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HABITAT FACTORS INFLUENCING THE DISTRIBUTION OF SMALL VERTEBRATES ON UNMINED AND PHOSPHATE-MINED FLATLANDS IN CENTRAL FLORIDA

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HABITAT FACTORS INFLUENCING THE DISTRIBUTION OF SMALL VERTEBRATES ON UNMINED AND PHOSPHATE-MINED FLATLANDS IN CENTRAL FLORIDA

FINAL REPORT

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DISCLAIMER

PERSPECTIVE

FIPR's purpose in funding the research was to gain information to guide wildlife habitat rehabilitation efforts on phosphate mined lands in central Florida. The general objectives of the study were to compare small vertebrate wildlife species distributions and habitat characteristics on unmined natural habitats and reclaimed mine sites; to correlate wildlife species presence with various habitat characteristics; and to identify possible ways to improve habitat restoration on mined lands. A previous study (FIPR Publication No. 03-100-129, "Habitat Factors Influencing the Distribution of Small Vertebrates on Unmined and Phosphate-Mined Uplands in Central Florida") emphasized xeric (drier, well-drained) habitats, while this study deals with mesic (intermediate moisture between xeric and wetland) habitats. Wetland habitats were not studied.

Small vertebrate species were trapped (e.g., mice, lizards, and toads) or observed (birds) on unmined natural habitats and on several reclaimed mine sites. Most of the mined sites had not been specifically reclaimed to mimic natural habitats, but they were thought to provide some wildlife habitat values and would provide a range of habitat characteristics that could possibly be correlated with the presence or absence of various wildlife species.

The study emphasized vertebrate species that were relatively common in unmined native habitats but were absent or underrepresented at reclaimed sites. Because the study "focused" on species that were underrepresented at reclaimed sites relative to "reference" (unmined, natural) sites, they were thus called "focal" species. A better understanding of the biology of these focal species may contribute to increasing their abundance on reclaimed sites in the future. The intent and hope was to identify habitat characteristics important to these species that could be recreated on reclaimed mined lands. While the study did identify relationships between various habitat characteristics and focal species, it was not always clear whether or not the underrepresentation of a species was because of unsatisfactory habitat or because the species had not yet reached the site. The subjects of site isolation, colonization, and habitat quality are being addressed for a few selected vertebrate species in FIPR Project 98-03-133, "Habitat Characteristics of Key Vertebrate Species that Are Under-Represented on Phosphate Mined Lands." It is quite possible that in addition to improving reclamation practices to provide the necessary habitat characteristics, we may need to reintroduce some species back to the reclaimed sites, as has been done with gopher tortoises (see Macdonald 1996 and Small and Macdonald 2001). Time is also an important factor that affects both vegetation development and colonization.

Another important point is that because some species were absent or underrepresented does not mean there were no vertebrate species on reclaimed lands. The references listed below indicate that a wide variety of wildlife utilize mined lands. Reclaimed lands tend to be more open – have lower density and cover of woody vegetation – than the unmined natural sites studied by Mushinsky and McCoy. Thus a few wildlife species that are better adapted to open habitats were actually more abundant on reclaimed lands than unmined lands. Conversely, as the study emphasized, the unmined sites tended to have greater woody vegetation cover with more complex structure, which favored the "focal" species. To reiterate, the purpose of this study was to gain insight into how to get more of the focal species on reclaimed lands.

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Steven G. Richardson
FIPR Director of Reclamation Research

ABSTRACT

We used “representativeness” as a means of comparing vertebrate wildlife species found on reclaimed phosphate mined land with vertebrate wildlife species found on unmined land in central Florida. Land properly reclaimed as wildlife habitat should support a flora and fauna that “represents” the native flora and fauna that existed prior to the mining. We identified the pool of resident species on unmined mesic flatlands (reference sites) for comparison with the species living on mined (reclaimed) lands. Those vertebrate species that are under-represented at reclaimed sites relative to their distributions and abundances at reference sites are identified as “focal species." Soil characteristics and vegetation profiles were measured at each of the sixty study sites used for the vertebrate wildlife comparisons. Many soil and vegetation differences exist between the reclaimed and reference sites. The vegetation structure at reclaimed sites was different than the reference sites. All reclaimed sites lacked a Middle-Canopy layer, and were dominated by a few foliage layers.

The resident species include 12 amphibian species, 17 reptile species, 6 mammal species, and 46 bird species. Twelve species including 1 amphibian, 2 lizard/turtle, 0 snakes, 0 mammals, and 9 birds are focal species; that is, these twelve species are found much more commonly at reference sites than reclaimed sites. Four bird species were found more frequently at reclaimed sites than at reference sites. We found that preferences for breeding sites (amphibians) or for vegetation structures (reptiles and mammals) could distinguish most of the focal species from the non-focal species. We found that vegetation structure alone could distinguish nearly all focal from non-focal bird resident species. The focal species all prefer wooded areas, some favoring areas with extensive tree canopy and others favoring areas with shrubs or low canopy, while the non-focal resident species almost all prefer open areas that are conducive to ground foraging.

We conclude that proper reclamation of mesic habitats will have to account for the high variation of species composition at a given site and incorporate a high degree of habitat heterogeneity. We suggest that existing patches of reclaimed mesic habitats are isolated from existing remnants of reference habitats as well as from other patches of reclaimed habitat. Wildlife would benefit if these patches were connected by additional reclamation. Likewise, wildlife likely would benefit if all upland reclamation efforts were tied to wetlands, both permanent and temporary. We support a broad regional approach to rehabilitating phosphate mined land for wildlife in Florida. A broad regional approach should include the entire Bone Valley and surrounding areas in Florida.

ACKNOWLEDGMENTS

This research could not have been completed without the support of the Florida Institute of Phosphate Research (FIPR) and the gracious cooperation of the phosphate industry in Florida. We especially thank Mr. Richard Coleman, Florida Lake Management Society, for his support and encouragement, and for introducing us to FIPR and the phosphate industry. Dr. Steven Richardson, FIPR Research Director for Reclamation, contributed to all phases of our research. We thank him for his guidance, insights, and patience as we worked through the study. As was true for our previous xeric study, Mr. Tim King, Florida Fish and Wildlife Conservation Commission, provided invaluable insights and recommendations as we were planning and identifying appropriate sites for this study. We acknowledge and thank the members of the FIPR Technical Advisory Committee for their assistance and advice during the planning stages of our research.

PREAMBLE

Although phosphate has been mined in Florida for more than 100 years, and a State mandatory reclamation act was put in place more than 25 years ago, no precise goals for restoring phosphate-mined lands for wildlife have been developed. Within the Bone Valley Region of Florida, the value of preserving and reclaiming wetland habitats for wildlife was recognized in the early 1980’s. The need for large-scale wildlife corridors and upland habitat became apparent later, in the late 1980’s and 1990’s. Also in the 1990's, reclamation efforts that promoted wildlife began on a mine-wide and regional scale, instead of individual parcels. At the time this research was initiated only a relatively few large reclaimed areas intended for wildlife were available for study.

Currently, the general goal for many habitat reclamation projects is for restored mines to have the appearance of undisturbed sites, such that a person is likely to observe the same wildlife at restored mine sites as one might observe at undisturbed sites. In other words, the reclaimed habitats should be representative of the natural habitats that existed prior to the mining. The purpose of our research was to provide information to assist the phosphate industry in improving future wildlife habitat reclamation efforts. Ideally, we would like to have had reclaimed sites that closely resembled reference sites in their soils and vegetation characteristics, etc. This goal couldn’t be met, however, except for a few reclaimed sites. In all fairness to the phosphate industry, we point out that few of the lands we have studied were restored specifically to support wildlife, and those lands have been expected to fulfill that role only recently in a post-hoc manner. Also, in fairness to all concerned parties, we consulted with numerous representatives of the phosphate industry who helped us select study sites that had the greatest potential to support wildlife. The reclaimed sites we studied had a relatively wide range of variation in physical and vegetational characteristics. We recognized and used the range of variation to established correlations of wildlife species presence and abundance with those physical and vegetational characteristics.

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EXECUTIVE SUMMARY

The mining of phosphate, the most valuable mineral resource in Florida, has a well-documented history. Florida currently provides about 75% of the nation's phosphate supply and about 25% of the world's supply. Our studies have focused on "Bone Valley," the larger and more southern of the two phosphate mining regions of the State. Most strip mining of phosphate rock in Florida uses the same procedure. Prior to mining, the surface is cleared completely of all vegetation, and, just recently, the surface soils may be set aside. The remaining soils are then removed by giant electric drag lines. The strip mines eventually are back-filled with overburden and "waste" sand tailings. If surface soils have been set aside prior to the strip mining, then those soils will be distributed over the surface prior to any attempts to establish vegetation.

Since 1975, the phosphate industry has been required not only to fill in the strip mines, but to "reclaim" the mined lands as well. The degree of reclamation varies concomitantly with the goal of the reclamation, from simply planting grass to support cattle to spreading native topsoil and planting shrubs and trees to attract wildlife. The research reported herein was designed to compare vertebrate wildlife species distributions and abundances on reclaimed phosphate mined land (reclaimed) and unmined (reference) land. We measured numerous habitat variables and examined the data for possible correlations with the presence and absence of vertebrates to identify possible areas for improving the wildlife habitat reclamation process. Previously, we have reported the findings of a similar study that focused on wildlife use of reclaimed xeric (dry, well-drained) uplands. As in the previous report, we use "representativeness" of vertebrate species as a measure of successful habitat reclamation for wildlife usage. Land properly reclaimed as wildlife habitat should support a flora and fauna that "represents" the native flora and fauna that existed prior to the mining event.

For clarity, we are following the classification of The Guide to the Natural Communities of Florida prepared by the Florida Natural Areas Inventory (FNAI 1990). We recognize that the mesic flatlands habitats include mesic flatwoods (also called pine flatwoods, pine barrens) and dry prairie (palm savannah, palmetto prairie). At present, mesic flatlands are most extensive in the lowland regions of Sarasota, Manatee, Hardee, Hillsborough, and Pasco Counties. Historically, mesic flatwoods were the most common habitat in the southeastern coastal plain and originally comprised approximately 50% of the land area of Florida. Mesic flatwoods and dry prairies share many of the same floristic components. Present day mesic flatwoods are characterized by a relatively open canopy of pines, an extensive low shrub layer, and a variable, but often sparse, layer of herbs and grasses at ground level. Because fire probably occurred about once every five to ten years historically, nearly all plants and animals inhabiting mesic flatlands are adapted to periodic burning, and several species are dependent upon fire for their continued existence.

To every extent possible, including this final report, we tried to duplicate the protocol we established for our previous research on xeric upland habitats. Inherent

differences between mesic and xeric habitats necessitated some alterations of our methods and attempts to improve upon other methods necessitated a few other modifications. Our research was designed to identify the pool of resident species on unmined mesic flatlands (reference sites) for comparison with a list of the species on mined (reclaimed) lands. We used the data we collected to identify species, called "focal species," that were under-represented at reclaimed sites relative to reference sites. A total of 30 trap arrays was installed at seven reference locations and four reclaimed locations. Note that a “site” is the specific positioning of an individual trap array, while a “location” is a relatively large geographic area occupied by the mesic flatland and is a collection of the three to six sites in that geographic area. Among the group of 30 reclaimed sites, are 13 that were mined prior to 1975 and 17 mined thereafter. The vast majority of mined sites were reclaimed by filling the strip mine cuts with sand tailings, which were then covered with overburden.

During our study, we collected data on soil characteristics and vegetation profiles at each site. Chemical and physical tests of the soil substrate used representative soil samples from randomly selected plots. Physical tests included texture and particle size, and chemical tests included pH, total nitrogen, available phosphorus and potassium, electrical conductivity, and organic matter. Foliage height profiles using as many as seven layers were characterized visually and measured with a clinometer. Canopy density was measured with a densitometer, and estimated visually. Vegetation density was measured within selected plots.

All locations were placed into categories of size, distance to seasonal water, distance to permanent water, and distance to other upland habitats. “Locations” are relatively large geographic areas that may include three to six mesic sites. Reclaimed sites were categorized further according to type of soil and vegetation reclamation. As expected, we detected few differences between reference and reclaimed sites for most physical variables. The locations for this study specifically were selected carefully to compare vertebrates residing at two types of mesic land, those that were reclaimed and those that were reference.

We were unable to detect any differences in soil texture among the seven reference locations. Soils at reclaimed sites tended to have higher percentages of fine sand than did those at reference sites, whereas reference site soils tended to have higher percentages of very fine sand. Three soil chemistry variables, pH, phosphorus levels, and potassium levels, varied substantially among the locations of reference sites. Soils at reference and reclaimed sites were very different in their chemistries. Soils at reference sites tended to have higher organic matter, lower pH, and lower phosphorus content than soils at reclaimed sites.

An analysis of life-form coverage indicated that plant forms differed among the seven reference locations. Reclaimed sites were much different than the reference sites; reclaimed sites had smaller percentages of woody ground cover and wiregrass and larger percentages of other grasses. An analysis of foliage layers at reference sites illuminated differences among them, particularly regarding the presence of an upper canopy. All reclaimed sites lacked a Middle-Canopy layer, and were dominated by a few foliage layers. Horizontal and vertical canopy coverage were similar among the reference sites. Reclaimed sites, however, were different than reference sites in both kinds of canopy closure. In general, the near absence of shrubs and snags at reclaimed sites makes comparisons of their densities between reclaimed and reference sites pointless.

To capture amphibians, reptiles, and mammals (collectively called quadrupeds, hereafter), we installed a trap array at each site. Trapping was done for seven consecutive days in each of six 2-month time periods of the year. Birds were not captured, rather, to make quantitative estimates of the relative abundance of avian species, we tallied the number of times a given species was observed at a site. The data we accumulated on quadrupeds and birds were tallied to produce lists of species present and estimates of their relative abundances at the study sites.

We compared the lists of species from reclaimed sites to those from reference sites. This comparison provided us with information about the numbers and types of species that had colonized reclaimed lands. Unfortunately, we know very little about the about dispersal capabilities or rates of colonization for most, if not all, of the species studied. Species that were found much more commonly at reference sites than at reclaimed sites were the focal species. To create the list of focal species we considered the magnitude of the difference in distribution of a species at reclaimed sites relative to reference sites and we produced a variable called “sites score” for each species. The higher the sites score, the greater the disparity between the species presence at reclaimed sites relative to reference sites.

Resident species are a subset of the greater local pool of species known to live in mesic flatlands. The list of resident species included 14 amphibians, 34 reptiles, 31 mammals, and 109 birds. The resident species actually captured or observed during this study include 12 amphibian species, 17 reptile species, 6 mammal species, and 46 bird species. Some general trends exist for the distributions of the 81 resident species. Species of lizards, turtles and mammals that are found at many reference sites also are found at many reclaimed sites. In contrast, species of amphibians, snakes, and birds, that are widespread among reference sites are found only at a few reclaimed sites. Likewise, some generalizations exist for the numbers of individuals of the 81 resident species. Species of lizards and turtles that occur in relatively large numbers at reference sites also occur in large numbers at reclaimed sites. In contrast, species of amphibians, snakes, mammals, and birds found in relatively large numbers at reference sites are found in small numbers at reclaimed sites. Correlations of numbers of individuals with spatial distributions indicated that amphibians, lizards, turtles, and birds that are widely distributed tend to occur in relatively large numbers, while snakes and mammals that are widely distributed tend not to be found in large numbers.

Twelve species, including 1 amphibian, 2 lizard/turtle, 0 snakes, 0 mammals, and 9 birds, were focal species; that is, these twelve species were found much more commonly at reference sites than reclaimed sites. Focal species can be considered targets for reclamation efforts aimed at making the vertebrate compositions of reclaimed sites more representative of those of mesic habitats. Four bird species are well-known inhabitants of relatively open areas and were more common at reclaimed than reference sites. The group of 12 focal species was used to document differences between the vertebrate compositions of reference and reclaimed lands. “Listed” species are those that, because of their limited numbers, are afforded protection by the State or federal government. Note that one of the listed resident species, Bachman’s sparrow, is in the group of focal species, but the others, such as the Florida gopher frog, gopher tortoise, eastern indigo snake, and American kestrel, are not in the group of focal species because they were found at too few reference sites to qualify as focal species according to our stated criterion.

We asked what aspects of the natural histories of resident species might distinguish focal from non-focal resident species. Among quadrupeds, we found that preferences for breeding sites (amphibians) or for vegetation structures (reptiles and mammals) could distinguish most of the focal species from the non-focal species. Among birds, we found that vegetation structure alone could distinguish nearly all focal from non-focal resident species. The focal species all prefer wooded areas, some favoring areas with extensive tree canopy and others favoring areas with shrubs or low canopy, while the non-focal resident species almost all prefer open areas that are conducive to ground foraging.

We compared the rankings of the representation of focal species for each site with the vegetation variables. At reference sites, focal species are strongly linked to more open sites, which lack a dense Shrub layer or Upper-Canopy. At reclaimed sites, focal species are strongly linked to more closed sites, which have relatively dense Ground and or Shrub layers (birds) or Upper Canopy (quadrupeds).

If we chose only the "best" reference or reclaimed sites, as indicated by representation of focal species, what physical and vegetation variables would correlate most strongly with rankings of representation? Our analysis suggested that the presence of cover at a height relevant to ground-dwelling focal quadrupeds promotes their presence at the best reference sites, and such cover is sparse at reclaimed sites. At the best reclaimed sites, bird focal species respond positively to the absence of a Shrub layer, while quadrupedal focal species respond positively to the presence of saw palmetto. At the best reclaimed sites, both groups of focal species respond positively to the presence of all kinds of structure. Any sort of vegetative structure serves to attract wildlife to reclaimed lands.

To examine further the relations among focal species and their habitats, we compared the physical and vegetation variables at sites where a particular species occurred with those variables at sites where it did not. The results for the physical variables indicated that none of the physical variables is important for the reclaimed sites, for any species. The results for the vegetation variables indicated that some of the focal species prefer relatively large amounts of woody and/or grassy ground cover, particularly at reclaimed sites. The results also show that some of the focal species avoid sites with relatively large amounts of bare ground. About two-thirds of the bird focal species respond strongly to the Shrub layer at reference sites, but about the same number of species prefer a relatively lush Shrub layer as a relatively sparse Shrub layer. The focal bird species seem to prefer a relatively high density of certain plant species, especially tall *Pinus* and *Quercus* spp. at reclaimed sites.

The final, and perhaps most important, portion of our analysis is a comparison of the data gathered in this study, on mesic flatlands, with data gathered previously, on xeric uplands. We shall concentrate on the similarities and differences among both habitat variables and vertebrate species in the two studies. Our goal in making this comparison is to make evident to the phosphate industry similarities and differences between the mesic and xeric habitats and similarities and differences among the faunas that inhabit these habitats. The xeric study incorporated a total of 60 sites, 30 previously-mined sites and 30 reference sites. The mesic study also incorporated 60 sites, divided evenly between reclaimed and reference sites, but some of the reclaimed sites were used for both studies. Because of a limited number of reclaimed mesic locations and the realization that many sites reclaimed to resemble xeric habitat were quite mesic-like, we selected 20 of the most mesic-like reclaimed sites out of the 30 sites used in the xeric study for inclusion in the mesic study.

Reflecting the manner in which the research was planned and the availability of study sites in xeric and mesic habitats, many of the physical characteristics of the study sites were quite similar. Most mesic reclaimed and reference locations were greater than 25 ha, and most xeric reference and reclaimed sites were less than 25 ha in area. Most xeric and mesic reference sites were less than 300 meters from similar habitats, and most xeric and mesic reclaimed sites were more than 300 meters from their respective reference habitats. While the kinds of habitats surrounding the xeric and mesic sites, especially the references sites, differed, the numbers of mesic and xeric sites surrounded by undeveloped land were similar. Soil texture was similar at reference and reclaimed sites, but soil particle size at reclaimed and reference sites differed. Soil chemistry also was different between reference and reclaimed sites.

Comparisons of the life-form vegetation coverage indicated that mesic sites tended to have more woody and grassy coverage than xeric sites, at both reclaimed and reference sites. Foliage, which was measured in as many as seven distinct layers and gaps, was less abundant and less defined at reclaimed sites. Mesic reclaimed sites tended to have more shrubs than xeric reclaimed sites. Many mesic reference sites had no middle canopy layer, the presence of which serves to attract numerous bird species. Canopy closure at xeric reclaimed sites was less complete than at xeric reference sites, and more complete at mesic reclaimed sites than mesic reference sites. Xeric reclaimed sites had less dense vegetation, at all levels, than xeric reference sites.

About 65% and 49% of the potential resident species were captured or observed at the xeric sites and mesic sites, respectively. At the reference sites, xeric sites typically supported more species than did mesic sites. At the best xeric reference site we captured or observed 32 species, while at the best mesic reference site we captured or observed only 19 species. At reclaimed sites, the number of resident species was similar at xeric and mesic sites, and at both kinds of reclaimed sites, the number of species was fewer than at the reference sites. The distributions of amphibians, lizards/turtles, and birds were positively related at xeric reference and reclaimed sites, but that relationship did not exist for snakes and mammals. In other words, sites that supported amphibians also tended to support lizards, turtles, and birds, but not snakes and mammals. At mesic reference and reclaimed sites, those that supported mammals also supported lizards and turtles, but not amphibians, snakes, and birds.

The relative abundances (numbers of individuals/observations) of resident species were more even at xeric sites, both reclaimed and reference, than at mesic sites. The number of species captured or observed at any given mesic reference site was relatively small, indicating that mesic-dwelling species have patchy distributions. The relative abundances of resident species at xeric reference and reclaimed sites were positively related for amphibians, lizards/turtles, and mammals, but not for snakes or birds; and abundances at mesic reference and reclaimed sites were positively related for lizards/turtles and birds but not for amphibians, snakes, or birds. Based on both the distributions of species and their relative abundances, it appears that lizards/turtles and mammals tend to respond positively to similar suites of habitat characteristics, but amphibians, snakes, and birds have more specific requirements.

The total list of focal species, from the xeric (28 species) and mesic (12 species) studies combined, includes 5 amphibians, 8 reptiles, 1 mammal, and 17 birds. Roughly 60% of the focal species resided only at xeric sites, 10% resided at mesic sites, and 30% were focal species in both habitats. The smaller list of focal species at mesic sites largely is a function of the more patchy distributions of resident species among reference sites in the mesic study than in the xeric study. The patchy distributions of the mesic species potentially translate into relatively low representation of resident species at each reference or reclaimed site. As we examined the data for patterns in the distributions of resident vertebrates, we found that the number of resident species per site varied between reference and reclaimed sites and between xeric and mesic reference sites. Again, reference sites, especially xeric ones, support more species than reclaimed sites. We detected no difference between numbers of resident species at xeric and mesic reclaimed sites.

In the xeric study, four aspects of the natural histories of resident species almost perfectly explained the separation of focal from non-focal species. These were distinct preferences for breeding site, burrowing substrate, vegetation cover, and burrow availability. In the mesic study, only two natural history aspects were required, preference for breeding site and vegetation cover.

Our data, as well as the findings of numerous other studies from the same general region of Florida suggest that greater heterogeneity or habitat patchiness exists among mesic reference sites than among xeric reference sites. This greater heterogeneity among mesic reference sites may complicate the reclamation of mesic lands. For example, if species composition varies more among mesic reference sites than among xeric reference sites, then incorporation of a relatively large segment of the pool of resident species might require more sites and/or more creative management (e.g., to incorporate habitat heterogeneity) for mesic reclamation than for xeric reclamation. Hence, the notion that reclamation of mesic habitats is less demanding than reclamation of xeric habitats may not be true, at least not if the goal of restoration is to create habitats that are representative of the regional wildlife. Although fewer species were designated focal species during the mesic study, our findings suggest that species that are representative of mesic flatwoods require considerable habitat heterogeneity.

If we go just beyond the direct boundaries of the data we collected during our two studies, some additional aspects of restoration ecology seem pertinent to our final summation. Existing patches of reclaimed mesic and xeric habitats are indeed isolated patches. Not only are they isolated from existing remnants of reference habitats, also they are isolated from other patches of reclaimed habitat. Wildlife likely would benefit if these patches were connected by additional reclamation. Likewise, wildlife likely would benefit if mesic and xeric reclamation efforts were tied to wetlands, both permanent and temporary. Reclamation of xeric and mesic habitats in the manner we propose would increase the area available to wildlife, facilitate movement among habitat patches, provide needed wetlands for reproduction, and provide the habitat heterogeneity required to support representative species. As we have stated in the previous report, we support a broad regional approach to rehabilitating phosphate mined land for wildlife in Florida. A broad regional approach should include the entire Bone Valley and surrounding areas in Florida.

INTRODUCTION

The mining of phosphate, the most valuable mineral resource in Florida, has a well-documented history (Pittman 1990; Odum and others 1998, pp. 261-267). Florida currently provides about 75% of the nation's phosphate supply and about 25% of the world's supply. More than 195,000 ha of land in central Florida is owned or controlled by the phosphate industry (Odum et al. 1998). Our studies have focused on "Bone Valley," the larger and more southern of the two phosphate mining regions of the State. Bone Valley extends eastward and southward about 80-90 km from Tampa, in central Florida. More than 100,000 ha of land have been impacted by the phosphate mining industry in Florida , and about 2300 ha are strip mined each year.

Most strip mining of phosphate rock in Florida uses the same efficient procedure. Prior to mining, the surface is cleared completely of all vegetation, and, just recently, the surface soils are set aside. The remaining soils are then removed by giant electric drag lines. First, the overburden (the materials above the phosphate rock) is removed, and then the phosphate matrix (a mixture of phosphate rock, sand and clay) is extracted to a depth of about 10-15 m below the original surface. The extracted matrix is pulverized with a water cannon and sent as slurry in high pressure pipes to a beneficiation plant. The open mine pits eventually are back-filled with "waste" sand tailings, and often the tops of the overburden peaks are spread over the sand tailings. If surface soils have been set aside prior to the strip mining, then those soils will be distributed over the admixture of overburden and sand tailings prior to any attempts to establish vegetation. The practice of removing surface soils prior to mining, and spreading those soils over the admixture of overburden and sand tailings after mining is a recent innovation and limited primarily to those parcels of land dedicated to reclamation as wildlife habitat.

A 1975 law required the phosphate industry not only to fill in the strip mines, but to "reclaim" the mined lands as well. The reclaimed lands in the relatively rural setting in which most of the mining occurs has been put to a variety of uses. Depending upon the specific goal of reclamation, the land has been used for pasturing; agriculture; residential, commercial, or industrial development; or wildlife conservation. The degree of reclamation varies concomitantly with the goal, from simply planting grass to support cattle to spreading native topsoil and planting shrubs and trees to attract wildlife. With one exception, reclaimed upland sites covered with native topsoils are too few and too recent to be included in this study. In contrast to wetland habitats, no clear standards for reclaiming mined upland habitats specifically for wildlife conservation have been established. Nor have any broad-based studies been undertaken to assess the success of the current procedures used to attract wildlife to these lands (Humphrey and others 1985; Schnoes & Humphrey 1987; Kale and Pritchard 1997). Previously, we have reported the findings of a similar study that focused on wildlife use of reclaimed xeric uplands (Mushinsky and McCoy 1996, McCoy and others 2000).

MESIC FLATLANDS HABITATS IN CENTRAL FLORIDA

Terrestrial habitats are categorized by their hydrological conditions and plant assemblages. For example, xeric upland habitats occur on well-drained soils and include scrub, sandhill, and a somewhat transitional plant assemblage called scrubby flatwoods. Mesic flatlands habitats occur on moderate to poorly drained soils and include plant assemblages called mesic flatwoods and dry prairies. Hydric lowlands occur on very poorly drained soils and include plant assemblages called hydric hammocks, and wet flatwoods. Mesic flatlands are more extensive in central Florida than xeric uplands. Because mesic flatlands are extensive and relatively homogeneous, restoration of mesic flatlands may be less demanding than restoration of xeric uplands. Mesic flatlands form a matrix that connects the relatively isolated fragments of xeric upland. Few plant or animal species exist that are restricted to mesic flatlands per se, rather the mesic flatlands are used by a broad variety of species, some more typical of the xeric uplands and some more typical of the hydric lowlands. Nevertheless, the wide distribution of mesic flatlands and their extensive use by a broad host of organisms suggests that mesic flatlands are an important component of the central Florida terrestrial ecosystem.

Mesic flatlands habitats, the focus of our study, are characterized by their flat, moderate- to poorly-drained sandy substrates, which contain an admixture of organic material, often with a shallow hard pan. The substrate typically consists of up to one meter of acidic soils generally overlying an organic hardpan of clayey subsoil (McCulley 1950). Mesic flatlands are most extensive in the lowland regions of Sarasota, Manatee, Hardee, Hillsborough, and Pasco Counties. Hydrological conditions of mesic flatwoods are a function of topography, soils, and seasonal precipitation. Soils often become waterlogged and poorly aerated during the wet season and the shallow hardpan may support the formation of temporary, shallow ponds. The hardpan below a flatwoods or a dry prairie substantially reduces the movement of water above and below it, such that flatwoods or dry prairies may become flooded for short periods during the rainy season. Because mesic flatwoods and dry prairies often surround scrub and sandhill habitats, these temporary ponds provide a source of water and function as breeding grounds for many species that reside in the more xeric upland habitats. During the dry season, high evapotranspiration draws much water from the upper horizons (Abrahamson and Hartnett 1990).

For clarity, we are following a recent classification of the natural communities of Florida (FNAI 1990). We recognize that the mesic flatlands habitats include mesic flatwoods (also called pine flatwoods, pine barrens) and dry prairie (palm savannah or palmetto prairie). Mesic flatwoods are the most common habitat in the southeastern coastal plain and originally covered approximately 50% of the land area of Florida (Davis 1967). Stands of mesic flatwoods may comprise thousands of hectares and form an extensive network surrounding islands of interspersed cypress heads, bayheads, hammocks, or marshes, and function to connect the less common xeric upland habitats such as sandhill, scrub, and scrubby flatwoods (Abrahamson and Hartnett 1990). Mesic flatwoods represent the matrix that ties together and merges with other vegetation types (Edmisten 1963). Mesic flatwoods are closely associated with, and often grade into wet flatwoods, dry prairie, or scrubby flatwoods. The differences among these habitats are generally related to minor topographic features. Wet flatwoods occupy the lower wetter areas, while scrubby flatwoods occupy the higher dryer areas. The term "prairie" has a different usage in Florida than in the central or western United States. The common feature of prairies is the treeless or nearly treeless grass-covered appearance. Florida dry prairies are open, grassy expanses which support few trees and a variety of grasses. Some mesic flatwoods differ from dry prairies only by having a pine overstory. When timbered, it is difficult to distinguish mesic flatwoods from dry prairies.

Mesic flatwoods and dry prairies share many of their floristic components. Present day mesic flatwoods are characterized by a relatively open canopy of pines, an extensive low shrub layer, and a variable, but often sparse, layer of herbs and grasses at ground level (Abrahamson and Hartnett 1990). Four species of pines dominate flatwoods in Florida; longleaf pine (*Pinus palustris*), two varieties of slash pine (*P. elliottii* var. *eliottii* and *densa*) and pond pine (*P. serotina*). Tree densities vary from high, with nearly closed canopies, to low with sparsely spaced trees creating a savannah-like appearance. The shrub layer includes saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), fetterbush (*Lyonia lucida*), and tarflower (*Befaria racemosa*). Because the pines self-prune their lower branches, there is a large gap between the relatively low shrub layer and the pine canopy. Saw palmetto may occur in very dense stands. Where tree density and canopy are relatively sparse, the ground cover, especially wiregrass (*Aristida beyrichiana*), can become relatively dense. Otherwise ground cover is relatively sparse. Resident species are adapted to a relatively dry habitat that is subject to frequent fires (Laessle 1942). Dry prairies are covered with a ground cover of wiregrass, bottlebrush three-awn (*Aristida spiciformes*), arrowfeather (*A. purpurascens*), broomsedge (*Andropogon virginicus*) and love grasses (*Eragrostris* spp.). The shrub layer includes saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), fetterbush (*Lyonia lucida*), and dwarf blueberry (*Vaccinium myrsinites*). Dry prairies often merge with mesic flatwoods or open hammock-dotted savannas (Abrahamson and Hartnett 1990).

Although most vertebrates found in mesic flatwoods or dry prairies habitats are found also in xeric upland habitats, a few species bear a common name that reflects their widespread, frequent occurrence in flatwoods. For example, the pinewoods treefrog (*Hyla femoralis)* and the pinewoods snake (*Rhadinea flavilata*) both are found in mesic pine flatwoods near cypress heads or wet prairies. Numerous small mammal species are found in pine flatwood habitats such as the cotton mouse (*Peromyscus gossypinus* and the cotton rat (*Sigmodon hispidus*). Relative to other nearby habitats, avian densities are low throughout most of the year, but they increase in cool weather as the winter migrants arrive. Dry prairies provide the primary habitat for several distinctive species of birds, including the burrowing owl (*Athene cunicularia*) and the Florida sandhill crane (*Grus canadensis*). As stated previously, most other vertebrates found in dry prairies and mesic flatwoods are found also in either the wetter or drier islands of habitat surrounded by the mesic flatwoods.

Historically, fire probably occurred about once every five to ten years in mesic flatlands habitats. Nearly all plants and animals inhabiting flatlands are adapted to periodic burning and several species are dependent upon fire for their continued existence. Without frequent fires, mesic flatwoods succeed into hardwood-dominated forests whose closed canopy can essentially eliminate the ground cover of herbs, grasses, and shrubs. If a dense litter layer accumulates in unburned mesic flatwoods it can effectively eliminate the recruitment of pine trees, which require a mineral soil substrate for germination. Thus, the integrity of the mesic flatwood habitats is dependent on periodic burning. On the other hand, fires that are too frequent or too hot would eliminate pine tree recruitment and transform mesic flatwoods into dry prairie.

Mesic flatwoods ecosystems changed markedly following human settlement of Florida. Founding Spanish settlers modified the mesic flatwoods for agriculture and livestock production. Most of the virgin pine trees were harvested during the Civil War. During the past century, the construction of roads and proliferation of cities, contributed to the fragmentation of all flatwoods habitats. With increasing human influence and development there was a concomitant decrease in the extent of natural fires (periodic burning has a strong influence on mesic flatwoods species composition). Expanding agriculture, increased urban development, and phosphate mining during the past 50 years have continued to fragment and reduce the areal extent of mesic flatwoods habitats throughout central Florida.

With proper restoration, phosphate mining may constitute only a temporary disturbance. Some research suggests that primary succession on unreclaimed spoil piles culminates in xeric or mesic oak forests that support a diverse array of vertebrates, indicating that some vertebrate species will re-colonize habitats after mining (Schnoes and Humphrey 1987). Of course, there must be a local source of animals, especially amphibians, reptiles, and mammals for their re-colonization to occur. In central Florida, there is a large pool of resident vertebrates (Layne and others 1977) to serve as potential colonists. Unfortunately, we know very little about rates of colonization of reclaimed habitats, and there are no established procedures for reintroduction of vertebrates onto reclaimed lands (Humphrey and others 1985).

Gopher tortoises have been relocated to reclaimed phosphate land. In 1988, 116 gopher tortoises were released at reclaimed phosphate mined land in Polk County, Florida (Macdonald 1996). The habitats where the tortoises were released were enhanced by planting 37,500 individuals of 20 species of plants know to be ingested by the gopher tortoise and mounds of sand were distributed to encourage the reintroduced tortoises to burrow at designated sites. By 1991, 40 individuals (34%) were recaptured. These recaptured gopher tortoises had dispersed to cover more than 2,000 hectares, and only 16% were within the study plots where they were released. Another study of reintroduced gopher tortoises produced similar results. In 1985, 83 gopher tortoises were reintroduced to a reclaimed sand tailings area planted with bahiagrass (Godley 1989). After two years, about 30% of the relocated tortoises remained within 0.5 km of the release area. Both studies suggest that, although a portion of the tortoises remained in the vicinity of the release points, the majority of reintroduced tortoises tended to disperse.

EVALUATING REHABILITATED WILDLIFE HABITAT

Our goal is to use the same logical standards for reclaimed terrestrial habitats as those that have been used to evaluate the success of reclaimed phosphate mined wetland habitats. In a recent report to the Florida Institute for Phosphate Research, Kale and Pritchard (1997, page 7-1) stated, "However, the mere presence of some fauna does not necessarily prove that a fully successful or optimal wetland has been created. Many wildlife species inhabit a wide variety of environments both uplands and wetlands, and their presence is not necessarily diagnostic of a wetland." In other words, the relative abundances and the kinds of species present at a reclaimed site, whether wetland or upland habitat, should reflect the natural conditions of the habitat under consideration. Our research was designed to recognize the great diversity of wildlife in any given patch of upland habitats. To that end, we use the term "rehabilitation" rather than "restoration" when applied to reclaimed phosphate mined uplands because we do not anticipate a full restoration of phosphate mined lands to their pre-mining conditions. Rather, we anticipate that the rehabilitated lands will be reclaimed as closely as possible to full restoration, and given sufficient time, rehabilitation may lead to restoration. The philosophy behind the manner in which we evaluate the success of rehabilitation efforts on phosphate-mined lands in central Florida has been explained previously (Mushinsky and McCoy 1996, McCoy and others 2000). For completeness of this report, we shall provide a brief review of our relatively broad measure of success, "representativeness." Representativeness is one of the criteria used to evaluate the conservation value of a natural habitat (Margules and Usher 1981). We have adopted the concept of representativeness and use it to measure the efficacy of rehabilitation of phosphate mined lands in Florida for wildlife. The central idea is that lands reclaimed for wildlife habitat should support a flora and fauna that represents the flora and fauna that existed on those lands prior to mining.

For our purposes, we define representativeness as the manifestation of the range of ecological variation in a particular habitat. Producing or preserving representative habitats for wildlife is part of an approach to conservation (and, as we have proposed to use it, restoration) rather than as a simple criterion for judging quality of natural areas (Smith and Theberge 1986). The concept of representativeness was the basis for establishing biosphere preserves to conserve natural habitats throughout the world (UNESCO 1974). Among the many aims of the Man and Biosphere (MAB) program were those designed to provide a sample of ecosystems in a natural state so as to maintain ecological diversity, conserve genetic resources, and facilitate education and research (IUCN 1978). The conserved areas then, are judged to be representative of the included habitats. We have modified the concept of representativeness (Margules and Usher 1981) to fit phosphate-mined lands, in particular: rehabilitated phosphate-mined lands should include typical or common vertebrate species as well as rare vertebrate species, in their typical relative abundances, to represent the full range of the biota. Building on this conceptual framework will produce a system of rehabilitated phosphate-mined lands that, collectively, encompass the broad range of vertebrate species typically found in areas that have not been mined or otherwise significantly modified.

We believe that the concepts of rehabilitation and representativeness together provide a reasonable framework for the reclamation of phosphate-mined lands in Florida.

Rather than placing extreme importance on rare and/or endangered or threatened species, representativeness emphasizes the value of preserving overall regional biodiversity. The concept of representativeness as applied to our specific rehabilitation effort facilitates maintenance of heterogeneous gene pools, the perpetuation of the full diversity of plant and animal species, and the opportunity to expand and connect the fragmented patches of vertebrate habitats, both "natural" and rehabilitated. By "natural," we mean typical and representative, and that the plants and animals living in the habitat are essentially complete or intact, and function as they would in the absence of humans (Margules 1986).

PROBLEMS, SOLUTIONS, AND PRODUCTS OF THE RESEARCH

- Problems (objectives)
    - Determine identities and inherent variation of resident vertebrate species on reference lands. [Existing reference lands must serve as the source for species to colonize reclaimed lands.]
    - Determine identities and inherent variation of resident vertebrate species on reclaimed lands.
    - Determine identities of the ecological variables correlated with the distribution of species found less often on reclaimed lands than on reference lands.
- Solutions (methods)
    - Identify and establish study sites throughout central Florida to allow us to gather data on resident vertebrates and to assess the inherent variation in vertebrate populations on reference and reclaimed lands.
    - Evaluate the information on resident vertebrates in light of the ecological variables we deem important to the biologies of these species (size of patch, distance of patch to nearest water, distance of patch to nearest upland habitat, and vegetation structure and composition).
    - Establish a series of correlations between the measured ecological variables and the presence or absence of the under-represented species at reclaimed lands.
- Products (results)
    - Lists of the relative abundances of vertebrate species at our reference and reclaimed study sites.
    - Lists of the ecological variables correlated with the presence/absence of species at our study sites.
    - Comparison of the results of the present study with a previous one that focused on xeric uplands in the same region.
    - Recommendations to improve reclaimed mined lands to support a flora and fauna representative of reference sites.

METHODS

The methods employed in this research follow, as closely as possible, the methods employed in our previous research on xeric uplands (Mushinsky and McCoy 1996). Where we have followed the previous methods precisely, we simply redescribe most of them. For a few of these methods, however, we have tried to improve upon the previous descriptions. Where we have not followed the previous methods precisely, we so indicate, and describe them anew.

