

COOPER ORNITHOLOGICAL SOCIETY

**PACIFIC COAST AVIFAUNA
NUMBER 32**

**Birds of Pine-Oak Woodland
in Southern Arizona and
Adjacent Mexico**

**BY
JOE T. MARSHALL, JR.**



**BERKELEY, CALIFORNIA
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SPOTTED SCREECH OWL
OTUS TRICHOPSIS

Edited by
ALDEN H. MILLER
and
FRANK A. PITELKA
at the
Museum of Vertebrate Zoology
University of California, Berkeley

NOTE

The publications of the Cooper Ornithological Society consist of two series—*The Condor*, a bimonthly journal, and the *Pacific Coast Avifauna*, for the accommodation of papers the length of which prohibits their appearance in *The Condor*. For information as to either series, address C. V. Duff, Business Manager, 2911 Antelo View Drive, Los Angeles 24, California, or Thomas R. Howell, Assistant Business Manager, Department of Zoology, University of California, Los Angeles, California.

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INTRODUCTION

Woodland of mixed pines and oaks is familiar mountain scenery in México, whence it extends into southeastern Arizona along with many kinds of Mexican birds. This woodland occupies a belt from about 5500 to 6500 feet in elevation between encinal (oak woodland) below and ponderosa pine forest above. It combines tree forms of both these zones so as to make a smooth transition between them. The present report compares the numbers of each species of breeding bird in a series of stations, within pine-oak woodland, which were visited in the summers of 1951, 1952, and 1953. These sites extend from the Pinaleno and Santa Catalina mountains in Arizona south into central Sonora and to the Sierra Madre Occidental of northwestern Chihuahua (fig. 1). The stations were selected in relatively flat terrain in well-developed pine-oak woodland where there was water and a good place to camp. The stations differed in the following ways which affected the local occurrence of birds: steepness, whether on a ridge or in a canyon, amount of water and riparian vegetation, stature and spacing of trees, amount of grass, and proximity to coniferous forest.

My censuses were linear; I walked about a mile along a road, stream, or canyon, whistling an owl call, particularly that of the Pygmy Owl, which rouses most of the small birds. Then I recorded each pair, flock, or singing male either on a map (fig. 2) sketched to scale and showing vegetation and topography, on a tabulation over a paced-off mile, or on a tabulation of a cross-country hike for which I estimated the distance. For localities visited two or more summers, the census on maps showed which species used the same territories in successive years. I also took notes in the field on behavior, especially feeding behavior, and collected specimens here and there, generally off the census places, to learn about breeding status and food taken as well as to authenticate critical records of occurrence. In addition to the census, I sought to learn how each kind of bird uses pine-oak vegetation in its hunting and what it chooses for its place of activity. From these considerations an attempt is made to explain its abundance and distribution within the study area.

Separated from each other by desert lowlands, the mountains of this area are small, steep and rugged, except for the Sierra Madre, which is a vast plateau. Therefore the pine-oak woodland, limited to mountains, occurs in isolated patches strung out to the north and west of its extensive domain in the Sierra Madre. Snow covers these mountains for short periods in the winter, but at least half the annual precipitation is rain from thunderstorms in July, August, and September, which is the growing season for grass and wildflowers. By June, the driest month, the ground is parched and is bare from grazing. There is pleasure and excitement in seeing for the first time which trees and birds are present on some of these remote peaks; for instance, to find *Quercus viminea* close to Arizona in the Pinitos Mountains; to record the Turkey and the Pygmy Owl in the Sierra de los Ajos; to see bears and Steller Jays in the Sierra Aconchi, which is only 60 miles airline from Hermosillo, Sonora; and to find a colony of House Wrens on the Sierra Azul.

Other ranges are well-known from previous study by biologists. Edgar Mearns (1907) was attracted to the border mountains, especially the San Luis range, during his service as biologist with the International Boundary Commission from 1892 to 1894. His descriptions of the area, its flora and animal life, and his adventures make fascinating reading. Forrest Shreve's classic, "The vegetation of a desert mountain range" (1915), pertains to the Santa Catalina Mountains, but it is the key to understanding the plant life of the whole region of my study. Wallmo (1955) has recently



Fig. 1. Study area and localities where observations were made in pine-oak woodland. The contour represents the lower border of pine-oak, at about 5500 to 6000 feet elevation.

studied the vegetation of the Huachuca Mountains. White (1948) and Le Sueur (1945) made large plant collections and analyzed the vegetation respectively of El Tigre Mountain and the northern part of the Sierra Madre Occidental. Brand (1937) also studied the vegetation of the Sierra Madre, in connection with his extensive geographical studies in northwestern Chihuahua. During 1890 Lumholtz (1905) visited the Sierra Nacori, where he saw the Imperial Ivory-billed Woodpecker (*Campephilis imperialis*). Among the many papers on birds of southeastern Arizona mountains Brandt's (1951: 644-703) is especially valuable to ecologists because it lists the plants and birds found

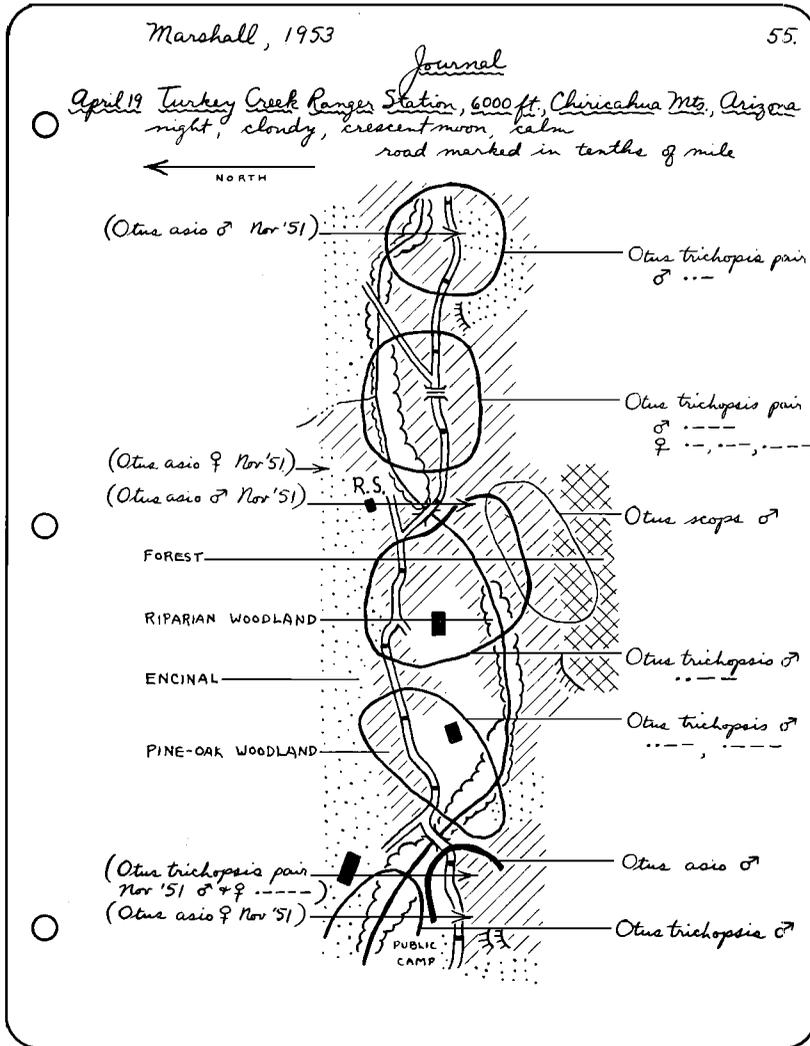


Fig. 2. A representative census map from the Chiricahua Mountains, showing three species of owls of the genus *Otus*. Dots and dashes refer to distinctive individual patterns in the syncopated song of the Spotted Screech Owl, *Otus trichopsis*. In parentheses are records for November, 1951, when, if all individuals present responded, the relative status of *trichopsis* and *asio* was apparently the reverse of that in the spring of 1953. However, neither species calls much in November; in fact the Spotted Screech Owls shown are the only ones I have ever heard in winter. The record for *Otus scops* (= *flammeolus*) is not particularly early, for this owl arrives at the end of March in the Santa Catalina Mountains and remains until well into October.

in the vicinity of a typical nest for each species. Scott (1886–1888) reported birds from the Catalina Mountains. The birds of the Sierra Madre in Chihuahua have been investigated by collectors ever since Nelson and Goldman's expeditions (Nelson and Goldman, 1926; Goldman, 1951; Friedmann, Griscom, and Moore, 1950). The important collections from the mountains of northern Sonora, aside from recent specimens taken

by A. R. Phillips and myself, are those of Mearns in the San Luis and San José mountains, B. Campbell on El Tigre, W. W. Brown in the Sierra de San Antonio, and J. C. Cahoon on the Oposura.

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Technical assistance was generously provided by the following persons who identified plants or discussed ecologic problems: Daniel I. Axelrod (paleobotany), Berry Campbell (unpublished notes on birds of El Tigre Mountains), William A. Dayton (pines), Joel Fletcher (soils), A. Starker Leopold (Río Gavilán), C. H. Lowe, Jr. (ecology), Robert R. Humphrey (effect of burning), Maximino Martínez (conifers), Alden H. Miller (instructions for locating certain rare species at the Río Gavilán—unfortunately to no avail!), N. T. Mirov (pines), Kittie Parker (herbarium methods), Frank A. Pitelka (suggested the problem), Edmund Schulman (climatic change indicated by tree-rings), Sanford S. Tepfer (pines), John M. Tucker (oaks), and Charles Wallmo (vegetation of Huachuca Mountains).

Work on the manuscript by Norine Barrie, Mary Lauver, Cheer Owens, A. R. Phillips, A. Richards, Elsie Marshall, and Dora Wright is greatly appreciated. Allan R. Phillips geared several of his expeditions to my problem, permitting me to share his transportation. His exhaustive knowledge of migration in this area permitted an understanding of several species which migrate as late as the middle of June. He made available his photographs, unpublished records, and a photostat of Edgar Mearns' notebooks. None of the above persons is in any way responsible for the views expressed here; even the names of plants are the responsibility of the author, who is more of a "lumper" than his botanist friends.

Scientific collecting permits were granted through the courtesy of the Dirección General Forestal y de Caza, México.

Some observations are included in this report from field work on another study conducted in 1954-55. This project was supported by W. J. Sheffler and a truck was loaned by Ed N. Harrison. I am indebted to William Adams, Manager of Rancho de Cananea for permission to visit the Sierra de los Ajos.

FLORA

In deference to Fosberg's (1950) plea that ecologic data be verified, I have taken specimens of all the following pines and oaks, and of most other trees and shrubs of the study sites. These were collected in Sonora and Chihuahua (table 1) and are deposited in the University of Arizona Herbarium, from which duplicates have been distributed.

The one indispensable reference for the identification of pines is Martinez (1948); Trelease (1924) is the authority for oaks. Other useful guides for plant identification are Kearney and Peebles (1951), Little (1950), Shaw (1909), and Standley (1920–1926). Since no single work covers my entire study area, I present the following characterizations of the plants composing pine-oak woodland.

Pines.—The pines of pine-oak woodland stand high above the oaks. Their foliage forms solid shade, but the branches are open so that small birds can be seen almost continually as they forage. Numerous dead snags of pines attract such birds as the Acorn Woodpecker and Purple Martin. In their color, stature, and columnar form, Chihuahua pine and Apache pine look like their forest relative, ponderosa pine. Many pine-forest birds, such as Flammulated Owls and Creepers, are attracted to the woodland because of this similarity.

Pinus leiophylla. The crown of the graceful Chihuahua pine is peppered with small, ovoid, persistent cones. Its foliage is dense; its needles are short and in three's in the northern variety which occupies my entire study area. It grows on steep, dry, or rocky hillsides at elevations below ponderosa pine. Its altitudinal range narrows from south to north in the study area, beyond which it exists only as a small colony in the White Mountains, near Whiteriver, Arizona, and in the Pinal Mountains, near Globe, Arizona. Chihuahua pine enters pine forest in a few places in the Pinaleno Mountains, Sierra Madre, and Sierra Nácori, where one notes with surprise that it grows larger and is more luxuriant than in woodland. Indeed there are some pure stands in the Sierra Madre that constitute true pine forest. This pine seems to be missing from the Pulpito and Oposura mountains.

Pinus engelmanni. Apache pine is a stately tree related to ponderosa pine, from which it differs by having huge needles (in three's in this northern form of the species), stout twigs, and larger cones. The erect pompoms, each with its pattern of light and shadow, stand out separately even in a distant view, whereas the foliage of the other pines blends. This pine thrives on flood-plains and mesas; otherwise it is distributed similarly to Chihuahua pine throughout the study area save that its northern limits are the Santa Rita and Chiricahua mountains (fig. 3). Its altitudinal range broadens southward, and it also enters ponderosa forest on the Sierra Nácori and composes forest in pure stands on the Sierra Pulpito and some mesas on the Sierra Madre, where its growth is superior to that in its normal woodland range.

Pinus ponderosa. Ponderosa pine enters pine-oak woodland here and there, on north slopes at the lower altitude of its tolerance range, where it mingles with silver-leaf oak. Throughout the study area its 5-needle variety prevails, save on the Pinaleno Mountains and in some colonies within the Sierra Madrean forest, where the 3-needle type predominates. Its principal range of altitude is broad and above that of the woodland oaks, where practically alone it composes a vast open forest. Several kinds of trees which may accompany this population are inconspicuous among or under the forest giants: Mexican white pine (*P. ayacahuite*), Gambel oak (*Quercus gambelii*), and grasses occur throughout the area; in the south are the large oaks, *Quercus reticulata*, *Q. fulva*, and *Q. durifolia*, and a shrub oak, *Q. depressipes*. The small ranges of my study area constitute patches of *Pinus ponderosa* which are strung between two great popu-

Table I
Selected List from Flora of Census Stations in Pine-oak Woodland
(Known occurrence on a mountain not indicated unless species is found in pine-oak.)

Specimen, Chihuahua Specimen, Sonora Position	PINALENO	CATALINA	SANTA RITA	HUACHUCA	CANANEA	AJOS	CHIRICAHUA	PELONCILLO	SAN LUIS	SIERRA MADRE east	PULPITO	PINITOS	AZUL	ACONCHI	OPOSURA	EL TIGRE	HUACHINERA	NACORI	SIERRA MADRE west	SIERRA MADRE high
U Pteridium aquilinum					o									•	•					•
x x Pinus leiophylla	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
x x Pinus ponderosa	•	•	o	•	o					•	o	o	o	•	•	•	o	o	•	•
x x Pinus engelmanni			•	•	•	•	•		•	•	•	•	•	o	•	•	•	•	•	•
x Pinus durangensis																			•	•
x x (R) Pseudotsuga taxifolia	o	o	•			•	o		•	o						o				
x R Cupressus arizonica							•		o								•	o		
x Juniperus deppeana	•	•	•	•	•	•	•	•	•	•	o	o	o			o	o	o	o	o
x x R Juniperus scopulorum ?							•													•
U grasses, other herbs		o	o			o	o	o	o	o	•	•	•	•	o		•	•	•	•
Agave parryi	o			•	o	o				o	o						o	o		
R Populus angustifolia		o								•										•
R Populus fremontii		o	o	o	o	•	o			•	o									o
x ru thickets of Salix						•	•				•		o							•
R Salix gooddingii				o		•														•
x R Juglans rupestris	•	•	•	•	o	•	•		o	•	o				•		•			
x R Alnus oblongifolia	•	•				•									•		•			
x x Quercus arizonica	•	•	•	•	•	•	•		o	•	•	•	•	•	•	•	•	•	o	•
x Quercus oblongifolia																		o	•	
x Quercus grisea								•												•
x x Quercus emoryi	•	•	•	•	•	•	•	o		•		•								•
x R Quercus durifolia																				•
x x Quercus viminea												•	•	•	•	o	•	•	•	•
x x Quercus hypoleucoides	•	•	•	•	•	•	•	o	•	•	•	•	•	•	•	•	•	•	•	•
x x Quercus endlichiana									o					o	•	•	•	•	•	•
x R Platanus racemosa	•	•	•	•	•	•	•				•	•	•	•	•	•	•	•	•	•
U Fallugia paradoxa							•	•												o
ru Prunus emarginata						•														
x (R) Prunus virens		•	•	•	•	•	•		o	•	•	•	•	•	•	•	•	•	•	•
ru Rhus radicans						•	•	•			•	•	•	•			•			•
x U Rhus trilobata		o	•	•	•	•	•	•	•	•	•		o							•
x U Rhus glabra						•					•									•
R Acer negundo	•	•																		
x R Acer grandidentatum				o		•	•													•
ru Rhamnus betulaeifolia	•					•	•	•	•	•	•	•	•							•
x x U Ceanothus huichagorare						•	•			•	•	•	o	•	•	•	•	•	•	•
x Arbutus arizonica	•	•	•	•	•	•	•	o	•	•	•	•	•	•	•	•	•	•	•	•
x x Arbutus xalapensis														•	•	o	o	o	o	o
U Arctostaphylos pungens	•	•	•	•	•	•	•	o	•	•	•					•	o			
x x R Fraxinus velutina	•	•				•	•	•	•	•	•				•	•	•	o		•
x ru Lobelia laxiflora														•			•			

U undergrowth in pine-oak woodland • conspicuous
R riparian tree o rare
ru undergrowth in riparian woodland

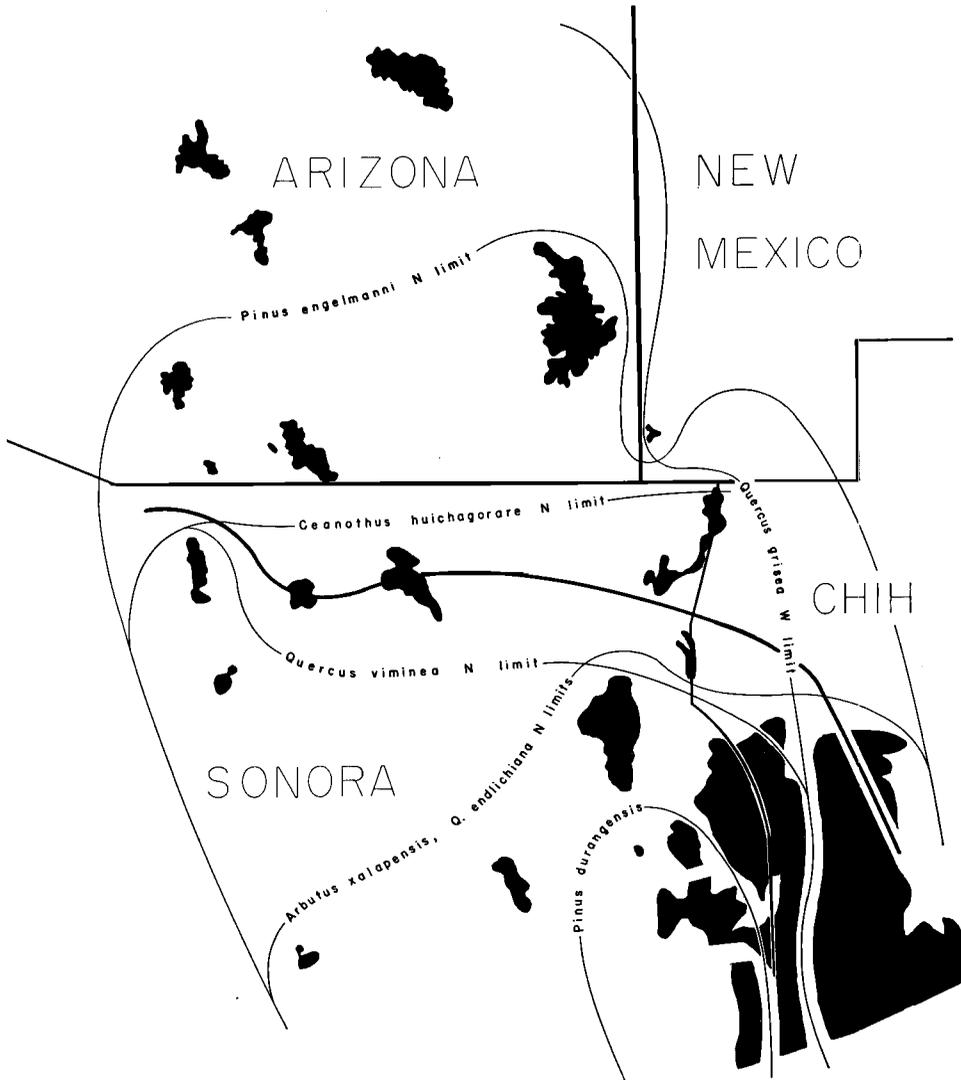


Fig. 3. Northern and western limits of important plants. The heavy line marks the zone of transition between dense woods with junipers in the northeast and open grassy woods in the southwest.

lations (fig. 20, inset): one to the north on the Mogollon Plateau, the other on the summit of the Sierra Madre Occidental. The occurrence of some pine-loving birds on the small ranges depends on the size of the ponderosa area and its distance from one of these two great forest tracts.

Pinus durangensis. This pine enters the extreme southern portion of the study area (fig. 3) at altitudes well below ponderosa pine, and it overlaps the span of blue oak, *Quercus oblongifolia*. This pine is bell-shaped, with longer branches and thinner foliage than the other pines. Its long thin needles are lax and in fives; its compact cones are ovoid.

Oaks.—All the species of oaks which compose encinal of the foothills also grow in pine-oak woods, where such encinal birds as the Bush-tit and Black-throated Gray Warbler find congenial surroundings. These oaks are "evergreen" except in some years of drought, when those at lower elevations, away from springs, turn brown or drop their leaves. All but the last species in the following list have small leaves and such dense foliage that birds entering the crown are often hidden from view. The first three treated are white oaks. In open groves these have a spherical crown formed by irregular branching from a single whitish trunk. They abound with natural cavities. In black oaks (*Q. emoryi* through *endlichiana*) the dark trunk continues into the top and often is divided into two or more erect axes which diverge to make the crown wider at the top than at the base of the tree. As far north as the Pinaleno and Catalina mountains all these Mexican oaks clothe entire mountain slopes below the level of ponderosa pine; beyond, they are mostly limited to canyon bottoms, flood-plains, and gullies.

Quercus arizonica. Arizona oak is found in a broad zone on slopes below the limit of ponderosa pine and is the most abundant white oak of the pine-oak association. Its light olive-green, oval leaves show prominent veins beneath and are not smooth or shiny on either surface. The acorns have short stalks. Arizona oak covers about the same altitudinal span throughout the study area; therefore it extends below the zone of Chihuahua pine in the north and is included within the realm of that pine farther south.

Quercus oblongifolia. Blue oak is distinguished by its blue leaves, which are smooth on both surfaces and of regular, oval shape. It is the first evergreen oak met in ascending a mountain, and it forms with grass an open encinal or savannah. Occupying a narrow altitudinal spread in the north, it expands southward to form a whole "life zone" to itself and to overlap the pines. A hillside of these oaks is of incomparable beauty during the rainy season when the grass is green, and when the sun is shining at a low angle lighting up the white trunks in contrast to the exquisite blue of the foliage. The tree is always colorful; in severe droughts whole mountainsides turn pinkish-tan, the color of its leaves, dried on the twigs, contrasting with the rust color of the next lower zone of the truly deciduous *Q. chihuahuensis*. I have seen blue oaks in such areas budding again in the rainy season, and I am convinced that they are not necessarily dead when leafless.

Quercus grisea. Gray oak is a small tree distinguished from Arizona oak by its smaller leaves of dull bluish-gray and by its longer acorn stalks. In the Peloncillos and several high Sierra Madrean localities (fig. 3) it is the dominant or only oak of pine-oak woodland. North of the study area, at Whiteriver in the White Mountains, it is little more than a shrub under ponderosa pines at the lower edge of the forest.

Quercus emoryi. Bellota, the sweet acorn of the Emory oak, is a delicacy for man as well as a principal diet of the acorn-eating birds. The shiny green leaves, more or less toothed and darker on the upper surface, present beneath a diagnostic small patch of fuzz on either side of the petiole. Although it covers nearly the same altitudinal range as Arizona oak, thus overlapping the pines, Emory oak attains its most impressive development upon the rich soil of valley floors at lower elevations. It is rare and local in the southern portion of the area.

Quercus durifolia. This giant was encountered only along the Río Gavilán and its tributaries, where it is largely confined to canyon bottoms, although at higher elevations it accompanies ponderosa pine on the mesas. The immense crown spreads from an erect clear trunk. Its lenticular leaves are arranged in flat horizontal sprays; their glossy upper surface is intensely dark green in contrast to the lower surface of purest silver-white.

Quercus viminea. The foregoing oaks have small leaves about twice as long as wide.

This and *hypoleucoides* have long lanceolate leaves, which in *viminea* are very slender, smooth and light yellow-green on both surfaces. Altitudinally, the range of this oak agrees with that of Chihuahuah pine and Apache pine, so that it is associated with pines and is generally absent from encinal. Its northern limits (fig. 3), including the Pinitos Mountains near Nogales, Sonora, practically coincide with the boundary of the open, tall, grassy woods characterizing the mountains of the southwestern half of the study area.

Quercus hypoleucoides. Of nearly universal occurrence from upper encinal to lowest pine forest, silver-leaf oak prospers on shady north slopes, whereas the equally abundant Arizona oak dominates the warmer slopes. Silver-leaf oak is easily identified by the woolly white undersurface of its slender leaves. Like Arizona oak, its altitudinal range southward becomes included within that of the pines, whose altitudinal span is greatest there. It is inconspicuous and uncommon north of the Pinaleno and Catalina mountains.

Quercus endlichiana. Like *viminea* this species occurs in woods with pines, and it is found only in the southern portion of the study area (fig. 3). Its leaves are shiny yellow-green above and covered with a golden bloom below. They are flat and oval, about three inches in diameter—big enough to support a standing Bush-tit.

Other plants in or near pine-oak woods.—Although Mexican piñon (*Pinus cembroides*) forms isolated pure stands of dense woodland on steep rocky slopes and occasionally is mingled with pines and oaks, it does not dominate the scenery of the lower mountains the way its relative, *P. edulis*, does (with junipers) to the north of the study area. Consequently there are no birds which reach their greatest abundance in these scattered tracts of piñons.

Alligator juniper (*Juniperus deppeana*), recognized by its checkered bark, accompanies woodland oaks below ponderosa pine forest. It is abundant and conspicuous in the northern part of the study area, particularly upon the Arizona mountains, where it may compose up to one-fourth of the cover. But it rarely dominates, as do its relatives farther north, such as *J. utahensis*, which with *Pinus edulis* forms continuous and extensive woodland. Alligator juniper becomes less numerous southward, in inverse relation to the amount of grass; it is absent from the Aconchi, Oposura, and Nácori mountains. Since it thrives under poor conditions of soil and moisture, it is most abundant in the arid San Luis Mountains and in ranges that have lost their grass and soil through misuse. Figure 7 shows the juniper as the only living tree on a drought-stricken spot in the Catalina Mountains.

Bunch grasses and gramas are most conspicuous in the woods and forest of the southern mountains, where juniper is rare and the trees are tall and far apart. In the higher parts of the Sierra Madre are large natural meadows, and grasses carpet the flood-plains as well as the space under the trees. Mountains with high bases are surrounded by grassland (fig. 20) as discussed by Shreve (1942). Artificial clearings within pine-oak woods in southern Arizona, as at Sunnyside in the Huachucas, support grass which tends to be replaced by alligator junipers. The amount of grass on a mountain varies not only with intensity of grazing, but also with the vagaries, often disastrous, of the summer rains. In 1953 there was no fall growth at all in much of eastern Sonora; but the crop of the following fall must have been extraordinary, for it was still standing luxuriantly in northern Sonora by the spring of 1955.

Ceanothus (*Ceanothus huichagorare*) is a thorny waist-high shrub which grows under the woodland shade, either in thickets or as individual bushes scattered among bunch grasses. House Wrens, Rufous-sided Towhees, and Rufous-crowned Sparrows

are partial to this loose cover, which occurs only as far north as the Pinitos Mountains (fig. 3).

Manzanita (*Arctostaphylos pungens*) and Toumey oak (*Quercus toumeyii*) are stiff-branched shrubs which grow close together in pure patches in the open, or are scattered among woodland trees. They do not form extensive and continuous chaparral in the study area as do scrub oak (*Quercus turbinella*, a close relative of *Quercus dumosa*) and its associates immediately north in the Pinal Mountains. Mountain mahogany (*Cercocarpus breviflorus*) grows among rocks in steep places and covers some mountains, especially those of limestone, from bottom to top, as on the south slope of Huachuca Peak. More important as chaparral is the regrowth of oaks following logging; this forms extensive thickets attractive to Scrub Jays, as at Cananea Mountain.

Arizona cypress (*Cupressus arizonica*), of spotty distribution, forms dense stands resembling forest. On some mountains, such as the Chiricahuas, it is limited at the altitude of pine-oak woods to stream courses. But in the San Luis Mountains it spreads in a solid forest over entire slopes from canyon bottom to summit. True riparian trees, the broad-leaved deciduous alders, maples, sycamores, walnuts, and ash form dense shady woods at springs and along streams crossing pine-oak areas. Like the cypress the different species are unpredictable in their occurrence; an abundant tree in one canyon may be entirely absent from an adjacent canyon.

Summary of flora (table 1).—The species which dominate pine-oak woodland (*Pinus leiophylla*, *P. engelmannii*, *Quercus arizonica*, and *Q. hypoleucoides*) occur nearly throughout the study area and confer some uniformity in flora to the places where censuses were taken. Differences between localities result from the addition southward (fig. 3) of another pine (*Pinus durangensis*), more kinds of oaks (including a species with large leaves, *Quercus endlichiana*), another madrone (*Arbutus xalapensis*), and a shrub (*Ceanothus huichagorare*).

DESCRIPTION OF CAMPS

NORTHEASTERN GROUP

According to the appearance of their pine-oak woods, I divide the mountains into two groups which intergrade through the Pinitos, Cananea, and Ajos ranges. The north-eastern mountains, including the eastern slope of the Sierra Madre, at the levels both of pine-oak and of encinal, have dense growth (often stunted due to crowding), abundant alligator junipers, and little grass. It is apparent from the narrow altitudinal range of Chihuahua pine and Apache pine that pine-oak woodland is limited in extent. Times and places of observations, in pine-oak only, are entered at the end of each description of a mountain range.

Pinaleno Mountains.—My censuses were made near Wet Spring, in a steep, cold gorge which has a tall alder grove and some high mountain species of plants and birds such as white fir, Gambel oak, Hairy Woodpecker, Western Flycatcher, and Western Tanager. Chihuahua pine occupies a small area since it is near its northern limits. It grows in a dense brushy community with alligator juniper, Arizona oak, Emory oak, and manzanita on the south slope. This is the site of soil profile no. 11 of Martin and Fletcher's (1943) study of soil, climate, and vegetation of Mount Graham. The opposite wall is clothed with ponderosa pines topping silver-leaf oaks. Owing to diversion of the water, the riparian trees below the spring were dead and falling in 1951; since then sycamores and box elders have sprung up.

Mapped census at Wet Canyon, 6037 feet: June 27–July 2, 1951; June 12–13, 1952; May 15–16, 1953. Other observations at Wet Canyon: November 25–27, 1949.

Santa Catalina Mountains.—The pine-oak woodlands are the same as on the Pinalenos. Fortunately a road and picnic grounds open up the dense scrubby growth at Bear Canyon (figs. 4 and 5) so that it attracts birds that otherwise would be absent, such as the Ash-throated Flycatcher and Mexican Junco. A steep cool gully brings alders, arboreal net-leaf oaks, a few Mexican white pines (*P. ayacahuite*), and a lush thicket of *Prunus emarginata* down to a narrow pine-oak zone (fig. 6) at Apache Camp, on the north side of the range. The entire sweep of the mountainside there from the lowest Chihuahua pines up through the association of tall ponderosa pines with silver-leaf oaks has been profoundly changing from at least as early as 1951, with a wholesale dying of trees, particularly the large ones and those on ridges and knolls. Proportionately this takes a heavier toll of the large pines than of the small oaks, and much of the slope is being converted into pure encinal. Higher, the ponderosa pines are also dying and the forest yields to pine-oak woodland, which thus maintains its original breadth while merely moving up-hill. Here and there grass is actually taking over, as shown in figure 7.

Mapped census at Apache Camp, 6000–6500 feet: July 23–26, 1951; June 3–5, 1952; April 25–26, May 22–23, August 14, 1953.

Mapped census at Bear Canyon, 5500–5700 feet: March 30, April 5, 12, June 25, October 12, 13, 1951; May 11–12, 24, June 5–6, 1952; February 7, March 26, April 26–27, May 21–22, 1953.

Other observations, mostly at Bear Canyon: October 24, 1949; April 10, 13, 21–22, May 18–19, September 25, October 5–6, 24–25, 1950; March 11, 17, 23, May 4, 12, 19, December 23, 1951; August 14, December 26, 1953; April 23, May 7, 1954; March 13, May 1, 22, 1955.

Santa Rita Mountains.—Gardner and Cave canyons, with virgin timber (fig. 8), broaden at the level of my study sites into basins where silver-leaf oaks form gloomy dense groves with large Chihuahua pines and Apache pines rising through the canopy



Fig. 4. Picnic ground at Bear Canyon, 5600 feet, Catalina Mountains, May 1, 1955. On Sundays hundreds of people throng to this area, where the most intensively studied mapped census route was located. Some bird students oppose development of such recreation areas because they believe it has an unfavorable effect on bird life. Nothing could be farther from the truth, as the census (table 2) proves. Six species of warblers frequent the ponderosa pines shown; juncos and jays steal table scraps; and in the evening *Flammulated Owls* can be heard over the hubbub of picnickers.

(fig. 9). In Madera Canyon most of the pines have been logged, but the large oaks and madrones hint at the former majestic proportions of the pine-oak woodland. In upper Florida Canyon are the largest Apache pines I have seen, growing with Douglas firs almost as a forest, scattered with oaks. In addition to the maturity of its stands, the steep and irregular Santa Rita range is remarkable for the jumbling together of tree species which are normally separated by altitude, and this applies to the areas of the census routes as well.

Florida Canyon: May 4, 1952; October 4, 1953.

Mapped census at Gardner Canyon, 6000–6300 feet: July 27–31, 1951; April 5–7, 26–27, 1952; January 29, 1955.

Madera Canyon and Littleshot Cabin, 5900–6500 feet: April 28, 1950; April 28, May 6, 1951; March 19, 1954; April 23, May 15 (measured census), 1955.



Fig. 5. Bear Canyon, Catalina Mountains, a few feet from site of figure 4, showing density of pine-oak woods away from the picnic clearing; January 22, 1955. *Pinus ponderosa* at left; right, an exceptionally large *Pinus leiophylla*. Oaks are *Quercus arizonica* and *Quercus emoryi*. This grove was inhabited for at least three summers by a Flammulated Owl with a peculiar voice.

Huachuca Mountains.—My censuses were taken from Sylvania to Sunnyside on the west base of the range, where there are ponds, clearings, only small second-growth pines following logging, and very dense growth heavily infested with junipers. On numerous flat areas the pines tend to form pure stands, excluding the oaks. Better growth would be expected because of the mild relief; but logging, grazing (some also claim fire prevention), and loss of soil have brought about such close spacing of the stunted trees that in places at Sunnyside one can scarcely walk among them. Many of the few large trees died between 1951 and 1952 as did those in the Catalina study sites. The Chihuahua pine grows as low as Sunnyside; both it and the Apache pine grow at Sylvania.

Huachuca Canyon: June 11, 1951. McClure Canyon: June 8, 1951. Sunnyside: May 13, 1951.

Mapped census from Sylvania, 6100 feet, to Sunnyside, 5800 feet: June 15–22, 1951; April 18–21, June 8–11, 1952; May 10–11, 1953.

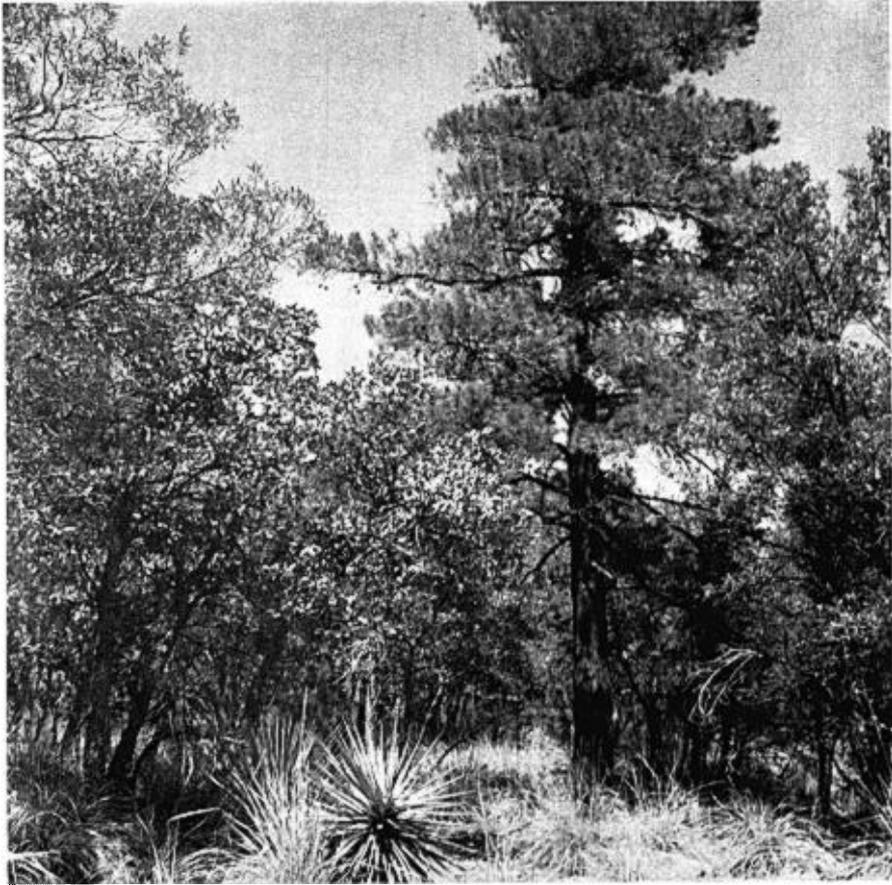


Fig. 6. Apache Camp, 6250 feet, Catalina Mountains, March 13, 1955. Dense stunted growth on south slope showing *Pinus leiophylla*, *Quercus arizonica* (center), *Quercus hypoleucoides* (left), and *Muhlenbergia virescens*.

Cananea Mountain.—The woodland pines are young second-growth following complete logging, and there are no large trees or snags. The oaks are reduced to dense stump sprouts by constant chopping for firewood. Away from the pines they compose an artificial chaparral (instead of encinal) attractive to Scrub Jays and Crissal Thrashers.

Measured census in second canyon east of Puertocito, 5800–6300 feet: July 18–20, 1953. Adjoining canyons: July 16–18, 1953.

Sierra de los Ajos.—There is much variation in the extensive pine-oak woods here (fig. 10). Some steep slopes support tall Apache pines and oaks with ground cover of bunch grass and scattered ceanothus bushes. There is open grassy pine-oak woodland in the broad valley of the Río Claro, where the grass was especially luxuriant in 1955. These places resemble the southern mountains. Elsewhere is found the usual dense scrubby oak growth, with pines towering above, some of which seems to be the result of fire. The great fire of June, 1954, swept in spotty fashion the slopes above the Río Claro, which I revisited just a year later. Certain previously open south slopes were covered with grass, but the dense woodland had become even more dense, for like the Gorgon's heads, a dozen sprouts had come up from each burned oak stump!



Fig. 7. *Muhlenbergia virescens* taking over naturally denuded area of thin soil overlying rocks tilted down-hill. Dead trees are *Pinus leiophylla* (left), *Quercus hypoleucoides* (right), *Arbutus arizonica* (center). *Juniperus deppeana* in back is unaffected by drought. Apache Camp, north slope, 6300 feet, Catalina Mountains, March 13, 1955.

In Molino Canyon flourishes the tallest and most varied riparian growth (fig. 11) of any camp, but the surrounding pines have been extensively logged. The Río Claro, however, has beautiful virgin timber.

Río Claro, 5200–6200 feet: July 20–24, 1953; June 1–3, 1955 (mapped census).

Mapped census in Ajo Canyon (= Molino Canyon), 5800–6450 feet: May 29–June 1, 1953. Other observations in Ajo Canyon, 5500–6450 feet: July 15–17, 28–August 2, 1952; May 28–29, 1953.

Chiricahua Mountains.—Here again the pine-oak woodland is dense and choked with junipers on the prevailing thin soil, but numerous Forest Service picnic grounds provide openings attractive to birds. Especially in Rucker Canyon, there is sorting of the flora here and there so that one finds nearly pure groves of Chihuahua pines, Emory oaks, or silver-leaf oaks, with various mixtures between. Tall Apache pines, Arizona cypresses, sycamores, chokecherries, and oaks mingle on the flood-plains. For a mile or two in rolling country below my study site in Rucker Canyon all the Chihuahua pines were dead except in gullies in 1951. Now most of this former pine-oak wood is encinal.



Fig. 8. Virgin pine-oak woodland at base of south slope in Gardner Canyon, 6200 feet, Santa Rita Mountains, January 29, 1955. *Pinus leiophylla* (left), *P. engelmanni* (right), *Quercus arizonica* (foreground), *Juniperus deppeana* (rear).

Mapped census at Turkey Creek, 6000 feet: April 19–20, 1953 (also visited November 2–4, 1951).

Cave Creek, 5100 feet: August 9–11, 1951; August 15–16, 1952; May 2–3, 1953.

Mapped census in Rucker Canyon, 6100 feet: August 5–9, 1951; April 13–15, August 12–15, 1952; May 1–2, 1953.

Peloncillo Mountains.—Clanton Canyon supports a small grove, two miles long, of Chihuahua pines with gray oaks (fig. 12). The surrounding gentle slopes are covered with piñons, junipers, Toumey oaks, and manzanita; some of these join the pine-oak growth. This is the smallest isolated area of pine-oak that I studied, and it is the only sizeable patch of pines other than piñons on this low range.

Clanton Canyon, 5350 feet: August 17, November 22, 1951; June 18–19, July 7–8, August 18–19, September 3–4, 1952; July 24–25, 29–30, 1954; April 8–9, 17–18, 1955.

San Luis Mountains.—Pines other than piñon are uncommon members of the incredibly jumbled flora of this mountain. I could find no pine-oak woodland quite re-



Fig. 9. Dense virgin pine-oak woodland at base of north slope in Gardner Canyon, 6250 feet, January 29, 1955. *Pinus leiophylla* and *Quercus hypoleucoides*; habitat of pair of Painted Redstarts whose behavior is discussed.

sembling the rest of the study sites and had to use the following situations in order to find a comparable group of birds. In Turkey Canyon there was a patch of a few acres consisting of this "improbable" mixture of trees: Douglas fir, piñon, Chihuahua pine, Apache pine, Arizona cypress, alligator juniper, net-leaf oak, silver-leaf oak, and Arizona madrone. My map census was along a gully cutting the alluvium at the mouth of the next canyon south of Turkey Canyon. The gully contains mostly silver-leaf oak and Douglas fir, while on the alluvium Chihuahua pines and Apache pines stand above an impenetrable manzanita chaparral. The San Luis is doubtless the most arid range in my area of study. There are only two small springs in the portion I traversed. Plants tolerant of drought, such as alligator juniper, piñon, and chaparral shrubs, flourish even throughout the rather stunted coniferous forest. However, conditions must be the same now as in Mearns' time, for Turkey Springs is still exactly like his photograph (Boundary Commission, 1898: facing p. 15) except that the huge maple is now replaced by three of its progeny. There is no logging and practically no grazing in these mountains.

