Longleaf Ecosystem Restoration in the Wake of Hurricane Hugo

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ABSTRACT

When hurricane Hugo hit the Francis Marion National Forest in September 1989, the forest had some 36,000 acres of longleaf pine, with about 22,000 acres in large trees, mostly 50 years and older—prime habitat for a thriving population of red-cockaded woodpecker (RCW) and other animal and plant species native to this ecosystem. On many acres, up to 95 percent of the larger pine stems were snapped off or uprooted. About half of the 50 + year longleaf stands had standing basal areas of less than 15 square feet, and much of this was in stems of doubtful survival potential.

Immediate post-storm activity focused on re-opening roads and ditches, preparing fire breaks, and assessing prospects for timber salvage and forest regeneration. Steps were also taken to reserve and protect all surviving pine (both longleaf and loblolly) to aid recovery of the RCW population.

Stand survey showed a variety of conditions for which stand-specific prescriptions were made. In areas having adequate longleaf regeneration, prescribed burning to control brown spot needle blight as well as invading loblolly pine and hardwoods was the immediate prescription. On the hardest hit areas where there was neither advance regeneration nor potential for natural seeding, sites having lighter debris loads were set up for planting by debris windrowing with subsequent disking or bedding, depending on soil/site drainage characteristics. On sites with significant residual pine and/or heavy salvage-logging debris, planting spots were created with Bracke scarifier/mounders or with spot application of approved herbicides. Bare-root longleaf seedlings were planted in 1991. In 1992, a significant number of containerized seedlings will be planted as well. A well-timed prescribed burning program will be essential to bring the longleaf seedlings through the competing vegetation and to favor associated fire-adapted species.

Post-storm research includes studies of RCW recovery in various stand conditions and configurations, and ecosystem-level work involving imposition of different fire regimes, with variables of season, frequency, and intensity of burn. Both management practices and supporting research affecting the longleaf resource will be governed by the Land Management Plan for the Francis Marion, now under post-storm revision. The revised plan will analyze alternatives to manage and perhaps to expand total longleaf acreage on the forest, to support RCW recovery, and to explore innovative management techniques for longleaf, including uneven-aged stand management, to better meet the variety of demands being placed on this important resource.

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Proceedings of the Tall Timbers Fire Ecology Conference, No. 18, The Longleaf Pine Ecosystem: ecology, restoration and management, edited by Sharon M. Hermann, Tall Timbers Research Station, Tallahassee, FL, 1993

PRE-STORM HISTORY

When the 250,000-acre Francis Marion National Forest (FMNF) was established in coastal South Carolina in 1934-36, some 75,000 acres were mapped as longleaf pine (*Pinus palustris*) forest types (Grumbine 1936). Few of these stands bore any resemblance, however, to the virgin longleaf forests of the Atlantic seaboard described by Bartram (1791), Chapman (1932), Coker (1987), Landers et al. (1989). The original longleaf forests were a mosaic of systems with components ranging from savannahs (Frost et al. 1986) to stands supporting more than 200 square feet of longleaf basal area per acre. Most had been since the 1700s heavily and destructively exploited for naval stores (tar, pitch, and related products) and timber. Old-growth longleaf, such as can be seen today in the Wade Tract Preserve, was virtually gone by the late 1920s.

Longleaf stands seen in the 1930s on FMNF were largely second growth that had, against all odds, regenerated naturally following removal of the original forests. Some of these stands were thrifty and well-stocked. Most, however, were unimpressive, poorly stocked, and often of mixed composition. Some contained older specimens passed over in earlier diameter-limit cuts. Many of these veterans bore "cat-faces" from earlier turpentine operations. Typically the longleaf that persisted was found on low ridges and in the poorly-drained flatwoods among the extensive swamps and bays that characterize the South Carolina Low Country.

There is considerable evidence that Europeans brought not only these kinds of qualitative changes to the longleaf resource of the FMNF, and to the Low Country in general, but substantially reduced its area as well.

