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Reproductive ecology of the burrowing owl, Athene cunicularia floridana, in Dade and Broward Counties, Florida

Brian Keith Mealey
Florida International University

FLORIDA INTERNATIONAL UNIVERSITY
Miami, Florida

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by

Brian Keith Mealey

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ABSTRACT OF THE THESIS

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Professor Martin Tracey, Major Professor

From 1988 to 1990 a study of the reproductive ecology of the burrowing owl was conducted to determine seasonality and reproductive success in Dade and Broward Counties. Reproductive data for each of the three years (1988-1990) reveal a higher reproductive success rate (54%) for 1990 than 1989 (40%) and 1988 (40%). Owls using previously used burrows had a higher success in fledging young (63%) than newly excavated burrows (19%). T-tests were conducted on several appendage measurements of male and female owls to determine sexual dimorphic traits. Metatarsus lengths of males and females were different ($t=2.36$, $p=0.02$). As of 1990, 197 owls had been banded in the study area. In 1989, 75% and in 1990, 83% of the banded adults were found on the same territory. Only 4 of 129 banded nestlings have been reencountered in the study sites.

THESIS COMMITTEE APPROVAL PAGE

To Professors: Dr. William Robertson, Dr. Joel Trexler and Dr. Martin Tracey

This thesis, having been approved in respect to form and mechanical execution, is referred to you for judgement upon its substancial merit.

Acting Dean Arthur W. Herriott
College of Arts and Sciences

This thesis of Brian Keith Mealey is approved.

William Robertson

Joel Trexler

Martin Tracey, Major Professor

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Dean Richard Campbell
Division of Graduate Studies

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REPRODUCTIVE ECOLOGY OF THE BURROWING OWL, ATHENE CUNICULARIA FLORIDANA, IN DADE AND BROWARD COUNTIES, FLORIDA

Burrowing owls, Athene cunicularia, are small crepuscular owls found throughout North America, the West Indies (Cory 1891, Howell 1932), portions of Central America (Land 1970) and the western coast of South America (Jaksic 1981). In North America there are two subspecies. The western burrowing owl, A. c. hypugaea, resides in the dry grasslands, prairies and farmlands (Coulombe 1971) of western North America. The Florida burrowing owl, A. c. floridana, primarily lives in naturally occuring high sandy ground of central, eastern and western Florida (Rhoads 1892, Bent 1932), pastures (Ligon 1963), airports (Owre 1978) as well as vacant and residential lots (Weseman 1986).

Athene spp. are represented on the continents of North America, Central America, South America and Europe and on several countries in the Caribbean such as Cuba, Bahamas, Dominican Republic and Haiti. Some of the representative species and subspecies are: A. c. dominicensis is found in the Dominican Republic and Haiti; Guadeloupe and Antigua are represented respectively by A. c. guadaloupensis and A. c. amaura; the Bahamas has two subspecies A. c. bahamensis and floridana (Cory 1891); Chile has one subspecies A. c. cunicularia (Jaksic and Marti 1981); and Europe has, A. noctua (Rufino, Araujo, Abreu, and Hernandez 1985).

A. cunicularia resides in underground burrows they dig or that have been previously dug by burrowing mammals (Coulombe 1971, Courser 1976, Neill 1954, Thomsen 1971). During the nesting season, the owls become active during the day but are crepuscular and nocturnal the rest of the year (Martin 1973). Their diurnal activity during nesting make them easy to observe and a good candidate for a study of reproductive ecology.

The western burrowing owl population is declining due to habitat destruction and alteration and extirpation of burrowing mammals. A. c. hypugaea rarely dig their own burrows (Thomsen 1971, Butts 1973, Green 1983). Due to the hard substrate (Martell pers. communication) they occupy the abandoned burrows of colonial rodents and other mammals (Butts 1973, Coulombe 1971, Green 1983). Burrowing mammals are being eradicated due to the dangers their burrows represent to cattle and also because they feed on cultivated crops (Green 1988) and this results in burrow loss for this owl.

Burrowing owls in Florida are presently expanding from their former range (Neill 1954). The burrowing owl was first recorded in Florida by N.B. Moore in 1874 (Courser 1979). Historically, this owl reproduced primarily in the central portion of the peninsula (Sprunt 1954). With the augmentation of development, dairy production and agriculture large expanses of native wooded areas have been cleared (Tebeau 1971). Land clearing and supplemental fill have provided more habitat for the burrowing owl in Florida (Betz 1932, Courser 1979, Ligon 1963, Garrido and Montana 1975).

Habitat selection among western burrowing owls was based primarily on response to differences in horizontal visibility (Green 1983). Nest site availability was thought to be a prime limiting factor for many raptors such as the American Kestrel, Falco sparverius, (Bird and Bowman 1987) and the Elf owl, Micrathene whitneyi, (Millsap 1988). Even though nesting holes were available in several habitats of the Columbia Basin, Oregon, habitat with low vegetation and high visibility was selected by the owls. This habitat selection coincides with other studies of the burrowing owl (Coulombe 1971, Martin 1973).

With the onset of human development a variety of new altered habitats are appearing. Airports, golf courses, sport fields, pastures and residential yards are but a few of the environmental alterations. The introduction of exotic vegetation such as the melaleuca tree, Melaleuca quinquenervia, and the brazilian pepper, Schinus terebinthifolius, have created monocultural habitats, that are unable to sustain natural species diversity (Wilson and Porras 1983). These aggressive and opportunistic species are primarily dominant in disturbed wetlands, hammocks and pine stands outside or adjacent to residential developments. Private residences are being landscaped with exotic fruit trees, rare palms and vegetation, representing continents and regions from most corners of the world (Bush 1972, Maxwell 1984). The continuing urbanization of southern Florida is permanently alterating existing natural ecosystems.

The urbanization of raptorial species has been made evident with the subsequent release and successful nesting of the peregrine falcon in large metropolitan cities of North America (Kiff 1988). The ability of these falcons to adapt to artificial nest sites is promising for the species. Another successful urban raptor has been the Mississippi kite in New Mexico. Their success has been attributed to low nest predation (Gennaro 1986). Another factor influencing success is the consistent availability of prey. The peregrine is known to feed on city pigeons, the European lesser kestrel uses city lights to catch insects (Goodwin 1978) and the barn owl feeds on rodents and small birds that commonly reside in urban settlements (Long 1981).

