

"Is a Bird in the Hand Worth Two in the GIS?": The Proposed Use of GRASS for Red-cockaded Woodpecker Management at Fort Polk, Louisiana

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Abstract. The red-cockaded woodpecker (RCW) is an endangered species native to the longleaf pine forests of the southeastern United States. Loss of habitat is the primary reason for the bird's endangered status. Much of the bird's range is now confined to federal lands, including several military installations. One of the largest populations is at Fort Polk, Louisiana.

This paper discusses some preliminary findings regarding the use of the GRASS GIS to evaluate and model RCW habitat. Locations of trees with RCW cavities have been accurately mapped for the first time by Fort Polk personnel using a global positioning system (GPS). Complete forest stand information has also recently been compiled for the installation. In conjunction with landcover classifications of SPOT (Système Probatoire d'Observation de la Terre) satellite imagery, these and other environmental parameters can now be incorporated as part of a more comprehensive management plan for the species. The GRASS GIS provides a platform to initiate more systematic studies.

Results of the analysis are compared with guidelines specified by the U.S. Forest Service RCW recovery plan (1985) and other current management policies. The adequacy of these measures as they pertain to the unique habitat conditions at Fort Polk is discussed. Recommendations are forwarded as to how GRASS can be used to customize habitat requirements on a case-by-case basis, thereby reducing the reliance on parameters derived for one habitat that may not necessarily be applicable across the whole range of the species. In this way, the needs of the woodpecker can be met in a manner more harmonious with local conditions and land use patterns.

Introduction

The United States military establishment is responsible for the care of millions of acres of public land, admittedly no easy task given the destructive capability of today's modern weaponry. The Department of the Army has realized, albeit belatedly, that it can determine its own fate with regard to environmental regulation by preparing enlightened conservation plans. The army now recognizes that the proper stewardship and management of the land and its inhabitant species is an essential component of realistic and effective training. An additional incentive for compliance is public perceptions; the army is showing an increased willingness to work with other government regulatory agencies, local officials, and the neighboring populace. A new generation of commanding officers has broadened the initiative to enforce and improve existing environmental policies.

Individual installations usually incorporate large tracts of land to support their missions. Nevertheless, because of pressure to reduce military expenditures, and because land is a scarce commodity, it is becoming increasingly difficult for the army to meet its training needs within the limits of existing property holdings without causing irreversible damage to the environment. Recent litigation and public disfavor against new military land acquisitions suggest that the land crunch will not abate in the near future, if ever. Although there are zones of intensive use, many installations contain large tracts of relatively unspoiled property that can be home to species of rare, threatened, or endangered plants and animals. The presence of protected species adds one more limitation to the use of those lands.

This environmental paradox is exhibited at Fort Polk, Louisiana. The base comprises an area of approximately 198,000 acres in west-central Louisiana near the Texas border (figure 1). Fort Polk is a primary training facility for the U.S. Army and is headquarters to the Fifth Infantry Division (Mechanized). Much of the area within the installation boundary has been severely affected by 50 years of continuous military exercises. However, large portions of the base are undisturbed and support a thriving wildlife population, including deer and wild turkeys. These and other animals are hunted for sport.

Fort Polk is also one of the last refuges of an endangered species, the RCW. This diminutive bird, though not as well known, is as politically sensitive, economically controversial, intensively studied, and indicative of its native ecosystem as the more famous northern spotted owl.

Time has almost run out for the RCW. Its native habitat, the old-growth longleaf pine forests of the southeast, no longer exists anywhere in a pristine state. Almost all of it has been replaced by monocultural pine plantations owned by paper companies. Consequently, the RCW population has become concentrated on federal lands, including military reservations such as Fort Polk, where remnants of the original forest remain. Recent estimates place 75 percent or more of all RCWs on federal property; of these, most are in the southeastern national forests, with the remainder in wildlife refuges and military bases. The status of the species on private and industrial lands is unknown, and few systematic surveys of these parcels have taken place. However, it is conceded that most of these populations have been lost and that the original ecosystem of the RCW can never be restored, despite the best intentions of the forest industry, military, and other agencies. The fate of the RCW is destined to remain forever in the hands of humans. This stark fact seldom has been completely admitted to by any students of the bird.

This paper reports preliminary findings regarding the use of the GRASS GIS to analyze RCW habitat at Fort Polk. The current work concentrates on the northern portion of the installation, the Peason

