A SURVEY OF THE VERTEBRATE AND INVERTEBRATE FAUNA OF FORT PULASKI NATIONAL MILITARY PARK

FORT PULASKI
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For

The National Park Service

By

Southeastern Wildlife Services, Inc.
113 Hoyt Street
Athens, Georgia 30601
(912) 543-3215

14 March 1981

PREFACE

The National Park Service initiated this study with a contract to Southeastern Wildlife Services, Incorporated (SWS, INC.) for a faunal survey of Fort Pulaski National Military Park. SWS, INC. would like to thank D. Stoneburner (NPS Cooperative Research Unit, Athens, Georgia) for his efforts in developing and initiating the survey. The continuing assistance of Superintendent G. Webb of Fort Pulaski and his administrative staff was greatly appreciated during all phases of field work on Park property.

Fort Pulaski National Military Park is a small bit of upland in a vast coastal system. An understanding of the fauna of Fort Pulaski requires an understanding of the Park's interactive role with the surrounding marshes and estuaries. This report has drawn heavily on the extensive surveys of the Georgia coast (Johnson et al. 1974, Hillestad et al. 1975) which have come before. SWS, INC. would like to express its special appreciation to G. Williamson (herpetofauna), H. N. Neuhauser (mammals) and W. W. Baker (mammals) for their work which preceeded and supported this faunal survey.

SWS, INC. thanks to J. Hamilton (mammals), E. Bozeman (fish) and J Richardson (birds) for their efforts in gathering the field data appearing in this report.

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INTRODUCTION

A vegetation map and inventory of the plant communities of Fort Pulaski National Military Park were submitted to the Regional Office of the National Park Service. A concurrent survey of fauna within the Park was initiated in June 1978 and continued until October 1979. This report summarizes the samples and observations of fauna collected during that 17 month period. The survey and final report were designed to be interactive with the vegetation inventory. The objectives of the survey were to provide quantitative and qualitative data on vertebrate and invertebrate fauna for use by the National Park Service in conjunction with Park resource management.

Fort Pulaski National Military Park is an historical park located on Cockspur and McQueens Islands at the mouth of the Savannah River. Cockspur Island has been used as a site of fortification since 1761 because of its strategic location at the entrance to Savannah harbor. Cockspur was designated as a National Military Park in 1924; this designation was expanded to include McQueens Island in 1938.

STUDY AREA

Fort Pulaski National Military Park is located in Chatham County, Georgia. The Park comprises 2,225 ha (5,497 acres),

including 275 ha (679 acres) on Cockspur Island and 1950 ha (4,817 acres) on McQueens Island (Southeastern Wildlife Services, Inc. 1980).

Cockspur Island is owned in part by the National Park Service and in part by private interests. The federally owned eastern portion is comprised of 55.3% salt marsh, 19.5% upland shrub and 25.3% lawn, savannah and spoil areas. Cockspur is a manmade island which exists today as a result of dikes and drainage canals, associated with the original fort construction, and spoil deposition associated with recent channel dredging in the Savannah River. The island is intersected by numerous drainage canals located both inside and outside the dike surrounding the fort. There is, in addition, a feeder canal which connects the moat surrounding the fort with the south channel of the Savannah River. McQueens Island is primarily a marsh island, with only 5.5% of its total area in upland associated with the U. S. Highway 80 causeway and an abandoned railroad grade.

METHODS

Survey efforts were focused primarily on upland populations of birds and mammals and on the fish associated with the drainage canal system. Observations of reptiles and amphibians were integrated with the extensive field records of G. Williamson (pers. comm.). Salt marsh fauna, invertebrates and noxious arthropods were not surveyed. They are common to all of Georgia's estuarine and coastal island ecosystems and have been exhaustively surveyed and reported in the literature (Teal and Teal 1969, Johnson et al. 1974, Hillestad et al. 1975).

BIRDS

Bird community surveys were restricted to upland areas of Cockspur Island, including all communities and plant associations above the high water line. The salt marshes, estuaries and tidal creeks located within and adjacent to the Park, including the Savannah River, are characteristic of much of the Georgia coast. Bird communities associated with tidal environments have been extensively surveyed (Johnson et al. 1974, Hillestad et al. 1975) and, therefore, were not resurveyed for this report.

The upland winter bird community was surveyed by discrete vegetational blocks, and an attempt was made to record all individuals in each block. Species and numbers of individuals were observed with 7 X 35 binoculars and their locations mapped. The usual survey technique of transect counts (Emlen 1971) was not applicable to this study because of the patchiness of Fort Pulaski's upland plant communities.

The summer nesting bird community was surveyed by direct observation, using 7 X 35 binoculars, and by voice counts of singing males. The method of counting singing males is commonly employed (Robbins 1970, 1978) and requires only an experienced observer familiar with the vocal patterns of resident nesting species. This method assumes that each singing male represents a nesting pair. As with winter birds, species and numbers of nesting birds were identified and mapped by discrete vegetational blocks and not by transect (Emlen 1971) or spot mapping (Robbins 1978) techniques. Family groups of the Carolina chickadee and starling were considered as single nesting pairs. Singing

cardinal females were not considered; nesting pairs were calculated as the sum of observed singing males.

Spring and fall transient bird populations were not surveyed within the Park. Virtually all of Georgia's 323 recorded coastal species (Johnson et al. 1974) might be expected to pass over or through Park grounds at some time during the year. Occasional surveys do not adequately measure the sporadic appearance of migrants whose movements are strongly affected by season and major weather patterns. The best estimate of Fort Pulaski migrants is obtained from the combined sight records (Appendix I) for the Georgia coastal region, collected over many years (Burleigh 1958, Johnson et al. 1974, Hillestad et al. 1975; Denton et al. 1977).

Weather was favorable on all survey dates. Winter birds were surveyed on 17 February 1979, under the following conditions; sunny, northwest winds of 10-15 mph, 40° F at 0800 hours. The summer bird population was surveyed on 5, 6 June 1978. Weather was characteristic of summer coastal conditions: sunny, warm, early morning temperatures in the 70's (F°), rising to 90° F and above by noon. Summer surveys were restricted to morning hours (0600-1100 hours) because high temperatures and windy conditions inhibit singing by territorial males. Summer midday temperatures exceed 90° F on clear days, and onshore seabreezes are a disturbing factor during the afternoon.

A species similarity index (S.I.) has been used to compare resident birds among various shrub communities (Odum 1971).

$$S.\ I. = \frac{2c}{(a+b)}$$

where a= species in area "a"

b= species in area "b"

c= species common to both areas

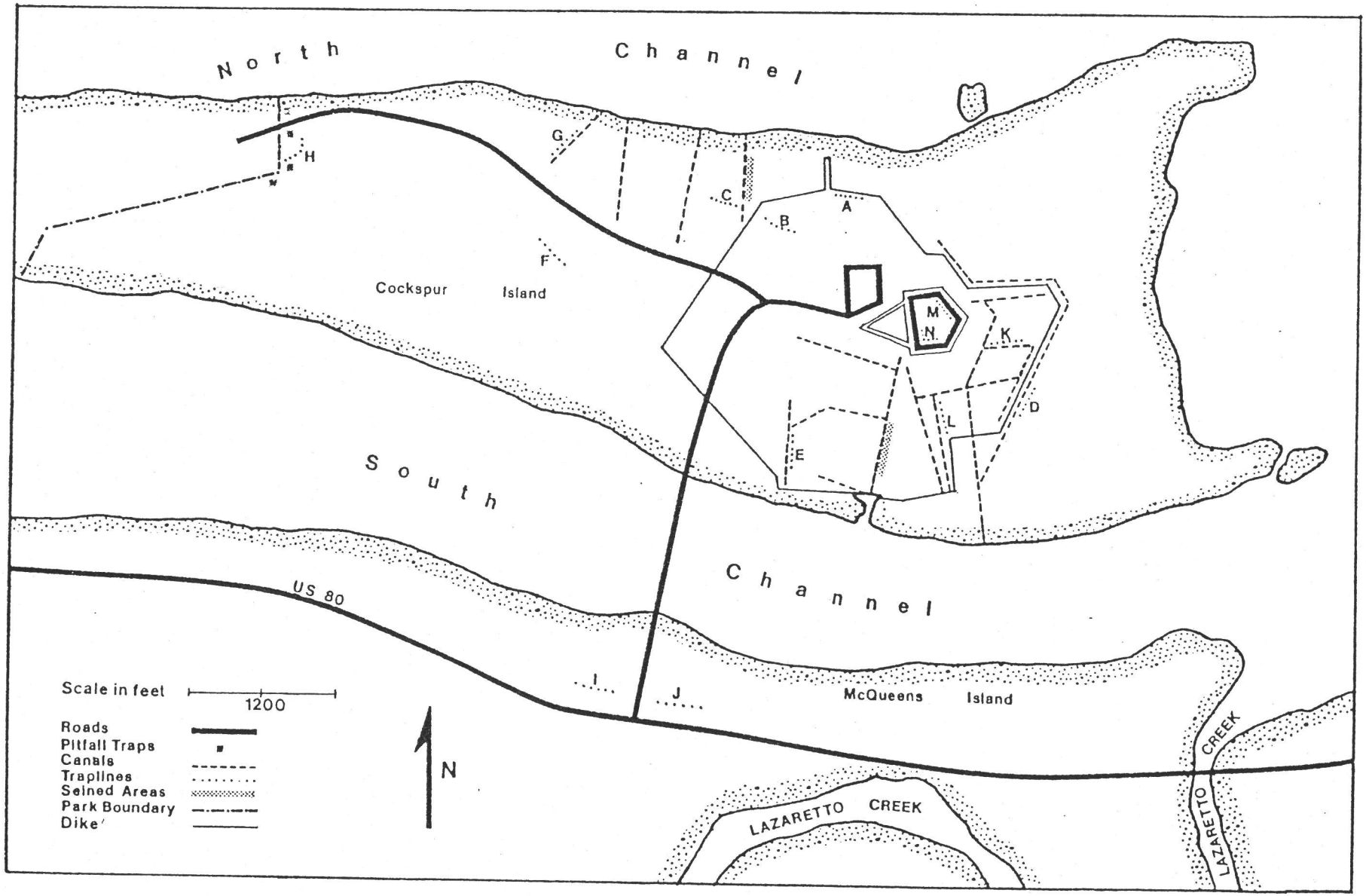
MAMMALS

Small mammals were surveyed 9-12 October 1979, using 10 snap-trap lines in various habitats around the park (Fig. 1). Eight lines were set on Cockspur Island and two lines were set on McQueens Island. Trap lines were located in the various terrestrial plant communities to determine habitat preferences. Each trap line consisted of 10 stations at approximately 10 m intervals, with one rat trap and two museum special traps at each station. The entire trapping effort was, therefore, equal to 1200 trap nights. Traps were baited with a mixture of oatmeal and peanut butter. After 2 nights of trapping, four unproductive lines (A, B, H, and F) were moved to areas which seemed more likely to harbor small mammal populations. Two of these lines were set inside the fort, and the remaining two were set along drainage canals in front of the fort. Specimens were identified, weighed and measured, and several skins and skulls of representative individuals were deposited with the University of Georgia at Athens.

Fifteen pitfall traps were set around abandoned bunkers, lumber piles and machinery near the western boundary of the park to sample for insectivores (Fig. 1). Each trap consisted of a # 10 can buried with the rim flush to the ground. Traps were located along walls, logs and other areas where insectivores would likely pass during foraging periods. A small amount of formalin, with a covering of mineral oil, was placed in each can to immobilize captured specimens.

Intermediate sized mammals, such as raccoons, opossums, mink, otter and marsh rabbits, were not surveyed during the study due to the possible high incidence of rabies in the raccoon population of the park.

Figure 1. Location of sampling stations used for the faunal survey on Cockspur and McQueens Islands, Fort Pulaski National Military Park.


North Channel
Cockspur Island
South Channel
US 80
McQueens Island
LAZARETTO CREEK
LAZARETTO CREEK
A
B
C
D
E
F
G
H
I
J
K
L
M
N
Scale in feet
1200
N
Roads
Pitfall Traps
Canals
Traplines
Seined Areas
Park Boundary
Dike

One confirmed case of rabies and several suspected cases were reported by Park Service personnel during the fall of 1979. Raccoons are usually surveyed by live trapping, an activity which was deemed potentially hazardous to the health of field personnel.

Deer were surveyed in October 1979 by night head counts and consultations with park administrative and maintenance personnel. In addition, one night count was made on private property to the west of the Park boundaries. The dense cover and lack of visitors on this part of the island make it attractive to deer as a bedding and grazing area.

HERPETOFAUNA

Herpetofauna were not systematically sampled during the survey so as not to duplicate the extensive work by Gerald Williamson of the Savannah Science Museum. Williamson's records from Cockspur and McQueens Islands extend over many years. Occasional herpetofaunal sightings during the survey were recorded and integrated with the Williamson records.

FISH

Fish were sampled 11 October 1979 from the moat feeder canal (high salinity) and from one of the drainage canals (low salinity) on the north side of Cockspur Island (Fig. 1). Samples were taken with a 50' x 4' x 1/4" mesh seine. Approximately 100 m of each system were seined, using 10' seines to block net the sampled areas. Each area was seined twice, and all captured fish were preserved in 10% formalin.

The fish in each sample were sorted to species and counted, and the preserved wet weights of each species were recorded to the nearest gram.

The moat was not sampled for fish because of its depth (7'). Moat fish would have to be taken with poison or boat drawn seine nets, neither of which were of practical application. It was determined that fish in the moat were not an important component of the Pulaski fauna because of their isolation from natural island food chains. The moat should be managed primarily for historical relevance rather than wildlife habitat.

RESULTS

BIRDS

Thirty species of birds (656 individuals) were observed on the upland habitats of Cockspur Island during the winter bird survey. The number of individuals seen, density (ind./ha) and estimated total numbers have been calculated for each of six vegetational communities, for the combined shrub communities and for the total upland area of Cockspur Island (Table 1).

Twenty-nine species of birds were observed on the upland habitats of Cockspur Island during the summer bird survey. These included 25 known or probable nesting species (258 observed nesting pairs) and four species of non-nesting visitors (7 ind.). The number of nesting pairs seen, density (nesting pairs/ha) and estimated total numbers of nesting pairs have been calculated for the same vegetational communities considered for winter birds (Table 2).

(text continued on p.25)

Table 1. Distribution and density of winter birds by habitat types, Cockspur Island, Fort Pulaski National Military Park, February 1979.

Species	1 Yaupon shrub			2 Juniper/ mixed shrub			3 Mixed shrub			1-3 Total shrub		
	N	ind./ha	total ind.	N	ind./ha	total ind.	N	ind./ha	total ind.	N	ind./ha	total ind.
1. Sharp-shinned Hawk	1	.08	1.4	-	-	-	1	.10	2.5	2	.07	3.9
2. Mourning Dove	1	.08	1.4	-	-	-	4	.38	10.0	5	.22	11.4
3. Yellow-shafted Flicker	-	-	-	1	.15	1.0	6	.58	14.9	7	.30	15.9
4. Fish Crow	-	-	-	-	-	-	-	-	-	-	-	-
5. Carolina Chickadee	1	.08	1.4	-	-	-	-	-	-	1	.03	1.4
6. Red-breasted Nuthatch	-	-	-	-	-	-	-	-	-	-	-	-
7. House Wren	4	.30	5.7	1	.15	1.0	3	.29	7.5	8	.27	14.2
8. Carolina Wren	5	.38	7.2	2	.30	2.0	1	.10	2.5	8	.22	11.7

Table 1. Continued

Species	4 Pine N	ind./ha	total ind.	5 Lawn and Savannah N	ind./ha	total ind.	6 Spoil N	ind./ha	total ind.	1-6 Total Upland N	ind./ha	total ind.
1. Sharp-shinned Hawk	-	-	-	-	-	-	-	-	-	2	.03	3.9
2. Mourning Dove	2	1.67	2.0	3	.52	30.3	-	-	-	10	.35	43.7
3. Yellow-shafted Flicker	2	1.67	2.0	-	-	-	-	-	-	9	.15	17.9
4. Fish Crow	7	5.80	7.0	-	-	-	-	-	-	7	.06	7.0
5. Carolina Chickadee	-	-	-	-	-	-	-	-	-	1	.01	1.4
6. Red-breasted Nuthatch	1	.83	1.0	-	-	-	-	-	-	1	.01	1.0
7. House Wren	-	-	-	-	-	-	-	-	-	8	.12	14.2
8. Carolina Wren	-	-	-	-	-	-	-	-	-	8	.10	11.7

Table 1. Continued

Species	1 Yaupon shrub N	ind./ha	total ind.	2 Juniper/ mixed shrub N	ind./ha	total ind.	3 Mixed shrub N	ind./ha	total ind.	1-3 Total shrub N	ind./ha	total ind.
9. Mocking-bird	1	.08	1.4	-	-	-	-	-	-	1	.03	1.4
10. Catbird	2	.15	2.9	-	-	-	8	.77	19.9	10	.44	22.8
11. Brown Thrasher	1	.08	1.4	2	.30	2.0	4	.38	10.0	7	.26	13.4
12. Robin	1	.08	1.4	-	-	-	-	-	-	1	.03	1.4
13. Hermit Thrush	2	.15	2.9	2	.30	2.0	4	.38	10.0	8	.28	14.9
14. Blue-gray Gnatcatcher	1	.08	1.4	-	-	-	-	-	-	1	.03	1.4
15. Ruby-crowned Kinglet	17	1.29	24.3	1	.15	1.0	5	.48	12.5	23	.72	37.8
16. Cedar Waxwing	100	7.58	143.2	-	-	-	9	.87	22.4	109	3.16	165.6

Table 1. Continued

Species	4 Pine			5 Lawn and Savannah			6 Spoil			1-6 Total Upland		
	N	ind./ha	total ind.	N	ind./ha	total ind.	N	ind./ha	total ind.	N	ind./ha	total ind.
9. Mocking-bird	-	-	-	1	.17	9.9	-	-	-	2	.09	11.3
10. Catbird	-	-	-	-	-	-	-	-	-	10	.19	22.8
11. Brown Thrasher	-	-	-	-	-	-	-	-	-	7	.11	13.4
12. Robin	-	-	-	-	-	-	-	-	-	1	.01	1.4
13. Hermit Thrush	-	-	-	-	-	-	-	-	-	8	.12	14.9
14. Blue-gray Gnatcatcher	1	.83	1.0	-	-	-	-	-	-	2	.02	2.4
15. Ruby-crowned Kinglet	-	-	-	-	-	-	-	-	-	23	.31	37.8
16. Cedar Waxwing	-	-	-	-	-	-	-	-	-	109	1.35	165.6

