# AN ECOLOGICAL SURVEY OF A MESQUITE BOSQUE

by

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ABSTRACT

An ecological survey was conducted from November 1971 to April 1973 in order to describe the vegetation and the vertebrate animals of a mesquite bosque. The purpose of this survey was to evaluate the wildlife, esthetic and scientific aspects of this habitat type.

Bird census transects were run almost weekly through the bosque and bird densities were computed where possible. A complete list of 95 species is included which also indicates their presence or absence in the bosque on a monthly basis. Small mammal trapping resulted in a low trap success of only 1.7 percent, although 15 species of mammals were found on the site. A list of all amphibians and reptiles found during the study is also included.

All plant species identified from the bosque as well as the major species from two adjacent vegetation zones were recorded. Quantitative data were taken on the bosque's herbaceous plant layer and it was found that few species compose this rather uniform stratum at any given time of year.

The future of mesquite bosques in Arizona is discussed as well as reasons usually given for the destruction of this habitat. These include the conversion of

floodplains into cropland, reduction of woody plants in order to favor grasses and forbs and the reduction of phreatophytes in order to conserve water use along drainage-ways.

# INTRODUCTION

The purpose of this study was to describe the vegetation and the vertebrate animals of a mesquite (Prosopis juliflora var. velutina) forest or bosque as accurately as possible. This was done so that this habitat type could be evaluated as to its wildlife, esthetic and scientific value. The mesquite trees, which may only attain shrub size on certain sites, has been heavily criticized in southern Arizona for many years by two main groups. Ranchers complain of the "invasion" of the desert grassland by this species and subsequent depletion of grass species with high forage value which can not compete with mesquite for available moisture. This change in the composition of grassland vegetation and possible explanations for it have been thoroughly covered by Humphrey (1958), Hastings (1963), and Hastings and Turner (1965).

The other main group of critics, which includes ranchers, farmers and water conservationists, argue that mesquite should be cleared from lowland or floodplain situations in order to prevent excessive use of ground water by this phreatophyte. Mesquite, willow (Salix sp.), sycamore (Platanus sp.), cottonwood (Populus sp.), ash (Fraxinus sp.) and hackberry (Celtis sp.), to name a few,

are referred to as phreatophytic species in the arid Southwest because they are capable of and in fact rely on the utilization of ground water in their metabolism. These winter deciduous species attain their greatest size and density development in areas adjacent to ponds, streams or rivers and commonly comprise the dominant species of what is called a riparian woodland (Lowe 1964). A riparian woodland may contain only one or a combination of phreatophytes and may be found at any elevation in southern Arizona.

I conducted this study in a woodland along the San Pedro River consisting of a closed canopy stand of mesquite, but also containing a scattering of Goodding willow (Salix gooddingii), velvet ash (Fraxinus pennsylvanica) and Fremont cottonwood (Populus fremontii).

Arnold (1940) conducted a similar study of a mesquite bosque along the Santa Cruz River west of Tucson, but his mesquite zone was so narrow and the habitat so varied that it is difficult to assign significance to the vertebrates found there as related to the presence of a Prosopis-dominated habitat. Arnold found 111 species of birds and approximately 25 species of mammals from this area, but he did not discuss the vegetation in any detail.

The data presented and discussed here were all collected from within the boundaries of the bosque, unless

otherwise stated, and are not a compilation of data from several plant associations in the vicinity of my study area. Only vertebrate animals actually observed by me are listed as being present, but mention is made of species that would be expected to be here even though never seen. Since more time was spent recording the mammalian and avian species' composition of the bosque, the treatment of these two groups is necessarily more complete than that of the amphibians and reptiles. Any species not recorded only indicates that it was not detected by me and is not to be interpreted as conclusive that this species is never found on the site. This is particularly true of many reptiles which are secretive and difficult to find and migratory birds which may pass through the bosque between my visits there.

Hopefully, this study will yield more than lists of plants and animals found in a mesquite bosque, but will initiate interest in and help to explain some of the ecological relationships found among the components of a biotic system unique to the Southwest. Because the continued existence of such a system in Arizona is a highly controversial issue between conservationists and certain economic interests, any additional facts that are publicized concerning the nature of this type of riparian woodland

should encourage intelligent and unbiased decisions to be made in the future.

The San Pedro Valley has apparently changed drastically during the last century, not only physically but biologically as well. Until the middle of the 19th century, beavers characteristically built dams across small rivers in southeastern Arizona such as the San Pedro. These dams created pools which often spread out to help maintain extensive grassy marshes along the edges of the river. Over part of its course, the San Pedro meandered through these marshes in a network of narrow, well-concealed channels (Davis, in prep.).

Further accounts of travelers and explorers are even more explicit. James Ohio Pattie wrote in 1826 that his group took 200 beavers from the San Pedro near its junction with the Gila River. At this junction, the stream bed of the San Pedro was covered with cottonwoods and willows. In 1846, Colonel Stephen Watts Kearney came to the lower San Pedro from the Gila River and said it was wide, with a dense growth of mesquite, willow and cottonwood, "through which it is hard to move without being unhorsed." Dr. John S. Griffin recalled that another name for the San Pedro was Hog River because of the abundance of javelina on its well-wooded floodplain. Lt. William Hemsley Emory wrote that the river bed, at its junction

with the Gila River, was "seamed" with tracks of deer and turkey, some signs of beaver and one trail of javelina (Davis, Chapter 2, in prep.).

In 1854, Lt. John G. Parks, a surveyor, and others moved up the San Pedro River and found it anything but uniform. Some areas of the valley were grassy and open with meadows and the river curved through these. The river was from a few inches below the meadows to much deeper. At Tres Alamos, the river was 15 inches deep and 12 feet wide, but flowed over a light sandy bed beneath vertical banks that were 15 feet high. In most places, timber did not line the river, although certain areas had a dense growth of willows, cottonwoods and undergrowth (Davis, in prep.).

A few weeks earlier, Colonel James D. Graham of the Topographical Engineers followed the river and found that it ran through a "soft, alluvial soil, and its rapid current has worn a deep bed for it, leaving steep banks on either side" (Davis, Chapter 2, in prep.).

From these last two accounts, it is evident that by the 1850's the arroyo cutting or channeling process that is so vital to the establishment of well developed mesquite bosques had already begun. The reason for this importance is explained by Hastings (1963:124) in this way. Along the part of the river where there was no trench, the

water table was high, the bottoms were marshy, the soil waterlogged and too poorly aerated during at least part of the year to support anything but a phreatophytic vegetation dominated by marsh grass. Where there existed an arroyo, the bottom of the trench fixed the elevation of the water and at the top of the bank, there existed a layer sufficiently well drained to support mesquite and other plants whose roots require aeration and can not tolerate waterlogging.

This terrace effect is evident on my study site and results in the formation of three distinct vegetation zones, each on a slightly different level of ground. Apparently, the present day channeling at Mammoth, Arizona, the area in which this study was conducted, occurred in August 1890, when a violent flood washed soil out in places 30 feet deep (Hastings 1963:153). This indicates that the bosque studied here may have developed to a greater extent after this date.

The history and nature of mesquite bosque development was best summarized by Hastings (1963:128):

> In summary, the valleys were wetter and more open than today, and relatively unchanneled. But the precise conditions varied from place to place and probably from time to time. As the tributary washes dumped greater or lesser amounts of debris, depending upon where heavy summer rains may have struck, the rivers had to transport varying loads of sediment at different points along their course. Channeling and

filling, aggradation and degradation . . . all may have been going on simultaneously, in various stages of development along various parts of the stream. If this dynamic situation existed, one can be sure that the vegetation reflected it. At a given time there may have been mesquite invading, where a temporary trench had sliced through the old flood plain, draining it; mesquite dying where the plain was aggrading and marshes being developed. The old accounts present a picture that is neither homogeneous, nor static. By postulating a dynamic situation one can reconcile the variety of conditions that evidently existed.

## THE STUDY SITE

The mesquite bosque that was studied here is located about one mile south of Mammoth, Arizona in Pinal County. It is situated on the east floodplain of the San Pedro River at an elevation of 2400 feet and map coordinates N32° 42', W110° 37'. Figure 1 is a map of the study site and surrounding area as drawn to scale from aerial photographs. The bosque is at the bottom of a bajada, or coarse-soiled slope, which starts about eight miles to the east in the Galiuro Mountains, and descends gradually to the San Pedro River. The weather station which most nearly approximates that of the study area is located in Winkelman, 22 miles downstream. The annual mean temperature there is about 65°F. and the annual rainfall is approximately 12.75 inches a year. In general, the area is hot and dry during spring and summer and moderate to cool in the winter with cold air drainage often bringing nighttime winter temperatures to near freezing. Rainfall occurs primarily during two periods, July to September and December to February, with the yearly total almost equally divided between the two periods.

