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Title: DISTRIBUTION AND MORTALITY OF THE PACIFIC COAST BAND-TAILED PIGEON

Abstract approved: Signature redacted for privacy.
Howard M. Wight

A study of the Pacific coast Band-tailed pigeon (Columba fasciata Say) was conducted from August 1966 to September 1968.[1] Bands recovered from 14,787 pigeons banded in the Pacific Coast states, 1929-65, were used to determine distribution, migration, and mortality. Data on the age structure of populations were obtained from 3,596 pigeons killed by Oregon hunters in September 1966-67, 64 pigeons killed by California hunters in December 1966, and 1,799 pigeons trapped in Oregon during May and June 1967-68.

The range of the band-tail extends along the Pacific coast from northern Baja California, Mexico to central British Columbia, Canada. Band recoveries indicate most pigeons left the wintering grounds in California by April 1. By June 10 nearly all

[1] This study was supported by the Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, and the Oregon Agricultural Experiment Station, Corvallis.

pigeons reached the northern breeding grounds. Fall migration from the northern part of the range was well-advanced by mid-September.

Estimates made by conservation agencies indicated the annual kill apprached 500 thousand pigeons. Approximately 50 percent of the kill occurred in California, 25 percent each in Oregon and Washington, and 1 to 2 percent in British Columbia.

One-third of the adult pigeons shot in Oregon during early September were caring for young. Undoubtedly this resulted in the mortality of some young.

The age structure of the Oregon kill was not representative of the population because some young were still in the nest and a differential in the migration of adults and immatures probably existed. The large percentage of subadults in spring populations indicated the kill was biased in favor of adults. The age structure of the kill on the wintering grounds in California was biased in favor of immatures because immatures were mor vulnerable to hunters than adults.

The average annual mortality for adults banded in the Pacific Coast states ranged from 31 to 39 percent. Immatures exhibited a somewhat greater mortality. A relatively small fraction, 26 to 43 percent, of the adult mortality was due to natural causes. This indicated that the majority of the mortality was a result of hunting.

This study indicated an important need for the following research: (1) Determination of the magnitude or existence of differentials in mortality, vulnerability, and migration by age and sex for pigeons banded during July and August; (2) Determination of the significance of the loss of young due to the late nesting of some adults during the September hunting season.

Distribution and Mortality of the Pacific Coast Band-Tailed Pigeon

by

Gene Donald Silovsky

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degree of

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The Oregon State Game Commission provided the names of band-tailed pigeon hunters used in the hunter survey.

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DISTRIBUTION AND MORTALITY OF THE PACIFIC COAST BAND-TAILED PIGEON

I. INTRODUCTION

This is a report on the distribution and mortality of the band-tailed pigeon (Columba fasciata Say) of the Pacific coast. My study was conducted at Oregon State University, Corvallis, Oregon, from August 11, 1966 to September 30, 1968.

The band-tailed pigeon is a migratory member of the family Columbidae which includes the pigeons and doves. Two geographically isolated populations of the species exist in North America; one along the Pacific coast, and the other primarily in the states of Colorado, Utah, Arizona, and New Mexico. The band-tail of the Pacific coast breeds from northern Baja California, Mexico to central British Columbia, Canada and winters in California and Baja California (Grinnell, 1913; Neff, 1947). This species has one of the lowest reproductive potentials of our game birds with one egg per clutch and one clutch per year commonly reported (Neff, 1947; Glover, 1953; Einarsen, 1954).

The objectives of this research were:

1. To determine the summer and winter ranges; routes of migration; timing of migration; and differentials in migration by age and sex.
2. To determine the relative importance of the kill by state

or province.

3. To determine productivity from a survey which provided wings from pigeons shot by hunters.
4. To determine the mortality rates by age and sex for various populations.
5. To determine the role of hunting and hunting regulations in the management of the band-tail.
6. To suggest further research needs.

In the early part of the 20th Century the band-tail and other migratory species were subjected to indiscriminate hunting. At this time, authorities (Grinnell, 1913; Chambers, 1912) thought the existence of the band-tail was in jeopardy. This indiscriminate hunting of migratory species prompted the U. S. Government to enact the Migratory Bird Law of 1913 which gave partial or complete protection to many birds. The band-tail was given complete protection by this law until 1918 when the Migratory Bird Treaty Act was negotiated with Great Britain. This act extended protection for the band-tail to the province of British Columbia. These acts kept the season closed until 1932 when the number of pigeons had increased sufficiently to allow hunting (Neff, 1947). The band-tail has been hunted in the Pacific Coast states and the province of British Columbia since 1932.

Although considered a "minor" game bird, the current kill approaches 500 thousand pigeons. Hunting pressure appears to be increasing. Smith (1968a) estimated the kill in California would reach 400 thousand pigeons by 1980. If a similar increase occurs in the other states and provinces, the annual kill could reach 750 thousand pigeons by 1980.

Grinnell (1913), Taylor (1924), Neff (1947), Morse (1950), and Einarsen (1954) reviewed the status of the band-tail and pointed out the major problems confronting this species. Neff (1947) stated that "... information is still inadequate for determination of the exact status of the species and definition of practical methods of management." In the 20 years since Neff summarized the available information on the band-tail, additional research has been limited.

The low reproductive potential and increasing kill of the band-tail suggest that management must become more intensive in the future. The information necessary for intensive management is not presently available. This study contributes to the information necessary for the management of the band-tail pigeon of the Pacific coast.

II. METHODS

Definitions

Certain terms used in this study were given precise meanings. For this reason a section of definitions is included.

Adult: a pigeon at least in its second calendar year of life that has completed its post-juvenile molt.

Band Reporting Rate: the percentage of banded pigeons shot and recovered by hunters that are reported to the Bird Banding Laboratory.

Direct Recovery: a banded pigeon shot during the first hunting season after it was banded and reported to the Bird Banding Laboratory.

Direct Recovery Rate: the percentage of pigeons banded during a year which are recovered the first hunting season after they were banded and are reported to the Bird Banding Laboratory.

Immature: a pigeon in its first calendar year of life.

Population: a group of pigeons banded, recovered or present in different geographic or political areas during a certain period of time.

Return: a pigeon that was recaptured at the original site of trapping at least 3 months after it was banded. The band numbers of returns were recorded and the pigeons released.

Shot Recovery: a report of a band from a pigeon shot during the regular hunting season.

Subadult: a pigeon in its second calendar year of life that has not completed its post-juvenile molt.

Determination of Age and Sex

Determination of Age

The methods of Silovsky *et al.* (1968) were used to determine the ages of pigeons in September and December. Juvenile plumage of the wing, present in immatures and absent in adults, was used to determine age in September. The glandular bursa of Fabricius, present in immatures and absent in adults, was used to determine age in December.

Remnant juvenile plumage of the wing, present in subadults and absent in adults, was used to determine age in May and June. Some known-age subadults, from a captive flock, had not completed their post-juvenile molt in May and June. The juvenile plumage remaining on the wings indicated these pigeons were hatched during the previous calendar year. It was assumed that wild pigeons with remnant juvenile plumage on the wings were subadults.

Determination of Sex

Cloacal characters (Miller and Wagner, 1955) were used to determine the sex of adults. The gonads were examined to determine the sex of immatures because cloacal characters diagnostic of sex were absent.

Sources and Analysis of Data

Banding Data

The Migratory Bird Population Station of the U. S. Fish and Wildlife Service supplied records of band-tailed pigeons banded and recovered in North America, 1929-65. Data from 14, 787 pigeons banded in the Pacific Coast states and British Columbia by the U. S. Fish and Wildlife Service, Washington State Department of Game, Oregon State Game Commission, California Department of Fish and Game, and Professor Stanley W. Harris were used in this study (Appendix Tables 1 and 2).

All records were from pigeons shot by hunters or from birds returning to the original site of trapping. The shot recoveries were reported to the Bird Banding Laboratory by three major sources: hunters, state or provincial conservation agencies, and federal conservation agencies. Returning pigeons were reported by the agency or individual conducting trapping.

In this study it was assumed that after a pigeon was trapped, banded, and released it returned to the population of which it originally was a member, became randomly distributed within that population, and when recovered was representative of that population. To meet these assumptions data used were restricted to pigeons banded and released in a "normal" manner. Wild pigeons banded with one standard U. S. Fish and Wildlife Service band and released uninjured immediately after they were captured and banded were considered normal.

Estimates of Mortality

Estimates of mortality were computed from shot recoveries using the composite dynamic method (Hickey, 1952; Geis and Taber, 1963). To use this method it was necessary to assume that the number of recoveries occurring each year after pigeons were banded reflected the total number of deaths occurring that year (Geis and Taber, 1963). It was also necessary to assume that the band reporting rates between the states or provinces and years were equal. The period for which the estimates of mortality were computed extended from the beginning of one hunting season to the beginning of the next.

Although only shot recoveries were used, the computed estimates of mortality represented the total mortality that a population incurred during a year from all causes.

Estimates of natural mortality were obtained from the linear regression between direct recovery rates and first-year mortality rates (Hickey, 1952). The point at which this regression line intercepted the first-year mortality axis provided the estimate of natural mortality. The direct recovery rate at this point was zero and indicated no further mortality due to hunting occurred.

Estimate of and indexes to first-year mortality were computed by dividing direct recoveries by the total number of recoveries that occurred the first 9 years after birds were banded. Recoveries of adults banded in Washington and California were all made by the 9th year and these data provided an estimate of first-year mortality. However, recoveries of adults banded in Oregon were made 11 and 13 years after birds were banded. Therefore, the computed first-year mortality rates were indexes. These indexes overestimated the natural mortality. The method of Wight, Mace and Batterson (1967) was used to correct these overestimates.

Estimates of the mortality due to hunting were made by subtracting the natural mortality from the first-year mortality rate (under column one - hunting seasons survived in the mortality tables).

Hunter Survey

A survey of band-tailed pigeon hunters in Oregon was conducted in 1966 and 1967. A group of hunters were asked to supply wings from pigeons they shot and information regarding their hunting activities.

An estimate of the age structure of the kill was obtained from the wings returned. Data on hunter effort, success, and the number of pigeons crippled were obtained from the information volunteered by hunters.

The names and addresses used in the survey were obtained from an annual questionnaire returned to the Oregon State Game Commission by hunters. This questionnaire was sent to a random sample of 6.0 percent of all buyers of Oregon hunting licenses. In 1966, 568 and in 1967, 434 names of band-tailed pigeon hunters which responded to this questionnaire were obtained. To increase the sample size in 1967, the 153 hunters that responded to the 1966 survey were contacted again.

Hunters were sent a packet containing envelopes in which to return wings, and on which to record information concerning their hunt (Appendix Figure 1). These survey envelopes were patterned after those used by the U. S. Fish and Wildlife Service to sample hunters that killed waterfowl. A letter explaining the purpose of the project and providing instructions was enclosed with the envelopes (Appendix Figure 2). Envelopes were mailed to hunters 2 weeks prior to the scheduled hunting season.

The hunter survey was modified in 1967. Because only two of the hunters responding used more than eight of the ten envelopes supplied in 1966, the number supplied was reduced to eight in 1967.

In 1967, a question was added to provide information on crippling loss.

Hunter Bag-Checks

Information on the age and sex structure of the kill, the condition of the crop of adults, and the molt of the primary feathers of immatures was obtained from examination of pigeons killed by hunters in Oregon and California. In September 1966, pigeons killed at mineral springs near Crawfordsville, Linn County, and Monroe, Benton County, Oregon, were examined. During September 1967, pigeons were checked at two additional mineral springs near Coquille, Coos County, and St. Helens, Columbia County, Oregon. Hunter bag-checks in California were made on Mt. Loma Prieta in Santa Clara County, December 16-22, 1966.

