ASSESSING WILDLIFE USAGE OF RECLAIMED PHOSPHATE-MINED LANDS AND UNMINED LANDS

by

Earl D. McCoy, Robert Kluson, Cherie Keller, Henry R. Mushinsky

Abstract. Although phosphate mining necessarily destroys extensive amounts of wildlife habitat, the industry attempts to minimize the long-term effects of the strip mining by reclaiming some of the land to make it suitable for wildlife. We have studied a spectrum of unmined (reference) and previously mined (reclaimed) lands to determine how well reclaimed lands can support vertebrate wildlife species. We studied 100 sites, spread over an area of about 1,000 square miles of west-central Florida. Thirty reference sites were xeric (dry) uplands (scrub, sandhill), and 30 were mesic (moderately wet) flatlands (pine flatwoods and dry prairies), and the remaining 40 were reclaimed sites that varied from mesic-like to xeric-like in their flora and fauna. Mesic flatlands are more extensive than the xeric uplands which often are patchy habitat islands surrounded by mesic flatlands. Collectively, xeric upland and mesic flatlands each support about 75 resident vertebrate species. Individually, mesic sites supported fewer species than mesic sites. Reclaimed sites, whether mesic-like or xeric-like, supported fewer species than respective reference sites. We documented a 50% overlap of resident species at mesic and xeric reference sites. "Focal species" are those that are under-represented at reclaimed sites relative to reference sites. The total list of focal species, from the xeric (28 species) and mesic (12 species) sites combined, includes 5 amphibians, 8 reptiles, 1 mammal, and 17 birds. Roughly 60% of the focal species resided at xeric reference sites, 10% resided at mesic reference sites, and 30 % were resident of both reference sites. Our findings indicate that current reclamation practices are not adequate to maintain a vertebrate fauna representative of the regional mesic flatlands and xeric uplands. All of our results indicate that the reclamation of terrestrial habitats for wildlife in central Florida should be planned on a broad scale and integrated to include the mostly protected hydric habitats, the relatively extensive mesic habitats, and the patchy xeric habitats.

Additional Key Words: Florida, Wildlife, Colonization, Focal Species, Phosphate mining, Regional planning

Earl D. McCoy, Robert Kluson, Cherie Keller, Henry R. Mushinsky, Department of Biology, Center for Urban Ecology, University of South Florida, Tampa, FL 33620

Introduction

Florida currently provides about 75% of the nation's phosphate supply and about 25% of the world's supply (Pitman 1990, Odum et al. 1998). Most strip mining of phosphate rock in Florida uses the same procedure. The surface is cleared completely of all vegetation; then the overburden, and finally the phosphate rock, are removed by giant electric drag lines. The strip mine eventually is back-filled with "waste" sand tailings from the phosphate recovery process and then usually covered by spreading the overburden. Occasionally, sand tailings may be maintained uncovered as substrate for reclaimed 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. Phosphate-mined lands have been reclaimed for pasturing; agriculture; residential; commercial; or industrial development; and wildlife conservation. The degree of reclamation varies concomitantly with intended use, from simply planting grass to support cattle to spreading native topsoil and planting shrubs and trees to attract wildlife. Here we focus our attention on the diversity of wildlife species found on reclaimed uplands that were designed to mimic unmined upland habitats.

Phosphate mining destroys extensive amounts of wildlife habitat, some of which is reclaimed to support the displaced species. We have studied phosphate-mined lands in Florida that have been reclaimed to varying degrees during the past few decades, to determine how well reclaimed land can support vertebrate wildlife species relative to unmined land. Specifically, our studies were designed to identify the wildlife species resident on unmined lands (reference sites), and to compare their distributions and relative abundances among reference sites with their distributions and relative abundances among previously-mined lands (reclaimed sites). We