The study area is bordered on the west by a paved road which separates the bosque from rocky hillsides of the

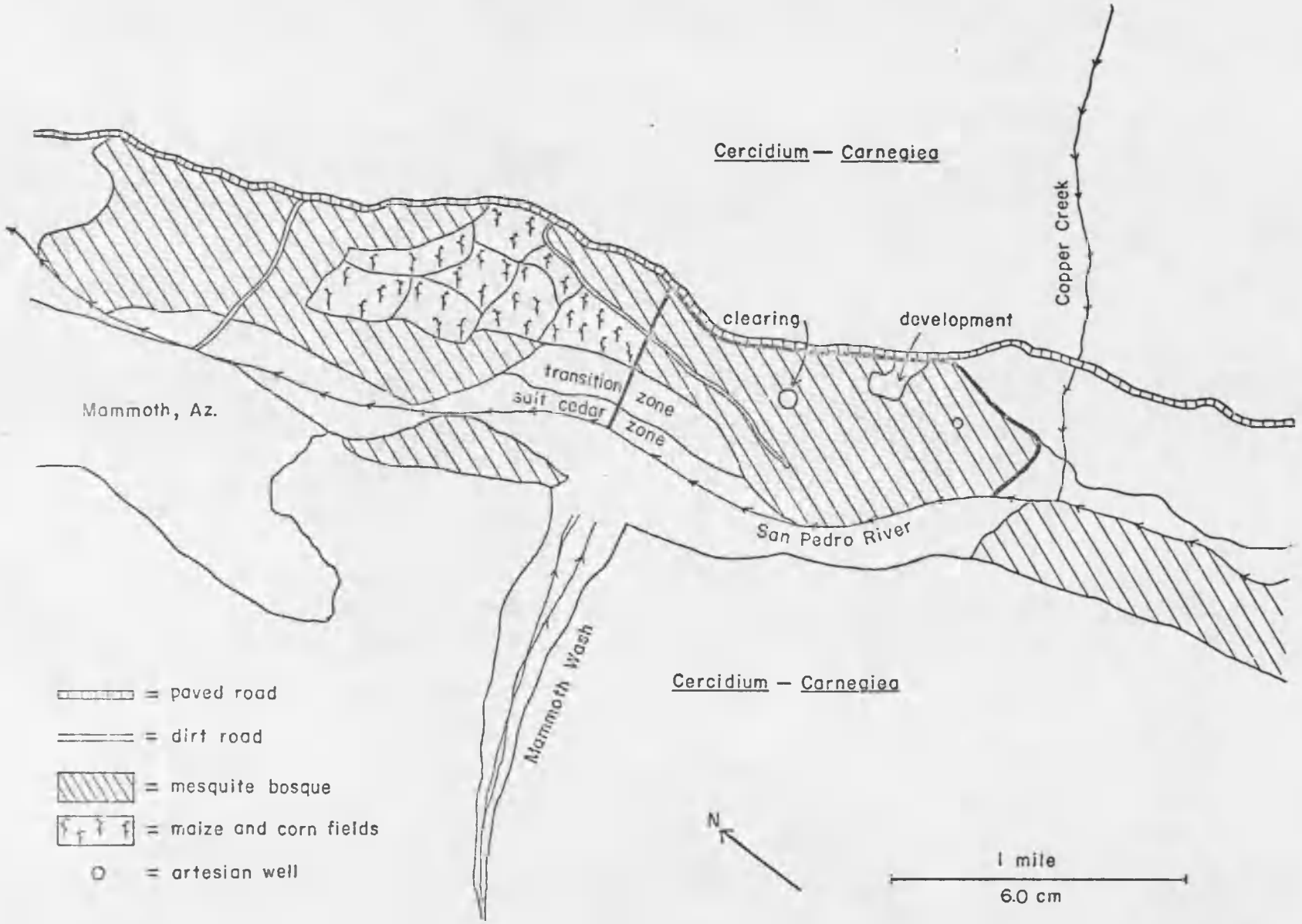


Figure 1. Map of study site and surrounding area. -- Heavy line borders study site.

typical Carnegiea-Cercidium association and on the west by the river. The northern edge was arbitrarily chosen to stop where the bosque meets a cultivated field and the southern boundary is Copper Creek, a tributary of the San Pedro which is dry most of the year. These boundaries encompass approximately 388 acres, of which 338 are mesquite bosque, 40 are of vegetation types to be explained later, and 10 acres are part of a housing development.

The site does slope downward slightly from east to west with an elevational relief of about 40 feet, but no washes or rocky outcroppings are found there. Probably the most important physical feature of the site is an artesian well which brings a continuous flow of warm, subterranean water to the surface. The result of this flow is a narrow, shallow stream that empties into a marshy pond about 50 meters from the well. This pond is only five inches deep and encompasses about one-third acre. This marshy area is the most hydric area of this bosque and supports several species of aquatic and semi-aquatic plants, certain amphibians and reptiles, and one species of minnow (Gambusia affinis).

The substrate of the San Pedro floodplain south of Mammoth is of Recent alluvial fill consisting of unconsolidated gravel, sand and more rarely silt and clay.

The thickness of this alluvium varies from 50-150 feet and the width of the river channel and floodplain averages one-half mile (Halpenny 1952).

## MATERIALS AND METHODS

### Avian Census Technique

The main technique used throughout this study for censusing avian species was an abbreviated form of a transect method developed by Emlen (1971). A detailed description of this method and an excellent comparison of currently available methods of censusing birds is included in this reference.

Briefly, with this method one can determine population densities of nonflocking land birds at any season of the year. The technique consisted of walking a straight line transect of one-half mile through the center of the bosque about 30 minutes after sunrise. All detections of any bird on either side of this straight line, whether visual or auditory, were recorded by species on a prepared field form. Each detection was represented by a dot which was placed in the proper column denoting the distance of that detection from the transect. When the transect was completed, the number of detections of any species and the distance of any detection from the transect line could be read directly from the data sheet. Distance columns on the sheet were subdivided into 10-foot intervals for the first 100 feet from the transect line, a 100-foot interval for

the distance 100-200 feet from the transect, and any detections thought to be from 200-400 feet away were placed in the last column. Detections can be made up to 400 feet away in the bosque and sometimes farther, but 412 feet to either side of a half-mile transect encompasses exactly 50 acres, an easy area for which to compute densities. This transect was run nearly every time I visited the study site, thereby giving 3-5 transects per month throughout the study. The transect data obtained in any given month were later combined so that the population densities computed on a monthly basis represent 1½-2½ miles of transect.

To compute the density of a particular species, the distance from the transect at which detections of that species decreases sharply must be determined. This can be easily determined by looking at the data sheet used on the transect. This distance from the transect is called the basal plateau and is used to project the number of detections from the transect to this distance over the entire distance being censused, or in this case 412 feet. For example, if the distance from the transect at which detections of Bewick's wren (Thryomanes bewickii) decrease markedly is 60 feet and if the number of detections from 0-60 feet for the half-mile transect is 8, then the density of Bewick's wren is: $\frac{412}{60}$ ft. x 8 = 54.4/50 acres or 108.8/100 acres. All densities were converted on the basis

of a 100 acre (40 hectares) area since this is most frequently used for animal densities.

The first assumption that is made with this technique is that the members of each species are randomly distributed throughout the habitat being censused. I chose an area of this bosque which is uniform with regard to vegetation to conduct the half-mile transect discussed above. Although a uniform habitat does not guarantee random distribution of bird species, the most important variable is minimized.

Secondly, there is the problem of censusing the same bird more than once, but this source of error can be reduced if the census taker does not spend much time at any given stopping point. Also, only birds detected at a point perpendicular to or slightly in front of the census taker are recorded. Initially, I measured or paced off many of the detections that I recorded to develop a sense of distance for certain areas or landmarks along the transect. But since I used the same transect line each time I visited the site, accurate estimates of detection distances could be made and plotted on the field data form properly.

## Mammal Population Study

Methods of determining what species of mammals were present on the site were of two types: observations of tracks, droppings and the animals themselves and kill

trapping for small mammal species. The first method involved recording the species that were detected through any visible sign and requires no detailed explanation.

The kill trapping technique consisted of setting as many Museum Special snap traps as possible, usually 100 traps, in the evening and collecting the trapped animals in the morning. Because most rodents are nocturnal in southern Arizona, the traps were set at this time. Some trapping was conducted during the day for ground squirrels (Spermophilus sp.) and on several occasions for pocket gophers (Thomomys sp.). The snap traps were not set in any systemic grid arrangement, but were placed in roughly a straight line through the bosque at approximately 10-foot intervals. This method was used only to collect mammals for species identification and is not a reliable indicator of absolute population densities. When possible, I trapped on several consecutive nights without moving the traps in order to increase the chances of rodents finding the trap positions. A combination of peanut butter and dry oatmeal was used as bait.

In addition, no attempt was made to identify species of bats that were seen flying over the bosque during the summer, as this would require trapping techniques that are time consuming and often yield few results.

## Analysis of Vegetation

Analysis of the study site vegetation mainly involved the identification of all species encountered regardless of their abundance or density. Quantitatively, I conducted a vegetational transect every three months (January, April, July, October) to measure the frequency of occurrence of plant species of the herbaceous layer. The method consisted of walking two half-mile transects through the bosque, dropping a 0.1 meter square behind my back every 20 paces, and recording all species present within the square. A 0.1 meter square was used instead of a meter square as this seemed to give a more pronounced separation of frequency of occurrence among the relatively few species found each quarter. I arbitrarily chose to take a total of 100 samples, or 50 on each half-mile transect. These two transects were roughly 40 paces apart, parallel to each other and ran lengthwise through the bosque.

By taking exactly 100 samples with the 0.1 meter square, the frequency of occurrence of any species could be converted directly to a percentage. Also, by setting up a ratio between the frequency of occurrence of any one species and the combined frequencies of occurrence of all species encountered on any one transect, the relative frequency of this species can be determined (Curtis and

McIntosh 1950). For example, if Sisymbrium irio occurs in 52 of 100 0.1 meter square samples, its frequency of occurrence if 52 percent. If the frequencies of occurrence of all species totals 350, including that of S. irio, then the relative frequency of S. irio equals $\frac{52}{350} \times 100$ percent = 14.8 percent. The relative frequency index is another way of presenting the same data as the frequency of occurrence index, but it illustrates more clearly which species are dominant.

