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TB 634 (1939) USDA TECHNICAL BULLETINS UPDATA
FOOD OF GAME DUCKS IN THE UNITED STATES AND CANADA
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FOOD OF GAME DUCKS IN THE UNITED STATES AND CANADA

By

A. C. MARTIN

and

F. M. UHLER

Associate Biologists
Section of Food Habits
Division of Wildlife Research
Bureau of Biological Survey

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PINTAIL DUCKS (DAFILA ACUTA TZITZIHOA) AT EDGE OF MARSH FEEDING IN BEDS OF AQUATIC VEGETATION.

Male on guard; female tipping for submerged food.

TECHNICAL BULLETIN No. 634 — MARCH 1939

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

FOOD OF GAME DUCKS IN THE UNITED STATES AND CANADA[1]

By A. C. MARTIN and F. M. UHLER, *associate biologists, Section of Food Habits, Division of Wildlife Research, Bureau of Biological Survey*

CONTENTS

[1] Submitted for publication May 17, 1938.

INTRODUCTION

An awakened public interest in the restoration of waterfowl calls for dependable information on which to base programs for the improvement of breeding and feeding grounds (pl. 1) of the birds by the production of food and cover. To minimize waste of funds and loss of effort through the introduction of unsuitable propagative material it is essential that the important plant and animal foods be known and that consideration be given to their normal distribution and to environmental and other limiting factors.

Over a period of many years the Bureau of Biological Survey has investigated the food habits of game ducks and has studied the propagation of the plants on which they feed. The results, dealing on the one hand with special groups of plants suitable for propagation and on the other with the food habits of particular groups of waterfowl, have been published in several reports (*39*, *41*, *42*, *43*, *44*, *45*, *48*, *63*, *87*) [2] most of which are no longer available for distribution. In this bulletin the writers have attempted to consolidate the available information on waterfowl foods, including much recently gathered in field investigations.[3] The material is presented in three major divisions, with a view to rendering three distinct services in the field of waterfowl research and management: The first part presents a statistical index to the preferred duck foods in the various regions of the United States and Canada, based on analyses of nearly 8,000 stomachs or gullets of 18 species of game ducks. The second part is designed to facilitate recognition of some 200 of the principal food items by means of a series of outline descriptions, illustrations, and distribution maps. The third part contains practical suggestions on the propagation of waterfowl foods and the development of feeding grounds and discusses principles related to the embryonic science of producing duck foods.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 143.

[3] Grateful acknowledgment is made of the help of numerous cooperators, particularly W. C. Muenscher, of Cornell University, for data on seed germination; R. T. Clausen, of Cornell University, for information on the taxonomy and range of the genus *Najas*; M. L. Fernald, of Harvard University, for assistance from numerous published studies on plant distribution; and J. R. Swallen, of the Bureau of Plant Industry, U. S. Department of Agriculture, for advice on grasses; and the following coworkers in the Section of Food Habits, Bureau of Biological Survey: Neil Hotchkiss, for many botanical determinations and for obtaining much illustrative material; A. L. Nelson, for illustrative specimens; W. S. Bourn, for contributions on matters of physiology and propagation; and Alma Rutledge, for aid in the elaboration of statistical data. Various regional and local floras, plant catalogs and lists, monographs on certain groups, and three herbaria have been consulted in determining nomenclature and range.

PART 1.—REGIONAL DATA ON DUCK FOODS

THE REGIONAL-LOCALITY BASIS OF FOOD EVALUATION

In attempting to make either a continental or a Nation-wide evaluation of duck-food resources it is essential to begin with regional subdivisions, in order to allow a correct appraisal of food plants that are of restricted distribution. Some of the most valuable of these have wide ranges, but many others are limited to circumscribed habitats. Thus wildrice and wildcelery and many other plants useful as duck foods, but less generally recognized as such, including sawgrass, jointed spikerush, alkali bulrush, waterhemp, and baldcypress, have little or no importance to waterfowl outside definite regions.

To give proper recognition to food elements of limited distribution, that is, to avoid either underrating or overrating them, the present treatment has delimited eight major regions of food resources for game ducks, of which six are more or less natural units in the United States and two are arbitrarily made for Canada. These are mapped in figure 1. The regions are designated as follows: 1, At-

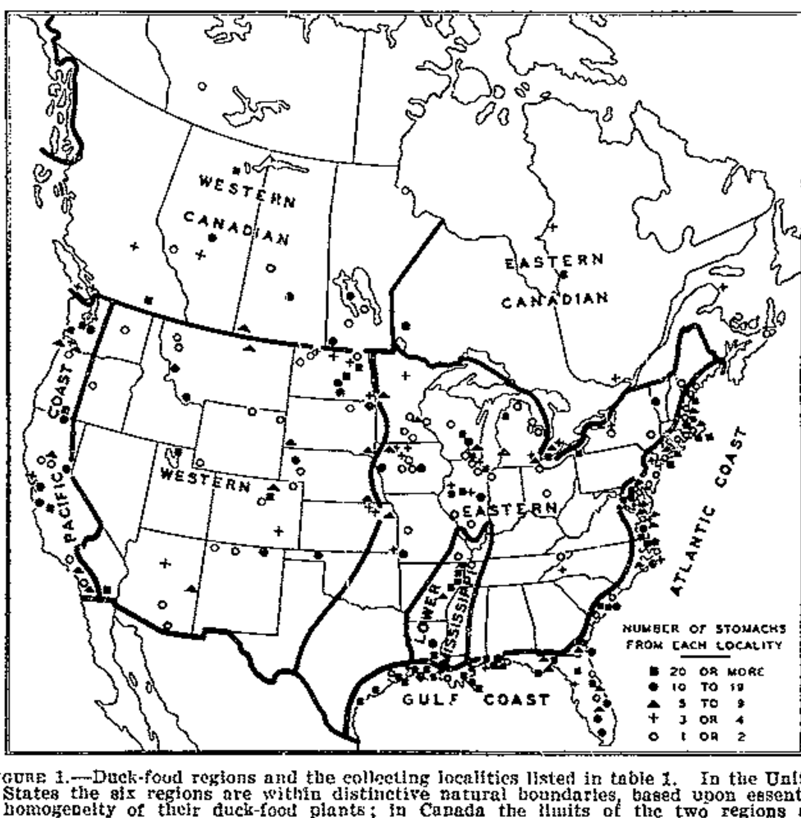

FIGURE 1.—Duck-food regions and the collecting localities listed in table 1. In the United States the six regions are within distinctive natural boundaries, based upon essential homogeneity of their duck-food plants; in Canada the limits of the two regions are arbitrarily made because of the meager data at hand; in all cases large regions have been chosen to avoid objectionable complexity.

lantic coast; 2 eastern; 3, lower Mississippi; 4, Gulf coast; 5, western; 6, Pacific coast; 7, eastern Canadian; 8, western Canadian.

In addition to these eight major food provinces, it has seemed desirable to employ many (247) secondary units, or "localities," in the effort to prevent statistical distortions arising from disproportionate emphasis on local collections of duck stomachs. In the Biological Survey's extensive files of stomach-analysis cards it happens that some duck-concentration localities are represented by one or only a few records, whereas others, favored by special cooperation or by some local investigation, such as an inquiry into oyster damage by scaups, may have their stomach-material totals running into the hundreds. To lump together indiscriminately such inequable accumulations would not yield a reliable index of regional food habits: the total would be excessively flavored by data from a few sources and might be much more representative of those few sources than of the region as a whole. Hence, the expedient has been employed of treating each locality as an entity, to be summarized individually and then to be combined with other summaries or with averages of numerous other localities within the region. Furthermore, rather than reduce all localities to single-weight level, it has been deemed advisable to grade or rank them in five categories, thereby giving graduated preference to places that are more adequately represented by stomach records and tending to level off extremes of inequality.

The basis of evaluation is to rate localities having 20 or more stomach analyses at 100 percent; those with 10 to 19, at 80 percent; 5 to 9, at 60 percent; 3 or 4, at 40 percent; and those represented by only 1 or 2 stomachs, at 20 percent. In effect the plan works thus: A station with 42 records (in the 100-percent group) retains its data unaltered; one with 14 records (in the 80-percent group) has its percentage reduced by one-fifth; and a locality with 2 records is allowed only 20 percent of the value of its original figures. A composite summary of these three or of many other stations is obtained by first modifying their individual averages as indicated.

It appeared appropriate to scale down the relative weight of meagerly represented localities for the reason that analysis of a single stomach, or even of several, cannot be relied upon to give a complete or fully typical idea of local food consumption. Even an incomplete diet picture of a particular marsh or lake area, however, may have considerable value, when combined with numerous other local increments of data, in helping to produce a balanced regional representation of food use. This is particularly true when, as frequently happens, the slighted locality is as important a feeding place for ducks as some others from which large numbers of records have been obtained. These considerations have induced moderation in scaling down scantily represented areas.

The minimum number of stomach records regarded as adequate for depiction of conditions in the average locality was set at 20, though it is realized that for a complete local appraisal—particularly on an extensive area with varied food resources—much more material might be required.

Probably no method of compiling stomach-analysis data in local, regional, or continental summaries could be entirely immune from the danger of distortion or misrepresentation, but it is believed that with the present material the locality basis here adopted serves better than any other to minimize such tendencies.

The locality units employed vary in size and character from a single small lake to a bay or a county. Often several collection stations have been combined into one unit because of proximity and essential similarity of conditions. Generally entries such as Washington, D. C., or Turpin, Okla., indicate rather indefinite areas in the vicinity of the places named. A complete list of the localities follows, and their positions are mapped in figure 1.

List of collecting localities (mapped in fig. 1) and the number of duck stomachs obtained at each

Atlantic Coast Region	
Connecticut:	
Great Island	5
Kensington	1
Portland	2
Stratford	5
District of Columbia: Washington	30
Maine:	
Kennebec River	1
Pine Point	210
Westbrook	1
Maryland:	
Betterton	1
Cecil County	8
Cedar Point	1
Dorchester County	9
Harford County	23
Holland Island	5
Prince Georges County	17
Massachusetts:	
Cape Cod Bay	5
Martha's Vineyard	103
Middleboro	2
Nantucket Island	51
Norfolk County	10
Plum Island	9
Wakefield	1
Wenham Lake	40
New Hampshire: Portsmouth	1
New Jersey:	
Delaware River	1
Madison	3
Ocean County	2
New York:	
Great South Bay	36
Rockaway	2
Suffolk County	36
North Carolina:	
Aurora	6
Cape Hatteras	4
Currituck Sound	362
Narrows Island	18
Ocracoke Island	13
Pea Island	2
Rhode Island: East Greenwich	2
South Carolina:	
Georgetown	2
Gough	30
Green Pond	1
Santee Club	69
South Island	12

Atlantic Coast Region—Continued	
Virginia:	
Back Bay	34
Cape Henry	17
Chesapeake Bay	2
Onancock	3
Prince William County	4
Smith Island	6
Wallops Island	5
Eastern Region	
Illinois:	
Alton	1
Carey	1
Centralia	2
Chicago	42
Fulton County	87
Galesburg	3
Grass Lake	4
Lombard	1
Normal	3
St. Joseph	12
Tazewell County	29
Indiana: Hobart	1
Iowa:	
Boone County	2
Clay County	5
Crystal Lake	4
Humboldt County	3
Jewell	1
Marshalltown	12
Onawa	11
Palo Alto County	3
Story County	2
Kansas:	
Leavenworth	6
Riverton	3
Maine: Kezar Pond	2
Michigan:	
Charity Island	2
Grand Traverse County	27
Monroe	5
New Richmond	7
Pigeon River	1
Portage Lake	1
Rush Lake	1
Washtenaw County	3
Minnesota:	
Albert Lea	1
Madison Lake	1
Minneapolis	1

Eastern Region—Continued

Minnesota—Continued.	
Ottertail County	6
St. Paul Park	8
Woodville	3
Missouri:	
Hartwell	2
Neosho	11
New York:	
Catskill	1
Geneva	1
Sodus Bay	3
North Carolina: Asheville	3
Ohio:	
Columbus	1
Port Clinton	1
Pennsylvania: Erie	29
Tennessee: Unicoi County	1
Vermont: Shoreham Township	10
Wisconsin:	
Bears	1
Beaver Dam	15
Delavan	34
Diamond Bluff	1
Green Lake County	670
Koshkonong	3
Milton	1
Milwaukee	6
Oshkosh	1

Lower Mississippi Region

Arkansas:	
Big Lake	67
Lake Wapanoca	252
Mud Lake	58
Stuttgart	5
Louisiana:	
Avoyelles Parish	801
Catahoula Lake	14
Missouri:	
Little River	27
St. Francis River	2
Tennessee: Reelfoot Lake	2

Gulf Coast Region

Alabama:	
Bayou la Batre	36
Mobile Bay	13
Nigger Lake	18
Orange Beach	9
Petit Bois Island	3
Florida:	
Amelia Island	16
Bassenger	7
Chassahowitzka River	4
Eau Gallie	14
Everglades	11
Hatchineha River	1
Lake Flirt	17
Leon County	6
Micanopy	413
Miccosukee Lake	28
Pensacola	1
St. Johns River	28
St. Marks	8
St. Vincent Island	112

Gulf Coast Region—Continued

Florida—Continued.	
Titusville	8
Volusia County	2
Georgia: Okefenokee Swamp	6
Louisiana:	
Avery Island	4
Belle Isle	37
Cameron	85
Carlisle	25
Chef Menteur	24
Florence	2
Grand Chenier	10
Gueydan	46
Gum Cove	4
Mississippi Delta	567
Triumph	221
Texas:	
Cove	2
High Island	25
Lake Surprise	91
Matagorda County	86
Rockport	111

Western Region

Arizona:	
Flagstaff	3
Lake Picacho	2
Marsh (Big) Lake	7
Santa Rita Range	2
California: Salton Sea	142
Colorado:	
Barr Lake	105
Crook	1
Denver	1
La Junta	3
Masters	9
Kansas:	
Blue Rapids	4
Onaga	4
Montana:	
Corvallis	15
Flathead Lake	1
Lake Bowdoin	7
Monida	10
Turtle Lake	1
Nebraska:	
Alliance	19
Badger	5
Garden County	1
New Mexico:	
Blanco	1
Koehler Junction	13
Lake Burford	1
North Dakota:	
Crystal Springs	43
Dawson	13
Devils Lake	3
Grinnell	1
Kenmare	4
Lostwood	1
Napoleon	13
Rush Lake	2
Stump Lake	41
Towner	3
Oklahoma: Turpin	10
Oregon: Crook County	2

Western Region—Continued

South Dakota:	
Aberdeen	2
Ardmore	16
Clay County	6
Hankinson	3
Lake Traverse	16
Utah: Bear River marshes	368
Washington: Tule Lake	1
Wyoming:	
Beulah	2
Bridger Pass	1
Sheridan	1

Pacific Coast Region

California:	
Carlsbad	1
Chico	6
Corona	8
Escondido	9
Gridley	2
Hayward	13
Lake Tahoe	13
Los Banos	26
Norman	1
Pasadena	1
Tomales Bay	3
Tule Lake	11
Watsonville	17
Oregon:	
Deer Island	3
Gaston	1
Klamath Falls	219
Netarts Bay	9
Portland	6
Washington:	
Nisqually Flats	14
Olympia	395
Willapa Bay	179

Eastern Canadian Region

Nova Scotia: Lochaber	1
Ontario:	
Lac Seul	19
Point Pelee	42
Port Rowan	3
Windsor	6
Prince Edward Island: Wolf Inlet	2
Quebec:	
Gaspe Peninsula	3
Hull	3
James Bay	27
Nastapoka River	3

Western Canadian Region

Alberta:	
Athabaska Delta	66
Jasper Park	1
Lac La Nonne	13
Red Deer Lake	3
British Columbia:	
Barkley Sound	3
Okanagan Landing	248
105-Mile House	3
Saturnia Island	3
Mackenzie: Fort Simpson	1
Manitoba:	
Carberry	1
Churchill	1
Lake Manitoba	18
Oak Lake	13
Shoal Lake	1
Saskatchewan:	
Cypress Lake	8
Last Mountain Lake	14
Osler	2

SOURCES AND SELECTION OF DATA

The statistical compilations of this report are founded on stomach-analysis records that have been in process of accumulation in the Biological Survey's files since 1901. They represent the efforts of many collectors of the Bureau in the field and of numerous laboratory analysts in the Food Habits Research Section. A large proportion of the pioneer work in duck-stomach analysis was done by McAtee; more recent analyses have been made by Mabbott, Kubichek, Holt, Cottam, Kalmbach, Sperry, and Uhler.

