BREEDING AND NESTING BEHAVIOR AND HABITAT OF THE RED-BILLED PIGEON (*COLUMBA FLAVIROSTRIS*) ALONG THE RIO GRANDE RIVER IN TEXAS

THESIS

Presented to the Graduate Council of
Southwest Texas State University
In Partial Fulfillment of
The Requirements

For the Degree

Master of Science

By

Jeffrey B. Breeden, B. S.

San Marcos, Texas
May 2002

ACKNOWLEDGMENTS

Several individuals were essential in making this study possible and their help is greatly appreciated. My major advisor, Dr. Baccus, always kept me on the right track throughout the study. The other members of my committee, Dr. Simpson and Dr. Manning, were there to give me advice when needed. Dr. Ott provided statistical advice. Jack Eitniear with the Center for the Study of Tropical Birds Inc. provided the idea for this study and much of the equipment and information. Gary Waggerman and Steve Benn with Texas Parks and Wildlife Department provided an internship opportunity which helped fund this study and much useful information about Red-billed Pigeons and historical records. Dr. Brush took me on a canoe trip through the study area prior to the study to point out areas where Red-billed Pigeons were found. The Valley Land Fund and Gale and Pat Dewind provided a location for basing my research. Calvin Snyder, manager of Falcon State Park, also provided a place to camp near the study area. Michael Evans with the International Boundary and Water Commission allowed me access to the spillway area of Falcon Dam. Jose Perez with SMTEI helped throughout the summer. A classmate, Kenneth Pruitt, helped me collect most of the vegetation information. I thank all those that helped me during this study.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT.)

LIST OF TABLES

Page

LIST OF FIGURES

Page

ABSTRACT

BREEDING AND NESTING BEHAVIOR AND HABITAT OF
THE RED-BILLED PIGEON (*COLUMBA FLAVIROSTRIS*) ALONG THE
RIO GRANDE RIVER IN TEXAS

By

Jeffrey B. Breeden, B.S.
Southwest Texas State University
May 2002

SUPERVISING PROFESSOR: John T. Baccus, Ph. D.

The Red-billed Pigeon (*Columba flavirostris*) is a declining species in Texas along the Rio Grande River. The main cause for decline in Texas is probably habitat loss due to agricultural and urban expansion. While once common throughout the lower Rio Grande River Valley, it is now restricted to a short section of the Rio Grande River immediately below Falcon Dam where mature riparian vegetation still exists. Little is known about the ecology of this species throughout its range. The purposes of this study were to address conservations strategies to prevent further decline of Red-billed Pigeons along the Rio Grande River, to determine the nesting cycle with corresponding breeding and nesting behavior, and to describe preferred habitat along the Rio Grande River. Courtship and pair formation behaviors were observed during the 2000 and 2001 breeding seasons. Behaviors and vocalizations observed were similar to behaviors described for other pigeon species. Twelve instances of nesting activity were observed during this study. The mean height of nests in trees was 6.72 m. The mean height of trees with nests was 10.48 m. Nests occurred in Texas sugarberry (*Celtis laevigata*), black willow (*Salix nigra*), Mexican ash (*Fraxinus berlandieriana*) and retama (*Parkinsonia aculeata*) trees. Nest construction was observed between the hours of 0800 and 1145 and took three to four days to complete. Red-billed Pigeons on average delivered one twig to the nest every 6.83 minutes. The line intercept method was used to analyze the breeding habitat and compare areas with Red-billed Pigeons present or absent. The nested ANOVA test was used to test the comparisons. In understory trees below 9.5 m tall, the relative density ($F = 15.01$, $p = 0.02$) and relative frequency ($F = 7.37$, $p = 0.05$) of retama trees was significant in non-pigeon habitat than Red-billed Pigeon habitat. In overstory trees above 9.5 m tall, relative density ($F = 40.66$, $p = 0.00$), relative dominance ($F = 19.60$, $p = 0.01$), and relative frequency ($F = 23.83$, $p = 0.01$) of the Texas sugarberry/Mexican ash component were significant in Red-billed Pigeon habitat. Red-billed Pigeons prefer a breeding habitat that contains tall, mature riparian trees. The future of this species in Texas depends on the maintenance of this riparian vegetation.

INTRODUCTION

The Red-billed Pigeon (*Columba flavirostris*) is a rare and declining species along the Rio Grande River in Texas. Unfortunately, there is a paucity of information on the ecology and habitat requirements of this species in Texas to assist in its conservation. Oberholser (1974) described the Red-billed Pigeon as a large, uniformly dark pigeon with a small, whitish-tipped, red bill, and swift, direct flight. The markings of the plumage include brownish forequarters, rich brown lesser wing-coverts, grayish brown back and scapulars, slaty hind-quarters, primaries, and secondaries. *Columba flavirostris* has an average body length of 37 cm, wingspan of 61 cm, and a weight of 315 g (Sibley 2000).

The distribution of the Red-billed Pigeon extends from extreme southern Texas along the Rio Grande River, south through Mexico and Central America to Costa Rica. Red-billed Pigeons inhabit woodlands or other open areas with patches of woodland or clumps of trees near water in arid or semi-arid environments (Goodwin 1983). Oberholser (1974) reported that in the Rio Grande River delta, Red-billed Pigeons commonly sought dense canopies and tall trees of Montezuma baldcypress (*Taxodium mucronatum*), tepeguaje (*Lucaena pulverulenta*), Texas ebony (*Pithecellobium flexicaule*), mesquite (*Prosopsis glandulosa*), Mexican ash (*Fraxinus berlandieriana*), hackberries (*Celtis*), elms (*Ulmus*), and black willow (*Salix nigra*). Preferred foods of the Red-billed Pigeon include small berries, fruits and acorns (Oberholser 1974, Goodwin 1983). This primarily arboreal species rarely visits the ground (Oberholser 1974).

The historical range of the Red-billed Pigeon in Texas extended from Cameron County west along the Rio Grande River through Hidalgo and Starr counties, then northwestward to Webb County and north along the coast from the Rio Grande River delta to Norias in Kenedy County (Fig. 1) (Oberholser 1974, unpublished field notes of a Texas Game, Fish and Oyster Commission employee 1945).

Prior to extensive settlement by Europeans, periodic flooding of the Rio Grande River delta maintained fertile soils and habitat for Red-billed Pigeons throughout the Rio Grande River Valley (Saunders 1976). In addition, habitat for the species existed at several lakes and swamps with large, dense tracts of riparian plants that resembled a jungle south of a line from Raymondville to Mission (Longoria 1997). Traveling through the Lower Rio Grande River Valley was difficult because of thick vegetation or areas often inundated with water (Longoria 1997). In his travels through the area, William Emory in 1850 commented on the jungle-like growth of the vegetation (Gehlbach 1993).

During the past century, the number of Red-billed Pigeons in the United States declined sharply (Oberholser 1974). Oberholser (1974) noted that 1920 marked the beginning of serious habitat destruction in the Rio Grande River delta. By 1945, ninety percent of the species' breeding trees and shrubs had been removed for agricultural use (Oberholser 1974). Other records from the 1940s indicated a noticeable decline in the number of pigeons during a 25-year period (unpublished field notes of a Texas Game, Fish and Oyster Commission employee 1941). In the 1940s, Red-billed Pigeon flocks of 25 to 500 birds moved over the Rio Grande River Valley and fed in the agricultural fields after the nesting season (unpublished field notes of a Texas Game, Fish and Oyster Commission employee 1945).

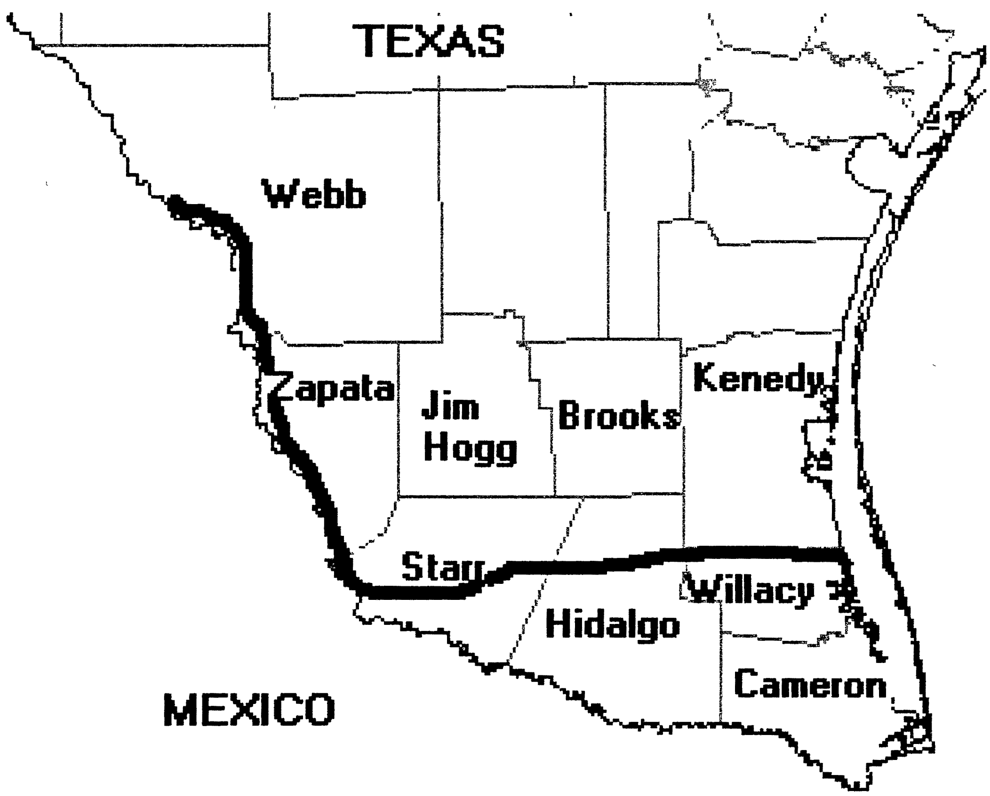

Figure 1. Map of South Texas showing the historical distribution of the Red-billed Pigeon in Texas. Red-billed Pigeons were most numerous in the Lower Rio Grande River Valley throughout the counties of Cameron, Willacy, Hidalgo, most of Starr and along the river northwest through Zapata and Webb counties.

Field records indicated that Red-billed Pigeons were most abundant in Cameron and Hidalgo counties of the Rio Grande River Valley (Oberholser 1974). After a devastating freeze in 1951, farmers switched from growing citrus fruit to cotton as the primary agriculture crop (Oberholser 1974). Red-billed Pigeons became confined to the only remaining riparian vegetation along the Rio Grande River in the 1940s (Unpublished field notes of a Texas Game, Fish and Oyster Commission employee 1941). In 1953 at Santa Ana National Wildlife Refuge, 150 pairs of Red-billed Pigeons were seen, 70 birds were seen in 1960, three nests were found in 1963, and by 1969 only two to three Red-billed Pigeons occurred on the refuge (Oberholser 1974). Although the distribution of this species in the Rio Grande River Valley once extended from Brownsville upriver through Webb County, the primary distribution now seems restricted to areas of the Rio Grande River upstream from Bentsen Rio Grande River Valley State Park to Falcon Reservoir (Brush 1998). Recent sightings in Zapata (Eitniear personal communication) and Webb counties (Woodin personal communication), indicate small peripheral populations still exist. However, it is estimated that less than 50 pairs occur in Texas (Eitniear unpublished data).

