coverts (Fig. 1). Wings from immature snipe contain median and lesser coverts with a faint black marginal line at the tip or coverts that are uniformly white or buffy at the tip (Fig. 2). Coverts on a few wings from immatures appear to have a narrow shaft line which, on closer inspection, is actually an unusually dark vane that extends to the tip of that particular feather. These coverts normally have the marginal black tip.

Acknowledgments.—We thank G. Ammann, F. Martin, E. Fritzell, and R. Lytle for providing the snipe specimens.

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Received 26 September 1978.
Accepted 7 January 1979.

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EFFECTS OF HELICOPTER CENSUSES ON WADING BIRD COLONIES

Managing and preserving colonially nesting wading birds (Ciconiiformes) requires that the status of colonies be monitored. Monitoring programs, especially when long-term, help to assess population fluctuations associated with environmental changes or management actions (Custer and Osborn 1977, Kushlan and White 1977). Monitoring involves 2 activities: surveys to determine location and general status of bird colonies, and censuses to identify species composition and numbers of birds in the colonies. The most accurate censuses are done on the ground by counting all active nests, counting birds flying over the colony, or by using standard sampling techniques. However, ground techniques are usually uneconomical for large-scale programs and are usually somewhat disruptive because they generally require entering the colony. Aircraft are often used for censusing bird colonies, although with few exceptions (Kadlec and Drury 1968, Dunnet 1977) their potential impact, accuracy, and costs have not been assessed. Use of fixed-wing aircraft seems to provide rather poor data for many species, particular-

ly for colonies where birds nest within the tree canopy. Helicopters allow more accuracy because of their slow speed and the excellent visibility from them. Buckley and Buckley (1976) noted, however, that helicopters are believed by some to cause substantial disturbances to nesting birds. The objectives of this study were to assess disruptive effects of helicopter censuses on wading bird colonies and to evaluate the accuracy and economics of helicopter use.

METHODS

The study was conducted at colony sites in southern Florida during April–June 1977. Observers near but not within the colonies recorded behavioral responses of nesting birds to a helicopter. Because fixed-wing aircraft have been used in southern Florida for over 20 years without noticeable impact on bird colonies, the disturbance caused by such an aircraft performing a similar census was used as the control. The fixed-wing aircraft was a "Lake" single engine amphibian, and the helicopter was a "Bell 47G-2." Ground observers positioned themselves near the colony before the 1st plane arrived. In the 1st 2 tests, the fixed-wing aircraft approached the colony at 120 m altitude and in 2 to 3 minutes circled the colony 3 to 5 times until a satisfactory count was completed. After 10 minutes the aircraft returned to the colony and repeated the procedure at 60 m altitude. A helicopter followed the same procedure 1½ to 2 hours later, first at 120 m and then at 60 m. The helicopter was used in the same way as the fixed-wing aircraft. It slowly circled the perimeter of the colony and took about the same number of circles and the same time as the fixed-wing aircraft. It did not hover over the colony. An ordered rather than random sequence of overflights was required for logistic reasons. Should disturbance have proven to be cumulative, the procedures used in the 1st 2 tests would have overestimated any adverse effect of helicopters. To evaluate the potential bias caused by habituation to disturbance, the helicopter census was flown before the fixed-wing aircraft in a 3rd test.

During the time the aircraft was circling and for 5 minutes thereafter, the ground observers each watched 3 to 6 nests and recorded the behavior of adult birds that were incubating or were at nests with nestlings. I considered that drastic disturbance occurred if a bird left its nest and failed to return within 5 minutes. Lesser reactions of the birds were assigned a value of 1 to 5: exhibited no reaction (1); looked up (2); stood up (3); walked from its nest but returned within 5 minutes (4); and flew from its nest but returned within 5 minutes (5). Comparisons between the fixed-wing aircraft and the helicopter were based on data from 192 observations of great egrets (*Casmerodius albus*), snowy egrets (*Egretta thula*), and Louisiana herons (*Hydranassa tricolor*). Additional observations (N = 28) of disturbance were made of double-crested cormorants (*Phalacrocorax auritus*) and wood storks (*Mycteria americana*) but these were not extensive enough for the comparative analyses. The Mann-Whitney U-test was used for statistical analysis. Qualitative observations of disturbance were also made by observers riding in the aircraft. After the results of the disturbance experiments were assessed, a test was made to estimate time and costs involved in censusing colonies in Everglades National Park.

