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Integrated Endangered Species Management Recommendations for Army Installations in the Southeastern United States

Assessment of the Potential Effects of the 1994 Army-wide Management Guidelines for the Red-Cockaded Woodpecker on Associated Endangered, Threatened, and Candidate Species

by
Robert A. Jordan, Kimberly S. Wheaton, Wendy M. Weiher, and Timothy J. Hayden

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Foreword

This report was prepared for the U.S. Army Environmental Center with funding through the Legacy Resource Management Program, Legacy Project 92-0375, "DOD Endangered Species Management Plan," under Military Interdepartmental Purchase Request (MIPR) No. E87920464, dated 19 August 1992. The technical monitor was John Parkinson, SFIM-AEC-ECN.

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Executive Summary

The goals of this project included: 1) assessment of the potential effects of management activities as described in the 1994 Army-wide Red-cockaded Woodpecker (RCW) Management Guidelines (Appendix A) on the array of endangered, threatened, and candidate species associated with RCWs on Army installations subject to the Guidelines; 2) development of recommendations for modifications and/or implementation of RCW management activities consistent with the objectives of the Guidelines; and 3) development of general management strategies, based on the previous analysis, which integrate identified habitat needs of the array of longleaf pine forest species and promote an ecosystem-based approach to endangered species management.

The Introduction and Chapters 1 and 2 of this report include a discussion of the project background and objectives, the scope and content of the Guidelines, and a brief description of the longleaf pine ecosystem and the woodpecker's place in it.

Chapter 3 is a detailed analysis of the potential effects of the Guideline's implementation on other endangered, threatened, candidate, and other sensitive species found in the longleaf pine landscape. The text references in-depth Stewardship Summaries and impact assessments for the 16 animal species and 31 plant species listed in Appendix B. The analysis considered the likely impacts of Habitat Management Unit (HMU) management (including prescribed burning and hardwood midstory control), extractive land uses (timber harvest and pine straw raking), and various restrictions on military training on each individual species and on four broadly defined plant communities. In general, greatest positive impacts are likely to be associated with prescribed fire, hardwood control, and restoration of longleaf pine. The greatest negative impacts are likely to be associated with fire management, extractive land uses, and hardwood control. Species are expected to demonstrate particular responses to habitat modification, but some trends were apparent resulting from shared use of sensitive habitats.

Chapter 4 provides recommendations to reduce the potential for adverse effects on non-target species and communities and to move RCW management toward multi-species management of the landscape. Specific comments and suggestions are provided on configuration of HMUs (including multiple use of RCW foraging stands), hardwood control (including measures to preserve mast and cavity-producing mature hardwoods for other species), prescribed burning, and extractive land uses (including the use of shelterwood cutting to reduce habitat fragmentation and promote the stability of ecosystem processes).

Chapter 5 provides guidance for the integration of ecosystem-based approaches into endangered species management. A brief discussion of the principles of ecosystem management is followed by overviews of several key components that may be incorporated into endangered species management planning to promote ecosystem integrity. Discussions are provided on the use of fire to promote stable ecosystems, protection of wetlands and aquatic habitats through control of soil erosion and stream stabilization methods, and on the management of longleaf pine herpetofauna, which are presented as an example of a group of species which integrates many of the ecosystem processes and management concepts presented earlier. The chapter closes with a suggested modification to HMU mapping that provides for the integration of ecosystem principles as part of an adaptive management process.

The Species Stewardship Summaries in Appendix B (furnished on attached diskette) were prepared to provide land managers with current management-related information on those endangered, threatened, or candidate species which may co-occur with the red-cockaded woodpecker or which are associated with particular habitat types which occur within the longleaf pine landscape. All species discussed are either known to occur or potentially occur on at least one of the U.S. Army installations subject to the 1994 RCW Management Guidelines. The Stewardship Summaries are organized to provide both basic information on the ecology of the species as well as an abstract of the best available information concerning its status and management. In each Stewardship Summary, the individual species account is followed by a review of the potential effects on the species from implementation of the 1994 RCW Management Guidelines.

Introduction

Background

The red-cockaded woodpecker (*Picoides borealis*) (RCW) was listed as federally endangered in 1970 and became one of the first species protected under the Endangered Species Act (ESA). The RCW was historically found throughout the pine forests and savannas of the southeastern United States; however, its current range is restricted to remnant areas of the once vast longleaf pine (*Pinus palustris*) forest ecosystem.

Nearly a quarter of all remaining RCW groups are found on nine military installations (Costa 1992). Existing RCW populations on U.S. Army installations play an increasingly important role in the recovery of the species as the available habitat on other lands continues to be degraded and fragmented. In particular, the available breeding habitat for the endangered woodpecker, old growth longleaf pine, is imperiled.

In 1994, the Army established RCW Management Guidelines (Guidelines) that outlined population goals, inventory requirements, and land management practices directed toward the protection and stewardship of RCW populations on Army lands. As part of the implementation process for the Guidelines, the Army began an assessment of the potential impacts of the Guidelines on other threatened and endangered (T&E) species on subject installations. Many rare, sensitive, federal candidate, and T&E species occur in association with RCWs and use similar habitats (Table 1). The Army seeks to develop conservation strategies that will inte-

Table 1. Distribution within major taxa of species of concern known from or potentially occurring on Army installations subject to the RCW Management Guidelines.

Taxon	E	T	C1/C2	Other	Total
Mammals	3	1	2	2	8
Birds	6	2	6	-	14
Reptiles	3	6	5	-	14
Amphibians	-	-	4	1	5
Fishes	1	2	2	-	5
Insects	1	-	6	-	7
Mollusks	1	-	10	2	13
ANIMALS	15	11	35	3	67
PLANTS	10	1	53	3	67
TOTAL	25	12	88	8	133

grate management requirements of RCWs and other associated sensitive species and result in an effective ecosystem or multi-species approach to T&E species stewardship.

The full text of the 1994 Army-wide RCW Management Guidelines is provided in Appendix A. Implementation of the Guidelines will:

1. Establish general Army policy goals for RCW conservation.
2. Require determination of installation RCW population goals and development of installation management plans to achieve those goals.
3. Establish inventory and monitoring requirements.
4. Require delineation of habitat management units (HMUs).
5. Prescribe management practices and marking guidelines within HMUs.
6. Establish consultation requirements and management recommendations in impact/danger areas and in direct live fire areas.
7. Define allowable military activities within HMUs.
8. Provide guidelines for augmentation and translocation of RCWs.

Guidelines affect all Army installations which either support currently active RCW cluster sites or which contain inactive cluster sites that installations continue to manage to promote reactivation. Nine Army installations meet these criteria (Table 2). Management activities prescribed in the Guidelines are conducted on two

Table 2. Location and RCW population status of U.S. Army installations subject to the Army-wide RCW Management Guidelines.

Installation	State	RCW Population Status
Fort Benning	Georgia	RCWs present
Fort Bragg	North Carolina	RCWs present
Fort Gordon	Georgia	Historical population
Fort Jackson	South Carolina	RCWs present
Fort McClellan	Alabama	Historical population
Fort Polk	Louisiana	RCWs present
Fort Stewart	Georgia	RCWs present
Louisiana Army Ammunition Plant	Louisiana	Historical population
Sunny Point Military Ocean Terminal	North Carolina	RCWs present

different spatial scales: 1) management around RCW cavity trees, within clusters, and in recruitment stands where RCWs currently nest or may be expected to nest in the near future; and, 2) management in larger-scale Habitat Management Units (HMUs) that may contain several clusters and recruitment stands, as well as areas designated for training and other military activities. The extent of management and training at each scale plays a large role in the impact of the Guidelines on other sensitive species associatedwith the woodpecker and its habitats.

Objectives

The objectives of this project were to: 1) assess the potential effects of management activities as described in the 1994 Army-wide RCW Management Guidelines on the array of endangered, threatened, and candidate species associated with RCWs on Army installations subject to the Guidelines; 2) develop recommendations for modifications and/or implementation of RCW management activities consistent with the objectives of the Guidelines; and 3) develop general management strategies, based on the previous analysis, which integrate identified habitat needs of the array of longleaf pine forest species and promote an ecosystem-based approach to endangered species management.

Approach

This document includes an assessment of the potential impacts of the 1994 RCW Management Guidelines on other endangered, threatened, and candidate species associated with the red-cockaded woodpecker which either occur, or may occur, on installations subject to the Guidelines. This analysis is used to provide suggested modifications of the Guidelines and guidance for the development of integrated management plans for the longleaf pine ecosystem. The project was completed in a series of phased steps:

Phase 1 Identification of a list of candidate and T&E species known or potentially occurring on the installations which may be affected by implementation of the Guidelines.

Phase 2 Completion of comprehensive literature reviews for each identified species to identify resource requirements and management strategies for each species.

Phase 3 Completion of an assessment of potential effects of management activities as described in the Guidelines for each identified species. Assessments identified those RCW management actions which were compatible or incompatible with the management requirements of associated T&E and candidate species.

Phase 4 Based on the individual species assessments, provision of recommended modifications of RCW management activities that are consistent with the objectives of the Guidelines and which promote a multi-species approach to T&E and candidate species management.

Phase 5 Development of regional guidance, incorporating information and recommendations developed in preceding tasks, which provides guidance to aid in the design of effective ecosystem/multi-species approaches to threatened and endangered (T&E) species management. The results of previous phases were used to produce general management recommendations which integrate identified habitat needs of both RCWs and other associated species of concern.

Scope

The report attempts to incorporate the most current available published information available to the authors. Its purpose is to assist land managers in meeting the goals of RCW management and the stewardship of the longleaf pine ecosystem upon which the bird depends. It cannot and does not attempt to provide all of the answers necessary to manage all of the species found in longleaf pine habitats. Many species have not been fully studied and few have been monitored relative to habitat needs and management practices. As stated elsewhere in the text, expected effects of management practices are estimates made by the authors based on the relevant species stewardship summaries found in Appendix B (furnished on diskette). Estimates are expected to be refined by the experience of those working in the field.

1 Ecosystem Description

The longleaf pine forests of the Southeastern Coastal Plain comprise one of the most endangered ecosystems in the world (Noss 1989). The longleaf pine forest once covered as much as 60 million acres in the Southeast, ranging from southeastern Virginia, to central Florida, and west to eastern Texas (Stout and Marion 1993). Total acreage of longleaf pine has declined by 98 percent since European settlement (Ware *et al.* 1993). Losses have been due to fire suppression, site preparation, other forms of silvicultural mismanagement, and agricultural and urban development. The remaining longleaf pine ecosystem is fragmented into small pockets of habitat that are used by hundreds of rare species. Concern for the endangered red-cockaded woodpecker has generated increased interest in the preservation and restoration of the longleaf pine forest ecosystem. Because of its relatively large range size, and its dependence on mature forest stands, the woodpecker integrates the needs of many other plants and animals dependent on this shrinking resource.

Red-cockaded woodpeckers inhabit open, mature pine woodlands and, rarely, deciduous or mixed pine-hardwoods located nearby (Steirly 1957, Hooper *et al.* 1980, U.S. Fish and Wildlife Service 1980, Kalisz and Boettcher 1991). Optimal habitat is characterized as a broad savanna with a scattered overstory of large pines and a dense ground cover containing a diversity of grass, forb, and shrub species (Hooper *et al.* 1980, AOU 1991). The understory is sparse or absent (Hooper *et al.* 1980, Locke *et al.* 1983, Hooper *et al.* 1991, Loeb *et al.* 1993). The open, park-like characteristic of red-cockaded woodpecker habitat is maintained by low intensity fires, which occurred historically during the growing season as often as every year to every 5-10 years (Christensen 1981, Platt 1988, Platt *et al.* 1988, Rebertus *et al.* 1989).

The dependence of this species on old-growth pine forests is the single most critical factor leading to its endangered status (AOU 1991). These habitat requirements conflict with timber management philosophies on some public and almost all private lands (Jackson 1986, Ligon *et al.* 1986, AOU 1991). Private timber stands in the southeastern U.S. are generally on short rotations (< 45 years) that do not permit trees to attain the characteristics sought by red-cockaded woodpeckers (Neel 1971, Ligon *et al.* 1986, Jackson 1976). Overall, only 2.5% of the current pine acreage in the southeastern U.S. is considered suitable nesting habitat (U.S. Fish and Wildlife Service 1985), and most of this exists on public lands. The few stands of old-growth timber remaining on private lands are under increasing pressures to be converted to short-rotation pine plantations (Neel 1971), and legal provisions for maintaining habitat on private lands are weak (Ligon *et al.* 1986).

RCW management will incorporate large tracts of longleaf pine forest. At the landscape level, preserves designed for this species should be dominated by open, mature pine forests. However any preserve established for a woodpecker population will necessarily include areas with young pines, hardwoods, and an array of other forests types.

The longleaf pine ecosystem upon which the woodpecker depends is a regional landscape of many plant associations (Noss 1989). Two species, longleaf pine (*Pinus palustris*) and wiregrass (*Aristida stricta*) are the characteristic components of communities throughout the southern coastal plain pine forest landscape. Within this landscape are multiple environmental gradients along which plants respond to different soil, moisture, and fire conditions. The vegetation changes abruptly with very slight changes in elevation. The landscape, shaped by fire frequency and moisture availability, is dissected by sluggish black water streams, seeps, swamps, and pocosins. Between the wettest and driest extremes, oak and mixed hardwood forest interweaves repeatedly with pine stands, with maple, gum, and cypress pushing up slope in stringers as far as the available groundwater will permit (McFarlane 1992). Longleaf pine forms the matrix in communities ranging from xeric sandhills to abrupt borders with shrub swamps (Noss 1989). Peet and Allard (1993), for example, described four major moisture series in longleaf pine-dominated vegetation (xeric, sub-xeric, mesic, and seasonally wet), divided into 23 community types and corresponding to geographic location and physiographic province (e.g., the Fall-line Sandhills). While these communities vary greatly in soil, moisture, and species composition, there are several general factors that apply to all of them: the important role of fire, the limited reproductive rate of many component species, and the high plant diversity at small scales within many of the communities (Schafale 1994).

Longleaf pine is intolerant of competition and has few codominants, so that stands of longleaf pine are almost pure except for a few other pines and understory hardwoods that are less tolerant of fire. Common understory hardwoods associated with longleaf pine on xeric sites include blackjack oak (*Quercus marilandica*), bluejack oak (*Q. incana*), and turkey oak (*Q. laevis*). Common species associated with longleaf pine on mesic to well-drained sites include slash pine (*Pinus elliottii*) (within its range), loblolly pine (*P. taeda*), sweetgum (*Liquidambar styraciflua*), and southern red oak (*Q. falcata*) (Brown 1964, Wright and Bailey 1992, TNC 1993). The number and vigor of hardwoods and other pine species in a longleaf pine stand increases with fire suppression and succession to other community types.

On the driest, most exposed ridgetop situations, sandhill vegetation is characterized by pine and turkey oak (*Quercus laevis*), with scattered clumps of shrubs and a unique herbaceous layer adapted to austere conditions (Wells and Shunk 1931, Christensen 1988). As available moisture increases, xeric sandhill communities grade subtly into pine-dominated flatwoods and savannas (Christensen 1988). Flatwoods tend to have greater canopy cover and an understory featuring a diverse array of shrubs and subcanopy trees. This shrub layer is generally lacking in savanna communities, which are characterized as broad expanses of grassland with widely spaced pine canopy, although the two types intergrade across the landscape.

Savannas are transitional between xeric pine communities and wetland pocosins and bayheads (Walker and Peet 1983, Jones and Gresham 1985). Most are seasonally wet, with pond pine (*Pinus serotina*) supplanting longleaf pine as the canopy dominant. Walker and Peet (1983) described a subtle gradient from xeric savanna, where longleaf pine dominates, into xeric sandhill vegetation at one extreme, and into mesic and wet savannas at the other. Mesic savannas support amazingly high plant diversity, including insectivorous plants like *Sarracenia*, *Drosera*, and *Dionaea muscipula* (Venus flytrap) found only in mesic savannas of the Carolinas. Wet savannas are found in depressions and in the ecotones between mesic savannas and pocosins and shrub bogs. In some places they may occur where fire has spread into a pocosin and eliminated the dominant shrubs (Walker and Peet 1983). Canopy trees may be entirely lacking.

At the wettest extreme of the landscape gradient are pocosins, peatlands often characterized by dense, nearly impenetrable cover of evergreen and ericaceous shrubs. They are found in flat "upland" areas between streams, in Carolina bays, near seeps, springs and along the margins of slow-flowing streams. In all cases, waters in these systems are nutrient poor and the pocosin plant communities are biogeochemically separated from the mineral soil substrates surrounding them. Some receive all their nutrients from rainwater and dry fall (Christensen 1988).

Longleaf pine is a "fire subclimax" species that depends on a relatively frequent fire regime for reproduction and survival. In fact, longleaf pine and its associated understory vegetation is highly flammable and acts as a source of fuel for the periodic fires (Noss 1989, TNC 1993). Longleaf pine requires fire to expose mineral soil as germination sites, to retard the spread of brown-spot needle disease, to restrict encroachment of other competing vegetation, and to reduce fuel build-up that could generate large-scale, high intensity fires. Herbaceous species associated with longleaf pine require periodic fires to create gaps in the canopy for increased light penetration, and to reduce competition from woody midstory vegetation. Midstory vegetation, which consists of shrubs and small trees that are taller than the herbaceous layer, can sometimes grow into the overstory if not suppressed by fire or other landscape disturbances. Without fire, longleaf pine-dominated communities will succeed to other community types that consist primarily of other pines and mixed hardwoods (Wahlenberg 1946, Brown 1964, Wright and Bailey 1982, Christensen 1988, Platt 1990).

Prior to European settlement in the Southeast, fires were caused naturally by lightning and artificially by Native American burning practices. The literature cites a variety of burn intervals, but the general historic fire frequency seems to have been about once in every 3 to 10 years, although the frequency varied with topography and dominant vegetation of a particular site (Wright and Bailey 1982). Longleaf pine and wiregrass communities apparently tolerated a fire frequency of about every 3 to 4 years (Wright and Bailey 1982, Christensen 1988). These fires were patchy surface fires of relatively low intensity. The fires that resulted from lightning strikes during the spring and summer thunderstorm season influenced the region's ecological dependence on fire. The extent and intensity of fires was highly variable from year to year, and the natural patchiness of fires allowed a greater diversity of species to survive a given fire event (Christensen 1981, Platt *et al.* 1988, Robbins and Myers 1992).

Open, park-like stands of longleaf pine and periodic fire, carried by pine litter and wiregrass across the longleaf landscape, fostered one of the most diverse herbaceous floras on Earth (Noss 1989, Stout and Marion 1993). The herbaceous layer is dominated by bunch grasses such as wiregrass (*Aristida* spp.) and bluestem (*Andropogon* spp.) and comprises species which are characteristically fire-adapted or fire-tolerant, resprout from underground parts, generally are long-lived, produce relatively few seeds, often have short distance seed dispersal, reproduce infrequently, and rarely recolonize a severely disturbed area (Schafale 1994).

There are over 250 other herbaceous species, many of which are threatened or endangered, that also are associated with longleaf pine (Brown 1964, Wright and Bailey 1982, Schafale 1994). For example, the North Carolina Sandhills comprise a fine scale mosaic of habitat or community types in response to soil attributes, topographic position, and fire history. Finer-textured soils support community types with some 40 species per square meter. This species diversity is lost when fire is excluded (Peet and Allard 1991). Hardin and White (1989) listed 191 species of plants associated with wiregrass throughout its range. Wiregrass communities include some 122 plants which are considered endangered or threatened throughout their ranges and 66 locally endemic plant taxa. A total of 84 species have protection status under the Endangered Species Act: six are endangered, one is proposed for endangered status, and the remainder are candidates for listing (Hardin and White 1989).

The open, but patchy habitats maintained by frequent ground fires in varying hydrologic conditions promoted an abundance of wildlife and a fauna distinctive to the region (Noss 1989). A minimum of 3500 species of arthropods probably occur in the sandhill and drier savanna habitats of the longleaf pine ecosystem (Folkerts *et al.* 1991). Guyer and Bailey (1991) list a total of 97 amphibian and 93 reptile species and subspecies found within the historic range of longleaf pine. About half prefer longleaf pine forests and some 25 percent of the species and subspecies are listed by state agencies as being of special concern. Means and Campbell (1981) showed that fire plays two important roles for sandhills reptile and amphibian fauna:

1. it maintains the characteristic species complex and physical structure of the longleaf pine-wiregrass-turkey oak plant associations to which many species are adapted, and

2. it produces islands of turkey oak-dominated sandy habitats in which certain amphibians and reptiles have evolved and where they reach their chief abundance today.

Finally, the U.S. Forest Service lists 17 endangered, threatened, or candidate species and subspecies of mammals and four birds which co-occur with RCWs (USFS 1995). For example, the recent decline of eastern fox squirrel numbers in the southeast is intimately related to the status of the remaining longleaf pine habitats upon which it depends. High quality habitat for eastern fox squirrel is characterized as longleaf pine-turkey oak sandhills, with large areas of mature longleaf pine forest forming a mosaic with other pine forest, mixed pine-hardwood forest, and mature bottomlands with numerous mast-producing trees. It may be that the observed declining range, numbers, and density of the eastern fox squirrel reflect their present occupation of marginal habitat and habitat remnants: "the habitat in which the eastern fox squirrel evolved may have already disappeared (pg. 72)" (Weigl *et al.* 1989) (and see also Lennartz 1988).

Indeed, losses of longleaf pine habitats in the Southeastern Coastal Plain since European settlement are comparable to or exceed losses of North American tallgrass prairie, the loss of freshwater wetlands, Brazilian moist coastal forest, and dry forests along the Pacific coast of Central America (Noss 1989). There is some evidence that longleaf pine-wiregrass communities are somewhat resilient and that degraded stands may be restored with proper management as long as the wiregrass ground cover remains intact (Clewell 1989). However, once the ground cover has been destroyed, wiregrass seldom if ever re-establishes itself. As Noss (1989) pointed out, with privately-owned examples of longleaf pine communities rapidly being converted or developed, increasingly urgent efforts must be directed toward improving the management of existing longleaf pine on public lands.

Management of public lands, including the national forests and military installations, offer the best opportunities for protection of longleaf pine habitats with such protection efforts often being driven by recovery of the red-cockaded woodpecker. In general, management recommendations for woodpecker habitat, as outlined in the U.S. Forest Service Regional Wildlife Habitat Management Handbook, including programs of growing season controlled burns, hardwood midstory control, and restoration of longleaf pine on suitable sites, would benefit many of the other components of the longleaf pine ecosystem. Management plans for the woodpecker should be adapted to take into account the requirements of ecosystem integrity, particularly when the needs goals of land managers and the needs of the ecosystem do not conflict.

2 RCW Management Guidelines*

U.S. Army Policies Regarding RCW Management

The purpose of the Guidelines is to provide standard RCW management guidance to Army installations to assist each installation in developing an endangered species management plan (ESMP) for the woodpecker. The Guidelines establish the *"baseline standards for Army installations in managing the RCW and its habitat (Appendix A, pg. 2)."* They apply to Army installations where the RCW is currently present and to installations with inactive RCW clusters that the installations continue to manage in efforts to promote reactivation. The installation-specific RCW ESMPs are required to employ *"all methods and procedures which are necessary for endangered and threatened species survival and to bring such species to the point of recovery where measures provided by the [Endangered Species Act (ESA)] are no longer necessary (Appendix A, pg. 3)."*

It is Army policy that *"installation and tenant unit mission requirements do not justify violating the ESA (Appendix A, pg. 3)."* Implementation of the Guidelines is expected to help installation managers balance mission requirements and conservation requirements through long-term planning and management which prevents or avoids potential conflicts between these interests.

Finally, the Guidelines recognize that *"conservation of the RCW and other species is part of a broader goal to conserve biological diversity on Army lands consistent with the Army's mission (Appendix A, pg. 3)."* Because the long-term survival of individual species such as the RCW depends on the continued health of the natural communities which sustain them, installation RCW ESMPs *"should promote ecosystem integrity (Appendix A, pg. 3)."*

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* Complete text of the 1994 Army-wide RCW Management Guidelines may be found in Appendix A.

U.S. Army RCW Management Strategy

The Guidelines require that subject installations adopt a long-term approach to RCW management that is consistent both with the military mission and the ESA. For each installation, this strategy is to take the following form (Appendix A, pg. 4):

1. In consultation with USFWS, installations must establish an installation RCW population goal using accepted methodologies.

2. Once a population goal is established, installations must designate sufficient nesting and foraging habitat to attain and sustain the goal. The population goal will dictate the required management intensity level for each installation and each managed area.

3. Installations must develop an ESMP to attain and sustain the installation RCW population goal in perpetuity.

4. Installations are required to ensure that all installation and tenant units and personnel that conduct training and other activities on the installation comply with the requirements of the RCW ESMP.

All management activities designed to promote recovery of the RCW and the sustainability of its habitat are to be driven by the Army's commitment to the preservation of biodiversity on its lands. Recognizing that certain components of RCW habitat may not be located entirely on installation lands, the Guidelines encourage the installations to establish cooperative management efforts with adjacent landowners where such efforts would promote the installation RCW conservation initiatives.

Key Terminology

The following analysis assumes familiarity with certain terms that are used throughout the Guidelines, this document, and the RCW literature in general:

Cavity - An excavation in a tree made, or artificially created, for roosting and nesting by RCWs.

Cavity tree - A tree containing one or more active or inactive RCW cavities or cavity starts (incomplete cavity).

Cluster - The aggregate area encompassing cavity trees occupied or formerly occupied by an RCW group plus a 200 ft buffer zone (formerly known as a "colony").

Group - A social unit of one or more RCWs that inhabits a cluster (formerly called a "clan"). A group may include a solitary, territorial male; a mated pair; or a pair with helpers (offspring from previous years).

Habitat Management Unit (HMU) - A designated area(s) managed for RCW nesting and foraging, including clusters and areas determined to be appropriate for recruitment and replacement stands.

Population - A RCW population is the aggregate of groups which are close enough together so that the dispersal of individuals maintains genetic diversity and all the groups are capable of genetic interchange. Population delineations are made irrespective of land ownership boundaries.

Recruitment stand - A stand of trees, minimum of 10 ac in size, with sufficient suitable RCW nesting habitat identified to support a new RCW group. Recruitment stands and supporting foraging area should be located within ⅜ mi to ¾ mi of an existing cluster or other recruitment stand.

Relict tree - A pine tree usually more than 100 yr old having characteristics making it attractive to RCWs for cavity excavation.

Replacement stand - A stand of trees, minimum of 10 ac in size, identified to provide suitable nesting habitat for colonization when a currently active cluster becomes unsuitable. The stand should be approximately 20 to 30 yr younger than the active cluster. While it is preferable for replacement stands to be contiguous with the active colony, at no time should they be more than ¼ mi from the cluster, unless there is no suitable alternative.

Stand - An aggregation of trees occupying a specific area and sufficiently uniform in species composition, age, arrangement, and condition so as to be distinguishable from the forest on adjoining areas.

Management Emphasis Areas

Implementation of the Guidelines centers on the establishment of Habitat Management Units (HMUs) which are to be designated to provide sufficient nesting and foraging habitat to enable installations to attain and sustain RCW population goals set in consultation with the U.S. Fish and Wildlife Service (USFWS). The impact analysis described below proceeded from a review of the expected effects of RCW management on the longleaf pine ecosystem, including the range of habitats which could be expected to be included in or adjacent to designated HMUs.

The management activities in the Guidelines are conducted on two different spatial scales: 1) management around the cavity trees, within clusters, and in recruitment stands where RCW currently nest or are expected to nest in the near future; and, 2) management in larger-scale Habitat Management Units (HMUs) that may contain several clusters and recruitment stands, as well as areas designated for training and other military activities. The extent of management and training at each scale plays a large role in the impact of the Guidelines on other sensitive species associated with the woodpecker and its habitats.

The impact tables for each species (Appendix B, furnished on diskette) summarize the primary habitat management activities and land use restrictions (i.e., on extractive uses, such as timber harvest, and on training activities within HMUs) envisioned in the Guidelines. Understanding of the impact analysis requires familiarity with the specific provisions of the Guidelines covering each management practice. In particular, positive or negative effects on each species were projected based on the potential effects of each management practice *as defined in the Guidelines* within designated HMUs, and not for those practices in general.

Review of the Guidelines suggested that proposed actions related to RCW management which are likely to affect other endangered, threatened and candidate species include:

1. the design and designation of HMUs·
2. prescribed burning;
3. midstory hardwood control; and
4. extractive land uses, including timber harvest and pine straw raking.

In some cases, management practices are relatively straight-forward (e.g., restrictions on pine straw raking). In others (e.g., midstory control), the potential for impact depends on the intensity with which the management option is practiced. The following summary details our understanding of several management practices or land use restrictions called for in the Guidelines which largely guided the impact analysis. Parenthetical designations refer to specific locations in the Guidelines (Appendix A).

Hardwood Control (V.E.1.b.)

Clusters and recruitment stands within HMUs are to be kept clear of dense midstory and are to be managed to create open, park-like stands of mature pine trees. All midstory within 50 ft of cavity trees will be removed. Beyond 50 ft, the following prescriptions are to be implemented:

1. hardwood stocking below 10 ft^2/acre,
2. hardwood canopy cover not to exceed 10%,
3. hardwood midstory cover not to exceed 10%.

Prescribed Burning (V.E.3.)

Midstory control will normally employ prescribed burning. Specifically:

1. Burns will be conducted at least every three years in longleaf, loblolly, slash, and shortleaf pine systems.

2. With the agreement of the USFWS, the burn interval may be increased to no more than five years after hardwood midstory has been brought under control.

3. Mechanical and chemical alternatives should only be used when burning is not feasible or is insufficient to control a well advanced hardwood midstory.

4. Cavity trees will be protected from fire damage during burning. Burning should normally be conducted in the growing season. Winter burns may be appropriate to reduce high fuel loads.

5. Use of fire plows in clusters will be allowed only in emergency situations

Pine Thinning (V.E.1.c.)

Thinning operations in clusters and recruitment stands will adhere to the following prescriptions:

1. Pine stocking should achieve 50 to 80 ft^2 basal area.
2. Stands should be thinned when pine basal area exceeds 80 ft^2.
3. No thinning cut should exceed 30 ft^2/acre.

4. Stands should approximate 25 ft spacing between mature trees, retaining scattered clumps.
5. All dead, dying, and inactive cavity trees will be retained.

Timber Harvest (V.E.1.e. and V.F.)

Timber harvest within HMUs is to be allowed only with the approval of trained biologists and is precluded during the RCW breeding season. In addition:

1. No rotation ages are to be set within clusters and recruitment stands. A 120-yr rotation (for longleaf pine) and 100-yr rotation (other pines) will be set throughout the remainder of HMUs.

2. Timber prescriptions should mimic natural processes to maintain historical conditions: old growth, uneven-aged longleaf pine stands with small (0.25 to 0.5 ac) even-aged patches of varying size.

3. Timber harvest should employ clearcut, seedtree or shelterwood cutting, retaining 6-10 relict trees per acre and all snags and relict trees in thinnings.

4. Off-site stands will be converted to longleaf pine.

Pine Straw Harvesting (V.E.1.e. and V.G.)

No pine straw harvest is allowed during the RCW breeding season without approval of a trained biologist. In addition:

1. Harvest activities should maintain an intact herbaceous layer and maintain adequate fuel levels to carry prescribed fire.

2. Pine straw should not be raked more frequently than once every three to six years.

3. No baling machines are allowed within clusters.

Training Restrictions (V.I.2. Protection of Clusters)

The Guidelines place certain restrictions on military training activities within RCW clusters in an effort to find a compromise between installation missions and operations and the protection of the woodpecker. Training restrictions, which apply only within RCW clusters, include:

1. Military training is limited to dismounted operations of a transient nature.

2. Establishment of bivouacs is not allowed.

3. Digging and cutting of vegetation other than hardwoods used for camouflage is restricted.

4. Use of CS gas, smoke, flares, or other incendiary devices is not permitted.

5. Vehicle traffic through clusters is limited to designated maintained roads and firebreaks.

6. The use of blanks in M16 handguns and rifles is permitted.

7. Off-road traffic by wheeled vehicles that weigh less than 5 tons traveling through clusters, 100 feet from cavity trees, is permitted on an infrequent basis if first approved through informal consultation with the USFWS.

The Guidelines include provision for expanded training activities under certain conditions. After consultation with the USFWS, up to 10 percent of RCW clusters may be designated to support expanded training activities that permit bivouacs more that 200 feet from cavity trees, the use of M60 MG blanks, and wheeled vehicles more than 200 feet from cavity trees as long as soil erosion levels remain within tolerance limits (Appendix A, pg. 18).

