well pecking by red-cockaded woodpeckers on old loblolly and shortleaf pine trees appears to affect preformed

resin flow. Direction and magnitude of these effects vary considerably with tree species and site conditions, however. Because of this variation it is difficult to generalize about **effects** of RCW activity on cavity tree vulnerability to bark beetles in terms of preformed resin flow. Given their general senescence, low vigor, and infection by pathogens, RCW cavity trees, especially shortleaf and loblolly, are naturally at a stage of life where vulnerability to mortality from all sorts of factors, including bark beetles, may be high.

Traditional approaches to bark beetle infestations include salvage cutting, cutting infested trees and applying insecticide, cutting **infested** trees plus a buffer zone and leaving these trees in the woods, and piling infested material and burning (Swain and **Remion**, 1981). All of these strategies except piling and burning may be appropriate under suitable conditions to prevent SPB infestations from reaching RCW cavity trees. Use of behavioral chemicals, such as the SPB anti-aggregation pheromone Verbenone, is currently being evaluated experimentally as a method of diverting attack away from high-value areas such as RCW colonies (Ron Billings pers. **comm.**). Artificial nest cavity **con-**

struction, most commonly involving insertion of a prefabricated nest box into a suitable living pine, is showing great promise in mitigating the impact of natural cavity tree loss. As important as these tactics are in the effort to prevent further decline in RCW populations and habitat, they are not substitutes for **planning** to reverse forest fragmentation and provide an adequate supply of natural habitat.

Long-term pro-active management strategies to favor the woodpeckers in loblolly-shortleaf stands must include reducing risk of bark beetle attack by increasing overall forest health. **Thinnings** to maintain low to moderate pine basal area, prescribed burning, and favoring **longleaf** pine in its native range are commonly suggested (Conner and Rudolph, 1989); Conner et al. 1991a; Conner et al. 1991b). Prompt response to SPB outbreaks is critical to reducing impact, but is inadequate unless accompanied by pro-active management. Devising innovative approaches to managing forest ecosystems for optimum health of their native constituents in conjunction with providing society with the forest products and values it demands is the continuing challenge facing foresters and other resource management professionals.

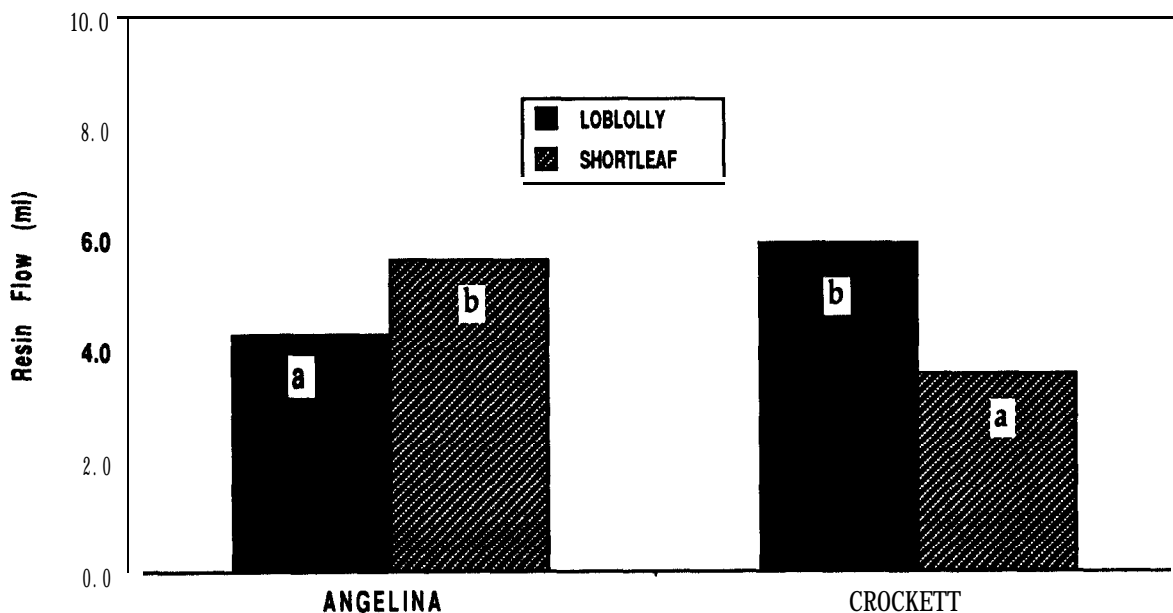


Figure 1. Eight-hour resin flow by species and forest.

