AN EVALUATION OF THE HELICOPTER FOR CENSUSING WATERFOWL IN LOUISIANA'S COASTAL MARSHES AND RICELANDS

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ABSTRACT

During the fall of 1969 a helicopter was evaluated for censusing waterfowl in Louisiana by comparing it with a Cessna 210 airplane.

The comparisons indicated that while a helicopter equipped with flotation gear was a safe and highly effective vehicle for censusing waterfowl, twice as much actual flight time was required to complete the same amount of work and operational costs were double those for the airplane.

About 1.5 times as many waterfowl were recorded from the helicopter as from the Cessna. However, statistical analysis indicated the difference between aircraft in the total number of ducks recorded was not significant. In contrast, significantly more mottled ducks (*Anas fulvigula maculosa*) were recorded with the helicopter, indicating it was more effective than the Cessna for counting this species.

A test of interaction between aircraft and months was not significant; thus, each type aircraft measured the same rate of change in total duck numbers from August-September to November. This suggests that both aircraft are equally effective in measuring large changes in waterfowl populations by the transect sampling system.

The helicopter provided advantages over the Cessna in visibility, slower air speed, and creates a noise level that induces inactive ducks to move. Its light fuel load, slow cruising speed and operational costs were major disadvantages.

Considering the results of this study, the Louisiana Wild Life and Fisheries Commission plans to continue using the Cessna 210 for waterfowl inventories. There are plans to improve it for this type of work with a Robertson STOL Conversion. This will reduce a 210's stall speed from 70 mph to about 40 mph and allow safe flying at 60 mph. Small helicopters will hopefully be used more often in situations requiring their unique flying abilities.

INTRODUCTION

The contributions of fixed-wing aircraft to the wildlife profession are widely recognized and are well documented. In recent years another type of aircraft, the helicopter, has become increasingly popular as a useful and versatile tool for many wildlife agencies. These unique aircraft have been effectively used in wildlife law enforcement (Perroux, 1969) censusing of sheep (Evans, 1968) and waterfowl (Brazda, unpublished, 1969), (Heyland, and Munroe, 1967) and sampling marsh vegetation, soils and water, (Chabreck, 1970).

The helicopter has been employed in many situations to aid wildlife managers and researchers, but its primary use has been in census and trapping efforts, (Perroux, 1969), (Howe, 1963), (Demney, 1966), (Neilson, 1967), (Russell, 1967) and (Lentfer, 1968).

Louisiana's 5 million acres of coastal marshes and ricelands annually winter from 4 to 6 million waterfowl. In addition, unmeasured numbers of transient waterfowl are temporarily sustained in this area enroute to wintering grounds south of the United States.

Monitoring the arrival, departure, distribution and relative abundance of this large wildlife population while dispersed over such a large acreage is a job of considerable complexity and importance in Louisiana. This study was undertaken to evaluate the helicopter for this work and in the process better understand the effectiveness and/or shortcomings of the methods and equipment presently used to census waterfowl in Louisiana.

METHODS

Waterfowl Inventory Procedure

Monthly estimates of fall and winter waterfowl populations in the coastal marshes and ricelands of Louisiana are computed from data gathered by a system of aerial transects. Because of the huge area to be covered, this method of sampling is the only practical means by which a reasonable estimate can be obtained. Singleton (1953), Diem and Lu (1960), Smith (1961), Martinson and Kaczynski (1967) and Glahn (1967) all suggest the transect sampling method for censusing waterfowl in large areas of unbroken waterfowl habitat, which applies ideally to Louisiana's coastal marshes and ricelands. Since 1953 Louisiana has used the transect method for obtaining estimates of waterfowl populations (Smith, 1961). Figure 1 illustrates the transect system used from 1959-1967 in the coastal marshes of Louisiana.

Louisiana's present inventory system consists of 27 north-south transect lines that cross coastal Louisiana from U.S. Highway 90 to the Gulf of Mexico (Fig. 2). Transect length ranges from 4 to 48 miles and the 27 lines combined represent about 755 linear miles. These transects lie along longitudinal lines at 7.5-minute intervals in the southwest coastal area of the state and 15-minute intervals in the southeast coastal area. The sampling rate in the southwest (3 percent) is twice that of the southeast (1.5 percent) because puddle duck populations there are generally twice as large as those found in the southeast. Figure 3 represents a completed inventory showing estimates of each species by census areas.