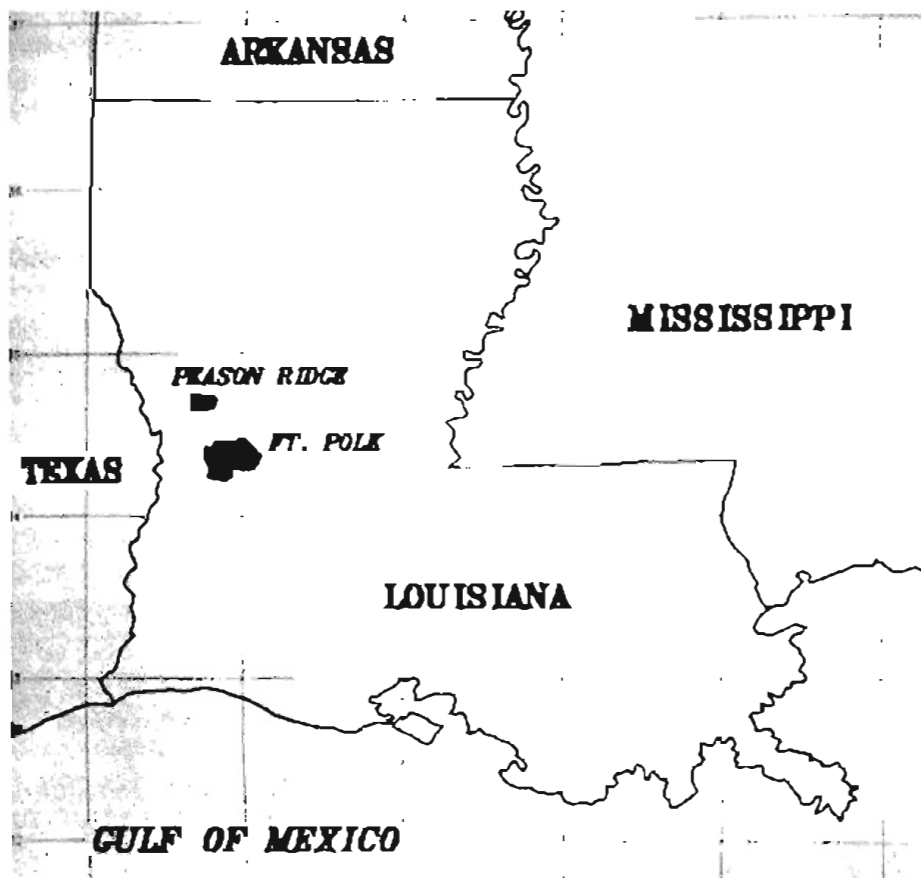


Figure 1. Location of Fort Polk and Peason Ridge training area, Louisiana.

Ridge training area. The database for this area contains the most complete environmental information necessary for conducting a GIS study of this kind. The paper is presented within the context of the scientific, political, and economic factors that have helped to shape current environmental policy toward the RCW. This policy is in turn manifested in existing U.S. Forest Service, U.S. Fish and Wildlife Service, and Department of the Army regulations. The author hopes that several shortcomings in current management policies will be revealed, especially with regard to issues of methodology and implementation. Problems with generalization and lack of site-specific habitat parameters will be forwarded.

This paper also proposes that solutions may be forthcoming, due in large part to the application of emerging technologies such as geographic information systems, satellite global positioning systems, and computerized expert management systems. The author's thesis work involves the application and use of such technologies in helping to resolve some of the above issues. In the case of the RCW, GIS makes it possible to construct a flexible, yet standardized system of management alternatives.

Background

Description and Natural History

The red-cockaded woodpecker (*Picoides borealis*) is a small bird about 7.5 inches in length. The downy woodpecker, familiar to residents of the northeast and midwest United States, and the hairy woodpecker are two close cousins. The cockade is a small tuft of red feathers found on the cheeks of the male bird; these feathers are revealed only during courtship and periods of intense excitement or perturbation. The lack of evident sexual dimorphism makes field identification of males and females difficult. Audubon and other early naturalists described the species as ubiquitous and abundant throughout the pine forests of the southeastern United States. The historical presence of the species is highly correlated with the known distribution of longleaf pine forests in the southeastern United States. The documented range of the bird is from the South Atlantic coast to eastern Texas and Oklahoma, and from the Gulf coast north into Kentucky and Virginia. Outlying populations have been reported from as far north as Maryland and from the Missouri Ozarks. Genetic and demographic studies indicate that the largest and densest populations occurred from South Carolina through northern Florida.

Since the days of Reconstruction following the Civil War, the southern pine forests, along with all others in the region, have been subjected to intensive and often destructive lumbering practices. Since at least the 1940s concerned observers of the bird had warned of its impending fate in the face of unrelenting habitat destruction. Besides the overall destruction of suitable forest types, a compounding problem is the increasing fragmentation of available habitat and the concomitant isolation of populations from each other. Barriers to gene flow and genetic drift pose serious long-term consequences for the species viability unless suitable alternatives such as captive breeding programs or translocation are successfully developed.

More subtle, if no less pernicious, than the outright felling of trees has been the imposition of "scientific" management techniques on the natural order of the forests. Modern timber management techniques have not ameliorated the situation because the rigid cycle of short-term, even-aged harvests does not allow time for the regeneration of old-growth forest.

Another management policy, that of fire suppression, has had drastic impacts as well. The primeval forests were periodically subjected to widespread, intense, yet rapidly burning forest fires caused by lightning strikes. The pine forests were supremely adapted to this destructive scenario. The fires killed the competing deciduous trees, cleared the canopy understory, and sustained an open setting that provided browsing and forage areas for a number of species. The reigning animal specialist of this biome was the RCW. Indeed, its unique adaptation of excavating its home cavity in still vital, mature trees is only the most obvious manifestation of this specialization.

