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Silvicultural systems and red-cockaded woodpecker management: another perspective

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Rudolph and Conner (1996) maintained that a modified even-aged silvicultural system using irregular shelterwood as the method of regenerating new stands provides greater benefits for red-cockaded woodpeckers (*Picoides borealis*) than uneven-aged systems. Their argument was confined to loblolly (*Pinus taeda*) and shortleaf (*P. echinata*) pine forest types and emphasized public lands. In a reply to Rudolph and Conner (1996), Engstrom et al. (1996) stressed the virtues of uneven-aged management, but rather than adhering to the context established by the former authors, framed their arguments largely around longleaf pine (*P. palustris*) on private lands. This resulted in some disparate comparisons which obscured some issues and overlooked others.

In an attempt to bring sharper focus to the issues, we offer the following thoughts. The context for our argument is the management of all southern pine forest types on national forest lands for red-cockaded woodpecker recovery.

Relative importance of southern pines to the recovery of the red-cockaded woodpecker

Implicit in the argument of Rudolph and Conner (1996) is the belief that shortleaf and loblolly pine forest types will be important in the recovery of the red-cockaded woodpecker. Engstrom et al. (1996) reiterated the importance of longleaf pine for red-cockaded woodpeckers and correctly pointed out that the Forest Service has given high priority to restoring longleaf on land previously converted to other forest types. However, Engstrom et al. (1996:334) erroneously stated, "Most National Forests that have large woodpecker populations are dominated by longleaf pine although loblolly pine is dominant in some areas." The large populations to which Engstrom et al. (1996) referred are those reported by James (1995). Of those populations, only the Vernon and Talladega populations occur in habitats dominated by longleaf pine (Table 1; U.S. Dep. Agric. For. Serv., unpubl. data). Eighty-three percent of national forest populations reported by James (1995) are dominated by pine species other than longleaf.

Recovery in some locales will be dependent on proper management of existing loblolly or shortleaf pine types that are not the result of past conversion from longleaf, and which will not be converted to longleaf in the future. These locales include the Oconee National Forest in Georgia, Daniel Boone National Forest in Kentucky, Bankhead National Forest in Alabama, Bienville National Forest in Mississippi, the Davy Crockett and Sam Houston National Forests in Texas, and the Ouachita National Forest in Arkansas (U.S. Dep. Agric. For. Serv., unpubl. data). Collectively, these areas are expected to support approximately 1,900 red-cockaded woodpecker groups in the future (U.S Dep. Agric. For. Serv. 1995). On the Francis Marion National Forest in South Carolina, the Talladega National Forest in Alabama, the Kisatchie Ranger District in Louisiana, and the Angelina and Sabine National Forests in Texas, substan-

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Understory conditions in a shortleaf pine stand under even-aged management for red-cockaded woodpecker habitat in the Poteau Ranger District, Ouachita National Forest. Photo courtesy of W. Montague.

tial areas of existing forest types are scheduled for eventual longleaf restoration (U.S. Dep. Agric. For. Serv., unpubl. data). However, restoration will require more than a century to effect. In the meantime, the existing pine types other than longleaf will be critical components of red-cockaded woodpecker habitat.

Silvicultural systems and red-cockaded woodpecker habitat

Engstrom et al. (1996:336) posed the critical question, "How can a forest be structured to allow regeneration and provide woodpecker cavity trees simultaneously?" They then argued that uneven-aged management systems in general, and the Stoddard-Neel uneven-aged method as practiced in the Red Hills area of Georgia and Florida in particular, are more suitable than modified even-aged methods for maintaining red-cockaded woodpecker habitat. We agree with Lennartz (1988), Rudolph and Conner (1996), the Red-cockaded Woodpecker Recovery Plan (U.S. Fish and Wildl. Serv. 1985), and the Southern Region's Longterm Strategy for Red-cockaded Woodpecker Recovery (U.S. Dep. Agric. For. Serv. 1995) that both even-aged and uneven-aged strategies can successfully provide suitable habitat. However, we think that even-aged strategies provide more potential cavity trees, offer better regeneration potential, result in better stand structure (i.e., fewer midstory problems), and provide better opportunities for the use of frequent prescribed fire than uneven-aged strategies.

The 2 most critical components of red-cockaded woodpecker habitat consist of potential cavity trees and suitable stand structure. Potential cavity trees are living pines with heartwood of sufficient diameter to contain excavated cavities in conjunction with a relatively narrow band of sapwood (Hooper 1988, Conner et al. 1994). In addition, the pool of potential cavity trees must have a high frequency of heart rot (Conner and Locke 1982, Hooper 1988, Hooper et al. 1991, Rudolph et al. 1995). Generally, 80- to 100-year-old loblolly and shortleaf pines, and 100- to 120-year-old longleaf pines have these characteristics (Clark 1992, 1993).

Stand structure is as important as potential cavity trees. Especially in the vicinity of cavity trees, stands need to be park-like and essentially devoid of hardwood and pine midstories. Encroaching midstories lead to woodpecker abandonment of cavity trees and ultimately to declines in the population of woodpeckers (Locke et al. 1983, Conner and Rudolph 1989, Costa and Escano 1989, and Loeb et al. 1992).