A fire prior to 1951 burned to the ground the dense cypress forests on the slopes above Turkey Canyon. These are now producing shrubs and brushy oak sprouts among abundant grasses and wildflowers.

Turkey Canyon: July 28, 1954, in the only patch of pine-oak found. (Observations elsewhere in the canyon from July 25–29, 1954, account for the many species recorded in vegetation other than pine-oak woods.)

Mapped census in next canyon south: August 18–19, 1951; September 2–3, 1952.



Fig. 10. Ajo Canyon, 5400 feet, Sierra de los Ajos; photograph taken by A. R. Phillips, July 17, 1952. *Pinus leiophylla* and *Quercus emoryi* on flood-plain; open encinal above, on south slope. Site of plant collections.

SOUTHWESTERN GROUP

The remaining southern sites, except for the east slope of the Sierra Madre, have taller trees spaced apart over grass, and junipers are rare. Most of these places have a richer variety of trees than the foregoing stations, and the encinal below pine-oak is likewise open and grassy. Pine-oak woodland occupies a broad zone, dominating the middle altitudes of the mountains.

Sierra Pulpito.—Apache pine is the only conifer I found on this mountain, aside from a few alligator junipers. This pine forms true forest with Gambel oak understory on the north slope. I observed pine-oak birds along the level ridge, which is a park of beautiful wind-swept, clear-trunked pines spaced widely over a carpet of tall grass and wildflowers. Arizona oaks and silver-leaf oaks line the edge of the park. So arid is this range that there was no surface water even in the rainy season, yet the marvelous growth of grass and herbs was moist, and the sod was springy.

Summit: August 5–7, 1952.

Pinitos Mountains.—The pine-oak woodland of this range is more open and grassy than that of its close neighbors in Arizona, and it further resembles the southern stations in possessing *Quercus viminea* and *Ceanothus huichagorare*. Much pine has been logged.

Los Pinitos: November 26–27, December 20, 1954; May 31, 1955 (mapped census).

Cerro del Oso, 4800–5000 feet: July 10, 1953.



Fig. 11. Riparian growth within pine-oak woodland of Molino Canyon, 5500 feet, Sierra de los Ajos; photograph taken by A. R. Phillips, July 17, 1952. *Juglans rupestris*, *Alnus oblongifolia*, and *Platanus racemosa* are shown.

Sierra Azul.—At the level of pine-oak woods the various slopes of this dome-shaped peak are quite different. The south slope is gentle with an open stand of Apache pine, Arizona oak, Emory oak, and abundant grass; the steep east side has dense growth with silver-leaf oak and Arizona madrone added; northward Chihuahua pine and *Quercus viminea* join the assemblage of all the above species. This area has been extensively logged.

North and east slopes, 5800–7100 feet: July 12–14, 1953.

Sierra Aconchi.—Few pines remain on this peak. Nevertheless the woodland is magnificent in its rich variety of huge oaks and madrones, and in its abundant grass. All the oaks were green in January, 1954, but by June, at the culmination of a long drought, those of the encinal and lower part of pine-oak were brown or leafless except



Fig. 12. Clanton Canyon, 5350 feet, Peloncillo Mountains, April 9, 1955, showing *Pinus leiophylla*, *Juniperus deppeana* (crooked trunk), *Quercus grisea*, *Arctostaphylos pungens* (bush at left). Locality occupied jointly by Plain and Bridled titmice and, in one summer, by Hairy and Arizona woodpeckers.

near springs. All these species are ordinarily evergreen. Rains came in the course of that visit, and in April, 1955, C. H. Lowe, Jr., reported that the oaks were again in leaf. For this one mountain, I have stretched my definition of pine-oak woodland to include the north slope with its conspicuous *Quercus viminea* and other very large oaks and madrones within the altitudinal range of the pines which escaped logging upon adjacent crags.

Cerro de los Locos, 5500–6000 feet: January 3, 1954; Locos and Aconchi Peak, about 5500–7000 feet: June 20–23, 1954.

Sierra de Oposura.—Pine-oak woodland covers practically the entire mountain above the blue oak encinal. There is little sorting of pine forest elements from pine-oak flora so that *Pinus ponderosa*, *P. ayacahuite*, arboreal *Quercus reticulata*, and even a few *Q. fulva* go along with *P. engelmanni* and its usual following of oaks. The growth is open and the trees are large, except that hand-sawing has removed the largest pines. Circumstances did not permit an accurate census or a search for night birds in the



Fig. 13. Looking north out of virgin ponderosa pine forest into partly logged pine-oak woodland of census route near upper Río Gavilán, 6750 feet, high Sierra Madre, Chihuahua, April 12, 1955. Numerous *Quercus grisea* are dwarfed by comparison with the tall *Pinus leiophylla* and *P. engelmanni*. At this spot were found three species of screech owls, Eared Trogon, and Brown Towhee.

extremely rocky southern portion visited, but the impoverishment in species and individuals of birds was obvious. The following species make up for this paucity, and it is my impression that they are more numerous here than they would be in a richer avifauna: Olivaceous Flycatcher, Bridled Titmouse, and Bewick Wren, and near the spring, Painted Redstart. J. C. Cahoon, who collected on this mountain in 1887, doubtless reached a more favorable spot, and I was disappointed not to see his *Mitrophanes*, *Troglodytes*, *Icterus wagleri*, *Aimophila rufescens*, and other extraordinary finds!

Southern portion, 5450–7250 feet: April 9–10, June 4–5, 1953.

El Tigre Mountains.—Because of steepness, pine-oak areas on north slopes are infiltrated with ponderosa pines. All that I could see had been completely logged and burned, with an all too obvious affect upon the Imperial Ivory-billed Woodpecker and Eared Trogon which might once have lived on this mountain. The second-growth is satisfactory but dense; however, White (1948: fig. 23) shows some virgin open grassy pine-oak on suitable terrain. My visit in April was too early for Whip-poor-wills, Grace Warblers, and other summer residents.



Fig. 14. Near upper Río Gavilán, 6600 feet, high Sierra Madre, April 11, 1955. Looking north from a fence into ungrazed woodland of *Pinus leiophylla*, *P. engelmanni*, *Quercus grisea*, and grass. Bushes are young gray oaks. Despite recent fire protection, the grass has held its own, through drought, against alligator juniper.

Above El Tigre Mine, 5500–7000 feet: April 4–8, 1953.

Sierra Huachinera.—On this western spur of the Sierra Madre Occidental the pine-oak zone is so broad that it includes blue oak at the bottom and *Arbutus xalapensis* at the top. Unlogged remnants consist of large trees over bunch grass and scattered ceanothus. The logged portions are covered with an artificial chaparral of young oaks above which pine skeletons tower. A beautiful riparian growth of Arizona cypress and maple enters even small gullies. The mapped census area at El Apache supports the richest avifauna in this study, but it showed profound differences in birds and vegetation from one visit to the next. In June, 1953, everything was green, and lobelias, visited by myriads of hummingbirds, bloomed along the creeks. But by June of the following year drought had taken its toll; there were no lobelias and about half of the pines and oaks on the dry slopes were dead.

Mapped census at El Apache, 5900 feet: June 14–18, 1953.

Other observations included El Apache, a southern canyon, and west slope at 6800 feet: July 4–12, 1954.



Fig. 15. Looking south into grazed area 100 feet from same fence as that involved in figure 14 and on same date. Cow skeleton and numerous young *Juniperus deppeana* in foreground.

Sierra Madre Occidental.—Unlike the other study sites this vast range consists mostly of plateaus and mesas with numerous farms, natural meadows, and openings. Almost all is being logged, but somewhat selectively, so that it still looks like woodland and forest, although ceanothus and scrubby young oaks are forming a brush understory in many places. Pines are large with clear trunks, and much of the woodland is carpeted with grass and wildflowers. Between my visits in 1952 and 1955 many of the pines in lower areas had died, apparently from drought. The pine-oak woodlands of the eastern, high central and western portions of the Sierra Madre differ from each other as much as do those of separate mountain ranges elsewhere in the study area. Accordingly these three sections are treated separately in the tables and in the following descriptions.

Eastern portion.—On the east slope, Arroyo Tinaja supports on its steep walls a woodland of the same species and same density as in southern Arizona. There are walnuts and cottonwoods along the creek, but no sycamores.

Tinaja Canyon, 6000–6600 feet: July 2–4, 5–6, August 21–23, 1952; April 10–11, 1955.

High portion.—Higher along both sides of the continental divide, at camps from



Fig. 16. Near upper Río Gavilán, 6750 feet, high Sierra Madre, April 12, 1955. Later stage in encroachment of *Juniperus deppeana*, showing solid growth chest-high derived from parent tree in right background; such growth not noticeable in 1951-52. The owner of this grazing area claimed that if he had been allowed to burn when there was enough grass to carry a fire, this reproduction of junipers would have been halted.

“Arch Valley” southwest to “upper Río Gavilán,” the woodland is an open park. Apache pines and some ponderosa and Chihuahua pines overshadow the relatively diminutive gray oaks (figs. 13 and 23), which nevertheless hold their own and allow oak-loving birds such as Mexican Jays and Bridled Titmice to ascend nearly to pine forest and to overlap their relatives the Steller Jays and Sclater Chickadees. But the most striking innovation among the “pine-oak birds” is a contingent of lowland species such as the Curve-billed Thrasher and Brown Towhee, which ascends to the edges of meadows and open flood-plains at these altitudes (6500 feet and higher). Riparian timber is practically absent along these upper reaches of the creeks, save for occasional narrow-leaf cottonwoods. Grazing by cattle is as extensive here as in most of my camps but the effect combined with virtual absence of the winter segment of the semi-annual rainfall in 1954, and perhaps the previous year or two, made some noticeable changes in ground cover between my visits. In the late summer rainy seasons of 1951 and 1952 tall grasses and wildflowers abounded, and even in the dry bare period of June, 1952, I noticed no



Fig. 17. Open pine-oak woodland and topography characteristic of western part of Sierra Madre on west slope of continental divide, 6800 feet, April 15, 1955. Shows *Pinus engelmanni*, *Quercus hypoleucoides* (left), and *Quercus arizonica* (right). Birds present here included the Flammulated Owl, Screech Owl, Eastern Bluebird, and Western Bluebird.

young junipers or excessive loss of soil. But in April, 1955, some of these same places had been pared by nearly starving cattle, save behind the fence dividing the contrasting scenes in figures 14 and 15. Exposed rock and deep erosion gullies were conspicuous, and under the few venerable junipers whole armies of their undesirable offspring were crowding up, chest-high (fig. 16).

Mapped census at Arch Valley: August 26–27, 1951; June 20–21, 1952.

Measured census at Poverty Flat: August 24–25, 1951; June 21–22, 1952.

Measured census at upper Río Gavilán, 6750 feet, west of Colonia García: June 25–26, 1952.

Other observations, including upper Río Gavilán, 6500–7000 feet: August 22–24, 29–September 5, 1951; June 22–25, August 30–31, 1952; April 11–14, 1955.

Western portion.—The flora of these stations, from the vicinity of Gavilancito (fig. 17) westward, is rich like that of the adjacent Sierra Huachinera, but the trees grow larger on the wooded mesas so characteristic of the Sierra Madre proper. My map census was along the gorge of the Río Gavilán just above Gavilancito, where tall riparian

sycamores and maples flourished. Leopold (1949) described this spot before it was logged.

Mapped census in gorge of Río Gavilán, 5700 feet, one mile east of Gavilancito, Chihuahua: June 27–July 1, 1952.

From west slope of continental divide north of Gavilancito, 6800 feet, to La Mesa, Sonora: June 26, July 1–2, August 23–29, 1952; April 15, 1955.

Sierra de Nácori Chico.—Like the Sierra Huachinera, this range is actually a westernmost segment of the Sierra Madre. The mapped study site at Pinos Altos, also with a rich avifauna, is in the unique vegetation dominated by blue oak and *Pinus durangensis*, the latter somewhat reduced in numbers by hand-sawing. On the upper half of the canyon slopes the blue oaks had dead pinkish-brown leaves, and the wash was dry except for a few pools. This steep rocky west slope supports an unusually dense woodland for a southern mountain, but it is not brushy. Heavy riparian timber along the gorge of the Río Zátachi at the west base attracts montane birds such as the Pygmy Owl, Whip-poor-will, Acorn Woodpecker, and Wagler Oriole far down into surroundings of desert and lower encinal vegetation.

Mapped census at Pinos Altos, 4650 feet: June 11–12, 1953. Other observations, higher: June 10, 1953.

VEGETATION

SPATIAL RELATIONS

Altitudinal position of pine-oak woodland.—A good reference zone for the position of pine-oak woodland is that of the ponderosa pine which forms a uniform forest over its vast domain. It grows on the summits of the Sierra Madre and of the mountains of northern Sonora, all of which are about 7500 feet high. North of the international boundary the mountain tops are about 10,000 feet. Here ponderosa forest is capped by closed forests of white fir and Douglas fir, and at higher elevations by alpine fir and Engelmann spruce. From the ponderosa forest on down to the desert or subtropical plant belts the slopes are occupied by the various kinds of pines and oaks mentioned earlier. These may be grouped in order of descent as pine-oak woodland (Chihuahua pine and Apache pine, approximately 5500–6500 feet), closed encinal of the same oaks as in pine-oak (chiefly Arizona oak, Emory oak, and silver-leaf oak, 4500–5500 feet), and lastly an open encinal of blue oak with grass (3500–4500 feet at the south). Blue oak, like ponderosa pine, constitutes a uniform zone of reference. Below it is saguaro desert at the north and deciduous woodland of *Quercus chihuahuensis* and *Lysiloma watsoni* at the south.

Figure 18 illustrates the arrangements of types of vegetation most likely to be met. It is diagrammatic and too simple, because it omits the many interruptions in these zones, particularly upon steep slopes. Ponderosa forest is in places interrupted by *Quercus reticulata* chaparral, by deciduous woodland of aspen, Gambel oak, or New Mexican locust, by Douglas fir forest, or by Arizona cypress forest. Pine-oak woodland in turn may yield to or be compressed by forest of Douglas fir or of Arizona cypress, by *Cercocarpus* chaparral, or by closed piñon woods. Encinal is more constant, although it may be eclipsed at intervals by chaparral of manzanita or Toumey oak, or by piñon woods. These intrusions and irregularities together with inconstant proportions of dominant species within each zone indicate the danger of a rigid classification in this area. Even the most broadly defined sequence—coniferous forest down through woodland to desert—is not universal. Would these irregularities be erased if the topography were more uniform? The variety of vegetation on the Sierra Madrean plateaus makes me think not.

It is well known that zones of vegetation on a mountain are affected by the altitude of the plain at the mountain's base (Shreve, 1922) and by the direction a particular mountainside faces. In east-west canyons the cool north-facing slope usually supports vegetation one step higher in the sequence than that of the opposite warm slope. At many of my camps these slopes consist of pine-oak and encinal, respectively, which with riparian woods at the bottom gives a variety of habitats for birds. Zones in some steep north-south canyons are inverted due to coolness of the canyon floor. Rucker Canyon in the Chiricahua Mountains, for instance, has pine-oak woodlands in the bottom, beneath encinal on the slopes.

Certain types of exposed rock favor pine growth; accordingly pine-oak woods may occur at exceptionally low altitudes of 4500 to 5000 feet. Chihuahua pine, which is especially tolerant of rocky slopes, grows on a band of stratified red rock on a south slope at the base of the Patagonia Mountains, at the level of lower encinal (fig. 19). A wall of light-colored rock traverses encinal on the west slope of the Peloncillos at the New Mexican boundary; Chihuahua pines and piñons grow upon it. The grove of pine-oak woods in Clanton Canyon of this range is also rocky and at low elevation. Just south of Aribabi, Sonora, which is west of the Sierra Huachinera, is a white rock formation

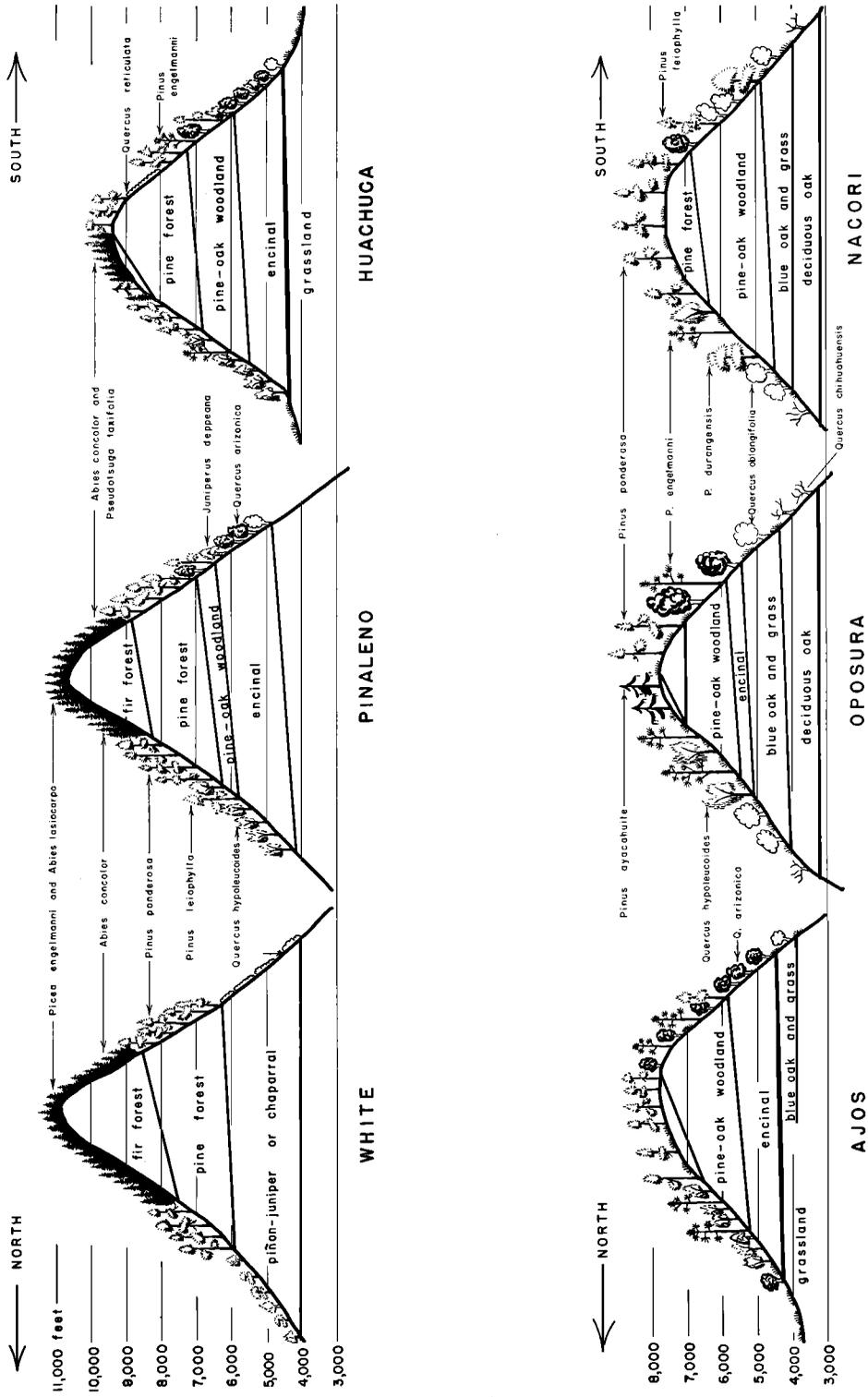


Fig. 18. Sequence of montane vegetation types with altitude and latitude.



Fig. 19. Patagonia Mountains, 4600 feet, Arizona, March 16, 1955. South slope of red rock supporting *Pinus leiophylla* at unusually low altitude. Above on the older soil of the flat is encinal of *Quercus emoryi* with *Arctostaphylos pungens*.

with woods of *Pinus durangensis* and *Quercus viminea* sharply marked off from surrounding blue oak encinal on dark stony soil.

Since neighboring vegetations make available their associated birds for occupancy of pine-oak woods, it is important to note the extent of this contact (fig. 20). Encinal everywhere borders and surrounds the lower edge of pine-oak and even joins some mountains with isolated pine-oak into north-south chains. But the contact with ponderosa forest, particularly on the smaller mountains south of the international boundary, is much less.

Geographic position of pine-oak woodland.—North of the Pinaleno and Catalina mountains, the species of pines and oaks which compose pine-oak woodland and encinal are left behind, are rare, or are limited to canyons. Their place on the slopes is taken by piñon-juniper woods (*Pinus edulis* and *Juniperus utahensis*, White Mountains) or by chaparral (*Rhus trilobata*, *R. choriophylla*, *Arctostaphylos pungens*, dominated by *Quercus turbinella*, in the Pinal Mountains). This zone where Mexican types of vegetation yield to Great Basin types provides a good boundary for my study area. It is the

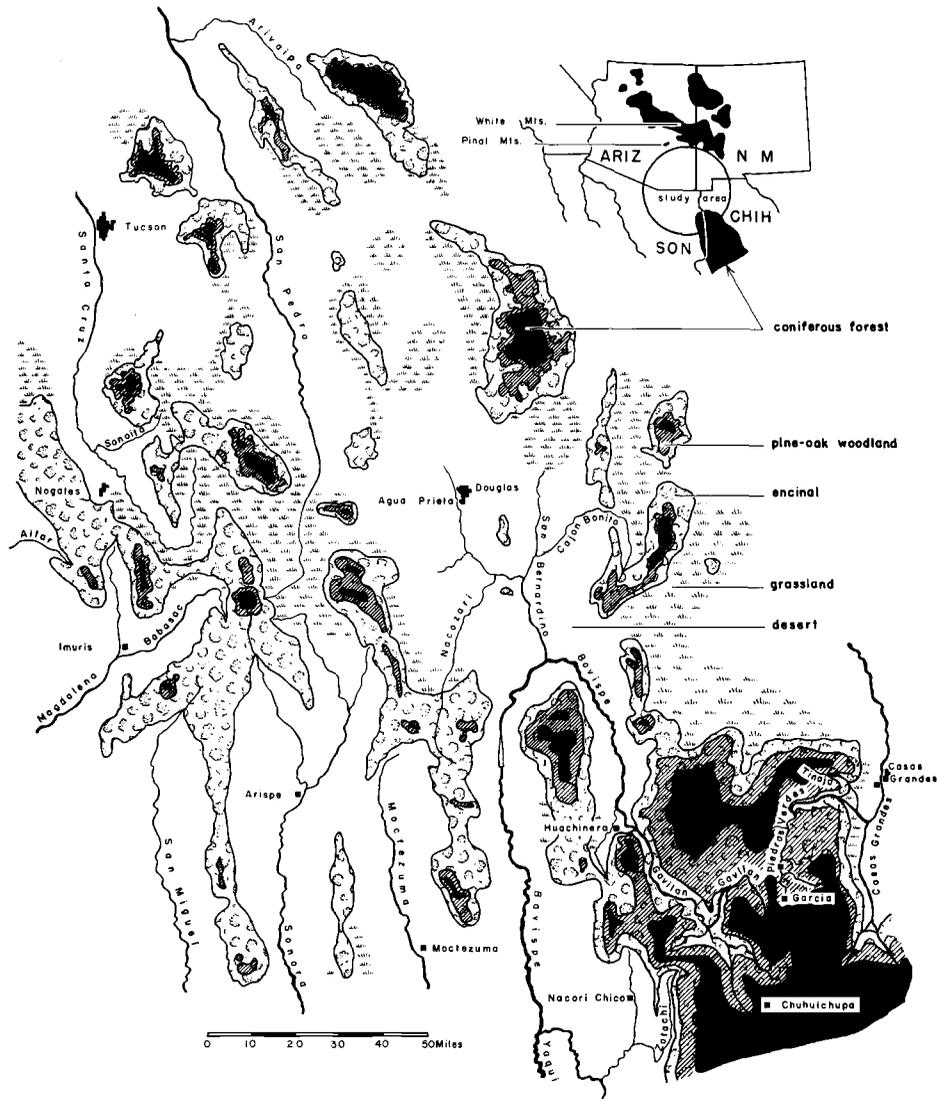


Fig. 20. Distribution of desert, grassland, encinal, pine-oak woodland, and coniferous forest.

This map shows the northern, northeastern, and western limits of the kind of pine-oak woodland treated in this report.

northern terminus for the type of pine-oak woodland and encinal discussed here. Continuity of plant environments for birds is not lost, however, for there are smaller tracts of piñon and of chaparral south of this boundary, and oaks can be found at the lower fringe of ponderosa pines in mountains of central Arizona, where many pine-oak birds occur. Pitelka (1951a:326-328) regards these latter places as pine-oak woodland but I think of them as forest because ponderosa pine is tall and harbors a preponderance of forest birds even at its lowest altitude. For instance, near Whiteriver, Arizona, the small gray oaks are dwarfed by the pines; at Pinal Mountain, the next range north of the

Catalinas, pines and oaks tend to be segregated upon slopes and in gullies, respectively. At the head of Russell Gulch, Arizona oaks and Emory oaks grow under the ponderosa pines in a narrow zone fronting chaparral. But the mixture is acceptable as forest to Hermit Thrushes.

Accordingly, the kind of pine-oak woods characterizing my census stations reaches its northern, western, and northeastern limits within the study area, as shown on figure 20. But southeastward into México it becomes increasingly prominent (Leopold, 1950; Sibley, 1950; Stager, 1954). Animas Peak is its northeastern outpost, for the next high mountain, Hachita Peak, is too arid for anything but piñons and junipers (Mearns, 1907:85). West of the Santa Rita and Huacomea mountains, there is some encinal, as at Baboquíviri Peak, Arizona, but there are no more pines, other than piñons, until the high mountains of the Pacific coast are reached. The Sierra del Carmen is the next patch of pine-oak woods to the east, over 200 miles from the Sierra Madre Occidental (Miller, 1955).

CLASSIFICATION OF PINE-OAK WOODLAND

Definition of pine-oak woodland in study area.—The pine-oak woods of the study area consist of one or more species of the pines *Pinus leiophylla*, *P. engelmanni*, *P. durangensis*; these are mixed among one or more of the following evergreen oaks: *Quercus arizonica*, *Q. oblongifolia*, *Q. grisea*, *Q. emoryi*, *Q. viminea*, *Q. hypoleucoides*, and *Q. endlichiana*. Although the oaks are shorter than the pines among which they are scattered, they grow in the open and do not form a layer beneath the pines. There may be abundant alligator junipers or abundant grass, and shrubs such as *Ceanothus huichogorare* and *Rhus trilobata* may occur. In this area pine-oak woodland is the only kind of vegetation with pines and oaks equally conspicuous. Its pines resemble ponderosa pine of the forest zone next above on a mountain, and its oaks are mostly the same species that compose encinal below. This combination of two forms of tree growth, segregated above and below, constitutes a transition between pine forest and woodland, a unique feature of my study area. Elsewhere, as immediately to the north, the tall pines of the lower border of the forest stand as a wall confronting dwarf growth of chaparral or piñon-juniper woods.

This definition is applicable only within my study area, for purposes of delineating the distribution of birds. It rules out nearby mixtures of piñon pines with oaks and junipers; also it eliminates ponderosa pine forest and the oaks that may accompany it locally. It is properly called "woodland" because its tall elements are separated by shorter spreading trees in a discontinuous canopy; a "forest" consists of much taller trees growing closer together and possessing vertical trunks.

There are elsewhere, of course, other kinds of pine-oak woodland, with many of the same birds that were found in the study area. The original pine-oak woodland of Weaver and Clements (1929:471) in California consists of Digger pine (*P. sabiniana*) and blue oak (*Q. douglasii*), and it has most of the birds of the northern Mexican pine-oak woodland except those species which require forest pines. The Digger pines cannot be classed as forest pines because they are spreading, irregularly branched, and spare-leaved, not resembling ponderosa pine in the least. The pines in the oak-pine subclimax of Pitelka (1941: fig. 1), which I have seen in Louisiana, have the same height, spreading shape, and dense foliage as the oaks with which they grow, and it is hard to distinguish the two in a distant view.

Classification by others.—Three botanists who made large collections in Sonora and Chihuahua tended to ignore pine-oak woodland, possibly because they preceded Martinez' (1945, 1948) taxonomic work on the pines. *Pinus engelmanni* (= "*macrophylla*")

= "*apacheca*" = "*latifolia*") bears a similar relationship to *P. ponderosa* (= "*arizonica*") as the latter does to *P. jeffreyi*, and Martinez believes that they hybridize. In view of this similarity and the confusion of names, a botanist who draws no distinction between the two species may be excused for regarding pine-oak woods as a successional stage leading to ponderosa pine forest. Gentry (1942) collected few pines and oaks in southeastern Sonora, but his photograph (plate 7) shows a beautiful pine-oak woodland which closely resembles my census station in the Sierra Nácori farther north. Le Sueur (1945) regarded forest as the climax vegetation in the mountains of northwestern Chihuahua; he presumed that oak woodland yielded to pine forest in a developmental sequence. White (1948) does not emphasize pine-oak-mixtures on El Tigre, which perhaps is a natural consequence of the mixup of vegetation zones there due to rugged terrain.

Brand (1936) speaks of a "pine-oak transition belt" between an oak-agave-juniper association dominated by oak, and the pine forest association at 6000 to 7000 feet in northern Chihuahua. Leopold (1950) gives a true picture through his appropriately loose terms, by which he describes the Mexican highland vegetation as forests and woods of pines or oaks or of pines mixed with oaks. Mearns, properly more interested in distribution of species than of vegetation types, does not mention pine-oak mixtures, which are scarcely noticeable in the San Luis Mountains anyway. Both he and Shreve (1939) knew the Apache pine, which doubtless aided Shreve in recognizing in Chihuahua a zone of intermingling pines and oaks, subsidiary in importance to pine forest and encinal.

The expression "pine-oak woodland," or "pine-oak forest," is freely and appropriately used by persons writing of the distribution of birds in México, for instance Davis (1951:49), Martin, Robbins, and Heed (1954), Miller (1955), Pitelka (1951*a*), Sibley (1950), and Stager (1954). As a concrete designation of a habitat for birds, the simple term is a great advance in precision over the diffuse categories related to theories of life zones or of biotic provinces.

HETEROGENEITY OF PINE-OAK WOODLAND

Altitudinal differences within pine-oak.—Lowest pine-oak woodland looks much like encinal because oaks predominate. From there upward the pines increase in size and number over the oaks, so that at higher elevations the woods take on more and more the appearance of pine forest. Thus pine-oak woodland forms a smooth transition between encinal and pine forest.

Geographic differences within pine-oak.—In the southern part of the area, pine-oak woodland covers a wide altitudinal zone. The mountain peaks are lower and as a result more of the uplands are covered by this vegetational type than in the north where pine-oak is only a fringe below the forest. The narrowness of this type of woodland in the north is a reflection of the more limited span of suitable climatic conditions. Toward the south there is more annual precipitation, concentrated in the season from July through September (Shreve, 1944; H. V. Smith, 1945; Turnage and Mallery, 1941: figs. 11–13); there are less severe extremes of temperature near the coast; and there is better soil on the less steep and rocky uplands. The flora accordingly is richer (fig. 3), the trees are taller and farther apart, alligator juniper is rare, and grass is abundant. This profound contrast, which may be seen also in encinal and pine forest, between the splendid clear-trunked trees of the southern woodlands and their dwarfed fellows of the same species in the mountains of southern Arizona is a measure of a favorable environment. With good soil and moisture the same species of trees are taller, fewer, and farther apart; whereas poor conditions produce short stature and crowding (for examples, see Gause, 1934). Apparently alligator juniper is more tolerant of poor conditions than its fellows, so that its abundance is directly related to environmental impoverishment. Al-

though our knowledge of the climate of Sonora is inadequate, and although there are local exceptions, it seems clear that the major north to south trend of difference in vegetation is due to difference in climate and soil.

But should the contrast be so great within only about two hundred miles, and should climate alone produce a fairly abrupt zone of vegetational change practically coincident with the international boundary? Perhaps man's use of the land—different in México from Arizona—has exaggerated the difference. The mountains of both sides of the border have been extensively logged and grazed, but their treatment differs mainly in that those north of the border have been more heavily grazed by cattle and have also been protected from natural fires. It is likely that before they were misused the southern Arizona woods and forests were grassy, open, had fewer junipers, and supported Sparrow Hawks, bluebirds, and Chipping Sparrows. At present these birds are limited to artificial clearings and burns. They are found where conditions are good for cattle; this brings us to the great practical importance of restoring grass to southern Arizona. There are many of these birds and abundant grass in the Pinitos, Ajos, and Púlpito mountains just on the other side of the Sonora border from Arizona. Two local opinions (discussed in Parker and Martin, 1952:14–15; Sauer, 1950), about which great controversy rages, as to how the grass was lost and the junipers "took over" are as follows: (1) Excessive grazing caused the extinction of numerous grasses which held soil on the slopes. The soil then eroded away, and junipers filled in among the other woodland trees. Alligator juniper's rather dense shade, peculiar leaf-litter and root system favors neither the retention of soil nor the return of grass. (2) Fire prevention has allowed junipers and young trees to crowd the mountains and shade out the grass. With less grass, a fire would not be hot enough to kill the young junipers. Under natural conditions periodic fires would clean out only the young trees before enough dead branches accumulated to fuel a destructive fire. Protection of mountains from fire in this dry climate with its frequent lightning storms merely delays the day when a fire will break loose to burn the forest or woods to the ground. Eventually enough litter accumulates to make such a fire inevitable, and the particular area involved is destined, after such destructive burning, to be replaced for a long time by dense brush.

My experience on the census stations convinces me that excessive misuse by man can shift an area from open "Mexican type" toward crowded "southern Arizona type" of woods even within the period of my study (figs. 14–16). Also I have seen the culmination of unfavorable conditions working over a much longer time on level terrain, at Sunnyside in the Huachuca Mountains, where large herds have been withdrawn because the grass has gone. Furthermore, I have been privileged to see an untouched area—the summit of the Sierra Púlpito—with its springy sod, tall grass, and open stand of clear-trunked pines. Two uneasy nights spent there convinced me that this area is a target for lightning, and there is evidence of frequent fire. Numerous burned snags stand among their unscathed fellows, for the growth is too open to carry fire from one tree to the next. In other places, as in the Sierra de los Ajos, the effect of fire on grass differs on opposite sides of the same canyon. The overall effect of the 1954 fire was to make the open slopes grassier and the woods denser due to sprouting of stumps.

CONCLUSIONS ON VEGETATION

Changes in vegetation.—Grazing, logging, and perhaps fire protection have produced undesirable changes in the vegetation of these mountains, but only in combination and where carried to excess. For grass will persist and re-establish itself (fig. 7) in the face of terrific disturbance and exploitation in this area, and its loss is a great dis-

grace since nature goes far more than half-way to help us keep it. Drought, a more natural agent, also produces change. It has set the stage for wholesale dying of trees, through insects and other immediate causes, in the Catalina, Huachuca, Chiricahua, and Huachinera mountains. But these mountains have also been greatly disturbed by man. Presumably they are more vulnerable than untouched areas, such as the San Luis, Pulpito, and Oposura mountains. I have not revisited the Pulpito, which would provide the best test of this theory, nor have I revisited the Oposura. However, I can say that the very arid and ungrazed San Luis Mountains showed no change from 1951 and 1952 to 1954, or any effect of drought. Indeed, the spring has not changed since Mearns' photograph of the 1890's!

Shreve (1944) saw the important effect on vegetation of fluctuations in an arid climate. In this particular area of low rainfall, there are great differences in rainfall from one year to the next. Several years of inadequate precipitation can raise havoc, as it did in 1954 when many cattle were lost in eastern Sonora. The wholesale death of trees, noted on several mountains, is perhaps due to the accumulated effects of scanty rainfall extending back decades, according to Schulman (1952). In his paper, figure 3 shows the curve for southern Arizona more below than above the expected rainfall line since 1920. Joel Fletcher has explained the differential effect of drought on large trees. These grow luxuriantly on flat spots with good soil favorable for retention of water; therefore they suffer great contrast between wet and dry years, and they are hard hit by drought. In contrast, small trees growing on rocks, steep slopes, or other unfavorable sites experience little difference between lean years and years of heavy rainfall, when most of the water runs off. It may be added that prolonged droughts and extinction of grass have the same effect in promoting the dwarfed, crowded growth with junipers which is characteristic of the southern Arizona mountains.

Although these changes have moved pine-oak woods up-hill by converting its lower edge into encinal, they have not transformed it in its entirety into another type of vegetation. Areas which were completely denuded of pines by logging, such as Sylvania in the Huachucas, Cananea Mountains, and El Tigre, are now pine-oak woodland again. Although I do not know the sequence in which the woods were restored, it is likely that they went through a chaparral stage composed of young oaks, as is seen today in the clearings of the Sierra Huachinera. It seems safe, therefore, to regard pine-oak woodland as a stable association, not as a successional transitory stage of vegetation. This type of woodland maintains itself even on flat areas, such as the northern part of the Ajos and on the mesas of the western Sierra Madre. It does not become forest because its hardy pines grow at altitudes well below those of ponderosa pine, and at these same levels are oaks and junipers which invariably hold their own among the pines, to perpetuate the mixture.

Presumed geologic history.—Although paleobotanists are silent about the pines, several of the oaks, the madrone, juniper, locust, and ash are modern representatives of an encinal association designated by Axelrod (1950) as the Arizona component of the Sierra Madrean woodland element of the Madro-tertiary flora, which ranged in former times much farther north and west than it does today (MacGinitie, 1953). This implies climatic changes in the study area, and if some periods were much colder or wetter than at present, it would not be hard to imagine that encinal, and possibly Chihuahua pine, could descend to fill many of the lowland gaps in their distribution (fig. 20). However, it may not be necessary to assume that colonization of mountains by particular plants depends on direct continuity of vegetation. For instance, Shreve (1919) believed, at least at one time, that colonizations could take place from large to small mountains possibly by birds. He was comparing the vegetation of the Pinaleno and Catalina moun-

tains, which he thought were never connected. The two are quite similar in flora, yet the Catalinas lack certain species such as *Picea engelmanni* and *Rhamnus betulaeifolia*, although they provide adequate habitat for them. These plants should have reached the Catalinas along with *Abies lasiocarpa* had there been a bridge of coniferous forest between the two mountains.

The community and independent species.—The unique distribution of each species of dominant plant in the mountains of the study area is a consequence of its range of tolerance to environmental conditions and its history. These are characters distinguishing it as a species. This independence in the area's setting of varied topography and rich flora produces a variety in grouping and appearance of vegetation that seems limitless. Species and their populations are the realities to be seen (Mason, 1947); their sortings and mixtures can be classified less objectively. For we find no close coincidence in occurrence of two or more species from one mountain to another or even from one canyon to the next. The trees influence each other by competing for space, but their haphazard arrangement indicates that the outcome of their interaction does not depend on which species are involved.

For instance we find on steep terrain in the Santa Rita Mountains a forest of Douglas fir with walnut understory at the head of Florida Canyon, whereas at the head of neighboring Madera Canyon, which has the same altitude and slope, is pure ponderosa pine forest. In the San Luis Mountains, where one expects more extensive pine-oak woods, Turkey Canyon supports instead Arizona cypress forest, whereas the next canyon south of it contains a mixed forest of Mexican white pine, Douglas fir, and alligator juniper! The north slope of the Sierra Pulpito, in the absence of ponderosa pine, is forested with Apache pine to produce exactly the same life form. Even on flat terrain, irregularities and unpredictable sortings persist. In the Sierra Madre, at approximately equal altitudes, one finds pine-oak woods on one mesa, ponderosa pine forest on another, while still others support pure forests of Apache pine or of Chihuahua pine, and elsewhere gray oaks mix with these pines to form another area of pine-oak woods. The vegetation of these level expanses is hardly more uniform than that on rugged mountains, but the transitions are gradual. Various mixtures and dilutions with each other and with chaparral, piñons, cypresses, and Douglas firs occupy more area than is filled by encinal, pine-oak woodland, or ponderosa forest in pure form. The middle altitudes might be regarded as supporting no single climax, as Shreve (1951:21) claims for desert terrain. Only after we realize these facts can we permit ourselves the luxury of speaking of vegetation types, associations, or communities as may be necessary for discussing the distribution of birds.

But with our very "lenient" definition of pine-oak woodland and enumeration of distinctive dominant species, from which its components in any one place will be drawn, we have a self-perpetuating type of vegetation that can confidently be expected at appropriate levels in the mountains, where it holds sway comparably to ponderosa forest and encinal. It is a habitat for birds, which cannot usefully be subdivided. It will give us a particularly sensitive test of what things birds choose for their niche, for we may expect some to choose the mixture, whereas pine-loving birds should drop out where there are too many oaks, and encinal birds may avoid the higher altitudes where oaks become too rare among the pines.

AVIFAUNA

MEASURED CENSUS

Method.—Initially birds were censused on an areal basis. It was soon evident that most species were deployed along the canyons and gullies of these steep mountains. Others with headquarters on the slopes, such as Poor-wills, Ash-throated Flycatchers, and Rufous-crowned Sparrows, frequently visited the canyon bottoms. Therefore a linear mapped census along the canyon proved most suitable. These censuses compose table 2. They include only the species thought to live or nest along the route and which utilize the pines and oaks in their activities. It may be recalled that except for some of the broad mesas in the Sierra Madre it was impossible to find a census place deep enough within uniform pine-oak woodland to exclude influences from other kinds of adjoining vegetation. An intensive census at one spot in each mountain disclosed an avifauna which was apt to reflect the peculiar juxtaposition of vegetations in the canyon chosen rather than to typify the mountain, its latitude, and climate. These local peculiarities and times of visits, which account for some of the differences from place to place and from year to year in the birds found, are mentioned in the descriptions of camps.

Size of territory or foraging area.—Numerous entries on the map for the same individuals over a period of several days gave a clue to the size of the area in which each lived and to the distances between neighbors of the same species. In places where birds are not accustomed to people they tend to move long distances ahead of the observer, possibly in excess of their usual foraging limits, and it was often necessary to walk rapidly in order to pass or leave behind individuals, particularly those that were responding to imitated calls. Coppery-tailed Trogons and Bush-tits retreated rapidly for long distances ahead, yet anyone familiar with Bush-tits in suburban areas, where they are used to humans, knows that they move more leisurely. An idea of more normal movement is gained when the observer remains inconspicuously in camp. Then he finds that some of the elusive species actually spend long periods at one spot, that many of the small woodland birds go through camp several times a day, and on successive days, in the same direction, as if following a planned route, and that they go beyond hearing distance, a matter of a few hundred yards. He also finds birds coming to water from longer distances. As Mrs. Nice says of her Song Sparrows (1937:12) "The birds must leave their territories several times a day to procure water for drinking and bathing purposes." On most of the census routes, springs were located in the canyon bottom, where I generally camped. But at Sylvania a spring and pond situated up one side of the broad canyon complicated matters for a linear census. There was a pair each of most of the small birds near the spring, and another pair, visiting the spring occasionally, in the adjacent canyon.