In southern Florida, Dade and Broward Counties, burrowing owls have established nesting territories in airports, pastures, sports fields, golf courses, university and college campuses, parking lots, roadway medians and in the yards of private residences. Remaining pastures in Broward County are under extreme demand from developers and county tax officials. In order to survive, the dairy industry has had to increase the number of cattle per acre to augment productivity. The higher number of cattle increases confrontations with the owls resulting in a higher number of destroyed burrows.

The burrowing owl's ability to successfully adapt to altered habitats is tentative. The percentage of development within a given site may determine the future success of these small raptors. In a project being conducted by the Nongame Division of the Florida Game and Fresh Water Fish Commission and the Southwest Audubon Society, they are correlating the percentage of development, housing projects, within their study sites and the burrowing owl's ability to successfully fledge young. In the first three years of their study, 1987-1989, they observed a decline in fledgling production when the development exceeded 75% of an area. Even though these owls have the ability to tolerate human intrusion, the decline of suitable nesting habitat may be their limiting factor (Millsap 1988, Weseman 1986).

Burrowing owls are very opportunistic (Schlatter et al 1980) in their feeding behavior. Studies have involved analysis of pellets (Errington 1930, Marti 1973) and remains of food at the edge of burrows. Their diet was believed to consist primarily of arthropods in the western states (Earhart and

Johnson 1970, Glover 1953, Robertson 1928) and Chile (Schlatter et al 1980), but may actually vary seasonally. In a research project conducted in the Columbia Basin, Oregon (Green 1983) the prey varied from primarily vertebrates in the early spring to insects during the summer. In Florida the burrowing owl displays opportunistic feeding patterns. Owls in Cape Coral, Florida fed on insects and Anolis sagrei, an introduced lizard (Weseman 1986, Wilson and Porras 1983). In two reports (Hennemann 1980, Lewis 1973), the burrows of A. c. floridana from Duval County and central Florida held remains of birds, amphibians and arthropods.

Natal site fidelity of Florida's burrowing owl is poorly understood. In 1932 a banded female western burrowing owl was caught in the same field two seasons later (Stoner 1932). Banded burrowing owls at the Oakland Municipal Airport, California displayed mate and site fidelity. During a two year period seventeen of twenty one banded adults reappeared on the study site. Previous banded pairs that survived the year remained paired bonded during the following nesting season (Thomsen 1971). Present studies being conducted in Cape Coral and southeast Florida will enable researchers to determine natal site and pair fidelity in the Florida burrowing owl.

The purpose of this project is to document the reproduction and general ecology of the burrowing owl in three different study sites in Dade and Broward Counties. This project was conducted between December of 1987 and September of 1990.

METHODS

STUDY SITES

Three sites were chosen for this project: the Miami International Airport (Dade County), a dairy farm (Imagination Farms) and private residences (southwestern Broward County). Approval from all owners was given prior to working on their property. The Miami International Airport (MIA) is operated by the Dade County Aviation Department. Permission was granted by the management in the Division of Airside Operations. Since the airport's security and safety was of priority, they graciously provided an escort and vehicle for the entire study period.

The Miami International Airport is located in western Dade County. It is bordered to the west by Milam Dairy Road (Northwest 72 Avenue), to the east by Le Jeune Road, to the north by N.W. 36 th street and to the south by Interstate 836. The entire compound is enclosed with a chain link fence. There are three runways, 27R-9L and 27L-9R (which run east-west) and 30-12 (which runs southeast-northwest; Appendix 1A). The airport covers 3,232 acres and 70% is developed and paved. There is continuing pressure for runway and terminal expansion to accomodate the increased flow of air traffic. The burrowing owls' territories are in the sandy medians between the runways, taxiways and the inner perimeter road. Most of the territories are located adjacent to the inner perimeter road.

The second study site is Imagination Farms, Inc., located in the southwest corner of Broward County, in the City of Davie. It is bordered to the west by S. W. 154 Avenue, to the east by Flamingo Road, to the north by private residences and to the south by Griffin Road. Imagination Farms, Inc. is a dairy farm covering 600 acres. Land tax increases are making it extremely difficult for the owner to continue operations in Broward County. The land is for sale and is zoned residential.

The third study site is located in several residential developments in southwestern Broward County. One portion is located in the Town of Davie, bordered to the north by S.W. 19 street, to the south by S.W. 26 street, to the east by S.W. 139 Avenue and to the west by S.W. 145 Avenue. The second portion is located in Rolling Oaks, bordered to the north by Griffin Road, to the south by S.W. 57 Court, to the east by S.W. 176 Avenue and to the west by S.W. 180 Avenue. The third portion is in Sunshine Ranches Estates, bordered to the south by Sheridan Road, to the east by Holotee Road, to the west by Hancock Road and to the north by Griffin Road. The fourth portion is located in the Rock Creek Residences in Cooper City, bordered to the north by Stirling Road, to the west by Flamingo Road, to the south by Sheridan Road and to the east by Hiatus Road. The last portion is located in Ivanhoe Estates, which is bordered by Griffin Road to the north, by Volunteer Road to the east, Stirling Road to the south and Interstate-75 to the west.

LOCATING SUBJECTS

Burrowing owls were located by driving a vehicle up and down roads, through pastures and along the airport's roadways. The Audubon Society's Christmas bird counts have always revealed low numbers of burrowing owls. At first these low numbers were of concern to the feasibility of conducting this study. After several surveys of the airport, residences and pastures from January through July, I realized that the diurnal appearance of these owls is seasonal. Burrowing owl population surveys should be conducted between the months of March and July. The birds were located through their up and down bobbing motion (Thomsen 1971) or by locating the highly exposed sandy mounds at the entrance of their burrows. Active burrows had evidence of excavated dirt and a clear unobstructed entrance. Inactive burrows were usually obstructed with grass, weeds and most had spider webs. Once the territories were identified the owls became highly visible.