In order to understand the recent history of the vegetation of my study site, I talked to residents of the Mammoth area, tried to locate old photographs of the river valley, and read accounts of 19th century travelers and ranchers. The evidence from these sources seemed to point to a particular time span during the last century when mesquite began its expansion along this area of the river. This expansion of mesquite resulted in the present day closed canopy bosques. On my site, there are no mesquite stumps or large fallen trunks to indicate that certain individual trees once existed that are no longer living, except for those instances in which man has interfered. Therefore, I can probably assume that the age of the largest standing mesquite trees in this bosque approximate the time when this particular bosque began its development.

To determine the age of these oldest trees, it is necessary to count the annual rings or to approximate the number of rings in some way. In order to count the rings directly, either the tree must be cut down or a bore taken from the trunk by using an increment borer. Cutting the tree down is too destructive and taking a bore is difficult to do without breaking an expensive borer, because of the hardness of mesquite wood.

I took cross sections of smaller mesquite tree stumps left by ranchers who had probably used the wood for fence posts. No such stumps could be found for the larger trees that I wanted to age. I collected five such cross sections of different diameters and sanded one side of each to a smooth finish with a belt sander. I then estimated their age by counting the porous rings with the aid of a dissecting scope and measured their diameters. From this information, a regression line was developed on graph paper by plotting the diameter of the sections on one axis and their age on the other. By measuring the diameters of the older trees in the bosque which are still standing, their age could be approximately determined by using the already constructed graph. It is probably safe to assume that the growth rate of those trees sampled was nearly identical, because all sections and diameters were obtained from trees on the same site.

# RESULTS

## Study Site Vegetation

The study site includes within its boundaries three distinct zones of vegetation, each located on a slightly different level of ground. The lowest level, which is adjacent to the river and about five feet above it, supports a nearly pure stand of salt cedar (*Tamarix pentandra*) with only a scattered distribution of burroweed (*Aplopappus tenuisectus*). These are the only two perennial species of any abundance here, although various annuals, including many species of the family Compositae, are present throughout the year.

The level adjacent to and slightly higher in elevation to the salt cedar zone contains species of both the salt cedar and the next higher level, the mesquite bosque. Because of this and because this level is between the salt cedar and bosque vegetation zones, I will refer to this area as the transition zone. The dominant species here are more typical of Lower Sonoran desert vegetation and include such plants as prickly pear (*Opuntia engelmannii*), cholla (*O. spinosier*), burroweed and mesquite. The mesquite trees that are found here, however, are not as large as

those found in the bosque, and are reminiscent of this species' growth form on upland grassland sites.

The next level, the mesquite bosque, is still higher and the zone farthest from the river. This zone occupies about 90 percent of the study site and is characterized by a closed canopy of mesquite trees 35-40 feet high. Over most of the site, there is an abbreviated shrub layer of gray-thorn (Condalia lycioides) and wolf-berry (Lycium sp.) and in places form impenetrable thickets. Table 1 lists all the plant species identified from the bosque and the ecologically important species of the other two zones.

The herbaceous layer of the bosque is composed almost entirely of annual grasses and forbs and is dominated by only two or three species at any given time of the year. Changes in the vegetation of this layer occur more slowly than in open desert areas of southern Arizona, as seen by the persistence of some species from one quarterly vegetation transect to the next (Table 2). During winter and early spring, the ground is completely covered with annual grasses of the genera Poa, Hordeum and Bromus. This changed markedly in 1972 with the drying of late spring and summer, when it was difficult to find any green plants at all. At this time, there were non-living remnants of previously green species still standing, but these were not considered on vegetation transects.

Table 1. List of all plant species identified from the mesquite bosque and major species from the transition and salt cedar zones.

| Bosque | Common Name (where given) |
|---|---|
| Common perennial and woody species | |
| *Prosopis juliflora* (Swartz) var. *velutina* (Woot.) Sarg.[a] | Common or honey mesquite |
| *Fraxinus pennsylvanica* Marshall subsp. *velutina* (Torrey) G. N. Miller | Velvet ash |
| *Populus fremontii* Wats. | Fremont cottonwood |
| *Salix gooddingii* Ball. | Goodding willow |
| *Condalia lycioides* (Gray) Weberb. | Gray-thorn |
| *Silybum marianum* (L.) Gaertn. | Milk-thistle |
| *Clematis ligusticifolia* Nutt. | --- |
| *Lycium* sp. | Wolf-berry |
| *Rumex* sp. | Dock |
| Uncommon or locally distributed perennials | |
| *Baccharis glutinosa* Pers. | Seep-willow |
| *Cucurbita digitata* Gray | --- |
| *Cephalanthus occidentalis* L. | Button-bush |
| *Ferocactus wislizeni* (Engelm.) Britt. & Rose. | Barrel cactus |

Table 1. (Continued) List of all plant species.

| Bosque | Common Name (where given) |
|---|---|
| *Larrea tridentata* (DC.) Coville[b] | Creosote-bush |
| *Acacia greggi* Gray.[c] | Catclaw acacia |
| *Aplopappus tenuisectus* (Greene) Blake. | Burro-weed |
| *Rorippa nasturtium-aquatica* (L.) Schinz & Thell. | Water-cress |
| *Datura* sp. | Thorn-apple |
| *Atriplex* sp. | Saltbush |
| *Juncus* sp. | Rush |
| Common annuals | |
| *Sisymbrium irio* L. | --- |
| *Erodium cicutarium* (L.) L'Her. | Heron-bill, filaree |
| *Amsinckia tessellata* Gray. | Fiddle-neck |
| *Lappula redowskii* (Hornem.) Greene. | Stick-seed |
| *Solanum elaegnifolium* Cav. | White horse-nettle |
| *Passiflora mexicana* Juss. | Passionflower |
| *Bowlesia incana* Ruiz & Pavon. | --- |
| *Hordeum stebbinsii* Covas. | Barley |
| *Bromus arizonicus* (Shear) Stebbins. | Brome |

Table 1. (Continued) List of all plant species.

| Bosque | Common Name (where given) |
|---|---|
| *Poa bigelovii* Vasey & Scribn. | Bigelow blue grass |
| Uncommon or locally distributed annuals | |
| *Lemna minor* L. | Duckweed |
| *Polygonum punctatum* Ell. | Smartweed |
| *Capsella bursa-pastoris* (L.) Medic. | Shepherds-purse |
| *Eschscholtzia mexicana* Greene. | Gold-poppy |
| *Lupinus sparsiflorus* Benth. | Lupine |
| *Streptanthus arizonicus* Wats. | Twist-flower |
| *Phacelia affinis* Gray. | --- |
| *Chloris virgata* Swartz. | Feather finger grass |
| *Trifolium dubium* Sibth. | Clover |
| *Euphorbia sp.* | Spurge |
| *Lepidium sp.* | Pepper-grass |
| *Setaria sp.* | Bristlegrass |
| *Bromus rubens* L. | Brome |

Table 1. (Continued) List of all plant species.

| Transition Zone | Common Name (where given) |
|---|---|
| Dominant perennials only | |
| *Prosopis juliflora* var. *velutina* | Common or honey mesquite |
| *Aplopappus tenuisectus* | Burro-weed |
| *Atriplex sp.* | Saltbush |
| *Opuntia engelmannii* Salm-Dyck. | Prickly pear |
| *Opuntia spinosier* (Engelm. & Bigel.) Toumey. | Cholla |
| *Lycium sp.* | Wolf-berry |

| Salt Cedar Zone | Common Name (where given) |
|---|---|
| Dominant perennials only | |
| *Tamarix pentandra* Pall. | Salt cedar |
| *Aplopappus tenuisectus* | Burro-weed |

[a]Scientific and common names taken from Kearney and Peebles (1951).

[b]Only one specimen found.

[c]Only three specimens found.

Table 2. Frequency of occurrence and relative frequency of plants found on quarterly transects of the bosque herbaceous layer.

| Species | April 17, 1972 | | July 13, 1972 | | October 15, 1972 | | January 21, 1973 | | April 22, 1973 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | F.O.[a] | R.F.[b] | F.O. | R.F. | F.O. | R.F. | F.O. | R.F. | F.O. | R.F. |
| Sisymbrium irio | 37 | 27.2 | -[c] | - | 20 | 15.1 | 19 | 13.7 | 14 | 10.2 |
| Gramineae (annual) | 18[d] | 13.2 | 38[e] | 65.5 | 87[f] | 65.9 | 96[f] | 69.5 | - | - |
| Erodium cicutarium | 2 | 1.4 | - | - | - | - | 2 | 1.4 | 3 | 2.2 |
| Bowlesia incana | - | - | - | - | 17 | 12.8 | 16 | 11.5 | 2 | 1.4 |
| Amsinckia tessellata | 5 | 3.6 | - | - | - | - | - | - | 4 | 2.9 |
| Hordeum stebbinsii | 72 | 52.9 | - | - | - | - | - | - | 94 | 69.1 |
| Clematis ligusticifolia | - | - | - | - | 4 | 3.0 | - | - | 2 | 1.4 |
| Lappula redowskii | - | - | - | - | - | - | 5 | 3.6 | 1 | 0.7 |
| Prosopis juliflora | - | - | 1 | 1.7 | 1 | 0.7 | - | - | - | - |
| Bromus arizonicus | - | - | - | - | - | - | - | - | 12 | 8.8 |
| Umbelliferae | - | - | 9 | 15.5 | - | - | - | - | - | - |
| Poa bigelovii | - | - | - | - | - | - | - | - | 4 | 2.9 |

Table 2. (Continued)

| Species | April 17, 1972 F.O.[a] | April 17, 1972 R.F.[b] | July 13, 1972 F.O. | July 13, 1972 R.F. | October 15, 1972 F.O. | October 15, 1972 R.F. | January 21, 1973 F.O. | January 21, 1973 R.F. | April 22, 1973 F.O. | April 22, 1973 R.F. |
|---|---|---|---|---|---|---|---|---|---|---|
| Lycium sp. | 1 | 0.7 | - | - | - | - | - | - | - | - |
| Euphorbia sp. | - | - | 3 | 5.1 | - | - | - | - | - | - |
| Setaria sp. | - | - | - | - | 3 | 2.2 | - | - | - | - |
| Unknown | 1 | 0.7 | 7 | 12.0 | - | - | - | - | - | - |

[a]Frequency of occurrence in percentage.

