PRODUCTION AND UTILIZATION OF WATERFOWL FOODS IN BRACKISH IMPOUNDMENTS IN SOUTH CAROLINA

MICHAEL B. PREVOST, Institute of Natural Resources and School of Forest Resources, University of Georgia, Athens 30602[a]

A. SYDNEY JOHNSON, Institute of Natural Resources and School of Forest Resources, University of Georgia, Athens 30602

J. LARRY LANDERS, School of Forest Resources, University of Georgia, Athens 30602[b]

Abstract: Waterfowl food production, availability, and use in brackish impoundments were studied in South Carolina. Widgeongrass (*Ruppia maritima*), dwarf spikerush (*Eleocharis parvula*), and seeds of saltmarsh bulrush (*Scirpus robustus*) were sampled each month. Standing crop of widgeongrass vegetation declined from 241.11 kg/ha in August to nearly none in December, due mainly to competition from filamentous algae (*Cladophora spp.*) Widgeongrass seed production was estimated at 6.16 kg/ha. Although waterfowl fed intensively on widgeongrass seeds, no depletion was detected, and seeds apparently accumulated from year to year. Standing crop of dwarf spikerush declined from 856.20 kg/ha in September to 363.46 kg/ha in February, apparently because of waterfowl use. Saltmarsh bulrush seed production was estimated at 464.60 kg/ha. Seasonal decrease in availability (from 38.58 kg/ha in October to 15.78 kg/ha in February) was attributed mainly to seed deterioration, but waterfowl consumed about 27% of the crop. The 3 species sampled made up 91.2% of the total volume of crop and gizzard contents from 186 ducks and 50 coots (*Fulica americana*). Waterfowl, mainly pintails (*Anas acuta*), consumed about 34% of the food produced by the 3 plant species studied.

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 32: 60-70

It is generally recognized that water manipulation of diked marshes along the southern Atlantic and Gulf coasts produces excellent habitat for wintering waterfowl. Management practices for the production of certain waterfowl food plants have been well described (Chabreck 1960, Neely 1960, Conrad 1966, Baldwin 1968, Neely 1968, and Morgan 1974). However, studies of seed and vegetative production are few (Low and Bellrose 1944, Singleton 1951, Harmon et al. 1960, Jemison and Chabreck 1962, Drake 1970). Only Singleton (1951) and Jemison and Chabreck (1962) studied availability of natural waterfowl foods in coastal marshes. Data on production and utilization are essentially lacking for managed impoundments along the southern Atlantic coast. These data are needed to better assess management practices and determine productivity of impoundments.

Major objectives of our study were to determine: (1) production and monthly availability of edible portions of saltmarsh bulrush, widgeongrass, and dwarf spikerush; (2) rates of utilization of these; and (3) carrying capacity of impoundments for wintering waterfowl.

Financial support was provided by the Institute of Natural Resources, University of Georgia. We are grateful to Mr. and Mrs. W. K. duPont, Mr. and Mrs. W. G. Reynolds, Mr. and Mrs. C. P. Schutt, and Mr. and Mrs. G. T. Weymouth for granting permission to conduct the study on their property and for providing facilities and vehicles. We thank Kinloch Plantation Manager R. K. Williams for his advice and assistance.

---

[a]Present address: South Carolina Department of Health and Environmental Control, Georgetown, South Carolina 29440.

[b]Present address: Southlands Experiment Forest, Bainbridge, Georgia 31717.

STUDY AREA

Kinloch Plantation in Georgetown County, South Carolina, borders the North Santee River approximately 10 km from the Atlantic Ocean. During the 17th to 19th centuries impoundments on the plantation were used for intensive culture of rice. Since establishment of the Kinloch Gun Club in 1912, the impoundments have been managed to attract waterfowl (Lachicotte 1955). In 1942 the United States Army Corps of Engineers diverted a major portion of the Santee River flow into the Cooper River, which flows into Charleston Harbor. The reduced flow of fresh water allowed saline water to penetrate further up the Santee, and management objectives on Kinloch were changed from production of food plants associated with freshwater marsh to production of brackish marsh plants. In 1976 the Corps of Engineers initiated a project to redivert the flow back into the Santee River. This increased flow should reduce salinity of Santee Delta waters and eventually cause many areas to revert to fresh marsh communities.

