Section 6 Report Review

Attachment to letter dated 24 May 2002

Project: "An Assessment of Three Potential Reintroduction Sites for the Attwater's Prairie Chicken"

Final or interim report? Final

Job #: WER28 (81)

Reviewer's Station: Corpus Christi Ecological Services Office

Lead station was contacted and concurs with the following comments:
___ Yes ___ No _X_ Not applicable (reviewer is from lead station)

Report: ____ is acceptable as is

____ is acceptable as is for an interim report, but the following comments are made for future reference

_X_ needs revision (listed below)

Comments: (Note to commenter: If you make comments directly on a copy of the report, write legibly and dark so comments will reproduce well when photocopied.)

This was a very ambitious project, especially in light of the amount of funding requested. However, there are some procedural/administrative concerns with this project that need to be addressed. Objective 1.e concerning assessing diseases at the reintroduction sites was dropped and Objective 3 was added over the course of the project. However, Objective 3 is not addressed or mentioned in the final report.

The report states that further analyses are planned to assess the nature of the habitat edges present at the study sites. Will this analyses be done as part of this project, even though a final report has been submitted? Will the Service be provided with the results of the analyses?

In addition, it would be helpful if the report consistently used either English or metric units, instead of a mixture.

FINAL REPORT

As Required by

THE ENDANGERED SPECIES PROGRAM

TEXAS

Grant No. E-1-13

Endangered and Threatened Species Conservation

WER 28(81): An Assessment of Potential Reintroduction Sites for the Attwater's Prairie Chicken

Prepared by: Lee Ann Johnson Linam

TEXAS PARKS & WILDLIFE

John Herron
Program Director, Wildlife Diversity

Robert Cook
Executive Director

March 31st, 2002

FINAL REPORT

STATE: Texas **GRANT NO:** E – 1 – 13

PROGRAM TITLE: Endangered and Threatened Species Conservation

PERIOD COVERED: September 1, 1996 – August 31, 2001

PROJECT NUMBER: WER 28 (81)

SEGMENT COST:
TOTAL - $10,205.14
FEDERAL SHARE - $7,653.88

PROJECT TITLE: An Assessment of Potential Reintroduction Sites for the Attwater's Prairie Chicken

PROJECT OBJECTIVES:

1. To examine the three potential reintroduction sites identified above and assess the following habitat characteristics:
   a. total native grassland area and degree of habitat fragmentation on the release site and surrounding areas
   b. vegetational characteristics of release sites, especially in relation to composition of the grass and forb community
   c. insect abundance on release sites
   d. predator abundance on release sites
   e. topographic features, including proclivity to flooding

2. To assess local land use trends, the support and concerns of local landowners and the local community, and the ability of the reintroduction effort to address those concerns at the three potential reintroduction sites.

3. To assess the availability of other tall-grass prairie sites within the state as potential reintroduction sites in the future.

PREPARED BY: Lee Ann Johnson Linam 03/25/02

APPROVED BY: [signature] 03/26/02
Neil E. Carter
Federal Aid Coordinator
Date

Project 81 - AN ASSESSMENT OF POTENTIAL REINTRODUCTION SITES FOR THE ATTWATER'S PRAIRIE CHICKEN - Lee Ann Johnson Linam - Texas Parks and Wildlife Department, Wimberley, TX; Jon R. Purvis - Texas Parks and Wildlife Department, Austin, TX; and Melisa J. Portis, M.D. Anderson Cancer Research Center, Smithville, TX.

ABSTRACT - Populations of Attwater's prairie chickens (*Tympanuchus cupido attwateri*) have declined precipitously in the past several decades, so that captive breeding and reintroduction are now being pursued as essential steps in the preservation of the species. This study examined the habitat characteristics of three potential reintroduction sites for APC in the Gulf Coast Prairies region of Texas during 1997 and 1998. Vegetation structure, brush density, vegetation canopy cover and basal dominance, plant species richness, insect biomass and family richness, and predator abundance were assessed at the Tatton Unit of Aransas National Wildlife Refuge, Mad Island Marsh Preserve and Mad Island Wildlife Management Area, and the Hoskins Mound Unit of Brazoria National Wildlife Refuge. Habitat type maps were constructed based on digital photography and habitat patch characteristics were examined.

Coastal prairie was superior to salty prairie in providing prairie chicken habitat needs. Study site, vegetation type, plant species richness, year, sample date, and management history were significant in various models affecting insect biomass, vegetation structure, plant species richness, and brush density. The Aransas site met most habitat goals, but also supported the highest predator populations. The Brazoria site provided the most habitat available, but was the most highly fragmented and had the most woody encroachment. The Mad Island site provided the least amount of habitat. As the only grazed site, it had the lowest brush density, but also had insufficient grass structure. All sites may not provide sufficient insect productivity, and habitat restoration in adjacent areas will likely be needed to provide minimum acreages for population establishment and persistence.

SIGNIFICANT DEVIATIONS

Due to software problems statistical analyses have not been completed on GIS habitat patch data. Further analyses are planned to assess the nature of the habitat edges present at these study sites.

This project originally aimed to assess habitat patch characteristics on areas surrounding the study sites, assess evidence of diseases of concern to APC on the study sites, assess topographic features, analyze land-use trends, and address private landowner concerns. The disease objective was dropped in response to suggestions from recovery team members and TAMU researchers that such an assessment would not be feasible. Topographic features have not been assessed due to problems in obtaining necessary digitized files. Private landowner concerns are being more effectively addressed by the Gulf Coast Prairies Initiative. Expanded habitat assessments and assessments of land-use trends have simply proven to be beyond the capability of this study, its time-frame, its funding, (and its primary investigator).

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INTRODUCTION

The Attwater's prairie chicken (APC) is a critically endangered species of the Texas coastal prairie. Once estimated to number up to one million birds occupying six million acres of prairie habitat, by the middle of the 20^{th} century there was already concern about its long-term survival (Lehman 1941). At the time the species was listed as endangered in 1967, 1,070 individuals were estimated to occupy 234,082 acres (Lehman 1968). Population declines continued throughout the final decades of the 20^{th} century, as habitat was lost due to urbanization, agriculture, and encroachment by native and exotic woody species (McKinney 1996). By 1990 populations had declined to less than 500 birds in three populations (USFWS 1992), and the recovery team for the species initiated a captive breeding program. Eggs and isolated adults were collected from the wild, and in 1993 the first APC chicks were produced in captivity (USFWS, unpubl. reports).

The goal of the captive breeding program is three-fold--to provide a reservoir of genetic material in case of extinction in the wild, to produce birds to supplement the two remaining wild populations on the Attwater's Prairie Chicken National Wildlife Refuge and The Nature Conservancy's Texas City Prairie Preserve, and to reintroduce APC into currently unoccupied restored habitat. To date, captive-reared birds have been used to supplement the two wild populations with moderate success. As the five captive breeding facilities increase their production capabilities, the recovery team hopes to begin repatriation of former habitat with captive-reared birds (T. Rossignol, pers. comm.).

Historically, reintroduction efforts with prairie grouse have achieved only limited success. In a review of translocation efforts, Snyder et al. (1999) found that only about one-third were successful in the long term. Other analyses of reintroduction efforts have consistently shown that habitat quality plays a major determining role in the ultimate success of reintroduction efforts (Griffith et al.1989), and habitat assessments are a common precursor to reintroduction efforts

(Bishop 1987). Several features may be considered important in ranking habitat quality for prairie grouse and other grassland birds, including (1) vegetational characteristics, such as species composition, life-form, floristics, height, density, and dispersion; (2) abundance of insects and other food sources; (3) predator abundance; and (4) habitat patch size, fragmentation, and edge influences (Lehman 1941, Lehmann and Mauermann 1963, Jones 1963, Yeatter 1963, Evans and Gilbert 1969, Robel et al. 1970a, Chamrad 1971, Kirsch et al. 1973, Kessler 1978, Cogar et al. 1977, Cogar 1980, Horkel et al. 1981, Lawrence 1982, Buhnerkempe et al. 1984, Johnson and Temple 1986, Morrow 1986, Toepfer 1988, Johnson and Boyce 1990, Mankin and Warner 1992, Riley et al 1992, Burger et al. 1994, Lutz et al. 1994, Herkert 1994, Heske 1995, McKee 1995, Pasitschniak 1995, McKinney 1996, Morrow et al. 1996, Peterson and Silvy 1996, Griffin et al. 1997, Bock et al. 1999, Merrill et al. 1999, Westemeier and Gough 1999, Jamison 2000, Niemuth 2000, Winter et al. 2000).

This study attempts to assess the suitability of three sites identified by the APC Recovery Team as potential reintroduction sites. In addition, this study makes comparisons between the suitability of various habitat types found on the sites and assesses the influence of management history on habitat suitability. Specifically, the study seeks to assess which sites and habitats meet the following habitat goals.

HABITAT GOALS

1) Vegetative structure

a) variable obstruction of vision in the range of 2 dm.

Several studies have shown that prairie grouse prefer a diversity in grassland structure, with some minimal screening cover required (Horkel et al. 1981, Jones 1963, Lehman 1941, Lutz 1994, Westemeier and Gough 1999, Morrow 1986, Morrow et al. 1996). Obstruction of vision is commonly used as a measure of grassland habitat structure (Robel et al. 1970). Several studies have suggested that an OV in the range of 2 dm is optimal for APC (Morrow 1986, 1999, Cogar et al. 1977, Horkel et al. 1981).

b) availability of bare ground

Ground-dwelling birds require open spaces at ground level for movement within habitats. This is especially true for hens and broods. Studies have shown a shift in preference for open ground classes between seasons, with less open ground (6-25%) preferred in winter and spring, and more open ground (51-95%) selected in summer months (Morrow 1986). Estimates of actual bare ground requirements vary with studies and techniques (Chamrad 1971, Kessler 1978, Cogar 1980, Morrow 1986); therefore this study will simply attempt to document availability and variability of bare ground.

2) Vegetative composition

a) litter canopy cover <25%

b) woody canopy cover <5%

c) forb canopy cover >5%

d) non-*Spartina* grass canopy cover >25%

McKee (1995) identified the above habitat preferences in a study of greater prairie chickens in Missouri. Her recommendations concur with others who have found that prairie chickens avoid areas with high litter accumulation (Kessler 1978, Morrow 1986, Westmemeier and Gough 1999). and woody cover (Lehman 1941), while requiring habitat with some threshold of forb and grass cover. Morrow (1986) found selection of areas with higher forb abundance, while Cogar (1980) found that forbs comprised 38% of the vegetative community in preferred habitats. Morrow found variation in grass cover classes selectively used, but identified a yearly preference for the 26-50% cover class. Cogar found that grass species made up 56% of the vegetative community in summer habitats. Although the Texas coastal prairie is characterized by inclusion of salty prairie areas dominated by gulf cordgrass (*Spartina spartinae*), both Cogar and Lehman (1941) found these habitats to be little used in relation to their abundance.

3) Maximize insect abundance

Insects are important in the diet of many prairie grouse, especially grouse chicks (Jamison 2000, Lehman 1941, Peterson and Silvy 1996, Davis et al. 1980, Johnson and Boyce 1980, Jones 1963). Lehman found that insects made up 88.5% of the food volume of APC chicks in summer, while Griffin (1998) determined that captive APC chicks consume 9-16 grams of insects daily. While some researchers have found that insects comprise a smaller percentage of the diet of adult APC in comparison to other grouse species (Cogar 1980), their contribution to the diet, especially in the summer, is still significant. Kessler found insects in more than 70% of adult droppings in the summer, while Lehman and Cogar found that they made up 29% and 7% of the food volume, respectively. Morrow (1986) found that adult APC selected habitats more abundant in insects in the summer.

Vegetative characters can be used as predictors of insect abundance. Haddad et al. (2001) found that insect abundance increased with plant biomass, plant species richness, and abundance of certain forb species. Fire and grazing can also affect insect abundance (Chamrad 1971, Warren et al. 1987, Evans 1988), although effects vary with combinations of treatment and time elapsed since treatment.

4) Minimize predator density

No research to date has identified predation of adults birds as a limiting factor for *T. cupido* (Berger et al. 1963, Hamerstrom et al. 1965); however, numerous studies have found that predation is the most important contributor to nest failure in ground-nesting birds (mult. Cit. In Peterson and Silvy 1996 and Jamison 2000). In addition, predation is often implicated in low survival of captive-reared birds. Numerous species have been identified as predators of APC or their nests, including opossum (*Didelphis virginianus*), spotted skunk (*Spilogale putorius*), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), coyote (*Canis latrans*), various raptor species, great-horned owl (*Bubo virginianus*), and snakes (Lehman 1941, USFWS 1992, M. Morrow pers. comm.).

5) Maximize patch size & minimize edges

Many researchers have proposed optimal landscape composition for prairie chickens, usually based on an estimate of minimum grassland cover required (Christisen and Krohn 1980, mult. cit. in Toepfer 1988, Niemuth 2000); however, little analysis has been done to suggest exactly how much habitat is needed to support a prairie chicken population. Lehman (1941) proposed that good habitat could support one prairie chicken/acre, but did not suggest how many acres should be required in a habitat block. Minimal conservation areas ranging from 520 to 1800 hectares have been suggested (Toepfer 1988, Niemuth 2000, Kirsch 1974), although actual data from Wisconsin demonstrate that about 5300 hectares supports viable greater prairie chicken populations (Westmeier and Gough 1999). In fact, the Attwater's prairie chicken recently (in 2000) disappeared from Refugio county, where at least 9355 hectares of habitat were still estimated to exist in 1990 (McKinney 1996).

Despite the lack of knowledge of a minimum habitat threshold, much evidence has accumulated regarding the deleterious effect of habitat fragmentation on grassland species. Nesting success has been documented to be lower in small habitat patches (Burger et al. 1994, Horkel et al. 1978) and near habitat edges (Pasitschniak 1995, Burger et al. 1994, Winter et al. 2000, Johnson and Temple 1986, Horkel et al. 1978). Grassland birds are also more abundant in larger, interior plots (Herkert 1994, Bock et al. 1999), while predators are often more abundant near habitat edges (Winter et al. 2000, Heske 1995). A few artificial nest studies have failed to document such edge or area effects (Lutz and Silvy 1980, Mankin and Warner 1992), but the overwhelming consensus points to a need to maximize patch size and minimize edge for grassland bird survival. Herkert (1994) suggested a minimal patch size ranging up to 55 hectares for some grassland songbirds, while Kirsch et al. (1973) suggested patches of at least 65 hectares for prairie chickens.

STUDY AREAS

The study sites were selected based on discussions by the APC Recovery Team regarding potential release sites based on at least partially publicly-owned properties. In addition, all three sites have undertaken management in recent years to restore native coastal prairie habitat.

Aransas - The 7,000 acre Tatton Unit of the Aransas National Wildlife Refuge was acquired by donation in 1967. The unit, located in Aransas county, contains approximately 2,000 acres of prairie habitat (USFWS 1992), with the remainder in wetland and brushland habitat. The unit is bounded on the north by privately-owned non-irrigated cropland, on the west by privately-owned rangeland currently in a shrub-dominated community, and on the south and east by Saint Charles Bay. APC were last seen on the Tatton Unit in 1991, when two chickens were recorded. Habitat management currently consists of an aggressive burn program, including summer burns.

Brazoria - The 30,178-acre Hoskins Mound Unit was added to the Brazoria National Wildlife Refuge in 1991 (USFWS 1992). The unit, located in Brazoria county, contains approximately 11,500 acres of prairie habitat in various stages of management (Miller, unpubl. data), with the remainder in rice farming, old fields, and wetland habitat. The unit is bounded on the east by Chocolate Bay, on the south by refuge wetlands, on the west by Austin Bayou and privately-owned wetlands, and on the north by privately-owned rice fields and heavily-grazed rangeland. APC were last seen on the unit in 1982. Habitat management consists of burning, tallow-removal efforts, rice-farming, and haying of selected tracts.

Mad Island - This site is composed of the 7,281-acre Mad Island Wildlife Management Area owned by Texas Parks and Wildlife Department since 1987 and the 7,048-acre Clive Runnells Family Mad Island Marsh Preserve owned by The Nature Conservancy of Texas since 1993. The site, located in Matagorda county, is comprised of freshwater to saline marshes, prairie habitats, and rice-farming tracts. The site is bounded on the west by privately-owned wetlands and rice fields, on the north by privately-owned rice fields and shrub-dominated rangeland, on the east by wetlands and bottomlands of the Colorado River, and on the south by the Intracoastal Canal. Specific records do not exist regarding APC population estimates for the site; however, local residents recall seeing prairie chickens throughout the 1970's. Habitat management consists of a grazing program with irregularly scheduled deferrals, rice-farming, and a prescribed burning program.

METHODS

Vegetation structure and insect abundance were assessed at each study site in late May through early June, 1997 and 1998. At each study site, sampling locations were randomly selected to represent the variety of prairie habitat types. A total of 24 locations were sampled at Aransas NWR (12 in 1997 and 12 in 1998); 27 were sampled at Brazoria NWR (14 in 1997 and 13 in 1998); and 24 were sampled at the Mad Island complex (12 in 1997 and 12 in 1998). GPS readings were recorded at all sample locations.

Vegetation Measures - 1997: A 30 meter transect was established at each sample location. Vegetation composition was sampled through line intercept readings taken at each 1-meter interval along the transect. Because vegetation was difficult to identify to species during the summer sampling period, hits were classed as cordgrass (*Spartina spartinae*), other grass, forb, sedge, woody, bare ground or litter. Basal hits were recorded as a measure of basal cover. The nearest plant species was also recorded in order to better sample dominance of each plant class, according to techniques used at APC National Wildlife Refuge (Mike Morrow, pers. comm.).

Brush density was assessed using a point-centered quarter method. The distance to the nearest brush species in each quadrant was taken. Results were converted to density/hectare.

Vegetation structure was assessed through the use of a Robel pole (Robel et al. 1970b). Readings were taken from both sides of the transect at the 10, 20, and 30 meter marks. Visual obstruction was recorded to the nearest decimeter, and an average OV was estimated based on the three sample points. A 1 m^2 quadrat was placed at the 0 meter mark to estimate % bare ground. The quadrat was also used to assess plant species richness. The number of different species occurring in the quadrat were recorded.

Vegetation Measures - 1998: Sampling techniques were modified in 1998, in order to better sample canopy cover of the different plant classes. A 30-meter transect was again established at the random location. A 1 m^2 quadrat was placed at the 10, 20, and 30 meter marks. At each quadrat total cover was allocated among the categories described above and described as a percent cover. In addition, "standing dead" was also recognized as a cover class. Results were standardized to cover classes described by Daubenmire (1959). Sampling techniques for brush density, visual obstruction, and species richness remained the same as in 1997, except that species richness was determined for both one quadrat and for the results of all three quadrat locations combined.

Insect Sampling: Insects were sampled used a standard 30 cm sweepnet, according to accepted techniques (Cogar 1980, Evans 1988, Jamison 2000). At each location three transects were swept, following along and perpendicular to the vegetation transect. The number of sweeps were recorded, with a swing representing a swing to the right and to the left. In 1998 an effort was made to standardize sampling to 75 sweeps at each location. Samples were placed in zip-lock bags and transported back to the vehicle to be immediately placed on ice.

Insects (including arachnids and snails) were frozen and then sorted to family when possible. Once sorted, the samples were freeze-dried at least 24 hours and weighed to the nearest 0.001 gram. Samples from all three transects at each location were combined in order to produce a measurable mass at each location. Results were standardized to an estimated mass/100 sweeps. Results were analyzed for total insect biomass (all references to "insect biomass" also include dry weight of Arachnida), total Orthoptera biomass, Acrididae biomass, and Tettigoniidae biomass, along with insect family richness.

Predator Abundance: Late afternoon diurnal raptor counts and nocturnal predator counts were conducted along roadways at each site in 1998, following techniques described by Morrow (1986). Three counts were conducted at each site in late February-early March while driving (one survey at Brazoria NWR also included a nocturnal count conducted from a marsh buggy). During the diurnal counts all raptors and other potential predators were counted within all visible areas; however, during the nocturnal counts only potential predators seen in the roadway or road right-of-way were counted because of variation in visibility between sites.

Habitat Mapping: 1995 Digital Orthographic Quadrangle (DOQQ) imagery was obtained for the three sites. Initial delineation in ArcView 3.2 was based on onscreen interpretation and interpretation of hard-copy 1995 aerial photography, with the exception of Brazoria, which was previously classified by Miller. Ground-truthing was conducted in the field to confirm or modify classifications. Vegetative transects conducted by Hays at the Tatton Unit were also referenced. Prairie habitats were classified as coastal prairie (grass species ratio less than 1 part gulf cordgrass : 2 parts other prairie grass species); salty prairie (ratio greater than 2 parts cordgrass : 1 part other grass); mixed prairie (ratio between 1:2 and 2:1), or old field (previously cultivated habitats still in a weedy condition). Modifiers of wet or woody were applied where applicable. Non-prairie areas were grossly classified as wetland, woodland, cultivated, or other. Total prairie areas, average patch sizes, average perimeter to area ratios, and average diversity indices (McKinney 1996) were calculated.

Statistical Analysis - Rank comparisons were used on all vegetation and insect data due to non-normal distributions. Wilcoxon scores were calculated for obstruction of vision (OV), plant species richness, Daubenmire canopy coverage, insect family richness, and insect biomasses and compared using the Kruskal-Wallis test. Point intercept vegetation data was compared using Chi-Square analysis. Multiple Analysis of Variances (MANOVA) were perfomed to assess the effects of multiple variables on insect family richness, insect biomass, OV, plant species richness, and brush density. Additional MANOVA analyses were performed excluding the salty prairie habitats. Insect data collected in this study were compared to data collected on the Attwater's Prairie Chicken National Wildlife Refuge using ANOVA techniques. Results were considered significant at the $\alpha = 0.05$ level. Statistical comparisons have not yet been made on predator density data or habitat patch data.

RESULTS

Habitat and Insect Characteristics by Vegetation Type

Each of the study sites (and indeed, much of the publicly-managed wildlife land in the Gulf Coast Prairies and Marshes ecoregion) is found in an area where upland coastal prairie rapidly grades into wetter salty prairie. One of the purposes of this study was to determine whether these different prairie types provide habitat of equal quality for APC, and therefore which vegetation types should be considered in the final analyses. Each of the 75 sample localities was characterized as one of four vegetation types at the microsite sampled--salty prairie, coastal prairie, mixed prairie, or old field, based upon the ratio of gulf cordgrass to other upland prairie grasses and site use history, as described in the methods section.

Results of the habitat characteristics analysis by vegetation type are shown in Table 1 and Figures 2 through 9. There were statistically significant differences between habitat types for several variables, including obstruction of vision, plant species richness, brush density, cordgrass canopy and basal cover, other grass canopy and basal cover, forb canopy and basal cover, sedge canopy and basal cover, insect family richness, total insect biomass, and Orthoptera biomass. Models constructed using MANOVA techniques demonstrated that vegetation type contributed significantly to the variation in obstruction of vision, plant species richness, brush density, insect richness, insect biomass, and Orthoptera biomass (Table 2).

The coastal prairie vegetation type provided the highest quality habitat--meeting all vegetation and insect goals, with the exception of a slightly-lower than desired obstruction of vision. The mixed prairie habitat type met most goals as well, although measures of diversity and insect biomass were lower at mixed prairie sites than at coastal prairie sites. Old field habitats provided the highest insect biomass and insect family richness; however, these sites tended to be marginal in the amount of grass cover and had the highest encroachment of woody species. Salty prairie was the least suitable vegetation type sampled. Forb canopy cover, plant species richness, insect family richness, and insect biomass were all lowest in salty prairie. Although it provides adequate structure, salty prairie seems unlikely to meet other habitat needs for APC.

Habitat and Insect Characteristics by Study Site

Results of the habitat and insect analysis by study site are shown in Tables 3 and 4 and Figures 10 through 21. Because of our findings that salty prairie constitutes a much lower quality habitat, site characteristics are presented both with and without salty prairie sampling locations included. With salty prairie included (Table 3) there were statistically significant differences between study sites for several variables, including obstruction of vision, brush density, vegetation canopy cover, bare ground basal cover, litter basal cover, and insect family richness. The same variables were significantly different between sites when salty prairie was excluded (Table 4). In addition, sedge basal cover differed between sites, and insect biomass differed at $\alpha = .06$. MANOVA models indicated that study site contributed significantly to the variation in obstruction of vision, brush density, insect richness, insect biomass, and Orthoptera biomass.

The Aransas site met most habitat goals, especially when salty prairie was excluded. Average obstruction of vision approached 2 dm, and brush density was fairly low (Figs. 10 and 11). Canopy cover classes met objectives identified by McKee (Figs. 14 and 15), and signficant open ground at the basal area probably reflected the results of a vigorous burn program (Figs. 16 and 17). Insect biomass was highest at Aransas, ranging from 1.3 g / 100 sweeps when salty prairie locations were included to about 1.5 g / 100 sweeps when salty prairie was excluded from the analysis (Figs. 18 and 19).

The Brazoria site also met obstruction of vision goals; however, average brush density was very high and average grass canopy cover did not meet the goal of 25% (excluding *Spartina*). These shortcomings probably represent the influence of significant acreages of old field at Brazoria that are in various stages of recovery to coastal prairie. Insect biomass at Brazoria was mid-way between the other two sites at 1.10 - 1.20 g / 100 sweeps.

The Mad Island site differed from the other two sites in several variables--likely reflecting an ongoing grazing program at the site that was rather intense at some sample locations. Obstruction of vision averaged about 1 dm, well below APC habitat goals; however, Mad Island had the lowest brush density of the three sites. Non-*Spartina* grass cover was somewhat low at Mad Island, and, while litter was low in the canopy composition, it made up a significant portion (~40%) of the basal hits. Insect biomass was lowest at Mad Island, at about 0.70 g / 100 sweeps.

Habitat Management

Although habitat management treatments were not manipulated in this study, data regarding management history were gathered at each sample location and examined along with other variables in the models generated by MANOVA. Results indicate that burn history may affect structure (as reflected in obstruction of vision), plant species richness, insect family richness and brush density (Table 2b). In contrast to some previous studies, this study did not detect an effect of burning on insect biomass (Chamrad 1971) or forb density (Kessler 1978). The effects of study area on structure, brush density, insect richness, insect biomass, and Orthoptera biomass may reflect an effect of grazing, as Mad Island was the only site currently being grazed.

Predator Abundance

Results of roadside predator sampling are presented in Table 5. Eight species of potential predators on APC or their nests were recorded during diurnal surveys in late afternoon, including four raptors, two wild carnivores, one feral carnivore, and feral pigs. A total of eight potential predator species were recorded during nocturnal spotlight surveys, including opossum, three wild carnivores, two feral carnivores, feral pigs, and undetermined owl species.

Density results for diurnal raptors ranged from 0.65 km / raptor at Aransas to 2.45 km / raptor at Brazoria. Density results for nocturnal carnivores ranged from 5.06 km / carnivore at Brazoria to 9.33 km / carnivore at Aransas. Density results for feral hogs ranged from 1.08 km / pig at Aransas to no feral pigs seen at Brazoria. Densities of carnivores were somewhat higher at all sites when compared to densities of 22.5 km / predator recorded at APC NWR (Morrow 1986). Direct comparison between sites is likely to be difficult, however, as the types of roadways and visibility varied greatly between sites.

Habitat Patch Characteristics

Current habitat type maps for Aransas and Mad Island based on interpretation and ground-truthing of DOQQ imagery (Figures 26 and 32) are presented in Figures 27 and 33. A current habitat type map for Brazoria based on ground-truthing of DOQQs (Figure 29) and updating earlier mapping efforts by Miller (Figure 30) is presented in Figure 31. Summary statistics for total habitat area and habitat patches are presented in Table 6 and Figures 22-25. Current habitat is defined to include coastal prairie, mixed prairie, old field, and moist coastal and mixed prairies. It does not include salty prairie, woody prairies, or wetlands. Although croplands, especially fallow rice fields, are used by APC (Lehman 1941, Kessler 1978), they are not included in the habitat estimates at these study sites. An estimate is also made of potential habitat, which includes current habitat plus woody coastal and mixed prairies that might be improved with burning or brush removal.