[b]Relative frequency in percentage.

[c]Indicates that this species did not occur on this transect.

[d]Includes grasses other than Hordeum.

[e]This grass completely dried up before developing an inflorescence, making identification impossible.

[f]The grasses in this group probably consisted of from one to three species, but did not develop an inflorescence until March 1973.

The vegetation of the bosque is quite uniform from one area to another with the exception of the vegetation in the vicinity of the artesian well and pond. Any species of plant in Table 1 that is associated with an aquatic environment is found in this area of the bosque only. Water-cress (Rorippa nasturtium-aquaticum), rushes (Juncus sp.), duckweed (Lemna minor) and smartweed (Polygonum punctatum) are good examples of this distribution. In addition, Goodding willow, Fremont cottonwood, and velvet ash are found in greatest abundance in this area and young trees of these species are found only adjacent to the stream which leads from the well. The largest individuals of these species are about 75 feet tall, and although few in number, create an intrusion through the mesquite canopy with pronounced effect on the distribution of bird species.

## Age of the Mesquite Bosque

In April 1973, diameters of 15 of the largest mesquite trees that were alive and standing in the bosque were taken. Because cross sections could not be taken from these 15 trees sampled, as explained earlier, their ages could not be determined by the tree ring method. Figure 2 shows the linear regression as determined by correlating the diameters of five mesquite cross sections taken from tree stumps with their ages, based on tree ring analysis (Steel and Torrie 1960). I then plotted two of the diameters

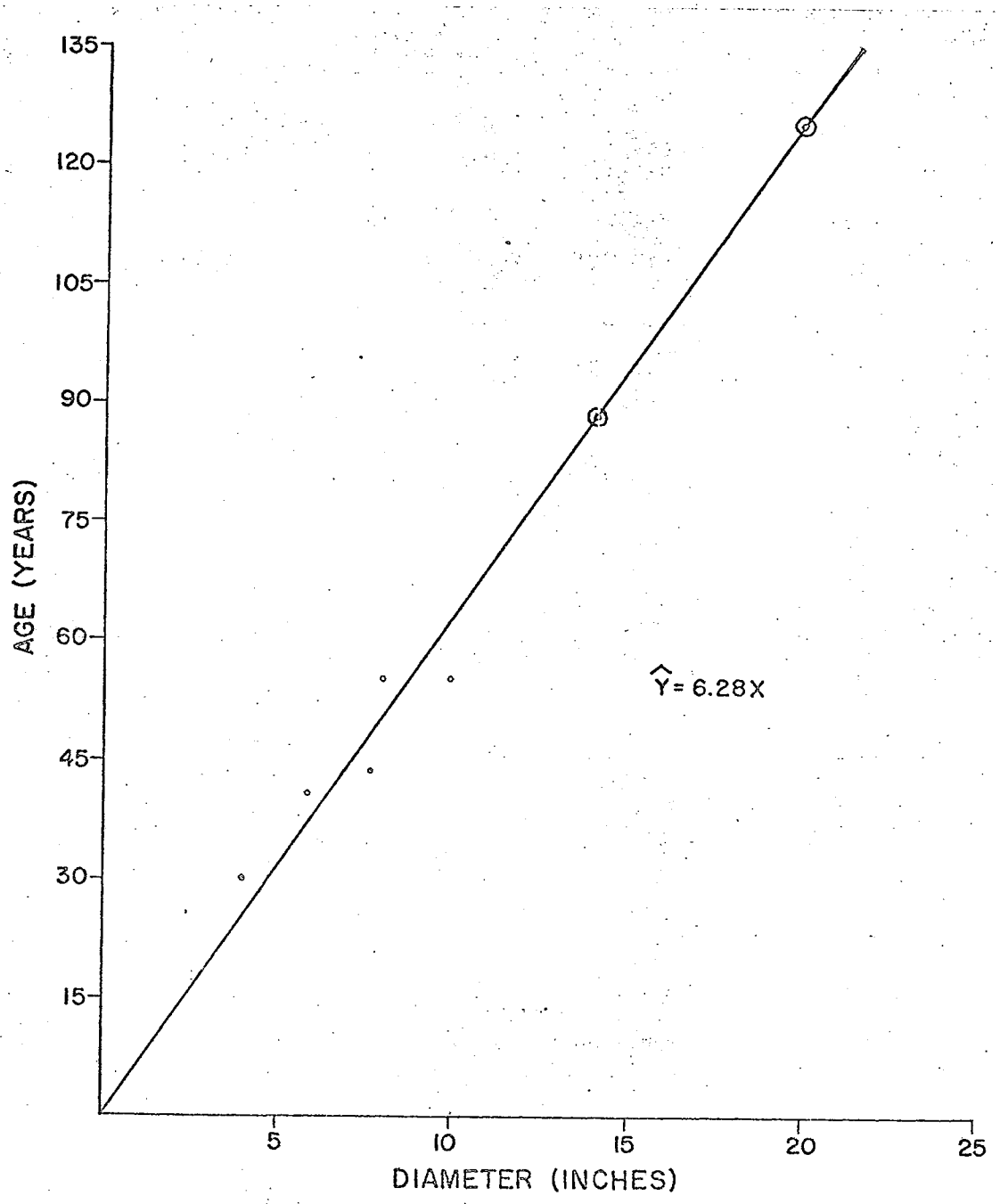


Figure 2. Correlation of mesquite (Prosopis juliflora) diameters with age based on five cross sections of known age. -- A dot represents a section of mesquite of known age based on tree ring analysis; a dot with a circle represents the diameter of a standing tree of unknown age.

of the 15 sampled from the bosque, the largest and the smallest, and read their estimated ages from the graph. From these data, it is apparent that the trees sampled are between the ages of 90-125 years old. Because the age of the oldest mesquite trees should approximate the age of this bosque, as I discussed earlier, this bosque probably originated in the mid 19th century. However, it must be kept in mind that this technique only gives an approximate age for those trees whose rings were not counted, based on an extrapolation which assumes that mesquite growth is linear (Thomas P. Harlan, Laboratory of Tree Ring Research, oral communication, 21 June 1973).

## Birds of the Mesquite Bosque

A complete list of the birds that were abundant enough in the bosque to calculate their densities is given in Table 3. These birds, which include 26 species, can be considered as the dominant or ecologically important species in this habitat type in the area of the study. It is important to realize that the transect used to census birds was conducted through an area completely dominated by mesquite. I purposely chose this route, because I was mostly interested in determining which birds were associated with this plant. If the transect had included the artesian well area with its stand of willows and ash, several species which were relegated to Table 4, such as the yellow warbler

Table 3. Calculated densities of dominant bird species in the bosque on a monthly basis from January 1972 to April 1973.

| Species | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1972 | | | | | | |
| Mourning dove | +[a] | 14.5[b] | 45.0 | 66.3 | 34.0 | 10.8 | 27.8 | 15.4 | + | + | + | -[c] |
| Ground dove | - | - | 1.5 | 6.0 | + | 8.0 | 7.2 | 6.6 | + | + | - | - |
| Flicker sp. | + | 22.9 | + | - | - | - | - | - | + | 16.4 | 4.0 | + |
| Gila woodpecker | - | + | + | - | + | + | + | + | 3.0 | + | + | + |
| Ladder-backed woodpecker | 11.6 | + | + | 9.0 | + | + | 5.4 | 12.0 | 15.7 | 17.0 | 10.8 | 8.2 |
| Yellow-bellied sapsucker | 16.4 | + | - | - | - | - | - | - | - | + | + | - |
| Vermilion flycatcher | - | + | 76.5 | 58.6 | 113.3 | 23.2 | 26.2 | 21.0 | 27.2 | - | - | - |
| Ash-throated flycatcher | - | - | 5.1 | 14.3 | 20.4 | 17.0 | 21.6 | 27.0 | + | + | - | - |
| Scrub jay | - | + | - | - | - | - | - | - | - | + | + | + |
| Verdin | + | + | + | 6.7 | 13.5 | + | 12.2 | 8.2 | + | + | + | + |
| White-breasted nuthatch | + | + | + | + | - | - | + | - | + | 5.2 | + | - |
| Bewick's wren | 49.2 | 61.2 | 40.6 | 61.5 | 36.0 | 54.0 | 34.2 | 37.4 | 33.7 | 39.0 | 24.6 | 12.0 |
| Robin | - | ++[d] | ++ | ++ | 12.3 | - | - | - | - | - | - | - |
| Ruby-crowned kinglet | 27.2 | 13.6 | 16.4 | - | - | - | - | - | + | - | 9.0 | + |
| Solitary vireo | - | - | + | 20.5 | - | - | - | - | - | - | - | - |
| Bell's vireo | - | - | 15.3 | 16.4 | 6.0 | 6.6 | 7.2 | + | + | - | - | - |
| Lucy's warbler | - | - | + | 254.2 | 135.0 | 190.4 | 22.8 | + | - | - | - | - |
| Audubon's warbler | - | + | 20.5 | + | + | - | - | - | - | + | + | + |
| Yellow-breasted chat | - | - | - | + | 6.0 | 9.2 | 4.8 | + | - | - | - | - |

