THE EFFECTS OF FUELWOOD CUTTING ON HOLE-NESTING BIRD POPULATIONS IN THE OAK-JUNIPER WOODLAND

by

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ABSTRACT

To evaluate the effect of fuelwood harvest on hole-nesting bird populations in southern Arizona, two study areas were located in the oak-juniper woodland. One study area included an area which the Forest Service had designated for public fuelwood cuttings, the other was uncut. A third study area was located at Madera Canyon to provide comparison with a riparian area of similar elevation.

Alligator Juniper (Juniperus deppeana) dominated both the cut and control areas. More nests were found on the cut area than the control area. Bird populations were nearly equal over the two oak-juniper study areas, but were higher at Madera Canyon. Quercus arizonicus was most frequently used as a nest tree by active nesters and by woodpeckers (past and present). Old woodpecker holes were chosen most often by hole-nesters. Trees with at least half their branches alive were chosen more often than those with less than half.

The importance of the oak-juniper woodland is indicated by the data; its composition may be changed in the future. A fuelwood project like this one will not be detrimental as long as a small percentage of the trees are cut and care is taken to preserve trees with nest holes.

INTRODUCTION

With the current fuel crisis, public pressure has been applied to government and private landowners to make trees available for fuelwood harvest. In southern Arizona, where the winter heating energy requirement is not as great as in northern latitudes, fuelwood could supply a substantial fraction of that need. The U.S. Forest Service has designated areas where fuelwood may be harvested by the public. Depending upon the extent and method of harvest, bird populations in these areas may be affected. One important avian requirement affected by fuelwood harvest is nesting habitat, specifically cavity-nesting trees. According to Scott and Patton (1975), twelve species of cavity-nesting birds use the oak-juniper type, prevalent in southern Arizona. In the past, dead trees (cavity-nesting trees may be dead) were routinely removed as fire hazards, forest health hazards (sources of disease inoculum) and as a part of logging operations. Problems may result as hole-nesters disappear from an area. An increase in destructive insect populations may follow (Michael and Thornburgh 1971). According to J. Verner (Smith 1975), the type of nest site utilized is a critical factor in habitat selection for many species. This is particularly true for those species of hole-nesting birds which do not excavate their own cavities. In this study, only three of eight hole-nesting birds are primary hole-nesters. The critical importance of management for retention of snags in a natural forest has been realized and substantiated by various authors (Balda 1969; Conner 1975; McClelland 1976).

THE FOREST SERVICE FUELWOOD PLAN (1978)

In response to public demand, the Forest Service Offices of the Sierra Vista and Nogales Districts have made permits available for the cutting of fuelwood. In southern Arizona, there are two types of harvest areas: mesquite sale areas, and oak-juniper sale areas. This report pertains to one of the oak-juniper areas. The objectives of the Nogales District plan are:

1. Increase food resources for livestock and wildlife;
2. Provide for perennial water sources for wildlife and livestock;
3. Reduce erosion and restrict off-road vehicle travel where needed;
4. Increase habitat diversity and edge effect;
5. Increase cover availability for wildlife; and,
6. Provide for the sustained yield of harvested fuelwood.

Further, the Forest Service claims that because of extensive fire suppression and historic overgrazing over the entirety of all small sale areas, tree and shrub invasions resulted in a general degradation of land resources and a monotyptic homogeneous vegetative type (Johnston 1978). An example of this is the invading Alligator Juniper (Juniperus deppeana) (Kearney and Peebles 1951), which now dominates areas formerly pine-oak (Balda 1969). More recently there has been a sharp increase in fuelwood demands by the public, mostly as the result of higher energy costs and the fast growth of communities surrounding the Nogales Ranger District. Providing fuelwood to meet this public demand was recognized as a means of accomplishing land management objectives similar to those stated for this plan. However, public harvesting of fuelwood has resulted in increased off-road vehicle travel, accelerated soil loss, fire hazards in the form of slash, and harvesting of similar age-class trees (due to preferential removal of larger diameter trees). Specifically, in the study area designated for fuelwood cutting by the Forest Service, only those trees marked are to be cut. Alligator Juniper and Emory Oak (Quercus emoryi) are selectively marked, leaving all Arizona Oaks (Quercus arizonicus) unmarked. According to the plan, cutting units should be small, preferably less than twenty acres. Uncut strips of vegetation need to be left between units for travel routes and escape cover. Selective marking should be used along zone edges creating buffer areas and for leaving cavity-bearing trees. Leaving two to three slash piles per acre will provide resting, escape and nesting cover for Mearn's Quail (Cyrtonyx montezumae merriami), turkey (Meleagris gallopavo), brown towhee (Pipilo fuscus), Mexican junco (Junco phaeonotus), chipping sparrow (Spizella passerina), and cottontail (Sylvilagus auduboni). Permit cost to the public was $2.50 per cord in 1979 (two-cord minimum, green wood or dead and down), limited to two cords per household per woodcutting year. These policies are as yet untested as far as wildlife is concerned.

The objectives of my study were:

1. To evaluate the effects of the Forest Service's fuelwood policy on avian cavity-nesters;

2. To determine the nest cavity preferences of hole-nesting birds; for instance, tree species, aspect of hole, size of hole, etc.;

3. To identify those snags which are unused by cavity-nesters; those that could be removed without nesting effect;

4. To identify key bird species that may indicate effects of cutting to foresters;

5. To compare the relative bird numbers and species of the study areas to those of Madera Canyon, a sycamore canyon with high bird density, thereby evaluating the relative importance of the oak-juniper type; and,

6. To provide forest managers with data upon which to base management decisions concerning fuelwood cutting in oak-juniper woodlands.

THE STUDY AREAS

In February 1979, I located two adjacent study areas in the northeastern foothills of the Santa Rita Mountains (Pima County) fifty miles southeast of Tucson, Arizona (Fig. 1 and 2) in the Santa Rita District of the Coronado National Forest. Adjacent canyons were Gardner and Fish to the south and Enzenberg and Box to the north. Sonoita, Arizona is 16 kilometers (KM) to the southeast of the study areas. Each area was roughly oval and contained 200 hectares. The two areas were divided by washes running north to south toward Gardner Canyon. The access road ran through the control area and encircled the cut area (Fig. 3). The topography sloped upward to a western ridge and to a northeastern hilltop. On the western ridge there was a television repeater (Fig. 1). Presumably, the access road was originally built to service the repeater. According to Johnston (1978), soils in the area are of the Bakerville-Gaddis complex, granitic in origin and highly erosive. The area's elevation ranged from 1,675 to 1,700 meters (M), map coordinates are N 31° 47', W 110° 48'; temperature was approximately 6 degrees Celcius cooler than Tucson. The closest weather station which approximates the study area's climate is Canelo, Arizona, to the south. At this station, the average yearly precipitation is 44.4 CM. There are 120 days per year in which the temperature is below freezing. The average latest freezing night occurs May 11. The weather was cool and wetter than normal over the study period. The mean temperature for March 1979 was .2° Celcius below normal. During that same time period 3.5 CM of rain and snow fell which was 1.4 inches above normal (N.O.A.A. 1978). The temperature was below freezing before dawn in February and March. The access road remained impassable to non four-wheel-drive vehicles until mid-April, due to heavy spring rain and snow. Consequently, woodcutting activity was not heavy over the period.