Total habitat areas of all types are highest at Brazoria, the largest of the study sites (Fig. 22). Approximately 4700 hectares of habitat are currently available there, of which 1530 hectares are coastal prairie. Habitat potential is 5500 hectares. Aransas offers about 1800 hectares of current habitat, including about 500 hectares of coastal prairie. Habitat potential at Aransas is 1900 hectares. The Mad Island complex includes about 950 hectares of current habitat, including 250 hectares of coastal prairie. Habitat potential is about 1300 hectares.

Mean habitat patch size is fairly constant at Aransas at 57 to 66 hectares (Fig. 23), and approaches the minimal patch sizes recommended by Kirsch (1973). Patch sizes are consistently much smaller at Mad Island, ranging from 17 to 28 hectares. Patch size is much more variable at Brazoria, ranging from a mean of 20 hectares in coastal prairie to a mean of 83 hectares in old field. Perimeter to area ratios are also much more variable at Brazoria, especially for coastal prairie (Fig. 24). This variability may be a reflection of more detailed habitat mapping performed by Miller, rather than an indication of smaller habitat patches with more edge at Brazoria. Further analysis of the juxtaposition of patches and types of edges is needed before conclusions may be drawn. Lower diversity indices (DI) at Mad Island indicate that patches there tend to be more regular and landscape-filling in shape (Fig. 25). Patches of mixed prairie and old field habitat at Brazoria and patches of old field habitat at Aransas tend to be less regular in shape.

CONCLUSIONS AND RECOMMENDATIONS

1) The Aransas site met most habitat composition and structure goals, and was the most productive site for insects. It appears that a summer burn program at this site has been successful in restoring good APC habitat. Two concerns may need to be addressed at this site in order to improve it as an APC release area. First, this site had the highest measured concentration of predators. In addition, since the completion of this study, an Aplomado falcon (*Falco femoralis*) release program has been initiated at the Tatton Unit. Predation would need to be closely monitored during any APC releases. Secondly, although habitat patch size is satisfactory at Aransas, total habitat available may be insufficient. The Tatton Unit was once contiguous with a much larger patch of coastal prairie habitat (Figure 28; McKinney 1996). If APC are released at Aransas, then efforts should be made to work with adjacent landowners to reduce brush encroachment and restore coastal prairie habitat.

2) The Brazoria site has the greatest acreage potential for APC habitat, but faces some management needs regarding woody species. The best coastal prairie habitats are currently fragmented from each other by unsuitable habitat, and the site is also dissected by major roadways. This site may have the best long-term potential for APC establishment, especially since some potential habitat exists north and east of the refuge, but intensive management will be required to bring habitat into condition and to maintain it.

3) The Mad Island complex failed to meet several of the habitat goals, including structure, grass cover, and litter reduction. The lower biomass of vegetation on the site probably also contributed to the lower insect biomass. If APC restoration were to take place at this site, then grazing pressure might need to be reduced and fire used a little more frequently to reduce litter at ground level. In addition, total habitat area available at Mad Island might be insufficient. APC released there might be able to make use of fallow rice fields during some periods of the year, but efforts should also be undertaken with neighboring landowners to improve native prairie habitats through grazing management and brush management.

4) The results of the insect sampling in this study add to some of the concerns that have been raised regarding carrying capacity of remnant Texas coastal prairie, especially for APC chicks. Biomasses recorded in this study in coastal prairie and old field habitats were similar to biomasses sampled at APC NWR in the last two decades (M. Morrow, pers. comm.); however, Griffin et al. (1998) suggested that insect levels at APC NWR were much less than weights measured by Cogar in Refugio county in the 1970's and would be insufficient to meet needs of growing APC chicks. This study does not shed any light on the causal factors implicated by Griffin et al., such as red imported fire ants (*Solenopsis invicta*), cattle egrets (*Ardea ibis*), or pesticide use, but it does offer some management implications. As in previous studies (Jones 1963, Haddad et al. 2001), insect productivity seems linked to forb diversity. It may be possible to increase insect biomass by using disturbance to increase forb

diversity. Insect abundance assessments will have to be standardized and long-term, as this study and others have shown that populations can fluctuate dramatically from one year to the next (M. Morrow, pers. comm; M. Quinn, pers. comm.). It may be possible to monitor insect productivity indirectly through monitoring forb abundance and diversity.

5) This study found a definite difference between different prairie types, with coastal prairie supporting a more diverse forb and insect community and greater insect biomass than salty prairie dominated by *Spartina spartinae*. Many of the publicly-owned wildlife areas are found near coastal wetlands where salty prairie makes up a large proportion of the prairie habitat. A new conservation emphasis may need to be placed on prairie habitat and APC restoration in more inland areas. In addition, given the limited acreage available in all these study sites and the increasing consensus that large tracts may be necessary for the conservation of prairie bird species, emphasis should continue on efforts to engage private landowners in prairie conservation and restoration.

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REFERENCES

Berger, D.D., F. Hamerstrom, and F.N. Hamerstrom, Jr. 1963. The Effect of raptors on prairie chickens on booming grounds. J.Wildl. Manage. 27(4):778-

Bergerud, A.T. and M.W. Grason, eds. 1988. Adaptive strategies of population ecology of northern
grouse. Univ. of MN Press, Minneapolis, MN, USA.

Bishop, M.A. 1987. Selection of potential reintroduction sites and foster parents for whooping crane reintroduction. Final Performance Report, Study No. E-II-6-2. FL Game and Freshwater Fish Comm. 42 pp. + fig.

Bock, C.E., Bock, J.H., and B.C. Bennett. 1999. Songbird abundance in grasslands at a surburban interface on the Colorado High Plains. Stud. in Avian Biol. 19:131-136.

Burger, L.D., L.W. Burger, Jr., and J. Faaborg. 1994. Effects of prairie fragmentation on predation on artificial nests. J. Wildl. Manage. 58:249-254.

Buhnerkempe, J.E., W.R. Edwards, D.R. Vance, and R.L. Westemeier. 1984. Effects of residual vegetation of prairie-chicken nest placement and success. Wildl. Soc. Bull. 12:382-386.

Burger, L.D., L.W. Burger, Jr., and J. Faaborg. 1994. Effects of prairie fragmentation on predation on artificial nests. J. Wildl. Mange. 58(2):249-253.

Chamrad, A.D. 1971. Effects of fire and grazing on coastal prairie rangeland and Attwater's prairie chicken habitat. Ph.D. Thesis. 120 pp.

Chamrad, A.D. and J.D. Dodd. 1972. Prescribed burning and grazing for prairie chicken habitat manipulation in the Texas coastal prairie. Proc. Tall Timbers Fire Ecol. Conf. 12:257-276.

Christisen, D.M. and R.B. Krohn. 1980. Land use: a key to greater prairie chicken habitat in Missouri. Pages 55-62 *in* Vohs, P.A., Jr., and F.L. Knopf, eds., Proceedings of the Prairie Grouse Symposium, Okla. St. Univ.

Cogar, V.F., J.D. Horkel, and N.J. Silvy. 1977. Vegetation type preferences of Attwater's prairie chicken in coastal prairie. Proc. Annual Cnf. S.E. Assoc. Fish & Wildl. Agencies 31:41-50.

__________. 1980. Food habits of Attwater's prairie chicken in Refugio County, Texas. Ph.D. Thesis. Texas A&M Univ. College Station. 119 pp.

Daubenmire, R.F. 1959. A canopy coverage method of vegetational analysis. Northwest Sci. 35:43-64.

Davis, C.A., T.Z. Riley, R.A. Smith, and M.J. Wisdom. 1980. Spring-summer foods of lesser prairie chickens in New Mexico. Pages 75-80 *in* P.A. Vohs, Jr. and F. L. Knopf, eds. Proc.of the prairie grouse symp. OK St. Univ., Stillwater, OK, USA.

Evans, E.W. 1988. Grasshopper assemblages of tallgrass prairie: influences of fire frequency, topography, and vegetation. Can. J. Zool. 66:1495-1501.

Evans, K.E. and D.L. Gilbert. 1969. A method for evaluating greater prairie chicken habitat in Colorado. J. Wildl. Manage. 33(3):643-649.

Griffin, C.P. 1998. Factors affecting captive prairie chicken production. Ph.D. Thesis. Texas A&M Univ. 99 pp.

Griffin, C.P., M.E. Morrow, and N.J. Silvy. 1997. Insects as a possible limiting factor for Attwater's
prairie-chicken *Tympunuchus cupido attwateri*. Wildl. Biol. 3:288.

Griffith, B., J.M. Scott, J.W. Carpenter, and C. Reed. 1989. Translocation as a species conservation tool: status and strategy. Science 245:477-480.

Haddad, N.M., D. Tilman, J. Haarstad, M. Ritchie, and J.M.H. Knops. 2001. Contrasting effects of plant richness and composition on insect communities: a field experiment. Amer. Midl. Nat. 158(1):17-35.

Hamerstrom, F., D.D. Berger, and F.N. Hamerstrom, Jr. 1965. The effect of mammals on prairie chicken booming grounds. J. Wildl. Manage. 29(3):536-542.

Havens K.J. and E.F. Sharp. 1998. Using thermal imagery in the aerial survey of animals. Wildl. Soc.
Bull. 26:17-23.

Herkert, J.R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecological Applications 4(3):461-471.

Heske, E.J. 1995. Mammalian abundances on forest-farm edges versus forest interiors in southern Illinois: Is there an edge effect? J. Mammal. 76(2):562-568.

Horkel, J.D., R.S. Lutz, and N.J. Silvy. 1978. The influence of environmental parameters on nesting success of upland game birds. Proc. Ann. Conf. Southeast Fish & Wildl. Agencies 32:234-241.

_________, V.F. Cogar, and N.J. Silvy. 1981. Cover use by radio-tagged Attwater's prairie chicken (*Tympanuchus cupido attwateri*) in Gulf Coast prairie of Texas. Stuckey & Reese. Ohio Biol. Surv. Biol. Notes No. 15.

Jamison, B.E. 2000. Lesser Prairie-Chicken Chick Survival, Adult Survival, and Habitat Selection and
Movements of Males in Fragmented Rangelands of Soutwestern Kansas. M.S. Thesis, Kansas
State Univ. 212 pp.

Jones, R.E. 1963. Identification and analysis of lesser and greater prairie-chicken habitat. J. Wildl.
Manage. 27:757-778.

Johnson, G.D. and M.S. Boyce. 1990. Feeding trials with insects in the diet of sage grouse chickes. J.
Wildl. Manage. 54:89-91.

Johnson, R.G., and S.A. Temple. 1986. Assessing habitat quality for birds nesting in fragmented tallgrass prairies. Pages 245-250 *in* J.A. Verner, M.L. Morrison, and C.J. Ralph, eds. Wildlife
2000. Univ. of Wisc. Press, Madison, Wisc., USA.

Kessler, W.B. 1978. Attwater's prairie chicken ecology in relation to agricultural and range management
practices. Ph.D. Thesis. Texas A&M Univ. 158 pp.

Kirsch, L.M., A.T. Klett, and H.W. Miller. 1973. Land use and prairie grouse population relationships in North Dakota. J. Wildl. Manage. 37(4):449-453.

Lawrence, J.S. 1982. Effect of predator reduction on the reproductive success of Attwater's prairie chicken. Ph.D. Thesis, Texas A&M Univ.

Lehmann, V.M. 1941. Attwater's prairie chicken, its life history and management. U.S. Dept. Interior, Fish and Wildl. Serv., Wash., D.C. n. Am. Fauna 57. 63 pp.

__________. 1968. The Attwater's prairie chicken, current status and restoration opportunities. Trans. N. Am. Wildl. Conf. 33:398-407.

__________ and R.G. Mauermann. 1963. Status of Attwater's prairie chicken. J. Wildl. Manage. 27:713-725.

Lutz, R.S. and N.J. Silvy. 1980. Predator response to artificial nests in Attwater's prairie chicken habitat. Pages 48-51 *in* Vohs, P.A., Jr., and F.L. Knopf, eds., Proceedings of the Prairie Grouse Symposium, Okla. St. Univ.

Lutz, R.S., J.S. Lawrence, and N.J. Silvy. 1994. Nesting ecology of Attwater's prairie-chicken. J. Wildl. Manage. 58(2):230-233.

Mankin, P.C. and R. E. Warner. 1992. Vulnerability of ground nests to predation on an agricultural habitat island in East-central Illinois. Am Midl. Nat. 128:281-291.

McKee, G. 1995. Ecology of greater prairie-chickens in relation to habitat characteristics in southwestern Missouri. M.S. Thesis. 112 pp.

________, M.R. Ryan, and L.M. Mechlin. 1998. Predicting greater prairie-chicken nest success from vegetation and landscape characteristics. 1998. J. Wildl. Manage. 62(1):314-321.

McKinney, L.B., Jr. 1996. Forty years of landscape change in Attwater's prairie chicken habitat within the coastal prairie of Texas. M.S. Thesis, Texas A&M Univ. 73 pp.

Merrill, J.D., K.A. Chapman, K.A. Poiani, and B. Winter. 1999. Land-use patterns surrounding greater prairie-chicken leks in northwestern Minnesota. J. Wildl. Manage. 63(1);189-198.

Morrow, M.E. 1986. Ecology of Attwater's prairie chicken in relation to land management practices on the Attwater's Prairie Chicken National Wildlife Refuge. Ph.D. Thesis. Texas A&M Univ. 100 pp.

_________, R.S. Adamcik, J.D. Friday, and L.B. McKinney. 1996. Factors affecting Attwater's prairie-chicken decline on the APC NWR. Wildl. Soc. Bull. 24: 593-601.

Niemuth, J.D. 2000. Land use and vegetation associated with greater prairie-chicken leks in an agricultural landscape. J. Wildl. Mange. 64(1):278-286.

Pasitschniak, A.M., and F. Messier. 1995. Risk of predation on waterfowl nests in the Canadian prairies: effects of habitat edges and agricultural practices. Oikos 73(7):347-355.

__________ and N.J. Silvy. 1994. Spring precipitation and fluctuations in Attwater's prairie-chicken numbers: hypotheses revisited. J. Wildl. Manage. 58:222-229.

__________ and N.J. Silvy. 1996. Reproductive stages limiting productivity of the endangered Attwater's prairie chicken. Cons. Biol. 19(4):1264-1276.

Riley, T.Z., C.A. Davis, M. Ortiz, and M.J. Wisdom. 1992. Vegetative characteristics of successful and unsuccessful nests of lesser prairie chickens. J. Wildl. Manage. 56:383-387.

Robel, R.J., J.W. Briggs, J.J. Cebula, N.J. Silvy, C.E. Viers, and P.G. Watt. 1970a. Greater prairie chicken ranges, movements, and habitat usage in Kansas. J. Wildl. Manage. 34(2)286-312.

________, J.W. Briggs, A.D. Dayton, and L.C. Hulbert. 1970b. Relationships between visual obstruction measurements and weight of grassland vegetation. J. Range Manage. 23:295-297.

Silvy, N.J., C.P. Griffin, M.A. Lockwood, M.E. Morrow, and M.J. Peterson. 1999. The Attwater's prairie-chicken—a lesson in conservation biology research. Pages 153-162 *in* W.D. Svedarsky, R.H. Hier, and N.J. Silvy, eds. The greater prairie-chicken: a national look. Misc. publ. 99. MN Ag Exp. St., Univ. of MN, St. Paul, MN, USA.

Snyder, J.W., E.C. Pelren, and J.A. Crawford. 1999. Translocation histories of prairie grouse in the United States. Wildl. Soc. Bull. 27(2):428-432.

Toepfer, J.E. 1988. The ecology of the greater prairie chicken as related to reintroductions. M.S. Thesis. Montana State Univ.

Southwood, T.R.E. 1978. Ecological methods: with particular reference to the study of insect populations. 2nd ed. John Wiley & Sons, NY, NY, USA.

U.S. Fish and Wildlife Service. 1992. Attwater's Prairie Chicken Recovey Plan. Albuquerque, NM. Vii +48 pp.

Warren, S.D., C.J. Scifres, and P.D. Teel. 1987. Response of grassland arthropods to burning: a review. Ag., Ecosystems, and Env. 19 (1987):105-130.

Westmeier, R.L. and S. Gough. 1999. National outlook and conservation needs for greater prairie chickens. Pages 169-187 *in* W.D. Svedarsky, R.H. Hier, and N.J. Silvy, eds. The greater prairie-chicken: a national look. Misc. publ. 99. MN Ag Exp. St., Univ. of MN, St. Paul, MN, USA.

Winter, M., D.H. Johnson, and J. Faaborg. 2000. Evidence for edge effects on multiple levels in tallgrass prairie. Condor 102:256-266.

Yeatter, R.E. 1963. Population responses of prairie chickens to land-use changes in Illinois. J. Wildl. Manage. 27(4):739-756.

Table 1. Habitat characteristics of four vegetation types at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

	Coastal Prairie Avg	*Coastal Prairie St Dev*	Mixed Prairie Avg	*Mixed Prairie St Dev*	Salty Prairie Avg	*Salty Prairie St Dev*	Old Field Avg	*Old Field St Dev*	Kruskal-Wallis P-value
Robel (dm)	1.38	*1.10*	1.36	*0.73*	1.83	*1.09*	1.83	*1.20*	0.1486
Plant species richness / (1 m^2)	9.42	*2.24*	7.80	*2.60*	5.26	*2.68*	8.88	*2.25*	<.0001
Plant species richness / (3 x 1 m^2)	16.11	*4.91*	13.25	*3.85*	9.17	*5.01*	15.29	*4.15*	0.0146
Brush density (/ha)	52.40	*73.05*	27.83	*23.20*	242.41	*781.67*	936.52	*2103.45*	0.0003
% bare ground canopy cover	22.00	*18.86*	28.75	*22.59*	21.26	*21.57*	25.40	*22.97*	
% litter canopy cover	6.11	*7.52*	5.54	*8.80*	12.25	*15.12*	4.29	*5.91*	0.1301
% standing dead canopy cover	10.33	*10.11*	14.09	*10.16*	4.58	*5.25*	15.29	*10.59*	
% vegetation canopy cover	56.56	*14.08*	53.34	*16.43*	61.58	*19.70*	68.86	*12.16*	0.6413
%cordgrass canopy cover	5.66	*6.04*	21.18	*7.57*	47.77	*21.56*	3.37	*5.74*	<.0001
%other grass canopy cover	30.22	*14.88*	20.20	*10.73*	3.75	*5.15*	23.47	*7.30*	0.0006
%forbs canopy cover	15.33	*7.44*	10.71	*5.58*	7.59	*5.21*	26.16	*13.09*	0.0310
%sedges canopy cover	5.34	*6.04*	1.25	*1.76*	1.92	*4.01*	13.49	*8.84*	0.0022
%woody canopy cover	0.00	*0.00*	0.00	*0.00*	0.56	*1.93*	2.37	*6.27*	0.5919
									Chi-square
basal hits - bare ground	37.78		28.10		28.57		43.70		0.0417
basal hits - litter	25.78		32.86		38.10		23.70		0.0004
basal hits - vegetation	36.44		39.05		33.33		32.59		0.0993
basal hits - cordgrass	2.89		12.86		22.38		1.11		<.0001
basal hits - other grass	22.67		15.24		3.81		16.67		<.0001
basal hits - forbs	5.11		5.71		6.19		4.81		0.7323
basal hits - sedges	5.78		5.24		0.95		10.00		0.0008
basal hits - woody	0.00		0.00		0.00		0.00		
basal nearest - cordgrass	7.24		26.62		57.43		2.15		<.0001
basal nearest - other grass	56.89		35.76		10.33		49.59		<.0001
basal nearest - forbs	20.87		20.95		28.52		19.56		0.0856
basal nearest - sedges	15.98		16.67		3.71		28.59		<.0001
basal nearest - woody	0.00		0.00		0.00		0.00		
									K-W
Insect family richness	18.59	*4.74*	19.50	*5.02*	9.60	*4.04*	20.09	*4.44*	0.0109
Insects/100 sweeps (g)	1.10	*0.71*	0.90	*0.90*	0.43	*0.39*	1.73	*1.27*	0.0001
Orthoptera/100 sweeps (g)	0.60	*0.50*	0.60	*0.87*	0.20	*0.31*	1.20	*1.23*	0.0004
Acrididae/100 sweeps (g)	0.22	*0.18*	0.31	*0.53*	0.11	*0.15*	0.68	*0.86*	0.0232
Tettigoniidae/100 sweeps (g)	0.37	*0.46*	0.29	*0.61*	0.09	*0.20*	0.50	*0.54*	0.0010

Table 2a. Best-fit models for selected insect and habitat variables at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas. Table depicts P-values resulting from SAS GLM multiple analyses of variance.

	Insect Richness	Insect Biomass	Orthoptera Biomass	Structure (OV)	Plant Species Richness	Brush Density
Model 1 - Structure						
Overall Model	0.0002	≤.0001	≤.0001			
R^2	0.6050	0.6301	0.5368			
Study Area	0.0115	0.0016	0.0133			
Veg Type	0.0042	0.1282	0.1568			
Year	0.0146	≤.0001	≤.0001			
Julian Date	0.7906	0.2242	0.3871			
Obstruction of Vision	0.7814	0.0174	0.2157			
Plant Species Richness	0.0364	0.0013	0.0138			
Brush density	0.1837	0.0906	0.0547			
Model 2a - Vegetative Composition						
Overall Model	0.6404	0.0521	0.1786			
R^2		0.6644				
Study Area		0.0115				
Veg Type		0.8932				
Julian Date		0.6754				
Obstruction of Vision		0.5002				
Plant Species Richness1		0.5974				
Plant Species Richness3		0.4719				
Brush Density		0.0737				
Dead Canopy Cover		0.6312				
Vegetation Canopy Cover		0.9083				
Cordgrass Canopy Cover		0.9070				
Other Grass Canopy Cover		0.2861				
Forb Canopy Cover		0.0711				
Sedge Canopy Cover		0.8075				
Model 2b - Vegetative Composition without Salty Prairie						
Overall Model	0.3953	0.0615	0.0268			
R^2		0.8738	0.9051			
Study Area		0.0034	0.0020			
Veg Type		0.9501	0.1533			
Julian Date		0.2060	0.1160			
Obstruction of Vision		0.2647	0.2058			
Plant Species Richness1		0.0493	0.0303			
Plant Species Richness3		0.4389	0.9858			
Brush Density		0.0818	0.0278			
Dead Canopy Cover		0.2766	0.1860			
Vegetation Canopy Cover		0.2667	0.2042			
Cordgrass Canopy Cover		0.3660	0.0911			
Other Grass Canopy Cover		0.3656	0.4251			
Forb Canopy Cover		0.1934	0.8381			
Sedge Canopy Cover		0.9973	0.1152			

Table 2b. Best-fit models for selected insect and habitat variables at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas. Table depicts P-values resulting from SAS GLM multiple analyses of variance.

	Insect Richness	Insect Biomass	Orthoptera Biomass	Structure (OV)	Plant Species Richness	Brush Density
Model 3a - Management						
Overall Model	0.0011	≤.0001	≤.0001	0.0013	≤.0001	0.0001
R^2	0.6128	0.6245	0.6125	0.3926	0.5146	0.4543
Study Area*	0.0689	0.6231	0.6719	0.0012	0.1055	0.0166
Veg Type	0.0010	0.0009	0.0023	0.1338	≤.0001	0.0008
Year	0.0062	<.0001	<.0001	0.3394	0.7838	0.6975
JulianDate	0.4353	0.0332	0.0724	0.9735	0.0535	0.0531
Burn in last 1 year	0.6496	0.1751	0.1665	0.0005	0.6975	0.9163
Burn in last 2 years	0.3192	0.7075	0.5238	0.0200	0.0190	0.9025
Burn in last 3 years	0.7919	0.3401	0.2696	0.2621	0.1703	0.8048
Hayed	0.0812	0.0627	0.0714	0.5458	0.0526	0.5419
Model 3b - Management (without year)						
Overall Model				0.0002	0.0067	0.0031
R^2				0.7078	0.5869	0.6187
Study Area*				0.0002	0.6405	0.0150
Veg Type				0.0325	0.0095	0.1209
JulianDate				0.3672	0.0362	0.2798
Burn in last 1 year				0.0013	0.3851	0.1432
Burn in last 2 years				0.0765	0.0138	0.1142
Burn in last 3 years				0.9221	0.0583	0.1985
Hayed				0.3555	0.0604	0.2765
Model 3c - Management without Salty Prairie						
Overall Model	0.0099			0.0014		0.0092
R^2	0.5616			0.7973		0.7253
Study Area*	0.0042			0.0643		0.0445
Veg Type	0.2566			0.7078		0.3484
Year	0.0005			not included		not included
JulianDate	0.7938			0.4208		0.8139
Burn in last 1 year	0.1359			0.0051		0.2350
Burn in last 2 years	0.0166			0.5850		0.0308
Burn in last 3 years	0.0997			0.2434		0.0633
Hayed	0.0184			0.3895		0.1164
Model 3d - Management including APC NWR data						
Overall Model		≤.0001				
R^2		0.4310				
Study Area*		0.2823				
Veg Type		0.0026				
Year		≤.0001				
JulianDate		0.0485				
Burn in last 1 year		0.2239				
Burn in last 2 years		0.2404				
Burn in last 3 years		0.3587				

*reflects a management type, since only Mad Island was grazed.

Table 3. Summary vegetation and insect statistics at three potential reintroduction sites for Attwater's Prairie Chicken, Texas Gulf Coast.

	Aransas		Brazoria		Mad Island		P-value
	MEANS	*STDEV*	MEANS	*STDEV*	MEANS	*STDEV*	Kruskal-Wallis
Robel (dm)	1.84	*1.18*	1.93	*0.98*	1.04	*0.89*	0.0014
Species richness (1 m^2)	7.83	*2.65*	7.85	*3.66*	8.21	*2.32*	0.8765
Species richness (3 x 1 m^2)	12.33	*5.14*	14.69	*6.51*	12.67	*4.60*	0.4368
Brush density (/ha)	265.57	*727.88*	500.35	*1609.38*	32.00	*29.51*	0.0004
% bare ground	25.17	*21.20*	15.82	*18.42*	30.50	*21.39*	
% litter	9.58	*12.56*	9.64	*11.63*	4.58	*7.81*	0.4860
% standing dead	10.00	*10.57*	13.90	*9.34*	7.08	*7.89*	
% vegetation	68.00	*12.81*	62.51	*12.89*	49.00	*18.02*	0.0051
%cordgrass	21.22	*21.48*	22.41	*26.63*	23.03	*22.34*	0.9281
%other grass	23.18	*17.58*	17.46	*12.47*	11.72	*11.19*	0.2641
%forbs	15.92	*14.83*	16.05	*10.09*	11.22	*5.20*	0.9029
%sedges	5.82	*8.27*	6.51	*6.68*	3.03	*5.89*	0.5032
%woody	1.94	*5.00*	0.08	*0.28*	0.00	*0.00*	0.1173
							Chi-square
% hits - bare ground	50.28		32.86		24.44		<.0001
% hits - litter	12.22		33.10		40.56		<.0001
% hits - vegetation	37.50		34.05		35.00		0.7191
% hits - cordgrass	7.22		6.67		10.00		0.2220
% hits - other grass	18.89		14.52		16.11		0.3245
% hits - forbs	5.28		5.48		5.28		0.9893
% hits - sedges	6.11		7.38		3.61		0.0873
% hits - woody	0.00		0.00		0.00		
% nearest - cordgrass	14.44		20.64		21.17		0.0645
% nearest - other grass	47.78		37.43		43.75		0.0823
% nearest - forbs	19.44		23.21		23.08		0.4474
% nearest - sedges	19.72		18.57		11.92		0.0404
% nearest - woody	0.00		0.00		0.00		
							Kruskal-Wallis
Insect family richness	15.80	*4.62*	20.65	*5.67*	16.78	*4.35*	0.0102
Insects/100 sweeps (g)	1.30	*1.28*	1.08	*0.80*	0.64	*0.43*	0.1422
Orthoptera/100 sweeps (g)	0.99	*1.20*	0.58	*0.57*	0.29	*0.26*	0.1227
Acrididae/100 sweeps (g)	0.45	*0.73*	0.30	*0.45*	0.16	*0.15*	0.5878
Tettigoniidae/100 sweeps (g)	0.52	*0.69*	0.27	*0.34*	0.12	*0.16*	0.0737

Table 4. Summary vegetation and insect statistics at three potential reintroduction sites for Attwater's Prairie Chicken, Texas Gulf Coast. Results exclude data from salty prairie vegetation type.