Table 1. Continued

Species	1 Yaupon shrub N	ind./ha	total ind.	2 Juniper/ mixed shrub N	ind./ha	total ind.	3 Mixed shrub N	ind./ha	total ind.	1-3 Total shrub N	ind./ha	total ind.
17. White-eyed Vireo	2	.15	2.9	-	-	-	5	.48	12.5	7	.29	15.4
18. Solitary Vireo	2	.15	2.9	-	-	-	-	-	-	2	.06	2.9
19. Black-and-white Warbler	3	.23	4.3	-	-	-	-	-	-	3	.08	4.3
20. Orange-crowned Warbler	1	.08	1.4	-	-	-	2	.19	5.0	3	.12	6.4
21. Yellow-rumped Warbler	146	11.06	209.0	49	7.31	49.0	56	5.39	139.5	251	7.59	397.5
22. Pine Warbler	-	-	-	-	-	-	-	-	-	-	-	-
23. Yellow-throat	2	.15	2.9	4	.60	4.0	2	.19	5.0	8	.23	11.9
24. Redwinged Blackbird	-	-	-	5	.75	5.0	4	.38	10.0	9	.29	15.0

Table 1. Continued

Species	1 Yaupon shrub N	1 Yaupon shrub ind./ha	1 Yaupon shrub total ind.	2 Juniper/ mixed shrub N	2 Juniper/ mixed shrub ind./ha	2 Juniper/ mixed shrub total ind.	3 Mixed shrub N	3 Mixed shrub ind./ha	3 Mixed shrub total ind.	1-3 Total shrub N	1-3 Total shrub ind./ha	1-3 Total shrub total ind.
25. Boat-tailed Grackle	-	-	-	-	-	-	-	-	-	-	-	-
26. Cardinal	17	1.29	24.3	8	1.19	8.0	22	2.12	54.8	47	1.66	87.1
27. Rufous-sided Towhee	-	-	-	5	.75	5.0	6	.58	14.9	11	.38	19.9
28. Savannah Sparrow	-	-	-	-	-	-	2	.19	5.0	2	.10	5.0
29. White-throated Sparrow	22	1.67	31.5	13	1.94	13.0	23	2.21	5.73	58	1.94	101.8
30. Swamp Sparrow	-	-	-	-	-	-	1	.10	2.5	1	.05	2.5
TOTAL	322	25.2	475	93	13.9	93	168	16.2	419	593	18.9	987

Table 1. Continued

Species	4 Pine			5 Lawn and Savannah			6 Spoil			1-6 Total Upland		
	N	ind./ha	total ind.	N	ind./ha	total ind.	N	ind./ha	total ind.	N	ind./ha	total ind.
25. Boat-tailed Grackle	-	-	-	6	1.03	60.0	-	-	-	6	.49	60.0
26. Cardinal	2	1.67	2.0	-	-	-	-	-	-	49	.72	89.1
27. Rufous-sided Towhee	-	-	-	-	-	-	-	-	-	11	.16	19.9
28. Savannah Sparrow	-	-	-	10	1.72	100.3	-	-	-	12	.86	105.3
29. White-throated Sparrow	6	5.00	6.0	-	-	-	-	-	-	64	.88	107.8
30. Swamp Sparrow	-	-	-	-	-	-	-	-	-	1	.02	2.5
TOTAL	42	35.0	42	21	3.6	210	-	-	-	656	10.1	1239

Table 2. Distribution and density of summer nesting birds (pairs) by habitat types, Cockspur Island, Fort Pulaski National Military Park, June 1978.

P=present; not nesting

Summer Bird Survey Species	1 Yaupon shrub			2 Juniper/ mixed shrub			3 Mixed shrub			1-3 Total shrub		
	N	prs./ha	total prs.	N	prs./ha	total prs.	N	prs./ha	total prs.	N	prs./ha	total prs.
1. Green Heron	1	.07	1.3	-	-	-	1	.06	1.6	2	.06	2.9
2. Killdeer	-	-	-	-	-	-	-	-	-	-	-	-
3. Willet	-	-	-	-	-	-	-	-	-	-	-	-
4. Mourning Dove	3	.20	3.8	1	.15	1.0	5	.28	7.3	9	.23	12.1
5. Yellow-billed Cuckoo	3	.20	3.8	-	-	-	-	-	-	3	.07	3.8
6. Barn Owl	P	-	-	-	-	-	-	-	-	P	-	-
7. Common Nighthawk	-	-	-	-	-	-	-	-	-	-	-	-
8. Chimney Swift	-	-	-	-	-	-	-	-	-	-	-	-
9. Eastern Kingbird	1	.07	1.3	-	-	-	2	.11	2.8	3	.08	4.1

Table 2. Continued

Summer Bird Survey Species	4 Pine			5 Lawn and Savannah			6 Spoil			1-6 Total Upland		
	N	prs./ha	total prs.	N	prs./ha	total prs.	N	prs./ha	total prs.	N	prs./ha	total prs.
1. Green Heron	-	-	-	-	-	-	-	-	-	2	.02	2.9
2. Killdeer	-	-	-	P	-	-	-	-	-	P	-	-
3. Willet	-	-	-	5	.17	9.9	2	.18	2.0	7	.10	11.9
4. Mourning Dove	-	-	-	2	.07	4.1	-	-	-	11	.13	16.2
5. Yellow-billed Cuckoo	-	-	-	-	-	-	-	-	-	3	.03	3.8
6. Barn Owl	-	-	-	-	-	-	-	-	-	P	-	-
7. Common Nighthawk	-	-	-	-	-	-	1	.09	1.0	1	.01	1.0
8. Chimney Swift	-	-	-	5	.17	9.9	-	-	-	5	.08	9.9
9. Eastern Kingbird	-	-	-	1	.03	1.7	-	-	-	4	.05	5.8

Table 2. Continued

P=present; not nesting

Summer Bird Survey	1 Yaupon shrub			2 Juniper/ mixed shrub			3 Mixed shrub			1-3 Total shrub		
Species	N	prs./ ha	total prs.	N	prs./ ha	total prs.	N	prs./ ha	total prs.	N	prs./ ha	total prs.
10. Great-crested Flycatcher	2	.13	2.5	2	.30	2.0	2	.11	2.8	6	.14	7.3
11. Eastern Wood Peewee	1	.07	1.3	-	-	-	-	-	-	1	.02	1.3
12. Barn Swallow	-	-	-	-	-	-	-	-	-	-	-	-
13. Fish Crow	-	-	-	-	-	-	-	-	-	-	-	-
14. Carolina Chickadee	2	.13	2.5	-	-	-	1	.06	1.6	3	.08	4.1
15. Carolina Wren	5	.33	6.2	3	.45	3.0	2	.11	2.8	10	.23	12.0
16. Mocking-bird	-	-	-	-	-	-	2	.11	2.8	2	.05	2.8
17. Brown Thrasher	1	.07	1.3	-	-	-	1	.06	1.6	2	.06	2.9
18. Starling	1	.07	1.3	1	.15	1.0	2	.11	2.8	4	.10	5.1

Table 2. Continued

Summer Bird Survey Species	4 Pine			5 Lawn and Savannah			6 Spoil			1-6 Total Upland		
	N	prs./ha	total prs.	N	prs./ha	total prs.	N	prs./ha	total prs.	N	prs./ha	total prs.
10. Great-crested Flycatcher	-	-	-	-	-	-	-	-	-	6	.06	7.3
11. Eastern Wood Peewee	-	-	-	-	-	-	-	-	-	1	.01	1.3
12. Barn Swallow	-	-	-	10	.34	19.8	-	-	-	10	.16	19.8
13. Fish Crow	P	-	-	-	-	-	-	-	-	P	-	-
14. Carolina Chickadee	1	.83	1.0	-	-	-	-	-	-	4	.04	5.1
15. Carolina Wren	-	-	-	-	-	-	-	-	-	10	.10	12.0
16. Mocking-bird	-	-	-	3	.10	5.8	-	-	-	5	.07	8.6
17. Brown Thrasher	-	-	-	-	-	-	-	-	-	2	.02	2.9
18. Starling	-	-	-	1	.03	1.7	-	-	-	5	.06	6.8

Table 2. Continued

P=present; not nesting

Summer Bird Survey	1 Yaupon shrub			2 Juniper/ mixed shrub			3 Mixed shrub			1-3 Total shrub		
Species	N	prs./ ha	total prs.	N	prs./ ha	total prs.	N	prs./ ha	total prs.	N	prs./ ha	total prs.
19. White-eyed Vireo	2	.13	2.5	-	-	-	8	.44	11.4	10	.27	13.9
20. Pine Warbler	P	-	-	-	-	-	-	-	-	P	-	-
21. Eastern Meadowlark	-	-	-	-	-	-	-	-	-	-	-	-
22. Redwinged Blackbird	-	-	-	29	4.33	29.0	34	1.88	48.7	63	1.48	77.7
23. Orchard Oriole	2	.13	2.5	-	-	-	2	.11	2.8	4	.10	5.3
24. Boat-tailed Grackle	13	.86	16.3	5	.75	5.0	18	.99	25.6	36	.90	46.9
25. Brown-headed Cowbird	-	-	-	-	-	-	1	.06	1.6	1	.03	1.6
26. Cardinal	12	.79	14.9	2	.30	2.0	14	.77	19.9	28	.70	36.8
27. Painted Bunting	4	.26	4.9	5	.75	5.0	13	.72	18.6	22	.54	28.5

Table 2. Continued

Summer Bird Survey Species	4 Pine			5 Lawn and Savannah			6 Spoil			1-6 Total Upland		
	N	prs./ha	total prs.	N	prs./ha	total prs.	N	prs./ha	total prs.	N	prs./ha	total prs.
19. White-eyed Vireo	-	-	-	-	-	-	-	-	-	10	.11	13.9
20. Pine Warbler	1	.83	1.0	-	-	-	-	-	-	1	.01	1.0
21. Eastern Meadowlark	-	-	-	1	.03	1.7	-	-	-	1	.01	1.7
22. Redwinged Blackbird	-	-	-	3	.10	5.8	-	-	-	66	.68	83.5
23. Orchard Oriole	-	-	-	1	.03	1.7	-	-	-	5	.06	7.0
24. Boat-tailed Grackle	-	-	-	4	.14	8.2	-	-	-	40	.45	55.1
25. Brown-headed Cowbird	-	-	-	3	.10	5.8	-	-	-	4	.06	7.4
26. Cardinal	-	-	-	1	.03	1.7	-	-	-	29	.31	38.5
27. Painted Bunting	-	-	-	-	-	-	-	-	-	22	.23	28.5

Table 2. Continued

P=present; not nesting

Summer Bird Survey	1 Yaupon shrub			2 Juniper/ mixed shrub			3 Mixed shrub			1-3 Total shrub		
Species	N	prs./ ha	total prs.	N	prs./ ha	total prs.	N	prs./ ha	total prs.	N	prs./ ha	total prs.
28. American Goldfinch	P	-	-	-	-	-	-	-	-	P	-	-
29. Rufous-sided Towhee	-	-	-	-	-	-	4	.22	5.7	4	.11	5.7
TOTAL	53	3.5	66	48	7.2	48	112	6.2	160	213	5.3	275
TOTAL (excluding Redwinged Blackbird)	53	3.5	66	19	2.9	19	78	4.3	112	150	3.8	197
Nesting species / Non-nesting species		15/3			8/0			17/0			19/3	
Hectares of habitat		18.9			6.7			25.9			52.4	
Percent area surveyed		80%			100%			70%			.76	

Table 2. Continued

Summer Bird Survey Species	4 Pine N	prs./ha	total prs.	5 Lawn and Savannah N	prs./ha	total prs.	6 Spoil N	prs./ha	total prs.	1-6 Total Upland N	prs./ha	total prs.
28. American Goldfinch	-	-	-	-	-	-	-	-	-	P	-	-
29. Rufous-sided Towhee	-	-	-	-	-	-	-	-	-	4	.05	5.7
TOTAL	2	1.7	2	40	1.3	78	3	.3	3	258	3.2	358
TOTAL (excluding Redwinged Blackbird)	2	1.7	2	37	1.2	72	3	.3	3	192	2.3	274
Nesting species / Non-nesting species	2/1			13/1			2/0			25/4		
Hectares of habitat	1.2			58.3			11.2			123.1		
Percent area surveyed	100%			50%			100%			.66		

Population estimates (number of species, density and estimated total numbers) have been summarized in Table 3 (winter birds) and Table 4 (summer birds), distributed according to the same vegetational communities considered in Tables 1 and 2. The palm shrub community was indistinquishable from mixed shrub and too small in total area (0.9 ha) to be considered separately. Quantitative estimates for the combined (total) shrub community include the palm community areas.

Note that summer nesting bird community values (Table 2) are calculated twice, first with redwinged blackbirds present and second with redwinged blackbirds absent. The redwinged blackbird proved to be a confounding species for bird community estimates because of its nesting habitat preference for the upland/high marsh and upland/salt pan interfaces. A dense association of salt tolerant shrubs (Baccharis halimifolia, Myrica cerifera, Iva frutescens) grows along these interfaces, providing prime nest sites for the blackbirds (Fig. 2, top). The ratio of interface length to the area of various upland vegetational communities on Cockspur Island is relatively large, causing redwinged blackbirds to appear to be an unnaturally dominant member of the bird community. This dominance ranged from zero in the yaupon shrub community (little interface with high marsh) to 70% in the juniper/mixed shrub community (much interface with high marsh). For this reason, community density values have been calculated without redwinged blackbirds, as well as with them, to permit a more realistic estimate of bird community structure.

Winter birds were twice as dense as summer birds (1239 individuals vs 358 nesting pairs) in the upland habitats of Cockspur Island.

Table 3. Summary of the nesting bird community recorded on Cockspur Island, Fort Pulaski National Military Park, October 1979.

Category	Plant Communities							
	1 Yaupon shrub	2 Juniper/ mixed shrub	3 Mixed shrub	1-3 Total shrub	4 Pine	5 Lawn and savannah	6 Spoil	1-6 Total Upland
Winter species	21	12	20	26	9	5	0	30
Individuals per hectare	25.2	13.9	16.2	18.9	35.0	3.6	0	10.1
Estimated total individuals	475	93	419	987	42	210	0	1239
Habitat area (ha)	18.9	6.7	25.9	52.4	1.2	58.3	11.2	123.1

Table 4. Summary of the nesting bird community recorded on Cockspur Island, Fort Pulaski National Military Park, June 1978.

Category	Plant Communities							
	1 Yaupon shrub	2 Juniper/ mixed shrub	3 Mixed shrub	1-3 Total shrub	4 Pine	5 Lawn and savannah	6 Spoil	1-6 Total Upland
Nesting species	15	8	17	19	2	13	2	25
Visitors	3	0	0	3	1	1	0	4
Nesting pairs per hectare	3.5	7.2	6.2	5.3	1.7	1.3	0.3	3.2
Estimated total pairs	66	48	160	275	2	78	3	358
Nesting pairs per hectare, excluding redwinged blackbirds	3.5	2.9	4.3	3.8	1.7	1.2	0.3	2.3
Estimated total pairs, excluding redwinged blackbirds	66	19	112	197	2	72	3	274
Habitat area (ha)	18.9	6.7	25.9	52.4	1.2	58.3	11.2	123.1



Figure 2. Top: The salt marsh/upland shrub interface is an important ecotonal community for nesting redwinged blackbirds and most of the native mammals. Bottom: Palm crowns provide arboreal refuge for black rats (Rattus rattus).

Winter densities were greatest in pine (35.0 ind./ha) and yaupon shrub (25.2 ind./ha) communities. With redwinged blackbirds not considered, summer nesting was most dense in the mixed shrub (4.3 pairs/ha) and yaupon shrub (3.5 pairs/ha) communities. Yaupon shrub and mixed shrub supported the greatest total numbers of winter birds (475 ind. and 419 ind., respectively) while mixed shrub was by far the most important plant community for total nesting birds (112 pairs). Spoil areas provided very poor habitat for the summer bird community (0.3 pairs/ha), and no winter birds were seen in this area at all.

There were, in addition to the upland bird communities, a number of heron species associated with the drainage canals, including the great egret, snowy egret and Louisiana heron during the summer survey and the great blue heron during the winter survey. Numbers of individuals feeding along the canal did not exceed 20 per species at any one time during the surveys.

MAMMALS

Forty-six species of mammals have been reported from the Georgia coastal islands (Golly 1962, Neuhauser and Baker 1974), including whales and dolphins (8 species), exotics (4 species), bats (6 species) and a number of introduced species and unsubstantiated records (8 species). Nineteen native species from this list, exclusive of bats, might logically be associated with upland plant communities on Fort Pulaski (Table 5). There are positive records for 10 upland species from Cockspur and McQueens Islands (Neuhauser and Baker 1974), and seven of these

Table 5. Mammal records from Cockspur and McQueens Islands, Fort Pulaski National Military Park.

Species	Possible occurrence	Records in literature	Observed during survey
Virginia opossum	X	X	X
Short-tailed shrew	X		
Least shrew	X		
Eastern mole	X		
Bat species (6)	X(6)	?	?
Marsh rabbit	X	X	X
Gray squirrel	X	X	
Fox squirrel	X		
Flying squirrel	X		
Rice rat	X	X	
Cotton mouse	X		
Cotton rat	X	X	X
Black rat	X	X	X
Norway rat	X		
House mouse	X		
Bottle-nosed dolphin	X	X	X
Raccoon	X	X	X
Mink	X	X	X
Otter	X	X	
Bobcat	X	?	
Manatee	X		
White-tailed deer	X	X	X
TOTAL	27	11	8

were observed during the current survey.

Marsupialia. A dead Virginia opossum (Didelphis virginiana) was found April 1978 in the mixed shrub community and occasional tracks were observed throughout Cockspur Island. The opossum is not considered a common mammal in the Park.