3 Impact Analysis

The longleaf pine ecosystem of the southeastern Coastal Plain comprises important habitats for a diversity of rare species of plants and animals. Weakley (1989) pointed out that approximately 600 species of North Carolina's flowering plants are found primarily in longleaf pine communities. Given the large number of species dependent upon longleaf pine communities, this report cannot practically be a definitive discussion of the impacts of the 1994 RCW Management Guidelines on all species of concern which are found in these habitats. Included in this discussion are only those species that are known to occur on or may potentially occur on U.S. Army installations subject to the Guidelines or their vicinities (USACERL 1994). All of these species have co-evolved with fire-maintained longleaf pine communities and are dependent on the periodic disturbance of fire to maintain their habitats and enable them to complete their life cycles. The species discussed here represent the range of longleaf pine habitats likely to be encountered on the nine installations subject to the Guidelines. Also included are species which are found in closely associated communities, such as pocosins, seepage bogs, drainages, and small wetland depressions. These species occur in the longleaf pine landscape and are thus dependent on its management.

The original list of species considered in this report was provided by the USFWS (USACERL 1994). Final lists were compiled through correspondence with natural resources personnel at each of the installations, with natural heritage programs in the respective states, Nature Conservancy state field offices, and with recognized experts in the academic community. A total of 66 animal species and subspecies and 62 plant species, subspecies, and varieties were initially included in the analysis.

A number of species known from or potentially present on the installations did not receive individual impact analysis (Tables 3 and 4). Some species were not considered for individual analysis because their habitat requirements placed them outside of the longleaf pine ecosystem (e.g., West Indian manatee, *Trichechus manatus*; stonecrops, *Sedum* spp.). Such species, while potentially present on or near one or more of the nine installations, are unlikely to be affected by RCW management activities. A number of additional species suggested as components of the longleaf pine ecosystem were not considered because their geographic ranges placed them outside of that covered by the Guidelines (e.g., Florida burrowing owl, *Athene cunicularia floridana*). Finally, some species were removed from further consideration owing to the transitory nature of their presence on installations (e.g., Peregrine falcons, *Falco peregrinus* spp., see below).

Table 3. Endangered, threatened, and candidate plant species which do not depend on the longleaf pine ecosystem or which do not co-occur with the RCWs on installations subject to the Guidelines.

Scientific Name	Common Name	Status[1]	Rationale
Amaranthus pumilus	Seabeach amaranth	PT	Habitat: coastal dunes
Arabis georgiana	Georgia rock-cress	C2	Habitat: rocky limestone woodlands
Bumelia thornei	Buckthorn	C2	Habitat: oak flatwoods, cypress pond borders
Calamintha ashei	Ashe savory	C1	Range: endemic to Florida
Carex chapmanii	Chapman's sedge	C2	Habitat: sandy hammocks, moist hardwood bottoms
Croomia pauciflora	Croomia	C2	Habitat: rich wooded ravines and river bluffs
Echinacea laevigata	Smooth coneflower	LE	Habitat: hardwoods and meadows on basic soil
Hymenocallis coronaria	Shoals spider-lily	C2	Habitat: rocky river shoals
Marshallia mohrii	Mohr's Barbara's buttons	LT	Limited range
Nestronia umbellula	Nestronia	C2	Habitat: hardwoods, some mixed hardwood/pine
Parthenium radfordii	Wavyleaf wild quinine	C2	Questionable taxon
Rhododendron prunifolium	Plumleaf azalea	C2	Habitat: moist soil in rich, wooded ravines
Scutellaria ocmulgee	Ocmulgee skullcap	C2	Habitat: bluffs
Sedum nevii	Nevius' stonecrop	C2	Habitat: limestone and shale outcrops
Sedum pusillum	Granite rock stonecrop	C2	Habitat: granitic flatrocks
Trichostema spp.	Blue curls	C2	Habitat: dunes and maritime forest openings
Trillium reliquum	Relict trillium	LE	Habitat: undisturbed mesic hardwoods
Xyris tennesseensis	Tennessee yellow-eyed grass	LE	Habitat: seeps and streams in hardwoods

[1] Federal status: LE = endangered; PT = proposed for federal listing as threatened; LT = threatened; C1 = anticipated future proposal for listing' C2 = candidate for federal listing as threatened or endangered.

Table 4. Endangered, threatened, and candidate animal species which do not depend on the longleaf pine ecosystem or which do not co-occur with the RCWs on installations subject to the Guidelines.

Scientific Name	Common Name	Status[1]	Rationale
Mammals			
Myotis austroriparius	Southeastern myotis	C2	Potentially affected (see text)
Myotis grisescens	Gray bat	LE	Habitat: caves near open water
Myotis sodalis	Indiana bat	LE	Limited range; habitat: caves
Plecotus rafinesquii	Rafinesque's big-eared bat	C2	Potentially affected (see text)
Trichechus manatus	West Indian manatee	LE	Habitat: large coastal rivers
Ursus americanus luteolus	Louisiana black bear	LT	Limited range; habitat
Birds			
Athene cunicularia floridana	Florida burrowing owl	C2	Range
Dendroica kirtlandii	Kirtland's warbler	LE	Limited range; transient during migration only
Charadrius melodus	Piping plover	LT	Habitat: coastal areas
Falco sparvarius paulus	Southeastern American kestrel	C2	Potentially affected (see text)
Falco peregrinus anatum	American peregrine falcon	LE	Habitat: cliff nesting; Transient only
Falco peregrinus tundrius	Arctic peregrine falcon	LT	Habitat: cliff nesting; Transient only
Haliaeetus leucocephalus	Bald eagle	LE	Habitat (see text)
Laterallus jamaicensis	Black rail	C2	Habitat: primarily coastal wetlands
Mycteria americana	Wood stork	LE	Habitat: primarily coastal wetlands
Sterna dougallii dougallii	Roseate tern	LE	Habitat: coastal and marine areas
Vermivora bachmanii	Bachman's warbler	LE	Habitat: bottomland hardwoods
Reptiles			
Alligator mississippiensis	American alligator	LT	Limited range; habitat
Caretta caretta	Loggerhead sea turtle	LT	Habitat: marine and coastal areas
Chelonia mydas	Green sea turtle	LT	Habitat: marine and coastal areas
Dermochelys coriacea	Leatherback sea turtle	LE	Habitat: marine and coastal areas
Eretmochelys imbricata	Hawksbill sea turtle	LE	Habitat: marine and coastal areas
Graptemys flavimaculata	Yellow-blotched map turtle	LT	Limited range; habitat: large river systems
Lepidochelys kempii	Kemp's ridley sea turtle	LE	Habitat: marine and coastal areas
Macroclemys temmincki	Alligator snapping turtle	C2	Limited range; habitat: large river systems
Fishes			
Acipenser brevirostrum	Shortnose sturgeon	LE	Habitat: large river systems and estuaries
Cyprinella caerulea	Blue shiner	LT	Restricted range; habitat

Scientific Name	Common Name	Status[1]	Rationale
Cyprinella callitaenia	Bluestripe shiner	C2	Restricted range
Cottus pygmaeus	Pygmy sculpin	LT	Restricted range
Elassoma boehlkei	Carolina pygmy sunfish	C2	Potentially affected (see text)
Insects			
Gomphus parvidens carolinus	Sandhills clubtail dragonfly	C2	Habitat: streams and stream margins
Problema bulenta	Rare skipper	C2	Habitat: brackish water marshes
Speyeria diana	Diana fritillary	C2	Range: Appalachian and Ozark Mountains

[1] Federal status: LE = endangered; LT = threatened; C2 = candidate for federal listing as threatened or endangered

Five sea turtles, two freshwater turtles, and the American alligator (*Alligator mississippiensis*) are known from areas on or near several of the installations subject to the Guidelines. The marine and coastal habitats of the sea turtles are unlikely to be affected by RCW management. The remaining species are found in wetlands associated with larger river systems. With the exception of the potential for discharge of erosional sediments in runoff from managed areas and improper use or accidental spills of herbicides that may be used in hardwood control, few direct or indirect affects of RCW management on these habitats are expected.

Two of the birds identified as occurring on or near the installations subject to the Guidelines, piping plover (*Charadrius melodus*) and roseate tern (*Sterna dougallii*), are primarily species of coastal and marine situations. Similarly, the black rail (*Laterallus jamaicensis*) and wood stork (*Mycteria americana*) are found primarily in larger wetlands, either coastal marshes or wetlands associated with permanent waters. While any of these species may occur as transients in habitats on or near the installations, they are unlikely to be directly affected by forest management for RCWs. Bachman's warbler (*Vermivora bachmanii*) is considered extirpated over much of its former range. It is known from dense, shrubby areas in bottomland hardwood forests. RCW management described in the Guidelines is not expected to directly affect these habitats.

Individual Species Accounts

Species Stewardship Summaries

Individual Species Stewardship Summaries were prepared for 16 animals and 31 plants (Tables 5 and 6). The individual species accounts found in Appendix B (provided on attached diskette) organize and summarize information from numerous sources including literature searches and interviews with researchers and managers actively working with the species or its habitat(s). In some cases, very little published information is available on a particular species and the Stewardship Summary points out the gaps in the present state of our understanding. In each Summary, the individual species account is followed by a review of the potential effects on the species from implementation of the RCW Management Guidelines. Where a species is fairly well known, the impact assessment generally follows from the review of the available information on its ecology and management.

We point out that in many instances, published assumptions regarding habitat selection by species have not been empirically tested and that, more generally, knowledge concerning particular habitat requirements of many of the species considered here remains a major limiting factor in their conservation. This remains particularly true of many southern ecosystems which remain either unstudied or understudied, particularly in regard to many of the lower vertebrates and invertebrates (Wilson 1994). In the case of species for which reproductive biology, ecology, and habitat requirements are poorly known, the impact analyses are only approximations. Often, particularly in the case of the plants, assumptions of a positive or negative impact were made based on the likely outcome of a management activity on a particular habitat type or community (e.g., streamhead pocosin) upon which the species appears to depend, rather than on the species itself. For many species of animals and plants, precise knowledge of habitat requirements is lacking and the effects of management practices must be correspondingly less certain. However, while there are inherent problems with the linking of species requirements to discrete habitat types, it remains a useful planning tool (Wilson 1994). In all cases, assessment of the potential effects of RCW management have been conservative, that is, erring on the side of the species. For a number of plant species that were identified by the USFWS as potentially occurring on one or more of the nine installations subject to the Guidelines, the available information, published and unpublished, was so meager that no detailed stewardship summary could be created. These species are indicated in Table 6.

Table 5. Endangered, threatened, and candidate animal species known from or potentially occurring on selected Army installations which may be affected by the RCW Management Guidelines.

Species Name	Common Name	Status[1]
Mammals		
Neotoma floridana floridana	Eastern woodrat	-
Sciurus niger niger	Eastern fox squirrel	-
Birds		
Aimophila aestivalis	Bachman's sparrow	C2
Ammodramus henslowii	Henslow's sparrow	C2
Lanius ludovicianus	Loggerhead shrike	C2
Reptiles		
Drymarchon corais couperi	Eastern indigo snake	LT
Gopherus polyphemus	Gopher tortoise	LT
Heterodon simus	Southern hognose snake	C2
Pituophis melanoleucus melanoleucus	Northern pine snake	C2
Pituophis melanoleucus mugitus	Florida pine snake	C2
Pituophis melanoleucus ruthveni	Louisiana pine snake	C2
Amphibians		
Ambystoma cingulatum	Flatwoods salamander	C2
Hyla andersonii	Pine barrens treefrog	3C
Rana capito aesopus	Florida gopher frog	C2
Rana capito capito	Carolina gopher frog	C2
Rana capito sevosa	Dusky gopher frog	C1
Insects		
Agrotis buchholzi	Buchholz's dart moth	C2
Atrytone arogos arogos	Arogos skipper	C2
Neonympha mitchellii francisci	Saint Francis's satyr	LE
Spartiniphaga carterae	Carter's noctuid moth	C2

[1] Federal status: LE = endangered; C1 = anticipated future proposal for listing; LT = threatened; C2 = candidate for federal listing as threatened or endangered; 3C = more abundant than previously believed

Table 6. Endangered, threatened, and candidate plant species known or potentially occurring on selected Army installations which may be affected by Army-wide RCW Management Guidelines.

Species Name	Common Name	Status[1]
grimonia incisa	Incised groovebur	C2
Amorpha georgiana var. confusa	Savanna indigo-bush	C2
Amorpha georgiana var. georgiana	Georgia indigo-bush	C2
Astragalus michauxii	Sandhills milkvetch	C2
Balduina atropurpurea	Purple balduina	C2
Baptisia arachnifera[*]	Hairy rattleweed	LE
Campylopus carolinae[*]	Savanna campylopus	C2
Dionaea muscipula	Venus flytrap	C2
Eupatorium resinosum	Pine barrens boneset	C2
Fimbristylis perpusilla	Dwarf fimbry	C2
Kalmia cuneata	White wicky	C2
Lilium iridollae	Panhandle lily	C2
Lindera melissifolia	Southern spicebush	LE
Lindera subcoriacea	Bog spicebush	C2
Litsea aestivalis[*]	Pondspice	C2
Lobelia boykinii[*]	Boykin's lobelia	C2
Lysimachia asperulifolia	Rough-leaf loosestrife	LE
Macbridea caroliniana[*]	Carolina bogmint	C2
Myriophyllum laxum	Loose watermilfoil	C2
Oxypolis canbyi	Canby's cowbane	LE
Oxypolis ternata[*]	Piedmont cowbane	C2
Parnassia caroliniana	Carolina grass-of-parnassus	C2
Plantago sparsiflora	Pineland plantain	C2
Potamogeton confervoides	Tuckerman's pondweed	C2
Pteroglossaspis ecristata	Eulophia	C2
Pyxidanthera barbulata var. brevifolia	Sandhills pyxie-moss	C2
Rhexia aristosa[*]	Awned meadowbeauty	C2
Rhus michauxii	Michaux's sumac	LE
Rhynchospora crinipes	Hairy-peduncled beak-rush	C2

Species Name	Common Name	Status[1]
Rudbeckia heliopsidis[*]	Sun-facing coneflower	C2
Sarracenia rubra ssp wherryi	Wherry's pitcher plant	C2
Schwalbea americana	American chaffseed	LE
Solidago pulchra	Carolina goldenrod	C2
Solidago verna	Spring-flowering goldenrod	C2
Sporobolus teretifolius	Wireleaf dropseed	C2
Stylisma pickeringii var. pickeringii	Pickering's dawnflower	C2
Thalictrum cooleyi	Cooley's meadowrue	LE
Tofieldia glabra	Smooth false asphodel	C2
Xyris scabrifolia	Harper's yellow-eyed-grass	C2

[1] Federal status: LE = endangered; C2 = candidate for federal listing as threatened or endangered.

[*] Indicates little or no stewardship information available/no stewardship summary has been prepared for Appendix B.

The vegetation community types which we have used in our analysis do not necessarily coincide with any standard classification scheme. Rather, they were selected as meaningful generalizations to facilitate discussion. Because the types discussed here are relatively arbitrary, they may mask some important natural variation within broad types. As with any discussion of this sort, there are sources of error in predicting the effects of landscape alteration on specific species or suites of species (Hamel 1982, Wilson 1994). Because of gaps in the published literature, impact grids are based on assumption and judgement. This is represented in Tables 7 and 9 by a range of possible values which suggest the uncertainty in our current state of understanding that is evidenced in the literature. Given potential sources of error, managers should use caution and their own judgement in developing predictions about management effects from them. However, we hope that application and testing of the principles presented here will improve management efforts and precision of predictions in the future.

Effects of RCW Management Guidelines on Animal Species

HMU Management Practices

Almost all of the animal species described in Appendix B may be adversely affected by HMU management practices as described in the Guidelines. As might be expected, minimal impacts are expected to accrue to species which are found in habitats (e.g., pocosins and bogs) that are not specifically used by RCWs, but which HMU boundaries are likely to overlap (e.g., pine barrens treefrog, eastern woodrat).

Other species which require the open, park-like longleaf pine stands which the Guidelines attempt to create may benefit or be unaffected by many of the HMU management prescriptions (e.g., Bachman's sparrow, fox squirrel) (Table 7).

Cavity Tree Protection. Protection of RCW cavity trees during prescribed burning, midstory control, and other activities is an important component of RCW recovery. The guidelines are not specific about the measures which may be employed in these activities, but they typically involve brush clearing and raking fuel from the base of cluster trees. To the degree that small areas of open sand are made available, without jeopardizing the integrity of herbaceous cover, species which require open sandy micro-habitats, such as the three snakes considered here, may benefit from this activity. Other species, such as the flatwoods salamander, gopher frog, and gopher tortoise, which require intact herbaceous layers for cover, may be adversely affected. The degree of adverse impact will depend upon the intensity of raking and brush control practiced and the extent of subsidiary soil and root mat disturbance. Still additional species, including Bachman's sparrow, may benefit from clearing brush from potential nesting areas, as long as ground layer disturbance is minimized.

Table 7. Potential effects of RCW Management Guidelines on animal species known from or potentially occurring on Army installations.

MANAGEMENT PRACTICE	INSECTS	AMCI	HYAN	RAC	DRC	GOPO	HESI	PIME	AIAE	AMHE	LALU	NEFL	SCNI
HMU MANAGEMENT	3,2,1	3,2,1	2	3,2,1	3	3	3	3,2,1	3,2,1	2,1	2,1	2	1
Cavity tree protection	3,2,1	3,2,1	2	3,2,1	3	3	3,2,1	3,2,1	3,2,1	2,1	2,1	2	2,1
Brush clearing	3,2,1	3	2	3	3	3	3	3,2,1	3,2,1	2,1	2,1	2	2,1
Fuel removal and raking	3,2,1	3	2	3	3	3	3	3,2,1	3,2,1	2,1	2,1	2	2,1
Midstory control	3,2,1	3,2,1	2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	1	1	1	1	1
Prescribed burning	1	3,2,1	1	1	1	1	1	1	1	1	1	1	1
Three-year fire return	1	1	1	1	1	1	1	1	1	1	1	1	1
Winter fire	3,2,1	3	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	1	2,1	2,1
Growing season fire	3,2,1	1	1	1	3,2,1	1	3,2,1	3,2,1	3,2,1	1	1	3,2,1	1
Fire management	3	3	3	3	3	3	3	3	3	3	2	3	3,2,1
Berm construction	3	3	4	3	3	3	3,2	3,2	3,2	3	2	3	2
Plowed fire lanes	4,3	4	4	4	4	4	4	4	3,2	3	2	3	3
Back fires	3	3	3	3	3	3,2,1	3,2,1	3,2,1	3,2	3	2	3	2
Natural fire breaks	1	1	1	1	1	1	1	1	1	1	2	1	1
Mechanical control	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1
Chemical control	3,2,1	3	3	3	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	2,1	3,2,1	3,2,1
Hardwood control	3,2,1	3,2,1	3,2,1	1	3,2,1	3,2,1	3,2,1	3,2,1	1	1	2,1	3,2,1	3
Pine thinning	1	1	1	1	1	3,2,1	3,2,1	3,2,1	1	1	1	1	1

MANAGEMENT PRACTICE	INSECTS	AMCI	HYAN	RAC	DRC	GOPO	HESI	PIME	AIAE	AMHE	LALU	NEFL	SCNI
Cavity tree retention	2	2	2	2	2	2	2	2	2	2	2	2	2,1
Pine beetle control	3,2,1	2	2	3	2,1	2,1	3,2,1	3,2,1	2,1	2	2,1	2,1	2,1
EROSION CONTROL	1	1	1	1	1	1	1	1	1	1	1	1	1
LONGLEAF PINE REGENERATION	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1
RCW POPULATION AUGMENTATION	2	2	2	2	2	2	2	2	2	2	2	2	2
Cavity management	2	2	2	2	2	2	2	2	2	2	2	2	2
Cavity closure	2	2	2	2	2	2	2	2	2	2	2	2	3,2
EXTRACTIVE LAND USES	3	3	3	3	3	3	3	3	3	3	3	3	3
Pine straw raking	4	4	3,2	4	3	3	3,2	3,2	3	3	2	2	3,2
Timber harvest	3	3	3	3	3	3	3	3	3	3	3	3	3
Lengthened rotations	1	1	2,1	1	1	1	1	1	1	1	1	1	1
Patch creation	1	1	2,1	1	1	1	1	1	1	1	1	1	1
Stand conversion	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1
TRAINING RESTRICTIONS	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1	3,2,1
Impact/Danger areas	2	2	2	2	2	2	2	2	2	2	2	2	2
Bivouac restrictions	1	1	2,1	1	1	1	1	1	1	1	1	1	1
Digging restrictions	1	1	1	1	1	1	1	1	1	1	1	1	1
Smoke/Gas/Incendiaries	2	2	2	2	2	2	2	2	2	2	2	2	1
Small arms firing	2	2	2	2	2	2	2	2	2	2	2	2	1
On-road vehicular traffic	1	1	1	1	1	1	1	1	1	1	1	1	1
Off-road vehicular traffic	3	3	3	3	3	3	3	3	3	3	3	3	3
EXPANDED TRAINING GUIDELINES	3	3	3	3	3	3	3	3	3	3	3	3	3

LEGEND:

AMCI = *Ambystoma cingulatum*, Flatwoods salamander

HYAN = *Hyla andersonii*, Pine barrens treefrog

RACA = *Rana capito*, Gopher frog

DRCC = *Drymarchon corais couperi*, Eastern indigo snake

GOPO = *Gopherus polyphemus*, Gopher tortoise

HESI = *Heterodon simus*, Southern hognose snake

PIME = *Pituophis melanoleucus*, Pine snake

AIAE = *Aimophila aestivalis*, Bachman's sparrow

AMHE = *Ammodramus henslowii*, Henslow's sparrow

LALU = *Lanius ludovicianus*, Loggerhead shrike

NEFL = *Neotoma floridana floridana*, Eastern woodrat

SCNI = *Sciurus niger niger*, Eastern fox squirrel

Management effects: 1 = beneficial effect; 2 = no effect; 3 = may adversely affect; 4 = adverse effect

NOTE: Refer to Chapter 2 for detailed discussion of the listed management practices. Expected effects of management practices are estimates made by the authors based on the species which occur in each habitat. Estimates are expected to be refined by the experience of those working in the field.

Midstory Control. Reduction of hardwood and pine midstory is likely to have very mixed impacts on populations of other non-target animals (Table 7). The Guidelines emphasize the use of prescribed fire to control midstory in most instances. With few exceptions, species which occur in longleaf pine communities are fire-adapted and may benefit from a regime of growing season prescribed fire, practiced at intervals (ca. 3 yr in most situations) which mimic natural conditions. The exact timing of fires that may be most beneficial for particular species vary and the relative effects of growing season versus winter burns may not be fully understood for many communities. For example, pine barrens treefrogs inhabit shrubby pocosins, a community type for which natural fire regimes remain poorly researched. Evidence suggests fire returns in excess of 5 to 10 years. In addition, treefrogs are known to disperse considerable distances from the centers of pocosins and may be found in the adjacent ecotones and often in adjacent uplands. In fire suppressed areas, litter accumulation at the pocosin edge may be substantial and fires, when re-introduced, can burn very hot in these areas. Care must be taken to reduce fuel loads gradually and to avoid burning when treefrogs are likely to be dispersing from breeding ponds. Similar proscriptions should be observed to avoid killing species, including flatwoods salamanders and gopher frogs, which seasonally disperse from temporary, often ephemeral, breeding ponds found embedded within more xeric surrounding habitats.

As with the amphibians, use of fire in the management of insects should proceed with caution. While all of the insects considered here are strongly associated with fire, they have varying levels of tolerance to fires at different times of the year. Some of the species are not able to survive fires at any time of the year and instead must rely on refugia and recolonization of burned areas from other populations. Many adverse impacts of prescribed fire are due to asynchrony between insect phenologies and the timing of management activities. For example, pre-pupal larvae of Buchholz's dart moth may be less vulnerable to winter burns because they hibernate under the soil and are somewhat protected from the heat of the fire. Larvae may be destroyed during growing season burns because they are then typically found on the host plant, *Pyxidanthera*, during the summer. However, summer ground fires may only burn the edges of pyxie-moss mats, and may leave the center of the mats intact where the moths may be able to survive the fires. While it seems as though winter burns may be better for the dart moth, winter burns may cause more damage to the pyxie-moss and reduce necessary host plant availability. Impacts of prescribed burns on adult dart moths are unknown.

In addition to these considerations regarding fire timing and intensity, issues of fire management activities are not adequately described in the Guidelines. As described below (see Chapter 4, Prescribed Burning), placement of fire control structures and use of fire plows can have particularly adverse effects on herbaceous plants, soil integrity, and local hydrology. Fire management practices may have potentially adverse effects on all species considered here. With the exception of the use of natural landscape features as fire breaks, all mechanical means of controlling fires, if improperly placed (e.g., within wetlands or counter to the prevailing topography) can disrupt drainage patterns, increase soil erosion, and disturb sensitive habitats (e.g., gopher tortoise burrows, hillside seepage bogs). Similarly, use of back fires, which can burn very hot and may destroy sensitive wetland soils if allowed to burn during dry periods, may have severe short and long-term adverse effects on some species and habitats. Some guidelines for fire management within HMUs are provided in Chapter 4.

When dense midstory vegetation cannot practically be controlled with fire, the Guidelines permit the use of chemical and mechanical control measures. No guidance is provided regarding the methods appropriate within clusters and HMUs. Ancillary impacts on other species will likely depend on the intensity of the management procedure used. For example, roller chopping to control hardwood encroachment into pine flatwoods is likely to have severe adverse effects on most amphibians and reptiles, including gopher tortoise burrow systems. Use of chain saws, on the other hand, is likely to have considerably less direct impact on sensitive species. Similarly, use of herbicides that are poorly targeted or used in inappropriate areas (e.g., in or near wetlands where spills can have ramifying effects on adjacent areas) can have severe adverse impacts over unexpectedly large areas.

Hardwood Control, Pine Thinning, and Pine Beetle Control. Potential adverse effects of hardwood control prescriptions are discussed in detail in Chapter 4. Adverse effects are primarily associated with the loss of hard mast and cavity-producing hardwood canopy trees and reduction in soft mast-producing midstory and shrub vegetation. As with midstory control and prescribed fire, to the extent that HMU management attempts to create open, park-like stands of mature longleaf pine, many species may benefit from reduced pine stocking, pine thinning to reduce pine beetle threat, and reduction of hardwood overstory (Table 7). Potential negative effects on several of the reptiles and amphibians may accrue from the use of heavy equipment in sensitive areas, such as highly erodible soils on steep slopes, or from clearing operations which do not preserve intact ground layer vegetation and root mats (particularly wiregrass root systems). With the exception of concerns for mast and cavity dependent species, most adverse impacts of overstory and understory thinning may be minimized using best management practices and flagging sensitive areas during management operations.

Extractive Land Uses and Longleaf Pine Regeneration

As with many of the other management activities discussed previously, the degree of any adverse effects on non-target animals in silvicultural and pine straw harvest operations will depend greatly on the management practices adopted (Table 7). Pine straw harvest, with its high potential for disturbing herbaceous vegetation, wiregrass root mats, and soil integrity, is expected to have adverse impacts on most species or their habitats. Use of even-aged logging and intensive site preparation to regenerate longleaf pine stands are likely to have very severe adverse impacts on most ground layer vegetation and ground-dwelling animals. Adoption of uneven-aged silviculture and reliance on prescribed fire for site preparation are discussed in Chapter 4. Timber harvest which emphasizes extended rotations and small group or single-tree selection cutting can be effectively used to restore natural, old growth-like conditions in second growth stands. To the extent that these activities create the habitats required by non-target species, and employ management practices which minimize disturbance to ground layer vegetation, soils, and local hydrology, they may benefit most species considered here (discussed in Chapter 4). However, timber harvest which employs clearcutting, mechanical site preparation, and inappropriate stand rotations, is likely to adversely effect herbaceous ground layers and soils, disturb wetland hydroperiods, and fragment forest habitats upon which these species depend.

Training Restrictions

The Guidelines place several restrictions on military training that will benefit most species found in HMUs, such as limiting mounted training, restricting the cutting of vegetation and soil disturbances, and keeping wheeled traffic on existing roads. However, these restrictions apply only to areas within RCW clusters. While restrictions in RCW clusters may benefit some species, benefits will accrue only in those places where their populations overlap with RCW clusters. On-road vehicular traffic may have indirect adverse effects on some species as a result of road maintenance operations (see below), but off-road traffic, even limited to vehicles less than 5 tons, may significantly damage sensitive wetland and temporary pond habitats. Expanded training activities within HMUs may adversely affect animal populations through increased trampling, soil compaction, soil erosion, and outright destruction of habitats.

Effects of RCW Management Guidelines on Plant Communities

Unlike many of the animals, detailed autecological information is available for very few of the plant species considered here. In most cases, determination of potential impacts of management practices were derived from studies of the ecological relationships which structure the communities in which they are found (e.g., Christensen 1981, Walker and Peet 1983), from synecological studies (e.g., Platt *et al.* 1988), and from animal studies in similar systems (e.g., Vickers *et al.* 1985).

Table 8 categorizes the plant species by broad community types. It can readily be seen that few species have been described from only one community type and that most occur in several. Over 60 percent of the listed species are either obligate or facultative hydrophytes and almost 80 percent tend to be found in the ecotonal situations between communities, particularly along wetland edges. This distribution of species has important implications for management activities which may disrupt local hydrological processes and for the placement of prescribed fire control lines which has often been done along the edges of wetlands to "protect" them from the burn.

Table 9 presents a summary of the potential effects of the major provisions of the RCW Management Guidelines on four broad community types. The division of the longleaf pine landscape into four community types was done based roughly on easily conceptualized physiognomic differences, general floristic composition, and landscape/hydrologic position. Our aim was to present the very broad outline of the potential impacts of RCW management practices, as described in the Guidelines, that can be supported by the literature and the experience of field biologists and managers. That these estimates, and those found in Appendix B, are only rough approximations in most cases, should suggest a high degree of caution in the choice of appropriate management procedures.

Table 8. Habitats of endangered, threatened, candidate, and other plant species known from or potentially occurring on selected Army installations subject to RCW Management Guidelines.

Species	Federal Status[1]	NWI Class[2]	Pocosin or Bog	Ecotone/ Other[3]	Wet/Mesic Savanna	Flatwood[4]	Pine - Oak	Xeric Sandhill
Agrimonia incisa	C2	NL					✓	
Amorpha georgiana var. *confusa*	C2	FACW			✓			
Amorpha georgiana var. *georgiana*	C2	FACW	✓	R,S,D	✓	M		
Astragalus michauxii	C2	NL					✓	✓
Balduina atropurpurea	C2	FACW	✓	H	✓	W		
Baptisia arachnifera	E	NL				M,D	✓	
Campylopus carolinae	C2	NL					✓	✓
Dionaea muscipula	C2	FACW		S,P,M,D	✓	W		
Eupatorium resinosum	C2	OBL	✓	P,S	✓			
Fimbristylis perpusilla	C2	FACW		B,M				
Kalmia cuneata	C2	FACW+		S,M				
Lilium iridollae	C2	NL	✓	S,P,R	✓	W		
Lindera melissifolia	E	OBL		M				
Lindera subcoriacea	C2	OBL	✓	S				
Litsea aestivalis	C2	OBL		M,H	✓			
Lobelia boykinii	C2	OBL	✓	H	✓	W		
Lysimachia asperulifolia	E	OBL	✓	S,P	✓	W	✓	
Macbridea caroliniana	C2	OBL	✓	H				
Myriophyllum laxum	C2	NL		A				
Oxypolis canbyi	E	OBL	✓	H,M	✓			
Oxypolis ternata	C2	OBL	✓	P,S,D	✓	W		
Parnassia caroliniana	C2	OBL	✓	S,P,R,D	✓	W		
Plantago sparsiflora	C2	OBL			✓	W		
Potamogeton confervoides	C2	OBL		A				
Pteroglossaspis ecristata	C2	NL		S,D	✓	M,D	✓	✓
Pyxidanthera barbulata var. *brevifolia*	C2	NL					✓	✓
Rhexia aristosa	C2	OBL		H,M,D	✓			
Rhus michauxii	E	NL		D			✓	
Rhynchospora crinipes	C2	OBL		B				
Rudbeckia heliopsidis	C2	NL	✓	R		M		
Sarracenia rubra ssp *wherryi*	C2	NL	✓	S	✓			
Schwalbea americana	E	FAC		P,S	✓	M,D	✓	
Solidago pulchra	C2	NL		P	✓	W,M		
Solidago verna	C2	OBL		S,R,D		W		

Species	Federal Status[1]	NWI Class[2]	Pocosin or Bog	Ecotone/ Other[3]	Wet/Mesic Savanna	Flatwood[4]	Pine - Oak	Xeric Sandhill
Sporobolus teretifolius	C2	FACW			✓			
Stylisma pickeringii var. *pickeringii*	C2	NL		D				✓
Thalictrum cooleyi	E	FACW+	✓	H,R,D	✓			
Tofieldia glabra	C2	FACW		S,P	✓	W		
Xyris scabrifolia	C2	OBL	✓	S,P				

[1] *Federal status*

E = endangered; C2 = candidate for federal listing as threatened or endangered

[2] *NWI Class: National Wetland Indicator*

OBL = Obligate Wetland = occurs with estimated 99% probability in wetlands

FACW = Facultative Wetland = estimated 67%-99% probability of occurrence in wetlands

FAC = Facultative = equally likely to occur in wetlands and non-wetlands (34%-66% probability)

Positive sign (+) indicates a frequency toward the higher end of a category (more frequently found in wetlands), and a negative sign (-) indicates a frequency toward the lower end of a category (less frequently found in wetlan[illegible]

After: Reed, P.B. Jr. 1988. National list [illegible]ecies that occur in wetlands: Southeast (Region 2). Biol. Rept. 88(26.2). National Wetlands Inventory, U.S. Fish and Wildl. Serv., Washington, DC.