Spring Observations

Age ratios were obtained from pigeons banded during May and June of 1967 and 1968. Pigeons were captured by a cannon-net trap one-half mile east of Corvallis, Oregon.

III. RESULTS

Distribution

Summer and Winter Range

Neff (1947) reported that the summer range of the band-tailed pigeon extended from the Queen Charlotte Islands and Bella Coola in British Columbia, south to Ensenada, Baja California. In British Columbia, Washington and Oregon the range of the species extended from the crest of the Cascade Mountains to the Pacific Ocean. In the northern three-fourths of California the band-tail ranged from the summit of the Cascade and Sierra Nevada Mountains to the coast. The range in the southern one-fourth of California and northern portion of Baja California was limited to the coastal mountain ranges.

Grinnell (1913) and Neff (1947) reported that most pigeons wintered from San Francisco south to Ensenada, Baja California in the coastal and Sierra Nevada Mountains. These authors indicated that flocks occasionally ranged as far north as the head of the California Trough. Surveys, conducted by the California Department of Fish and Game (McKibben, 1968; H. T. Harper, pers. comm. 1968) in late January indicated that the northern limits of the winter range extend to the three most northern counties in the state.

In this study the records of pigeons banded and recovered in the Pacific coast, 1929-65, were reviewed to obtain information on the summer and winter ranges. These records did not provide any new information on the summer and winter ranges of the band-tailed pigeon.

Resident Populations. The occurrence of non-migratory populations of pigeons has been reported. W. H. Ransom in a personal communication to Neff (1947) indicated birds regularly wintered near Bellevue and Medina (adjacent to Seattle), Washington. C. H. Lostetter (pers. comm. 1968) informed me about the presence of a resident population in the Portland, Oregon area. Resident populations at Carmel and Pasadena, California were found by Smith (1968a).

Pigeons banded and recovered at the same trap site throughout most of the year indicated the presence of resident populations. The occurrence of resident populations at Seattle, Washington and Carmel, California, previously reported in the literature, were confirmed. A resident population 30 miles east of San Diego, California was discovered.

Timing of Migration

Spring Migration. Northward migration from the wintering grounds in central California usually was complete by the first of April (Smith, 1968a). Pigeons first arrived at Arcata in northern California during the last week in March. Migration was at its peak in April and continued through June (Glover, 1953). The earliest dates of arrival for pigeons in the northern part of their range were March 5, Mercer, Oregon; April 9, Clallom Bay, Washington; and May 31, Courtenay, British Columbia (Neff, 1947).

In this study the time pigeons arrived at a trapping site was determined from the dates at which pigeons were first banded. This was based on the assumption that pigeons were banded as soon as they arrived; an assumption which may not be valid. Pigeons first arrived at Arcata, California during the 4th week in March (Table 1). Glover (1953) reported pigeons arrived at Arcata in the 4th week in March. At Reedsport and Nehalem, Oregon pigeons arrived during the 2nd and 3rd weeks in April.

Although pigeons were banded throughout June, most bands recovered north of the trapping sites occurred from pigeons banded prior to June. Bands recovered north of the trapping site suggested most migration from the central wintering ground near Carmel, California was completed by April 1, with some migration continuing until May 21 (Table 1). Migration from Arcata in northern California was nearly completed by May 11, but some migration continued until June 10. At Nehalem in northern Oregon most migration was completed by May 21; some migration occurred until June 10.

Glover (1953) reported the migration of pigeons at Arcata, California continued throughout June. The analysis of banding data

Table 1. Numbers of band-tailed pigeons banded by 10-day periods, February-June, at four locations in California and Oregon and the numbers recovered, the numbers recovered per 1,000 banded, and the cumulative percent recovered per 1,000 banded north* of the trap site.

Location and Time Banded		Numbers Banded	Numbers Recovered	North of Trap Site: Numbers Recovered Per 1,000 Banded	North of Trap Site: Cumulative Percent Recovered Per 1,000 Banded
Carmel, Calif., 1952-65					
Feb.	1-10	16	1	62.5	16.5
	11-20	30	1	33.3	25.3
	21-28	29	3	103.4	52.6
Mar.	1-10	15	0	0	52.6
	11-20	38	1	26.3	59.5
	21-31	56	2	35.7	68.9
Apr.	1-10	87	2	23.0	75.0
	11-20	12	0	0	75.0
	21-30	212	4	18.9	80.0
May	1-10	70	0	0	80.0
	11-20	48	3	62.5	96.5
	21-30	73	1	13.6	100.0
June	1-10	60	0	0	
	11-20	86	0	0	
	21-31	55	0	0	
Totals		887	18	379.2	
Arcata, Calif., 1962-65					
Mar.	21-31	79	0	0	
Apr.	1-10	135	2	14.8	24.4
	11-20	155	1	6.4	35.0
	21-30	270	2	8.8	49.5
May	1-10	350	4	11.4	68.3
	11-20	235	0	0	68.3
	21-30	185	2	10.8	86.1
June	1-10	121	1	8.3	100.0
	11-20	116	0	0	
	21-31	48	0	0	
Totals		1701	12	60.5	
Reedsport, Ore., 1952-57					
Apr.	21-30	181	0	0	
May	1-10	912	13	14.3	46.9
	11-20	601	4	6.6	68.9
	21-30	259	2	7.7	94.3
June	1-10	560	1	1.8	100.0
Totals		2513	20	30.4	

continued

Table 1. (continued)

Location and Time Banded		Numbers Banded	Numbers Recovered	North of Trap Site: Numbers Recovered Per 1,000 Banded	North of Trap Site: Cumulative Percent Recovered Per 1,000 Banded
Nehalem, Ore., 1952-57					
Apr.	11-20	171		0	
	21-30	140	1	5.3	18.3
May	1-10	684	7	10.2	53.6
	11-20	575	4	6.9	77.5
	21-30	622	0	0	77.5
June	1-10	650	4	6.5	100.0
	11-20	177	0	0	
	21-31	17	0	0	
Totals		3086	16	28.9	

* At least one degree of latitude north of the trap site.

in this study indicated migration from Arcata terminated in early June (Table 1). At Corvallis, Oregon pigeons which reached their summer range often remained in large pre-breeding flocks as late as June 15. A similar situation may have occurred at Arcata causing Glover to attribute the dispersal of pre-breeding flocks to migration.

Observations of pigeons in September were made at two Oregon hunting areas, Crawfordsville and Monroe, 1966-68. By September 14, in each of the 3 years, relatively few pigeon were present at these areas in contrast to the large numbers present on September 1. Small numbers of pigeons were observed at these areas until September 30 when observations were discontinued.

Fall Migration. After extensive interviews and observations in Washington and Oregon, Neff (1947) concluded fall migration in these states began in late August and continued into October, with most migration completed by the end of September. Smith (1968a) stated that "... usually by late September the majority of birds from the northern coastal states have arrived in California and by mid-October are entirely within the state." These authors indicated that weather and food conditions were important factors affecting the onset and duration of spring and fall migration.

The timing of fall migration was determined from shot recoveries made in British Columbia, Washington, and Oregon during September, 1952-65. Approximately 72 to 87 percent of the shot recoveries in British Columbia, Washington, and Oregon were made by September 14 (Table 4). Although the distribution of recoveries by time was influenced by hunter interest and effort, it can be assumed that these recoveries generally reflected the availability of pigeons to the hunter. These recoveries suggested that most pigeons had migrated from these states and province by mid-September. A few recoveries made in Washington and Oregon on September 30 indicated some migration occurred in October or later.

Routes of Fall Migration

The routes of fall migration were obtained by plotting fall and winter shot recoveries of pigeons banded during the spring in Washington and Oregon, 1950-65. The summer range of these birds was assumed to be near or north of the trap site and recoveries south of the trap site indicated the routes of migration.

The use of shot recoveries for determining routes of migration has limitations. The accuracy in reporting the location of recovery varies among hunters. The straight line between the points of banding and recovery does not necessarily indicate the route used by the bird to reach the recovery site. Rugged and inaccessible areas, such as the Cascades in Washington and Oregon, receive little hunting pressure. If pigeons migrated through these areas, it would not be evident from shot recoveries.

Figure 1. Apparent routes of fall migration of adult band-tailed pigeons based on the distribution of shot recoveries from pigeons banded April through June in Washington, 1950-65. Recoveries in British Columbia, Washington, and Oregon were made in September. Recoveries in the northern third of California were made in October and in the remainder of the state during December and January.