	Aransas - without salty prairie		Brazoria - without salty prairie		Mad Island - without salty prairie		P-value
	MEANS	*STDEV*	MEANS	*STDEV*	MEANS	*STDEV*	Kruskal-Wallis
Robel (dm)	1.74	*1.25*	1.77	*0.86*	1.00	*0.99*	0.0061
Species richness (1 m^2)	8.47	*2.39*	9.19	*2.75*	8.94	*2.02*	0.5017
Species richness (3 x 1 m^2)	13.13	*4.58*	17.30	*4.19*	14.71	*4.35*	0.1676
Brush density (/ha)	143.76	*234.31*	605.96	*1820.32*	29.18	*24.66*	0.0052
% bare ground	27.95	*22.04*	16.42	*17.35*	30.25	*21.72*	
% litter	7.13	*8.11*	6.73	*7.21*	3.43	*8.22*	
% standing dead	12.38	*12.00*	16.17	*8.69*	10.00	*9.07*	0.8222
% vegetation	69.75	*12.69*	59.77	*8.74*	46.00	*15.42*	0.0060
%cordgrass	7.91	*9.77*	10.90	*9.97*	10.95	*11.38*	0.9501
%other grass	32.57	*13.07*	21.20	*11.11*	18.33	*10.06*	0.0744
%forbs	19.00	*17.19*	19.67	*8.37*	13.52	*4.38*	0.6248
%sedges	8.32	*9.23*	7.90	*7.04*	3.19	*6.11*	0.3544
%woody	2.08	*5.67*	0.10	*0.32*	0.00	*0.00*	0.3456
							Chi-square
% hits - bare ground	50.61		35.45		23.33		<.0001
% hits - litter	12.73		29.09		41.11		<.0001
% hits - vegetation	36.67		35.45		35.56		0.0140
% hits - cordgrass	5.15		3.03		5.93		0.6970
% hits - other grass	19.39		18.48		20.00		0.2199
% hits - forbs	5.45		4.85		5.19		0.6353
% hits - sedges	6.67		9.09		4.44		0.0023
% hits - woody	0.00		0.00		0.00		
% nearest - cordgrass	10.30		7.09		13.67		0.6778
% nearest - other grass	49.09		47.64		54.00		0.0523
% nearest - forbs	20.61		21.73		18.89		0.0103
% nearest - sedges	21.52		23.36		13.33		<.0001
% nearest - woody	0.00		0.00		0.00		
							Kruskal-Wallis
Insect family richness	16.92	*3.68*	21.37	*4.80*	18.14	*3.18*	0.0132
Insects/100 sweeps (g)	1.53	*1.33*	1.31	*0.75*	0.72	*0.50*	0.0561
Orthoptera/100 sweeps (g)	1.17	*1.27*	0.72	*0.58*	0.34	*0.29*	0.0710
Acrididae/100 sweeps (g)	0.53	*0.80*	0.37	*0.48*	0.18	*0.16*	0.5811
Tettigoniidae/100 sweeps (g)	0.62	*0.74*	0.34	*0.36*	0.14	*0.16*	0.0663

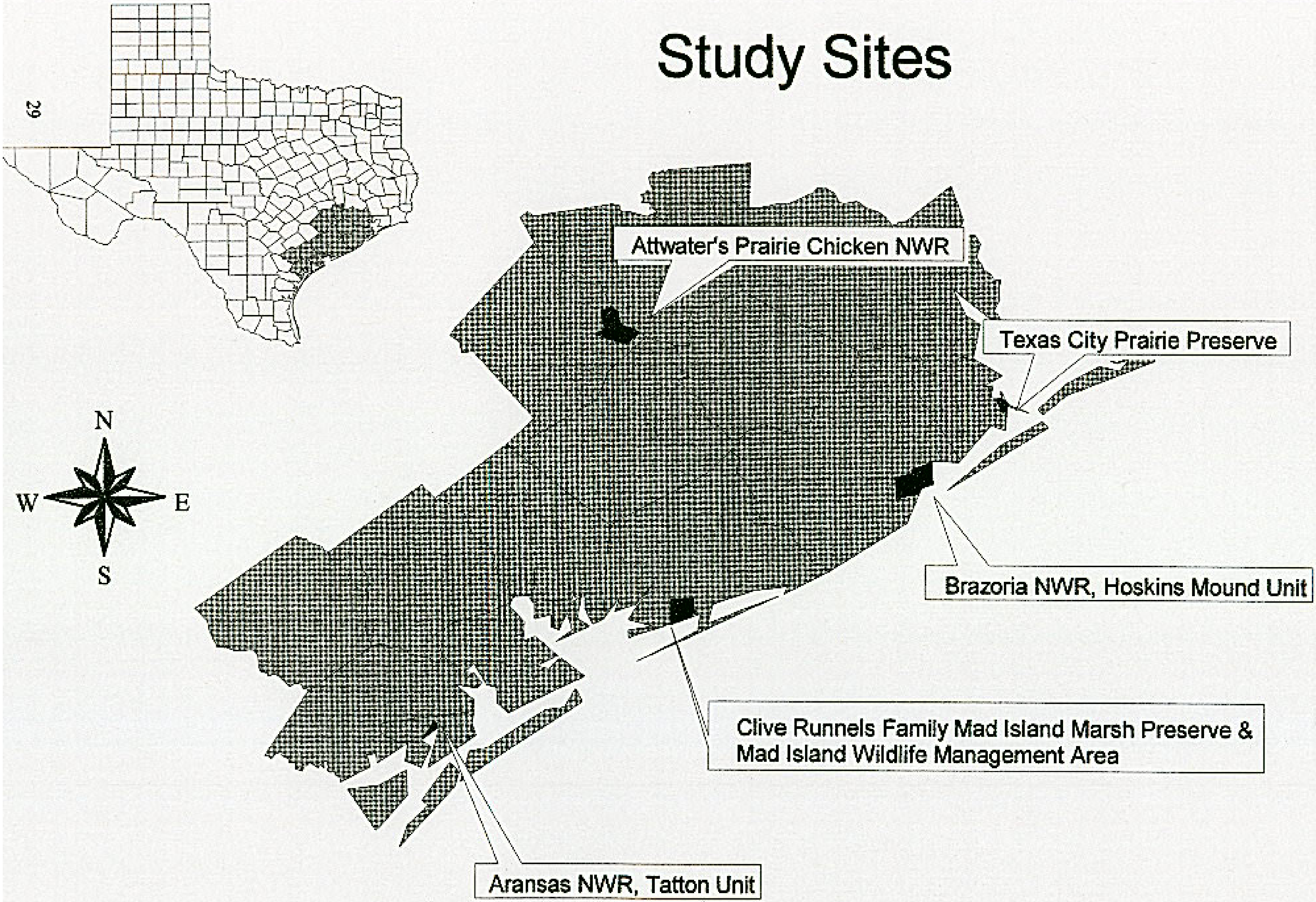


Figure 1. Locations of current Attwater's prairie chicken populations and potential reintroduction study sites

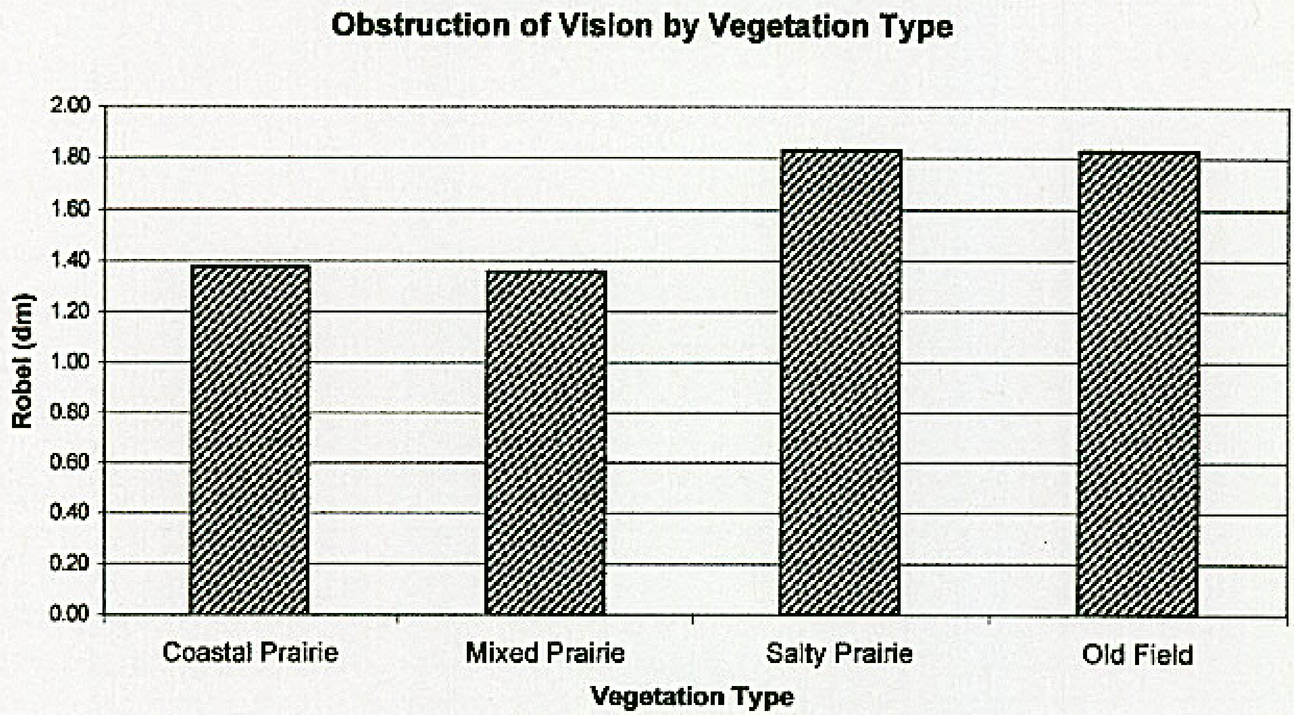


Figure 2. Obstruction of Vision (OV) mean values of four vegetation types at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

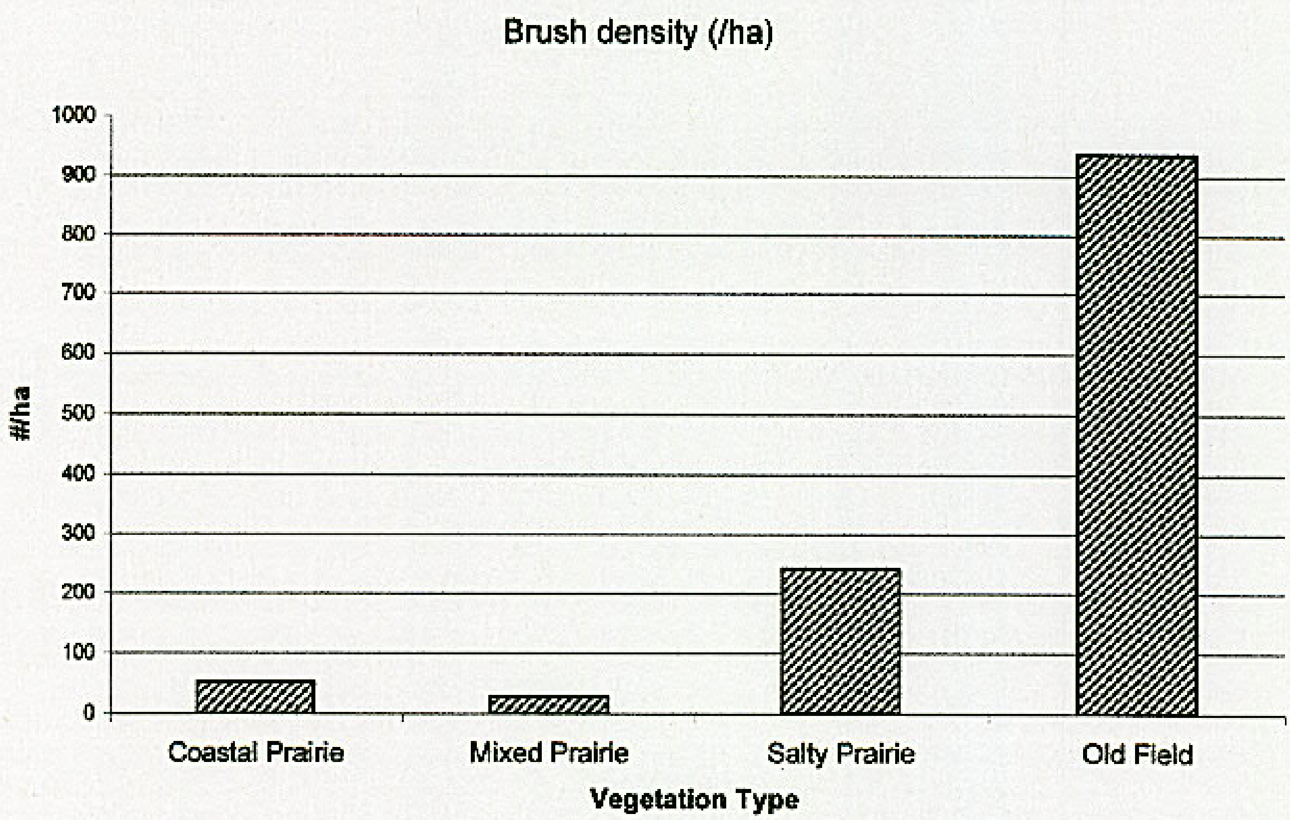


Figure 3. Mean brush density for four vegetation types at three potential reintroductions sites for Attwater's prairie chicken, coastal Texas.

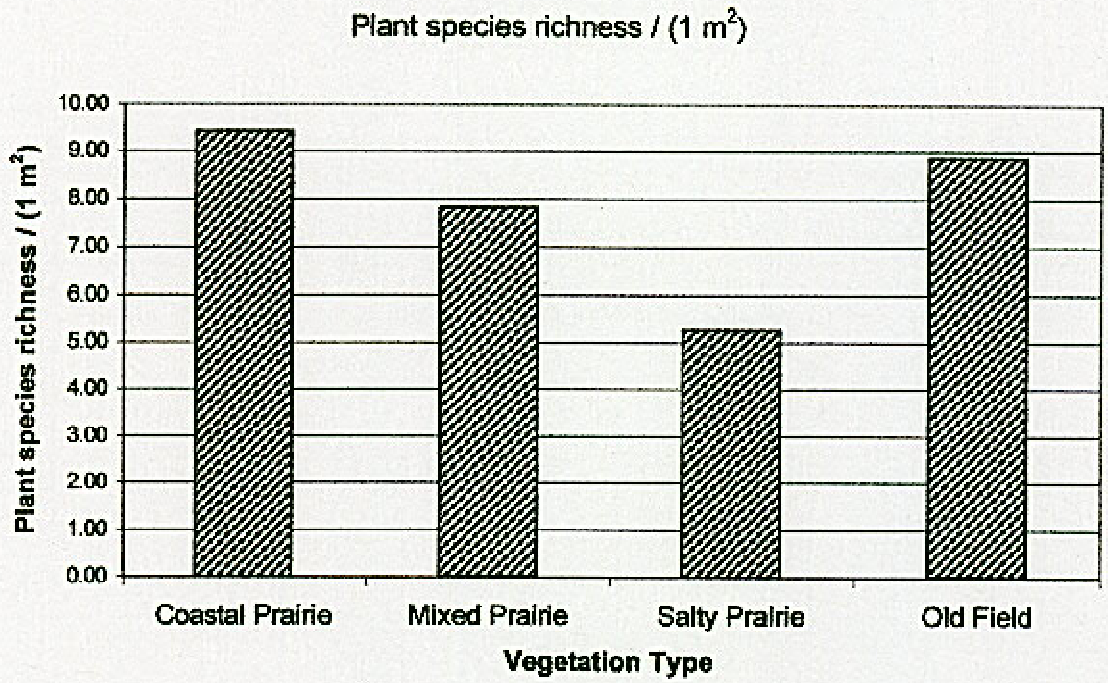


Figure 4. Mean plant species richness / m^2 for four vegetation types at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

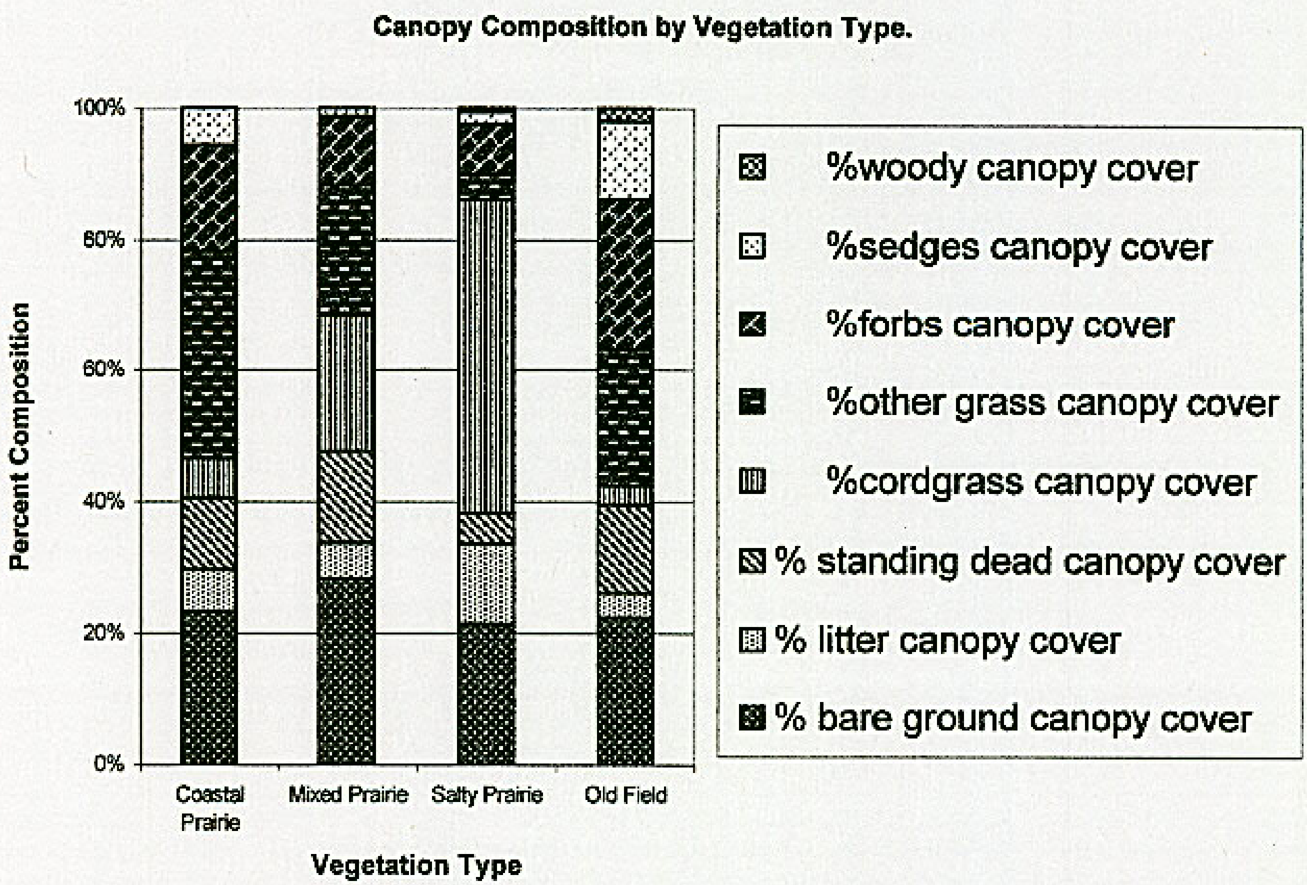


Figure 5. Canopy composition of four vegetation types at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

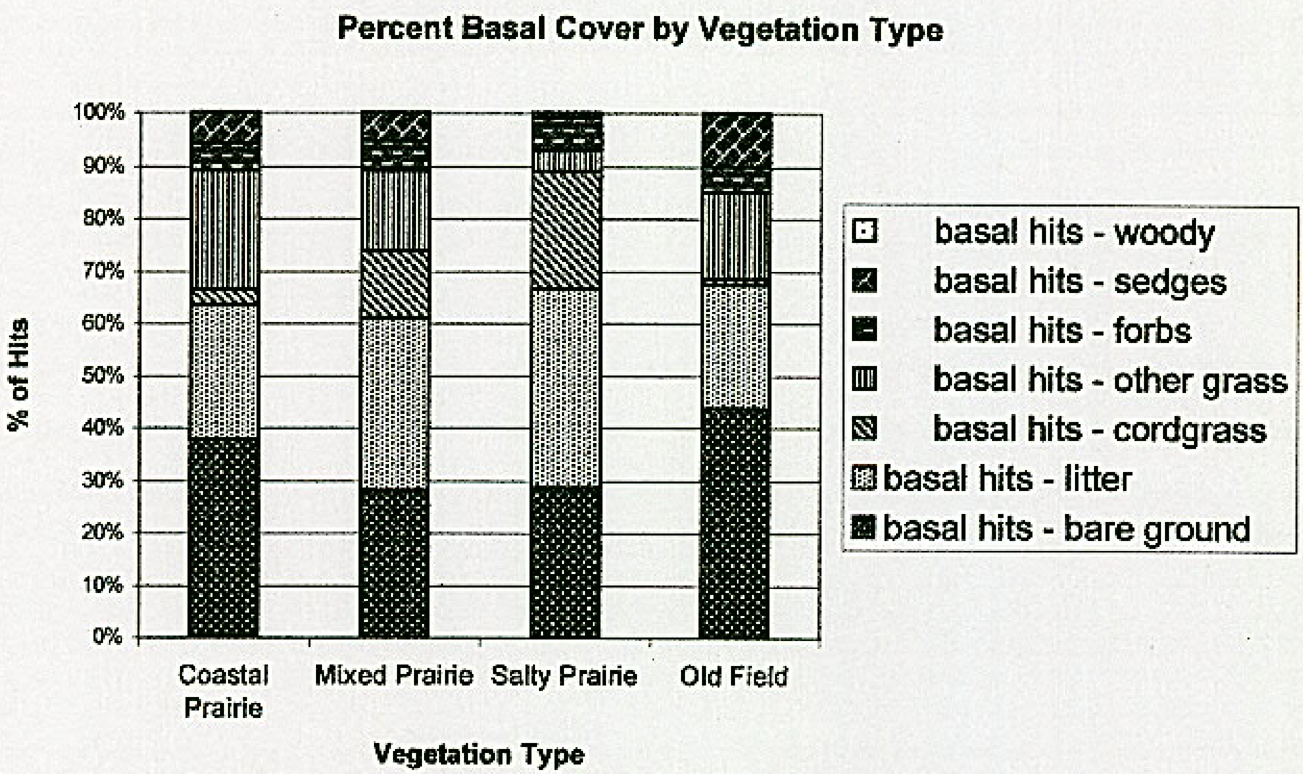


Figure 6. Percent basal composition of four vegetation types at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

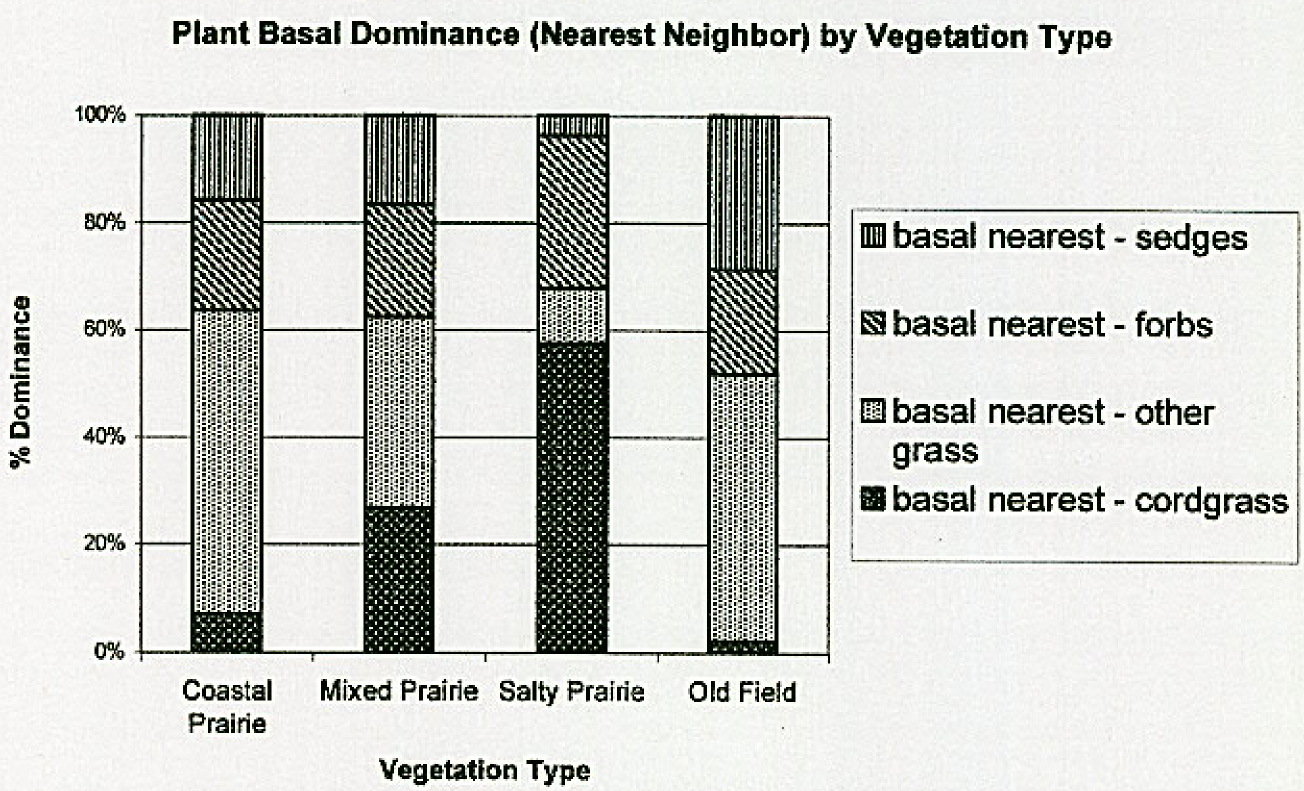


Figure 7. Percent composition of nearest plant to point intercepts in four vegetation types sampled at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

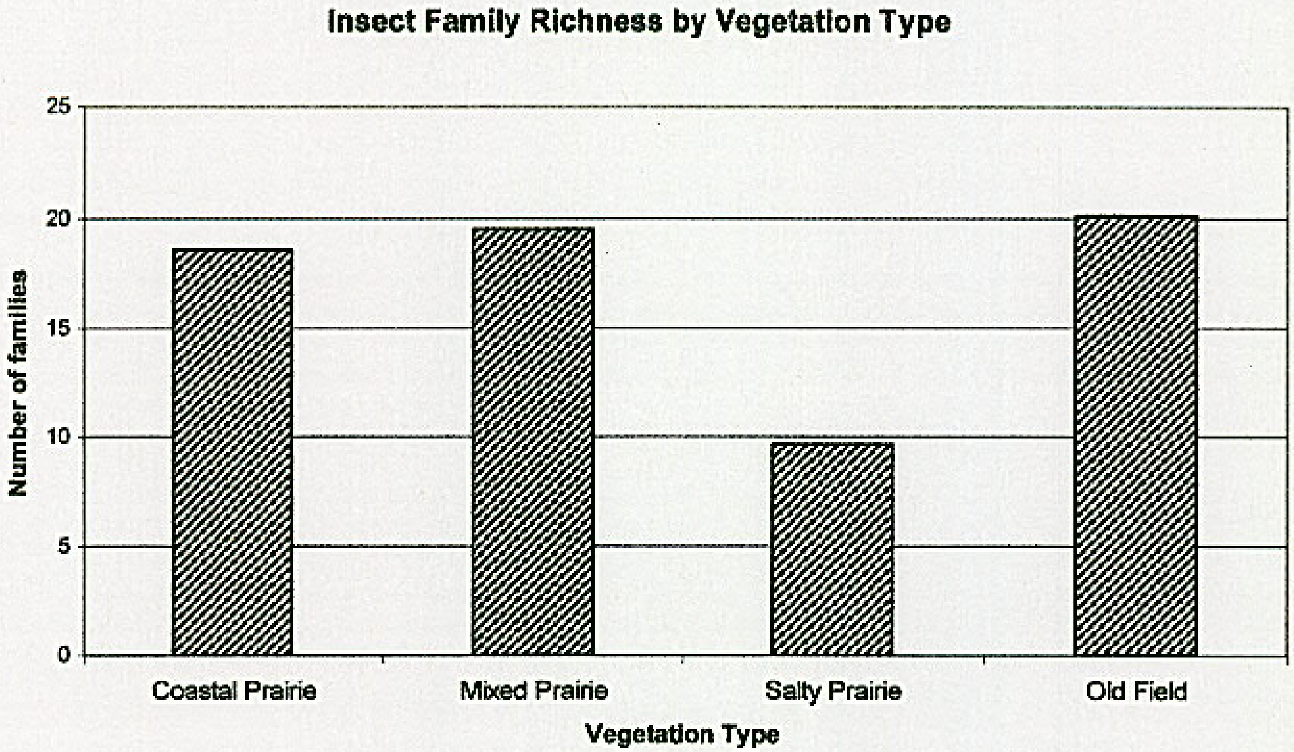


Figure 8. Insect family richness by vegetation type at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