The 1st test was at a small colony (East River). Complete ground censuses indicated that this colony contained 25 wood stork and 150 great egret nests at the time

Table 1. Disturbance of colonial nesting wading birds by a fixed-wing aircraft or a helicopter flying over the colony.

	% in disturbance index[a] class					
	1	2	3	4	5	N
Great egret	69	14	17			70
Snowy egret	73	16		9	2	64
Louisiana heron	85	9	3	3		58
Wood stork		100				2
Cormorant	46	46			2	26
All species, $\bar{x}$	71	19	6	3	2	220

[a] Scale increases in severity of disturbance, 1 to 5.

Table 2. Comparison of fixed-wing (FW) versus helicopter (H) aircraft used in censusing colonially nesting, wading birds in Florida. Symbols show which type of aircraft caused less disturbance than the other type; blanks indicate no difference between types ($P > 0.05$, Mann-Whitney U-test).

		Altitude of test	
Test	Species	120 m	60 m
1	Great egret		H
2	Great egret		
	Snowy egret	H	FW
	Louisiana heron	H	H
3	Great egret		H
	Snowy egret		
	Louisiana heron	H	H

of the test. To determine whether the response by birds differed in a large colony, the 2nd test was at Rodgers River colony. It contained 155 great egret, 720 snowy egret, 431 Louisiana heron, 22 little blue heron (*Florida caerulea*), 27 white ibis (*Eudocimus albus*), 3 anhinga (*Anhinga anhinga*), and 5 cormorant nests. The final test also was conducted at Rodgers River colony. In both colonies, birds nested on islands covered with mangrove (*Rhizophora mangle*). Qualitative observations of disturbance made at other colonies included 3 additional species, great blue heron (*Ardea herodias*), brown pelicans (*Pelicanus occidentalis*), and laughing gulls (*Larus atracilla*).

RESULTS AND DISCUSSION

In all tests, no bird that left its nest failed to return within 5 minutes. Eleven birds that did leave returned to their nests in an average of 1.4 minutes. Thus neither a fixed-wing aircraft nor a helicopter drastically disturbed colonies when flying at altitudes as low as 60 m. There was no reaction in nearly ¾ of the 220 observations, and in 90% of the observations a bird either showed no reaction or merely looked up (Table 1).

In the 1st test, there was no difference ($P > 0.05$) in the reaction of great egrets to fixed-wing aircraft and helicopters at 120 m, and the helicopter caused less disturbance ($P < 0.05$) than the fixed-wing aircraft at 60 m (Table 2). Great egrets, snowy egrets, and Louisiana herons were then observed in 2 tests conducted at the larger colony, where the fixed-wing aircraft flew over the colony 1st (test 2) and then the helicopter 1st (test 3). In 11 of 12 comparisons made during these tests, the helicopter caused the same or less disturbance than the fixed-wing aircraft (Table 2). The helicopter caused more disturbance of only 1 species in 1 comparison. Results of tests 2 and 3 indicate no increase in the effect of the helicopter when it flew over the colony before the fixed-wing aircraft. Additional qualitative observations of brown pelicans nesting on bushes, cormorants on top of trees, white ibis within the tree canopy, wood storks and great blue herons in trees, and laughing gulls on the ground failed to show any disturbance from helicopters.

Disturbance from helicopter censuses was minor and of short duration. In all but 1 case, disturbance was no greater or less than that caused by fixed-wing aircraft. No predation occurred on the few nests that were abandoned for a short time in response to the aircraft. Some birds flew up and circled around the col-

Table 3. Accuracy of aerial censuses from fixed-wing aircraft and helicopter compared to complete ground censuses of the colony.

