RESULTS OF THE FOUR CORNERS COOPERATIVE BAND-TAILED PIGEON INVESTIGATION

A Cooperative Research Effort Conducted by the States of Arizona, Colorado, New Mexico, and Utah

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ABSTRACT

This report provides the results of intensive studies conducted from June 1967 through October 1972, of band-tailed pigeons (*Columba fasciata*) breeding in the Four Corners States of Arizona, Colorado, New Mexico, and Utah. Organized trapping and banding of band-tailed pigeons resulted in 25,730 pigeons being banded, 2,878 of which were young of the year. Bandtails were found throughout forested mountains from northern Colorado and central Utah through Arizona and the western two-thirds of New Mexico into Mexico. Wintering areas were found to be primarily along the Sierra Madre Occidental as far south as Michoacan, Mexico. Distribution of pigeons was closely related to the distribution of pine and oak, generally from 1,575 to over 3,355 m (5,000 to over 11,000 ft) elevation. Major feeding sites were in montane conifer forest, evergreen woodlands, and chaparral where mast was available, but feeding also occurred at lower elevations in cultivated fields and livestock feeding areas. In Mexico, as mast was depleted in the oak-pine woodlands, bandtails were found in the subtropical deciduous forest as low as 244 m (800 ft). Peak spring migration of bandtails was in late April to mid-May. Fall migration peaked in mid-September in Colorado and Utah and mid-October in Arizona and New Mexico. Two major southward migrations routes in the United States were identified: one from south central Colorado southwest across New Mexico to extreme southwestern New Mexico and southeastern Arizona; the other southwest from central and western Colorado to east central Arizona, where a route from Utah converged, then south along the New Mexico and Arizona boundary. Northward migration is presumed to follow the same routes. Usuable recoveries were available from 556 pigeons banded in 1967–1972. Only five recoveries were recorded from West Coast areas, indicating little mixing of Interior and Coastal populations. The mean annual, 1st-yr direct recovery rate was 1.5% for adults and 2.2% for immatures. Adjusted recovery rates (harvest rates) were 1.7% for adults and 2.4% for immatures. Mean annual harvest rates were lowest in New Mexico (1.3%) and Colorado (1.6%) and highest in Utah (2.9%) and Arizona (2.4%). Mean annual survival rates for adults and immatures were 63.9% and 58.3% respectively. An estimated 29% of the Interior band-tailed pigeon harvest occurred in Mexico. During the 5-yr study, 13,432 permits for hunting band-tailed pigeons were issued. The 7,246 permitees who actually hunted reported a total retrieved harvest of 19,971 or about 4,000 per yr. Average reported crippling loss was 15% of the retrieved harvest. Public and hunter attitudes toward pigeon hunting were favorable throughout the Four Corners Region.

INTRODUCTION

Band-tailed pigeons (*Columba fasciata*) are large, mobile columbids that occupy suitable forest and woodland habitats in western North America, Central America, and northern South America (Goodwin 1967). North of Mexico, two populations are recognized. The Coastal population (*C. f. monilis*) breeds throughout California, western Oregon, and Washington, and into south central British Columbia. Some birds occur as far north as southeast Alaska. This Coastal population winters from south central California into Baja California Norte. The Interior population (*C. f. fasciata*), north of Mexico, breeds primarily in Colorado, Utah, New Mexico, and Arizona (hereafter referred to as the Four Corners States), with some pigeons occurring in the mountains of southern Nevada, Wyoming, and Trans Pecos, Texas. Pigeons of the Interior populations mainly winter in and adjacent to the Sierra Madre Occidental in north central Mexico where they mingle with resident pigeons of the same species.

Little was known about numbers, distribution, and population biology of the Interior race before the late 1960's. Hunting seasons for the Interior population of bandtails were discontinued in Colorado after 1944 and in Arizona and New Mexico after 1950 due to concern that numbers of pigeons might be declining throughout the region. Pigeons had not been legal game in Utah since establishment of game laws. In the absence of quantitative data and lack of funding, band-tailed pigeons received little attention; consequently, hunting seasons for the Interior race remained closed until 1968. In order to ascertain the distribution, preferred habitats, mortality, survival, migration routes, and harvest patterns of band-tailed pigeons seasonally resident in the Four Corners States, personnel from the four States formed a technical committee in 1967 to coordinate activities, to avoid duplication, and to insure uniform studies. This group, the Four Corners Cooperative Band-tailed Pigeon Technical Committee (FCPC), consisted of one person from each State responsible for directing pigeon research activities in his State. Work was initiated in Arizona in 1967, in New Mexico in 1968, and in Colorado and Utah in 1969. Once these research efforts had begun, hunting seasons were necessary to obtain sufficient band recovery data so that harvest levels and mortality rates could be estimated and migration routes and wintering areas identified. Experimental hunting seasons for pigeons were requested and approved in Arizona and New Mexico in 1968, and in Colorado and Utah in 1970.

The availability of funding from the Accelerated Research Program (ARP), for research on migratory shore and upland game birds provided impetus for research on band-tailed pigeons. The funds received, administered through the U.S. Fish and Wildlife Service, were not substantial but were adequate to support much of the work accomplished in New Mexico and Utah. Most pigeon research in Arizona and Colorado was funded by the Pittman-Robertson Federal Aid to Wildlife Restoration Act. In Colorado and New Mexico, some ARP funds supported graduate research projects on band-tailed pigeon molting patterns (White 1973) and reproductive biology (Gutierréz 1973). This report covers the principle research period of 1 June 1967 to 1 June 1973.

REVIEW OF LITERATURE

Neff (1947) published the first general account concerning life history and naturalistic observations of pigeons north of Mexico. In the mid-1950's, studies emphasizing nesting of bandtails in California were conducted by Glover (1953) and MacGregor and Smith (1955). Interest in the Coastal population increased in the 1960's with studies at Oregon State University. These studies concerned calling rates (Sisson 1968), overall mortality rates (Silovsky 1969), crop gland activity cycles (Zeigler 1971), and the feasibility of using pigeon calling counts as an indicator of population trends (Keppie et al. 1970; Keppie 1973). In California, Peeters (1962) studied nesting and courtship behavior, and Smith (1968) reported on earlier general studies of pigeons. Houston (1963) studied reproductive ecology in northern California, and Drewien et al. (1966) reported on weights of pigeons of that population. Recovery data from long term banding at one site in Oregon were reported by Mace and Batterson (1961), and Wight et al. (1967) reanalyzed and extended the data from this site.

Age characters of bandtails were reported by Silovsky et al. (1968) from examinations of birds captured and harvested in Oregon and California. Limited surveys of parasites from bandtails of the Interior population have been reported by Stabler and Matteson (1950), Stabler (1951), and Sileo and Fitzhugh (1969). More recently, studies of breeding phenology and biology, and use of minerals by band-tailed pigeons in British Columbia have been reported by March and McKeown (1973) and March and Sadlier (1970; 1972).Braun (1972b; 1973b) recently reported on subpopulations, distribution, and habitats of pigeons breeding in Colorado. Most other published reports concerning band-tailed pigeons pertain to distribution, nest observations, and hunting; the literature has been reviewed and summarized by Fitzhugh (1970).

METHODS

Distribution and Habitat

Data relating to distribution, occupied habitats, and relative abundance of band-tailed pigeons of the Interior population were obtained in part through surveys of field personnel of the four State conservation agencies, U.S. Fish and Wildlife Service, U.S. Forest Service, National Park Service, and Bureau of Land Management. FCPC personnel and other cooperators reported observations of bandtails on standardized monthly observation forms. Efforts were made to locate all reported observations on County or National Forest maps, which were later combined for a composite distribution map. Most locations were visited by FCPC personnel for visual classification of the vegetation and physical features of the environment. Some additional location data were available from hunter questionnaire and wing surveys. Collections of bandtails provided information on habitat preferences and food utilization. Present distribution and habitat preferences of bandtails were compared with those described in published and unpublished reports and correspondence files of the agencies involved. Distribution of and habitats utilized by band-tailed pigeons wintering in Mexico were ascertained through band recovery data and field inspection of localities where bands were recovered (Brown 1972; Braun 1973c).