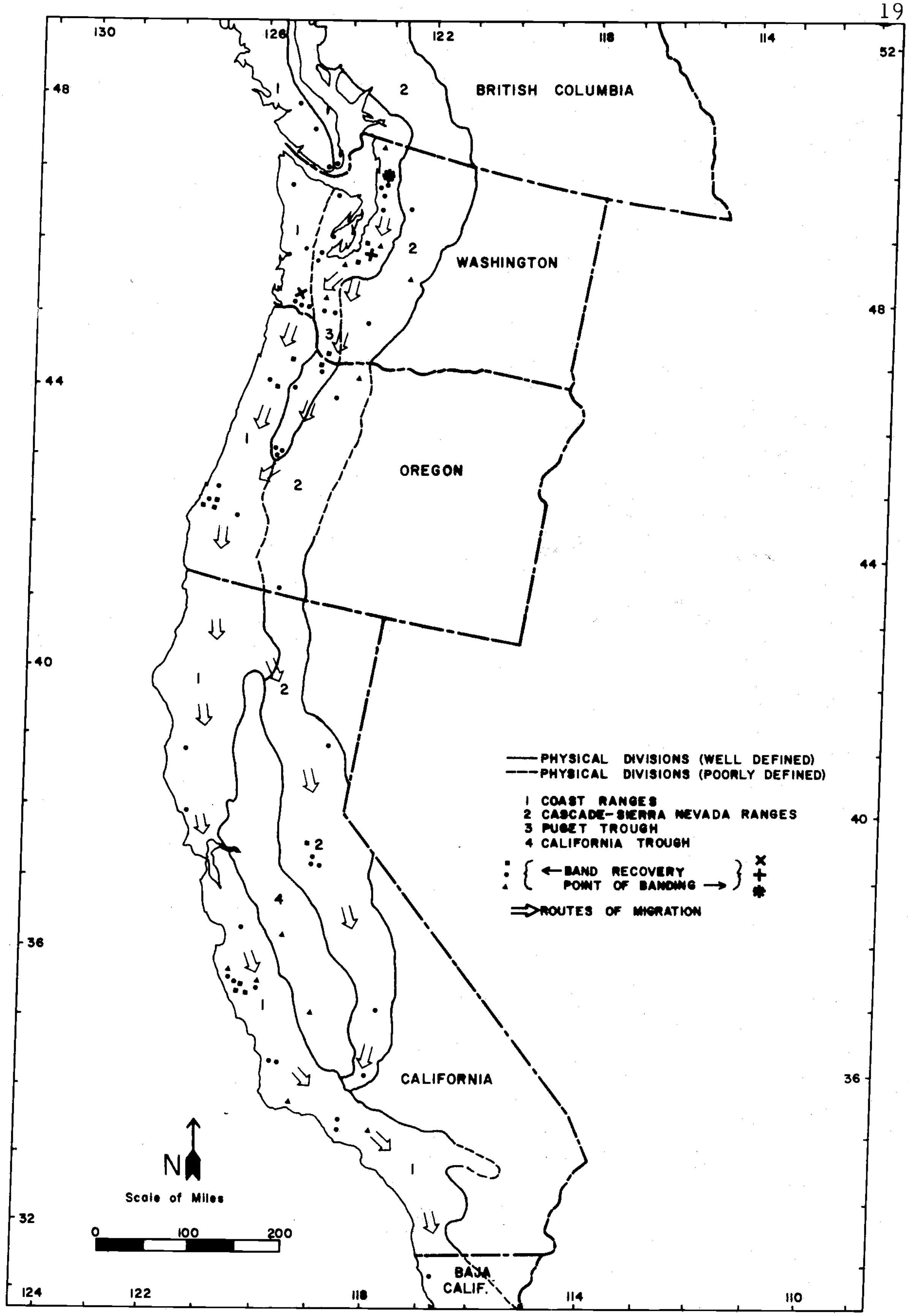
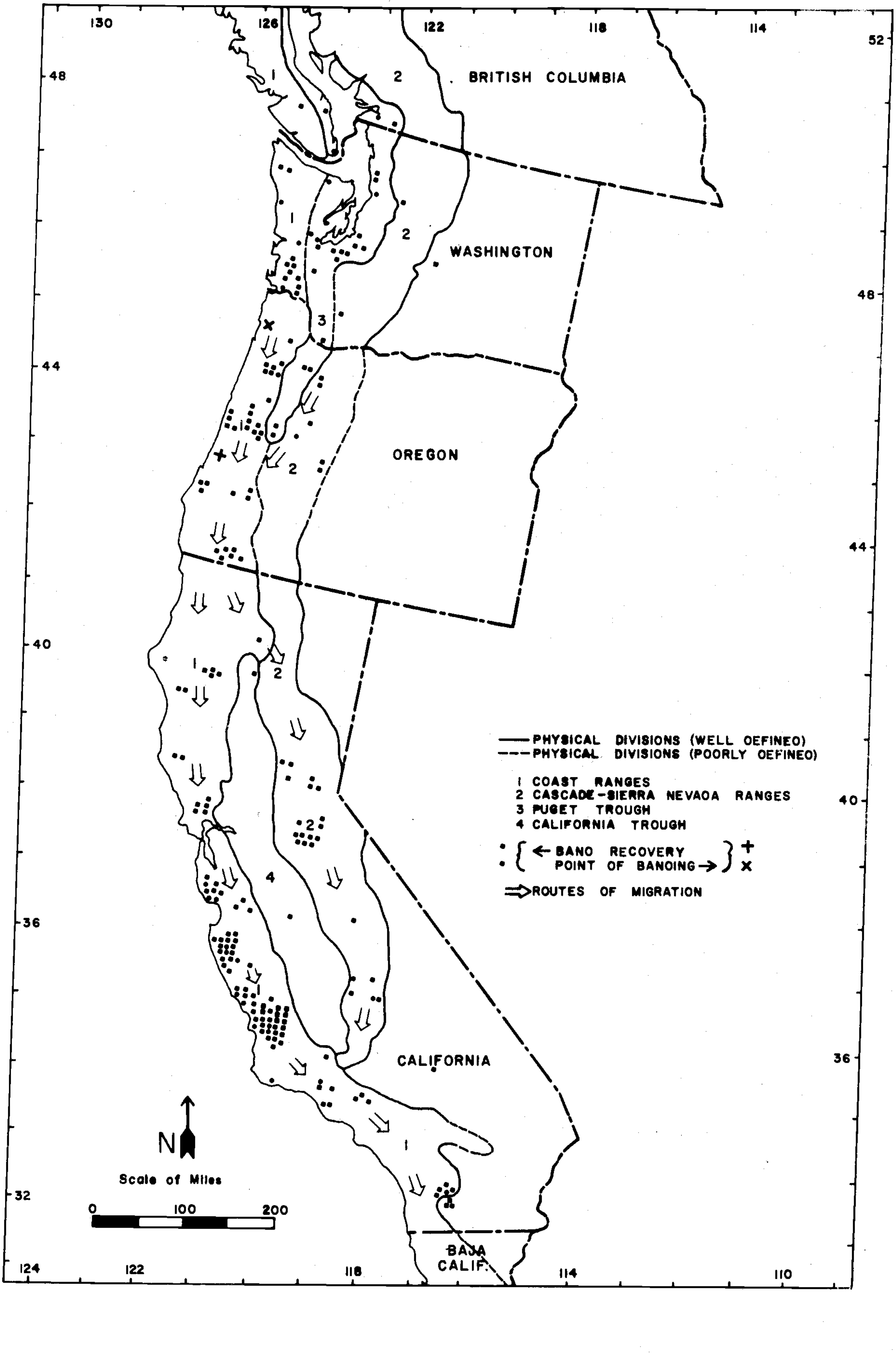

BRITISH COLUMBIA
WASHINGTON
OREGON
CALIFORNIA
BAJA CALIF.
PHYSICAL DIVISIONS (WELL DEFINED)
PHYSICAL DIVISIONS (POORLY DEFINED)
1 COAST RANGES
2 CASCADE-SIERRA NEVADA RANGES
3 PUGET TROUGH
4 CALIFORNIA TROUGH
BAND RECOVERY
POINT OF BANDING
ROUTES OF MIGRATION
N
Scale of Miles
0 100 200

Figure 2. Apparent routes of fall migration of adult band-tailed pigeons based on the distribution of shot recoveries from pigeons banded April through June in Oregon, 1952-65. Recoveries in British Columbia, Washington, and Oregon were made in September. Recoveries in the northern third of California were made in October and in the remainder of the state during December and January.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1 COAST RANGES
2 CASCADE-SIERRA NEVAOA RANGES
3 PUGET TROUGH
4 CALIFORNIA TROUGH
BANO RECOVERY
POINT OF BANOING
ROUTES OF MIGRATION
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Scale of Miles
0
100
200
130
126
122
118
114
52
48
44
40
36
32
124
122
118
114
110

Apparently, two major routes of fall migration existed in Washington and Oregon (Figures 1 and 2). One route was in or along the coastal mountain ranges from west central Washington to the Oregon-California border. The second was from northern Washington on the east side of Puget Sound south through the Puget Trough and the foothills of the Cascades to west central Oregon. At this point the route appeared to turn west and joined the coastal route. Some pigeons using the interior route also crossed over to the coastal route just south of Puget Sound.

The routes of fall migration in California (Figures 1 and 2) were identical to those first described by Smith (1968a). In northern California the single coastal route coming from southern Oregon separated into two distinct routes. One was a continuation of the Oregon coastal route. This route followed the California coastal mountain ranges into Baja California. The second route swung eastward at the north end of the California Trough and followed the Sierra Nevada Mountains until they intercepted the southern coast ranges. At this point some pigeons might follow the coast ranges into Baja California.

The Kill of Pigeons By Hunters

Distribution of the Kill by State and Province

The distribution of the kill by state and province was determined from the distribution of shot recoveries, 1952-57 (Table 2). To use this method it was necessary to assume that band reporting rates between the states and provinces were equal. The validity of this assumption could not be tested with existing data.

Table 2. Numbers of band-tailed pigeons banded in Washington, Oregon and California, and the numbers recovered, numbers recovered per 1,000 banded, and the percent recovered per 1,000 banded in British Columbia, Washington, Oregon, and California, 1952-57.

Location Banded	Numbers Banded	Numbers Re-covered	Numbers Re-covered Per 1,000 Banded	Percent Recovered Per 1,000 Banded			
				British Columbia	Washington	Oregon	California
Washington	531	40	75.2	0	55.1	9.9	35.0
Oregon	2313	106	45.8	0.9	10.5	56.6	32.0
California	1929	86	44.1	3.6	14.1	19.9	64.2
Totals	—	—	165.1	1.2	31.7	25.6	41.5

The distribution of the kill by state and province was also determined from estimates of the annual kill (Table 3) provided by state conservation agencies, 1961-65 (McKibben, 1968; Oregon State Game Commission, 1965, and Swanson pers. comm., 1967). These estimates of the annual kill were derived from information supplied by hunters who returned questionnaires to the conservation agencies. An estimate of the annual kill in British Columbia was made for me by W. G. Smith, Chief, Wildlife Management (pers. comm., 1967).

Table 3. Percent distribution of the average annual kill of band-tailed pigeons by state and province, 1961-65. This distribution was derived from annual estimates of the kill made by state or provincial conservation agencies.

Average Annual Kill	State or Province			
	British Columbia	Washington	Oregon	California
486,000	2.0	23.4	22.6	52.0

These data suggested that the largest fraction of the kill occurred in California and most of the remaining kill was equally distributed between Washington and Oregon. Approximately 1.0 to 2.0 percent of the kill occurred in British Columbia.

Distribution of the Kill by Time in the States and Province

British Columbia, Washington, and Oregon. The distribution of the kill during the September hunting seasons in British Columbia, Washington, and Oregon derived from shot recoveries was similar, 1950-65 (Table 4).

The distribution of the kill by time in Oregon during the September 1966 and 1967 seasons was derived from the hunter survey. Although the magnitude of the kill varied by time periods, the distribution of the kill followed the same trend as the distribution of shot recoveries (Table 5).

Table 4. Percent distribution of shot recoveries of adult band-tailed pigeons banded in Washington, Oregon, and California by time of recovery during the September hunting season in British Columbia, Washington, and Oregon, 1950-65.

State or Province of Recovery	Location Banded	Numbers Recovered	September 1-7	8-14	15-21	22-30
British Columbia	Washington	2	0	0	0	100
	Oregon	4	75.0	25.0	0	0
	California	5	80.0	0	20.0	0
Totals		11	63.6	9.1	9.1	18.2
Washington	Washington	99	65.6	22.2	9.1	3.1
	Oregon	29	65.5	6.9	17.2	10.3
	California	19	57.9	15.8	5.3	21.0
Totals		147	64.6	18.4	10.2	6.8
Oregon	Washington	21	33.3	33.3	19.0	14.3
	Oregon	249	69.5	18.9	8.4	2.8
	California	30	66.7	23.3	10.0	0
Totals		300	66.7	20.3	9.7	1.0

Table 5. Percent distribution of hunters afield and band-tailed pigeons killed by time during the 1966 and 1967 hunting seasons in Oregon. This distribution was obtained from the hunter survey.

Category and Year	Numbers	Time of Season (Days) 1-7	8-14	15-21	22-28
Hunters Afield					
1966	345	58.5	19.7	11.2	9.6
1967	315	50.0	32.4	12.8	3.8
Pigeons Killed					
1966	1340	59.2	18.6	11.6	10.6
1967	1283	48.6	34.9	10.1	3.4

Three years (1966-68) of subjective observations at hunting areas in Oregon suggested the distribution of the kill by time was a function of the availability of pigeons. The large number of hunters afield during the early part of the season was due, in part, to the high interest among hunters associated with the beginning of any season. However, my observations suggested the number of hunters afield and their kill generally was dependent on the number of birds available at hunting areas.

California. Shot recoveries indicated most of the kill in California occurred in the southern two-thirds of the state during the December-January hunting seasons. The October hunting seasons accounted for only 18 of the 219 recoveries made in the state, 1953-65.

The kill in southern California during December and January was well distributed throughout the season. The large fraction, 36.8 percent, of the kill during the initial 8 days of the season was probably due, in part, to the high interest among hunters and effort associated with the start of any season (Table 6). The drop in the kill during the second 8 days of the season had no explanation. The kill was similar during the two remaining 8-day periods and accounted for approximately 50 percent of the total kill. This large kill in the second half of the season suggested that large numbers of pigeons were present on the California wintering grounds throughout the season. Hunters apparently took advantage of the availability of birds and hunted throughout the season but without the effort or enthusiasm associated with the beginning of the season.