PERSONNEL

Following, we list the key personnel involved in designing, and executing our research. A brief description of the role played by each person is included.

Henry R. Mushinsky and Earl D. McCoy, Professors of Biology, University of South Florida, were co-principal investigators for this research project. They were responsible for the administration of the research, hiring research assistants and other personnel, selection of study sites, installation of trap arrays, analyzing the data collected, and preparation of reports.

Robert A. Kluson, Ph.D. was hired for the post-doctoral position for our research. Dr. Kluson had experience in soil science and botany. He has been involved in site selection, installation of trap arrays, and collecting data. His expertise and contributions proved highly valuable for soil and vegetation analyses.

Cherie Keller, M.S. was hired as a research assistant. Cherie had considerable ornithological experience in Florida and was responsible for censusing birds at each study site. Cherie also helped with the site selection process, installation of trap arrays, developing methods for bird surveys, and data collection.

Wesley Shockly, M.S. was hired temporarily during 1997-1998 to manage the data base and extract required data for analysis.

A group of undergraduate students from the University of South Florida were employed periodically to construct funnel traps, which are used in conjunction with the drift fences and pitfall traps, and to aid researchers with data collection.

SITES

Reclamation goals must be sensitive to existing conditions; hence, our research was designed to identify the local pool of resident species on reference mesic flatlands for comparison with a list of the species collected previously and simultaneously on reclaimed lands. Recall that we already have studied the species that have been able to re-colonize 30 reclaimed lands (Mushinsky and McCoy 1996). The procedure we used to evaluate vertebrates on reclaimed land follows from our notion that rehabilitated lands should represent the full range of biological variation of the region in which the rehabilitation is occurring. We do not expect an individual rehabilitated site to contain the full range of variation, but we do expect a series of sites taken collectively to come close to achieving that end. The information necessary for making appropriate comparisons between upland habitats and previously-mined lands was obtained from two principal sources. One source was documented occurrences of vertebrates within the central Florida region, such as confirmed lists of species from Development of Regional Impact Statements (DRI's). The other source of information was direct sampling of the resident vertebrates.

We focused our attention on several groups of the regional terrestrial vertebrate species. The first such group was the local pool of resident species. This local pool establishes the possible limits of rehabilitation efforts. For example, if species X is extremely rare in reference areas, then it may be unrealistic to expect to establish large populations of species X, even in the best of the reclaimed areas. To determine the pool of local resident species, we reviewed all existing information on species' distributions and collected additional information at reference sites from field samples and observations within the general area of past and present phosphate mining operations. To determine which elements of the resident species pool have successfully re-colonized reclaimed lands, we collected information from field samples and observations on the reclaimed lands themselves. With this information in hand, we were able to identify species, called "focal species," from the local pool of resident species that were relatively abundant on the reference land, but under-represented on reclaimed phosphate-mined lands.

We also focused our attention on sites that were reclaimed over a relatively broad time period. Recognizing the history of phosphate mining, and changes in the laws that govern the reclamation of phosphate-mined lands in central Florida, we decided that our study sites should include two categories of previously-mined lands, those mined prior to the mandatory reclamation laws of 1975 and those mined since 1975. We recognize also that a considerable period of time may pass between mining and reclamation, and that a great variation exists in the procedures used to reclaim lands. Considering the previously-mined lands in this fashion, however, acknowledges the various time periods some lands have had for re-colonization and the various reclamation methods that may have been employed since 1975.

A great deal of research has shown that succession and disturbance interact to create a mosaic of habitats which are colonized most rapidly when the habitat patches are relatively large and relatively near sources of potential colonists. Colonization and extinction, caused primarily by habitat dynamics, are primary causes of the positive species-area relationship (Seagle and Shugart 1985). Small populations, even when protected from human interference, appear unusually prone to extinction (Simberloff

1986), especially when they are isolated. Relatively large patches of habitat tend to be colonized more rapidly, offer species greater protection from extinction, and support more species than equally-isolated smaller patches of habitat. Unlike the relatively small patches of reclaimed xeric upland, which were previously studied (Mushinsky and McCoy 1996), the reclaimed mesic flatlands tended to be much larger and often associated with a large drainage basin or riverine habitat.

Mesic flatlands tend to be much more widespread than xeric upland habitats, and do not occur as small isolated patches of habitat. In particular, the reference mesic locations we used for this study were large expanses of flatlands integrated into swamp and cypress dome ecosystems, or associated with riverine systems. A total of 30 trap arrays was installed at seven reference locations and four reclaimed locations, mostly on public and industry lands, in the counties of Hillsborough, Manatee, Hardee, Sarasota, and Polk (Figure 1). Each location was fitted with three to six trap arrays. We refer to these individual arrays as "sites" (Table 1). At all sites, whether reclaimed or reference, each trap array was at least 500 meters from the nearest trap array, often much more distance separated the arrays.

In our proposal to the Florida Institute for Phosphate Research (FIPR), we indicated that we planned to use the data we had collected previously at 30 reclaimed sites (Mushinsky and McCoy 1996) for comparison with newly-collected data from 30 reference mesic sites. Although our previous study focused on xeric upland habitats, many of the reclaimed sites that we studied actually had many characteristics of mesic habitats. In fact, it was the relatively mesic composition of the reclaimed lands that prompted us to expand our research into the mesic flatlands. Nevertheless, in response to requests from the Technical Advisory Committee of FIPR, we installed ten new trap arrays at four reclaimed locations thought to be among the best examples of restoration of mesic habitats. The four new reclaimed locations were selected in consultation with Mr. Tim King (Florida Game and Freshwater Fish Commission), Dr. Steve Richardson (Director of Reclamation), and members of the Florida Institute for Phosphate Research Technical Advisory Committee.

Despite our best efforts, at both the reference and newly-selected reclaimed sites, to install trap arrays at distances far enough from one another effectively to isolate the sites, one could argue that each site is not independent of the others at the same location. In other words, the sites at any given location could be sampling the same populations of resident vertebrates, and are not true replicates. This problem is recognized as pseudoreplication (Hurlbert 1984), and it can alter how one interprets the findings of a study. Pseudoreplication can affect the outcome of any study because it artificially inflates the number of replicates for statistical comparisons of the data obtained. We recognize this potential problem and report the findings of our study on the basis of locations where we deem necessary. Because we used ten new reclaimed sites, we

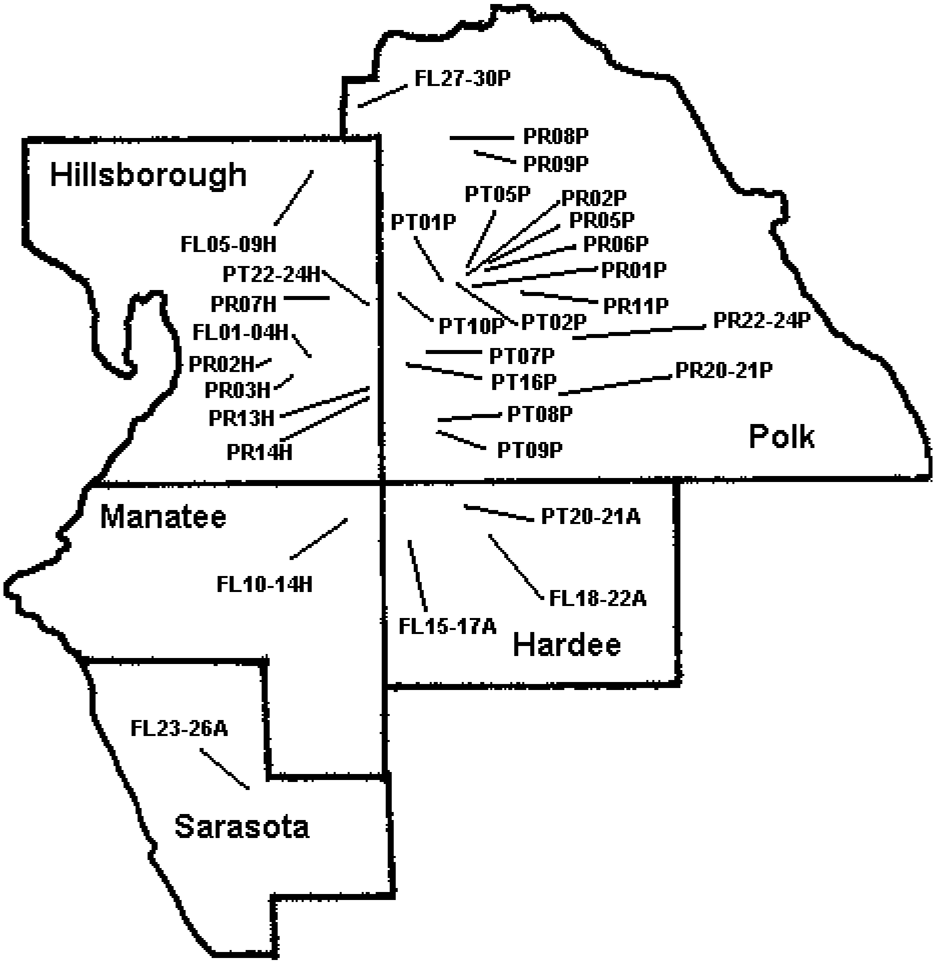


Figure 1. Study Sites.

Table 1. Study Sites.

Site	Location	R, T, S	Habitat	County
FL01H	A	21E,30S,28	Flatwoods	Hillsborough
FL02H	A	21E,30S,28	Flatwoods	Hillsborough
FL03H	A	21E,30S,28	Flatwoods	Hillsborough
FL04H	A	21E,30S,28	Flatwoods	Hillsborough
FL05H	A	20E,27S,24	Flatwoods	Hillsborough
FL06H	B	20E,27S,24	Flatwoods	Hillsborough
FL07H	B	20E,27S,24	Flatwoods	Hillsborough
FL08H	B	20E,27S,24	Flatwoods	Hillsborough
FL09H	B	20E,27S,19	Flatwoods	Hillsborough
FL10M	C	21E,34S,02	Flatwoods	Manatee
FL11M	C	21E,34S,02	Flatwoods	Manatee
FL12M	C	21E,34S,02	Flatwoods	Manatee
FL13M	C	21E,34S,02	Flatwoods	Manatee
FL14M	C	21E,34S,03	Flatwoods	Manatee
FL15A	D	23E,33S,29	Flatwoods	Manatee
FL16A	D	23E,33S,29	Flatwoods	Hardee
FL17A	D	23E,33S,29	Flatwoods	Hardee
FL18A	D	24E,33S,30	Flatwoods	Hardee
FL19A	E	24E,33S,30	Flatwoods	Hardee
FL20A	E	24E,33S,30	Flatwoods	Hardee
FL21A	E	24E,33S,30	Flatwoods	Hardee
FL22A	F	24E,33S,30	Flatwoods	Hardee
FL23S	F	20E,37S,29	Flatwoods	Sarasota
FL24S	F	20E,37S,29	Flatwoods	Sarasota
FL25S	F	20E,37S,31	Flatwoods	Sarasota
FL26S	G	20E,37S,31	Flatwoods	Sarasota
FL27P	G	23E,26S,04	Flatwoods	Polk
FL28P	G	23E,26S,04	Flatwoods	Polk
FL29P	G	23E,26S,04	Flatwoods	Polk
FL30P	G	23E,26S,04	Flatwoods	Polk
PT20A	H	24E,33S,01	Mine>1975	Hardee
PT21A	H	24E,33S,12	Mine>1975	Hardee
PT22H	I	22E,30S,25	Mine>1975	Hillsborough

Table 1. Study Sites (Cont.)

Site	Location	R, T, S	Habitat	County
PT23H	I	22E,30S,25	Mine>1975	Hillsborough
PT24H	I	22E,30S,25	Mine>1975	Hillsborough
PT01P		22E,30S,25	Mine>1975	Polk
PT02P		24E,31S,16	Mine>1975	Polk
PT05P		24E,30S,21	Mine>1975	Polk
PT07P		23E,31S,10	Mine>1975	Polk
PT08P		23E,31S,27	Mine>1975	Polk
PT09P		23E,31S,34	Mine>1975	Polk
PT10P		23E,30S,30	Mine>1975	Polk
PT16P		23E,31S,18	Mine>1975	Polk
PR20P	J	24E,30S,23	Mine<1975	Polk
PR21P	J	24E,30S,23	Mine<1975	Polk
PR22P	K	25E,30S,35	Mine<1975	Polk
PR23P	K	25E,30S,35	Mine<1975	Polk
PR24P	K	24E,30S,27	Mine<1975	Polk
PR01P		24E,29S,34	Mine<1975	Polk
PR02H		21E,31S,16	Mine<1975	Hillsborough
PR03H		21E,31S,16	Mine<1975	Hillsborough
PR07H		21E,29S,28	Mine<1975	Hillsborough
PR13H		22E,31S,23	Mine<1975	Hillsborough
PR14H		22E,31S,26	Mine<1975	Hillsborough
PR05P		24E,29S,27	Mine<1975	Polk
PR06P		24E,29S,32	Mine<1975	Polk
PR08P		24E,27S,26	Mine<1975	Polk
PR09P		24E,27S,25	Mine<1975	Polk
PR10P		24E,30S,05	Mine<1975	Polk
PR11P		25E,30S,29	Mine<1975	Polk

needed to use data from only 20 of the 30 reclaimed sites from our first study (Mushinsky and McCoy 1996) to create a balanced experimental design. To select the 20 sites, we reasoned that reclaimed lands that supported the broadest array of plants and animals indicative of xeric uplands should be the ones eliminated from consideration. We examined the vegetation profiles as well as the lists of vertebrates found at the 30 reclaimed sites.

In particular, we focused on sites that supported xeric plants such as sand pines, rosemary, or wiregrass and vertebrates that typically inhabit xeric lands, such as the gopher tortoise and Florida mouse. We ranked the 30 sites, based on their vegetation profiles and faunal compositions, from most like xeric to least like xeric, eliminated the ten most like xeric, and retained the remaining 20 sites as part of the present study. Thus, the 30 mesic reclaimed sites for this study included 10 new sites plus 20 of the most mesic sites from the previous study. Among this group of 30 sites, are 13 that were mined prior to 1975 and 17 mined thereafter. The vast majority of mined sites were reclaimed by filling the strip mine cuts with sand tailings and smoothing the remaining overburden piles to create a shallow covering over the sand tailings. Physical, soil, vegetation, and vertebrate species data are presented only for the 30 reference and ten newly-selected reclaimed sites; data for the other 20 reclaimed sites are presented elsewhere (Mushinsky and McCoy 1996).

SURVEY METHODS

Sizes, Distances, and Other Physical Variables

Sizes and distances to permanent water, other upland habitat, and seasonal water were determined from examination of recent maps and aerial photographs, followed by field observations, using a combination of Global Positioning System (GPS), compass, and tape measurements. Because of the nature of mesic flatlands, sites were nested within larger areas that we refer to as “locations” (see Table 1). Measurements of physical variables thus refer to locations. Locations less than 25 hectares (62.5 acres) are considered "small," while locations larger than 25 hectares are considered "large." We created similar dichotomies for each of the three distance measures. Distances less than 300 meters from permanent water, or other upland habitat, or seasonal wetlands are considered "near," while distances greater than 300 meters are considered "far" for each category. The size and distance measurements used to create these categories were derived from our previous studies of upland habitats in Florida (e.g., McCoy and Mushinsky 1994, 1999).

We measured several other physical variables for each location. Because the quality of lands surrounding our study sites may influence the vertebrates that occur there, we characterized the lands surrounding each location. All surrounding lands within an area four times greater than the area of a location were classified into one of ten possible categories: upland habitat, wetland, citrus grove, pasture, farm, active mine, inactive mine, reclaimed land, old field, and residential. We also noted whether or not cattle were present at a location during our sampling. Our previous attempts to obtain additional information by sending out questionnaires to land owners/managers were relatively unsuccessful, especially for reference lands (Mushinsky and McCoy 1996), so we eliminated this time-consuming and costly undertaking.

Soils

Chemical and physical soil tests used representative soil samples for each randomly selected plot (see Survey Methods: Vegetation) from all sites. Two representative soil samples were obtained for each plot, at two depths (15 and 30 cm), and consisted of pooled subsamples. Soil subsamples were collected with a probe (6 cm diameter) along the constructed 10m line transect at 2m intervals. In our previous research (Mushinsky and McCoy 1996), we also completed detailed analyses of soil profiles, including litter depth, compaction, and root density. The data from these time-consuming measurements proved to be of only modest use, because of the clear and consistent difference between reference and reclaimed sites, so we eliminated them in the current research.

Preparation of the representative soil samples from pooled subsamples was done in the lab by air-drying, mixing, and sieving (2 mm). Then, a representative sample (100g) was collected for the chemical and physical analyses. Physical tests were conducted at the Physical Geography Laboratory, Geography Department, University of South Florida, Tampa. Chemical tests were conducted at the Analytical Research Laboratory, Department of Soils and Water Science, University of Florida, Gainesville.

Physical tests included texture and sand particle size. The tests used standard methods (R. Brinkman, Associate Professor, Lab Director, Geography Department, University of South Florida, Tampa): texture by the Bouyoucos hydrometer method, for USDA size classes of sand (2-0.05 mm), silt (0.05-0.002 mm), and clay (<0.002 mm); and sand particle size by dry sieving, with 10 min. of automated shaking, at full PHI intervals for USDA size classes of very coarse (2-1 mm), coarse (1-0.50 mm), medium (0.50-0.25 mm), fine (0.25-0.10 mm; actual interval measured was 0.25-0.125 mm), and very fine (0.10-.005; actual interval measured was 0.125-0.063 mm).

Soil chemical tests included pH, total nitrogen (N), available phosphorus (P) and potassium (K), electrical conductivity (i.e., total salts), and organic matter. The tests used standard methods (Research soil sample information sheet. August, 1994. Analytical Research Laboratory, Department of Soil and Water Science, Institute of Food and Agricultural Sciences, University of Florida, Gainesville): pH and electrical conductivity were determined in 2:1 water:soil ratio, total N by the Kjeldahl method (Personal Communication. February, 1995. J. Bartos, Lab Coordinator, Analytical Research Laboratory, Department of Soil and Water Science, Institute of Food and Agricultural Sciences, University of Florida, Gainesville), available P and K by the Mehlich-1 method, and organic matter by Walkley-Black dichromate method.

Vegetation

The vegetation data were collected on plots measuring 10 x 10 meters. Plots were randomly placed within the delineated boundaries of each site. Randomization was accomplished by constructing imaginary x-y axes at the edge of a site. The shape of each site was generalized to a regular geometry to facilitate usage of the two axes. Distances along each axis were selected from a table of random numbers, to establish the starting point of each plot or transect. Three to five plots or transects were sampled at each plot, more at sites with high variability.

Life-form coverage along transects was measured by line-intercept on a 10m line transect across the middle of each plot. We determined percent ground cover from ground level to one meter above ground. We recorded life-form coverage as the relative amount of ground in a plot that was covered by one or more of the categories wiregrass, other grasses, legumes, forbs, woody species, litter, bare ground (= absence of a life-form), and mycophytes (= lichens + fungi), pteriphytes (= ferns + clubmosses), and mosses. [We recognize that one of these categories -- bare ground -- does not represent a "life form" in the strict sense of the phrase; it belongs with the other categories, however, because, in combination, all of the categories describe the entirety of ground cover.] For most analyses, the last three categories were combined into a single category called "crust." Only pre-dominant vegetation was counted, overlapping vegetation was not recorded. We complied a list of species at a site based on plant observations and collections made during all our visits to each site. All identified species were collected only initially for verification with identified specimens at the USF herbarium. Identifications of unknown specimens were conducted under the guidance of Dr. Richard Wunderlin of USF Department of Biology.

Foliage layer height profiles were characterized by visually analyzing the vegetation structure outside plots for seven different layers, Ground, Gap1, Shrub, Gap2, Middle-Canopy, Gap3, and Upper-Canopy strata. Height of each identified layer was estimated with a clinometer at each plot.

Canopy density within plots was measured in two ways. Total canopy cover over 1 and 2.5 m above ground level was determined with a hand-held densitometer (horizontal canopy density). The 2.5m reading was taken by standing on a ladder. Readings were made at 0, 5 and 10m positions of each line transect in all four compass directions. Canopy density also was estimated by visually scoring the percent cover of a board (2 x 1m) held at pre-selected heights and from a standardized 10m distance (vertical canopy density). We did this by viewing the board across each plot from N-S and E-W compass directions at 3.3 and 6.6m positions along the edge of the plot. The pre-selected board heights were 2, 4, 6, and 8m above the ground, and the observer was positioned at a corresponding height with the use of a ladder.

Vegetation density was measured using the following procedures. Trees, saw palmetto, and shrubs were counted and classified according to height (< 0.5, 0.5-1.0, 1.0-2.0, > 2.0m) classes within each plot. We selectively counted certain tree (*Quercus*, *Pinus*) and shrub (*Lyonia*, *Myrica*, *Vaccinium*) species useful for our vegetation classification, as well as snags. The counting procedure for saw palmetto took into account the low-lying, branching growth habit of the species. Individual clumps were defined by locating the origin of connected branches, and counts were made of these clumps, instead of the separate branches that often can appear to be separate plants. In our previous research (Mushinsky and McCoy 1996), we also counted and classified trees and shrubs according to DBH (diameter-at-breast-height) classes. The data from this other counting and classification scheme proved to be of only modest use, because of their close relationship to the data from the height counting and classification scheme, so we eliminated them in the current research.

Vertebrates

After we selected a study site, we installed a complete trap array (Campbell and Christman 1982) there, to capture amphibians, reptiles, and mammals. At each site selected for our study, we carefully examined the general vicinity of the site prior to determining where the trap array would be placed. We placed each trap array in an setting that we considered to be typical and representative of the habitat we were sampling. Briefly, a trap array consists of four 7.5 meter long drift fences (an individual drift fence is a "wing") arranged in a plus shaped (+) and fitted with eight 20 liter buckets buried in the ground at each end of the fence. A gap of 15 meters is maintained between the centers of the north-south and east-west facing wings. For each array, eight funnel traps were constructed and placed near the middle on both sides of each wing. Most of the data reported herein on terrestrial vertebrates were collected from organisms captured in trap arrays. Although trap arrays capture many species of amphibians, reptiles, and mammals, and are probably the best single technique for sampling a wide variety of vertebrates, they are not perfect. They do not, of course, capture meso- and large mammals, or bats. Trap arrays have variable success in capturing tree frogs, large snakes, and arboreal lizards. We noted all other observations of the presence of vertebrate organisms including carcasses, scat, footprints, scrapemarks, and remnants of foraging activities that might help identify an organism. Gopher tortoises were surveyed at each site by taking one 100 x 7 meter belt transect parallel to each wing of a trap array, beginning at the end of each wing and extending distally form the trap array.

We divided each year of the study into six two-month trapping sessions, and trapped each study site for seven days during each session. Because traps were checked daily and were dispersed over a broad area, it was not possible to open and check all traps simultaneously. All traps were opened and checked during each two month trapping session, however, to assure consistency of our sampling effort. The plant cover at our study sites was variable, comprised mainly of shrubby species with occasional understory and/or pine trees. Because of the variability among sites, even within locations, bird surveys were associated closely with the individual trap arrays at the sites. We adopted the following methods for our bird surveys:

Transect-surveys. Approximately 100 meters of transect was associated with each trap array. Transects were taken to incorporate local habitat variation, such as edge, that would represent the complete variety of species present.

Time of surveys. All bird surveys were conducted between sunrise and 3 hours after sunrise, the period of the day when most species of birds are most active. We did not conduct evening surveys, hence we may have missed some observations of owls and other nocturnal species.

Survey procedures. All sites were relatively open with wide visibility and so all sites could be surveyed in the same manner. The surveyor walked the transect recording all birds seen or heard within 30 meters of the centerline.

Duration of surveys. All transects were walked at a slow and consistent pace.

Recording data. All bird species detected that were perceived to be using the habitat on the study site were recorded. We recorded as "using the habitat" any species observed perching in a tree or shrub, or hunting/foraging on the wing over the habitat (for example, hawks or swallows). Birds seen flying over the study site, but not perceived as suing the habitat were not recorded.

Establishing nesting. Nesting behavior was recorded if detected. Individual birds were determined to be nesting in the habitat if they exhibit certain behaviors. These behaviors include territorial defense by males (e.g., singing and fighting between males), courtship behavior (e.g., males perusing females or offering food to females), nest building (e.g., observing individuals carrying nest materials or actually building a nest), and presence of fledglings.

We made no attempt to capture or mark any birds. Rather, to make quantitative estimates of the relative abundance of avian species, we tallied the number of times a given species was observed at a site. Each transect was visited once during the winter season, and four times during the breeding season to observe species whose peak breeding may vary across the season. Surveys conducted during the winter season (December through February) determined the resident species. Surveys conducted across the breeding season determined the breeding birds. All bird surveys were conducted by the same person.

RESIDENT AND FOCAL SPECIES SELECTION

The vertebrate species that are likely to colonize rehabilitated lands in abundances similar to those in mesic flatlands habitats in central Florida are the resident species. Resident species, then, are a subset of the greater total pool of species known to occur in local mesic flatlands. Some species from the local pool of species occasionally may use mesic flatlands, but do not establish residency in these habitats. Numerous bird and snake species, for example, may traverse the mesic flatlands, even periodically, but are not considered to be residents. We used several sources to construct our list of resident vertebrate species. We considered a species to be a resident of the upland habitats if two of the three sources agreed that it was so; other species found in these habitats are considered non-resident, or transient, species. Note that we did not necessarily use the same source for each taxonomic grouping -- amphibian, reptile, mammal, bird. Sources used to construct lists of local resident species follow.

Layne, J. N., J. A. Stallcup, G. E. Woolfenden, M. N. McCauley, and D. J. Worley. 1977. Fish and wildlife inventory of the seven-county region included in the Central Florida phosphate area wide environmental impact study. Prepared by Archbold Biological Station for the Fish and Wildlife Service. [All groups of vertebrates]

O'Neill, E.D. 1995. Amphibian and reptile communities of temporary ponds in a managed pine flatwoods. MS Thesis, University of Florida, Gainesville. AND O'Neill, E.D. and S.P. Christman. 1997. Personal communications. [All groups of vertebrates]

Ashton, R. E., Jr., and P. S. Ashton. 1988. Handbook of reptiles and amphibians of Florida, Part 3, The amphibians. Windward Publishing Co., Miami. [Amphibians]

Ashton, R. E., Jr., and P. S. Ashton. 1985. Handbook of reptiles and amphibians of Florida, Part 2, Lizards, turtles and crocodilians. Windward Publishing Co., Miami. [Lizards and turtles]

Ashton, R. E., Jr., and P. S. Ashton. 1981. Handbook of reptiles and amphibians of Florida, Part 1, The snakes. Windward Publishing Co., Miami. [Snakes]

Brown, L. B. 1993. Mammals of Florida. Windward Publishing Co., Miami. [Mammals]

Kale, H. W, II, and D. S. Maehr. 1990. Florida's birds, a handbook and reference. Pineapple Press, Sarasota. AND Robertson, W.B., and G.E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Special Publication Number 6, Gainesville. [Birds]

We compared the lists of species from reclaimed sites to those from reference sites. This comparison provided us with information about the number and types of species that colonize previously-mined lands without any particular help. Species which are found much more commonly--locally--on reference mesic flatlands than on reclaimed mesic lands are called “focal species.” To determine which of the resident vertebrate species actually might be present at our sites, we supplemented our own data with information on species distributions gathered from certain other sources. We reviewed all Development of Regional Impact (DRI) and final reports on file in the FIPR Library in Bartow or the Florida Fish and Wildlife Conservation Commission Office, in Lakeland, but tabulated only data from on-site sampling that were included in those reports. Many DRI's reported data obtained from pre-existing information (i.e., field guides to the mammals, birds, amphibians and reptiles of North America); because these sources do not identify specific habitats, we did not use them. DRI and final reports used to construct lists of local resident species follow.

Evaluation of Xeric Habitat Reclamation at a Central Florida Phosphate Mine, prepared by Tim King, Brian Toland and Jim Feiertag, Office of Environmental Services, Florida Game and Fresh Water Fish Commission, Lakeland, Florida for IMC Fertilizer Co., July 1992.

Boyette Tract Wildlife Assessment, prepared by Post Buckley Schuh, and Jernigan, Inc., November 1989.

Kingsford Mine Extension, prepared by Gurr and Associates, Inc., June 1986, updated April 1987.

Noralyn/Phosphoria Mine Extension, prepared by Gurr and Associates, Inc., June 1985.

Haynsworth Conceptual Reclamation Plan, prepared by Brewster Phosphates Inc., October 1981.

Bonny Lake Mine Conceptual Reclamation Plan, prepared by W. R. Grace and Co., October 1981.

Fishhawk Ranch, prepared by Florida Land Design and Engineering, November 1988.

Hillsborough County Mines, prepared by IMC Fertilizer Co., June 1990.

Lonesome Mine, prepared by Brewster Phosphates Inc., August 1973.

Big Four Mine, prepared by Amax Phosphate, Inc., October 1981.

Kingsford Mine (Hillsborough Tract), prepared by Conservation Consultants Inc., February 1974.

IDENTIFYING FOCAL SPECIES

We identified focal species in the following manner. We decided that no existing method fit our needs for comparing reclaimed sites to reference sites, so we developed a new one. Our method consists of six steps. The first three steps are designed to focus attention on those species that inhabit a relatively large number of reference sites but not reclaimed sites, because these species account for most of the difference between reference and reclaimed sites. (1) Calculate the ratio of the number of reference sites at which a species is found to the number of reclaimed sites at which it is found, for all species. For example, the ratio for *Thryothorus ludovicianus* (Carolina wren) is 24:0. (2) Calculate the magnitude of the deviation between observed and expected ratios. The latter is the ratio expected if a species occurs at the same proportion of restored sites as reference sites. The magnitude of the deviation can be assessed with the binomial coefficient, phi coefficient, or some other similar kind of coefficient (McCoy and Rey 1983). For example, the binomial coefficient for a ratio of 24:0 as opposed to a ratio of 12:12 is 20.72. (3) Select those species for which the magnitude of the deviation is significantly large at a pre-determined probability, say $p = 0.10$. The selection can be made with a contingency table; the number of species selected depending directly on the level of significance chosen. For example, the ratio for *Anolis c. carolinensis* (green anole; 15:5, binomial coefficient = 2.72) is significantly large at $p = 0.10$ but the ratio for *Picoides pubescens* (downy woodpecker; 12:4, binomial coefficient = 2.16) is not significant at this probability. The second three steps are designed to incorporate the abundances of the focal species and then calculate and test the overall resemblance between reference and reclaimed sites. (4) Adjust the values of the coefficients for differences in abundance between reference sites and reclaimed sites. The adjustment can be made by calculating the mean abundance of each species at both the reference sites and the reclaimed sites where it is present; dividing (the mean at the reference sites) by (the mean at the reclaimed sites), if (the mean at the reclaimed sites) > 0, or dividing (the mean at the reference sites + 1) by (the mean at the reclaimed sites +1), if (the mean at the reclaimed sites) = 0; and then multiplying the value of the coefficient by the resulting quotient. For example, the adjusted value of the binomial coefficient for *Thryothorus ludovicianus* is 82.88 (20.72 x 4). Note that the adjusted values of the coefficient can be used directly, or they can be scaled. (5) Calculate the overall difference in resemblance between reference sites and reclaimed sites. The overall difference in resemblance is the sum of the adjusted values of the coefficients. (6) Compare the overall difference in resemblance to the maximum possible difference. Our method is unbiased and will identify those species that are over-represented as well as those under-represented at reclaimed sites relative to the reference sites. Because our research is designed to identify potential causes for the under representation of species at reclaimed sites, most of our efforts concentrate on under-represented focal species. Assuming that no "penalty" is imposed for species that are over-represented at reclaimed sites relative to reference sites, the maximum possible difference is easily computed, by calculating hypothetical coefficients under the condition that each species is found at the actual number of reference sites in the actual mean abundance, but at no reclaimed sites, and then summing the coefficients. Clearly, the maximum possible difference varies according to the number of species, the number of reference sites at which each species occurs, and the mean abundance of each species at the reference sites.

As are all methods, ours is accompanied by a set of assumptions, and we list some of the more important for clarity. The reader should remember that our method to compare reference and reclaimed sites was derived in response to the specific goal that reclaimed sites resemble reference sites in terms of the kinds of species present and their abundances. Our assumptions include the following. (1) The landscape level, across many sites, is the appropriate level of examination. (2) Species that are under-represented--and not equally- or over-represented--at reclaimed sites relative to reference sites are the appropriate units of examination. (3) Specification of the degree to which each species is under-represented at reclaimed sites relative to reference sites is important. (4) The degree to which species are missing entirely from reclaimed sites is more important than the degree to which abundances of those species differ between reference and reclaimed sites. (5) Multiplication of distributions and abundances (as detailed above to identify the "Focal Species") yields the appropriate representations of the interrelationships between species' distributions and abundances. If these assumptions are reasonable, or at least not debilitating, then ranking of sites follows as a logical consequence of ranking of species. On the one hand, if no species were recognized as focal species, because all species were equally abundant on reclaimed and reference sites, then no sites scores, and, therefore no cumulative sites scores, would even exist. On the other hand, if all focal species were completely restricted to reference sites, and thus completely absent from reclaimed sites, then the distribution of cumulative sites scores for reclaimed sites would be at maximum separation from the distribution of scores for the reference sites. In other words, increasing the number of focal species and/or the magnitudes of their accompanying sites scores essentially "drags" the distribution of cumulative sites scores for reclaimed sites away from the distribution for reference sites, toward maximum separation. Hypothetically, "maximum separation" would occur when the focal species were present at the actual number of reference sites, in their actual abundances, but were absent from reclaimed sites.

A simple randomization procedure can be employed to determine which, if any, reclaimed sites have unusually high cumulative sites scores. Unusually high cumulative sites scores are those that exceed a certain number of the randomly-generated cumulative sites scores. For example, exceeding 90 randomly-generated cumulative sites scores corresponds closely to $p < 0.10$. The procedure consists of five steps. (1) Construct a pool consisting of the focal species that occurred at both reference and reclaimed sites. Each species is represented in the pool a number of times equal to the number of reclaimed sites at which it occurred. (2) Select species at random from the pool and assign them to reclaimed sites. Each site receives the actual number of species that occurred there. (3) Compute the resulting cumulative sites scores. (4) Repeat steps 1 and 2 at least 100 times. (5) Compare actual cumulative sites scores against randomly generated ones.

LOGIC AND STATISTICAL ANALYSES

The logic of the study led directly to the analyses we employed. We envisioned the study as a series of eight steps:

- Choose species and sites to be used in subsequent analyses
- Arrange and categorize species and sites
- Determine number of species per site and number of sites per species
- Determine number of individuals per species and number of individuals per site
- Identify patterns among species and among sites
- Derive explanations for the patterns, based on physical and vegetation variables
- At all steps, compare reference sites to reclaimed sites
- Synthesize the information and compare results with those obtained from xeric upland sites (Mushinsky and McCoy 1996), to produce recommendations

Standard statistical methods, mostly non-parametric, were used to analyze the data. These methods included Spearman's Rank Correlation Analysis (Sokal and Rohlf 1995, p. 598); the Mann-Whitney U-test, a non-parametric method used in lieu of a one-way ANOVA (Sokal and Rohlf 1995, p. 427); Kolmogorov-Smirnov One- and Two-sample Tests for goodness of fit (Sokal and Rohlf 1995, p. 708); the G-test of independence (Sokal and Rohlf 1995, p. 729), and Fisher's Exact Test (Sokal and Rohlf 1995, p. 730). All analyses using these five methods were performed with SIGMASTAT or SYSTAT software.

Several less-standard methods also were used to analyze the data. The Variance-Ratio Test (Schluter 1984) was used to test for associations among the presences/absences of species. The test statistic *W* determines significant departures from the expected value of no association. Monothetic Divisive Cluster Analysis (also called Association Analysis) (Madgwick and Desrochers 1972) was used to separate sites into so-called homogeneous groups based on associations among the presences/absences of species. We employed the so-called trial-and-error stopping rule (Ludwig and Reynolds 1988). All analyses using these two methods were performed with BASIC software programs (Ludwig and Reynolds 1988).

RESULTS

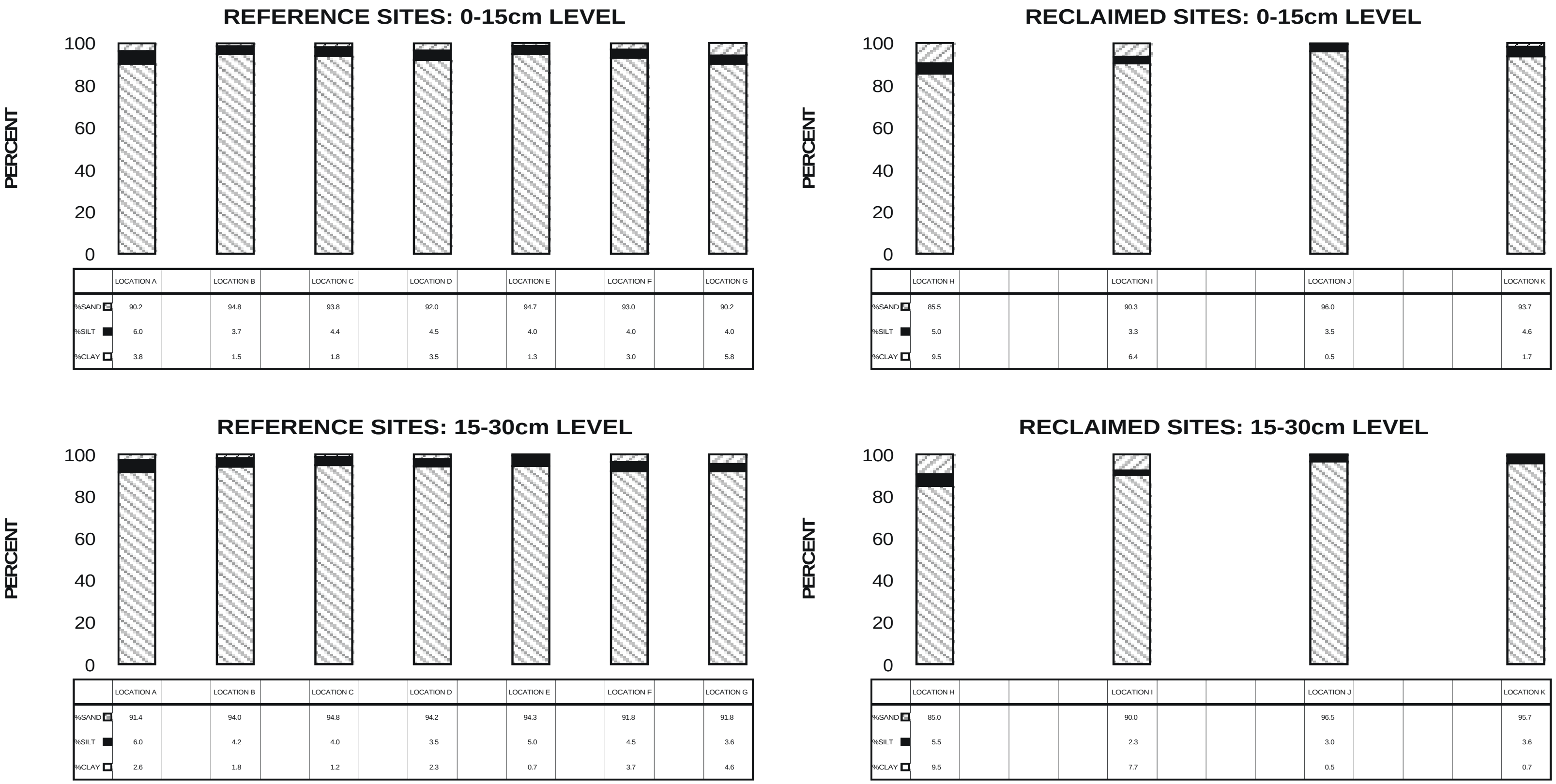
SIZES, DISTANCES, AND OTHER PHYSICAL VARIABLES

All 11 locations (40 sites) were placed into categories of size [small (less than 25 ha), large (greater than 25 ha)], distance to seasonal water [near (less than 300 meters), far (greater than 300 meters)], distance to permanent water (near, far), and distance to other upland habitats (near, far), and the habitats (upland habitat, wetland, citrus grove, pasture, farm, active mine, inactive mine, reclaimed land, old field, residential) immediately surrounding the sites were recorded (Table 2). Presence/absence of cattle grazing during the study also was recorded (Table 2). The 4 reclaimed locations were categorized further according to type of soil (overburden, sand tailings/overburden, sand tailings) reclamation (Table 3). Type of vegetation reclamation was not known. The year(s) in which reclamation took place also were recorded (Table 3).