The easiest area to locate the owls was the airport, due to the well maintained low vegetation. The residential areas were slightly more difficult due to the amount and variety of landscape vegetation. Instead of perching on the mounds these birds had better visibility while perched in the trees. Pastures were the most difficult area in which to approach and locate owls. The rough terrain, high grassy vegetation and flooding tendencies were always obstacles while driving a vehicle. The cow patties, which became pasted on the tires and underside of the vehicle provided a pungent aroma. Walking was a frequent mode of travel when locating new territories or visiting established territories in the pastures.

TERRITORIES

All territories were checked once a week between March and June. Once the presence of a burrow or burrows was established several questions were answered: Was the burrow site active? Was the site decorated? Was dung being used? Is this a used or new burrow? Are there satellites burrows in the territory?

OWL IDENTIFICATION

The burrowing owls were individually identified with a numbered aluminum band provided by the United States Fish and Wildlife Service's Bird Banding Laboratory and a plastic numbered color band purchased from the Gey Band and Tag Company. The band size used for burrowing owls was No. 4. The banding was possible due to the collaboration and instruction of Brian

Millsap from the Nongame Division of the Florida Game and Fresh Water Fish Commission.

The owls were caught using a variety of methods. The most common technique was through the use of a noose carpet attached to a 180 gram weight that was placed at the entrance and perimeter of the burrow (Kahn and Millsap 1978, Bloom 1987). The Bal-chatri trap was used on several occasions (Berger and Mueller 1959, Beebe and Webster 1976) with infrequent success. The last method was simply approaching the burrow from the blind side and quickly inserting an arm down the burrow. This method proved quite successful in catching young at the airport and residences. Since there was a possibility of venomous snakes in the pastures, I felt it prudent to rely on the noose carpet and Bal-chatri traps in pastures.

The noose carpet was most effective when the owls would dig or continuously move around at the entrance of the burrows. The legs would become snagged on the 2.5 cm nooses. While attempting to escape, the noose carpet and the 180 grams weight would provide enough drag to prevent the owl from effectively flying. The trap is designed to minimize any risk of injury to the owls. Once captured the owls were immediately wrapped in a cloth to act as a hood. This handling technique proved effective in preventing tongue snapping injuries, a stress induced response. If a cloth was not readily available, the mandibles were held closed with fingers. While wrapped in the cloth the owls were promptly banded in the event of an early escape. The aluminum band was attached to the bird's right distal metatarsus. A color band (s) was attached to the left distal metatarsus. This sequence enabled me to have two opportunities in reading band numbers for the owl's identification.

Measurements were taken to evaluate the possibility of sexual dimorphism (Martin 1973, Courser 1976). The measuring techniques are described in the North American Bird Banding Techniques, Volume II that was prepared by the Canadian Wildlife Service and the U.S. Fish and Wildlife Service in July of 1977. All measurements were recorded in the metric system. The lengths of two appendages, body length and the weight were recorded for each owl. The two appendages measured were: metatarsus length and wing chord. The measurements were recorded by using a pointed slide-caliper and straight edge metal ruler. Weights were recorded using an Ohaus-Triple Beam Scale.

Weekly owl censuses were conducted at each territory in all of the study sites. The census involved recording: total number of owls observed, the number of adults present, total number of young, total number of fledged young and the number of banded owls.

DATA ANALYSIS

Seasonality was determined by the number of owls observed during the weekly visits to the study sites. No attempts were made to distinguish the young and adult owls for the seasonality data. The highest weekly count of owls in a given month was used to plot the graph. The seasonality data were plotted with pooled and individualized monthly data for each of the study sites. Productivity was determined by observation of young outside the burrow and the number that successfully fledged from a territory. A territory is considered successful if it fledges one or more young (Steenhof 1987). Mean values in results are followed by $\pm$ two standard errors. In 1988, field inexperience may account for a measurement error in the number of territories observed in the study sites. Several pairs had satellite burrows (Thomsen 1971, Weseman 1986) at distances of over 30 meters that may have been mistaken for territories. The territories observed in 1989 and 1990 were closely scrutinized to minimize this error. Productivity bias could not be accounted for by using the Mayfield Model (Mayfield 1975) because observations could not be made of the number of eggs laid and the hatching rate.

Data were analyzed by using statistical methods described in Sokal and Rohlf (1981) and with ABSTAT (1984), KREBS (1989), and ECOLOGICAL ANALYSIS (1986) statistical software packages. Unless identified all variances between the computer software were not significantly different.

RESULTS

SEASONALITY

Three years of data show a late spring peak in burrowing owl numbers in all of the study sites (Graphs 1-4). The seasonal increase in numbers has also been observed in New Mexico (Martin 1973). Owls appear in January and sightings rapidly increase until about the month of June. Numbers peak between late May and early June. During the following months, the sightings begin to decrease as adults shift to a more crepuscular and nocturnal behavior, while most of the young begin to disperse to new areas. The onset of summer and the rainy season probably play major roles in the shift in behavior and in fledgling dispersal due to limited diurnal prey availability and flooding of burrows.

PRODUCTIVITY

Pooled reproductive data for each of the years (1988-90) reveals a higher success rate (54%) for the 1990 reproductive season than 1988 (41%) and 1989 (40%) season (Table 1). This success rate is also reflected in a higher value for the mean number of young produced in 1990, $\overline{X} = 1.59 \pm 0.36$ versus 1988, $\overline{X} = 1.03 \pm 0.34$ and 1989, $\overline{X} = 0.99 \pm 0.32$. The fledging rate in 1990, $\overline{X} = 1.41 \pm 0.34$ versus $\overline{X} = 0.97 \pm 0.32$ in 1988 and $\overline{X} = 0.99 \pm 0.32$. The mean brood size $\overline{X} = 2.8 \pm 0.32$ and the fledging rate $\overline{X} = 2.73 \pm 0.34$ for the successful territories is also higher.