Insectivora. Pitfall traps, deployed to catch shrews in mixed shrub at the western Park boundary, were unsuccessful. The short-tailed shrew (Blarina brevicauda) and least shrew (Cryptotis parva) occur on several of the coastal islands and might possibly be expected to occur on Cockspur. The eastern mole (Scalopus aquaticus) is also a potential inhabitant of the Park, although it was not observed during the survey.

Chiroptera. Six species of bats have been reported from the Georgia coastal islands (Neuhauser and Baker 1974), any of which might be expected to occur from time to time within the Park boundaries. Occasional individuals of unknown species were observed feeding at dusk over the upland areas of Cockspur Island during the spring months. No bats were collected within the Park, however, in order to avoid the use of guns, which is the usual method for collecting these animals. Bats are a minor component of the Pulaski mammal community.

Lagomorpha. The marsh rabbit (Sylvilagus palustris) is a ubiquitous member of the high marsh and marsh/terrestrial interface communities of Pulaski and occurs throughout the Georgia coast. Specimens have been collected from Cockspur and McQueens Islands (Neuhauser and Baker 1974). Preferred habitat within the Park include the upland perimeter of Cockspur and the highway and

abandoned railroad rights-of-way on McQueens Island.

Rodentia. Thirteen rodents were captured in snaptraps during a 4 day survey, including the black rat (Rattus rattus) and the cotton rat (Sigmodon hispidus) (Table 6). The low capture rate of 1.1 animals per 100 trap nights was due, in part, to trap raiding by raccoons and possibly by other large mammals in the Park. Sixteen traps disappeared during the survey, and 12 traps had obviously been raided of their catches.

Most of the captures occurred along drainage canals on Cockspur Island and along the abandoned railroad grade on McQueens Island (Fig. 1). A single black rat was taken in the dense yaupon shrub community during 240 trap nights in this area. Trap lines on Cockspur at the western boundary of the Park (line H), the picnic area (line F) and within the fort (lines M and N) were totally unproductive, although there was some indication of trap raiding on lines F and H. The Park has been poisoning rodents within the fort, and this effort seems to have been successful. The wide range of size classes of the cotton rats and black rats taken during this survey indicate that both species were reproducing at population sustaining rates.

Observations during field work in June included a dead cotton rat found in mixed shrub, a live cotton rat seen foraging in weedy vegetation on the edge of a spoil deposit and a live black rat climbing in yaupon shrub. The latter ascended a small yaupon holly, transferred at a height of 2 m to the dead frond

Table 6. Small mammals collected from Cockspur and McQueens Islands, Fort Pulaski National Military Park, October 1979.

Trap Line	Habitat	Species	Number	Length (mm)	Weight (g)
A	Yaupon shrub	--	--	--	--
B	Yaupon shrub	--	--	--	--
C	Yaupon shrub	*Rattus rattus*	2	264 256	183.6 159.7
D	Grassy area along drainage canal	*R. rattus*	1	294	280.2
		Sigmodon hispidus	2	227 211	104.2 53.1
E	Grassy area along drainage canal	*R. rattus*	1	226	67.4
F	Edge of salt marsh	--	--	--	--
G	Mixed shrub along drainage canal	*R. rattus*	1	149	26.8
		S. hispidus	1	230	71.0
H	Lawn-savannah	--	--	--	--
I	Mixed shrub on RR grade on McQueens Is.	*S. hispidus*	1	229	73.0
J	Mixed shrub on RR grade on McQueens Is.	*R. rattus*	1	343	141.8
		S. hispidus	2	233 116	71.8 22.4
K	Grassy area along drainage canal	*R. rattus*	1	365	202.5
L	Grassy area along drainage canal	--	--	--	--
M	Inside fort	--	--	--	--
N	Inside fort	--	--	--	--

of a sabal palm and disappeared into the thick crown of the palm. (Fig. 2, bottom, p.28) This behavior indicates a potential arboreal habitat and refuge for the black rat on Cockspur Island, in addition to on-the-ground habitat.

Rice rats (Oryzomys palustris) were not observed during the survey, but specimens have been collected from Cockspur Island (Neuhauser and Baker 1974). The rice rat in undoubtedly a ubiquitous resident of the Spartina marsh community (Sharp 1967).

Norway rats (Rattus norvegicus) and house mice (Mus musculus) were not seen during the survey, although they have been reported from Oysterbed Island (Neuhauser and Baker 1974), a spoil island similar in many respects to Cockspur Island. Oysterbed is located on the north side of the Savannah River, adjacent to Cockspur. House mice are abundant on Tybee Island (J. Richardson pers. comm.). The evidence would suggest that the norway rat and house mouse are probable residents of the Park in low numbers. The cotton mouse (Peromyscus gossypinus) occurs on several of the Georgia coastal islands (Neuhauser and Baker 1974) but is a highly doubtful member of the Fort Pulaski mammal community.

The gray squirrel (Sciurus carolinensis) was not observed during the survey, although it has been recorded for Cockspur Island (Neuhauser and Baker 1974). Although some individuals may exist on private property at the west end of Cockspur, the gray squirrel is not a common species within the Park. The fox squirrel (Sciurus niger) and flying squirrel (Glaucomys volans) have never been reported for the Park.

Cetacea. A group of 12 common dolphins (Tursiops truncatus) were observed moving upstream in the north channel of the Savannah River in June 1979. Common dolphins occur at all seasons within the estuaries and larger tidal creeks of the Park.

Carnivora. Raccoons (Procyon lotor) were observed throughout the duration of the survey in a variety of habitats, including all shrub communities, salt marsh communities and the marsh/terrestrial interface. Some of these animals appeared normal, but others were sick and weakened, and some were found dead. An emaciated individual was observed March 1978 as it drank from a small water hole in the bed of a dry drainage canal. The water hole, approximately 10 cm in diameter and 20 cm in depth, had obviously been excavated by raccoons, probably an indication of a critical shortage of available fresh water on the island at the time (Fig. 3, top). Three recently dead raccoons were discovered February 1979, including two found floating in the drainage canals. The disease impacting the Pulaski raccoon population at that time was not determined, but Park personnel reported (pers. comm.) at least one confirmed case of recent rabies and several other suspected cases.

A mink (Mustela vison) was observed dead on Highway 80 of McQueens Island in March 1978, the evident victim of a car. Although no live animals were observed, this elusive predator is a common mammal of the Georgia coast, occurring within Pulaski boundaries in salt marsh communities and along drainage canals.

The river otter (Lutra canadensis) was not observed during the survey. It is a common and mobile member of the marshland



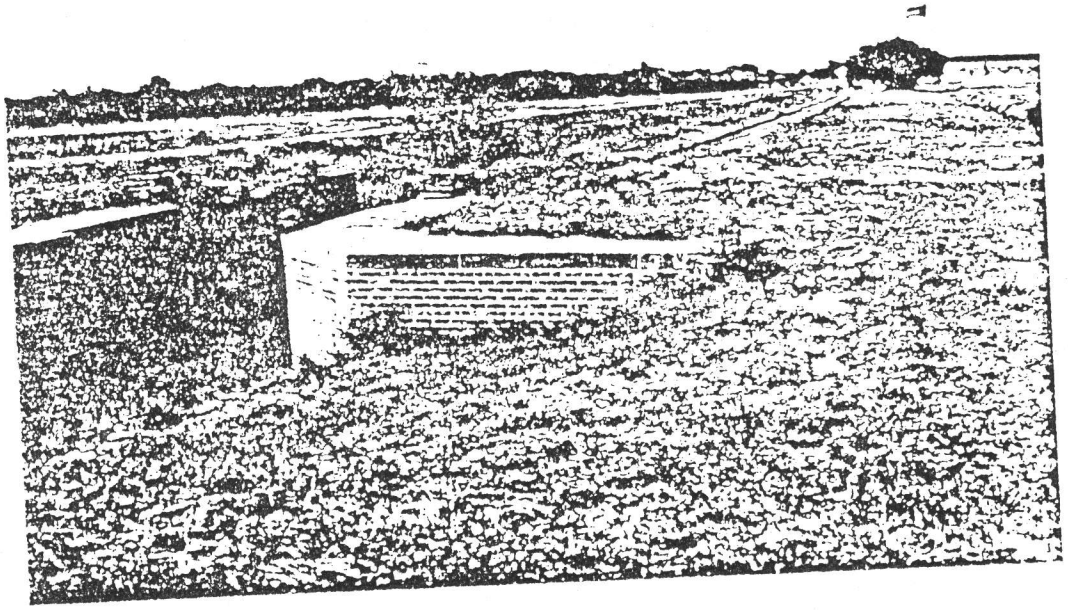


Figure 3. Top: Fresh water is a limiting resource during drought. Isolated water holes are prime suspects for the transmission of contagious disease among raccoons. Bottom: The feeder canal supports a community of euryhaline fish species which are adapted to fluctuating water levels.

community and should be expected from time to time within the Park boundary.

The bobcat (Lynx rufus) was not observed during the survey, and its occurrence within the Park is considered very rare. John Richardson, Park Ranger-Naturalist at Fort Pulaski, reported seeing a bobcat "passing through" Cockspur Island in the 1950's, but the record has never been substantiated (Neuhauser and Baker 1974). The bobcat is common on the mainland but rare on the coastal islands.

Sirenia. The manatee (Trechechus manatus) was not observed during the survey, but it should be considered a rare summer visitor to the tidal creeks within the Park. It occurs in low numbers in Georgia's tidal creeks and estuaries during summer months (Anon. 1978), and the marks left by its grazing activity in the low Spartina marsh appear regularly along the Georgia coast. Tomkins (1958) collected a skull from Savannah harbor.

Artiodactyla. The white-tailed deer (Odocoilus virginianus) is a permanent resident of Fort Pulaski, ranging over most of the terrestrial habitats of Cockspur Island. Tracks were observed in all shrub communities and along the marsh/terrestrial interface. One individual of unknown sex was flushed in February 1979 from the juniper/mixed shrub community, one of the most limited of all shrub communities for deer habitat.

Most deer sightings were in areas of savannah and lawn on the western end of Cockspur Island. Park maintenance and administrative personnel reported previously seeing a herd of 6 deer prior to the October 1979 survey. This herd, consisting of 1 spike

buck, 2 does and 3 yearlings, was sighted in the grassy area east of the harbor pilot's pier. One large buck was also seen occasionally at the west end of the Park.

A total of 9 deer were sighted during night head counts on Cockspur Island. Five deer (2 does and 3 yearlings) were seen grazing on the lawn east of the Superintendent's house on the night of 9 October 1979. A doe and 2 yearlings, perhaps part of the previous night's herd, were seen grazing in the same area on the following evening. One unidentified deer was sighted on private property to the west of the Park boundary on 10 October 1979.

The October 1979 herd was roughly estimated to be 8 individuals, for a density of 1 individual per 14 ha of upland Park property on Cockspur Island. All deer sighted during the survey appeared to be in good health. No deer carcasses, skulls or skeletons were observed. Most significantly, there was no indication of a browse line within any of the plant communities on Cockspur Island. It was concluded that the present Park herd was within the carrying capacity of the available food resources.

HERPETOFAUNA

Reptiles and amphibians recorded for Fort Pulaski are presented in Table 7. There were no additions or known deletions made to this list during the survey.

Leopard frogs (Rana utricularia) were observed in June 1978 in small drainage canals south of the visitors' center. Conditions were very dry at the time. Narrow-mouth toads

Table 7. Reptiles and amphibians observed at Fort Pulaski National Military Park and from the records of the Savannah Science Museum.

ORDER
Family
Scientific name
Common Name

CROCODYLIA

Alligatoridae
Alligator mississippiensis
American Alligator

Snakes

SQUAMATA (Suborder Serpentes)

Viperidae
Agkistrodon piscivorus piscivorus
Eastern cottonmouth

Crotalus adamanteus
Eastern diamondback rattlesnake

Colubridae
Opheodrys aestivus
Rough green snake
Elaphe guttata guttata
Corn snake
Elaphe obsoleta quadrivittata
Yellow rat snake
Lampropeltis getulus getulus
Eastern kingsnake
Coluber constrictor priapus
Southern black racer

Lizards

SQUAMATA (Suborder Lacertilia)

Iguanidae
Anolis carolinensis carolinensis
Green anole

Scincidae
Leiolopisma laterale
Ground skink
Eumeces inexpectatus
Southern five-lined skink

Anguidae
Ophisaurus ventralis
Eastern glass lizard

Frogs and Toads

ANURA

Bufonidae
Bufo terrestris
Southern toad

Microhylidae
Gastrophryne carolinensis
Eastern narrow-mouthed toad

Hylidae
Hyla cinerea
Green tree frog
Hyla squirella
Squirrel treefrog
Acris gryllus gyllus
Southern cricket frog

Ranidae
Rana utricularia
Southern leopard frog

(Gastrophryne carolinensis) and southern toads (Bufo terrestris) were found in burrows beneath discarded plywood adjacent to the same drainage canals.

A rattlesnake (Crotalus adamanteus) was observed at mid afternoon on 9 October 1979 crossing a spoil area near the western Park boundary on Cockspur Island. The snake was estimated to be 1.2-1.4 m in length. No cottonmouths (Agkistrodon piscivorous) were observed during the survey. Several yellow rat snakes (Elaphe obsoleta quadrivitatta) were observed in April 1978 in mixed shrub and yaupon shrub communities. One individual was coiled in an abandoned redwinged blackbird nest in the mixed shrub community.

Alligators, a threatened species on the Georgia coast, were not observed during the survey, but they frequently occur on Cockspur Island in the moat and in the larger drainage canals. Alligators commonly occur in salt marshes, tidal creeks and estuaries; their presence in the salt marsh habitats of Cockspur and McQueens Islands should be anticipated.

FISH

The combined fish collections from the two sampling sites totalled 1053 individuals, representing 6 families and 8 species. The total preserved wet weight of the samples was 1204 g (Table 8). The moat feeder canal (Fig. 3, bottom, p36) contained 8 species, a numbers density of 5 individuals per linear meter and a biomass density of 8.5 g wet weight per linear meter. The drainage canal contained 4 species, a numbers density of 6 individuals per linear

Table 8. Fish samples taken from the moat feeder and drainage canals of Cockspur Island, Fort Pulaski National Military Park, October 1979.

FAMILY Scientific name Common Name	Total number	Total weight (g)	Catch by number (%)	Catch by weight (%)
	Moat Feeder Canal			
MUGILIDAE				
Mugil cephalus Gray mullet	40	338	7.9	39.7
ELOPIDAE				
Elops saurus Ladyfish	2	102	0.4	14.1
GOBIIDAE				
Dormitator malculatus Fat sleeper	3	92	0.6	10.8
CYPRINODONTIDAE				
Fundulus heteroclitus Atlantic mummichog	6	49	1.2	5.6
Cyprinodon variegatus Sheepshead minnow	27	53	5.4	6.2
POECILIIDAE				
Poecilia latipinna Sailfin molly	248	149	49.4	17.5
Gambusia affinis Mosquitofish	173	51	34.5	6.0
SERRANIDAE				
Centropristis striata Black seabass (larvae)	3	1	0.6	0.1
	502	852	100.0	100.0
	Drainage Canal			
MUGILIDAE				
Mugil cephalus Gray mullet	4	88	0.7	25.0
CYPRINODONTIDAE				
Fundulus heteroclitus Atlantic mummichog	4	18	0.7	5.1
POECILIIDAE				
Poecilia latipinna Sailfin molly	324	183	58.8	52.0
Gambusia affinis Mosquitofish	219	63	39.7	17.9
	551	352	99.9	100.0

meter and a biomass density of 3.5 g wet weight per linear meter.

Three larval black seabass (Centropristis striata) were taken from the moat feeder canal. This important commercial species uses estuaries as nursery grounds during summer and fall before migrating offshore as juverniles (Bozeman and Dean 1980). It was the most stenohaline (narrow salinity tolerance) of all the species taken.

Seven other species taken in the moat feeder canal were characteristic euryhaline species, i.e., capable of tolerating a broad range of salinities. The gray mullet (Mugil cephalus), sheepshead minnow (Cyprinodon variegatus), Atlantic mummichog (Fundulus heteroclitus), sailfin molly (Poecilia latipinna) and mosquitofish (Gambusia affinis) enter protected pools in the high marsh because of an abundance of detrital food and relative protection from a host of predaceous fish species inhabiting the adjacent tidal creeks and estuaries. The ladyfish (Elops saurus) and fat sleeper (Dormitator maculatus--a goby) are predaceous on other fish and are present in such bodies of water because of the abundance of easily accessible prey.

All species taken from the drainage canal were also present in the larger moat feeder canal. These, the mullet, mummichog, molly and mosquitofish, are the most tolerant of very low salinities, and all but the mummichog have been collected in tidally influenced rivers many miles inland from the nearest salt water (Smith-vaniz 1968, Hoese and Moore 1977).

Within the feeder canal, the mullet was the dominant biomass species (39.7% of total wet weight) and the sailfin molly

was the most numerous (49.4% of individuals). The molly, mosquitofish and mullet accounted collectively for 63.2% of the biomass and 91.8% of total individuals at that site. Within the drainage canal, the molly was the most dominant in biomass (52.0% of total wet weight) and numbers (58.2% of individuals). The molly, mosquitofish and mullet accounted collectively for 94.9% of the biomass and 98.5% of total individuals taken from the drainage canal.

DISCUSSION

Fort Pulaski National Military Park is located within a rich and varied coastal habitat (Johnson et al. 1974). However, the numbers and species richness of the fauna associated with the Park are considerably less than regional totals. Faunal diversity is closely linked to habitat diversity. Upland areas in the Park, located primarily on Cockspur Island, are not as extensive as on most other coastal islands, with a concomitant reduction in habitat diversity as a result. Furthermore, Cockspur Island is a heavily impacted, manmade spoil island, resulting in further limitations of habitat types. Nevertheless, the Park does support populations of resident and transient fauna which are characteristic of regional barrier islands. Pulaski fauna add considerable scientific and educational dimension to the Park.

BIRDS

Vegetative mapping units reflected different categories or aspects of the Fort Pulaski bird community. An exception to

this was the juniper/mixed shrub community which, in terms of bird habitat, is considered a subset of the larger mixed shrub community. Except for the palm community, which was too small in area to be considered separately, all other plant communities appeared to have unique qualities which affect the structure of their associated bird communities. The following mapping units are considered individually.