Trapping

Bandtails were trapped whenever concentrations (usually of 30 or more birds) were located. Most pigeons were trapped by cannon and rocket projected nets (Dill and Thornsberry 1950; Dill 1969). Most nets were of a 32 mm (1¼ in) mesh and measured approx. 9.1 × 18.3 m (30 × 60 ft) and were projected by three cannons or rockets. Additionally, 0.91m² (3 ft²) modified cage type funnel traps (Reeves et al. 1968) and clap net traps (Christensen 1962) were used, mostly at sites too small for cannon nets. A few pigeons were captured in standard mist nets as described by Reeves et al. (1968). A summary of

various techniques employed is provided by Evans (1972).

Bait varied with the site; grains such as barley (*Hordeum vulgare*), wheat (*Triticum aestivum*), corn (*Zea mays*), and milo (*Sorghum vulgare*) were used most frequently. Generally, pigeons were trapped at livestock feeding areas and in harvested or newly seeded grain fields in mountainous regions. In Arizona, most pigeons were captured at sites where they were obtaining salt. In Colorado and New Mexico, substantial numbers of pigeons were also trapped where they were attracted to residential feeding stations maintained for smaller birds. Most pigeons banded in Utah were captured adjacent to a commercial grain elevator.

Age and Sex Determination

Most of the pigeons trapped were classified only as adult (AHY) or immature (HY) (Silovsky et al. 1968); after 1970, Colorado and New Mexico also distinguished subadults (SY) using criteria reported by White (1973). Initially, sex of pigeons was determined by cloacal inspection (Miller and Wagner 1955), but this method proved to be tedious and time consuming, and was replaced for most individuals by visual examination of plumage characters. Reliability of the plumage character sexing method was tested annually on collected pigeons, and proved to be at least 95% accurate (Braun, unpublished data).

Migration and Mortality

Migration activity was originally tabulated as to arrival and departure by the presence or absence of field observations. As the study progressed and large numbers of banded birds became available, band recoveries provided the major method of determining migration patterns.

Mexican recoveries were plotted and arranged in chronological categories to delimit the wintering range, heretofore unknown (Brown 1972). Major concentrations within the wintering range were identified as additional band recoveries became available. With data collected during interviews with hunters, Braun (1973c), verified the location of band recoveries and conducted field investigations in selected areas where Mexican recoveries were concentrated. Most band recovery data were examined to provide further insight into migration and movement.

Recovery rates and annual mortality estimates were based on band recoveries. To calculate these rates, bandtails were divided into adult (including subadults) and immature categories. Those birds banded in areas closed to hunting were excluded from the analysis until the areas were opened. First-year recovery rates for the Interior population were calculated by pooling the data from all pigeons banded from 1967 through the summer of 1972. All "shot", computer code (01), and "found dead", code (00), recoveries through June 30 of the year following banding were divided by the number of pigeons banded to determine a mean annual, 1st-yr recovery rate.

Mortality rate estimates were also based on pooled banding data. Mean annual 1st, 2nd, 3rd, and 4th yr recovery rates were calculated from the pooled banding data for the Four Corners banded population by a method similar to that for deriving mean, direct recovery rates. Because of extensive hunting surveys, it was thought that nearly all recoveries in the United States were reported. Therefore, a weight factor of 1 was assigned to each U.S. recovery. Since recoveries from Mexico decreased with time, probably only 50% of those recoveries were reported. Consequently, a weight factor of 2 was arbitrarily assigned to all recoveries from Mexico (Braun 1973c, Brown 1972, Brown 1973).

Harvest Studies

Each year, all band-tailed pigeon hunters in the Four Corners Area were required to obtain free permits from State conservation agencies. This requirement provided a mailing list for the distribution of questionnaires pertaining to harvest and hunting activity, as well as postpaid envelopes for collecting wings. Consequently, annual samples of wings from harvested birds were available for determining age ratios and hatching dates of immatures. Standardized mail questionnaire surveys were conducted each year in all four States im-

mediately following the hunting season. In addition, field bag checks were conducted annually in selected areas to ascertain the number of adult (and subadult) pigeons still showing evidence of nesting activity. Interior linings of crops were examined and classified as active, stimulated, or inactive (Zeigler 1971). All pigeons with crop gland development were considered to be still rearing young.

Other Studies

Individual States participating in the overall project conducted studies of food habits, molting rates, reproductive biology, seasonal changes in weights and body condition, parasites, and pesticide levels. Some of these studies have been reported in Federal Aid Job Completion reports. Others are, or will be published elsewhere.

RESULTS AND DISCUSSION

Distribution

Distribution of band-tailed pigeons in the Four Corners States (Fig. 1) was determined from field investigations, literature review, and band recoveries. No discernible change in distribution from that previously reported is apparent in the United States. Wintering range and distribution in Mexico is in need of further investigation, but the present study provided initial insight into these phenomena.

The Interior race of the band-tailed pigeon has its ecological center of abundance in the Sierra Madre Occidental of Mexico. Habitat becomes less suitable as the range of the bandtail extends northward through the higher forested mountains of Arizona, New Mexico, and west Texas, to north central Colorado and southern Wyoming, and westward into southern and central Nevada. Distribution in many of the Mexican sierras is unknown, but scattered records (Leopold 1959) indicate that birds occur throughout the montane conifer forest and oak-pine woodlands in the Mexican States of Sonora and Chihuahua, south along the crest of the Sierra Madre Occidental to Michoacan. Band-tailed pigeons known to inhabit the Sierra Madre del Sur and southward are now presumed to be separate populations.

The northern boundary of the wintering range of the Interior race is irregular; pigeons remain through some winters in the Mexican States of Sonora and Chihuahua, and in extreme southern Arizona (Phillips et al. 1964), extreme southwestern New Mexico (Sands and Zapatka, unpublished data) and Texas (Wauer 1973). Wintering in these northern regions appears to be related to the availability of food. Band recoveries indicate that the bulk of the Interior population spends the late winter and early spring in the high gorges or *barrancas* of the Sierra Madre Occidental along the Durango-Sinaloa border (Fig. 2).

Habitats Occupied

Depending upon the season, band-tailed pigeons of the Interior population occupy a wide variety of habitats, ranging from agricultural areas as low as 244m (800 ft) to berry producing shrub areas at or over 3,355m (11,000 feet) elevation. The highest densities of bandtails in the Four Corners States generally occur at elevations between 1,677m (5,500 ft) and 2,593m (8,500 ft), particularly in forests dominated by ponderosa pine (*Pinus ponderosa*) and Gambel oak (*Quercus gambelii*). These and other communities in the temperate montane conifer forest (Fig. 3) are generally the most important habitats for bandtail nesting and feeding in the Four Corners States. Vegetation type names follow the classification of Brown and Lowe (1974a and b).