Of 2,289 ha of wetlands on Kinloch, 1,450 ha consisted of tidal impoundments intensively managed for production of foods for wintering waterfowl. Most of this (902 ha) was managed for brackish marsh plants and supported stands of saltmarsh bulrush on higher flats and widgeongrass and dwarf spikerush at lower elevations. Edges of internal drainage canals and the highest areas of several impoundments were dominated by big cordgrass (*Spartina cynosuroides*), tropical cattail (*Typha domingensis*), and narrow-leaved cattail (*T. angustifolia*). One 534-ha impoundment being converted from brackish to fresh water management was dominated by saltmarsh bulrush, wild millet (*Echinochloa walteri*), sprangletop (*Leptochloa spp.*), big cordgrass, and other grasses. A 14-ha impoundment was planted to corn and Japanese millet.

The 2 impoundments in which plant foods were sampled, Richfield Island (227 ha) and Horry Island (157 ha), supported more homogeneous stands of saltmarsh bulrush, widgeongrass, and dwarf spikerush than other impoundments. As measured from aerial photographs and ground checks, stands of saltmarsh bulrush composed 48%; widgeongrass 28%; dwarf spikerush 20%; and other plants 4% of the vegetation of Richfield Island. In Horry Island dominant vegetative types were saltmarsh bulrush-cattail, dwarf spikerush, and widgeongrass, composing 48, 46 and 6% of the vegetation, respectively.

Managed impoundments on Kinloch generally attracted 25,000 to 30,000 ducks annually. Pintails were the principal species, with peak populations of 10,000 to 15,000. Mallards (*A. platyrhynchos*), black ducks (*A. rubripes*), gadwalls (*A. strepera*), wigeons (*A. americana*), and teals (*A. crecca*, *A. discors*) were other major species. Coots generally numbered from 5,000 to 8,000. From 100 to 500 Canada geese (*Branta canadensis*) and snow geese (*Anser caerulescens*) occasionally used the impoundments.

METHODS

Field Procedure

Each food plant was sampled monthly from August, 1976 through February, 1977. Plant parts of each species considered to be food sources were: saltmarsh bulrush—seeds; widgeongrass—stems, leaves, and seeds; dwarf spikerush—culms, roots, and tubers. Portions of widgeongrass and dwarf spikerush, other than seeds, are referred to hereafter as vegetation.

Production of saltmarsh bulrush seed in Richfield Island was sampled in plots during August, before most mature seeds had fallen. Floating wooden frames enclosing 0.5m^2 were placed at random within a stand, and seed heads and floating seeds within the frame were collected. This procedure was repeated in all major stands within the impoundment, providing a total of 24 sample plots.

Twenty-four 1 m^2 exclosures constructed of steel reinforcing rod covered with fish netting were placed in widgeongrass and dwarf spikerush stands in Richfield and Horry

Islands to aid in determining whether changes in availability resulted from consumption by waterfowl or from deterioration. Twelve were set at selected locations in stands within each impoundment. Beginning in September, the netting of 2 exclosures per impoundment was removed monthly. A 0.5 m^2 aluminum frame covered with small mesh hardware cloth was placed in the center of the exclosure, and plant material was removed with a modified garden rake and stored in a plastic bag.

Widgeongrass and dwarf spikerush were sampled monthly at predetermined points around the exclosures. Prior to August sampling, 8 points were established at 6 m and 12 m from the corners of each exclosure. A monthly sample was taken at 1 point at each exclosure by lowering the aluminum frame to the bottom and raking the interior clean. This was done in both impoundments, providing 24 sample units each month.

For monthly sampling of seeds on the bottom, a stainless steel cylinder on an iron pipe handle was inserted into the marsh floor until it was level with the bed. A 15 cm-diameter core was removed, and the top 5 cm was sheared off and stored in a plastic bag. Twenty-four cores were taken each month in saltmarsh bulrush stands in Richfield Island. Beginning in December an additional 24 cores were taken at widgeongrass-dwarf spikerush sample sites in Richfield and Horry Islands. Bottom samples also were collected monthly from within the exclosures in each impoundment from which netting was removed for sampling widgeongrass and dwarf spikerush.