The data in this bulletin are based on the analyses of stomachs of 7,998 ducks of 18 species, as shown in table 1. Specimens were collected from many widely scattered localities and represent all months of the year, but the majority were obtained in fall, winter, and early spring. In general, the ratio of ducks collected in various areas has conformed fairly well to the normal abundance of the species, and the effect of local exceptions in this regard has been minimized and largely absorbed by the locality method of rating the material.

Records of stomachs less than a quarter filled were excluded, as were those containing unidentifiable material in excess of a third of the total content. No food items were tabulated if they appeared as less than 1 percent on the stomach cards. Gullet contents alone were used in a few cases where stomach material was unavailable or unsuitable. Barrow's goldeneye (*Glaucionetta islandica*) and the European wigeon (*Mareca penelope*) were omitted because of their comparative rarity, as was the wood duck (*Aix sponsa*), because its food differs so materially from that of the others. Volumetric percentage is regarded as the most significant index of food value, but figures on frequency of use as well as on the number of localities concerned are also presented in the tables.

TABLE 1.—*List of 18 species of ducks studied and the total number of stomachs of each analyzed (analysis by regions shown in tables 3 to 10)*

Common name	Scientific name	Stomachs analyzed
Shoal-water ducks:		*Number*
Common mallard	*Anas platyrhynchos platyrhynchos*	1,948
Common black duck	*Anas rubripes tristis*	374
Florida duck	*Anas fulvigula fulvigula*	32
Mottled duck	*Anas fulvigula maculosa*	21
Gadwall	*Chaulelasmus streperus*	357
Baldpate (wigeon)	*Mareca americana*	244
American pintail (pl. 1)	*Dafila acuta tzitzihoa*	853
Green-winged teal	*Nettion carolinense*	513
Blue-winged teal	*Querquedula discors*	263
Cinnamon teal	*Querquedula cyanoptera*	31
Shoveler	*Spatula clypeata*	73
Diving ducks:		
Redhead	*Nyroca americana*	330
Ring-necked duck	*Nyroca collaris*	627
Canvasback	*Nyroca valisineria*	335
Greater scaup duck	*Nyroca marila*	686
Lesser scaup duck	*Nyroca affinis*	846
American goldeneye	*Glaucionetta clangula americana*	327
Ruddy duck	*Erismatura jamaicensis rubida*	153
Undetermined species		2
Total		7,996

Because plants as sources of game-duck food are in general considerably more important than animals, and also are more amenable to propagation, they have been treated in greater detail in this bulletin. For vegetable foods, the genus or, in many cases, the species has been adopted as the basis for computing percentages; for animals, classes have been used.

SUMMARY OF DATA FOR THE UNITED STATES AND CANADA

In table 2 the figures and ranking are derived from the assembled percentages (adjusted as indicated in the previous section, p. 7) of 247 localities in the United States and Canada; they do not represent an averaging of the data of the eight regions. In considering the relative ranking of plant- and animal-food items it is essential that allowance be made for the fact that plant data are based chiefly on the genus, whereas animal foods are listed under more comprehensive classes. Finality is not implied in the percentages and rankings of the items in the continental list or in the regional lists that follow it. Before the exact extent of use of certain foods is completely determined there will need to be additional analyses of stomachs from regions and localities that have been inadequately represented. Also it will be desirable to have more extensive, careful field observations to supplement present conclusions, which are founded primarily on laboratory analyses.

Tables 3 to 10 present the rankings and percentages of food use in the eight regions, beginning with the Atlantic coast and proceeding westward in the order in which they are numbered on pages 3–4.

TABLE 2.—*Foods of game ducks in the United States and Canada listed in the order of their percentages of the total food as indicated by analyses of 7,998 ducks of 18 species collected in 247 localities*

Scientific name [1]	Common name	Volumetric percentage (plant items above 0.33 percent shown graphically)
PLANT MATERIAL		
Potamogeton	Pondweed	11.04
Scirpus	Bulrush	6.42
Polygonum	Smartweed	4.71
Ruppia, chiefly *R. maritima*	Wigeongrass	4.27
Chara, et al	Muskgrass	2.48
Echinochloa, chiefly *E. crusgalli*	Wild millet	2.38
Vallisneria spiralis	Wildcelery	2.33
Najas	Naiad	1.98
Zizania aquatica	Wildrice	1.95
Cyperus, chiefly *C. esculentus*	Chufa (chiefly)	1.41
Brasenia schreberi	Watershield	1.36
Oryza sativa [2]	Rice	1.28
Eleocharis	Spikerush	1.25
Lemna, Spirodela, Wolffia, Wolffiella	Duckweed	1.23
Zea mays [2]	Corn	1.16
Ulva, Spirogyra, et al	Algae	1.13
Castalia	Waterlily	1.07
Ceratophyllum demersum	Coontail	1.04
Zostera marina	Eelgrass	1.02
Sagittaria	Arrowhead	.94
Zannichellia palustris	Horned pondweed	.88
Carex	Sedge	.83
Cladium, chiefly *C. jamaicense*	Sawgrass	.77
Sparganium	Burreed	.72
Sorghum vulgare [2]	Sorghum	.68
Hordeum vulgare [2]	Barley	.67
Panicum		.54
Leersia, chiefly *L. oryzoides*	Cutgrass	.52
Acnida, chiefly *A. cannabina*	Waterhemp	.51
Rynchospora	Beakrush	.41
Myriophyllum	Watermilfoil	.40
Setaria	Pigeongrass	.39
Cephalanthus occidentalis	Buttonbush	.36
Quercus	Oak	.35
Salicornia	Glasswort	.30
Fagopyrum esculentum [2]	Buckwheat	.26
Triglochin maritima	Arrowgrass	.24
Distichlis	Saltgrass	.24
Amaranthus	Pigweed	.23
Myrica	Waxmyrtle	.23
Bidens	Beggartick	.22
Paspalum		.21
Pontederia	Pickerelweed	.19
Hordeum pusillum	Little barley	.19
Glyceria	Mannagrass	.18
Taxodium	Baldcypress	.17
Jussiaea	Waterprimrose	.17
Nymphaea	Spatterdock	.16
Rumex	Dock	.16
Triticum aestivum [2]	Wheat	.14
Spartina	Cordgrass	.11
Hippuris vulgaris	Marestail	.10
Ranunculus	Buttercup	.10
Heliotropium	Heliotrope	.10
Avena sativa [2]	Oats	.09
Cuscuta	Dodder	.09
Damasonium californicum		.09
Hydrocotyle	Pennywort	.09
Planera aquatica	Water-elm	.08
Proserpinaca	Mermaidweed	.07
Limnobium spongia	Frogbit	.07
Heteranthera	Mudplantain	.07
Equisetum	Horsetail	.07
Bacopa	Waterhyssop	.07
Liquidambar styraciflua	Sweetgum	.07
Vitis	Wild grape	.05
Alnus	Alder	.05
Cleome serrulata	Bee-plant	.05

[1] A generic name without species indicates that 2 or more species may be involved; class names are used for animals.
[2] Cultivated—total farm crops in table, 4.32 percent.

TABLE 2.—*Foods of game ducks in the United States and Canada, etc.*—Continued

Scientific name	Common name	Volumetric percentage (plant items above 0.33 percent shown graphically)
PLANT MATERIAL—continued		
Eragrostis	Lovegrass	0.05
Medicago sativa [2]	Alfalfa	.04
Ambrosia	Ragweed	.04
Opuntia	Pricklypear	.04
Fluminea festucacea	Whitetop	.04
Chenopodium	Goosefoot	.04
Marsilea	Pepperwort	.03
Miscellaneous		9.60
Total		73.07
ANIMAL MATERIAL		
Mollusca [3]	Mollusks	9.84
Insecta	Insects	9.74
Crustacea	Crustaceans	3.44
Pisces	Fishes	.95
Miscellaneous		2.96
Total		26.93

[2] Cultivated—total farm crops in table, 4.32 percent.
[3] Snails (Gastropoda), 7.12 percent; bivalves (Pelecypoda), 2.72.

TABLE 3.—*Foods of game ducks in the Atlantic coast region listed in the order of their percentages of the total food as indicated by analyses of 1,213 stomachs (species listed at foot of last column) from 49 localities*

Scientific name [1]	Common name	Times used	Localities	Volumetric percentage (plant items above 0.33 percent shown graphically)
PLANT MATERIAL				
		Number	*Number*	
Potamogeton	Pondweed	500	27	11.73
Vallisneria spiralis	Wildcelery	122	12	6.82
Ruppia maritima	Wigeongrass	385	22	6.37
Polygonum	Smartweed	151	19	4.96
Scirpus	Bulrush	216	22	4.62
Zostera marina	Eelgrass	94	17	3.07
Zea mays	Corn	20	9	2.91
Zizania aquatica	Wildrice	38	9	2.61
Acnida cannabina	Tidemarsh water-hemp.	7	2	2.51
Najas	Naiad	130	12	2.48
Ulva, et al.	Algae	33	8	2.37
Echinochloa, chiefly *E. crus-galli*.	Wild millet	17	5	1.49
Eleocharis	Spikerush	87	12	.95
Myrica	Waxmyrtle, bayberry.	59	14	.91
Chara, et al.	Muskgrass	120	7	.87
Brasenia schreberi	Watershield	29	9	.73
Oryza sativa	Rice	11	3	.71
Sparganium	Burreed	71	13	.61
Sagittaria	Arrowhead	18	7	.60
Lemna, Spirodela, et al.	Duckweed	9	3	.51
Spartina	Cordgrass	39	8	.45
Pontederia, chiefly *P. cordata*	Pickerelweed	21	6	.45
Cladium		28	13	.43
Triticum aestivum	Wheat	1	1	.42
Carex	Sedge	40	10	.38
Bidens	Beggartick	3	3	.37
Proserpinaca	Mermaidweed	10	4	.31
Cyperus		19	5	.30
Panicum		11	6	.13
Ceratophyllum demersum	Coontail	11	5	.10
Fimbristylis		14	2	.10
Salicornia	Glasswort	8	2	.09
Castalia	Waterlily	5	4	.08
Rynchospora	Beakrush	8	3	.08
Zannichellia palustris	Horned pondweed.	9	5	.05
Solanum dulcamera	Bitter nightshade.	1	1	.05
Aneilema sp.	Dayflower	1	1	.05
Cephalanthus occidentalis	Buttonbush	4	2	.04
Gaylussacia sp.	Huckleberry	3	1	.03
Myriophyllum	Watermilfoil	10	3	.02
Peltandra virginica	Arrow-arum	1	1	.01
Miscellaneous				7.40
Total				69.77
ANIMAL MATERIAL				
Gastropoda	Snails	283	28	11.04
Pelecypoda	Bivalves	233	21	6.35
Crustacea	Crustaceans	251	24	6.27
Insecta	Insects	132	19	1.93
Pisces	Fishes	50	9	.98
Miscellaneous				3.66
Total				30.23

DUCKS EXAMINED

Common mallard	132
Common black duck	314
Gadwall	36
Baldpate	52
American pintail	86
Green-winged teal	39
Blue-winged teal	54
Shoveler	2
Redhead	37
Ring-necked duck	21
Canvasback	24
Greater scaup duck	147
Lesser scaup duck	131
American goldeneye	97
Ruddy duck	39
Undetermined	2
Total	1,213

[1] A generic name standing alone indicates that 2 or more species may be involved; "sp." denotes 1 undetermined species; class names are used for animals.

TABLE 4.—*Foods of game ducks in the eastern region listed in the order of their percentages of the total food as indicated by analyses of 1,102 stomachs (species listed at foot of last column) from 58 localities*

Scientific name [1]	Common name	Times used	Localities	Volumetric percentage (plant items above 0.33 percent shown graphically)
PLANT MATERIAL		*Number*	*Number*	
Potamogeton	Pondweed	625	42	13.29
Polygonum	Smartweed	197	36	6.69
Zizania aquatica	Wildrice	403	10	5.10
Scirpus	Bulrush	401	36	4.90
Najas flexilis	Northern naiad	146	17	4.32
Lemna, Spirodela, et al	Duckweed	26	10	2.97
Vallisneria spiralis	Wildcelery	168	9	2.49
Zea mays	Corn	33	9	2.30
Leersia, chiefly *L. oryzoides*	Cutgrass	52	12	2.02
Chara et al	Muskgrass	35	10	1.87
Setaria	Pigeongrass	15	5	1.62
Echinochloa, chiefly *E. crusgalli*	Wild millet	19	10	1.59
Fagopyrum esculentum	Buckwheat	5	1	1.40
Sparganium	Burreed	79	23	1.33
Carex	Sedge	42	14	1.21
Sagittaria	Arrowhead	25	8	1.00
Brasenia schreberi	Watershield	29	12	.95
Algae	Algae	12	8	.87
Castalia	Waterlily	2	2	.77
Ceratophyllum demersum	Coontail	116	13	.77
Bidens	Beggartick	9	5	.65
Cyperus		20	7	.57
Sorghum vulgare	Sorghum	1	1	.51
Pontederia cordata	Pickerelweed	3	3	.48
Hippuris vulgaris	Marestail	1	1	.42
Panicum		12	8	.40
Myriophyllum	Watermilfoil	55	11	.38
Equisetum sp	Horsetail	4	1	.36
Heteranthera	Mudplantain	1	1	.36
Cephalanthus occidentalis	Buttonbush	12	5	.33
Cladium mariscoides		8	7	.23
Amaranthus	Pigweed	6	3	.18
Ruppia maritima	Wigeongrass	5	4	.14
Butomus umbellatus	Flowering-rush	1	1	.14
Eleocharis	Spikerush	21	11	.08
Eragrostis hypnoides	Lovegrass	3	2	.07
Anacharis	Waterweed	3	3	.07
Zannichellia palustris	Horned pondweed	1	1	.06
Nelumbo pentapetala	American lotus	2	2	.06
Rumex sp	Dock	1	1	.04
Proserpinaca	Mermaidweed	5	3	.01
Miscellaneous				11.36
Total				74.36
ANIMAL MATERIAL				
Insecta	Insects	360	40	13.55
Gastropoda	Snails	120	24	4.61
Crustacea	Crustaceans	61	17	2.44
Pelecypoda	Bivalves	32	16	1.21
Pisces	Fishes	15	6	.25
Miscellaneous				3.58
Total				25.64

DUCKS EXAMINED

Common mallard	223
Common black duck	25
Gadwall	8
Baldpate	12
American pintail	30
Green-winged teal	50
Blue-winged teal	72
Shoveler	5
Redhead	40
Ring-necked duck	19
Canvasback	36
Greater scaup duck	59
Lesser scaup duck	451
American goldeneye	49
Ruddy duck	23
Total	1,102

[1] See footnote 1, table 3.