Table 3. (Continued).

| Species | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brown-headed cowbird | - | - | - | + | 18.0 | 21.0 | 34.6 | - | - | - | - | - |
| Summer tanager | - | - | - | + | 18.0 | 30.6 | 21.2 | 19.2 | 18.4 | - | - | - |
| Blue grosbeak | - | - | - | - | + | + | 16.4 | + | + | - | - | - |
| Abert's towhee | 36.2 | 3.0 | 20.6 | 10.0 | + | 18.0 | 7.2 | 15.4 | 7.6 | 4.0 | + | + |
| Black-throated sparrow | - | + | 15.4 | + | + | - | + | + | - | - | - | + |
| Chipping sparrow | - | - | 20.5 | 15.7 | - | - | - | - | - | - | - | - |
| Song sparrow | - | + | 34.0 | 10.2 | + | + | + | + | - | - | - | - |
| | | | | | | | 1973 | | | | | |
| Mourning dove | - | + | - | 20.5 | | | | | | | | |
| Ground dove | - | - | - | - | | | | | | | | |
| Flicker sp. | + | + | + | + | | | | | | | | |
| Gila woodpecker | 2.0 | + | + | + | | | | | | | | |
| Ladder-backed woodpecker | 18.0 | + | 27.2 | 13.6 | | | | | | | | |
| Yellow-bellied sapsucker | + | 16.4 | - | - | | | | | | | | |
| Vermilion flycatcher | - | + | 54.8 | 53.5 | | | | | | | | |
| Ash-throated flycatcher | - | - | - | 16.4 | | | | | | | | |
| Scrub jay | 4.0 | 2.6 | + | + | | | | | | | | |
| Verdin | + | + | + | + | | | | | | | | |
| White-breasted nuthatch | + | + | + | + | | | | | | | | |
| Bewick's wren | 21.0 | 42.6 | 34.0 | 38.9 | | | | | | | | |

Table 3. (Continued).

| Species | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Robin | + | 23.8 | ++ | 6.6 | | | | | | | | |
| Ruby-crowned kinglet | + | + | + | + | | | | | | | | |
| Solitary vireo | + | - | + | + | | | | | | | | |
| Bell's vireo | - | - | - | + | | | | | | | | |
| Lucy's warbler | - | - | - | 188.5 | | | | | | | | |
| Audubon's warbler | + | + | + | + | | | | | | | | |
| Yellow-breasted chat | - | - | - | - | | | | | | | | |
| Brown-headed cowbird | - | - | - | + | | | | | | | | |
| Summer tanager | - | - | - | 18.0 | | | | | | | | |
| Blue grosbeak | - | - | - | - | | | | | | | | |
| Abert's towhee | + | 4.0 | + | 2.0 | | | | | | | | |
| Black-throated sparrow | - | - | - | - | | | | | | | | |
| Chipping sparrow | - | - | - | 4.5 | | | | | | | | |
| Song sparrow | - | - | + | + | | | | | | | | |

[a]Plus sign indicates that this species was found in the bosque during the month, but not in densities great enough to be calculated.

[b]Densities are individuals per 100 acres.

[c]Minus sign indicates that this species was not seen in the bosque during the month.

[d]Double plus indicates that this species was seen in a large, roving flock that made density calculations impossible.

Table 4. Additional species of birds seen in the bosque from January 1972 to April 1973.

| Species | 1972 | | | | | | | | | | | | 1973 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A |
| Canada goose | F[a] | F | -[b] | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Gadwall | - | - | - | - | - | - | - | - | +[c] | - | - | - | - | - | - | - |
| Turkey vulture | - | - | F | F | F | F | + | + | F | + | - | - | - | - | F | F |
| Mississippi kite | - | - | - | - | - | - | - | F | - | - | - | - | - | - | - | - |
| Goshawk | + | - | - | - | - | - | - | - | - | - | - | F | - | F | - | - |
| Cooper's hawk | - | - | + | + | - | - | - | - | + | + | - | - | - | + | + | F |
| Rough-legged hawk | - | - | - | - | - | - | - | - | - | - | - | - | - | - | F | - |
| Red-tailed hawk | + | - | - | - | - | - | - | - | - | - | - | - | - | F | - | - |
| Swainson's hawk | - | - | F | F | F | - | F | - | - | - | - | - | - | - | - | - |
| Zone-tailed hawk | - | - | - | - | F | - | - | - | - | - | - | - | - | - | - | - |
| Gambel's quail | + | + | - | + | - | + | + | - | + | - | - | - | - | - | - | - |
| Snowy egret | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| Killdeer | - | - | F | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Common snipe | - | - | - | - | - | - | - | - | - | - | + | - | - | - | - | - |
| White-winged dove | - | - | - | F | + | + | + | + | - | - | - | - | - | - | - | + |
| Yellow-billed cuckoo | - | - | - | - | - | - | - | - | + | - | - | - | - | - | - | - |
| Roadrunner | + | + | + | + | - | + | + | - | + | + | + | + | - | - | - | - |

Table 4. (Continued) Additional species of birds.

| Species | 1972 J | F | M | A | M | J | J | A | S | O | N | D | 1973 J | F | M | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Screech owl | - | - | - | - | - | - | - | - | - | + | - | - | - | - | - | + |
| Great-horned owl | - | - | - | - | - | + | + | + | - | + | - | - | - | - | - | + |
| Long-eared owl | - | - | - | + | - | - | - | - | - | - | - | - | - | - | - | - |
| Barn owl | - | - | - | - | - | + | - | - | - | - | - | - | - | - | - | - |
| Elf owl | - | - | - | - | - | + | - | - | - | - | - | - | - | - | - | - |
| Lesser nighthawk | - | - | - | - | - | F | + | - | - | - | - | - | - | - | - | - |
| White-throated swift | F | - | - | - | F | - | - | - | - | - | - | - | - | - | F | - |
| Hummingbird sp.[d] | - | - | - | + | + | + | + | - | + | - | - | - | - | - | - | + |
| Belted kingfisher | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| Western kingbird | - | - | - | - | - | + | + | + | + | - | - | - | - | - | - | + |
| Black phoebe | - | + | - | - | - | - | - | - | - | + | - | + | + | + | + | - |
| Say's phoebe | + | - | - | - | - | - | - | - | - | - | - | + | - | - | - | - |
| Gray flycatcher | - | + | + | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Beardless flycatcher | - | - | - | - | - | - | - | - | - | - | + | - | + | + | + | + |
| Western wood pewee | - | - | - | - | + | - | - | - | + | - | - | - | - | - | - | - |
| Tree swallow | - | - | - | + | + | - | - | F | - | - | - | - | - | - | - | - |
| Rough-winged swallow | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| Purple martin | - | - | - | F | - | - | - | F | - | - | - | - | - | - | - | - |

Table 4. (Continued) Additional species of birds.

| Species | 1972 | | | | | | | | | | | | 1973 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A |
| Common raven | F | F | - | F | - | - | - | - | - | - | - | - | - | F | - | - |
| White-necked raven | F | F | F | F | - | F | + | - | F | - | F | - | - | F | - | - |
| Raven sp.[e] | - | - | F | - | - | + | - | - | - | - | F | F | F | - | F | + |
| Mountain chickadee | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| Bridled titmouse | - | - | + | - | - | - | - | - | - | - | - | + | + | + | - | - |
| Brown creeper | - | + | + | - | - | - | - | - | - | - | + | - | + | + | + | - |
| Mockingbird | - | - | - | - | - | - | - | + | + | - | - | - | - | - | - | - |
| Brown thrasher | - | - | - | - | - | - | - | - | - | - | + | - | - | - | - | - |
| Curve-billed thrasher | - | - | - | - | - | + | - | - | - | + | - | - | - | - | - | - |
| Hermit thrush | - | - | - | - | - | - | - | - | - | - | - | - | - | + | - | - |
| Phainopepla | - | - | - | F | + | + | - | - | - | - | - | - | - | - | - | - |
| Starling | - | - | - | F | - | - | - | - | - | - | - | - | - | - | - | - |
| Orange-crowned warbler | - | - | - | - | - | - | - | + | - | - | - | - | - | - | - | - |
| Yellow warbler | - | - | - | + | + | + | + | + | + | - | - | - | - | - | - | + |
| Black-throated gray warbler | - | - | - | - | - | - | - | - | - | - | - | - | - | + | - | - |
| Yellowthroat | - | - | + | - | - | - | - | - | - | - | - | - | - | - | - | + |
| MacGillivray's warbler | - | - | - | - | - | - | - | + | - | - | - | - | - | - | + | - |

Table 4. (Continued) Additional species of birds.