The Rio Grande River Valley is one of the most intensively farmed areas of the United States. The clearing of native brush on land for agricultural use caused concern about the loss of wildlife habitat as early as 1940 (unpublished field notes of a Texas Game, Fish and Oyster Commission employee 1941). Jahrsdoerfer and Leslie (1988) estimated that during the past century, over 90% of the native vegetation of the Rio Grande River Valley was destroyed by agricultural use and increasing urban expansion.

Small, mesquite tree-choked tracts, usually less than 40 ha in size remain in areas that were once heavily wooded (Gehlbach 1993).

In 1953, the construction of Falcon Dam was completed. A purpose of the reservoir was control of the periodic flooding, which was essential to maintaining the native riparian habitat (Saunders 1976). The reservoir curtailed the flow of so much water that the water table of the Rio Grande River delta dropped, killing most of the large native trees along the river (Oberholser 1974). Near Santa Ana National Wildlife Refuge, a stand of sugarberry trees died within 10 years after Falcon Dam was completed (Gehlbach 1993).

Red-billed Pigeons are absent from habitat along the Rio Grande River during winter, but the exact wintering area for these birds remains unknown. Jack Eitniear (personal communication) suggested that the Red-billed Pigeons occuring in Texas during the summer probably winter in the mountains of northern Mexico. Oberholser (1974) reported sweeping flocks of Red-billed Pigeons near Padilla and Xilitla, San Luis Potosi in the Sierra Madre Oriental in the 1950s.

Currently, the largest concentrations of Red-billed Pigeons occupy a 30-km stretch of the Rio Grande River from Falcon Dam in western Starr County downstream to Roma (Fig. 2). This area has the only remaining stand of thick, undisturbed riparian vegetation.

The purposes of this study were to address conservation strategies to prevent further decline of Red-billed Pigeons along the Rio Grande River, to determine the nesting cycle with corresponding breeding and nesting behavior, and to describe preferred habitat along the Rio Grande River.

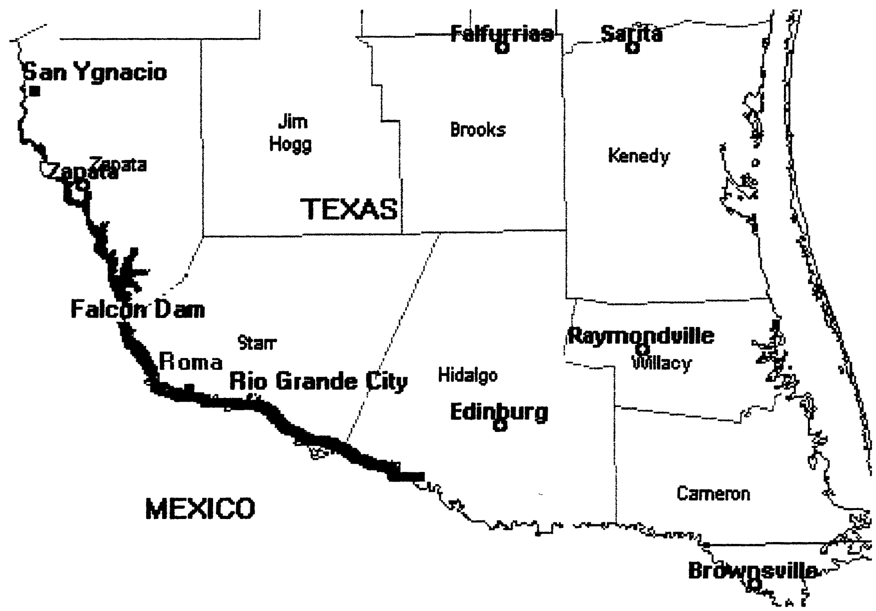

Figure 2. Map of South Texas showing the primary distribution of the Red-billed Pigeon in Texas. The largest known concentrations of Red-billed Pigeons are along a 30-km section of the Rio Grande River between Falcon Dam and Roma. They are occasionally seen downstream to Hidalgo County. There have been recent sightings in Webb and Zapata counties.

STUDY AREA

This study was conducted along a 30-km section of the Rio Grande River between Falcon Dam and Fronton, Texas. In this area, the Falcon Woodlands comprises the largest undisturbed remnant of tropical thorn woodland left in the United States (Jahrsdoerfer and Leslie 1988). Common trees in the area are black willow, Mexican ash, Texas sugarberry (*Celtis laevigata*), and retama (*Parkinsonia aculeata*) (Jahrsdoerfer and Leslie 1988). The only known grove of Montezuma bald cypress in the United States occurs here. Small islands along this stretch of the river have the same dense riparian habitat.

This area was chosen for study because the largest known concentrations of Red-billed Pigeons in Texas occur along this section of the Rio Grande River. Butterwick and Strong (1976) described this area as having a gently rolling topography dissected by numerous arroyos that converge in the Rio Grande River. The vegetation zone consists of two components. The floodplain supports riparian vegetation that attains a considerable height, and the land above the floodplain supports xerophytic thorny shrubs. (Butterwick and Strong 1976). There are three main plant associations; the Mexican ash-black willow association along the banks of the Rio Grande River, mesquital-granjenal association on the high alluvial terraces, and chaparral association throughout the mesa area (Butterwick and Strong 1976, Jahrsdoerfer and Leslie 1988). The Mexican ash-black willow association along the riverbank supports a riparian community of black willow, Mexican ash, and Texas sugarberry trees as the dominant structural components of the community. The mesquital-granjenal association occurs in an intermediate location between the floodplain and upper mesas and is characterized by sandy silt of alluvial origin (Butterwick and Strong 1976). Honey mesquite, spiny hackberry (*Celtis pallida*), retama, Texas sugarberry, and huisache (*Acacia smalii*) trees compose the community (Butterwick and Strong 1976). There is a thick understory of thorny shrubs in this association (Butterwick and Strong 1976). I focused my study on two areas of this section of the Rio Grande River in the Mexican ash-black willow and mesquital-granjenal associations. These were located at the Spillway of Falcon Dam and near the city of Salineño (Fig. 3).

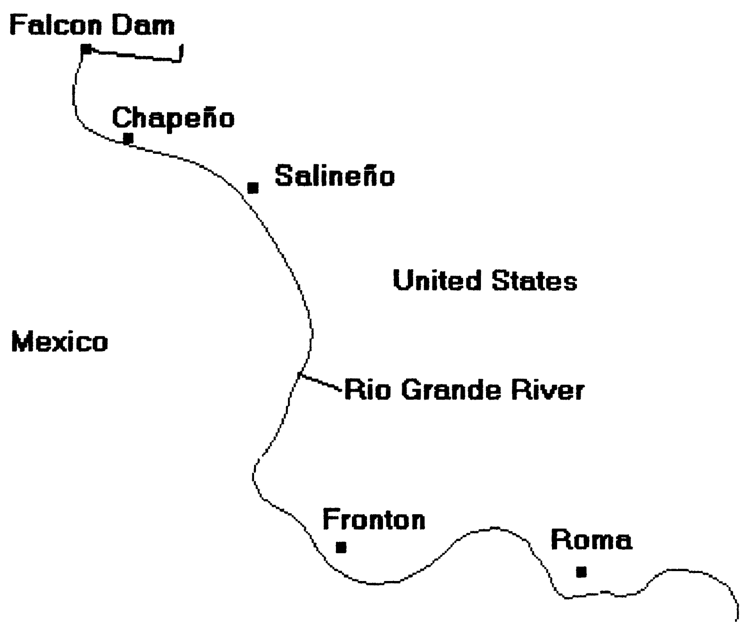

Figure 3. Map of the section of the Rio Grande River between Falcon Dam and Fronton where this study was conducted. This area has the largest known concentrations of Red-billed Pigeons in Texas. Salineño is approximately 9-km downstream from Falcon Dam. Roma is approximately 30-km downstream from Falcon Dam.

BREEDING BEHAVIOR

Introduction

Courtship and pair formation behaviors of Red-billed Pigeons during breeding are poorly understood. *Columba flavirostris* is present in Texas from late February through late September. Throughout spring and early summer, they are seen as singles or pairs except at feeding or watering areas (Oberholser 1974). At this time, they call from perches on tall, bare limbs above the canopy (DeGraaf and Rappole 1995) and are easily seen and heard. Adult Red-billed Pigeons begin flocking in September with fledglings and disappear later during the month (Eitniear unpublished data). In southern areas of its range, *C. flavirostris* forms large flocks during winter (Oberholser 1974).

Some basic behaviors observed throughout the range of the Red-billed Pigeon include their characteristic coo calling from tops of trees and circle display flights (Skutch 1964, Leopold 1972, Oberholser 1974, and DeGraaf and Rappole 1995). Johnston and Janiga (1995) suggested that all columbids use a similar suite of behavioral displays during courtship and pair formation. Breeding behaviors of other species of pigeons, such as Rock Doves or feral pigeons (*Columba livia*), Band-tailed Pigeons (*Columba fasciata*) and White-crowned Pigeons (*Columba leucocephala*) were used in this study as models in describing behaviors of the Red-billed Pigeon (Peeters 1962, Jeffrey 1977, Wiley and Wiley 1979, Braun 1994, and Johnston and Janiga 1995). To assess the status and describe the breeding behavior of the Red-billed Pigeon in the Rio Grande River Valley, Red-billed Pigeons were observed during spring and summer for two years. Observations of Red-billed Pigeons were made from a small boat or canoe in the river. Most searching and observing of Red-billed Pigeons took place during the morning from sunrise until noon in areas where they were regularly seen. Searching consisted of patrolling up and down the river until a Red-billed Pigeon was spotted. Its activities were observed and noted while it remained in view. Most often, daily observations alternated between the spillway of Falcon Dam and the Salineño area.

Courtship and Pair Formation

Sightings of small flocks of Red-billed Pigeons at study sites in the Rio Grande River Valley first occurred in early February. Birds in these flocks produced few vocalizations. By middle March, cooing was heard on a regular basis. From March into early June, most evidence of pair formation occurred. By June, the rate of cooing slowed and nesting activity increased and continued through July. By early August, cooing had almost completely stopped, and Red-billed Pigeons were seen in small scattered flocks again. Sightings steadily declined throughout the month. By September, no Red-billed Pigeons were observed in the study area. However in mid November 2001, unverified reports by the Texas Rare Bird Alert stated that a few Red-billed Pigeons had been seen in the area.

During this study, I observed courtship displays of Red-billed Pigeons similar to those described in the literature as common among other species of Columbidae. These behaviors were advertisement cooing, circle display flights, bowing courtship displays, allopreening, chasing, and bill wiping. I also heard a variety of vocalizations. Most calls by Red-billed Pigeons came from within the dense canopy in the riparian zone except for advertisement calls from prominent perches above the canopy. Because of the small number of Red-billed Pigeons in the area, instances of courtship and pair formation were not easily observed.

The most common behavior observed during this study was advertisement. Red-billed Pigeons vocalized an advertisement call from an exposed leafless branch at the top of the tallest trees where the bird could be easily seen and heard. This was a loud and commonly heard call in areas with Red-billed Pigeons.