The sampling procedure for Louisiana's present waterfowl inventory was adapted from a design used by Chabreck, Joanen and Palmisano (1969) to type map the coastal vegetation of Louisiana. The inventory techniques used follow the recommendations of Singleton (1953), Diem and Lu (1960), Smith (1961) and Glahn (1967) for width of census strip, and altitude of the aircraft, etc. Concord Model 350 automatic, portable tape recorders were used to record and retrieve the data.

Eight species of puddle ducks (*Anatinae*) and the American coot (*Fulica americana*) (See Table 1), are widely distributed over the entire census area and warranted inclusion in this study. Geese (*Anserinae*) in Louisiana are not inventoried by this method because of their erratic distribution. Diving ducks (*Aythyinae*) account for less than 5 percent of the "in-shore" duck population in Louisiana and were not recorded for this study.

Comparison of the Two Aircraft

A helicopter (Bell, Model G47-4A) and a Cessna (Model 210) were used to fly the transect lines with one waterfowl observer and a pilot. Data recording, flying procedures, with the exception of air speed, and width of census strip (1/8 mile) were duplicated with each aircraft along each transect line. Air speed was 70 m.p.h. in the helicopter in contrast to 90 to 100 m.p.h. in the Cessna.

Normally, about 3 days is required to complete the entire inventory with the Cessna. For comparison purposes, the helicopter and the Cessna were used on alternate days to complete a fixed number of transect lines. This helped to reduce the effects of differences in weather conditions, bird activity and losses or gains in the number of birds on individual transects. However, since twice as much time was required to do an equal amount of transect coverage in the

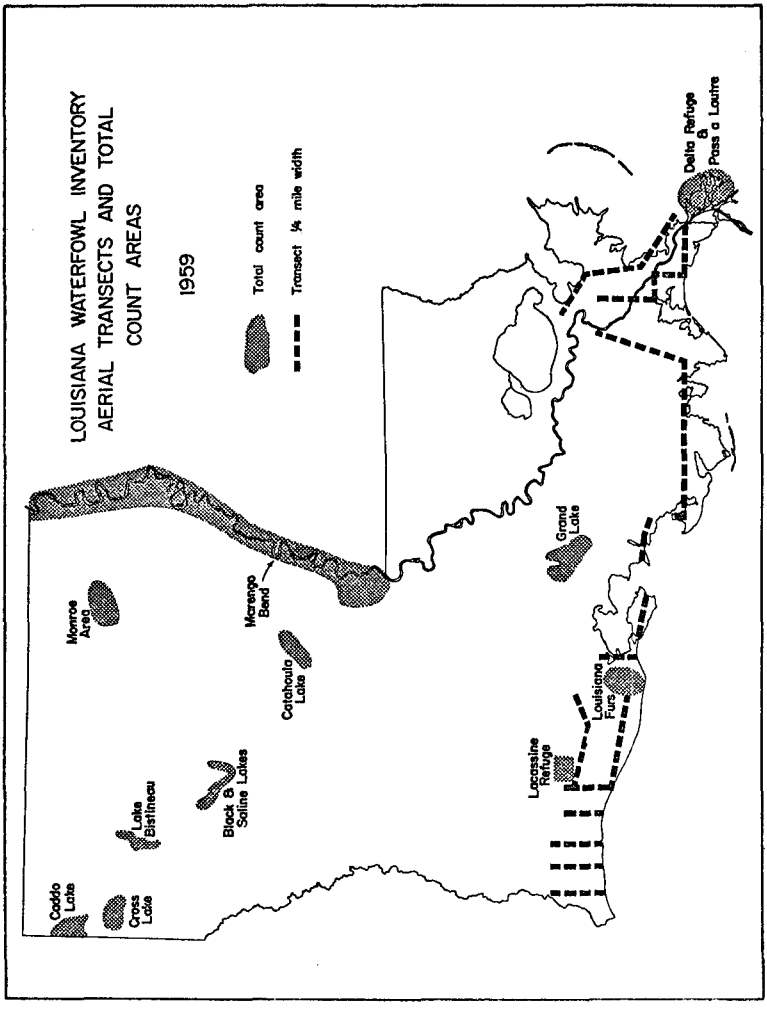
LOUISIANA WATERFOWL INVENTORY
AERIAL TRANSECTS AND TOTAL
COUNT AREAS
1959
Total count area
Transect ¼ mile width
Caddo Lake
Cross Lake
Lake Bisthineau
Black & Saline Lakes
Monroe Area
Marengo Bend
Catahoula Lake
Grand Lake
Lacassine Refuge
Louisiana Furs
Delta Refuge & Pass a Loutre