The woodpeckers, nuthatches, and creepers regularly took long zig-zag flights through the tree tops, and they covered large areas. Others with big territories were the Pygmy Owl, Spotted Owl, Eared Trogon, Ash-throated Flycatcher, Coues Flycatcher, and Brown-headed Cowbird. The Buff-breasted Flycatcher, Western Wood Pewee, and Rufous-sided (Spotted) Towhee were the most crowded and most restricted in their movements. It is well known that within a group of species with similar feeding habits the larger birds have more extensive territories, and this is demonstrated very well on the maps for the three species of owls of the genus *Otus*. In *Myiarchus* flycatchers on the contrary, the large Wied Flycatcher (Arizona Crested) was more restricted in its movements than the smaller Ash-throated and Olivaceous flycatchers. Individual Elf Owls,

of comparable size and feeding method to the Flammulated Owl, were similarly close together. On the other hand the small but carnivorous Pygmy Owl had an immense forage area; it fitted in a territory sequence with the Spotted Owl. The Coues Flycatcher had a much larger foraging area than did its smaller relative, the Western Wood Pewee, but in this case the discrepancy in area was far out of proportion to body size.

Permanence of territories.—As shown in table 2, the species most faithfully inhabiting the same spot in successive years are the Turkey Vulture, Cooper Hawk, Band-tailed Pigeon, Flammulated Owl, Black-chinned Hummingbird, Red-shafted Flicker, Arizona Woodpecker, Ash-throated Flycatcher, Mexican Jay, Creeper, Hutton Vireo, and Painted Redstart. Most of these migrate, and for at least the hawk, Flammulated Owl, Creeper, and Painted Redstart some of the reoccupations were by different individuals. Thus a site or territory or nest can have a permanence exceeding the life of any one occupant; it can be sensed by members of the particular species, year after year, as being exceptionally desirable. One can predict the few sites favorable to the Turkey Vulture and Cooper Hawk, but for the rest of these species I could not detect those factors which distinguished "permanent" from non-permanent territories.

Changes in successive years.—Many of the apparent irregularities in numbers of a species from summer to summer were due to luck, weather, time of visit, and the species being at times inconspicuous. For instance the Whip-poor-will's absence from Turkey Creek meant simply that my visit was made before this bird's arrival in May. Often it was difficult or impossible to record owls because of thunderstorms at night; more were noticed on calm nights with full moon. Elf Owls were mostly silent after early June, except that they hooted on bright moon-lit nights into later June. Rufous-sided Towhees sang much more in July and August than previously, and this made great differences in their apparent numbers at the same spot. After weeding out such irregularities, there were some evident changes in actual populations. Some abundant species decreased noticeably in the Pinaleno, Catalina, and Huachuca mountains from 1951 to 1952. The Olivaceous Flycatcher suffered at its northern limits, Wet Canyon and Apache Camp, and it was further diminished at the latter place by 1953. At Sylvania in 1952 the Flammulated Owl dropped out of the lower half of the area, Screech Owls were gone, and Acorn Woodpeckers were less in evidence. The most noticeable change involved the birds which had resided around the spring and ponds at Sylvania in 1951, although the water remained as before. The pairs each of Cassin Kingbirds, Sulphur-bellied Flycatchers, Coues Flycatcher (missing from Apache Camp also), and Chipping Sparrows were gone in 1952. Instead of the breeding pairs of Mourning Doves and Robins of 1951 there were males which several times a day arrived, sang a while, then left in the direction of Sunnyside, a mile and a half away, which was the nearest open area. Several of the affected birds were migratory insectivores. They must have suffered lean times in 1951, a year when drought killed many trees. The census at El Apache in the Sierra Huachinera was made in June of 1953, when flowers and hummingbirds were abundant and parrots were absent. Although I did not make a complete census there the following year, it was noted that the flowers had not bloomed, probably because of the drought, and that there were practically no Blue-throated and Broad-tailed hummingbirds. Rivoli Hummingbirds, still numerous, were up the wooded slopes instead of along the stream. Thick-billed Parrots were numerous.

AUGMENTED CENSUS

Method.—In an effort to demonstrate geographic trends in the relative numbers of birds, I was led to explore additional canyons within several mountains, in order to cancel out local differences, and also to visit neighboring mountains. Difficult terrain or

Table 2
Number of Pairs, singing Males, Flocks, or Colonies of pine-oak Birds found on mapped and measured Census Routes

	Pinaleno		Catalina		Santa Rita	Huachuca	Cananea	Ajos	Chiricahua	San Luis	Sierra Madre		Occidental			
	Wet Canyon	Apache Camp	Bear Canyon	Gardner Canyon	Sylvania	east of Puertocito	Ajo Canyon	Turkey Creek	Rucker Canyon	s. of Turkey Spring	Huachinera	high portion	Poverty Flat	upper Gavilan	Nacori west	Pinos Altos
miles of pine-oak, day	.7	1	.7	1	1.5	1	1	.3	1.3	.8	.8	1	.5	.5	1	.7
miles of riparian included	.7	.7		.2	.7	.3	.3	1.3		.8			.5	1	1	.7
miles of pine-oak, night	.7	1	.7	1	1.5	.7	.5	1.3		.5	.8	1	.5	.5	1	.7
year	51 52 53	51 52 53	51 52 53	51 52	51 52 53	51 52 53	53 53	53 53	51 52 53	51 52	53	51 52	51 52	52 52	52 53	
<i>Cathartes aura</i>	1f 1f	1f 1f	1	1f 1f	2 2	1	2		1		2	1f 1f	1	1	1	1
<i>Accipiter cooperii</i>		r1 r1 r1			r1 r1 r1		r1	1	1							
<i>Accipiter striatus</i>							r1					1				
<i>Buteo jamaicensis</i>	1	1		1	1	1	1		1		1					1
<i>Buteo albonotatus</i>	1															
<i>Buteogallus anthracinus</i>															r1	
<i>Falco sparverius</i>												1	1	1		
<i>Cyrtonyx montezumae</i>					3	6	1	1			2				4	1
<i>Meleagris gallopavo</i>						2	1	1	1	1	2					
<i>Columba fasciata</i>	2 2	4 1 4	2 2 1	3	1 1	2	1f	2	1	1f 1f	3	2f	1f	1	1	
<i>Zenaidura macroura</i>	1				2 2				3 4 2		1	1	2 3	1	3	1
<i>Rhynchopsitta pachyrhyncha</i>												2	1	1	1	
<i>Geococcyx californianus</i>								1	1		1					
<i>Otus flammeolus</i>	1 1 2	2 6 7	5 9 7	1	1 1 7 1		3	1	2 3 3	2 3	1	1		1	1	
<i>Otus asio</i>	r1 r1				2	1		1	1	1		4	1	1		
<i>Otus trichopsis</i>		1 1 2			6 6 2	1	1 3	5	3 1 1		r4			1	r3	9
<i>Bubo virginianus</i>							1	1	1	1	1	1			1	
<i>Glaucidium gnoma</i>	1				2	1	1	1	1	1	1	1			2	1
<i>Microathene whitneyi</i>	r2 r2	1 1 3	3 6		4 2	r1	r1									2
<i>Strix occidentalis</i>		1		1				1								
<i>Chordeiles minor</i>					2 5							2	2	2	4	
<i>Phalaenoptilus nuttallii</i>		1			2 1			1	1			1	4	5		
<i>Caprimulgus vociferus</i>	2 1	1 7 3	2 3 3 3	1	6 7	5 7	2 1 1	3 6	2	1 7 2		1 7 2				
<i>Hylocharis leucotis</i> ♂											1					
<i>Lampornis ciemenciae</i> ♂											r6				r1	
♀											r1				r2	
<i>Eugenes fulgens</i> ♂							r2	r1	1	1	r4					
♀					r1 r2		r3	2								
<i>Archilochus alexandri</i> ♂	r1	1	2		2	r1		2 1								
♀	r5 r2	r2 r2 r6	3	r1	r6 r5 r1	r3		2 3								
<i>Selasphorus platycercus</i> ♂		2 4 2						2 3			4					
♀		r1 r1 r2						r3 r3			r4					
		3 1 2									r1					
<i>Euptilotis neoexenus</i>		r1 r1										1	1		1	
<i>Trogon elegans</i>					1		r2				r5				r3	4
<i>Colaptes cafer</i>	2 2 2	3 4 4	1 1 2 3	2 2 2 2	2 4 1	3 3 3	3 2	4 2 2 2 1	2 4 2							
<i>Melanerpes formicivorus</i>	r2c 2c	2c 2c 2c	2c 2c 2c	4	2c 1c 2c	4c	3c 3c	12 3 6 3c 6 3c	8 3c							
<i>Dendrocopos villosus</i>	r1															
<i>Dendrocopos arizonae</i>	1 1 1	3 3 1	2 2 2	3 3	5 4 3	1 5	3 2 1	1 1 4								
<i>Lepidocolaptes leucogaster</i>																
<i>Tyrannus vociferans</i>					r1 r4 r2	r1					1 1 1	2 2 1	r2	1		
<i>Tyrannus crassirostris</i>																r2
<i>Myiodynastes luteiventris</i>	r1 r1			r2	r1 r1	r3				r3				r3	r5	
<i>Myiarchus cinerascens</i>	1	1 1	2 2 2		3 1 4 2	1						1 1 1				
<i>Myiarchus tyrannulus</i>							r1								r1	r1
<i>Myiarchus tuberculifer</i>	5 1	2 3 3	1 1 4		7 7 2	4 2	7 2	3		6					4 6	r2

e one territory occupied three summers f flocks c colony r in riparian woodland

Table 2 (continued)

	Pinaleno		Catalina			Santa Rita	Huachuca	Cananea		Ajos	Chiricahua	San Luis	Sierra Madre	Occidental		Nácori				
	Wet Canyon		Apache Camp	Bear Canyon	Gardner Canyon	Sylvania	east of Puertecito	Ajo Canyon	Turkey Creek	Rucker Canyon	s. of Turkey Spring	El Apache	high portion	Poverty Flat	upper Gavilán	Río Gavilán	west Pinos Altos			
year	51	52	53	51	52	53	51	52	53	53	51	52	53	51	52	53	51	52	53	
<i>Contopus richardsonii</i>	r7	r3		r1	r1		r2	r1	r4	r2	r3	r9							r6	r3
<i>Contopus perlinax</i>				r1																
<i>Empidonax difficilis</i>	r1	r1																		
<i>Empidonax fulvifrons</i>																				
<i>Pragne subis</i>																				
<i>Tachycineta thalassina</i>																				
<i>Corvus corax</i>																				
<i>Aphelocoma ultramarina</i>	3f	2f	2f	4f	4f	5f	2f	2f	3f	2f	3f	5f	4f	4f	2f	4f	1f	1f	1f	1f
<i>Cyanocitta stelleri</i>				2f	1	2f			2f	1	3	3f	3f	1	3	1f	1f	2f	2f	3f
<i>Parus sclateri</i>																				
<i>Parus wollweberi</i>	3	2		3	2	2	2	2	5	8	3	8	8	3	3	5	3	4f	7	5
<i>Psaltriparus minimus</i>	3	3		2	2	1		3	2f	7	6	3	1f	4	2	1f	5	2	1f	1f
<i>Sitta carolinensis</i>				2	1	2	2	3	3	2	2	1	2							
<i>Sitta pygmaea</i>																				
<i>Certhia familiaris</i>																				
<i>Thryomanes bewickii</i>	4	5	3	8	5	6	2	4	8	1	11	15	7	11	4	1	3	2	4	2
<i>Tragodytes aedon</i>	r2	r1		r2	r2															
<i>Toxostoma curvirostre</i>																				
<i>Sialia sialis</i>																				
<i>Sialia mexicana</i>																				
<i>Turdus migratorius</i>	r1																			
<i>Poliophtia caerulea</i>	3	1		1	1	1	2	4	1	1										
<i>Vireo huttoni</i>	3	1		2	3	4	1	5	5	5										
<i>Vireo solitarius</i>	1	1		r2	r1	r1		1	3	2										
<i>Vireo gilvus</i>	r5	r4		r1																
<i>Vermivora virginiae</i>	2	4		7	3		6	5	1											
<i>Peucedramus toaniatus</i>	r2	r1		r3	r3															
<i>Dendroica auduboni</i>																				
<i>Dendroica nigrescens</i>	3	3	2	6	10	12	1	8	12	4	1	12	12	4	5	3	4	7	6	7
<i>Dendroica graciae</i>	r2	r1		2	5	3	2													
<i>Cardellina rubrifrons</i>																				
<i>Setophaga picta</i>	1	1		3	4	3	2	5	3	7	6	1								
<i>Molothrus ater</i>	r1	r1	r1	r1	r1	r2														
<i>Icterus parisorum</i>	1	2		2	1	1														
<i>Icterus wagleri</i>																				
<i>Piranga flava</i>	5	5	2	5	7	1	5	6	4	3		6	10	5	2	7	4	1	3	3
<i>Piranga ludoviciana</i>	r3	r2	r1																	
<i>Pheucticus melanocephalus</i>	2	2	2	1	3		1	5	3	2										
<i>Spinus notatus</i>	r1	r2	r1	r1	r2	r2														
<i>Spinus psaltria</i>																				
<i>Loxia curvirostra</i>																				
<i>Pipilo erythrophthalmus</i>	3	2		2f	7	7	4	5	7											
<i>Pipilo fuscus</i>	r4			2	2	2														
<i>Plagiospiza superciliosa</i>																				
<i>Aimophila rufescens</i>																				
<i>Aimophila ruficeps</i>	3	3	2	1	2	2														
<i>Junco phaeonotus</i>				2	1	5	5	5												
<i>Spizella passerina</i>																				

• one territory occupied three summers f flock c colony r in riparian woodland

bad weather was frequently encountered, or time was consumed in identifying plants or in attempting to decide, often by collecting, which birds were breeding and which were migrating. Accordingly I did not succeed in getting accurately measured censuses in several localities. However, I kept a record of individuals in my field notes and often also on unmeasured maps. These were least accurate for very abundant species. In addition there were accurate mapped censuses each for the Ajos, Pinitos, and Huachinera, which were not included in table 2 because they lacked night birds. In order to present this additional information on distribution and numbers, I tabulated all the individuals seen in pine-oak woods of each locality during my explorations on foot in search of suitable spots for map censuses. Then I estimated the distances involved and found for the total distance of all these "estimated censuses" the average number of pairs (or singing males, flocks, colonies) of each species per mile of pine-oak woodland. This figure for nearly all species was the same as that derived from the total distance of accurate censuses, which seemed to justify combining the accurate and estimated censuses in tables 3 and 6. Only the highest figure for each species is used if a choice of counts from several visits to the same place was available.

DISTRIBUTION

The "pine-oak birds" listed in tables 2, 3, and 6 were only those species presumed to breed within pine-oak woodland or its associated riparian woods, meadows, or clearings and observed to utilize the pines and oaks extensively in their feeding activities. All other birds found on the censuses, from April to September, were migrants, vagrants, lingering winter residents, or visitors from adjoining habitats. Their numbers were sufficient throughout the entire summer to influence the ecology of the breeding population, and although I have not analyzed this relation, I have presented their numbers and status, as currently understood, in the species accounts. The addition of three species to the species accounts, namely the Red-breasted Nuthatch, Dipper, and Golden-crowned Kinglet, permits the report to include every species known to breed in the mountains of the study area. Returning to table 3, the breeding distribution of each "pine-oak" species was supplemented by showing with a dot that it was found in summer on a particular mountain, although not in pine-oak woodland. Its habitat there can be inferred from table 6, which lists habitat preferences. Another symbol (#) in table 3 shows that the species has been found during the breeding season by others: Bailey (1923), Brandt (1951:644-703), Miller (1932), Phillips (MS), Sutton (1943), Swarth (1914), and van Rossem (1936) for the southern Arizona mountains; Mearns (notebooks) for the San Luis Mountains; Campbell (field notes) for El Tigre (specimens cited in van Rossem, 1945); and Cahoon for the Sierra de Oposura (specimens listed by van Rossem, 1934:426-486). Also Alden H. Miller (personal communication) provided records from the Sierra Madre in 1948 of certain birds I did not find there. A specimen is known to exist for every species of bird in each state to which it is ascribed in table 3. Migrants are represented only by specimens specifically referred to in the species accounts.

As an example of how the distributional information can be used, consider the Western Flycatcher. The accurate census (table 2) shows that a pair was present in riparian woodland of Wet Canyon for two consecutive summers and that the birds occasionally fed in neighboring pines and oaks. In table 3, the augmented census, this same pair is responsible for the figure of one pair per mile of riparian woodland within the pine-oak area of the Pinaleno Mountains. The dot shows that the species was found by me in summer in the Catalina Mountains, in a type of vegetation other than pine-oak. Reference to table 6 dealing with habitat preferences, shows that it was probably in fir forest. The remaining three symbols indicate that the Western Flycatcher breeds as far south

as the Santa Ritas (Sutton), Huachucas (Swarth), and Chiricahuas (Brandt), whereas all the blank spaces show that it probably breeds nowhere else in the study area. Reference to the detail at the end of the species account of *Empidonax difficilis* discloses that migrants are common within pine-oak areas well into June.

This preoccupation with distribution follows from the fact that the "pine-oak species" listed in the censuses do not consistently share a particular geographic or ecologic area. Their individual species distributions and habitats, ascertained from tables 3 and 6, must be understood before comparing their relative numbers from place to place. Most of these 93 species are wide-ranging and are found far to the north, south, east, and west of this area; many occur in other habitats far beyond the range of the particular kind of pine-oak woodland considered here. A few (fig. 21, table 9) find either the northern or southern termination of their breeding ranges within the study area, but not one is confined within it.

Southern limits.—Limits of breeding ranges of birds whose southern boundaries fall within the study area correspond with changes in vegetation, although for some this may be a coincidence. The Black-chinned Hummingbird and Black-throated Gray Warbler (fig. 21) nest as far south, approximately, as the southern limits of the dense juniper-choked woodlands; the Plain Titmouse ends within the last extensive piñon woods. The Western Flycatcher (with reference to the interruption in its range), Virginia Warbler, and Western Tanager end with the tall mountains supporting fir forests.

Northern limits.—An obvious climatic difference within this area is an increase southward in summer rainfall compared to that of winter. Wildflowers, grass, and insects flourish in late summer when southern species such as the Mearns Quail and Sulphur-bellied Flycatcher are hatching their young. Northern species, like the Black-throated Gray Warbler, must feed their first broods a month or two earlier during dry and barren times. Conceivably, birds adapted to early or to late breeding times could be limited to appropriate areas along the summer rainfall gradient. But my nesting records show no more tendency of the birds to follow general rules for nesting time than for any other aspect of their behavior. Accumulation of more information, especially from persons now studying the nesting of Sonora birds, will help to clarify the relation of nesting time and breeding range to climate. Because they are inconclusive, I have withdrawn my nesting data from this report.

The Arizona Woodpecker and Olivaceous Flycatcher range north as far as encinal and pine-oak woodland; the Spotted Screech Owl and Sulphur-bellied Flycatcher (fig. 21) come close to the same boundary. Others reaching their northern limits within the study area are suspected of sensitivity to climate because their distribution shows little correspondence with changes in vegetation from south to north. They are the Thick-billed Parrot, White-eared Hummingbird, Blue-throated Hummingbird, Rivoli Hummingbird, Eared Trogon, Coppery-tailed Trogon, White-striped Woodhewer, Thick-billed Kingbird, Sclater Chickadee (fig. 21), Eastern Bluebird, Wagler Oriole, Black-headed Siskin, Striped Sparrow, and Rusty Sparrow.

Mountain mass.—The Thick-billed Parrot, Purple Martin, Sclater Chickadee, and Audubon Warbler occur on mountains supporting large areas of pine forest. They are absent from small ranges peripheral to their metropolis in the vast Sierra Madre. The Spotted Owl, Hairy Woodpecker, Steller Jay, Grace Warbler, and Crossbill are also partial to pines but do not show as much limitation. The Peloncillo range supports a small isolated grove of pines shunned by the following birds, which evidently require a more extensive pine stand and a taller, shadier woodland than Clanton Canyon affords: Flammulated Owl, Spotted Screech Owl, Red-shafted Flicker, Steller Jay, Sclater Chickadee, White-breasted Nuthatch, Creeper, Grace Warbler, and Painted Redstart.

Table 3 (continued)

	PINALENO	CATALINA	SANTA RITA	HUACHUCA	CANANEA	AJOS	CHICAHUA	PELONGILLO	SAN LUIS	SIERRA MADRE eastern slope	PULPITO	PINITOS	AZUL	ACONCHI	OPOSURA	EL TIGRE	HUACHINERA	NACORI	SIERRA MADRE western part	SIERRA MADRE high central part	
Western Wood Pewee	1r11	2r1	1r6	r24	1r10	1r12	3r7	9	•	r6	6	1r8	•	5r9			1r2	r4	1r10	7	
Coues Flycatcher	#	3r1	1r2	1r1	•	1r1	#	3		1	6		8	1	r4		5	1	4r4	5	
Western Flycatcher	rl	•	#	#			#														
Buff-breasted Flycatcher		#	#	•		1r2	#				12						rl		4r4	1	
Purple Martin							#			1							1	1	1r1	1	
Violet-green Swallow	•	1	•	1			1				1				1		1	1	1r3	4	
Raven	1	1	•	1	1	1	#		•		1	•		3	1	1	•	•	1	1	
Scrub Jay	•	•	•	•	•	•	•	•	•	•	•									1	
Mexican Jay	4	4	3	4	3	4	4	4	4	5	2	3	2	1	1	3	3	4	4	2	
Steller Jay	•	1	3	2	1	2	3		5	1	4	•	4	1	2	1	1r2	1	6	5	
Scalder Chickadee								•	4	3	6					3	2	•	7	8	
Plain Titmouse							#	6	•												
Bridled Titmouse	4r1	5r3	6r2	5r2	3	6r1	7r1	8	2	5	2	4	6	7r6	8	4	4r2	11	5	1	
Bush-tit	4	3	1	4	1	4	5	9	2	5	2	2	2	2	1	1	3	1	5	4	
White-breasted Nuthatch	1	4	3	1r1		2r1	4		#	3	5	1	2	3r4	1		2	3	6	6	
Pygmy Nuthatch	•	•	#	•	•	•	•		#				•			#	•	•	•	2	
Creepers	•	•	1	1	1	2r1	5		2	4	6	1	5	1r3	1	rl	2r2	4	3r5	5	
Bewick Wren	5	9	2	7	9	8	3	15	6	9	6	3	6	13	8	2	4	1	4r1	3	
House Wren	r3	r3	#	•	1r3	1r1	#						2	#			1r1	•	rl	5	
Curve-billed Thrasher			•	•	•	1		•	•	5		•	•	•	•	•	•	1	3	5	
Eastern Bluebird			#	1		1r1						2	•	3	1r1		1		3		
Western Bluebird	#	•	#				•		•	1	4								5	5	
Robin	rl	•	r2	r6	1r10	1r3	3r1			r6		1		r6			4r2	1r1	5r11	7	
Blue-gray Gnatcatcher	4	3	1	1		1	1	3	•							•	3	4	#		
Hutton Vireo	3	5r4	6	2r2	5	4r1	5	6	7	6	2	2	6r8	1r2	2	3	4r2		5	1	
Solitary Vireo	2r3	2r3	2	1r6	•	1r3	3r1	6	#	3	6			rl			2r2	1	5r3	4	
Warbling Vireo	r7	rl	•														r3	r3	rl		
Virginia Warbler	5r3	7r4	1	#			2														
Olive Warbler	#	1	1	#	•	•							•		1	1	rl	•	2	2	
Audubon Warbler	•	•	#			#														3	
Black-throated Gray Warbler	4r3	13	7r2	6r5	5	6r1	9	9	2			?					2r1	1	11	5	
Grace Warbler	•	3	1	2		2	6			3				#			2r1	1	11	5	
Red-faced Warbler	•	1	1	•	rl	1		1								#	rl			1	
Painted Redstart	4r1	5r3	5	1	4	5r3	7		3	3	6	7	1r2	1r9	3	5	9r5	4	5	2	
Brown-headed Cowbird	•	•	r2	1r10	1r2			6		r2	•	•	1r1					1	r3	1	
Scott Oriole	2	2	1	1	1	1	1	6	1	5r2	•	2	•	3	1		3	1	•		
Wagler Oriole														#				1			
Hepatic Tanager	7	8	2	6	1	5r1	5	12	4	9	8	4	5	6r4	2	#	8	4	5	5	
Western Tanager	r6	•	•	•		#															
Black-headed Grosbeak	4r3	5r3	3	1r2	5r7	2r3	3r1	3	2	1r2	4	1	2	1		#	2r2	1	1r3	3	
Black-headed Siskin																	2				
Lesser Goldfinch			•	rl		1r1	1		#			•		1r13	1		1r2	rl	3r3	2	
Red Crossbill	•	1	•	#	•	1	1	1		3	1	1						•	2	1	
Rufous-sided Towhee	5r6	15	•	3r2	25r20	5	1	15	8	10	10	2r3	8		3	6	10	1	3	1	
Brown Towhee	•	•	1	•	1				•	4	•	•	•	1	•	•	1	3	6	6	
Striped Sparrow																				3	
Rusty Sparrow														2r3	#		6	•	#		
Rufous-crowned Sparrow	3	2	1	1	4	2	•	9	•	8	8	2r3	2	4	3	•	10	•	8		
Mexican Junco	•	5	1	•	3	1r1	2		#	1	10	•	2			1	1	•	2	3	
Chipping Sparrow				1	1	3				1										4	7

• found by author in another type of montane vegetation # found on mountain by observers acknowledged in text
r in riparian woodland (applies to numerals which follow this symbol)

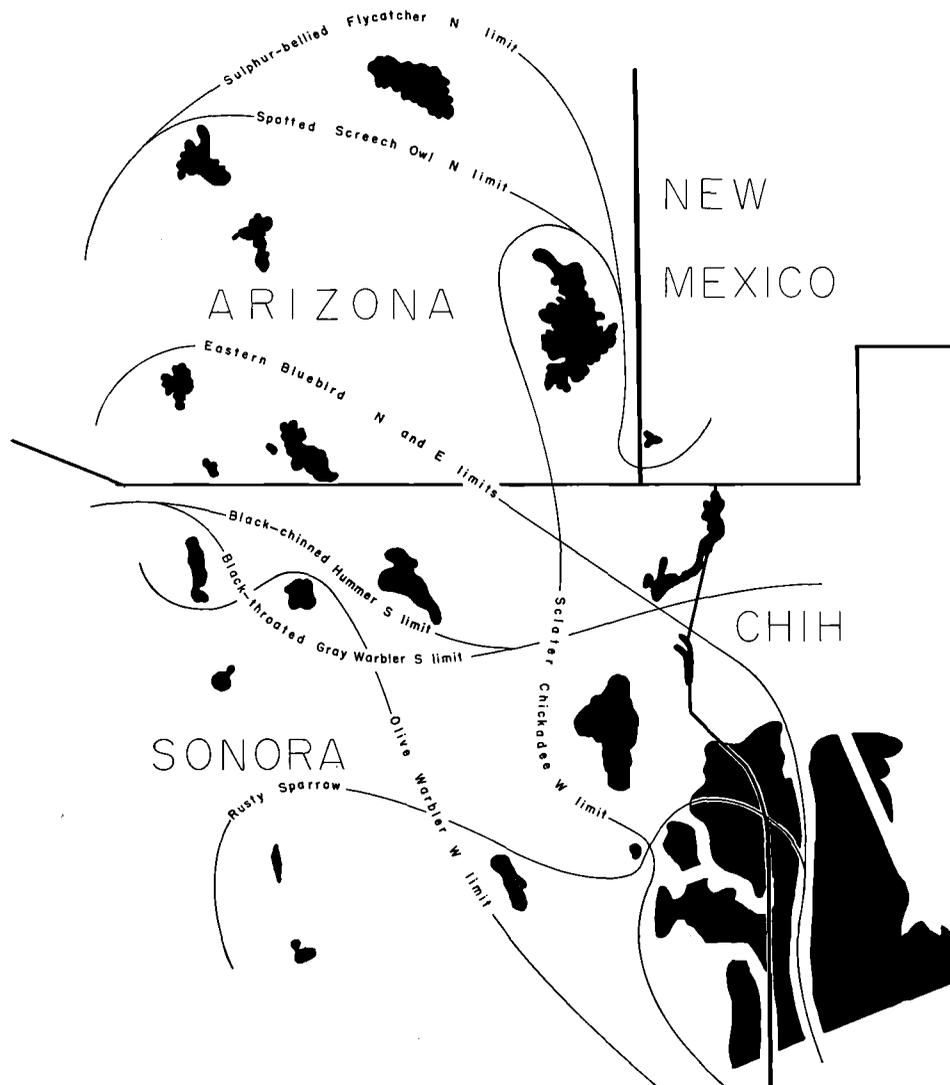


Fig. 21. Distributional limits of certain birds.

Proportion of pines to oaks.—There is an increase in forest birds over encinal birds with increased altitude in the pine-oak zone. As the pines increase over the oaks, so do the Steller Jays, Sclater Chickadees, and House Wrens increase, respectively, over the Mexican Jays, Bridled Titmice, and Bewick Wrens. The extreme in this contrast is between the upper Río Gavilán (high, mostly pine) and Pinos Altos (low, mostly oaks) in table 2. Other localities in this table, representing upper pine-oak, are Cananea and Turkey Creek; those representing lower pine-oak are Huachuca, Ajos, and Huachinera. The relation can also be discerned from the augmented census by ranking all pine-oak areas in order of decreasing prevalence of pines (see table 4). However, this is complicated by logging, presence of brush, and geographic position of the localities.

Table 4

Ratios of Total Numbers within Species Pairs from Localities Listed in Order of Decreasing Predominance of Pines Relative to Oaks

	Flam- mulated Owl	Whip- poor-will	Hairy Woodpecker	Steller Jay	Sclater Chickadee	House Wren	Solitary Vireo	Grace Warbler	Mexican Junco
	Elf Owl	Poor- will	Arizona Woodpecker	Mexican Jay	Bridled Titmouse	Bewick Wren	Hutton Vireo	Black- throated Gray Warbler	Rufous- crowned Sparrow
Sierra Madre (high)	3/0	5/9	2/1	23/7	37/5	23/14	17/2	24/	15/0
Púlpito		3/0	2/1	2/1	3/1	/3	3/1		6/4
Pinaleno	2/4	2/0	1/1	0/4	/5	2/5	4/3	0/6	0/3
Cananea		7/0	/2	3/6	/6	2/19	0/12	/10	7/8
Catalina	23/11	12/2	0/6	2/9	/12	2/17	5/13	6/26	9/4
Azul		2/	/5	4/2	/6	2/6	/10		2/2
El Tigre	2/		/2	2/5	4/6	/3	/5		2/0
Chiricahua	7/3	5/3	0/6	5/8	0/14	0/6	8/9	11/17	3/0
Sierra Madre (east)	0/2	6/0	0/3	1/4	2/4	0/7	2/5	2/	1/6
Santa Rita	18/4	17/0	0/14	10/14	/27	0/9	8/25	4/32	2/3
Sierra Madre (west)	4/0	11/5	0/4	15/9	16/12	1/10	15/12	26/	4/19
Pinitos	/0	0/0	/1	0/5	/8	/5	/4		0/5
Peloncillo	/8	2/3	1/1	/2	/4	/5	2/2	/3	/3
San Luis	3/0	3/0	0/1	5/4	4/2	/5	0/6	/2	0/0
Huachuca	20/7	10/5	0/9	5/12	/19	0/24	10/9	7/26	0/2
Huachinera	1/0	15/0	0/6	3/6	3/10	2/7	6/10	4/	2/18
Oposura		1/0	0/2	4/2	/20	0/20	/4	0/	/8
Ajos	4/14	10/3	0/15	8/18	/37	4/39	16/23	8/31	5/11
Nácori	/2	2/	0/2	1/3	0/8	0/1	1/	1/	0/0
Aconchi		6/1	/3	1/3	/18	/27	1/3		/9

Influence of openness, tree stature, and grass.—The outstanding difference in the pine-oak vegetation, along a geographic gradient through the study area, is the increase in height of the woodland, its openness, and the amount of grass toward the southwest. Table 3 is constructed to show the influence of openness and grass on the occurrence and numbers of birds by means of grouping the localities in a geographic sequence which roughly follows the gradient of vegetational difference. The mountains with low dense woods are listed on the left (Pinaleno through eastern portion of the Sierra Madre), whereas those with open grassy woods follow to the right (Púlpito through high Sierra Madre). Species whose numbers increase toward the right side of the table apparently respond to the openness and grass; they are the Sparrow Hawk, Mourning Dove, Roadrunner, Nighthawk, Cassin Kingbird, Purple Martin, Violet-green Swallow, Curve-billed Thrasher, both species of bluebirds (*Sialia*), Brown Towhee, Striped Sparrow, Mexican Junco, and Chipping Sparrow. Several of these occur at the northern stations because of artificial clearings and Forest Service campgrounds, thus interrupting, fortunately, what might otherwise be a smooth trend. The species whose numbers increase toward the left and seem therefore to flourish in the more crowded or brushy growth are the Elf Owl, Ash-throated Flycatcher, Blue-gray Gnatcatcher, Black-throated Gray Warbler, Scott Oriole, and Rufous-sided Towhee.

Role of riparian woodland.—The number of pairs in streamside growth (indicated by "r" in tables 2, 3, and 6) associated with pine-oak shows the importance of this vegetation even for those species which can dispense with streams, namely, those present in censuses of the Peloncillos, high Sierra Madre, Púlpito, and other places with no mile-

age entered for riparian woodland. Its height, diversity, rich understory of herbs, shrubs, and flowers, and its extended edge permit a greater concentration of birds, considering its narrowness, than in the surrounding pine-oak woods. However, the census totals fail to show this, because riparian woodland at the elevation of pine-oak is very narrow and interrupted. There will be a great concentration of birds at a patch of sycamores in a canyon, but it may be several hundred yards to the next sizable patch. There may be a few straggling trees between, patrolled by such species as the Sulphur-bellied Flycatcher, which necessitate adding mileage for these thin stands. Based on an average of the total census (table 6), one expects to find in a mile of riparian woodland 49 pairs of birds, 11 of which belong to species which would not be in this canyon unless the riparian growth were there. On the adjoining slopes of pine-oak, 113 pairs per mile are dispersed in more staggered fashion. Presumably a single or double row of pines and oaks would support considerably fewer birds than the 49 pairs in riparian growth. The 11 species which probably would not occur on the censuses without riparian woodland (or the actual stream for the Mexican Black Hawk) are the Cooper Hawk, Mexican Black Hawk, Blue-throated Hummingbird, Black-chinned Hummingbird, Thick-billed Kingbird, Sulphur-bellied Flycatcher, Wied Flycatcher, Western Flycatcher, Warbling Vireo, Brown-headed Cowbird, and Western Tanager. These would not have been counted on the list of "pine-oak birds" had they not frequently foraged in the adjacent pines and oaks, or nested in them as did the Cooper Hawk and the Mexican Black Hawk. Tall groves of riparian trees, such as alders, simulate forest in their height and close spacing, and this forest aspect accounts for the presence of the Western Flycatcher and Western Tanager on the foregoing list. They were present only in the Pinaleno census, where the dense grove of alders also attracted to an abnormally low altitude the Hairy Woodpeckers and House Wrens recorded there.

The riparian avifauna at this altitude differs somewhat from that of the lowlands. It includes optional inhabitants from pine-oak (Spotted Screech Owl, Hutton Vireo, and many others), high mountain riparian birds (Broad-tailed Hummingbird, Warbling Vireo), lowland riparian birds (female Black-chinned Hummingbird, Thick-billed Kingbird, Wied Flycatcher), certain ubiquitous riparian birds (Cooper Hawk, Mexican Black Hawk, Sulphur-bellied Flycatcher), and three species which reach their maximum numbers in it, namely the Blue-throated and Rivoli hummingbirds and the Coppery-tailed Trogon. Peculiarities in the relation to riparian growth of the Western Wood Pewee, Buff-breasted Flycatcher, Robin, Black-headed Grosbeak, Black-headed Siskin, and Lesser Goldfinch are best discussed under the respective accounts of those species.

BEHAVIOR

Manner and site of feeding.—My notes included, and for some species emphasized, their unusual or striking feeding habits. Thus the species accounts which follow later depict the range of potentialities of each type of bird, whereas table 5 shows the normal method of feeding. Of course what is needed once the range of activity is established for a species is a quantitative comparison of different kinds of food captures in different sites. This method, devised by F. A. Pitelka, has been used by Dixon (1954) in comparing similar species of *Parus*. Important references on feeding by birds of this area tend to substantiate my data: Campbell (1934), Cottam and Knappen (1939), Jacot (1931), Leopold (1949), van Rossem (1936), Wagner (1946), Wetmore (1935), and the many sections of Bent's "Life Histories" pertaining to southern Arizona, including the studies there of A. C. Bent, himself. The data in these references will not be repeated in the species accounts.

Joint feeding.—Some birds are versatile enough in their foraging behavior to take

advantage of unusual concentrations of food. Following a rain on a July afternoon in Arroyo Tinaja, the air was filled with small hymenopterans. Red-shafted Flickers, Acorn Woodpeckers, Cassin Kingbirds, and Western Wood Pewees were in continuous high flight catching them, thus for the moment adopting the method of swallows.

On the Río Gavilán one evening in June a crowd of birds was attracted to ants at the base of a Chihuahua pine. The ants were pouring out of holes in the lowest four feet of the trunk and swarming up the bark to eight feet. The workers were one-quarter of an inch long but the winged ones, which were not flying, were about one inch in length. A family of flickers fed from perched positions upon the trunk, reached by hopping along the ground or by flying low from adjacent trees. Each stayed at the trunk a short time while capturing several ants, then retreated. Acorn Woodpeckers reached similar perches for equally short durations by flying down from higher positions on the same trunk. Both members of a pair of Wied Flycatchers, gathering loads of ants for young in a nest, would hover and pick off just one ant on each flight from a low branch of a neighboring Chihuahua pine. A pair of Robins, feeding juveniles scattered about the neighborhood, took the ants by hovering at the trunk and by walking up to it along the ground. In contrast to these adaptable species, a pair of Western Wood Pewees, although attracted to the mixed assemblage, persisted in stereotyped aerial feeding from the top of the ant tree.

In pine forest of the Sierra Nácori, Nighthawks, Acorn Woodpeckers, and Mexican Jays fed continuously one morning on some abundant high-flying insects. A dozen Nighthawks took these insects in characteristic flight well above the tree tops. The woodpeckers caught them during continuous flight over the trees as well as by separate captures launched from the tops of dead pines. The flock of jays arrived later but commenced feeding at once. Each jay would capture several insects over the canyon in the course of a single flight from the top of a dead pine.

A flight apparently of large termites, swarming over a gorge in pine forest of the Sierra Huachinera on a July morning, produced a show of expert flycatching by a large assembly of Acorn Woodpeckers and jays, whereas two Hepatic Tanagers and a Black-headed Grosbeak attempted captures by comparatively clumsy leaps and short flights from the top foliage of oaks. The woodpeckers dived downward (one with wings nearly folded), flew up, or sailed horizontally outward from their perches, so as to take the insects with ease in any direction. Mexican Jays made one capture in each long flight, and either returned to the same perch or continued across the gorge to a new one. Seven or eight Steller Jays also fed gracefully on the wing in the same manner. All along Gardner Canyon the same three species made spectacular flycatching sorties on a January morning. They launched out from snags high on the canyon walls, and the jays often flew and glided clear across the canyon. More often the Mexican Jays returned to the sunny north canyon wall, while the Steller Jays centered on the heavily wooded south wall.

Agave parryi attracts birds to its upright yellow blossoms, which contain juice and numerous insects. The robust colonial variety of this plant in the Huachucas, where most of the following was observed, is pictured in Kearney and Peebles (1942: plate 13). The coatimundi (*Nasua*) pokes its long and flexible nose into the flowers to nuzzle and lick them. It also paws at the blossoms. One lay down upon the floral platform, yawned four times and rested. Then it stood with its hind legs upon one horizontal "rung" and licked the flowers of an upper spray. A large and heavy beast, this individual had bent down the three lowest clusters so that they hung by their broken stems. Rivoli and Black-chinned hummingbirds also fed at these flowers, males of the latter species often tyrannizing other birds. The Black-chin dips its bill in the flowers, then perches nearby

Table 5

Feeding of Birds whose Feeding Site Depends on Vegetation

Foliage and twigs (arthropods)	Olivaceous Flycatcher
Pines	Buff-breasted Flycatcher
Sclater Chickadee	Air (arthropods)
Olive Warbler	In continuous flight
Grace Warbler	Nighthawk
Pines and riparian trees	From ground
Solitary Vireo	Poor-will
Red-faced Warbler	From trees
Oaks	Cassin Kingbird
Plain Titmouse	Thick-billed Kingbird
Bridled Titmouse	Western Wood Pewee
Bush-tit	Coues Flycatcher
Hutton Vireo	Crown foliage (vegetable matter)
Black-throated Gray Warbler	Pines
Riparian Trees	Thick-billed Parrot (pine seeds)
Sulphur-bellied Flycatcher	Eared Trogon (also arthropods)
Wied Flycatcher	Red Crossbill (pine seeds)
Warbling Vireo	Oaks
Brush	Band-tailed Pigeon (acorns)
Bewick Wren	Pines, oaks, and riparian trees (arthropods
Virginia Warbler	also)
Brush and fallen trees	Coppery-tailed Trogon
House Wren	Scott Oriole
Foliage and twigs (birds)	Wagler Oriole
Goshawk	Hepatic Tanager
Cooper Hawk	(Western Tanager)
Sharp-shinned Hawk	Black-headed Grosbeak
Branches and trunks (arthropods)	Black-headed Siskin
Pines	Lesser Goldfinch
Hairy Woodpecker	Ground, trees, and air (arthropods)
Pygmy Nuthatch	Eastern Bluebird
Creeper	Western Bluebird
Oaks	Ground (arthropods)
Arizona Woodpecker	Sparrow Hawk
White-striped Woodhewer	Screech Owl
Pines, oaks, and riparian trees	Roadrunner (lizards also)
Spotted Screech Owl (also to ground)	Pygmy Owl (lizards also)
White-breasted Nuthatch	Spotted Owl (mammals also)
Foliage and air (arthropods)	Robin
Pines	Ground (seeds, vegetable matter, arthropods)
Flammulated Owl	Mearns Quail (bulbs)
Broad-tailed Hummingbird	Turkey
Audubon Warbler	Mourning Dove
Oaks	Curve-billed Thrasher (bulbs)
Elf Owl	Rufous-sided Towhee
Ash-throated Flycatcher	Brown Towhee
Riparian growth	Striped Sparrow
Blue-throated Hummingbird	Rusty Sparrow
Black-chinned Hummingbird	Rufous-crowned Sparrow
(Western Flycatcher)	Mexican Junco
Brush	Chipping Sparrow
Blue-gray Gnatcatcher	Site general (food includes acorns)
Pines and oaks	Red-shafted Flicker
Whip-poor-will	Acorn Woodpecker
Painted Redstart	Scrub Jay
Pines, oaks, and riparian growth	Mexican Jay
Rivoli Hummingbird	Steller Jay

and licks the bill with its tongue. Acorn Woodpeckers are methodical, taking one or two dabs, with pink tongue emerging, at each flower along the row. The head movements are short and deliberate, aimed sidewise as far as the bird can reach from its fixed position along the horizontal stem. An immature Arizona Woodpecker clung inverted as it probed the blossoms. Mexican Jays perch on the horizontal stems, stand high, and reach in with the bill from above. Steller Jays also feed there. Scott Orioles usually come in pairs and drive off other orioles until they are through feeding. This species actually walks or stands on top of the stiff flowers, or it may stand with one foot upon the horizontal stem and grasp a flower with the other to steady itself while inserting the bill repeatedly. The Hepatic Tanager also regularly feeds at agaves.