Weekly surveys of waterfowl populations were conducted by riding dikes and counting waterfowl with the aid of binoculars from 15 August, 1976 to 28 February, 1977. During the hunting season, gizzards and crops of hunter-killed ducks and coots were collected and preserved by freezing.

Laboratory Procedure

Saltmarsh bulrush seeds collected in plots (wooden frames) were separated from debris by hand. Clean seeds then were air-dried and weighed, and average plot yield (kg/ha) was calculated as an estimate of seed production per 0.5 m^2.

Widgeongrass seeds were removed from a known weight of air-dried vegetation, counted, and weighed. Seed production was calculated from the ratio between a known quantity of air-dried vegetation and associated number of seeds produced.

Vegetation samples were washed through sieves with meshes ranging from 5.6 mm to 9.6 mm and further cleaned by hand. Vegetation was then shaken to remove free water and weighed while damp. Ten small samples were air-dried and weighed to obtain factors for converting wet weight to air-dry weight (widgeongrass 1.000:0.078 g, dwarf spikerush 1.000:0.135 g) to estimate dry weights from plot samples weighed in a moist condition. Data for each month were expressed as kg/ha (dry weight). Estimates for total annual production of widgeongrass and dwarf spikerush were based on the monthly samples outside exclosures in which yields of each species were highest.

Bottom samples were washed through sieves, and saltmarsh bulrush and widgeon-grass seeds were separated from debris and counted. Saltmarsh bulrush seeds in unsound (deteriorated) condition were counted separately. Average yields (kg/ha) were calculated from known weights of seeds (25 saltmarsh bulrush seeds = 0.080 g, 25 widgeongrass seeds = .0.025 g).

Contents of crops and gizzards were analyzed to substantiate utilization of available foods and to evaluate preferences. Techniques were similar to those described by Landers et al. (1976).

Estimation of Carrying Capacity

A method similar to that proposed by Sincock (1965) was used to estimate the total food consumed by wintering waterfowl. The approximate daily food intake of a species, 10 percent of the average body weight (Sincock 1965), was multiplied by the number of use-days for that species to estimate the amount of food consumed by the wintering

population of the species. Weights were taken from Kortright (1943). The projected winter food consumption of a given waterfowl species was multiplied by the decimal fraction of the diet made up by each food item as revealed in analysis of stomach contents of that species. This yielded an estimate of the annual consumption of each food item, by each duck species. Estimates of consumption of each food were summed for all waterfowl species for an estimate of the amount of that food consumed by all wintering waterfowl. These values were compared to the amount of each food produced as estimated from the product of the yield per unit of area and the total area occupied by the plant species. Areas occupied by the plants, including those in impoundments on Kinloch not sampled, were estimated from measurements of habitat types from aerial photographs (scale 1:6,000 and 1:20,000). Ground checks were made to compare vegetative composition in impoundments not sampled with that in Richfield and Horry Islands.

RESULTS AND DISCUSSION

Total Food Production

Estimated production of duck food during 1976 is presented by plant species in Table 1. Vegetative yield of widgeongrass from samples collected during August in Richfield and Horry Islands was 241.11 kg/ha. This value, an estimate of production, compares closely to the 197.0 kg/ha (air dry) in coastal marsh impoundments in Louisiana (Jemison and Chabreck 1962). On the Texas Gulf Coast, Singleton (1951) found a yield of 1,970,0 kg/ha (air dry). His sample size was smaller (five 1 m^2 plots), and collections may have been only in areas of very heavy widgeongrass growth.

Table 1. Estimated production of food plants that were objects of management—Richfield and Horry Islands, Kinloch Plantation, 1976.

Plant Species	*Plant Parts*	*Production (kg/ha air dry wt.)*
Ruppia maritima	leaves and stems	241.11
	seeds	6.16
Eleocharis parvula	culms, roots, tubers	856.20
Scirpus robustus[a]	seeds	464.60
Total		1,568.07

[a]Based on samples collected in Richfield Island only.