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used published records to help us decide which of the total pool of "potential" species that occur in central Florida should be considered "resident species " in the two broad categories (mesic and xeric) of upland habitats we studied. Those "potential" species that pass through, fly over, or use a habitat for only a short time period were not included in our studies. Those "potential" species that spend extensive time periods and/or reproduce in the habitats we studied were considered "resident" species. We compared distributions and relative abundances of resident species to determine if any species were less or more common at reclaimed sites than at reference sites. Those resident species that were under-represented at reclaimed sites, relative to reference sites, we refer to as "focal species." Focal species are a subset of resident species that are less common at reclaimed sites than at reference sites. We based our assessment of the success of reclaimed lands to attract and support wildlife on the concept of "representativeness." This concept has been used as a simple criterion for judging the quality of natural areas for their conservation (Smith and Theberge 1986), as well as serving as the conceptual basis for establishing biosphere preserves to conserve natural habitats throughout the world (UNESCO 1974, IUCN 1978). We have modified the concept as presented by Margules and Usher (1981) to fit phosphate-mined lands; so that representative reclaimed 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. Because of the severe disruption of the natural habitats, we recognize that the reclamation of strip-mined land to the extent that it supports representative flora and fauna must be considered a long-term goal. The first critical step toward achieving that goal, however, should be to reclaim phosphate-mined lands sufficiently to support the focal species. Although under-represented on reclaimed lands, the focal species are a subset of the resident species pool that are relatively widespread among the unmined reference sites in the region where the reclamation is occurring. As detailed below, however, rare species or those with patchy distributions were not sufficiently represented at reference sites to qualify statistically as focal species. Reclamation of previously mined lands to support this group of rare and specialized vertebrates would require true habitat restoration (Bradshaw 1987) and should be considered an ultimate long-term goal.

We studied two types of mesic (moderately wet) flatlands habitats (Mushinsky and McCoy in press), and three types of xeric (dry) uplands habitats (Mushinsky and McCoy 1996). Readers are directed to those published reports for greater details of our studies than can be presented here. Our habitat classification scheme follows the Florida Natural Areas Inventory (FNAI 1990). Mesic flatlands habitats occur on moderately- to poorly-drained soils, and include common and widespread habitats, such as pine flatwoods and dry prairies (Edmisten 1963). Mesic flatlands, especially pine flatwoods, are more extensive in central Florida than are xeric uplands (Davis 1967). Because mesic flatlands form the matrix that connects the relatively isolated patches of xeric uplands and hydric (wet) lowlands, there are few vertebrate species that are restricted to mesic flatlands. Rather, the mesic flatlands are used by a broad variety of vertebrate species, some typical of the xeric uplands and some typical of the hydric lowlands. In central Florida, only a few meters in elevation may separate xeric from hydric habitats. Xeric uplands habitats occur on deep, well-drained white to yellow or grayish sandy soils deposited by the high water levels of ancient seas (Laessle 1942). The three kinds of xeric upland habitats we studied are scrub, scrubby flatwoods, and sandhill. Scrub and scrubby flatwoods are very similar in plant composition (Myers 1990). Scrubby flatwoods occurs at sites that are higher and better drained than pine flatwoods, but lower and less well-drained than scrub (Abrahamson and Hartnett 1990); thus, scrubby flatwoods actually may be an ecotone between pine flatwoods and scrub. Sandhill is readily distinguished from the other xeric uplands by its plant composition (Myers 1990). Xeric uplands support a diverse array of organisms, including a relatively large number of vertebrate species that are considered threatened or endangered, or otherwise of special concern (Mushinsky and McCoy 1996, in press).

