EXECUTIVE SUMMARY

CURRENT STATUS

The red-cockaded woodpecker (*Picoides borealis*) is a federally listed endangered species endemic to open, mature and old growth pine ecosystems in the southeastern United States. Currently, there are an estimated 14,068 red-cockaded woodpeckers living in 5,627 known active clusters across eleven states. This is less than 3 percent of estimated abundance at the time of European settlement. Red-cockaded woodpeckers were given federal protection with the passage of the Endangered Species Act in 1973. Despite this protection, all monitored populations (with one exception) declined in size throughout the 1970's and into the 1980's. In the 1990's, in response to intensive management based on a new understanding of population dynamics and new management tools, most populations were stabilized and many showed increases. Other populations remain in decline, and most have small population sizes. Our major challenge now is to bring about the widespread increases in population sizes necessary for recovery.

BASIC ECOLOGY AND POPULATION DYNAMICS

Red-cockaded woodpeckers are a cooperatively breeding species, living in family groups that typically consist of a breeding pair with or without one or two male helpers. Females may become helpers, but do so at a much lower rate than males. The ecological basis of cooperative breeding in this species is unusually high variation in habitat quality, due to the presence or absence of a critical resource. This critical resource is the cavities that red-cockaded woodpeckers excavate in live pines, a task that commonly takes several years to complete.

Red-cockaded woodpeckers exploit the ability of live pines to produce large amounts of resin, by causing the cavity tree to exude resin through wounds, known as resin wells, that the birds keep open. This resin creates an effective barrier against climbing snakes. Longleaf pine is a preferred tree species for cavity excavation because it produces more resin, and for a longer period of time, than other southern pines.

Group living has profound influence over population dynamics. In non-cooperatively breeding birds, breeders that die are replaced primarily by the young of the previous year. Thus, variation in reproduction and mortality can have strong, immediate impacts on the size of the breeding population. However, in red-cockaded woodpeckers and other cooperative breeders, a large pool of helpers is available to replace breeders. As a result, the size of the breeding population is not strongly affected by how many young are produced each year, or even on how many breeders may die. Because of this, we use the number of potential breeding groups rather than number of individuals as our measure of population size. A potential breeding group is an adult female and adult male that occupy the same cluster, with or without one or more helpers, whether or not they attempt to nest or successfully fledge young.

Because of the cooperative breeding system, red-cockaded woodpecker populations are unusually resistant to environmental and demographic variation, but highly sensitive to the spatial arrangement of habitat. The buffering effect of helpers against annual variation operates only when helpers can readily occupy breeding vacancies as they arise. Helpers do not disperse very far and typically occupy vacancies on their natal territory or a neighboring one. If groups are isolated in space, dispersal of helpers to neighboring territories is disrupted and the buffering effect of the helper class is lost. When this happens, populations become much less likely to persist through time. Also, the cooperative breeding system does not allow rapid natural growth of populations. Colonization of unoccupied habitat is an exceedingly slow process under natural conditions, because cavities take long periods of time to excavate and birds do not occupy habitat without cavities. As forests age and old pines become abundant, rates of natural cavity excavation and colonization may increase.

Understanding these three components of the population dynamics of red-cockaded woodpeckers provides us the foundation for recovery efforts: (1) population size and trend are determined by the number of potential breeding groups rather than annual variation in reproduction and survival; (2) the buffering capacity of the helper class must be maintained, by maintaining close aggregations of territories; and (3) colonization of unoccupied habitat will be very slow without management assistance.

HABITAT REQUIREMENTS AND LIMITING FACTORS

Red-cockaded woodpeckers require open pine woodlands and savannahs with large old pines for nesting and roosting habitat (clusters). Large old pines are required as cavity trees because the cavities are excavated completely within inactive heartwood, so that the cavity interior remains free from resin that can entrap the birds. Also, old pines are preferred as cavity trees, because of the higher incidence of the heartwood decay that greatly facilitates cavity excavation. Cavity trees must be in open stands with little or no hardwood midstory and few or no overstory hardwoods. Hardwood encroachment resulting from fire suppression is a well-known cause of cluster abandonment. Red-cockaded woodpeckers also require abundant foraging habitat. Suitable foraging habitat consists of mature pines with an open canopy, low densities of small pines, little or no hardwood or pine midstory, few or no overstory hardwoods, and abundant native bunchgrass and forb groundcovers.