[3] *Ecotone classes:*

R = between mesic savanna/flatwood terraces and rivers or bottomland/floodplain forests or hardwood swamp

M = margins of ponds, shallow depressions, sinks, or Carolina Bays in pinelands

S = between stream head pocosins, sandhill seeps, or seepage slopes and pine-oak woodlands

P = between pocosins or seepage areas and mesic savannas or flatwoods

D = disturbed areas - firebreaks, power line right-of-ways, mowed roadsides, ditches, cleared areas, etc.

Other habitat classes:

A = aquatic - found in ponds, lakes, backwaters, impoundments, pools in bogs/peatlands, etc.

B = silty stream banks

H = hardwood swamps, cypress-pine swamps, cypress ponds, or small stream swamps

[4] *Flatwood types:*

W = wet

M = mesic

D = dry

Table 9. Summary of the potential effects of the RCW Management Guidelines on plant community types

Management Practice	Pocosin	Savanna/ Bog	Flatwoods	Pine-Oak Woodland/ Xeric Sandhill
HMU MANAGEMENT				
Cavity tree protection	3,2	3,2	3,2	3,2
Brush clearing	3,2	3,2,1	4,3	3,2,1
Fuel removal and raking	3,2	4,3	4,3	4,3
Midstory control	4	3,2,1	3,2,1	3,2,1
Prescribed burning	3,1	1 / 3,2,1	1	1
Three-year fire return	4	1 / 3,2,1	1	1 / 4,3
Winter fire	3,2	3,2	3,2	3,2
Growing season fire	1	1	1	1
Fire management	3	3	3	3,2
Berm construction	4,3	4,3	4,3	3
Plowed fire lanes	4,3	4,3	4,3	3
Back fires	3	3	3	3
Natural fire breaks	1	1	1	1
Mechanical control	4	3,2,1	3,2,1	3,2,1
Chemical control	4,3,2	3,2,1	3,2,1	3,2,1
Hardwood control	4	3,2,1	3	3,2,1
Pine thinning	3,2	3,2,1	3,2,1	3,2,1
Cavity tree retention	2	2	2	2
Pine beetle control	2	2	2	2
Thinning	3,2	3,2,1	3,2,1	3,2,1
Pheromones	2	2	2	2
EROSION CONTROL	1	1	1	1
LONGLEAF PINE REGENERATION	4,3	3,2,1/4,2	3,2,1	3,2,1
RCW POPULATION AUGMENTATION	2	2	2	2
Cavity construction	2	2	2	2
Cavity restriction	2	2	2	2
Cavity closure	2	2	2	2
EXTRACTIVE LAND USES	2	4,3	4,3	4,3
Pine straw raking	2	4	4	4

Management Practice	Pocosin	Savanna/ Bog	Flatwoods	Pine-Oak Woodland/ Xeric Sandhill
Timber harvest	2	3 / 2	3	3
Lengthened rotations	2	1	1	1
Patch creation	2	1	1	1
Stand conversion	2	3,2,1	3,2,1	3,2,1
TRAINING RESTRICTIONS	1	1	1	1
Impact/Danger areas	2	2	2	2
Bivouac restrictions	1	1	1	1
Digging restrictions	1	1	1	1
Smoke/Gas/Incendiaries	2	2	2	2
Small arms firing	2	2	2	2
On-road vehicular traffic	1	1	1	1
Off-road vehicular traffic	3	3	3	3
EXPANDED TRAINING GUIDE-LINES	3	3	3	3

LEGEND: 1 = beneficial effect; 2 = no effect; 3 = possible adverse effects; 4 = adverse effects / = impacts on habitat types are different

NOTE: Refer to Chapter 4 for detailed discussion of the listed management practices. Expected effects of management practices are estimates made by the authors based on the species which occur in each habitat.Estimates are expected to be refined by the experience of those working in the field.

HMU Management Practices

Cavity Tree Protection. Brush clearing and fuel removal within the 50 ft buffer area around cavity trees is likely to affect only a minimal portion of the larger HMU. Because savanna plant species generally benefit from opening the midstory, brush clearing around cavity trees may be beneficial to these species (Table 9). However, depending on the intensity and methods employed, clearing activities (e.g., fuel raking) can have deleterious effects on small herbaceous species, particularly those that are found in restricted areas and isolated populations. Excessive trampling by work crews, especially in less stable moist areas like the pine savanna-pocosin ecotone, or other habitat disturbance resulting from brush clearing and fuel removal, can crush plants, destroy root mats, and exacerbate soil erosion.

Midstory Control. Prescribed burning to control midstory encroachment into cluster sites is likely to have mixed effects in the different community types (Table 9). The nature of those effects will vary depending on natural fire return intervals, length of fire suppression, and timing of the burn. In general, winter burns should only be used to reduce high fuel loads in areas where fire has been restricted. Following fuel reduction, a regular program of growing season burns are recommended because they are more likely to mimic natural burning regimes. Frequent growing season burns are likely to have beneficial effects on species in most communities. Prescribed burning in savannas, flatwoods, and in the ecotones between these areas and drier community types, provides an open-canopied habitat, free (for at least several years following a burn) of a dense, competing shrub layer. It may be that many populations of *Kalmia cuneata* (white wicky) have died off in the last several decades due to fire suppression and the subsequent shading and loss of habitat. Fire suppression over most of white wicky's range for the last several decades has allowed potential habitats to become overgrown by taller, coarser shrubs. In the case of *Lysimachia asperulifolia*, an endangered species known from an array of wetland habitats, maintenance of vigorous, sexually and asexually reproducing occurrences appear to require regular growing season fires. Research indicates that burning every two years may be optimal (Appendix B).

Most pocosin species are fire-adapted. However, because natural fire return intervals for pocosin habitats are significantly longer (from 15 to 30 years in some studies) than the three year interval recommended by the management guidelines, a three year fire interval is likely to be harmful. Caution should be used when returning fire to severely fire-suppressed pocosin or bog ecotones. Such areas lack finer fuels which help to carry fires and hot, very destructive fires are sometimes necessary to kill back the invasive shrub layer. This kind of fire may have severe adverse effects on species such as *Lindera subcoriacea* and *Kalmia cuneata* often found in ecotonal situations.

As a general rule, prescribed fire is highly desirable for most savanna, flatwood, and bog species because it maintains an open habitat free of woody species which shade and compete with the herbaceous and graminoid ground cover. Fires at one to three year intervals are recommended for most savanna species. Optimal fire returns in bog habitats are poorly known and may be as short as one to three years (in pitcher plant bogs) or longer than 10 years. Fires at three to five year intervals are recommended for most flatwoods species. Because winter fires are often not sufficient to prevent the invasion of woody species, growing season burns are recommended for these habitats. Also, flowering and seed set are often timed to growing season fires in these systems. Most species in pine-oak woodlands and xeric sandhills are also fire-adapted, although little is known about the frequency of naturally occurring fires in these habitats. Prescribed fire at three to five year intervals is usually recommended to maintain the open understory of the wiregrass dominated pine-scrub oak woodlands. Natural fire returns for xeric scrub sandhills are believed to be longer, from 10 to 25 years in some instances, so that enforcement of three year fire intervals may be detrimental.

In all cases, prescribed burning not timed to the reproductive cycle of a particular species could prevent or reduce its reproductive success. For example, areas supporting *Lysimachia* should not be burned repeatedly during the flowering and fruiting months (mid-May to mid-June and July to October, respectively). Planning of burns which do not adjust to the presence of sensitive plant populations can have adverse effects on community structure, as well as species survival.

Natural fire breaks (topographic features, wetland boundaries) should be favored over artificial means of controlling fire in all habitats, since use of natural breaks more closely mimics natural ecosystem processes. Digging of fire lines to suppress wildfires could physically impact the rare plant species or cause damage to the topography and hydrologic patterns of wetland habitats. For example, the savanna-pocosin ecotones where *Solidago pulchra* is often found are often targeted for the placement of fire lines. This zone is also perhaps the most vulnerable to fire line disturbance, since it harbors a highly diverse herbaceous layer within a narrow band on the circumference of the pocosin.

Hardwood Control and Pine Thinning. Potential adverse effects of hardwood control prescriptions are discussed in Chapter 4. To the extent that HMU management attempts to create open, park-like stands of mature longleaf pine, many species may benefit from reduced pine stocking and reduction of hardwood overstory (Table 9). Potential negative effects to herbaceous layer plant species may result from the use of heavy equipment in sensitive areas, such as highly erodible soils on steep slopes, or from clearing operations which do not preserve intact ground layer vegetation and root mats (particularly wiregrass root systems). All mechanical methods for control and thinning can compact the soil, alter hydrology, and destroy shrubs and ground cover vegetation. Chemical control measures should be avoided, particularly in wetlands and wetland ecotones, because of the potential mobility of herbicide chemicals in wet habitats. Most adverse impacts of overstory and understory thinning may be minimized using conservative practices and flagging sensitive areas prior to management operations.

Extractive Land Uses and Longleaf Pine Regeneration

Re-establishment of longleaf pine and the regeneration of existing long-leaf pine stands have the potential to increase available sites for the species adapted to these habitats. Regeneration of existing longleaf pine stands should use natural means in order to avoid high-impact artificial methods. Site preparation should employ fire where possible, and mechanical methods such as discing, chopping, and especially bedding should be avoided. Forestry operations should be prohibited within a minimum of 100 ft from wetland margins.

Pine straw raking has been shown to destroy ground-layer vegetation and longleaf pine seedlings and to cause or exacerbate erosion problems. Plants can be directly damaged or destroyed by tractors pulling harrows to rake the pinestraw. Removal of natural vegetative cover can promote the invasion of weedy species and contribute to the degradation of wetlands through siltation and chemical runoff. Site preparation for harvest often includes spraying of potentially harmful herbicides. In the long-term, removal of pine straw fuels may also alter fire regimes, actually preventing even a low intensity fire from occurring in some cases, and therefore negatively affect fire-dependent species.

Merchantable timber does not normally grow in wetter habitats, including pocosin, bog, and pond pine flatwoods, so species in these habitats should not be directly affected by timber extraction. A buffer zone (100 ft) between the ecotones of these habitats and forestry operations should be observed: The heavy machinery used to harvest trees in adjacent habitats can negatively impact distant hydrology.

Timber harvest which shifts forest stands toward longer rotations and replaces off-site pines and hardwoods with longleaf pine should help restore natural fire and nutrient dynamics in flatwoods and pine-hardwood stands. But the use of heavy machinery for timber extraction could destroy plant populations, compact the soil, exacerbate erosion, and alter the hydrology of wet habitats. As described below (Chapter 4, Extractive Land Uses), timber management that employs indefinite rotations, group selection and shelterwood methods, and natural regeneration, should minimize many of the adverse effects possible in timber harvest. In general, best management practices should be used to avoid the negative impacts of forestry operations, and all activities should be avoided within 100 feet of embedded wetlands.

Training Restrictions

Restrictions on training activities within HMUs, to the extent that they minimize disturbance to vegetation and soils, should benefit all plants. Vehicular activities, road maintenance, and road expansions can threaten nearby plant populations. Roadside rights-of-way in mesic areas are essentially artificially maintained, open wet savannas. Mowing which is not restricted to the dormant period of the vegetation may interfere with reproductive cycles. Road maintenance, such as ditching and scraping, and road widening could physically impact rare species which may become established in wetland habitats at roadside sites (e.g., *Dionaea muscipula*, *Tofieldia glabra*). Vehicular traffic on roadways should be monitored to prevent these threats.

Off-road traffic should be prohibited as it is highly deleterious to ground cover, soil structure, and hydrologic patterns. Many of the bog, savanna, and wet ecotonal species are shallow rooted and are susceptible to drying from surface ditches caused by vehicle tires. Where off-road traffic is unavoidable, it should be prohibited from within 100 ft of sensitive plant populations and wetland boundaries.

Additional Elements of Concern

One of the objectives of this project was the development of integrated management strategies for threatened, endangered and candidate species associated with RCWs which will ultimately provide for an ecosystem oriented approach to species management. With this view in mind, several additional species and species groups should be addressed in any assessment of management options in the longleaf pine ecosystem.

Wiregrass (Aristida stricta)

Wiregrass is recognized as the characteristic ground cover species of the longleaf pine ecosystem. Along with pine needle litter, it is the primary fuel for the frequent fires which historically maintained these communities. Wiregrass habitats are floristically rich and contain numerous low-growing herbs and shrubs (Walker and Peet 1983, Clewell 1989). It is found across the landscape, from the driest sandhills under turkey oak (*Quercus laevis*) to seasonally wet flatwoods and bogs. Thus, wiregrass substantially affects the structure and composition of the ecosystem. Management programs for RCW which aim at the overall protection of the longleaf pine ecosystem must consider the potential impacts on this keystone species.

Clewell (1989) suggested that the longleaf pine-wiregrass ecosystem is somewhat forgiving of disturbance and that it can be restored with proper management as long as wiregrass ground cover is maintained. However, once that is destroyed by clearing for development, plowing for agriculture, or site preparation in forestry, wiregrass seldom recolonizes because of its negligible reproductive capacity (Clewell 1989). Summer burning may be the only means of producing adequate wiregrass seed to potentially repopulate former habitats. When wiregrass is lost many of the characteristic species of the ground layer are lost as well (Noss 1989).

RCW management prescriptions can be used to promote the stewardship and recovery of wiregrass within HMUs. Restoration of periodic growing season fire, hardwood midstory control, and lengthened rotations in forestry operations are likely to positively affect wiregrass populations. However, use of mechanical site preparation, artificial fire breaks in management of prescribed fires, and pine straw raking have the potential to increase soil disturbance, promote soil erosion, and disturb or destroy wiregrass root mats. Brush and litter clearing around RCW cavity trees to protect them during prescribed fires may also damage wiregrass roots.

Management and use of lands which support established wiregrass ground cover should be limited to activities that foster the persistence of wiregrass as a dominant species (Clewell 1989). Such a policy does not preclude extractive timber harvest or training, but it should discourage pine straw harvest in many areas. Tree harvesting and planting activities should minimize impacts to wiregrass and other ground-layer species. Natural regeneration of longleaf pine in managed stands should effectively eliminate site preparation in most cases. Summer burning should help to encourage seed production and reduce shrub competition. Management to perpetuate wiregrass populations and protect their integrity should be extended to all areas within HMUs.

Fox Squirrel (Sciurus niger)

The ultimate goal of management for RCW on Army installations should be the maintenance of the longleaf pine ecosystem upon which the species depends. By its adaptations for feeding on the large cones of longleaf pine and for moving across broad savanna openings, the fox squirrel is particularly representative of old growth longleaf pine communities and appears to play an important role in the natural regeneration of longleaf pine stands by spreading the spores of mycorrhizal fungi (P. Weigl, pers. comm.). In addition, high quality habitat for eastern fox squirrel is characterized as longleaf pine-turkey oak sandhills, with large areas of mature longleaf pine forest forming a mosaic with other pine forest, mixed pine-hardwood forest, and mature bottomlands with numerous mast-producing trees. Because of its large size, and consequent large home range, and its dependence on mature forest stands, the fox squirrel integrates the needs of many other plants and animals dependent on this shrinking resource. Finally, recent information indicates that fox squirrel numbers are declining over much of its range, apparently due in part to habitat loss and degradation which has led to competition with more numerous, and energetically more efficient, gray squirrels (*Sciurus carolinensis*).

Despite the growing concern among many researchers over the status of the fox squirrel in the Southeast, present population levels are not well known. Decline of fox squirrel numbers in the Southeast is intimately related to the status of the remaining longleaf pine habitats upon which it depends. While human modification of the landscape has benefitted western fox squirrels (Weigl *et al.* 1989), eastern fox squirrels have generally suffered. Their large body size requires substantial food supplies and large nesting cavities which are found in open stands of mature, mast-producing trees. When these forests are logged, the second growth woodland which replaces these habitats, often with a dense understory, provides less of both key resources and also places a large cursorial species like the fox squirrel at higher risk of predation and at a competitive disadvantage to the smaller, more numerous gray squirrels. Persistence of fox squirrel populations depends on the preservation of large tracts of remaining forest, restoration of disturbed forest, and provision of habitat linkages to obviate fragmentation of squirrel populations.

Competition and predation pressures on eastern fox squirrels increase as the acreage of preferred mature pine-oak forest is reduced and fox squirrels are forced into bottomland and successional forest, pine plantations, and developed areas. In addition, where large gray squirrel populations increase the prey base, sympatric fox squirrels may suffer higher predation, which an animal with low reproductive rates may not be able to support. Consequently, as the fox squirrel is forced into marginal habitats which favor other sciurids, they may be eliminated.

In general, management recommendations for RCW habitat would apply equally well to the fox squirrel. In particular, institution of a regime of growing season fires on a 2 to 3 year rotation to control the hardwood midstory, maximize the regeneration and growth of ground cover, and prepare a suitable seedbed for longleaf pine, is important to the maintenance of fox squirrel habitat as well. Reducing physical impediments to burning, including roads and habitat fragmentation, would help reduce the isolation of squirrel subpopulations. Also, the use of uneven-aged timber management with no rotation age, would help provide contiguous areas of foraging habitat for both squirrels and woodpeckers.

However, Weigl *et al.* (1989) point to a number of instances where woodpecker management and fox squirrel management may conflict. The primary difference between the woodpecker and the fox squirrel lies in the provision of hardwood forest habitats for the squirrel. Eastern fox squirrels are highly adapted to and dependent on limited food supplies, so that anything which diminishes the quantity or quality of that habitat can have devastating effects. Removal of all or most of the larger oaks and hickories from among the older pine-oak stands would have significant adverse effects on food supply and nest cavity availability for fox squirrels. The low diversity and seasonality of resource availability typical of their habitat requires large areas to support fox squirrel populations and reduce potential conflicts with gray squirrels, which are better adapted to exploit hardwood forest and wetland areas.

Other Mammals

The largest animals which may occur on installations which support RCW populations are the Louisiana black bear and Florida panther. Both are unlikely to occur sympatrically with RCWs on the installations. Historical accounts suggest that black bears were common in longleaf pine areas, where they apparently fed on berry-producing shrubs and hardwood mast (Rostlund 1960, Landers *et al.* 1990). However, given the current restricted distribution of Louisiana black bears and Florida panthers, they are unlikely to occur within ¾ mi of colony sites. While RCW management could negatively impact bears through reduced escape cover and hard mast, in some instances where forest management sets back successional processes, it could increase herbaceous forage and some soft mast production. In general, however, the direct impacts of RCW management on these species are expected to be minimal.

Most bat species require a permanent water source (ponds, lakes, or slow-moving streams) as foraging habitat. Bats also use adjacent wooded bottomlands as roosting habitat during foraging and to escape predation. Gray bats (*Myotis grisescens*) roost year-round in caves, with few exceptions (Hall and Wilson 1966, Barbour and Davis 1969, Tuttle 1976). However, forested floodplains and riparian areas are important summer habitats for both the Indiana bat (*M. sodalis*) (Humphrey *et al.* 1977, Brack 1989, Garner 1991) and the southeastern myotis (*M. austroriparius*) (Barbour and Davis 1969, Soule 1992), and may be important for Rafineque's big-eared bat (*Plecotus rafenesquii*) (Barbour and Davis 1969). Garner (1991) reported that Indiana bats make extensive use of upland forests as well. Brack (1989) pointed out that, despite efforts to protect winter hibernacula and riparian habitats in the summer range, Indiana bat populations continue to decline. He suggested that protecting the riparian forests was inadequate and that protection efforts must extend to the adjacent uplands. Similar measures are probably appropriate for other species.

The bat species considered here may be found during migration or during summer maternity roosting in longleaf pine habitats, although they are more likely to be found in bottomland or other riparian areas that provide suitable foraging habitat. The RCW Guidelines are unlikely to directly affect any of these species. However, summer roosts should be identified and maintained in as natural a state as possible. Retention of large snags, particularly hollow trees, both hardwood and pine, should be practiced within 100 ft of wetland margins. Firewood cutting should be prohibited in wetland forest areas.

Raptors

Bald Eagle (Haliaeetus leucocephalus). While found throughout the Southeast, the Bald Eagle is generally a transient species on most of the installations subject to the Guidelines. Nesting sites are limited primarily to peninsular Florida and, to a much lesser extent, coastal Louisiana, Mississippi, and South Carolina. Nesting habitat is generally associated with large, usually living, trees within two miles of large bodies of open water. Foraging habitat includes large bodies of water with nearby trees for perching and roosting. Foraging is almost always near estuaries, lakes, large ponds, open marshes, larger rivers, and shorelines. Such habitats may abut RCW clusters, but are unlikely to be directly affected by RCW management activities. Protection of relict and older age-class trees, extended rotation ages, and midstory control will maintain open stand conditions and mature trees for roosting and nesting.

Eagles are known to have nested on Fort Stewart in 1993 and are known to occur on Fort Benning, where a potential nest site was identified. The site on Fort Benning is located more than a mile from the nearest RCW cluster site and is unlikely to be affected by RCW management activities (USACERL 1994). If monitoring confirms nesting at either location, controlled burns should be managed to minimize the potential for invasive smoke interfering with breeding activity during the late winter and spring. Other potential disturbance could result from human activity near roosts or nests incidental to RCW forest management.

The Bald Eagle is a protected species and any activity which could potentially affect it is subject to review under the Endangered Species Act. A protection radius of 1500 ft is suggested around known nesting locations: a primary zone of 330 ft around the nest where all land use activities are prohibited; a secondary zone extending an additional 660 ft where no significant habitat modification is allowed, but where some human activity may be permitted; and a tertiary zone extending out 0.25 to 0.5 mi from the nest within which additional human activity may be allowed, as long as such activities are not visible from the nest. Similar protection zones of up to 0.25 mi are recommended for wintering and summer roosts in exposed situations, 330 ft where roosts are effectively screened (Green 1985, Hall and LeGrand 1989a).

Peregrine Falcon (Falco peregrinus). Peregrine falcons are uncommon migrants and winter visitors over much of the Southeast. Atlantic and Gulf Coastal areas generally see more birds than interior areas (Chamberlain 1974, Hall and LeGrand

1989b). Nests are almost always located on cliffs, with only a few records of nests in cavities in large (70 to 90 ft) cypress and sycamore trees. Nests are generally located near open water. It is unlikely that suitable nesting habitat will be found in areas supporting RCWs. The transient presence of this species makes it unlikely to be substantially affected by forest management for the woodpecker. Apart from protection of individuals, little direct management of the species during migration and wintering periods can be done. To the extent that RCW management promotes the creation of perching trees adjacent to open grassland areas (e.g., in open pine savannas), it should favor transient birds.

Southeastern American Kestrel (Falco sparvarius paulus). The American kestrel is the smallest falcon in the United States and is a permanent resident throughout the southeastern Coastal Plain (Potter *et al.* 1980). Its primary habitat is large open areas away from cultivated fields, often in open pine savannas and their margins (Hamel *et al.* 1982). They are cavity nesters, using either natural or man-made cavities, and often appropriating woodpecker holes. Cavities are found in trees > 12 in. (30.5 cm) in diameter. Kestrels hunt from perches and feed primarily on large insects, small mammals and birds. Their population status is uncertain over most of the species range, but the reasons for its apparently declining numbers are unknown (Hamel *et al.* 1982), although its insect diet may implicate agricultural chemicals. Forest management which restores open longleaf pine savanna and flatwoods habitats, favors lengthened rotations, and preserves larger snags and relict trees should favor this species. Habitat goals for restoration and management of RCW habitats should have positive effects on kestrel populations.

Neotropical Migrant Songbirds

Longleaf Pine Avian Communities. The effects of red-cockaded woodpecker management and longleaf pine restoration have been of special interest as they affect various neotropical migrants that have been demonstrating marked and widespread population declines (Holmes *et al.* 1986, Robbins *et al.* 1989). In particular, the elimination of hardwood midstory reduces vertical habitat structure, apparently the primary factor influencing avian species diversity and abundance (Johnston and Odum 1956, Noble and Hamilton 1976, Dickson and Segelquist 1979, Johnson and Landers 1982).

However, while few studies of the avifauna of old growth southern pine forests exist (Jackson 1988), Dickson (1991) suggested that pre-colonial longleaf pine forests supported a very diverse and abundant community of birds. For example, mature stands of natural longleaf pine are important habitat for breeding and wintering birds on the Apalachicola National Forest (Labisky and Hovis 1987). Fire-maintained longleaf pine flatwoods support a high diversity of vertebrates, including birds, due to the complex patterning of various community types within the pine forest (Johnson and Landers 1982, Stout and Marion 1993). Longleaf pine forests support more bird species, but far fewer total individuals, per unit of area than hardwood communities (Landers *et al.* 1990). In general, during the winter, summer-resident species migrate out of pine stands or expand their activity into mesic hardwoods (Briggs *et al.* 1982, Landers *et al.* 1990). Landers *et al.* (1990) suggested that such shifts out of pine communities may have been less common when larger acreages supported various post-fire stages of pine succession, including communities which supplied abundant soft and hard mast.

Effects of Midstory Control. Engstrom *et al.* (1984) monitored changes in the avian community of a mature longleaf pine forest during 15 years of fire exclusion and in a second longleaf stand that was fire-maintained. Within five years of exclusion, open habitat species (Eastern kingbird, loggerhead shrike, blue grossbeak and Bachman's sparrow) were eliminated. Within nine years, a dense shrub layer was well-established and species such as yellow-breasted chat and prairie warbler were lost. After a subcanopy of sapling oak was established, there was an increase in species associated with mesic woodlands (yellow-billed cuckoo, wood thrush, red-eyed vireo, hooded warbler). The ground-nesting and foraging guild of species, an important component of the open longleaf forest, was the first group lost. After 15 years, species richness was higher in the burned longleaf stand than in either the unburned stand or in a nearby stand of mature hardwoods.

Wilson *et al.* (1995) explicitly addressed the effects of RCW management on songbird communities on the Ouachita National Forest in Arkansas. RCW cluster site management included midstory and codominant pine and hardwood thinning, followed by dormant-season prescribed fire every 3 yr. Following cluster management, stands were characterized by open midstories with dense ground covers of slash, shrubs, vines, grasses and forbs. Posttreatment breeding bird densities were highest in twice-burned stands and lowest in control stands, while mean species richness did not differ among treatments.

Pine-grassland species (brown-headed nuthatch, pine warbler, chipping sparrow, and indigo bunting) were found in highest densities in burned areas. The eastern wood-pewee was most abundant in managed stands and was absent from control plots. The prairie warbler was most frequently found in thrice-burned stands. Ground/shrub foraging species increased in all treatments relative to controls, whereas midstory foragers and nesters were less common in burned stands than in controls. Ground nesting birds were more abundant in control stands, while shrub- and canopy-nesting birds were more abundant in burned stands.

Midstory removal and burning reduced the densities of birds that require hardwood-dominated habitats (ovenbird, whip-poor-will, black-and-white warbler), while species associated with forest edges and neotropical migrants associated with early successional or open forest habitats (eastern wood-pewee, chipping sparrow, indigo bunting, prairie warbler) appeared to benefit from treatments. Wilson *et al.* (1995) cautioned that brown-headed cowbird appeared most frequently in the first two seasons after a burn. The influence of this nest parasite on breeding birds in the southeastern coastal plain needs to be addressed.

Conclusions. Control of midstory hardwoods and pines may cause the elimination of certain forest birds from RCW cluster sites where they currently occur. However, neotropical migrant birds in the longleaf pine landscape tend to be species of forested wetlands that are not typically burned (Pashley 1994) (Table 10). Most of these species are unlikely to be adversely affected by RCW management as long as the habitats upon which they depend are undisturbed. Many of the species found in fire-suppressed longleaf stands (e.g., tufted titmouse, Carolina chickadee, blue-gray gnatcatcher, hooded warbler, black-and-white warbler, and red-eyed vireo) are species more typical of edges with or interiors of hardwood forests (Dickson 1981, Conner *et al.* 1983).

Table 10. Population trends (26-yr), by physiographic area, for selected avian species identified by the Southeast Management Working Group for Partners in Flight as in immediate need of management and/or monitoring attention.

	Physiographic Area[1]					
Species	**B1**	**B2**	**C1**	**D1**	**D2**	**Generalized Habitat**
Cerulean warbler *(Dendroica cerulea)*	(?)[2]	(?)	(?)	(?)	(?)	Deciduous woods, riparian areas
Swainson's warbler *(Limnothlypis swainsonii)*	+*	?	O	+	-	Swamps, bogs, stream bottoms
Prothonotary warbler *(Protonotaria citrea)*	+*	-*	-*	-*	-*	Wooded swamps
Wood thrush *(Hylocichla mustelina)*	-*	-*	-*	-	-*	Deciduous woodland
Northern prairie warbler *(Dendroica discolor discolor)*	O	-*	-*	-*	(-*)	Brushy pastures and low pines
Blue-winged warbler *(Vermivora pinus)*	NP	(-)	(?)	NP	NP	Woodland openings, undergrowth
Worm-eating warbler *(Helmitheros vermivorous)*	+	(?)	(+*)	O	(?)	Dry woods, undergrowth, ravines
Louisiana waterthrush *(Seiurus motacilla)*	+*	+*	+*	+	(?)	Brooks, ravines, wooded swamps
Hooded warbler *(Wilsonia citrina)*	O	+	+*	-	+	Woodland undergrowth, swamps
Acadian flycatcher *(Empidonax virescens)*	+*	-*	+*	-	-	Deciduous forest, ravines, swamps
Yellow-throated vireo *(Vireo flavifrons)*	+*	+*	O	-	O	Wood edges, brush, undergrowth
Yellow-billed cuckoo *(Coccyzus americanus)*	O	+*	-*	-*	-*	Woodlands, thickets
Eastern wood-pewee *(Contopus virens)*	O	O	-*	-*	-*	Woodlands, groves
Great crested flycatcher *(Myiarchus crinitus)*	O	+	O	+	-	Woodlands, groves
White-eyed vireo *(Vireo griseus)*	O	+	O	-*	-*	Woods edges, brush, undergrowth
Kentucky warbler *(Oporomis formosus)*	+*	O	+	-*	+*	Woodland undergrowth
Orchard oriole *(Icterus spurius)*	+*	+	-	-*	-*	Woods edges, shade trees

Source: Hunter *et al.* (1993).

[1] Physiographic area follows Hunter *et al.* (1993): B1 = South Atlantic Coastal Plain (GA, NC, SC); B2 = Southern Piedmont (GA, NC, SC); C1 = East Gulf Coastal Plain (AL, LA); D1 = West Gulf Coastal Plain (LA); D2 = Mississippi Alluvial Plain (LA)

[2] Trend designations follow Hunter *et al.* (1993):; NP = species not known to be present in the physiographic area; ? = present but trends unclear or no available data; +* = increase; + = possible increase; -* = decline; - = possible decline; O = no trend

Trends in parentheses refer to species occurring peripherally in the physiographic area.