An excellent reference to the changed and changing nature of the Francis Marion Forest is provided in Grumbine's (1936) detailed inventory and management plan developed immediately after the Forest was established. Based on some 1700 0.2-acre plots on the 243,000 acres comprising the Forest in 1936 (98 percent of the current land base), the inventory's data and descriptive accounts provide insight into the original extent of longleaf pine in FMNF. They also help us understand why the area in longleaf continued to decline even after the land came under management as a national forest.

In this 1936 survey, 31% of the national forest was typed as longleaf pine (the 75,000 acres mentioned previously), 32% as loblolly (*Pinus taeda*), 9% pine-hardwood, 9% bottom hardwoods, 3% hardwood swamp, 13% pond, 2% bay and 1% non-forest. About 32% (24,000 acres) of the longleaf type resembled a forest but less that half of these acres had >2000 board feet of timber per acre. Of the 51,200 acres supporting <1000 board feet per acre, only 27% were stocked with longleaf regeneration. Thirty percent was stocked with small hardwoods ($\leq$3 inches dbh), 15% with small loblolly, and 28% was non-stocked (Grumbine 1936).

Evidence of a significantly wider distribution of longleaf on the FMNF prior to the 1936 survey is seen in the presence of overgrown tar pits in many loblolly stands, and even in hardwood stands of advanced age on the forest (Pers. Comm., Robert Morgan, Archeologist, FMNF.) The presence of these primitive naval stores processing sites indicates that the area in their immediate vicinity once supported longleaf forests, since kilns were always sited close to significant quantities of longleaf wood.

Casual factors in the progressive decimation of the longleaf resource from colonial times to the present are numerous and interactive. They are the subject of a fascinating historical-sociological-ecological treatise on the Atlantic seaboard forests during the period 1500-1800 (Silver 1990). Two of the more important ecological factors cited by Silver came even more strongly into play after 1800. These are feral hogs (*Sus scrofa*) and forest fire.

The lack of longleaf regeneration noted by Grumbine (1936) and others was in part a consequence of an increasingly abundant and pervasive population of feral hogs in the coastal forests. Grumbine (1936) stated that, "Hogs range everywhere over the Forests, causing considerable damage to longleaf pine reproduction. Stock laws in both Berkeley and parts of Charleston County are not enforced, and stock are permitted to range at large over the entire Forest."

Although the impact of feral hogs, and their voracious appetite for the heavy taproot of longleaf seedlings eventually became well recognized (Wahlenberg 1946), it was not until the mid-1960s that the Forest Service made a major effort to control them (Lucus 1977). The abundance of feral hogs on the land in South Carolina for 3 decades under National Forest management, and for many years previously, doubtless played a role in the decline of the longleaf resource in FMNF, as it did elsewhere in the South.

Fire, or more precisely, changes in frequency and kinds of fire, was another major factor in the retreat of longleaf in the Low Country landscape. Settlement and the resulting fragmentation of the forest incident to its exploitation broke the continuity of longleaf forests that previously had allowed frequent natural fires and those set by the native people to suppress off-site tree and shrub species that compete with slow-starting longleaf seedlings. Disruption in pre-settlement burning patterns also set the stage for the buildup of heavy fuel loads which often were followed by catastrophic wildfire. Such fires understandably were seen as enemies of regenerating forests and a hazard to those living on the land. Hence when the Francis Marion was established, an early goal was wildfire prevention, suppression, and control.

These early fire control programs were highly successful (Grumbine, 1936). However, while accomplishing legitimate forest protection goals, they further accelerated the pace of forest type conversion on the FMNF. Loblolly pine and light seeded hardwood species, (e.g. sweetgum, *Liquidambar styraciflua* and red maple, *Acer rubrum*), earlier confined to the wetter sites by frequent ground fires, expanded aggressively onto the non-stocked longleaf sites described by Grumbine (1936). They also invaded recently abandoned agricultural lands, and took over the understory of poorly stocked longleaf stands. As the second growth longleaf was harvested or taken out in windstorms, new forest types--comprised of loblolly and various hardwoods—became dominant.