Ecological Summary

The RCW excavates its roost and nest cavities in living pine trees. Preferred trees are longleaf pines over 95 years old and loblolly pines over 75 years old. These older trees are more likely to be infected with the red heartrot fungus, *Phellinus pinii*, which may assist the bird in its laborious task. Nevertheless, a bird can take months or even years to complete a cavity.

Clusters of cavity trees, called colonies, may include up to 30 trees (figure 2). Not all of the trees are necessarily occupied simultaneously. Each colony is occupied by a clan of related individuals. A typical clan includes a single breeding pair, the most recent brood of immature offspring, and male juveniles up to three years old. Juvenile females disperse from the natal group upon fledgling. RCWs are cooperative breeders, and the juvenile male offspring often assist with the care and feeding of the newest clutch, an altruistic behavior that may increase both the survival rate of the offspring and the breeding success of the juvenile males. Several studies confirm that the breeding pair, and their nest cavity in particular, are the referential and social loci for the entire clan. Ties to the home territory are strong; the cavity trees are valuable real estate, both in territorial and genetic terms. Male helpers acquire breeding status by inheriting existing territory or, secondarily, by usurping nearby existing colonies. Territorial budding into abandoned colonies is rare, and colonization of virgin territory has not been observed.

Historical Background

The RCW was first brought to the attention of western science in the early 1800s. John James Audubon was the first to paint a living specimen. The recent history behind efforts to study and save the RCW from extinction is almost as interesting as the ecology of the bird itself. Despite a few seminal studies, little attention was paid to the bird until it was placed on the endangered species list in 1968, which resulted in an intense, albeit belated, flurry of scientific inquiry. In 1971 the first symposium on the ecology and management of the RCW was convened with participants from the lumbering industry, federal agencies, and the scientific community (Thompson 1971). The goals of the symposium were understandably modest given the limited knowledge of the RCW at the time.

During the next decade a spate of basic research ensued, including surveys, banding, field observations, habitat assessment, population censuses, and colony demarcation. A special panel was appointed to formulate recovery efforts. Active research programs were located in North Carolina, South Carolina, Florida, and Texas. The first rangewide census of RCWs on federal property was conducted in 1979. This work culminated in the first RCW recovery plan (Jackson et al. 1979). However, opponents within the forest industry and the U.S. Forest Service succeeded in disbanding the original panel and nullifying the first recovery plan.