Limiting factors are those that directly affect the number of potential breeding groups, because this is the primary determinant of population size and trend. Several factors currently impact the persistence of breeding groups. Foremost among these are the factors that limit suitable nesting habitat, namely fire suppression and lack of cavity trees. Fire suppression has resulted in loss of potential breeding groups throughout the range of red-cockaded woodpeckers, because the birds cannot tolerate the hardwood encroachment that results from lack of fire. This limitation is addressed through the use of prescribed burning. Lack of cavity trees, and potential cavity trees, limits the number of breeding groups in most populations. This limitation is addressed in the short-term

through cavity management tools such as artificial cavities and restrictor plates, and over the long-term by growing large old trees in abundance.

Another factor directly limiting the number of potential breeding groups is habitat fragmentation and consequent isolation of groups, which results in disrupted dispersal of helpers and failure to replace breeders. This limitation is best addressed through the appropriate placement of clusters of artificial cavities, and implementation of silvicultural practices that minimize fragmentation.

There are several other threats to the existence and recovery of the species, not limiting most populations currently, but which will become more important as the current limitations are addressed. Chief among these are (1) degradation of foraging habitat through fire suppression and loss of mature trees, and (2) loss of valuable genetic resources because of small size and isolation of populations. As currently limiting factors such as lack of cavities are relieved, the continued growth and natural stability of red-cockaded woodpecker populations will depend on provision of abundant, good quality foraging habitat and careful conservation of genetic resources.

POPULATION AND SPECIES VIABILITY

Four types of threats to species and population viability have been identified: genetic stochasticity (consisting of both inbreeding and genetic drift), demographic stochasticity, environmental stochasticity, and catastrophes. We now have some knowledge of population sizes of red-cockaded woodpeckers necessary to withstand these extinction threats, primarily from research performed with a spatially explicit, individually based simulation model of population dynamics developed specifically for this species.

Red-cockaded woodpeckers exhibit inbreeding depression and inbreeding avoidance behaviors. Inbreeding is expected to affect population viability in populations of less than 40 potential breeding groups, and may be a significant factor affecting viability in isolated populations of 40 to 100 potential breeding groups as well. Immigration rates of 2 or more migrants per year can effectively reduce inbreeding in populations of any size, including very small ones.

Effects of demographic stochasticity on population viability vary with the spatial arrangement of groups. Populations as small as 25 potential breeding groups can be surprisingly resistant to random demographic events, if those groups are highly aggregated in space. Populations as large as 100 potential breeding groups can be impacted by demographic stochasticity, if groups are not aggregated and dispersal of helpers is disrupted. Demographic stochasticity is not expected to affect populations larger than 100 potential breeding groups. Similarly, effects of environmental stochasticity vary with the spatial arrangement of groups. Based on preliminary results of the model and estimates of environmental stochasticity derived from the North Carolina

Sandhills, 250 potential breeding groups will likely withstand effects of environmental stochasticity regardless of their spatial arrangement.

Loss of genetic variation through the process of genetic drift is an inevitable consequence of finite population size. New genetic variation arises through the process of mutation. In large populations, mutation can offset loss through drift and genetic variation is maintained. Just how large a population must be to maintain variation is a difficult question. Currently, researchers recognize that in general, only populations with actual sizes in the thousands, rather than hundreds, can maintain long-term viability and evolutionary potential in the absence of immigration. However, if populations are connected by immigration rates on the order of 1 to 10 migrants per generation (0.5 to 2.5 migrants per year), the genetic variation maintained by these populations is equal to that of one population as large as the sum of the connected populations. Thus, sufficient connectivity among populations can maintain genetic variation and long-term viability for the species.

RECOVERY GOAL

The ultimate recovery goal is species viability. This goal is represented by delisting. Once delisting criteria are met, the size, number, and distribution of populations will be sufficient to counteract threats of demographic, environmental, genetic, and catastrophic stochastic events, thereby maintaining long-term viability for the species as defined by current understanding of these processes. Regions and habitat types currently occupied by the species will be represented to the best of our ability, given habitat limitations.

RECOVERY CRITERIA

Recovery criteria have been formulated using eleven recovery units delineated according to ecoregions. Populations required for recovery are distributed among recovery units to ensure the representation of broad geographic and genetic variation in the species. Viable populations within each recovery unit, to the extent allowed by habitat limitations, are essential to the recovery of the species as a whole.

Population sizes identified in recovery criteria are measured in number of potential breeding groups. A potential breeding group is an adult female and adult male that occupy the same cluster, with or without one or more helpers, whether or not they attempt to nest or successfully fledge young. A traditional measure of population size has been number of active clusters. Potential breeding groups is used in recovery criteria in addition to active clusters, because number of active clusters can include varying proportions of solitary males and captured clusters. (A captured cluster is one that does not support its own group, but is kept active by a member or members of a neighboring group.) Increases in proportions of captured clusters and solitary males are early indicators of population decline. Estimates of all three parameters—number of active

clusters, proportion of solitary males, and proportion of captured clusters—are required to derive estimates of potential breeding groups.

