1991

Susceptibility of Red-Cockaded Woodpecker Colony Areas to Southern Pine Beetle Infestation in East Texas

James H. Mitchell

David L. Kulhavy
dkulhavy@sfasu.edu

Susceptibility of Red-Cockaded Woodpecker Colony Areas to Southern Pine Beetle Infestation in East Texas[1]

James H. Mitchell *and* **David L. Kulhavy,** *School of Forestry, Stephen F. Austin State University, Nacogdoches, Texas 75962;* **Richard N. Conner,** *Southern Forest Experiment Station, USDA Forest Service, Nacogdoches, TX 75961 and* **Charles M. Bryant V,** *Texas Forest Service, Conroe, Texas.*

*ABSTRACT. Seven red-cockaded woodpecker (*Picoides borealis*) colonies and stands within a one-quarter mile radius were hazard-rated for susceptibility to the southern pine beetle (*Dendroctonus frontalis *Zimm.). Individual colonies generally were ranked low to moderate hazard using the Texas Hazard system and moderate hazard using the National Forest Risk system. Within one-quarter mile of the colonies, 28% of the stands were low hazard, 25% moderate, 0.3% high and 7.5% extreme with Texas Hazard. Four percent were low hazard, 52% moderate, and 6% high with National Forest Risk. Moderate to extreme hazard stands within one-quarter mile of the colonies could increase the probability of beetle infestation in these areas, thus threatening foraging areas and individual colony trees. Documented bark beetle activity within colonies did not correspond directly with hazard ratings, suggesting that development of a different model may be needed for these RCW colonies to incorporate stand characteristics, disturbances, cavity tree condition, and other bark beetle species.*

South. J. Appl. For. 15(3):158–162.

The red-cockaded woodpecker (RCW) (*Picoides borealis*) is an endangered species endemic to mature loblolly (*Pinus taeda*), shortleaf (*P. echinata*), and longleaf (*P. palustris*) pine forests of the southern United States. A major threat to RCW populations is the loss of old growth southern pines for nesting habitat (U.S. Fish and Wildlife Service 1985). Only 2.5% (1.6 million acres of commercial forestland in the South is currently considered acceptable nesting habitat, a decline of 13% over the past 25 years (Lennartz et al. 1983). RCW populations have declined severely on National Forests in Texas (Conner and Rudolph 1989) and southwide (Ligon et al. 1986). The number of active colonies on the Angelina National Forest, TX, has decreased from 38 in 1983 to 22 in 1987 to 19 in 1988, a 42% decline in four years. Similar trends have been observed on the Davy Crockett and Sabine National Forests (Conner and Rudolph 1989).

One of the major threats to currently active colonies is the loss of cavity trees from southern pine beetle (SPB) (*Dendroctonus frontalis* Zimm.) infestations (Kulhavy et al 1990, USDA Forest Service 1987). In the Four Notch Further Planning Area, TX, 5 of 12 known RCW colonies were infested by SPBs and abandoned in an outbreak covering 3750 ac (55% of the area) in 1983 (Billings and Varner 1986). In the Kisatchie Hills Wilderness in 1986, all cavity trees in one active colony were destroyed by SPBs, and two colonies were abandoned after subsequent control activities (Kulhavy et al. 1991). In addition to direct cavity tree mortality, reduction in the acreage of potential cavity trees and foraging habitat can also occur due to SPBs (Billings and Varner 1986, Kulhavy et al. 1991, USDA Forest Service 1987).

Red-cockaded woodpeckers most commonly select mature living pines for cavity excavation and are the only North American woodpeckers to nest in living pines exclusively. Excavation of a single cavity in a tree may require less than four months if the heart rot fungus (*Phellinus pini*) is present, and up to 2 years or longer if no decay is present (Conner and O'Halloran 1987). Cavity trees used by a RCW clan are commonly clustered in a colony containing from 1 to 30 cavity trees spaced up to 2400 ft apart (Jackson and Thompson 1971).