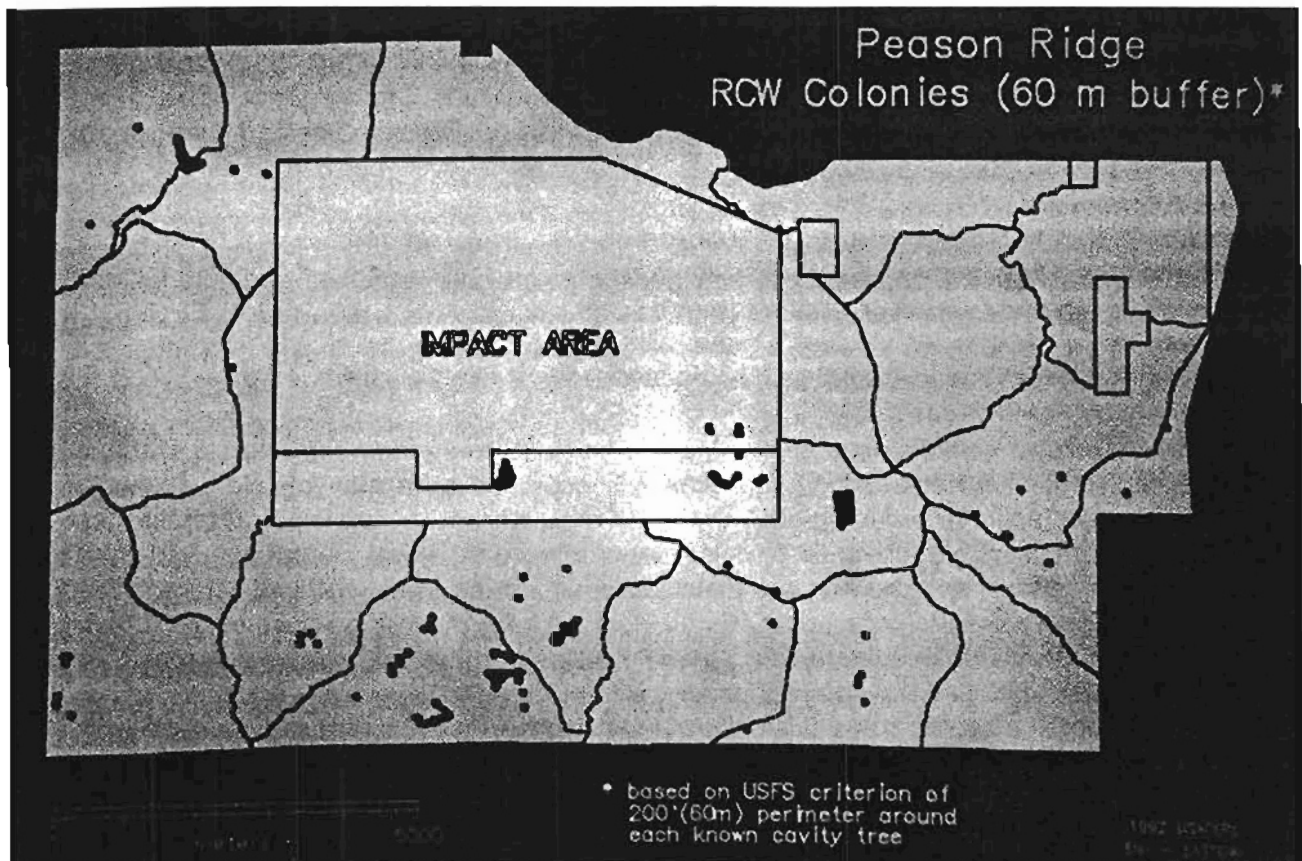


Figure 2. Red-cockaded woodpecker (RCW) colonies on Peason Ridge.

In the midst of this furor a second RCW symposium was held (Wood 1983). The rift between the forces of outright conservation on one hand and less restrictive management on the other was evident by this time. However, complete polarization was circumvented, and the level of scientific understanding of the bird was raised substantially, both quantitatively and qualitatively. Nevertheless, the same year the U.S. Fish and Wildlife Service appointed another biologist to write a new recovery plan.

The revised plan was released in 1985 (U.S. Fish and Wildlife Service 1985). It was, in turn, heavily criticized by proponents of the old plan. During this period about all that could be agreed on was that numbers of the birds were continuing to diminish and that suitable habitat was disappearing at a rapid rate. The International Council for Bird Preservation and the American Ornithologists Union (AOU) published their own separate opinions and recommendations on RCW recovery (Ligon et al. 1986).

There have been two primary objections to the 1985 recovery act. The first objection is that the level of protection specified was based on the perceived minimum habitat requirements rather than on optimum conditions. The plan emphasizes minimum ages for cavity trees, minimum forage areas, and minimum population sizes. Opponents feel that this level leaves little or no margin for error in calculating sustainable populations of the bird.

The second major objection to the plan is that it was based almost exclusively on data collected for only one RCW population, that in the Francis Marion National Forest in South Carolina. This was the largest and healthiest population at the time. Moreover, the plan's recommendations were supported largely by a single study of this population (Hooper et al. 1982). Despite acknowledging that most RCW populations are on marginal lands that necessitate much larger habitats, the plan was approved. At the time the AOU committee warned: "The Recovery Plan and Handbook recommendations will be inadequately modified to other areas. This is one danger of recommending a specific average value for a geographically widespread area" (Ligon et al. 1986, p. 851). Another author commented: "Extrapolation from this single healthy site for use as a basis of management of the species throughout its entire range is scientifically unsound" (Jackson 1986, p. 1164).

The latter statement was almost prophetic — in September of 1989, Hurricane Hugo slammed into the coast of South Carolina with winds exceeding 125 mph. The center of the storm passed directly over Francis Marion National Forest. The forest was obliterated; of the 1,900 or so known RCWs, 1,000 died or disappeared. Most of the remainder had no cavity trees to live in or were so disoriented that clan social life was completely disrupted. An emergency team constructed 600 artificial cavities in the trees that were left standing. The good news is that 65 percent of these artificial homes were occupied. The bad news is that the model habitat on which almost all RCW policy is based no longer exists. The fate of this population is now in as serious jeopardy as any other. Without intensive human assistance, its chances for survival are precarious.

The disaster at Francis Marion sent shock waves through the scientific community studying the RCW. In response to legal pressures and to appease its critics, the Fish and Wildlife Service issued an interim implementation guide for RCW management (U.S. Department of Agriculture, Forest Service 1990). For the first time a desired increase in the numbers of birds and available habitat was made explicit. Severe restrictions were placed on harvest methods and timber takes within prescribed zones around known colonies. Surveys of timber management units were to be undertaken before any proposed action. Colony boundaries were to be delineated and clearly marked. In addition the interim agreement stated: "Colony site maps should be so accurate that someone unfamiliar with the area can find the colony site and locate all known cavity trees without assistance. Consideration should

be given to GIS tracking of colony data" (U.S. Department of Agriculture, Forest Service 1990, p. 8). However, with regard to the latter statement, no proposed methodology or implementation schedule for such work has been forthcoming.

GIS in Ecological Modeling and Avian Studies

The use of GIS for wildlife habitat assessment is still novel. Most studies have tended to concentrate on larger mammalian species. A reason for this is that animals such as bears, moose, and large cats can be collared with radio transmitters and tracked, either by ground-based antennas or satellite. Such kinetic tracking has been linked to vegetation maps and remotely sensed imagery to provide basic data on habitat preferences and home range for a number of mammalian species.

It is more difficult to fit birds with receivers. Large species such as albatross and pelicans have been fitted with receivers revealing startling information about transoceanic migration patterns. Several attempts were made to fit RCWs with tiny transmitters, but these attempts usually ended in the death of the bird. Given the bird's endangered status, such studies were rapidly abandoned.