Yaupon shrub. The evergreen aspect (Ilex vomitoria, Sabal palmetto, Prunus caroliniana, etc.), canopy height (5 m) and depth (200 m) of this community make it the most forest-like of any habitat on the island. Its winter bird density (25.2 ind.) and total estimated numbers (475 ind.) were higher than for most other upland areas, perhaps relecting its value as shelter from winter weather or as a source of available food. With the exception of the solitary vireo and black-and-white warbler, yaupon shrub supported winter bird species found in other upland shrub communities as well. Its value to the winter bird community, therefore, is one of good quality habitat rather than unique habitat.

The yaupon shrub community provides unique nesting habitat for the yellow-billed cuckoo and eastern wood peewee and good quality nesting habitat for an additional 13 species of birds found in other areas of the Park.

Mixed shrub. The density of wintering birds in the mixed shrub community was 16.2 individuals per hectare or approximately 60% of yaupon shrub density. Its larger size (25.9 ha versus 18.9 ha for yaupon shrub) accounts for its near equal importance as habitat for total numbers (419 ind.) Species composition was approximately

the same, with a similarity index of 81% between the two shrub communities. Mixed shrub contains a winter bird community similar to the yaupon shrub, but the habitat supports fewer numbers per unit area.

Mixed shrub supported the highest density of nesting pairs on the island (4.3 pairs/ha) and nearly half the estimated total number of nesting pairs (112/274). The painted bunting and white-eyed vireo favored mixed shrub over yaupon, and the rufous-sided towhee was found nesting only in the mixed shrub community. Similarity of the breeding bird communities between yaupon shrub and mixed shrub. (S.I.=73%) was less than for winter birds but still high.

Pine An important coastal plant community is represented by the 1.2 hectare stand of slash pine at the picnic area, although additional pines may be found on private property west of the Park boundary on Cockspur Island. The remnant of pines at the picnic area supported the highest winter bird density in the park (35 ind./ha), indicating the desirability of this limited winter habitat as a foraging area. The pine community provided the only nesting habitat in the Park for the pine warbler. The limited area (1.2 ha) may also explain the absence of such common coastal nesting species as the yellow-throated warbler and summer tanager.

Lawn and savannah The value of lawn and savannah was low for winter habitat (3.6 ind./ha) but surprisingly high for summer nesting species (13) and nesting density (1.2 pairs/ha), considering the percentage of open lawn with little or no protective trees.

(Fig. 4, top) Scattered trees and shrubs provided an important nesting habitat for boat-tailed grackles and mockingbirds, while open areas were important for willets and the only meadowlark observed. Barn swallows and chimney swifts used these areas for feeding; the swallows nested under the access bridge and the swifts nested in the chimney of the Superintendent's home.

Spoil The least habitable of all upland communities was the spoil area (Fig. 4, bottom, p.47). There were no winter birds observed on spoil, and only two species, the common nighthawk and willet, appeared to utilize the area in small numbers for nesting.

In summary, nesting densities for shrub communities (3.8 pairs/ha) were low but still within the range of densities for other, similar brush and scrub communities (2.47-7.41 pairs/ha) surveyed throughout the United States (Udvardy 1957). Considering the two major shrub communities, yaupon shrub appeared more important as winter habitat while mixed shrub was more important as summer nesting habitat. Palm and juniper/mixed shrub were considered equivalent to mixed shrub as bird habitat. Pine is an important but severly limited habitat on Cockspur Island for summer nesting and winter habitats. Lawn and savannah supported limited numbers of winter birds but a considerable assemblage of summer residents. Spoil areas were of no value to wintering birds and of very little value to summer residents.

Areas influenced by the tide were not surveyed, since they are rarely affected by Park management and because they support few bird species. The clapper rail and long-billed marsh wren are common summer residents, nesting in cordgrass, Spartina alterniflora. Seaside

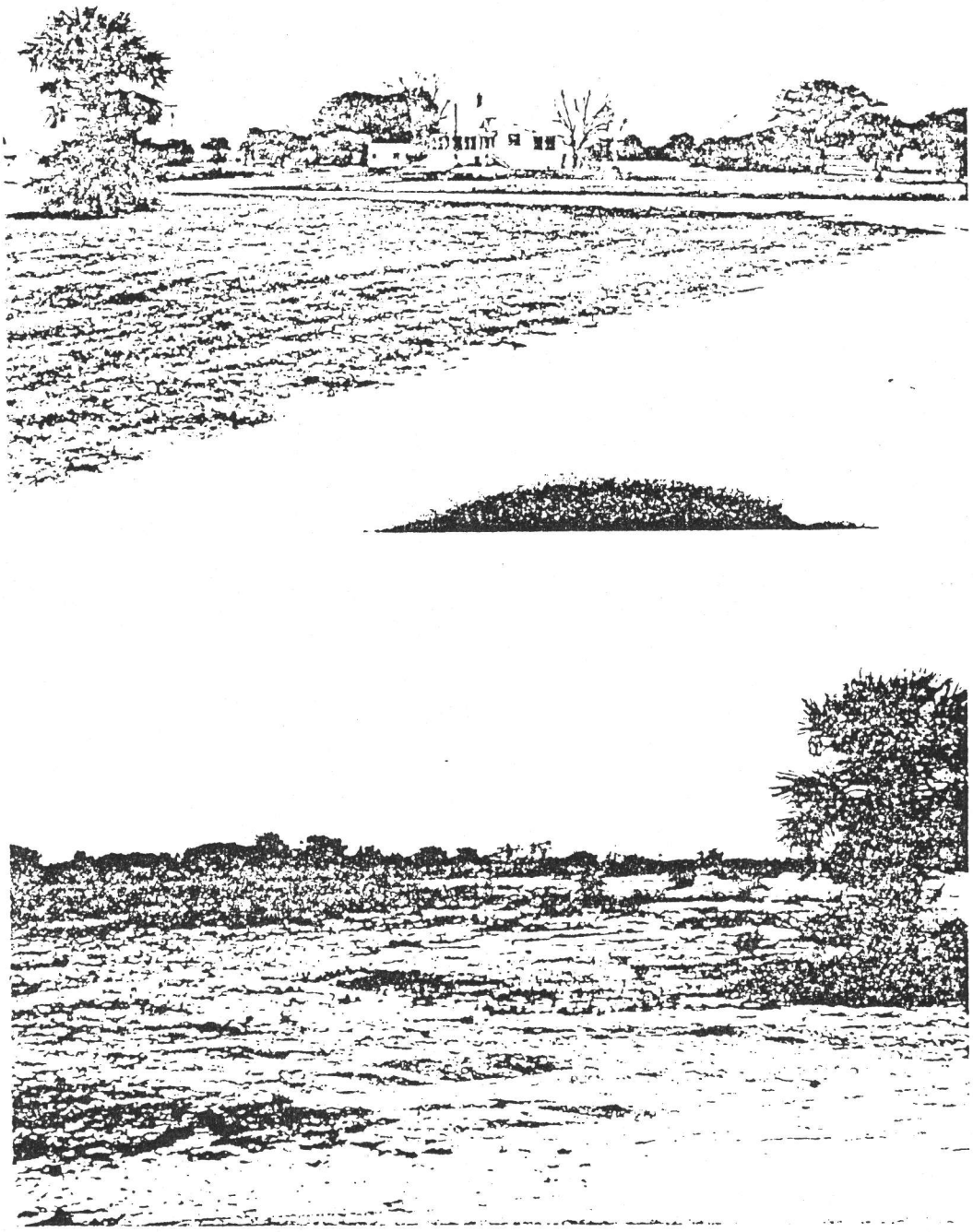


Figure 4. Top: Lawn and savannah provide important habitat for a variety of nesting bird species. Bottom: Spoil deposits provide limited habitat for nesting birds and almost no habitat for wintering birds.

sparrows may nest in low shrubbery along the high marsh, and an occasional pair of American oystercatchers will nest with willets on raised, isolated mounds scattered throughout the low marsh community. Most abundant of all are the redwinged blackbirds, which nest in the woody shrubs of the salt marsh shrub border communities or edge zone marsh (Wharton 1978). The prevalence of this habitat makes the redwinged blackbird a pervasive nesting species on the perimeter of Cockspur Island and along the railroad and highway rights-of-way of McQueens Island.

Many birds feed in the salt marsh but nest elsewhere. Important among these are the willet, great blue heron, little blue heron, Louisiana heron, great and snowy egrets, white ibis and marsh hawk (Wharton 1978). A few birds, such as the short-eared owl, winter in the salt marsh. Similarly, a diversity of shorebirds are usually present at low tide, feeding on the tidal flats at the east end of Cockspur Island.

Management Recommendations

1) Pine plantation. The pine community is a severly limited habitat on Cockspur Island. Furthermore, the amount of regeneration by young pine seedlings at the picnic area is almost nonexistent because of the impaction by people, recreational vehicles and mowing. There is no second generation to replace the present trees as they die. A substantial pine plantation could be planted and developed south of the maintenance road, from the existing picnic area to the Park's western boundary of Cockspur Island. Containerized slash

pine (Pinus elliottii) seedlings, selected for forestation of spoil areas on Cockspur Island, should be local stock. Furthermore, the seedlings should be artifically fumigated with a pure culture of the ectomycorrhizal fungus, Pisolithus tinctorius. This symbiotic fungus endows pine seedlings with considerable resistence to acidity (low pH), high soil temperature, and low soil nutrients, conditions which may well be associated with Cockspur Island spoil deposits. The resulting pine plantation of this size would ultimately increase the diversity and abundance of the upland bird community, reclaim spoil areas as useful wildlife habitat and provide an expanded area for picnicing and/or camping. If the development of a pine plantation is undertaken, the proven method of periodic, controlled burning should be considered to prevent takeover by a shrub community after the pine stand is established.

2) Edge effect versus minimum habitat requirements. The continuity of the shrub communities is disrupted by the pattern of mowing within and around the areas. This mowing pattern has resulted in an increased amount of edge relative to the total area of these communities. Edge enhances habitat quality for a variety of species, including the painted bunting, but its extent can be overdone if the remaining habitat untis become too small to support home range for nesting pairs. The reduced number of winter and summer birds associated with the juniper/mixed shrub community occurs because the form of the area is long and narrow, leaving little shelter and depth of cover. Mowing practices on Corkspur appear to be reducing the volume of shrub communities by undercutting the vegetation along edges. This practice should be modified so that further reduction and fractionalization

of shrub habitat do not occur. The current limiting factor for nesting birds is probably home range volume and not the availability of edge.

3) Mowing practices. Ground nesting species, such as the willet and meadowlark, are undoubtedly impacted by spring mowing of lawn and savannah habitats. These birds could probably complete an initial brood if spring mowing was postponed until late June or early July. The diversity and abundance of meadow flowers would also be increased by a late spring mowing schedule.

4) Snag habitats. A number of birds are cavity nesting species, depending on hollow snags for nest sites. Such species were noticeably reduced or absent from the Ft. Pulaski summer bird community. Present but in small numbers were the great crested flycatcher and Carolina chickadee. Cavity nesters absent from the summer survey included the screech owl, titmouse, bluebird and all species of woodpeckers. Thus, standing dead trees and snags should be protected as critically limiting habitat for cavity nesters. A program to build and distribute nesting boxes on Cockspur Island would greatly increase the value of the area for cavity nesters. A nest box program could become an interesting research and educational effort, which might be pursued jointly with local schools or youth groups, the Savannah Science Museum or the Oatland Island environmental education program situated adjacent to the Park. A followup community study of cavity nesting species would provide insight into the ecology of limiting factors on Cockspur Island (Conner 1978) if a nest box program were to be established.

5) Interpretation. The highest priority should be placed on interpretive nature walks, raised board walks and marsh walks, because of the educational quality compatibility of the experience with the historical aspects of a visit to Fort Pulaski. The extent of a nature trail system should be determined, in part, by the amount of Park visitor use in order to maintain a high quality experience (Ike and Richardson 1974).

A nature trail, extended through the juniper/mixed shrub and mixed shrub communities to the north and east of the Fort (Fig. 1), would complement existing trails and add considerably to the opportunities for observing bird life on Cockspur Island. The eastern terminus of the trail could culminate with a short board walk through the marsh and an observational platform for visitors to study the rich variety of shorebirds which feed at low water on the mudflats adjacent to the old lighthouse. Also accessible at this point for interpretation are excellent examples of low marsh, high marsh and salt pan communities, as well as the high marsh/shrub interface with its dense numbers of nesting redwinged blackbirds. The trail should be at least 2 m in width, for protection against poisonous snakes, and accessible at several points by simple foot bridges which would cross the drainage canal bordering the parade ground. A nature trail through the juniper/mixed shrub and mixed shrub communities would not adversely affect nesting birds or other forms of wildlife. The current trail system is restricted almost entirely to the yaupon shrub community.

6) Critical areas. There are no critical areas with birds which are vulnerable to disturbance by the presence of visitors on Cockspur and McQueens Islands. There are no heronries or other nesting assemblages which need special protection. Nesting and feeding is disbursed throughout the upland plant communities and would be little affected by the presence of visitors on the trail systems. In fact, certain species, such as herons, adapt quickly and will tolerate visitation by people, if visitation is a common and continuous event (Hillestad et al. 1975). The presence of feeding herons and egrets in the Park drainage canals will not be affected and possibly will be increased with greater numbers of Park visitors.

7) Supplemental feeding. Most visitors to Fort Pulaski arrive without binoculars and are unaware of the painted bunting, one of the Park's most abundant and strikingly colored nesting species. A millet or mixed seed feeder, located by the door of the visitors' headquarters, would attract large numbers of these beautiful birds during the summer months. Visitors could view these and other island species from a distance of only a few feet. A feeder is an inexpensive and easily maintained structure which would add a considerable additional dimension to the visitors' experience. Additional feeding, to support and/or increase total numbers of birds on Cockspur Island, is unnecessary and not advised. The upland habitats are rich with berry-producing plant species, probably accounting in large part for the present diversity and abundance of upland birds within the Park.

MAMMALS

The mammal community of Cockspur and McQueens Islands is typical of small Georgia coastal islands with a restricted variety of habitats and a depauperate mammal community (Johnson et al. 1974, Hillestad et al. 1974, Richardson and Worthington 1975). Local extinction rates are high because of marginal habitat and uncertain food and water supplies. Recolonization is slower than on the mainland because of the natural barriers associated with insularity. Species present are highly mobile (bats), at home in the salt marsh environment (marsh rabbit, mink, otter) or can swim well (rats, raccoon, deer).

Mammals associated primarily with the estuaries, Spartina marshes and the salt marsh/terrestrial interface are part of a much larger estuarine ecosystem and require no management considerations for Fort Pulaski. Included in this category are the marsh rabbit, rice rat, cotton rat, bottle-nosed dolphin, mink, otter and manatee. These are native species which should be considered a highly desirable component of the Fort Pulaski system. Bats are transient species which require no management, unless fecal deposits associated with roosts or nursery areas in buildings become aesthetically unacceptable. No such situation currently persists within the Park boundaries.

Raccoons present a serious management challenge for Fort Pulaski. Coastal populations are unstable and frequently more dense (individuals per unit area) than associated mainland populations (Hillestad et al. 1975). This characteristic is probably the result of a boom and bust food supply and a lack

of natural predators. Island population levels are regulated by intrinsic population controls, including a reduction in fertility of females, reduction of litter size, increased infant mortality, parasites and disease. Population control by disease is usually accomplished by distemper and sylvatic rabies, although the incidence of sylvatic rabies is relatively low, as raccoons tend to be somewhat resistent to the disease (Johnson 1969). Once a disease is introduced into an island population, usually by unvaccinated pets or by wild animals moving along the highway corridor from the mainland, the rate of spread and duration of an epidemic will depend on the raccoon population density.

Respiratory disease (pleurisy, pneumonia) and canine distemper have been the primary causes of disease related raccoon mortality in Alabama (Johnson 1970) and Kiawah Island, South Carolina (Dr. F. Arnold-pers. comm.). Alabama mortality occurred during the colder months of November through April. Sick animals were seen during daylight hours, and their behavior was diagnostic. Afflicted individuals appeared unusually tame and indifferent to the presence of humans and offered no resistence when captured.

A number of sick and dead raccoons were observed on Cockspur Island during the colder months of the survey. In March 1978 an emaciated animal exhibited the characteristic indifferent behavior of the Alabama animals. Three recently dead animals were seen in February 1979, two of them floating in the drainage canals. Animals observed in June 1979 were active and apparently healthy. Disease other than rabies is probably the primary controlling agent of Pulaski raccoon populations, although a confirmed case of rabies has been reported (Fort Pulaski Park personnel-pers. comm.).

The black rat is a dominant member of the Fort Pulaski small mammal fauna and is found throughout all of the upland plant communities. It is a pest species introduced from Europe and an agressive competitor of the native cotton rat for available food and space. Numbers of individuals in the Pulaski population are probably determined by the flux of excess individuals from adjacent industrial complexes and harbor facilities of the Savannah region, as well as by reproduction within the island population. The arboreal capability of the black rat makes it a potential predator of nesting songbirds in the Park.

The white-tailed deer is a ubiquitous member of coastal mammal populations, wherever shrub or forest communities are found. Although a woodland browser by preference, deer will readily graze roadsides, lawns and the high salt marsh. They are excellent swimmers, capable of crossing the Savannah River and moving from one island to another. Deer from coastal populations tend to be smaller than their mainland counterparts, occur in denser numbers and have a lower reproductive rate (Osborne 1976).

The Cockspur Island deer herd of about 8 animals represents a low density (1 deer per 14 ha) population relative to most other coastal islands. One individual per 4 ha is considered a high density population for Blackbeard (Osborne 1976) and Sapelo Islands (C. V. Waters-pers. comm.), both Georgia coastal islands. The 58 ha of lawn and savannah and 53 ha of shrub and forest communities, plus the private holdings on the west end of Cockspur Island, are more than adequate to support 8 animals. The lack of a browse line on palatable shrubs (Juniperus, Bumelia) and vines (Ampelopsis, Smilax) supports this observation.

Reasons for a reduced density of the Cockspur Island deer herd are unclear. Hunting pressures on the private portion of the island are not known, but Park Service personnel (pers. comm.) indicate that little, if any, hunting activity occurs there. There is no evidence to suggest that in past years the Pulaski herd was overpopulated and crashed and that it is now in a building phase. The herd could increase in the future, since the carrying capacity of the island has not yet been reached. If present numbers are low because of past disease or hunting pressure, an increase in the Pulaski herd would be expected. Animals are probably recruited from Jones, Turtle and Oysterbed Islands, located north of the Savannah River.