As described by Lowe (1964), the study areas are typical of oak woodland areas of southeastern Arizona. Included in the two, 200 hectare areas were 1) open oak-grass savanna (open encinal), and 2) oak-woodland (dense encinal).

The woodland canopy was comprised of Alligator Juniper, Arizona White Oak, and Emory Oak. These trees were 2 to 15 M tall. The tallest individuals were Arizona White Oaks near gullies and a few old junipers. The canopy was most continuous near washes, least on ridgetops where Alligator Juniper was dominant. Beneath the canopy were a few shrubby species, although grasses comprised most of the understory. Some of these shrubs were velvet-pod mimosa (Mimosa dysocarpa), skunkbush (Rhus trilobata), buckbrush (Ceanothus fendleri), Mt. Mahogany (Cercocarpus montanus), silktassel (Garrya wrightii), pincushion cactus (Mamillaria vivipara), and hedgehog cactus (Enchinocereus troglichidiatus). Rare species in the areas included cholla (Opuntia sp.) and Mexican Pinyon (Pinus cembroides). The savanna portions of the area were mainly near ridges. In these

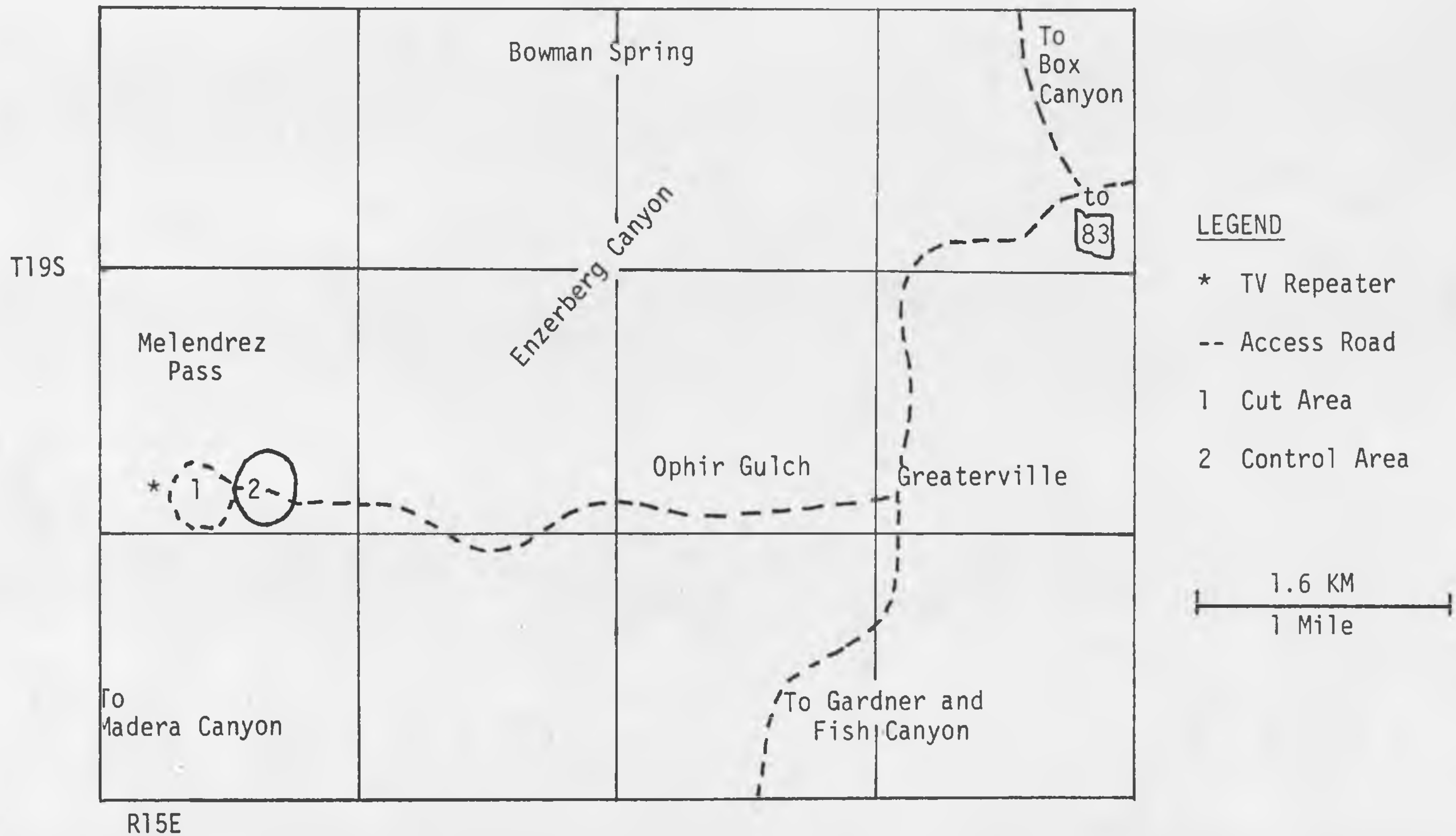

FIG. 1. THE AREA SURROUNDING THE OAK-JUNIPER STUDY AREA

FIG. 2. THE OAK-JUNIPER STUDY AREAS WITH TV REPEATER IN BACKGROUND

FIG. 3. THE ACCESS ROAD AS IT RUNS THROUGH THE CONTROL AREA

areas, grasses dominated. Presumably grassy areas would be increased according to the Forest Service plan. Some common species were bullgrass (*Muhlenbergia emersleyi*), blue grama (*Bouteloua gracilis*), bluestem (*Andropogon scoparius*), and plains lovegrass (*Eragrostis intermedia*).

Wildlife in the area included many bird species, to be mentioned later (Table 3), as well as white-tailed deer (*Odocoileus virginanus cousei*), gray fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), deer mouse (*Peromyscus maniculatus*), cottontail (*Sylvilagus floridanus*), striped skunk (*Mephitis mephitis*), rock squirrel (*Citellus variegatus*), and Arizona gray squirrel (*Sciurus arizonensis*).