To facilitate use of potential breeding groups as a measure of population size, we have provided a range of numbers of active clusters considered the likely equivalents of the required number of potential breeding groups. Estimated number of active clusters is likely to be at least 1.1 times the number of potential breeding groups, but it is unlikely to be more than 1.4 times this number. Thus, an estimated 400 to 500 active clusters will be necessary to contain 350 potential breeding groups, depending on the proportions of solitary males and captured clusters and also on the estimated error of the sampling scheme. It is expected that all recovery populations will have sampling in place that is adequate to judge potential breeding groups. If this is not the case, only the highest number of active clusters in the range given can be substituted to meet the required population size.

Delisting

Delisting shall occur when each of the following criteria is met. Rationale for each criterion is given immediately following this list. See Tables 1, 2, and 3 for population designation. All properties identified as part or all of a recovery population (Tables 1, 2, and 3) should be managed for maximum size that the habitat designated for red-cockaded woodpeckers will allow. (Maximum size is generally based on 200 ac [81 ha] per group).

Criterion 1. There are 10 populations of red-cockaded woodpeckers that each contain at least 350 potential breeding groups (400 to 500 active clusters), and 1 population that contains at least 1000 potential breeding groups (1100 to 1400 active clusters), from among 13 designated primary core populations, and each of these 11 populations is not dependent on continuing installation of artificial cavities to remain at or above this population size. The 13 designated primary core populations, and the recovery units in which they are located, are listed in Table 1.

Criterion 2. There are 9 populations of red-cockaded woodpeckers that each contain at least 250 potential breeding groups (275 to 350 active clusters), from among 10 designated secondary core populations, and each of these 9 populations is not dependent on continuing installation of artificial cavities to remain at or above this population size. The 10 designated secondary core populations, and the recovery units in which they are located, are listed in Table 2.

Criterion 3. There are at least 250 potential breeding groups (275 to 350 active clusters) distributed among designated essential support populations in the South/Central Florida Recovery Unit, and six of these populations (including at least two of the following: Avon Park, Big Cypress, and Ocala) exhibit a minimum population size of 40 potential breeding groups that is independent of continuing artificial cavity installation.

Designated essential support populations in the South/Central Florida Recovery Unit are listed in Table 3.

Criterion 4. The following populations are stable or increasing and each contain at least 100 potential breeding groups (110 to 140 active clusters): (1) Northeast North Carolina/Southeast Virginia Essential Support Population of the Mid-Atlantic Coastal Plain Recovery Unit, (2) Talladega/Shoal Creek Essential Support Population of the Cumberlands/Ridge and Valley Recovery Unit, and (3) North Carolina Sandhills West Essential Support Population of the Sandhills Recovery Unit; and these populations are not dependent on continuing artificial cavity installation to remain at or above this population size. These populations are also listed in Table 3.

Criterion 5. For each of the populations meeting the above size criteria, responsible management agencies shall provide (1) a habitat management plan that is adequate to sustain the population and emphasizes frequent prescribed burning, and (2) a plan for continued population monitoring.

Rationale for Delisting Criteria

Criterion 1. A population size of 350 potential breeding groups is considered highly robust to threats from environmental stochasticity as well as inbreeding and demographic stochasticity. It is the lowest current estimate of the minimum size necessary to offset losses of genetic variation through genetic drift. One primary core population has the potential to harbor 1000 potential breeding groups within the near future; this criterion is included because such a large population may well be resistant to loss of genetic variation through drift. Eleven of 13 primary core populations are required for delisting because it is recognized that at any given time, one or two may be suffering hurricane impacts. Thirteen primary core populations are designated because of available habitat and because this number, together with 10 secondary core populations (below), may serve to facilitate natural dispersal among populations and maximize retention of genetic variability. Primary and secondary core populations provide for the conservation of the species within each major physiographic unit in which it currently exists, with the exception of South/Central Florida. This recovery unit is represented by several, smaller, essential support populations (below). Populations that depend on continuing artificial cavity installation to maintain stable or increasing trends are barred from meeting delisting criteria because this management technique is considered appropriate for short-term management only.

Criterion 2. A population size of 250 potential breeding groups is the minimum size considered robust to environmental stochasticity, and is well above the size necessary to withstand inbreeding and demographic stochasticity. Nine of 10 designated secondary core populations are required for delisting to allow for hurricane impacts.