Table 6. Percent distribution of shot recoveries of adult band-tailed pigeons in the southern two-thirds of California by time during the December - January hunting season, 1953-65. These pigeons were banded in the three Pacific coast states.

Year	Season				Total Recoveries	Time of Recovery (Days)			
						1-8	9-16	17-24	25-31
1953-57	December	1-31			112	41.1	9.8	20.5	28.6
1958-59	December	11	January	10	22	36.4	18.2	31.8	13.6
1960	"	17	"	15	15	53.3	26.7	13.3	6.7
1961	"	16	"	14	11	18.2	27.3	45.4	9.1
1962	"	15	"	13	19	15.8	15.8	36.8	31.6
1963	"	14	"	12	10	0	0	0	100.0
1964	"	12	"	10	4	75.0	0	25.0	0
1965	"	11	"	9	8	50.0	25.0	0	25.0
Totals					201	36.8	13.4	22.4	27.4

Hunting Effort, Success, and Crippling Loss in Oregon

Data on the effort and success of hunters and the number of pigeons crippled were obtained from the 1966 and 1967 hunter surveys. Comparisons of data between years were restricted to those obtained from hunters not previously contacted by the survey.

Response to the 1966 survey, 27.6 percent, was not as large as in 1967, 33.2 percent (Appendix Table 3). Approximately 65 percent of the total response each year, was provided by hunters returning one or two envelopes. The large response in 1967 was not expected because the scheduled opening of the season was postponed due to hazardous fire conditions in the forests.

Hunter Effort and Success. Hunters averaged 2.2 hunting trips per season in 1966 and 1967. The average number of pigeons killed per hunting trip was relatively uniform throughout the season and was similar in both years (Table 7.)

Table 7. Average number of band-tailed pigeons killed per hunter per hunting trip by time during the 1966 and 1967 hunting season in Oregon. Data were obtained from the hunter survey.

Time (Days)	Number of Hunters Afield		Number of Pigeons Killed		Number of Pigeons Killed Per Hunter Per Trip	
	1966	1967	1966	1967	1966	1967
1- 7	202	154	793	621	3.9	4.0
8-14	68	102	250	448	3.7	4.4
15-21	42	40	155	130	3.7	3.3
22-30	33	12	142	43	4.3	3.6
Totals	345	308	1340	1242	3.9	4.1

The distribution of bag sizes among hunters was similar each year (Table 8). As the bag size increased from one to eight, the number of hunters achieving each bag size declined until the limit (8) category was reached. The number of hunters achieving a limit increased greatly. The large percentage of hunters with limits, 14 to 17 percent, may be due to several factors. The pride or self satisfaction associated with attaining a limit might increase the reporting rate of these hunters. My field experience suggested the large number of hunters with limits was a result of the increased effort by hunters with six or seven pigeons to achieve a limit.

Table 8. Percent distribution of bag sizes of band-tailed pigeon hunters in Oregon during 1966 and 1967. Data were obtained from the hunter survey.

Year	Numbers of Hunters	Bag Size							
		1	2	3	4	5	6	7	8
1966	345	19.1	21.4	12.2	10.4	8.4	7.2	6.7	14.5
1967	315	19.7	14.3	14.0	14.3	8.2	5.7	6.7	17.1

Crippling Loss. A quantitative estimate of crippling loss was first obtained from the 1967 hunter survey. Hunters were asked to report the number of birds they shot which fell to the ground but which could not be found. The estimate of crippling loss was obtained by dividing the number of birds which could not be found by the total number shot. Hunters shot 1,506 birds but could not find 326 for a crippling loss of 21.6 percent. This estimate of crippling loss is minimal because some hunters probably failed to report cripples or report a reduced number.

Jay B. Long, Professor of Wildlife Ecology, Oregon State University, observed crippling loss at the Monroe hunting area in

1967. He reported hunters shot 528 pigeons but could not find 132 for a crippling loss of 25.0 percent.

Crop Conditions of Adults Shot in Oregon

Members of both sexes of the band-tailed pigeon engage in incubation, brooding, and feeding the young (Neff, 1947; Peeters, 1962). The young of band-tails are fed pigeon milk, a substance produced by the thickened crops of both adults. Little is known about the time pigeon milk first forms in the crops of adult band-tails or the length of time it is fed to young. In adult domestic pigeons (*Columba livia*) pigeon milk appears during late incubation and is fed to squabs until they are 7 to 10 days old (Levi, 1957).

The crops of adult band-tails killed by hunters during the first half of September were examined to determine if adults were in the late stages of incubation or feeding young. Three crop conditions were recognized: (1) Active - crop wall swollen, convoluted and pigeon milk present; (2) Stimulated - crop wall swollen convoluted but no pigeon milk present; (3) Normal - crop thin walled, no convolutions and no pigeon milk present.

The presence of active crops in samples of pigeons shot at four widely separated points in Oregon during 1967 (Table 9) indicated some adults were in the late stages of incubation or feeding young throughout their range in this state. Most adult pigeons

Table 9. Per cent distribution of crop conditions of adult band-tailed pigeons examined at four hunting areas in Oregon during September 1966 and 1967.

Period	Location	Sex	Number checked	Crop Conditions: Active	Stimulated	Normal
1966						
Sept. 1-10	Crawfordsville	Male	74	39.2 (29)*	31.1 (23)	29.7 (22)
		Female	82	12.2 (10)	46.3 (38)	41.5 (34)
3	Monroe	Male	12	41.7 (5)	0 (0)	58.3 (7)
		Female	12	8.3 (1)	41.7 (5)	50.0 (6)
SUB-TOTAL		Male	86	39.4 (34)	26.7 (23)	33.7 (29)
		Female	94	11.7 (11)	45.7 (43)	42.6 (40)
TOTAL		Both	180	25.0 (45)	36.7 (66)	38.3 (69)
1967						
Sept. 6-16	Crawfordsville	Male	136	56.6 (77)	15.4 (21)	27.9 (38)
		Female	123	24.5 (30)	47.5 (60)	27.0 (33)
6	Monroe	Male	13	30.7 (4)	53.8 (7)	15.5 (2)
		Female	11	18.2 (2)	45.5 (5)	36.3 (4)
6	St. Helens	Male	15	53.3 (8)	33.3 (5)	13.4 (2)
		Female	10	30.0 (3)	50.0 (5)	20.0 (2)
6	Coquille	Male	21	42.8 (8)	23.8 (6)	33.3 (7)
		Female	30	20.0 (6)	33.0 (10)	47.0 (14)
SUB-TOTAL		Male	185	53.0 (97)	20.5 (39)	26.5 (49)
		Female	174	23.6 (41)	45.4 (80)	31.0 (53)
TOTAL		Both	359	38.7 (138)	32.6 (109)	28.7 (102)
1966-67						
SUB-TOTAL		Male	271	48.7 (131)	22.5 (62)	28.8 (78)
		Female	268	19.4 (52)	45.5 (123)	35.1 (93)
TOTAL		Both	539	34.1 (183)	33.9 (185)	32.0 (171)

*Figures in parentheses are sample size.

migrated from Oregon by mid-September. Therefore, most adults with active crops were probably in the late stages of feeding young during the last nesting attempts of the season.

Stimulated crops (Table 9) might appear at two stages in the nesting cycle; during incubation or after the feeding of pigeon milk to young had increased. The advanced date of the nesting season also suggested that most adults with stimulated crops had completed feeding young pigeon milk.

Adults with normal crops (Table 9) were presumed to have completed any nesting they attempted.

Males with active crops were 2.5 times as numerous as females with active crops (Table 10). Chi-square tests indicated the sex ratio of this group was significantly different ($P < 0.01$) from the expected ratio of 1:1. Females with stimulated crops were 2.0 times as numerous as males with stimulated crops. Chi-square tests indicated this ratio was significantly different ($P < 0.01$) from the expected ratio of 1:1. There was no significant difference ($X^2 = 1.488$, 1 d.f.) in the ratio of males to females with normal crops from the expected ratio of 1:1.

I believe that the uneven sex ratio of pigeons with active crops in the kill was due to the difference in the incubation and brooding schedules of the sexes. Peeters (1962) and Neff (1947) found that band-tails had a relatively rigid incubation and brooding schedule.

Table 10. Male to female ratios of adult band-tailed pigeons with active, stimulated and normal crops killed by hunters in Oregon during September, 1966 and 1967.

Year	Crop Conditions		
	Active	Stimulated	Normal
1966	3.1: 1(34: 11)*	0.54: 1(23: 43)	0.73: 1(29: 40)
1967	2.4: 1(97: 41)	0.49: 1(39: 80)	0.90: 1(49: 53)
Totals	2.5: 1(131: 52)	0.50: 1(62: 123)	0.84: 1(78: 93)

*Figures in parentheses are sample sizes.

These authors reported males took over incubation and brooding from the female at about 10:30 a.m. Approximately 70 percent of the pigeons I examined in 1966 and 1967 were killed prior to 10:30 a.m., when males with active crops were available to hunters and females were on the nest.

I cannot explain the differential vulnerability of the sexes with stimulated crops.

Age Structure

Age Structure of the Kill in Oregon

The Oregon State Game Commission (1965) conducted annual hunter bag-checks, 1949-64, to determine the age structure of the kill. During these years, 24.0 percent of the 26,287 pigeons examined were immatures. The percentage of immatures ranged from 21.0 in 1953 to 27.7 in 1964. The criteria of age identification and a correction factor used by the Oregon State Game Commission (1965) to obtain these percentages were checked against the methods used in my study. I found the method used by this agency overestimated immatures in the kill by approximately 2.0 percent in contrast to my method.

In my study the estimates of the age structure of the kill obtained from hunter bag-checks (Table 11) and the hunter survey (Table 12) were similar in 1966 and 1967. The hunter survey provided the best estimate because it sampled the kill throughout the state and during the entire season.

Table 11. Age and sex of band-tailed pigeons examined at four hunting areas in Oregon during the September 1966 and 1967 season.

Period	Location	Adults Number Checked	Adults Percent Females	Immatures Number Checked	Immatures Percent Females	Percent Immatures
1966						
Sept. 1-10	Crawfordsville	196(3)*	56.1	51	—+	20.4
3	Monroe	25	48.0	4	—	13.8
Totals		221(3)	55.2	55	—	19.7
1967						
Sept. 6-16	Crawfordsville	260	47.3	58(8)	44.8	20.2
6	Monroe	24	45.8	1	100	4.0
6	St. Helens	25	40.0	3(2)	66.7	16.6
6	Coquille	51	58.8	9(1)	44.4	16.4
Totals		360	48.3	71(11)	45.0	18.5
1966-67						
Totals		581(3)	50.8	71(66)	45.0	19.0

*Figures in parentheses indicate the number of additional pigeons for which sex was not obtained.

+Immatures were not checked for sex in 1966.

The lowest percentage of immatures in the kill occurred during the first week in September (Table 12). This suggested some immatures were not available to hunters during the early part of September. I believe this might be due to a differential in migration whereby some immatures produced early in the nesting season migrated south earlier than most adults. No data were available to verify this suggested differential in migration.

Table 12. Percent distribution of immature band-tailed pigeons in the Oregon kill by 10-day periods. Data were obtained from the 1966 and 1967 hunter survey.

Year	September			Totals
	1-10	11-20	21-30	
1966	12.5(955)*	25.1(239)	27.4(167)	16.5(1361)
1967+	15.0(678)	18.8(803)	30.4(191)	18.6(1672)#
Totals	13.5(1633)	20.2(1042)	29.9(358)	17.6(3033)

*Figures in parentheses are sample size.

+Because there was no difference in the age structure of the kill made by the two groups of hunters sampled in 1967 the data from these two groups was combined.