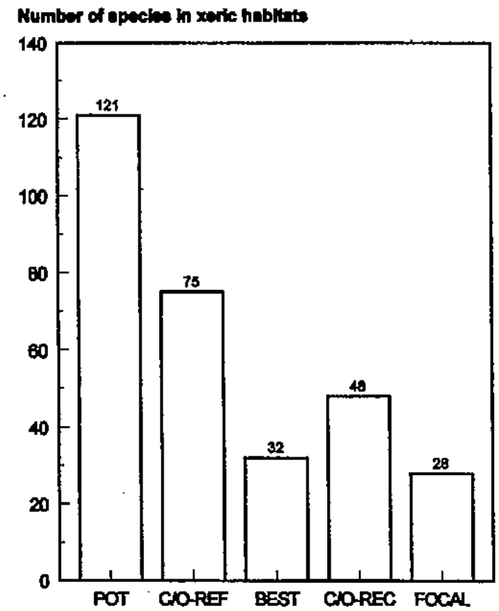
Methods and Background Data

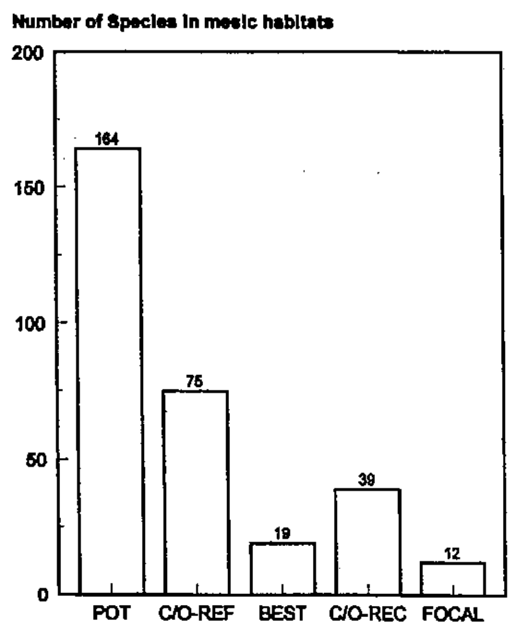
During the past few decades, the phosphate industry has reclaimed both mesic flatlands and xeric uplands to mimic natural habitats in the manner in which they attract and support wildlife representative of those habitats. With the aid of several local industry reclamation experts and the Reclamation Director for Florida Institute of Phosphate Research, we selected and studied a broad spectrum of reclaimed habitats that varied from mesic-like to xeric-like in the flora and fauna they supported. All study sites are located in Bone Valley, the larger and more southern of the two principal phosphate mining regions of the Florida, which extends southward and eastward from Tampa. In all, we have studied 100 sites, spread over an area of about 1,000 square miles. Thirty sites were reference habitats that supported xeric uplands. Another 30 sites were reference habitats that supported mesic flatlands. Mesic flatlands habitats are more extensive than the xeric uplands, which often are surrounded by mesic habitats. We selected a large number of xeric and mesic reference sites for study because we anticipated, and found, considerable variation among reference sites. The remaining 40 study sites were reclaimed sites. The amount of time that had passed between the reclamation of the sites and our study ranged from about 25 to 8 years. Both the reference and reclaimed sites were dispersed among three counties in the Bone Valley region of Florida. For the comparisons summarized below, we used the 30 reclaimed sites that most resembled (based on soils, vegetation and fauna) xeric habitat and called them "xeric-like" reclaimed lands and the 30 sites that most resembled the mesic habitat we called them "mesic-like" reclaimed lands. We categorized all study sites by size, distance to seasonal water, distance to permanent water, and distance to other upland habitats. We categorized reclaimed sites further, by type of soil reclamation, type of vegetation reclamation, and time since reclamation (Mushinsky and McCoy 1996, in press).

We captured or observed vertebrates with two techniques. At each site, for a period of two years, amphibians, reptiles, and (small) mammals (collectively called quadrupeds) were captured by a trap array (Campbell and Christman 1982). A trap array consisted of four 7 m-long by 50 cm-high drift fences, placed in a cross pattern. One edge of each rolled-aluminum drift fence was buried into the ground to a depth of about 20 cm. The drift fence was constructed to direct ground-dwelling quadrupeds into either bucket or funnel traps. Each fence was equipped with two buckets buried in the ground at the ends of the fence and two double-ended funnel traps placed along the sides. At each site, birds were sampled by visual censuses taken during the breeding season and again at the peak of migration during the winter months. Breeding of resident birds was established by witnessing courtship or nesting.