Often while cooing, Red-billed Pigeons would launch into a circle display flight. This display flight was observed during spring and early summer. It involved a slow flight with little wing flapping. The bird held its wings in a high V over the back, alternating gliding and slow flapping to maintain altitude above the canopy. Occasionally, a clapping sound occurred as the pigeon left its perch to engage in this display. The pigeon crossed approximately 30 to 50 m of open water before returning to the original perch, where it resumed cooing. On three occasions during early spring, I observed the behavior of a pair of Red-billed Pigeons when this display flight was performed. The vocalizing individual left the tree, performed the circle display, and returned to the same spot. When back together, the pair autopreened with no vocalizations. On all three occasions, both pigeons flew away without further contact. On two other occasions, the displaying pigeon, after landing, was joined by another pigeon. Both flew off moments later.

I observed displays or direct contact between Red-billed Pigeons that were indicative of pair formation. Some displays involved only gestures. Other interactions resulted in physical contact. A chasing behavior observed once in June and twice in early July involved a pigeon hopping from branch to branch in a tree, while being chased by another as if attempting to mate. Each time this behavior resulted in the two pigeons sitting close to each other autopreening momentarily, and then flying away together. On one occasion, while observing a Red-billed Pigeon on a perch, another pigeon landed in the top of the same tree and began cooing. It then flew down to the location of the original bird and began chasing it from branch to branch until they both disappeared together into the dense canopy.

Direct physical contact between Red-billed Pigeon pairs included bill wiping, allopreening, and bowing courtship display sessions. All of these interactions ended with both birds flying into the dense canopy. On one instance in early April, I observed a Red-billed Pigeon preening in a tree. Another Red-billed Pigeon flew from below and landed next to the original, and they bill wiped for a brief period. They moved apart for about two minutes and autopreened, then moved together again and resumed bill wiping. The first Red-billed pigeon jumped to a lower branch and the other immediately followed. Then both flew off and disappeared into the dense foliage together. I observed this behavior again in late July. Two Red-billed Pigeons landed in a tree, bill wiped for a brief period, and autopreened.

I observed the bowing courtship display on two occasions. It involved two Red-billed Pigeons close together facing each other. The display began with one bird bobbing its body and head up and down while vocalizing. On one occasion in late May, a Red-billed Pigeon landed next to another, bowed its head twice, and began cooing. After no apparent response from the other, it flew across the river, alighted in a tree and began cooing. On another occasion, two Red-billed Pigeons engaged in a bowing session that was followed by a brief period of allopreening. They flew away at different times. On another occasion in early July, two Red-billed Pigeons in the top of a tree allopreened for approximately 30 seconds, and then autopreened for the next five minutes. One flew away and left the other. Then the other flew away a few minutes later. Two other incidences observed in early August seemed to be courtship behavior. In an incidence in late July, a pair of Red-billed Pigeons flew into the lower canopy of a tree, and a brief period of bill wiping followed. One then flew away. The other cooed once and flew away a minute later.

Similar courtship and pair formation behaviors as observed in Red-billed Pigeons have been described in other pigeon species. Johnston and Janiga (1995) described behaviors of feral pigeons and stated that species of Columbidae use a similar suite of behavioral displays to bring about pairing of the sexes. In White-crowned Pigeons, pair formation began with the male coo calling from an advertisement perch and performing display flights (Wiley and Wiley 1979). When a female landed in a male's territory, the male moved to her, performed the courtship display and followed the female if she flew. A session of allopreening suggested acceptance of the male by the female (Wiley and Wiley 1979). The Band-tailed Pigeon also gave its advertisement coo from an exposed perch (Peeters 1962). In feral pigeons, Band-tailed Pigeons and White-crowned Pigeons, males attracted females by coo calls, performed the courtship display, and if the female seemed accepting, allopreening and bill wiping commenced (Peeters 1962, Wiley and Wiley 1979 and Johnston and Janiga 1995).

Johnston and Janiga (1995) described display flights in feral pigeons as a postcopulatory display. The pigeons moved apart and autopreened after copulation, and then the male launched into a display flight circling 30 to 60 m. Wiley and Wiley (1979) described a similar behavior in White-crowned Pigeons. White-crowned Pigeons flew the display flight during pair formation, courtship, nest building, and early incubation. Display flights usually took place after courtship bouts and after territorial conflicts and before courtship displays. Coo calling often preceded or followed the flights (Wiley and Wiley 1979). In this study, copulation by Red-billed Pigeons was never observed. The display flight was seen most frequently in spring and early summer. Peeters (1962) described the pair formation sequence in Band-tailed Pigeons. It started with the male cooing from an advertisement perch to attract a female. When a female arrived, the male pigeon alternated between courtship displays and circle display flights. The female then joined the male, they bill wiped, and eventually copulated. Peeters (1962) also suggested that the display flight was not just for courtship but also signified a nesting territory.

From behavioral observations made in this study and behaviors documented in the literature for other species of pigeons, the pair formation sequence of the Red-billed Pigeon can be inferred. The sequence starts with the male Red-billed Pigeon coo calling from an open perch on top of the canopy usually on a leafless branch, where he can be easily seen and heard. With a female present, the male flies the circle display flight and performs chasing behavior to determine if the other bird is an accepting female. When it is apparent that the female is accepting, pair bonding begins. With pairing established, the courtship bow-coo display occurs from within the canopy, which explains why this behavior was seldom seen. Allopreening, bill wiping, and eventually copulation follow. Nest building then begins.

I observed that Red-billed Pigeons are territorial when nesting. The circle display flight is probably used to define the territory as well as courtship behavior. During courtship, the male's circle-display flight probably indicates an established nesting territory to the female.

Vocalizations

I identified four different vocalizations made by Red-billed Pigeons. The standard coo call was the most common vocalization heard during the study. The call consisted of a "Whoooooaoooo, hu-cu'c'coo, hu-cu'c'coo, hu-cu'c'coo". The second part of the call is usually repeated two to five times. This call was heard from early spring throughout summer. It seemed most frequent during May and early June. I concluded that this was the display call. When vocalizing this call, the pigeon was easily seen sitting at the top of the tallest perch in the area, usually from a leafless limb in the open.

Another vocalization emitted by Red-billed Pigeons was a two note "Whoao-Whoao". This call was heard in the dense canopy. On one occasion, this call was emitted by a pigeon sitting on a nest. This call is either a nest call or a distress call. My presence in the area elicited this call, possibly to alert the mate to defend the territory.

Another vocalization made by the Red-billed Pigeon was a growl consisting of a "rrrrrwhoa, rrrrrwhoa". This call came from birds within the dense canopy. On one occasion while walking through the riparian zone, a pigeon flew into a tree directly above me, and then immediately flew to another tree and began a frequent growling. It then began alternating growls with a slower version of the coo call. At the same time, another pigeon flew to the area and began hopping from tree to tree in a circle around me. Wiley and Wiley (1979) observed White-crowned Pigeons growling in association with nesting activity, especially after an intruder had been driven away. It seems probable that the growl call of the Red-billed Pigeon was associated with defense of the nesting territory because the pigeon flew around me in a circle growling and landed briefly in several trees as if trying to scare or distract me from the area.

The other vocalization made by the Red-billed Pigeon was between two birds during an apparent courtship display. This vocalization was heard on two occasions during early August. While two pigeons were facing each other, one would bob its head up and down while calling "ooWOOW-ooWOOW". This call appeared to be part of the male courtship display.

NESTING ACTIVITY AND BEHAVIOR

Introduction

The Red-billed Pigeon nest is a frail platform of sticks, grass, and roots lined with fine weed stems, grass, and rootlets (Oberholser 1974). Females lay one pure white egg, very rarely two (Oberholser 1974). During 1993 to 1996, seven nests were discovered from May through August on small islands on a 20-km section of the Rio Grande River between Chapeño, located approximately 4-km downstream from Falcon Dam, and Fronton, which is located approximately 30-km downstream from Falcon Dam (Brush 1998).

These nests were located at an average height of 6.5 m in trees along the river (Brush 1998). As with other columbid species, Red-billed Pigeons construct their nests by the male bringing one twig at a time to the female building the nest (Eitniear unpublished data). In this study, the small number of Red-billed Pigeons in the area and location of nests within the dense canopy made finding nests extremely difficult.

Nests were found opportunistically while searching for pigeons. When a pigeon was observed carrying nesting material, I followed it and attempted to locate the nest. When a nest was located, I observed activities from a distance and recorded all behaviors.

Observed Nesting Activity in 2000 and 2001

During this study, 12 instances of nesting activity were observed from April through early August. Seven nests were positively identified. Three nests were located in Texas sugarberry trees, one in a retama tree, two in black willow trees, and one in a Mexican ash tree (Table 1).

The mean height of trees with a nest was 10.48 m (N = 4, range 7.1 to 13.5 m). The mean height of nests in trees was 6.72 m (N = 5, range 3.1 to 11.5 m). The first nest was found on 9 April 2000 in a Texas sugarberry tree. This tree was located on the Mexico bank of the river in the Salineño area. Two Red-billed Pigeons were seen in the nest area, but a check of the nest again on 7 May indicated no activity at the nest. The nest had either been lost to predation or the young had fledged. On 29 May, a Red-billed Pigeon was observed carrying a twig to a nest in a retama tree. I returned to the nest one week later after a strong storm and the nest was gone. On 25 June, I observed a pigeon carrying twigs across Island 2. On 3 July, a pigeon was observed collecting twigs in a Texas sugarberry tree on the U. S. bank near Salineño. In both of these instances, I could not locate the nest.

In the 2001 breeding season, the first evidence of nesting activity was observed on 14 June. A pigeon was observed on a nest in a black willow tree in a cove near the mouth of the spillway. I checked the nest seven times through 29 June. Each time, it was occupied by a Red-billed Pigeon that did not move when I approached the tree. On 2 July, I found the nest unoccupied. Also on 14 June, a Red-billed Pigeon was seen delivering a twig to a nest in a Texas sugarberry tree. I observed nest construction on 15 and 18 June. A Red-billed Pigeon was observed sitting on the nest on 26 June. Two days later, I checked the nest and it was unoccupied. On 16 June, I observed a Red-billed Pigeon delivering twigs to a Mexican ash tree on an island near Salineño. The nest could not be marked and it was not found again on subsequent days.

Table 1. Tree species used for nesting by Red-billed Pigeons in the vicinity of Falcon Dam and Salineño during 2000 and 2001. Data include nests and signs of nesting activity, such as observing pigeons carrying twigs, date, species of nest tree, tree height, and height location of the nest in the tree.

Date	Tree Species	Tree height (m)	Nest height (m)
9 April 2000	Texas sugarberry	7.10	5.90
29 May 2000	Retama		3.10
25 June 2000			
3 July 2000			
14 June 2001	Black willow	10.50	8.90
14 June 2001	Texas sugarberry	13.50	11.50
16 June 2001	Mexican ash		
18 June 2001			
20 June 2001			
2 July 2001			
4 July 2001	Black willow	10.82	4.18
25 July 2001	Texas sugarberry		

On 18 and 20 June, I saw a Red-billed Pigeon in the cove of the spillway pick a twig from a black willow tree and fly upstream. On 2 July, a bird watcher reported to me the observation of a Red-billed Pigeon carrying a twig on the river bank near the spillway of Falcon Dam. On 4 July, a Red-billed Pigeon was observed delivering twigs to a nest in a black willow tree. On 9 July, a Red-billed Pigeon was observed on the nest. The nest was checked on four other days. On 7 August, two Red-billed Pigeons flushed from the nest and were not seen again. One was a fledgling and the other was either an adult or a rare second fledgling. They both fluttered down into reeds before I could clearly distinguish the age of the other bird. The total time from the first observation of nest building to fledging was 34 days. The last observed nesting in 2001 was on 25 July. A pigeon was observed upstream from the Spillway area of Falcon Dam carrying twigs from the Mexico bank to a Texas sugarberry tree on the U. S. bank. I did not locate this nest.