Observant foresters recognized these changes in the forest succession process and the role of fire in them, and began to work to harness fire as a silvicultural tool. Trials of experimental burning were begun on FMNF in the late 1930s, and by 1944 prescribed burning was adopted as a major management activity. Winter burns were made every 3-5 years on about 45,000 acres each year (U.S. Forest Service 1985). In 1946 a long term prescribed burning study was started by the Southeastern Forest Experiment Station on the Santee Experimental Forest (Waldrop et al. 1987). This work, and other research across the region, contributed greatly to understanding effects of prescribed burning in southern pine silviculture and to its wider and more effective application. The use of prescribed burning could not, of course, reverse the changes that 200+ years of perturbation had set into motion.

During the past two decades, significant efforts have been made to reverse the decline of longleaf on the FMNF. These efforts have been spurred by reawakened interest in and concern for the longleaf resource generally, and on the FMNF, by concern for the welfare of the Forest's population of the endangered red-cockaded woodpecker (*Picoides borealis*) (RCW). Efforts have included longleaf regeneration both naturally and artificially (planting), and by use of species-specific prescribed burning regimes. Progress has been slow, but regeneration successes have been recorded, and both existing and regenerated stands of longleaf on the FMNF have been returned to the open understory conditions more closely resembling those in the original forests.

It is a source of satisfaction to managers of FMNF that the forests in their care have not only produced an abundance of conventional multiple-use benefits, but also have provided the core of habitat for the only population of RCW known to have been increasing in size, and approaching a recovered level (Hooper et al. 1991a). Sixty percent of the woodpecker's cavities on FMNF in 1989 were in longleaf pine, even though only 25 percent of the pine stands were longleaf. It is not clear if these percentages represented a preference for longleaf over loblolly for cavity trees. Because the birds clearly prefer trees with decayed heartwood (red heart disease) for cavity excavation (Hooper et al. 1991b), it may be that the high percentage of longleaf used as cavity trees simply reflected the greater proportion of longleaf trees old enough to have developed favorable heartwood conditions. Unquestionably, however, the presence of extensive stands of large longleaf contributed to the well-being of the RCW on the FMNF.

To conclude and summarize this brief effort to describe and interpret the condition of the FMNF prior to Hurricane Hugo, and to provide a basis for description of and rationale for post-storm restoration efforts, we must point out that prior to the storm, the FMNF was a beautiful, ecologically diverse, and highly productive forest. It presented, however, quite a different landscape and composition from that viewed by the earliest Europeans to visit it. In the immediate pre-storm period its longleaf component represented by our estimates less than one-fourth of its original area (i.e. 34,000 vs perhaps 150,000 acres). This forest was also quite different qualitatively from its predecessor, not only in the nature of the trees and timber resource, but in many other plant and animal components as well. Surveys made in the immediate pre-storm period (U.S. Forest Service 1985), showed a forest composed of approximately 51 percent loblolly pine, 19 percent longleaf pine, 2 percent pond pine (*P. serotina*), 25 percent hardwoods (mostly swamp and bottomland species), and 3 percent mixed pine-hardwood types. Evidence cited above suggests that prior to European settlement, all of the area in longleaf forest type, much of the loblolly type, and even some of the hardwood types present just prior to Hugo's landfall were originally occupied by longleaf.

THE STORM AND ITS EFFECTS

On the night of September 21-22, 1989, the FMNF was struck head on by Hurricane Hugo. Maximum sustained winds at landfall were estimated to be 135 mph. Wind gusts over the FMNF were estimated as high as 145 mph (Powell et al. 1991). Because the eye of the storm passed just to the south, the midsection of FMNF (Hook et al. 1991) was subjected to the winds of greatest force. Though wind speeds began to drop over land, hurricane-force winds were sustained at the storm's center well across South Carolina.

The entire FMNF was affected, but wind damage was considerably less on the northern side. Tidal surges ranged up to 20 feet; these were highest northeast of the storm's path.