In northern areas (Utah, Colorado, and portions of New Mexico) pigeons are present (and nest) in low numbers in spruce-alpine fir communities (Fig. 4) of the boreal subalpine conifer forest. The forests are usually characterized by Engelmann spruce (*Picea engelmanni*), Douglas fir (*Pseudotsuga menziesii*), subalpine fir (*Abies lasiocarpa*); and the subclimax species, lodgepole pine (*Pinus contorta*), limber pine (*Pinus flexilis*), and aspen (*Populus tremuloides*). Periodically, pigeons may be found at lower elevations feeding in orchards and pinyon-juniper woodlands. Cottonwood (*Populus* spp.) and other riparian deciduous forest communities adjacent to grain

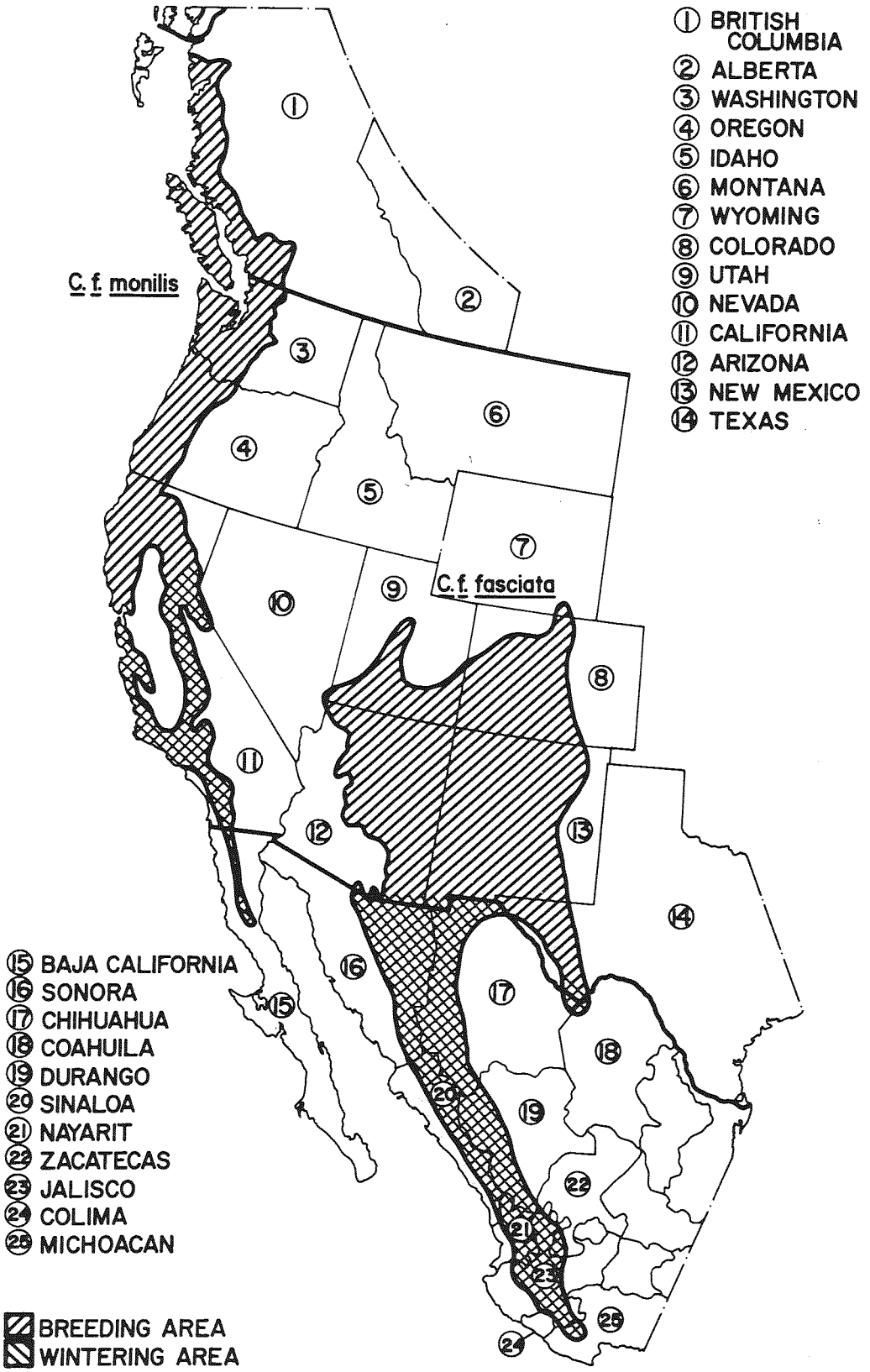

FIGURE 1.—Breeding and wintering distribution of the Coastal and Interior races of band-tailed pigeons.

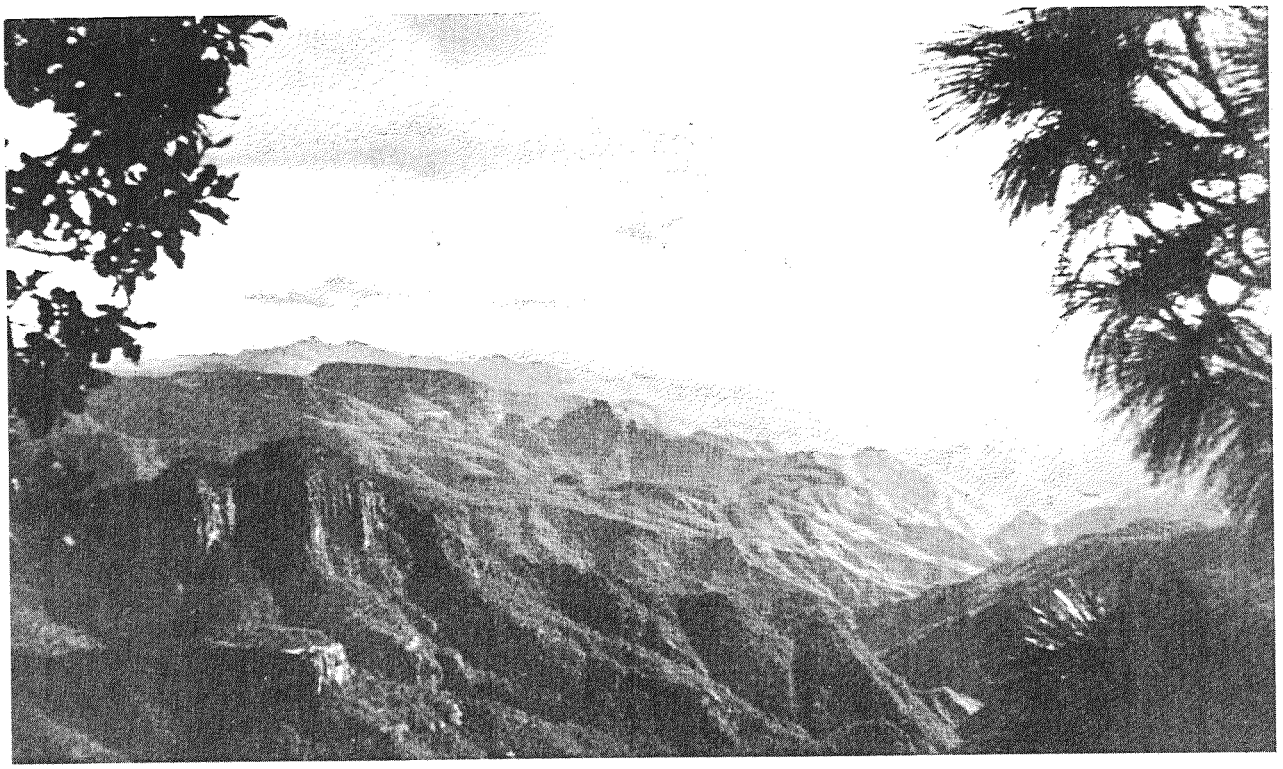

FIGURE 2.—Interior band-tailed pigeon winter range, Sierra Madre Occidental Mountains, Durango-Sinaloa border, Mexico.

FIGURE 3.—Montane conifer forest, Mogollon Rim, Arizona.