Cavity trees are classified as active (used for nesting and roosting) or inactive (abandoned) (Jackson 1977, 1978). Of the active trees within a colony, only one is used as the nest tree. Barring death of the tree or loss of the cavity to competing woodpeckers, the RCWs will use the same cavity tree for years or even decades (U.S. Fish and Wildlife Service 1985). A unique behavior of the RCW is to peck numerous resin wells above and below the entrance of a cavity and along the tree bole (Jackson 1978). This pecking activity presumably stimulates the flow of pine oleoresin that acts as a barrier against rat snake predation. Protection of

[1] This work was supported by a cooperative agreement between the Southern Forest Experiment Station and Stephen F. Austin State University, Nacogdoches, TX. Appreciation is extended to Steve Cannel and Glenn Donnahoe (Angelina Ranger District) and Mack Little (National Forests in Texas) for providing CISC data, compartment maps, and aerial photographs. We also thank Ronald F. Billings, Peter L. Lorio, Jr., Ray R. Hicks, Jr., Roger P. Belanger, Timothy D. Schowalter, Wesley A. Nettleton and William M. Lannan for critical comments on an earlier draft of this manuscript. Current address for J.H. Mitchell: Department of Entomology, Oregon State University, Corvallis, OR 97331.

these trees is crucial to the survival of existing populations of RCWs, particularly in areas such as the Angelina National Forest where populations are declining.

Some of the most useful forest management tools developed from SPB research are techniques to rank forest stand susceptibility to SPB infestation (Billings et al. 1985, Hicks et al. 1980, 1981, 1987, Lorio and Mason 1982). These techniques are referred to as hazard- or risk-rating systems. Researchers have developed different definitions for hazard and risk. For our purposes, hazard indicates the relative susceptibility of an area, based solely on site and stand factors and host abundance. Risk is defined as the probability of bark beetle infestations becoming established within a given time span and results from the interaction of hazard and existing SPB populations (Paine et al. 1984).

Applications of hazard- and risk-rating techniques have been used to determine susceptibility of active RCW colonies to SPB infestation in loblolly and shortleaf pine types (Belanger et al. 1988, Kulhavy et al. 1988, Mitchell 1987). Belanger et al. (1988) found that hazard and risk of RCW colony stands to SPB infestation in Georgia were very low. However, that study did not evaluate the potential of infestation from stands adjacent to RCW colonies.

The objectives of our study were (1) to determine the susceptibility of RCW colonies and stands within 1320 feet of each colony to SPB attack using validated hazard-rating systems for east Texas and (2) to monitor the effects of bark beetle activity within colonies relative to stand hazard ratings. These findings should provide important data for management of southern pine forests containing RCW colonies.

METHODS AND MATERIALS

Seven of the eight active red-cockaded woodpecker colonies in loblolly and shortleaf pine types located in or near the Bannister Wildlife Management Area on the Angelina National Forest were chosen for the study. Adequate aerial photo coverage for the eighth colony was not obtained and thus it was not included in the study. Forest cover of the area is predominantly pine, with 16% of the area in hardwood types.

Susceptibility of RCW colonies and surrounding stands within a 1320 ft radius were determined using two hazard-rating methods: TX Hazard (Mason et al. 1981) and NF Risk (Lorio et al. 1981). The TX Hazard system was developed for east Texas utilizing basal area and stand height data from aerial photographs and landform information from topographic maps (Hicks et al. 1980, 1981, Mason et al. 1981). The NF Risk system (defined here as a hazard-rating system) was developed on national forestlands in Louisiana utilizing readily available stand inventory data (Lorio and Sommers 1981). The two systems produced similar results when compared in Texas and Louisiana (Lorio et al. 1982).

Within 1320 ft of a selected center point in each colony, circular 125 ac areas were hazard-rated using the TX Hazard and NF Risk systems. The TX Hazard system was implemented by locating RCW colonies on acetate overlays covering 1982 color infrared aerial photographs. Stand harvesting in the study area beginning in 1985 required the acquisition of updated 1986 aerial photography to indicate changing stand conditions within 1320 feet of each colony. Basal areas in 40 ft^2 classes and stand height in 25 ft increments were then coded on the photos after stereoscopic examination. A ground check was applied to each colony area to determine interpretation accuracy. Landform was determined from USGS topographic maps and classified as bottom, ridge, or other. Basal area, tree height, and landform classes were combined, and a hazard classification was applied (Table 1). Hardwood, clearcut, and open areas as well as pine stands less than 4 in. dbh were classified as nonhazardous. Area measurements of hazard classes were made with an image analyzer and microcomputer.

