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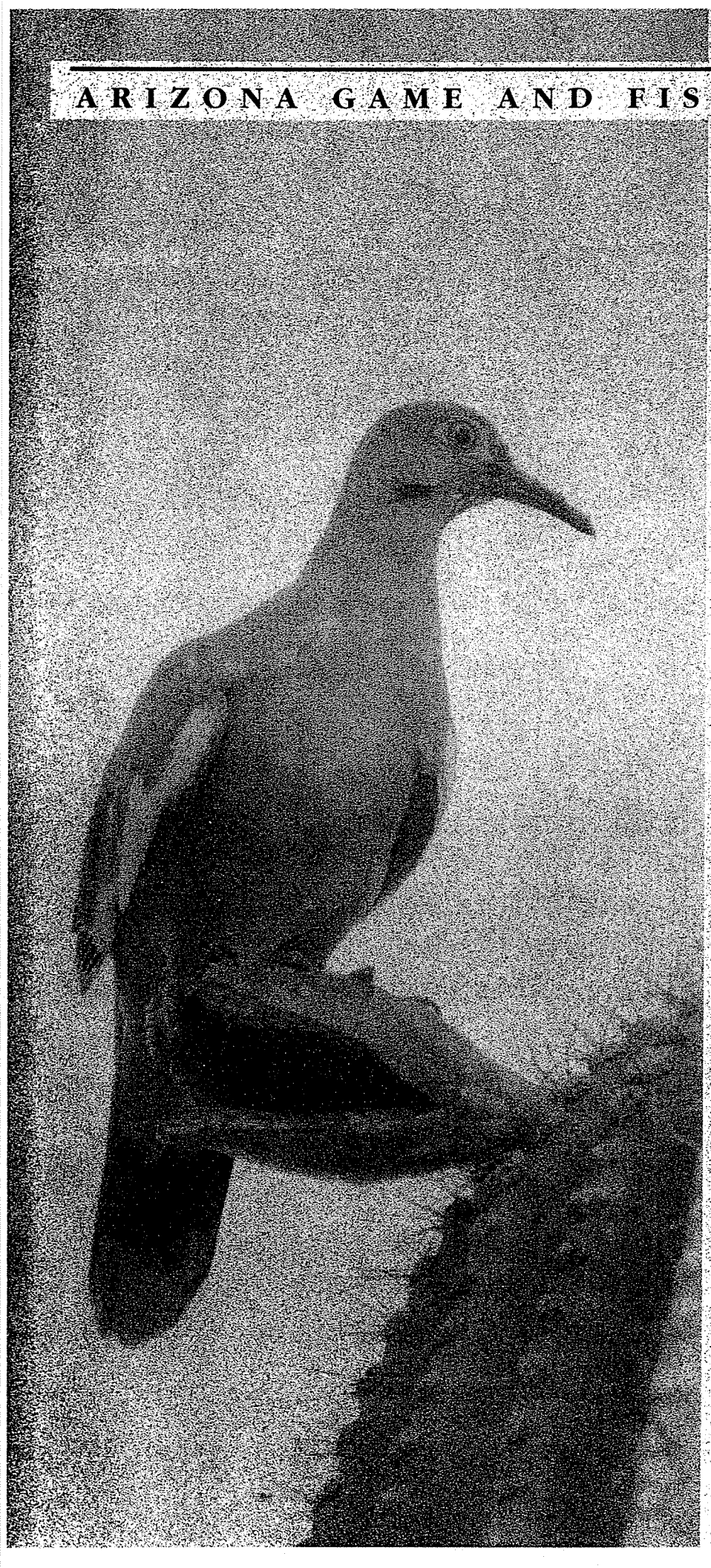

RESEARCH BRANCH
TECHNICAL REPORT #26

FOOD HABITS AND NESTING CHARACTERISTICS OF SYMPATRIC MOURNING AND WHITE-WINGED DOVES IN BUCKEYE-ARLINGTON VALLEY, ARIZONA

A Final Report

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September 1997

FEDERAL AID IN WILDLIFE
RESTORATION PROJECT

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To conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs, and to provide wildlife resources and safe watercraft and off-highway vehicle recreation for the enjoyment, appreciation, and use by present and future generations.

Arizona Game and Fish Department
Research Branch

Technical Report Number 26

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Federal Aid in Wildlife Restoration
Project W-78-R

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Cunningham, S. C., R. W. Engel-Wilson, P. M. Smith, and W. B. Ballard. 1997. Food habits and nesting characteristics of sympatric mourning and white-winged doves in Buckeye-Arlington Valley, Arizona. Ariz. Game and Fish Dep. Tech. Rep. 26, Phoenix. 36pp.

ISSN 1052-7621
ISBN 0-917563-34-4

CONTENTS

Abstract 1

Introduction 1

Study Area 2

Methods 5
- Food Habits 5
- Nesting 5

Results 9
- Food Habits 9
  - Mourning Dove 9
  - White-winged Dove 11
- Feeding Strategy 12
- Nesting 17
  - Chronology 17
  - Nest-Site Selection 17
  - Habitat Selection 20
  - Nesting Success 24

Discussion 27
- Feeding 27
  - Food Habits 27
  - Feeding Site Selection 29
  - Feeding Behavior 29
- Nesting 30

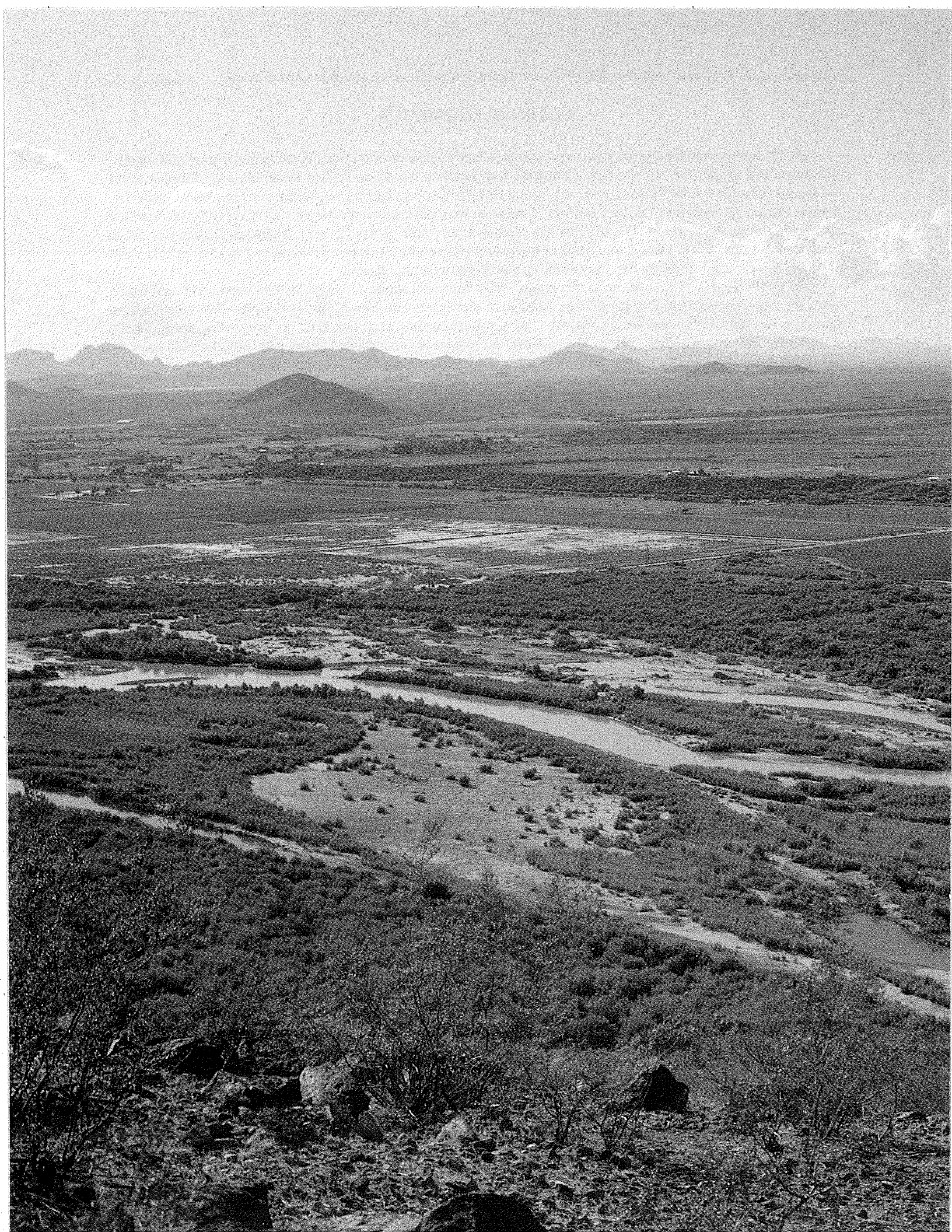
Management Options 33

Literature Cited 34

ACKNOWLEDGMENTS

As with most research projects, this study could not have been completed without the help of many individuals. Pat Crouch, Bill Dodds, Jim Hinkle, Tom McMahon, Neil Moeller, Ward Ogden, Don Roderick, Jerry Stringer, John and Donna Theobald, Julie Thomas, and Lori Young all helped collect nesting, vegetation, or food habits data. Dr. Thomas Martin, Dr. Robert D. Ohmart, and Roy Tomlinson were advisors on the project. Dr. Carl Gustavson helped with statistical analysis. Don Ellis of Ellis Art Studios made most of the figures. Vannessa Dickenson, Steve Rosenstock, and Jim deVos all reviewed drafts of this manuscript and its contents were improved by their efforts. The talent and efforts of Vicki Webb during typesetting and layout were appreciated.

This publication is a result of studies undertaken with financial support provided by the Federal Aid in Wildlife Restoration Act Project W-78-R of the Arizona Game and Fish Department. The Act is popularly known as the Pittman-Robertson Act after its Congressional sponsors. The Act provides for a manufacturers' tax on sporting arms, pistols, ammunition, and certain archery items. The collected tax monies are apportioned to the states on a formula basis by the U. S. Fish and Wildlife Service for the conservation and management of birds and mammals. Thus, sport hunters, target shooters, and archers contribute to a program that benefits everyone.



FOOD HABITS AND NESTING CHARACTERISTICS OF SYMPATRIC MOURNING AND WHITE-WINGED DOVES IN BUCKEYE-ARLINGTON VALLEY, ARIZONA

Stan C. Cunningham, Ronald W. Engel-Wilson, Phillip M. Smith, and Warren B. Ballard

Abstract: Feeding and nesting ecology of mourning (*Zenaida macroura*) and white-winged (*Z. asiatica*) doves were studied during 1983 through 1985 in Buckeye-Arlington Valley, Arizona. Objectives were to determine food habits and nesting site characteristics to provide a basis for habitat management. Mourning doves fed on seeds from > 15 plant species, and use of annual grasses, forbs, and agricultural crops varied among years. White-winged doves were dependent on agricultural grains, principally barley, during all years. Mourning doves fed primarily in agricultural fields but exhibited no philopatry in feeding site selection. White-winged doves exhibited fidelity to specific agricultural fields, ignoring closer areas with more grain to return to habitually used fields. Mourning doves traveled to agricultural fields in small groups (1-2) and fed in smaller numbers (100-1,000) than white-winged doves. White-winged doves flew to feeding areas in larger groups ($\bar{x}$= 12 birds) and whole nesting colonies tended to feed in the same field (>5,000 birds). Neither dove species fit predictions of optimal foraging theory. Mourning doves preferred nesting in mixed honey mesquite (*Prosopis glandulosa*) and salt cedar (*Tamarix chinensis*), but were more general in nesting habitat use than white-winged doves. Ninety percent of the variation in white-winged dove nesting was explained by the presence of tall (>9 m) salt cedar trees. White-winged doves did not nest in honey mesquite, which historically had been used. Mourning doves nested just below areas of dense foliage, whereas white-winged doves nested higher in thick foliage from 2.5 to 6 m above ground level. There was no significant difference in nest site characteristics for either dove species that produced fledglings versus those that were predated. Tall salt cedar had the highest nest success rate and honey mesquite the lowest. Mourning dove nest density declined 25% each year, whereas white-winged dove levels were stable. Mourning dove nesting chronology was similar during all years, but white-winged doves varied among years.

Key Words: Arizona, food habits, optimal foraging, mourning dove, nesting habitat, white-winged dove, *Zenaida asiatica*, *Zenaida macroura*

INTRODUCTION

Both white-winged and mourning doves are important game species in Arizona, with an average annual statewide harvest of 125,000 and 1.5 million, respectively (Reeves et al. 1993). The number of dove hunters in Arizona steadily increased from 1970 to 1985 (Ariz. Game and Fish Dep., unpubl. data). The most popular hunting areas are desert river bottom thickets and adjacent agricultural fields that harbor the largest populations of both dove species.

The white-winged dove population in the southwestern United States has fluctuated markedly over the past century. The species became prevalent in Arizona and Texas in the late 1800s, probably due to increased grain production which supplied birds with an abundant food source (Cottam and Trefethan 1968). However, Arizona populations declined during 1915 to 1940, because of overshooting and clearing of riparian areas for agriculture (Neff 1940). White-winged dove populations increased again until the 1960s, after the hunting season opening date was moved from August 1 to September 1 (Cottam and Trefethan 1968). In the 1960s, white-winged doves were so numerous that a daily bag limit of 25 birds was allowed. By 1968, the population again began declining apparently due to continued loss of riparian nesting habitat combined with a possible overharvest (Brown 1977). Production of agricultural grains also declined dramatically during this period (Smith 1983).

Presently, the white-winged dove population is still low as evidenced by harvest rates. The average dove hunter took 2.1 white-winged dove/hunter/season in 1993 (bag limit = 6/day) compared to 15.1 in 1967 (bag limit = 25/day) (Ariz. Game and Fish Dep., unpubl. data). The mourning dove population has remained stable over the past 50 years, but harvest declined 9% from 1970-85 (Ariz. Game and Fish Dep., unpubl. data).