Promotion of periodic growing season fires and pine thinning prescriptions can be expected to benefit pine-grassland species whose habitats are presently scarce in the Southeast (Stout and Marion 1993). Several temperate migrants (Henslow's sparrow) and permanent residents (Bachman's sparrow, brown-headed nuthatch, northern bobwhite), that are considered priority species by the Partners in Flight Southeast Management Working Group, are dependent upon fire-maintained longleaf pine landscapes. Restoration and reestablishment of longleaf pine can be expected to benefit a number of other avian species of concern in the Southeast including prairie warbler, great crested flycatcher, summer tanager, orchard oriole, and Eastern wood-pewee (Johnston and Odum 1956, Meyers and Johnson 1978, Dickson and Segelquist, 1979, Dickson 1981, Repenning and Labisky 1985, NCPIF 1994).

An ecosystem approach to managing landscapes must work to restore and manage for those community types best suited to and historically present on a given area (James 1994, Pashley 1994). Interior nesting species and those requiring hardwood forest may be excluded by longleaf pine management, but they are likely to find harborage in adjacent bottomlands and other areas which historically have supported hardwoods.

The severity of any adverse impacts of RCW management will depend on the intensity of the management regime and on its extent. The greatest change in the avian community in managed stands is likely to occur in the cluster sites where hardwood and pine midstory control and pine thinning are likely to be the most severe. In the foraging and replacement stands, where creation of RCW nesting habitat is not the primary emphasis, these impacts will likely be less drastic.

Ultimately, regional bird community diversity benefits from a mosaic of forest types in different successional stages. Species typical of longleaf stands are often ephemeral at a given site because resources upon which they depend vary greatly, both temporally and spatially, due to disturbance regimes. For example, Bachman's sparrow depends on herb and grass seeds which peak in abundance within a year or two following a burn (Landers *et al.* 1990). Similarly, various post-fire phases of vegetation, with consequent opening and closing of treeless areas, are likely to favorably influence kestrels, loggerhead shrikes, mockingbirds, and meadowlarks, among others (Landers *et al.* 1990). If longleaf pine management for RCWs is used to also establish an array of seral communities through the imposition of growing season prescribed burns and patchy burn regimes, it can increase the availability of diverse habitat types. This will improve conditions for many species over current situations where abrupt borders exist between older pine and hardwoods.

Cavity-dependent Wildlife

The community of cavity nesters performs a number of important ecosystem functions, including insect control, pollination, and seed dispersal (McFarlane 1992, Thill *et al.* 1993). Reduction of hardwood basal area in foraging and recruitment stands could potentially constrain availability of cavity substrates in RCW HMUs, with adverse effects on the suite of cavity nesting wildlife (Table 11). Reduction of hardwood relicts in drier forest areas, and preserving them only in bottomlands and in wetland stringers, could concentrate cavity-dependent animals into limited areas. For example, restricting the areas which support acceptable hardwood cavity trees places fox squirrels and flying squirrels (*Glaucomys* spp.) at a competitive disadvantage to more numerous gray squirrels in closed canopy hardwood stands (Doby 1984, Weigl *et al.* 1989, Taulman and Thill 1994).

Table 11. Cavity nesting birds that use snags in longleaf/slash pine forest stands.

American kestrel	Yellow-bellied flycatcher
Screech owl	Carolina chickadee
Barred owl	Tufted titmouse
Northern flicker	White-breasted nuthatch
Red-bellied woodpecker	Red-breasted nuthatch
Hairy woodpecker	Brown-headed nuthatch
Downy woodpecker	Carolina wren
Eastern bluebird	Great crested flycatcher

Source: Wood and Niles (1978).

Cavities may be occupied by different species, one after another, in a single season (McFarlane 1992). This rapid turnover in occupancy indicates the limiting nature of this important resource. Few southern forests currently sustain snag densities sufficient to support stable populations of cavity nesters. This is particularly true of those species which require snags ≥ 35 cm in diameter (d.b.h.), such as pileated woodpeckers (*Dryocopus pileatus*), red-bellied woodpeckers (*Melanerpes carolinus*), red-headed woodpeckers (*M. erythrocephalus*), and barred owls (*Strix varia*) (Carmichael and Guynn 1983, Harlow and Guynn 1983, McComb *et al.* 1986).

Walters (1991) pointed out that RCW recovery efforts were unlikely to be successful unless management increased the numbers of acceptable cavity trees to reduce the loss of existing clusters and promote the creation of new clusters. Consequently, management is often directed toward reducing competition for available cavities between RCWs and other cavity nesting animals. A number of the species in Table 11, including red-bellied woodpecker, northern flicker (*Colaptes auratus*), Carolina chickadee (*Parus carolinensis*), tufted titmouse (*P. bicolor*), white-breasted nuthatch (*Sitta carolinensis*), and great crested flycatcher (*Myiarchus crinitus*), are documented cavity competitors with RCWs (McFarlane 1992). Those species such as the pileated woodpecker which destroy cavities by enlarging them, can have a significant long-term effect on RCW territory acceptability and reproduction. Use of cavity restrictors can have some effect on species requiring holes larger than those of RCWs, but little effect on southern flying squirrels (*Glaucomys volans*) which do not need to enlarge existing RCW cavities (Weigl 1994).

Lack of available den trees and snags has been hypothesized to increase interspecific aggression between cavity nesters, including competition between southern flying squirrels and RCWs (Dennis 1971, Loeb 1993). Effects on RCWs may be exacerbated if lack of hardwood cavities adversely affects predators on RCW cavity competitors, such as the eastern screech owl, a secondary cavity nester which preys on southern flying squirrels (Rosenberg and Anthony 1992, Weigl 1994). Cutting of hardwood stringers in drains and stream branches, coupled with hardwood encroachment into pine forests with fire exclusion, brings RCWs in direct conflict with pileated woodpeckers for cavities (Ware *et al.* 1993).

In pine forests with scarce hardwoods, RCW cavities become increasingly important to other cavity nesters. Because only RCWs excavate cavities in living pine trees, management that seeks to significantly reduce numbers of mature hardwoods will both decrease suitable cavities for an array of species and increase eviction pressure on RCWs. Several authors have addressed the management of cavity substrates in forest stands (see Chapter 4, Hardwood *Control*, Managing Hardwoods within HMUs). In general, however, management efforts which focus solely on producing more suitable cavity trees for RCWs, while failing to insure the integrity of nearby mature hardwood areas (e.g., stringers, bottomlands, or isolated clumps of mature hardwoods distributed across the pine-dominated landscape) may result in unforeseen adverse effects on both RCWs and other cavity-dependent species which perform valuable roles in the longleaf pine ecosystem.

Mast-dependent Wildlife

Hardwood control and pine regeneration can be expected to have impacts on the availability of hard and soft mast upon which some wildlife species depend. While some midstory trees may benefit from opening the forest canopy through midstory control, other species of hardwood trees and shrubs may be greatly reduced through prescribed burning, midstory control, and conversion of stands to longleaf pine (Goodrum *et al.* 1971).

Many species of animals in the longleaf pine landscape are adapted to a relatively resource poor environment, with food distribution patchy both spatially and temporally. Longleaf pine produces substantial seed crops (mast years) only every five to seven years. Several larger species of birds and mammals are heavily dependent upon mast produced by hardwood trees during some or all of the year. Notable examples include fox squirrel, transient black bears (*Ursus americanus*), southern flying squirrel, gopher tortoise, and wild turkey (*Meleagris gallopavo*), as well as somewhat less well known species including the eastern woodrat (*Neotoma floridana*).

For example, availability of hard mast during the fall and winter is critically important to fox squirrels in the longleaf pine communities of the North Carolina Sandhills. Winter food supplies, and reproduction in the following spring, are closely tied to the quality of fall mast crops (Weigl *et al*. 1989). In dry uplands, hard mast is produced by a low diversity hardwood component dominated by turkey oak (*Quercus laevis*). The low diversity of hard mast producing species makes the supply of mast closely subject to vagaries of weather. Other sources of hard mast, such as mesic areas supporting hickory and other hardwoods, must be shared with smaller, more energy-efficient, and more abundant gray squirrels.

Similarly, shrub-produced soft mast is very important in the diets of birds during the non-breeding season (Dickson 1981) and for other transient wildlife such as the black bear. Wintering bird populations are typically larger than breeding bird populations in the Southeast and bird density, species richness, species diversity, and biomass in winter populations have been linked to availability of food resources (Labisky and Hovis 1987). Areas such as shrubby pocosins and seeps, as well as shrubby clumps in mesic and wet pine flatwoods are important sources of this mast. Published reports suggest mixed results of the effects of fire on mast producing shrubs and trees (Hamilton 1981). Prescribed burning at intervals shorter than 3 yr can lead to eradication of shrubs and hardwoods, substantially reducing fruit production. Repeated fires at intervals < 3 yr can also set back fruit set in some species of shrubs (Dickson 1981). However, Johnson and Landers (1978) and Landers *et al*. (1979) showed that a three-year fire return interval resulted in substantial increases in fruiting of huckleberries (*Gaylussacia* spp.), blueberries (*Vaccinium* spp.), and gallberries (*Ilex* spp.).

As in the previous discussion regarding cavity availability, management of mast-producing hardwoods, as well as fruit-producing shrubs, is not explicitly considered in the Guidelines. Provision for continued availability of these resources in areas managed for RCW populations, even in areas where current RCW population density requires intensive stand management, need not conflict with RCW management goals. Maintenance of existing mature hardwoods, particularly in wetland areas, a measured approach to hardwood management in HMUs (see Chapter 4, Hardwood

Control), and institution of growing season fires managed using naturally-occurring fire breaks (see Chapter 4, Prescribed Burning), represent relatively minor modifications to the Guidelines that may be used to promote the integrity of the longleaf pine ecosystem upon which RCW recovery depends.

Herpetofauna of Temporary Ponds

More than 60 species of reptiles and amphibians have been associated with longleaf pine-turkey oak sandhills. In particular, the temporary ponds found within sandhill and pine flatwoods communities are a critical, although often ephemeral, habitat for many important elements of the longleaf pine fauna (Stout and Marion 1993). Bailey (1990) described seasonal use of temporary ponds in sandhill habitats in southern Alabama by dusky gopher frogs (*Rana areolata sevosa*). Moler and Franz (1988) described a breeding assemblage of 16 anuran species in such wetlands in Florida. The smallest ponds tended to support greatest numbers of breeding individuals due to a lack of predatory fishes and insects. Dodd and Charest (1988) captured 39 species of reptiles and amphibians from a single 0.16 ha pond over 27 days. Dodd (1992) trapped 26 species of reptiles and 16 species of amphibians over five years in a temporary pond in longleaf pine sandhills. Between 62.5 % and 87.5 % of amphibian species and 65 % and 81 % of reptile species were captured in any one year.

The herpetofaunal use of isolated temporary wetlands is often determined by the microhabitats available in surrounding uplands, including the amount of bare ground, litter, shrub cover, and fallen woody material. Post-larval flatwoods salamanders (*Ambystoma cingulatum*) have been tracked as far as 1.7 km from breeding sites (Ashton 1992). The availability of these microhabitats is, in turn, determined by the frequency, timing, spatial patterning, and intensity of fire (Anderson and Tiebout 1993, Greenberg *et al.* 1994). Ecotonal areas around temporarily flooded wetlands are thus important habitats for many species breeding in standing water (Dodd and Charest 1988).

Red-cockaded woodpecker management which controls hardwood midstory and restores periodic growing-season fires to sandhills and flatwoods areas should have beneficial effects on herpetofauna associated with embedded wetlands and temporary ponds. However, the ephemeral nature of many of these ponds, with standing water present for only limited periods during the year, makes them vulnerable to accidental disturbance when dry. Vehicular traffic destroys pond-floor topography, destroys herbaceous vegetation, and can break the hardpan which seals the bottoms of such ponds, preventing water from draining away (see Stewardship Summary for *Rana capito*, Appendix B). Off-road vehicle use or poorly designed sand roads and fire lanes which pass through or adjacent to temporary ponds pose significant threats. Erosion from improperly maintained roads can result in sedimentation into temporary ponds through storm runoff. Finally, silvicultural site preparation which includes ditching or building berms in flatwoods can alter water levels and shorten hydroperiods (Vickers *et al.* 1985, Enge and Marion 1986, Riekerk 1987).

As discussed below (see Chapter 4, Extractive Land Uses and Chapter 5, Protection of Wetlands And Aquatic Habitats), forest management prescriptions proposed in the Guidelines should have an overall beneficial effect on many of the herpetofaunal species associated with temporary wetlands. However, ancillary activities in support of those prescriptions (e.g., site preparation in the restoration of longleaf pine to sites currently supporting off-site stands, proposed use of chemical methods for the control of hardwood midstory, and expanded training in certain circumstances) may have significant adverse effects only indirectly related to RCW management practices.

Aquatic Fauna

Threats to biodiversity in freshwater fauna are many: Removal of surrounding vegetation in a drainage system, or unwise use of trails and unimproved roads, which can result in siltation; increased temperature because of loss of shade; loss of nutrient inputs from falling leaves; and, increased chance of droughts and floods. Siltation destroys microhabitats on stream bottoms and suspended sediments reduce photosynthesis by algae and other plants upon which stream fauna depend for food. Sediments can also clog nets and hairs of filter-feeding animals. Dredging and channelizing streams remove structure and increase flow rates, destroying habitats and altering water chemistry.

Freshwater invertebrates are difficult to protect because they are small and frequently go unnoticed in cryptic habitats, many can be distinguished only by close inspection by a handful of experts, and the public does not empathize with invertebrates in the way that it does with birds and mammals (Fuller 1979, Morse 1979, Adams 1990). Animals which spend their lives within very small territories tend to be habitat specialists that are very sensitive to changes in their environments. For example, many insects have acquired particular behavioral traits that have enabled them to partition the resources in their environment, in some cases to the point of living only on certain sides of rocks or in certain parts of particular plants. Thus, even very small alterations of a waterway can eliminate a number of species (Morse 1979).

Freshwater Mollusks. This is a suite of species, including mussels and snails, critically dependent on the maintenance of the aquatic environment, both water quality and hydrologic regime. There are at least 13 listed or candidate species of freshwater mollusks known or potentially occurring on one or more of the installations subject to the Guidelines (Table 12). Of these, the Tulotoma snail (*Tulotoma magnifica*) is federally listed as endangered. Two species, the fine-lined pocketbook mussel (*Lampsilis altilis*) and southern pigtoe mussel (*Pleuobema georgianum*) have been proposed for federal listing. A total of 10 species are candidates for listing.

As a group, freshwater mollusks remain very poorly understood (Fuller 1979). The most drastically imperiled group are the Unionidae (bivalve mollusks). In North Carolina, for example, more than half of the known species have been declining and are considered candidates for listed status (SCFTM 1990). Unionid mussel life cycles make them particularly susceptible to pollutants and disturbances. They are filter feeders and their reproductive behaviors are intimately tied to water quality and often the availability of specific host fishes. Because males broadcast sperm, which is taken up by females in filtering, population densities must be maintained above a threshold to insure successful recruitment. For the near term, once a population is lost from a given stream, it is probably gone for decades (Adams 1990).

The primary threat to freshwater mussels in the Coastal Plain is probably the introduction of foreign substances into their habitats. Longleaf pine ecosystems tend to be nutrient poor so that the introduction of nutrients, through changes in land use or erosional siltation, can have significant effects on the fauna of pineland streams (Adams 1995). Coastal plain streams tend to be characterized by sandy bottoms and there are considerable gaps in our understanding of the ecology of the fauna associated with such substrates. Bottom sediments tend to be naturally re-arranged by storm events and unusual stream discharges. Mussels and other animals are probably adapted to withstand a certain degree of change in bed loads and suspended sediment. However, the effects of changes in stream discharge are only poorly understood, particularly resultant effects on immature life stages. Mussel colonies may persist for years but may fail to reproduce due to sublethal effects of habitat alterations on subadults.

Freshwater Fishes. The southeastern United States supports a highly diverse freshwater fish fauna. At least 490 species and subspecies of native freshwater fishes constituting more than 60 percent of all fishes known from the lower 48 states, occur in waters of the Southeast. In coastal drainages from the Savanna River to Lake Pontchartrain, 29 percent of the freshwater fishes are endemic (Warren *et al.* 1994). The Sandhills of North and South Carolina, and nearby areas of the Coastal Plain, are a particular site of endemism (Hocutt *et al.* 1986). Bailey (1977) estimated that the Lumber and Pee Dee River systems in the Sandhills supported 37 native species, of which 20 percent had restricted distributions. At least two species, the pinewoods darter (*Etheostoma mariae*) and Sandhills chub (*Semotilus lumbee*) are endemic (Rohde 1989).

Most species of freshwater fishes are threatened because of limited distributions or degradation of habitat (Loyacano and Gilbert 1979). Five species of freshwater fishes may occur on one or more of the installations subject to the Guidelines. Four of these species are unlikely to be affected by longleaf pine forest management for the red-cockaded woodpecker. The shortnose sturgeon (*Acipenser brevirostrum*) is a species of large tidal rivers and estuarine areas. The blue shiner (*Cyprinella caerulea*) is endemic to the Cahaba and Coosa Rivers in Alabama, Georgia and Tennessee where

Table 12. Mollusk species known from or potentially occurring on selected Army installations in the southeastern United States.

Species	Rank[1]	Possible or Transient Occurrence
Alasmidenta arcula Altamaha arc-mussel	C2	Fort Stewart
Elliptio marsupiobesa Cape Fear spike mussel	C2	Fort Bragg
Elliptio nigella Winged spike mussel	C2	Fort Benning
Elliptio shepardiana Altamaha lance mussel	C2	Fort Stewart
Elliptio spinosa Altamaha spiny mussel	C2	Fort Stewart
Fusconia masoni Atlantic pigtoe mussel	C2	Fort Bragg
Lampsilis altilis Fine-lined pocketbook mussel	PT	Fort McClellan[2]
Lampsilis binominata Lined pocketbook mussel	C2	Fort Benning
Planorbella magnifica Magnificent rams-horn snail	C2	Sunny Point Terminal
Pleurobema georgianum Southern pigtoe mussel	PE	Fort McClellan[2]
Stiobia nana Sculpin snail	C2	Fort McClellan[2]
Toxolasma pullus Savannah lilliput mussel	C2	Fort Stewart
Tulotoma magnifica Tulotoma snail	LE	Fort McClellan[2]

[1] Federal status rankings: LE = endangered; LT = threatened; PE = proposed for federal listing as endangered; PT = proposed for federal listing as threatened; C2 = candidate for federal listing as threatened or endangered.
[2] Species is known from waters in the vicinity of installation.

it inhabits large, clear, cool streams with gravel-rubble-small boulder substrates (Gilbert *et al.* 1979). The pygmy sculpin (*Cottus pygmaeus*) is known from only one locality in Coldwater Spring, a tributary of the Coosa River in northeastern Alabama (Boschung 1979). Finally, the bluestripe shiner (*Cyprinella callitaenia*) is endemic to the Chattahoochee and Flint Rivers in Alabama, Georgia, and Florida and is a species of larger streams with open, sandy or rocky bottomed channels and little aquatic vegetation (Bailey and Gibbs 1956, Gilbert 1992). None of these species is likely to occur in streams within areas managed for recovery of the red-cockaded woodpecker.

The Carolina pygmy sunfish (*Elassoma boehlkei*) is known from only two areas in the Waccamaw River drainage and one in the middle Santee River drainage of North and South Carolina (Rhode and Arndt 1987). Habitat for the species appears to be small, slow-flowing streams with mud-sand bottoms and considerable aquatic vegetation. It is also known from various human-altered habitats, including a roadside ditch, a flooded rice field, and a seasonal pond in lowland forest (Rohde and Arndt 1987). This species, as well as the pinewoods darter and Sandhills chub (both C2 species), may occur in streams which drain RCW management areas.

Effects of RCW Management Guidelines on Freshwater Fauna. Management activities directed at RCW recovery are compatible with and should not compromise sensitive aquatic habitats. To the extent that RCW Management Guidelines limit the spread of erosion and lead to stabilized herbaceous layers in adjacent upland areas, they should act to improve downstream habitats for sensitive freshwater mollusks, fishes, and other fauna. Prescribed burning using natural landscape features as fire breaks should open stream-side canopies and ensure proper insolation of stream waters. Increased insolation should foster the establishment of in-stream aquatic vegetation required for breeding and resting habitats for certain species. Fire management should avoid construction of plowed fire lines adjacent to stream corridors. All fire lines should be constructed to minimize erosion potential. Herbicides should not be used within 100 ft of stream corridors and aquatic herbicides should not be employed upstream of known fish habitats. Management prescriptions for the recovery of the red-cockaded woodpecker which insure protection of aquatic systems on managed areas should help promote the survival of these sensitive species (see Chapter 5: Integrating Ecosystem-based Approaches into Endangered Species Management on Southeastern Army Installations).

Wetlands

Forest management for RCW recovery is likely to have various direct and indirect effects on an array of wetland plant communities found within the longleaf pine ecosystem. Wetlands are scattered throughout the largely pine-dominated forest of the southeastern Coastal Plain, with complex patterns of soils, elevation, and hydrology creating a great diversity of aquatic, terrestrial and ecotonal plant and animal communities across the landscape (Christensen 1988, Stout and Marion 1993).

Institution of periodic growing season prescribed fires, to control hardwood midstories in cluster sites and foraging stands, would be of particular benefit to mesic and moist longleaf pine flatwoods and savannas which historically experienced fire on a frequency of 1-3 years (Ware *et al.* 1993). Suppression of fire promotes rapid shrub invasion, which can reduce or replace many of the herbaceous species typically found in the open savanna. However, high intensity and too-frequent fires can have adverse effects on some wetland shrubs in flatwoods and along the margins of pocosins.

Uplands and wetlands are juxtaposed over very short longitudinal distances (a few meters) and separated by very slight differences in elevation (a few centimeters) (Stout and Marion 1993). Heavy equipment, whether used for fire suppression, in training activities, or for timber or pine straw harvesting, can easily alter local hydrology and topography with detrimental effects on wetlands (Niering 1988). Digging of fire lines to suppress wildfires and control prescribed burns could significantly damage the topography and hydrologic patterns of wetlands. Fire lines are often located at the boundary between pine uplands and pocosins, often in an attempt to "protect" the adjacent wetland. This transition zone is also perhaps the most vulnerable to fire line disturbance, since it harbors a highly diverse herbaceous layer within a narrow band around the circumference of the pocosin. Similarly, excessive foot traffic, especially in less stable moist areas like the savanna-pocosin ecotone, or other habitat disturbance resulting from firewood cutting or training activities, can adversely affect sensitive wetland plants.

Seepage streams and streamhead pocosins are created in areas where deep, unconsolidated sands overlie impermeable layers of clay or limestone. Lateral groundwater flow along the hardpan eventually intersects a slope face, creating a naturally eroded basin. Similarly, hillside or seepage bogs occur in the slopes of ravines and hills in the upland pine forest. They are underlain by an impervious sandstone or clay layer that causes groundwater to constantly seep to the soil surface (Smith 1988). Such areas are often very small (< 1 ac up to several acres), but are intimately dependent upon local hydrologic patterns. Silvicultural site preparation or fire control activities which damage the underlying hardpan, jeopardize groundwater flows, or alter water chemistry can have irreversible negative effects or highly diverse plant assemblages (in excess of 100 species may be supported in bog communities).

Where sites are to be managed to reestablish longleaf pine, intensive mechanical site preparation can be very damaging to wetland herbaceous and shrub layers (Moore *et al.* 1982, Riekerk and Korhnak 1985). In adjacent uplands, removal of natural vegetative cover can promote the invasion of weedy species and contribute to degradation of wetlands through siltation and chemical runoff (herbicides and fertilizers).

In general, RCW habitat management activities described in the Guidelines would tend to have favorable short- and long-term direct effects on many of the wetland communities found in longleaf pine forests. However, to the extent that RCW management shifts other activities, including extractive uses, longleaf pine restoration or regeneration, and training, into sensitive wetlands and wetland ecotones, there may be adverse indirect effects on these systems (see Chapter 5, Protection of Wetlands And Aquatic Habitats).

4 Proposed Modifications to The RCW Management Guidelines

Hooper *et al.* (1980) listed five primary management objectives most important for the recovery of the red-cockaded woodpecker:

1. Retain existing cavity trees.
2. Provide trees for new cavities.
3. Provide adequate foraging habitat.
4. Control hardwood midstory in cluster sites.
5. Provide future cluster sites.

Costa (1992) suggested that RCW recovery on federally-owned lands will require implementation of several habitat management actions:

1. increasing rotation ages for pine forests,
2. installation or artificial cavities,
3. translocation of birds between existing and planned populations,
4. hardwood midstory control,
5. growing season prescribed burning programs, and
6. restoration of degraded and/or altered sites, such as restoring longleaf pine in stands where off-site pines have been established.

The following discussion addresses those aspects of the RCW Management Guidelines which are designed to meet these objectives and actions. A brief summary of the prescriptions found in the Guidelines is followed by a discussion of the rationale behind them and of some likely effects of their implementation. Suggestions are then provided for modification or augmentation of the prescriptions based on the habitat needs of co-occurring species of concern.

Habitat Management Unit (HMU) Configuration

Designating Habitat Management Units

Paragraphs III.H. and V.D. provide guidance for the designation of Habitat Management Units (HMUs): areas managed for RCW nesting and foraging, which include all clusters, areas designated for recruitment and replacement, and adequate foraging habitat necessary to attain and sustain the installation RCW population goal (**Paragraph V.D.**). Delineation of HMUs defines the future geographic configuration of the installation RCW population and also of installation management options.

The minimum amount of land needed for a single red-cockaded woodpecker group is the group's territorial area plus some fraction of the extra-territorial area*. The average size of territorial areas calculated by Hooper *et al.* (1982) was 86.9 ha. Year-round ranges averaged 70.3 ha and varied from 30-195 ha. Extra-territorial areas are estimated to average about 8.4 ha (Hooper *et al.* 1982) but may be as large as 30 ha (Hooper *et al.* 1982, Porter and Labisky 1986, DeLotelle *et al.* 1987). Hooper *et al.* (1980) suggested that 40 ha (100 acres) is the minimum area needed to sustain a group, while the Southeast Negotiation Network (SNN) (1990) suggested that minimum area requirements were on the order of 80-160 ha (200-400 acres). The minimum area likely falls within the general range of 40-160 ha (100-400 acres), but habitat quality influences the specific area requirements (Conner and Rudolph 1991a). SNN (1990) suggested that sites with fewer than 50 active clusters were potentially "sensitive" to the processes of extinction and proposed the following thresholds to measure population stability, with stability increasing dramatically at each level:

Level 1 A population with 0 birds but with potential habitat that could be occupied; minimum acreage requirements suggest an area of 40-160 ha is needed for a single group of birds.

Level 2 A small number of breeding pairs (6-7) that can be sustained for a 20-year period, or longer, even in an isolated condition; based on area estimates provided above, a population of this size would require about 240-1120 ha (600-2,800 acres).

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* Discussion of the habitat and management needs of the red-cockaded woodpecker includes information from: Cox, J. 1995. Draft Element Stewardship Abstract for *Picoides borealis*. The Nature Conservancy, Eastern Regional Office, Boston, MA.

Level 3 A "genetically desirable" condition of 25 active clusters capable of short-term viability (e.g., 50+ years); based on area estimates provided above, a population of this size would require a minimum area of about 1,000-4,000 ha (2,470-9,890 acres).

Level 4 A "desirable condition" of 400 breeding pairs to achieve long-term recovery of populations; based on area estimates provided above, a population of this size would require a minimum area of about 16,000-64,000 ha (35,520-158,080 acres).

Minimum area requirements must also consider the percentage of groups of solitary males in the population. This percentage will vary from site to site and has been reported to range from 10-35% (Walters 1990, James 1991). Minimum area requirements may need to be increased by 10-35% accordingly.

Given the large areas required by the bird, designation of the HMUs represents a long-term commitment to RCW management over very large tracts of land. For example, the U.S. Forest Service recommends minimum areas of between 100,000 to 150,000 ac in long-term management for support of 500 RCW groups in recovery populations (USFS 1995). On Fort Bragg and Camp Mackall, North Carolina, seven HMUs for RCW management have been designated totalling some 87,789 ac (Draft ESMP for Fort Bragg and Camp Mackall, 1994).

The Guidelines make distinctions in allowable management intensity in different stand types within HMUs (e.g., recruitment versus foraging stands). However, because entire HMUs will be managed for a long-term commitment to RCW recovery, the entire HMU should be managed using the same or similar levels of intensity, with the exception of less intensive hardwood control outside of clusters. Cluster area restrictions on extractive land uses (timber and pine straw) and on site preparation in forestry operations should also be extended throughout the HMUs (see below). In particular, replacement and recruitment stands are designated as areas that are to provide suitable nesting habitat for RCWs when existing clusters become unsuitable or to support new RCWs groups, respectively. Therefore, setting timber rotation ages in such stands that are any shorter than those enforced in existing clusters is counter-productive since this would delay their reaching conditions suitable for RCW colonization. In addition, recent research suggests that a mean age of 30 yr for pine trees in foraging stands may be the minimum acceptable limit required by foraging RCWs. Stands of younger age or in which there are not large numbers of older trees, may not provide adequate foraging substrates. In all cases, therefore, it seems prudent to extend the no-rotation age guidelines currently mandated in clusters and recruitment stands, to the entire HMU.

Recovery of RCW populations represents a long-term commitment of resources (designated recruitment stands may not support new populations for 50 or more years). The spatial and temporal scale of this commitment provides a valuable opportunity to achieve the effective stewardship of many other species and natural communities of concern which are found in the longleaf pine landscape. Modifying the Guidelines to erase many of the distinctions between clusters and replacement stands, between recruitment stands and foraging stands, will better enable managers to address endangered species concerns using a landscape perspective. With this in mind, they can also better manage for the array of candidate species that are dependent on the longleaf pine ecosystem which is often characterized by the red-cockaded woodpecker.

RCW Foraging Habitat

The Guidelines do not adequately address issues related to habitat fragmentation. Fragmentation is a primary concern in the management of most forest wildlife (Hunter 1990). The configuration and placement of RCW foraging habitat within HMUs offers the potential for reducing forest fragmentation, while providing various habitat types for an array of wildlife species.

Provision of adequate foraging habitat is necessary for successful RCW population management (Delotelle *et al.* 1983, Hovis and Labisky 1985, Conner and Rudolph 1991b, Loeb *et al.* 1992). However, woodpeckers forage in a diversity of forested habitat types that includes pines of various ages as well as some hardwood-dominated habitats (Hooper *et al.* 1980, U.S. Fish and Wildlife Service 1985). Hooper and Harlow (1986) found most stands used for foraging were >30 years, but above this threshold stand usage was highly variable. Birds will forage in areas with well-developed hardwood understory (Crosby 1971, Hooper *et al.* 1980, Wood 1983), but most foraging appears to take place on older pine trees or in open pine habitats (Hooper *et al.* 1980, Hooper and Lennartz 1981, Delotelle 1983) and RCW territories tend to be smaller in areas managed with fire to control hardwoods (Hooper *et al.* 1980).

Hooper and Lennartz (1981) reported foraging birds using living pines almost exclusively, and although birds did not avoid areas with a high percentage of hardwood trees, they tended to forage on scattered pines within such areas (Hooper *et al.* 1980, Hooper and Lennartz 1981). Extensive use of live pines was also reported in Ligon (1970), Nesbitt *et al.* (1978), Morse (1972), Wood (1983), and Skorupa and McFarlane (1976).

In general, 100 ac (40.5 ha) of good habitat (mature pine) may be sufficient for some groups, but may vary with habitat quality (up to several hundred acres for some groups in poor habitat. Adults bring food to nestlings from up to 700 yd (640 m) away from cavity trees (Hooper *et al.* 1980). The actual amount of foraging habitat available within each HMU is determined by the present age class distribution of the stands, pine stand stocking levels, and RCW population density (USFS 1995). Average foraging habitat equivalents set by USFWS are (Henry 1989):

1. at least 8,490 ft^2/ac basal area in pine stems > 5 in d.b.h.,
2. at least 6,350 pine stems ≥ 10 in d.b.h. and ≥ 30 yr old.

The goal is to provide the highest quality foraging habitat as close as possible to RCW cluster sites, rather than large areas of poor habitat. Foraging habitat must be:

1. within ½ mi of the geometric center of the cluster,
2. continuous and contiguous with the cluster, and
3. include only pine and pine-hardwood stands.