Calculated production of widgeongrass seeds on plants from Richfield and Horry Islands was 6.16 kg/ha. Available widgeongrass seeds, estimated from bottom samples from within the exclosures, amounted to 11.94 kg/ha. These data and those from monthly sampling outside exclosures (Table 2) indicate that seeds persist to succeeding seasons and accumulate on the bottom. Jemison and Chabreck (1962) estimated widgeongrass seeds available prior to the arrival of waterfowl at 5.12 kg/ha.

Yield of dwarf spikerush in September, the month with the highest yield, from Richfield and Horry Islands was 856.20 kg/ha. Jemison and Chabreck (1962) found a yield of 155.46 kg/ha.

Saltmarsh bulrush seed production in pure stands in Richfield Island was 464.60 kg/ha. Singleton (1951) reported a yield of 335 kg/ha for saltmarsh bulrush.

Table 2. Waterfowl foods available by sampling periods on Horry and Richfield Islands, Kinloch Plantation, 1976-77.[a]

Food Plant	Portion Sampled	Amount Available (kg/ha air dry wt.)						
		Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Ruppia maritima	stems and leaves	241.11 98.00	102.67 70.00	65.33 35.78	46.67 18.67			
	seeds	---	---	---	---	10.36 3.06	10.87 3.18	10.18 3.06
Eleocharis parvula	culms, roots, tubers	823.85 145.39	856.20 145.39	807.69 183.08	630.00 91.54	538.46 78.08	457.69 94.23	363.46 67.31
Scirpus robustus[b]	seeds	32.88 5.26	24.55 1.75	38.58 5.26	28.06 3.51	28.06 3.51	19.29 1.75	15.78 1.75

[a]Within a column for a given food plant and sampling period, the upper value is amount of waterfowl food and the lower value is 1 standard error.

[b]Based on samples collected in Richfield Island only. Only sound seeds are included.

Seasonal Availability of Foods

Seasonal availability of the 3 food plants encouraged by management is summarized in Table 2. All 3 species declined in availability during fall and winter, but the causes of decline varied by species.

Widgeongrass vegetation declined steadily from a maximum of 241.11 kg/ha in August until its disappearance in December (Fig. 1). Although waterfowl undoubtedly consumed much widgeongrass, the primary cause of its decline was competition from filamentous algae, a common problem in ponds managed for widgeongrass in South Carolina. Algae formed dense mats blanketing the submerged vegetation and greatly reducing light penetration, thereby slowly killing the plants. Widgeongrass in exclosures disappeared at about the same rate as outside (Fig. 1).

Joanen and Glasgow (1966) estimated that waterfowl consumed approximately 63 percent of the standing crop of widgeongrass in Louisiana. Jemison and Chabreck (1962) attributed the consistent seasonal reduction of widgeongrass in coastal marsh impoundments of Louisiana to waterfowl usage. If algae had not interfered with utilization of widgeongrass on Kinloch, results similar to those in Louisiana probably would have been evident. Although no widgeongrass was found in samples after November, a few small patches were noted in February at several locations on Horry Island.

From December to February no appreciable decline in widgeongrass seeds was evident (Fig. 1). These results are consistent with those of Jemison and Chabreck (1962). Waterfowl use of areas once dominated by dense stands of widgeongrass was very heavy. In Richfield Island, as many as 3,500 pintails and 2,000 coots were seen. Food habits data confirmed that they were feeding heavily on widgeongrass seeds.

As illustrated in Fig. 1, dwarf spikerush attained maximum availability (856.20 kg/ha) in September and declined to less than half (363.46 kg/ha) by February. Quantities of dwarf spikerush collected from exclosures remained high, and plants in exclosures showed no apparent deterioration over the 7-month period; the decline outside the exclosures was attributed to waterfowl feeding. The dominant waterfowl species utilizing dwarf spikerush stands were coots, pintails, wigeons, and gadwalls.