Not all pine stands in FMNF were affected the same. Stand age and stocking appeared to be related to severity of damage. Many 30- to 40-year-old stands lost less than 20 percent of their trees, even in the region of maximum winds. Stands younger than this (i.e., small pole-sized timber) tended to suffer both breakage and severe bending, but many will survive as manageable stands. Saplings also were heavily damaged where winds were highest, with many trees badly bent or tipped and root-sprung. The outlook for these stands is uncertain; only time will tell about the quality of wood produced by the survivors. In some 10,000 of the 22,000 acres of longleaf more than 50 years old, up to 95 percent of the larger stems were snapped off or uprooted. About half these stands had a surviving basal area of less than 15 square feet per acre compared to 60-90 square feet prior to Hugo. Many of the trees still standing are leaning or have severely damaged tops and are of questionable survival potential. Damage in stands more than 50 years old appeared to be related to stocking density. Some stands with basal areas more than 90 square feet per acre withstood strong winds with only moderate damage while similar and nearby stands, recently thinned, were decimated.

In the areas of most intense wind, there did not appear to be a difference in survival of longleaf and loblolly. However, 15 miles north of the FMNF in Hobcaw Barony, where wind velocities were lower, longleaf survived the storm much better than loblolly (95 vs. 52 percent survival (Hook et al. 1991). In both species, trees that survived were smaller than those that were either broken or uprooted.

Observations from both the FMNF and Hobcaw Barony indicated that baldcypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*) present in forested wetlands suffered significantly less damage than either longleaf or loblolly pine. However, high quality bottomland hardwoods, including stands of cherrybark oak (*Quercus falcata* var. *pagodaefolia*) on the Santee Experimental Forest (adjoining the FMNF) were damaged heavily, with many trees uprooted (Hook et al. 1991). Large, dominant trees were hardest hit.

In addition to the trees, many species of wildlife were severely impacted—directly and indirectly—by the storm (Cely 1991). Of special concern to the FMNF was the loss of habitat critical to the RCW. It was estimated that 87 percent of their cavity trees were destroyed and 63 percent of the birds were killed. In addition, more than 50 percent of the sawtimber-size pines needed for future cavity trees and foraging habitat were destroyed (Hooper et al. 1990).

POST-STORM MANAGEMENT ACTIVITIES

Work in the FMNF commenced immediately after the storm. After the most pressing humanitarian needs had been addressed, work was focused on reopening roads and ditches. Months of work followed to assess timber salvage prospects (a billion board feet of highly valuable timber was on the ground), to process and manage timber salvage sales, to prepare firebreaks (to protect against catastrophic wildfire), and to plan forest regeneration. Steps also were taken to protect all pines (both longleaf and loblolly) having any reasonable prospect for survival, to aid recovery of the RCW. These measures to preserve habitat were reinforced with an intensive effort to create artificial cavities to provide shelter and nesting sites for the surviving birds (Hooper et al. 1990).

Extensive stand surveys were made, utilizing foresters and technicians called in from many other National Forests. These surveys identified a wide variety of conditions for which stand- and site-specific recommendations were developed.

Early on, decisions were made to rule out timber salvage in stands where logging would severely impact the overall forest resource. Where logging was deemed ecologically acceptable, every attempt was made to suit logging systems to site and stand conditions. Low impact salvage methods, including helicopters, mule and horse teams, cable systems and low ground-pressure rubber-tired skidders, were used extensively. In concert with salvage logging plans, forest regeneration strategies and prescriptions were developed.

Sites that had adequate young (seedling) natural regeneration when the storm struck were identified and scheduled for prescribed burning when conditions would permit. In these young stands, little else was required immediately. In these situations, appropriately prescribed fire will help control brownspot needle blight on longleaf, and discourage invading loblolly pine and light-seeded hardwoods. Some of these stands likely will require subsequent release work, and perhaps thinning, as well.

In heavily-damaged stands where an adequate longleaf overstory remained, plans were made for natural regeneration. Unfortunately, the 1989 cone crop on longleaf was very light, and no natural reproduction of longleaf occurred following the storm. (This was in contrast to loblolly, which had a good cone and seed crop that was sufficiently mature when the storm struck to produce significant post-storm regeneration of this species on many sites). Longleaf stands judged suitable for regeneration from natural seedfall were identified for monitoring of conelet and cone production. When an adequate seed crop for successful natural seeding is anticipated, these sites will be prepared by burning, disking or scarification prior to seedfall.