| Species | 1972 J | F | M | A | M | J | J | A | S | O | N | D | 1973 J | F | M | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wilson's warbler | - | - | - | - | + | - | - | + | + | - | - | - | - | - | - | - |
| Red-winged blackbird | - | - | - | F | - | - | - | - | - | - | - | - | - | - | - | - |
| Hooded oriole | - | - | - | + | + | - | - | - | - | - | - | - | - | - | - | + |
| Bullock's oriole | - | - | - | - | + | + | + | - | - | - | - | - | - | - | - | + |
| Western tanager | - | - | - | - | - | - | - | - | + | - | - | - | - | - | - | - |
| Cardinal | + | - | - | + | - | - | - | - | - | - | - | - | - | + | - | + |
| Black-headed grosbeak | - | - | - | - | - | - | - | + | + | - | - | - | - | - | - | - |
| House finch | + | - | - | + | + | + | + | + | + | - | - | - | + | - | - | + |
| Lesser goldfinch | - | - | + | - | + | + | + | - | + | - | - | - | - | + | + | + |
| Green-tailed towhee | - | - | - | - | + | - | - | - | - | - | - | - | - | - | - | - |
| Rufous-sided towhee | - | - | - | - | - | - | - | - | + | - | - | + | - | - | - | - |
| Vesper sparrow | - | + | - | + | - | - | - | + | - | - | - | - | - | - | - | - |
| Lark sparrow | - | - | - | - | + | - | - | - | - | + | - | - | - | - | - | - |
| Oregon junco | + | + | - | - | - | - | - | - | - | - | - | + | + | - | - | - |
| Gray-headed junco | - | - | - | - | - | - | - | - | - | - | + | - | - | - | - | - |
| Brewer's sparrow | + | - | + | + | - | - | - | - | + | + | + | + | + | - | - | - |

Table 4. (Continued) Additional species of birds.

| Species | 1972 J | F | M | A | M | J | J | A | S | O | N | D | 1973 J | F | M | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| White-crowned sparrow | - | + | + | + | + | - | - | - | + | - | - | - | - | - | - | - |
| Lincoln's sparrow | - | - | - | - | - | - | - | - | + | - | - | - | - | - | - | - |

[a]Indicates that this species was seen only flying over the bosque during the month.

[b]Indicates that this species was not seen in the bosque during the month.

[c]Indicates that this species was seen in the bosque during the month, but not in great enough densities to be calculated.

[d]Only females were seen, making identification to species impossible.

[e]Includes only ravens that could not be identified to species.

(Dendroica petechia) and lesser goldfinch (Spinus psaltria), would certainly have been in Table 3. Table 4 includes birds which were not sufficiently abundant along the transect route, less than four sightings per month, to compute their densities.

Tables 3 and 4, then, include all bird species seen within or flying immediately over the bosque during the year and a half study. Where density figures are not given, the presence or absence of each species is indicated on a monthly basis. A calendar month was arbitrarily chosen as the unit of time with which to present these data and, therefore, a single sighting of any species, whether on or off the transect, resulted in that species being recorded as present during that month. Status designations (e.g., winter resident, summer resident, etc.) were not given to any species, as many birds did not fit clearly into any category and no attempt was made to create designations to fit all situations. I recorded 95 species during the study, 11 of which were seen flying over the bosque, but never actually perched on the site. These species can usually be considered of less ecological importance than others, although they may have been foraging for food while in flight over the bosque. This was certainly true of the purple martins (Progne subis), white-throated swifts

(Aeronautes saxatilis) and the Mississippi kite (Ictinia misisippiensis) that I observed.

The importance of the bosque in the life history of any bird can usually be surmised by noting what months that species occurs there. A bird that is present during the spring and summer can usually be assumed to nest in the bosque or at least adjacent to it. Lucy's warbler (Vermivora luciae), vermilion flycatcher (Pyrocephalus rubinus), ash-throated flycatcher (Myiarchus cinerascens) and summer tanager (Piranga rubra) are good examples of nesting species that are not found in the bosque during the winter. Birds that are found here only during the winter, probably nest elsewhere but rely on the bosque for winter cover. The brown creeper (Certhia familiaris), yellow-bellied sapsucker (Sphyrapicus varius), Audubon's warbler (Dendroica auduboni) and white-breasted nuthatch (Sitta carolinensis) are such species. Only four species were found in the bosque during every month of the year: Bewick's wren, ladder-backed woodpecker (Dendrocopos scalaris), Abert's towhee (Pipilo aberti) and the verdin (Auriparus flaviceps).

Since the San Pedro Valley is situated in a north-south direction and is bordered by north-south trending mountains along at least part of its length, it is ideal for birds which are migrating between Mexico and areas north of southern Arizona (Welty 1962:452). This probably

explains the spring and fall sightings of certain species such as the western wood pewee (Contopus sordidulus) which was seen only in May and September, the yellowthroat (Geothlypis trichas) only during March 1972 and April 1973, Wilson's warbler (Wilsonia pusilla) during May, but not again until August, and the lark sparrow (Chondestes grammacus), which was recorded only in May and October. The presence of the snowy egret (Leucophoyx thula), gadwall (Anas strepera) and common snipe (Capella gallinago) can be directly attributed to the small marshy area created by the artesian well. In addition, the sighting of at least one species in the bosque can be considered unusual. The brown thrasher (Toxostoma rufum), which was seen in November 1972, is infrequently seen in Arizona and considered rare in the state (Phillips, Marshall and Monson 1964).

Although observation time was fairly constant on the site from one month to the next, the amount of time spent at night throughout the study varied greatly. Because most nighttime work was done during the summer, the occurrence of nocturnal species according to Table 4 will reflect this.

Nesting data for species known to have nested in the bosque is given in Table 5 and includes 21 species. Active nests were found of most of these species, but when they could not be located, displays of territorial or

Table 5. Birds that nested in the bosque and plant species in which various nests were found from January 1972 to April 1973.

| Species | Nest Site (where known) |
|---|---|
| Mourning dove | *Prosopis juliflora* (5)[a] |
| Ground dove | *Prosopis juliflora* (1) |
| Hummingbird sp. | *Prosopis juliflora* (2) |
| Vermilion flycatcher | *Prosopis juliflora* (4) |
| Western kingbird | *Populus fremontii* (1), *Fraxinus pennsylvanica* (1) |
| Ash-throated flycatcher | *Prosopis juliflora* (probable) |
| Bewick's wren | *Prosopis juliflora* (2) |
| Bell's vireo | *Prosopis juliflora* (1) |
| Yellow warbler | *Fraxinus pennsylvanica* (1) |
| Hooded oriole | *Populus fremontii* (1) |
| Abert's towhee | *Prosopis juliflora* (4), *Condalia lycioides* (4), *Lycium sp.* (2) |
| Black-throated sparrow | *Prosopis juliflora* (1)[b] |
| Song sparrow | *Condalia lycioides* (1), *Prosopis juliflora* (1) |
| Brown-headed cowbird | Bell's vireo nest (1) |
| Ladder-backed woodpecker | *Prosopis juliflora* (probable) |
| Verdin | *Condalia lycioides* (6)[c] |
| Lucy's warbler | *Prosopis juliflora* (probable) |
| Yellow-breasted chat | Unknown |
| Summer tanager | Unknown |

Table 5. (Continued)

| Species | Nest Site (where known) |
|---|---|
| Blue grosbeak | Unknown |
| Lesser goldfinch | *Fraxinus*, *Salix*, or *Populus* (probable) |

| Additional Probable Nesting Species | Probable Nest Site |
|---|---|
| Screech owl | --- |
| Great-horned owl | --- |
| Lesser nighthawk | *Prosopis juliflora* |
| Gila woodpecker | --- |
| White-winged dove | *Prosopis juliflora* |
| Beardless flycatcher | *Prosopis juliflora* |
| Bullock's oriole | *Populus fremontii* |

[a]Number in parentheses represents nests found.

[b]Found in branches of dead limb on the ground.

[c]None of these nests were active spring nests and may represent winter nests.

courting behavior and the presence of immatures during spring and summer were enough to include them in this list. Table 5 also includes seven additional species which had a high probability of nesting in the bosque, but with less substantial evidence. This evidence consisted mainly of the presence of these birds during the breeding season, but with no observed behavior which would indicate active nesting. As would be expected, mesquite was the most common nest site, followed by the larger and less common phreatophytic species.

## Mammals of the Mesquite Bosque

In compiling a list of mammals present on my study site, I included only species that I knew existed there based on my own observations. These data are presented in Table 6 and include 15 species of mammals. All species listed in the table were actually seen by me on one or several occasions with the single exception of the raccoon (*Procyon lotor*), which was identified by tracks left in soft mud.

Although no technique was used to estimate the size of mammal populations, the frequency with which certain species or their sign were seen may be an indicator of their abundance. Fresh diggings of the pocket gopher (*Thomomys bottae*) were common throughout the bosque and probably indicated that this was the rodent species of greatest

Table 6. Mammals found in the bosque from December 1971 to April 1973.

| Species | Common Name |
|---|---|
| Sylvilagus auduboni[a] | Desert cottontail |
| Lepus californicus | Black-tailed jack rabbit |
| Spermophilus variegatus | Rock squirrel |
| Thomomys bottae | Botta's pocket gopher |
| Perognathus penicillatus | Desert pocket mouse |
| Dipodomys merriami | Merriam's kangaroo rat |
| Peromyscus eremicus | Cactus mouse |
| Neotoma albigula | White-throated woodrat |
| Canis latrans | Coyote |
| Procyon lotor | Raccoon |
| Mephitis mephitis | Striped skunk |
| Conepatus mesoleucus | Hog-nosed skunk |
| Lynx rufus | Bobcat |
| Dicotyles tajacu | Collared peccary |
| Odocoileus hemionus | Mule deer |

[a]Scientific and common names taken from Jones, Carter and Genoways 1973.

biomass, if not absolute number. Two pocket gopher traps were set on one occasion in separate holes and resulted in the capture of two animals.