We could detect no difference between reference and reclaimed locations for most physical variables. All locations, reference and reclaimed, because of the nature of the habitat, were near seasonal water. Virtually all locations, reference and reclaimed, also were large (five of seven reference locations, three of four reclaimed locations) and ungrazed (six of seven reference locations, three of four reclaimed locations). All reference locations were far from permanent water, but two of four reclaimed locations were near permanent water (Fisher Exact Test, $p = 0.11$). All reference locations also were near other uplands, but three of four reclaimed locations were far from other uplands (Fisher Exact Test, $p < 0.10$). Finally, we detected tendencies for reference locations to be surrounded by fewer habitats than reclaimed locations (M-W U-Test, $p = 0.11$), for reclaimed locations to abut inactive reclaimed lands more than reference locations (Fisher Exact Test, $p = 0.11$), and for reclaimed locations to abut reclaimed lands more than reference locations (Fisher Exact Test, $p < 0.10$). Note that only reference locations abut citrus and residential development, but the tendency for reference locations to abut these two habitats more than reclaimed locations is not a strong one.

SOILS

An analysis of soil texture is presented in Figure 2. Texture varied little among the seven locations of reference sites in either the 0-15 cm or 15-30 cm horizon. Mean percent-sand, percent-silt, and percent-clay all were very similar among the locations, and we were unable to detect any substantial difference in either of the two sampled horizons (Mann-Whitney U-test, $p > 0.10$). [Note that in all subsequent analyses in this section, trends will be identified at a p-value of 0.10, and that the analyses themselves are M-W U-tests, unless otherwise specified.] We also were unable to detect any substantial difference in mean percent-sand, percent-silt, or percent-clay between reference and reclaimed sites in either of the two sampled horizons.



REFERENCE SITES: 0-15cm LEVEL

	LOCATION A		LOCATION B		LOCATION C		LOCATION D		LOCATION E		LOCATION F		LOCATION G
%SAND ▨	90.2		94.8		93.8		92.0		94.7		93.0		90.2
%SILT ■	6.0		3.7		4.4		4.5		4.0		4.0		4.0
%CLAY □	3.8		1.5		1.8		3.5		1.3		3.0		5.8

RECLAIMED SITES: 0-15cm LEVEL

	LOCATION H				LOCATION I				LOCATION J				LOCATION K
%SAND ▨	85.5				90.3				96.0				93.7
%SILT ■	5.0				3.3				3.5				4.6
%CLAY □	9.5				6.4				0.5				1.7

REFERENCE SITES: 15-30cm LEVEL

	LOCATION A		LOCATION B		LOCATION C		LOCATION D		LOCATION E		LOCATION F		LOCATION G
%SAND ▨	91.4		94.0		94.8		94.2		94.3		91.8		91.8
%SILT ■	6.0		4.2		4.0		3.5		5.0		4.5		3.6
%CLAY □	2.6		1.8		1.2		2.3		0.7		3.7		4.6

RECLAIMED SITES: 15-30cm LEVEL

	LOCATION H				LOCATION I				LOCATION J				LOCATION K
%SAND ▨	85.0				90.0				96.5				95.7
%SILT ■	5.5				2.3				3.0				3.6
%CLAY □	9.5				7.7				0.5				0.7

Figure 2. Soil Texture. Means Are Displayed for the 0-15 cm Level (Upper Left) and 15-30 cm Level (Lower Left) at Reference Sites, and for the 0-15 cm Level (Upper Right) and 15-30 cm Level (Lower Right) at Reclaimed Sites.

Table 2. Size, Isolation and Cattle Usage of Study Locations.

		Distance to				
Location	Size	Seasonal Water	Permanent Water	Upland	Surr. Habs	Grazing
A	Small	Near	Far	Near	2, 3, 7, 10	Yes
B	Large	Near	Far	Near	3, 7, 10	No
C	Large	Near	Far	Near	1, 3, 7	No
D	Small	Near	Far	Near	2, 3, 5, 7	No
E	Large	Near	Far	Near	1, 3, 5, 7, 10	No
F	Large	Near	Far	Near	2, 3, 7	No
G	Large	Near	Far	Near	3	No
H	Large	Near	Near	Near	2, 3, 4, 7, 8	No
I	Large	Near	Far	Far	3, 5, 7, 8	No
J	Small	Near	Far	Far	3, 5, 6, 7, 8	No
K	Large	Near	Near	Far	2, 3, 5, 6, 8	Yes

Small locations are <25 ha and large locations are >25 ha, near locations are <100m and far locations are >300m. Surrounding habitats (Surr. Habs.) are: 1 = citrus, 2 = pasture, 3 = wetland, 4 = farm, 5 = active mine, 6 = inactive mine, 7 = upland habitat, 8 = reclaimed land, 9 = old field, 10 = residential.

Table 3. Treatment History of Reclaimed Study Locations.

Location	Year Treated	Soil Treatment
H	1991	OB
I		
I	1991	ST/B
J		
J		
J	1988-89	OB
K		
K	1989-91	OB
L		
L		

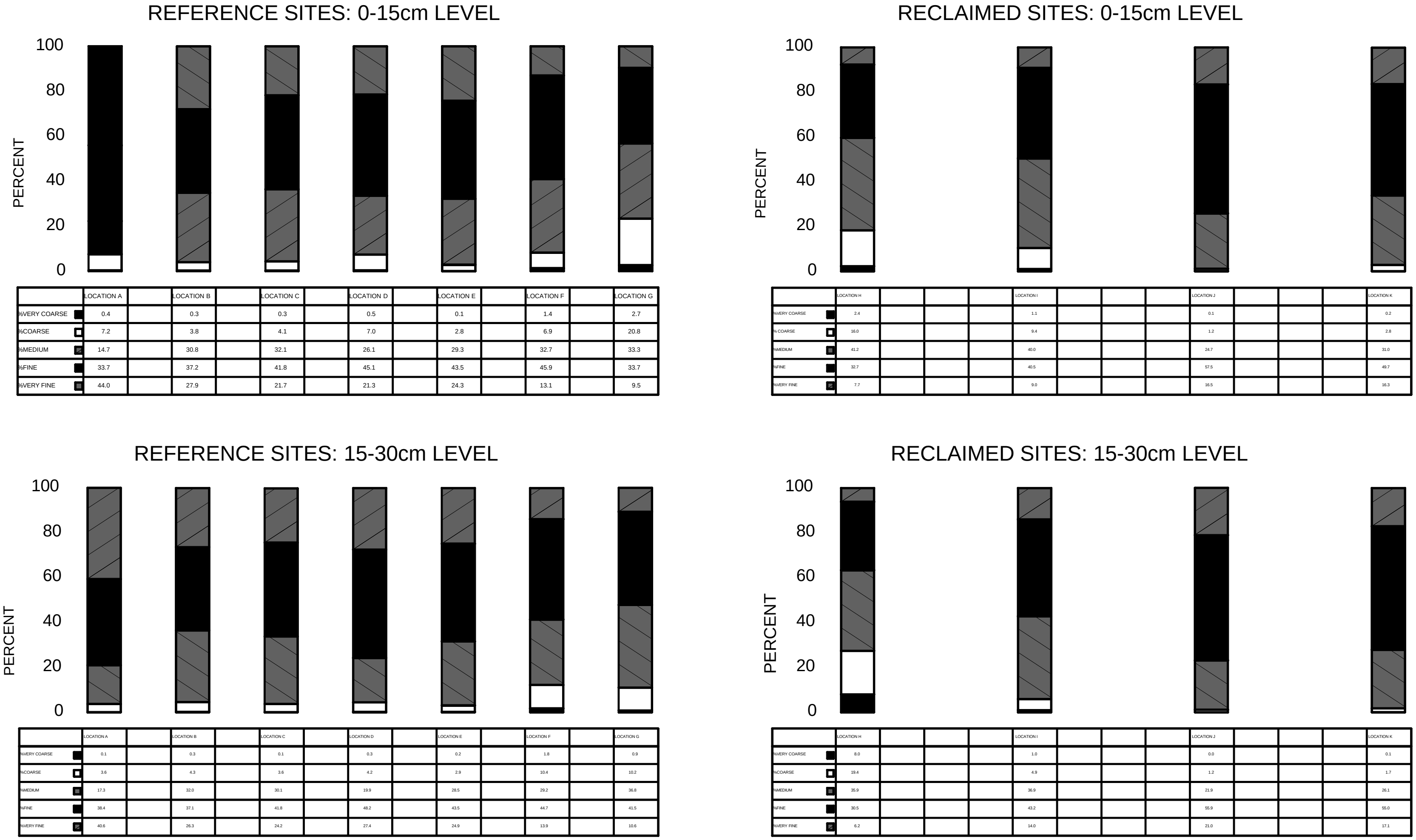
Open spaces indicate data were unavailable. Soil treatments are: OB = overburden, ST = sand tailings. Vegetation treatments are undocumented.

An analysis of sand particle size distribution is presented in Figure 3. We were unable to detect any differences among the seven locations of reference sites in either the 0-15 cm or 15-30 cm horizon. Reclaimed sites tended to have higher percentages of fine sand than did reference sites, whereas reference sites had higher percentages of very fine sand, in both of the sampled horizons.

An analysis of soil chemistry is presented in Figure 4. [Note that the data for electrical conductivity are not presented in the figure, because they were always either 0.0 or 0.1 mmho/cm. Note also that data on soil chemistry often were highly-variable, so the power of the statistical analysis is not great.] Three soil chemistry variables, pH, phosphorus levels, and potassium levels, varied substantially among the locations of reference sites. Sites at Flatwoods, Green Swamp, and Horse Creek tended to have higher pH than sites at the other locations in either the 0-15 cm or 15-30 cm horizon. Levels of potassium tended to be higher for sites at Horse Creek and Myakka, in the 0-15 cm horizon, and for sites at Horse Creek, Myakka, and Shirttail, in the 15-30 cm horizon. Levels of phosphorus tended to be higher for sites at Fishhawk, Flatwoods, and Shirttail, but only in the 15-30 cm horizon. Reference and reclaimed soils were very different in their chemistries, with the exception of potassium and nitrogen contents. Reference soils tended to have higher organic matter (0-15 cm horizon only), lower pH, and lower phosphorus content (0-15 cm and 15-30 cm horizons) than reclaimed locations.

VEGETATION

An analysis of life-form coverage (percentage of woody vegetation, wiregrass, etc.) is presented in Figure 5. As one might expect from inspection of the figure, the percentages of the vegetation in the various categories of life form coverage differed among the seven locations of the reference sites (Kolmogorov-Smirnov Two-sample Test, $p < 0.10$). [Note that in all subsequent analyses in this section, trends will be identified at a p-value of 0.10, and that the analyses themselves are M-W U-tests, unless otherwise specified.] The differences largely reflect a tendency for sites at four locations, Duette, Flatwoods, Fishhawk, Shirttail, to have larger percentages of woody ground cover than sites at the other locations; and for sites at three locations, Flatwoods, Green Swamp, Horse Creek, to have larger percentages of grassy ground cover than sites at the other locations. Reclaimed sites also were much different than reference sites, tending to have smaller percentages of woody ground cover and wiregrass and larger percentages of other grasses. We computed evenness of the distribution of life-form coverage for each reference and reclaimed site. It was computed as the maximum difference (max-D value) derived from comparing the percentage of the total ground cover in each life-form category with a uniform distribution, using the Kolmogorov-Smirnov One-sample Test. Evenness was lower for reclaimed sites than for reference sites, indicating that reclaimed sites tended more strongly than reference sites to be dominated by a few life-form categories.



REFERENCE SITES: 0-15cm LEVEL

	LOCATION A		LOCATION B		LOCATION C		LOCATION D		LOCATION E		LOCATION F		LOCATION G
%VERY COARSE ■	0.4		0.3		0.3		0.5		0.1		1.4		2.7
%COARSE □	7.2		3.8		4.1		7.0		2.8		6.9		20.8
%MEDIUM ▨	14.7		30.8		32.1		26.1		29.3		32.7		33.3
%FINE ■	33.7		37.2		41.8		45.1		43.5		45.9		33.7
%VERY FINE ▨	44.0		27.9		21.7		21.3		24.3		13.1		9.5

RECLAIMED SITES: 0-15cm LEVEL

	LOCATION H				LOCATION I				LOCATION J				LOCATION K
%VERY COARSE ■	2.4				1.1				0.1				0.2
% COARSE □	16.0				9.4				1.2				2.8
%MEDIUM ▨	41.2				40.0				24.7				31.0
%FINE ■	32.7				40.5				57.5				49.7
%VERY FINE ▨	7.7				9.0				16.5				16.3

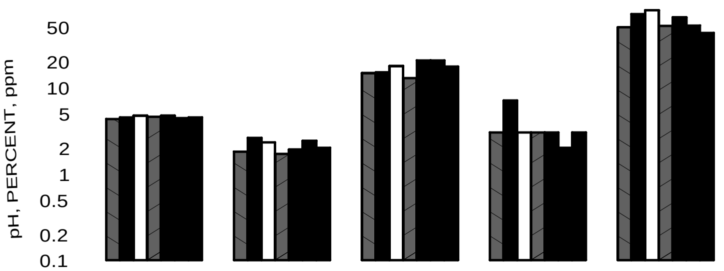
REFERENCE SITES: 15-30cm LEVEL

	LOCATION A		LOCATION B		LOCATION C		LOCATION D		LOCATION E		LOCATION F		LOCATION G
%VERY COARSE ■	0.1		0.3		0.1		0.3		0.2		1.8		0.9
%COARSE □	3.6		4.3		3.6		4.2		2.9		10.4		10.2
%MEDIUM ▨	17.3		32.0		30.1		19.9		28.5		29.2		36.8
%FINE ■	38.4		37.1		41.8		48.2		43.5		44.7		41.5
%VERY FINE ▨	40.6		26.3		24.2		27.4		24.9		13.9		10.6

RECLAIMED SITES: 15-30cm LEVEL

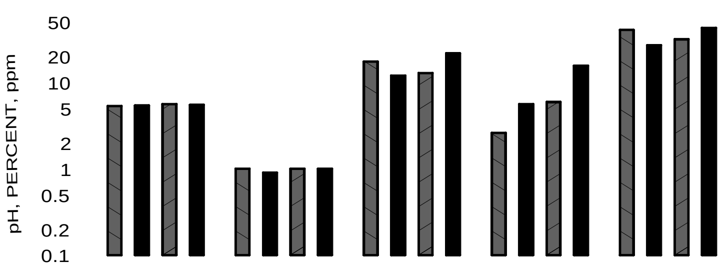
	LOCATION H				LOCATION I				LOCATION J				LOCATION K
%VERY COARSE ■	8.0				1.0				0.0				0.1
%COARSE □	19.4				4.9				1.2				1.7
%MEDIUM ▨	35.9				36.9				21.9				26.1
%FINE ■	30.5				43.2				55.9				55.0
%VERY FINE ▨	6.2				14.0				21.0				17.1

Figure 3. Sand Particle Size. Means Are Displayed for the 0-15 cm Level (Upper Left) and 15-30 cm Level (Lower Left) at Reference Sites, and for the 0-15 cm Level (Upper Right) and 15-30 cm Level (Lower Right) at Reclaimed Sites.



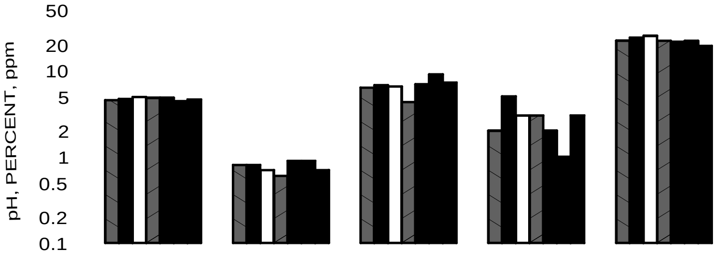
REFERENCE SITES: 0-15cm LEVEL

		pH	%ORGANICS	ppmK	ppmP	ppmN (X 10)
LOCATION A	▧	4.3	1.8	14.6	3.0	49.5
LOCATION B	■	4.5	2.6	14.9	7.0	70.2
LOCATION C	□	4.7	2.3	17.7	3.0	78.0
LOCATION D	▨	4.6	1.7	12.9	3.0	51.6
LOCATION E	■	4.7	1.9	20.5	3.0	64.3
LOCATION F	■	4.4	2.4	20.5	2.0	52.0
LOCATION G	■	4.5	2.0	17.4	3.0	42.6



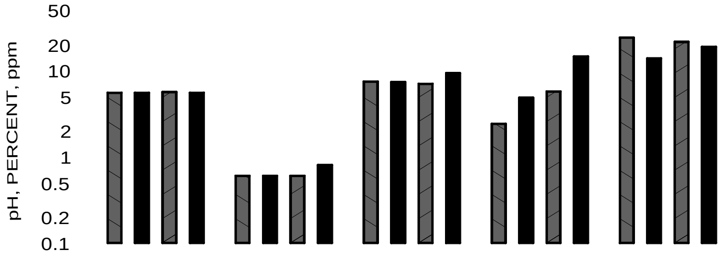
RECLAIMED SITES: 0-15cm LEVEL

		pH	%ORGANICS	ppmK	ppmP (X100)	ppmN (X10)
LOCATION H	▧	5.3	1.0	17.4	2.6	40.4
	□					
LOCATION I	■	5.4	0.9	12.0	5.6	26.9
	□					
LOCATION J	▨	5.6	1.0	12.8	5.9	31.3
	□					
LOCATION K	■	5.5	1.0	21.7	15.6	42.9



REFERENCE SITES: 15-30cm LEVEL

		pH	%ORGANICS	ppmK	ppmP	ppmN (X10)
LOCATION A	▧	4.5	0.8	6.3	2.0	22.1
LOCATION B	■	4.7	0.8	6.7	5.0	23.9
LOCATION C	□	4.9	0.7	6.5	3.0	25.1
LOCATION D	▨	4.8	0.6	4.3	3.0	21.9
LOCATION E	■	4.8	0.9	6.9	2.0	21.5
LOCATION F	■	4.4	0.9	9.0	1.0	21.9
LOCATION G	■	4.6	0.7	7.2	3.0	19.1



RECLAIMED SITES: 15-30cm LEVEL

		pH	%ORGANICS	ppmK	ppmP (X100)	ppmN (X10)
LOCATION H	▧	5.5	0.6	7.4	2.4	23.9
	□					
LOCATION I	■	5.5	0.6	7.3	4.8	13.7
	□					
LOCATION J	▨	5.6	0.6	7.0	5.7	21.4
	□					
LOCATION K	■	5.5	0.8	9.3	14.5	18.7

Figure 4. Soil Chemistry. Means Are Displayed for the 0-15 cm Level (Upper Left) and 15-30 cm Level (Lower Left) at Reference Sites, and for the 0-15 cm Level (Upper Right) and 15-30 cm Level (Lower Right) at Reclaimed Sites. Scaling Was Used Simply to Facilitate Visual Presentation.

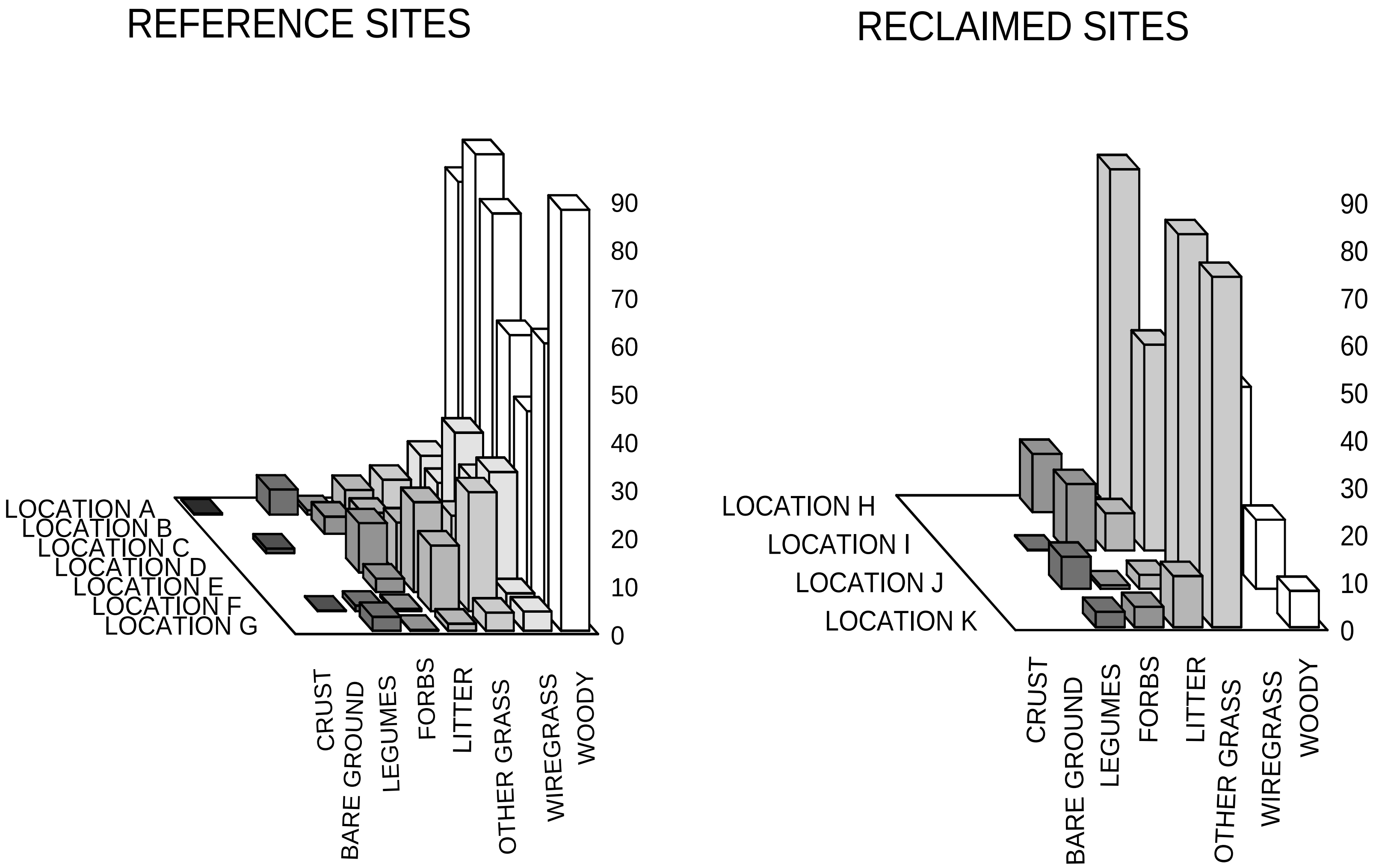


Figure 5. Percent Coverage of Life-Form Categories. Means Are Displayed for Reference Sites (Left) and Reclaimed Sites (Right).

An analysis of foliage layers (Ground, Gap1, Shrub, Gap2, etc.) is presented in Figure 6. Sites within the seven locations have been subdivided into those with an Upper-Canopy layer (18 sites) and those without an Upper-Canopy layer (12 sites). When it was present, the Upper-Canopy layer tended to be larger for sites at certain locations, particularly Shirttail. The Middle-Canopy layer was absent for sites at all locations, except Duette and Green Swamp. The Lower-Canopy layer tended to be larger for sites at Duette, Flatwoods, and Green Swamp than for sites at the other locations. We were unable to detect any substantial effect of whether or not an Upper-Canopy layer was present on the size of the Lower-Canopy layer. Reclaimed sites with an Upper-Canopy layer (8 sites) were much shorter in stature, overall, than reference sites with an Upper-Canopy layer. All reclaimed sites lacked a Middle-Canopy layer. We computed evenness of the distribution of foliage among layers for each study site. It was computed as the maximum difference (max-D value) derived from comparing the percentage of the total canopy height in each layer with a uniform distribution, using the Kolmogorov-Smirnov One-sample Test. Evenness was lower for reclaimed sites than for reference sites, indicating that reclaimed sites tended more strongly than reference sites to be dominated by a few foliage layers. Evenness of foliage distribution among layers is known to influence bird species richness (e.g., MacArthur and MacArthur 1961). Analyses of horizontal (using a densitometer) and vertical (using a white board) canopy closure are presented in Figure 7. Although horizontal closure was highly variable among sites, we were unable to detect any substantial difference among the seven locations of reference sites. We also were unable to detect any substantial difference in vertical closure among locations, at heights above 2m, but the small number of sites with canopy layers at those heights reduced the power of our tests to detect differences. Below 2m, vertical canopy closure was greater for sites at certain locations, particularly Duette. Reclaimed sites were very different than reference sites in both kinds of canopy closure, tending to have greater horizontal closure at 1m and greater vertical closure above 2m. We were unable to detect any substantial difference between reclaimed and reference sites in vertical canopy below 2m, but finer-scale examination revealed that reference sites tended to have greater vertical closure nearer the ground, below 1m.

An analysis of the density of trees, saw palmetto, shrubs, and snags by height class is presented in Figures 8A through 8G. We could detect no substantial difference in the densities either individually or collectively, for trees, saw palmetto, shrubs, or snags with a single exception. Although we could detect no substantial difference in the density of saw palmetto at any particular height, we could show a difference for all heights combined. This “total density” of saw palmetto tended to be greater for sites at Fishhawk, Flatwoods, and Horse Creek than for sites at other locations. We could detect no difference in density of *Pinus* spp. of any height class between reclaimed and reference sites, when only sites at which *Pinus* spp. actually occurred were included in the analysis. Density of *Quercus* spp. tended to be greater at reclaimed sites, for those height classes that actually were represented. The general rarity of shrubs and snags at reclaimed sites makes comparisons of their densities between reclaimed and reference sites pointless.

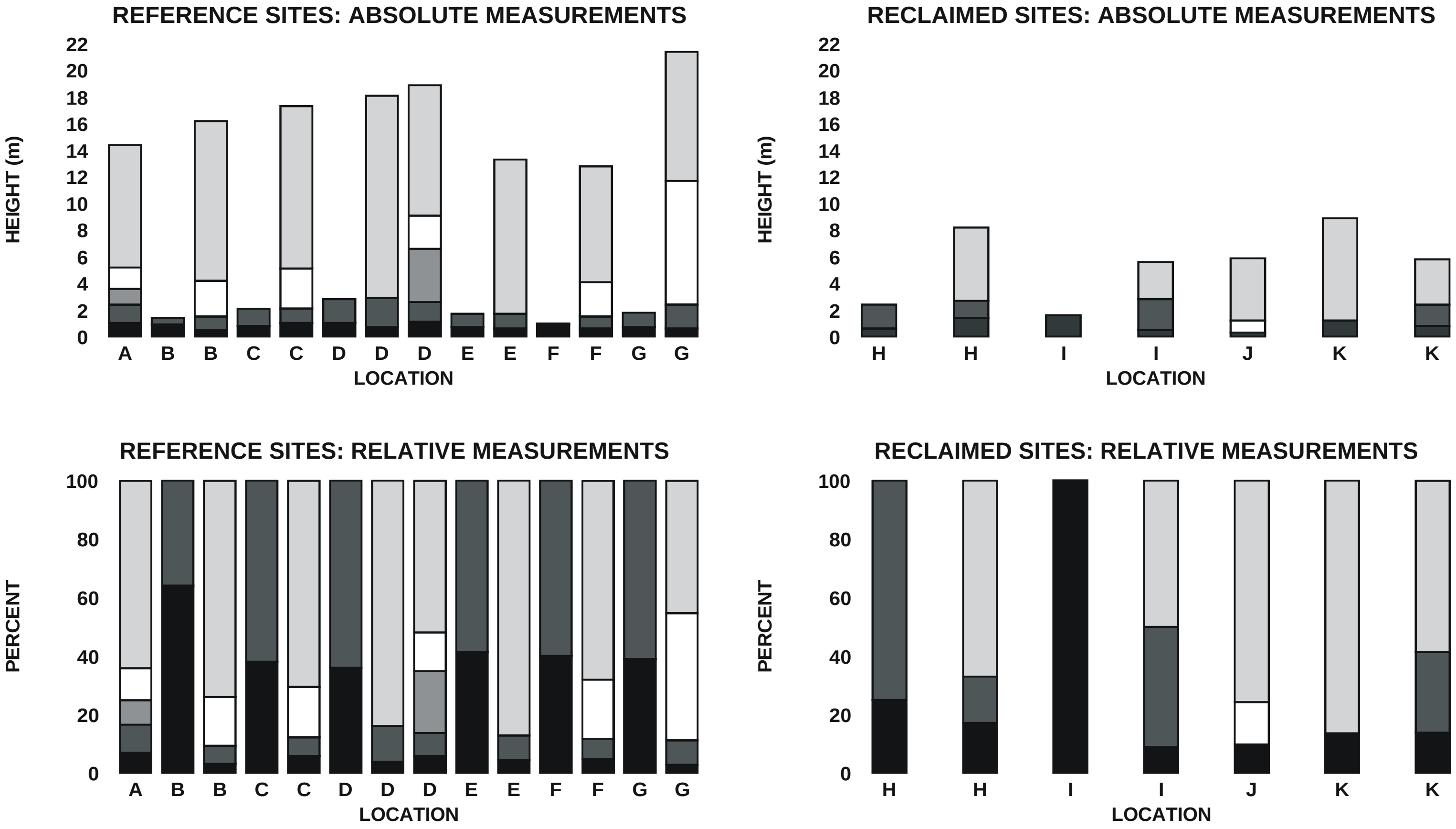


Figure 6. Foliage Layers. Means Are Displayed for Absolute (Upper Left) and Relative (Lower Left) Measurements at Reference Sites, and for Absolute (Upper Right) and Relative (Lower Right) Measurements at Reclaimed Sites. The Four Layers (Ground, Shrub, Middle-Canopy, Upper-Canopy) Are the Bands of Decreasing Intensity, from Bottom to Top, and the Intervening Gaps (Gap1, Gap2, Gap3) Are the White Bands, from Bottom to Top.

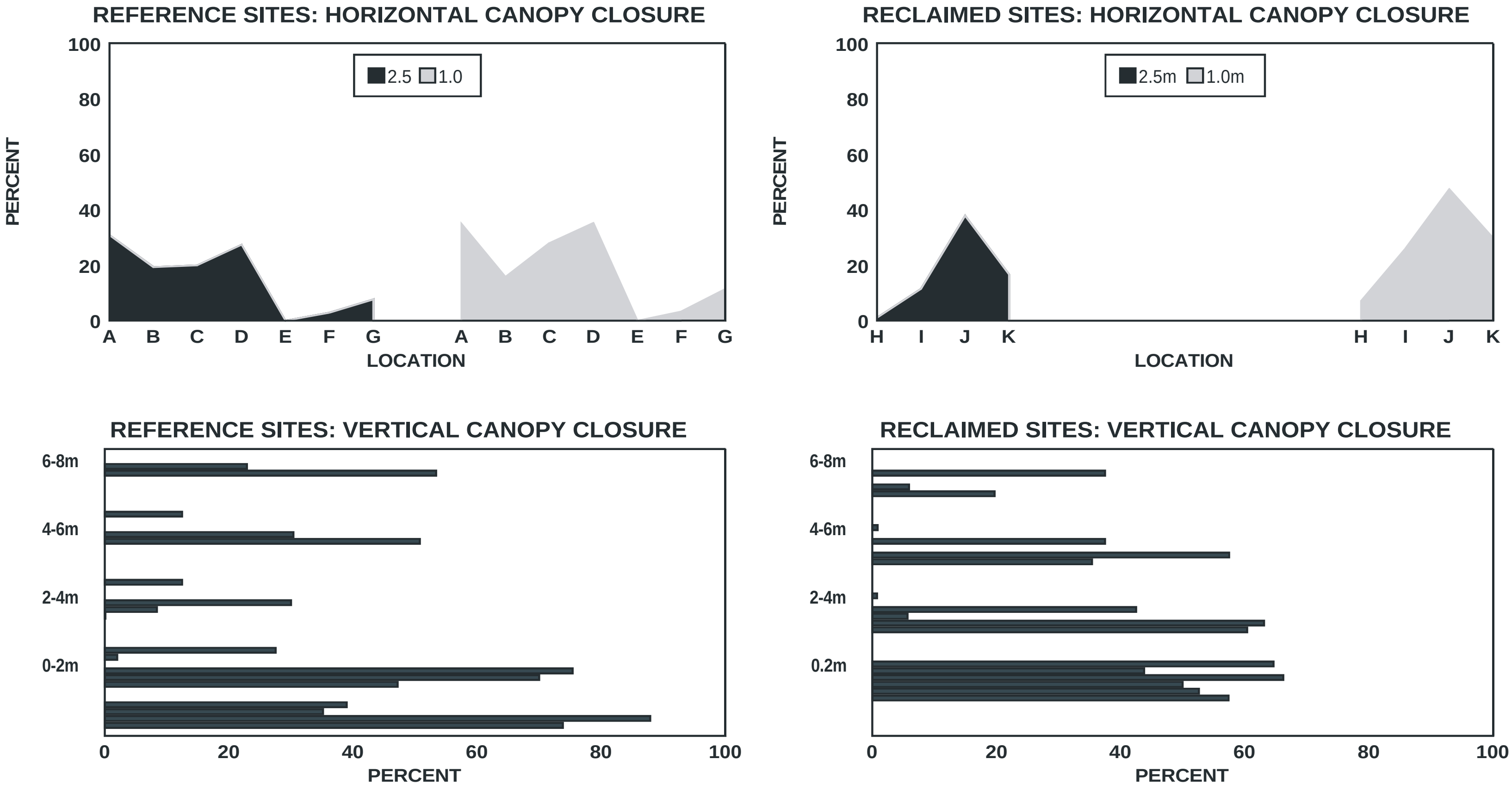
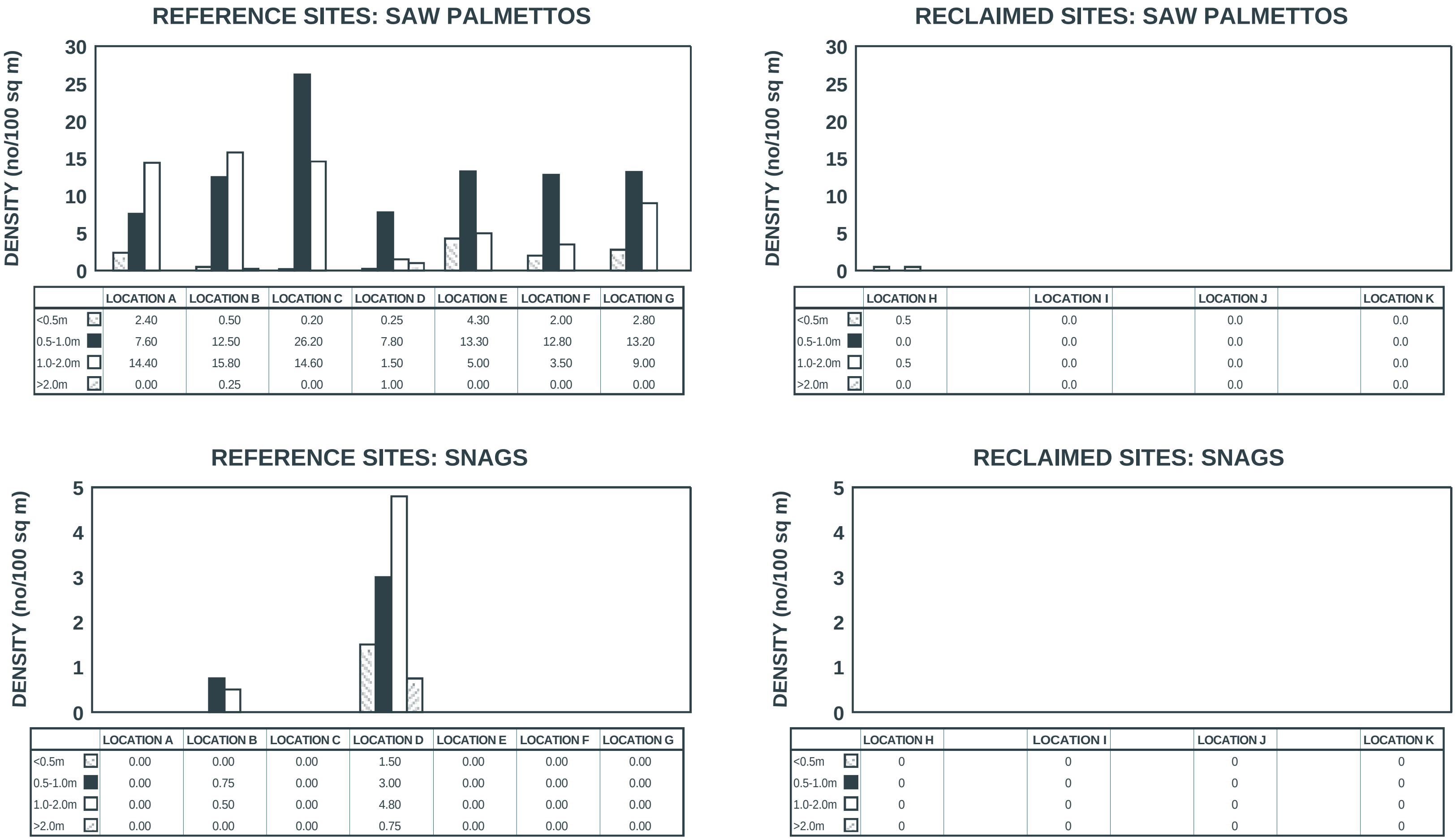


Figure 7. Canopy Closure. Means Are Displayed for Horizontal (Upper Left) and Vertical (Lower Left) Measurements at Reference Sites, and for Horizontal (Upper Right) and Vertical (Lower Right) Measurements at Reclaimed Sites.



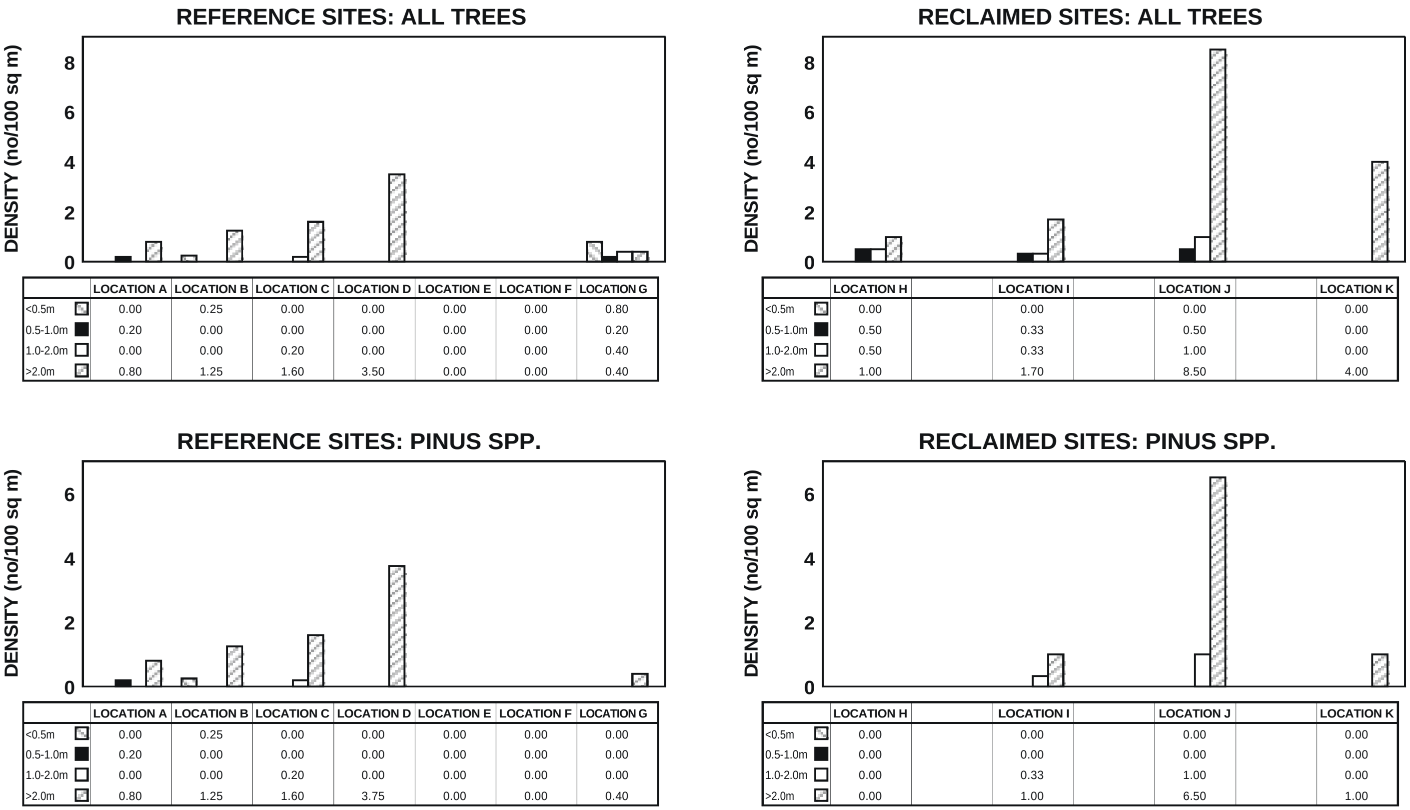
		LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m	▨	2.40	0.50	0.20	0.25	4.30	2.00	2.80
0.5-1.0m	■	7.60	12.50	26.20	7.80	13.30	12.80	13.20
1.0-2.0m	□	14.40	15.80	14.60	1.50	5.00	3.50	9.00
>2.0m	▨	0.00	0.25	0.00	1.00	0.00	0.00	0.00

		LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m	▨	0.5		0.0		0.0		0.0
0.5-1.0m	■	0.0		0.0		0.0		0.0
1.0-2.0m	□	0.5		0.0		0.0		0.0
>2.0m	▨	0.0		0.0		0.0		0.0

		LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m	▨	0.00	0.00	0.00	1.50	0.00	0.00	0.00
0.5-1.0m	■	0.00	0.75	0.00	3.00	0.00	0.00	0.00
1.0-2.0m	□	0.00	0.50	0.00	4.80	0.00	0.00	0.00
>2.0m	▨	0.00	0.00	0.00	0.75	0.00	0.00	0.00

		LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m	▨	0		0		0		0
0.5-1.0m	■	0		0		0		0
1.0-2.0m	□	0		0		0		0
>2.0m	▨	0		0		0		0

Figure 8A. Density of Saw Palmettos (Upper) and Snags (Lower) of Different Height Classes. (Means Are Displayed for Reference Sites [Left] and Reclaimed Sites [Right].)