Walker (1995) modeled various strategies for providing red-cockaded woodpecker habitat. He found that even-aged strategies provided more potential cavity trees than uneven-aged strategies. Several even-aged strategies (clearcutting, shelterwood, irregular shelterwood, shelterwood with relic patches) in loblolly pine provided 50–63% more potential cavity trees than either of 2 uneven-aged methods (group selection and single-tree selection; Walker 1995; Table 4, 100-yr rotation). For longleaf pine, the even-aged strategies (clearcutting, shelterwood, shelterwood with relic patches) produced 70–129% more potential cavity trees than the uneven-aged approaches (group and single-tree selection; Walker 1995; Table 6, 120-yr rotation; Fig. 5).

The reason even-aged strategies can provide more potential cavity trees than uneven-aged approaches is that the 3 southern pines most important to the red-cockaded woodpecker are intolerant of competition for moisture, nutrients, and light. They survive, grow, and develop best in full sunlight and when they are relatively free of competition (Baker and Balmer 1983, Burns 1983, Baker 1987, Boyer and White 1990).

Table 1. Area of pine forest types on national forests (NF) with major red-cockaded woodpecker populations[a]

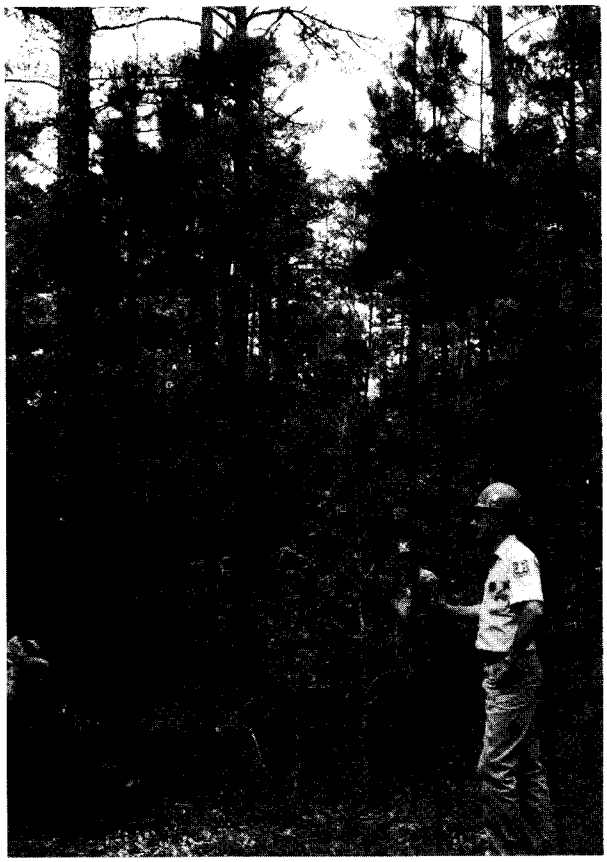
Population	Longleaf		Slash		Loblolly		Shortleaf		Pond		Total
	ha	(%)	ha	(%)	ha	(%)	ha	(%)	ha	(%)	ha
Apalachicola NF	54,672	(46.2%)	61,094	(51.6%)	2,053	(1.7%)	0		539	(<1.0%)	118,358
Francis Marion NF	12,166	(24.8%)	145	(<1.0%)	34,521	(70.5%)	0		2,163	(4.4%)	48,995
Vernon, Kisatchie Ranger Districts[b]											
Vernon	16,895	(68.5%)	4,038	(16.4%)	3,720	(15.1%)	0		0		24,653
Kisatchie	11,680	(39.0%)	3,098	(10.3%)	14,583	(48.7%)	587	(2.0%)	0		29,948
Sam Houston NF	85	(<1.0%)	96	(<1.0%)	49,165	(88.5%)	6,238	(11.2%)	0		55,584
Talladega NF[c]	23,908	(59.2%)	0		16,222	(40.2%)	253	(<1.0%)	0		40,383
Bienville NF	1,534	(2.9%)	25	(<1.0%)	48,921	(92.2%)	2,565	(4.8%)	0		53,045
Croatan NF	5,128	(9.6%)	1	(<1.0%)	11,675	(22.0%)	8	(<1.0%)	36,373	(68.4%)	53,185
Evangeline District Kisatchie NF	7,411	(26.8%)	6,726	(24.3%)	13,177	(47.7%)	327	(1.2%)	0		27,641
Osceola NF	7,850	(19.6%)	32,046	(80.2%)	77	(<1.0%)	0		6	(<1.0%)	39,979
Angelina, Sabine NFs	10,310	(10.5%)	2,373	(2.4%)	55,496	(56.5%)	30,091	(30.6%)	0		98,270
Piedmont NWR, Oconee NF[d]	0		9	(<1.0%)	30,605	(97.3%)	854	(2.7%)	0		31,468
Total	151,639	(24.4%)	109,651	(17.6%)	280,215	(45.1%)	40,923	(6.6%)	39,081	(6.3%)	621,509

[a] Population names are from James (1995). Forest type is the existing tree species and is not necessarily the species that historically occurred on a given site.