Approximately 850 trap nights of small mammal trapping resulted in the capture of only 15 rodents of four species as follows: Perognathus penicillatus (11), Dipodomys merriami (2), Peromyscus eremicus (1) and Neotoma albigula (1). This represents a trap success of only 1.7 percent, suggesting that rodent populations are low in the bosque. The P. eremicus that was caught was trapped along a small, stony wash and the D. merriami were caught in a clearing with sparse mesquite growth and almost no ground vegetation. The latter species is typically found in southern Arizona in creosote-bush (Larrea tridentata) communities, a community which is most nearly approximated in the bosque by a clearing. N. albigula abundance can often be judged by the presence of its "pile of sticks" type of nest. This nest was found infrequently in the bosque and was always adjacent to hollow Goodding willow logs. Only one specimen of this species was caught, but another woodrat was seen running from a willow log after a striped skunk (Mephitis mephitis) entered the same log.

The following accounts of species seen in the bosque may help to explain the importance of this habitat in their life cycles:

Sylvilagus auduboni. --The desert cottontail was the most commonly seen mammal in the bosque during this study, although my field notes indicate that they were seen much more frequently in 1972 than during the comparable period in 1973. Since I often had a dog with me beginning in the autumn of 1972, it is possible that any trend of this type with any mammal species is due to this bias. Young cottontails were seen on the site several times, indicating that the cottontail probably dens in the bosque. Sightings of this type were most common in the vicinity of man-made mesquite brush piles.

Lepus californicus.--Only one jackrabbit was seen in the bosque during this study. It was seen in January 1972 and was foraging on plants of the herbaceous layer.

Spermophilus variegatus.--The rock squirrel was seen only two or three times in the bosque, each time along the eastern edge. These squirrels had undoubtedly come from the rocky slopes east of the bosque, where they were commonly seen.

Canis latrans.--Even though I saw coyotes in the bosque several times, their droppings were even more evident and could be found along cow paths and the dirt service road at any season of the year. During the fall and winter, these droppings were often full of partially digested mesquite beans. It is doubtful that this species actually

denned in the bosque, since the terrain is very flat and contains no dirt banks in which to dig burrows. However, many suitable denning areas are east and west of the bosque and are probably the source of coyotes found on my study site.

Procyon lotor.--This mammal's tracks were positively identified from soft mud bordering the small stream in the bosque. Since this stream supports an abundant number of bullfrogs (Rana catesbeiana), both adults and tadpoles, it is probable that raccoons forage in this area for food.

Mephitis mephitis.--The striped skunk was the most commonly seen carnivore in the bosque. It was actually seen only during the summer and early fall of 1972, but tracks were common on the site throughout the study. During one half-mile bird transect on September 1, 1972, I saw two of these skunks apparently foraging for food.

Conepatus mesoleucus.--This skunk was seen only once, in April 1973, and was climbing inside of a hollow willow tree at that time. It had been digging at the base of the tree, apparently constructing a den, and used the hollow trunk as escape cover when I approached.

Lynx rufus.--I saw only one bobcat in the bosque during this study, but the observation related below was an important one. I observed this animal for about 10

minutes in September 1972 adjacent to the marshy pond. During this time it stalked and captured a pocket gopher which was apparently on the surface of the ground next to its burrow. This incident occurred in the morning after the sun was up, and it indicated the importance that this very common fossorial rodent may have as a food source for carnivores and large raptorial birds in the bosque.

Dicotyles tajacu.--The collared peccary was seen on two occasions in the bosque, both times in August 1972. On August 20, I saw one adult moving rapidly through the bosque from west to east. On August 25, and in approximately the same location as the August 20 sighting, I saw 13 adults with two young moving from west to east in single file. These javelina may have been cutting through the bosque on their way from the river bottom to the large rocky washes east of my study site, or they may have been feeding in the bosque.

Odocoileus hemionus.--Antlerless mule deer were seen on three occasions in the bosque, twice in April 1972 and once in September 1972. On each occasion the lone deer was seen in the same general location and was always moving from west to east. This location was very near the area that I made all of my javelina observations and may represent a commonly used corridor through the bosque.

## Amphibians and Reptiles of the Bosque

Although I did not spend extensive time searching for amphibians and reptiles during this study, all species encountered between January 1972 and April 1973 were noted and listed in Table 7. The bosque pond was the site of large populations of two species, the bullfrog and the checkered garter snake (Thamnophis marcianus). This snake is an aquatic species and feeds mainly on frogs and tadpoles, which are common in this area. Several other species were seen only once or a very few times during the study, but were always found in the vicinity of this pond. They were the western spadefoot (Scaphiopus hammondi), western box turtle (Terrapene ornata), desert-grassland whiptail (Cnemidophorus uniparens) and the kingsnake (Lampropeltis getulus). There may or may not be any significance to finding these species only in this area; certainly the whiptail was found here because of the presence of a clearing and not because of the presence of water. The spadefoot was found on a rainy night in July and commonly breeds in small pools of water at this time of year (Stebbins 1966). The kingsnake, which feeds on frogs and snakes as well as other food items, would find hunting rather easy in the pond area (Stebbins 1966).

Again, quantitative data were not collected on this vertebrate group, but I can safely state that the bullfrog,

Table 7. Amphibians and reptiles found in the mesquite bosque between January 1972 and April 1973.

| Species | Common Name |
|---|---|
| *Scaphiopus hammondi*[a] | Western spadefoot |
| *Bufo alvarius* | Colorado River toad |
| *Rana catesbeiana* | Bullfrog |
| *Terrapene ornata* | Western box turtle |
| *Gopherus agassizi* | Desert tortoise |
| *Sceloporus clarki* | Clark's spiny lizard |
| *Sceloporus undulatus* | Eastern fence lizard |
| *Urosaurus ornatus* | Tree lizard |
| *Cnemidophorus uniparens* | Desert-grassland whiptail |
| *Lampropeltis getulus* | Common kingsnake |
| *Thamnophis marcianus* | Checkered garter snake |
| *Crotalus atrox* | Western diamondback snake |

[a]Scientific and common names taken from Stebbins 1966.

checkered garter snake and tree lizard (Urosaurus ornatus), were the most frequently seen. The completeness of Table 7 is certainly open to question, especially when considering the snakes, which are mainly nocturnal in southern Arizona. Only three species were ever encountered in the bosque and certainly do not represent the entire snake fauna of the site. Lizards, which are diurnal, are easily found and Table 7 is probably complete in this regard. Tree lizards, fence lizards (Sceloporus undulatus) and spiny lizards (Sceloporus clarki) are all largely arboreal and were common on mesquite and willow trees. These species were rarely seen on the ground, but when found there, immediately ran to the nearest tree.

# DISCUSSION

The autecology of mesquite and other southern Arizona phraetophytes is important in determining the vegetational composition of bosques. Zimmerman (1969) found that drainage area, geology and flow regimen were most important in the distribution of valley-floor vegetation. However, he stated that since the mesquite bosques of the San Pedro Valley grow about 20-30 feet above the entrenched channel, an elevation now presumably no longer reached by channel flow, their relation to stream flow is indirect. Also, mesquite taproots are commonly 30 feet long. In general, where the ground water exceeds 40 feet in depth, closed canopy mesquite forests do not exist, but only open stands of shrubs or savannas (Zimmerman 1969).

The other major phreatophytes of the San Pedro Valley, seepwillow (Baccharis glutinosa), ash, willow, sycamore (Platanus wrightii), salt cedar and cottonwood need sustained flows to saturate substrate for successful germination and seedling establishment, especially during winter and early spring (Zimmerman 1969). Because these conditions only exist immediately adjacent to the river or in the area of the artesian well on my study site, these species are limited, in the main, to these moister areas.

Water quality is also important in the distribution of these species along valley floors. Salt cedar can stand a very high concentration of dissolved solids in the ground water, more than 8000 parts per million, while ash, willow and cottonwood are very intolerant of such conditions. Mesquite is apparently intermediate in its tolerance of dissolved solids (Zimmerman 1969, Robinson 1958).

As stated in the Introduction, the purpose of this study was to evaluate the mesquite bosque as to its wildlife, scientific and esthetic value. Although the determination of any one of these values may contain a certain amount of subjective influence, the determination of the esthetic value of the habitat is entirely so. At any rate, this will be discussed from the point of view of one who has spent hundreds of hours in such a habitat type over the past year and a half.

The wildlife value of the mesquite bosque can be divided into three general categories: (1) source of food, (2) cover or shade, and (3) nesting or denning site. Of the species of plants found in the bosque, the mesquite tree is probably the most valuable as a food source. Martin, Zim and Nelson (1951) who compiled wildlife food values for many species of plants, found that 25 species of birds and mammals in the Southwest utilized the mesquite's bark, leaves, twigs and seeds for food. These animals, many of

which were found on my site, included the white-winged dove (Zenaida asiatica), Gambel's quail (Lophortyx gambelii), coyote, mule deer, several species of cottontails and jack-rabbits, and the gray fox (Urocyon cineroargenteus). Other plants found on my study site that were reported by Martin et al. as wildlife food sources include Erodium cicutarium, Condalia lycioides, Lycium sp., Amsinckia tessellata and species of Poa and Bromus. Because the seeds of the annuals mature in late winter or early spring and those of the woody species ripen during summer and fall, it is only from December to February when plant food is relatively scarce in the bosque.

Animal food can be subdivided into two basic types, vertebrate and invertebrate. I have seen evidence of raptorial bird predation on flickers (Centurus sp.), mourning doves (Zenaidura macroura) and Abert's towhees and I observed a bobcat capture a pocket gopher. These are probably common types of predator-prey interactions in the bosque and represent only a small number of such examples when one considers the endless possibilities of interactions that may exist between 95 species of birds, 15 species of mammals and at least a dozen species of amphibians and reptiles.