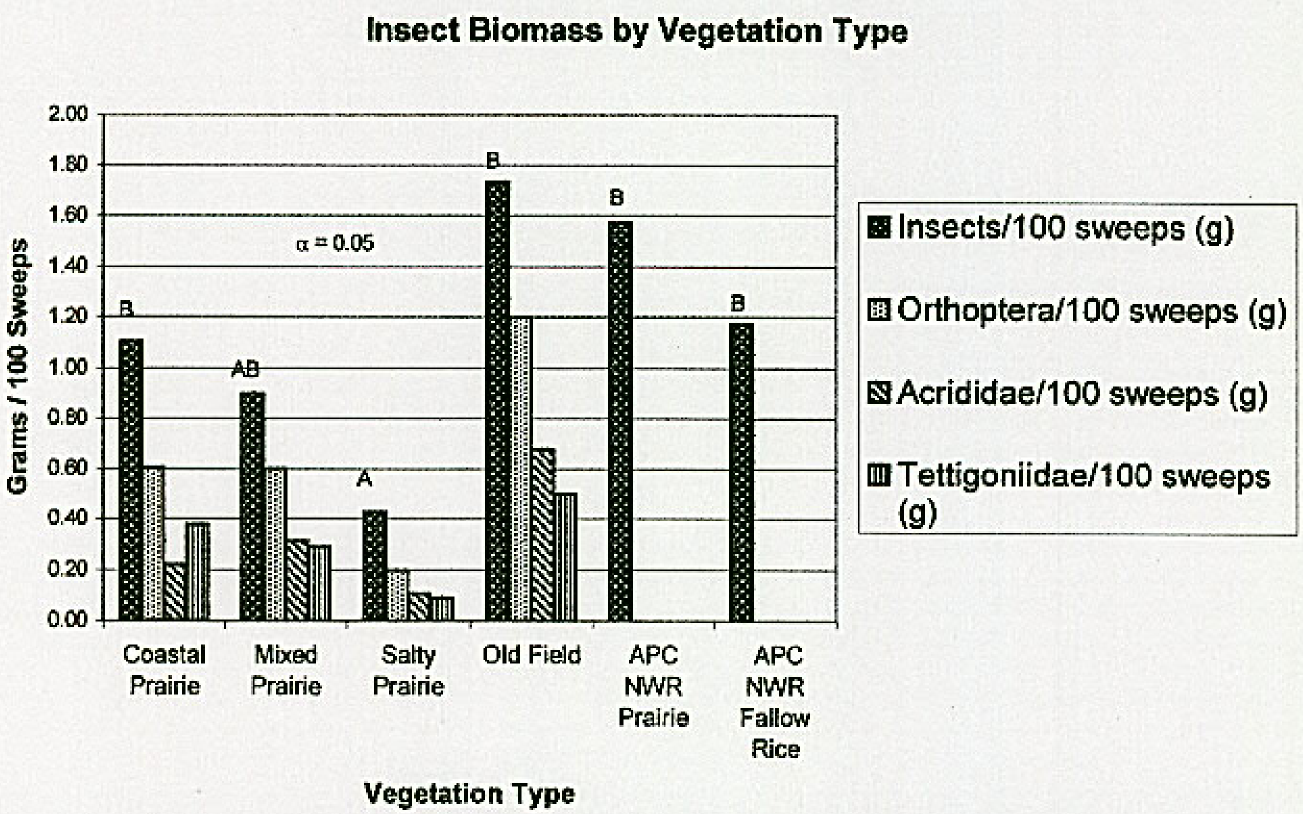


Figure 9. Insect biomass in four vegetation types sampled at three potential reintroduction sites for Attwater's prairie chicken and in two vegetation types at the Attwater Prairie Chicken National Wildlife Refuge, coastal Texas.

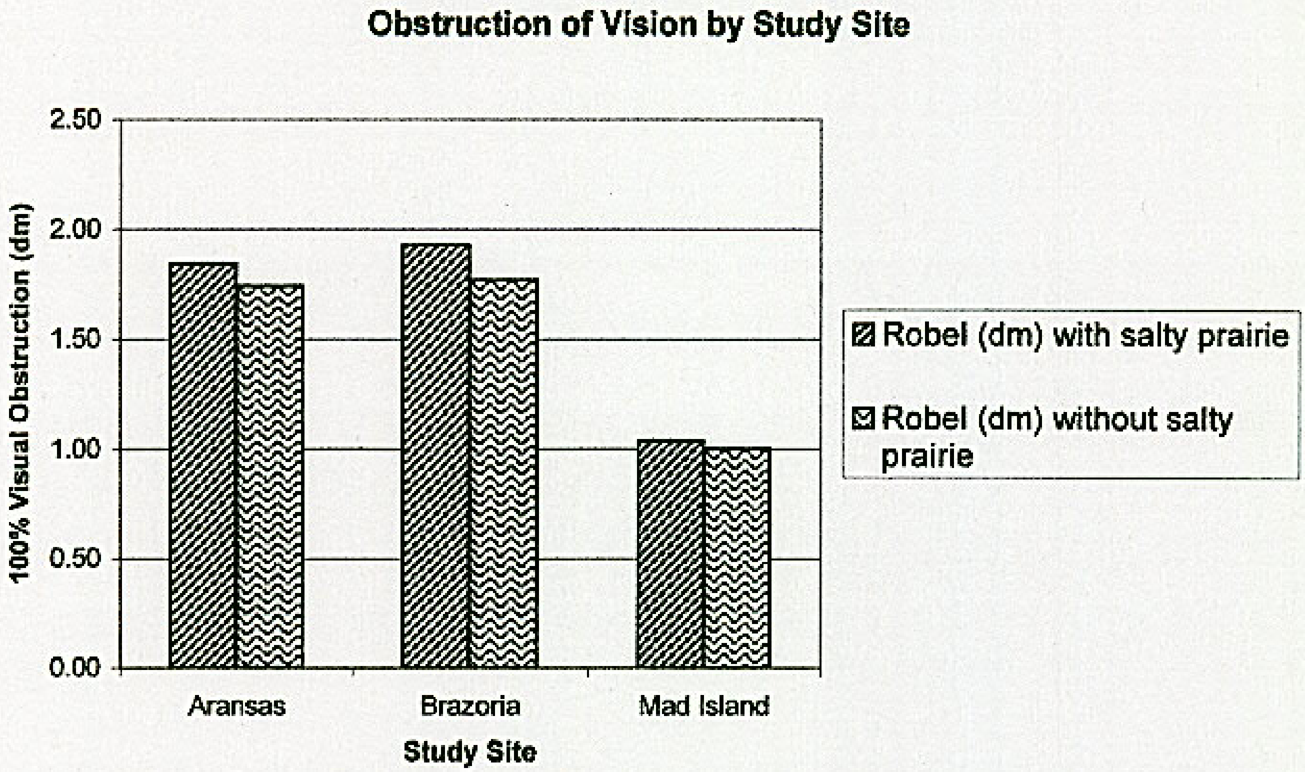


Figure 10. Mean Obstruction of Vision (OV) values at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas. Results depict means both including and excluding salty prairie vegetation type.

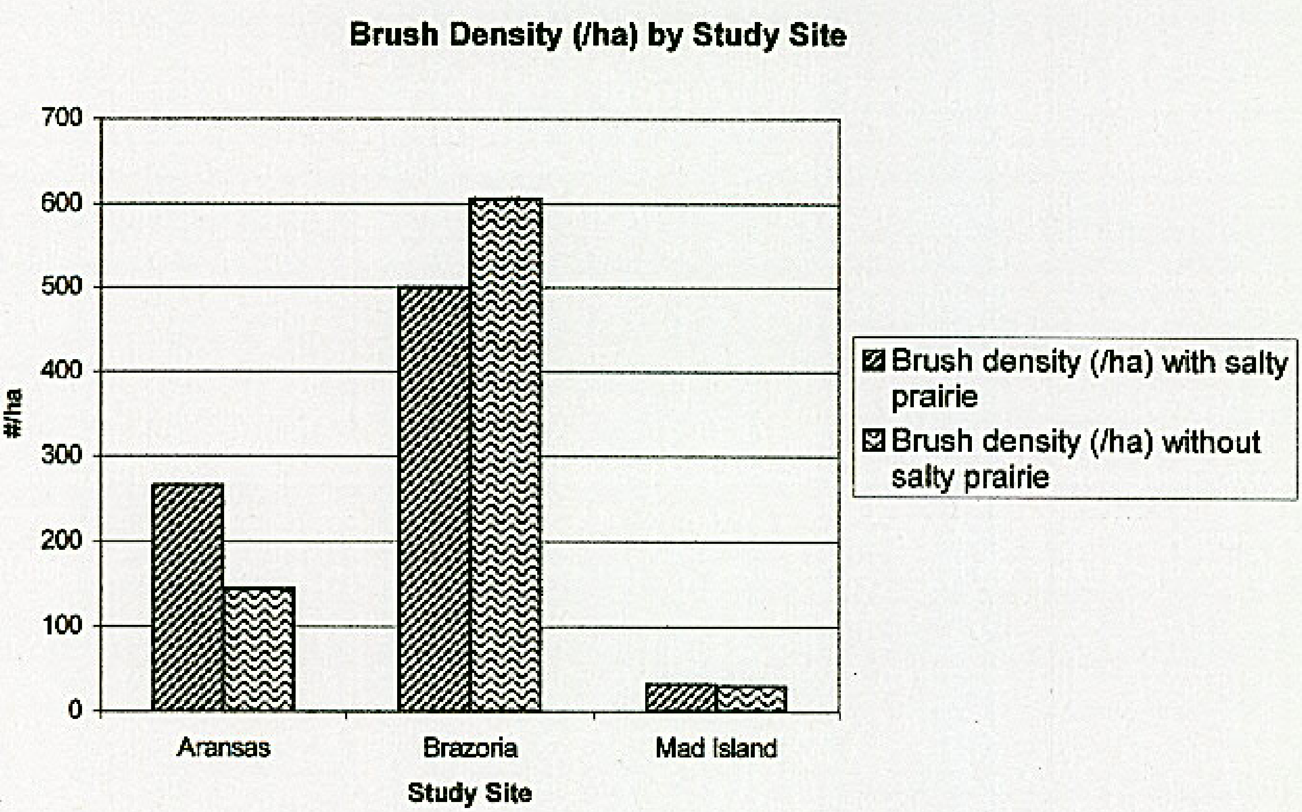


Figure 11. Mean brush densities (#/ha) at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas. Results depict means both including and excluding salty prairie vegetation type.

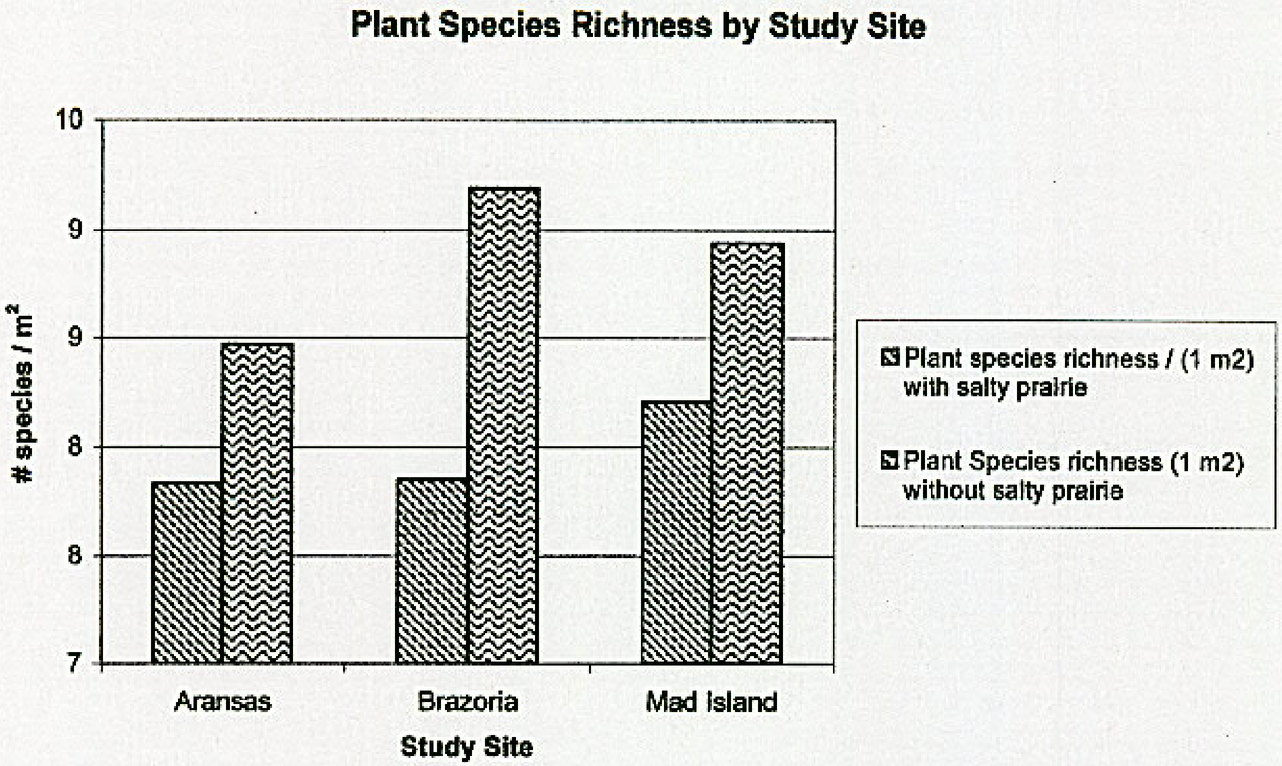


Figure 12. Mean plant species richness / m^2 at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas. Results depict means both including and excluding salty prairie vegetation type.

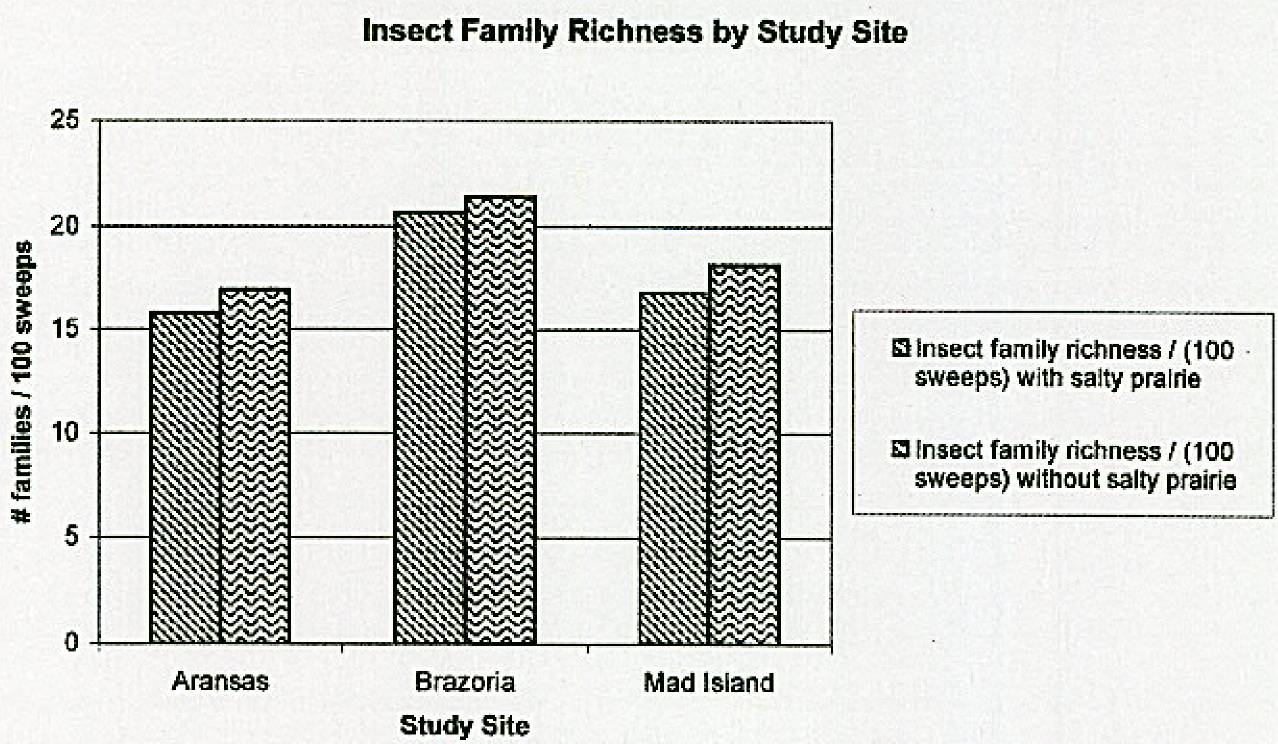


Figure 13. Mean insect family richness / 100 sweeps at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas. Results depict means both including and excluding salty prairie vegetation type.

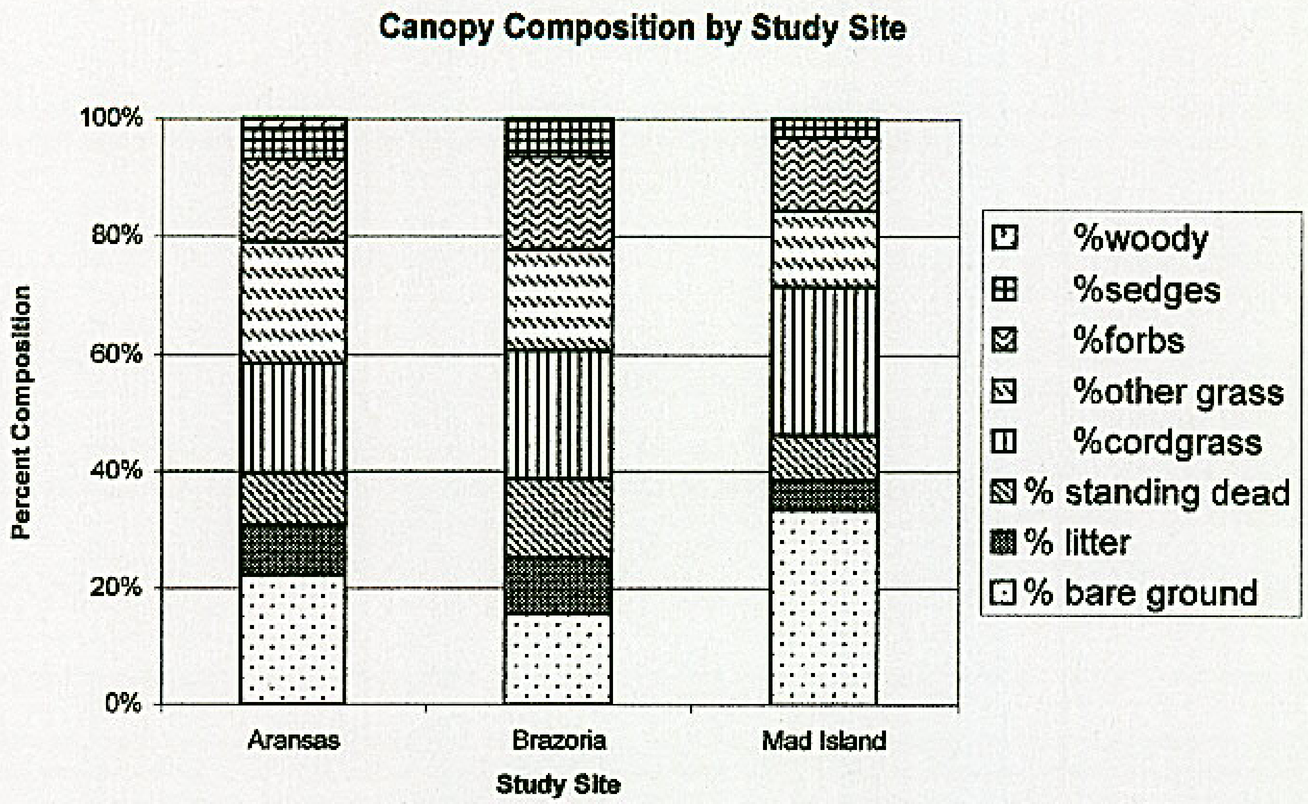


Figure 14. Canopy composition at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

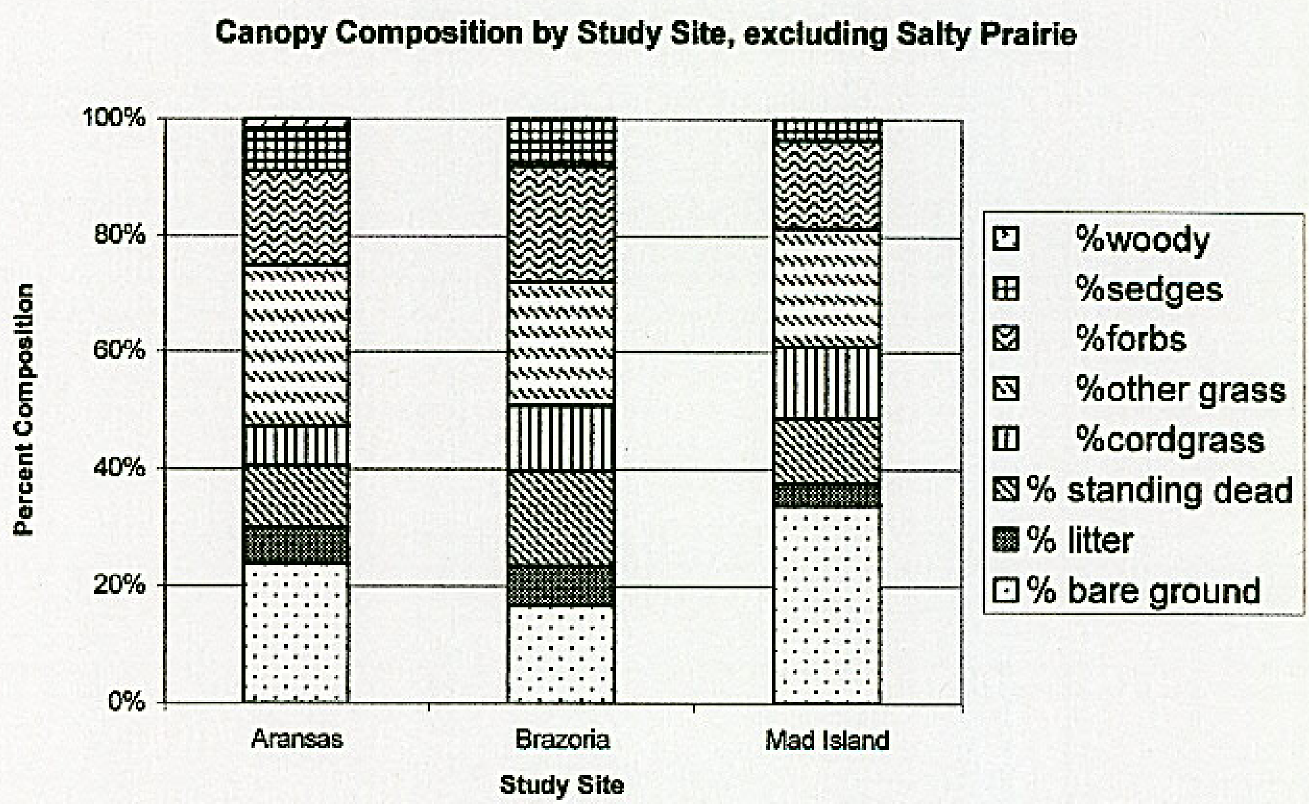


Figure 15. Canopy composition at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas. Results exclude salty prairie vegetation type.