[b] In 1991 it was determined that the Vernon and Kisatchie Ranger Districts were 2 separate populations (U.S. Dep. Agric. For. Serv. 1991).

[c] The Talladega National Forest consists of 2 red-cockaded woodpecker populations. The population referenced by James (1995) is the Oakmulgee population of the Talladega National Forest.

[d] Figures are only for Oconee National Forest habitats.



Midstory and understory conditions in a shortleaf pine stand under uneven-aged management in the Womble Ranger District, Ouachita National Forest. Photo courtesy of R. Raines.

Of the 3 species, longleaf is the most intolerant. Boyer (1993) found that as little as 2 m^2/ha of overstory basal area reduced growth of the younger trees by 55%. He also found that >6.2 m^2/ha of overstory basal area prevented retention of adequate regeneration in longleaf. The effect of competition from mature trees is apparent up to 30 m into openings (Farrar 1993, Platt and Rathbun 1993). Young longleaf pines in openings of 0.1 ha are suppressed by adjacent large trees, while in a 2.0-ha opening they are free from such competition only in the center 1.25 ha of the opening (Farrar 1993). Platt et al. (1988) reported that openings from the death of single trees in the Red Hills colonized slowly. Platt and Rathbun (1993) found the minimum-size opening for recruitment in the Red Hills was about 30 m in diameter. Except in sparsely stocked stands, removal of a single tree would not usually create an opening that large. On the other hand, group selection methods, in which large patches are created, can easily meet the minimum patch-size criterion.

Suppressed, slow-growing longleaf seedlings may be killed by prescribed fires before reaching a resistant size (Boyer 1974, Boyer and White 1990, Boyer 1993). Seedlings in large openings grow to a fire-resistant size faster than those in smaller openings and thus have a greater chance of surviving fire. In addition, fuel loads from needle cast are heaviest near mature trees, which increases the mortality rate of seedlings from fire (Boyer 1974, Platt and Rathbun 1993).

Because of its intolerance to competition and the influence of fire on seedling survival, longleaf pines typically grow in even-aged patches. Patch size of a cohort in old-growth forests has been found to vary from <0.4 ha to several hundred ha (Schwarz 1907, Chapman 1923, Wahlenberg 1946, Boyer and White 1990, Platt and Rathbun 1993). It may be possible to perpetuate longleaf pine using small patch sizes if regeneration is already present prior to cutting, or if extreme care is used with fire, and one is willing to wait long enough for regeneration to become established in a given patch. However, the diameter distributions reported by Lindeman (1994) for the Red Hills, where small patch sizes have been used for >50 years, suggest that reproduction is marginal at best. This condition may reflect the greater difficulty in burning so as not to destroy suppressed regeneration while at the same time attempting to control hardwoods. Also, in some cases reproduction has been intentionally destroyed in the Red Hills area to maintain the open stand structure preferred by landowners for quail hunting (U.S. Dep. Agric. For. Serv. 1995). In any case, we are lacking examples of uneven-aged longleaf forests with adequate numbers of small-diameter trees. Such forests would have much less of the open structure typically associated with preferred red-cockaded woodpecker habitat. To what extent these denser forests would affect the woodpecker is unknown.

Loblolly and shortleaf pines are somewhat more tolerant of competition than longleaf and thus are more adaptable to uneven-aged management (Baker et al. 1996). However, at least for large-scale application, we agree with Rudolph and Conner (1996) that the problem of midstory control makes uneven-aged management undesirable for providing habitat for red-cockaded woodpeckers in loblolly and shortleaf pine forests. Prescribed burning is severely constrained because fire-susceptible regeneration is present across the landscape. Baker et al. (1996) stated that herbicides were necessary every 10–20 years to control hardwoods for pine management. Similar herbicide use would be required for red-cockaded woodpecker management (U.S. Dep. Agric. For. Serv. 1995). Some publics object to use of herbicides and, as Rudolph and Conner (1996) pointed out,

burning has ecosystem benefits that herbicide use does not.

Ecosystem management and silvicultural systems

Engstrom et al. (1996) articulated several key goals of ecosystem management that include maintaining native biota, and perpetuating natural forest structure and function when resources are used by humans. We agree with those goals. They then described the kinds of natural disturbances to which upland southern pines have been subjected throughout their evolutionary history and the natural even-aged and uneven-aged forest structure that resulted. Their description of natural structure in pine forests of the South in the pre-exploitation era is consistent with other accounts (Schwarz 1907, Chapman 1909, Mattoon 1915, Chapman 1923, Turner 1935, Wahlenberg 1946, Boyer and White 1990, Platt and Rathbun 1993).

However, we are left with the impression that Engstrom et al. (1996) find no place in ecosystem management for silvicultural systems that mimic less frequent, larger-scale disturbance events which result in even-aged forest structure. They argued that it makes ecological sense for management "to mimic the least severe form of disturbance because the most severe forms of disturbance will occur regardless of human activities" (Engstrom et al. 1996:335), thus implying that it makes no ecological sense for management to mimic any larger-scale disturbances. The logic in this escapes us, for it is equally true that certain small-scale disturbance events, such as lightning strikes and windthrow of single or small groups of trees, will occur regardless of the silvicultural system in practice.