The size of non-foraging habitat which would make adjacent foraging habitat noncontiguous will vary depending upon the type of habitat, its configuration, the particular site characteristics, and the expected response of the individual RCW group involved. In general, a narrow hardwood stringer, road, powerline right-of-way, or small opening would not be a deterrent to foraging movements. A stand-sized clearcut, opening, or hardwood area; an extensive hardwood bottom; or a large river or lake would be a deterrent. In general, nonforaging habitat >10 ac or > 330 ft in width would make adjacent foraging habitat noncontiguous (Henry 1989).

Because RCWs appear able to accept an array of different stands as foraging habitat, managers should explore ways of developing foraging stands that can be managed to support the needs of other species on the landscape (e.g., to supply hardwood cavities and mast producing hardwoods and shrubs). Hardwood control is less critical in foraging stands than it is in the cluster, recruitment and replacement stands. Hooper (1994) suggested that three midstory hardwoods per acre would probably not be detrimental to RCWs in most cases. In foraging areas, up to 50 percent hardwoods in dominant and codominant classes "entirely acceptable" unless the restrictions on available land area requires an emphasis on production of mature pines in these stands.

Within the guidelines listed above, managers should attempt to place foraging stands adjacent to hardwood-pine stands or other areas supporting large hardwood basal area, such as large wetland systems. This would reduce habitat edge by allowing managers to avoid the juxtaposition of dissimilar stand types and ages. In addition, a mean age of 30 yr for pine trees in foraging stands should be considered the minimum acceptable limit. Recent research supports the idea that the number of older stems may be more important than the number of larger stems (Hardesty, pers. comm.: Walters pers. comm.). As with other areas within HMUs, no rotation ages should be set in foraging stands.

Deletion of Cluster Sites

Paragraph V.D.3. provides for the "gradual, long-term shifting of RCW sub-populations into more suitable areas [which minimize conflicts with installation missions/operations] through natural demographic shifting, recruitment, and in exceptional cases, augmentation and translocation (pg. 12)."

Since designation of HMUs, and recruitment and replacement stands in particular, assumes a long-term commitment to the management of RCW populations and their habitats, it would be proactive to also consider the habitat needs of other sensitive species. Managing for candidate species in the near term may help to prevent future listing of those species.

No clusters should be deleted from HMU management unless or until the other available replacement clusters are active. Simple availability of suitable cluster sites does not insure maintenance of the population (Walters 1991). As a rule of thumb, clusters should remain open until new clusters have demonstrated continual occupation for five years, with successful nesting in three of those years (Hardesty 1994). Closure of cluster sites, and consequent shifting of management goals within HMUs, should consider the potential effects of new management goals on species of concern found within the subject HMU. For example, are there unique features in the existing HMUs or cluster sites that will be lost if RCW management is discontinued (e.g., an area of temporary wetlands used as breeding sites by *Ambystoma cingulatum* or *Rana capito*, or a population of rare plants that is locally or regionally significant or a significant community occurrence?) Mapping the distribution of sensitive plant and animal species can assist in the selection of replacement HMUs and in the selection of existing HMUs which might be closed with the minimum possible impact on other species (see Chapter 5, Mapping RCW Habitat Management Units In An Ecosystem Context).

Hardwood Control

Midstory Management within HMUs

Paragraph V.E.1. stipulates that clusters and recruitment stands will be kept clear of dense midstory. Management should target an open, park-like pine stand. All midstory within 50 ft of cavity trees would be eliminated. Beyond 50 ft, some pine midstory would be left for regeneration and some selected hardwoods would be retained for foraging by species other than RCWs. Hardwoods should not exceed 10 percent of the area of the canopy nor 10 percent of the below canopy cover within cluster and recruitment stands. Hardwood stocking would be kept below 10 ft^2/ac basal area.

Hardwood encroachment has been implicated in the decline of numerous RCW populations (Walters 1991). It is believed that hardwood trees clustered around cavity trees provide gray rat snakes or flying squirrels, a potential nest predator and a potential nest usurper (Jackson 1974, Jackson 1978b), with access to cavities without having to cross fresh protective resin (Dennis 1971, Jackson 1974). Hardwood encroachment may also increase interspecific competition for cavities (Costa and Escano 1989), affect the flight path to a cavity (Wood 1983a, Kelly *et al.* 1993), or the quality of foraging habitat (Conner and Rudolph 1991a). Hardwood midstory encroachment has been associated with RCW cluster abandonment and with failure to initiate new clusters (reviewed by Hooper *et al.* 1991).

The USFWS RCW Recovery Plan (Lennartz and Henry 1985) recommends a hardwood density <4.6 m^2 (49.2 square feet) per ha, but lower densities are generally reported. Grimes (1977), VanBalen and Doerr (1978), Locke (1980), and Loeb *et al.* (1992) reported average hardwood basal areas of 1.53 m^2 (16.4 ft^2), 4.6 m^2 (49.2 ft^2), and 6.9 m^2 (73.8 ft^2) per ha, respectively. Loeb *et al.* (1992) developed a logistic regression model showing that the probability of abandoning a group of cavities increased considerably when the midstory basal area was >6.7 m^2 per ha.

Hooper *et al.* (1980) contended that proper RCW habitat conditions require that few or no hardwood should exceed 4.6 m (15 feet) in height, particularly within 15.2 m (50 feet) of cavity trees. When the midstory (hardwoods and pines) reaches heights level with RCW cavity openings, a high rate of cavity abandonment occurs leading to the eventual loss of the group (Hooper *et al.* 1980). However, a few hardwoods and shrubs < 15 ft (4.57 m) in height, widely scattered, do not appear to harm RCWs and can benefit other species. Preserving hardwoods requires continued management to prevent midstory encroachment on cavity trees.

Under the Guidelines, clusters and recruitment stands will receive the highest intensity of management to meet the reproductive needs of RCWs. Cluster sites would be managed to provide a source of new cavity trees. Hooper *et al.* (1980) estimated that some 4-9 % of all cavity trees die each year and other cavities become unusable for other reasons. The cluster site should encompass at least 10 ac to ensure a suitable number of well-spaced cavities (Hooper *et al.* 1980). Intensive hardwood and pine midstory control is probably justified in these areas which generally comprise < 20 % of RCW managed areas (Hooper 1994). In some cases, intensive midstory control, coupled with growing season fire, can be used in larger areas to improve conditions for Bachman's sparrow. Liu *et al.* (1995) demonstrated that such intensive management in fairly young pine stands (50 to 80 yr) could produce conditions approaching those found in the old growth stands normally favored by this species.

Prior to any midstory control activities around cavity trees, areas should be surveyed for the presence of populations or aggregations of sensitive plants or other critical habitats (e.g., wetlands, temporary breeding ponds). Locations of sensitive species and the boundaries of habitats should be flagged to avoid disturbance. For example, *Pyxidanthera barbulata* var. *brevifolia* (a C2 species) is commonly found growing on or adjacent to the bases of longleaf pines. Tall, mast-producing shrubs > 50 ft from cavity trees should be preserved. Hardwoods > 50 ft from cluster trees should be preserved in clumps where possible and larger, mast producing oaks should be preserved to provide habitat and food for other species. In HMU areas outside of cluster sites somewhat less stringent control should be considered that will provide: 1) hard and soft mast, 2) cavities for other species, and 3) reduce eviction pressure on RCWs (see below: Managing Hardwoods Within HMUs).

Hardwood control in cluster sites should rely on the use of prescribed fire. Use of fire is the most cost-effective means of controlling understory vegetation on the large areas needed by populations of red-cockaded woodpeckers (Robbins and Myers 1992). Fire also plays an important role in the life-histories of many plant and animal species characteristic of red-cockaded woodpecker habitat (Platt *et al.* 1983, Myers and Robbins 1992) (see below: Prescribed Burning).

Waldrop *et al.* (1992) studied the effects of different fire management prescriptions on loblolly pine stands in South Carolina. Their results suggest that it requires some 20 years of annual fires to completely eradicate hardwoods and create grassland habitats. Hardwood sprouts persisted after periodic summer or winter burns (fire return varied between 3 and 7 yr) even after 43 years of burning. Management of midstory vegetation in cluster sites should not attempt the eradication of hardwoods, but should simply control encroachment into RCW nesting areas. Prescribed burning carried out to eradicate hardwood understory rather than controlling it to desired levels can have significant adverse effects on bird communities (Wood and Niles 1978).

Mechanical and Chemical Control

Mechanical clearing of hardwood understory may be needed in some areas where fire suppression has occurred for many years and where fire by itself does not effectively eliminate an established hardwood midstory (Brender and Cooper 1968, Conner and Rudolph 1989). Fire is generally incapable of effective hardwood control of stems > 5 cm, however it will top kill and girdle stems < 12.5 cm d.b.h. (Waldrop *et al.* 1992). No guidance is provided regarding the methods appropriate within clusters and HMUs. Ancillary impacts on other species will likely depend on the intensity of the management procedure used. For example, roller chopping has been used effectively at Carolina Sandhills National Wildlife Refuge where hardwoods in cavity clusters have been chopped on a 5-year rotational basis (Richardson and Smith 1992). However, roller chopping may not be effective where stems are >10 cm, and it damages both ground cover vegetation and the root system of pine trees (Richardson and Smith 1992). As indicated previously, poorly targeted herbicides can have unexpected effects on the surrounding vegetation.

In all cases, midstory control, with the exception of some prescribed burns, should be done after the breeding season of ground and shrub-level nesting birds and of amphibians using temporary wetlands to avoid disturbance. Mechanical midstory control must minimize disturbance to soils and ground layer vegetation and should be avoided in mesic and wet pine flatwoods and in wetland-upland ecotones where equipment can create ruts which may alter local hydroperiods. No herbicides should be applied within wetlands or wetland ecotones and no broadcast application of herbicides should be made. Only spot application and injection should be used to minimize non-target effects.

In general, mechanical and chemical control are likely to have adverse effects on herbaceous layers. It is preferable to execute cool season fires to reduce fuel loads and bring the hardwood midstory under control gradually.

Managing Hardwoods within HMUs

The Guidelines make no provision for the protection of mature cavity- and mast-producing hardwoods within HMUs. A number of species are dependent on the availability of suitable nesting and roosting cavities, primarily in older hardwood trees and snags. Such species include the American kestrel and great crested flycatcher. Hard and soft mast produced by hardwood trees and shrubs forms a sometimes critically important part of the diets of many species including fox squirrels (Weigl *et al.* 1989). HMU management prescriptions should consider the potential impacts on species which require the availability of suitable mature hardwood trees as cavity substrates or sources of mast.

However, interspecific competition for existing RCW cavities may threaten some small RCW populations (Jackson 1978a, Harlow and Lennartz 1983, Rudolph *et al.* 1990b, Loeb 1993). As many as 56% of the cavities in a cluster may be used by species other than RCWs (Harlow and Lennartz 1983). The southern flying squirrel (*Glaucomys volans*) is perhaps the most common usurper of RCW cavities (Jackson 1978b, Harlow and Lennartz 1983, Rudolph *et al.* 1990, Loeb 1993), followed by (in approximate order of frequency of use) red-bellied woodpecker, red-headed woodpecker, eastern bluebird, northern flicker, great crested flycatcher, and tufted titmouse (*Parus bicolor*) (Jackson 1978b, Harlow and Lennartz 1983, Rudolph *et al.* 1990). Flying squirrels may occupy 10-21% of the cavities in some areas (Loeb 1993). However, there is little evidence of RCW predation by flying squirrels during the nesting season (Harlow and Doyle 1990) and the impacts of flying squirrels are being debated, at least for large RCW populations (Weigl 1994). Walters (1991) contends that flying squirrels represent a minor management problem since they do not enlarge the entrance of the cavity. Flying squirrels were the major competitor for nest cavities in Texas (Rudolph *et al.* 1990) and South Carolina (Loeb 1993), but competition was not thought to be a major factor influencing the stability of the woodpecker population in Texas (Rudolph *et al.* 1990).

Other woodpeckers may significantly modify cavities, and once a cavity has been modified, it is rarely used again by RCWs (Walters 1991). The pileated woodpecker is particularly destructive since it enlarges a large number of red-cockaded cavities (Jackson 1978a, Walters 1991). However, unlike RCWs, other woodpecker species are more generalized in their selection of habitat for foraging and nesting and make significant use of hardwood trees as foraging substrates, particularly in winter. Woodpeckers are very aggressive in defense of foraging and nesting substrates and tend to space themselves in the available habitat. Different species construct cavities that are as small as possible to avoid expropriation and build in the smallest possible limb, or on the undersides of limbs, for the same reason (McFarlane 1992). Reducing the availability of mature hardwoods removes these other habitats and increases the relative importance of RCW cavities for other cavity-dependent species. This leads to increased competition for these remaining cavities and puts increased eviction pressure on nesting and roosting RCWs.

Use of cavity restrictor plates (Carter *et al.* 1989) may be used to prevent other species from damaging or enlarging cavities. Carter *et al.* (1989) concluded that this management technique may be useful in various situations:

1. in developed areas where populations of cavity-nesting species are high and other management options are limited;
2. in clusters in which cavity enlargement is a problem, particularly by pileated woodpeckers;
3. in clusters with few cavities or few cavity trees;
4. in small populations where loss of cavities and reduction of reproductive output must be minimized; and,
5. in rehabilitated clusters where all existing cavities are enlarged already.

However, Weigl (1994) cautions that cavity restrictors have little effect on southern flying squirrels which do not enlarge RCW cavities.

In addition to lessening eviction pressure on RCW, retaining scattered overstory hardwoods, especially in RCW foraging stands, appears to increase the use of RCW managed areas by species such as red-eyed vireo (Masters 1995). Small clumps of understory hardwoods which commonly escape natural fires in pine flatwoods and sandhills (Rebertus *et al.* 1989) support birds, such as the white-eyed vireo, that are not normally associated with pine stands (Johnson and Landers 1982). Similarly, maintaining hardwoods in wet drainages and in small units within pine stands provides substrates for cavity nesting and bole gleaning species (e.g., prothonotary warbler), watch posts for raptors such as the American kestrel, and habitats for many uncommon species of neotropical migrants (Johnson and Landers 1982).

Therefore, care should be taken to protect scattered hardwoods, including clumps of hardwoods, in foraging stands where RCW nesting is not the primary concern. This is of particular value in areas adjacent to bottomlands and hardwood stringers, to avoid fragmentation of hardwood habitats, and in areas with no hardwoods at all. Removal of snags and trees with cavities reduces suitability of pine flatwoods for many species of wildlife (Marion and Harris 1981).

Dead pine trees may stand and be heavily used for five to 15 years, but some planning must be done to insure a continuing population of available snags (Wood and Niles 1978). Wood and Niles (1978) suggest a dead tree stocking of one stem per acre as highly desirable. Woodpeckers need from 14 (for pileated woodpeckers) to 160 (for hairy woodpeckers) cavities per 100 ac (Hunter 1990).

The Forest Service preferred alternative for RCW management (USFS 1995) permits retention of up to three desirable midstory trees per acre and up to 10 overstory, dominant and codominant, hardwood trees per acre in clusters. Reduction of hardwood midstory is called for outside clusters, but only within RCW management units. There is no restriction on the quantity of overstory hardwoods which can occur nor is the intent to totally eliminate midstory hardwoods. An average of three selected midstory hardwoods per acre can remain in cluster sites (e.g., dogwood, redbud, or other shrubby to midstory sized fruiting species).

Weigl (1994) suggests protection of 10 to 12 mast-producing oak trees per acre to insure production of adequate hard mast to support fox squirrels. Firewood cutting, particularly of oak trees > 13 in d.b.h., is a significant threat to provision of hard mast and should be prohibited in management areas.

Hooper (1994) points out that where cluster sites are a very small portion of the landscape (e.g., < 15 percent on the Francis Marion NF), it is probably ill-advised to create superior habitat for RCW competitors surrounding it. However, where cluster sites and recruitment or replacement stand boundaries include natural hardwood areas, including stream bottoms, stringers, and hardwood stands, hardwood trees in these areas should not be subject to control. Outside of clusters, recruitment stands, and replacement stands but within HMUs, reduction of hardwood midstory should be done in pine and pine-hardwood stands only to improve foraging habitat and should be done using prescribed fire where ever possible.

Landers *et al.* (1990) described the management of midstory scrub oaks in longleaf pine sandhills habitats. To provide adequate mast crops, they suggested large sandhills areas contain 10-20 percent coverage by clumps of mature scrub oaks with full crowns. A slightly greater percentage is suggested where narrow sand ridges provide the major source of acorns, but in all cases the scrub oak component should be confined to small groves (e.g., ¼ to 1 ac) surrounded by pine grasslands. Mast-producing oaks should be held less than 30 percent of total cover. Fire, set in varying fuel moisture conditions, should be used to attain the desired habitat conditions.

Managing limited forest resources for an array of competing uses has been an ongoing struggle for managers since the creation of wildlife science as a discipline in the 1930's. In the case of snag management in RCW HMUs, there are clearly situations where the needs of RCWs for suitable breeding cavities, free of competition from other species of birds and mammals, may be of paramount importance. However, hardwood and softwood snags continue to be a limiting resource throughout Southeastern forests, as evidenced by the intense competition among cavity nesting birds for the available snags. This increased competition for dwindling resources probably contributes to the competitive pressure on RCWs in longleaf pine stands where improper management has allowed the encroachment of hardwoods and where conversion to pine monoculture forestry has eliminated traditional habitats for other cavity-nesting species. Some modification of the RCW Guidelines can foster careful placement and proper management of RCW foraging stands, protection of existing hardwood areas, and judicious control of hardwoods in HMUs, coupled with the use of cavity exclusive devices in clusters. Maintenance of a continuous supply of snags indefinitely may require that small patches of old forest be preserved among younger stands (e.g., one 0.1 ha patch for each 2 ha of forest) (Hunter 1990). However, an adaptive approach should allow the proper balance to be struck between single-species management for RCW reproduction and ecosystem-based management of dead and dying wood and its many wildlife values.

Pine Beetle Control

Paragraph V.E.1.d. provides that trees within HMUs affected by pine beetles (e.g., *Ips* spp., southern pine beetle) infestation should be evaluated for treatment in consultation with the USFWS. Possible treatments include the use of pheromones and cutting and leaving, cutting and removing, or cutting and burning the infected trees.

Cyclic or patchy infestations of pine beetles may have been an integral part of the historic southern pine landscape. In any case, southern pine beetle infestation seldom kills all trees in a longleaf pine stand or even a majority of trees in most cases. Beetle infestation areas are seldom much more than a small fraction of RCW territories (McFarlane 1992). Pine beetle management involving clear-cutting of large areas or establishing cleared buffers around cavity trees can be detrimental to both the RCW population and the surrounding forest. Beetle depredations are elevated by fire suppression which creates stands that are multi-layered, over-stocked, and susceptible to infestation. Severity and duration of outbreaks could be returned to historical ranges of variability by reducing stand stocking and increasing spacing of trees. Jackson (1986) suggests that the control of pine beetles can best be accomplished through implementation of appropriate burn programs.

Where treatment is necessary, managers should choose to leave beetle-vacated trees in place as they may provide cavity and feeding substrates for an array of birds. Where RCW cavities are limited and competition from other species is a problem, cavity augmentation should be considered to reduce eviction pressure on RCWs. Leaving standing snags may provide cavity sites for many years and cutting them to reduce available nesting substrates for RCW cavity competitors will only increase eviction pressure on RCWs as remaining cavities become more desirable.

Prescribed Burning

Paragraph V.E.3. states that prescribed burning will be the primary method of hardwood midstory control. Burns will be conducted at least every three years in longleaf, loblolly, slash, and shortleaf pine systems. With the agreement of the USFWS, the burn interval may be increased to no more than five years after the hardwood midstory has been brought under control. Burning would normally be conducted in the growing season since the full benefits of fire are not achieved from non-growing season burns. Winter burns may be appropriate to reduce high fuel loads. Use of fire plows in clusters would be used only in emergency situations.

It is generally recognized that habitat conditions favored by red-cockaded woodpeckers are best maintained by growing season burns, every 2-6 years, because of enhanced control of hardwoods (Platt 1988, Robbins and Myers 1992, SNN 1990). Burning was probably the natural control method and serves other important ecosystem functions in the longleaf pine forest and surrounding habitats, including triggering reproduction in many plant species. Recent research at Fort Bragg, North Carolina, has shown that frequent growing season burns are very effective at achieving stewardship of different habitat types. In two years since growing season burns were initiated, dense, fire-suppressed pocosins were converted to open, species rich bogs and ecotones and overgrown uplands were converted to scenic longleaf pine savannas (TNC 1993).

While growing season burns probably represent the natural seasonal regime for southeastern pine forests (Platt 1988), a fire-management program must be tailored to the particular managed area and cannot be strictly held to a "growing-season-only" philosophy. Fire in any season is better than no fire at all (Robbins and Myers 1992), and dormant season burns may be preferred initially to reduce fuel loads and avoid hazardous or damaging fires. Fuel reduction burns should avoid consuming all forest litter and duff and altering structure and color of mineral soils on more than 20% of areas burned. They should use techniques designed to reduce soil heating (e.g., use of backing fires on steep slopes, scattering slash piles and heavy fuel accumulations). Sites that are severely fire-suppressed should first be burned in winter to reduce heavy fuel loads. Subsequent growing season burns should be done two to three years following the winter, fuel-reduction burn. Proper restoration of fire-suppressed areas may require a long-term commitment of time and effort. For example, particular caution must be employed when returning fire to severely fire-suppressed pocosins or bogs which may support sensitive species such as bog spicebush (*Lindera subcoriacea*). Overgrown, shrub-dominated sites often lack finer fuels which help to carry ground fires. Consequently, hot, very destructive fires are sometimes necessary to kill back the shrub layer. Since it is not clear how bog spicebush responds to hot fires, it would be more advisable to use several, low-intensity burns spread out over extended periods to reduce the shrub layer to more "natural" levels rather than using one hot, very destructive fire. If properly managed, areas will support future fires determined by fuel loads and other conditions.

Winter fires may serve other landscape purposes as well. Winter burns on a 3 yr rotation should be employed in flatwoods, but intervals of 5-10 yr in mixed pine-hardwood habitats to allow mast-producing species to reach fire-resistant size. Also, ecotones between pine and pine-scrub oak ridges and Carolina bays or hardwood swamps can be burned during the winter on a medium to long rotation to enhance production of soft mast (Hamilton 1981).

Burning should employ a variety of techniques and use both nongrowing season and growing season burns of varying fire intensities and prescription cycles to achieve management objectives. Variation in the frequency of fires in longleaf pine systems is important (but sometimes overlooked) since a longer fire interval (8-10 years) is occasionally needed to allow pine seedlings to establish (Robbins and Myers 1992). Areas with new trees should be excluded from the fire program for 12-15 years so that young trees can grow past the critical stage where a fire might kill them (SNN 1990). Robbins and Myers (1992) provide detailed guidelines for establishing burning programs in longleaf pine systems.

Burning to accomplish habitat goals may require burning whenever conditions permit, year-around. Prescribed burns should be coordinated with wildlife biologists to avoid adverse impacts to specific species (e.g., dispersing indigo snakes during winter and nesting Bachman's sparrows during growing season) and sensitive communities (e.g., during drought conditions, organic muck soils of bogs, along with subsoil plant organs, can be consumed or damaged by fire). Specific burning recommendations for species may be found in Species Stewardship Abstracts (Appendix B).

Managers should reduce the number of burn units and increase the size of burn units by closing existing fire breaks where possible. Use of natural firebreaks (streams, wetlands, lakes, etc.) should be encouraged wherever possible to reduce the impacts of constructing firelines. Larger burn units would result in more patchy fires, since touch ups and repeat burns would be less likely and natural fire breaks would modify the effects of the burn on different habitats. Natural fire tension zones (e.g., steep slopes, wetland edges) result in changes in natural fire frequencies.

Managers should attempt to restore conditions that could support frequent fires, rather than enforce a three or five year burn interval (Table 13). Natural fire return is a function of fuel loads, ignition sources, and prevailing weather conditions. Cluster management should strive to maintain an intact ground layer. In particular, avoid disturbance of wiregrass (*Aristida stricta*) and other grasses (e.g., *Sporobolus*) which provide the fine fuels necessary to carry frequent, low-intensity fires which would promote the open stands that traditionally were used by RCWs.

Fire may damage or destroy special habitat elements such as den trees (snags) and fruit/mast trees. Prescribed fire in Arizona ponderosa pine forests can cause a 45% net decrease in snags > 15 cm in diameter in the first year after burning. Snags >50 cm in diameter or that are in advanced stages of decay are especially vulnerable because of debris that accumulates at their base (Horton and Mannan 1988, Hunter 1990). Fire frequency and intensity can influence the fruit production of the forest understory: fruit production is often temporarily reduced when shrubs are set back by fire (Hunter 1990). Johnson and Landers (1978) in Georgia slash pine concluded that the maximum number of species fruiting occurs 6-10 yr after a fire and some species take 4 yr to reach peak production. A 3 yr interval between burns yielded best overall fruit production.

Table 13. Estimated fire return intervals in habitat types influenced by fire originating in longleaf pine forests (after Landers et al. 1990).

Habitat Type	Soil Type	Drainage	Topographic Exposure	Inferred Fire Return Interval
Sand pine-scrub	sandy	rapid	very low	20-100 yr
Sandhill	sandy	rapid	moderate	3-20 yr
Longleaf pine savanna	loamy-sand	moderate	high	2-4 yr
Longleaf pine flatwoods	sandy	slow	high	2-4 yr
Slash pine flatwoods	sandy	slow	moderate	5-10 yr
Canebrake	sandy	slow	moderate	5-7 yr
Herb bog	sandy-peaty	slow	moderate	periodic
Freshwater marsh	sandy-peaty	very slow	moderate	periodic
Baygall	sandy-peaty	very slow	low	12-16 yr
Shrub-pond pine bog	sandy-peaty	very slow	low	10-20 yr
Swamp forest	sandy-peaty	very slow	very low	25-33 yr

These examples suggest that, rather than addressing the specific needs of a single species (e.g., midstory control in RCW cluster sites), fire management should be conducted in an ecosystem context: managing fire as a natural agent to maintain the integrity of ecosystem processes across landscapes. A fire management plan of this sort suggests a series of broad objectives (from Babb 1990):

1. reduction of hazardous fuels through cool season burns;

2. maintenance of habitat for rare plant and animal species;

3. maintenance of rare fire-adapted natural communities;

4. creation of a vegetation mosaic by varying the intensity, frequency, and timing of burns within each of the fire-maintained natural communities;

5. maintenance of natural transition zones between vegetation types;

6. use of fire as a disturbance agent in non-pyrophytic vegetation types to create patches of vegetation in different stages of development, maintaining and enhancing habitat diversity;

7. reintroduction of growing season fire regime; and

8. stimulation of flowering of herbs and forbs.

Many species require particular strategies to insure their persistence in managed environments. For example, in managing for rare insects, Hall and Schweitzer (1993) recommended prescribed burns that create patch heterogeneity so that the species that are unable to escape fires will be able to persist in and recolonize from unburned sites. Prescribed burns in areas which harbor rare insects should be modified to include activities which promote small-scale habitat heterogeneity (Wheaton 1995):

1. Divide the HMU into small multiple burn units. Burn only a fraction of the HMU or management area during a given season. Recommendations vary from setting aside half of the area to two-thirds, so only one-third of a burn unit (not an entire HMU) would be burned in a given year. Adjacent units should not be burned consecutively so that the insects will be able to move easily from one area to another.

2. Information regarding the location of insect populations should be used to determine which areas to burn during a given year.

3. An attempt should also be made for each burn unit to contain populations of food plants, nectar sources, or other habitat features necessary for the insects. Where these features are concentrated in only one part of an HMU or burn unit, that area should be handled with special precautions such as wetting down the areas of critical importance to the rare insects.

4. Allow sufficient time for colonists to spread out from unburned refugia. Recolonization may take several years so that adjacent units should not be burned in successive years and that burned units should not be re-burned before they can serve as significant recolonization sources for other burn areas. This automatically imposes a 4-yr burn cycle in areas where only 2 burn units are used. Where the area is divided into 3 burn units, the burn rotation may be reduced to every 3 yr. Again, specific information on the individual species population size and status should be used to modify the rotation schedule.

5. Fires should be intense enough to reduce midstory and shrub layers, but not kill host plant foliage.

6. Reduce the use of backfires since they travel more slowly and are hotter than headfires.

7. Prohibit the re-torching of skipped areas, particularly in wet sites (Panzer 1988). Particular restraint should be used in burning shrubs occurring in wet swales and in pockets of pocosin or swamp forest habitat because these sites harbor several rare species including flightless grasshoppers (*Melanoplus* spp.) and several moths.

Similar management strategies may be effectively employed for reptiles and amphibians. Maintenance of habitat patches with varying times since they were last burned appears to be important in structuring the herpetofauna inhabiting the longleaf pine forest, since not all species require the same habitat conditions (Campbell and Christman 1982).

Protecting RCW Cavity Trees

The loss of active clusters coupled with the lack of new group formation have been serious obstacles in RCW recovery efforts (Walters 1991). Some cavities can be lost to the prescribed fires required to maintain appropriate habitat conditions. Cavity trees are extremely susceptible to burning because of volatile turpenes in abundant, fresh resin flows (Conner and Locke 1979, Stamps *et al.* 1983).

Stamps *et al.* (1983) suggested low intensity procedures to protect cavity trees from fire that would also maintain natural ground cover. They raked away combustible materials and set back fires on the leeward side of each cavity tree. This created head and flank fires burning away from the tree, and these were controlled in turn by back fires being set concurrently on the leeward end of the timber stand. When the leeward cavity tree was secured, areas around the other cavity trees were secured using the same method. Temperature readings monitored in two nests did not threaten nestlings. More recently, a fire-retardant foam has been used as an effective fire break in situations where maintenance of ground cover is important. This foam can be used to protect cavity trees as well. The foam is a detergent-water mixture that is aerated and applied prior to a burn. The foam increases the moisture content of plants to the point that they do not burn, and it also impedes the fire directly.

Burning should be monitored closely where it has the potential for damaging dead standing trees. Fire protection should be considered for inactive cavity trees and other snags, including hardwood snags. Loss of such snags to fire could increase eviction pressure on RCWs. Standing snags are also important habitat substrates for many species of birds and several species of reptiles (Wilson 1994).

Fire Management

Fire planning and fire management becomes increasingly important as the goals of the fire program become more complex. Prescribed burns should follow a site-specific fire management plan which details ecological and technical information needed to determine whether a prescribed fire is ecologically justified and technically feasible. A fire plan should:

1. define and justify burn units and burn schedules;
2. describe site-specific fuel conditions and burn prescription parameters; and,
3. stipulate site-specific fire management operations.

Smoke management is important to prevent adverse public health impacts that could jeopardize acceptance of habitat management. Fire management planning should include tactics to reduce or control smoke, including rapid ignition, accelerated mop-up, and avoiding burns during stagnant weather conditions or when weather predictions suggest adverse impacts to surrounding areas.

Fire control vehicles should stay as much as possible on roads and firebreaks. Off road areas pose hazards to vehicles and occupants and are often sensitive to disturbance (e.g., wetland soils). Creation of fire lines should employ discing rather than plowing to promote regeneration of natural cover after fire control operations are completed.

Because the location of fire control lines can have significant adverse impacts on an array of wildlife habitats and natural communities, restrictions on use of fire plows should be extended to all areas of the HMUs. The Natural Resources Management Plan for Eglin Air Force Base (USDOD/DAF 1993) devotes considerable coverage to this issue. Fire management should adopt low-impact procedures where ever possible:

1. Avoid location of fire lines in soils with high erosion hazard and on steep slopes except in emergency situations.

2. Use existing control lines where ever practicable to avoid creation of new lines.

3. Existing trails and unimproved roads should be cleared or skimmed for use as fire control lines where ever practicable to minimize creation of new lines.

4. Location of new lines should be done to avoid impacts to sensitive habitats:

   a. Avoid wetland edges and in general avoid placement in habitat ecotones.
   b. Avoid placement within 100 ft of streams.
   c. Avoid placement in areas supporting wiregrass (*Aristida stricta*) communities.
   d. Use alternative methods for securing control lines in sensitive areas (e.g., hose lays, handlines).

In emergency situations, use backfires from roads, fencelines, and field edges. High impact techniques, such as plow lines and retardants, should be restricted to installation perimeters as much as possible. Where plowed fire lines are unavoidable, they should be located to minimize adverse impacts (USDOD/DAF 1993):

1. Use the minimum number of plow lines necessary to contain the fire.

2. Fire plow lines depth should be no greater than the minimum needed to contain the fire.

3. Avoid location of fire plow lines in habitat ecotones unless absolutely unavoidable. In wetland areas, offset fire lines up slope of wetland edge.