Our previous reports focused on comparisons between resident vertebrates on reference and reclaimed lands, both mesic (Mushinsky and McCoy in press) and xeric (Mushinsky and McCoy 1996); we will not attempt to repeat the details of those findings in this paper. Rather, we will present a brief quantitative summary to apprize the reader about the major conclusions of those studies and then compare mesic and xeric habitats as targets for future reclamation of phosphate-mined land. At the 30 xeric-like reclaimed sites, we found one (bird) species over-represented, and 28 species under-represented relative to the 30 xeric reference sites. Five of nine resident amphibians were sufficiently under-represented at reclaimed sites to be considered focal species, as were 8 of 24 reptiles, 1 of 7 (trappable) mammals, and 14 of 39 birds. Of the 121 potential resident species known to reside in xeric habitats in central Florida (Figure 1), we captured or observed 79

Figure 1. Numbers of potential (POT) species, species captured/observed at reference sites (C/O-REF), found at the single best reference site (BEST), captured/observed at reclaimed sites (C/O-REC), and determined to be focal species (FOCAL).





(note, four species only were captured or observed at reclaimed sites). Some of the rarest species in central Florida (McCoy and Mushinsky 1992) did not qualify as focal species because they were present at just a few reference sites (see below for a more detailed explanation of focal species).

If we examine closely the biologies of the species found at xeric reference sites, but under-represented at xeric-like reclaimed sites, then four characteristics of the natural histories of resident species almost perfectly separated focal from non-focal species. These four characteristics of the focal species form the core of a series of recommendations made to the phosphate industry to improve the quality of their reclaimed lands to attract and support wildlife (Mushinsky and McCoy 1996). These natural history characteristics were breeding site requirements (focal species of amphibians require temporary ponds (no fish present)), burrowing substrate requirements (focal species of snakes require a sandy substrate with a litter covering), vegetation cover requirements (most other focal species require canopy/understory/litter), and burrow requirements (one focal mammal species requires burrows constructed by other species such as the burrows constructed by the gopher tortoise).

At the 30 mesic-like reclaimed sites, we found no species over-represented and 12 species under-represented relative to 30 reference mesic sites. One of twelve resident amphibians was sufficiently under-represented to be considered a focal species, as were two of 17 reptiles, and 13 of 46 birds. Of the 164 potential resident species known to occur in mesic flatlands in central Florida (Figure 1), we captured or observed 81(note six species only were captured or observed at reclaimed sites). Again, the rarest species did not qualify as focal species because they were present at too few reference sites. If we examine the biologies of species found at mesic reference and reclaimed sites, for use as a basis for recommendations to the industry, then only two characteristics of the resident species' natural histories were required to separate focal from non-focal species. As was demonstrated at xeric sites, breeding site requirements, for amphibians, and vegetation cover requirement, for most other species (Mushinsky and McCoy in press) seem most responsible for the observed differences. Part of the reason for this simplified explanation was the lower number of focal species in the mesic habitats, but another part was the slight-to-moderate increase of some species in their relative occurrences at mesic sites, compared to xeric sites.

Here, we compare mesic flatlands and xeric uplands reference sites as targets for reclamation of phosphate-mined lands for vertebrate wildlife. We make this comparison to illustrate both the differences and similarities between the two types of upland habitats. Specifically, we address the following questions. 1. Are mesic flatlands and xeric uplands similar targets for reclamation or do inherent differences exist in the distributions and relative abundances of vertebrates that are representative of the two kinds of reference sites? 2. Are the suites of focal species similar when either mesic flatlands habitats or xeric uplands habitats are used as reference sites? 3. What is the influence of local habitat quality on representative vertebrates, and would our perceptions change if xeric and mesic habitats are viewed at the landscape level?