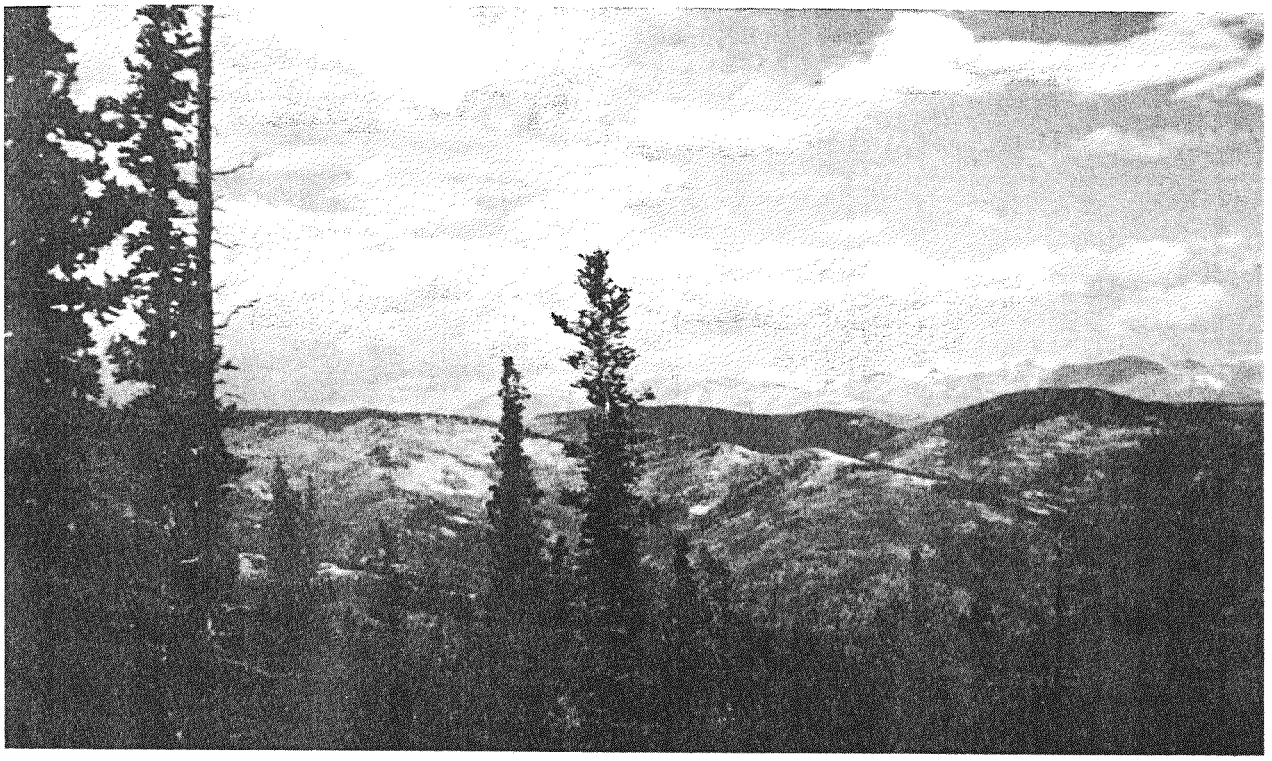

FIGURE 4.—Boreal sub-alpine conifer forest, north central Colorado.

fields are often of major importance during the breeding and premigration seasons. Mixed sclerophyll communities of Great Basin chaparral ("brush") in Utah and Colorado are occasionally used by feeding bandtails.

In addition to the montane conifer forest, evergreen woodlands described by Brown and Lowe (1974a,b) as Mexican oak-pine and "encinal" or oak (*Quercus*) communities (Fig. 5), provide breeding habitat for bandtails in southern Arizona, extreme southwestern New Mexico, Trans Pecos Texas, and Mexico. Also in Arizona, pigeons are observed feeding frequently in interior chaparral, and less frequently in desert grassland or even Sonoran desertscrub.

Preliminary, limited data indicate that bandtails wintering in Mexico inhabit oak-pine woodlands, encinal woodlands, and montane conifer forests in the Sierras of and adjacent to the Sierra Madre Occidental in late fall to midwinter. As mast supplies are depleted, pigeons feed throughout the subtropical Sinaloan deciduous forest (short tree communities) (Fig. 6) and even thornscrub to as low as 244m (800 ft) elevation (Braun 1973c).

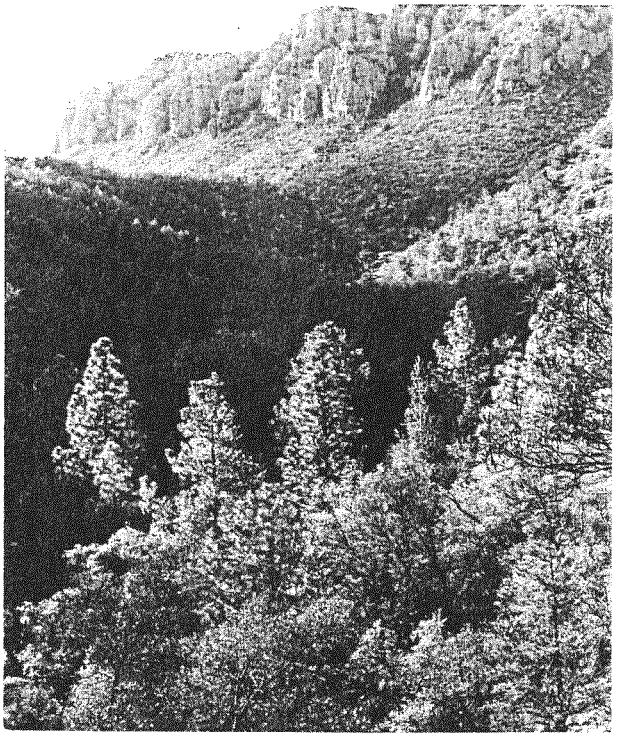

FIGURE 5.—Mexican oak-pine community, Chiricahua Mountains, Arizona.

FIGURE 6. —Mixed short tree community, Alamos, Sonora.

Trapping and Banding

Organized trapping and banding of the Interior race of band-tailed pigeons was initiated in Arizona in 1967 when 383 pigeons were banded. New Mexico began trapping in 1968 and Colorado and Utah first banded pigeons in 1969. From 1967 through 1972, 25,730 bandtails were banded in the Four Corners States (Table 1). Numbers banded per year varied from 383 to 9,391, averaging about 4,300 birds per year. From 1969 through 1971, trapping was conducted annually in each of the four States. Trapping effort was not uniform in each State nor was distribution of bandings during each year of the study; thus, numbers sampled did not necessarily have a relationship to available populations.

Of the 25,730 pigeons trapped, banded, and released, 22,852 (88.8%) were classified as adults (including subadults) (AHY) and 2,878 (11.2%) were classified as young of the year (immatures) (HY). Trapping of immatures proved difficult in some areas and was consistently successful only in Colorado and Utah (13.6 and 13.7% of all birds captured, respectively). These two states provided 82.5% of all immatures captured (2,374 of 2,878) but only 66% of all adults and subadults. These data suggest that real differences occur either in pigeon productivity, site selection, trapping techniques and effort; or in pigeon behavior among the four States.