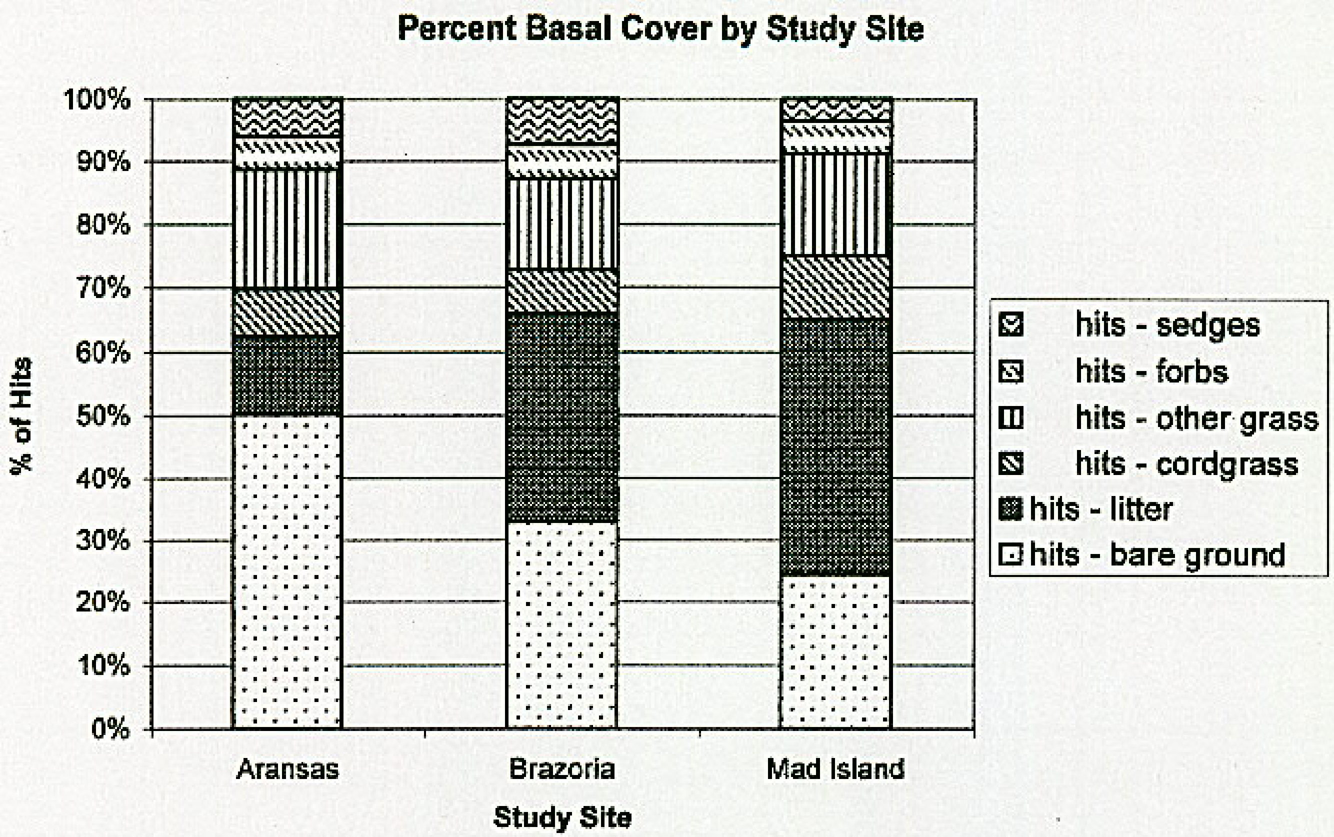


Figure 16. Percent basal composition at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

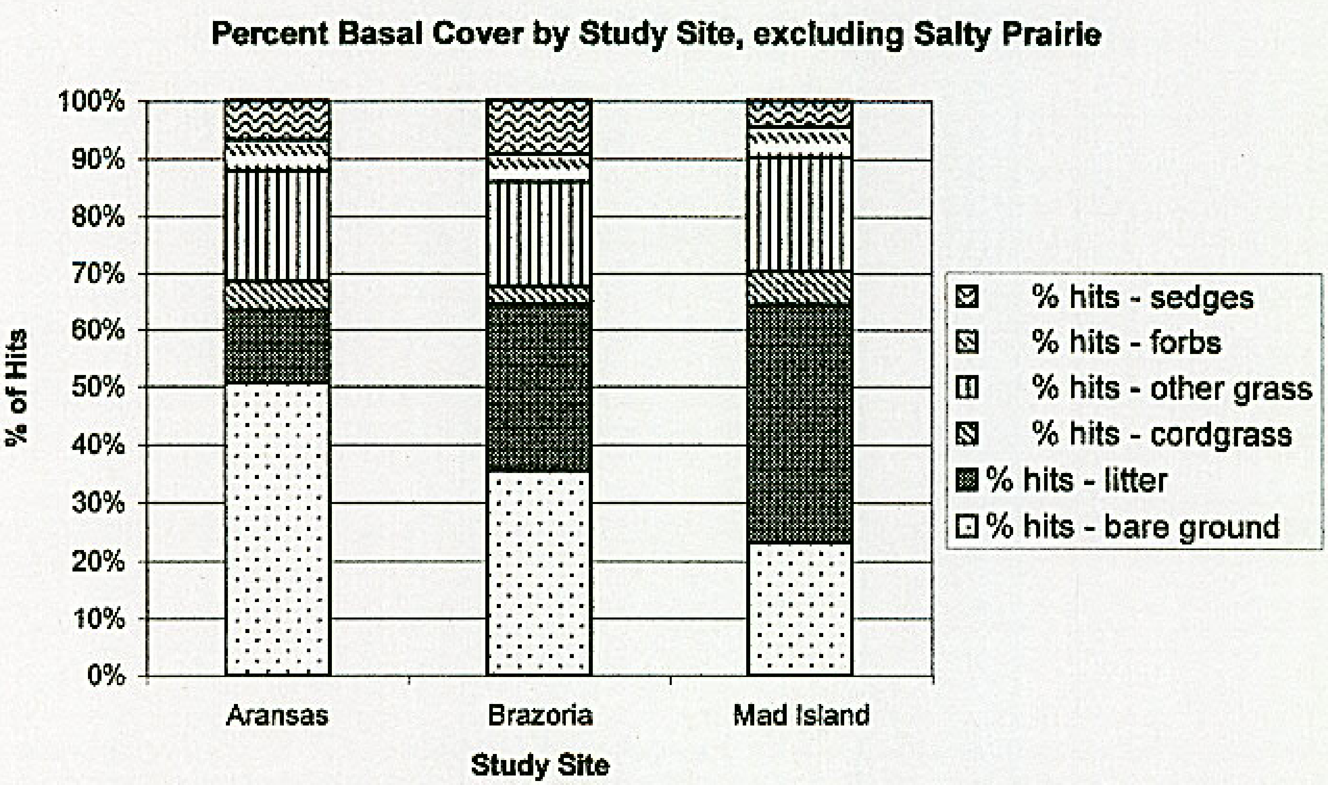


Figure 17. Percent basal composition at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas. Results exclude salty prairie vegetation type.

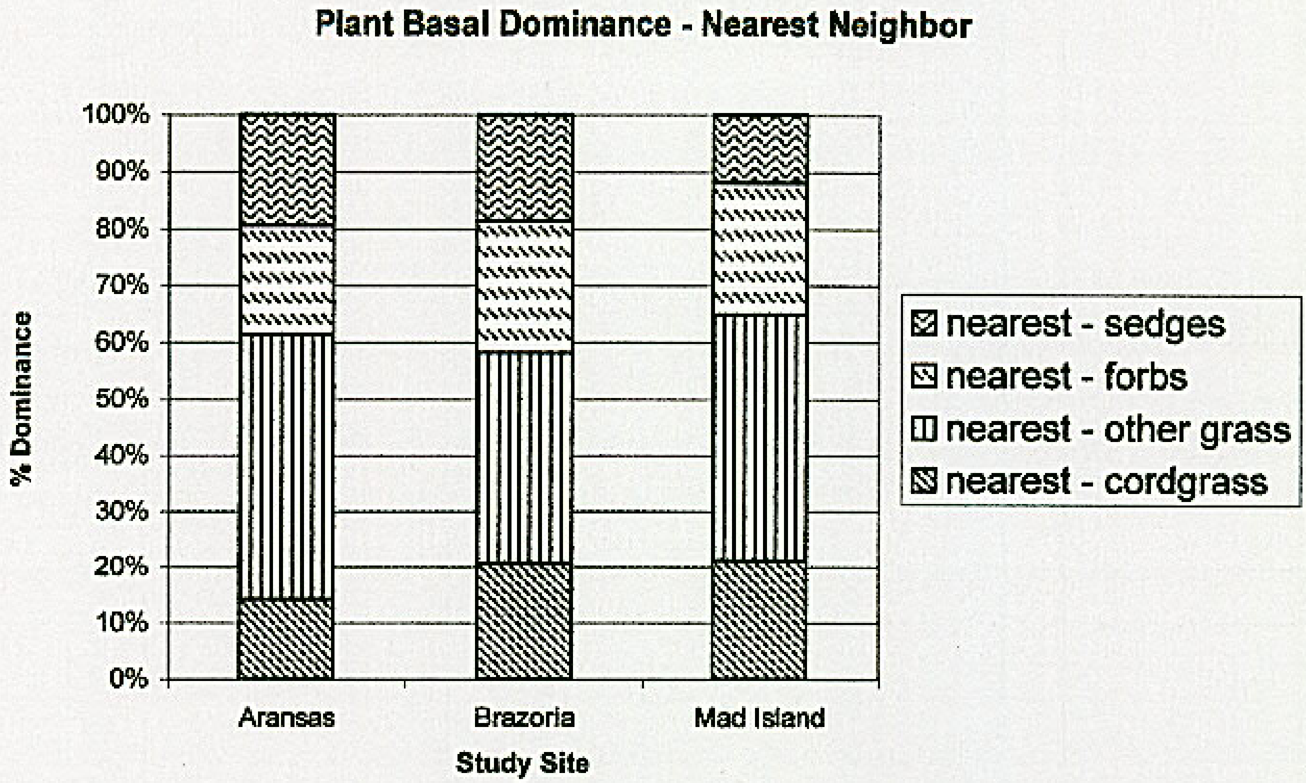


Figure 18. Percent composition of nearest plant to point intercepts at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

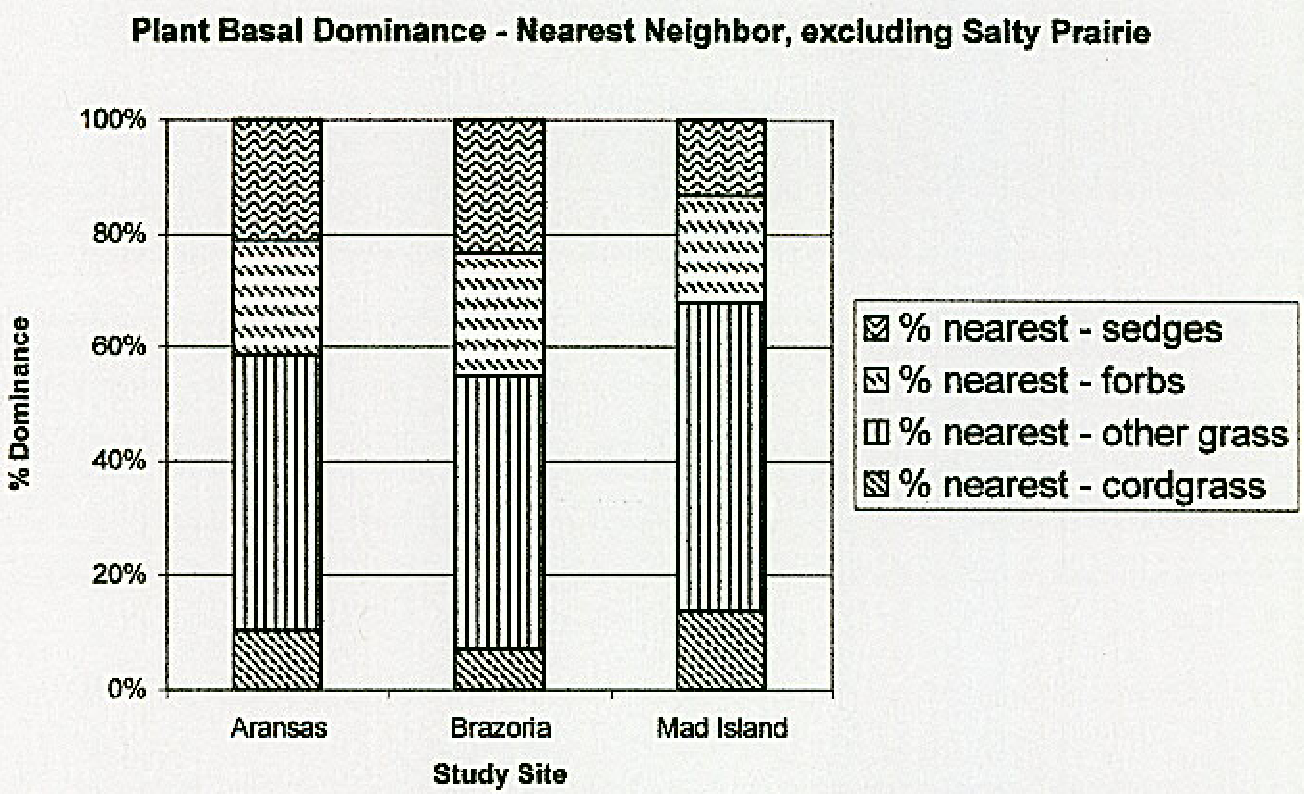


Figure 19. Percent composition of nearest plant to point intercepts at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas. Results exclude salty prairie vegetation type.

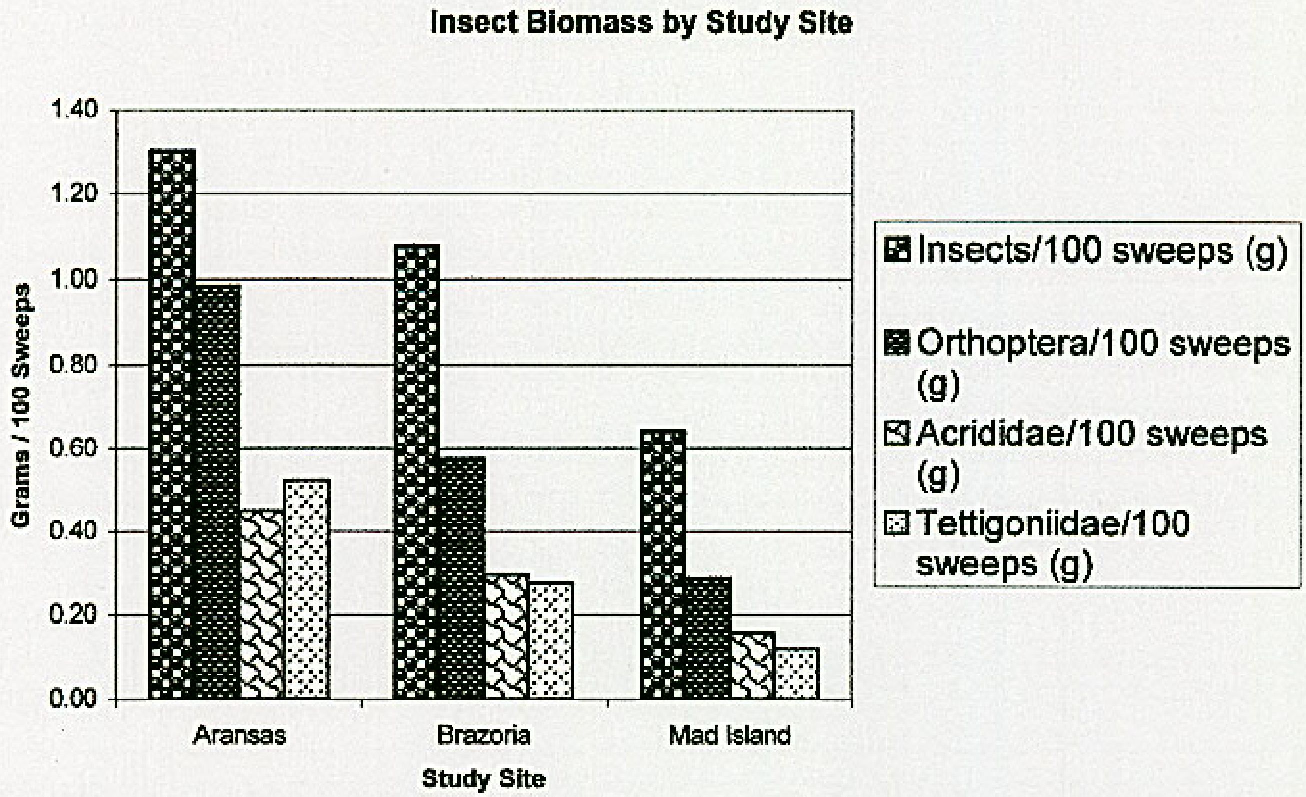


Figure 20. Mean insect biomass (dry weight in grams / 100 sweeps) at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

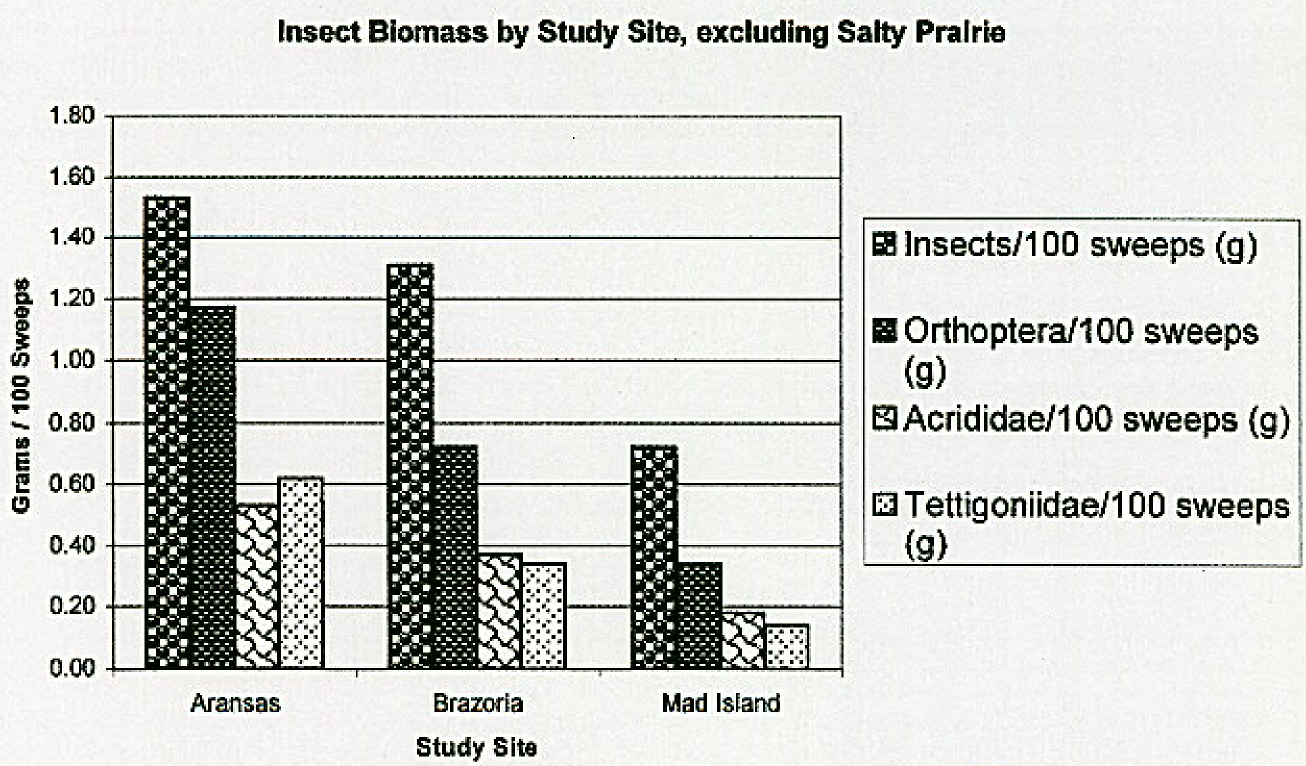


Figure 21. Mean insect biomass (dry weight in grams / 100 sweeps) at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas. Results exclude salty prairie vegetation type.

Table 5. Results of roadside predator surveys at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

	Aransas	Brazoria	Mad Island	APC NWR
DIURNAL				
Km surveyed	*28*	*54*	*69*	
*Northern Harrier	38	11	28	
*White-tailed Hawk	4	5	3	
*Red-tailed Hawk		6	9	
*Unknown buteo	1		6	
Merlin			1	
American Kestrel	2	8	11	
Dark-shouldered Kite	3			
Caracara			5	
Striped Skunk	3			
Bobcat			3	
Feral cats		1		
Feral pigs	26		6	
Km/raptor*	**0.65**	**2.45**	**1.5**	
Km/carnivore	**9.33**	**54**	**23**	
Km/feral pig	**1.08**	**na**	**11.5**	
NOCTURNAL				
Km surveyed	*28*	*60.7*	*69*	
Opossum		3	1	
Raccoon	1		3	
Striped Skunk	1	1	5	
Coyote	1	4		
Feral cats		1		
Feral dogs		2		
Unknown		1		
Feral Pigs			24	
Owls	3	1	1	
Km/carnivore**	**9.33**	**5.06**	**7.67**	**22.5**
Km/feral pig	**na**	**na**	**2.88**	
Km/owl	**9.33**	**60.7**	**69**	

*these four were the only raptors considered to be predators on APC.
**includes opossums; APC NWR data also includes armadillos.

Table 6. Attwater's prairie chicken habitat patch characteristics at three potential reintroduction sites, coastal Texas.

	Aransas	Brazoria	Mad Island
Total Study Area (ha)	2969	13876	5464
Coastal Prairie			
Total area (ha)	476	1531	254
Number patches	8	75	9
Mean patch area (ha)	59	20	28
Std. dev.	67	40	53
Mean P/A ratio	0.0091	0.2335	0.0225
Std. dev.	0.0048	1.5682	0.0176
Mean Diversity Index	1.4943	1.7058	1.4646
Std. dev.	0.3182	0.9721	0.3434
Mixed Prairie			
Total area (ha)	511	715	486
Number patches	9	15	18
Mean patch area (ha)	57	48	27
Std. dev.	59	40	27
Mean P/A ratio	0.0094	0.0154	0.0131
Std. dev.	0.0050	0.0075	0.0051
Mean Diversity Index	1.6095	2.4622	1.4778
Std. dev.	0.4340	1.1144	0.3296
Old Field			
Total area (ha)	790	2235	34
Number patches	14	27	2
Mean patch area (ha)	66	83	17
Std. dev.	106	125	16
Mean P/A ratio	0.0169	0.02654	0.01389
Std. dev.	0.0074	0.02204	0.00841
Mean Diversity Index	2.477	2.1944	1.2471
Std. dev.	1.3339	1.4183	0.0790
All Current Habitat*			
Total area (ha)	**1825**	**4658**	**946**
All Potential Habitat**			
Total area (ha)	**1922**	**5464**	**1268**
Cropland (Rice)			
Total area (ha)	0	456	614

*Includes all currently suitable habitat, including wet prairie. Excludes salty prairie.
**Includes woody prairie which could be made suitable with habitat management. Excludes salty prairie.

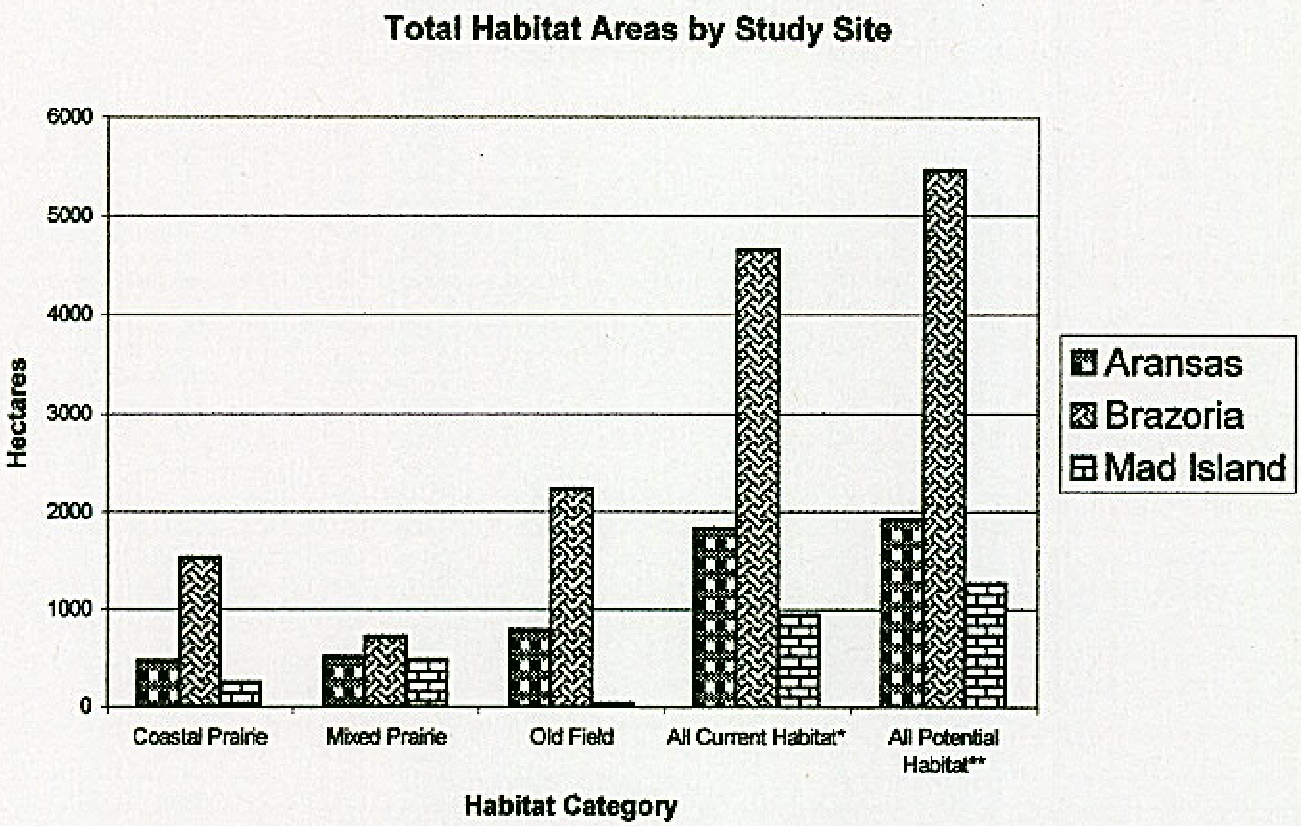


Figure 22. Total area of all habitat types at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

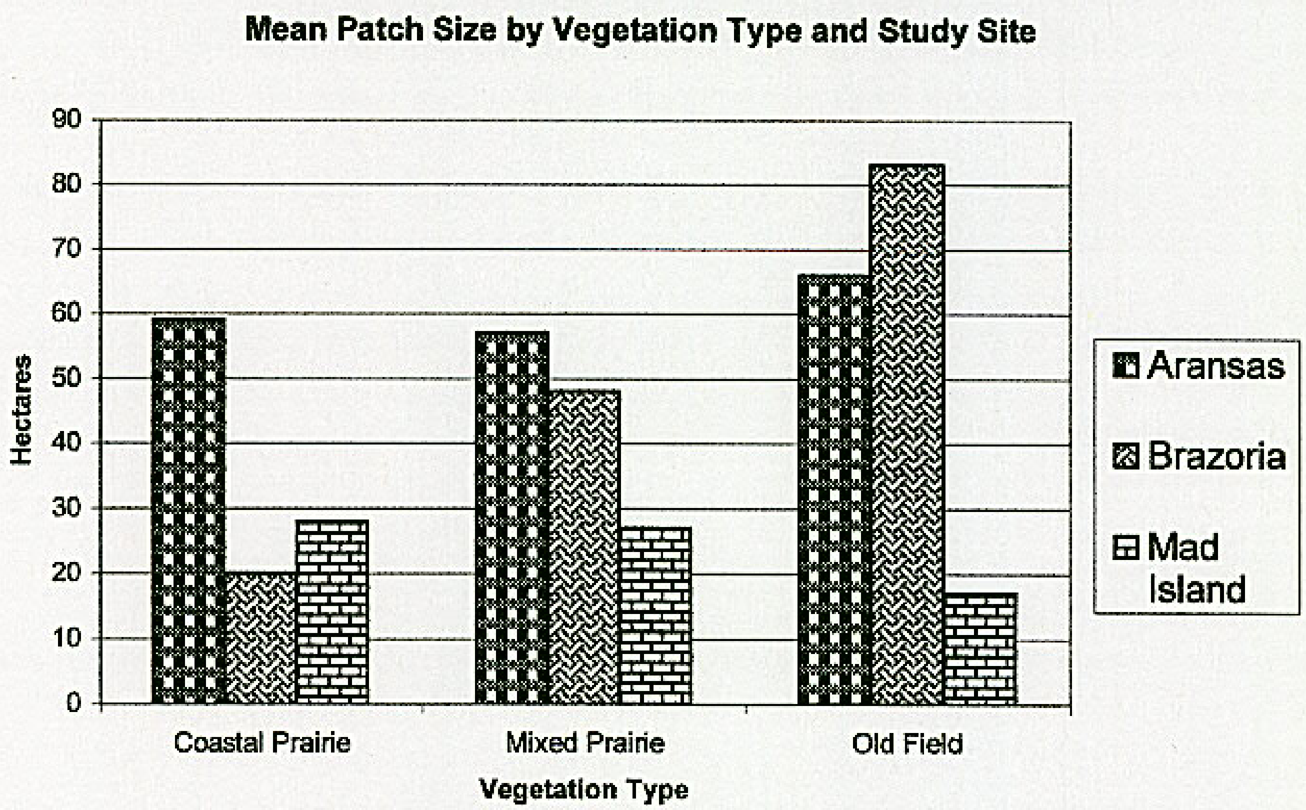


Figure 23. Mean patch size of different vegetation types at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