The NF Risk system was applied by drawing a 1320 ft radius circular area (125 ac) around each RCW colony on U.S. Forest compartment maps and obtaining the hazard ratings from the Continuous Inventory of Stand Conditions (CISC) data for the Angelina National Forest. Variables used for hazard rating include forest type, stand condition class, method of cut, operability, and site index (Lorio and Sommers 1981). Area measurements of hazard classes were made with a polar planimeter.

Average cavity-tree and colony stand characteristics including age, dbh, height, and pine and hardwood basal areas were summarized from Conner and O'Hal-

Table 1. Categories, codes, and discriminant equation for the Texas Hazard stand classification system (Mason et al. 1981).

Basal area (ft^2/ac)	Stand height (ft)	Landform	Classification code
<40	<50	ridge	1
41–80	51–75	other	2
81–120	76–100	bottom	3
>121	>101		4

$$HAZ = -5.90 + 1.09\,BAC + 0.65\,HTC + 0.56\,LDC$$

< −0.059	= low hazard
−0.059 – 0.54	= moderate hazard
0.54 – 1.12	= high hazard
>1.12	= extreme hazard

where:

HAZ = Hazard classification
BAC = Basal area code
HTC = Height code
LDC = Landform code

Table 2. Mean tree and stand characteristics of seven red-cockaded woodpecker colonies in loblolly and shortleaf pine types on the Angelina National Forest (from Conner and O'Halloran 1987).

Variable	N	Mean	Standard deviation
Cavity tree age (yr)	38	86.8	11.4
Cavity tree dbh (in.)	43	21.0	3.2
Cavity tree height (ft)	43	93.5	7.5
Pine basal area (ft^2/ac)	43	66.1	18.9
Hardwood basal area (ft^2/ac)	43	5.7	7.0

loran (1987) for the seven RCW colonies that we studied. Methods for collection of these data are described there.

RESULTS

Average within-colony stand characteristics show relatively low pine and hardwood densities (71.8 ft^2, Table 2). These lower stand densities are the result of silvicultural treatments including prescribed fire and thinning to remove midstory hardwoods and pines.

A total of 871 ac was hazard-rated using the TX Hazard system for the seven RCW colonies (Table 3). Two pairs of colonies were located less than one-half mile apart and thus had overlapping hazard-rated areas. In 1985–1986, acreages in hazard classes were reduced primarily by timber harvesting. Clearcutting of 100 ac (12%) of the total area within 1320 ft of the colonies resulted in a reduction in acreage of 4, 5, 0.2, and 3% for low, moderate, high, and extreme hazard classes, respectively.

High and extreme hazard stands were found within one-quarter mile of each colony but occupied only a small fraction of the total area rated. Cavity trees within each colony were typically located in low to moderate hazard stands. One colony was located in an extreme hazard stand.

Hazard-rating using the NF Risk system indicated that six of seven RCW colonies were located in moderate hazard stands and the seventh colony was within a high hazard stand (Table 4). More than one-half of the total colony areas were classified as moderate hazard. High hazard stands were detected within the 125 ac areas of only one colony. Almost one-fourth of the areas within 1320 ft of the colonies was in private ownership and were not hazard-rated using the NF Risk system data. These private lands contained young loblolly pine plantations (less than 12 years old) and were rated as nonhazardous to low hazard using the TX Hazard system.

Some discrepancies were found in comparison of the TX Hazard and NF Risk systems for hazard rating individual colonies (Table 5). Using the TX Hazard system, four colonies were found to be low hazard, two moderate, zero, high, and one extreme. The NF Risk system indicated that zero colonies were rated low hazard, six were moderate, and one high. The colonies classified as extreme and high, respectively, were different for the two systems.

Bark beetle activity was variable within the colonies. Four active, 1 inactive, and 13 noncavity-trees were attacked and killed by SPBs and black turpentine beetles (BTBs) (*D. terebrans*) from 1985–1987. More colony trees without cavities were lost in 1985 (an epidemic SPB year in Texas) than in 1986 and 1987 (years of low populations) combined. However, only one active cavity-tree (a nest tree) was lost in 1985. Two cavity-trees were lost in each of the following years. The proportion of BTBs to SPBs in attacked cavity-trees increased in 1986–1987 (J.H. Mitchell, personal observation). SPB activity did not seem to correspond to the hazard-rating indicated by either system. More noncavity-trees were lost in moderate hazard stands Cavity-tree mortality was uniform across hazard classes using the TX Hazard system and greater in the high hazard colony with the NF Risk system.