It is certainly true that large-scale events like hurricanes and tornadoes will occur regardless of human activities (Hooper and McAdie 1995). However, at least 2 natural disturbance agents with the potential to be large in scale (i.e., wildfires and southern pine beetle [*Dendroctonus frontalis*]) outbreaks, are routinely suppressed by human activities while still small in scale. In no way do these particular agents operate on modern landscapes in the same manner that they likely operated over evolutionary time scales.

Silvicultural systems that mimic frequent, small-scale disturbance events and those that mimic less frequent, large-scale disturbance events have an ecological basis and make ecological sense. In terms of producing sufficient numbers of pines of sufficient age and size to meet foraging and nesting needs, each system can be made compatible with the habitat requirements of the red-cockaded woodpecker (Walker 1995).

We suggest that the issue is to decide how best to work within the evolutionary biology of southern pine ecosystems to maintain ecological integrity, including recovery of the red-cockaded woodpecker, and allow for human resource use. Criteria that should discriminate among silvicultural systems for application in any specific case include suitability of the resultant stand structure for red-cockaded woodpeckers, operational feasibility, the ease or difficulty with which prescribed fire can be integrated, the wellbeing of other biota, and compatibility with other land-management objectives. Several of these criteria are likely to vary among ownerships.

Technical considerations versus operational feasibility

Engstrom et al. (1996) responded to issues about the technical difficulty of selection management raised by Rudolph and Conner (1996) in 2 ways. First they stated that implementation of selection management requires a higher level of ecological knowledge than that required for even-aged systems, and second, that Forest Service employees often lack such knowledge. We disagree on both counts. Any silvicultural system requires application of ecological knowledge, but if there is a higher level of understanding required, it is in planning even-aged regeneration treatments, where landscape-level aspects of juxtaposition, isolation, and connectivity come into consideration. These are not normally important considerations in planning uneven-aged treatments.

Engstrom et al. (1996) were particularly disparaging in regard to Forest Service timber markers. This is unjustified. Forest Service timber markers implement prescriptions prepared by professional foresters, biologists, and ecologists. They are well trained and undergo a rigorous certification process before being allowed to mark trees. And, they routinely and successfully mark trees under both uneven-aged and even-aged management prescriptions.

Rudolph and Conner (1996) discussed operational differences between even-aged and uneven-aged management. We concur with their assessment. However, we would mention 2 other major operational differences not covered in their paper: marking efficiency and inventory procedures. From 3 to 5 times more total land area must be traversed and marked annually under uneven-aged systems in order to produce a timber volume equal to that under even-aged systems. Also, inventory procedures under un-

even-aged systems are more time consuming to conduct, and thus, more costly. These additional requirements mean that more personnel and funding are required to practice uneven-aged management. Increases in either Forest Service personnel or funding are unlikely. Implementation problems with selection management are not rooted in technical difficulty or a lack of ecological knowledge among Forest Service employees as claimed by Engstrom et al. (1996), but rather in operational practicality and efficiency.

Use of prescribed fire

Rudolph and Conner (1996) correctly pointed out the difficulty of using prescribed fire with sufficient frequency and intensity in uneven-aged management programs because vulnerable reproduction is present at all times. Engstrom et al. (1996) replied that if done carefully, it is possible to burn young loblolly pine stands without destroying them, as has been demonstrated in research plots in the Tallahassee, Florida area.

However, it does not necessarily follow that carefully applied treatments on research plots are also feasible at operational scales. Weather conditions with suitable combinations of temperature, humidity, and windspeed may occur frequently enough to allow "careful" burning of research plots, but be altogether too rare to allow for operational burning of the hundreds of thousands of hectares of red-cockaded woodpecker habitat that need treatment each year. We agree with both Rudolph and Conner (1996) and Engstrom et al. (1996) that effective prescribed burning on national forest lands for red-cockaded woodpecker habitat management is essential. However, we doubt that this is logistically compatible with large-scale uneven-aged management in pine forest types, especially in loblolly, shortleaf, and slash pine.

The Forest Service strategy for red-cockaded woodpecker recovery calls for 365,000 ha of prescribed burning annually in habitat management areas alone (U.S. Dep. Agric. For. Serv. 1995). In recent years the amount of prescribed burning for all purposes in the southern region of the Forest Service has averaged about 250,000 ha and has never exceeded 285,000 ha (U.S. Dep. Agric. For. Serv., unpubl. data). Any additional restrictions on burning imposed by uneven-aged management will widen the gap between what needs to be burned and what can be burned each year.

The Red Hills population

The Red Hills, an area of approximately 121,500 ha in southwestern Georgia and northwestern Florida with a red-cockaded woodpecker population of about 179 groups (Engstrom and Baker 1995), was offered by Engstrom et al. (1996) as a model for managing public lands. However, the observed gross density of active red-cockaded woodpecker clusters in the Red Hills area is about 1/680 ha. This density is <25% of the overall targeted density for national forest lands (U.S. Dep. Agric. For. Serv. 1995).