Discussion

Brush (1998) provided the only other documented records of recent nesting activity by the Red-billed Pigeon in the Rio Grande River Valley. In his study, he listed the date nesting activities were observed, the tree species, and height of the nest in the tree (Table 2).

A scenario of the nesting season for the Red-billed Pigeon in the Rio Grande River Valley can be developed by examining the data collected in this study and previous records by Brush (1998). Nesting of the Red-billed Pigeon in the Rio Grande River Valley starts in April and extends into August (N = 21) with peak nesting in June.

Table 2. Nesting activity by Red-billed Pigeons on the Rio Grande River from 1993 to 1996. Data include the date of nesting activity, tree species, and height of the nest in the tree (Brush 1998).

Date	Tree Species	Nest height (m)
9 May 1996	Mexican Ash	10.00
8 June 1996	Mexican Ash	9.00
8 June 1996	Mexican Ash	9.00
10 June 1995	Mexican Ash	11.00
27 June 1996	Texas sugarberry	7.00
9 July 1994	Retama	5.00
July 1993		
7 August 1993	Retama	3.00
20 August 1994	Mexican Ash	3.00
Summer 93	black willow	4.00
Summer 93	black willow	4.50

Ten (47%) observations of nesting occurred in this month. Six (28.6%) observations of nesting occurred in July. By pooling the nest tree and nest height data for this study with Brush's (1998) data, the mean height of all documented nests was 6.6 m (N = 15, range 3 to 11.5 m). In the breeding habitat, the overstory mean canopy height was 14 m with a minimum height of 9.5 m. It appears that Red-billed Pigeons prefer to nest in the lower part of the nest tree canopy. All nests were located within the dense canopy except for one that was located in the open on an un-obscured limb of a black willow tree. No nests were recovered because of their height, location, and difficulty to obtain the nest.

Nest Construction

All observations of nest construction occurred between 0830 and 1145 hr. On one occasion, I observed a Red-billed Pigeon collecting twigs from a Texas sugarberry tree. On all other occasions, Red-billed Pigeons collected twigs from black willow trees. Red-billed Pigeons seemed to discriminate among twigs. They tugged at several leafless twigs until pulling one free. On a few occasions, after breaking a twig free, they released it, as if, it was not suitable and continued tugging at more twigs. They carried one twig at a time to the nest. When nest building, one individual remained at the nest and constructed, while the other collected twigs. When a Red-billed Pigeon returned with a twig, it landed on an outside limb, hopped over to the nest, laid the twig in front of its mate, and immediately left to continue collecting. The distance a Red-billed Pigeon flew in gathering nesting material was usually 10 to 30 m from the nest. On one occasion, a Red-billed Pigeon consistently flew across the river from the United States side to the Mexico side to collect twigs. In all of my observations, Red-billed Pigeons seemed to visit the same tree each time to gather twigs. Their return flight to the nest always seemed to be at a different angle than their departure flight. The whole flight from the nest to collecting tree and back to the nest formed a circle. The mate that remained at the nest could be seen moving around on the nest presumably placing twigs.

On a few occasions when I entered the area of nest building, both Red-billed Pigeons would be perched together away from the nest. I observed quietly for a short time, and they resumed nest building. When nest building was taking place, Red-billed Pigeons seemed to have no concerns with my presence. The mate carrying a twig would often fly within 3 m directly overhead.

Red-billed Pigeons displayed territorial behavior with respect to their nest tree and twig collecting tree. Other Red-billed Pigeons in the area received antagonistic behavior, while other species were tolerated. On one occasion, a Red-billed Pigeon making collecting trips flew to another tree to rest and preen. Another Red-billed Pigeon flew to and lit on the twig collecting tree. The resident Red-billed Pigeon immediately flew to the intruder and drove it away by attacking its back and flapping it hard with its wings. Immediately after the intruder left the area, twig collection resumed. On another occasion at a different nest, a Red-billed Pigeon returned to a nest with a twig, when another Red-billed Pigeon landed near the nest. The resident Red-billed Pigeon immediately dropped the twig in mid-flight and drove off the intruder in the same manner as in the previous incident. It then immediately resumed the collection of twigs.

During another occasion of nest building, a Red-billed Pigeon made four trips to a nest with twigs from 0945 to 1000 hr. I remained in the area until 1030 hr and saw no signs of a continuation of collecting trips. The next day, I arrived at the area at 0840 hr and saw a Red-billed Pigeon picking at twigs in the same tree. It collected twigs intermittently until 0907 hr. In 42 minutes of observation, the Red-billed Pigeon took five twigs from the collecting tree for an average of 8.4 minutes for each twig delivered.

I observed nesting activities by a Red-billed Pigeon on 14 June 2001 from 1044 hr until 1132 hr. The bird collected from a black willow tree approximately 30 m from the nest. During this time, the Red-billed Pigeon delivered eight twigs to the nest. The next day, I observed nest building activity at the same nest from 0926 hr until 1140 hr. During this time, the Red-billed Pigeon delivered 25 twigs from the same black willow tree as on the previous day. At this nest, I observed nest building for 182 minutes. During this time, the Red-billed Pigeon delivered 33 twigs to the nest, or one twig per 5.52 minutes.

On 16 June 2001, I observed nest building activity at 0950 hr. Between 1009 and 1115 hr, the pigeon delivered 10 twigs to the nest from a black willow tree that was approximately 20 m from the nest. At this nest, I observed nest building for 66 minutes. One twig was delivered to the nest every 6.6 minutes. The mean twig delivery time for these three incidences of nest construction was 6.83 minutes (S. E. = 0.845) per twig delivered.

Discussion

In Band-tailed Pigeons, both sexes participate in nest construction, but the female does most of the twig placement (Braun 1994). Nest building takes between three to six days (Peeters 1962). There are indications that Band-tailed Pigeons may have two nestings per year (Braun 1994). The clutch size of the Band-tailed Pigeon consists of a single egg most of the time with two eggs 8% of the time (Braun 1994). Incubation in the Band-tailed Pigeon is 19 to 20 days. Fledging the young takes 20 to 28 days. The total nesting cycle takes 40 to 49 days (Braun 1994). In the Band-tailed Pigeon, the female occupied the nest before 1000 hr and after 1600 hr with the male on the nest between 1000 and 1600 hr (Braun 1994). In 111 Red-billed Pigeon nests observed in Mexico and Texas, the clutch size was a single egg 91% of the time with two eggs 9% of the time (Eitniear unpublished data). This is similar to the clutch size of the Band-tailed Pigeon.

The greatest activity of nest building in White-crowned Pigeons occurred between 0830 and 1000 hr. Male White-crowned Pigeons usually gathered twigs close to the nest at an average distance of 33 to 54 m from the nest. Frequently, twig gathering areas were defended against intruding pigeons. All twigs were taken from trees. Occasionally after tugging a twig, it was shaken, rejected, and followed by further searching. Twig gathering by the White-crowned Pigeons was interspersed with feeding, maintenance, loafing, courtship, and defense activities. In all nests observed, the female remained on the nest while the male delivered twigs to the nest. The male White-crowned Pigeon laid twigs in front of the female, or she took them from him and arranged the twig into the nest structure (Wiley and Wiley 1979). They also observed four White-crowned Pigeon nests. Nest building took four mornings for two of the nests and three mornings for the other two with an egg being laid the next day. On average, White-crowned Pigeons spent 8.48 hours building the nest, delivered a mean of 108.75 twigs, with an average of 4.57 minutes per trip. Wiley and Wiley (1979) occasionally observed White-crowned Pigeons continuing nest building with both sexes bringing twigs to the nest, while the birds were incubating the clutch. The mean incubation period for White-crowned Pigeon eggs was 13.8 days with a mean nestling period of 21.3 days, which is a nest cycle of approximately 35 days. This time cycle is similar to the one case observed in this study.

Wiley and Wiley (1979) noted that White-crowned Pigeons are multi-brooded with up to two to four nesting attempts per year at the same nest. This has also been documented in Band-tailed Pigeons (Jeffrey 1977).

Evidence of multi-brooding has not been documented in the Red-billed Pigeons nor was it observed in this study. Observations of several nests in Mexico indicated that the same nest was not used by Red-billed Pigeons for re-nesting (Eitniear unpublished data). In northern Mexico, Red-billed Pigeons constructed nests between 0800 and 1000 hr and deliver an average of 133 twigs to a nest (Eitniear unpublished data). Eitniear (personal communication) estimated a mean of 530 minutes to build a nest over three to four days. Pigeons spent a mean of 3.3 minutes away from the nest and an average of 27 seconds at the nest. The mean trip time delivering nest material was 3 minutes, 47 seconds per twig. The differences in delivery time between the 2000-2001 study on the Rio Grande River and the Mexico study could be caused by Red-billed Pigeons taking a 20 minute break from building in mid-morning on two occasions. This resting time was included when determining the mean delivery time.

Data from this study and the study in Mexico indicate that nest construction is completed in 3 to 4 days with peak nest construction from 0800 to 1145 hr each day. As with other pigeon species, nest maintenance probably occurs during incubation. The incubation and nestling cycle need further investigation to determine the length of these cycles. In this study, one nest cycle was 34 days from nest construction to fledging.

ANALYSIS OF BREEDING HABITAT

Introduction

In the study area, certain sites had Red-billed Pigeons present and other sites had no pigeons. A question arose about the differences among the sites where Red-billed Pigeons occurred and sites where pigeons did not occur. No previous studies have documented the habitat requirements of Red-billed Pigeons. Lonard et al (2000) described the components of the plant community in the area as a whole. The purpose of this study was to assess habitat components in specific sites used by Red-billed Pigeons for breeding.

During this study, Red-billed Pigeons were only seen in the riparian zone along the Rio Grande River. The riparian association along the riverbank is often subject to flooding. Aggregations of hydrophilic species such as black willow, Mexican ash, Texas sugarberry, buttonbush (*Cephalanthus occidentalis*), huisache, retama, and white mulberry (*Morus alba*) are common plants of the association. The ground cover is characterized by a variety of forbs and grasses (Butterwick and Strong 1976). One study indicated that the dominant tree species in the Starr County riparian woodland is mesquite with other important species being retama, Mexican ash, and Texas sugarberry (Lonard et al. 2000). The two dominant species of the shrub layer were granjeno (*Celtis pallida*) and saplings of Texas sugarberry trees (Lonard et al. 2000).

Methods

To analyze breeding habitat, three sites were chosen where Red-billed Pigeon activity occurred on a regular basis, and three sites were chosen where Red-billed Pigeons never occurred during the study (Fig. 4 and 5). I accessed these locations by boat using the Salineño and Falcon Dam spillway access points. Three sites located at each area were designated as 01, 02, and 03. The first site, SAL-01NP, was located immediately downstream from the Salineño river access on the United States riverbank. The second site, SAL-02P, was located on an island labeled as "Island 2" approximately 1 km downstream from the river access point. The third Salineño site, SAL-03NP, was located immediately downstream from "Island 2" on the United States riverbank. The first spillway site, SP-01P, was located immediately downstream from the spillway access point on the United States riverbank. The second spillway point, SP-02P, was located on an island approximately 0.5 km upstream from the access point on the United States side of the river channel. The third spillway point, SP-03NP, was located on the same island, 1.25 km upstream from the river access point by the discharge area from the power plant on the United States side of the border.