A third study area was located at Madera Canyon to the west, also in the Santa Rita Mountains. This canyon drains the two tallest peaks of the Santa Ritas: Mt. Wrightson and Mt. Hopkins. I chose the area to provide contrast with the bird populations of the previous areas which were relatively dry. Madera Canyon has a year-round water supply and is locally famous for its abundance of bird life. Map coordinates for Madera are N 31° 43', W 111° 52'. The elevation of the study area was 1,460 M. Vegetation near the creek was typical of a riparian woodland in southeastern Arizona. The riparian area was dominated by large (up to 15M) trees, mainly Arizona Sycamore (*Platanus wrightii*), Walnut (*Juglans major*), Alder (*Alnus oblongifolia*), and Cottonwood (*Populus fremontii*). The adjoining hillsides contained vegetation similar to that of the oak-juniper study areas. Oaks (*Quercus sp.*) dominated.

METHODS

The oak-juniper study sites were visited three to four times weekly, from January 1979 through June 1979. I began by locating and tagging all trees (dead or alive) in each area with any sort of cavity. Large yellow tags were attached to a low limb of each tree with a cavity to facilitate location at a later date. I found that the hours of 7:00 to 11:00 a.m. were best for field work because avian activity was greatest at sunrise and nesting activity was greatest in the mid-morning. To locate potential nest trees, I thoroughly searched the area rather than use a transect or sampling method. This was necessary because snags were not easily found in either area. Searching was most easily done because all hole trees were found near dry washes which traversed the area. On my tree density transects, in which 80 trees were cataloged in each area, only two potential nest-hole trees were encountered (1%). It would have taken many transects to find all the holes in each area. The ninety-one holes discovered in each area must be considered nearly all those available to the birds. To avoid bias in this survey, I ignored only those holes that provided easy access to predators, due to large hole diameter or softness of wood. I ignored trees with cavity diameter greater than 15 CM. An equal number of holes (91) had been located and tagged in each area by the end of the breeding season. I stopped searching at 91 holes because it was becoming increasingly difficult to locate new hole trees, and I needed to recheck the ones I had located earlier.

It was intended that by choosing adjacent study areas, habitat continuity between control and cut areas would be achieved. A technique designed by Balda (1969) was used to quantify this continuity (Table 1). The point-quarter method by Cottam and Curtis (1956) was used to determine relative density, relative frequency, relative dominance, and importance value (an average of the former three) for the three dominant tree species on the study area. These were calculated over twenty points (80 trees) per area.

At each potential nest hole the following data were recorded:

1. Tree species;
2. Diameter breast height (DBH) of nest tree;
3. Hole exposure (facing up/down/horizontally);
4. Status
   1. Dead
   2. At least half branches dead
   3. At least half branches alive
   4. Alive
5. Hole aspect (direction of hole face: N to E; E to S; S to W; W to N), hole diameter (to nearest half CM); and type of hole (woodpecker caused, crack, branch stub, etc.)

I chose to evaluate live trees as well as dead snags because I found cavities in many of them. The Forest Service policy for Region III (1980) regarding snags considers only DBH and amount of bark remaining when evaluating snag quality. I found that tree species and nest hole data were also important.

I estimated bird populations at each oak-juniper area and at Madera Canyon in May and June 1979. Means calculated from this data were compared using the student's t test at the one percent level of significance. Three different circular plots were set up at each of the three study areas. Circular plot center points were chosen for their visibility characteristics. Those with a wide range were preferred. This was necessary due to the hilliness of the terrain. Avian densities were calculated using the Variable Circular Plot Method (Reynolds et al 1978). Each plot was censused five times and means were calculated for each species (Table 3).

This census technique has two advantages over the popular transect method described by Emlen (1971). First, more time is spent searching for birds and less watching the transect path when the observer is stationary. Second, a standing observer should have a lesser effect on the activity of the avifauna. The advantages seem especially relevant for the hilly terrain of the oak-juniper study areas.

Censusing took place at or shortly after sunrise. At each census point, all birds were counted during a fifteen-minute period and their distances from the observer noted using a range finder. No distinction was made between visual and auditory sensing. Birds up to 200 M distant were recorded. Increments of 5 M were used from 0 to 50 M, and 10 M increments from 50 to 200 M. Population densities were then calculated for each of the radii from 5 to 200 M. These numbers are converted to individuals per hectare and placed in a histogram. The point of inflection of this curve is assumed to be the distance (X) in which all individuals are seen or heard. Density is then determined by summing the number of individuals recorded in the circle of radius (X), dividing by the area and converting density to a standard area. For example: if the distance from the observer at which detections of the bridled titmouse begin to decrease is 70 M, and the number of detections were 10, the calculated density for that bird would be 10,000 M^2/hectare $\div$ 4900 M^2 X 3.14 X 10 birds = 6.5 birds/hectare. All densities, converted to a per hectare basis, are presented in Table 3. Also, all bird species observed while searching for hole-nests on the study areas were recorded, as well as those noted in less than half the density trials. However, no densities were calculated for these species. Only a "+" was used in Table 3 to indicate their presence.

RESULTS

Vegetation data for tree species are summarized in Table 1. I intended that these data evaluate differences in tree densities over the two oak-juniper areas. I used a technique introduced by Balda (1969) to compute these densities. I measured three parameters: 1) relative density, 2) relative dominance, and 3) relative frequency (Balda 1969). The importance value is the average of the former three. I collected these data after the breeding season had ended. In each of the oak-juniper study areas, Alligator Juniper was the dominant tree (importance value), although Emory Oak dominated according to two of three calculations in the uncut area (relative dominance and relative frequency) (Table 1).

Data pertaining to active hole-nesting species are shown in Table 2. These data also appear in Tables 5 through 10. Twenty-one of twenty-two nests were found in Arizona White Oaks. All nests faced either horizontally or downward, and the majority of the active nest holes were drilled by woodpeckers. Bird population estimates appear in Table 3. These are density figures (birds/hectare) for each of the two oak-juniper areas, as well as for Madera Canyon. I intended that these numbers provide a relative comparison between the three areas. I used a technique outlined by Reynolds et al (1978 unpublished) to calculate densities. I recorded more species at Madera Canyon and populations were significantly higher (t test 1%).

Eight of twenty-nine species were noted only at the oak-juniper areas, seventeen of thirty-seven at Madera only.

Nesting data appear in Table 2. These data represent the active nests found on either of the oak-juniper areas during the breeding season. To find these hole nests I used the thorough search method, and I consider these birds nearly all of the hole-nesting species in the areas. Although these data seem the most relevant, the relatively small number of nests found on either area makes it suspect. To draw conclusions concerning nest-hole characteristics I used data concerning active and non-active woodpecker holes.