Agricultural grains are important in the diet of both dove species (Chambers 1963, Cottam and Trefethan 1968, Carpenter 1971, Davis 1974, Armstrong and Noakes 1981, Lewis 1993). However, due to rising energy costs, conversions of farmland to urban use, and a decrease in grain prices, the amount of grain grown in Maricopa County,

Arizona declined by 88% (91,336 to 11,012 ha) from 1967 to 1980 (Smith 1983).

The most plausible explanation of feeding site selection by doves is that they choose agricultural grain fields where food requirements can be satisfied most efficiently. Profitability of a field to doves should decline as waste grain declines, or is harder to find (Schoener 1971). The idea of selecting feeding patches based on energy gain per unit of time is not new and is represented by a large body of literature referred to as optimal foraging (see Pyke et al. 1977, Krebs 1980 for reviews).

White-winged doves are selective in nesting habitat, preferring specific structural attributes within riparian communities (Neff 1940, Shaw and Jett 1959, Carr 1960). In Arizona, both dove species which nest in riparian communities produce 2-3 times more young than within other habitat types (Wigal 1973). Research during the 1930s (Neff 1940) found that white-winged doves preferred to nest in honey mesquite bosques consisting of large (>6 m tall) trees. Butler (1977) found highest white-winged dove nesting densities in mixed salt cedar and screwbean mesquite (*P. pubescens*) habitats, intermediate densities in salt cedar habitats, and lowest densities in honey mesquite habitats. Mourning doves are more of a generalist in nest site selection than white-winged doves. Preferences vary from ground, trees and shrubs, orchards, riparian areas, urban areas, and shelter belts (Boldt and Hendrickson 1952, Swank 1955, Hanson and Kossack 1963, Wells et al. 1979, Sayre and Silvy 1993).

The Arizona Game and Fish Department (AGFD) manages several wildlife areas designed to enhance small game populations. Because of declining grain production and destruction of nesting habitat, we initiated a study to determine if availability and distribution of nesting habitat and cultivated crops in Buckeye-Arlington Valley, Arizona were sufficient to maintain high densities of white-winged and mourning doves. We sought to determine factors affecting field selection and nesting habitat requirements. We studied feeding behavior and food habits of both dove species and examined underlying mechanisms triggering these behaviors. Given the importance of riparian communities to white-winged and mourning doves in Arizona, we studied the differences in nesting densities and productivities in different habitat types within Buckeye-Arlington Valley, Arizona.

STUDY AREA

Our study was conducted along the lower Gila River in Buckeye-Arlington Valley, Arizona. The 30 km² study area included the Robbins Butte Wildlife Area and the Powers Butte Wildlife Area (Fig. 1). Both are managed by AGFD primarily for mourning and white-winged doves.

The study area contained 1 of the last remaining stands of honey mesquite along the lower Gila River, and had large stands of salt cedar in a continuum of height classes. However, we only examined medium (>3 m but <9 m tall), and tall (>9 m) salt cedar classes because salt cedar <3 m had few to no dove nesting attempts (S. C. Cunningham, unpubl. data). There were 2 stands of tall salt cedar (>9 m) and both were considered nesting colonies for white-winged doves. These 2 colonies were referred to as Highway and Hassayampa nesting colonies. Vast acreages of Sonoran desert scrub consisting of creosote bush (*Larrea divaricata tridentata*), saguaro (*Carnegiea gigantea*), palo verde (*Cercidium* spp.), and ironwood (*Olneya tesota*) occurred south of the Gila River.

Buckeye-Arlington Valley is well known for its dove shooting; doves were so numerous that farmers in the 1950s-60s would buy shells for hunters to reduce their grain loss (Cottam and Trefethan 1968). This area, known as the "Green Belt," was considered the most productive and important dove nesting area in the state (Brown 1977).

During the study, approximately 90% of agricultural crops grown in the valley were cotton and alfalfa fields from 4 to 30 ha. The most common grain crop grown was barley (86.6%). Safflower and milo made up the remainder of cereal crops.

Approximately 65 ha of crops were cultivated on the wildlife area. These included barley, safflower, milo, bermuda grass (*Cynodon dactylon*), and canary grass (*Phalaris* spp.). Grain crops were planted at different time intervals so food sources for doves were available beginning in May (i.e., barley) and through summer (i.e., safflower in mid-June, milo in mid-August or early September). Also, strips of saltbush (*Atriplex* spp.), cottonwood (*Populus fremontii*), sunflower (*Helianthus annus*), willow (*Salix* spp.), and other native shrubs were provided for additional feeding and loafing cover. Common annual "weed" species found in the area included canary grass, goosefoot (*Chenopodium* spp.), inkweed (*Suaeda* spp.), buckwheat (*Polygonum* spp.), and patata (*Monolepis nuttaliana*).

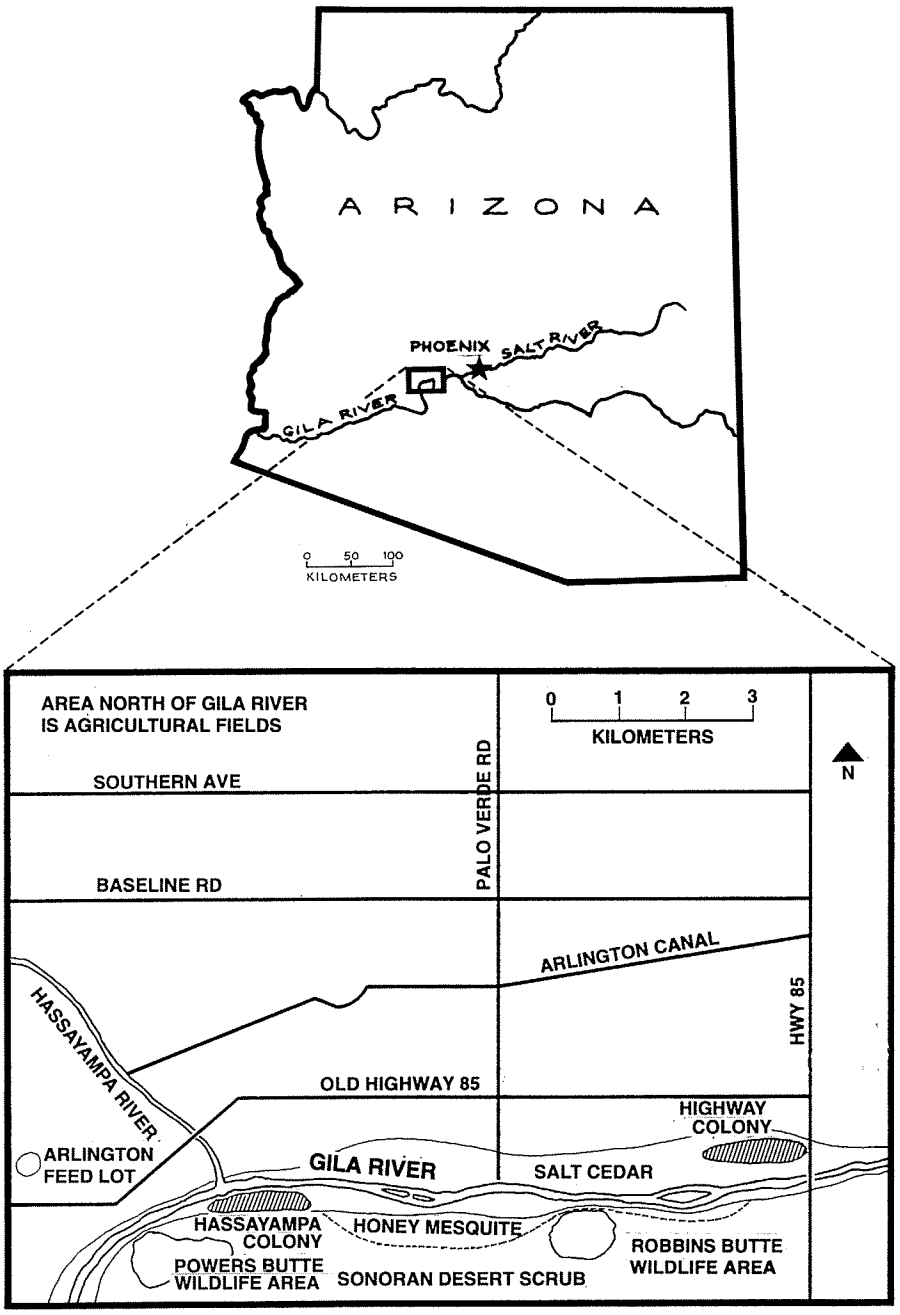


Figure 1. Boundaries of Buckeye-Arlington Valley, Arizona study area where mourning and white-winged dove food habits and nesting characteristics were studied during 1983-85.

METHODS

Food Habits

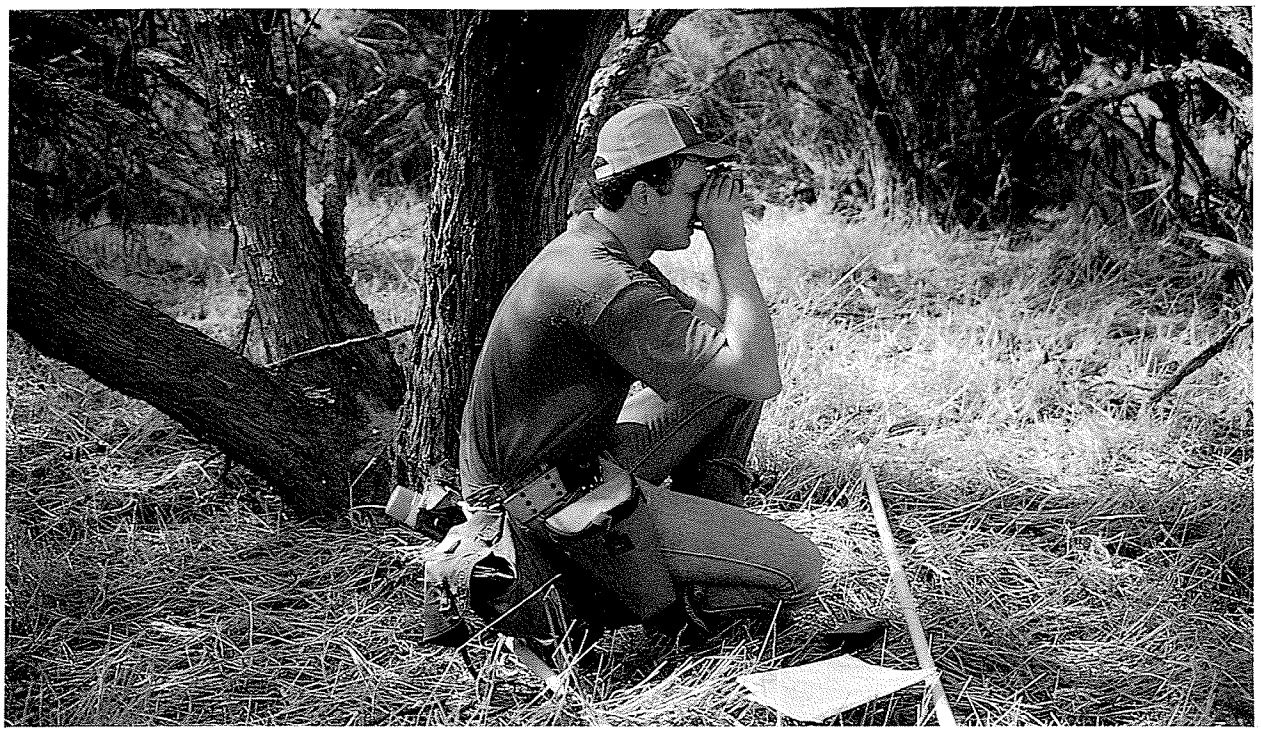
White-winged and mourning doves were collected for study by shooting with a shotgun from May to August 1983-85. We attempted to collect 30 of each species per month. Birds were shot along Gila River bottom lands during evening post-feeding flights to avoid the bias of knowing where birds fed. After collection, we removed crop contents and placed them in envelopes. Species, date, sex, and age of each bird were recorded. We recorded crop gland development as described by Mirarchi and Scanlon (1982).

Food items from each crop were separated, identified, and measured volumetrically using graduated cylinders. Amounts smaller than 0.05 ml were recorded as trace. For each species, we calculated mean volume contributed by each seed species by averaging percentage values of that item for all birds collected in each month of each year (after Martin et al. 1946). Diet items for both dove species were compared by sex, maturity, crop status, and reproductive stage by MANOVA. Use of annual seeds was correlated with precipitation using linear regression. Precipitation and temperature data were from the Buckeye weather station as reported by the U.S. National Oceanic & Atmospheric Administration (NOAA).

During 1984 and 1985, we estimated the number of each dove species using cultivated grain fields within the study area. Each grain field was surveyed a minimum of every 14 days from 1-3 hr before sunset. Numbers of birds were grouped into the following categories: 0, 1-10, 11-100, 101-1,000, >1,001, >5,000. A chi-square contingency test was used to examine differences in cultivated grain field selection by the 2 species.

We counted group sizes of both dove species which were en route to or leaving feeding areas. Counts were conducted adjacent to riparian areas either 1-2 hours after sunrise or 1-2 hours before sunset. We counted birds in 3, 10-minute staggered periods (i.e., count all groups for 10 minutes, rest for 10 minutes). Birds were considered a "group" when no member was >30 m from the nearest member. Similar count methods were used to determine group sizes leaving nesting areas in areas of high and low nesting density. Differences in group sizes were compared by t-test.

Amount of waste grain in cultivated barley fields (n = 27) was estimated monthly in 1985. Twenty random throws of a 0.25-m^2 hoop were used to count number of seedheads (not number of kernels) in each field.



