MIDDLE RIO GRANDE BIOLOGICAL SURVEY

Final Report

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ABSTRACT

A biological survey of riparian habitats of the Middle Rio Grande Valley between Española and San Acacia, New Mexico was carried out by a study team from the Center for Environmental Studies at Arizona State University. The study was a multiple agency effort by the Corps of Engineers, the Bureau of Reclamation, the Fish and Wildlife Service, and the New Mexico Department of Game and Fish. The objectives of the study were to identify the major types of riparian habitat within the study reach, and to characterize the vegetation and terrestrial vertebrate communities of each type. Two consecutive years were spent in field data collection. The study focused on the area within and including the drains and levees that parallel the river.

The major communities were cottonwood/Russian olive, cottonwood/coyote willow, cottonwood/juniper, Russian olive, cattail marsh, salt cedar, and sandbar/river channel; drains and the vegetation at the edges of the bosque along the levees were also treated as distinct communities. Six vegetation structure types were defined within the communities, based on the overall height of the vegetation and the amount of vegetation in the lower layers.

The riparian community as a whole supported a rich assemblage of vertebrate species, particularly birds, and population densities were comparable to those observed in other Southwestern riparian systems. The highest densities and diversities of vertebrate wildlife were found in mature cottonwood/Russian olive stands and in dense, intermediate-aged cottonwood/coyote willow stands, especially along the edges of the levees. Cattail marshes supported high population densities but fewer numbers of species, although a relatively large proportion of the species occurring in cattail marsh habitats were unique to them. Open areas, early growth stands, salt cedar habitats, and the river channel supported lower densities and numbers of vertebrate species.

Detailed vegetation maps of the study area were prepared and are included with the report. General recommendations for management of the riparian/riverine resource were presented, and specific recommendations were made regarding the biological impacts of a proposed Corps of Engineers levee rehabilitation project.

INTRODUCTION

The cottonwood bosque of New Mexico's Middle Rio Grande Valley has survived the impacts of development better than many other major Southwestern riparian forests. Although channelization, construction of drains, levees and dams, conversion of large portions of the floodplain to agricultural and residential use, and the spread of exotic plant species have altered the system substantially, it is the most extensive remaining gallery cottonwood forest in the Southwest.

Over the past decade the value of riparian habitats to wildlife in this arid region has been widely recognized (Hubbard 1971, Carothers et al. 1974, Johnson and Jones 1977, Brown 1982, Ohmart and Anderson 1982). In addition to its value as wildlife habitat the Middle Rio Grande bosque, because of its proximity to Albuquerque, has great potential value as a recreational and educational resource (Chambers et al. 1975). At the same time, this location exposes the bosque to an ever-growing threat of adverse impacts associated with continuing urban development. These varied interests, along with the concerns of managing the river water for irrigation and flood control, place conflicting pressures on the riparian ecosystem and on those with responsibility for managing it. To permit wise planning and decision-making for multiple use of the area, good baseline information is essential.

The lack of an integrated data base on the flora and fauna of this ecosystem led to the initiation of this two-year survey of the riparian habitats of the Middle Rio Grande Valley. Our primary objectives were to identify and describe the major riparian habitat types within this reach and to obtain two consecutive years' data on the vegetation and terrestrial vertebrate fauna associated with each type. This information will be used to assess biological impacts of woodland and channel modification on specific habitat types and on the riparian community as a whole, and to make recommendations on mitigating such impacts. The Corps of Engineers, which has responsibility for assessing and planning for flood control, fish and wildlife, and recreational and water needs associated with the Rio Grande, will use this information to guide planning for future construction and mitigation efforts. The data will also provide the Bureau of Reclamation, which is mandated by the Rio Grande Compact of 1939 and the Treaty of 1906 to operate and maintain the river channel, with a basis for more effective environmental management. These agencies under NEPA and the Endangered Species Act and other Federal laws and executive orders are required to carry out their activities in such a way as to consider riparian biological resources in their planning, construction, and operational activities. The study was carried out with the intention that other persons or organizations concerned with the management of the riverine/riparian zone should also be able to make use of the information gathered.

This study was accomplished as a multiple agency effort by the Corps of Engineers, the Bureau of Reclamation, the Fish and Wildlife Service, and the New Mexico Department of Game and Fish. Each agency has responsibilities associated with the Rio Grande and its resources, and data obtained from the study will assist those agencies in carrying out these responsibilities while maximizing protection, preservation, and enhancement of riparian resources. The Corps of Engineers initiated the study and provided major funding. Each of the other participating agencies contributed substantial financial assistance and technical recommendations. The Soil Conservation Service also participated in making valuable technical contributions and in reviewing preliminary and draft reports.

DESCRIPTION OF THE STUDY AREA

The Rio Grande in New Mexico flows through a series of basins flanked by steep mountain ranges, which were formed by warping of the earth's crust during the Cretaceous Period. The region is part of the Southern Rocky Mountains fault belt (Kelley et al. 1976). The river drains a watershed of a quarter million square miles, the sixth largest in North America (Hansman and Scott 1977).

The study area encompassed 163 river miles of the valley between Española, at the south end of the Rio Grande Gorge, and the San Acacia Constriction, in north-central New Mexico (Fig. 1). It included the Española Basin, White Rock Canyon, and the Albuquerque Basin (Kelley et al. 1976). The area of intensive study extended from the city of Bernalillo to the Bosque Bridge (NM 346), approximately 60 miles. Elevations in the study area range from 5,580 ft at Española to 4,675 ft at the San Acacia Diversion Dam (USGS Quadrangle maps). Except for the section through White Rock Canyon, the river has a relatively low gradient in this reach (5 ft/mi or less), and the floodplain is level and broad, from 1 to 5 mi across. The floodplain is bounded by terraces and upland plains that slope upward toward the mountains to the east and west.

The floodplain is composed of deep, highly stratified alluvial soils of mixed origin, fine to medium in texture. There are some small areas of saline soil (Maker et al. 1978).

The climate ranges from arid in the southern part of the study area to semiarid from around Albuquerque north. Because of the rainshadow effect of the mountains, rainfall is low over the entire area, about 8 to 10 in annually. About half of the annual precipitation comes in late summer (July to September) in the form of convection storms (Tuan and Everard 1965). Between 1941 and 1970, January temperatures at the Albuquerque airport averaged a low of 22°F and a high of 46°F, and July temperatures averaged 66° and 92°F, respectively (National Oceanic and Atmospheric Administration [NOAA] 1980). During the two years of the study, the average lows were in accordance with the 30-year norms, but average highs for July 1981 and for January and July 1982 were about 2° above the norms, and in January 1981, when the study began, the average high was 6° above the 1940-70 norms (NOAA 1981, 1982). Inspection of NOAA climatological records for 1981 and 1982 suggests that temperatures in the valley were more extreme than those recorded on the mesa at the airport. Monthly average lows in 1981-82 at weather stations in the valley at Bernalillo and Los Lunas were 2 to 3° lower, and the monthly highs were 1 to 3° higher, than those at the Albuquerque station.

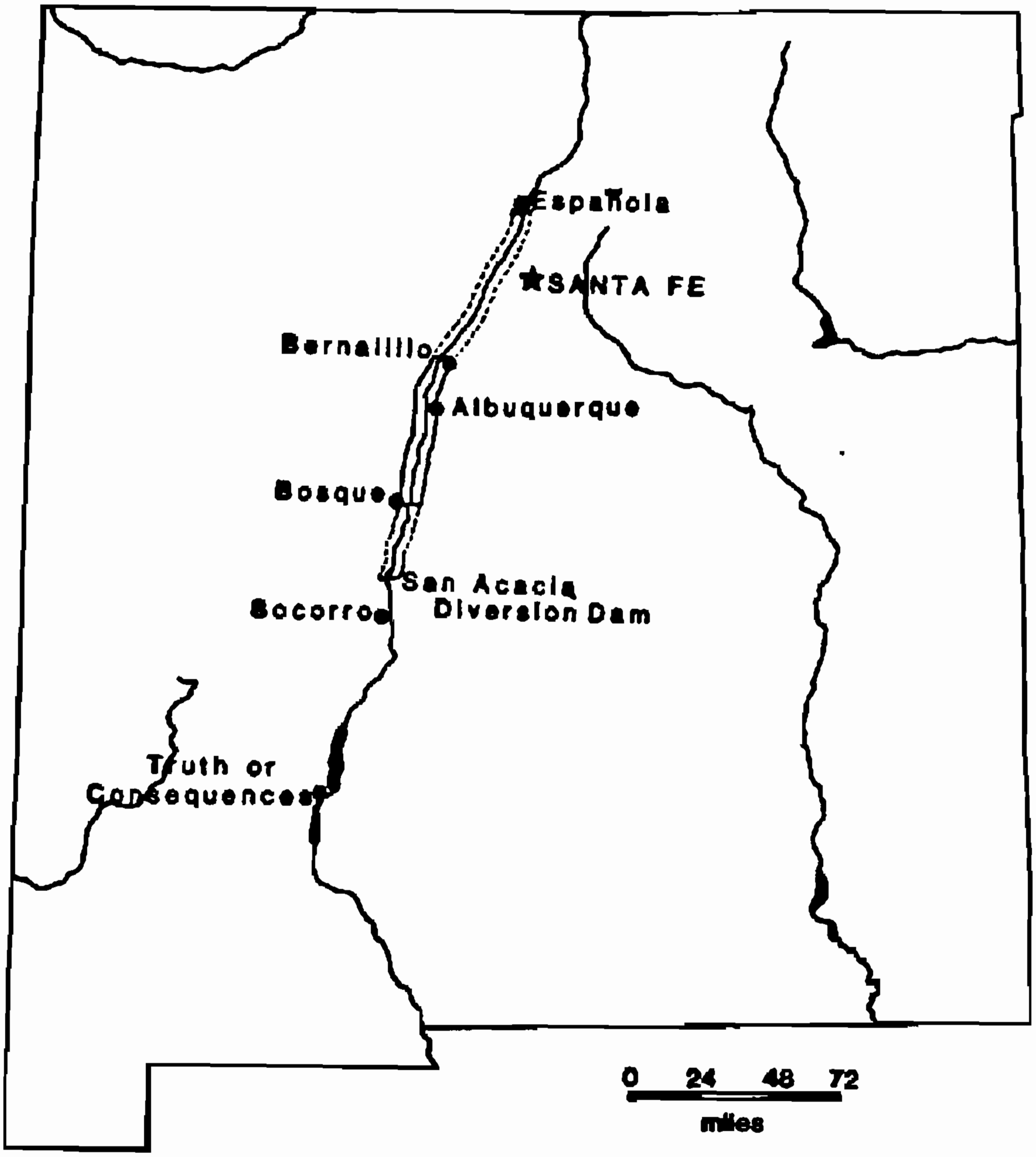

Figure 1. Location of the study area in New Mexico. Solid lines paralleling the river denote the intensive study area and broken lines denote the general study areas.

The study area lies at the juncture of two major biotic provinces, the warm-temperate Chihuahuan and the cold-temperate Great Basin provinces (Fig. 2; Brown 1982). The sloping upland flanking the floodplain, or abutting the river channel in a few places, supports one of several different vegetation communities, depending on elevation (Brown and Lowe 1980). There is Chihuahuan Desertscrub from around La Joya south and Semidesert Grassland between La Joya and Isleta. Both of these communities are within the Chihuahuan Province and are classified as warm-temperate. Most of the area north of Isleta is Great Basin Grassland, with Great Basin Conifer Woodland through the White Rock Canyon area (Brown and Lowe 1980). In the Great Basin Grassland, there are scattered one-seed junipers (Juniperus monosperma) beginning around Bernalillo and increasing in frequency northward. Scattered ponderosa pines (Pinus ponderosa) reach the river at the mouths of tributary streams in White Rock Canyon. Like the surrounding upland areas, the riparian vegetation communities lie in the transition zone between warm- and cold-temperate biomes. The riparian communities of the study area bear closest resemblance to Great Basin Riparian Forests, a cold-temperate type (Brown 1982), but they include some species typical of warm-temperate riparian forest communities.

Most of the riparian forest lies either within the levees that parallel the river or immediately adjacent to them, although isolated groves of old trees are scattered throughout the floodplain. The remainder of the floodplain has largely been converted to agriculture (mostly alfalfa [Medicago sativa]) or residential areas, and the valley is dissected by numerous irrigation canals and ditches. Together, the canals and drains typically carry more water than the river channel during the irrigation season, which runs from late March through October.

Our study was largely focused on the forested floodplain area immediately adjacent to the river, including the levees and drains which run parallel to it. These features now limit the area that the river can inundate during seasonal high flows under normal conditions. In sections of the river where no levees were present, the study area extended laterally as far as the riparian vegetation. Some sampling, such as raptor and large bird censusing, included the agricultural and residential areas outside the drains, and some other study sites, including several artificial ponds and most of the transects south of Bernardo, were outside the confines of the levees. All of Isleta Marsh was included in the study area as well.

The study area was divided into two reaches, with a difference in emphasis in the study of each (see Figs. 1 and 2). The intensive study area, between Bernalillo and the Bosque Bridge (NM 346), included the areas within which levee modification work has been proposed. The predominant vegetation in this section was Rio Grande cottonwood (Populus fremontii var. wislizenii, hereafter referred to as "cottonwood") forest, although some shrubland, cleared areas, ponds, and marshes were also present. This reach was sampled intensively, with attention to all major habitat types and to specific areas which may be subject to various impacts of construction and/or habitat removal. The general study areas to the north and south included additional habitat types, notably salt cedar (Tamarix chinensis) woodland, which covers an extensive area south of Bernardo.

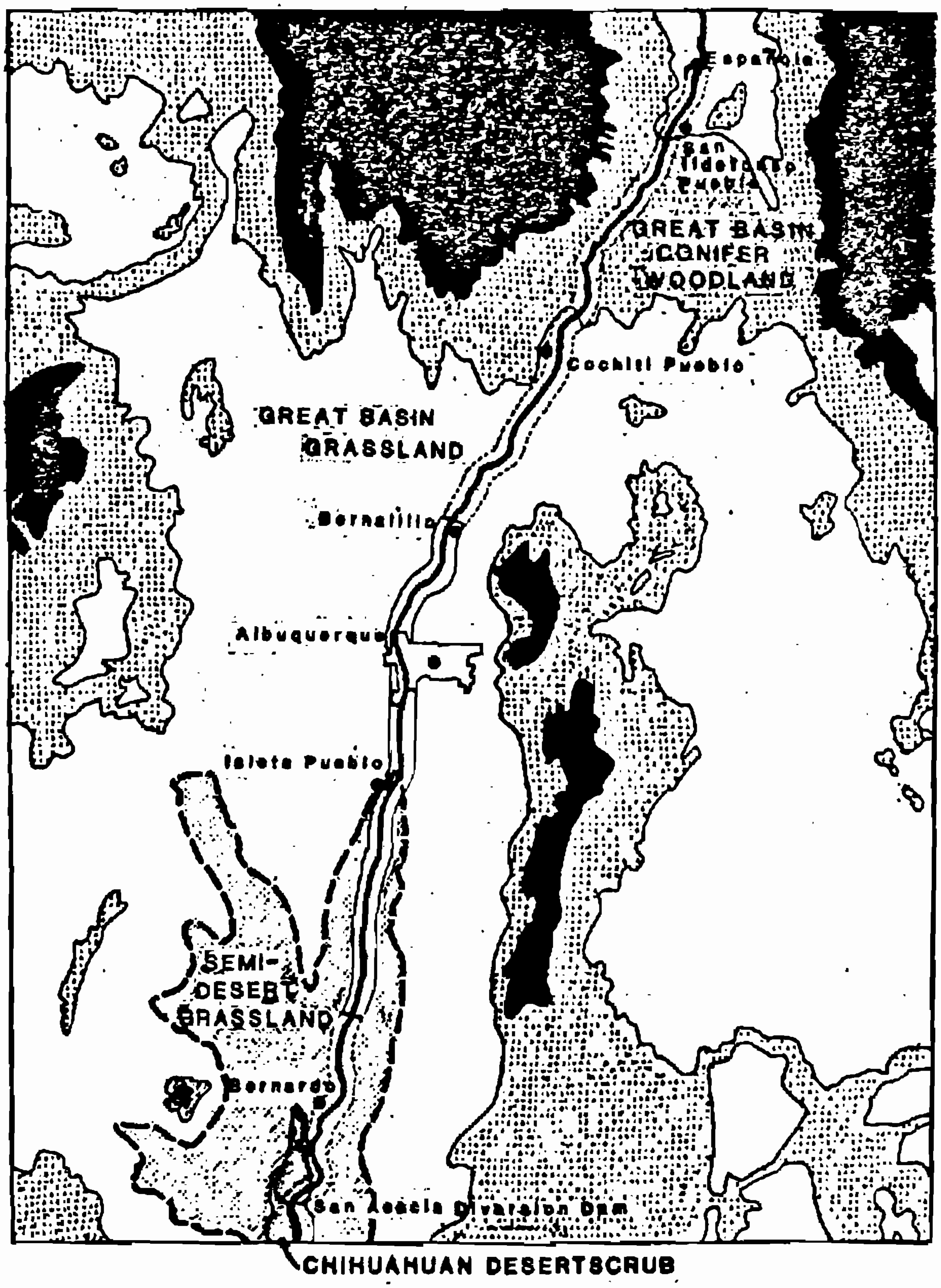

Figure 2. Map of the study area, including major surrounding biotic communities. The heavy dashed line marks the approximate boundary between the Great Basin and the Chihuahuan Biotic Provinces (after Brown and Lowe 1980). Solid lines paralleling the river denote the intensive study area; broken lines denote the general study areas. Dark areas are mountains.

The general study area was sampled less intensively, with the objectives of (1) providing a context for the intensive study area so that its uniqueness could be judged, and (2) obtaining data on additional community types that were absent from or were of limited extent in the intensive study area. Sampling in the general study area not only provided a more holistic view of the riparian resource but also facilitated comparisons between the Middle Rio Grande and other Southwest riparian ecosystems.

MATERIALS AND METHODS

Establishment of Study Sites

Field work was begun on 1 February 1981. Following reconnaissance and study of aerial photographs of the intensive study area, transect sites were chosen to represent the range of community types (defined by dominant vegetation species) and structure types (based on vertical distribution of foliage) that occurred within this reach. We define community type as a distinctive, local assemblage of species, the designation of which is based on the dominant or codominant species in canopy and shrub vegetation layers (see Dick-Peddie 1981). Our community type is similar to the Association (sixth level) in the Brown-Lowe-Pase classification system (Brown et al. 1979) and equivalent to Dick-Peddie's (1981) Habitat Type. Four vegetation community types (cottonwood/coyote willow [Salix exigua], C/CW; cottonwood/Russian olive [Elaeagnus angustifolia], C/RO; Russian olive, RO; and marsh, MH) were recognized in the intensive study area. In addition to these vegetation communities defined by plant species composition, we also established transects to sample "community types" defined by physical characteristics or man-made alterations. These included levees and drains or canals adjacent to levees (DR), woodland edge along levees (C/CW E and C/RO E), sandbars in the river channel (SB), and the river itself (RV). Hereafter in this report, the terms "community" and "community type" refer to both those communities described by physical characteristics and those defined by plant species composition. Each of the community types is described in detail in the first part of the Results section.

Structure types correspond to classification at the subassociation (seventh) level in the Brown-Lowe-Pase system (Brown et al. 1979). We recognized six structure types, designated by Roman numerals I through VI, which were defined by two general factors: the overall height of the vegetation and the amount of vegetation in the lower layers. Structure types I and II were mature forest, types III and IV were intermediate-age forest or woodland, and types V and VI were shrub habitats. The first of each of these pairs (types I, III, V) had substantial understory or shrub vegetation, while the others (types II, IV, VI) had sparse shrub layers. The six structure types are described in detail in the Results section.

Particular stands or areas defined according to both community type and structure type are referred to herein as community-structure or C-S types. Initially, the C-S type of each transect was assessed qualitatively. C-S type designations were later modified if necessary after vegetation parameters were quantified.

We attempted to establish at least three transects within each major community-structure type that occurred in the intensive study area. Wherever possible, transects were established in relatively homogeneous stands at least 2500 ft long and 800 ft wide. However, several habitat types of particular interest (drains, sandbars, young stands of Russian olive, areas adjacent to the river channel in the early stages of vegetation establishment) typically occurred in short and/or narrow strips. In such habitats, transects were established with a minimum length of 2000 ft and a width of 100 ft. Each transect was marked off in 500-ft lengths, or intervals; a 2500-ft transect has 10 intervals, five 500-ft intervals on each side of the transect line.

To assess the value of woodland edge relative to interior woodland, paired transects were established at seven sites. One standard transect (2500 X 800 ft) was established in the interior of a stand, approximately 400 ft from the levee, and a second one-sided transect (2500 X 400 ft) was located parallel to the first, along the levee edge. At two of the sites, a third parallel transect was located along the riverine edge of the woodland.

In many cases the community-structure types of edge transects do not match those of the interior transects they parallel. Vegetation along edges frequently differs from that of the interior of a stand in having denser understory, somewhat different species composition, or a greater proportion of mature trees. These differences in vegetation structure were considered to be a component of the difference between edge and interior. However, included in the entire set of transects there were representatives of the same community-structure types among both interior transects and levee edge transects, to permit comparison of edge and interior transects of the same structure type.

To assess human impact on wildlife populations, five transects (in four different C-S types) were established in an area of the bosque in Albuquerque near Candelaria Farms Nature Center that receives substantial human use (hiking, dirt biking, woodcutting, etc.). Data collected on these transects were compared with data from transects of the same habitat types that receive relatively little use. To evaluate the effect of dredging operations on bird and mammal use of drains, transects were established along drains dredged during early 1981 as well as along several drains that were undisturbed from that time through winter 1981.

Altogether, 78 transects were established in the intensive study area. They are listed in Table 1 by community type, structure type, and dimensions. Transects crossing lines of jetty jacks, "human impact" transects, and transects along drains dredged in spring 1981 are also indicated in this table. The exact location of each transect is shown on the vegetation maps in Appendix XI.

Reconnaissance and transect placement in the general study area were completed in summer 1981. Transect placement in this portion of the study area was constrained by three factors: the relatively small amount of time available for sampling in this reach, difficulty of access to certain areas, and denial of right of entry by three of the

Table 1. Intensive study area transects. Abbreviations for community types are in parentheses. Transects which cross lines of jetty jacks are indicated by an asterisk. Drain transects dredged during spring 1981 are indicated with +. Under census method, E = modified Emlen, D = direct count. Community and structure types are described in the first part of the Results section.

Transect	Community type	Structure type	Length (ft)	Width (ft)	Census method	Location
KW 01	Cottonwood/Russian olive (C/RO)	II	2500	800	E	Albuquerque
02	Cottonwood/coyote willow levee edge (C/CW E)	I	2500	400	E	Albuquerque
03	Drain (DR)	V	2500	100	D	Albuquerque
04	Cottonwood/Russian olive	I	2500	800	E	Albuquerque
05	Cottonwood/coyote willow (C/CW)	IV	2500	800	E	Albuquerque
06	Sandbar (SB) and River (RV)	VI	2000	400	D	Albuquerque
07	Cottonwood/coyote willow river edge (C/CW E)	I	2000	400	E	Albuquerque
NW 06	Cottonwood/coyote willow	V	2500	800	E	Corrales
07	Cottonwood/Russian olive levee edge	I	2500	400	E	Corrales
+08	Drain	VI	2500	100	D	Corrales
09	Sandbar and River	VI	2500	400	D	Corrales
10	Cottonwood/coyote willow levee edge (Burn)	V	2500	400	E	Corrales
+11	Drain	VI	2500	100	D	Corrales
12	Sandbar and River	VI	2500	400	D	Bernalillo
13	Cottonwood/coyote willow	VI	2000	100	D	Bernalillo

Table 1. (Cont.)

Transect	Community type	Structure type	Length (ft)	Width (ft)	Census method	Location
NW 14	Cottonwood/coyote willow	I	2500	800	E	Bernalillo
15	Cottonwood/coyote willow	IV	2500	800	E	Bernalillo
16	Cottonwood/coyote willow	VI	2000	100	D	Corrales
17	Cottonwood/coyote willow	VI	3000	100	D	Corrales
18	Cottonwood/coyote willow river edge	I	2500	400	E	Bernalillo
NE 01	Cottonwood/Russian olive Human impact	I	2500	800	E	Albuquerque
*02	Cottonwood/coyote willow Human impact	IV	2500	800	E	Albuquerque
03	Cottonwood/coyote willow Human impact	IV	2500	800	E	Albuquerque
*04	Cottonwood/coyote willow levee edge Human impact	IV	2500	400	E	Albuquerque
05	Drain Human impact	VI	2500	100	D	Albuquerque
07	Cottonwood (C)	V	2000	100	D	Albuquerque
SW 00	Russian olive (RO)	V	2000	100	D	Isleta
01	Cattail Marsh (MH)	V	500	400	D	Isleta
02	Cottonwood/coyote willow	IV	2500	800	E	Isleta
03	Cottonwood/Russian olive	II	2500	400	E	Isleta

Table 1. (cont.)

Transect	Community type	Structure type	Length (ft)	Width (ft)	Census method	Location
SW 04	Cottonwood/coyote willow levee edge	I	2500	400	E	Isleta
05	Drain	VI	2500	100	D	Isleta
*06	Cottonwood/coyote willow	V	2500	800	E	Los Lunas
07	Cottonwood/coyote willow Artificial pond site	V	500	400	D	Los Lunas
08	Cottonwood/coyote willow	I	2500	800	E	Los Lunas
09	Cottonwood/coyote willow	V	2500	800	E	Los Lunas
10	Cottonwood/coyote willow	V	2500	800	E	Los Lunas
11	Cottonwood/coyote willow levee edge	V	2500	400	E	Los Lunas
12	Drain	VI	2500	100	D	Los Lunas
*13	Cottonwood/coyote willow	I	2500	800	E	Los Lunas
14	Cottonwood/coyote willow levee edge	III	2500	400	E	Los Lunas
15	Drain	VI	2500	100	D	Los Lunas
16	Cottonwood/coyote willow	V	2500	800	E	Belen
*18	Cottonwood/Russian olive	I	2500	800	E	Bosque Bridge
*19	Cottonwood/Russian olive	I	2500	800	E	Bosque Bridge
20	Russian olive	V	2500	100	D	Bosque Bridge

Table 1. (cont.)

Transect	Community type	Structure type	Length (ft)	Width (ft)	Census method	Location
SW 21	Cottonwood/Russian olive levee edge	I	2500	400	E	Bosque Bridge
22	Drain	VI	2500	100	D	Bosque Bridge
23	Sandbar and River	VI	2500	400	D	Los Lunas
24	Cottonwood/coyote willow river edge	I	2500	400	E	Los Lunas
25	Sandbar and River	VI	2000	400	D	Belen
26	Russian olive	V	3000	100	D	Belen
27	Cottonwood/Russian olive levee edge (Burn)	I	2500	400	E	Belen
28	Drain	VI	2500	100	D	Belen
29	Cattail Marsh	V	2000	400	E	Isleta Marsh
30	Cattail Marsh	V	2500	400	E	Isleta Marsh
31	Drain	V	2000	100	D	Isleta Marsh
32	Drain	V	2500	100	D	Isleta Marsh
SE 04	Cottonwood/Russian olive	I	2500	800	E	Isleta
05	Cottonwood/Russian olive levee edge	I	2500	400	E	Isleta
06	Drain	VI	2500	100	D	Isleta
07	Cottonwood/coyote willow	IV	2500	800	E	Isleta
08	Cottonwood/coyote willow	I	2500	800	E	Isleta
09	Sandbar and River	VI	2500	400	D	Bosque Farms
*10	Cottonwood/coyote willow river edge	III	2500	400	E	Bosque Farms

Table 1. (cont.)

Transect	Community type	Structure type	Length (ft)	Width (ft)	Census method	Location
SE 11	Cottonwood/coyote willow	I	2500	800	E	Bosque Farms
12	Cottonwood/coyote willow levee edge	I	2500	400	E	Bosque Farms
+13	Drain	VI	2500	100	D	Bosque Farms
14	Cottonwood/coyote willow levee edge	III	2500	400	E	Bosque Farms
+15	Drain	VI	2500	100	D	Bosque Farms
*16	Cottonwood/coyote willow	V	2500	100	D	Los Lunas
17	Cottonwood/coyote willow	I	2500	800	E	Los Lunas
18	Russian olive	VI	2500	100	D	Bosque Bridge
19	Cottonwood/Russian olive river edge	III	2500	400	E	Bosque Bridge
20	Cottonwood/Russian olive levee edge	I	2500	400	E	Bosque Bridge
21	Drain	VI	2500	100	D	Bosque Bridge
22	Cottonwood/coyote willow levee edge	II	2500	400	E	Los Lunas
23	Drain	VI	2500	100	E	Los Lunas
24	Cottonwood/coyote willow levee edge	III	2500	400	E	Bosque Farms
+25	Drain	VI	2500	100	D	Bosque Farms

pueblos. The range of habitat types that could be sampled was therefore somewhat limited. Two additional plant community types (cottonwood/juniper, C/J; and salt cedar, SC) were recognized in the general study area. These two types are also described in the Results section. Thirty-one transects were established in the general study area, 11 near Bernardo, 5 near La Joya, 5 at the mouth of the Jemez River, 6 on the Cochiti Pueblo, and 4 on San Ildefonso Pueblo. Seventeen of these transects were in the two community types that do not occur in the Bernalillo-to-Bosque Bridge reach. Table 2 lists general study area transects by community and structure type. The precise location of each of these transects is also shown on maps in Appendix XI.

Vegetation

Tree and Shrub Counts

To obtain estimates of tree and shrub density, all trees and shrubs >2 ft tall within 50 ft of each transect line were counted by species and height class (canopy, >10 ft, or shrub, <10 ft). Totals for each species and height class were recorded separately for each side of every 100-ft-long section of transect. A 2500-ft, two-sided transect therefore yielded 50 segments, or plots, each 50-by-100-ft, in which the numbers of trees and shrubs were tallied. After tree counts had been completed on 30 transects, we undertook preliminary analysis of the results. The estimates of tree density obtained from calculations based on data from only 25 of the plots were very similar to (and statistically the same as) the estimates obtained from calculations based on all 50 plots. For the majority of the C-S types, estimates based on counts from only 15 plots still gave similar results for all but the rare species. For the remainder of the transects, then, trees and shrubs were counted in a minimum of 25 plots per transect. For two-sided transects, trees and shrubs were counted along the entire length of the transect, but on alternate sides every 100 ft; e.g., 0-100 ft were counted on the east side of the transect line, 100-200 ft on the west, 200-300 ft on the east, etc. Every plot had to be counted on one-sided transects, such as those along levee edges, to obtain the minimum of 25 plot counts per transect.

Each bole that emerged separately from the ground was counted as one tree, but boles joined above the ground were counted as single trees. Where salt cedar, coyote willow, and seepwillow (*Baccharis salicina*) grew thickly, it was not possible to distinguish individual plants. In these situations, a 4-by-4-ft area covered by the species was counted as one plant. Snags and dead shrubs (brush) were counted in the same manner as live plants.

For each transect, an estimate of the number per acre of each species of tree and shrub was calculated by multiplying the mean number per plot of each species by:

$$\frac{43{,}560\ \text{ft}^2/\text{a}}{5000\ \text{ft}^2/\text{block}} = 8.712$$

Table 2. General study area transects. Under census method, E = modified Emlen, D = direct count. See Results section for descriptions of community and structure types.

Transect	Community type	Structure type	Length (ft)	Width (ft)	Census method	Location
GN-01	Salt cedar/ cottonwood/ cattail (MS)	V	2500	400	E	Jemez River
02	Salt cedar edge (SC E)	VI	2500	400	E	Jemez River
03	Salt cedar	V	2500	800	E	Jemez River
04	Salt cedar	VI A	2500	800	E	Jemez River
05	Salt cedar	VI A	2500	800	E	Jemez River
06	Cottonwood/juniper (C/J)	I	2500	800	E	Cochiti
07	Cottonwood/Russian olive	IV	2500	800	E	Cochiti
08	Cottonwood/juniper	I	2500	800	E	Cochiti
09	Drain	VI	2500	100	D	Cochiti
10	Cottonwood/Russian olive	IV	2500	800	E	Cochiti
11	Cottonwood/juniper	IV	2500	800	E	Cochiti
12	Cottonwood/juniper	IV	2500	800	E	San Ildefonso
13	Cottonwood/Russian olive edge	III	2000	50	D	San Ildefonso
15	Cottonwood/Russian olive	I	2500	800	E	San Ildefonso
16	Cottonwood/Russian olive	I	2500	800	E	San Ildefonso
GS-01	Cottonwood/coyote willow	II	2500	800	E	3 mi NE Bernardo
02	Cottonwood/coyote willow levee edge	I	2500	400	E	3 mi NE Bernardo

Table 2. (cont.)

Transect	Community type	Structure type	Length (ft)	Width (ft)	Census method	Location
GS-03	Drain	VI	2500	100	D	3 mi NE Bernardo
04	Cottonwood-coyote willow	V	2000	100	D	Bernardo Bridge
05	Cottonwood/coyote willow river edge	I	2500	400	E	Bernardo Bridge
06	Cottonwood/coyote willow	I	2500	800	E	Bernardo Bridge
07	Salt cedar	VI	2500	800	E	Bernardo Bridge
08	Salt cedar	V	2500	800	E	Bernardo Bridge
09	Salt cedar	VI	2500	800	E	2 mi S Bernardo
10	Salt cedar	VI	2500	800	E	2 mi S Bernardo
11	Salt cedar	VI	2500	800	E	2 mi S Bernardo
12	Russian olive	V	2500	800	D	La Joya
13	Drain	VI	2500	100	D	La Joya
14	Salt cedar	VI	2500	800	E	La Joya
15	Salt cedar	VI	2500	800	E	La Joya
16	Salt cedar	VI	2500	800	E	La Joya

The sum of the means of all species ">10 ft" was multiplied by the same factor to yield total tree density, and total shrub density was then calculated from the sum of means of all species "<10 ft." Total density was the sum of the total tree and total shrub densities. The snag and brush categories were tallied separately and were not included in any of the totals.

The values for tree and shrub density for each C-S type were obtained by averaging the values of all transects belonging to that type, i.e., each C-S type estimate is a mean of means. The relative density of each species in each of the two layers (canopy and shrub) was calculated by dividing the density of that species by the combined density of all species in that layer.

Percent Cover and Frequency

Percent cover and frequency were estimated only by C-S type. Three transects were used to represent each C-S type whenever possible. For those C-S types that included more than three transects (the majority), the transects in the group with the greatest and the least amounts of total cover were chosen, along with one transect in the intermediate range. Ten sample plots were used per transect, one on each side of the transect line in the center of each interval, for a total of 30 plots per C-S type. For the C-S types that comprised only two transects each, 25 plots per C-S type were sampled.

Each 15-by-15-ft sample plot was centered on a point 25 ft perpendicular to the transect line. Percent cover in the ground layer (0-2 ft) and the shrub layer (2-15 ft) was estimated visually to the nearest 2% (making use of the fact that 1 yd^2 equalled 4% of the total area of the sample plot). The maximum cover value per layer was 100%. A spherical densiometer was employed for estimating cover in the canopy layer (>15 ft). We used the technique developed by Strickler (1959) whereby 1/4 of the densiometer grid (17 intersection points) is read at a time. The observer stood at the center of the sample plot and took one reading in each of the four cardinal directions. The sum over all four readings of the number of points covered by foliage on the densiometer grid was multiplied by 1.5 and the proper correction factor (-1 or -2) was applied, yielding a single canopy cover estimate for the point.

The mean percent cover for each layer by species and for all species combined was calculated (1) for each sampled transect by averaging the 10 plot estimates, and (2) for each C-S type by averaging all 30 points together. Total percent cover in both cases was the sum of the cover values for each layer (maximum = 300%). The relative cover of each species in the canopy and shrub layers was calculated by dividing that species cover value by the combined cover value of all species in that layer.

Frequency values were obtained from records of species occurrence in the cover sample plots. The number of plots in which a particular species occurred was divided by the number of plots in that C-S type to yield percent frequency for that species in that type. Means were calculated for each sampled transect and for each C-S type as for percent cover, above. Relative frequency was also calculated for tree and shrub layers, in the same manner as relative density and relative cover.

Relative importance values (RIV) were calculated for each of the major species in canopy and shrub layers in each C-S type. A species' RIV is the sum of its relative density, relative cover, and relative frequency values. As each of the component relative measures has a maximum value of 100, the maximum possible RIV is 300. The RIV value is frequently divided by 3 to yield importance percent (IP).

Foliage Density Measurements and Foliage Height Diversity

Relative foliage density was estimated for each transect using the MacArthur board technique (MacArthur and MacArthur 1961). Three stations were established on each side of every 500-ft transect interval, and at each station the distance to the nearest vegetation that would cover half of a 9-by-18-in board was estimated (to the nearest ft) at each of the following heights: 6 in, 2 ft, 5 ft, 10 ft, 15 ft, 20 ft, 25 ft, 30 ft, 40 ft, 50 ft, 60 ft, and 70 ft. This yielded a maximum of 12 sample points per station, or 360 sample points per 2500-ft transect. Distance to foliage was used to compute the amount of leaf surface area per cubic unit of space at each of the sample points, using the following formula:

$$\text{Foliage density} = \ln 2/\text{distance}$$

All values for a given height along the transect were then averaged to give a mean value for the relative foliage density at that height for the transect as a whole. These mean values taken together constitute the foliage density profile of the transect. Foliage density profiles were used as variables in subsequent analyses of vegetation structure. The total foliage density for the transect is the sum across all heights of the mean foliage density values.

The foliage height diversity (FHD) value for each transect was also calculated from the foliage density data, using the Shannon-Weaver diversity index:

$$\text{FHD} = -\Sigma\,(p_i \ln p_i)$$

where p_i equals the proportion of total foliage density in a given layer: ground (0-6 in), shrub (5-15 ft), or canopy (>15 ft). The proportion per layer was calculated by dividing the foliage density value for that layer (an average of all sample points within that layer, weighted by the number of feet in that layer) by a total foliage density value (also calculated using sample points weighted by the number of feet they represented).

Multivariate Analysis of Vegetation Structure

Two general types of multivariate analyses were run on foliage density data: multivariate ordination and cluster analysis. The purpose of both types of analyses is to clarify and simplify the pattern of relationships among a number of cases (the transects) that differ on a number of attributes (the foliage profile measurements). Such simplification is possible because the different attributes are usually to some degree interrelated; e.g., transects with much foliage at 6 in are also likely to have much foliage at 2 ft.

Multivariate ordination techniques achieve simplification of relationships among transects by arranging the transects along one or more axes of variation. The principal axis reflects the major trend of variation in the data set, as reflected by the greatest interrelationships among the foliage measurements. Additional axes reflect secondary trends. Because each axis is defined by the foliage measurements, the position of each transect may be plotted on each axis using the foliage measurements of that transect, yielding a graphical representation of the pattern of relationships among transects.

For the ordination analyses, we used the Cornell University Ordiflex program (Gauch 1977) and chose to use three types of ordination techniques: principal components analysis, reciprocal averaging, and polar ordination. Two or more axes of variation were extracted in each ordination, and each transect was plotted against the two principal axes in a scatter diagram.

Cluster analysis seeks to clarify the pattern of relationships among cases by delineating groups of similar cases (transects) hierarchically. For each pair of transects an index of similarity is first calculated, based, in this case, on its respective foliage density. This set of all pairwise similarities of transects is then searched, and transects with the greatest similarities are combined. This procedure is repeated iteratively (with a different pair of transects forming a new cluster, an additional transect being combined with an existing cluster, or pairs of clusters being combined in each step), until all cases (transects) have been hierarchically arranged. The most similar transects group early in the sequence, and groups of quite different transects are combined only in the final steps. Groups of vegetationally similar transects thus form clusters well removed from other, vegetationally different transects.

Several cluster analyses were run using the Clustan program (Wishart 1978). The index of similarity used was euclidean distance, and two different clustering options were used (Ward's method and group average).

In addition to using the complete foliage density profiles as variables in the ordination and cluster analyses, the sample heights were combined into layers in several different ways and analyzed again. The goal of these multiple runs was to determine which combinations of habitat measurements produced the clearest and most understandable pattern.

Results of the various ordination and cluster analyses were used in complementary fashion to detect the patterns of variation in vertical foliage distribution among transects, and hence to identify groups of similar transects. Structure type designations were assigned to six major structural groups. Mean foliage profiles were obtained by averaging foliage density values of all transects within (1) each of the six structural groups, and (2) each C-S type.

Vegetation Type Mapping

Stands of relatively homogeneous vegetation were identified visually on aerial photographs provided by the Corps. These stands were outlined on USGS 7.5-minute topographic quadrangle maps, using a zoom transfer scope. Stands of vegetation were mapped on a relatively fine scale: areas as small as two acres were outlined. Quadrangle maps served as vegetation work sheets, for use by field personnel in ground truthing.

Vegetation patches outlined on the quadrangle maps were checked in the field to ascertain vegetation species composition (community type) and vegetation structure (structure type). Size and shape of the outlined patches were revised in the field, if necessary, to conform to recent changes in the vegetation and to reflect first-hand observations. Impermanent features such as sandbars and vegetation along drains and canals (which are frequently disturbed by dredging, burning, and mowing) were not mapped. Otherwise the maps reflect composition and structure of the vegetation in the valley as of 1982. A description of the criteria used in designating the C-S types precedes the maps, in Appendix XI.

The acreage of each of the mapped vegetation patches was measured directly on the 7.5-minute scale final maps. Most of the patches $\geq$20 acres in size could be reliably planimetered, using the electronic planimeter provided by the Corps. Planimetering of smaller patches and of very narrow strips did not yield repeatable results with the electronic planimeter, so the acreages of such patches were measured using a transparent grid of one-acre-sized squares.

Phenology

To collect data on the timing of phenological events, the first individual of each major tree and shrub species encountered beginning from an arbitrarily chosen point on each transect was tagged. Initially the height, diameter at breast height (dbh), and mean foliage diameter of each were recorded. Sex was also recorded for dioecious species at flowering time. At each transect reading (three times per month), the phenophase (stage of development of buds, leaves, flowers, etc.) of each tree was recorded in a manner similar to that used by Bell and Johnson (1975). At least 25 individuals of each of the following species were sampled: cottonwood, Russian olive, coyote willow, salt cedar, seepwillow, and false indigo (*Amorpha fruticosa*). Fifty-one tree willows were also sampled. Twenty-five were identified as probable Goodding willows (*Salix gooddingii*) and 26 were probably peach-leaf willow (*S. amygdaloides*), but the difficulty of separating the two species made these totals indefinite.

Coded observations were sorted by computer according to species and week. For each species each week, the percent of tagged individuals observed to be at each of the phenological stages was calculated. Sorting, summarizing, and graphical plotting of the data was accomplished by the use of programs in the Statistical Analysis Systems (SAS Institute, Inc. 1979, 1982).

Plant Species Lists

In order to compile a list of the plant species present in the study area, plants were collected along each transect, usually immediately after bird censusing. Collections were made throughout the growing season, and an effort was made to collect each species as it bloomed. We attempted to collect and press at least one specimen of each plant (or twig of unknown trees or shrubs) that occurred in the study area. Pressed specimens were keyed or otherwise identified by project staff, by Dr. William Moir of the U.S. Forest Service in Albuquerque or Dr. Richard Spellenberg. Dr. Spellenberg verified most of the identifications. The University of New Mexico herbarium, the Forest Service herbarium, and a small collection of verified herbarium specimens at the Albuquerque field office of the New Mexico Department of Game and Fish were consulted, and Dr. Spellenberg used comparison material from the herbarium at New Mexico State University. A list of species was compiled and is included as Appendix I.

Endangered, Threatened, and Rare Plant Species

The U.S. Fish and Wildlife Service Review of plant taxa for listing as endangered or threatened species (Federal Register 1983) and the New Mexico Natural Heritage Program list of New Mexico taxa listed, proposed or under review (current as of January 1984) were consulted to find out whether any Federally listed plant species might occur in the study area. Plant species on these lists were checked against range maps in Flora of New Mexico (Martin and Hutchins 1981). Only seven species included in the Federal lists occurred within any of the counties intersecting the study area. Information on the known ranges and habitat associations of these species in Martin and Hutchins (1981) was reviewed to investigate the likelihood that any of them might occur in riparian habitats.

William Isaacs and Rex Wahl of the New Mexico Natural Heritage Program were also consulted regarding rare, threatened, and endangered plants. In addition to their list of (plant and animal) species threatened, endangered or "of special concern" in New Mexico, the Heritage Program maintains a computerized file of information on such species including records of occurrence, with specific localities, by county. Rex Wahl kindly carried out a special search of these files for records of such species from our study area.

Terrestrial Vertebrates

Reptiles and Amphibians

To obtain estimates of relative abundances of reptiles and amphibians in the various C-S types, pitfall traps were established along a representative transect of each non-edge type in the intensive study area. Each pitfall trap consisted of a 4.5-gal plastic bucket sunk below ground level and shaded by a lid or cover 1-2 in above ground level. Ten pitfall traps were set out at approximately even intervals within a 1250-X-100-ft strip centered on the transect line. Efforts were made to place buckets so as to cover the perceptible range of microhabitat variation within the strip and to place buckets where captures appeared likely. The size of the sample plot was determined as follows: traps were set out subjectively to cover the range of variation in microhabitat, with the constraints that traps had to be at least 100 ft apart and within 50 ft of the transect line. A 1250-ft-long strip was required on a test transect that appeared to have a substantial amount of variation in microhabitat.

In 1981, pitfall trap grids were established on 13 transects representing 11 different C-S types, all in the intensive study area. Trapping began in mid-April and continued through the first week of December. In 1982, trapping was begun in mid-March and continued through the end of November. This second year, there were grids on 11 transects in the intensive study area, representing 11 C-S types, but one type (MH V), was dropped, and another (C/CWE III), was added in 1982 (See Table 8 in Results). Ten of the 12 C-S types sampled in the intensive study area were therefore sampled both years. Pitfall traps were on the same transects both years in most cases, but the grids were shifted to different portions of those transects the second year. Sampling was conducted on different transects in 1981 than in 1982 for three C-S types. Dry type V and VI open areas (OP V and OP VI) were also sampled in 1982. (Explanation of the OP types is included under Methods, Open Areas and Artificial Pond.)

Five pitfall trap grids were established in the general study area during 1982. Two regular 10-bucket grids were established in salt cedar habitats at the mouth of the Jemez River (GN-02 and GN-05) and were run through the entire season (March through November 1982). A grid of 20 buckets was set out for a month at a time at each of three additional sites: at Bernardo (August 1982), at San Ildefonso (July 1982), and at Cochiti (September 1982).

Pitfall trap grids in the intensive study area and at GN-02 and GN-05 (Jemez) were checked weekly throughout the season. Traps at Bernardo, Cochiti, and San Ildefonso were each checked twice during the sampling months. Captured animals were measured, sexed if possible, and removed from the sample plots. Searches of the sample plots were carried out each time traps were checked, and additional sightings were recorded. Percent and type of cover on the ground, at 2 in to 2 ft, and above 2 ft, were estimated at each bucket (to the nearest 10%) using a 2-yd circle. The mean of the 10 estimates was the percent cover for that grid.

One pitfall trap open for 24 hours was considered one trap day. Buckets filled with sand, leaves, or water were not included in trap-day totals. Table 8, in the Results section, gives number of trap days for each C-S type each year.

Data were summarized as follows: capture rates were calculated by month for each species in each C-S type by dividing the total number of individuals of that species captured by the total number of trap days in that type that month. Yearly capture rates for each species in each type were obtained by dividing the total number of captures of that species by the total number of trap days for the type that year. Total capture rates (all species combined) were calculated for each C-S type each month by summing species capture rates. The yearly total capture rate for each C-S type was the mean of the monthly total capture rates. The overall total capture rate for each type was the average of the 1981 and 1982 yearly total capture rates. All capture rates were expressed as number per 100 trap days. Number of species was always the total number captured in that C-S type, per year or over both years combined.

A Student's t-test (Sokal and Rohlf 1969) was used to determine whether there was a significant difference between 1981 and 1982 capture rates. The yearly total capture rates of only those 10 C-S types that were sampled both years were used in the t-test. Mann-Whitney U-tests (Siegel 1956) were used for pairwise comparisons of 1981 and 1982 total capture rates for each C-S type to test whether there were significant differences in total capture rates between years in any of the types. The Kruskal-Wallis one-way analysis of variance (Siegel 1956) was used to test whether there were significant differences among the C-S types with regard to total capture rate (1) for each year and (2) for both years combined. The variables used in the C-S type analyses were the monthly total capture rates for each type. Pearson product-moment correlations (Sokal and Rohlf 1969) were run between the 1981 and 1982 yearly mean total capture rates for each C-S type to test whether there was a significant association between the by-type capture rates for the two years. The test was repeated for the 1981 and 1982 capture rates by C-S type for each of the three most frequently captured species.

Associations between the overall total capture rate for each sampled transect and several vegetation variables were also tested for significance using Pearson product-moment correlations. Vegetation variables tested were percent cover, foliage volume (0-6 in, 0-2 ft, 0-5 ft, 0-15 ft, and total), and patchiness index (same categories as foliage volume).

Small Mammals

Small mammal populations were sampled with snap-trap grids consisting of 30 trap stations arranged in two parallel lines 50 ft apart. The 15 stations on each line were set 50 ft apart, so that the total dimensions of the grid were 750 X 50 ft. Two museum special traps and one rat trap were placed at each station (within an area of approximately 1 yd^2), yielding a total of 90 traps per grid. Traps were baited with rolled oats and peanut butter mixed with 1/24 volume of dimethyl phthalate to repel ants (Anderson and Ohmart 1977), and they were checked and reset each day for three consecutive days. This gave a total of 270 trap nights per grid. Number of captures of each species over the three days was totalled to give an estimate of relative density, expressed as the number of captures per 270 trap nights.

Percent vegetation cover was recorded for a yd^2 plot at each trap station to provide information on microhabitat characteristics of the grid. Percent and type of cover were estimated to the nearest 10% at ground level and from 2 in to 2 ft, and to the nearest 25% above 2 ft.

Standard external body measurements were taken for each captured mammal, including weight, total length, tail length, hind foot, and ear. Animals were then dissected for measurement of reproductive organs. Testis length and width and length of seminal vesicle were measured on males, and females were checked for mammary gland development and presence of placental scars, embryos, and follicles. All specimens were then frozen and periodically transported to Dr. Charles Thaeler at New Mexico State University for confirmation of species identification. One or more individuals of each species were prepared by Dr. Thaeler as voucher specimens, to be preserved in the mammal collection at New Mexico State University at Las Cruces. A list of 194 preserved mammal specimens is given in Appendix IX.

Mammal trapping was initiated in May 1981 and continued through the end of the study in January 1983. During these 21 months, 266 trap grids (71,820 trap nights) were run. Most C-S types were trapped 10 to 12 times over the course of the study (approximately every other month), with the trapping effort in each type distributed as evenly as possible across the year. Two representative C-S types, one with a high mammal population density and one with a relatively low density, were selected for more frequent (approximately monthly) trapping in the effort to assess annual fluctuation.

Three uncommon habitat types were sampled by trapping in an effort to locate populations of rarer species and to better cover the range of small mammal microhabitats in the study area. Wet edge habitats (WET E V) and small dry openings (OP V and VI) were sampled to complement the survey of small open areas. Wet meadows (MH VI), which occur over a limited area primarily near Isleta Marsh, were trapped in an effort to locate populations of the woodland jumping mouse (Zapus hudsonius luteus) and the tawny-bellied cotton rat (Sigmodon fulviventer). Twenty-five designated C-S types were sampled by snap trapping, and 20 of them were trapped at least 10 times over the course of the study. Table 13, in the Results section, gives the number of trap grids per each C-S type sampled.

Two seasons were defined empirically, based on observed fluctuations in total capture rates. "Summer" was April through October and "winter" was November through March. Thus the small mammal population data cover four seasons altogether: summer 1981 and 1982, and winter 1981-82 and 1982-83.

Trap data were summarized as follows: capture rate of each species in each C-S type was the mean of that species' per grid capture rates in that type. Total capture rate (all species combined) for each C-S type was the mean of the per grid total capture rates. Total capture rates were calculated for each C-S type each season (seasonal total capture rates) and over the entire two years of the study (overall total capture rates). Because of relatively small sample sizes per C-S type within a season, further seasonal analysis was carried out using seasonal means across all C-S types (mean total capture rate). Mean total capture rate for a given season was calculated two ways: as an average (1) of the seasonal total capture rates of all C-S types trapped that season and (2) of only those 16 types trapped in all four seasons. The major portion of the analysis focused on overall total capture rates. All capture rates were expressed as number captured per 270 trap nights (which is equivalent to the number captured per grid). In all cases, the number of species was the total number trapped in that C-S type or during that season.

Distributions of the total capture rate data by grid for each C-S type were tested for normality using the Shapiro-Wilk W-statistic (Shapiro and Wilk 1965) and for equality of variances using Levene's test (Brown and Forsythe 1974b). For the majority of C-S types, the distributions were non-normal. Two different methods were then used to test whether differences among C-S types in total capture rate were significant. First, the Kruskal-Wallis one-way analysis of variance by ranks (Siegel 1956) was applied to the raw data to test for differences among types. The data were then transformed using log(n + 1), which yielded normal distributions for all but five types. A one-way analysis of variance statistic that does not assume equality of variances (Brown and Forsythe 1974a) was then used to test the log-transformed capture rate data for significant differences among C-S types. To locate where within the set of 25 C-S types the differences occurred, simultaneous separate-variance t-tests were run for all pairwise comparisons of the 25 types. A Bonferroni probability of $P \leq 0.000171$ was equivalent to significance at the $P \leq 0.05$ level for a particular comparison (Neter and Wasserman 1974). The UNIVARIATE program of the Statistical Analysis System (SAS) was used to test for normality, and the SAS NPAR1WAY program calculated the Kruskal-Wallis statistic (SAS Institute, Inc. 1979). One-way analysis of variance, t-statistics, and the Bonferroni probability level were computed by the Biomedical Computer Programs (BMDP) P7D program (Dixon 1983).

An effort was made to compare small mammal populations in recently dredged drains with populations in undredged drains, and to sample drains of structure types V and VI. The former objective was accomplished during the first year of sampling, as several sections of drains were dredged in spring 1981 and then left undisturbed through winter of that year. Recently dredged and undredged drains were trapped six times each during this period. This effort, as well as the attempt to separate most drains into structure types V or VI, was dropped after the first winter as it became apparent that vegetation along drains in general was subject to frequent disturbance (approximately every second year) due to burning, mowing, and dredging operations. With three exceptions, a particular drain transect could not be characterized as dredged or undredged, or as structure type V or VI, except in the short term. Of the DR transects which were sampled by snap trapping, only three (KW-03, SW-30, and SW-32) had not been disturbed for a relatively long time (>5 years) and could be designated as type V throughout the study. A second comparison was therefore made between the periodically dredged DR VI transects and the relatively undisturbed DR V transects. It should be noted, however, that in late summer, type VI drains that had not been disturbed for a year or so could support sufficient vegetation to merit temporary designation as structure type V.

The potential impact of human recreational and other activity in an area on small mammal populations was examined in C/RO I and C/CW IV by comparing trap data from transects in the "heavy human use" area in Albuquerque with data collected on transects of the same C-S types in less-used areas.

For dredged/undredged drain and human impact comparisons, Mann-Whitney U-tests (Siegel 1956) were used to compare total capture rate data and also capture rates of selected species. Differences in the frequency of capture of different species were examined using G-tests (Sokal and Rohlf 1969).

Large Mammals

Systematic searches for tracks and sign of large mammals were made three times a month on each transect after bird censusing. In addition, sightings, sign, and roadkills of mammals throughout the study area were recorded. New Mexico Department of Game and Fish trapping surveys for 1980-82 were consulted, and trappers and a fur buyer were interviewed to obtain additional information and to provide an historical perspective.

Avian Populations

Each transect in the intensive study area was censused at least twice and generally three times monthly to estimate bird population densities and species richness. Transects were censused by one of two different methods, depending on the size of the habitat patch or stand in which the transect was located. For the majority of transects, those that were in patches at least 2000 X 800 ft or along one edge of a stand at least 2000 X 400 ft, censusing and calculation of estimated bird density was accomplished through a technique first described by Emlen (1971), modified by Balph et al. (1977), and further modified by us (Anderson et al. 1977). For transects censused by this technique, the census area in a particular vegetation stand was considered to extend 412 ft lateral to the census line on both sides. Thus, a standard transect 0.5 mi long, censused 412 ft on each side (824 ft total), encompassed approximately 50 acres.

When conducting the census, the observer slowly walked the length of the transect and recorded all bird species seen or heard within the census area. Each detection was recorded as being 0-50 ft, 50-100 ft, 100-200 ft, or 200-400 ft lateral to the transect, and its location as to transect interval was also recorded. At the conclusion of the census, each species had a distribution of detection points with a peak of the distribution in one of the distance categories listed above. The peak of distribution occurred at that distance beyond which detectability of that species decreased. It was determined by selecting the number of detections in a given distance interval that when summed with the detections in the intervals closer to the transect line and multiplied by the lateral distance conversion factor, yielded the highest population estimate. Lateral distance conversion factors for the distance intervals of 0-50 ft, 0-100 ft, 0-200 ft, and 0-400 ft were 8.24, 4.12, 2.06, and 1.03, respectively, and they served to extrapolate the peak number of detections over the entire census area. The resulting population estimate was then expressed as the number of birds per 100 acres. This technique was applied individually to each bird species, the density of each species was rounded to the nearest whole number, and the species totals were then summed to yield a total bird density.

Transects located in narrow strips of habitat (100-300 ft in width), or in small patches, were censused by direct count. In such counts the observer recorded all birds detected within 50 ft lateral to the transect line, or out to 100 ft on one side for drain transects. Because of nearly complete visibility and the lack of vegetation to mask the censuser from the birds on sandbars (SB VI) and in open water (RV), birds detected out to 200 ft were direct counted. The total number of individuals of each species was divided by the number of acres censused to yield an estimated number per unit area. Since the actual areal extent of direct-counted C-S types other than DR V and VI was not much greater than the approximately 5.7 acres covered by the typical direct-count census strip, it is somewhat misleading to extrapolate the results to density per 100 acres; these C-S types did not occur in 100-acre patches and if they had, they might well have supported higher numbers of species and different (higher or lower) population densities of birds. However, extrapolation of density over an area of only 5 acres greatly increases rounding error and yields poorer resolution of differences in density among the C-S types than extrapolation over a larger area. Therefore, for purposes of comparison of direct-counted C-S types with Emlen-counted C-S types, population estimates were extrapolated and expressed as the number of birds per 100 acres. We emphasize that these estimates are to be interpreted as the number of birds and numbers of species per 100 acres of the habitat as it presently exists in the study area, i.e., as a series of small (5 to 10 acres) patches. Again, total density was the sum of the species densities. Transects and habitat types censused by direct count are indicated in Table 1.

Within a month, each transect was, in most cases, censused by three different observers to reduce bias due to possible variation among observers, and each observer generally censused every transect in the study area once every two months. One observer censused a group of two to three transects in a morning, during the first three hours after sunrise. The order in which the transects in the group were censused, as well as the end of the transect from which the observer started the census, were alternated wherever possible to reduce the potential bias of decreased bird activity from early morning to late morning.

For transects in the intensive study area, bird densities were computed on a monthly basis as the average of at least two, and generally three, censuses. Species richness was the total number of species detected within the month in densities $\geq$0.5 per 100 acres.

Bird population data for the intensive study area transects were also analyzed on a seasonal basis. For this study, four 3-month seasons were recognized: Spring included March-May; Summer was June-August; Fall was September-November; and Winter was December-February.

General study area transects were sampled on a seasonal basis only, with each transect censused three times during each 3-month season. Bird density and species richness were computed for each transect on a seasonal basis by averaging data from the three censuses. Species richness was the total number of species with a density $\geq$0.5 per 100 acres over the three censuses. As in the intensive study area, densities and species richness in direct-counted C-S types were also expressed as the number of birds per 100 acres.

Data for both intensive and general study areas were summarized by C-S type for each season as follows: data from all transects of one C-S type were averaged to yield seasonal density and species richness values for that type. The species richness value was the total number of species present in that C-S type in densities $\geq$0.5 per 100 acres overall within the season. The total number of species detected over all transects in each C-S type each season was also tallied.

To permit more accurate comparison of C-S types censused by Emlen count with those censused by direct count, all Emlen-counted transects were re-analyzed as though they had been direct counted, i.e., counting only those birds detected within 50 ft on either side of the transect line. Calculations for each month and season were carried out as for direct-count transects, and the resulting densities and species richness values were expressed per 100 acres.

Sampling of avian populations in the intensive study area was begun shortly after the first transects were established in February 1981, and each transect was censused as soon as it was completed. The set of transects was largely complete by June 1981, and censusing continued through January 1983. General study area transects were established during June, July, and August 1981. All but the five northernmost of these transects were censused three times each during the 1981 summer season, although some of these censuses were rather late in the summer (late July through August). All general study area transects were censused three times each subsequent season until the second winter (1982-83), when each could be censused only twice.

In analysis of avian population data, a variety of parametric and nonparametric statistical tests were employed. These tests are referenced in the Results section as appropriate. The major sources consulted were Sokal and Rohlf (1969) and Siegel (1956). Statistical software programs in the Statistical Analysis System (SAS Institute, Inc. 1979, 1982) and BMDP Statistical Software (Dixon 1983) were used in carrying out many of the analyses.

Habitat breadth (HB) was calculated for selected species in summer and winter. Six community types were used: C/RO, C/CW, RO, DR, and SB/RV (sandbar and river channel combined). Edge transects were included with their respective vegetation communities. A single estimate of density for each species in each community each season was obtained by averaging 1981 and 1982 seasonal densities. Habitat breadth was calculated using the information theory equation:

$$HB = - \Sigma \, p_i \ln p_i$$

where p_i is the proportion of the density of each species in the i^{th} community type. Percent of maximum HB was calculated by dividing the HB value for the species by the maximum possible HB value, which is $\ln 6 = 1.7918$ when total density is evenly distributed among all six communities.

Forty-seven bird specimens, representing 28 different species plus one hybrid (Black-capped Chickadee X Mountain Chickadee [Parus atricapillus X P. gambeli]) were obtained through collection and salvage. All bird specimens were turned over to Dr. J. David Ligon of the University of New Mexico, to be curated in the collection of the Museum of Southwest Biology at the University of New Mexico. A list of bird specimens is given in Appendix IX.

Raptor/Large Bird Counts

To estimate the relative numbers of large birds (raptors, ducks, geese, cranes, shorebirds, herons, egrets, pheasants, kingfishers, roadrunners) in different portions of the valley, seven auto census routes were established within the intensive study area. Census routes ranged from about 5 to 12 mi in length and followed the levee roads. Table 3 gives the length and location of each route.

Each route or raptor transect was censused three times a month, each time by at least two observers. They drove 12-15 mph and recorded by species all large birds seen or heard in the riparian woodland and in the adjacent agricultural or residential land. The census routes were divided into 0.5 mi segments, or intervals (measured by odometer from fixed points), and each detection was localized to a particular interval. Raptors and large birds were censused once during March 1981 and three times per month thereafter.

Data were summarized separately for each transect. For each census, the following quantities were calculated: number of detections per 10 mi for (1) each species, (2) designated groups of species, e.g., raptors, ducks and geese, herons and egrets, and (3) all species combined. Number of detections per 10 mi, or detection rate, was the total number of detections on that transect divided by the transect length in miles, times 10. Detection rates for species groups and for all species were the sum of the individual species detection rates. The number of species and number of species per group were also tallied.

Data were summarized by month for each transect as follows: species' detection rates for the three censuses within the month were averaged to give the monthly detection rate for that species. The monthly detection rates for all raptors and for all species were also averages based on the three censuses. The number of species for the month was the total number of species seen on the transect during the month.

Seasonal and yearly detection rates were averages of the monthly detection rates for each category. Again, the number of species was the total for the season or for the year.

Table 3. Raptor/large bird census routes.

Number	Length (miles)	Number of 0.5 mi intervals	Side of river	Location
1	7.8	16	West	From Alameda Bridge north through Corrales
2	8.9	18	East	From Central Avenue Bridge north to Alameda Bridge
5	4.3	9	West	From the south end of Isleta Marsh south to Los Lunas Bridge
6	8.3	17	East	From 1 mi south of Isleta Bridge south to Los Lunas Bridge
7	12.4	25	West	From Los Lunas Bridge south to Belen Bridge
8	11.8	24	East	From Los Lunas Bridge south to Belen Bridge
9	8.4	17	West	From Belen Bridge south to Bosque Bridge

Artificial Pond

In order to evaluate the potential for creating pond or marsh habitat by excavating sub-water table borrow pits within the riparian corridors, and to assess the value of such areas to wildlife, an artificial pond was constructed near Los Lunas by the Corps of Engineers. Sampling was carried out at the site of the artificial pond both before and after construction. A 500-ft transect line (SW-07) following the center line of the future pond was established in April 1981. The line extended about 250 ft beyond the area to be excavated. The location of the pond and transect line are mapped in Appendix XI. Birds were direct counted three times a month in a 400-X-500-ft plot centered on the transect line.

Prior to construction, relative foliage density was estimated at three points on each side of the line, by the method described previously. All trees and shrubs within 50 ft of the line on both sides were counted by species in >10- and <10-ft height classes to obtain an estimate of tree density and to describe species composition on the plot. Fifteen 50-ft long line intercepts were used to roughly estimate (to the nearest ft) tree and shrub cover. Small mammal, reptile, and amphibian populations were sampled along a transect adjacent to the pond site (SW-06).

The pond was constructed during January and February of 1982. Most of the trees and shrubby vegetation in the immediate area of the pond were removed during construction. To monitor reestablishment of vegetation in the area, five line intercepts were established perpendicular to the pond's gradually sloping south side, running from the water's edge to the outside of the berm, in summer 1982. Percent cover was estimated to the nearest cm in each of three layers (0-2 ft, 2-15 ft, >15 ft) along each of the intercepts in August 1982, when foliage density was at a maximum for the year. Each intercept was marked by permanent posts, and it was intended that these measurements be repeated annually to continue monitoring of the area's development. Photographs were taken at each post when line intercepts were run.

The open area immediately surrounding the pond (designated OP VI) was trapped for small mammals twice during the year following construction, and 10 pitfall traps were placed around the periphery of the pond to sample reptiles and amphibians in the area. Regular observations of the flora and fauna of the site were made by the study team and by Mark Sifuentes of the Corps. Photographs were taken at five designated points around the periphery of the pond approximately every three months to document vegetation development.

Open Areas

To gain additional insight into the probable effects of creating openings, e.g., of excavating borrow pits, within the woodland zone it was deemed necessary to gather specific data concerning wildlife use of existing openings and the woodland edges surrounding those openings. Sample plots were established at seven locations to monitor 14 existing openings within the woodland. The openings varied in size and character. Nine were wetlands, either ponds (WET OP VI), like Shady Lakes (a group of artificial trout fishing ponds), or small marshy areas (WET OP V), such as those which occur at the periphery of the woodland near Isleta Marsh. The remaining five were dry openings (OP V, OP VI) such as old borrow areas or the periodically cleared strips below gas pipelines at river crossings. Table 4 lists the various opening/edge sample sites. The locations of these sites are indicated on the maps in Appendix XI.

The woodland edge (EG) adjacent to each opening (OP) was marked off in one or more 500-ft-long intervals, depending on the length of the opening. The total length of woodland edge sampled was 20 500-ft strips, the equivalent in length of three-and-a-half 2500-ft transects. Thirteen of the intervals were adjacent to wet openings, and the remaining seven were adjacent to dry openings (see Table 4).

Since the small size of these areas made our usual sampling methods inappropriate, they were modified as necessary. To sample avian use of openings and adjacent edges, all birds within the openings were direct counted, and birds within 50 ft of the woodland edge along the marked interval(s) were direct counted; 50 ft was subjectively set as the limit of the area likely to be most influenced by edge effects. Along with the opening/edge censuses, a comparison site (CT) in the interior of the woodland of approximately the same dimensions and area as the edge plot(s) was censused by the same observer and/or on the same day, also by direct count. Comparison sites were matched as closely as possible to the edges in terms of species composition and structure and were generally less than 0.5 mi from the opening/edge sites. Beginning with October 1981, each opening/edge/interior set was censused three times per month for one year, from October 1981 through September 1982.

For sampling mammals within the openings, the same number of traps was used as for other grids, and stations were all 50 ft apart, but the traps were set out in a grid pattern in openings less than 750 ft long. Ten pitfall traps to sample reptiles and amphibians were set out in the largest of the dry openings along two parallel strips (approximately 750 X 100 ft and 400 X 100 ft) from March through December 1982. Dry OP V sites supported vegetation similar to C/CW V, and dry OP VI were open fields with scattered shrubs, like a sparse C/CW VI habitat. The "OP V" and "OP VI" C-S types included in summaries of small mammal and herptile data refer to the dry small opening sample sites. WET OP V sites were cattail (*Typha latifolia*) marsh (MH V) and wet OP VI sites were ponds.

RESULTS AND DISCUSSION

In this section, presentation of summarized data, analysis of data, and discussion of findings are integrated into a narrative. Additional data summaries are included as appendices.

Summaries, analyses, and discussion are primarily at the C-S type level, with reference to the more inclusive categories of community type and structure type where appropriate. Although transect data formed the basis of all analyses, space constraints preclude presentation or discussion of results at this level. Data on particular transects are available upon request.

Table 4. Open area sample sites. Most of the open area transects included two or more individual openings. Each of the openings on a transect is listed separately in Columns 3-5, and is designated by OP number in column 3.

Site	Open area (OP) transect	OP No	Type	Approximate size (acres)	Edge (EG) transect	Number of intervals	Length (feet)	Interior comparison (CT) transect	Community/ structure type	Number of intervals
Shady Lakes	OP-01	1	Pond	2	EG-01	2	1000	CT-01	C/RO I	2
		2	Pond	3.5						
Isleta Marsh	OP-02	1	Marsh	2.9	EG-02	4	2000	CT-02	C/CW I	4
		2	Marsh	2.1						
		3	Marsh	0.5						
		4	Marsh	1.3						
Montaño	OP-04	1	Dry V	2	EG-04	1	500	CT-02	C/RO III	1
Isleta	OP-08	1	Dry V	3.8	EG-08	2	1000	CT-08	C/CW I	4
		2	Dry V	0.8						
Belen	OP-17	1	Pond	3.5	EG-17	3	1500	CT-17	C/RO I	2
Bosque	OP-19	1	Dry VI	1.8	EG-19	4	2000	CT-19	C/RO I	4
		2	Dry VI	2.5						
Madrone	OP-20	1	Pond/Marsh	10.5	EG-20	3	1500	CT-20	C/RO I	2
		2	Pond/Marsh	2.2						
TOTALS		14		39.4		19	10,000			19
Pond and Marsh		9		28.5		12	6500		C/RO	11
Dry		5		10.9		7	3500		C/CW	8

Biohistorical Account

Because the Middle Rio Grande Valley had been settled, and irrigated agriculture had been practiced for over 200 years before the first written accounts, we have no descriptions of the valley prior to human modification. It has been estimated that over 25,000 acres of land were irrigated and farmed by the Pueblo Indians in the area between Cochiti and San Marcial prior to the arrival of the Spanish (Burkholder 1928, USDI Bureau of Reclamation 1977). The information we were able to review from early Spanish accounts was largely anecdotal. Castañeda, chronicler of Coronado's expedition through the area in 1540, commented on the abundance of geese, cranes, turkeys, and other native fowl in the valley (quoted in Bailey 1928). Turkeys formerly came down inuo the valley from the nearby mountains during winter (Bailey 1928) and apparently were domesticated by the Pueblo Indians (Espejo 1582 and Oñate 1599 in Boulton 1908). The Spaniards also noted the existence of "many salines on both sides of the river" (Espejo 1582), suggesting that poor drainage conditions prevailed in portions of the valley.

Josiah Gregg in 1844 described the river near Santa Fe as several hundred yards wide but quite shallow, often less than knee-deep, with cottonwoods "scantily scattered along" its banks, except that the banks were "nearly bare throughout the whole range of settlements," owing to cutting of wood for fuel (Gregg 1844). J. W. Abert travelled the valley between Socorro and Santa Fe in 1846-47, taking detailed notes on wildlife and collecting specimens. He recorded seeing mallards, "brant" (Canada Geese [Branta canadensis]), snow geese, "blue" cranes, sparrow hawks (American Kestrel [Falco sparverius]), quail, "red-winged" flickers, a "sapsucker" (=White-breasted Nuthatch [Sitta carolinensis]), western meadowlarks, and many muskrats, as well as noting large flocks of sheep and cattle. He described the Rio Grande near Socorro as a "magnificent stream winding along, its apparent continuity broken by meanders and islands, so that it looked like a chain of silver lakes" (Abert 1848). Abert mentions large cottonwood trees, often infested with mistletoe, near Socorro and Valverde, and describes the valley near La Joya as "heavily timbered with cottonwood." Like Gregg, however, he noted an absence of trees near human settlements: there was no wood to be had within 9 to 10 miles of Albuquerque (Abert 1848).

The earliest detailed information on floodplain vegetation communities was given by Watson (1912). He described two major floristic associations: (1) cottonwood forest, composed of open nearly pure stands of Rio Grande cottonwood, with a few willows and scattered clumps of Baccharis wrightii and Cassia bauhinioides [=Senna bauhinioides], and on the ground Juncus balticus, Trifolium rydbergii [=T. longipes var. reflexum], Aster spinosus and little grass; (2) a wet meadow-like association dominated by Juncus balticus and Houttuynia [=Anemopsis californica]. Baccharis wrightii, Amorpha fruticosa, Helianthus annuus, Dyssodia papposa, Onagra jamesii, and Rumex berlanderi also occurred in this association. Watson described the cottonwood forest as uniform and composed of small trees, attributing the trees' small size to their being harvested for fuel and fence wood. Exposed mudbanks colonized by cottonwood, willow, and cattails (Typha sp.) were considered to be an early seral stage in cottonwood forest succession. He also noted that dense thickets composed of Cassia, willows, sunflowers, Solidago canadensis var. arizonica, and others grew along irrigation ditches. In another publication, Watson (1908) noted that salt cedar was commonly planted in Albuquerque as a hedge plant, but does not mention it growing in the wild, and he does not mention Russian olive at all.

A series of maps showing natural vegetation and land use of the valley in the area between Cochiti and San Marcial were drawn up in 1917-1918 in connection with a land use survey. These will be discussed in a later section.

Fergusson (1931) described the valley (prior to extensive levee construction) as wide and scarred with abandoned channels that "except in very dry seasons, tend to fill with stagnant alkaline waters... furnishing refuge for wild fowl and for countless striped water snakes [probably common gartersnakes, Thamnophis sirtalis] and green frogs [probably leopard frogs, Rana pipiens]." The river was edged by a strip of dense cottonwood forest, about 20 or 30 feet high, and then by a "narrow belt of marshy meadow where the coarse grass is grizzled with alkali." Close to the river channel stands of trees frequently washed out and regenerated as the river meandered, but away from the channel they developed into groves of mature trees.

Agricultural development had increased under Spanish and Anglo settlement to a maximum of over 124,000 acres under irrigation by the 1880's, but drainage problems and increasing salinity, along with water shortages, caused the abandonment of nearly 85,000 acres by the late 1920's (Burkholder 1928). Burkholder's report discussed the results of the 1918 land use survey and detailed plans for the construction of a valley-wide drainage system, along with plans for rehabilitation of the irrigation canals and the levees.

A number of changes took place in the flora and fauna of the floodplain around this time. Both salt cedar and Russian olive had apparently escaped from cultivation sometime after 1910, and began to spread in the 1920's. Salt cedar began to increase rapidly in the 1920's and had become widely naturalized between 1929 and 1936 (Thompson 1958, Robinson 1965). Russian olive, first collected on the floodplain in 1920, was widespread by 1935 (Freehling 1982). Mink (Mustela vison), which had been captured in Los Lunas (Findley et al. 1975) and are said to have occurred as far south as La Joya and Elephant Butte (C. J. Mitchell [fur buyer] pers. comm.), were last reported in the valley just before 1920, and river otters (Lutra canadensis), which had been reported prior to 1930 in the northern part of the study area near Española (Bailey 1932, C. J. Mitchell pers. comm.), have also disappeared. Bullfrogs (Rana catesbeiana) were introduced sometime in the early 1930's (Little and Keller 1937), possibly initiating the decline of the leopard frog population in the valley (Applegarth 1983). The first records of Red-headed Woodpeckers (Melanerpes erythrocephalus) for the valley (and for the state) also date from around this time (Leopold 1919 a, b).

Van Cleave (1935) described floodplain vegetation communities during this period, and detailed the changes that took place as a result of drainage. She described five types of floodplain communities present prior to the construction of drains: (1) Small lakes maintained by river seepage. These supported aquatic plants (Lemna minor, Chara sp., Myriophyllum spicatum, Ceratophyllum demersum) and algae and were edged by a marsh-like community and a fringe of woody vegetation, including willows, cottonwood, salt cedar, and Russian olive; (2) Swampland (=marsh), composed of cattail (Typha sp.), sedges (Carex sp., Eleocharis sp.), rush (Juncus sp.), scouring rush (Equisetum hiemale), watercress (Radicula nasturtium-aquaticum), and buttercup (Ranunculus cymbalaria), also fringed by woody vegetation; (3) A wet meadow-like community where the water table was at or just below the surface, which supported sedges, rush, salt grass (Distichlis spicata) and yerba-mansa, similar to the Juncus-Houttuynia [=Anemopsis] association described by Watson (1912). This was the most extensive habitat type in the valley; (4) Grass-woodland bosque on elevated sites in the meadowland, composed of willows (Salix argophylla = S. exigua), cottonwood, salt cedar, and Russian olive, with an understory of salt grass, yerba-mansa, fleabane (Erigeron philadelphicus) and horseweed (Leptilon canadense); (5) Cottonwood-willow forest along the river, several hundred yards wide, with little understory vegetation except patches of salt grass where alkali had accumulated, or sparsely distributed herbaceous plants. The cottonwood-willow forest was noted as being frequently flooded, and Van Cleave does not mention salt cedar or Russian olive in it.

After drainage, the lake and marsh communities "disappeared almost immediately" (i.e., within the first year), and these sites were quickly invaded by cottonwood, willow, salt cedar, and Russian olive. The meadows became drier and many were made into agricultural fields, and the willows in the woodland bosque and the river edge cottonwood-willow forest died out. Vegetation communities similar to those of the former swamps and lakes developed along the margins of the drains, though they were limited in extent due to steep sides and the moving currents. Borrow areas also developed this type of vegetation if they were below the water table.

There is no published information on the biotic communities of the valley between 1935 and the 1960's. Around the early 1960's the Bureau of Reclamation apparently conducted some vegetation surveys in the area between Bernardo and San Acacia (USDI Bureau of Reclamation 1977), the results of which we were unable to review due to time constraints. Aerial photographs of the valley from Cochiti to San Marcial were also taken in 1962 (to be discussed in a later section). By this time Russian olive and salt cedar had invaded the river edge riparian forest and become well-established there (Campbell and Dick-Peddie 1964). The cottonwood forest communities described in Campbell and Dick-Peddie's study are similar to those present in the study area today.

Vegetation

Community Types

Most of the study area north of Bernardo was dominated by cottonwood, which occurred in association with a variety of understory shrubs and small trees, chiefly Russian olive, coyote willow, salt cedar, seepwillow, indigo bush, New Mexico olive (Forestiera neomexicana) and, in the northern portion of the general study area, one-seed juniper. Goodding and peach-leaf willow trees also occurred locally in stands of cottonwoods but in relatively low numbers. We recognized three major cottonwood-dominated community types based on the type and abundance of understory species. The first two occurred throughout the study area, while the third was limited to the northern portion of the general study area.

Cottonwood/coyote willow (abbreviated C/CW) communities had a mixed understory that may have included all the aforementioned species. The most abundant understory plant was usually coyote willow, followed by salt cedar and Russian olive or seepwillow, in either order. Ground cover consisted of mixed grasses and forbs. The degree of dominance of the understory species varied, presumably in relation to successional stage and various environmental factors such as soil conditions, depth of the water table, amount of sunlight penetrating to lower layers, and local history. Drain habitats (DR) were most often dominated by cottonwood and coyote willow and may be considered part of the C/CW community.

Cottonwood/Russian olive (C/RO) communities were characterized by a nearly monotypic understory of dense to moderately dense Russian olive. Some of the larger Russian olive trees were $\geq$40 ft high, reaching into the cottonwood canopy. In the northern part of the general study area, New Mexico olive was common in the shrub layer in some stands, especially at San Ildefonso. Herbaceous growth was sparse to absent.

Cottonwood/juniper (C/J) communities occurred in the northern part of the general study area. The principal understory plant in these cottonwood communities was one-seed juniper, but Russian olive, New Mexico olive, snakeweed (*Gutierrezia sarothrae*), and rabbit brush (*Chrysothamnus nauseosus*) also occurred in the understory. There was little herbaceous growth, and these communities were relatively open and sandy.

In addition to the cottonwood communities, we recognized two other types of vegetation communities in the intensive study area. Russian olive (RO) communities occurred mainly in narrow strips (approx. 50-200 ft wide) adjacent to the river channel. They were dominated by young to intermediate-aged Russian olives with a maximum height of about 20 ft. Coyote willows, patches of seedling cottonwood trees, salt cedar, and seepwillow also occurred in these stands in lesser numbers, and there was a thick layer of mixed grasses and forbs covering the ground. The stands we surveyed were apparently about 5-10 years old.

Cattail marsh (MH) communities occurred in areas that were frequently inundated. Cattail was overwhelmingly dominant, but some bulrush (*Scirpus acutus*) and sedge also occurred in these communities. Mixed forbs, and occasionally coyote willow, grew along marsh edges and in the drier portions of the habitat. Wet meadows dominated by salt grass and sedges were also considered to be marsh communities.

Sandbars (SB) and the river channel (RV) were treated as separate community types. Sandbars, the largest of which were up to 0.4 mi long and 300 ft wide, were primarily bare sand but occasionally supported patches of sparse grass, annual plants, and cottonwood seedlings, or isolated clumps of coyote willow. The area of exposed sand varied with the amount of water in the river channel, and most were inundated during the high flows of June 1982. Channel width varied from over 400 ft (bank-to-bank), during high flows, to 0 ft, during late summer 1981, when diversion of water for irrigation left most of the riverbed dry.