A number of studies have been done to assess the utility of using remotely sensed data in defining migratory bird habitat. The potential utility of GIS techniques in avian studies has only recently been explored (Shaw et al. 1990). The linkages to more advanced types of mathematical ecology and spatial analysis are even more tenuous, and there is not even a consensus as to what kinds of statistical treatments are appropriate for studies of this kind (Verner et al. 1986).

The best information about RCW ecology has resulted from concerted fieldwork efforts. The most detailed data on habitat requirements and spatial distribution have come from individual studies of selected populations such as those at Francis Marion. Purposive survey, banding, and behavioral observation all have contributed substantially to knowledge of the bird. There is no substitute for basic fieldwork. But such studies are too labor-intensive and costly to do on a large scale over a wide area within a short time frame. They also require a certain level of expertise that not everyone possesses and no small lack of personal dedication, commitment, and perseverance. Hence, GIS is envisioned as one way to synthesize all of this detailed knowledge about certain localities across the wider spectrum of the bird's range, but not to do it as arbitrarily and rigidly as current policies dictate, until such a time as surveys for all known colony sites are completed as mandated by law.

Methods

Data Development

A misconception still exists on the part of the layperson and, to a large extent, public officials and managers as to the amount of work it takes to make a database usable before any analysis takes place. We are still a long time away from the day in GIS when all one has to do is query the computer, push a red button, and the results (note: all precisely spatially accurate and statistically valid) will spew forth on the screen.

The truth is that a lot of grunt work still needs to be done, and this is no less the case for Fort Polk. Only recently has the database become complete enough to initiate serious analysis of the RCW, and this only for one part of the installation, the Peason Ridge training area, which is considered here.

Even these data are rapidly becoming outdated; the SPOT imagery is almost four years old and the original RCW survey data predate that. Nevertheless, this effort is presented as a foray into exploratory data analysis and a working out of the kinks in the methodology for the day when the newest survey data (currently under completion) and the most recent satellite image (October 1991 Thematic Mapper (TM)) can be linked with the forest inventory data (completed during the fall of 1991). However, a cursory first attempt initiates a temporal vector important for subsequent studies.

Components of GIS Analysis

The following descriptions illustrate more or less the procedural gestalt used in developing this approach to RCW habitat assessment. First, the GRASS data layers important for the analysis are described.

Cavity Tree Locations. Several surveys of the RCW population at Fort Polk have been conducted over the years. The survey data and accompanying maps showing the known cavity tree locations are kept on file at the Natural Resources Division office and are continually updated by the staff. The tree locations were digitized from a standard U.S. Geological Survey (USGS) quad sheet and are stored in the GRASS database as a site list (Universal Transverse Mercator Easting and Northing coordinate pair). For the current RCW survey, we have the capability to download the coordinates for each tree location directly from the GPS receiver into the GIS.

SPOT Image. The SPOT satellite scene in the Peason Ridge database was recorded in December 1988. The enhanced false-color image emphasizes the "leaf-off" conditions and is especially useful for its distinction between deciduous and coniferous vegetation. Bright red areas represent pine cover (still photosynthetically active), while light blue to white hues denote progressively more disturbed and eroded areas (armored vehicle trails and firing ranges). Most of the deciduous cover is located in the stream bottoms, or baygalls, and appears gray green in color on the image.

SPOT Landcover Classes. An unsupervised maximum likelihood classification of the SPOT scene was completed within GRASS. Fourteen classes were initially identified. Coniferous cover is especially hard to discriminate using remotely sensed imagery. However, comparison of the image with photographs from the air has been useful in distinguishing certain cover types, at least areas of healthy, mature pine forest. Image-enhancement techniques such as textural analysis and principal components transformation show promise for subsequent studies. The selection of supervised training sites might improve class separation and accuracy. The new TM image, because of its better spectral resolution, may also prove more useful.

Forest Stands. The most discrete unit of forest management is the stand. Based on a sample survey and aerial photo-interpretation, the stand is assigned certain attributes, such as stand age, cover classes (pine, hardwood, etc.), condition types (sawtimber, poletimber, etc.), basal area, and diameter at breast height. RCW management is based on the stand level of detail. However, the attributes for stands are determined more on economic terms than ecological ones. This determination has presented problems for RCW studies in the past, when the translation of terms describing forest types had not been parsimonious. However, with a GIS, using the stand data in consort with other layers, principally satellite imagery, may overcome many of the inherent discrepancies. Problems of detail still arise; RCWs seek out individual relict trees (over 80 years old) to excavate cavities in them. These trees are limited in number, yet their presence is crucial to determine alternate stands for potential RCW habitation. The presence of these trees is usually noted

during stand surveys, but the exact locations are not. Such an observation may require a rethinking of the basic methodology concerning determination of RCW habitat even before data are entered into the GIS.

Condition/Cover Classes. The stand information is aggregated by the installation foresters to convey information about the condition and dominant vegetation cover of an area. Within GRASS, polygons are created that represent areas of longleaf and loblolly pine sawtimber, usually the most mature stands of trees; these have been shown to be the preferred habitat of the RCW. For the purposes of GIS analysis, the condition/cover classes by themselves are too crude to make habitat estimations. However, additional layers can be compared with the condition/cover classes to explore various relationships.