Table 4 gives the tree species preference of avian hole-nesters. Arizona White Oak is by far the hole-nesting tree most often used. Table 5 catalogs all holes found, used and unused, as well as those selected by active nesters. Woodpecker holes were most commonly used for nests, while branch stub holes were most prevalent among unused holes. Table 6 shows the mean DBH of trees with cavities as compared with those without. On each study area, the Arizona Oaks with cavities were larger than those without.

Aspect, or direction of face, is shown in Table 7. In each case, N to E was used most often. However, the data were divided regarding the second most used aspect. Table 8 describes the condition of the trees with nest holes. Trees with less than one-half their branches dead were preferred by woodpeckers and active hole-nesters. Table 9 shows the mean diameter of the nest hole. The mean cavity diameter for woodpecker holes and active nests was less than for all cavities found. Active nest hole diameter ranged from 3 to 9 CM. Finally, the angle of the nest hole to the vertical is cataloged in Table 10. In each area the majority of woodpecker holes and active nests faced downward or horizontally. Unused holes tended to face upward. These data are shown for the control and cut areas to provide a comparison (see Tables 1-10).

TABLE 1. DOMINANT TREE SPECIES IN THE OAK-JUNIPER AREAS (%)

	Relative Density[a]	Relative Dominance[b]	Relative Frequency[c]	Importance Value[d]
	CONTROL AREA			
Juniperus deppeana	36	57	34	42
Quercus emoryi	40	31	36	36
Quercus arizonicus	24	12	30	22
	100	100	100	100
	CUT AREA			
Juniperus deppeana	51	60	44	52
Quercus emoryi	17	10	20	15
Quercus arizonicus	32	30	36	33
	100	100	100	100

a: $\frac{\text{Number of Individuals of the Species}}{\text{Number of Individuals of all Species}} \times 100$

b: $\frac{\text{Basal Area of the Species}}{\text{Basal Area of all Species}} \times 100$

c: $\frac{\text{Number of Points of Occurrence of the Species}}{\text{Number of Points of Occurrence of all Species}} \times 100$

d: Average of Relative Dominance, Density, Frequency

TABLE 2. NEST HOLES USED BY BIRDS DURING SPRING 1979

CONTROL AREA (NO WOODCUTTING)

Bird Species	Status[1]	DBH (CM)	Diameter of Hole (CM)	Type of Hole	Aspect	Exposure	Tree Species
Ash-throated Flycatcher	2	56	3.8	Woodpecker	NE	Down	Q. arizonicus
Bridled Titmouse	4	41	5.1	Woodpecker	SW	Down	Q. arizonicus
Arizona woodpecker	1	67	5.1	Woodpecker	N	Horiz.	Q. arizonicus
Flicker *	4	36	7.7	Branch Stub	NE	Horiz.	Q. arizonicus
Bridled Titmouse *	1	67	5.1	Woodpecker	N	Horiz.	Q. arizonicus
Flicker	3	82	5.1	Branch Stub	N	Horiz.	Q. arizonicus
Wb. Nuthatch	2	26	2.6	Woodpecker	E	Horiz.	Q. arizonicus
Bewicks Wren *	3	108	6.4	Branch Stub	S	Down	Q. arizonicus
Arizona Woodpecker	3	56	3.8	Woodpecker	W	Down	Q. arizonicus

LEGAL WOOD-CUTTING AREA

Bird Species	Status[1]	DBH (CM)	Diameter of Hole (CM)	Type of Hole	Aspect	Exposure	Tree Species
Eastern Bluebird	3	31	5.1	Woodpecker	N	Down	Q. arizonicus
Birdled Titmouse	4	26	3.8	Woodpecker	E	Down	Q. arizonicus
Ash-throated Flycatcher	4	36	5.1	Woodpecker	NW	Down	Q. arizonicus
Wb. Nuthatch	2	31	5.1	Woodpecker	N	Down	Q. arizonicus
Bewicks Wren	4	46	5.1	Woodpecker	W	Horiz.	Q. arizonicus
Bridled Titmouse	3	67	2.6	Woodpecker	N	Down	Q. arizonicus
Bewicks Wren *	4	41	3.8	Woodpecker	W	Down	Q. arizonicus
Arizona Woodpecker	2	46	9.0	Woodpecker	NE	Horiz.	Q. emoryi (See Fig. 6)
Wb. Nuthatch *	1	62	6.4	Branch Stub	NE	Horiz.	Q. arizonicus
Flicker	4	62	6.4	Woodpecker	N	Down	Q. arizonicus
Bridled Titmouse	2	31	2.6	Branch Stub	SW	Down	Q. arizonicus
Bridled Titmouse *	4	41	3.8	Woodpecker	N	Down	Q. arizonicus

[1] 1 = dead; 2 = at least half branches dead; 3 = at least half branches alive; 4 = alive

* unsuccessful (no birds fledged)

TABLE 3. ESTIMATED BIRD POPULATIONS (#/HECTARE) AT EACH OF THE STUDY AREAS

	N = 37 Madera	N = 27 Control	N = 29 Cut Area
Turkey vulture	+[1]	+	+
Cooper's hawk	+	-[2]	-
Sharp-shinned hawk	-	+	+
Red-tailed hawk	+	+	+
Kestrel	-	+	+
Mearn's quail	-	+	+
Mourning dove	-	6.3[3]	3.8
W.w. dove	5.1	+	+
Great horned owl	-	+	+
Screech owl	+	+	+
Pygmy owl	+	-	-
Flammulated owl	+	-	-
Whiskered owl	-	+	+
Whip-poor-will	+	-	-
White-thr. swift	+	-	-
Hummingbird sp.	+	-	-
Red-shafted flicker	+	1.3	1.9
Acorn woodpecker	12.0	+	+
Arizona woodpecker	+	1.6	1.6
Sulphur-bellied flycatcher	2.5	-	-
Ash-throated flycatcher	+	1.9	1.3
Cassin's kingbird	7.6	-	-
Coues' flycatcher	+	-	-
W. wood pewee	12.6	-	-
Mexican jay	+	3.2	4.8
Stellar's jay	+	-	-
Common raven	+	+	+
Bridled titmouse	+	5.0	6.3
Common bushtit	+	-	-
White-breasted nuthatch	5.1	5.4	5.0

[1]Species was found in the area, but not in densities great enough to be calculated.

[2]Species was not recorded in the area.

[3]Density as determined by "variable circular plot method" by Reynolds et al (unpublished).