Nesting

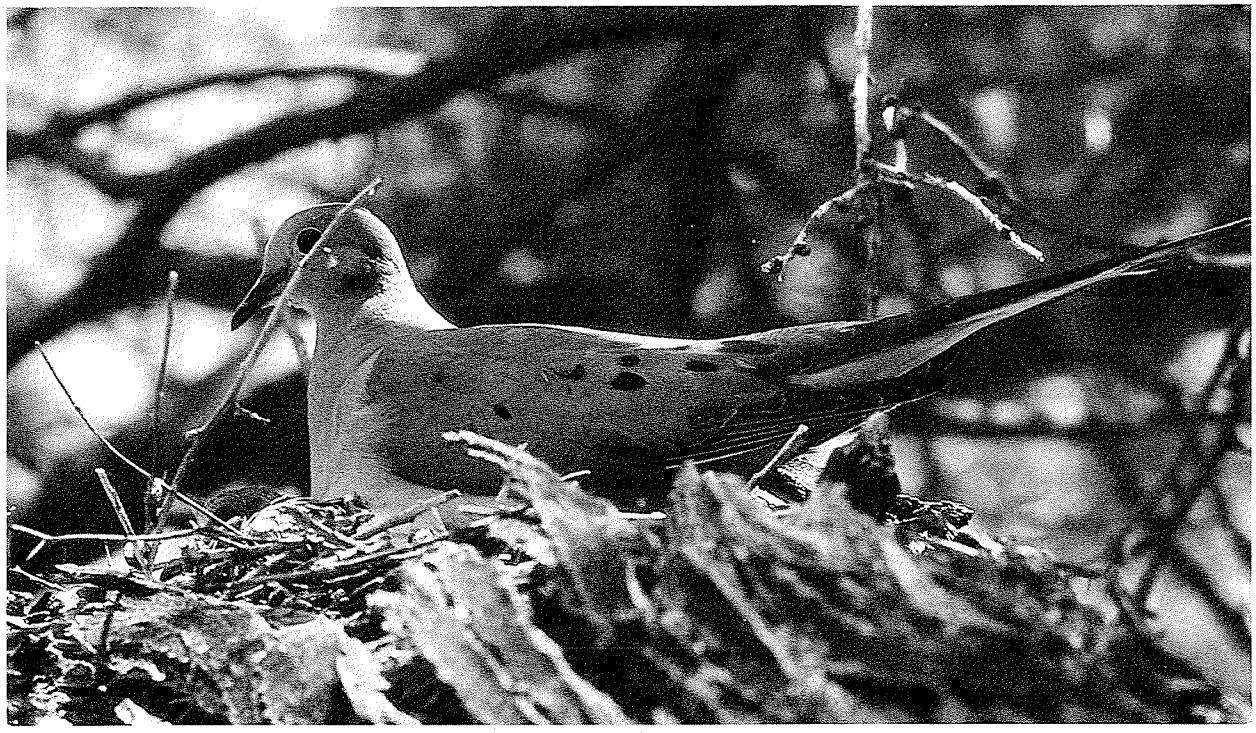
Nesting densities and productivities were determined using a modified King strip census method (Overton and Davis 1969). Transects totaling 4.2 ha within 5 habitat types (i.e., desert, salt cedar <9 m tall, salt cedar >9 m tall, honey mesquite, and mixed honey mesquite and salt cedar) were sampled at 7 to 10-day intervals from May 10 to September 4 each year. On each transect, nests were counted within 3 m of the center line (transect width = 6 m). Transects were located systematically at varying distances from agricultural grain crops (0-0.1 km, 0.1-0.2 km, 0.4-0.5 km, 0.9-1.0 km, 1.5 km, and 2.0 km) to examine the effect of proximity of food on nest site selection.

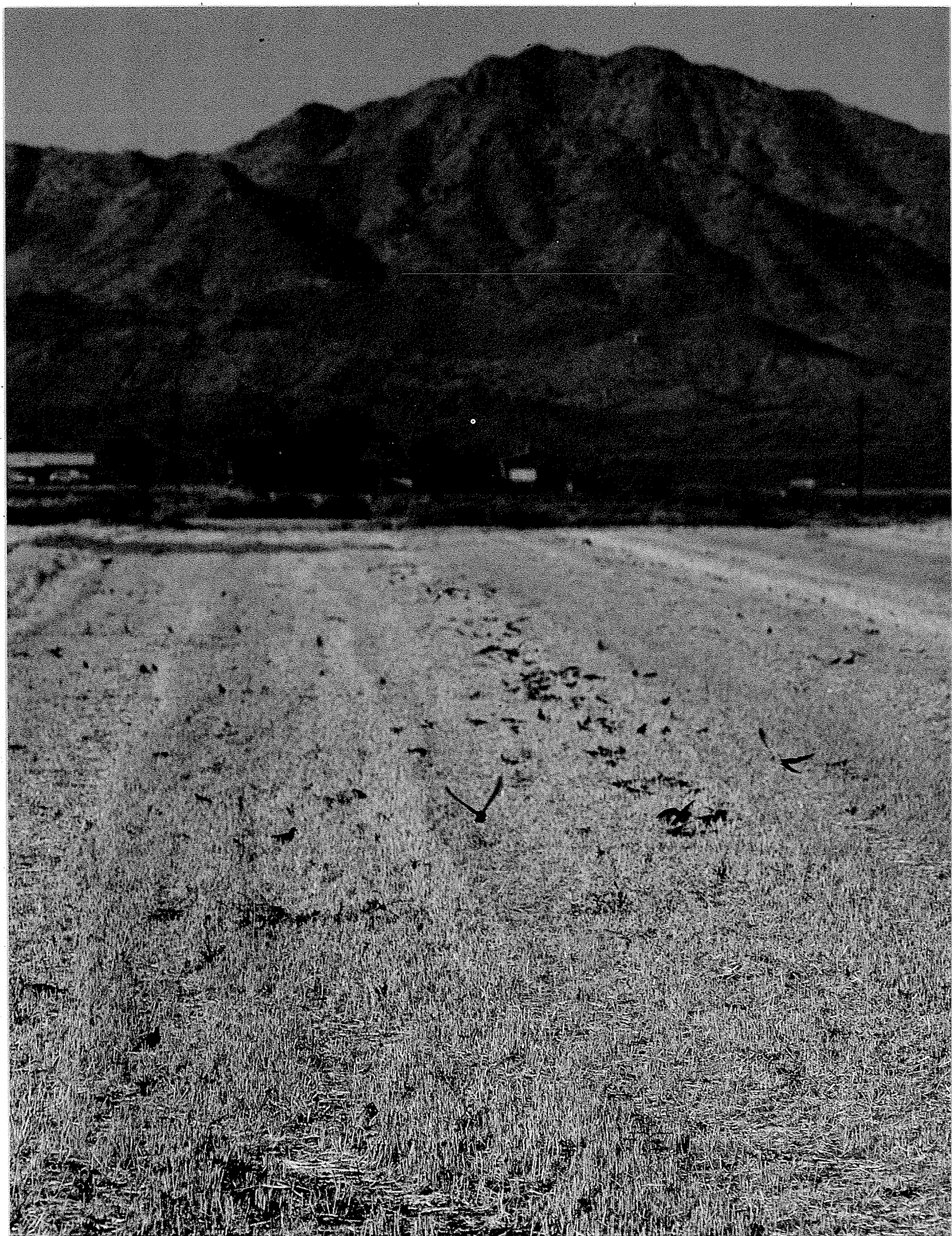
Information collected on each nest included: date, species, number of eggs, chicks or fledglings, nest height, distance from trunk, tree species, tree height, and the amount of cover around the nest. The nest cover index was subjectively rated on a scale of 1-5 with 1 being open and 5 being dense. Nests were examined only in early morning hours to prevent exposing eggs to excessive heat (often >45 C) in afternoon hours. Nest-site selection data were compared using MANOVA and Chi-square contingency tests.

Nesting density was calculated by dividing the number of nesting attempts on each transect by the total area sampled within that transect over each season. Fledgling success was calculated by dividing the number of young fledged by the number of eggs laid. Nesting chronology for each species was determined by walking the same transects each summer. Differences in nesting chronology between years and species were compared by Kolmogorov-Smirnov test.

We used foliage height diversity (FHD) (MacArthur and MacArthur 1961) to describe vegetation along each nest transect. We used a 25.4 x 45.7 cm board attached to a pole that was lifted to a height of 12 m. Sampling was done systematically every 20 m at heights of 0.15, 0.3, 1.5, 2.0, 3.5, 4.6, 6.1, 7.6, 9.01, and 12.2 m. Species composition of each transect was sampled by the 5-m square method (Engel-Wilson and Ohmart 1979).

Multiple stepwise linear regression was used to determine the influence of habitat factors on number of nests and fledgling success for each species. Factors used in the analysis included habitat type (tree species and height classes), FHD at 5 different height intervals (Class I = 0.15 - 0.3 m; Class II = 1.5 - 2.0 m; Class III = 3.5 - 6.1 m; Class IV = 7.6 - 9.01 m; Class V = 12.2 - 15.1 m), and distance of the nesting habitat to grain fields and water. For all statistical tests, $P \leq 0.1$ was considered significantly different.





RESULTS

Food Habits

Mourning doves used a greater variety of food resources than white-winged doves. White-winged doves used agricultural grains (3 yr $\bar{x}$ = 97%) almost exclusively, while mourning doves frequently utilized annual seeds (3 yr $\bar{x}$ = 32%). Percent diet overlap during the study was 65%, most (95%) of the overlap was barley. Even though there was high degree of diet overlap in the use of barley, there was still a subdivision in the utilization of food resources.

Mourning Dove. Use of annual seeds by mourning doves varied among years and months during each year (Table 1). During 1983, barley was the most consumed food, followed by canary grass. Annual seeds were used more in 1983 than in 1984 or 1985. Excluding canary grass, other annual species comprised 9.6% of the diet (e.g., primarily goosefoot and buckwheat).

During 1984, 12 seed species were eaten and barley was used most (Table 1). Use of annual species was high in May, but not during the remainder of the summer. Canary grass was eaten frequently in May but declined during summer as an apparent result of heavy cattle grazing.

Table 1. Percent volume of seed species in mourning dove crops collected from May through August, 1983-85 in Buckeye-Arlington Valley, Arizona.[a,b]

		Month				
Food type	Year	May	June	July	August	Weighted $\bar{x}$
Agricultural grains						
Barley	1983	39.5	42.5	80.2	44.4	54.0
	1984	44.3	84.7	81.4	71.0	73.2
	1985	67.4	76.2	47.7	57.4	58.7
Commercial bird seed	1983	0	0	0	0	0
	1984	0	7.2	1.4	0	2.5
	1985	16.5	0	0	0	2.5
Milo	1983	13.9	0	0	0	3.0
	1984	2.1	0	1.1	15.5	3.8
	1985	0	0	4.8	12.3	5.5
Safflower	1983	1.4	0	0	0	0.3
	1984	1.3	0	0	0	0.3
	1985	0	0	0	0	0
Annual or non-agricultural seeds						
Buckwheat	1983	T	T	0	9.4	2.5
	1984	5.2	1.5	6.8	13.0	6.2
	1985	8.5	T	33.6	27.7	22.0
Canary grass	1983	40.0	49.4	18.2	31.6	33.1
	1984	36.0	0.1	T	0	7.0
	1985	7.3	3.3	8.8	0	4.9

Table 1. (continued)

Food type	Year	Month May	June	July	August	Weighted $\bar{x}$
Globemallow	1983	0	T	0	0	T
	1984	0	0.6	0	0	0.2
	1985	0	0	0	0.1	T
Goosefoot	1983	5.2	8.0	1.6	9.6	5.8
	1984	2.2	2.2	9.3	0.4	4.2
	1985	0.1	10.2	0.2	1.7	2.4
Graminae	1983	0	0	0	4.5	1.2
	1984	0	0	0	0	0
	1985	0	0	0	0	0
Johnson grass (*Sorghum halepense*)	1983	0	0	0	0	0
	1984	0	0	0	0	0
	1985	0	T	0	0	T
Mustard (*Brassica* spp.)	1983	0	0	0	0	0
	1984	8.9	0	0	0	1.7
	1985	0	4.3	T	0	0.8
Patata	1983	0	0	0	0	0
	1984	0	0	0	0	0
	1985	0.2	0	0	0	T
Saltbush	1983	0	0	0	0	0
	1984	0	3.6	0	0	1.0
	1985	0	6.1	0.9	0	1.4
Wild sunflower	1983	0	T	0	0	T
	1984	0	T	0	0	T
	1985	0	0	3.9	0.8	1.7
Unidentified	1983	0	T	0	0.4	0.1
	1984	T	T	0	0	T
	1985	0	0	0	0	0
Total agricultural grains	1983	54.8	42.5	80.2	44.4	57.3
	1984	47.7	91.9	83.9	86.5	79.8
	1985	83.9	76.2	52.5	69.7	66.7
Total annual or non-agricultural seeds	1983	45.2	57.4	19.8	55.5	42.7
	1984	52.3	8.0	16.1	13.4	20.3
	1985	16.1	23.9	47.4	30.3	33.2

[a] Monthly and annual number of doves sampled was as follows: 1983 - May = 9, June = 9, July = 13, August = 11, and overall = 42; 1984 - May = 15, June = 22, July = 26, August = 15, and overall = 78; and 1985 - May = 12, June = 14, July = 29, August = 24, and overall = 79.

[b] T = <0.05 ml.

During 1985 mourning doves used a high proportion of agricultural grains until July when summer annuals, primarily buckwheat, became dominant food items. Barley was the primary cereal grain eaten and was also the predominant food during all months. Buckwheat was the annual species eaten most.

Use of annual seeds by mourning doves was correlated with winter precipitation (Jan.- May, $r = 0.94$, $P < 0.03$). During 1983 and 1985, mourning doves with active crop glands used the highest proportion of annuals, but small sample size (n = 3 in 1985) prevented analysis. Females with developing eggs (largest follicle >6 mm; Mirachi 1993) used almost twice the volume of annual species as other groups (F = 3.44, d.f. = 3, $P = 0.07$) (Fig. 2).

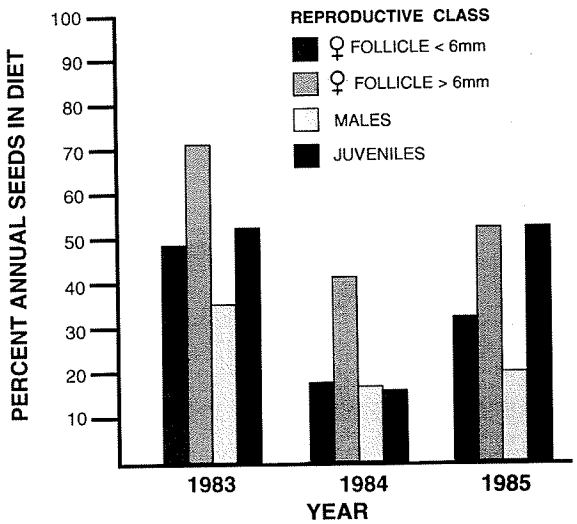


Figure 2. Percentage of annual species found in diets of mourning doves during 1983-85, by sex, maturity, and reproductive status in Buckeye-Arlington Valley, Arizona study area.