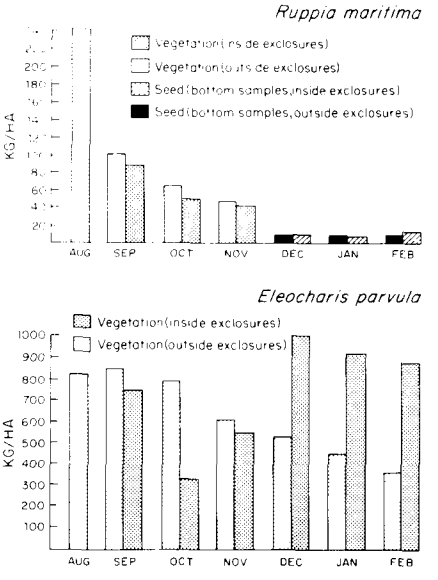

Fig. 1. Seasonal availability of *Ruppia martima* (top) and *Eleocharis parvula* (bottom) Richfield and Horry Islands, Kinloch Plantation, 1976-1977. Vegetation bars include weights of seeds remaining on the plants. No exclosure samples were collected in August.

Jemison and Chabreck (1962) found that waterfowl consumed the entire standing crop of dwarf spikerush by December. Waterfowl use on their area was much greater than on Kinloch.

Throughout the study period monthly estimates of available saltmarsh bulrush seed were considerably below the estimate of seed production. Saltmarsh bulrush does not deposit its entire seed crop at one time; seeds are persistent on plants and drop throughout fall and winter. The mean number of seeds in the samples increased slightly during the 7-month period, but sound seeds generally decreased as unsound seeds increased (Fig. 2). Neely (1956) found that of 25 duck foods tested, saltmarsh bulrush was the most resistant to decay, with only 1% deterioration after 90 days underwater. However, seeds were continuously falling from the plants on Kinloch resulting in some seeds being under water for periods far in excess of 90 days. Seed deterioration must have accelerated after this period. Although saltmarsh bulrush stands received intensive use by pintails, mallards, black ducks, and teals, deterioration accounted for much of the decrease in sound seeds available (Fig. 2).

Waterfowl Food Habits

Data on foods (Table 3) were obtained from 50 coots and 186 ducks of 7 species. Species distribution of stomach samples generally approximated the composition of populations using the areas as indicated by weekly waterfowl surveys; however, coots were under-represented in the sample (21% of sample, 38% of use-days).

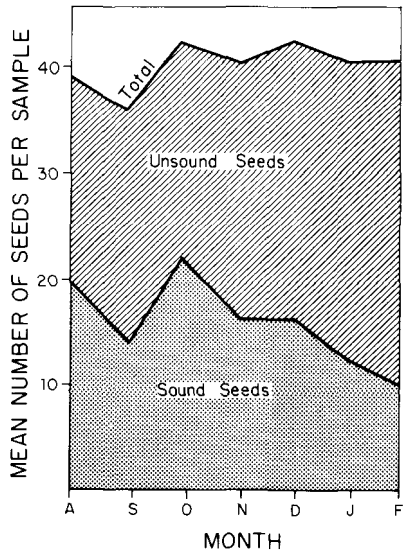

Figure 2. Mean number of *Scirpus robustus* seeds per sample per month – Richfield Island, Kinloch Plantation, 1976-1977.

Plant foods composed over 99% of the volume, with saltmarsh bulrush, widgeongrass, and dwarf spikerush making up over 90%. The remaining portion consisted of species that were not objects of management in brackish impoundments.

Of the 3 major food plants encouraged by management, saltmarsh bulrush was most important. Seeds of this species composed 45.8% of the total volume and were the primary food of pintails, mallards, and black ducks. In previous studies in coastal South Carolina, saltmarsh bulrush ranked fourth by volume (Kerwin and Webb 1972, Landers et al. 1976). Chamberlain (1959) found saltmarsh bulrush to be fifth by volume in coastal Louisiana. These studies, however, included ducks collected from both fresh and brackish habitats.

Widgeongrass had the highest frequency of occurrence (91.9%) and was second in volume (29.8%). Both seeds and vegetative parts are consumed; but, probably because of algae's decimating effect,in seeds were used more by ducks in this study. Landers et al. (1976) found widgeongrass the most important food on areas where it was the primary object of management, being consumed in greatest quantities by scaups (*Aythya affinis*, *A. marila*) and wigeons. On Kinloch, it was most important to wigeons, but it also composed a large portion of the diet of pintails, teals, coots, and gadwalls. Scaups do not use Kinloch intensively.