Table 3. Southern pine beetle hazard classes of seven red-cockaded woodpecker colonies and surrounding 125 ac areas in 1982 and 1986 using the Texas Hazard system.

	1982		1986	
Classification	Acres	Percent	Acres	Percent
Hazard				
Low	275.1	32.0	244.5	28.0
Moderate	264.4	30.0	218.3	25.0
High	4.5	0.5	3.4	0.3
Extreme	94.1	11.0	65.3	7.5
Nonhazard				
Young plantations	178.3	20.5	178.3	20.5
Hardwood stands	29.8	3.0	29.8	3.0
Open areas	16.6	2.0	16.6	2.0
Young natural stands	8.0	1.0	8.0	1.0
Clearcut areas	0.0	0.0	100.0	12.0
SPB control areas	0.0	0.0	6.6	0.7
Total	870.8	100	870.8	100

Table 4. Southern pine beetle hazard classification of seven red-cockaded woodpecker colonies and surrounding 125 ac areas in 1986 using the NF Risk system.

Classification	Acres	Percent
Hazard		
Low	37	4
Moderate	443	52
High	48	6
Nonhazard	131	15
Unrated (private ownership)	200	23
Total	859	100

DISCUSSION

Average stand characteristics and hazard ratings (TX Hazard) were similar to those reported by

Table 5. Southern pine beetle hazard-rating of red-cockaded woodpecker colonies in 1986 using the Texas Hazard and NF Risk systems and the number of noncavity and cavity trees killed by bark beetles from 1985–1987.

Hazard-rating system	RCW colonies (number)	Noncavity-trees killed	Cavity-trees killed
Texas Hazard			
Low	4	4	3
Moderate	2	8	1
High	0	0	0
Extreme	1	1	1
Total	7	13	5
NF Risk			
Low	0	0	0
Moderate	6	13	3
High	1	0	2
Total	7	13	5

Belanger et al. (1988) for RCW colonies in Georgia. Periodic stand thinnings and midstory removal of hardwoods and pines lowered basal areas, thus reducing potential spot growth within the colonies. However, results from the hazard-rating systems indicate a high potential for SPBs from adjacent stands to affect RCW colonies. Though more than one-half of the individual colonies were rated low hazard (TX Hazard system), approximately one-third of the stands within 1320 ft of the colonies were rated moderate to extreme hazard. Disturbances such as harvesting, lightning strikes, and thinning within 1320 ft of RCW colonies, combined with moderate to extreme hazard classifications, may increase the probability of SPB infestation occurrence in these areas. Bark beetle activity has been associated with stand disturbances (Hicks et al. 1987, Nebeker and Hodges 1983). These disturbances could result in direct colony tree mortality (Table 5) as well as a significant loss in available foraging habitat for each colony of birds. Timber harvesting and SPB control have resulted in a loss of 13% of the pine stands within one-quarter mile of the colonies. Any further loss of this potential foraging habitat is believed to be detrimental to the population of woodpeckers found in these colonies (Conner and Rudolph 1989).

Hazard-rating RCW colonies and surrounding stands with the NF Risk system resulted in a lumping of small pockets of extreme hazard stands into a predominantly moderate hazard category. High hazard stands were detected within only one of the colony areas. This system works well for large area planning, but is not sufficiently sensitive to identify extreme hazard stands close to a RCW colony, where loss of a single cavity or nest tree or of critical foraging habitat could severely impact a declining population. Extreme hazard stands can serve as "reservoirs" for SPB populations where beetle activity is concentrated during endemic periods (Mason et al. 1981, Hicks et al. 1987). Recognition of the potential limitations of the NF Risk system in assessing the susceptibility of RCW colony areas to SPB attack is important in silvicultural planning for hazard reduction on National Forests in the Gulf Coastal Plain. Other hazard or risk systems which identify pockets of extreme hazard conditions can better assess the susceptibility of RCW colony areas to SPB attack.