Salt cedar (SC), common as an understory plant through much of the intensive study area, was the dominant plant species throughout much of the southern portion of the general study area. It dominated the riparian flora of the study area from Bernardo to San Acacia, where most of the cottonwood bosque was apparently cleared. Salt cedar communities were also found in a limited area of the northern general study area, at the mouth of the Jemez River. Most stands were essentially monotypic salt cedar, with widely scattered wolfberry (_Lycium andersonii_) shrubs or (from La Joya south) patches of arrowweed (_Tessaria_ [=_Pluchea_] _sericea_) in more open parts of the stand. There was a sparse to dense layer of grasses with some forbs in SC communities. In the two most xeric sites at Jemez, the individual salt cedars were widely spaced, rabbit brush, sagebrush (_Artemisia dracunculoides_), and snakeweed were relatively frequent, and there was little herbaceous growth.

Structure Types

Vegetation stands were also characterized according to structure or vertical distribution of foliage. We recognized six structure types, which were defined by two general factors: overall height of the vegetation, and amount of vegetation in the lower layers. Figure 3 presents mean foliage profiles for each of the six structure types. Types I, III, and V had a significant amount of understory, whereas II, IV, and VI were relatively sparse at the lower layers. Within each of these two groups there was a gradation in height, from ≥50 ft to ≤10 ft.

Structure type I had vegetation in all foliage layers, with trees generally reaching 50 or 60 ft in height. Type I areas were mature to mixed age class stands and they occurred in cottonwood/coyote willow (C/CW), cottonwood/Russian olive (C/RO), and cottonwood/juniper (C/J) communities, including cottonwood edges (C/CW E I, C/RO E I).

Type II areas were mature stands of trees up to 50 to 60 ft tall with most of the foliage in the canopy layer ≥30 ft. There was a sparse, patchy understory and little herbaceous growth. Such stands were relatively rare in the study area, being represented by two C/RO II transects in the intensive study area and one C/CW II near Bernardo.

Stands of intermediate-age cottonwood trees with a thick understory of willow or Russian olive were characteristic of structure type III. There was dense vegetation up through about 30 ft, but little above 30 ft in type III. This structure type occurred primarily along levee and river edges (C/CW E III).

Relatively open stands of intermediate-age cottonwoods were typical of type IV, which was represented in C/CW IV, C/RO IV, and C/J IV

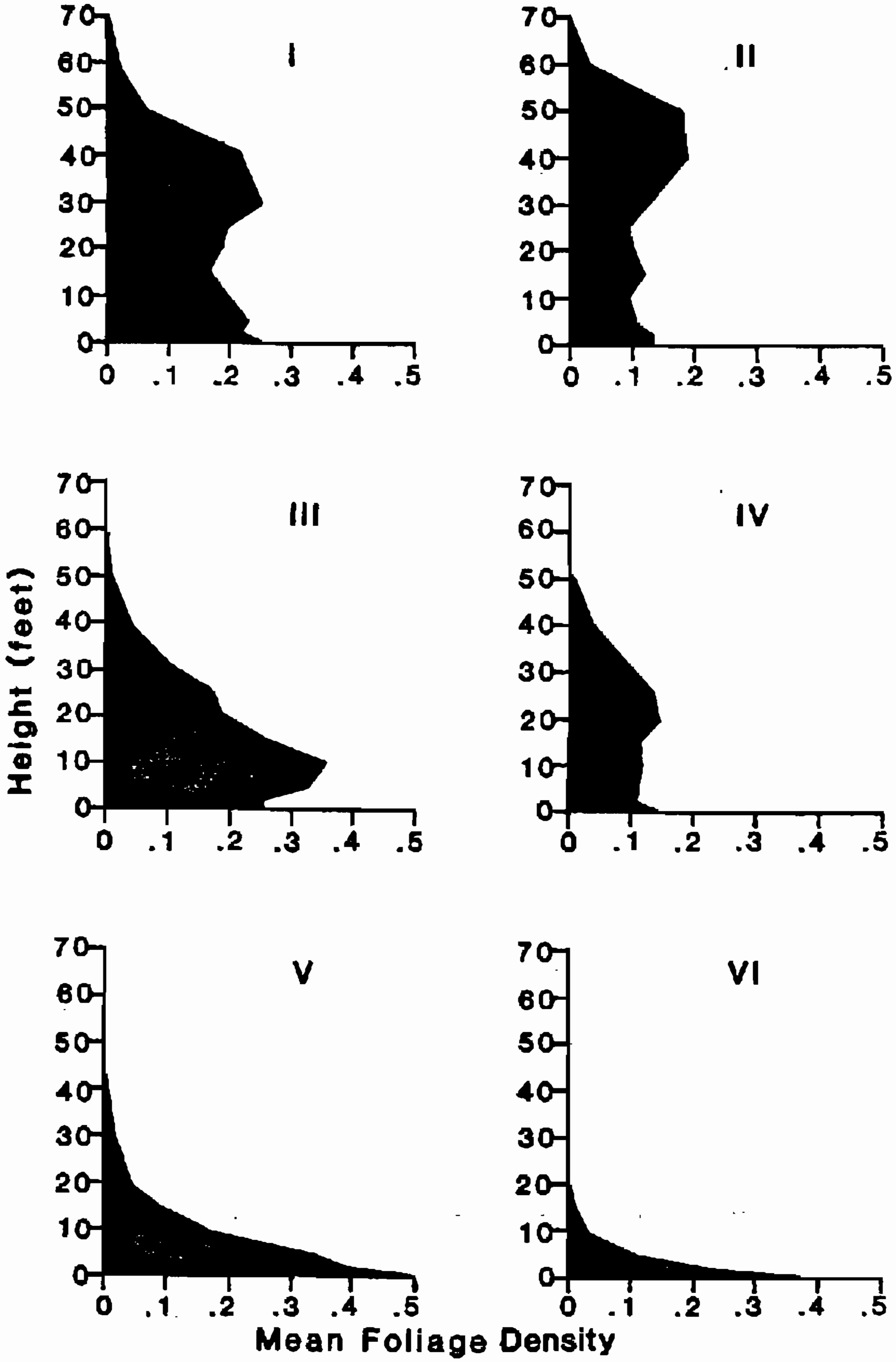

Figure 3. Mean foliage profiles for each structure type. The units of the x-axis are number of square feet of leaf surface area per cubic foot of space.

communities. Most of the foliage was between 20 and 40 ft; shrubs were widely spaced, and herbaceous growth was sparse.

Type V had dense vegetation through about 10 or 15 ft, often including a thick layer of grass and annuals. Generally (but not always), some taller trees were scattered throughout. This structure was found in C/CW V, SC V, DR V, RO V communities, and all cattail marsh (MH V).

Type VI had low and relatively sparse herbaceous and/or shrubby vegetation, with most of the foliage below 5 ft. All sandbars (SB VI), one Russian olive stand (RO VI), early stage cottonwood/coyote willow communities (C/CW VI), sparsely vegetated drains (DR VI), and much of the salt cedar vegetation fit into this type. In most cases, salt cedar of structure type VI occurred as low, sparse, but relatively uniformly distributed stems, but on sites farther from the river, salt cedars were widely spaced and grew as larger, denser individual plants. These were designated types SC VI and SC VI A, respectively.

Quantitative Vegetation Data

Community-structure (C-S) types were initially designated by qualitative assessment of vegetation species composition (community type) and structure (structure type). Transects were established so as to cover the perceptible range of compositional and structural variation in the study area, and each transect was given a tentative C-S type designation. Species composition and structural characteristics of the transect sites were subsequently quantified by means of a series of vegetation measurements, permitting verification of C-S type designations or, in a few cases, resulting in reclassification of particular transects. The C-S type designations presented in the report reflect the results of this quantification, which are summarized below.

Vegetation Species Composition and Relative Abundance.—Quantitative description of plant community composition is typically accomplished with reference to the density, cover, and frequency of the major component species (Mueller-Dombois and Ellenberg 1974). Estimates of the density of each species in a stand were obtained from tree and shrub counts, percent cover by species was estimated in a series of sample plots, and frequency values were obtained from records of species occurrence within these sample plots. From these data the relative importance values (RIV, the sum of relative density, relative cover, and relative frequency) of the major plant species in each C-S type were calculated. See Table 5 for plant species abbreviations used in text, tables, and figures.

Tree and shrub density. The four major species in the study area, cottonwood, Russian olive, salt cedar, and coyote willow, occurred in all community types. Community types differed primarily in the relative abundance of these species, with one or two of them being dominant in each type (Table 6). In most C-S types, the dominant species in a given layer had the highest density among the species present in that layer.

Cottonwood was the dominant species throughout most of the study area. It was the highest density tree species (>10 ft in height) in all C/CW,

Table 5. Key to plant species and community type abbreviations used in text, tables, and figures.

Abbreviation	Common name	Scientific name
C	Rio Grande cottonwood	Populus fremontii var. wislizenii
RO	Russian olive	Elaeagnus angustifolia
SC	Salt cedar	Tamarix chinensis
CW	Coyote willow	Salix exigua
TW	Peach-leaf willow or Goodding willow	Salix amygdaloides or Salix gooddingii
SE	Siberian elm	Ulmus pumila
SW	Seepwillow	Baccharis salicina
I	Indigo bush	Amorpha fruticosa
J	One-seed juniper	Juniperus monosperma
Wb	Wolfberry	Lycium andersonii
Sn	Snakeweed	Gutierrezia sarothrae
Rb	Rabbitbrush	Chrysothamnus nauseosus
Sa	Sagebrush	Artemisia filifolia, A. dracunculoides
NMO	New Mexico olive	Forestiera noemexicana
Op	Prickly-pear or Cholla	Opuntia spp.
Cat	Cattail	Typha latifolia
Gr	Grasses	
Ann	Annual plants	
DR	Drain	
LV	Levee	
E	Edge	
MH	Marsh	
OP	Small opening	
SB	Sandbar	
RV	River channel	

Roman numbers refer to vegetation structure types

Note: Nomenclature of plants throughout this report follows Lehr (1978) and USDA Soil Conservation Service (1982).

Table 6.--Abbreviations

C = Cottonwood (*Populus fremontii* var. *wislizenii*)

RO = Russian olive (*Elaeagnus angustifolia*)

SC = Salt cedar (*Tamarix chinensis*)

CW = Coyote willow (*Salix exigua*)

TW = Tree willow (*Salix gooddingii*, *S. amygdaloides*)

SE = Siberian elm (*Ulmus pumila*)

NMO = New Mexico olive (*Forestiera neomexicana*)

I = Indigo bush (*Amorpha fruticosa*)

SW = Seepwillow (*Baccharis salicina*)

J = Juniper (*Juniperus monosperma*)

Wb = Wolfberry (*Lycium andersonii*)

Rb = Rabbit brush (*Chrysothamnus nauseosus*)

SB = Sandbar

MH = Marsh

DR = Drain

E = Edge

Roman numerals = Structure types

Table 6. Estimated densities of major tree and shrub species, expressed as the number of plants per acre. All densities were rounded to the nearest whole number; > = tree (>10 ft tall); < = shrub (<10 ft tall); P = present in densities of <0.5 per acre.

	C/RO			C/CW								
Species	I	EI	II	I	EI	EIII	IV	EIV	V	EV	VI	SB VI
C>	91	41	111	100	116	62	118	89	33	34	15	
C<	4	4	40	11	38	9	38	20	10	5	257	9
RO>	127	103	43	20	35	53	15	9	23	22	4	
RO<	102	63	40	34	18	36	14	19	10	12	19	1
SC>	48	17	2	42	24	46	12	1	73	13	14	
SC<	87	46	9	146	37	77	84	7	198	8	166	
CW>	P			1	1	2	P			1	2	
CW<	29	32	50	185	98	475	58	165	1121	1191	679	14
TW>	3	6	11	2	12	16	1		2	12	1	
TW<	1	19	24	2	9	7	5	P	5	3	5	
SE>	1	P		P	P	1	P		P	3		
SE<		1				P		1	P	3	P	
NMO>	P			P								
NMO<			1	1		2	P		P	33		
I<	4	6	11	6	12	1	3	40	7	16	2	
SW<	35	1	2	156	2	2	3	2	72	1	2	
Misc. shrubs	1	15*	6	P	2	22**	P	2	2	41***	P	
Total>	270	168	167	165	187	189	146	99	131	84	36	0
Total<	263	186	183	541	216	621	205	254	1422	1312	1130	24
No. spp.	15	11	12	11	11	14	15	14	13	11	9	3
Snags>	19	1	14	5	P	1	3	1	1	1	9	0
Brush<	6	P	28	12	P	2	8	6	8	0	101	0

*Primarily *Lycium andersoni*, wolfberry.
**Primarily *Ailanthus altissima*, tree of heaven.
***Primarily *Shepherdia argentea*, silver buffalo berry.

Table 6. (cont.)

						General study area					
	MH V	RO V	RO VI	DR V	DR VI	C/J I	C/J IV	C/RO IV	SC V	SC VI	SC VIA
C>		12		1	3	50	46	48	P		P
C<		119			1	2	15	10			
RO>		120	9	13	5	12	34	33	1	1	P
RO<	P	98	69	9	4	8	38	37	P	1	P
SC>		15	3	23	1	1	P	P	24	2	13
SC<	11	31	15	12	9	P	8	1	745	1331	53
CW>				24	12						
CW<	142	74	8	231	129		1			1	
TW>		P		1	1	1			P	P	
TW<	7	P			1	1	P				
SE>				P	1						
SE<				P	1						
NMO>					P	1	P	P			
NMO<					2	2	3	P	P		
J>						15	14	4			
J<						204	90	64		P	
I<		1		1	7		P				
SW<		10	1		P		P		P	2	
Wb<					1				25	58	P
Rb<							12	44			9
Misc. shrubs		P	2	P	2	10*	22*	14*	1	5	48**
Total>	0	147	12	62	22	78	95	85	25	3	13
Total<	160	333	95	252	156	218	171	112	771	1395	110
No. spp.	4	8	5	8	15	9	18	10	9	9	10
Snags>	1	0	0	2	1	1	P	4	P	P	P
Brush<	2	0	1	3	2	4	6	0	0	0	0

*Primarily _Opuntia_ spp., Prickly-pear and cholla.
**Primarily _Artemisia_ spp., sage.

C/J, and DR communities and in two of the three C/RO C-S types. Cottonwood was also present in the shrub (<10 ft) layer in all communities except salt cedar. It was especially numerous in C/CW VI and RO V, indicating that it has been reproducing in these habitats in the recent past; there were large patches of seedling cottonwoods in these early-growth stands. Cottonwood occurred in very low density in non-cottonwood habitats other than RO V, especially SC, MH, and RO VI. Only a few widely scattered cottonwood trees occurred in the latter three C-S types.

Russian olive (an exotic species widely naturalized in Great Basin riparian habitats) was present as a shrub or small tree in every C-S type. This species was fairly numerous in the shrub layer in C/CW and C/J habitats as well as in C/RO. Russian olive was generally associated with cottonwood, being numerous in cottonwood C-S types and usually of low density where cottonwood was rare.

Salt cedar (another widespread exotic species) was also widely distributed among the C-S types, but it tended to be most dense in areas where Russian olive was uncommon. This probably reflects the fact that salt cedar grows best in open sun (Horton et al. 1960), whereas Russian olive often grows in dense stands even under a closed cottonwood canopy. For unknown reasons, salt cedar was much less common in edge stands than in interior stands of the same C-S types. Salt cedar was overwhelmingly abundant in both vegetation layers in the three SC types, occurring in nearly monotypic stands. It accounted for 90 to 95% of total density in both tree and shrub strata, wolfberry being the only other species reaching densities of more than one per acre in SC V and VI and VI A.

Coyote willow had a somewhat more limited distribution among types than the preceding three species. This species is associated with low, moist areas (Elmore 1976) and like salt cedar, thrives in openings and sunny situations. It occurred in C/CW, DR, RO, and MH, reaching greatest densities in shrub habitats with a sparse canopy layer: C/CW III, V, and VI, and DR V. Coyote willow was sparse in the shady C/RO stands and was absent from the dry, sandy C/J and SC communities.

Six species (three trees and three shrubs) were of widespread occurrence in the study area, but were uncommon to rare in most of the C-S types where they were found. These species were chiefly associated with cottonwood communities:

Two species of willow trees, Goodding and peach-leaf willow, occurred in the study area, but since separation of the two by field characters was difficult, they were combined for analytical purposes. Tree willows were found in all community types but were of low or very low density. Most were found in C/CW and C/RO communities.

Siberian elm (Ulmus pumila), an introduced tree species, was present only in C/CW, DR, and C/RO communities, in very low density.

Seepwillow, a shrubby composite, occurred in low density in most C-S types, but moderate numbers were recorded in C/CW I and IV, C/RO I and RO V.

Indigo bush (Amorpha fruticosa) had a distribution similar to that of seepwillow but was less numerous, and it did not occur in SC.

New Mexico olive was rare and limited entirely to cottonwood-dominated communities (C/CW, C/RO, C/J, DR). It occurred in densities >1 per acre only in an old burn area in Corrales and in the northernmost C/RO transects at San Ildefonso.

The remaining species had very limited distributions, being present only in certain C-S types:

Juniper was limited to C/J I and IV and C/RO IV, both of which occurred only in the general study area above Algodones. Cactus and rabbit brush were likewise largely restricted to these three C-S types, indicating the distinctness of these types and suggesting affinities with upland habitats. Rabbit brush was also found in SC VI A, which bore the greatest resemblance to upland habitats of any of the C-S types.

Wolfberry, as mentioned above, was associated with extensive stands of salt cedar. It also occurred in C/RO E I and occasionally in DR VI, growing in the dry, loose soil of levee banks. Sagebrush (Artemisia spp.) also occurred in very low numbers in dry levee banks and more commonly in SC VI A.

A few colonies of tree of heaven (Ailanthus altissima, another exotic) grew at the edge of the bosque closely adjacent to the levee, mostly in the area from Los Lunas to Belen. Silver buffalo berry (Shepherdia argentea, a close relative of Russian olive, but native to this area) was common only at the previously mentioned burn site in Corrales.

Percent cover. A slightly different picture of species dominance was presented by percent cover data (Table 7). While for the most part those species which were present in highest density in a particular vegetation layer also yielded the highest percent cover values, there were differences in degree, and Russian olive provided a notable exception. Russian olive generally accounted for a greater percentage of total cover than total density in the shrub layer. In several C-S types (C/CW IV and V, DR V and VI, C/RO II) Russian olive reversed positions with salt cedar or coyote willow in rank order of relative density and cover. For instance, Russian olive accounted for 20% of total shrub density but 84% of total shrub cover in C/RO II, whereas the values for coyote willow were 27% and 7%, respectively. This difference arises from the fact that individual Russian olive plants <10 ft are larger and more spreading than coyote willow, salt cedar, seepwillow, or juniper plants in the same height class.

The opposite was true in the tree layer. While Russian olives were large among the shrubs, they were smaller than the mature cottonwoods that provided the majority of canopy-level cover. Hence Russian olive was less important in terms of cover than density in the tree stratum. Tree-sized salt cedars (>10 ft) were similar to Russian olives in this regard, providing an insignificant amount of canopy cover in proportion to their density.

Table 7.--Abbreviations

C = Cottonwood (*Populus fremontii* var. *wislizenii*)

RO = Russian olive (*Elaeagnus angustifolia*)

SC = Salt cedar (*Tamarix chinensis*)

CW = Coyote willow (*Salix exigua*)

TW = Tree willow (*Salix gooddingii*, *S. amygdaloides*)

SW = Seepwillow (*Baccharis salicina*)

I = Indigo bush (*Amorpha fruticosa*)

Cat = Cattail (*Typha latifolia*)

J = Juniper (*Juniperus monosperma*)

Ann = Annuals

Gr = Grass

Se = Sedge (*Carex* sp. and *Eleocharis* sp.)

Sn = Snakeweed (*Gutierrezia microcephala*)

Wb = Wolfberry (*Lycium andersonii*)

Rb = Rabbit brush (*Chrysothamnus nauseosus*)

Op = *Opuntia* sp.

Sa = Sage (*Artemisia* sp.)

MH = Marsh

DR = Drain

SB = Sandbar

Roman numerals = Structure types

Table 7. Percent cover (PC) and percent frequency (PF) of plant species in canopy (>15 ft), shrub (2-15 ft), and ground (0-2 ft) vegetation layers. Highest values for each layer are underlined. P = present.

	C/RO I		C/RO II		C/CW I		C/CW IV		C/CW V		C/CW VI	
	PC	PF	PC	PF	PC	PF	PC	PF	PC	PF	PC	PF
>15 ft												
C	88.5	97	86.8	100	64.1	100	41.6	100	19.4	47	3.0	13
RO	2.0	10			P	3			3.2	13	1.2	3
SC	1.8	7							0.9	6		
2-15 ft												
C	0.1	10	0.2	8	1.6	23	5.4	30	7.2	13	6.2	43
RO	32.1	80	4.6	40	1.0	10	1.4	13	5.2	10	4.7	17
SC	6.2	30	0.2	8	6.2	37	3.9	37	4.6	43	5.0	27
CW	0.2	7	0.4	16	9.2	57	0.2	3	43.3	90	15.7	50
TW			0.2	8	1.3	6			0.1	3	0.2	3
SW					8.2	37			3.9	23		
I	0.7	3			0.3	6			2.3	6	1.7	3
Ann	2.7	3	5.7	20	12.1	47	3.9	17	2.3	17	15.0	43
0-2 ft												
C			P	4	P	3	0.8	13	0.1	3	4.1	30
RO	0.4	10	1.3	20	0.2	3			P	3	P	3
SC	0.3	10	0.7	12	1.1	13	1.9	33	1.8	27	3.3	33
CW		3	P	4	1.9	23	0.3	13	2.0	37	9.9	57
SW			P	4	9.0	43			4.5	27		
I	0.1	3	P	4					1.0	3	0.7	3
Ann	3.8	13	10.7	48	25.8	73	14.6	90	30.9	83	21.5	73
Gr	0.7	3	P	8	14.5	47	3.3	43	27.5	57	25.1	77
Se					4.8	20			2.4	6		

Table 7. (cont.)

	DR V		DR VI		MH V		RO V		RO VI		SB VI	
	PC	PF	PC	PF	PC	PF	PC	PF	PC	PF	PC	PF
>15 ft												
C	5.6	17	8.5	6			0.4	6				
RO	1.2	10	0.2	3			3.6	17				
2-15 ft												
C	0.3	3	0.2	6			8.6	33			2.0	6
RO	11.8	27	0.5	3			33.1	87	13.5	60		
SC	2.1	13					3.9	20				
CW	17.2	43	10.8	23	P	3	3.8	30			0.4	6
Cat	1.2	6	0.3	3	95.3	100						
SW							0.8	10				
I	2.7	3	0.8	3								
Ann	20.3	60	11.5	73	P	3	5.9	40	0.8	20	0.7	6
0-2 ft												
C			0.2	6			0.8	17			11.1	40
RO	1.9	13					6.6	43	2.0	30		
SC	0.3	3					0.6	3			0.1	3
CW	10.0	30	25.3	23	0.7	3	0.9	20			1.6	20
Cat	0.8	6	0.3	3	94.3	100						
SW							0.2	10				
I			13.3	10								
Ann	34.7	80	25.3	97	0.2	3	19.7	93	8.1	90	9.2	67
Gr	22.9	77	35.3	87	P	3	51.9	100	67.3	100	7.6	53
Se			8.9	40	P	3	9.8	43	16.1	90	0.2	3
Sn			7.4	23								

Table 7. (cont.)

	C/J I		C/J IV		C/RO IV		SC V		SC VI		SC VI A	
	PC	PF	PC	PF	PC	PF	PC	PF	PC	PF	PC	PF
>15 ft												
C	48.4	97	25.3	92	37.4	90						
SC							0.7	4				
2-15 ft												
C	4.5	37	1.3	12	4.5	47	0.6	3				
RO	7.2	23	3.0	12	8.1	40	P	3	2.0	3		
SC					0.1	3	5.0	32	34.2	73	4.6	47
CW					0.1	3						
SW											P	3
J	8.9	47	10.5	52	0.4	6						
Wb									2.4	17		
Ann					0.1	3	7.8	24			0.1	3
0-2 ft												
C					0.9	13						
RO	1.7	13	1.0	8	0.9	20	P	3				
SC							5.6	36	20.7	73	5.4	37
J	7.3	60	8.8	56	0.5	10						
Sn	1.6	17	6.1	68	2.1	47					10.8	63
RB	0.9	20	0.2	16	0.6	13					1.5	20
Op	0.3	13	0.8	36	0.2	6						
Wb									0.7	10		
Sa											2.7	43
Ann	2.8	33	1.9	32	2.5	48	15.9	80	7.9	37	20.2	93
Gr	15.5	90	13.0	100	6.2	60	43.0	80	29.2	87	23.0	77

Percent cover was estimated for the 0-2-ft (ground) vegetation layer as well as for trees and shrubs. Herbaceous vegetation (annuals, grasses, and grass-like species) was the most abundant type of cover in this layer, accounting for a greater proportion of total 0-2-ft cover than low shrubby vegetation in most C-S types. RO stands had the greatest total percent ground cover (nearly 100%), composed mostly of grass, with some sedge and annuals. Grass was of major importance in SC V and VI as well. In SC VI A and most other C-S types, a mixture of grass and annuals accounted for most of the ground cover, with shrubs contributing a third or less of the total. The C/RO community was notably depauperate of low-level vegetation, with only about 5 to 10% grass and annual plant cover and 1 to 3% low shrub cover. The one exception to the prevalence of herbaceous over shrubby ground level vegetation was C/J IV, in which juniper, snakeweed, and New Mexico olive together exceeded the combined grass/annuals percent cover value.

Frequency. Frequency and cover values for a particular species within a C-S type were closely related, with high-cover species also being very frequent and low-cover species usually infrequent (Table 7). There were a few instances when species with low density and cover values in a particular type occurred with relatively high frequency. This was true of snakeweed in C/RO IV and C/J (0-2 ft) and sage in SC VI A (0-2 ft).

Relative importance values. Communities were designated by the dominant species in both canopy and shrub layers. For all vegetation community types except C/CW, there were clearly recognizable dominant species in each layer having relative cover or percent importance values, or both, of ≥50% (Fig. 4). These were the canopy and shrub dominants for which the communities were named. In certain of the C/CW types, however, the shrub layer was more diverse. The highest percent importance values for any single species in C/CW I and C/CW VI were 33% and 45%, respectively. Coyote willow had the highest relative density, cover, and frequency values among the species in the shrub layer, but salt cedar, seepwillow, and cottonwood also contributed significantly to the shrub layer vegetation in these C/CW stands. Salt cedar had greater percent importance in the shrub layer than coyote willow in the sparsely vegetated C/CW IV type and also in C/CW I and C/CW II stands near Bernardo in the general study area. However, coyote willow was the most abundant shrub species among the C/CW community as a whole, so that community type designation was retained.

Drains of both structure types V and VI had cottonwood and coyote willow as canopy and shrub layer dominants, respectively, so that the vegetated portions of the drains can be classified in the C/CW community type. The small amount of vegetation growing on sandbars was also primarily cottonwood and willow: patches of cottonwood seedlings and widely scattered stands or clumps of coyote willow. Because the sandbars were largely bare of vegetation, however, they were not considered to be part of the C/CW community proper. Cottonwood levee edge stands of structure type I were referable to either the C/CW community (C/CW E I) or the C/RO community (C/RO E I), having species composition and relative abundance typical of these types, respectively. The remaining cottonwood levee edge, and river edge, stands were all C/CW (C/CW E III,

Figure 4.--Abbreviations

C = Cottonwood (*Populus fremontii* var. *wislizenii*)

RO = Russian olive (*Elaeagnus angustifolia*)

SC = Salt cedar (*Tamarix chinensis*)

CW = Coyote willow (*Salix exigua*)

TW = Tree willow (*Salix gooddingii*, *S. amygdaloides*)

SW = Seepwillow (*Baccharis salicina*)

I = Indigo bush (*Amorpha fruticosa*)

J = Juniper (*Juniperus monosperma*)

NMO = New Mexico olive (*Forestiera neomexicana*)

Wb = Wolfberry (*Lycium andersonii*)

Sa = Sage (*Artemisia* spp.)

Cat = Cattail (*Typha latifolia*)

DR = Drain

MH = Marsh

SB = Sandbar

Roman numerals = Structure types

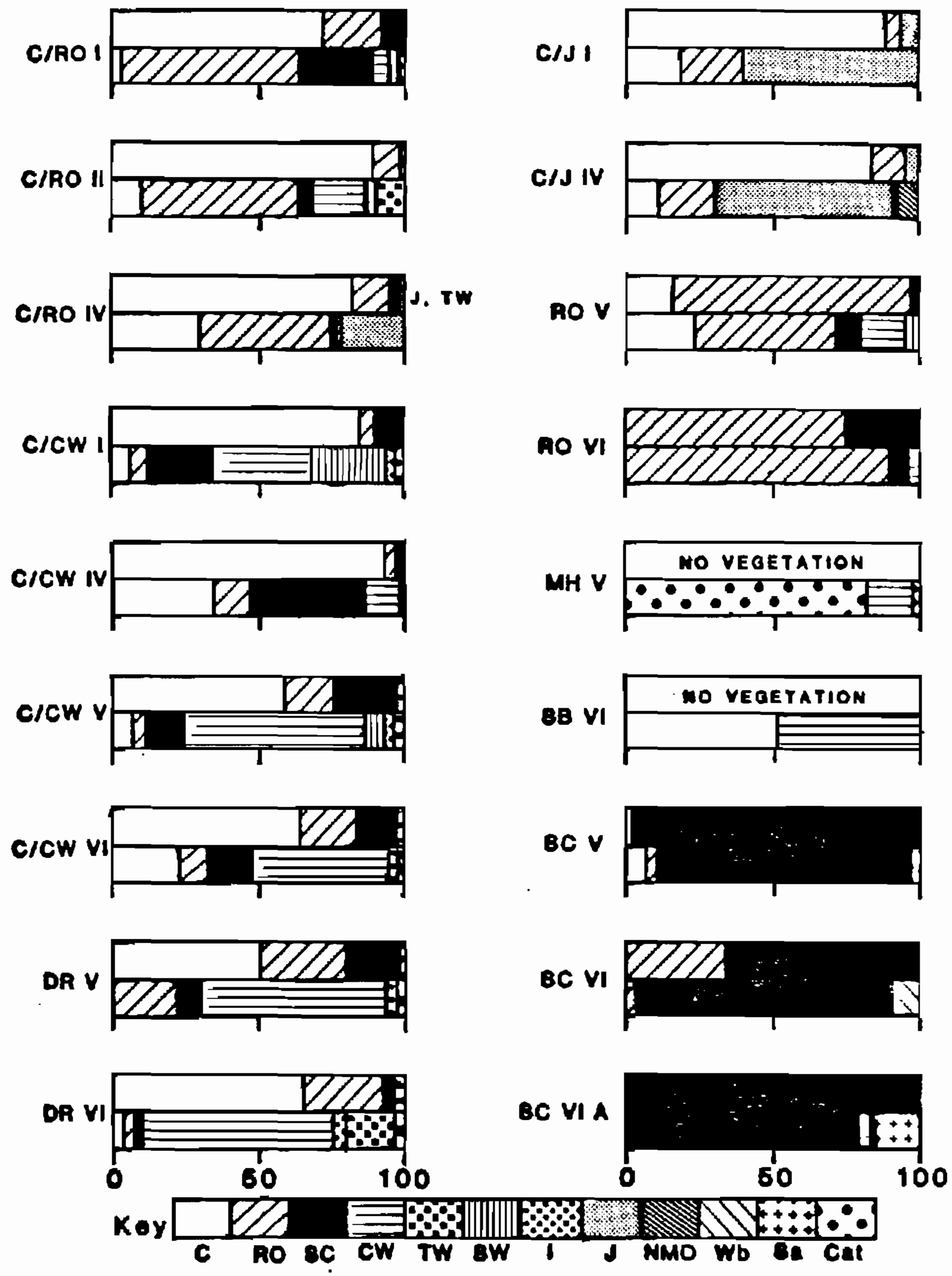

Figure 4. Importance percent values of major plant species in canopy and shrub layers in each community-structure type. Upper bar = canopy layer, lower bar = shrub layer. See facing page for abbreviations.

C/CW E IV, C/CW E V). See Appendix V, Table V-1 for relative density, relative cover, and relative frequency values of each species in each C-S type.

Vegetation Structure.--Cluster and ordination analyses of foliage density data were the major means through which structure types were distinguished. Tree and shrub density and percent cover data for all species combined (total density and total cover) provide additional descriptive data on vegetation structure.

Foliage density and foliage height diversity (FHD). There was a 15-fold range of variation in total foliage density values among transects. Values ranged from 0.112 for a very sparsely vegetated sandbar transect (KW-06) to 2.88 for a tall, dense cottonwood/Russian olive levee edge (SE-05), with fairly continuous variation between the extremes. FHD values ranged from 0.108 (SE-09, a sandbar) to 1.098 (GN-06, C/J I). Foliage density profiles and FHD values for each transect are presented in Appendix V, Tables V-3 and V-4, respectively.

Multivariate analysis of foliage density data. Ordination analysis reflected the major components of variation in the foliage density data. Principal components analysis (PCA) defined a major axis, which accounted for 55% of the total variation in the data, and along which transects were arranged, primarily according to overall height and, less clearly, total foliage density. Transects with only low vegetation were placed low on this axis (or gradient), and as vegetation height on the transects increased, the transects were ordinated progressively higher on this axis. The second axis (which defined a second, more or less independent gradient in the data) accounted for an additional 19% of the variation and was related to the distribution of foliage. Transects having most of their foliage at upper layers, such as mature cottonwood communities with little understory, appeared at one extreme of this axis and those with most of the foliage at lower layers, such as young cottonwood stands or salt cedar communities, were at the opposite end. The scatter plot showed transects arranged in a broad band diagonally across the page, with tall, dense transects having most of their foliage in the upper layers at one extreme and transects with foliage concentrated in the lower layers at the other. Reciprocal averaging (RA) produced axes very similar to PCA, although scatter plots were less clear.

In the polar ordination (PO), transects were arranged along the first axis in order, from those with little foliage at lower layers to those with much foliage at lower layers (regardless of the presence or absence of canopy vegetation). The second axis appeared to arrange transects primarily according to total foliage density, although vegetation height was also reflected in a general way. The scatter diagram resembled that of the PCA fairly closely. For PO we used the option to designate the endpoints of the first axis prior to analysis, so the results reflected to some extent our biases as to which were the important vegetation characteristics. This was not true of the PCA or RA ordinations.

The 12 cluster analyses all produced essentially similar results, but they were more difficult to interpret than ordinations because they produced a single-axis arrangement of transects. These analyses grouped transects primarily on the basis of total foliage density, and secondly on height. Cluster analysis did have the advantage of indicating distinct breaks between groups. Most transects were associated with the same major cluster in each analysis.

The results of these analyses were used in a complementary manner to designate structure types. The scatter plots with individual transects plotted against ordination axes were roughly divisible into quadrants or regions which included, respectively, tall transects with dense understory, tall with sparse understory, low-dense, and low-sparse; an intermediate height range was also recognizable. Boundaries between groups were based on the cluster analyses, such that transects that grouped together consistently in cluster analysis and were close together on PO and PCA plots were included within one group, and divisions were drawn between groups separated in the cluster analysis. Subjective decisions were made when the results of the two analyses did not agree. In such cases, location on the ordination diagrams was accorded more weight than cluster grouping, because of the greater resolution afforded by derivation of the second axis. The structure types listed for the transects in Table 1 were based on the results of these analyses.

After all transects had been classified according to community and structure type, the foliage density data were used to calculate mean foliage profiles for each C-S type. The mean foliage profile of a C-S type is the average of the density values at each sample height over all transects of that C-S type. C-S type profiles are presented graphically in Figure 5. The mean profiles for the six general structure types (presented in Fig. 3) are averages over all transects within each structure type. The profile for C-S type C/CW E III would be the same as that shown in Figure 3 for type III, because all transects of structure type III belonged to that one community type.

Total percent cover. Mean percent cover estimates for the canopy (>15 ft), shrub (2-15 ft), and ground (0-2 ft) layers varied widely among C-S types, ranging from at least 5% to 95% in all three layers. Percent cover in canopy and ground layers tended to fall toward the extremes of the range, either >60% or <30%, while the shrub layer values more often fell toward the middle of the range (Fig. 6; Table V-2, Appendix V).

There was a highly significant negative correlation between percent canopy cover and percent ground cover ($r = -0.73$, $P<0.001$). That is, in C-S types that had high canopy-level percent cover, there was little herbaceous or other ground-level vegetation, whereas ground vegetation was abundant in areas with little canopy cover where sunlight penetrates to the lower levels. Percent cover in the ground layer and the shrub layer were significantly positively correlated ($r = 0.51$, $P<0.05$), since many of the plants common in the lower stratum (notably sweet clover [*Melilotus officinalis*, *M. albus*, and *M. indicus*] and coyote willow) were >2 ft high, thus extending into the shrub layer.

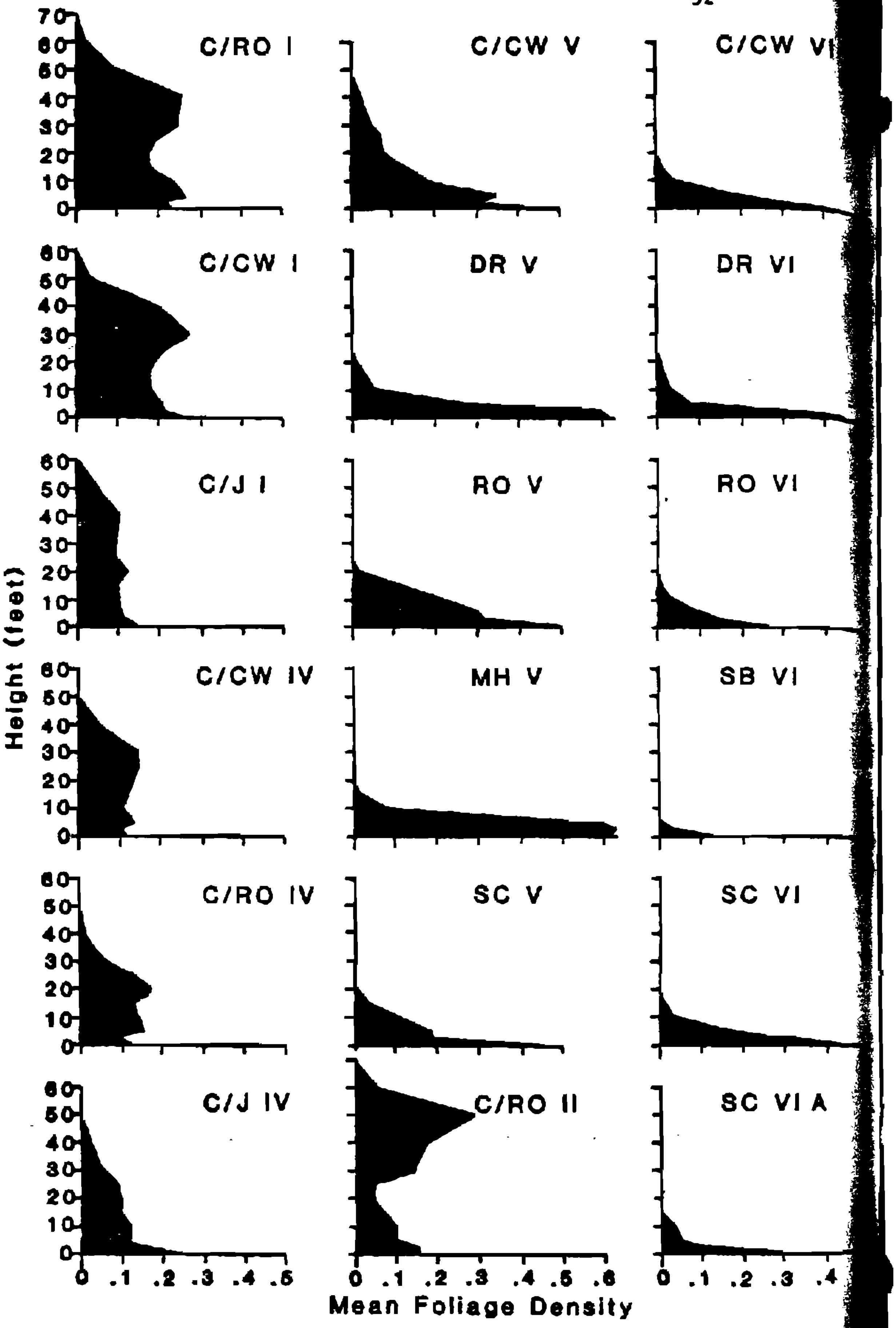

Figure 5. Mean foliage profiles for each community-structure type. The units of the x-axis are number of square feet of leaf surface per cubic foot of space. See facing page for abbreviations.

Figure 5.--Abbreviations

C/RO = Cottonwood/Russian olive

C/CW = Cottonwood/coyote willow

C/J = Cottonwood/juniper

RO = Russian olive

SC = Salt cedar

DR = Drain

MH = Marsh

SB = Sandbar

Roman numerals = Structure types

Figure 6.--Abbreviations

C/RO = Cottonwood/Russian olive

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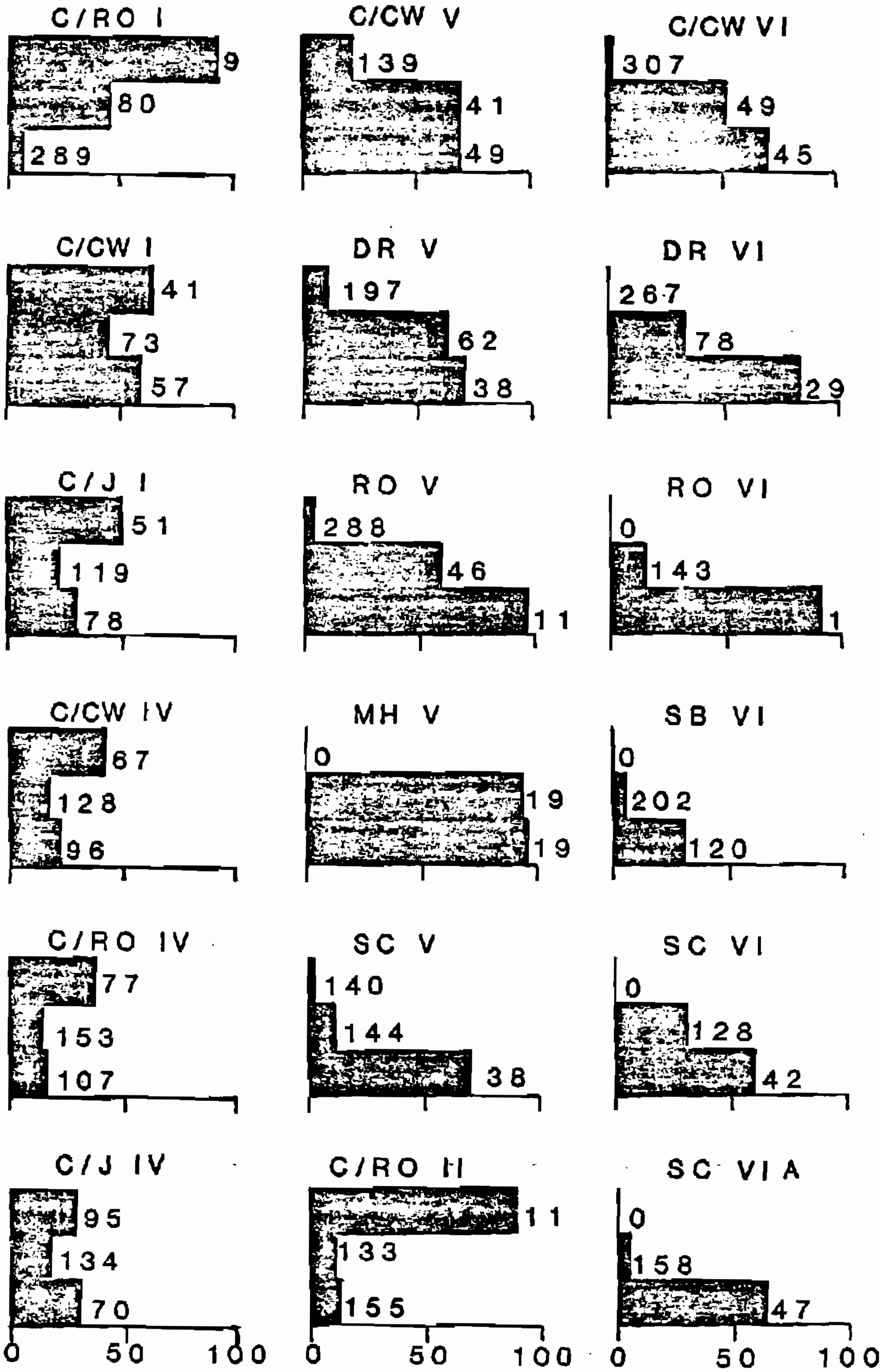

Figure 6. Mean total percent cover in canopy, shrub, and ground vegetation layers. Upper bar = canopy layer; middle bar = shrub layer; lower bar = ground layer. The number to the right of each bar is the coefficient of variation associated with that mean. See facing page for abbreviations.

The coefficient of variation (CV), which is the standard deviation expressed as a percent of the mean, is commonly used to compare the amount of variation in two different populations independent of the size of their means. A high CV value associated with the mean percent cover of a particular layer indicates high plot-to-plot variation, or patchiness, in vegetation cover in that layer, whereas a low CV value indicates uniformity. Structure types I and II were notable for having relatively low coefficients of variation associated with canopy cover means, indicating a uniform, nearly closed-canopy structure (see Fig. 6). The herb and shrub layer means for these two types, by contrast, had higher coefficients of variation, indicating patchy cover. This situation was reversed in type V and VI communities, where canopy cover was highly variable, but the two lower layers had relatively low coefficients of variation, indicating that ground and shrub cover was fairly uniform in these young, fast-growing stands (with some exceptions, e.g., SB VI). Type IV communities had very patchy cover overall, indicated by high coefficients of variation in all three layers.

Percent cover profiles by layer (Fig. 6) corresponded roughly to foliage density profiles for each C-S type (Fig. 5). That is, those types with high foliage density over a particular height interval also had high percent cover values for the layer that encompassed that height interval. Because in percent cover estimates the coverage of foliage over a broad height interval is projected onto a plane, differences in vertical structure are not as easily discernible in the percent cover profiles as in the volume profiles. For example, C/J I and C/CW IV had similar percent cover profiles, but the canopy layer in C/J I extended from 15 to 60 ft, whereas in C/CW IV the maximum height was only 30 ft. Consequently, foliage density profiles provide a more complete picture of vertical vegetation structure, whereas the percent cover figure gives more information about the density and patchiness of the vegetation on a horizontal plane.

Total tree and shrub density. Total tree and shrub density data and relationships between tree and shrub densities contribute information on horizontal structure as well as probable age of vegetation stands. The greatest excess of shrubs over trees was observed in type V and VI habitats, underscoring the prevalance of shrubby vegetation in these areas. These may be viewed as early successional-stage stands in all communities except SC. Type VI stands were more open and presumably more recently disturbed than the dense type V stands. In the case of SC, type VI appeared to represent early-growth stands, but types V and VI A occurred in higher, drier situations at the interface of riparian and upland zones, areas which might not support further growth of vegetation.

Conversely, in type I and II communities shrub densities were much lower, and tree densities were at their maximum. Comparison of data from C/CW I and C/RO I stands reveals that the latter had fewer shrubs and fewer >10-ft cottonwoods. C/RO, however, had a greater amount of canopy cover and more foliage volume over 40 ft. There were fewer but larger and taller cottonwood trees in C/RO I and II than in C/CW I stands, forming a closed canopy. C/CW I, with more numerous, smaller trees, had a broken canopy (64% canopy cover) that allowed a greater number of shrubs to grow in lower layers. The implication is that the C/RO stands were more mature than C/CW. The greater density of snags in C/RO than in C/CW supports this.

C/J I and IV and C/RO IV stands had lower total tree and shrub densities than corresponding structure types in other cottonwood communities. This emphasizes their openness and, together with their unique species composition, suggests that these C-S types had a greater upland influence than the other cottonwood-dominated communities. The fact that all three were grazed may have influenced both structure and composition in these stands.

Areal Extent of the Various Community-Structure Types

The total acreage of each of the major C-S types in the study area, derived from planimetering of the vegetation stands outlined on the maps in Appendix XI, is presented in Table 8. Acreages of stands located within and outside the confines of the levees were tallied separately, as were totals for the intensive, general north, and general south portions of the study area. Totals were obtained by combining acreages of all stands of one structural type having in common the two major (canopy and/or shrub) species. A more detailed breakdown of the acreage per C-S type, which lists separately each specific type as it is labelled on the maps, is included with the maps in Appendix XI.

Altogether 31,128 acres of riparian vegetation were mapped in the 163-mi-long study area, including 16,374 acres (52.6%) of cottonwood forest (structure types I, II, III, and IV may be considered "forest"), 12,819 acres (41.2%) of shrubland and woodland (types V and VI), and 1,440 acres (4.6%) of marshes and ponds (MH V, MH VI, "water in MH", and ponds). About 65% of this area was either within the confines of the levees or occurred along segments of the river where there were no levees. There were few openings in the riparian vegetation excluding the river channel; only 467 acres of the area within the levees (about 1.5%) were classified as open area, i.e., dry and without woody vegetation.

In the intensive study area, cottonwood forest of structure type I was the most abundant type of vegetation, composing 37% of the total, and 42% of the within-levee total, acreage. Russian olive was the most commonly occurring understory species in these mature cottonwood stands, although in most stands (1,964 a) it occurred in association with other shrubs, especially salt cedar (see Table XI-1, Appendix XI). Cattail marsh (MH V) was the least abundant type of habitat, with its 236-acre total representing only 2.1% of the intensive study area. Type IV and type VI stands were also uncommon in the intensive study area, each representing about 7% of the total.

There was a marked difference in the relative abundance of certain C-S types inside and outside the levees. While cottonwood I was the most abundant forest type within the levees, most of the forest vegetation occurring outside the confines of the levees was type II cottonwood. Cottonwood II was the only type of vegetation in the intensive study

Table 8.--Abbreviations

C = Cottonwood (*Populus fremontii* var. *wislizenii*)

RO = Russian olive (*Elaeagnus angustifolia*)

CW = Coyote willow (*Salix exigua*)

SC = Salt cedar (*Tamarix chinensis*)

J = One-seed juniper (*Juniperus monosperma*)

NMO = New Mexico olive (*Forestiera neomexicana*)

SW = Seepwillow (*Baccharis salicina*)

ATX = Four-wing salt bush (*Atriplex canescens*)

SE = Siberian elm (*Ulmus pumila*)

MH = Marsh

MIX = Mixture of species: C, TW, SE, RO, SC, CW

Table 8. Areal extent of each community-structure (C-S) type in acres. Asterisks indicate C-S types that were included in transect sampling. A more detailed breakdown of types, listing each classification that appears on the type maps, is given in Appendix XI.

	Intensive study area		General study area - north		General study area - south		Totals	
C-S type	Within levees	Outside levees	Within levees+	Outside levees	Within levees+	Outside levees	Within levees	Outside levees
C/RO I	2820*	182	1388*	0	120	56		
C/CW I	848*	9	0	0	4	9		
C/SC I	318	0	211	0	475*	266		
C/J I	0	0	325*	101	0	0		
Total type I	3986	191	1924	101	599	331	6509	623
C II	184	226	714	182	0	27		
C/RO II	379*	309	776	0	0	0		
C/CW II	79	21	(C-TW)16	0	0	0		
C/SC II	21	296	209	143	108*	212		
C/J II	0	0	394	80	0	0		
Total type II	663	852	2109	405	108	239	2880	1496
C/RO III	675*	34	626*	0	101	10		
C/CW III	140*	0	21	0	55	0		
C/SC III	173	0	76	0	455	89		
SC-RO III	77	8	8	0	24	0		
MIX++ III	97	9	0	0	0	0		
Total type III	1162	51	731	0	635	99	2528	150
C IV	20	97	101	63	0	0		
C/RO IV	109	120	363*	19	0	0		
C/CW IV	311*	0	13	0	39	0		
C/SC IV	158	0	368	7	0	6		
C/J IV	0	0	394*	0	0	0		
Total type IV	598	217	1239	89	39	6	1876	312
Total types I-IV (Total forest)	6409	1311	6003	595	1381	675	13,793	2581

Table 8. (cont.)

	Intensive study area		General study area - north		General study area - south		Totals	
C-S type	Within levees	Outside levees	Within levees+	Outside levees	Within levees+	Outside levees	Within levees	Outside levees
C V	4*	0	39	0	0	0		
C/RO V	86	0	111	0	0	0		
RO V	408*	33	207	39	247*	228		
C/CW V	463*	0	45	0	143*	29		
CW V	310	10	21	0	0	0		
C/SC V	284	0	25	0	229	32		
SC V	398	41	188*	28	637*	1403		
C/J V	0	0	33	0	0	0		
C/NMO V	0	0	80	0	0	0		
Total type V	1953	84	749	67	1256	1692	3958	1843
Total types I-V	8362	1395	6752	662	2637	2367	17,751	4396
C/RO VI	76	0	31	0	0	27		
RO VI	277*	38	40	0	111	38		
C/CW VI	114*	0	9	30	0	0		
CW VI	77	5	75	0	0	0		
C/SC VI	123	0	38	0	0	0		
SC VI	72	32	777*	0	2123*	2169		
J-RO VI	0	0	39	0	0	0		
SW VI	0	0	0	0	18	0		
ATX VI	0	0	0	0	0	707		
Total type VI	739	75	1009	30	2252	2941	4000	3046
Total types V and VI (Total shrubland)	2692	159	1758	97	3508	4633	7958	4889

Table 8. (cont.)

	Intensive study area		General study area - north		General study area - south		Totals	
C-S type	Within levees	Outside levees	Within levees+	Outside levees	Within levees+	Outside levees	Within levees	Outside levees
Total acres of forest and shrubland	9101	1470	7761	692	4889	5308	21,751	7470
MH V (Cattail)	189*	47	25	60	416	67	630	174
Water in MH V	19	19	0	0	0	299	19	318
MH VI (salt grass)	0	134	0	98	0	0	0	232
Ponds	18*	23	26*	0	0	0	44	23
Open areas	173*	--	243	--	51	--	467	--
Combined totals	9500	1693	8055	850	5356	5674	22,911	8217
Grand total								31,128

++MIX = C-TW-SE-RO/RO-SC-CW

area that was more abundant outside the levees than within them, excluding MH VI, which occurred only outside the levees.

Inspection of Table 8 reveals several notable differences among the three segments of the study area in regard to the occurrence of the various vegetation types. C/J was found only in the northern portion of the general study area. C/RO was much less common in the southern portion of the general study area than in the other two segments, with only 314 (<4%) of the 8,418 total acres of this type occurring south of the Bosque Bridge (the southern boundary of the intensive study area) and none south of Bernardo. SC, on the other hand, was far more abundant in the southern part of the general study area than elsewhere: 77% of the total acreage of salt cedar-dominated habitat occurred south of the Bosque Bridge. C/CW habitat, especially of the forest types (I-IV), was heavily concentrated in the intensive study area. Eight-three percent of all C/CW habitat, and 91% of C/CW forest, was found within the intensive study area.

Differences in the abundances of various structure types within the three divisions of the study area were also apparent. Although type I forest was the most heavily represented habitat in the intensive study area, type II was the most common structure type in the northern portion of the general study area, and type VI dominated the southern portion. The total proportion of shrub habitat (structure types V and VI) was much greater in the southern part of the general study area (80%) than in the intensive study area or the northern general study area (27% and 22%, respectively). This significant concentration of shrub habitat in the southern portion of the study area arises in large part from the abundance of salt cedar there, much of which has been periodically mowed for the purpose of water salvage.

A set of maps showing natural vegetation and land use in the Middle Rio Grande Valley between Cochiti and San Marcial were drawn up in 1917-18 by the State of New Mexico under the direction of George M. Neil. The northern segment of the area covered by the 1918 maps overlapped a substantial portion of our study area, the 130-mile reach between Cochiti and San Acacia. In the 1918 maps, natural vegetation was classified as "timber and brush," "marsh," "salt grass," "meadow," or "alkali." The "timber and brush" category corresponds roughly to vegetation of types I through V (excluding MH V) in the present report, "marsh" was presumably cattail marsh (MH V plus "water in MH V"), and one or more of the latter three categories is probably comparable to MH VI (wet saltgrass meadow).

The 1918 maps of the 130-mile reach between Cochiti and San Acacia were recently planimetered by the Corps to obtain an accurate estimate of the historical extent of riparian forest, shrub, and marsh habitats. According to the results of this planimetering, there were 18,294 acres of "timber and brush" and 3585 acres of "marsh" in the valley between Cochiti and San Acacia in 1918 (M. Sifuentes pers. comm.). Table 9 compares the 1918 acreages for this reach with acreages obtained by planimetering the corresponding area on the 1982 maps. Because of marked differences in the character of the present vegetation above and below Bernardo, the two segments (Cochiti to Bernardo and Bernardo to San Acacia) were each examined separately.

Table 9. Comparison of the acreage of riparian forest/shrub and cattail marsh present between Cochiti and San Acacia in 1918 and 1982. Acreages for the 109-mile reach between Cochiti and Bernardo and the 21-mile reach between Bernardo and San Acacia are also presented separately.

	Forest and shrub habitats		
	1918	1982	
	"Timber and brush"	I,II,III,IV,V (except MH V)	Difference
Cochiti to Bernardo	17,422	18,285	+863
Bernardo to San Acacia	872	1,853	+981
Cochiti to San Acacia	18,294	20,138	+1,844 (+9%)

	Marsh habitats		
	1918	1982	
	"Marsh"	MH V	Difference
Cochiti to Bernardo	3,439	351	-3,088*
Bernardo to San Acacia	146	782	+636
Cochiti to San Acacia	3,585	1,133	-2,452 (-68%)

	Totals		
	1918	1982	Difference
Cochiti to Bernardo	20,861	18,636	-2,225
Bernardo to San Acacia	1,018	2,635	+1,617
Cochiti to San Acacia	21,879	21,271	-608

The total acreage of type I through V vegetation in the 130-mile reach between Cochiti and San Acacia in 1982 was about 9% higher than the total acreage of "timber and brush" present in this reach in 1918. In the 109-mile segment between Cochiti and Bernardo, which at present includes nearly all the cottonwood forest within the area under consideration, the 1918 total of 17,422 acres was within 5% of the 1982 estimate of 18,285 acres of type I through V vegetation. There was a much greater discrepancy between the 1918 and 1982 acreages for the 21-mile-long Bernardo to San Acacia reach than for the Cochiti to Bernardo reach. The 1918 maps show only about half as much forest/shrub habitat within this southernmost portion of the present study area as the 1982 maps. Most of the "type I through V" vegetation in this reach in 1982 was SC V (see Table 8). The increase in woody riparian growth between Bernardo and San Acacia appears to be attributable to salt cedar having invaded areas that were either sand flat or salt grass in 1918. Overall, however, the total acreage of riparian forest and shrub present in the study area between Cochiti and San Acacia today is very close to the acreage present in 1918.

The comparison is rather different for cattail marsh. The amount of cattail marsh habitat between Cochiti and San Acacia has apparently decreased by 68% overall since 1918. The decrease occurred within the 109 miles between Cochiti and Bernardo, where 3,088 acres were lost. This loss was offset somewhat by a gain of 782 acres between Bernardo and San Acacia, attributable to the development of large areas of marsh on the La Joya and Bernardo State Game Refuges. However, there was still a net decrease of 2,452 acres of cattail marsh in the study area as a whole over the past 64 years.

It appears that forest/shrub habitat and agricultural fields have replaced much of the cattail marsh formerly occurring in the Cochiti to Bernardo reach. The succession of forest into former marsh areas together with the increase in SC V south of Bernardo, presumably accounts for the small net gain in forest/shrub habitat overall. The decrease in marsh habitat, however, outweighs the slight gain in riparian forest and shrub habitat, and if acreages in these two categories are combined there has been a small net loss of habitat.

The greatest change has been in the amount of wet meadow habitat, areas classified as "salt grass," "meadow," and "alkali" on the 1918 maps. According to the maps, and to descriptions of vegetation communities by Watson (1912) and Van Cleave (1935), these wet meadows were the most extensive habitat type in the valley in the early part of this century. In 1982, only 232 acres of wet meadow (MH VI) were mapped. Most of the former saltgrass and meadow habitat in the valley has been converted to agricultural fields.

Aerial photographs of the valley taken in 1962 (USDI Bureau of Reclamation 1962) provide some additional insight into changes in vegetation in the valley. A series of jetty fields is visible, set out across what appear in the photographs to be large, open, sandy areas along meander bends (e.g., three areas of from 15 to 40 acres each just north of the Isleta Bridge and Diversion Dam on sheet No. 34). By 1982, woody vegetation, typically C/CW V, SC V, RO V, or combinations thereof, had been established on these formerly open jetty fields. This infilling of vegetation immediately adjacent to the channel may also account, in part, for increases in timber/brush habitat, and probably offset losses of habitat outside the area now confined by the levees. In 1918, the forest occurred in broader patches and was less continuous along the river edge than it is now. The current maps show the forest being much more heavily concentrated in a continuous narrow band immediately adjacent to the river channel within the levees.

The 1962 photographs also show several large stands of cottonwoods immediately south of the Bernardo Bridge (NM 60), which were cleared during the experimental water salvage project in the Bernardo Prototype Area (USDI Bureau of Reclamation 1962:sheets No. 54 and No. 55, USDI Burau of Reclamation 1967:plate 923-512-25). These cleared areas (which have been periodically mowed sine they were first cleared) now support nearly pure stands of SC V or SC VI. Although the 1962 photographs show substantial amounts of salt cedar between Bernardo and San Acacia, especially south of the Rio Salado confluence, the clearing project apparently increased the abundance of salt cedar in this reach.

Phenology

The timing and duration of phenological stages in the eight most common plant species in the study area are illustrated in Figures 7 and 8. The period of data collection extended from late March 1981 through January 1983, so the figures cover the major part of two annual cycles of flowering, fruiting, fruit/seed production, and leaf development, maturation and abscission.

The graphic plot of the phenology of those trees tenatively identified as Goodding willows was nearly identical to that of the peach-leaf willow group, so the data for these two groups were combined and designated "tree willow." Plots of the phenology of male and female trees of dioecious species were also quite similar, so sexes were combined for presentation.

Although leaf budding was observed about three weeks earlier in Russian olive, salt cedar, and seepwillow (Fig. 8) than in the four species in the willow family (cottonwood, coyote willow and the two tree willows, Fig. 7), all seven of these species reached full leaf development at approximately the same time, around the second to third week in May. Siberian elm reached the full leaf stage slightly earlier and indigo bush about a month later. Leaf abscission began around the same time in all species, roughly the first week of October. The onset and duration of flowering and fruit/seed production, by contrast, varied among species to a much greater degree than leaf phenology.

Siberian elm was the first species to break dormancy. In early March it produced inconspicuous flowers and began to set seed. (Flowering took place before we began data collection in 1981.) The fruits, which are clusters of samaras, matured and dried over the following two months and began to drop just prior to the onset of leaf development in early May. This was the only one of the nine species to complete its reproductive cycle so early in the year, and before leafing out.

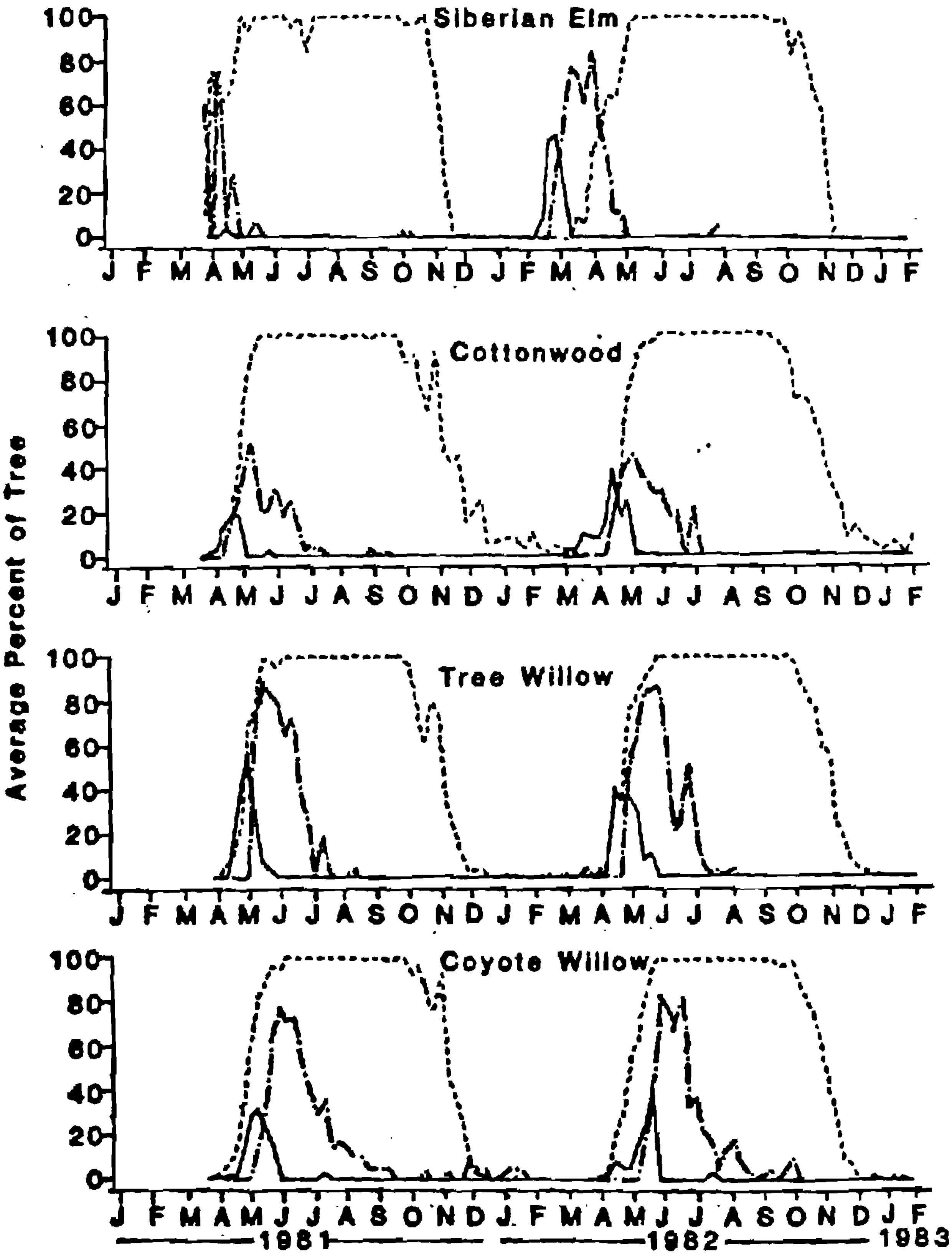

Figure 7. Phenology of Siberian elm, cottonwood, tree willow, and coyote willow. Solid line = flower; dash-dot-dash line = fruit; short dashed line = leaf.

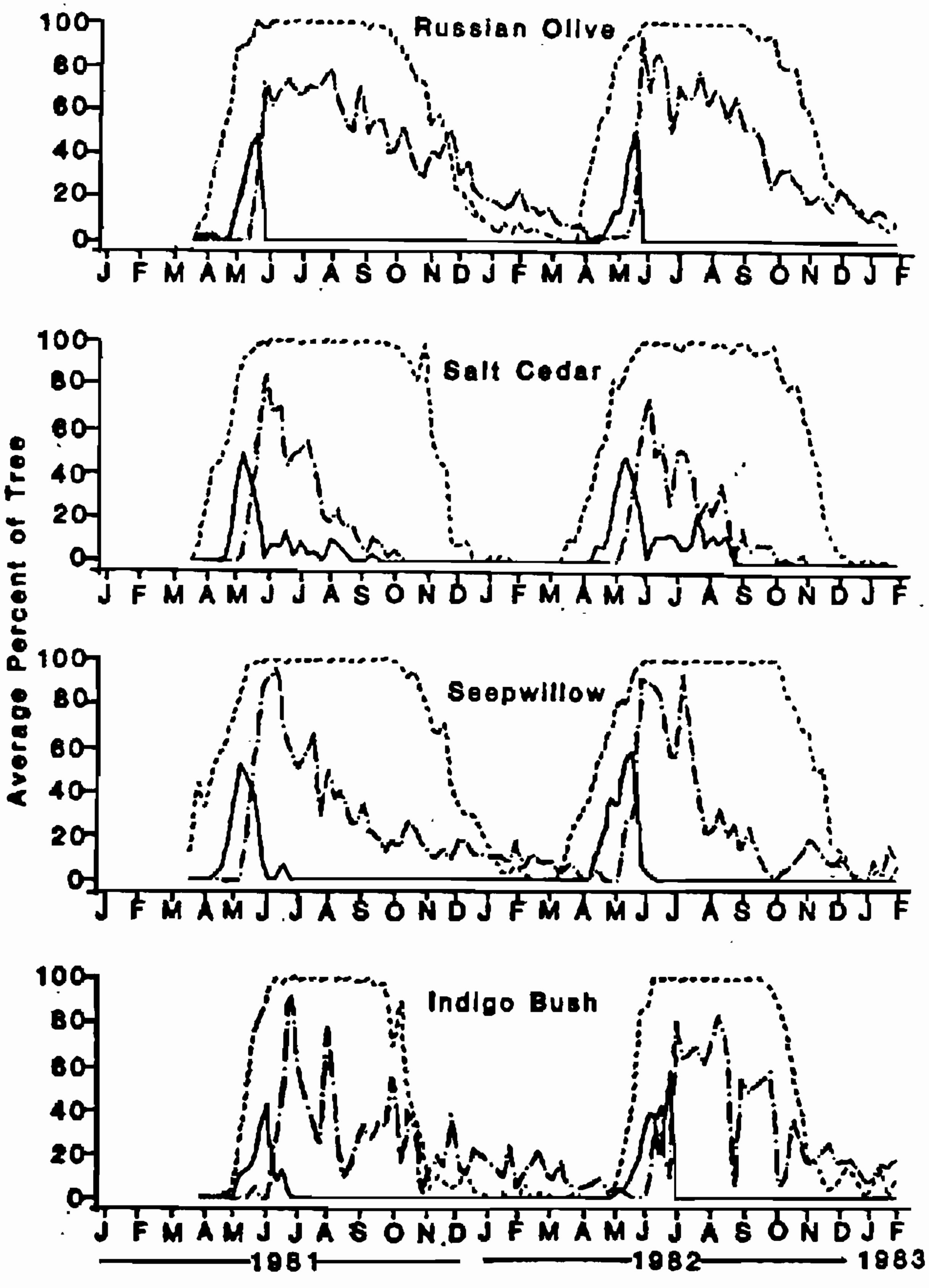

Figure 8. Phenology of Russian olive, salt cedar, seepwillow, and indigo bush. Solid line = flower; dash-dot-dash line = fruit; short dashed line = leaf.

Cottonwood was the second species to begin flowering, around late March. It was followed closely by the tree willows, which began to flower in early April. The peak of flowering in these three species was in mid-April, nearly coinciding with the period of most rapid leaf development. Timing of seed dispersal was also the same in cottonwood and tree willows. The small, "cottony" seeds were mature by the second week of May and began to disperse. Seed dispersal continued through May and June, tapering off gradually and ending around the first week of July.

Flowering in coyote willow began in mid-April and peaked at the beginning of May, about three weeks after this species leafed out. Seeds matured rapidly and began to disperse around the third week of May.

Salt cedar began to flower about a month after leafing out, with the first and largest peak of flowering in early May. Unlike all the other major floodplain species, it continued to flower throughout the summer months, as late as September in some cases. A single plant (even a single branch) frequently bore mature fruits and newly opened flowers simultaneously (V. Hink pers. obs.). This extended reproduction period may favor the germination and establishment of salt cedar over other floodplain species in disturbed situations, particularly if the disturbance takes place after early summer.

Seepwillow also flowers during the first and second weeks of May. The fruits form by early June, and some persist on the plant through the winter.

The four species that are members of the willow family, along with salt cedar and seepwillow to a lesser extent, share characteristics typical of riparian floodplain-associated species: early spring blooming period, large regular annual seed crop, small, light seeds dispersed by wind and/or water, and an early summer seed dispersal period (White 1979). White considers these aspects of reproductive biology to constitute obvious adaptations to an environment characterized by flood disturbance.

Russian olive, like salt cedar, began flowering four to five weeks after leafing out, and the peak of flowering was in the middle of May. The drupelike fruits became noticeable as the flowers dropped off, and they grew throughout the summer, becoming sweet, soft, and about 1/2 to 3/4 in long at maturity. Many of these fruits persisted on the trees through the winter, providing a food source for wintering birds and mammals.

Indigo bush was the last species to leaf out and to flower and was the first to lose its leaves in fall. It did not flower until early June, and fruits became noticeable around the third week of that month. As in seepwillow, some of the fruits were persistent.

It is noteworthy that the two common exotic shrubs, salt cedar and Russian olive, possess certain phenological and reproductive characteristics that differ from those of the common native riparian floodplain species. Salt cedar's potentially 5-month-long seed production season and approximately 12-week seed viability period contrast with the approximately 1-1/2-month-long seed-production season and 7-week seed viability of cottonwoods and willows (Horton et al. 1960). Russian olive's relatively large seed is apparently animal-dispersed and has extended viability, becoming dormant in winter and remaining viable the following year (Vines 1960). Thus salt cedar and Russian olive have an extended period for potential germination, which probably gives them advantages in colonization of certain types of disturbed sites or during certain times of the year.

Comments on Vegetation Succession

These comments refer primarily to the communities of the intensive study area among which there are many similarities in plant species composition, structural characteristics, and physical environment. Much of the discussion is necessarily speculative, since there has been relatively little documentation of the vegetation history of the study area.

In the Middle Rio Grande Valley, as in many river systems throughout North America, there have been substantial alterations in the natural dynamics of the river system. A discussion of riparian forest succession must be placed in the context of such alterations by acknowledging their past and potential future impacts. We will attempt to outline the probable dynamics of the Middle Rio Grande system prior to substantial modification, and to suggest the influence of river system alterations on present riparian community development.

In natural river systems, riparian forest communities are maintained by periodic flood disturbance (White 1979, Rupp 1982), and are best viewed as non-equilibrium systems of which frequent disturbance is an integral part. The dominant vegetation species in riparian forest communities often share a number of physiological and life-history attributes related to existence in a periodically flooded environment. These include flood tolerance, large annual seed crops, early spring blooming period, early summer seed dispersal (directly related to annual flood cycles), light wind- or water-dispersed seeds, short seed viability period, necessity for moist alluvium for germination, low shade tolerance, and rapid germination rates (White 1979 and references therein). The major native riparian species of the Middle Rio Grande exhibit most of these characteristics (see previous section on phenology).

There is little documentation available on the dynamics of the Middle Rio Grande riparian community prior to substantial human impact. However, the dynamics of riparian forest succession have been studied on other major river systems (Everitt 1968, Wilson 1970, Johnson et al. 1976), and it is probable that conditions were similar on the Rio Grande. We quote from the study by Johnson et al. (1976:65-67) on the Missouri River to illustrate the processes that we suggest were prevalent in the Middle Rio Grande Valley prior to substantial human modification:

> As the river meanders, it deposits alluvium on the inside of river curves, while on the opposite side it erodes away established banks often covered with forest vegetation in different stages of development. The fresh, fully exposed alluvium is prime habitat for the establishment of seedlings of pioneer tree species [e.g., cottonwood and willows]....If such sites remain uneroded, forests of these species may develop.... In places where the river has moved systematically in a uniform direction, a gradient in forest vegetation has been produced with the youngest stands (usually of pure cottonwood and willow) nearest the river.
>
> The erosional-depositional character of the river preserves forest heterogeneity on the floodplain. The meandering pattern of the river, however, regulates the spatial distribution of these different communities. In places where the river has historically meandered rapidly, stands have been recycled rapidly, resulting in a relatively low mean stand age.
>
> ...[F]ew stands escape erosion and attain sufficient age to reach advanced successional stages. In contrast...low erosional frequency near the outer edge of the floodplain.... [accounts for the occurrence of the more mature older stands there.]

Available descriptions of the Middle Rio Grande Valley indicate that as on the Missouri River, meandering and flooding were common (e.g., Abert 1848, Watson 1912, Burkholder 1928, Fergusson 1931) and the effort expended on channelization and flood control measures in the valley further attests to this. Watson (1912) briefly discussed vegetation succession on mudbanks exposed after flooding, which took place in a manner very similar to that described above by Johnson et al. (1976) on the Missouri River; cottonwoods, willows and cattails colonized the exposed soil. Fergusson (1931) described cyclic destruction and regeneration of cottonwood stands through river meandering, and noted that "Most of the cottonwood forest never lives long enough to be more than a dense covert, twenty or thirty feet high, but whenever the trees escape the river for a period of years they grow into beautiful groves...." These patterns of large-scale channel migration, annual flooding, and regeneration probably characterized the riparian ecosystem until around the 1920's.

Since that time two factors have greatly altered the character of the system: (1) substantial changes in river dynamics as a result of the construction of levees and dams and channelization, and (2) the introduction and spread of exotic plant species, particularly salt cedar and Russian olive. These two factors are apparently interrelated (Everitt 1980).

Salt cedar was commonly planted as an ornamental in Albuquerque in the early 1900's (Watson 1908) and had become widely naturalized in the valley by 1930-35 (Thompson 1958, Robinson 1965). Russian olive was introduced into the valley between 1900 and 1915, probably in Albuquerque, and rapidly became established and widespread in the wild between 1920 and 1935 (Freehling 1982). Both Russian olive and salt cedar have a longer potential germination season than the dominant native riparian species, which may give them an advantage in becoming established under altered river flow patterns, as discussed previously. Salt cedar, like cottonwood and willow, colonizes exposed moist soil, but can do so later in the season, and once established, it is better able to tolerate subsequent flooding and salinity than cottonwood or willow (Potter 1975, Everitt 1980). These characteristics have contributed to its establishment and dominance along much of the lower Rio Grande as well as along other major southwestern rivers. Russian olive not only readily colonizes disturbed areas but can also tolerate shade and invade existing stands of woodland (Campbell and Dick-Peddie 1964, V. Hink pers. obs.).

Levees were constructed beginning around the 1920's, confining the river within a narrow floodway under normal conditions. Many years of irrigation on a large scale had either caused or contributed to poor drainage and increasing salinity in the valley, and this, in combination with water shortages, had led to the abandonment of over 75,000 acres of farmland, about 60% of the total acreage that had been cultivated in the 1880's (Burkholder 1928). To remedy these problems, rehabilitation of the irrigation system, along with the construction of a system of drains from Cochiti to San Marcial, was undertaken by the Middle Rio Grande Conservancy District in the 1930's. The levee system was also improved and made more continuous at this time.

Van Cleave (1935) described the vegetation communities present in the valley at that time, and the changes that took place as a result of drainage. As previously discussed in the Biohistorical Account, prior to drainage there were five types of communities: lakes, marshes, wet meadows, mixed species woodland (cottonwood, tree willow, salt cedar and Russian olive) and, fringing the river, a cottonwood-willow forest several hundred meters wide. Drainage resulted in the disappearance of lakes and marshes, drying up the meadows, and the death of willows in both the woodlands and the river edge forest. Former lake, marsh, and meadow sites were colonized by cottonwood, salt cedar, and Russian olive.

Although Van Cleave (1935) mentioned neither Russian olive nor salt cedar occurring in the river edge cottonwood forest, she noted that both occurred in the other valley communities by 1935. It is notable that the dates of widespread establishment of these two exotic species (1920-35) coincided with the time when significant disturbance of the valley was taking place in connection with the construction activities of the Middle Rio Grande Project, during 1925-1935.

There is no record of the development of riparian vegetation from 1935 until 1965. Beginning around 1950, however, another series of construction projects was undertaken in the valley (described in USDI Bureau of Reclamation 1977). To preserve the levees and further diminish the threat of destructive flooding, the river channel was straightened and channelized using the Kellner jetty system, which was first implemented on a large scale in 1953 (Woodson 1961). The first of a series of flood- and silt-control dams on the Rio Grande and its tributaries, the Jemez Canyon Dam, was completed in 1953. Abiquiu Dam, on the Chama, was completed in 1963, Galisteo Dam on Galisteo Creek in 1970, and most recently, Cochiti Dam on the Rio Grande, was completed in 1975. Collectively, the dams have diminished the peaks of spring flows and extended the early summer high-water period in the Middle Rio Grande (USDI Bureau of Reclamation 1977; Corps of Engineers, Albuquerque District). The river still floods the area between the levees periodically (about every 5-7 years), but since Cochiti Dam was completed the rate of water release is kept below what would threaten the integrity of the levees and flooding is thus unlikely to be of sufficient magnitude to remove established woody vegetation. The last flooding episodes that apparently cleared a significant acreage of bosque occurred in 1941-42 (Corps of Engineers, Albuquerque). Under the current operation and maintenance program the river channel is kept free of all vegetation and debris (by river flows and clearing), and woody vegetation is periodically cleared from a designated portion of the floodway adjacent to the straightened river channel.

Although the levees had greatly reduced the area over which the river meandered, until channelization was completed in the 1950's, the river still migrated within the floodway and continued to expose new sites for colonization by cottonwood and other riparian species. Immediately following channelization, the newly created jack fields stabilized large areas of moist alluvium which then were rapidly colonized by cottonwood, willow, salt cedar, and Russian olive (see photographs, Woodson 1961 and USDI Bureau of Reclamation 1977). Hence much of the existing C/CW forest in the valley, though confined within the floodway, probably developed under conditions approximating natural patterns of riparian succession in that the starting point was flooding and subsequent colonization of alluvium by seedlings. The earliest stages of vegetation establishment in such areas probably resembled present sandbar (SB VI) communities, with patches of seedling cottonwoods, coyote willows, and salt cedars. Within a few years such stands probably developed into stands resembling the one at NW-17, an open, sandy C/CW VI community which includes cottonwoods, coyote willows, salt cedars, and scattered Russian olives as well as grasses and annual plants. As vegetation progressively stabilized the area and many of the seedlings died off, it probably came to resemble a C/CW V stand, such as NW-06 or SW-16, a moderate-to-dense shrubby growth of coyote willow, salt cedar, and Russian olive, with a few taller cottonwoods scattered throughout. Sparse C/CW V stands or those in higher, drier spots may have developed into C/CW IV, while denser stands in low, moist areas may have developed into C/CW III communities.

As cottonwoods matured and canopy cover increased, sun-loving coyote willows and salt cedars decreased in abundance while Russian olives increased in size (and may have increased in frequency by reproduction and/or invasion), leading to the development of C/CW I and eventually C/RO I stands (Campbell and Dick-Peddie 1964). A mature, essentially two-species C/RO I stand at Isleta (SE-04) may represent the most advanced stage in this type of development. It is notable that the largest and presumably oldest trees in the study area today are concentrated near the levees farthest from the river channel where they would have been least subject to destruction by a shifting channel.