For the 10,000 acres of longleaf sawtimber stands where the overstory had been heavily damaged, approximately 8,000 acres had little or no advanced longleaf regeneration and insufficient surviving trees for successful natural regeneration through seeding. If these were to be retained as longleaf stands, it was clear that artificial regeneration (i.e. planting or direct seeding) would be required.

Three obstacles to regeneration immediately were apparent: (1) it would be necessary to work around the residual pines reserved to support the surviving RCW population, (2) most of the stands had tremendous quantities of debris on the ground, and would have even following salvage logging, and (3) many stands supported, or would soon be invaded by, young loblolly and light-seeded hardwood brush that would compete strongly with planted longleaf seedlings.

Since planted longleaf pine seedlings usually need some form of site preparation to gain advantage over established competing plants, prescriptions for these kinds of activity were developed based on site conditions. On most areas with standing residual pines and heavy logging debris, traditional site preparation methods for longleaf planting, such as shearing, debris windrowing and combinations of disking, chopping and bedding prior to planting were deemed to be unfeasible or environmentally unacceptable. These methods would have been extremely difficult to apply in most situations, carry a high risk of site degradation, especially under wet conditions, and damage residual trees. When applied across the entire area being prepared, they also can have undesirable effects on the natural plant community in the understory.

Given these considerations, two methods of site preparation were favored. In the first, the Bracke scarifier/mounder, which can be pulled behind a path-clearing tractor, was used to create a line of scarified patches or mounds of mineral soil. The Bracke also can be fitted with equipment for simultaneous band application of selective herbicide to control competing brush in the planting row. The Bracke-built mounds provide well-aerated microsites (roughly one foot square) and a measure of temporary relief from competing plants.

The second preferred method was spot application of herbicide on a grid pattern using backpack sprayers. The latter method generally was prescribed where little or no salvage was done, and the debris on the ground was too heavy for the Bracke to work.

Both of these low-impact methods affect only a few square feet around each planted seedling, a major departure from more conventional site preparation methods, some of which affect the entire area. The Bracke provides a favorable planting spot, and both techniques offer the opportunity to relieve the severe localized competition that can overwhelm newly planted seedlings. Both also minimize undesirable impact on highly valued indigenous plants, including (on FMNF) sensitive species such as the yellow fringeless orchid (*Habenaria integra*) and American chaffseed (*Schwalbea americana*).

In some areas where few large pines were left standing, where normal salvage logging was unfeasible, and where heavy stands of young brush were present, whole tree chippers were used to remove some of the badly-broken debris. The residual debris was windrowed and the sites either disked or bedded to prepare them for machine planting.

Bedding was used on some of the more poorly drained soils, since they were expected to be unusually wet during planting season due to the absence of a transpiring overstory and impedance of drainage in natural channels by debris. While longleaf is often found on poorly drained sites, it typically shows higher survival and early growth when transplants are afforded some measure of improved aeration in their rooting zone. Bedding thus provides both reduction of competition and improved aeration of the planting zone.

In the 1990 and 1991 planting season, most of the sites variously prepared were planted. While machine planting had been used on some sites on the FMNF prior to Hugo, and was intended for use in some of the intensively prepared sites previously described, the two winters following the storm have been quite rainy, and all sites were judged to be too wet to accommodate machine planters. Consequently, hand planting has been used exclusively on the Forest since the storm. In spring 1990, bare-root 1-0 longleaf seedling stock was planted. In 1991, over 1800 acres were planted with containerized longleaf seedlings (tubelings), based on preliminary trials where these had shown superior survival and growth over bare-root stock.

Since the site preparation methods used provide less competition control than traditional methods, a well-timed prescribed burning program will be essential to bring the longleaf pine seedlings through. Release of developing seedlings by thin-line stem application or directed foliar spray of herbicide will probably be necessary in some areas.