White-winged Doves. White-winged doves were almost totally dependent on agricultural waste grains (particularly barley) for food during all years (Table 2). Barley was the most common cereal crop and waste grain available in all years. There was only 1 commercial 40 ha field of safflower in the valley in 1983 and it received heavy use in July and August as it ripened. The only milo and other safflower fields available during the study period were on Robbins Butte or Powers Butte wildlife areas.

During 1984 barley was again the most important diet item with milo and safflower utilized in August as they became available. The only deviation from agricultural grains was use of saguaro seeds in June. White-winged doves that fed on saguaro had to make up to 6 km deviations from feeding-flight routes to make a small addition to their daily diet (saguaro seeds <10% of the total diet of any bird).

Barley was also the most utilized food source in all months and overall during 1985. Milo was used in late August as it became available. There was more use of wild (non-agricultural) seeds during 1985. In June, saguaro made up 10.3% of the diet and was found in 15.4% of crops. In July, non-agricultural seeds made up 16.7% of the diet. By August, white-winged doves were using agricultural grains almost exclusively (99%).

White-winged doves consumed fewer seeds than mourning doves (S. C. Cunningham, unpubl. data). Saguaro was the only seed found in the diet which could be considered small ($\bar{x}$ width = 1.5 mm), and its' cuplike fruit allowed white-winged doves to secure many seeds from 1 fruit. All other consumed seeds were larger (milo - 4 mm in length; barley - 8 mm; safflower - 7 mm). No difference was found in the diets of white-winged doves by sex, age, reproductive status, or crop gland stage.

Table 2. Percent volume of seed species in white-winged dove crops collected from May through August, 1983-85 in Buckeye-Arlington Valley, Arizona.[a,b]

Food Type	Year	Month				Weighted $\bar{x}$
		May	June	July	August	
Agricultural grains						
Barley	1983	83.3	81.8	54.7	62.1	64.6
	1984	95.5	94.2	100.0	57.9	86.2
	1985	100.0	89.7	83.3	94.7	89.8
Corn	1983	0.0	0.0	0.0	0.0	0.0
	1984	4.5	0.0	0.0	0.0	1.0
	1985	0.0	0.0	0.0	0.0	0.0
Milo	1983	16.6	0.0	0.0	0.0	2.0
	1984	0.0	T	0.0	38.4	10.1
	1985	0.0	0.0	0.0	4.5	1.5
Safflower	1983	0.0	18.2	45.2	37.9	33.3
	1984	0.0	0.0	0.0	3.4	0.9
	1985	0.0	0.0	0.0	0.0	0.0
Annual or non-agricultural seeds						
Canary grass	1983	0.0	0.0	T	0.0	T
	1984	0.0	0.0	0.0	0.0	0.0
	1985	0.0	0.0	0.0	0.0	0.0
Saguaro	1983	0.0	T	0.0	0.0	T
	1984	0.0	5.7	T	0.0	1.7
	1985	0.0	10.3	4.0	0.0	4.5
Wild sunflower	1983	0.0	0.0	0.0	0.0	0.0
	1984	0.0	0.0	0.0	0.2	T
	1985	0.0	0.0	4.0	0.7	1.5
Unidentified	1983	0.0	0.0	0.0	0.0	0.0
	1984	0.0	0.0	0.0	0.0	0.0
	1985	0.0	0.0	8.7	0.0	2.7

[a] Monthly and annual number of doves sampled was as follows: 1983 - May = 6, June = 8, July = 22, August = 13, and overall = 49; 1984 - May = 22, June = 29, July = 22, August = 26, and overall = 99; and 1985 - May = 4, June = 26, July = 26, August = 27, and overall = 83.

[b] T = <0.05 ml.

Feeding Strategy

Mourning doves fed in a wider variety of field types than did white-winged doves. We observed mourning doves feeding in safflower, barley, "weedy", alfalfa, fallow, cotton, pasture, and desert scrub habitats. We only observed white-winged doves feeding in barley, safflower, milo, or fallow fields. The only fallow fields used by white-winged doves were plowed-under barley fields. Mourning doves were also observed occasionally feeding in small weedy patches (<1 m²) and in

standing barley crops. No white-winged doves were observed in standing barley crops.

The dependence of both dove species on agricultural grains resulted in a decline in the number of feeding areas as summers progressed. From May through July there were 20-29 fields with up to 315 ha waste grain available, but 70-83% of the fields were plowed under by August 1. After that time, both dove species concentrated their feeding activities on the few remaining unplowed grain fields (6 in 1984; 5 in 1985).

Use of available grain fields differed by dove species ($X^2 = 176.38$, d.f. = 5, $P < 0.001$). Mourning doves used more of the available barley fields than did white-winged doves (Table 3).

White-winged doves appeared more selective in feeding areas than were mourning doves. The majority (18 of 28 in 1985) of cut barley fields were unused by white-winged doves throughout the nesting season.

During 1984 and 1985, we observed mourning doves feeding in groups of 11-100 or 101-1,000 most (70%) often. Mourning doves were found in large numbers (>1,000) in fields but not in as large a number (>5,000) as white-winged doves. Large groups of mourning doves were found in the same fields as large white-winged dove groups and appeared to follow the larger flocks of white-winged doves.

The 2 white-winged dove nesting colonies (Hassayampa and Highway) utilized different feeding areas (Fig. 3). All 3 years, the Hassayampa colony flew northeast up to 14 km to feed in waste grain fields in the central area of the valley. When all northeasterly grain fields were plowed under, most of the colony fed on waste grain at the Arlington feedlot. Some birds used the Powers Butte Wildlife Area when safflower was available.

We never observed white-winged doves from this colony fly in the direction of Robbins Butte Wildlife Area. Field No. 9 (Fig. 3) was the first field utilized by the Hassayampa colony each year. Use continued until it was plowed under and birds even returned to it when it was fallow in 1985. Subsequent use of other fields varied among years. The only times this colony did not fly in a northeasterly direction was to use grain planted at the Powers Butte Wildlife Area or the Arlington feedlot.

The Highway colony also showed fidelity to particular feeding areas (Fig. 3). During May-July of each year, white-winged doves from this colony flew directly north approximately 4 km to cut barley fields. Only after fields in the area were tilled did they begin to use grain at the Robbins Butte Wildlife Area. This was the only nesting concentration of white-winged doves which used the Robbins Butte Wildlife Area.

Table 3. Frequency of group size classes of mourning and white-winged doves observed feeding in grain fields from May to September, 1984-85 in Buckeye-Arlington Valley, Arizona.

	No. of cut grain fields					
	size classes					
Dove group size	0	1-10	11-100	101-1,000	1,001-5,000	>5,000
Mourning doves						
1984	11	31	70	71	19	0
1985	0	18	41	34	12	0
TOTAL	11	49	111	105	31	0
White-winged doves						
1984	94	29	30	29	21	3
1985	40	12	18	8	25	8
TOTAL	134	41	48	37	46	11

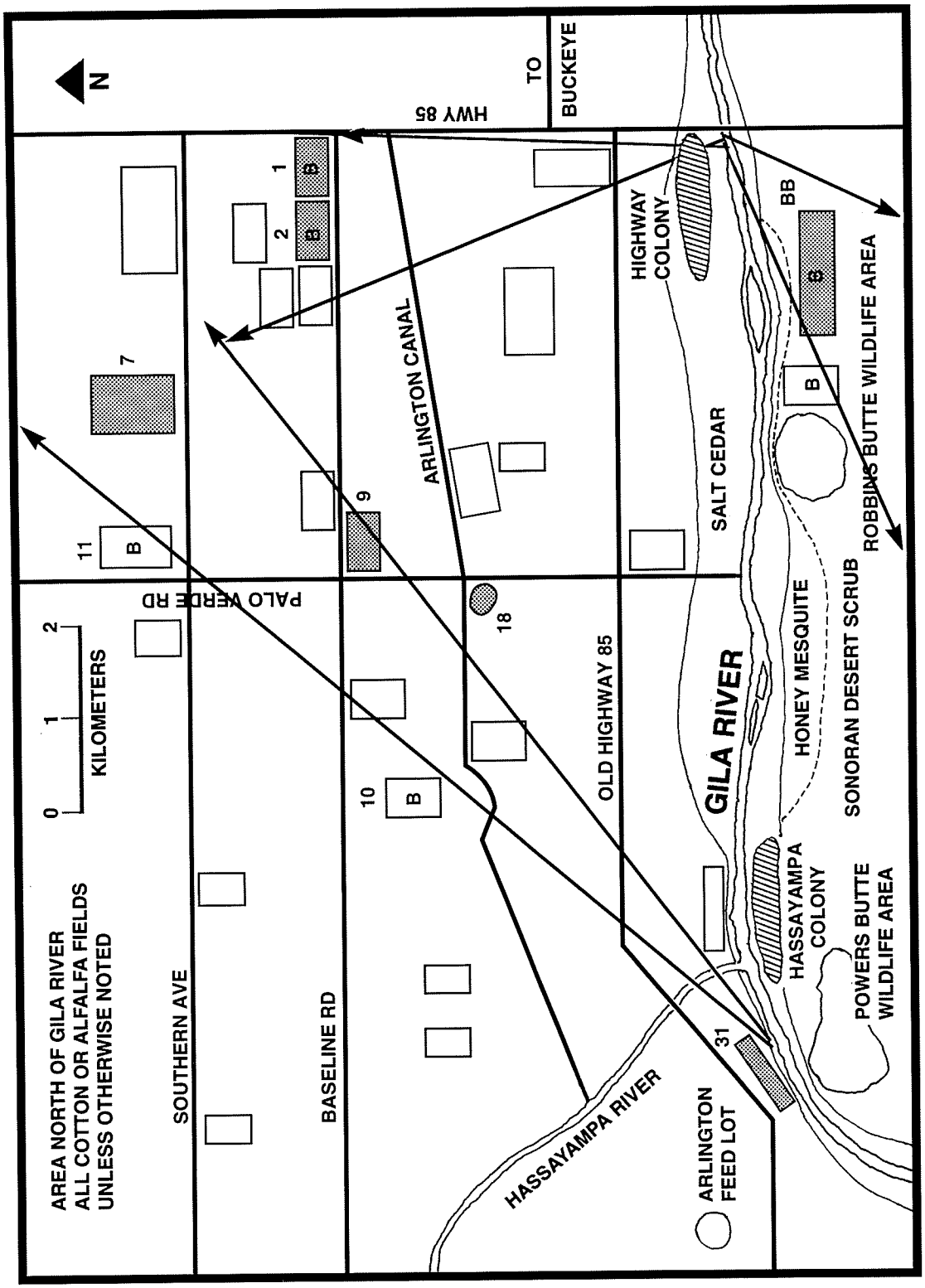


Figure 3. Location of white-winged dove feeding routes during 1985 in Buckeye-Arlington Valley, Arizona study area. Diagonal lines originating at the 2 colonies indicate direction the birds flew. Rectangles or squares indicate cut grainfields. Shaded boxes indicate fields where >1,000 white-winged doves were found feeding. Boxes containing a "B" are cut grainfields that had >10 barley seedheads/m². Field numbers correspond with Table 4.

White-winged doves did not select grain fields closer to nesting areas when grain was more available, instead they continued to feed in habitually used fields (Table 4). The Hassayampa colony used fields in the northeastern portion of the study area (Fig. 3; field Nos. 7, 9, and 11) during May and June. The quantity of barley found in this area was relatively low, compared to other fields that were closer to the nesting colony. Field No. 31 was only 0.8 km from the colony and had relatively high amounts of grain, but it was not used until the end of June. The Highway colony used field Nos. 1 and 2 until they were plowed under on July 8. These fields had abundant grain available (41.6 seedheads/m²) but were farther from the colony than Robbins Butte which had twice the grain available. Use of the Robbins Butte barley field was high (>5,000 white-winged doves) but only after July 22, 2 weeks after field Nos. 1 and 2 were plowed under. We found no differences in stubble height, distance to water, or size of field between used and unused fields.

Mourning doves tended to feed independently of other mourning doves, usually going to feeding areas in groups of 1-2 (Fig. 4). We compared feeding group size between high (42 pairs/ha) and low (3.4 pairs/ha) density nesting areas and found no significant differences in group sizes either leaving or returning to nesting areas ($P = 0.48$). In contrast, the majority of white-winged doves flew in groups of 11-12 (Fig. 5). These larger groups appeared to follow each other. Average group size of white-winged dove groups returning from feeding areas was smaller ($\bar{x} = 3.1$ vs. 8.6; $P < 0.01$) than groups leaving to feed.

Table 4. Summary of white-winged dove group sizes using barley fields in 1985 in Buckeye-Arlington Valley, Arizona[a]. P indicates plowed under and ( ) indicates number of seedheads per m² after plowing. Field numbers correspond to Figure 3.

	Field #							
Date	1	Robbins Butte	7	9	10	11	18	31
5/27	uncut	101-1,000	>1,000	P (0.3)	0	0	>1,000	11-100
6/3	101-1,000	11-100	11-100	0	0	0	>1,000	11-100
6/17	>1,000	11-100	P (0)	0	0	0	1-10	11-100
6/26	>5,000	11-100	--	1-10	0	0	101-1,000	>1,000
7/1	>5,000	11-100	--	>1,000	1-10	P (0)	>1,000	>1,000
7/4	>5,000	11-100	--	>1,000	0	--	P (0)	>1,000
7/8	>5,000	1-10	--	>1,000	0	--	--	>1,000
7/10	P (0)	11-100	--	>1,000	1-10	--	--	>1,000
7/16	--	101-1,000	--	>1,000	1-10	--	--	101-1,000
7/22	--	>5,000	--	>5,000	1-10	--	--	101-1,000
8/6	--	>5,000	--	P (0)	11-100	--	--	>1,000
8/13	--	>5,000	--	--	0	--	--	>1,000
8/20	--	>5,000	--	--	11-100	--	--	101-1,000
8/30	--	>5,000	--	--	1-10	--	--	101-1,000

[a] Mean seedheads per m² on June 1, by field, were as follows: 1 = 41.6, Robbins Butte = 86, 7 = 2.6, 9 = 0.3, 10 = 23.6, 11 = 21.8, 18 = 7.2, and 31 = 25.8. Distance (km) to individual fields from nesting colony were as follows: 1 = 3.2, Robbins Butte = 2.6, 7 = 9.6, 9 = 7.2, 10 = 3.2, 11 = 8.9, 18 = 5.7, and 31 = 0.8.