Results and Discussion

The value of a large number of replicate reference sites

At the 30 xeric reference sites,we captured or observed at total of 75 species, while at the 30 xeric-like reclaimed sites we captured or observed 48 species (Figure 1). If we had selected only one reference site, say the one that turned out to be the most species-rich site, then we would have captured or observed only 32 vertebrate species or about 43% of the known pool of xeric habitat residents. At the 30 mesic reference sites, we captured or observed a total of 75 species, while at the thirty mesic-like reclaimed sites we captured or observed 39 species (Figure 1). If we had only selected one reference site, again the most species-rich site, then we would have captured or observed only 19 species or about 25% of the known pool of mesic habitat residents. These findings underscore the importance of studying a large number of reference sites to adequately sample the distribution of resident species. Finding only 25% of the resident species at the most species-rich site, compared to 43% at the most species-rich xeric site, indicates that the vertebrates that reside at mesic sites have more patchy distributions than those who reside at xeric sites.

Species' Distributions and Relative Abundances

Based on our review of existing literature and our captured/observed data, xeric uplands support about 120 vertebrate species while mesic flatlands support about 165. Approximately 65% and 49% of the potential resident species were captured or observed at the xeric and mesic reference sites, respectively (Table 1). The potential overlap in resident species between xeric and mesic reference sites was about 59%, but the actual overlap was only about 50%. Distributions of resident species among sites varied between xeric and mesic reference sites. The median number of xeric reference

TABLE 1 . Potential and actual resident and transient species captured/observed at the xeric and mesic habitats. Figures for mammals include trappable species (total species).

	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

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. Our findings indicate that resident species are more evenly distributed at xeric than mesic habitats, and numbers of sites occupied by resident species was greater at xeric than mesic sites.

Number of resident species per site varied at xeric and mesic reference sites. Xeric reference sites tended to support more resident species of both quadrupeds and birds than mesic sites (Table 2). 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). Abundances of resident species were relatively high at some mesic sites. These high abundances mostly were attributable to *Bufo quercicus* (Oak toad) and, to a lesser degree, other species of amphibians that exhibit explosive breeding.
Relative abundance distributions of species based on captures or observations of individuals also varied between xeric and mesic reference sites. Numbers of individuals at xeric sites was greater than and more even than at mesic sites. At mesic sites, often one, or a few species, would be quite abundant while many other species were uncommon or completely absent.

Our first question asked if mesic flatlands and xeric uplands are similar targets for reclamation. We conclude that the reference xeric and mesic habitats we studied in central Florida exhibit substantial inherent differences in the relative abundances and distributions of vertebrate species. Based upon data from 60 reference study sites, we found only a 50% overlap of resident species at mesic and xeric habitats. Additionally, resident species at xeric lands are more evenly distributed than residents species at mesic lands, and numbers of individuals of a species tends fluctuate more at mesic than xeric sites. While mesic habitats are much more contiguous and extensive than the patchy xeric habitats, the pattern of distribution of resident species seem to be just the opposite. Species are much more patchily distributed in mesic habitats. Provided that a nearby source for colonization exists, we predict that a properly reclaimed patch of xeric habitat will attract a relatively representative sample of resident xeric species. In contrast, and reflective of the uneven distribution of

TABLE 2. Potential and actual resident species captured/observed only at mesic, only at xeric, or at both habitat types.

	XERIC ONLY	BOTH	MESIC ONLY
POTENTIAL RESIDENT SPECIES			
AMPHIBIANS	0	10	4
REPTILES	7	28	5
MAMMALS	3	4	3
BIRDS	5	64	45
TOTAL	15	106	57
ACTUAL RESIDENT SPECIES			
AMPHIBIANS	0	9	3
REPTILES	11	13	4
MAMMALS	3	4	2
BIRDS	10	29	17
TOTAL	24	55	26

species that reside in mesic habtats, a properly reclaimed patch of mesic habitat may only attract a small portion of the species representative of the mesic habitat.