As seedling longleaf stands develop, a systematic program of stand monitoring and silvicultural treatment will be necessary. This will involve periodic prescribed burning, competition control as required, and, where natural regeneration is employed, appropriate management of the overstory once natural regeneration is established. Post-Hugo guidelines for RCW recovery, which require retention of all surviving pines, have raised concern that retention of *all* overwood after successful longleaf regeneration will severely retard growth of the young stands (a phenomenon commonly observed across the South, Boyer 1989). A compromise presently being considered is that clumps of surviving trees be left after successful establishment of longleaf seedlings, while scattered survivors are removed. This could provide continuing foraging habitat and future colony sites for RCW in the clumps, while freeing the remaining young stand to grow rapidly to provide additional future foraging habitat, as well as enhancing other resource values.

Similarly, the significant acreage of damaged longleaf in sapling and small pole size classes would benefit from thinning to remove severely deformed stems and root-sprung individuals, and to permit rapid development of high-potential survivors. Again, compromise on post-storm RCW guidelines may be appropriate for the good of the total resource.

Perhaps the most important post-storm policy issue on FMNF has to do with regeneration of storm-devastated, salvage-logged loblolly stands on the better-drained soils. These situations present an opportunity for reestablishment of longleaf. The extent to which this opportunity is pursued will depend on decisions that are reached in the revision of the Land Management Plan which is now underway.

Many factors will affect such decisions. However, as it has for the past two decades, the welfare of the RCW will continue to be a major consideration. Some wildlife biologists have suggested that the bird has a preference for longleaf pine (USFWS 1985). In our opinion such a preference has not been sufficiently demonstrated. Nevertheless, we think there are compelling arguments for trying to provide longleaf pine habitat for the RCW. First, longleaf pine probably constituted most of the habitat for the species in FMNF in pre-Columbian times. Second, longleaf is much longer-lived than loblolly and is more resistant to damaging insects and diseases than loblolly. Thus, colony sites in longleaf stands can be expected to last more than twice as long as those established in loblolly stands. Third, it appears that longleaf has a higher survivability in moderate hurricanes than loblolly. While hurricanes of Hugo's intensity are relatively rare, milder hurricanes are not. Hooper et al. (1990) estimated that the FMNF has been subjected to hurricane-force winds on average of once every 16 years. A longleaf pine forest—with a good distribution of age classes—might thus survive and provide more suitable RCW habitat over the next several hundred years than one composed primarily of loblolly pine. Besides, a strong case can be made for longleaf pine ecosystem restoration on appropriate sites even without the particular values placed on RCW.

Another factor that must be considered in planning on national forests is the National Forest Management Act's requirement that habitat be provided to support viable populations of flora and fauna that naturally occur on each national forest (i.e., not only endangered species such as RCW). This requirement presents a host of significant questions and challenges for National Forest managers everywhere.

POST-HUGO RESEARCH

In the Southeastern Forest Experiment Station's post-Hugo research program, several major initiatives involving longleaf pine are being pursued (Van Sickle, 1990). In two of these, the longleaf ecosystem is the focus. In another, genetic variation among longleaf provenances is being studied. In a fourth, that important component and inhabitant of the ecosystem, the RCW is at the center.

The longleaf ecosystem work is embodied in two complementary studies. One is being led by Dale Wade of the Southeastern Station's Macon Research Unit, in concert with Principal Investigators Jeff Glitzenstein and Donna Streng, associate researchers at Tall Timbers Research Station. David Van Lear of Clemson University and Bill Harms of the Southeastern Station's Charleston Unit are co-leaders of the other. Both studies grew out of a planning session convened in Charleston to secure input from a group representing diverse interests and expertise relating to longleaf ecology and management from across the South.

The Glitzenstein/Streng study plan has three main elements:

1. Historical and paleoecological investigations aimed at identifying the characteristics of presettlement vegetation on various types of sites in the forest.
2. A field experiment testing the effectiveness of different fire regimes for restoration of longleaf pine communities. This work includes appraisal of effects of fire regimes on planted pine seedlings as well as on existing and artificially introduced groundcover vegetation.
3. Replication of experimental treatments across a full range of drainage classes. This feature will allow for tests of interactions between site conditions and fire regimes on current and restored vegetation, as well as on growth, vigor and development of the planted pine seedlings.