I collected vegetational data by the line intercept method using a 100 m tape measure (Bookhout 1996). At each of the six sites, 10 line intercepts started at the waters edge and extended perpendicular to the riverbank into the vegetation. The first line began 10 m from a randomly chosen starting point at each site. I picked a random number between 20 to 40 m as the starting point for the other nine lines. Each line was independent of the other lines with no overlap in the canopy. Every line, except for those at site SAL-02P, extended across the plant community to a distinguishable point where

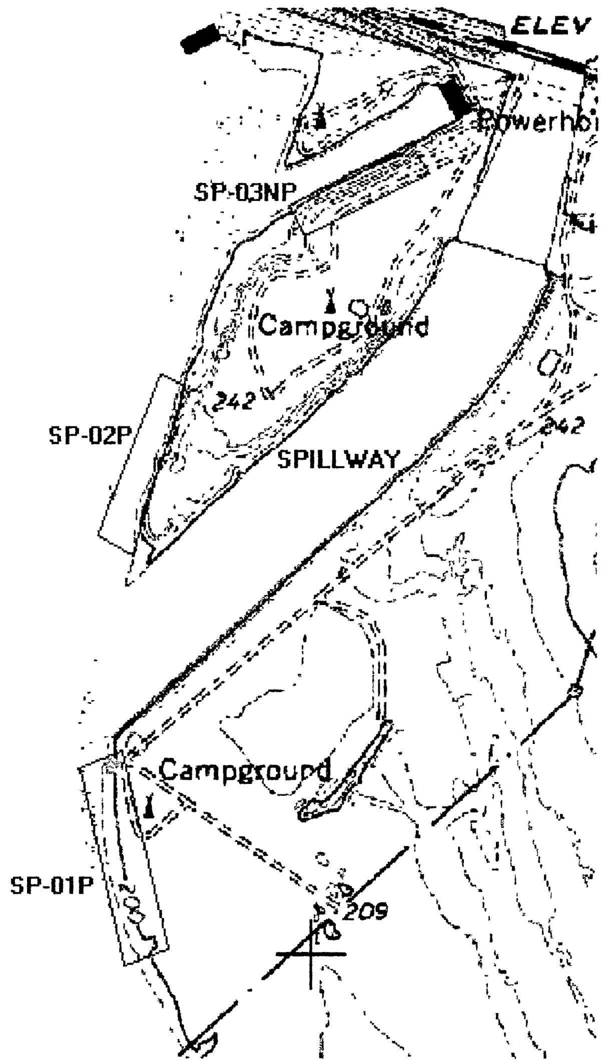

Figure 4. Map of the spillway of Falcon Dam. The labeled boxes indicate the sites where the plant community was sampled. A "P" after the site name indicates Red-billed Pigeon habitat, and a "NP" indicates non-pigeon habitat.

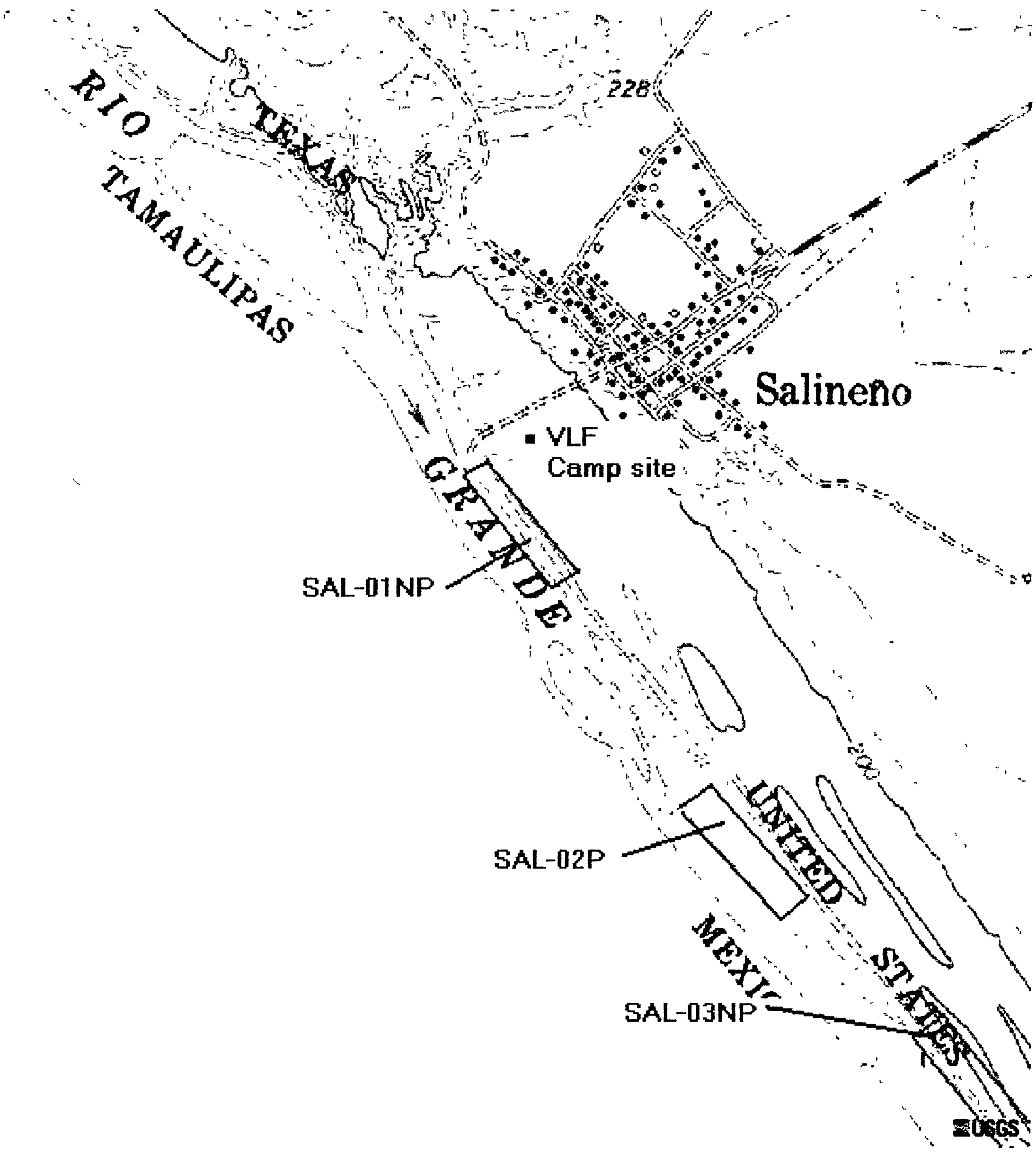

Figure 5. Map of the Salineño area. The labeled boxes indicate the sites where the vegetation was sampled. A “P” after the site name indicates pigeon habitat, and a “NP” indicates non-pigeon habitat.

the riparian zone ended. The lines at SAL-02P extended across the island. Along each intercept line, all woody species at least 1 m high that touched the line were measured. Woody plants were identified using field guides to woody species of the area (Everitt and Drawe 1993, Taylor et al. 1997). At a random spot on each line, four measurements of the overstory canopy density were taken with a spherical densitometer (Bookhout 1996).

Plant data measured on each line were entered into a Microsoft Excel spreadsheet, and the following values were calculated: total plant density for each line, percent ground cover for each species, absolute and relative density, dominance, and frequency for each species. An importance value was also calculated for all species. The importance value expressed the importance of each species in the plant community composition in relation to the other species at each site. I calculated the importance value by averaging the relative density, relative dominance and relative frequency (Cox 1996).

Data for height of trees where Red-billed Pigeons occurred were analyzed using a cluster analysis. This test indicated two clusters in the height of trees, one at 4.7 m (N = 200) and one at 14.1 m (N = 119). Using these results, I split data for measurements of trees into overstory and understory subsets.

The understory consisted of all trees < 9.5 m and the overstory consisted of all trees ≥ 9.5 m. All variables previously listed were calculated for overstory and understory vegetation. Throughout the sites, Texas sugarberry and Mexican ash seemed to be reciprocals of each other at different sites because of similar structure and size. These two species were combined and treated as one species in the analysis.

I used correlation analysis to compare absolute and relative measurements of vegetation. Absolute vegetation measurements were highly correlated with relative measurements, so the relative measurements of variables were used in the analysis. Variables were compared in Red-billed Pigeon habitat and non-pigeon habitat using the nested ANOVA test to determine differences between the two habitat types.

Results

The zone of riparian vegetation extended 20 to 40 m from the waters edge. There was a distinct line where the riparian vegetation ended, usually at a slope. Site SAL-02P was an island and was sampled at its widest area. The length of line intercepts across the island ranged from 90 to 110 m.

Black willow, Mexican ash, and Texas ebony occurred in the overstory of Red-billed Pigeon habitat sites, but not in non-pigeon habitat sites. Texas sugarberry occurred at all sites and mesquite occurred only in non-pigeon habitat sites. The scientific and common names of woody species that occurred in pigeon and non-pigeon habitats are listed in Appendix A.

The only species in the overstory of both Red-billed Pigeon habitat and non-pigeon habitat was Texas sugarberry. In the overstory, I tested for differences in the relative density, relative dominance and relative frequency in the Texas sugarberry and the Texas sugarberry/Mexican ash component between the two habitat types. There was a significant difference in the relative density, relative dominance, and relative frequency of the Texas sugarberry/Mexican ash component in Red-billed Pigeon habitat (Table 3). The mean of the means importance values for the Texas sugarberry/Mexican ash component in Red-billed Pigeon habitat 79.94 (S. E. = 5.96), was higher than in non-pigeon habitat, 40.51, (S. E = 4.27) (Table 4, Fig. 6).

Table 3. Results of ANOVA tests comparing the effects of relative density, relative dominance and relative frequency of Texas sugarberry and the sugarberry/ash component between Red-billed Pigeon habitat and non-pigeon habitat.

Species	Variable	F	p
Texas Sugarberry			
	Relative Density	1.01	0.37
	Relative Dominance	0.32	0.60
	Relative Frequency	0.36	0.58
Sugarberry/Ash			
	Relative Density	40.66	0.00
	Relative Dominance	19.60	0.01
	Relative Frequency	23.83	0.01

Table 4. Mean importance values for plant species in the overstory of the plant community in Red-billed Pigeon habitat and non-pigeon habitat. A "P" at the end of the site name indicates Red-billed Pigeon habitat and a "NP" indicates non-pigeon habitat.