Management Recommendations

1) Freshwater supplies. Available freshwater appears to be a limiting factor at certain times of the year for Pulaski mammals, particularly the raccoon. Restricted water holes during droughts are prime suspects for the transfer of communicable diseases (Johnson 1970). Sources of flowing water, available year around at several remote locations on Cockspur Island, would alleviate much of this potential problem. A dish pan to collect water from a dribbling hose would suffice. A drip bath near the headquarters would attract many local birds and be an added interpretive dimension for visitors. Supplemental feeding of any of the native mammal species, including deer and raccoon, should be avoided.

2) Raccoons and disease. The raccoon is a suspected carrier

of a wide variety of diseases, some of potential public health significance. The American dog tick (Dermacentor variabilis), which commonly occurs on raccoons, has been implicated in St. Louis encephalitis, spotted fever and tularemia (Johnson 1970). Raccoons act as reservoirs for such human diseases as leptospirosis, rabies, Chagas' disease and tularemia. The propensity for wild raccoons, particularly coastal populations, to carry diseases makes them an important candidate for management.

Sick raccoons and raccoons exhibiting unusual behavior should be live trapped and transferred for examination to the Communicable Disease Center in Atlanta, the Southeastern Cooperative Wildlife Disease Unit in Athens or other qualified organizations. Detained animals should be considered contagious and treated with caution.

Disease in coastal populations of raccoons, including Cockspur and McQueens Islands, is a fact of life. Most diseased raccoons will probably have distemper, which is not infectious to humans. Poison and trap removal of healthy raccoons should be unnecessary if caution is exercised when sick animals are present. Under no circumstances should wild raccoons be attracted to human high use areas by inefficient trash removal or directed feeding at picnic areas or camp sites. If an occasional raccoon becomes a persistent visitor to such areas, it should be removed from the island.

3) Black rats and disease. The black rat, and its associated fleas and ticks, has been implicated in a wide variety of diseases, many of them of importance to humans. The black rat is a carrier of leptospirosis which is infective to both raccoons and man (F. Hayes-pers. comm.). There exists the potential for the transfer of disease

to Pulaski from city sewage and foreign ships. The considerable population of black rats on Pulaski grounds should thus be treated with suspicion concerning disease and managed accordingly.

A number of black rats should be live trapped and sent to authorities for survey. This procedure would at least provide an initial indication of the scope of the problem. Efforts should continue for removing black rats with poison bait around buildings and the fort, with care that the poison does not become overly accessible to raccoons and native rodents in the shrub communities.

Removal of black rats by predators should be encouraged, but feral cats should be avoided at all costs as they are detrimental to a wide variety of native fauna. Resident rat snakes, corn snakes and king snakes are prime rat hunters that should be protected. The addition of more of these predators, perhaps with the contracted efforts of a local herpetology club, should be considered. Another major consumer of rats is the barn owl, Tyto alba, one of which was flushed from the crown of a sabal palm on Cockspur Island during the June 1978 nesting bird survey. If a pair of these birds could be enticed to nest in a secluded portion of the fort or in a suitable nest box structure located elsewhere on the island, they would probably remove more than a thousand rats a year at no cost or danger of contamination to the environment. There is no known nesting sites available for barn owls on Cockspur Island.

4) Deer. There is no current need for managing deer within the Park boundaries, other than the hands-off policy now in effect. If the Pulaski deer herd exceeds carrying capacity in the future,

becomes emaciated in condition and stresses available food resources, there is a possibility of deer dieoffs. This, in itself, provides no danger to human visitors, but its visual effect can be disturbing. If conditions should warrent, a trap removal program could be initated.

5) Interpretation. Much could be done to describe the role of Pulaski mammals within the coastal ecosystem. Certain small mammal species, such as the marsh rabbit, cotton rat and rice rat, might be kept alive as part of a visitors' interpretive program at headquarters. These are elusive species that are rarely seen by the average Park visitor. Raccoons and deer should probably not be tamed or kept for interpretive purposes near headquarters because of greater logistical problems and the possibility of disease transmission.

HERPETOFAUNA

The low number of herpetofaunal species within the Park, relative to the Georgia coastal region, is expected. Species richness appears directly related to the available area of upland and freshwater habitat (Fig. 5). The causes of this relationship include insularity (natural barriers against colonization) and an increase in local extinction rate and decrease in habitat diversity from larger to smaller islands (MacArthur and Wilson 1967).

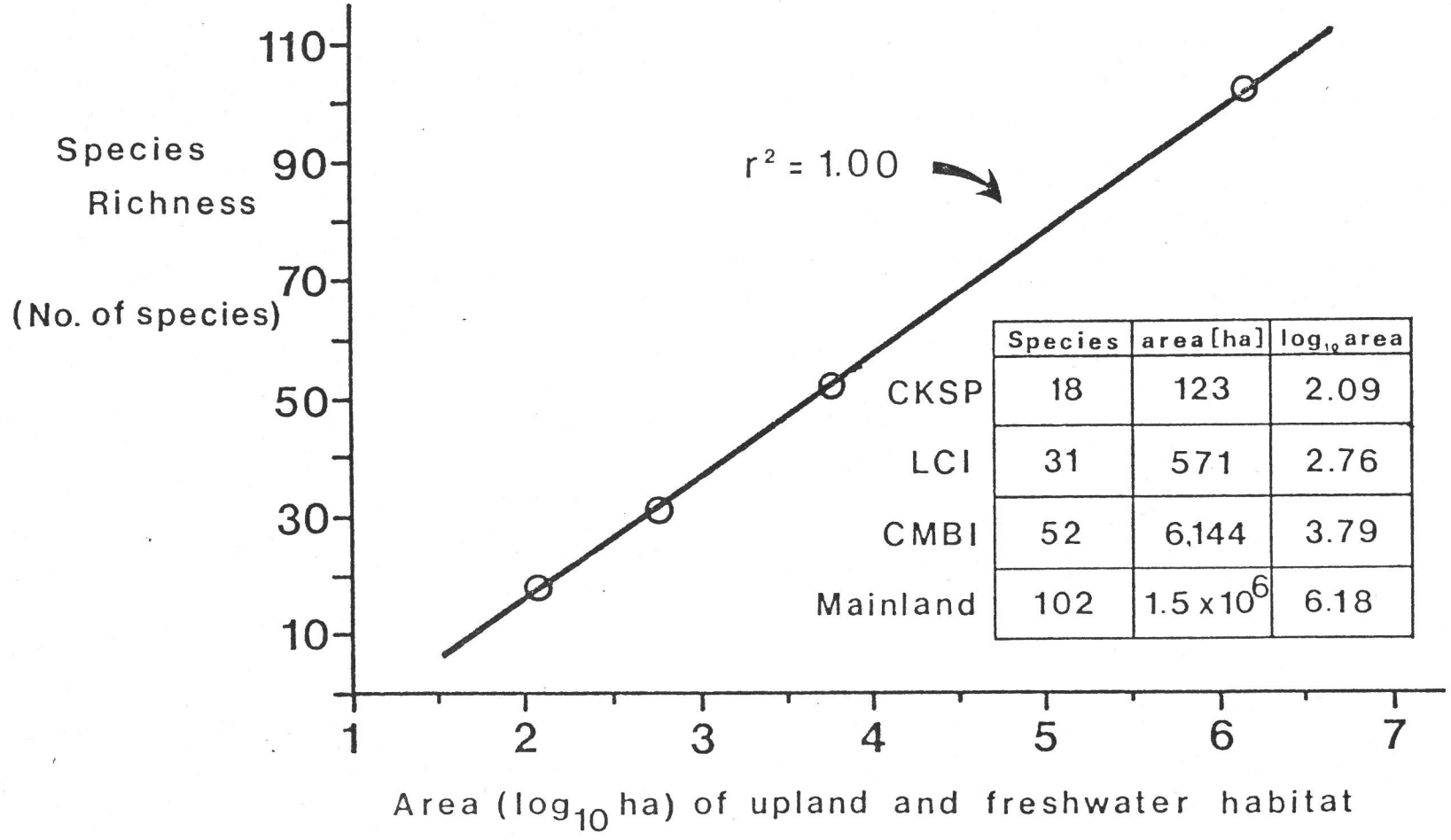
Amphibians are relatively more reduced on coastal islands than are reptiles, primarily because of the uncertainity of fresh water supplies on islands (Hillestad et al. 1975). Most amphibians

Figure 5. The linear relationship of herpetofaunal species richness to the total area of upland and freshwater habitat ($\log_{10}$ha) being surveyed. Locations are Cockspur Is. (CKSP), Little Cumberland Is. (LCI), Cumberland Is. (CMBI), and the lower coastal plain (LCP) of mainland Georgia. Data are from Hillestad et al. (1975) and G. Williamson (pers. comm.).

are opportunistic species, coordinating their life cycles to occasional periods of rain and standing fresh water (Richardson and Worthington 1975). In addition, Pulaski amphibians, including the narrow-mouthed toad (Hardy 1953, Neill 1958), southern leopard frog (Pearse 1911, Carr 1940) and southern toad (Allen 1932, Neill 1958), are particularly tolerant of occasional saline conditions. Salamanders are not as tolerant of saline water and are absent from the Park.

Reptiles constitute two-thirds of the Pulaski herpetofaunal species list. The cottonmouth, diamondback rattlesnake, corn snake, yellow rat snake and kingsnake are important rodent eaters. The kingsnake also feeds on other snakes, and the yellow rat snake is able to climb trees and thus takes nestling birds. The black racer specializes on frogs and lizards, and the green snake is an insect feeder. Pulaski lizards are insect eaters.

The cottonmouth and diamondback rattlesnake are of particular interest because of their potential danger to Park visitors. These two venomous species occur throughout all plant communities in the Park and may be active at any time of the year, even in winter, during periods of warm weather. They are highly mobile, moving with ease across salt marshes, tidal creeks and estuaries. Rattlesnakes are not uncommonly seen swimming at sea, miles from the nearest coastal island (G. Williamson-pers. comm.). Populations of these two species of snakes on Pulaski are probably regulated more by the flux of individuals moving into and out of the Park than by reproduction within the Park. The diamondback rattlesnake feeds on small mammals (rats, mice, rabbits) and can find its



	Species	area [ha]	$\log_{10}$ area
CKSP	18	123	2.09
LCI	31	571	2.76
CMBI	52	6,144	3.79
Mainland	102	1.5×10^6	6.18

food throughout the Georgia estuarine system, particularly along the interface of the salt marsh and terrestrial communities. Thus, these animals are probably most likely to be concentrated where dens are available rather than where food is available. Burrows, rubbish heaps, piles of palm fronds, abandoned and collapsed buildings and equipment dumps are all prime denning areas on Cockspur Island.

Turtles were not observed during the survey and have not been recorded by Williamson (Table 7, p.39) There is insufficient fresh water habitat for most "pond" turtles. The loggerhead sea turtle, common on adjacent islands, does not nest in the Park because of the absence of shoreline dunes. The mud turtle (Kinosternon subrubrum) and diamondback terrepene (Malaclemys terrapin) are common in the Georgia salt marshes and should be expected to nest on upland areas of both Cockspur and McQueens Islands.

Alligators occur throughout all Georgia coastal habitat, including salt marshes, estuaries and upland plant communities. They are particularly attracted to ponds, both fresh and salt, but are also capable of living and reproducing on the smallest of coastal islands. Coastal alligators frequently dig burrows under the banks of island sloughs, even where surface water is absent for much of each year. They build nest mounds in the sloughs during occasional wet years and feed primarily in the tidal creeks. The very young alligators feed on frogs and insects attracted to standing water in the burrows excavated by the adult alligators. As alligator population numbers increase

on the Georgia and South Carolina coasts, as anticipated, occasional individuals may take up permanent residence along the banks of the drainage canals on Cockspur Island, although present sight records appear to be only of transient individuals. If resident alligators appear in the future, their occurrence should be considered a valuable addition to the Pulaski fauna and not a danger to island visitors.

Management Recommendations

1) Resident herpetofauna. There are no management needs indicated for the majority of herpetofaunal species in the Park. Resident amphibians are adapted to the unpredictable water regime of the drainage canal systems. Resident reptiles are terrestrial and adapted to the existing variety of upland shrub and savannah communities.

2) Venomous snakes. Rattlesnakes and cottonmouths are a regular component of the Pulaski community and should be managed as such. The removal of occasional individuals is acceptable, but this effort will not eliminate poisonous snakes from upland areas because of the continued influx of these animals from adjacent regions. Park visitors should be warned of the presence of venomous snakes and instructed how to avoid them. Nature trails should be kept wide (2 m) and clear of potential sheltering material, such as brush piles or stacks of palm fronds. Denning sites should be eliminated whenever possible. Raised foot bridges across drainage canals will allow visitors to

observe this wetland community without placing them in contact with possible cottonmouths. Existing mowing practices presently function well to keep tall grass away from the trails. Vegetation along the canal banks provides a high risk location for cottonmouths.

FISH

The Fort Pulaski fish community provides a classic example of species associated with a series of high marsh, limited access aquatic systems (Dahlberg and Odum 1970). These range landward from high salinity salt marsh creek heads to low salinity high marsh pools and fresh water systems, with occasional connection to the estuarine environment (Richardson and Worthington 1975).

The species of fish associated with the Pulaski canal system are particularly adaptable to a wide and varying range of environmental conditions. Water temperatures may occasionally dip to 0° C and rise to 40° C. Dissolved oxygen does not remain in solution when water becomes too warm; several of the Pulaski species, including the molly and mosquitofish, are capable of gulping air at the surface when dissolved oxygen drops to zero (Odum and Caldwell 1955). Salinities also range widely, from normal sea water (20 ppt) when spring tides flood the canals, to hypersaline (30 ppt) when evaporation concentrates the canal water, to fresh (0 ppt) when heavy rains flush the canals. Most capable of tolerating the widest range of ambient conditions are the molly and mosquitofish, which collectively accounted for 98% of the individuals and 70% of the wet weight fish biomass collected from the low salinity drainage canal. Both of these species

prefer low salinities and can thrive in fresh water (Hoese and Moore 1977)

Management Recommendations

1) Canal system fish community. There are no management suggestions directed specifically to the fish community of the canal system. The perpetuation of the fish will follow from the maintenance of the canals as a fluctuating water level system (see management of aquatic systems).

2) Interpretation of fish community. The euryhaline species of fish from the canal systems are particularly amenable to captivity in aquaria. One of more such aquaria could be easily maintained as an interpretive aid at or near the visitors' center. A striking example of Pulaski fish ecology may be achieved with paired tanks, one saline (20 ppt) and the other fresh, both with similar species of fish.

ENDANGERED/THREATENED SPECIES

The American alligator is the only protected species which occurs regularly within upland habitats and the drainage canal system of the Park (Odom et al. 1977, U. S. Fish and Wildlife Service 1968). The status of the alligator has recently been moved from endangered to threatened in coastal areas of Georgia and South Carolina. There is little open water habitat on the upland portions of Pulaski that would attract alligators in significant numbers. If an occasional nuisance alligator above 6' in length

is encountered, the Georgia Department of Natural Resources, Office of Non-game/Endangered Species, should be called to assist with its removal.

There were no threatened or endangered species of birds observed within the Park boundaries during the study period, nor is there nesting or wintering habitat within the Park that might be considered of significance to populations of threatened or endangered bird species. The brown pelican occurs occasionally over the Savannah River and larger tidal creeks. Bald eagles, particularly the young birds, wander extensively during the late summer and fall and might be expected to pass through the Park at any time. The peregrine falcon is a fairly common migrant on the Georgia coast in October and November (Burleigh 1958).

There are no threatened or endangered mammals on the terrestrial portions of Fort Pulaski. The manatee occurs in the adjacent tidal creeks, but its aquatic existence removes it from conflict with the Park management program. The Sherman's pocket gopher (Geomys fontanelus) is recorded for Chatham County (Odom et al. 1977), but it has never been seen within the boundaries of the Park. It is currently listed as endangered on Georgia's protected species list.

Except for the alligator, there are no threatened or endangered reptiles or amphibians that might occur within the Park. The short-nosed sturgeon (Acipenser brevirostrum) is the only endangered fish in the Savannah River region, and it is not expected to enter the drainage canal system of Cockspur Island. There are no endangered invertebrates occurring within the Park.

EXOTIC SPECIES

An exotic species is any animal that is not a member of the native fauna. It may be introduced by man (i.e., fallow deer, Dama dama, on Saint Simons Island) or may be self-colonizing (European starling). There are no introduced exotic species within the Park. Self-colonizing exotics have become an integral part of the native faunal community. These include the European starling and the black rat. Only the black rat should be considered for management for reasons of disease transmission (see MAMMALS, DISCUSSION section, p.53).

INVERTEBRATES

Fort Pulaski has a rich and varied invertebrate fauna associated with the salt marshes, the drainage canal aquatic system and the upland. The role of salt marsh invertebrates in the estuarine ecosystem has been extensively interpreted in the literature (Teal 1958, Smalley 1960; Teal and Teal 1969) and in local exhibits at Skidaway Island and Oatland Island. Some interpretation of these invertebrates at Fort Pulaski could be part of an elevated, self-teaching, marsh boardwalk and nature trail. The high marsh fiddler crab (Uca minax) is an impressively large invertebrate that would be visible from a nature trail that transects the juniper/mixed shrub community.

Noxious insects are the invertebrates of greatest interest to Park visitors and staff, and they are the invertebrates most often targeted for management. Two species of salt marsh mosquito (Aedes taeniorhynchus and Aedes sollicitans) breed in the very

high marsh, where low salinity water collects under stands of salt grass (Distichlis spicata) or in the cracks of drying sediments associated with salt pans and spoil deposits (King et al. 1960). Blood sucking midges (Culicoides sp.), horse flies (Tabanus sp.) and deer flies (Chrysops sp.) also breed in the salt marshes, becoming at times unbearably abundant during warm weather which may last eight months in Georgia (Johnson et al. 1974).

Blood sucking insects are an integral, though noxious, part of the estuarine environment. They come primarily from the vast areas of salt marsh and not from relatively insignificant ecosystems such as the drainage canals on Cockspur Island. The drainage canals are of critical importance to upland fauna but a minor source of Fort Pulaski's biting insects. Misdirected efforts to control biting insects in the drainage canal system would provide little relief while perhaps damaging one of Cockspur's most valuable habitats. Use of the more persistent pesticides (Chlordane, Diazanone) in and around the canals should be cautiously avoided, for such pesticides may become rapidly concentrated in food chains which extend to fauna of the upland terrestrial habitat.