TABLE 3. ESTIMATED BIRD POPULATIONS (#/HECTARE) AT EACH OF THE STUDY AREAS

Cont'd

	N = 37 Madera	N = 27 Control	N = 29 Cut Area
Bewick's wren	+	6.0	6.3
Curve-billed thrasher	-	+	+
Robin	5.0	+	+
E. bluebird	+	1.3	1.3
Solitary vireo	2.5	-	-
Bl. Thr. gray warbler	+	3.1	2.5
Painted redstart	+	-	-
Olive warbler	+	-	-
Grace's warbler	+	+	+
Bullock's oriole	+	-	-
Western tanager	+	+	+
Bl. headed grosbeak	1.3	-	-
House finch	-	+	+
Rufous-sided towhee	3.8	+	+
Brown towhee	-	+	+
Mex. junco	+	-	-
Chipping sparrow	-	+	+

TABLE 4. TREE SPECIES IN WHICH HOLES WERE FOUND (%)

	Control Area	Cut Area
Arizona Oak	99	91
Emory Oak	1	5
Alligator Juniper	0	4

TABLE 5. NEST-HOLE TYPES FOUND
AND THOSE SELECTED BY HOLE-NESTERS (%)

		Cut Area	Control Area	$\overline{X}$
ALL HOLES:	Woodpecker Holes	37	25	31
	Branch Stubs	56	70	63
	Natural Cavities (cracks, etc.)	7	5	6
ACTIVE NEST HOLES:	Woodpecker Holes	85	67	76
	Branch Stubs	15	33	24

TABLE 6. MEAN DIAMETER BREAST HEIGHT OF TREES (WITH AND WITHOUT HOLES)

		Control Area	Cut Area
Mean DBH All Arizona Oaks	N = 26, 19	33 CM	24 CM
Mean DBH All Hole Trees	N = 76, 78	50 CM	47 CM
Mean DBH Woodpecker Trees	N = 22, 27	45 CM	45 CM
Mean DBH Active Nest Trees	N = 9, 13	60 CM	43 CM

TABLE 7. ASPECT OF NEST HOLES (%)

	Control Area	Cut Area	$\bar{X}$
All Holes Facing N to E	31	34	32
All Holes Facing W to N	22	19	20
All Holes Facing S to W	29	32	30
All Holes Facing E to S	19	15	17
Woodpecker Holes Facing N to E	26	55	40
Woodpecker Holes Facing W to N	43	15	29
Woodpecker Holes Facing S to W	17	18	18
Woodpecker Holes Facing E to S	14	12	13
Active Nest Holes Facing N to E	56	54	55
Active Nest Holes Facing W to N	11	30	20
Active Nest Holes Facing S to W	22	8	15
Active Nest Holes Facing E to S	11	8	10

TABLE 8. CONDITION OF NEST TREES (%)

	Control Area	Cut Area	$\overline{X}$
Dead[1] Trees Drilled by Woodpeckers	43	39	41
Live[2] Trees Drilled by Woodpeckers	57	61	59
Dead Trees Used by Active Nesters	44	31	38
Live Trees Used by Active Nesters	56	69	62

[1] At least half branches dead

[2] At least half branches alive

TABLE 9. ENTRANCE DIAMETERS OF NEST CAVITIES (%)

	Control Area	Cut Area	$\overline{X}$
Mean Diameter of All Cavities	6.7	5.6	6.2
Mean Diameter of All Woodpecker Cavities	4.9	4.9	4.9
Mean Diameter of All Active Trees	4.9	4.6	4.8

TABLE 10. DIRECTION OF FACE OF NEST CAVITIES (%)

	Control Area	Cut Area	$\overline{X}$
Holes Facing Upward	44	42	43
Holes Facing Downward	25	36	30
Holes Facing Horizontally	31	22	26
Woodpecker Holes Facing Upward	9	0	4
Woodpecker Holes Facing Downward	65	82	74
Woodpecker Holes Facing Horizontally	26	18	22
Active Nests Facing Upward	0	0	0
Active Nests Facing Downward	44	69	56
Active Nests Facing Horizontally	56	31	44

DISCUSSION

Before bird populations and nesting success can be compared, one must analyze the vegetation in each study area. My hope was that the two oak-juniper areas would be identical in tree species and density. Data pertaining to the study areas appear in Table 1. I used a technique introduced by Balda (1971) to measure the relative abundance of trees on each study area (Table 1). Considering the importance value, Juniperus deppeana is the dominant tree on each area. In each case (relative density, relative dominance, and relative frequency), Quercus emoryi is more abundant than Quercus arizonicus on the control area, but less abundant on the cut area.

This contrast of dominance could be attributed to selective cutting of Quercus emoryi by the public, since Arizona White Oaks cannot be legally cut on the woodcutting area. However, the extent of cutting in the cut area was not great enough to explain such a wide difference. I encountered few Emory Oak stumps in my density transects through the cut area. I must hypothesize, therefore, that the higher elevation, greater steepness of slope, and general dryness of the control area has led to a higher density of Quercus emoryi in the control area. Conversely, the cut area may be a wetter and more suitable habitat for Arizona Oaks. Quercus arizonicus was clustered near washes in both areas. The cut area had running water in its washes late in the dry season (mid May); the control area had none. I concluded that, although Juniperus deppeana dominates each area, the second most dominant tree is Quercus arizonicus in the cut area, the Quercus emoryi in the control area.

More nests were found (13) in the cut area than in the control area (9). Ten of thirteen nesting attempts were successful (at least one bird fledged) in the cut area; six of nine in the control area (Table 2). In estimating bird populations over the two areas, I found only two species (Ash-throated Flycatcher, Black-throated Gray Warbler) in greater abundance in the control area. I found one species in the cut area that was not counted in the control area (hummingbird sp.), and populations were not statistically different over the two areas (t test 1%) (Table 3). These data seem to indicate that woodcutting has not affected bird populations or nesting success. However, the areas may not be equally able to support bird populations. The greater density of Arizona Oaks in the cut area (Table 1) may allow it to support a greater density of birds. Thus, the data's interpretation is unclear. One may argue that the effects of woodcutting are not limited to the cut area, that bird populations are affected on either area. The access road traversed the control area (Fig. 3) but its effects are difficult to quantify. I saw no evidence of illegal cutting on the control area, but there was some evidence in the cut area. Lower limbs were often removed from large unmarked trees, especially junipers. Noise from chain saws was often heard on the control area, but its effect may be minimal. In my estimation, the vegetational contrast between the two areas is due in a small part to woodcutting; more importantly, it is due to elevation, slope, water, experimental error, etc. This vegetation difference may explain the nesting success on the cut area.