TABLE 5.—*Foods of game ducks in the lower Mississippi region listed in the order of their percentages of the total food as indicated by analyses of 1,228 stomachs (species listed at foot of last column) from 9 localities*

Scientific name [1]	Common name	Times used	Localities	Volumetric percentage (plant items above 0.33 percent shown graphically)
PLANT MATERIAL		*Number*	*Number*	
Cyperus, chiefly *C. esculentus*	Chufa (chiefly)	56	4	12.25
Ceratophyllum demersum	Coontail	664	5	8.35
Lemna, *Spirodela*, et al	Duckweed	318	5	7.04
Potamogeton	Pondweed	157	6	6.06
Polygonum	Smartweed	246	6	5.54
Oryza sativa	Rice	17	2	5.39
Echinochloa	Wild millet	39	4	5.35
Cephalanthus occidentalis	Buttonbush	301	6	3.61
Glyceria	Mannagrass	12	2	3.57
Taxodium distichum	Baldcypress	193	5	3.49
Quercus	Oak	32	3	3.46
Jussiaea	Waterprimrose	27	3	3.44
Sparganium	Burreed	36	6	2.74
Najas guadalupensis	Southern naiad	26	5	2.68
Scirpus	Bulrush	209	3	2.52
Planera aquatica	Water-elm	157	2	1.77
Limnobium spongia	Frogbit	146	1	1.41
Bacopa rotundifolia	Roundleaf water-hyssop.	6	1	1.30
Ranunculus	Water buttercup	17	2	1.33
Liquidambar styraciflua	Sweetgum	14	2	1.29
Vitis	Wild grape	211	5	1.10
Carex	Sedge	74	4	.84
Chara, et al	Muskgrass	14	4	.77
Zannichellia palustris	Horned pondweed	4	1	.63
Riccia fluitans		3	2	.56
Zizaniopsis miliacea	Giant cutgrass	7	2	.55
Styrax	Snowbell	4	2	.54
Zea mays	Corn	7	2	.53
Algae	Algae	7	3	.30
Carya	Hickory	66	1	.28
Hydrocotyle	Pennywort	136	1	.28
Brunnichia cirrhosa	Buckwheat-vine	16	2	.26
Platanus occidentalis	Sycamore	2	2	.22
Toxicodendron radicans	Poison-ivy	62	5	.15
Cladium jamaicense	Sawgrass	44	2	.13
Paspalum		3	2	.10
Bidens sp	Beggartick	15	1	.08
Nyssa	Gum	22	4	.06
Eleocharis	Spikerush	41	2	.06
Crataegus	Hawthorn	72	2	.05
Brasenia schreberi	Watershield	16	2	.05
Heliotropium indicum	Heliotrope	40	1	.03
Leptochloa	Sprangletop	2	2	.02
Forestiera acuminata	Swamp-privet	16	1	.02
Castalia sp	Waterlily	1	1	.02
Leersia hexandra	Southern cutgrass	1	1	.02
Proserpinaca sp	Mermaidweed	6	1	.01
Miscellaneous				2.13
Total				92.64
ANIMAL MATERIAL				
Gastropoda	Snails	287	6	3.51
Insecta	Insects	294	7	2.12
Crustacea	Crustaceans	18	5	1.37
Pelecypoda	Bivalves	12	3	.09
Pisces	Fishes	7	3	.06
Miscellaneous				.21
Total				7.36

DUCKS EXAMINED	
Common mallard	942
Common black duck	6
Gadwall	58
Baldpate	4
American pintail	27
Green-winged teal	63
Blue-winged teal	4
Shoveler	7
Redhead	11
Ring-necked duck	88
Canvasback	6
Greater scaup duck	3
Lesser scaup duck	7
Ruddy duck	2
Total	1,228

[1] See footnote 1, table 3.

TABLE 6.—*Foods of game ducks in the Gulf coast region listed in the order of their percentages of the total food as indicated by analyses of 2,101 stomachs (species listed at foot of last column) from 38 localities*

Scientific name[1]	Common name	Times used	Localities	Volumetric percentage (plant items above 0.33 percent shown graphically)
PLANT MATERIAL				
		Number	*Number*	
Ruppia maritima	Wigeongrass	288	19	8.47
Polygonum	Smartweed	261	21	5.94
Scirpus	Bulrush	1032	24	5.39
Brasenia schreberi	Watershield	376	12	4.94
Castalia	Waterlily	269	11	4.50
Echinochloa	Wild millet	97	12	4.11
Potamogeton	Pondweed	241	22	3.99
Oryza sativa	Rice	110	6	3.60
Cladium jamaicense	Sawgrass	289	24	2.99
Sagittaria, chiefly *S. platyphylla*	Arrowhead	421	3	2.63
Eleocharis	Spikerush	327	20	2.07
Rynchospora, chiefly *R. corniculata*.	Beakrush	51	12	1.96
Panicum		45	9	1.87
Najas guadalupensis	Southern naiad	17	5	1.71
Salicornia ambigua	Glasswort	33	3	1.36
Algae	Algae	27	7	1.20
Vallisneria spiralis	Wildcelery	14	4	1.06
Paspalum		12	6	1.02
Quercus	Oak	5	2	.88
Chara, et al	Muskgrass	56	9	.71
Nymphaea	Spatterdock	77	5	.50
Cuscuta	Dodder	17	11	.46
Cyperus		44	11	.42
Zizania aquatica	Wildrice	13	3	.42
Heliotropium, chiefly *H. curassavicum*.	Wild heliotrope	39	7	.30
Hydrocotyle	Pennywort	3	2	.36
Ceratophyllum demersum	Coontail	44	10	.34
Zannichellia palustris	Horned pondweed	13	1	.30
Myrica	Waxmyrtle	29	12	.23
Myriophyllum	Watermilfoil	13	7	.22
Setaria	Pigeongrass	18	4	.20
Distichlis spicata	Saltgrass	15	5	.17
Cephalanthus occidentalis	Buttonbush	2	1	.16
Lemna, et al	Duckweed	36	5	.15
Centella asiatica		1	1	.10
Axonopus furcatus		2	1	.09
Spartina	Cordgrass	8	6	.09
Ranunculus	Buttercup	12	3	.08
Juncus sp	Rush	1	1	.07
Pontederia	Pickerelweed	30	9	.06
Leersia sp	Cutgrass	3	1	.05
Thalia dealbata		3	2	.05
Lippia sp		1	1	.04
Fimbristylis		8	2	.03
Cabomba caroliniana	Fanwort	1	1	.03
Alternanthera philoxeroides	Alligatorweed	3	1	.02
Liquidambar styraciflua	Sweetgum	7	1	.01
Sparganium sp	Burreed	1	1	.01
Heteranthera dubia	Waterstargrass	1	1	.01
Miscellaneous				9.73
Total				75.16
ANIMAL MATERIAL				
Gastropoda	Snails	664	30	11.62
Insecta	Insects	288	20	4.43
Pisces	Fishes	73	13	2.86
Pelecypoda	Bivalves	55	12	1.35
Crustacea	Crustaceans	92	19	1.06
Miscellaneous				3.52
Total				24.84

DUCKS EXAMINED

Common mallard	421
Common black duck	15
Florida duck	32
Mottled duck	24
Gadwall	140
Baldpate	41
American pintail	367
Green-winged teal	113
Blue-winged teal	56
Shoveler	30
Redhead	65
Ring-necked duck	456
Canvasback	183
Greater scaup duck	18
Lesser scaup duck	123
American goldeneye	5
Ruddy duck	10
Total	2,101

[1] See footnote 1, table 3.

TABLE 7.—*Foods of game ducks in the western region listed in the order of their percentages of the total food as indicated by analyses of 909 stomachs (species listed at foot of last column) from 45 localities*

Scientific name [1]	Common name	Times used	Localities	Volumetric percentage (plant items above 0.33 percent shown graphically)
PLANT MATERIAL				
		Number	*Number*	
Potamogeton	Pondweed	522	30	16.29
Scirpus	Bulrush	381	27	11.19
Ruppia	Wigeongrass	201	8	6.26
Chara, et al.	Muskgrass	59	9	5.67
Echinochloa, chiefly *E. crusgalli*.	Wild millet	69	8	4.19
Polygonum	Smartweed	99	18	3.89
Sorghum vulgare	Sorghum	30	2	3.02
Zannichellia palustris	Horned pondweed	58	7	2.95
Carex	Sedge	32	12	1.62
Ceratophyllum demersum	Coontail	23	7	1.50
Hordeum vulgare	Barley	73	1	1.48
Hordeum pusillum	Little barley	5	2	1.21
Amaranthus	Pigweed	12	5	1.19
Eleocharis	Spikerush	50	13	1.08
Algae	Algae	18	6	.97
Lemna, *Spirodela*, et al	Duckweed	6	2	.87
Leersia oryzoides	Rice cutgrass	3	1	.76
Zea mays	Corn	2	2	.67
Cyperus		18	8	.66
Puccinellia nuttalliana	Alkali-grass	3	1	.56
Myriophyllum	Watermilfoil	48	13	.47
Cleome serrulata	Bee plant	1	1	.32
Najas	Naiad	3	3	.31
Setaria	Pigeongrass	5	3	.28
Alnus	Alder	3	3	.27
Medicago sativa	Alfalfa	14	1	.26
Chenopodium	Goosefoot	6	4	.26
Ambrosia	Ragweed	9	3	.25
Opuntia sp	Pricklypear	2	1	.25
Phleum alpinum	Alpine timothy	1	1	.24
Avena sativa	Oats	2	1	.19
Heliotropium	Wild heliotrope	4	3	.14
Sparganium	Burreed	6	6	.14
Bidens	Beggartick	12	3	.13
Prosopis glandulosa	Mesquite	1	1	.09
Marsilea	Pepperwort	9	3	.08
Helianthus sp	Sunflower	3	1	.07
Salicornia ambigua	Glasswort	10	1	.05
Triticum aestivum	Wheat	2	2	.05
Melilotus indica	Yellow sweet-clover.	29	1	.05
Juncus sp	Rush	1	1	.04
Glyceria sp	Mannagrass	1	1	.01
Distichlis, chiefly *D. stricta*	Saltgrass	5	2	.01
Salix sp	Willow	1	1	.01
Miscellaneous				8.75
Total				79.35
ANIMAL MATERIAL				
Insecta	Insects	280	36	16.69
Crustacea	Crustaceans	19	9	1.57
Gastropoda	Snails	37	10	.88
Pisces	Fishes	3	3	.12
Miscellaneous				1.39
Total				20.65

DUCKS EXAMINED

Common mallard	113
Gadwall	95
Baldpate	62
American pintail	170
Green-winged teal	145
Blue-winged teal	53
Cinnamon teal	18
Shoveler	12
Redhead	68
Ring-necked duck	5
Canvasback	44
Greater scaup duck	47
Lesser scaup duck	26
American goldeneye	12
Ruddy duck	39
Total	909

[1] See footnote 1, table 3.

TABLE 8.—*Foods of game ducks in the Pacific coast region listed in the order of their percentages of the total food as indicated by analyses of 937 stomachs (species listed at foot of last column) from 21 localities*

Scientific name [1]	Common name	Times used	Localities	Volumetric percentage (plant items above 0.33 percent shown graphically)
PLANT MATERIAL				
		Number	*Number*	
Potamogeton	Pondweed	149	14	12.14
Scirpus	Bulrush	155	12	4.78
Cyperus		8	4	4.38
Zannichellia palustris	Horned pondweed	9	3	3.12
Zostera marina	Eelgrass	3	2	3.03
Eleocharis	Spikerush	50	8	2.91
Triglochin maritima	Arrowgrass	89	2	2.57
Distichlis	Saltgrass	18	5	2.24
Ruppia maritima	Wigeongrass	19	8	2.19
Polygonum	Smartweed	60	11	1.79
Rumex	Dock	8	4	1.67
Oryza sativa	Rice	1	1	1.52
Ceratophyllum demersum	Coontail	13	3	1.50
Hordeum vulgare	Barley	7	3	1.17
Damasonium californicum		2	1	.95
Cephalanthus occidentalis	Buttonbush	1	1	.78
Carex	Sedge	16	8	.76
Algae	Algae	20	5	.75
Sparganium	Burreed	23	6	.70
Avena	Oats	2	2	.69
Myriophyllum	Watermilfoil	67	4	.66
Triticum aestivum	Wheat	4	4	.48
Najas	Naiad	9	2	.47
Lemna, et al.	Duckweed	8	2	.39
Eragrostis sp.	Lovegrass	1	1	.39
Chara, et al.	Muskgrass	4	2	.28
Medicago	Medick, burclover	7	4	.27
Picea sp.	Spruce	1	1	.21
Nymphaea	Spatterdock	9	2	.21
Marsilea	Pepperwort	3	3	.19
Cicuta sp.	Water-hemlock	18	1	.18
Hippuris vulgaris	Marestail	41	1	.17
Pseudotsuga mucronata	Douglas fir	2	1	.16
Echinochloa	Wild millet	2	2	.12
Plantago sp.	Plantain	2	1	.12
Amaranthus	Pigweed	6	3	.12
Rubus sp.		1	1	.08
Trifolium sp.	Clover	2	1	.08
Alnus oregana	Red alder	1	1	.08
Ranunculus	Buttercup	9	2	.06
Suaeda	Sea blite	2	2	.04
Eschscholtzia californica	California-poppy	1	1	.03
Cuscuta sp.	Dodder	1	1	.03
Salicornia ambigua	Glasswort	2	1	.01
Miscellaneous				14.25
Total				68.72
ANIMAL MATERIAL				
Gastropoda	Snails	246	13	8.57
Pelecypoda	Bivalves	360	8	8.48
Insecta	Insects	110	15	7.23
Crustacea	Crustaceans	248	8	4.37
Miscellaneous				2.63
Total				31.28

DUCKS EXAMINED	
Common mallard	84
Gadwall	15
Baldpate	69
American pintail	156
Green-winged teal	62
Blue-winged teal	3
Cinnamon teal	13
Shoveler	17
Redhead	4
Ring-necked duck	6
Canvasback	27
Greater scaup duck	313
Lesser scaup duck	55
American goldeneye	91
Ruddy duck	22
Total	937

[1] See footnote 1, table 3.

TABLE 9.—*Foods of game ducks in the western Canadian region listed in the order of their percentages of the total food as indicated by analyses of 399 stomachs (species listed at foot of last column) from 17 localities*

Scientific name[1]	Common name	Times used	Localities	Volumetric percentage (plant items above 0.33 percent shown graphically)
PLANT MATERIAL		*Number*	*Number*	
Potamogeton	Pondweed	147	13	12.73
Scirpus	Bulrush	149	13	10.58
Chara et al.	Muskgrass	177	7	9.20
Polygonum	Smartweed	29	8	2.49
Myriophyllum	Watermilfoil	72	9	2.28
Carex	Sedge	66	11	1.50
Sparganium	Burreed	50	7	.67
Fluminea festucacea	Whitetop	1	1	.61
Cyperus		3	3	.52
Hordeum vulgare	Barley	1	1	.51
Ruppia	Wigeongrass	4	3	.34
Najas	Naiad	6	4	.31
Ceratophyllum demersum	Coontail	7	2	.28
Eleocharis	Spikerush	31	10	.23
Sagittaria sp.	Arrowhead	6	1	.24
Nymphaea polysepala	Spatterdock	3	1	.22
Lemna sp.	Duckweed	3	1	.16
Ranunculus	Buttercup	19	6	.15
Zannichellia palustris	Horned pondweed	6	2	.11
Hippuris	Marestail	23	2	.09
Vallisneria spiralis	Wildcelery	3	1	.05
Rosa	Wild rose	2	2	.05
Algae	Algae	8	3	.04
Galium	Bedstraw	10	2	.02
Symphoricarpos	Snowberry	3	2	.02
Cladium mariscoides		2	1	.01
Miscellaneous				9.64
Total				53.19
ANIMAL MATERIAL				
Insecta	Insects	190	13	27.16
Gastropoda	Snails	49	7	6.35
Crustacea	Crustaceans	51	11	6.07
Pisces	Fishes	34	5	1.58
Pelecypoda	Bivalves	18	6	.81
Miscellaneous				4.84
Total				46.81

DUCKS EXAMINED

Common mallard	23
Gadwall	5
Baldpate	2
American pintail	3
Green-winged teal	27
Blue-winged teal	9
Redhead	104
Ring-necked duck	17
Canvasback	13
Greater scaup duck	72
Lesser scaup duck	49
American goldeneye	58
Ruddy duck	17
Total	399

[1] See footnote 1, table 3.