Of the four active cavity trees killed by bark beetles, three were used for nesting the year they were killed. In one colony, the RCWs did not fledge any young in 1985 after the nest tree was killed by SPBs that year (R.N. Conner, personal observation). The other active tree killed by SPBs was a cavity start tree (cavity in the process of excavation) next to the old nest tree, which may have prevented the birds from nesting in 1986. Disturbances from colony stand thinnings, lightning strikes, and subsequent bark beetle attacks resulted in the loss of three of the cavity-trees and four noncavity-trees. The pecking behavior of the RCWs as well as the advanced ages of the trees may have also been contributing factors. The constant flow of oleoresin down the active cavity tree boled may provide a consistent, fresh source of bark beetle attractants. This is particularly important as active cavity-trees could be more susceptible to SPB attacks because of low oleoresin flow rates in comparison with inactive and other colony trees (Mitchell 1987). Further research is needed to fully understand relationships between stand structure, disturbances, cavity-tree age and physiology, and attractiveness to bark beetles. These complex relationships may necessitate the need for development of a different bark beetle (SPB and BTB) hazard-rating model for these RCW colonies.

Although the results of this study indicate that hazard-rating did not correspond directly with observed mortality of RCW colony trees, the small number of colonies that we rated limits the application of the results to the management of other RCW populations. Studies of larger number of colonies, in different geographic locations and with other hazard- or risk-rating systems may yield more consistent results. Hazard- and risk-rating systems still provide forest managers the most useful methodology for evaluating stand susceptibility to SPB attack and silvicultural planning for hazard reduction.

In Texas, forested stands within 1320 ft of RCW colonies are being thinned to 60–90 ft^2 per acre to improve RCW foraging habitat and reduce southern pine beetle hazard. Stand thinnings have been shown to reduce SPB hazard (Belanger and Malac 1980) provided that stand disturbances and damage to residual trees are minimized (Nebeker and Hodges 1983). Hazard reduction should be done when insect populations in the forest region are low to further minimize the effects of disturbances (Hicks et al. 1987). Continued assessment of bark beetle

damage in RCW colonies during and after stand thinnings will be needed to evaluate the effectiveness of this hazard reduction method for minimizing losses of RCW colony trees to bark beetle infestations. □

Literature Cited

BELANGER, R.P., R.L. HEDDEN AND M.R. LENNARTZ. 1988. Potential impact of the southern pine beetle on red-cockaded woodpecker colonies in the Georgia Piedmont. So. J. Appl. For. 12:194–199.

BELANGER, R.P., AND B.F. MALAC. 1980. Silviculture can reduce losses from the southern pine beetle. USDA Comb. For. Pest Res. Dev. Prog., Tech. Bull. 1612.

BILLINGS, R.F., AND F.E. VARNER. 1986. Why control southern pine beetle infestations in wilderness areas? The Four Notch and Huntsville State Park experiences. P. 129–134 *in* Wilderness and natural areas in the Eastern United States: A management challenge, Kulhavy, D.L., and R.N. Conner (eds.). Center for Applied Studies, School of Forestry, Stephen F. Austin State Univ., Nacogdoches, TX. 416 p.

BILLINGS, R.F., C.M. BRYANT V, AND K.H. WILSON. 1985. Development, implementation and validation of a large area hazard- and risk-rating system for the southern pine beetle. P. 226–232 *in* Integrated Pest Management Research Symposium: The Proceedings, Branham, S.J., and R.C. Thatcher (eds.). USDA For. Serv. Gen. Tech. Rep. SO-56. 385 p.

CONNER, R.N., AND K.A. O'HALLORAN. 1987. Cavity-tree selection by red-cockaded woodpeckers as related to growth dynamics of southern pines. Wilson Bull. 99:398–412.

CONNER, R.N., AND D.C. RUDOLPH. 1989. Red-cockaded woodpecker colony status and trends on the Angelina, Davey Crockett and Sabine National Forests. USDA For. Serv. Res. Pap. SO-250. 15 p.

HICKS, R.R., JR., ET AL. 1980. Rating forest stand susceptibility to southern pine beetle in east Texas. For. Ecol. Manage. 2:269–283.

HICKS, R.R., JR., ET AL. 1981. Rating east Texas stands for southern pine beetle susceptibility. South. J. Appl. For. 12:194–199.

HICKS, R.R., JR., J.E. COSTER, AND G.N. MASON. 1987. Forest insect hazard rating. J. For. 85:20–26.