Malathion is a rapidly biodegradable insecticide. Its application as a fog on Cockspur Island can be effective for short periods of time in selected sites. Its impact is not selective but, in fact, broadly lethal to the entire insect community, including dragon flies, and spiders which prey upon large numbers of noxious insects. Malathion application to canal vegetation will be maximally destructive to the natural insect

community while not attacking noxious insects at their source in the salt marsh. Malathion fog should never be applied on Cockspur Island as a regularly scheduled practice but only when conditions dictate.

Management Recommendations

1) Noxious insects in terrestrial habitats. Reliance on a single method of insect suppression, i.e., malathion fog to kill adult biting flies, cannot be expected to provide an acceptable solution to all noxious arthropod problems on Cockspur Island. The application of malathion to shrubbery in the vicinity of houses and picnic areas will bring temporary relief to local areas, but the effects on nesting birds in the area are not known. Mechanical traps for the control of deer flies and horse flies should be considered, if needed. The balloon or canopy traps are quite effective. Other mechanical devices include light traps, suction traps and electric grids.

2) Miscellaneous pest arthropods. Ticks and chiggers did not appear to be a serous problem on Cockspur Island during the faunal survey. Gravel and macadam surfaces on nature trails and access walks appear to shield most Park visitors from these pests. A word of warning to visitors who wish to explore the shrub communities should be sufficient.

3) Canal systems. The primary management goal should be to maintain fluctuating water level systems in the drainage canals

for the maximum benefit of island fauna. Within this constraint, a number of steps can be taken to ensure that the canals are not adding noticeably to the biting fly problem.

a. Drainage canals, when flooded, must have a connection to the estuaries in order for fish to gain access for mosquito control. Drainage canals north of the access road, between Battery Hambright and the Superintendent's house, are functioning in this manner at the present time.

b. Drainage canals and shallow impoundments without adequate access to the estuaries should be provided with that access or with refugia pits for mosquitofish to survive periods of drought. Ditches and depressions located within and around mixed shrub communities on either side of the entrance road, as it enters Cockspur Island from the South Channel bridge, are likely areas for isolated impoundments.

c. If conditions are such that chemical control of larval mosquitoes in drainage canals becomes essential, a highly selective agent should be found. Certain larviciding oils, such as FLIT and MLO, are toxic only to surface breathing larval insects, such as mosquitoes and a few other fly species, and the oils ultimately degrade with no toxic residues left in the system.

Other pest species include fire ants, web worms, cockroaches and termites. The Park is licensed to use selected chemicals for these pests. Spot applications, as needed, are not considered a danger to the Pulaski faunal communities.

4) Interpretation Noxious insects are an integral part of Fort Pulaski and the surrounding estuarine environment. Visitors should be appraised of their presence, guided in methods to avoid them and urged to endure tolerable levels of annoyance. For example, fire ant mounds are easily avoidable if visitors are instructed to avoid them.

The introduction of visitors to moderate levels of pest

Superintendent
Fort Pulaski National Monument
P. O. Box 98
Tybee Island, Georgia 31328

annoyance is not without its historical lesson. Early living conditions in the fort must, at times, have been nearly intolerable. Remedies in the late 18th century to repel mosquitoes and biting midges were probably quite different from today's methods. A question for the Park visitor to ponder is whether the pests of yesterday are more or less tolerable than the poisons of today. Historical Savannah was decimated several times by yellow fever, but fewer people died of cancer then than now.

PULASKI ECOSYSTEMS

A central tenant of ecology states that the environmental whole is more than the sum of its parts. The ecosystem has qualities which are more than (cannot be explained by) the sum of the communities which make up the ecosystem. The Pulaski faunal survey has, to this point, dealt primarily and individually with discrete animal groups (birds, fish, etc.). A more complete understanding of Pulaski fauna may be achieved by looking at the interaction of the animal groups with each other and with the ambient environment.

The Drainage Canals as an Aquatic Ecosystem

In the absence of naturally occurring swamps and ponds, the drainage canals of Fort Pulaski play an important modifying role in the ecology of Cockspur Island. They contain the only source of fresh water for much of the island wildlife. They are nutrient traps and areas of rapid plant growth. They are a source of food and shelter for a wide variety of aquatic and terrestrial organisms. In this respect, most island food chains are affected or modified at some point by the

presence of the canals. Habitat diversity and species richness are enhanced by the canal system.

If shallow aquatic systems have unvarying water levels and salinities, there is a tendency for succession to proceed from open water to dense emergent vegetation and then to a terrestrial shrub community. Periodic disruptions interrupt succession, reestablish original conditions and increase faunal diversity within the system. The Fort Pulaski canal system is a pulse-stabilized aquatic ecosystem because varying water levels and salinities provide disruptive pulses which stabilize the successional stage at an earlier, open water condition. Similarly, the surrounding salt marshes are a tidally pulse-stabilized aquatic ecosystem.

The fish of the Pulaski canal system are opportunistic species, living a precarious existence on the interface between fresh and salt water. They avoid most fresh and salt water fish predators, which cannot tolerate the physical uncertainties of the canal system, and they are provided with an abundance of rich detrital food. Under these circumstances, maximum reproduction may be realized. Densities in excess of 1000 fish per square meter have been measured in similar communities (Wharton 1978).

When conditions are wrong, which might occur during an extended drought, many thousands of fish may become trapped and die. The boom and bust characteristic of fluctuating water levels is so predictable that one species of bird, the wood stork (Mycteria americana), has become dependent on concentrations of trapped fish to successfully feed its young (Kahl 1964). The heron species which frequent the Pulaski drainage canals are opportunistic

feeders, locating pools and portions of canals where receding water levels trap and concentrate their fish prey.

Pulaski amphibians are also tied to fluctuating water levels and the temporary aquatic system. Treefrogs, scattered throughout the shrub communities, will go for months without breeding. Sudden torrential rains will fill some of the drainage ditches, providing an instant habitat rich with food and free of predators. Synchronized breeding insures that maximum reproduction begins immediately. Growth of the tadpoles must be rapid, for receding water levels may trap tardy individuals. As frog production peaks, terrestrial predators move in, and the benefits of the reproductive surge pass on into higher levels of the island food chains.

The secret of successful colonization of a fluctuating water level system depends on refugia. The animals which live in the system must have somewhere to go when the ponds go dry. Treefrogs find refuge in the forest, requiring open water only long enough for the tadpole to reach maturity. Narrow-mouthed toads and southern toads borrow beneath the ground. The fish of the Pulaski canal system find refuge in the adjacent estuary, gaining access to the flooded canals by moving in with a tidal surge or up the outflow of a rainwater runoff. There would be no fish in the Pulaski canal system without access to the Savannah River through flood gates and drainage pipes under the surrounding dikes.

Mosquitoes and other aquatic insects thrive in fluctuating water level systems which have no access to the marshes, for these systems are free of fish predators. Fish, particularly the mosquitofish and molly, sometimes find refugia during drought periods in alligator

burrows or an occasional deep pool. When the system becomes flooded, the fish are there to feed on the mosquitoes.

Management Recommendations

Fort Pulaski drainage canals function as a pulse-stabilized aquatic ecosystem and should be managed as such. Maximum faunal diversity will be realized in canals with occasional flooding from high tides (2-4 times yearly), access to the Savannah River via runoff drainage pipes and a sill which maintains a water depth of approximately 30-40 cm following flood conditions. Water at depths that are too shallow will evaporate before life cycles can be completed. Water that is too deep may never dry out and pulse-stabilize the system. Optimum water depths that would produce a variety of aquatic systems among different drainage canals could be determined with a small amount of additional investigation.

Some lesser drainage canals, particularly those located among mixed shrub communities south of the visitors' center, may be too removed from the Savannah River for fish to gain access after moderate flooding. These canals are prime breeding habitat for mosquitoes. An occasional deep hole, excavated by backhoe, would provide the necessary refugia for colonization by mosquitofish and mollies and natural control of mosquito larvae.

The Upland as a Terrestrial Ecosystem

The various faunal populations of the upland lawn and shrub communities of Fort Pulaski are inflexibly linked to the tidal marsh

ecosystem and the aquatic canal ecosystem. Nearly all of the resident mammal species depend on the salt marsh and the marsh/upland interface for food or shelter. Amphibians depend on the aquatic canal system and reptiles, particularly the snakes, depend on prey that are linked to the canal and marsh ecosystems. The redwinged blackbird, most abundant of Pulaski nesting species, requires the shrubs of the marsh/upland interface for its nesting sites, and the boat-tailed grackle feeds in the marsh. Most independent of the marsh and canal ecosystems are many of the small, nesting song birds and a few of the lizards.

Management Recommendations

The upland fauna of Fort Pulaski are a product of existing conditions of the various vegetative upland communities and of the proximity of the upland to salt marsh and aquatic canal ecosystems. The species present are adapted to Pulaski conditions. A few specific management suggestions have been targeted at selected faunal groups, such as raccoons and cavity nesting birds, but the majority of the upland Pulaski fauna is being properly managed under existing practices. The expansion of the pine community has been suggested, but for the most part, the Park should maintain its present upland floral and faunal diversity at current levels. The greatest opportunity for a faunal management program should be the interpretation of existing faunal communities and coastal island ecology, as an added dimension for Park visitors.

SUMMARY

Fort Pulaski National Military Park is an historical monument. Its upland habitats on Cockspur Island were raised from the Georgia salt marshes to support a fort in defense of Savannah harbor. Today's plant communities on Cockspur Island are the product of succession on spoil upland, and the fauna have come to colonize shrub thickets where salt marsh existed before. Fort Pulaski has attracted its fauna to itself; there is no record of a native upland faunal community existing in the area prior to fortification construction in the 19th century. The Park's current wildlife management philosphy should primarily be focused on the proper management of its faunal immigrants-turned-residents.

Faunal diversity in the Park is low because habitat diversity and total upland area is low relative to other coastal islands and the mainland. Fort Pulaski supports no unique or vanishing plant communities whose preservation might call for special protection. There are no major heron rookeries, unusual assemblages of wildlife, or significant numbers of rare and endangered species which might require priority management decisions. A few wildlife enhancement measures have been suggested in this report, such as extending the existing pine community to adjacent spoil areas. For the most part, however, current Park management practices have attracted the existing fauna. The proposed widening of U. S. Highway 80 from two lanes to four lanes would not adversely affect existing fauna since the end result would be a shoulder right-of-way community of mixed shrubs not unlike present

conditions.

Fort Pulaski fauna is probably most sensitive to the availability of fresh and hyposaline canal water. Some Park animals will be severly stressed when Park canals run dry. Two important suggestions discussed in the report were to perpetuate the canals as fluctuating water level systems (see Discussion - drainage canals as an equatic ecosystem) and to provide fresh drinking water during periods of drought. Another priority management consideration, perhaps related to drought stress, is the high incidence of disease in the raccoon population and the potential threat of contagion to humans. Management should be particularly cognizant of the problems associated with the canals and with the resident raccoon population. The remainder of Fort Pulaski's fauna is expected to continue as before, inspite of little additional Park management in its behalf.

Perhaps the greatest challenge lies with environmental interpretation. The proximity of upland, marsh, and estuary make Cockspur Island an ideal outdoor classroom for an educational program in coastal ecology. Environmental interpretation would complement the historical experience and require relatively little capital outlay. An extension to the existing nature walk and the construction of a marsh boardwalk have been suggested. Environmental education is clearly a mission of the NPS which could be developed beyond current levels without threatening the Park's historical directives.

communities that need management protection within the legal boundaries on Fort Pulaski.

Fort Pulaski is maintained as a monument with emphasis on the historical importance of the area. Part of this maintainance includes extensive mowing of areas of the park, preventing the invasion of successional plant species. This does not imply that the mowing practice is ecologically unwise, only that it is maintaining the present prevalent grassland community.

There is an opportunity for the Park Service to expand the existing nature trail system which presently explores only part of the variety of plants and wildlife existing on the island. An additional trail could be built in a juniper/yaupon shrub forest located on the E, NE and SE end of Cockspur Island inside and outside of the drainage canal. Not only would the area provide visitor exposure to a representative maritime shrub forest, but it would also furnish excellent opportunity for bird watching. The terminus of the trail could reach the mud flats at the E end of the island where an abundance of shore bird and wading bird observation would be made available to visitors at Fort Pulaski. Construction of the trail would merely require trimming the shrubby vegetation and building foot bridges across the drainage ditch.

Proposed highway construction of two additional lanes of US Highway 80, which is located through McQueens Island, would affect only the cordgrass community on either side of the already existing road and would consequently be of minor additional ecological impact. Even less alteration and disturbance of the marsh ecosystem would occur if both of the additional lanes were constructed to the side of highway 80 between the highway and

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APPENDIX I

The following is a checklist of birds observed in the coastal region of Georgia (Burleigh 1958, Johnson et al. 1974, Hillestad et al. 1975, Denton et al. 1977). Any of these species could occur in Fort Pulaski National Military Park at some time or another. Generalized categories of status, seasonal occurrence and preferred habitat are included. A key to abbreviations follows:

C - common: encountered nearly every time one visits preferred habitat.

FC - fairly common: encountered approximately 30-70% of the time one visits preferred habitat.

UNC - uncommon: encountered less than 30% of the time one visits preferred habitat.

R - rare: encountered infrequently in preferred habitat.

Acc - accidental: very few records of occurrence; generally of extralimital occurrence.

EXN - extinct.

EXP - extirpated.

Irr - irregular

loc - local (used in combination with other status category): occurring in restricted areas.

* - known to nest.

ORDER / FAMILY / SPECIES / COMMON NAME	STATUS	SEASONAL OCCURRENCE					PREFERRED HABITAT						
		PERMANENT RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	TRANSIENT	UNCERTAIN	OFFSHORE	BEACHES, DUNES, MUD FLATS	FORESTS	FIELDS, PASTURES	FRESHWATER MARSHES, PONDS	SALT MARSHES	ESTUARIES, SOUNDS
GAVIIFORMES													
Gaviidae													
Gavia immer	UNC			●	●		●						●
Common Loon													
G. stellata	FC			●			●						●
Red-throated Loon													
PODICIPEDIFORMES													
Podicipedidae													
Podiceps grisegena	UNC			●									●
Red-necked Grebe													
Podiceps auritus	C			●									●
Horned Grebe													
**Podilymbus podiceps*	C			●	●						●		●
Pied-billed Grebe	UNC		●										
PROCELLARIIFORMES													
Procellariidae													
Puffinus gravis	UNC		●				●						
Greater Shearwater													
P. griseus	Acc						●						
Sooty Shearwater													
P. lherminieri	Acc						●						
Audubon's Shearwater													
P. diomedia	Acc						●						
Cory's Shearwater													
Hydrobatidae													
Oceanites oceanicus	UNC		●				●						
Wilson's Storm Petrel													
PELECANIFORMES													
Pelecanidae													
Pelecanus erythrorhynchos	R		●		●		●					●	
White Pelican													
P. occidentalis	FC	●					●					●	
Brown Pelican													
Sulidae													
Morus bassanus	FC		●				●						
Gannet													

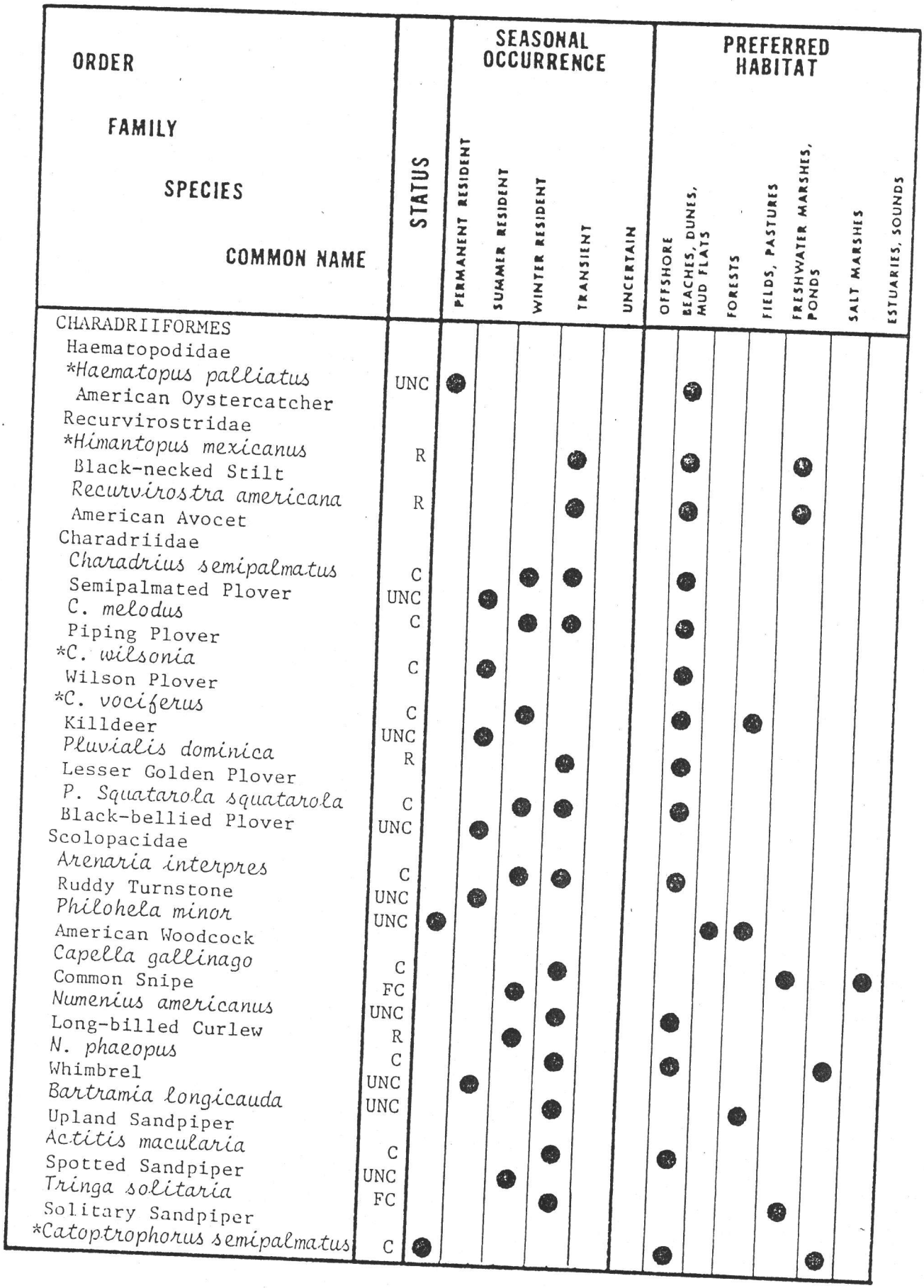
ORDER / FAMILY / SPECIES / COMMON NAME	STATUS	SEASONAL OCCURRENCE: PERMANENT RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	TRANSIENT	UNCERTAIN	PREFERRED HABITAT: OFFSHORE	BEACHES, DUNES, MUD FLATS	FORESTS	FIELDS, PASTURES	FRESHWATER MARSHES, PONDS	SALT MARSHES	ESTUARIES, SOUNDS
Phalacrocoracidae													
Phalacrocorax carbo	R			●			●						●
Great Cormorant													
P. auritus	C			●			●						●
Double-crested Cormorant	UNC		●										
Anhingidae													
**Anhinga anhinga*	FC		●								●		
Anhinga	UNC												
Fregatidae													
Fregata magnificens	R				●		●						●
Magnificent Frigate-bird													
CICONIFORMES													
Ardeidae													
**A. herodias*	FC	●					●				●	●	●
Great Blue Heron													
**Butorides striatus*	C		●								●	●	●
Northern Green Heron	UNC			●									
**Florida caerulea*	C	●									●	●	●
Little Blue Heron													
**Bubulcus ibis*	A		●							●			
Cattle Egret	R			●									
Dichromanassa rufescens	Acc												●
Reddish Egret													
**Casmerodius albus*	C		●					●			●	●	●
Great Egret	FC			●									
**Egretta thula*	C	●						●			●	●	●
Snowy Egret													
**Hydranassa tricolor*	C		●								●	●	●
Louisiana Heron	FC			●									
**Nycticorax nycticorax*	FC			●							●	●	●
Black-crowned Night Heron	UNC		●										
**Nyctanassa violacea*	FC		●								●	●	●
Yellow-crowned Night Heron	R			●									
**Ixobrychus exilis*	FC			●							●		
Least Bittern	R		●										
Botaurus lentiginosus	FC			●	●						●		
American Bittern	R												
Ciconiidae													