One must consider the positive effects of woodcutting -- creation of slash being an important one (Fig. 4). According to the Forest Service manual (Johnston 1978), slash must be piled in drainages, where available, to be used as erosion control, wildlife habitat, or to be burned at a later date by Forest Service personnel. Slash piles were commonly found on the cut area, especially near the access road. I noted a greater population of cottontails (Sylvilagus floridanus) in the cut area than in the control area. Many were flushed from slash piles left by woodcutters. In his study of hole-nesting birds, McClelland (1976) mentions that woodcutting may be detrimental when feeding sites are covered with cut trees and branches. In my study area, these piles were used to a limited extent by insectivorous birds. However, I do not consider slash piles a negative effect of woodcutting. This is partly because there was only one common ground feeder found in the study areas: the rufous-sided towhee.

Increased food resources for livestock is a positive effect of woodcutting noted by the Forest Service. The Forest Service plans to prune existing trees and clearcut to accomplish this. Extensive pruning has been done, but only near the access road (Fig. 3). This practice may increase the growth of grass, but seems offset by poor aesthetics. Clear-cutting would benefit the Mearn's Quail, among others, which has been reduced with the decrease of grass in southern

FIG. 4. SLASH PILES LEFT BY WOODCUTTERS ON THE WESTERN OAK-JUNIPER AREA

Arizona. It prefers grassy woods (Marshall 1957). However, forest species of birds would surely suffer. Further goals not yet completed are:

1. Provision for perennial water sources for wildlife and livestock;

2. Increased cover availability for wildlife; and,

3. Provision for the sustained yield of harvestable timber.

Finally, some erosion has been prevented on the woodcutting area by creation of slash piles and blockage of auxiliary roads through the area. However, erosion has been considerable along the access road, making it impassable for the winter season and most of the spring. If the full benefits of the fuelwood program are to be realized, the Forest Service must make an effort to keep the access road passable, especially for non four-wheel-drive vehicles.

It became apparent early in the study that Quercus arizonicus was the preferred hole-nesting tree to Quercus emoryi and Juniperus deppeana. The abundance of Quercus emoryi (16% cut, 35% control, importance value) is far above the proportion of Emory Oak hole trees found during search for hole nests (3 cut area, 1 uncut area) to the total number of hole trees found (76 cut area, 78 uncut area) (Table 1). On the other hand, 91% of hole trees were Arizona Oak on the cut area and 99% on the control area (Table 4). Importance values for Arizona Oak were 22% (control) and 33% (cut area). I would hypothesize that Quercus arizonicus is selected over Quercus emoryi by hole-nesters because of its decay characteristics. Thus, woodpeckers are able to excavate suitable cavities. Other authors have noted hole-nesters' preference for soft wooded trees; for instance, Aspen was preferred by flickers (Dennis 1969). Juniperus deppeana was completely ignored by hole-drillers despite a great number of large dead junipers with suitable limbs (Fig. 5). Apparently woodpeckers cannot break the outer hardwood of Juniperus deppeana and have a comparatively difficult time with Quercus emoryi.

Several classifications of hole types were used in the study:

1. Those drilled by woodpeckers (Fig. 6);
2. Those resulting from branch stub decay (Fig. 7); and,
3. Other natural cavities (cracks, etc.).

The most common type of hole that I found was the branch stub type (56% cut area, 70% control area) (Table 5). The abundance of branch-stub caused holes in the population may be due to lack of selectivity in procedure. I was not selective in tagging potential nest holes and tagged many that may have been unsuitable for one reason or another. Pinkowski (1976) claims that of the unused cavities he found, most 1) had a larger cavity diameter, and 2) had a greater number of dead branches than those trees which were used by hole-nesters.

Holes drilled by woodpeckers were second most prevalent (37% cut area, 25% control area). However, secondary hole-nesting birds preferred woodpecker holes. On the control area, 67% of active nest holes were drilled by woodpeckers; on the cut area 85% of the active nest holes were woodpecker-caused. Woodpecker holes are preferred by

FIG. 5. A DYING ALLIGATOR JUNIPER WITHOUT NESTING CAVITIES

FIG. 6. NEST HOLE MADE BY AN ARIZONA WOODPECKER
IN AN EMORY OAK

FIG. 7. A HOLE RESULTING FROM BRANCH STUB ROT
IN AN ARIZONA WHITE OAK

secondary hole-nesting birds because their diameter is small enough to keep predators out and large enough to permit entrance by the bird. This preference for woodpecker holes points out the ecological importance of primary hole-nesters in the oak-juniper woodland. Without these birds, secondary hole-nesters would have to move elsewhere. In this case, the hole-drillers are Arizona woodpeckers and flickers.

To the forester, possibly the most important measure of all is the average DBH of the nest trees (Table 6). Trunk diameter may affect avian preference since many Arizona Oaks with holes were larger (greater than 77 CM DBH) than the largest Emory Oak (67 CM). However, some extremely small Arizona Oaks (DBH: 26 CM) were found with a woodpecker hole, so DBH is probably not a limiting factor. The average DBH for all hole trees on the two areas was nearly equal (50 CM cut area, 47 CM uncut area), and the average DBH of trees with woodpecker holes was identical (45 CM). However, woodpecker holes were found in larger Arizona Oaks than average: 45 CM to 24 CM on the cut area, 45 CM to 33 CM on the uncut area (Table 6). This may be because Arizona Oak trees less than 26 CM were insufficiently large to provide trunk space for a nest. McClelland (1976) noted that few nests were found in sites where pole (DBH less than 23 CM) or where smaller size trees predominated. Sixty percent of the hole trees were less than or equal to 46 CM DBH; 40% were greater than 46 CM DBH. Apparently the preferred oaks were less than 46 CM DBH. Greater DBH than average trees are selected for trunk cavity space.

The aspect of the nest hole was also recorded (Table 7). This refers to the direction the entrance hole faces. I divided the compass into four 90° sectors: N to E (0-90°); E to S (90-180°); S to W (180-270°); and W to N (270-360°) for hole-nest classification. I included each nest in one of these sectors. For all holes found (woodpecker, stub, etc.), N-E and S-W were the most used aspects. However, as we have seen, many of these holes may never have been used, so a better measure of aspect preference is woodpecker holes. In this sample, N to E and W to N are the most commonly found, but there is disagreement in the two study areas. An average of the two areas shows N to E the preferred direction (40% N-E, 29% W-N). N to E was the overwhelming choice according to the nesting data (56% control area, 54% cut area). There may be several explanations:

1. Avoidance of the summer afternoon sun;
2. Avoidance of summer thunderstorms (usually associated with southerly winds) and winter frontal rains (usually associated with westerly winds), thus keeping rain water out of the nest hole.

In addition, S to W (18%) and E to S (13%) seem to be selected against, presumably for the same reasons.