The origin and development of type II communities is problematic. They may have originated as very dense cottonwood stands (like NE-07) in which shrubs never became established, or, more likely, some external factor such as livestock grazing, heavy vehicular traffic, clearing or burning of undergrowth limited development of a shrub layer.

When channelization was completed there was a fundamental change in river dynamics which led to far-reaching changes in patterns of vegetation succession. With the elimination of channel migration, the river no longer exposed new areas of alluvium outside the established, cleared river channel. Now colonization of sandbars by cottonwood and other seedlings takes place primarily and perhaps exclusively within the sandy river channel. The SB VI and C/CW VI communities that develop from such colonization are typically washed away by the river or removed during floodway clearing operations and are thus prevented from developing into more mature forest communities. (The one apparent exception is the dense stand of 15-20 ft cottonwood saplings at the edge of the floodway under the Bernalillo Bridge [NE-07; C V] that appears to have developed from a patch of seedlings on a sandbar.)

Another pattern of vegetation development is observable within the periodically cleared floodway. In certain early growth stands at the margins of the river channel (RO VI) Russian olive is the dominant, and often the only, woody plant species. In more mature stands of this type (RO V) patches of young cottonwood, coyote willow, and salt cedar plants occur, but Russian olive is still dominant. Both RO V and RO VI stands typically occur in poorly drained soil, and are characterized by a lush growth of grass and sedge. They occur in narrow strips parallel to the river channel, and meet the adjacent levee-ward vegetation community along a sharply defined, nearly straight border. These RO communities appear to have developed on areas that were cleared during the last floodway maintenance operations, around 1972 (M. Sifuentes pers. comm.).

Some of the C/CW VI stands, e.g., at NW-13 and NW-16, also appear to have developed on such previously cleared portions of the floodway. Like the RO stands, they occur as strips along the river channel, with a straight, sharply defined boundary where they meet adjacent vegetation. They are on somewhat better-drained soil than the RO stands, but they still support dense grass cover. These C/CW VI stands (subsequently referred to as C/CW VI A) have much more grass cover than C/CW VI stands within the river channel (89% vs. 45%, respectively), and a much lower density of woody plants (195 per acre vs. 103 per acre, respectively). These RO and C/CW VI A communities are thus different in origin and in structure from the types of early successional communities that occur today within the sandy river channel, and from the early succession communities that presumably existed under the natural river system. Both the type of disturbance initiating succession, and its timing, are unrelated to river flow patterns.

The remainder of the floodway is not subject to periodic clearing, and most of it is forest, or bosque. Succession in the bosque is now most likely to be initiated by disturbances resulting from human activity, such as burning, cutting of firewood, or bulldozing of roads. For example, many C/CW V stands, usually those that are most dense, show evidence of past fires. Thus, as in the case of the cleared floodway, disturbances that initiate succession are unrelated to river flow patterns. Artificial disturbance has now largely replaced river meandering and flood cycles as the starting point of succession within the riparian community.

The long-term impacts of this change are open to speculation. With disturbance no longer tied to the annual flood cycle, native riparian species may be at a serious disadvantage. If disturbances often take place at times or under conditions that prevent native species from colonizing the new site, exotic species may become increasingly abundant. Prolongation of the period of spring high flow rates by flood control dams, along with increasing disturbance associated with urban development, are serious considerations. While salt cedar has not been observed to displace existing cottonwood stands in the valley in the absence of disturbance, salt cedar has invaded and become dominant in areas where cottonwoods were cleared (e.g., in the northern portion of the Bernardo Prototype Area) or killed by extended inundation (e.g., at Bandelier National Monument, Potter 1981; also on the Bill Williams River in western Arizona, Hunter et al. in prep.). Within the intensive study area salt cedar is particularly common in parts of the bosque within the city of Albuquerque (see maps, Appendix XI), which may be related to the degree of disturbance there.

Russian olive, because it tolerates shade and apparently can invade existing cottonwood stands as well as disturbed areas, may present a greater problem. Once Russian olive becomes firmly established at a particular site, it may be able to perpetuate itself in its own shade, whereas cottonwood (and other species that germinate in sunny locations) would be unable to reproduce there. As cottonwoods mature and die out, the result could be increasingly numerous stands of nearly pure Russian olive.

At present, cottonwood appears to be regenerating locally within the bosque, but whether this is from seed or primarily through vegetative means is unknown. Greater understanding of the patterns and processes of current vegetation development in the valley is urgently needed in order to develop sound management policies. Additional research is strongly recommended.

Endangered, Threatened, and Rare Plant Species

According to the U.S. Fish and Wildlife Service Review of Plant Taxa for Listing as Endangered or Threatened Species (Federal Register 1984) and the New Mexico Natural Heritage Program list of New Mexico taxa listed, proposed, or under review, there are currently eight species of plants listed as endangered or threatened in New Mexico. None of them has occurred or would be expected to occur within the study area. Of the species currently proposed for listing or under review, only seven, according to maps in Martin and Hutchins (1981), occurred within any of the counties that intersected the study area. All of them were classified as "under review." Descriptions of the known ranges and habitat associations of these species in Martin and Hutchins (1981) indicated that none had been known to occur within the study area.

Habitat descriptions for two of these species (Abronia bigelovii and Senecio quaerens), however, did not exclude the study area as potential habitat. Abronia bigelovii, which occurs at "around 6000 feet" and is "apparently restricted to Sandoval and Santa Fe counties" (Martin and Hutchins 1981:663), could possibly occur in dry, sandy habitats in the northern half of the study area. Although several specimens of plants in the genus Abronia were collected in this part of the study area (see Tables I-1 through I-3, Appendix I), none proved to be Abronia bigelovii. Senecio quaerens, although not noted as being in the Rio Grande Valley, is associated with riparian habitats. It is "apparently restricted to damp ground near streams in the western part of New Mexico (including Socorro County), at 5000 to 8000 feet" (Martin and Hutchins 1981:2215). Four specimens of plants in the genus Senecio were collected, including one from the southern part of Valencia County, but Senecio quaerens was not found. Based on consultation with Natural Heritage Program biologists as well as the information in the literature, it is our opinion that it is unlikely that either of these species occurs in the study area.

The search of the Natural Heritage Program files on species considered threatened, endangered, or of special concern in New Mexico yielded two records of rare plant species from within our study area. Both were orchids, classified as "special concern elements." Spiranthes of the Great Plains (Spiranthes magnicamporum) had been recorded in 1974 in a "bog" (probably MH VI, possibly MH V) "west of U.S. Highway 85 and about one mile south of the railroad overpass south of Isleta," (T 8 N, R 2E, SE 1/4 S 27) i.e., at the northwest edge of Isleta Marsh. Giant Helleborine (Epipactis gigantea) was found in 1977 in the bottom of White Rock Canyon "below the old sewage plant" (T 18 N, R 7 E, S 3). William Isaacs also informed me that three other rare plant species were known to occur in the study area: a gentian (Eustoma exaltatum) and a species of sunflower (Helianthus paradoxa), both of which were known to occur in the valley in alkaline soils as far north as La Joya (W. Isaacs pers. comm.), and an endemic species of prairie clover, Petalostemon scariosum [=Dalea scariosa], which grows in open, sandy areas and is "apparently restricted to the Rio Grande Valley of central New Mexico" (Martin and Hutchins 1981:1104).

During our plant survey we documented the presence of three of these species in additional localities. A specimen of Giant Helleborine was collected on transect SW-02, at the perimeter of a stand of C/RO II (Bernalillo Co., T 8 N, R 2 E, SW 1/4 S 13). Eustoma exaltatum was found on GN-02, a dense stand of SC VI about 50 ft from a marshy area (in Sandoval Co., T 13 N, R 4 E, NE 1/4 S 17). Petalostemon scariosum was found in the same general area, in a sandy, open salt cedar stand, on GN-04 (Sandoval Co., T 13 N, R 4 E, SW 1/4 S 9) and also by W. Howe in 1983 at the artificial pond (SW-07) near Los Lunas (Valencia Co., T 7 N, R 2 E, NE 1/4 S 22). The records of Eustoma exaltatum and Petalostemon scariosum in Sandoval County may represent extensions of those species' known ranges in New Mexico. We did not locate any specimens of Helianthus paradoxa or Spiranthes of the Great Plains during the survey.

Terrestrial Vertebrates

Reptiles and Amphibians

Pitfall trapping yielded information on the distribution and abundance of small, primarily terrestrial species of reptiles and amphibians in the different C-S types. Mean total capture rates ranged from 0.12 to 3.48 captures per 100 trap days (Table 10) and averaged 1.20 $\pm$ 1.05 across C-S types. Eighteen different species were taken in pitfall traps, three of which (eastern fence lizard [*Sceloporus undulatus*], New Mexican whiptail [*Cnemidophorus neomexicanus*], and Woodhouse toad [*Bufo woodhousei*]) were common and widespread. The other 15 species were captured infrequently or were of limited distribution or both. Except for toads, amphibians were poorly represented in pitfall traps, but two species (chorus frog [*Pseudacris triseriata*] and bullfrog) were known to be seasonally and/or locally common.

Total Capture Rates.--Reptiles and amphibians were sampled by pitfall trapping in 17 different C-S types altogether. Thirteen of the types were in the intensive study area, and 10 of the 13 were sampled both years. The other four occurred primarily in the general study area and were sampled only in 1982.

There were three cases where one C-S type was represented by two different transects during the same season: C/CW IV and C/RO I in 1981, and C/CW V in 1982 (Table VI-1, Appendix VI). In all three cases, there was no significant difference between the total capture rates for the two transects of the same type. For two of the three pairs (C/RO I excepted) the rates were remarkably close. Because of this similarity in capture rates, these data were pooled to yield single values for each C-S type each year. Subsequent analyses were based on these pooled capture rate values.

There were marked differences among the C-S types with regard to total herptile capture rates (Fig. 9). A Kruskal-Wallis one-way analysis of variance indicated that there were highly significant differences among the intensive study area C-S types in total capture rate: (1) in 1981, (2) in 1982, and (3) when data for both years were combined ($P<0.0001$ for all three tests). The greatest differences were among types at the upper end of the range in total capture rates, whereas the seven types at the low end had very similar mean total capture rates.

These differences are related to vegetation characteristics. Herptile capture rates were highest (>2.01 per 100 trap days) in areas of relatively open vegetation with sandy soil and sparse ground cover (C/CW IV, DR VI, OP VI). The lowest capture rates were obtained in C-S types characterized by thick understory vegetation, either herbaceous plants or Russian olive, or a mixture of both (MH V, C/CW E III, C/CW V, C/CW VI, RO V, C/RO I). Most of the C-S types falling in the intermediate range of capture rates may be described as having a variable or patchy understory. Accordingly, two different vegetation parameters were correlated with total capture rate. There was a significant negative correlation between the mean total capture rates and total foliage density of the transects sampled ($r = -0.593$, $P<0.05$). Percent

Table 10. Summary of reptile and amphibian trap data for each community-structure (C-S) type.

	N/100 trap days			Number of species			Number of trap days		
C-S type	$\overline{x}$	1982	1981	Total	1982	1981	Total	1982	1981
Intensive Study Area									
C/CW IV	2.83	2.77	2.89	5	4	5	6650	2414	4236
DR VI	2.64	1.95	3.33	5	4	4	4477	2461	2016
C/CW VI	1.67	2.59	0.75	5	4	5	4558	2548	2010
SB VI	1.67	1.30	2.03	5	4	5	3377	1313	2064
C/CW I	1.40	1.86	0.94	4	4	3	4666	2530	2136
C/RO II	0.94	0.77	1.11	1	1	1	4743	2593	2150
C/CW V	0.78	0.94	0.61	5	2	4	4692	2560	2132
MH V	0.59	--	0.59	2	-	2	854	--	854
OP V	0.57	0.57	--	3	3	-	1758	1758	--
C/CW E III	0.51	0.51	--	3	3	-	2549	2549	--
C/CW VI A	0.42	0.35	0.48	5	3	3	4660	2560	2100
RO V	0.29	0.24	0.34	6	3	4	3264	1654	1610
C/RO I	0.18	0.00	0.36	3	0	3	6688	2580	4108
OP VI	2.73	Artificial pond		6			1466	1466	--
General Study Area (sampled 1982 only)									
SC VI A	3.48	Jemez River		7			2533		
SC VI	0.12	Jemez River		1			2519		
SC VI	1.66	Bernardo		4			600		
C/J I	2.35	Cochiti		4			684		
C/J IV	2.84	San Ildefonso		4			600		

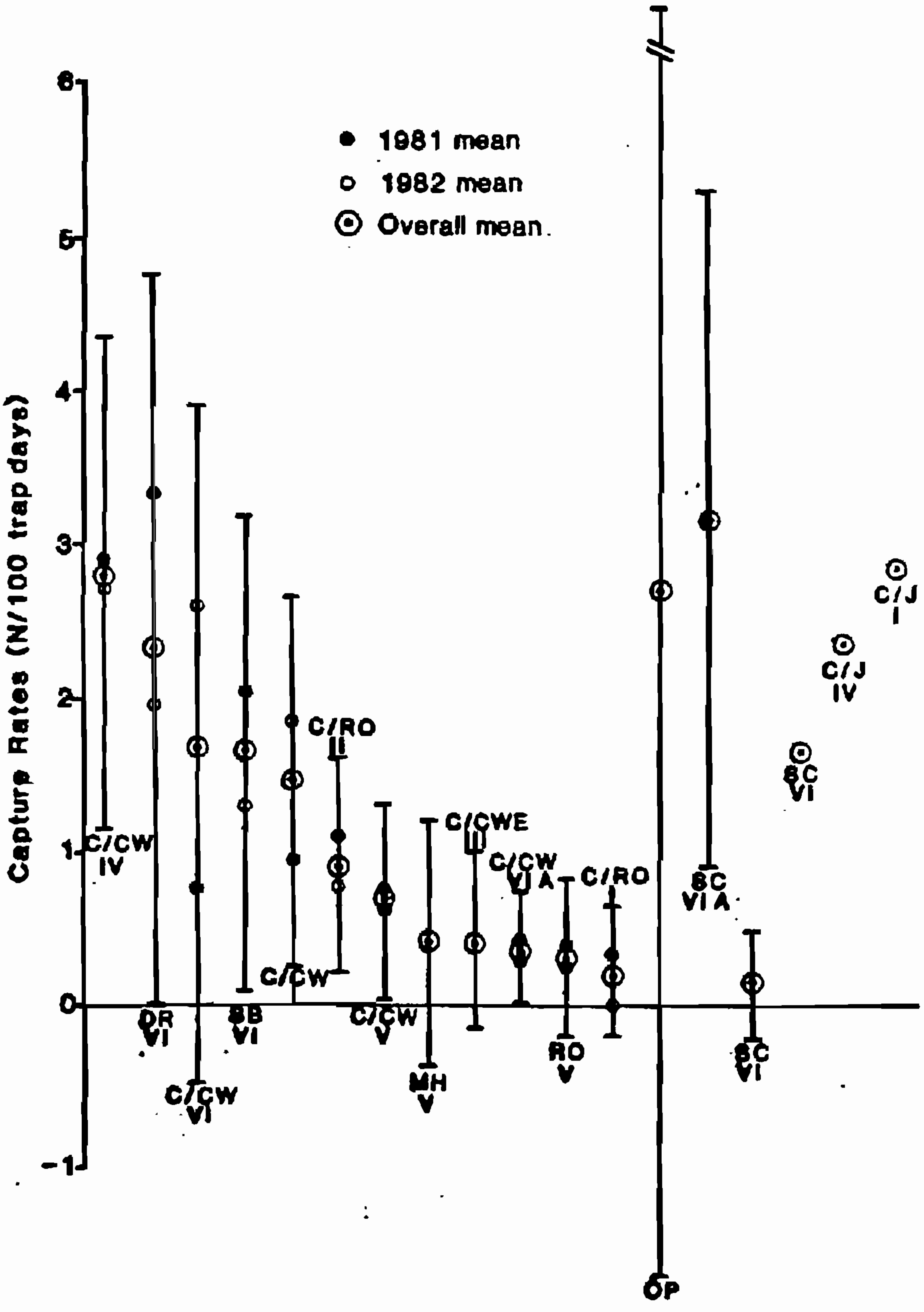

Figure 9. Total capture rates of reptiles and amphibians in each community-structure type. Bars represent standard deviations of the overall mean. See facing page for abbreviations.

Figure 9.--Abbreviations

C/RO = Cottonwood/Russian olive

C/CW = Cottonwood/coyote willow

C/J = Cottonwood/juniper

RO = Russian olive

SC = Salt cedar

DR = Drain

MH = Marsh

SB = Sandbar

OP = Small openings

Roman numerals = Structure types

vegetation cover (as estimated from 1- and 2-yd^2 plots centered on each pitfall trap) was also significantly negatively correlated with capture rate ($r = -0.608$, $P<0.05$) on a C-S-type-by-C-S type basis.

These relationships between vegetation characteristics and total capture rate hold when the general study area data are included. When the two salt cedar transects at the Jemez River that were sampled for a full season (SC VI and SC VI A) are included in the Kruskal-Wallis test, the result is the same: there are significant differences in total capture rate among the C-S types ($P<0.0001$). Likewise, the negative correlations of total foliage density and percent cover with capture rate also hold when the Jemez transects are included ($r = -0.607$, $P<0.05$ and $r = -0.678$, $P<0.01$, respectively). The SC VI A type yielded the highest capture rate of any sampled C-S type and had less vegetation cover than any habitat except sandbars. Although the data from Bernardo, Cochiti, and San Ildefonso are not strictly comparable because trapping did not span the season, they support the other results. The significance of the two correlations is improved when all 18 sampled C-S types are included ($r = -0.615$, $P<0.01$ and $r = -0.680$, $P<0.01$, respectively).

From these results, we may generalize that for primarily terrestrial species and habitats throughout the study area, the more open the vegetation in a habitat, the greater the overall capture rate of amphibians and small reptiles in that habitat. We may assume that capture rates reflect to some extent relative abundances of small terrestrial herptiles in these habitats. It must be noted, however, that larger species such as snakes and some lizards that could escape from the 4.5-gallon buckets were not sampled adequately by pitfall trapping, nor were species associated with wetter habitats.

It was not feasible to compare edge versus interior habitats for amphibians and reptiles. The small size of most of the common species makes it difficult to define and sample edge habitats for them. We infer that since (1) most lizards were found in open areas rather than in densely vegetated areas, and (2) drain habitats yielded some of the highest total capture rates, greater numbers of lizards would be found along the levee-side edges of a particular C-S type than in the interior of the stand. For species other than lizards, relative use of edge vs. interior habitat is unknown.

<u>Seasonal and Yearly Fluctuation in Total Capture Rates</u>.--There was little difference between the two years' results, as illustrated by comparison of 1981 and 1982 total capture rates for those 10 C-S types sampled both years (Table 10 and Fig. 9). The absolute capture rates were quite similar, and the rank order of the types with regard to total capture rate was also largely consistent over the two years. This was true despite the fact that different transects were used to represent three of those C-S types the second year and that the 1982 season was two months longer than the 1981 season. A t-test indicated that there was no significant difference between 1981 and 1982 mean total capture rates (based on those 10 C-S types sampled both years). Year-to-year consistency in the capture rate for each of the types was indicated by the results of pairwise comparisons using the Mann-Whitney U-test:

there were no significant differences between 1981 and 1982 total capture rates for any of the 10 types. The 1981 and 1982 total capture rates for the 10 types were also significantly correlated ($r = 0.636$, $P<0.05$).

The only notable difference between the two years' total capture rates was observed on NW-17, representing the C/CW VI A type (a very sparsely vegetated C/CW VI). Comparison of the 1981 and 1982 data for NW-17 (Table VI-1, Appendix VI) reveals that the increase in capture rate from 0.75 in 1981 to 2.59 in 1982 was due to a change in the capture rate of one group, whiptail lizards (Cnemidophorus spp.). Whiptails were captured 10 times more often there the second year than the first. Parthenogenetic whiptails have high reproductive potential, so such fluctuation in frequency of capture at one site is not surprising. The fluctuation may have been related to the greater amount of water in the river channel in 1982, as NW-17 was on one of the higher sandbars at the edge of the channel. Whiptails may have been displaced from lower-lying areas that were inundated. The increased capture rate for NW-17 was complemented by a decrease (of lesser magnitude) in the capture rate for NW-09 (SB VI), a lower-lying sandbar near NW-17 that was inundated for two months during 1982.

Total capture rates fluctuated seasonally (i.e., across months) and this fluctuation was reflected in the standard deviations of the mean total capture rates. Those types with the highest mean total capture rates exhibited the greatest fluctuation, varying from 0 captures per 100 trap days in the cool months (March, April, October, November) up to 6-8 per 100 trap days in some C-S types during July through September. These high capture rates in summer were related to the appearance of young in the traps. A discussion of seasonal fluctuation and reproductive season in the two major species is given in Appendix VI.

Species Richness, Composition, and Habitat Associations.—The number of species captured in a C-S type was not consistently related to its total capture rate. Those C-S types with the highest capture rates had the highest species totals, 5 to 7 species (Table 10). However, three transects with low capture rates (<0.80) had equally high species totals.

The three most widespread and frequently captured species were eastern fence lizard, New Mexican whiptail, and Woodhouse toad (Table 11). For each of the three species, 1981 and 1982 capture rates over the ten C-S types were significantly correlated ($r = 0.672$ and $r = 0.748$, $P<0.05$; and $r = 0.989$, $P<0.01$, respectively). Thus, year-to-year consistency was true not only of total capture rates but applied also to individual species' capture rates. The eastern fence lizard, the most commonly trapped species, accounted for 65% and 39% of total captures in 1981 and 1982, respectively. This species was taken at least once in 17 of the 18 C-S types sampled (all C-S types sampled except MH V), and was the most commonly captured species in 7 of those types. The New Mexican whiptail was the second most common species at 19% and 25% of total 1981 and 1982 captures, respectively. It was less widespread than the eastern fence lizard, occurring in only 12 of 18 C-S types, but it was the most common species in 5 of those types. Both fence lizards and

Table 11. Capture rates of reptile and amphibian species in the intensive study area community-structure types. Each value is the average of the 1981 and 1982 capture rates for that species in that type. All capture rates are expressed as the number of individuals captured per 100 trapdays (N/100 TD). * = notable difference between 1981 and 1982 captures. The annual data from which these values were calculated are given in Appendix V-1.

Species	C/RO I	C/CW I	C/RO III	C/CW E III	C/CW IV	C/CW V	OP V	RO V	MH V	C/CW VI A	C/CW VI	DR VI	SB VI	OP VI
Tiger salamander														.20
Plains spadefoot toad					.01						.03	.03		
Woodhouse toad		.02			.07	.03		.16		.03	.11	.12	.82	1.30
Great Plains toad					.03									
Chorus frog	.01						.28							
Bullfrog														.95
Spiny softshell turtle								.03						
Eastern fence lizard	.14	1.08	.94	.16	2.40	.49		.03		.27	.61	.93*	.28	.07
Great Plains skink		.05				.03	.06	.03	.12			.27*		
New Mexican whiptail				.31	.32	.14	.23	.03	.47	.06	.59*	1.31	.41	.14
Chihuahuan whiptail	.03	.26				.10				.07	.54*		.14	.07
Common gartersnake				.04				.03					.03	
Number of species	3	4	1	3	5	5	3	6	2	4	5	5	5	6
Total No./100 trap days	.18	1.41	.94	.51	2.83	.79	.57	.28	.59	.63	1.68	2.66	1.68	2.73

whiptails favored sandy, open habitats characterized by sparse or scattered understory vegetation, such as C/CW IV, C/CW VI A, and levee banks (DR VI). Because of the abundance of these two species, total capture rates and their correlations with vegetation parameters largely reflect the habitat relationships of these two open area species. Chihuahuan whiptails (Cnemidophorus exsanguis), rarer in the valley than congeneric New Mexican whiptails, also occurred in greatest densities in these open habitats, as did Woodhouse toads (the third most commonly captured species), Great Plains toads (Bufo cognatus), and plains spadefoot toads (Scaphiopus bombifrons). Toads were particularly numerous on sandbars (SB VI), where their capture rate exceeded that of fence lizards.

For the remaining species (other amphibians, skinks, gartersnakes, softshell turtles) that were less frequently captured, a different pattern of distribution was evident. This second group of species was associated with the wetter or more densely vegetated habitats.

Great Plains skinks (Eumeces obsoletus), unlike the other lizards, were taken most frequently in C-S types with substantial herbaceous and shrubby vegetation in the lower layers. Skinks were captured once each in C/CW I and C/CW V both years; in RO V in 1981; and in 1982, 13 skinks were taken at the DR VI site. At the latter site, as discussed below, five of the buckets were adjacent to the drain where there was a thick cover of annual plants. No skinks were taken in the open, sandy C-S types favored by fence lizards and whiptails.

The association of skinks with well-vegetated sites explains a difference between the 1981 and 1982 data at the species level in the DR VI type. Fewer fence lizards were taken in DR VI in 1982 (0.12 per 100 trap days) than in 1981 (1.74), while skinks, which were not taken in DR VI in 1981, had a high capture rate (0.53) in that C-S type the second year. DR VI was sampled somewhat differently the second year than the first. In 1981, all 10 buckets were placed in the most open portion of the habitat, the unvegetated levee bank. In 1982, half the buckets were on the levee bank and half were placed immediately adjacent to the drain, a moister location that supported a thick cover of grass and herbaceous plants. The capture rate of the open-area species, fence lizard, decreased in 1982, while the skink, which is associated with moist areas, was taken more often. The total capture rate for DR VI decreased somewhat in 1982, as would be expected because of the greater proportion of vegetation cover on the sample plot that year.

Bullfrogs, chorus frogs, and tiger salamanders (Ambystoma tigrinum) were found only in association with temporary or permanent open water: at the artificial pond (OP VI), at OP V (a small C/CW V opening that was flooded for three months in 1982), or beside channels running through the bosque (in C/RO I, C/J I). Since these species require open water seasonally for reproduction, they should be considered dependent on wetter riparian habitats where temporary or semipermanent pools form. A species notably absent from our traps was the leopard frog.

Common gartersnakes and spiny softshell turtles (Trionyx spiniferus) were taken too rarely to permit generalization about their habitat use based on pitfall trap data. Field observations suggest that gartersnakes favored moist habitats: pond and river banks, wet sandbars; and softshell turtles occurred in ponds, drains, and along the river (further discussion below).

Table 12 presents capture rates for each species for the C-S types sampled in the general study area. Lizards were the most numerous species captured there. In addition to the three lizards most common in the intensive study area (Eastern fence lizard, New Mexican whiptail, and Chihuahuan whiptail), five more were taken in the salt cedar and cottonwood-juniper C-S types to the south and north: round-tailed horned lizard (Phrynosoma modestum), little striped whiptail (Cnemidophorus inornatus), plateau whiptail (C. velox), lesser earless lizard (Holbrookia maculata), and side-blotched lizard (Uta stansburiana). The general study area C-S types sampled were for the most part more sparsely vegetated, sandier, and more arid than those in the intensive study area. The lesser earless, side-blotched, and round-tailed horned lizards are primarily upland species that used these more arid riparian habitats. All three are present in the upland habitats adjacent to the intensive study area, but they are not found in the moister riparian habitats of the intensive study area. Besides having a greater upland character than most of the intensive study area, the general study area extended over a larger area. Consequently, it intercepted the geographic ranges of the little striped and plateau whiptails that reached the valley in the north. Woodhouse and Great Plains toads also occurred in the sandy general study area C-S types, and one small glossy snake (Arizona elegans) was captured at the Jemez River site.

Of the water-associated species found in the intensive study area, only the tiger salamander was captured in the general study area. It was found in association with a wet channel a C/J I stand. If there had been an opportunity to sample wet areas, or if we could have sampled earlier in the season in the general study area, it is likely that more of the water-associated amphibians would have been captured there.

The pitfall trap data summarized above present only a partial picture of the amphibian and reptile fauna occurring in the study area, because such traps are strongly biased toward small, terrestrial species. Larger animals, or those otherwise able to escape from the buckets by jumping or other means, were not adequately sampled by pitfall trapping. Furthermore, pitfalls could not be used effectively in very low, wet spots (such as marshes or pond edges) because fluctuating water tables frequently flooded buckets or forced them out of the ground; nor were aquatic habitats directly sampled. Therefore, snakes, larger lizards, turtles, frogs, and salamanders were all probably seriously under-represented in the pitfall traps. Field observations, collection records, regular searches, and incidental finds supplemented the trap data, providing information on the occurrence and habitat distribution of those species not vulnerable to pitfall traps.

Although snakes were rarely captured in pitfall traps, several species were recorded in the study area. Three of them were encountered

Table 12. Capture rates of reptile and amphibian species in general study area community-structure types. The data are also summarized by community type. Capture rate = N/100 trap days.

Species	SC VI GN-02	SC VI A GN-05	SC VI GS-10	C/J I Cochiti	C/J IV San Ildefonso
Tiger salamander				0.17	
Woodhouse toad			0.17	0.17	
Great Plains toad		0.08			
Eastern fence lizard		0.75		1.67	0.44
Round-tailed horned lizard		0.04			
New Mexican whiptail	0.12	0.95	0.83		
Chihuahuan whiptail			0.33		
Little striped whiptail					0.15
Plateau whiptail				0.83	1.32
Lesser earless lizard		0.12			0.44
Side-blotched lizard		1.50	0.33		
Arizona glossy snake		0.04			
Number of trap days	2519	2533	600	600	684
Number of species	1	7	4	4	4
Number/100 trap days	0.12	3.48	1.66	2.84	2.35
Number of trap days		5652		1284	
Number of species		9		6	
Number/100 trap days		1.75		2.60	

regularly and may be considered fairly common: Common gartersnake, gopher snake (Pituophis melanoleucus), and coachwhip (Masticophis flagellum).

Common gartersnakes were much more common than pitfall trap data suggest. In addition to the three captures represented in the trap data, there were 47 sight records during the two years of the survey. Common gartersnakes were most frequently found along grassy river banks, drains, and pond edges (23 of the 47 sightings), on sandbars (9 of 47), and in moist bosque habitats such as C/CW V (5 of 47). Seven were sighted on levee roads, and only three were sighted in dry bosque habitats (C/CW IV, C/RO II).

Gopher snakes appeared to favor drier areas. Of the 32 gopher snakes recorded, 27 were seen along levee roads, one was found in dry cottonwood bosque, and one in a dry salt cedar stand, while only three were found in moister habitats (RO V and riverbank). Coachwhips were also recorded most often along levees and roads (10 of 22 sightings) and in dry cottonwood bosque (2 of 22) but were sighted in moist habitats only slightly less frequently. Five of the 22 coachwhips were sighted along drains, three along grassy riverbanks, one on a sandbar, and one in moist bosque (C/CW V). While simple enumeration of sight records per habitat type is undoubtedly subject to a number of biases, these records do suggest relative differences in habitat use among these three common species. Gartersnakes and coachwhips appear to be more strongly associated with moist habitats than gopher snakes.

Three other species of snakes were seen occasionally in the study area. Prairie rattlesnakes (Crotalus viridis) were recorded three times, all on levee roads. Two western hognose snakes (Heterodon nascius) were found, both in dry parts of the bosque, and one common kingsnake (Lampropeltis getulus) was sighted along a railroad embankment near Isleta Marsh. Other species that are known to occur in the study area were not found during the survey (e.g., checkered gartersnake [Thamophis marcianus], western diamondback rattlesnake [Crotalus atrox], and others; see Appendix II).

Of the three species of frogs occurring in the study area (chorus frog, bullfrog, and leopard frog), two were common to abundant in certain types of habitat. Chorus frogs were locally common in marshy areas, ponds, and in small pools and puddles within the bosque, especially in early spring or after the summer rains. Their calls were often heard at night and in early morning in small, temporary pools scattered through low, wet parts of the bosque (22 records). Calling chorus frogs were recorded during the months of March, April, and May; the earliest date of record was March 17 and the latest was May 18. Chorus frogs were less vocal but still active much later in the season, as we took specimens in pitfall traps in July, late September, and early October. All our records of chorus frogs were from the area between Isleta and the Bosque Bridge. The chorus frogs of the study area form an apparently isolated population of the species, occurring only in the area between Albuquerque and Bernardo in the Middle Rio Grande Valley (Applegarth 1981).

Bullfrogs, which were probably introduced into the Rio Grande in the early 1930's (Little and Keller 1937), are well-established in the study area today. They were by far the most frequently recorded amphibian species, represented by over 100 records. Bullfrogs were abundant along drains and canals throughout the study area, although they were never captured in pitfall traps along drains, perhaps because they could easily escape from the buckets. They were also numerous at Isleta Marsh and in larger ponds within the bosque, such as the Corps' artificial pond (see OP VI, Table 11) and the old fishing pond near Belen (OP-17, Table 4). Our records spanned the period of April through September, and the area from San Ildefonso south to La Joya.

Leopard frogs, by contrast, were rarely encountered, despite concerted efforts by members of our study team and by John Applegarth, who concurrently conducted a study of this species in the same area, to locate them (Applegarth 1983). Although they were common in the study area earlier in this century, leopard frogs were recorded at only six sites in the study area during the two years of our survey. Small populations were found at two localities: a wet, grassy meadow just north of Bernardo (10 individuals?; Applegarth 1983) and in a small woodland pond between two levees about 3 miles north of the Bosque Bridge (3 individuals?). Specimens were obtained by Applegarth from the large marsh near Peña Blanca (on the Santo Domingo Reservation), near Isleta Marsh (U.S. 85), at a second shallow marsh near Bernardo, and at the Corps' artificial pond by Los Lunas (Applegarth 1983), and leopard frog calls were heard at Madrone Ponds (OP-20, Table 4) and from a pool in the bosque near the Mid-Valley Airpark (SW-11). Applegarth's (1983) report discusses the rapid decline of the leopard frog in the valley over the past four decades and its possible causes, concluding that direct predation by bullfrogs is the most likely cause of the leopard frogs' near extirpation. He recommends (1) legal protection for the valley's remaining leopard frogs, (2) creation of new (artificial) shallow marsh habitat, and (3) bullfrog control.

Three species of turtles were found in the study area, ornate box turtles (Terrapene ornatus), painted turtles (Chrysemys picta), and spiny softshell turtles. Box turtles are largely terrestrial and were found three times on levee roads and once in dry woodland. Most of the box turtles in the valley are probably escaped pets (J. Applegarth pers. comm.), although the sighting of one individual in a nonresidential area near Bernardo and the capture of a baby (2-in-long) box turtle in the bosque suggest that native or escaped pet box turtles may be reproducing in the study area.

Painted turtles were sighted frequently along drains and in small ponds, and occasionally along the river channel. There were 72 individuals sighted altogether, with 51 of them sighted along drains and another three on levees near drains. Most of the painted turtles seen along drains were observed from vehicles on levee roads during the raptor/large bird censuses. Such observations were most frequent in spring and early summer before vegetation along drains became so thick and tall in many areas that it obscured the view from the levee road, and many turtles probably went undetected in drains later on in summer and fall. Thus painted turtles were even more common in drains within the study area than the 51 sightings might suggest. Most or all small permanent ponds also supported painted turtles, as they were seen at least once in every such pond we knew of within the intensive study area (16 records total). Painted turtles were observed twice in backwater portions of the river channel, and one was found on a sandbar. These three river channel sightings represent relatively few records considering the amount of time spent by members of the study team censusing and observing along the river, which suggests that the river channel is not regularly used by this species.

In his report Applegarth (1983) also reviewed the status of painted turtles in the study area. He felt that although painted turtles are often observed along drains, these steep-banked waterways may not provide suitable nest sites for them. Consequently, he considers the population of painted turtles in the area to be limited by the small amount of marsh habitat available for nesting. Applegarth urged legal protection for the Rio Grande population of painted turtles and creation of additional marsh habitat to provide nesting areas.

Spiny softshell turtles were seen much less frequently than painted turtles. They were observed on seven occasions, with a total of 30 individuals recorded altogether. On three occasions, single individuals were seen in drains during raptor/large bird censuses, six individuals (3 pairs) were seen on exposed mud in the river channel just above the Isleta Diversion Dam (where there is a permanent pool) and one juvenile was captured in a pitfall trap in a grassy area near the riverbank (in a RO V stand). The other 20 individuals were observed from a helicopter during a wildlife survey and vegetation mapping flight; all 20 were on mud or sandbars along the river channel. Although the aforementioned visibility problems along drains in late summer also apply to softshell turtles, so that records of softshells in drains are biased downward, it appears that this species uses the river channel to a greater extent than do painted turtles. The spiny softshell is considered to be primarily a river turtle in New Mexico and is often found in areas with sandy bottoms where the current is moderate to strong, in contrast to the painted turtle, which favors quiet water with aquatic vegetation (Degenhardt and Christiansen 1974). Because it is a highly aquatic species, our survey probably underrepresented the abundance of the spiny softshell turtle in the study area. Degenhardt and Christiansen (1974) reported that there were specimen records for this species only as far north as Bernalillo on the Rio Grande, with unconfirmed reports from the Española area. We observed spiny softshells as far north as Cochiti, just below the dam. As this species' status and distribution are incompletely known, and it is strongly associated with the riverine ecosystem, further study directed toward establishing status, distribution, habitat-use patterns, and vulnerability in the face of changes in the river channel or in river flow patterns may be warranted.

Because of their association with moist and aquatic riparian habitats, species such as the leopard frog, chorus frog, painted turtle, and spiny softshell turtle, as well as the common gartersnake and the Great Plains skink, should be more sensitive to disturbances of the riparian zone than the primarily terrestrial lizards and snakes abundant in drier, open habitats. The semiaquatic frogs and turtles are particularly vulnerable because suitable aquatic habitat in the valley is limited and potentially threatened.

The species currently of greatest concern, leopard frog and painted turtle, are both dependent on aquatic and/or marshy habitats. Disturbance or destruction of the habitats that now support these species, especially the leopard frog, should be stringently avoided. The creation of additional ponds and/or marshes could potentially benefit both the leopard frog and the painted turtle, as well as other species associated with wet habitats.

See Appendix II for an annotated list of all amphibian and reptile species recorded during the survey, with brief comments on the abundance and distribution of each.

Small Mammals

Since small mammal populations of C-S types limited to the general study area were sampled as often as those of intensive study area C-S types, results for C-S types in both portions of the study area will be discussed together in this section.

There was substantial variation within the study area in the abundance of small mammals as estimated by total capture rates. The mean total capture rate over all 266 grids was 6.98 ± 10.04, with single grids yielding from 0 to a maximum of 86 captures per 270 trap nights. Fourteen different mammal species were captured in snap traps, and three additional species were found in pitfall traps, bringing the total to 17 species. Three common, widespread species (white-footed mouse [*Peromyscus leucopus*], western harvest mouse [*Reithrodontomys megalotis*], and house mouse [*Mus musculus*]) accounted for the great majority of captures, and total capture rates largely reflect the abundance of these three species. The C-S types differed in species composition primarily in the relative importance and distribution of the less common species.

Total Capture Rates.--Among the 25 C-S types in which small mammal populations were sampled, overall total capture rates covered a wide range, from 0.6 to 22.8 captures per 270 trap nights (Table 13). Both a Kruskal-Wallis test of the raw total capture rate data and a one-way analysis of variance of the log-normalized $[\log_{10}(n + 1)]$ data indicated that there were highly significant differences among the C-S types in overall total capture rate ($P<0.00001$ for both tests).

The C-S types may be divided into four groups based on the total capture rate data together with the results of statistical tests (Fig. 10). Those C-S types at the far left in Figure 10 form an easily identifiable "high" capture rate group. Total capture rate in this group ranged from 14 to 23 per 270 trap nights, and most types in the group were characterized by high variances. (The exception, DR V, was represented by only two grids.) All high-capture rate C-S types were of structure types III or V, and many were edges or were associated with water, or both. The adjacent "moderately high" group had capture rates ranging

Table 13. Summary of small mammal trap data for each community-structure (C-S) type.

	Summer			Winter			Overall		
	N/270 trap nights			N/270 trap nights					
C-S type	Mean	1982	1981	Mean	1982	1981	Mean N/270 trap nights	Total No. species	Total No. grids
C/CW E V	19.7	29.8	9.5	15.0	18.0	12.0	22.8	3	10
MH V	16.6	16.2	17.0	35.5	58.0	13.0	20.2	6	10
DR V	19.5	21.0	18.0	-	-	-	19.5	3	2
C/CW E III	12.9	19.7	6.0	14.5	26.0	3.0	17.3	5	10
WET E V	12.5	15.0	10.0	12.5	16.0	9.0	14.0	6	10
RO V	12.2	11.0	13.3	7.5	12.0	3.0	10.4	5	11
C/CW V	8.6	11.2	6.0	7.4	4.5	10.3	8.5	5	20
C/CW E I	10.3	17.0	3.5	4.0	4.0	-	7.0	5	9
*SC VI	7.7	7.0	8.4	10.5	14.0	7.0	8.1	9	14
DR VI	7.0	9.0	4.9	3.5	2.0	5.0	6.4	7	23
C/RO E I	8.6	8.8	8.3	3.8	0.0	7.5	7.5	7	10
MH VI	5.4	6.7	4.0	-	-	-	6.3	7	4
OP VI (C/CW)	5.5	5.5	-	6.5	12.0	1.0	5.2	3	6
OP V (C/CW)	4.7	4.7	-	4.7	4.7	-	4.7	3	6
C/CW VI	4.7	5.0	4.4	5.3	-	5.3	4.8	5	12
*SC VI A	4.6	6.2	3.0	4.0	3.0	5.0	5.1	8	10
*SC V	3.9	4.7	3.0	4.3	6.5	2.0	4.4	7	10
*C/RO IV	3.0	3.0	3.0	4.0	4.0	-	3.3	3	4
C/CW E IV	3.0	3.0	3.0	-	-	-	3.0	1	2
C/CW I	2.5	2.3	2.7	7.0	14.0	0.0	3.3	4	13
SB VI	3.5	4.0	3.0	0.0	0.0	0.0	2.4	4	11
C/RO I	2.5	1.3	3.7	0.5	-	0.5	2.1	2	21
C/RO II	2.5	4.0	1.0	1.8	3.0	0.5	2.1	3	10
*C/J I	2.4	2.3	2.5	0.0	0.0	0.0	1.7	2	7
C/CW IV	0.7	0.3	1.0	1.8	2.5	0.0	0.8	4	20
*C/J IV	0.7	0.8	0.5	0.0	-	0.0	0.6	2	7

*C-S type sampled only in general study area.

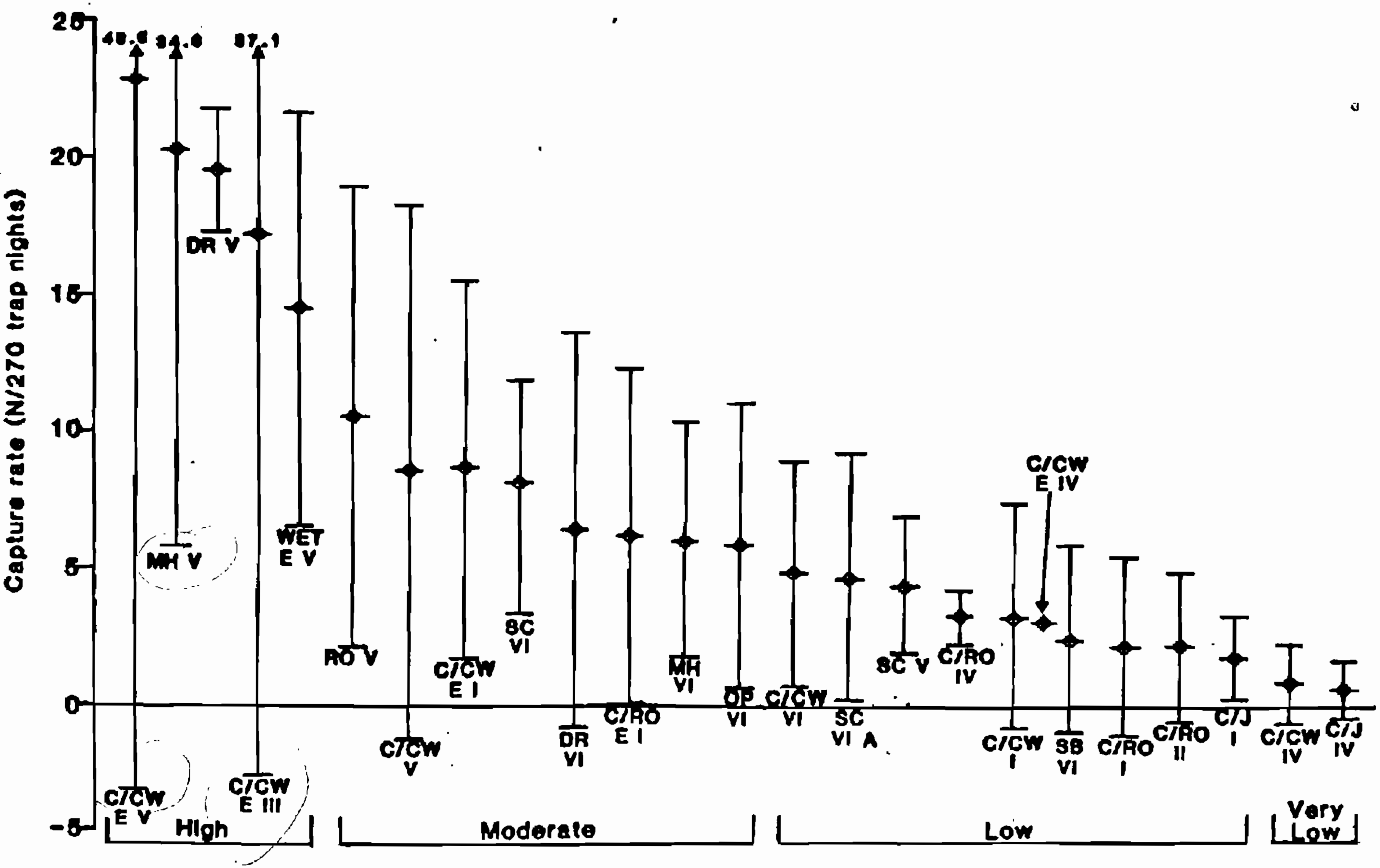

Figure 10. Mean total capture rates of small mammals in each community-structure type. Bars represent standard deviations of mean capture rates. See facing page for abbreviations.

Figure 10.--Abbreviations

C/RO = Cottonwood/Russian olive

C/CW = Cottonwood/coyote willow

C/J = Cottonwood/juniper

RO = Russian olive

SC = Salt cedar

DR = Drain

MH = Marsh

SB = Sandbar

OP = Small openings

E = Edge

Roman numerals = Structure types

from 5 to 11. It included two more type V, two type I edge, and several type VI communities. The "low" capture rate group included most of the remaining types, which had capture rates between 1 and 5. C-S types in the "low" group represented a variety of structure types (I, II, IV, VI, and the remaining type V), but all tended to be dry and relatively sparsely vegetated within their respective types. Two type IV communities, at the far right on Figure 10, had "very low" total capture rates (>1 per 270 trap nights).

The division of C-S types into these four groups was supported by the results of simultaneous t-tests of all pairs of C-S types. Fifty of the 300 possible pairs of C-S types were significantly different in overall total capture rate. There were no significant differences among the members of any one group, but there were significant differences between C-S types in the "high" and "low" groups ($P<0.05$ or less), between the "high" and "very low" groups ($P<0.001$ or less), and between the "moderate" and "very low" groups ($P<0.05$ or less). Thus, although differences between adjacent groups were not significant, there were significant differences between alternate groups.

Dividing the C-S types into groups in this manner facilitated identification of factors associated with differences in capture rate. These factors include vegetation structure (structure type), the presence of edge, moisture, and, to some extent, vegetation species composition (community type). Structure type appears to have had the greatest influence. All communities in the high group were of structure types III or V, all type IV and type II communities had either low or very low capture rates, and all of the type I and VI communities fell between the two extremes. This indicates that the highest populations of rodents were found in areas where there is dense herbaceous and shrub level vegetation (0 to 10 or 15 ft) but little canopy. C-S types with the major part of the foliage in the canopy layer and little shrub or ground cover had the fewest small mammals. Structure types that had an intermediate amount of shrub and/or herbaceous cover, I and VI (see Fig. 3), were intermediate with regard to total capture rate.

Edge, which is really another aspect of vegetation structure, also appeared to have a strong influence on capture rate. For all C-S types in which edge was sampled, the edge stands were in a higher capture rate group than the corresponding interior community.

Presence of surface water in a habitat was also associated with high capture rates, particularly if combined with a type V structure. DR V, MH V, and WET E V all included or were adjacent to water, and C/CW V occurred in low areas where small temporary pools formed, i.e., four of the five communities in the high group were wet. That neither structural type nor surface water alone can be identified as the dominant factor is illustrated by the fact that the water-associated type VI communities (DR VI and MH VI) were in the middle range with regard to total capture rate, as were two type V communities.

Community type was associated with capture rate to a limited extent. SC V, which had a markedly different vegetation species composition than the others, had a significantly lower capture rate than the other type V communities. The species of the major understory shrub in a community may have influenced small mammal capture rate, since C/CW I > C/RO I > C/J I and C/CW IV > C/RO IV > C/J IV in total capture rate. This was not a pronounced trend, however, and structural characteristics of the C-S types appeared to outweigh vegetation species composition as influential factors.

The abundance of small mammals in the moister, well-vegetated habitats was probably related to the heavy growth of grasses and annual plants, which may provide abundant forage. Another potentially important factor was the cover and protection from predators afforded by the dense to impenetrable growth of shrubs, particularly coyote willow, in the habitats which supported the highest populations of small mammals.

Seasonal and Yearly Fluctuation in Total Capture Rates.--Total capture rates fluctuated both between seasons and between years (Table 13 and Fig. 11). Two seasons were defined empirically, based on observed fluctuations in total capture rate over the annual cycle. The summer season included the warmer months of April through October, and winter included November through March. This division yielded data for four seasons over the two-year duration of the study: summer 1981, winter 1981-82, summer 1982, and winter 1982-83.

Mean total capture rates for each season were calculated (1) including all C-S types trapped within a particular season (closed circles in Fig. 11), and (2) including only those 16 types for which we had data all four seasons (open circles in Fig. 11), to eliminate potential bias due to lack of data on certain C-S types in one or more seasons. The results were the same in both cases: mean total capture rates were highest in summer and showed a slight, but consistent, decrease each winter. Means for each season were very similar when only the three coldest months (December, January, and February) were included in the winter season.

Superimposed on this pattern of population decline from summer to winter there was a general increase in mean total capture rate over the two years. In both winter and summer 1982, total capture rates were higher than those observed in 1981. The increase in capture rates between 1981 and 1982 was such that more mammals were captured during the winter of the second year, on the average, than during the summer of the first year. However, while these seasonal and between-year differences were consistent, none was statistically significant.

We speculate that higher capture rates observed in 1982 may have been related to wetter conditions (due to a higher water table) that year. Increased moisture may have resulted in a better growth of herbaceous plants and better seed production, and/or flooding of low areas may have concentrated mammals in locally higher, drier areas. It is notable that differences between years were greater than seasonal differences, suggesting that small mammal populations in the floodplain may not be winter-limited.

Species Richness, Composition, and Habitat Associations.--The number of species found in a particular community-structure type varied widely,

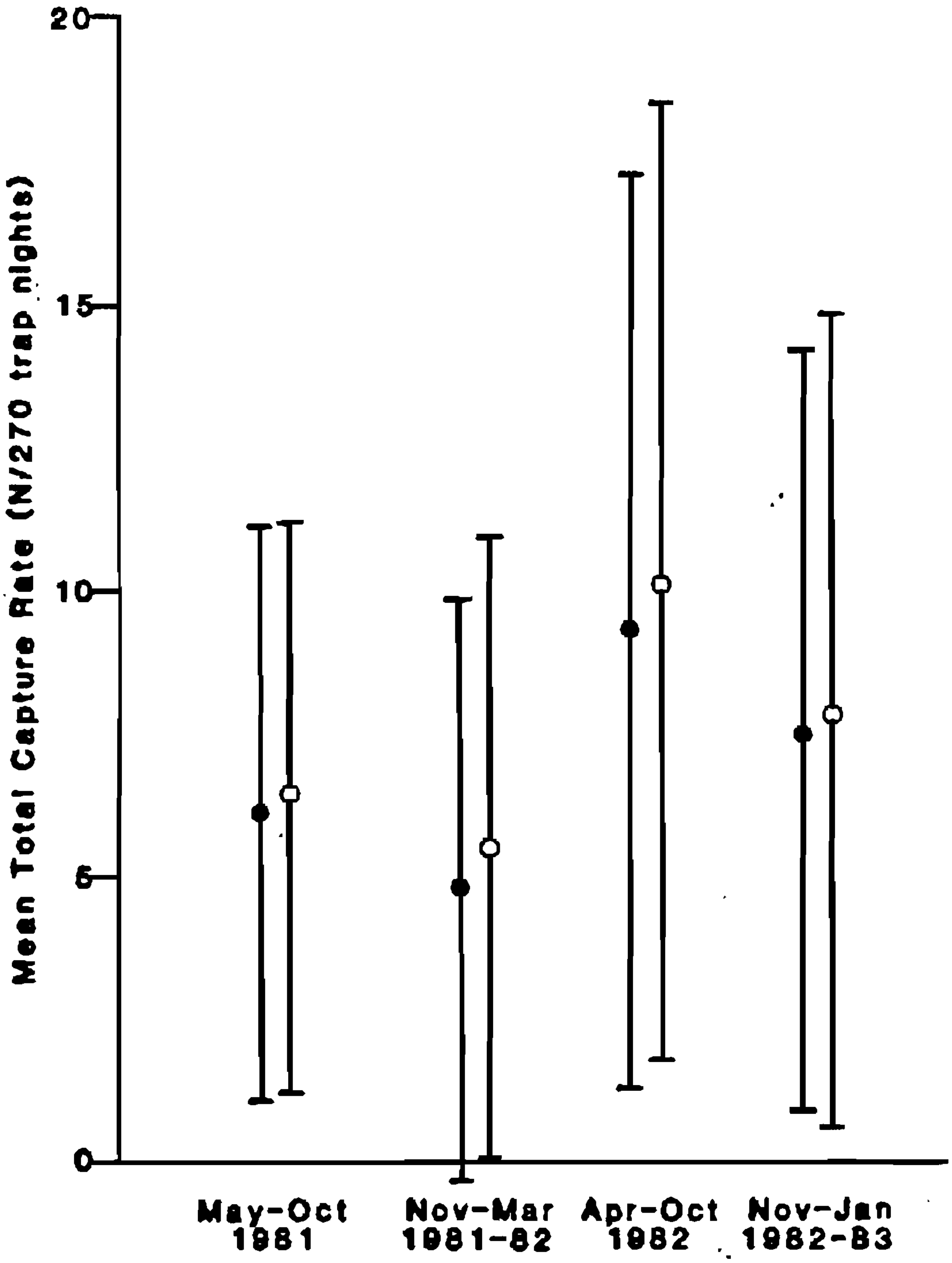

Figure 11. Seasonal and annual fluctuation in mean total capture rates of small mammals. Closed circles are means based on all community-structure types trapped that season; open circles are means based on only those community-structure types trapped all four seasons. Bars represent standard deviations.

from one in C/CW E IV to nine in SC VI and SC VI A (Table 13). The high species totals for salt cedar, seven to nine species per structure type, arise from the addition of several primarily upland heteromyid species to the riparian floodplain fauna in this ecotonal community. The species total of seven in MH VI is particularly notable because it is based on a relatively low total of 880 trap nights (4 grids). Furthermore, the MH VI type, once common, is now of rather limited extent in the valley, occurring primarily at Isleta Marsh. Six of the seven species found in MH VI, including two that are rare in the valley, woodland jumping mouse and tawny-bellied cotton rat, were captured at this one site. (The seventh species in MH VI was the hispid cotton rat [Sigmodon hispidus], which occurs only as far north in the valley as Belen.)

Differences between community types were more evident with regard to species composition of the small mammal fauna than total capture rate (Table 14). For example, while the communities of structure type V in the "high" group were similar in total capture rate, MH V and DR V differed from the others in that house mice were unusually abundant, outnumbering the usually predominant white-footed mouse in these two communities. Likewise, hispid cotton rats were numerous only in RO V, and western harvest mice were more abundant in RO V than in the other type V communities. The presence of several heteromyids in salt cedar structure types V and VI but not in other structure type V and VI communities is another case in point.

In most C-S types the major species were white-footed mouse, western harvest mouse, and house mouse, in that order of abundance (Table 13). Together these three species accounted for 92% of all mammals captured.

The white-footed mouse was by far the most common species. With an average capture rate across all habitats of 4.6 per 270 trap nights, this species made up 61% of total captures. It was found in all 25 C-S types sampled and was the most abundant species in 19 of the 25 types. Although this species occurs in both upland and riparian habitats throughout New Mexico (Findley et al. 1975), it apparently is much more common in riparian habitats than in adjacent upland mesas in the middle Rio Grande Valley. In the grasslands on the mesa just west of Albuquerque, densities of 0, 1, and 1 white-footed mouse per hectare were estimated from live trap data collected in September 1979, 1980, and 1981, respectively (C. Henderson pers. comm.). Converting our overall mean of 4.6 per 0.86 acres (the approximate size of our trap grids) to hectare measurement, we obtain an estimated density of 13 white-footed mice per ha in the riparian zone in 1981-82. In the C/CW V habitats where the species was most abundant, the estimated number varied from 44 to 62 per ha. Densities as low as those observed in the upland were found in only three C-S types, all in the general study area: C/CW IV, C/J IV, and SC VI A. Because of its abundance and broad distribution throughout the riparian zone compared with its relative scarcity in adjacent uplands, the white-footed mouse may be considered a characteristically riparian species in the middle Rio Grande Valley.

The western harvest mouse had nearly as broad a distribution across C-S types as the white-footed mouse, but it was much less common. This

Table 14. Capture rates of small mammal species in each community-structure (C-S) type. All capture rates are expressed as the number of animals captured per 270 trap nights (TN). The number of species is the total number found over all trap grids within a particular C-S or community type. P = present, but captured only in pitfall traps in that C-S type.

Species	C/ RO I	C/ RO II	*C/ RO IV	C/ CW I	C/ CW IV	C/ CW V	C/ CW VI	C/ RO E I	C/ CW E I	C/ CW E III	C/ CW E IV	C/ CW E V	WET E V
Desert shrew				P		P	P			P			
Rock squirrel		0.1			0.1				0.1				
Ord kangaroo rat					0.1		0.1	0.2					
Western harvest mouse	0.1			0.8		0.9	1.4	1.9	1.8	1.4		1.0	1.7
Deer mouse			1.5	0.1	0.1			0.1	0.1	0.1		0.3	0.1
White-footed mouse	2.0	1.8	1.0	2.5	0.6	7.2	3.1	4.8	5.1	15.4	3.0	21.5	10.1
Piñon mouse			0.8			0.2							
Hispid cotton rat								0.1					
Norway rat													0.1
House mouse		0.2				0.1	0.2	0.5	0.4	0.4			1.8
Woodland jumping mouse								0.1					0.2
No. of grids	21	10	4	13	20	20	12	10	9	10	2	10	10
No. of species	2	3	3	4	4	5	5	7	5	5	1	3	6
$\bar{x}$ N/270 TN	2.1	2.1	3.3	3.3	0.8	8.5	4.8	7.5	7.0	17.3	3.0	22.8	14.0

Table 14. (cont.)

Species	DR V	DR VI	MH V	MH VI	RO V	SB VI	OP V	OP VI	*C/J I	*C/J IV	*SC V	*SC VI	*SC VI A
Desert shrew		P	P								P	P	
Rock squirrel		0.04											
Silky pocket mouse		P											P
Plains pocket mouse													P
Ord kangaroo rat		0.04									0.2	0.2	2.0
Merriam kangaroo rat													0.6
Plains harvest mouse					0.1								
Western harvest mouse	1.0	2.4	2.4	1.8	3.3	0.3	0.2	1.3			1.4	3.5	1.3
Deer mouse			0.1	0.3		0.3			0.3	0.4	0.1	0.1	0.5
White-footed mouse	9.0	3.6	4.0	1.0	4.4	1.4	4.3	4.0	1.4	0.1	2.5	4.0	0.4
Piñon mouse											0.1		
Northern grasshopper mouse												0.1	0.3
Hispid cotton rat				0.3	2.6							0.2	
Tawny-bellied cotton rat				0.8							0.1	0.1	

Table 14. (cont.)

Species	DR V	DR VI	MH V	MH VI	RO V	SB VI	OP V	OP VI	*C/J I	*C/J IV	*SC V	*SC VI	*SC VI A
House mouse	10.0	0.4	13.6	1.8	0.2	0.6	0.2						
Woodland jumping mouse			0.1	0.3	P								
No. of grids	2	23	10	4	11	11	6	4	7	7	10	14	10
No. of species	3	7	6	7	6	4	3	2	2	2	7	9	8
$\bar{x}$ N/270 TN	19.5	6.4	20.2	6.3	10.4	2.4	4.7	5.3	1.7	0.6	4.4	8.1	5.1

*C-S type sampled only in the general study area.

species accounted for 15% of total captures and was found in 19 of 25 C-S types. It was absent only from the forest C-S types with the least understory vegetation: no harvest mice were captured in any type IV areas, nor were they taken in C/J I or C/RO II. The highest capture rates for this species, 2.4 to 3.5/270 trap nights, were observed in C-S types characterized by thick grassy and herbaceous vegetation and few trees: RO V, MH V, DR VI, and SC VI. In such areas they were nearly as abundant as white-footed mice. Western harvest mice outnumbered white-footed mice in SC VI A, the C-S type bearing the closest resemblance to adjacent grassland habitats. Western harvest mice are common throughout the grasslands of New Mexico (Findley et al. 1975) and appeared to be almost as numerous at the grassland trap grid on the Albuquerque mesa (up to 3 per ha,; C. Henderson pers. comm.) as in the riparian zone overall (3 per ha on the average). The highest estimated densities of harvest mice (up to 10 per ha) were recorded in the grassy Russian olive and salt cedar riparian habitats. Unlike the white-footed mouse, then, the western harvest mouse was especially abundant only in certain parts of the riparian zone, i.e., where grasses and herbaceous plants are most abundant.

House mice were captured about as often as western harvest mice, but had a more limited distribution among the C-S types. They were found in 14 of the 25 types but reached moderate capture rates (>0.5 per 270 trap nights) in only five types. By contrast, western harvest mice were captured at rates ≥0.5 per 270 trap nights in 17 of the 19 habitats where they occurred. Our observations contrast with the account of the house mouse in Findley et al. (1975) in that we did not find this species to be the most common small mammal in the floodplain, nor was it often trapped in dry cottonwood forest habitats. The house mouse was most abundant in thick herbaceous and shrubby vegetation near the water's edge in two of the wettest C-S types: MH V, where it was the most abundant species by far, and DR V. It was also relatively common in other types associated with water: WET E V, MH VI, and to a lesser extent, SB VI, which is along the river channel. When house mice were captured in forest habitats, they were usually in the vicinity of channels or other wet spots (V. Hink pers. obs.). Although house mice were about as abundant as western harvest mice in the riparian zone overall (about 15% of total captures), no house mice were captured by Henderson (pers. comm.) on the mesa. This suggests that house mice are more common in nonforest riparian habitats than in upland grassland in central New Mexico.

The deer mouse (<u>Peromyscus maniculatus</u>) is closely similar to the abundant white-footed mouse, and the two species are difficult to distinguish even for experienced workers. However, there were marked differences in the distribution, and presumably in the ecology, of the two species in the study area. Deer mice were found primarily in the northern portion of the general study area. Although deer mice were captured at least once in 16 of the C-S types, they were uncommon, accounting for only 2% of the total number of small mammals captured during the survey. This species accounted for a significant proportion of total captures (≥10% and ≥0.3 per 270 trap nights) in only six C-S types: C/CW IV, SB VI, C/J I, SC VI A (all about 10%), C/RO IV (45%), and C/J IV (80%). All six of these C-S types may be characterized as sandy and open, with sparse ground cover and low total foliage volume. By contrast, white-footed mice were most abundant in C-S types with abundant shrub cover. Deer mice were captured occasionally as far south as Isleta in a wide variety of C-S types, but they were rare (<3% of captures) in all the intensive study area types except the two open, sandy types mentioned above (C/CW IV and SB VI). In general, deer mice were rare in the riparian zone except in a few of the northern C-S types, which were relatively dry and sparsely vegetated.

One more species belonging to the genus Peromyscus, the pinyon mouse (P. truei), was captured in the valley. Like the deer mouse, it was rare and occurred primarily in the northern portion of the general study area. The pinyon mouse was captured in only three of the C-S types (at only three sites total) and was the least-often-captured species in all three of the types where it occurred. Three specimens were captured in 810 trap nights in C/RO IV at Cochiti, making this the C-S type with the highest estimated density of pinyon mice. One specimen was taken in SC V, at the mouth of the Jemez River, and, surprisingly, four were captured at the edge of a dense stand of cottonwood saplings (C V) under the Bernalillo Bridge. This species is typically found in pinyon (Pinus edulis)-juniper woodland in New Mexico and occasionally in sandy grasslands with scattered shrubs (Harris 1963, Findley et al. 1975), so its appearance in the floodplain was unexpected. This suggests that the wooded riparian zone here is acting as a corridor through which the distributions of woodland-associated species may extend into lower elevation habitats (Thomas et al. 1979).

Two species of cotton rats, the hispid cotton rat and the tawny-bellied cotton rat, were captured occasionally in areas of thick grass. The ranges of the two species in the Rio Grande Valley appear to be mutually exclusive (Petersen 1977). The hispid cotton rat, which was uncommon in the study area, occurs throughout the southern part of the valley at present, the northernmost records being from the vicinity of Belen (Findley et al. 1975). We captured the species most frequently in the RO V and MH VI C-S types, both of which are moist and support a lush growth of sedges, annuals, and grasses. Two hispid cotton rats were taken in SC VI at Bernardo, and one was found in C/RO I edge (C/RO E I) by the Belen Bridge. Our northernmost specimen locality was 1.5 mi N.E. of Belen.

The tawny-bellied cotton rat appears to be rare in the valley at this time. The northern disjunct portion of this species' known range in New Mexico lies entirely within the study area (Findley et al. 1975). Although it was known to occur farther south in the valley in the early 1900's and had been found at Bernardo as recently as 1940, it is absent from those parts of the valley today (Gardner 1948, Findley et al. 1975). It has been suggested that the hispid cotton rat has displaced the tawny-bellied cotton rat from these areas (Mohlenrich 1961). We captured only four tawny-bellied cotton rats during the survey, two in MH VI at Isleta Marsh, and two in SC VI (in the vicinity of a small marsh) near the mouth of the Jemez River. No tawny-bellied cotton rats were found within the range of the hispid cotton rat. It is noteworthy that while the two species were not found together at any one site, they were found in the same C-S types, MH VI and SC VI. The possibility that progressive changes in the ecology of the valley have favored the expansion of the hispid cotton rat at the expense of the tawny-bellied cotton rat should be considered, but Petersen (1977) could find little evidence of differences between the habitats where she captured each of these species. Because the tawny-bellied cotton rat is rare in the valley and is associated with relatively rare marsh habitats, it should be given particular consideration in assessing potential impacts of habitat alterations.

Isleta Marsh was the only locality within the study area where the woodland jumping mouse was found. This mouse had been trapped a few times in other parts of the valley (Española, Socorro, and near Bosque del Apache National Wildlife Refuge) in the early part of the century (Findley et al. 1975), but it had not been recorded anywhere in the valley since the 1930's when it was rediscovered at Bosque del Apache in 1976 (Hafner et al. 1981). Subsequent research revealed that the valley population, formerly known as Zapus luteus australis or Z. princeps luteus, is a disjunct subspecies (Z. hudsonius luteus) of the northern jumping mouse. This subspecies is found only in a few New Mexico and Arizona mountain ranges and in the Middle Rio Grande Valley (Hafner et al. 1981). The six specimens captured during our survey were the first recorded from this part of the valley, although it seems likely that the existing population is relict and that the species has been present at Isleta Marsh for some time. All specimens were from the vicinity of the marsh in wet and/or grassy areas: MH V, MH VI, RO V, WET E V, C/RO E I. (The latter C-S type adjoins a drain; C/RO is presumably atypical habitat for the species.) Marshes and wet grass/sedge meadows were more extensive in the valley before drains were constructed in the 1930's (Van Cleave 1935), and jumping mice may have been more numerous then. The capture of six individuals from the marsh area suggests that a viable population exists there. However, failure to locate the species in any other part of the valley, despite extensive trapping, suggests that Isleta Marsh may be the only locality in the study area where it now persists. The woodland jumping mouse is currently listed as endangered in New Mexico (as of 22 July 1983; J. P. Hubbard pers. comm.).

Norway rats (Rattus norvegicus) were recorded twice during the survey. One was trapped at a local dump at the perimeter of a small pond (WET E V) within the bosque near Belen. The second was a roadkill found near the Bosque Bridge, about 300 ft from the cottonwood bosque, near a residence. While black rats (Rattus rattus) are found in the southern part of the valley near Las Cruces (C. Thaeler pers. comm.), and "might be expected at least as far north as Truth or Consequences" (Findley et al. 1975:267), we found none in the study area. Also absent from the valley in our area were white-throated woodrats (Neotoma albigula), which occur in the valley near Las Cruces (C. Thaeler pers. comm.) and were fairly common (1-2 per ha) on the mesa at Albuquerque (C. Henderson pers. comm.).

Rock squirrels (Spermophilus variegatus) were common throughout the study area, particularly along levee roads at the perimeter of the bosque. They were infrequently captured, however, perhaps because most individuals were too large to be taken easily in rat traps.

Desert shrews (Notiosorex crawfordi) were captured only in pitfall traps. Initially, finding this species in the valley at several localities was surprising, because the species' habits and distribution are little known and it has been regarded as rare (Hall 1980, Findley et al. 1975). However, desert shrews were not uncommon in the study area: 49 specimens were taken over the two seasons of pitfall trapping, in eight different C-S types (Table 14). Most of the sites that yielded shrews were densely vegetated and tended to be moist, similar to those areas where the white-footed mouse was most abundant. A thick growth of coyote willow was common to many of the sites where desert shrews were captured, although two specimens were taken at Bernardo and one at the mouth of the Jemez River in nearly pure salt cedar stands.

Since a much more limited area of the valley was sampled by pitfall traps than by mammal snap-trap grids, we cannot be certain of the distributional limits of the desert shrew in the valley. However, it was found at nine sites along the Rio Grande between the Jemez River and the Rio Puerco, a reach spanning the entire intensive study area and including portions of both northern and southern general study areas. It is likely that substantial populations of desert shrews exist in areas of dense shrub vegetation throughout the valley.

The remaining five species captured during the survey were desert grassland-associated animals: four heteromyids, the silky pocket mouse (Perognathus flavus), plains pocket mouse (P. flavescens), Ord kangaroo rat (Dipodomys ordii), and Merriam kangaroo rat (D. merriami), and the northern grasshopper mouse (Onychomys leucogaster). With the exception of the Ord kangaroo rat, which was taken occasionally in the sandier areas within the bosque, these species were almost entirely restricted to arid salt cedar habitats (primarily SC VI A) that supported a mixture of upland and riparian plants and animals. Silky pocket mice and plains pocket mice were captured only in pitfall traps. One silky pocket mouse was captured in DR VI by the levee road at the edge of the bosque, in what appeared to be atypical habitat for the species.

One specimen of the plains harvest mouse, Reithrodontomys montanus, was captured in a moist, grassy RO V stand near Isleta. This species which had been recorded previously in the study area (Findley et al. 1975), is considered rare and is very difficult to distinguish from the western harvest mouse, which was common in the area. Some of our harvest mouse specimens, especially those taken during winter, fell into the weight range of the plains harvest mouse, which is smaller and lighter than the western harvest mouse (Findley et al. 1975). Study of the skulls of the small specimens (99 in number) by Dr. C. Thaeler revealed one that could be positively identified as plains harvest mouse. Because of the difficulties involved in identification of skulls of immature animals, there is a possibility that there may have been more than one. However, the plains harvest mouse is undoubtedly rare in the study area. Its presence in RO V, the C-S type yielding the highest density of western harvest mice, suggests that these two species occur in the same type of habitat.

In summary, we may define several groups of small mammals according to their habitat associations in the study area. Two species were most strongly associated with well-vegetated, moist forest and woodland habitats, especially where coyote willow was predominant: the white-footed mouse and the desert shrew. A second group of six species occurred in well-vegetated moist areas, but this group was most strongly associated with grassy rather than forested habitats: western harvest mice, hispid cotton rats, and probably plains harvest mice reached high densities within the riparian zone in those habitats that included a well-developed stratum of grass, sedges, and annuals; house mice were abundant in wetter areas, around marsh and drain edges; and the tawny-bellied cotton rat and the woodland jumping mouse occurred primarily in wet salt grass/sedge meadow at Isleta Marsh. Another set of two species, the deer mouse and the piñon mouse, occurred primarily in open cottonwood habitats in the northern part of the general study area, where juniper and other upland shrubs entered the floodplain. Finally, there was the group of five desert-grassland species that occurred in the open salt cedar habitats that most closely resemble the upland habitat flanking the riparian zone.

Among small mammals, as among reptiles and amphibians, two species of concern were strongly associated with wet or marshy habitats. The woodland jumping mouse and the tawny-bellied cotton rat were both rare and of very limited distribution, Isleta Marsh being the only, and one of only two, localities, respectively, where these species were found. The fact that their habitat is itself rare in the valley increases the vulnerability of these species. This reinforces our recommendation that marshy habitats, and Isleta Marsh in particular, should be preserved from further disturbance or destruction. Although it is uncertain whether either the woodland jumping mouse or the tawny-bellied cotton rat would colonize new areas, the creation of additional marsh or wetland habitat might possibly benefit one or both species.

Large Mammals and Bats

Eighteen species of large mammals (including squirrels and other large rodents) were recorded during the survey. Nine species of bats are also known to occur in the study area (Findley et al. 1975).

Of the large mammals, three species, beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), and raccoon (*Procyon lotor*), may be considered riparian-dependent, occurring only in association with permanent water. All three species were common in the study area. Beavers and muskrats were found in drains, ponds, and marshes, as well as in parts of the river channel that remain wet, such as the area immediately upstream from the Isleta Diversion Dam.

Beavers were sighted on 30 different occasions during the survey. Sightings were mostly of single individuals in drains, although groups of two or more were noted several times in the KW-03 drain, and up to six were observed at one time in the river channel near Isleta Marsh. Beaver sign was abundant near ponds and drains and was noted regularly (several times a month) along RV/SB, DR, and MH transects, occasionally (8 times) in dry C/CW stands, and once in RO V.

Muskrats were sighted on 87 occasions, with records totaling 108 individuals. They were seen in DR, MH, and small ponds (wet OP VI, such as OP-01) throughout the study area. Sign was observed near marshes and drains and occasionally along the river channel.

Raccoons were rarely seen (3 sightings total), but tracks were noted regularly ($\geq$10 times per month). They were found along sandbars, in marshes, along drains and pond edges, and in all types of C/RO and C/CW habitat as well. The raccoon was probably one of the most abundant large mammals in the study area.

Two other riparian-dependent large mammals that once occurred in the study area, mink and river otter, have disappeared from the valley since the early 1900's, and both are listed as endangered in New Mexico (Hubbard et al. 1979). According to a fur buyer, mink were taken in the valley as far south as La Joya and Elephant Butte before 1920 (Findley et al. 1975, C. J. Mitchell pers. comm.), but they now are found in New Mexico only in the mountains and possibly in the Rio Grande near the Sangre de Cristos (Findley et al. 1975). River otters have not been known to occur in the Middle Rio Grande Valley since before 1930; this species is now probably extinct in New Mexico (Findley et al. 1975).

The terrestrial woodland habitats in the study area support a variety of species, most of which are facultative users of riparian habitats. Porcupines (Erethizon dorsatum) were sighted 19 times. They were seen most often in C/CW (9 times) and C/RO (6 times) occasionally in RO V, and once in SC VI. It was typical to sight them high up in cottonwood and Russian olive trees. While not restricted to riparian habitats, they are probably more common in riparian forests than in surrounding non-forest habitats because of the abundance of herbaceous plants, leaves, and bark available for forage.

Long-tailed weasels (Mustela frenata) were particularly common at Isleta Marsh, where we sighted them three times and obtained two road-killed specimens. Additional sightings were on NM 85 near Shady Lakes, on SE-06 (a drain transect), and south of SE-21 (another drain). They were also sighted twice in the vicinity of Belen in 1983, near well-vegetated areas (W. Howe pers. comm.). Like porcupines, they are probably more numerous in riparian habitats than in uplands.

Striped skunks (Mephitis mephitis) were common along levees and in agricultural fields, as well as in the bosque. Skunk tracks were recorded regularly in C/CW, C/RO, DR (levees), and SB, and we sighted the species 27 times, excluding roadkills. The frequent occurrence of striped skunks in the valley may be as much related to their association with areas of human disturbance (Findley et al. 1975) as with riparian habitats.

Rock squirrels were conspicuous and abundant along levee roads and drains during all but the three coldest months; they frequently climbed cottonwood and Russian olive trees along levee roads. Three to five rock squirrels were recorded during each raptor/large bird census, on the average. Rock squirrels were also seen in interior portions of cottonwood stands but were less common there than along levee edges of the stands.

Pocket gopher mounds were common in many parts of the bosque. They were especially abundant in loose, sandy soil where trees were not too dense but where there was shrub and herbaceous cover (e.g., C/CW V). All the gopher specimens we collected were Botta pocket gopher (Thomomys bottae). Although the yellow-faced pocket gopher (Pappogeomys castanops) is known to have occurred in the Rio Grande Valley at least as far north as Albuquerque in the first half of this century (Bailey 1932), there are no recent records of this species from our study area (Findley et al. 1975).

Desert cottontails (Sylvilagus auduboni) were common throughout the study area. They were seen daily in cottonwood stands and grassy areas and along levees.

Mule deer (Odocoileus hemionus) apparently occur in the study area on occasion (Findley et al. 1975), although we encountered neither deer nor deer sign during the survey. Mule deer are known to occur regularly in the area of White Rock Canyon and side canyons (M. S. Sifuentes pers. comm.). In other parts of the study area, they probably occur only while passing through the valley en route from one mountain range to another.

It was difficult to assess the abundance of coyotes (Canis latrans), gray foxes (Urocyon cinereoargenteus), and bobcats (Felis rufus) in the area because of the prevalence of domestic dogs (Canis familiaris) and cats (Felis domesticus), which often have similar tracks.

Coyotes were sighted 36 times (47 individuals), including seven sightings within Albuquerque. They were probably fairly common throughout the study area. Eleven of the sightings were in the general study area; this is a high proportion of total sightings considering how infrequently these areas were visited. Groups of two or three coyotes were more often seen in the general study area than in the intensive study area, and coyote howls were heard twice as often in the general study area as in the intensive study area.

There were three sightings of gray fox, two on levee roads and one in C/CW V. One gray fox skull was found in a C/CW I stand, and at least 10 scats were identified as fox. No bobcats were sighted, but we knew of one trapped at KW-04 (near the Oxbow), and trappers said they were not uncommon in the valley. According to C. J. Mitchell (pers. comm.), coyotes and gray foxes are about as common now as they were in the 1930's, and bobcats have become more common.

Domestic and feral dogs were probably the most abundant large mammals in the study area. Domestic cats were less obvious members of the large mammal fauna, but they were also commonly seen throughout the study area. Domestic livestock (cattle) were grazed in the bosque on lands belonging to several Indian Pueblos (Isleta, Santa Ana, Cochiti, San Ildefonso; possibly Sandia, Santo Domingo, Santa Clara) or on privately owned bosque land, in Algodones, Bernalillo, and Albuquerque, and in much of the salt cedar habitat south of Bernardo.

The remaining six species of large mammals recorded in the study area were uncommon to rare or of local distribution. Black-tailed jackrabbits (Lepus californicus) were seen on 75 occasions, sometimes in bosque areas (20 records), but mostly in more arid, peripheral riparian habitats. They were especially common in salt cedar stands (41 records) and were also seen in C/J (4 records). Spotted ground squirrels (Spermophilus spilosoma) were seen in the study area only twice, on levee roads. Individual Gunnison prairie dogs (Cynomys gunnisoni) were seen three times on levee roads, and there was one colony of about 100 burrows by an alfalfa field near Isleta. Badger (Taxidea taxus) sign (a fresh dig), was observed within the study area along a levee just north of Isleta. The aforementioned four species are primarily associated with upland desert and/or grassland habitats in New Mexico (Findley et al. 1975). The last two species represent unusual records: a red squirrel (Tamiasciurus hudsonicus) was found in a stand of cottonwoods at San Ildefonso, out of its usual conifer-zone habitat, and chipmunks (Eutamias sp.) of uncertain species (probably Colorado chipmunks [E. quadrivittatus]) were once heard and once seen in the same area.

Information on bats is based on the species accounts in Findley et al. (1975) and on consultation with Dr. Findley. Of the 11 species known from the valley, only two are restricted to riparian or water-associated habitats: the Yuma myotis (Myotis yumanensis) and the little brown bat (M. lucifugus). Both breed in the valley and forage over open water, such as drains, canals, ponds, or the river. Their distribution is tied to the presence of permanent watercourses. The pallid bat (Antrozous pallidus), the Brazilian free-tailed bat (Tadarida brasiliensis), and the big free-tailed bat (T. macrotis) are all widespread species that may use riparian habitats but are not dependent on them. These three species breed in upland areas. Townsend's big-eared bat (Plecotis townsendii) has been recorded in Albuquerque and may use the valley also. The remaining five species occur in the valley only in migration. They are the long-legged myotis (Myotis volans), the silver-haired bat (Lasionycteris noctivagans), the big brown bat (Eptesicus fuscus), the hoary bat (Lasiurus cinereus), and the rare spotted bat (Euderma maculatum).

See Appendix III for an annotated list of mammal species occurring in the study area.

Birds

Birds were the largest and most diverse group among the terrestrial vertebrate fauna of the study area. The total number of species recorded within the bosque or in adjacent agricultural areas of the valley during the two years of the survey was 277. This is over 60% of the total number of bird species known to occur in New Mexico (Hubbard 1978). Of the total of 277 species, 239 were considered to be within their normal geographic range in the valley, while the other 38 represented records of species outside their usual range or habitat. Eighty-five to 95 of the normally occurring bird species probably breed in the valley. Most of these species were primarily associated with riparian shrub or forest habitats.

In addition to being rich in species, the riparian habitats of the valley supported high densities of birds. Estimated densities of 300 to 600 birds per 100 acres were about average for cottonwood habitats in the intensive study area, but densities of over 1,000 birds per 100 acres were estimated for certain C-S types in certain seasons. The high avian population densities and species richness values observed during the study were consistent with those observed in studies of other Southwest riparian ecosystems (Hubbard 1971, Carothers et al. 1974, Ohmart and Anderson 1982, Rosenberg et al. 1982, and others) and are indicative of the value of these unique and limited habitats to bird populations in the arid Southwest.