Species	Complete ground census	Fixed-wing census	Error[a] (%)	Helicopter census	Error (%)
Great egret	155	100	35	130	16
Snowy egret	720	250	65	650	10
White ibis	27	0	100	30	11
Louisiana heron	431	15	97	30	93
Little blue heron	22	15	32	0	100
Anhinga	3	0	100	3	0
Cormorant	5	0	100	5	0
Total	1,363	380	72	848	28

[a] Calculated by $(G - A)/G$, where G = ground census, A = aerial census.

ony in response to both helicopter and fixed-wing aircraft flights, but ground observations indicated that these were birds without active nests. Several birds that were engaged in pair formation during the census did not fly away. Thus, under the conditions studied, there was no countermanding evidence against use of helicopters near colonies. Although the small impacts shown in this study are probably typical, the effects of aircraft surveys may differ under other conditions or with other aircraft. Tests should therefore be conducted for each use of censusing by helicopter.

The accuracy of helicopter censuses was analyzed by comparison of results with a nest by nest ground count of the large colony (Table 3). The helicopter census achieved reasonable accuracy (10–16% error) for white birds such as great egrets, snowy egrets, and white ibis, and for dark birds such as anhingas and cormorants that nest atop trees. The fixed-wing aircraft census was less accurate for these species 32–100% error). Both methods were inaccurate for small dark birds such as Louisiana and little blue herons that nested within the canopy. The errors associated with a helicopter census should be balanced against the disturbance often caused by a ground census which, in the case of this colony, required 3 people to be in the colony for 2 hours. On the scale used in this study, the disturbance indices for such ground counts were at least 3 or 4 for almost all birds in the colony, although such effects were not lasting. That the helicopter disturbed the birds much less than persons entering the colony may be an important consideration in designing a monitoring program. The acceptable level of disturbance, the accuracy needed by a particular monitoring program, the nature of the colony sites, and the species present will determine applicability of helicopter censuses in any given circumstance.

Costs of helicopter censuses were tested by a trial census flight that covered 10 colony sites within an area of 770 km^2 in Everglades National Park. The helicopter base station was 25 km from the 1st colony and 13 km from the last colony censused. Flight time averaged 8 minutes per colony, and the total cost, including salary for ½ man-day, was $15/colony. A ground census of each of these colonies averaged 1.0 man-day at a cost of $52/colony. Because the time, effort, and salaries involved in ground censuses may require full-time assignment of personnel to monitoring activities, use of helicopters may alleviate some manpower

constraints on conducting colonial bird monitoring programs.

Because of flight time limitation and slow speed, helicopters are less effective than fixed-wing aircraft in locating colony sites over large expanses of potential habitat. When highly accurate counts of nesting birds are required, ground censuses will generally need to be conducted. Helicopters appear to be suited best for general monitoring programs where reasonable but approximate census data are needed.

Certain procedures can help minimize possible effects of aircraft near colonies. The colony should be approached gradually by first circling it at a distance, either altitudinally or horizontally, and then moving in closer for the count. The aircraft should fly around the periphery of the colony. Helicopters should fly slowly but not hover over the colony. Continual attention should be paid to signs of drastic disturbance during the census. With such precautions and suitable baseline testing, helicopters should prove to be a useful tool for some monitoring efforts.

Acknowledgments.—I thank those who assisted in this study, especially M. C. Baumann and R. B. Lawson. I thank M. S. Kushlan, W. F. Loftus, O. L. Bass, D. MacArthur, and T. W. Schmidt for help in ground observations and R. Miele and A. Lassier for piloting the fixed-wing aircraft. I also thank W. B. Robertson, Jr., G. E. Davis, O. L. Bass, L. C. McEwan, A. Lassier, and especially R. Miele for their helpful comments.

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Received 25 October 1977.
Accepted 11 August 1978.

EFFECTS OF RADIO PACKAGES ON BEHAVIOR OF WILD TURKEY HENS

The effect of radio packages on wild turkey (*Meleagris gallopavo*) behavior has not been documented. Captive radio-equipped, female red grouse (*Lagopus l. scoticus*) reduced their feeding during the first 6 days after instrumentation, and activity was reduced in males and females for about 2 weeks (Boag 1972). Radio packs did not affect the survival, dispersal, or growth of juvenile male ring-necked pheasants (*Phasianus colchicus*) (Johnson 1971). Instrumented captive mallards (*Anas platyrhynchos*) and blue-winged teal (*A. discors*) experienced weight loss, feather wear, and skin irritation (Greenwood and Sargeant 1973). They observed that treated ducks preened more than controls and exhibited a partial