4. Fire plow lines should be oriented to follow slope contours and maintain the integrity of local topography.

5. Fire plow lines should not be located within 200 ft of RCW cluster sites unless the hazard from the fire exceeds the expected impact from plow line construction.

6. Fire plow lines should not cross or merge with waterways or riparian zones, be placed down slope at right angles to steep slopes unless required by the emergency.

7. All emergency plow lines located in sensitive areas or in highly erodible soils should be stabilized or restored immediately after emergency fire suppression.

A post-burn evaluation should be conducted within two weeks to compare the results with management objectives. This provides feedback for planning future activities and to modify planning where objectives are not being met. The effects of burns should be closely monitored so that new occurrences of species may be documented. In addition, the most suitable fire frequencies and regimes for many species are either unknown or poorly known and monitoring can supply data necessary for appropriate adaptive management.

Extractive Land Uses

Timber Harvest

Where there are no other competing land uses, forest management for RCW cavity production and foraging habitat requires simply that stands be burned regularly and allowed to age naturally. Where timber production must be supported, as on the national forests, logging operations place constraints on the management options available. Timber harvest generally has an adverse effect on populations of red-cockaded woodpeckers. However, there are situations where timber operations can be made more compatible with RCWs and where the reestablishment of suitable habitat conditions for RCWs may be aided by certain timber operations. This may be particularly true in areas that are heavily stocked with dense pine and hardwood (Loeb *et al.* 1992).

Paragraph V.F. provides that timber harvesting in HMUs will be permitted if consistent with the conservation of the red-cockaded woodpecker. Harvest methods are required to maintain or regenerate the historical pine ecosystem, described as old growth longleaf pines in an uneven-age forest, with small (¼ to 5 ac) even-age patches varying in size. Timber harvesting is required to achieve and maintain historical conditions through the emulation of natural processes.

Timber harvest in HMUs should be considered if it will not adversely affect RCWs and their habitat. Stewardship of HMUs should not be driven by an attempt to practice multiple-use management in the HMUs. The first goal of any silvicultural operations should be to restore longleaf and loblolly stands within HMUs to suitable RCW habitat and to avoid the fragmentation of that habitat. After that has been achieved, the suitability of any stands within the HMUs for limited harvest may be assessed. Timber harvest not designed to meet the needs of RCW management should be directed to other stands, such as off-site stands scheduled for conversion to longleaf pine.

Rotation Lengths. The Guidelines mandate that no rotation lengths are to be set in cluster sites or replacement stands. In other areas of the HMU, rotations are to be lengthened to 120 yr for longleaf pine and 100 yr for other species. These requirements fall within the ranges suggested for situations where RCWs must be managed in conjunction with forestry operations (Lennartz and Henry 1985, SNN 1990). However, if designation of HMUs represents a long-term commitment of resources to the recovery of RCW populations, it seems prudent to extend the no-rotation age guidelines to the entire HMU, including areas outside of clusters and replacement stands. Habitat Management Units should provide sustainable RCW nesting and foraging habitat for the long-term, rather than provide multiple uses. Managing HMUs to maintain ecosystem process integrity will also benefit other species of concern, thus ameliorating any adverse effects of future demographic shifting of RCW clusters required to avoid installation mission conflicts.

However, there are serious deficiencies in the age class distributions of forests currently managed for RCWs (Hooper 1995, pers. comm.). For example, longleaf pine stands on Fort Bragg and the Sandhills Gamelands in North Carolina are approaching single-aged forest conditions, with the majority of stands 80 yr of age and with little regeneration present to replace current RCW clusters in the next 50 yr (Sharpe 1995, pers. comm.). Simply extending rotations or eliminating them can provide relatively large amounts of habitat in all parts of the HMU for some period of time. However, timber harvests may make available habitat conditions highly cyclical. The current unbalanced age distributions in forests are the result of past exploitative harvests. Without some guidelines for correcting and regulating age distributions over time, there will be drastic oscillations in both habitat availability and distribution. Lennartz (1988) suggested that this situation may be partially avoided by:

1. imposing no rotation lengths in managed areas;

2. leaving relict trees scattered across the area; and,

3. leaving remnant groups of trees unharvested and allowed to mature to decadence evenly distributed throughout the managed area.

Leaving remnant trees and patches evenly distributed over clusters, recruitment, and replacement stands will aid in providing continuous supply of older trees and provide old-growth conditions for other species. Retention of relict trees should include relict hardwoods. Snags should be retained indefinitely and protected in prescribed burns.

Silvicultural Prescriptions. Where timber harvest is required in HMUs, the selection of harvest methods (including the frequency of entry into stands) should be assessed according to the likely impacts on other sensitive species (particularly understory plants). For this reason, natural regeneration of longleaf pine is recommended in HMUs. It is a cost effective management prescription in areas like HMUs where there is existing longleaf pine with well-distributed seed producing trees (Boyer and White 1989). Natural regeneration offers an array of management options and avoids the potentially adverse effects of intensive site preparation and planting required in artificial regeneration (see below: Site Preparation). While it requires substantially more active management and monitoring, it also provides the flexibility needed for adaptive management planning.

Even-aged Management. There is considerable evidence that clear-cutting is inappropriate as a means of managing for RCWs and longleaf pine. McFarlane (1992) pointed out that the historic condition in longleaf pine forest was old growth with disturbance affecting only some 10 percent of the landscape (catastrophic fire or blow down) creating isolated, widely dispersed clearings. In the contemporary forest, the situation is reversed. The isolated patches are islands of old growth in a sea of secondary growth stands in various ages. Clear cutting and plantation forestry forces RCWs to seek out the scattered old growth islands in a matrix of inhospitable habitats. This is very different from avoiding island clearings in a broad old growth forest.

Hooper *et al.* (1980) reported that red-cockaded woodpeckers abandoned sites where extensive clear cuts were created within the foraging area. Conner and Rudolph (1991b) found that the removal of forest cover within 800 m of cavity clusters was associated with cluster inactivation. The effects of forest removal were particularly noticeable in small populations. Forest fragmentation created by clear-cutting also influenced a group's access to foraging habitat by forcing birds to go through territories of adjacent groups. This increases the probability of cluster inactivation. Fragmentation leads to more edge between stands. Edge situations are favored by other woodpecker species and other competitors for RCW cavity trees (McFarlane 1992). Clear cuts may also funnel strong winds into areas with cavities (Conner *et al.* 1991), which could increase loss of cavity trees from wind damage.

In addition, clearcut and seed tree prescriptions are not practical methods of natural regeneration. Clearcutting can destroy much of the available advanced reproduction in longleaf pine stands (Boyer and Peterson 1983). On average sites, and with the optimum number and quality of seed-bearing trees available, seed crops adequate for regeneration occur, on average, once every four years (Croker and Boyer 1975). Intensive site preparation necessary to establish seedlings in clearcuts can have significant adverse impacts to forest ground layer vegetation and soils (see below).

Because of the very limited seed dispersal range of longleaf pine, most of the cleared area in a seed tree cut must be within 100 ft (30.5 m) of a seed source. Leaving 8 to 10 scattered trees per acre (20-25/ha) does not constitute a forest acceptable to nesting or foraging RCWs (McFarlane 1992). If there is an extended delay before the next seed crop, the open space may be occupied by hardwoods and brush. The unwanted understory would then have to be removed prior to the seed crop which may or may not be adequate to regenerate the area (Boyer and Peterson 1983). Even with periodic burning, the lower fire intensity in seed tree stands, resulting from the lack of a heavy needle-litter fuel load, can permit hardwood encroachment to escape to fire-resistant size.

Uneven-aged Management. Because longleaf pine is resistant to fire at all ages except young seedlings (< 0.3 in (0.8 cm) root-collar diameter), it is well suited to uneven-aged management (Boyer and Peterson 1983). Uneven aged management procedures offer a number of benefits. Small group selection cuts minimize forest fragmentation, provide better distribution of foraging habitat, reduce beetle infestation hazards, and minimize the potential impacts of stochastic events (Engstrom and Evans 1990, SNN 1990). Selection cutting does present several potential drawbacks, including site disturbance from the construction and repeated use of access roads, difficulty of burning in some stands, and the potential for pine midstory encroachment in cluster sites.

Shelterwood cutting offers a number of advantages over even-aged methods that makes it probably the most suitable means of naturally regenerating longleaf pine (Boyer and Peterson 1983):

1. The final harvest of mature trees is delayed until adequate advanced regeneration is established.

2. Shelterwood stands produce enough needle-litter to fuel fires capable of restricting hardwood and brush encroachment and maintaining an understory that is primarily grass and forbs.

3. Shelterwood overstory inhibits the development of brown-spot needle blight on established pine seedlings (Boyer 1975).

A shelterwood overstory of 30-40 ft^2/ac (6.9-9.2 m^2/ha) maximizes seed production and in good seed years produces three times as many seeds as a seed tree stand (Boyer and White 1989). This approaches the lower limit of suggested basal area (9-14 m^2/ha) recommended for RCW stands (Jackson *et al.* 1986) and should not be managed below this stocking level. Shelterwood cuts also maintain residual trees for foraging, maintain foraging habitat over a greater area, provide good distribution of old growth trees of known age, and minimizes costs and environmental impacts of stand regeneration (SNN 1990). Forest managers on Fort Bragg, North Carolina, have reported significant success using shelterwood cuts and prescribed fire to regenerate longleaf pine on thousands of acres (Sewell 1992).

Group or patch shelterwood cuts allow managers to create a diverse age structure that fosters the provision of RCW cavity trees in the long-term (McFarlane 1992). Patches are small (< 10 ac) regeneration areas within the HMU that are created and regenerated over time to obtain a desired distribution of age classes. Patch shelterwood cuts can be even-aged or uneven-aged. In the latter case, the entire stand is treated as the patch and no consideration is given to the various age or size classes within the cut. Cutting is regulated by volume or stand structure (diameter distribution) control (Boyer and White 1989). In either case, McFarlane (1992) suggests that the shelterwood trees not be harvested in the subsequent cutting cycle, at least in some patches, to provide older growth individuals distributed in HMUs. Group shelterwood cutting produces patches of the successional habitats favored by Bachman's sparrow and can produce them in clusters which are more easily reached by dispersing juveniles. This increases the likelihood that sparrow populations will remain stable or increase in limited areas (Liu *et al.* 1995).

Boyer and White (1989) point out that patch shelterwood management requires careful use of prescribed fire. Burning or protecting from burning a single age class will be impossible since age classes will be widely distributed throughout HMUs. However, because longleaf pine is resistant to fire throughout much of its life cycle, careful burns should result in minimal damage to regenerating pine. Uneven-aged shelterwood practices provide many of the components of ecological forestry compatible with timber production (Neel 1991):

1. patch regeneration and gradual release of pines;
2. variety of pine age classes, dominance classes, snags, and treeless areas within a mosaic of stand types;
3. minimal disturbance to soils and ground cover vegetation; and
4. frequent burning to maintain open, park-like conditions.

Uneven-aged silvicultural practices used to increase habitat availability for RCWs should have positive effects on many associated species. Group shelterwood cuts which create diverse, all-age stands of longleaf pine with open understories will benefit fox squirrels, Bachman's sparrows, and pine snakes. Lengthened rotations provide for longer periods of time when pine stands may support large bird populations. Harvest methods which employ natural regeneration and thinning practices improve stand complexity and the availability of an array of bird habitats (Wood and Niles 1978). Uneven-aged, patchy cuts can reduce habitat fragmentation while preserving a diversity of mature and regenerating forest habitats across the landscape, mimicking to some extent natural forest processes. Use of natural regeneration that eschews intensive site preparation will benefit most plant species in the forest ground layer, as well as reptiles and amphibians which rely on forest floor microsites (see below: Site Preparation). Finally, reliance on prescribed burning to prepare longleaf pine seedbeds, coupled with the promotion of all-age canopies, will help insure the integrity of an array of ecosystem processes across the managed landscape (Lennartz 1988, Hunter 1990, Petit *et al.* 1994).

Site Preparation. Longleaf pine seeds require direct contact with mineral soil for successful germination and establishment (Boyer and White 1989). However, silvicultural practices in longleaf pine forests within HMUs should minimize the need for intensive site preparation. Mechanical site preparation can have positive effects on plant species requiring some sort of disturbance for successful regeneration, but appears to be detrimental to most species (Robinson 1977). Stransky and Halls (1980) compared mechanical site preparation (chopping and KG blading) to burning and recorded significantly more soil disturbance and negative effects on fruiting by shrubs because of damage to woody stems caused by mechanical methods.

Soil disturbance can adversely effect native plants (Cox *et al.* 1987, Komarek 1982, Means and Campbell 1981, Tanner and Terry 1981). Moore *et al.* (1982) showed that mechanical site preparation changes species composition of herbaceous layers and reduces the aerial coverage of soft mast-producing shrubs such as *Vaccinium* spp. and *Gaylussaccia* spp.

High intensity site preparation is considered to have adverse effects on most species of flatwoods wildlife (Marion and Harris 1981). Intensive site preparation reduced abundance of soil arthropods and small mammals in comparison to low and moderate intensity preparation (White *et al.* 1975). Mowing indiscriminately kills young trees and shrubs and can kill gopher tortoises. Roller chopping and web plowing can destroy gopher tortoise burrows.

Drainage of flatwoods has negative effects on most species and should not be done even to restore longleaf pine stands (Robinson 1977). Many flatwoods species are adapted to soils where the water table is seldom below 4 ft from the surface and at or near the surface at some point during the growing season. Riekerk and Korhnak (1985) showed that timber management in flatwoods can lead to acid runoff and nutrient depletion, suggesting long-term site degradation.

Of particular concern is that site preparation should minimize adverse impacts to wiregrass and other ground-layer species. Wiregrass biomass and the frequency of occurrence of associated herbaceous species is negatively affected by intensity of site preparation measures (White 1975, White *et al.* 1975). Wiregrass can tolerate some levels of disturbance, but will not survive severe soil disturbance. It is a poor colonizer and once removed from a site it is unlikely to reappear for many years, if at all. Wiregrass is also a crucial component of the fire ecology of longleaf pine forests and without it, or with reduced cover, other less effective, more costly, and more potentially damaging methods of hardwood control may be necessary (e.g., mechanical or chemical control). Restoration of wiregrass is labor intensive, costly, and unproven in many cases.

As discussed previously, fire is preferable to mechanical manipulation in site preparation. Use of prescribed fire:

1. reduces the amount of ground litter, reducing the threat of unplanned wildfires;
2. quickly releases nutrients to the soil;
3. does not disturb soil and wildlife resources to the extent that mechanical techniques do (Cox *et al.* 1987); and,
4. is less expensive than mechanical techniques (Tanner and Terry 1981, Means and Campbell 1981).

Pine Straw Harvesting

Paragraph V.G. (pg. 15) allows pine straw harvest in HMUs, with the provision that sufficient pine straw be left to allow for effective prescribed fires and to maintain soils and herbaceous vegetation. Areas within HMUs are not to be raked more than once every three to six years and bailing machinery will not be used or parked within clusters.

Pine straw harvesting is generally not an appropriate use in HMUs. At Fort Bragg, mechanized harvest (metal rakes mounted on tractors) on annual or biennial schedules was found to destroy ground-layer herbs and longleaf pine seedlings, concentrate pine seeds into unnaturally high densities, cause or accelerate erosion, and adversely influence fire dynamics (TNC 1993). Raking of pine straw removes drought-resistant cover which maintains mesic refugia for some reptiles and amphibians (Enge and Marion 1986).

Fire frequency is related at least in part to fuel accumulation. In some areas sufficient pine litter and ground fuel to carry low-intensity fire may accumulate within 3 to 5 yr, but in driest sites in the sandhills, 30 to 40 yr may be required to accumulate sufficient fuel to carry a fire (Christensen 1981). No pine straw harvest should be allowed in HMUs until a 3 yr fire return interval has been established. After regular growing season fire has been established, assessments may be made to determine whether sufficient pine straw is available for harvest without altering the burn regime. In some areas it is conceivable that even a six year harvest return may alter the burn regime in HMUs.

Pine straw harvest should be excluded from areas known to support any endangered, threatened, or candidate plant species. Harvesting should be restricted to off-site or degraded stands not suitable as cluster sites. Degraded areas may be replanted to longleaf pine to provide suitable areas for pine straw harvest in the future.

Where pine straw is allowed in HMUs, the extended 6 yr rotation should be enforced, if it does not interfere with the maintenance of fuel loads necessary to carry low-intensity fires. Pine straw raking should not be practiced in heavily vegetated areas, particularly in mesic and wet pine flatwood habitats. Harvesting should be done manually, using hand rakes, pitchforks or other hand tools. Populations of sensitive species should be flagged prior to any harvest within HMUs. Harvesters should be made aware of sensitive plant populations and their locations. Any pine straw harvest prescriptions must include effective monitoring protocols to assess the effects of harvest on sensitive plants, wiregrass cover, and soil integrity.

5 Integrating Ecosystem-based Approaches into Endangered Species Management on Southeastern Army Installations

"All management is a long-term experiment, and decisions are always made with less than complete information" (Agee and Johnson 1988, pg. 226).

Some Principles of An Ecosystem Approach to Management

An ecosystem approach to management recognizes that autecological information necessary for the management of individual species is often lacking, but that all species would benefit from proper management of the ecosystems in which they are found. Instead of focusing efforts on small discrete populations and management units, an *ecosystem approach fosters* the management of species within the context of the natural communities in which they occur (Hart and Lester 1993). Landscape-level management, focusing on the entire mosaic of community types and the processes that shape them, attempts to mimic those processes or allow them to continue unimpeded (Hardesty 1992). It recognizes that single management decisions taken at seemingly small scales may produce cumulative effects over much larger scales (Walters 1991).

The Department of Defense has recognized that ecosystem management may provide the best chance for reconciling training requirements and conservation of bio-diversity, including endangered species (Trame and Tazik 1995). In 1994, the Office of the Under Secretary of Defense issued a memo calling for implementation of ecosystem management in the Department of Defense (DOD; DUSD[ES]/EQ-CO memo, 08 Aug 1994).

A primary goal of ecosystem management is the maintenance of biological diversity (Grumbine 1994). As pointed out by Everett *et al.* (1995): "...no species or habitats are expendable. When some species are considered expendable, the unstated intention is to manage for declining ecosystem adaptability, and a declining number of management options (pg. 22)."

Grumbine (1994) suggested that the most important goal of ecosystem management is the maintenance of ecosystem integrity. He listed five common objectives related to reaching this goal:

1. Maintain viable populations of all native species *in situ*.
2. Represent, within protected areas, all native ecosystem types across their natural range of variation.
3. Maintain ecological and evolutionary processes.
4. Manage over periods of time long enough to maintain the evolutionary potential of species and ecosystems.
5. Provide for human use and occupancy within these constraints.

Ecological Integrity

Karr (1990) defined system integrity as the capability of "supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition and functional organization comparable to that of the natural habitat of the region." Human needs and desired levels of outputs must also be embedded within defined limits of ecosystems (Hardesty and Murin 1994).

Managing for ecosystem integrity includes maintaining the processes which shape and drive the system at large scales (e.g., fire, flooding, grazing) and small scales (e.g., windthrows, insect damage, soil disturbance). Ecosystem processes include movement and interaction among organisms, transformation of energy and material, and the successional trajectories, changes in patchiness, or responses to environmental change that a system exhibits (e.g., disturbance regimes, hydrological processes, nutrient cycles, food webs, etc.) (Pickett and Parker 1994).

Integrity thus includes the historical ranges of variability for landscape disturbance effects (frequency, extent, and intensity). However, disturbance regimes (such as fire in the longleaf pine landscape) that maintained historical ecosystems may not be appropriate in some contemporary ecosystems. Historical disturbance regimes are reference points and not recipes.

Holling *et al.*, cited in Hardesty and Murin (1994), suggest that not all processes or elements are of equal importance in maintenance of ecological integrity. A relatively small subset of abiotic and biotic factors may actually structure the entire system.

This implies that identification and maintenance of these structuring factors should result in maintenance of the system and of its ecological integrity (Hardesty and Murin 1994).

As Hardesty and Murin (1994) point out, while overly simplistic, this concept permits the development of criteria for setting measurable ecological objectives and associated monitoring programs. Such a monitoring system depends on:

1. developing specific management objectives which are stated as ecosystem conditions to be achieved or maintained (e.g., a given fire return interval, the presence or absence of a particular species), and

2. selecting indicators that measure whether objectives are being maintained within desired ranges (e.g., a fire return of 3-8 yr).

Selection of indicators and acceptable ranges derives from expert opinion, management experience, and from adaptive experience over time.

Adaptive Management

Few management practices are either universally beneficial or universally damaging to ecosystems or landscapes (Everett *et al.* 1994). Management practices must be applied at the time, place, and scale that is appropriate to meet stated objectives.

Adaptive resource management recognizes that all resource policy is experimental, that all outcomes are uncertain and that both short and long-term effects will be unpredictable (Hardesty and Murin 1994). Liu *et al.* (1995) showed that management for RCWs can have unforeseen consequences for other species such as Bachman's sparrow that may be impossible to predict prior to implementing RCW management plans. This is especially true when management options affect habitat distribution and quality over large areas or produce changes that may not be identifiable for several years. As pointed out by Walters and Holling (1990) "...some actions may change the sensitivity of managed systems to natural environmental factors that themselves have complex temporal patterns (pg. 2065)."

Ecosystem management is intuitively adaptive management. Managers have to adopt a policy of learning from mistakes. Adaptive management strategies assume that knowledge of the system in which we work is incomplete and "the system itself is a moving target, evolving because of the impacts of management and the progressive expansion of the scale of human influences... (Walters and Holling 1990, pg. 2067)." Better project results can be achieved by working with flexible objectives and adopting changes to management plans as new information obtained from monitoring or research becomes available or as resource priorities change.

Developing Ecological Indicators

Successful management requires that there must be a consensus among all affected parties on the specific indicators of desired future conditions and on the constraints on achieving those conditions (Agee and Johnson 1988). At Avon Park Air Force Range, Florida, selection of indicators was based on the identification of structural and process variables which could be used to track the condition of the ecosystem, rather than on selection of particular "indicator species" (Hardesty 1994). The selection process involved the distribution of a questionnaire to managers suggesting 20 to 30 possible ecological indicators derived from the literature which described the natural communities on the installation (e.g., Is the mean age of pine stands increasing or decreasing? What is the trend in age class distributions and how do you know?). An iterative process of discussions among all interested personnel was used to define the final list of appropriate indicators which compared current installation conditions to a generally accepted set of desired future conditions.

Indicators should provide direct and indirect measures of the status of important ecosystem factors. They should be (adapted from Hardesty and Murin 1994):

1. measurable;
2. based on management goals and objectives set in advance;
3. easily interpreted, displayed, and communicated to all interested parties;
4. efficiently measured and analyzed by existing staff with existing resources, programs, and partners;
5. capable of detecting real change within specified levels of confidence;
6. able to provide threshold levels of change in indicators and their relationship to management strategies (Agee and Johnson 1988) that indicate need for management action;
7. able to directly assess compliance with legal mandates;
8. directly or indirectly measure one or more indicators related to ecosystem integrity;

9. represent multiple levels of biological organization measured at appropriate spatial and temporal scales.

Setting Management Priorities: Inventory, Monitoring, and Dialog

Management priorities are set through the integrated use of inventory, monitoring, and continuing dialog (Hardesty and Murin 1994).

Inventory is the initial key component of any endangered species management plan, providing the baseline, pre-management data that can be used to assess change and the effects of management actions. The inventory should characterize compositional, functional, and structural components of the landscape at one or more points in time. A completed inventory:

1. illustrates the spatial distribution of species and communities, including the best examples of each;

2. places the installation in a regional context and defines its role in protecting regional biodiversity; and

3. helps direct management priorities and goals by demonstrating which species or communities are most at risk (e.g., at Fort Bragg management emphasis is placed on those key species or communities with five or fewer occurrences on the installation).

Monitoring includes procedures and programs used to assess the effects of management actions and on-going land uses. Specifically, monitoring tracks the status and trends of particular abiotic elements, plant and animal populations, communities, ecosystems, and indicators. By definition it is a repeated, long-term activity and often includes the measurement of attributes (indicators) that are thought to act as surrogates for the health of guilds, whole communities, or even of ecosystems (Hardesty and Murin 1994).

Repeated sampling detects trends not observable otherwise and points out areas where monitoring procedures (e.g., trap grid placement) should be modified. Useful monitoring indicators should provide rapid and readily observable indications of change in response to disturbance or management alterations, have low variance in measurable parameters, be amenable to replication, and be inexpensive to sample. Monitoring procedures must have acceptable level of accuracy, be repeatable over years among personnel, be long-term enough to capture the important natural processes or responses to management, and meet the logistical needs of the manager.

Multiple reference sites in all managed habitats should be selected to characterize ecosystem potentials, processes, unmanaged ecosystem characteristics, and variability among sites.

Monitoring should be designed to answer pertinent questions: Which management practices are most ecologically sound? How do current and proposed activities alter ecosystem composition, structure, and function and at what spatial and temporal scales do they operate?

Dialog seeks to bring scientists, regulators, and managers together on a regular basis around specific issues and questions (Hardesty and Murin 1994). For example, at Eglin Air Force Base, initial dialogs focused on the qualitative assessment of initial conditions (e.g., the longleaf pine sandhills) while subsequent dialog focused on particular issues (e.g., RCW recovery, defining ecological integrity). Continuing dialog helps to define what various installation programs value and how these values can be expressed in management (Hardesty and Murin 1994).

Significance of Military Installations

Recent work on Fort Bragg, North Carolina, Fort Stewart, Georgia, and Eglin Air Force Base, Florida, has clearly demonstrated the important role military installations play in the preservation and maintenance of landscape level biodiversity in the Southeast.

1. Military installations possess natural features that are of regional, national, and international significance, including outstanding examples of many different community types and populations of rare and endemic species.

2. Because of their large size, installations offer the opportunity to manage relatively intact longleaf pine landscapes.

3. Natural areas on the installations are becoming increasingly valuable as the rate of loss of longleaf pine forest on private lands continues.

4. Large contiguous tracts of longleaf pine on the installations do not exist in isolation. They are linked ecologically with other state and/or federal lands adding to the significance of protected lands complex.

5. Experience at Fort Bragg, Eglin Air Force Base, and Fort Hood, Texas, demonstrates that military missions and sound natural resource management are largely compatible.

Some Emphasis Areas for Longleaf Pine Ecosystem Management

Ecosystem management planning is meaningful only in the context of specific installation landscapes and management objectives. However, certain goals may be generalizable across the range of longleaf pine ecosystems (Stout *et al.* 1988):

1. maintenance of normal ecosystem processes;
2. soil conservation;
3. maintenance or restoration of normal hydrologic processes;
4. prevention of establishment of exotic species; and
5. minimization or prevention of human disturbance.

The following paragraphs provide overviews of several key components that should be incorporated into ecosystem management planning in longleaf pine landscapes:

1. Identification and management of natural areas.
2. Use of fire to protect and promote ecosystem integrity.
3. Protection of wetland and aquatic habitats.
4. Management for reptiles and amphibians.
5. Mapping RCW Habitat Management Units in an ecosystem context.

The first three topics provide some specific management procedures and recommendations adaptable to particular management goals. The fourth is provided as an example of a group of species which integrates many of the ecosystem processes and management concepts discussed previously. The final topic provides a suggestion for integrating ecosystem principles into the designation of RCW management areas as a first step in an adaptive management process.

Identification and Management of Natural Areas

Federally listed Endangered species are protected under the Endangered Species Act of 1973 and sites supporting them should be marked as off limits to incompatible fixed-site activities and disturbances. Sites which support Threatened and Candidate 2 species or State-listed Endangered and Threatened species have no special protection.

However, protection of species on an occurrence by occurrence basis may promote management of fragmented habitats. To avoid this, installation inventories should include identification and description of significant natural areas. Natural areas are identified as units of land (ranging in size from several acres to an entire watershed or physiographic region) that contain assemblages of plant and animal communities whose characteristics and functioning are shaped by the processes of evolution and ecological interactions over long periods of time, without the overriding influence of modern human activities (Schafale and Weakley 1990).

Natural areas should be selected based on compatibility with the military training and testing mission, consultation with regional experts, published historical descriptions, and comparisons with other areas on the installation (TNC 1993). Experts should be familiar with the potential sites and with the general distribution and rarity of plant communities and rare plants in the region. Possible criteria for selection include overall quality and diversity of plant communities, abundance and diversity of rare plants, area size, and representativeness (i.e., relative rarity of the plant community types at local, state, and regional levels) (TNC 1993).

Significance of Natural Areas

Designation, protection, and management of such areas will aid in the survival of rare plants and help installation managers avoid potential future conflicts with endangered species. Scott *et al.* (1989) pointed out that protecting groups of species in self-maintaining communities offers a cost-effective supplement to endangered species recovery. "Identifying and protecting areas rich in regional diversity is, in fact, proactive endangered species management: its goal is the long-term security of most of the planet's biodiversity (pg. 85)."

In addition to individual rare species, plant communities should be included as biological features that are unique to a region or landscape. Communities are significant landscape elements that are important to the support of biological diversity. By protecting examples of all of the natural community types that occur on an installation, the majority of species dependent on those communities can be protected. These protected examples of community types can provide standards from which recovery of damaged ecosystems can be judged (TNC 1993).

Finally, natural areas provide protection of landscape-level functions. Species and communities interact with each other in complex ways, and they require intact, contiguous landscapes upon which to carry out these interactions. For example, as discussed below, many amphibians in the longleaf pine ecosystem use seasonally flooded pools for breeding, while living as adults in adjacent flatwoods or sandhills habitats. On a larger scale, species such as fox squirrels and pine snakes occupy extensive home range areas comprising longleaf pine forests and adjacent hardwood and bottomland areas. Landscape level protection is the best means of insuring that corridors between these habitats remain intact.

Wetlands

The longleaf pine ecosystem is characterized by a number of unique plant communities. Many are transitional areas between major forest types or wetland areas embedded within a broader forest landscape. Several community types typical of forests supporting RCWs are recognized by the Nature Conservancy as globally imperiled, including Coastal Plain Hillside Herbaceous Seepage Bogs and Coastal Plain Pitcher Plant Flats.

Hillside seepage bogs are relatively uncommon throughout the southeastern Coastal Plain. For example, in North Carolina, good to excellent hillside seeps are restricted to the fire-maintained areas of Fort Bragg, Camp Mackall, and Sandhills Game Land (TNC 1993). Of the approximately 100 examples of hillside bogs identified by Bridges (1988) and Orzell (1987) in the West Gulf Coastal Plain, probably less than 30 bogs remain relatively undisturbed (Bridges and Orzell 1989).

The greatest threats to these communities, which support a number of candidate species such as *Xyris scabrifolia*, include: 1) habitat destruction by conversion to urban, suburban, agricultural, silvicultural, or military use; 2) alteration of hydrology as a result of habitat fragmentation; and, 3) loss of herb diversity due to fire suppression (see Chapter 5, Protection of Wetlands And Aquatic Habitats).

As part of installation inventory and the identification of key natural areas, the extent of all wetland areas should be delineated and recorded on USGS 7.5' topographic quadrangles or other suitable scale mapping. The hydrologic integrity of mapped wetlands should be protected by identifying those adjacent areas which contribute to the inflow and maintenance of water levels and which may be threatened by land use on the installation.

Protection of sites which support rare species or communities should be encouraged to the extent that such actions can be accommodated within the training mission of the installation. Management of natural areas should emphasize the conservation of rare, threatened, and endangered species and the natural communities in which they are found. Training and other land uses should be minimized in these areas. As a general rule, extractive land uses, including timber harvest and pine straw raking, should be prohibited.

Use of Fire to Protect And Promote Ecosystem Integrity

The restoration of longleaf pine community integrity can most effectively be achieved through the judicious use of prescribed fire (Myers 1991). Both Myers (1991) and Baker (1992) pointed out that prescribed fire on contemporary landscapes is unlikely to ever approach the extent or effects of pre-settlement burns due to changes in other components of the landscape (e.g., distribution of development, changes in forest acreage). Current management can only approximate historical conditions. Natural resource management beyond general principles is an idiosyncratic process that may concern endemic species, restoration of specific communities, and a range of other concerns (Stout *et al.* 1988). Consequently, managers should not develop fire programs that adhere strictly to fire return intervals without considering other site specific factors which may argue for subtle variation in the timing and extent of prescribed fires.