Fig. 1

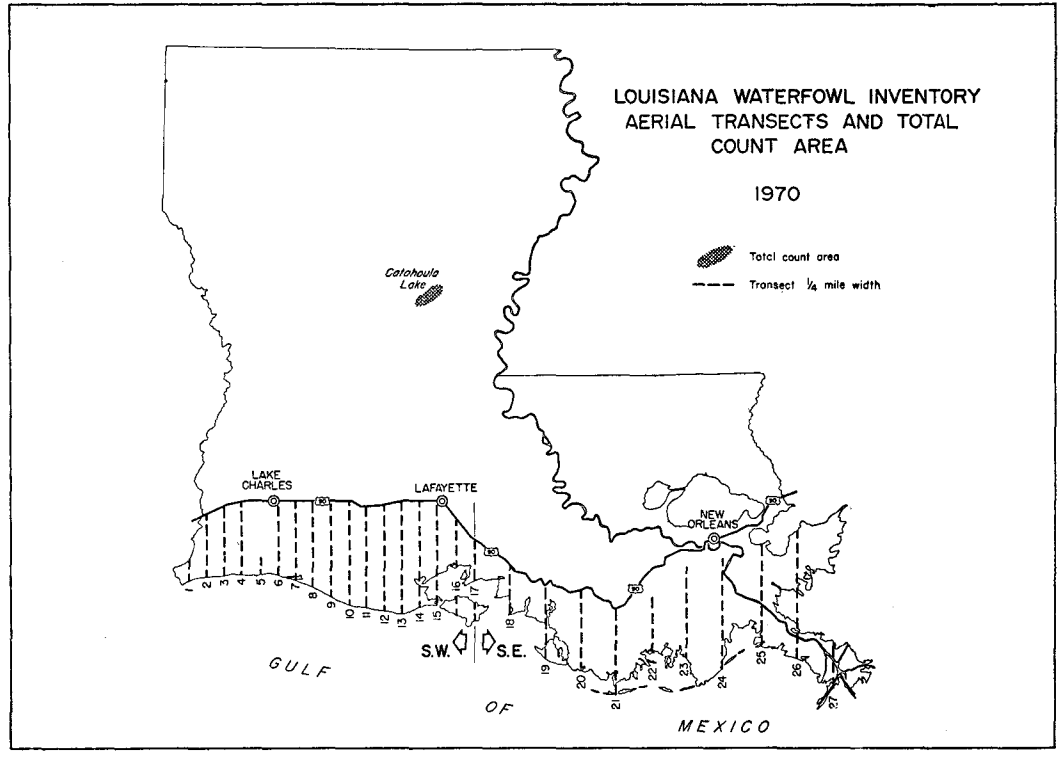
LOUISIANA WATERFOWL INVENTORY
AERIAL TRANSECTS AND TOTAL
COUNT AREA
1970
Total count area
Transect 1/4 mile width
Calcasieu Lake
LAKE CHARLES
LAFAYETTE
NEW ORLEANS
S.W.
S.E.
GULF OF MEXICO

Fig. 2

LOUISIANA WILD LIFE AND FISHERIES COMMISSION
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Periodic Waterfowl Population Estimates in Louisiana's Coastal Marsh and Riceland Below U. S. Hwy. 90 and on Catahoula Lake

DATE: December 8, 9, 10 & 11, 1969

REPORTED BY: Bateman, Summerell & Wycoff

Estimates made from Cessna 210 Aircraft

SPECIES	SOUTHWEST	SOUTHEAST	CATAHOULA LAKE	TOTALS
Mallard	315,000	115,000	46,000	476,000
Gadwall	866,000	653,000	* *	1,519,000
Baldpate	692,000	264,000	* *	956,000
Green W. Teal	323,000	422,000	* *	745,000
Blue W. Teal	12,000	20,000	0	32,000
Shoveler	126,000	59,000	* *	185,000
Pintail	371,000	72,000	187,000	630,000
Mottled Duck	36,000	47,000	0	83,000
TOTAL DABBLERS	2,741,000	1,652,000	233,000	4,626,000
Redhead	* *	8,000	0	8,000
Canvasback	1,000	5,000	* *	6,000
Scaup	150,000*	600,000*	* *	750,000*
Ringnecked	35,000	7,000	* *	42,000
Ruddy	* *	* *	* *	* *
Merganser	2,000	10,000	0	12,000
TOTAL DIVERS	188,000	630,000	* *	818,000
TOTAL DUCKS	2,929,000	2,282,000	233,000	5,444,000
Coots	194,000	743,000	* *	937,000

*Includes off-shore estimates
**Estimate less than 500

Figure 3

helicopter, time of day and observer fatigue may have been more of an influence than is desirable (Smith, 1961).