TABLE 10.—*Foods of game ducks in the eastern Canadian region listed in the order of their percentages of the total food as indicated by analyses of 109 stomachs (species listed at foot of last column) from 10 localities*

Scientific name [1]	Common name	Times used	Localities	Volumetric percentage (plant items above 0.33 percent shown graphically)
PLANT MATERIAL		*Number*	*Number*	
Potamogeton	Pondweed	64	6	12.47
Scirpus	Bulrush	50	6	11.02
Zizania aquatica	Wildrice	29	3	9.58
Chara, et al.	Muskgrass	11	4	6.12
Vallisneria spiralis	Wildcelery	4	2	5.53
Eleocharis	Spikerush	13	4	4.02
Sparganium	Burreed	32	5	2.01
Sagittaria	Arrowhead	3	2	1.93
Najas flexilis	Northern naiad	11	2	1.80
Carex	Sedge	20	5	1.32
Cladium mariscoides		17	2	.78
Nymphaea	Spatterdock	11	2	.76
Brasenia schreberi	Watershield	10	1	.71
Polygonum	Smartweed	14	2	.45
Ruppia maritima	Wigeongrass	1	1	.39
Agrostis sp.	Bentgrass	1	1	.27
Cyperus sp.		3	1	.14
Hippuris vulgaris	Marestail	2	1	.05
Myriophyllum	Watermilfoil	5	3	.03
Ranunculus	Buttercup	2	2	.03
Miscellaneous				6.14
Total				65.55
ANIMAL MATERIAL				
Insecta	Insects	50	8	17.67
Crustacea	Crustaceans	9	4	9.81
Gastropoda	Snails	13	5	3.59
Pelecypoda	Bivalves	1	1	2.27
Miscellaneous				1.11
Total				34.45

DUCKS EXAMINED	
Common mallard	10
Common black duck	14
Baldpate	2
American pintail	14
Green-winged teal	14
Blue-winged teal	10
Redhead	1
Ring-necked duck	15
Canvasback	2
Greater scaup duck	7
Lesser scaup duck	4
American goldeneye	15
Ruddy duck	1
Total	109

[1] See footnote 1, table 3.

PART 2.—PRINCIPAL DUCK FOODS: THEIR IDENTIFICATION, VALUE, AND RANGE

The foods of game ducks discussed collectively by region are here treated individually and in systematic order. The range maps[4] inserted for many plants will serve as a ready index to the species that are suitable for propagation in any particular section of the country. Failure to give proper consideration to the normal ranges of plants and to the factors that limit species to certain definite ranges has been one of the principal causes of disappointment in many experiments in duck-food propagation. The maps are based on data and interpretations from field notes of members of the Bureaus of Biological Survey and Plant Industry and from herbaria, local plant lists, and standard floras. Authentic additions or amendments to these maps are invited.

The usefulness of various foods is stated in the paragraph headed "Value," in such terms as slight, fair, good, and excellent. The designation "seed" is here applied to the numerous seedlike structures (achenes, drupelets, samaras, nutlets, etc.) popularly regarded and spoken of as seeds; the technical term is usually indicated parenthetically under the heading "Parts Consumed."

Plants treated in smaller type are reputed to be utilized to some extent locally as duck foods, but further studies will be necessary before recommendations can be made regarding their value.

As an aid to field identification, illustrations are given of many of the species of plants here recommended for use as duck foods. To assist in the recognition of some of the common aquatics having finely divided leaves a series of these are arranged for comparison in figure 2.

PLANT FOODS

ALGAE

Algae: Frogspit (pl. 117, *B*), kelp, rockweed, seaweed, (pl. 2, *A*), sea-lettuce (pl. 2, *B*).

Value.—Probably low, except in emergencies when other foods are scarce or lacking. The group ranks surprisingly high (sixteenth) in the continental ranking of duck foods (table 2), but some of the consumption, particularly in inland waters, may be merely incidental to the process of taking insects or desirable plant foods that chance to be enmeshed in the tangle of filaments. On the other hand, the use of marine algae appears to be largely intentional rather than accidental. It has been reported by J. J. Lynch, of the Biological Sur-

[4] In the range maps the heavily shaded parts denote areas of greatest abundance, and it is in such areas that the species mapped are most likely to be important as duck food; the lighter shading extends to the limits of definitely known general range; the lightly dotted parts are areas of uncertain distribution; and the black circles denote definite but somewhat isolated occurrences.

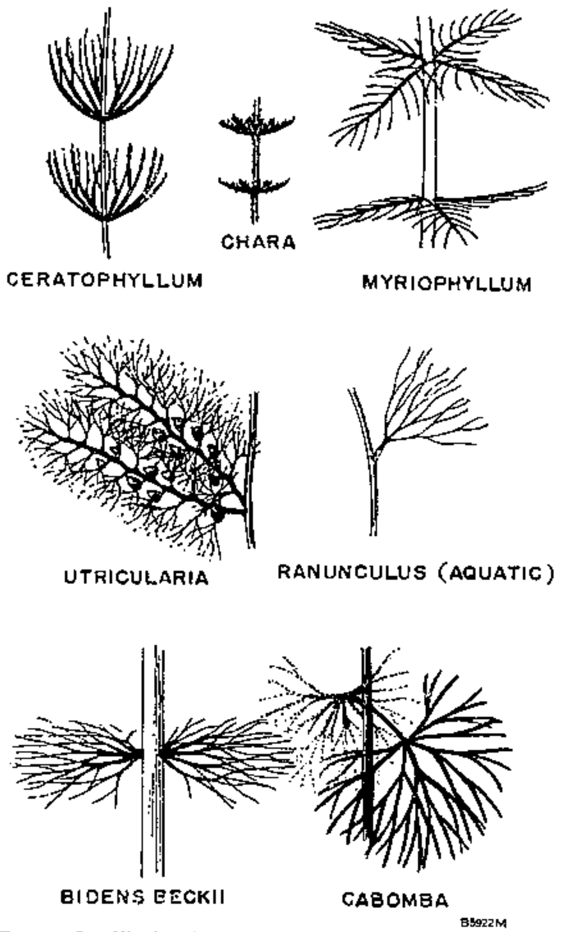

FIGURE 2.—Finely divided leaves of some common aquatic plants, slightly reduced, showing distinctive features in arrangement of parts.

vey, that at times during winter the entire food of the baldpate along the coast of Rhode Island is made up of sea-lettuce and closely related forms (*Ulva* spp., including *U. lactuca*), and that also in the same area the droppings of black ducks contain high percentages of green algae (*U.* (*Enteromorpha*) *intestinalis*, *U.* (*E.*) *clathrata*, *Chaetomorpha linum*, and *Cladophora expansa*). Lynch reports that the cells of various forms of marine algae found in excreta often reveal incomplete digestion, inasmuch as the cell walls are frequently intact though the fluid contents may have been drained.

Parts consumed.—The plants entire or in part.

Identification.—The group is not readily characterized because of its diversity, ranging as it does from microscopic colonies through the various delicate threadlike forms common in stagnant waters to the relatively coarse marine species (pl. 2, *A* and *B*). Algae are simple types of plants lacking such structures as true roots, leaves, and seeds. Some forms grow attached, others are free floating.

Environment.—Water of various qualities and depths.

Propagation.—Suggestions on propagation are unnecessary, because algae in quantity are generally undesirable, and as they compete with good duck-food plants they are likely to be more of a liability than an asset.

CHARACEAE: MUSKGRASSES

Chara:[6] Muskgrasses (pl. 3; figs. 2–3).

Value.—Good to excellent. Muskgrasses are eaten by many kinds of waterfowl and are particularly sought by diving ducks. It is

[6] Often classed as part of the Algae but here treated independently.

sometimes claimed that the plants produce an undesirable flavor in the flesh of the ducks that eat them.

Parts consumed.—All parts of the plants are used, but apparently the reproductive structures (oögonia, pl. 3, *C*) are especially relished, more than 300,000 having been found in a single stomach. Occasionally minute tuberlike structures are formed near the base of the plant and doubtless these also have considerable food value.

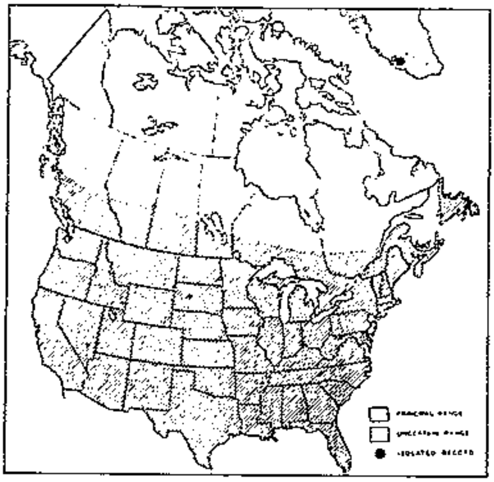

FIGURE 3.—Range of genus *Chara*.

Identification. — The whorls of tiny branches (fig. 2), often bearing minute oval reproductive bodies, are fairly diagnostic, as is also the musky odor emanating from some species and the frequent presence of a limy encrustation, which causes a certain degree of rigidity.

Environment.—Muskgrasses grow entirely submerged in water at depths varying from a few inches to more than 30 feet. Their habitats are diverse, but limestone localities or alkaline or saline situations are preferred. Rich soil does not seem to be required.

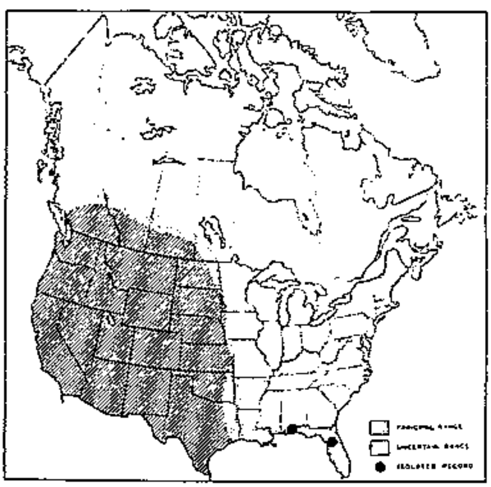

FIGURE 4.—Range of *Marsilea vestita*.

Propagation.—Transplanting should be accomplished during the growing season. The presence of mature (dark-colored) oögonia will help to insure successful propagation. Plantings in deep water should be weighted down with balls of clay; in shallow water the transplants may be merely pushed into the mud by hand.

Related genera.—Doubtless the genus *Nitella* also has value as a duck food, but at present there is no positive evidence to prove it. The same is true of *Tolypella* (pl. 3, *A*). Usually *Chara* may be distinguished from these two genera by the outer cortex, or sheath of cells, present on the stems and branches of most, but not all, of its species.

MARSILEACEAE: PEPPERWORTS

Marsilea vestita: Pepperwort, water shamrock (pl. 4, *A* and *B*; fig. 4).

Value.—Fair; the plants are useful but generally are not abundant enough to be important as a duck food.

Parts consumed.—The reproductive capsules (sporocarps, pl. 4, *B*).

Identification. — The floating cloverlike leaves with four leaflets are sufficient for recognition (pl. 4, *A*). The name "water shamrock," sometimes applied, is descriptive.

Environment. — Pepperworts are aquatics that root at shallow depths (usually less than 1 foot) in ponds and ditches. They occur in fresh or mildly saline water throughout alkaline regions.

Propagation. — By portions of the rootstocks and by mature sporocarps.

FIGURE 5.—Range of *Taxodium distichum*.

Related species.—There are several other species of *Marsilea*, but *M. vestita* has the widest distribution in the United States and is the only one of recognized duck-food value. It is probable that *M. quadrifolia*, a Eurasian species that has become established at Bantam Lake, Conn., whence it has been introduced into other northeastern areas, will be found to be useful in shallow fresh waters of the northern States. Titcomb (*81*) reported that the floating leaves of this species have been found completely covering the surface of water having a depth as great as 2 feet.

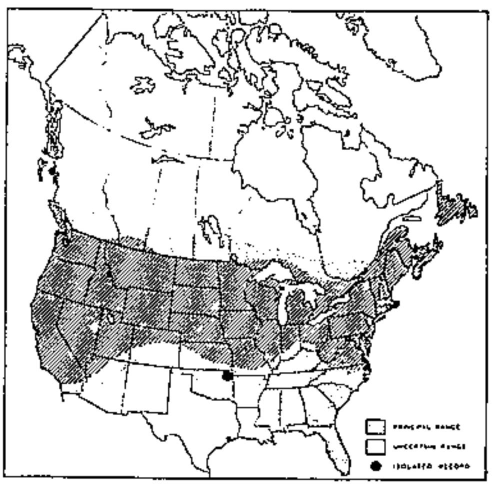

FIGURE 6.—Range of *Sparganium eurycarpum*.

PINACEAE: BALDCYPRESS

Taxodium distichum: Baldcypress (pls. 4, *C*, and 124, *A*; fig. 5).

Value.—Fair, but utility is confined mainly to the lower Mississippi region.

Parts consumed.—The seeds, enclosed in the woody scales of the globular cones.

Identification.—The baldcypress, a typical tree of southern swamps, is generally characterized by greatly enlarged bases and is the only conifer in the South that sheds all its leaves in winter.

Related species.—Two species of *Taxodium* occur in the United States but *T. distichum* is the only one that is of known value as a duck food.

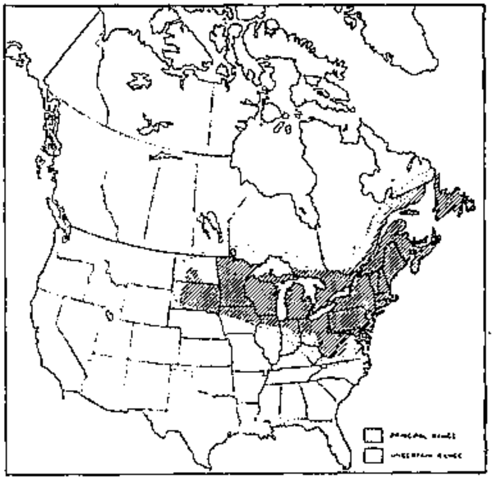

FIGURE 7.—Range of *Sparganium chlorocarpum*.

SPARGANIACEAE: BURREEDS

Sparganium: Burreeds (pls. 5–7; figs. 6–10).

Value.—Fair; used most frequently in the Northwest, particularly in Canada.

Parts consumed.—Despite the fact that a fairly thick corky coat and an inner woody covering protect the central starchy portion of the burreed seeds (nutlike fruits), they are frequently eaten by ducks, though usually in limited quantities. More than 300 seeds have been found in individual stomachs of several species of ducks, and at times these have constituted the major part of the contents.

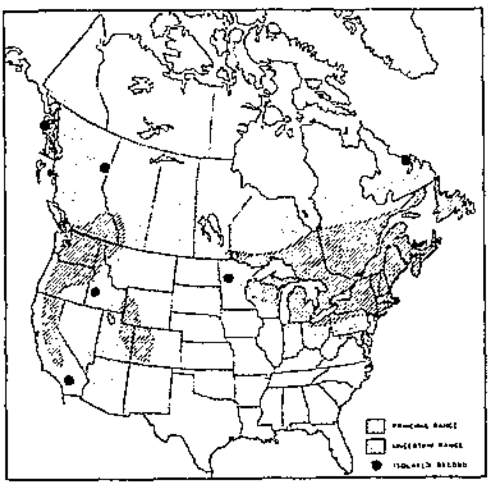

FIGURE 8.—Range of *Sparganium angustifolium*.