To put this into perspective, the Forest Service expects a recovered red-cockaded woodpecker population, approximately 500 groups, of which 250 are actively breeding (U.S. Dep. Agric. For. Serv. 1995), to require about 80,000 ha. At the observed Red Hills density, a recovered population would require approximately 340,000 ha, an areal extent that not even the largest National Forest in the South can provide. The current red-cockaded woodpecker density in the Red Hills may not be at the maximum level; on the other hand, the capability of this area to support a greater density under existing management cannot be assumed.

A word about regulation

The goal of nearly all forest management programs is the sustained yield of products and benefits (Smith 1986). The way that sustained yields of products and benefits, including red-cockaded woodpecker habitat or ecosystem conditions in general, is assured is through regulation of the forest (Walker 1995). Regulation is achieved when the area occupied by each age class or size class of trees is represented in equal proportion and consistently grown to provide a continual and approximately equal amount of outputs indefinitely (Davis 1966). This holds for either even-aged or uneven-aged silvicultural strategies.

Engstrom et al. (1996) briefly discussed regulation for selection-management systems, but made no mention of whether or not regulation is a goal for managers and landowners in the Red Hills, or whether or not the presently favorable habitat situation for red-cockaded woodpeckers there derives from regulated forest conditions. There are indications (U.S. Dep. Agric. For. Serv. 1995; Lindeman 1994) that few, if any, of the uneven-aged forests in the Red Hills are near a regulated condition. Further, a model developed by Lindeman (1994) for the Red Hills area, which simulated trees per unit area over 1,000 years, suggests that wide fluctuations can be expected. These fluctuations would likely result in "boom and bust" flows for both timber yields and red-cockaded woodpecker habitat over time (Seagle et al. 1987).

For national forest lands, assuring sustained yields is a requirement of law (Multiple Use-Sustained Yield Act, 74 Stat. 215; 16 U.S.C. 528-531). Therefore,

managers of national forests must work toward a goal of forest regulation. A regulated uneven-aged structure will be very different from the present prevailing conditions in the Red Hills: there would be many more smaller and middle-sized trees, and conditions for the red-cockaded woodpecker would likely be much less favorable than they now are.

Management examples from national forests

Engstrom et al. (1996) implied that even-aged management of the National Forests has failed to provide recovery of the red-cockaded woodpecker, and that future recovery using even-aged management is not feasible. We feel that the following examples are sufficient to counter such notions.

The Francis Marion National Forest

After having its old-growth pine forests removed between 1885 and 1930, the land for the Francis Marion National Forest was purchased by the federal government and designated a National Forest in 1936 (U.S. Dep. Agric. For. Serv. 1977). Based on surviving timber volumes (A. A. Grumbine, Management Plan, Francis Marion National Forest, unpubl. rep., U.S. Dep. Agric. For. Serv., 1936), a fair amount of woodpecker habitat was present in 1936 (Watson et al. 1995) and could have supported >100 groups of woodpeckers (R. G. Hooper, unpubl. data). Prescribed burning, mostly dormant-season burns but with some growing-season fires, was begun on a regular basis in 1944. Even-aged management was begun in 1950 (U.S. Dep. Agric. For. Serv. 1977). The first documented increase in any population of red-cockaded woodpeckers occurred in the Francis Marion National Forest between 1981 and 1988 (Hooper et al. 1991). Prior to Hurricane Hugo in 1989, the Francis Marion supported 477 red-cockaded woodpecker groups, a population density 3 times higher than that of the Red Hills (1 group/212 ha vs. 1 group/680 ha, respectively).

The Vernon District

When it was established in 1935, the Vernon Ranger District of the Kisatchie National Forest in Louisiana was a 34,460-ha "wasteland" in the middle of a 2 million-ha "wasteland" (Cruikshank 1939). E. J. Schlatter (Boundary revision of Vernon Unit Kisatchie National Forest, unpubl. rep., U.S. Dep. Agric. For. Serv., 1933) stated that on the area that would become the future Vernon Ranger District: (1) all the virgin longleaf pine had been cut, (2) all the merchantable second growth had been cut, and (3) 90% of the poles and pilings had been cut, with only the smallest sizes remaining. Analysis of aerial photos taken in 1935 revealed only 2.7 sawtimber-size pines and 8.4 pulpwood-size pines per hectare (R. G. Hooper, unpubl. data). In 1936 ≤12 red-cockaded woodpecker groups could have survived, and it is possible that none did. Under even-aged management and an aggressive prescribed burning program, the population expanded to 175 groups by 1992. Today, it is the largest population west of the Mississippi River (James 1995) and probably has the highest density of any extant large population. The population density of red-cockaded woodpeckers on the Vernon District is >3 times higher than the Red Hills population (1 group/197 ha vs. 1 group/680 ha, respectively).