Two different methods of estimating bird population density and species richness were employed during the survey, as described in the methods. Modified Emlen censusing is an accurate and efficient method of estimating bird populations in relatively homogeneous habitat patches of sufficient size (Emlen 1971, Balph et al. 1977, Engel-Wilson et al. 1980). Modified Emlen censuses were conducted in all C-S types occurring in habitat patches of $\geq$50 acres: C/RO, five of the six C/CW types, MH, SC, and C/J. Direct counts were used to census C-S types that occurred in small patches or narrow strips: C V, C/CW VI, DR, RO, SB, and RV. In order to compare population density and species richness values among C-S types as estimated by the two different methods, data from Emlen-censused transects were reanalyzed as though those transects had been direct counted, by counting only those birds detected within 50 ft on either side of the transect line (i.e., within the first detection interval).

Population density estimates, species richness values (the number of birds present in densities $\geq$0.5 per 100 acres), and the total numbers of species detected, according to both modified-Emlen and direct-count calculation procedures, are presented in Table 15 for six Emlen-censused C-S types. Population density estimates yielded by modified Emlen censusing were about 18% higher on the average than densities estimated from direct counts of 100-ft wide strips. The two sets of population density estimates are highly significantly correlated, however (Table 15), indicating that relative differences among C-S types are accurately reflected using either type of estimation. Species richness values obtained from the Emlen-census calculations were also typically greater than species richness values obtained from the direct-count calculations, and the two values were strongly correlated in three of four seasons. Emlen censusing also usually yielded higher total numbers of species than direct-count censusing. Species totals for Emlen and direct counts were also significantly correlated all four seasons.

<u>Avian Populations in the Intensive Study Area</u>.--Seventy-eight transects representing 21 different C-S types were censused in the intensive study area. Three were of limited areal extent in the valley and were represented by a single transect each. Analysis and discussion of results will focus on the remaining 18 major C-S types.

<u>Total density and species richness</u>. Total density varied widely among C-S types and seasons (Table 16). The highest total densities were consistently observed in C/RO E I. Densities (as estimated by

Table 15. Avian density estimates, species richness values (Sp Rich.), and total numbers of species detected (Sp Total) for Emlen-counted community-structure types. 1981 and 1982 data were averaged. EC = modified Emlen census method, DC = direct-count method. All densities are expressed as the number of birds per 100 acres. Species richness values include all species present with a density of $\geq$0.5 per 100 acres. r = correlation coefficient.

	C/RO I		C/RO II		C/CW I		C/CW IV		C/CW V		MH V		
	EC	DC	EC	DC	EC	DC	EC	DC	EC	DC	EC	DC	r
SPRING													
Density	392	323	434	382	205	152	160	106	317	236	1615+	1327+	0.999**
Sp Rich.	44	33	50	36	46	36	34	24	44	36	35+	20+	0.927**
Sp Total	65	43	55	36	48	44	62	36	66	46	41+	20+	0.961**
SUMMER													
Density	392	341	512	439	244	186	253	205	418	345	1014+	972+	0.999**
Sp Rich.	33	27	41	32	35	28	36	26	40	31	17+	11+	0.987**
Sp Total	50	34	43	32	49	30	55	35	55	42	20+	11+	0.956**
FALL													
Density	235	187	271	227	295	243	175	112	374	308	1164	1092	0.999**
Sp Rich.	35	27	35	29	43	37	31	24	48	42	25	17	0.997**
Sp Total	53	38	40	29	56	41	54	35	67	50	25	17	0.986**
WINTER													
Density	419	373	176	148	147	114	196	161	342	283	1131+	793	0.999**
Sp Rich.	17	17	17	16	20	16	15	15	27	20	18+	12	0.628
Sp Total	25	19	22	16	26	16	27	17	36	24	18+	12	0.938**

+Includes data from only one year.
**$P<0.01$.

Table 16. Comparison of total avian density and species richness in major intensive study area community-structure types, based on direct-count calculations. 1981 and 1982 data were averaged to yield one density and one species richness value for each season. All densities are expressed as the number of birds per 100 acres. Species richness is the number of species present in densities ≥0.5 per 100 acres.

	Spring		Summer		Fall		Winter	
C-S type	Density	Species richness	Density	Species richness	Density	Species richness	Density	Species richness
C/RO E I	1086	47	971	47	1115	49	2159*	25
MH V	1327+	20+	972+	11+	1092	17	793*	12
C/CW E V	726	40	623	29	821	32	1209*	22
C/CW E III	871	33	535	30	670	38	1166*	17
RO V	673+	49+	528	42	676	46	1133*	29
C/CW E I	550	49	511	43	829	55	933	25
DR V	417	41	558	38	811	48	617	28
DR VI	366	51	258	43	427	50	924	41
C/CW VI	202	34	265	36	603	41	505	22
C/RO II	382	36	439	32	227	29	148	16
C/CW V	236	36	345	31	308	42	283*	20
C/RO I	323	33	341	27	187	27	373*	17
C/CW E IV	332	19	346	15	340+	24+	109*+	5+
RO VI	130	8	199*	21*	159	14	453*	8
C/CW I	152	36	186	28	243	37	114	16
C/CW IV	106	24	205	26	112	24	161	15
SB VI	52	15	98	18	112	18	273*	15
RV	100	14	47	7	51	7	167*	9

+Includes data from only one year.
*Marked difference between 1981 and 1982.

direct-count calculations) averaged over 900 birds per 100 acres in all four seasons in C/RO E I, slightly higher than in MH V and notably higher than those observed in the next most heavily used C-S type, C/CW E V. C/CW E V, RO V, C/CW E I, and C/CW E III also consistently had high total bird densities, all averaging over 500 birds per 100 acres all four seasons. These high-density C-S types were all densely vegetated, especially in the lower vegetation layers, and five of the six were edges. DR V often had slightly lower total densities of birds than the previous group, but usually yielded densities >500 birds per 100 acres. The C-S types with total bird densities at the upper end of the range, therefore, were all either type I edge, type III edge, or type V.

DR VI, C/CW VI, C/RO II, C/RO I, and C/CW E IV were similar to one another in total density, with approximately 200 to 450 birds per 100 acres. The C-S types that consistently yielded the lowest total density estimates (usually <200 per 100 acres) were C/CW I and IV, RO VI, SB VI, and RV. Except for C/CW I, these C-S types had relatively little vegetation cover. Total avian density was significantly correlated with total foliage volume during spring, summer ($P<0.01$), and fall ($P<0.05$) but not during winter. (Pearson product-moment correlation coefficient [Sokal and Rohlf 1969] used here and in subsequent tests.)

Species richness values ranged from seven or eight per C-S type per season to as many as 55. The number of species detected per C-S type varied more irregularly than density, and overall patterns were less easy to discern. RO VI, SB VI, and RV habitats all yielded relatively low numbers of species, and MH V and C/CW E IV had only slightly higher species richness values. Two of these C-S types, RO VI and C/CW E IV, were represented by a single transect each, which probably accounts for the low species richness values at least in part. The highest species richness values (>50) were observed in DR VI (which was represented by 15-18 transects) in spring, and DR VI and C/CW E I in fall.

Among the cottonwood C-S types, however, species richness was quite similar, usually averaging between 30 and 50. Not only was the number of species similar among the various cottonwood-dominated C-S types, but the species complement also overlapped substantially among them. Within a particular season cottonwood C-S types differed more in terms of density than in species richness or composition.

In general those C-S types having the greatest total densities of birds also yielded the highest species richness values. These two parameters were significantly correlated in three of four seasons ($P<0.05$ for all three). The notable exception to the pattern of high densities being associated with high species richness was MH V. Although MH V had consistently high total densities, it was poor in species, ranking among the four poorest C-S types in this regard (Table 17). When MH V was dropped, the correlation between total density and species richness among C-S types was substantially improved: there was a significant correlation all four seasons ($P<0.01$ for all four). In MH V a relatively small number of species typically occurred in very high density. For example, Red-winged Blackbirds (Agelaius phoeniceus), occurred in densities up to ten times as great as the next most common

Table 17. Relative rank order of major community-structure (C-S) types with regard to total avian density and species richness. Ranks are based on the data in Table 16.

	Density				Species richness			
C-S type	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
C/RO E I	2	2	1	1	4	1	3	4.5
MH V	1	1	2	7	14	17	16	15
C/CW E V	4	3	4	2	6	10	10	6.5
C/CW E III	3	5	7	3	11.5	9	8	9.5
RO V	5	6	6	4	2.5	4	5	2
C/CW E I	6	7	3	5	2.5	2.5	1	4.5
DR V	7	4	5	8	5	5	4	3
DR VI	9	13	9	6	1	2.5	2	1
C/CW VI	13	12	8	9	10	6	7	6.5
C/RO II	8	8	13	16	8	7	11	11.5
C/CW V	12	10	11	12	8	8	6	8
C/RO I	11	11	14	11	11.5	12	12	15
C/CW E IV	10	9	10	17	15	15	13.5	18
RO VI	15	15	15	10	18	14	17	17
C/CW I	14	16	12	18	8	11	9	11.5
C/CW IV	16	14	16.5	15	13	13	13.5	13.5
SB VI	18	17	16.5	13	16	16	15	13.5
RV	17	18	18	14	17	18	18	16

species in MH V. In the other C-S types, most of which were forest or shrub, density was much more evenly distributed among species. Species richness was not significantly correlated with foliage volume during any of the four seasons.

Seasonal and yearly fluctuation in total density and species richness. The relative rank order of C-S types with regard to total density and species richness was fairly consistent across seasons, indicating that the gross patterns of habitat use by the avian community as a whole were similar throughout the year (Table 17). That is, those C-S types with high total density and species richness values in one season tended to have similarly high values in all seasons, and those with low values tended to have low values all four seasons. Spearman-rank correlation coefficients (Siegel 1956) were used to test whether the rank order of C-S types with regard to (1) total density and (2) species richness were correlated across seasons. All pairwise comparisons of C-S type ranks between seasons yielded significant correlation coefficients ($r_s \geq 0.730$, $P<0.01$).

There was little difference between 1981 and 1982 total densities in spring, summer, or fall in any C-S type except RO VI in summer (see Table 16 and supplements to Appendix VII). Mean total avian density (the average total density over all 18 C-S types) thus fluctuated only slightly over these three seasons (Fig. 12). In 1981, mean total density fluctuated by less than 50 birds per 100 acres from spring through fall. In 1982, mean total avian density fluctuated only slightly more, by 120-150 birds per 100 acres across these three seasons, with the lowest density observed during summer.

In winter 1982-83 mean total density was similar to densities observed spring through fall. In winter 1981-82, however, mean total density was notably greater than in any of the other seven seasons, yielding a higher mean density for the winter season overall. Total avian densities were much greater during winter 1981-82 than during winter 1982-83 in 14 of the 18 major C-S types (Fig. 13).

The primary reason for this difference in total density between winters was the presence of large flocks of American Robins in the valley during winter 1981-82. The impact of American Robins on total avian densities is illustrated in Figure 13. Whereas total density differed substantially between winters when all species are included, when robins are subtracted the difference between the two winters becomes small in most C-S types. The impact of robins on density differences between winters was greatest in edge C-S types and those that included high numbers of Russian olive trees (left side of Fig. 13), where the largest flocks of robins congregated.

In RV VI and SB VI, the difference in density between winters was not due to the 1981-82 influx of robins, but to differences in the estimated densities of ducks, especially Mallards (*Anas platyrhynchos*), which were concentrated along the river channel. The lower duck density estimates for the second winter are attributable to the fact that censusing was carried out for only the first two months of the winter 1982-83 season. The number of ducks in the valley increased in late winter 1981-82,

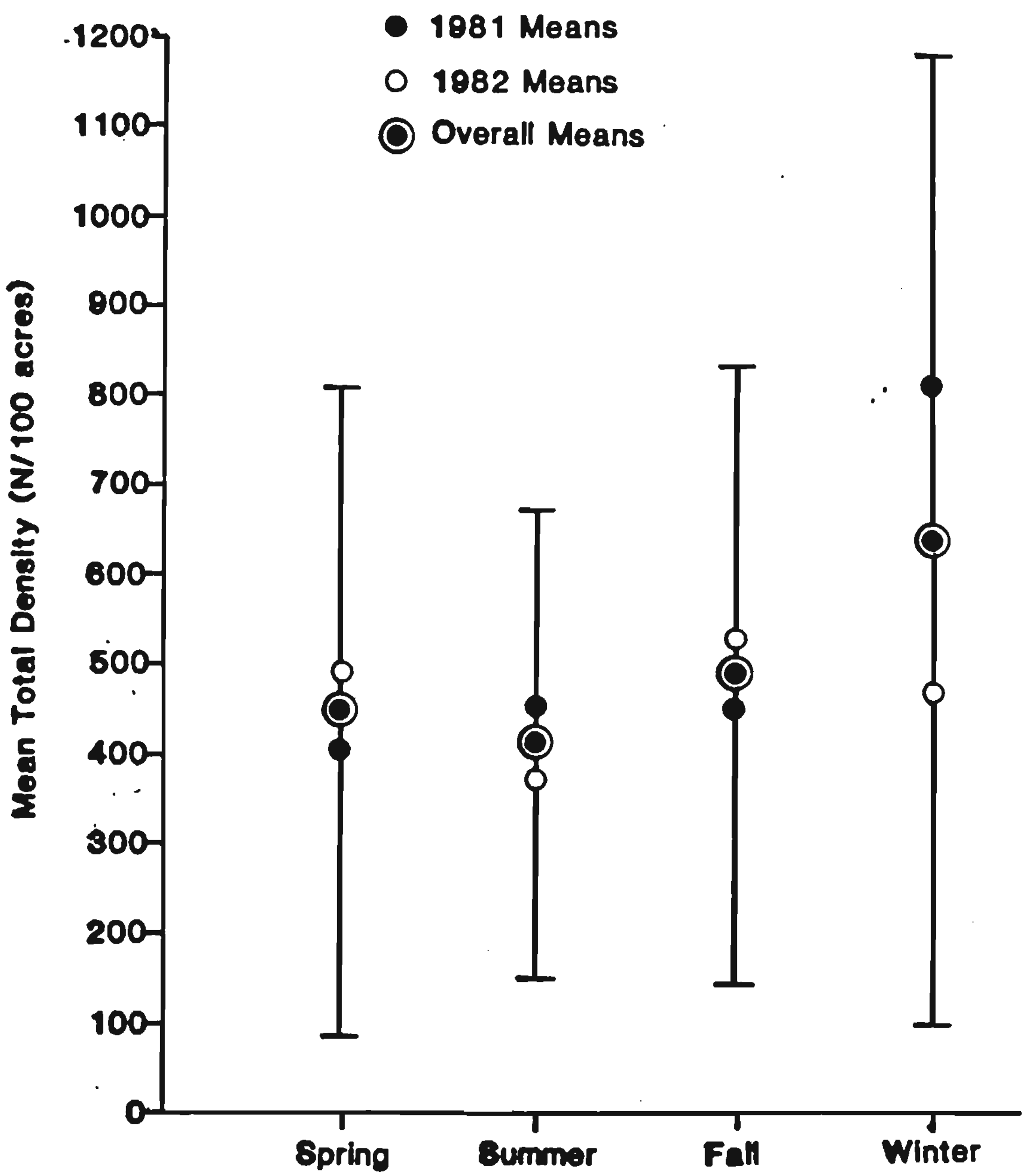

Figure 12. Seasonal and annual fluctuation in mean total avian density. Bars represent standard deviations of overall means.

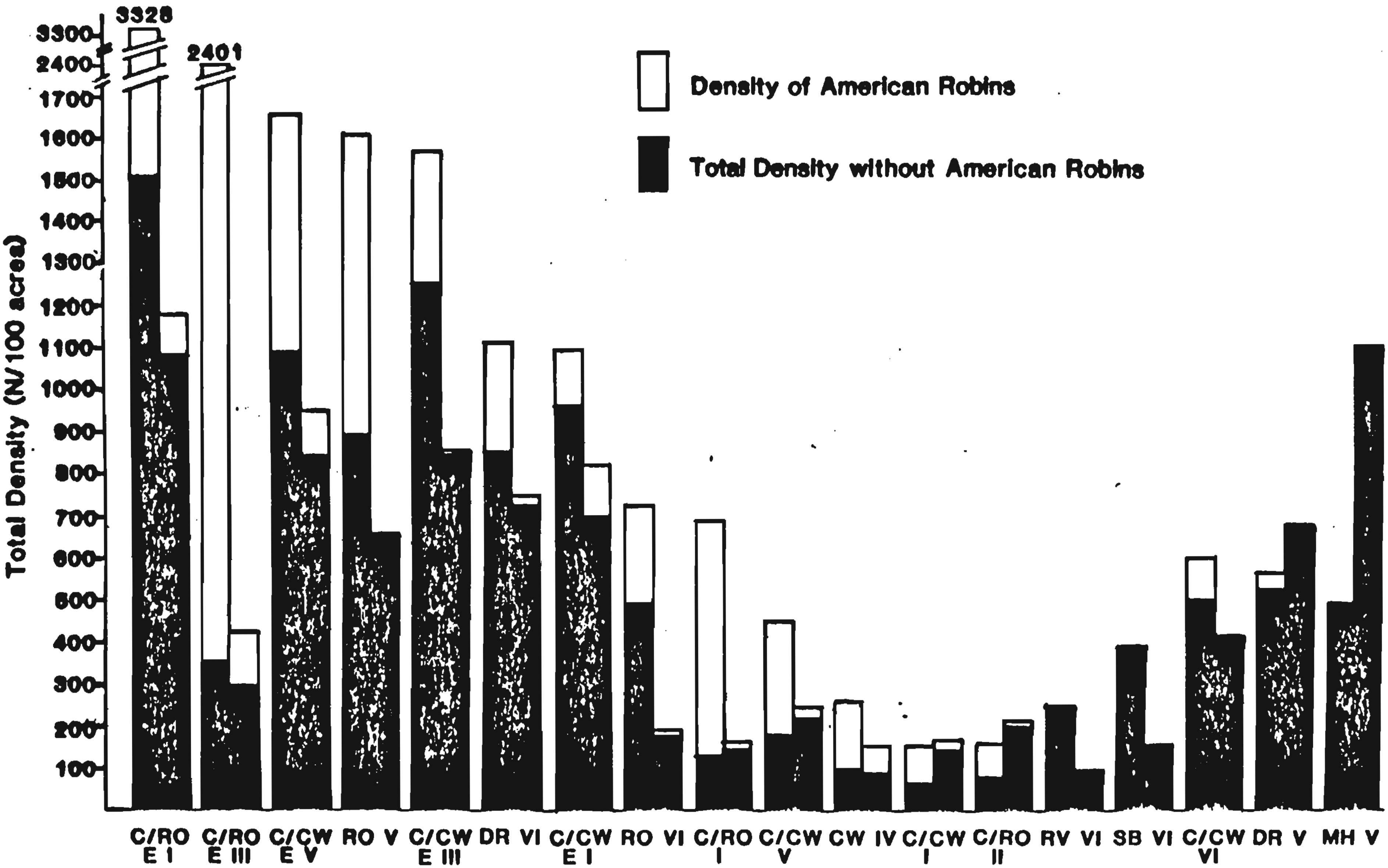

Figure 13. Total avian density in winter 1981-1982 (left bar) and 1982-1983 (right bar) in each community-structure type. The lower portion of each bar shows total density of all species except American Robins.

beginning around the middle of January; a late winter influx of ducks would have been missed because of the shortened 1982-83 winter censusing season. Lower numbers of Yellow-rumped Warblers in 1982-83 also contributed to lower total density on sandbars that winter.

MH V was the only C-S type in which there was a large increase in total density in winter 1982-83. This increase was due to much greater numbers of Song Sparrows and White-crowned Sparrows in MH V the second winter.

Species richness was greatest during spring and fall, because of the influx of migrating species and the presence of both winter and summer residents during parts of these seasons. Species richness was slightly lower during summer in most C-S types, and notably lower during winter than the rest of the year.

Species composition and habitat associations. The avian community in the valley included permanent resident species, summer resident species that bred in the area and were present during late spring and summer, transient species that occurred in large numbers during certain periods in spring and fall migration, and the winter residents that were present for varying lengths of time between September and April. In general, permanent residents occurred in low densities throughout the study area, while many of the transients and seasonal residents tended to be more abundant and to be unevenly distributed over time or among C-S types. Densities for each species in each C-S type by season are presented in the Supplement to Appendix VII.

The distribution of permanent resident and summer resident species among C-S types was similar during spring and summer. The most abundant species in most of the cottonwood forest C-S types (C/CW I, IV, V, C/CW E I, III, V, C/RO I, C/RO E I) during spring and summer were two summer residents, Mourning Dove (*Zenaida macroura*) and Black-chinned Hummingbird (*Archilochus alexandri*). As with many of the common species, their highest densities were recorded along levee edges. Additional common species in cottonwood habitats were Gambel Quail (*Callipepla gambelii*), Northern Flicker (*Colaptes auratus*), Ash-throated Flycatcher (*Myiarchus cinerascens*), Ring-necked Pheasant (*Phasianus colchicus*), European Starling (*Sturnus vulgaris*), American Robin (*Turdus migratorius*), Northern Oriole (*Icterus galbula*), Black-headed Grosbeak (*Pheucticus melanocephalus*), Lesser Goldfinch (*Carduelis psaltria*), Rufous-sided Towhee (*Pipilo erythrophthalmus*), Blue Grosbeak (*Guiraca caerulea*), and Brown-headed Cowbird (*Molothrus ater*). Yellow-billed Cuckoo (*Coccyzus americanus*), a late-arriving species, was restricted to cottonwood communities but exhibited no strong association with a particular C-S type. Lazuli and Indigo buntings (*Passerina amoena* and *P. cyanea*, respectively) were fairly broadly distributed among cottonwood habitats, with a slight preference for areas with denser vegetation. Lazuli Buntings were more common than Indigo Buntings during early spring, whereas the reverse was true during summer.

In C/RO II communities the most common breeding species differed. Besides the widely distributed summer residents, Mourning Doves and Black-chinned Hummingbirds, Downy Woodpeckers (*Picoides pubescens*), Black-capped Chickadees (Parus atricapillus), White-breasted Nuthatches, and Western Wood-Pewees (Contopus sordidulus) were the most common species. The first three are bark foragers, and pewees are associated with an open undercanopy. Although these species also occurred in the other cottonwood forest types, they were most abundant in C/RO II. Species associated with dense understory or lush foliage were notably absent from this habitat, which is characterized by tall trees, closed canopy, and very sparse understory vegetation.

Several of the type V communities (C/CW E V, C/CW V, and MH V) supported large numbers of Red-winged Blackbirds, Common Yellowthroats (Geothlypis trichas), Yellow-breasted Chats (Icteria virens), and Rufous-sided Towhees. Gray Catbirds (Dumetella carolinensis), uncommon summer residents, also favored the low, dense vegetation typical of type V communities.

C-S types that included areas of open water attracted a unique set of species. American Robins and Red-winged Blackbirds were among the most common species along the drains in spring and summer. Mallards, Belted Kingfishers (Ceryle alcyon), and Black Phoebes (Sayornis nigricans) were also recorded along drains regularly. Species encountered on drains and sandbar river channel transects in spring and summer included Spotted Sandpipers (Actitis macularia), Killdeer (Charadrius vociferus), and Black-crowned Night-Herons (Nycticorax nycticorax), Snowy Egrets (Egretta thula), Great Blue Herons (Ardea herodias) and Green-backed Herons (Butorides striatus).

Common transient species in spring and fall included Empidonax flycatchers, House Wrens (Troglodytes aedon), Warbling Vireos (Vireo gilvus), Orange-crowned (Vermivora celata), Virginia (V. virginiae), Yellow (Dendroica petechia), Yellow-rumped (D. coronata), MacGillivray (Oporornis tolmiei), and Wilson (Wilsonia pusilla) warblers. (A few Yellow Warblers remained throughout summer.) Northern Waterthrushes (Seiurus noveboracensis) came through in numbers greater than expected and were found in dense vegetation near water. Wilson and Orange-crowned warblers were found in greatest concentrations in the dense type V habitats, especially C/CW E V. The other warblers were most numerous along cottonwood and levee edges, while probable Dusky Flycatchers (Empidonax oberholseri) and Warbling Vireos were about equally common in cottonwood interior and edge communities. Warbling Vireos occurred most frequently in the cottonwood I habitats (C/CW E I, C/RO E I, C/RO I, C/CW I). Calliope (Stellula calliope) and Rufous (Selasphorus rufus) hummingbirds were early fall migrants, appearing in July. Like the Black-chinned Hummingbirds, they were most commonly seen along levee edges. House Wrens were more common as fall migrants than in spring. While a strong habitat preference was not evident in spring, perhaps because relatively low densities were recorded, the species was most numerous in C/CW E III in fall.

Winter resident species began to arrive in the valley in fall. Species common in cottonwood habitats included White-crowned Sparrows (Zonotrichia leucophrys), Dark-eyed Juncos (Junco hyemalis), Hermit Thrushes (Catharus guttatus), American Goldfinches (Carduelis tristis), Ruby-crowned Kinglets (Regulus calendula), Yellow-rumped Warblers, Brown

Creepers (*Certhia americana*), Brewick Wrens (*Thryomanes bewickii*), Song Sparrows (*Melospiza melodia*), and large flocks of American Crows (*Corvus brachyrhynchos*). American Robins, which were present in moderate numbers during the breeding season, increased markedly and became very abundant in fall and winter of 1981-1982, as previously discussed. Northern Flickers, another species present throughout the year, also increased sharply in fall 1981, with estimated densities double or triple the spring and summer densities for most habitats. This increase represented an apparent large-scale movement of flickers through the study area in late October through early November 1981. During winter 1982-83, flocks of Bushtits (*Psaltriparus minimus*) and Mountain Chickadees (*Parus gambeli*) moved into the study area. They were among the most abundant species in cottonwood habitats that season. Scrub Jays (*Aphelocoma coerulescens*) were also more common in winter 1982-83 than the previous year.

During fall and winter, most of the common species again reached their greatest estimated densities in cottonwood habitats along levee edges, but Song Sparrows and American Goldfinches favored dense type V habitats. American Robins, White-crowned Sparrows, and Dark-eyed Juncos were especially common on levees and along cottonwood edges. The juncos foraged on the ground along the levee roads (DR VI), and also used the adjacent cottonwood areas, whereas White-crowned Sparrows favored thick shrubby vegetation, such as C/CW V, C/CW E V, DR V, and MH V. Robins tended to concentrate in areas of thick Russian olive, where they fed on the fruits. A few more Hairy Woodpeckers (*Picoides villosus*) were recorded during fall and winter than in other seasons, although the species was still less common overall than previous reports had indicated. White-crowned Sparrows, Dark-eyed Juncos, and Song Sparrows were present in the valley in large numbers through early spring.

Drain and sandbar/river channel transects in fall and winter again were characterized by a distinctive complement of species. They included the Great Blue Heron and a variety of ducks, the most common of which were Mallards, Cinnamon Teal (*Anas cyanoptera*), American Wigeon (*A. americana*), Gadwall (*A. strepera*), and Northern Shoveler (*A. clypeata*). The numbers of Mallards and Great Blue Herons in these habitats were greater in winter than in summer. Water Pipits (*Anthus spinoletta*) and Mountain Bluebirds (*Sialia currucoides*) were found primarily on sandbars, and Common Snipe (*Gallinago gallinago*) and Marsh Wrens (*Cistothorus palustris*) occurred along the drains.

Avian use of vegetation communities and habitat breadth values. Habitat breadth values, which are based on the percent distribution of a species' total population density among habitat types, provide insight into patterns of habitat use among species. Analysis of percent distribution and habitat breadth provides information on three different aspects of bird-habitat relationships: (1) the degree of preference of individual species for a particular habitat type or types is indicated by the percent of that species density occurring in that type; (2) habitat breadth values provide a means of comparing the degree to which particular species are specialists, strongly tied to one or two habitats, or generalists, having their population density more evenly distributed across the range of habitats within the riparian community as a whole; and (3) the value of particular habitat types to the avian community as a whole may be assessed by counting the number of species using the habitat, as well as the number that are dependent on or strongly tied to it. Habitat breadth analysis by community type was carried out for 62 selected species, including 23 permanent resident, 23 summer resident, and 16 winter resident bird species occurring in the Middle Rio Grande Valley.

The data for summer are presented in Table 18. The permanent and summer resident species selected for this analysis included all the common species, along with several species that were of interest because of their rarity or limited habitat distribution.

The 13 species having the most limited distributions among community types in summer included 9 that were strongly associated with water or wet communities: Pied-billed Grebes (Podilymbus podiceps), Virginia Rails (Rallus limicola), Soras (Porzana carolina), American Coots (Fulica americana), and Yellow-headed Blackbirds (Xanthocephalus xanthocephalus) were largely restricted to MH, Snowy Egrets, Killdeer, and Spotted Sandpipers occurred primarily in SB/RV, and Black Phoebes were found only in drains. The other four species of limited distribution were forest birds: Great Horned Owls (Bubo virginianus), Hairy Woodpeckers, and Mountain Chickadees occurred primarily in C/RO, whereas Lewis Woodpeckers (Melanerpes lewis) were found only in C/CW. All of the above-mentioned species had habitat breadth values <0.6 (<33% of maximum), and may be considered habitat specialists in summer. (Note that since these data are from daylight censusing, the preference of Great Horned Owls for C/RO pertains to their daytime roost sites.)

Five species, Black-headed Grosbeaks, Blue Grosbeaks, Black-chinned Hummingbirds, and, surprisingly, Gray Catbirds and Yellow Warblers, were clearly habitat generalists, having habitat breadth values of ≥1.2, and >66% of maximum. These were all primarily forest birds, but they occurred almost as often in DR and RO as in the two cottonwood communities. Only 2 of the 46 species, Black-chinned Hummingbirds and Mourning Doves, occurred in all six communities.

Four of the six communities, C/RO, C/CW, RO, and DR, were used by large numbers of species, whereas the other two, MH and SB/RV, were used by relatively few species (Table 18). In addition to being used by large numbers of bird species, C/RO and C/CW were also preferred habitat (as defined in Table 18) for a large proportion of those species. Thirty of the 46 breeding species listed in the table showed preference for one or both of these communities, illustrating the importance of the riparian cottonwood forest to the breeding bird community in the Middle Rio Grande. C/RO was preferred by the greatest number of species, with over two-thirds of the 35 species using that community showing preference for C/RO, and almost half of those showing preference showed strong preference. About half of the 34 species using C/CW showed preference for that community, but only 4 of these showed strong preference.

Most of the cavity-nesting species (American Kestrels, Hairy Woodpeckers, Northern Flickers, Black-capped and Mountain chickadees, White-breasted Nuthatches) preferred C/RO over C/CW, as did the

Table 18. Avian use of vegetation communities in summer. Percent of total population density per community type and habitat breadth (HB) values for selected species are shown. Data from 1981 and 1982 were averaged. P = present.

Species	C/RO	C/CW	RO	DR	MH	SB/RV	HB	Percent of max. HB
Pied-billed Grebe					100		0.00	0
Green-backed Heron	11	5		42	21	21	1.41	79
Black-crowned Night-Heron		4		35		53	1.03	58
Snowy Egret					19	81	0.49	27
Mallard	P		2	20	15	62	1.03	57
American Kestrel	59	28	3	8		2	1.05	59
Ring-necked Pheasant	33	40	24	3			1.18	66
Gambel Quail	46	41	1	11		1	1.06	59
Virginia Rail					100		0.00	0
Sora					100		0.00	0
American Coot				3	97		0.13	8
Killdeer		1		2	1	96	0.21	12
Spotted Sandpiper				25		74	0.56	31
Mourning Dove	55	31	7	5	1	1	1.12	63
Yellow-billed Cuckoo	42	45	12	1			1.02	57
Greater Roadrunner	20	44	26	10			1.26	71
Great Horned Owl	100						0.00	0
Black-chinned Hummingbird	28	39	11	7	14	1	1.47	82
Belted Kingfisher	6	7		51		37	1.06	69
Lewis Woodpecker		100					0.00	0
Downy Woodpecker	47	47	1	5			0.91	51
Hairy Woodpecker	100						0.00	0
Northern Flicker	60	31	5	4			0.95	53
Western Wood-Pewee	67	26	2	5			0.85	47
Western Kingbird	70	14	4	10		2	0.88	49
Black Phoebe				100			0.00	0
Ash-throated Flycatcher	53	38	7	2			0.97	54
Black-capped Chickadee	68	24	5	3			0.86	48
Mountain Chickadee	85		15				0.42	24
White-breasted Nuthatch	60	37	2	1			0.80	46
American Robin	46	42	6	6			1.06	59
Gray Catbird	35	18	29	18			1.34	75
European Starling	44	51		5			0.85	48
Yellow Warbler	35	13	43	9			1.58	88
Common Yellowthroat	3	9	12	29	47		1.18	66

Table 18. (cont.)

Species	C/RO	C/CW	RO	DR	MH	SB/RV	HB	Percent of max. HB
Yellow-breasted Chat	16	40	42	2			1.10	62
Summer Tanager	66	19		15			0.87	49
Black-headed Grosbeak	42	35	17	6			1.20	67
Blue Grosbeak	24	30	30	15		1	1.40	78
Indigo Bunting	24	52	4	20			1.11	62
Rufous-sided Towhee	49	20	27	4			1.15	64
Red-winged Blackbird	P	3	21	P	76		0.64	36
Yellow-headed Blackbird				100			0.00	0
Brown-headed Cowbird	40	28	20	12			1.17	65
Northern Oriole	25	56	12	7			1.11	62
Lesser Goldfinch	53	30	13	2		2	1.12	62
Mean habitat breadth							0.8	40.0
Mean percent use of communities	32.9	22.8	8.8	13.1	12.8	9.4		
Number of species	35	34	29	37	13	14		
Number with preference*	24	15	2	4	5	6		
Number with strong preference**	11	4	0	2	5	5		

*Preference means percent density twice the expected random distribution, i.e., $\geq$33.3%.

**Strong preference means percent density three times the expected random distribution, i.e., $\geq$49.8%.

flycatchers (Western Wood-Pewees, Western Kingbirds [Tyrannus verticalis], and Ash-throated Flycatchers), and Gray Catbirds, Summer Tanagers (Piranga rubra), Rufous-sided Towhees, Lesser Goldfinches, and Mourning Doves. The strong association of cavity nesters with C/RO may be related to the concentration of larger, more mature trees in that community, providing potential nest cavities. Gray Catbirds and Rufous-sided Towhees were often found in areas characterized by a dense growth of Russian olive, and both occurred in RO communities in relatively high proportions as well as in C/RO. Summer Tanagers occurred in association with mature cottonwood stands. Mourning Doves often nested in high densities in Russian olive thickets under a forest canopy in the Middle Rio Grande (Hink et al. 1983).

A number of breeding species, although tending to be concentrated in cottonwood forest, showed no clear preference for one of the two cottonwood communities over the other. Ring-necked Pheasants, Gambel Quail, Downy Woodpeckers, American Robins, European Starlings, and Black-headed and Blue grosbeaks occurred in C/RO and C/CW in about equal proportion.

A few breeding bird species were more common in C/CW than C/RO. These included Greater Roadrunners (Geococcyx californianus), Black-chinned Hummingbirds, Yellow-breasted Chats, Indigo Buntings, and Northern Orioles. Yellow-breasted Chats and Indigo Buntings occurred in greatest density in the shrubby C/CW V habitats, which suggests a structural rather than a community type preference as C/RO stands were all of structure type I or II. The concentration of Northern Orioles in C/CW also results from this species' concentration in C/CW V. Orioles used scattered larger trees within the shrubby C/CW V habitat.

DR and RO communities, although they were used by about as many species as the two cottonwood communities, were preferred habitat for very few. Green-backed Herons and Black-crowned Night-Herons showed preference for DR, and Belted Kingfishers and Black Phoebes both showed strong preference for DR. However, 32 of the 37 species occurring in drains were more common in other communities. Only two species, Yellow-breasted Chats and Yellow Warblers, showed any preference for RO, and it was not a strong preference in either case. Yellow-breasted Chats used C/CW (V) habitats about as often as RO, and this probably reflects a structural more than a community type preference. Yellow Warblers used C/RO almost as much as RO. It is of note that while the RO community is distinct in terms of vegetation structure and species composition, it does not attract a distinct complement of bird species. The bird species occurring in RO were the same as those occurring in cottonwood forest. When RO occurs in association with cottonwood (i.e., C/RO communities), however, it apparently contributes to the attractiveness of that community to many species of birds.

MH and SB/RV were used by far fewer bird species than the other four communities, but of the species that did use the MH and SB/RV communities, a high proportion (over one-third), showed strong preferences for them. Pied-billed Grebes, Virginia Rails, Soras, and Yellow-headed Blackbirds occurred only in MH. Common Yellowthroats, American Coots, and Red-winged Blackbirds were more common in MH than in any other community, the former showing preference and the latter two showing strong preference. Black-crowned Night-Herons, Snowy Egrets, Mallards, Killdeer, and Spotted Sandpipers showed strong preference for SB/RV, and Belted Kingfishers, although most common along drains, also showed a preference for SB/RV.

Altogether, only 13 of the 46 species in Table 18 used MH and 14 of the 46 used SB/RV. However, the degree to which most of those species were tied to these communities indicates that they contribute a unique component to the overall species richness of the Middle Rio Grande avian summer resident community.

Winter habitat use data for 39 species, including the same 23 permanent resident species and 16 winter resident species, are presented in Table 19. There was little change in habitat use at the community type level from summer to winter among permanent residents, and habitat breadth values for these 23 species were similar during summer and winter. The few shifts in habitat use that did occur did not involve changes in preferred habitat, except possibly in one case (Hairy Woodpecker, discussed further below). Three of the permanent residents were more restricted to their preferred communities (i.e., had lower habitat breadth) in winter than in summer. Mallards were more heavily concentrated in the river channel in winter, and Mourning Doves, which were present in much lower density during winter than summer, were more concentrated in C/RO. Belted Kingfishers were not observed along the river channel (SB/RV) in winter but were more often seen in drains. Two of the permanent residents showed notably greater habitat breadth during winter than summer. Mountain Chickadees, which became more common in the valley in winter, occurred in two additional communities, C/CW and DR, and European Starlings were observed in RO in winter. The apparent change in the distribution of Virginia Rails is not significant. This species was seen only twice in winter, and one of the two times was in a small patch of cattails in a drain; MH was this species' primary habitat throughout the year.

Among the species present in winter, eight may be regarded as specialists, having habitat breadth values <0.6 and <33% of maximum. They included five water-associated species: American Coots and Red-winged Blackbirds in MH, Common Snipe restricted to DR, Killdeer and Water Pipits found primarily on sandbars; and three forest species: Great Horned Owls in C/RO, and Townsend Solitaires (Myadestes townsendi) and Hairy Woodpeckers in C/CW. The latter had been found only in C/RO in summer, but the relative rarity of Hairy Woodpeckers in summer makes that apparent preference uncertain. Hairy Woodpeckers in general were found in association with mature cottonwood trees.

Seven species had habitat breadth values >1.2 (>66% of maximum) and may be classified as generalists in winter: Ring-necked Pheasants, Bewick Wrens, Cedar Waxwings (Bombycilla cedrorum), European Starlings, White-crowned Sparrows, Dark-eyed Juncos, and American Goldfinches. The latter three species occurred in all six community types. White-crowned Sparrows and Dark-eyed Juncos had the highest habitat breadth values among all species considered in either summer or winter.

Table 19. Avian use of vegetation communities in winter. Percent of total population density per community type and habitat breadth (HB) values for selected species are shown. Data from 1981 and 1982 were averaged. P = present.

Species	C/RO	C/CW	RO	DR	MH	SB/RV	HB	Percent of max. HB
Pied-billed Grebe				33	66		0.64	36
Great Blue Heron				42	23	35	1.07	60
Mallard		1		9	1	89	0.41	23
American Kestrel	46	36		18			1.03	58
Ring-necked Pheasant	12	44	33	10	1		1.26	70
Gambel Quail	32	44	4	20			1.18	66
Virginia Rail				50	50		0.69	39
American Coot					100		0.00	0
Killdeer			6	10		84	0.55	30
Common Snipe				100			0.00	0
Mourning Dove	77	17	2	4			0.71	40
Greater Roadrunner	16	39		45			1.02	57
Great Horned Owl	100						0.0	0
Belted Kingfisher		14	18	68			0.85	47
Downy Woodpecker	38	56	1	5			0.89	50
Hairy Woodpecker		100					0.00	0
Northern Flicker	50	21	24	5	P	P	1.17	65
Black-capped Chickadee	49	42	4	5			0.99	55
Mountain Chickadee	49	38	10	3			1.05	59
White-breasted Nuthatch	60	37	P	3			0.78	44
Brown Creeper	65	32		4			0.77	43
Bewick Wren	31	34	12	20	3		1.41	79
Marsh Wren	1	1	4	15	79		0.69	39
Ruby-crowned Kinglet	40	34	3	20	3		0.98	54
Townsend Solitaire		100					0.00	0
Hermit Thrush	57	24	13	6			1.10	61
American Robin	60	24	10	4		2	1.09	61
Water Pipit				14		86	0.40	22
Cedar Waxwing	25	10	50	15			1.21	67
European Starling	31	39	25	5			1.23	68
Yellow-rumped Warbler	45	8	33	14		P	1.20	67
Rufous-sided Towhee	38	28	26	7			1.26	70
Song Sparrow	2	10	2	29	57	P	1.07	60
Swamp Sparrow	7				93		0.25	14
White-throated Sparrow	3	26	65	6			0.90	50

Table 19. (cont.)

Species	C/RO	C/CW	RO	DR	MH	SB/RV	HB	Percent of max. HB
White-crowned Sparrow	18	28	9	30	13	2	1.59	89
Dark-eyed Junco	23	36	13	18	1	9	1.54	86
Red-winged Blackbird	1	9	1	13	75		0.59	33
American Goldfinch	13	29	11	35	2	9	1.22	68
Mean habitat breadth							0.9	51.0
Mean percent use of communities	25.4	24.6	9.7	17.6	14.5	8.1		
Number of species	29	30	25	34	16	11		
Number with preference*	14	13	3	7	7	4		
Number with strong preference**	7	3	2	3	7	3		

*Preference means percent density twice the expected random distribution, i.e., >33.3%.

**Strong preference means percent density three times the expected random distribution, i.e., >49.8%.

Patterns of community use by wintering bird species were similar to those observed in summer with one notable exception. Whereas C/RO was preferred over C/CW by a large proportion of the summer bird community, C/RO and C/CW were used more equally during winter. The two cottonwood forest communities were used by about the same number of species during winter, and in both communities about half the species showed preference. C/RO was distinguished by having a greater number of species exhibiting strong preference for that community, but this was still a lower proportion of the total than in summer. C/RO was apparently a preferred breeding season habitat for many of the summer resident species, but the wintering species did not exhibit as great a preference for C/RO. Use of C/CW, on the other hand, was nearly the same during both summer and winter.

Among winter resident forest species, Brown Creepers, Yellow-rumped Warblers, and Hermit Thrushes were most common in C/RO, whereas Bewick Wrens and Ruby-crowned Kinglets used C/RO and C/CW about equally. Townsend Solitaires were found only in C/CW. Dark-eyed Juncos were somewhat more common in C/CW than in other communities, but large flocks of juncos moved among all communities in winter.

RO, and especially DR, were more heavily used during winter than summer. Two of the winter residents showed strong preference for RO: Cedar Waxwings and White-throated Sparrows (Zonotrichia albicollis). Cedar Waxwings fed on Russian olive fruits; their second greatest density was in C/RO. White-throated Sparrows preferred shrubby thickets such as RO V. The drains supported Great Blue Herons and Common Snipe in winter, which showed preference and strong preference for this community, respectively. In addition, large numbers of Song Sparrows and White-crowned Sparrows used the margins of drains in winter. American Goldfinches were also found most commonly along drains and showed a preference for DR habitat. The latter two species may have been attracted by the seed crop produced by herbaceous plants that grew abundantly along the moist edges of the drains.

MH and SB/RV, as in summer, were used by fewer species than the previous four communities, but the proportion of species strongly tied to these communities remained high. MH, in particular, was strongly preferred by a high proportion of species in winter. Of the 16 species using MH in winter, 7 showed strong preference; in addition to the 4 permanent resident marsh species, Marsh Wrens, Song Sparrows, and Swamp Sparrows (Melospiza georgiana) also occurred in highest concentrations in MH. The SB/RV community was strongly preferred by Water Pipits, flocks of which were observed foraging on sandbars. Finally, in addition to Mallards, many other species of ducks (not listed in the table) occurred in marshes, drains, and along the river channel during winter, the most common of which were Green-winged Teal (Anas crecca), Blue-winged Teal (A. discors), Cinnamon Teal, American Wigeons, Gadwalls, Northern Shovelers, Ring-necked Ducks (Aythya collaris), and Northern Pintails (Anas acuta).

Seasonal changes in habitat use by the Middle Rio Grande avian community were subtle, more a matter of degree rather than of marked shifts in species-habitat associations. The overall pattern was similar throughout the year, with a high proportion of the avian community being associated with or showing preference for one or both of the cottonwood forest communities, and a smaller, more habitat-specific group associated with marsh or riverine habitats. The two most regularly disturbed communities, drains and RO stands, were used by large numbers of species but were preferred habitat for very few. The main difference in habitat use between summer and winter avian communities was the greater preference among the summer (breeding) species for C/RO.

Comparison of avian populations along levee edge and interior transects. Avian use of levee edge versus interior portions of cottonwood forest stands in the intensive study area was investigated by means of two separate but related types of analyses. The first of these compared avian densities along edge and interior transects of the same C-S types. This was done to permit evaluation of edge effects while attempting to control for differences in vegetation composition and structure between edges and interiors of stands. The statistical test used was a two-way analysis of variance (ANOVA) for paired comparisons (Sokal and Rohlf 1969), using seasonal average densities (based on direct-count analysis of 50-X-2500-ft strips) as variables (Tables 20 and 21). In C/RO I there were three edge and five interior transects contributing to each seasonal average, and in C/CW I, there were five edge and six interior transects.

The results of this analysis indicated that avian density was significantly greater along edges than within the interiors of stands in both C/RO I (Table 20) and C/CW I (Table 21). There was no significant additional variance due to differences among seasons in either C-S type. Therefore, the difference in density between edge and interior did not change significantly from season to season.

The second type of analysis run on the levee edge/interior data tested for differences in avian density between parallel edge and interior transects at six particular sites, irrespective of the C-S types of the paired transects. For example, KW-02, a C/CW I levee edge transect, was parallel to KW-01, an interior C/RO II transect, and the densities observed on these two transects were compared (Table 22). Wilcoxon matched-pairs signed-ranks tests were used to compare total densities of each of the edge/interior transect pairs, using seasonal total avian densities for the respective transects as variables. In all six tests, bird densities on the edge transects were significantly greater than densities observed along interior transects at the same sites ($P<0.02$ or less for all six tests). Further underscoring the significance of these results, the binomial probability of obtaining six such differences in the same direction (that is, levee edge densities greater than interior densities) by random chance alone is 0.016. In other words, if 1000 such paired transect comparisons were made, we would expect only 16 of them to yield results this extreme based on random chance. We therefore conclude, based on the results of both types of analyses, that strips of cottonwood habitat along levee edges support significantly higher densities of birds than comparable areas in the interior of cottonwood stands.

Table 20. Comparison of avian population densities and species richness values for levee edge and interior strips in cottonwood/ Russian olive I. Densities are expressed as the number of birds per 100 acres. Species richness is the number present in densities $\geq$0.5 per 100 acres. All values are based on direct counts of 2500-X-50-ft strips. The ANOVA table (Sokal and Rohlf 1969) for comparison of edge and interior densities is given at bottom. * indicates a significant difference.

	Density		Species richness	
	Edge	Interior	Edge	Interior
Spring 1981	932	327	42	29
Summer 1981	1162	402	44	34
Fall 1981	985	225	50	32
Winter 1981-1982	3230	663	27	15
Spring 1982	1240	336	51	38
Summer 1982	779	281	50	24
Fall 1982	1244	191	47	34
Winter 1982-1983	1087	115	23	15
MEAN	1332.38	317.50	41.75	27.63

Source of variation	df	SS	MS	F_s
Edge/Interior	1	4,119,885.1	4,119,885.1	19.2920*
Seasons	7	2,992,715.9	427,530.8	2.002
Remainder	7	1,494,878.0	213,554.0	

$F_{.05[1,7]} = 8.07$

Table 21. Comparison of avian population densities and species richness values for levee edge and interior strips in cottonwood/coyote willow I. Densities are expressed as the number of birds per 100 acres. Species richness is the number present in densities ≥0.5 per 100 acres. All values are based on direct counts of 2500-X-50-ft strips. The ANOVA table (Sokal and Rohlf 1969) for comparison of edge and interior densities is given at bottom. * indicates a significant difference.

	Density		Species richness	
	Edge	Interior	Edge	Interior
Spring 1981	504	133	35	37
Summer 1981	594	239	45	32
Fall 1981	754	218	54	40
Winter 1981-1982	1069	104	28	15
Spring 1982	596	202	62	29
Summer 1982	428	186	41	30
Fall 1982	903	323	56	31
Winter 1982-1983	796	135	22	10
MEAN	705.50	192.50	42.89	28.00

Source of variation	df	SS	MS	F_s
Edge/Interior	1	3,215,745.6	3,215,745.6	127.459*
Seasons	7	181,764.9	25,966.4	1.029
Remainder	7	176,607.8	25,229.7	

$F_{.05[7,7]} = 4.99$

Table 22. Comparison of avian population densities and species richness values of parallel levee edge and interior transects. Densities are expressed as the number of birds per 100 acres. Species richness is the number of species present in densities $\geq$0.5 per 100 acres. All values are based on direct counts of 2500-X-50-ft strips. Results of comparisons using the Wilcoxon test (Siegel 1956) are given at bottom. Data for one pair of transects are given as an example.

	Density			Species richness		
	Levee edge KW-02	Interior KW-01	Sign of difference	Levee edge KW-02	Interior KW-01	Sign of difference
Spring 1981	397	248	-	22	20	-
Summer 1981	714	532	-	24	17	-
Fall 1981	895	258	-	28	24	-
Winter 1981-82	830	72	-	14	9	-
Spring 1982	643	595	-	34	34	0
Summer 1982	425	469	+	26	27	+
Fall 1982	1540	379	-	29	22	-
Winter 1982-83	768	155	-	9	12	+

Wilcoxon matched-pairs signed-ranked test statistic = T

Density N = 8

T = 1

0.01<P<0.02

Species richness N = 7

T = 4

Difference not significant

Other transect pairs tested: SE-04, 05; SW-03, 04; SE-11, 12; SW-10, 11; NE-02, 04

Although there was a tendency for greater numbers of species to be detected along levee edges than in the interior of a stand (Tables 20-22), these differences were not as consistent as the differences in density, and in most instances they were not statistically significant.

In order to determine which species contributed most heavily to the high avian densities observed along levee edges, the percent of a species' total density in cottonwood habitats occurring along edge and interior C-S types was calculated. C/CW and C/RO types were combined for this analysis, so that "Edge" densities include C/CW E and C/RO E, and "Interior" include C/CW and C/RO. As in other edge/interior analyses, direct-count estimated densities were used. A species was considered to use edge and interior about equally if percent densities were within nine percentage points of 50% for edge and interior.

In summer, percent use of edges for the 26 most common cottonwood forest bird species averaged 60% (Table 23). Fifteen of the 26 species were more abundant (≥60% density) along levee edges than in interiors of stands, and in six species, >75% of their population density in cottonwood habitats was concentrated along the edges. Of the six species most heavily concentrated along edges, two (Ring-necked Pheasant and Gambel Quail) were ground birds that often foraged along the levee roads and banks as well as in cottonwood stands. The Greater Roadrunner, another ground bird, was nearly as heavily concentrated along the edge (74%) as were pheasants and quail. Two flycatchers (Western Kingbird and Ash-throated Flycatcher), Mountain Chickadee, and European Starling were also among the six species using levee edges most heavily during summer. The latter two species were strongly associated with mature trees, which were most common along levee edges of stands, as discussed in the section on vegetation succession. Six species were more abundant in interiors than along levee edges, and five species used edge and interior about equally.

During winter, use of edges was much more pronounced, averaging 73.8% among 25 species (Table 24). Eighteen of these 25 species were more abundant (percentage-wise) along edges than in interiors, and 15 of the 25 had >75% of their density along levee edges, a much higher proportion than in summer. Prominent among these edge species were winter residents such as Dark-eyed Juncos, White-crowned Sparrows, White-throated Sparrows, and Song Sparrows, as well as Ring-necked Pheasants, European Starlings, Hairy Woodpeckers, and Mourning Doves, all with >90% density along edges. The winter resident sparrows were abundant along both drains and levees as well as along levee edges of cottonwood stands. These species used ground and shrub vegetation layers and tended to be most numerous where shrub cover was dense. Their concentration along edges probably reflects their attraction to drains and dense shrub cover as much as to edge habitat per se. American Robins, which along with Dark-eyed Juncos and White-crowned Sparrows were among the most abundant species in the study area in winter, were also heavily concentrated along levee edges. Only three species, all of relatively low density, used interiors of stands more often than edges during winter, and four used edge and interior about equally.

Table 23. Percent use of levee edge and interior cottonwood stands by forest birds in summer. Data for 1981 and 1982 were averaged. A species was considered to show preference if $\geq$60% of its density was concentrated in edge or interior.

Species	Edge	Interior	Preference
Ring-necked Pheasant	76	24	Edge
Gambel Quail	77	23	Edge
Mourning Dove	59	41	0
Yellow-billed Cuckoo	70	30	Edge
Greater Roadrunner	74	26	Edge
Great Horned Owl	0	100	Interior
Black-chinned Hummingbird	50	50	0
Downy Woodpecker	39	61	Interior
Northern Flicker	72	28	Edge
Western Wood-Pewee	27	73	Interior
Western Kingbird	100	0	Edge
Ash-throated Flycatcher	79	21	Edge
Black-capped Chickadee	45	55	0
Mountain Chickadee	100	0	Edge
White-breasted Nuthatch	58	42	0
American Robin	63	37	Edge
Gray Catbird	40	60	Interior
European Starling	92	8	Edge
Yellow-breasted Chat	26	74	Interior
Black-headed Grosbeak	63	37	Edge
Blue Grosbeak	74	26	Edge
Indigo Bunting	25	75	Interior
Rufous-sided Towhee	60	40	Edge
Brown-headed Cowbird	71	29	Edge
Northern Oriole	71	29	Edge
Lesser Goldfinch	57	43	0
Mean percent use	60.0	40.0	
Number of species $\geq$60%	15	6	

Table 24. Percent use of levee edge and interior cottonwood stands by forest birds in winter. Data for 1981 and 1982 were averaged. Preference was defined as in Table 23.

Species	Edge	Interior	Preference
Ring-necked Pheasant	92	8	Edge
Gambel Quail	59	41	0
Mourning Dove	97	3	Edge
Greater Roadrunner	35	65	Interior
Great Horned Owl	0	100	Interior
Downy Woodpecker	81	19	Edge
Hairy Woodpecker	100	0	Edge
Northern Flicker	86	14	Edge
Black-capped Chickadee	57	43	0
Mountain Chickadee	66	34	Edge
White-breasted Nuthatch	54	46	0
Brown Creeper	37	63	Interior
Bewick Wren	81	19	Edge
Ruby-crowned Kinglet	72	28	Edge
Hermit Thrush	49	51	0
American Robin	82	18	Edge
European Starling	95	5	Edge
Yellow-rumped Warbler	83	17	Edge
Rufous-sided Towhee	74	26	Edge
Song Sparrow	92	8	Edge
White-throated Sparrow	93	7	Edge
White-crowned Sparrow	97	3	Edge
Dark-eyed Junco	92	8	Edge
Pine Siskin	81	19	Edge
American Goldfinch	89	11	Edge
Mean percent use	73.8	26.2	
Number of species $\geq$60%	18	3	

Temperature may also have influenced the use of edges during winter. On cold mornings, bird activity was typically concentrated in sunny locations (V. Hink pers. obs.). East-facing levee edges were among the first places to catch the morning sunlight and warm up, and transects along these edges yielded high densities, especially of the flocking species that contributed so heavily to total avian density in winter.

The bird species concentrating along levee edges thus included the most abundant species in the study area, especially during winter. Among species using edges most heavily were several Greater Roadrunners, Gambel Quail, wintering sparrows, and juncos that appear to have been attracted by features associated with adjacent levee roads and/or drains. Others (European Starlings, Mountain Chickadees, Hairy Woodpeckers, Northern Flickers) were associated with the mature trees that are also concentrated along levee edges of cottonwood stands. A proportion of these species, including the flycatchers and probably Blue Grosbeaks, Northern Orioles, and American Robins, were probably attracted to features of the edge habitat itself. It should be noted, however, that since a substantial number of the species that contribute heavily to the high densities observed along levee edges, especially during winter, were associated with features such as adjacent drains and levees, or mature trees, which are particularly associated with levee edges, these high densities cannot necessarily be directly extrapolated to other types of edge habitat within the study area. The high densities observed along levee edges do nonetheless indicate that this type of habitat is among the most heavily used of avian habitats in the study area, and a large proportion of the bird species using cottonwood habitats, especially in winter, use levee edges of cottonwood stands more often than the interiors of those stands.

Avian Populations in the General Study Area.--Thirty-one transects, representing 16 different C-S types, were censused in the general study area. Seven of these 16 C-S types were sampled in the intensive study area as well as the general study area, and the remaining nine were either unique to the general study area (e.g., C/J, C/RO IV) or occurred in the intensive study area only in patches too small to be censused (SC, C/CW).

Seven of these 16 C-S types were represented by a single transect each, and another eight were represented by only two transects each. SC VI, with its total of eight transects, was the only C-S type represented by more than one or two transects in the general study area. Furthermore, general study area transects were censused only one-third as often as those in the intensive study area, often at irregular intervals during the season. For general study area C-S types other than SC VI, then, seasonal total density and species richness estimates were based on 6 to 12 censuses over the two-year period of the survey, as compared to a minimum of 36 regularly spaced censuses per season (for a two-transect C-S type) in intensive study area C-S types. The general study area data were thus potentially subject to a much greater degree of sampling error than intensive study area data, and should be viewed as approximations.

Total density and species richness. Total avian densities in the general study area were in the same range as those observed in the intensive study area, varying from 9 to over 1,800 birds per 100 acres (Table 25; compare with Table 16). As in the intensive study area, the C-S types yielding total densities in the high end of the range (>500 birds per 100 acres according to direct-count calculations) were all type I edge, type III edge, or type V: C/RO E III, C/CW E I, MS V, RO V. Some type I and IV cottonwood habitats (C/RO I, C/J I, C/J IV), SC E VI, DR VI, and C/CW V were in the middle range with regard to total density, with about 200-450 birds per 100 acres. The non-edge SC C-S types, along with C/RO IV, C/CW I, and C/CW II, were at the low end of the range, generally having densities <200 birds per 100 acres. All the C-S types that were censused in both the general study area and the intensive study area yielded total density values within the same general range (high, intermediate, low) in both subdivisions of the study area (Table 26).

Species richness varied much less among C-S types in the general study area than in the intensive study area, ranging from 1 to a maximum of only 35 (Table 25). Also, C-S types with high total densities did not tend to have greater numbers of species than low-density C-S types in the general study area, as was true in the intensive study area. In the general study area, total density was significantly correlated with species richness only in winter ($r = 0.66$, $P<0.01$).

The lower numbers of censuses of the general study area transects and the small number of transects per C-S type probably both contributed to lower species richness values in the general study area. C-S types represented by a single transect in the general study area all had low species richness values (all <15), whereas those represented by two or more types typically had higher species richness values. For C-S types censused in both the general and the intensive study area, only those types represented by the same number of transects in both areas had similar species richness values for both; otherwise the species richness value was higher where the C-S type was represented by a greater number of transects (Table 26).

Despite the obvious influence of the number of transects per C-S type on species richness, however, it is clear that salt cedar habitats had very low species richness values (Table 25). SC V and SC VI A had lower species richness values than any other C-S type represented by two transects, and SC VI, although represented by eight transects, had fewer species than several of the two-transect C-S types. These data support impressions formed during fieldwork that salt cedar habitats were species poor with regard to birds. Cottonwood/juniper habitats, on the other hand, appeared to yield species richness values comparable to those observed in other cottonwood habitats of similar structure types. Species richness values for C/RO I, C/J I, C/RO IV, and C/J IV (all represented by two transects each) were quite similar all four seasons, with the single exception of C/RO I in summer.

Seasonal fluctuation in total density and species richness. As in the intensive study area, there was little seasonal fluctuation in total density. Total density was somewhat higher in winter than in spring,

Table 25. Comparison of total avian density (Den) and species richness (Sp Rich) in major general study area community-structure (C-S) types based on direct-count calculations. 1981 and 1982 data were averaged. Densities are expressed as the number of birds per 100 acres and species richness is the number of species present in densities ≥0.5 per 100 acres.

	Spring+		Summer		Fall		Winter		
C-S type	Den	Sp Rich	Den	Sp Rich	Den	Sp Rich	Den	Sp Rich	Number of transects
C/RO E III	1250	13	656+	12+	1077	15	677	8	1
MS V (MH)**	838	13	808*	11	558*	8	767*	6	1
C/CW E I	624	20	532	16	699	21	288*	6	2
RO V	117	11	477*	13	1068	13	1820*	12	1
C/RO I	258	19	329+	35+	226*	15	301	12	2
DR V	178	26	176	23	346	23	1601	24	2
SC E VI**	141	8	374*	8	478*	10	995*	8	1
C/J I**	207	15	214	15	250*	14	375	14	2
C/J IV**	255	16	219	15	166	14	284	11	2
C/CW V**	238	14	297	12	188*	9	35	2	1
C/RO IV**	129	12	172*	13	149*	11	235	9	2
SC VI**	68	21	85	19	223*	18	36	8	8
SC V**	33	10	142	11	108	9	155*	7	2
SC VI A**	112	9	120	8	85	7	92	2	2
C/CW I	64	7	159	8	100*	8	15	2	1
C/CW II	111	9	105	7	37	7	9	1	1

+Includes data from only one year.
*Marked difference between 1981 and 1982.
**C-S type censused only in general study area.

Table 26. Comparison of data from general study area (GSA) and intensive study area (ISA) for community-structure types sampled in both areas. Data are from Emlen estimates except as indicated. Densities (Den) are expressed as the number of birds per 100 acres and species richness (SpR) is the number of species present in densities $\geq$0.5 per 100 acres. SpT = Species total.

	C/CW E I		C/RO I		C/CW I		C/CW II	C/CW E II	C/RO E III*		RO V*		DR VI*	
	GSA	ISA	GSA	ISA	GSA	ISA	GSA	ISA	GSA	ISA	GSA	ISA	GSA	ISA
N**	2	5	2	5	1	5	1	1	1	1	1	3	2	18
SPRING														
Den	710	634	431	392	127	205	191	307	1250	445	117	673	178	366
SpR	28	56	35	44	20	46	19	15	13	13	11	49	26	51
SpT	28	63	38	65	20	48	19	15	13	15	11	49	26	77
SUMMER														
Den	409	585	473	392	289	244	229	316	656	349	477	528	176	258
SpR	25	45	32	33	17	35	19	13	12	17	13	42	23	43
SpT	26	54	32	50	19	49	21	13	12	17	14	42	24	61
FALL														
Den	753	890	326	235	134	295	70	697	1077	364	1068	676	346	427
SpR	26	55	22	35	17	43	15	14	15	14	13	46	23	50
SpT	28	62	24	53	20	56	18	14	19	15	14	46	27	72
WINTER														
Den	304	957	348	419	25	147	13	820	677	1411	1820	1133	1601	924
SpR	9	25	17	17	6	20	5	8	8	8	12	29	24	41
SpT	10	31	20	25	8	26	6	8	10	9	13	29	25	50

*Density and species richness from direct-count data.
**N = number of transects.

summer, and fall, except in C/CW (Table 25). Species richness was lower in winter than during the rest of the year in most general study area C-S types, as it was in the intensive study area.

Species composition and habitat associations. Nearly all the bird species that occurred in the intensive study area were also found in one or both parts of the general study area. Patterns of habitat use by both resident and migrant species in the intensive study area also applied to corresponding C-S types in the general study area, and avian use of C/J was comparable to use of C/RO stands of similar structure. Salt cedar C-S types, however, were distinct in terms of avian habitat use and will be discussed separately. Densities for each species by season in each of the C-S types sampled in the general study area are presented in the Supplement to Appendix VII.

A few species of birds were either limited to or largely confined to either the northern or southern portion of the general study area. They included several species that were near the extreme northern or southern limits of their respective geographic ranges, which did not extend into the intensive study area. Another group of species was associated with C-S types (especially SC types) that occurred primarily or exclusively in the general study area.

Cottonwood habitats in the northernmost part of the general study area between Cochiti and Española supported several resident and/or breeding species that did not occur elsewhere in the study area. The Black-billed Magpie (Pica pica), a species whose geographic range centers in Great Basin riparian habitats (Brown 1982), occurred regularly only in cottonwood C-S types in the northern part of the general study area, where it was a common permanent resident. The Plain Titmouse (Parus inornatus), another permanent resident species limited to northern general study area cottonwood habitats, was uncommon to rare. Two species, Bewick Wren and Chipping Sparrow (Spizella passerina), which occurred elsewhere in the study area only as migrants, were common summer residents in these northern cottonwood stands, and Lazuli Buntings bred more commonly there than farther south. The Williamson Sapsucker (Sphyrapicus thyroideus), a rare migrant, was recorded only in this northern area. Finally, the Pinyon Jay (Gymnorhinus cyanocephalus) occurred regularly in the study area only in C/J at Cochiti. This species was the only one to occur in C/J more commonly than in the other cottonwood communities.

Four species that were of regular occurrence farther south were rare in or absent from the northern part of the general study area. Gambel Quail did not occur north of Bernalillo, and Greater Roadrunners were rare north of Bernalillo and did not occur north of Cochiti. Neither Sandhill Cranes (Grus canadensis) nor Whooping Cranes (G. americana) were seen in the northern part of the general study area except passing through during migration.

Species normally limited to the southern part of the general study area included Verdin (Auriparus flaviceps), Phainopepla (Phainopepla nitens), Lucy Warbler (Vermivora luciae), and Chihuahuan Raven (Corvus cryptoleucus), all of which were recorded only occasionally during the survey. Verdins and Phainopeplas occurred mostly in mesquite/desert habitats adjacent to the riparian zone south of Bernardo, but probably used riparian habitats at times. Lucy Warblers recorded in cottonwood stands near Bernardo had been presumed to be migrants, but the discovery of a nest in C/RO habitat near Bosque Bridge in 1983 (W. Howe pers. comm.) indicates that the species is at least occasionally resident in the southern part of the study area. Chihuahuan Ravens are probably at least irregular residents near Bernardo.

The salt cedar C-S types supported a distinct assemblage of summer resident species. Besides the ubiquitous Mourning Dove and the Blue Grosbeak, the most common species in salt cedar in summer were Northern Mockingbird (Mimus polyglottos), Lark Sparrow (Chondestes grammacus), and Western Meadowlark (Sturnella neglecta). In SC VI A, the Black-throated Sparrow (Amphispiza bilineata) was also common and possibly a summer resident. The latter four common salt cedar community species rarely if ever occurred in other riparian habitats. The Blue-gray Gnatcatcher (Polioptila caerulea), which occurred only as a migrant in other communities in the study area, was a rare summer resident in salt cedar habitats. Three pairs of Blue-gray Gnatcatchers bred in salt cedar near the mouth of the Jemez River in 1982. One rare permanent resident species, the Crissal Thrasher (Toxostoma dorsale), was also apparently limited to salt cedar. This species occurred in SC VI both at Bernardo and at the mouth of the Jemez River, but not in any of the intervening non-salt cedar habitats.

In winter, salt cedar C-S types supported much the same avian community as the other forest and woodland C-S types in the study area. White-crowned Sparrows, Dark-eyed Juncos, American Robins, and Northern Flickers were the most common species. The principal difference between salt cedar and non-salt cedar habitats in winter was the greater abundance of Western Meadowlarks in salt cedar.

Raptor/Large Bird Counts.--There were notable differences in the complement of raptor and other large bird species in the study area from season to season (Tables 27, 28, and 29). Since many species of raptors migrate through or winter in the valley, the greatest numbers of raptor species were present during fall and winter, and the smallest numbers in summer, although the total number of raptor detections was greatest in summer due to the abundance of breeding American Kestrels. If American Kestrels are discounted, there were about three times as many raptors in the study area in winter than in summer. The greatest number of detections per 10 miles of all species was observed in winter for most of the census routes and reflected in large part the wintering populations of Sandhill Cranes and Canada Geese in the valley. If crane and goose detections are subtracted from the total detection rate, however, the mean overall winter detection rate is only 17.3 as compared with a mean overall summer rate of 24.9. Thus, for groups other than raptors and cranes, higher numbers of birds were present in summer than in winter.

There were clearly differences among the census routes, and these differences tended to be consistent across various bird groups (Tables 27 and 28). Census routes having relatively high numbers of raptors per

Table 27. Comparison of raptor/large bird census routes during the summer season (June through August). Data are detection rates per 10 miles and represent the average of 1981 and 1982 data. Values for the column labeled "All routes" were derived by dividing the total number of birds detected on all transects by the total length of all transects combined.

Species	Census routes 1	2	5	6	7	8	9	All routes
DETECTION RATES								
Raptors (excl. kestrel)	0.9		0.3	1.7	0.7	1.5	1.0	0.9
American Kestrel	7.9	7.6	7.2	7.8	8.1	15.1	10.8	9.6
Herons and egrets	0.4	0.1	2.1	2.0	5.7	2.9	7.1	3.1
Ducks, geese, and coot	0.5	0.3	8.5	1.3	6.6	4.5	5.4	3.8
Shorebirds and ibis	0.5	0.7	2.2	1.7	0.5	0.4	0.4	0.8
Ring-necked Pheasant	0.4	0.1	0.6	0.9		0.1	0.6	0.4
Greater Roadrunner	2.8	4.9	2.7	6.4	6.0	7.2	7.3	5.6
Belted Kingfisher	2.4	0.2	0.3	0.7	0.5	0.2	0.1	0.6
Miscellaneous (incl. grebes, cormorants, gulls, rails)		0.1	0.1				0.5	0.1
Total detection rate	15.8	14.2	24.0	22.6	28.1	31.9	33.2	24.9
NUMBER OF SPECIES								
Raptors (incl. kestrel)	4	1	3	4	5	8	6	10
Herons and egrets	1	1	3	3	4	5	5	6
Ducks, geese, and coot	2	1	3	2	2	2	2	5
Shorebirds	3	2	1	2	3	1	2	3
Miscellaneous species	3	4	4	3	3	4	4	6
Total number of species	13	9	14	14	17	20	19	30
Length of transect (mi)	7.8	8.9	4.3	8.3	12.4	11.3	8.4	61.4

Table 28. Comparison of raptor/large bird census routes during the winter season (December through February). Data are detection rates per 10 miles and represent the average of 1981-1982 and 1982-1983 data. Values for the column labeled "All routes" were derived by dividing the total number of birds detected on all transects by the total length of all transects combined.

	Census routes							
Species	1	2	5	6	7	8	9	All routes
DETECTION RATES								
Raptors (excl. kestrel)	2.2	1.8	4.8	4.4	3.8	4.7	7.3	4.1
American Kestrel	0.8	1.2	1.8	2.2	2.0	4.9	2.9	2.4
Herons and egrets	0.1		0.3	0.2	0.2	0.4	1.1	0.3
Ducks, geese, and coot	9.4	6.1	12.0	3.9	9.6	212.4	9.6	45.6
Cranes		18.3	44.1	130.8	13.0	1068.0	928.2	349.5
Shorebirds and ibis		0.2		0.1	0.0	0.3	0.3	0.1
Ring-necked Pheasant			0.3	0.2	0.1	0.2	0.1	0.1
Greater Roadrunner	0.8	1.2	2.1	3.1	2.4	4.3	2.8	2.5
Belted Kingfisher	0.5	0.2	0.4	0.3	0.9	0.3	1.7	0.6
Miscellaneous (incl. grebes, cormorants, gulls, rails)	0.2						0.3	0.1
Total detection rate	14.0	29.0	65.6	145.3	32.1	1295.0	954.4	405.6
NUMBER OF SPECIES								
Raptors (incl. kestrel)	5	6	5	6	6	7	6	10
Herons and egrets	1		1	1	1	1	1	1
Ducks, geese, and coot	5	4	5	2	3	6	4	14
Cranes		1	1	1	1	2	2	2
Shorebirds		1		1	1	1	1	1
Miscellaneous species	3	2	3	3	3	6	4	7
Total number of species	14	14	15	14	15	23	18	35
Length of transect (mi)	7.8	8.9	4.3	8.3	12.4	11.3	8.4	61.4

Table 29. Detection rates of raptors and large birds each season, expressed as the number of birds seen per 10 miles. Data from 1981 and 1982 were averaged. P = present in densities ≤0.1 per 10 miles.

Species	Spring	Summer	Fall	Winter
Pied-billed Grebe	0.1	P	0.1	0.1
Double-crested Cormorant				P
Olivaceous Cormorant				P
Great Blue Heron	0.3	0.1	0.7	0.2
Great Egret		P		
Snowy Egret	0.4	1.0	0.2	
Little Blue Heron		P		
Green-backed Heron	0.3	1.6	0.3	
Black-crowned Night-Heron	0.2	0.5	P	
White-faced Ibis	0.6		0.2	
White-fronted Goose				0.1
Snow Goose				0.2
Canada Goose			0.3	41.5
Wood Duck	0.1	P	P	P
Green-winged Teal	0.3	P	0.5	0.2
Mallard	10.3	3.6	1.0	2.7
Northern Pintail	0.1			
Blue-winged Teal	0.1		P	
Cinnamon Teal	0.4	0.2	P	0.2
Northern Shoveler	P			P
Gadwall	P	P		P
American Wigeon	0.4			0.7
Canvasback				0.2
Lesser Scaup	P			
Common Goldeneye				P
Bufflehead	P			
Common Merganser	0.2			
Ruddy Duck				P
Turkey Vulture	0.2	0.2	0.6	P
Osprey	P			
Mississippi Kite	P	0.3	P	
Bald Eagle				P
Northern Harrier	0.1	P	0.3	0.3
Sharp-shinned Hawk	0.1		0.2	0.2
Cooper Hawk	0.2	0.2	0.2	0.2
Northern Goshawk	P			P
Broad-winged Hawk	P	P		
Swainson Hawk	0.1	0.1	P	
Red-tailed Hawk	1.1	0.1	1.8	3.2
Ferruginous Hawk	0.1		0.1	0.1
Rough-legged Hawk			P	
American Kestrel	7.8	9.6	4.3	2.4
Prairie Falcon	P	P		P
Ring-necked Pheasant	0.8	0.4	0.4	0.1
Virginia Rail	P			

Table 29. (cont.)

Species	Spring	Summer	Fall	Winter
American Coot	P		P	P
Sandhill Crane	27.4		71.0	349.5
Whooping Crane			P	0.1
Killdeer	0.4	0.7	2.0	0.1
American Avocet			P	
Greater Yellowlegs	0.1			
Lesser Yellowlegs	0.1		P	
Solitary Sandpiper		P	P	
Spotted Sandpiper	0.1	0.1	0.1	
Long-billed Curlew	0.1			
Long-billed Dowitcher	0.1			
Franklin Gull	0.1			
Ring-billed Gull	1.8	0.1		P
Greater Roadrunner	4.3	5.6	2.6	2.5
Western Screech-Owl	P			
Great Horned Owl	P	0.1	P	
Belted Kingfisher	0.4	0.6	0.6	0.6
Total detection rate	59.3	24.9	87.9	405.6
Total number of species	47	29	34	35

10 miles also tended to have high numbers of herons, ducks, and other species. The number of species was generally greatest on census routes with the greatest detection rates per 10 miles, and neither appear to be functions of census route length.

During both summer and winter, census route 8 produced the greatest number of detections per 10 miles for raptors, kestrels, and roadrunners and had the greatest or the maximum number of species in all categories. Route 8 also produced the highest detection rates of cranes in winter. A large flock of cranes (from 2,000 to 3,000 birds) was observed regularly in agricultural fields near Edeal Dairy in Los Lunas. Route 8 was among the longest of the census routes (11.3 mi), which may have contributed to its high species richness. That length alone is not sufficient to account for the high totals is attested to by the fact that census route 7, with relatively lower values, was slightly longer than route 8. Routes 7 and 8 were roughly parallel to each other, on opposite sides of the river channel.

The greatest detection rates for raptors and for herons and egrets were recorded on census route 9, the southernmost route (Fig. 14). Despite its 8.4-mi length, it had a relatively high species total, ranking second among the seven routes. Ducks were particularly common along census route 5, which was close to Isleta Marsh. Belted Kingfishers were seen most often along route 1, in the Corrales area.

The lowest values in nearly every category were obtained on census route 2. This route, located within the city of Albuquerque, goes through areas of relatively dense residential development for most of its length. By contrast, census routes 9 and 5 were probably the least affected by residential development of the seven routes. It is evident that the numbers of raptors and large birds increase in a general way with distance from Albuquerque, the major urban center.

Sixty-two species were detected altogether along these census routes (Table 29). Fifteen of these species were raptors, most of which occurred in low numbers. Red-tailed Hawks and American Kestrels were the only species detected more often than once per 10 miles. Six species, Northern Harriers (*Circus cyaneus*), Sharp-shinned Hawks (*Accipiter striatus*), Red-tailed Hawks, Ferruginous Hawks (*Buteo regalis*), Rough-legged Hawks (*B. lagopus*), and Bald Eagles (*Haliaeetus leucocephalus*), occurred primarily in fall and winter, whereas five species, Turkey Vultures (*Cathartes aura*), Ospreys (*Pandion haliaetus*), Mississippi Kites (*Ictinia mississippiensis*), American Kestrels, and Prairie Falcons (*Falco mexicanus*) were present during summer. Cooper Hawks (*Accipiter cooperii*) were detected about equally often during all four seasons. The remaining raptor species occurred in the valley during migration, sometimes being recorded between June and August as late spring or early fall migrants.

Sandhill Cranes began to arrive in the valley during October. Large flocks were observed daily from November through February at the Edeal Dairy and, particularly during the latter part of the winter, at the Belen State Game Refuge. One or two Whooping Cranes were observed regularly in these flocks.

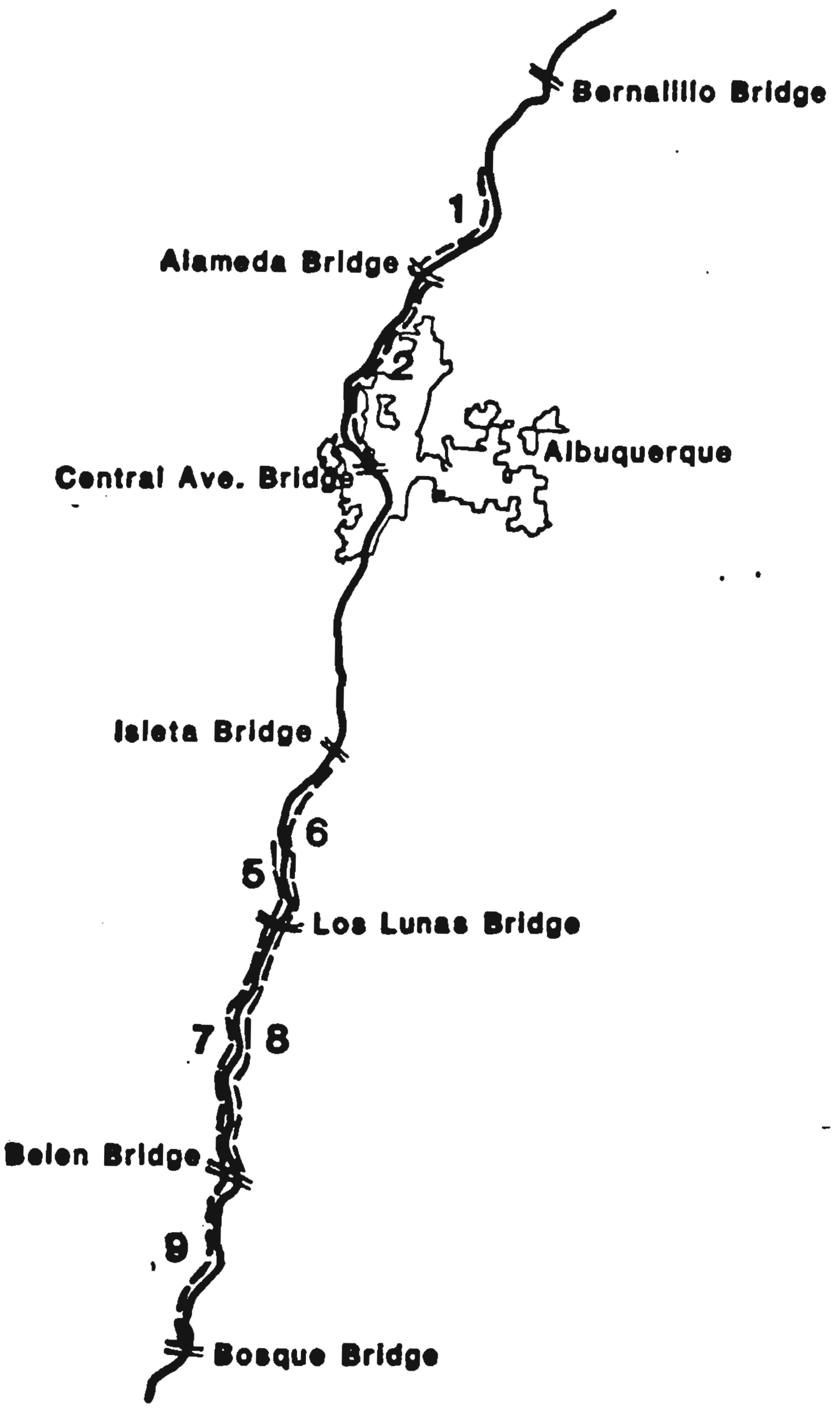

Figure 14. Location of raptor/large bird census routes. Double lines are bridges, dashed lines are census routes. All census routes terminate at bridges.

Fifteen species of ducks were detected along the census routes. The numbers of ducks in the valley were low most of the year but began to increase during winter, and the highest numbers were observed during the spring season. The most abundant species were Mallards, Green-winged Teal, Blue-winged Teal, Cinnamon Teal, and American Wigeons. Only Mallards, Cinnamon Teal, and possibly Blue-winged Teal bred in the valley. The three species of geese using the valley were recorded only during winter, and only the Canada Goose was detected regularly. Groups of Canada Geese joined the large flocks of Sandhill Cranes at the Edeal Dairy and on the Belen State Game Refuge.