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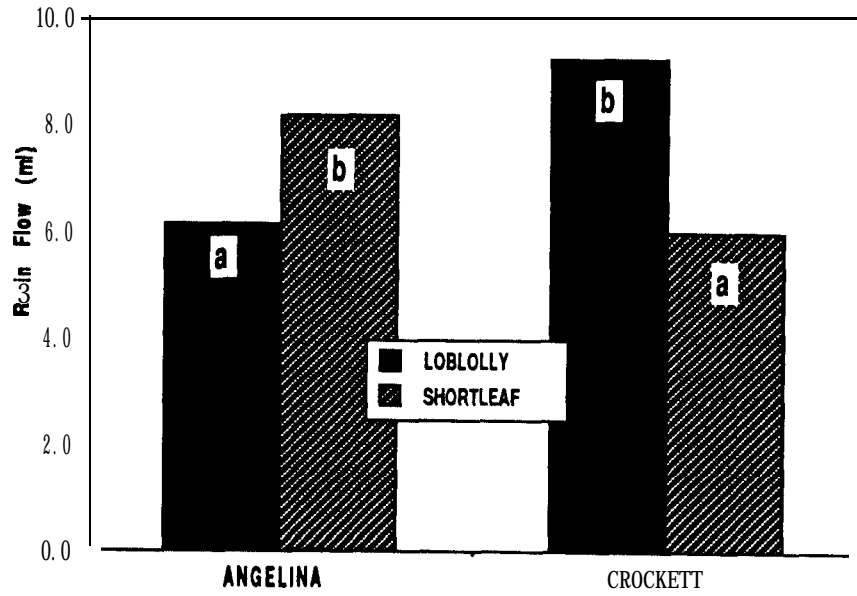


Figure 2. *Twenty-four-hour resin flow by species and forest.*

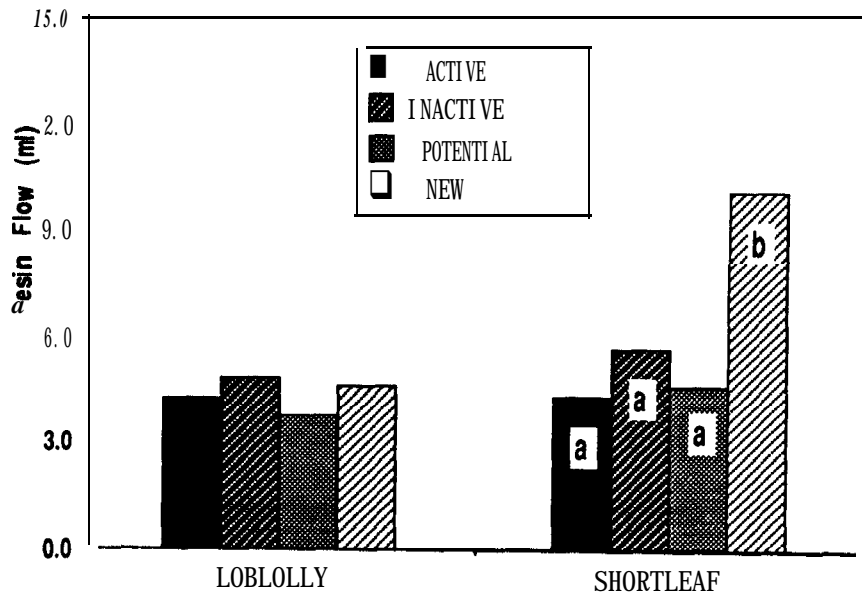


Figure 3. *Eight-hour resin flow by cavity tree type and species, Angelina National Forests.*

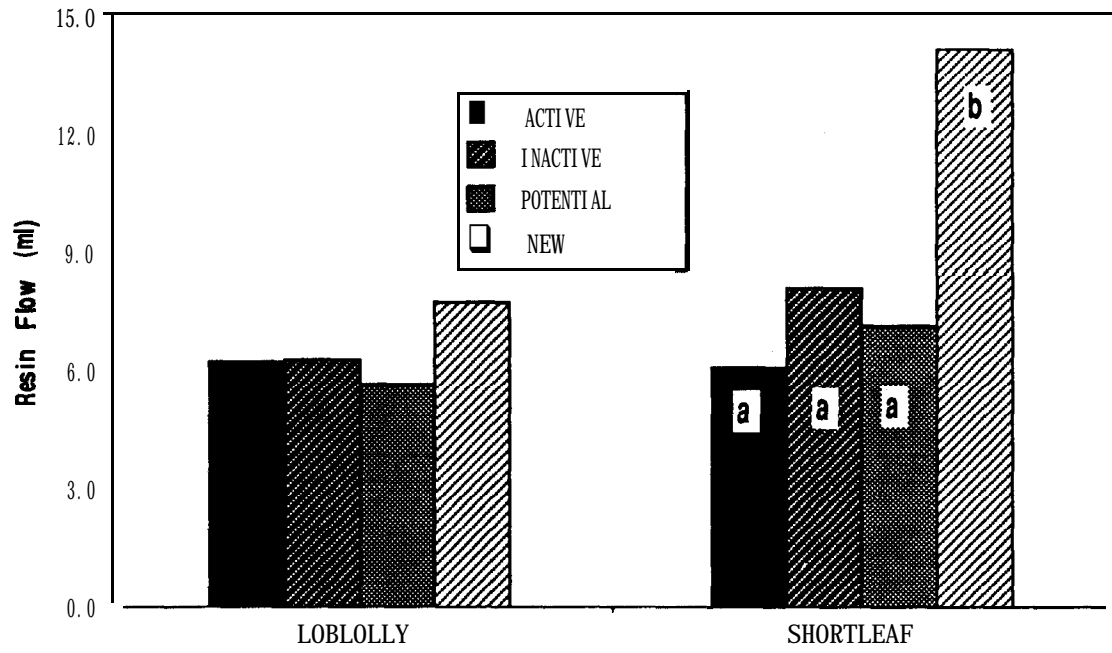


Figure 4. Twenty-four-hour resin flow by cavity tree type and species, *Angelina* National Forest.