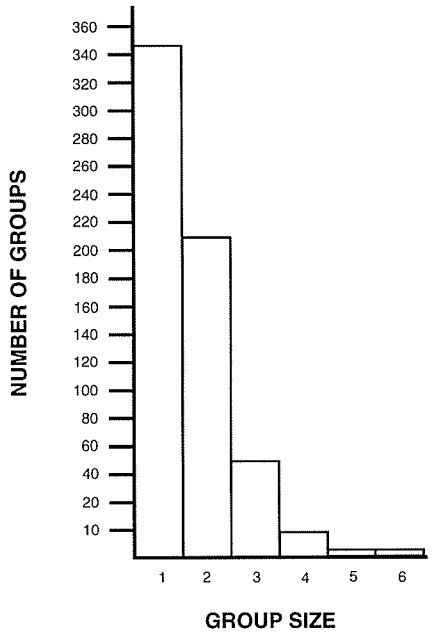


Figure 4. Mourning dove feeding flight group sizes counted in 1984 and 1985 in Buckeye-Arlington Valley, Arizona study area.

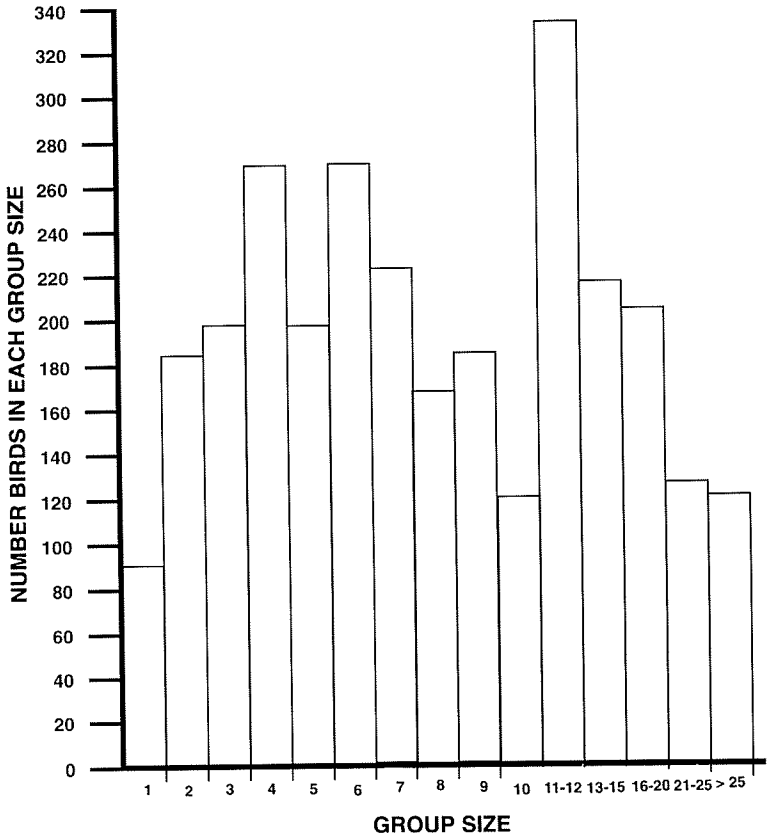


Figure 5. Number of white-winged doves counted in different group sizes during feeding flights in 1984 and 1985 in Buckeye-Arlington Valley, Arizona study area.

Nesting

Chronology. Mourning doves initiated nesting activity later than white-winged doves, and nested later throughout the summer than white-winged doves in 1983 and 1985 ($P < 0.05$). Mourning doves had 3 peaks whereas white-winged doves had 1 or 2 nesting activity peaks. Mourning doves had similar nesting patterns during all years but white-winged dove nest timing differed among years (Fig. 6).

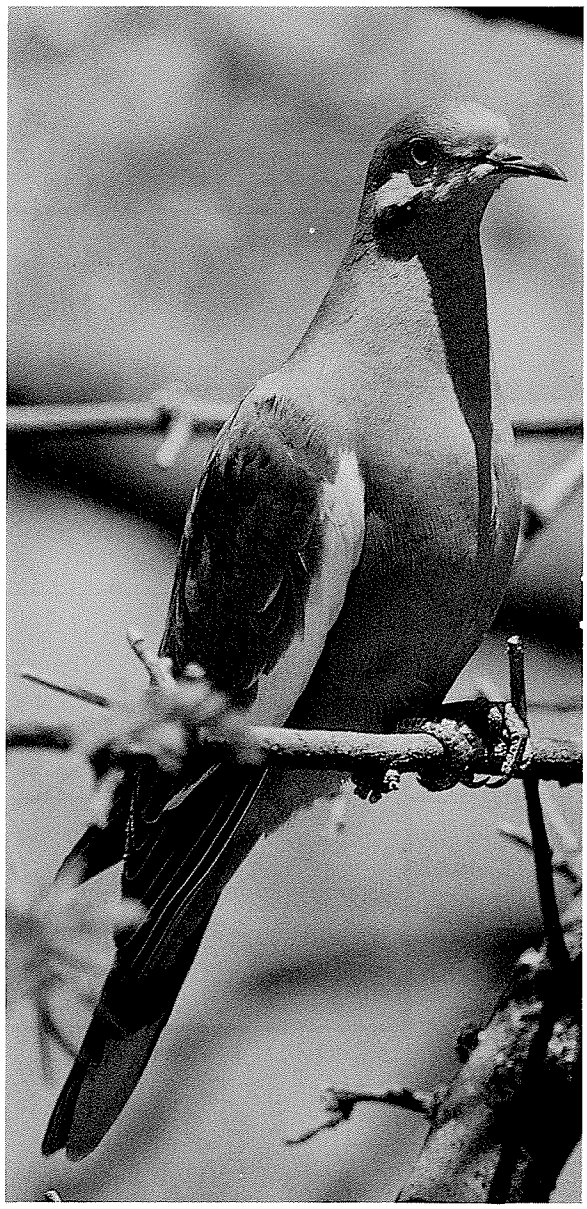
During 1983, mourning doves initiated nesting in mid-May and ended just before September 1. There were 3 active nests on September 1 at the onset of the hunting season and all 3 fledged young. There were 3 nesting peaks, starting at the beginning of each month (June, July, and August). There was more late season nesting in 1983. Seventy-five percent of nesting activity was completed by the end of June in 1984 and 1985, but not until the end of July in 1983. During 1984, mourning dove nesting activity started earlier in May and finished at the end of August. The 3 peaks started at the first of May and June and the second week of July. In 1985, there were only 2 nesting peaks, the first in mid-May and the second near July 1.

There was a 25% annual decline in mourning dove nesting attempts during the 3-year period; in 1983 we found 165 nests, in 1984 - 124, and in 1985, only 83. However, there were no changes in the amounts of nesting habitat or available food.

There were 2 white-winged dove nesting peaks during 1983; the first at the end of May and a second peak in July. There were also 2 peaks in 1984, but they were later than in 1983, occurring in the first week of June and at the end of July. There were also more nesting attempts during August 1984 than 1983 or 1985. The nesting season in 1985 was different ($P < 0.001$) from the preceding 2 years, ending earlier with no second nesting peak. Seventy-five percent of the nesting was completed by June 16. There was no difference in the nesting chronology between the 2 colonies (Hassayampa and Highway) in any year ($P = 0.47$).

Nest-Site Selection. Mourning doves nested slightly lower to the ground than white-winged doves in all habitat types (Table 5), however, these differences were not significant ($F = 1.11$, d.f. = 13, $P = 0.22$). Nest sites were lowest in honey mesquite and medium salt cedar and highest in tall salt cedar. Nest height was not a factor in nest success as differences in nest height between successful and unsuccessful nests were not significant ($F = 0.98$, d.f. = 11, $P = 0.41$).

Mourning doves nested in trees averaging from 5 to 6 m in height in all habitat types except tall salt cedar. White-winged doves nested in trees averaging >6 m in all habitat types except honey mesquite. There was no difference in average nest tree height between successful and predated nests ($F = 1.07$, d.f. = 11, $P = 0.33$). Both species nested in trees with DBH averaging between 14 and 20 cm. Average diameters of the branch at nest for both species was between 5 and 9 cm, but variance was high in each habitat type.



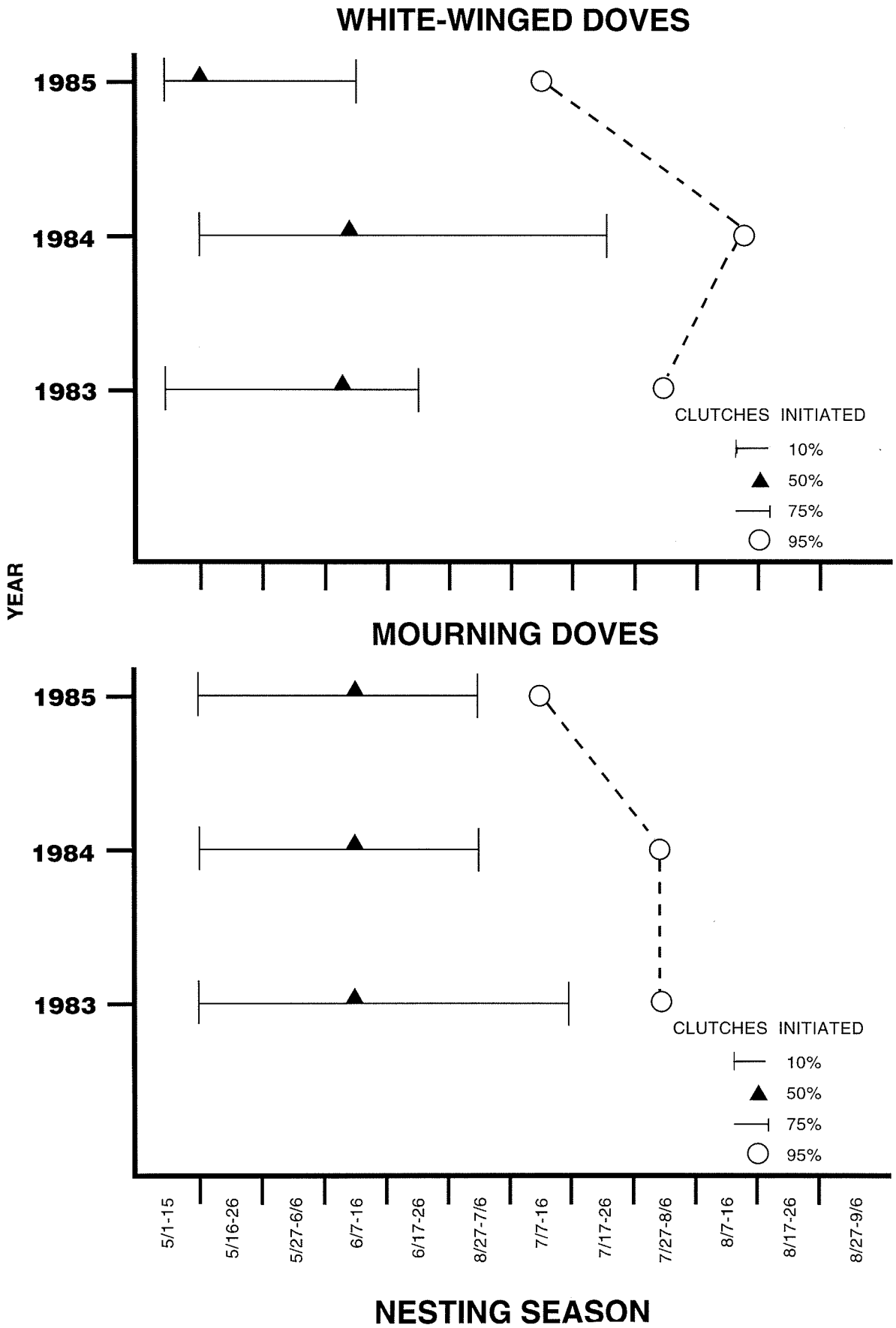


Figure 6. Phenology and duration of white-winged (A) and mourning dove (B) in Buckeye-Arlington Valley, Arizona study area, 1983-85. Dates are shown when 10, 50, 75, and 95% of the total clutches were initiated.

Table 5. Mourning and white-winged dove average nest-site characteristics by species, habitat type, and nest outcome in Buckeye-Arlington Valley, Arizona, 1983-85.

		Nest Classification		Nest	Tree			Nest Cover Index				
Dove species	Habitat type	Type	n	Height (m)	Height (m)	DBH[a] (cm)	DBN[b] (cm)	1	2	3	4	5
Mourning dove	Honey mesquite	Successful	76	2.8	5.9	18.2	9.3	1	20	28	4	0
		Predation	124	2.5	6.0	15.0	7.3	9	30	25	3	1
		Subtotal	200	2.6	5.9	16.2	8.1	10	50	58	7	1
White-winged dove	Honey mesquite	Subtotal	1	3.1	5.6	14	1	0	0	0	1	0
Mourning dove	Medium salt cedar	Successful	27	2.8	5.5	14.9	7.0	3	5	6	1	0
		Predation	22	2.5	5.4	12.3	7.9	0	8	3	3	1
		Subtotal	49	2.7	5.5	13.7	7.4	3	13	9	4	1
Mourning dove	Tall salt cedar	Successful	27	3.5	7.0	17.6	5.0	2	8	7	2	0
		Predation	7	2.8	7.0	16.7	7.7	2	6	2	3	0
		Subtotal	34	3.4	7.0	17.4	5.6	4	14	9	5	0
White-winged dove	Tall salt cedar	Successful	162	3.9	7.7	19.4	6.0	3	37	44	30	13
		Predation	48	4.2	7.9	19.5	5.3	1	10	10	2	0
		Subtotal	210	4.0	7.7	19.4	5.8	4	47	54	32	13
Mourning dove	Mixed honey mesquite-salt cedar	Successful	25	2.6	5.6	15.6	8.4	4	6	6	4	0
		Predation	31	2.7	6.1	18.8	8.6	0	12	7	4	0
		Subtotal	56	2.6	5.4	18.2	8.9	4	18	13	8	0

[a] Diameter of nest tree at breast height.
[b] Diameter of largest branch supporting the nest.