Focal Species

We identified focal species in the following manner. The ratio of reference:reclaimed sites at which a species was present was compared to a 1:1 ratio with a binomial distribution. The magnitude of the deviation from a 1:1 ratio (the Binomial Test Score) was used to rank all species and is called the "Sites Scores." For example, if a species was found at 24 reference sites but no reclaimed sites, then the sites score was 20.72, or if a species was found at 21 reference sites and 6 reclaimed sites, then the sites score was 4.6. If an inherently rare species was found at say only three or four reference sites and no reclaimed sites, then, based upon binomial probabilities, it was not considered to be a focal species. Those species for which the ratio was not 1:1 at a probability of 0.10, did not qualify as focal species by the criteria we developed. Note that the probability level used to identify focal species was chosen purposely to reduce the number of designated focal species to include only those species that strongly satisfy the criterion of differential distribution between reference and reclaimed sites. The probability value can be increased as much as one wishes, so that, when it is sufficiently high, all species are included. Note also that focal species and sites scores are based only on the presence or absence of resident species. If the abundances of individuals at reference sites relative to reclaimed sites is considered, then the magnitude of the differences increases but does not alter any of our conclusions.

The total number of focal species, from the xeric and mesic reference habitats combined is 31, including 5 amphibians, 8 reptiles, 1 mammal, and 17 birds (Table 3). In both habitats, however, the potential exists for the number of focal species to increase significantly if those species captured at a very few reference sites are included. The number of focal species is greater at the xeric-like reclaimed sites (28) than at the mesic-like reclaimed sites (12). Of the 31 species, 19 were designated as focal species only at the xeric-like sites, 3 as focal species only at the mesic-like sites, and 9 as focal species at both types of sites. Two of the focal species unique to the xeric habitats were not considered resident species in the mesic habitats, and neither was captured/observed at the mesic sites. All 3 of the focal species unique to the mesic habitats were not considered resident species in the xeric habitats, 2 would have

TABLE 3. Total list of focal species captured/observed at the xeric and mesic habitats.

	HABITAT	
SPECIES	XERIC	MESIC
AMPHIBIANS		
Bufo quercicus (Oak toad)	Yes	Yes
Eleutheodactylus p. planirostris (Greenhouse frog)	Yes	No
Hyla femoralis (Pine woods treefrog)	Yes	Yes
Hyla squirella (Squirrel treefrog)	Yes	No
Scaphiopus h. holbrookii (Eastern spadefoot toad)	Yes	No
REPTILES		
Anolis carolinensis (Green anole)	Yes	No
Cemophora c. coccinea (Florida scarlet snake)	Yes	No
Drymarchon corais couperi (Eastern indigo snake)	Yes	No
Eumeces inexpectatus (Southeast five-lined skink)	Yes	Yes
Gopherus polyphemus (Gopher tortoise)	Yes	No
Sceloporus u. undulatus (Southern fence lizard)	Yes	No
Scincella laterale (Ground skink)	Yes	No
Tantilla relicta neilli (Florida crowned snake)	Yes	No
MAMMALS		
Podomys floridanus (Florida mouse)	Yes	No
BIRDS		
Aimophila aestivalis (Bachmann's sparrow)	No	Yes
Aphelocoma coerulescens (Scrub jay)	Yes	No
Caprimulgus carolinensis (Chuck-will's-widow)	Yes	No
Cardinalis cardinalis (Northern cardinal)	Yes	Yes
Cyanocitta cristata (Blue jay)	Yes	No
Dendroica pinus (Pine warbler)	Yes	Yes
Geothlypis trichas (Common yellowthroat)	No	Yes
Melanerpes carolinus (Red-bellied woodpecker)	Yes	Yes
Myiarchus crinitus (Great crested flycatcher)	Yes	No
Parula americana (Northern parula)	Yes	No
Parus bicolor (Tufted titmouse)	Yes	Yes
Pipilo erythrophthalmus (Rufous-sided towhee)	Yes	Yes