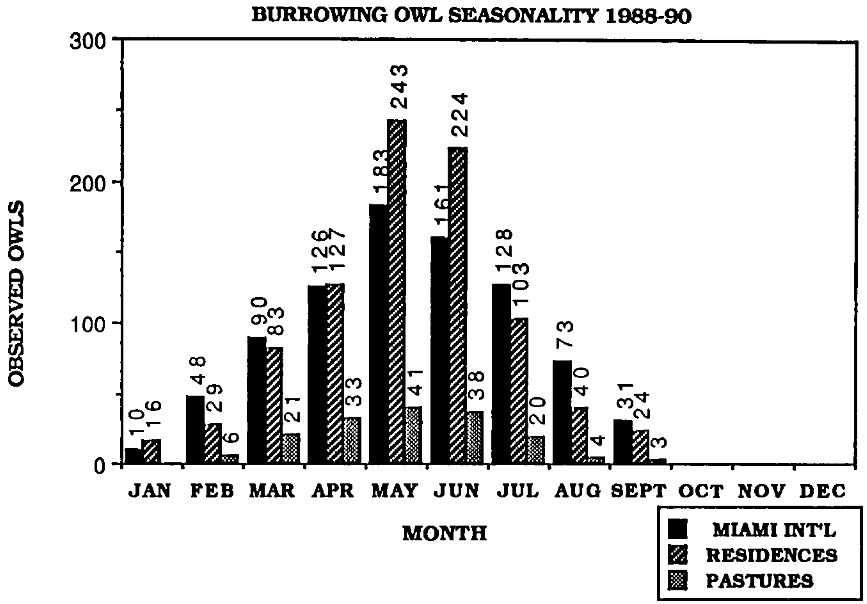

Figure 1. Burrowing owl sightings increase as they shift from a predominantly crepuscular and nocturnal mode to around the clock activities during reproduction. Observed owls include adults and young on the territories.

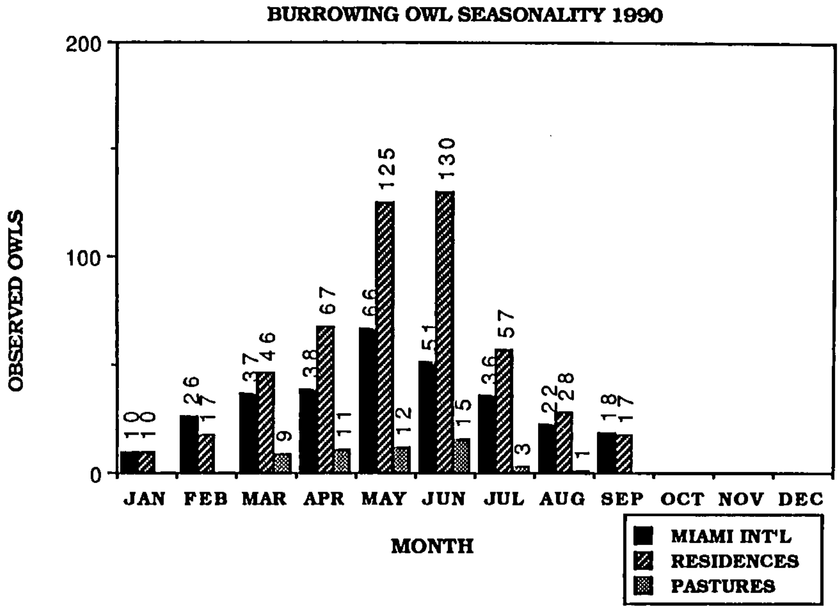

Figure 2. Burrowing owl seasonality graph of the three study sites for 1990. Observed owls include young and adults on the territories.

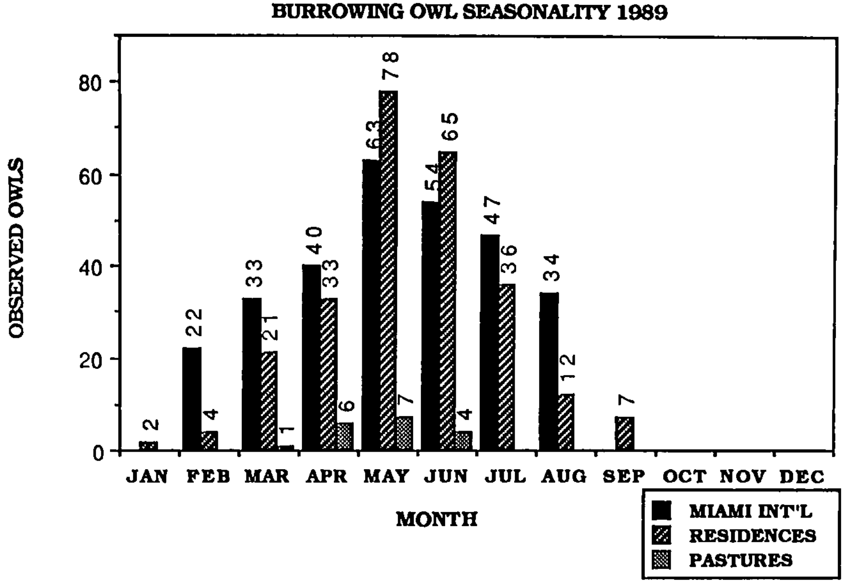

Figure 3. Seasonality graph of the three study sites for 1989.

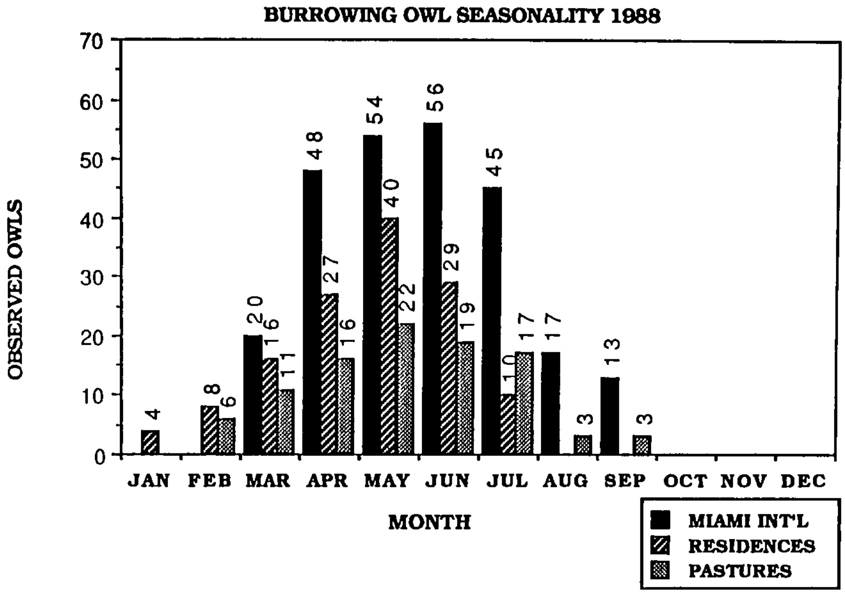

Figure 4. Seasonality graph of the three study sites for 1988. Observed owls reflects adults and young on the territories.