Criterion 3. This unique habitat type is represented to the extent that available habitat allows. Unique genetic resources are conserved as much as reasonably possible.

Because of small size, some of these populations will remain vulnerable to extinction threats and may eventually be lost. The likelihood of extirpation of small populations is minimized by enhancing the spatial arrangement of territories so that they are highly aggregated.

Criterion 4. These unique or important habitats, and genetic resources contained within this population, will be represented at the time of delisting. This population size is midway in estimates of sizes necessary to withstand threats from inbreeding depression and is considered robust to demographic stochasticity if territories are moderately aggregated in space.

Criterion 5. Continued habitat management and population monitoring are necessary to ensure that the species does not again fall to threatened or endangered status.

Downlisting

Downlisting shall occur when each of the following criteria is met. Rationale for each criterion is presented immediately following this list.

Criterion 1. The Central Florida Panhandle Primary Core Population in the East Gulf Coastal Plain Recovery Unit is stable or increasing and contains at least 350 potential breeding groups (400 to 500 active clusters).

Criterion 2. There is at least one stable or increasing population containing at least 250 potential breeding groups (275 to 350 active clusters) in each of the following recovery units: Sandhills, Mid-Atlantic Coastal Plain, South Atlantic Coastal Plain, West Gulf Coastal Plain, Upper West Gulf Coastal Plain, and Upper East Gulf Coastal Plain.

Criterion 3. There is at least one stable or increasing population containing at least 100 potential breeding groups (110 to 140 active clusters) in each of the following recovery units: Mid-Atlantic Coastal Plain, Sandhills, South Atlantic Coastal Plain, and East Gulf Coastal Plain.

Criterion 4. There is at least one stable or increasing population containing at least 70 potential breeding groups (75 to 100 active clusters) in each of four recovery units, Cumberlands/Ridge and Valley, Ouachita Mountains, Piedmont, and Sandhills. In addition, the Northeast North Carolina/Southeast Virginia Essential Support Population is stable or increasing and contains at least 70 potential breeding groups (75 to 100 active clusters).

Criterion 5. There are at least four populations each containing at least 40 potential breeding groups (45 to 60 active clusters) on state and/or federal lands in the South/Central Florida Recovery Unit.

Criterion 6. There are habitat management plans in place in each of the above populations identifying management actions sufficient to increase the populations to recovery levels, with special emphasis on frequent prescribed burning during the growing season.

Rationale for Downlisting Criteria

Criterion 1. A population size of 350 potential breeding groups is considered highly robust to threats from environmental stochasticity as well as inbreeding and demographic stochasticity. It is the lowest current estimate of the minimum size necessary to offset losses of genetic variation through genetic drift.

Criterion 2. This population size, 250 potential breeding groups, is sufficient to withstand extinction threats from environmental uncertainty, demographic uncertainty, and inbreeding depression. These 6 populations, in combination with the single population identified in criterion (1), will represent each major recovery unit.

Criterion 3. A second population in these coastal recovery units will decrease the species' vulnerability to hurricanes. The West Gulf Coastal Plain is excluded because there are no candidate populations there. The lower size, 100 potential breeding groups, is considered sufficient to withstand threats from demographic uncertainty and inbreeding depression, and is much more quickly attained than 250 potential breeding groups thought necessary to withstand environmental stochasticity.

Criterion 4. These special habitats will be represented at the time of downlisting. This population size is midway in estimates of sizes necessary to withstand threats from inbreeding depression and is considered robust to demographic stochasticity if territories are moderately aggregated in space.

Criterion 5. This unique region will be represented at the time of downlisting. Forty potential breeding groups is at the lower end of estimates of sizes necessary to withstand inbreeding depression and are considered robust to demographic stochasticity if territories are highly aggregated in space.

Criterion 6. These habitat management plans are necessary to ensure progress toward delisting.

ACTIONS NEEDED

The primary actions needed to accomplish the ultimate (delisting) and interim (downlisting) recovery goals are (1) application of frequent fire to both clusters and foraging habitat, (2) protection and development of large, mature pines throughout the landscape, (3) protection of existing cavities and judicious provisioning of artificial cavities, (4) provision of sufficient recruitment clusters in locations chosen to enhance the

spatial arrangement of groups, and (5) restoration of sufficient habitat quality and quantity to support the large populations necessary for recovery.

DATE OF RECOVERY

We estimate that, with full implementation of this recovery plan, red-cockaded woodpeckers will be downlisted by the year 2050 and delisted by 2075.