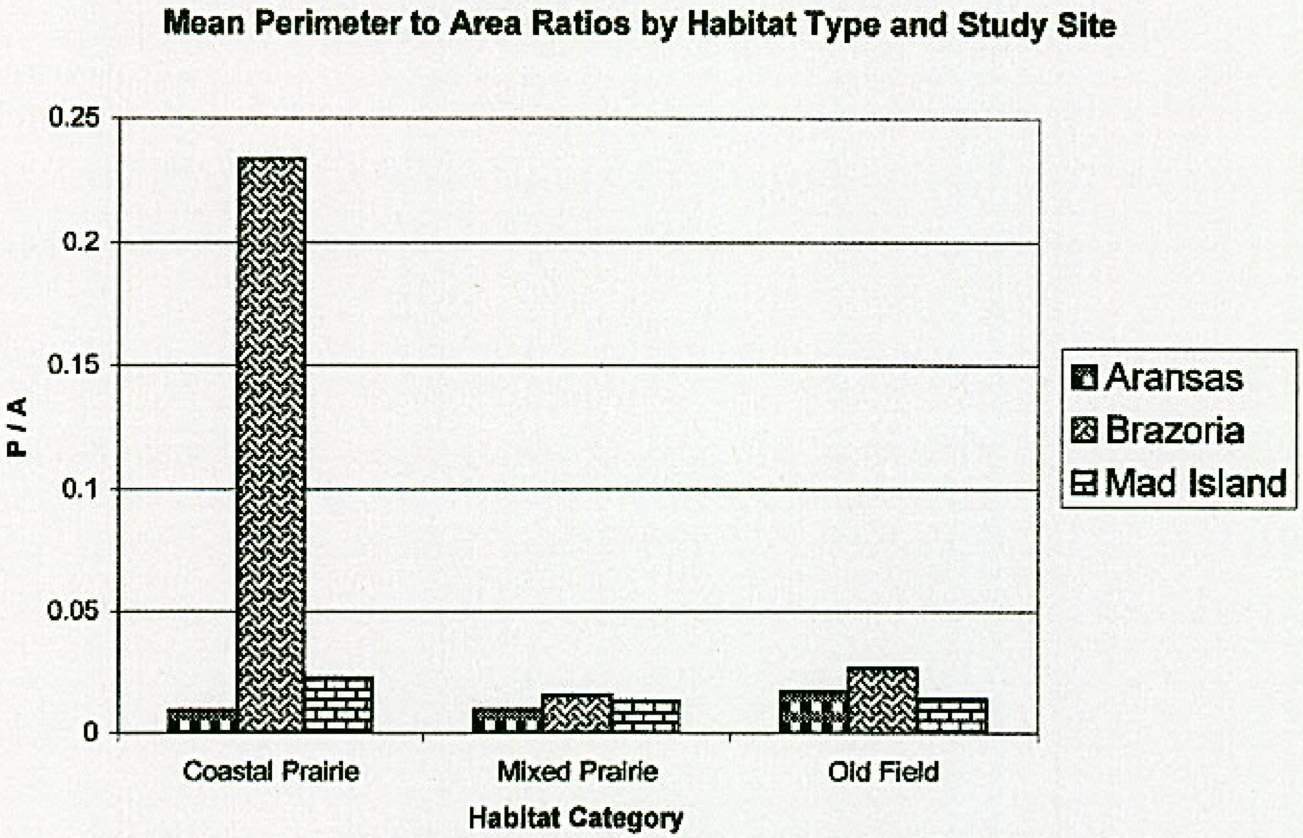


Figure 24. Mean perimeter to area ratios of different vegetation types at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

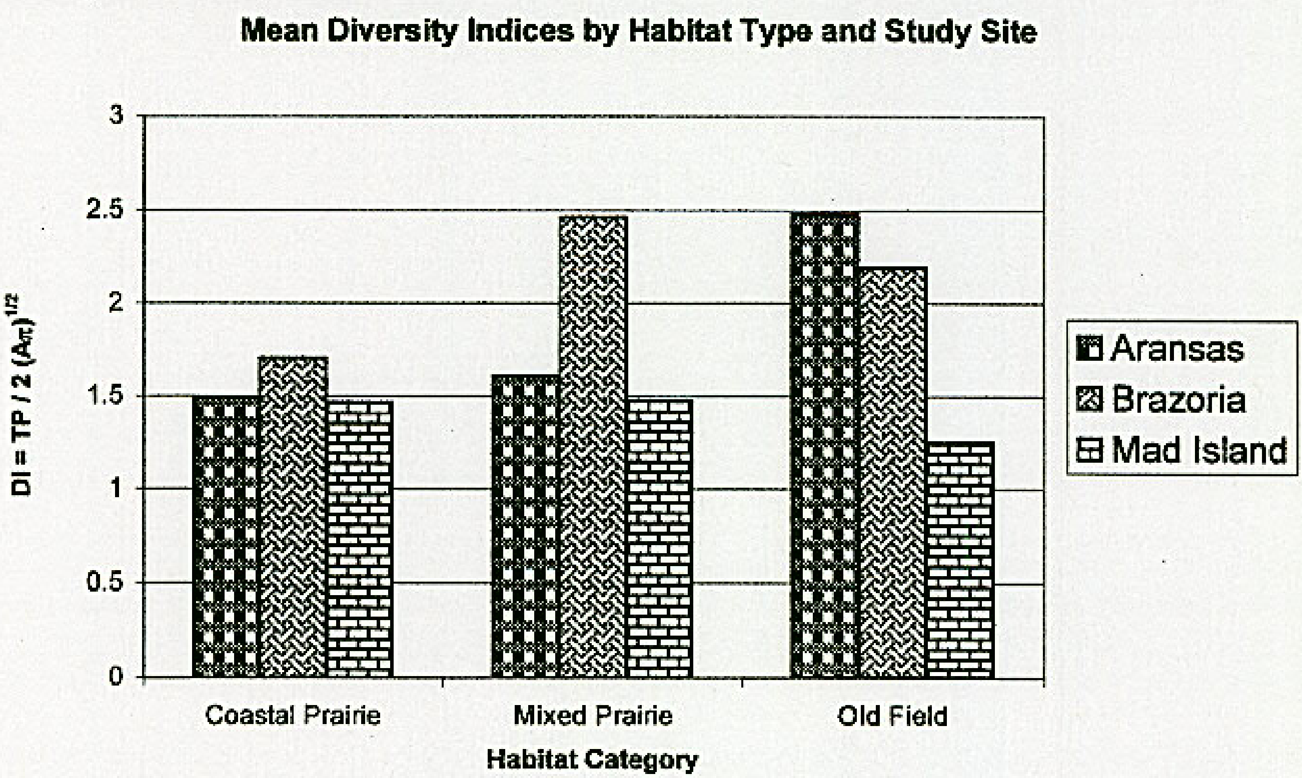


Figure 25. Mean diversity indices (McKinney 1996) of three different vegetation types at three potential reintroduction sites for Attwater's prairie chicken, coastal Texas.

Aransas NWR - Tatton Unit
1995 DOQQ

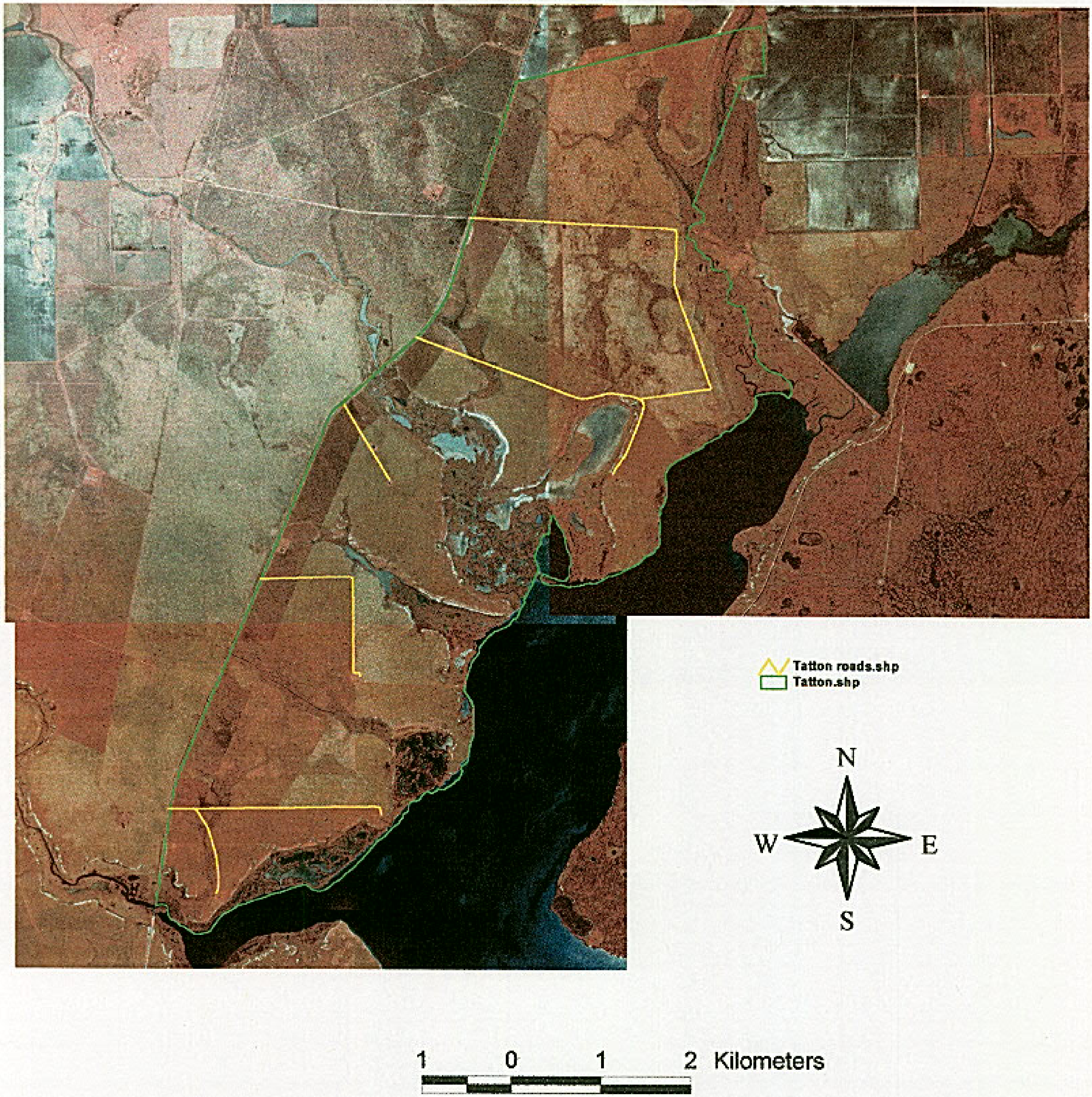


Figure 26. Aerial photography of the Aransas study site. DOQQ 1995 image.

Aransas NWR - Tatton Unit
Current Vegetation with Sampling Points

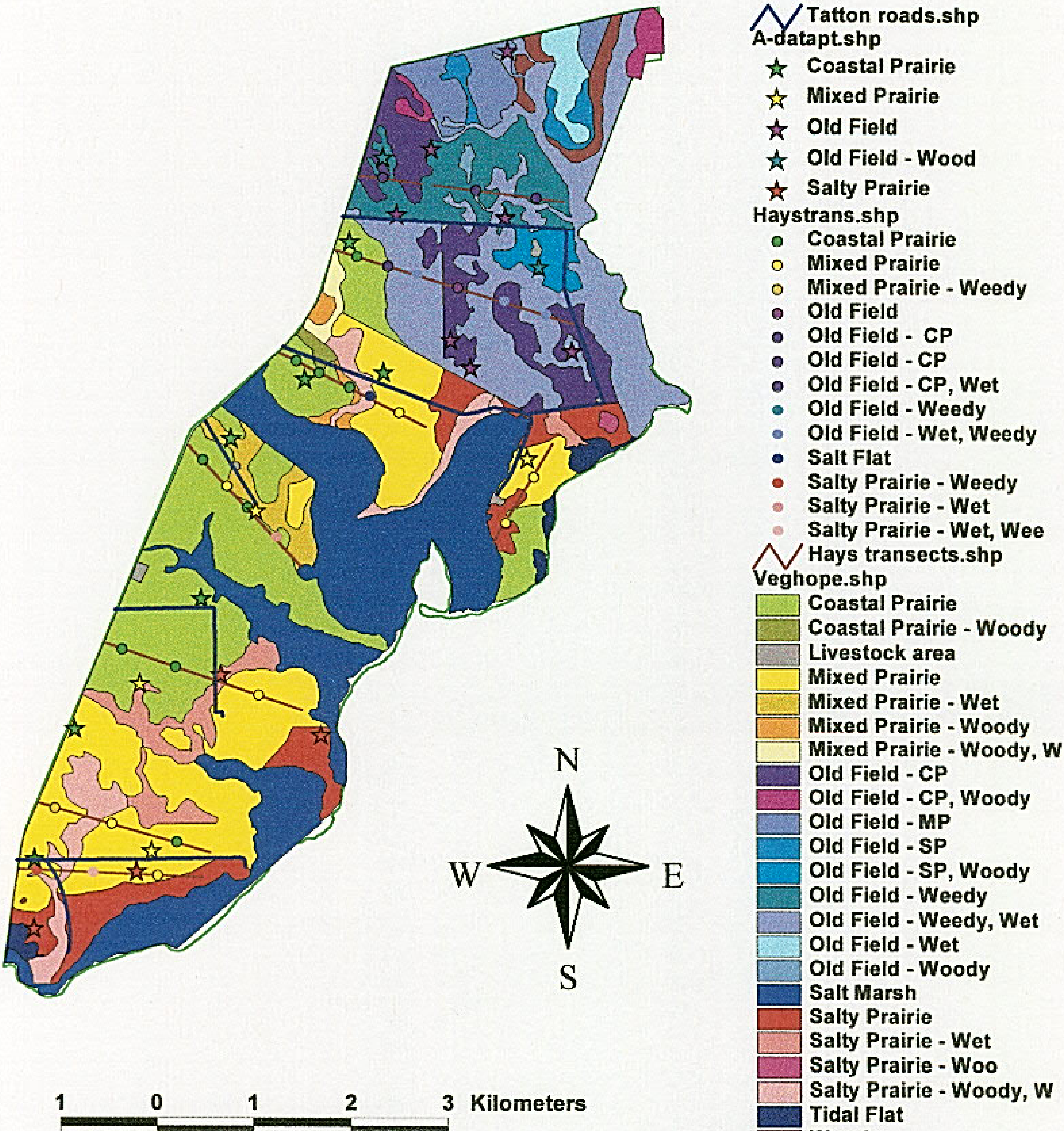


Figure 27. Classification of potential Attwater prairie chicken habitat based on DOQQ 1995 image - Aransas NWR, coastal Texas.

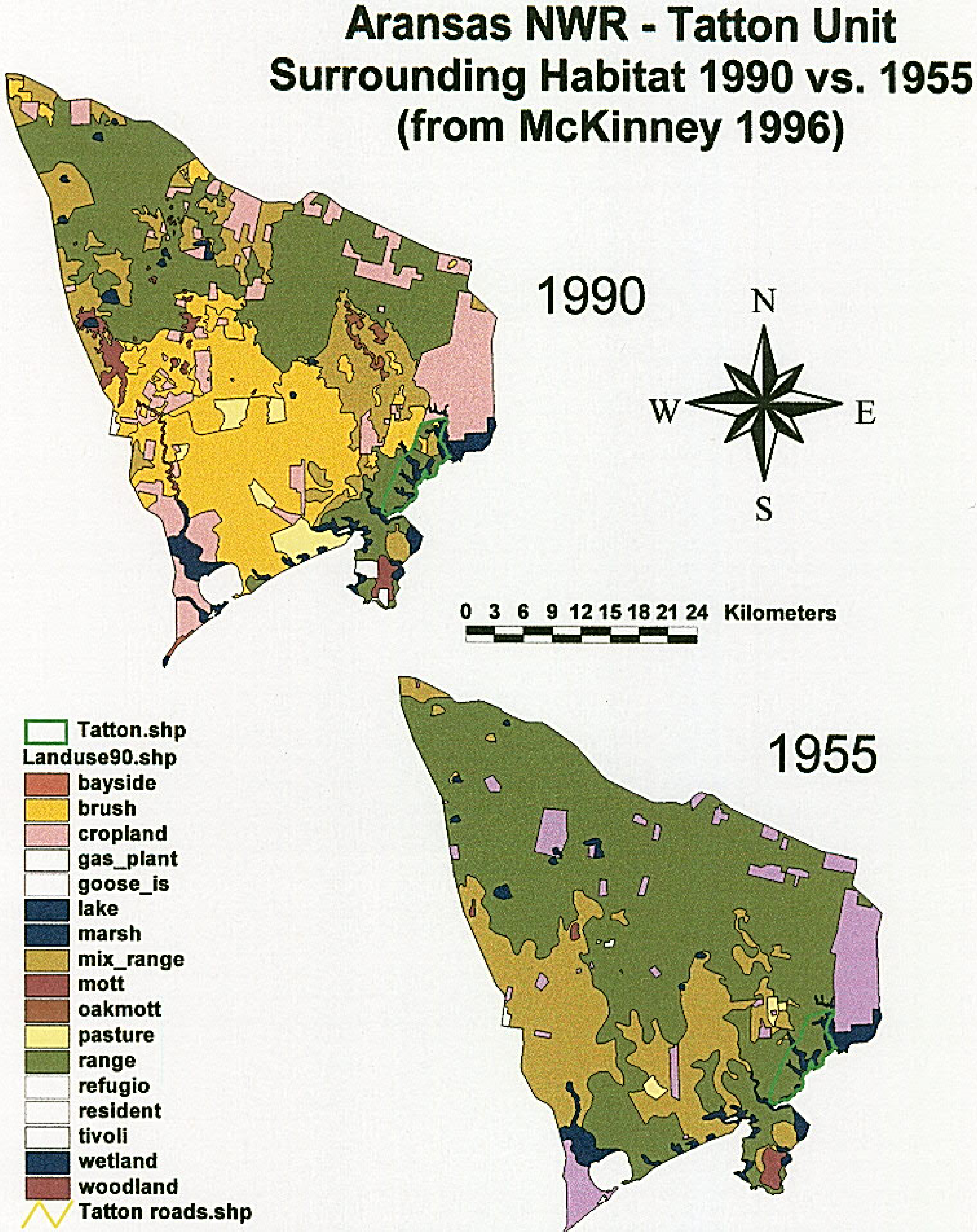


Figure 28. Aransas NWR - Tatton Unit and surrounding habitat in 1990 in Aransas and Refugio counties, Texas. From McKinney 1996.

Figure 29.

Brazoria NWR - Hoskins Mound Unit
1995 DOQQ

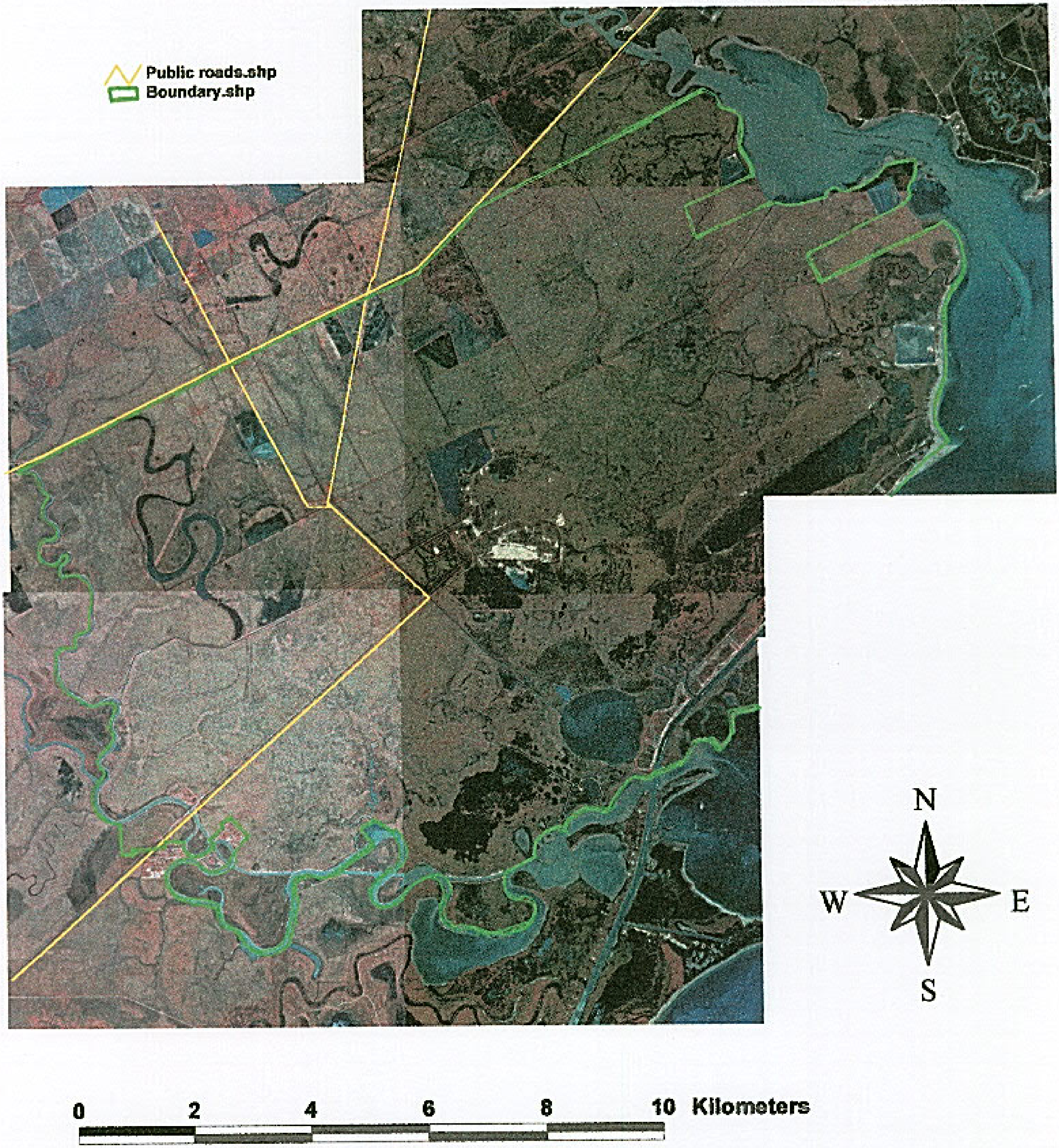


Figure 30.

Brazoria NWR - Hoskins Mound Unit Potential Vegetation (from Miller 1983)

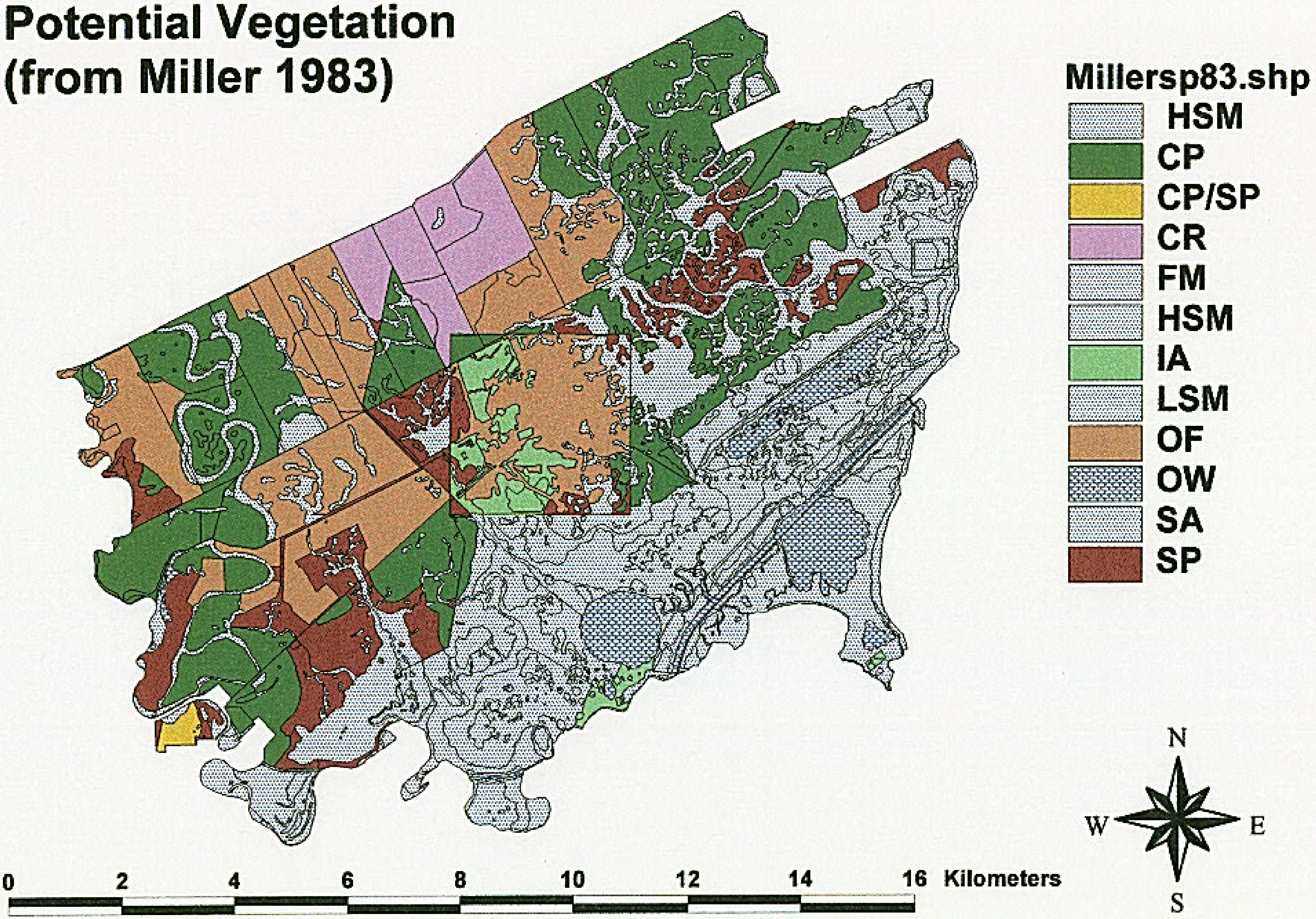


Figure 31.

Brazoria NWR - Hoskins Mound Unit Current Vegetation

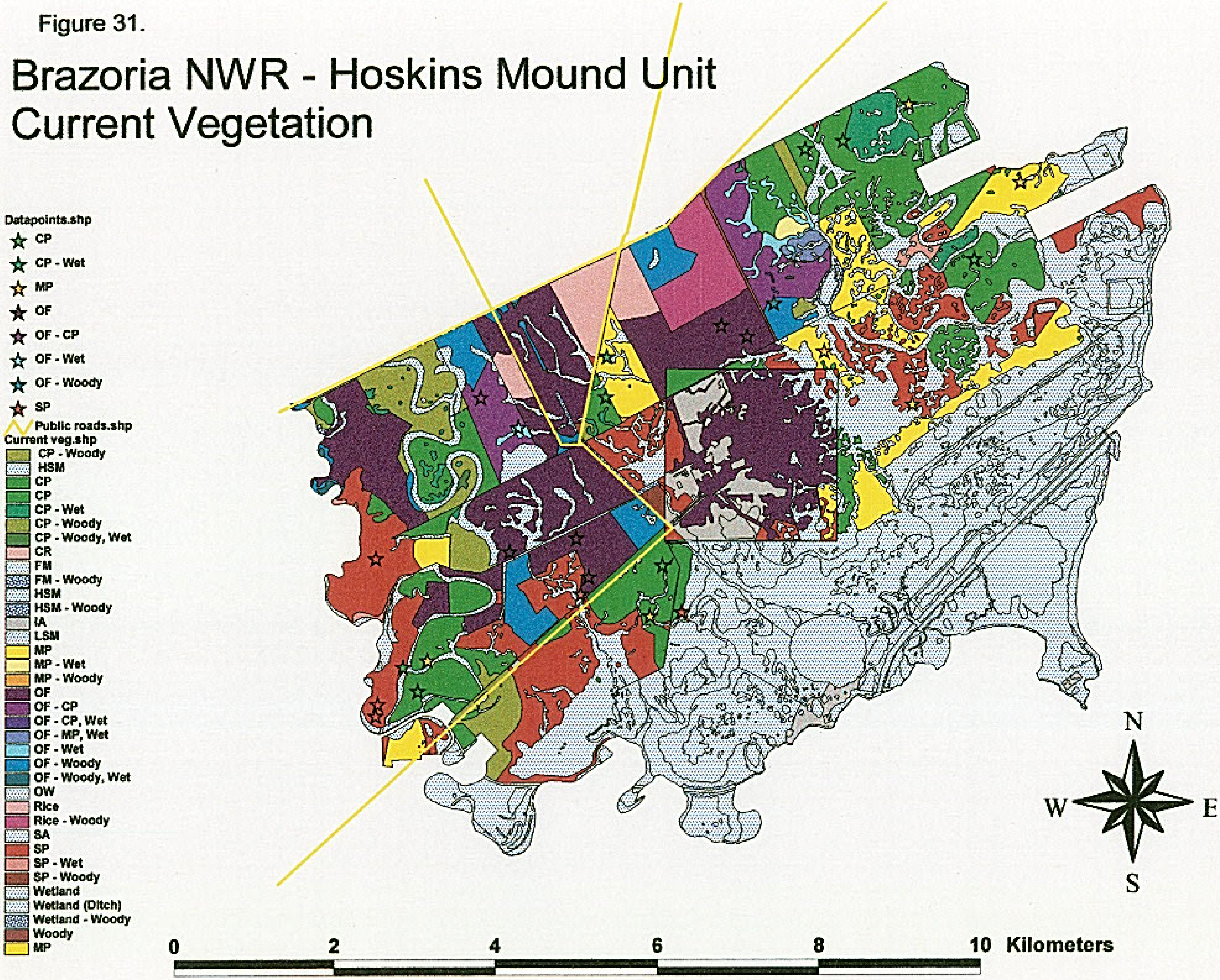


Figure 32.