The aspect of nest location has been discussed by many authors, and there seems to be considerable disagreement regarding it. From central Ontario, Lawrence (1967) reports that southeast facing is the preferred direction. In Massachusetts, Dennis (1969) found south and east facing holes most abundant. In Michigan, Pinkowski (1976) reported that southeast is the most commonly found direction that nest holes face. Only Conner et al (1975) found more nests facing northeast (in Virginia), but he said that it was due to the slope of the land. Slope in the area was such that, to excavate a hole on the down-facing side of the trunk, the hole must face northeast. Evidently, warmth from the morning sun plays a part in the nest-hole selection from these studies in northern latitudes. On the oak-juniper study areas, slope was variable in and around the dry washes, and difficult to evaluate. Avoidance of afternoon sun seems to be a factor in choosing an Arizona nest hole. Finally, these authors have further explanations for hole nest selectivity which may also apply to Arizona. Blume (1961) suggests that folds and other types of growth of the wood caused by scars, branches, fungi, or the weather may afford conditions for easier excavation of cavities. These growths are most prevalent on a tree's north side. Lawrence (1967) points out the importance of the roughness of bark, resulting in a good foothold. Apparently bark is rougher on the north side of the tree.

Another variable measured in this study was the relative health of the nest tree (Table 8). I used four categories ranging from dead to alive, depending upon the amount of live foliage. Woodpecker holes seem to provide the most consistent data because these holes were used at one time. The majority (59) of the trees with woodpecker holes had more than one-half live branches. This may be because many dead trees which are easily excavated by woodpeckers are also easily destroyed by predators. Gray foxes and coyotes frequented the study area. Due to the relatively small size of the nest trees, these predators are probably able to reach lower branches. Also, nearly dead trees may blow over in summer thunderstorms which are often accompanied by strong winds. Ideally, a woodpecker may search for a tree just soft enough to excavate but not soft enough to be entered by a predator. Pinkowski

(1976) found that of the unused cavities he found, most were found in trees with more dead branches than those which were used by hole-nesters. Foresters should be careful to leave large live Arizona Oaks and those with a few dead branches.

Because of predation, hole diameter is important to hole-nesters (Table 9). Many branch stub holes were probably unused because their diameters were too large. Mexican jays in the area may raid cavity nests with diameters large enough to permit entry. Small birds are able to enter amazingly minute holes so it is no surprise that the average woodpecker hole was 4.9 CM in diameter. The average diameter of all holes was larger (6.2 CM) because many large diameter unused nests were tagged.

Exposure of the nest hole is an important selective factor. Exposure refers to the angle with the vertical that the hole faces (Table 10).

I used three categories:

1. Facing up (Fig. 6);
2. Facing down; and,
3. Facing horizontally (Fig. 5).

I consider the woodpecker holes to be the best measure of hole preference. Only 9% of all woodpecker holes faced upward on the control area; none on the cut area. The remainder of the holes on each area was divided between down-facing and horizontally-facing, with more facing down in each case. None of the active nests faced upward in either area. In Southern Arizona, rainfall as well as direct sunlight may discourage birds from choosing holes with an upward facing exposure. Rainwater may drip into an upward facing hole or a horizontally facing one, but is less likely to fill a down-facing one. As high as the summer sun reaches in June (9° south of directly overhead at mid-day), it would be difficult to keep an upward facing nest cool. Birds in both study areas selected horizontally or down-facing holes. Other authors found this to be the case. Lawrence (1967) found that most holes faced downward; she claimed this was because downward-facing holes are less visible to predators. Conner (1975) believes that the underside of the tree trunk is a better microenvironment for fungi, thus, permitting easier excavation of the hole. He also mentioned that a downward-facing hole is easier to defend than an upward or horizontally facing one.

Seventy-two percent of the Ponderosa Pines (Pinus ponderosa) and 60% of the Quaking Aspens (Populus tremuloides) in the nearby Santa Catalina Mountains had more than one hole per hole-nesting tree. The following data shows that most hole-nesting trees on the oak-juniper study areas had only one hole per tree. Only four of twenty-seven (15%) woodpecker-drilled nest trees had more than one hole in the cut area. In the control area, one of twenty-two (4%) had more than one nest hole. McClelland (1976) found that 70% of western larch nest trees had three or more nest holes, indicating reuse from year to year. Apparently there are not as many possible nest hole sites on the Arizona White Oak because of its relatively small size. These data seem to emphasize the importance of retaining a large number of potential Arizona White Oak nest trees in an area, since no one nest tree can accommodate a large number of hole-nesters.

As I mentioned earlier, bird populations of the control area and the cut area are not significantly different (Table 3) (t test 1%). Therefore, I will consider the differences between Madera Canyon counts and oak-juniper study area counts (elevation of each approximately 1,524 M).

The most notable difference is the number and abundance of species at Madera Canyon. Speaking of the riparian woodland, Marshall (1957) notes its height, diversity, rich understory of herbs, shrubs, and flowers, and its extended edge permit a greater concentration of birds, considering its narrowness. The author mentions that eleven species from his pine-oak woodland list would not occur on the consensus (pine-oak woodland) without riparian woodland: Cooper's Hawk, Mexican Black Hawk, Blue-throated Hummingbird, Black-Chinned Hummingbird, etc. This trend seems to fit my data since seventeen species observed at Madera Canyon were not noted at the study areas. Eight species were observed on the oak-juniper study areas, but not at Madera Canyon. It should also be mentioned that riparian flora of Madera Canyon, especially old Arizona Sycamores, provides an abundance of hole-nesting space. Some of the larger trees contained as many as five cavities, presumably drilled by Acorn Woodpeckers, but used also by secondary hole-nesters. As Marshall (1957) points out, there is a greater variety of species (16) in the riparian woodland (such as Madera Canyon) than there is in oak-juniper areas (14). However, he found thirteen pairs (birds) per mile in the riparian woodland, twenty-nine pairs per mile in the oak-juniper. Bailey (1923) recorded fifty-three species at Gardner Canyon (near the oak-juniper study areas), sixty-five species at Madera. Although most birds recorded on the study areas are found in vegetation types other than the oak-juniper type, some are more or less dependent upon it. One example of a bird that can exist in a variety of vegetational types is the Spotted Screech Owl, which was found on the eastern study areas and at Madera Canyon. Marshall (1957) claims that the Spotted Screech Owl is at home in any kind of woodland. The Arizona Woodpecker, however, is restricted to woods in which oaks are plentiful (Marshall 1957). Because it is a primary hole-nester, its disappearance would result in the exodus of secondary hole-nesters such as those in this study.