The entire comparison procedure was completed in 6 days, once in late August and early September and then a second time in early November. Two inventories provided the volume of data needed for reliable comparisons of the two aircraft and allowed an evaluation of their effectiveness during periods when both low and high numbers of waterfowl are present in Louisiana.

Cost comparisons of the helicopter and Cessna were based on actual flying time required for this study and quoted rental and operation costs from flying services in Louisiana and the aircraft manufacturers.

Statistical Analysis

The mean number of total ducks, mottled ducks and mottled duck sightings was calculated for each transect line for each aircraft and each month. Total ducks represent the sum of all species recorded on each transect, mottled ducks represent the total number recorded of that species only on each line and mottled duck sightings represent the number of times mottled ducks were seen and re-

corded on each line. A 2 x 2 factorial arrangement of treatments (2 months x 2 aircraft) was used in a randomized block design where blocks were composed of 27 transect lines. This analysis follows methods described by Snedecor (1956).

Mottled ducks were examined separately as they provided a stable, non-migratory population. This species occurred largely as singles, pairs and small flocks well distributed over the entire census area which reduced the magnitude of error involved when estimating large numbers.

RESULTS AND DISCUSSION

Inventory Comparison Techniques

The use of each aircraft on alternate days was an adequate technique for comparison purposes. There were some problems and they will be discussed here.

The 7 to 8 hours of flying each day with the helicopter resulted in starting earlier and ending later than was required with the Cessna. This resulted in working with the helicopter when birds may have been more active and accordingly more visible as described by Diem, et. al., (1960).

There also was the influence of observer fatigue which was noticeable after 4 or 5 hours of census work. Smith (1961) indicated this as a factor to be considered in aerial censusing of waterfowl.

Early morning and late evening flying also created a glare problem which was quite serious before 9:00 a.m. and after 3 p.m. When the observer was looking into the sun vision was impaired. Inadequate visibility for safe flying is frequently a problem in Louisiana due to haze and fog conditions that develop near the warm Gulf waters. Early morning and late evening flying is not in the best interest of safety as visibility conditions tend to worsen at these times.

Had there been more time allowed to complete the 27 lines with the helicopter, most of these problems could have been eliminated and the daily work schedules with each aircraft would have been more compatible.

Another problem encountered was one of navigating precise transect lines each day with a different aircraft and pilot. The helicopters were equipped with simple magnetic compasses and maintaining exact bearings on long transects was difficult. On some of the longer transects there was variation up to 1/4 mile east or west of the line actually pursued by each aircraft.

August - September Inventory

The results of the first inventory comparing the two aircraft are illustrated in Table 1. More ducks were recorded from the helicopter than from the Cessna on 22 of the 27 transects. The total difference was 1,514 ducks or about 59 percent.

During the first inventory the waterfowl population present in the census area was much smaller than that found during November. Blue-winged teal (*Anas discors*) and mottled ducks accounted for 99 percent of the ducks recorded during the August - September inventory.

Because of extreme heat during August - September the door of the helicopter was removed. This provided excellent visibility and comfort but the engine and rotor blades created a loud and annoying sound. This noise was picked up by the tape recorder and delicate volume settings were required to insure clear voice recordings.

November Inventory

The results of the November inventory (Table 1) illustrate the large number of waterfowl encountered during a wintering period inventory in Louisiana's coastal marshes. The large masses of birds presented difficult problems in estimating total numbers and the number of each species with accuracy. Since