REFERENCE SITES: ALL TREES

		LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m	▨	0.00	0.25	0.00	0.00	0.00	0.00	0.80
0.5-1.0m	■	0.20	0.00	0.00	0.00	0.00	0.00	0.20
1.0-2.0m	□	0.00	0.00	0.20	0.00	0.00	0.00	0.40
>2.0m	▨	0.80	1.25	1.60	3.50	0.00	0.00	0.40

RECLAIMED SITES: ALL TREES

		LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m	▨	0.00		0.00		0.00		0.00
0.5-1.0m	■	0.50		0.33		0.50		0.00
1.0-2.0m	□	0.50		0.33		1.00		0.00
>2.0m	▨	1.00		1.70		8.50		4.00

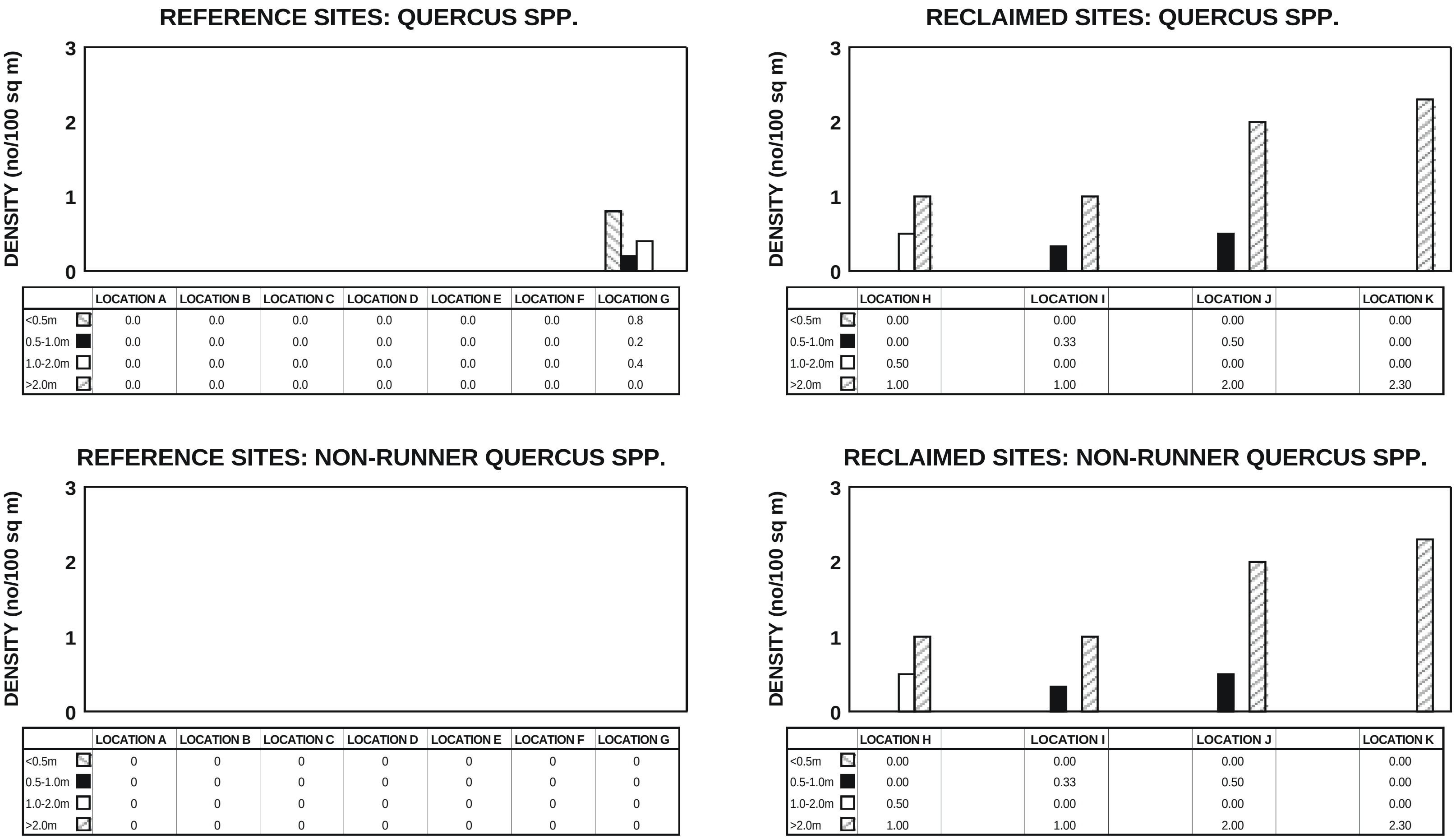
REFERENCE SITES: PINUS SPP.

		LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m	▨	0.00	0.25	0.00	0.00	0.00	0.00	0.00
0.5-1.0m	■	0.20	0.00	0.00	0.00	0.00	0.00	0.00
1.0-2.0m	□	0.00	0.00	0.20	0.00	0.00	0.00	0.00
>2.0m	▨	0.80	1.25	1.60	3.75	0.00	0.00	0.40

RECLAIMED SITES: PINUS SPP.

		LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m	▨	0.00		0.00		0.00		0.00
0.5-1.0m	■	0.00		0.00		0.00		0.00
1.0-2.0m	□	0.00		0.33		1.00		0.00
>2.0m	▨	0.00		1.00		6.50		1.00

Figure 8B. Density of All Trees (Upper) and *Pinus* Spp. (Lower) of Different Height Classes. Means Are Displayed for Reference Sites (Left) and Reclaimed Sites (Right).



REFERENCE SITES: QUERCUS SPP.

		LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m	▨	0.0	0.0	0.0	0.0	0.0	0.0	0.8
0.5-1.0m	■	0.0	0.0	0.0	0.0	0.0	0.0	0.2
1.0-2.0m	□	0.0	0.0	0.0	0.0	0.0	0.0	0.4
>2.0m	▨	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RECLAIMED SITES: QUERCUS SPP.

		LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m	▨	0.00		0.00		0.00		0.00
0.5-1.0m	■	0.00		0.33		0.50		0.00
1.0-2.0m	□	0.50		0.00		0.00		0.00
>2.0m	▨	1.00		1.00		2.00		2.30

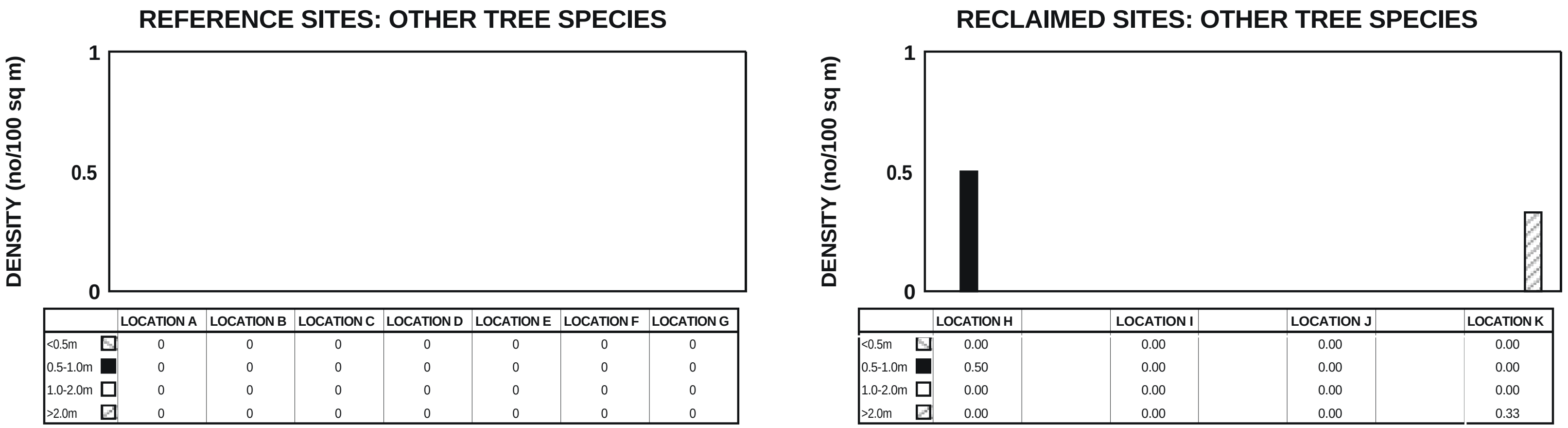
REFERENCE SITES: NON-RUNNER QUERCUS SPP.

		LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m	▨	0	0	0	0	0	0	0
0.5-1.0m	■	0	0	0	0	0	0	0
1.0-2.0m	□	0	0	0	0	0	0	0
>2.0m	▨	0	0	0	0	0	0	0

RECLAIMED SITES: NON-RUNNER QUERCUS SPP.

		LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m	▨	0.00		0.00		0.00		0.00
0.5-1.0m	■	0.00		0.33		0.50		0.00
1.0-2.0m	□	0.50		0.00		0.00		0.00
>2.0m	▨	1.00		1.00		2.00		2.30

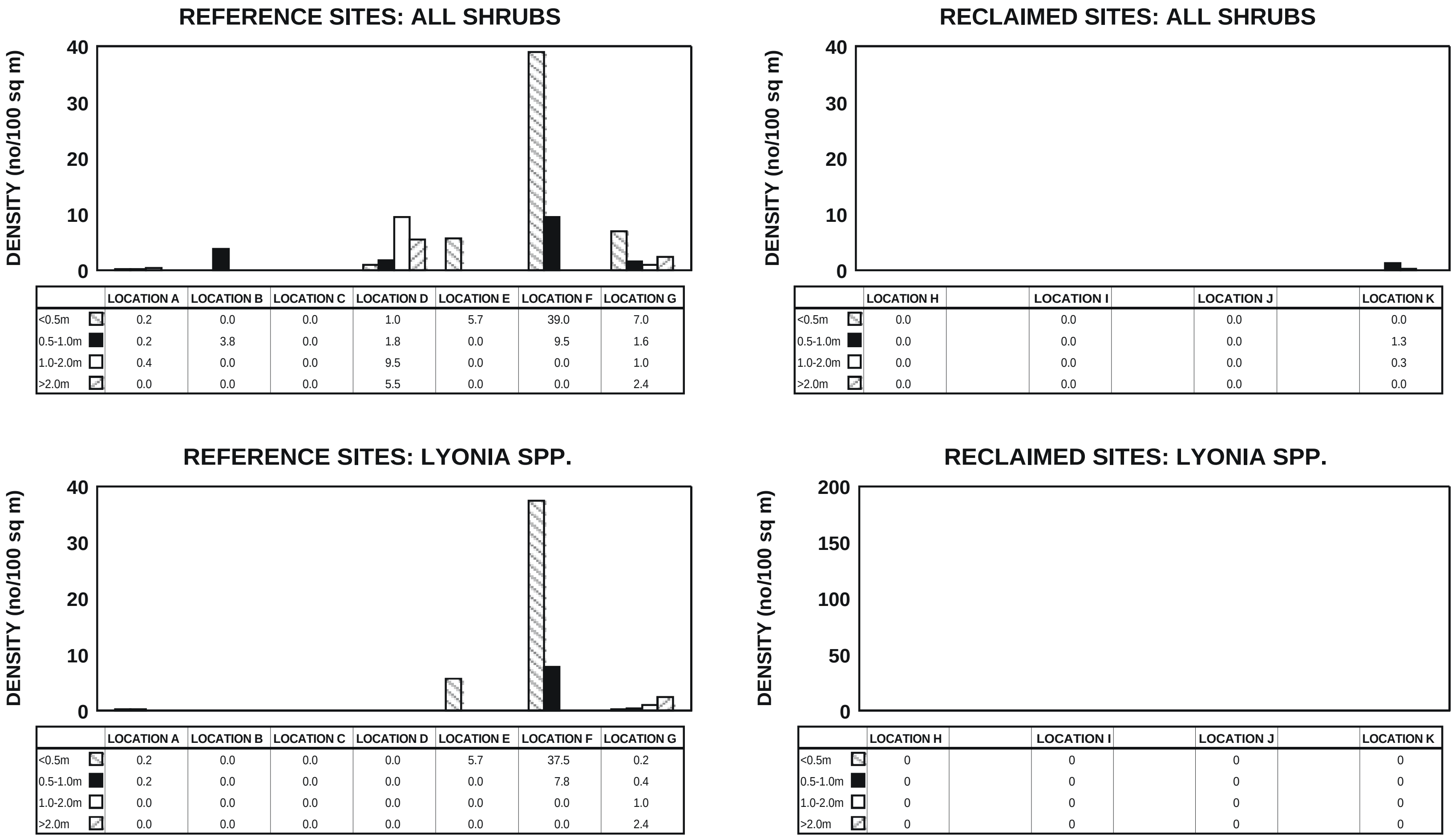
Figure 8C. Density of *Quercus* Spp. (Upper) and Non-Runner *Quercus* Spp. (Lower) of Different Height Classes. Means Are Displayed for Reference Sites (Left) and Reclaimed Sites (Right). Note That Runner *Quercus* Spp. Were Not Found at Reclaimed Sites.



	LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m ▧	0	0	0	0	0	0	0
0.5-1.0m ■	0	0	0	0	0	0	0
1.0-2.0m □	0	0	0	0	0	0	0
>2.0m ▨	0	0	0	0	0	0	0

	LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m ▧	0.00		0.00		0.00		0.00
0.5-1.0m ■	0.50		0.00		0.00		0.00
1.0-2.0m □	0.00		0.00		0.00		0.00
>2.0m ▨	0.00		0.00		0.00		0.33

Figure 8D. Density of Other Tree Species of Different Height Classes. Means Are Displayed for Reference Sites (Left) and Reclaimed Sites (Right).



REFERENCE SITES: ALL SHRUBS

	LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m ▧	0.2	0.0	0.0	1.0	5.7	39.0	7.0
0.5-1.0m ■	0.2	3.8	0.0	1.8	0.0	9.5	1.6
1.0-2.0m □	0.4	0.0	0.0	9.5	0.0	0.0	1.0
>2.0m ▨	0.0	0.0	0.0	5.5	0.0	0.0	2.4

RECLAIMED SITES: ALL SHRUBS

	LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m ▧	0.0		0.0		0.0		0.0
0.5-1.0m ■	0.0		0.0		0.0		1.3
1.0-2.0m □	0.0		0.0		0.0		0.3
>2.0m ▨	0.0		0.0		0.0		0.0

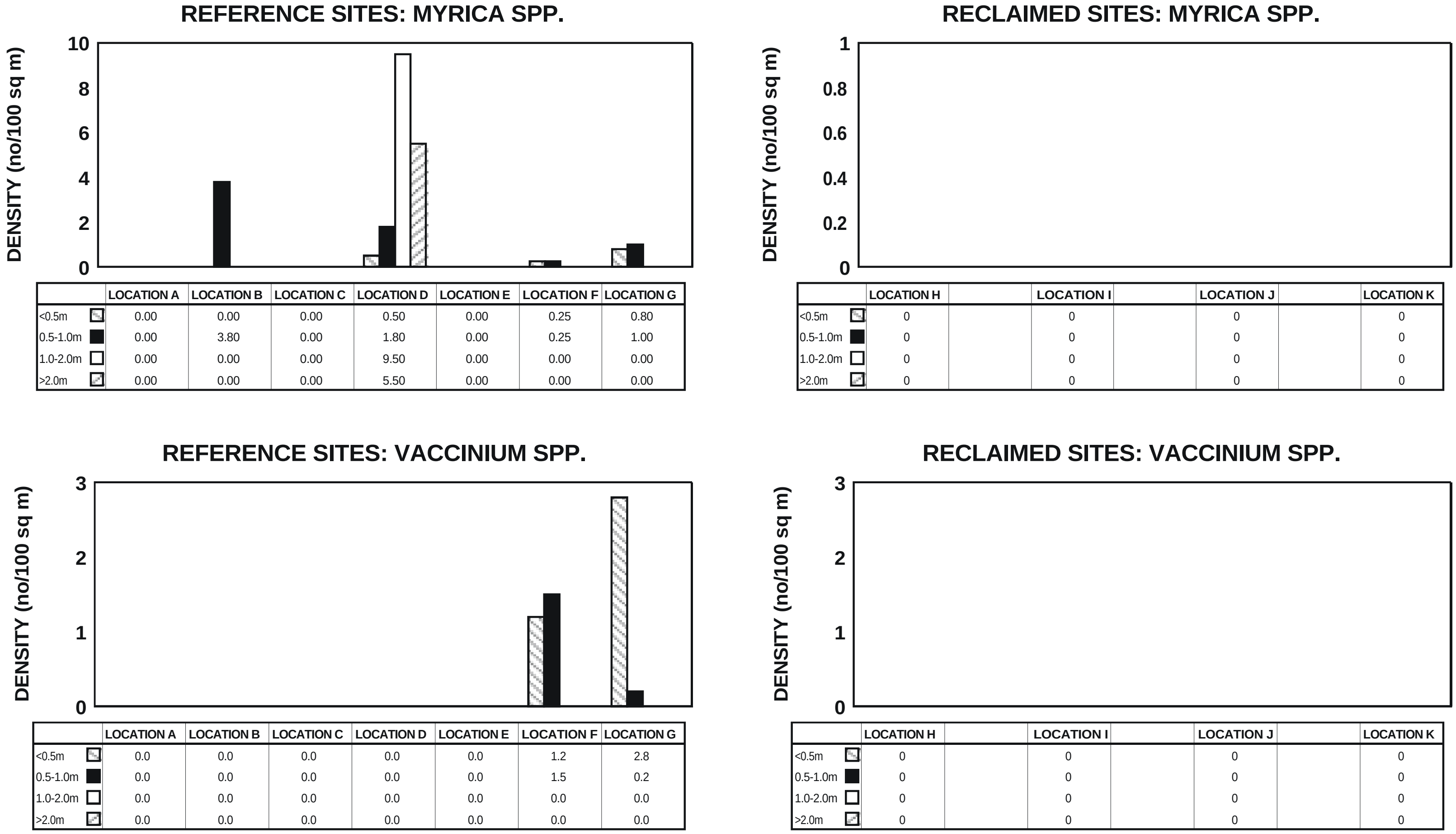
REFERENCE SITES: LYONIA SPP.

	LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m ▧	0.2	0.0	0.0	0.0	5.7	37.5	0.2
0.5-1.0m ■	0.2	0.0	0.0	0.0	0.0	7.8	0.4
1.0-2.0m □	0.0	0.0	0.0	0.0	0.0	0.0	1.0
>2.0m ▨	0.0	0.0	0.0	0.0	0.0	0.0	2.4

RECLAIMED SITES: LYONIA SPP.

	LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m ▧	0		0		0		0
0.5-1.0m ■	0		0		0		0
1.0-2.0m □	0		0		0		0
>2.0m ▨	0		0		0		0

Figure 8E. Density of All Shrubs (Upper) and *Lyonia* Spp. (Lower) of Different Height Classes. Means Are Displayed for Reference Sites (Left) and Reclaimed Sites (Right).



REFERENCE SITES: MYRICA SPP.

RECLAIMED SITES: MYRICA SPP.

REFERENCE SITES: VACCINIUM SPP.

RECLAIMED SITES: VACCINIUM SPP.

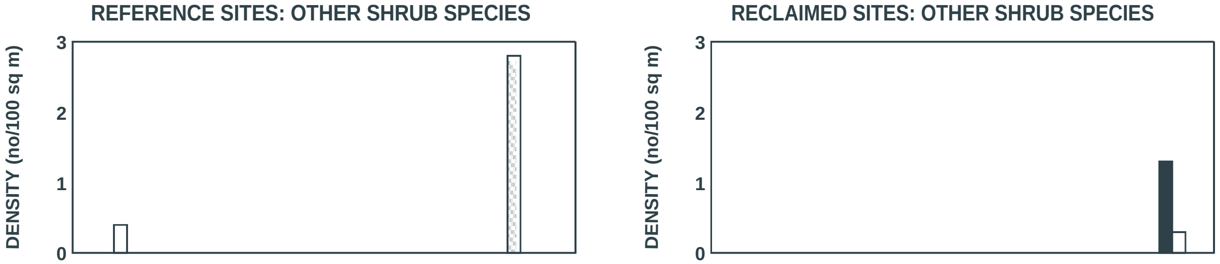
	LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m ▧	0.00	0.00	0.00	0.50	0.00	0.25	0.80
0.5-1.0m ■	0.00	3.80	0.00	1.80	0.00	0.25	1.00
1.0-2.0m □	0.00	0.00	0.00	9.50	0.00	0.00	0.00
>2.0m ▨	0.00	0.00	0.00	5.50	0.00	0.00	0.00

	LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m ▧	0		0		0		0
0.5-1.0m ■	0		0		0		0
1.0-2.0m □	0		0		0		0
>2.0m ▨	0		0		0		0

	LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m ▧	0.0	0.0	0.0	0.0	0.0	1.2	2.8
0.5-1.0m ■	0.0	0.0	0.0	0.0	0.0	1.5	0.2
1.0-2.0m □	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>2.0m ▨	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m ▧	0		0		0		0
0.5-1.0m ■	0		0		0		0
1.0-2.0m □	0		0		0		0
>2.0m ▨	0		0		0		0

Figure 8F. Density of *Myrica* Spp. (Upper) and *Vaccinium* Spp. (Lower) of Different Height Classes. Means Are Displayed for Reference Sites (Left) and Reclaimed Sites (Right).



	LOCATION A	LOCATION B	LOCATION C	LOCATION D	LOCATION E	LOCATION F	LOCATION G
<0.5m ▨	0.0	0.0	0.0	0.0	0.0	0.0	2.8
0.5-1.0m ■	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0-2.0m □	0.4	0.0	0.0	0.0	0.0	0.0	0.0
>2.0m ▨	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	LOCATION H		LOCATION I		LOCATION J		LOCATION K
<0.5m ▨	0.0		0.0		0.0		0.0
0.5-1.0m ■	0.0		0.0		0.0		1.3
1.0-2.0m □	0.0		0.0		0.0		0.3
>2.0m ▨	0.0		0.0		0.0		0.0

Figure 8G. Density of Other Shrub Species of Different Height Classes. (Means Are Displayed for Reference Sites (Left) and Reclaimed Sites (Right).

INTERCORRELATIONS AMONG VARIABLES AND DATA REDUCTION

We examined the size, isolation, and grazing data for independence (G-test, $p < 0.10$), so that two or more physical variables that essentially measured the same thing were not included in subsequent analyses. All locations, because of the nature of the habitat, were near seasonal water. Most locations also were large (five of seven reference locations, three of four reclaimed locations), far from permanent water (seven of seven reference locations, two of four reclaimed locations), near other upland (seven of seven reference locations, one of four reclaimed locations), and ungrazed (six of seven reference locations, three of four reclaimed locations). The make-up of the data thus meant that the physical variables could not be shown to be correlated.

We also examined the vegetation data for intercorrelations (Spearman's Rank Correlation Coefficient, $p < 0.10$), so that two or more vegetation variables that essentially measured the same thing were not included in subsequent analyses. First, we looked for correlations among categories within each kind of vegetation data -- life-form coverage, foliage layers, horizontal and vertical canopy closure, density by height class -- and then for correlations among the kinds of vegetation data. At each stage, the intercorrelations were used, in conjunction with the vegetation data themselves (Figures 5-8), to reduce the number of variables to be employed in subsequent explanations for vertebrate distributions and abundances.

Eight categories were identified for the first kind of vegetation data, life-form coverage (Figure 5). The intercorrelations among these categories, for reference and for reclaimed sites, are presented in Table 4. For reference sites, woody vegetation and wiregrass generally account for about 78% of coverage (Figure 5). Woody vegetation is negatively correlated, and wiregrass positively correlated, with the other life-form categories, with two interesting exceptions. The correlations are reversed for bare ground, and both woody vegetation and wiregrass are negatively correlated with other grasses. Woody vegetation and wiregrass are themselves negatively correlated. These results indicate the following.

The ground cover of reference sites tends to be comprised largely of woody vegetation and wiregrass.

- At reference sites, where woody vegetation occurs, other life-form categories tend not to occur. Bare ground was the only exception.
- At reference sites, where wiregrass occurs, other life-form categories also tend to occur. Bare ground was the only exception.
- At reference sites, where neither woody vegetation nor wiregrass is common, the ground cover can be comprised of substantial amounts of other grasses.

For reclaimed sites, woody vegetation and grasses other than wiregrass generally account for about 83% of coverage (Figure 5). Woody vegetation, with one exception, is positively correlated, and other grasses negatively correlated, with the other life-form categories. Woody vegetation and other grasses are themselves negatively correlated. These results indicate the following.

Table 4. Intercorrelations (Spearman's Rank Correlation Coefficient) of Vegetation Variables Measuring Life-Form Coverage (See Text).

<table>
<tr><td colspan="8">Reference Sites</td></tr>
<tr><td></td><td>CR</td><td>LR</td><td>WG</td><td>OG</td><td>LG</td><td>FB</td><td>BG</td></tr>
<tr><td>WD</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>+*</td></tr>
<tr><td>CR</td><td></td><td>+</td><td>+*</td><td>-</td><td>-</td><td>+</td><td>-*</td></tr>
<tr><td>LR</td><td></td><td></td><td>+</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>WG</td><td></td><td></td><td></td><td>-*</td><td>+</td><td>+</td><td>-*</td></tr>
<tr><td>OG</td><td></td><td></td><td></td><td></td><td>-</td><td>+</td><td>-</td></tr>
<tr><td>LG</td><td></td><td></td><td></td><td></td><td></td><td>-</td><td>-</td></tr>
<tr><td>FB</td><td></td><td></td><td></td><td></td><td></td><td></td><td>-</td></tr>
<tr><td colspan="8">Reclaimed Sites</td></tr>
<tr><td></td><td>CR</td><td>LR</td><td>WG</td><td>OG</td><td>LG</td><td>FB</td><td>BG</td></tr>
<tr><td>WD</td><td>+</td><td>-</td><td>+</td><td>-</td><td></td><td></td><td>+*</td></tr>
<tr><td>CR</td><td></td><td>-*</td><td>-*</td><td>-</td><td></td><td></td><td>+*</td></tr>
<tr><td>LR</td><td></td><td></td><td>+*</td><td>-</td><td></td><td></td><td>+</td></tr>
<tr><td>WG</td><td></td><td></td><td></td><td>-*</td><td></td><td></td><td>+</td></tr>
<tr><td>OG</td><td></td><td></td><td></td><td></td><td></td><td></td><td>+*</td></tr>
<tr><td>LG</td><td></td><td></td><td></td><td></td><td></td><td></td><td>-*</td></tr>
<tr><td>FB</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Note: WD = woody, CR = crust, LR = litter, WG = wiregrass, OG = other grasses, LG = legumes, FB = forbs, BG = bare ground. Minuses indicate negative correlations, pluses indicate positive correlations, and asterisks indicate $p < 0.10$.

- The ground cover of reclaimed sites tends to be comprised largely of woody vegetation and grasses other than wiregrass.

- At reclaimed sites, where woody vegetation occurs, other life-form categories also tend to occur, with the exception of litter.

- At reclaimed sites, where other grasses occur, other life-form categories tend not to occur.

Based on all of these results, we reduced the number of categories of life-form coverage from eight to four: wiregrass, other grasses, woody vegetation, and litter.

Seven categories were identified for the second kind of vegetation data, foliage layers (Figure 6). The intercorrelations among these seven categories, for reference and for reclaimed sites with Upper-Canopy, are presented in Table 5. Note (cf. Figure 6) that at reference sites and most reclaimed sites, the Gap1 category was missing, indicating that the ground and shrub layers were contiguous, and that at reclaimed sites and most reference sites, the Gap2 and Middle-Canopy categories were missing, indicating that the intermediate foliage layer was absent. For reference sites, development of a particular layer was positively correlated with development of other layers, with but one exception. For reclaimed sites, development of a Ground layer was positively correlated with development of an Upper-Canopy, but negatively correlated with development of a Shrub layer. For reference and reclaimed sites lacking an Upper-Canopy, development of a Ground layer also was negatively correlated with development of a Shrub layer. These results indicate the following.

- The presence of a well-developed Ground layer tends to be associated with the presence of a well-developed Shrub layer at reference sites that possess an Upper-Canopy, but a well-developed Ground layer tends to be associated with a poorly-developed Shrub layer at reference sites that do not possess an Upper-Canopy and at any of the reclaimed sites.

- The presence of a well-developed Ground layer tends to be associated with the presence of a well-developed Upper-Canopy -- for those sites that possess an Upper-Canopy -- for both reference and reclaimed sites.

Based on these results, we reduced the number of categories of foliage layers from seven to four: Ground layer, Shrub layer, Middle-Canopy, and Upper-Canopy.

The categories identified for the third kind of vegetation data, canopy density, were two for horizontal canopy closure and four for vertical canopy closure (Figure 7). The intercorrelations among these categories, for reference and for reclaimed sites, are presented in Table 6. The two measures of horizontal canopy closure were very strongly positively correlated, for both reference and reclaimed sites. Vertical canopy closure measurements taken at adjacent heights were all positively correlated, although not strongly, for both reference and reclaimed sites. Closure near the ground, at heights of

Table 5. Intercorrelations (Spearman's Rank Correlation Coefficient) of Vegetation Variables Measuring Foliage Layers (See Text).

Reference Sites			
	GAP1SHB	GAP2MID	GAP3UPR
GRD GAP 1	+*	+	+ +
SHB GAP 2		+	+ +*
MID GAP 3			+ -
			+*

Reclaimed Sites			
	GAP1SHB	GAP2MID	GAP3UPR
GRD GAP 1	-		+*
SHB GAP 2			-
MID GAP 3			

Note: GRD= Ground layer, SHB = Shrub layer, MID = Middle-Canopy, UPR = Upper-Canopy. Minuses indicate negative correlations, pluses indicate positive correlations, and asterisks indicate $p < 0.10$.

2m, was not a very good predictor of closure of the canopy, at heights greater than 4m, at reference sites. These results indicate the following:

- The horizontal measurements tend to be similar, regardless of the heights at which they are taken.

- The vertical measurements tend to be similar, when taken either relatively near the ground or relatively far above it.

Based on these results, we reduced the number of categories of horizontal canopy closure from two to one: height of 1m; and the number of categories of vertical canopy closure from four to two: heights of 2m and 4m.

Horizontal canopy closure at 1m and vertical canopy closure at 4m were strongly positively correlated for both reference and reclaimed sites (Table 6) -- that is, both measurements essentially provided the same information -- so we eliminated the measure of horizontal canopy closure entirely. We note for the future, however, that horizontal canopy closure is much easier to measure, and, therefore, perhaps is to be preferred over vertical canopy closure.

Table 6. Intercorrelations (Spearman's Rank Correlation Coefficient) of Vegetation Variables Measuring Canopy Density (See Text.)

<table>
<tr><td colspan="6">Reference Sites</td></tr>
<tr><td></td><td>HC2</td><td>VC1</td><td>VC2</td><td>VC3</td><td>VC4</td></tr>
<tr><td>HC1</td><td>+*</td><td>+</td><td>+*</td><td></td><td></td></tr>
<tr><td>HC2</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>VC1</td><td></td><td></td><td>+</td><td>-*</td><td>-</td></tr>
<tr><td>VC2</td><td></td><td></td><td></td><td>+</td><td>-</td></tr>
<tr><td>VC3</td><td></td><td></td><td></td><td></td><td>+</td></tr>
<tr><td colspan="6">Reclaimed Sites</td></tr>
<tr><td></td><td>HC2</td><td>VC1</td><td>VC2</td><td>VC3</td><td>VC4</td></tr>
<tr><td>HC1</td><td>+*</td><td>+</td><td>+*</td><td></td><td></td></tr>
<tr><td>HC2</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>VC1</td><td></td><td></td><td>+</td><td>+</td><td>+</td></tr>
<tr><td>VC2</td><td></td><td></td><td></td><td>+</td><td>+</td></tr>
<tr><td>VC3</td><td></td><td></td><td></td><td></td><td>+</td></tr>
</table>

Note: HC1 = horizontal closure at 1m, HC2 = horizontal closure at 2.5m, VC1 = vertical closure at 2m, VC2 = vertical closure at 4m, VC3 = vertical closure at 6m, VC4 = vertical closure at 8m. Minuses indicate negative correlations, pluses indicate positive correlations, and asterisks indicate $p < 0.10$.

Many categories were identified for the fourth kind of vegetation data, vegetation density (Figure 8). The intercorrelations among these categories, for reference and for reclaimed sites, are presented in Table 7. Densities of tree species other than *Pinus* spp. and *Quercus* spp., of snags, and of individual shrub taxa were so low and/or the taxa were restricted to so few locations at both reference and reclaimed sites that we did not attempt correlations among height categories for these groups. Likewise, we also did not attempt correlations among densities of height categories of *Quercus* spp. at reference sites, or of densities of height categories of saw palmetto and of all shrub taxa combined at reclaimed sites. Finally, we eliminated consideration of densities of all tree taxa combined, because they almost entirely reflected density of *Pinus* spp. for reference sites and densities of *Pinus* spp. and *Quercus* spp. for reclaimed sites. Densities of saw palmetto at reference sites generally were positively correlated for height categories individually and combined. Densities of *Pinus* spp. at reference sites were less strongly correlated among height classes, and combined densities less strongly correlated with individual height categories. Densities of shorter trees tended to be negatively correlated with densities of taller trees, however. Densities of shorter shrubs at reference sites also tended to be negatively correlated with densities of taller shrubs, but combined densities were positively correlated with height categories, strongly so for shorter shrubs. The pattern for densities of height classes of *Quercus* spp. at reclaimed sites is similar to that of shrubs at reference sites, with the exception that combined densities were more strongly positively correlated with densities of taller trees. These results indicate the following:

Table 7. Intercorrelations (Spearman's Rank Correlation Coefficient) of Vegetation Variables Measuring Vegetation Density (See Text).

Reference Sites											
	SP2	SP3	SP4	PS2	PS3	PS4	PS5	SH2	SH3	SH4	SH5
SP1	+	-*	+								
SP2		-	+*								
SP3			+*								
PS1				-	-	+	+				
PS2					-	+	+				
PS3						-	-				
PS4							+				
SH1								+	-	-	+*
SH2									-	-	+*
SH3										+*	+
SH4											+

Reclaimed Sites			
	QS3	QS4	QS5
QS2	-	-	+
QS3		+	+
QS4			+*

Note: SP1-3 = density of saw palmetto at <0.5m, 0.5-1m, and 1-2m, respectively (no records at >2m), SP4 = total density of all height categories combined, PS1-4 = density of *Pinus* spp. at the same heights, PS5 = total density of all height categories combined, SH1-4 = density of shrubs at the same heights, SH5 = total density of all height categories combined, QS2-4 = density of *Quercus* spp. at the same heights (no records at <0.5m), QS5 = total density of all height categories combined. Minuses indicate negative correlations, pluses indicate positive correlations, and asterisks indicate $p < 0.10$.

The densities of the vegetation at reference and reclaimed sites result from different species, principally saw palmetto, *Pinus* spp., and shrubs at reference sites, and *Quercus* spp. at reclaimed sites.

- For all types of vegetation, with the exception of saw palmetto, densities of shorter shrubs/trees are greater where densities of taller shrubs/trees are less, and vice-versa.

Based on these results, we eliminated height categories of saw palmetto, and used combined density for further analysis. We retained two height categories of *Pinus* spp., shrubs, and *Quercus* spp., 0.5-1m and >2m.

Correlations among the four kinds of vegetation data were performed for reference and for reclaimed sites separately. First, we correlated canopy density with the other three kinds of vegetation data. Vertical canopy closure at 2m is not strongly correlated with any of the measures of vegetation density at either reference or reclaimed sites. Vertical canopy closure at 4m is strongly positively correlated with the density of *Pinus* spp. at reference sites and with the density of *Quercus* spp. at reclaimed sites. Vertical canopy closure at 2m is strongly correlated positively with size of Shrub layer at reference sites.

Vertical canopy closure at 4m is strongly positively correlated with size of Upper-Canopy layer at reference sites, and with size of both Shrub and Upper-Canopy layers at reclaimed sites. Vertical canopy closure at 2m is strongly positively correlated with percent woody ground cover and strongly negatively correlated with percent grassy ground cover at reference sites, but is not strongly correlated with percentages of any of the lifeform categories at reclaimed sites. As one would expect, vertical canopy closure at 4m is not strongly correlated with percentages of any of the lifeform categories at either reference or reclaimed sites. Based on these results, we eliminated the two measures of vertical canopy closure, but retained the remaining life-form categories and measures of foliage layering and vegetation density. Although vertical canopy closure provides a good general assessment of vegetation density, we reasoned that the other kinds of vegetation data provide more useful information for further analysis.

Second, we correlated foliage layers with and the two remaining kinds of vegetation data. Size of the Ground layer is not strongly correlated with any of the measures of vegetation density, at either reference and reclaimed sites. Size of Shrub layer is strongly positively correlated with density of both *Pinus* spp. and tall shrubs, and size of Upper-Canopy layer is strongly positively correlated with density of tall shrubs, at reference sites. Size of Shrub layer is not strongly correlated with any of the measures of vegetation density at reclaimed sites, but the size of the Upper-Canopy layer is strongly negatively correlated with the density of tall pines. Size of both Ground layer and Shrub layer is strongly negatively correlated with the percent grassy ground cover (grasses other than wiregrass, only) at reference sites. Size of shrub layer also is negatively correlated with the percent grassy ground cover at reclaimed sites, but only marginally ($r_s = -0.54$, $p = 0.12$). Size of Ground layer is strongly negatively correlated, and size of Shrub layer is strongly positively correlated, with percent woody ground cover at reclaimed sites, however. Based on these correlations, we retained the four measures of foliage layering, as well as the remaining life-form categories and measures of vegetation density.

Finally, we correlated vegetation density with the single remaining kind of vegetation data. Only densities of *Pinus* spp. are strongly correlated with any of the lifeform categories. Densities of *Pinus* spp., especially tall trees, are strongly correlated with percent wiregrass ground cover at reclaimed sites, and with percent litter ground cover at both reference and reclaimed sites. Based on these results, we decided that it was necessary to retain all remaining life-form categories, with the exception of litter ground cover, and measures of vegetation density.

Interrelationships between physical variables and vegetation variables were determined with Mann-Whitney U-tests ($p < 0.10$). The only potentially meaningful comparisons involved the physical variables size and grazing, because they varied among the reference locations. No interrelationships were found between either size or grazing and the life-form categories or measures of vegetation density. It should be noted that only one reference location (four sites) was grazed and only two locations (seven sites) were These results indicate the following. Our analyses were not specifically designed to detect the effects of grazing, however, and additional research in this area would seem warranted, as our previous study (Mushinsky and McCoy 1996) indicated the potential of grazing to affect wildlife.

VERTEBRATES

Resident Species Captured or Observed

The list of resident species includes 14 amphibians, 34 reptiles, 31 mammals (of which 7 are trappable in our arrays), and 109 birds. We note that the method of identifying resident species that we used provided satisfactory discrimination, in our opinion. The species actually captured (amphibians, reptiles, mammals) or observed (birds) during this study (Table 8) include 12 resident amphibian species (86% of all resident amphibian species), 17 resident reptile species (50% of all resident reptile species), 6 resident mammal species (86% of all trappable resident mammal species), and 46 resident bird species (42% of all resident bird species). This group of 81 species (42% of all resident species) is the group from which focal species are selected. Note that DRI's indicate that another 14 or so resident species have been captured or observed in the general vicinity of our study sites in the past, but we have no way of judging the validity of these records.