Of the eight species of shorebirds detected, six occurred only during migration. Killdeer were present throughout the year, and Spotted Sandpipers were summer residents. Six species of herons and egrets were detected on census routes. Of these six, only Great Blue Herons were normally present during winter. Snowy Egrets, Black-crowned Night-Herons, and Green-backed Herons were most numerous during summer and bred in the study area. Great Egrets (Casmerodius albus) and Little Blue Herons (Egretta caerulea) were of rare occurrence. Flocks of White-faced Ibis (Plegadis chihi) were observed during spring and fall migration.

American Coots, Pied-billed Grebes, and Belted Kingfishers were present throughout the year along drains. Ring-necked Pheasants and Greater Roadrunners, commonly seen on levee roads, were also present year round.

Seasonal summaries of detection rates by species for each of the seven census routes are included in Appendix VII.

Endangered Vertebrate Species

We recorded seven species of birds and one species of mammal that are currently listed as endangered in New Mexico (New Mexico Department of Game and Fish 1983), and one additional bird species that was listed as endangered in New Mexico during the time the survey was conducted (Hubbard et al. 1979, New Mexico Department of Game and Fish 1981-82). Three of the bird species (indicated below by double asterisks) are also on the Federal Endangered Species List (Federal Register 1984).

Olivaceous Cormorants (Phalacrocorax olivaceus) are probably regular visitors to the study area. They were sighted at Madrone Ponds and also were seen flying upriver as far north as the confluence of the Jemez River with the Rio Grande, in both 1981 and 1982. This species is known to breed as far north as Elephant Butte Lake on the Rio Grande (Hubbard 1978), but we found no evidence of breeding within the study area.

Mississippi Kites were seen regularly during summer in the vicinity of Los Lunas and less often at Belen, perching in large cottonwood trees or snags in open areas outside the bosque. They were sighted elsewhere occasionally in flight. They have been known to breed in the valley (Hubbard 1978). In June 1981, we observed two adults that appeared to be paired, and some immature birds were seen in the area both years, suggesting that this species may have bred there one or both years. However, we did not obtain any direct evidence of nesting.

Bald Eagles** regularly winter at Cochiti Lake and White Rock Canyon (Johnson 1979, 1980, 1981, 1982). We observed groups of up to 5 on the lake, and occasionally sighted single birds perched in cottonwoods near the river's edge below the dam. Bald Eagles were seen irregularly elsewhere in the study area, although one bird apparently spent a month along a relatively undisturbed section of the river just south of Bernalillo in late winter 1982. There was one summer sighting: an adult bird was seen in the cottonwood bosque at Cochiti, in June 1982.

Peregrine Falcons** (Falco peregrinus) migrated through the study area in spring and fall in low numbers. They were seen three times in the study area.

One or two Whooping Cranes** were seen regularly between late October and February with large flocks of Sandhill Cranes feeding in agricultural fields adjacent to the study area. They were seen primarily at the Edeal Dairy near Los Lunas and, especially in late winter, at the Belen State Game Refuge.

A Bell Vireo (Vireo bellii) was recorded once in the study area at Albuquerque. This is apparently the first record of this species in the valley north of Socorro.

One or two McCown Longspurs (Calcarius mccownii) were tentatively identified by call in a flock of Chestnut-collared Longspurs (Calcarius ornatus) flying over the river.

The woodland jumping mouse was added to the New Mexico state list of endangered species and subspecies in July 1983. We captured six individuals of this endemic subspecies in the vicinity of Isleta Marsh. All were captured during the months of June through August. Collection sites included wet meadow, cattail marsh, Russian olive, and coyote willow stands, and the edge of a mature cottonwood/Russian olive stand adjoining a drain. All collection sites were moist and well-vegetated. Failure to locate populations in other parts of the study area, despite extensive trapping, suggests that the woodland jumping mouse may be limited to the Isleta Marsh area.

The Red-headed Woodpecker was listed as endangered in New Mexico during the two years of the study. Red-headed Woodpeckers were rarely encountered during the survey. There were single sightings at Isleta Marsh and at a burn site near Belen, and a group of three were seen at Bernalillo, all in summer 1981. None was found the second year. Although the species has been known to breed in this part of the Rio Grande Valley (Cole 1978, Hubbard 1978), we obtained no evidence of breeding activity during the study. The Red-headed Woodpecker was removed from the New Mexico state list of endangered species as of July 1983.

A complete list of sightings of endangered species, including dates, localities, and number of individuals, is given in Appendix VIII.

Effects of Dredging on Vertebrate Populations

We examined the effects of dredging on vegetation lining drains and on small mammal populations, avian populations, and sightings of the large aquatic mammals, beaver and muskrat. Transect data were used to make comparisons between recently dredged and undredged drains.

Dredging of drains constituted a marked but relatively short-term disturbance of the vegetation lining drains. Drag lines scraped plants and soil from the bottom and sides of the drain and deposited the spoil along the banks, on top of other vegetation. Approximately 0.25 mi of drain could be dredged per day, so direct physical disturbance was short-term.

Recovery of vegetation to pre-dredging condition was fairly rapid. Following early spring dredging in March-April 1981, grasses, annual plants, and fast-growing shrubs, especially coyote willow, quickly covered the newly exposed soil. By August there was little difference between recently dredged and undredged type VI drains in total foliage density between 0 and 15 ft (1.215 and 1.157, respectively). The direct effects of disturbance of the vegetation were therefore short-lived. However, the three type V drains, which had apparently not been disturbed by dredging for several years longer than any of the type VI drains, supported much more vegetation than those that were subject to regular dredging (approximately once every 2 years). The average total foliage density of type V drains (between 0 and 15 ft) was 1.566, substantially greater than in DR VI. Hence, type VI drains, which included the majority of drains in the study area, were continually maintained in an early stage of vegetation succession that was reestablished quickly following disturbance. In the type V drains, vegetation had developed to a later successional stage in the >5-year interval since the last dredging operations had been completed.

Comparison of recently dredged and undredged type VI drains therefore reflects short-term response to disturbance, i.e., the "undredged" type VI drains were really "less recently dredged," having been undisturbed for only a year or so longer than those classified as "recently dredged." Comparison of type V (DR V) and VI (DR VI) drains gives a longer-term perspective, since the type V drains had not been disturbed for at least five years prior to the study.

Small Mammals

There were no significant differences between recently dredged and "undredged" type VI drains in total capture rate of small mammals, or in capture rates of particular species of small mammals. However, a G-test indicated that the overall proportions of white-footed mice and western harvest mice differed significantly between recently dredged and undredged type VI drains ($G = 6.41$, $P<0.05$). There was a ratio of two white-footed mice to three western harvest mice in undredged type VI drains, while in the recently dredged type VI drains the ratio was two to one, suggesting that white-footed mice may increase following habitat disturbance. There were few house mice along either recently dredged or undredged type VI drains.

There were significant differences in small mammal populations between DR V and DR VI in all but one parameter--the capture rate of the western harvest mouse. DR V had a much higher total capture rate than DR VI ($P<0.01$) and higher mean capture rates for both the white-footed and house mouse. Moreover, the relative proportions of white-footed and house mice in DR V and DR VI were quite different ($G= 24.11$, $P<0.001$). There was a great excess of white-footed mice over house mice in DR VI (approximately 8:1), whereas there were fewer white-footed mice than house mice in DR V (approximately 1:2). Again, this indicates that the white-footed mouse tends to be numerous in the more recently disturbed drains, while the house mouse does not appear to be as disturbance-tolerant in these situations. An analagous situation was reported by Gehlbach (1981), concerning pre- and post-flood trapping in the lower Rio Grande riparian habitats at Santa Ana National Wildlife Refuge. Whereas white-footed and house mice were the two most abundant small mammal species prior to a hurricane and flood in 1971, greater numbers of white-footed mice but no house mice were captured at the same sites after the flood. Gehlbach (1981) suggests that house mice were unable to withstand flooding, whereas native species apparently had adapted to this periodic natural disturbance.

Aquatic Mammals

Dredging appeared to have a negative impact on aquatic mammals, especially beavers. Only one of the 38 beavers sighted during the survey was sighted in a recently dredged section of drain. Of the 108 muskrats sighted, only 10 were sighted in sections of drain that had undergone dredging within the previous 10 months. The impact of dredging on beavers in particular was suggested even more strongly by the comparison of the number of sightings of aquatic mammals in DR V and DR VI. Nineteen of the 38 beavers sighted were in type V drains, despite the rarity of this type among the drain transects. (There were 18 type VI drains sampled versus only three type V drains.) By contrast, 15 of the 108 muskrats sighted were in DR V, a ratio more proportional to the availability of the two types of drains. Dredging presumably disrupted the burrows of beavers and muskrats as well as diminished their food source.

Birds

To assess the impact of dredging on avian populations, comparisons were made between avian populations along (1) recently dredged and undredged type VI drains (DR VI) and (2) DR V and DR VI. Two-way analysis of variance (Sokal and Rohlf 1969) was employed to test for effects of dredging and seasons on total bird density. There were no significant differences in total bird density among recently dredged DR VI and "undredged" DR VI or among seasons. There was no significant difference between DR V and DR VI in total bird density, but there were significant differences among seasons in total bird density ($P<0.007$), and there was significant interaction between drain type and season ($P<0.005$), i.e., the degree of difference among seasons was greater in DR V than in DR VI. In general, however, we conclude that dredging has a relatively small effect on total bird density along drains. This is not unexpected because dredging does not heavily disturb the woody vegetation that lines the drains, and most of the bird species occurring along drains are primarily forest species. Because of the rapid recovery of low-level vegetation along drains, even the species using ground vegetation probably suffer displacement for a relatively short period of time, less than a season.

Effects of Recreational Use on Vertebrate Populations

Five transects subject to heavy recreational and other types of human use because of their location near residential areas of Albuquerque were selected for assessing the impact of human activity on wildlife populations. The area in which these transects were located was used heavily by people jogging, cutting wood, picnicking, walking their dogs, birdwatching, bicycling, dirt biking, or driving cars or trucks through the bosque. There were also several dump sites within the area. The area was about 3 mi from downtown Albuquerque, and there was high-density residential development immediately adjacent to the bosque on both sides of the river along this section. Data on small mammal populations and avian populations from these transects were compared with data from transects of similar vegetation (i.e., of the same C-S types) located in more rural areas to evaluate the impact of human activity.

Small Mammals

There were no significant differences in small mammal populations between transects subject to heavy human use and those in less-used areas, in either C/RO I or C/CW IV. Capture rates, species richness, and species composition of small mammals were similar for transects within a C-S type, regardless of the observed level of human use in the transect area.

Birds

Two-way analysis of variance (Sokal and Rohlf 1969) was used to compare avian densities on transects in heavily used areas with those in less-used areas, testing for the effects of human impact and seasons on total bird densities. There were no significant differences in total avian density between the heavily used transects and the less-used transects in C/CW IV or DR VI, but there was a significant difference in C/RO I. The less-used C/RO I transect (KW-04) had significantly higher total bird density than the one near downtown Albuquerque ($P<0.04$), suggesting that human impact may diminish bird use of an area in some situations. However, as this was true for only one of the three pairs of transects tested, this data is at best suggestive.

No part of the valley today is or has been wholly protected from human impact. On a local scale, the chief impact of human use of an area is probably alteration of the habitat by burning, extensive woodcutting, clearing of undergrowth, or mowing and dredging of drains, such that the alteration would change the vegetation composition and/or structure (that is, the C-S type) of the area. Since all of the above comparisons were made within C-S types, they did not address this type of impact. The animal/habitat relationships discussed in previous sections indicate that areas of dense vegetation support more small mammals and birds than those with little vegetation. Therefore, any human impact which reduces the amount of vegetation in an area should be expected to reduce the small mammal and avian populations of the area (see Figs. 3, 5 and Tables 13 and 16).

Vertebrate Use of Habitat in Jetty Fields

A total of eight transects in the intensive study area intersected one or more lines of jetty jacks (see Table 1). These transects represent five different C-S types: C/RO I (2 transects), C/CW I (1 transect), C/CW E III (1 transect), C/CW IV (2 transects), and C/CW V (2 transects). Inspection of the 1962 aerial photographs of the study area indicated that jetty fields in the type I and type IV stands were established within existing forest habitat, whereas those in what are presently type III and type V stands appear to have been established across areas that were then largely unvegetated (USDI Bureau of Reclamation 1962).

There were no apparent differences between vertebrate use values for transects crossing fields of jetty jacks and transects of the same C-S types that did not intersect jetty fields. The wildlife use values for C/CW E III and C/CW V habitats in Tables 10, 13, and 16 thus apply to these stands that developed as a result of vegetation succession on areas stabilized by jetty fields. Avian and small mammal use of C/CW E III and C/CW V stands was relatively high, indicating that vegetation succession initiated by jetty fields has contributed to the development of some areas of valuable wildlife habitat.

Artificial Pond

As an experimental mitigation measure, the Corps of Engineers constructed a small pond by excavating sub-water table borrow pits. The pond is located on the west side of the Rio Grande about one mile north of Los Lunas. The purposes of constructing the pond were to evaluate the potential for creating new pond and/or marsh habitat within the riparian corridor and to assess the potential effects on local wildlife populations. Sampling of vegetation and wildlife populations at the pond site was conducted during the nine months immediately preceding construction (April through December 1981) to establish baseline data and then through the first year following construction to monitor vegetation succession and corresponding changes in use of the site by amphibians, reptiles, small mammals, and birds. This section discusses the results of the before- and after-construction sampling, and the potential benefit to wildlife of creating more such ponds within the study area.

Before Construction

Vegetation.--Prior to construction, the site of the future artificial pond supported vegetation comparable to that of the sparser C/CW V communities, such as NW-06 or SW-16. Much of the site was covered by a 5-10 ft growth of coyote willow, with lesser amounts of salt cedar and seepwillow. Shrub growth was relatively sparse toward the levee side of the site, and became quite dense closer to the river. A mixture of grass and annual plants formed a sparse-to-moderate ground vegetation layer in more open areas and beneath shrubs, and several young (20-30 ft) cottonwood trees were scattered throughout the site. Vegetation characteristics of SW-07, the transect running through the centerline of the future pond and SW-06, the transect adjacent to the pond, are summarized and compared with data from other C/CW V areas in Table 30.

Vertebrates.--Small mammal, amphibian, and reptile populations at the pond site were sampled prior to construction along the first two intervals of SW-06, about 200 ft north of the future pond's centerline. Birds were censused in a plot centered on SW-07, the transect line following the centerline of the pond.

Amphibians and reptiles. Pitfall trapping in the vicinity of the future pond before construction yielded few captures. Only two specimens were taken in seven months of sampling, one eastern fence lizard and one Great Plains toad, yielding a total capture rate of 0.19 per 100 trap days. This was one of the lowest capture rates observed at any site sampled. While it was among the lowest observed capture rates, it was consistent with the fact that type V habitats in general yielded few herptile captures (See Table 10).

Small mammals. The capture rate of small mammals at the pond site before construction was also very low. The two trap grids yielded only two captures each, and a total of only two species. Two white-footed mice were captured in the first grid and one white-footed mouse and one western harvest mouse were caught in the second grid. While this species composition is typical for C/CW V habitat, the mean capture rate of 2 per 270 trap nights was low for C/CW V (see Table 13).

Birds. Avian censusing at the pond site during the nine months prior to construction of the pond yielded a total list of 44 bird species known to have used the site during that period. Eight of them were permanent resident species, 24 were seasonal (summer or winter) residents, and the remaining 13 were migrants. Estimated total densities for the pond site during spring, summer, and fall 1981 were 591, 257, and 328 birds per 100 acres, respectively, yielding an average of 392 per 100 acres over the entire preconstruction period. The two groups of species contributing most heavily to density totals in spring and summer were small and medium-sized insectivores: 444 of 591 in spring and 181 of 257 in summer. During fall, granivores became more abundant (152 of 328, versus 131 of 328 for insectivores). Ring-necked Pheasants were seen in the area regularly (mean density = 12) and Mourning Doves were common there (mean density = 53).

Construction of the Pond

Pond construction began in early January 1982. During construction all shrub vegetation was cleared from a total area of about 2 acres (roughly twice the area of the future pond) as a result of bulldozer activity. The 10 or so small cottonwood trees on the site were preserved. The pond was excavated by a bulldozer down to the water table, about 3 ft below the soil surface, and then a dragline was used to excavate soil

Table 30. Vegetation characteristics of the artificial pond site (SW-07) prior to construction of the pond. Data for the first two intervals of SW-06 and for an "average" C/CW V habitat are given for comparison.

	Tree and shrub density (/acre)			Percent cover+	
	SW-07	SW-06	C/CW V*	SW-07	C/CW V**
Tree layer (>10 ft)					
Cottonwood	29	21	33		19
Salt cedar	8	49	73		1
Total >10 ft	37	70	131	<5	20
Shrub layer (<10 ft)					
Cottonwood	60	11	10	12	7
Coyote willow	1594	1090	1121	26	43
Salt cedar	161	374	198	7	5
Seepwillow	390	337	72	9	4
Miscellaneous	0	6	17	13	10
Total <10 ft	2205	1818	1422	67	69

Foliage density profiles

	6 in	2 ft	5 ft	10 ft	15 ft	20 ft	25 ft	30 ft	40 ft	Total
SW-07	0.30	0.28	0.27	0.07	0.09	0.06	0.04	0.03	0.002	1.15
SW-06	0.39	0.47	0.41	0.06	0.04	0.03	0.03	0.02	0.003	1.44
C/CW V***	0.42	0.30	0.35	0.19	0.13	0.09	0.07	0.05	0.040	1.62

*From Table 6.
**From Table 7.
***From data used in Figure 5.
+Percent cover was not estimated for SW-06.

about another 5 ft below the mean water table, to create a permanent pond. One bank of the pond was steeply graded (1:3) while the other sloped gradually (1:12) to provide a shallow water area for cattails and other emergent vegetation (Fig. 15). Most of the excavated soil was hauled away but some was used to construct a low berm encircling the pond. The soil was leveled but not smoothed, so that the rough soil surface could trap seeds. Construction was completed by 1 March 1982, leaving a pond 0.75 acres in size, with a fluctuating water level, surrounded by a cleared, open, sandy area encompassing approximately another 1.25 acres.

Bird censusing was continued throughout the construction period. Although the censuses were carried out in early morning when there was no heavy equipment in use, few birds were observed in the area during this period. The resulting species richness and density values for winter were quite low: only 10 species were recorded altogether during the winter 1981-82 season, and estimated density was 66 birds per 100 acres. The average density in C/CW V (as estimated by direct count) that winter was 386, and 11 species were seen per transect, on the average. It appears that construction activities and/or vegetation clearing markedly diminished avian density at the pond site, but did not reduce the number of species using the area. Human (and dog) traffic at the site, on the other hand, increased sharply as construction progressed.

After Construction

Vegetation.--The pond site remained bare of ground vegetation until spring. Around mid-April, herbaceous plants, primarily cocklebur (*Xanthium strumarium*), colonized the sandier parts of the site, while coyote willow, cottonwood, and seepwillow began to sprout through vegetative reproduction from plants damaged and/or buried during construction. By June, a number of additional species, including salt grass, sweet clover, annual sunflower (*Helianthus annuus*), and yellow nutgrass (*Cyperus esculentus*) had appeared, and most of the cleared area had been colonized by some type of vegetation. There was rapid growth, especially of coyote willow and sweet clover, during summer, and by late August both the excavated area and the surrounding berm supported a moderate to dense growth of vegetation, averaging between 1 and 2 ft in height. The chronology of vegetation establishment at the pond site is summarized in Table 31. A list of all plant species found at the site during 1981 in given in Table 32.

By the time foliage development had reached its maximum for the season the shallow south slope of the pond supported the densest vegetation growth, largely sweet clover, with sunflowers and goldenrod appearing along the top of the berm. Cocklebur also grew on both the south slope and the berm, but was much less dense there than sweet clover. The north, west and east sides, where the pond sloped steeply, were higher and drier than the south slope; most of the area adjacent to the pond on these three sides was about as high as the berm (Fig. 15). In these drier portions of the site, cocklebur was the most common plant. There was also a ring of plants all around the pond just at and above the water line, composed primarily of cottonwood and salt cedar seedlings, with some yellow nutgrass and coyote willow.

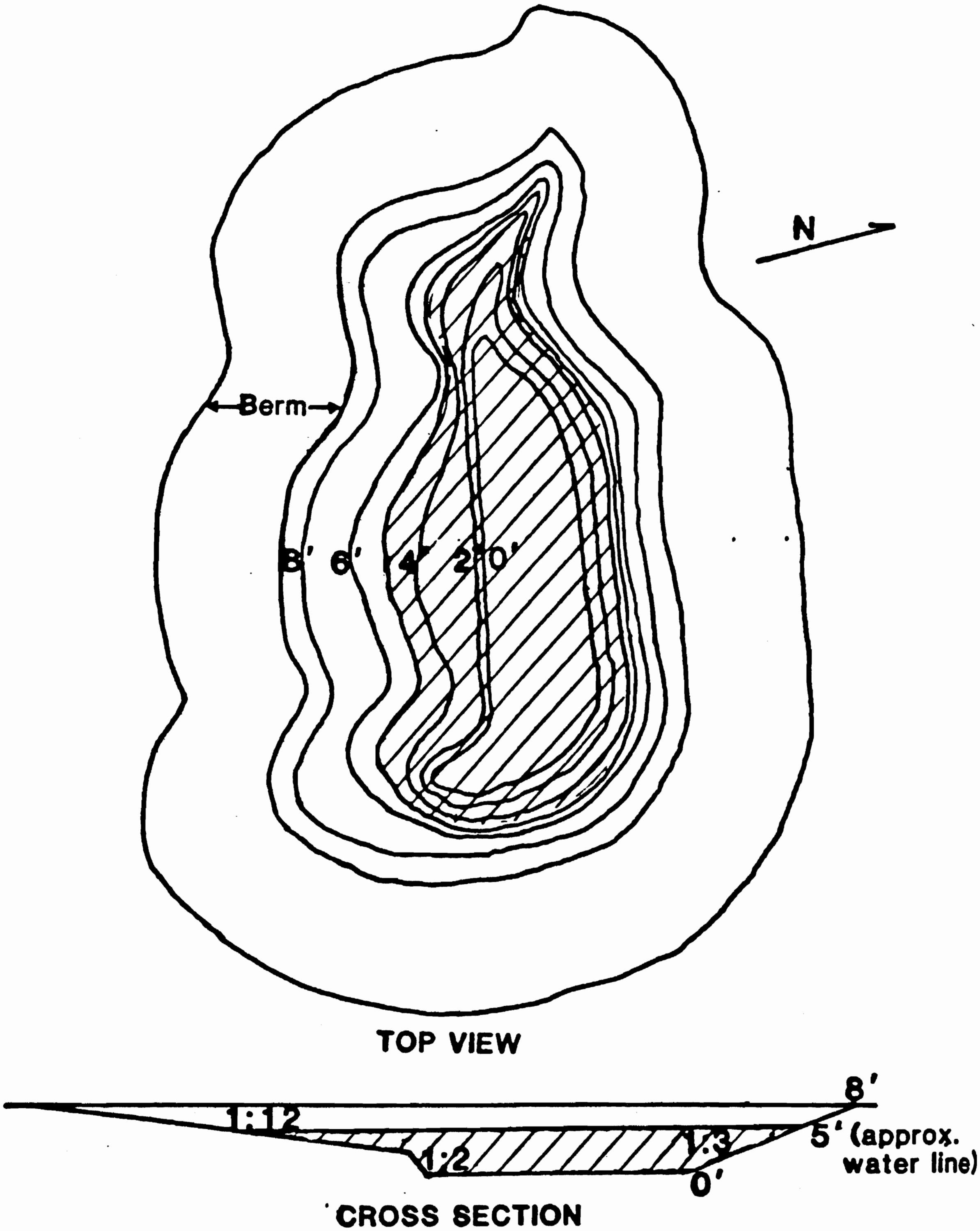

Figure 15. Design plan of the artificial pond. Shaded area indicates approximate area of open water. Dimensions (excluding berm): length = 275 ft; width = 140 ft; maximum depth = 8 ft.

Table 31. Chronology of vegetation development at artificial pond site during 1981, the first year after construction of the pond.

January	Construction began on 4 January. Bulldozer cleared site and dug to water table. Dragline excavated pond below water table.
February	Dragline excavation completed on 5 February. Fill was hauled off, then bulldozer leveled site and built berm. Patches of algae 10-15 in in diameter appeared on pond surface by 10 February.
March	Construction activities completed by 1 March. Green algal blooms appeared on sunny days, died and sank to bottom on cloudy days.
April	Algal bloom cycle continued through the month. First green sprouts appeared by 3 April: cocklebur (<u>Xanthium</u> spp.), coyote willow (<u>Salix exigua</u>), and cottonwood (<u>Populus fremontii</u>). Cocklebur was abundant everywhere by 17 April, 1-2 in high. Coyote willow reached 10 in by mid-month. Cottonwood sprouts grew to 4 in by mid-April. Seepwillow (<u>Baccharis salicina</u>) appeared at pond edge by 23 April.
May	Filamentous algae was noted on 1 May. Algal mat present in northeast corner from 9-22 May. Saltgrass (<u>Distichlis spicata</u>) colonizing south (shallow) slope by mid-month. Coyote willow reached 2 ft by 15 May, 3 ft by end of month. Cocklebur spread and grew, reaching 6 in by end of May; most common plant species were on the site by end of May.
June	A small algal mat formed slowly through 18 June in the northeast corner, then died off in a few days. Numerous floating mats appeared during the last week of the month, quickly covering most of the pond. Yellow sweet clover (<u>Melilotus officinalis</u>) appeared on south slope the first week, grew to 1 ft by 18 June, 2 ft by last week. Yellow nutgrass (<u>Cyperus esculentus</u>) at pond edge by mid-month. Sunflower (<u>Helianthus annuus</u>) growing on berm and south slope. Saltgrass 5 in high on south slope by end of first week, dense by 20 June. Cocklebur reached 1.5 ft by 13 June, up to 2 ft by 18 June. Coyote willow 3.5 ft by 18 June. Cottonwood seeds appeared on pond surface during first week, nearly covered pond by 13 June; seedlings growing along pond edge by 18 June, numerous by 20 June.

Table 31. (cont.)

July	Large algal mat persisted through the first week, then died back, leaving a small mat in northeast corner. Soil Conservation Service drill-seeded eight species of grass along the pond's south slope on 12 July. Broadleafed aquatic plants visible on bottom of pond. One cattail (*Typha latifolia*?), 4 in high, appeared on 8 July; was eaten by 11 July. Two more appeared on 18 July and remained through the month. Sweet clover 3 ft tall by 17 July, 4 ft tall by 23 July; most abundant on south slope below berm. Nutgrass very abundant by mid-month appearing along water's edge as well as around pond; grew to 6 in by mid-month. Sunflowers up to 5 ft tall by end of month, concentrated on berm and south slope. Cocklebur 2.5 ft high by end of month, growing on berm and flat areas around pond. Coyote willow 6 ft tall at end of month, mostly at east end of pond. Cottonwood seeds covered pond through first week; 6 to 12-in-wide band of seedlings above waterline, 2 in high by end of month.
August	Algae increased following rains and rise in pond water level, covering 1/4 to 1/3 of surface all month. Algae also thriving beneath surface and on bottom of pond, sometimes forming "ropes" from bottom to top. Broadleafed aquatic plants on pond bottom: 6 in in diameter, 2 in high. Salt cedar (*Tamarix chinensis*) seedlings appearing in a band around waterline, mixed with the band of cottonwood seedlings; reached 4 in by month's end. Cattails reached 4 in by 5 August, 7 in by end of month. Sweet clover continued growing through August, reaching a maximum height of 6 ft; majority were still <2 ft. Sunflowers reached 7 ft and bloomed. Cottonwood seedlings continued to grow; were 6 in high at end of month. Remainder of plants did not grow or increase noticeably during August.
September	Algae in scattered patches or clusters on and below surface throughout the month; less than in August. Salt cedars coming up on north side of pond, seedlings persisting in band at water's edge. Some of the cottonwood seedlings began to die off in early September. Cattails continued to survive in the northeast corner. Many of the annual plants began to dry out by the end of the month; grasshoppers defoliated many, especially sweet clover.

Table 31. (cont.)

October	Algal patches persisted through the middle of the month, then began to die off slowly. Cattail reached 12 in by middle of month. Sedge around pond reached 2 ft. Cocklebur, sunflowers, and grasses (except saltgrass) died off by the second week, sweet clover by the last week. Coyote willows, cottonwoods, salt cedars dropped leaves during the last two weeks.
November	Algae was gone from pond surface by 10 November; gone from deeper waters by 21 November. Broadleafed aquatic plants in 3 in of water along north and east banks - still green. Saltgrass still green.
December	Salt grass remained green through December.

Table 32. Plant species found at the artificial pond site during 1981, the first year after construction of the pond.

CYPERACEAE	
Cyperus esculentus L.	Yellow nutgrass
GRAMINEAE	
Cenchrus insertus M. A. Curtis (*C. pauciflorus*)	Field sandbur
Distichlis spicata (L.) Greene (*D. stricta*)	Desert saltgrass
Echinochloa crusgalli (L.) Beauv.	Barnyard grass
Eragrostis cilianensis (All.) Link	Stinkgrass
Panicum capillare L.	Panicum
Polypogon monspeliensis (L.) Desf.	Rabbitfoot grass
TYPHACEAE	
Typha sp. (probably *latifolia* L.)	Cattail
NAJADACEAE	
Potamogeton pectinatus L.	Sago pondweed
CHENOPODIACEAE	
Cycloloma atriplicifolium (Spreng.) Coult.	Winged pigweed
Kochia scoparia (L.) Schrad.	Summer cyress belvedere
TAMARICACEAE	
Tamarix chinensis Louriero	Salt cedar
SALICACEAE	
Populus fremontii Wats.	Cottonwood
Salix exigua Nutt.	Coyote willow
LEGUMINOSAE	
Melilotus albus Desr. ex. Lam.	White sweet clover
M. indicus (L.) All.	Alfalfilla
M. officinalis (L.) Lam.	Yellow sweet clover
EUPHORBIACEAE	
Euphorbia serpyllifolia Pers.	Spurge
HALORAGACEAE	
Myriophyllum spicatum L.	Water milfoil
VERBENACEAE	
Verbena bracteata Lay. & Rodr.	Prostrate vervain
OROBANCHACEAE	
Orobanche ludoviciana Nutt.	Broom rape

Table 32. (cont.)

COMPOSITAE	
Ambrosia psilostachya DC.	Ragweed
Baccharis salicina Torr. & Gray	Baccharis
Grindelia aphanactis Rydb.	Gumweed
Helianthus annuus L.	Common sunflower
Solidago occidentalis (Nutt.) Torr. & Gray	Western goldenrod
Xanthium strumarium L.	Common cocklebur

In mid-August, five line intercepts were established along the south slope of the pond to estimate percent vegetation cover by species. The results are presented in Table 33. The mean cover value was 58.6% for vegetation <2 ft. Sweet clover was the overwhelmingly dominant species, accounting for 85% of total vegetation cover. Cottonwood, which was mostly confined to the band of seedlings at the water line, and common sunflower each contributed about 5%, and the remainder was represented by 15 additional species. Most of the vegetation was less than 2 ft high. Total cover >2 ft was only 4.65%, and was almost entirely composed of sweet clover and annual sunflowers.

In early July, the Soil Conservation Service seeded eight species of grasses in a series of narrow strips along the south side of the pond. Intercepts 4 and 5 were located within seeded strips. While germination of the seeded grasses was poor, and neither of the intercepts picked up any of the species that had been planted, total percent cover was notably greater on intercepts 4 and 5 than on 1, 2, and 3. There was also more cover >2 ft. This difference in vegetation density in the two areas (which was easily noticeable) was attributable to the greater density of sweet clover in the seeded areas. It appears that the process of seeding, which was done mechanically, enhanced the growth of sweet clover in these areas.

Other than percent cover estimation, vegetation measurements taken in 1981 could not be repeated after construction because the previous sample points fell within the limits of the pond. It was obvious that as a result of clearing, foliage volume and tree density initially dropped almost to zero, and had only begun to recover by the end of summer. The vegetation in the area surrounding the pond had changed from C/CW V to sparse OP VI dominated by low, herbaceous vegetation.

Vertebrates.--The chronology of vertebrate use at the pond site from the time of construction through January 1983 is summarized in Table 34.

Amphibians and reptiles. The results of pitfall trapping at the pond site during the year following construction of the pond were strikingly different from the results of preconstruction sampling. Whereas before construction (in 1981) only two lizards had been captured during an entire season of trapping, after construction the pond site yielded one of the highest amphibian and reptile capture rates observed during the study (Table 35 and Table 10).

Six different species were captured at the pond site during 1982 (compared to only two species in 1981 before construction), and most of the species were captured several to many times. Five of these six species had not been found there prior to pond construction. Three of the new species, tiger salamander, bullfrog, and Woodhouse toad, all of which were probably attracted to the area by the pond, bred in the pond water in 1982. The latter two species produced large numbers of tadpoles and young. The other two species new to the site were New Mexican whiptail and Chihuahuan whiptail, both of which occurred in greatest abundance in open, sandy habitats within the study area. The whiptails were presumably attracted to the site because of the newly cleared area around the pond's perimeter. This cleared area probably

Table 33. Percent vegetation cover on five line intercepts at the artificial pond site, August 1981. Most of the vegetation was <2 ft in height.

	Line intercepts					
Vegetation species	1	2	3	4*	5*	Mean
Bare ground	43.25	50.07	50.85	37.30	25.38	41.37
Melilotus spp.	48.11	49.37	38.64	59.10	54.50	49.94
Populus fremontii	3.61	2.67	4.60	2.14	1.40	2.88
Helianthus annuus	2.41	5.46	2.40	0.72	2.57	2.71
Panicum capillare	0.46	1.50	4.77	1.15	0.45	1.67
Solidago occidentalis	1.36	1.01	2.40	0.72	2.57	1.61
Salix exigua	3.03	2.25	0.16	2.01	0.09	1.51
Xanthium strumarium		2.56		1.28	1.44	1.06
Tamarix chinensis	0.77	0.67	0.95	0.64	0.40	0.69
Echinochloa crusgalli		0.48	3.36		0.09	0.79
Distichlis spicata	1.12	1.88	0.08			0.62
Unknown forb (basal leaves)		0.52		0.94		0.29
Kochia scoparia	0.70	0.07	0.20	0.08		0.21
Ambrosia psilostachya	0.62	0.37	0.08			0.21
Eragrostis cilianensis			0.41	0.55		0.19
Cycloloma atriplicifolia		0.94				0.19
Cyperus esculentus	0.03	0.03	0.08	0.64	0.04	0.16
Grindelia aphanactis		0.22				0.04
Polypogon monspeliensis				0.08		0.02
Total percent cover (<2 ft)	56.75	49.93	49.15	62.70	74.62	58.63
Total percent cover (>2 ft)	0.38	0	4.89	7.75	10.23	4.65
Intercept lengths (meters)	25.71	26.55	24.09	23.35	22.18	

*Indicates intercepts crossing areas seeded with grasses (other than above species) by the Soil Conservation Service in July 1981.

Table 34. Chronology of vertebrate use of the artificial pond site during the first year after construction. Only first records are noted for birds. No vertebrates other than bird species present prior to construction were seen before April.

April	10	Mallards and teal (probably Cinnamon Teal) have begun to visit pond regularly.
	23	First Killdeer recorded along pond edge.
	24	Adult Woodhouse toad (*Bufo woodhousei*).
May	1	Numerous Woodhouse (?) toad eggs in pond. Mosquitofish (*Gambusia affinis*) visible in water (artificially stocked).
	6	Thousands of tadpoles in pond, and three new clusters of toad eggs.
	8	Ten Woodhouse toads mating in pond.
	11	First Spotted Sandpiper at pond edge.
	15	Ruddy Duck and American Coot in pond.
	16	Gartersnake (probably *Thamnophis sirtalis*). Turtle (probably *Chrysemys picta*).
	21	Big brown bat (*Eptesicus fuscus*) foraging over pond. Covey of Gambel Quail.
June	5	Tracks of Great Blue Heron at pond edge.
	6	Three gartersnakes. Painted turtle.
	13	Raccoon (*Procyon lotor*) tracks at pond edge. Desert cottontail (*Sylvilagus audubonii*) tracks in clover. Painted turtle 8 in in diameter now seen regularly.
	16	Toad tadpoles have developed legs, and are resorbing tails. Three gartersnakes were killed; another live one sighted.
	20	Young toads beginning to emerge from pond. Three more gartersnakes. Cottontail tracks are numerous, seen regularly.
	28	Two adult bullfrogs (*Rana catesbeiana*) seen in pond. Mosquitofish becoming numerous.
July	2	Green-backed Heron at pond edge.
	14	Toad tadpoles nearly all metamorphosed; many small toads on banks of pond.
	17	Snowy Egret tracks. Duck (Mallard?) tracks.
	18	Bullfrogs calling -- at least three present.
	23	Two tiger salamander (*Ambystoma tigrinum*) larvae, 3 in long. Common Nighthawks and Cliff Swallows foraging over pond regularly.
	30	Bullfrog tadpoles appeared in pond. Possible Wood Duck.

Table 34. (cont.)

August	5	Bullfrog tadpoles 1-1.3 in; more numerous.
	9	One leopard frog (<u>Rana pipiens</u>) seen in pond.
	13	Salamander larvae have rear legs.
	26	Belted Kingfisher first noted (feeding on mosquitofish).
	29	Bullfrog tadpoles 3-4 in.
September	1	Salamander larvae 7 in long.
		Bullfrog tadpoles 4 in long, developing rear legs.
		Large gartersnake.
	19	Bullfrog tadpoles have front and rear legs, losing tails.
		Second cohort of bullfrog tadpoles (approx. 500) on pond bottom.
	30	Two adult bullfrogs shot with .22-caliber rifle.
		Painted turtle(s) still present.
October	3	Young bullfrogs emerging from pond.
	11	Pairs Ring-necked Ducks on pond.
	17	Solitary Sandpiper (feeding on mosquitofish).
		Pond again full of young bullfrogs (second cohort).
	28	Four Green-winged Teal.
November	19	Dead Sharp-shinned Hawk found shot, floating in pond.
	21	Common Merganser.
December	5	A few small bullfrogs still active.
		Canvasback duck.
January	6	Dead leopard frog salvaged from bottom of pond, along with several dead bullfrogs -- cause of death unknown.

Table 35. Capture rates of amphibians and reptiles and of small mammals in the vicinity of the artificial pond (SW-07) before and after construction of the pond. Before-construction data are from the first interval of SW-06, about 200 ft north of the pond site and vegetationally very similar to it. P = present but not captured in pitfall traps.

	Before construction (SW-06)	After construction (SW-07)
Reptiles and amphibians		
Tiger salamander	0.0	0.20
Leopard frog	-	P
Woodhouse toad	0.0	1.30
Great Plains toad	0.11	0.0
Bullfrog	0.0	0.95
Painted turtle	-	P
Eastern fence lizard	0.11	0.07
New Mexican whiptail	0.0	0.14
Chihuahuan whiptail	0.0	0.07
Total number per 100 trap days	0.22	2.73
Number of species	2	6
Number of trap days	1075	1466
Small mammals		
White-footed mouse	1.5	1.0
Western harvest mouse	0.5	0.0
Total number per 270 trap nights	2.0	1.0
Number of species	2	1
Number of trap nights	540	540

also enhanced the sites' attractiveness to Woodhouse toads. Eastern fence lizards, present both before and after pond construction, were also associated with open habitats.

In addition to those captured in pitfall traps, two more species were sighted at the pond in 1982, the painted turtle and the leopard frog. Both of these species were undoubtedly attracted to the area by the new pond. The first painted turtle was spotted in the pond in May, and a total of at least four was known to have been present there in summer (M. Sifuentes, pers. comm.). Although they suffered harassment from shooting (and one was killed by a rifle shot), painted turtles apparently persisted through the first year. The single leopard frog was first seen in early August but survived only until winter. It was found dead of unknown causes in early January 1983 (Applegarth 1983, M. Sifuentes, pers. comm.). As discussed by Applegarth (1983) and earlier in this report, there is concern about the status of both the painted turtle and the leopard frog in the Middle Rio Grande Valley at present. It is notable that the new pond apparently provided acceptable habitat for both of these species and that they were able to colonize it so quickly.

Small mammals. The capture rate of small mammals at the pond site in 1982 was even lower than that observed on the preconstruction sample site. Only two mice were captured altogether on the two grids set out along the pond's perimeter. This yielded a very low mean capture rate of 1 per 270 trap nights, half as great as the preconstruction capture rate (Table 35). Both the captured specimens were white-footed mice; the western harvest mouse, which had been captured there during preconstruction sampling, was not found. Because of the low small mammal capture rates observed in other open habitats throughout the study area, the small number of captures at the pond site in 1982 was not surprising. The number of small mammals at the site will probably increase if the amount of vegetation cover, especially of shrubs and grasses, continues to increase.

Birds. There was a net decrease in the estimated population density of birds at the pond site during the first year after construction, as well as marked changes in the relative abundances of many species. However, the total number of species recorded there during censusing in 1982 was the same as the total recorded during censusing in 1981: 44 species. When casual sightings of birds (i.e., species seen at the pond but not recorded during censuses) are included, the species totals for 1981 and 1982 are 48 and 58, respectively, yielding a net increase in the number of bird species using the site after the pond was built. It must be noted, however, that since the site was rarely visited except during censusing during 1981, there were fewer opportunities to add to the species list through casual observation. The difference in species totals is therefore probably biased in favor of the postconstruction period, when the site was visited more often.

Total avian population densities and species richness as estimated by censusing in 1981 (before) and in 1982 (after) construction are summarized by season in Table 36. For both spring and summer seasons, estimated density and species richness were markedly greater at the site

Table 36. Estimated densities of birds at the artificial pond site before and after construction. All densities are expressed as the number of birds per 100 acres. P = seen at pond site, but not during censusing.

	Before construction 1981			During constr.	After construction 1982–(1983)				Change (excl. DJF)
	AM	JJA	SON	DJF	MAM	JJA	SON	DJ	
Great Blue Heron						P	P		+
Green-backed Heron						P			+
Green-winged Teal							P		+
Mallard					15			15	+
Blue-winged Teal						5			+
Cinnamon Teal					P				+
Canvasback								4	+
Ring-necked Duck							P		+
Ruddy Duck					P				+
Sharp-shinned Hawk			P				P		0
Ring-necked Pheasant	33		2	2	5	5			-
Gambel Quail			P			P			0
American Coot					P				+
Killdeer					7	2		8	+
Solitary Sandpiper							P		+
Spotted Sandpiper					5	2			+
Mourning Dove	55	51			29	5			-
Yellow-billed Cuckoo			2			P			-
Greater Roadrunner						2			+
Black-chinned Hummingbird		17	2		7	10			-
Calliope Hummingbird		2							-
Broad-tailed Hummingbird			2						-
Rufous Hummingbird			2						-
Belted Kingfisher							7	4	+
Downy Woodpecker		2		2				4	-
Northern Flicker	11	2	22	5	5	2	15	22	-
Western Wood-Pewee					2				+
Dusky Flycatcher (prob.)						2			+
Ash-throated Flycatcher	4								-
Violet-green Swallow		P				P			0
Barn Swallow	11								-
American Crow			P			P			0
Black-capped Chickadee						2	5		+
Mountain Chickadee							2	11	+
White-breasted Nuthatch							2	8	+
Brown Creeper								4	0
Bewick Wren			17	7			5	22	-
House Wren	4								-
Ruby-crowned Kinglet			22	5				4	-
Blue-gray Gnatcatcher			2		7				+

Table 36. (cont.)

	Before construction			During constr.	After construction				Change (excl. DJF)
	1981				1982-(1983)				
	AM	JJA	SON	DJF	MAM	JJA	SON	DJ	
Hermit Thrush				2					-
American Robin	22		10		5		5	4	-
European Starling	33	7							-
Warbling Vireo						2			+
Orange-crowned Warbler	11		7						-
Virginia Warbler	11	32	10			5	2		-
Yellow Warbler	8								-
Yellow-rumped Warbler	15		19				2		-
MacGillivray Warbler	8	2	2				7		-
Common Yellowthroat	22	10			2	P			-
Wilson Warbler	15	5	5				10		-
Yellow-breasted Chat	8	10			2	2			-
Western Tanager	11		7		2				-
Black-headed Grosbeak	77	34	2		22	10			-
Blue Grosbeak	4	24	7			12	12		-
Lazuli Bunting	8								-
Indigo Bunting	8	7				10			-
Green-tailed Towhee			7				2		-
Rufous-sided Towhee	11	7	14	10	5	2	12	19	-
Chipping Sparrow	22						2		-
Song Sparrow			15	12	2		5	11	-
White-crowned Sparrow	22		10	2			39	15	+
Dark-eyed Junco			38	19			126	174	+
Red-winged Blackbird	109	2				P			-
Western Meadowlark	11								-
Brown-headed Cowbird	33	39			2				-
Northern Oriole	4	2			2				-
Pine Siskin			2				56	18	+
Lesser Goldfinch	22	2					10		-
American Goldfinch			102				2	26	-
Total Density*	591	257	328	66	126	80	328	373	-
Species Richness*	29	19	25	10	18	17	21	18	-
Number of species increasing or introduced in 1982 (according to census data)*									16
Total number of species increasing or introduced in 1982 (incl. casual sightings, P)									25
Number of species decreasing or not returning in 1982 after construction*									39

*only birds recorded during censusing are included in totals.

in 1981, before construction of the pond. For fall, estimated density was the same both years, but, as in spring and summer seasons, species richness was greater in 1981, before construction. "Before and after" values may not be similarly compared for winter, because construction activities were in progress during January and February 1982, that is, for the greater part of the season. The much lower density and species richness observed during that winter relative to the following one suggest that construction activities had a negative effect on bird use of the area. This inference is supported by the fact that in the study area in general, bird densities were much higher during winter 1981-82 (when construction took place) than during winter 1982-83. If construction activities had not affected bird use of the area, one would expect the 1981-82 winter densities at the site to have been greater than the 1982-83 winter densities, reflecting the pattern observed in the study area as a whole.

A comparison of the estimated densities of each bird species at the site before and after construction of the pond yields insight into changes in avian-use patterns related to the changes in habitat (see Table 36). The pond attracted a new group of water-associated species to the area, including Great Blue Heron, Green-backed Heron, American Coot, Killdeer, Spotted Sandpiper, Belted Kingfisher, and seven species of ducks. The herons and Belted Kingfisher fed on the mosquito fish, and perhaps the tadpoles and young frogs that were abundant in the pond, and shorebirds foraged along the shallow south bank. Ducks usually visited the pond in evening, perhaps feeding there on aquatic vegetation or seeds. White-crowned Sparrows and Dark-eyed Juncos were present in higher numbers during the fall and winter after the pond was built. These species were presumably attracted by the large seed crop produced by herbaceous plants that colonized the site after shrubby vegetation had been cleared. Increased use of the site by these two flocking species largely accounts for the relatively high avian use values observed during fall and winter 1982.

Use of the site by small- and medium-sized insectivores, which accounted for the bulk of the avian density in spring and summer 1981, dropped sharply in 1982 after the pond was built. Among the species most affected were summer residents (Common Yellowthroats, Yellow-breasted Chats, Black-headed and Blue grosbeaks, and Brown-headed Cowbirds), migrants (Orange-crowned Warblers, Virginia Warblers, Yellow-rumped Warblers, Wilson Warblers, and Western Tanagers), and a winter resident (Ruby-crowned Kinglet). These species generally occurred in areas with well-developed shrub-layer vegetation, including the C/CW V habitat at the site in 1981, and the clearing of shrubs from the site was probably the reason for their decreased use of the area in 1982. There was little change in use of the site by hummingbirds, which was low except for one species, the Black-chinned Hummingbird. There was also little change in densities of flycatchers and bark-foraging species, which were also low both years.

Overall, 16 to 25 species either increased in density or were first recorded at the site in 1982 after the pond was built, 14 of which were presumably attracted by the pond itself, and at least two of which were probably drawn by the annuals growing in the cleared area. A total of

39 species either decreased in density or were not recorded again in 1982. Many of these were insectivores that favored areas of greater vegetation cover. As conditions change over the next few years, and in particular if/when cottonwood and willow vegetation becomes re-established on the site, use of the area by insectivorous birds is likely to increase again.

Value of the pond to wildlife.--While construction of the pond and the associated clearing of woody vegetation from the site had a negative impact on populations of small mammals and many bird species, the pond created habitat for a number of other species of birds, amphibians and reptiles. Several of the species colonizing the pond, including leopard frogs, painted turtles, and Blue-winged Teal in summer, were rare or of limited distribution in the study area.

The negative impacts observed were primarily associated with the clearing of vegetation from the site and with increased use of the area by humans. If woody vegetation with species composition similar to that formerly present, i.e., not salt cedar, becomes re-established in the cleared areas, the negative impacts of pond construction should be temporary. On the other hand, the introduction of aquatic habitat and the species it attracts should constitute a long-term benefit, especially if marsh habitat develops in association with the pond. Considering that aquatic habitat (other than drains) and marshes are rare in the valley and have been decreasing steadily over at least the past 50 years, while there is a relatively large amount of bosque and shrub habitat remaining (see Table 8), the construction of a number of ponds and/or marshes would probably be of net benefit to the wildlife community in the valley as a whole. Development of cattail marsh would probably enhance the value of these areas. However, this is predicated on the assumption that salt cedar does not invade these areas, that woody vegetation becomes re-established around ponds, and that the negative impacts of human use of these areas can be controlled.

Wildlife Use of Small Interior Openings and Edges

Sampling of wildlife populations in existing small openings within the riparian forest and along the forest edges surrounding those openings was undertaken to complement the study of the experimental artificial pond site, as well as to evaluate the relative wildlife use of the different types of established openings and adjacent forest edges, compared to stands of unbroken cottonwood forest.

Openings of various types were sampled at seven different sites within the intensive study area. Each site encompassed one to four openings, for a total of 14 openings altogether (Table 4). The openings ranged in size from 0.8 to 10.5 acres and were classified into four types: OP V, dry openings with shrubby vegetation similar to C/CW V; OP VI, dry openings with grassy/herbaceous vegetation, comparable to C/CW VI; WET OP V, small patches of cattail marsh habitat; and WET OP VI, ponds. All the openings had been in existence for over five years and all were surrounded on at least three sides by intermediate or mature cottonwood forest. At each of the seven sample sites, the opening(s) (OP), adjacent forest edge(s) (EG), and a comparison, or control, transect (CT), in nearby unbroken cottonwood forest were sampled and evaluated separately.

Because of the relatively small size and low number of available sample sites, estimates of wildlife populations in small openings and along adjacent edges are particularly subject to sampling error. The small size of most of the openings was a particular problem. Because of the danger of trapping out populations and/or drawing in animals that were actually using adjacent habitats, small mammals could be trapped only infrequently, and in the larger openings, resulting in small sample sizes. The area available for avian censusing at most sites was also suboptimal, as avian density estimates based on censusing of short strips (≤1,800 ft) are strongly subject to random fluctuations (Engel-Wilson et al. 1981). Furthermore, since the openings we sampled varied in both size and character, it is difficult to draw generalizations. For these reasons caution must be exercised in interpreting density and species richness estimates. This applies especially in making comparisons between estimated avian density and species richness values for small openings and edges and analogous values for the much more intensively sampled major C-S types.

Amphibians and Reptiles

Amphibians and reptiles were sampled by pitfall trapping for one season (1982) in the largest dry OP V site (OP-08), and for six months in 1982 at the artificial pond site (SW-07), which included dry OP VI and WET OP VI areas. Since pitfall trapping in small openings was almost as intensive as in the major C-S types, data from the C/CW I and C/RO I pitfall trap grids (each sampled for two seasons) were used to provide values for unbroken cottonwood forest (CT). For reasons discussed previously, amphibians and reptiles were not sampled along edges.

The artificial pond site data were subdivided into capture rates for the dry, sandy opening surrounding the pond (dry OP VI) and for the pond itself (WET OP VI), to ascribe probable use values to both wet and dry openings (Table 37). The values listed under WET OP VI represent species that probably would not have been present at the site if the pond had not been there, including breeding tiger salamanders and bullfrogs, neither of which were found away from water. Woodhouse toads also bred in the pond, and large numbers of emerging toadlets contributed substantially to the high capture rate for that species at the pond site. The capture rate for Woodhouse toad was tentatively divided between the wet and dry parts of the site based on the average capture rate of that species in the other dry, sandy habitats in the intensive study area (C/CW IV, C/CW VI A, SB VI), which was 0.30.

WET OP VI yielded the highest total capture rate for herptiles (primarily amphibians) and the greatest number of species, among the types of sites sampled. There was little difference among dry OP V, OP VI, and unbroken cottonwood forest in total capture rate or in the types of species captured. All three yielded total capture rates much lower than WET OP VI and many fewer amphibians, but they supported larger numbers of lizards. Comparison of data for OP V and OP VI with data

Table 37. Capture rates of amphibians and reptiles in small openings (OP) and in unbroken cottonwood forest (CT). Capture rates are expressed as the number of individuals captured per 100 trap days. *The WET OP VI column represents animals that probably would not have been present if the pond had not been present. P = present but not captured in traps. See Tables 10 and 11, and Fig. 9, for comparison with other C-S types.

Species	Dry OP V (OP-08)	Dry OP VI (artificial pond site)	WET OP VI* (artificial pond site)	CT (C/CW I, SW-08)	CT (C/RO I, KW-04, SE-04)
Tiger salamander			0.20		
Woodhouse toad		0.30	(1.00?)	0.02	
		1.30			
Chorus frog	0.28				0.01
Leopard frog			P		
Bullfrog			0.95		
Painted turtle			P		
Eastern fence lizard		0.07		1.08	0.14
Great Plains skink	0.06			0.05	
New Mexican whiptail	0.23	0.14			
Chihuahuan whiptail	___	0.07	___	0.26	0.03
Total capture rate	0.57	0.58	2.15*	1.40	0.18
		2.73		$\bar{x}$ = 0.79	
Number of species	3	4	5	4	3
		8		$\bar{x}$ = 3.5	
Number of trap days	1758	1466		4666	6688

from the major C-S types they most closely resemble (C/CW V and C/CW VI A, respectively) reveals that the small openings yielded capture rates and species similar to those observed in larger stands of comparable vegetation types (Table 10).

These data suggest that amphibian and reptile populations in small dry openings of type V or type VI do not differ appreciably from those in unbroken forest stands. The addition of a pond to such an opening, however, may substantially increase the use of the site by amphibians, attracting additional species to the area by providing breeding habitat for them.

Small Mammals

Small mammals were sampled in both types of dry openings, OP V and OP VI, at a marshy WET OP V site, along dry and wet edges, EG and WET EG, and at comparison sites in cottonwood forest, CT. The highest capture rates were found in the two wet habitats (Table 38). Small marshy openings (WET OP V) yielded the highest capture rate, among the highest observed in the study area, and edges along wet openings (WET EG) yielded the second highest capture rate and the greatest number of species. The dry openings (OP V and OP VI) both had capture rates in the intermediate range, with cottonwood forest (CT) slightly lower, and the lowest capture rates, surprisingly, were observed along dry edges (EG). The small sample size for EG, only two grids, and the higher capture rates observed in C/CW E I and C/RO E I (Table 13) cast doubt on the reliability of this low estimated capture rate for EG, however.

The white-footed mouse was the most common species in all the types. The western harvest mouse occurred in all but one type but was proportionately more common in dry areas than in wet areas. The house mouse occurred primarily in the two wet habitats, where it was the second most common species. The rarely captured deer mouse and Norway rat were taken only in WET EG (but this type was sampled more often than most).

Total capture rates for the small openings and edges other than dry EG were similar to those observed in larger stands of comparable vegetation (Table 13). The species composition of WET OP V differed from that of larger cattail marshes (MH V), however, in that the house mouse was the most abundant species in the latter.

The data on small mammals in interior openings and associated edges indicate that there is little difference in population density or species composition between dry openings and unbroken forest. Marshy openings and the forest edges adjacent to ponds and marshes appear to support substantially higher densities of small mammals than do dry openings, dry edges, or forest.

Birds

Avian populations were sampled at all seven sites three times per month for a period of one year, from October 1981 to October 1982. Estimates of avian density and species richness were obtained for all four types

Table 38. Capture rates of small mammals in small openings (OP), along edges of small openings (EG), and in adjacent unbroken cottonwood forest (CT). Capture rates are expressed as the number of individuals captured per 270 trap nights (i.e., per trap grid). See Tables 13 and 14 and Fig. 10 for comparison with other C-S types.

Species	Dry OP V (OP-04, OP-08)	Dry OP VI (artificial pond site, OP-19)	WET OP V (OP-02)	Dry EG (EG-04, EG-08)	WET EG (EG-02, EG-17, EG-20)	CT (CT-01, CT-08, CT-19, CT-20)
Western harvest mouse	0.2	2.0	2.0		1.4	0.1
Deer mouse					0.1	0.1
White-footed mouse	4.3	4.0	16.7	2.0	10.4	3.7
Norway rat					0.1	
House mouse	0.2		4.3		1.9	
Total capture rate	4.7	6.0	23.0	2.0	13.8	3.9
Number of species	3	2	3	1	5	3
Number of trap grids	6	4	3	2	8	11

of small openings (OP V, OP VI, WET OP V, WET OP VI), dry EG and WET EG, and for comparison forest stands (CT). Densities for each species in each of these habitat types by season are presented in the Supplement to Appendix VII. Density and species richness data are presented separately for each of the seven OP/EG/CT sample sites each season in Table 39, and combined by type in Table 40. Although the areas sampled were sometimes less than an acre in size, densities were expressed as the number of birds per 100 acres as for other direct-count data on small habitat patches, as discussed in Methods. Because avian species richness is closely related to the size of the area sampled, species richness values of different sample sites, which varied in size, are not directly comparable. Species richness comparisons are meaningful only within a sample site, where EG and CT sample areas were matched.

The seven sites sampled over four seasons yield 28 comparisons of relative density on OP, EG, and CT transects within a sample site (Table 39). The one consistent pattern to emerge from these comparisons was that, in almost every case, the greatest densities were observed along EG transects. In 26 of the 28 cases, the estimated density for EG was greater than the density for both OP and CT at the same site, and in no case was EG density the smallest of the three. There were no consistent relationships between relative densities of OP and CT, either for the 28 cases taken together or within any of the subdivisions by type. In 14 of the cases, OP>CT, and in the other 14, OP<CT, and within OP V, OP VI, WET OP V, and WET OP VI, OP transects yielded greater densities than CT in 3/8, 2/4, 4/8, and 5/8 cases, respectively.

Species richness was greater for EG transects than CT in 26 of 28 cases. Species richness values for EG transects also tended to be greater than for adjacent openings (23 of 28 cases), even though the openings covered a greater area than the EG sample strips.

The relative use of different types of OP and EG areas varied from season to season (Table 40). WET OP V yielded the highest avian density values during spring and summer, WET OP VI and dry OP VI had the highest values in fall, and dry OP VI yielded by far the highest avian densities for winter. These seasonal differences in use of different types of openings are related to the types of birds that are most abundant in the respective seasons. In spring and summer, large numbers of insectivores and marsh birds, including Red-winged Blackbirds, and a variety of ducks, herons, egrets, and swallows contributed to the high densities in WET OP V and other marshy habitats. Large flocks of wintering Dark-eyed Juncos and White-crowned Sparrows, along with American Robins and European Starlings, used the dry, open OP VI areas in fall and winter, and wintering ducks, concentrated on ponds, produced the high densities in WET OP VI.

There was less difference between estimated avian densities along wet versus dry edges than between densities in wet and dry openings. The slight differences that did exist paralleled patterns of use of wet and dry openings for three of the four seasons, suggesting that avian use of openings and adjacent edges is not independent. However, no overall trend toward greater avian use of wet versus dry areas was evident, for either edges or openings.

Table 39. Comparison of total avian density and species richness estimates for each small opening/edge/interior comparison (OP/EG/CT) site. Densities are expressed as the number of birds per 100 acres, and species richness is the number present in densities >0.5 per 100 acres. The number of intervals per transect is given in parentheses.

	Spring			Summer			Fall			Winter		
Opening	OP	EG	CT	OP	EG	CT	OP	EG	CT	OP	EG	CT
Dry OP V												
OP-04 (1)	739	2281	580	98	688	504	171	773	393	508	1719	677
	12	10	10	8	8	11	10	15	5	7	9	4
OP-08 (2)	263	1597	162	151	1016	174	342	1034	206	129	263	257
	3	34	8	16	23	7	26	29	12	11	12	6
Dry OP VI												
OP-19 (4)	223	785	288	191	690	259	527	928	215	2529	3512	669
	15	26	11	16	24	9	21	28	14	11	16	7
WET OP V												
OP-02 (4)	748	990	540	535	839	638	461	555	308	180	332	149
	32	23	19	21	19	16	31	28	23	13	14	15
OP-20 (3)	923	1526	572	380	1191	350	192	977	374	503	1120	586
	35	37	20	28	19	14	32	40	18	23	24	13
WET OP VI												
OP-01 (2)	370	1441	102	266	1549	116	696	2122	15	1698	997	29
	15	30	4	17	24	5	15	21	2	14	18	2
OP-17 (3)	19	1433	812	6	409	310	0	1607	1082	162	2848	1026
	2	37	18	2	21	13	0	28	19	2	18	11

Table 40. Avian density and species richness estimates for small openings (OP), edges of small openings (EG), and adjacent unbroken cottonwood forest (CT) summarized by type. Densities are expressed as the number of birds per 100 acres and species richness values are the number of species present in densities ≥0.5 per 100 acres.

	Number of intervals	Spring	Summer	Fall	Winter
Dry OP V	3	500 30	122 20	253 22	319 13
Dry OP VI	4	223 15	191 16	495 13	2529 11
WET OP V	7	859 50	458 35	343 53	344 29
WET OP VI	5	194 15	136 18	500 12	929 14
All Dry OP	7	413 36	150 29	332 27	1059 16
All WET OP	12	521 42	298 34	392 34	638 30
Dry EG	7	1552 42	793 34	805 34	1830 22
WET EG	12	1346 66	998 43	1238 46	1323 34
All OP	19	467 55	224 47	362 58	849 36
All EG	19	1449 71	896 50	1022 65	1577 37
CT	19	372 38	287 29	283 30	426 23

When data for all sites and types are combined, the high avian densities of EG relative to OP and CT are readily apparent. The openings combined had somewhat higher avian densities than the CT sites in all seasons but summer. Species richness values for OP and EG were consistently greater than for CT.

The data on relative avian use of small openings, edges, and unbroken forest exhibited different patterns than the herptile and small mammal data. Unlike the latter two groups, birds did not consistently use wet openings/edges more heavily than dry openings/edges. Birds were, however, the only group to use edge habitats more heavily than either wet or dry openings or forest. Estimated avian densities were markedly and consistently greater along both wet and dry edges than in openings or unbroken forest, during all four seasons of the year. Wet openings do enhance the diversity of the local bird community, however, by attracting the relatively less common aquatic and marsh-dwelling bird species to an area.

Comparison of the Middle Rio Grande with Other Major Southwest Riparian Systems

The middle Rio Grande, like the lower Colorado, lower Gila in Arizona, lower Salt-Verde, Pecos, and lower Rio Grande riparian ecosystems, is located in an arid desert region. The total annual precipitation is similar on all these river systems, approximately 8 inches. There are substantial differences in elevation among them, however, and at 5,000 ft the middle Rio Grande has a much cooler climate than any of the other Southwest river systems. Because of the combination of aridity and a cool climate, along with geographic location, flora and fauna of the middle Rio Grande have affinities to Plains/Great Basin riparian communities as well as to the lowland desert riparian communities of the other major river systems of the Southwest (Brown 1982).

Vegetation

The most striking difference between the middle Rio Grande and the other Southwest riparian systems is the dominance of cottonwood in the riparian flora. Cottonwood forest covered over 57% of the >31,000-acre study area between Española and San Acacia, and it was the dominant species over 143 miles of the 163 river miles in that reach. Salt cedar, which has invaded and dominated the flora in other river systems, is part of the middle Rio Grande flora, but it is not as abundant there as on the lower Colorado, lower Pecos, lower Rio Grande, or the lower Gila. Salt cedar has become dominant on the middle Rio Grande only in the 15-mile reach of the study area south of Bernardo, and salt cedar-dominated stands covered slightly <8,000 acres of the >31,000 acres mapped in the study. North of Bernardo, salt cedar frequently occurs as an understory species in cottonwood stands or as a codominant with coyote willow but rarely as a dominant species. By contrast, salt cedar-dominated communities account for the major portion of the riparian vegetation along the lower Colorado, lower Gila, Pecos, and lower Rio Grande river systems. Although there are relatively few salt cedar-dominated stands on the lower Salt and Verde rivers, there is little cottonwood either; velvet mesquite (*Prosopis velutina*) is the dominant species in that river system at present.

Another important factor distinguishing the riparian flora of the middle Rio Grande is the abundance of Russian olive there. This exotic species is absent from all the other systems except the Pecos, where it occurs only rarely. The importance of Russian olive in the vegetation community and its value to wildlife have been discussed previously in this report. The presence of this species links the middle Rio Grande to Great Basin riparian communities, in which Russian olive has become well established.

As the climate and flora of the middle Rio Grande are distinctive among major Southwest riparian systems, so are its faunal communities. As each of the major river systems supports a somewhat different assemblage of species, so that each is in certain ways unique, it is beyond the scope of this report to undertake detailed faunal comparisons among river systems. This discussion will focus on notable differences among the most common species of the middle Rio Grande relative to the lower Pecos, lower Rio Grande, lower Colorado, and lower Salt-Verde rivers. Some comparisons of overall abundances of small mammals and birds in C-S types that are common to several of the river systems will also be made. These are rough comparisons and represent only a first attempt at assessing differences among these river systems. Unless otherwise stated, data are from the following sources: lower Rio Grande, Engel-Wilson and Ohmart 1978; lower Colorado, Anderson and Ohmart 1984; lower Pecos, Hildebrandt and Ohmart 1982; lower Salt-Verde, Higgins and Ohmart 1981. Data from the lower Gila were not included in these comparisons.

Amphibians and Reptiles

Many of the amphibian species found in the middle Rio Grande valley, including bullfrogs, leopard frogs, Woodhouse toads, and Great Plains toads, occurred on all the river systems. The chorus frog, however, which was locally common on the middle Rio Grande, did not occur on any of the other systems. The common reptile fauna of the middle Rio Grande included more distinctive elements than the amphibian fauna. One species, the common gartersnake, was unique to the middle Rio Grande, and several other species were markedly more common there than elsewhere. The eastern fence lizard, which was the most abundant lizard in the middle Rio Grande, occurred elsewhere only along the Pecos and lower Rio Grande, where it was rare. The New Mexican whiptail, the second most common lizard on the middle Rio Grande, also occurred in parts of the lower Rio Grande valley but not elsewhere, and it appears to be most common in the middle Rio Grande. The painted turtle also had a limited distribution among rivers. This species was common along the middle Rio Grande and along parts of the Pecos (Degenhardt and Christiansen 1974) but did not occur on any of the other river systems under discussion (lower Rio Grande, lower Colorado, lower Salt-Verde). On the other hand, except for the common gartersnake, the most common snake species of the middle Rio Grande (coachwhip, gopher snake, hognose snake) were widely distributed and occurred on all the other river systems as well.

Mammals

The middle Rio Grande mammal fauna includes some distinctive species. Mink, which may still occur in the Rio Grande near Española, are found on none of the other four river systems, and beavers and muskrats, while not unique to the middle Rio Grande, occurred there in much higher densities than on the other river systems. The abundance of beavers and muskrats is probably related to both the abundance of cottonwood and willow vegetation and the presence of many miles of vegetated dirt-lined drains with permanent water flows. Beavers were rare on the other river systems, and occurred mostly in association with remnant cottonwood stands. Muskrats were also rare outside the middle Rio Grande, except in agricultural canals in the lower Colorado River valley.

Among small mammals, three notable species were unique to the middle Rio Grande: the woodland jumping mouse, the piñon mouse, and the tawny-bellied cotton rat. These species were rare, however, and had very limited habitat distributions. The high frequency of capture of desert shrews was also exceptional, although because of less extensive pitfall trapping their rarity or absence on the other river systems has not been ascertained.

Data from small mammal population surveys of the five river systems indicate that the small mammal community of the middle Rio Grande bears a number of similarities to those of the Pecos and the lower Rio Grande, but the small mammal fauna of these three systems differs from that found on the Arizona rivers (Table 41). In cottonwood communities the most abundant species on the former three river systems was the white-footed mouse, and the western harvest mouse was either the second or third most common species in most cottonwood habitats on these rivers. On the Arizona rivers, the most abundant species in cottonwood habitats was the cactus mouse (*Peromyscus eremicus*), followed by either the white-throated woodrat or the desert pocket mouse (*Perognathus penicillatus*). The house mouse occurred on all the rivers, but it was far more abundant along the middle Rio Grande (in cottonwood communities) than on any of the other habitats surveyed.

In salt cedar communities, certain upland desert-associated species were sometimes more common than the normally dominant *Peromyscus* species, e.g., Merriam kangaroo rats in SC V on the lower Colorado River, and Ord's kangaroo rats in SC VI A on the middle Rio Grande (Table 42). Otherwise, species composition among rivers followed the same patterns as in cottonwood communities, i.e., the three New Mexico river systems were similar to each other in species composition but were different from the Arizona rivers.

Total densities of small mammals in the cottonwood communities of the different rivers sytems differed markedly (Table 41). Since small mammal densities were combined across structure types for the cottonwood communities of the lower Rio Grande and the Pecos River, these data are not directly comparable to the rest. It appears that the small mammal densities on these two rivers were somewhat lower than on the other rivers. There was a striking difference in the relative densities of

Table 41. Comparison of data on small mammals in cottonwood habitats of five major Southwest riparian systems. Total density is the number captured per 270 trap nights and species richness is the total number of species captured in that habitat by snap trapping.

	River system and structure type							
	Lower Colorado			Salt-Verde*	Lower Rio Grande*	Pecos	Middle Rio Grande	
	I	II	V	II	(I, V)	(II, V)	I	V
Total density	27.8	28.4	5.7	21.2	7.3	4.4	5.2	15.7
Species richness	5	6	5	4	6	7	4	5
Major species in order of abundance	PE	PE	PE	PE	PL/PM	PL/PM	PL	PL
	NA	NA	NA	PP	RM	DO	RM	MM
	RM	PM	PP	SH	SH	RM	MM	RM
	MM	PP	PM	NA	MM	OL	PM	PM

DO = *Dipodomys ordii*, Ord kangaroo rat
MM = *Mus musculus*, House mouse
NA = *Neotoma albigula*, White-throated woodrat
OL = *Onychomys leucogaster*, Northern grasshopper mouse
PE = *Peromyscus eremicus*, Cactus mouse
PL = *Peromyscus leucopus*, White-footed mouse
PM = *Peromyscus maniculatus*, Deer mouse
PP = *Perognathus penicillatus*, Desert pocket mouse
RM = *Reithrodontomys megalotis*, Western harvest mouse
SH = *Sigmodon hispidus*, Hispid cotton rat

*Based on data from a single year.

Table 42. Comparison of data on small mammals in salt cedar habitats of five major Southwest riparian systems. Total density is the number of captures per 270 trap nights and species richness is the total number of species captured in that habitat by snap trapping.

	River system and structure type								
	Lower Colorado		Salt-Verde*	Lower Rio Grande*	Pecos		Middle Rio Grande		
	V	VI	(IV)	(II, III, IV)	V	VI	V	VI	VI A
Total density	14.6	7.5	7.5	4.4	11.3	6.7	4.4	8.1	5.1
Species richness	7	9	4	4	12	11	7	9	8
Major species in order of abundance	DM	PM	PE	PL/PM	PL/PM	PL/PM	PL	PL	DO
	PE	PE	NA	PE	RM	OL	RM	RM	RM
	PP	PP	PP	MM	OL	RM	DO	DO	DM
	PM	DM	RM	PP, DM	DM	MM	PM	PM	PM

DM = Dipodomys merriami, Merriam kangaroo rat
DO = Dipodomys ordii, Ord kangaroo rat
MM = Mus musculus, House mouse
NA = Neotoma albigula, White-throated woodrat
OL = Onychomys leucogaster, Northern grasshopper mouse
PE = Peromyscus eremicus, Cactus mouse
PL = Peromyscus leucopus, White-footed mouse
PM = Peromyscus maniculatus, Deer mouse
PP = Perognathus penicillatus, Desert pocket mouse
RM = Reithrodontomys megalotis, Western harvest mouse

*Based on data from a single year.

small mammals in mature versus shrubby cottonwood/willow communities of the lower Colorado and Salt-Verde rivers on one hand, and the middle Rio Grande on the other. Whereas mature (type I and II) cottonwood communities yielded the highest density estimates on the Colorado and Salt-Verde rivers, the shrubby type V cottonwood communities yielded the highest densities on the middle Rio Grande. While the lower densities on the lower Colorado River and middle Rio Grande were similar (both between 5 and 5 per 270 trap nights), the high densities observed in cottonwood/willow I and II on the lower Colorado and Salt-Verde rivers were almost twice as high as those observed in the high density cottonwood/coyote willow V in the middle Rio Grande. None of the middle Rio Grande C-S types yielded estimated small mammal densities as high as those observed in cottonwood/willow I and II on the lower Colorado River (see Table 13). Small mammal species richness, by contrast, varied little among the cottonwood communities of the five riparian systems.

Total densities of small mammals varied less widely in salt cedar habitats of the several rivers (Table 42). The highest density was again observed on the lower Colorado River, in salt cedar V. Among the three river systems where salt cedar type V and VI were sampled, the middle Rio Grande was unique in having higher densities in type VI than type V. Small mammal species richness varied more across salt cedar communities than across the cottonwood communities. The Pecos River salt cedar communities were particularly notable, yieldling higher numbers of species than any other community-structure type on any of the rivers. Small mammal species richness in middle Rio Grande salt cedar communities was comparable to that observed on the lower Colorado River.

Birds

The avian community of the middle Rio Grande included a number of common species that either did not occur on the lower Rio Grande, lower Pecos, lower Salt-Verde, or lower Colorado, or occurred only rarely or in migration. American Robins, Black-capped and Mountain chickadees, White-breasted Nuthatches, and Downy Woodpeckers were all common permanent residents, and Western Wood-Pewees, Gray Catbirds, Lazuli Buntings, and the very abundant Black-headed Grosbeaks were summer residents only in the middle Rio Grande. Notable rare species that occurred regularly only in the middle Rio Grande were Hairy Woodpeckers, Mississippi Kites, and Whooping Cranes. The Black-billed Magpie, a characteristics species of Great Basin riparian forest (Brown 1982), also occurred only in the middle Rio Grande.

Bird densities in cottonwood/willow habitats of the middle Rio Grande in summer were similar to those observed on the other riparian systems (Table 43). One small difference was that C/CW V on the middle Rio Grande tended to have higher densities than the other cottonwood/willow V habitats. Except for the ubiquitous Mourning Dove and the Brown-headed Cowbird, however, the complement of species contributing most heavily to total density in cottonwood communities of the middle Rio Grande was distinct. It included Black-headed Grosbeaks and American Robins, which, as previously mentioned, were not breeding species on the other rivers, and Black-chinned Hummingbirds and Blue Grosbeaks, which were far more common on the middle Rio Grande than

Table 43. Comparison of data on avian populations in cottonwood/willow communities of five major Southwest riparian systems.

	River system and structure type									
	Lower Colorado			Salt-Verde*	Lower Rio Grande*		Pecos		Middle Rio Grande**	
	I	II	V	II	I	V	II	V	I	V
Total density	3-400	6-700	3-400	490	780	340	4-500	3-400	350-450	5-600
Species richness	29	25	24	40	32	22	19	27	33	34
Major species in order of abundance	WWD	MD	MD	LW	HF	WWD	MD	MD	MD	MD
	AT	WWD	BHC	AT	WWD	MD	CG	LS	BCH	BHG
	BHC	AT	GQ	YW	YBC	YBC	NM	NO	BHG	AR
	MD	BHC	WWD	NO	BHC	BHC	NO	WK	BG	BCH
	NO		AT	MD	CY	CY		NM	BHC	BG
				BHC	OO				AR	

AR = American Robin
AT = Abert Towhee
BCH = Black-chinned Hummingbird
BG = Blue Grosbeak
BHC = Brown-headed Cowbird
BHG = Black-headed Grosbeak
CG = Common Grackle
CY = Common Yellowthroat
GQ = Gambel Quail
HF = House Finch
LS = Lark Sparrow
LW = Lucy Warbler
MD = Mourning Dove
NM = Northern Mockingbird
NO = Northern Oriole
OO = Orchard Oriole
WK = Western Kingbird
WWD = White-winged Dove
YBC = Yellow-breasted Chat
YW = Yellow Warbler

*Based on data from a single year.

**Densities of transient bird species have been excluded in order to make Middle Rio Grande bird densities comparable to those of other river systems.

elsewhere. Species richness was also greater on the middle Rio Grande than anywhere else except the Salt-Verde rivers.

The middle Rio Grande was unique among the five rivers in supporting higher total bird densities in cottonwood/willow in winter than in summer (Table 44). The middle Rio Grande C/CW habitats, especially C/CW V, had total densities greater than those observed on any of the other rivers in winter, although cottonwood/willow I on the lower Rio Grande was comparable. Large flocks of wintering Dark-eyed Juncos, American Robins, and, on both the middle and lower Rio Grande, White-crowned Sparrows, contributed substantially to the high total densities. These species were either less common or were absent from cottonwood/willow communities on the other rivers. On the other hand, the wintering small insectivores, chiefly Yellow-rumped Warblers and Ruby-crowned Kinglets, that accounted for the greatest proportion of total density on the two Arizona rivers and contributed heavily on the lower Rio Grande were far less common on the middle Rio Grande.

Neither salt cedar V nor salt cedar VI was common enough to be censused on the lower Rio Grande or the Salt-Verde river systems. Density and species richness values for the most similar C-S type sampled on these rivers, SC IV, are included in the tables for completeness. However, because of differences in vegetation structure, these data will not be included in further discussions. Comparison of avian communities in salt cedar focus on the middle Rio Grande, Pecos River, and lower Colorado River salt cedar communities.

In salt cedar habitats during summer, the Mourning Dove and/or White-winged Dove were prominent in all the river systems (Table 45). Among the three rivers where SC V and VI were sampled, density and species richness varied little. The salt cedar communities of the middle Rio Grande were quite similar to those of the Pecos River with regard to both total density and species composition: both had total densities of approximately 1-200 birds per 100 acres and the Northern Mockingbird, Mourning Dove, and Blue Grosbeak were among the major species. The presence of large numbers of Lark Sparrows in SC VI and VI A on the middle Rio Grande, however, was distinctive. Although the lower Colorado River had total density and species richness values similar to those observed on the New Mexico rivers, the species occurring there, except for Mourning Dove, were all different.

In salt cedar communities during winter, the White-crowned Sparrow was common to all the river systems, but the remainder of the species complement varied (Table 46). The middle Rio Grande had total densities similar to those observed on the other river systems except for SC VI on the Pecos River, which yielded the unusually high total density of 800 birds per 100 acres. Species richness was somewhat lower on the middle Rio Grande than elsewhere, especially in SC VI A. As in summer, the species complement of the middle Rio Grande salt cedar habitats was most similar to that of the Pecos River.

In summary, the middle Rio Grande differs from the other river systems primarily in regard to the extent and characteristic attributes of its cottonwood communities. The dominance of cottonwood forest over a large

Table 44. Comparison of data on avian populations in cottonwood/willow communities of five major Southwest riparian systems.

	River system and structure type									
	Lower Colorado			Salt-Verde*	Lower Rio Grande*		Pecos		Middle Rio Grande	
	I	II	V	II	I	V	II	V	I	V
Total density	2-300	2-300	50	360	800	80	150-200	150-250	5-600	750-850
Species richness	28	20	14	38	33	15	13	16	22	25
Major species in order of abundance	YRW	YRW	RCK	RCK	HF	RCK	MD	DEJ	DEJ	DEJ
	RCK	RCK	YRW	AT	WCS	BW	NF	NF	AR	WCS
	MW	AT	AT	YRW	RCK	DEJ	DEJ		ES	AR
	OCW			BW	GQ				NF	ES
	AT			OCW					WCS	SS

AR = American Robin
AT = Abert Towhee
BW = Bewick Wren
DEJ = Dark-eyed Junco
ES = European Starling
GQ = Gambel Quail
HF = House Finch
MD = Mourning Dove
MW = Marsh Wren
NF = Northern Flicker
OCW = Orange-crowned Warbler
RCK = Ruby-crowned Kinglet
SS = Song Sparrow
WCS = White-crowned Sparrow
YRW = Yellow-rumped Warbler

*Based on data from a single year.

Table 45. Comparison of data on avian populations in salt cedar communities of five major Southwest riparian systems in summer.

	River system and structure type								
	Lower Colorado		Salt-Verde*	Lower Rio Grande*	Pecos		Middle Rio Grande**		
	V	VI	IV	IV	V	VI	V	VI	VI A
Total density	150	150	960	310	115	200	230	150	190
Species richness	20	20	15	30	23	20	21	22	15
Major species in order of abundance	MD	MD	YBC	YBC	NM	NM	NM	LS	LS
	GQ	GQ	WWD	WWD	MD	MD	MD	WM	MD
	AT	WWD	AT	BHC	BG	WK	BG	NM	BHG
	WWD	AT	GQ	CY	BHC	BHC	CS	BG	BTS
		BG	WM		BG				

AT = Abert Towhee
BG = Blue Grosbeak
BHC = Brown-headed Cowbird
BHG = Black-headed Grosbeak
BTS = Black-throated Sparrow
CS = Chipping Sparrow
CY = Common Yellowthroat
GQ = Gambel Quail
LS = Lark Sparrow
MD = Mourning Dove
NM = Northern Mockingbird
WK = Western Kingbird
WM = Western Meadowlark
WWD = White-winged Dove
YBC = Yellow-breasted Chat

*Based on data from a single year.

**Densities of transient bird species have been excluded in order to make Middle Rio Grande bird densities comparable to those of other river systems.

Table 46. Comparison of data on avian populations in salt cedar communities of five major Southwest riparian systems in winter.