Tree species	SP-01P		SAL-02P		SP-02P		SAL-01NP		SAL-03NP		SP-03NP	
Texas sugarberry	Mean	68.42	Mean	16.67	Mean	72.55	Mean	48.64	Mean	34.17	Mean	38.73
	S.E.	12.71	S.E.	5.47	S.E.	9.52	S.E.	13.25	S.E.	14.93	S.E.	13.88
Sugarberry/ash	Mean	68.42	Mean	88.34	Mean	83.07	Mean	48.64	Mean	34.17	Mean	38.73
	S.E.	12.71	S.E.	2.62	S.E.	8.02	S.E.	13.25	S.E.	14.93	S.E.	13.88
Black willow	Mean	0.00	Mean	9.86	Mean	15.53	Mean	0.00	Mean	0.00	Mean	0.00
	S.E.	0.00	S.E.	2.76	S.E.	7.45	S.E.	0.00	S.E.	0.00	S.E.	0.00
Texas ebony	Mean	13.31	Mean	0.00	Mean	0.00	Mean	0.00	Mean	0.00	Mean	0.00
	S.E.	10.18	S.E.	0.00	S.E.	0.00	S.E.	0.00	S.E.	0.00	S.E.	0.00
Mesquite	Mean	0.00	Mean	0.00	Mean	0.00	Mean	24.69	Mean	15.83	Mean	51.14
	S.E.	0.00	S.E.	0.00	S.E.	0.00	S.E.	11.61	S.E.	11.00	S.E.	14.42
Mexican Ash	Mean	0.00	Mean	73.47	Mean	10.54	Mean	0.00	Mean	0.00	Mean	0.00
	S.E.	0.00	S.E.	5.74	S.E.	5.41	S.E.	0.00	S.E.	0.00	S.E.	0.00

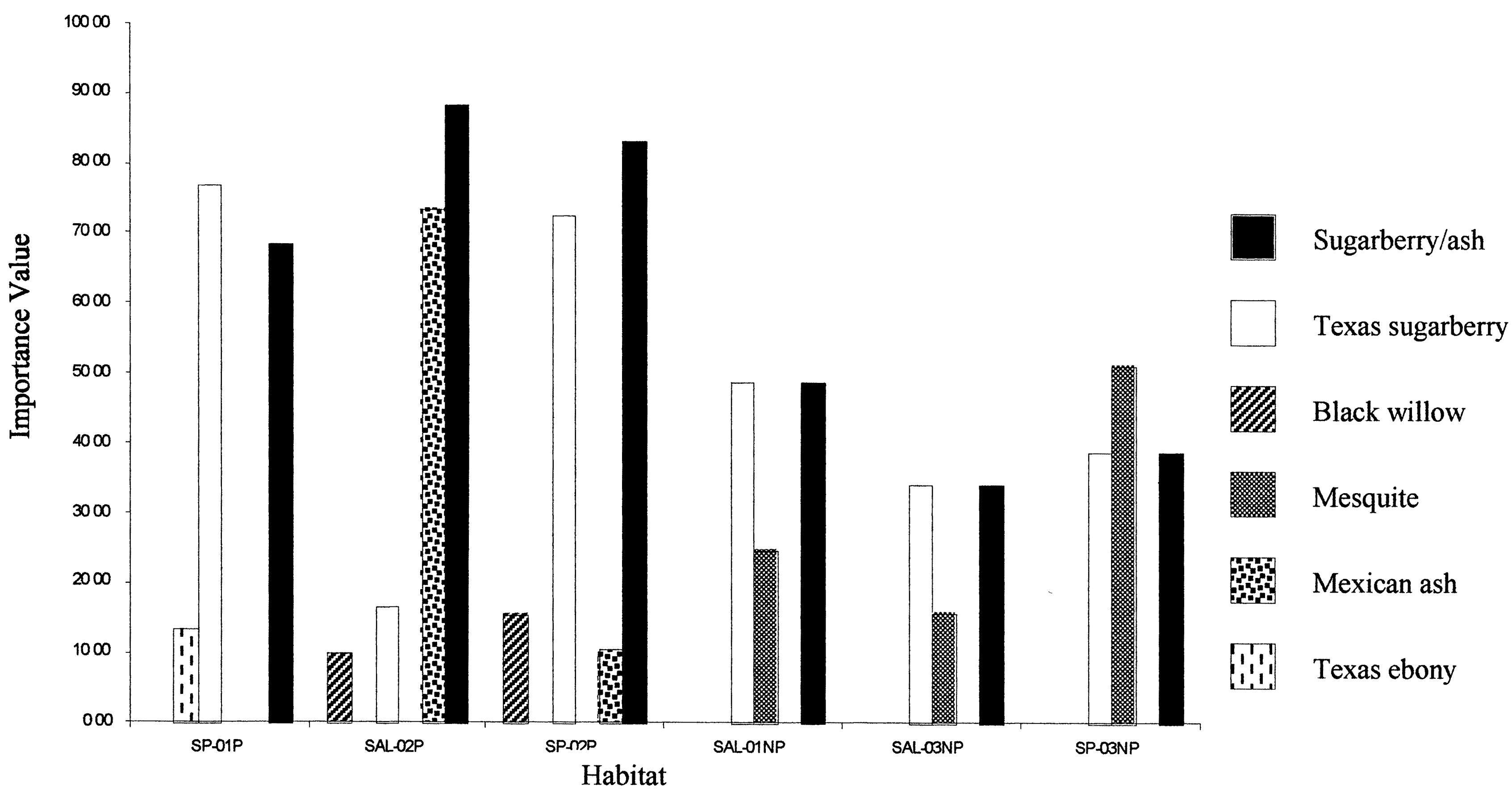

Figure 6. Histogram comparing overstory mean importance value of plant species at sites with Red-billed Pigeon habitat and non-pigeon habitat. A “P” at the end of the site name indicates Red-billed Pigeon habitat. A “NP” indicates non-pigeon habitat

The results of ANOVA tests indicated no difference in the total overstory tree density ($F = 1.592$, $p = 0.276$), total understory tree density ($F = 1.546$, $p = 0.282$), and total overstory canopy cover ($F = 0.039$, $p = 0.854$) between Red-billed Pigeon habitat and non-pigeon habitat.

The species that occurred in the understory of Red-billed Pigeon and non-pigeon habitat were Coma (*Bumelia celastrina*), granjeno, huisache, mesquite, retama, and the Texas sugarberry/Mexican ash component. Other species present were minor components of the habitat based on importance values. Granjeno, Texas sugarberry, huisache, retama and the Texas sugarberry/Mexican ash component occurred at all sites.

Relative density, relative dominance, and relative frequencies of all plant species were compared between Red-billed Pigeon habitat and non-pigeon habitat using the nested ANOVA test. The relative density and relative frequency of retama were higher (Table 5) in non-pigeon habitat than in Red-billed Pigeon habitat. There was no difference between the two habitat types with respect to these variables for the other tree species (Table 5). The mean of means importance value for retama was higher in non-pigeon habitat (6.57, S. E. = 1.26) than in Red-billed Pigeon habitat (2.16, S. E. = 0.88) (Table 6, Fig. 7).

The results of the vegetation analysis showing density, relative density, dominance represented as percent ground cover, relative dominance, frequency, and relative frequency are listed in Tables 7, 8, 9, 10, 11 and 12.

Table 5. Results of ANOVA tests comparing relative density, relative dominance, and relative frequency of understory species in Red-billed Pigeon habitat and non-pigeon habitat.

Species	Variable	F	p
Coma	Relative Density	0.02	0.89
	Relative Dominance	0.11	0.75
	Relative Frequency	0.23	0.66
Ebony	Relative Density	0.23	0.66
	Relative Dominance	0.11	0.75
	Relative Frequency	0.09	0.78
Granjeno	Relative Density	0.93	0.39
	Relative Dominance	0.57	0.49
	Relative Frequency	0.49	0.52
Texas Sugarberry	Relative Density	0.02	0.89
	Relative Dominance	0.00	0.98
	Relative Frequency	0.01	0.94
Huisache	Relative Density	1.57	0.28
	Relative Dominance	2.71	0.18
	Relative Frequency	2.87	0.17
Mesquite	Relative Density	3.58	0.13
	Relative Dominance	4.58	0.10
	Relative Frequency	3.28	0.14
Retama	Relative Density	15.01	0.02
	Relative Dominance	5.87	0.07
	Relative Frequency	7.37	0.05
Sugarberry/ash	Relative Density	0.78	0.42
	Relative Dominance	1.31	0.32
	Relative Frequency	1.34	0.31

Table 6. Mean importance values for plant species in the understory of the plant community in Red-billed Pigeon habitat and non-pigeon habitat.

Tree species	SP-01P		SAL-02P		SP-02P		SAL-01NP		SAL-03NP		SP-03NP	
Coma	Mean	6.98	Mean	0.00	Mean	3.16	Mean	0.00	Mean	3.04	Mean	5.46
	S.E.	3.02	S.E.	0.00	S.E.	2.68	S.E.	0.00	S.E.	2.06	S.E.	3.22
Granjeno	Mean	13.30	Mean	3.47	Mean	4.18	Mean	6.74	Mean	15.91	Mean	8.76
	S.E.	4.54	S.E.	3.10	S.E.	2.52	S.E.	2.18	S.E.	5.53	S.E.	3.62
Texas sugarberry	Mean	42.62	Mean	36.44	Mean	69.15	Mean	67.12	Mean	22.28	Mean	54.27
	S.E.	8.11	S.E.	5.78	S.E.	9.16	S.E.	7.49	S.E.	6.35	S.E.	6.76
Huisache	Mean	2.90	Mean	1.19	Mean	4.97	Mean	1.90	Mean	11.44	Mean	11.22
	S.E.	2.90	S.E.	0.88	S.E.	3.12	S.E.	1.90	S.E.	6.25	S.E.	3.17
Mesquite	Mean	0.65	Mean	0.00	Mean	2.38	Mean	4.61	Mean	13.72	Mean	4.02
	S.E.	0.65	S.E.	0.00	S.E.	1.76	S.E.	2.39	S.E.	4.94	S.E.	4.02
Mexican Ash	Mean	0.00	Mean	46.27	Mean	7.30	Mean	0.00	Mean	0.00	Mean	0.00
	S.E.	0.00	S.E.	4.51	S.E.	4.93	S.E.	0.00	S.E.	0.00	S.E.	0.00
Retama	Mean	1.84	Mean	0.82	Mean	3.82	Mean	8.77	Mean	4.41	Mean	6.52
	S.E.	1.23	S.E.	0.82	S.E.	2.72	S.E.	3.80	S.E.	2.49	S.E.	4.35
Sugarberry/ash	Mean	42.62	Mean	82.46	Mean	76.44	Mean	67.12	Mean	22.28	Mean	54.27
	S.E.	8.11	S.E.	3.95	S.E.	7.94	S.E.	7.49	S.E.	6.35	S.E.	6.76