HABITAT

Habitat selection.—Many bird species were more numerous in adjoining habitats than in pine-oak woodland. Although I did not take censuses in forest or encinal, I made numerous observations in them which permitted the subjective estimate of habit preference shown in table 6. Kendeigh (1945) shows that in a rather monotonous environment of beech and hemlock, warblers locate themselves where appropriate nest sites and nest materials occur. By contrast the jumbled mixture of floral and terrain features in pine-oak canyons provides nearly everywhere the nest requirements listed by Chapman (1907) for the local warblers. Perhaps choice here depends more upon suitability of a site for feeding. For most pine-oak birds this foraging site is provided by vegetation, and it is assumed that birds sense differences in the shape of vegetation. Each species has its unique requirement, this being one of the attributes that makes it a species, resulting in an occurrence different from that of any other species. My concept of this requirement, or constellation of necessities, is shown in tables 5 and 6 and is amplified in the species accounts. It is based on attributes of the environment noted where the species flourishes that are lacking where it is less numerous or absent. I shall now try to defend this method against the criticism that the species' requirements may not be the same throughout the region being studied.

Geographic variation in requirements.—If geographic races within an avian species differ in average hereditary attributes responsible for habitat choice (Miller, 1942:33), we should find more examples of races adjoining each other in different habitats or at different altitudes. Most of the supposed "ecologic" or "altitudinal" races are found, upon analysis, to be separated spatially by sheer distance or by unfavorable habitat in which the species is sparse or absent. For instance, the Song Sparrow was thought to have ecologic races in the San Francisco Bay area, California. The four races there show the greatest amount of local geographic variation of any North American bird species. The population of the metropolis of each race is 100 per cent separable from the other three on the basis of only a single crude color character plus one of bill size. Although they occupy different types of marsh, including salt, brackish, or fresh, the races have been shown (Marshall, 1948) to be geographic, not strictly ecologic, races. Each occupies all the kinds of marsh which are suitable for the species and available to that race.

The reader may judge from the species accounts which follow whether the habitat requirement of a given species in the study area is basically different from that known to him elsewhere. Miller (1951*b*:541-542) discusses interpretations of such presumed differences, of which I prefer the idea that the bird "may be reacting merely to local availability of habitats," rather than being especially adapted. It might surprise some to notice that in Arizona the Western Flycatcher lives in spruce and fir forests. But except for a few large alder groves there is insufficient leafy shade for this bird at lower elevations. In its adherence to these tall shady trees it keeps to the species niche which

Table 6

Habitat Preference and Numbers of Birds in 40.9 Miles of Pine-oak Woodland,
Including 14.2 Miles of Riparian (r) and 25.5 Miles Traversed at Night

Number flocks, colonies	Total pairs, singing males, flocks, colonies	Pairs per mile where species should occur	Species	Preferred montane habitats; those separated by commas are listed in order of decreasing preference	Category of environment assigned in table 8
8 flocks	63	2—	Turkey Vulture	Cliffs and ridges and open country	9
	3	1—	Goshawk	Forest and woods above encinal	6
	3	r5	r1— Cooper Hawk	Riparian woodland	2
	2	r1	1— Sharp-shinned Hawk	Forest and woods above encinal	6
	23	1—	Red-tailed Hawk	Cliffs and ridges and open country	9
	11	1—	Zone-tailed Hawk	Any woods	4
		r4	r1 Mexican Black Hawk	Rivers	2
	21	1—	Sparrow Hawk	Openings near trees with holes	8
1 flock	50	1	Mearns Quail	Pine-oak woodland, encinal	1
20 flocks	16	1—	Turkey	Forest and woods	5
	77	r1	2 Band-tailed Pigeon	Forest and woods (not riparian)	5
	60	r3	2— Mourning Dove	Openings	8
	4	1—	White-winged Dove	Lowlands, foothill woods	3
6 flocks	24	2	Thick-billed Parrot	Pines of forest and pine-oak	7
	13	1—	Roadrunner	Slopes with low or sparse growth or rocks	3
	86	r1	3 Flammulated Owl	Pines of forest and pine-oak	7
	27	r2	1 Screech Owl	Any woods	4
	56	r14	2 r1 Spotted Screech Owl	Dense pine-oak woods, adjacent encinal and riparian	1
	12	1—	Horned Owl	Cliffs and open country	9
	32	r1	1 Pygmy Owl	Woods and forest	5
	50	r6	2 Elf Owl	Any woods	4
	9	1—	Spotted Owl	Forest conifers	7
	1 male roost	52	2	Nighthawk	Open flat country
30		r1	1 Poor-will	Slopes with sparse growth	3
129		5	Whip-poor-will	Densely wooded or forested canyons	1
1		1—	White-eared Hummingbird ♂	Near spring in pine-oak woods	1
1		1—	♀	Near spring in pine-oak woods	1

Number flocks, colonies	Total pairs, singing males, flocks, colonies	Pairs per mile where species should occur	Species	Preferred montane habitats; those separated by commas are listed in order of decreasing preference	Category of environment assigned in table 8
	r11	r1	Blue-throated Hummingbird ♂	Riparian woodland	2
	1 r7	r1—	♀	Riparian woodland	2
	11 r12	1— r1	Rivoli Hummingbird ♂	Riparian woods, pine-oak woods, forest	2
	15 r14	1— r1	♀	Riparian woods, pine-oak woods, forest	2
	9 r3	1— r1—	Black-chinned Hummingbird ♂	Foothill slopes	3
	13 r42	1 r5	♀	Riparian woodland	2
	8 r7	3 r4	Broad-tailed Hummingbird ♂	Low deciduous growth within forest	7
	4 r2	2 r1	♀	Low deciduous growth within forest	7
	4	1	Eared Trogon	Pine forest	7
	14 r28	1— r2	Coppery-tailed Trogon	Riparian woodland, pine-oak woodland	2
	122 r2	3	Red-shafted Flicker	Forest and woods above encinal	6
51 colonies	146 r6	4—	Acorn Woodpecker	Pine-oak woods, encinal, and pine forest containing oaks, snags, roosts	1
	5 r1	1	Hairy Woodpecker	Forest	7
	84 r1	2	Arizona Woodpecker	Encinal, pine-oak woods	3
	1	1	White-striped Woodhewer	Any woods?	4
	36 r10	1 r1	Cassin Kingbird	Openings	8
	r2	r1—	Thick-billed Kingbird	Riparian woodland	2
	r39	r3	Sulphur-bellied Flycatcher	Riparian woodland	2
	44 r1	1	Ash-throated Flycatcher	Slopes of encinal, of pine-oak woods	3
	2 r15	1— r1	Wied Crested Flycatcher	Riparian woodland	2
	178 r21	5 r1	Olivaceous Flycatcher	Any woods, forest	1
	71 r124	2 r9	Western Wood Pewee	Riparian woods, pine-oak woods, forest	2
	74 r10	2 r1	Coues Flycatcher	Pine-oak woods, forest, riparian woods	1
	r1	r1	Western Flycatcher	Spruce and fir forest and adjacent riparian trees	2
	19 r14	1— r1	Buff-breasted Flycatcher	Riparian woods, pine-oak woods, pine forest	2
6 colonies	11 r1	1—	Purple Martin	Forest openings with snags	7
5 flocks	28 r3	1—	Violet-green Swallow	Forest openings with snags	7
	27	1—	Raven	Cliffs and summits	9
	2	1—	Scrub Jay	Chaparral	10
all flocks	124	3	Mexican Jay	Encinal, pine-oak woods	3
65 flocks	92 r2	2	Steller Jay	Forest, pine-oak woods	7

Number flocks, colonies	Total pairs, singing males, flocks, colonies	Pairs per mile where species should occur	Species	Preferred montane habitats; those separated by commas are listed in order of decreasing preference	Category of environment assigned in table 8		
18 flocks	69	4	Sclater Chickadee	Forest, pine-oak woods	7		
1 flock	3	1—	Plain Titmouse	Encinal near piñons and junipers	3		
31 flocks	205	r19	5	r1	Bridled Titmouse	Encinal, pine-oak woods	3
44 flocks	123		3		Bush-tit	Encinal, pine-oak woods	3
	105	r7	3		White-breasted Nuthatch	Forest and woods	5
	10		1—		Pygmy Nuthatch	Forest pines	7
	86	r16	2	r1	Creepers	Forest, pine-oak woods, riparian woods	7
	231	r1	6		Bewick Wren	Encinal, chaparral, brushy pine-oak woods	3
	30	r8	1	r1—	House Wren	Forest, pine-oak woods, riparian woods	7
	38		1		Curve-billed Thrasher	Openings	8
8 flocks	21	r4	1—	r1—	Eastern Bluebird	Pine-oak woods, encinal, pine forest	1
12 flocks	39		1		Western Bluebird	Pine-oak woods, pine forest, encinal	1
4 flocks	65	r43	2	r3	Robin	Openings and water near tall trees	8
	23		1—		Blue-gray Gnatcatcher	Chaparral, encinal, pine-oak woods	10
	141	r17	3	r1	Hutton Vireo	Pine-oak woods, encinal	1
	70	r28	2	r2	Solitary Vireo	Forest, riparian woods, pine-oak woods	7
		r13		r1	Warbling Vireo	Riparian woodland	2
	23	r5	2	r1	Virginia Warbler	Forest and deciduous brush	7
	20	r1	1—		Olive Warbler	Forest	7
	14		1—		Audubon Warbler	Forest	7
1 flock	142	r11	7	r1	Black-throated Gray Warbler	Encinal, pine-oak woods	3
	92	r1	2+		Grace Warbler	Pines of forest, pine-oak woods	7
	11	r2	1—		Red-faced Warbler	Deciduous trees within forest	7
	186	r33	5—	r2	Painted Redstart	Pine-oak woodland	1
1 flock	13	r17	1—	r1	Brown-headed Cowbird	Riparian woods near cattle ranches	2
	41	r1	1		Scott Oriole	Slopes of encinal, pine-oak woods	3
	1		1—		Wagler Oriole	Any woods	4
	193	r4	5		Hepatic Tanager	Pine-oak woods, forest, encinal	1
		r4		r1	Western Tanager	Forest	7
	82	r25	2	r2	Black-headed Grosbeak	Forest, pine-oak woods	7
	4		2		Black-headed Siskin	Pine-oak woods near riparian trees	2

Number flocks, colonies	Total pairs, singing males, flocks, colonies		Pairs per mile where species should occur		Species	Preferred montane habitats; those sepa- rated by commas are listed in order of decreasing preference	Category of environ- ment assigned in table 8
11 flocks	23	r18	1—	r1	Lesser Goldfinch	Riparian woodland	2
	16		1—		Crossbill	Forest conifers	7
	210	r13	5	r1	Rufous-sided Towhee	Chaparral and brush within woods or forest	10
	54		1		Brown Towhee	Openings	8
	13		3		Striped Sparrow	Mountain meadows	8
	15	r2	2—	r1—	Rusty Sparrow	Variou—see species account	11
	104	r1	3—		Rufous-crowned Sparrow	Encinal, chaparral, pine- oak woods, pine forest	3
1 flock	55	r3	1		Mexican Junco	Forest, tallest pine-oak woods	7
11 flocks	53		1		Chipping Sparrow	Openings	8

is provided by laurels, large oaks, or other tall timber on the Pacific coast, cloud forest in Central America, and even by oak groves in canyons on Catalina Island, California. Lack of extensive shade in most of the mountains of this study area probably accounts for the hiatus in its breeding range.

Several species, notably the Screech Owl, Poor-will, Purple Martin, and Curve-billed Thrasher, have been thought to show altitudinal variation within my study area. If their variation in color and size can be shown not to relate to altitude, then the claim that they are adapted genetically to different altitudes must fall also. Actually only the flickers might constitute an example if it could be shown that the Gilded Flicker of lowland saguaros and riparian trees and the Red-shafted Flicker of adjacent mountain tops are the same species, which is by no means obvious. The bulk of the Poor-will population occupies desert knolls and foothills. Poor-wills on the higher mountain slopes represent the fringes of this same population and, contrary to former opinion, are not racially distinct (van Rossem, 1936:135). The nesting sites of two "altitudinal" forms of the Purple Martin were observed in this study. The species requires aggregations of nesting holes, provided in the west by giant saguaros (Imuris, Sonora and Tucson, Arizona), eastward by tall pine snags (Chiricahuas and Sierra Madre). Both types of trees are tall, clear-trunked, and contain abundant woodpecker holes. Absence of colony sites in the area interposed between their breeding ranges provides the isolation necessary for maintaining the two geographic races. Saguaros do not grow in the section occupied by the mountain race nor are there abundant pine snags on the small mountain within the area occupied by the lowland form. Isn't it at least simpler to assume that each race is taking whatever suitable nest sites are available to it rather than to maintain that the two races choose, or are adapted to, saguaros versus pine snags, deserts versus mountain tops?

As to the Screech Owl and Curve-billed Thrasher, these are examples of lowland species which exhibit geographic clines of beautifully distinct color differences from west to east along the region of the international boundary. The land tilts upward to the east, and the Sierra Madre, unlike the southern Arizona mountains, provides openings congenial to them. Consequently these species find themselves at higher altitudes in the east than in the west. A person comparing specimens from points not far removed will be convinced of an altitudinal variation, which is only an accident of topography,

for color gradients have not been demonstrated upon any one mountain. In fact it is difficult to find these birds in the mountains of southern Arizona; the Screech Owl seems to be pushed downward from its potential range by the Spotted Screech Owl, and the woods are too dense for the Curve-billed Thrasher.

A better place for disproving altitudinal races is at the east slope of the Sierra Madre, where lowland populations in riparian woods and farms, surrounded by mesquite desert, ascend the high Sierra Madre, roughly 2000 feet above. Here they inhabit open grassy woods, meadows and clear flood-plains surrounded by pines. Table 7 lists the birds I have found in summer, presumably breeding, all the way from the Río Casas Grandes,

Table 7

Breeding Birds of Río Casas Grandes, 4800 Feet, Whose Populations Extend Upward to High Sierra Madre at 6500 Feet

	Number of specimens collected	
	Río Casas Grandes	High Sierra Madre
Turkey Vulture		
Sparrow Hawk		
Killdeer		
Mourning Dove		
Screech Owl	4	7
Nighthawk		
Red-shafted Flicker	2	3
Hairy Woodpecker	1	1
Cassin Kingbird		
Ash-throated Flycatcher		
Black Phoebe		
Barn Swallow		
Raven		
White-breasted Nuthatch	1	1
Bewick Wren		
Mockingbird		
Curve-billed Thrasher	1	4
English Sparrow		
Blue Grosbeak		
Brown Towhee	1	2

4800 feet (fig. 22), up the arroyos to the high Sierra Madre, 6500 feet and higher, on the far side of the continental divide (fig. 23). Such a continuous population structure, in view of the short distance up the slope, is hardly conducive to the formation of a race on the mountain, and I have collected the specimens listed (table 7) in an effort to demonstrate that fact. No size or color differences are discernible in them although they were taken during the same week in April, and the Río Casas Grandes birds have worn and faded tips of primaries indicating an advance in nesting schedule over their mountain brothers. The specimens are perhaps too few for certainty except for those of flickers, which species has no size difference comparable to that between Gilded and Red-shafted flickers in Arizona, and the Screech Owls. My 40 fresh, recent, fall skins of Screech Owls from localities at various altitudes, scattered between Tucson and the Sierra Madre, aid in demonstrating that the Sierra Madre and Casas Grandes birds fit as a unit into the expected rank on the west-east cline of increasingly dark back and larger black streaks. This owl is further encouraged in the Sierra Madrean heights because the woods are too open for its competitor, the Spotted Screech Owl. Miller and Miller (1951:168) have proved that races of the Screech Owl in this study area are not sharply set off by altitude or vegetation type although they hesitate to abandon the notion of a subtle change with altitude.



Fig. 22. Río Casas Grandes, 4800 feet, Chihuahua, April 17, 1955. Habitat of Screech Owl, Red-shafted Flicker, and Curve-billed Thrasher, species which also occur in the high Sierra Madre (center background).

In the absence of proven altitudinal racial differences among the birds entered in table 7 it seems logical to expect that the montane segments of their populations are not uniquely adapted to the mountain existence. We might also assume that these species could occupy mountain clearings in southern Arizona if these were available to them; in other words they do not exhibit different habitat selection over their ranges. We know that individuals and populations of a species differ in genetic traits affecting size, proportions, coloration, and physiology. But is it really necessary to assume that they vary in the same manner in their capacity to choose a particular habitat? It seems to me that genetic control of a bird's response to its visual perception of minutiae, of *subdivisions* of its ecologic niche, is hard to imagine and would be difficult to demonstrate. Is it not easier to assume that birds are aware of an overall species niche and that they utilize whatever local manifestation of this niche is available? If a local population fills only a portion of the available habitat span of the species as a whole, I think adverse competition should be suspected rather than special genetic adaptation. Similarly if a population, especially on an island or isolated area, utilizes a novel habitat, this may be due



Fig. 23. Upper Río Gavilán, 6500 feet, high Sierra Madre, Chihuahua, April 14, 1955. Pine-oak woodland of *Pinus engelmanni* and *Quercus grisea*; large natural meadow now being cultivated. Habitat of Screech Owl, Curve-billed Thrasher, Brown Towhee, and Striped Sparrow.

to absence of competitors normally associated with that habitat. For instance the Scrub Jay of the Cape of Baja California invades mangrove and subtropical habitats utilized on the mainland by *Xanthoura* and *Cissilopha* (Pitelka, 1951a:381). In the absence of Rufous-crowned Sparrows, the Song Sparrow is able to inhabit brush away from streams on Santa Rosa Island, off the California coast (Miller, 1951a:118).

COMPETITION

If Gause's (1934) laboratory proof that species of identical requirements cannot coexist applies to natural environments, we should find differences which permit the concurrence of the numerous pairs or trios of congeners we see around us. Such differences are not obvious, and one wonders if they exist at all, especially among species of *Tyrannus* and of *Myiarchus* in Sonora. Pitelka's work (1951b) shows that the accommodations for competition may be subtle and evident only on the average and over the years. A species may adjust to avoid contact with a competitor in the following ways: by relinquishing its territory (Pitelka, *op. cit.*); by narrowing its ecologic range (Svardson, 1949:160) through contraction into its optimal span (Odum, 1953:174) or retreat to suboptimal terrain (Dixon, 1954); by holding exclusive territories (Simmons, 1951); by aversion to joining the same flocks (which also results in spatial separation); and by utilizing a different foraging site (Snow, 1949). Competition is more obviously manifested by chasing, fighting, and depressed population levels (Pitelka, *op. cit.*), by interspecific response to territorial songs and calls (Dixon, *op. cit.*: 120), and perhaps also by haphazard although complementary geographic distribution—as if occupancy of an area depended merely on which of the two competing species happened to get there first (Brown and Marshall, 1953). Congeners or other similar species existing together in

normal numbers and not showing these adjustments must elude serious competition because of their different ecologic niches, different feeding methods or size (Lack, 1944: 274), or different food (Lack, 1949:301), if not by different time of taking the same food. An overabundance of food may alleviate competition temporarily (Stewart and Aldrich, 1952).

In applying these criteria of competition to the similar species occupying pine-oak woodland, I have ignored chasing at the nest, since some birds are indiscriminate in their aggression near home. Details for the following summary are in the species accounts. Skutch (1951) discusses how such pairs of species avoid competition for nest sites.

Families of Goshawks and Sharp-shinned Hawks were located within hearing distance, but both species were so rare that I saw no contacts either between them or with the Cooper Hawk. Red-tailed Hawks fought and vanquished Zone-tailed Hawks on one occasion. The Flammulated Owl's numbers seem unaffected by its larger relatives, and territories of the three species of *Otus* often overlap. The Screech Owl reaches its usual dense population in pine-oak woods but only where the Spotted Screech Owl is absent. Where they occur together, one predominates, the other is rare. Usually this involves reduced numbers and curtailed ecologic span of the Screech Owl, which relinquishes higher areas otherwise suitable. I have one instance of a suspected fight between these two, whose distribution and proportionate numbers give, I believe, the most clear-cut evidence of competition among the species of this area.

The Flammulated Owl and Elf Owl are of equivalent size and feeding behavior and are largely complementary in altitude, but their coexistence in maximum numbers at Cave Creek in the Chiricahuas and at Sylvania disproves competition. Because of the Horned Owl's apparent local aversion to mountains, it rarely comes near a Spotted Owl's location, unlike the situation along the Pacific coast. Although Poor-wills and Whip-poor-wills mingle in canyon bottoms, their respective headquarters are on opposite sides. The Poor-will centers its activities in the sparse growth of the warm south exposure; the Whip-poor-will favors the densely wooded north-facing wall. Thus the two avoid competition by choosing substantially different habitats.

Both Blue-throated and Rivoli hummingbirds are numerous along certain streams, where I saw no conflict between them, although special attention was paid to males whose territorial posts were in full view of each other. The display territories of the male Black-chinned and Broad-tailed hummingbirds are generally far removed by altitude; the female Broad-tail was not seen in sycamores, the principal nesting environment of female Black-chins in the mountains. The Hairy Woodpecker and Arizona Woodpecker are almost entirely separated by altitude, for the first prefers forest pines, while the second chooses woodland oaks.

The Cassin Kingbird seems to be pushed to the edge of its favored riparian clearings and perhaps suffers a diminution in numbers in the presence of the Thick-billed Kingbird. The Sulphur-bellied Flycatcher, so similar in size, habitat, and foraging to the Wied (Crested) Flycatcher, arrives late at its summer home; therefore the two may avoid competition by staggering their crucial periods of feeding young. Serious fighting was suspected between Ash-throated and Olivaceous flycatchers; otherwise I could see no indication of strife among the three species of *Myiarchus*, which are as numerous as usual and occupy a greater latitude of habitat southward, in spite of more frequent occurrence together, even in the same trees. Between the Coues Flycatcher and Western Wood Pewee there was considerable fighting and chasing; more often the Coues Flycatcher was the aggressor. The peculiarities of their distribution seem unrelated, however. Perhaps their feeding at different heights and the much greater forage area of the larger bird alleviates competition for food and forage space. Western Wood Pewees

chased Olivaceous Flycatchers, but they are so abundant together in some places that they must ordinarily avoid competing by the disparity in size of their territories and in sites and methods of catching food.

As shown in the foregoing section on joint feeding, flocks of Mexican Jays and of Steller Jays often feed in exactly the same way, at the same time and place. Yet they retain in most instances their separate organizations and eventually go their separate ways, which could be a definite spatial adjustment to avoid competition. The ranges of the Mountain Chickadee and Sclater Chickadee are separated by the Santa Rita and Huachuca mountains, where neither species occurs. Choice of different kinds of vegetation keeps the bulk of the Sclater Chickadee population separated at altitudes above that of the Bridled Titmouse, in the nesting season at least. Where these species overlap, they do not avoid each other's company. On the contrary, the Plain Titmouse and Bridled Titmouse avoid mixing even in winter. Their resulting spatial segregation, both of pairs and of family groups, is possibly more complete than that of the Plain Titmouse and Chestnut-backed Chickadees studied by Dixon (*op. cit.*), and there is much greater similarity in the two species here. The White-breasted and Pygmy nuthatches show no effect on each other and utilize rather different feeding sites appropriate to their sizes. Although Bewick Wrens and House Wrens conflict in parts of their ranges (E. V. Miller, 1941), their different choice of habitat here, reflected in an altitudinal gap, usually keeps them apart.

Intense competition is suggested by the peculiar distribution of the two bluebird species, which are geographically complementary over much, but not all, of the study area. Pairs or family groups, each sequestered from the other species, were dispersed apparently at random throughout the western part of the Sierra Madre. It remains to be seen how stable the two populations are in the area of overlap. I did not find the two species mingling even in winter, although they could be found in the same places at different times.

Hutton Vireos frequently sang in response to phrases very similar to their own which were uttered by the Solitary Vireo. However, I think they were momentarily confused, and this did not lead to territorial strife. These species and Warbling Vireos were often together in the riparian trees, to which the latter is restricted. The Hutton Vireo feeds at lower levels in the trees than does the Solitary Vireo. The Olive, Audubon, and Grace warblers all feed and sing in the tops of tall ponderosa pines, where some aggression among them is evident. Although I have not yet seen an Olive Warbler chase an Audubon Warbler, the "peck order" seems to be Olive over Grace over Audubon. A Scott Oriole chased a Wagler Oriole. I found no sign of disharmony between the Hepatic and Western tanagers, although they overlap widely in Arizona forests. The former is almost entirely separated by altitude from the Summer Tanager, which prefers lowland stream-side growth.

The Lesser Goldfinch and Black-headed Siskin are perhaps the most similar species in the area; segregation between them reaches an astonishing extreme, for I found them in the same trees but on different days! It is an annoying consequence of Gause's law that the more similar are the requirements of two species, the harder it is to find them together in order to study them. Territories of Rufous-sided Towhees apparently overlapped those of Rusty Sparrows, but the latter's chaotic distribution obscures its relations with the Rufous-crowned Sparrow. Possibly there would have been more Rufous-crowned Sparrows in parts of the Aconchi and Huachinera mountains had not these spots supported "colonies" of Rusty Sparrows.

CONCLUSIONS ON AVIFAUNA

Pine-oak birds associated elsewhere.—Aside from Mexican species like the Coppery-tailed Trogon and Painted Redstart, the assemblage of breeding birds at the census stations is similar to that of other foothill areas in the southwestern United States. For example, the following birds are conspicuous both in Mexican pine-oak woodland and in the Digger pine-blue oak woodland of central California (Grinnell, Dixon, and Linsdale, 1930): Screech Owl, Red-shafted Flicker, Acorn Woodpecker, Ash-throated Flycatcher, Western Wood Pewee, a titmouse, Bush-tit, White-breasted Nuthatch, Bewick Wren, Western Bluebird, Blue-gray Gnatcatcher, Hutton Vireo, Black-throated Gray Warbler, Rufous-sided Towhee, Brown Towhee, Rufous-crowned Sparrow, and Chipping Sparrow.

Stager (1954:22) lists the following birds involved in the present study for the pine-oak woodland of the Barranca de Cobre, Chihuahua: Band-tailed Pigeon, Thick-billed Parrot, Flammulated Owl, Pygmy Owl, Blue-throated Hummingbird, Red-shafted Flicker, Acorn Woodpecker, Steller Jay, Mexican Jay, Sclater Chickadee, Robin, Eastern Bluebird, Painted Redstart, Red Crossbill, and Mexican Junco. The intrusion of pine forest species is to be expected from his description and the photographs that show mostly pines.

In El Salvador, a grove of *Pinus oöcarpa*, spaced as in pine-oak woodland but growing with brush, contained the following pine-oak birds whose subspecies vernaculars may be translated (from Marshall, 1943:21) as: Red-tailed Hawk, Spotted Screech Owl, Horned Owl, Whip-poor-will, Red-shafted Flicker, Acorn Woodpecker, Coues Flycatcher, Buff-breasted Flycatcher, Steller Jay, Raven, Eastern Bluebird, Olive Warbler, Painted Redstart, Wagler Oriole, Hepatic Tanager, and Rusty Sparrow.

Miller (1955) believes that past curtailment of habitats and forest area on the Sierra del Carmen, Coahuila, eliminated certain species which have not re-established themselves since the expansion of forest to its present dimensions. He found, among others, numerous Mearns Quails, Whip-poor-wills, Acorn Woodpeckers, Hutton Vireos, Painted Redstarts, and Hepatic Tanagers in pine-oak woods; but the Spotted Screech Owl, Coues Flycatcher, Olivaceous Flycatcher, and the bluebirds are apparently absent. Similarly Martin, Robins, and Heed (1954) believe that although the Sierra de Tamaulipas was connected to the Sierra Madre Oriental by a pine-oak belt in the Pleistocene and therefore once had an equivalent avifauna, species have dropped out due to drying and small size of the now isolated pine-oak area. Of 44 inhabitants of pine-oak in the Sierra Madre Oriental, only 20 persist on the Sierra de Tamaulipas. Among the 20 are these involved in the present study area: Mexican Black Hawk, Mearns Quail, Acorn Woodpecker, Olivaceous Flycatcher, Coues Flycatcher, Raven, Hutton Vireo, Olive Warbler, Hepatic Tanager, Rufous-crowned Sparrow, and Red Crossbill.

Several of the following species, which utilize both pine-oak and encinal in the study area, find their requirements satisfied in piñon-juniper woodland of Utah (Hardy, 1945): Ash-throated Flycatcher, Plain Titmouse, Bush-tit, Blue-gray Gnatcatcher, and Black-throated Gray Warbler. In ponderosa pine forest of the White Mountains, Arizona, I noted in early July the following species which are abundant within pine-oak woodland of the present study area: Flammulated Owl, Red-shafted Flicker, Acorn Woodpecker, Olivaceous Flycatcher (wanderer, specimen), Western Wood Pewee, Steller Jay, White-breasted Nuthatch, Robin, Western Bluebird, Solitary Vireo, Virginia Warbler, Grace Warbler, Hepatic Tanager, and Black-headed Grosbeak.

In the Pinal Mountains, the first range north of the Catalinas, "pine-oak" birds at the lower edge of ponderosa pine forest, where it interdigitates with oak groves in gullies, included the Whip-poor-will, Coues Flycatcher, Hutton Vireo, Painted Redstart, and

Hepatic Tanager. The principal differences from my study area were the abundance of Sharp-shinned Hawks and of birds such as Scrub Jays from adjacent chaparral, and the absence of Mearns Quail, Spotted Screech Owl, Acorn Woodpecker, Olivaceous Flycatcher, and the bluebirds. The next range northward is the Sierra Ancha, from which Swarth (1920) records, among others, the Whip-poor-will, Acorn Woodpecker, Coues Flycatcher, Western Bluebird, Painted Redstart, and Hepatic Tanager. The profound hiatus dividing two major sections of the genus *Junco* (yellow-eyed and brown-eyed types) occurs between the Pinals and the Sierra Ancha, only 37 miles apart (Miller, 1941:210). This is of interest to our discussion because the Mexican Junco, a typically Middle American bird, thus overreaches by one mountain range the northern limit of a Mexican flora.

A pine-oak community.—Since the distribution of most pine-oak birds is governed by their recognition of a suitable life form of plants, a classification of the environment based on life form is likely to be most useful, if we must have a classification at all. The community and biome concept fill this need (Odum, 1945; Pitelka, 1941). Unfortunately, practically all the voluminous distributional literature on animals of the area under review (Burt, 1938; Dice, 1943; Goldman and Moore, 1946; Smith, 1939, 1940; Swarth, 1914; van Rossem, 1936, 1945) is in the very subjective terms of life-zones and biotic provinces, with virtually no reference to dominant plant species. It is therefore most refreshing to find even a listing of dominant plants and birds, as given by Brandt (1951). Life-zone categories have obscured an understanding of the important environments for birds in this area; it is my impression that the biotic areas have been concocted by taxonomic sleight-of-hand. They seem meaningless unless defined so generously as to consist of an entire biome. Under the community concept, the pine-oak association of this study area might be regarded as a sort of self-perpetuating ecotone. It consists of a permanent mixture of tree forms and birds from two biomes, represented locally by ponderosa pine forest and encinal, enabling it to support a greater variety of birds than do the biomes separately.

Some types of vegetation are inhabited by bird species which select similar environmental features, and whose evolutionary association with that vegetation is attested by appropriate adaptations. An example is grassland with its Horned Larks, pipits, and longspurs converging in long inner secondaries, streaked dorsum, flight song, and the "larkspur." Similarly, the adaptations for eating seeds of conifers, for camouflage by ventral streaking, for movement and concealment among dense twigs by short wings, long tail, and brown color typify specializations of birds in coniferous forest, marshes, and chaparral, respectively.

Pine-oak woodland boasts no such group adaptation, and it lacks a distinctive avifauna in the sense that species most abundant in pine-oak of the study area occur beyond its borders. Only a small proportion of bird species seems to depend upon the *combined* life forms of pine and oak, as does the Painted Redstart, for instance. Therefore an interdependent community of vertebrates and plants was hardly evident. As the dominant plants were inconsistent in their groupings, so were the birds. Aside from a few instances of predation, competition, parasitism, and the dependence of several species upon holes of Acorn Woodpeckers for nest sites, each species seemed to obey its unique laws of distribution, oblivious to its fellows. Whole niches were thus left vacant in some pine-oak areas; for instance (table 2) the woodland floor was unoccupied at Gardner Canyon, Turkey Creek, and Pinos Altos, except for a Brown Towhee in a clearing.

Since pine-oak woodland is intermediate between pine forest and encinal, it is not surprising that most of its bird species are derived from those two zones. Table 8 gives the average number of pairs from the entire census (93 species, 5301 pairs in 40.9 miles)

in a mile of pine-oak woodland, all the pairs of a species being assigned to the one category of table 6 in which it reaches its greatest abundance. For the hummingbirds only the preponderant sex is counted except that both the male and female Black-chinned Hummingbirds are counted in their respective environments. Imagine that this average mile is along a canyon containing one-third of a mile of riparian woodland and that one-half of a mile has been scouted for owls. The encinal pairs are more numerous than those of the greater number of infrequent forest species, doubtless because pine-oak woodland is surrounded by encinal, whereas its junction with forest is limited. It is of interest that the eleven species reaching their maximum abundance here in pine-oak woods make, as a group, the largest contribution of pairs. They are the Mearns Quail, Spotted Screech Owl, Whip-poor-will, Acorn Woodpecker, Olivaceous Flycatcher, Coues Flycatcher, Eastern Bluebird, Western Bluebird, Hutton Vireo, Painted Redstart, and Hepatic Tanager.

Table 8

Numbers of Birds from Entire Census Classified According to Habitat in which Each Species is Most Abundant

Habitat	Number of species	Number of pairs	Number of pairs per mile
1 Pine-oak woodland	12	1323	32
2 Riparian woodland	16	524	13
3 Encinal	14	1196	29
4 Any woodland	5	98	2
5 Forest and woodland	4	239	6
6 Forest and woodland above encinal	3	130	3
7 Forest	23	953	23
8 Openings and meadows	9	448	11
9 Cliffs and ridges and open country	4	125	3
10 Chaparral	3	248	6
11 Varied	1	17	1

History of a pine-oak avifauna.—In view of the lack of fossil records, both of birds and of trees within the study area, and considering the lack of cohesion within the present-day assemblage, it seems futile to attempt an explanation of the occurrence of these birds in terms of past movements of the Madro-tertiary flora. (A study of lizards and snakes, of which a great number of interesting forms was seen and collected during this study, would doubtless be more rewarding.) It is particularly striking that most of the birds characteristic of these pine-oak woodlands do not heed the obvious northern termination of the floral community at the Pinaleno and Catalina mountains. Even more than in the plants, it is perhaps unnecessary to postulate vegetational continuity as essential for the spread of a bird species from one mountain to the next.

In the course of this study I witnessed several apparent northern extensions in range, dispersals, and pioneering by certain birds. The Sulphur-bellied Flycatcher and Olivaceous Flycatcher were present in the Pinaleno Mountains, where earlier collectors had not found them; I saw my first Sulphur-bellied Flycatcher on the south slope of the Catalinas in 1955 in a canyon I had visited frequently since 1950, and I took a wandering Olivaceous Flycatcher in the White Mountains. The Coppery-tailed Trogon changed from year to year in its observed northern limits. One was present in January of 1953 on the desert at Tucson. The Berylline and White-eared hummingbirds reached the Sierra Huachinera in 1953, but apparently they did not occupy this locality in the following year. A pair of Hairy Woodpeckers was present at Clanton Canyon only at the time of one summer visit. A flicker sang constantly there on April 18, 1955, as if intend-

Table 9

Mountains along North-south Axis where Breeding Ranges of Birds Terminate

Southern limits	Northern limits
White Mountains, Arizona	
Dendragapus obscurus	Cyrtonyx montezumae
Sphyrapicus varius	Micrathene whitneyi
Sphyrapicus thyroideus	Empidonax fulvifrons
Dendrocopos pubescens	Contopus pertinax
Picoides tridactylus	Aphelocoma ultramarina
Empidonax wrightii	Parus wollweberi
Empidonax griseus	Peucedramus taeniatus
Contopus borealis	Setophaga picta
Perisoreus canadensis	
Gymnorhinus cyanocephalus	
Nucifraga columbiana	
Dumetella carolinensis	
Hylocichla fuscescens	
Sialia currucoides	
(Myadestes townsendi, discontinuous)	
Anthus spinoletta	
Setophaga ruticilla	
Oporornis tolmiei	
Pinicola enucleator	
Pipilo chlorura	
Junco caniceps	
Passerella lincolni	
Pinaleno Mountains, Arizona	
Parus gambeli	Buteo albonotatus
Vermivora celata	Caprimulgus vociferus
	Eugenes fulgens
	Dendrocopos arizonae
	Myiodynastes luteiventris
	Myiarchus tuberculifer
	Junco phaeonotus
Chiricahua Mountains, Arizona	
(Aegolius acadicus, discontinuous)	Otus trichopsis
(Empidonax difficilis, discontinuous)	Lampornis clemenciae
	Trogon elegans
	Parus sclateri
Sitta canadensis	
Hylocichla guttata	
(Regulus satrapa, discontinuous)	
Regulus calendula	
Vermivora virginiae	
Piranga ludoviciana	
San Luis Mountains, Sonora	
Archilochus alexandri	
Parus inornatus	
Dendroica nigrescens	

Sierra Pulpito, Sonora

Sialia sialis

Sierra Madre Occidental, Sonora, including Huachinera and Nacori Mountains

Thryomanes bewickii

Rhynchopsitta pachyrhyncha
Hylacteris leucotis
Amazilia beryllina
Euptilotis neoxenus
Lepidocolaptes leucogaster
Tyrannus crassirostris
 (*Myadestes townsendi*,
 discontinuous)
Icterus wagleri
Spinus notatus
Plagiospiza superciliosa
 (Chihuahua only)
Aimophila rufescens

ing to establish itself. A wandering Hairy Woodpecker scouted the summit of the San Luis Mountains for pine forest in July, 1954. This bird seemed lost, for it called loudly and moved long distances from the top of one scrubby tree to the next along the margin of the burned area. Finally it plunged far down the west slope toward the cypress forest.

Several species of mountain birds, usually regarded as sedentary, disperse to lowlands. For instance Arizona Woodpeckers, Scrub Jays, Bridled Titmice, and Hutton Vireos can be seen in desert riparian growth in winter. It is not hard to imagine that some might go up the "wrong" mountain to breed, after leaving the stream valley between two ranges. Actually there are very few resident mountain birds in this area, other than the Mexican Junco, which do not have individuals moving in winter to elevations far below the breeding range.

In summary, if we consider the entire assemblage of mountain birds found in the study area, there is only a minute proportion, such as the Mexican Junco and perhaps the Spotted Screech Owl, that is so sedentary and so limited to higher altitudes that it could be used to indicate past discontinuities in montane vegetation. The other species either occur normally in lowlands and thus bridge the gaps between mountain ranges, as do the Bridled Titmouse and White-breasted Nuthatch along riparian woods, or they perform such extensive wanderings, migrations, or lowland dispersals that they could conceivably reach different mountains by their next breeding season.

Furthermore, this study has revealed striking differences in avifauna within continuous mountain vegetation. The western portion of the Sierra Madre, including the Huachinera and Nacori mountains, and the east slope of the same mountain mass are as different in their bird-life as isolated ranges elsewhere. Birds restricted to the west slope are the White-eared Hummingbird, Blue-throated Hummingbird, Rivoli Hummingbird, White-striped Woodhewer, Thick-billed Kingbird, Eastern Bluebird, Wagler Oriole, Black-headed Siskin, and Rusty Sparrow.

The mountains of southeastern Arizona have a reputation for harboring a distinctively Mexican assemblage of birds, but this impression is enhanced by several species of only casual or vagrant status. We may look for avifaunal limits among birds which actually and regularly breed in the mountains as shown on table 9 (data for the White Mountains are from Phillips, MS). Although this table shows a hiatus between the White and Pinaleno mountains in an important segment of the Rocky Mountain boreal avifauna (left), there is little to indicate a past barrier to dispersal of the peculiarly Mexican group shown on the right. Accordingly I have interpreted the distribution of

pine-oak species in terms of presence of available habitat, size of habitat, climate, and competition. I have assumed that each could have reached any mountain range in the study area in the past by sporadic dispersal if not by former continuity of montane vegetation.

A tabulation of pairs into Mayr's (1946) groupings of families according to their continental origins merely emphasizes the chaotic diversity of the birds. Evidently in this particular area with its diversity of topography, vegetation, and avifauna the particular capabilities and immediate history of each bird species takes precedence over membership in an avifauna, community, or taxonomic group in determining its occurrence.

ACCOUNTS OF SPECIES

An attempt is made in this section to characterize the feeding method and habitat preference of each species. These statements are not meant to be dogmatic; their relative importance and quantitative basis can be judged by the number of pairs seen (table 6). Some species may appear in unfamiliar roles, and it is with the intention of pointing out the local behavior that the accounts are derived only from my own field notes in the study area. The reader may therefore note the frequency with which one observer, working in a fairly uniform environment for three summers, may expect to see particular types of feeding or drinking activity.

Instances of birds found in pine-oak woods but not regularly feeding or nesting there are marked with an asterisk; such occurrences are not included in the tables. The three species marked with a dagger were not found in pine-oak but are included in order to give a complete account of the known distribution of montane birds in the study area.

**Ardea herodias*. Great Blue Heron. Along large rivers, 2: west Sierra Madre, June and August.

Cathartes aura. Turkey Vulture. Found singly or in groups up to 11 in all mountains visited. These birds soared with head inclined downward as if inspecting the ground. Only three times did I find Turkey Vultures apparently feeding in pine-oak: seven gathered at the bottom of a brushy gully in the Pinaleno Mountains, but I could not locate the food; a group alighted under oaks at the Sierra Aconchi and each ran along the ground with its wings up as it prepared to leave; in the Sierra Madre several ate a dead hog under cover of the woodland trees. Otherwise, only near cliffs or hilltops did the birds alight or frequent a particular headquarters area to sit, display, or sun themselves. Feathers found in a pool near the edge of a steep rock slope indicated bathing by this species.

Accipiter gentilis. Goshawk. The few adult Goshawks seen hunted by dashing among trees to a low shaded perch, then, after a brief stop, flying on. In this way they could move widely and secretly in order to observe prey with a minimum of disturbance. One failed to catch a Mourning Dove in a long chase over a meadow. On July 22, 1953, in the Ajos, two begging juveniles with short tails were flushed from the ground on a ridge at the upper extremity of pine-oak, and one of them was collected. Its stomach bulged with torn up remains of a Band-tailed Pigeon, whereas the entire breast meat, in one chunk, occupied its esophagus.

*One migrant (?): Santa Rita, April 7, 1952.

Accipiter cooperii. Cooper Hawk. One of these hawks caught an animal by a swift downward plunge through the trees, apparently with wings partly folded. Others soared high in circles or flapped low over the woods; this activity must be preliminary inspection for concentrations of birds. Such conspicuous flight divests the hawk of surprise necessary for a successful attack, and the true hunting method is doubtless represented by those sitting quietly in dense trees, ready to dash as described above. Even tame noisy juveniles are difficult to see because of this tendency to sit behind screening foliage. A pair nesting at our camp in the Ajos was particularly active and noisy at dusk, when the male would fly in with prey. The female would leave the nest to meet him; it was too dark to see whether he gave her the food or whether she took it forcibly. A stomach contained one Acorn Woodpecker.