Mourning doves nested in more open areas than white-winged doves as nest sites were skewed towards nest cover indices 1, 2, and 3. White-winged dove nest cover indices were more normally distributed than mourning dove nest indices. The most common cover types used were indices 2 and 3, similar to mourning doves, but they used thick cover types (indices 4 and 5) ($X^2 = 30.4$, d.f. = 4, $P < 0.001$) more often.

White-winged dove nest placement was correlated with foliage volume ($r^2 = 0.85$, $P < 0.001$). Maximum leaf volume occurred between 2.5 and 6 m height, where 89.5% (205 of 229) of the nests were found (Fig. 7). White-winged doves exhibited a preference for nesting in high foliage volume as nest sites were available from 0.5 to 13 m height in tall salt cedar habitat types. In contrast, 64.4% of mourning doves nested between 1.5 and 3.0 m height (228 of 354 nests), just below the highest foliage volume (Fig. 8).

Habitat Selection. White-winged doves nested predominantly in tall salt cedar ($\bar{x}$ = 135 pairs/ha or nests/ha for 1984-85) (Table 6) and rarely in honey mesquite ($\bar{x}$ = 1.0 pairs/ha). One honey mesquite transect had high foliage densities between 2.5 and 6 m height, similar to tall salt cedar, but white-winged doves did not nest in this area. Medium salt cedar received moderate use, but most of the nesting activity was on 1 transect which had high foliage densities between 2.5 and 6 m height.

Presence of tall salt cedar habitat type accounted for 90% of the variation in white-winged dove nesting density ($r^2 = 0.9$, $F = 24.9$, $P < 0.001$). Seventy-seven percent of the variation in white-winged dove nesting was explained by foliage density from 3.5 to 15.1 m height (Class III-V). Class IV was the most important foliage density for white-winged doves as 58% of nesting variation was explained by high foliage density in this height range. This probably reflected the growth of tall salt cedar and not nest placement, which was between 2.5 - 6 m height.

The highest density of mourning dove nests occurred in mixed honey mesquite-salt cedar habitats ($\bar{x}$ = 180 pairs/ha; Table 7). During 1984, we observed a density of 250 pairs/ha over the season, which was the highest density ever observed for mourning doves (Sayre and Silvy 1993). The second highest densities during this study were recorded in honey mesquite during all years (51 pairs/ha). The highest densities in honey mesquite were recorded on transects with high foliage densities. The more open transects had lower nesting densities, although nesting success was higher. In 1983, 1 honey mesquite transect had the second highest mourning dove nesting density of all transects in all habitat types (28.2 pairs/ha), but in 1984 and 1985 the number of nesting attempts declined (1984 - 10.9 pairs/ha; 1985 - 2.8 pairs/ha). There was no change in foliage density, except for excessive livestock grazing beginning in 1984.

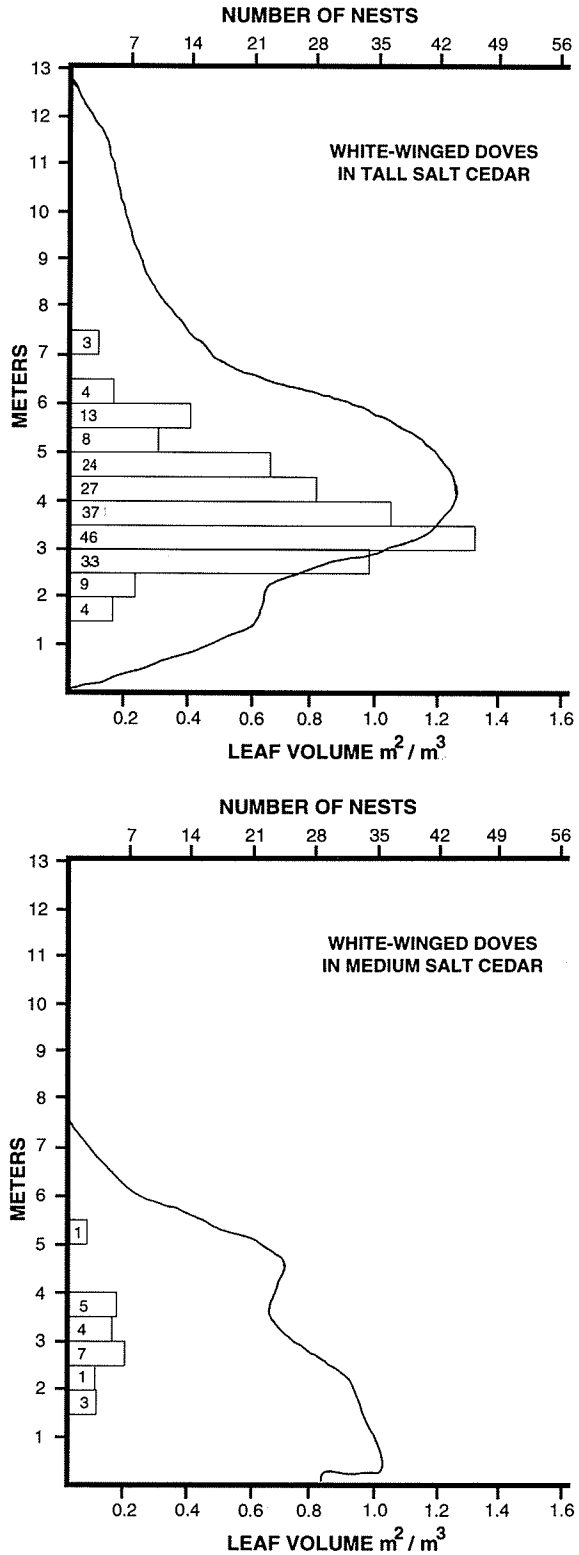


Figure 7. Foliage volume, nest height, and number of nests for white-winged doves in tall (A) and medium (B) salt cedar habitats in Buckeye-Arlington Valley, Arizona study area during 1983-85. Solid line depicts foliage volume while numbers inside histogram indicate number of nests.

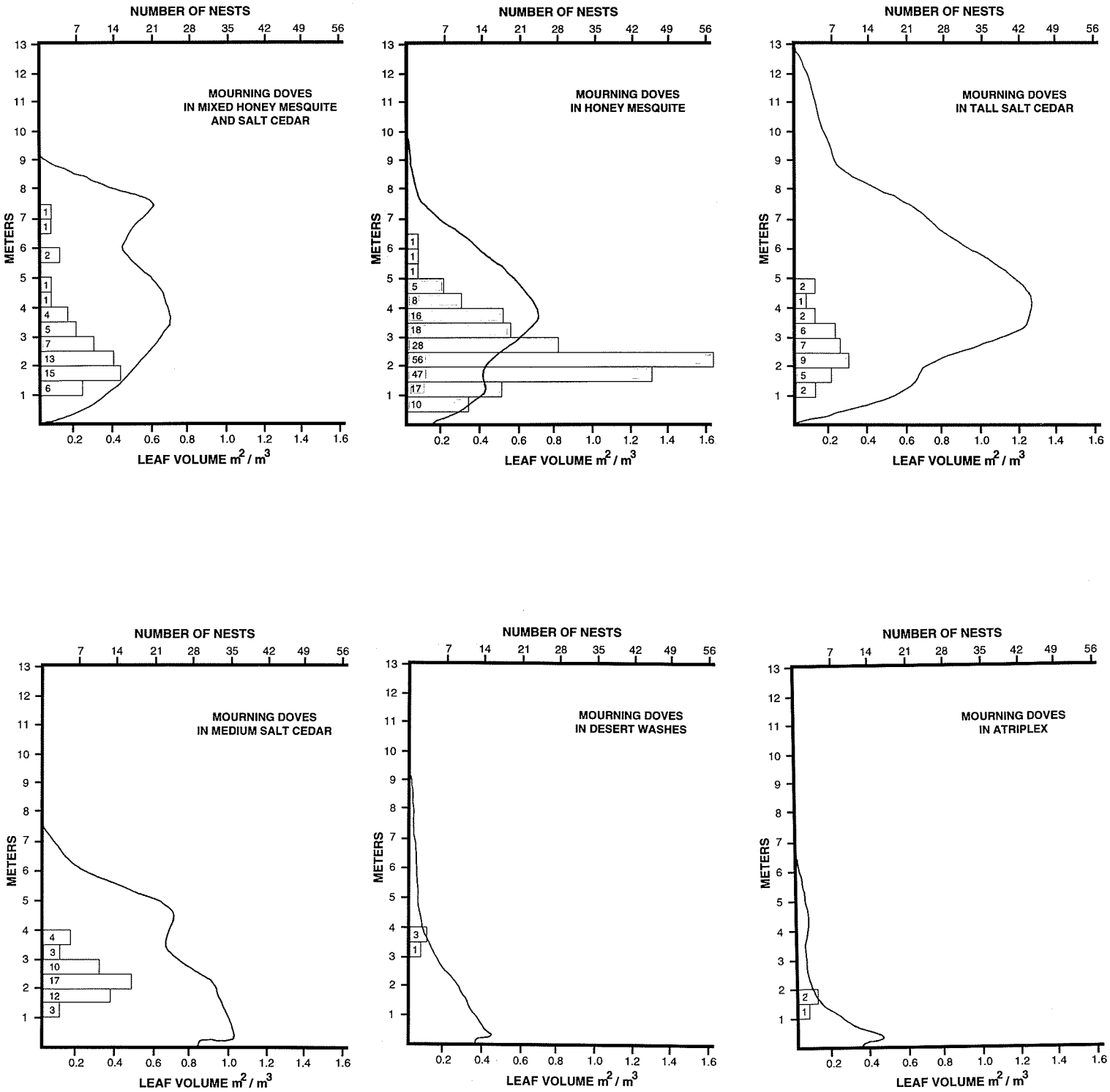


Figure 8. Foliage volume, nest height, and number of nests for mourning doves in all nesting habitats in Buckeye-Arlington Valley, Arizona study area during 1983-85. Solid line depicts foliage volume while numbers outside histogram indicate number of nests.

Table 6. Summary of nesting attempts and seasonal nest density of white-winged doves by habitat type during 1983-85 in Buckeye-Arlington Valley, Arizona.

		1983		1984		1985	
Habitat type	Area sampled (m^2)	No. nesting attempts	Density (pairs/ha)	No. nesting attempts	Density (pairs/ha)	No. nesting attempts	Density (pairs/ha)
Mixed honey mesquite & salt cedar	1,200	1	8	0	0	0	0
Atriplex spp. flat	2,400	0	0	0	0	0	0
Medium salt cedar	4,800	6	13	12	25	6	13
Tall salt cedar	5,400	46	85	85	158	60	111
Honey mesquite	15,000	2	1	1	1	2	1
Desert wash	4,800	5	10	0	0	0	0
Creosote flat	6,000	0	0	0	0	0	0

Table 7. Summary of nesting attempts and seasonal nest density of mourning doves by habitat type during 1983-85 in Buckeye-Arlington Valley, Arizona.

		1983		1984		1985	
Habitat type	Area sampled (m^2)	No. nesting attempts	Density (pairs/ha)	No. nesting attempts	Density (pairs/ha)	No. nesting attempts	Density (pairs/ha)
Mixed honey mesquite & salt cedar	1,200	21	175	30	250	14	116
Atriplex spp. flat	2,400	3	13	0	0	0	0
Medium salt cedar	4,800	20	42	17	35	14	29
Tall salt cedar	5,400	12	22	16	30	15	28
Honey mesquite	15,000	99	66	76	51	54	36
Desert wash	4,800	5	10	0	0	0	0
Creosote flat	6,000	0	0	0	0	0	0

Mixed honey mesquite and salt cedar habitat type explained 43% of mourning dove nesting variation ($r^2 = 0.69$, $F = 6.3$, $P < 0.007$). Foliage density from 3.5 to 6.1 m height (Class III) was the most important to mourning doves, but it was weakly correlated ($r^2 = 0.26$) with nest density.

Nesting Success. Nest success was related to several factors including predation, accidents, and abandonments. Predation was the largest cause of nest loss as there were few accidents or abandonments (<10). Possible predator species included cactus wren (*Campylorhynchus brunneicapillus),* Gila woodpecker *(Melanerpes uropygialis),* great-tailed grackle *(Quiscalus mexicanus)*, great-horned owl (*Bubo virginianus*), coachwhip *(Masticophis* spp.), kingsnake (*Lampropeltis* spp.), rattlesnake *(Crotalus* spp.), woodrats (*Neotoma* spp.), deer mice (*Peromyscus* spp.), and gray fox (*Urocyon cinereoargenteus*). We were unable to determine which predator species was responsible for each nest predation. However, we observed 2 predation incidents; 1 by a kingsnake and the other by a gray fox.

White-winged doves had higher fledgling success than mourning doves in all habitat types during the study ($F = 9.99$, d.f. = 21, $P = 0.004$). Annual fledgling rates for white-winged doves ranged from 61-100% (Table 8).