The Van Lear/Harms study also addresses fire ecology, but takes a broader perspective. It addresses the hypothesis that in pre-settlement times, interactions between fire and hurricanes played a significant role in the establishment and maintenance of plant communities of the Coastal Plain, some of which (such as prairies and savannahs) are no longer well-represented in the landscape. For example, intense fires in heavy debris may create conditions favorable for development of grass-forb communities, and continued burning at periodic intervals could favor establishment of longleaf pine savannahs, while annual summer fires might encourage development and maintenance of treeless prairies.

The study will be installed on the Santee Experimental Forests and includes five fire treatments. Following plot installation, composition and structure of plant communities developing in hurricane-impacted stands will be assessed and followed prior to application of (a) annual summer, (b) annual winter, (c) periodic summer, (d) periodic winter and (e) no burn (control) treatments. Nutrient pools and dynamics also will be characterized during the early hurricane-recovery phase.

The longleaf pine genetic variation study is under the leadership of Earl Sluder of the Southeastern Station's Regeneration Unit at Macon. It addresses the adaptability of different geographic provenances (seed sources) as planting stock for the FMNF. This work is being done because good seed crops on longleaf pine occur infrequently, and sometimes sufficient seed and seedlings of local origin are unavailable when needed. In anticipation of future major planting efforts in post-storm or other disaster scenarios, this study can help FMNF managers make more intelligent selections among available planting stock and seed lots to be sown. The eight sources to be evaluated are from

Mississippi, Alabama, North and South Carolina, Georgia and Florida. Container-grown tubelings from these provenances were planted in May 1991 at 5 locations on the FMNF. Their performance will be followed for as long as seems appropriate.

The work with RCW is led by Bob Hooper. A basic premise of this series of studies is that hurricanes are a significant factor in the ecology of coastal plain longleaf pine ecosystems, and a major factor to be considered in planning for the long-term recovery of the red-cockaded woodpecker. Hooper et al. (1990) estimated that Hugo-class hurricanes have occurred about every 6 years since 1899 within the range of the RCW (and within the range of coastal plain longleaf).

Lesser hurricanes occur at less than 1 year intervals on average. Thus, the likelihood of a hurricane striking somewhere in the bird's range in a given year is quite high. But the probability of a given point being struck in a given year is quite low. Certainly, the situation suggests a need for a broad distribution of reserves for longleaf pine ecosystems and their fauna.

RCWs are particularly at risk to hurricanes because of the vulnerability of their cavity trees and foraging habitat. Research was begun immediately after Hugo to develop better understanding of how the RCW responds to such catastrophic events. These events will doubtless continue to plague the species in coastal plain longleaf pine ecosystems, and ways are needed to mitigate the impacts.

Specifically, the demography of the woodpecker population after Hugo is being documented. Most clans have much less habitat than was previously thought necessary for support. Clan performance under these impoverished habitat conditions is being quantified. Most RCWs on the FMNF are now living in artificial cavities. The efficacy of the three types of artificial cavities that have been installed is being evaluated. A host of other cavity-nesting species of the longleaf pine forest have lost their nesting sites. As a consequence they are severely competing with the RCW. On a trial basis, nest boxes are being installed for these other species as a possible means of lessening interspecific pressure on the woodpecker.

A CONCLUDING PERSPECTIVE

Hurricane Hugo dealt the FMNF, the people who have nurtured, studied and protected it for many years, and the communities dependent upon it, a devastating blow. The effects will be evident for several decades. But such events typically present opportunities as well. Our task is to recognize and exploit them. On the FMNF, lessons already have been learned about how better to manage coastal forests to minimize some of the damaging effects of such windstorms (Hooper et al. 1990). Other lessons are still unfolding. Hugo's devastation of many FMNF forest communities that developed under unnatural and often suboptimal conditions also has provided an opportunity and a challenge to us to start, in many cases with a nearly clean slate, to manage the forest more appropriately in the future, and to continue to expand our understanding of the now widely-appreciated longleaf pine ecosystem.

It is our hope that the management and research we've described is equal to these challenges, and that these and other efforts to restore highly functional longleaf pine ecosystems to their historical niche in the Low Country's landscape, and elsewhere in the South, will be successful.

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