Year	# of territories	# of success territories	% of success territories	$\bar{X}$ young all territories	$\bar{X}$ brood size successful territories	$\bar{X}$ fledged all territories	$\bar{X}$ fledged successfull territories
1990	79	43	54%	1.59 ± .36	2.80 ± .32	1.41 ± .34	2.73 ± .34
1989	75	30	40%	.99 ± .32	2.46 ± .38	.99 ± .32	2.46 ± .38
1988	66	27	41%	1.03 ± .34	2.56 + .44	.97 ± .32	2.37 ± .40

TABLE 1. Reproductive analysis for all territories from 1988 through 1990 with a ± 2 standard error. Columns 4 and 6 are mean values for all territories (successful and failed). Columns 5 and 7 are mean values for only the successful territories.

STUDY SITE	#of Territory	# of Success Territories	% of Success Territories	$\bar{X}$ young all territories	$\bar{X}$ brood size successfull territories	$\bar{X}$ fledged all territories	$\bar{X}$ fledged successfull territories
1990							
Miami Int'l Airport	24	14	58%	1.45 ± .58	2.50 ± .5	1.41 ± .56	2.42 ± .5
Residential	48	28	58%	1.87 ± .5	2.90 ± .44	1.54 ± .48	2.84 ± .46
Pastures	7	1	14%	.57 ± 1.14	4 ± 0	.57 ± 1.14	4 ± 0
1989							
Miami Int'l Airport	27	12	44%	.96 ± .48	2.16 ± .54	.96 ± .48	2.16 ± .54
Residential	42	16	38%	1.09 ± .46	2.75 ± .56	1.09 ± .46	2.75 ± .56
Pastures	6	2	33%	.66 ± .84	2.00 ± 0	.66 ± .84	2.00 ± 0
1988							
Miami Int'l Airport	32	15	47%	1.15 ± .5	2.46 ± .52	1.09 ± .48	2.33 ± .54
Residential	20	8	40%	1.20 ± .72	3.00 ± .74	1.10 ± .66	2.75 ± .72
Pastures	14	4	29%	.50 ± .5	1.75 ± .94	.50 ± .5	1.75 ± .94

TABLE 2. Burrowing Owl reproductive data (± 2 standard errors) from the three study sites from 1988-1990. Columns 4 and 6, respectively, include the mean value for young produced and fledged for all territories . Columns 5 and 7 are the means values for only the successfull territories.

Study Site	# of Territory	# of Success territories	% of Success successfull territories	$\overline{X}$ young all territories	$\overline{X}$ Brood size successfull territories	$\overline{X}$ Fledge all territories	$\overline{X}$ fledged successfull territory
1990							
Rock Creek	9	3	33%	.55 ± .58	1.66 ± .66	.55 ± .58	1.66 ± .66
Rolling Oaks	7	5	85%	2.28 ± .1.04	2.66 ± .84	1.57 ± .84	2.20 ± .40
Davie	11	6	54%	1.72 ± 1.08	3.16 ± .80	1.45 ± .88	2.66 ± .80
Sunshine Ranches	16	9	56%	2.06 ± .92	3.00 ± .84	1.62 ± .96	3.25 ± .98
Ivanhoe	5	4	80%	2.80 ± 1.72	3.50 ± 1.28	2.40 ± 1.62	3.00 ± 1.40
1989							
Rock Creek	7	0	0%	0	0	0	0
Rolling Oaks	7	3	43%	.86 ± .80	2.00 ± 0	.86 ± .80	2.00 ± 0
Davie	9	5	55%	1.44 ± 1	2.60 ± .80	1.44 ± 1	2.60 ± .80
Sunshine Ranches	15	7	47%	1.33 ± .88	2.86 ± 1	1.33 ± .88	2.86 ± 1
Ivanhoe	4	1	25%	1.25 ± 2.5	5.00 ± 0	1.25 ± 2.5	5.00 ± 0
1988							
Rock Creek	6	0	0%	0	0	0	0
Rolling Oaks	6	1	16%	.33 ± .66	2.00 ± 0	.33 ± .66	2.00 ± 0
Davie	6	5	83%	3.00 ± 1.2	3.60 ± .48	2.66 ± 1.2	3.20 ± .74

TABLE 3. Reproductive data (± 2 standard errors) from specific residential study sites in southwest Broward County.

The pastures was the only study site that showed a decline in the percent of successful territories in 1990 (14%, Table 2). This decrease is probably due to the increased number of cattle per acre and also the infrequent mowing schedule that caused the vegetation to close the opening of the burrow. The Miami International Airport and the residences both showed an increase in the number of successful territories (58%) and in the mean value of the brood size, MIA $\overline{X}$ =2.50 $\pm$ 0.5; Res.$\overline{X}$ =2.90 $\pm$ 0.44 in 1990. The mean value of young fledging was higher at MIA $\overline{X}$=2.42 $\pm$ 0.5 in 1990 and at the Residences $\overline{X}$ =2.84 $\pm$ 0.46.

The residential sites are an array of estates located in southwest Broward County. From three study sites in 1988, I added two additional study sites (Sunshine ranches and Ivanhoe estates) in 1989-90. From 1988-90 all study sites had an increase in the number of territories (Table 3). This does not necessarily reflect a population increase. Except for Davie, all study sites also had an increase in the percent of territory success.

NEST DECORATION

Burrows were often decorated with a variety of materials found within or outside the boundaries of the territory. This included animal fecal material, aluminum foil, paper, string, other trash, and animal parts. Decorated burrows were a sign of occupied teritories. The data were analyzed to determine if there is a relationship between decorated burrows and

	DECORATION	
	PRESENT	ABSENT
SUCCESSFUL TERRITORIES	84 (42)	0 (42)
FAILED TERRITORIES	80 (48)	16 (48)

TABLE 4. Burrow decoration and its relationship to the owls reproductive success. Territories fledging at least one young are defined as successful territories. Numbers outside parenthesis are observed results. Numbers in parenthesis are expected results.