Model Development. The GIS data layers used in consort with information in the literature provide ample fodder for the formulation of any number of inductive models that can be refined and expanded on with the accumulation of subsequent empirical data. For example, several studies indicate a statistically significant orientation in a westerly direction of RCW cavities, centering on 270 degrees azimuth. This information can be extrapolated to consider southly and westerly aspects in the digital terrain data for Fort Polk. Another study indicates that RCWs tend to avoid areas within 150 meters of streams and bodies of water where they may incur increased interspecific competition for their cavities from red-bellied and pileated woodpeckers (Jackson 1977, 108). A third layer describing areas of forest types potentially attractive to the bird (loblolly and longleaf pine sawtimber and poletimber) can be incorporated. Using programs within GRASS, a simple model is created that shows the relationship of RCW trees to the aspect, stream buffer, and forest cover raster files (figure 3).

Certain patterns are suggested and can be investigated by the input of other parameters. For example, it can be hypothesized that the occurrence of a larger than expected number of cavity trees close to streams may be due to pressures exerted on the birds by training activities, which tend to occur in the uplands and not in the swampy bottoms, thereby forcing the birds into this less suitable habitat.

Such a heuristic approach is often ignored in GIS studies of this kind. With the development of more refined expert systems, neural networks, and computers that can emulate the human learning process, such an approach is certain to become more prevalent in the not too distant future. Until such intelligent systems are created, however, the models are largely relegated to static, synchronic approximations of existing (or past) conditions. Predictive validity is all but uncertain at this point. The important thing to remember is that these models should not be taken at face value, something often forgotten when examining GIS analyses and their visually seductive results.

Red-cockaded Woodpecker Policy and GIS

The basic environmental layers used in the analysis and how they might be applied in model development were introduced earlier. Now some current RCW management criteria and how they relate to the GIS analysis are examined. Under existing regulations one-quarter, one-half, three-quarter, and, in some cases, one-mile management zones are stipulated (U.S. Department of Agriculture, Forest Service 1990). The army has its own similar set of guidelines (U.S. Department of the Army n.d.). Within each zone there are certain management recommendations regarding such things as timber harvesting, prohibited military activities, allowable understory vegetation cover, pine-hardwood density, stand age percentages, and prescribed burning cycles. As the critics predicted,

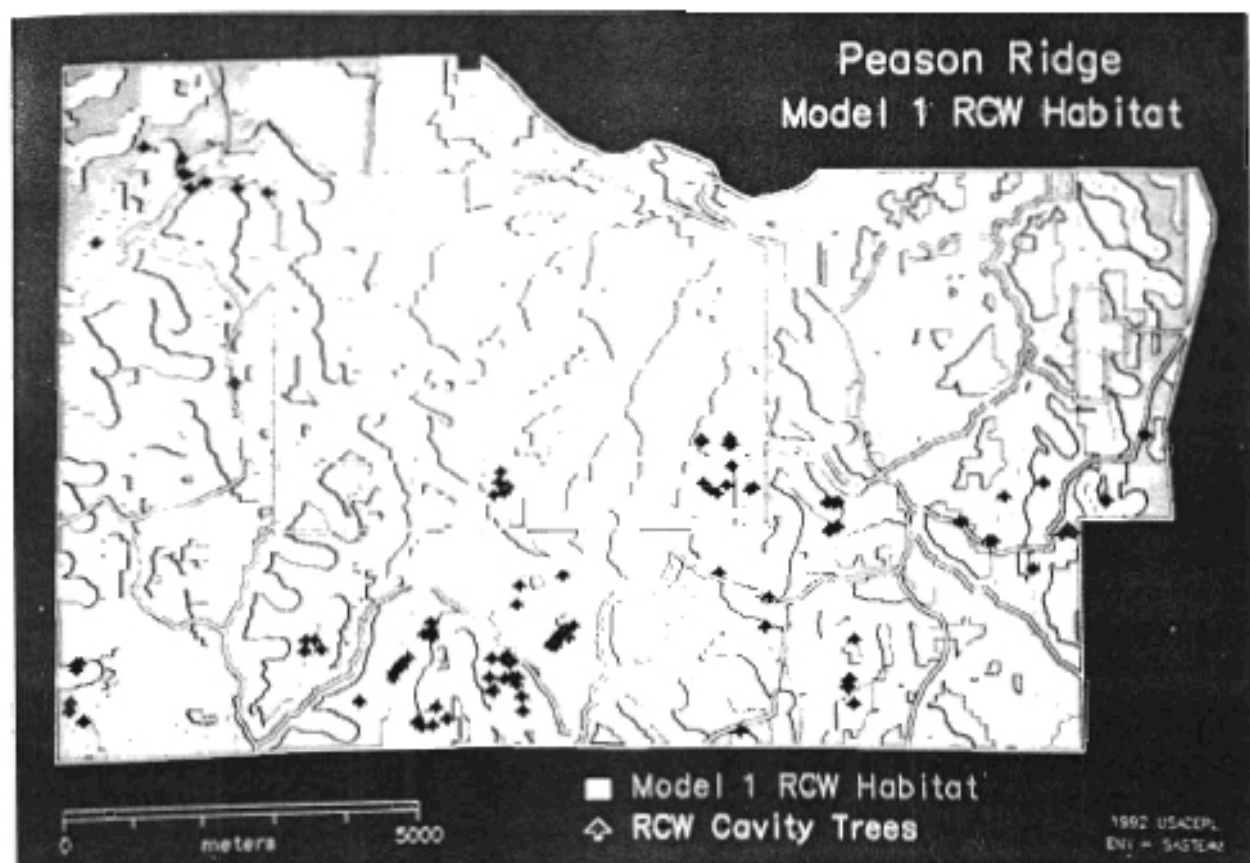


Figure 3. Model of potential Peason Ridge RCW habitat based on aspect, stream buffer, and forest condition cover classes in the GRASS database.