The Appalachicola District

The Appalachicola Ranger District in Florida had an early history similar to the Francis Marion National Forest (E. R. DeSilvia, Management report for the Appalachicola Purchase Unit, unpubl. rep., U.S. Dep. Agric. For. Serv., 1935), but apparently had less surviving habitat than the Francis Marion. It has been managed by even-aged strategies and has had a very aggressive prescribed-burn program. Today, the Appalachicola District supports the largest population of red-cockaded woodpeckers in existence (504 groups).

Other national forests

Red-cockaded woodpecker populations on other national forests have not done as well as those on the 3 national forests discussed above. In most cases the reasons that populations have either declined or never increased since the exploitive era of logging (1880–1930; Williams 1989) are relatively certain. These include a lack of sufficiently old trees for useable cavities, a lack of midstory control, and isolation of small populations (Hooper 1988, Conner and Rudolph 1989, Costa and Escano 1989, Krusac et al. 1995). Some of these same problems exist in the Red Hills, where 1 subpopulation was extirpated (Baker 1983), possibly as a result of isolation.

Summary

The advantages and disadvantages of even-aged and uneven-aged systems for red-cockaded woodpecker management can be summarized as follows.

Even-aged systems

Under even-aged management, forest stands are comprised of trees of approximately the same

age. Regulation is achieved among stands at the landscape level and is accomplished by equalizing the area occupied by the various age classes of trees. For example, at regulation, a landscape being managed under a 120-year rotation and a 10-year entry cycle would have about 8.5% of the total area in each of 12 10-year age classes, and regeneration cutting each year would be applied in stand-sized units on approximately 0.85% of the total area. In order to perpetuate the system and assure sustainability, reproduction need be secured only once during the rotation for any particular stand.

For red-cockaded woodpecker management, the advantages of even-aged systems are most apparent in the ease with which prescribed fire can be integrated and open park-like conditions can be maintained over most of the landscape. At any given time, most of the landscape can be burned without regard to its effects on tree reproduction. At any given time, the relatively small portion of the landscape in stands comprised of vulnerable small trees can be easily excluded from burns.

The supposed disadvantages of these systems arise from regeneration cutting. The use of clearcutting or standard seedtree and shelterwood cuts eliminates the foraging potential of a stand for as long as 30 years and its potential as a cluster site for as long as 80-100 years. While the use of irregular shelterwood or seedtree cutting, where seed trees are retained indefinitely, does not immediately eliminate foraging or cluster-site potential; unsuitable conditions do occur 15-20 years later when a dense sapling midstory develops (Gresham 1996). However, under rotations of 120 years for longleaf and shortleaf pines, and 80-100 years for other pine species (U.S. Dep. Agric. For. Serv. 1995), an abundance of high-quality habitat with open stand conditions exists (Walker 1995). Several populations have increased under even-aged management, 2 of these to a recovered level.

Uneven-aged systems

Under uneven-aged management trees of various ages and sizes are grown within each stand. Regulation is achieved by assuring that the diameter distribution of trees within each stand is structured so that there are adequate numbers of trees in all diameter classes sufficient to sustain yields through periodic cutting entries, usually 5-10 years apart. A regulated uneven-aged stand will have a large number of seedlings, many saplings, fewer medium-sized trees, and a small number of large trees per unit area. In order to perpetuate the system and assure sustainability, reproduction needs to be secured within each stand with each cutting cycle.

For red-cockaded woodpeckers, the chief advantage of uneven-aged systems is that foraging and potential nesting habitat, at least in terms of numbers and sizes of trees, could theoretically be present in all stands all the time. Therefore, no portion of the landscape would be lacking basic habitat resources at any time.

A possible disadvantage of uneven-aged systems for red-cockaded woodpecker management is related to difficulty in maintaining open park-like stand conditions. One reason for this is that prescribed fire generally cannot be used with the same frequency or intensity as in even-aged stands because vulnerable regeneration is present in all stands all the time. But by far, the more important reason is that the targeted stand structure in regulated uneven-aged stands includes a large number of small- and medium-sized trees in subordinate canopy positions, a condition that is inherently dense and closed. This condition is antithetical to the open park-like conditions preferred by the red-cockaded woodpecker. The Red Hills area which supports a sizeable and stable red-cockaded woodpecker population has been under uneven-aged management for >50 years. However, regulation has not been achieved there. We have no examples of significant red-cockaded woodpecker populations thriving under regulated uneven-aged conditions.

Conclusion

Recovery of the red-cockaded woodpecker is the mutual goal of all parties to the current debate over what silvicultural system should be used on national forest lands to effect that end. We intend no criticism of the Stoddard-Neel method as it has been applied in the Red Hills area. For >50 years it has met the primary objectives of the landowners, while providing some level of timber products, supporting habitat for a significant population of red-cockaded woodpeckers, and providing general protection for native biota in those ecosystems. We agree with Engstrom et al. (1996) that research on its potential applicability and that of other uneven-aged systems on public lands is warranted. However, until the results of such research are available, we feel that advocating widespread use of selection systems for red-cockaded woodpecker habitat management on national forest lands is premature. In the meantime, we have enough research information and case history results to know that properly designed even-aged systems will meet all of the habitat requirements of the red-cockaded woodpecker.