DUNG USE VS REPRODUCTIVE SUCCESS

	PRESENT	ABSENT
FLEDGLINGS	46 (43.5)	41 (43.5)
NO FLEDGLINGS	69 (53)	37 (53)

TABLE 5: One of the materials consistently used in a burrow's decoration is mammalian dung. This table illustrates the presence of dung and its relationship to the owls reproductive success. Numbers outside parenthesis are observed results and numbers inside parenthesis are expected results.

EXISTING BURROWS VS NEW BURROWS

	SUCCESSFUL	NOT SUCCESSFUL
EXISTING	53 (64%)	31 (37%)
NEW	9 (19%)	38 (81%)

TABLE 6: Data illustrates a relationship between nesting in an existing or previously used burrow and the owl's reproductive success; failure rates are much higher in new burrows.

reproductive success of the owls, the parenthesis enclose expected figures. There was a suggestion of a relationship between decorated burrows and fledging young (84) or failure rates (0) (table 4). The use of dung has been shown to have little value in increasing a pairs potential to fledge young in these study sites of southeast Florida (Table 5).

BURROWS

During the three years of this study 60% of the burrows were reused from previous years. A relationship existed between reused burrows and a pair's ability to successfully fledge young: sixty three percent of reused burrows fledged young while only nineteen percent of new burrows were successful (Table 6).

NEST FAILURES

Identifying the primary causes for nest failure is difficult. From 123 known failures only 33 (27%) had attributable causes. The primary reason for known nesting failures was flooding (N=21, 63%). Other causes were collapse due to cow trampling (N=6, 18%), human activities (N=4, 12%) and predation (N=2, 6%).

MORTALITY

Mortality data are for banded and unbanded specimens found in the study sites. Of eighteen records, 9 (50%) were killed by cars, 4 (22%) by drowning, 2 (11%) due to borrow collapse, 2 (11%) by predation and 1 (5%) was electrocuted.

BANDING RESULT

At the end of the 1990 season 197 burrowing owls had been banded in the study area: 36 adult males, 32 adult females and 129 fledglings or hatch year (HY) (Table 7).

By 1990, 32 previously banded burowing owls were trapped or observed in the study areas, 8 in 1989 and 24 in 1990. Twenty of the owls were adults banded in previous years. Two of the juveniles banded in 1988 were observed in 1989 and again in 1990 making them third-year birds. Two juvenile owls banded in 1989 were retrapped in 1990. Three out of four of these birds successfully fledged young (2 males and one female) and remained in the study site. The fourth owl, a male, successfully set up a territory approximately 3 miles from its birth site but its mate was found dead outside the burrow prior to incubation.

Forty six percent of the banded males (n=12) and 50% of the banded females (n=11) were re-encountered in 1990. In 1989, 75% of the banded adults remained on the same territory and in 1990 this increased to 83% reoccupancy of territories. Preliminary results after 3 years of banding revealed that the average number of years that a banded owl was known to have occupied a territory in 1989 was 1.75 years $\pm$ 0.32 (n=8) in 1990 was 2.21 years $\pm$ 0.24 (n=23).

BANDING RESULTS

BURROWING OWLS BANDED:	**(1988-90)**	**197**
	(1988-89)	128
	(1988)	49
	(1989)	79
	(1990)	69
BANDED ADULTS:	**(1988-90)**	**68 (35%)**
MALES:	(1988-90)	36 (18%)
FEMALES:	(1988-90)	32 (16%)
BANDED HATCH YEAR (HY):	(1988-90)	129 (65%)
RECOVERIES:	**(1989-90)**	**32 (24%)**
	(1989)	8 (16%)
	(1990)	24 (18%)
ADULTS FROM TOTAL:	(1988-89)	20 (16%)
ADULTS FROM ADULTS:	(1988-89)	20 (37%)
HY FROM TOTAL:	(1988-89)	4 (3%)
HY FROM HY:	(1988-89)	2 (3%)
MALES FROM TOTAL:	(1988-89)	12 (9%)
MALES FROM ADULTS:	(1988-89)	12 (25%)
MALES FROM MALES:	(1988-89)	12 (46%)
FEMALES FROM TOTAL:	(1988-89)	11 (9%)
FEMALES FROM ADULTS:	(1988-89)	11 (22%)
FEMALES FROM FEMALES:	(1988-89)	11 (50%)
TERRITORY FIDELITY:	**(1988-89)**	**75%**
(BANDED ADULTS)	(1989-90)	91%
	(1988-90)	83%

TABLE 7. Banding results of the burrowing owl reencounters during the study period.

SEXUAL DIMORPHISM

Appendage measurements were incorporated into this study to possibly identify body areas which might enable determination of the sex of a particular burrowing owl. The metatarsus, wing chord, body length and weight were recorded on each of the trapped owls. Independent t-tests were conducted on the measurements using ABSTAT. The values of the t-test for the wing chord, body length and weights were not significantly different between the sexes. The metatarsus lengths of males and females were different ($t=2.36$, d.f.=62, $p=0.02$). The males metatarsi had an average value of 45.70mm $\pm$1.46 (s.d.), n=32 and the females average 44.89 $\pm$1.28 (s.d.), n=32.

GROWTH MEASUREMENTS OF NESTLINGS

A total of 6 chicks were raised either artificially (n=4) or by captive parents (n=2). The four artificially raised chicks were brought in as eggs to the Wildlife Care Center, Inc. of Broward County by The Florida Game and Fresh Water Commission in the spring of 1988. A bulldozer destroyed the burrow during a development site ground clearing. The eggs were promptly transferred to The Falcon Batchelor Bird of Prey Center at the Miami Museum of Science due to the availability of an incubator. After an incubation period of 17 days, they began to hatch. This short incubation period is due to the eggs being partially incubated by the female prior to the burrow being destroyed. One pair of captive burrowing owls at the museum layed 5 eggs in an artificial burrow in January of 1990. The exact day of laying was undetermined. The incubation was estimated at approximately 25 (+ or - 2) days. One chick hatched on January 27 and a second on January 29, the remaining three eggs proved to be infertile.