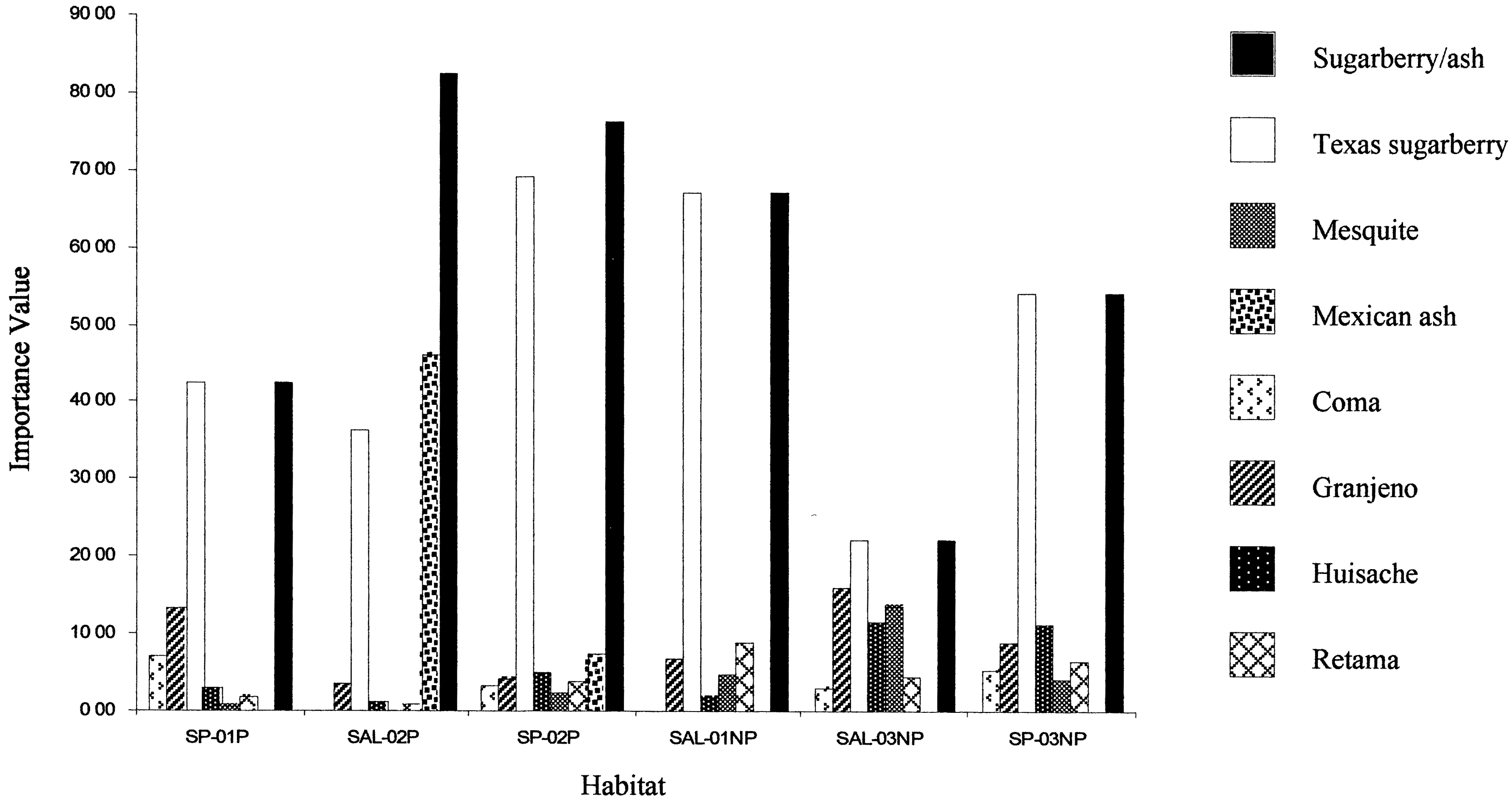

Figure 7. Histogram comparing understory mean importance value of plant species at sites with Red-billed Pigeon habitat and non-pigeon habitat. A "P" at the end of the site name indicates Red-billed Pigeon habitat. A "NP" indicates non-pigeon habitat.

Table 7. Density, dominance, frequency and importance value measurements for plant species at the Falcon Dam spillway site (SP-01P) for understory and overstory vegetation. A “P” at the end of each site name indicates pigeon habitat. A “NP” indicates non-pigeon habitat.

	Density		Dominance		Frequency		
Species	Absolute	% Relative	% Ground Cover	% Relative	Absolute	% Relative	Importance Value
Understory							
Coma	1.37	6.72	5.91	6.66	6.08	7.56	6.98
Coyotillo	0.55	2.93	1.03	1.63	1.33	2.32	2.29
Texas ebony	4.37	27.89	18.13	28.12	15.69	24.92	26.98
Granjeno	1.60	14.44	6.84	11.47	7.51	13.98	13.30
Texas sugarberry	5.88	40.32	34.63	46.45	29.88	41.10	42.62
Huisache	0.11	1.43	2.90	3.51	3.00	3.75	2.90
Colima	0.23	2.05	0.81	1.51	1.17	2.33	1.97
Lotebush	0.42	2.14	1.30	1.23	1.33	1.33	1.57
Mesquite	0.13	0.63	0.50	0.66	0.50	0.67	0.65
Retama	0.24	1.46	1.53	2.02	1.69	2.03	1.84
Sugarberry/ash	5.88	40.32	34.63	46.45	29.88	41.10	42.62
Overstory							
Texas Ebony	0.09	13.33	4.21	13.26	4.43	13.33	13.31
Texas sugarberry	0.66	76.67	32.56	76.74	30.83	76.67	76.69
Sugarberry/ash	0.66	76.67	32.56	76.74	30.83	76.67	76.69

Table 8. Density, dominance, frequency and importance value measurements for plant species at the Salineño site (SAL-02P) for understory and overstory vegetation. A "P" at the end of each site name indicates pigeon habitat. A "NP" indicates non-pigeon habitat.

	Density		Dominance		Frequency		
Species	Absolute	% Relative	% Ground Cover	% Relative	Absolute	% Relative	Importance Value
Understory							
Black willow	0.21	3.17	2.23	3.45	2.46	4.12	3.58
Buttonbush	0.10	1.72	0.75	1.31	0.88	1.59	1.54
Texas ebony	0.05	1.54	0.46	0.98	0.40	0.82	1.11
Granjeno	0.34	6.60	0.66	1.94	0.65	1.87	3.47
Texas sugarberry	4.18	41.79	19.69	33.98	16.86	33.56	36.44
Huisache	0.08	1.22	0.45	0.98	0.62	1.39	1.19
Mexican ash	3.06	38.23	30.02	51.26	26.03	49.33	46.27
Mullberry	0.46	4.77	3.69	5.39	3.97	6.51	5.56
Retama	0.06	0.95	0.53	0.71	0.50	0.81	0.82
Sugarberry/ash	7.24	80.02	49.71	85.25	41.66	82.13	82.46
Overstory							
Black willow	0.12	9.23	8.72	9.62	8.25	10.73	9.86
Texas sugarberry	0.25	19.07	11.68	15.49	10.51	15.46	16.67
Mexican ash	1.21	71.70	68.82	74.88	57.54	73.82	73.47
Sugarberry/ash	1.45	90.77	80.50	90.38	64.73	83.87	88.34

Table 9. Density, dominance, frequency and importance value measurements for plant species at the Falcon Dam spillway site (SP-02P) for understory and overstory vegetation. A “P” at the end of each site name indicates pigeon habitat. A “NP” indicates non-pigeon habitat.

	Density		Dominance		Frequency		
Species	Absolute	% Relative	% Ground Cover	% Relative	Absolute	% Relative	Importance Value
Understory							
Black willow	0.12	0.91	1.50	1.87	1.50	2.31	1.70
Buttonbush	0.14	1.43	0.77	0.77	1.00	1.00	1.07
Coma	0.40	3.33	0.83	2.95	1.17	3.21	3.16
Coyotillo	0.26	0.83	0.30	0.24	0.50	0.36	0.48
Granjeno	1.10	4.81	3.19	3.43	3.70	4.30	4.18
Texas sugarberry	9.32	72.32	43.63	69.23	36.94	65.89	69.15
Huisache	1.20	4.84	5.80	4.93	6.17	5.13	4.97
Colima	0.43	1.55	0.91	0.78	1.31	1.17	1.16
Lotebush	0.14	1.11	0.31	0.32	0.38	0.49	0.64
Mesquite	0.55	1.74	3.15	2.62	3.50	2.77	2.38
Mexican ash	0.43	3.79	8.67	8.77	9.32	9.33	7.30
Retama	0.56	3.33	4.45	4.10	4.73	4.04	3.82
Sugarberry/ash	9.75	76.11	52.30	78.00	46.26	75.22	76.44
Overstory							
Black willow	0.21	13.33	12.53	16.61	12.89	16.64	15.53
Texas sugarberry	7.83	77.50	41.31	70.43	41.08	69.70	72.55
Mexican ash	0.12	7.50	11.56	11.75	11.89	12.36	10.54
Sugarberry/ash	7.95	85.00	52.87	82.18	51.46	82.04	83.07

Table 10. Density, dominance, frequency and importance value measurements of plant species at the Salineño site (SAL-01NP) for understory and overstory vegetation. A "P" at the end of each site name indicates pigeon habitat. A "NP" indicates non-pigeon habitat.

	Density		Dominance		Frequency		
Species	Absolute	% Relative	% Ground Cover	% Relative	Absolute	% Relative	Importance Value
Understory							
Brasil	0.13	2.71	1.41	3.08	1.51	3.27	3.02
Buttonbush	0.70	4.86	2.73	3.69	3.08	4.16	4.23
Granjeno	1.02	9.52	4.14	3.88	5.15	6.83	6.74
Texas sugarberry	8.42	67.93	46.94	69.60	39.33	63.82	67.12
Huisache	0.09	0.67	2.75	2.36	3.00	2.67	1.90
Colima	0.13	1.00	0.08	0.06	0.40	0.38	0.48
Mesquite	0.57	5.33	3.48	3.58	3.90	4.92	4.61
White mullberry	0.27	2.10	2.52	3.41	2.88	3.89	3.13
Retama	0.47	5.88	5.96	10.34	6.04	10.08	8.77
Sugarberry/ash	8.42	67.93	46.94	69.60	39.33	63.82	67.12
Overstory							
Texas sugarberry	0.69	40.00	46.94	53.36	25.03	52.57	48.64
Mesquite	0.20	20.00	8.29	26.64	8.76	27.43	24.69
Sugarberry/ash	0.69	40.00	46.94	53.36	25.03	52.57	48.64

Table 11. Density, dominance, frequency and importance value measurements of plant species at the Salineño site (SAL-03NP) for understory and overstory vegetation. A "P" at the end of each site name indicates pigeon habitat. A "NP" indicates non-pigeon habitat.

	Density		Dominance		Frequency		
Species	Absolute	% Relative	% Ground Cover	% Relative	Absolute	% Relative	Importance Value
Understory							
Brasil	1.71	3.58	3.59	3.28	4.00	2.49	3.12
Coma	0.74	4.50	2.12	2.24	2.66	2.38	3.04
Texas ebony	6.11	14.66	21.89	17.96	24.66	16.77	16.46
Granjeno	5.16	19.39	11.44	14.97	13.77	13.36	15.91
Texas sugarberry	7.10	21.49	34.33	23.87	34.90	21.47	22.28
Huisache	1.39	9.34	13.18	12.35	14.61	12.64	11.44
Colima	0.31	2.00	0.50	0.87	0.63	1.11	1.33
Lotebush	3.16	11.39	5.64	7.39	6.54	6.10	8.29
Mesquite	2.36	9.32	16.71	12.86	28.65	18.98	13.72
Retama	0.92	4.34	5.99	4.21	6.68	4.69	4.41
Sugarberry/ash	7.10	21.49	34.33	23.87	34.90	21.47	22.28
Overstory							
Texas sugarberry	0.42	35.00	21.32	33.69	23.10	33.81	34.17
Mesquite	0.16	15.00	12.40	16.31	12.67	16.19	15.83
Sugarberry/ash	0.42	35.00	21.32	33.69	23.10	33.81	34.17

Table 12. Density, dominance, frequency and importance value measurements of plant species at the Falcon Dam spillway site (SP-03NP) for understory and overstory vegetation. A "P" at the end of each site name indicates pigeon habitat. A "NP" indicates non-pigeon habitat.