TABLE 1. TOTAL WATERFOWL* RECORDED BY TRANSECT LINE FROM EACH AIRCRAFT EACH MONTH

	AUGUST - SEPTEMBER		NOVEMBER	
TRANSECT NUMBER	CESSNA	HELICOPTER	CESSNA	HELICOPTER
1	16	50	741	640
2	137	404	6,284	17,831
3	105	1,052	5,296	5,559
4	271	192	4,620	4,091
5	24	23	499	727
6	7	40	6,854	2,954
7	24	36	1,499	1,494
8	123	148	1,800	3,600
9	88	321	3,612	11,135
10	21	44	1,605	3,419
11	102	174	571	506
12	11	21	44,980	1,121
13	88	174	2,569	972
14	8	6	62	46
15	13	10	58	422
16	50	174	147	74
17	0	0	33	87
18	20	24	275	131
19	11	11	144	734
20	196	268	1,925	6,035
21	80	256	519	737
22	22	91	5	65
23	823	167	2,311	3,450
24	27	60	500	2,266
25	290	278	753	943
26	5	16	11	32
27	0	36	1,525	5,044
TOTALS	2,562	4,076	44,980	74,115
MEAN	94.88	150.96	166.62	274.50

*Combined totals of mallard (*Anas platyrhynchos platyrhynchos*), pintail (*Anas acuta tzitzihoa* gadwall (*Anas strepera*), American widgeon (*Marecia americana*), shoveler (*Spatula clypeata*), blue-winged teal, green-winged teal (*Anas carolinensis*), mottled duck and the American coot recorded on each transect.

the same observer was used throughout this study the effect of this type of error (the observer's ability to estimate numbers in large flocks) was assumed to be constant for both aircraft.

In November 29,135 more ducks (65 percent) were recorded from the helicopter than from the Cessna. This was very similar to the results of the August-September comparison. During November, however, there were more ducks recorded from the helicopter on only 18 of the 27 transects lines. Totals for two of the nine species recorded during November were greater from the Cessna than from the helicopter, but species composition was very similar among the total waterfowl recorded with each aircraft.

The lack of precision in deplicating the exact route to be followed by each aircraft was of considerable influence in November. Large flocks of wintering ducks were not evenly distributed and differences in the actual flight path taken be each aircraft influenced the number of ducks recorded.

Aircraft Comparisons

The helicopter had these features that provided waterfowl counting advantages over the Cessna: visibility, noise and slower air speed. Air speed and visibility were very influential in allowing the observer to see and identify waterfowl within the census strip from the helicopter. The large Plexiglas bubble provided excellent visibility ahead and alongside of the helicopter as it moved along each transect. This was quite an improvement over the Cessna in which visibility is restricted to the side of the aircraft. The noise created by the helicopter engine and rotor blades was quite disturbing to waterfowl. Many single birds and small flocks that otherwise might have been undetected either flushed or swam a short distance as the helicopter approached and thus revealed their presence. Lotter and Cornwell, (1969) reported similar reactions by waterfowl to a helicopter in Florida. During the November inventory this created somewhat of a problem as frequently large numbers of ducks would flush up to 1/4 mile ahead of the helicopter. Under these circumstances there was considerable difficulty in determining the proper number and species of ducks as they departed or entered the census strip.

Air speed was maintained at 70 mph in the helicopter as opposed to 90 to 100 mph with the Cessna. At 100 to 150 foot elevations the slower air speed provided a noticeable advantage for seeing small flocks or single ducks.

Statistical Comparisons

Statistical examination of the data provided some interesting results. Table 2 illustrates the mean number of all ducks, mottled ducks and mottled duck sightings recorded per transect line from each aircraft during each month. These means represent the basis for the analysis of variance tests that were conducted.

The difference in the total number of ducks recorded between months was highly significant, as expected (Table 3). No interaction was found between aircraft and months, indicating that the difference in number of ducks recorded remained essentially the same across all transects between aircraft each month. Thus, both aircraft were consistent and equally effective in measuring the change in total duck numbers from August - September to November.

Although 59 percent more ducks were recorded from the helicopter than from the Cessna in August-September and 65 percent more in November, statistically there was no difference, i.e. that the difference was very likely due to chance (Table 3). The great amount of variation in the total number of ducks recorded per transect line from each aircraft was concluded to be the factor resulting in the failure of this statistical test to show a true difference between aircraft.

The total number of mottled ducks and mottled duck sightings recorded per transect line from both aircraft exhibit less variation (Table 4). The results of the analysis of variance test on mottled ducks recorded per line are presented in Table 5. The difference between aircraft was significant ($P<.05$). Here again there was no interaction between aircraft and months indicating that the difference remained the same between the Cessna and helicopter across the transects for both inventories.

Similar results were produced from a test of the number of mottled duck sightings recorded per line from each aircraft (Table 6). The difference between aircraft was highly significant ($P<.01$). No significant interaction between aircraft and months was detected by this test on mottled duck sightings.