This evidence seems to point out the importance of retaining the oak-juniper woodland as well as the riparian woodland. Hopefully, retention of the oak-juniper woodland is not the issue here. The question should be: How much shall it be changed? Some species will benefit by its change; others will not. As mentioned earlier, a greater abundance of grassy areas, created by fuelwood cutting of oaks, may result in a greater number of Mearn's Quail, as well as Eastern Bluebirds, which prefer savannah-like woods or frequent clearings (Marshall 1957). According to Balda (1969), the Black-throated Gray Warbler, Chipping Sparrow, Bridled Titmouse, Black-Chinned Hummingbird are able to utilize successfully the high foliage density provided by Alligator Juniper. These birds' populations would probably be reduced with the removal of that species. Ash-throated Flycatchers prefer rocky or brushy encinal slopes (Marshall 1957), so this species would benefit from a reduction in tree density. The Rufous-sided Towhee is favored by logging, clearing, and fuelwood cutting which results in the growth of oak scrub. The Brown Towhee as well prefers open woods and prevalence of meadows. Its greatest numbers are reached in grassy woods. Continuous chapparal and scrubby oak and juniper-choked woods of Southern Arizona Mountains are of course unacceptable (for the Brown Towhee) (Marshall 1957). Finally, a key species whose disappearance would indicate change of the environment's composition may be the Arizona Woodpecker. As I have mentioned, this bird relies on the oak type and will disappear if there is too much cutting. Foresters should monitor this bird's population as fuelwood cutting programs progress.

The importance of the oak-juniper woodland to avian as well as other wildlife species cannot be doubted. Although this study fails to quantify this belief as Balda did (1971), all trees in the environment are used to some extent by birds. Although Juniperus deppeana is an invader and provides no hole-nesting space, it is extensively used by several species for roosting, foraging, nesting, etc. Morse (1967) and McArthur and Levins (1964) found that the volume of foliage may be an important factor in limiting density of some species of birds. Thus, the impact of extensive cutting as practiced in the Sierra Vista Forest Service District (adjacent to the east) may be significant. Sixty to eighty percent removal of trees in that area may have affected bird populations. It seems far better to remove a small percentage of selected trees from many areas (as in the Nogales district), than a large percentage from a new area. Since there is no shortage of nest-hole trees on the study areas, 20 to 30% of all trees could be removed without affecting hole-nesting birds. Special care should be taken to leave all Arizona Oak trees, of 40 CM or greater DBH near gullies, as well as all trees with woodpecker holes. Due to the relatively small size of the trees in the oak-juniper woodland, foresters can identify trees with holes easily and insure that they are not cut.

These guidelines should be followed in future oak-juniper fuelwood programs.

1. Several designated areas per forest service district should be available to the public to avoid overuse of a few areas;
2. Only specifically marked trees should be cut;
3. Oaks should be cut to a limited extent, junipers or other invading species to a greater extent;
4. No trees should be cut in or near dry or flowing washes;
5. Periodic avian censuses should be taken to evaluate the effects of tree removal, with special attention paid to Arizona woodpeckers.

If these guidelines are considered, the integrity of the oak-juniper woodland may be preserved and fuelwood needs satisfied.

LITERATURE CITED

Bailey, Florence Augusta.
1923. Birds Recorded From the Santa Rita Mountains in Southern Arizona. 60 p.

Balda, Russel P.
1969. Foliage Used by Birds of the Oak-Juniper Woodland and Ponderosa Pine Forest in Southeastern Arizona. Condor 71(4): 399-412.

Blume, D.
1961. Uber die Lebenweise einiger Spechtarten. Journ. Ornithology 102: 1-115.

Conner, Richard.
1975. Orientation of Entrances to Woodpecker Nest Cavities. Auk 92(2):371-374.

Conner, Richard; Hopper, Robert G.; Crawford, Hewlette S. and Mosby, Henry S.
1975. Woodpecker Nesting Habitat in Cut and Uncut Woodlands in Virginia. J. of Wildl. Manage. 39(1):144-150.

Cottam, G. and Curtis, J. T.
1956. The Use of Distance Measures in Phytosociological Sampling. Ecology 37:451-460.

Dennis, John.
1969. The Yellow-shafted Flicker (Colaptes auratus) on Nantucket Island, Massachusetts. Bird Banding 40(4):290-308.

Emlen, J. T.
1971. Population Densities of Birds Derived From Transect Counts. Auk 88(2):323-342.

Erskine, A., and McClaren, W.
1972. Sapsucker Nest Holes and Their Use by Other Species. Canad. Fld. Nat. 86(4):357-361.

Forest Service U.S.
1980. Region Three Sang Management Policy on National Timber Sales. F.S.M. 3/78 R-3. Supp. 130. 4 p.

Johnston, A. L.
1978. Environmental Analysis Report: Fuelwood Sale Project, U.S. Forest Service, Nogales District, Arizona. 5 p.

Kearney, Thomas H. and Peebles, Robert H.
1951. Arizona Flora, U. of Calif. Press, 1081 p.

Lawrence, Louise.
1967. A Comparative Life History Study of Four Species of Woodpeckers. Ornithological Monographs No. 5. 156 p.

Lowe, Charles H.
1964. Arizona's Natural Environment; Landscape Habitat. U. of Ariz. Press, Tucson, Arizona. 136 p.

Marshall, Joe T.
1957. Birds of Pine-Oak Woodland in Southern Arizona and Adjacent Mexico. Pacific Coast Avifauna 32. 125 p.

McArthur, R. H., and Levins, R.
1964. Competition, Habitat Selection, and Character Displacement in a Patchy Environment. Proc. Natl. Acad. Sci. 51:1207-1210.

McClelland, R.
1976. Relationships Between Forest Snags and Birds in the Northern Rocky Mountains. Ph.D. Dissertation (Summary). U. of Mont. 7 p.

Michael, Edwin, and Thornburgh, P.
1971. Immediate Effects of Hardwood Removal and Prescribed Burning on Bird Populations. S.W. Nat. 15(3):359-370.

Morse, D. H.
1967. Competitive Relationships Between Parula Warblers and Other Species During the Breeding Season. Auk 84:480-502.

National Oceanic and Atmospheric Administration
1978. Climatological Data. Vol. 83, No. 3.

Pinkowski, Benedict.
1976. Use of Tree Cavities by Nesting Eastern Bluebirds. J. of Wildl. Manage. 40(3):556-563.

Reynolds, R. T., Scott, J. M., and Nussbaum, R. A.
1978. A Variable Circular Plot Method for Censusing Birds. Unpublished.

Scott, Virgil, and Patton, David.
1975. Cavity-nesting Birds of Arizona and New Mexico Forests. USDA Forest Service, General Technical Report, RM-10, 51 p.

Verner, J. (Technical Coordinator)
1975. Proceedings of the Symposium on Management of Forest and Range Habitats for Nongame Birds. USDA Forest Service, General Technical Report, WO-1, 343 p.