	Density		Dominance		Frequency		
Species	Absolute	% Relative	% Ground Cover	% Relative	Absolute	% Relative	Importance Value
Understory							
Coma	1.26	6.74	4.75	4.94	5.28	4.69	5.46
Coyotillo	0.56	2.57	0.72	0.62	1.20	1.12	1.44
Forestiera	0.21	0.83	0.52	0.43	0.80	0.71	0.66
Granjeno	1.79	9.67	6.20	7.90	7.15	8.72	8.76
Texas sugarberry	9.71	57.12	45.68	54.50	42.85	51.18	54.27
Huisache	1.63	9.00	11.10	11.49	12.54	13.18	11.22
Colima	0.92	5.83	4.80	5.81	5.49	6.33	5.99
Lotebush	0.16	1.43	1.32	1.66	1.60	1.90	1.66
Mesquite	0.36	1.25	10.45	5.62	10.45	5.19	4.02
Retama	1.00	5.56	2.80	7.03	3.20	6.97	6.52
Sugarberry/ash	9.71	57.12	45.68	54.50	42.85	51.18	54.27
Overstory							
Texas sugarberry	0.69	37.50	22.28	38.93	20.30	39.76	38.73
Mesquite	0.43	52.50	27.65	50.69	25.85	50.24	51.14
Sugarberry/ash	0.69	37.50	22.28	38.93	20.30	39.76	38.73

Discussion

The results showed the understory component of the vegetation was similar between Red-billed Pigeon habitat and non-pigeon habitat except for the relative density and relative frequency of retama, which was slightly higher in non-pigeon habitat. The overstory component of Red-billed Pigeon habitat was composed of taller, more mature riparian trees than non-pigeon habitat. Black willow, Mexican ash, and Texas sugarberry trees were the major components of Red-billed Pigeon habitat. Mexican ash and Texas sugarberry were very similar in structure and seemed mutually interchangeable as habitat components for call perches and nesting habitat. Some habitat sites had a dominance of Mexican ash, whereas; other sites had a dominance of Texas sugarberry.

There was no difference in the presence of Mexican ash and Texas sugarberries in the understory of both habitat types. The presence of these species as saplings in the non-pigeon habitat could indicate a cycle of replacement is currently taking place. The issue of plant community succession of a xerarch being replaced by a more hydrarch seral stage will probably depend on the maintenance of the water level in the river. The natural replacement of the current plant community by the Mexican ash-Texas sugarberry association could be a mechanism to provide more nesting habitat, and thus, increase the abundance of Red-billed Pigeons along the Rio Grande River. I observed that the non-pigeon habitat sites were on a slight to significant slope. On the slope, these more mesic trees may not get enough moisture to grow as tall as trees occupying the flatter floodplain closer to the water.

The characteristic that best describes preferred Red-billed Pigeon habitat was the dominance of large, mature deciduous riparian trees such as Texas sugarberry, Mexican ash, and black willow in the overstory. The Red-billed Pigeons may prefer the dense foliage of these trees for concealment from predators and nesting purposes. These riparian overstory trees were also taller in Red-billed Pigeon habitat. It seems structure of the plant community is more important than species composition in habitat selection by Red-billed Pigeons. Displaying males always cooed from the tops of the tallest trees in the area. Height of trees and density of the overstory canopy may be important criteria for suitable habitat in male territory preference and female mate selection. The reason this habitat type is preferred by Red-billed Pigeons must be further investigated.

CONSERVATION AND MANAGEMENT

Historical records indicate that Red-billed Pigeons commonly occurred in flocks of thousands in the early 1900's throughout the Rio Grande River Valley and scattered resacas that maintained dense woodland (Unpublished field notes of a Texas Game, Fish and Oyster Commission employee 1941). In the early part of the 20^{th} century, wildlife habitat was lost because of clearing of native brush for expanding agriculture and urbanization (Jahrsdoerfer and Leslie 1988). As habitat was cleared, Red-billed Pigeons were confined to the remaining wooded vegetation along the Rio Grande River (Unpublished field notes of a Texas Game, Fish and Oyster Commission employee 1941). In 1953, Falcon Dam was constructed to control the flooding in the valley and the devastation it was causing on expanding urbanization. Much of the riparian vegetation along the river died as a result of the loss of water flow by the impoundment of Falcon Reservoir and intensive irrigation downstream from Falcon Dam. As habitat decreased downstream, Red-billed Pigeons were displaced upstream and confined to their present location -- the last remaining stand of mature riparian vegetation.

It is unlikely that the remaining riparian vegetation in the study area will be cleared in the near future. The area is unsuitable for farming and the United States owns much of it. The results of this study indicated that some sections of the Rio Grande River between Falcon Dam and Roma are not suitable habitat for Red-billed Pigeons. Suitable habitat occurs in small, fragmented patches.

Reforestation in the Rio Grande River Valley will be necessary for the restoration of Red-billed Pigeons to areas where they once occurred. Increased water flow in the Rio Grande River will be needed to sustain the re-growth of riparian vegetation. Water management will be necessary in the United States and Mexico. Because the Red-billed Pigeon is migratory, habitat conservation will also be necessary in Mexico to provide travel corridors from the Rio Grande River to the wintering range in the mountains of northern Mexico.

This study only focused on a small section of the Rio Grande River. In the future, more intensive research will be necessary in other areas downstream from Salineño to assess the current status of habitat and use by Red-billed Pigeons. There have also been reports of recent sightings of 8 to 10 Red-billed Pigeons in Webb County (Woodin personal communication). The section of the Rio Grande River in Webb County cannot be easily accessed because the land surrounding the river is privately owned. This area may support Red-billed Pigeons and thus must be further investigated. Surveys along the Rio Grande River upstream to Eagle Pass will be used to identify other fragmented populations. The continuance of the Red-billed Pigeon as an extant species of Texas will require considerable conservation effort. This species should already be on the endangered species list for Texas. It is imperative that a recovery plan and management strategies for the species be implemented immediately. Otherwise, the Red-billed Pigeon will cease to be an extant species in Texas.

LITERATURE CITED

Brush, T. 1998. Recent nesting and current status of red-billed pigeon along the lower Rio Grande in southern Texas. Bulletin Texas Ornithological Society 31:22-26.

Bookhout, T. A., Editor. 1996. Research and management techniques for wildlife and habitats. The Wildlife Society, Bethesda, Maryland.

Braun, C. E. 1994. Band-tailed pigeon. Pages 60-74 *in* Migratory shore and upland game bird management in North America (T. C. Tacha and C. E. Braun eds.). International Association of Fish and Wildlife Agencies, Washington, D. C.

Butterwick, M., and S. Strong 1976. A vegetational survey of the Falcon Dam area. Rio Grande-falcon thorn woodland. Pages 27-48 *in* A natural area survey. No. 13. Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin, Austin, Texas.

Cox, G. W. 1996. Laboratory manual of general ecology. Wm. C. Brown Publishers, Dubuque, Iowa.

DeGraaf, R. M., and J. H. Rappole 1995. Neotropical birds natural history, distribution, and population change. Cornell University Press, Ithaca, New York.

Everitt, J.H., and Drawe, D.L. 1993. Trees, shrubs, and cacti of South Texas. Texas Tech University Press, Lubbock, Texas.

Gehlbach, F. R. 1993. Mountain islands and desert seas. Texas A&M University Press, College Station, Texas.

Goodwin, D. 1983. Pigeons and doves of the world. Cornell Universtiy Press, Ithaca New York.

Jahrsdoerfer, S. E., and D. M. Leslie, Jr. 1988. Tamaulipan brushland of the Lower Rio Gande Valley of South Texas: description, human impacts, and management options. U.S. Fish and Wildlife Service, Biological Report 88. Albuquerque, New Mexico.

Jeffrey, R. G. 1977. Band-tailed pigeon (*Columba fasciata*). Pp 211-245 *in* Management of migratory shore and upland game birds. (G. C. Sanderson ed.). International Association of Fish and Wildlife Agencies, Washington D. C.

Johnston and Janiga 1995. Feral Pigeons. Oxford University Press, New York, New York.

Lonard, R. I., F. W. Judd, J. H. Everitt, D. E. Escobar, M. R. Davis, M. M. Crawford, and M. D. Desai 2000. Evaluation of color-infared photography for distinguishing annual changes in riparian forest vegetation of the lower Rio Grande in Texas. Forest Ecology and Management 128:75-81

Longoria, A. 1997. Adios to the brushlands. Texas A&M University Press, College Station, Texas.

Leopold, A.S. 1972. Wildlife of Mexico, the game birds and mammals. University of California Press, Berkeley, California

Oberholser, H. C. 1974. The bird life of Texas, Vol. 1 (E. B. Kincaid, Jr., ed.). University of Texas Press, Austin, Texas.

Peeters, H. J. 1962. Nuptial behavior of the band-tailed pigeon in the San Francisco bay area. The Condor 64:445-470

Saunders, B. D. 1976. Historical survey of the Rio Grande River area in Starr County. Pp 3-12 *in* Rio Grande-falcon thorn woodland, A natural area survey No. 13. Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin, Austin, Texas.

Sibley, D. A. 2000. National Audubon Society, The Sibley Guide to Birds. Chanticleer Press, Inc., New York, New York

Skutch, A.F. 1964. Life histories of Central American pigeons. Wilson Bulletin 76:211-247

Taylor, R.B., J. Rutledge, and J.G. Herrera 1997. A field guide to common South Texas shrubs. Texas Parks and Wildlife Press, Austin, Texas.

Texas Game Fish and Oyster Commission [Author not listed] 1945. Principal Game Birds and Mammals of Texas, Their Distribution and Management. Texas Game, Fish and Oyster Commission.

Wiley, J. W. and B. N. Wiley 1979. The biology of the white-crowned pigeon. Wildlife Monographs 64:1-54.

APPENDIX A

List of woody species identified in the habitat analysis.

Family	Scientific Name	Common Name
Fabaceae	*Prosopis glandulosa*	Honey Mesquite
	Parkinsonia aculeata	Retama
	Pithecellobium ebano	Texas Ebony
	Acacia smallii	Huisache
Rhamnaceae	*Condalia hookeri*	Brasil
	Karwinskia humboldtiana	Coyotillo
	Ziziphus obtusifolia	Lotebush
Ulmaceae	*Celtis laevigata*	Texas Sugarberry, Hackberry
	Celtis pallida	Granjeno, Spiny Hackberry
Oleaceae	*Fraxinus berlandieriana*	Mexican Ash, Rio Grande River Ash
	Forestiera angustifolia	Elbowbush, Narrow-leaf Forestiera
Salicaceae	*Salix nigra*	Black Willow
Sapotaceae	*Bumelia celastrina*	Coma
Rubiaceae	*Cephalanthus occidentalis*	Common Buttonbush
Rutaceae	*Zanthoxylum fagara*	Lime Prickly Ash
Moraceae	*Morus alba*	White Mulberry

VITA

Jeff Breeden was born in Houston, Texas, on August 1, 1974, son of Donald and Luana Breeden. He was raised in Brownsville, Texas, and graduated from St. Joseph's Academy in 1992. He then enrolled in college at the University of Texas at San Antonio. In December 1996, he transferred to Southwest Texas State University, San Marcos, and graduated in May 1999 with a B.S. degree in wildlife biology. While in college, he was president of the SWT student chapter of The Wildlife Society for two years, and worked as a summer intern with Texas Parks and Wildlife Department for three summers. After graduating, he enrolled at SWT in the graduate school to earn a master's degree in wildlife ecology. While in graduate school, he worked as an instructional assistant for the biology department teaching laboratory sections for Human Anatomy and Physiology, Comparative Vertebrate Anatomy, and Wildlife Management.

Permanent address: 2 Sunset Drive
Brownsville, Texas 78520

This thesis was typed by Jeffrey B. Breeden