#The 1967 season was Sept. 1 - Oct. 5. During October 1-5, 24 wings (16 from immatures) were returned. The total percentage of immatures in the hunter survey was 19.3.

Each year, as the season progressed an increasing percentage of the kill was composed of immatures (Table 12). This increase of immatures was due, in part, to young leaving the nest and becoming available to hunters. Evidence supporting this hypothesis was obtained from the primary feather molt of immatures. The percentage of immatures in the youngest age class, those which had not lost their first juvenile primary, increased as the season progressed (Table 13).

The increase of immatures in the kill may also be due, in part, to a differential in migration whereby adults departed earlier than those immatures recently off the nest.

Table 13. Percent distribution of the primary feather molt* of immature band-tailed pigeons in the Oregon kill by 10-day periods. Data were obtained from the 1966 and 1967 hunter survey.

Period		Sample Size	Number of Last Primary Molted							
			0+	1	2	3	4	5	6	7
1966										
Sept.	1-10	120	17.5	20.8	16.6	20.0	16.6	4.2	3.3	0.8
	11-20	60	21.6	16.6	20.0	13.3	13.3	11.6	3.3	0
	21-30	48	22.9	18.7	16.6	14.5	12.5	8.3	0	6.2
Totals		228	20.0	19.2	17.8	17.0	14.7	7.1	2.7	1.3
1967										
Sept.	6-10	106	23.6	17.9	20.8	17.9	13.2	5.7	0	1.0
	11-20	159	26.9	25.6	19.9	12.2	10.3	3.8	0.6	0.6
	21-30	60	35.0	18.3	21.7	13.3	6.7	0.5	0	0
Oct.	1-5	16	6.2	43.7	18.8	18.8	6.2	6.2	0	0
Totals		340	26.2	22.6	20.3	14.4	10.9	4.7	0.3	0.6

* The molt begins with the intermost primary (1) and advances towards the outermost primary (10).
\+ All juvenile primaries present.

The age structure of the Oregon kill was biased by late nesting and probably by differentials in migration. Therefore, this age structure did not provide a valid estimate of production for this population.

Age Structure in Oregon During Spring

The age structure of a pigeon population in the spring was sampled near Corvallis, Oregon. From May 5 to June 18, 1967, 729 pigeons were captured; 19.9 percent were subadults. In 1968, 13.9 percent of the 1,070 pigeon captured May 1 to June 3 were subadults. The mean percentage of subadults for the two years was 16.9. All subadults could not be recognized in spring because 35.0 percent had lost the juvenile plumage diagnostic of age as early as December (Silovsky *et al.*, 1968). Therefore, the spring samples underestimated the percentage of subadults by at least 35.0 percent. On this basis I estimate that the percentage of subadults in the spring population for the two years should have been a minimum of 26.0 percent ($\frac{16.9}{X} : \frac{(100-35)}{100}$).

The mean percentage of subadults (adjusted) in the spring sample was considerably greater than the mean percentage of immatures in the kill the previous fall (Table 12). If the age structure of the spring sample was representative of the Oregon population, this suggested the age structure of the kill underestimated the the number of immatures in the fall population.

Age Structure of the California Kill

An estimate of the age structure of the kill on the wintering grounds in California was obtained from bag-checks conducted during December, 1966. Of 64 birds examined, 40.6 percent were immatures. Smith (pers. comm., 1968b) examined 1,705 birds killed in southern California during December 1952-54; 39.1 percent were immature. The criteria of age identification in my study were identical to those used by Smith.

Recovery Rates

Hickey (1951) and Bellrose *et al.* (1961) demonstrated that the different recovery rates of the age or sex classes provided information on differential vulnerability to the gun.

Direct Recovery Rates Associated with Age

Chi-square tests indicated that the direct recovery rate of immatures was significantly greater ($P < 0.05$) than the direct recovery rate of adults (Table 14). This indicated immatures were more vulnerable to the gun than adults. Because the number of immatures banded was quite small, I do not place any confidence in the magnitude of the difference between the direct recovery rates of the two age classes. Therefore, I have not computed a relative recovery rate.

Table 14. Numbers banded, numbers of direct recoveries, and direct recovery rates of adult and immature band-tailed pigeons banded and recovered in Washington, Oregon, and California, 1950-65.

Numbers Banded		Numbers of Direct Recoveries		Direct Recovery Rates	
Adults	Immatures	Adults	Immatures	Adults	Immatures
9557	261	223	11	.0233	.0421

Direct Recovery Rates Associated with Sex

No significant differences were observed between the direct recovery rates of adult males and females (Table 15), banded in Washington-Oregon (X^2 = 2.124, 1 d.f.) and California (X^2 = 0.132, 1 d.f.). This indicated the sexes were equally vulnerable to hunters assuming an equal sex ratio in the population. Because the number of adults sexed and banded in Washington-Oregon was quite small, I do not place any confidence in this estimate of vulnerability for the sexes. I believe the California sample was adequate and indicated no difference in the vulnerability of the sexes existed in that state.

Mortality

Knowledge of the mortality that a species undergoes is a prerequisite for its management. Estimates of age and sex specific mortality and the percent of the total mortality due to hunting and to natural causes were made.

Table 15. Numbers banded, numbers of direct recoveries, and direct recovery rates of adult male and female band-tailed pigeons banded in the Pacific coast states and recovered in British Columbia, Washington, Oregon, and California, 1950-65.

Location	Numbers Banded		Numbers of Direct Recoveries		Direct Recovery Rates	
Banded	Males	Females	Males	Females	Males	Females
Washington and Oregon	514	387	8	11	.0155	.0284
California	1393	1308	22	23	.0157	.0175

Mortality Associated with Age

Mortality of Adult Pigeons Banded in Washington. The estimate of the average annual mortality of adult pigeons banded in Washington, 1950-65, was 37.8 percent (Table 16). This estimate was derived from two groups of pigeons: summer residents and non-migratory pigeons. It was not possible to separate these two groups because they were banded at the same time. Therefore, this estimate of mortality may not be representative of either group of pigeons.

Mortality of Adult Pigeons Banded in Oregon. Wight, Mace and Batterson (1967) were the first to compute estimates of mortality for band-tailed pigeons. These authors used shot recoveries to compute an average annual mortality of 28.7 percent for adults banded at Nehalem, Oregon, 1952-65. These authors also used records from banded pigeons returning to the Nehalem banding site to compute a mortality estimate of 29.1 percent for this same period.

I recalculated the mortality for pigeons banded at Nehalem for the period, 1952-57. The estimate of average annual mortality for this period was 31.1 percent (Table 17). The estimate of average annual mortality for adults banded near Reedsport, Oregon, 1952-57 was 32.1 percent (Table 18). My data indicate these two populations were composed of summer residents, whose summer range was near or north of the banding sites.

Mortality of Adult Pigeons Banded in California. Smith (1968a) computed a mortality estimate of 42.7 percent for adult and immature pigeons (combined) banded in California, 1952-58. Because Smith used data from immatures and adult pigeons his estimate of mortality is not directly comparable to mine.

The estimate of the average annual mortality of adults banded in California 1952-65 was 38.9 percent (Table 19). Two groups of pigeons were present in this banded population: winter residents and non-migratory pigeons. A large number of these pigeons were known to be from non-migratory populations (MacGregor and Smith, 1955; Smith, 1968a). Therefore, this estimate of mortality may not be representative of either group of pigeons.

Immature Mortality. It was necessary to combine the limited data on immatures from all the states to obtain a sample sufficiently

Table 16. Estimated rate of mortality of adult band-tailed pigeons banded in Washington, 1950-65.

Year banded	Number banded	Hunting Seasons Survived 1	2	3	4	5	6	7	8	9	Direct recovery rate	Total recoveries
1950	18	1	0	1	0	0	0	0	0	0	.0555	2
1951	47	0	1	1	0	1	0	0	0	0	0	3
1952	36	1	0	0	1	0	0	0	0	1	.0277	3
1953	211	6	6	4	1	2	1	0	0	0	.0284	20
1954	107	2	3	4	1	0	1	0	0	0	.0186	11
1955	33	3	1	1	0	0	0	0	0	0	.0909	5
1956	106	0	1	0	1	1	0	0	0	0	0	3
1957	38	1	0	1	0	0	0	0	0	0	.0263	2
1958	9	2	0	0	0	0	0	1	0		.2222	3
1959*												
1960	570	19	7	4	0	2	1				.0333	33
1961	180	7	2	0	1	1					.0388	11
1962*												
1963	460	0	7	3							0	10
1964	144	2	2								.0138	4
1965	771	18	—	—	—	—	—	—	—	—	.0233	18
TOTALS	2730	62	30	19	5	7	3	1	0	1	.0227	128
Banded birds available		2730	1959	1815	1355	1355	1175	605	605	596		
Recoveries/ 1000 banded		22.9	15.3	10.5	3.7	5.2	2.5	1.6	0	1.7	$\Sigma = 63.4$	
Alive at beginning of period		63.4	40.5	25.2	14.7	11.0	5.8	3.3	1.7	1.7	$\Sigma = 167.3$	
Mortality rate		.361	.377	.416	.251	.472	.431	.484	0	1.00	$\frac{63.4}{167.3} = .378^{+}$	

* No useable bandings. + Average annual mortality rate 1 through 9 years.

Table 17. Estimated rates of mortaility of adult band-tailed pigeons banded at Nehalem, Oregon, 1952-57.*

Year banded	Number banded	Hunting Seasons Survived 1	2	3	4	5	6	7	8	9	10	11	12	13	Direct recovery rate	Total recoveries
1952	69	0	2	4	1	0	1	0	1	0	0	0	0	0	0	9
1953	248	13	10	3	2	0	1	1	2	0	1	0	0	1	.0524	34
1954	294	10	10	7	3	1	1	1	2	2	1	0	0		.0340	38
1955	196	6	1	4	1	1	1	0	2	0	0	0			.0306	16
1956	483	25	9	8	2	2	2	3	0	1	2				.0517	54
1957	226	8	7	6	5	1	0	0	0	1	—	—	—	—	.0354	28
TOTALS	1516	62	39	32	14	5	6	5	7	4	4	0	0	1	.0408	179
Banded birds available		1516	1516	1516	1516	1516	1516	1516	1516	1516	1290	807	611	317		
Recoveries/1000 banded		40.8	25.7	21.1	9.2	3.3	3.9	3.3	4.5	2.6	3.1	0	0	3.2	$\Sigma = 120.9$	
Alive at beginning of period		120.9	80.0	54.3	33.3	24.0	20.7	16.8	13.5	8.9	6.3	3.2	3.2	3.2	$\Sigma = 388.1$	
Mortality rate		.338	.321	.388	.277	.137	.190	.196	.341	.297	.496	0	0	1.00	$\frac{120.9}{388.1} = .311^{+}$	

*Recalculated from a life table of adult band-tailed pigeons 1952-65 in the Journal of Wildlife Management [1967, (31) 3] by permission of the authors, H. M. Wight, R. U. Mace and W. M. Batterson.

+ Average annual mortality rate, 1 through 13 years.

Table 18. Estimated rates of mortaility of adult band-tailed pigeons banded near Reedsport, Oregon, 1952-57.