Identification.—The globular burs, or heads, should serve to identify a *Sparganium*. Emergent forms of burreeds can be distinguished from other similar plants by the leaves, which are shallowly and broadly triangular in cross section.

Environment.—Members of the genus *Sparganium* inhabit fresh-water situations; generally they are found in marshes or bordering open water, but some species occur almost entirely submerged. *S. fluctuans* (pl. 7, *A*) sometimes grows in water about 5 feet deep.

Propagation.—By rootstocks or by transplanting young rooted specimens. Propagation by means of seeds has at times given discouraging results; further information on germination requirements is essential.

Species.—The giant burreed (*S. eurycarpum*) (pl. 5) is the largest plant of the genus, and its seeds are distinct in being somewhat angular and usually two-celled. Its use by ducks has been noted more frequently than that of any other burreed, and at times it forms an important food item. *S. minimum* (pl. 7, *B*), *S. multipedunculatum*, *S. chlorocarpum* (pl. 6), *S. angustifolium*, and *S. americanum* have each been recorded 10 or more times from duck stomachs; *S. fluctuans*, though not similarly recorded, is also regarded as of some value to ducks, particularly in streams.

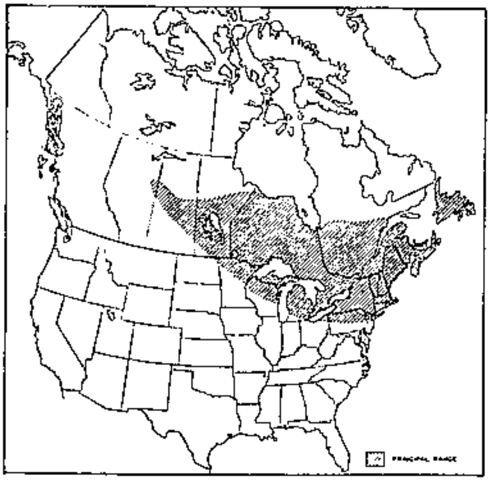

FIGURE 9.—Range of *Sparganium fluctuans*.

NAJADACEAE: PONDWEEDS, WIGEONGRASS, NAIADS, EELGRASS

Potamogeton: Pondweeds (pls. 8–26; figs. 11–28).

Value.—Good to excellent.

Parts consumed.—Various parts, depending on the species involved. The seeds (drupelike fruits) of practically all pondweeds are eaten freely; the subterranean tubers of sago pondweed (*Potamogeton pectinatus*) (pl. 8, *B* and *C*) are a very choice food, and the rootstocks and stems of some species, particularly of claspingleaf pondweed (*P. perfoliatus*) (pl. 25) and sago pondweed, are used. The winter buds of *P. friesii* (pl. 14), *P. pusillus* (pl. 12), and related types are consumed, as are the tender leaves of several species.

Identification.—The members of this aquatic genus are quite diverse in appearance, but the seeds have constant similarities. The individual species illustrated and described will serve to characterize the group.

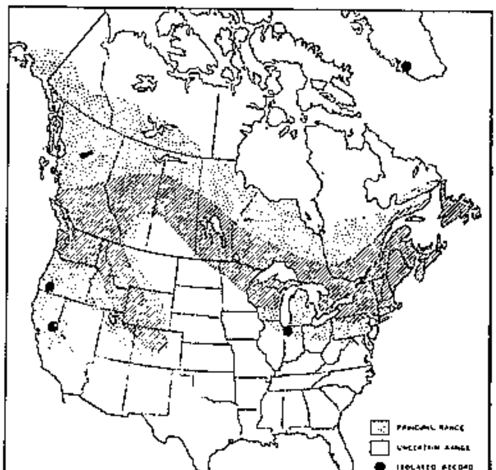

FIGURE 10.—Range of *Sparganium minimum*.

Environment.—Pondweeds grow at depths varying from a few inches to several feet. In water of average clarity 6 to 8 feet is usually considered the maximum depth for successful growth, but in exceptionally clear water certain species have been found growing at 20 feet or more. A few pondweeds (notably *P. pectinatus* and *P. perfoliatus*) tolerate or thrive in saline or alkaline water, but the majority require fresh water. *P. gramineus* (pls. 23 and 24) can subsist on firm sand or gravelly bottoms, but in general the group grows best in soil of moderate richness and softness.

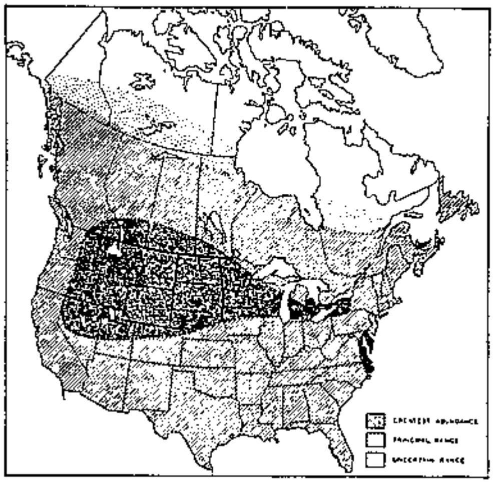

FIGURE 11.—Range of *Potamogeton pectinatus*.

Propagation.—Most pondweeds are well adapted to vegetative propagation; rooted parts can readily be transplanted early in the growing season, and from present indications it appears probable that many members of the genus can regenerate quickly from broken pieces of the leafy stems. The utilization of this faculty for regeneration probably affords the most practical general method of increasing or propagating desired species of pondweeds. In addition, sago pondweed can be disseminated by means of its tubers (weighted down by a coating of clay mud); and *P. zosteriformis*, *P. pusillus*, *P. friesii*, *P. obtusifolius*, and others, by special reproductive structures known as "winter buds" (compact clusters of leaves and stipules). Nearly all species (*P. robbinsii*, *P. crispus*, and *P. friesii* fruit rarely) can be grown from mature seeds that have been kept immersed and cool between the time of harvesting and planting. For further particulars on germination and propagation see pages 103 to 142.

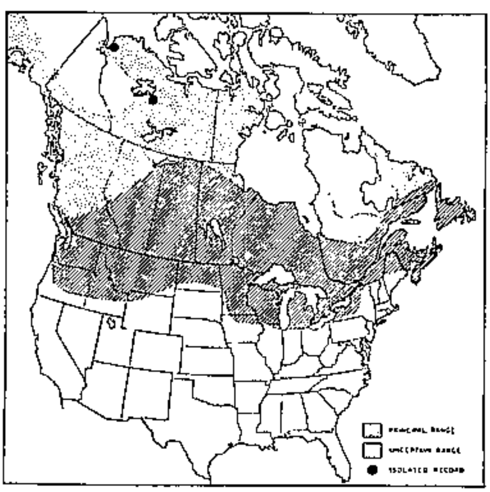

FIGURE 12.—Range of *Potamogeton vaginatus*.

Potamogeton pectinatus: Sago pondweed (pls. 8 and 120; fig. 11).

Value.—Excellent. This is probably the most important single waterfowl food plant on the continent and is responsible for about half, or more, of the total food percentage credited to the genus *Potamogeton*.

Parts consumed.—The tubers, seeds, and rootstocks, and other portions to a lesser degree.

Identification.—The fanlike spreading of the leaves at the water surface is fairly characteristic. The seeds can be distinguished from those of all other pondweeds by the rounded apex of the "trap door" (the portion of the edge that opens to permit sprouting) (pl. 8, *D*, *b* and *c*). Wigeongrass (*Ruppia*, pl. 27) in the vegetative state is sometimes confused with sago pondweed, but the latter can be recognized by the acute points of its stipules (one-eighth to one-half inch or more long), whereas in *Ruppia* the stipule projections are shorter and rounded.

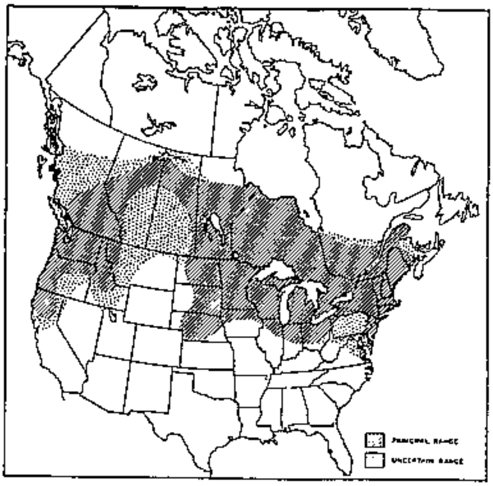

FIGURE 13.—Range of *Potamogeton zosteriformis.*

Environment.—Optimum growth is usually made on bottoms of sandy mud in water ranging from 2½ to 5 feet or more in depth. Though sago pondweed grows well in fresh water, Bourn (*5*) has shown that it benefits by salinity concentrations up to 20 percent of normal sea water (see discussion, p. 124). At Swanquarter, N. C., plants in good health were noted in October 1935 growing in water with salt content equaling about 44 percent of normal sea water. This species and wigeongrass are the most common and most important aquatics in the alkaline lakes of the West.

Propagation.—By tubers, by parts of rootstocks, by regeneration from pieces of leafy stems, and by seeds.

Related species.—*Potamogeton vaginatus* (pl. 9; fig. 12) and *P. filiformis* are closely allied species restricted to the Northern States and Canada. The former is a coarse plant with broad stipules and greatly elongated leaves. *P. filiformis*, on the other hand, is a more slender type, with seeds that are distinguished by a broad, sessile stigma. Both species bear tubers that probably are of some value as duck foods.

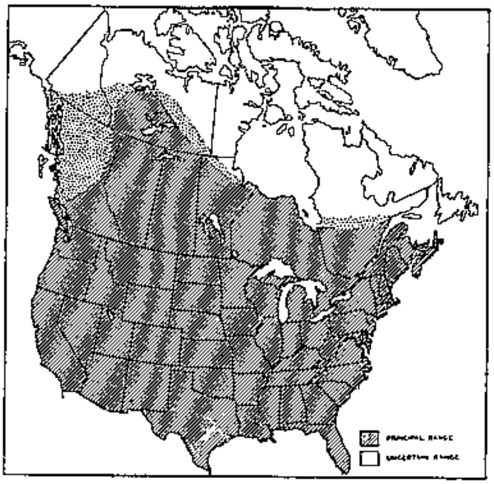

FIGURE 14.—Range of *Potamogeton foliosus.*

Potamogeton zosteriformis (P. zosterifolius): Flatstem pondweed (pl. 10; fig. 13).

Value.—Fair.

Parts consumed.—The seeds.

Identification.—The flatstem pondweed is the largest member of the group of pondweeds that bear only linear (grasslike) leaves. It is distinct in having a rather broad, flattened, zigzag stem, and it is further characterized by large winter buds and flat seeds.

Environment.—This plant grows best on mucky bottoms in the fresh-water lakes or ponds. It occurs at various depths and in clear water is known to grow successfully at more than 20 feet.

Propagation.—By winter buds and seeds.

Potamogeton foliosus: Pondweed (pl. 11; fig. 14).

Value.—Fair to good.

Parts consumed.—The seeds and foliage.

Identification.—In *Potamogeton foliosus* the seeds bear a prominent crest along one edge; all the leaves are linear and their bases are usually glandless, whereas in *P. pusillus*, *P. panormitanus*, and several other allied species the seeds are crestless and a pair of distinct, minute glands are generally present at the base of each leaf.

Environment. — Principally sluggish streams and fresh-water lakes on bottoms containing considerable humus. Experiments by Bourn (*6*) indicate that this species tolerates moderately brackish water. He states that "the optimum salt content for the promotion of growth in this plant lies between 4 and 12 percent sea water."

FIGURE 15.—Combined ranges of *Potamogeton pusillus* and *P. panormitanus*.

Propagation.—By seeds or by direct transplanting.

Potamogeton pusillus: Pondweed (pl. 12; fig. 15).

Value.—Fair to good.

Parts consumed.—The seeds and foliage.

Identification.—*Potamogeton pusillus* is a common pondweed of the grass-leaved type, resembling *P. foliosus* superficially but differing in the ability to produce winter buds and in other particulars listed under the latter species.

Environment.—Fresh or mildly brackish water of lakes and streams, generally at depths of 1 to 5 feet and usually in fairly rich soil.

Propagation.—By seeds or winter buds.

Related species.—*Potamogeton panormitanus* (fig. 15) is a form recognized by Fernald (21) as distinct from *P. pusillus*.

P. obtusifolius (pl. 13; fig. 16) is a northern pondweed that may be distinguished from *P. panormitanus* by its wider, rather flaccid leaves, more conspicuous glands, and larger seeds. It may be propagated either by seeds or winter buds. Fernald (21) has described a very similar type under the name *P. porsildiorum* and has recorded specimens from the James Bay section of Quebec, northwestern Mackenzie, and northern Alaska.

FIGURE 16.—Range of *Potamogeton obtusifolius*.

In *P. friesii* (pl. 14; fig. 17) the foliage and winter buds are more rigid than in other species of the grass-leaved group. The winter buds are comparatively abundant and are conspicuously flattened and compact. They constitute the principal means of propagation, since this species fruits very rarely.

P. strictifolius, *P. longiligulatus* (pl. 15), *P. fibrillosus*, *P. hillii*, and several other closely allied species recently described by Fernald (21) appear to be of lesser importance but need further study to determine their true status.

FIGURE 17.—Range of *Potamogeton friesii*.

Potamogeton spirillus (group): Pondweeds (pls. 16–17; figs. 18–19).

Value.—Fair.

Parts consumed. — The seeds and possibly other parts.

Identification.—*Potamogeton spirillus*, *P. diversifolius*, and *P. capillaceus* closely resemble one another in general appearance and therefore they are treated together. They are diminutive pondweeds with miniature floating leaves and grasslike submerged leaves. The majority of the flattish, circular seeds are borne submerged in the axils of the leaves.

Environment.—Fresh, often mildly acid, water at depths of 6 inches to 4 feet, usually on bottoms containing much humus. They are frequently found in the brownish-stained streams and lakes. *P. spirillus* is limited primarily to the Northeastern or North Central States and adjacent Canada, and *P. capillaceus* to the Atlantic and Gulf coasts, but *P. diversifolius* occurs widely scattered throughout the United States, with the exception of the New England States. The last-mentioned species has frequently been found thriving in newly excavated ditches in clayey soils.

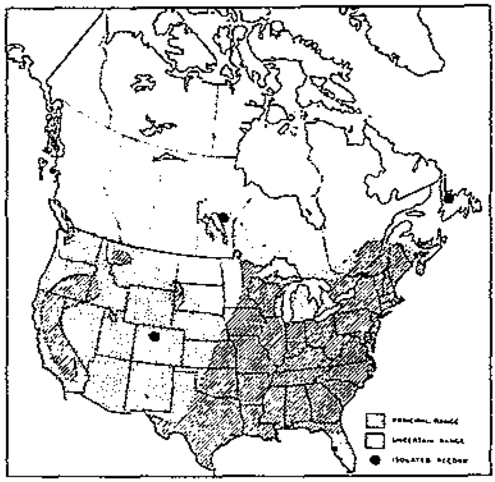

FIGURE 18.—Combined ranges of *Potamogeton spirillus*, *P. diversifolius*, and *P. capillaceus*.

Propagation.—By seeds, and by transplanting young plants.