Dwarf spikerush ranked third by volume (15.6%) and frequency (36.9%). It was most important to coots, wigeons, and gadwalls, which consumed both culms and roots. Martin et al. (1951) stated that ducks eat the tubers as well as the seeds. Of the ducks collected on Kinloch, seeds and tubers occurred only in pintails and then in relatively small amounts. Further analysis of pintail gizzards showed a correlation between occurrence of dwarf spikerush tubers and aquatic gastropods, which may indicate incidental ingestion of one or the other. The value of dwarf spikerush as a waterfowl food is well documented (Neely 1960, Baldwin 1968); however, its importance seems to vary considerably depending on its relative availability. Singleton (1951) stated that large beds

Table 3. Foods of waterfowl collected during 1976-77 hunting season, Kinloch Plantation.[a]

Food Plant	Species[b]								
	Pi (*102*)[c]	*Coot* (*50*)	*GWT* (*28*)	*BWT* (*17*)	*Ma* (*14*)	*Wi* (*14*)	*BD* (*6*)	*Ga* (*5*)	*All* (*236*)
Scirpus robustus	55.6 95.1	0.3 26.0	17.6 75.0	21.7 94.1	75.3 92.8	1.0 57.1	89.7 100.0	Tr 60.0	45.8 75.4
Ruppia maritima	35.9 94.1	23.4 100.0	22.1 75.0	28.0 94.1	5.8 78.6	57.2 100.0	10.3 100.0	17.4 60.0	29.8 91.9
Eleocharis parvula	3.9 20.6	75.8 100.0			2.8 14.3	41.8 71.4		78.3 100.0	15.6 36.9
Corn	0.7 0.9		12.4 10.7	44.7 53.9	11.2 7.1				3.9 5.9
Echinochloa walteri	3.3 6.9		6.2 14.3	0.3 17.6	2.0 7.1				2.3 7:2
Panicum dichotomiflorum	0.2 4.9		19.3 21.4	0.7 17.6	0.2 7.1				0.9 6.8
Cyperus odoratus			7.6 7.1						0.3 0.8
Distichlis spicata	Tr 0.9			Tr 5.9	2.7 7.1		Tr 16.7	Tr 20.0	0.2 2.1
Setaria magna			1.8 3.6						0.2 0.4
Gastropods	0.3 6.9			Tr 5.9					0.2 2.5
Fimbristylis spp.			1.4 10.7						0.1 0.8
Polygonum punctatum			4.1 14.3	0.3 5.9					0.1 1.7
Eleocharis spp.	Tr 3.9		1.4 7.1		Tr 7.1				0.1 2.5
Pluchea spp.			4.1 7.1						0.1 0.8
Panicum agrostoides				3.3 5.9					0.1 0.4
Elateridae			1.4 3.6						0.1 0.4
Totals	99.9	99.5	99.4	99.0	100.0	100.0	100.0	95.7	99.8

[a]These contributed at least 0.1% each of the food volume of all ducks. Within a column, for a given food plant the upper value is % of total volume and the lower value is % occurrence.

[b]Pi, pintail; GWT, green-winged teal; BWT, blue-winged teal; Ma, Mallard, Wi, wigeon, BD, black duck, Ga, gadwall; all, all species.

[c]Sample size.

seem to be especially attractive to ducks and coots. In a sample of over 400 ducks from southeastern Texas, he found it to be second in importance only to cultivated rice. In South Carolina, however, the studies of Kerwin and Webb (1972) and Landers et al. (1976) did not show it to be one of the more important winter foods.

Estimated Carrying Capacity and Total Food Consumed

Waterfowl use and estimated consumption of major foods in brackish marsh impoundments are presented in Table 4. Foods that were not objects of management were not abundant in impoundments and are not presented; therefore total quantities consumed by the major waterfowl species may exceed the sum of the food items. The amount of food consumed by waterfowl populations is based on the amount of food eaten per day by each individual in the population, the size of the population, its duration in the area, and the relative percentage of each food item in the diet.

Of the major waterfowl species, pintails and coots were the most important consumers. Pintails consumed 58,760 kg or about 50% of the total quantity of foods eaten

Table 4. Waterfowl use of brackish marsh impoundments and estimated food consumption, Kinloch Plantation, 1976-77.