Tarsus length, wing chord, body length and weights were recorded daily on the artificially raised chicks and approximately every other day on the naturally raised young. Metric measurements were taken by using calipers and a ruler and weights were measured by using a triple beam Ohaus scale. Measurements were taken for 49 days or until the young fledged.

Measurements were variable among the owls and therefore the mean value of the measurements will be used only for estimating ages (Table 8). All of the owls dropped in weight during their fledgling period (Graph 5). This was probably due to the increase of running and wing flapping exercise. Their mean weight value at fledging was 119.25 grams $\pm$ 3.80. Other mean values increased as they approached fledging on the 49 day. The mean values on the 49 day for the other appendages were: wing chord mean was 168.5 mm $\pm$ 9.0 , tarsus mean was 46 mm $\pm$ 2.0 and body length mean was 203.5 mm $\pm$ 12.7.

DAY	MEAN WEIGHT	+2 S.E.	WING CHORD	+2 S.E.	BODYMEAN	+2 S.E.	TARSUS MEAN	+2 S.E.
1	8.094	0.32	9.6	0.48	54.8	2.31	9.2	0.97
2	9.25	1.78	9.63	0.47	56	2.94	10	0
3	11.506	2.07	10.1	1.11	61	1.54	10.7	1.16
5	17.808	4.29	10.8	0.4	67	1.78	12.5	1.48
6	24.41	7.75	13.48	2.39	73.56	5.16	14.72	1.72
7	26.33667	12.044	13.83	1.20	75.3333	5.69	14.83	2.72
9	48.475	12.79	22.82	3.71	89.875	4.76	19.48	3.04
12	77.2675	17.66	33.9	6.23	99.375	4.68	25.75	3.03
13	83.8575	17.085	35.625	5.37	105.13	5.63	27.18	3.20
19	117.97	16.97	70.63	8.97	129	5.47	36.4	1.89
22	118.2067	22.38	83.5	12.28	142.6667	14.43	37.33	0.33
26	126.1	7.051	109.67	11.39	162.167	18.22	42.17	1.20
27	136.1867	21.63	111.33	9.68	160.83	10.65	41.83	1.20
34	127.5125	14.50	144	2.79	178.5	9.98	43.88	0.85
37	125.6025	9.54	153.25	2.06	188	5.71	44.13	0.85
41	117.9667	3.11	159.67	2.66	193.6667	12.71	45.33	1.76
49	119.25	3.809	168.5	9.0	203.5	12.7	46	2.0

TABLE 8. The mean values of the growth measurements of nestling burrowing owls ± 2 standard errors.

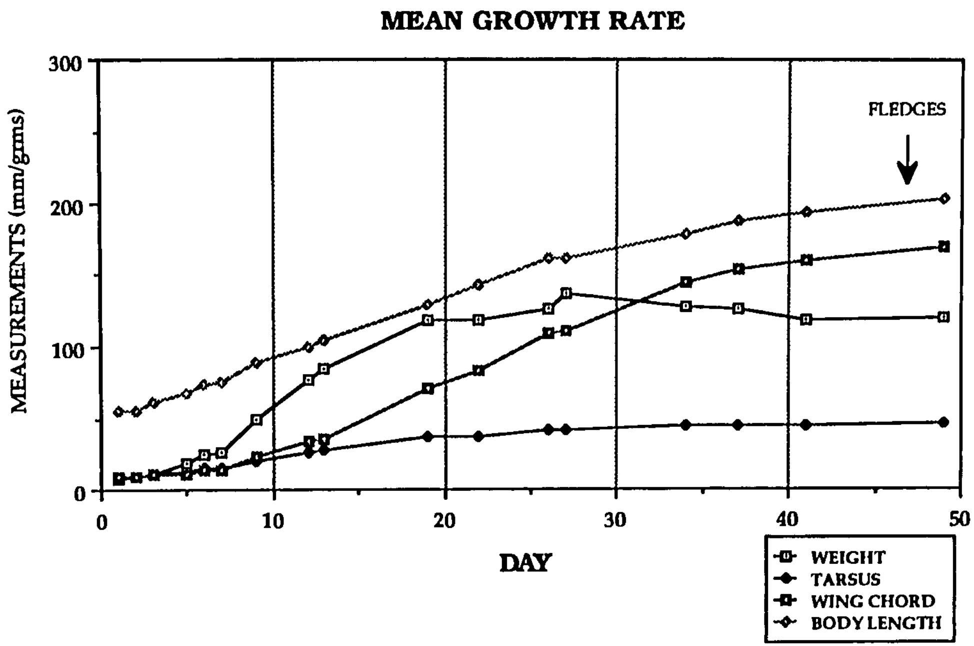

Figure 5. Mean growth measurements of seven captive raised burrowing owls at the Falcon Batchelor Bird of Prey Center at the Miami Museum of Science.

DISCUSSION

The Florida burrowing owl is currently listed as a species of special concern by the Florida Game and Fresh Water Fish Commission (FGFWFC). These owls are most commonly seen during the breeding season (Millsap 1988). The owls appear in January and sightings rapidly increase until about the month of June. The increase in numbers has also been observed in New Mexico (Martin 1973), where numbers peak in late May and early June. During the following months, sightings begin to decrease as adults shift to a more crepuscular and nocturnal behavior (Thomsen 1971), and most of the young begin to disperse to new areas (Martin 1973). This diurnal behavior change during the breeding season can assist biologists in monitoring the burrowing owl population

The status of this species is somewhat controversial. In areas categorized as heavy development by Millsap (1988, i.e. approximately 75% of a zoned area) the populations began to decline. In 1988, 60% of nesting failures in Cape Coral were a direct result of human activities (Millsap 1988). Courser (1976) documented a population decline due to development in a similar area near Tampa, Florida. Comparing overall fledgling rate per breeding pair in studies of the western burrowing owl, the Florida burrowing owl has a lower productivity. Thomsen (1971) and Martin (1973) report fledgling rates between 2.2- 5.5 per breeding pair of western burrowing owl and Millsap (1988) and Mealey (this thesis) report fledgling rates of 1.59 - 2.75 for the Florida burrowing owl. In Dade and Broward Counties the population appears to be expanding to areas of new development. In areas that are zoned for residences with one acre or more, preliminary results indicate a stable population. This could be due to limited number of people and fenced in yards that provide protection and a food source. The residential areas of this study with one or more acres include Ivanhoe Estates, Sunshine Ranches, Davie, and Rolling Oaks. The limiting factors are flooding, human intolerance and the use of home pesticides. Preliminary banding results (Millsap 1988) show territory fidelity. Currently nesting behavior is used to identify the sexes. Incubation is believed to be primarily conducted by the females (Muller 1990). Males provide food and select the territory. It is assumed that if a pair dissappears from its territory that at least the male is dead (Millsap per comm.). Land alteration and development has been the boom of the burrowing owl population and eventually may be the bust of the species.