Related species.—The ribbonleaf pondweed (*P. epihydrus*) pl. 17; fig. 19), with its elongate submerged leaves and circular fruits, is essentially a large edition of the above species. It is an inhabitant of slow streams or fresh-water lakes and appears to tolerate a greater degree of acidity and denser shade than most pondweeds.

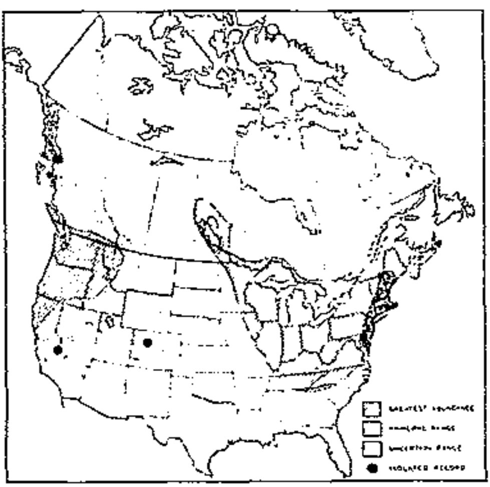

FIGURE 19.—Range of *Potamogeton epihydrus*.

Potamogeton tenuifolius (alpinus): Pondweed (pl. 18; fig. 20).

Potamogeton tenuifolius (*alpinus*) is a northern pondweed, distinguished by its ruddy color, oblanceolate floating leaves, and lanceolate, nearly sessile, submerged leaves. It generally grows at depths of 1 to several feet, in sluggish streams, particularly in old logging streams having considerable woody debris.

Related species.—*Potamogeton pulcher* (fig. 21) is a Coastal Plain species with broad floating leaves and black-spotted stems. It grows commonly in the brownish-colored water of coastal ponds and streams, generally at depths less than 4 feet.

Potamogeton amplifolius: Largeleaf pondweed (pl. 19; fig. 22).

Value.—Fair.

Parts consumed.—The seeds.

Identification.—*Potamogeton amplifolius* is the coarsest and largest leaved of the pondweeds. The submerged leaves are usually arched or curved; floating ones are frequently lacking.

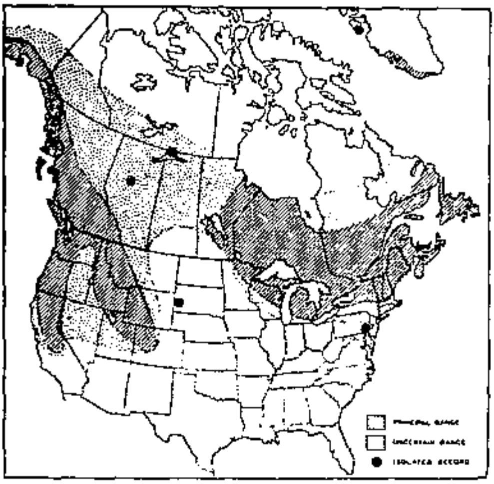

FIGURE 20.—Range of *Potamogeton tenuifolius.*

Environment.—Fresh water (chiefly in lakes); most common at depths of 3 to 12 feet on moderately soft bottoms containing considerable organic matter.

Propagation.—By seeds, rootstocks, and terminal portions of leafy stems.

Potamogeton americanus: Longleaf pondweed (pl. 20; fig. 23).

Value.—Fair to good.

Parts consumed.—The seeds.

Identification.—The longleaf pondweed is an example of the group of pondweeds that have two types of leaves; in this species the floating leaves are generally elliptic, and the lanceolate submerged ones usually have long leafstalks.

Environment.—*Potamogeton americanus* grows in fresh water at variable depths—commonly in 3 to 5 feet. It occurs in lakes and ponds but is usually most plentiful in sluggish streams. In the Potomac River it has been found extending downstream from the fresh-water section just to the head of brackish water (where the salt content during the average growing season is equivalent to less than 0.5 percent of normal sea salinity). This pondweed survives complete emergence on moist margins and also withstands severe floods better than any other.

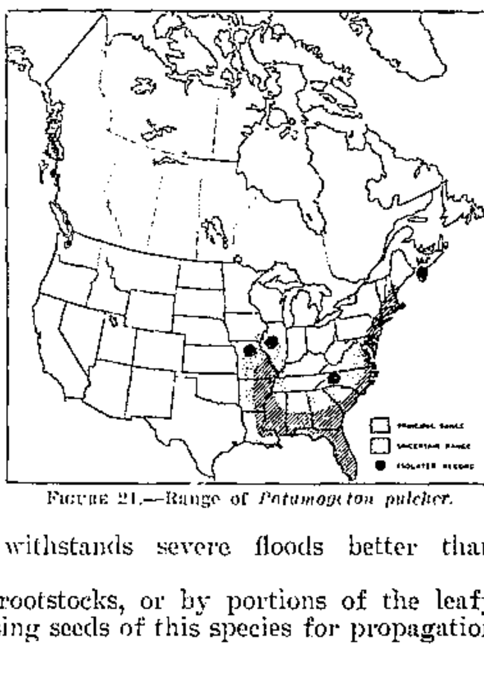

FIGURE 21.—Range of *Potamogeton pulcher.*

Propagation.—By seeds, rootstocks, or by portions of the leafy stems. The feasibility of using seeds of this species for propagation without preliminary cold storage is indicated by a laboratory test in which seeds harvested near Washington, D. C., in mid-September 1935, were immediately subjected to favorable growing conditions; germination commenced in 3 months and was practically completed within 6 months.

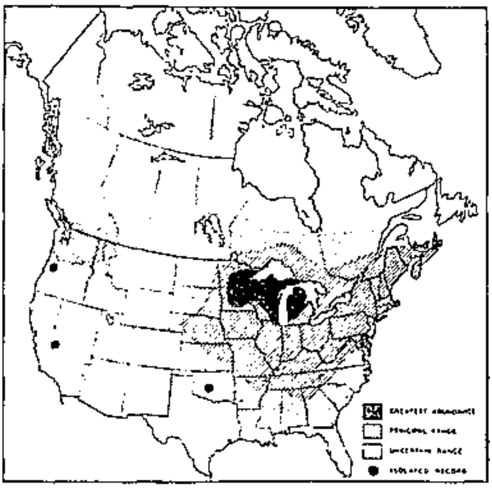

FIGURE 22.—Range of *Potamogeton amplifolius*.

Potamogeton natans: Floatingleaf pondweed (pl. 21; fig. 24).

Value.—Fair to good.

Parts consumed.—The seeds.

Identification.—The common floatingleaf pondweed has numerous oval floating leaves but the submerged leaves are reduced to bladeless leafstalks.

Environment. — Freshwater ponds and lakes at moderate depths, usually 1 to 5 feet; appearing to tolerate more strongly acid water than many pondweeds. It seems to thrive best on moderately soft, rich soils.

Propagation.—By seeds and rootstocks.

Related species.—*Potamogeton oakesianus* is a closely related northeastern species, but differs from *P. natans* in having a fruiting stalk much thicker than the stem and in having seeds without depressions on the sides.

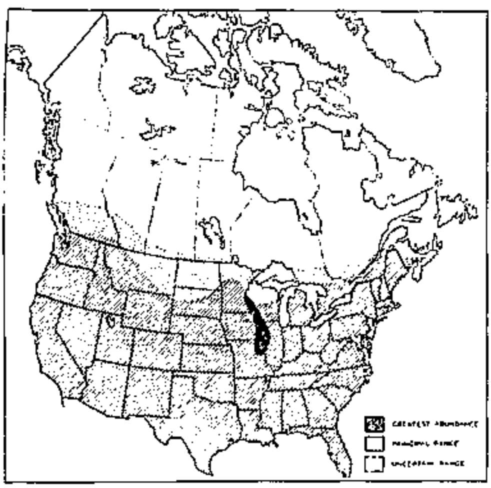

FIGURE 23.—Range of *Potamogeton americanus*.

Potamogeton illinoensis (group) (pl. 22).

Comparatively little accurate information is at hand on the distribution and waterfowl value of the group of pondweeds that includes *Potamogeton illinoensis* (pl. 22), *P. angustifolius*, and *P. lucens*. *P. illinoensis* occurs frequently enough in the Great Lakes area to have some minor consequence there, but the other two species, though credited by the manuals with very extensive ranges, appear to be none too well defined and are at most local or uncommon.

Potamogeton gramineus (P. heterophyllus): Variableleaf pondweed (pls. 23–24; fig. 25).

Value.—Fair to good.

Parts consumed.—The seeds and probably portions of rootstocks.

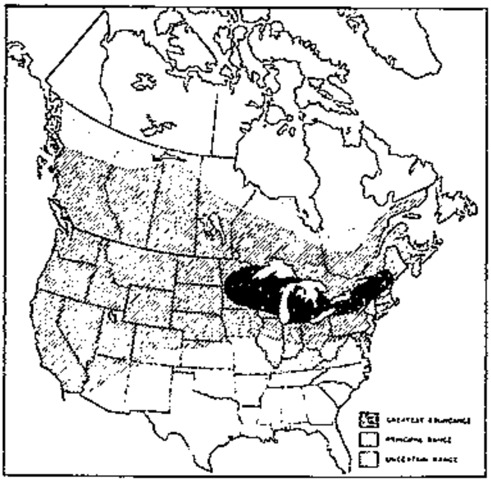

FIGURE 24.—Range of *Potamogeton natans.*

Identification. — In the variableleaf pondweed the submerged leaves are sessile and lanceolate to oblanceolate, and though diverse in size are generally rather small (about ¾ to 1½ inches long). The floating leaves are oval or elliptic.

Environment. — Rather shallow (1 to 5 feet) fresh water, usually near shore; commonly growing on sandy or gravelly bottoms. This species, like *Potamogeton americanus,* withstands complete emergence as long as the soil remains moist.

Propagation.—By seeds, rootstocks, and probably by portions of the leafy stems.

Potamogeton perfoliatus (inclusive of varieties): Claspingleaf pondweed, redheadgrass (pl. 25; figs. 26–27).

Value.—Good, ranking among the more valuable pondweeds.

Parts consumed.—The seeds, rootstocks, and portions of stems.

Identification. — The broad clasping bases of the leaves are distinctive in both forms of this pondweed: *Potamogeton perfoliatus richardsonii* has lanceolate leaves and is the common form in the interior, whereas the *P. p. bupleuroides* type has ovate or roundish leaves, smaller seeds, and is restricted primarily to the Atlantic coast.

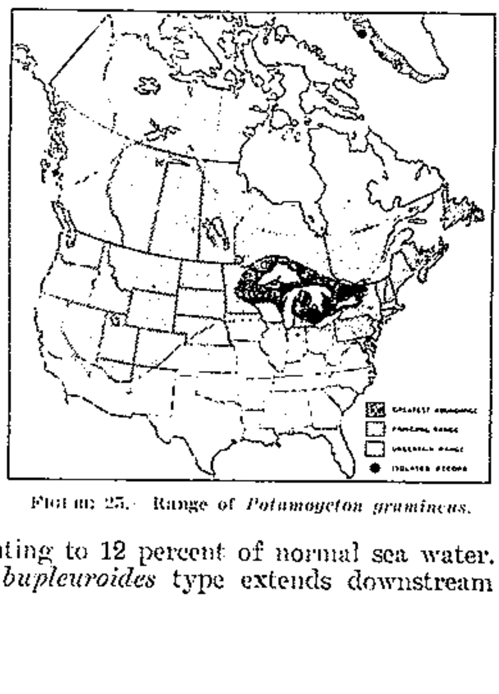

FIGURE 25.—Range of *Potamogeton gramineus.*

Environment. — Both forms grow well in fresh water but also thrive in moderately brackish situations. Bourn (*5*) has reported maximum growth of *P. perfoliatus* as occurring in salt concentrations amounting to 12 percent of normal sea water. In the Potomac River the *bupleuroides* type extends downstream from fresh water to a point where the salt content, during the average growing season, is equivalent to about 25 percent of normal sea water. Claspingleaf pondweeds are usually found on mucky or sandy soils, and thrive in either still or running water ranging from 2 to 5 feet in depth.

Propagation.—By rootstocks, cuttings, and seeds.

Related species.—The whitestem pondweed (*P. praelongus*) (pl. 26; fig. 28) is an allied species of somewhat less value. It may be distinguished from *P. perfoliatus* by its long leaves, its somewhat zigzag whitish stems, and the long-stalked fruiting spikes. This fresh-water species is known to thrive on moderately soft bottoms and inhabits deeper water than many of the other pondweeds—in Lac Vieux Desert, Vilas County Wis., plants were found growing luxurianty at depths of 10 to 12 feet.

Ruppia maritima: Wigeongrass (pl. 27; fig. 29).

Value.—Excellent.

Parts consumed.—The seeds (drupes) and vegetative portions.

Identification.—Though wigeongrass and sago pondweed have some resemblance to each other in their vegetative parts (refer to treatment, p. 26, of *Potamogeton pectinatus* for comparison), their seeds (pl. 27, *B*) are very different. In wigeongrass the seeds are small, blackish, and pointed and are borne in slender-stalked clusters (umbels).

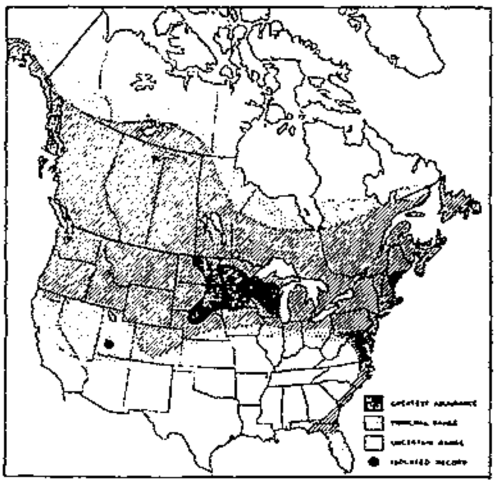

FIGURE 26. Range of *Potamogeton perfoliatus* (including var. *richardsonii*).

Environment.—Wigeongrass is a characteristic plant of brackish coastal waters and of alkaline lakes in the West. In the Potomac River it is found all the way up from the strongly brackish water of Chesapeake Bay to a point where the average salt content is equivalent to only about 2 to 3 percent of normal sea salinity. Bourn (7) found experimentally that this plant thrives in water having salt concentrations ranging from 0 to 80 percent of normal sea salinity and appeared healthy after 3 months in concentrations up to 150 percent of sea salinity, although it did not make active growth or produce seeds in the higher salt concentrations. *Ruppia* grows on either fertile or sandy bottoms at depths ranging from a few inches to several feet.

Propagation.—By portions of rootstocks or by seeds.

Related species.—*Ruppia occidentalis* (pl. 28) is a large form of wigeongrass that occurs locally in alkaline or saline lakes of the West.

By some authorities it is regarded as a variety of *R. maritima* rather than a distinct species. McAtee (*63*) reported that this species was the dominant submerged plant in a lake that apparently represented the most alkaline conditions prevailing in any water area examined during the Biological Survey's study of the Nebraska sand hills in 1915. In Norway Lake, Kandiyohi County, Minn., a coarse, possibly distinct, form of *Ruppia* has been found making a luxuriant growth in water that was practically fresh.