ORDER / FAMILY / SPECIES / COMMON NAME	STATUS	SEASONAL OCCURRENCE: PERMANENT RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	TRANSIENT	UNCERTAIN	PREFERRED HABITAT: OFFSHORE	BEACHES, DUNES, MUD FLATS	FORESTS	FIELDS, PASTURES	FRESHWATER MARSHES, PONDS	SALT MARSHES	ESTUARIES, SOUNDS
*Mycteria americana Wood Stork	FC R		●	●						●	●		
Threskiornithidae													
*Plegadis falcinellus Glossy Ibis	UNC		●								●	●	●
*Eudocimus albus White Ibis	C UNC		●	●						●	●	●	
Ajaia ajaja Roseate Spoonbill	R		●									●	●
ANSERIFORMES													
Anatidae													
Olor columbianus Whistling Swan	R			●									●
*Branta canadensis Canada Goose	FC loc			●	●					●	●		
B. bernicla Brant	Acc												●
Anser albifrons Greater White-fronted Goose	R			●				●					●
Chen caerulescens Snow Goose	UNC			●				●					●
Dendrocygna bicolor Fulvous Whistling Duck	UNC			●				●			●		
*Anas platyrhynchos Mallard	FC loc		●	●							●		●
A. rubripes American Black Duck	FC R		●	●							●		●
A. fulvigula Mottled Duck	Acc										●		●
A. strepera Gadwall	UNC			●							●		●
A. acuta Common Pintail	FC			●			●				●		
A. crecca Green-winged Teal	C			●	●						●		●
A. discors Blue-winged Teal	C				●						●		●
A. penelope	UNC R			●									●

ORDER / FAMILY / SPECIES / COMMON NAME	STATUS	SEASONAL OCCURRENCE					PREFERRED HABITAT						
		PERMANENT RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	TRANSIENT	UNCERTAIN	OFFSHORE	BEACHES, DUNES, MUD FLATS	FORESTS	FIELDS, PASTURES	FRESHWATER MARSHES, PONDS	SALT MARSHES	ESTUARIES, SOUNDS
Eurasian Widgeon *A. americana*	C			●							●		
American Widgeon *A. clypeata*	FC			●	●						●		
Northern Shoveler **Aix sponsa*	C	●									●		
Wood Duck *Aythya americana*	UNC			●	●								●
Redhead *A. collaris*	FC				●						●		●
Ring-necked Duck	C			●									●
A. valisineria	FC			●	●								●
Canvasback *A. marila*	R			●									●
Greater Scaup *A. affinis*	C			●	●						●		●
Lesser Scaup *Bucephala clangula*	UNC			●	●								●
Common Goldeneye *B. albeola*	C			●	●								●
Bufflehead *Clangula hyemalis*	UNC			●									●
Oldsquaw *Somateria spectabilis*	R			●									●
King Eider *Melanitta deglandi*	UNC			●			●						●
White-winged Scoter *M. perspicillata*	UNC			●			●						●
Surf Scoter *Melanitta nigra*	UNC			●			●						●
Black Scoter *Oxyura jamaicensis*	C			●							●		●
Ruddy Duck *Lophodytes cucullatus*	R		●								●		●
Hooded Merganser *Mergus merganser*	FC			●	●						●		●
Common Merganser *M. serrator*	C			●							●		●
Red-breasted Merganser	R		●										

ORDER / FAMILY / SPECIES / COMMON NAME	STATUS	SEASONAL OCCURRENCE					PREFERRED HABITAT							
		PERMANENT RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	TRANSIENT	UNCERTAIN	OFFSHORE	BEACHES, DUNES, MUD FLATS	FORESTS	FIELDS, PASTURES	FRESHWATER MARSHES, PONDS	SALT MARSHES	ESTUARIES, SOUNDS
FALCONIFORMES													
Cathartidae													
*Cathartes aura	C		●					●	●	●			
Turkey Vulture													
*Coragyps atratus	C		●					●	●	●			
Black Vulture													
Accipitridae													
*Elanoides forficatus	UNC		●		●				●	●			
Swallow-tailed Kite													
*Ictinia misisippiensis	FC		●							●			
Mississippi Kite													
Accipiter striatus	UNC			●					●				
Sharp-shinned Hawk													
*A. cooperii	UNC	●							●				
Cooper's Hawk													
*Buteo jamaicensis	C	●								●			
Red-tailed Hawk													
*B. lineatus	FC	●							●	●			
Red-shouldered Hawk													
B. platypterus	FC				●				●				
*Broad-winged Hawk	UNC		●										
B. lagopus	R			●	●					●			
Rough-legged Hawk													
Aquila chrysaetos	R			●	●					●			
Golden Eagle													
*Haliaeetus leucocephalus	R			●	●				●	●			●
Bald Eagle													
Circus cyaneus	FC			●						●	●	●	
Northern Harrier													
Pandionidae													
*Pandion haliaetus	FC		●								●		●
Osprey	R			●									
Falconidae													
Falco peregrinus	R			●	●			●	●	●	●		
Feregrine Falcon													
F. columbarius	UNC				●			●		●			
Merlin	R			●									
*F. sparverius	C			●						●			
American Kestrel	UNC		●										

ORDER / FAMILY / SPECIES / COMMON NAME	STATUS	SEASONAL OCCURRENCE: PERMANENT RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	TRANSIENT	UNCERTAIN	PREFERRED HABITAT: OFFSHORE	BEACHES, DUNES, MUD FLATS	FORESTS	FIELDS, PASTURES	FRESHWATER MARSHES, PONDS	SALT MARSHES	ESTUARIES, SOUNDS
GALLIFORMES													
Cracidae													
*Ortalis vetula	FC	●	Sapelo Is.						●				
Plain Chachalaca													
Phasianidae													
*Colinus virginianus	C	●							●	●			
Common Bobwhite													
Meleagrididae													
*Meleagris gallopavo	C	●							●	●			
Wild Turkey	loc												
GRUIFORMES													
Gruidae													
Grus americana	EXP									●			
Whooping Crane				●	●					●	●		
Grus canadensis	C												
Sandhill Crane	UNC		●										
Aramidae													
Aramus guarauna	R					●					●		
Limpkin													
Rallidae													
*Rallus elegans	UNC			●							●		
King Rail	FC		●									●	
*R. longirostris	C	●											
Clapper Rail											●	●	
R. limicola	C			●	●								
Virginia Rail											●	●	
Porzana carolina	C				●								
Sora	UNC			●	●						●	●	
Coturnicops noveboracensis	R			●	●					●			
Yellow Rail												●	
Laterallus jamaicensis	R				●								
Black Rail													
*Porphyrula martinica	C		●								●		
Purple Gallinule	loc												
*Gallinula chloropus	FC	●									●		
Common Gallinule													●
*Fulica americana	C			●	●								
American Coot	R		●										


ORDER
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OFFSHORE
BEACHES, DUNES, MUD FLATS
FORESTS
FIELDS, PASTURES
FRESHWATER MARSHES, PONDS
SALT MARSHES
ESTUARIES, SOUNDS
CHARADRIIFORMES
Haematopodidae
*Haematopus palliatus
American Oystercatcher
UNC
Recurvirostridae
*Himantopus mexicanus
Black-necked Stilt
R
Recurvirostra americana
American Avocet
R
Charadriidae
Charadrius semipalmatus
Semipalmated Plover
C
C. melodus
Piping Plover
UNC
*C. wilsonia
Wilson Plover
C
*C. vociferus
Killdeer
C
Pluvialis dominica
Lesser Golden Plover
UNC
P. Squatarola squatarola
Black-bellied Plover
R
Scolopacidae
Arenaria interpres
Ruddy Turnstone
C
Philohela minor
American Woodcock
UNC
Capella gallinago
Common Snipe
UNC
Numenius americanus
Long-billed Curlew
C
N. phaeopus
Whimbrel
FC
Bartramia longicauda
Upland Sandpiper
UNC
Actitis macularia
Spotted Sandpiper
UNC
Tringa solitaria
Solitary Sandpiper
R
*Catoptrophorus semipalmatus
C
UNC

ORDER / FAMILY / SPECIES / COMMON NAME	STATUS	SEASONAL OCCURRENCE: PERMANENT RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	TRANSIENT	UNCERTAIN	PREFERRED HABITAT: OFFSHORE	BEACHES, DUNES, MUD FLATS	FORESTS	FIELDS, PASTURES	FRESHWATER MARSHES, PONDS	SALT MARSHES	ESTUARIES, SOUNDS
Willet													
Tringa melanoleucus	C				●			●			●		●
Greater Yellowlegs	FC			●	●								
	R		●										
T. flavipes	C				●						●		●
Lesser Yellowlegs	UNC			●									
Calidris canutus	C				●			●					
Red Knot	FC			●									
	R		●										
C. alba	C	●						●					
Sanderling													
C. maritima	UNC			●				●					
Purple Sandpiper													
C. melanotos	FC				●					●	●		
Pectoral Sandpiper													
C. fuscicollis	UNC				●			●					
White-rumped Sandpiper	loc												
C. minutilla	C			●	●			●			●		
Least Sandpiper	UNC		●										
C. alpina	C			●	●			●					
Dunlin	R		●										
C. pusilla	C				●			●					
Semipalmated Sandpiper	UNC		●	●									
C. mauri	C	●						●					
Western Sandpiper													
Limnodromus griseus	C				●			●					
Short-billed Dowitcher	UNC			●									
L. scolopaceus	UNC			●	●			●			●		
Long-billed Dowitcher													
Micropalama himantopus	UNC				●			●			●		
Stilt Sandpiper													
Tryngites subruficollis	R				●					●			
Buff-breasted Sandpiper													
Limosa fedoa	UNC			●	●			●					
Marbled Godwit													
Phalaropus fulicarius	Acc				●		●						
Red Phalarope	loc												
Steganopus tricolor	R				●		●	●			●		
Wilson's Phalarope													
Lobipes lobatus	R				●		●						

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Northern Phalarope													
Stercorariidae													
Stercorarius parasiticus	R			●			●						●
Parasitic Jaeger													
S. pomarinus	R			●			●						●
Pomarine Jaeger													
Laridae													
Larus hyperboreus	R			●			●						
Glaucous Gull													
L. glaucoides	Acc							●					●
Iceland Gull													
L. marinus	UNC			●				●					●
Great Black-backed Gull													
L. argentatus	C			●	●			●				●	●
Herring Gull	UNC		●										
L. delawarensis	C			●	●			●				●	●
Ring-billed Gull	UNC		●										
L. atricilla	C		●		●			●				●	●
Laughing Gull	FC		●	●									
L. philadelphia	C			●	●			●					●
Bonaparte's Gull													
Xema sabini	Acc												●
Sabine's Gull													
**Gelochelidon nilotica*	UNC		●		●			●					●
Gull-billed Tern	loc												
Sterna forsteri	C			●	●			●					●
Forster's Tern	R		●										
S. hirundo	FC				●			●					●
Common Tern	R			●									
S. fuscata	Acc						●						
Sooty Tern													
S. anaethetus	Acc						●						
Bridled Tern													
**S. albifrons*	UNC		●		●			●					●
Least Tern	loc												
**S. maxima*	C	●						●					●
Royal Tern													
S. sandvicensis	UNC				●			●					●
Sandwich Tern													
S. caspia	C	●						●					●

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Caspian Tern													
Chlidonias niger	C			●	●			●					●
Black Tern													
Anous stolidus	Acc						●						
Noddy Tern													
Rynchopidae													
**Rhynchops niger*	C	●						●					●
Black Skimmer													
Alcidae													
Alca torda	Acc						●						
Razorbill													
Alle alle	Acc						●						
Dovekie													
COLUMBIFORMES													
Columbidae													
Columba livia	C	●								●			
Rock Dove													
Zenaida asiatica	Acc									●			
White-winged Dove													
**Zenaida macroura*	C	●								●			
Mourning Dove													
Ectopistes migratorius	EXN												
Passenger Pigeon													
**Columbina passerina*	C	●								●			
Ground Dove													
PSITTACIFORMES													
Psittacidae													
Conuropsis carolinensis	EXN												
Carolina Parakeet													
CUCULIFORMES													
Cuculidae													
**Coccyzus americanus*	C		●						●				
Yellow-billed Cuckoo													
C. erythropthalmus	UNC				●				●				
Black-billed Cuckoo													
STRIGIFORMES													
Tytonidae													
**Tyto alba*	FC	●								●		●	
Barn Owl													

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Strigidae													
*Otus asio	FC	●							●	●			
Screech Owl													
*Bubo virginianus	FC	●							●				
Great Horned Owl													
Nyctea scandiaca	Acc									●			
Snowy Owl													
*Strix varia	UNC	●							●				
Barred Owl													
Asio otus	R			●					●				
Long-eared Owl													
A. flammeus	FC			●	●			●		●		●	
Short-eared Owl	loc												
Aegolius acadicus	R			●					●				
Saw-whet Owl													
CAPRIMULGIFORMES													
Caprimulgidae													
*Caprimulgus carolinensis	C		●						●	●			
Chuck-will's-widow													
C. vociferus	UNC			●	●				●				
Whip-poor-will													
*Chordeiles minor	C		●					●		●			
Common Nighthawk													
APODIFORMES													
Apodidae													
*Chaetura pelagica	C		●						●				
Chimney Swift													
Trochilidae													
*Archilochus colubris	FC		●						●				
Ruby-throated Hummingbird	C				●								
CORACIIFORMES													
Alcedinidae													
Megaceryle alcyon	FC	●									●	●	
Belted Kingfisher													
PICIFORMES													
Picidae													
*Colaptes auratus	C	●							●				
Common Flicker													
*Dryocopus pileatus	C	●							●				