My records of occurrence of the Cooper Hawk represent nesting sites occupied at each visit, for of all the pine-oak birds it was the most faithful in returning to the same spot to nest. At one site it was revealed by the immature or adult plumages that the pair did not consist of the same two individuals for the three summers.

I could not predict the reaction of small birds to the hawks in the vicinity of the hawk nests. Some, particularly those dwelling beneath the nests, paid no attention. Although it has been stated that some birds seek nesting sites near this hawk, it seemed in this study that the Cooper Hawk, Black-chinned Hummingbird, and Solitary Vireo were brought together through their mutual preference for sycamores.

The nests and families of Cooper Hawks were in dense riparian timber at permanent streams in broad canyons. An immature was several times flushed from a creek, where it actually stood in a pool. Within a mile or so of the nests, adults were occasionally seen hunting. Some of the best streams are in the southern part of this area, and I am at a loss to explain the apparent absence of Cooper Hawks there.

*Migrants, 3: Oposura, April 10, 1953; high Sierra Madre, August 24 and 31, 1951.

Accipiter striatus. Sharp-shinned Hawk. The few adult Sharp-shins I saw hunting in pine-oak flew at high speed through trees. One perched close to me on a log beneath some spreading maples. It must have been attracted by the squeaks of juvenal Creepers and Bridled Titmice in the grove. An adult which soared in circles at a great height was doubtless prospecting for a hunting spot. Still less productive of immediate reward is the futile chasing of Steller Jays and smaller birds by young hawks flying in the open. This I interpret as serious hunting rather than the kind of play described by Bent (1937:104, 106). Bereft of necessary surprise, the frenzied hawk is out-manuevered by the jay, which recovers even after being driven to the ground. On the other hand, one non-adult Sharp-shinned Hawk perched conspicuously at the tops of dead pines and dashed twice at a male Sparrow Hawk which screamed from adjacent pine tops and was retreating. Its long legs enable the Sharp-shinned Hawk to run rapidly over the ground, as one did in approaching a pond to drink.

In 1953 accipiters were spaced in the Sierra de los Ajos as follows: among alders and sycamores of Ajo Canyon were two occupied *cooperii* nests three miles apart, a hunting male and female *striatus* one mile above the upper Cooper Hawk nest; along the Claro were a family of *striatus* and one of *gentilis* within hearing distance of each other up a tributary lacking riparian growth, and an adult Goshawk, probably from the same family, was seen foraging along a gully three miles downstream. A pair of Cooper Hawks nested near the latter spot in 1955, and the other species were not seen that year.

*Migrants, 3: Santa Rita, May 6, 1951; west Sierra Madre, August 28, 1952; high Sierra Madre, September 3, 1951.

Buteo jamaicensis. Red-tailed Hawk. These hawks, seen in pairs or singly, soared parallel to canyon walls, circled overhead, or balanced over ridges, suggesting that most hunting is by inspection of the ground while flying. One flapped low over a wooded hillside, just clearing the small oaks. A stomach contained remains of a ground squirrel and what was apparently a gopher snake. Only rarely was this species seen perched and then on such places as a cliff, a dead pine, small junipers, dense Apache pines, and pines along a mountain crest. Apparently it did not perch to watch for prey (its principal method of hunting in the east according to Bent, 1937:158), but rather to rest or scream in conversation with the mate. One reached its perch by a spectacular dive with only its tail spread. Although soaring Red-tails were seen in even spacing throughout the mountains, only the six pairs recorded from the Santa Ritas, Ajos, Huachineras, and western Sierra Madre seemed to be centered in pine-oak.

Red-tails were chased by Sparrow Hawks and a Cassin Kingbird; in turn they stooped at Ravens. One pair chased a pair of Zone-tailed Hawks down a canyon leading to the latter's nest. Each Red-tail, easily gaining 100 feet or so over its respective adversary, dove repeatedly, reaching out with the talons at the bottom of each stoop. The Zone-tails, screaming pitifully, turned upon their backs to meet the dives with their feet,

and they were quickly driven far down and close to the trees. A half hour later I was surprised to see one of each pair far up the canyon again, the Red-tail flapping low over an oak slope and above it the Zone-tail, which slipped past on bent wings and dove to the nest.

At the summit of El Tigre, a Red-tail displayed its marvelous ability to balance in mid-air while facing a strong breeze. Above the line of ridges and crests the hawk would maintain an absolutely fixed position in space for several minutes at a time; then it would sail along the ridge a few hundred yards, turn into the wind, and "hang" some more. Its wing surface was decreased by a bend at the wrist. It constantly adjusted this angle of the primaries as well as the tail's position about the longitudinal axis. These were the hawk's only movements as it balanced with head extended toward the ground, the feet drooping a little, and the tail spread.

**Buteo swainsoni*. Swainson Hawk. Visitor from lowlands, 1: Aconchi. Migrant(?) at large meadow, 1: high Sierra Madre, April 12-14, 1955.

Buteo albonotatus. Zone-tailed Hawk. A pair of these hawks from the long-used nest site in sycamores within encinal of the Santa Ritas, hunted far up the adjacent slopes, thus covering pine-oak. The single record of conflict between this pair and the Red-tailed Hawks, mentioned earlier, seems to indicate the superiority in competition of the Red-tail even near the Zone-tail's nest.

In addition to soaring like a Turkey Vulture (to which the Zone-tail is remarkably similar in color, outline, position of wings, and slight side-to-side tipping), this hawk can hunt more energetically by gliding low and rapidly along ridges and in canyons. It bursts ahead with powerful flaps or downward coasting. Such patrolling of a small area was watched for an hour in a dead calm. When soaring in a strong wind with wings straight, the resemblance to the vulture is again lost.

Balancing in the wind differs somewhat from similar behavior in the Red-tailed Hawk. A Zone-tail high over a ridge of El Tigre continually veered and flopped although maintaining the same fixed point in space. It twisted the tail slightly and flexed the primaries as did the Red-tail. Its head was straight down and the legs dangled. Descending from the height in a series of stoops, it broke its fall and balanced for a moment three times before dropping to the ground behind some young pines near the crest. These stoops were initiated by a roll, then with wings folded it dove with the belly toward the wind. Presently it soared from behind the pines, reached back with its bill to its feet, apparently to swallow its prey, then majestically it simply spread the wings and rose in a straight vertical line back to its former height. A few minutes later it repeated the series of stoops to tree-top level. A stomach of this species brought in by hunters contained a large lizard.

Buteogallus anthracinus. Mexican Black Hawk. The Río Gavilán and some of its tributaries in the Sierra Madre of Chihuahua are large enough at pine-oak altitudes for Mexican Black Hawks. Two occupied nests in Apache pines at the river bank bore no relation to presence or absence of riparian woodland, for one was above the altitudinal limits of that growth. This hawk has a graceful manner of floating slowly down to the nest, with its legs outstretched and the wings partly closed.

**Aquila chrysaetos*. Golden Eagle. Open hillsides, cliffs, ridges, 9: Catalina, Santa Rita, Huachuca (2), Ajos, Chiricahua, San Luis, east Sierra Madre, Pinitos.

**Pandion haliaëtus*. Osprey. Migrant at lake, 1: Chiricahua, April 14, 1952. A game ranger claimed three had recently been shot there, together with a merganser and 10 to 15 kingfishers because they were eating trout planted in this lake.

**Falco mexicanus*. Prairie Falcon. Cliffs, 3: Pinaleno, Chiricahua (1951, 1952), San Luis.

**Falco peregrinus*. Peregrine Falcon. Cliffs, 1: Chiricahua (same place as *mexicanus* but in 1953).

Falco sparverius. Sparrow Hawk. This bird feeds on small prey taken at the ground and detected from above, either in flight or from a high perch, such as the tip of a pine at the edge of a meadow. Such hunting of course requires open country; consequently the species was numerous, mostly in pairs which were evidently breeding, in the Sierra Madre. A few inhabited clearings or openings near grassland in other pine-oak areas. A male followed by a few minutes the exact route of his mate in foraging on a large meadow. It used the same perches on various dead pines and stumps and even hovered over the same spots as if the two were playing follow-the-leader.

In hovering, 30 to 50 feet above the ground, the bird maintains a stationary position by moving the wings in a small amplitude. One bird, hunting along a ridge in a strong breeze, hovered in place with the extended wings held still most of the time, but occasionally it took a few incisive, shallow strokes. After a few minutes it would turn and be carried in a semicircular glide 100 yards along the ridge. As the end of the turn brought it again facing the wind, it would stretch the head up high and ascend a few feet before becoming stationary. Then the head was restored to the downward position. When beginning a dive to the ground, the alula was conspicuously extended and the feet were lowered. Often after hovering into the wind the birds might reach their prey by parachuting slowly down before diving near the ground.

Insects seem to be taken in the bill and mice in the feet. Sometimes the bird stands upon its prey at the point of capture and eats it there. This hawk is versatile, yet I was surprised to see one hunt like a Killdeer by running to and fro upon a lawn! Occasionally it increased its speed by flapping. Another hunted in an alfalfa field as it jumped along the ground.

Robins throughout the Sierra Madre vehemently protested the Sparrow Hawk's approach. Having killed a full-sized juvenile Robin, one male bumped his prey along the ground in trying to rise and finally reached a low stump, where he was unable to lift it to the level of the perch. His mate dashed past, took the Robin, and flew away more easily with it. Another male spent most of a day trying to catch young chicks at a ranch house, but at each dash the Robins' shrill cries warned the hen in time to defend them.

Cyrtonyx montezumae. Mearns Quail. These quail are more abundant than my records show, for in places revisited in early summer their singing revealed many more than had come to attention at other seasons. From after sunset until dark their chorus accompanied that of the owls and goatsuckers.

Mearns Quail scratch at the bases of tufts of tall grass or ceanothus bushes within woodland shade and spend considerable time at one spot. Within 30 square yards two pairs together had scratched up 25 plots 4 to 5 inches in diameter, raking away the oak leaves and digging one-half inch into the soil. When I arrived, each bird squatted so as to blend itself with the surrounding leaves and also to conceal the dark spot of earth in which it worked. Presently they edged away, holding their bodies close to the ground, their feathers fluffed out, and their backs always toward me. When I advanced closer, they abandoned efforts at concealment and ran head-long, noisily scuffing the dead leaves.

One crop was full of the shelled halves of acorns together with two small insects and a few seeds. Bulbs are commonly eaten (Leopold, 1949:11). A pair flushed from the edge of a pool had apparently been drinking. How these quail can fly with such frightening suddenness is revealed by one which I happened to see before it "exploded." It crouched motionless with its wings outstretched in preparation for its takeoff which was made when I came closer.

Meleagris gallopavo. Turkey. Having found Turkeys only twice in the Sierra Madre proper, I must assume that they have been reduced since Leopold's visits (1949:11). This reduction in numbers, as in the Sonora mountains, is doubtless related to a large volume of transportation over the logging and mining roads (Leopold, 1948) and on well-used trails in more remote places such as the Nácori Mountains. Even on the Oposura, the least accessible of any range visited, where I saw the most Turkey tracks, the local people speak of hunting them at night and taking up to 40 (!) from a single roost in the trees. Turkeys, reintroduced to the Arizona mountains, frequent pine-oak less than the higher zones. One was seen apparently drinking at a creek.

**Charadrius vociferus*. Killdeer. Large streams and meadows, 11: east Sierra Madre, 2; west Sierra Madre, 2 places, including a flock in August; high Sierra Madre, 7.

**Tringa solitaria*. Solitary Sandpiper. Migrant on large stream, 1: high Sierra Madre, April 11, 1955 (specimen).

**Capella delicata*. Wilson Snipe. Migrant on wet meadow, 1 group of 10 to 12: high Sierra Madre, April 14, 1955.

Columba fasciata. Band-tailed Pigeon. It is difficult to count Band-tailed Pigeons because they fly far, the nesting birds flock (Grinnell, Bryant, and Storer, 1918:580), and the breeding season is either irregular or very long. On a summer day in the mountains one is apt to hear one or two hooting in the morning and to see single pigeons, pairs, or flocks up to 14 flying high overhead in various directions. Displaying individuals break away momentarily from the flock to perform. The greatest number I saw fed upon a rich acorn crop in the western Sierra Madre in the fall of 1952. These birds were uniformly scattered throughout the woods in groups of three to seven. They swallowed the large acorns whole without the cup (one stomach). Pigeons feeding on acorns in the foliage were adept at remaining concealed. When resting in the pines nearby, they also remained behind screening leaves. The flock might alight in a tall dead pine preparatory to entering the oaks for feeding; there, of course, the birds were conspicuous. Another stomach contained *Nolina* fruit. A Band-tailed Pigeon was eaten by a young Goshawk. Floating powder and feathers, indicating recent bathing, were found in the same pool with the vulture feathers, and two pigeons were seen drinking at a creek.

Due to wanderings and migrations in search of abundant food, pigeons were irregular in occurrence. Therefore it was surprising to find them in successive years at certain favored groves, such as a patch of large pines, including dead ones used for song perches in Bear Canyon. A nest with egg was found in pine-oak of the Ajos on July 16, 1952.

Zenaidura macroura. Mourning Dove. This dove, primarily a bird of open country, utilized pines even in fairly dense stands for singing and roosting. It also sang from riparian timber and ascended narrow and heavily wooded gorges in order to drink at pools. Feeding is of course carried on at the ground in grassy areas, which need not be very large to attract these birds into mountain canyons, for with their strong flight they can visit such places over a large area. One pair fed on bare spots surrounding ant-hills. Only on the Sierra Pulpito was a dove seen in pine-oak far from water. A nest was found in pine-oak of the Sierra Huachinera. Mourning Doves in the open were able to outmaneuver hawks; one escaped from a Goshawk, another eluded a Prairie Falcon. Prairie Falcon.

Zenaida asiatica. White-winged Dove. Apparently because of the great abundance of White-winged Doves throughout encinal of the Pinitos, some ascended to nest in pine-oak, where in densely wooded gullies I found two couples of bob-tailed juveniles barely able to fly and a pair alarmed as if nesting on July 10, 1953. A nest with eggs was found there on May 31, 1955. White-winged Doves visited other study sites, from open areas below, to sing for a while in the pines.

*Visitors, 10: Cananea, 2; Ajos, 3; Peloncillo, 1; Aconchi, 4.

Rhynchopsitta pachyrhyncha. Thick-billed Parrot. During my few weeks' stay in the Sierra Madre, in 1951 and 1952, I noted in pine-oak 18 pairs of Thick-billed Parrots (in a few instances there were two pairs flying together), one single bird tagging along behind a pair, and three flocks of about 50, 60, and 8. Several days might pass without any being seen. Populations shift from year to year doubtless in relation to the crop of pine cones. I saw parrots only twice in the Sierra Madre in 1955; they were numerous in 1954 in the Sierra Huachinera, where I had seen none the previous year.

Not only do these parrots fly very rapidly with their shallow wing-beats, but they also glide for long distances. One soared in circles at a great height while exchanging obscenities with its partner on a far ridge of the Oposura. The ear-splitting calls of this species of course carry a great distance, which facilitates communication among the widely roaming individuals. When two pairs fly in company, they preserve a distance of several feet between pairs, with the mates flying nearly tip-to-tip, one slightly ahead of the other. The one small flock seen was organized into a compact "V"; the flock of 60 was in several "V" subdivisions but proceeding as one overall unit. In the Huachinera the birds spent much time in pines along the summits. Groups in flight generally went along or parallel to the ridges. A flock rose with tremendous outcry from the bottom of a deep canyon and spiralled slowly upward, gaining altitude each time the birds soared into the breeze, until it was high enough to clear the ridge in level flight. There were about 22 birds in the spiral, subdivided into four or five groups and pairs.

This parrot must feed efficiently, on various pine seeds, for it seems to have plenty of leisure time and I saw none eating, partly because of their long silences which make it difficult to locate the birds.

At three places, a pair would arrive near camp one day, stay over-night and remain during part of the next day. One such pair spent a whole afternoon just sitting in a dead pine, on branches shaded by the trunk. One climbed this trunk with the aid of its bill, which it hooked into successive storage holes of the Acorn Woodpecker.

The nests reported by Thayer (1906:223) from this same region were in holes of the Imperial Woodpecker (*Campephilus imperialis*), a species which unfortunately now appears to be extinct locally. Some holes probably made by this woodpecker are to be seen on a logged part of the pine forest of the Sierra Huachinera. Apparently the Thick-billed Parrot requires a vast pine area for its permanent home; therefore it is limited to the Sierra Madre and its associated ridges. There is reported to be a high waterfall in the Sierra Madre to which thousands of these parrots come to drink.

**Coccyzus americanus*. Yellow-billed Cuckoo. Belated migrant or wanderer in riparian timber, 2: Huachuca, June 15-16, 1951; Ajos, July 17, 1952.

Geococcyx californianus. Roadrunner. Most of my records of the Roadrunner are of individuals singing in rocky places where scrub growth penetrates or adjoins pine-oak. Because much of their time is spent on the ground behind screening boulders or brush, only a few of the birds were seen, usually as they sailed down slopes. A tame bird at camp in Arroyo Tinaja frequently sang and clacked, particularly at a family of Spotted Owls, thus revealing his route, which was retraced several times each day. This bird prowled by short swift runs along open ground, through a brush patch, and along large boulders. Also he leaped from one boulder to the next. He paused frequently to look around or to eat large insects captured from the ground. In addition much time was spent in trees—oaks, when making his periodic check-up on the owls, a tall Apache pine when sunning, preening, singing, and clacking. He easily ascended the bare parts of this pine by leaps and short flights and ran gracefully along its horizontal branches. Likewise his flight downward was graceful, but a crash landing in foliage from an upward flight was ludicrous.

A Roadrunner near Tucson ran about 10 feet up a nearly vertical trunk of a tamarisk, but this was preceded by a rush down an adjacent branch, which provided momentum to make the climb without aid from its wings. The Roadrunner's elegant glide down a slope, just skimming the brush, is a spectacular habit. In contrast to these capabilities in locomotion, and limitations above the ground, by which we picture the bird as efficiently engaged in covering a large foraging area quickly and secretly, are his mannerisms which resist explanation in terms of survival. Perhaps we should conclude that these exist purely for comic relief, to delight the person fortunate enough to encounter the Roadrunner at close quarters.

Otus flammeolus. Flammulated Owl. This owl feeds in flight and from perches within the foliage of trees. It flies straight into the space between pines, swoops abruptly, then alights at a new perch. A pair fluttered rapidly in the tops of two flowering madrones whose blossoms had attracted many insects, and the birds seemed to capture several of these in each flight. Stomachs of 27 specimens contained the following (A. R. Phillips collected 10 of these, including 8 from the Hualpai Mountains in western Arizona, of which 3 were examined by L. P. Wehrle): 81 beetles, 60 moths, 38 caterpillars, 17 crickets, 15 other insects mostly of flying types, 12 centipedes, 5 small mole crickets, 5 katydids, 3 crane flies, 3 weevils, 2 spiders, 2 scorpions, a daddy-long-legs (Phalangida), a solpugid, an orthopteran, and a pellet of insect parts. These prey items are mostly of medium size and of types likely to be caught in the air or in foliage, with lesser amounts taken from the ground or large branches.

Flammulated Owls feed mostly at dawn and dusk, when they fly at astonishing speed from one tall pine to another and seldom hoot. Less active at night, they spend hours on the same perch, hooting incessantly.

Primarily a bird of ponderosa pine forest, the Flammulated Owl enters pine-oak in great numbers and even spills into woods of piñon, oak, and juniper 100 yards or so from pines in the Santa Ritas and Huachucas. My census shows absence or rarity of this species on many of the southern mountains, as well as fewer numbers compared to the Screech Owl in the high Sierra Madre. I think this is due to my bad luck with thunderstorms at night and possible disturbance from logging rather than to actual rarity or competition with *asio*, for in two undisturbed spots in the Sierra Madre I found normal numbers; one was a pine-oak locality (fig. 17), the other was ponderosa forest (fig. 13).

Individuals differ in voice, by which some may be recognized on successive visits to a territory. A male with a peculiar barking song occupied the same grove in Bear Canyon (fig. 5) each summer from 1950 to 1952; in 1953 a new male was in that territory. Given a territory containing a large alligator juniper, the owl will consistently use that tree as a refuge and headquarters, from which it will threaten an intruder. This attraction to the irregularly branched tree is unexpected, for the juniper is absent from the more favored habitat, pine forest. At Sunnyside the only change in a population was noted. In 1951 there were five males between Sunnyside and Sylvania Canyon ($\frac{3}{4}$ mile, below the range of Apache pine) and 13 along Sylvania Canyon to its head ($1\frac{1}{2}$ miles). The next summer there were 14 along the canyon and none below. The lower portion of pine-oak had been vacated. Again in 1953 at least one male was at Sunnyside, but the census had to be abandoned because of bad weather on my only visit there.

Otus asio. Screech Owl. When hunting, the Screech Owl perches on twigs projecting slightly from the foliage at the side of a tree or beneath the canopy of leaves. Although inconspicuous against the foliage, it has a clear view of bare or grassy ground. Food remains in 48 stomachs, mostly from the lowlands within the study area, were 83 crickets, 39 grasshoppers, 30 mole crickets, 24 caterpillars, 19 spiders, 18 beetles, 18 centipedes, 16 moths, 12 other insects, 8 walkingsticks, 7 katydids, 5 scorpions, 4 praying

mantids, 4 roaches, 3 sowbugs, 3 large orthoptera, 2 mice (1 a *Perognathus*), and one each of daddy-long-legs, vinegarone, small bird (winter), nocturnal snake (*Hypsiglena ochroryncha*, 170 mm.), and a nocturnal lizard (*Colionyx variegatus*, 75 mm.). In contrast to the food of the Flammulated Owl, most of these prey remains are very large. They were probably taken at or near the ground and were folded and swallowed whole.

The Screech Owl is at home in any kind of woodland and can reach its normal abundance in pine-oak woods not inhabited by the Spotted Screech Owl such as that in the Peloncillos and high Sierra Madre. But it will yield dense woodland of mountain slopes and canyons to *trichopsis* and retain in un-reduced numbers only its lowland domain and the most open and flat mountain woods. This owl is therefore rare and irregular from year to year in pine-oak. At Wet Canyon in the Pinaleno Mountains, north of the area of *trichopsis*, it lives in dense oak groves, showing that what appears to be a preference for open places is really a restriction effective within the range of its competitor.

Otus trichopsis. Spotted Screech Owl. This owl hunts in foliage and branches of dense groves on mountain slopes and in canyons. I have seen it capture prey at the end of a rapid straight flight from an exposed branch. One victim was seized thus upon the ground, another upon the dead branch of a neighboring tree. A bird fluttering rapidly back and forth in tops of maples apparently took numerous insects in succession, with hardly any pauses between captures. Items in eight stomachs (one empty at dusk) were a mouse (winter) and the following medium to large insects suggesting emphasis upon captures in trees: 15 caterpillars, 14 beetles, fuzzy insect material apparently the remains of many small moths, 13 crickets, and 5 other large orthopterans.

This species' numbers do not taper at the northern end of its range in the Catalinas and Chiricahuas. This limit is not related to an obvious change in vegetation, for the next range to the north, the Pinaleno Mountains, affords attractively dense oak groves in Wet Canyon, but these are occupied by *Otus asio*. The greatest numbers of Spotted Screech Owls are found in pine-oak woodland. This seems due not to the combination of plants but rather to the large size and dense foliage attained by the broadleaved trees at these elevations. The Spotted Screech Owl is also attracted to riparian groves and to dense parts of encinal. It seems to require extensive screening masses of foliage. These are not offered by the small gray oaks of the Peloncillos and the high Sierra Madre (one exception, fig. 13), the only places in pine-oak where *trichopsis* is replaced by *asio*.

Although each species of *Otus* has a different optimum habitat, adjoining areas will here and there support it in undiminished numbers. All three are found together only in pine-oak. *Flammeolus* and *trichopsis* develop maximum numbers together, as at Sylvania, and the former is generally separated from *asio* by altitude; therefore it is not suspected of competing with its two larger relatives. In its small size, aerial hunting, and short feeding period it is more like a goatsucker than like its fellow screech owls. *Asio* and *trichopsis* are nearly alike in habits; *trichopsis* is only a trifle smaller. They overlap in encinal, where *asio* is favored, and in pine-oak woodland, where *trichopsis* gets the upper hand. Table 2, for Sylvania and Rucker Canyon, illustrates the rarity and impermanence of *asio* in the latter areas of overlap. But the territories vacated by it are not entirely suitable for *trichopsis* since they embrace open encinal of slopes, whereas *trichopsis* continues to occupy the dense groves in the canyon bottoms which have more pines. Thus my maps show that the two species are already deployed, not by interspecific territoriality, since their territories partly overlap, but by ecologic segregation brought about by *asio's* retreat to the most open groves. The situation at Turkey Creek (fig. 2) is different, if we assume that seasonal up-hill movements of *asio* are not involved, which I think is correct. The *asio* territories of the winter of 1951 were all in dense enough growth for *trichopsis*. The latter had taken most of these territories by the spring of

1953. This action was facilitated by the removal of the *asios* for specimens. A dynamic relationship between the species is evident, although the conflict implied must be subtle, for I noticed only one suspected fight between males. The result nevertheless is the seizure of the upper part of *asio*'s broad potential habitat by *trichopsis*.

The Spotted Screech Owl (frontispiece) was the most pugnacious of all territorial birds encountered. This produced some excitement when imitated calls were sounded for the purpose of locating the owls. One male, partly blinded by the flashlight, pounced upon his own mate. Together they fell to the ground, where they grappled with each other until the female uttered an anguished trill. This identified her to the male, since the call of all females is much higher in pitch than that of the males, and they abruptly parted. A fully aroused male, his feathers puffed up and his wings dragging along the ground, struts like a Turkey toward the intruder. Generally he can be picked up; he continues to hoot as long as he is held right-side-up. I carried one such male into the territory next to his own. When released, he clutched the local "owner" in a sycamore with such ferocity that both tumbled to the grass. I picked up the birds, and with some difficulty disentangled them. Upon their release, the "intruding" bird terrorized the "owner" for twenty minutes more, until finally he got back to his own territory. Thus the law that a bird on his own territory is invincible was temporarily suspended while the fighting bird was so thoroughly aroused and so oblivious to his surroundings.

Bubo virginianus. Horned Owl. This owl looks for prey in open country from a perch on a tall tree or telegraph pole. Although numerous in lowlands, the species is practically absent from mountains in the study area. Two pairs with juveniles occupied pine-oak woods in the Chiricahua and high Sierra Madre mountains and four more pairs performed duets each dawn at camps in pine-oak of the Púlpito and the former two ranges. Only a feather was found in the Oposura. The remaining four records from pine-oak are of wandering males which were present only one day of several spent at a camp. The two families, one of the pairs, and two of the wandering males were at or near cliffs, which are preferred for roosts and nesting.

Glaucidium gnoma. Pygmy Owl. This species, unlike the screech owls, responds at all seasons to imitated calls. Since these were used throughout the study to attract small birds, it is likely that I have counted nearly the entire population within hearing distance of my routes. Generally these owls spend the morning on warm slopes, preferring juniper; therefore they can hear and be heard far along the canyon, and they come from the ends of their immense territories to hoot at the intruder. This and the evenness of their spacing gives an impression of abundance despite the distance of more than a mile which separates pairs. Actually the species is no more abundant than the Screech Owl, which is a comparative rarity in pine-oak. The Pygmy Owl is only slightly more numerous than the Sparrow Hawk, and it is outnumbered two to one by the Elf Owl. I followed one busy Pygmy Owl for three-quarters of a mile, not an unusual distance to be patrolled by the foraging birds. Apparently the territories are edge to edge, although in only the following instances is this hinted by records of more than one pair on a study site: a male one and one-half miles from a nesting pair in the Huachucas, a male each in three neighboring canyons on Cananea Mountain, two males collected within 100 yards (but two hours apart) in the Oposura, and two males a mile apart in the Sierra Madre, where one roamed to within 1200 yards of his neighbor.

The only limitation I can detect here for the Pygmy Owl is desert, which imposes the lower altitudinal boundary. Why this owl is so rare in the Catalina Mountains is a mystery to me. Only two pairs of titmice, usually the most responsive bird, in the Catalinas showed alarm at imitated calls of this owl.

Of 20 specimens, not all from pine-oak, 12 had each eaten a lizard (including 7

Urosaurus ornatus, 2 *Cnemidophorus*, and 1 *Sceloporus undulatus* about five inches long) probably taken from tree trunks, ground, and boulders, respectively, in the daytime. Other remains were 8 grasshoppers, 3 cicadas, 1 huge hawk moth, 1 katydid, and an Eastern Bluebird taken near dusk in winter. Four stomachs contained only small insects, and one was empty at noon.

Micrathene whitneyi. Elf Owl. The Elf Owl occurs in close-spaced pairs in all kinds of woodland, reaching its upper altitudinal limit within pine-oak, where it is undiminished numerically and prefers slopes, as does *Glaucidium gnoma*. It does not answer imitated calls, and it can be detected by its constant racket only on moonlit nights in spring and early summer—hence the spotty record. This owl uses Acorn Woodpecker holes for roosts and nests; consequently there is great din and mutual protest at dusk when the owls emerge and the woodpeckers retire in the same trees. Of a wide habitat range practically coextensive in this area with that of *Otus asio*, its only limitation seems to be intolerance to pure stands of pine. The Elf Owl's territory is very small; much of its noise comes from near or within the entrance to its hole which is located at hearing distance from the next pair. Four dead Chihuahua pines in one-half mile were occupied in the Peloncillos.

In active hunting after dusk, the bird moves rapidly from one perch to another; these perches are low bare or dead branches of trees and bushes overlooking clear ground. One foraging owl whisked along, skimming the grass; another caught a large hawk moth in flight; and a pair fed with a pair of Flammulated Owls by fluttering among the abundant flowers of large madrones, where insects were numerous. Four stomachs contained scorpions, grasshoppers, moths, and other flying insects. Large black crickets or roaches, probably taken from the ground, were brought to juveniles. These owls dawdle interminably with large insects. The prey is transferred from one foot to the bill, then to the other foot and so on, the bird meanwhile standing high on its long slender legs, as if to avoid mussing its plumage; the ankles are bent together to give it a comical knock-kneed appearance. After several minutes of handling a large hawk moth, one Elf Owl had accomplished nothing more than biting the head and attempting to take off the wings. In bringing the large orthopterans to the young, the adult performs the same finicky manipulations, rendered more ludicrous when both birds sway from side to side as they approach each other. Once a parent climbed "hand over hand" like a parrot, reversing its position with each step up an inclined twig toward its offspring.

This information on food of the five small owls which occur together in much of the area studied agrees with the data of Jacot (1931), Campbell (1934), and van Rossem (1936), showing that they subsist primarily upon arthropods except that *Glaucidium* takes lizards also. On the other hand, Brandt's contention (1951:364–365) that these owls ravage passerine bird populations seems unfounded. I admit my strong prejudice in favor of the owls; nevertheless the censuses show that where the habitat is varied and not too badly misused the owls and song birds abound together.

Strix occidentalis. Spotted Owl. The occurrence of the Spotted Owl in this area may be favored by the virtual absence of Horned Owls from mountain forests. Only one of the latter species was noted, as a one-day visitor, in a Spotted Owl territory. Spotted Owl pairs range over a large area of about one square mile in a single night. Most of these territories embrace ponderosa or Douglas fir forest in addition to pine-oak. The birds of the Sierra Madre and Ajos were found two years in the same area, but each Arizona pair was seen only once, possibly due to mishaps which can befall such tame birds in these populated mountains. In the ranges where two pairs were found, these were on opposite sides, miles apart, so it is not possible to state how close together the

territories could be. Spotted Owls prefer dense coniferous timber on steep slopes adjacent to canyons with shady roosting sites.

Although I have not seen the Spotted Owl hunting, its capabilities may be judged from the following. Its long neck permits it to inspect the ground behind and below it by looking backward under its feet. Flight is powerful and rapid, even uphill. In approaching a perch, it alternately flaps and sails toward a point a couple of feet below the branch, which it reaches with a buoyant upward glide. Capable of immediate flight when startled, it usually is leisurely about getting aloft, for it extends the neck and inclines forward into a horizontal position several seconds before taking off. The bird is sensitive to slight sounds, for it is attentive at the dying campfire where it evidently hears cracklings inaudible to human ears. Three stomachs contained respectively many mole crickets (*Stenopelmatus*), 8 huge roaches, and a wood rat (*Neotoma*). Thirty pellets from the family roost in the Sierra Madre contained rodents (*Neotoma*, *Peromyscus*), a bat (*Eptesicus*), a young rabbit, bones of a large frog or toad, and many large scarabs. Huey (1932) mentions that moths are eaten.

Chordeiles minor. Nighthawk. This species feeds on the wing on insects taken high in the air during the early morning and late afternoon, but at dusk the birds skim among treetops or low over rivers and meadows. Except on bright moonlit nights, there is an abrupt diminution in activity after dark. They drink while in slow flight over the surface of a pond. A specimen taken in the morning contained flies and other insects.

Nighthawks occur at the highest of the grassland areas (fig. 20) from which individuals travel and feed several miles up nearby canyons and are seen over pine-oak in the Pelonillos, Ajos, and Huachucas. An impressive afternoon flight of males, in silence and single file, down Clanton Canyon must have come from a large roost. Only the Sierra Madre, because of its flat terrain and openings, supported a large population of the birds entirely within pine-oak.

*Migrants or wanderers, 2: Chiricahua, August 5, 1951; Aconchi, June 21, 1954.

Phalaenoptilus nuttallii. Poor-will. The Poor-will catches flying insects (6 stomachs: moths, grasshoppers, beetles, crane flies) during leaps or short flights from the ground. It waits for an approaching moth to come close before capture and generally takes only one before returning to the ground. The bird stands with its horizontally held body one-half inch clear of the ground and holds its head high while watching for prey. In this position it can hop rapidly along smooth ground. Grasshoppers up to 5 cm. long are folded double in the stomach, which is crammed during the brief but efficient feeding periods at dusk and dawn. Boulders in creek beds and smooth ground on hillsides, in washes, or at the edge of a pond are preferred places for feeding. The Poor-will drinks while flying over the pool slower than does the Nighthawk, so that it practically hovers while dipping its bill. A Poor-will which picked up prey, possibly spiders, from a road surface seemed to alternate the feet rather than to hop. It walked with a slight waddle from side to side, and several times it ran fast for a few inches with its wings held quivering high over its back before pausing to reach down with the bill.

The Poor-will likes warm slopes with sparse vegetation, from which it sails gracefully with wings inclined upward in order to reach a feeding place downhill. Each bird feeds and calls over a large area; I have not found them in the same spots on successive evenings. Although their boundaries may be vague, the males are as aggressive as most territorial birds. Their startling displays effectively utilize sound (the speeded-up song, guttural notes, and a vocal clapping sound), color (flash of white tail spots, blinking of throat patch), and motion (dips, glides, and wings snapped together over back at each vocal clap). Although the female can sing (Brauner, 1953), collecting shows that singing birds in the field are almost invariably males.

Most of the records in pine-oak are of birds which enter these woods temporarily

in their wanderings from adjacent encinal slopes. But at Clanton Canyon the Poor-wills apparently remained within pine-oak woods all night.

Caprimulgus vociferus. Whip-poor-will. This species watches for flying insects (3 stomachs) and catches them in flight from its perch on a bare twig at the lower border of the tree canopy; here also it dozes after completing its meal at dusk. It requires dense growth of tall trees on canyon walls and therefore is rare on the Sierra Madrean wooded mesas. Otherwise it is universally present and abundant in pine-oak woods. Differences in my censuses merely reflect different times of my visits with respect to its spring arrival date. Tall riparian timber attracts the species down canyon bottoms through encinal. Blackford (1953) remarks on this bird's preference for canyons. It finds there suitable nest spots and roosts on the shady banks of the creek. The acoustics of the steep slopes and canyons amplify its resounding calls.

Like the Poor-will, the Whip-poor-will first calls at dusk from high up the slope. Soon it begins to move rapidly for long distances along and across the canyon. An individual, traced by the peculiar details of its song, roams widely through areas where others are singing, and it is difficult to count these "males." Repeatedly they sing at dawn from spots vacated in the evening. A bird with a peculiar slow song occupied the same gully at Apache Camp for two summers.

East-west canyons provide pine-oak for Whip-poor-wills on the north-facing wall and encinal for the Poor-will on the opposite side. The two species come together when they cross to sing in each other's domain or descend to feed in the canyon bottom. On long north slopes, such as that of Florida Canyon and at Apache Camp, the two practically replace each other altitudinally. Could competition restrict the Poor-will's feeding site to the ground, or is it a coincidence that I have seen none feeding from trees here? Poor-wills occasionally use trees such as eucalyptus, oaks, and pines in California, where there are no Whip-poor-wills.

**Aëronautes saxatalis*. White-throated Swift. Cliffs and high in air, 27 places (including 9 flocks). Noted over pine-oak of all mountains except six. Of these, present in other zones in San Luis, Púlpito and Azul; no record from Peloncillo, Pinitos, and Oposura.

**Cynanthus latirostris*. Broad-billed Hummingbird. Uphill wanderer from lower zones, 16: Ajos (specimen), Pinitos (specimens), Azul, Aconchi daily seen and possibly breeding, Oposura (specimen), El Tigre, Nácori.

Hylocharis leucotis. White-eared Hummingbird. A male of this species chased a Pygmy Owl in camp on the Sierra Huachinera. This bird and a female (collected) had been seen daily at a spring just off my map area by A. R. Phillips, and they probably were breeding.

**Amazilia beryllina*. Berylline Hummingbird. Male with enlarged testes collected by Phillips at spring on map census plot, El Apache, Sierra Huachinera, June 16, 1953.

Lampornis clemenciae. Blue-throated Hummingbird. This species feeds by hovering in front of flowers, which it probes with its bill; also it gathers small insects (1 stomach) on or near foliage. At the Sierra Huachinera one fed beneath maples by repeatedly darting upward to pick things from the lower surfaces of leaves. Another gleaned from cypress twigs over a creek. Both males and females occupy riparian woodland along streams through pine-oak and encinal. They are rarely seen elsewhere; a female was taken in fall on a ridge where flowers were numerous, far above the Río Gavilán, and a male briefly visited a knoll of pines and oaks near its riparian headquarters. Wildflowers near water attract this hummingbird: Huachinera, *Lobelia laxiflora*; Río Gavilán, *Pentstemon*; Nácori, *Nicotiana*. Males preserve their territorial rights by loud calling from a conspicuous perch, where they are seen at nearly every visit, on a bush of *Rham-*

nus or *Prunus* in the riparian undergrowth, often near a spring. Because of the drought and absence of lobelias at my map area in the Huachineras in July of 1954, I found only one Blue-throated Hummingbird where there had been seven the previous year. Although I have not used records of Blue-throated and Rivoli hummingbirds based only on sound, I think they can be distinguished confidently by the loud "seep" of *Lampornis* contrasted with the "chip" of *Eugenes*, which resembles the call of a Black Phoebe.

Eugenes fulgens. Rivoli Hummingbird. This hummingbird catches small insects (3 stomachs) during continuous flight at foliage, especially of sycamores and Apache pines. Insects are also gleaned from bark surfaces; with a dancing movement like an ovipositing dragonfly, the hovering bird advances four or five times to touch its bill deliberately against the branch. Some use this same bobbing motion as they probe small twigs and leaves, evidently taking numerous insects in succession. One bird hovered before a silver-leaf oak trunk, full of holes, against which it would hold its bill for a second at a time. Often the Rivoli Hummingbird takes a station on a shaded bare twig three or four feet above the creek bed or pool and flies out a foot or two every few seconds, apparently to take a small flying insect, then returns to its perch. At sunset one took insects from a large aggregation over camp. Leaving its perch at the top of an oak it gradually ascended vertically for 200 feet meanwhile twisting, squirming, hovering, and bending the tail to the side as it reached for the tiny prey. Finally it dove abruptly, levelling into a glide to the oak top, then fed again as before. Each individual spends much time daily at a certain feeding spot. At the Sierra Pulpito, although wildflowers grew in profusion, Rivoli Hummingbirds fed only in the Apache pine foliage. At other places they occasionally visited agave, lobelia, pentstemon, and *Nicotiana* flowers. A typical perch in the pine is a small twig on the underside of a shady bough where it is clear beneath.

Males and females frequent the same environment. Riparian woodland in the mountains is preferred, and the hummingbird drinks at the creek, but this species can dispense with both moist habitat and flowers. Therefore it frequents pine-oak woodlands far from streams. Because of this independence, the species was as abundant in the Sierra Huachinera in 1954, a summer of drought and practically no flowers, as it had been in the previous summer. On the other hand, Blue-throated Hummingbirds were severely reduced. At the Sierra Huachinera some of the posts of displaying male Rivoli Hummingbirds were in view of those of the Blue-throats which were similarly placed in the riparian undergrowth. A male of each species, stationed at camp, permitted close watch for several days, but we saw no sign of antagonism between them. The different tendencies in feeding and in range of habitat choice are apparent in each species whether or not the other is present in the same area. Competition between them was not noticeable.

**Calliothorax lucifer*. Lucifer Hummingbird. Northward wanderer in fall, 1: Pulpito, August 6, 1952, specimen, non-breeding female.

Archilochus alexandri. Black-chinned Hummingbird. This species feeds on small gnats and other tiny insects (3 stomachs) caught as the bird darts and hovers about the peripheral foliage of broad-leaved trees and junipers, but rarely of pines. Females sometimes perch on the bare twigs of sycamores and catch passing insects in short flights. Flowers are regularly visited. Dawn feeding may differ from that of later hours: each morning one bird hovered over a cottonwood and darted repeatedly into the foliage; two, hovering with their backs to the rising sun, daily ate gnats from a swarm lighted by the first rays. Also at dawn one bird bathed by fluttering in dew on willow foliage; another drank from a spring.

Black-chinned Hummingbirds were generally found in the same spots in successive

summers. One nested two summers on the same piñon twig beneath a Cooper Hawk nest. Females are bunched together in sycamore groves at less than 100-yard intervals. They occasionally visit agaves far up adjacent slopes of open encinal. There most of the males are stationed on conspicuous perches, and they tyrannize other hummingbirds visiting the blossoms. Since most of their time is occupied on these slopes in territorial activity and in feeding at the flowers that grow there more numerous than in the adjacent pine-oak, these local males are apt to be missed on the pine-oak and riparian census.

*Migrants, 5: Pulpito, August 6, 1952, specimen, immature female.

**Stellula calliope*. Calliope Hummingbird. Migrant, one bird at same place each time: Catalina, September 25 and October 6, 1950, April 27, 1953.

Selasphorus platycercus. Broad-tailed Hummingbird. This hummingbird hovers at the outer foliage of pines while it probes among the needles with its bill, taking tiny insects (2 stomachs). It feeds for several minutes in the crown of one pine and may return to it after a circuit through neighboring trees. As in the Rivoli Hummingbird, a favorite perch is a shaded twig on the underside of a pine bough with a clear view beneath. Several were noted hawking flies and gnats. They seemed actually to catch these insects, and they returned often to their perches, as if in a hurry. Wagner (1946: 78, 80) believes, however, that the species is not proficient at this flycatching. Of course this hummingbird also feeds at flowers, such as those of *Echinocereus*, *Robinea*, *Lobelia*, *Arctostaphylos*, and *Pentstemon*, and these to a great extent determine its local occurrence. In *Robinea* thickets haste is again evident as the bird hustles from flower to flower, probing each for only a second.