Sex was ascertained for 21,292 (93.2%) of the 22,852 adult (including subadult) pigeons banded. Some pigeons were not classified as to sex for various reasons, usually related to inexperience of banding crews and the need to quickly process as many as 200 birds at a time. Of the pigeons that were sexed, 11,340 (53.3%) were males, and 9,952 (46.7%) were females. Males dominated trap samples in all years except 1972. Braun (1972a, 1973a) documented changes in sex ratios of trapped pigeons according to time of day. Males constituted about 68% of the adults trapped prior to 1000 MDT, females comprised about 65% of all adults trapped between 1000 and 1600 MDT, and equal proportions of the sexes were captured after 1600 MDT. Sex ratios

Table 1. *Numbers of band-tailed pigeons banded in the Four Corners States, 1967-72.*

Year and States	Adults[a] (AHY)			Immatures (HY)		Total
	Males	Females	Unclassified	Number	Percent	
1967						
Arizona	210	123	32	18	4.70	383
New Mexico	—	—	—	—	—	—
Colorado	—	—	—	—	—	—
Utah	—	—	—	—	—	—
Sub-total	210	123	32	18	4.70	383
1968						
Arizona	659	370	1	97	8.61	1,127
New Mexico	44	5	42	0	0.00	91
Colorado	—	—	—	—	—	—
Utah	—	—	—	—	—	—
Sub-total	703	375	43	97	7.96	1,218
1969						
Arizona	546	731	3	138	9.73	1,418
New Mexico	242	68	1	16	4.89	327
Colorado	—	—	1,223	377	23.56	1,600
Utah	147	51	0	39	16.46	237
Sub-total	935	850	1,227	570	15.91	3,582
1970						
Arizona	311	285	0	21	3.40	617
New Mexico	279	143	26	109	19.57	557
Colorado	1,776	958	10	548	16.65	3,292
Utah	254	94	0	54	13.43	402
Sub-total	2,620	1,480	36	732	15.04	4,868
1971						
Arizona	89	71	0	2	1.23	162
New Mexico	887	722	222	48	2.55	1,879
Colorado	1,789	1,929	0	288	7.19	4,006
Utah	110	52	0	79	32.78	241
Sub-total	2,875	2,774	222	417	6.63	6,288
1972						
Arizona	—	—	—	—	—	—
New Mexico	644	1,036	0	55	3.17	1,735
Colorado	3,069	3,197	0	985	13.58	7,251
Utah	284	117	0	4	0.99	405
Sub-total	3,997	4,350	0	1,044	11.12	9,391
1967-1972						
Arizona	1,815	1,580	36	276	7.45	3,707
New Mexico	2,096	1,974	291	228	4.97	4,589
Colorado	6,634	6,084	1,233	2,198	13.61	16,149
Utah	795	314	0	176	13.70	1,285
Grand Total	11,340	9,952	1,560	2,878	11.19	25,730

[a] Including those birds classified as subadults.

of trapped samples are undoubtedly related to the daily brooding and squab-rearing cycle; males attend the nest during day and females at night and during the early morning (Neff and Niedrach 1946).

Migration Patterns and Chronology

Northward movements of band-tailed pigeons apparently began in March, with a few pigeons arriving in central Colorado and Utah by late March in some years. Migration intensified in early April and small groups of pigeons were at feeding sites throughout the Four Corners States by 20–25 April. The peak of northward migration occurred from late April to mid-May, and most birds were present in breeding areas by the end of May. Migration northward appeared to be fairly rapid between Mexico and northern breeding areas. Only 2.0% of the pigeons trapped in early May in southern Colorado were recaptured further north later in the same year (Braun 1972b). However, inspection of 29 recaptures of birds banded in New Mexico that were trapped later in Colorado reveals that 9 (31.0%) were retrapped north of their initial capture location in the same year. It is probable that these pigeons were migrating at time of initial capture. Factors influencing spring migration are unknown. Proximate factors are possibly low pressure systems north of Mexico and the appearance of flowers and buds on deciduous trees and shrubs.

Some workers (Neff 1947; Smith 1968) have suggested that pigeons are nomadic throughout the year, but these studies were based on observations of unmarked birds. Braun (1972b), working with recaptures and recoveries of banded birds, determined that movement became localized and related to food availability once pigeons reached breeding areas. Examination of recaptures and recoveries throughout the Four Corners States support Braun's (1972b) work, and it is apparent that discrete subpopulations of pigeons do occur annually in breeding areas. Limited evidence from southwestern New Mexico, however, suggests that some subpopulations of pigeons are nomadic or at least fail to breed in areas where food supplies are undependable (Gutierréz 1973).

Examination of observation and recovery data reveals that southward migration of bandtails starts in middle to late August and increases rapidly to mid-September in northern areas; few pigeons remain north of central New Mexico and Arizona as late as mid-October. The presence of pigeons in Colorado and Utah after mid-October has been documented, but most verified reports pertain to only a few birds.

In contrast to rapid northward migration in spring, fall migration is often gradual, although departures in some areas may be abrupt. Examination of band recoveries reveals that pigeons east of the Continental Divide in Colorado and New Mexico drift south and then southwest across New Mexico where they intermingle with pigeons from west of the Continental Divide. Pigeons from Utah appear to move south through east-central Arizona and western New Mexico and combine with pigeons from Arizona. Most pigeons of the Interior population migrate through extreme southwestern New Mexico and southeastern Arizona into Mexico on both sides of the Sonora-Chihuahua boundary. Some pigeons breeding east of the Continental Divide in Colorado and New Mexico apparently migrate south through east-central New Mexico, possibly even into west Texas before moving southwest into Chihuahua, Mexico. In Mexico, southward movement appears to be diffuse; the pigeons move south through the Sierra Madre Occidental and most recoveries occured along the west side of that range. Timing of the southward migration varies annually and is possibly initiated by unfavorable weather and food availability in northern areas. Fall migration does not appear to be related to food shortages as food in some areas may be abundant.

Migration of pigeons of the Interior population west to coastal areas appears to be of minor significance; only five recoveries (all direct) have been reported (four from California and one from Washington). Thus, although some interchange occurs between the two populations, the migration of pigeons in the Four Corners States is along a north-south axis.

Mortality and Survival

556 recovered pigeons that were banded in the Four Corners States in 1967–72 give a (Table 2),

mean annual, 1st-yr direct recovery rate of 1.5% for adults and 2.2% for immatures. Adjusted direct recovery rates (corrected for an estimated 50% Mexican reporting rate) for these categories were 1.7% and 2.4%, respectively. Therefore, the mean annual harvest of the Interior population of band-tailed pigeons is probably less than 2%. Estimated mean annual harvest rates for the various states during this period were: Arizona, 2.4%; Colorado, 1.6%; New Mexico 1.3%; and Utah 2.9%. The relatively high rate for Utah was inflated by data obtained in 1971 when banding continued up to the opening of the hunting season and hunting occurred adjacent to the principal trap site, resulting in a disproportionate harvest of newly banded birds. Exclusion of the 1971 cohort gives a 1.4% harvest rate for Utah. Immature recovery rates were higher than those for adults in states from which more than five immatures were recovered. Differential recovery rates between adult males and females were not calculated for all States because of possible sex classification errors in the pooled banding sample of adults. Data from Arizona and Utah indicate that 1st-yr recovery and harvest rates for adult females were significantly lower than those for adult males. Recoveries of pigeons banded in Colorado did not reveal differential mortality between males and females. It should be realized that timing of harvest, especially in breeding areas, may directly affect proportion of males and females obtained in the harvest.

The mean annual survival and mortality rate for adults as determined from adjusted recovery rates (Table 2) using the formula (modified from Hickey 1952) are:

$$\hat{S} = \frac{(B) + (C) + (D)}{(A) + (B) + (C)}$$

$$\hat{M} = 1.000 - \hat{S}$$

Where: $\hat{S}$ = calculated mean annual adult survival rate
$\hat{M}$ = derived mean annual adult mortality rate

A = pooled first year adult band recovery rate
B = pooled second year adult band recovery rate
C = pooled third year adult band recovery rate
D = pooled fourth year adult band recovery rate

$$\hat{S} = \frac{.011 + .008 + .004}{.017 + .011 + .008} = \frac{.023}{.036} = .639$$

$$\hat{M} = 1.000 - .639 = 36.1\%$$

The mean annual, first year mortality rate for immatures was calculated using the formula (modified from Hickey 1952):

$$\hat{s} = \frac{b}{a}$$

$$\hat{m} = 1.000 - \hat{s}$$

Where: a = pooled first year immature band recovery rate
b = pooled second year band recovery rate
$\hat{s}$ = estimated mean annual survival rate
$\hat{m}$ = estimated mean annual mortality rate

$$\hat{s} = \frac{.014}{.024} = .583$$

$$\hat{m} = 1.000 - .583 = 41.7\%$$

The above mortality rates correspond closely to those determined for the Coastal population (Wight et al. 1967; Silovsky 1969) and for the Arizona population (Brown 1972; 1973). These rates appear to be well within the recruitment capabilities of the population (long breeding season, multiple nesting, one egg per clutch most common but up to 8% of all nesting attempts have two eggs) as determined by Gutierréz (1973).