Year banded	Number banded	Hunting Seasons Survived											Direct re-covery rate	Total recoveries
		1	2	3	4	5	6	7	8	9	10	11		
1952	61	2	0	1	1	0	1	0	0	0	0	0	.0372	5
1953	391	11	3	2	2	1	0	0	1	1	3	0	.0281	24
1954	490	10	5	6	6	2	1	3	2	0	0	1	.0204	36
1955	268	7	0	5	3	1	0	1	1	0	0	0	.0261	18
1956	739	12	22	6	8	4	2	1	0	0	0		.0162	55
1957	364	9	3	4	4	5	2	0	0	0	—	—	.0247	27
TOTALS	2313	51	33	24	24	13	6	5	4	1	3	1	.0220	165
Banded birds available		2313	2313	2313	2313	2313	2313	2313	2313	2313	1949	1210		
Recoveries/ 1000 banded		22.0	14.3	10.4	10.4	5.6	2.6	2.2	1.7	.4	1.5	.8	$\Sigma = 71.9$	
Alive at beginning of period		71.9	49.8	35.6	25.2	14.9	9.3	6.7	4.5	2.8	2.4	.8	$\Sigma = 223.9$	
Mortality rate		.306	.286	.291	.410	.377	.279	.323	.381	.153	.649	1.00	$\frac{71.9}{223.9} = .321^{+}$	

+ Average annual mortality rate, 1 through 11 years.

Table 19. Estimated rates of mortality of adult band-tailed pigeons banded in California, 1952-65.

Year banded	Number banded	Hunting Seasons Survived 1	2	3	4	5	6	7	8	9	Direct recovery rate	Total recoveries
1952	136	2	3	2	0	0	1	0	0	1	.0147	9
1953	794	16	11	7	3	0	2	0	0	0	.0214	39
1954	633	17	3	3	2	2	1	2	0	0	.0268	30
1955	269	5	1	2	1	3	0	0	1	0	.0186	13
1956	66	3	0	0	0	0	0	0	0	0	.0454	3
1957	31	0	0	0	1	0	0	0	0	0	0	1
1958-60*												
1961	11	0	0	0	0	0					0	0
1962	243	7	0	1	0						.0288	8
1963	343	0	2	0							0	2
1964	390	2	3								.0051	5
1965	771	12	—	—	—	—	—	—	—	—	.0155	12
TOTALS	3687	64	23	19	7	5	4	2	1	1	.0173	126
Banded birds available		3687	2916	2526	2183	1940	1929	1929	1929	1929		
Recoveries/ 1000 banded		17.3	7.9	7.5	3.2	2.6	2.1	1.0	.5	.5	Σ = 42.6	
Alive at beginning of period		42.6	25.3	17.4	9.9	6.7	4.1	2.0	1.0	.5	Σ = 109.6	
Mortality rate		.407	.312	.431	.323	.384	.501	.500	.500	1.00	$\frac{42.6}{109.6} = .389^{+}$	

*No useable bandings.

+ Average annual mortality rate,1 through 9 years.

Table 20. Estimated rates of mortality of immature band-tailed pigeons banded in Washington, Oregon and California, 1950-65.

Year banded	Number banded	Hunting Seasons Survived 1	2	3	4	5	6	7	8	9	10	11	Direct recovery rate	Total recoveries
1950	9	1	0	0	0	0	0	0	0	0	0	0	.1111	1
1951	16	0	0	0	0	0	0	1	0	0	0	0	0	1
1952	26	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	68	3	0	1	2	1	0	0	0	0	0	1	.0441	8
1954	66	4	2	0	0	0	0	0	0	0	0	0	.0606	6
1955	6	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	4	0	0	0	0	0	0	0	0	0	0		0	0
1957	4	0	0	0	1	0	0	0	0	0			0	1
1958	1	0	0	0	0	0	0	0	0				0	0
1959	3	0	0	0	0	0	0	0					0	0
1960	1	0	0	0	0	0	0						0	0
1961	2	0	0	0	0	0							0	0
1962	12	2	0	0	0								.1666	2
1963	5	0	0	0									0	0
1964	8	0	0										0	0
1965	30	1											.0333	1
TOTALS	261	11	2	1	3	1	0	1	0	0	0	1	.0421	20
Banded birds available		261	231	223	218	206	204	203	300	199	195	191		
Recoveries/ 1000 banded		(42.1)	[8.6	4.5	12.7	4.8	0	4.9	0	0	0	5.2]	[Σ]= [40.7]	
Recoveries/ 1000 banded		(82.8)	[40.7	32.1	27.6	14.9	10.1	10.1	5.2	5.2	5.2	5.2]	[Σ]= [115.6]	
Mortality rate		.508*	.211	.104	.460	.322	0	.485	0	0	0	1.00		

$$\frac{(42.1)}{(82.8)} = .508^{*} \qquad \frac{[40.7]}{[115.6]} = .352^{+}$$

*Immature mortality rate.

+ Average annual adult mortality rate, 2 through 11 years.

large enough to compute mortality. The estimate of first year mortality for immatures banded in Washington, Oregon and California, 1950-65, was 50.8 percent (Table 20). The estimate of the average annual adult mortality 2 through 11 years for these pigeons was 35.2 percent.

Mortality Associated with Sex

Estimates of the sex specific mortality of adults varied between the sexes and different populations (Tables 21, 22, 23, and 24). These estimates of mortality were computed from relatively small samples and may not be representative of the populations. In addition, the method or accuracy of sex identification for these pigeons was unknown.

Natural Mortality

Hickey (1952) and Geis (1959) found strong evidence that natural mortality occurred in addition to and not in place of hunting mortality for several species of waterfowl. These authors suggested that natural mortality was relatively constant for waterfowl, therefore as hunting mortality increased the total mortality also increased. Geis (1963) suggested this relationship also occurred with the white-winged dove (*Zenaida asiatica*), a species closely related to the band-tailed pigeon.

Table 21. Estimated rates of mortality of adult male band-tailed pigeons banded in California, 1952-65.

Year banded	Number banded	Hunting Seasons Survived 1	2	3	4	5	6	7	Direct recovery rate	Total recoveries
1952	11	0	0	0	0	0	0	0	0	0
1953	310	7	6	2	2	0	1	0	.0225	18
1954	170	6	1	0	1	0	0	1	.0352	9
1955	126	1	0	1	0	1	0	0	.0079	3
1956	7	0	0	0	0	0	0	0	0	0
1957	3	0	0	0	0	0	0	0	0	0
1958-61*										
1962	119	3	0	0	0				.0252	3
1963	126	0	0	0	0				0	0
1964	186	0	1						0	1
1965	335	5	—	—	—	—	—	—	.0149	5
TOTALS	1393	22	8	3	3	1	1	1	.0157	39
Banded birds available		1393	1058	872	746	627	627	627		
Recoveries/ 1000 banded		15.8	7.6	4.3	4.0	1.6	1.6	1.6	$\Sigma = 36.4$	
Alive at beginning of period		36.4	20.7	13.1	8.8	4.8	3.2	1.6	$\Sigma = 88.6$	
Mortality rate		.433	.366	.329	.457	.333	.500	1.00	$\frac{36.4}{88.6} = .412^{+}$	

*No useable bandings.

+ Average annual mortality rate,1 through 7 years.

Table 22. Estimated rates of mortality of adult female band-tailed pigeons banded in California, 1952-65.

Year banded	Number banded	Hunting Seasons Survived								Direct recovery rate	Total recoveries
		1	2	3	4	5	6	7	8		
1952	9	0	1	0	0	0	0	0	0	0	1
1953	268	4	3	3	0	0	1	0	0	.0149	11
1954	210	5	1	0	0	1	0	1	0	.0238	8
1955	141	3	1	1	1	2	0	0	1	.0212	9
1956	4	0	0	0	0	0	0	0	0	0	0
1957-61*											
1962	113	4	0	1	0					.0353	5
1963	174	0	2	4						0	6
1964	136	2	2							.0147	4
1965	253	5	—	—	—	—	—	—	—	.0197	5
TOTALS	1308	23	10	9	1	3	1	1	1	.0175	49
Banded birds available		1308	1055	919	745	632	632	632	632		
Recoveries/ 1000 banded		17.6	9.5	9.7	1.3	4.7	1.6	1.6	1.6	$\Sigma = 47.6$	
Alive at beginning of period		47.6	30.0	20.5	10.8	9.5	4.8	3.2	1.6	$\Sigma = 127.9$	
Mortality rate		.369	.316	.473	.124	.500	.333	.500	1.00	$\frac{47.6}{127.9} = .372^{+}$	

*No useable bandings.

+ Average annual mortality rate, 1 through 8 years.

Table 23. Estimated rates of mortality of adult male band-tailed pigeons banded in Washington and Oregon, 1951-65.

Year banded	Number banded	Hunting Seasons Survived 1	2	3	4	5	6	Direct recovery rate	Total recoveries
1951	28	0	0	0	0	1	0	0	1
1952	19	0	0	0	1	0	0	0	1
1953	32	0	1	0	0	0	0	0	1
1954	56	1	1	0	1	0	1	.0178	4
1955	18	2	0	1	0	0	0	.1111	3
1956	51	0	1	0	0	1	0	0	2
1957	7	1	0	0	0	0	0	.0588	1
1958-63*									
1964	113	0	4					0	4
1965	180	4	—	—	—	—	—	.0222	4
TOTALS	514	8	7	1	2	2	1	.0155	21
Banded birds available		514	334	221	221	221	221		
Recoveries/ 1000 banded		15.5	20.9	4.5	9.0	9.0	4.5	$\Sigma = 63.6$	
Alive at beginning of period		63.6	48.0	27.1	22.6	13.6	4.5	$\Sigma = 179.4$	
Mortality rate		.244	.436	.167	.400	.667	1.00	$\frac{63.6}{179.4} = .354^{+}$	

*No useable bandings.

+ Average annual mortality rate, 1 through 6 years.

Table 24. Estimated rates of mortality of adult female band-tailed pigeons banded in Washington and Oregon, 1951-65.

Year banded	Number banded	Hunting Seasons Survived									Direct recovery rate	Total recoveries
		1	2	3	4	5	6	7	8	9		
1951	19	0	1	1	0	0	0	0	0	0	0	2
1952	8	1	0	0	0	0	0	0	0	1	.1250	2
1953	22	1	1	4	0	0	0	0	0	0	.0454	6
1954	45	1	2	2	0	0	0	0	0	0	.0222	5
1955	15	1	1	0	0	0	0	0	0	0	.0666	2
1956	44	0	0	0	1	0	0	0	0	0	0	1
1957	20	0	0	1	0	0	0	0	0	0	0	1
1958-63*												
1964	69	2	2								.0289	4
1965	145	5	—	—	—	—	—	—	—	—	.0344	5
TOTALS	387	11	7	8	1	0	0	0	0	1	.0284	28
Banded birds available		387	242	173	173	173	173	173	173	173		
Recoveries/ 1000 banded		28.4	28.9	46.2	5.8	0	0	0	0	5.8	$\Sigma = 115.1$	
Alive at beginning of period		115.0	86.7	57.8	11.5	5.8	5.8	5.8	5.8	5.8	$\Sigma = 300.1$	
Mortality rate		.247	.333	.800	.500	0	0	0	0	1.00	$\frac{115.1}{300.1} = .384^{+}$	

*No useable bandings.

+ Average annual mortality rate,1 through 9 years.

Wight, Mace and Batterson (1967) used the method of Hickey (1952) to estimate the natural mortality for pigeons banded at Nehalem, Oregon, 1953-62. Of a total mortality of 31.0 percent, 54.8 percent was due to natural causes and 45.2 percent was due to hunting.

The natural mortality of pigeons banded in Oregon (Figures 3 and 4) and Washington (Figure 5) was a relatively small fraction, 26.3 to 43.2 percent, of the total mortality. This indicated the majority of the total mortality incurred by pigeons was due to hunting. Of a total mortality of 33.8 percent for pigeons banded at Nehalem, Oregon, 1952-57, 26.3 percent was due to natural causes and 73.7 percent was due to hunting. Of a total mortality of 30.6 percent for pigeons banded near Reedsport, Oregon, 1952-57, 30.7 percent was due to natural causes and 69.3 percent was due to hunting. Of a total mortality of 36.1 percent for pigeons banded in Washington, 1950-57, 43.2 percent was due to natural causes and 56.8 percent was due to hunting.