At the Sierra Huachinera in June, 1953, territorial males had fixed perches in oaks along the edge of the stream gully, where they were seen daily. Lobelias flourished along the stream and were frequented by the birds. There were no flowers there the following summer, although the spring was not dry, and there were no Broad-tailed Hummingbirds along this mapped census route.

Breeding males are concentrated at their display territories in willow thickets and other riparian shrubbery within coniferous forests, well above pine-oak areas. Females may build farther down the slopes and into the pine-oak zone (Phillips, MS). Within pine-oak I have arbitrarily chosen only the mapped censuses at Apache Camp (Catalina) and El Apache (Huachinera) to represent breeding populations. At the former a number of females was present at the proper time for nesting; at the latter, aggressive and sexual display was actually seen. Most other records were of males whose distinctive trilling rattle was heard as they flew overhead—always going somewhere else—and of aggregations of birds in female plumage, mixed with Rufous Hummingbirds, during August. I am provisionally regarding these as not breeding along the census routes.

*Migrants and visitors from higher zones, 75 or more males, 50 or more females: numerous in pine-oak of all mountains except: rare in pine-oak of San Luis and Oposura; absent from pine-oak but rare in a higher zone at Azul and Nacori; no record in any zone of Cananea, Pulpito, Pinitos, and Aconchi. Specimen from pine-oak in eastern part of Sierra Madre.

**Selasphorus rufus*. Rufous Hummingbird. Migrant, late June through August, about 50: Pinaleno, Catalina, Chiricahua (specimen), east Sierra Madre, and west Sierra Madre (specimen).

Euptilotis neoxenus. Eared Trogon. The magnificent Eared Trogon gleans arthropods from pine foliage while hovering an instant with body vertical; then it falls, levels off, and flies to a bare horizontal branch. The hovering position is reached at the end of a short flight inclined upward. Nearly all the activity I saw took place at middle height in tall pines; flights are above the intervening oaks.

The species is practically limited to the Sierra Madrean forest; territories in pine-oak woods include adjacent white pine and ponderosa pine forest. A pair crosses a mile of forage area daily and ceremoniously returns over the same route at dusk. A lone male travelled about two miles along a ridge three times in one day; his conspicuous song and large territory contrasted with those of a pair inspecting tree holes near camp. The latter birds sang only when this male came near. Another bird sang two miles farther down the same ridge of forest-like Apache pines. Thus there were three singing males in as many miles, but the roving bird sang all around and within the small area of the mated pair.

Trogon elegans. Coppery-tailed Trogon. This species feeds at middle height in broad-leaved deciduous trees and occasionally in pines in the same manner as its relative—by hovering in a stall for an instant while it picks an object from the foliage. This is accomplished at the end of a buoyant upward flight from a bare horizontal branch. Once a bird flew up, pounced upon a leafy twig, grasped something in its bill, and ate it after returning to the perch. Like the Eared Trogon, this species sits like a statue between forays; its arthropod prey thus undisturbed might be more likely to reveal itself by movement. A male foraged by rapid short flights in oaks from a vertical stance on twigs. The Coppery-tailed Trogon prefers riparian woodland but daily it moves long distances up dry gullies and into pines on slopes. Pairs or families tend to travel along a canyon beside or ahead of the observer, so that counting them is difficult.

This species fluctuates in numbers from year to year at the north end of its range. I found none in 1952 at places in the Huachucas and Chiricahuas where the species had been present on about the same date the previous year. But farther south, in the Ajos, this trogon was equally numerous in 1952 and 1953. Like the Olivaceous Flycatcher, it uses a greater altitudinal range in the south of this area than in the north, where it is confined to riparian woodland at the level of pine-oak. For instance, it inhabits the Sierra Nácori from the Río Zátachi in the foothills to pine forest near the summit. Thus it shares the forest on that mountain with its large relative, the Eared Trogon.

**Ceryle alcyon*. Belted Kingfisher. Migrant at a lake, 1: Chiricahua, May 2, 1953.

Colaptes cafer. Red-shafted Flicker. The versatile Red-shafted Flicker opens ant hills, pecks among fallen leaves, hacks in bare ground, pecks on live and dead pine trunks, plucks berries, drinks at pools, and is an early arrival at unusual food supplies. One clung inverted for five minutes while pecking upward to extract insects from the broken end of an oak branch projecting downward. It automatically flexed its tail although no contact with the branch was possible in that position. Another, at Tucson, picked hackberries with a graceful sweeping motion of the bill while it leaned or hung in the foliage. Eleven stomachs contained berries, beetles, white grubs, brown pupae, termites, barley, small seeds, small leaf bugs, caterpillars, ants and other small insects, and gravel. Flickers depend upon such varied feeding sites that their numbers reflect local diversity of terrain and vegetation. For example, they were most abundant at the Sierra Huachinera map area, where pine-oak, riparian, encinal, clearings, and brush are juxtaposed.

The flicker requires extensive groves of large trees; therefore it apparently does not nest in the Peloncillos. Perhaps the Sierra Aconchi is too small and too far removed from other forested areas to support this species in the summer at least. It occupies forest and pine-oak woodland but eschews narrow riparian woods and encinal. These evergreen oaks are evidently too small to furnish a proper environment for flickers; also their tough wood may not be suitable for nest construction. Thus nature frustrates study of the relations of *C. cafer* with *C. chrysoides* of lower elevations by interposing the entire foothill oak zone between their breeding ranges.

The flicker ranges widely over canyon sides, preferring slopes for singing. Both sexes drum, sing, and intrude on neighbors' areas, with consequent uproar. Although difficulties in counting pairs thus arise, it is evident, nevertheless, that the birds use the same nest trees and inhabit the same spots in equal numbers year after year (4 years at all seasons, Bear Canyon). Because the flicker is loud-voiced and conspicuous, it is probably favored on the census, resulting in counts somewhat higher than they should be in proportion to smaller birds such as titmice and Hutton Vireos.

*Migrants and post-breeding wanderers, 1-5: Peloncillo, April, late July, or August of three years, but absent in June.

Melanerpes formicivorus. Acorn Woodpecker. These woodpeckers feed on ants, leaf bugs, insects caught on the wing, and on acorns. I have not seen them in bushes or on the ground, except when fighting, but three stomachs contained gravel in addition to some of the above items, showing that they come to the ground. A fourth specimen, taken just as it returned from an insect-capturing flight, had a small hymenopteran in its esophagus, together with acorns and other ground-up vegetable matter in its stomach. One bird preferred to drink at a water hole 15 feet up in a *Quercus durifolia* rather than at the river a few yards away. These woodpeckers feed in the ways mentioned under "joint feeding" and many other ways, such as clinging to Chihuahua pine foliage while pecking among the leaves, crawling, sometimes inverted, in foliage of a gray oak infested with plant bugs, and picking these bugs from the leaf bases before and after stripping off the leaves. One plucked an acorn and dropped it into a cranny in a pine stump. In addition they feed like "real" woodpeckers by steady pecking on the trunks of walnuts, oaks, and live or dead Chihuahua pines. Acorns are stored on dead pine trunks and also in bark of live pines.

Oaks (for acorns and roost cavities) and tall pine snags (soft wood for acorn storage and nest holes) enable this species to reach its maximum abundance in pine-oak woodland. Its numbers even in the high Sierra Madre, where gray oaks are modestly developed, show greatest dependence on the dead pines. The numerous snags left from logging operations at Sierra Huachinera enable more than 25 individuals per mile to crowd that district; in contrast the species is rare in the Cananea and San Luis mountains, where there are practically no dead pines. Colonies inhabit snags overlooking steep canyons, with plenty of space for maneuvers after flying insects. On a study site a mile in length, Apache Camp for example, there will be three colony headquarters but only two in use at one time. Thus there are shifts and unexpected vacancies, especially in spring, possibly connected with acorn supplies and availability of roosts, but these woodpeckers were found at all seasons on the Bear Canyon map area. These widely spaced colonies of three or more individuals constitute the bulk of the census outside of the Huachinera and Sierra Madre, where Acorn Woodpeckers, tabulated as "pairs," were everywhere. The birds make long excursions to feeding places, water, and agaves, and they dive down slopes at great speed.

Interspecific relations among most pine-oak birds are confined to isolated predation, chasing from nests, alarm at hawks, mixed flocking, and mobbing of owls. But the Acorn Woodpecker must actually influence the abundance of species like the Elf Owl, Purple Martin, and Violet-green Swallow which are dependent on its holes for nests.

**Sphyrapicus thyroideus*. Williamson Sapsucker. Winter resident, 2: Chiricahua, April 15, 1952, specimen; high Sierra Madre, April 12, 1955.

Dendrocopos villosus. Hairy Woodpecker. This species may have nested earlier than my visits in the few highest pine-oak sites tabulated and also at Clanton Canyon, although the latter is certainly unlikely habitat for the species. A pair of adults industriously worked there all the morning of June 19, 1952, upon the bark of live pines; the

male also worked briefly up the trunk of a gray oak, where he had difficulty progressing through the maze of small twigs. Elsewhere Hairy Woodpeckers took food by a variety of methods. One worked all morning flaking off the bark and delivering loud pecks on the trunk of a recently killed ponderosa pine. It remained on the shady side of the trunk and occasionally backed down. Another pecked on a rotten log. Several birds drilled through husks at the tip of corn ears, evidently taking caterpillars. Conical holes excavated neatly against the vertical grain of pine stumps to reach the galleries of insect larvae were possibly the work of this species. An adult female and juvenal female spent a morning gleaning insects from needles at the tips of the lowest branches of some large ponderosa pines. The juvenile copied all the movements of its parent and seemed to feed itself but also shrieked for and received food. The adult did no pecking but merely picked things from the outermost twigs and the bases of the needles. It had to cling inverted to these drooping twigs in progressing outward along them, eventually reaching a vertical head-down position at the tip. When on larger twigs of about one-half inch in diameter, it would crawl around to the top as if it preferred that position. Food in 13 stomachs included insects and larvae, large cotyledons (acorns?), pieces of large seeds (conifers?), and green caterpillars.

The Hairy Woodpecker requires coniferous forest for its early nesting season in this area. Then families move down the mountain, especially along streams. For instance, at the map area along the lower Río Gavilán, I first saw these woodpeckers on the morning of July 1, 1952, my fifth day at camp. There was a solitary female, a lone juvenile, a juvenile following an adult, and two juveniles begging from an adult female. They moved downstream from one willow thicket to the next and pecked on the willow stems. A noisy family of *D. arizonae* had been at camp the whole week.

*Post-breeding down-hill wanderers from June 22 on, 19: Sierra Madre, western part, 11, high part, 8.

Dendrocopos arizonae. Arizona Woodpecker. This woodpecker feeds at trunks of oaks, junipers, sycamores, and pines by extracting insect larvae, sometimes within a foot of the ground. It delivers vigorous knocks with the head and body held as a rigid unit, but it may not sound as much like a carpenter as does the Hairy Woodpecker, for it usually works on smaller, thinner-barked, less resounding trees. I noticed only two instances of feeding "unbecoming" a woodpecker: a juvenile probed agave blossoms; an adult pecked its way crosswise for a complete revolution around a one-third inch horizontal silver-leaf oak twig. Items in four stomachs show a varied diet, however: insects (larvae, pupa, adults, caterpillar, ants), broken cotyledons (probably acorns), and a small crystal. Two juveniles bathed in a creek at sunrise.

The Arizona Woodpecker is limited to woods in which oaks are plentiful. Therefore, it is almost entirely separated from the Hairy Woodpecker in the breeding season. If the pair of Hairies at Clanton Canyon had actually nested there, the two species must have lived in proximity; Arizona Woodpeckers worked in the same trees there at my later visits. After the downhill trek of Hairy Woodpeckers in early summer, the two postbreeding species jointly inhabit pine-oak woods in fall and winter; occasionally they feed in the same tree together.

Lepidocolaptes leucogaster. White-striped Woodhewer. This species was met at only one spot, by A. R. Phillips, who collected members of a family in blue oaks at Pinos Altos.

**Platyparis aglaiae*. Rose-throated Becard. Present at two places in sycamores and alders of Sierra Aconchi at unusually high altitude for this species—about the level of lowest pines.

**Sayornis nigricans*. Black Phoebe. Streams, 9 pairs: Chiricahua, 1, nest; western

Sierra Madre, 4; high part, 4, singing, paired. Post-breeding single wanderers up streams from lower altitudes, 5: Huachuca 1, Ajos 2, Chiricahua 1, Nácori 1.

**Sayornis saya*. Say Phoebe. Clearings, 3 pairs: Huachuca, Cananea, and high Sierra Madre.

**Pyrocephalus rubinus*. Vermilion Flycatcher. Clearing in stream valley, 1 pair: Ajos. Uphill wanderer, 1: high Sierra Madre, specimen, male with enlarged gonads, April 14, 1955.

**Tyrannus verticalis*. Western Kingbird. Migrant in broad fields, 2 individuals: high Sierra Madre, September 1 and 4, 1951.

Tyrannus vociferans. Cassin Kingbird. This kingbird inhabits river bottoms, fields, meadows, and clearings from desert to white pine forest. Tall lookout trees are necessary in addition to the openings over which insects (large bumblebees in 1 stomach) are caught in flight from the perch. Sometimes graceful upward flights are made to capture insects 200 feet or more overhead. Insect captures follow flights also from fences, low weeds, and the ground. Individuals roam far, visiting pine-oak sites from neighboring clearings, but these are not included on tables 2 and 3: Cananea, 3; Pulpito, 1 flock; Pinitos, 1.

Tyrannus crassirostris. Thick-billed Kingbird. Of similar feeding method to the foregoing, the Thick-billed Kingbird is, however, more restricted to lowlands. The birds at Pinos Altos are unusually high for the species in this area. One individual resided in sycamores within closed woods up the canyon; another pair lived in sycamores at the edge of a field. The only Cassin Kingbird seen was in an open grove of oaks across this field. Its apparent adjustment to a competitor follows a pattern more strikingly evident at two desert riparian localities where these species coexist: Río Zátachi and Coyote (between Nácori Chico and Bacadéhuachi), both in Sonora. There the Cassin Kingbirds remained up the rather inhospitable desert slopes, leaving *crassirostris* in possession of the sycamore groves. On the Río Babasac, near Imuris, these and *T. melancholicus* lived in the cottonwoods; *vociferans* alone made frequent trips to the fields. Of course the bulk of the Cassin Kingbird population eludes possible competition by surpassing the ranges of the other two species northward and upward. The situation is complicated by the fact that *crassirostris* also is not entirely restricted to riparian woodland.

Myiodynastes luteiventris. Sulphur-bellied Flycatcher. This species takes insects from foliage as it hovers after a short flight inclined upward. Then it may alight near the point of capture, return to the original perch, or go to a new one; these perches are horizontal twigs in the interior of large trees. The bird is silent, motionless, stooped, and well concealed in the foliage between flights. Sometimes it flies from a dead twig in the open to capture insects upon the foliage of adjacent trees or bushes.

Sulphur-bellied Flycatchers live in riparian woodland, but the pair frequently travels up dry gullies or ascends slopes to feed in pines or oaks. Where the species is uncommon, it can be seen that some vociferous single birds travel about a mile along the canyon, covering a route several times a day. In areas of great abundance such trips by the mated pairs are not as long; nevertheless, one bird joined its mate in a swift plunge one-quarter of a mile across a wide canyon.

This flycatcher occurs on all the mountains where riparian woodland is extensive and continuous with lowland riparian woods. It is abundant in broad stream valleys and comparatively rare in narrow steep canyons where the riparian woodland is narrow. A late arrival in spring, it was not found at our camp in the Ajos in May of 1953 until the 31st.

Myiarchus cinerascens. Ash-throated Flycatcher. This species catches insects in foliage as it hovers following a short flight from a perch within or at the periphery of

small trees with sparse foliage. Several captures may be made in a continuous series of graceful arcs within the same tree; the wings bang against the leaves and a loud snap of the bill announces these attempts. The preference of this flycatcher for sparse vegetation results in more foraging from an exposed perch into the air or to the outside of a tree than is true of its close relatives. Beetles, a large unidentified insect, and flies were present, respectively, in three stomachs.

Ash-throated Flycatchers prefer rocky or brushy encinal slopes, but they enter pine-oak near their favorite south exposures. The territory of a pair embraces a wide expanse on both sides of a canyon, with most of the foraging time being spent high up the slope of encinal, although there are flights to the opposite side (pine-oak) and to the riparian woodland at the bottom. Members of the pair generally stay near each other. Favorite perches are dead twigs sticking out from the foliage of oaks, tops of agave stalks and dead trees, and the lower branches of oaks and junipers. The same trees and fences were used through the two to four summers that some of the territories were occupied.

Myiarchus tyrannulus. Wied Flycatcher. This bird, known best as the Arizona Crested Flycatcher, feeds from horizontal twigs within the dense foliage of large trees in the same manner as its congeners and *Myiodynastes*. This is accomplished by short flights to the foliage, where an insect is picked off at once or during a brief flutter as the bird hovers before or below the leaves. (Two stomachs contained a large hawk moth, parts of other large insects and of small beetles.) It frequents the lower and middle heights of trees, preferring sycamores. Normally it is found in pairs; once four birds were fighting in the same tree. In most of the mountains studied I found it only in luxuriant riparian woodland with water, whence occasionally it travelled a short distance up adjacent slopes. But in the Sierra Aconchi it was also abundant in encinal, along with Ash-throated and Olivaceous flycatchers. In southern Arizona it lives in riparian woods and among giant cacti. Occupancy of such strikingly different sorts of vegetation bears no relation to the distribution of *Myiodynastes* or to the distribution of the other *Myiarchus* flycatchers. The territory of the Arizona Crested Flycatcher is evidently small compared to that of *Myiodynastes*, for I have not noticed long sorties by this species; also it is more restricted in its movements than the two smaller members of its genus. At one camp a bird spent the whole day within hearing distance, foraging in a few adjacent sycamores and around the edge of a cattle watering trough.

The range of the Wied Flycatcher embraces the entire area of study, but it appears in pine-oak only in the few places with wide and continuous riparian woodlands. It is less tolerant of narrow riparian growth than *Myiodynastes*. Therefore, in all instances of the occurrence of *Myiarchus tyrannulus*, *Myiodynastes* was also found, generally in greater numbers, because of the better habitat than where it occurred alone. The crested flycatcher was established in May in the Ajos well before the arrival of *Myiodynastes*, suggesting that the two could avoid competition by nesting and therefore feeding young at different times. I could see no difference in their foraging sites and manner of feeding within riparian woodland.

Myiarchus tuberculifer. Olivaceous Flycatcher. This bird flies from a horizontal twig in the shady interior of a tree, hovers briefly in front of the foliage as it picks an insect from the leaf or twig, then alights, usually in another place. In a series of such short forays it moves through or around and around within the interior of the tree. Like the other flycatchers which feed among leaves, its flights are short. At the edge of a clearing it will hover at the outside foliage of trees. The sites of foraging are more varied than those of its relatives of similar feeding behavior; it feeds in junipers, in small oaks, middle parts of large oaks and pines, low in dense thickets of young pines, and near the tops of sycamores. One fed rapidly for 20 minutes within a large blue oak, its wings

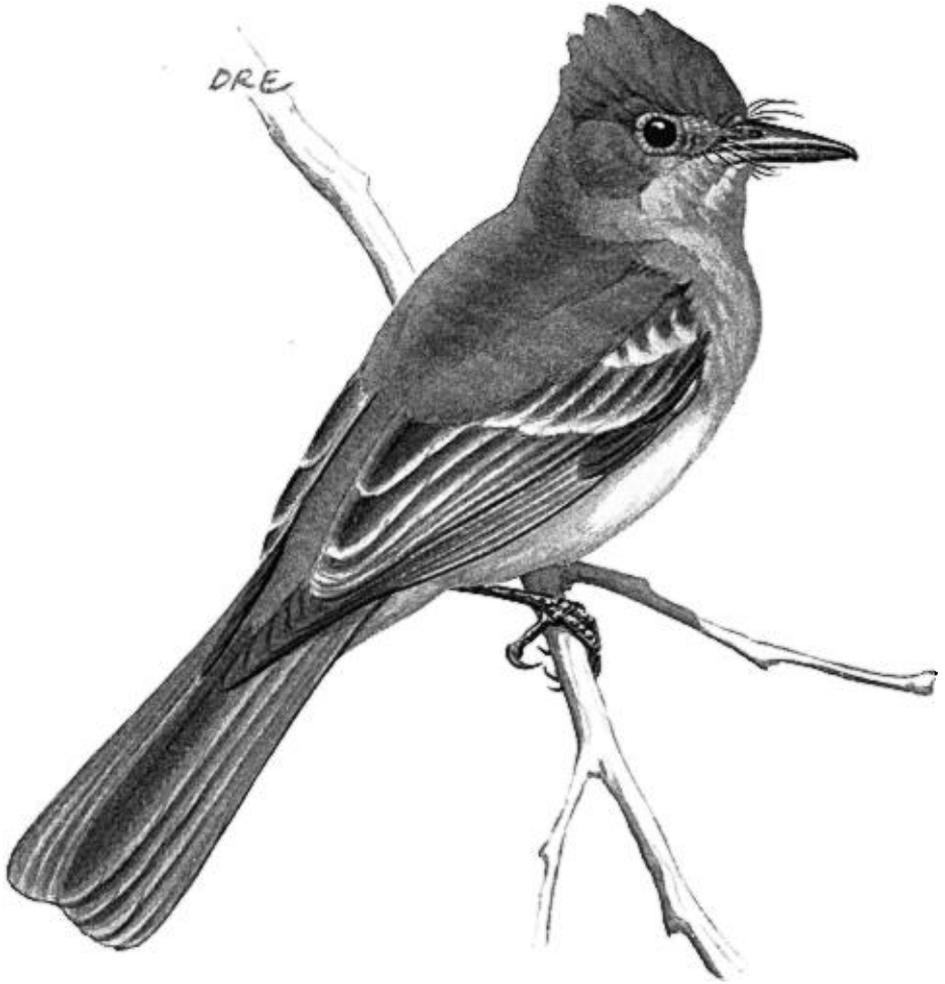


Fig. 24. Oliveaceous Flycatcher; natural size. Drawing by Don R. Eckelberry.

banging noisily against the leaves. The same steady prolonged feeding by another took place in a large *Prunus virens*. Among flycatchers, only this and the Buff-breasted Flycatcher spend much time catching insects from the leaves of pines.

The Oliveaceous Flycatcher requires dense woods of large trees. Although it frequently comes to riparian woodland, its favorite haunts are the slopes. It avoids areas in which conifers predominate over broad-leaved trees. Although practically limited to pine-oak at the north end of its range, farther south it spreads into a variety of habitats from desert riparian to some open pine forests. The pair forages near the canyon bottom and up both adjacent slopes, but the movements are more restricted than those of the Ash-throat, and the pairs are much closer together.

In so common a species it is no surprise to find most of the territories occupied in successive years. But at the northern edge of its range it was abundant as pairs in 1951

and rare in 1952 and 1953. In the Pinalenos in 1952 only a single plaintively calling bird was present on the study site. In the Catalinas that year a pair and three wandering solitary birds were seen; in 1953 a lone pair occupied the same riparian territory used in all three summers.

The three species of *Myiarchus* and the Sulphur-bellied Flycatcher feed in the same way and can be found together, but they seem not to influence each others' distribution and numbers. *Myiarchus cinerascens* and *tuberculifer* often fed in the same tree. Only once did I observe behavior which seemed to represent an actual conflict between the two species. This involved a loudly squawking pair of each.

**Contopus (Nuttallornis) borealis*. Olive-sided Flycatcher. Migrant, 4 individuals: Huachuca, June 11, 1951; Chiricahua, August 13, 1952; east Sierra Madre, August 21, 1952; west Sierra Madre, August 27, 1952.

Contopus richardsonii. Western Wood Pewee. The Western Wood Pewee eats flying insects (5 stomachs) which it catches with a loud snap of its bill at the end of a straightaway dash into the open air. Then it returns to its perch, where it sits upright, briskly turning the head from side to side in its inspection of the surrounding air for passing insects. The same perch at low to middle tree height is used for a series of captures; it commands a view of an unobstructed area required for the maneuvers and for the detection of prey. The flight is rapid, and the bird can follow dodging prey with agility. Flights are long compared with those of its foliage-feeding relatives, with captures being made from 10 to 50 feet out from the perch, indicating remarkable vision.

Pairs are so crowded around openings in riparian woodland that adjacent nests may be only 75 yards apart. Hence the size of the forage area and of the territory defended against the same and many other species is smaller than the "pairs per mile" suggest. A bird watched during two successive days at the edge of a small meadow 75 yards long spent the entire first day foraging from perches in three or four small dead willows and walnuts eight feet tall, catching prey mostly just above the meadow grass, at one end of the meadow. The following day was spent at a few perches at the opposite end of the same meadow. It shifted its small sphere of activity in this meadow on previous and subsequent days. Pewees also feed and sing until nearly dark, while Whip-poor-wills and Poor-wills are active.

Despite the lack of open country in pine-oak in the northern part of the study area, some pewees live away from stream vegetation which provides the edge usually necessary. This capacity is fully realized in the high Sierra Madre, where the species is abundant in the open grassy woods containing large pines. Although riparian timber is absent at these altitudes, the pewee is still concentrated at the edges of little creeks where grassy flood-plains are open (fig. 13). In the Sierra Aconchi, pewees at the lower level of pine-oak are restricted to riparian timber, but at the summit they become abundant throughout the giant oaks which are spaced over grass. The only Western Wood Pewees found in the Sierra Huachinera were at the spring and clearing at El Apache.

In parts of Rucker Canyon this pewee's distribution (openings in broad parts) complements that of the Olivaceous Flycatcher (dense woods of narrow parts). This seems to be the result of habitat choice rather than competition, although the two species are of similar size and feeding capabilities. A Western Wood Pewee, apparently not near a nest, chased a squawking, dodging Olivaceous Flycatcher for several hundred yards.

It is difficult to give a clear interpretation of this pewee's distribution, but the main points seem to be these three: its local numbers and ecologic niche seem to be independent of the Olivaceous Flycatchers and Coues Flycatchers which are usually present at the same places; it spreads over a great altitudinal range in the south, where it reaches desert riparian woods; it requires large shady trees at the edges of open spaces.

*Probable migrants, at least 9: Catalina, May 12, 1952, 2; San Luis, September 3, 1952, 1; Oposura, June 4, 1953, 1; west Sierra Madre, August 25, 28, 1952, 5.

Contopus pertinax. Coues Flycatcher. This flycatcher or pewee forages in the same way as the Western Wood Pewee but flies farther to its prey and works from a higher perch. In these respects it is intermediate between *richardsonii* and *Contopus borealis*. Unlike the latter, it rarely perches on a tree-top. It prefers the ends of dead pine branches at middle tree height but frequently descends to the lowest branches. Such elevated and exposed stations for feeding and singing are met in extensive tall woods and forests. The Coues Flycatcher is absent from pine-oak areas whose pines are small. It can normally dispense with riparian woodland and is in fact a typical pine-oak bird. In marked contrast to *richardsonii*, pairs have large forage areas. An individual, apparently unmated, may come through camp only twice in a morning, which is spent in dashing several hundred yards from one forage perch to the next. The occurrence of this pewee in riparian woodland is capricious and seems to bear no relation to availability of suitable conifers and absence of possible competitors. At the Sierra Huachinera, the birds spent much of the day in riparian shade and spread into surrounding pine-oak in early morning and late afternoon, when actively feeding and singing.

Contopus pertinax and *C. richardsonii* are remarkably similar in behavior; they agree even in the second phrase of their songs. But the size difference must cause their divergence in forage site and radius, producing somewhat unrelated habitat distribution, in which a role of competition cannot be discerned so far. However, Coues Flycatchers, still singing in August, frequently chased Western Wood Pewees, apparently non-breeding or migrants, in the Sierra Madre. Also I have seen a Western Wood Pewee attack its larger relative.

**Empidonax hammondi*. Hammond Flycatcher. Migrant, 3: San Luis, September 3, 1952, 2, specimen; east Sierra Madre, August 31, 1952, specimen.

**Empidonax wrightii*. Wright Flycatcher. Migrant 2: Pulpito, August 6, 1952, specimen; Ajos, May 29, 1953, specimen, A. R. Phillips.

Empidonax difficilis. Western Flycatcher. The Western Flycatcher takes insects (1 stomach) in short flights of 3 to 10 feet among the branches of large trees. Some captures, perhaps the minority, are made on the foliage, whereas the rest are made in the openings among the branches. This flycatcher can often be detected by the flicking of its wings against the leaves. One launched from an alder and twisted and turned as it took four or five flies from a swarm over a creek before returning to its perch. Foraging is in the upper half of tall slender conifers and at various heights in riparian vegetation from low willow bushes to high in the interior of alders. It prefers tall trees closely spaced: forest of Engelmann spruce and alpine fir, aspens, and dense riparian groves. The last type, an alder grove, attracted the only breeding Western Flycatchers to a pine-oak area—at Wet Spring in the Pinalenos. With the exception of one bird there which travelled through the pines and oaks but seemed not to be feeding, the forage area proved to be very small; most of the day was spent within a few adjacent trees.

There is no evidence that the Western Flycatcher nests in Sonora or northwestern Chihuahua, and this area south of the Arizona border constitutes a striking discontinuity in its range. A true breeding record to the south is at Barranca de Cobre, Chihuahua (Stager, 1954:28).

*Migrants in riparian growth, 19: Pinaleno (summer resident?), May 16, 1953, 1; Santa Rita, July 28, 1951, 1; Huachuca, June 18–21, 1951, 6; Ajos, May 28–30, 1953, 7, specimen, A. R. Phillips (several of these Ajos birds uttered the thin *peee-eeest* call of the coastal race, *difficilis*, and another on the 30th gave the strident *wheesit* of interior *hellmayri*); Ajos, June 2, 1955, 1; Pinitos, May 31, 1955, 1; Aconchi, June 23, 1954, 1;

Huachinera, June 16, 1953, 1, possibly same bird which previous day uttered call of race *difficilis*, specimen, A. R. Phillips.

Empidonax fulvifrons. Buff-breasted Flycatcher. The versatile Buff-breasted Flycatcher combines the feeding methods of the foregoing flycatchers, but its flights are shorter and more frequent, in proportion to its diminutive size. Its speed is to be compared with the swift pewees in contrast to the more leisurely crested species (*Myiarchus*). From a twig in the open, it flies out, usually in a horizontal direction, snaps up the passing insect and returns. In foliage it often changes perches after each capture so that it progresses rapidly within one tree or several neighboring trees. The bird can hover with the buoyancy of a kinglet as it grasps its prey from a leaf. Forage sites are various; most frequent is the top of a bush comprising the riparian or pine-oak understory (low clumps of maple bushes, *Ceanothus*, *Rhus trilobata*, or small oak bushes). This flycatcher also feeds among the lowest bare branches of sycamores and high in pines and dead snags. The size of the insect prey is small (3 stomachs); birds which several times captured a kind of white moth a trifle less than a half inch long took considerable time to pound each against a branch; they then swallowed them laboriously. It may be assumed that this prey is too large for convenient handling.

In riparian woodland these birds were singing, paired, and evidently breeding, whereas it is not certain that those in pine-oak were all on their breeding grounds. Those at the Pulpito Mountain in early August were paired and stationary; but in a pine-oak area removed from riparian growth in the Sierra Madre, the species was numerous in late August, whereas there had been none at the same spot in early July of the same year.

The Buff-breasted Flycatcher was found in colonies of three or four pairs spaced within hearing distance of each other along a stream. There were five pairs in about 400 yards along the Río Claro. Often separate pairs were noted within a half-mile of such colonies. The species occupies riparian vegetation at encinal and pine-oak levels, pine-oak, and open ponderosa pine forest. The environmental conditions of the few places of record are duplicated within practically every mountain range studied, yet the species shows erratic and unpredictable occurrence. Its rarity certainly finds no explanation in its versatile feeding manner and the wide range of vegetation types occupied.

The territory is extraordinarily small in this species. On one day as well as on successive days the pair may stay in the same bushes or in the same three or four trees.

*Post-breeding wanderers, 5: west Sierra Madre, August 24, 1952, specimen.

**Eremophila alpestris*. Horned Lark. Grassland, 2: high Sierra Madre (Colonia Garcia, singing in June).

Progne subis. Purple Martin. This species takes flying insects (2 stomachs) captured in straightaway flight or while gliding. Compared with the small swallows, its flight is swifter, more direct, with less twisting and turning. The bird is carried along by deeper, more powerful and less frequent wing beats. It feeds over the tops of the forest trees, at middle tree height along rivers, low over meadows, a few feet from the water at broad open stretches of river, far up in the air, or along the faces of cliffs. Martins frequently drink at broad pools, reached by a plunge into a gorge, with the wings folded. Near the surface the wings are spread and the mandible touches the water at the bottom of a graceful arc. The daily span of activity is long; singing birds are on the wing at dawn, and flocks will feed until nearly dark in the evening, hawking over a stream in company with Nighthawks and Rough-winged and Violet-green swallows.

Martins in the eastern part of the study area occur in small colonies of from two to five pairs, mostly in open coniferous forest. Two males may sing from the same dead pine. The foraging area is large, so that at a camp one or two miles from a colony, single birds can be heard singing before daylight on successive days, and one or more foraging

birds will come over camp several times in the course of the day. Most of the records pertain to such visitors, whereas actual breeding sites were found only in the Huachinera Mountains and the high Sierra Madre. The distribution of this species seems not to depend on vegetation, but the Sierra Madre and its associated spurs provide a congenial environment with water, meadows or clearings, and tall dead trees containing Acorn Woodpecker holes for nesting. The only trees in which Martins were seen to alight were dead pines being utilized by these woodpeckers.

**Stelgidopteryx ruficollis*. Rough-winged Swallow. River-bank, 5 pairs: high Sierra Madre.

**Hirundo rustica*. Barn Swallow. Village and farm buildings, 8 pairs and 1 flock: west Sierra Madre, 1; high Sierra Madre, 7 and 1 flock, including a nest with young, September 5, 1951.

Tachycineta thalassina. Violet-green Swallow. The Violet-green also eats insects caught in straightaway flight, or during glides, or in bursts of increased speed. It twists and turns in taking successive insects close together. These birds frequently visit ponds to drink, or they may catch insects flying low over the surface of open stretches of rivers. In drinking, they may come on a long glide like a White-throated Swift, but they also may turn and drop suddenly to the surface from above the edge of the pond. They scoop a bit of water as they skim with the wings held high over the back.

The forage area is large. The birds feed in open spaces, among the crowns of tall conifers, low over meadows, along cliffs, and high over canyons. They are especially active at dusk, when they dash among the tops of pines or join Rough-winged Swallows, Purple Martins, Nighthawks, and bats in foraging low over the river. Generally pairs were found, although up to a dozen birds gather at large pools. But in the Chiricahuas, flocks of from 30 to 150 were seen in April, May, and August.

The Violet-green Swallow was found at the same sites with Purple Martins in the Sierra Madre, where the only breeding places in pine-oak were seen; but in addition it was found on smaller mountains. Like the martin, its metropolis is open pine forest, not because of the vegetation, but rather because of the nest cavities, water, and open spaces. A flock of four examined holes in a tall dead woodpecker tree at Bear Canyon in April; the next month none was there, as apparently the place was found to be unsuitable. Violet-green Swallows might compete with martins for nest holes; however, the abundance of Acorn Woodpeckers and their holes in the prevalent dead pines of the Sierra Madre doubtless provides ample nesting facilities for all three species.

Corvus corax. Raven. Ravens can seek out a variety of food sources. They were seen feeding only a few times: upon a cow carcass in encinal with Turkey Vultures and Black Vultures and upon picnic scraps at three different unoccupied Forest Service campgrounds. A Raven carried bread on three trips from one of the picnic grounds and flew out of sight down the canyon each time. Hunting consists of soaring in circles or straight glides high above the ground or at tree height along a ridge, while scanning the terrain with what must be very acute vision. With their powers for soaring flight, Ravens cover great distances in hunting, but they can be seen each year several times a day at the same camp. Usually singles and pairs were seen in pine-oak areas, although flocks gathered at mountain summits. Sometimes these groups joined Turkey Vultures and Red-tailed Hawks in the air. The Raven's distribution must depend on cliffs for nesting sites, rather than on vegetation.

**Nucifraga columbiana*. Clark Nutcracker. Lingering winter resident, 7 individuals; Huachuca (specimens), remained through June 16, 1951.

Aphelocoma caerulescens. Scrub Jay. My only notes on feeding by the Scrub Jay in this area (in scrubby encinal) are of one which plucked a juniper berry, whacked it

against a branch, and apparently ate it and of another which caught flying insects from a tree-top. A stomach contained seeds, beetles and rocks; another stomach contained large hard pieces of seeds or acorns and insect parts. Limited to chaparral, the Scrub Jay occasionally visited pine-oak in the few places where these two vegetation types are contiguous (Pinaleno, Catalina, and Peloncillo). Elsewhere, as at Cananea, where scrub vegetation adjoined the study site, these jays were not seen crossing the habitat boundary. Pitelka (1951a:384) suggests that the restriction of this jay to chaparral in southern Arizona is due to the prevalence of Mexican Jays in woods which the Scrub Jay might otherwise utilize. However, very large populations of the Scrub Jay in scrubby encinal or chaparral are able to hold their own in adjoining woods. At Oracle, at the north base of the Catalina Mountains, where there is much low encinal and Toumey oak, Scrub Jays were abundant and I found no Mexican Jays there in 1955. Yet within the last decade, according to Anders H. Anderson of Tucson, Mexican Jays had been abundant in the area. At Pinal Mountain, with its vast expanse of chaparral, Scrub Jays outnumber Mexican Jays in the ponderosa pines and oak groves bordering the chaparral. Elsewhere, in the study area, chaparral is so rare and discontinuous that Scrub Jays do not build up numbers sufficient to demonstrate this potentiality.

A single nesting in pine-oak admits this jay to our list. A pair attended young, just fledged, in an open stunted pine-oak area at the outskirts of Gavilancito, a mill town on the Río Gavilán, June 27, 1952. Scattered Chihuahua pines, one Apache pine, some scrubby alligator junipers, and Arizona oaks grew over the bare ground at this spot. The following birds were also present: Cassin Kingbird, White-breasted Nuthatch, Bewick Wren, Western Bluebird, Solitary Vireo, Grace Warbler, Brown Towhee, and Chipping Sparrow. In April, 1955, a Scrub Jay visited a dooryard, frequented also by Mexican Jays and Steller Jays, in this same town.

*Occasional visitor from adjacent chaparral, 4: Pinaleno, 1; Catalina, 2; Peloncillo, 1.

Aphelocoma ultramarina. Mexican Jay. The flycatching of Mexican or Arizona Jays and their feeding at agave blossoms have been described in the section on "joint feeding." Four stomachs contained acorns, beetles, insect parts, nuts, seeds, and gravel. Jays at picnic grounds took bacon and flew off with whole slices of bread. Members of a flock grasped acorns in their bills while they fluttered at the outside of an oak. They would pull off acorns, using the weight of their hanging bodies, and carry them to branches where they rapped with the bill while holding the acorn against the branch in one foot. A flock fed at a garbage dump. One jay, while feeding in foliage of a silver-leaf oak, swallowed a long caterpillar. At campgrounds jays hunted by bounding with long hops across level ground strewn with oak leaves. Each would stop and thrash the leaves sideways with its down-pointed bill by a vigorous movement of the whole body first to one side, then to the other. Then it would pick things thus exposed. The numerous diggings where several individuals worked were three to four inches in diameter and deep enough to expose the moist humus beneath the leaves.

The flock moves through the woods, its members deployed from the ground to the tops of oaks over a broad front. In dense groves open beneath, as at Forest Service camps, the birds inspect the ground during short flights and glides from one low branch to another at three to six feet above the ground. On slopes they climb to the tops of the oaks, then they pitch down the slope to reassemble farther below. The forage area is large; the flock flies high across a wide canyon, patrols both sides to the top, and visits riparian trees below. Where there is sufficient food available a flock stays in a grove about four hours. The flock comes through camp several times a day, often over a fixed route. At Gardner Canyon in the Santa Ritas, Mexican Jays stayed in the amphitheatre

area which is one-half mile across. Sounds carry well there and it is easy for the jays to keep track of each other. They remained within hearing all that day and on various days in the same and successive years. At least 50 individuals assembled there at imitated *Strix* hoots but most of the time they were scattered in small groups throughout the entire area. Other observations showed likewise that the flock tends to disperse somewhat when stationary, but this is not usual over a large area. Flocks varied from four to 50 individuals, with most containing from a dozen to 15. In spring and summer stationary pairs or "threes" tended nests or young. They were visited from time to time by the flock.

The varied manner of feeding and scouting for food uses the powerful but generalized construction of the bill, foot, and wing and is doubtless related to high intelligence in this species, as in other corvids. This is demonstrated by its recognition of unusual food supplies and by the variety of conversational calls used to maintain the flock's organization.

On all the mountains, save the high Sierra Madre, each flock roamed through both encinal and pine-oak woods, which were present because of varied topography. Those flocks near forest entered it as well. Oaks, as conspicuous members of the vegetation, are required within the forage area. Therefore the Mexican Jay is absent from pine-oak of the upper Río Gavilán, where oaks are few and the Steller Jay is numerous. Although they broadly overlap, the populations of these two jays center at different altitudes as a consequence of the Mexican Jay's preference for woodland oaks as opposed to the Steller Jay's choice of forest conifers. Mexican Jays were unexpectedly rare in the Aconchi and Oposura mountains. The few flocks I saw there were in encinal and lowest pine-oak, with a gap separating them from Steller Jays on the summits. I think this rarity was determined by local food supply, not by competition.

This appraisal of the habitat relations of the Mexican Jay and Steller Jay applies to my area, where both species invariably occur on all mountains high enough to support forest. But in the Sierra del Carmen of Coahuila, Steller Jays are absent. There Miller (1955:159) found that the Mexican Jay extended its ecologic span into pure coniferous forest. Conceivably it could occupy the pine-dominated woods of the upper Río Gavilán if there were no Steller Jays there, and we should therefore admit a role of competition influencing their distribution in the study area.

The following selected observations illustrate some facets of the Mexican Jay's behavior. A communal nest, seen in April, consisted of a platform, a foot wide, of leafy oak twigs in a high crotch of an Arizona oak. At least three members of the flock stood on it for a minute, one at a time; each looked around, uttered peculiar calls and reached into the top of the platform with the bill. In the Huachinera, more than two adults voiced alarm when I approached a begging juvenile. The juvenile flew toward another adult which arrived with food. A flock made a terrific din at some hawk or owl. The birds flew around the trees making loud *clap clap* noises with their wings. The predator apparently left, for the jays perched and observed a moment of utter silence. Then they all gave one soft descending *cherrr* of relief and were quiet again. Another flock pursued a gray fox; every time it crossed an opening the jays would fly toward it and squawk. They followed for several hundred yards until it reached some dense growth.

A Mexican Jay bathed in a pool one afternoon, flew to a Chihuahua pine branch, fluffed out its feathers, and seemed to rub itself against the foliage. It perched, spread out against the trunk of another pine, then came to the ground, where it pecked the dirt with its bill.

There are times when these noisy birds are silent. One April day I could find none about a picnic ground which was usually frequented and finally saw one perched very

erect at the top of a pine. This sentinal squawked when I came close, was answered by another bird which had been concealed in the crown of an oak, and then the rest of the curiosity-seekers assembled.