As shown in Table 4, amazing similarities occurred during August-September and November in the total number of mottled ducks and mottled duck sightings recorded with each aircraft. Since the total number of waterfowl (Table 1) recorded increased dramatically and at the same rate with each aircraft between August-September and November (approximately 18 times), the consistent estimates with both aircraft of mottled ducks during this same period demonstrate reliability in the censusing procedure. The mottled duck

data provided ideal tests for comparing the two aircraft and evaluating the transect method for estimating populations of waterfowl in Louisiana's coastal marshes and ricelands.

Operational Cost Comparisons of the Cessna 210 and Bell G47-4A Helicopter

Table 7 presents figures on a rental and operational cost per hour basis for each aircraft. The flying time required to complete the 27 transects is also listed to illustrate the added expense incurred with the slower helicopter. Using the rental or operational costs plus the added time required, the helicopter was four times as expensive to operate as the Cessna. This difference would increase accordingly if the rental and operational costs of a Cessna 150, Piper Super Cub or other less expensive aircraft were compared with the helicopter.

The helicopter could be rented on a daily basis with a reduced per hour cost. This system can be used at a savings if more than 4 or 5 hours per day is anticipated to complete the scheduled work.

As most wildlife agencies are set up for use and maintenance of fixed-wing aircraft, the transition to full time use and maintenance of a helicopter would be quite involved with additional expenses.

CONCLUSIONS

The results of this study are rather conclusive on several points: (1) the helicopter is a safe and effective censusing vehicle for waterfowl in Louisiana's coastal marshes and ricelands, (2) the Cessna and helicopter were equally effective in providing a measure of large changes in wintering populations of waterfowl, (3) the helicopter was more effective than the Cessna for estimating a population consisting of well dispersed, small individual flocks of waterfowl such as mottled ducks and (4) the helicopter was about four times as expensive to operate as the Cessna.

The major advantages provided by the helicopter over the Cessna were reduced air speed and exceptional visibility. It is likely, therefore, that any slow-flying aircraft affording good visibility would also be more effective than the Cessna.

In Louisiana, as in most states, the use of any single aircraft is not restricted to waterfowl censusing but is usually involved in many types of work. Often, budgets and work loads are such that the aircraft available must be used in situations where they are adequate but certainly not ideal. Louisiana's Cessna 210 is frequently used for transportation of men and equipment throughout the state. It is also used on extended cross-country trips to Mexico and Canada for waterfowl population and habitat surveys. Its speed, long range and comfort are extremely valuable in these situations. In contrast, a small helicopter is hardly suited for these duties.

The Louisiana Wild Life and Fisheries Commission plans to continue using the Cessna 210 for our waterfowl inventory work. There are plans to improve it for aerial censusing by adding a Robertson STOL Conversion (short take-off or landing) which will reduce minimum safe-flying air speed from 90 mph to 60 mph. We also hope to use small helicopters more frequently in special situations requiring their unique flying abilities.

TABLE 2. MEAN NUMBER OF TOTAL DUCKS, MOTTLE DUCKS AND MOTTED DUCK SIGHTINGS* RECORDED PER TRANSECT LINE FROM EACH AIRCRAFT EACH MONTH

ALL DUCKS

	HELICOPTER	CESSNA 210	MONTHS MEAN
AUGUST - SEPTEMBER	150.96	94.88	122.92
NOVEMBER	274.50	166.62	220.56
AIRCRAFT MEAN	212.73	130.75	

MOTTLED DUCKS

	HELICOPTER	CESSNA 210	MONTHS MEAN
AUGUST - SEPTEMBER	55.70	39.14	47.42
NOVEMBER	55.85	30.51	43.18
AIRCRAFT MEAN	55.77	34.82	

MOTTLED DUCK SIGHTINGS

	HELICOPTER	CESSNA 210	MONTHS MEAN
AUGUST-SEPTEMBER	10.11	6.55	8.33
NOVEMBER	10.48	8.25	9.36
AIRCRAFT MEAN	10.29	7.40	

* Total mottled duck sightings is the mean number of times these ducks were recorded on each transect.