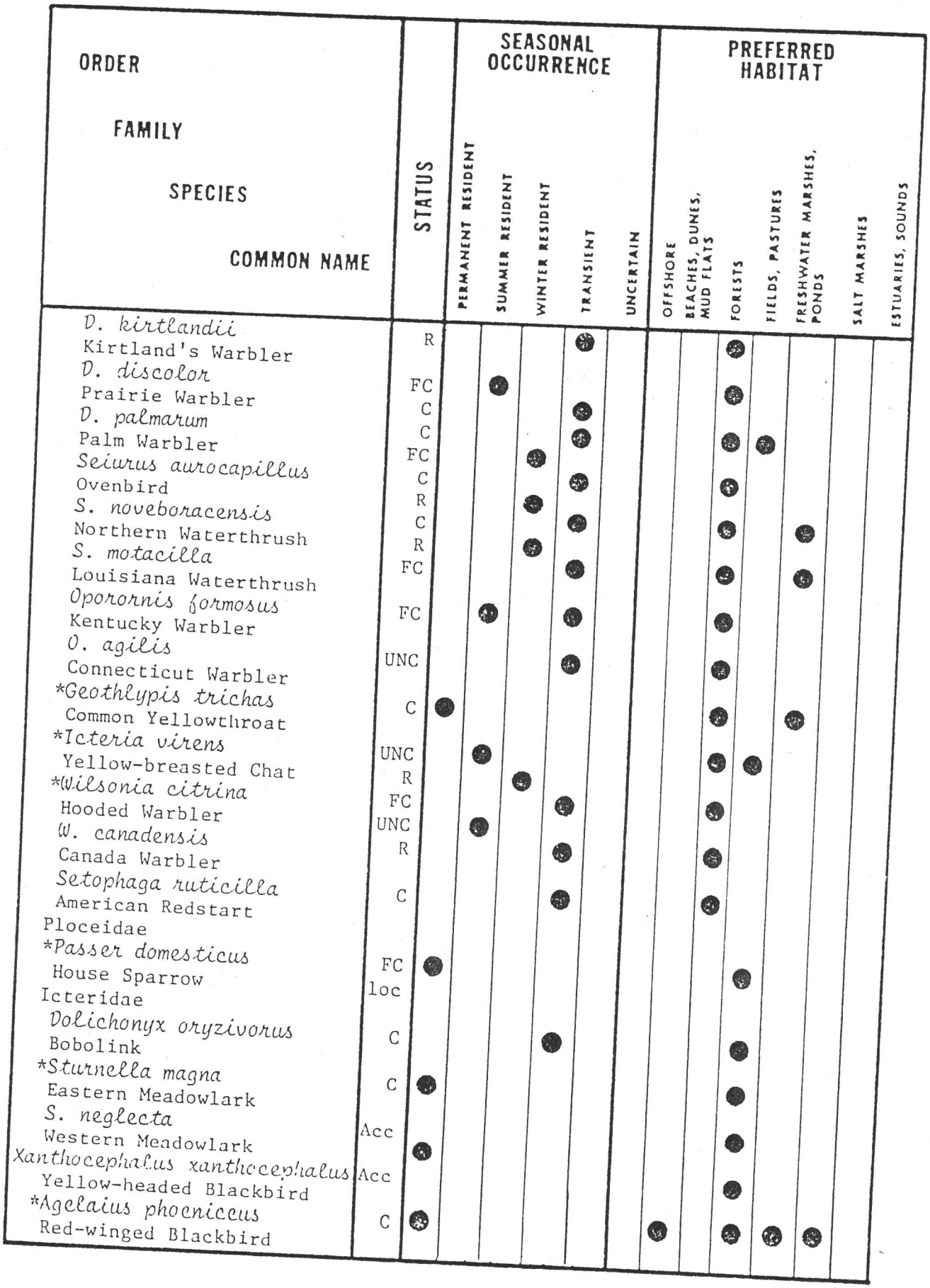
ORDER / FAMILY / SPECIES / COMMON NAME	STATUS	SEASONAL OCCURRENCE					PREFERRED HABITAT						
		PERMANENT RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	TRANSIENT	UNCERTAIN	OFFSHORE	BEACHES, DUNES, MUD FLATS	FORESTS	FIELDS, PASTURES	FRESHWATER MARSHES, PONDS	SALT MARSHES	ESTUARIES, SOUNDS
Pileated Woodpecker													
*Melanerpes carolinus	C	●							●				
Red-bellied Woodpecker													
*M. erythrocephalus	FC	●							●				
Red-headed Woodpecker	loc												
Sphyrapicus varius	C			●					●				
Yellow-bellied Sapsucker													
*Picoides villosus	R	●							●				
Hairy Woodpecker													
*P. pubescens	C	●							●				
Downy Woodpecker													
P. borealis	UNC	●							●				
Red-cockaded Woodpecker													
Campephilus principalis	EXP								●				
Ivory-billed Woodpecker													
PASSERIFORMES													
Tyrannidae													
*Tyrannus tyrannus	C		●							●			
Eastern Kingbird													
*T. dominicensis	R		●		●					●			
Gray Kingbird													
T. verticalis	R			●						●			
Western Kingbird													
Muscivora forficata	R							●		●			
Scissor-tailed Flycatcher													
*Myiarchus crinitus	C		●						●				
Great Crested Flycatcher													
Sayornis phoebe	C			●	●				●				
Eastern Phoebe													
Empidonax flaviventris	R				●				●				
Yellow-bellied Flycatcher													
*E. virescens	FC		●						●				
Acadian Flycatcher													
E. traillii	R				●				●				
Willow Flycatcher													
E. minimus	R				●				●				
Least Flycatcher													
*Contopus virens	C		●						●				
Eastern Wood Peewee													

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Nuttallornis borealis	R				●				●				
Olive-sided Flycatcher													
Pyrocephalus rubinus	R			●						●	●		
Vermilion Flycatcher													
Hirundinidae													
Iridoprocne bicolor	C				●						●	●	
Tree Swallow	R			●	●								
Riparia riparia	UNC				●						●	●	
Bank Swallow													
**Stelgidopteryx ruficollis*	UNC		●		●						●	●	
Rough-winged Swallow													
**Hirundo rustica*	C				●						●	●	
Barn Swallow	UNC		●										
Petrochelidon pyrrhonota	R				●						●	●	
Cliff Swallow													
**Progne subis*	C		●		●				●		●	●	
Purple Martin													
Corvidae													
**Cyanocitta cristata*	FC	●							●				
Blue Jay	loc												
Aphelocoma coerulescens	Acc									●			
Scrub Jay													
**Corvus brachyrhynchos*	C	●							●	●			
Common Crow													
**C. ossifragus*	C	●						●	●	●	●	●	
Fish Crow													
Paridae													
**Parus carolinensis*	C	●							●				
Carolina Chickadee													
P. bicolor	C	●							●				
Tufted Titmouse													
Sittidae													
Sitta carolinensis	FC	●							●				
White-breasted Nuthatch													
S. canadensis	UNC			●	●				●				
Red-breasted Nuthatch													
**S. pusilla*	C	●							●				
Brown-headed Nuthatch													
Certhiidae													
Certhia familiaris	UNC			●	●				●				

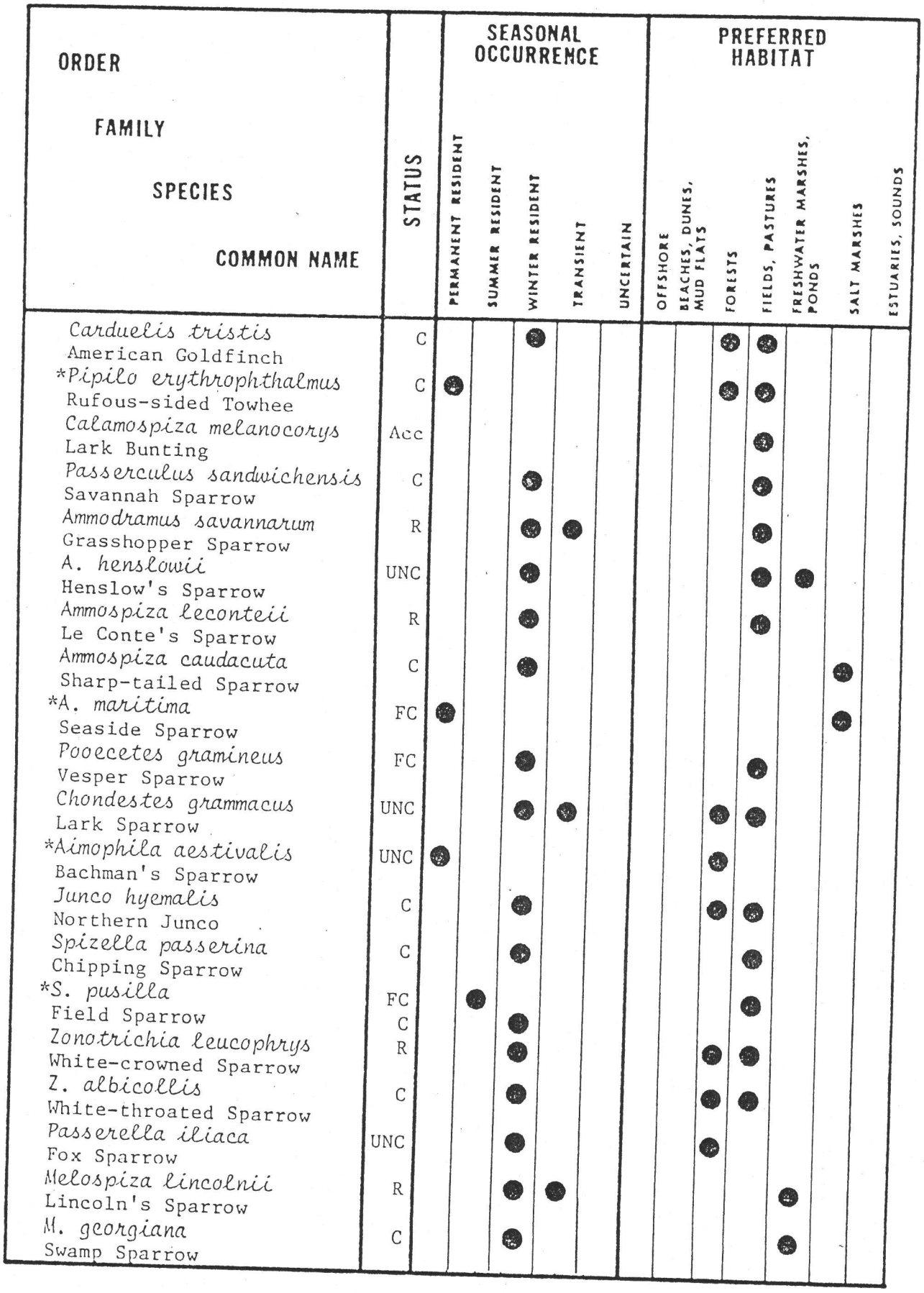
ORDER / FAMILY / SPECIES / COMMON NAME	STATUS	SEASONAL OCCURRENCE: PERMANENT RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	TRANSIENT	UNCERTAIN	PREFERRED HABITAT: OFFSHORE	BEACHES, DUNES, MUD FLATS	FORESTS	FIELDS, PASTURES	FRESHWATER MARSHES, PONDS	SALT MARSHES	ESTUARIES, SOUNDS
Brown Creeper													
Troglodytidae													
Troglodytes aedon	UNC			●	●				●				
House Wren													
T. troglodytes	FC			●					●				
Winter Wren													
Thryomanes bewickii	R			●						●			
Bewick's Wren													
**Thryothorus ludovicianus*	C	●							●				
Carolina Wren													
**Cistothorus palustris*	C	●									●	●	
Marsh Wren													
Cistothorus platensis	UNC			●	●					●		●	
Sedge Wren													
Mimidae													
**Mimus polyglottos*	C	●							●	●			
Northern Mockingbird													
**Dumetella carolinensis*	C		●	●					●				
Gray Catbird													
**Toxostoma rufum*	C	●							●				
Brown Thrasher													
Turdidae													
**Turdus migratorius*	C			●	●				●	●			
American Robin	R		●										
**Hylocichla mustelina*	FC		●						●				
Wood Thrush	C				●								
Catharus guttata	C			●					●				
Hermit Thrush													
C. ustulata	C				●				●				
Swainson's Thrush													
C. minimus	UNC			●					●				
Grey-cheeked Thrush													
C. fuscescens	UNC			●					●				
Veery													
**Sialia sialis*	C	●							●	●			
Eastern Bluebird													
Sylviidae													
**Polioptila caerulea*	C		●						●				
Blue-gray Gnatcatcher	UNC												
Regulus satrapa	FC			●					●				

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Golden-crowned Kinglet													
R. calendula	C			●					●				
Ruby-crowned Kinglet													
Motacillidae													
Anthus spinoletta	C			●				●		●			
Water Pipit													
A. spragueii	R			●				●		●			
Sprague's Pipit													
Bombycillidae													
Bombycilla cedrorum	C			●					●				
Cedar Waxwing													
Laniidae													
**Lanius ludovicianus*	FC	●								●			
Loggerhead Shrike													
Sturnidae													
**Sturnus vulgaris*	C	●							●	●			
European Starling													
Vireonidae													
**Vireo griseus*	C		●						●				
White-eyed Vireo	UNC			●									
**V. flavifrons*	UNC		●	●	●				●				
Yellow-throated Vireo													
V. solitarius	FC				●				●				
Solitary Vireo	UNC			●									
**V. olivaceus*	C		●		●				●				
Red-eyed Vireo													
V. philadelphicus	UNC				●				●				
Philadelphia Vireo													
V. gilvus	R				●				●				
Warbling Vireo													
Parulidae													
Mniotilta varia	C				●				●				
Black-and-White Warbler	UNC			●									
**Protonotaria citrea*	FC		●		●				●		●		
Prothonotary Warbler													
Limnothlypis swainsonii	UNC		●						●		●		
Swainson's Warbler													
Helmitheros vermivorus	UNC				●				●				
Worm-eating Warbler													
Vermivora chrysoptera	R				●				●				

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Golden-winged Warbler *V. pinus*	R				●				●	●			
Blue-winged Warbler *V. bachmanii*	EXP								●		●		
Bachman's Warbler *V. peregrina*	R				●				●				
Tennessee Warbler *V. celata*	FC			●	●				●				
Orange-crowned Warbler **Parula americana*	C		●		●				●				
Northern Parula Warbler *Dendroica petechia*	R			●	●				●		●		
Yellow Warbler *D. magnolia*	C				●				●				
Magnolia Warbler *D. tigrina*	UNC				●				●				
Cape May Warbler *D. caerulescens*	C				●				●				
Black-throated Blue Warbler *D. coronata*	FC				●				●				
Yellow-rumped Warbler *D. nigrescens*	C			●	●				●				
Black-throated Gray Warbler *D. virens*	Acc								●				
Black-throated Green Warbler *D. cerulea*	R				●				●				
Cerulean Warbler *D. fusca*	R				●				●				
Blackburnian Warbler **D. dominica*	R				●				●				
Yellow-throated Warbler *D. pensylvanica*	C		●		●				●				
Chestnut-sided Warbler *D. castanea*	FC			●	●				●				
Bay-breasted Warbler *D. striata*	R				●				●				
Blackpoll Warbler **D. pinus*	UNC				●				●				
Pine Warbler	C				●				●				
	C	●								●			


ORDER
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FORESTS
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FRESHWATER MARSHES, PONDS
SALT MARSHES
ESTUARIES, SOUNDS
D. kirtlandii
Kirtland's Warbler
R
D. discolor
Prairie Warbler
FC
D. palmarum
Palm Warbler
C
Seiurus aurocapillus
Ovenbird
C
S. noveboracensis
Northern Waterthrush
FC
S. motacilla
Louisiana Waterthrush
C
Oporornis formosus
Kentucky Warbler
R
O. agilis
Connecticut Warbler
C
*Geothlypis trichas
Common Yellowthroat
FC
*Icteria virens
Yellow-breasted Chat
UNC
*Wilsonia citrina
Hooded Warbler
R
W. canadensis
Canada Warbler
UNC
Setophaga ruticilla
American Redstart
R
Ploceidae
*Passer domesticus
House Sparrow
C
Icteridae
Dolichonyx oryzivorus
Bobolink
FC
*Sturnella magna
Eastern Meadowlark
loc
S. neglecta
Western Meadowlark
C
Xanthocephalus xanthocephalus
Yellow-headed Blackbird
C
*Agelaius phoeniceus
Red-winged Blackbird
Acc
Acc
C

ORDER / FAMILY / SPECIES / COMMON NAME	STATUS	SEASONAL OCCURRENCE: PERMANENT RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	TRANSIENT	UNCERTAIN	PREFERRED HABITAT: OFFSHORE	BEACHES, DUNES, MUD FLATS	FORESTS	FIELDS, PASTURES	FRESHWATER MARSHES, PONDS	SALT MARSHES	ESTUARIES, SOUNDS
*Icterus spurius	C		●						●				
Orchard Oriole													
I. galbula	UNC			●	●				●				
Northern Oriole													
Euphagus carolinus	UNC			●					●		●		
Rusty Blackbird													
E. cyanocephalus	UNC			●					●		●		
Brewer's Blackbird													
*Quiscalus major	C	●						●		●		●	
Boat-tailed Grackle													
*Q. quiscula	C	●							●	●	●		
Common Grackle													
Molothrus ater	C	●							●	●			
Brown-headed Cowbird	loc												
Thraupidae													
Piranga olivacea	FC				●				●				
Scarlet Tanager													
*P. rubra	C		●						●				
Summer Tanager													
Fringillidae													
*Cardinalis cardinalis	C	●							●		●		
Cardinal													
Pheucticus ludovicianus	FC				●				●				
Rose-breasted Grosbeak													
*Guiraca caerulea	FC		●						●		●		
Blue Grosbeak													
*Passerina cyanea	FC		●						●		●		
Indigo Bunting	R			●									
*P. ciris	C		●						●		●		
Painting Bunting	R			●									
Spiza americana	R			●	●						●		
Dickcissel													
Hesperiphona vespertina	UNC			●					●				
Evening Grosbeak													
Carpodacus purpureus				●					●		●		
Purple Finch	UNC												
Carduelis pinus	Irr			●					●				
Pine Siskin													


ORDER
FAMILY
SPECIES
COMMON NAME
STATUS
SEASONAL OCCURRENCE
PERMANENT RESIDENT
SUMMER RESIDENT
WINTER RESIDENT
TRANSIENT
UNCERTAIN
PREFERRED HABITAT
OFFSHORE
BEACHES, DUNES, MUD FLATS
FORESTS
FIELDS, PASTURES
FRESHWATER MARSHES, PONDS
SALT MARSHES
ESTUARIES, SOUNDS
Carduelis tristis
American Goldfinch
C
*Pipilo erythrophthalmus
Rufous-sided Towhee
C
Calamospiza melanocorys
Lark Bunting
Acc
Passerculus sandwichensis
Savannah Sparrow
C
Ammodramus savannarum
Grasshopper Sparrow
R
A. henslowii
Henslow's Sparrow
UNC
Ammospiza leconteii
Le Conte's Sparrow
R
Ammospiza caudacuta
Sharp-tailed Sparrow
C
*A. maritima
Seaside Sparrow
FC
Pooecetes gramineus
Vesper Sparrow
FC
Chondestes grammacus
Lark Sparrow
UNC
*Aimophila aestivalis
Bachman's Sparrow
UNC
Junco hyemalis
Northern Junco
C
Spizella passerina
Chipping Sparrow
C
*S. pusilla
Field Sparrow
FC
Zonotrichia leucophrys
White-crowned Sparrow
C
R
Z. albicollis
White-throated Sparrow
C
Passerella iliaca
Fox Sparrow
UNC
Melospiza lincolnii
Lincoln's Sparrow
R
M. georgiana
Swamp Sparrow
C

ORDER / FAMILY / SPECIES / COMMON NAME	STATUS	SEASONAL OCCURRENCE					PREFERRED HABITAT							
		PERMANENT RESIDENT	SUMMER RESIDENT	WINTER RESIDENT	TRANSIENT	UNCERTAIN	OFFSHORE	BEACHES, DUNES, MUD FLATS	FORESTS	FIELDS, PASTURES	FRESHWATER MARSHES, PONDS	SALT MARSHES	ESTUARIES, SOUNDS
M. melodia Song Sparrow	C			●					●	●	●		
Calcarius lapponicus Lapland Longspur	R			●						●			
Plectrophenax nivalis Snow Bunting	Acc									●			