The two species of *Aphelocoma* in this area generally stay apart. I saw them at the same spot on one December day at the edge of chaparral in Bear Canyon, where two Scrub Jays stayed on their perches and paid no attention to a flock of Mexican Jays which drifted past. The Mexican Jays came in front, behind, and straight at the Scrub Jays; some lit momentarily in the same piñons with them, but the Scrub Jays were still on their perches after their larger relatives had passed.

Cyanocitta stelleri. Steller Jay. In feeding, the Steller Jay resembles the Mexican Jay except that less versatility is recorded in my notes, probably because of fewer observations. It travels in smaller groups than does the Mexican Jay and has, therefore, less chance of detecting an unusual food supply. Steller Jays mostly feed high in pines, but they have also been watched in oak foliage, apparently taking acorns. One hopped among logs and bushes, eating beetles. In the crowns of pine trees they peck the opened cones or cling to the exterior of the foliage while picking things off with the bill; then they carry these objects to a branch and pound them loudly. Various assortments of seeds, acorns, berries, hard-shelled nuts, beetles, a caterpillar, other insects, bones, pits, rocks, and gravel were contained in 31 stomachs. Much of this food is hard and coarse. One jay was seen drinking at a creek. Steller Jays in a flock harrassing a young Sharp-shinned Hawk seemed deliberately to expose themselves to attack and accurately to gauge the hawk's limitations, as if really playing.

In travelling through the woods, members of a pair or flock may follow the same route, often in single file or in a straggling procession, but at a feeding area the group will spread out considerably, remaining in the vicinity for hours at a time and keeping in touch by various calls. After alighting low in a pine, the birds ascend to the top by long leaps from one horizontal branch to the next above, spiralling about the trunk. Upon reaching the top, they swoop away in undulating glides or in steady flight high across large meadows and canyons. Flocks, and pairs to a lesser extent, cover a large forage area of about a half-mile diameter. They return to the starting point at dusk, after working along canyons and slopes, occasionally visiting agaves on high ridges, in the course of the day.

The Steller Jay's numbers are directly related to the abundance, stature, and extent of tall conifers; it tolerates pine-oak woods dominated by pines. Most abundant in coniferous forest, its numbers decrease with loss of altitude through the pine-oak zone. Flocks of from four to ten individuals were seen from August through May and were evidently not breeding. Other records in pine-oak pertained to birds which probably bred in coniferous forest, except those in the high Sierra Madre. There, in June, widely spaced, noisy pairs stayed all day within small areas, as if near a nest; singing and considerable fighting also was noticed.

In winter some large flocks of Steller Jays, briefly observed, seemed actually to be mixed with one or the other species of *Aphelocoma*. But in summer, at least, Steller and Mexican jays came together only when their independent paths happened to cross. For instance, at a picnic ground a flock of Mexican Jays worked on the ground and tables from earliest dawn into the morning, while Steller Jays were busy in the tall Apache pines directly overhead. At Sunnyside a large flock of each species fed around a garbage heap from dawn until late in the morning. However, all the Steller Jays arrived first, one at a time, and were followed by all the Mexican Jays, which also arrived in single file over the same path. This route through a pine grove led to a view of the food through an alleyway, traversed by swooping 100 yards downhill. At another place two flocks,

one of each species, fed within 100 to 200 yards of each other for an entire morning; they came to the same trees only at imitated *Strix* hoots but did not mix. The flocks mentioned previously under "joint feeding" fed in the same manner, place, and time. Yet they maintained their separate organization. Most flocks, apart from those attracted to unusual concentrations of food, foraged separately. Possibly these tendencies toward exclusiveness effect on the average a spacing akin to territoriality, which might lessen competition between these two similar species.

Parus sclateri. Sclater Chickadee. These birds pick small objects in foliage as they hop among the coarser twigs. Occasionally they flutter or cling inverted. They feed in tall pines and to a lesser extent in oaks, including those with large leaves such as *Quercus reticulata* and *Q. fulva*. In addition postbreeding birds fed in Arizona cypress, sycamore, alligator juniper, fallen pines, corn plants, and trees at the edges of meadows. Three stomachs contained small caterpillars and other insects. Preferring coniferous forest, this chickadee was found breeding in pine-oak only in the Sierra Madre, where abundant but separated pairs attended fully grown juveniles in June. In the Chiricahuas I found it in pine-oak, where it sings a great deal, only in its nonbreeding period, for it evidently ascends to forests for nesting. Its confinement to the Sierra Madrean axis, except for a skip over the Peloncillos to the Chiricahua range, implies dependence on coniferous forests of great extent. The Sclater Chickadee does not overlap the range of the dissimilar Mountain Chickadee.

*Down-hill "migrants" from higher altitudes, 3: Chiricahua, August 6-10, 1951, and 13-15, 1952.

**Parus gambeli*. Mountain Chickadee. Attracted down from nearby forest by owl calls, 1: Pinaleno. Resident in coniferous forest of Pinaleno, Catalina, and Rincon mountains, where it reaches its southern limit.

Parus inornatus. Plain Titmouse. The limitation of the Plain Titmouse to the arid ranges at the northeast corner of my study area, where the piñon is comparatively abundant, suggests possible dependence on this tree as in other parts of its range. These titmice were found in pairs and families and they fed in foliage while hopping at a leisurely pace on the larger twigs and branches within Emory oaks, gray oaks, alligator junipers, Chihuahuan pines, and piñon pines. Caterpillars and other insects filled the stomachs of two birds taken in encinal of the San Luis Mountains, where the species was found by A. R. Phillips.

Parus wollweberi. Bridled Titmouse. Insects predominated in nine stomachs of the Bridled Titmouse. This bird searches for them among leaves, twigs, and smaller branches from low in manzanita bushes to high in riparian trees, pines, and every kind of tree in the study area; but it mostly frequents the middle height in oaks. Its numbers depend on the abundance of evergreen oaks; accordingly it is most numerous in encinal. The Bridled Titmouse approaches foliage from the interior of the tree, taking long hops from twig to twig. It does not hover at the outside leaves. One, however, flew from the outside of an Arizona oak to rest by its outstretched wings as if parachuting on top of a leaf cluster. From this position it picked at the leaf bases. This unusual behavior was repeated several times by the one bird, although its mate did not indulge in it. Another fed more characteristically by hopping deliberately around and up the ladder of twigs on a vertical oak branch. It stayed close to the main branch and pecked hard at the leaf bases, knocking off those leaves that were dead. In one Arizona oak with particularly large leaves, each titmouse would hang on a leaf while pecking hard at it. Bathing and drinking at ponds were noticed.

Stationary pairs on large territories were found as early as February, but in bad April weather they rejoined mixed flocks. They normally occur in such flocks during

fall and winter. The distribution of this titmouse complements, altitudinally, that of the Sclater Chickadee, as is expected from their respective habitat choices. When in the same vicinity, they did not avoid each other, and they joined the same mixed flocks in fall. Their voices are quite different. I could discern no gross difference in occurrence of the Bridled Titmouse in mountains untenanted by the chickadee. The only pine-oak area where these titmice are not abundant is the high Sierra Madre, where *sclateri* is numerous, but more importantly, the oaks are few and small. The Bridled Titmouse occupies riparian woodland where available and in some lowland localities is limited to it. But it is not dependent on such vegetation, as the census in dry areas, such as the Oposura, show.

Clanton Canyon, in the Peloncillos, is occupied jointly with the Plain Titmouse. The practically identical voices of the two may be distinguished by the higher, squeakier, less coarse, more rapid notes of the smaller Bridled Titmouse. I have not found the undisturbed birds together even in winter. They came at different times over the same route. When attracted to the same tree, by imitated owl calls, they left in different directions and at different times to continue their foraging on opposite sides of the valley. Such evident aversion must achieve spacing of the two species, thus lessening competition. The passage through the same trees at different times, mentioned above, occurred in July, August, and September. This was not seen in April and June, when the birds may have kept mutually exclusive territories.

Psaltriparus minimus. Bush-tit. The small size of this species allows it to move within the finest peripheral foliage, where with agile climbing it can reach food from any position, even when inverted. It takes insects and some vegetable material (24 stomachs) from the leaves and fine twigs of practically every kind of tree and bush occurring in pine-oak woods. It seems to prefer woodland in which evergreen oaks are plentiful, for it feeds mostly in these oaks, although frequenting pines and junipers as well. One flock worked in a grove of young ponderosa and Chihuahua pines, where the birds climbed to the ends of twigs, clinging in various positions while probing the needle bases. A tendency to avoid trees with large leaves is shown by their preferring Chihuahua pine over Apache pine and by the action of a flock in an oak wood consisting of Chihuahua oak, with large leaves, mixed with blue and Emory oaks. This flock consistently by-passed each Chihuahua oak along its forage route in an hour's watching. At other places, however, flocks visited trees with large leaves such as alders, walnuts, and sycamores. They also fed in the large-leaved *Quercus reticulata*, *Q. fulva*, and *Q. endlichiana*. In these oaks a Bush-tit will actually stand upon a single stiff leaf.

According to the season, Bush-tits roam in pairs, families, or, for most of the year, in flocks up to 30. In bad spring weather pairs may join flocks of other small birds or band together. Because of an early nesting period, most of the summer records are of flocks. The few solitary birds seen moved far and rapidly as if searching for companions. On the other hand, pairs, regularly and widely spaced, were more stationary; they fed for long periods in a single grove and crossed through camp daily along a definite route. The two mates usually stayed within a yard or two of each other. The newly arrived flock spreads through a grove or brush area and feeds for an hour or more while slowly progressing in a certain direction. Then the birds in the lead start calling as they ascend to the top of a take-off tree. Others answer and head for this tree, the first birds having by now left in their faltering, pitching flight. The procession follows this route and all loudly call, particularly those in the rear, until they gather in a tree at the next forage area, where they are silent again.

The Sclater Chickadee, Bridled Titmouse, and Bush-tit join mixed fall flocks. The last two are abundant in the same places, although not associating until fall. I found



Fig. 25. Bush-tits; natural size. Male (left) and female of black-eared form.
Drawing by Don R. Eckelberry.

the titmouse in more places per mile than the Bush-tit, but a greater proportion of the latter are in flocks. Their respective numbers generally agree with expectations based on the vegetation, except that in the Nácori Mountains the titmouse was particularly abundant and the Bush-tit inexplicably rare. Of the two species, the Bush-tit more often feeds in pines. It extends farther through coniferous forest but not as far below encinal as does its relative. Of several oak-loving species the Bush-tit was least diminished in the high Sierra Madre, where pines predominate. I cannot explain various irregularities in census figures for this species, except to state that the bird is very secretive during certain periods of its nesting cycle.

Sitta carolinensis. White-breasted Nuthatch. This bird takes insects from trunks and main branches of live and dead trees. It picks them from the surface of the bark, from crevices within the bark, and doubtless also from the interior of the wood, for it frequently pounds loudly like a woodpecker. Its large agile feet permit movement on all bark surfaces. For instance it can hop smoothly along while hanging inverted from the underside of a large horizontal trunk. It favors branches unobstructed by foliage in middle and upper portions of all the various pines, oaks, and riparian trees. One was seen flycatching in the air. Sometimes nuthatches alight on the ground to retrieve food dropped from above and to collect the rocks and crystals found in stomachs. Ten stomachs also contained beetles, caterpillars, other insects, pine seeds, parts of acorns, and

various other seeds. This nuthatch hops with the body close to and parallel with the bark. At frequent pauses it tilts the body so that the head is high, permitting a view of the surface ahead.

Although families are seen in late July and August, the usual occurrence throughout the year is in pairs spaced beyond hearing distance of each other. The members of the pair tend to work in adjacent trees rather than in the same tree. These may join mixed flocks, but they are also often independent. In the Sierra Madre a pair was found at each camp and at every stop along the way, suggesting that the rather sparse population is uniform in the proper environment of tall timber with plentiful snags. This nuthatch is rare or absent on mountains lacking snags (San Luis), including those which have been extensively logged and burned (Cananea, El Tigre) and those on which the trees are small (Peloncillo).

†*Sitta canadensis*. Red-breasted Nuthatch. Not in pine-oak woodland. Spruce and fir forests south to Pinaleno, Catalina, and Chiricahua mountains; probably nests also in Huachuca Mountains.

Sitta pygmaea. Pygmy Nuthatch. This species feeds like the White-breasted Nuthatch, but works on finer twigs and even in foliage. The birds climb to the ends of ponderosa pine twigs, clutch the needles, and from various positions peck the leaf bases; also they climb around opening cones, probing within and scattering the seed wings. Exceptions to feeding in the tops of tall pines are rare: one bird flycatching, one in a *Quercus fulva*, another pecking a bone at a picnic ground, a flock on a fallen pine, another flock of 30 chopping and consuming a flaky layer of ice at Bear Canyon, in a very dry winter. Three stomachs contained insects and large seeds, apparently of a conifer.

Practically all of the records for June and July are of pairs widely spaced. Large flocks, sometimes joined by other small birds, are the rule from August to April.

The Pygmy Nuthatch is fastidious about the kind of pine growth it uses while nesting. It tolerates as small a forest as that of the Sierra Azul, but it is intolerant of separation of the pines due to intervening oaks. It is therefore practically limited to coniferous forest in the breeding season. During the rest of the year flocks often descend to pine-oak woods.

*Visitors from higher forests, 9 (including 4 flocks), April, July, and August: Catalina, 2; Chiricahua, 2; Huachinera, 1; west Sierra Madre, 4.

Certhia familiaris. Creeper. Using its slender bill as a forceps, the Creeper takes small insects (22 stomachs) from crevices and surface of bark. It has the most inflexible feeding method and site of any pine-oak bird. It hops with the feet in unison, tail used for support, head uppermost, on the vertical trunk, progressing from the base upward to where the twigs become uncomfortably thick. From there the bird flies down to the base of an adjacent tree and again spirals up the trunk. Rarely, the bird will fly a few feet down the same trunk and continue upward again. One crept along the clear underside of an inclined oak branch, so that it was nearly inverted. Creepers climb trees with clear vertical branches and trunks; they take pines, oaks, and deciduous trees as they come to them, but most often they are in pines. One Creeper varied the routine consistently in visits to several Arizona oaks, a walnut, and six small pines. It would alight at the bottom of a tree, as close to the needle-strewn ground as possible for an upright position, then it would turn and go still lower so that its right side nearly touched the ground. In this horizontal attitude it crawled slowly half-way around the very base of the trunk, picking things from the bark but not from the ground; then it would ascend the trunk in normal fashion.

The flight from one tree to another is swift and confusingly erratic. Even when in motion on the trunk Creepers are nearly invisible because of their posture and the blend-

ing of their color pattern with the bark, facilitated by their adherence to shade. Because of this protection, the Creeper can afford to be oblivious of other species in its community—even owls and hawks. Sometimes a pair or family stays in a grove all morning; at other times they move rapidly through the woods. Singing males are generally spaced within hearing distance of each other. At Sylvania the second-growth pines are rather small and the Creeper is rare, making its adherence to certain Apache pine groves in successive summers the more noticeable. I do not know why Creepers did not appear on my censuses in the Pinaleno and Catalina mountains; they are common at higher elevations there. Within pine-oak areas they were most numerous in the high Sierra Madre, which provides the largest expanses of tall, shady trees. They are absent from the Peloncillo range probably because the woods are neither dense, shady, nor tall.

†*Cinclus mexicanus*. Dipper. Mountain streams. Not in pine-oak. I did not find the Dipper in the study area although I searched almost the entire length of Sabino Creek, in the Catalina Mountains, in May, 1951. It had been regularly found there by A. R. Phillips through 1947. Similarly in June of 1952 I searched the Río Gavilán, in the Sierra Madre in vain for the birds A. H. Miller had seen in 1948. A. R. Phillips has records in February and March from the Chiricahuas.

Thyromanes bewickii. Bewick Wren. Insects (6 stomachs) are grasped by the Bewick Wren from the surface of twigs, leaves, branches, and tree trunks and from crevices in bark. Progression is by agile hops. One bird flew to the ground to pick up a large insect, returned with it to the oak in which it had been feeding, and pounded the insect with its bill. Another hopped along a horizontal oak branch directly to the hollow broken end, where with no hesitation it leaned far over and extracted a spider. Another climbed like a nuthatch high up a cottonwood snag and picked things from holes and crevices. The most frequent site of foraging for the Bewick Wren, in pine-oak woods, is among dense twigs of oaks; it is rarely found in pines. But the birds prowl in the twigs of all broad-leaved trees from the crowns of tall cottonwoods to bushes and brush piles at the ground. Often in spring the male mounts to the top of an oak or small pine snag to sing; the population is dense, and two or more may be within hearing. Members of a pair stay close together in their foraging area of about 100 yards in diameter.

The Bewick Wren here inhabits woods and some types of scrub from desert lowlands to lower pine-oak. Brush is not essential for this wren, for it lives in grassy oak woods; but it is more abundant in pine-oak localities where brushy oak thickets predominate. As expected, it was absent from the census at the upper Río Gavilán, where pines dominate over the oaks. Nor did I find it down the gorge of this river until it opened into the broad valley at Gavilancito, 1000 feet lower, where the Scrub Jay was also found. While searching for an explanation of the Bewick Wren's rarity in the Sierra Nácori, I was surprised to note that this is the southernmost record for Sonora. A singing male was heard there by A. R. Phillips at a ranch house just off my map area at Pinos Altos.

Troglodytes aedon. House Wren. This bird has been called the Brown-throated Wren from the Huachucas southward. It feeds on insects, usually small ones (68 stomachs). Some of the items are small ants, very large ants, an entire medium sized wasp, large and small caterpillars, bugs, a small millipede, a small zonitid snail, ladybird beetles, and other small beetles. The House Wren hunts in dark places under fallen logs, under piles of fallen branches, around and under rocks, on the ground under ferns, ceanothus, and poison-oak, and upon the trunks and branches of trees. An adult male foraging in a rock slide on the Catalinas watched flying insects, jumped to catch them when they came near or alighted, pounded them, then delivered each to the juveniles. The insects sometimes escaped during the pounding and had to be recaptured. Another male, in the Sierra Madre, flew rapidly down the slope from his song perch high in a Chihuahua pine

and immediately returned with a white object in his bill, which he banged on a fence wire and swallowed. He climbed like a nuthatch around the trunk of a small gray oak, picking things off the bark, then grasped prey as he hopped on the needle-strewn ground and under a boulder. The hops were vigorous and long, both feet moving in unison, and tail held up a little. Twice he fed young in the nest which was in a natural cavity in a blue oak, each time following the same route. Presently both the male and female were hopping on the bare ground and around the edges of boulders scattered there. The female fed these young every five to 10 minutes and used her own route. There was no brush or herbaceous vegetation at this spot.

A pair in the Ajos resided within a poison-oak thicket which covered logs beneath a large alder. Every 10 to 15 minutes they would emerge, call, and forage on the ground under the poison-oak and along stumps and logs. They both would ascend the alder, where the male would sing briefly while the female would hop along branches and cling or flutter to catch prey on the vertical trunk. Then they would return to the thicket and be quiet. Such branch feeding was also seen high in pines.

Water, in pools and as rain, is used at least for bathing, but it does not affect this bird's distribution, which depends on forest or other heavy timber resembling forest at slightly lower elevations, such as high pine-oak of the upper Río Gavilán and tall riparian trees in cool gorges. Pairs were uniformly spaced in the high Sierra Madre west of the continental divide, sometimes as little as 50 yards apart. But on the small mountains this species occurred in colonies in pine-oak, consisting of a few birds detached from the bulk of the population high in closed coniferous or deciduous forest: Graham, 2 pairs; Catalina, 2 pairs; Ajos, 2 colonies each of 2 pairs about 2 miles apart. On the Sierra Azul a colony of about six pairs, all within hearing, occupied the north face of the summit, the lowest two pairs reaching pine-oak. One isolated pair was found in three miles along the lower Río Gavilán. The forage area is larger than the spacing of singing males indicates. In addition to tall timber, the requirement met in all localities where the House Wren breeds were any one of the following: rocks, bracken, a fallen tree, shrubbery over moist ground, or ceanothus thickets.

Like the *Dendrocopos* woodpeckers, the two species of wrens are removed from each other by different habitat preference, resulting usually in an altitudinal gap between them. One Bewick Wren left his oak slope to sing briefly in the cherry thicket inhabited by House Wrens at Apache Camp; otherwise the two species were not found near each other as breeding birds.

*Post-breeding wanderers, 8: east Sierra Madre, August 22, 1952, 1, specimen; west Sierra Madre, August 25-28, 1952, 7. Winter resident or migrant, 2: Santa Rita, April 24, 1954, April 23, 1955.

**Salpinctes obsoletus*. Rock Wren. Rocks, 15 pairs: Catalina, 1; Cananea, 3; east Sierra Madre, 2; Aconchi, 1; El Tigre, 4; west Sierra Madre, 1; high Sierra Madre, 3.

**Catherpes mexicanus*. Canyon Wren. Ranch house, 1: Nácori. Rock gorges, 49 (some were fall wanderers; 17 were at cliffs of Cave Creek in Chiricahuas): all mountains except Huachuca, San Luis, Púlpito, Pinitos, and Huachinera, where, however, they were found in other portions except in the Púlpito.

Toxostoma curvirostre. Curve-billed Thrasher. Open country necessary for the Curve-billed Thrasher, a familiar bird of Arizona and Sonora lowlands, is provided by the Sierra Madrean meadows and fields. The thrasher is at home at rather high altitudes elsewhere, such as: grassy areas within encinal in the Santa Ritas and Huachucas and openings at the lower edge of pine-oak in the Ajos, Cananea, El Tigre, and Nácori mountains. But the main reason for not considering the high Sierra Madrean birds as

uniquely endowed is that they are merely part of a population throughout the eastern canyons and lowlands of the east base of the range, 2000 feet below.

The Sierra Madre birds whistle to each other across large meadows, and individuals fly far out to lone trees, bushes, or fallen logs in these openings. They do not penetrate woodland, but at its edge they perch in pines and gray oaks along with Brown Towhees and Striped Sparrows. Parents and young may gather in a shady Apache pine at the edge of a field to sit, preen, peer about, and run along the horizontal branches. The two-whistle call is prominent in fall when this species gathers to roost in dense gray oaks.

The Curve-billed Thrasher feeds on the ground, using the long decurved bill for digging with a sideways motion to scatter leaves and soil; then it picks up objects thus exposed. Progression over the bare ground is by swift running, with the legs moving alternately. An adult watched in the Sierra Madre fed by running along, coming to an abrupt stop, whacking the ground so as to stir up dust, and picking up various insects. It flushed a large insect which began to fly off, but the thrasher ran and caught it. Three times in 10 minutes the bird pushed aside small masses of horse dung or larger dried cow dung eight inches in diameter and probed for the numerous insects thus revealed. The dung was moved by a powerful sideways thrust of the bill. This thrasher rapidly dug its way into the ground under a bush, and its offspring tried twice to crowd into the hole to pick something for itself. Items in nine full stomachs in order of decreasing numbers are bulbs (of *Brodiaea*, apparently), rocks, seeds, insects, greens, and a huge white grub. One thrasher vigorously plucked berries from a small alligator juniper.

**Toxostoma dorsale*. Crissal Thrasher. Chaparral at edge of pine-oak, 7: Catalina, 1; Huachuca, 1; Cananea, 4; Peloncillo, 1.

**Mimus polyglottos*. Mockingbird. Open country, 6: Ajos, 4; Peloncillo, 1; high Sierra Madre, 1.

Sialia sialis. Eastern Bluebird. *Sialia mexicana*. Western Bluebird. The two species of bluebirds feed on insects caught at the end of a flight of four to 25 feet. Sometimes they alight to make the capture, but more often they hover briefly and return to the same or a different perch. Captures are made in the open air, upon the outside foliage of trees, upon grass or bare ground, or against the trunk of a tree. Exposed lookout posts afford a view of the surrounding air and of the grass or bare ground beneath. These perches are the lowest twigs of browsed oaks, the periphery of dense oaks, fences, corn stalks, the lowest branches of pines in a meadow, the tops of dead pines, knobs on the vertical trunks of large oaks, stumps, and logs. The birds can hop rapidly along horizontal branches. I have more records of *mexicana* foraging from the tops of tall dead pines than of *sialis*. Such foraging of *mexicana* may be in company of Coues Flycatchers, Violet-green Swallows, and Audubon Warblers. Also I have noticed only *mexicana* making several aerial captures in one flight. The flight of bluebirds is graceful and buoyant; often they soar to make a capture or float to the ground. In the Sierra Madre in August, Western Bluebirds fed in meadows with Robins, Audubon Warblers, and Chipping Sparrows. *Sialis* was only once seen to join a mixed flock of chickadees, nuthatches, and warblers in trees, whereas *mexicana* frequently did so in the same area.

Members of a foraging pair follow the same route and stay close together; one flies to a new perch and is joined a minute or two later by the mate. The forage and singing area of *sialis* is large. A male sang several times a day on the top of a sycamore at Sunnyside and could not be found within a half mile each time it left. A pair spent June 9, 1952, feeding around the edge of the clearing at Sylvania but was not seen before or after this date. At the summit of the Sierra Azul singing males zoomed from one end of the peak to the other and far out over its sides. Likewise *mexicana* flies high across wide meadows and clearings in its daily foraging.

These bluebirds are paired in early summer, they travel in family-sized flocks of molting birds in August, and they gather into larger flocks in winter. There is a tendency for both species to occur in "colonies." Savannah-like woods or forests must be extensive, or clearings frequent, in order to attract bluebirds, and if there is one pair, there will usually be many more at intervals of a few hundred yards. However, only isolated pairs were found in the Huachuca, Chiricahua, and Huachinera mountains. One pair of *mexicana* was found in three miles along the gorge of the Río Gavilán, although the species was numerous in more level country below the mouth of this gorge.

Western Bluebirds roosted side by side along horizontal Apache pine branches roofed over by dense foliage. A *sialis* bathed in a creek.

The following insects filled 12 stomachs of *sialis*: mole crickets, small grasshoppers, and beetles. One *mexicana* stomach (November) contained hackberries, and a winter flock fed on mistletoe berries. A Pygmy Owl ate a *sialis*.

Both species utter the *cut-cut-cut* call. The locative note, *kew*, of the Western Bluebird is used as its predawn flight chorus, and the same note appears in *sialis* as the first phrase of its beautiful song.

Both bluebird species utilize open grassy woods or forests from the lowest encinal to the white pine forest; between them they occupy all such habitat within the study area. But since there is little of this type of vegetation, other than artificial clearings and burns in southern Arizona, bluebirds are rare there. Within the range of *mexicana* such openings are more frequent in forests; in the range of *sialis*, where forest is not extensive, encinal provides much savannah formation. These circumstances give *mexicana* a reputation of being a forest bird, whereas *sialis* is regarded as preferring encinal. However, I believe that open, grassy pine-oak woods provide the optimum habitat for both; maximum numbers are attained there.

The two species of bluebirds coexist in the breeding season in the western part of the Sierra Madre and apparently also on the Sierra Pulpito. In neither place are they separated ecologically. Their behavior and requirements are so nearly identical that they must compete for space. Unfortunately I did not visit these areas of overlap at the time of actual nesting, so my evidence for adjustment to avoid competition is limited to their peculiar geographic distribution and their marked aversion to mixing. Briefly, *Sialia sialis* breeds in the mountains of Sonora and of extreme southern Arizona, beyond which *Sialia mexicana* prevails eastward and northward.

In the western Sierra Madre, in late August of 1952, both species were abundant, and many not on the census were seen during travel along the road. They occurred in family flocks, including molting juveniles, which were spaced apart from neighboring flocks. The two species were dispersed at random, but each flock contained only one kind of bluebird. A possible exception was one group overhead from which call notes of both species seemed to issue. On April 15, 1955, at a place farther east (also in pine-oak woodland, fig. 17) a pair of *mexicana* called at camp while a male *sialis* sang first on one side of camp, then on the other. On the summit of the Sierra Pulpito in early August of 1952 a pure flock of *mexicana* roosted at camp; another flock, judging only from call notes, seemed to include both species. On the wintering grounds in encinal only unmixed flocks were found, although the two species might visit the same place at different times: Sierra Huacomea, 1 flock of *sialis*, 2 of *mexicana*; Sierra Aconchi, 2 flocks of each plus 2 lone *sialis*. These are my only records of the two species together, but the tendencies indicating competition seem strong: first, to have geographically complementary distributions; second, to be spatially segregated in areas of overlap.

*Winter resident, *Sialia mexicana*, 1 flock: Catalina, April 23, 1954.

**Myadestes townsendi*. Townsend Solitaire. Summer resident in pine forest of the

Sierra Huachinera, from which two (specimens) trespassed briefly into the upper pine-oak. Within my study area this is the only mountain where the solitaire is known to breed. This implies considerable discontinuity in its summer range, for the next station to the north is in the White Mountains, Arizona. Winter resident, 3: Huachuca, April 19-20, 1952.

**Hylocichla ustulata*. Swainson Thrush. Migrant in riparian woodland, 5: Ajos, May 29-31, 1953, 4, including a specimen, A. R. Phillips; Pinitos, May 31, 1955, 1.

**Hylocichla guttata*. Hermit Thrush. Breeds in forests of spruce or fir, reaching its southern limits in the Huachuca and Chiricahua mountains. One sang in gully of ponderosa pines at upper edge of pine-oak in the Pinalenos. Winter resident and migrant, April to May 22, 14: Pinaleno, Catalina, Santa Rita, Huachuca, Oposura, high Sierra Madre.

Turdus migratorius. Robin. The Robin feeds by running along the ground, the body horizontal, the feet working alternately; then it stops, stands erect, and scans the soil or grass ahead of it for food to be picked up. One foraged along level ground in this manner, but it also ran over oak leaves and among sparse bunch grasses. It would stoop to scatter the leaves with a sideways motion of its bill, in the manner of Mexican Jays watched at the same place. A breeding specimen had eaten small fruits. Fully grown juveniles were taken by the Cooper Hawk and the Sparrow Hawk.

All breeding places of Robins provided water and level ground, either under widely spaced trees, or in open flood-plains and meadows. Patches of short grasses and sedges on moist ground were frequently visited. Forest Service campgrounds, by providing openings near water, attracted Robins to lower elevations for nesting than they would normally occupy. Pairs were bunched at the infrequent suitable areas, except in the high Sierra Madre, where any place was favorable. Some "colonies" were very small: one pair on the entire Sierra Azul and two together in the south portion of the Oposura. In the Ajos, at least three different adults constantly travelled through camp on their way to and from a spring, where they were possibly gathering mud. However, the Robin's dependence on water is not necessarily explained by its need for mud, for nests found by W. J. Sheffler in Sonora and Chihuahua (Stager, 1954:30) were made without mud. Robins, apparently breeding, may go more than one-half mile in a single flight; they move into a variety of habitats to roost or sing where, however, they do not feed or nest. Birds which visited Sylvania pond in 1952 to sing and fight, when the species did not nest there, apparently returned daily to the Sunnyside colony one and one-half miles away. They were headed that way when seen at various points between, especially at dusk. But at some stages in the breeding cycle Robins are very sedentary.

*Winter residents or migrants, 3 places: Catalina, May 19, 1950, and May 7, 1954, 1 pair; Huachuca, May 13, 1951, 1 flock; El Tigre, April 6, 1953, 1. Postbreeding wanderers, 11; Catalina, July 24-26, 1951, 7, August 14, 1953, 1; Peloncillo, July 25, 1954, 1; Pulpito, August 5-6, 1952, 2.

Poliophtila caerulea. Blue-gray Gnatcatcher. This bird feeds on small insects (two stomachs), including small green caterpillars, taken with rapid movements among fine twigs in dense foliage and from the air. Its small size enables the gnatcatcher to enter a finer twig structure than is possible for any other pine-oak bird. Insect-catching flights into the air within three or four feet of foliage are less frequent than gleaning of insects from the leaves and twigs. The usual site of foraging is in shrubbery, generally in the open, not under the woodland trees. One bird worked rapidly along a ridge top in patches of three-foot tall manzanitas and silver-leaf oak bushes. It stayed close to the ground and rarely came to the tops of the bushes. It would fly below the bush height when crossing openings, so that it was at all times difficult to see. Gnatcatchers also fed in



Fig. 26. Hutton Vireo; natural size. Drawing by Don R. Eckelberry.

trees such as junipers, Arizona cypress, small oaks, tops of silver-leaf oaks, in *Quercus viminea*, and in Chihuahua pines. Pairs were usually found, the two birds foraging close together. The forage area was large for so small a bird. Pairs and also a lone singing male rapidly travelled two or three hundred yards through trees and shrubbery, then were lost to sight and hearing.

This species, which is rare in pine-oak, tends to show up in the same map area in successive years; four territories were occupied through at least two summers. Thus its scattered occurrence in pine-oak is not haphazard; it must reflect abundance in adjacent encinal and patches of chaparral. *Ceanothus huichagorare*, because it is low and grows in the shade, is not acceptable.

†*Regulus satrapa*. Golden-crowned Kinglet. Not in pine-oak in summer. Within study area breeds in spruce or fir forests of Pinaleno, Catalina, and Chiricahua mountains, south of which is a large discontinuity in its range.

**Regulus calendula*. Ruby-crowned Kinglet. Winter resident and migrant, abundant (not counted) in pine-oak of mountains visited in April, some remaining until May 15 (Santa Rita): Catalina, Santa Rita, Huachuca, Chiricahua, Peloncillo, El Tigre, Sierra Madre. The southern limits of this kinglet's breeding range are the spruce-fir forests of the Pinaleno and Chiricahua mountains. I could not find it in the alpine fir forest of the Catalinas.

**Bombycilla cedrorum*. Cedar Waxwing. Lingering winter resident in riparian trees, 2: Ajos, May 30–31, 1953.

**Phainopepla nitens*. Phainopepla. Brief visitor from encinal, 2: Huachuca, Cananea.

**Lanius ludovicianus*. Loggerhead Shrike. Wanderer from lower open areas, 2: Cananea (family), July 17, 1953; high Sierra Madre, August 31–September 4, 1951.

Vireo huttoni. Hutton Vireo. A feeding Hutton Vireo resembles a kinglet in slow motion as it works through peripheral foliage and hovers before leaves at the outside of the tree. However, it hunts in coarser twigs than do the kinglets and gnatcatchers; instead of rushing from twig to twig to inspect each upon arrival, it sits and cranes its head, examining the foliage for insects at longer range. Insects, including fairly large ones (three stomachs) are grasped from twigs and leaves. Two adults, accompanied by a couple of juveniles in some silver-leaf oaks, busily darted after, caught, pounded, then swallowed big insects. In pounding, the insect is held in the bill and rapped against a branch.

Hutton Vireos foraged at all levels in large oaks. In fall, they joined mixed flocks of small birds, but they usually remained in oaks while the chickadees and warblers went through the pines nearby. However, they also visited pines, cypresses, junipers, and riparian trees including *Prunus virens*; a few fed in white pines, Douglas fir, and *Rhus trilobata*.

In pine-oak areas where the trees are small, pairs of these vireos bunch in the few closed woodland groves. Two or three pairs are within hearing distance of each other, resulting in much competitive singing. Great differences in the amount of singing at different stages in the breeding cycle produce the apparent discrepancies in the numbers of this species recorded. It was found wherever expected except, for reasons unknown, in the Sierra Nácori. Some singing males move through an area 300 yards in diameter, but pairs which seem to be nesting are restricted, although they patrol riparian growth and bases of adjacent slopes—encinal on one side and pine-oak on the other. Several times Hutton Vireos sang in answer to a phrase strikingly like their own in the Solitary Vireo's song. They seemed momentarily confused but no competitive encounters were seen although the two species were often in the same groves.

The habitat required is woodland providing large oaks and shade. Because encinal trees are small, these vireos favor pine-oak over encinal. They prefer tall continuous canopies in gullies to open growth on slopes. This brings them into riparian woodland, but even there they prefer oaks, such as the stately *Quercus durifolia*, to sycamores and alders. Preference for the large oaks of pine-oak woods and regular feeding in pines make this species almost as typical a pine-oak bird in this area as the Painted Redstart. It is not dependent upon riparian vegetation or water.

Vireo solitarius. Solitary Vireo. This vireo feeds like the Hutton Vireo but works in more open branches. Thus it prefers tall pines and tall riparian timber, the feeding site being comparable in both, and it rarely feeds in oaks. The bird slowly hops high among horizontal twigs interior to the peripheral foliage, and from one perch it looks this way and that before flying or hopping to the next. It thus sees its prey at a greater distance than do the smaller foliage-hunting birds. One spied a large caterpillar in a madrone while it was feeding low in a ponderosa pine; then it flew several yards over to the madrone to catch the grub. Ten stomachs contained insects, some very large, and a kind of purple caterpillar. The Solitary Vireo stays right-side-up, and I did not observe any hovering at the foliage. Like the Hutton Vireo, members of the pair forage close together, and the species is present in the same groves year after year. Males whose territories center in groves in the canyon bottom go 200 yards or more up sunny slopes to sing and feed in the morning. The two activities run concurrently. Steady singing is

a poor criterion of breeding, for singing migrants of the green race *cassinii* may be collected in trees adjacent to the gray breeding birds.

The Solitary Vireo's strange distribution here is unaffected by small mountain area, for it includes the Peloncillo pine stand; yet the bird seems to avoid the small western ranges. Nor is this distribution explained by preference for riparian woodland in the north as against pine timber in the south. The census shows that both north and south in the study area this vireo makes no distinction between tall pines and tall riparian trees for foraging. It uses one or both, even within the same territory, as they are available.

*Migrants of the race *cassinii* singing in riparian trees, 2: Ajos, May 29, 1953, and June 2, 1955 (specimens, A. R. Phillips).

**Vireo olivaceus*. Red-eyed Vireo. Migrant in riparian woodland, 4: Ajos, July 16-17, 1952, specimen taken by A. R. Phillips.

Vireo gilvus. Warbling Vireo. In feeding, the Warbling Vireo hops from one small horizontal twig to another and picks up insects, which are gulped or hammered down its throat with forward dabs of the bill. It lives only near water and was seen to bathe. Feeding is at various heights, usually far up, in tall riparian trees. One hovered at sycamore foliage like a kinglet as it took an insect from a leaf. A pair was attracted by Pygmy Owl calls from its alder grove to a pine slope, along with a pair of Solitary Vireos; both pairs remained to feed high in some tall Chihuahua pines. Six stomachs contained ladybird beetles, caterpillars (one 35 mm. long), and various leaf insects.

One fledged a Brown-headed Cowbird at the Río Gavilán on June 30. This is the only Warbling Vireo I found in the Sierra Madre; there was no male evident in the days before and after the cowbird left the nest at camp. The previously tame vireo became alarmed at my approach after the cowbird was out.

The species prefers deciduous groves within forest, whence it spills down the coldest canyons to riparian woods within the pine-oak zone in the Pinaleno and Catalina mountains. Birds at the other three stations were not overflow from higher dense populations. I can account for those occurrences no more than for the absence of the species, except as migrants, at Ajo Canyon.

*Migrants in riparian woodland, 23: Santa Rita, May 15, 1955, 2; Ajos, July 17, 1952, specimen taken by A. R. Phillips, August 2, 1952, 4, May 29-June 1, 1953, 11, specimens, June 1-2, 1955, 5, specimen.

**Vermivora celata*. Orange-crowned Warbler. Migrant, 10: Santa Rita, May 15, 1955, 1; Ajos, May 29, 1953, 1, June 2, 1955, specimen by A. R. Phillips; Chiricahua, August 7-8, 1951, 3, August 16, 1952, 1; west Sierra Madre, August 26, 1952, 3. Within the study area this warbler is known to breed only in the Catalina Mountains in riparian growth within coniferous forest.

**Vermivora ruficapilla*. Nashville Warbler. Migrant, 1: San Luis, September 3, 1952, specimen.

Vermivora virginiae. Virginia Warbler. This warbler fed on insects grasped from fine twigs and leaves. One caught a long caterpillar in a silver-leaf oak and bowed jerkily in order to bang it against the twig and swallow it. Another picked insects from willow catkins and twigs. Most of the foraging was in low bushes, either of riparian or chaparral vegetation, such as *Prunus emarginata*, *Robinea*, and manzanita. In contrast males sang from tree tops and did not combine feeding with this activity.

South of Arizona, the mountains are not high or moist enough to provide deciduous brush close to forest, which is the Virginia Warbler's preferred habitat. In the pine-oak areas it occupied a mixture of pines, oaks, and bushes of any kind. Some territories of males were 150 to 200 yards long and were bunched together in "colonies." A lone territory in Bear Canyon was 100 by 150 yards and thus was no larger than those in groups.

*Migrant, 1: Chiricahua, April 20, 1953.

**Vermivora luciae*. Lucy Warbler. Wanderer upstream from lower levels, 2: Huachuca, June 11, 1952; Ajos, July 21, 1953.

**Parula americana*. Parula Warbler. Riparian woodland of Sierra de Los Ajos, 1 pair: male, enlarged testes, July 16, 1952, specimen taken by A. R. Phillips; female, old brood patch, same spot, July 29, 1952, specimen. The closest known breeding colonies of this genus are of the species *pitiayumi*: Sierra San Antonio (van Rossem, 1945: 219), and Río Zátachi at west base of Sierra Nácori, specimen.

Peucedramus taeniatus. Olive Warbler. This species feeds on insects (five stomachs) on foliage and twigs high in the tallest pines. It hops rapidly through this foliage, picking at the twigs and leaf bases with its bill. Feeding in gray and silver-leaf oaks was observed a few times, but most of the foraging was in ponderosa pines. The flight, when leaving one tree and entering the next, is swift and erratic. Olive Warblers were usually found in pairs. Their forage area is large, for a bird will move rapidly from one pine to the next for a quarter of a mile, taking some long flights. On the other hand, they were repeatedly found in particular groves: seven times in three years at one territory in the Catalinas; four days (February to May) in the same year for the territory next to this. The distribution of the Olive Warbler in the study area depends on coniferous forests, whose extent evidently must be at least that found in the Santa Rita Mountains.

*Down-hill wanderer, 1: Chiricahua, August 8, 1951.

**Dendroica petechia*. Yellow Warbler. Summer resident in riparian woodland, 1: Ajos, specimen by A. R. Phillips. Migrant, 4: Ajos, May 29, 1953, 1; Chiricahua, August 10, 1951, 1; high Sierra Madre, August 24, 1951, 1, August 31–September 4, 1951, 1, the same bird.

**Dendroica coronata*. Myrtle Warbler. Winter resident, 1: Chiricahua, April 14, 1952, specimen.

Dendroica auduboni. Audubon Warbler. These warblers feed in and from the uppermost foliage of tall pines. They hop among and along the twigs to pick insects (four stomachs) from twigs and leaves; also they fly 10 feet or more into the air to catch passing insects. Adhering mostly to tall conifers in summer, they occasionally adopt their winter style of feeding in meadows in the company of Robins, Western Bluebirds, and Chipping Sparrows. Audubon Warblers perched with bluebirds along fence wires and flew to the ground to catch prey in June at a ranch in the high Sierra Madre. They occasionally fed in gray oaks and in *Quercus fulva*, an associate of ponderosa pine. The few pairs in highest pine-oak, near forests of large extent, were spaced at much greater intervals than the 200 yards characterizing their abundance in closed coniferous forest.

*Migrants, through June 1 (Ajos) in spring, 31 individuals: Catalina, Santa Rita, Huachuca, Ajos, Chiricahua, San Luis (September 3, 1952), east Sierra Madre.