Polioptila caerulea (Blue-gray gnatcatcher)	Yes	No
Setophaga ruticilla (American redstart)	Yes	No
Sialia sialis (Bluebird)	No	Yes
Thryothorus ludovicianus (Carolina wren)	Yes	No
Vireo griseus (White-eyed vireo)	Yes	Yes

qualified as focal species had they been considered resident species, while the other was not observed at the xeric sites. Of the remaining 17 species, 13 simply were captured at too few mesic reference sites to be considered focal species. All but 3 of these species were captured/observed at more mesic reference than mesic-like 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 mesic sites to have been considered focal species, but they did not meet our statistical criterion. The smaller list of focal species at reclaimed mesic-like sites largely is a function of the narrower distribution of resident species among reclaimed mesic-like sites than at reclaimed xeric-like sites. In other words, the patchy distributions of species at mesic habitats limited the number of reference sites at which a species was found, thereby reducing the number of species that met our stringent criterion for focal species consideration.

Our second question asked if the suites of focal species are similar when either mesic flatlands habitats or xeric uplands habitats are used as reference sites. We conclude that fewer resident species were recognized as focal species at mesic-like reclaimed sites than at xeric-like reclaimed sites. Roughly 60% of the focal species resided in xeric habitats, 10% resided in mesic habitats, and 30 % were resident of both habitats. Some may interpret our finding to suggest that reclaiming phosphate mined land to support wildlife representative of mesic habitats is more achievable than reclaiming mined land to support wildlife representative of xeric habitats. Further considerations, however, suggest that such is not the case. If we consider the differences in the patterns of distributions of the species that reside within each type of habitat, then we have to qualify that interpretation. The patterns of distributions indicate a more narrow and patchy distribution of many species that reside at mesic habitats when compared to species that reside at xeric habitats. Xeric reference sites tend to have more resident species than mesic reference sites, and resident species tend to be more evenly distributed among xeric reference sites than among mesic reference sites. If we consider that the total lists of resident species in the two unmined habitats are identical in size (75 species in the xeric and mesic habitats), then greater heterogeneity in species composition would exist among mesic reference sites than among xeric reference sites. A greater heterogeneity among mesic habitats than xeric habitats would complicate the reclamation process. Proper reclamation of mesic habitats to insure that they can support a wildlife fauna representative of mesic flatlands would have to approximate the habitat variability we observed among reference sites. Recall that at the best mesic reference site, we captured only 25% of the species resident to that habitat.

Habitat Quality, and Scale

At all 100 study sites we assessed habitat quality for wildlife by taking numerous measures of the composition and physical structure of vegetation. Here, we summarize only the methods relevant to the most important of these measures, the methods used to create vegetation profiles used for comparisons among sites. The vegetation data were collected on three to five randomly selected plots measuring 10 X 10 meters. Foliage layer height profiles were characterized by visually analyzing the vegetation structure for seven different layers. Height of each identified layer was measured or estimated with a clinometer at each plot. Canopy density within plots was measured in two ways. Total canopy cover higher than 1 and 2.5 m above ground was determined with a hand-held densiometer, and canopy density also was estimated by visually scoring the percent cover of a board held at pre-selected heights and from a standardized distance. Vegetation density was assessed by counting and classifying shrubs and trees according to height within each plot.

We found that the Sites Scores correlated with a variety of the habitat quality variables we measured at the xeric sites, but not at the mesic sites (Mushinsky and McCoy 1996, in press). 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. Many amphibians, reptiles, and small mammals require low shrubby vegetation and ground cover for shelter and as a place to locate food. If tree canopy develops to approach closure, and shades out the understory, then many species will abandon the area to search for better quality habitat. 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 layers, and negatively related to the presence of vegetation cover at the high layer. Again, at mesic habitats the quadrupeds seek certain kinds of vegetation. While it appears that some types of vegetation at mesic sites can get too dense for birds, in general, the majority of vertebrates responded positively to vegetative cover, and in particular, vegetative cover at the ground and intermediate layers.