Mad Island Complex
1995 DOQQ

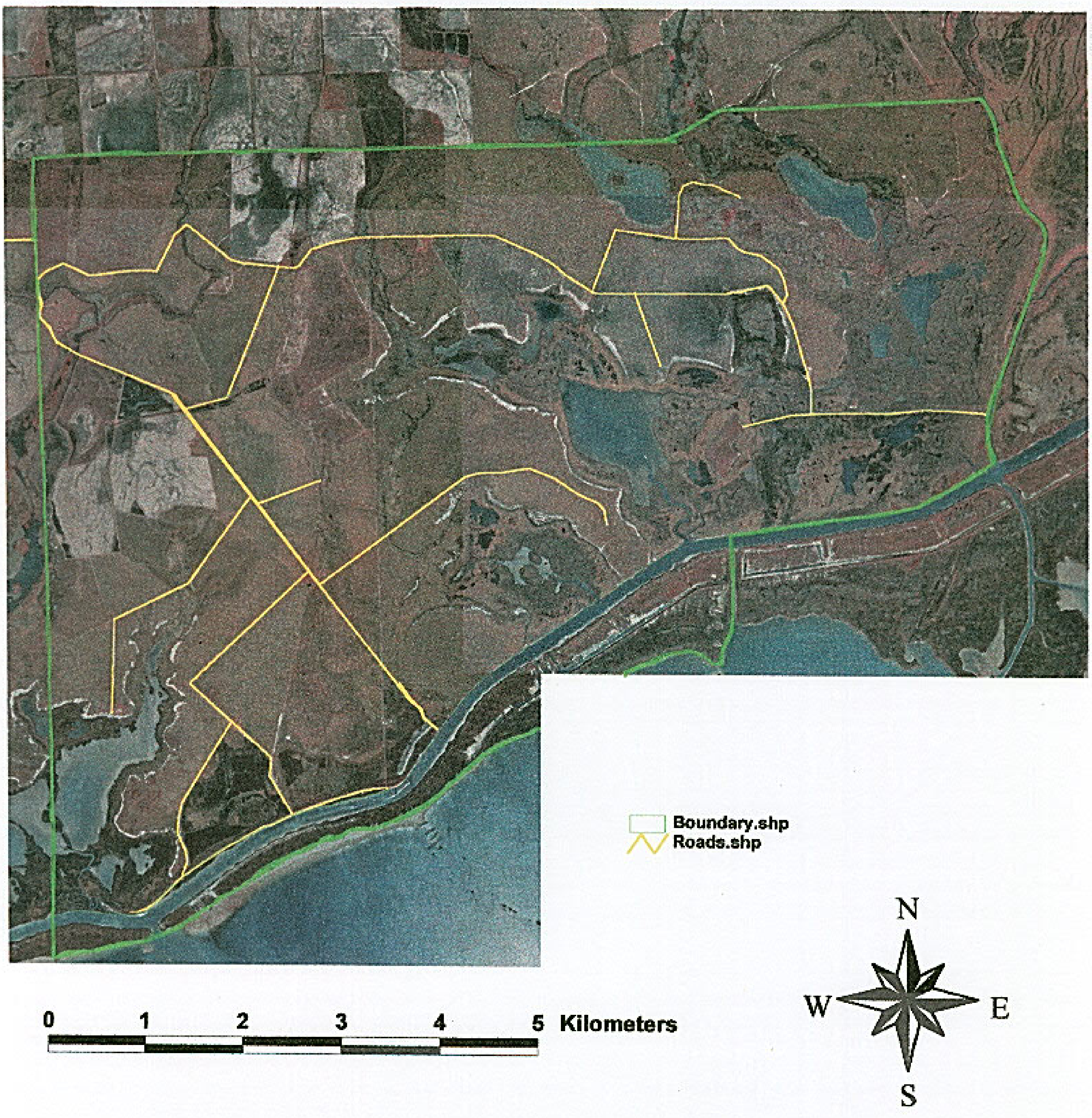
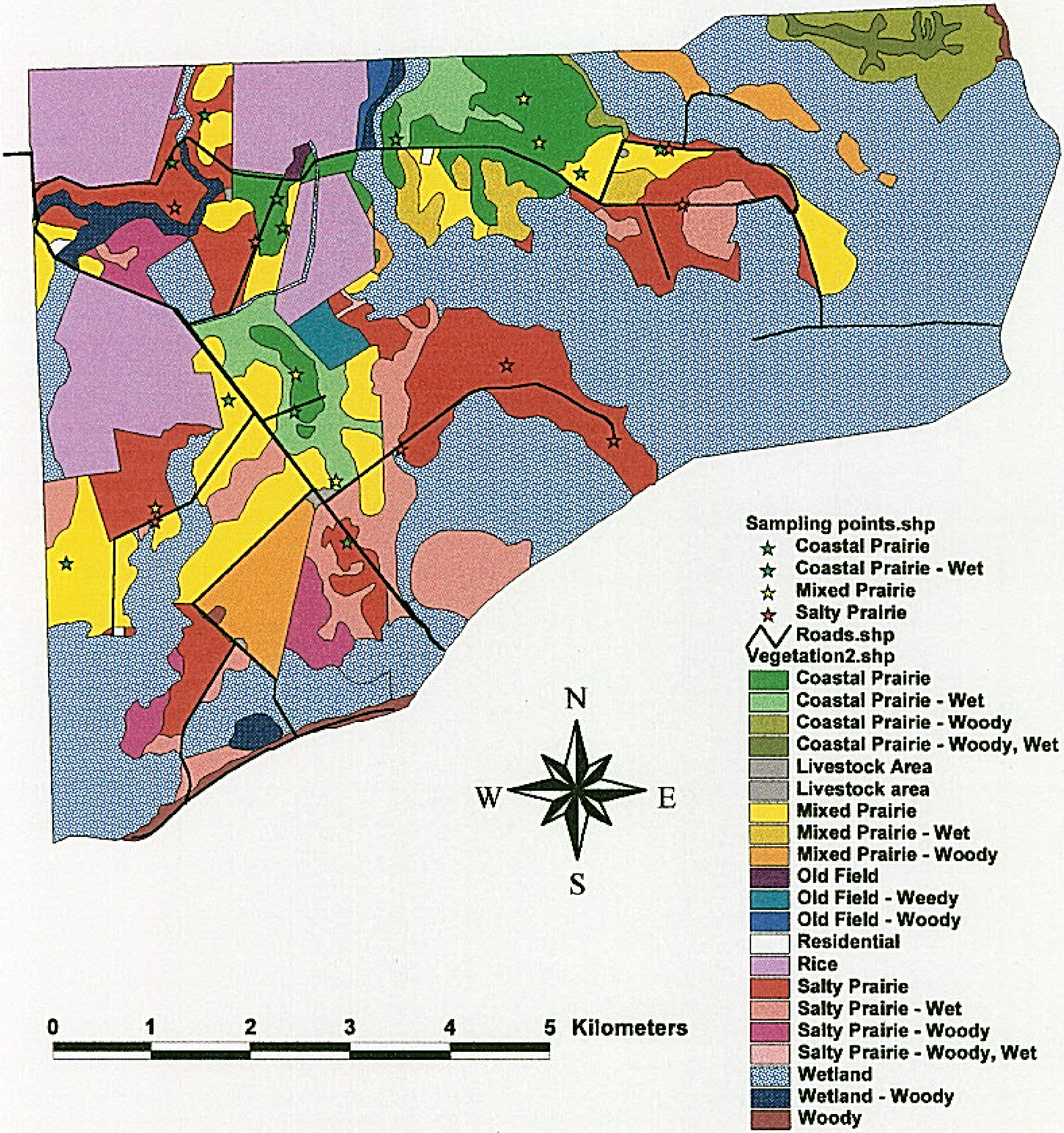


Figure 33.

Mad Island Complex
Current Vegetation with Sampling Points



Appendix 1 - Habitat data by sampling location

Site	A01A	A02A	A03A	A04A	A05A	A06A	A07A	A08A	A09A	A10A	A11A	A12A		
Date	97-05-30	97-05-30	97-05-30	97-05-30	97-06-12	97-06-12	97-06-12	97-06-12	97-07-10	97-07-10	97-07-10	97-07-10	1997	
Habitat type	coastal	coastal	coastal	old field	mix	mix	old field	old field	old field	old field	mix	salty	MEANS	STDEV
Robel (dm)	1	1	0.75	0.5	1.8	0.83	0.5	1.9	1.4	1	1.3	1.3	**1.11**	0.451751
Species richness (1 m2)	14	8	8	8	9	9	9	7	6	11	8	6	**8.58**	2.193309
Species richness (3 x 1 m2)	na	na	na	na	na	na	na	na	na	na	na	na	**na**	na
Brush density (/ha)	15.4	13	34.6	340	19.6	15.2	24.8	na	44.6	102	11.1	11.1	**57.40**	97.3811
% bare ground	15	40	45	65	5	60	55	50	30	50	30	10	**37.92**	19.93835
hits - bare ground	16	19	13	18	4	18	21	14	8	21	15	14	50.27778	
hits - litter	3	0	2	0	15	0	2	4	13	1	2	2	12.22222	
hits - vegetation	11	11	15	12	11	12	7	12	9	8	13	14	37.5	
hits - cordgrass	1	2	0	0	3	5	0	0	0	1	5	9	7.222222	
hits - other grass	6	6	14	3	4	4	4	4	8	6	5	4	18.88889	
hits - forbs	4	2	1	4	1	0	2	1	1	0	2	1	5.277778	
hits - sedges	0	1	0	5	3	3	1	7	0	1	1	0	6.111111	
hits - woody	0	0	0	0	0	0	0	0	0	0	0	0	0	
nearest - cordgrass	4	1	0	0	5	6	0	0	0	4	14	18	14.44444	
nearest - other grass	16	17	25	10	9	7	22	9	20	18	9	10	47.77778	
nearest - forbs	9	10	5	7	4	11	7	3	3	4	5	2	19.44444	
nearest - sedges	1	2	0	13	12	6	1	18	7	4	2	0	18.33333	
nearest - woody	0	0	0	0	0	0	0	0	0	0	0	0	0	
Sweeps	72	72	75	75	75	75	75	75	83	93		93		
Insect family richness	18	na	19	20	20	15	na	na	17	21		na	**18.57**	2.070197
Insects/100 sweeps (g)	2.13	1.50	1.28	2.13	0.63	3.02	4.35	4.20	1.34	2.85		1.57	**2.27**	1.208587
Orthoptera/100 sweeps (g)	1.94	1.20	0.95	0.70	0.40	2.82	4.04	3.62	0.56	2.47		1.31	**1.82**	1.259567
Acrididae/100 sweeps (g)	0.17	0.23	0.22	0.04	0.11	0.47	1.70	2.79	0.15	2.06		0.51	**0.77**	0.952574
Tettigoniidae/100 sweeps (g)	1.77	0.97	0.73	0.64	0.29	2.35	2.10	0.82	0.41	0.35		0.80	**1.02**	0.719103
Yrs. since last burn	0.5	0.5	0.5	0.5	2	1	3	1	>3	1	2	1		
Burn Type	WIN	WIN	WIN	WIN	SUM			SUM		SUM	SUM	SUM		
Yrs. since last hayed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Disturbance in last 1 yr?	Y	Y	Y	Y	N	Y	N	Y	N	Y	N	Y		
Disturbance in last 2 yrs?	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y		
Disturbance in last 3 yrs?	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y		
Currently grazed?	N	N	N	N	N	N	N	N	N	N	N	N		
Previously cultivated?	N	N	N	Y	N	N	Y	Y	Y	Y	N	N		

Site	A9801	A9802	A9803	A9804	A9805	A9806	A9807	A9808	A9809	A9810	A9811	A9812		
Date	98-05-26	98-05-26	98-05-26	98-05-26	98-06-15	98-06-16	98-06-16	98-06-16	98-07-07	98-07-07	98-07-07	98-07-07	1998	
Habitat type	old field	coastal	coastal	salty	old field	old field	coastal	salty	salty	mix	old field	salty	MEANS	STDEV
Robel (dm)	5.7	2.8	3.7	1.3	1.9	1.7	1.1	2.8	2.8	2.1	2.1	2.9	**2.58**	1.234449
Species richness (1 m2)	8	10	11	3	10	6	6	4	9	3	10	5	**7.08**	2.93748
Species richness (3 x 1 m2)	10	10	12	6	19	10	20	5	19	8	16	13	**12.33**	5.140452
Brush density (/ha)	694	48.3	24.6	3460	746	11.1	47.8	18.3	16.9	35.5	360	14.1	**456.38**	983.8398
% bare ground	4	4	0	40	2	22	37	3	15	5	12	5	**12.42**	13.70772
% litter	8	17	15	0	0	0	0	41	0	17	0	17	**9.58**	12.55865
% standing dead	2	2	8	0	28	28	0	7	2	23	8	12	**10.00**	10.57441
% vegetation	86	77	77	60	70	50	63	49	83	55	80	66	**68.00**	12.81335
%cordgrass	0	15	7.3	38.33333	0	0	14.66667	46	53	26	0.33	54	**21.22**	21.48314
%other grass	18.2	48	53	0	27	16.66667	37.33333	0.666667	12	27.33333	33	5	**23.18**	17.58291
%forbs	48	10	3.7	15	15	21.66667	10.33333	2	15	1.666667	41.66667	7	**15.92**	14.83134
%sedges	3.2	5	13	0	28	11.66667	0.666667	0.333333	3	0	5	0.00	**5.82**	8.268931
%woody	16.6	0	0	6.666667	0	0	0	0	0	0	0	0	**1.94**	4.999027
	86	78	77	60	70	50	63	49	83	55	80	66	**68.08**	12.88028
Sweeps	38	38	38	38	75	75	75	75	75	75	75	75		
Insect family richness	22	12	12	11	13	19	na	na	6	12	na	na	**13.38**	4.955156
Insects/100 sweeps (g)	0.65	0.31	0.28	0.17	0.23	1.29	0.24	0.01	0.17	0.21	0.70	0.44	**0.41**	0.363864
Orthoptera/100 sweeps (g)	0.40	0.07	0.14	0.01	0.00	1.04	0.14	0.00	0.00	0.08	0.47	0.31	**0.22**	0.304381
Acrididae/100 sweeps (g)	0.19	0.04	0.02	0.00	0.00	0.65	0.14	0.00	0.00	0.05	0.47	0.31	**0.16**	0.214896
Tettigoniidae/100 sweeps (g)	0.19	0.03	0.13	0.01	0.00	0.38	0.00	0.00	0.00	0.03	0.01	0.00	**0.07**	0.116217
Yrs. since last burn	2	2	2	1	1	2	1	>4	1	UNK.	1	UNK.		
Burn Type	SUM	SUM	SUM	WIN	SUM	SUM	WIN		SUM		WIN			
Yrs. since last hayed	NA	NA	NA	NA	NA	NA	NA	NA	NA		NA			
Disturbance in last 1 yr?	N	N	N	Y	Y	N	Y	N	Y		Y			
Disturbance in last 2 yrs?	Y	Y	Y	Y	Y	Y	Y	N	Y		Y			
Disturbance in last 3 yrs?	Y	Y	Y	Y	Y	Y	Y	N	Y		Y			
Currently grazed?	N	N	N	N	N	N	N	N	N	N	N	N		
Previously cultivated?	Y	N	N	N	Y	Y	N	N	N	N	Y	N		

Sito	BC01	BC03	BC04	BC05	BC10	BF01	BF02	BF05	BF10	BS01	BS02	BS03	BS04	BS10		
Date	97-05-29	97-06-11	97-06-11	5/29/97	97-07-12	97-06-11	97-06-11	97-05-27	97-07-12	97-06-11	97-06-11	97-05-29	97-05-29	97-07-12	1997	
Habitat Type	coastal	coastal	coastal	coastal	coastal	old field	old field	old field	old field	mix	salty	salty	salty	coastal	MEANS	STDEV
Robel (dm)	2.9	1.8	2.4	1.2	0.58	1.3	1.9	2.4	2.6	1.6	0.83	2.7	1.5	1.3	1.79	0.723598
Species richness (1 m2)	11	8	9	5	10	10	13	5	10	4	4	1	2	6	7.00	3.637412
Species richness (3 x 1 m2)	na	na	na	na	na	na	na	na	na	na	na	na	na	na	0.00	na
Brush density (/ha)	352	16.8	25.9	22	25.6	51.8	730	85.5	8264	25	141	198	188	76.9	728.75	2177.304
% bare ground	0	5	10	0	30	na	50	0	0	50	60	0	15	10	16.43	22.13739
hits - bare ground	7	10	17	9	12	11	20	4	1	8	17	1	3	18	32.86	
hits - litter	18	10	2	9	4	3	0	18	23	7	2	22	19	2	33.10	
hits - vegetation	5	10	11	12	14	16	10	8	6	15	11	7	8	10	34.05	
hits - cordgrass	0	1	2	1	0	1	1	0	0	4	5	7	6	0	6.67	
hits - other grass	3	4	5	7	4	10	4	4	2	8	0	0	0	10	14.52	
hits - forbs	0	2	1	3	2	1	0	2	2	3	5	0	2	0	5.48	
hits - sedges	2	3	3	1	8	4	5	2	2	0	1	0	0	0	7.38	
hits - woody	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	
nearest - cordgrass	1	5	4	4	0	1	1	0	0	7	14	26	23	1	20.64	
nearest - other grass	19	13	14	17	8	16	14	13	12	14	0	0	0	17	37.43	
nearest - forbs	3	8	5	7	4	5	10	4	10	7	15	4	7	9	23.21	
nearest - sedges	7	4	7	2	18	8	5	13	8	2	1	0	0	3	18.57	
nearest - woody	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	
Sweeps	75	75	75	66	93	75	75	75	93	75	75	75	75	93		
Insect family richness	20	23	26	19	19	28	27	18	20	27	NA	NA	7	19	18.07	5.79119
Insects/100 sweeps (g)	0.93	1.40	2.64	0.25	2.45	2.07	1.12	0.36	2.32	0.75	1.03	0.14	0.05	0.98	1.18	0.881163
Orthoptera/100 sweeps (g)	0.39	1.03	1.50	0.15	0.98	1.26	0.47	0.16	1.54	0.08	0.32	0.00	0.00	0.60	0.61	0.553586
Acrididaa/100 sweeps (g)	0.03	0.51	0.14	0.11	0.45	1.07	0.37	0.00	0.46	0.08	0.30	0.00	0.00	0.49	0.29	0.300835
Tettigoniidae/100 sweeps (g)	0.36	0.52	1.36	0.04	0.54	0.20	0.10	0.16	1.07	0.00	0.02	0.00	0.00	0.12	0.32	0.424091
Yrs. since last burn	>3	2	0.3	>3	>3	1	1	3	2	>3	>3	>3	>3	3		
Burn Type																
Yrs. since last hayed	1	NA	NA	NA	1	NA	NA	NA	1	NA	NA	NA	NA	NA		
Disturbance in lst 1 yr?	Y	N	Y	N	Y	Y	Y	N	Y	N	N	N	N	N		
Disturbance in last 2 yrs?	N	Y	Y	N	N	Y	Y	N	Y	N	N	N	N	N		
Disturbance in last 3 yrs?	N	Y	Y	N	N	Y	Y	Y	Y	N	N	N	N	Y		
Currently grazed?	N	N	N	N	N	N	N	N	N	N	N	N	N	N		
Previously cultivated?	N	N	N	N	N	Y	Y	Y	Y	N	N	N	N	N		

Site	B9801	B9802	B9803	B9804	B9805	B9806	B9807	B9808	B9809	B9810	B9811	B9812	B9813		
Date	98-06-04	98-06-04	98-06-04	98-06-04	98-06-04	98-06-19	98-06-19	98-06-19	98-06-19	98-07-01	98-07-01	98-07-01	98-07-01	1998	
Habitat type	salty	salty	coastal	old field	old field	mix	coastal	old field	salty	coastal	mix	mix	old field	MEANS	STDEV
Robel (dm)	2.4	2.8	1.8	1.1	1.2	0.75	0.83	2	4.5	1.5	1	3.3	3.8	2.08	1.21
Species richness (1 m2)	7	1	7	11	11	12	13	7	4	11	7	11	12	8.77	3.59
Species richness (3 x 1 m2)	12	2	12	21	15	16	24	16	4	18	12	16	23	14.69	6.51
Brush density (/ha)	116	37.3	175	196	186	13.5	48.4	2212	104	85	25.3	51.8	56.6	254.38	591.42
% bare ground	7	1	7	15	23	30	20	3	0	23	48.3333	1	3	13.95	14.46
% litter	15	2	15	7	0	0	7	15	41	1	0	3.33333	19	9.64	11.63
% standing dead	16	0	32	18	5	17	17	18	3	15	0	21.6667	18	13.90	9.34
% vegetation	62	97	46	60	72	53	56	64	56	61	51.6667	74	60	62.51	12.89
%cordgrass	36	95	8.33333	10	13.3333	25	0	0	51.3333	2.33333	16.6667	28.3333	5	22.41	26.63
%other grass	15	0	11.6667	20	16.6667	16.6667	21	32.6667	0	38	15	36.3333	4	17.46	12.47
%forbs	8	2	25	16.6667	20	11.3333	26.6667	20	2	17	16.6667	6.66667	36.6667	16.05	10.09
%sedges	3	0	1	13.3333	22	0	8.33333	11.3333	2.66667	3.66667	3.33	2.66667	13.3333	6.61	6.68
%woody	0	0	0	0	0	0	0	0	0	0	0	0	1	0.08	0.28
	62	97	46	60	72	53	56	64	56	61	51.6667	74	60	62.51	12.89
Sweeps	75	75	75	75		75	75	75	75	75	75	75	75		
Insect family richness	na	na	8	16		26	23	na	na	22	19	25	21	20.00	5.81
Insects/100 sweeps (g)	0.26	0.21	1.15	0.94		0.95	1.29	1.22	0.09	1.25	2.81	0.68	0.68	0.96	0.72
Orthoptera/100 sweeps (g)	0.18	0.13	0.55	0.46		0.72	0.30	0.78	0.00	0.68	2.30	0.14	0.24	0.54	0.61
Acrididae/100 sweeps (g)	0.02	0.00	0.00	0.19		0.59	0.18	0.00	0.00	0.47	2.06	0.00	0.17	0.31	0.59
Tettigoniidae/100 sweeps (g)	0.15	0.13	0.43	0.27		0.13	0.09	0.78	0.00	0.21	0.24	0.14	0.07	0.22	0.21
Yrs. since last burn	1	1	1	1	1	1	>3	3	4	1	0.3	2	2		
Burn Type															
Yrs. since last hayed	na	na	na	na	na	2	2	2	na	na	na	na	na		
Disturbance in last 1 yr?	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	N	N		
Disturbance in last 2 yrs?	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y		
Disturbance in last 3 yrs?	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y		
Currently grazed?	N	N	N	N	N	N	N	N	N	N	N	N	N		
Previously cultivated?	N	N	N	Y	Y	N	N	Y	N	N	N	N	Y		

Site	M01A	M02A	M03A	M04A	M05	M06	M07	M08	M09	M10	M11	M12		
Date	97-05-31	97-05-31	97-05-31	97-05-31	97-06-14	97-06-14	97-04-14	97-06-14	97-07-11	97-07-11	97-07-11	97-07-11	1997	
Habitat Type	salty	coastal	mix	coastal	coastal	coastal	coastal	mix	mix	salty	coastal	salty	MEANS	STDEV
Robel (dm)	1.3	0.42	0.83	0	4.1	1.5	1	1.7	1.5	1.3	0.67	1.9	1.35	1.026032
Species richness (1 m2)	6	13	5	10	9	9	10	11	7	8	11	8	8.92	2.274696
Species richness (3 x 1 m2)														
Brush density (/ha)	131	26.6	96.2	11.1	40	51.5	11.9	50.3	25.1	23.3	14.8	33.1	42.91	36.38707
% bare ground	5	5	50	50	0	15	20	5	15	50	40	5	21.67	20.03784
hits - bare ground	5	3	6	18	3	3	6	3	5	7	16	13	24.44444	
hits - litter	13	13	8	3	20	16	8	20	17	13	6	9	40.55556	
hits - vegetation	12	14	16	9	7	11	16	7	8	10	8	8	35	
hits - cordgrass	8	1	6	0	1	2	2	2	2	7	0	5	10	
hits - other grass	2	9	6	8	4	8	8	3	2	1	6	1	16.11111	
hits - forbs	1	2	3	1	0	0	3	0	3	2	2	2	5.277778	
hits - sedges	1	2	1	0	2	1	3	2	1	0	0	0	3.611111	
hits - woody	0	0	0	0	0	0	0	0	0	0	0	0	0	
nearest - cordgrass	17	3	10	0	1	3	5	5	9	11	1	11	21.16667	
nearest - other grass	4	18	13	24	16	17	13	11	12	4	22	4	43.75	
nearest - forbs	5	4	4	6	3	7	9	8	5	13	5	14	23.08333	
nearest - sedges	4	5	3	0	10	3	3	6	4	2	2	1	11.91667	
nearest - woody	0	0	0	0	0	0	0	0	0	0	0	0	0	
Sweeps	66	66	66	66	82	82	82	72	93	93	83	75		
Insect family richness	8	18	na	na	20	na	24	na	16	16	na	na	17.00	5.329165
Insects/100 sweeps (g)	0.66	0.88	0.6	1.23	0.77	0.59	1.8	1.01	0.51	0.78	1.51	0.67	0.92	0.402247
Orthoptera/100 sweeps (g)	0.45	0.19	0.19	0.75	0.54	0.2	0.91	0.75	0.27	0.23	0.51	0.22	0.43	0.25791
Acrididae/100 sweeps (g)	0.02	0.08	0.1	0.53	0.22	0.03	0.42	0.29	0.15	0.11	0.38	0.17	0.21	0.163642
Tettigoniidae/100 sweeps (g)	0.43	0.11	0.08	0.12	0.32	0.17	0.49	0.45	0.12	0.11	0.09	0.02	0.21	0.16561
Yrs. since last burn	2	>5	2	1	>5	>5	>5	>5	>5	>2	1	2		
Burn Type	SPR		FALL	SUM							SUM			
Yrs. since last hayed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Disturbance in last 1 yr?	N	N	N	Y	N	N	N	N	N	N	Y	N		
Disturbance in last 2 yrs?	Y	N	Y	Y	N	N	N	N	N	N	Y	Y		
Disturbance in last 3 yrs?	Y	N	Y	Y	N	N	N	N	N	UNK.	Y	Y		
Currently grazed?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
Previously cultivated?	N	N	N	N	N	N	N	N	N	N	N	N		

Site	M9801	M9802	M9803	M9804	M98-05	M9806	M9807	M9808	M9809	M9810	M9811	M9812		
Date	98-06-12	98-06-12	98-07-15	98-06-23	98-06-12	98-06-12	98-07-15	98-06-23	98-06-23	98-07-15	98-06-23	98-07-15	1998	
Habitat type	mix	mix	coastal	mix	salty	salty	salty	salty	coastal	mix	salty	coastal	MEANS	STDEV
Robel (dm)	1.7	0.5	0.25	0.75	0.33	0.083	1.9	0.58	0.33	0.71	1.5	0.083	0.73	0.63
Species richness (1 m2)	7	9	8	6	7	6	11	4	9	9	4	10	7.50	2.24
Species richness (3 x 1 m2)	17	15	12	7	8	12	14	10	21	15	5	16	12.67	4.60
Brush density (/ha)	11.1	15.6	62.1	11.1	36.2	32.6	15.7	12.8	11.1	11.1	16.3	17.3	21.08	15.39
% bare ground	4	39	51	67	34	35	26	71	49	22	22	52	39.33	19.62
% litter	22	2	0	0	19	7	0	0	0	0	5	0	4.58	7.81
% standing dead	28	2	5	13	5	2	0	8	12	8	0	2	7.08	7.89
% vegetation	46	57	44	20	42	56	74	21	39	70	73	46	49.00	18.02
%cordgrass	15	26.66667	0	6.666667	28.33333	30	55	13.33333	0	25	73	3.333333	23.03	22.34
%other grass	9	22.33333	25	4	3.333333	1	7.333333	0.666667	11.33333	30	0	26.66667	11.72	11.19
%forbs	18	8	18.33333	8.333333	10.33333	11	11.66667	7	11	15	0	16	11.22	5.20
%sedges	4	0	0.67	1	0	14	0	0	16.66667	0	0	0	3.03	5.89
%woody	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
	46	57	44	20	42	56	74	21	39	70	73	46	49.00	18.02
Sweeps	75	75		75	75	75	75	75	75	75	75	75		
Insect family richness	18	17		na	na	na	na	na	14	na	na	na	16.33	2.08
Insects/100 sweeps (g)	0.71	0.27		0.12	0.21	0.53	0.62	0.32	0.38	0.30	0.16	0.11	0.34	0.20
Orthoptera/100 sweeps (g)	0.41	0.08		0.02	0.06	0.22	0.31	0.00	0.14	0.11	0.00	0.01	0.12	0.14
Acrididae/100 sweeps (g)	0.24	0.08		0.00	0.04	0.22	0.31	0.00	0.11	0.10	0.00	0.00	0.10	0.11
Tettigoniidae/100 sweeps (g)	0.17	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.05
Yrs. since last burn	2	>5	3	1	1	1	1	3	>5	2	1	>5		
Burn Type	SUM			SUM	FALL	FALL	SUM			SUM	SUM			
Yrs. since last hayed	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Disturbance in last 1 yr?	N	N	N	Y	Y	Y	Y	N	N	N	Y	N		
Disturbance in last 2 yrs?	Y	N	N	Y	Y	Y	Y	Y	N	Y	Y	N		
Disturbance in last 3 yrs?	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N		
Currently grazed?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
Previously cultivated?	N	N	N	N	N	N	N	N	N	N	N	N		

Appendix 2 – Detailed habitat patch characteristics

Table 1. Area summaries (in square meters) for habitat patches at Aransas NWR, Tatton Unit.