Insects are undoubtedly the most common invertebrate group used as food, though centipedes and scorpions

are easily found beneath woody debris. Two insect families deserve special mention due to their abundance in the bosque: Tenebrionidae and Cicadidae. Tenebrionid beetles are common from March to October and can be found in the open during these months, or under logs during the colder months. Many species of birds and both species of skunks found on my study site take beetles as food. The "eruption" of cicadas in the bosque occurred the last week of June in 1972, with adult cicadas present until the middle of July. One mesquite trunk that I examined contained exoskeletons of 40 cicadas that had emerged. Because the bird population of the bosque was highest on my site from May until early July, it is probably safe to assume that the synchrony of the cicada emergence with this period of high avian concentrations results in the use of this insect as food.

It is difficult to determine to what extent an animal searches out cover, such as a bosque, for shade during the intense summer heat of southern Arizona. It has been shown that forests have a more moderated climate than adjacent communities, with temperatures lower in summer and higher in winter, due to the blanketing effect of trees (Allee et al. 1949). Anthony (1972), who worked on mule deer in the San Cayetano Mountains in southern Arizona, found them extremely hard to find during the summer. He maintained that they became nocturnal at this time and

spent the daylight hours bedded down in mesquite thickets at lower elevations. Similar use of mesquite drains was found in southern Texas, where this habitat type was considered "loafing cover" for deer (Inglis 1964). I observed mule deer in the bosque only during the months of April and September, not during the intervening months, and therefore, can not conclude that deer used this site for its shade. Javelina, however, were only seen in the bosque in August and may indicate a preference for this habitat type during the summer.

The nesting utility of the bosque was presented in Table 5 for bird species that I found there. All species of large, common, woody plants were used to some extent as nest sites for birds. I found no ground nesting activity whatsoever during the study, possibly due to intensive grazing on the site by cattle and horses.

Of the mammals, only three species were ever seen in a den situation: the two species of skunks and the white-throated woodrat. All three of these observations involved Goodding willow logs or hollow trees. Goodding willow makes the best den tree for mammals in the bosque because of its tendency to become hollow and yet remain standing. I saw many such trees that could support mammals as large as raccoons and may also provide nest sites for certain species of owls.

Certain species of vertebrates were not seen in the bosque which one might expect to be present, based on geographical distribution and habitat preference (Cockrum 1960, Burt and Grossenheider 1964). These include the gray fox, hooded skunk (Mephitis macroura) and several species of Peromyscus and Perognathus. It is likely that some or all of these species occur in the bosque, but were never detected through observations or trapping. The conspicuous absence of certain terrestrial genera of lizards, Callisaurus, Holbrookia and Phrynosoma, is probably due to the absence of a suitable habitat (substrate). These lizards require open areas for hunting prey or running to escape predators. With the bosque floor covered with a dense grass stand for several months of the year, these adaptations are essentially nullified. Although Cnemidophorus uniparens, a "runner", was seen on the site in 1972, all sightings were in the same clearing and were believed to be the same individual.

Direct comparisons between the wildlife value of one habitat and that of another are usually difficult due to a lack of quantitative data. However, National Audubon Society breeding bird surveys are conducted every spring in many areas of the country. From 1969 to 1971, this survey was run near Phoenix, Arizona in the saguaro-palo verde (Carnegiea-Cercidium) association, a habitat common in southern Arizona and typical of the Sonoran Desert.

The number of bird species found breeding on the selected site during May of 1969, 1970 and 1971 was 13, 14, and 10 species respectively (Radke and Jones 1971). Although I used a different technique on my site for determining breeding species, I found 20 species of territorial and/or nesting birds in the bosque during May 1972.

It is not surprising that the vegetation of a riparian habitat has a greater number of nesting species than adjacent areas. Bird populations are very low in the open desert (0-37 pairs/100 acres) but may reach 108 pairs/100 acres in the desert near water where there is greater diversity of vegetation (Kendeigh 1961:336). Allee et al. (1949) stated the same phenomenon in a different way by saying that "as a consequence of stratification, the forest community has a large intracommunity surface in proportion to its volume, and its inhabitants (animals) have a greatly increased variety of food . . ." (p. 479).

As I see it, setting aside at least one well-developed mesquite bosque is important in a scientific sense. If such an area were completely excluded from human disturbance and grazing, it could serve as a valuable monitor of natural changes in a riparian habitat. Changes or the lack of change in the vegetation and dependent wildlife populations could be used as a control with which to compare riparian habitats that are victims of human encroachment. To my knowledge, no such area is being

preserved in Arizona for this purpose, although the Arizona Academy of Sciences has made preliminary studies in that direction (Dr. E. L. Smith, Arizona Academy of Sciences, Phoenix, Arizona, personal communication, 31 January 1973).

A closed canopy mesquite bosque has a certain esthetic appeal to this observer, possibly because it is reminiscent of the forests of eastern United States. It is unique in that it is the only type of winter-deciduous forest in Arizona; other phreatophytes often form a narrow, "gallery" stand along drainageways that can not be considered a forest. At certain times of the year (spring and late summer) the bosque has a lush aspect of green grass and shade producing trees that approaches the floral "richness" of a Pinus-Pseudotsuga-Populus association of some of the Arizona mountains. This aspect of the bosque is usually in marked contrast to adjacent desert areas, where ground vegetation is sparse and shade is lacking.

The future of mesquite bosques in southern Arizona is at best tenuous. Hundreds of acres have already been cleared in the San Pedro Valley alone, presumably to increase the usefulness of the floodplain for grazing and for planting agricultural crops. Clearcutting, in order to increase available water for irrigation by decreasing water use by phreatophytes, is a second reason given for bosque destruction. However, studies of phreatophyte clearing for water conservation in the Southwest were

reviewed by Campbell (1970) and led to these conclusions: (1) clearcutting riparian plants increases surface flows if sufficient plants existed on the site; (2) increased water yields are modest, probably because of increased surface evaporation; (3) retreatment of the site is necessary, thus the cost of periodic maintenance must be included in the total cost of harvested water. In other words, justification for future vegetation manipulation on low elevation floodplains will be based on the value of additional water harvested and the cost-benefit analyses of alternate land uses, including recreation (Campbell 1970).

Undoubtedly, more areas will be cleared in order to develop the land into trailer parks, private homes and rental units. This has already occurred to a great extent on the east side of the San Pedro River across from Mammoth and represents, in my opinion, the greatest threat to the continued existence of low elevation riparian habitats.

Finally, there is one other important factor in the prognosis of this habitat type and, although man-caused, has a natural effect on riparian woodlands: lowering of the water table. I have mentioned that mesquite roots seldom penetrate farther than 30-35 feet into the ground. Therefore, if the water table is lowered much below 40 feet, the mesquite will not be able to survive in the tree growth form. This is apparently what happened to the bosques of

the Santa Cruz River south of Tucson in addition to being the victim of widespread clearcutting.

It is important to consider riparian woodlands as separate and distinct communities, if they are to attain significant status and protection against further encroachments. Lowe (1964:62) stated this concept as well as it can be said:

> It is incorrect to regard this biotic formation as merely a temporary unstable, seral community. It is an evolutionary entity with an enduring stability equivalent to that of the landscape drainageways which form its physical habitat. That is, it is a distinctive climax biotic community! Moreover, it is, as are all ecologic formations and their subdivisions, locally subject to, and often dissolved by, the vicissitudes of human occupation . . . .

## SUMMARY

An ecological survey of a mesquite bosque was conducted from November 1971 to April 1973 in a woodland along the San Pedro River south of Mammoth, Arizona. This riparian woodland was composed almost entirely of a closed canopy stand of mesquite trees, 35-40 feet tall, but with a scattered distribution of Goodding willow, velvet ash and Fremont cottonwood. The ground cover consisted of annual grasses and forbs for most of the year, with Erodium cicutarium and grasses of the genera Poa and Bromus making up the important food plants of this stratum.

The San Pedro Valley has undergone drastic changes during the last century, physically and botanically, and this has no doubt been the result of several factors. Mesquite bosque development has not been an irreversible process through time, but has probably occurred periodically as changing physical conditions allowed it. This has made accounts of 19th century pioneers seem confusing and contradictory, when many such reports on the vegetation may have been accurate for a given localized area.

I recorded 95 species of birds on the site during the study, of which 28 species nested there. Only Bewick's wren, ladder-backed woodpecker, Abert's towhee and the

verdin were found in the bosque during every month of the year. Common winter residents included Audubon's warbler, white-breasted nuthatch and the brown creeper. Lucy's warbler, vermilion flycatcher, ash-throated flycatcher and summer tanager were abundant during the summer and nested in the bosque.

Fifteen species of mammals were observed or trapped in the bosque. The most common species were the coyote, striped skunk, desert cottontail, Botta's pocket gopher and Perognathus penicillatus. Of 850 trap nights spent attempting to trap small mammals, only 15 animals were caught for a trap success of only 1.7 percent.

Although 12 species of amphibians and reptiles were found in the bosque, the list is probably not complete. The nocturnal habits of most Arizona snakes undoubtedly led to several species being undetected. The bullfrog, checkered garter snake and the tree lizard were the most frequently encountered "herptiles" on the site.

The mesquite bosque has value not only as a wildlife habitat, but it also has an esthetic and scientific value that are difficult to measure. A well-developed bosque should be preserved as a control area with which to compare riparian woodlands that are influenced by human encroachment.

The future of mesquite bosques in Arizona is at best tenuous. They have been cleared for raising agricultural crops, to "improve" grazing lands, and to enable the floodplains to be developed. They may be cleared in order to increase available water supplies, but this procedure must be considered carefully in relation to cost-benefit analyses. Riparian woodlands must be thought of as distinct biotic communities if they are to receive the status and protection necessary for their survival.

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