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Literature cited

Baker, J. B. 1987. Production and financial comparisons of uneven-aged and even-aged management of loblolly pine. Pages 267-273 *in* D. R. Philips, editor. Proceedings of the fourth biennial southern silvicultural conference. U.S. Department of Agriculture Forest Service, General Technical Report SE-42.

Baker, J. B., and W. E. Balmer. 1983. Loblolly pine. Pages 148-152 *in* Silvicultural systems for major forest types of the United States. U.S. Department of Agriculture Handbook 445.

Baker, J. B., M. D. Cain, J. M. Guldin, P. A. Murphy, and M. G. Shelton. 1996. Uneven-aged silviculture for the loblolly and shortleaf pine forest cover types. U.S. Department of Agriculture Forest Service, General Technical Report SO-118.

Baker, W. W. 1983. Decline and extirpation of a population of red-cockaded woodpeckers in northwest Florida. Pages 44-45 *in* D. A. Wood, editor. Proceedings of the Red-cockaded Woodpecker Symposium II. 27-29 January 1983, Panama City, Florida. Florida Game and Fresh Water Fish Commission.

Boyer, W. D. 1974. Impact of prescribed fire on mortality of released and unreleased longleaf pine seedlings. U.S. Department of Agriculture Forest Service, Research Note SO-182.

Boyer, W. D. 1993. Regenerating longleaf pine with natural seeding. Pages 299-309 *in* S. M. Hermann, editor. The longleaf pine ecosystem: ecology, restoration, and management. Proceedings of the Tall Timbers fire ecology conference, Number 18.

Boyer, W. D., and J. B. White. 1990. Natural regeneration of longleaf pine. Pages 94-113 *in* R. M. Farrar, editor. Proceedings of the symposium on management of longleaf pine. U.S. Department of Agriculture Forest Service, General Technical Report SO-75.

Burns, R. M. 1983. Introduction. Pages 1-2 *in* R. M. Burns, editor. Silvicultural systems for major forest types of the United States. U.S. Department of Agriculture Handbook 445.

Chapman, H. H. 1909. A method of studying growth and yield of longleaf pine applied in Tyler County, Texas. Proceedings of the Society of American Foresters 4:207-220.

Chapman, H. H. 1923. The causes and rates of decadence in stands of virgin longleaf pine. The Lumber Trade Journal 84:(6)11,16,17.

Conner, R. N., and B. A. Locke. 1982. Fungi and red-cockaded woodpecker cavity trees. Wilson Bulletin 94:64-70.

Conner, R. N., and D. C. Rudolph. 1989. Red-cockaded woodpecker colony status and trends on the Angelina, Davy Crockett, and Sabine National Forests. U.S. Department of Agriculture Forest Service Research Paper SO-250.

Conner, R. N., D. C. Rudolph, D. Saenz, and R. R. Schaefer. 1994. Heartwood, sapwood, and fungal decay associated with red-cockaded woodpecker cavity trees. Journal of Wildlife Management 58:728-734.

Costa, R., and R. E. F. Escano. 1989. Red-cockaded woodpecker: status and management in the southern region in 1986. U.S. Department of Agriculture Forest Service, Technical Publication R8-TP12.

Cruikshank, J. W. 1939. Forest resources of Southwest Louisiana. U.S. Department of Agriculture Forest Service, Southern Forest Experiment Station, Forest Survey Release 43.

Davis, K. P. 1966. Forest management: regulation and valuation. McGraw-Hill Book Co., New York, New York.

Engstrom, R. T., and W. W. Baker. 1995. Red-cockaded woodpeckers on Red Hills hunting plantations: inventory, management, and conservation. Pages 489-493 *in* D. L. Kulhavy, R. G. Hooper, and R. Costa, editors. Red-cockaded woodpecker: recovery, ecology and management. Center for Applied Studies, College of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.

Engstrom, R. T., L. A. Brennan, W. L. Neel, R. M. Farrar, S. T. Lindeman, W. K. Moser, and S. M. Hermann. 1996. Silvicultural practices and red-cockaded woodpecker management: a reply to Rudolph and Conner. Wildlife Society Bulletin 24:334-338.

Farrar, R. M. 1993. Growth and yield in naturally regenerated longleaf pine stands. Pages 311-335 *in* S. M. Hermann, editor. The longleaf pine ecosystem: ecology, restoration, and management. Proceedings of the Tall Timbers fire ecology conference, Number 18.

Gresham, C. A. 1996. Loblolly pine (*Pinus taeda*) irregular shelterwood development and red-cockaded woodpecker management—a case study. Southern Journal of Applied Forestry 20:90-93.

Hooper, R. G. 1988. Longleaf pines used for cavities by red-cockaded woodpeckers. Journal of Wildlife Management 52:392-398.

Hooper, R. G., D. L. Krusac, and D. L. Carlson. 1991. An increase in a population of red-cockaded woodpeckers. Wildlife Society Bulletin 19:277-286.