most of these policies have been implemented in cookie-cutter fashion over the entire range of the bird, with little regard for local conditions. However, no alternatives have been proposed to counter the imposition of arbitrary boundaries on the landscape that try to force the bird's behavioral patterns into this structure. Imposing such boundaries may make the job easier for managers, but it has not been demonstrated what relevance, if any, the boundaries have for the RCW. Nevertheless, it is important to understand how these arbitrarily imposed zones do or do not represent reality, as seen from the bird's point of view, before the existing policies can be adequately criticized and rational alternatives forwarded.

For example, the basic unit of RCW management is the colony. The accepted biogenetic definition of a colony, as described above, is a group of individual cavity trees occupied by a group of related birds called a clan. The regulatory definition of a colony is the aggregate of cavity trees plus a 200-foot (about 60-meter) buffer zone around them, encompassed by a 1,500-foot (about 500-meter) diameter circle. This 1,500-foot guideline was originally intended as a colony estimation technique (Harlow et al. 1983), but it has been adopted in the RCW recovery plan and by many managers. However, its validity across the range of existing RCW habitat has not been adequately tested.

In reality, colony determination can only be made based on ground truth survey data. Often this means capturing and banding birds, then recapturing them over a period of time, preferably a number of years, to note how they have dispersed and what cavities are occupied by members of a particular clan. This method involves laborious work. Such genealogical histories have been compiled for only a few populations. At this time no valid method exists for inferentially assigning colony boundaries by statistical or computer-based means.

However, with a GIS the computer at least can standardize the current procedure used to define colony boundaries and to generate the various management zones. For example, figure 4 is zoomed in on one colony on Peason Ridge, Impact Buffer Zone Colony A. The details of the colony and management zones become more apparent and reveal how these zones might be applied to a GIS context.

In the center are the individual mapped cavity tree locations represented by the triangular icon. The 60-meter colony buffer, the colony centroid, and the outlying zones were generated by the GIS from the criteria specified in the management guidelines. Using this simple procedure, a colony and its buffer zones could be defined in a matter of minutes.

Now that the management zones are created, the GIS provides an ideal way to compare the habitat parameters of the colonies. For example, the potential environmental differences between healthy and unhealthy colonies can be assessed. In figure 2, note the presence of isolated individual colonies dispersed throughout the area. These isolated colonies are of special concern because they are usually inhabited by single male birds. However, these colonies are not swinging bachelor pads by any means; because of their isolation, these birds usually have trouble finding a mate. A number of studies indicate that these colonies are the ones suffering from the highest mortality and rates of abandonment. Research suggests that there is some critical threshold relating to colony viability, both in socio-behavioral and environmental terms (Jackson and Jackson 1985). From this observation it may be hypothesized that single colonies represent the most marginal conditions that RCWs will tolerate.

On the other hand, the parameters that may promote healthier colonies can also be examined. The survey records were used to separate out ten colonies that have been in existence since at least the