A curious phenomenon was noticed when comparing Mexican recoveries with those from the United States. Mexican recoveries represented only 8.0% of the 1st-yr direct recoveries, but jumped to 34.6% of the 2nd-yr, 28.6% of the 3rd yr, and 42.9% of the 4th-yr recoveries (Table 2). Of the 556 total recoveries received, 97 (17.5% were from Mexico. If the 50% reporting rate is applied to those bands received from Mexico, between one-fourth and one-third (29.7%) of the bandtail harvest of the Interior population occurs outside the United States. It is possible that the relatively low number of direct recoveries from Mexico results from hunters in the United States being aware of where banding has occurred; consequently the concentrated 1st yr banded birds are harvested at a higher rate than birds banded in previous years because the latter birds are more widely distributed in the population. It is also possible that some pigeons do not migrate north every year; these individuals would not be exposed to hunting in the United States but would be vulnerable to hunting for a longer period in Mexico.

Table 2. *Summary of recoveries of band-tailed pigeons banded in Four Corners States, 1967-72*[a].

State	Number banded[b]			Number recovered			Recovery rate					
	AHY	HY	Total[c]	AHY	HY	Total[c]	AHY		HY		Total	
First Year Recoveries[d]												
Arizona	2,910	255	3,165	58(63)[e]	8(8)[e]	66(71)[e]	.022[f]	(.023)[g]	.031[f]	(.031)[g]	.022[f]	(.024)
Colorado	11,611	1,683	13,294	152(168)	31(32)	183(200)	.014	(.016)	.019	(.020)	.015	(.016)
New Mexico	3,959	212	4,171	44(49)	1(1)	45(50)	.012	(.013)	—	—	.012	(.013)
Utah	911	137	1,048	19(19)	8(9)	27(28)	.021	(.021)	.066	(.073)	.027	(.029)
Pooled total	19,391	2,287	21,678	273(299)	48(50)	321(349)	.015	(.017)	.022	(.024)	.016	(.017)
Second Year Recoveries												
Arizona	3,242	273	3,548	13(29)e	0	13(29)e	.009	(.014)[g]	—	—	.008	(.013)
Colorado	7,013	1,117	8,130	48(60)	5(11)[e]	53(71)	.009	(.010)	.009	(.015)	.009	(.012)
New Mexico	2,590	173	2,763	9(14)	0(2)	9(16)	.005	(.007)	.001	(.002)	.006	(.008)
Utah	708	172	880	9(12)	1(2)	10(14)	.017	(.021)	—	—	.016	(.020)
Pooled total	13,553	1,735	15,321	79(115)	6(15)	85(130)	.008	(.011)	.007	(.014)	.008	(.011)
Third Year Recoveries												
Arizona	3,115	271	3,386	6(16)[e]	1(1)[e]	7(17)[e]	.005	(.008)[g]	—	—	.005	(.008)
Colorado	3,967	925	4,892	18(22)	4(5)	22(27)	.006	(.007)	—	—	.006	(.007)
New Mexico	850	125	975	4(7)	1(1)	5(8)	.007	(.008)	—	—	.008	(.011)
Utah	546	93	639	10(10)	1(1)	11(11)	.018	(.018)	—	—	.017	(.017)
Pooled total	8,478	1,414	9,892	38(55)	7(8)	45(63)	.006	(.008)	.006	(.006)	.006	(.008)
Fourth Year Recoveries												
Arizona	2,703	252	2,955	6(10)[e]	1(2)[e]	7(12)[e]	.004	(.005)[g]	—	—	.004	(.006)
Colorado	1,223	377	1,600	0(1)	0	0(1)	—	—	—	—	—	—
New Mexico	402	16	418	0(0)	1(1)	3(5)	—	—	—	—	—	—
Utah	198	39	237	0(0)	0(0)	0(0)	—	—	—	—	—	—
Pooled total	4,526	684	5,210	6(11)	2(3)	8(14)	.002	(.004)	.004	(.006)	.003	(.004)

[a] Includes all shot (01) and found dead (00) recoveries.
[b] Excludes pigeons banded in areas closed to hunting.
[c] Includes unclassified pigeons banded.
[d] A recovery year is from date to banding through June 30 of the following year.
[e] Figures in parentheses include those bands recovered in Mexico.
[f] Direct recovery rate.
[g] Figures in parentheses are adjusted for a 50% reporting rate for Mexican recoveries.

Hunting

Experimental hunting seasons were allowed in Arizona and New Mexico in 1968–72 and in Colorado and Utah in 1970–72. All pigeon hunters were required to obtain permits that allowed States to collect data on harvest, hunting pressure, hunting success, crippling loss, and age composition of the harvest. Most data were obtained through mail questionnaires. Seasons lengths and opening dates varied among States and years (Table 3). Daily bag and possession limits were 5 and 10 birds, respectively, throughout the study period.

Hunting Pressure

During the 5-yr study period, 13,432 hunting permits were issued. From 1968 through 1971 the number of permits issued gradually increased in all States, but in 1972 the number of permittees decreased sharply in Arizona. The decrease came in a year when fewer pigeons were available. The average number of permits issued annually and the number of hunters afield were: 1,634 (817) in Arizona, 708 (437) in New Mexico, 483 (275) in Colorado, and 90 (50) in Utah. Only 53.9% of all permittees reported that they hunted, confirming field observations that many hunters obtained permits so they could shoot pigeons if encountered while hunting other game species. Days hunted per hunter varied from 2.4 in Colorado, to 1.7 in Arizona; the region-wide average was 1.9 days. Number of permits issued, hunter numbers, and total hunter days varied directly with hunter success and retrieved harvest (Table 3).

Harvest

The total retrieved harvest of band-tailed pigeons in the Four Corners States during the 5-yr period was 19,971 or about 4,000 birds per year. Hunters harvested 9,685 pigeons in Arizona, 7,086 in New Mexico, 2,724 in Colorado, and 476 in Utah. Harvests were highest during this period in 1970 in Arizona, 1971 in Colorado, and 1972 in New Mexico and Utah (Table 3). Forty percent of the bands recovered in New Mexico by shooting were originally placed on the pigeons in Colorado (Zapatka 1972). Whereas scattered recoveries of banded birds shot outside of the State of banding occurred, no pattern other than fidelity to the banding area could be detected in origin of harvest except for Colorado and New Mexico.

Hunter Success

The average hunter of band-tailed pigeons in the Four Corners area bagged 1.4 birds per day afield, and 2.8 birds during the season. Highest daily success was in Arizona (2.0 pigeons per hunter in 1970) and Utah (2.1 in 1970). The lowest daily success occurred in Arizona in 1971 and 1972 due to unfavorable weather which caused early migration and only 0.7 and 0.5 pigeons, respectively, were bagged per hunter-day. Overall average daily success during 1968–72 among the four States was similar: 1.2 birds per day in Arizona, 1.3 in Colorado, 1.4 in New Mexico, and 1.7 in Utah (Table 3).