				Food Item Consumed (kg)		
Major Waterfowl Species	*Waterfowl Use-Days*	*Food Consumed per Duck per Day (g)*	*Total Consumed by Population (kg)*	*Scirpus robustus*	*Ruppia maritima*	*Eleocharis parvula*
Mallard	58,870	113.4	6,675.86	5,026.92	387.20	186.92
Black duck	15,190	113.4	1,722.55	1,545.12	177.42	
Pintail	647,850	90.7	58,760.00	32,670.56	21,094.84	2,291.64
Gadwell	20,930	86.1	1,802.07	Tr	313.56	1,411.02
Wigeon	93,590	72.6	6,794.63	67.95	3,886,53	2,840.16
Blue-winged teal	51,730	40.8	2,110.58	458.00	590,96	
Green-winged teal	123,410	36.3	4,479.78	788.44	990.03	
Coot	644,420	54.4	35,056.45	105.17	8,203.21	26,572.79
Other[a]	26,530	70.3[b]	1,865.06			
Totals	1,682,520		119,266.98	40,662.17	35,643.76	33,302.54

[a]Includes use by northern shovelers (*Anas clypeata*), ring-necked ducks (*Aythya collaris*), lesser scaup, and ruddy ducks (*Oxyura jamaicensis*) too small to be noted separately; no food habits data were available for these species.

[b]Based on average body weights of the four species.

by all waterfowl species and were the leading consumers of saltmarsh bulrush and widgeongrass seeds. Coots were the leading consumers of dwarf spikerush and ranked second as overall consumers. Although green-winged teals were the third most abundant species (123,410 use-days), they consumed less food than wigeons and mallards, which ranked fourth and fifth in abundance, respectively. Wigeons were the second most important consumers of dwarf spikerush, and mallards ranked second in consumption of saltmarsh bulrush. Black ducks, gadwalls, and blue-winged teals accounted for about 5% of the total waterfowl use-days and were the least important of the major consumers.

It was estimated that waterfowl consumed the following percentages of foods produced: saltmarsh bulrush, 27; dwarf spikerush, 28; and widgeongrass, 74 (Table 5). Calculated consumption of widgeongrass is too high to be consistent with observed deterioration of widgeongrass in Richfield and Horry Islands. Ducks may have been feeding in other areas where damage to the widgeongrass crop was less severe. Also, substantial error may have accumulated during the various steps in sampling and calculation. Thirty-four percent of the standing crop of all major foods was consumed. Assuming that waterfowl species composition remained about the same, it might be inferred that an approximate 3-fold increase in the waterfowl population would deplete these 3 major foods.

Other investigators also have found that various wetland habitats produce food sufficient to support more wintering waterfowl than are ordinarily present. Sincock (1965) estimated that stands of submerged aquatics in Back Bay, Virginia, and Currituck Sound, North Carolina could feed about 5 times the waterfowl population normally present. Jemison and Chabreck (1962) found that, although waterfowl consumed large quantities of seed from coastal marsh impoundments in Louisiana, they consumed less than 20% of the seeds available.

CONCLUSIONS

This study illustrates certain relationships between foods produced in brackish marsh impoundments and waterfowl utilization of these foods. Filamentous algae may destroy vegetative parts of widgeongrass, but the remaining seeds can be an important food. Although saltmarsh bulrush seeds deteriorate after extended periods of submergence, seed production by large stands is sufficient to provide adequate quantities of this food throughout fall and winter. Dwarf spikerush is an important food of coots but is of limited value to ducks when more desirable foods are available. Marsh impoundments managed under brackish water systems attract large numbers of wintering waterfowl, especially pintails, and produce enough food to support more than are ordinarily present. Obviously, factors other than food availability may limit waterfowl use of an area. Nevertheless, intensive management may be necessary where desirable habitat is abundant and there is great competition among landowners for a limited number of waterfowl. Also, capital investments for intensive management as practiced on Kinloch are no greater than for less intensive management because dikes and water control structures are necessary for any type of effective management of brackish marsh. Annual costs of habitat management are primarily associated with water manipulation and do not vary significantly with the type of manipulation (Morgan 1974:71).

Table 5. Percentage consumption of standing crop of major foods, Kinloch Plantation, 1976-77.