Our last question asked if the local or regional habitat quality would influence representation of vertebrates, and if our perceptions of representativeness would change if xeric and mesic habitats are viewed at the landscape level. We conclude that inherent differences in the distributions of resident species, sizes of local populations and responses to local habitat quality suggest that the reclamation of mesic and xeric habitats should be considered on a broad and integrated scale (Cates 1992, Nieman and Merkin 1995). Recall that our study areas were distributed over 1,000 square miles, and the phosphate industry is in the process of getting permits to nearly double the number of acres that have already been mined. While other human development activities and agriculture also influence the abundances and distributions of wildlife species throughout Bone Valley, the extensive disturbance created by mining is hard to minimize. Xeric and mesic habitats are not evenly distributed in Bone Valley. Unlike the scrub or sandhill upland habitats in central Florida which tend to be naturally fragmented into relatively isolated patches (McCoy and Mushinsky 1994, 1999), the mesic flatlands tend to cover vast areas that connect adjacent drainage basins. Collectively, the xeric uplands and mesic flatlands create a mosaic of habitats. Furthermore, because mesic flatlands often are associated with lakes, rivers, streams and temporary ponds, their broad scale reclamation may promote the movement of representative mesic and xeric species along the waterways to facilitate the colonization of reclaimed lands. In fact, reclamation of terrestrial habitats for wildlife in central Florida should be planned and integrated to include the mostly protected hydric habitats, as well as the relatively extensive mesic habitats, and the patchy xeric habitats. Ongoing research on scrub restoration just north of Bone Valley in Florida indicates that scrub habitat restored near or contiguous to existing natural scrub habitat will support more representative scrub species than isolated restored scrub habitat (Mushinsky and McCoy, unpublished). Large scale planning, across traditional ownership and political boundaries is essential if we hope to maintain vertebrate species that are representative of the mesic and xeric habitats of Florida. Large scale planning seems essential to create integrated habitats with sufficient local variation to accommodate the breadth of the variation exhibited at reference sites.

The extensive mining in the northern portions of Bone Valley has produced a highly fragmented landscape of small remnant patches of unmined habitats interspersed among the wide-ranging mined lands. Relatively small portions of the mined lands have been reclaimed for wildlife and most of those reclaimed patches are isolated from the remaining natural habitat patches, or even other patches reclaimed to support wildlife. It is hard to imagine a more poorer background upon which to attempt to design and implement a regional plan to recover the biodiversity that existed as few as fifty years ago. Virtually no data exist on the rates of natural colonization for most species that reside in Bone Valley; hence, it is impossible to distinguish among several possible causes for species to be under-represented on reclaimed lands. In particular, we recognize three, not mutually-exclusive, possible reasons for species to be under-represented on reclaimed lands. Species may be under-represented because the quality of the reclaimed land is not sufficient to meet the minimum requirements of the focal species. For example, the construction of temporary ponds, if other aspects of the reclaimed lands are appropriate, may permit several focal frog species to establish on reclaimed lands (see above). Species may be under-represented because the degree of geographic isolation of reclaimed land is sufficient to prevent successful colonization by focal species. We are conducting studies of translocated amphibians and reptiles to attempt to gain insight into the habitat quality versus habitat isolation dichotomy. Lastly, species may be under-represented because an insufficient amount of time has passed since the reclamation to allow focal species to establish in the reclaimed land. Our research on xeric uplands and mesic flatlands, however, does not indicate that the amount of time since reclamation is as important as the quality of habitat issues already mentioned (Mushinsky and McCoy unpublished).

Integration of mesic and xeric reclaimed lands on a broad regional basis may help counteract another disturbing trend that we detected at our reference sites. In the region of central Florida where phosphate mining is extensive and has the longest history, we found that the unmined patches of xeric habitats supported fewer species of vertebrates than similar patches of unmined habitat in areas with less extensive mining. A comprehensive plan for reclamation of hydric, mesic, and xeric lands, one that establishes connections of reclaimed lands with existing unmined patches of natural habitats, may thwart the continued decline of wildlife species richness. If connections can be established with currently protected lands, such as county, state, or federal parks that can serve as a source for colonization, then perhaps some of the previously mined and poorly re-colonized reclaimed lands will support wildlife that is representative of the entire region.

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