Average seasonal success during the study period was similar in Colorado (3.1), New Mexico (3.0) and Utah (3.2), but somewhat lower in Arizona (2.1). The low value for Arizona reflected unusually poor success in 1971 and 1972. Annual hunter success per season ranged from 0.8 pigeons per hunter in Arizona (1972) to 4.5 in Colorado (1971) (Table 3).

Percentage hunter success (the proportion of permittees afield bagging one or more pigeons) averaged 45.0% for the four States combined for all experimental seasons. Thus, more than one-half of the hunters afield failed to bag a pigeon in an average year. Hunter success ranged from 21% in Arizona in 1972 to 58.0% in Arizona in 1970 and Colorado in 1971. Utah had the highest average hunter success (49.1%), more the result of low hunting pressure than of high pigeon populations (Table 3).

Crippling Loss

Reported crippling loss (expressed as the percentage of the number of birds retrieved) varied annually from 6% in Arizona (1972) to 26% in New Mexico (1968) and Utah (1970). State averages for the duration of the study were 11% in Arizona, 12% in Colorado, 16% in Utah, and 18% in New Mexico. The overall average for all States was 15%.

State harvest totals were adjusted to reflect crippling losses. This increased the total estimated kill for the experimental period in the combined States from 19,971 to 22,559 bandtails (Table 3). Crippling losses were reported volun-

Table 3. *Harvest statistics, experimental band-tailed pigeon hunting seasons, in the Four Corners States, 1968-72.*

State and season dates	Year	Number of permits issued	Number of hunters afield	Percent of permittees afield	Hunters days	Days per hunter	Retrieved harvest	Pigeons per hunter	Harvest per hunter per day	Percent of hunters successful	Reported crippling loss in %	Estimated total mortality[a]
Arizona												
Sept. 28-Oct. 6	1968	1,316	851	64.7	1,498	1.8	2,085	2.4	1.4	43.1	15	2,398
Oct. 11-19	1969	1,609	968	60.2	1,719	1.8	2,820	2.9	1.6	55.2	12	3,158
Oct. 17-25	1970	1,853	1,069	57.7	1,815	1.7	3,545	3.3	2.0	58.3	10	3,900
Oct. 16-24	1971	1,965	622	31.6	1,076	1.7	782	1.3	0.7	29.0	10	860
Oct. 14-23	1972	1,427	576	40.4	968	1.7	453	0.8	0.5	20.8	6	480
Average		1,634	817	50.0	1,415	1.7	1,937	2.1	1.2	41.3	11	2,159
New Mexico												
Sept. 28-Oct. 6	1968	488	278	57.0	556	2.0	500	1.8	0.9	35.2	26	631
Oct. 11-19	1969	399	218	54.7	392	1.8	719	3.3	1.8	52.1	19	856
Oct. 17-25	1970	716	440	61.4	818	1.9	859	2.0	1.1	35.5	20	1,030
Sept. 11-Oct. 3	1971	858	559	65.2	1,240	2.2	2,027	3.6	1.6	45.9	14	2,302
Sept. 2-24	1972	1,080	692	64.1	1,666	2.4	2,981	4.3	1.8	49.3	11	3,313
Average		708	437	61.8	934	2.1	1,417	3.0	1.4	43.6	18	1,626
Colorado												
Sept. 12-20	1970	364	182	50.0	374	2.1	458	2.5	1.2	42.3	15	541
Sept. 4-26	1971	524	344	65.6	851	2.5	1,537	4.5	1.8	58.4	11	1,723
Sept. 9-Oct. 1	1972	562	298	53.0	762	2.6	729	2.4	1.0	41.6	11	822
Average		483	275	56.8	662	2.4	908	3.1	1.3	47.4	12	1,029
Utah												
Sept. 12-20	1970	57	34	59.6	53	1.5	109	3.2	2.1	52.9	26	137
Sept. 4-26	1971	93	54	58.1	110	2.0	156	2.9	1.4	51.8	13	176
Sept. 1-24	1972	121	61	50.4	122	2.0	211	3.5	1.7	42.6	10	232
Average		90	50	55.0	95	1.9	159	3.2	1.7	49.1	16	182
Four Corners States												
Summary	1968	1,804	1,129	62.6	2,054	1.8	2,585	2.3	1.3	39.1	20	3,029
	1969	2,008	1,186	59.1	2,111	1.8	3,539	3.0	1.7	53.6	15	4,014
	1970	2,990	1,725	57.7	3,060	1.8	4,971	2.9	1.6	47.2	18	5,608
	1971	3,440	1,579	45.9	3,277	2.1	4,502	2.9	1.4	46.3	12	5,061
	1972	3,190	1,627	51.0	3,518	2.2	4,374	2.7	1.2	38.6	10	4,847
Total	1968-72	13,432	7,246		14,020		19,971					22,559
Average		2,686	1,449	53.9	2,804	1.9	3,994	2.8	1.4	45.0	15	4,512

[a] Including birds reported crippled and lost.

tarily on questionnaires and wing envelopes and should be viewed as minimal values. Inasmuch as pigeons are usually hunted in forested or chaparral areas with dense understory vegetation or in rugged terrain, crippling loss may have been as high as 25% of the total birds retrieved.

Age Composition of Harvest

Wings, which provided an estimate of the age ratio in the harvest, were retrieved in special envelopes sent to a sample of the permit holders. During the 5-yr period, 11,123 individual wings were received—55.7% of the total retrieved harvest. Annual samples varied from 55 in 1972 in Arizona to 1,889 in 1972 in New Mexico, and averaged 2,225 per year for all the Four Corners States (Table 4).

The proportion of immatures in the harvest varied considerably, both annually and by States, and averaged 23% per year throughout the region. The lowest value was recorded in New Mexico in 1971 when immatures made up only 7% of the harvest and the highest (53%) was in Arizona in 1972. Because of differential sampling, immature percentages were weighted by sample size (Table 4) to provide a more realistic approximation of relative numbers of immatures in the harvest. Weighting did not materially affect averages in Colorado, New Mexico, and Utah, but in Arizona, the weighted average for all 5 years was 23% compared to the inflated value of 33% (due to small samples in 1971 and 1972). Immatures (weighted) contributed 33% of the annual harvest in Colorado, 23% in Arizona, and 15% in New Mexico and Utah. Age ratios in the harvest in Colorado compare favorably with the relatively high percentage (13.6%) of immatures in trap samples (Table 1); in the other three States, immatures made up 7.1% of all trap samples. These differences suggest that immatures are more vulnerable than adults to hunting; this hypothesis is partially supported by recovery data. Use of age ratios in the harvest is limited because of possible differential migration and vulnerability between adults and immatures. Because no consistent pattern of young:adult ratios was evident from harvest data, caution must be exercised in using age ratios derived from wing surveys and hunter bag checks as an index to production.

Crop Gland Development

A major concern in band-tailed pigeon management is avoiding excessive harvest of actively nesting birds. Development of crop glands, (areas of specialized epithelial tissue in each lobe of the crop that slough off cheesy material termed "milk [Zeigler 1971])was used as an index to nesting and squab rearing activity. Field bag checks were conducted to ascertain the proportion of harvested adults that had active, stimulated, or inactive crop glands. Pigeons with either active or stimulated crop glands were considered to be caring for nestlings. Both daily and seasonal crop-milk cycles have been described (Zeigler 1971), but the significance of the observed stages of glandular development in harvested birds is difficult to assess. Piegons have been observed feeding free-flying young (Braun, unpublished data); Zeigler (1971) found that regression of some crop glands was not complete until 10 days after fledging of the young. The age of independence of young bandtails is unknown but under ideal conditions in the aviary, young pigeons were self sufficient (feeding) at time of fledging (White and Braun, unpublished data). By considering all birds with glandular development as being active nesters, the extent of nesting activity is probably over estimated.