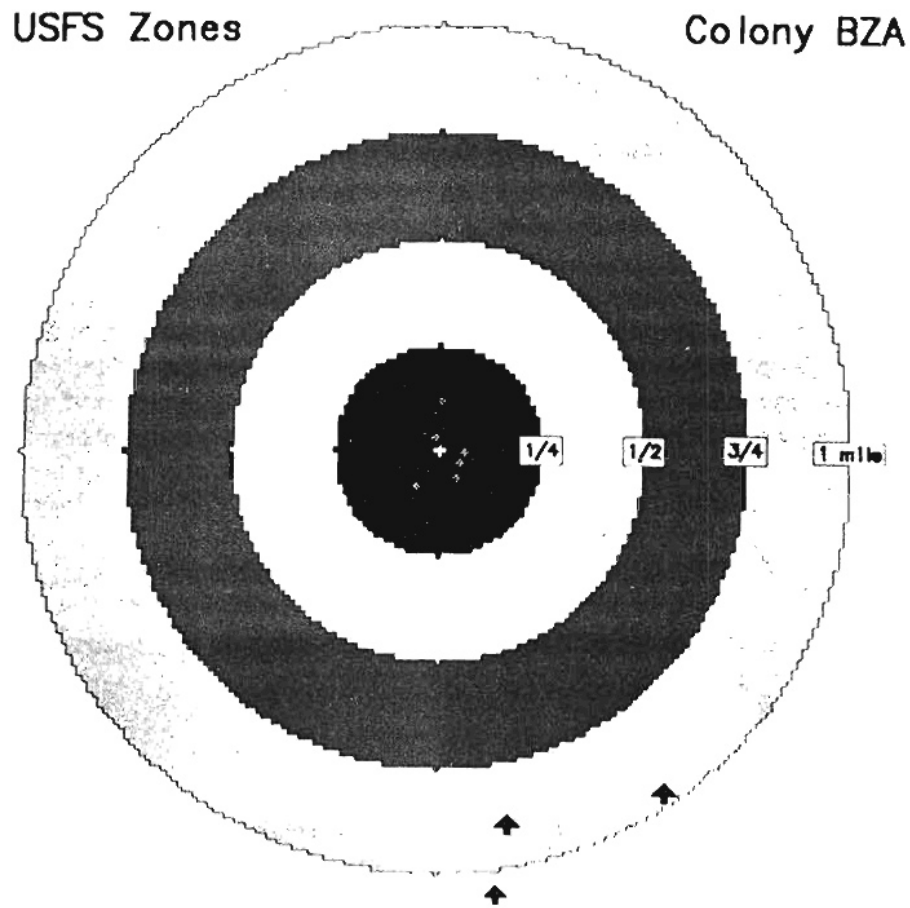


Figure 4. Management zones for Peason Ridge RCW Colony BZA as generated by the GRASS GIS.

mid-1980s until the fall of 1991. Only colonies that have maintained four or more cavity trees during this period were considered. The distribution of the largest colonies is closely associated with the areas of mature pine forest cover noted in the SPOT image and vegetation cover maps. The colonies also tend to cluster. Obviously, some process is occurring to make these areas more favorable for the bird. The trick is to be able to differentiate the factors manifesting themselves in this pattern and to avoid the temptation to declare blindly these more heavily occupied areas as ideal habitat. Ideal habitat can only be defined in relative terms: Ideal compared to what? It is highly unlikely that ideal habitat for the RCW at Fort Polk is exactly the same as ideal habitat at Francis Marion National Forest or at Fort Bragg. At this stage there is no basis for objective comparison and only educated guesses can be made.

Such GIS analyses set the stage for analyses within and between zones for one colony and subsequently for comparisons with zones for other colonies. For example, indices of diversity, juxtaposition, and interspersation on vegetation cover types can be performed to look for clues to identify patterns that may reveal habitat parameters. The overlap between intersecting management zones of neighboring colonies can be calculated precisely so that the complex task of dividing shared habitat resources can be performed more accurately and objectively. The relationships could then be explored to perhaps predict which colonies might be in imminent danger of extirpation. Such analyses are just the beginning. These analyses lay the foundation for a methodology that is standardized and replicable, not only with the same population but also across the range of RCW distribution. For the first time relationships between disjunct habitats have the potential to be directly compared.

Conclusion

In this paper I have proposed, with a few relatively simple GIS techniques and use of GRASS programs, how a more objective, scientific, yet flexible approach can be posited for the assessment of RCW habitat. However, the results are still out. For the moment, at least, it cannot be stated that any GIS analysis, especially one relying on parameters derived from spatial data of poor quality or status quo regulations, is an adequate substitute for empirical research based on exacting survey methods and field observations. Hence the question posed in the title of this paper. But I optimistically believe the potential for conducting more progressive research and implementing more realistic management programs is within our grasp. Certainly we can progress beyond the level of cookie-cutter ecology where this species is concerned.

Some recent events have placed several government agencies in a compromising position regarding their policies toward the RCW. Recent modifications to existing policies indicate that the Forest Service, the Fish and Wildlife Service, and the army are becoming more sincere in their efforts to deal with management of the bird. However, the agencies charged with promoting, implementing, and enforcing policies toward conservation of the species are becoming increasingly factionalized as they squabble over scarce funding and resources and potential reductions in staff. There is still a long way to go before the bird is out of the proverbial woods. Most of the original goals of the first RCW symposium, now over 20 years old, still have not been achieved.

The RCW is now, more than ever, a hot biopolitical and economic topic (McFarlane 1992). Fortunately, as endangered species go, the bird appears amenable to conservation management techniques modified to suit its particular ecological idiosyncracies. It is gregarious and not averse to the presence of most human activities in close proximity to its colonies. Indeed, the bird's presence

within artillery impact areas at installations such as Fort Polk attests to its biological tenacity and ecological flexibility. Short of outright destruction of all available habitat, the bird can survive with a little cooperation from its human hosts.

If the RCW were to disappear from the face of the earth today, relatively few people would notice its absence or mourn its passing. The more cynical side of me says that some in the forest industry would declare "good riddance" at the prospect of the bird's demise. No compelling data exist to suggest that the extinction of the bird would pose any significant disruption in the pine forest ecosystem it has been a part of for countless generations. Most of this ecosystem has been destroyed by man anyway. Nevertheless, what we do to defenseless creatures that happen to be an "inconvenience" for us or stand in the way of "progress" reflects how we treat our fellow humans, not just lesser inhabitants of the planet Earth. Our fate as a species is mirrored in our actions. We need to determine where we and an obscure yet interesting little bird fit into the grander scheme of things.

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