TABLE 3. ANALYSIS OF VARIANCE OF TOTAL NUMBERS OF WATERFOWL RECORDED FROM EACH AIRCRAFT EACH MONTH

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F
Total	107	643,893,699.65	6,017,698.12	-
R (Transects)	26	211,562,012.90	8,137,000.49	2.11
A (Aircraft)	1	8,655,839.12	8,655,839.12	2.25
B (Months)	1	117,002,156.76	117,002,156.76	30.45**
A X B	1	7,031,372.67	7,031,372.67	1.83
Error	78	299,642,318.27	3,841,568.18	-

**Significant at the .01 level of probability

TABLE 4. TOTAL NUMBERS AND SIGHTINGS* OF MOTTLED DUCKS BY TRANSECT LINE RECORDED FROM EACH AIRCRAFT EACH MONTH

	AUGUST - SEPTEMBER INVENTORY				NOVEMBER INVENTORY			
	CESSNA		HELICOPTER		CESSNA		HELICOPTER	
Line No.	Sightings	Ducks	Sightings	Ducks	Sightings	Ducks	Sightings	Ducks
1	3	16	6	39	4	12	6	16
2	18	91	31	146	23	68	24	182
3	9	68	16	172	10	78	23	165
4	14	114	25	92	7	27	11	57
5	4	14	4	10	1	4	2	5
6	4	6	4	21	11	58	14	52
7	6	22	6	36	10	27	23	44
8	5	21	13	68	5	13	8	56
9	13	43	18	73	14	36	19	341
10	3	13	8	44	14	84	18	134
11	3	37	13	158	5	11	8	22
12	2	11	4	21	10	43	9	55
13	12	48	11	158	17	49	21	64
14	2	8	2	6	3	6	5	10
15	2	5	2	10	4	20	3	8
16	4	9	3	41	7	34	3	15
17	0	0	0	0	2	9	4	8
18	4	10	2	8	0	0	3	21
19	1	11	2	11	1	2	3	11
20	29	89	52	195	18	44	14	44
21	8	36	5	26	11	32	20	70
22	3	22	2	7	1	2	4	13
23	8	301	14	37	3	10	2	4
24	8	21	6	17	6	22	11	27
25	9	36	16	94	27	96	15	57
26	3	5	6	11	6	11	6	17
27	0	0	2	3	3	26	4	10
Totals	177	1,057	273	1,504	223	824	283	1,508
Mean	6.55	39.14	10.11	55.70	8.25	30.51	10.48	55.85

* A mottled duck sighting is recorded as one or more observations of these ducks seen along each transect

TABLE 5. ANALYSIS OF VARIANCE OF TOTAL NUMBERS OF MOTTLED DUCKS RECORDED FROM EACH AIRCRAFT EACH MONTH

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Squares	F
Total	107	359,976.91	-	-
R (Transects)	26	155,832.16	5,993.54	2.44
A (Aircraft)	1	11,844.08	11,844.08	4.82*
B (Months)	1	485.56	485.56	.19
A X B	1	520.08	520.08	.21
Error	78	191,295.01	2,452.50	-

* Significant at the .05 level of probability

TABLE 6. ANALYSIS OF VARIANCE OF TOTAL MOTTLED DUCK SIGHTINGS RECORDED FROM EACH AIRCRAFT EACH MONTH

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Squares	F
Total	107	7,351.62	-	-
R (Transects)	26	2,862.62	1,725.48	60.55
A (Aircraft)	1	225.33	225.33	7.90**
B (Months)	1	29.03	29.03	1.01
A X B	1	12.00	12.00	.42
Error	78	2,222.62	28.49	-

**Significant at the .01 level of probability

TABLE 7. FLIGHT TIME REQUIRED, RENTAL[1] AND OPERATIONAL[2] COST COMPARISONS FOR THE CESSNA 210 LAND PLANE AND THE BELL G47-4A MODEL HELICOPTER

ITEM	CESSNA 210	HELICOPTER
Initial Cost (New)	$35,000.00	$58,000.00
Rental Cost/Hr.	$45.00	$100.00 or $200.00/day plus $30/hr.
Operational Cost/Hr.	$17.02 (500 hrs./yr.)	$39.12 (700 hrs./yr.)

Flight Time Required to Complete 27 Lines	Aug.-Sept.	November	Aug.-Sept.	November
	10 hrs.-45 min.	10 hrs.-10 min.	19 hrs.-53 min.	19 hrs.-49 min.

[1]Rental based on quoted prices from several Louisiana flying services.

[2]Operation costs based on 1970 estimates from Cessna and Bell Aircraft Companies, includes gas, oil, engine change reserve, insurance, depreciation, inspections and maintenance and storage (does not include pilot's salary).