Numbers of Sites Occupied by Vertebrates

The resident vertebrate species that we captured or observed potentially could have been recorded from 30 reference sites and 10 reclaimed sites. The 81 species are

Table 8. Numbers of Resident Species Captured or Observed.

Location	Quadrupeds	Birds
A	14	17
B	20	21
C	23	14
D	12	13
E	18	17
F	18	17
G	14	14
TOTAL (A-G)	35	40
H	9	10
I	7	9
J	11	7
K	12	16
TOTAL (H-K)	17	22
TOTAL (A-K)	35	46
L DRI's ONLY	9	5
TOTAL (A-L)	44	51

Note: Quadrupeds = amphibian + reptilian + (trappable) mammalian species. DRI's only = additional species recorded in impact surveys.

Table 9. Number of Sites (Locations) at Which Resident Quadrupedal Species Were Captured, Ranked by Numbers at Reference Sites.

Species	Common Names	Reference	Mesic Reclaimed	Xeric Reclaimed
Blarina carolinensis	Southern short-tailed shrew	28 (7)	10 (4)	5
Bufo quercicus	Oak Toad	24 (7)	0 (0)	1
Gastrophryne c. carolinensis	Narrow-mouth toad	21 (7)	9 (4)	14
Sigmodon hispidus	Hispid cotton rat	16 (7)	4 (3)	6
Rana utricularia	Leopard frog	16 (7)	3 (2)	6
Anolis c. carolinensis	Green anole	14 (6)	3 (2)	4
Eumeces inexpectatus	Southeastern five-lined skink	14 (6)	1 (1)	2
Coluber constrictor priapus	Southern black racer	13 (6)	4 (3)	11
Bufo terrestris	Southern toad	13 (4)	0 (0)	7
Scincella laterale	Ground skink	10 (6)	5 (3)	5
Peromyscus gossypinus	Cotton mouse	10 (6)	4 (4)	3
Mus musculus	House mouse	6 (4)	1 (1)	1
Thamnophis sauritus sackeni	Peninsula ribbon snake	6 (5)	0 (0)	1
Hyla femoralis	Pine woods tree frog	6 (4)	0 (0)	0
Thamnophis s. sirtalis	Eastern garter snake	5 (5)	0 (0)	5
Hyla squirella	Squirrel treefrog	4 (3)	2 (2)	0
Cryptotis parva	Least shrew	4 (2)	0 (0)	14
Gopherus polyphemus	Gopher tortoise	4 (4)	0 (0)	

Table 9. (Cont.) Number of Sites (Locations) at Which Resident Quadrupedal Species Were Captured, Ranked by Numbers at Reference Sites.

Species	Common Names	Reference	Mesic Reclaimed	Xeric Reclaimed
Diadophis p. punctatus	Southern ringneck snake	3 (3)	2 (2)	1
Eleutherodactylus p. planirostris	Greenhouse frog	3 (2)	1 (1)	0
Ophisaurus ventralis	Eastern glass lizard	3 (3)	0 (0)	0
Acris gryllus dorsalis	Florida cricket frog	2 (2)	3 (3)	0
Drymarchon corais couperi	Eastern indigo snake	2 (2)	0 (0)	0
Ophisaurus attenuatus longicaudus	Eastern slender glass lizard	2 (2)	0 (0)	0
Pseudacris nigrita verrucosa	Florida chorus frog	2 (2)	0 (0)	0
Rana capito aesopus	Florida gopher frog	2 (1)	0 (0)	0
Scaphiopus h. holbrooki	Eastern spadefoot toad	2 (1)	0 (0)	0
Sistrurus miliarius barbouri	Dusky pygmy rattlesnake	2 (1)	0 (0)	0
Hyla cinerea	Green treefrog	1 (1)	2 (2)	1
Thamnophis sirtalis similis	Bluestripe garter snake	1 (1)	1 (1)	1
Cemophora c. coccinea	Florida scarlet snake	1 (1)	0 (0)	3
Elaphe g. guttata	Corn snake	1 (1)	0 (0)	2
Masticophis f. flagellum	Eastern coachwhip	1 (1)	0 (0)	2
Neotoma floridana	Eastern woodrat	1 (1)	0 (0)	0
Opheodrys aestivus	Rough green snake	0 (0)	1 (1)	1

Note: Column designations refer, respectively, to the 30 reference sites in the current study, 10 reclaimed sites in the current study, and 20 selected reclaimed sites from the xeric study.

Table 10. Number of Sites (Locations/Transects) at Which Resident Bird Species Were Observed, Ranked by Numbers at Reference Sites.

Species	Common Names	Reference	Mesic Reclaimed	Xeric Reclaimed
Geothlypis trichas	Common yellowthroat	28 (7/7)	7 (4/4)	1
Pipilo erythrophthalmus	Rufous-sided towhee	26 (7/7)	5 (3/3)	6
Aimophilus aestivalis	Bachmann's sparrow	14 (7/7)	0 (0/0)	0
Vireo griseus	White-eyed vireo	13 (6/6)	3 (3/3)	0
Thryothorus ludovicianus	Carolina wren	12 (7/7)	4 (3/3)	0
Melanerpes carolinus	Red-bellied woodpecker	12 (5/7)	1 (1/2)	2
Colinus virginianus	Northern bobwhite	10 (6/7)	2 (2/3)	6
Cardinalis cardinalis	Northern cardinal	10 (7/7)	1 (1/3)	1
Parus bicolor	Tufted titmouse	8 (4/7)	1 (1/1)	0
Dendroica pinus	Pine warbler	8 (6/7)	0 (0/0)	0
Sialia sialis	Bluebird	4 (2/3)	0 (0/0)	0
Myiarchus crinitus	Great crested flycatcher	3 (2/4)	0 (0/0)	0
Mimus polyglottos	Northern mockingbird	2 (1/6)	2 (1/3)	9
Parula americana	Northern parula	2 (1/4)	1 (1/1)	0
Columbina passerina	Common ground-dove	2 (1/4)	0 (0/1)	7
Cyanocitta cristata	Blue jay	2 (2/6)	0 (0/0)	6
Agelaius phoeniceus	Red-winged blackbird	1 (1/2)	10 (4/4)	11

Table 10. (Cont.) Number of Sites (Locations/Transects) at Which Resident Bird Species Were Observed, Ranked by Numbers at Reference Sites (Cont.).

Species	Common Names	Reference	Mesic Reclaimed	Xeric Reclaimed
Colaptes auratus	Northern flicker	1 (1/2)	0 (0/0)	3
Picoides pubescens	Downy woodpecker	1 (1/7)	0 (0/2)	3
Chordeiles minor	Common nighthawk	1 (1/2)	0 (0/0)	2
Caprimulgus carolinensis	Chuck-will's-widow	1 (1/1)	0 (0/0)	0
Dendroica coronata	Yellow-rumped warbler	1 (1/4)	0 (0/0)	0
Molothrus ater	Brown-headed cowbird	1 (1/1)	0 (0/0)	0
Pandion heliaetus	Osprey	1 (1/1)	0 (0/1)	0
Parus carolinensis	Carolina chickadee	1 (1/2)	0 (0/0)	0
Piranga rubra	Summer tanager	1 (1/2)	0 (0/0)	0
Sturnella magna	Eastern meadowlark	0 (0/1)	4 (4/4)	14
Zenaida macroura	Mourning dove	0 (0/5)	3 (2/3)	4
Quiscalus quiscula	Common grackle	0 (0/1)	2 (1/2)	0
Sayornis phoebe	Eastern phoebe	0 (0/0)	1 (1/2)	3
Buteo lineatus	Red-shouldered hawk	0 (0/3)	1 (1/1)	0
Coccyzus americanus	Yellow-billed cuckoo	0 (0/0)	1 (1/1)	0
Dendroica palmarum	Palm warbler	0 (0/2)	0 (0/3)	12
Toxostoma rufum	Brown thrasher	0 (0/1)	0 (0/0)	3
Dendroica dominica	Yellow-throated warbler	0 (0/0)	0 (0/0)	2

Table 10. (Cont.) Number of Sites (Locations/Transects) at Which Resident Bird Species Were Observed, Ranked by Numbers at Reference Sites.

Species	Common Names	Reference	Mesic Reclaimed	Xeric Reclaimed
Troglodytes aedon	House wren	0 (0/0)	0 (0/0)	2
Turdus migratorius	American robin	0 (0/4)	0 (0/1)	2
Buteo jamaicensis	Red-tailed hawk	0 (0/2)	0 (0/0)	1
Corvus ossifragus	Fish crow	0 (0/2)	0 (0/0)	1
Falco sparverius	American kestrel	0 (0/2)	0 (0/0)	1
Polioptila caerulea	Blue-gray gnatcatcher	0 (0/4)	0 (0/0)	1
Tyrannus tyrannus	Eastern kingbird	0 (0/0)	0 (0/0)	1
Accipiter cooperii	Cooper's hawk	0 (0/2)	0 (0/0)	0
Bombycilla cedrorum	Cedar waxwing	0 (0/1)	0 (0/0)	0
Cathartes aura	Turkey vulture	0 (0/2)	0 (0/2)	0
Coragyps atratus	Black vulture	0 (0/2)	0 (0/2)	0
Corvus brahyrhynchos	American crow	0 (0/3)	0 (0/0)	0
Dumetella carolinensis	Gray catbird	0 (0/2)	0 (0/1)	0
Dryocopus pileatus	Pileated woodpecker	0 (0/5)	0 (0/0)	0

Note: Column designations refer, respectively, to the 30 reference sites in the current study, 10 reclaimed sites in the current study, and 20 selected reclaimed sites from the xeric study.

ranked by the number of reference sites at which each was recorded; the rankings are done separately for amphibians, reptiles, and mammals (Table 9) and for birds (Table 10).

For lizards/turtles ($r_s = 0.75$, $p < 0.10$) and mammals ($r_s = 0.97$, $p < 0.05$), those species found at a relatively large number of reference sites also tend strongly to be found at a relatively large number of reclaimed sites, but the same is not true among amphibians ($r_s = 0.11$, $p > 0.10$), snakes ($r_s = 0.14$, $p > 0.10$), or birds ($r_s = 0.14$, $p > 0.10$). These relationships remain the same if locations, rather than individual sites, are use in the analysis, with one exception. Among birds ($r_s = 0.26$, $p < 0.05$), those species found at a relatively large number of reference locations also tend strongly to be found at a relatively large number of reclaimed locations. When the 20 selected reclaimed sites from the xeric study are added to the 10 from the current study, no relationship can be detected for any of the groups of species. These relationships indicate the following:

- Lizard, turtle, and mammal species that are found at a relatively large number of reference sites also tend strongly to be found at a relatively large number of reclaimed sites.

- Amphibian, snake, and bird species that are found at a relatively large number of reference sites do not tend to be found at a relatively large number of reclaimed sites.

Numbers of Individuals

The 81 species also are ranked by the median number of individuals captured (amphibians, reptiles, mammals) or median number of times individuals were observed at reference sites (birds); the rankings are done separately for amphibians, reptiles, and mammals (Table 11) and for birds (Table 12). After the species had been ranked by number of individuals or number of observations, we compared the resulting orderings (Tables 11, 12) with the orderings based on site distribution (Tables 9, 10), using Spearman's Rank Correlation Coefficient.

For lizards/turtles ($r_s = 0.88$, $p < 0.10$) and birds ($r_s = 0.30$, $p < 0.10$) those species found in relatively large population sizes at reference sites also tend strongly to be found in relatively large population sizes at reclaimed sites, but the same is not true for amphibians ($r_s = 0.08$, $p > 0.10$), snakes ($r_s = -0.17$, $p > 0.10$), or mammals ($r_s = 0.51$, $p > 0.10$). When the 20 selected reclaimed sites from the xeric study are added to the 10 from the current study, the only relationship that changes is for birds ($r_s = 0.10$, $p > 0.10$). These relationships indicate the following:

- Among lizards/turtles, those species that are found in relatively large population sizes at reference sites also tend strongly to be found in relatively large population sizes at reclaimed sites.

- Among amphibians, snakes, mammals, and birds, those species that are found in relatively large population sizes at reference sites do not tend strongly to be found in relatively large population sizes at reclaimed sites.

Table 11. Median Number of Individuals at Sites at Which Resident Quadrupedal Species Were Captured, Ranked by Numbers at Reference Sites.

Species	Reference	Mesic Reclaimed	Xeric Reclaimed
Bufo terrestris	20.5	0.0	1.0
Blarina carolinensis	14.0	6.5	1.0
Gastrophryne c. carolinensis	6.0	25.0	3.5
Eumeces inexpectatus	6.0	2.0	5.5
Bufo quercicus	5.0	0.0	1.0
Scaphiopus h. holbrooki	5.0	0.0	0.0
Eleutherodactylus p. planirostris	4.0	1.0	0.0
Sistrurus miliarius barbouri	4.0	0.0	0.0
Rana utricularia	3.0	2.5	3.5
Anolis c. carolinensis	3.0	1.5	1.0
Peromyscus gossypinus	2.5	1.0	1.0
Cryptotis parva	2.5	0.0	2.0
Sigmodon hispidus	2.0	2.0	3.5
Acris gryllus dorsalis	2.0	1.0	0.0
Cemophora c. coccinea	2.0	0.0	1.0
Rana capito aesopus	2.0	0.0	0.0
Coluber constrictor priapus	1.5	2.0	1.0
Scincella laterale	1.5	2.0	1.0
Mus musculus	1.5	1.0	1.0
Hyla femoralis	1.5	0.0	0.0
Hyla squirella	1.0	12.0	0.0
Gopherus polyphemus	1.0	0.0	1.5
Diadophis p. punctatus	1.0	1.0	1.0
Hyla cinerea	1.0	1.0	1.0
Thamnophis sirtalis similis	1.0	1.0	1.0
Elaphe g. guttata	1.0	0.0	1.0

Table 11. (Cont.) Median Number of Individuals at Sites at Which Resident Quadrupedal Species Were Captured, Ranked by Numbers at Reference Sites.

Species	Reference	Mesic Reclaimed	Xeric Reclaimed
Thamnophis sauritus sackeni	1.0	0.0	1.0
Thamnophis s. sirtalis	1.0	0.0	1.0
Drymarchon corais couperi	1.0	0.0	0.0
Neotoma floridana	1.0	0.0	0.0
Ophisaurus attenuatus longicaudus	1.0	0.0	0.0
Ophisaurus ventralis	1.0	0.0	0.0
Pseudacris nigrita verrucosa	1.0	0.0	0.0
Opheodrys aestivus	0.0	1.0	1.0

Note: Column designations refer, respectively, to the 30 reference sites in the current study, 10 reclaimed sites in the current study, and 20 selected reclaimed sites from the xeric study. Data are from marked individuals, except * = data from number of active burrows, ** = data from captures.

Table 12. Median Number of Observations at Sites at Which Resident Bird Species Were Captured, Ranked by Numbers at Reference Sites.

Species	Reference	Mesic Reclaimed	Xeric Reclaimed
Pipilo erythrophthalmus	7.0	3.0	2.0
Geothlypis trichas	6.0	2.0	
Parus bicolor	3.0	1.0	0.0
Cardinalis cardinalis	2.7	1.0	1.0
Vireo griseus	2.5	1.0	0.0
Mimus polyglottos	2.0	2.0	1.5
Melanerpes carolinus	2.0	1.0	1.5
Parula americana	2.0	1.0	0.0
Columbina passerina	2.0	0.0	1.5
Aimophilus aestivalis	2.0	0.0	0.0
Sialia sialis	2.0	0.0	0.0
Colinus virginianus	1.5	1.5	1.2
Thryothorus ludovicianus	1.5	1.0	0.0
Myiarchus crinitus	1.5	0.0	0.0
Agelaius phoeniceus	1.0	13.5	
Colaptes auratus	1.0	0.0	2.0
Chordeiles minor	1.0	0.0	1.5
Picoides pubescens	1.0	0.0	1.5
Cyanocitta cristata	1.0	0.0	1.0
Caprimulgus carolinensis	1.0	0.0	0.0
Dendroica coronata	1.0	0.0	0.0
Dendroica pinus	1.0	0.0	0.0
Molothrus ater	1.0	0.0	0.0
Pandion heliaetus	1.0	0.0	0.0
Parus carolinensis	1.0	0.0	0.0

Table 12. (Cont.) Median Number of Observations at Sites at Which Resident Bird Species Were Captured, Ranked by Numbers at Reference Sites.

Species	Reference	Mesic Reclaimed	Xeric Reclaimed
Piranga rubra	1.0	0.0	0.0
Zenaida macroura	0.0	2.5	1.5
Quiscalus quiscula	0.0	2.0	0.0
Sayornis phoebe	0.0	1.0	1.2
Sturnella magna	0.0	1.0	
Buteo lineatus	0.0	1.0	0.0
Coccyzus americanus	0.0	1.0	0.0
Dendroica palmarum	0.0	0.0	2.0
Buteo jamaicensis	0.0	0.0	1.0
Corvus ossifragus	0.0	0.0	1.0
Dendroica dominica	0.0	0.0	1.0
Falco sparverius	0.0	0.0	1.0
Polioptila caerulea	0.0	0.0	1.0
Toxostoma rufum	0.0	0.0	1.0
Troglodytes aedon	0.0	0.0	1.0
Tyrannus tyrannus	0.0	0.0	1.0
Turdus migratorius	0.0	0.0	
Accipiter cooperii	0.0	0.0	0.0
Bombycilla cedrorum	0.0	0.0	0.0
Cathartes aura	0.0	0.0	0.0
Coragyps atratus	0.0	0.0	0.0
Corvus brahyrhynchos	0.0	0.0	0.0
Dumetella carolinensis	0.0	0.0	0.0
Dryocopus pileatus	0.0	0.0	0.0

Note: Column designations refer, respectively, to the 30 reference sites in the current study, 10 reclaimed sites in the current study, and 20 selected reclaimed sites from the xeric study. Species for which no individuals are listed were observed only on transects.

Correlations with site distribution are strongly positive for both reference and reclaimed sites for amphibians ($r_s = 0.50$, $p < 0.05$, reference; $r_s = 0.70$, $p < 0.05$, reclaimed), lizards/turtles ($r_s = 0.92$, $p < 0.05$, reference; $r_s = 0.88$, $p < 0.05$, reclaimed), and birds ($r_s = 0.95$, $p < 0.05$, reference; $r_s = 0.96$, $p < 0.05$, reclaimed). Correlations are strongly positive for reclaimed but not reference sites for mammals ($r_s = 0.67$, $p > 0.10$, reference; $r_s = 0.95$, $p < 0.05$, reclaimed). Correlations are strongly positive for neither reference nor reclaimed sites for snakes ($r_s = 0.33$, $p > 0.10$, reference; not calculated for reclaimed). When the 20 selected reclaimed sites from the xeric study are added to the 10 from the current study, the only relationship that changes is for mammals ($r_s = 0.53$, $p > 0.10$, reclaimed). These relationships indicate the following:

- Among amphibians, lizards/turtles, and birds, those species that are found at a relatively large number of either reference or reclaimed sites also tend to be found in relatively large populations sizes there.

- Among snakes and mammals, those species that are found at a relatively large number of either reference or reclaimed sites do not tend very strongly to be found in relatively large population sizes there.

Our results suggest that, for amphibians, lizards/turtles, and birds (but not for snakes or mammals), species' distributions strongly predict species' abundances for both reference and reclaimed sites. Our results also suggest, however, that, only for lizards/turtles, do species' distributions and abundances at reference sites strongly predict species' distributions and abundances at reclaimed sites.

Focal Species

Focal species are those species that are found much more commonly--locally--on reference lands than on reclaimed lands. These focal species, therefore, serve as targets for reclamation efforts aimed at making the vertebrate compositions of reclaimed sites more representative of those of upland habitats. The list of focal species (Table 13) includes 1 amphibian, 2 lizard/turtle, 0 snakes, 0 mammals, and 9 birds. This group of 12 species was used to document differences between the vertebrate compositions of reference and reclaimed lands. We are satisfied with this group of focal species, with the possible exception of *Gopherus polyphemus* (gopher tortoise). We have excluded it as a focal species, even though it met our criterion for inclusion, because of some uncertainty in its distribution among sites. We note that one of the listed (Wood 1991) resident species, *Aimophila aestivalis* (Bachman's sparrow), is in the group of focal species, but the others--*Rana capito aesopus* (Florida gopher frog), *Gopherus polyphemus* (gopher tortoise), *Drymarchon corais couperi* (eastern indigo snake), *Falco sparverius* (American kestrel)--are not. The four excluded taxa simply occur at too few reference sites to determine if any difference in their distributions exists between reference and reclaimed lands. Four bird species, *Agelaius phoenecius* (red-winged blackbird), *Dendroica palmarum* (palm warbler), *Sturnella magna* (eastern meadowlark), and *Zenaida macroura* (mourning dove) actually were demonstrably more common at reclaimed than reference sites. These four species all are well-known inhabitants of relatively open areas.

Table 13. Focal Species. The Sites Column Includes Both Reference (First Number) and Reclaimed (Second Number) Sites.

Species	Sites	Sites Score	Factor	Adjusted Sites Score
Bufo quercicus (BQ)	24- 1	15.28	5	76.40
Aimophila aestivalis (AA)	14- 0	12.08	3	36.24
Eumeces inexpectatus (EI)	14- 3	4.16	4	16.64
Dendroica pinus (DP)	8- 0	6.88	2	13.76
Hyla femoralis (HF)	6- 0	5.16	2.5	12.90
Sialis sialis (SS)	4- 0	3.46	3	10.38
Cardinalis cardinalis (CC)	10- 2	3.10	2	6.20
Geothlypis trichas (GT)	28- 8	6.14	1	6.14
Pipilo eryophthalmus (PE)	26-11	3.20	1.5	4.80
Vireo griseus (VG)	13- 3	3.56	1	3.56
Parus bicolor (PB)	8- 1	3.40	1	3.40
Melanerpes carolinus (MC)	12- 3	3.04	1	3.04
Zenaida macroura	0- 7	6.06		
Dendroica palmarum	0-12	10.35		
Agelaius phoeniceus	1-21	12.93		
Sturnella magna	0-18	15.54		

Note: The sites scores are the binomial test scores, reflecting the strengths of the differences of the real site distributions (reference:reclaimed) and equal distributions (see text). Only species for which the significance (p-value) of the binomial test score is < 0.10 are included. Factors are indications of relative differences in abundance, with 1 indicating no difference (see text). The factor scores are (sites scores X factors), and are the scores used to rank species. Note that no species is included solely on the basis of relative differences in abundance.

Distributions Among Sites

Numbers of resident species captured or observed (Table 14) at the 60 sites, and their relative abundances there (Table 15) are presented. Sites also are ranked by their representation of focal species; separate rankings are presented for quadrupeds (= amphibians + reptiles + mammals) (Table 16) and birds (Table 17). These rankings of sites are used in all subsequent analyses. Among all 60 sites, rank based on number of resident quadruped species is not strongly correlated with rank based on number of resident bird species ($r_s = -0.06$, $p > 0.10$). Rank based on representation of focal quadruped species is strongly positively correlated with rank based on representation of focal bird species, however ($r_s = 0.69$, $p < 0.05$). Among the 30 reference sites alone, the correlations are strongly negative for number of resident species ($r_s = -0.36$, $p < 0.10$) but not strong for representation of focal species ($r_s = -0.06$, $p > 0.10$). Among the 30 reclaimed sites alone, the correlations are not strong either for numbers of resident species ($r_s = 0.07$, $p > 0.10$) or for representation of focal species ($r_s = 0.11$, $p > 0.10$). These relationships indicate the following.

- Resident quadrupeds and birds are found at substantially different suites of reference sites, perhaps because the suites differ in size, isolation, vegetation structure, or other ways, that may be differentially important to the two groups of species. Focal species alone do not display the same pattern.

- Resident quadrupeds and birds display little tendency either to be found at different or similar suites of reclaimed sites, perhaps because reclaimed sites differ in fewer important ways than to reference sites.

- Focal quadrupedal and bird species display little tendency either to be found at different or similar suites of reclaimed sites.

Interestingly, regardless of which of the three groups of sites -- reference, reclaimed, reference and reclaimed combined -- are employed, correlations between numbers of resident species and representation of focal species, both for quadrupeds and birds, are strongly positively correlated (r_s's = 0.26-0.59, p's < 0.10). This relationship indicates the following:

- Representation of focal species, either quadrupeds or birds, at a site gives a strong indication of the relative species richness at that site.

If any tendency exists for species to be particularly common or uncommon in a particular location or county, then this tendency could account for some of the differences found between reference and reclaimed sites, because our reference and reclaimed sites

Table 14. Number of Trappable Resident Amphibian (AM), Reptile (RL =Lizards/ Turtles, RS = Snakes), Mammal (MA), and Total Quadruped (QA) Species Captured, and Number of Bird (BI) Species Observed, at the 60 Study Sites.

Site	Number of Species					
	AM	RL	RS	MA	QA	BI
PT08P	3	3	4	4	14	15
FL23S	6	3	2	3	14	5
FL04H	4	3	1	4	12	6
FL11M	4	2	2	3	11	7
FL13M	3	3		4	10	7
FL18A	3	2	1	4	10	7
PT10P	2	1	4	3	10	7
PR05P	2		4	1	7	10
FL10M	2	2	3	3	10	6
PT24H	2	1	1	2	6	10
FL01H	2	2	1	3	8	7
FL07H	3	3		1	7	8
PR20P	2	3	1	3	9	6
PR10P	1		2	2	5	10
PR13H	2			3	5	10
FL16A	3		2	1	6	9
FL02H	2	1		3	6	8
FL06H	3		2	2	7	7
FL12M	4	1	1	3	9	4
FL15A	3	2	1	2	8	5
FL22A	4	2	1	3	10	3
FL25S	7	1	1		9	4
FL26S	6	1	1	1	9	4

Table 14. (Cont.) Number of Trappable Resident Amphibian (AM), Reptile (RL =Lizards/Turtles, RS = Snakes), Mammal (MA), and Total Quadruped (QA) Species Captured, and Number of Bird (BI) Species Observed, at the 60 Study Sites.

Site	Number of Species					
	AM	RL	RS	MA	QA	BI
FL30P	3	2	1	3	9	4
PT16P	4		2	1	7	6
FL03H	2	1		2	5	7
FL05H	1	2	1	3	7	5
FL08H	6		1	2	9	3
FL09H	2	3	1	1	7	5
FL21A	4		1	3	8	4
FL24S	4		1	2	7	5
PR09P	2	1	2	1	6	7
PR01P	1	1	1	1	4	8
FL14M	3	2		1	6	5
FL19A	1		1	1	3	8
FL20A	5	2	3	1	11	0
FL27P	2	3		1	6	5
FL28P	2	2		1	5	6
FL29P	1		2	2	5	6
PT20A	2	3		2	7	4
PT02P	3		2	2	7	4
PR22P	3		1	2	6	5
PT05P	2		1	2	5	6
PR11P				2	2	9
PR14H	2	1		2	5	6
PR21P	2	2		1	5	5
PR23P	3	1	1	2	7	3
PR24P	3	2		2	7	3
PT21A			1	3	4	5

Table 14. (Cont.) Number of Trappable Resident Amphibian (AM), Reptile (RL =Lizards/Turtles, RS = Snakes), Mammal (MA), and Total Quadruped (QA) Species Captured, and Number of Bird (BI) Species Observed, at the 60 Study Sites.

Site	Number of Species					
	AM	RL	RS	MA	QA	BI
PT01P	3			2	5	4
FL17A	2	1		1	4	4
PT23H	1	1		1	3	5
PT09P	1	1		3	5	3
PR03H	2	1	2	2	7	1
PR06P	1		1		2	6
PR08P	1	1	1		3	5
PR07H	1	1	2	3	7	0
PT22H	2			1	3	3
PT07P	2	1			3	2
PR02H	2		1	1	4	1
Sites Medians						
Reference	3	2	1	2	8	5.5
Reclaimed	2	1	1	2	6	5
Locations Medians						
A (Reference)	2	1.5	0.5	3	7	7
B	3	2	1	2	8	5
C	3.5	2	1.5	3	10	6.5
D	3	1	1	1	6	5
E	4	2	1	2	9	4
F	6	1	1	1	9	4.5
G	2	2	0.5	1.5	6	5.5
H (Reclaimed)	1	1.5	0.5	2.5	5.5	4.5
I	2	1	0	1	4	5

Table 14. (Cont.) Number of Trappable Resident Amphibian (AM), Reptile (RL =Lizards/Turtles, RS = Snakes), Mammal (MA), and Total Quadruped (QA) Species Captured, and Number of Bird (BI) Species Observed, at the 60 Study Sites.

Locations Medians						
J	2	2.5	0.5	2	7	5.5
K	3	1	1	2	7	3
Other	2	0.5	1	2	5.5	6
County Medians						
Hardee (Reference)	3	1.5	1	1.5	7	4.5
Hardee (Reclaimed)	1	2.5	0.5	2.5	6.5	4.5
Hillsborough (Reference)	2	1.5	1	2	6.5	7
Hillsborough (Reclaimed)	2	1	0.5	2	5.5	4
Manatee (Reference)	3.5	2	1.5	3	10	6.5
Polk (Reference)	2	2	0.5	1.5	6	5.5
Polk (Reclaimed)	2	1	1	2	6	6
Sarasota (Reference)	6	1	1	1	9	4.5

Note: Sites are ranked by combined numbers in all groupings. Medians are provided for reference and reclaimed sites, locations, and counties.

Table 15. Relative Abundance of Trappable Resident Amphibian (Am), Reptile (RL= Lizards/Turtles, RS = Snakes), Mammal (MA), and Quadruped (QA) Individuals Captured, and Relative Abundance of Resident Bird (BI) Individuals Observed, at the 60 Study Sites.

Site	Individuals or Observations					
	AM	RL	RS	MA	QA	BI
PR23P	11.58	1.00	3.00	1.00	10.85	0.95
PT09P	13.00	1.00		1.22	10.22	0.56
FL23S	6.80	1.33	1.50	1.00	5.97	1.33
FL26S	5.58	1.00	1.00	0.67	5.21	1.75
PR13H	6.25			1.27	5.39	0.82
FL19A	4.20		2.00	4.33	4.12	1.12
PR21P	4.17	1.00	1.00	0.33	3.78	1.15
PT01P	1.62			6.00	3.50	1.31
FL24S	3.54		2.00	1.66	3.22	1.20
PT10P	4.67	1.00	2.50	4.22	3.47	0.79
PR24P	3.08	2.00	1.00	0.84	2.87	1.15
PT02P	1.00		1.00	4.00	3.18	0.60
PT08P	2.04	3.56	1.50	3.00	2.77	1.00
PR20P	2.33	1.00	1.50	1.56	1.91	1.50
PR11P				2.50	2.50	0.85
FL09H	0.75	2.44	1.00	0.33	1.94	1.40
FL13M	0.80	3.56		1.07	2.31	1.00
FL25S	1.52	2.00	1.00		1.54	1.75
FL18A	1.83	3.50	1.00	1.33	2.14	1.14
PR14H	2.53	1.00		2.00	2.36	0.79
FL27P	2.50	1.56		0.67	1.86	1.20
FL17A	1.25	1.00		1.33	1.26	1.75
FL01H	1.00	1.17	1.00	1.22	1.12	1.86

Table 15. (Cont.) Relative Abundance of Trappable Resident Amphibian (Am), Reptile (RL= Lizards/Turtles, RS = Snakes), Mammal (MA), and Quadruped (QA) Individuals Captured, and Relative Abundance of Resident Bird (BI) Individuals Observed, at the 60 Study Sites.

Site	Individuals or Observations					
	AM	RL	RS	MA	QA	BI
FL15A	0.89	1.00	1.00	2.17	1.73	1.20
FL29P	1.00		2.50	1.16	1.75	1.17
PR08P	2.33	1.00	2.00		2.13	0.78
FL02H	0.67	1.00		1.67	1.40	1.50
PT24H	1.83	1.00	1.00	2.33	1.95	0.92
FL30P	1.44	1.00	1.00	1.11	1.24	1.50
FL28P	1.00	2.00		1.00	1.40	1.33
FL04H	0.88	0.89	1.00	1.17	1.00	1.67
FL22A	0.81	0.84	3.00	1.22	1.34	1.33
PT20A	1.17	1.00		1.00	1.08	1.58
PR03H	2.15	1.33	1.00	1.00	1.64	1.00
PR07H	3.00	1.00	3.50	1.11	2.60	
PR22P	0.61		1.00	1.84	1.34	1.25
PT22H	1.08			0.33	0.97	1.60
FL21A	1.25		2.00	1.22	1.31	1.25
FL14M	1.00	1.34	1.00	1.67	1.34	1.17
FL12M	1.02	0.67	1.00	1.56	1.25	1.25
FL10M	0.84	1.17	1.00	1.67	1.32	1.17
FL11M	1.96	0.83	1.00	1.22	1.49	1.00
FL05H	1.67	0.84	3.00	1.67	1.48	1.00
FL08H	0.67		1.00	0.84	0.78	1.67
PR09P	1.00	1.00	1.50	2.00	1.19	1.26
PR02H	1.33		1.00	2.00	1.44	1.00
PR05P	1.00		1.50	1.00	1.27	1.12
PT07P	1.50	1.00			1.37	1.00
PT21A			1.00	1.33	1.28	1.00

Table 15. (Cont.) Relative Abundance of Trappable Resident Amphibian (Am), Reptile (RL= Lizards/Turtles, RS = Snakes), Mammal (MA), and Quadruped (QA) Individuals Captured, and Relative Abundance of Resident Bird (BI) Individuals Observed, at the 60 Study Sites.

Site	Individuals or Observations					
	AM	RL	RS	MA	QA	BI
PT23H	1.33	1.00	1.00	1.33	1.26	1.00
FL03H	0.84	1.00		1.00	0.94	1.29
FL06H	0.61		1.50	0.84	0.98	1.14
FL16A	1.06		1.00	1.00	1.03	1.00
FL07H	1.00	1.00		1.00	1.00	1.00
PR10P	0.67		1.00	1.50	1.12	0.84
FL20A	2.03	1.11	1.75	2.00	1.93	
PR06P	1.00		1.00		1.00	0.79
PR01P	0.67	1.00	1.00	1.00	0.92	0.83
PT05P	0.84		1.00	1.00	0.92	0.76
PT16P	1.00		1.00	1.00	1.00	0.56
Sites Medians						
Reference	1.01	1.00	1.00	1.22	1.40	1.25
Reclaimed	1.56	1.00	1.00	1.33	1.78	1.00
Locations Medians						
A (Reference)	0.76	1.00	1.00	1.42	1.06	1.58
B	0.75	1.00	1.25	0.84	1.00	1.14
C	1.00	1.17	1.00	1.56	1.34	1.17
D	1.06	1.00	1.00	1.33	1.26	1.20
E	1.83	1.11	2.00	1.33	1.31	1.20
F	4.56	1.33	1.25	1.00	4.22	1.54
G	1.22	1.56	1.75	1.06	1.58	1.26
H (Reclaimed)	1.17	1.00	1.00	1.16	1.18	1.29
I	1.33	1.00	1.00	1.33	1.26	1.00

Table 15. (Cont.) Relative Abundance of Trappable Resident Amphibian (Am), Reptile (RL= Lizards/Turtles, RS = Snakes), Mammal (MA), and Quadruped (QA) Individuals Captured, and Relative Abundance of Resident Bird (BI) Individuals Observed, at the 60 Study Sites.

Locations Medians						
	Individuals or Observations					
Site	AM	RL	RS	MA	QA	BI
J	3.25	1.00	1.25	0.92	2.84	1.32
K	3.08	1.50	1.00	1.00	2.87	1.15
Other	1.50	1.00	1.00	1.27	1.88	0.84
County Medians						
Hardee (Reference)	1.25	1.00	1.75	1.33	1.73	1.20
Hardee (Reclaimed)	1.17	1.00	1.00	1.16	1.18	1.29
Hillsborough (Reference)	0.88	1.00	1.00	1.00	1.00	1.40
Hillsborough (Reclaimed)	1.99	1.00	1.00	1.30	1.80	1.00
Manatee (Reference)	1.00	1.17	1.00	1.56	1.34	1.17
Polk (Reference)	1.22	1.56	1.75	1.06	1.58	1.20
Polk (Reclaimed)	1.62	1.00	1.00	1.22	2.32	0.84
Sarasota (Reference)	4.56	1.33	1.25	1.00	4.22	1.54

Note: Sites are ranked by combined numbers in all groupings. Medians are provided for reference and reclaimed sites, locations, and counties.

Table 16. Sites Ranked by Their Representation of Quadrupedal Focal Species.

Site	Score	Factor	Adjusted Sites Score
FL23S	24.60	5.97	24.60
FL22A	24.60	1.34	24.60
FL12M	24.60	1.25	24.60
FL26S	20.44	5.21	20.44
FL25S	20.44	1.54	20.44
FL06H	20.44	0.98	20.03
PT08P*	19.44	2.77	19.44
FL13M	19.44	2.31	19.44
FL09H	19.44	1.94	19.44
FL27P	19.44	1.86	19.44
FL11M	19.44	1.49	19.44
FL10M	19.44	1.32	19.44
FL01H	19.44	1.12	19.44
FL04H	19.44	1.00	19.44
FL24S	15.28	3.22	15.28
FL29P	15.28	1.75	15.28
FL15A	15.28	1.73	15.28
FL02H	15.28	1.40	15.28
FL28P	15.28	1.40	15.28
FL17A	15.28	1.26	15.28
FL30P	15.28	1.24	15.28
FL16A	15.28	1.03	15.28
FL07H	15.28	1.00	15.28
FL03H	15.28	0.94	14.36
FL08H	15.28	0.78	11.92
PR24P*	4.16	2.87	4.16

Table 16. (Cont.) Sites Ranked by Their Representation of Quadrupedal Focal Species.

Site	Score	Factor	Adjusted Sites Score
FL20A	4.16	1.93	4.16
PR03H	4.16	1.64	4.16
FL05H	4.16	1.48	4.16
FL14M	4.16	1.34	4.16
PR23P		10.85	
PT09P		10.22	
PR13H		5.39	
FL19A*		4.12	
PR21P		3.78	
PT01P		3.50	
PT10P		3.47	
PT02P		3.18	
PR07H		2.60	
PR11P		2.50	
PR14H		2.36	
PR08P		2.13	
PT24H		1.95	
PR20P		1.91	
PR02H		1.44	
PT07P		1.37	
PR22P		1.34	
FL21A*		1.31	
PT21A		1.28	
PR05P		1.27	
PT23H		1.26	
PR09P		1.19	

Table 16. (Cont.) Sites Ranked by Their Representation of Quadrupedal Focal Species.

Site	Score	Factor	Adjusted Sites Score
PR10P		1.12	
PT20A		1.08	
PT16P		1.00	
PR06P		1.00	
PT22H		0.97	
PT05P		0.92	
PR01P		0.92	

Note: The sites' score is computed from the presences of focal species; the factor is the median abundance of resident species, relative to their abundances elsewhere; and adjusted sites' score is (sites score X factor), if factor < 1, or (sites score), otherwise. Maximum possible adjusted sites score = 24.60. Open spaces indicate sites at which no focal species were recorded. Asterisks indicate either reference sites that are not among the first 30 sites or reclaimed sites that are.

Table 17. Sites Ranked by Their Representation of Bird Focal Species.

Site	Score	Factor	Adjusted Sites Score
FL16A	38.36	1.00	38.36
FL04H	31.48	1.67	31.48
FL02H	31.48	1.50	31.48
FL28P	31.40	1.33	31.40
FL15A	28.38	1.20	28.38
FL19A	28.38	1.12	28.38
FL11M	28.30	1.00	28.30
FL29P	28.08	1.17	28.08
FL17A	24.98	1.75	24.98
FL12M	24.72	1.25	24.72
FL24S	24.46	1.20	24.46
FL03H	23.24	1.29	23.24
FL06H	22.66	1.14	22.66
FL01H	22.36	1.86	22.36
FL25S	21.42	1.75	21.42
FL26S	21.42	1.75	21.42
FL14M	19.40	1.17	19.40
FL07H	19.34	1.00	19.34
FL10M	19.32	1.17	19.32
FL08H	18.22	1.67	18.22
FL18A	16.68	1.14	16.68
FL21A	15.94	1.25	15.94
FL13M	15.94	1.00	15.94
FL09H	15.84	1.40	15.84
FL05H	12.64	1.00	12.64
FL27P	12.44	1.20	12.44

Table 17. (Cont.) Sites Ranked by Their Representation of Bird Focal Species.