Over the period of study (1968–72), opening dates of hunting seasons were adjusted in an effort to minimize the proportion of nesting pigeons that were harvested. In Arizona and New Mexico, the greatest proportions of individuals with crop gland development (81 and 50%, respectively) were found in the 1968 hunting season when the opening date was 28 September. Proportions were progressively lower in Arizona and New Mexico over the next 2 yr as the season opened progressively later (11 October 1969 and 17 October 1970). Conversely, in Colorado and Utah the highest proportion of birds with crop gland development (52 and 61%, respectively) were associated with the latest opening date (12 September 1970). Crop gland development was lowest in Colorado and Utah when the season opened early in September.

It is suspected that percentages of pigeons with crop gland development harvested in Colorado and Utah are strongly influenced by migration. Nesting is probably completed earlier in the more northern latitudes than in

Table 4. *Age composition and crop gland development of the band-tailed pigeon harvest. Four Corners States, 1968–72.*

State	Year	Sample size	Weight factor	Age composition: Adults %	Adults Weighted %	Immatures %	Immatures Weighted %	Adult pigeons with crop gland development: %	Sample size
Arizona	1968	1,017	0.2343	78	18.28	22	5.15	81	197
	1969	1,304	0.3004	77	23.13	23	6.91	52	173
	1970	1,884	0.4340	77	33.42	23	9.98	38	220
	1971	81	0.0187	58	1.08	42	0.79	—	—
	1972	55	0.0127	47	.60	53	0.67	—	—
Average	1968–72	868	1.0001	67	76.51	33	23.50	57	197
New Mexico	1968	352	0.0802	87	6.98	13	1.04	50	35
	1969	492	0.1121	80	8.97	20	2.24	51	105
	1970	539	0.1228	75	9.21	25	3.07	36	56
	1971	1,118	0.2547	93	23.69	7	1.78	—	—
	1972	1,889	0.4303	85	36.58	15	6.46	—	—
Average	1968–72	878	1.0001	84	85.43	16	14.59	46	65
Colorado	1970	394	0.1949	68	13.25	32	6.24	52	89
	1971	1,113	0.5504	68	37.43	32	17.61	29	324
	1972	515	0.2547	65	16.56	35	8.91	51	169
Average	1970–72	674	1.0000	67	67.24	33	32.76	44	194
Utah	1970	92	0.2486	87	21.63	13	3.23	61	57
	1971	109	0.2946	79	23.27	21	6.19	55	31
	1972	169	0.4568	87	39.74	13	5.94	57	51
Average	1970–72	123	1.0000	84	84.64	16	15.36	58	46
Four Corner States									
Summary	1968	1,369	0.1231	80	9.85	20	2.46	76	116
	1969	1,796	0.1615	78	12.60	22	3.55	52	139
	1970	2,909	0.2615	76	14.87	24	6.28	44	105
	1971	2,421	0.2177	74	16.11	26	5.66	—	—
	1972	2,628	0.2363	71	16.77	29	6.85	—	—
Average	1968–72	2,225	1.0001	76	75.20	23	24.80	—	—
Total		11,123							

southern New Mexico and Arizona, and those pigeons which have completed nesting tend to migrate earlier. It is thought that adult pigeons remaining into middle or late September in northern areas are primarily those which are still rearing young. This results in higher proportions of crop gland activity during hunting seasons opening in mid-September than in late September in northern areas. It follows that more adults which have completed nesting would still be available to Colorado and Utah hunters in early September and that the proportion of pigeons in the harvest showing crop gland development should be lower.

No significant correlation was found between the percentage of immatures in the harvest of the four States and the percentage of adults having crop gland development ($r = 0.33$, $N = 12$). Due to the paucity of data, no patterns in crop gland activity were apparent. In Colorado and New Mexico, timing and duration of nesting are related to food availability (Gutierréz 1973). In Colorado, food production and availability are thought to have been low in 1971. Percentage immatures trapped (7.2%) and crop gland development (29%) in 1971 were the lowest recorded for that State. These data strongly suggest that the percentage of crop gland development observed was related to time of the hunting season and food availability. In years of average to good food production, a high proportion of pigeons with crop activity can be anticipated regardless of when the hunting season is conducted. This is because band-tailed pigeons are multi-brooded and at least some birds will continue nesting when conditions are favorable. A large proportion of adult pigeons exhibiting glandular development of crops during the hunting season should not necessarily be interpreted as indicating a numerically high loss of squabs. Although the data should be closely scruntinized from State to State, a high percentage of active adult crops in the harvest more likely represents late-nesting adults remaining in local areas after many of the immatures and early-nesting adults have migrated.

Evaluation of Hunting

A primary objective of the experimental hunting seasons from 1968 to 1972 was to investigate the feasibility of harvesting the Interior, or Four Corners, band-tailed pigeon population on a sustained basis. Results have clearly shown that harvest levels were not detrimental to the population and that annual hunting seasons are feasible. This conclusion is based primarily upon low harvest rates (less than 3%) of pigeons banded during the period of study.

Hatching data derived from trap samples and wing surveys suggest that substantial numbers of immatures migrated south before the opening of hunting seasons (Braun 1972a, 1973a; Fitzhugh 1974). Braun (1973a) reported that only 14.2% of 1,169 immatures examined in Colorado in 1972 fledged after 1 September, and only 6.9% fledged after 10 September. Hunter bag samples indicated that most harvested immatures had hatched after late July. Because progeny of early and mid-season nesting attempts are not represented in the harvest, the data strongly support the hypothesis of differential migration between early and late hatched young.

It is difficult to measure the impact of hunting on the reproductive success of late nesting pigeons, but in view of extremely low direct recovery rates in the Four Corners area and the fact that most of the annual production occurs before September, it is safe to assume that this effect is low. Zeigler (1971) estimated that hunting caused a loss of 3.5 to 7.2% of the annual production in Oregon. It is doubtful that the effect of hunting in the Four Corners area would equal that level.

Public attitudes toward pigeon hunting by both participants and nonparticipants were favorable. Hunter cooperation was enthusiastic and no adverse criticism other than timing of the season was received in any of the Four Corners States.

RECOMMENDATIONS

Research

1. Many facets of research are dependent on development of a population census or monitoring technique. This should be the first priority for additional research. The audio-census technique developed in Oregon (Keppie et al. 1970) was attempted in Colorado (Braun, unpublished data), Arizona (Fitzhugh, unpublished data) and Utah (Pederson, unpublished data) and was found to be inadequate.
2. Next in priority is a basic ecological study of pigeons in Mexico. Initial studies should concentrate in the area within 40 air miles east of Culiacan, Sinaloa. These locations, near Tamazula and Canelas, Durango, are major recovery sites for pigeons.
3. Further investigations are needed to relate crop gland development to nesting phenology, reproductive success, migration, and hunting.
4. Survival rates of pigeons, particularly immatures, should be more thoroughly investigated.

Management

1. With an annual harvest of less than 3%, band-tailed pigeons of the Interior race can be hunted on a sustained basis without harm to the population. Therefore, we recommend that band-tailed pigeon seasons be continued on an operational basis in the Four Corners States.
2. A permit system should be retained to provide an adequate sampling frame for gathering harvest data.
3. An integrated Four Corners banding program should have the objective of obtaining 50 direct recoveries (total for all States) in years of normal hunting success. To accomplish this objective, the number of pigeons to be banded by each state should continue to be based on a proportion of the harvest in each State. Presently the goals are: Arizona, 800; Colorado, 500; New Mexico, 1,125; Utah, 75. Pigeons should be banded in areas that normally contribute to pigeon harvest.
4. Opening dates and the length of the season should be adjusted locally to avoid overlapping with breeding and nesting activity by band-tailed pigeons.

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