Dendroica nigrescens. Black-throated Gray Warbler. This species picks caterpillars and other insects (six stomachs) from the leaves and twigs of trees as it hops rapidly through the foliage. One stomach had the tip of a piñon needle three-eighths inch long in it. Large insects are swallowed with difficulty after considerable banging against a branch. The warbler often climbs foliage at the outside of the tree and reaches far out from its insecure perch; this is done in preference to hovering. One took caterpillars in a flowering oak, and others were frequently attracted to insects among these flowers. In the top of a large Chihuahuan pine one worked in the foliage and also upon the bases of the branches where they join the trunk. This species was observed to bathe in a creek, but it occurred in several places far from permanent water.

Black-throated Gray Warblers sing and feed in practically all kinds of bushes and trees, but they prefer scrubby oaks and junipers. They often feed in pines and are abun-



OLIVE WARBLER
PEUCEDRAMUS TAENIATUS
Male and female
Painting by Don R. Eckelberry

dant in pine-oak areas. But the territories there tend to occupy dry south slopes and lie along the borders between pine-oak and encinal. Riparian woods are also used for feeding, and in July families gather to roost in dense parts of sycamores. This warbler avoids large dense groves of pines. The Cananea Mountains were visited too late to see actual nesting by the species, but its abundance and the many adults in heavy molt suggest that it breeds there. Its breeding range (fig. 21) thus includes the mountains supporting plentiful junipers and piñons (fig. 3) but the species is absent from the east slope of the Sierra Madre.

Territorial strife among Black-throated Gray Warblers is conspicuous because their great numbers bring rival males into contact; frequent fights and competitive singing ensue. Generally at least two males are attracted by imitated Pygmy Owl calls. In some places, stationary singing males, which feed between songs, are little over 200 yards apart. The area covered in a day's activity is of larger diameter than this, for these warblers like to sing and forage on sunny slopes. Most of the morning is spent on west canyon walls; as the sun shifts the birds enter riparian vegetation of the bottom and finally work up the east slopes. They move along gullies choked with scrubby oak growth, which traverse areas of pine-oak.

*Migrants, 16 individuals: Púlpito, August 6, 1952, 3; Pinitos, May 31, 1955, 1 male, specimen, gonads enlarged; Azul, July 13, 1953, 1; Sierra Madre (throughout), August 22-September 3, 1951, 10, April 11, 1955, 1.

**Dendroica townsendi*. Townsend Warbler. Migrants, 16 individuals: Santa Rita, May 6, 1951, 5, May 15, 1955, 2; Ajos, May 29-31, 1953, 6; Aconchi, June 23, 1954, 1 specimen; Oposura, April 10, 1953, 1; high Sierra Madre, September 3, 1951, 1.

**Dendroica occidentalis*. Hermit Warbler. Migrants, 15: Santa Rita, May 6, 1951, 5, May 15, 1955, 1; Huachuca, June 19, 1951, 1; Ajos, May 29, 1953, 1; San Luis, July 28, 1954, 1; east Sierra Madre, August 22, 1952, 1; west Sierra Madre, August 27-28, 1952, 5.

Dendroica graciae. Grace Warbler. This warbler feeds high in tall pines by hopping and flitting rapidly from twig to twig and grasping small insects (5 stomachs) from the finer foliage, twigs, and bases of the needles. One was flycatching into the air. Another hovered before an Apache pine branch and picked something off the needles, then stood upon some of these stiff leaves while it reached up and pulled an object out of a spider web. A female, dashing about to gather food for a hungry cowbird, repeatedly made upward flights within a maple and hovered as it picked food from the foliage. Grace Warblers occasionally fed in oaks and riparian trees; they did this more often than did the Olive and Audubon warblers.

Pairs of Grace Warblers often are close together on small territories. Two pairs came at the same time to a small pine-covered knoll and "chipped" in adjacent pines, then the males sang 200 yards apart. On the contrary, a lone territory in the Ajos was 400 yards in diameter. Long flights are taken from time to time. Although the male may adopt fixed song perches, usually he moves about, foraging as he sings.

The Grace Warbler's distribution here is similar to that of the Olive Warbler; doubtless for the same reasons it is absent from peripheral ranges of small forest area. Its much greater abundance in pine-oak, contrasted to that of the Olive and Audubon warblers, proclaims its greater tolerance for pines spaced widely among intervening oaks. In logged areas, such as the Ajos and Huachinera, Grace Warblers used shady riparian and oak groves; nevertheless they included all available pines in their circuits.

A few chases, away from the nests, indicate a "peck order" of Olive over Grace over Audubon Warbler. Competition among these three species of very similar habitat and feeding method would best be studied in their metropolis, namely, coniferous forest. I

saw no conflict between the Black-throated Gray and Grace warblers; they were frequently in the same tree together.

**Seiurus aurocapillus*. Ovenbird. Vagrant in riparian woods, 1: Aconchi, June 21, 1954, specimen of singing male.

**Oporornis tolmiei*. Tolmie Warbler. Migrant in brush, 4: Sierra Madre (throughout), August 22, 25, 26, 1952, September 1, 1951.

**Geothlypis trichas*. Yellowthroat. Extensive willow thickets in meadow, 2: high Sierra Madre. Vagrant, 1: high Sierra Madre, June 23, 1952.

**Wilsonia pusilla*. Pileolated Warbler. Migrant, 24: Catalina, April 26, 1953, 1, May 23, 1953, 1; Santa Rita, May 15, 1955, 1; Huachuca, April 19, 1952, 1; Ajos, May 29-31, 1953, 10, June 2-3, 1955, 2, specimen by A. R. Phillips; San Luis, August 19, 1951, 1, September 3, 1952, 5, and fresh specimen, one of a group working low on rocks and small *Quercus reticulata* shrubs, taken from belly of rattlesnake, *Crotalus willardi*; high Sierra Madre, September 3-4, 1951, 1.

Cardellina rubrifrons. Red-faced Warbler. This species catches insects (1 stomach) in the interior of dense foliage, especially of deciduous trees. One fed on a white pine branch, where it pounced on top of the leaves, half fluttering as it reached to the base of the needles. Later it thrashed a long caterpillar in its beak. Flycatching, by short flights out from the foliage, was rarely seen. A male moved rapidly in low oaks and cherries under pines, picked at the leaves and twigs, and paused frequently to sing. This bird at times came within two feet of the ground; another was seen on the ground, but most of these warblers were in tall trees.

A lone territory is very large. The male of the single pair at Ajos covered at least 500 yards from the alders at a spring to a grove of maples far in the canyon below, and its loud song could barely be heard from one end of the territory to the other. This male sang steadily through the morning and into mid-day. It kept within shady foliage of alders, maples, and walnuts and sometimes came near the ground. It moved so fast that only three or four songs were uttered during a visit to any one large tree. Several times, having arrived at the spring, it would leave, to be heard a few seconds later from the far end of the territory. The same was true of a pair in the Huachinera.

This species was equally rare wherever it happened to occur in pine-oak; the records were from highest pine-oak woods and riparian growth within them, near forest. Its preferred place is among deciduous trees, such as Gambel oaks, within coniferous forest.

**Setophaga ruticilla*. Redstart. Vagrant, two males in same stage of molt from immature to black adult plumage: Ajos, July 16, 1952, specimen, skull ossified.

Setophaga picta. Painted Redstart. This species eats insects (two stomachs and numerous close observations) taken from the ground, rocks, trunks, branches, foliage, and the air. Prey is grasped in the bill as the bird hops rapidly along, or flies gracefully up or out from a perch. It is difficult to separate foraging behavior from display, but perhaps the bird divides the two little, if at all. The following observations are thought to represent typical feeding. In a shady grove of silver-leaf oaks (fig. 9) in the Santa Ritas, on a cloudy evening in April, a pair was watched for a half hour, its activity ceasing only a half hour before total darkness. First a single bird called every two or three seconds from its perch upon an arched horizontal fallen trunk, six feet above the ground, in a clear avenue beneath the continuous canopy. About every second it simultaneously spread its tail, extended the wings, and turned abruptly to one side. The next turn would be to the opposite side. The bird averaged one call to every two or three of these "twitches." Repeated flights after insects were made straight upward or in graceful arcs to the side. After some of these flights it perched on another arch a short distance away, but usually it returned to the same spot. It also flew to the foliage overhead and seemed

to catch things as it hopped among the leaves. The flights were fluttery, with wings and spread tail shaking. The resemblance of this action to the foraging of a Whip-poor-will, Poor-will, or Trogon was further heightened by the flashing white tail patches. Suddenly the bird speeded up its calls to about one every second; after a half minute the mate appeared from the gloom and the two birds foraged in the same way, staying always within a few yards of each other. When perched, their bodies were horizontal. The new bird, apparently the female, differed in that its call was softer and shorter; it did not flex its wings when perched, and it turned more emphatically so that, at every two or three twitches it completely reversed its position on the perch. The first bird went into the foliage, visited a ball of leaves there, apparently a squirrel's nest, and became silent; meanwhile the "female" called louder and more frequently than before. She joined the other at the squirrel's nest, then both returned to the original perch. It was too dark for me to see insects, although I assume that the birds were feeding on them.

Two days later the same pair was watched at various times from 10:30 a.m. until 2:00 p.m. in a large juniper overlooking an open space in the canyon bottom. This tree was in strong sunlight and the two birds fed while hopping about within its shady foliage. Also the male (singing) repeatedly flew horizontally out toward the sun about 50 feet and fluttered to catch two or three insects before returning to the juniper. Apparently the prey, too small to be seen by me, was more easily detected in the direction of the sun. A neighboring pair fed in dense oak foliage, where the male hopped, made short flights, perched horizontally while wagging from side to side, and reached to pick objects off the fine twigs.

At Rucker Canyon in the Chiricahuas, three fed together over a pool in the open. They flew from perches eight to ten feet up in neighboring small trees. Each bird fluttered six to eight feet above the pool, twisting, turning, and making several consecutive captures, apparently of tiny gnats, before returning to the original perch. Creeper-like feeding consists of progression straight up a vertical pine trunk, beginning at the base. The body is abruptly turned through 90 degrees at each hop. The only resemblance to the Creeper is the apparent taking of insects from the bark; the spread tail and military facings make the redstart very conspicuous. Other notes on feeding record hopping along horizontal branches between flights upward to foliage, hopping in fallen pines, flycatching by juveniles which click their bills loudly and drive medium-sized insects to the ground in a series of attempted captures, feeding in a *Baccharis glutinosa* thicket by a river, hopping on the pine needle mat on the ground, feeding among the highest branches of a pine snag, and foraging among rocks and boulders at the ground. Bathing was seen.

To summarize, the feeding on stationary and flying insects takes place at levels from the ground to tree tops and mostly in and from foliage of pines and oaks. As might be expected in view of this versatility, the optimum habitat is vegetation made up of contrasting tall and short elements, furnished most abundantly in pine-oak woodland. Records from coniferous forest and encinal are from the lower limits of the former and the uppermost canyon phase (usually in Arizona cypress) of the latter. Correlated with its crepuscular tendencies, this warbler forages mostly in shady places, such as are met in canyon bottoms and densely wooded north slopes. This requirement accounts for apparent irregularities in its distribution and numbers, for it is rare or absent in places where the trees are small or not very shady, as at Sylvania, Clanton Canyon and the Río Claro. These locations are on fairly level terrain where dense canyon or north-slope vegetation is lacking. Nevertheless the Painted Redstart is the most characteristic "pine-oak bird" of all the species discussed here.

A pair of redstarts seemed to be prospecting for a nest on April 7 in the Santa Ritas.

Both birds fed in adjacent oaks, then the female flew to a boulder in the canyon bottom, continued from rock to rock, paused on hanging vines and fallen branches, and worked steadily up the canyon while inspecting the base of the shaded slope. She did not feed on these rocks, but she occasionally looped gracefully into the air to catch insects. The male followed along over her, staying at middle height in the oaks.

For the most part these warblers roam in pairs, the two members staying near each other. Redstarts move along higher and more rapidly than do the mixed flocks they momentarily join in fall. A male sings from commanding positions on one and then the other side of a canyon and moves along it for several hundred yards, so that the territory is large and it was difficult to keep track of individuals. The species is so abundant that where one is singing another can be heard nearby; frequently two males sing competitively in adjacent pines. By July juveniles begin to "accumulate" along riparian timber (Río Gavilán, Ajo Canyon, and the Sierra Azul), where they become so numerous that they seem to be in flocks. Only two redstarts were seen in the western Huachucas: one in June of 1951, the other at the same shady gully in May of 1953. The second was a peculiar orange color, obviously a different individual.

**Passer domesticus*. English Sparrow. Villages and some farm buildings, three places near censuses: high Sierra Madre in village, also flock of about 20 at ranch house at 6500 feet in fall, 1951, but only one or two pairs nesting there in June, 1952; west Sierra Madre, several at a farm.

**Tangavius aeneus*. Red-eyed Cowbird. Clearings near cattle, 2: Ajos, specimen; Nácori.

Molothrus ater. Brown-headed Cowbird. These birds fed on the ground of clearings and cattle corrals, where they walked along under the animals while foraging. Five stomachs contained arthropods, seeds, grass leaves, and gravel. Some fed by energetically scuffing the dry manure in a pen. The birds seemed to scratch with the bill and both feet all at once, thus raising a small cloud of dust. Also they turned over cow chips by prying forward with the bill. Cowbirds drank at ponds and rivers daily; they probably require water within the breeding area. Breeding activity, consisting of singing, chasing, and prowling for nests in which to lay the eggs, is mostly in riparian woodland. Nests of prospective victims are concentrated there, and conspicuous song perches are provided by tall sycamores. Such activity was seen in two dry places which lacked riparian vegetation: Clanton Canyon of the Peloncillo Mountains, and one camp in the Sierra Aconchi. However, the birds could have reached areas with water and cattle within a mile and a half. Thus the feeding area and the breeding area may differ, although water is necessary for both the cattle and the riparian woodland. Cowbirds often perched in pines to sing and to pause during their zig-zag flights along the canyons.

The following species fed young cowbirds in riparian vegetation within pine-oak woodland: Western Wood Pewee, Warbling Vireo, Grace Warbler, and Black-throated Gray Warbler. The Brown-headed Cowbird probably affects their reproduction less than that of its victims at lower elevations, where it is more numerous.

Icterus parisorum. Scott Oriole. This species feeds at yucca and agave blossoms and in foliage. Its preference for south-facing slopes of open encinal allows its distribution practically to coincide with that of the agave. The Scott Oriole often feeds and sings in pines, oaks, and riparian trees within pine-oak areas. It is dependably found in this habitat, but all the records from pine-oak, and the few in pine forest, are in places adjacent to dry encinal slopes so that the territory covered by a singing male embraces pine-oak and encinal at their junction, except in the Oposura Mountains. There this oriole lived within an extensive continuous pine-oak area.

A bird which was collected had been feeding within the foliage of an alder; its stom-

ach contained small soft bugs. Another was watched for several hours on two successive days, alternately singing and probing at the bases of Apache pine needles. It would actually stand upon the stiff needles, in the manner described previously for the Grace Warbler, at the periphery of the tree, facing the trunk. Some of the foliage of these pines was dead, indicating possible insect activity; on the first day most of the feeding was among the dead hanging needles; on the second day, most of it was on the live twigs. A Scott Oriole stayed within *Prunus virens* trees, some of which had ripe cherries which it may have eaten; but for an hour at midday it merely sat. Others fed in dense sycamore foliage, foraged secretively with Hepatic Tanagers and migrating Western Tanagers in dense leaves of blue oaks, or crept within the skirt of dead leaves on yucca stalks. Dependence upon water or riparian vegetation was suggested by one bird's visit to a pond, by a nest placed next to a waterfall, and by a pair alarmed, possibly near its nest, in a large cottonwood tree. But similar alarm by a pair evidently near its nest was noticed in open pine forest of the Sierra Huachinera.

The Scott Oriole's elaborate song, containing chromatic phrases of astonishing art, is the finest to be heard in woodlands of this area. Singing males are widely spaced. Each covers a tremendous territory, embracing canyon walls from the bottom to far up the slopes. Their resulting low density belies the actual prominence of the species, for the song resounds over a great distance. They sing from the tops of tall conifers, oaks, and agave stalks and are strongly territorial, judging from frequent fighting and chasing.

Icterus wagleri. Wagler Oriole. This oriole was found only in the Sierra Nácori, in a local distribution pattern fully as erratic as that of the Rusty Sparrow at the same place. On the Río Zátachi several called from bushes on the rocky desert wall of the canyon, then flew to some sycamores where they foraged high in the crown foliage, keeping well concealed. An adult female, not in breeding condition, was collected. Its stomach contained insects. An immature male with enlarged testes was collected at the summit of the range, in pine forest. Its stomach was full of caterpillars.

Unfortunately the records for Pinos Altos consist of sight identifications of two birds in immature plumage, which are possibly acceptable in view of their bright orange-yellow underparts and lack of wing bars, which distinguish them from *parisorum* and *cucullatus* that also occur in the vicinity. The two birds were together one evening in some oaks and a large juniper of the canyon bottom, calling at the same time that a *parisorum* was singing on the ridge. The next morning at the same place one, evidently the female, gathered fibers from yucca leaves and returned after being chased away by the Scott Oriole, which fed at the flowers of this yucca. Nearby another, with a black loreal patch, foraged in the top foliage of blue oaks, uttering from time to time a whisper song resembling that of the Hooded Oriole.

**Icterus cucullatus*. Hooded Oriole. Wanderer from lower elevations, three individuals: Ajos, Peloncillo, Nácori (apparently breeding).

**Xanthocephalus xanthocephalus*. Yellow-headed Blackbird. Migrant, open country, two flocks: west Sierra Madre, August 23-24, 1952; high Sierra Madre, September 5, 1951.

**Sturnella neglecta*. Western Meadowlark. Large meadows, 3: high Sierra Madre.

**Piranga rubra*. Summer Tanager. Riparian woodland, 5: Ajos, 2; Aconchi, 3. Wanderer from lower elevations, two birds together: high Sierra Madre, August 24-25, 1951.

Piranga flava. Hepatic Tanager. Most of the Hepatic Tanager's foraging is in foliage ranging from that of low oaks to the upper parts of tall pines. The birds hop slowly and rather awkwardly among the branches, constantly stopping to peer at the foliage. One pair fed in scrubby second-growth oaks and Chihuahua pines. The two birds stayed together and hopped slowly among the ends of the lowest branches, reaching deliber-

ately out among the leaves and grasping objects in their bills. They flew low from one tree to the next, and once the female hopped along the ground to pick up something. Occasional graceful, long, and successful insect-capturing flights were seen. Usually the bird took the flying insect by only a slight deviation in its direct course to a new perch. One left the center of a tree and dipped its head to pick something from the outer foliage, on its way to the next tree, where it sat and swallowed this prey. Another fed by leaping from branches into the foliage of *Quercus viminea*. These few observations and five stomachs taken in November and July indicate a diet of insects. The birds are attracted to flowers of agaves, madrones, and oaks. Practically every available kind of tree is used for foraging.

Pairs are usually found; the members stay close together as they forage, and one follows the other in swift flight, sometimes from one side of a large canyon to the other. Because of this roaming, the paths of different pairs frequently cross. In one "pair" the bird in female plumage proved upon collecting to be a male.

The Hepatic Tanager seems to be strongly territorial, which results in frequent bickering and chasing. Its song, the most conspicuous in the dawn chorus, begins while the caprimulgids are still singing. It continues for a half hour or so while the males are stationary in their respective pines. Six or seven can be heard from the same observation point. Later, they begin to move widely, singing from various trees for a while; then most are still until the next day.

Although the Hepatic Tanager seems to need groves of tall trees, its greatest abundance is in pine-oak areas, particularly where the terrain is rugged so that different kinds of vegetation come together. But it is common in open ponderosa pine forest northward in Arizona, far beyond the limits of pine-oak woodland.

Piranga ludoviciana. Western Tanager. These birds inhabited the alder groves at Wet Canyon and occasionally wandered into junipers and Chihuahuan pines to sing. They frequented the same riparian groves as did *Piranga flava*, but they seemed not to affect the numbers of that abundant species. Both species are numerous in pine forest areas of Arizona.

The relatively few records of feeding by the Western Tanager reveal differences from its relative, although the two have similar "equipment." These observations are of migrants through pine-oak, however. One was flycatching from high in a dead pine, whereas flycatching by *flava* is lower, between trees. Groups in tall riparian trees picked food from walnut flowers. A bird would jump upon a spray of leaves, shaking it, then would crawl in leisurely fashion while reaching to pick objects off the foliage. Two stomachs contained fruit and other plant material.

In view of this tanager's requirement for dense tall forest, it is unlikely that it breeds anywhere in Sonora. Singing by migrant males and the great spread of its migration period excuses van Rossem (1945:249) from assuming the contrary, as the following roster of migrants in pine-oak or nearby riparian vegetation will illustrate.

*Migrants, about 74 individuals: Pinaleno, May 16, 1953, many, mostly males; Catalina, May 19-24, of several years, 6, June 4, 1952, 1, not there next day, July 24-26, 1951, 2; Santa Rita, July 30, 1951, 1; Huachuca, June 9, 1952, 1 singing, not there next day; Ajos, May 29-June 1, 1953, 13 plus 3 small flocks, June 3, 1955, 1, July 16, 1952, 2, July 21, 1953, 1; Chiricahua, August 9-16, 1951 and 1952, 13; San Luis, August 19, 1951, 1, September 3, 1952, 3; Pulpito, August 6, 1952, 1; Oposura, June 5, 1953, 2; high Sierra Madre, September 1, 1951, 1.

Pheucticus melanocephalus. Black-headed Grosbeak. This species fed in foliage on arthropods and vegetable material. Three specimens had eaten, respectively, caterpillars and large beetles, caterpillars, and insects and numerous pine seeds; the latter evidently

were taken from opened cones, for the seed leaves were green. One bird clung inverted at the end of an upright pine twig and ate a large insect picked from the base of needles. One evening, when numerous insects were clicking in alders, I looked from the canyon side down on a grosbeak which hopped and darted on top of the horizontal mass of foliage, apparently taking these insects. A pair fed on the green seeds of a prostrate milkweed. Another grosbeak ate mistletoe in a ponderosa pine. One, perched at the top of a sycamore, flew high, and chased a moth in the air. My only other observation of attempted flycatching (see joint feeding, p. 51) indicates that grosbeaks are not proficient at this activity. In a flowering Arizona oak one moved deliberately within the peripheral foliage, peered this way and that, and frequently reached toward the catkins with its bill. This female was not at first recognized as a bird, for it resembled instead a chipmunk or small squirrel by constantly keeping its head down and body horizontal; it actually crawled along the horizontal twigs. Another bird in an Emory oak crawled in this same way. Bathing in creeks was noticed at two places.

Two migrant adult males fed in *Prunus virens* under an Apache pine grove. In the course of 45 minutes they stayed within a few yards of each other and concentrated on two small trees in leaf. The grosbeaks diligently searched every twig for leaves which were rolled up half their length, enclosing a large green caterpillar. Each bird would fly to a slender twig, bending it so as to cling head-down; as it rocked up and down it would deftly pluck the leaf and then fly a few inches to normal posture on a steady twig. With a few quick movements of the bill the grosbeak would tear open the rolled up leaf, discard it with a shake of the head, and wind up with the caterpillar in its mouth. It subdued each caterpillar by biting along its length, then swallowed it whole. These dexterous operations were achieved entirely by the bill, with no help from the feet, nor was there any resting or pounding of the prey against the twig.

The Black-headed Grosbeak was found most dependably in ponderosa pine forest. In high pine-oak of the Sierra Madre it was numerous in the uniform woodland with tall pines predominating, whereas in the same range at lower elevations it was absent from three miles of riparian timber along the Río Gavilán. At the Sierra Huachinera and Sierra Nácori it increases as the ponderosa pine areas are reached, although riparian woodland is diminished at those altitudes. It is therefore rather astonishing to find evidence of breeding at low altitudes elsewhere in Sonora as follows: a male with enlarged gonads collected far down in the Chihuahua oak zone (below true encinal) of the Sierra Aconchi on June 24, 1954; a female with active brood patch in pine-oak at about 4500 feet near Aribabi, Sonora. Migrants seem to prefer riparian woodland. A. R. Phillips estimates that like the Western Flycatcher and Western Tanager, there is a period only from mid-June to July 4, in which the presence of more than single birds would indicate breeding in the area. Birds entered on the census were thought to be on their breeding grounds, and these include two specimens with enlarged testes and cloacal tubules (Cananea, July 18, 1953, and Pinitos, May 31, 1955).

*Supposed migrants: Pinaleno, May 16, 1953, many flocks: Huachuca, May 11, 1953, 2; Chiricahua, May 2, 1953, 2; Oposura, June 5, 1953, 1.

**Guiraca caerulea*. Blue Grosbeak. Mountain meadows and corn fields, 10: west Sierra Madre, 4; high Sierra Madre, 6. Wanderer from lower levels, 1: Huachuca, June 21, 1951.

**Passerina amoena*. Lazuli Bunting. Migrant, 5: Huachuca, May 11, 1953, 1; Chiricahua, May 3, 1953, 1; Ajos, May 29, 1953, 3, specimen.

**Hesperiphona vespertina*. Evening Grosbeak. Wanderer from adjacent pine forest, 6 places: Catalina, April 27, 1953, 1, May 12, 1952, 1, specimen; west Sierra Madre, June 27, 30, 1952, pair and small flock; high Sierra Madre, April 11-12, 1955, several,

June 24, 1952, 2. Present in Sonora: pine forest, Sierra Huachinera, July, 1954, specimen.

**Carpodacus cassinii*. Cassin Finch. Winter visitant, 1: high Sierra Madre, April 14, 1955, sight record only, but specimens had been taken in Sonora in the same winter.

**Carpodacus purpureus*. Purple Finch. Winter resident, 1: Santa Rita, April 23, 1955.

**Carpodacus mexicanus*. House Finch. Fields and clearings, and wanderer into adjacent pine-oak woods, 24 pairs: Huachuca, 9; Cananea, 2; Ajos, 7; Chiricahua, 1; Peloncillo, 1; Aconchi, 1; El Tigre, 3.

**Spinus pinus*. Pine Siskin. Migrant and wanderer from pine forest, 9 places, including 6 flocks: Pinaleno, May 16, 1953, flock of 15; Santa Rita, May 15, 1955, flock, specimen; Huachuca, June 16–22, 1951, 1 daily to drink; Ajos, May 29–June 1, 1953, flock, specimen by A. R. Phillips, and June 3, 1955, 1; Chiricahua, April 20, 1953, flock, May 3, 1953, 1; high Sierra Madre, September 2, 1951 and June 26, 1952, 1, September 5, 1951, 2 flocks.

Spinus notatus. Black-headed Siskin. A flock of Black-headed Siskins, several of which sang constantly, was seen high in sycamores and *viminea* oaks near a spring on the west slope of the Sierra Huachinera on two successive days in June, 1953, and on July 8, 1954. At the latter visit another flock was in Arizona cypresses and silver-leaf oaks a half mile north of this spring, and a solitary female with an old brood patch was collected as it sat in an Apache pine. Its stomach contained seeds. In the second group were two males which sang and chased each other in short flights as they moved around and around through the trees. The voice of this species is strikingly similar to that of *Spinus psaltria*. The song, plaintive descending call, and shivering flight note are the same except for a slight roughness or harshness. In addition *notatus* utters a slight *check* of alarm, a buzzing *tzweee* like that of the Pine Siskin but not as long (heard only once), and a grace-note, *pit*, which may immediately precede the plaintive descending whistle.

Spinus psaltria. Lesser Goldfinch. On the Sierra Huachinera these goldfinches were confined to the same district described for the Black-headed Siskin. Since the area contains the best riparian growth on the mountain, this vegetation is perhaps influential in the distribution of both species. On July 8, 1954, the same day that the siskins were observed, a pair of Lesser or Arkansas Goldfinches fed in an alder patch four-tenths of a mile down the canyon from the spring. (The same trees had been occupied on two successive days the previous year but the species was not determined at that time with certainty.) The next day *notatus* was not found, but a lone male *psaltria* was at the spring. A half mile west in riparian growth and oaks, two singing males (1 specimen) pursued each other around and around exactly as described for *notatus*. An unidentified bird in "female *psaltria*—immature *notatus*" plumage came to a clearing by the spring in 1953. Unfortunately these are all the observations I have on the genus *Spinus* in the course of 15 days in two summers at various parts of the Sierra Huachinera. However, it is obvious that an interesting problem in competition may be involved. The two species are remarkably similar in voice; neither was found elsewhere on the mountain; both were in the same habitat; both spent much time high in the foliage of broad-leaved trees near springs; both seemed to be in the same stage of the reproductive cycle. In the foregoing eleven encounters with the genus the two species were never seen together or within hearing distance of each other although all were seen within an area a mile in diameter, and both came to the same spring at different times.

In the Sierra Aconchi, Lesser Goldfinches were scattered sparingly through woodlands, but they were concentrated in musical aggregations in the tops of tall sycamores and alders at the few springs. Elsewhere their relation with riparian growth was less clear. Many of my records for pine-oak are of single birds in flight high overhead which

were decoyed down to a pine by an imitated call. In the Sierra Madre such birds could have been in transit between villages, where they were numerous in planted shade trees. The record from the Oposura, where at least one bird called for over an hour, is the only one in extensive pine-oak away from a farm, clearing, or river. There was a spring at this place, however.

Feeding seems to be largely on seeds of annual flowering plants, taken above the ground as the birds cling to the flower stalks. Two stomachs contained long narrow seeds, apparently of composites, and assorted beautiful crystals and colored rocks; another had green tender shoots. These goldfinches came daily to drink at ponds.

Loxia curvirostra. Red Crossbill. Although there was no evidence of the Red Crossbill's breeding in pine-oak areas, it often fed on seeds of the pines. Examination of eight specimens showed that they cram the esophagus with seeds until it is greatly distended; they also ingest gravel. Apparently they eat their fill in a short time, and this explains their periods of inactivity in shade within clumps of conifers. The stomachs and throats held seeds appropriate to the area of collecting: Engelmann spruce, ponderosa pine, and Chihuahua pine. The crossbill flock is noisy in flight and for a short time after alighting conspicuously in tree tops. Soon the birds become silent; then they sift down into the foliage, scattering so that they are extremely hard to detect.

At Arroyo Tinaja in July a flock of six juveniles alighted in the top of a dead walnut, then drank at the creek. All flew up when an Acorn Woodpecker squawked; then they returned to drink. Presently they scattered within a group of small Chihuahua pines, whose old cones kept falling off as the crossbills reached for them. One bird loosened a large cone, one and one-half inches in diameter, held it in its bill and walked along the twig. Then it transferred the cone to its foot, picked at it, raised it again in the beak, and finally let it drop. There were also green cones in these trees to which some of the crossbills clung upside-down as they fed. These juveniles, one of which was collected, belong to a large, husky-billed race. I doubt that smaller crossbills could handle the cones in this manner.

**Pipilo chlorura*. Green-tailed Towhee. Migrant, 1: Peloncillo, September 4, 1952.

Pipilo erythrophthalmus. Rufous-sided Towhee. This species, known variously as Spotted Towhee and Red-eyed Towhee, feeds upon the ground by picking up seeds, other vegetable matter, arthropods, and gravel (nine stomachs), which it finds after kicking away dead leaves. This loud scratching is accomplished by both feet kicking backward simultaneously and repeatedly, for there may be several scratches at the same spot before the bird takes something from the ground thus exposed. Foraging takes place under bushes in the open (chaparral and oak scrub) or in the shade (undergrowth of woodland and forest). A pair came to a camp each morning to drink at a spring. The female followed closely behind the male and the same route was taken each day: a flight to a juniper, next to a low bush, then along the grass to the edge of the spring.

Juveniles are abundant in late July and August. Pairs are found through the spring and summer, but most of the records are of males singing. Singing increases greatly in July and August as contrasted with April through June, resulting in very different census results at the same station. In areas of abundance, eight or ten birds can be heard from one spot. They are sedentary, and their territories, battled over in spring, are small.

In pine-oak this towhee is most abundant where oak bushes are numerous. It is favored by logging, clearing, and fuel-cutting which results in the growth (and perpetuation at Cananea) of this scrub. It is rare compared to its associate, the Rufous-crowned Sparrow, in the short ceanothus brush of the Sierra Madrean woods. As this bird's Sonoran range continued to unfold, I began to expect it everywhere and therefore was surprised not to find it at the Sierra Aconchi. There is no chaparral there, but some

willow thickets and masses of *Rubus*, poison-oak, and other vines in ravines looked like good habitat. They were occupied instead by Rusty Sparrows.

Pipilo fuscus. Brown Towhee. This bird feeds like the Rufous-sided Towhee, but differs from it in that the scratching takes place on level open ground rather than in the thick mat of leaves under bushes. Sixteen stomachs contained seeds of many kinds, gravel, and a few parts of tiny insects. Some of this material is amazingly small. Dozens of seeds one-half mm. in diameter are a fraction of the volume in a stomach, but they must represent much time spent in picking them up. The appearance of some of these stomach contents suggests that the birds pick up anything that is shiny, colorful, and of regular outline.

The Brown Towhee is most abundant, as a pine-oak bird, in the Sierra Madre, due to the open woods and prevalence of meadows, farms, and open places along creeks. It is partial to log fences around fields and the scrap lumber of abandoned mills. Scattered records from other mountains show that members of other racial populations can live at altitudes of pine-oak wherever some clearing or opening is provided by man. Although the Brown Towhee does not go into deep grass, its greatest numbers are reached in grassy woods, for this type of woodland fulfills most completely the following basic requirements of the species (Davis, 1951:12): edge of an open place for feeding and bush or tree growth for shelter and nesting. The level "open place" occurs around boulders and tree trunks, beneath shady trees, and at the edge of washes. The bird's distribution does not depend on the particular flora found in the openings. In this region this towhee resides in various kinds of desert and riparian associations through encinal to highest pine-oak (figs. 13, 23). Continuous chaparral and scrubby oak- and juniper-choked woods of the southern Arizona mountains are of course unacceptable.

**Passerculus sandwichensis*. Savannah Sparrow. Migrant on wet meadow, about 15, which flushed in 2's: high Sierra Madre, April 14, 1955, specimen.

**Chondestes grammacus*. Lark Sparrow. Fields and clearings, 11 places: Ajos, 1; Chiricahua, 2 migrants or vagrants, August 7-8, 1951; western part of Sierra Madre, 3 flocks in August; high Sierra Madre, 5 pairs.

Plagiospiza superciliosa. Striped Sparrow. This species feeds on the ground in high mountain meadows of tall grass. Four stomachs of adults contained seeds; that of a juvenile being fed by its parents had green plant material and insects. These birds fly far over the meadow to feed, often joining Lark Sparrows. On approaching the feeding spot the bird flutters slowly with its tail spread. Having landed upon a tall stem, it jumps to the ground and disappears within the grass. Individuals were repeatedly flushed from beneath lone bushes and fallen logs in the middle of the meadow. Numerous fresh droppings there indicated much time spent in these secluded spots.

In late June of 1952, some of the adults were found in two's but all the local birds would gather to voice alarm if one juvenile was approached. They did not seem to have territorial boundaries. Their forage routes apparently crossed and overlapped, and they answered each other from all sides and the middle of this meadow on the upper Río Gavilán. A colony of about 24 adults lived on the meadow (fig. 23) which was three-fourths of a mile in diameter; an additional pair with juveniles was at a small meadow enclosed by tall woods a couple of miles away.

When flushed, these sparrows retire to the gray oaks and Apache pines at the edge of the meadow, and they spend much time resting, singing, and calling in these trees. They run along the horizontal branches of the pines and ascend from their landing place on the lowest branch by jumping from one horizontal branch to the next in the manner of the Steller Jay and Curve-billed Thrasher.

Aimophila rufescens. Rusty Sparrow. This sparrow feeds on the ground (five stomachs contained seeds, insects and gravel) under bushes and tangles of vines, at the base of bunch grasses, and along cow paths on grassy hillsides. On the Huachinera, at least, it was numerous in pine-oak woodland and logged pine forest. However, in the Sierra Nácori it appeared on a desert slope next to the Río Zátachi and in open pine forest with low patches of ceanothus and bracken. Only singing males were noticed, these being spaced more widely and encompassing greater areas by their song posts than did the Rufous-sided Towhees and Rufous-crowned Sparrows which occurred with them on the Sierra Huachinera. Of seven males found on the mapped census there, three were in dense oak-ceanothus brush growing in a logged area, where they sang high on dead pine snags; the rest were in the undisturbed pine-oak of large trees spaced widely over bunch grass and scattered ceanothus. On the Sierra Aconchi the birds were found on a grassy hillside and a boulder slope in encinal, in thickets of *Rubus* and other riparian growth in ravines at the level of pine-oak, and along rock-walled gorges.

The species occurs in "pockets" or colonies like the Buff-breasted Flycatcher, but apparently with no regard for terrain or vegetation. On the ground it is so similar in behavior, form, and color to the Rufous-crowned Sparrow that I was unable to distinguish the two species in the field unless the distinctive songs or calls (other than the squeak common to both) were heard. The Rusty Sparrow occurs variously with Rufous-crowned Sparrows, Rufous-sided Towhees, and Brown Towhees, or it may be the only ground sparrow present. Its numbers seem unrelated to the presence or absence of these neighbors whose territories it may actually overlap.

Aimophila ruficeps. Rufous-crowned Sparrow. This species feeds so well concealed by grass, low bushes, and boulders that only three were watched foraging for suitably long periods. They hopped rapidly and could bound straight uphill at undiminished pace. The head and tail were held high, and the wings were frequently and emphatically flicked. Scratching was never seen, and the restless birds kept a steady advance by picking up only one item from the ground at each brief stop. They hopped along ledges, into caves among boulders, and around bunch grasses, and they jumped upon rocks. The bill was poked into tufts of grass, where also the foraging birds would jump to pick things from higher on the grass. Six stomachs taken in winter contained seeds, gravel, and tiny insects, whereas two summer birds had eaten caterpillars and other insects.

This species was found in pairs, or during August, in family-sized flocks. In areas of abundance, pairs might be only 100 yards apart, suggesting a small territory size. As in Hutton Vireos and Painted Redstarts, adjacent territorial males sometimes advanced to trees within a few yards of each other and engaged in competitive singing for hours at a time.

Rufous-crowned Sparrows live on hillsides in a variety of vegetation types whose common attribute seems to be the presence of grass broken up by boulders, scattered trees, or clumps of low bushes. Numbers in pine-oak of the Arizona border ranges are small because the birds remain on south-facing canyon walls of encinal, the opposite pine-oak slopes being too dense. Eastward because of more brush, and southward due to increasing grass and ceanothus, the Rufous-crowned Sparrow reaches great abundance in pine-oak. It is especially numerous in the western Sierra Madre, but in the high Sierra Madre it is replaced by the Mexican Junco.

It is a surprise to see these sparrows alight in pines and run along the horizontal branches. They are clever at concealment in grass, bushes, and rocks, and they can creep rapidly and undetected even through sparse growth. When a bird has to cross an opening and knows it is being watched, it hides behind the last vestige of grass before making a mouse-like dash to concealment again. Two decoying devices, apparently near

nests, were watched: tumbling off of bushes, and the rodent-run (feet alternate); both were preceded by a flight at the intruder.

At the Sierra Huachinera there were singing birds in the same places as *Aimophila rufescens*: only one or two in the brush area and three in ceanothus and bunch grass under the big oaks and pines. One of the latter sang from a bare oak twig used for the same purpose at other times by *rufescens* and a Bewick Wren. Possibly the species could be more numerous here if there were not so many Rusty Sparrows. In the Nácori, where *ruficeps* was unaccountably rare, the two species were not found together. Most of the *rufescens* at Aconchi occupied narrow ravines and vine tangles unsuitable for *ruficeps*.

**Junco oreganus*. Oregon Junco. Winter resident, 2: Catalina, April 5, 1951.

**Junco caniceps*. Gray-headed Junco. Winter resident, 16: Catalina, May 4, 1951, 8; Peloncillo, April 18, 1955, 4; El Tigre, April 4-7, 1953, 3.

Junco phaeonotus. Mexican Junco. This junco feeds on the ground on seeds, other vegetable matter, and insects (seven stomachs, insects in summer-taken specimens only). Quantities of gravel also are ingested. A few instances were recorded of feeding above ground: in foliage of *Holodiscus* thickets; in foliage of Douglas firs; a family reaching from the ground to pluck flowers and pendant fruits from a small milkweed; one bird climbing into twigs of an oak and reaching up to pick something off the trunk bark; another bird climbing up a tall grass stem until the stem bent over. This last bird was later seen chewing a portion of the flower of this grass. On the ground these yellow-eyed juncos shuffle, the feet moving alternately, over the leaves, as they pick up food. They also run with long true hops after moving insects, which they catch, pound, and swallow.

Mexican Juncos can scratch their way down through thick leaf litter under bushes; they also scratch to find seeds in gravel and among pine needles. It looks as though each scratch is initiated by rocking forward to take the weight off the feet, with the head up while the feet are advanced. Then the feet are simultaneously scraped backward, kicking out gravel and catching the body again as the head end tilts down—a convenient position for picking up the seed. The feet are far apart and kept close to the surface of the ground.

The Mexican Junco is a resident of numerous Forest Service picnic grounds in pine-oak of the Arizona mountains, where it becomes very tame, taking crumbs from the table and feeding its young in camp. At one camp a junco repeatedly picked up and chewed the edge of a large piece of newspaper. Apparently food or salt was smeared on the paper, because several sheets, with bill marks around the edges, had been torn up by birds and animals. I was astonished to see three birds feeding in the water at Rucker Creek. They picked up small light-colored objects (pollen or seeds) which were either floating in the slowly moving shallow water or were stuck against rocks at the waterline. The birds jumped in and fed while standing in water covering the feet or which reached the belly; then they would hop or fly out again. Also they shuffled along the rocks that stuck out of the water, reached to the surface to pick up objects, and made prodigious leaps from one rock to another, sometimes aided by the wings.

This junco sits perfectly still and upright for 10 minutes or more on a low horizontal branch, between periods of feeding. Like the Rufous-sided Towhee, it increases its singing in July and early August. This yellow-eyed junco, a bird of forests, requires tall conifers with open leaf-strewn ground beneath. In two places where pairs were found in very dense woods it was evident from numerous fresh droppings that the birds spent much of their time on the wide trail itself. The Mexican Junco's occurrence in pine-oak can be explained by proximity to forest, presence of riparian Douglas firs or Arizona cypresses which simulate forest at some places, or by campgrounds that provide openings.

Spizella passerina. Chipping Sparrow. Eight stomachs of Chipping Sparrows included seeds, gravel, and green material from a flowering oak, with insects appearing only in a breeding bird and a juvenile. Feeding is mostly upon the ground near edges of fields and meadows. One pair spent much time each day at an open stretch of damp creek bed, where there were many insects; here they hopped over the gravel and among the rocks. One flew after a flying insect. Some members of a flock seen in early May fed on catkins of an Emory oak, while the rest hopped upon the bare ground beneath. A pair sneaked among bases of grazed bunch grasses and often leapt up to pull off objects from this grass.

Separate pairs were found in summer in the Sierra Madre, a singing male in the Ajos, and a colony with three singers in the clearing at Sunnyside. Large flocks were seen at other times, some of which could have been migrants.

Chipping Sparrows seem to require level, bare, or grassy ground near or between widely spaced trees. They sing in trees at some distance from the meadow or clearing and perch in the lowest branches when flushed from the ground and when resting. Within pine-oak woodland their optimum habitat is provided in the Sierra Madre; in the Arizona mountains the only suitable clearings in this vegetation are man-made.

*Migrants, 3: Ajos, May 29, 1953, 1, specimen, August 2, 1952, 2.

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