Site	Score	Factor	Adjusted Sites Score
FL22A	12.38	1.33	12.38
FL23S	12.38	1.33	12.38
PT24H*	13.26	0.92	12.20
PR20P	9.34	1.50	9.34
PT20A	9.18	1.58	9.18
PR23P	9.34	0.95	8.87
PR22P	6.76	1.25	6.76
FL30P*	6.30	1.50	6.30
PT22H	6.14	1.60	6.14
PR21P	6.14	1.15	6.14
PT21A	6.14	1.00	6.14
PT23H	6.14	1.00	6.14
PR11P	4.80	0.85	4.08
PR10P	4.80	0.84	4.03
PR13H	4.80	0.82	3.94
PR24P	3.20	1.15	3.20
PR05P	3.20	1.12	3.20
PR09P	3.04	1.26	3.04
PT10P	3.20	0.79	2.53
PT01P		1.31	
PT07P		1.00	
PR02H		1.00	
PR03H		1.00	
PR01P		0.83	
PR06P		0.79	
PR14H		0.79	

Table 17. (Cont.) Sites Ranked by Their Representation of Bird Focal Species.

Site	Score	Factor	Adjusted Sites Score
PR08P		0.78	
PT05P		0.76	
PT02P		0.60	
PT09P		0.56	
PT16P		0.56	
FL20A*			
PR07H			

Note: The sites' score is computed from the presences of focal species; the factor is the mean abundance of resident species, relative to their abundances elsewhere; and adjusted sites' score is (sites score x factor), if factor < 1, or (sites score), otherwise. Maximum possible adjusted sites score = 44.86. Open spaces indicate sites at which no focal species were recorded. Asterisks indicate either reference sites that are not among the first 30 sites or reclaimed sites that are.

are not uniformly distributed among locations and counties. Mann-Whitney U-tests showed that reference sites at FH, HC, and MY tended to have higher ranks in representation of focal species (quadrupeds + birds) than reference sites at other locations. No difference among counties could be detected.

Nestedness and Species' Associations

We determined whether or not the distributions of quadrupeds and birds among sites were nested. The Sites by Species matrices (Tables 18-19) indicate that some nestedness exists. These results suggest that the species compositions of less-rich sites tend, at least in part, to include more widely distributed species preferentially. Because the distributions of species among sites are nested, we also determined the associations of species that tended to occur at the sites. Variance Ratio Tests indicated that associations among species were indeed present, as was to be expected from the nestedness analyses. For all focal species, $W = 25.05$ ($p < 0.05$) at reference sites and $W = 53.93$ ($p < 0.05$) at reclaimed sites. We then used simple monothetic divisive cluster analysis to identify associations (Table 20). Among reference sites, the presence of *Aimophila aestivalis* (Bachman's sparrow) tended very strongly to group the sites with the greatest representation of focal species. We are not prepared to suggest, however, that this species be used as an "indicator," especially as it was recorded from all seven of the locations of the reference sites. Among reclaimed sites, no particular tendency for sites with the greatest representation of focal species to group could be detected. We note, however, that the presence of *Bufo quercicus* and *Parus bicolor* separated out the two reclaimed sites with the greatest representations of focal species.

Table 18. Sites at Which Twelve Focal Species Were Observed or Captured.

Site	PE	GT	BQ	EI	VG	MC	AA	CC	PB	DP	HF	SS
FL04H	X	X	X	X	X	X	X					X
FL16A	X	X	X		X		X	X	X	X		
FL01H	X	X	X	X		X		X		X		
FL02H	X	X	X		X	X	X					X
FL06H	X	X	X			X			X	X	X	
FL12M		X	X	X		X	X				X	X
FL13M	X	X	X	X	X	X						
FL22A	X	X	X	X		X					X	
FL23S	X	X	X	X		X					X	
FL11M	X	X	X	X			X			X		
FL09H	X	X	X	X				X	X			
FL10M	X	X	X	X				X		X		
FL07H	X	X	X		X	X			X			
FL29P	X	X	X		X		X	X				
FL15A	X	X	X		X		X		X			
FL03H	X	X	X		X					X		X
FL28P	X	X	X				X	X		X		
FL14M	X	X		X	X			X	X			
FL27P	X	X	X	X				X				
PT08P	X	X	X	X				X				
FL17A	X	X	X		X		X					
FL24S	X	X	X			X	X					
FL25S	X	X	X				X				X	
FL26S	X	X	X				X				X	
FL18A	X			X	X	X				X		
FL19A	X	X			X		X	X				

Table 18. (Cont.) Sites at Which Twelve Focal Species Were Observed or Captured.

Site	PE	GT	BQ	EI	VG	MC	AA	CC	PB	DP	HF	SS
FL21A	X	X			X	X						
PT24H	X				X			X	X			
FL05H		X		X				X	X			
FL30P	X		X					X				
FL08H		X	X				X					
PR20P	X	X										
PR23P	X	X										
PR24P	X			X								
PR22P	X				X							
FL20A		X		X								
PT21A		X			X							
PT20A		X				X						
PT10P	X											
PR05P	X											
PR10P	X											
PR11P	X											
PR13H	X											
PT22H		X										
PT23H		X										
PR21P		X										
PR03H				X								
PR09P						X						
PT01P												
PT02P												
PT05P												
PT07P												
PT09P												

Table 18. (Cont.) Sites at Which Twelve Focal Species Were Observed or Captured.

Site	PE	GT	BQ	EI	VG	MC	AA	CC	PB	DP	HF	SS
PT16P												
PR01P												
PR02H												
PR06P												
PR07P												
PR08P												
PR14H												

Note: Sites are arranged from most (top) to least (bottom) species rich and species are arranged from most (left) to least (right) widespread among sites. Abbreviations refer to binomials in Table 13.

Table 19. Sites' X Species Matrix for Focal Species (Birds Only).

Site	PE	GT	VG	MC	AA	CC	PB	DP	SS
FL16A	X	X	X		X	X	X	X	
FL04H	X	X	X	X	X				X
FL02H	X	X	X	X	X				X
FL07H	X	X	X	X			X		
FL19A	X	X	X		X	X			
FL29P	X	X	X		X	X			
FL15A	X	X	X		X		X		
FL14M	X	X	X			X	X		
FL03H	X	X	X					X	X
FL01H	X	X		X		X		X	
FL06H	X	X		X			X	X	
FL28P	X	X			X	X		X	
FL13M	X	X	X	X					
FL21A	X	X	X	X					
FL17A	X	X	X		X				
FL24S	X	X		X	X				
FL11M	X	X			X			X	
FL09H	X	X				X	X		
FL10M	X	X				X		X	
FL18A	X		X	X				X	
PT24H	X		X			X	X		
FL12M		X		X	X				X
FL22A	X	X		X					
FL23S	X	X		X					
FL25S	X	X			X				
FL26S	X	X			X				

Table 19. (Cont.) Sites X Species Matrix for Focal Species (Birds Only).

Site	PE	GT	VG	MC	AA	CC	PB	DP	SS
FL27P	X	X				X			
PT08P	X	X				X			
FL05H		X				X	X		
PR20P	X	X							
PR23P	X	X							
PR22P	X		X						
FL30P	X						X		
PT21A		X	X						
PT20A		X		X					
FL08H		X			X				
PR24P	X								
PT10P	X								
PR05P	X								
PR10P	X								
PR11P	X								
PR13H	X								
FL20A		X							
PT22H		X							
PT23H		X							
PR21P		X							
PR09P				X					
PT01P									
PT02P									
PT05P									
PT07P									
PT09P									
PT16P									

Table 19. (Cont.) Sites X Species Matrix for Focal Species (Birds Only).

Site	PE	GT	VG	MC	AA	CC	PB	DP	SS
PR01P									
PR02H									
PR03H									
PR06P									
PR07P									
PR08P									
PR14H									

Note: Sites are arranged from most (top) to least (bottom) species-rich, and species are arranged from most (left) to least (right) widespread among sites. Abbreviations refer to binomials in Table 13.

Table 20. Groupings of Sites Derived from Monothetic Divisive Cluster Analysis.

Reference Sites			Reclaimed Sites	
IA	FL12M 1		I	PT08P 1
	FL04H 3			
	FL02H 5		(1) *Bufo quercicus*	
(2) *Sialia sialis*			IIA	PT24H 2
IB	FL16A 2		(2) *Parus bicolor*	
	FL11M 4			
	FL28P 6		IIB	PR20P 3
	FL15A 7			PR23P 3
	FL29P 8			PT20A 5
	FL17A10			PR22P 6
	FL08H			PT21A 7
	FL19A			PT22H 7
	FL24S			PT23H 7
	FL25S			PR21P 7
	FL26S			PR24P
				PT10P
(1) *Aimophila aestivalis*				PR03H
				PR05P
IIA	FL06H 9			PR09P
	FL03H			PR10P
	FL07H			PR11P
	FL13M			PR13H
	FL18A			
	FL20A			

Table 20. (Cont.) Groupings of Sites Derived from Monothetic Divisive Cluster Analysis.

Reference Sites			Reclaimed Sites	
	FL21A			
	FL22A			
	FL23S			
(3) *Cardinalis cardinalis*				
IIB	FL01H			
	FL05H			
	FL09H			
	FL10M			
	FL14M			
	FL27P			
	FL30P			

Note: The species which provided the basis for clustering are listed, and numbered in the order in which the cluster were derived (e.g., the presence/absence of *Aimophila aestivalis* provided the first two clusters of reference sites, I and II). The numbers following the sites designate the ten sites with the largest representation of focal species (quadrupeds + birds). Reclaimed sites PT01P, PT02P, PT07P, PT09P, PT16P, PR01P, PR02H, PR06P, PR07H, PR08P, and PR14H had no focal species.

EXPLANATIONS

FOCAL AND NON-FOCAL SPECIES

For amphibians, reptiles, and mammals (quadrupeds), and for birds, we asked what aspects of their natural histories might distinguish focal from non-focal resident species. Realize that this question is not appropriate for those resident species which occurred at too few reference sites to be recognized mathematically as focal species, and we have, therefore, not included them in the analysis. The excluded species include 13 resident quadruped species (Table 9) and 28 resident bird species (Table 10).

Among quadruped focal species, we found that preferences for breeding sites -- for amphibians -- and for vegetation structures could distinguish most of the focal species from the non-focal species (Table 21). We assume that at least some focal species may be relatively-poor colonizers, as well, but we have no direct evidence to support this assumption.

Two non-focal resident quadruped species, *Eleutherodactylus p. planirostris* (greenhouse frog) and *Hyla squirella* (squirrel treefrog), were not included in Table 21 because they prefer temporary ponds, rather than permanent bodies of water, for breeding. Three other non-focal resident quadruped species, *Anolis c. carolinensis* (green anole), *Thamnophis sauritus sackeni* (ribbon snake), and *Peromyscus gossypinus* (cotton mouse), were not included in Table 21 because they prefer closed, rather than open, areas -- *P. gossypinus*, in fact, is a forest resident. All five of these species are, therefore, more like many of the focal species in habitat preference. All of the species occupied more reference than reclaimed sites, but the discrepancy was not large enough to recognize them as focal species, according to the criterion we employed.

Among birds, we found that vegetation structure alone could distinguish nearly all focal from non-focal resident species (Table 21). The focal species all prefer wooded areas -- some favoring areas with extensive tree canopy and others favoring areas with shrubs or low canopy -- while the non-focal resident species almost all prefer open areas that are conducive to ground foraging. These non-focal resident species may also favor areas with nearby trees, however.

One non-focal resident bird species, *Thryothorus ludovicianus* (Carolina wren), was not included in Table 21 because it prefers closed, rather than open, areas. The species had a much greater discrepancy between the number of reference and reclaimed sites occupied than other non-focal resident bird species, but the discrepancy was not sufficiently large to recognize it as a focal species. Two other non-focal bird resident species, *Picoides pubescens* (downy woodpecker) and *Sayornis phoebe* (eastern phoebe), also were not included in Table 21, because they have no particular preference either for wooded or for open areas.

Table 21. Differences in Habitat Selection by Focal and Non-Focal Resident Species.

Focal Species	Non-Focal Species
I Breeding Site	
Temporary Ponds	Permanent Bodies of Water
Bufo quercicus	*Acris gryllus dorsalis*
Hyla femoralis	*Bufo terrestris*
	Gastrophryne c. carolinensis
	Rana utricularia
II Vegetation Cover	
Canopy/Understory/litter	Open
Eumeces inexpectatus	*Blarina carolinensis*
Aimophila aestivalis	*Cryptotis parva*
Cardinalis cardinalis	*Sigmodon hispidus*
Dendroica pinus	*Colapter auratus*
Geothlypis trichas	*Colinus virginianus*
Melanerpes carolinus	*Columbina passerina*
Parus bicolor	*Mimus polyglottos*
Pipilo eryophthalmus	
Vireo griseus	

Note: The species that did not fit these categories are discussed in text.

Most of the remaining non-focal quadruped and bird species may display a preference for dryer (i.e., more xeric) habitats. We defer their discussion (see "Comparisons Between Mesic and Xeric Habitats"). A single focal species, *Sialia sialis* (eastern bluebird), and three non-focal species, *Hyla cinerea* (green treefrog), *Coluber c. constrictor* (eastern black racer), and *Mus musculus* (house mouse) resist clear categorization.

QUALITY OF SITES AS INDICATED BY FOCAL SPECIES COLLECTIVELY

We compared the rankings of the representation of focal species for each site with as many of the physical variables related to size, distance to seasonal water, distance to permanent water, distance to upland habitats, and presence/absence of cattle grazing as possible. We made the comparisons separately for quadrupeds and birds, and for reference and reclaimed sites. [Note that relationships could be found for either the sites score, which takes only presence/absence into account, or for the adjusted sites score, which also takes relative abundance into account, or for both.] Only size of sites, large vs. small, differed enough among reference sites to produce meaningful comparisons. Representation of focal bird species alone, or focal quadruped and bird species combined (which overwhelmingly is composed of bird species), tended to be higher at reference sites within relatively small locations than at reference sites within relatively large locations (M-W U-test, $p < 0.10$). We can suggest no reason why the representation of focal species should be affected by size of location. It is more likely that the negative correlation between representation of focal species and size of location is spurious, meaning that at least some of the small locations have relatively strong representation for other, at present unknown, reasons. Most of the physical variables- all except distance to permanent water and presence/absence of grazing- differed enough among reclaimed sites to produce meaningful comparisons. None of these physical variables was correlated strongly with representation of quadruped or bird focal species at reclaimed sites, however. This finding does not imply that no such relationships actually might exist (cf. McCoy and Mushinsky 1994, 1999; Mushinsky and McCoy 1996), rather that other variable(s) account more strongly for the differences among reclaimed sites.

We compared the rankings of the representation of focal species for each site with the vegetation variables. We made the comparisons separately for quadrupeds and birds, and then for the two groups combined. We also made the comparisons separately for reference and reclaimed sites. Neither focal quadrupeds nor focal birds had very strong responses, either positive or negative, to the vegetation structure at reference sites, except for foliage layering. The strongest correlations for aspects of vegetation structure other than foliage layering were a positive correlation between amount of grassy ground cover and representation of focal birds ($r_s = 0.26$, $p = 0.17$) and a negative correlation between total density of saw palmetto and representation of focal quadrupeds and birds combined ($r_s = -0.27$, $p = 0.16$). Representation of both focal quadruped and focal bird species tended to be higher at reference sites with a relatively sparse Shrub layer and/or a relatively sparse Upper-Canopy (for sites with an Upper-Canopy). Recall that Middle-Canopy, which proved to be an important aspect of vegetation structure, especially for birds, in our previous study of reference xeric sites (Mushinsky and McCoy 1996), is virtually absent from our reference mesic sites.

Both quadrupeds and birds had much stronger responses to vegetation structure at reclaimed sites than at reference sites. Reclaimed sites with vegetation structure attracted more vertebrates species than those sites with less vegetation. Representation of focal bird species alone or focal quadruped and bird species combined tended to be higher at reclaimed sites with relatively large amounts of woody ground cover, and lower at reclaimed sites with relatively large amounts of bare ground. Representation of quadruped focal species tended to be lower at reclaimed sites with a relatively abundant Shrub layer, but representation of bird focal species tended to be higher at the same kind of reclaimed sites. Representation of quadruped focal species, on the other hand, tended to be higher at reclaimed sites with relatively abundant Upper-Canopy (for those sites with Upper-Canopy). Recall that Middle-Canopy is missing entirely at reclaimed sites. Representation of bird focal species tended to be higher at reclaimed sites with relatively high densities of *Pinus* spp., both short and tall, and/or tall *Quercus* spp.

All of these results indicate the following:

- At reference sites, the group of focal species is strongly linked to relatively open sites, which lack a relatively dense Shrub layer and/or Upper-Canopy.

- At reclaimed sites, the group of focal species is strongly linked to more closed sites, which possess relatively dense Ground and/or Shrub layers (birds) or Upper-Canopy (quadrupeds). Dense Ground and Shrub layers accompany relatively high densities of virtually any plant species (i.e., *Pinus* spp., *Quercus* spp., saw palmetto, shrubs).

For reclaimed sites, we compared the representation of focal species with the time that has elapsed since reclamation procedures were initiated. Representation of quadruped and bird species combined tended to be greater for older reclaimed sites. This relationship is of relatively minor importance, however, to the relationships between representation of focal species and the variables associated with vegetation structure (see "Comparisons Between Mesic and Xeric Habitats"). In other words, time alone may not heal the reclaimed sites sufficiently to attract a representative vertebrate fauna. With the passage of time, vegetative cover increases at reclaimed sites and colonists likely will have a greater opportunity to find and establish a population on a relatively old reclaimed patch of land. Without a proper initial reclamation effort to jumpstart the recovery process, however, we doubt that a representative vertebrate fauna will become established.

We asked the question: If we chose only the "best" reference or reclaimed sites, as indicated by high representation of focal species, what physical and/or vegetation variables then would correlate most strongly with representation? In other words, this procedure should reveal reasons for a second level of habitat choice by the focal species, a level nested within the group of sites already chosen by them for, perhaps, other reasons. We selected the set of "best" reference sites as the smallest set of sites, beginning with the highest ranking site in terms of representation of focal species, that cumulatively contained the entire collection of focal species. We selected the set of "best" reclaimed sites as the set of sites that each contained at least one focal species. We made these choices independently for quadrupeds and for birds.

Relationships between representation of focal species and the physical and vegetation variables were fewer for reference sites than for reclaimed sites. The best reference sites for quadrupeds (n = 2) tended to have a relatively high total density of saw palmetto (M-W U-test, $p < 0.10$). The best reference sites for birds (n = 2) tended to have a relatively sparse Shrub layer, as did the best reference sites for quadrupeds and birds combined (n = 3). The best reclaimed sites for quadrupeds (n = 3) showed a marginal tendency to have a relatively high amount of grassy ground cover (M-W U-test, p = 0.13) and a relatively high total density of saw palmetto (M-W U-test, p = 0.12). The best reclaimed sites for birds (n = 18), which were also the best sites for quadrupeds and birds combined, tended to have a relatively high amount of woody ground cover, a relatively dense Shrub layer and Upper-Canopy (for sites with Upper-Canopy), relatively dense tall *Pinus* spp. and *Quercus* spp., and a low amount of bare ground.

All of these results indicate the following:

- At the best reference sites, focal bird species respond positively to the absence of one kind of structure, a Shrub layer, but the quadrupeds respond positively to presence of another, similar, kind of structure, saw palmetto.

- At the best reclaimed sites, both bird and quadruped focal species respond positively to presence of a virtually any kind of vegetation structure.

QUALITY OF SITES AS INDICATED BY FOCAL SPECIES INDIVIDUALLY

We used the sites score, which takes only presence/absence into account, and the adjusted sites score, which also takes relative abundance into account, for each focal species (Table 13) to examine habitat choice more closely. We did this by comparing the physical and vegetation variables of sites where a particular species occurred with those variables at sites where it did not, for each of the 12 focal species. The results for the physical variables indicate that small size of reference sites is important for several species, but that none of the physical variables is important for the reclaimed sites, for any species. We have already indicated why these relationships may not be meaningful for the focal species taken as a group, and the same arguments likely apply to individual focal species, as well.

The results for the vegetation variables are presented in three tables, one concerning the vegetation variables relating to life-form coverage, one concerning the vegetation variables relating to vegetation layers, and one concerning the vegetation variables relating to plant density. The results for life-form coverage (Table 22) show that about one-quarter of the species seem to prefer relatively large amounts of woody and/or grassy ground cover, particularly at reclaimed sites. The results also show that about one-sixth of the species seem not to prefer relatively large amounts of bare ground. The results for foliage layers (Table 23) show that two-thirds of the bird focal species respond strongly to the Shrub layer at reference sites, but approximately equal numbers seem to prefer a relatively large layer and a relatively small layer. A few bird focal species also seem to prefer a relatively large Shrub layer or Upper-Canopy (for sites with an Upper-Canopy) at reclaimed sites. The meaning, if any, of the results for quadrupeds

Table 22. Individual Focal Species' Responses to Life-Form Categories.

Species		Life-Form Category				
		WD	WG	OG	LT	BG
Bufo quercicus	Reference Sites					
	Reclaimed Sites					
Eumeces inexpectatus	Reference Sites	H				
	Reclaimed Sites			H		L
Hyla femoralis	Reference Sites					
	Reclaimed Sites					
Aimophila aestivalis	Reference Sites				H	
	Reclaimed Sites					
Cardinalis cardinalis	Reference Sites	L				
	Reclaimed Sites					
Dendroica pinus	Reference Sites					
	Reclaimed Sites					
Geothlypis trichas	Reference Sites					
	Reclaimed Sites	H				L
Melanerpes carolinus	Reference Sites					
	Reclaimed Sites					
Parus bicolor	Reference Sites		H			
	Reclaimed Sites	H				
Pipilo eryophthalmus	Reference Sites					
	Reclaimed Sites					
Sialia sialis	Reference Sites					
	Reclaimed Sites					
Vireo griseus	Reference Sites					
	Reclaimed Sites					L

Note: WD = woody vegetation, WG = wiregrass, OG = other grasses, LT = litter, BG = bare ground. H = prefers high values, L = prefers low values; blank indicates no preference detected.

is not clear. The results for plant density (Table 24) show that some of the focal bird species seem to prefer a relatively high density of certain plant species, especially tall *Pinus* and *Quercus* spp. at reclaimed sites.

Table 23. Individual Focal Species' Responses to Foliage Layers.

Species		Foliage Layer			
		GRD	SHB	MID	UPR
Bufo quercicus	Reference Sites				H
	Reclaimed Sites				
Eumeces inexpectatus	Reference Sites				
	Reclaimed Sites				
Hyla femoralis	Reference Sites		L		L
	Reclaimed Sites				
Aimophila aestivalis	Reference Sites		L		
	Reclaimed Sites				
Cardinalis cardinalis	Reference Sites		H		
	Reclaimed Sites				
Dendroica pinus	Reference Sites		H		
	Reclaimed Sites				
Geothlypis trichas	Reference Sites		H		
	Reclaimed Sites				
Melanerpes carolinus	Reference Sites		L		
	Reclaimed Sites				H
Parus bicolor	Reference Sites		L		
	Reclaimed Sites				
Pipilo eryophthalmus	Reference Sites				
	Reclaimed Sites		H		
Sialia sialis	Reference Sites		L		
	Reclaimed Sites				
Vireo griseus	Reference Sites				H
	Reclaimed Sites				

Note: GRD = Ground layer, SHB = Shrub layer, MID = Middle-Canopy, UPR = Upper-Canopy. H = prefers high values, L = prefers low values; blank indicates no preference detected. First line for each species is reference sites, second line is reclaimed sites.

Table 24. Individual Focal Species' Responses to Plant Density.

Species		Plant						
		SP	SPI	TPI	SSH	TSH	SQU	TQU
Bufo quercicus	Reference Sites							
	Reclaimed Sites							
Eumeces inexpectatus	Reference Sites							
	Reclaimed Sites							
Hyla femoralis	Reference Sites							
	Reclaimed Sites							
Aimophila aestivalis	Reference Sites							
	Reclaimed Sites							
Cardinalis cardinalis	Reference Sites			H				
	Reclaimed Sites							
Dendroica pinus	Reference Sites							
	Reclaimed Sites							
Geothlypis trichas	Reference Sites							
	Reclaimed Sites			H				H
Melanerpes carolinus	Reference Sites		H					

Table 24. (Cont.) Individual Focal Species' Responses to Plant Density.

Species	Plant							
Parus bicolor	Reference Sites							
	Reclaimed Sites							
Pipilo eryophthalmus	Reference Sites							
	Reclaimed Sites							
Sialia sialis	Reference Sites							
	Reclaimed Sites							
Vireo griseus	Reference Sites							
	Reclaimed Sites			H				H

Note: SP = saw palmetto, SPI/TPI = *Pinus* spp. (short/tall), SSH/TSH = shrubs, SQU/TQU = *Quercus* spp. H = prefers high values, L = prefers low values; blank indicates no preference detected.

COMPARISON BETWEEN MESIC AND XERIC HABITATS

In this section, we compare the data gathered in this study, on mesic flatlands, with data gathered previously, on xeric uplands (Mushinsky and McCoy 1996). We shall refer to these two studies in the rest of the section as “the mesic study” and “the xeric study,” respectively. We shall illustrate the similarities and differences between both habitat variables and vertebrate species in the two studies. We shall then discuss the implications of these similarities and differences for reclamation of phosphate-mined lands.

SITES AND PHYSICAL VARIABLES

The xeric study incorporated a total of 60 sites, 30 previously-mined (“reclaimed”) sites and 30 reference (“reference”) sites. The mesic study also incorporated 60 sites, divided evenly between reference and reclaimed sites. All 30 mesic reference sites and 10 mesic reclaimed sites were new sites. The 30 reference sites were distributed among 7 distinct locations, and the 10 reclaimed sites among 4 distinct locations. An additional 20 reclaimed sites were chosen from among the 30 reclaimed sites used in the xeric study. These previously-used sites were selected because we judged them to be the least xeric in nature. In other words, we created a dichotomy among the 40 reclaimed sites we studied. The most “xeric-like” reclaimed sites were used for comparisons with unmined xeric habitats, and the 30 most “mesic-like” reclaimed sites were used for comparisons with the unmined mesic habitats.

Size

- 18 xeric reference sites were less than 25 ha in size, 5 mesic reference locations were more than 25 ha in size
- 20 xeric reclaimed sites were less than 25 ha in size, 3 mesic reclaimed locations were more than 25 ha in size

Isolation

- Most (24) xeric reference sites and all mesic reference sites were less than 300 m from similar habitats
- Most (21) xeric reclaimed sites and most (23) mesic reclaimed sites were more than 300 m from habitats similar to those at the reference sites
- Most (22) xeric reference sites were less than 300 m from both standing and permanent water, and all mesic reference sites were less than 300 m from

standing water, but more than 300 m from permanent water

- Most (24 and 23, respectively) xeric reclaimed sites and most (24 and 21, respectively) mesic reclaimed sites were less than 300 m from both standing and permanent water

Surrounding Habitats

Some sharp contrasts in the identities of surrounding habitats exist between xeric and mesic sites, especially reference sites (Figure 9).

- Numbers of mesic and xeric sites surrounded by undeveloped land were similar

Cattle Grazing

- 13 xeric reference sites and 4 mesic reference sites had cattle grazing at them
- 4 xeric reclaimed sites and 5 mesic reclaimed sites had cattle grazing at them

Reclamation Treatments

- Mesic sites could not be shown to be different than xeric sites, because the power of the test was relatively low

SOILS

Texture

Soil texture at all sites was dominated by the sand component. At both 0-15 cm and 15-30 cm depths, xeric reference sites (n = 30) averaged about 95% sand (about 1.5% silt and 3.5% clay), and xeric reclaimed sites (n = 30) averaged about 92.5% sand (about 2% silt and 5.5% clay). Xeric reclaimed sites tended to have lower percentages of sand and higher percentages of clay than xeric reference sites. At both 0-15 cm and 15-30 cm depths, mesic reference sites (n = 30) averaged about 93% sand (about 4% silt and 3% clay), and mesic reclaimed sites (n = 10) averaged about 92% sand (about 3.5% silt and 4.5% clay). The reclaimed sites could not be shown to be different than the reference sites, because the power of the test was relatively low.

- Soil texture was similar at mesic and xeric sites, and could not be shown to be different between the two kinds of sites, because variability was relatively high

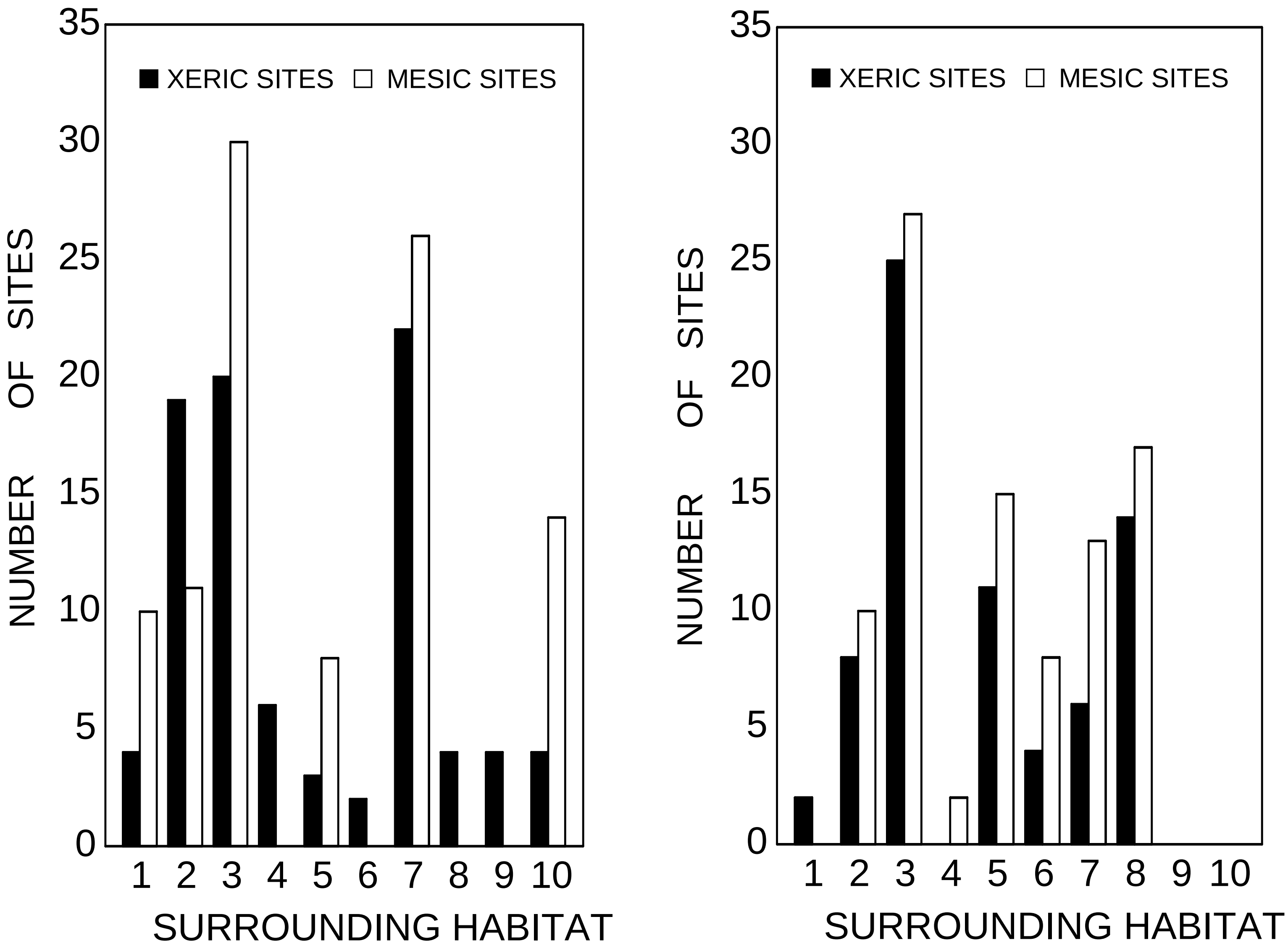


Figure 9. Numbers of Sites with Various Kinds of Habitat Adjacent to Them. Kinds of Habitat (1-10) Are Identified. Reference Sites Are on the Left, Reclaimed Sites on the Right.

Particle Size

Soil particle size at all sites was dominated by the medium and fine components (Figure 10). Soils at xeric reclaimed sites tended to have higher percentages of coarse and very coarse particles and lower percentages of very fine particles than soils at xeric reference sites, for both 0-15 cm and 15-30 cm depths combined. Soils at mesic reclaimed sites tended to have higher percentages of fine particles and lower percentages of very fine particles than soils at mesic reference sites, for both 0-15 cm and 15-30 cm depths combined.

- Soil particle size was similar at mesic and xeric sites, and could not be shown to be different between the two kinds of sites, because variability was relatively high

Especially notable was the variability among mesic sites: for example, soil particle size distributions were substantially different for sites at two of the reference locations (MY, ST) than for sites at the other reference locations, and for sites at two of the reclaimed locations (CJ, NW) than for sites at the other reclaimed locations.

Chemistry

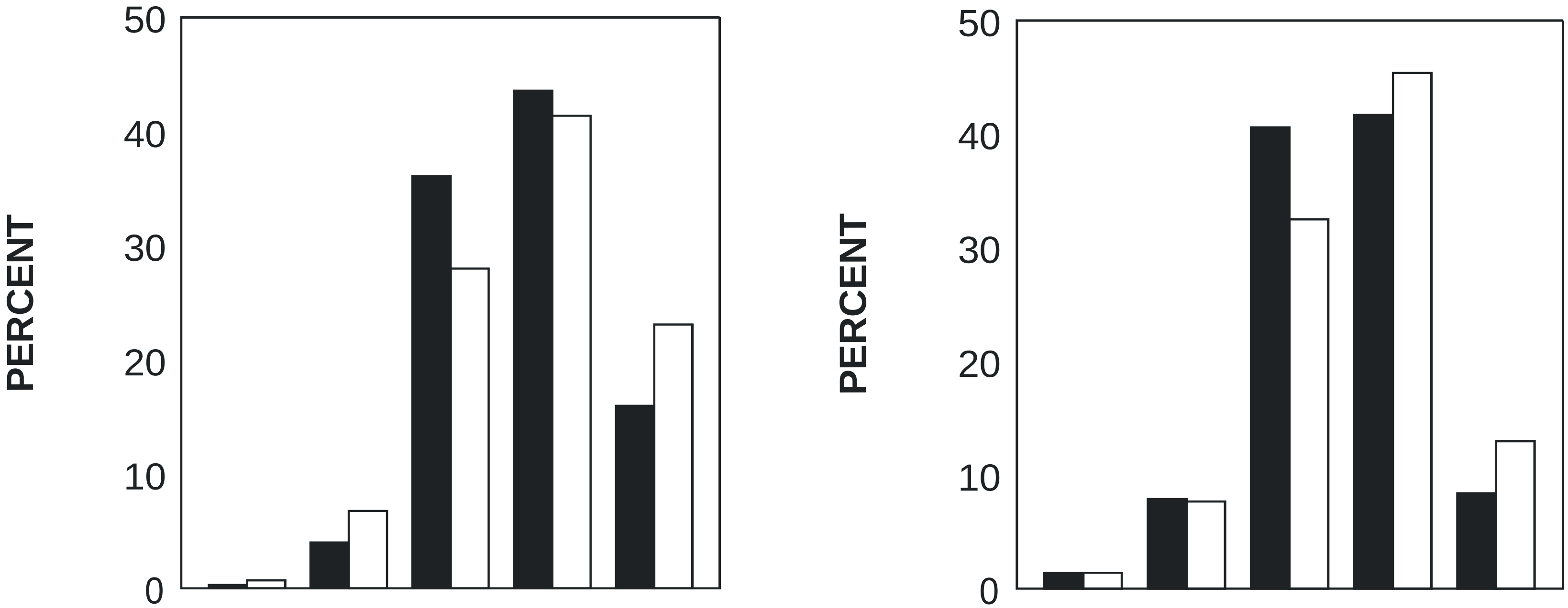
Important aspects of soil chemistry measured included pH, organic content, and K, P, and N levels (Figure 11). Soils at xeric reclaimed sites tended to have higher pH, K, and P, and lower organic content than soils at xeric reference sites, for both 0-15 cm and 15-30 cm depths combined. Soils at mesic reclaimed sites tended to have higher pH and P, and lower organic content than soils at mesic reference sites, for both 0-15 cm and 15-30 cm depths combined.

- Soil chemistry was similar at mesic and xeric sites (N levels at reference sites and P levels at reclaimed sites were possible exceptions), and could not be shown to be different between the xeric and mesic sites, because variability was relatively high

VEGETATION

Life-Form Coverage

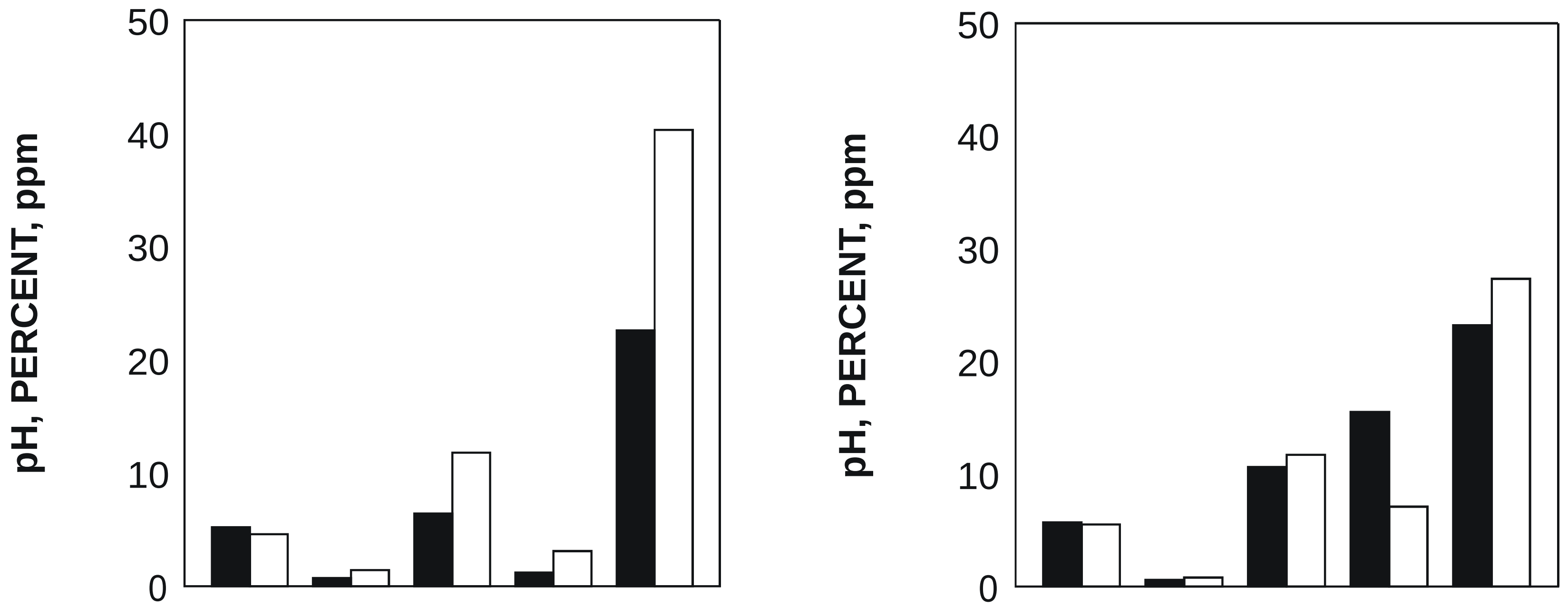
Life-form coverage included percentage of the ground surface covered by eight different coverage types (Figure 12). Coverage at both xeric and mesic reference sites was dominated by woody species, litter, and wiregrass (86.1% and 86.6%, respectively). Coverage at xeric reclaimed sites was dominated by grasses other than wiregrass, legumes, forbs, and bare ground (88.2%), and coverage at mesic reclaimed sites was dominated by grasses other than wiregrass and woody species (83.3%). Xeric reclaimed



	V. COARSE	COARSE	MEDIUM	FINE	V. FINE
XERIC SITES ■	0.3	4.0	36.1	43.6	16.0
MESIC SITES □	0.7	6.8	28.0	41.4	23.1

	V. COARSE	COARSE	MEDIUM	FINE	V. FINE
XERIC SITES ■	1.4	7.9	40.6	41.7	8.4
MESIC SITES □	1.4	7.7	32.5	45.4	13.0

Figure 10. Soil Texture, Averaged Over All Samples. Reference Sites Are on the Left, Reclaimed Sites on the Right.



	pH	ORGANICS	K	P	N
XERIC SITES ■	5.2	0.7	6.4	1.2	22.6
MESIC SITES □	4.6	1.4	11.8	3.1	40.3

	pH	ORGANICS	K	P	N
XERIC SITES ■	5.7	0.6	10.6	15.5	23.2
MESIC SITES □	5.5	0.8	11.7	7.1	27.3

Figure 11. Soil Chemistry, Averaged Over All Samples. Reference Sites Are on the Left, Reclaimed Sites on the Right.