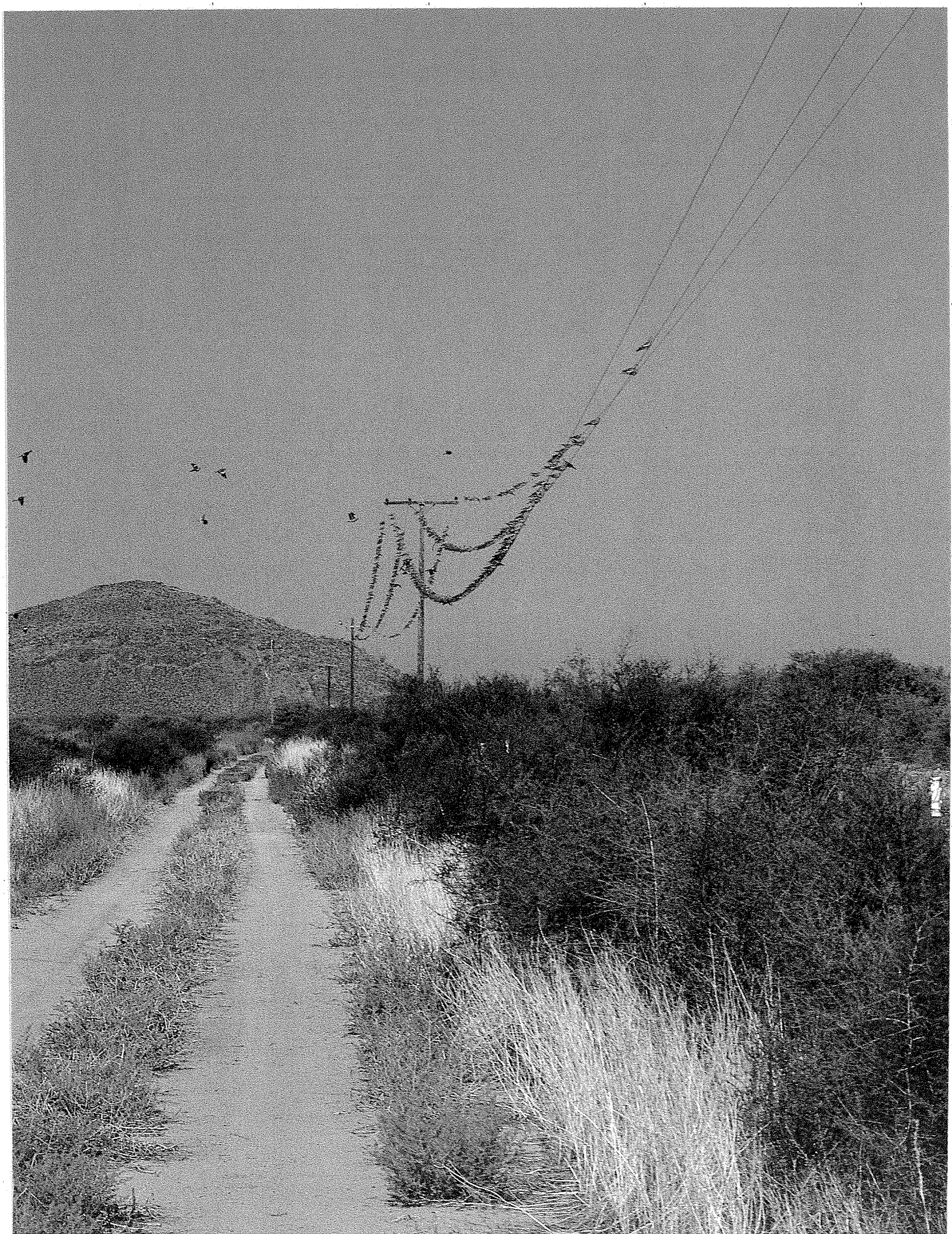
Fledgling success for mourning doves varied from 35-63%, depending on habitat type and year (Table 9). Mourning dove fledgling success was greatest in tall salt cedar and lowest in desert washes. Magnitude of nest predation was variable between habitat types and years, and varied greatly between transects within the same habitat type. For example, on 1 transect within dense foliage honey mesquite, nest success was only 26% (the lowest value for mourning doves), whereas on an open foliage honey mesquite transect only 200 m south, nesting success was the highest (67%). Fledgling success for both dove species did not decline over time.

Table 8. Number of white-winged dove nest attempts and proportion of young fledged by habitat type in Buckeye-Arlington Valley, Arizona 1983-85.

	1983		1984		1985	
Habitat type	No. nesting attempts	Proportion fledged	No. nesting attempts	Proportion fledged	No. nesting attempts	Proportion fledged
Mixed honey mesquite & salt cedar	1	1.0	0	0	0	0
Atriplex spp. flat	0	0	0	0	0	0
Tall salt cedar	53	0.73	85	0.76	60	0.86
Medium salt cedar	6	0.83	12	0.61	6	0.83
Honey mesquite	0	0	1	1.00	2	1.00
Desert wash	0	0	0	0	0	0
Creosote flat	0	0	0	0	0	0

Table 9. Number of mourning dove nest attempts and proportion of young fledged by habitat type in Buckeye-Arlington Valley, Arizona 1983-85.

	1983		1984		1985	
Habitat type	No. nesting attempts	Proportion fledged	No. nesting attempts	Proportion fledged	No. nesting attempts	Proportion fledged
Mixed honey mesquite & salt cedar	21	0.63	30	0.46	14	0.46
Atriplex spp. flat	3	1.00	0	0	0	0
Tall salt cedar	8	0.56	16	0.63	15	0.57
Medium salt cedar	21	0.64	17	0.36	14	0.56
Honey mesquite	95	0.40	74	0.35	39	0.45
Desert wash	5	0.30	0	0	0	0
Creosote flat	0	0	0	0	0	0



DISCUSSION

Feeding

Food Habits. It is well documented that 2 closely related, sympatric, avian species will utilize different resources (MacArthur and Levins 1964, Orians and Horn 1969, Lack 1971, Baker and Baker 1973, Gutierrez 1980). By using different food resources the 2 species reduce the chance for competition (Fig. 9). Over time, competition leads to a divergence in the diets of sympatric species.

White-winged and mourning doves have only been sympatric in this area of Arizona for a short period in evolutionary time (ca. 80 years). White-winged doves became numerous in southern Arizona around the turn of the century with the advent of irrigated agriculture (Cottam and Trefethan 1968). Although there was some range overlap in Mexico, the 2 species tend to use different habitat types during the breeding season. We doubt that 80 years of sympatry could cause a major dietary shift.

The mourning dove diet reported in this study was similar to that found in other areas of the United States where no white-winged doves exist. Mourning doves frequently use a mixture of annual species and waste agricultural grains (Chambers 1963, Ward 1964, Carpenter 1971, Griffing and Davis 1974, Davis 1974, Armstrong and Noakes 1981, Lewis 1993). The white-winged dove diet in this study was also similar to that of white-winged doves elsewhere in Arizona and Texas (Cottam and Trefethan 1968).

Competition would occur, assumedly, if there was only enough waste grain to support 1 species of dove. Only recently has there been a decline in grain crops, and data collected in this study suggested there was still ample grain available even during the relative shortage in 1985. We suggest that selective forces on dietary selection occurred prior to the range extension of white-winged doves, and that food competition currently does not occur.

Volume of annual species in mourning dove diet indicated this food source was important, but annual species were never >50% of the diet. Because annual seeds are generally smaller than cultivated grains, mourning doves on average had larger numbers of seeds in each crop than did white-winged doves. During March 1983, 1 mourning dove was collected which contained 30,000 patata seeds in the crop. Mourning dove crops commonly contained 2,000 annual and 60 barley seeds which comprised 15 and 85% of the volume, respectively. None of the annual species used as food during this study occurred in clumped or pod-like structures which would allow several seeds to be eaten at once. Although not quantified, it was common to observe mourning doves making rapid, pecking-like motions as they gathered annual seeds. The latter behavior was not observed in white-winged doves.

Handling time can influence dietary selection of avian species. Most research in this area has focused on the difficulty of predators catching different sizes of prey by insectivores, not granivores. All of the food types used (excluding saguaro) by white-winged doves were larger than 4 mm, similar to results of other studies (Cottam and Trefethan 1968, Anderson and Ohmart 1982). We suggest that perhaps the larger bill and gape width of white-winged doves exclude them from using smaller annual seeds often used by mourning doves.

Because nutrition of food items is important in dietary selection, the increased use of annual species by gravid mourning doves may provide insight into nutritional needs during summer. Armstrong and Noakes (1981) suggested that parent birds may feed nestlings smaller seeds. Although not quantified, the rapid pecking motions needed to collect 1,000-2,000 seeds which made up 10-20% of the daily diet should result in increased energy expenditure for food gathering. Optimal foraging theory predicts that an individual should select the larger, more easily gathered, food source. This has been documented in both field and laboratory conditions (Werner and Hall 1974, Goss-Custard 1977, Krebs et al. 1977). We expected mourning doves feeding in barley fields to select barley (large and plentiful) instead of searching for smaller annual seeds, which we often observed.

The nutritional needs of mourning doves (Blockstein and Westmoreland 1993, Mirachi 1993) and white-winged doves (Schacht et al. 1995) have been intensively studied but many questions remain. It would be important for managers to know if gravid mourning doves have increased nutritional needs during egg production, along with the already established increased need during crop milk production. If correct, perhaps this need was met by mourning doves through preference of annual seeds over agricultural grains. It is difficult to understand, however, why mourning doves would need more protein than the closely related white-winged dove, especially since high fledgling success for white-winged doves was documented. Schacht et al. (1995) found that a diet of agricultural grains during the breeding season was not limiting white-winged dove productivity, and suggested that the need for high

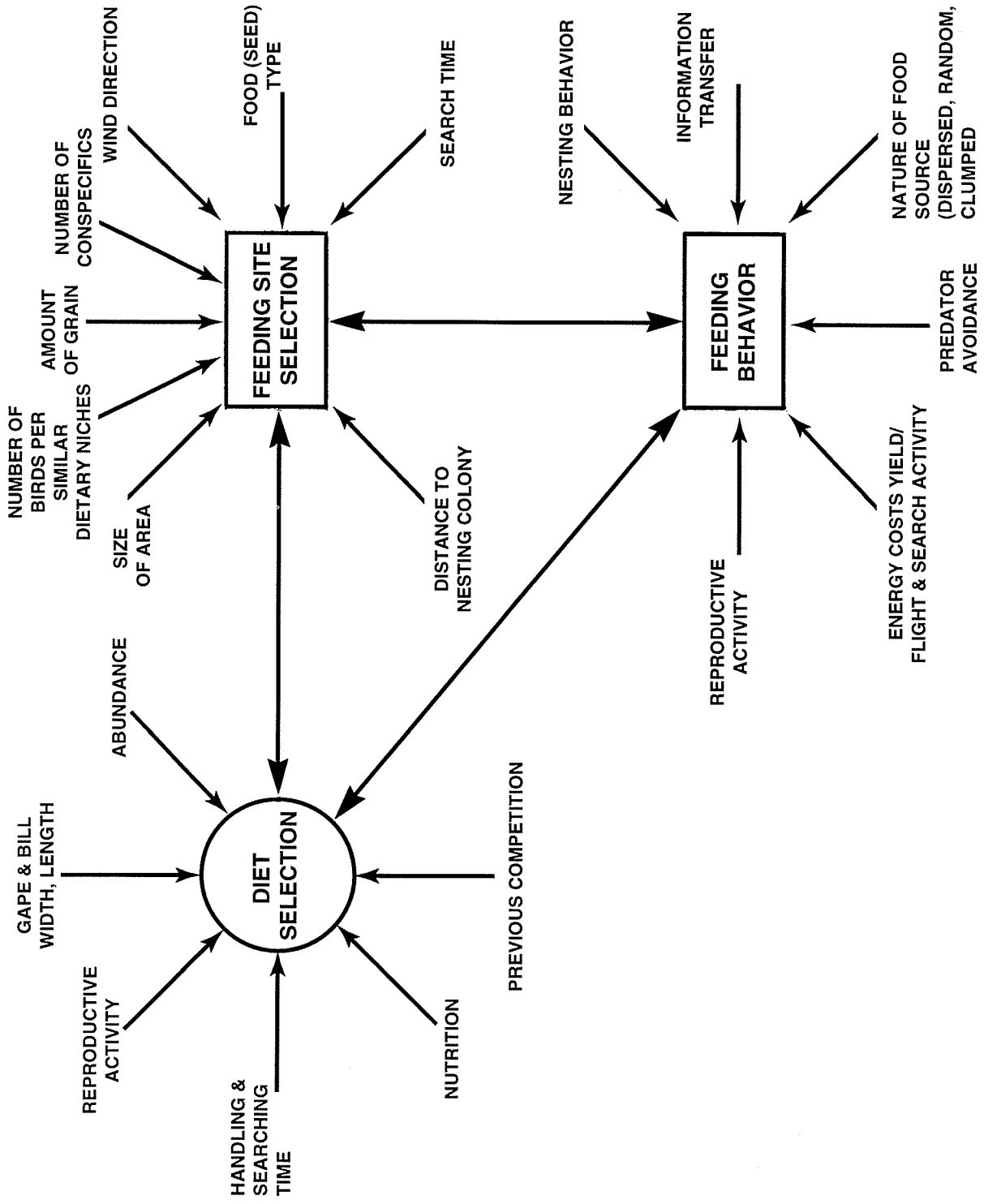


Figure 9. Theoretical model of how various factors interact and affect dove diet and feeding area selections.

energy foods was most important after white-winged doves returned from migration.

Feeding Site Selection. An agricultural valley with changing farm practices could be viewed as a coarse-grained patchy environment, where waste grain fields serve as patches which must be chosen for feeding by both dove species. Optimal foraging theory predicts that both species should feed in areas where food was most plentiful and to reduce distances traveled to each feeding patch (Pyke 1984). A variety of animals, and even insect parasitoids, tend to aggregate in regions of high prey density, thus increasing energy intake while decreasing energy expenditure. It is common to find many individuals of the same species exploiting 1 "patch" with the highest food resources, known as the "aggregate response" (Hassel and May 1974). Both dove species in this study were often found in large numbers in 1 field (patch) but neither species fit the optimal foraging model in field selection. White-winged doves did not respond to grain abundance and often flew to habitually used fields while ignoring closer areas with more grain. There was no reason to expect differences in the nutritional quality of barley between fields.

Previous researchers have found species avoiding more profitable food patches because of predation pressure (Caraco et al. 1980, Caraco 1981, 1982). Our casual observations suggest that Cooper's hawks (*Accipiter cooperii*), were present in the valley from November-March, but during breeding or nesting there were few avian predators.