Plant Species	*Quantity Produced (kg)*[a]	*Quantity Consumed (kg)*[b]	*% Consumed*
Scirpus robustus	150,995	40,662	27
Eleocharis parvula	120,521	33,303	28
Ruppia maritima	47,992	35,644	74
Totals	319,508	109,609	34

[a]Based on the product of the yield per unit of area and the total area occupied by the respective plants.

[b]Data from Table 4.

LITERATURE CITED

Baldwin, W. P. 1968. Impoundments for waterfowl on South Atlantic and Gulf coastal marshes. Pages 127-133 *in* J. D. Newsom, ed. Proc. Marsh and Estuary Manage. Symp. Louisiana State Univ., Baton Rouge.

Chabreck, R. H. 1960. Coastal marsh impoundments for ducks in Louisiana. Proc. Southeastern Assoc. Game and Fish Commissioners 14:24-29.

Chamberlain, J. L. 1959. Gulf coast marsh vegetation as food of wintering waterfowl. J. Wildl. Manage. 23(1):97-102.

Conrad, W. B., Jr. 1966. A food habits study of ducks wintering on the lower Pee Dee and Waccamaw Rivers, Georgetown, South Carolina. Proc. Southeastern Assoc. Game and Fish Commissioners 19:93-98.

Drake, S. O. 1970. Winter foods of mallards on the Eufaula National Wildlife Refuge. M.S. Thesis. Auburn Univ., Auburn, Ala. 130 pp.

Harmon, B. G., C. H. Thomas, and L. L. Glasgow. 1960. Waterfowl foods in Louisiana ricefields. Trans. N. Am. Wildl. Nat. Resour. Conf. 25:153-162.

Jemison, E. S., and R. H. Chabreck. 1962. The availability of waterfowl foods in coastal marsh impoundments in Louisiana. Trans. N. Am. Wildl. Nat. Resour. Conf. 27:288-300.

Joanen, T., and L. L. Glasgow. 1966. Factors influencing the establishment of widgeongrass stands in Louisiana. Proc. Southeastern Assoc. Game and Fish Commissioners 19:78-92.

Kerwin, J. A., and L. G. Webb. 1972. Foods of ducks wintering in coastal South Carolina, 1965-1967. Proc. Southeastern Assoc. Game and Fish Commissioners 25:223-245.

Kortright, F. H. 1943. The ducks, geese and swans of North America. The Stackpole Co., Harrisburg, Pa. 476 pp.

Lachicotte, A. M. 1955. Georgetown rice plantations. The State Commercial Printing Co., Columbia, S.C. 222 pp.

Landers, J. L., A. S. Johnson, P. H. Morgan, and W. P. Baldwin. 1976. Duck foods in managed tidal impoundments in South Carolina. J. Wildl. Manage. 40(4):721-728.

Low, J. B., and F. C. Bellrose, Jr. 1944. The seed and vegetative yield of waterfowl food plants in the Illinois River Valley. J. Wildl. Manage. 8(1):7-22.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American wildlife and plants: a guide to wildlife food habits. McGraw Hill Book Co., New York, N.Y. 500 pp.

Morgan, P. H. 1974. A study of tidelands and impoundments within a three river delta system—the South Edisto, Ashepoo, and Combahee rivers of South Carolina. M. S. Thesis. Univ. Georgia, Athens. 92 pp.

Neely, W. W. 1956. How long do duck foods last underwater? Trans. N. Am. Wildl. Conf. 21:191-198.

_____. 1960. Managing *Scirpus robustus* for ducks. Proc. Southeastern Assoc. Game and Fish Commissioners 14:30-34.

_____. 1968. Planting, disking, mowing, and grazing. Pages 212-221 *in* J. D. Newsom, ed. Proc. Marsh and Estuary Manage. Symp. Louisiana State Univ., Baton Rouge.

Sincock, J. L. 1965. Estimating consumption of food by wintering waterfowl populations. Proc. Southeastern Assoc. Game and Fish Commissioners 16:217-221.

Singleton, J. R. 1951. Production and utilization of waterfowl food plants on the east Texas Gulf Coast. J. Wildl. Manage. 15(1):46-56.