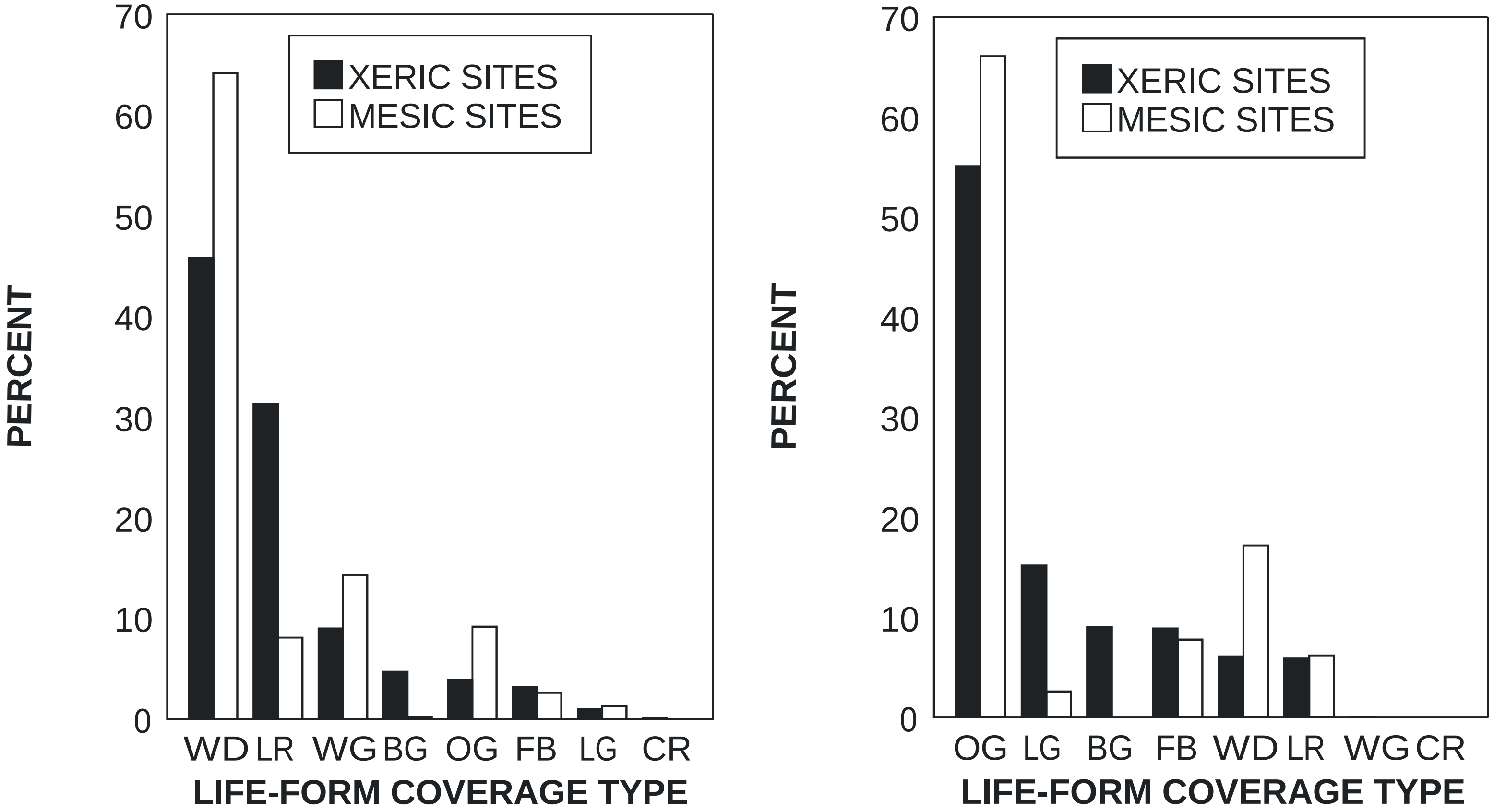


Figure 12. Percent Coverage of Life-Form Categories, Averaged Over All Samples. Categories (WD-CR) Are Identified in Text. Reference Sites Are on the Left, Reclaimed Sites on the Right.

sites tended to have less woody species and litter, but more grasses other than wiregrass and legumes, than xeric reference sites. Mesic reclaimed sites tended to have less woody species and wiregrass, but more grasses other than wiregrass than mesic reference sites. The distribution of coverage types was less even for both xeric and mesic reclaimed sites than the distribution for the respective reference sites.

- Although variability was relatively high, mesic sites, both reference and reclaimed, tended to have larger percentages of woody species and grassy coverage than xeric sites

Foliage Layers

Foliage layering included percentage of the foliage in seven different layers (Figure 13). For both xeric and mesic sites, reclaimed sites had lower evenness than reference sites. Reclaimed sites also had no middle canopy layer and the foliage tended to be absolutely shorter than that at reference site: an average of 11.69 m and 4.92 m for xeric reference and reclaimed sites, respectively; 16.55 m and 6.42 m for mesic reference and reclaimed sites, respectively.

- Although variability was relatively high, xeric reference sites tended to have relatively larger middle-canopy layers and gaps between middle- and upper-canopy layers than mesic reference sites (middle-canopy was missing entirely from many mesic sites)

- Although variability was relatively high, mesic reclaimed sites tended to have relatively larger shrub layers than xeric reclaimed sites

Horizontal and Vertical Canopy Closure

Horizontal canopy closure measurements were taken at two heights and vertical canopy closure measurements at four heights (Figure 14). Both horizontal and vertical canopy closure tended to be lower, in general, at xeric reclaimed sites than at xeric reference sites, but higher, in general, at mesic reclaimed sites than at mesic reference sites.

- Although variability was relatively high, xeric reference sites tended to have greater horizontal and vertical canopy closure, at all heights, than mesic reference sites

- Although variability was relatively high, mesic reclaimed sites tended to have greater horizontal and vertical canopy closure, at all heights, than xeric reclaimed sites

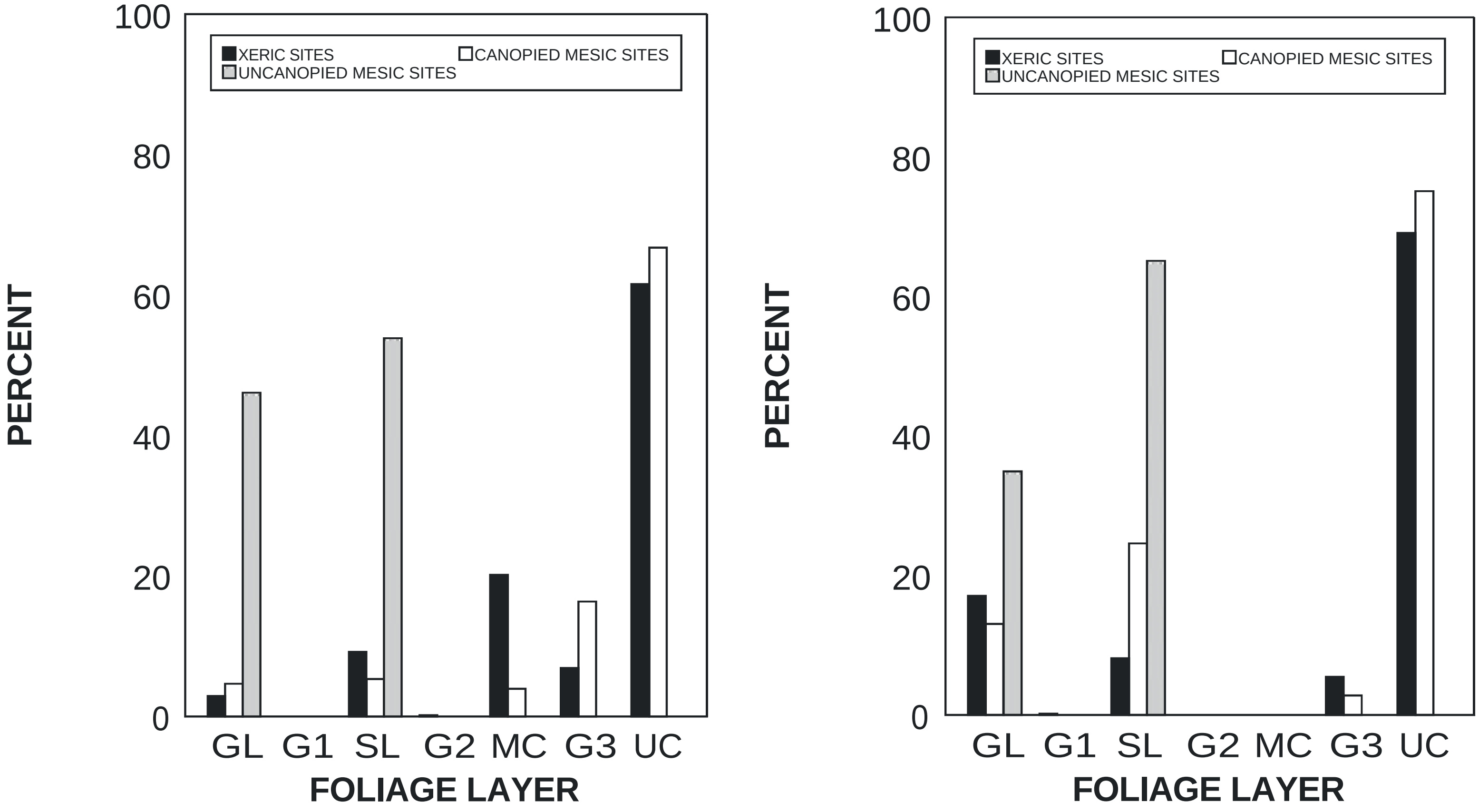


Figure 13. Percent Coverage of Foliage Layers, Averaged Over All Samples. Categories (GL-UC) Are Identified in Text. Reference Sites Are on the Left, Reclaimed Sites on the Right.

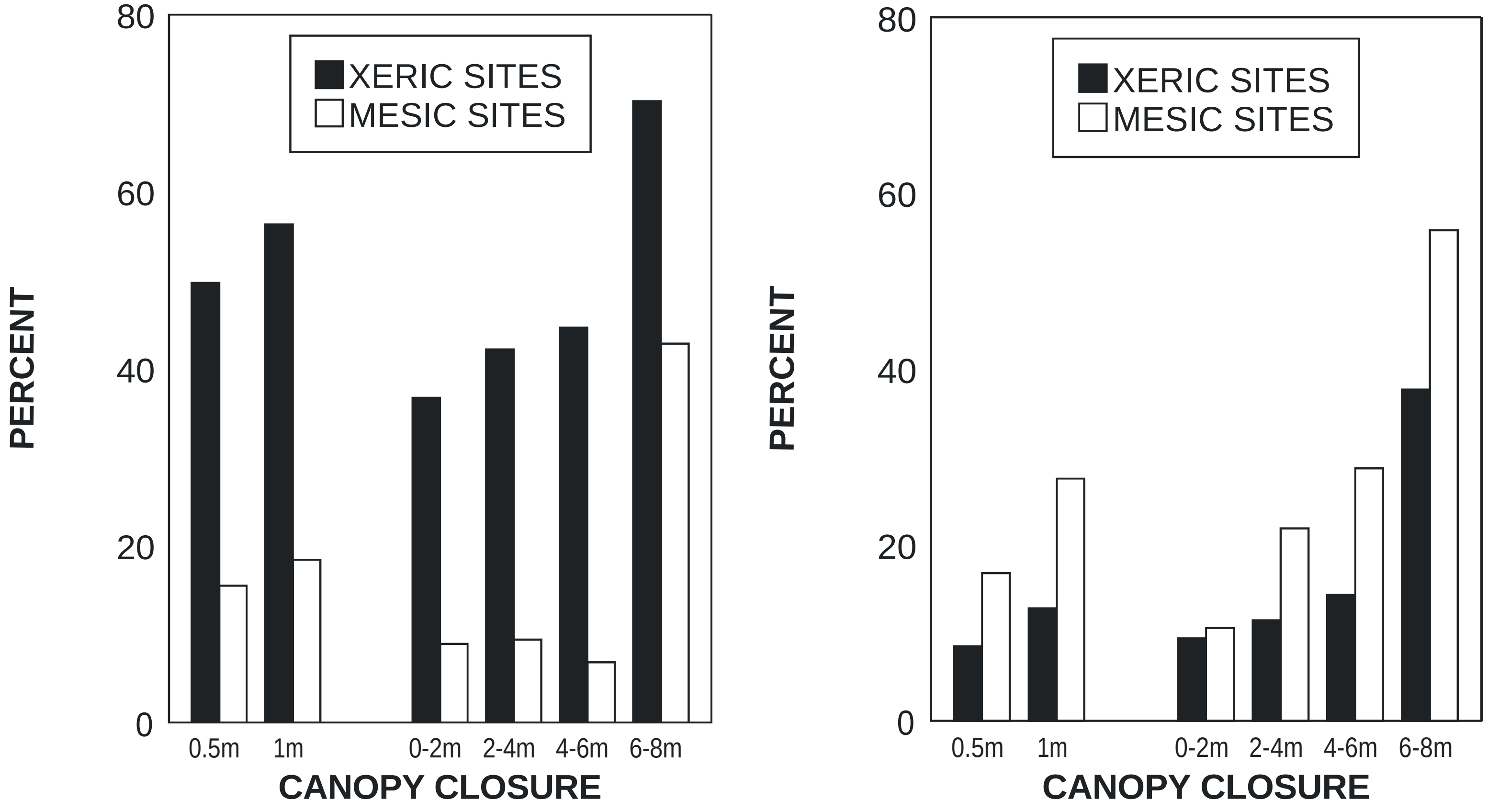


Figure 14. Percent Canopy Closure, Averaged Over All Sites. Reference Sites Are on the Left, Reclaimed Sites on the Right. Horizontal Closure Is on the Left of Each Panel, Vertical Closure on the Right.

Plant Density

Comparisons of plant density measurements include saw palmetto, pines, oaks, and snags (Figure 15). Other tree species and shrub species were not included. All height classes of plants tended to be less dense at xeric reclaimed sites than at xeric reference sites, with the exception of tall pines (and other tree species). All height classes of saw palmetto tended to be less dense, and all height classes of oaks more dense, at mesic reclaimed sites than at xeric reclaimed sites. Snags (and shrubs) were missing almost entirely from mesic reclaimed sites.

- Although variability was relatively high, xeric reference sites tended to have higher densities of oaks, but lower densities of saw palmetto, than mesic reference sites

- Although variability was relatively high, xeric reclaimed sites tended to have higher densities of oaks, but lower densities of tall pines, than mesic reclaimed sites

VERTEBRATES

Resident Species

About 65% and 49% of the potential resident species were captured or observed at the xeric sites and mesic sites, respectively (Table 25). About half of the species that were considered residents in only one study (i.e., were not considered resident species at both xeric and mesic sites) were considered transients in the other study. Six species were considered transients in both studies. The potential overlap in resident species between xeric and mesic sites was about 59%, and the actual overlap was about 50% (Table 26).

Numbers of Sites

Distributions of resident species among sites varied between reference and reclaimed sites and between xeric and mesic studies (Figures 16A and 16B). The median number of xeric reference sites occupied by a resident species was 9 for quadrupeds and 6 for birds, and the median number of mesic reference sites occupied by a species was 4 for quadrupeds and 1 for birds. The median number of xeric reclaimed sites occupied by a resident species was 2 for quadrupeds and 2 for birds, and the median number of mesic reclaimed sites occupied by a species was 2 for quadrupeds and 1 for birds.

- Distributions of resident species among sites tended to be more even at xeric reference sites than at mesic reference sites, and, median numbers of sites occupied by a resident species tended to be higher at xeric than at mesic reference sites

- Distributions of resident species among sites were relatively similar at xeric and mesic reclaimed sites

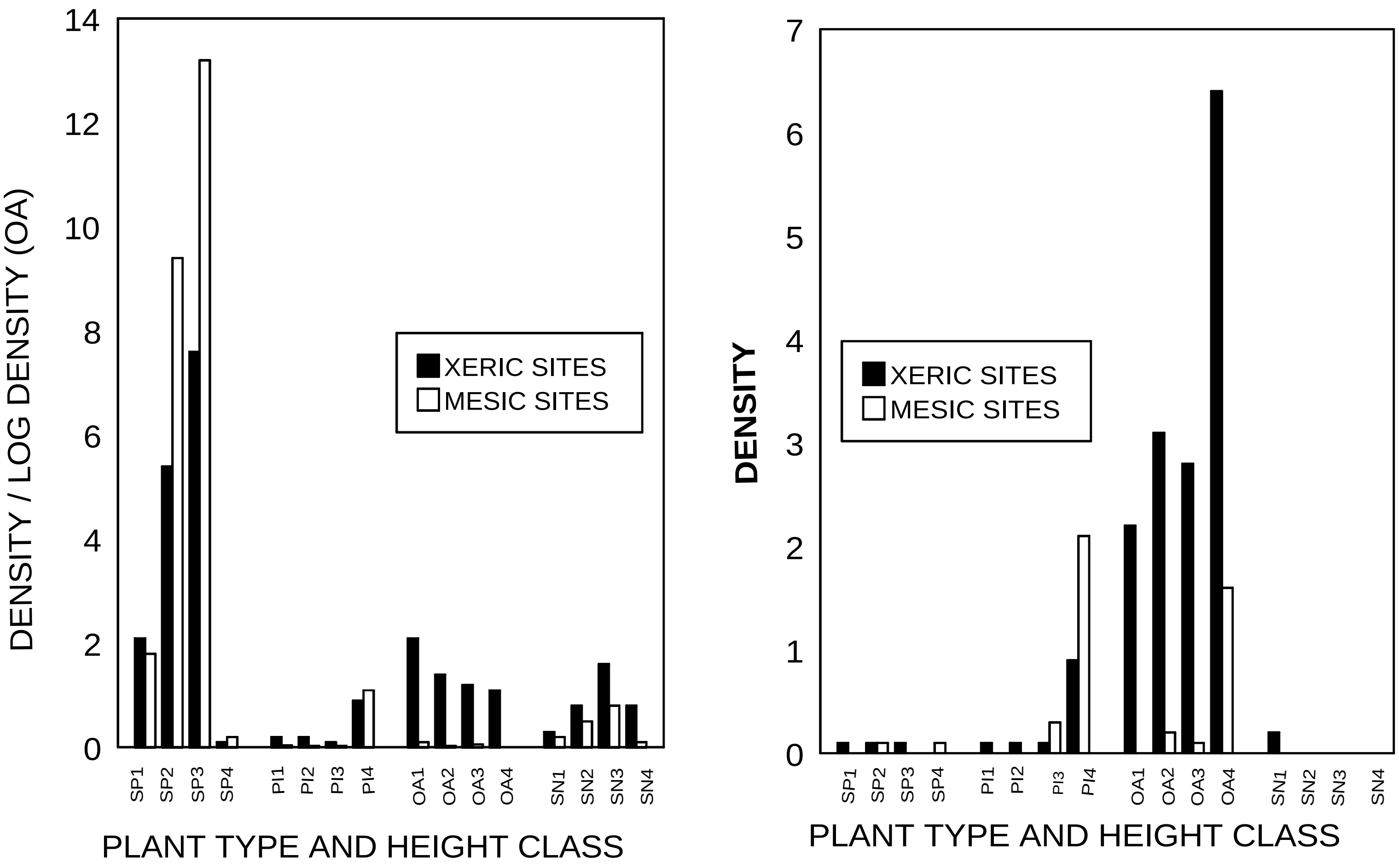


Figure 15. Density of Height Classes of Plant Types. Categories (SP1-SN4) Are Identified in Text. Reference Sites Are on the Left, Reclaimed Sites on the Right.

Table 25. Potential and Actual Resident and Transient Species Captured/Observed During the Xeric and Mesic Studies.

	Potential			Actual	
	Xeric	Mesic		Xeric	Mesic
Resident Species					
Amphibians	10	14		9	12
Reptiles	35	34		24	17
Mammals	7 (26)	7 (31)		7	6
Birds	69	109		39	46
Total	121	164		79	81
Transient Species					
Amphibians	9	9		3	3
Reptiles	8	9		6	7
Mammals	6 (12)	5 (13)		3	4
Birds	56	61		13	4
Total	79	84		25	26

Note: Figures for mammals include only trappable species, but total species are given in parentheses.

Table 26. Potential and Actual Resident Species Captured/Observed Only During the Xeric Study, Only During the Mesic Study, or During Both Studies.

	Xeric Only	Both	Mesic Only
Potential Resident Species			
Amphibians	0	10	4 (4)
Lizards/turtles	6 (1)	9	1 (1)
Snakes	1 (1)	19	4 (3)
Mammals	3 (2)	4	3 (3)
Birds	5 (5)	64	45 (17)
Total	15	106	57
Actual Resident Species			
Amphibians	0	9	3 (2)
Lizards/turtles	3 (1)	6	0
Snakes	8 (0)	7	4 (3)
Mammals	3 (2)	4	2 (1)
Birds	10 (1)	29	17 (7)
Total	24	55	26

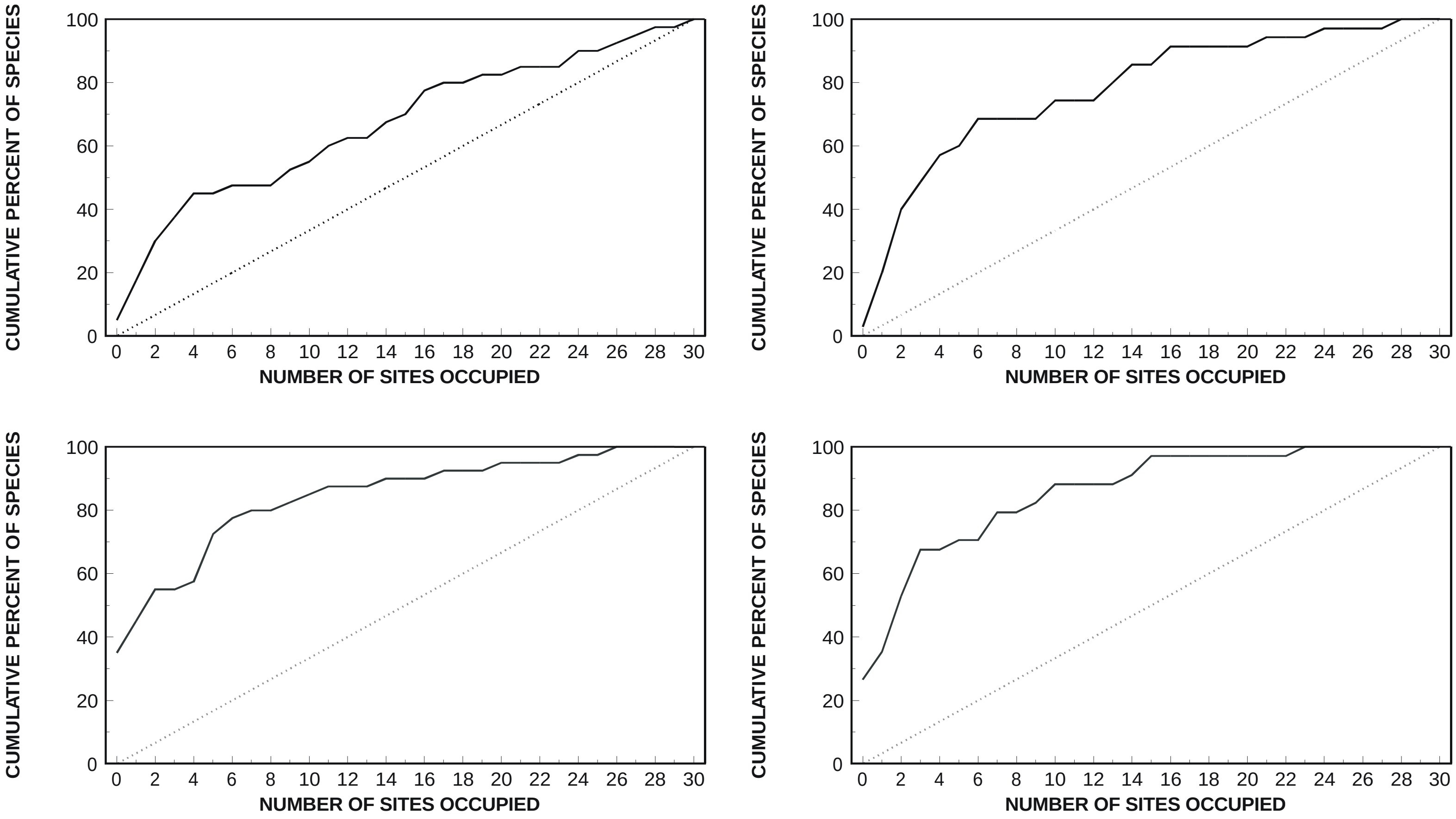


Figure 16A. Cumulative Distribution of Quadruped Species Occupying Increasing Numbers of Sites. Reference Sites Are on the Left, Reclaimed Sites on the Right; Xeric Sites Are on the Top, Mesic Sites on the Bottom. Dashed Lines Indicate an Even Distribution.

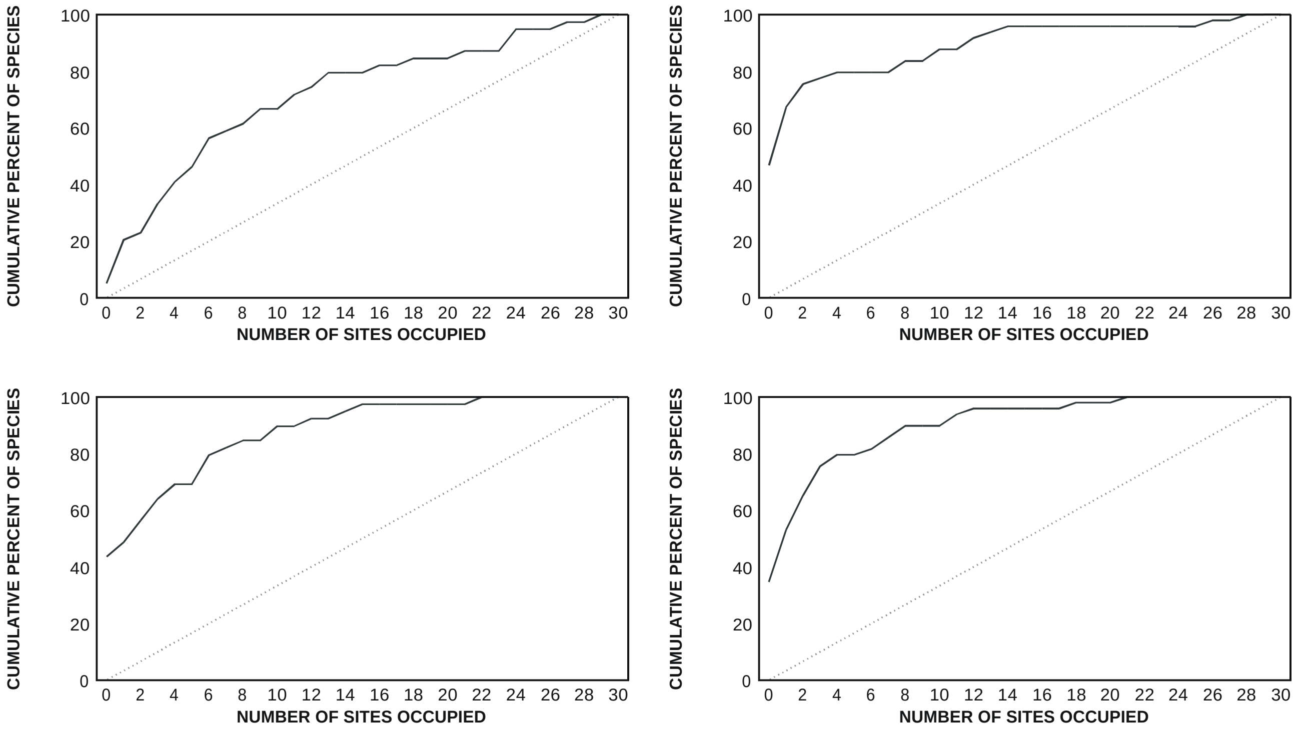


Figure 16B. Cumulative Distribution of Percent of Bird Species Occupying Increasing Numbers of Sites. Reference Sites Are on the Left, Reclaimed Sites on the Right; Xeric Sites Are on the Top, Mesic Sites on the Bottom. Dashed Lines Indicate an Even Distribution.

Numbers of xeric reference and reclaimed sites occupied tended to be positively related for amphibians, lizards/turtles, and birds (but not for snakes or mammals); and numbers of mesic reference and reclaimed sites occupied tended to be positively related for lizards/turtles and mammals (but not for amphibians, snakes, or birds). The relationships in the mesic study remained the same when locations, rather than sites, were employed, except that numbers of sites occupied tended to be positively related for birds. All of these positive relationships held when only the 10 new reclaimed sites were included, but they disappeared when the 20 reclaimed sites from the xeric study were added to raise the total number of reclaimed sites to 30.

Numbers of Individuals

Relative abundance distributions (individuals and/or observations) of resident species varied between reference and reclaimed sites and between xeric and mesic studies (Figure 17). Distributions were less even at reclaimed sites, primarily because of the relatively large number of species that did not occur at reclaimed sites, and because of the predominance of a few species, primarily at mesic sites. Included are *Gastrophryne carolinensis* (narrowmouth toad), *Hyla squirella* (squirrel treefrog), *Blarina carolinensis*(short-tailed shrew), and *Agelaius phoeniceus* (red-winged blackbird).

- Relative abundance distributions tended to be more even at xeric sites, both reference and reclaimed, than at mesic sites

Abundances at xeric reference and reclaimed sites tended to be positively related for amphibians, lizards/turtles, and mammals (but not for snakes or birds); and abundances at mesic reference and reclaimed sites tended to be positively related for lizards/turtles and birds (but not for amphibians, snakes, or birds). The relationships in the mesic study remained the same when locations, rather than sites, were employed. The relationships in the mesic study also remained the same when the 20 reclaimed sites from the xeric study were added, except that the positive relationship for birds disappeared.

Abundances at xeric sites, both reference and reclaimed, tended to be positively related to number of sites occupied for amphibians, snakes, mammals, and birds (but not lizards/turtles). Abundances at mesic reference sites tended to be positively related to number of sites occupied for amphibians, lizards/turtles, and birds (but not snakes or mammals); abundances at mesic reclaimed sites tended to be positively related to number of sites occupied for amphibians, lizards/turtles, mammals, and birds (but not snakes).

Focal Species

The total list of focal species, from the xeric and mesic studies combined, includes 5 amphibians, 8 reptiles, 1 mammal, and 17 birds (Table 27). Of these 31 species, 19 were designated as focal species only in the xeric study, 3 as focal species only in the

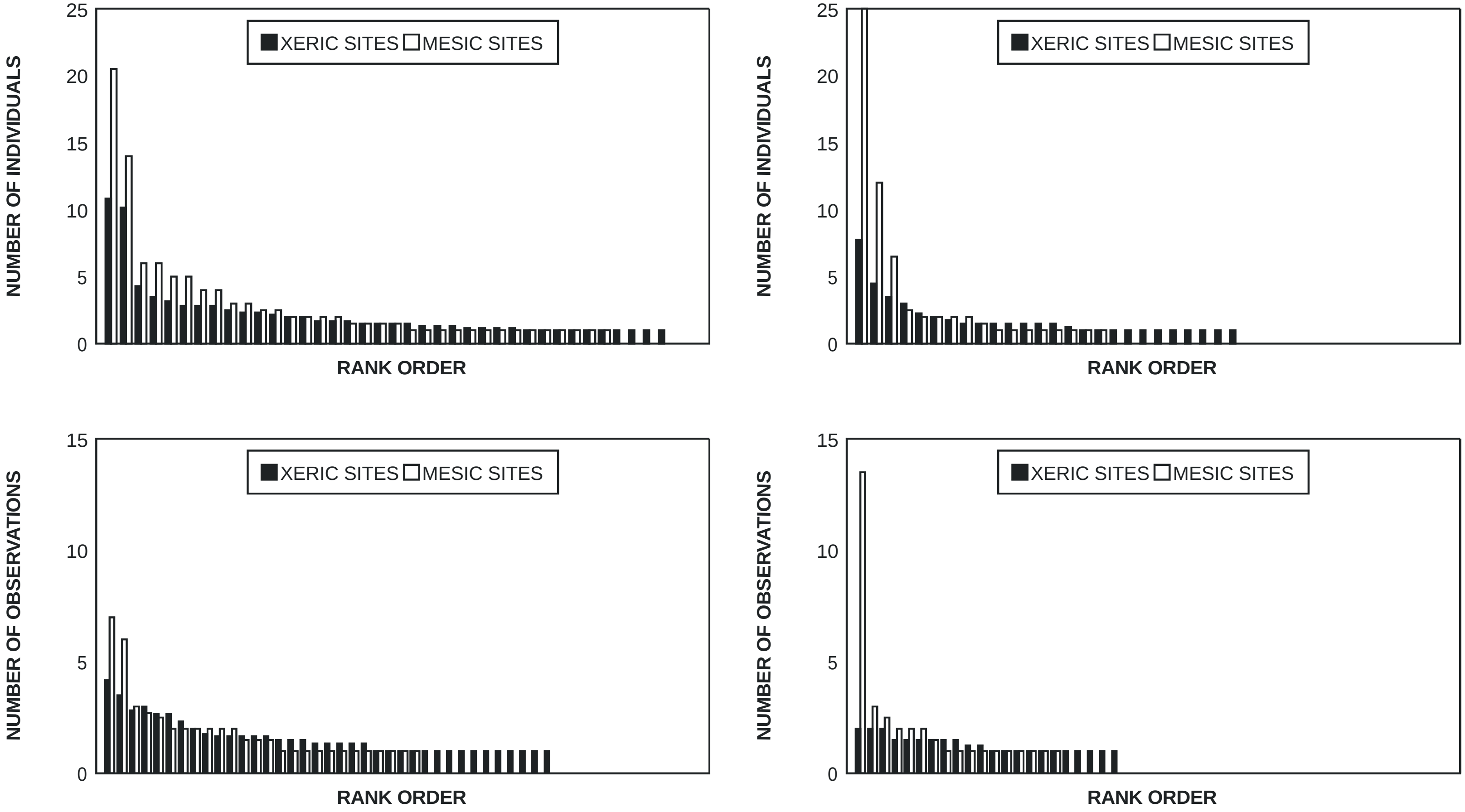


Figure 17. Median Numbers of Individuals at Sites, with Sites Arranged in Rank Order. (Reference Sites Are on the Left, Reclaimed Sites on the Right; Quadrupeds Are on the Top, Birds on the Bottom.)

Table 27. Total List of Focal Species Captured/Observed During the Xeric and Mesic Studies.

	Study	
Species	Xeric	Mesic
Bufo quercicus	Yes	Yes
Eleutheodactylus p. planirostris	Yes	No
Hyla femoralis	Yes	Yes
Hyla squirella	Yes	No
Scaphiopus h. holbrooki	Yes	No
Anolis carolinensis	Yes	No
Cemophora c. coccinea	Yes	No
Drymarchon corais couperi	Yes	No
Eumeces inexpectatus	Yes	Yes
Gopherus polyphemus	Yes	No
Sceloporus u. undulatus	Yes	No
Scincella laterale	Yes	No
Tantilla relicta neilli	Yes	No
Podomys floridanus	Yes	No
Aimophila aestivalis	No	Yes
Aphelocoma coerulescens	Yes	No
Caprimulgus carolinensis	Yes	No
Cardinalis cardinalis	Yes	Yes
Cyanocitta cristata	Yes	No
Dendroica pinus	Yes	Yes
Geothlypis trichas	No	Yes
Melanerpes carolinus	Yes	Yes
Myiarchus crinitus	Yes	No
Parula americana	Yes	No

Table 27. (Cont.) Total List of Focal Species Captured/Observed During the Xeric and Mesic Studies.

	Study	
Species	Xeric	Mesic
Parus bicolor	Yes	Yes
Pipilo erythrophthalmus	Yes	Yes
Polioptila caerulea	Yes	No
Setophaga ruticilla	Yes	No
Sialia sialis	No	Yes
Thryothorus ludovicianus	Yes	No
Vireo griseus	Yes	No

mesic study, and 9 as focal species in both studies. Two of the focal species unique to the xeric study were not considered resident species in the mesic study, and neither was captured/observed at the mesic sites. All 3 of the focal species unique to the mesic study were not considered resident species in the xeric study; 2 would have qualified as focal species had they been considered resident species and the other was not observed at the xeric sites. Of the remaining 17 species, 13 simply were captured at too few sites during the mesic study to be considered focal species. All but 3 of these species were captured/observed at more mesic reference than mesic reclaimed sites, however. The remaining 4 species, *Hyla squirella* (squirrel treefrog), *Anolis carolinensis* (green anole), *Scincella laterale* (ground skink), and *Thryothorus ludovicianus* (Carolina wren), were captured at enough sites during the mesic study to have been considered focal species, but they were not.

- The list of focal species is larger for xeric sites (28) than for mesic sites (12)
- The smaller list of focal species at mesic sites largely is a function of the narrower distribution of resident species among reference sites in the mesic study than in the xeric study

VERTEBRATE DISTRIBUTIONS AMONG SITES

Resident Species

Number of resident species per site varied between reference and reclaimed sites and between xeric and mesic studies (Figure 18). Reference sites, both xeric and mesic, tended to harbor more species than reclaimed sites. The median numbers of resident species at xeric reference sites were 13 (quadrupeds) and 12 (birds), and the median numbers at mesic reference sites were 8 (quadrupeds) and 5.5 (birds). Although locations had larger cumulative numbers of resident species than individual sites in the mesic study, no location had more than 10 resident species of quadrupeds or 7 resident species of birds. The median numbers of resident species at xeric reclaimed sites were 6 (quadrupeds) and 4.5 (birds), and the median numbers at mesic reference sites were 6 (quadrupeds) and 5 (birds).

- Xeric reference sites tended to have more resident species of both quadrupeds and birds than mesic reference sites

- Numbers of resident species at xeric and mesic reclaimed sites could not be shown to differ between xeric and mesic sites

Abundances of resident species were relatively high at some mesic sites, both reference and reclaimed. These high abundances mostly were attributable to *Bufo quercicus* (oak toad) and, to a lesser degree, other amphibian species.

- Abundances of resident species could not be shown to differ between xeric and mesic sites

Cumulative Sites Scores and Adjusted Cumulative Sites Scores

For comparison, cumulative sites scores [magnitude of the deviation from a 1:1 ratio of numbers of reference sites to reclaimed sites occupied, summed over all focal species] and adjusted cumulative sites scores [sites scores adjusted for differences in abundance between reference and reclaimed sites] were placed on a common scale. Scaling was done by adjusting the scores to percent of maximum possible scores. Adjusted cumulative sites scores followed much the same pattern as cumulative sites scores, so further reference will be made only to cumulative sites scores. Cumulative sites scores varied between reference and reclaimed sites and between xeric and mesic studies (Figure 19). Clearly, reference sites, both xeric and mesic, tended to have larger cumulative sites scores than reclaimed sites.

Mesic reference sites appeared to have more large cumulative sites scores than xeric reference sites for quadrupeds, but more small cumulative sites scores for birds. On the other hand, mesic reclaimed sites appeared to have more small cumulative sites scores for quadrupeds, but more large cumulative sites scores for birds. These tendencies were not strong, however. We shall return later to the substantial absolute differences between cumulative sites scores at xeric and mesic sites.