	River system and structure type								
	Lower Colorado		Salt-Verde*	Lower Rio Grande*	Pecos		Middle Rio Grande**		
	V	VI	IV	IV	V	VI	V	VI	VI A
Total density	75	250	230	65	200	800	210	50	120
Species richness	13	20	11	14	17	14	9	12	4
Major species in order of abundance	WCS	MD	AT	RCK	WCS	WCS	DEJ	DEJ	DEJ
	YRW	YRW	WCS	BTG	DEJ	BW	WCS	NF	AR
	RCK	RCK	GQ	WCS	BW	NF	AR	WCS	BW
	AT	V	BW	BW			NF	BW	

AR = American Robin
AT = Abert Towhee
BTG = Black-tailed Gnatcatcher
BW = Bewick Wren
DEJ = Dark-eyed Junco
GQ = Gambel Quail
MD = Mourning Dove
NF = Northern Flicker
RCK = Ruby-crowned Kinglet
V = Verdin
WCS = White-crowned Sparrow
YRW = Yellow-rumped Warbler

*Based on data from a single year.

**Densities of transient bird species have been excluded in order to make Middle Rio Grande bird densities comparable to those of other river systems..

portion of the valley's riparian zone and the uniqueness of the associated understory plants set the riparian flora of the middle Rio Grande apart from that of the lower Rio Grande and the lower Colorado, Gila, Salt-Verde, and Pecos rivers. The greater avian and small mammal use values of C/CW V versus C/CW I on the middle Rio Grande was unique, as were the high avian populations in cottonwood communities in winter. Finally, the middle Rio Grande cottonwood communities supported a distinctive complement of bird species and several unique species of small mammals and herptiles.

Salt cedar communities of the middle Rio Grande were more similar to those of other river systems, in terms of both floral composition and vertebrate use (as measured by densities and species richness). Although distinct from that of the lower Colorado River, species composition in middle Rio Grande salt cedar communities bore a number of similarities to those of Pecos River and lower Rio Grande salt cedar communities.

CONCLUSIONS

The middle Rio Grande valley of New Mexico supports lush riparian vegetation, including extensive acreages of cottonwood forest and several notable wetlands. These provide valuable habitat for a large number of wildlife spécies, many of which are otherwise rare in the region. Of particular note are the variety of riparian forest birds, some of which occur in very high densities, and the species dependent on marsh and aquatic habitats.

Inventories of the various types of riparian habitat along the middle Rio Grande indicated that the greatest concentrations of vertebrates occurred along the edges of cottonwood stands adjacent to levees, and in marshes. Isleta Marsh is a particularly valuable wildlife area. It provides habitat for a number of species that are rare in the valley, including the leopard frog and the endangered woodland jumping mouse, which was found nowhere else in the study area. Stands of cottonwood forest that include large trees are also particularly valuable to wildlife. Forest edges, marshes, and areas with large trees should be given special consideration in management planning.

The spread of exotic plant species in middle Rio Grande vegetation communities is a continuing problem. Russian olive and salt cedar, because of a combination of phenological and physiological characteristics, have the potential to continue to increase in abundance, most likely at the expense of native species. On the other hand, the opportunity for cottonwood and willow trees to regenerate has diminished as natural river flow patterns have been increasingly modified. Development of management plans to encourage regeneration of cottonwood and discourage or control the spread of Russian olive, salt cedar, and other exotics should be a primary objective. Additional research on vegetation dynamics is strongly recommended.

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APPENDICES

APPENDIX I

LIST OF PLANT SPECIES FOUND IN THE STUDY AREA

In the lists that follow are the scientific and common names of all plant species found by the study team during the survey. The first list includes all species collected or identified within the intensive study area. The following two lists include species collected or identified within the northern and southern portions of the general study area. These latter two areas were visited less frequently than the intensive study area, so the lists are less complete, particularly with regard to grasses and forbs. Listed under Habitats are all community types within which we have documented the presence of a given species, either through field records or by a collected specimen. This list of community types is not exhaustive, however; the fact that a community type is not listed for a particular species does not mean that the species does not occur in that type.

While it was impossible to ascertain the community type distribution of every plant species encountered during the survey, certain patterns in distribution could be discerned. The community types may be roughly divided into three groups, within which plant species distribution would be expected to overlap heavily:

forest - C/RO, C/CW (I, II, III)
wet or moist - MH, RO, DR, pond edge, C/CW (V, VI)
dry, sandy - SB, SC, LV, C/CW (IV), C/J (general north)

If a species occurred in one or more communities within a certain group, it was likely to occur in the others as well. Thus the list of community types may be used as a guide to the probable distribution of a species among community types in the valley. It should be noted that many of the species occurring in the study area were widespread and/or weedy, occurring in more than one group of communities.

Under growth form, H = herbaceous (grass or forb), S = shrub, T = tree, V = vine, and ? = identification uncertain.

Plants are listed in phylogenetic order according to:

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Table 1-1. Plants found in the intensive study area.

Scientific name	Common name	Growth form	Habitats
	PTERIDOPHYTA		
EQUISETACEAE			
Equisetum laevigatum A. Braun	Smooth scouring-rush	H	RO, OP, C/CW
	SPERMATOPHYTA **Gymnospermae**		
CUPRESSACEAE			
Juniperus monosperma (Engelm.) Sarge	One-seed juniper	S	C/J, C/CW
	Monocotyledoneae		
NAJADACEAE			
Potamogeton pectinatus L.	Sago pondweed	H	Pond, DR
JUNCACEAE			
Juncus balticus Willd.	Rush	H	DR, RO, C/CW, OP
J. nodosus L.	Rush	H	C/CW
J. torreyi Coville	Rush	H	DR, RO, C/CW, OP
CYPERACEAE			
Carex hystricina Muhl.	Porcupine caric-sedge, bottle-brush caric-sedge	H	Pond, C/RO, C/CW, RO
Cyperus aristatus Rottb.	Flat sedge	H	C/CW, SB, RO
C. esculentus L.	Chufa, yellow nut sedge, yellow nut grass	H	OP, SB, C/CW, RO
Eleocharis atropurpurea (Retz.) J. & K. Presl.	Spike rush	H	C/RO, C/CW, RO
Eleocharis (montevidensis Kunth. ?)	Spike rush	H	SB, C/CW, RO
Scirpus acutus Muhl.	Bulrush, great bulrush	H	DR, MH, RO
S. americanus Pers. (includes S. olneyi Gray)	Three-square bulrush	H	DR, MH, RO
Scirpus sp.	Bulrush	H	RO
GRAMINEAE			
Agropyron elongatum	Wheatgrass	H	OP, C/CW, C/RO
A. smithii Rydb.	Western wheat grass	H	C/RO
Agrostis semiverticillata (Forsk.) C. Chr.	Water bent	H	SB

Table I-1. (cont.)

Scientific name	Common name	Growth form	Habitats
A. stolonifera L. (A. alba L.)	Red top	H	DR, RO, SB
Aristida divaricata H. & B.	Poverty three-awn	H	C/CW, LV
Bothriochloa barbinodis (Lag.) Herter (Andropogon barbinodis Lag.)	Blue stem	H	C/CW, RO
Bromus japonicus Thunb.	Japanese chess	H	RO, OP
Cenchrus insertus M. A. Curtis (C. pauciflorus Benth.)	Field sandbur	H	OP, C/CW
Diplachne fascicularis (Lam.) Beauv. (Leptochloa fascicularis (Lam.) A. Gray)	Beaded sprangletop	H	SB
Distichlis spicata (L.) Greene ssp. stricta (Torr.) Beetle	Desert saltgrass	H	C/RO, MH, DR, C/CW, RO
Echinochloa crusgalli (L.) Beauv.	Barnyard grass	H	C/CW
Echinochloa muricata (Beauv.) Fernald	Cock spur	H	DR-LV
Elymus canadensis L.	Canada wild rye	H	DR-LV, OP
Eragrostis cilianensis (All.) Link	Stink grass	H	C/CW, DR
E. pectinacea (Michx.) Nees (includes E. diffusa Buckl.)	Lovegrass	H	C/CW, SB
Hordeum jubatum L.	Fox-tail barley	H	OP, RO
Leersia oryzoides (L.) Swartz	Rice cutgrass	H	DR-LV
Muhlenbergia asperifolia (Nees & Mey.) Parodi	Scratchgrass	H	RO, OP, LV, C/RO
M. racemosa (Michx.) B.S.P.	Muhly	H	C/CW
Oryzopsis hymenoides (R. & S.) Ricker	Indian ricegrass	H	OP, C/CW, LV
Panicum capillare L.	Panicum	H	C/CW
P. obtusum H.B.K.	Vine mesquite	H	C/CW, OP
Poa arida Vasey	Plains bluegrass	H	C/RO
Polypogon monspeliensis (L.) Desf.	Rabbitfoot grass	H	RO, C/CW, SB
Setaria glauca (L.) Beauv. (S. lutescens (Weigel) Hubb.)	Yellow bristlegrass	H	DR-LV, OP, RO
Sorghastrum nutans (L.) Nash	Indian grass	H	DR-LV, Pond, DR, MH
Sorghum halepense (L.) Pers.	Johnson grass	H	OP
Sporobolus airoides (Torr.) Torr.	Alkali sacaton	H	OP, DR-LV
S. cryptandrus (Torr.) Gray	Sand dropseed	H	DR-LV
S. flexuosus (Thurb.) Rydb.	Mesa dropseed	H	C/CW
S. giganteus Nash	Giant dropseed	H	DR-LV

Table I-1. (cont.)

Scientific name	Common name	Growth form	Habitats
Vulpia octoflora (Walt.) Rydb. (Festuca octoflora Walt.)	Six-weeks fescue	H	RO
TYPHACEAE			
Typha latifolia L.	Broad-leaved cattail	H	MH, DR, C/CW, C/RO
LILIACEAE			
Asparagus officinalis L.	Garden asparagus	H	C/CW, C/RO
ORCHIDACEAE			
*Epipactis gigantea Dougl. ex. Hook	Giant helleborine	H	C/RO
Spiranthes cernua (L.) L.C. Rich.	Lady's tresses	H	C/CW, RO
Dicotyledoneae			
SAURURACEAE			
Anemopsis californica (Nutt.) Hook & Arn.	Yerba-mansa	H	C/CW, C/RO, MH
RANUNCULACEAE			
Clematis ligusticifolia Nutt.	Clematis	H	C/CW
Ranunculus cymbalaria Pursh	Buttercup	H	C/RO
ULMACEAE			
Ulmus pumila L.	Siberian elm	T	C/CW, C/RO, DR
MORACEAE			
Maclura pomifera (Raf.) C.K. Schneid.	Osage orange	T	C/CW
Morus microphylla Buckl.	Texas mulberry	T	C/CW, C/RO, DR
NYCTAGINACEAE			
Abronia fragrans Nutt.	Snowbell, sweet sand verbena	H	C/CW
Tripterocalyx cyclopterus			OP, SC
CACTACEAE			
Opuntia sp.	Prickly pear cactus	H	C/RO, SC, C/CW

Table I-1. (cont.)

Scientific name	Common name	Growth form	Habitats
PORTULACACEAE			
Portulaca oleracea L.	Common purslane, verdolaga	H	SB
CHENOPODIACEAE			
Atriplex argentea (?) Nutt.	Salt bush	S	C/CW
A. canescens (Pursh.) Nutt.	Four-wing salt bush	S	C/CW, DR-LV
Chenopodium fremontii Wats.	Goosefoot	H	C/CW, C/RO
C. leptophyllum (Nutt. ex. Moq.) S. Wats.	Slimleaf goosefoot	H	DR-LV
Cycloloma atriplicifolium (Spreng.) Coult.	Winged pigweed	H	C/CW, SB
Kochia americana Wats.	Red molley	H	DR-LV
K. scoparia (L.) Schrad.	Summer cypress belvedere	H	C/CW, C/RO, DR-LV
POLYGONACEAE			
Polygonum lapathifolium L.	Willow smartweed	H	DR, C/CW, SB, C/RO
Polygonum pensylvanicum L.	Pinkweed	H	MH
Polygonum sp.		H	MH
Rumex mexicanus Meisn. (R. triangulivalvis (Danser) Rech. f.)	Dock	H	RO, DR-LV, C/CW, SB, C/RO
MALVACEAE			
Malvella leprosa (Ort.) Krapov (Sida hederacea (Dougl.) Torr., S. leprosa (Ort.) K. Schum.)		H	DR-LV
Sphaeralcea coccinea (Pursh) Rydb.	Scarlet globe mallow	H	
S. fendleri Gray	Fendler globe mallow	H	LV, OP
TAMARICACEAE			
Tamarix chinensis Loureiro (T. pentandra sensu K. & P.)	Salt cedar	S,T	C/CW, C/RO, C/SC, DR, MH, SC, SB
LOASACEAE			
Mentzelia pumila (Nutt.) Torr. & Gray	Blazing star	H	DR-LV
CUCURBITACEAE			
Cucurbita foetidissima H.B.K.	Buffalo gourd, calabazilla	H	LV, MH

Table I-1. (cont.)

Scientific name	Common name	Growth form	Habitats
SALICACEAE			
Populus fremontii Wats. var. wislizenii	Rio Grande cottonwood	T	C/CW, C/SC, C/RO, DR, MH, SB, SC
Salix amygdaloides Andress.	Peach-leaf willow	T	C/RO, C/CW
Salix exigua Nutt.	Coyote willow	S	C/CW, C/RO, C/SC, DR, MH
Salix gooddingii Ball	Goodding willow	T	C/RO
CLEOMACEAE			
Cleome serrulata Pursh	Rocky Mountain bee plant	H	C/CW, LV
Polansia dodecandra (L.) DC. ssp. trachysperma (Torr. & Gray) Iltis (P. trachysperma Torr. & Gray)	Western clammyweed	H	SB
CRUCIFERAE			
Dimorphocarpa wislizenii (Engelm.) Rollins (Dithyrea wislizenii Engelm.)	Spectacle pod	H	C/CW, SC, DR-LV
Lepidium latifolium L.	Pepper grass	H	C/CW
Lesquerella fendleri (Gray) Wats.	Bladder pod	H	OP
ROSACEAE			
Fallugia paradoxa (D. Don) Endel.	Apache plume	S	C/J
Potentilla anserina L. (?)	Silverleaf, silverweed	H	DR-LV
P. norvegica L.	Rough cinquefoil	H	C/RO
Rosa woodsii Lindl. (prob.)		S	LV
LEGUMINOSAE			
Amorpha fruticosa L.	Indigo bush, false indigo	S	C/RO, C/CW, DR-LV, RO
Astragalus ceramicus Sheldon	Milk vetch, loco weed	H	C/J, C/CW, SB
A. mollissimus Torr.	Milk vetch, loco weed	H	C/CW, SB
Astragalus sp. (fls. only)	Milk vetch, loco weed	H	C/CW
Dalea lanata Spreng. var. terminalis (M.E. Jones) Barneby (D. terminalis M.E. Jones)	Indigo bush, pea bush	H	C/CW, OP, SC
D. scoparia Gray	Broom pea	H	SC, LV

Scientific name	Common name	Growth form	Habitats
Desmanthus illinoensis (Michx.) Macmil. ex. B. Rob. & Fernald	Bundleflower	H	C/RO, DR-LV
Glycyrrhiza lepidota (Nutt.) Pursh	Licorice	H	C/CW
Melilotus albus Desr. ex. Lam.	White sweet clover	H	C/CW, DR-LV, MH, C/RO, OP, RO
M. indicus (L.) All.	Alfalfilla, annual yellow sweet clover	H	C/CW, C/RO, DR, MH, OP, RO
M. officinalis (L.) Lam.	Yellow sweet clover	H	C/CW, OP, C/RO
Parryella filifolia T. & G. ex. Gray		H	LV, SC
*Petalostemon scariosum (Wats.) Wemple		H	C/CW
Prosopis pubescens Benth.	Screwbean mesquite	T	C/RO, SC
Psoralea lanceolata Pursh	Lemon weed	H	C/CW, LV, SC
Sphaerophysa salsula (Pall.) DC.			C/CW, SC
HALORAGACEAE			
Myriophyllum spicatum L.	Water milfoil	H	Pond, DR
ONAGRACEAE			
Gaura coccinea Pursh	Scarlet gaura	H	C/RO
G. parviflora Dougl.	Lizard tail, velvet leaf gaura	H	DR, C/CW, OP
Oenothera pallida Lindl. (?)	Evening primrose	H	C/CW
O. hookeri Torr. & Gray	Evening primrose	H	C/CW
ELAEAGNACEAE			
Elaeagnus angustifolia L.	Russian olive	T	C/CW, C/RO, C/J, C/SC, DR, MH, SC
Shepherdia argentea (Pursh) Nutt.	Silver buffalo berry	S	BURN
EUPHORBIACEAE			
Euphorbia neomexicana Greene	Spurge	H	C/CW
E. parryi Engelm.	Parry euphorbia	H	C/CW
E. serpyllifolia Pers.	Spurge	H	C/CW, OP, SB
Euphorbia sp.	Spurge	H	C/CW
VITACEAE			
Vitis acerifolia Raf.	Grape	V, S	C/RO

Table I-1. (cont.)

Scientific name	Common name	Growth form	Habitats
ACERACEAE			
Acer negundo L.	Box elder	T	C/RO
ANACARDIACEAE			
Rhus trilobata Nutt.	Squaw bush	S	C/J, C/CW
SIMAROUBACEAE			
Ailanthus altissima (Mill.) Swingle	Tree of heaven	T	C/CW, C/RO
ZYGOPHYLLACEAE			
Kallstroemia parviflora Norton			DR-LV
Kallstroemia sp.			DR-LV
GENTIANACEAE			
Centaurium calycosum (Buckl.) Fern.	Buckley's centaury	H	RO, C/CW
APOCYNACEAE			
Apocynum sibiricum Jacq.	Clasping leaf dogbane		C/CW
A. suksdorfii Greene var. angustifolium (Wooton) Woodson	Prairie dogbane	H	C/CW, MH
ASCLEPIADACEAE			
Asclepias speciosa Torr.	Showy milkweed	H	C/CW
A. subverticillata (Gray) Vail	Poison milkweed, western whorled milkweed	H	RO, C/CW, DR-LV
SOLANACEAE			
Datura quercifolia H. B. K.	Oak leaf thorn apple	V, H	DR-LV
D. wrightii Regel (D. meteloides DC)	Sacred datura, tolguacha	V, H	LV
Lycium andersonii Gray	Anderson thornbush	S	C/RO, DR, SC
Physalis virginiana Miller	Longleaf ground cherry	H	DR-LV
P. virginiana Miller var. subglabrata	Ground cherry	H	C/RO
Solanum elaeagnifolium Cav.	Silverleaf nightshade, trompillo	H	LV, OP
S. sp. (nigrum L. ?)		H	C/CW
S. rostratum Dunal.	Buffalo bur, mala mujer	H	OP

Table I-1. (cont.)

Scientific name	Common name	Growth form	Habitats
CONVOLVULACEAE			
Convolvulus arvensis L.	Field bindweed	V, H	DR-LV
POLEMONIACEAE			
Ipomopsis longiflora (Torr.) V. Grant	White-flowered gilia	H	C/RO, C/CW
HYDROPHYLLACEAE			
Nama hispidum Gray		H	C/CW, C/RO
Phacelia integrifolia Torr.	Crenate leaf phacelia	H	OP, LV
BORAGINACEAE			
Cryptantha crassisepala (T. & G.) Green	Thick-sepaled cryptantha	H	C/RO
Heliotropium convolvulaceum (Nutt.) Gray	False morning glory	H	C/CW
H. curassavicum L.	Heliotrope	H	SC, OP, LV, C/RO
VERBENACEAE			
Verbena bracteata Lag. & Rodr.	Prostrate vervain	H	C/CW, DR-LV, C/RO
LABIATAE			
Lycopus americanus Muhl.	Cutleaf horehound	H	C/RO, C/CW
Mentha arvensis L.	Mint	H	C/RO
PLANTAGINACEAE			
Plantago major L.	Common plantain	H	C/RO
OLEACEAE			
Forestiera neomexicana Gray	New Mexico olive	S	C/CW, C/RO
Fraxinus velutina	Ash	T	C/CW
SCROPHULARIACEAE			
Castilleja minor Gray (sp. ?)	Paintbrush	H	C/CW
Penstemon sp.	Beardtongue	H	C/RO
Veronica americana (Raf.) Schwein.	American brookline	H	C/RO
V. anagallis-aquatica L.	Water speedwell	H	SB
OROBANCHACEAE			
Orobanche ludoviciana Nutt.	Broom rape, cancer root	H	C/CW

Table I-1. (cont.)

Scientific name	Common name	Growth form	Habitats
COMPOSITAE			
Ambrosia artemisiifolia L.	Ragweed	H	LV, C/CW
A. psilostachya DC.	Western ragweed	H	LV, C/RO, C/CW
A. psilostachya DC. var. lindheimerana (Scheele) Blankinsh.	Ragweed	H	C/CW
Artemisia dracunculoides Pursh	Sagebrush	H	C/CW
A. filifolia Torr.	Sand sagebrush	S	LV, SC, C/CW
Aster falcatus ssp. commutatus (T. & G.) A.G. Jones (A. commutatus (T. & G.) Gray)	Aster	H	OP, C/CW, SB, RO, LV
A. foliaceus Lindl.	Aster	H	DR-LV
A. frondosus (Nutt.) T. & G.	Aster	H	RO
A. herperinus Gray	Aster	H	RO
A. spinosus Benth.	Spiny aster, Mexican devil weed	H	C/CW
Baccharis salicina Torr. & Gray	Seepwillow, baccharis	S	C/CW, C/RO, SC, OP, C/SC, SB, DR-LV, MH
Baileya multiradiata Harv. & Gray	Wild marigold, desert baileya	H	LV, SC
Bidens frondosa L. (sp. ?)	Sticktight, beggar ticks	H	RO, OP, C/RO C/CW, DR
Centaurea repens L.	Russian knapweed	H	DR-LV, C/RO, DR
Chrysothamnus nauseosus (Pall.) Britt.	Rubber rabbit brush	S	DR-LV, SC, C/CW
Cirsium ochrocentrum Gray	Yellow spine thistle	H	C/CW
Conyza canadensis (L.) Cronq.	Horseweed	H	C/CW, OP
Erigeron bellidiastrum Nutt. (sp. ?)	Western fleabane	H	SB
E. divergens T. & G.	Spreading fleabane	H	C/CW
E. modestus A. Gray (?) (E. nudiflorus Buckl.)	Fleabane	H	C/RO
Flaveria campestris J. R. Johnst.		H	C/CW, OP
Gnaphalium chilense Spreng.	Small-flowered cudweed, cotton batting	H	OP
Grindelia aphanactis Rydb.	Gum weed	H	C/RO, OP, C/CW

Table I-1. (cont.)

Scientific name	Common name	Growth form	Habitats
Gutierrezia microcephala (DC.) Gray	Three-leaf snakeweed	S	C/CW, SC
G. sarothrae (Pursh) Britt. & Rusby	Broom snakeweed	S	SC, DR-LV
Haplopappus spinulosus (Pursh) DC.	Ironplant, goldenrod	H	DR-LV, C/RO, C/CW, SB
Helenium autumnale L.	Sneeze weed	H	C/CW
Helianthus annuus L.	Common sunflower, mirasol	H	RO, C/CW, DR-LV
H. ciliaris DC.	Plains sunflower	H	LV, OP, DR-LV
Heterotheca villosa (Pursh) Shinners (Chrysopsis villosa (Pursh) Nutt.)	Hairy golden aster	H	DR
Hymenoxys odorata DC.	Bitterweed	H	DR, MH
Isocoma wrightii (Gray) Rydb. (Haplopappus heterophyllus (Gray) Blake)	Jimmy weed	H	LV
Lactuca pulchella (Pursh) DC.	Large blue lettuce	H	DR, RO, OP, C/CW
L. serriola L.	Prickly lettuce, wild lettuce	H	OP
Machaeranthera parviflora Gray (?)		H	DR-LV
Palafoxia sphacelata (Nutt. ex. Torr.) Cory		H	C/CW, RO
Pyrrhopappus multicaulis DC.	False dandelion	H	C/CW
Ratibida tagetes (James) Barnhart	Prairie coneflower	H	LV
Senecio douglasii var. longilobus (Benth.) L. Benson	Thread leaf groundsel	H	LV, DR-LV
S. riddelli Torr. & Gray	Groundsel	H	C/CW, C/RO
Solidago canadensis L.	Goldenrod	H	MH, C/CW, C/RO, OP, DR-LV, RO
S. occidentalis (Nutt.) T. & G.	Western goldenrod	H	C/RO, C/CW
S. sparsiflora Gray	Goldenrod	H	RO
Tragopogon pratense L.	Goats beard	H	OP
Xanthium strumarium L.	Common cocklebur	H	C/CW, OP, DR-LV
X. strumarium L. var. wootoni (Ckll.) M. & H.	Cocklebur	H	OP

Table I-2. Plants found in the northern part of the general study area.

Scientific name	Common name	Growth form	Habitats
	PTERIDOPHYTA		
EQUISETACEAE			
Equisetum laevigatum A. Braun	Smooth scouring-rush	H	RO, OP, C/CW
	SPERMATOPHYTA		
	Gymnospermae		
CUPRESSACEAE			
Juniperus monosperma (Engelm.) Sarg.	One-seed juniper	S	C/J, C/CW
	Monocotyledoneae		
JUNCACEAE			
Juncus balticus Willd.	Rush	H	DR, RO, C/CW, OP
J. torreyi Coville	Rush	H	DR, RO, C/CW, OP
TYPHACEAE			
Typha latifolia L.	Broad-leaved cattail	H	MH, DR, C/CW, C/RO
	Dicotyledoneae		
ULMACEAE			
Ulmus pumila L.	Siberian elm	T	C/CW, C/RO, DR
CACTACEAE			
Opuntia sp.	Cholla cactus	S	C/J, S/RO, SC
Opuntia sp.	Prickly pear cactus	S	C/J, C/RO, SC, C/CW
CHENOPODIACEAE			
Atriplex canescens (Pursh.) Nutt.	Four-wing saltbush	S	C/CW, DR-LV
TAMARICACEAE			
Tamarix chinensis Loureiro (T. pentandra sensu K. & P.)	Salt cedar	S, T	C/CW, C/RO, C/SC, C/J, DR, MH, SC, SB
CUCURBITACEAE			
Cucurbita foetidissima H.B.K.	Buffalo gourd, calabazilla	H	LV, MH

Table I-2. (cont.)

Scientific name	Common name	Growth form	Habitats
SALICACEAE			
Populus fremontii Wats. var. wislizenii	Rio Grande cottonwood	T	C/CW, C/RO, C/SC, C/J, DR, MH, SB, SC
Salix amygdaloides Andress	Peach-leaf willow	T	C/RO, C/CW
S. exigua Nutt.	Coyote willow	S	C/CW, C/RO, C/SC, DR, MH
ROSACEAE			
Fallugia paradoxa (D. Don) Endel.	Apache plume	S	C/J
LEGUMINOSAE			
Amorpha fruticosa L.	Indigo bush, false indigo	S	C/RO, C/CW, DR-LV, RO
Astragalus ceramicus Sheldon	Milk vetch, loco weed	H	C/J
Lupinus concinnus Agardh.	Elegant lupine	H	C/J
Melilotus albus Desr. ex. Lam.	White sweet clover	H	C/CW, DR-LV, MH, OP, RO, C/RO
M. officinalis (L.) Lam.	Yellow sweet clover	H	C/CW, OP, C/RO
Parryella filifolia Torr. & Gray ex. Gray		H	LV, SC
*Petalostemon scariosum (Wats.) Wemple		H	SC
Psoralea lanceolata Pursh	Lemon weed	H	SC, C/CW, LV
ELAEAGNACEAE			
Elaeagnus angustifolia L.	Russian olive	T	C/CW, C/RO, C/J, C/SC, DR. MH, SC
EUPHORBIACEAE			
Croton texensis (Klotzch) Muell. Arg.	Dove weed	H	SC
VITACEAE			
Vitis acerifolia Raf.	Grape	V, S	C/RO
LINACEAE			
Linum aristatum Engelm.	Flax	H	SC

Table I-2. (cont.)

Scientific name	Common name	Growth form	Habitats
GENTIANACEAE			
Eustoma exaltatum (L.) D. Don.	Catchfly gentian	H	SC
CONVOLVULACEAE			
Ipomoea leptophylla Torr.	Bush morning glory	H	SC
BORAGINACEAE			
Heliotropium curassavicum L.	Heliotrope	H	SC, OP, LV, C/RO
Lappula redowskii (Hornem.) Greene		H	C/J
SOLANACEAE			
Lycium andersonii Gray	Anderson thornbush	S	C/RO, DR, SC
OLEACEAE			
Forestiera neomexicana Gray	New Mexico olive	S	C/CW, C/RO, C/J
SCROPHULARIACEAE			
Penstemon ambiguus Torr.	Gilia penstemon	H	SC
OROBANCHACEAE			
Orobanche ludoviciana Nutt.	Broom rape, cancer root	H	C/J
COMPOSITAE			
Artemisia dracunculoides Pursh	Sagebrush	S	C/J
A. filifolia Torr.	Sand sagebrush	S	LV, SC, C/CW, C/J
Baccharis salicina Torr. & Gray	Seepwillow, baccharis	S	C/CW, C/RO, C/SC, MH, DR-LV, SC, OP, SB
Chrysothamnus nauseosus (Pall.) Britt.	Rubber rabbit brush	S	C/J, SC, LV
C. nauseosus (Pall.) Britt. ssp. *bigelovii* (Gray) Hall & Clem	Bigelow rubber rabbit brush	S	SC, C/J
C. nauseosus (Pall.) Britt. ssp. *graveolens* (Nutt.) Piper	Greenplume rubber rabbit brush	S	C/J
Gutierrezia microcephala (DC.) Gray	Three leaf snakeweed	S	SC

Table I-2. (cont.)

Scientific name	Common name	Growth form	Habitats
G. sarothrae (Pursh) Britt. & Rusby	Broom snakeweed	S	SC, DR-LV
Helianthus annuus L.	Common sunflower mirasol	H	RO, C/CW, DR-LV
Heterotheca horrida (Rydb.) V.L. Harms			SC
H. villosa (Pursh) Shinners (_Chrysopsis villosa_ (Pursh) Nutt.)	Hairy goldaster	H	SC
Isocoma wrightii (Gray) Rydb. (_Haplopappus heterophyllus_ (Gray) Blake)	Jimmy weed	H	SC
Malacothrix fendleri Gray		H	SC
Senecio riddellii Torr. & Gray		H	C/J
Solidago canadensis L.	Goldenrod	H	MH, C/CW, C/RO, OP, DR-LV, RO
Xanthium strumarium L.	Common cocklebur	H	C/CW, OP, DR-LV

Table 1-3. Plants found in the southern part of the general study area.

Scientific name	Common name	Growth form	Habitats
	PTERIDOPHYTA		
EQUISETACEAE			
Equisetum laevigatum A. Braun	Smooth scouring-rush	H	RO, OP, C/CW
	SPERMATOPHYTA		
	Monocotyledoneae		
JUNCACEAE			
Juncus balticus Willd.	Rush	H	DR, RO, C/CW, OP
J. torreyi Coville	Rush	H	DR, RO, C/CW, OP
TYPHACEAE			
Typha latifolia L.	Broad-leaved cattail	H	MH, DR, C/CW, C/RO
	Dicotyledoneae		
ULMACEAE			
Ulmus pumila L.	Siberian elm	T	C/CW, C/RO, DR
MORACEAE			
Maclura pomifera (Raf.) C.K. Schnied.	Osage orange	T	C/CW
Morus microphylla Buckl.	Texas mulberry	T	C/CW, C/RO
CACTACEAE			
Opuntia sp.	Prickly pear cactus	H	C/J, C/RO, SC, C/CW
CHENOPODIACEAE			
Allenrolfea occidentalis (Wats.) Kuntze	Pickleweed	H	SC
Suaeda suffrutescens Wats.	Inkweed	H	SC
POLYGONACEAE			
Eriogonum rotundifolium Benth.		H	SC
TAMARICACEAE			
Tamarix chinensis Loureiro (T. pentandra sensu K & P)	Salt cedar	S, T	C/CW, C/RO, C/SC, C/J, DR, MH, SC, SB

Scientific name	Common name	Growth form	Habitats
CUCURBITACEAE			
Cucurbita foetidissima H.B.K.	Buffalo gourd, calabazilla	H	LV, MH
SALICACEAE			
Populus fremontii Wats. var. wislizenii	Rio Grande cottonwood	T	C/CW, C/RO, C/SC, C/J, DR, MH, SB, SC
Salix exigua Nutt.	Coyote willow	S	C/CW, C/RO, DR, MH
S. gooddingii Ball	Goodding willow	T	C/RO
LEGUMINOSAE			
Amorpha fruticosa L.	Indigo bush, false indigo	S	C/CW, C/RO, DR-LV, RO
Astragalus ceramicus Sheldon	Milk vetch, loco weed	H	SC
Melilotus albus Desr. ex. Lam.	White sweet clover	H	C/CW, DR-LV, MH, C/RO, OP, RO
M. officinalis (L.) Lam.	Yellow sweet clover	H	C/CW, OP, C/RO
Prosopis pubescens Benth.	Screwbean mesquite	T	C/RO, SC
Sphaerophysa salsula (Pall.) DC			C/CW, SC
ELAEAGNACEAE			
Elaeagnus angustifolia L.	Russian olive	T	C/CW, C/RO, C/J, C/SC, DR, MH, SC
EUPHORBIACEAE			
Croton texensis (Klotzch) Muell. Arg.	Dove weed	H	SC
SOLANACEAE			
Lycium andersonii Gray	Anderson thornbush	S	C/RO, DR, SC
L. torreyi Gray	Squaw thorn	S	SC
HYDROPHYLLACEAE			
Nama hispidum Gray var. spathulatum (Torr.) C.L. Hitchc.	Hispid nama	H	SC

Table I-3. (cont.)

Scientific name	Common name	Growth form	Habitats
BORAGINACEAE			
Cryptantha crassisepala (Torr. & Gray) Green	Thick-sepaled cryptantha	H	SC
COMPOSITAE			
Aphanostephus ramosissima DC.			SC
Artemisia filifolia Torr.	Sand sagebrush	S	LV, SC, C/CW
Baccharis salicifolia (R. & P.) Pers. (*B. glutinosa* Pers.)	Seepwillow	S	C/CW, DR, SC
B. salicina Torr.	Seepwillow, baccharis	S	C/RO, C/CW, SC, OP, DR, RO, MH
Chrysothamnus nauseosus (Pall.) Britt.	Rubber rabbit brush	S	SC, LV
Coreopsis sp.	Tickseed	H	SC
Gaillardia pinnatifida Torr.	Blanket flower	H	SC
Helianthus annuus L.	Common sunflower, mirasol	H	RO, C/CW, DR-LV
Hymenoxys odorata DC.	Bitterweed	H	SC
Senecio douglasii DC.		H	SC
S. multicapitatus Greenm. (sp.?)			H SC
Solidago canadensis L.	Goldenrod	H	MH, C/CW, C/RO, OP, DR-LV, RO
Tessaria sericea (Nutt.) Shinners (*Pluchea sericea* (Nutt.) Coville)	Arrowweed	S	SC
Townsendia annua Beaman		H	SC
Xanthium strumarium L.	Common cocklebur	H	C/CW, OP, DR-LV

APPENDIX II.

ANNOTATED LIST OF AMPHIBIAN AND REPTILE SPECIES FOUND IN THE STUDY AREA

The following list includes all amphibian and reptile species found in the study area during the survey, or known to have occurred in this part of the valley through museum records or records of other observers. Those species not found during the survey are indicated by a +.

Amphibians

Tiger salamander (Ambystoma tigrinum)

Found in and near ponds at Los Lunas and Cochiti and known to occur throughout the study area. We recorded this species only four times, but it is probably fairly common at ponds and other wet areas, as tiger salamanders imported into the state for use as fish bait have become widely established. The status of native versus introduced populations in the valley is unknown, but the three specimens we captured do not appear to be of the local form.

Plains spadefoot toad (Scaphiopus bombifrons)

Taken only occasionally in pitfall traps but known to occur throughout the study area in sandy habitats (MSB).

+Couch spadefoot toad (Scaphiopus couchii)

Recorded in the valley as far north as the Otowi Bridge, where NM 4 crosses the Rio Grande (MSB). There are numerous records for the study area (MSB, Applegarth 1982, T. L. Brown).

+New Mexico spadefoot toad (Scaphiopus multiplicata)

Recorded as far north as Santo Domingo and 3 mi south of Peña Blanca (T. L. Brown). Applegarth (1982:192) describes this species as "most often found on alluvial fans and floodplains within hilly terrain."

+Red-spotted toad (Bufo punctatus)

There are records from the valley from as far north as Bernalillo County, including Isleta, Albuquerque, and Alameda, e.g., mouth of the Conservancy ditch opposite Alameda (MSB).

Woodhouse toad (Bufo woodhousei)

Common and widespread throughout the study area, particularly along sandbars in the river channel but also in other areas with sandy substrate.

Great Plains toad (Bufo cognatus)

Somewhat less common than Woodhouse toads. They occur in sandy areas both within the bosque and along the river channel at least as far north as Peña Blanca (T. L. Brown pers. comm.).

Western chorus frog (Pseudacris triseriata triseriata)

Chorus frogs breed in small pools within certain parts of the bosque, where they are locally common. We recorded the species near ponds and in moist areas in the bosque throughout the area between Albuquerque and the Bosque Bridge. The range of the apparently isolated population of chorus frogs in the Rio Grande Valley extends from around Albuquerque south to Bernardo (Applegarth 1982).

Northern leopard frog (Rana pipiens)

Uncommon in the study area. During the study the species was recorded at only six localities: at Madrone Ponds, and at shallow woodland ponds inside a loop in the west levee about 3 mi north of the Bosque Bridge (by our study team), at the Corps' artificial pond near Los Lunas, at a shallow pond in a meadow near Bernardo, at Isleta Marsh, and near the large marsh on the Santo Domingo reservation (Applegarth 1983). The leopard frog has declined rapidly over the past two decades in the valley and may be endangered in the area (Applegarth 1983). Applegarth (1983) believes that the leopard frog's decline is due to direct predation by bullfrogs (R. catesbeiana).

Bullfrog (Rana catesbeiana)

Introduced into the Rio Grande Valley early in this century (Little and Keller 1937), bullfrogs are found throughout the study area today. They are abundant in drains, canals, and at ponds at least as far north as San Ildefonso. The bullfrog's expansion in this area has apparently been associated with the leopard frog's decline (Applegarth 1982, 1983). Bullfrogs frequently feed on smaller frogs and have been observed to prey upon leopard frogs (Vitt and Ohmart 1974, J. Applegarth pers. comm.).

Reptiles

Painted turtle (Chrysemys picta)

Occur commonly throughout the study area in drains, canals, and ponds. We have seen painted turtles only as far as Cochiti (April 1982), but the northernmost known specimens from New Mexico were taken near Española (MSB, Degenhardt and Christiansen 1974).

Ornate box turtle (Terrapene ornata ornata)

Found in the study area four times. Three of them were close to residential areas, and were probably escaped pets. One individual was found in a relatively undeveloped area near Bernardo. A small (2 in long) individual was trapped near Corrales, suggesting that native or escaped pet box turtles may be breeding in the area.

Spiny softshell turtle (Trionyx spiniferus)

Uncommon, found in drains and in slower-moving parts of the river channel. We have sighted this species as far north as Cochiti Dam. The northernmost specimen locality in the Rio Grande is Bernalillo, although there are unconfirmed reports of the species in the vicinity of Española (MSB, Degenhardt and Christiansen 1974).

Lesser earless lizard (Holbrookia maculata)

Common in open sandy areas where ground cover is sparse, such as sparse salt cedar (SC IV A) and cottonwood/juniper (CJ IV) stands. We recorded them in the valley only from the Jemez River salt cedar stand north to San Ildefonso, although they occur on the mesas to the south.

Collared lizard (Crotaphytus collaris)

Seen at the periphery of the riparian zone in very sparse salt cedar near the mouth of the Jemez River, and along nearby cliffs. This species barely enters the riparian zone.

Leopard lizard (Crotaphytus wislizenii)

One was sighted at the Jemez River salt cedar stand. Like the collared lizard, this species occurs only at the periphery of the riparian zone.

+Desert spiny lizard (Sceloporus magister)

Probably occurs in drier peripheral riparian habitats (e.g., sparse salt cedar) in the southern part of the study area. Applegarth (1982) found this species in shrubby vegetation near the mouth of the Rio Salado.

Eastern fence lizard (Sceloporus undulatus)

Abundant and widespread throughout the study area and found in all terrestrial habitats. This was the most often encountered reptile in the study area.

Side-blotched lizard (Uta stansburiana)

Found in open sandy areas, primarily salt cedar stands, in the general study area as far north as the mouth of the Jemez River, and seen occasionally in some sandy parts of the bosque near Isleta. There were no records of this species north of the Jemez River (MSB).

+Texas horned lizard (Phrynosoma cornutum)

Has been recorded in the southern part of the study area, along U.S. 85 near Bernardo (T. L. Brown). One was collected in Albuquerque near University of New Mexico (escaped pet?; MSB).

Short-horned lizard (Phrynosoma douglassi)

The species was sighted once at the Jemez River salt cedar stand and once at Candelaria Farms in Albuquerque. The third record, an individual we captured near Belen, was the southernmost specimen from the valley. The species occurs on the mesas farther south (Applegarth 1982).

Round-tailed horned lizard (Phrynosoma modestum)

Four were found at the Jemez River salt cedar stand. Known as far north as the mouth of the Rio Chiquita (MSB).

Great Plains skink (Eumeces obsoletus)

Uncommon in the study area. Skinks were found in moist, well-vegetated areas from Bernalillo to Bernardo during the study. The northernmost record for this species in the valley was one taken at Ancho Canyon (C. L. Bogert pers. comm.).

New Mexican whiptail (Cnemidophorus neomexicanus)

Abundant in terrestrial habitats as far north as Cochiti and have been recorded in the valley north to the San Ildefonso area (T. L. Brown pers. comm.). This was the second most frequently captured species in the study area.

Little striped whiptail (Cnemidophorus inornatus)

One specimen was found at San Ildefonso. This species occurs primarily in grassland habitats (Applegarth 1982).

+Desert grassland whiptail (Cnemidophorus uniparens)

Recorded on the banks of the Rio Grande in Rio Arriba County, 6 mi south of Rinconada (MSB); we are uncertain whether records of this species from farther south were within the valley.

Plateau whiptail (Cnemidophorus velox)

Uncommon; recorded only in the northern part of the study area, at Cochiti and San Ildefonso. Plateau whiptails appeared to be more common than New Mexican whiptails at both these sites.

Chihuahuan whiptail (Cnemidophorus exsanguis)

This species was captured in a variety of habitats from Corrales to south of Bernardo and probably occurs uncommonly throughout the study area; however, it was much less common than the New Mexican whiptail.

+Western whiptail (Cnemidophorus tigris)

Recorded in the southern part of the study area in the vicinity of San Acacia Diversion Dam, La Joya State Game Refuge, and near Bernardo (MSB, Applegarth 1982).

+Checkered whiptail (Cnemidophorus tesselatus)

Found on the west shore of Cochiti Lake (T. L. Brown). Probably occurs only in dry, peripheral parts of the study area.

Western hognose snake (Heterodon nascius)

Seen twice during the study. This species is probably uncommon throughout the study area.

+Racer (Coluber constrictor)

There is a single record of this species in the valley, from 1 mi north of La Joya (MSB). Applegarth (1982:214) describes it as "rare and probably limited to marshy areas of the Rio Grande Valley."

Coachwhip (Masticophis flagellum)

Common and frequently sighted as far north as Cochiti.

+Striped whipsnake (Masticophis taeniatus)

Recorded along the Rio Grande as far north as the Otowi Bridge (NM 4; T. L. Brown). Probably uncommon.

Gopher snake (Pituophis melanoleucus)

Common and frequently sighted throughout the study area in a variety of habitats.

Mountain patchnose snake (Salvadora grahamiae)

One specimen was found in juniper grassland just outside the riparian zone. This species is generally rare. There are at least three records of the species within the riparian zone; two from the Otowi Bridge (NM 4) and another from the mouth of Sandia Canyon (MSB, T. L. Brown).

Glossy snake (Arizona elegans)

One small individual was captured at the Jemez River salt cedar stand. The species has been reported to occur at least as far north as Cochiti and within the valley at Sabinal, Belen, Los Lunas, Isleta, and Bernalillo as well (T. L. Brown pers. comm.).

Common kingsnake (Lampropeltis getulus)

One was found on an embankment near Isleta Marsh.

+Longnose snake (Rhinocheilus lecontei)

Recorded near Peña Blanca several times (T. L. Brown) and near Albuquerque (valley?; MSB, T. L. Brown).

Common gartersnake (Thamnophis sirtalis)

Common and widespread throughout the study area, especially in moist, well-vegetated areas.

+Western terrestrial gartersnake (Thamnophis elegans)

There is one record from the Rio Grande Valley (MSB), but Applegarth (1982) regards the record as either an error or an import. This species normally occurs in the mountains in New Mexico.

+Blackneck gartersnake (Thamnophis cyrtopsis)

Occurs in the northern part of the study area, beginning in Sandoval County. Recorded along the Rio Grande at Bernalillo, Pajarito Village, La Mesilla, Buckman, and Española (MSB, T. L. Brown).

+Checkered gartersnake (Thamnophis marcianus)

Found in the valley from around Albuquerque south. There are records from Albuquerque and from the area between Bernardo and Belen (MSB, T. L. Brown).

+Plains blackhead snake (Tantilla nigriceps)

Has been recorded in the valley near Bernalillo, Belen, Sabinal, and Bernardo (T. L. Brown, MSB, Applegarth 1982). Probably uncommon.

+Night snake (Hypsiglena torquata)

Recorded in the valley at least as far north as Peña Blanca (T. L. Brown). Probably rare.

+Massasauga (Sistrurus catenatus)

Has been recorded in the valley on U.S. 85 south of Los Lunas and in the vicinity of marshes (MSB, Applegarth 1982).

+Western diamondback (Crotalus atrox)

Probably uncommon in the study area. Recorded within the Rio Grande Valley (e.g., near Isleta) to as far north as Ancho Canyon (T. L. Brown, MSB). This species is associated with dense vegetation and permanent water (C. M. Bogert pers. comm., Applegarth 1982).

Prairie rattlesnake (Crotalus viridis)

Encountered twice on levee roads, once at Corrales, and once near Belen. Not seen within the bosque.

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MSB = Museum of Southwest Biology, University of New Mexico, Albuquerque, New Mexico.

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APPENDIX III.

ANNOTATED LIST OF MAMMAL SPECIES FOUND IN THE STUDY AREA

The following list includes all mammal species found in the study area during the survey, along with species known to occur or to have occurred in the valley through reports in the literature. Species not directly encountered by members of the study team are indicated by a +. All are resident unless the species account states otherwise. Information on bats is taken from Findley et al. (1975). A single asterisk (*) indicates that the species is listed as endangered in New Mexico (New Mexico Department of Game and Fish 1983). A double asterisk (**) indicates that the species is also on the Federal Endangered Species List (Federal Register 1983).

+Virginia opossum (Didelphis virginiana)

Sands (1960) reported six records of opossums in New Mexico, including two road-killed specimens found 3 mi north of Belen on U.S. 85 (1955 and 1956), which is adjacent to the study area. The other records were sight records, mostly from the vicinity of Belen. Findley et al. (1975:7) note that opossums "in the Rio Grande Valley may be expected to inhabit cottonwood forests." There have been no records since the late 1950's.

Desert shrew (Notiosorex crawfordi)

Although it had not been recorded in this area previously, the desert shrew may be fairly common in moister, more heavily vegetated habitats throughout the valley, including marshes and wetter areas in salt cedar stands, as well as cottonwood habitats. A total of 49 specimens was captured in pitfall traps over the two years of the study, at various sites from the mouth of the Jemez River to south of Bernardo. Shrews were active at least from June through early November.

+Yuma myotis (Myotis yumanensis)

The Yuma myotis is a summer resident and is present in the valley through much of the year, but there are no December or January records. This species requires permanent water in its habitat. It breeds in the bosque or in nearby buildings or other structures, and forages over open water.

+Little brown myotis (Myotis lucifugus)

This species is a summer resident tied to permanent watercourses, breeding and roosting in the valley and foraging over open water. Findley et al. (1975) believe it is likely that these bats hibernate near their summer range.

+Long-legged myotis (Myotis volans)

This species migrates through the valley in spring and fall.

+Silver-haired bat (Lasionycteris noctivagans)

Spring and fall migrant.

+Big brown bat (Eptesicus fuscus)

Spring and fall migrant.

+Hoary bat (Lasiurus cinereus)

Spring and fall migrant.

+Spotted bat (Euderma maculatum)

Very rare migrant, recorded once at Albuquerque. This is one of the rarest North American bats.

+Townsend big-eared bat (Plecotus townsendii)

Occurs over a wide range of habitats in New Mexico, from deserts to mountains. The species has been taken in Albuquerque and it is not unlikely that it enters the valley, at least occasionally.

+Pallid bat (Antrozous pallidus)

Although it is most common in and usually breeds in desert habitats, the pallid bat is widespread and has been captured often in the valley. It is a migrant and summer visitor in the area.

+Brazilian free-tailed bat (Tadarida brasiliensis)

This species is common and has a broad habitat distribution. It also enters the valley both during summer and in migration, but breeds in desert, grassland, and pinyon-juniper habitats.

+Big free-tailed bat (Tadarida macrotis)

This species, though much less common than the Brazilian free-tailed bat, also has a broad habitat distribution. It probably enters the valley both during summer and in migration.

Desert cottontail (Sylvilagus auduboni)

Very common in the bosque and also frequently seen along drains and levee roads throughout the study area.

Black-tailed jackrabbit (Lepus californicus)

Fairly common in the drier and more open areas at the periphery of the riparian zone, especially in salt cedar areas; rare in cottonwood forest.

Colorado chipmunk (Eutamias quadrivittatus) (?)

Chipmunks were recorded twice in a cottonwood stand near San Ildefonso, out of their usual habitat. They could not be positively identified as to species but were probably this form. One was seen; the other was only heard.

Spotted ground squirrel (Spermophilus spilosoma)

Seen only twice on levee roads. The northern limit of the species in the valley is Española (Findley et al. 1975).

Rock squirrel (Spermophilus variegatus)

Abundant along levee roads and in cottonwood trees at the edges of the bosque, throughout the study area.

Gunnison prairie dog (Cynomys gunnisoni)

A colony of about 100 burrows exists along an alfalfa field on the Isleta Reservation. Single individuals were sighted twice on levee roads south of Belen.

Red squirrel (Tamiasciurus hudsonicus)

One out-of-habitat red squirrel was found on a cottonwood tree in the bosque near San Ildefonso Pueblo. This species is normally found in coniferous habitats in New Mexico, but occasional vagrants are known to occur at lower altitudes (J. Hubbard pers. comm.).

Botta pocket gopher (Thomomys bottae)

Common in sandy soil throughout the riparian zone. Gopher mounds are locally abundant in certain areas of deep, sandy soil where trees are not too dense and coyote willow is the dominant plant species.

+Yellow-faced pocket gopher (Pappogeomys castanops)

Known to have occurred in the Rio Grande Valley at least as far north as Albuquerque during the early part of the 20th century (Bailey 1932), but there are no recent records from the study area (Findley et al. 1975).

Silky pocket mouse (Perognathus flavus)

One was also found along a levee bank at the edge of the bosque, in the vicinity of Bosque Farms, but this appeared to be atypical habitat for the species in our area.

Plains pocket mouse (Perognathus flavescens)

One specimen was taken in open salt cedar habitat at the mouth of the Jemez River. This species is probably rare in the valley, even in the more arid peripheral areas.

+Rock pocket mouse (Perognathus intermedius)

This species has been taken in the valley near Algodones (Findley et al. 1975).

Ord kangaroo rat (Dipodomys ordii)

Common in open salt cedar habitats at the periphery of the riparian zone. Uncommon to rare and local in the bosque, in open, sandy areas (e.g., C/CW IV).

+Banner-tailed kangaroo rat (Dipodomys spectabilis)

Has been recorded in the valley as far north as the mouth of the Jemez River (Findley et al. 1975).

Merriam kangaroo rat (Dipodomys merriami)

This species was found in open salt cedar near the mouth of the Jemez River. Six specimens altogether were captured at this site, which is the northernmost locality for the species in New Mexico.

Beaver (Castor canadensis)

Common to locally abundant in drains, marshes, and deeper parts of the river channel (e.g., upstream from the Isleta Diversion Dam), wherever water is sufficiently deep.

Plains harvest mouse (Reithrodontomys montanus)

One specimen, captured in a moist, grassy Russian olive stand near Isleta was postively identified on the basis of skull characters by Dr. C. Thaeler at New Mexico State University. Findley et al. (1975:195) report that this species has been taken "in well-developed grasses in the floodplain.

Western harvest mouse (Reithrodontomys megalotis)

Common in most areas of the bosque where there is at least a moderate amount of ground cover. Locally abundant in moist areas where grass and herbaceous plants grow denseely. This was the second most common small mammal in the study area.

+Cactus mouse (Peromyscus eremicus)

Has occurred within the valley (Findley et al. 1975), probably in dry, peripheral habitats.

Deer mouse (Peromyscus maniculatus)

Rare in the valley south of Bernalillo in cottonwood stands, wet meadows, and salt cedar areas. Nine specimens were taken in this part of the study area; the southernmost specimen was taken at Bernardo.

Deer mice were more common (21 specimens) between Bernalillo and Española, where they were captured regularly in areas of more open vegetation, especially where junipers invade the floodplain.

White-footed mouse (Peromyscus leucopus)

Common throughout the riparian zone and abundant in the more densely vegetated habitats. This species was by far the most commonly captured species in the study area. Density decreased north of Bernalillo, however, and this species occurred in the valley only as far north as Española (Findley et al. 1975).

+Brush mouse (Peromyscus boylii)

Has been taken in the Rio Grande Valley near San Ildefonso Pueblo (Findley et al. 1975).

Pinyon mouse (Peromyscus truei)

While it is common in pinyon-juniper woodland (Findley et al. 1975), the piñon mouse was rarely captured in the valley. Four specimens were taken in cottonwood/juniper areas near Cochiti, and four were captured at the edge of a dense stand of cottonwood saplings in Bernalillo.

+Rock mouse (Peromyscus difficilis)

Found in the northern part of the Rio Grande Valley. Specimens have been taken near the Otowi Bridge (NM 4) and northwest of San Ildefonso Pueblo (Findley et al. 1975).

Northern grasshopper mouse (Onychomys leucogaster)

Rare in the study area. Found only in arid salt cedar stands at the outer periphery of the riparian zone.

+Southern grasshopper mouse (Onychomys torridus) [=arenicola]

Occurs in the Rio Grande Valley south of Albuquerque (Findley et al. 1975), probably in dry, peripheral habitats, such as salt cedar. The recognition of O. arenicola as a species distinct from O. torridus follows Hinesley (1979).

Hispid cotton rat (Sigmodon hispidus)

Uncommon to fairly common locally in grassy areas as far north as Belen. The northernmost specimen we captured was taken 1.5 mi north of Belen.

Tawny-bellied cotton rat (Sigmodon fulviventer)

We found this species at only two localities — in a wet meadow at Isleta Marsh (three specimens), and in a moist area within a salt cedar stand near the mouth of the Jemez River (one specimen). Tawny-bellied cotton rats may be more numerous in other grassy areas of the floodplain outside the levees. The northern disjunct portion of the species' range falls entirely within the study area (Findley et al. 1975).

+Southern Plains woodrat (Neotoma micropus)

Occurs near Albuquerque, possibly within the valley, e.g., "15 mi N. Albuquerque, Sandoval Co." (Findley et al. 1975:240).

+White-throated woodrat (Neotoma albigula)

Has been taken within the valley, e.g., at San Acacia and Española (Findley et al. 1975). Albuquerque records are from the mesas.

Muskrat (Ondatra zibethicus)

This species is common to locally abundant in drains, ponds, and marshes.

Norway rat (Rattus norvegicus)

We found two in the vicinity of Belen; one near a residence not far from the Bosque Bridge, and the other at a dump site in the bosque. The southern limit of this species' range in the Rio Grande Valley is uncertain, but only black rats (Rattus rattus) occur from Las Cruces south (Findley et al. 1975, C. Thaeler pers. comm.).

House mouse (Mus musculus)

This species was found in a variety of habitats in the bosque but was numerous only in the wettest areas. It was common along drains and other wet, grassy areas and was abundant around marshes.

*Woodland jumping mouse (Zapus hudsonius luteus)

We found this mouse only in the vicinity of Isleta Marsh, despite trapping efforts in other areas. Altogether, six specimens were taken. These were, to our knowledge, the first from this part of the valley.

Porcupine (Erethizon dorsatum)

Common in cottonwood and Russian olive stands throughout the valley.

Coyote (Canis latrans)

Presumably common in the study area, but because of the large number of dogs in the area, it was difficult to identify tracks with any certainty. We sighted coyotes 30 times over the two years, including six times near downtown Albuquerque.

+Kit fox (Vulpes macrotis)

Has been recorded in Albuquerque (Findley et al. 1975), and may occur in the valley at least occasionally.

Gray fox (Urocyon cinereoargenteus)

Uncommon to fairly common throughout. We recorded three sightings and found one skull of this species.

+Black bear (Ursus americanus)

The distribution map in Findley et al. (1975) shows this species' range extending into the valley in White Rock Canyon; has also strayed along the Rio Grande near Albuquerque (J. Hubbard, pers. comm.).

Raccoon (Procyon lotor)

Very common, especially around ponds, marshes, drains, and other wet areas. Tracks were recorded almost daily along the river channel. Local trappers felt that populations of raccoons have been increasing in the area over the past two decades. In addition to native animals, a number of raccoons have been released near Albuquerque by sportsmen.

Long-tailed weasel (Mustela frenata)

We recorded weasels primarily at Isleta Marsh, where there were several sightings and where two road-killed specimens were obtained. One weasel was seen near the Belen railroad bridge and another just south of the Bosque Bridge in summer 1983 (W. Howe), and it is not unlikely that they occur in other wet areas in the valley. Both specimens had the dark mask characteristic of southern forms of the species, e.g., M. f. neomexicanus (Findley et al. 1975).

+*Mink (Mustela vison)

Mink have been reported as far south as La Joya and Elephant Butte prior to 1920 (C. J. Mitchell pers. comm.), although there are no specimens to document this. The southernmost specimen is from Los Lunas (Findley et al. 1975). Findley et al. (1975) state that this species is found at present in mountain areas and perhaps in the Rio Grande Valley near the Sangre de Cristos.

+Badger (Taxidea taxus)

We found probable badger sign once, along a levee bank. Findley et al. (1975) list one record from the valley in Albuquerque.

Striped skunk (Mephitis mephitis)

Common in the valley. Tracks were seen regularly along levee roads and drains throughout the study area, and we sighted 20 animals in the bosque along drains and levees.

+*River otter (Lutra canadensis)

Reportedly occurred in the upper Rio Grande Valley before 1930 (Bailey 1932, C. J. Mitchell pers. comm.), but may be extinct in New Mexico today.

+Bobcat (*Felis rufus*)

Known to use the bosque but never sighted and relative density is unknown. A bobcat was trapped in a stand of mature cottonwoods just north of the oxbow in December 1981 (V. Hink encountered the trapper shortly after he took it from his trap). The number of bobcats in the valley is said to have increased over the past few decades (C. J. Mitchell pers. comm.).

+Mule deer (*Odocoileus hemionus*)

The distribution map for this species in Findley et al. (1975) includes those portions of the study area north of Bernalillo County and south of Valencia County. Mule deer are known to occur regularly only in the White Rock Canyon area, but probably pass through other parts of the study area at times.

Barbary sheep (*Ammotragus lervia*)

This exotic ungulate has been reported once in the area; an animal near Peña Blanca (J. P. Hubbard, pers. comm.).

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Findley, J. S., A. H. Harris, D. E. Wilson, and C. Jones. 1975. Mammals of New Mexico. Univ. New Mexico Press, Albuquerque, New Mexico. 360 pp.

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Hubbard, J. P. New Mexico Department of Game and Fish, Santa Fe, NM.

Mitchell, C. J. Aztec, N.M.; has been a trapper and fur buyer since the 1920's.

New Mexico Department of Game and Fish. 1983. Regulation No. 624. Listing of endangered species and subspecies of New Mexico, July 22, 1983.

APPENDIX IV.

ANNOTATED LIST OF BIRD SPECIES FOUND IN THE STUDY AREA

The following lists include all species recorded during our survey or known to have been found in the area by other observers during (and/or just prior or subsequent to) the period when the survey was conducted. The first list includes species of regular to irregular occurrence in the valley (defined as in Hubbard 1978, and below). Records from the literature of additional species known to have bred in the study area, and of migrant and winter resident species of at least irregular occurrence, have also been included in this list, indicated by a +. The second list includes species that are recorded only occasionally or casually (c.f. Hubbard) in the study area and are considered to be out of their usual range or habitat there. Species of occasional or casual occurrence that were not recorded during the study have not been included. Species listed as endangered in New Mexico (Hubbard et al. 1979) are marked with a single asterisk. A double asterisk indicates that the species is also on the Federal Endangered Species List (Federal Register 1984). Status, frequency of occurrence, and abundance (numbers) categories are defined as in Hubbard (1978) and below.

Status

Resident - present all year, generally breeding.
Summer - present during warmer months, generally breeding (approximately May-September).
Winter - present during colder months (approximately November-March).
Migration - present between summer and winter.
Breeder/nonbreeder - in the study area; self-explanatory.

Frequency of Occurrence

Regular - always present in season.
Irregular - less than annual occurrence (e.g., every other year).
Occasional - less than irregular (about once in five years).
Casual - less than occasional (once in 10 years or less).

Numbers

Abundant - very high density for the species.
Common - high density.
Fairly common - moderate density.
Uncommon - low density for the species.
Rare - very low density.

All references to species occurrences, status, and abundance refer to the riparian habitats of the Middle Rio Grande Valley between Española and San Acacia. Unless the species account states otherwise, distributions are throughout the cottonwood bosque habitats of this reach, and it was assumed that migrant birds could occur throughout the study area.

Species identification of Empidonax flycatchers normally cannot be verified except in the hand. Identification of species in this notoriously difficult group was mainly based on songs, calls, behavior, and/or field marks and are suppositional until verified by hand-examined birds.

Bird Species of Regular to Irregular Occurrence in the Study Area

+Common Loon (Gavia immer)

A rare migrant and winter resident throughout most of New Mexico, occurring on larger bodies of water (Hubbard 1978). This species probably occurs and may be regular at Cochiti Lake.

Pied-billed Grebe (Podilymbus podiceps)

Fairly common resident. Seen in ponds, marshes, and drains throughout the study area. Breeds at Isleta Marsh and Madrone Ponds.

Eared Grebe (Podiceps nigricollis)

Uncommon all year in drains, ponds, and marshes throughout the study area. Rare in summer at Isleta Marsh.

Western Grebe (Aechmophorus occidentalis)

Uncommon throughout the year but possibly resident at Cochiti Lake.

Double-crested Cormorant (Phalacrocorax auritus)

Regular and uncommon in spring, summer, and fall; rare and probably irregular in winter. Seen near water or flying overhead. Groups of up to ten birds were observed in the area between Bernardo and Cochiti, and there were two to seven sightings a month.

*Olivaceous Cormorant (Phalacrocorax olivaceus)

Irregular visitor in winter, spring, and summer, at least as far north as Madrone Ponds -- once to the mouth of the Jemez River. The species is rare but may be increasing in occurrence in the study area.

American Bittern (Botaurus lentiginosus)

Rare but probably regular at Isleta Marsh in migration. There was one sighting at Isleta Marsh during the study, but because of the secretiveness of this species, it might have been undetected at other times.

Least Bittern (Ixobrychus exilis)

Uncommon summer resident at Madrone Ponds and Isleta Marsh.

Great Blue Heron (Ardea herodias)

Common in winter and in migration, uncommon in summer. Seen frequently in ponds, marshes, drains, and along the river channel. We found no breeding areas.

Snowy Egret (Egretta thula)

Fairly common summer resident. Seen regularly in drains, marshes, and ponds and along the river. A rookery that included at least 60 Snowy Egret nests was found near Belen in 1982. (This rookery was active again in 1983; W. Howe.)

Green-backed Heron (Butorides striatus)

Common summer resident from Bernalillo south, most common in the southern part of the study area. There was only one sighting north of Bernalillo, and there were three winter records. Found along drains and the river channel.

Black-crowned Night-Heron (Nycticorax nycticorax)

Common summer resident in the study area. Frequently seen in drains, ponds, marshes, and along the river. The rookery found at Belen in 1982 had at least 40 Black-crowned Night-Heron nests.

White-faced Ibis (Plegadis chihi)

Uncommon but regular spring and fall migrant, seen in flocks of up to 70 birds.

Greater White-fronted Goose (Anser albifrons)

We sighted the species only once, but it has occurred in the area previously (Hubbard 1978).

Canada Goose (Branta canadensis)

Common in winter and in migration. Flocks of Canada Geese joined flocks of Sandhill Cranes (Grus canadensis) feeding in agricultural fields, especially between Los Lunas and Bosque.

Wood Duck (Aix sponsa)

Uncommon to fairly common and regular during fall, winter, and spring. Rare but probably regular in summer. Seen most often between Bernalillo and Belen, but they probably occur elsewhere in the study area as well. Wood Ducks may occasionally breed in the study area.

Green-winged Teal (Anas crecca)

Common in winter and early spring, uncommon in summer and fall, in open water.

Mallard (Anas platyrhynchos)

Resident. Abundant in winter throughout the study area. Large groups of Mallards may be seen in drains, ponds, marshes, and along the river. Fairly common in summer, breeding throughout the bosque. Birds resembling the Mexican form of the Mallard were seen on two occasions:

a female with a dark tail was seen at the La Joya State Game Refuge, and a male was seen near the mouth of the Jemez River.

Northern Pintail (Anas acuta)

Rare or uncommon in winter and spring. Rare in summer.

Blue-winged Teal (Anas discors)

Fairly common in late winter and early spring. Probably a rare summer resident. A female, thought to be of this species, was sighted with nine young at a pond near Isleta in summer 1982.

Cinnamon Teal (Anas cyanoptera)

Common in late winter and early spring in ponds, drains, and marshes. Locally common summer resident, breeding at Isleta marsh and Madrone Ponds.

Northern Shoveler (Anas clypeata)

Fairly common locally in winter in ponds and drains. Rare to uncommon the rest of the year.

Gadwall (Anas strepera)

Fairly common in winter and spring. Rare to uncommon in summer and fall in open water habitats. We obtained no breeding records.

American Wigeon (Anas americana)

Common in winter and early spring, uncommon in fall, in open water. Rare in summer, but may occasionally breed at Isleta Marsh.

Canvasback (Aythya valisineria)

Uncommon but probably regular in winter and early spring.

Redhead (Aythya americana)

Regular but rare in summer. Probably breeds at Isleta Marsh, as a pair was present there in 1981 and up to ten birds were seen in 1982.

Ring-necked Duck (Aythya collaris)

Fairly common in winter and early spring in ponds. Rare and irregular in summer but not breeding.

Lesser Scaup (Aythya affinis)

Uncommon in fall, winter, and early spring.

Common Goldeneye (Bucephala clangula)

Uncommon in winter and early spring. Most often seen at Cochiti Lake.

Bufflehead (Bucephala albeola)

Uncommon in winter and early spring.

Hooded Merganser (Lophodytes cucullatus)

There were two sightings during the study.

Common Merganser (Mergus merganser)

Uncommon in winter and early spring, rare in summer. Most often found at Cochiti Lake.

Red-breasted Merganser (Mergus serrator)

Rare (and irregular?) in winter and spring. Most often seen in the northern part of the study area.

Ruddy Duck (Oxyura jamaicensis)

Common in winter, uncommon at other seasons. Summer resident at Isleta Marsh and Madrone Ponds. W. Howe found three broods at Isleta Marsh in 1983.

Turkey Vulture (Cathartes aura)

Uncommon in summer, probably breeding in or near the valley but not in the bosque. Turkey Vultures foraged over the study area and perched in snags and trees.

Osprey (Pandion haliaetus)

Rare to uncommon but regular migrant along the Rio Grande. There were three sightings in spring 1981 and nine in spring 1982, but only one fall record each year.

*Mississippi Kite (Ictinia mississippiensis)

Regular but rare in summer between Isleta and Bosque Bridge (NM 346), and seen once near Bernalillo. The species may have bred in the area near Los Lunas, as groups of juveniles were observed there both years.

**Bald Eagle (Haliaeetus leucocephalus)

Regular and fairly common in winter at Cochiti Lake. Seen irregularly farther south. One bird stayed for a month along the river near Bernalillo, and there were single observations there, at Isleta and at Los Lunas. One adult was seen at Cochiti in summer (27 June 1982).

Northern Harrier (Circus cyaneus)

Fairly common in migration and winter, primarily in agricultural areas.

Sharp-shinned Hawk (Accipiter striatus)

Uncommon but regular in migration and winter throughout the study area, primarily in cottonwood forest.

Cooper Hawk (Accipiter cooperii)

Fairly common resident, more numerous during migration. Five nests were found in 1981 and six in 1982. One of the 1982 nests was in Albuquerque, in a heavily used area of the bosque.

Northern Goshawk (Accipiter gentilis)

Goshawks were uncommon but apparently regular migrants in the study area. They may also winter in low numbers, as there were four winter records (December to February) for the study area during the two years.

+*Common Black-Hawk (Buteogallus anthracinus)

A pair nested in a stand of mature cottonwoods on the Sandia Reservation in 1971 and produced at least one young (Hundertmark 1974). One adult sighted at Bosque, April 1984 (W. Howe).

Broad-winged Hawk (Buteo platypterus)

Rare spring migrant, with two records in 1981 and three in 1982 in the area between Isleta and Belen.

Swainson Hawk (Buteo swainsoni)

Fairly common in migration. Uncommon but regular in summer as a breeding species. A pair nested in a stand of large cottonwoods near the Bosque Bridge (NM 436) and fledged two young the summer of 1982. A pair nested between Los Lunas and Belen in 1981, and a territorial pair was observed in this area again in 1982.

Red-tailed Hawk (Buteo jamaicensis)

Resident. Uncommon in summer. One nest was found on a cliff at the edge of the valley near the mouth of the Jemez River, active in 1981 and again in 1983. Common in migration and in winter in both the bosque and in nearby agricultural areas. Dark-phase birds were present in migration and in winter, but they were somewhat less common than light-phase individuals. Although birds with whitish tail feathers were observed on several occasions, we were not able to positively identify any as B. j. harlani. One such individual was present both winters in the vicinity of Isleta, and another was observed near Los Lunas in winter 1981-82.

Ferruginous Hawk (<u>Buteo</u> <u>regalis</u>)

Uncommon and regular in migration and winter in agricultural areas of the valley. As many as five birds were seen together in open fields.

Rough-legged Hawk (<u>Buteo</u> <u>lagopus</u>)

Rare but probably regular in the agricultural areas of the valley from late fall through early spring. Three were seen during the first winter of the study.

Golden Eagle (<u>Aquila</u> <u>chrysaetos</u>)

A rare resident in the area although we did not find any breeding pairs. There was an unverified report of a nest in the vicinity of the Jemez Canyon Dam. Most sightings were near Cochiti, but others were from as far south as Bernardo.

+Crested Caracara (<u>Polyborus</u> <u>plancus</u>)

A pair apparently bred near Belen in 1953 (Ligon 1961), but the species has not been recorded in the study area since then (Hubbard 1978).

American Kestrel (<u>Falco</u> <u>sparverius</u>)

Common migrant and summer resident, nesting in cottonwoods within the bosque and in adjacent agricultural areas. Less common in winter.

Merlin (<u>Falco</u> <u>columbarius</u>)

There were two definite records of the species during the study, one in fall (1981) and one in spring (1982). Also, one was seen at Bernardo in September 1983 (W. Howe).

**Peregrine Falcon (<u>Falco</u> <u>peregrinus</u>)

Probably a regular migrant in small numbers throughout the study area.

Prairie Falcon (<u>Falco</u> <u>mexicanus</u>)

Uncommon but regular resident in the valley, presumably breeding on nearby cliffs. There were one or two sightings a month on the average, but fewer than that during the last four months of the study.

Ring-necked Pheasant (<u>Phasianus</u> <u>colchicus</u>)

Fairly common resident, especially in or near areas of dense vegetation.

Scaled Quail (<u>Callipepla</u> <u>squamata</u>)

A few were seen at the outer margins of the riparian zone, but this species occurred primarily in nearby grassland habitat.

Gambel Quail (Callipepla gambelii)

Common along edges and in more open areas of the bosque from Corrales south. Only a few were seen near Bernalillo and none farther north.

Virginia Rail (Rallus limicola)

Resident, fairly common in summer and uncommon in winter. Found primarily at Isleta Marsh but also seen occasionally along drains.

Sora (Porzana carolina)

Fairly common during migration, and uncommon at other times, primarily occurring in marshes. Breeding status unknown, but it is likely that it does breed in the area.

Common Moorhen (Gallinula chloropus)

Uncommon resident at Isleta Marsh. Several young were seen in 1982.

American Coot (Fulica americana)

Abundant resident. Found at all ponds and marshes in the valley, as well as occasionally in drains and along the river.

Sandhill Crane (Grus canadensis)

Abundant winter resident in the southern part of the study area. Flocks of 2,000 to 3,000 were seen regularly at the above-mentioned areas, and smaller groups were encountered throughout the area south of Albuquerque. Cranes were much less common north of Albuquerque except during migration.

**Whooping Crane (Grus americana)

Regular in winter in the southern part of the study area. One to two birds were seen from October to February both years with large flocks of Sandhill Cranes at Los Lunas and at the Belen State Refuge, feeding in agricultural fields.

Black-bellied Plover (Pluvialis squatarola)

There were two sightings of this species in spring 1982, one at Cochiti Lake and another at a sewage pond.

Semipalmated Plover (Charadrius semipalmatus)

We have only one record, from spring 1981 at Santo Domingo.

Killdeer (Charadrius vociferus)

Common resident, occurring primarily on sandbars along the river channel. Killdeer were also frequently seen in agricultural fields in the valley.

Black-necked Stilt (Himantopus mexicanus)

The species has been recorded only twice between Isleta and Bosque but it was seen more frequently at the Bernardo Refuge, where it is an uncommon regular migrant. We were unable to ascertain breeding status.

American Avocet (Recurvirostra americana)

This species was a common breeder at the Bernardo State Game Refuge in 1981 and 1982. Elsewhere, it was a rare migrant. Seen on sandbars and in flooded fields through most of the study area.

Greater Yellowlegs (Tringa melanoleuca)

Regular and uncommon in spring and fall. Rare and irregular (?) in winter. Found in flooded fields, ponds, and drains throughout the study area.

Lesser Yellowlegs (Tringa flavipes)

Regular uncommon migrant. From 2 to 12 birds were seen in flooded fields, sewage ponds, and along drains each month from July to September, with up to five individuals seen together. Less common in spring.

Solitary Sandpiper (Tringa solitaria)

Regular but uncommon spring and fall migrant. Recorded along drains and elsewhere near water throughout the study area, with up to five individuals seen at one time. There were fewer records in 1982 than 1981.

Spotted Sandpiper (Actitis macularia)

Fairly common summer resident and migrant. Seen primarily on sandbars in the river channel and sometimes along drains.

Long-billed Curlew (Numenius americanus)

Uncommon regular migrant. A few small flocks were seen each spring and fall in agricultural areas near the riparian edge.

Western Sandpiper (Calidris mauri)

Uncommon in spring and fall migration along the river channel, around ponds, and in flooded fields.

Least Sandpiper (Calidris minutilla)

Uncommon in spring and fall migration. Same habitats as Western Sandpiper.

Baird Sandpiper (Calidris bairdii)

Uncommon fall migrant. Seen primarily at flooded fields and artificial (sewage) ponds.

Stilt Sandpiper (Calidris himantopus)

We recorded the species only twice, once at the sewage pond at Cochiti in fall 1981 and once at a flooded field, in fall 1982.

Long-billed Dowitcher (Limnodromus scolopaceus)

Fairly common in spring and fall migration. Observed in flooded fields, near ponds, and along the river channel.

Common Snipe (Gallinago gallinago)

Uncommon but regular in migration and winter. This species was most often encountered along drains. There is a possibility that this species may breed in the study area, as two were heard singing near Santo Domingo in May 1981.

Red-necked (Northern) Phalarope (Phalaropus lobatus)

We recorded the species three times in fall at ponds between Isleta and Bernalillo.

Franklin Gull (Larus pipixcan)

An uncommon regular migrant in spring, seen late March to May. There was only one sighting in fall 1981.

Ring-billed Gull (Larus delawarensis)

Uncommon but regular in winter and in migration, along the river and at Cochiti Lake. Fairly common to common at Cochiti Lake.

California Gull (Larus californicus)

Recorded twice, once at Cochiti Lake and once (probable) at Bernalillo February 1982 and April 1982.

Forster Tern (Sterna forsteri)

Rare to uncommon but probably regular migrant. Individuals were seen flying up the river channel on two occasions.

Black Tern (Chlidonias niger)

We detected Black Terns only in spring and summer 1982 as they were flying up river and at Isleta Marsh. Also, three were seen at Bernardo in September 1983 (W. Howe).

Rock Dove (Columba livia)

Locally common resident in towns and cities, but rarely encountered in the bosque.

Mourning Dove (Zenaida macroura)

Abundant summer resident throughout the study area, breeding in the bosque and feeding along levees and in adjacent agricultural areas. Nests commonly in Russian olive and cottonwood trees, in dense vegetation, and also in stands of large salt cedar trees.

Yellow-billed Cuckoo (Coccyzus americanus)

Uncommon summer resident throughout the study area. Found primarily in mature or mixed-aged cottonwood stands.

Greater Roadrunner (Geococcyx californianus)

Fairly common resident as far north as Corrales, and a few were seen as far north as Cochiti. The northern limit of the species is apparently somewhere north of San Ildefonso. Most often seen along levee roads and at the edge of the bosque.

Common Barn-Owl (Tyto alba)

Barn-Owls are uncommon residents presumably in cottonwood bosque between Albuquerque and the Bosque Bridge.

Western Screech-Owl (Otus kennecotti)

Resident, probably uncommon to fairly common, throughout the study area in wooded habitats. Groups of near-fledgling-stage young were found on two occasions.

Great Horned Owl (Bubo virginianus)

Fairly common resident throughout the study area. Known to nest regularly at Shady Lakes (J. Phillips, pers. comm.). W. Howe found a family group south of Bosque in 1983.

Burrowing Owl (Athene cunicularia)

Encountered uncommonly at the periphery of the riparian zone in spring and summer. There were one or two breeding colonies in Albuquerque during the time of the study.

Long-eared Owl (Asio otus)

Probably a rare resident throughout the study area. A pair nested at Corrales in 1982 and 1983. The 1982 pair were known to have fledged five young. Sightings outside breeding season: Isleta March 1981, Los Lunas March 1981, and San Ildefonso September 1982.

+Short-eared Owl (Asio flammeus)

Rare and local migrant and winter resident statewide; occurrence in Bernalillo County has been verified (Hubbard 1978). Probably occurs in the study area at least irregularly.

Northern Saw-whet Owl (Aegolius acadicus)

There were three sightings during the study, i.e., Isleta April 1982, Bosque December 1981, Corrales January 1982.

Lesser Nighthawk (Chordeiles acutipennis)

No sightings during study. One at Bernardo spring 1984 (W. Howe).

Common Nighthawk (Chordeiles minor)

Common in migration and fairly common in summer, flying over the bosque and adjacent agricultural fields.

Common Poorwill (Phalaenoptilus nuttallii)

There were three records in spring during the study.

White-throated Swift (Aeronautes saxatalis)

Flocks were seen in spring and fall at Cochiti and in spring at Corrales, but rarely elsewhere.

Black-chinned Hummingbird (Archilochus alexandri)

Abundant migrant and summer resident throughout the valley. Present in all habitat types, but especially along the edges of the bosque.

Calliope Hummingbird (Stellula calliope)

Fairly common late-summer migrant. Locally abundant along drain edges where annuals were in flower.

Broad-tailed Hummingbird (Selasphorus platycercus)

Common in migration and in summer throughout the study area, but probably does not breed in the valley.

Rufous Hummingbird (Selasphorus rufus)

Fairly common late-summer migrant; favoring the edges of drains.

Belted Kingfisher (Ceryle alcyon)

Uncommon but widespread resident. Seen primarily along drains and canals, less often along the river. We did not locate any nest sites, but a family group was seen at Isleta Marsh in summer 1982.

Lewis Woodpecker (Melanerpes lewis)

Uncommon resident as far south as Corrales. The species is rare farther south, but bred at Belen in both 1981 and 1982 and probably near Los Lunas in 1982.

Red-headed Woodpecker (Melanerpes erythrocephalus)

Rare and may be irregular in summer in the valley at this time. There were seven sightings of this species in 1981, including a group of three at Bernalillo for a month in July-August, and single birds recorded at Bernalillo, Alameda (one immature), Isleta Marsh, and Belen (twice). However, no Red-headed Woodpeckers were recorded anywhere in the study area in 1982. All were associated with mature cottonwood trees near open areas. No nests were found. The Red-headed Woodpecker was on the New Mexico state list of endangered species until July 1983.

Yellow-bellied Sapsucker (Sphyrapicus varius)

An uncommon migrant in spring and fall. There was a total of 20 records.

Williamson Sapsucker (Sphyrapicus thyroideus)

We recorded the species four times in fall, three times at San Ildefonso and once at Cochiti, in mature cottonwood stands.

Ladder-backed Woodpecker (Picoides scalaris)

A rare resident, irregular over much of the study area, but regular and rare to uncommon at Cochiti, and uncommon to fairly common at Bernardo. There were two to four detections each season through spring 1982 in cottonwood habitats throughout the study area. This species was found only at Bernardo from summer 1982 through the end of the study.

Downy Woodpecker (Picoides pubescens)

Fairly common to uncommon resident at least as far south as Bernardo. The southernmost confirmed breeding record is 1.5 mi south of the Bosque Bridge (summer 1983, W. Howe), but the species probably breeds throughout the cottonwood bosque of the study area.

Hairy Woodpecker (Picoides villosus)

A rare resident throughout the study area. From two to 10 birds were detected each season during the study, with detections least frequent in summer and most frequent in fall and winter. Most were in mature cottonwood stands. We did not locate any breeding pairs.

Northern Flicker (Red-shafted form) (Colaptes auratus)

Common resident throughout the study area. Abundant at times, presumably when mountain populations move down into the valley. There was an apparent invasion in fall 1981.

Olive-sided Flycatcher (<u>Contopus</u> <u>borealis</u>)

Fairly common migrant throughout the bosque.

Western Wood-Pewee (<u>Contopus</u> <u>sordidulus</u>)

Common migrant and summer resident. Most numerous in mature cottonwood stands with open understory and a closed canopy.

Willow Flycatcher (<u>Empidonax</u> <u>traillii</u>)

Apparently regular and fairly common in migration. We recorded eight pairs in densely vegetated areas that were probably breeding, but no nests were located.