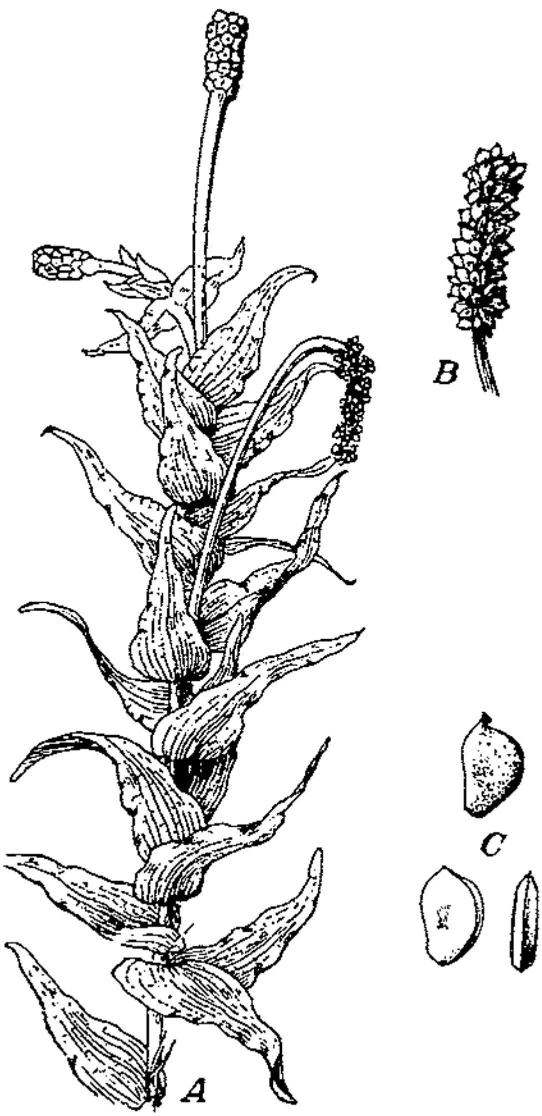

FIGURE 27.—*A*, *Potamogeton perfoliatus* var. *richardsonii*, × 1; *B*, mature fruiting spike, × 1; *C*, seeds × 5.

Zannichellia palustris: Horned pondweed (pl. 29; fig. 30).

Value.—Fair to good.

Parts consumed.—The seeds (nutlets) and vegetative portions.

Identification.—The horned pondweed has a superficial resemblance to young growths of wigeongrass (*Ruppia*), but its leaves occur in pairs (opposite) rather than singly, and the hornlike seeds are distinctive. The latter occur in the leaf axils, generally in aggregations of two to four.

Environment.—*Zannichellia* is a submerged aquatic that grows on good soil in fresh water (particularly in springs) as well as in strongly brackish water. Along the eastern shore of Chesapeake Bay it has been found thriving in water having a salt content equivalent to about 40 percent of normal sea water.

Propagation.—By transplanting growing portions of the plant or by seed.

Zostera marina: Eelgrass (pl. 30; fig. 31).

Value.—Good.

Parts consumed.—Chiefly the seeds; the leaves and rootstocks to a lesser extent.

Identification.—Clusters (2,000 to the square yard in *Zostera*) of elongate, tapelike leaves characterize both wildcelery and eelgrass, but the latter is an inhabitant of saline coastal waters and its leaf margin is smooth, lacking the fine serrations of wildcelery.

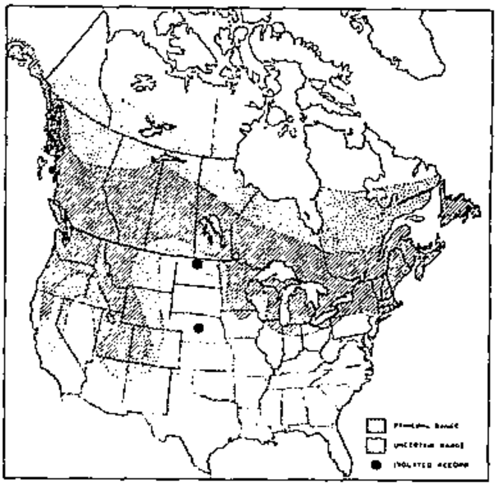

FIGURE 28.—Range of *Potamogeton praelongus*.

Environment.—Eelgrass grows submerged (usually in 2 to 6 feet of water) on tide flats of coastal bays and sounds. It thrives in normal sea water and extends upstream in the estuaries to a point where the salt content averages about 25 percent of normal sea salinity. Inability to survive high temperatures is ascribed by Setchell (*78, p. 431*) as the reason for the plant's absence from southern latitudes.

Propagation.—Preferably by portions of rootstocks; seeds also may be used.

Remarks.—Along the Atlantic coast, eelgrass has recently become scarce or has disappeared from extensive areas where it was formerly abundant—presumably because of a funguslike disease. Current experiments include the introduction of a robust, wide-leaved form (referred to as *Zostera marina* var. *latifolia*) from the Pacific coast, in the hope that it may prove resistant to this malady.

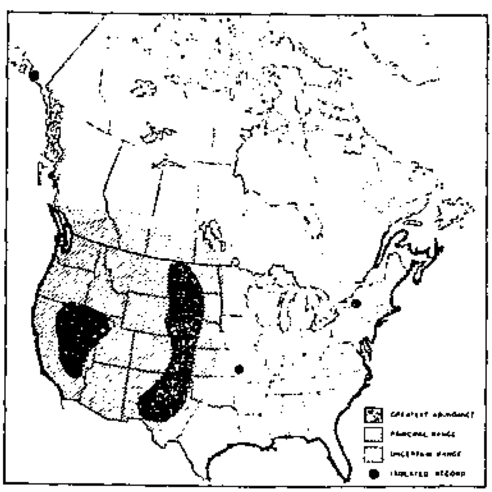

FIGURE 29.—Range of *Ruppia maritima*.

Cymodocea manatorum: Manateegrass (pl. 31).

Recent field observations along the Florida coast indicate that manateegrass may be of some value as a duck food. It is a marine plant locally abundant in parts of the Gulf region. The cylindrical leaves (rounded in cross section) make identification simple.

Halodule wrightii: Shoalgrass (pl. 32–33).

Recent stomach studies and field observations (both of very limited extent) indicate that the marine shoalgrass (*Halodule wrightii*) is an important waterfowl food along the Gulf and South Atlantic coasts, but its true importance remains for future determination. It has been found particularly abundant in the important redhead feeding grounds of Laguna Madre, along the coast of southern Texas.

The plants are frequently found growing with *Ruppia* and are sometimes confused with it, but *Halodule* is distinct in its obliquely triangular leaf tips, flanked by two minute teeth, and in the close series of brownish rings (nodal scars) that are present on certain parts of the rootstocks (pl. 33).

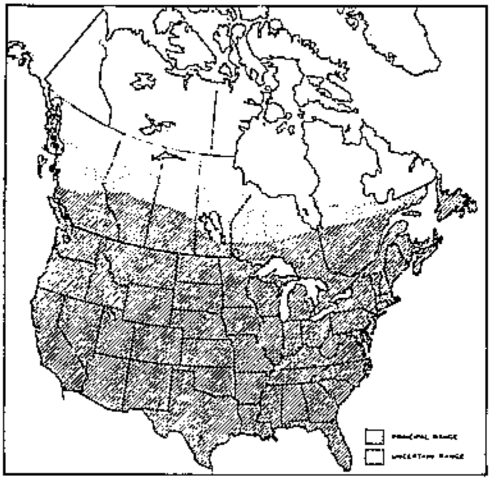

FIGURE 30.—Range of *Zannichellia palustris.*

Najas: Naiads (pls. 34–38; figs. 32–35).

Value.—Excellent in the two species *Najas flexilis* and *N. guadalupensis;* fair to slight in *N. marina* and *N. gracillima.* Three other species are known to be of local occurrence in the United States but at present their importance to ducks is undetermined.

Parts consumed. — The seeds (nutlets) and leafy parts of the plants.

Identification. — The genus consists of fairly delicate (except *N. marina*), freely branching aquatics having pairs or whorls of narrow, serrate leaves and solitary, awl-shaped seeds located in the leaf axils. The leaves have broadened, sheathlike bases, and in this regard are distinct from waterweed (*Anacharis*).

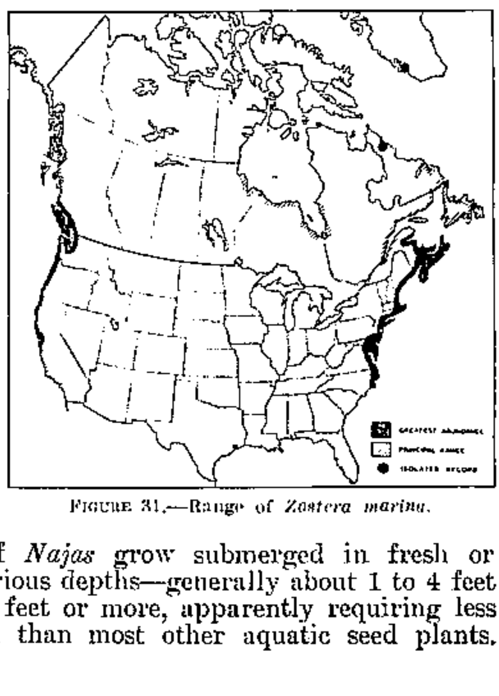

FIGURE 31.—Range of *Zostera marina.*

Environment.—Species of *Najas* grow submerged in fresh or mildly brackish water at various depths—generally about 1 to 4 feet but locally at depths of 20 feet or more, apparently requiring less light for successful growth than most other aquatic seed plants.

Usually they inhabit soils containing a considerable proportion of sand, but beds of naiads may also be found on somewhat mucky bottoms. In the Potomac River, *N. guadalupensis* extends downstream from the fresh-water section to a point with a salinity approximating 18 to 28 percent of normal sea water during the average growing season but becoming fresher during brief periods following heavy rains.

Propagation.—By transplanting growing parts of the plants or by seeds.

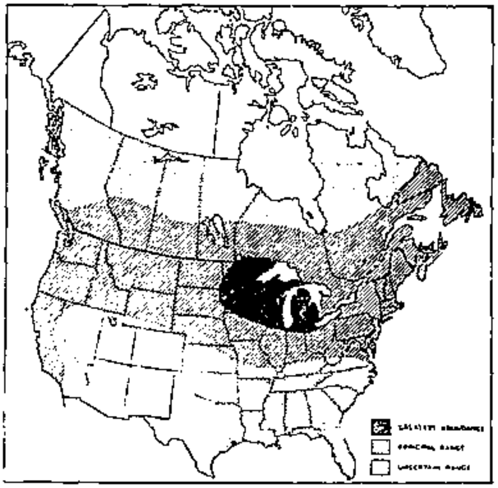

FIGURE 32.—Range of *Najas flexilis*.

Najas flexilis: Northern naiad, bushy pondweed (pl. 34; fig. 32).

The northern naiad is the prevailing representative of its genus in the northern half of the United States and in southern Canada; it ranks as one of the most useful of all North American duck foods. In the vicinity of the Great Lakes it is particularly plentiful and is commonly found growing on sandy bottoms in association with wildcelery (*Vallisneria spiralis*).

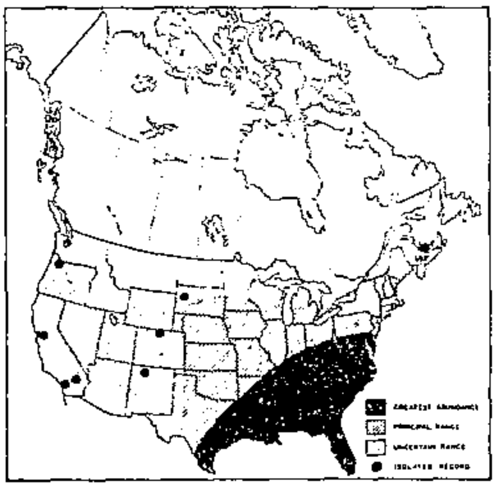

FIGURE 33.—Range of *Najas guadalupensis*.

Najas guadalupensis: Southern naiad (pls. 35–36; fig. 33).

In contrast with the northern naiad (*Najas flexilis*), the southern species (*N. guadalupensis*) has its greatest abundance in the lower Mississippi Basin and in the southeastern Coastal Plain. In the latter region it ordinarily withstands moderately brackish water. This species can be distinguished from the northern naiad by the deeply pitted reticulations of its short seeds. A coarse form has been found that grows at depths of 25 feet in clear Florida springs and also thrives in water less than 2 feet deep.

Other species of Najas: (pls. 37–38; figs. 34–35).

Najas muenscheri is a species recently segregated by Clausen (*10*) from the *N. flexilis–N. guadalupensis* aggregate and is reported by him to be the dominant species of *Najas* in the tidal parts of the Hudson River. Evidence regarding its utility to waterfowl is lacking, but it is probable that when more stomachs are examined from its range this naiad may prove to be a valuable duck food.

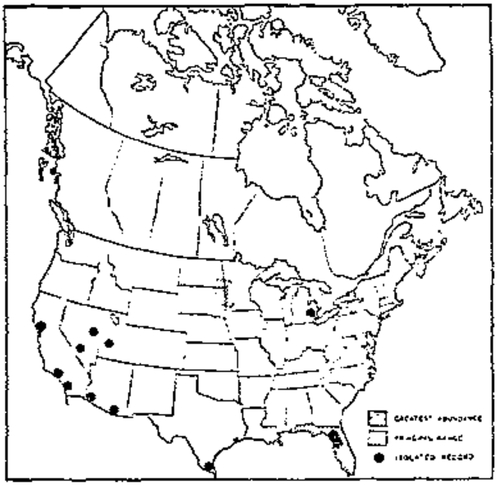

FIGURE 34.—Range of *Najas marina*.

The spiny naiad (*Najas marina*) (pl. 37; fig. 34) is a coarse form with prominent teeth on the leaves and with large seeds, and *N. gracillima* (pl. 38; fig. 35) is an extremely slender species. Both are usually too scarce and too localized to have appreciable value as duck foods.

Najas minor, an introduced European species, recorded locally from New York, and *N. conferta*, of western Florida, are restricted forms that need further study to determine their value as waterfowl foods.

JUNCAGINACEAE: ARROWGRASS

Triglochin maritima: Arrowgrass (pl. 39; fig. 36).

Value.—Locally fair to good (in the Northwestern States); its use appears to be consequential only in certain marsh-meadow localities that have been temporarily inundated. Clawson and Moran (*11*) reported that this plant has occasionally been found poisonous to livestock, particularly under drought conditions.

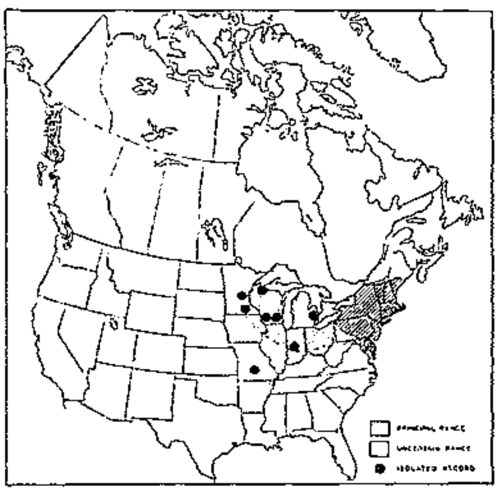

FIGURE 35.—Range of *Najas gracillima*.

Parts consumed.—The capsules containing the seeds.

Identification.—Arrowgrass is characterized by a cluster of grasslike, thickish leaves, from the base of which arise the long, slender stalks bearing the capsules.

Environment.—Moist, alkaline, or brackish situations.

Related species.—Three species of *Triglochin* are known in the United States and Canada, but only *T. maritima* has been consumed by ducks in significant quantities.

ALISMACEAE: ARROWHEADS, DELTA DUCKPOTATO

Sagittaria: Arrowheads, delta duckpotato, wapato (pls. 40–44; figs. 37–40).

Value.—Excellent locally in the case of *Sagittaria platyphylla;* fair locally in *S. heterophylla*, *S. cuneata* and *S. latifolia;* probably slight in other species.

Parts consumed.—The tubers; the use of seeds (achenes) is slight.