- Cumulative sites scores (and adjusted cumulative sites scores) could not be shown to differ between xeric and mesic sites

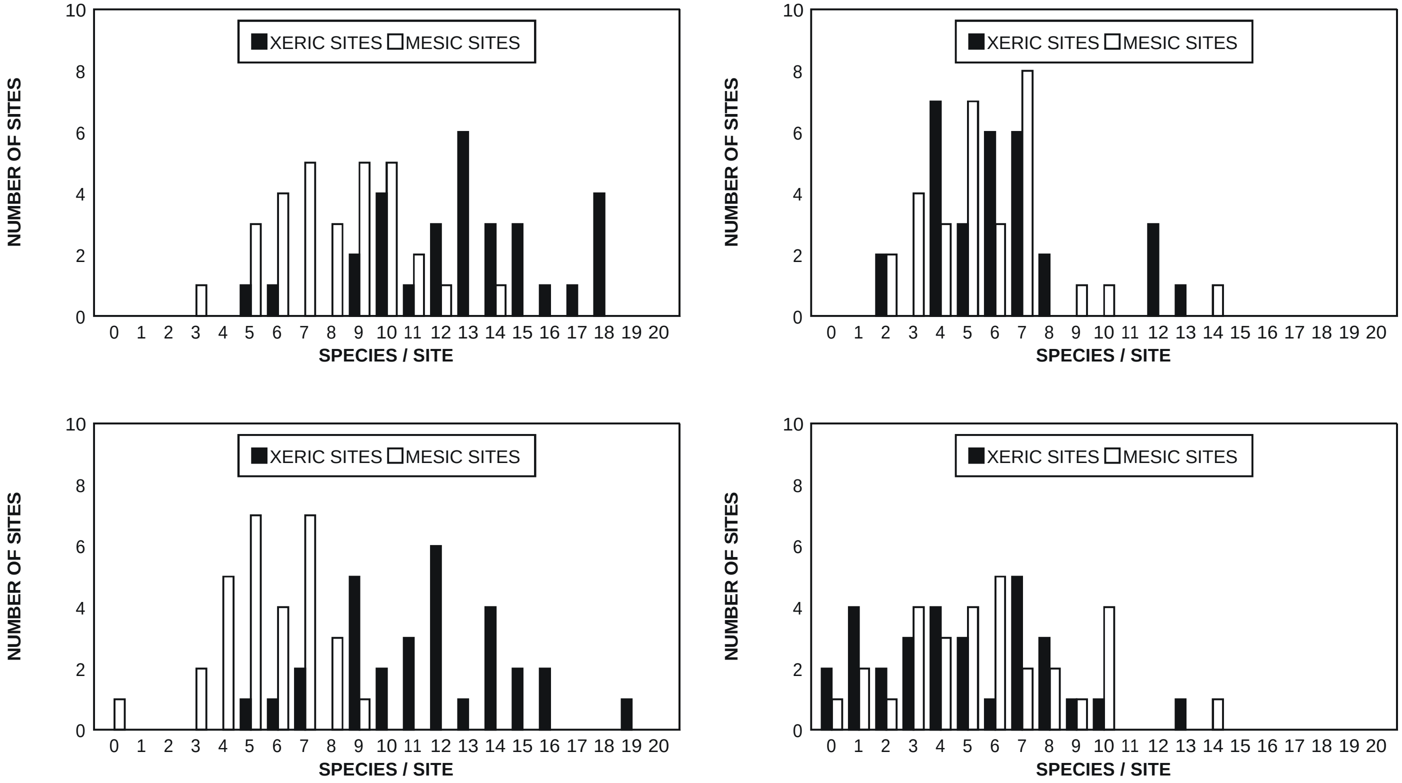


Figure 18. Distribution of Number of Resident Species per Site. Reference Sites Are on the Left, Reclaimed Sites on the Right; Quadrupeds Are on the Top, Birds on the Bottom.

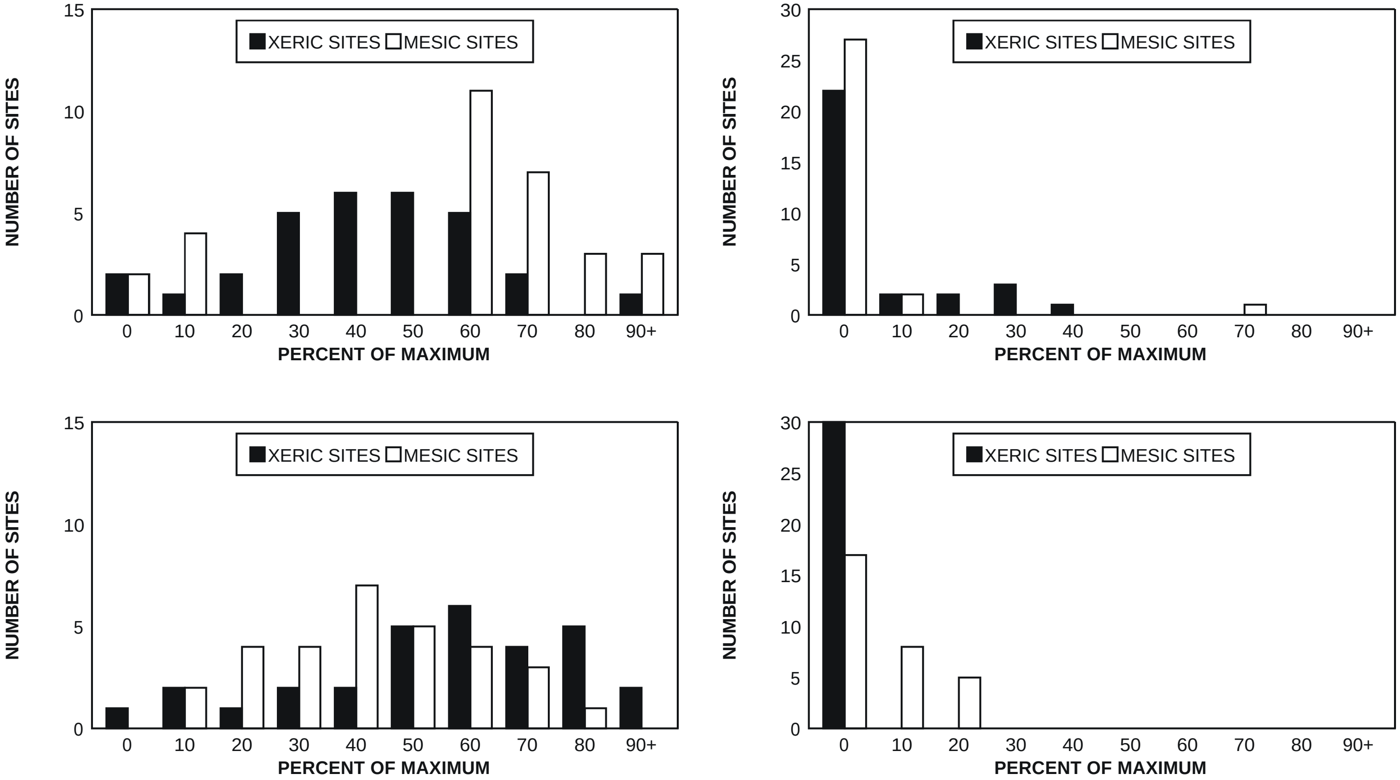


Figure 19. Distribution of Cumulative Sites Scores, Reported as a Percent of Maximum Possible Score. Reference Sites Are on the Left, Reclaimed Sites on the Right; Quadrupeds Are on the Top, Birds on the Bottom.

Species Associations

Distributions of focal species among sites were nested, for both xeric and mesic sites. As well, associations of species at sites were present, for both xeric and mesic sites. Monothetic divisive cluster analysis indicated that the associations of species at sites with the highest cumulative sites scores had a key component species, except for xeric reclaimed sites. For xeric reference sites and, to a lesser degree, for mesic reclaimed sites, this species was *Parus bicolor* (tufted titmouse). For mesic reference sites, this species was *Aimophila aestivalis* (Bachman's sparrow). We reiterate our warning that neither species should be used as an "indicator" species without additional confirmation, however.

COMPARATIVE EXPLANATIONS

In the xeric study, four aspects of the natural histories of resident species almost perfectly separated focal from non-focal species. These aspects were breeding site preference (focal species of amphibians tended to prefer temporary ponds), burrowing substrate preference (focal species of snakes tended to prefer sand with a litter covering), vegetation cover preference (most other focal species tended to prefer canopy/understory/litter), and burrow preference (one focal mammal species tended to prefer areas with gopher tortoise burrows). In the mesic study, only two aspects of the natural histories of resident species separated focal from non-focal species, breeding site preference and vegetation cover preference. In part, the reason for this reduction is a reflection of the lower number of focal species in the mesic study, but another part of the reason for the reduction was the slight-to-moderate shift of some species in their relative occurrences at mesic reference and reclaimed sites, compared to xeric reference and reclaimed sites. In other words, a few of the species that qualified as focal species in the xeric study were more common at the mesic reclaimed sites so they did not qualify as focal species during the mesic study. These species included *Anolis c. carolinus* (green anole), *Eletherodactylus p. planirostris* (greenhouse frog), *Hyla squirrela* (squirrel treefrog), and *Thryothorus ludovicianus* (Carolina wren).

Many of the relatively large number of correlations of sites scores [magnitude of the deviation from a 1:1 ratio of numbers of reference sites to reclaimed sites occupied] with size, isolation and grazing present in the xeric study were not present in the mesic study. At xeric reference sites, sites scores tended to be positively related to the presence of vegetation cover at low (quadrupeds) and intermediate (birds) levels, which, in turn, tended to be negatively related to the presence of vegetation (canopy) cover at high levels. At mesic reference sites, sites scores tended to be positively (quadrupeds) or negatively (birds) related to the presence of certain kinds of vegetation cover at the intermediate level, and negatively related to the presence of vegetation cover at the high level. At both xeric and mesic reclaimed sites, sites scores tended to be positively related to the presence of virtually any kind of vegetation cover. Results tended to be similar for occurrences of individual quadruped and focal species at xeric reference and reclaimed sites and for bird focal species at mesic reclaimed sites. Results were not consistent or easily interpreted for quadruped focal species at mesic sites. They also were not consistent for bird focal species at mesic reference sites, sometimes responding positively to vegetation cover, especially at the intermediate level, and sometimes responding negatively.

Fewer species were designated focal species in the mesic study than in the xeric study, and focal species in the mesic study generally had lower sites scores (and adjusted sites scores) than focal species in the xeric study. These differences appeared to be a function largely of the narrower distribution of many resident species at mesic reference sites than at xeric reference sites. The narrower distribution at mesic reference sites could result from at least three, not mutually-exclusive, explanations. One possibility simply is that species indeed do tend to occur at fewer mesic sites than xeric sites.

Another possibility is that the number of individuals representing a species tends to be lower at mesic sites than at xeric sites and, therefore, identical sampling, by chance, would miss more species at mesic sites than at xeric sites. A third possibility in that the mesic study was conducted during a time period that was less favorable to organisms (e.g., it was a particularly dry period) than was the xeric study and numbers of individuals representing most species were reduced temporarily; and, therefore, identical sampling missed--by chance, once again--more species at our mesic sites than at our xeric sites. The latter two possibilities, both involving the problem of small sample sizes, can be addressed by comparing the data from the xeric and mesic studies with data collected during other studies in the same kinds of habitats.

We compared our data with a data compilation for amphibians and reptiles (Enge 1997). We did this by calculating the rate at which individuals of resident species were captured by trap arrays in each study and then relating the number of resident species captured to the calculated rate in each study. The amphibian and reptile data from 43 other studies (Enge 1997) conducted in central and southern Florida indicate that the number of species captured is related closely to the rate of capture of individuals (Figures 20A, B, & C). Although individuals of some species (e.g., amphibians in mesic habitats, lizards in xeric habitats) often are captured at relatively high rates, the data from xeric and mesic sites all fall more-or-less on the same line, indicating that the number of individuals representing a species does not tend to be lower at mesic sites than at xeric sites. Comparison of our data from the xeric and mesic studies with the trends displayed by the 43 other studies does not indicate that median rates at which individuals were captured at reference sites in our two studies (amphibians: 0.130 and 0.241 individuals/array-days, for the xeric and mesic study, respectively; lizards: 0.232 and 0.058; snakes: 0.063 and 0.019) or median numbers of species associated with the rates (amphibians: 9 and 12 for the xeric and mesic study, respectively; lizards: 8 and 5; snakes: 12 and 10) were unusually low.

We also compared our data with a data compilation for birds from central Florida (Engstrom 1993). We did this by standardizing the number of individuals observed in each study and then relating the standardized number of species (note that we could not separate out the resident species) to the standardized number of individuals. The bird data from 16 other studies conducted in central and southern Florida (Breeding Bird Censuses and Winter Bird Population Studies) indicate that the expected number of species on a standard-sized (8.1 ha) plot, as determined by rarefaction analysis, is related closely to the density of individuals (Figure 21). The data from xeric and mesic sites all fall more-or-less on the same line, indicating that the number of individuals representing a species does not tend to be lower at mesic sites than at xeric sites. A slight, but perceptible, tendency appears to exist for the ratio to be somewhat smaller for mesic sites, however. It is difficult to compare our data from the xeric and mesic studies with the trends displayed by the other 16 studies, because we did not quantify numbers of individuals. Comparison of the numbers of species observed in the xeric and mesic studies, using the rarefaction procedure employed by Engstrom (1993) and assuming that relative density and relative abundance of individuals are similar among studies (tenuous, but necessary, assumptions), indicates that median numbers of resident species at

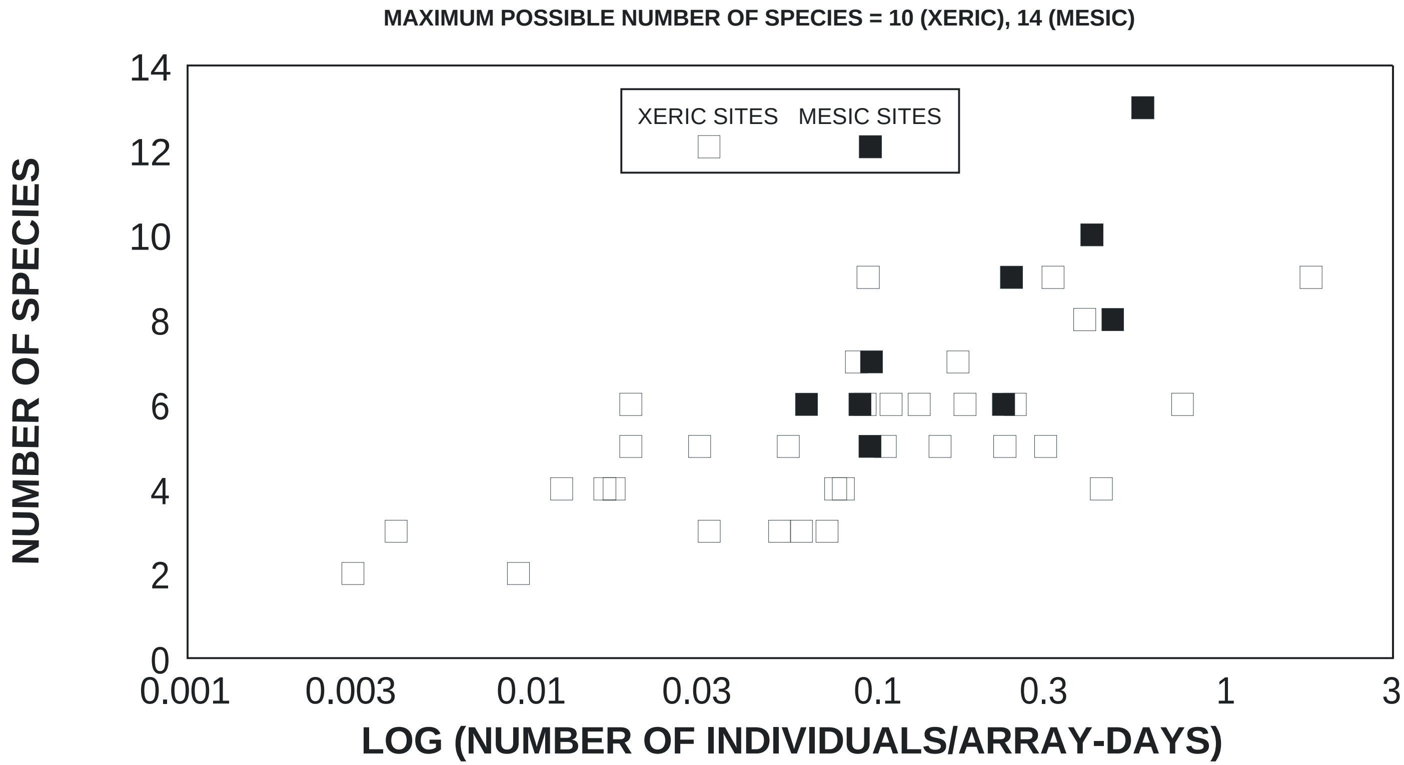


Figure 20A. Number of Resident Amphibian Species Captured, Relative to Rate of Capture of Individuals. Data Are from 43 Studies in Central and Southern Florida That Employed Trap Arrays.

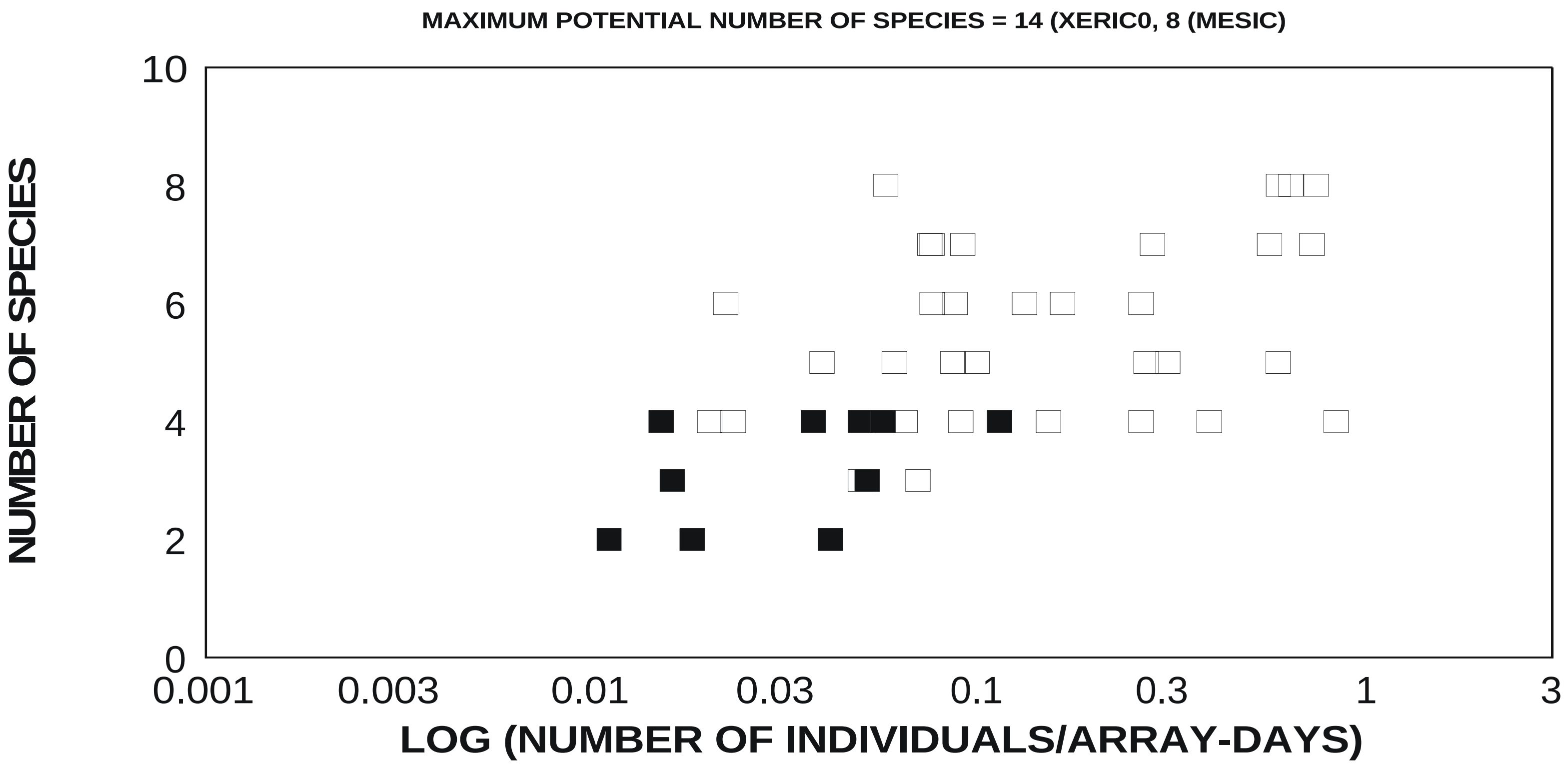


Figure 20B. Number of Resident Lizard Species Captured, Relative to Rate of Capture of Individuals. Data Are from 43 Studies in Central and Southern Florida That Employed Trap Arrays.

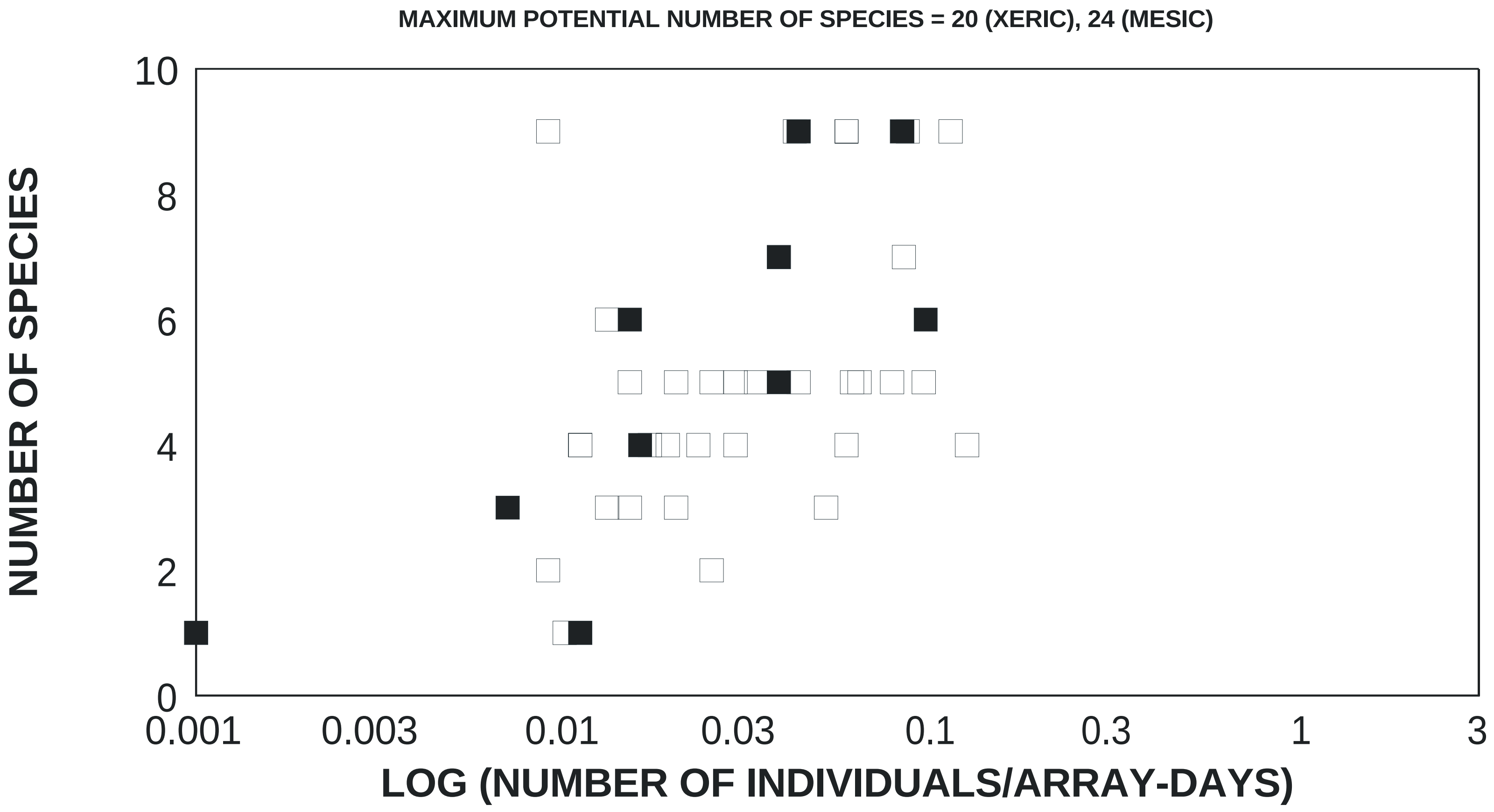


Figure 20C. Number of Resident Snake Species Captured, Relative to Rate of Capture of Individuals. Data Are from 43 Studies in Central and Southern Florida That Employed Trap Arrays.

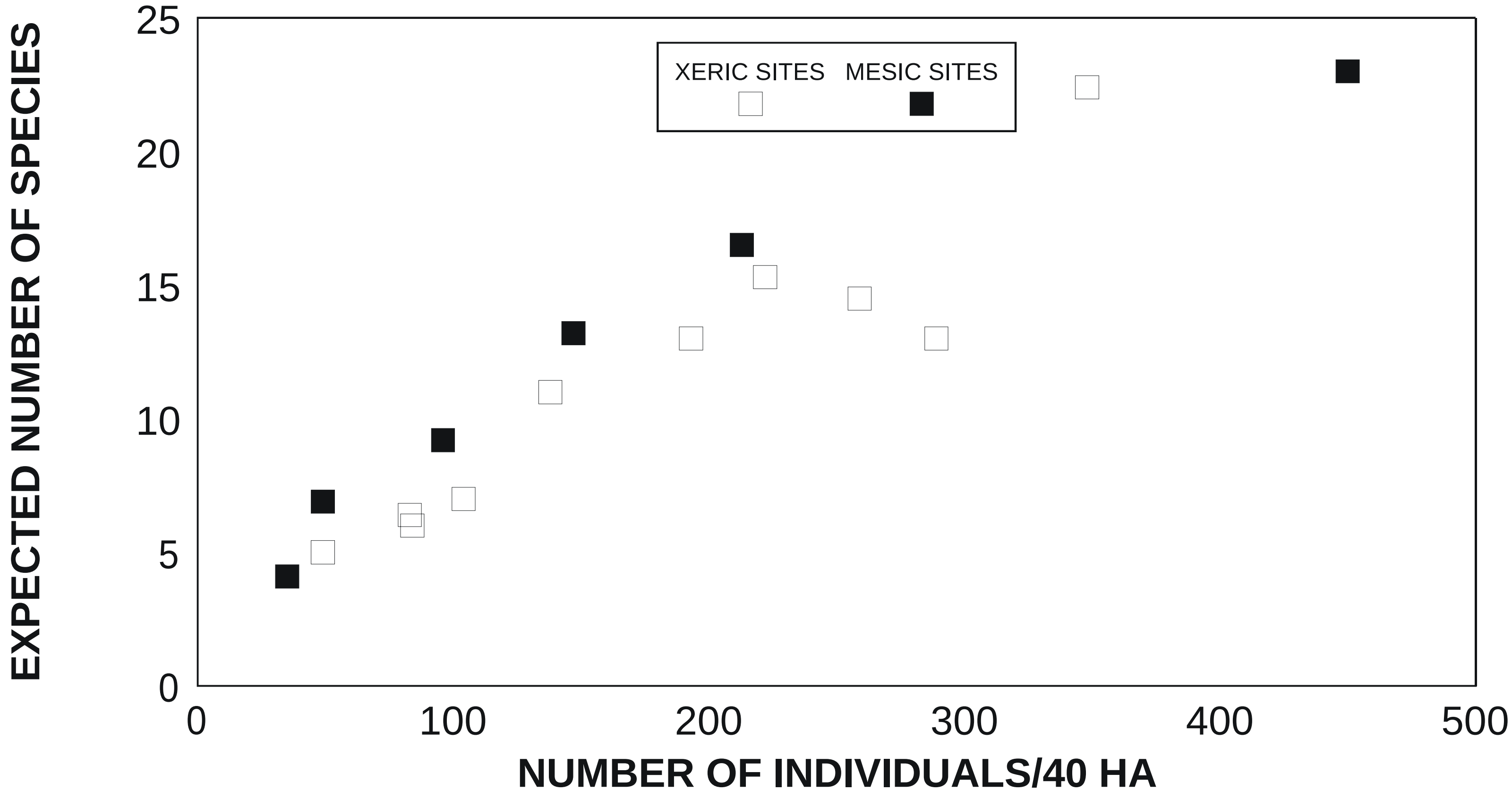


Figure 21. Number of Bird Species Expected To Be Observed in 8.1 Ha, Relative to Number of Individuals Observed in 40 Ha. Data Are from 16 Studies in Central and Southern Florida.

reference sites (12 and 5.5, for the xeric and mesic study, respectively) are lower than expected numbers of species at reference sites (15 and 16, for the xeric and mesic study, respectively). Considering that transients and accidentals were included in the calculation of expected numbers of species, the observed number of resident species probably is similar to the expected number for the xeric study, but substantially lower than the expected number for the mesic study. We note, however, that the conclusions drawn for birds are quite different if locations, rather than sites are used. Recall that the 30 reference sites were located within seven, substantially larger, locations. The number of resident species observed at these locations ranged from 18 to 29. The number of species observed in other studies of relatively large plots ($\geq$ 40 ha) of mesic flatwoods encompassed a virtually identical range, 19 to 31 (Engstrom 1993).

We can safely conclude for amphibians and reptiles that rates of capture/observation of individuals (a measure of abundance) during either the xeric study or the mesic study were not unusual. Because rates of capture were not unusual, we can also safely conclude that, at the local scale, our observations are valid: xeric reference sites do tend to have more resident species than mesic reference sites, and resident species do tend to be more widely distributed among xeric reference sites than among mesic reference sites. We are reluctant to draw the same conclusions for birds, however. Additional study is needed to determine if the species richness of birds at our mesic sites is unusually low (see Mushinsky and McCoy 1996); and, if it is low, then whether such low species richness is a permanent or only a temporary phenomenon. If the difference between bird species richness in the xeric and mesic studies is real, but only a temporary phenomenon (i.e., that in other years the observed numbers of species would be closer to the expected numbers), then the magnitude of the sites scores for mesic reference sites could increase, and become more similar to those for the xeric study. If the difference between bird species richness in the xeric and mesic studies is real, and a permanent phenomenon, then we would be able to draw the same conclusions as we did for amphibians and reptiles, above. In this case, because the total lists of resident species captured/observed in the two studies were virtually identical in size (79 species in the xeric study, 81 species in the mesic study), greater heterogeneity in species composition would exist among mesic reference sites than among xeric reference sites (compare, for example, Tables 20 and 21 in Mushinsky and McCoy (1996) with Table 18, above). This greater heterogeneity among mesic reference sites would complicate the reclamation process. On the one hand, the difference in the magnitude of cumulative sites scores (and adjusted cumulative sites scores) between the two studies would indicate that reclamation of individual reclaimed sites to match the vertebrate composition of mesic reference sites may be achieved more readily than reclamation to match the vertebrate composition of xeric reference sites. On the other hand, because species composition would vary more among mesic reference sites than among xeric reference sites, incorporation of a relatively large segment of the pool of resident species might require more sites and/or more creative management (e.g., to incorporate habitat heterogeneity) for mesic reclamation than for xeric reclamation.

RECOMMENDATIONS

In the Introduction to this report, we listed the problems, solutions, and products of the flatlands research project. So far, we have provided three of the four products that we promised: (1) lists of the relative abundances of vertebrate species at our study sites, (2) lists of the physical variables correlated with the presence/absence of focal species at our study sites, and (3) a comparison of the present study with a previous one that focused on xeric uplands in the same region. In addition, we have provided much other information about the vertebrates and their habitats. Following, we provide the fourth product: (4) recommendations to improve rehabilitated reclaimed lands to support a representative flora and fauna. We have organized the recommendations in much the same way as we did previously (Mushinsky and McCoy 1996). The key recommendations are the most important, in our estimation; the remaining ones may be meaningless for wildlife if those in the first section are not followed. The secondary recommendations, those most directly related to our research, focus on necessary attributes of the habitat structure of rehabilitated lands. The third set of recommendations is speculative. While they may be important the areas addressed were not prominent components of our research, and, therefore, these recommendations are couched as speculations. The recommendations in the first three sections, for mesic flatlands sites, should be compared with those listed previously, for xeric sites (Mushinsky and McCoy 1996). The recommendations in the fourth section are expressed as an action plan, and incorporate elements from both the xeric study and the mesic study.

KEY RECOMMENDATIONS

- Rehabilitated habitat patches should be as large as possible. Large habitat patches support a greater representation of vertebrate species than smaller patches. Large patches also facilitate the incorporation and management of relatively-large scale habitat heterogeneity, so that a variety of vertebrate species, with different habitat and microhabitat requirements, can be accommodated.

- Rehabilitated habitat patches should be as near other habitat patches, both undisturbed and rehabilitated, as possible. Habitat patches relatively-near other habitat patches support a greater representation of vertebrate species than patches relatively-far from other patches. Rehabilitated lands may be used to connect other patches of habitat, either natural or rehabilitated.

- Rehabilitation efforts should be coordinated with existing conservation and management plans. Coordination will help to increase the effective size of the rehabilitated habitat patches and to decrease their isolation.

- Rehabilitation efforts should be part of a broad, regional approach to both conservation and management. A regional approach is more likely to sustain the regional species pool needed for the recolonization and subsequent maintenance of vertebrate populations at rehabilitated habitat patches. A regional approach would include all of the Bone Valley and surrounding habitats.

- Rehabilitation efforts should be thoroughly and consistently documented. The various groups actively involved in rehabilitation of previously-mined lands should be able to share information, to ensure that successes are repeated and failures are not. The data gathered during each project should be reported in some standard way and stored in some readily-accessible central location (e.g., the library of the Florida Institute of Phosphate Research).

SECONDARY RECOMMENDATIONS

- Rehabilitated habitat patches should have woody vegetation near ground level. Patches with this structural feature support a greater representation of bird species than patches without it.

- Rehabilitated habitat patches should have a mixture of relatively dense and relatively sparse shrubs. Patches with this structural feature support a greater representation of bird species, but a lesser representation of quadruped species, than patches without it.

- Rehabilitated habitat patches should have relatively tall vegetation, overall. Patches with this structural feature support a greater representation of vertebrate species than patches without it.

- Rehabilitated habitat patches should have a diversity of foliage layers. Not all vertebrate species respond in the same way to structure of the ground layer, intermediate layers, or canopy layers.

- Rehabilitated habitat patches should have a diversity of plants. Vertebrate species do not respond in the same way to all plant species or to size classes within species.

- Rehabilitated habitat patches should provide some open grassy areas that are created to support temporary or seasonal ponds.

- Rehabilitated habitat patches may be (re)stocked with selected vertebrates by relocating them out of harm’s way as new land is prepared for strip mining.

SPECULATIONS

- Habitat rehabilitation may be improved by paying close attention to the importance of soil texture, compaction, and chemistry in influencing the vegetation, and, in turn, the vertebrates.

- Habitat rehabilitation may be improved by paying close attention to the importance of soil microflora and microfauna in influencing the vegetation, and, in turn, the vertebrates.

- Habitat rehabilitation may be improved by a better understanding of the process of succession -- replacement of plant and animal species at a site over time -- in flatland habitats.

ACTION PLAN TO CONSERVE WILDLIFE HABITAT IN CENTRAL FLORIDA

- To conserve representative wildlife in Florida, the industry should reclaim mesic and xeric habitats in proportion to the amount of land disturbed by the mining process. Careful, long-range plans should be made to coordinate and oversee the mining and the reclamation processes. Flatland and upland, as well as wetland, reclamation should be done in concert, not in isolation from one-another. Reclaimed lands should be used to increase the size of existing preserves and to connect currently isolated habitat patches. Provisions should be made to produce a landscape that creates temporary ponds during the normal wet seasons. Temporary ponds are important breeding grounds for amphibians. All conservation and reclamation activities should be coordinated on a regional level, that is, coordinated throughout the entire Bone Valley Region of Central Florida. Recommendations:

    - Reclaim mined flatland and upland habitats, acre for acre
    - Integrate the reclamation of flatlands, uplands, and wetlands
    - Reclaim lands to increase the size of habitat patches
    - Reclaim lands to connect existing habitat patches
    - Reclaim lands to produce temporary ponds
    - Coordinate reclamation regionally

- Future reclamation of mined lands for vertebrate wildlife may be more effective if the reclamation process uses the native topsoil in which the local flora has evolved. We believe that the upper 20-25 cm of topsoil should be saved prior to mining and reapplied during reclamation to support vegetation and vertebrate wildlife representative of mesic or xeric habitats. A mixture of sand tailings and overburden can be used as subsoil, to fill the deep strip mine cuts before the native topsoil is spread across the surface. The topsoil plus subsoil should be deep enough and not compacted so as to accommodate the deep roots of native trees and shrubs and not inhibit burrowing animals. The subsoil should be engineered to ensure that its hydrologically-related features mirror those of undisturbed mesic and xeric habitats. These features should include a mixture of relatively dry areas, where rainwater percolates rapidly out of the system, and relatively wet areas, where rainwater collects temporarily during the wettest part of the year. Recommendations:

  - Save the topsoil before mining
  - Contour the subsoils and apply topsoil after mining
  - Ensure that topsoil is spread deep enough for plant growth
  - Ensure that rainwater percolates rapidly in some places
  - Ensure that rainwater collects temporarily in some places

- Vertebrate wildlife representative of mesic or xeric habitats respond strongly to vegetation structure. Re-establishing the vegetational structure of reclaimed lands will require well-planned initial revegetation and subsequent management practices. Knowledge of potential "indicator species," such as key invertebrates like ants, springtails, and crickets, potentially could be used to track and modify the course of succession. Comparison of successional development of native plant assemblages on reclaimed mined land with that on land that has been cleared, but not mined, likely would illustrate how the mining process itself affects the successional development of plant assemblages. Recommendations:

  - Create a vegetation structure after mining that is specifically designed to attract and retain vertebrate wildlife
  - Do not allow high-density cattle grazing
  - Conduct research to establish direct connections between vegetation structure and the presence of individual vertebrate species
  - Conduct research to define a desirable course of succession
  - Conduct research to define a set of species ("indicator species") that can be used to monitor the course of succession
  - Monitor the course of succession periodically, and redirect it, if necessary

- Reclaimed lands that function as mature mesic or xeric habitats, in terms of representation of plants and animals, will take many years to create. The pool of vertebrates in central Florida is in decline and may not remain intact for many more decades, so steps that could hasten the reclamation recovery process seem to be necessary. Initial plantings of fast-growing shrubs and trees may be used to "rescue" elements of the invertebrate and vertebrate fauna until more desirable, but slow-growing plants have an opportunity to become established. As the initial plantings mature they can be replaced selectively by slow growing native species. Such initial plantings could employ native species such as slash pine, live oak, wax myrtle, beauty berry, and salt bush, or non-invasive exotic species. The fast-growing plants may need to be selectively thinned. Clearly, planting exotic species should be viewed as a last resort. We make such a recommendation because time may be running out to "rescue" many vertebrate species in central Florida. Our research has demonstrated that even relatively small stands of exotic trees attract and support wildlife. Because native plant species may take several years to establish on reclaimed lands, planting fast-growing, non-invasive exotic species might provide a temporary home as the native species become established. One reclaimed site used for this research was reclaimed with a non-invasive eucalyptus, it provided habitat for many vertebrate species. Recommendations:

  - Plant rapidly growing species initially, to be replaced with slower growing species
  - Consider the use of both native and non-invasive exotic plant species

- Mined lands that have been reclaimed previously cannot be redone to accommodate the practices we have just recommended. They can be improved to attract and retain a greater variety of vertebrate wildlife, however. Those lands that support pine plantations could be improved by adding more vegetation structure. Planting diverse ground covers and shrubs will add some of the missing vegetation layers. If the pine trees on some of these lands are too densely planted to attract and retain wildlife, then they could be selectively thinned to create heterogeneity and more open space. Those lands that have been neglected for many years, and have become badly overgrown, could be both selectively harvested and burned. Shallow depressions that could support temporary ponds could be created within the pine plantations. Recommendations:

  - Conduct research on the compatibility of simultaneous wildlife and silvicultural usage of reclaimed lands
  - Employ secondary plantings
  - Employ selective thinning
  - Employ prescribed burning
  - Employ habitat modification to create temporary ponds.

- Active management of reclaimed mined lands is necessary to more fully benefit vertebrate wildlife. Mined lands do become revegetated and are colonized by some vertebrate wildlife species with little or no active management (or even initial reclamation, in some cases), but a number of wildlife species are underrepresented or absent on reclaimed lands. The species that are successful colonists are not fully representative of the vertebrate fauna of unmined habitats and reclaimed lands lack species diversity ("focal species" are missing). Development of management plans that include secondary plantings, controlled burns, and species translocations will be necessary to attract and retain a variety of vertebrate wildlife. Reintroduction or translocations of selected vertebrate species may also be necessary to establish their populations. Management practices will need to change as a site matures. For example, woody vegetation should be encouraged early in the reclamation process but woody vegetation may become too dense and require controlled burning. Recommendations:

  - Create a management plan that uses the variety of management practices already available
  - Create a management plan that is adaptable, in the sense that it can incorporate site-specific practices

  - Create a management plan that is adaptable, in the sense that it can respond to the need for changing management practices as sites mature

- Setting and achieving goals for the rehabilitation of phosphate mined lands involves policy and economic considerations, as well as the biological considerations we have addressed through our studies. Knowing the biological condition of reclaimed lands as we do, allows us to make compelling arguments for paying more attention to the responses of vertebrates, as well as other organisms, to reclamation efforts. As a basis for making recommendations to improve the quality of reclaimed lands for resident vertebrates, we employed "representativeness" to identify and create lists of "focal species." A meaningful goal for the immediate future should be to reclaim uplands and flatlands sufficiently to support these focal species. Realization of this goal can come only with economic and political support from local and State governments. Ultimately, we would hope that the use of focal species could be abandoned entirely, to the benefit of all species. For example, many of the vertebrate species that are relatively rare regionally failed to make our lists of focal species. In time, phosphate mined lands may be sufficiently reclaimed so as to provide habitat for these rare species, as well. Recommendations:

  - Engender sufficient economic and political support for habitat reclamation
  - In the short term, employ "representativeness" as a goal of habitat reclamation
  - In the long term, strive for a goal that accommodates all species

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