JACKSON, J.A. 1977. Determination of the status of red-cockaded woodpecker colonies. J. Wildlife Manage. 41:448–452.

JACKSON, J.A. 1978. Analysis of the distribution and population status of the red-cockaded woodpecker. P. 101–110 *in* Proc. Rare and Endangered Wildlife Symp., Odum, R.R., and L.L. Landers (eds.). Ga. Dep. Natur. Resour. Game Fish Div. Tech. Bull. WL4.

JACKSON, J.A., R.N. CONNER, AND B.J.S. JACKSON. 1986. The effects of wilderness on the endangered red-cockaded woodpecker. P. 71–78 *in* Wilderness and natural areas in the Eastern United States: A management challenge, Kulhavy, D.L., and R.N. Conner (eds.). Cent. Appl. Studies, School For., Stephen F. Austin St. Univ., Nacogdoches, TX.

JACKSON, J.A., AND R.L. THOMPSON. 1971. A glossary of terms used in association with the red-cockaded woodpecker. P. 187–188 *in* Ecology and management of the red-cockaded woodpecker, Thompson, R.L. (ed.). Bur. Sport Fish & Wildl. and Tall Timbers Res. Stn., Tallahassee, FL.

KULHAVY, D.L., ET AL. 1991. Forest protection in wilderness management: The southern pine beetle and the red-cockaded woodpecker. *In* Proc. 4th World Wilderness Congr., Krumpe, E.E., and P. Weingarten (eds.). For. & Wildlife Range Exp. Stn., Univ. Idaho, Moscow, ID. (In press.)

KULHAVY, D.L., J.H. MITCHELL, AND R.N. CONNER. 1988. The southern pine beetle and the red-cockaded woodpecker: Potential for interaction. P. 337–343 *in* Integrated Control of Scolytid Bark Beetles, Payne, T.L., and H. Saarenmma (eds.). IUFRO working party and XVIII Internat. Congr., Entomol. Symp. Virginia Poly. Inst. & State Univ., Blacksburg.

LENNARTZ, M.R., ET AL. 1983. Status of red-cockaded woodpecker nesting habitat in the south. P. 13–19 *in* Red-cockaded woodpecker symposium II, Wood, D.A. (ed.). Proc. State Florida Game Fresh Water Fish Comm. Tallahassee

LIGON, J.D., ET AL. 1986. Report of the American Ornithologist Union committee for the conservation of the red-cockaded woodpecker. Auk. 103:848–855.

LORIO, P.L., JR., G.N. MASON, AND G L AUTRY. 1982. Stand risk rating for the southern pine beetle: Integrating pest management with resource management. J. For. 80:202–214.

LORIO, P.L., JR., AND R.A. SOMMERS. 1981 Use of available resource data to rate stands for southern pine beetle risk. P 75–78 *in* Hazard-rating systems in forest insect pest management, Hedden, R.L , S.J. Barras, and J.E. Coster (eds.). USDA Tech. Rep. WO-27.

MASON, G.N., ET AL. 1981. Rating southern pine beetle hazard by aerial photography. P. 109–114 *in* Hazard-rating systems in forest insect pest management, Hedden, R.L., S.J. Barras, and J.A. Coster (eds.). USDA Tech. Rep WO-27.

MITCHELL, J.H. 1987. Hazard- and risk-rating of red-cockaded colony areas and relative susceptibility of cavity trees to the southern pine beetle. M.S. For Thesis, Stephen F. Austin State Univ , Nacogdoches, TX. 113 p.

NEBEKER, T.E., AND J.D. HODGES. 1983 Influence of forestry practices on host susceptibility to bark beetles. Z. Ang. Entomol. 96:194–208.

PAINE, T.D., F.M. STEPHEN, AND H A TAHA. 1984. Conceptual model of infestation probability based on bark beetle abundance and host tree susceptibility Environ. Entomol. 13:619–624.

USDA FOREST SERVICE. 1987. Final environmental impact statement for the suppression of the southern pine beetle South. Reg. Manag. Bull. R8-MB2.

U.S. FISH AND WILDLIFE SERVICE. 1985 Endangered species recovery plan: Red-cockaded woodpecker (*Picoides borealis*) U.S. Fish & Wildl. Serv. Reg. 4, Atlanta, GA. 88 p.