ACKNOWLEDGEMENTS

The Author wishes to express appreciation for the advice and assistance received concerning statistical problems from Dr. Prentiss Schilling, Associate Professor of Experimental Statistics, Louisiana State University and Mr. Dan Tabberer, graduate student, Louisiana State University.

LITERATURE CITED

Brazda, A. R. 1969. Helicopter/Aircraft/Ground Comparative Data, Waterfowl Breeding Pair Survey, Block Study Areas and Transects in Eastern Montana and Western North and South Dakota. Bureau of Sport Fisheries and Wildlife. Lafayette, Louisiana (Unpublished) 6 p.

Chabreck, R. H. 1970. Marsh Zones and Vegetation Types in the Louisiana Coastal Marshes. Unpublished Ph.D. Dissertation Louisiana State University. Baton Route. 113 p.

Chabreck, R. H., T. Joanen and A. W. Palmisano. 1968. A Vegetative Type Map of the Louisiana Coastal Marshes. Louisiana Wild Life and Fisheries Commission. New Orleans. (Map & Illus.)

Cornwell, and F. C. Lotter. 1969. Comparison of Airplane, Airboat and Helicopter for Censusing Florida Ducks (*Anas platyrhynchos fulvigula*). Proc. 23 Annual Conference Southeastern Association of Game and Fish Commission. 13 p.

Denney, R. N. 1966. Neck Banding Techniques with the Helicopter. Proc. 47th Annual Conference Western Association Game and Fish Commission. p. p. 134-141.

Diem, K. L. and K. H. Lu. 1960. Factors Influencing Waterfowl Censuses in the Parklands Alberta, Canada. Journal of Wildlife Management. Volume 24 (2). 21 p.

Evans, P. K. 1967. The Auodad Sheep, An Exotic Introduction in the Palo Duro Canyon of Texas. Proc. 21st Annual Conference Southeastern Association of Game and Fish Commission. p.p. 183-188.
Glahn, R. 1967. Waterfowl from the Air, An Inventory Guide, U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Division of Refuges. Portland, Oregon. 26 p.
Heyland, J. D. and W. T. Munroe. 1967. The Use of Helicopters in Hunting Waterfowl Nests. J. Wild. Mgmt. 31 (1). p.p. 200-201.
Howe, R. E. 1963. Successful Live Trapping of Elk on Their Winter Range. Proc. 43rd Annual Conference Western Association Game and Fish Commission. p.p. 147-150.
Kortright, F. H. 1967. The Ducks, Geese and Swans of North America, The Stackpole Company, Harrisbury, Penn. and the Wildlife Management Institute. Washington, D. C. 476 p.
Lentfer, J. W. 1968. A Technique for Immobilizing and Marking Polar Bears J. Wild. Mgmt. 32 (2). p.p. 317-321.
Martinson, K. R. and C. F. Kaczynski, 1967. Factors Influencing Waterfowl Counts on Aerial Surveys. 1961-66. U. S. Fish and Wildlife Spec. Sci. Report: Wildl. No. 105. 78 p.
Neilson, A. E. and W. M. Shaw. 1967. A Helicopter — Dart Gun Technique for Capturing Moose. Proc. 47th Annual Conference Western Association Game and Fish Commission. p.p. 183-199.
Perroux, Joe W. 1967. The Helicopter. Proc. 21st Annual Conference, Southeastern Association of Game and Fish Commission. p.p. 134-139.
Peterson, R. T. 1962. A Field Guide to the Birds. Houghton Mifflin Company, Boston, Mass. 290 p.
Russell, N. J. 1967. Rhinos, Whirlybird and M 99. Animal Kingdom, 70 (4). p.p. 98-105.
Smith, K. C. 1969. A Technique for Capturing White-tailed Deer in the Delta Marsh by Use of Airboats and Helicopters. Louisiana Wild Life and Fisheries Commission. Baton Rouge. (mimeo). 11 p.
Smith, M. M. 1961. Louisiana Waterfowl Population Study, Final Report July 1949 through June 1961. Project W-17R and W-29R, Louisiana Wild Life and Fisheries Commission. New Orleans, Louisiana. 116 p.
———————, Louisiana Mottled Duck Surveys Final Report July 1951 through June 1958 P-R Projects W-17R and W-29R. 21 p.
Snedecor, G. W. 1956. Statistical Methods. Iowa State College Press. Ames. 535 p.
Stuzenbacker, C. D. 1969. Helicopter Supported Mottled Duck Banding. Federal Aid Project W-96-4, Texas Parks and Wildlife. Austin, (Unpublished). 5 p.