The estimate of natural mortality computed for pigeons banded at Nehalem in my study was thought to be more accurate than that obtained by Wight, Mace and Patterson (1967). These authors cited indirect evidence that band reporting rates declined during the later part of their study. This decline in band reporting rates would ten to overestimate their indexes to first-year mortality.

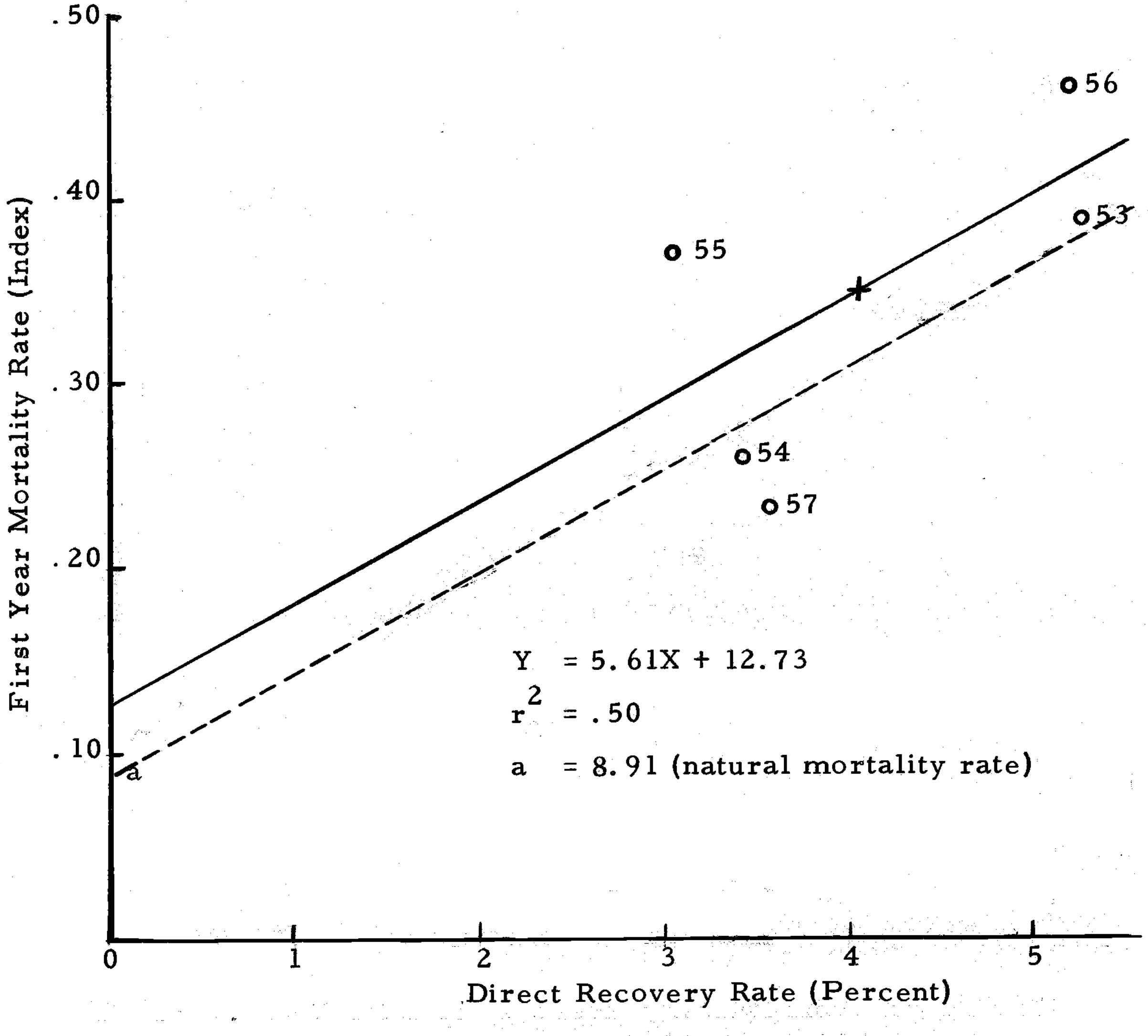

Figure 3. Estimates of the average natural mortality rate of adult band-tailed pigeons banded at Nehalem, Oregon, 1953-57. The dashed line provides the corrected estimate of natural mortality.

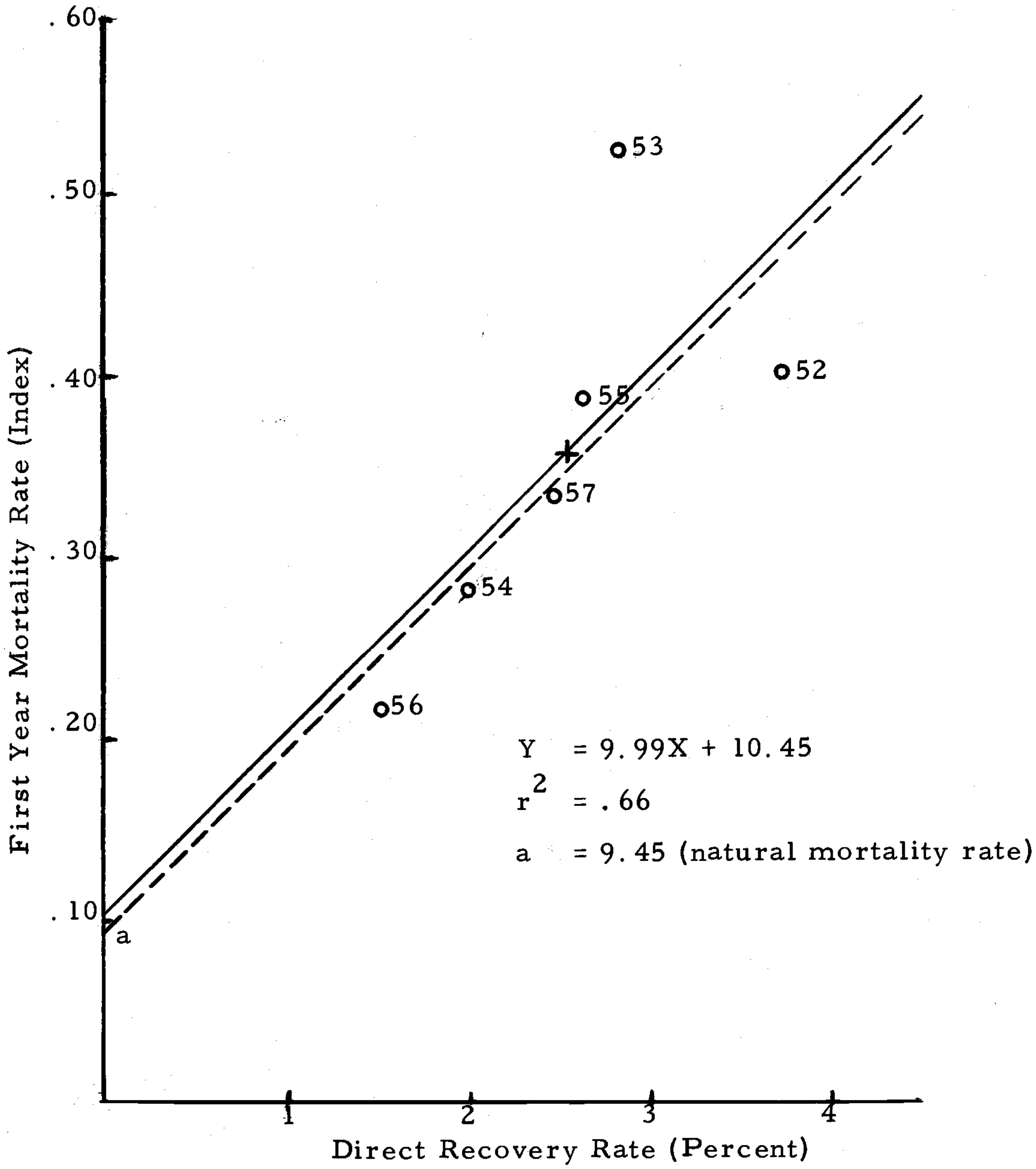

Figure 4. **Estimate of the average natural mortality rate of adult band-tailed pigeons banded near Reedsport, Oregon, 1952-57. The dashed line provides the corrected estimate of natural mortality.**

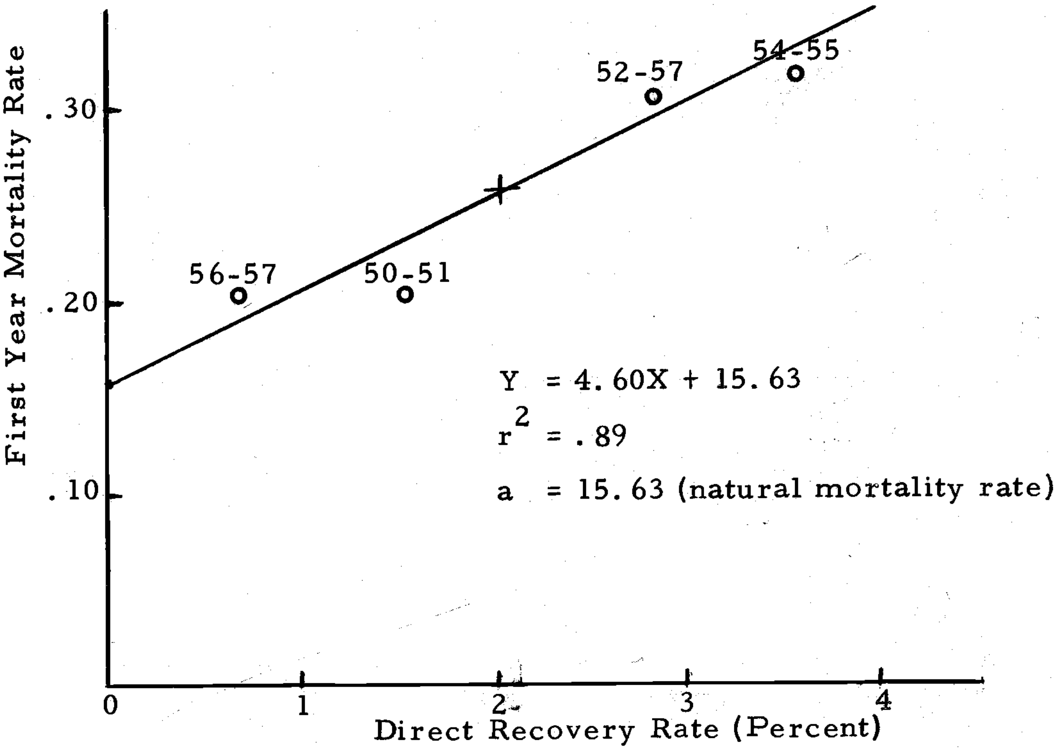

Figure 5. Estimate of the average natural mortality rate of adult band-tailed pigeons banded in Washington, 1950-57.