Use of prescribed fire in RCW management areas and fire management practice have already been discussed (see Chapter 4, Prescribed Burning). Several additional points should be emphasized in the use of fire in ecosystem approaches to managing longleaf pine systems.

Emphasize Understory Diversity and Integrity

Fire is the most important functional process in the longleaf pine landscape. Fire supports, and is supported by, a diverse understory and a relatively simple overstory, both of characteristic composition and structure (Christensen 1988, Stout and Marion 1993). The longleaf pine canopy may be the most important *structural* element of the landscape. However, from an ecosystem perspective, the understory and ground layer herbaceous community of plants is the most important *functional* element, both because it is remarkably diverse and because it provides the fine fuel matrix essential for carrying frequent, low-intensity fire and for creating the conditions necessary for the natural regeneration of longleaf pine (Hardesty 1992).

Fire suppression and mechanical soil disturbance leads to changes in biological diversity as indicated by changes in key indicators of composition, structure, and function. A more proactive management approach tolerates, preserves, and restores ecosystem functions (e.g., fire regimes, hydrological gradients, pine beetle outbreaks), structure (e.g., removal of hardwood midstory through fire), and composition (e.g., preservation or reintroduction of ground layer vegetation, reclamation of roads and plow lines). Ultimately, such management emphasis helps to maintain ecological integrity at the ecosystem and landscape levels (Hardesty 1992).

Management strategies should emphasize the protection of the natural understory and the reintroduction of growing season fire. Strategies that emphasize the overstory (e.g., intensive site preparation and the artificial regeneration of longleaf pine) do not represent an ecologically-based approach to resource management (Hardesty 1992).

Use Appropriate Prescribed Fire Regimes

The prescribed fires should attempt to mimic the natural fire regime in frequency, predictability, and seasonality, and should be tailored to different community types. Hart and Lester (1993) suggested using a weighted randomized burning schedule, in which the likelihood of fire increases with the number of years since the last burn to allow for variance in fire periodicity. Such a schedule would also allow for variability in the magnitude and severity of prescribed burns. As suggested previously, burns should not be constrained by uniformity. Patchy burns increase landscape heterogeneity and provide refugia for wildlife.

Fire management may benefit management-sensitive species by providing a mosaic of habitat types. For example, a rotational system of burning in some areas in which sections are burned on a regular rotation, resulting in a variety of habitats in every year and providing habitats across a spectrum of fire dependence (Herkert 1994). Komarek (1964) and Landers *et al.* (1990) suggest ways of managing the temporal variability of prescribed burns. Landers *et al.* (1990) pose several questions for land stewards trying to devise appropriate burn schedules:

1. Did late-summer fires in the natural forest commonly burn on into or reignite during the dormant seasons?

2. Did lightning induced fires starting in the drier dormant seasons cover much greater extents than the ignition frequency might imply?

3. Did natural history aspects of some native species become attuned to burning at times other than at peak lightning ignition periods?

Finally, aggressive suppression of wildfires and mission-caused fires often leads to degradation of the understory through use of emergency plow lines and the fragmentation of forest stands which may have been scheduled for prescribed burning in the future. Rather, such fires should be incorporated as controlled management burns whenever possible. Similarly, prescribed fire rotations designed to protect longleaf pine regeneration (i.e., limiting growing season fires in "regenerating stands") does not address ecosystem goals and is probably unnecessary (see Chapter 4, Extractive Land Uses).

Emphasize the Use of Natural Fire Breaks

Rebertus *et al*. (1991) pointed out that the relative frequency of natural fires probably influenced the abundance of longleaf pine savannas relative to adjacent, less pyrogenic communities. Boundaries between longleaf pine savannas and xeric scrub or hammock, as well as ecotones between savannas and downslope wetlands, were probably dynamic, changing with the frequency of fire. They suggest that some of the mesic and wetland communities probably depend for the maintenance of structure and composition on periodic fires spreading from drier, more frequently burned savannas.

Burn units should be bounded by existing landscape features to minimize habitat fragmentation. Use of plowed fire lines should be minimized (see Chapter 4, Prescribed Burning). Permanent fire breaks should be established where they can be maintained to avoid having to construct emergency lines where fires must be strictly controlled (e.g., at installation boundaries, around cantonment areas).

Frost (1994) suggested adaptive management principles which use landscape patterns to determine appropriate fire frequencies as a means of developing the framework for a burning program, including:

1. location of indicator species that are fire-tolerant or fire-adapted

2. location of historic indicator community types (e.g., with fire suppression, canebrakes succeed to shrubby swamps and pocosins)

3. successional processes observed on different soil types at different locations on the installation that are subject to various treatment or management

4. current landscape structure (e.g., fire tension zones between community types or changes in soil type that create natural differences in fire frequency)

5. historic patterns of lightning frequency and historic fire records.

Recognize the Influence of Other Disturbance Factors

As pointed out by Landers *et al.* (1990), "arranging a set of key plant species into a preconceived pattern with appropriate prescribed fires may not insure that community members will all fall into place (pg. 160)." For some species (e.g., *Agrimonia incisa*), it is possible that individuals persist after the cessation of fire, but disturbance such as animal burrowing, creation of tree-fall mounds, or fire-generated patches of open soil may be required for recruitment of new individuals into the population. Many species in longleaf pine communities appear to benefit directly from soil disturbance, and some of the rarest species depend upon it for their persistence (Landers *et al.* 1990). Several historical disturbance agents (e.g., bison, pocket gophers) have been either completely removed or significantly reduced in the current landscape. Consequently, the interactions between growing season fires and these forces is poorly understood. However, management beyond simple re-introduction of growing season fire may be required to perpetuate all members of the forest community (Landers *et al.* 1990).

Protection of Wetlands And Aquatic Habitats

The general ecological value of wetlands in an array of different landscapes has been addressed elsewhere (e.g., Mitch and Gosselink 1993). In the present context, it is significant to note that 63 percent of the candidate, threatened, and endangered plants considered in this report are either obligate or facultative hydrophytes. In all, 78 percent of the species are found either in wetlands or in the adjacent ecotone. A number of amphibians, including the flatwoods salamander and gopher frog, require intact ephemeral wetland depressions in longleaf pine flatwoods as breeding habitat and spend much of the nonbreeding season in wetland ecotones. Adams (1990) pointed out that the habitat niches of most, if not all, terrestrial mollusks in the longleaf pine forest are so poorly known that we have no tools to adequately assess the potential impacts of any proposed action on a given population. They may live in pocosin edges, but move out into surrounding areas due to population pressures or on humid nights (Adams 1995).

Wetlands are of particular importance for many longleaf pine endemics. For example, all four of the known extant populations of the state endemic *Amorpha georgiana* var. *confusa* occur within the Green Swamp Nature Preserve in Brunswick County, North Carolina, scattered primarily within seasonally saturated pine savannas. The endangered Saint Francis' satyr (*Neonympha mitchellii francisci*) is known solely from herbaceous wetlands in the impact areas of Fort Bragg, North Carolina (Hall 1993).

Apart from the direct conversion of wetlands in development, agriculture, and silviculture, the greatest threats to the integrity of longleaf pine wetland communities are fire suppression, interruption of hydrologic patterns, and soil erosion.

Fire Suppression

Frequent fire is essential for maintaining the high species diversity and vegetational structure in most wetlands, such as wet savannas and seepage bogs. Lack of periodic fire in these communities has a number of adverse consequences:

1. Suppression of fire will promote rapid shrub invasion, out competing rare herbaceous species for sunlight and nutrients. In the more mesic upland savannas, shrub invasion may be slow, but certain graminoids, such as *Schizachyrium scoparium* (Little Bluestem), may predominate, leaving little open ground available for colonization by herbaceous species.

2. The dense woody cover which develops after years of suppression may also change the hydrologic conditions of seepage slopes and other wetlands, as woody vegetation alters evapotranspiration rates in hydric soils.

3. The absence of fire may reduce the availability of soil nutrients. Reproductive cycles and long-term health of wetland plants may depend on nutrient pulses usually available following a burn.

Growing-season burns on a three- to five-year rotation are recommended for moderately fire-suppressed habitats (i.e., sites that have not been burned in the last 10-15 years). Excessively hot fires should be avoided. Sites that are more severely fire-suppressed should first be burned in winter to reduce heavy fuel loads. Subsequent burns (two to three years following the winter, fuel-reduction burn) should be done in the growing season.

Wetland management should require fire regimes for all types of habitats. For example, fires should not only be conducted in savannas and ecotones but should also penetrate into adjacent pocosins. To burn pocosin edges, Peterson (1992) (cited in Smith 1993) suggests burning on two- to three-year rotations. This allows enough fuel to accumulate in bordering habitats to start fires that will burn into the edges of pocosins. These burns should be done in the winter when pocosins are less likely to burn out of control (Peterson 1992). However, it still remains to be determined if winter burns are as effective as summer burns in producing the desired results. Any prescribed burning programs should include prompt post-fire assessment and monitoring across several seasons (see Chapter 4, Prescribed Burning, Fire Management).

Disturbance of Hydrologic Patterns

Wetlands are directly threatened by foot and vehicle trails, fire plowlines, and roads which all work to disrupt natural hydrologic patterns. These communities are dependent on intact recharge areas upslope and undisturbed discharge areas downslope. Fragmentation of recharge areas may lead to extended low-moisture conditions, which may seriously affect habitat conditions for most obligate species such as *Xyris scabrifolia*. Plant habitats may also be adversely affected by flooding caused by backed up discharge areas. Roads or trails located at the base of seepages often cause this type of flooding.

Numerous streamhead pocosins and sandhill seeps, rare communities on Fort Bragg and Camp Mackall, North Carolina, have been dissected and severely degraded by firebreaks and trails created in the 1960s and 1970s (TNC 1993). In addition, fire plowlines were placed around most seepage slopes, small streams and other wetlands by wildlife biologists and foresters who felt that fires passing into wetlands were destructive to animal populations. While this practice has been stopped, the plowlines still persist and continue to prevent effective burning of wetland areas, while disrupting water recharge and the natural nutrient flow from adjacent areas.

Management of wetland communities should include protecting sites against any mechanical damage (e.g., fire plowlines), sedimentation from adjacent upland areas, and ditching or other forms of drainage. In areas where the threat of mechanical damage is high, signs should be posted to help protect the site from disturbance. On Fort Bragg, as populations of endangered plants are located, a white-line buffer is marked around the site and permanent signs emplaced stating "Endangered Species Site - Do Not Disturb - No Fixed Activity" (TNC 1993).

Soil Erosion and Siltation

Soil erosion causes direct destruction of plant communities and natural features such as seeps and bogs. Erosion also disturbs soil nutrient and water regimes. Eroded firebreaks and gullies can act as drains which alter hydroperiods of nearby wetlands. Erosion from poorly maintained roads and fire breaks has been observed to have several direct adverse impacts on wetlands and aquatic habitats at Fort Bragg, North Carolina (TNC 1993):

1. Direct siltation of streams and open water bodies. Siltation in black water streams creates anoxic soil conditions unsuitable for aquatic plants and plant species diversity is significantly altered in areas immediately upstream and downstream of fire break stream crossings.

2. Firebreaks and roads alter flow regimes in streams by directing unnaturally large volumes of surface runoff into stream channels during storms. The resulting increased stream-flow rates damage stream integrity by altering channel shape, increasing streambank erosion, and destroying stream bottom microhabitats.

3. Degraded intermittent stream channels carry high sediment burdens into perennial streams during storm events. Adjacent floodplain vegetation can be smothered by siltation fans deposited from streams during flood periods.

In general, excess numbers of poorly-maintained secondary roads and fire breaks compromise watersheds within longleaf pine landscapes. Changing inappropriate management practices now is more cost effective than attempting to restore degraded wetland communities later.

Planning for Erosion Control and Stream Integrity

Control of erosion is an important tool in the protection of wetlands, streams, and other sensitive habitats. Erosion control plans should be a key component of endangered species management on the installations. Plans should identify existing problem areas and identify suitable mitigation measures.
Erosion control measures should include (adapted from USDOD/DAF 1993):

1. Erosion-prone sites and structures should be inspected quarterly to identify maintenance and mitigation needs. Surveys should identify existing problem areas along major roads and stream crossings, as well as disturbed wetlands and stream channels that require mitigation.

2. Fire management should avoid construction of plowed fire lines adjacent to stream corridors. All fire lines should be constructed to minimize erosion potential. Stabilize and restore emergency plowed fire lanes as soon as possible after fire suppression.

3. Silvicultural activities should avoid impacts to wetlands, particularly in flatwoods sites. Wetland ecotones, embedded wetlands, temporary ponds, and other significant habitats should be flagged prior to forestry operations.

a. Logging roads should be designed and located to prevent ponding of water and other disruption of natural hydrology.

b. No skid trails should be established in wetlands or in wetland ecotones.

c. No harvesting activities should be allowed on sustained slopes with highly erodible soils.

d. No harvesting should be allowed within 100 ft of streams.

e. Upon completion of silvicultural activities, access roads should be blocked off and seeded with native vegetation.

f. Pine thinning operations should avoid soil disturbance and ground layer disturbance, especially on erosion-prone soils. Disturbance of soils should be stabilized.

4. All perennial and intermittent streams should be protected using vegetation transition areas.

5. All surface and subsurface waters should be protected from herbicide use. Herbicides should not be used within 100 ft of stream corridors and aquatic herbicides should not be employed upstream of known fish habitats.

6. All stream crossings should be evaluated for erosion presently or potentially entering streams and the adverse effects of practices and materials used in road, bridge, or culvert construction.

a. Use of bioengineering principles and low-tech solutions should be emphasized where possible. In all cases, avoid the use of exotic species for soil stabilization, especially in or near wetlands and wetland ecotones.

b. Evaluate, close, and stabilize unnecessary stream crossings with potential for adverse effects on known populations of sensitive species.

c. Stream crossings using culverts should minimize elevational differences which would prevent movement of fishes along stream channels. Borrow pits should be stabilized.

7. The requirements of intensive military training make some indirect impacts to wetlands and water courses unavoidable.

a. In areas designated for dismounted infantry training, personnel should flag temporary wetlands and wetland ecotones to keep off-road traffic from destroying these habitats.

b. In Direct Fire Areas, protective berm construction (e.g., for protection of RCW cluster sites) should take into account local topography and the hydrologic patterns which support wetlands. Recharge and discharge pathways should not be disturbed. Use of heavy equipment should avoid damage to sensitive wetland ecotones.

c. Identify areas where unauthorized off-road vehicles are degrading near stream areas. Areas subject to high erosion potential may be prevented with a series of poles or poles and cables to prevent vehicular access.

Roadways and Firebreaks

The existing installation road networks should be reviewed and the purposes and value of existing secondary roads and trails assessed.

1. Road maintenance standards should be upgraded to reduce erosion from road surfaces and shoulders.

2. In coordination with military trainers, plan and implement phased closures and restoration of active unimproved roads and fire lanes which are no longer required for mission support or other installation operations.

3. New trails, roads and fire breaks constructed in HMUs, after consultation with the USFWS, must observe the topographic contours, highly erosion-prone soils, and the location of sensitive plants. Avoid any new wetland or stream crossings.

Rich *et al.* (1994) showed that secondary roads as narrow as 16 to 23 m wide significantly reduced the abundance of neotropical migrant songbirds in oak-pine forests in southern New Jersey. Such narrow forest-dividing corridors affected the distribution and abundance of birds in ways typically associated with the effects of forest fragmentation. They suggested that, at the landscape level, the ubiquitous distribution of paved and secondary roads and powerline rights-of-way through forested areas "raises the prospect of significant cumulative reduction in the potential abundance of forest-interior species (pg. 1117)."

Of equal concern is the fact that a number of rare species, including *Plantago sparsiflora*, *Rhus michauxii*, and *Amorpha georgiana* are known from localized populations in disturbed or artificially maintained habitats, such as roadside ditches, powerline rights-of-way, and even fire breaks. These populations are especially vulnerable to direct damage through heavy equipment use for road maintenance, alterations to roadside ditches, poorly timed mowing which interferes with reproductive cycles, or other side effects of maintaining the area for human purposes. Roadsides and utility rights-of-way may need sensitive maintenance to avoid adverse impacts to isolated populations of rare species.

Fragmentation of Aquatic Habitats

Streams should be surveyed to characterize faunal and floral composition and they should be protected, including protecting flow rates and water quality. This is the best way of protecting instream biodiversity, particularly for rare aquatic insects which may otherwise be very difficult to protect (Morse 1979). Preservation of streams and watersheds now will preserve populations of rare species which may then be available to colonize new areas; also provides potential for alternatives in the future (Morse 1979).

Dodd (1990) discussed the effects of fragmentation of the habitats of stream-dwelling species. Alteration of stream habitats can result from direct modification of stream channels (e.g., channelization, damming, diversion) and from adverse modification of water quality (e.g., sewage effluent, siltation, and chemical spills). Fragmentation results in occurrences of species in stream reaches that are widely separated by degraded conditions. Snelson and Suttkus (1978) pointed out that streams in the Carolina Sandhills are subject to extremely low flows during dry periods. During periods of low water flow, or when flows are interrupted due to human interference, the receding water concentrates both animals and contaminants into smaller and smaller areas, exacerbating adverse effects (Adams 1995). Any action which would result in diverted or restricted flows should be reviewed and mitigated.

Management for Reptiles And Amphibians

Landers *et al.* (1990) suggested that the real challenge in maintaining community integrity occurs as the pine-grassland balance begins to be restored. Many indigenous wildlife species may be adversely affected if habitat uniformity is over-emphasized (e.g., eradication of hardwoods, reduction in available fruiting shrubs). Certain habitats may have always been scarce on the landscape, however managers must recognize that in excess of 60 million acres of longleaf pine once covered the Southeast. Even rare habitats would have covered significant areas. In the contemporary landscape, with only a small fraction of the longleaf forest remaining, it becomes necessary to narrow the management focus and tighten the scale at which some habitat components occur. Such habitats thus become more important.

The guild of longleaf pine herpetofauna presents important examples of this trend toward declining habitat availability. Amphibians and reptiles have received very little attention relative to management in comparison to other vertebrate groups (Wilson 1994). In contrast to the years of breeding bird census data and density estimates available in the literature, reptiles and amphibians have only recently begun to be incorporated into management planning (Szaro *et al.* 1988). From the perspective of ecosystem integrity, this group offers in microcosm the array of features necessary for successfully implementing an ecosystem approach to the management of the longleaf pine landscape:

1. reliance on fire-maintained habitats;
2. adaptation to specific old-growth microhabitats;
3. sensitivity to local hydrology and water quality; and,
4. dependence on a mosaic of different habitats.

Reliance on Fire-maintained Habitats

Fire suppression in longleaf pine forests allows woody succession to obliterate the microhabitats of small vertebrates narrowly adapted to xeric pinelands. The eastern indigo snake depends on active management of existing intact stands of mature longleaf pine and turkey oak to restore or maintain the open, parklike understory conducive to both the indigo snake and the gopher tortoise upon whose burrows the snake depends for refugia. In Florida sandhills habitats, annual fires increased herpetofaunal diversity by reducing the density of herbs and grasses (Mushinksy 1985). Some fire frequencies are better than others: A two-year return did not control the vegetation or provide open sand microhabitats and thus supported lower species diversity.

Growing season fire appears to be important to the maintenance of larval gopher frog habitat. The wetlands in which gopher frogs breed characteristically dry out completely or partially during the lightning season. A fire passing through these sites when dry would consume herbaceous vegetation and possibly kill woody vegetation, thus maintaining the open, grass-dominated character typical of most gopher frog breeding ponds. In addition, fire releases nutrients bound in plant material. This release of nutrients results in a flush of primary productivity that would be available to herbivorous gopher frog tadpoles the following winter. Similarly, the grassy wetland/upland ecotone around seasonally flooded wetlands appears to be critical to successful flatwoods salamander reproduction. Maintenance of these conditions requires burning during the growing season when wetlands are dry or nearly dry (Huffman and Blanchard 1990).

Timing of prescribed fires is an important consideration in the management of herpetofaunal habitats. As already discussed, natural fires in the longleaf pine ecosystem were probably largely lightning derived, most often between May and September (Robbins and Myers 1992). Such fires promote flowering of much of the ground cover flora, such as wiregrass, and lightning-season fires are outside the reproductive period of gopher frogs and other species and thus would not interfere with dispersal between breeding and wintering sites. However, Zappalorti (1994) pointed out that growing season fires may have adverse impacts on pine snakes in some cases and suggested that winter fires, where appropriate, would avoid impacts as snakes would tend to be in hibernacula. Also, eastern indigo snakes are particularly active during the spring months, but winter burns at intervals of 2 to 4 years have been shown to be beneficial (USFWS 1982).

Adaptation to Specific Old-growth Microhabitats

In most managed forests, large (>30 cm dbh) downed trees are typically salvaged. However, downed trees provide at least three small-scale disturbance microhabitats used by amphibians, reptiles, and other small animals: 1) tip-up mounds, 2) burned out areas of ground cover associated with hot spots created by excess fuel from downed trees, and 3) patchy burns due to temporary fire breaks created by the downed tree. Such disturbances may be critical to establishment and spatial patterns of ground cover species and longleaf pine (Hermann 1991) and the reptile fauna in xeric longleaf pine habitats is often determined by the amount and availability of bare ground, litter, shrub cover, fallen woody material, and associated micro-climate features (Greenberg *et al.* 1994). For example, hot spots burned around fallen trees in high fuel areas create open sandy areas required by pine snakes and other species (Means and Campbell 1981, Stout *et al.* 1988). Flatwoods herpetofauna are characterized by species preferring mesic conditions and whose main refugia are often plant litter, stumps, and fallen logs (Enge and Marion 1986).

Sensitivity to Changes in Local Hydrology and Water Quality

Amphibians, probably more than any other terrestrial vertebrate taxon, are dependent upon environmental moisture, since most depend on standing water in which to complete their larval stages (Wilson 1994). Vickers *et al.* (1985) showed that herpetofauna of Florida flatwoods were very sensitive to changes in hydroperiod resulting from ditching during timber harvest. Altered hydroperiods, with less consistent water depths and less persistent standing water, reduced species richness during dry weather. The relative abundance of terrestrial species compared with aquatic species was greater in ditched habitats. Ditching resulted in greater water level fluctuation and removed standing water before young of the year could successfully metamorphose (Enge and Marion 1986).

Gopher frog breeding sites are readily disturbed or are destroyed by off-road vehicle (ORV) use or by sand roads that pass through or adjacent to the ponds (J. Palis, pers. comm.). Vehicular traffic disrupts pond floor micro-topography and eliminates herbaceous vegetation used for oviposition and cover. Erosion of unpaved roads lying adjacent to breeding sites may result in an influx of sedimentation from surrounding uplands during rainstorms. Finally, the large tires used on ORVs may break the organic hardpan that lies below the pond floor. Breaking the hardpan could result in a shorter hydroperiod and thereby make some wetlands unsuitable for gopher frog reproduction or result in complete drainage of the wetland.

Breeding ponds used by pine barrens treefrogs are typically small (5 to 10 m diameter), sphagnum-filled depressions dependent on disturbances such as fire to maintain the appropriate species composition and vegetation structure. Also of critical importance is the characteristic water chemistry of these wetland systems, particularly a very low pH and low nutrient content. Protection and management must concentrate on maintaining community integrity as well as water quality within critical habitats. Similar sensitivity to water conditions is undoubtedly shared by many of the other amphibians using longleaf pine-associated wetlands.

Dependence on a Mosaic of Different Habitats

Pine snake home ranges typically comprise an array of habitats, with a substantial mature pine-oak component, but with ready access to bottomland forest. For most amphibian species, management should supply a mosaic of xeric pinelands, mesic forests, and seasonal and permanent wetlands (Enge and Marion 1986, Stout *et al.* 1988). Many species require more than one contrasting habitat. Eastern narrow-mouthed toads (*Gastrophryne carolinensis*) are commonly encountered in sandhills habitats as much as 100 m from the nearest water source (Dodd and Charest 1988). Moler (1985) pointed out that indigo snakes have home range requirements that include upland and wetland habitats spread over areas as large as 122 to 202 ha.

Gopher frogs live primarily in tortoise burrows in longleaf pine-turkey oak sandhills in late spring, summer and early fall. However, they migrate up to 2 km into temporarily wet seasonal depressions in flatwoods to breed during the winter and early spring (Moler and Franz 1988). Flatwoods salamanders are known to travel up to 1.7 km between reproductive and non-reproductive habitat. Management of both of these species thus requires maintenance of a mosaic of upland and wetland habitats in close proximity (Appendix B). High quality occurrences include several wetlands within a matrix of pine flatwoods and savanna (for the salamander) and xeric upland pine-dominated communities (in the case of the gopher frog). Based on the maximum distance adults of these species are known to travel between breeding and wintering habitat, each breeding site should be surrounded by at least 12 km^2 of terrestrial habitat. A suite of wetlands guards against extirpation at any one breeding site, since animals can immigrate from nearby wetlands.

Conclusions

The admittedly scant literature on the ecology of longleaf pine-associated h-erpetofauna in general, and that of small isolated wetlands in particular, suggests a number of key issues related to their management (Dodd and Charest 1988):

1. Large numbers of species use isolated, often ephemeral, wetland habitats: some are permanent residents, some are migrants, and some use these areas on an irregular basis. The species composition in ponds may vary within years: some species are found only in one season, some predominate at one time but are found commonly at other times, and some species are only rarely observed.

2. Reproductive output varies widely among species: in one year spring breeders may be successful, in other years summer breeders may be successful, in other years both probably produce young, and in some years neither may successfully reproduce.

3. These wetland habitats are used year-round, despite seemingly unfavorable periods of drought and cold weather. Activity patterns change seasonally and annually. Amphibian activity in temporary sandhills ponds increases dramatically during and immediately after periods of rainfall or high humidity.

4. All pond-breeding species live in the surrounding terrestrial habitats during the non-breeding season so that both the pond and a portion of this terrestrial habitat are equally important for species persistence.

5. Long-term studies and monitoring are required to develop an understanding of these complex communities that is adequate for management and conservation.

Determination of the total number of species using such temporary wetlands can be best accomplished using spring and early summer sampling, but single season or even annual sampling will not identify all species. Quick surveys underestimate both numbers of species and individuals, as well as annual variation, and thus underestimate the importance of isolated sandhills wetlands.

Unlike birds, most reptiles and amphibians have limited dispersal capabilities (Wilson 1994). Because of their relatively slow dispersal rates, stand conversion from one to another cover type may have unanticipated results. In fragmented habitats, without adequate dispersal corridors between habitat patches, there may sometimes exist suitable habitat without species being present. Also, creating suitable habitats for a given species does little good without providing suitable corridors for dispersal from existing habitat patches.

Maintenance of intact longleaf pine-wiregrass habitats, and the ephemeral wetlands found within them, by mimicking natural forces, such as lightning-season fire, is the most appropriate form of management. Periodic burning is essential to the maintenance of these habitats to insure the open, grassy areas between widely-spaced trees. Reducing physical impediments to burning, including roads and habitat fragmentation, would help reduce the isolation of subpopulations. Tree harvest should be restricted to dry periods to prevent soil compaction and rutting. Clearcutting should be replaced with selective timber harvest and natural regeneration enhanced by fire, particularly lightning-season fire. Mechanical disturbance of the wetland-upland ecotone should be avoided, and the practice of "protecting" wetlands by encircling them with plow line abandoned. Where present, berms should be removed and drainage ditches filled. Reduced human disturbance, particularly off-road vehicle traffic, would help keep sandhill ridges intact and prevent erosion.

Mapping RCW Habitat Management Units In An Ecosystem Context

Habitat Management Units are unlikely to capture the entire range of the landscape habitat mosaic required by all species. We propose that known locations or potential distributions of other elements of concern (rare species populations or significant natural communities) should be overlaid on the installation RCW HMU map. This additional data layer could be used to either modify management prescriptions in particular HMUs or to aid in selection of stands to include in HMUs. Location of other elements would assist in setting management priorities for stands outside of cluster sites.

Mapping locations of other species, even potential distributions based on likely habitat preferences, can suggest ways of shifting management emphasis among stands in the HMU to benefit other species. For example, without such additional element mapping, a stand which abuts a forested wetland may be designated as a recruitment area when it might more productively be less intensively managed for foraging habitat: Fox squirrels and cavity-nesting birds which use the hardwood area might benefit from the availability of hardwood snags that could be preserved in a foraging stand, but which would be selected against in a recruitment stand.

Mapping locations of other species and significant community locations may suggest areas where HMUs might be expanded to include other habitats not necessarily used by RCWs and extend HMU-level protection (or some lesser degree of management protection) to these additional areas. For example, a wetland system which falls partly outside the boundary of an HMU drawn strictly based on the management needs of RCWs could be fully incorporated within the HMU boundary. Species such as *Lindera melissifolia* which are found in pocosin margins and other wetland ecotones would benefit from such actions that could help protect adequate recharge and discharge areas for wetlands upon which they depend. Using the distribution of species and landscape features to help designate HMU in this way boundaries will facilitate the maintenance of ecosystem process integrity (**Paragraph III.D. pg. 3**).

Conclusions

Military installations are often defacto refuges for plants and animals in developing landscapes of increasingly degraded habitats (Hayden and Tazik 1993). Managers face the unique challenge of stewarding valuable resources in which the public has an abiding interest, while fulfilling the primary mission of maintaining a well-trained, combat-ready fighting force.

As habitat loss continues in surrounding areas, and species acquire legal protection, their presence on an installation can significantly impact training as access to endangered species habitats is constrained, with potentially direct impact on military readiness. The military has recognized both its responsibility as the steward of significant areas of public lands and a definite self-interest in conserving species before they require legal protection.

The single-species approach to the conservation of endangered species is increasingly being supplanted as the guiding paradigm in land management by multiple-species or ecosystems-based planning. An ecosystems-approach promotes species management within the context of the natural communities in which they occur and thus focuses on the larger system in which discrete populations or management units are found (Hart and Lester 1993). Such an approach strives to conserve as many occurrences of species and community types as possible to accommodate unforeseen fluctuations in demographic parameters and land use changes, reduce fragmentation and isolation of habitats, and maintain the natural ecological gradients which structure and shape the landscape.

Ecosystem management directed toward the conservation of the longleaf pine forest is driven primarily by the recovery needs of the red-cockaded woodpecker. However, even in the case of a species such as the red-cockaded woodpecker, whose habitat needs and home range size appear to integrate the needs of many other species and make it a ready candidate for umbrella species status, it is increasingly apparent that management which focuses only on the needs of the one species may have unappreciated adverse effects on other key components of the longleaf pine ecosystem (Liu *et al.* 1995).

Simberloff (1991) suggested that longleaf pine forests may be unique in terms of conservation prospects in the face of human exploitation. While they appear to be subject to the same negative effects of fragmentation that have affected other forested systems, the structure and organization of longleaf pine forests characteristically differ from those of many of these other threatened forest systems in three important ways:

1. The majority of the biological diversity in longleaf pine forests is associated with the ground cover stratum rather than the canopy.

2. Second-growth trees can provide, to at least some extent, structural aspects of the "natural" system provided by canopy trees.

3. The sparseness of trees, the prevailing edaphic conditions, and gentle terrain permit economical selective logging of the type that would be exceedingly difficult in a system such as the mountainous rain forest of the Pacific Northwest.

Simberloff (1991) pointed out that large tracts of longleaf pine must be preserved in order to carry out the controlled experimentation necessary to address these issues in a way that considers a large array of components of the community. With only 2 or 3% of the original longleaf pine ecosystem remaining in the Southeast (Ware *et al.* 1993), we are challenged to manage what is left to guarantee the survival of all of the native plant and animal species and the full array of original communities. In this context, managers cannot assume that providing suitable habitat for RCWs and attempting to mimic historic conditions will capture the habitat needs of the array of species dependent upon longleaf pine communities. Endangered, threatened, and candidate species should not be considered either a by-product or a constraint on land management. Rather, managers must look beyond installation boundaries and plan for effective multi-species management that contributes to the conservation needs of the states, physiographic provinces, and regions within which they reside (Gaines 1993).

In developing and adopting the Guidelines, the Army has entered into a long-term commitment to the recovery of the red-cockaded woodpecker and the protection cf its habitat. We hope that the application and testing of the suggested modifications to the Guidelines presented in this report will help to focus management efforts on the broader context within which woodpecker recovery must operate. Never designated or meant to serve as reserves of biodiversity, military installations are not designed with the conservation of biodiversity in mind. Neither do they necessarily capture the range of diversity inherent in the longleaf pine ecosystem. However, these suggestions may assist managers to promote a management philosophy that is responsive to short-term and long-term environmental and social changes and which conserves the ecological potential of the areas within their care.