Unlike the western subspecies, which needs the protection of the natural habitat and the burrowing mammal population (Green 1983), the survival of the Florida subspecies may depend no the proper education of residents in documented key residential breeding grounds and limiting the percentage of alteration in future development sites (Millsap 1987). The burrowing owl population breeding success at the Miami International Airport coincide with success rates in Oregon of 57% (1980) and 50% (1981), (Green 1983) and at the Oakland Municipal Airport in California of 54% (1971) (Thomsen 1971). The continuing existence of the burrowing owl population at the Miami International Airport will be closely tied to the amount of development that will take place to accomodate future air travel. The continuing existence of the burrowing owl will depend on strict and enforceable management regulations that could be imposed by the state, counties or cities. Cooper City in Broward County, as of January 1990, is requiring that all developers have an environmental survey conducted on the land site prior to any development. The FGFWFC requires developers to rope or fence off with a 30 feet radius any active nests. The state and federal governments will cite and fine individuals or businesses that deliberately harass the owls or destroy the burrows.

Burrowing owls can only temporarily halt a project. The FGFWFC and the U.S. Fish and Wildlife Service issue permits to take or destroy inactive burrows outside of the nesting season. On occasion a permit may be issued during the nesting season to destroy a nest after the young have fledged. Care must be taken on premature permit issuing during the nesting season because even though young may be defined as fledged they are still dependent on the primary and satellite burrows for a period of 30 to 60 days after they are flying. Temporary restrictions to halt development may be futile for any wildlife population.

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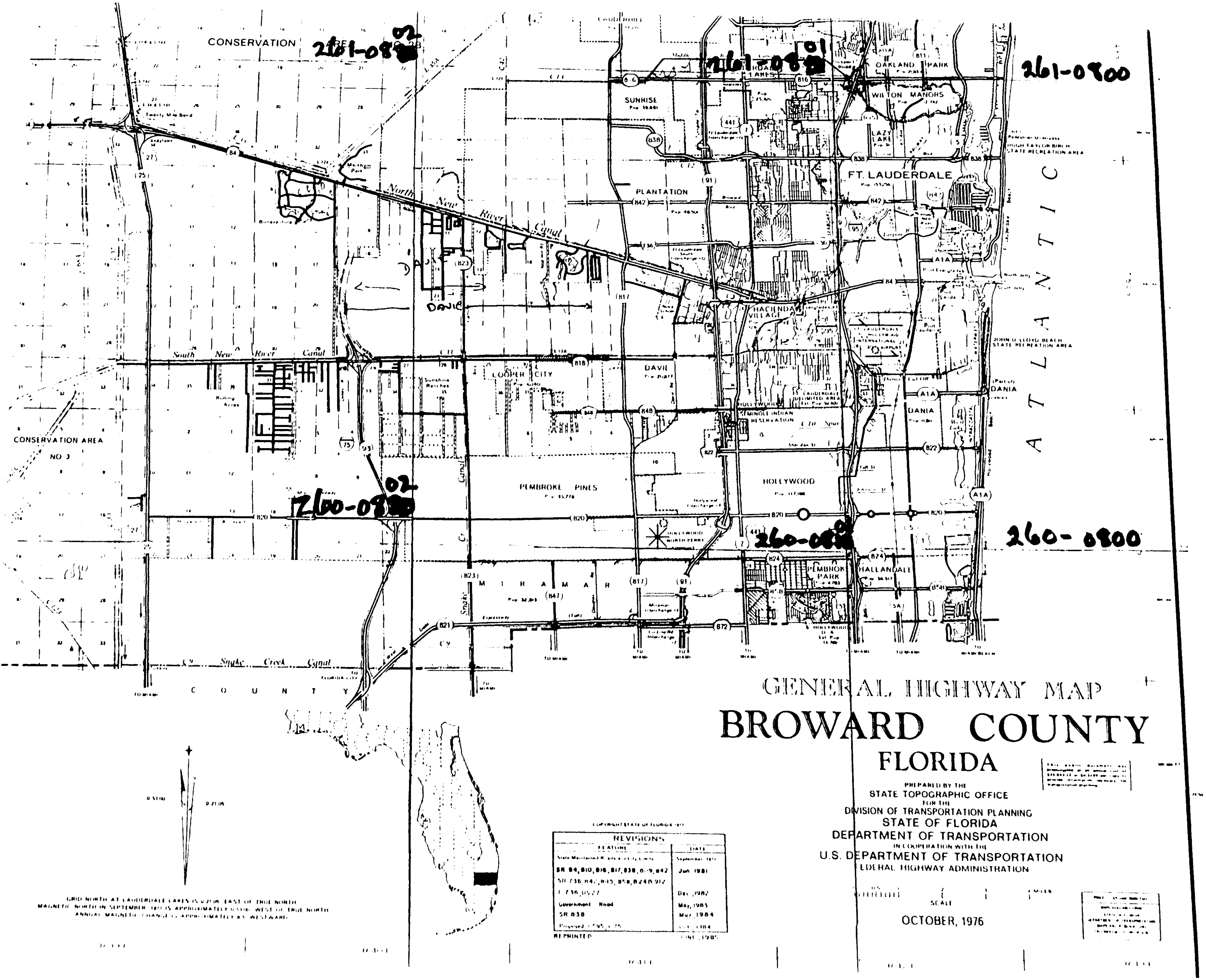

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