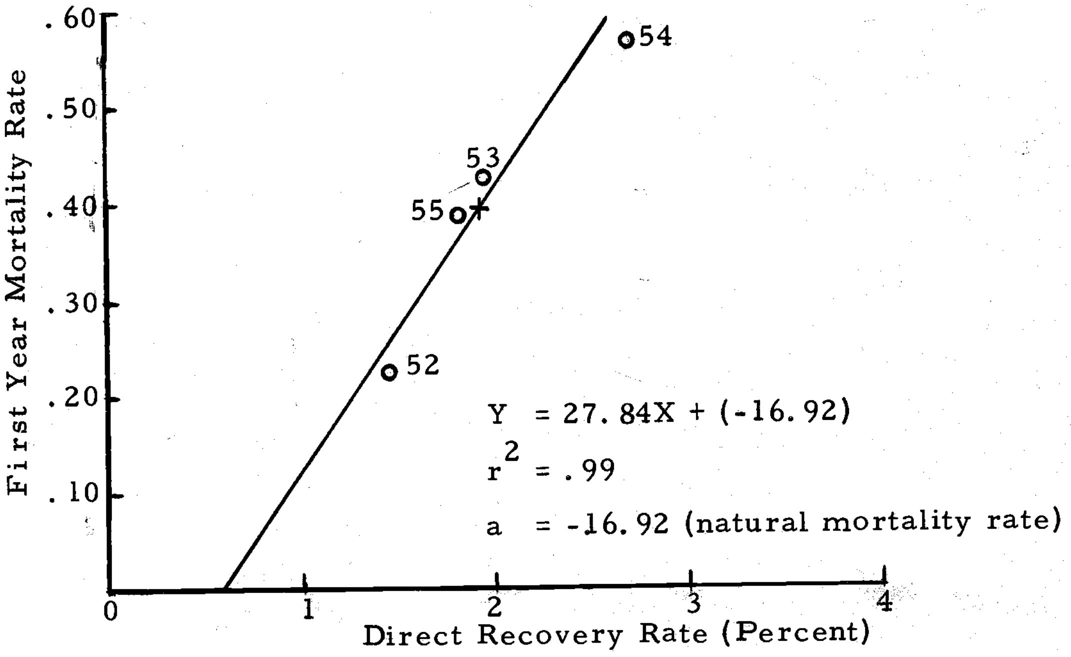

Figure 6. Estimate of the average natural mortality rate of adult band-tailed pigeons banded in California, 1952-55.

A negative estimate of natural mortality, minus 16.9 percent, was computed for pigeons banded in California (Figure 6). It is not possible for a population to have a negative mortality rate. I believe when additional data become available for this population the natural mortality will be a relatively small fraction of the total mortality.

Production Required to Maintain a Stable Population

For a population to remain stable the annual production must replace the annual mortality. The productions required to maintain stable populations employing the estimates of mortality in this study were computed (Table 25). The method of Hickey (1952) and Henny, Overton and Wight (in press) was used for these computations.

Table 25. Production of band-tailed pigeons required to maintain a stable population under the rates of adult and immature mortality computed in this study. It was assumed that adults nested at 1 year of age and the mortality of the sexes was equal.

Population	Adult Mortality Rates*	Immature Mortality Rates						
		31.5	35	38.5	40	45	51+	55
		Production Required Per Pair						
Oregon	31.5	.92	.96	1.02	1.06	1.14	1.28	1.40
Washington or California	38.5	—	—	1.24	1.28	1.40	1.56	1.70

* Approximate adult mortality rates computed in this study.

+ Approximate immature mortality rate computed in this study.

In my study no valid estimates of production were obtained for the various populations. Therefore, it was not possible to determine if the populations were achieving the production required to remain stable.

IV. DISCUSSION AND RECOMMENDATIONS

The distribution of band recoveries provided information on the summer and winter ranges of the band-tailed pigeon. These recoveries supported the observations of other investigators.

A few non-migratory populations of pigeons existed in Washington, Oregon, and California.

Northward migration from the central California wintering grounds was nearly completed by April 4. By the 2nd week of June nearly all pigeons had reached their northern breeding grounds. Southward migration from British Columbia, Washington, and Oregon was completed by mid-September.

The average annual kill currently approached 500 thousand pigeons. Approximately one-half of the kill occurred in California and one-fourth in each Oregon and Washington. Relatively few pigeons were killed in British Columbia. Approximately one-tenth of the kill in California occurred in the northern third of the state during October. Most of the kill occurred in remainder of the state during the December-January season.

In British Columbia, Washington, and Oregon at least three-fourths of the kill occurred during the first half of the September seasons. The kill in California was well distributed throughout the December-January season.

The presence of active crops in some adults shot at various points in Oregon during September suggested some adults were caring for young. Undoubtedly, a similar situation occurred in Washington and British Columbia.

The age structure of the kill in Oregon was not representative of the age structure of the population because it was biased by late nesting and differentials in migration of the age classes. The percentage of subadults in the Oregon population during spring was considerably greater than the percentage of immatures in the kill. This suggested the age structure of the kill was biased in favor of adults.

The percentage of immatures in the kill in California was considerably greater than that in Oregon. The California kill occurred after nesting and migration were completed. The age structure of this California kill was thought to overestimate the number of immatures in the wintering population because immatures were somewhat more vulnerable than adults. The magnitude of this differential vulnerability could not be determined because of the small sample of immatures banded.

Estimates of the average annual mortality of adults computed from band recoveries were thought to be reliable. However, these estimates of mortality were not representative of breeding populations near sites at which these pigeon were trapped and banded. The estimate of immature mortality may have been imprecise because of the small sample. However, this estimate did indicate immatures incurred a greater mortality than adults. Estimates of adult sex specific mortality were not reliable because they also were computed from small samples.

A relatively small fraction (26 to 43 percent) of the total average annual mortality of adults banded in Washington and Oregon was a result of natural causes. This indicated that the majority of the total mortality of the band-tailed pigeon was due to hunting.

Estimates of the productions required to maintain stable populations were computed from the estimates of mortality. However, these estimates of required production did not relate to identifiable breeding populations.

This study indicated that additional information was required before a sound management program for the band-tailed pigeon can be implemented. Research in the following areas should contribute materially to the formation of this program:

1. Establish a major program to band pigeons during July and August to determine differentials in mortality, vulnerability, and migration by age and sex classes.

Reliable information on the existence or magnitude of differentials in mortality, vulnerability, and migration of the age and sex classes should be obtained. These data will be necessary to obtain estimates of production from the age structure of the kill. These estimates of production then can be compared to the production required to maintain a stable population computed from estimates of mortality. These data will indicate if the populations are remaining stable, increasing or decreasing.

Information on these differentials can be obtained most readily from banded pigeons, but only if the age and sex of all pigeons banded are identified and recorded. Pigeons banded during July and August will be representative of populations near breeding areas, and will include immatures that can be banded prior to the hunting seasons.

2. Determine the significance of active crops in adult pigeons during September hunting seasons.

The shooting of adults with active crops may cause mortality among nestlings. The magnitude of this loss should be determined.

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APPENDIX

Appendix Table 1. Numbers of band-tailed pigeons by age and sex classes, banded in British Columbia, Washington, Oregon, and California to 1965.

Location and Period Banded	Adults			Immatures	Age and Sex Not Determined	Totals
	Male	Female	Unknown	Sex Not Determined		
British Columbia, 1935-57	—	—	—	—	32	32
Washington, 1950-65	248	197	2,048	91	646	3,230
Oregon, 1932-65	338	259	5,468	67	188	6,320
California, 1929-65	1,550	1,499	722	318	1,116	5,205
Totals	2,136	1,955	8,238	476	1,982	14,787

Appendix Table 2. Numbers of band-tailed pigeons banded by month of year in British Columbia, Washington, Oregon, and California for 1965.

	Month Banded												
Location and Period Banded	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
British Columbia, 1955-57	--	4	--	--	17	--	9	--	1	1	--	--	32
Washington, 1950-65	109	104	522	445	1,200	377	31	249	89	54	--	--	3,230
Oregon, 1932-65	--	--	--	543	4,328	1,415	4	23	6	1	--	--	6,320
California, 1929-65	120	228	749	1,008	1,088	582	530	345	129	300	120	5	5,205
Totals	230	336	1,271	1,446	6,633	2,374	574	667	225	356	120	5	14,787

Appendix Table 3. Number of band-tailed pigeon hunters sampled by, total percent responding to, and the percent frequency of response to the 1966 and 1967 survey in Oregon.

Year	Number of Hunters Sampled	Percent Responding (Total)	Number of Responses Possible*									
			1	2	3	4	5	6	7	8	9	10
1966	568	27.6	45.7	21.6	15.2	8.2	3.1	2.6	2.5	0.6	0.2	0.2
1967	434	33.2	39.6	25.7	10.4	13.2	6.3	2.8	0	2.0	-	-
1967+	153	26.8	41.5	17.1	17.1	17.1	2.4	2.4	0	2.4	-	-

* Ten responses were possible in 1966 and eight in 1967.

\+ Data from the resampling of 1966 respondents.

BAND-TAILED PIGEON HUNTERS

We need a wing from each band-tailed pigeon you kill this season. From these wings we can determine the ratio of young to old birds. This tells us how well the breeding population produced young.

PROCEDURE

1. Use ONE envelope for each day's hunt, and enclose ONE COMPLETE wing from all the pigeons YOU bag on this hunt.
2. DO NOT give envelopes to other hunters and DO NOT enclose wings from birds they shoot.
3. Fill in blanks and answer questions below.
4. Do NOT wrap wings in foil or plastic as this causes spoilage.
5. Mail as soon as possible -- NO POSTAGE REQUIRED.
6. Send envelopes containing wings from pigeons you shoot during the entire season.
7. If more envelopes are needed, place a check mark in the space at the bottom of the envelope. Thank you for your help.

FOR TODAY'S HUNT RECORD THE FOLLOWING (PLEASE PRINT)

Date of hunt: September ____, 1967.

Nearest town: ________________________

County: ________________________

Type of area in which pigeons were hunted.

1. Mineral Spring
2. Watering Area
3. Pass Shooting
4. Other (Describe) ________________________

Number of birds shot that fell to the ground but were not found? ____________

If banded, list band number(s) here. ____________

Check here if you need more envelopes. ________

Please do not write in this block.

Molt	Imm.	Ad.	
0			Unknown
1			
2			
3			
4			
5			Imm. Ad.
6			
7			
8			
9			
10			
Complete			Damaged

Appendix Figure 1. Envelope sent to band-tailed pigeon hunters during the 1967 survey. Envelopes used in 1966 were similar.

OREGON STATE UNIVERSITY
DEPARTMENT OF FISHERIES AND WILDLIFE

BAND-TAILED PIGEON PRODUCTION STUDY
Corvallis, Oregon

Dear Pigeon Hunter:

Your name has been selected from a list of Oregon sportsmen who have indicated (in last year's mail survey of hunters, conducted by the Oregon Game Commission) that they hunt band-tailed pigeons.

We would appreciate your cooperation in a research project designed to learn about production of young in Oregon band-tails.

We can determine production by obtaining a collection of wings from cooperating sportsmen and identifying wings of those pigeons that were hatched this past summer. The number of young pigeons compared to the number of adult pigeons that you and others kill is our best estimate of the nesting success that occurred during the past breeding season.

Enclosed are 8 envelopes. Will you please place a wing from each of the band-tails that you shoot during one day's hunt in one of the postage-paid envelopes. Use one envelope for each day's hunt. Mail the envelope as soon as possible after the hunt. DO NOT WRAP THE WINGS (this causes spoilage). Unwrapped wings merely dry without odor. We are interested only in your wings and hunting records; not those of your friends or family. Please do not include pigeon wings taken by other hunters. Also, please fill in the information blanks and answer the questions on the back of the envelope before mailing.

Thank you, and good hunting!

Gene D. Silovsky
Graduate Research Assistant

GDS/mkk
Encl.

Appendix Figure 2. Letter of instruction and explanation enclosed with envelopes sent to band-tailed pigeon hunters in Oregon during the 1967 survey. Hunters sampled in 1966 received a similar letter.