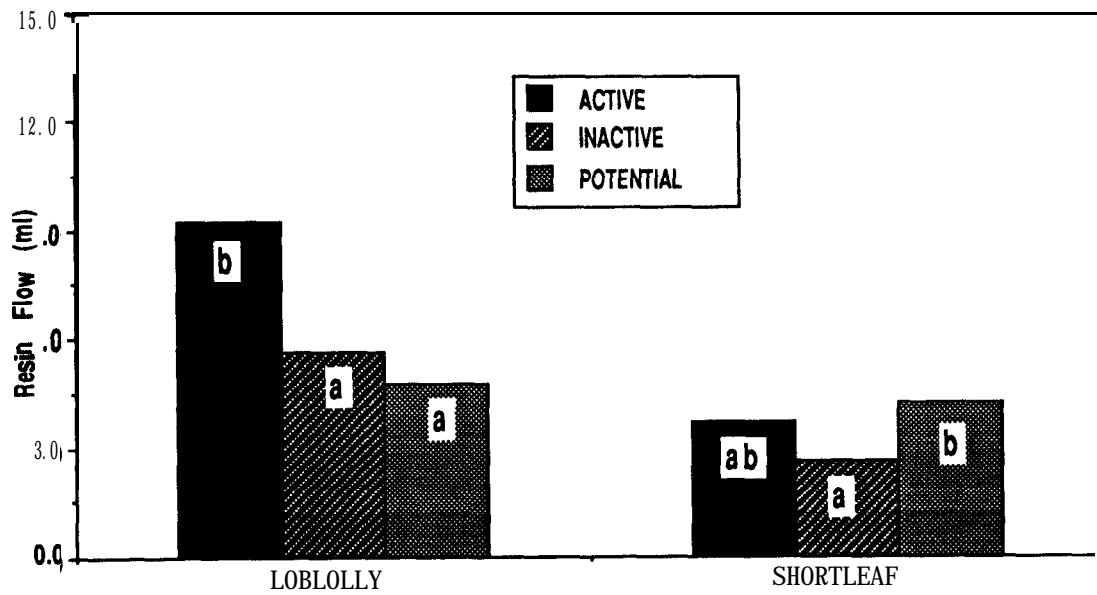


Figure 5. Eight-hour resin flow by cavity tree type and species, *Davy Crockett* National Forest.

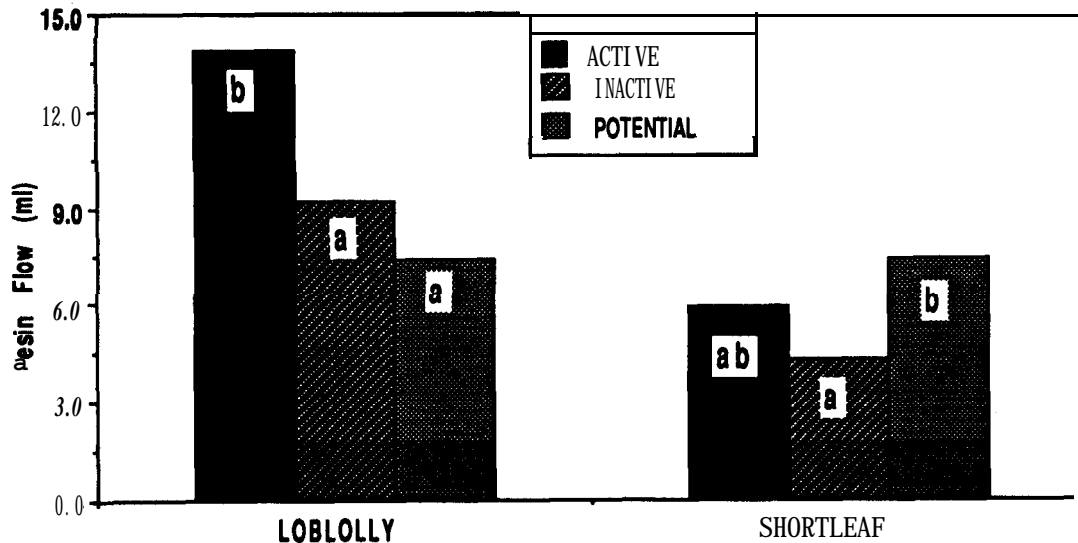


Figure 6. Twenty-four-hour resin flow by cavity tree type and species, Davy Crockett National Forest.

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