VEGTYPE	COUNT	AVE_AREA	SUM_AREA	MIN_AREA	MAX_AREA	STDDEV_AREA	VAR_AREA
Coastal Prairie	8	594966	4759728	150	1765504	673245	453259227296
Coastal Prairie - Woody	1	71387	71387	71387	71387	0	0
Livestock area	7	9706	67945	3321	22123	6978	48690603
Mixed Prairie	9	567491	5107422	411	1530312	587365	344997107568
Mixed Prairie - Wet	1	485852	485852	485852	485852	0	0
Mixed Prairie - Woody	4	34904	139616	22430	58769	16663	277662096
Mixed Prairie - Woody, W	1	135180	135180	135180	135180	0	0
Old Field - CP	4	418080	1672322	31999	642309	267143	71365230969
Old Field - CP, Woody	2	119025	238050	71166	166884	67683	4581035818
Old Field - MP	2	369202	738404	109489	628915	367289	134901303480
Old Field - SP	2	134879	269758	94658	175100	56882	3235509246
Old Field - SP, Woody	1	352200	352200	352200	352200	0	0
Old Field - Weedy	3	430564	1291691	42729	1194963	662013	438260962492
Old Field - Weedy, Wet	2	1936396	3872791	48129	3824662	2670412	7131099719051
Old Field - Wet	1	323439	323439	323439	323439	0	0
Old Field - Woody	1	34876	34876	34876	34876	0	0
Salt Marsh	4	1490418	5961674	146	3467420	1456006	2119953423812
Salty Prairie	7	233409	1633865	97855	573729	163394	26697613110
Salty Prairie - Wet	3	289156	867467	70894	574864	258666	66908171328
Salty Prairie - Woo	1	33751	33751	33751	33751	0	0
Salty Prairie - Woody, W	5	204211	1021056	109	606559	243319	59204192042
Tidal Flat	4	66751	267004	35090	111597	36403	1325152567
Woody	5	68156	340782	2511	223155	88383	7811516299
TOTAL			**29686261**				

Table 2. Perimeter summaries (in meters) for habitat patches at Aransas NWR, Tatton Unit.

VEGTYPE	COUNT	AVE_PERIME	SUM_PERIME	MIN_PERIME	MAX_PERIME	STDDEV_PER	VAR_PERIME
Coastal Prairie	7	4177	29239	1046	8976	2997	8982907
Coastal Prairie - Woody	1	1364	1364	1364	1364	0	0
Livestock area	7	391	2740	233	609	145	21110
Mixed Prairie	7	4791	33540	967	8791	3175	10079957
Mixed Prairie - Wet	1	7479	7479	7479	7479	0	0
Mixed Prairie - Woody	4	948	3791	691	1219	244	59729
Mixed Prairie - Woody, Wet	1	2620	2620	2620	2620	0	0
Old Field - CP	4	5469	21876	793	7736	3163	10007016
Old Field - CP, Woody	2	2069	4138	1975	2163	133	17658
Old Field - MP	2	4285	8571	1572	6999	3838	14730610
Old Field - SP	2	2823	5646	2131	3515	979	957999
Old Field - SP, Woody	1	3816	3816	3816	3816	0	0
Old Field - Weedy	3	5269	15808	1127	13394	7037	49518575
Old Field - Weedy, Wet	2	21843	43685	1494	42191	28777	828125428
Old Field - Wet	1	3377	3377	3377	3377	0	0
Old Field - Woody	1	1004	1004	1004	1004	0	0
Salt Marsh	3	11988	35965	10320	14221	2011	4043180
Salty Prairie	7	2997	20978	2148	5898	1333	1776787
Salty Prairie - Wet	3	4603	13809	1507	8788	3761	14143650
Salty Prairie - Woody	1	698	698	698	698	0	0
Salty Prairie - Woody, Wet	4	4012	16047	595	7913	3046	9279292
Tidal Flat	4	1494	5975	880	2231	590	347983
Woody	5	1433	7165	195	4145	1558	2427381

Table 3. Perimeter to area ratios for habitat patches at Aransas NWR, Tatton Unit.

VEGTYPE	COUNT	AVE_P_A	MIN_P_A	MAX_P_A	STDDEV_P_A	VAR_P_A
Coastal Prairie	7	0.0091	0.0044	0.0186	0.0048	0.0000
Coastal Prairie - Woody	1	0.0191	0.0191	0.0191	0.0000	0.0000
Livestock area	7	0.0499	0.0275	0.0708	0.0169	0.0003
Mixed Prairie	7	0.0094	0.0054	0.0185	0.0050	0.0000
Mixed Prairie - Wet	1	0.0154	0.0154	0.0154	0.0000	0.0000
Mixed Prairie - Woody	4	0.0294	0.0184	0.0360	0.0077	0.0001
Mixed Prairie - Woody, W	1	0.0194	0.0194	0.0194	0.0000	0.0000
Old Field - CP	4	0.0159	0.0120	0.0248	0.0060	0.0000
Old Field - CP, Woody	2	0.0211	0.0118	0.0304	0.0132	0.0002
Old Field - MP	2	0.0128	0.0111	0.0144	0.0023	0.0000
Old Field - SP	2	0.0213	0.0201	0.0225	0.0017	0.0000
Old Field - SP, Woody	1	0.0108	0.0108	0.0108	0.0000	0.0000
Old Field - Weedy	3	0.0205	0.0112	0.0264	0.0081	0.0001
Old Field - Weedy, Wet	2	0.0210	0.0110	0.0310	0.0141	0.0002
Old Field - Wet	1	0.0104	0.0104	0.0104	0.0000	0.0000
Old Field - Woody	1	0.0288	0.0288	0.0288	0.0000	0.0000
Salt Marsh	3	0.0073	0.0041	0.0102	0.0031	0.0000
Salty Prairie	7	0.0147	0.0103	0.0233	0.0045	0.0000
Salty Prairie - Wet	3	0.0175	0.0153	0.0213	0.0033	0.0000
Salty Prairie - Woo	1	0.0207	0.0207	0.0207	0.0000	0.0000
Salty Prairie - Woody, W	4	0.0196	0.0130	0.0268	0.0064	0.0000
Tidal Flat	4	0.0240	0.0200	0.0303	0.0048	0.0000
Woody	5	0.0342	0.0186	0.0777	0.0246	0.0006

Table 4. Diversity indices for habitat patches at Aransas NWR, Tatton Unit.

VEGTYPE	COUNT	AVE_DI	MIN_DI	MAX_DI	STDDEV_DI	VAR_DI
Coastal Prairie	7	1.4943	1.1574	2.0514	0.3182	0.1013
Coastal Prairie - Woody	1	1.4398	1.4398	1.4398	0.0000	0.0000
Livestock area	7	1.1822	1.0813	1.3492	0.0949	0.0090
Mixed Prairie	7	1.6095	1.1937	2.4197	0.4340	0.1884
Mixed Prairie - Wet	1	3.0268	3.0268	3.0268	0.0000	0.0000
Mixed Prairie - Woody	4	1.4673	1.2575	1.8699	0.2796	0.0782
Mixed Prairie - Woody, W	1	2.0098	2.0098	2.0098	0.0000	0.0000
Old Field - CP	4	2.3261	1.2503	2.7228	0.7179	0.5153
Old Field - CP, Woody	2	1.8253	1.3637	2.2870	0.6529	0.4262
Old Field - MP	2	1.9148	1.3398	2.4898	0.8132	0.6612
Old Field - SP	2	2.1616	1.9536	2.3695	0.2941	0.0865
Old Field - SP, Woody	1	1.8140	1.8140	1.8140	0.0000	0.0000
Old Field - Weedy	3	2.1855	1.5381	3.4565	1.1008	1.2117
Old Field - Weedy, Wet	2	4.0035	1.9213	6.0858	2.9447	8.6715
Old Field - Wet	1	1.6753	1.6753	1.6753	0.0000	0.0000
Old Field - Woody	1	1.5168	1.5168	1.5168	0.0000	0.0000
Salt Marsh	3	2.5653	2.1544	2.8961	0.3773	0.1423
Salty Prairie	7	1.7978	1.5078	2.1964	0.2483	0.0616
Salty Prairie - Wet	3	2.3239	1.5971	3.2698	0.8576	0.7355
Salty Prairie - Woo	1	1.0719	1.0719	1.0719	0.0000	0.0000
Salty Prairie - Woody, W	4	2.2008	1.1263	2.8661	0.8282	0.6859
Tidal Flat	4	1.6405	1.3253	1.8836	0.2322	0.0539
Woody	5	1.5279	1.0988	2.4755	0.5533	0.3062

Diversity Indices are calculated as $DI = TP / 2 (A\pi)^{1/2}$, based on McKinney 1996.

Table 5. Area summaries (in square meters) for habitat patches at Brazoria NWR, Hoskins Unit.

VEGTYPE	COUNT	AVE_AREA	SUM_AREA	MIN_AREA	MAX_AREA	STDDEV_ARE	VAR_AREA
CP	75	204172	15312869	0	2172830	405649	164551081262
CP - Wet	24	66116	1586788	1570	1000318	203876	41565358551
CP - Woody	10	439318	4393182	28075	1277264	447074	199874760245
CP - Woody, Wet	1	49113	49113	49113	49113	0	0
HSM	317	107305	34015587	6	5852454	456241	208156197301
IA	44	73245	3222778	1635	554942	133148	17728351672
LSM	130	71680	9318429	518	2645353	258743	66947830852
MP	15	476409	7146128	57150	1377517	400738	160591024008
MP - Wet	1	186811	186811	186811	186811	0	0
MP - Woody	1	10665	10665	10665	10665	0	0
OF	17	1070748	18202719	2697	4987092	1458043	2125889053668
OF - CP	2	1594704	3189409	1174705	2014703	593968	352798351082
OF - CP, Wet	3	7074	21221	6224	8039	913	833959
OF - MP, Wet	1	264298	264298	264298	264298	0	0
OF - Wet	4	167858	671432	5242	399282	169929	28875885838
OF - Woody	19	186988	3552780	0	852851	286903	82313259992
OF - Woody, Wet	3	17532	52596	4476	35228	15892	252565324
OW	78	82333	6421996	8	1819219	317193	100611276386
Rice	3	797161	2391483	355231	1301596	476268	226831627298
Rice - Woody	1	2172639	2172639	2172639	2172639	0	0
SA	59	72688	4288580	134	453610	82557	6815679885
SP	80	158200	12656016	0	2281047	385760	148810734673
SP - Wet	4	69033	276132	5066	171351	74476	5546698482
SP - Woody	1	169965	169965	169965	169965	0	0
Wetland	147	59157	8696069	0	658625	118574	14059741427
Wetland - Woody	5	62007	310035	15114	122591	45833	2100631030
Woody	2	89194	178388	23222	155165	93298	8704475777
Unclassified	17	313	5326	1	2478	594	352542
TOTAL			138763432				

Table 6. Perimeter summaries (in meters) for habitat patches at Brazoria NWR, Hoskins Mound Unit.

VEGTYPE	COUNT	AVE_PERIME	SUM_PERIME	MIN_PERIME	MAX_PERIME	STDDEV_PER	VAR_PERIME
CP	75	2339	175441	2	23818	3773	14234663
CP - Wet	24	1073	25743	157	8851	1832	3357930
CP - Woody	10	4599	45994	1015	14021	4155	17263503
CP - Woody, Wet	1	1157	1157	1157	1157	0	0
HSM	317	1859	589333	16	111295	7319	53571014
IA	44	1431	62977	163	7878	1893	3581678
LSM	130	1466	190542	93	25015	2756	7596708
MP	15	6067	90999	1804	18398	5109	26099563
MP - Wet	1	2605	2605	2605	2605	0	0
MP - Woody	1	619	619	619	619	0	0
OF	17	8821	149950	198	58734	14469	209364170
OF - CP	2	12958	25916	8205	17710	6721	45171923
OF - CP, Wet	3	456	1367	366	574	107	11432
OF - MP, Wet	1	5111	5111	5111	5111	0	0
OF - Wet	4	4686	18744	272	11365	4898	23987259
OF - Woody	19	1947	36997	1	6451	1917	3676185
OF - Woody, Wet	3	556	1669	277	932	338	114248
OW	78	1203	93820	15	15675	2623	6880701
Rice	3	3821	11464	2621	5179	1286	1654240
Rice - Woody	1	7359	7359	7359	7359	0	0
SA	59	1744	102881	60	8516	1759	3093945
SP	80	2277	182176	1	22006	3624	13133795
SP - Wet	4	1877	7508	312	3837	1671	2792293
SP - Woody	1	1869	1869	1869	1869	0	0
Wetland	147	1747	256806	1	16325	2883	8313657
Wetland - Woody	5	2416	12078	537	4566	1829	3346319
Woody	2	3620	7239	695	6544	4136	17106284
Unclassified	17	217	3681	5	1345	324	105236

Table 7. Perimeter to area ratios for habitat patches at Brazoria NWR, Hoskins Mound Unit.

VEGTYPE	COUNT	AVE_P_A	MIN_P_A	MAX_P_A	STDDEV_P_A	VAR_P_A
CP	75	0.2335	0.005388	13.616438	1.5682	2.4593
CP - Wet	24	0.0498	0.008848	0.099895	0.0237	0.0006
CP - Woody	10	0.0208	0.006507	0.058085	0.0159	0.0003
CP - Woody, Wet	1	0.0236	0.023561	0.023561	0.0000	0.0000
HSM	317	0.1162	0.006395	2.687148	0.2627	0.0690
IA	44	0.0448	0.009880	0.099559	0.0250	0.0006
LSM	130	0.0779	0.009456	0.292306	0.0569	0.0032
MP	15	0.0154	0.005971	0.031571	0.0075	0.0001
MP - Wet	1	0.0139	0.013944	0.013944	0.0000	0.0000
MP - Woody	1	0.0580	0.058045	0.058045	0.0000	0.0000
OF	17	0.0210	0.004657	0.073533	0.0201	0.0004
OF - CP	2	0.0084	0.008097	0.008742	0.0005	0.0000
OF - CP, Wet	3	0.0639	0.058824	0.071412	0.0067	0.0000
OF - MP, Wet	1	0.0193	0.019339	0.019339	0.0000	0.0000
OF - Wet	4	0.0328	0.022041	0.051931	0.0131	0.0002
OF - Woody	19	1.9964	0.006161	23.944444	5.9129	34.9618
OF - Woody, Wet	3	0.0413	0.026457	0.061826	0.0183	0.0003
OW	78	0.2231	0.003761	1.994277	0.3367	0.1133
Rice	3	0.0063	0.004987	0.007379	0.0012	0.0000
Rice - Woody	1	0.0034	0.003387	0.003387	0.0000	0.0000
SA	59	0.0452	0.009299	0.443188	0.0576	0.0033
SP	80	0.5734	0.004992	39.529412	4.4247	19.5776
SP - Wet	4	0.0369	0.022395	0.061529	0.0172	0.0003
SP - Woody	1	0.0110	0.010997	0.010997	0.0000	0.0000
Wetland	147	0.3252	0.007347	39.800000	3.2784	10.7477
Wetland - Woody	5	0.0378	0.034480	0.043517	0.0035	0.0000
Woody	2	0.0361	0.029929	0.042176	0.0087	0.0001
	17	1.5600	0.072935	4.372800	1.2070	1.4568

Table 8. Diversity indices for habitat patches at Brazoria NWR, Hoskins Mound Unit.

VEGTYPE	COUNT	AVE_DI	MIN_DI	MAX_DI	STDDEV_DI	VAR_DI
CP	75	1.7058	1.0293	7.4920	0.9721	0.9450
CP - Wet	24	1.4215	1.0329	2.4964	0.4531	0.2053
CP - Woody	10	1.9074	1.3758	3.1091	0.5419	0.2937
CP - Woody, Wet	1	1.4730	1.4730	1.4730	0.0000	0.0000
HSM	317	1.7276	1.0118	12.9778	1.0843	1.1756
IA	44	1.6686	1.0345	3.3936	0.5784	0.3346
LSM	130	1.9264	1.0278	4.7688	0.9143	0.8359
MP	15	2.4622	1.1687	5.2625	1.1144	1.2418
MP - Wet	1	1.7001	1.7001	1.7001	0.0000	0.0000
MP - Woody	1	1.6910	1.6910	1.6910	0.0000	0.0000
OF	17	2.0626	1.0678	7.4192	1.5189	2.3071
OF - CP	2	2.6989	1.8513	3.5464	1.1986	1.4367
OF - CP, Wet	3	1.5199	1.3091	1.8062	0.2570	0.0661
OF - MP, Wet	1	2.8046	2.8046	2.8046	0.0000	0.0000
OF - Wet	4	2.8554	1.0606	5.0736	1.7825	3.1773
OF - Woody	19	1.7832	1.1376	3.5464	0.6018	0.3622
OF - Woody, Wet	3	1.2373	1.1441	1.4008	0.1421	0.0202
OW	78	2.0491	1.0222	6.6291	1.0884	1.1846
Rice	3	1.3191	1.2058	1.5109	0.1670	0.0279
Rice - Woody	1	1.4085	1.4085	1.4085	0.0000	0.0000
SA	59	1.8717	1.0612	5.3224	0.8398	0.7052
SP	80	1.8097	1.0136	4.9262	0.8421	0.7092
SP - Wet	4	1.9586	1.2354	2.7472	0.8361	0.6991
SP - Woody	1	1.2790	1.2790	1.2790	0.0000	0.0000
Wetland	147	1.9361	1.0188	5.9871	1.0808	1.1682
Wetland - Woody	5	2.5301	1.2332	3.6896	1.1899	1.4159
Woody	2	2.9865	1.2866	4.6865	2.4041	5.7797
Unclassified	17	3.9530	1.0242	18.3200	4.3064	18.5451

Diversity Indices are calculated as $DI = TP / 2 (A\pi)^{1/2}$, based on McKinney 1996.

Table 9. Area summaries (in square meters) for habitat patches at Mad Island Marsh Preserve and Mad Island Wildlife Management Area.

VEGTYPE	COUNT	AVE_AREA	SUM_AREA	MIN_AREA	MAX_AREA	STDDEV_ARE	VAR_AREA
Coastal Prairie	9	281985	2537866	5578	1651510	525724	276386240976
Coastal Prairie - Wet	2	709346	1418692	489913	928779	310325	96301689561
Coastal Prairie - Woody	2	602877	1205754	98722	1107032	712983	508345086654
Coastal Prairie - Woody, Wet	1	352573	352573	352573	352573	0	0
Livestock Area	3	8598	25793	5515	11688	3086	9524709
Livestock area	1	34418	34418	34418	34418	0	0
Mixed Prairie	18	270124	4862231	37764	941304	270921	73398033937
Mixed Prairie - Wet	4	166655	666620	53991	241734	87880	7722818400
Mixed Prairie - Woody	7	221313	1549194	10110	965340	339305	115127576309
Old Field	1	54185	54185	54185	54185	0	0
Old Field - Weedy	1	282292	282292	282292	282292	0	0
Old Field - Woody	1	118265	118265	118265	118265	0	0
Residential	3	16611	49834	11526	21747	5111	26119286
Rice	5	1227345	6136726	212567	2280021	799126	638602774074
Salty Prairie	18	348771	6277870	5640	2016158	503917	253932283550
Salty Prairie - Wet	13	250648	3258421	13252	762310	219142	48023231217
Salty Prairie - Woody	5	201702	1008512	16942	401489	182877	33443956033
Salty Prairie - Woody, Wet	1	26006	26006	26006	26006	0	0
Wetland	12	1977356	23728268	72546	15479264	4355724	18972335329496
Wetland - Woody	3	234598	703795	91838	472126	207100	42890337277
Woody	3	115392	346176	25305	271876	136036	18505682935
TOTAL			54643490				

Table 10. Perimeter summaries (in meters) for habitat patches at Mad Island Marsh Preserve and Mad Island Wildlife Management Area.

VEGTYPE	COUNT	AVE_PERIME	SUM_PERIME	MIN_PERIME	MAX_PERIME	STDDEV_PER	VAR_PERIME
Coastal Prairie	9	2433	21898	356	10482	3150	9919424
Coastal Prairie - Wet	2	7866	15732	4696	11036	4483	20094985
Coastal Prairie - Woody	2	7828	15657	2677	12980	7286	53082612
Coastal Prairie - Woody, Wet	1	6923	6923	6923	6923	0	0
Livestock Area	3	385	1154	276	478	102	10346
Livestock area	1	881	881	881	881	0	0
Mixed Prairie	18	2547	45841	826	5192	1472	2166631
Mixed Prairie - Wet	4	2091	8364	916	3031	1026	1052975
Mixed Prairie - Woody	7	973	6810	0	5050	1853	3432753
Old Field	1	1075	1075	1075	1075	0	0
Old Field - Weedy	1	2244	2244	2244	2244	0	0
Old Field - Woody	1	2255	2255	2255	2255	0	0
Residential	3	544	1632	432	667	118	13855
Rice	5	4791	23955	2542	7083	1662	2763586
Salty Prairie	18	3111	56003	344	9189	2639	6963741
Salty Prairie - Wet	13	2640	34316	497	5531	1639	2684771
Salty Prairie - Woody	5	2395	11975	782	4516	1598	2554360
Salty Prairie - Woody, Wet	1	1193	1193	1193	1193	0	0
Wetland	12	7570	90838	1743	38549	10262	105315956
Wetland - Woody	3	3714	11141	1444	7389	3212	10318440
Woody	3	2505	7515	0	6890	3810	14519781

Table 11. Perimeter to area ratios for habitat patches at Mad Island Marsh Preserve and Mad Island Wildlife Management Area.

VEGTYPE	COUNT	AVE_P_A	MIN_P_A	MAX_P_A	STDDEV_P_A	VAR_P_A
Coastal Prairie	9	0.0225	0.006347	0.063793	0.0176	0.0003
Coastal Prairie - Wet	2	0.0107	0.009586	0.011882	0.0016	0.0000
Coastal Prairie - Woody	2	0.0194	0.011725	0.027113	0.0109	0.0001
Coastal Prairie - Woody, Wet	1	0.0196	0.019636	0.019636	0.0000	0.0000
Livestock Area	3	0.0458	0.040909	0.050106	0.0046	0.0000
Livestock area	1	0.0256	0.025609	0.025609	0.0000	0.0000
Mixed Prairie	18	0.0131	0.005368	0.024066	0.0051	0.0000
Mixed Prairie - Wet	4	0.0133	0.011072	0.016964	0.0026	0.0000
Mixed Prairie - Woody	7	0.0123	0.000000	0.058194	0.0219	0.0005
Old Field	1	0.0198	0.019841	0.019841	0.0000	0.0000
Old Field - Weedy	1	0.0079	0.007947	0.007947	0.0000	0.0000
Old Field - Woody	1	0.0191	0.019066	0.019066	0.0000	0.0000
Residential	3	0.0334	0.030661	0.037491	0.0036	0.0000
Rice	5	0.0056	0.003107	0.011958	0.0037	0.0000
Salty Prairie	18	0.0206	0.004232	0.060986	0.0148	0.0002
Salty Prairie - Wet	13	0.0157	0.004564	0.037503	0.0085	0.0001
Salty Prairie - Woody	5	0.0247	0.008800	0.064262	0.0233	0.0005
Salty Prairie - Woody, Wet	1	0.0459	0.045866	0.045866	0.0000	0.0000
Wetland	12	0.0146	0.002490	0.059698	0.0162	0.0003
Wetland - Woody	3	0.0170	0.010323	0.025134	0.0075	0.0001
Woody	3	0.0167	0.000000	0.025343	0.0145	0.0002

Table 12. Diversity indices for habitat patches at Mad Island Marsh Preserve and Mad Island Wildlife Management Area.

VEGTYPE	COUNT	AVE_DI	MIN_DI	MAX_DI	STDDEV_DI	VAR_DI
Coastal Prairie	9	1.4646	1.1280	2.3009	0.3434	0.1179
Coastal Prairie - Wet	2	2.5615	1.8927	3.2303	0.9458	0.8946
Coastal Prairie - Woody	2	2.9417	2.4031	3.4802	0.7616	0.5801
Coastal Prairie - Woody, Wet	1	3.2890	3.2890	3.2890	0.0000	0.0000
Livestock Area	3	1.1712	1.0497	1.2476	0.1064	0.0113
Livestock area	1	1.3402	1.3402	1.3402	0.0000	0.0000
Mixed Prairie	18	1.4778	1.1059	2.2477	0.3296	0.1086
Mixed Prairie - Wet	4	1.4282	1.1119	1.7796	0.3355	0.1126
Mixed Prairie - Woody	7	0.6505	0.0000	1.6506	0.8140	0.6626
Old Field	1	1.3029	1.3029	1.3029	0.0000	0.0000
Old Field - Weedy	1	1.1912	1.1912	1.1912	0.0000	0.0000
Old Field - Woody	1	1.8496	1.8496	1.8496	0.0000	0.0000
Residential	3	1.1932	1.1354	1.2755	0.0732	0.0054
Rice	5	1.3269	1.1569	1.5552	0.1492	0.0223
Salty Prairie	18	1.7121	1.1173	2.9006	0.5159	0.2662
Salty Prairie - Wet	13	1.5870	1.1240	2.5921	0.4281	0.1833
Salty Prairie - Woody	5	1.7313	1.3022	2.3595	0.4698	0.2207
Salty Prairie - Woody, Wet	1	2.0865	2.0865	2.0865	0.0000	0.0000
Wetland	12	2.0741	1.1325	5.0718	1.0559	1.1148
Wetland - Woody	3	2.0904	1.0890	3.0336	0.9736	0.9479
Woody	3	1.6121	0.0000	3.7277	1.9142	3.6641

Diversity Indices are calculated as $DI = TP / (A\pi)^{1/2}$, based on McKinney 1996.