Neither dove species appeared to respond to grain abundance or proximity to nesting area in patch choice. Mourning doves did not exhibit the same fidelity to feeding areas as did white-winged doves, but they were found feeding in areas adjacent to nesting habitat and in grain fields up to 14 km from nesting habitat. Our data suggested that feeding in a less profitable patch (1 seedhead/m^2 versus 86/m^2) or traveling distances up to 14 km to feeding patches did not affect fledgling success.

No physical differences were found between fields used versus those unused by white-winged doves. Evans (1972) found that small fields of grain planted in Texas failed to attract white-winged doves on their daily flights into Mexico. He felt that the small size of the plots (2 to 4 ha) were not attractive. During 1983 there was little use of fields <12 ha by white-winged doves. However, in 1984 and 1985 >5,000 white-winged doves were found feeding in fields <6 ha. We believe the reason they did not use small feeding areas in 1983 was that there were no small fields found in their habitually used flight paths as in 1984 and 1985.

Neither species avoided conspecifics or competitors. Mourning doves were found most often in relatively small groups but were frequently observed feeding with >5,000 white-winged doves in 1 field. White-winged doves seemed to prefer feeding in large groups which was reflected by their flight behavior in that large groups flew en masse to feeding areas.

Feeding Behavior. White-winged doves were more gregarious in their flight and nesting behavior than mourning doves. Coloniality is common among species that are dependent on patchy food sources. Hypotheses explaining this phenomenon include: (1) information transfer of food source location (Ward and Zahavi 1973, Krebs 1974, Burger 1981, Waltz 1982), (2) dependence on patchy ephemeral food sources (Horn 1968), and (3) reduced predation risk for the individual (Hamilton 1971, Burger 1981).

Ward and Zahavi (1973) postulated that birds join assemblages for resting (roosts) and breeding (colonies) because information exchange between neighbors can facilitate location of unpredictable food supplies. Krebs (1974) found that colony departures of blue herons (*Ardea herodias*) were clumped temporarily and assumed that there were "followers" (previously unsuccessful foragers) who were following previously successful foragers. To accept the information center hypothesis we would have to demonstrate (1) philopatry (successful birds return to that site), (2) differential success, (3) detection (how an unsuccessful forager recognizes a successful one), (4) departure synchrony, (5) following, (6) toleration, and (7) payoff. Qualitative observations that white-winged doves followed each other (group by group) and quantitative data demonstrating that white-winged doves from 1 nesting colony usually feed in the same field indicates following behavior. The continued use of fields until they were plowed indicates philopatry. However, observations of white-winged dove differential success did not support the information center hypothesis. There were always a few (e.g. <100) white-winged doves feeding in fields which contained more grain than those which were being used by larger groups, but only when habitually used fields were plowed under did the majority of the colony feed in these other fields. Waltz (1982) listed 2 environmental parameters that were central to the information center hypothesis model: (1) distance between food patches relative to the average distance between nest and food patches (the distance ratio),

and (2) probability of foragers moving to better feeding areas. For this hypothesis to be correct, we would expect followers to minimize the distance ratios and move to patches where food could be gathered more efficiently. White-winged doves did not fit this model.

Horn (1968) presented a model which examined the adaptive significance of colonial nesting for species which depend on patchy ephemeral food sources. White-winged dove dependence on grain fields appears to fit this model. Mourning doves, with their relatively high use of annual species, would not fit this model because potential feeding areas were more dispersed. Horn (1968) demonstrated mathematically that species which are dependent on ephemeral food sources minimize energy expenditure by nesting together in 1 area. Optimal selection of the most profitable patch was not included in Horn's model.

Differences between the gregarious feeding nature of white-winged doves and the more solitary feeding nature of mourning doves may have evolved due to use of different food sources (i.e., different food patches). Mourning doves are generalist feeders (Lewis 1993) and gain no advantage in feeding together. To follow another conspecific to a 1 m^2 weed patch would not appear advantageous. In comparison, white-winged doves, with their diets restricted to larger seeds are limited to patchy, temporal food sources. In these cases, following other doves and nesting close to food sources would appear beneficial. White-winged doves in Buckeye-Arlington Valley did not forage optimally, but white-winged dove feeding behavior did not evolve in agricultural waste grain situations. Riparian-nesting white-winged doves in Mexico, Arizona, and Texas, not located near agricultural areas, are dependent on large perennial or annual seed species which have patchy distributions (Cottam and Trefethan 1968). Doveweed (*Croton* spp.), torchwood (*Bursera* spp.), sunflower (*Vigueria* spp.), and other composites make up the majority of white-winged dove diets collected in Sonora, Mexico and south Texas where agricultural grains are not available. Since some of the aforementioned plant species are perennial, it might explain why white-winged doves had fidelity to specific feeding areas. It would be advantageous for doves to return to the same feeding areas each year since perennials are more dependable for seed production than are annual species.

Nesting

White-winged doves were found to nest almost exclusively in tall salt cedar habitat types. A majority of nesting occurred in highest foliage densities between 2.5 and 6 m height. Similar to this study, Butler (1977) found a significant correlation between numbers of white-winged dove nests and high foliage densities between 3 and 6 m height in 17 areas on the lower Colorado River. High foliage density could be important to white-winged doves for several reasons: (1) to reduce susceptibility to predation through better concealment, (2) better nest structural support, and (3) a favorable microclimate surrounding the nest.

Butler (1977) reported that white-winged doves which nested in higher foliage densities had significantly lower predation risk than individuals which nested in lower foliage volumes. In this study, birds that nested underneath areas of highest foliage density had similar predation risks. White-winged doves had a higher fledgling rate than mourning doves, which did not nest in high foliage density areas.

Since number of branches increased as foliage density increased, it appears intuitive that nest structural support would also increase. During this study only 2 white-winged dove nests were found that were believed to have been destroyed by wind storms. Only 5 mourning dove nests were destroyed by wind, where nesting occurred just underneath the highest foliage density, but still in high foliage areas (1.5-3.0 m).

Walsburg and Voss-Roberts (1983) found that desert-nesting mourning doves cool their eggs during incubation. We found that flushing incubating doves off nests within honey mesquite habitats during afternoon hours caused nest abandonment due to egg mortality (S. C. Cunningham, unpubl. data). Physiological microclimate is an important factor in nest site selection in many species (Calder 1973, Walsburg and King 1978*a*,*b*, Walsburg 1981). High foliage densities in salt cedar habitats should provide relatively cool microclimates for nesting because of increased shade and relatively higher transpiration rates.

Mourning doves which nested below high density foliage would receive less exposure to solar radiation, but may experience a less favorable microclimate. Nest abandonment only occurred during afternoon hours in honey mesquite habitats. No abandonment occurred in salt cedar (S. C. Cunningham, unpubl. data), probably because the microclimate in the honey mesquite habitats may

have been hotter and drier. White-winged doves did not nest in honey mesquite. While examining barley fields we found several ground-nesting mourning doves. Temperatures in these fields near ground easily reached >50 C.

Neff (1940) reported that white-winged dove colonies which were located in honey mesquite bosques were common to southwestern riparian systems in Arizona during the 1930s. Salt cedar began to invade the lower Gila River area during the early 1940s and was common by the early 1960s. By this time, it had become important habitat for nesting white-winged doves (Shaw 1961). There were 2 stands of tall, dense salt cedar within the study area, and both served as high-density nesting areas for white-winged doves. There was moderate use of 1 transect in medium salt cedar by white-winged doves and this area had scattered tall (>9 m) trees. Butler (1977) suggested that tall salt cedar was the preferred habitat of white-winged doves along the lower Colorado River.

White-winged doves did not utilize honey mesquite as nesting habitat in our study area. One 400 m mesquite transect was similar in vegetation profile to tall salt cedar but was also not used by white-winged doves. Based on reports by Neff (1940), avoidance of native honey mesquite was not expected. The density of mammalian, reptilian, and avian predators is higher in mesquite than in tall salt cedar habitats, (Anderson and Ohmart 1982) but we would not expect predation to cause such large changes (approx. 10-15 years) in habitat use. One possible explanation was that salt cedar was similar to tropical riparian flora in southern Mexico and Central America, where white-winged doves evolved.

Mourning doves are more generalistic in their nesting habits than white-winged doves, but they did tend to avoid dense areas, as evidenced by nest site selection. Mixed honey mesquite and salt cedar were more open than salt cedar. Mourning doves tended to nest directly underneath high density foliage where white-winged doves nested. Perhaps white-winged doves could be excluding mourning doves from these areas. However, our observations agree with those of Butler (1977) that there were many suitable nesting sites, but mourning doves still preferred to nest below dense foliage areas even in areas where white-winged doves were absent (honey mesquite, medium salt cedar, desert wash).

In this study, all nesting habitats were close (<2 km) to water, therefore water was not a factor in nest habitat selection. There also were no differences in nesting densities in relation to distance to feeding areas. Butler (1977) suggested that distance to feeding areas limited dove nesting distribution on the lower Colorado River, but he sampled areas >9 km from cultivated crops. In this study, only 1 transect was >2 km from cultivated crops.

Lack of a second nesting attempt by white-winged doves during 1985 could not be explained. Grain abundance was similar to 1984. Rainfall patterns in late June and July were similar during all 3 years, but August, 1985 had the lowest rainfall during the study. Temperatures were 2 degrees hotter during 1985, but this difference was probably not a factor. Although white-winged doves did not renest during 1985, they did not leave the valley and dove harvests were relatively high.

Although mourning dove nesting chronology was similar during the 3 years of study, the number of nesting attempts declined each year (approximately 25% each year). There were no changes in either fledgling success, amount of grain grown, or amount of nesting habitat. In fact, nesting habitat increased as young salt cedar matured. We did not quantify dove populations during this study, but each year it was more difficult to collect the numbers of mourning doves needed for food habits analysis.

Number of hunters during the first 2 days of the hunting season increased from 1970 to 1985 (Ariz. Game and Fish Dep., unpubl. data). Increased hunting pressure could effect this localized dove population which are restricted to a few feeding areas during the initiation of the hunt.

Heavy livestock grazing may have affected mourning dove nest habitat selection. Mourning dove nesting density on 1 transect declined from 28.2 to 2.8 pairs/ha with the only noticeable difference being heavy grazing of undergrowth (primarily canary grass) by cattle and horses. Hitchcock and Mirarchi (1984) determined that the surrounding nesting area was important to fledgling birds and adults. Perhaps heavy grazing by livestock on food such as canary grass caused breeding mourning doves to look elsewhere. The effects of grazing on mourning and white-winged dove nesting habitat is poorly understood.

MANAGEMENT OPTIONS

Because annual "weed" species were important in the diet of mourning doves, weed control should be minimized. Extensive spraying could also prove detrimental to other small game species that use annuals for food and cover. Given the preference for canary grass by mourning doves, we recommend planting it at existing and future wildlife areas. Other valuable species included goosefoot, patata, buckwheat, and mustard. The introduction of patches of doveweed at Robbins Butte and other wildlife areas would provide another potential food source for white-winged doves at little additional cost.

The fidelity of white-winged dove to individual feeding areas may cause problems for managers attempting to manipulate flights and provide additional food sources. Texas Parks and Wildlife Department planted grain along the United States-Mexico border to try and stop white-winged doves from flying into Mexico to feed, but they had little success (Evans 1972). Evans (1972) suggested that the food plots were too small. Results of this study would suggest that even large fields may not have short-stopped white-winged doves from their predictable feeding areas. The use of Robbins Butte grain fields by white-winged doves was negligible until preferred areas were plowed, and only 1 colony utilized the area. It may be more practical to urge or pay farmers in historically used areas to leave harvested grain fields unplowed rather than trying to establish new food sources. Feeding areas can be easily identified by managers as white-winged doves were easy to follow to feeding areas. When new wildlife areas are established, emphasis should focus on providing nesting habitat and gaining cooperation of farmers in preferred areas.

If grain production continues to decline in the study area, establishment of new feeding areas will have to be considered. We first recommend leasing areas habitually used by white-winged dove. If this is not feasible, new areas should consider the following criteria: (1) locate feeding areas as close as possible to traditional flight paths so white-winged doves can locate new fields, (2) field size should be >25 ha, and (3) plant food species which are most commonly used by doves in the area. Based upon our observations we would not expect white-winged or mourning doves to rapidly use new food sources outside of established patterns. Further experimentation (e.g., trying new grains, planting schemes, etc.) to induce birds to use new areas may be fruitless and expensive.

Current management (1983-85) at the Robbins Butte Wildlife Area appears adequate to sustain local dove populations. The large acreage of barley provides white-winged and mourning doves with a valuable food source, and its early maturity makes it available at the onset of breeding season. The large fields of barley (25 ha) were only established in 1984 and their use may increase as dove nesting colonies recognize them. Past changes in grain planting (10-acre strips, changes in grain, etc.) did not enhance use of the area by white-winged doves, and large plantings of milo and safflower excluded mourning doves, quail, and rabbits until it was cut. Further experimentation with crops seems unnecessary, expensive and is not recommended unless needed to reestablish soil fertility.

Given the continued loss of riparian habitats in the Southwest, the need for reestablishing and protecting nesting areas is imperative. White-winged doves were dependent on tall salt cedar habitats. Although salt cedar is an exotic, the importance of this habitat to white-winged doves is obvious. We recommend that areas of tall salt cedar with high foliage density be protected. Our data suggest that removal of salt cedar habitats would be deleterious to white-winged dove populations. A potential management strategy for white-winged doves would be to purchase areas containing tall salt cedar vegetation to provide additional and future nesting habitat.

Mourning doves were much less selective in habitat selection than were white-winged doves, although a preference for mixed honey mesquite and salt cedar types was found. Future nesting habitat for mourning doves could be established on wildlife areas by planting honey mesquite as was done at Robbins Butte. We also recommend that existing salt cedar patches be protected. Other native tree species may provide doves with adequate nesting habitat, but further experimentation is necessary.

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Layout, design, and typesetting by Vicki L. Webb.

Photos by:

George Andrejko (Cover, Pages 4, 7, 17, 36)
Stan Cunningham (Pages iv, vi, 5, 6, 8, 11, 20, 24, 26, 32).

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