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Appendix A: 1994 Army-wide Red-cockaded Woodpecker Management Guidelines

Table of Contents
(References to paragraphs)

I. **General**.

A. Purpose. The purpose of these guidelines is to provide standard RCW management guidance to Army installations for developing installation endangered species management plans (ESMPs) for the Red-cockaded Woodpecker (RCW). Installation RCW ESMPs will be prepared according to these guidelines and chapter 11, AR 420-74, Land, Forest, and Wildlife Management. These guidelines establish the baseline standards for Army installations in managing the RCW and its habitat. Installation RCW ESMPs will supplement these guidelines with detailed measures to meet installation-specific RCW conservation needs. The requirements in RCW ESMPs will apply to all activities on the installation.

B. Applicability. The guidelines are applicable to Army installations where the RCW is present and to installations with inactive clusters that the installation, in consultation with the U.S. Fish and Wildlife Service (FWS), continues to manage in an effort to promote reactivation.

C. Revision. These guidelines will be revised as necessary to be consistent with the latest RCW recovery plan and to incorporate the latest and best scientific data available.

D. Mission. The Army's goal is to train for assigned combat and other missions while concurrently developing and implementing methods to assist in the recovery and delisting of the RCW.

E. Existing Biological Opinions. Installations will continue to comply with the requirements of existing biological opinions until RCW ESMPs are prepared in accordance with these management guidelines and chapter 11, AR 420-74 and are approved through consultation with the FWS. RCW ESMPs should be drafted to incorporate the requirements of existing biological opinions, as modified to conform to these management guidelines through consultation with the FWS.

II. **Consultation**.

A. In preparing RCW ESMPs and taking action that may affect the RCW, installations will comply with the consultation requirements of section 7 of the Endangered Species Act (ESA); the implementing FWS regulations at 50 CFR part 402; and chapter 11, AR 420-74.

B. Early entry into informal consultation with the FWS is key to resolving potential problems and establishing the foundation to address issues in a proactive and positive manner. If, through informal consultation, the FWS concurs in writing that the RCW ESMP or other action is not likely to adversely affect any endangered or threatened species, formal consultation is not required. Issue resolution through informal consultation is the preferred method of consultation.

C. In consulting with the FWS on RCW ESMPs and other actions that may affect the RCW, the opinions of the FWS will normally be consistent with these guidelines. In exceptional cases, however, FWS opinions may require installations to take measures inconsistent with these guidelines. After every effort has been made at the installation and MACOM levels to resolve inconsistencies, installations will report, through MACOM channels, to the Office of the Director of Environmental Programs (ODEP), Headquarters, Department of the Army, FWS opinions that are not consistent with these guidelines. ODEP will expeditiously review these reports and determine if HQDA-level action is necessary. If feasible, installations should delay implementation of measures recommended by the FWS that are inconsistent with these guidelines until after the ODEP review is completed.

III. **Army Policies Applicable to RCW Management.**

A. *Conservation.* Implementation of RCW ESMPs, prepared in accordance with these guidelines, will meet the Army's responsibility under the ESA to assist in conservation of the RCW. Conservation, as defined by the ESA, means the use of all methods and procedures which are necessary for endangered and threatened species survival and to bring such species to the point of recovery where measures provided by the ESA are no longer necessary.

B. *Mission Requirements.* Installation and tenant unit mission requirements do not justify violating the ESA. The keys to successfully balancing mission and conservation requirements are long-term planning and effective RCW management to prevent conflicts between these interests. In consultations with the FWS, installations will attempt to preserve the ability to maintain training readiness, while meeting ESA conservation requirements.

C. *Cooperation with U.S. Fish and Wildlife Service.* The Army will work closely and cooperatively with the FWS on RCW conservation. Installations should routinely engage in informal consultation with the FWS to ensure that proposed actions are consistent with the ESA requirements.

D. *Ecosystem Management.* Conservation of the RCW and other species is part of a broader goal to conserve biological diversity on Army lands consistent with the Army's mission. Biological diversity and the long-term survival of individual species, such as the RCW, ultimately depend upon the health of the sustaining ecosystem. Therefore, RCW ESMPs should promote ecosystem integrity. Maintenance of ecosystem integrity and health also benefit the Army by preserving and restoring training lands for long-term use.

E. *Staffing and Funding.* Installation commanders are responsible for ensuring that adequate professional personnel and funds are provided for the conservation measures prescribed by these guidelines and RCW ESMPs. Commanders are responsible for accurately identifying the funding needed to meet the requirements of these guidelines. RCW conservation projects are funded through environmental channels and will be identified in the Environmental, Pollution Prevention, Control and Abatement Report (RCS 1383).

F. *Conservation on Adjacent Lands.* Necessary habitat for the RCW includes nesting and foraging areas. Both of these RCW habitat components may be located entirely on installation lands. There may be instances, however, where one of these components is located on installation land, while the other is located on adjacent or near-by non-Army land. Installations should initiate cooperative management efforts with these landowners, if such efforts would compliment installation RCW conservation initiatives.

G. *Regional Conservation.* The interests of the Army and the RCW are best served by encouraging conservation measures in areas off the installation. Installations should participate in promoting cooperative RCW conservation plans, solutions, and efforts with other federal, state, and private landowners in the surrounding area.

H. *Management Strategy.* These guidelines require installations to adopt a long-term approach to RCW management consistent with the military mission and the Endangered Species Act. First, installations are required to establish an installation RCW population goal in consultation with the FWS using the methodology described in para V.B below. Once established, the installation must designate sufficient nesting and foraging habitat to attain and sustain the goal. The goal will also dictate the required management intensity level. Next, installations must develop an ESMP to attain and sustain the installation RCW population goal in perpetuity in accordance with chapter 11, AR 420-74. Third, installations are required to ensure that all units and personnel that conduct training and other activities at the installation comply with the requirements of the installation RCW ESMP.

IV. **Definitions.**

Augmentation - Relocation of an RCW, normally a juvenile/fledgling female, from one active cluster to another active cluster.

Basal area (BA) - The cross-sectional area (square feet) of trees per acre measured at approximately four and one-half feet from the ground.

Biological diversity - The variety of life and its processes. It includes the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur.

Buffer zone - The zone extending outward 200 feet from the outermost cavity trees in a cluster.

Cavity - An excavation in a tree made, or artificially created, for roosting and nesting by RCWs.

Cavity restrictor - A metal plate that is placed around an RCW cavity to prevent access by larger species. A restrictor also prevents a cavity from being enlarged, or if already enlarged, shrinks the cavity entrance diameter to a size that prevents access by larger competing species.

Cavity start - An incomplete cavity excavated by, or artificially created for, RCWs.

Cavity tree - A tree containing one or more active or inactive RCW cavities or cavity starts.

Cluster - The aggregate area encompassing cavity trees occupied or formerly occupied by an RCW group plus a 200 foot buffer zone (formerly called "colony").

Effective breeding pairs - Groups that successfully fledge young.

Group - A social unit of one or more RCWs that inhabits a cluster (formerly called "clan"). A group may include a solitary, territorial male; a mated pair; or a pair with helpers (offspring from previous years).

Habitat Management Unit (HMU) - Designated area(s) managed for RCW nesting and foraging, including clusters and areas determined to be appropriate for recruitment and replacement stands.

Impact/danger areas - The ground within the training complex used to contain fired or launched ammunition or explosives and the resulting fragments, debris, and components from various weapons systems.

Population - A RCW population is the aggregate of groups which are close enough together so that the dispersal of individuals maintains genetic diversity and all the groups are capable of genetic interchange. Population delineations should be made irrespective of land ownership.

Provisioning - The artificial construction of cavities or cavity starts.

Recovery population - A total of 250 or more effective breeding pairs annually, for a five year period.

Recruitment - The designation and management of habitat for the purpose of attracting a new breeding group to that habitat.

Recruitment stand - A stand of trees, minimum of 10 acres in size, with sufficient suitable RCW nesting habitat identified to support a new RCW group. Stand and supporting foraging area should be located 3/8 mile to 3/4 mile from a cluster or other recruitment stand.

Relict tree - a pine tree usually more than 100 years old having characteristics making it attractive to the RCW for cavity excavation.

Replacement stand - a stand of trees, minimum of 10 acres in size, identified to provide suitable nesting habitat for colonization when the current cluster becomes unsuitable. The stand should be approximately 20 - 30 years younger than the active cluster. While it is preferable for replacement stands to be contiguous to the active colony, at no time should they be more than 1/4 mile from the cluster, unless there is no suitable alternative.

Stand - an aggregation of trees occupying a specific area and sufficiently uniform in species composition, age, arrangement, and condition so as to be distinguishable from the forest on adjoining areas.

Sub-population - the aggregate of groups which are close enough together to allow for demographic interchange between groups. A sub-population does not have a significant demographic influence on adjacent sub-populations, but there is sufficient genetic interchange between the sub-populations to be considered one population.

Translocation - the relocation of one c more RCWs from an active cluster to an inactive cluster or recruitment stand that contains artificially constructed cavities.

V. **Guidelines for Installation RCW ESMPs.**

Installations will prepare RCW ESMPs and manage RCW populations according to the following guidelines.

A. *RCW ESMP Development Process.*

Preparation of installation RCW ESMPs requires a systematic, step-by-step approach. RCW populations (current and goal), RCW habitat (current and potential), and training and other mission requirements (present and future) must be identified. Detailed analysis of these factors and their interrelated impacts are required as a first step in the development of an ESMP. Installations should use the following or a similar methodology in conducting this analysis:

1. Identify the current RCW population and its distribution on the installation.

2. Identify areas on the installation suitable or potentially suitable for RCW nesting and foraging habitat.

3. Establish the installation RCW population goal with the FWS according to the guidance in B below. The installation RCW population goal will at least equal the current population.

4. Identify installation and tenant unit mission requirements. Overlay these requirements on the RCW distribution scheme.

5. Identify mission requirements that are incompatible with the conservation of RCW habitat.

6. Identify areas where conflicting mission requirements could be relocated to avoid RCW habitat.

7. Identify critical mission areas where activities cannot be relocated.

8. In consultation with the FWS, identify areas that will be subject to the expanded training guidelines in paragraph V.I.2.c below.

9. Identify areas which could support RCW augmentation or translocation.

10. Identify areas suitable for RCW habitat and free of conflicting present and projected mission activities. These are prime areas for designation as recruitment stands.

11. Analyze the information developed above using the guidance contained in these guidelines.

12. Prepare the RCW ESMP to implement the best combination of options, consistent with meeting the established RCW population goal, while minimizing adverse impacts to training readiness and other mission requirements.

B. *RCW Population Goal.*

1. One of the first steps in RCW management is to determine an installation population goal in accordance with paragraph V.B.2 below. Once this goal is established, it is used to designate the amount of land needed for RCW HMUs and the appropriate level of management intensity.

2. ESMPs must clearly state the installation RCW population goal. This goal will be established through informal or formal consultation with FWS. Goals should be carefully calculated considering the current and future installation and tenant unit missions, the amount and distribution of current and future suitable habitat on and off the installation, the quality of the habitat, the current size of the RCW population, the distribution of clusters, the configuration of sub-populations, the land ownership patterns, the recovery potential (*see* 3 below), the RCW Recovery Plan objectives, etc. The goal should strike a reasonable balance between the present and future installation and tenant unit missions and conservation. Once established, the population goal will determine the amount of installation land to be managed as RCW habitat. Goals should be considered long-term but are subject to change, through consultation with the FWS, based upon changing circumstances and new scientific information

3. The population goal established for an installation will dictate the required RCW management intensity level. A population that has achieved the installation goal need only be maintained at that level, however, installations should continue to encourage population growth where feasible and compatible with the military mission. In contrast, any population that has not achieved its population goal requires an active recruitment/augmentation strategy. A maintenance strategy is appropriate for populations which have attained the maximum population that can be supported by available suitable habitat, irrespective of population size. However, maintenance activities will vary according to the population size, for example, smaller nonviable populations may require occasional augmentation, predator control, etc.

C. *Surveys, Inspections, and Monitoring Programs.*

1. Installations will conduct the following surveys and monitoring programs.

a. Five-Year installation-wide RCW surveys. Effective management of the RCW requires an accurate survey of installation land for RCW cavity and cavity-start trees. The survey must document the location of RCW cavity and cavity-start trees as accurately and precisely as possible (using Global Positioning System and Geographic Information System, if available) and the activity within all clusters. An installation-wide survey will be conducted every five years. Installations may conduct the survey over the five year period, annually surveying one-fifth of the installation.

b. Project surveys. Prior to any timber harvesting operations, construction, or other significant land-disturbing activities, excluding burning, a 100-percent survey of the affected area will be conducted by natural resources personnel trained and experienced in RCW survey techniques and supervised by a RCW biologist, if one has not occurred within the preceding year. Installations will conduct project surveys in accordance with the survey guidance in V. Henry, Guidelines for Preparation of Biological Assessments and Evaluations for the Red-cockaded Woodpecker, U.S. Fish and Wildlife Service, Southeast Region, Atlanta, Georgia (September 1989). In the case of range construction, the survey will also include the surface danger zone for the weapons to be used on that range.

c. Annual inspections. Clusters that have not been deleted from management in accordance with paragraph V.D.2.b below and recruitment stands must be inspected annually. These are prescriptive inspections, used to develop treatments and modifications of treatments to maintain suitable nesting habitat. At a minimum, installations will inspect and record data for:

(1) density and height of hardwood encroachment;

(2) height of RCW cavities;

(3) condition of cavity trees and cavities;

(4) a description of damage from training, fires (prescribed or wild), etc.; and

(5) evidence of RCW activity for each cavity tree (includes each cavity in the tree) within the cluster. See 2a below for guidance on the maintenance of survey and monitoring records.

d. Ten-year forest survey. In addition to an RCW survey required in 1a above, installations will conduct, as required by AR 420-74, an installation-wide forest survey at least every ten years. In conducting the forest survey, data will be gathered to accurately determine the quantity and quality of available foraging and nesting habitat for the RCW. Alternately, installations may survey ten percent of the installation annually. Forest surveys will be conducted using a recognized plot sampling technique, such as the random line plot cruise, the random point sample cruise, or the line strip cruise method. Forest surveys in impact areas may be conducted using scientifically accepted, aerial photography interpretation methods.

e. Monitoring. Installations will conduct monitoring programs to scientifically determine demographic trends within the population as a whole. Sample sizes will be determined by the number of clusters and their dispersion on the installation by habitat category (*e.g.*, longleaf pine/scrub oak, pine flatwoods, pine mixed hardwoods) and by category of use (*e.g.*, non-dud producing ranges, mounted and dismounted training areas, cantonment areas, bivouac areas, etc.). Sample sizes will be of sufficient size to have statistical validity and to ensure that population trends and important biological information can be determined for the entire installation. Installations with 25 clusters or less will monitor all sites. Installations with greater than 25 clusters will monitor sample sizes based on the following: 25 percent of the RCW clusters (active and inactive) located in each habitat and usage category on the installation, with a minimum of three RCW clusters per habitat type or a total of 25 clusters, whichever is greater. Monitoring activities will be done annually to acquire data to determine the number of adults and fledglings per site, sex of birds, number of breeding groups, and number of nests. Monitoring will include color banding of birds.

2. Results from surveys and monitoring will be recorded as follows:

a. Survey/monitoring records. Survey and monitoring results will be recorded and retained permanently allowing for trend analysis.

b. RCW map. Survey data will be used to generate installation RCW maps accurately depicting the location of RCW clusters, HMUs, etc. The map will be widely distributed for use by those conducting land use activities on the installation, including military training, construction projects, range maintenance, etc. Maps will be updated at least every five years to coincide with the installation-wide RCW survey or when a 20 percent change in the number of clusters occurs, whichever is sooner.

D. *RCW Habitat Management Units.*

1. Designation of habitat management units (HMUs). Installation RCW ESMPs will provide for the designation of nesting and foraging areas within HMUs sufficient to attain and sustain the installation RCW population goal. Determination of the installation population goal is a prerequisite to HMU designation. HMU delineation is an important step in the planning process because it defines the future geographic configuration of the installation RCW population. Areas

designated as HMUs must be managed according to these guidelines.

2. Areas included within HMUs.

a. HMUs will encompass all clusters, areas designated for recruitment and replacement, and adequate foraging areas as specified in d below.

b. After consultation with the FWS, clusters that have been documented as continuously inactive for a period of five consecutive years or more may be deleted from HMUs. Once deletion of a cluster from management is approved by the FWS, existing cavities may be covered to discourage reactivation. This will be part of a long-term plan to shift the RCW population to areas on the installation where conflicts between RCW management and critical mission requirements will be minimized. Inactive clusters will not be deleted from HMU management unless sufficient clusters and recruitment stands exist on the installation, provisioned in accordance with these guidelines, to support the installation's RCW population goal (*See* 1 above).

c. In designating HMUs, fragmentation of nesting habitat will be avoided. Installations will attempt to link HMUs with HMU corridors, allowing for demographic interchange throughout the installation population.

d. Adequate foraging habitat, in size, quality, and location, must be provided within HMUs. The foraging habitat needed to support clusters will be calculated and designated according to the range-wide guidelines in V. Henry, Guidelines for Preparation of Biological Assessments and Evaluations for the Red-cockaded Woodpecker, U.S. Fish and Wildlife Service, Southeast Region, Atlanta, Georgia (September 1989) or other physiographic-specific guidelines approved by the FWS. The objective is to provide high quality habitat as close as possible to the cluster, rather than large areas of poor habitat.

3. Minimization of RCW management impacts on the installation's mission.

a. To the extent consistent with RCW biological needs, HMUs should be located where there will be a minimum impact upon current and planned installation missions/operations and should be consistent with land usage requirements in the Real Property Master Plan. This is particularly important regarding HMUs designated for recruitment/replacement purposes.

b. On installations where the RCW is present in areas where there are or potentially could be significant impacts on installation missions/operations, especially training-related operations, the RCW ESMP should provide for the following:

(1) The installation should designate additional HMUs beyond those needed to attain and sustain the installation population goal. Installations should manage these additional HMUs to promote population growth in these areas.

(2) To the extent that RCW biological and demographic needs allow, installations should locate these additional HMUs where RCW management requirements will not have a significant impact on mission/operations. This will allow for a gradual, long-term shifting of RCW sub-populations into more suitable areas through natural demographic shifting, recruitment, and, in exceptional cases, augmentation and translocation (described in paragraph V.J below). In accordance with 2 above, the movement of RCWs away from high mission-conflict areas can be further encouraged by the deletion of documented, inactive clusters from RCW management, while at the same time providing quality recruitment/replacement sites in areas with reduced mission conflicts.

4. Demographic and genetic interchange. Installations should delineate HMUs to maximize the linkage between sub-populations on and off the installations and with populations off the installation. Where fragmentation exists, installations should develop plans to link sub-populations on the installation by designating habitat corridors where practical.

E. *HMU Management Practices*. All HMU management activities and practices will be consistent with the conservation of other candidate and federally listed species.

1. Clusters and recruitment stands within HMUs.

a. Due to RCW biological needs, clusters require a higher management intensity level than other areas within HMUs. Within HMUs, maintenance priority will be given to active clusters over both inactive clusters and recruitment stands.

b. Clusters and recruitment stands will be kept clear of dense midstory. An open, park-like pine stand is optimal. All midstory within 50 feet of cavity trees will be eliminated. Beyond 50 feet, some pine midstory should be retained for regeneration and some selected hardwoods may be retained for foraging by species other than the RCW. Hardwoods should not exceed 10 percent of the area of the canopy cover nor 10 percent of the below canopy cover within the cluster or recruitment stand. Hardwood stocking should be kept below 10 square feet per acre.

c. The priority of forest management in cluster sites and recruitment stands is maintenance and production of potential cavity trees greater than 100 years of age. For this reason, no rotation age shall be set in these areas. In thinning clusters and recruitment stands, dead, dying, or inactive cavity trees will be left for use by competitor species. Thinning should occur only when pine species basal area (BA) exceeds 80 and should not exceed the removal of more than 30 BA to avoid habitat disruption (timber prescriptions within clusters should normally be on a 10 year cycle). Pine species basal areas should be kept within the range of approximately 50 to 80 square feet, maintaining average spacing of 20 to 25 feet between trees, but retaining clumps of trees.

d. Trees within HMUs affected by beetle (e.g., Ips beetle, southern pine beetle) infestation should be evaluated for treatment and treated appropriately. Treatment options will be developed in consultation with the FWS. Possible treatments include the use of pheromones or cutting and leaving, cutting and removing, or cutting and burning infected trees. Cavity trees may be cut only with the approval of the FWS. Prior to cutting an infected cavity tree, a suitable replacement cavity tree will be identified and provisioned.

e. Timber cutting, pine straw harvesting, and habitat maintenance activities, with the exception of burning activities, will not be conducted during the nesting season, occurring from April through July depending upon the installation's location. If a biologist, experienced in RCW management practices, determines that habitat maintenance activities, exclusive of timber cutting and pine straw harvesting, will have no effect on nesting activities, they may be conducted at anytime.

2. Other areas within HMUs. While not requiring the same level of intense management for clusters and recruitment stands, the quality of foraging and replacement stands should be maintained by a prescribed burning program sufficient to control hardwood growth and ground fuel buildup and to eliminate dense midstory. Improving the quality of foraging habitat will reduce the quantity (acreage) required to maintain the installation RCW population.

3. Midstory control. Prescribed burning is normally the most effective means of midstory control and is recommended as the best means of maintaining a healthy ecosystem. Prescribed burning will be conducted at least every three years in longleaf, loblolly, slash pine, and shortleaf pine systems. Burning must be conducted in accordance with applicable Federal, state, and local air quality laws and regulations. With the agreement of the FWS, the burn interval may be increased to no more than five years after the hardwood midstory has been brought under control. Mechanical and chemical alternatives should only be used when burning is not feasible or is insufficient to control a well advanced hardwood midstory. Application of herbicide must be consistent with applicable Federal, state, and local laws and

regulations. Cavity trees will be protected from fire damage during burning. Burning should normally be conducted in the growing season since the full benefits of fire are not achieved from non-growing season burns. Winter burns may be appropriate to reduce high fuel loads. Use of fire plows in clusters will be used only in emergency situations.

4. Erosion control. Installations will control excessive erosion and sedimentation in all HMUs. Erosion control measures within clusters will be given priority over other areas within HMUs.

5. Impact/danger and direct fire areas.

a. Impact/danger areas.

(1) Impact/danger areas that contain or likely contain unexploded ordnance or other immediate hazardous materials (radiological or toxic chemicals) can pose danger to personnel. Natural resources conservation benefits to be gained by intensive management in high risk areas generally are not justified.

(2) Designation of impact/danger areas, safety restrictions on human access to impact/danger areas, range operations in impact/danger areas, and the associated effects of these actions on RCW management activities may adversely affect the RCW and other federally listed species within impact/danger areas, including the possibility of incidental take. Installations are responsible for consulting with the FWS on these potential effects.

(3) To the degree practicable, clusters and surrounding foraging area should be designated as "no fire areas" to protect clusters from projectile damage.

b. Direct fire areas.

(1) Direct fire, non-dud producing impact areas that do not contain unexploded ordnance or other immediate hazardous materials may be included within HMUs, subject to the guidelines set forth below.

(2) In HMUs which are not impacted upon by weapons firing, RCW management will be the same as for HMUs outside of impact areas. In HMUs where there is a significant risk of projectile damage to foraging or nesting habitat, the following guidelines apply:

(a) Range layout will be modified/shielded to protect HMUs from projectile damage, if practicable. Protective measures that will be considered include reorienting the direction of weapons fire, shifting target arrays, establishing "no fire areas" around RCW clusters or HMUs, revising maneuver lanes, constructing berms, etc.

(b) Installations should develop alternate HMUs near existing HMUs but outside the affected range complex. Augmentation and translocation should be considered as a means of removing RCWs from high risk areas.

F. *Timber Harvesting and Management in HMUs.*

1. Timber harvesting in HMUs will be permitted if consistent with the conservation of the RCW. If permitted, a harvest method will be implemented that maintains or regenerates the historical pine ecosystem. In most ecosystems inhabited by the RCW, historical conditions are characterized by old-growth longleaf pines in an uneven-age forest, with small (1/4 to 5 acres) even-age patches varying in size. Timber harvesting methods must be carefully designed to achieve and maintain historical conditions through emulation of natural processes.

2. Longleaf sites will not be regenerated to other pine species. Where other species have either replaced longleaf pine (due to fire suppression) or been artificially established on sites historically forested with longleaf, forest management will be directed toward regeneration back to longleaf by natural or artificial methods.

3. At a minimum, sufficient old-growth pine stands will be maintained by: lengthening rotations to 120 years for longleaf pine and 100 years for other species of pine; indefinitely retaining snags, six to ten relict and/or residual trees per acre when doing a clearcut, seedtree cut, or shelterwood cut; and indefinitely retaining snags, all relicts, and residuals in thinning cuts. No rotation age will be established for cluster sites or replacement stands. The above rotation ages and retention rates do not apply to off-site stands of sand pine, loblolly pine, or slash pine that will be converted back to longleaf.

G. *Pine Straw Harvesting within HMUs.* Sufficient pine straw must be left in HMUs to allow for effective burning and to maintain soils and herbaceous vegetation. Areas within HMUs will not be raked more than once every three to six years. Baling machinery will not be used or parked within clusters.

H. *Restoration and Construction of Cavities.*

1. Restoration. Active and inactive cavities found to be in poor condition during periodic inspections will be repaired whenever feasible to prolong their use. Cavity restrictors can be installed on enlarged RCW cavity entrance holes (greater than

two inches in diameter) to optimize the availability of suitable cavities. They also may be installed to protect properly-sized cavities where suitable cavities are limited, the threat of enlargement is great, or where another species is occupying a cavity. Priorities for the installation of restrictors, in descending order, will be: (a) active single tree clusters, (b) single bird groups, (c) clusters with less than four suitable cavities, and (d) others. Restrictors will be installed according to scientific procedures accepted by the FWS. Restrictors will be closely monitored, especially in active clusters. Adjustments to the positioning of the restrictors will be made to ensure competitors are excluded and RCW access is unimpeded.

2. Construction. Artificial cavities will be constructed in areas designated for recruitment or translocation and in active clusters where the number of suitable cavities is limiting. The objective is to provide at least four suitable cavities per active cluster and two cavities plus three advanced starts for each recruitment stand. Priorities for installation of artificial cavities in descending order will be: (a) single cavity tree active clusters, (b) active clusters with insufficient cavities to support a breeding group, (c) inactive clusters designated as and managed for replacement or recruitment stands with an insufficient number of usable cavities within one mile of an active cluster, (d) new replacement/recruitment stands within one mile of an active cluster, (e) inactive clusters designated as and managed for replacement or recruitment stands within three miles of an active cluster, (f) recruitment or potential habitat within three miles of an active cluster, (g) inactive clusters and (h) replacement/recruitment stands beyond three miles of an active cluster. Cavity construction may be by either the drilling or insert techniques. Construction must be according to scientific procedures accepted by the FWS and accomplished by fully trained personnel.

I. *Protection of Clusters.*

1. Markings. The following uniform marking guidance for RCW clusters will supersede the marking guidance issued by the Directorate of Environmental Programs, dated 8 Jan 1993.

a. Cavity and cavity-start trees. These trees will be marked with two white bands, approximately four to six inches wide and one foot apart. The bands will be centered approximately four to six feet from the base of the tree. A uniquely numbered small metal tag will be affixed to the cavity tree for monitoring and identification purposes.

b. Clusters. Buffer trees on the outer perimeter of clusters will be marked with a one to two foot-wide white band four to six feet from the base of the tree. Warning signs (c below will be posted at reasonable intervals facing to the outside of clusters and along roads, trails, firebreaks, and other likely entry points into clusters.

c. Warning sign. Signs posted at clusters will be constructed of durable material, ten inches square (oriented as a diamond), white or yellow in color, and of the design in Figure 1. The RCW graphic and the lettering "Endangered Species Site" and "Red-cockaded Woodpecker" will be printed in black. The lettering "Do Not Disturb" and "Restricted Activity" will be printed in red. All lettering will be 3/8 inches in height.

d. Installations will conform to the uniform markings guidelines in a through c above by 1 Jan 1997. Signs erected and markings made after the effective date of these guidelines will conform to the standards in a through c above.

e. Training on non-Army lands. Installations conducting long-term training on private, state, or other federal lands with RCW habitat will attempt to obtain agreement from the landowners on compliance with these markings guidelines. If a landowner does not agree to compliance with these guidelines, even with the installation paying the costs associated with compliance, installations will educate troops training on such lands to recognize the markings used by the landowner.

2. Training within RCW clusters.

a. The training guidelines in this section apply within clusters, as defined in paragraph IV above. RCW-related training restrictions do not apply to recruitment and replacement stands and foraging areas.

b. Standard training guidelines within clusters.

(1) Military training is limited to dismounted training of a transient nature.

(2) No bivouacs.

(3) No digging or cutting of vegetation, except for hardwoods used as camouflage.

(4) Use of CS gas, smoke, flares, incendiary devices, artillery, artillery simulators, mortars, or similar devices is prohibited within clusters. Elsewhere on the installation, units will coordinate with both the installation natural resources office and range control prior to using CS gas and smoke, other than smoke grenades. Use of blanks in M16 rifles and handguns is permitted.

(5) Vehicle travel through clusters is limited to designated and maintained roads, trails, and firebreaks identified on official installation maps used for this purpose. Installations must consult with FWS prior to the establishment of new trails, roads, or firebreaks in or through RCW clusters.

(6) With FWS approval through informal consultation, off-road through-traffic by wheeled vehicles, 5 tons or less, travelling at least 100 feet away from cavity trees may be permitted on an infrequent basis for specific exercises. The effects of this off-road vehicular traffic will be monitored and documented to determine long-term trends.

c. Expanded training guidelines within clusters.

(1) In consultation with the FWS, the installation may designate clusters, not to exceed 10 percent of the RCW clusters on the installation, that will be subject to expanded training guidelines. In these designated clusters, the standard training [illegible]es in 2b above apply, except that the following additional activities, with stated restrictions, are allowed:

(a) Bivouacs and battalion-level and below command posts are allowed, providing they remain at least 200 feet away from cavity trees. Digging is prohibited. These fixed activities will be limited in duration to 18 consecutive hours or less from 1 August through 31 March and to 6 consecutive hours or less from 1 April through 31 July.

(b) Use of blanks in individual and crew-served (M60 MG and below) weapons is permitted.

(c) Wheeled vehicles are permitted to travel and remain in clusters so long as soil erosion levels remain within tolerance limits for that soil series under Soil Conservation Service standards. Vehicles will remain at least 200 feet from all cavity trees at all times except as allowed under the standard training guidelines in 2b(5) above.

(2) Installations will implement a monitoring plan, approved by the FWS, to record the effects of the expanded training activities and to identify any potential adverse impacts on the RCW. In the event potential adverse impacts are identified, the installation will suspend the expanded training guidelines and implement the standard training guidelines in 2b(5) above and will consult the FWS.

d. Training guidelines will be actively enforced through installation training and natural resources enforcement programs, prescribed in chapters 1 and 11, AR 420-74, and installation range regulations.

J. *Augmentation and Translocation.*

1. Augmentation can be a useful tool to expand and disperse the RCW population into designated HMUs. Augmentation also provides a means to maintain genetic viability in populations with less than 250 effective breeding pairs. Installation plans will provide for the augmentation of single-bird groups. Clusters will be made suitable in accordance with the requirements/procedures outlined in paragraph V.H. above before augmentation is attempted.

2. In exceptional situations, installations may translocate RCWs from active clusters to inactive clusters or recruitment/replacement stands where cavities have been artificially constructed. For example, translocation could be used to move RCWs from live fire areas where there is a significant risk of harm to the birds. The current scientific literature indicates serious limitations in successfully translocating adult RCWs, in particular, adult territorial males. Translocation will be accompanied by an intensive monitoring program.

3. In areas to receive RCW, habitat designation and improvement work ensuring that nesting and foraging habitat meet the standards established by these guidelines (V.E.1.b and c, V.E.2, V.D.2.d) must be completed before augmentation or translocation is attempted.

4. Neither augmentation nor translocation will be undertaken without the approval of and close coordination with the FWS. Installations must obtain an ESA section 10 permit (scientific purposes) or an incidental take statement under ESA section 7 and all applicable marking, banding, and handling permits prior to moving any RCW through augmentation or translocation.

Appendix B: Individual Species Accounts

(Provided on Attached Diskette)

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