Hooper, R. G., and C. J. McAdie. 1995. Hurricanes and the long-term management of the red-cockaded woodpecker. Pages 148-166 *in* D. L. Kulhavy, R. G. Hooper, and R. Costa, editors. Red-cockaded woodpecker: recovery, ecology, and management. Center for Applied Studies, Department of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.

James, F. C. 1995. The status of the red-cockaded woodpecker in 1990 and the prospect of recovery. Pages 439-451 *in* D. L. Kulhavy, R. G. Hooper, and R. Costa, editors. Red-cockaded woodpecker: recovery, ecology and management. Center for Applied Studies, College of Forestry, Steven F. Austin State University, Nacogdoches, Texas.

Krusac, D. L., J. M. Dabney, and J. J. Petrick. 1995. An ecological approach to recovering the red-cockaded woodpecker on southern national forests. Pages 61-66 *in* D. L. Kulhavy, R. G. Hooper, and R. Costa, editors. Red-cockaded woodpecker: recovery, ecology and management. Center for Applied Studies, College of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.

Lennartz, R. M. 1988. The red-cockaded woodpecker: old-growth species in a second-growth landscape. Natural Areas Journal 8:160-165.

Lindeman, S. T. 1994. An evaluation of ecological forest management for the Red Hills region of Georgia and Florida. Master of Forestry Project, School of the Environment of Duke University, Durham, North Carolina.

Locke, B. A., R. N. Conner, and J. C. Kroll. 1983. Factors influencing colony site selection by red-cockaded woodpeckers. Pages 46-50 *in* D. A. Wood, editor. Proceedings of the Red-cockaded Woodpecker Symposium II. 27-29 January 1983, Panama City, Florida. Florida Game and Fresh Water Fish Commission.

Loeb, S. C., W. D. Pepper, and A. T. Doyle. 1992. Habitat characteristics of active and abandoned red-cockaded woodpecker colonies. Southern Journal of Applied Forestry 16:120-125.

Mattoon, W. R. 1915. Life history of shortleaf pine. U.S. Department of Agriculture Forest Service, Bulletin Number 244.

Platt, W. J., G. W. Evans, and S. L. Rathbun. 1988. The population dynamics of a long-lived conifer (*Pinus palustris*). American Naturalist 131:491-525.

Platt, W. J., and S. L. Rathbun. 1993. Dynamics of an old-growth longleaf pine population. Pages 275-297 *in* S. M. Hermann, ed-

itor. The longleaf pine ecosystem: ecology, restoration and management. Proceedings of the Tall Timbers fire ecology conference, Number 18.

Rudolph, D. C., and R. N. Conner. 1996. Red-cockaded woodpeckers and silvicultural practices: is uneven-aged silviculture preferable to even-aged? Wildlife Society Bulletin 24:330-333.

Rudolph, D. C., R. N. Conner, and R. R. Schaefer. 1995. Red-cockaded woodpecker detection of red heart infection. Pages 338-342 *in* D. L. Kulhavy, R. G. Hooper, and R. Costa, editors. Red-cockaded woodpecker: recovery, ecology and management. Center for Applied Studies, College of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.

Seagle, S. W., R. A. Lancia, D. A. Adams, M. R. Lennartz, and H. A. Devine. 1987. Integrating timber and red-cockaded woodpecker habitat management. Transactions of the North American Wildlife Natural Resource Conference 52:41-52.

Schwarz, G. F. 1907. The longleaf pine in virgin forests: silvicultural study. John Wiley and Sons, New York, New York.

Smith, D. M. 1986. The practice of silviculture. John Wiley and Sons, New York, New York.

Turner, L. M. 1935. Catastrophes and pure stands of southern shortleaf pine. Ecology 2:213-215.

U.S. Department of Agriculture Forest Service. 1977. Francis Marion National Forest Land Management Plan—Final Environmental Impact Statement. U.S. Department of Agriculture Forest Service, Columbia, South Carolina.

U.S. Department of Agriculture Forest Service. 1991. Decision notice, finding of no significant impact and supplement to the environmental assessment interim standards and guidelines for protection and management of RCW habitat within 3/4 mile of colony sites as it pertains to the Apalachicola and Kisatchie National Forests. U.S. Department of Agriculture Forest Service, Atlanta, Georgia.

U.S. Department of Agriculture Forest Service. 1995. Final environmental impact statement for the management of the red-cockaded woodpecker and its habitat on national forests in the southern region. Management Bulletin R8-MB 73. U.S. Department of Agriculture Forest Service, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1985. Red-cockaded woodpecker recovery plan. U.S. Fish and Wildlife Service, Atlanta, Georgia.

Wahlenberg, W. G. 1946. Longleaf pine: its use, ecology, regeneration, protection, growth and management. Charles Lathrop Pack Forest Foundation, Washington, D.C.

Walker, J. S. 1995. Potential red-cockaded woodpecker habitat produced on a sustained yield basis under different silvicultural systems. Pages 112-130 *in* D. L. Kulhavy, R. G. Hooper, and R. Costa, editors. Red-cockaded woodpecker: recovery, ecology and management. Center for Applied Studies, College of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.

Williams, M. 1989. Americans and their forests. Cambridge University Press, New York, New York.

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