Least Flycatcher (<u>Empidonax</u> <u>minimus</u>)

One bird was apparently this species detected in spring 1981 and two in spring 1982. There were no definite fall records, due to difficulty in identification.

Hammond Flycatcher (<u>Empidonax</u> <u>hammondii</u>)

Two were identified by their song in spring 1982.

Dusky Flycatcher (<u>Empidonax</u> <u>oberholseri</u>)

Apparently common in migration throughout the study area.

Gray Flycatcher (<u>Empidonax</u> <u>wrightii</u>)

Apparently rare to uncommon regular migrant in cottonwood bosque areas, with 14 birds thought to be this species identified during the two years of the study.

Western Flycatcher (<u>Empidonax</u> <u>difficilis</u>)

Two to four individuals, apparently this species, were detected each spring and fall.

Black Phoebe (<u>Sayornis</u> <u>nigricans</u>)

Resident and fairly common in summer. Uncommon and perhaps irregular in winter. Most often seen along drains, as far north as Cochiti. Nests in culverts and under bridges.

+Eastern Phoebe (<u>Sayornis</u> <u>phoebe</u>)

Irregular in migration in the Middle Rio Grande Valley, with records at Española and La Joya State Game Refuge (Hubbard 1978).

Say Phoebe (Sayornis saya)

This species occurs mostly in nearby open fields, but is seen occasionally along drains and in openings at the edge of the bosque.

Ash-throated Flycatcher (Myiarchus cinerascens)

Common summer resident throughout the bosque in the study area.

Cassin Kingbird (Tyrannus vociferans)

Rare but regular summer resident; also, rare but regular summer and fall migrant. Found in open areas in the valley, primarily in the northern part of the study area. A pair nested at Bernalillo near the perimeter of the bosque in 1982.

Western Kingbird (Tyrannus verticalis)

Common summer resident and migrant. Found in agricultural and other open areas of the valley. Occurs in open salt cedar habitats where taller trees or windrows are interspersed. Uncommon within the bosque.

Eastern Kingbird (Tyrannus tyrannus)

This species is rare in summer in the valley near open fields. Probably breeds at Isleta Marsh irregularly or regularly and may have bred at Bernalillo as well.

Horned Lark (Eremophila alpestris)

Uncommon in migration and winter along the river. Wintering flocks were seen on sandbars or in open areas. This species is primarily found in agricultural fields in the valley.

Tree Swallow (Tachycineta bicolor)

Uncommon but regular spring and fall migrant.

Violet-green Swallow (Tachycineta thalassina)

Common spring and fall migrant, sometimes occurring in very large flocks. Occasionally visits in summer.

Northern Rough-winged Swallow (Stelgidopteryx serripennis)

Fairly common summer resident and spring and fall migrant.

Bank Swallow (Riparia riparia)

Rare summer resident and uncommon migrant. A small colony of five nests was found in a mud bank near Bernalillo in 1982.

Cliff Swallow (Hirundo pyrrhonota)

Common during migration. Locally common summer resident. Nests under nearly every major bridge and at dams.

Barn Swallow (Hirundo rustica)

Common during migration. Locally common summer resident. Breeds under bridges and in buildings.

Steller Jay (Cyanocitta stelleri)

A rare but apparently regular visitor to the bosque. We observed them in the study area five times, and individuals remained in an area from two to four weeks. Three of the records were in fall, one in April 1982 and another in June 1982.

Scrub Jay (Aphelocoma coerulescens)

Regular migrant and visitor to the bosque. Rare to fairly common at times. There were many more Scrub Jays sighted the second year of the study than the first.

Pinyon Jay (Gymnorhinus cyanocephalus)

Fairly commonly seen throughout the year in the riparian woodland at Cochiti, where junipers enter the floodplain. They presumably breed in pinyon-juniper areas nearby. Pinyon Jays were rare to uncommon, but regular visitors elsewhere in the study area, mostly in fall.

Black-billed Magpie (Pica pica)

Common resident at San Ildefonso and fairly common at Cochiti. Farther south we recorded them only once, at Bernalillo.

American Crow (Corvus brachyrhynchos)

Breeds regularly in small numbers, almost as far south as Belen. Nests have been found at Bernalillo, Corrales, and 6 mi south of Los Lunas. Common to locally abundant in winter.

Chihuahuan Raven (Corvus cryptoleucus)

Rare in the southern part of the study area north to Belen. Seen more often in spring than during the rest of the year. Breeding status in the valley is unknown.

Common Raven (Corvus corax)

Fairly common north of Cochiti but uncommon farther south. A pair fledged six young in the vicinity of the Bosque Bridge in 1982.

Black-capped Chickadee (Parus atricapillus)

Uncommon resident south to Bernardo in cottonwood habitats. Population levels fluctuated, and there was a notable decrease in numbers the second winter.

Mountain Chickadee (Parus gambeli)

Rare breeder between Isleta and Bernardo, but not known to breed in the valley farther north. Rare to uncommon throughout the study area during fall, winter, and spring. There were about three times as many detected the second winter as the first. This species hybridizes with the Black-capped Chickadee in the valley south of Belen (W. Howe unpubl. data).

Plain Titmouse (Parus inornatus)

Uncommon resident at San Ildefonso, plus one sighting (in June) at Cochiti.

Verdin (Auriparus flaviceps)

The northern limit of this species' distribution in the study area is San Acacia, but probably regular in mesquite habitats adjacent to the floodplain north to Bernardo.

Bushtit (Psaltriparus minimus)

Flocks of up to 30 regularly visited densely vegetated areas of the bosque throughout the year. Flocks remained in an area for up to two weeks, and they were more common during the second year of the study. Sporadic breeders may be the source of summer flocks in the valley. Also, a pair nested near the Bosque Bridge in 1983 (W. Howe, pers. comm.).

Red-breasted Nuthatch (Sitta carolinensis)

Rare to uncommon and probably regular migrant. Fall migrants were seen as early as July.

White-breasted Nuthatch (Sitta carolinensis)

Uncommon resident throughout the study area, especially in mature cottonwood stands.

Pygmy Nuthatch (Sitta pygmaea)

Irregular visitor from nearby mountains. Several flocks were sighted in the valley during August and November 1982.

Brown Creeper (Certhia americana)

Fairly common migrant and winter resident, found primarily in more mature cottonwoods.

Rock Wren (Salpinctes obsoletus)

This species is primarily found in rocky peripheral areas, but it occasionally enters the riparian zone.

Canyon Wren (Catherpes mexicanus)

Found only in rocky areas at the edges of the floodplain, not in the study area proper. Our records of this species are from spring and summer.

Bewick Wren (Thryomanes bewickii)

Fairly common throughout the study area in migration and in winter, i.e., 22 records in January 1982. Common summer resident in the northern part of the study area; we found them breeding at both Cochiti and San Ildefonso.

House Wren (Troglodytes aedon)

Fairly common regular migrant in spring and fall. There was one unusual record of this species in summer. Rare in winter, sighted at Los Lunas and Bernardo.

Winter Wren (Troglodytes troglodytes)

A rare, possibly regular migrant through the study area. Winter Wrens were found in areas of dense undergrowth in the cottonwood bosque. Two in fall 1981, three in spring 1982, and one specimen spring 1984 (W. Howe).

Sedge Wren (Cistothorus platensis)

We sighted one individual in October 1981 and a second, which appeared in November and remained in the area, was collected in January 1982. This was the first specimen for New Mexico.

Marsh Wren (Cistothorus palustris)

Fairly common winter resident and migrant, occurring in marshes, at ponds, and along drains.

Golden-crowned Kinglet (Regulus satrapa)

An irregular or perhaps regular visitor to the study area. Seen both years in October-November and in April 1982. Much more numerous the first year than the second.

Ruby-crowned Kinglet (Regulus calendula)

Common migrant and winter resident throughout the bosque.

Blue-gray Gnatcatcher (Polioptila caerulea)

Uncommon in migration throughout the study area. Summer resident only in salt cedar. Three pairs apparently bred at the Jemez River salt cedar stand in 1982.

Eastern Bluebird (Sialia sialis)

Uncommon but widespread in winter in 1981-82. The species may be of irregular occurrence, as none was seen in 1982-83.

Western Bluebird (Sialia mexicana)

Rare between late September and late March, seen as far south as Bernardo. This was the least-often encountered bluebird in the study area.

Mountain Bluebird (Sialia currucoides)

Uncommon but probably occurs regularly in winter. Flocks of up to 40 birds were observed, usually on sandbars. There was one summer record (June 1982).

Townsend Solitaire (Myadestes townsendi)

Mostly rare in late winter and in migration, but this species was fairly common during spring 1982.

Swainson Thrush (Catharus ustulatus)

This species was not detected by members of the study team, but there were sightings in fall 1981 and in spring 1982 (New Mexico Ornithological Society Field Notes 1982).

Hermit Thrush (Catharus guttatus)

Uncommon to fairly common locally in winter and in migration.

American Robin (Turdus migratorius)

Common resident throughout the valley, becoming abundant at times in winter as flocks move down from the mountains.

Gray Catbird (Dumetella carolinensis)

Fairly common summer resident, breeding in dense vegetation from the Angostura Diversion Dam south to La Joya. Most numerous between Corrales and Madrone Ponds. Two birds were seen in winter 1982, one of which remained near the Bosque Bridge for a month.

Northern Mockingbird (Mimus polyglottos)

Fairly common summer resident in salt cedar habitats. Rare in summer and in migration in other parts of the study area.

Sage Thrasher (Oreoscoptes montanus)

This species occurred regularly in the valley only in sparse salt cedar stands at the mouth of the Jemez River, where it was rare to uncommon. Breeding status unknown.

Brown Thrasher (Toxostoma rufum)

A rare but regular migrant and winter visitor. This species was seen seven times during the months of October through January and once in April, over the two years of the study.

Crissal Thrasher (Toxostoma dorsale)

An uncommon resident in salt cedar habitats, as far north as Bernardo. One individual was seen in the Jemez River salt cedar stand, which is the only large stand of salt cedar in the valley north of Bernardo.

Water Pipit (Anthus spinoletta)

Uncommon during migration and winter. Most often seen on sandbars or along drains. More common in agricultural fields than in the bosque.

Cedar Waxwing (Bombycilla cedrorum)

Uncommon to fairly common in migration and winter, varying from year to year in abundance. Occurs occasionally in summer (as late migrants?); W. Howe sighted a flock in early June 1983.

Northern Shrike (Lanius excubitor)

A rare winter visitor, probably irregular. Four adults were recorded November to December 1981, in sparse salt cedar and in grassland areas outside the bosque.

Loggerhead Shrike (Lanius ludovicianus)

Uncommon resident, occurring primarily in open salt cedar areas and in agricultural fields.

European Starling (Sturnus vulgaris)

Fairly common resident. The greatest numbers were found along the edges of the bosque, particularly in the vicinity of large cottonwood trees.

Solitary Vireo (Vireo solitarius)

Uncommon but regular spring and fall migrant. Most often seen in mature cottonwood habitats.

Warbling Vireo (Vireo gilvus)

Fairly common regular migrant in spring and fall.

Red-eyed Vireo (Vireo olivaceus)

A rare regular migrant in spring, plus one record each in summer and fall during the study.

Tennessee Warbler (Vermivora peregrina)

Locally uncommon to rare spring migrant, with four to five seen each year during May.

Orange-crowned Warbler (Vermivora celata)

Uncommon to fairly common regular migrant in spring and fall.

Nashville Warbler (Vermivora ruficapilla)

A rare but regular migrant. One to four birds were seen each spring and fall during the study.

Virginia Warbler (Vermivora virginiae)

Common spring and fall migrant. Virginia Warblers reappeared in the valley in late June, about three weeks after the end of spring migration. These birds may be early fall migrants or perhaps unmated individuals.

Lucy Warbler (Vermivora luciae)

Probably regular in the vicinity of Bernardo, where one definite and three probable records were obtained. One bird was seen in Albuquerque. W. Howe found the species breeding in the bosque south of Belen in summer 1983.

Northern Parula (Parula americana)

Seen once in April and a very rare summer visitor, seen four times in June 1982. A pair attempted to breed in the bosque at Algodones in 1977 (Cole 1978).

Yellow Warbler (Dendroica petechia)

Common summer resident in cottonwood bosque at San Ildefonso. Common during spring and fall migration but uncommon as a summer resident south of San Ildefonso.

Yellow-rumped Warbler (Dendroica coronata)

Abundant in migration and fairly common in winter throughout the study area. Most are of the Audubon race, but individuals of the Myrtle race were regular and at times fairly common.

Black-throated Gray Warbler (Dendroica nigrescens)

An uncommon regular migrant in spring and fall throughout the study area.

Townsend Warbler (Dendroica townsendi)

Rare but probably regular in spring migration, but more abundant (i.e., uncommon) in migration in fall.

Black-and-white Warbler (Mniotilta varia)

Rare but regular migrant in both fall and spring in cottonwood habitats, with six records altogether.

American Redstart (Setophaga ruticilla)

Rare but regular migrant and in summer. There were one to four records each spring, summer, and fall in the cottonwood bosque, and the species was observed several times in summer 1981 near Isleta Marsh.

Prothonotary Warbler (Protonotaria citrea)

Probably regular migrant through the study area. There were one or two records each spring and one fall record (1981).

Ovenbird (Seiurus aurocapillus)

Rare migrant and summer visitor, with one record in spring 1982, two in summer 1981, and one in early fall 1981. Found in moist, well-vegetated areas of the bosque.

Northern Waterthrush (Seiurus noveboracensis)

Uncommon regular spring migrant (15 and 19 records). Seen throughout the valley along drains and at the edges of small pools. Very rare in fall (two records), and two individuals apparently wintered in the valley 1981-82. One collected in February 1982 was the first verified winter record for New Mexico.

MacGillivray Warbler (Oporornis tolmiei)

Common in migration, especially in wet, densely vegetated areas, e.g., along drains and in coyote willow areas.

Common Yellowthroat (Geothlypis trichas)

Common summer resident and migrant. Rare and probably irregular in winter. Most numerous in moist, dense areas, such as coyote willow thickets and marshes.

Hooded Warbler (Wilsonia citrina)

Rare in summer and fall, with three records in 1981, all from cottonwood stands with a dense undergrowth of Russian olive.

Wilson Warbler (Wilsonia pusilla)

Abundant during spring and fall migration throughout the study area.

Yellow-breasted Chat (Icteria virens)

Common summer resident. Found primarily in moist, well-vegetated areas.

Summer Tanager (Piranga rubra)

Fairly common at Bernardo, but rare to uncommon north of the Bosque Bridge. Recorded north to San Ildefonso in 1982.

Western Tanager (Piranga ludoviciana)

Common spring and fall migrant; early fall migrants were seen beginning early to mid-July.

Rose-breasted Grosbeak (Pheucticus ludovicianus)

Rare migrant. One female was sighted in fall 1982.

Black-headed Grosbeak (Pheucticus melanocephalus)

Very abundant summer resident and migrant; one of the most numerous species in the bosque during the breeding season.

Blue Grosbeak (Guiraca caerulea)

Common summer resident and fairly common migrant.

Lazuli Bunting (Passerina amoena)

Fairly common in migration, uncommon as a summer resident, mostly north of Albuquerque. Several Lazuli X Indigo hybrids were seen, mostly in the southern part of the study area (W. Howe).

Indigo Bunting (Passerina cyanea)

Fairly common summer resident and migrant.

Green-tailed Towhee (Pipilo chlorurus)

Fairly common spring and fall migrant. Most common in well-vegetated areas.

Rufous-sided Towhee (Pipilo erythrophthalmus)

Common resident, but less common in winter than during other seasons.

Brown Towhee (Pipilo fuscus)

Uncommon in fall and spring where the mesas encroached on the cottonwood bosque, as at Cochiti, Bernalillo, and San Acacia. Rare elsewhere in the valley along levee roads.

American Tree Sparrow (Spizella arborea)

Uncommon and local but regular in winter throughout the study area in low or sparse shrub habitats.

Chipping Sparrow (Spizella passerina)

Probable summer resident in cottonwood habitats from Cochiti north, where it was fairly common. Common in migration through the rest of the study area in spring and fall. One flock of three individuals was sighted at Isleta in January 1982. Also, one at Los Lunas January 1982.

Clay-colored Sparrow (Spizella pallida)

We recorded this species in migration once each year in the bosque, but it was more numerous in the agricultural areas of the valley. Apparently much more common in migration in 1983 than during either year of the study (W. Howe).

Brewer Sparrow (Spizella breweri)

Fairly common in spring and fall migration, especially in open areas and along drains and edges. More common in adjacent agricultural fields.

Vesper Sparrow (Pooecetes gramineus)

We detected low numbers of Vesper Sparrows within our study area during migration.

Lark Sparrow (Chondestes grammacus)

Common resident in salt cedar habitats and in the cottonwood/juniper areas from Cochiti north.

Black-throated Sparrow (Amphispiza bilineata)

This primarily upland species was fairly common in summer (resident?) in open salt cedar stands at the periphery of the study area.

Sage Sparrow (Amphispiza belli)

Uncommon migrant, seen primarily in open salt cedar habitats. Recorded only once near the bosque along a woodland/levee edge.

Lark Bunting (Calamospiza melanocorys)

Rare but regular migrant in the riparian zone and nearby agricultural fields. There were sightings the first spring, and sightings both years in summer - fall.

Savannah Sparrow (Passerculus sandwichensis)

Seen during migration in agricultural fields and in open areas outside the bosque. Uncommon to rare but regular in winter from Bernalillo south.

Fox Sparrow (Passerella iliaca)

There were two sightings in November 1981.

Song Sparrow (Melospiza melodia)

Fairly common in winter and during migration. Locally abundant in wet, densely vegetated areas, such as well-vegetated drains, pond edges, and around Isleta Marsh.

Lincoln Sparrow (Melospiza lincolnii)

Uncommon spring and fall migrant. Most often detected along drains and edges. Winters in small numbers from Bernalillo south; rare to uncommon but regular.

Swamp Sparrow (Melospiza georgiana)

Rare in migration and winter, occurring in wetter areas of the valley, such as Isleta Marsh, Madrone Ponds, and along drains.

White-throated Sparrow (Zonotrichia albicollis)

Uncommon and widespread in moist, densely vegetated habitats throughout the study area from late September to early May. As many as eight were seen together, and groups of three or four were frequent.

+Golden-crowned Sparrow (Zonotrichia atricapilla)

Has been recorded in the study area at La Joya State Game Refuge (Hubbard 1978).

White-crowned Sparrow (Zonotrichia leucophrys)

Abundant in winter and in migration throughout the study area. Most numerous along well-vegetated drains and in other moist, well-vegetated areas.

Harris Sparrow (Zonotrichia querula)

Rare but regular winter and spring visitor, seen along drains and river edges. Four records altogether.

Dark-eyed Junco (Junco hyemalis)

Abundant in winter, especially along levees, edges, and open areas. Large flocks were mainly composed of Oregon and pink-sided juncos, but there were a few records of Slate-colored and White-winged juncos. Gray-headed Juncos were uncommon.

*McCown Longspur (Calcarius mccownii)

One to two individuals of this species were tentatively identified in a flock of Chestnut-collared Longspurs (C. ornatus) once during the study.

Chestnut-collared Longspur (Calcarius ornatus)

Regular spring and fall migrant. Uncommon, seen by sewage ponds and along sandbars in the river channel, or flying overhead. The species was rare in winter throughout the study area.

Red-winged Blackbird (Agelaius phoeniceus)

Resident. Abundant in summer and fairly common in winter in marshy areas.

Western Meadowlark (Sturnella neglecta)

Resident, common in open salt cedar stands and agricultural fields but uncommon in the bosque.

Yellow-headed Blackbird (Xanthocephalus xanthocephalus)

Locally common in marshy areas during migration. Fall migration begins in early July.

Brewer Blackbird (Euphagus cyanocephalus)

Fairly common and local in migration, uncommon to rare in winter. Mostly seen flying over the bosque.

Great-tailed Grackle (Quiscalus mexicanus)

Uncommon and local as a resident in agricultural areas. Locally common in summer, primarily outside the bosque. Recorded as far north as San Ildefonso but less numerous in the northern part of the study area. Breeds regularly in the riparian zone at Isleta Marsh and Madrone Ponds.

Common Grackle (Quiscalus quiscula)

Locally uncommon to fairly common in summer between San Ildefonso and the Bosque Bridge, generally outside the cottonwood bosque.

Brown-headed Cowbird (Molothrus ater)

Common summer resident throughout the study area.

Northern Oriole (Bullock form) (Icterus galbula)

Uncommon summer resident in cottonwood areas.

Cassin Finch (Carpodacus cassinii)

One fall and one winter record.

House Finch (Carpodacus mexicanus)

Common resident in residential areas but uncommon in the bosque, where it occurs mostly along edges.

Red Crossbill (Loxia curvirostra)

Rare and probably irregular in the valley. There was a summer flight of Red Crossbills from late June to early August 1981, and one record in June 1982.

Pine Siskin (<u>Carduelis pinus</u>)

Fairly common in winter and in migration. Also, Pine Siskins were found nesting in Albuquerque in 1982 and 1983 (W. Howe).

Lesser Goldfinch (<u>Carduelis psaltria</u>)

Common summer resident throughout the study area. Uncommon in migration and rare in winter.

American Goldfinch (<u>Carduelis tristis</u>)

Fairly common in winter and migration. Occasional individuals were seen in summer.

Evening Grosbeak (<u>Coccothraustes vespertinus</u>)

Rare in the riparian zone in fall (13 sightings over the two years), as far south as Los Lunas. Flocks were also sighted in the valley in August 1981 and 1982 and twice in spring 1982.

House Sparrow (<u>Passer domesticus</u>)

Resident, locally common in the vicinity of residential developments. Uncommon within the riparian zone.

Bird Species of Occasional to Casual Occurrence in the Study Area That were Recorded During 1981-1982

This list includes species that were recorded less than five times during the study and that were considered to be out of their normal range or habitat in the valley. The total number of sightings of each during the two years of the study is given in parentheses.

Red-throated Loon (Gavia stellata) (1)
Great Egret (Casmerodius albus) (1)
Little Blue Heron (Egretta caerulea) (3) (May have nested near Belen in 1983; W. Howe.)
Cattle Egret (Bubulcus ibis) (1) (Found nesting near Belen in 1983; W. Howe.)
Tundra Swan (Cygnus columbianus) (1)
Harris Hawk (Parabuteo unicinctus) (2)
Sanderling (Calidris alba) (1)
Short-billed Dowitcher (Limnodromus griseus) (1)
American Woodcock (Scolopax minor) (1)
Bonaparte Gull (Larus philadelphia) (2)
Sabine Gull (Xema sabini) (1)
Band-tailed Pigeon (Columba fasciata) (3)
Common Ground-Dove (Columbina passerina) (1)
Purple Martin (Progne subis) (1)
Blue Jay (Cyanocitta cristata) (1)
Veery (Catharus fuscescens) (1)
Phainopepla (Phainopepla nitens) (1)
*Bell Vireo (Vireo bellii) (1) (Northernmost record for New Mexico.)
Yellow-throated Vireo (Vireo flavifrons) (1)
Blue-winged Warbler (Vermivora pinus) (2)
Chestnut-sided Warbler (Dendroica pensylvanica) (1)
Magnolia Warbler (Dendroica magnolia) (2)
Black-throated Blue Warbler (Dendroica caerulescens) (1)
Black-throated Green Warbler (Dendroica virens) (1)
Grace Warbler (Dendroica graciae) (2)
Palm Warbler (Dendroica palmarum) (3)
Bay-breasted Warbler (Dendroica castanea) (1)
Blackpoll Warbler (Dendroica striata) (1)
Kentucky Warbler (Oporornis formosus) (2)
Scarlet Tanager (Piranga olivacea) (1)
Northern Cardinal (Cardinalis cardinalis) (3)
Dickcissel (Spiza americana) (1)
Lapland Longspur (Calcarius lapponicus) (1)
Bobolink (Dolichonyx oryzivorus) (3)
Rusty Blackbird (Euphagus carolinus) (1)
Orchard Oriole (Icterus spurius) (1)
Scott Oriole (Icterus parisorum) (1)

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APPENDIX V.

SUPPLEMENTARY VEGETATION DATA

ABBREVIATIONS USED IN APPENDIX V

C Rio Grande cottonwood (Populus fremontii var. wislizenii)

RO Russian olive (Elaeagnus angustifolia)

SC Salt cedar (Tamarix chinensis)

CW Coyote willow (Salix exigua)

TW Tree willow (Goodding and peachleaf; S. gooddingii, S. amygdaloides)

SW Seepwillow (Baccharis salicina)

Cat Cattail (Typha latifolia)

J One-seed juniper (Juniperus monosperma)

NMO New Mexico olive (Forestiera neomexicana)

Wb Wolfberry (Lycium andersonii)

Rb Rabbitbrush (Chrysothamnus nauseosus)

Sa Sagebrush (Artemisia filifolia, A. dracunculoides)

DR Drain

MH Marsh

SB Sandbar

Table V-1. Relative density (RD), relative cover (RC), and relative frequency (RF) values for major trees and shrubs in each community-structure type. These values were summed to yield relative importance values (RIV) and averaged to yield importance percent (I%). I% values of dominant species in each layer are underlined.

	Canopy				Shrub								
	C	RO	SC	TW	C	RO	SC	CW	SW	I	TW	Cat	J
C/CW I													
RD	61	12	25	1	2	6	27	34	29	1	<1	0	0
RC	98	1	0	0	6	4	22	33	29	1	5	0	0
RF	97	3	0	0	13	6	21	32	21	4	4	0	0
RIV	256	16	25	1	21	16	70	99	79	6	9	0	0
I%	85	5	8	0	7	5	23	33	26	2	3	0	0
C/CW IV													
RD	81	10	8	<1	19	7	41	28	1	1	2	0	0
RC	100	0	0	0	50	13	36	2	0	0	0	0	0
RF	100	0	0	0	36	16	44	4	0	0	0	0	0
RIV	281	10	8	1	105	36	121	34	1	1	2	0	0
I%	94	3	3	0	35	12	40	13	0	0	1	0	0
C/CW V													
RD	25	18	56	2	<1	<1	14	79	5	<1	<1	0	0
RC	83	14	4	0	11	8	7	63	6	3	<1	0	0
RF	70	20	10	0	11	5	21	44	11	3	2	0	0
RIV	178	52	70	2	22	13	42	186	22	6	3	0	0
I%	59	17	23	1	7	5	14	62	7	2	1	0	0
C/CW VI													
RD	42	11	39	8	22	2	15	60	<1	<1	<1	0	0
RC	71	29	0	0	17	13	13	42	5	5	<1	0	0
RF	80	20	0	0	30	12	19	35	2	2	2	0	0
RIV	193	60	39	8	69	27	47	137	7	7	2	0	0
I%	64	20	13	3	23	9	16	46	2	2	1	0	0
DR V													
RD	3	34	61	3	0	4	5	91	0	<1	0	--	0
RC	82	18	0	0	<1	33	6	47	0	7	0	3	0
RF	63	38	0	0	3	28	14	45	0	3	0	6	0
RIV	148	90	61	3	3	65	25	184	0	10	0	9	0
I%	49	30	20	1	1	22	8	61	0	3	0	5**	0
DR VI													
RD	30	50	10	10	<1	3	6	83	0	5	<1	—	0
RC	98	2	0	0	1	3	0	65	0	5	24	2	0
RF	66	33	0	0	12	6	0	41	0	6	29	6	0
RIV	194	85	10	10	13	12	6	189	0	16	53	8	0
I%	65	28	3	3	4	4	2	63	0	5	18	4**	0
C/CW $\bar{x}$ I%	69	17	12	1	13	9	17	46	6	2	4	1**	0

Table V-1. (cont.)

	Canopy				Shrub								
	C	RO	SC	TW	C	RO	SC	CW	SW	I	TW	Cat	J
C/RO I													
RD	34	47	18	1	2	39	33	11	13	2	<1	0	0
RC	95	3	2	0	<1	82	16	<1	0	2	0	0	0
RF	85	9	6	0	8	60	25	5	0	3	0	0	0
RIV	214	59	26	1	10	181	74	17	13	7	<1	0	0
I%	71	20	9	0	3	63	25	6	4	2	0	0	0
C/RO II													
RD	66	26	1	7	20	20	5	27	1	6	13	0	0
RC	100	0	0	0	4	84	4	7	0	0	4	0	0
RF	100	0	0	0	10	50	10	20	0	0	10	0	0
RIV	266	25	1	7	34	154	19	54	1	6	27	0	0
I%	88	8	0	2	11	51	6	18	0	2	9	0	0
C/RO IV			J										
RD	56	39	5	0	9	33	<1	0	0	0	0	0	57
RC	100	0	0	0	34	62	<1	<1	0	0	0	0	3
RF	100	0	0	0	47	40	3	3	0	0	0	0	7
RIV	256	39	5	0	90	135	4	3	0	0	0	0	67
I%	85	13	2	0	30	45	1	1	0	0	0	0	22
C/RO $\bar{x}$ I%	81	14	SC/J 3/1	1	15	52	11	13	1	1	3	0	7
C/J I										NMO			
RD	64	15	19	1	1	4	0	0	0	0	<1	0	94
RC	100	0	0	0	22	36	0	0	0	0	0	0	43
RF	100	0	0	0	34	22	0	0	0	0	0	0	44
RIV	264	15	19	1	57	62	0	0	0	0	<1	0	181
I%	88	5	6	0	19	21	0	0	0	0	0	0	60
C/J IV													
RD	48	36	15	0	9	22	5	<1	0	0	0	0	53
RC	100	0	0	0	8	18	0	0	0	9	0	0	61
RF	100	0	0	0	14	14	0	0	0	10	0	0	62
RIV	248	36	15	0	31	54	5	0	0	19	0	0	176
I%	83	12	5	0	10	18	2	0	0	6	0	0	59
C/J $\bar{x}$ I%	86	9	3	0	15	20	1	0	0	3	0	0	60

Table V-1. (cont.)

	Canopy				Shrub								
	C	RO	SC	TW	C	RO	SC	CW	SW	I	TW	Cat	J
RO V													
RD	8	82	10	<1	36	29	9	22	3	0	<1	0	0
RC	10	90	0	0	16	63	7	7	2	0	0	0	0
RF	29	71	0	0	19	48	11	17	6	0	0	0	0
RIV	47	243	10	<1	71	140	27	46	11	0	<1	0	0
I%	16	81	3	0	24	47	9	15	4	0	0	0	0
RO VI													
RD	0	75	25	0	0	73	16	8	1	0	0	0	0
RC	0	0	0	0	0	96	0	0	0	0	0	0	0
RF	0	0	0	0	0	100	0	0	0	0	0	0	0
RIV	0	75	25	0	0	269	16	8	1	0	0	0	0
I%	0	75*	25*	0	0	90	5	3	0	0	0	0	0
RO $\overline{x}$ I%	8	78	14	0	12	69	7	9	2	0	0	0	0
SC V											Wb		
RD	0	4	96	<1	0	0	97	0	0	0	3	0	0
RC	0	0	100	0	11	0	89	0	0	0	0	0	0
RF	0	0	100	0	10	10	80	0	0	0	0	0	0
RIV	0	4	296	<1	21	10	266	0	0	0	3	0	0
I%	0	1	99	0	7	3	89	0	0	0	1	0	0
SC VI													
RD	0	33	66	0	0	0	95	0	<1	0	4	0	0
RC	0	0	0	0	0	5	89	0	0	0	6	0	0
RF	0	0	0	0	4	4	79	0	0	0	18	0	0
RIV	0	33	66	0	4	9	263	0	<1	0	28	0	0
I%	0	33*	66*	0	1	3	88	0	0	0	9	0	0
SC VI A								Rb			Sa		
RD	0	0	100	0	0	0	48	8	0	0	44	0	0
RC	0	0	0	0	0	0	100	0	0	0	0	0	0
RF	0	0	0	0	0	0	93	0	7	0	0	0	0
RIV	0	0	100	0	0	0	241	8	7	0	44	0	0
I%	0	0	100*	0	0	0	80	3	2	0	15	0	0
											Wb/Sa		
SC $\overline{x}$ I%	0	11	88	0	3	2	86	1	1	0	3/3	0	0
MH V													
RD	0	0	0	0	0	0	7	89	0	0	0	--	0
RC	0	0	0	0	0	0	0	0	0	0	0	100	0
RF	0	0	0	0	0	0	0	0	0	0	0	100	0
RIV	0	0	0	0	0	0	7	89	0	0	0	200	0
I%	0	0	0	0	0	0	2	30	0	0	0	100**	0

Table V-1. (cont.)

	Canopy				Shrub								
	C	RO	SC	TW	C	RO	SC	CW	SW	I	TW	Cat	J
SB VI													
RD	0	0	0	0	20	0	0	80	0	0	0	0	0
RC	0	0	0	0	83	0	0	17	0	0	0	0	0
RF	0	0	0	0	50	0	0	50	0	0	0	0	0
RIV	0	0	0	0	153	0	0	147	0	0	0	0	0
I%	0	0	0	0	51	0	0	49	0	0	0	0	0

*RC and RF in the canopy layer totaled zero (none of the canopy species occurred in the sample plots), so RC and RF were not included in computation of I%.

**Cattails could not be counted accurately, so no density value was obtained. The I% of cattail was based on RC and RF only.

Table V-2. Total percent cover values for each selected transect and community-structure type.

C/RO I		Transects					Total	
		SE-04	KW-04	NE-01	Mean	Standard deviation	(Max. 300)	(Max. 100)
	n	10	10	10	30	30	30	
	>15 ft	92	92	95	92.8	8.0		
	2-15 ft	41	38	50	42.7	34.0	140.9	47.0
	0-2 ft	3	5	8	5.4	15.6		

C/CW I		Transects					Total	
		NW-14	SE-11	SW-08	Mean	Standard deviation	(Max. 300)	(Max. 100)
	n	10	10	10	30	30	30	
	>15 ft	74	63	56	65.1	26.8		
	2-15 ft	28	54	38	40.0	29.1	163.3	54.4
	0-2 ft	61	51	62	58.2	32.9		

C/J I		Transects				Total	
		GN-06	GN-08	Mean	Standard deviation	(Max. 300)	(Max. 100)
	n	15	15	30	30	30	
	>15 ft	48	49	49.3	25.3		
	2-15 ft	22	20	20.6	24.6	100.3	33.4
	0-2 ft	16	45	30.4	23.8		

C/RO II		Transects				Total	
		SW-03	KW-01	Mean	Standard deviation	(Max. 300)	(Max. 100)
	n	15	10	25	25	25	
	>15 ft	94	85	90.4	10.0		
	2-15 ft	7	18	11.2	14.9	115.3	38.4
	0-2 ft	12	17	13.7	21.3		

Table V-2. (cont.)

C/CW IV		Transects SE-07	NE-02	SW-02	Mean	Standard deviation	Total (Max. 300)	(Max. 100)
	n	10	10	10	30	30	30	
	>15 ft	51	51	24	41.6	27.7		
	2-15 ft	33	2	9	14.8	19.0	77.6	25.9
	0-2 ft	33	11	20	21.2	20.3		

C/RO IV		Transects GN-07	GN-10	Mean	Standard deviation	Total (Max. 300)	(Max. 100)
	n	15	15	30	30	30	
	>15 ft	44	31	38.4	29.4		
	2-15 ft	19	7	13.2	20.2	65.6	21.9
	0-2 ft	13	16	14.0	15.0		

C/J IV		Transects GN-11	GN-12	Mean	Standard deviation	Total (Max. 300)	(Max. 100)
	n	15	10	25	25	25	
	>15 ft	29	20	25.2	24.0		
	2-15 ft	21	12	17.1	22.9	72.8	24.3
	0-2 ft	36	29	30.5	21.5		

C/CW V		Transects SW-10	SW-06	NW-06	Mean	Standard deviation	Total (Max. 300)	(Max. 100)
	n	10	10	10	30	30	30	
	>15 ft	15	17	38	23.5	32.7		
	2-15 ft	87	69	55	70.5	28.8	164.7	54.9
	0-2 ft	73	57	82	70.7	34.8		

Table V-2. (cont.)

RO V	Transects			Mean	Standard deviation	Total (Max. 300)	Total (Max. 100)
	SW-00	SW-20	SW-26				
n	8	10	12	30	30	30	
>15 ft	15	0	0	4.1	11.8		
2-15 ft	43	51	78	60.0	27.6	161.4	53.8
0-2 ft	93	99	99	97.3	11.1		

MH V	Transects			Mean	Standard deviation	Total (Max. 300)	Total (Max. 100)
	SW-01	SW-29	SW-30				
n	3	12	15	30	30	30	
>15 ft	0	0	0	0.0	0.0		
2-15 ft	95	100	91	94.8	10.1	190.1	63.4
0-2 ft	100	100	90.7	95.3	18.0		

DR V	Transects			Mean	Standard deviation	Total (Max. 300)	Total (Max. 100)
	KW-03	SE-06	NW-11				
n	10	10	10	30	30	30	
>15 ft	13	4	19	11.8	23.3		
2-15 ft	81	36	72	62.7	38.8	146.2	48.7
0-2 ft	82	72	61	71.7	27.6		

SC V	Transects		Mean	Standard deviation	Total (Max. 300)	Total (Max. 100)
	GN-03	GS-08				
n	10	10	20	20	20	
>15 ft	2	0	1.0	1.4		
2-15 ft	5	18	11.4	16.4	83.0	27.7
0-2 ft	64	78	70.6	27.0		

Table V-2. (cont.)

C/CW VI		Transects			Mean	Standard deviation	Total (Max. 300)	Total (Max. 100)
		NW-13	NW-16	NW-17				
	n	8	8	12	30	30	30	
	>15 ft	0	12	0	4.2	12.9		
	2-15 ft	66	54	41	52.1	25.3	126.1	42.0
	0-2 ft	97	80	45	69.8	31.6		

DR VI		Transects			Mean	Standard deviation	Total (Max. 300)	Total (Max. 100)
		NE-05	SW-12	SE-15				
	n	10	10	10	30	30	30	
	>15 ft	0	1	0	0.3	0.8		
	2-15 ft	35	22	44	33.8	26.3	117.0	39.0
	0-2 ft	68	99	81	82.9	23.9		

RO VI		Transects	Mean	Standard deviation	Total (Max. 300)	Total (Max. 100)
		SE-18				
	n	10	10	10	10	
	>15 ft	0	0	0		
	2-15 ft	16	16.0	22.8	109.5	36.5
	0-2 ft	94	93.5	8.2		

SB VI		Transects			Mean	Standard deviation	Total (Max. 300)	Total (Max. 100)
		KW-06	NW-09	NW-12				
	n	10	10	10	30	30	30	
	>15 ft	0	0	0	0	0		
	2-15 ft	0	8	8	5.3	10.7	33.6	11.2
	0-2 ft	16	32	42	28.3	34.1		

Table V-2. (cont.)

SC VI		GN-02	GS-10	GS-14	Mean	Standard deviation	Total (Max. 300)	Total (Max. 100)
	n	10	10	10	30	30	30	
	>15 ft	0	0	0	0.0	0.0		
	2-15 ft	55	58	4	29.0	37.2	88.6	29.5
	0-2 ft	60	69	50	59.6	25.1		

SC VI A		GN-04	GN-05	GS-07	Mean	Standard deviation	Total (Max. 300)	Total (Max. 100)
	n	10	10	10	30	30	30	
	>15 ft	0	0	0	0.0	0.0		
	2-15 ft	3	3	8	4.7	7.5	68.4	22.8
	0-2 ft	37	59	96	63.7	29.7		

Table V-3. Mean foliage density profiles for each transect. Total foliage density for each transect is given in the far right column.

Transect	6 in	2 ft	5 ft	10 ft	15 ft	20 ft	25 ft	30 ft	40 ft	50 ft	60 ft	70 ft	Total
GN-01	0.613	0.328	0.270	0.069	0.039	0.013	0.003	0.001					1.335
02	0.452	0.311	0.323	0.041	0.014	0.002							1.143
03	0.381	0.181	0.172	0.054	0.017	0.006	0.001						0.812
04	0.286	0.130	0.055	0.028	0.006	0.002	0.002	0.001	0.000				0.511
05	0.311	0.089	0.050	0.035	0.008	0.001	0.000	0.000					0.495
06	0.175	0.135	0.109	0.080	0.094	0.068	0.050	0.047	0.057	0.056	0.016		0.889
07	0.120	0.080	0.151	0.157	0.118	0.155	0.144	0.113	0.018	0.000			1.057
08	0.138	0.114	0.119	0.125	0.108	0.193	0.136	0.134	0.156	0.063	0.002		1.287
09	0.102	0.065	0.006	0.004	0.003	0.003	0.001	0.001	0.001				0.187
10	0.158	0.117	0.155	0.142	0.151	0.197	0.129	0.044	0.004				1.098
11	0.242	0.184	0.136	0.144	0.123	0.095	0.115	0.052	0.015	0.002	0.000		1.108
12	0.251	0.126	0.121	0.115	0.081	0.108	0.074	0.066	0.040	0.002			0.985
13	0.350	0.266	0.220	0.296	0.329	0.242	0.180	0.258	0.094	0.014			2.249
15	0.232	0.323	0.282	0.217	0.128	0.071	0.113	0.146	0.222	0.185	0.062	0.001	1.983
16	0.240	0.243	0.304	0.118	0.121	0.087	0.104	0.101	0.071	0.055	0.014		1.457

Table V-3. (cont.)

Transect	6 in	2 ft	5 ft	10 ft	15 ft	20 ft	25 ft	30 ft	40 ft	50 ft	60 ft	70 ft	Total
CS-01	0.099	0.139	0.127	0.091	0.085	0.067	0.091	0.146	0.343	0.128	0.023		1.339
02	0.115	0.126	0.160	0.287	0.187	0.179	0.236	0.316	0.263	0.077	0.065		2.011
03	0.425	0.202	0.078	0.045	0.050	0.023	0.021	0.025	0.004				0.874
04	0.244	0.270	0.474	0.196	0.093	0.023	0.008						1.308
05	0.206	0.265	0.292	0.156	0.173	0.225	0.311	0.432	0.254	0.010			2.324
06	0.609	0.487	0.203	0.082	0.106	0.146	0.177	0.245	0.035	0.000			2.091
07	0.327	0.090	0.089	0.070	0.051	0.023	0.001						0.651
08	0.508	0.204	0.196	0.157	0.055	0.010							1.131
09	0.445	0.468	0.245	0.084	0.033	0.018	0.009	0.006	0.001	0.001			1.309
10	0.387	0.392	0.198	0.014	0.009	0.002							1.002
11	0.334	0.344	0.154	0.011	0.008	0.003	0.001						0.855
12	0.114	0.081	0.031	0.007	0.001								0.234
13	0.395	0.356	0.341	0.222	0.110	0.021							1.446
14	0.661	0.136	0.080	0.032	0.001								0.910
15	0.461	0.212	0.119	0.005	0.000								0.798
16	0.497	0.315	0.121	0.006	0.002								0.942

Table V-3. (cont.)

Transect	6 in	2 ft	5 ft	10 ft	15 ft	20 ft	25 ft	30 ft	40 ft	50 ft	60 ft	70 ft	Total
KW-01	0.153	0.181	0.111	0.143	0.088	0.065	0.053	0.224	0.219	0.272	0.102		1.610
02	0.215	0.210	0.247	0.273	0.262	0.294	0.271	0.268	0.209	0.118	0.002		2.369
03	0.544	0.521	0.294	0.097	0.061	0.016	0.009	0.006	0.003				1.552
04	0.122	0.157	0.303	0.320	0.280	0.237	0.239	0.181	0.238	0.101	0.028		2.205
05	0.125	0.151	0.215	0.174	0.177	0.146	0.221	0.270	0.166	0.005			1.651
06	0.090	0.018	0.004										0.112
07	0.153	0.215	0.273	0.279	0.280	0.262	0.317	0.423	0.234				2.436
NW-06	0.384	0.222	0.198	0.111	0.148	0.118	0.083	0.026	0.007	0.001	0.000		1.298
07	0.263	0.187	0.197	0.108	0.126	0.088	0.126	0.133	0.179	0.012			1.419
08	0.552	0.317	0.101	0.075	0.083	0.104	0.110	0.072	0.013	0.002			1.430
09	0.204	0.035	0.006										0.246
10	0.483	0.220	0.289	0.073	0.126	0.106	0.170	0.166	0.155	0.022	0.008		1.819
11	0.640	0.507	0.245	0.054	0.032	0.027	0.025	0.081	0.035	0.027			1.675
12	0.212	0.032	0.009										0.252
13	0.556	0.411	0.219	0.031	0.011								1.228

Table V-3. (cont.)

Transect	6 in	2 ft	5 ft	10 ft	15 ft	20 ft	25 ft	30 ft	40 ft	50 ft	60 ft	70 ft	Total
NW-14	0.457	0.305	0.203	0.142	0.111	0.131	0.113	0.200	0.320	0.002			1.985
15	0.092	0.073	0.103	0.101	0.154	0.211	0.229	0.182	0.012				1.157
16	0.630	0.222	0.101	0.074	0.022	0.006	0.004						1.059
17	0.213	0.193	0.217	0.047	0.011								0.682
18	0.306	0.208	0.236	0.235	0.303	0.187	0.169	0.191	0.111	0.092	0.014		2.053
NE-01	0.122	0.133	0.157	0.215	0.255	0.170	0.152	0.263	0.490	0.205	0.005		2.168
02	0.061	0.099	0.095	0.092	0.093	0.135	0.207	0.183	0.137	0.002			1.104
03	0.111	0.094	0.107	0.123	0.214	0.117	0.095	0.161	0.036	0.001			0.968
04	0.139	0.121	0.255	0.122	0.127	0.081	0.082	0.118	0.050				1.095
05	0.510	0.227	0.045	0.001									0.783
07	0.429	0.405	0.238	0.388	0.214	0.041	0.002						1.718
SW-00	0.354	0.270	0.272	0.205	0.148	0.030	0.003	0.000	0.000				1.284
01	0.632	0.690	0.632										1.955
02	0.182	0.094	0.083	0.072	0.089	0.080	0.037	0.038	0.007				0.683
03	0.155	0.126	0.103	0.068	0.053	0.048	0.066	0.060	0.142	0.316			1.137

Table V-3. (cont.)

Transect	6 in	2 ft	5 ft	10 ft	15 ft	20 ft	25 ft	30 ft	40 ft	50 ft	60 ft	70 ft	Total
SW-04	0.259	0.119	0.150	0.126	0.139	0.222	0.299	0.352	0.352	0.161	0.003		2.182
05	0.509	0.437	0.143	0.004	0.003	0.001	0.001						1.099
06	0.483	0.376	0.460	0.165	0.064	0.069	0.046	0.022	0.010	0.000			1.695
07	0.301	0.284	0.266	0.073	0.091	0.061	0.041	0.026	0.002				1.146
08	0.318	0.284	0.212	0.107	0.157	0.162	0.241	0.204	0.112	0.002			1.797
09	0.306	0.283	0.451	0.194	0.167	0.167	0.074	0.025	0.003				1.670
10	0.644	0.402	0.414	0.324	0.153	0.057	0.029	0.017	0.040	0.043	0.027		2.151
11	0.483	0.292	0.310	0.496	0.252	0.105	0.153	0.194	0.156	0.019	0.000		2.461
12	0.675	0.539	0.127	0.019	0.008	0.007	0.026	0.025	0.014	0.006			1.445
13	0.352	0.259	0.215	0.174	0.149	0.224	0.264	0.325	0.174	0.030			2.166
14	0.281	0.187	0.165	0.279	0.183	0.160	0.139	0.097	0.069	0.011			1.571
15	0.363	0.213	0.093	0.046	0.011	0.004							0.729
16	0.443	0.266	0.260	0.078	0.071	0.082	0.087	0.035	0.023	0.011	0.001		1.357
18	0.296	0.297	0.242	0.203	0.148	0.220	0.229	0.337	0.257	0.002			2.231
19	0.261	0.287	0.300	0.328	0.338	0.214	0.231	0.231	0.113	0.003			2.305

Table V-3. (cont.)

Transect	6 in	2 ft	5 ft	10 ft	15 ft	20 ft	25 ft	30 ft	40 ft	50 ft	60 ft	70 ft	Total
SW-20	0.587	0.233	0.298	0.267	0.145	0.027	0.005	0.001					1.563
21	0.349	0.260	0.331	0.251	0.152	0.236	0.204	0.310	0.191	0.005			2.288
22	0.608	0.426	0.168	0.061	0.053	0.014	0.003	0.003	0.002				1.337
24	0.387	0.265	0.324	0.345	0.168	0.183	0.181	0.170	0.095	0.012	0.003		2.133
26	0.680	0.421	0.306	0.139	0.059	0.012	0.001						1.618
27	0.430	0.378	0.496	0.270	0.084	0.034	0.072	0.075	0.111	0.065	0.004		2.020
28	0.678	0.401	0.075	0.015	0.017	0.011	0.007	0.002					1.205
29	0.640	0.640	0.640										1.919
30	0.567	0.581	0.473	0.268	0.063	0.001							1.953
31	0.664	0.649	0.315	0.051	0.024	0.011	0.001						1.176
32	0.640	0.617	0.202	0.015	0.005	0.003	0.001						1.485
SE-04	0.083	0.141	0.195	0.203	0.115	0.206	0.167	0.190	0.372	0.303	0.140		2.116
05	0.097	0.149	0.300	0.406	0.206	0.302	0.377	0.548	0.438	0.055	0.001		2.879
06	0.477	0.296	0.212	0.222	0.116	0.053	0.010	0.000	0.000				1.386
07	0.150	0.123	0.110	0.119	0.135	0.189	0.133	0.067	0.005				1.031

Table V-3. (cont.)

Transect	6 in	2 ft	5 ft	10 ft	15 ft	20 ft	25 ft	30 ft	40 ft	50 ft	60 ft	70 ft	Total
SE-08	0.243	0.196	0.177	0.103	0.103	0.206	0.211	0.278	0.146	0.009			1.673
09	0.103	0.047	0.043										0.153
10	0.238	0.362	0.514	0.477	0.273	0.212	0.087	0.029	0.008				2.200
11	0.269	0.323	0.201	0.172	0.224	0.138	0.157	0.225	0.146	0.001	0.000		1.856
12	0.145	0.101	0.197	0.178	0.171	0.207	0.451	0.555	0.408	0.022	0.001		2.436
13	0.517	0.292	0.108	0.033	0.027	0.026	0.024	0.003	0.001				1.032
14	0.217	0.286	0.454	0.386	0.261	0.297	0.343	0.196	0.013	0.005	0.004		2.462
15	0.601	0.412	0.163	0.070	0.029	0.027	0.024	0.024	0.000				1.350
16	0.459	0.428	0.382	0.196	0.092	0.074	0.051	0.038	0.013	0.001			1.733
17	0.192	0.218	0.248	0.246	0.117	0.134	0.090	0.082	0.107	0.025	0.000		1.460
18	0.276	0.154	0.097	0.033	0.011	0.002							0.573
19	0.275	0.254	0.339	0.197	0.228	0.132	0.166	0.039	0.005				1.634
20	0.492	0.283	0.441	0.242	0.178	0.131	0.170	0.288	0.229	0.069	0.027		2.550
21	0.565	0.566	0.302	0.016	0.005								1.455
22	0.114	0.079	0.084	0.063	0.251	0.247	0.165	0.071	0.019	0.013	0.010	0.002	1.118

Table V-3. (cont.)

Transect	6 in	2 ft	5 ft	10 ft	15 ft	20 ft	25 ft	30 ft	40 ft	50 ft	60 ft	70 ft	Total
SE-23	0.311	0.160	0.018	0.023	0.043	0.023	0.024	0.039	0.031	0.025			0.697
24	0.225	0.197	0.297	0.522	0.320	0.131	0.074	0.066	0.050	0.057	0.014		1.933
25	0.632	0.494	0.224	0.006									1.357

Table V-4. Foliage height diversity values for each transect and community-structure type. Foliage height layers used were: 0-2 ft (herbaceous layer), 5-15 ft (shrub layer), and >20 ft (canopy layer).

Community-structure type	Transect	Foliage height diversity
Cottonwood/Russian olive I	GN-15	1.087
	GN-16	1.094
	KW-04	0.983
	NW-07	1.094
	NE-01	0.921
	SE-04	0.861
	SE-05	0.882
	SE-20	1.096
	SW-18	1.059
	SW-19	1.073
	SW-21	1.082
	SW-27	1.038
Cottonwood/coyote willow I	GS-02	0.941
	GS-05	1.012
	GS-06	1.011
	KW-02	1.023
	KW-07	0.997
	NW-14	1.069
	NW-18	1.082
	SE-08	1.033
	SE-11	1.097
	SE-12	0.832
	SW-04	0.907
	SW-24	1.091
Cottonwood/juniper I	GN-06	1.098
	GN-08	1.010
Cottonwood/Russian olive II	KW-01	0.970
	SW-03	0.992
Cottonwood/coyote willow II	SE-22	1.025
	GS-01	0.952
Cottonwood/Russian olive III	SE-19	1.052
Cottonwood/coyote willow III	SE-10	0.960
	SE-14	1.052
	SE-24	0.972
	SW-14	1.089
Cottonwood/Russian olive IV	GN-07	1.047
	GN-10	1.080

Table V-4. (cont.)

Community-structure type	Transect	Foliage height diversity
Cottonwood/coyote willow IV	KW-05	1.016
	NE-02	0.934
	NE-03	1.060
	NE-04	1.061
	NW-15	0.970
	SE-07	1.087
	SW-02	1.075
Cottonwood/juniper IV	GN-11	1.083
	GN-12	1.093
Cottonwood/coyote willow V	NW-06	1.033
	NW-10	1.088
	SW-06	0.922
	SW-09	1.012
	SW-10	0.944
	SW-11	1.075
	SW-16	1.006
Cottonwood V	NE-07	0.792
Russian olive V	GS-13	0.759
	SW-00	0.798
	SW-20	0.778
	SW-26	0.663
Drain V	KW-03	0.701
	SW-31	0.575
	SW-32	0.444
Marsh V	SW-29	0.637
	SW-30	0.681
Miscellaneous V	GN-01	0.658
Salt cedar V	GN-03	0.656
	GS-08	0.700
Cottonwood/coyote willow VI	NW-13	0.548
	NW-16	0.534
	NW-17	0.675
Russian olive VI	SE-18	0.579
Drain VI	GN-09	0.406
	GS-03	0.766
	GS-12	0.759
	NE-05	0.225

Table V-4. (cont.)

Community-structure type	Transect	Foliage height diversity
Drain VI (cont.)	NW-08	0.940
	NW-11	0.832
	SE-06	0.833
	SE-13	0.642
	SE-15	0.694
	SE-21	0.530
	SE-23	0.845
	SE-25	0.455
	SW-05	0.415
	SW-12	0.543
	SW-15	0.540
	SW-22	0.593
	SW-28	0.380
Salt cedar VI	GN-02	0.644
	GN-04	0.519
	GN-05	0.508
	GS-07	0.771
	GS-09	0.701
	GS-10	0.542
	GS-11	0.534
	GS-14	0.375
	GS-15	0.433
	GS-16	0.400
Sandbar VI	KW-06B	0.140
	NW-09B	0.121
	NW-12B	0.152
	SE-09B	0.108
	SW-25B	0.455

APPENDIX VI.

SUPPLEMENTARY DATA ON AMPHIBIANS AND REPTILES

Table VI-1. Capture rates of reptiles and amphibians in the intensive study area by species, for each community-structure type and year. The mean overall capture rate and number of species for both years combined is given at bottom. All capture rates are expressed as the number captured per 100 trapdays.

	C/RO I			C/CW I		C/RO II		C/CW E III	C/CW IV			C/CW V		(OP V)	MH V
Species	1981	1981	1982	1981	1982	1981	1982	1982	1981	1981	1982	1981	1982	1982	1981
Plains spadefoot toad										.04					
Woodhouse toad					.04					.19	.04	.05			
Great Plains toad										.05	.04				
Chorus frog		.05												.28	
Eastern fence lizard	.57			.70	1.46	1.11	.77	.16	2.92	2.05	2.32	.23	.74		
Great Plains skink				.05	.04							.05		.06	.12
New Mexican whiptail				.19	.32			.31	.05	.47	.37	.28		.23	.47
Chihuahuan whiptail	.10												.20		
Common gartersnake								.04							
Number of species		3	0	3	4	1	1	3	5		4	4		5	2
Number/100 trap days		.36	0.00	.94	1.86	1.11	.77	.51	2.89		2.77	.61	.94	.57	.59
Number of species 1981 and 1982		3		4		1		3		5			6		2
Number/100 trap days 1981 and 1982		.18		1.60		.94		.51		2.83			.68		.59

Table VI-1. (cont.)

Species	RD V		C/CW VI A		C/CW VI		DR VI		SB VI		OP VI
	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982	1982
Tiger salamander											.20
Plains spadefoot toad					.05		.05				
Woodhouse toad	.19	.12	.05		.10	.12	.15	.08	.87	.76	1.30
Bullfrog											.95
Spiny softshell turtle	.05										
Eastern fence lizard	.05		.38	.16	.35	.47	1.74	.12	.48	.08	.07
Great Plains skink	.05							.53			
New Mexican whiptail		.06		.12	.20	.98	1.39	1.22	.44	.38	.14
Chihuahuan whiptail			.05	.08	.05	1.02			.19	.08	.07
Common gartersnake		.06							.05		
Number of species	4	3	3	3	5	4	4	4	5	4	6
Number/100 trap days	.34	.24	.48	.35	.75	2.59	3.33	1.95	2.03	1.30	2.73
Number of species 1981 and 1982	6		4		5		5		5		6
Number/100 trap days 1981 and 1982	.29		.42		1.67		2.64		1.67		2.73

See A-90 after A-88 →

Capture Rates and Timing of Reproduction in Eastern Fence Lizards and New Mexican Whiptails

Snout-vent length was recorded for all captured reptiles and amphibians. Assuming that the frequency of capture of individuals of certain sizes reflects to some extent the actual size class distribution of that species population, these data provide insight into activity seasons, approximate age structure, and timing of reproduction in these populations. There were sufficient sample sizes to warrant summarization of these data for the two most commonly captured species.

Monthly capture rates for eastern fence lizards (Sceloporus undulatus) and New Mexican whiptails (Cnemidophorus neomexicanus) in 1981 are illustrated in Figure VI-1. Figures VI-2 and VI-3 present frequency histograms of monthly capture rates by 10-mm size classes for eastern fence lizards and New Mexican whiptails, respectively, in 1981.

Two major peaks were observable in the monthly capture rates for eastern fence lizards in 1981. The first was in June, evidently representing individuals that overwintered (Fig. VI-1); none of the June lizards was less than 30 mm and most were over 40 mm in length (Fig. VI-2). Capture rates decreased sharply in July, then rose in August as hatchlings (individuals ≤30 mm) began to appear in the traps. Hatchlings made up 39% of all August captures and increased to 51% in September, when overall capture rates also increased again. Another 43% of the individuals captured in September were in the 30-40 mm size class, presumably reflecting growth of the first group of 1981 hatchlings.

The second and larger peak in 1981 eastern fence lizard capture rate occurred in October, with 68% of captured individuals being in the 30-40 mm size class and 14% in the 20-30 mm class; the latter may represent another cohort of hatchlings. Although overall capture rate of eastern fence lizards dropped, the proportion of 20-30 mm individuals among the November captures (53%) was much greater than the 14% observed in October. The remaining 47% of individuals captured in November were 30-40 mm; no larger lizards were caught. This may support the idea of a second hatch in fall, and/or simply reflect the fact that larger individuals, both larger young of the year and individuals more than a year old, entered dormancy at an earlier date than the smallest of the season's hatchlings.

S. Crowley (pers. comm.), working with eastern fence lizards from a study area at the base of the Sandia Mountains, found that most females lay two clutches per season. He found that the mean size of hatchlings is approximately 23 mm, and that they grow at a rate of approximately 0.3 mm/day under favorable conditions. These data agree closely with our observations. Crowley also observed two groups of hatchlings at his study area, one in mid-July and another in September, and he found that the larger adult lizards go into dormancy several weeks before the young.

The graph of 1981 monthly capture rates for New Mexican whiptails showed a pattern similar to that shown by eastern fence lizards. The first peak in capture rate was observed in June (Fig. VI-1) and most of the animals captured then were relatively large (≥50 mm; Fig. VI-3).

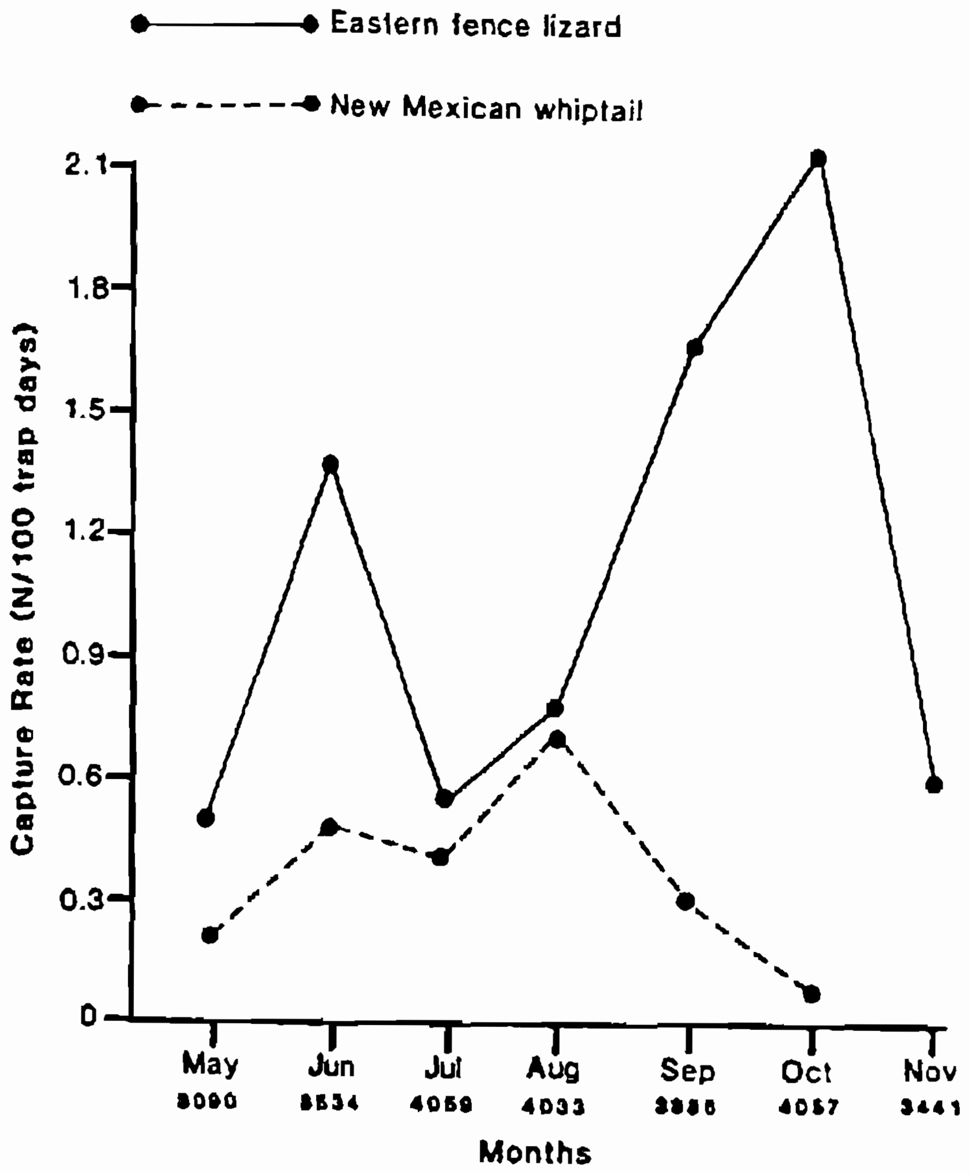

Figure VI-1. Monthly capture rates of eastern fence lizards and New Mexican whiptails, May-November 1981. The number of trap days per each month is given below the name of that month.

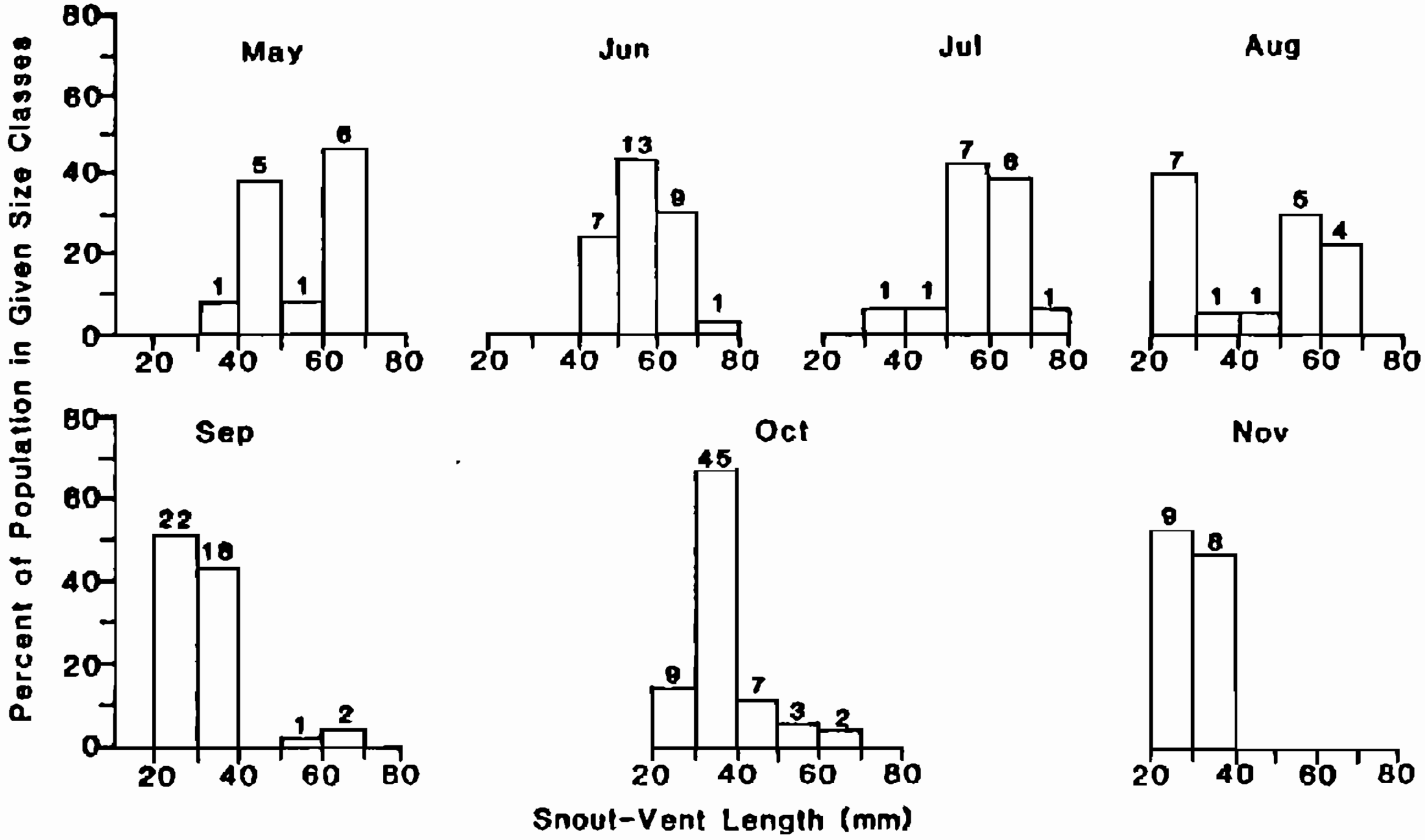

Figure VI-2. Monthly size-class distributions of captured eastern fence lizards, May-November 1981.

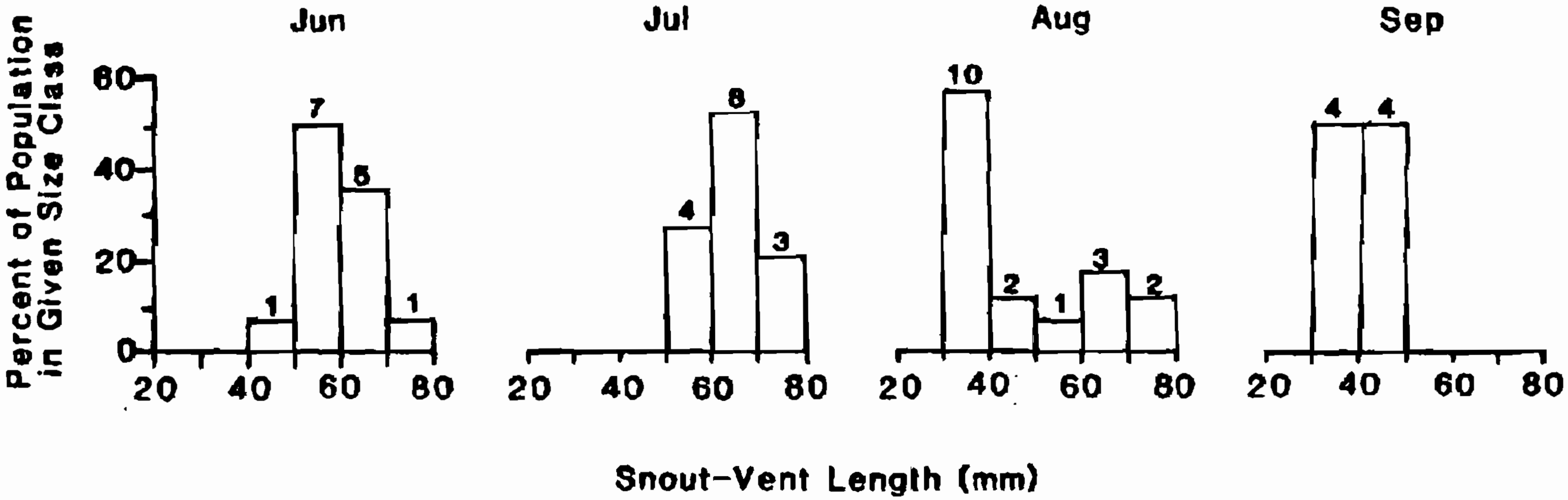

Figure VI-3. Monthly size-class distributions of captured New Mexican whiptails, June-September 1981.

Capture rate declined slightly in July, then reached a second peak in August as the young whiptails (<40 mm) began to appear in traps. As in fence lizards, the proportion of small (<50 mm) whiptails to larger (≥50 mm) generally increased through the season (Fig. VI-3). Capture rate declined sharply after August and no whiptails were captured after early October. All the late-season whiptails were small (<50 mm).

The 1982 capture data for these two species of lizards were in most ways similar to the 1981 data. The major difference was that the overall capture rates of both species in late summer were notably lower in 1982 than in 1981.

In 1982, the pattern of early summer capture rates for both species was similar to that observed in 1981, with peaks for both occurring in June (Fig. VI-4). Relatively more whiptails were captured in 1982, however. As in 1981, the May and June captures consisted primarily of large individuals, ≥40 mm in eastern fence lizards (Fig. VI-5) and ≥50 mm in New Mexican whiptails (Fig. VI-6). Individuals in the smaller size classes began to appear in the traps at the same time as they had the previous year. Eastern fence lizards <30 mm were found starting in July and made up an increasing proportion of total captures thereafter through November. New Mexican whiptails <50 mm began appearing in the traps in large numbers in August and increased in proportion of total captures over the remaining two months.

The capture rate maxima observed in both species in association with the capture of larger proportions of small individuals in 1981 were not observed in 1982, however. In eastern fence lizards, capture rate dropped sharply after June 1982 and increased thereafter much more slowly than it had the previous year. There was a second peak in capture rate of eastern fence lizards in October, but it was lower than the June peak and much lower than the October 1981 peak. Only about one-third as many individuals were captured in October 1982 as in October 1981.

For New Mexican whiptails, capture rate declined gradually from June 1982 through October, never reaching a second peak. However, the actual number of individuals captured between August and October was not very much lower than in 1981. The overall pattern of capture rates was different for this species because of the relatively greater number of captures in June and July the second year. Small sample sizes may have been a problem.

These data suggest that the number of young produced in 1982 was less than the number produced in 1981, particularly for eastern fence lizards. This may have been related to the higher water table associated with higher runoff and rates of water release from Cochiti Dam in 1982. Peak flows were observed in June and July. It is possible that many sites that were suitable for hatching lizard eggs in 1981 were too wet in 1982.

The earlier start of trapping in 1982 yielded a more complete picture on the length of the activity season in these two common species. At least a few eastern fence lizards were active throughout the period from March

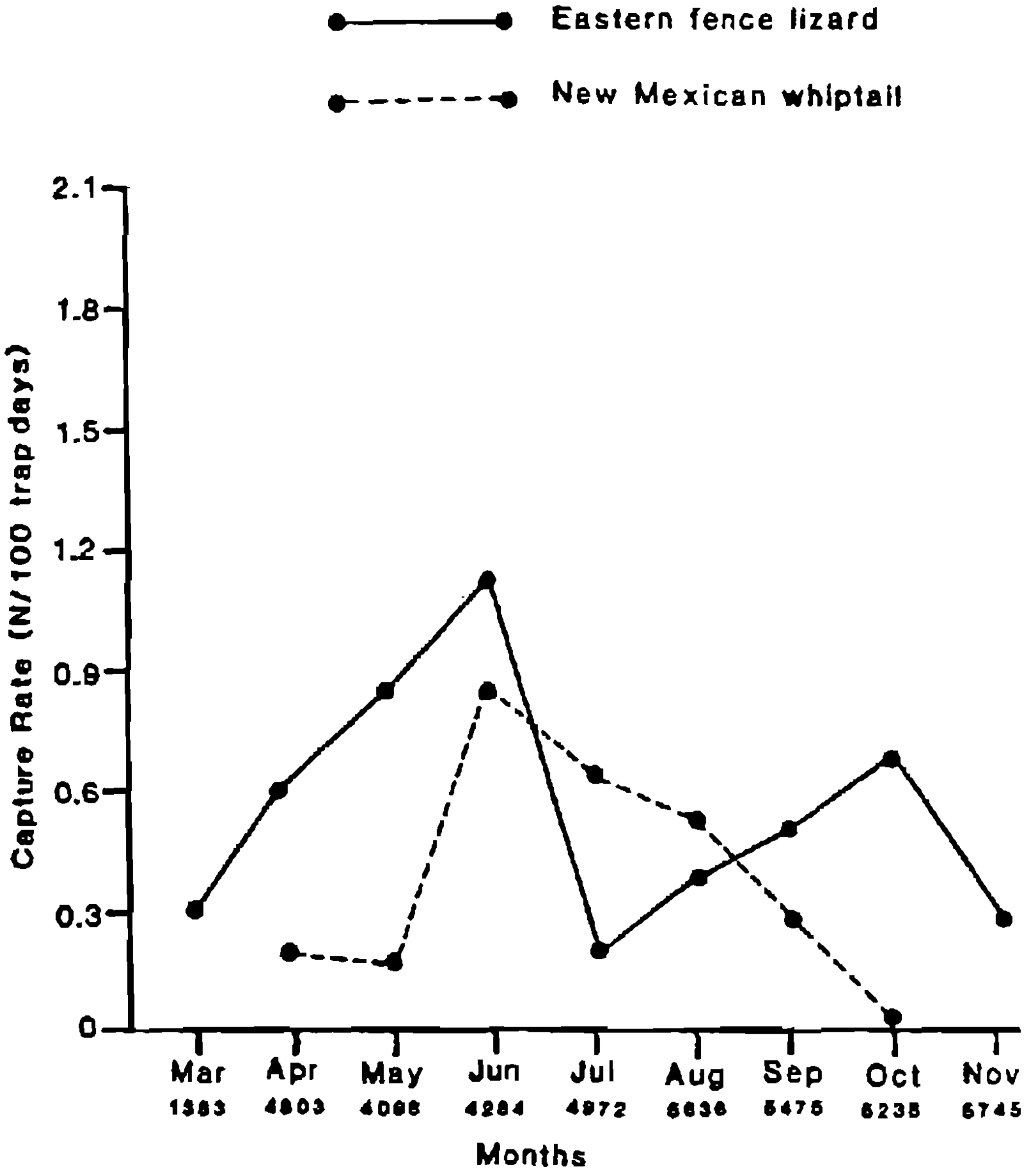

Figure VI-4. Monthly capture rates of eastern fence lizards and New Mexican whiptails, March-November 1982. The number of trap days per each month is given below the name of that month.

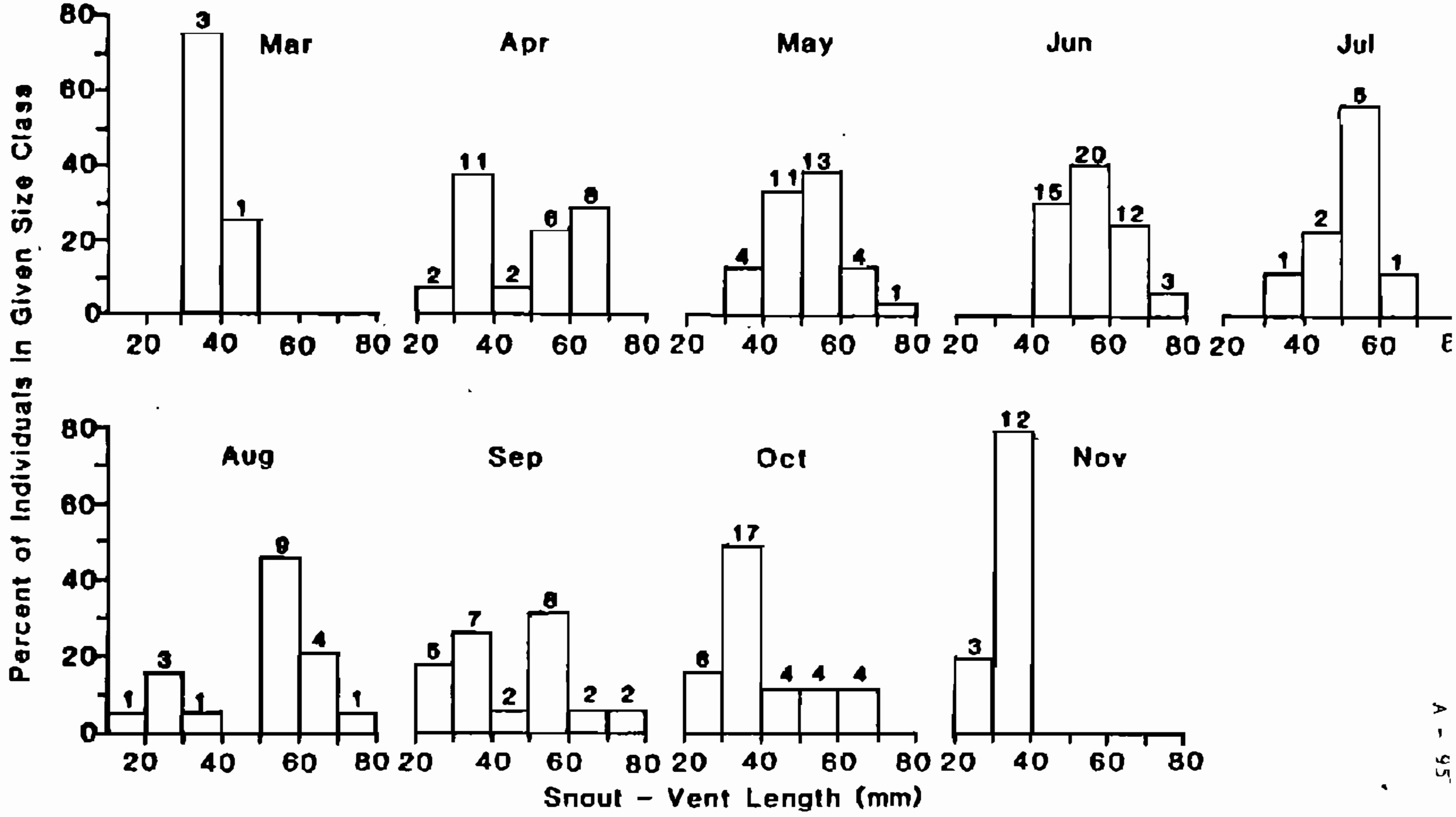

Figure VI-5. Monthly size-class distributions of captured eastern fence lizards, March-November 1982.

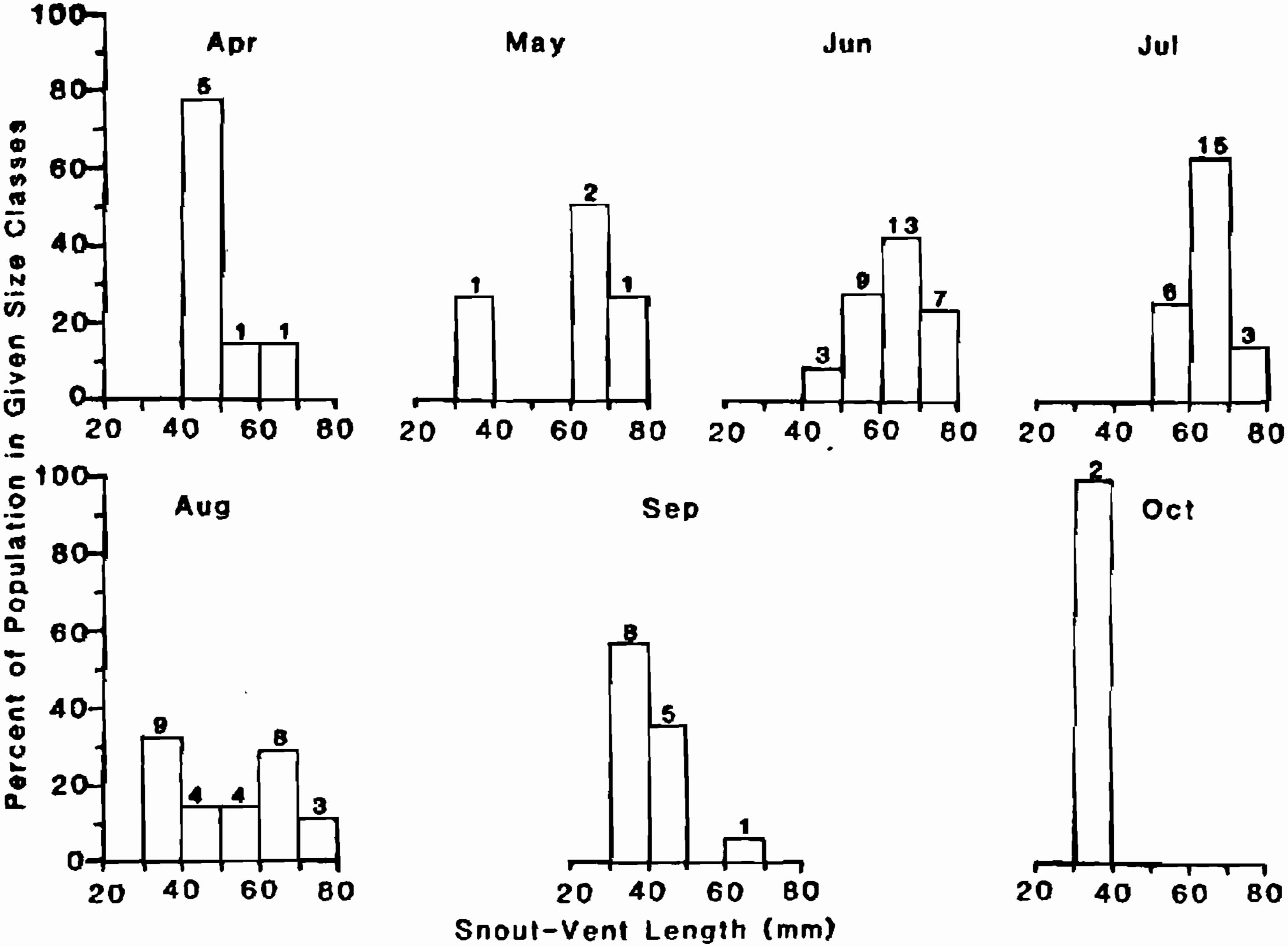

Figure VI-6. Monthly size-class distributions of captured New Mexican whiptails, April-October 1982.

through November. Single individuals were also sighted on unusually warm days as early as the last week in February. New Mexican whiptails apparently have a shorter activity season, approximately April through early October. The shorter activity season of whiptails relative to fence lizards, suggested by our data, may be in part an artifact of the lower overall capture rate (and abundance) of the whiptails. However, whiptails tend to be active at higher ambient temperatures than many other lizards so it is not unlikely that their activity season is actually somewhat shorter than that of eastern fence lizards.

APPENDIX VII.

SUPPLEMENTARY DATA ON BIRD POPULATIONS

NOTE: Values for the column labeled "All routes" in Tables VII-1 through VII-8 were derived by dividing the total number of birds detected on all transects by the total length of all transects combined.

Summaries of seasonal bird species densities for each community-structure type by season, for the intensive study area and the general study area, are included in the Supplements to this Appendix.

Table VII-1. Raptor/large bird detection rates for each census route, spring 1981. Detection rates are expressed as the number of birds seen per 10 miles.

	Census routes							
Species	1	2	5	6	7	8	9	All routes
Pied-billed Grebe		0.2	0.4		0.3		0.4	0.2
Great Blue Heron	0.2				0.3	0.1		0.1
Snowy Egret					2.0			0.4
Green-backed Heron	0.2					0.4	1.0	0.2
Black-crowned Night-Heron					0.1	0.1		0.1
White-faced Ibis						6.0		1.1
Wood Duck						0.6		0.1
Green-winged Teal						0.1	1.8	0.3
Mallard	0.9	2.3	6.6	3.8	10.3	19.8	9.7	8.6
Blue-winged Teal						0.4		0.1
Cinnamon Teal					0.3		0.8	0.2
Turkey Vulture	1.3					0.3	0.2	0.2
Osprey						0.1		0.0
Mississippi Kite				0.4				0.1
Northern Harrier				0.2		0.1	0.2	0.1
Sharp-shinned Hawk							0.2	0.0
Cooper Hawk	0.9	0.2			0.4	0.3	0.4	0.3
Northern Goshawk	0.2							0.0
Swainson Hawk					0.4	0.3	0.2	0.2
Red-tailed Hawk			0.4			0.6	0.4	0.2
American Kestrel	4.7	6.6	5.8	5.8	5.6	9.6	7.1	6.6
Prairie Falcon				0.2				0.0
Ring-necked Pheasant	1.5	0.6	0.8	0.6	1.5	1.2	0.4	1.0
Virginia Rail			0.8					0.1
American Coot							0.2	0.0
Killdeer				1.0	0.1		0.8	0.3
Spotted Sandpiper		0.4			0.1			0.1
Long-billed Curlew						1.6		0.3
Long-billed Dowitcher						1.6		0.3
Ring-billed Gull	0.4							0.1
Greater Roadrunner	2.4	6.7	1.9	5.4	3.5	3.4	2.2	3.8
Belted Kingfisher	1.9		0.4	0.2	0.3			0.4
Total detection rate	14.5	17.4	17.1	17.7	25.3	46.9	26.0	25.2
Total number of species	11	7	8	9	14	19	16	32

Table VII-2. Raptor/large bird detection rates for each census route, spring 1982.

Species	Census routes 1	2	5	6	7	8	9	All routes
Pied-billed Grebe		0.1						0.0
Great Blue Heron	0.1		1.6	0.3	0.2	0.6	1.9	0.6
Snowy Egret			0.8	0.9	0.6	0.4	0.8	0.5
Green-backed Heron	0.1			1.3	0.4	0.5	0.7	0.5
Black-crowned Night-Heron				0.1	0.2	0.5	1.7	0.4
White-faced Ibis		0.9				1.9		0.5
Wood Duck						0.6		0.1
Green-winged Teal			0.5	0.5		1.4	0.3	0.4
Mallard	1.7	2.5	13.4	17.8	9.4	15.5	45.4	14.9
Northern Pintail				2.0				0.3
Blue-winged Teal			0.5		0.2	0.2		0.1
Cinnamon Teal			5.9		0.1		0.7	0.7
Northern Shoveler	1.4			0.1				0.0
Gadwall			0.5		0.3			0.1
American Wigeon		0.6	9.6					0.8
Lesser Scaup					0.1			0.0
Common Goldeneye			0.5					0.0
Common Merganser	0.3				0.1	0.9	0.7	0.3
Turkey Vulture	0.4				0.2	0.2	0.4	0.2
Osprey		0.1			0.1			0.0
Mississippi Kite				0.3				0.0
Northern Harrier						0.3	0.4	0.1
Sharp-shinned Hawk	0.4		0.3		0.1	0.2	0.4	0.2
Cooper Hawk	0.6	0.2		0.3		0.3	0.1	0.2
Broad-winged Hawk							0.1	0.0
Swainson Hawk	0.3					0.2	0.1	0.1
Red-tailed Hawk	1.7	1.2	2.8	1.5	1.2	2.6	3.7	2.1
Ferruginous Hawk	0.1				0.1	0.4	0.1	0.1
American Kestrel	6.7	6.2	9.6	14.3	5.7	20.5	14.6	11.3
Ring-necked Pheasant	1.0	0.1	3.6	1.1	0.4	1.2	0.8	1.0
Sandhill Crane					27.5	38.1	308.9	54.8
Killdeer	0.1	0.4		0.5	0.3	1.6	1.2	0.7
Greater Yellowlegs						0.8		0.3
Lesser Yellowlegs						1.5		0.1
Spotted Sandpiper					0.1		0.3	0.1
Long-billed Curlew							0.5	0.1
Long-billed Dowitcher						0.2		0.0
Franklin Gull						0.6		0.1
Ring-billed Gull	1.7			0.8		10.4	9.8	3.6
Greater Roadrunner	2.8	6.6	1.8	11.5	3.2	10.2	4.0	6.1

Table VII-2. (cont.)

Species	Census routes 1	2	5	6	7	8	9	All routes
Western Screech-Owl	0.1							0.0
Great Horned Owl						0.1		0.0
Belted Kingfisher	1.1	0.1	0.3	0.1	1.0	0.5	1.1	0.6
Total detection rate	20.9	19.2	51.7	53.5	51.3	112.1	398.4	101.8
Total number of species	18	12	15	17	22	29	25	43

Table VII-3. Raptor/large bird detection rates for each census route, summer 1981.

Species	Census routes 1	2	5	6	7	8	9	All routes
Pied-billed Grebe			0.3		0.1			0.0
Great Blue Heron				0.1	0.3		0.1	0.1
Snowy Egret						0.1		0.0
Green-backed Heron	0.4		1.3	1.2	1.0	0.8	4.2	1.2
Black-crowned Night-Heron			0.3	0.1	0.5		0.7	0.2
Wood Duck			0.5					0.0
Mallard	0.1	0.5	4.1	0.9	4.0	2.5	2.2	2.1
Cinnamon Teal				0.8	0.2		0.3	0.2
Gadwall	0.1							0.0
Turkey Vulture	0.7						0.1	0.1
Mississippi Kite				1.6				0.2
Cooper Hawk	0.3			0.5		0.1		0.1
Broad-winged Hawk				0.1				0.0
Swainson Hawk					0.4		0.1	0.1
Red-tailed Hawk						0.3		0.1
American Kestrel	0.3	9.6	8.3	7.8	11.1	13.6	14.4	10.9
Ring-necked Pheasant	0.4	0.1	1.0	1.2			0.4	0.4
Killdeer	0.3	0.6	2.3	2.1	0.6	0.3	0.7	0.9
Solitary Sandpiper	0.1				0.1			0.0
Spotted Sandpiper	0.1	0.2		0.1			0.1	0.1
Greater Roadrunner	3.1	5.0	2.6	8.0	7.0	6.2	9.9	6.3
Belted Kingfisher	4.0	0.4	0.5	0.4	0.1	0.2	0.3	0.7
Total detection rate	19.1	16.5	21.2	25.2	25.4	24.0	33.6	23.9
Total number of species	12	7	10	14	12	9	13	22

Table VII-4. Raptor/large bird detection rates for each census route, summer 1982.

Species	Census routes							All routes
	1	2	5	6	7	8	9	
Pied-billed Grebe						0.1		0.0
Great Blue Heron				0.3		0.1	0.1	0.1
Great Egret						0.1		0.0
Snowy Egret			1.0		5.1	1.8	3.4	1.9
Little Blue Heron							0.1	0.0
Green-backed Heron	0.4	0.2	0.5	1.9	3.4	2.4	3.7	2.0
Black-crowned Night-Heron			1.0	0.4	1.2	0.5	1.9	0.7
Green-winged Teal						0.1		0.0
Mallard	0.7	0.1	12.1	0.9	8.2	6.4	8.2	5.0
Cinnamon Teal			0.3		0.7			0.2
Turkey Vulture	0.3				0.4	0.7	0.3	0.3
Mississippi Kite			0.3	1.1		0.8	0.5	0.4
Northern Harrier					0.1			0.0
Cooper Hawk	0.3			0.1	0.2		0.7	0.2
Swainson Hawk			0.3		0.3	0.2		0.1
Red-tailed Hawk	0.1					0.2	0.3	0.1
American Kestrel	6.6	5.8	6.2	7.9	5.1	16.6	7.1	8.2
Prairie Falcon						0.1		0.0
Ring-necked Pheasant	0.4	0.1	0.3	0.7		0.3	0.8	0.3
Killdeer	0.1	0.6	2.1	1.2	0.2	0.5		0.5
Spotted Sandpiper	0.3				0.1			0.1
Ring-billed Gull							0.9	0.1
Greater Roadrunner	2.4	4.7	2.8	4.7	4.9	8.2	4.8	5.0
Great Horned Owl						0.7		0.1
Belted Kingfisher	0.9	0.1		0.9	0.9	0.2		0.5
Total detection rate	12.5	11.9	26.9	20.1	30.8	39.8	32.8	26.0
Total number of species	11	7	11	11	14	19	14	25

Table VII-5. Raptor/large bird detection rates for each census route, fall 1981.

Species	Census routes: 1	2	5	6	7	8	9	All routes
Pied-billed Grebe						0.1	0.3	0.1
Great Blue Heron	0.7		0.3	0.5	0.9	1.4	1.3	0.8
Snowy Egret					0.2			0.0
Green-backed Heron				0.4	0.1	0.1	1.7	0.3
Black-crowned Night-Heron							0.1	0.0
White-faced Ibis					1.6			0.3
Green-winged Teal						0.4		0.1
Mallard				0.7		1.2	0.4	0.4
Turkey Vulture	0.6	1.1	0.8		0.1	0.7	1.7	0.7
Northern Harrier		0.1		0.3	0.1	1.0	0.1	0.3
Sharp-shinned Hawk	0.1	0.1	0.3	0.4	0.3	0.4	0.3	0.3
Cooper Hawk	0.4			0.1	0.2	0.4	0.3	0.2
Swainson Hawk						0.2		0.0
Red-tailed Hawk	0.7	0.5	1.8	1.2	1.7	2.1	4.2	1.8
Ferruginous Hawk			0.5			0.2	0.4	0.1
Rough-legged Hawk						0.1		0.0
American Kestrel	3.1	3.7	5.2	3.6	4.4	6.9	4.9	4.6
Ring-necked Pheasant			0.8	0.1	0.6	0.6	0.7	0.4
Sandhill Crane			25.8	13.8	8.2	341.7	4.5	68.8
Whooping Crane						0.3		0.1
Killdeer				0.1		0.2		0.1
Solitary Sandpiper							0.1	0.0
Spotted Sandpiper					0.1			0.0
Greater Roadrunner	1.6	1.4	2.3	5.0	4.0	4.0	2.6	3.1
Great Horned Owl						0.1		0.0
Belted Kingfisher	1.3	0.1	0.5		0.9	0.3	1.6	0.7
Total detection rate	8.5	7.1	38.2	26.2	23.3	362.2	25.3	83.2
Total number of species	8	7	10	12	15	21	17	26

Table VII-6. Raptor/large bird detection rates for each census route, fall 1982.

Species	Census routes 1	2	5	6	7	8	9	All routes
Pied-billed Grebe		0.1				0.1	0.1	0.1
Great Blue Heron	0.3		0.3	0.4	0.5	0.7	2.0	0.6
Snowy Egret					1.5			0.3
Green-backed Heron				0.7	0.3	0.2	0.4	0.2
White-faced Ibis			0.5					0.0
Canada Goose					2.2	1.2		0.7
Wood Duck				0.3				0.0
Green-winged Teal						4.9	0.7	1.0
Mallard	0.6	0.2	0.5	0.1	0.4	4.0	5.2	1.7
Blue-winged Teal			1.3					0.1
Cinnamon Teal							0.3	0.0
Turkey Vulture	0.3				0.4	1.8	1.3	0.6
Mississippi Kite						0.4	0.1	0.1
Northern Harrier	0.1		0.5	0.1		0.6	0.5	0.3
Sharp-shinned Hawk	0.3	0.2		0.1		0.1	0.8	0.2
Cooper Hawk	0.3		0.3	0.3	0.1	0.3	0.7	0.3
Swainson Hwak				0.1				0.0
Red-tailed Hawk	0.9	0.9	1.6	1.6	1.3	1.8	5.2	1.9
Ferruginous Hawk				0.3		0.2		0.1
American Kestrel	2.3	1.9	1.6	3.6	4.5	5.0	7.5	4.0
Ring-necked Pheasant	0.1		0.3	0.1	1.3	0.1	0.5	0.4
American Coot		0.1						0.0
Sandhill Crane		22.5			6.1	311.1	83.5	73.2
Whooping Crane						0.2		0.0
Killdeer			42.6	0.7		4.4	0.5	4.0
American Avocet			0.3					0.0
Lesser Yellowlegs			1.3					0.1
Spotted Sandpiper					0.4	0.1		0.1
Greater Roadrunner	0.6	1.7	2.1	2.1	3.0	2.6	2.0	2.1
Great Horned Owl				0.1				0.0
Belted Kingfisher	0.7	0.2	0.5	0.4	0.3	0.7	1.6	0.6
Total detection rate	6.4	28.0	53.5	11.1	22.2	340.4	112.8	92.7
Total number of species	11	9	14	16	14	21	18	31

Table VII-7. Raptor/large bird detection rates for each census route, winter 1981-82.

Species	Census routes 1	2	5	6	7	8	9	All routes
Pied-billed Grebe							0.1	0.0
Double-crested Cormorant						0.1		0.0
Olivaceous Cormorant						0.3		0.1
Great Blue Heron	0.1		0.5	0.3	0.2	0.4	1.3	0.4
Greater White-fronted Goose						0.7		0.1
Snow Goose						1.3		0.2
Canada Goose			5.4		13.4	218.5	6.6	44.2
Wood Duck						0.2		0.0
Green-winged Teal							2.0	0.3
Mallard		0.9	0.3	1.2	4.7	3.5	8.3	3.0
Cinnamon Teal			6.7					0.5
Northern Shoveler	0.3							0.0
Gadwall	0.3							0.0
American Wigeon	1.4		0.5					0.2
Canvasback						2.0		0.4
Common Goldeneye		0.1						0.0
Northern Harrier	0.4		0.3	0.3	0.3	0.6	0.3	0.3
Sharp-shinned Hawk	0.1	0.5	1.0	0.5			0.3	0.3
Cooper Hawk	0.4	0.2		0.1	0.2	0.2	0.4	0.2
Northern Goshawk		0.2						0.0
Red-tailed Hawk	2.1	1.1	7.0	3.7	3.9	4.5	7.9	4.1
Ferruginous Hawk			0.5		0.3	0.3	0.1	0.2
American Kestrel	0.9	2.0	2.3	1.9	2.6	6.6	3.4	3.0
Prairie Falcon						0.1		0.0
Ring-necked Pheasant			0.3	0.1		0.5	0.3	0.2
American Coot	0.1							0.0
Sandhill Crane		36.6	54.0	159.8	15.9	1963.0	1756.0	635.5
Whooping Crane						0.4	0.7	0.2
Killdeer		0.2			0.1	0.3	0.4	0.2
Ring-billed Gull						0.1		0.0
Greater Roadrunner	1.4	2.0	2.6	4.8	3.1	6.9	4.2	3.8
Belted Kingfisher	0.7	0.1	0.8	0.4	1.7		2.1	0.9
Total detection rate	8.4	44.1	82.2	173.2	46.4	2210.0	1795.0	698.4
Total number of species	12	11	14	11	12	21	17	32

Table VII-8. Raptor/large bird detection rates for each census route, winter 1982-83.

	Census routes							
Species	1	2	5	6	7	8	9	All routes
Pied-billed Grebe	0.5					0.2	0.7	0.2
Great Blue Heron	0.3			0.2	0.5	0.7	1.7	0.5
Snow Goose							1.7	0.2
Canada Goose		13.3	16.7	6.0		357.3	1.0	69.8
Green-winged Teal			2.3					0.2
Mallard	14.9	6.7	0.5	6.0	1.8	0.2	1.4	4.3
Gadwall	0.3							0.0
American Wigeon	14.9		0.5		0.3			2.0
Ruddy Duck		0.2						0.0
Turkey Vulture				0.2				0.0
Bald Eagle						0.2		0.0
Northern Harrier	0.3	0.2		0.5	0.8	0.7	0.7	0.5
Sharp-shinned Hawk	0.3	0.2		0.5	0.2		0.2	0.2
Cooper Hawk	0.3	0.4		0.7	0.2	0.4	0.5	0.4
Red-tailed Hawk	1.5	1.8	1.4	5.3	3.7	5.1	8.8	4.2
Ferruginous Hawk					0.5	0.2		0.1
American Kestrel	1.3	0.9	2.3	4.6	2.4	5.8	4.3	3.2
Prairie Falcon						0.2		0.0
Ring-necked Pheasant			0.5	0.5	0.2			0.1
Sandhill Crane			61.4	183.1	18.4	309.4	178.8	114.2
Killdeer		0.2		0.2		0.7	0.2	0.2
Greater Roadrunner	0.3	0.7	2.8	2.7	2.9	3.0	2.6	2.2
Belted Kingfisher	0.5	0.4		0.5	0.3		2.1	0.6
Total detection rate	35.1	25.2	88.4	211.1	32.1	684.1	204.8	203.2
Total number of species	12	11	9	14	13	14	14	23

APPENDIX VIII.

RECORDS OF SIGHTINGS OF ENDANGERED SPECIES

The following is a complete list of our sightings of species listed as endangered by the New Mexico Department of Game and Fish (Hubbard et al. 1979, New Mexico Department of Game and Fish 1983; one asterisk) and/or for the U.S. Fish and Wildlife Service (Federal Register 1984; two asterisks). The number of individuals, age (if known), date, and approximate locality are given for each record. All locations were within the floodplain, either within the riparian zone or in adjacent agricultural areas. ad = adult, imm = immature, pr = pair.

Species	Number	Age	Date	Location
*Olivaceous Cormorant (Phalacrocorax olivaceus)	3		22 Feb 1982	Los Lunas
	3		21 Apr 1982	Madrone Ponds
	1		21 May 1982	Confluence of Jemez River and Rio Grande
	1		9 Jun 1982	Madrone Ponds
	2		13 Jun 1982	Madrone Ponds
	1		21 Jul 1982	Madrone Ponds
	1		27 Jul 1982	Madrone Ponds
*[a]Mississippi Kite (Ictinia mississippiensis)	2	ad (pr)	15 May 1981	Los Lunas
	1	ad	16 Jun 1981	Near Isleta
	1	ad	23 Jun 1981	Bernalillo
	2	ad	26 Jun 1981	Los Lunas
	4	imm	9,16 Jul 1981	Los Lunas
	1	ad	6 Aug 1981	Isleta
	1	ad	7 Aug 1981	Los Lunas
	4	ad	14 Aug 1981	Los Lunas (3); Isleta (1)
	1	ad	17 May 1982	Isleta
	2	ad	25 May 1982	Los Lunas
	1		2 Jun 1982	Isleta
	3	ad	7 Jun 1982	Belen
	5		8 Jun 1982	Los Lunas
	1		15 Jun 1982	Near Bosque Bridge
	1		22 Jun 1982	Los Lunas
	1	imm	6 Jul 1982	Isleta
	1		27 Jul 1982	Los Lunas
	3		28 Jul 1982	Los Lunas
	2		3 Aug 1982	Near Bosque Bridge
	3		4 Aug 1982	Los Lunas
	2		9 Aug 1982	Los Lunas
	1	ad	1 Sep 1982	Near Bosque Bridge
	1		2 Sep 1982	Belen
	1		3 Sep 1982	Near Bosque Bridge
	2	(1 ad, 1 imm)	7 Sep 1982	Near Bosque Bridge (1 immature); south of Los Lunas (1 adult)

Species	Number	Age	Date	Location
Mississippi Kite	1		14 Sep 1982	Belen
(cont.)	1	ad	6 Oct 1982	Belen
**Bald Eagle	1	ad	12 Feb 1981	Corrales
(Haliaeetus	1	ad	11 Dec 1981	Cochiti bosque
leucocephalus)	4	(2 ad, 2 imm)	15 Dec 1981	Cochiti Lake
	1	ad	12 Jan-10 Feb 1982	Bernalillo
	2	imm	5 Feb 1982	Cochiti Lake
	1	imm	16 Feb 1982	Cochiti Lake
	1	ad	16 Feb 1982	San Ildefonso
	1	ad	26 Mar 1982	Cochiti bosque
	1	imm	13 Apr 1982	Bernalillo
	1	ad	27 Jun 1982	Cochiti bosque
	1	imm	26 Nov 1982	Isleta Marsh
	2	(1 ad, 1 imm)	14 Dec 1981	Cochiti Lake (1 adult); Cochiti bosque (1 immature)
	1	ad	15 Dec 1982	Cochiti Lake
	1	imm	3 Jan 1983	Los Lunas
	1	imm	24 Jan 1983	Cochiti bosque
	1	ad	26 Jan 1983	Cochiti Spillway
**Peregrine Falcon	1		7 Aug 1981	Isleta
(Falco peregrinus)	1		29 Sep 1981	Cochiti
	1		30 Jul 1982	Corrales
**Whooping Crane	1	ad	12 Feb 1981	Near Madrone Ponds
(Grus americana)	1	ad	20 Oct 1981	All between Los Lunas and Belen
	2	ad	24 Nov 1981	
	1	imm	17 Nov 1981	
	2	ad	1 Dec 1981	Los Lunas
	2	ad	2 Dec 1981	Belen
	1	ad	14 Dec 1981	Los Lunas
	1	ad	16 Dec 1981	3 miles south of Los Lunas
	1	ad	11 Jan 1982	Belen
	1	ad	19 Jan 1982	Belen
	1	ad	24 Jan 1982	Belen
	1	ad	30 Jan 1982	Belen
	2	ad	8 Feb 1982	Belen
	1	ad	15 Feb 1982	Los Lunas
	1	ad	20 Feb 1982	1 mile south of Isleta Bridge
	1	ad	24 Feb 1982	1 mile south of Isleta Bridge

Species	Number	Age	Date	Location
Whooping Crane (cont.)	1	ad	27 Feb 1982	1 miles south of Isleta Bridge
	1	ad	9 Nov 1982	Los Lunas
	1	ad	15 Nov 1982	Los Lunas
	2	ad	16 Nov 1982	Los Lunas
	1	ad	Dec 1982	Near Bosque Bridge
	3	ad	14 Jan 1983	Near Bosque Bridge
*[d]Red-headed	1	ad	11 May 1981	Bernalillo
Woodpecker	1	ad	31 May 1981	Isleta Marsh
(*Melanerpes*	1	ad	5,19 Jun 1981	Belen
erythrocephalus	3	ad	20 Jul and 18, 25 Aug 1981	Bernalillo
	1	ad	27 Aug 1981	Bernalillo
	1	imm	22 Sep 1981	Alameda
*Bell Vireo (*Vireo bellii*)	1 (singing)		22 Jun 1981	Albuquerque
*McCown Longspur (*Calcarius mccownii*) (tentative)	1-2		21 Feb 1982	Bernalillo
*[b]Woodland jumping	1		13 Jun 1981	Isleta RR Marsh[c]
mouse (*Zapus*	3		24 May 1982	Isleta RR Marsh[c] (2); Isleta Marsh (1)
hudsonius luteus)	1		17 Jun 1982	Isleta (SW-00)
	1		28 Aug 1982	Isleta (SW-05) bosque

[a] Although age was not specifically recorded for many of the later Mississippi Kite records, most, if not all, of these birds were adults. The few immature birds were recognized as unusual and thus were generally noted as such.

[b] Added to the list of species endangered in New Mexico as of July 22, 1983.

[c] "Isleta RR Marsh" is a small cattail marsh immediately upriver from the railroad bridge across the Rio Grande by Isleta, about 2 miles northeast of the pueblo.

[d] Removed from the list of species endangered in New Mexico as of July 22, 1983.

APPENDIX IX.

LIST OF BIRD AND MAMMAL SPECIMENS

BIRDS

Common name	Scientific name	Number of specimens	Where curated
Cinnamon Teal	Anas cyanoptera	1	MSB
Sharp-shinned Hawk	Accipiter striatus	1	MSB
Gambel Quail	Callipepla gambelii	1	MSB
Common Moorhen	Gallinula chloropus	1	MSB
Common Barn-Owl	Tyto alba	1	MSB
Western Screech-Owl	Otus kennicottii	1	MSB
Common Poorwill	Phalaenoptilus nuttallii	1	MSB
Northern Flicker	Colaptes auratus	1	MSB
Dusky Flycatcher	Empidonax oberholseri	1	MSB
Black-capped Chickadee	Parus atricapillus	1	MSB
Black-capped Chickadee X Mountain Chickadee	Parus atricapillus X Parus gambeli	1	MSB
Bewick Wren	Thryomanes bewickii	4	MSB
Sedge Wren	Cistothorus platensis	1	MSB
Marsh Wren	Cistothorus palustris	1	MSB
Hermit Thrush	Catharus guttatus	1	
American Robin	Turdus migratorius	1	MSB
Yellow-rumped Warbler	Dendroica coronata	1	MSB
Northern Waterthrush	Seiurus noveboracensis	1	MSB
MacGillivray Warbler	Oporornis tolmiei	1	MSB
Common Yellowthroat	Geothlypis trichas	1	MSB
Wilson Warbler	Wilsonia pusilla	1	MSB
Western Tanager	Piranga ludoviciana	1	MSB
Green-tailed Towhee	Pipilo chlorurus	2	MSB
Rufous-sided Towhee	Pipilo erythrophthalmus	1	MSB
Brown Towhee	Pipilo fuscus	1	MSB
White-throated Sparrow	Zonotrichia albicollis	1	MSB
White-crowned Sparrow	Zonotrichia leucophrys	9	MSB
Dark-eyed Junco	Junco hyemalis	6	MSB
Western Meadowlark	Sturnella neglecta	2	MSB

MAMMALS

Common name	Scientific name	Number of specimens	Where curated
Desert shrew	*Notiosorex crawfordi*	15*	NMSU
		(7 skulls only, 2 in alcohol)	
		10	MSB
		2	JA
Botta pocket gopher	*Thomomys bottae*	7	NMSU
Silky pocket mouse	*Perognathus flavus*	4*	NMSU
		(1 skull only)	
Plains pocket mouse	*Perognathus flavescens*	3	NMSU
Ord kangaroo rat	*Dipodomys ordii*	6	NMSU
Merriam kangaroo rat	*Dipodomys merriami*	5	NMSU
Western harvest mouse	*Reithrodontomys megalotis*	105*	NMSU
		(99 skulls only)	NMSU
Plains harvest mouse	*Reithrodontomys montanus*	1	NMSU
		(skull only)	
Deer mouse	*Peromyscus maniculatus*	9	NMSU
White-footed mouse	*Peromyscus leucopus*	4	NMSU
Piñon mouse	*Peromyscus truei*	6	NMSU
Northern grasshopper mouse	*Onychomys leucogaster*	4	NMSU
Hispid cotton rat	*Sigmodon hispidus*	6	NMSU
Tawny-bellied cotton rat	*Sigmodon fuliventer*	4	NMSU
Muskrat	*Ondatra zibethicus*	2	NMSU
Norway rat	*Rattus norvegicus*	1	NMSU
House mouse	*Mus musculus*	6	NMSU
Woodland jumping mouse	*Zapus hudsonius luteus*	6	NMSU
		(tissues of 3)	MSB

* Total number of specimens, including skin and skull, skull only, and alcohol specimens. Specimens are skin and skull unless otherwise indicated.

Abbreviations:

MSB = Museum of Southwest Biology, at the University of New Mexico, Albuquerque, NM.

NMSU = Mammal collection at New Mexico State University, Las Cruces, NM. The mammals at NMSU constitute Accession 372, catalog Nos. 13637-13830.

JA = Dr. John Applegarth, 2576 Moon Mountain Dr., Eugene, OR.

APPENDIX X.

ANNOTATED BIBLIOGRAPHY OF THE MIDDLE RIO GRANDE VALLEY

Part I - Current References

Alexander, H., and L. Martinez. 1982. Invertebrate colonization of an artificial pond. Corps of Engineers, Albuquerque District. 30 pp.

Survey of invertebrates at the Corps' artificial pond near Los Lunas, during the first summer after construction of the pond (1982). High populations of insects and other invertebrates were found at the pond. The insect/vertebrate populations at the pond exceeded those sampled at a comparison site in Isleta Marsh.

Applegarth, J. S. 1982. Ecological distribution of amphibians and reptiles in three potential silt-control reservoirs on the Rio Puerco (Hidden Mountain Site) and Rio Salado (La Jencia and Loma Blanca sites) in west-central New Mexico. Corps of Engineers, Albuquerque District. 291 pp.

Includes information on distribution, natural history, and ecological requirements of many of the amphibians and reptiles occurring in the Middle Rio Grande Valley.

Applegarth, J. S. 1983. Status of the leopard frog (Rana pipiens) and the painted turtle (Chrysemys picta) in the Rio Grande of north-central New Mexico. Research report, Corps of Engineers, Albuquerque District. 78 pp.

Electrophoretic analysis (done by R. D. Sage) suggested that the Rio Grande population of leopard frogs may constitute a distinct species taxon. The remaining population is small and of very limited distribution, with individuals found at only six locations in the study area. The decline of the leopard frog is hypothesized to be due to direct predation by bullfrogs. Painted turtles are thought to be threatened due to decreases in suitable breeding habitat (marsh). Management recommendations are made for both species.

Borell, A. E. 1951. Russian olive as a wildlife food. Journal of Wildlife Management 15:109-110.

Notes that Russian olive is abundant in the Albuquerque area and on adjacent Rio Grande. Lists species of birds and mammals that eat the fruits of Russian olive.

Bourn, W. S., and C. Cottam. 1939. The effect of lowering water levels on marsh wildlife. Transactions of the North American Wildlife Conference 4:343-350.

Brown, A. F., R. Q. Palmer, J. G. Kangler, and H. B. Elmendorf. 1951. Report to the Salt Cedar Interagency Council by the Salt Cedar Interagency Task Force. Intradepartment document, Department of the Interior, Albuquerque, New Mexico.

Summarized available information on water consumption by phreatophytes (collectively referred to as "salt cedar" but including cottonwood, willow, and seepwillow as well), known methods of controlling (i.e., removing) them, and potential for revegetating cleared areas with economically useful species. Recommended that a program of experiments and field trials be set up, with coordinated data collection and analysis, and with surveys of vegetation both before and after clearing so that results could be evaluated. Includes maps of the river from Cochiti to Caballo Reservoir, illustrating the extent of "salt cedar" (i.e., phreatophyte) vegetation in the valley as of 1951.

Brown, D. E., editor. 1982. Biotic communities of the Southwest-United States and Mexico. Desert Plants 4(1-4):3-341.

Presents a habitat classification system for the Southwest, including description and discussion of the Great Basin Riparian biotic community, to which most of the Middle Rio Grande bosque belongs.

Campbell, C. J., and W. A. Dick-Peddie. 1964. Comparison of phreatophyte communities on the Rio Grande in New Mexico. Ecology 45:492-502.

Ecological study of a series of 18 stands of native riparian vegetation located between Albuquerque, New Mexico and El Paso, Texas, six of which were within the present study area. The entire floodplain community was characterized as extremely heterogeneous and as "postclimax", highly disturbed due to human alterations. The introduction of salt cedar and Russian olive was deemed the most influential factor in the bosque communities' recent development.

Chambers, Campbell, Isaacson, and Chaplin, Inc. 1975. The Rio Grande in the Albuquerque metropolis. (The City Edges Study.) City of Albuquerque, New Mexico, 3 vols.

Comprehensive look at the role of the Rio Grande in the Albuquerque urban environment. Includes discussion of the ways in which the Albuquerque community uses the river resources, description/classification of the riparian vegetation, and a volume exploring Albuquerque residents' perceptions of the river as part of their environment.

Christensen, E. M. 1963. Naturalization of Russian olive (Elaeagnus angustifolia L.) in Utah. American Midland Naturalist 70:133-137.

Gives an account of the extensive planting of Russian olive in Utah beginning around 1900, and documents its establishment in the wild around 25 years later. The author also measured the growth rate of Russian olive, and reviewed historical accounts of its establishment in other western states, including New Mexico.

Christiansen, E. M. 1964. The recent naturalization of Siberian elm (Ulmus pumila L.) in Utah. Great Basin Naturalist 24:103-106.

Clark, R. E. 1971. Water rights problems in upper Rio Grande. Natural Resources Journal 11:48.

Discusses the history of present-day conflicts over water rights, with reference to the varied influences of Spanish and English legal systems.

Cole, D. C. 1978. The breeding avifauna of riparian woodlands in the central Rio Grande Valley, New Mexico. New Mexico Department of Game and Fish, Study No. 516-65-17, unpublished report, Santa Fe, New Mexico. 19 pp.

Breeding bird survey of five mature stands and riparian cottonwood forest located along the Rio Grande between Algodones and Bernardo. In addition to presenting data on the average number of nesting species (per 40 ha) of the major species, the report includes information on habitat use by each of the 40 breeding species, and assesses the probable degree of dependence of the breeding avifauna on the riparian habitat. Includes plant species list and vegetation data.

Conant, R. 1978. Semiaquatic reptiles and amphibians of the Chihuahuan Desert and their relationships to drainage patterns of the region. Pp. 455-491 in H. Waver and D. H. Riskind (eds.), Transactions of the symposium on the biological resources of the Chihuahuan Desert Region, United States and Mexico. U.S. Department of the Interior, National Park Service, Proceedings and Transactions Series No. 3, xxii + 658 pp.

Crosby, A. L. 1966. The Rio Grande; life for the desert. Garrard Publishing Company. 96 pp.

Degenhardt, W. G., and J. L. Christiansen. 1974. Distribution and habitats of turtles in New Mexico. Southwestern Naturalist 19:21-46.

Descriptions and maps of the New Mexico distributions and habitats of all species and subspecies of turtles known to occur in the state. Three taxa (Terrapene ornata ornata, Chrysemys picta belli, and Trionyx spiniferus emoryi) occur within the study area.

Dortignac, E. J. 1956. Watershed resources and problems of the Upper Rio Grande Basin. USDA Forest Service, Fort Collins, Colorado. 107 pp.

Engel-Wilson, R. W., and R. D. Ohmart. 1978. Floral and attendant faunal changes on the lower Rio Grande between Fort Quitman and Presidio, Texas. Pp. 134-147 in R. R. Johnson and J. F. McCormick (tech. coords.), Strategies for protection and management of floodplain wetlands and other riparian ecosystems. USDA Forest Service General Technical Report WO-12.

Documents the existence of lush cottonwood-willow forest along the lower Rio Grande prior to 1850, the clearing of the floodplain for agriculture, and the subsequent decline of agriculture and invasion of salt cedar. Clearing, overgrazing, changes in river flow patterns due to upstream dams and irrigation, increasing salinity, and the effects of two catastrophic floods are implicated in the replacement of native riparian vegetation by salt cedar.

Everitt, B. L. 1980. Ecology of saltcedar -- a plea for research. Environmental Geology 3:77-84.

Briefly discusses the distribution and environmental correlates of salt cedar infestations. Salinity, sediment size, timing of peak annual discharge, base flow rates, and the frequency of inundation are suggested to be influential factors requiring further research. The author urges interdisciplinary cooperation in salt cedar research.

Findley, J. S., A. H. Harris, D. E. Wilson, and C. Jones. 1975. Mammals of New Mexico. University of New Mexico Press, Albuquerque, New Mexico. 360 pp.

Species accounts include information on habitat, ecology, taxonomy, and historical status of all species of mammals known to occur (or to have occurred in the past) in the Middle Rio Grande Valley. Distribution maps and specimen records are also given for each species.

Freehling, M. D. 1982. Riparian woodlands of the Middle Rio Grande Valley, New Mexico: A study of bird populations and vegetation with special reference to Russian-olive (Elaeagnus angustifolia). U.S. Fish and Wildlife Service, Office of Environment, Region 2, Albuquerque, New Mexico. 25 pp.

This report (1) presents a review of the available information on the historical character of the riparian vegetation along the Middle Rio Grande, with special reference to the introduction and naturalization of Russian olive in the area, and (2) presents data from a 1973-1979 survey of the avifauna present in four stands of riparian cottonwood forest in Bernallilo County, all of which were characterized by high densities of Russian olive. Includes vegetation data.

Hafner, D. J., K. Peterson, and T. L. Yates. 1981. Evolutionary relationships of jumping mice (genus Zapus) in the southwestern United States. Journal of Mammology 62:501-512.

Taxonomic study of the jumping mice in the Southwest, with special reference to the Rio Grande Valley population which is herein reclassified as Zapus hudsonius luteus. Threats to the remaining populations of Z. h. luteus are discussed in light of their restriction to habitats vulnerable to development.

Hale, W. E. 1967. Quality of water conditions along the Rio Grande in New Mexico. U.S. Geological Survey, Open File Report, USGS, Albuquerque, New Mexico.

Hansman, E. W., and N. J. Scott. 1977. A natural history survey of the Rio Grande Valley between Bernalillo and Elephant Butte Reservoir. National Fish and Wildlife Laboratory, Museum of Southwest Biology, University of New Mexico, Albuquerque, New Mexico.

Brief account of the geology, topography, soils, climate, vegetation, and vertebrate fauna of the Middle Rio Grande Valley, drawn from a survey of the literature.

Harris, A. H. 1959. A distributional checklist of New Mexican mammals. M.S. thesis, University of New Mexico. 463 pp.

Presents species accounts and distributional information by county for all species of mammals known from New Mexico.

Harris, D. R. 1966. Recent plant invasions in the arid and semi-arid Southwest of the U.S. Annals of the Association of American Geographers 56:408-422.

Implicates the construction of reservoirs in the spread of salt cedar. Reservoirs provide muddy deltas for seedbeds and also alter river flow regimes downstream from dams such that the establishment of salt cedar is promoted while that of native species is hindered.

Horton, J. S., F. C. Mounts, and J. M. Kraft. 1960. Seed germination and seedling establishment of phreatophyte species. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Research Station Paper 48. 26 pp.

Documents results of experimental studies of seed production, viability, germination, and seedling establishment of salt cedar (primarily) and also seepwillow, broom baccharis, cottonwood, and arrowweed. Suggests that salt cedar may be controlled by management of water flow: slow recession of water favors salt cedar establishment, while rapid recession hinders it.

Howe, W. H. 1983. Plant succession and vertebrate use at an artificial pond in Los Lunas, New Mexico. Research report, Corps of Engineers, Albuquerque, New Mexico. 16 pp.

Presents results of monitoring the artificial pond site during the second year after construction of the pond. Dense vegetation up to 6 ft high (primarily herbaceous), covered the previously cleared areas and densities of birds around the pond were significantly greater than on an adjacent terrestrial comparison site. The numbers of reptiles and amphibians in the area had also increased since before construction, while small mammal use of the site remained low. It was emphasized that until perennial vegetation becomes established on the site, year-to-year fluctuations in vertebrate use may be significant.

Hubbard, J. P. 1977. Importance of riparian ecosystems: Biotic considerations. Pp. 14-18 in R. R. Johnson and D. A. Jones (tech. coords.), Importance preservation and management of riparian habitat: A symposium. USDA Forest Service General Technical Report RM-43.

Hubbard, J. P. 1978. Revised check list of the birds of New Mexico. New Mexico Ornithological Society Publication No. 6. 120 pp.

Gives account of the present status, distribution, and abundance of all species of birds recorded from New Mexico. Over 60% of these bird species have been recorded in the Middle Rio Grande valley at least once.

Hundertmark, C. A. 1974. Breeding range extensions of certain birds in New Mexico. Wilson Bulletin 86:298-300.

Hundertmark, C. A. 1978. Breeding birds of Elephant Butte marsh. New Mexico Ornithological Society Publication No. 5. 17 pp.

Ivey, R. D. 1957. Ecological notes on the mammals of Bernalillo County, New Mexico. Journal of Mammalogy 38:490-502.

Species taken in the river valley included: Silver-haired bat, pallid bat, Mexican free-tailed bat, black-tailed jackrabbit, desert cottontail, "prairie dog" (probably Gunnison's), rock squirrel, Botta's pocket gopher, Ord's kangaroo rat, beaver, western harvest mouse, white-footed mouse, yellow-bellied cotton rat, muskrat, Norway rat, house mouse, porcupine, gray fox, raccoon, long-tailed weasel, and striped skunk. Deer mice were found adjacent to, but not in the valley, as were badgers, although the latter were noted as being present in the river bottom in "adjacent counties".

Johnson, R. R. 1970. Tree removal along southwestern rivers and effects on associated organisms. American Philosophical Society Yearbook. pp. 321-22.

Preliminary results of Johnson's study of nesting birds in riparian cottonwood forest in north-central Arizona. Severely thinned plots supported 524-484 pairs/100 a, moderately thinned plots 885-962 pairs/100 a, and unmanipulated forest supported 1000-1300 pairs/100 a. "The latter is the highest number of non-colonial birds per unit area ever recorded for North America" (p. 322).

Johnson, T. H. 1979. Bald Eagle winter habitat study, 1978-79; Bandelier National Monument, New Mexico. Research Report, National Park Service, Southwest Region. 57 pp.

Johnson, T. H. 1980. A study of Bald Eagles wintering near Cochiti Reservoir. Research Report, National Park Service, Southwest Region. 51 pp.

Johnson, T. H. 1981. The status of the Bald Eagle near Cochiti Reservoir - 1981. Research Report, National Park Service, Southwest Region. 48 pp.

Johnson, T. H. 1982. The status of the Bald Eagle near Cochiti Reservoir. Research Report, National Park Service, Southwest Region. 22 pp.

Johnson, T. H. 1983. The Bald Eagle near Cochiti Reservoir -- 1983. Research Report, National Park Service, Southwest Region. 22 pp.

A series of annual reports documenting population fluctuation, habitat use, behavior, foraging patterns, and prey items of the Bald Eagles wintering at Cochiti Lake. Includes discussion of impacts of fluctuations in water level and recreational use of the area.

Jojola, J. R., Sr. 1977. Bird populations and habitat in a riparian woodland, Isleta Indian Reservation, central New Mexico. Unpublished M.S. thesis, New Mexico State University, Las Cruces, New Mexico.

Comparative avian survey of three types of cottonwood habitat near Isleta. Nests of seven species were found in the mature cottonwood habitat (total nest density = 231/100 a), while young cottonwood-Russian olive yielded four species (260 nests/100 a) and young cottonwood only two species (213 nests/100 a). During censuses of the study plots, 45 species were recorded on the mature cottonwood plot, 24 on the young cottonwood-Russian olive, and 22 on the young cottonwood. Includes plant species list and vegetation data.

Kelley, V. C., L. A. Woodward, A. M. Kudo, and J. F. Callender. 1976. Guidebook to the Albuquerque Basin of the Rio Grande Rift, New Mexico. New Mexico Bureau of Mines and Mineral Resources Circular No. 153. 31 pp.

Ladd, G. S. 1971. Statement of the Director of the New Mexico Department of Game and Fish on the proposed Rio Grande Water Salvage Project, at the Interstate Stream Commission hearing, June 18, 1971.

Comments on the impact of the proposed project on game animals. Opposes clearing of river vegetation. (Rex Funk)

Lamb, S. H. 1971. Woody plants of New Mexico and their value to wildlife. New Mexico Department of Game and Fish Bulletin No. 14.

Ligon, J. S. 1961. New Mexico birds and where to find them. University of New Mexico Press, Albuquerque, New Mexico. 360 pp.

Summarizes the status and distribution of all bird species known from New Mexico through 1961. Also includes notes on the behavior, nesting and habitat preferences of each species, and discussion of changes in species distributions in response to habitat modification.

Molles, M. C., Jr., and R. D. Pietruska. 1983. Comparison of the aquatic and semi-aquatic invertebrates of Los Lunas Pond and Isleta Marsh. Corps of Engineers, Albuquerque District. 20 pp.

This study represents a continuation of investigations conducted by Alexander and Martinez in 1982. Results were similar to those of the previous study. Similar taxa were collected in both studies and both documented a higher biomass of invertebrates at the Los Lunas Pond than at the comparison site at Isleta Marsh. The diversity of terrestrial invertebrates was higher at the Los Lunas Pond, but Isleta Marsh had the greatest overall diversity of invertebrates.

New Mexico Department of Game and Fish. 1972. Symposium on rare and endangered wildlife of the southwestern United States. University of New Mexico, Albuquerque, New Mexico.

New Mexico Department of Game and Fish. 1978-1981. Performance reports on game bird studies. Project No. W-104-R-19. Prepared by T. Zapatka, G. Downer, and J. Sands. Santa Fe, New Mexico.

A series of four annual reports summarizing results of dove nesting surveys in four types of riparian habitat: mature cottonwood forest, mature salt cedar-Russian olive mix, young salt cedar, and young Russian olive. Dove nests were found in both of the mature habitats in large numbers (around 4-5 nests per acre on the average) but were uncommon in the two shrub habitats. Plant species list in 1979 report, vegetation data in 1979 and 1980 reports.

New Mexico State Engineer. 1972. Environmental statement: Water salvage project, Española and Middle Rio Grande valleys.

Nordin, C. F., Jr., and J. P. Beverage. 1965. Sediment transport in the Rio Grande. U.S. Geological Survey Professional Paper 462-F.

Patterson, C. C. 1970. An analysis of the impact of the waste water effluent of the city of Albuquerque on the water quality of the Rio Grande. New Mexico Municipal League, Inc.

Comprehensive report with maps, charts, and figures. (Rex Funk)

Petersen, K. E. 1977. Ecological comparison of Sigmodon hispidus and Sigmodon fulviventer in the Rio Grande Valley, New Mexico. M.S. thesis, University of New Mexico, Albuquerque, New Mexico.

Found that the current distributions of these two species of cotton rats in the Middle Rio Grande Valley are apparently mutually exclusive. The study compared sex ratios, reproduction rates, behavior, diets of the two species and the vegetation characteristcs of the sites where each species was trapped.

Potter, L. D. 1981. Plant ecology of the shoreline zone of Rio Grande-Cochiti Lake, Bandelier National Monument. Final report (Contract No. NPS CX 702900003), National Park Service, Southwest Region Report, Albuquerque, New Mexico. 73 pp.

Describes the effects of high water during 1979-80 on various vegetation communities along the shoreline of Rio Grande-Cochiti Lake in Bandelier National Monument. Flood waters killed most of the cottonwoods and other broadleaf species and deposited a layer of lake silt 8-10 in deep on level terrace areas. Salt cedar quickly

became established on these terraces, where it will probably persist indefinitely. The author considered the establishment of salt cedar to be one of the most serious long-term impacts of the flooding.

Raitt, R. J., and M. C. Delasantro. 1980. Avifauna census, Elephant Butte and Caballo reservoirs, New Mexico. Final report to U.S. Water and Power Resources Service (Bureau of Reclamation), Rio Grande Project, El Paso, Texas. 195 pp. + appendix.

Robinson, T. W. 1965. Introduction, spread, and areal effect of saltcedar (Tamarix) in the western states. U.S. Geological Survey Professional Paper 491-A.

Sands, J. 1956. Distribution and taxonomy of the pocket gopher Thomomys bottae in Bernalillo County, New Mexico. Unpublished M.S. thesis, University of New Mexico, Albuquerque, New Mexico. 24 pp.

Sands, J. 1960. The opossum in New Mexico. Journal of Mammalogy 41:393.

Summarizes records of opossum in New Mexico, including two road-killed specimens found 3 mi north of Belen on Highway 85 (1955 and 1956), a pelt purchased from a man trapping near Albuquerque (1956), and sight records from 4 mi north of Belen (1952), in the Belen Refuge (1955), and between Tijeras and San Antonio in Bernalillo County (1958). Tracks were also reported from the vicinity of Belen and the Belen Refuge.

Sheppard, F. V. 1962. An annotated checklist of the bats of Bernalillo County, New Mexico. Unpublished M.S. thesis, University of New Mexico, Albuquerque, New Mexico.

Stalheim, W. 1965. Some aspects of the natural history of the rock squirrel, Citellus variegatus. Unpublished M.S. thesis, University of New Mexico, Albuquerque, New Mexico. 55 pp.

Thompson, C. B. 1958. Importance of phreatophytes in water supply. American Society of Civil Engineers, Irrigation and Drainage Division, Proceedings 84(1R1):1502-1-1502-17.

Discusses the introduction and spread of salt cedar in the Rio Grande Valley.

U.S. Army Corps of Engineers. 1974. Final environmental statement: Cochiti Lake, Rio Grande, New Mexico. Corps of Engineers, Albuquerque District, Albuquerque, New Mexico.

Environmental impacts downstream include flood protection for urban areas, "reverse advancing aggradation of the riverbed and promote degradation", "improve water quality", and regulation of streamflow. Some background on natural communities. (Rex Funk)

U.S. Department of the Interior, Bureau of Reclamation. 1973. Rio Grande: Velarde, New Mexico to Elephant Butte Dam, Middle Rio Grande and Rio Grande projects. (16 mm sound film).

Aerial tour of the river valley. (Rex Funk)

U.S. Department of the Interior, Bureau of Reclamation. 1977. Final environmental impact statement: Operation and maintenance program for the Rio Grande -- Velarde to Caballo Dam, Rio Grande and Middle Rio Grande projects. 2 vols.

Discusses previous and proposed operation and maintenance practices, including maintenance of a cleared floodway, clearing of phreatophytes for water salvage, and construction of pilot channels and levee jacks to stabilize the river channel. Experimental clearing of the Bernardo Prototype Area and proposals for clearing at Elephant Butte and Caballo are treated in detail. Includes descriptions and photos of vegetation communities and wildlife in the project area, and good before-and-after photos of levee jack installations and pilot channels.

U.S. Department of the Interior, Fish and Wildlife Service. 1976. Birds of the Bosque del Apache National Wildlife Refuge. RF-22520-2. Loose-leaf publication.

Van Dersal, W. R. 1939. Birds that feed on Russian olive. Auk 56:483-484.

Advocated planting of Russian olive for erosion control and wildlife benefits. Bird species feeding on the fruits included: Bohemian Waxwing, American Robin, Pheasant, Sharp-tailed Grouse, Cedar Waxwing, Hungarian Partridge, Bobwhite, Evening Grosbeak, Valley Quail (sp.?) (Miller 1937, Boise, Idaho), also "songbirds" and "finches".

Woodson, R. C. 1961. Stabilization of the Rio Grande in New Mexico. Journal of the Waterways and Harbors Division, Proceedings of the American Society of Civil Engineers 87:1-15.

Discusses stabilization of the river channel within the study area by means of Kellner jetty jacks. Stated purposes were (1) to

maintain the improved (i.e., straightened) channel and protect the levees and (2) to effect water salvage and drainage through the resulting channel degradation. Includes before-and-after aerial photos of jetty field installations completed in 1953, illustrating vegetation succession on sedimentation in the jetty fields.

Part II - Historical References

Abert, J. W. 1848. Notes of Lieut. J. W. Abert, pp. 386-414 and Report of Lieut. J. W. Abert of his examination of New Mexico in the years 1846-1847, pp. 417-546. Appendix No. 6 in W. H. Emory (1848) Notes of a military reconnaissance from Fort Leavenworth in Missouri, to San Diego in California, including parts of the Arkansas, Del Norte and Gila Rivers. 30th Congress, First Session, Executive Document No. 41.
Reprinted in 1982 as: Abert's New Mexico report. Horn and Wallace Press, Albuquerque, N.M.

Report on several trips through the Middle Rio Grande Valley in 1846. Includes good descriptions of wildlife seen enroute, including specimens collected, and some description of the river and riverside vegetation.

Bailey, F. M. 1928. Birds of New Mexico. New Mexico Department of Game and Fish, Santa Fe, New Mexico. 807 pp.

A comprehensive summary of descriptions, ranges, and state records of all bird species known to occur in New Mexico through 1928. Also includes summaries of the routes traveled by explorers and ornithologists, and gives the locations of early collections of New Mexico birds.

Bailey, V. 1913. Life zones and crop zones of New Mexico. American Fauna 35:1-100.

Baird, S. F. 1858. Explorations and surveys for a railroad route from the Mississippi River to the Pacific Ocean. Birds. Vol. 9, Part 2, 1005 pp. 33rd Congress, Executive Document No. 78.

Boulton, H. E., ed. 1908. Spanish exploration in the Southwest. Barnes and Noble, Inc., New York. 486 pp.

Translations of original Spanish explorers' narratives of their travels. Espejo (1582) mentions "many salines on both sides of the river [near the pueblos north of Socorro]. On each bank there are sandy flats more than a league wide." He also mentions that turkeys were kept at the Pueblos. Oñate (1599) also mentions turkeys, and the cultivation of cotton by valley residents.

Burkholder, V. L. 1928. Report of the chief engineer. Middle Rio Grande Conservancy District, New Mexico. 248 pp.

Report on land use and agriculture in the Middle Rio Grande Valley in the 1920's, with specific reference to irrigation and drainage problems. Discussed the frequency of destructive floods, and the accelerating loss of agricultural land because of rising water tables and salinity, and presented detailed plans for the Middle Rio Grande Conservancy District. Includes table giving acreages of land supporting riparian vegetation ("timber" or "bosque"), marsh ("swampland"), and various types of agriculture as of 1918.

Castañeda. 1540. Cited in Bailey, F. M. 1928. Birds of New Mexico. New Mexico Department of Game and Fish, Santa Fe, New Mexico, page 16.

Castañeda, who chronicled the Coronado Expedition through New Mexico, mentions that "quail" were given to Friar Marcos de Niza by the Indians, that "a very large number of cranes and wild geese and starlings [blackbirds?] live on what is sown", that "There are a great many native fowl in these provinces, and cocks with great hanging chins" [wild turkeys] and that "tame eagles" were kept at the Pueblos.

Clark, J. D., and H. Mauger. 1932. The chemical characteristics of the waters of the Middle Rio Grande Conservancy District. University of New Mexico Bulletin, Chemical Series 2:1-35.

Coues, E. 1865. Ornithology of a prairie journey, and notes on the birds of Arizona. Ibis 1865:157-165.

Pages 158-160 include records of specimens from New Mexico.

Emory, W. H. 1848. Notes of a military reconnoissance from Fort Leavenworth in Missouri, to San Diego in California. H. Long & Bros., New York, New York. Original reference: 30th Congress, First Session, Executive Document No. 41, pp. 1-230. Reprinted as: Lieutenant Emory Reports. University of New Mexico Press, Albuquerque, New Mexico.

Evermann, B. W. 1888. Ornithology from a railroad train. Ornithology and Oology 13:65-67.

Includes notes on birds seen at Albuquerque and San Marcial.

Fergusson, H. 1931. Rio Grande. William Morrow and Company, New York, New York. 296 pp.

An Albuquerque native's account of the history of human settlement in the Rio Grande Valley. Includes some description of the river valley and its vegetation prior to the construction of drains.

Ford, F. 1911. Preliminary list of birds of New Mexico. Report No. 1, Conservation and Natural Resources Commission of New Mexico. pp. 17-63.

Garcia, F. 1903. Shade trees and other ornamentals. New Mexico Agricultural Experiment Station Bulletin 47:1-55.

Gave general instructions on benefits of and methods for planting shade trees in New Mexico. Recommends Ailanthus altissima (tree of heaven), cottonwood, Russian mulberry, Osage orange, salt cedar, and Russian olive, among others. Salt cedar was recommended enthusiastically and was reported to be in Albuquerque as hedges and "some trees". Less enthusiastic about Russian olive, though its use as a hedge plant in some parts of the western United States was mentioned.

Goodding, L. N. 1938. Notes on native and exotic plants in Region 8, with special reference to their value in the Soil Conservation Program. Soil Conservation Service, Regional Bulletin No. 247, Albuquerque, New Mexico. 152 pp.

Floristic guide with brief exposition of morphological features and in some instances economic use of various plant species.

Gregg, J. 1844. Commerce of the prairies. Lippincott, Philadelphia, Pennsylvania. 2 vols.

Noted that cottonwoods were "scantily scattered along the banks of the Rio Grande, and that the trees had been cut" throughout the range of settlements leaving the banks "nearly bare."

Hansen, N. E. 1901. Ornamentals for South Dakota. South Dakota Agricultural Experiment Station Bulletin 72:95-206.

Advocated Russian olive for ornamental planting. Reviewed history of introduction of Russian olive into the Plains states.

Hening, H. B. 1908. The Central Rio Grande Valley of New Mexico. New Mexico Bureau of Immigration. 48 pp.

Henshaw, H. W. 1873. Report upon and list of birds collected by the expedition for geographical and geological exploration and surveys west of the 100th Meridian in 1873, Lieut. G. M. Wheeler, Corps of Engineers, in charge.

Kennerly, C. B. 1853. Report of the zoology of the expedition (IV, Part IV, pp. 1-17, 1856) and report on the birds collected on the route (X, Part VI, No. 3, pp. 19-35, 1859) in Report of survey for a railroad to the Pacific: Route near the thirty-fifth parallel, explored by Lieut. A. W. Whipple, Topographical Engineer, in 1853 and 1854.

Leopold, A. 1918. Are the Red-headed Woodpeckers moving West? Condor 20:122.

Suggests that the species followed telegraph poles to extend their range westward into New Mexico.

Leopold, A. 1919. Notes on Red-headed Woodpeckers and Jack Snipe in New Mexico. Condor 21:40.

Records of occurrence of both species in the valley near Albuquerque.

Leopold, A. 1919. Relative abundance of ducks in the Rio Grande Valley. Condor 21:122.

In descending order of abundance: Mallard, Green-winged Teal, Pintail, "Spoonbill" (Shoveler?), Baldpate (American Wigeon), Mottled Duck (?), Red-breasted Merganser, Blue-winged Teal, Gadwall, Canvasback, Redhead, Goldeneye. Compiled from his duck hunting daily bag, taken within 50 miles of Albuquerque.

Leopold, A. 1919. A breeding record for the Red-headed Woodpecker in New Mexico. Condor 21:173-174.

The first two breeding records for the state, one near Albuquerque, another at Fort Sumner.

Leopold, A. 1920. Range of the Magpie in New Mexico. Condor 22:112.

Magpies were present in the Rio Grande Valley from Alameda to Bernardo during winter, 1918 and 1919, and all year in Rio Arriba County.

Leopold, A. 1921. A hunter's notes on doves in the Rio Grande Valley. Condor 23:19.

Observed that the squabs remain near the nests in cottonwood bosque until well grown, while adults flew some distance to feed on wheat stubble. Estimated annual increase of about 100%, based on the ratio of squabs to adults in his hunting bag.

Leopold, A. 1925. A seven-year duck census in the Middle Rio Grande Valley. Condor 27:8.

Discussed year-to-year fluctuations in the total abundance of ducks in the valley based on ocular estimates. Disputed the contention that duck populations were increasing.

Ligon, J. S. 1927. Wildlife of New Mexico. New Mexico State Game Commission, Santa Fe, New Mexico. 212 pp.

Extensive review of the status of game and predatory animals in New Mexico prior to 1927.

McCall, G. A. 1851. Some remarks on the habits, etc. of birds met within western Texas between San Antonio and the Rio Grande, and in New Mexico, with descriptions of several species believed to have been hitherto undescribed. Proceedings of the Academy of Natural Science, Philadelphia. pp. 213-224.

Mead, I. R. 1898. Study of the life in the tornillo zone. B.S. thesis, New Mexico State University. 28 pp.

Monson, G. 1946. Notes on the avifauna of the Rio Grande Valley, New Mexico. Condor 48:238-241.

Field notes from observations in the vicinity of Bosque del Apache National Wildlife Refuge during 1940 and 1941. Documents the presence of three species and four subspecies previously not known to occur in New Mexico, as well as new wintering records and range extensions for several species. Includes a record of Eastern Kingbird near San Antonio, and states that Black-billed Magpies were "frequent" in winter.

National Resources Committee. 1938. Regional planning, part VI. The Rio Grande joint investigation in the Upper Rio Grande basin in Colorado, New Mexico, and Texas, 1936-1951. Government Printing Office, Washington, D.C. 2 vols.

Speer, W. S. 1881. The encyclopedia of the new West. The United States Biographical Publishing Co., Marshall, Texas. 1014 pp.

Stephens, F. 1878. Notes on a few birds observed in New Mexico and Arizona in 1876. Bulletin of the Nuttall Ornithological Club 3:92-94.

Tidestrom, I. and Sister T. Kittell. 1941. A flora of Arizona and New Mexico. The Catholic University of America Press, Washington, D.C. 897 pp.

Van Cleave, M. 1935. Vegetation changes in the Middle Rio Grande Conservancy District. M.S. thesis, University of New Mexico, Albuquerque. 46 pp.

Study of ecological succession taking place in the Middle Rio Grande Valley following construction of drains in the 1930's. Describes in detail the major plant associations present before and after drainage.

Van Denburgh, J. 1924. Notes on the herptology of New Mexico, with a list of species known from that state. California Academy of Science, Proceedings (fourth series) 13(12):189-230.

Watson, J. R. 1908. Manual of the more common flowering plants growing without cultivation in Bernalillo Co., N.M. University of New Mexico, Albuquerque, New Mexico. 107 pp.

Prepared for use by the author's botany students; local and not exhaustive. Includes salt cedar (Tamarix gallica [=T. chinensis]) which is described as "commonly planted on the campus and in the town as a hedge plant" (p. 80), but not Russian olive or Siberian elm.

Watson, J. R. 1912. Plant geography of north central New Mexico. Contributions from the Hull Botanical Laboratory 160:194-217. Reprinted from the Botanical Gazette 54:194-217.

Includes earliest scientific descriptions of Rio Grande river valley vegetation associations. The two major associations were: cottonwood forest, which was an open and more or less pure forest of Populus fremontii var. wislizenii, "monotonously uniform and poor in species," and a wet meadowlike association of Juncus balticus and Houttuynia [=Anemopsis] californica. Watson also described early vegetation succession on newly exposed riverbanks, and the vegetation growing along irrigation ditches.

Wheeler, G. M. 1875. Report upon the geographical and geological exploration and surveys west of the 100th Meridian. (Includes, in pp. 133-507, Report upon the ornithological collections made in portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona, during the years 1871, 1872, 1873, and 1874.)

Wislizenus, A. 1847. A tour to northern Mexico. Col. Doniphan's expedition in 1846-1847. Senate Miscellaneous Document 26, 30th Congress, 1st Session. 141 pp.

Woodhouse, S. W. 1853. Report on the natural history of the country passed over by the exploring expedition under the command of Brev. Capt. L. Sitgreaves, U.S. Topographical Engineer, during the year 1851. Pp. 31-105 in Sitgreaves' expedition of the Zuni and Colorado rivers.

Wooton, E. D., and P. C. Standley. 1915. Flora of New Mexico. Contributions of the U.S. National Herbarium 19:1-794.

APPENDIX XI.

VEGETATION TYPE MAPS OF THE STUDY AREA

Criteria Used in Vegetation Mapping

Community types were designated according to the dominant and/or codominant species in canopy and shrub layers. A species was considered dominant in a layer if it comprised at least 50% of the vegetation in that layer (by visual estimate). Codominants comprised at least 25% of a layer. From one to four species could potentially be listed for each layer, but typically there was a single canopy dominant (cottonwood) and one to three shrub (co)dominants. The species were listed in order of importance in each layer (separated by commas), and the species in the two layers were separated by a slash, e.g., C/RO,SC (after Radford 1978, cited in Dick-Peddie 1979).

Structure type designations followed the classification scheme discussed in the text. A key to the plant species abbreviations used in the maps, a brief description of each structure type, and a set of foliage profile diagrams are included here for reference.

Vegetation community and structural types are not discrete entities. Rather, they represent points along a continuum reflecting gradients in both species composition and three-dimensional foliage distribution. Hence, as in any classification system, not all stands were easily classified. Boundaries of types were sometimes difficult to draw because some stands graded from one community or structure type into another over some distance. Since a useful classification scheme cannot include all possible structure variations, we encountered some stands that were intermediate or that fit none of the types well. In such cases, subjective decisions had to be made. "Problem" stands were most frequently encountered in the intermediate-age structure types, III, IV, and V.

Similarly, a stand with a relatively uniform structure might vary in species composition, especially in the understory layer. An area of one structure type was not divided into two community types unless there was a distinct break or substantial difference in species composition across the stand. Instead, the different species were included as codominants.

Vegetation Structure Types

Type I. Tall or mature to mixed-age class trees ($\geq$40 ft) with well-developed understory vegetation. Substantial foliage in all height layers.

Type II. Tall or mature trees ($\geq$40 ft) with little or no understory vegetation. Majority of foliage above 30 ft.

Type III. Intermediate-sized trees (20-40 ft) with dense understory vegetation. Majority of foliage between 0 and 30 ft.

Type IV. Intermediate-sized (20-40 ft), openly spaced trees with little understory. Majority of foliage between 15 and 30 ft.

Type V. Younger stands with dense shrubby growth. Majority of foliage between 0 and 10 or 15 ft.

Type VI. Very young, low, and/or sparse stands. Majority of foliage between 0 and 5 ft.

Scattered. Very sparsely distributed riparian vegetation.

Abbreviations used in Table XI-1., Table XI-2., and Table XI-3.

C = Cottonwood (*Populus fremontii* var. *wislizenii*)
RO = Russian olive (*Elaeagnus angustifolia*)
SC = Salt cedar (*Tamarix chinensis*)
CW = Coyote willow (*Salix exigua*)
TW = Tree willow (*Salix gooddingii*, *S. amygdaloides*)
J = One-seed juniper (*Juniperus monosperma*)
NMO = New Mexico olive (*Forestiera neomexicana*)
SE = Siberian elm (*Ulmus pumila*)
A = Indigo bush (*Amorpha fruticosa*)
B = Seepwillow (*Baccharis salicina*)
SB = Silver buffaloberry (*Shepherdia argentea*)
ATX = Four-wing salt bush (*Atriplex canescens*)

MH = Marsh

Roman numerals = Structure types

Table XI-1. Acreages per community-structure (C-S) type in the intensive study area. On the left side of the table are listed all C-S types shown on the vegetation type maps. The columns on the right give acreages of types combined into more general categories.

	All types shown on maps			Combined types	
C-S type	Within levees	Outside levees	C-S type	Within levees	Outside levees
C/RO I	856	140	C/RO I	856	140
C/RO-SC I	1304	42	C/RO-SC I	1964	42
C/RO-SC-CW I	303	--			
C/RO-CW-SC I	146	--			
C/RO-CW I	142	--			
C-TW/RO-SC(CW) I	69	--			
C/CW I	81	9	C/CW I	848	9
C/CW-RO I	216	--			
C/CW-RO-SC I	232	--			
C/CW-SC I	257	--			
C/CW-NMO I	8	--			
C-TW/CW-SC I	54	--			
C/SC I	114	--	C/SC I	318	--
C/SC-CW I	80	--			
C/SC-RO I	119	--			
C-SE/SC I	5	--			
Total acres of type I cottonwood forest				3986	191
C II	184	226	C II	184	226
C/RO II	358	289	C/RO II	379	309
C/RO-A II	--	20			
C/RO-CW II	21	--			
C/CW II	68	21	C/CW II	79	21
C/CW-NMO II	11	--			
C/SC II	3	296	C/SC II	21	296
C/SC-RO II	18	--			
Total acres of type II cottonwood forest				663	852

Table XI-1. (cont.)

C-S type	All types shown on maps		C-S type	Combined types	
	Within levees	Outside levees		Within levees	Outside levees
C/RO III	204	34	C/RO III	675	34
C/RO-CW III	46	--			
C/RO-SC III	425	--			
C-TW/RO-SC-CW III	16	--	Mix (C-TW-SE-RO/RO-SC-CW III)	97	9
C-TW/SC III	8	--			
TW-C/SC-RO III	24	9			
C-TW/CW-SC-RO III	18	--			
RO-SE-C-TW/CW III	19	--			
C-SE/CW-SC-RO III	12	--			
C/CW III	58	--	C/CW III	140	--
C/CW-RO III	75	--			
C/NMO III	7	--			
C/SC III	82	--	C/SC III	173	--
C/SC-CW III	40	--			
C/SC-RO III	51	--			
SC III	--	8	SC,RO-SC III	77	8
SC-RO III	31	--			
RO-SC III	46	--			
Total acres of type III vegetation				1162	51
C IV	20	97	C IV	20	97
C/RO IV	61	120	C/RO IV	109	120
C/RO-SC IV	48	--			
C/CW-RO IV	116	--	C/CW(SC) IV	311	--
C/CW-SC-RO IV	129	--			
C/CW-SC IV	66	--			
C/SC IV	86	--	C/SC IV	158	--
C/SC-RO IV	72	--			
Total acres of type IV cottonwood forest				598	217

Table XI-1. (cont.)

	All types shown on maps			Combined types	
C-S type	Within levees	Outside levees	C-S type	Within levees	Outside levees
C V	4	--	C V	4	--
C/RO V	57	--	C/RO V	86	--
C/RO-TW V	9	--			
C-TW/RO-SC V	20	--			
RO V	253	19	RO V	408	33
RO-CW V	27	14			
RO-SC V	57	--			
RO-SC-CW V	50	--			
RO-C V	21	--			
C/CW V	171	--	C/CW V	463	--
C/CW-CAT V	4	--			
C/CW-SC V	149	--			
C/CW-SC-RO V	78	--			
C-TW/CW-RO V	16	--			
C-TW/CW-SB V	21	--			
TW-C/CW-SC V	24	--			
CW V	81	--	CW V	310	10
CW-RO V	135	10			
CW-SC V	48	--			
CW-SC-RO V	46	--			
C-SC V	147	--	C/SC V	284	--
C/SC-RO V	41	--			
C/SC-CW V	47	--			
C/SC-CW-RO V	49	--			
SC V	50	--	SC V	398	41
SC-RO V	137	41			
SC-CW V	158	--			
SC-CW-RO V	29	--			
SC-TW-RO V	13	--			
SC-RO-TW V	11	--			
Total acres of type V vegetation				1953	84

Table XI-1. (cont.)

	All types shown on maps			Combined types	
C-S type	Within levees	Outside levees	C-S type	Within levees	Outside levees
C/RO VI	76	--	C/RO VI	76	--
RO VI	197	38	RO VI	277	38
RO-SC VI	33	--			
RO-CW VI	47	--			
C/CW-RO VI	49	--	C/CW VI	114	--
C/CW-SC VI	14	--			
C/CW VI	22	--			
C/CW-ATX VI	12	--			
C-SE/CW VI	17	--			
CW VI	53	5	CW VI	77	5
CW-SC VI	15	--			
TW VI	5	--			
TW-RO VI	4	--			
C/SC VI	123	--	C/SC VI	123	--
SC VI	13	32	SC VI	72	32
SC-C-RO VI	12	--			
SC-CW VI	19	--			
SC-TW VI	20	--			
SC-CW-RO VI	8	--			
Total acres of type VI vegetation				739	75
MH V (cattail)	189	47	MH and Water	226	223
Water in MH V	19	19			
MH VI (salt grass)	--	134			
Water (ponds)	18	23			
OP VI (open areas)	173	--	OP VI	173	--
Total acres mapped in intensive study area				9500	1693

Table XI-2. Acreages per community-structure (C-S) type in the northern portion of the general study area. Format as in Table XI-1.

	All types shown on maps			Combined types	
C-S type	Within levees	Outside levees	C-S type	Within levees	Outside levees
C I	13	--	C I	13	--
C/RO I	854	--	C/RO I	1291	--
C/RO-NMO I	178	--			
C/RO-J I	227	--			
C-TW/RO I	32	--			
C/RO-SC I	68	--	C/RO-SC I	84	--
C/RO-SC-NMO I	11	--			
C/RO-SC-CW I	5	--			
C/SC I	72	--	C/SC I	211	--
C/SC-J I	30	--			
C/SC-RO I	109	--			
C/J I	135	33	C/J I	325	101
C/J-RO I	190	68			
Total acres of type I cottonwood forest				1924	101
C II	714	182	C II	714	182
C/RO II	732	--	C/RO II	776	--
C/RO-NMO II	29	--			
C/RO-J II	8	--			
C/RO-J-NMO II	7	--			
C/SC II	130	143	C/SC II	209	143
C/SC-CW II	64	--			
C/SC-RO II	15	--			
C/J II	378	80	C/J II	394	80
C/J-NMO II	16	--			
C/TW II	16	--	C/TW II	16	--
Total acres of type II cottonwood forest				2109	405

Table XI-2. (cont.)

	All types shown on maps			Combined types	
C-S type	Within levees	Outside levees	C-S type	Within levees	Outside levees
C/RO III	349	--	C/RO III	398	--
C/RO-J III	35	--			
C/RO-TW III	14	--			
C/RO-SC III	203	--	C/RO-SC III	228	--
C/RO-SC-CW III	25	--			
C/CW-RO III	21	--	C/CW III	21	--
C/SC III	12	--	C/SC III	76	--
C/SC-RO III	58	--			
C/SC-CW III	6	--			
SC-RO III	8	--	SC-RO III	8	--
Total acres of type III vegetation				731	--
C IV	101	63	C IV	101	63
C/RO IV	172	19	C/RO IV	363	19
C/RO-J IV	149	--			
C/RO-SC IV	42	--			
C/CW IV	13	--	C/CW IV	13	--
C/SC IV	270	7	C/SC IV	368	7
C/SC-RO IV	18	--			
C/SC-CW IV	35	--			
C/TW-SC IV	45	--			
C/J IV	130	--	C/J IV	394	--
C/J-SC IV	108	--			
C/J-RO IV	137	--			
J/RO IV	19	--			
Total acres of type IV vegetation				1239	89

Table XI-2. (cont.)

C-S type	All types shown on maps: Within levees	All types shown on maps: Outside levees	Combined types: C-S type	Combined types: Within levees	Combined types: Outside levees
C V	39	--	CV	39	--
C/RO V	51	--	C/RO V	111	--
C/RO-CW V	60	--			
RO V	89	39	RO V	207	39
RO-SC V	64	--			
RO-SC-C V	40	--			
RO-TW V	8	--			
RO-CW V	4	--			
RO-J V	2	--			
C/CW V	7	--	C/CW, TW V	45	--
C/TW-NMO V	36	--			
C/TW-SC V	2	--			
TW V	6	--	CW, TW V	21	--
CW V	15	--			
C/SC V	25	--	C/SC V	25	--
SC V	160	28	SC V	188	28
SC-CW V	24	--			
SC-RO V	4	--			
C/J V	17	--	(C)/J V	33	--
J V	16	--			
C/NMO V	80	--	C/NMO V	80	--
Total acres of type V vegetation				749	67
C/RO VI	31	--	(C)/RO VI	71	--
RO VI	40	--			
CW VI	19	--	CW-C-TW VI	84	30
CW-SC VI	33	--			
CW-TW-SC VI	17	--			
TW VI	6	--			
C-CW VI	9	--			
C-TW-RO-SC VI	--	30			

Table XI-2. (cont.)

	All types shown on maps			Combined types	
C-S type	Within levees	Outside levees	C-S type	Within levees	Outside levees
SC VI	721	--	SC VI	815	--
SC-RO VI	56	--			
SC-C VI	15	--			
C-SC VI	23	--			
C/J-SC VI	1	--	(C)/J VI	39	--
C/J VI	18	--			
J-RO VI	20	--			
Total acres of type VI vegetation				1009	30
MH V (cattail)	25	60	MH and Water	51	158
Water in MH V	--	--			
MH VI (salt grass)	--	98			
Water (ponds)	26	--			
OP VI (Open areas)	243	--	OP VI	243	--
Total acres mapped in general study area north				8055	850

Table XI-3. Acreages per community-structure (C-S) type in the southern portion of the general study area. Format as in Table XI-1.

	All types shown on maps			Combined types	
C-S type	Within levees	Outside levees	C-S type	Within levees	Outside levees
C/RO I	1	19	C/RO I	1	19
C/RO-SC I	119	37	C/RO-SC I	119	37
C/CW I	4	9	C/CW I	4	9
C/SC I	281	76	C/SC I	473	266
C/SC-RO I	49	190			
C/SC-CW I	128	--			
C/SC-RO-CW I	15	—			
TW-SC I	2	--	TW-SC I	2	--
Total acres of type I cottonwood forest				599	331
C II	—	27	C II	--	27
C/SC II	108	60	C/SC II	108	212
C/SC-RO II	--	152			
Total acres of type II cottonwood forest				108	239
C/RO III	6	10	C/RO III	101	10
C/RO-SC III	34	--			
C/RO-CW-SC III	61	--			
C/CW-SC III	55	--	C/CW-SC III	55	--
C/SC III	389	84	C/SC III	455	89
C/SC-RO III	66	5			
SC III	24	—	SC III	24	--
Total acres of type III vegetation				635	99
C/CW IV	39	—	C/CW IV	39	--
C/SC IV	--	6	C/SC IV	--	6
Total acres of type IV cottonwood forest				39	6

Table XI-3. (cont.)

	All types shown on maps			Combined types	
C-S type	Within levees	Outside levees	C-S type	Within levees	Outside levees
RO V	44	2	RO V	247	228
RO-SC V	96	226			
RO-SC-CW V	107	--			
C-CW V	63	1	C/CW(SC) V	143	29
C-CW-SC V	43	--			
CW-SC V	37	28			
C-SC V	187	32	C-SC V	229	32
C-SC-CW V	24	--			
C-SC-RO-CW V	18	--			
SC V	424	913	SC V	637	1403
SC-RO V	72	80			
SC-RO-TW V	17	--			
SC-RO-C V	52	--			
SC-TW V	3	--			
SC-C V	55	410			
SC-B V	14	--			
Total acres of type V vegetation				1256	1692
RO VI	29	30	RO VI	111	65
RO-CW VI	9	--			
RO-C VI	--	27			
RO-SC VI	73	8			
SC VI	1961	2195	SC VI	2123	2229
SC-C VI	12	--			
SC-B VI	--	24			
SC-RO VI	150	10			
B VI	18	--	B VI	18	--
ATX VI	--	707	ATX VI	--	707
Total acres of type VI vegetation				2252	3001
MH V (cattail)	416	67	MH and Water	416	366
Water in MH V	--	299			
Water (ponds)	--	--			
OP VI (Open areas)	51	--		51	--
Total acres mapped in general study area south				5356	5674

Appendix VII Supplement.--Abbreviations used in general study area bird data summaries

Vegetation type: On this line, the letters refer to community type abbreviations and numbers refer to the method by which bird density was calculated. If the third letter of the community type abbreviation is D, the community was censused only by direct count.

CJ Cottonwood/juniper

CR Cottonwood/Russian olive

CS Cottonwood/salt cedar (comparable to cottonwood/coyote willow)

CSE Cottonwood/salt cedar edge (comparable to cottonwood/coyote willow edge)

MS Miscellaneous (salt cedar-cottonwood-cattail)

SC Salt cedar

SCE Salt cedar edge

CWD Cottonwood/coyote willow (direct count)

DRD Drain (direct count)

ROD Russian olive (direct count)

1 Density calculated as for modified-Emlen censusing

3 Density calculated as for direct-count censusing

Structure type: Numbers refer to vegetation structure types. These were designated by Roman numerals elsewhere in the report, but by Arabic numbers in these summaries. Also, structure type VI A is designated 7 herein.

Appendix VII Supplement.--Abbreviations used in intensive study area bird data summaries

Vegetation type: On this line, the letters refer to community type abbreviations and numbers refer to the method by which bird density was calculated. If the third letter of the community type abbreviation is D, the community was censused only by direct count.

CR	Cottonwood/Russian olive
CRE	Cottonwood/Russian olive edge
CW	Cottonwood/coyote willow
CWE	Cottonwood/coyote willow edge
MH	Cattail marsh
COD	Cottonwood (direct count)
CWD	Cottonwood/coyote willow (direct count)
DRD	Drain (direct count)
MHD	Cattail marsh (direct count)
ROD	Russian olive (direct count)
RVD	River channel (direct count)
SBD	Sandbar (direct count)
1	Density calculated as for modified-Emlen censusing
3	Density calculated as for direct-count censusing

Structure type: Numbers refer to vegetation structure types. These were designated by Roman numerals elsewhere in the report, but by Arabic numbers in these summaries.

Appendix VII Supplement.--Abbreviations used in summaries of bird data for small openings, edges of small openings, and adjacent stands of cottonwood forest

Vegetation type: On this line, the letters refer to community type abbreviations and the number 3 indicates that densities were calculated as for direct-count censusing. The third letter of the community type abbreviations is D, indicating that they were censused only by direct count.

CTD Cottonwood forest (direct count)

DED Dry edge (direct count)

DOD Dry opening (direct count)

WED Wet edge (direct count)

WOD Wet opening (direct count)

Structure type: Numbers refer to vegetation structure types. These were designated by Roman numerals elsewhere in the report, but by Arabic numbers in these summaries.