Identification.—Members of the genus *Sagittaria* are rather diverse in appearance but uniform in having white flowers in whorls of three and somewhat succulent leafstalks marked with cross veins. The leaf blades vary from arrow shaped, as in *S. cuneata* (pl. 43, *A* and *C*) and *S. latifolia* (pl. 40, *C*), to elliptic, in *S. platyphylla* (pl. 41), and linear, in *S. subulata* (pl. 43, *D*).

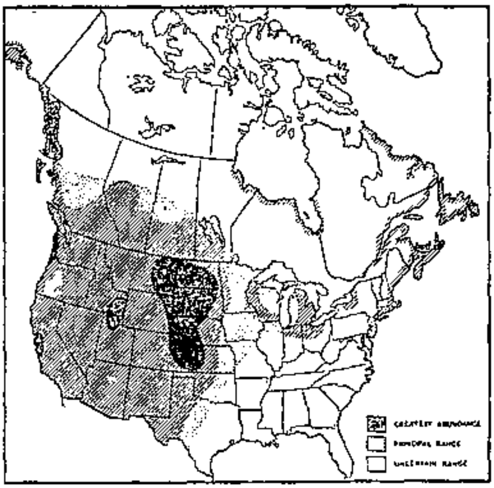

FIGURE 36.—Range of *Triglochin maritima.*

Environment.—Sagittarias are, in the main, fresh-water plants, but some species endure mild degrees of brackishness. A few grow largely or entirely submerged, but the more common types are found in marshes or on mud flats as well as in shallow water along the margins of lakes and streams.

Propagation.—By tubers, by plants, or by seed.

FIGURE 37.—Range of *Sagittaria platyphylla.*

Sagittaria platyphylla: Delta duckpotato (pl. 41; fig. 37).

The delta duckpotato is probably the only sagittaria of primary importance as a duck food. Its tubers (pls. 41, *B*, and 44, *A*) are of moderate size and occur at shallow depths and hence are much used in their limited native habitat along the Gulf coast. Duckpotatoes as a group constitute less that 1 percent (0.94) of the total food (table 3), and more than half of this item consists of the delta duckpotato.

Sagittaria heterophylla: Arrowhead (pl. 42; fig. 38).

Sagittaria heterophylla, a common species of arrowhead, normally grows in shallow water or in marshes of soft mud, and since its tubers are of medium size they are frequently available as duck food. As implied by the scientific name the leaves of this plant are extremely variable ranging from linear or elliptic to arrow shaped.

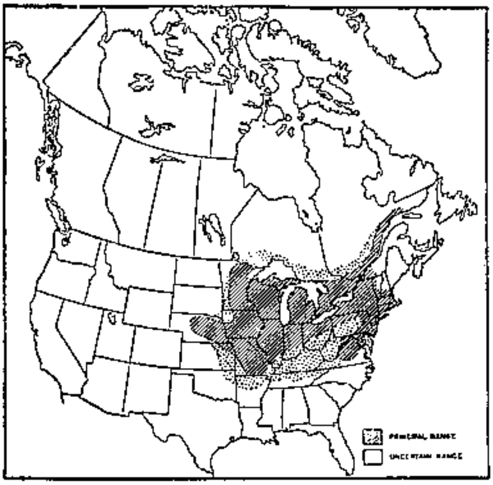

FIGURE 38.—Range of *Sagittaria heterophylla*.

Sagittaria weatherbiana.

In the strongly acid water of the Dismal Swamp, in southeastern Virginia and adjacent North Carolina, a species (*Sagittaria weatherbiana*), recently described by Fernald (*22*, pp. 387–389), produces tubers similar to those of *S. platyphylla* and *S. heterophylla*. This plant is worthy of careful study as a possible source of duck food in darkly stained shaded waters of the Southeast.

Sagittaria cuneata (**S. arifolia**) and **S. latifolia:** Arrowheads, duckpotatoes (pls. 43–44; figs. 39–40).

These are the two common species of arrowhead-leaved duckpotatoes, or wapatos. Their tubers (particularly those of *Sagittaria latifolia*) incline to be rather large (see pl. 44 showing relative size of tubers of *S. latifolia* and *S. platyphylla*) for duck consumption, and ordinarily they are buried too deeply to be readily available unless in soft mud. Though both plants are plentiful in many parts of the country their tubers have been used in significant quantity in only a few instances, and therefore it appears that the high regard that has been accorded them as duck foods has not been fully merited. *Sagittaria cuneata* is usually a lower plant than *S. latifolia* and its tubers average smaller, but the most reliable means of identification is by the seed: The seeds of *S. cuneata* have a minute suberect beak (pl. 43, *B*), whereas in *S. latifolia* the beak is long and either horizontal or diagonal.

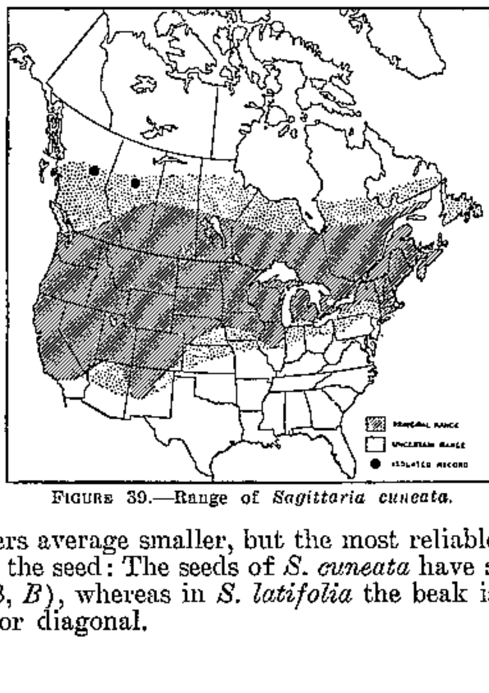

FIGURE 39.—Range of *Sagittaria cuneata*.

Other species of Sagittaria.

Other species of *Sagittaria*, including the linear-leaved *S. subulata* and *S. cristata*, may be useful as duck foods, but at present their status is uncertain.

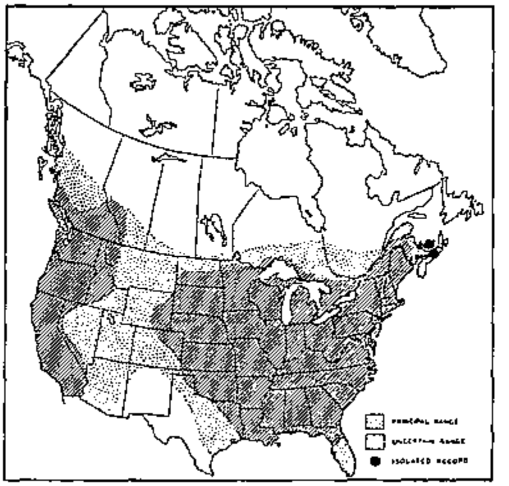

FIGURE 40.—Range of *Sagittaria latifolia*.

Lophotocarpus calycinus (pl. 45; fig. 41).

Recent field observations along the Illinois and Mississippi Rivers indicate that the seeds (achenes) of the large, arrowhead-leaved plant *Lophotocarpus calycinus* are eaten commonly by shoal-water ducks and may be of considerable local value. The head of seeds protected by the enfolding calyx appears to persist intact longer than in *Sagittaria* and therefore may be more available for consumption.

Damasonium californicum (fig. 42).

Value.—Locally fair; in spite of an extremely restricted distribution fairly large quantities of the seeds of *Damasonium* have been recorded from two duck stomachs in one California locality (Chico).

Parts consumed. — The seeds (achenes).

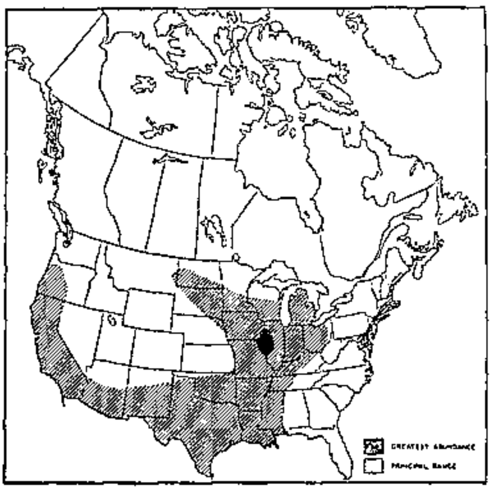

FIGURE 41.—Range of genus *Lophotocarpus*.

Identification. — *Damasonium* is somewhat similar to its relative, waterplantain (Alisma), but differs in having fringed flowers and long-beaked seeds.

Environment. — Shallow water or mud.

Propagation.—By transplants or by seed.

BUTOMACEAE: FLOWERING-RUSH

Butomus umbellatus: Flowering-rush (pl. 46, *B*).

The flowering-rush, a European immigrant, has become locally abundant on the St. Lawrence River and at the southern end of Lake Champlain, and recently has been found in the Lake Erie marshes near Toledo, Ohio. Current investigations indicate that it may prove to be a useful duck food. The plant produces numerous slender corms at shallow depths. A number of these corms constituted about half the contents of a green-winged teal stomach collected late in October 1935 just north of the Lake Champlain beds. The plant can be readily propagated by corms, rootstocks, or seeds.

HYDROCHARITACEAE: WILDCELERY, FROGBIT, WATERWEEDS

Halophila engelmannii (pl. 46, *A*).

It appears probable that *Halophila engelmannii*, a marine plant of Florida and Texas coasts, is fed upon by ducks, but substantiating evidence is wanting. *Halophila* is distinct in having its oblanceolate or elliptic, serrulate leaves in whorls of five.

FIGURE 42.—Range of *Damasonium californicum*.

Anacharis (Elodea): Waterweeds (pl. 47; fig. 43).

Value.—Generally slight. Though waterweeds have wide distribution and are rather common, they produce seeds rarely, and the records of their occurrence in duck stomachs are infrequent. A redhead collected on the Potomac River, however, contained nearly 600 of these seeds, which formed half the stomach contents. Because the plants are grown easily and rapidly they are useful as a "salad" course for captive or other grain-fed ducks.

Parts consumed.—The seeds (small fruits) and leaves.

Identification. — Waterweeds resemble naiads (*Najas*) in several respects, but the leaves differ in not being broadened at the base.

Environment. — Waterweeds grow submerged at various depths in fresh water—generally on mucky bottoms.

Propagation.—By transplanting fragments of growing plants. The stems root readily in water. They grow rapidly, and since they sometimes become so dense as to choke out other vegetation they should be introduced only where more valuable aquatic species cannot thrive.

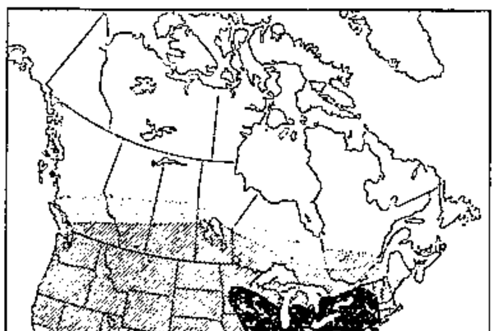

FIGURE 43.—Range of genus *Anacharis*.

Species.—There are several species in the genus *Anacharis*, but *A. canadensis* (pl. 47, *A*) and *A. occidentalis* (pl. 47, *B*) are the most common.

Vallisneria spiralis:[6] Wildcelery (pl. 48; fig. 44).

Value.—Excellent; a large southern form (pl. 48, *D*) common in spring-fed streams and lakes of the Gulf coast from Florida to Louisiana does not seem to be so valuable as the northern type (pl. 48, *A* and *C*). The southern form has been found with an abundance of mature fruit during late December in Sumter County, Fla.; in the North the fruits mature from September to early November.

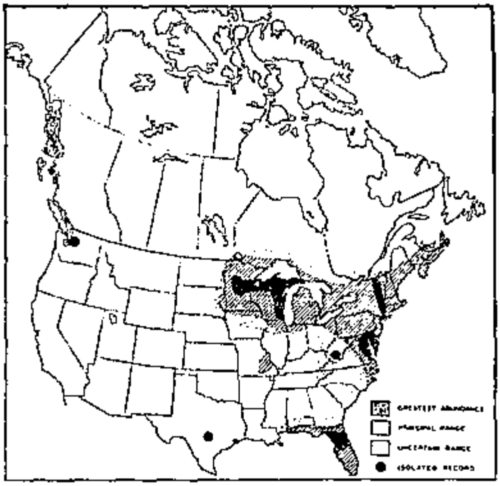

Figure 44.—Range of *Vallisneria spiralis.*

Parts consumed. — The underground parts and the leaves and podlike fruits.

Identification.—The tapelike leaves and the spirally coiled, slender stalks on which the elongate fruits are borne serve as distinguishing characters.

Environment. — Wildcelery grows in fresh water at depths of 1 to 5 feet or more and occurs submerged or with the upper part of its leaves floating at the surface. The plants thrive in water having a sluggish current and appear to make the best growth on bottoms having a large proportion of sand or coarse silt.

The greatest beds in the country are found in the fresh-water sections of the tidal streams along the Atlantic Coastal Plain. In the Potomac River they extend downstream from the fresh-water section to a point where the salt content, during the average growing season, is about 18 to 28 percent of normal sea salinity. Bourn (*6*) has shown experimentally that wildcelery could not be grown successfully in concentrations of sea water greater than 12 percent or in water with a total concentration of salts greater than 0.5 percent.

Figure 45.—Range of *Limnobium spongia.*

Propagation.—By seeds, winter buds, or by transplanting sprouted portions of the rootstock.

[6] This specific name is considered by some botanists to apply only to the European form of *Vallisneria.*

Thalassia testudinum: Turtlegrass (pl. 49).

Turtlegrass (*Thalassia*) is frequently associated with *Cymodocea* and *Halodule* in coastal waters of the Gulf region, and recent field investigations indicate that it has some value as a duck food. Its leaves are somewhat similar to those of eelgrass but are coarser and more firm.

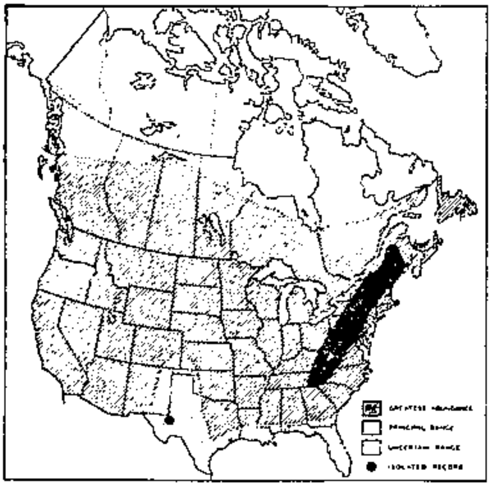

FIGURE 46.—Range of *Glyceria striata*.

Limnobium spongia: Frogbit (pl. 50; fig. 45).

Value. — Fair locally; though frogbit occurs throughout the South, it has been recorded from duck stomachs in significant percentages only in Avoyelles Parish, La.

Parts consumed. — The many-seeded fruit.

Identification. — The heart-shaped outlines of the leaf blades of frogbit, together with the pad of spongy, purplish - colored tissue on the lower side of floating leaves, are adequate for identification.

Environment.—The plants float on the surface of fresh-water ponds and swamps or grow on muddy bottoms from which the water has receded. They withstand a considerable degree of shade.

Propagation.—By young plants sprouted from the prostrate floating stems or rootstocks, and probably by seed.

GRAMINEAE: WILDRICE, WILD MILLETS, CEREALS

Glyceria striata: Mannagrass (pl. 51; fig. 46).

Value.—Fair.

Parts consumed. — The seeds (grains).

Identification.—It is impossible satisfactorily to characterize grasses without reference to technical details. Mannagrass (pl. 51) is generally 1 to 3 feet tall and has flat leaves, some of which may be submerged.

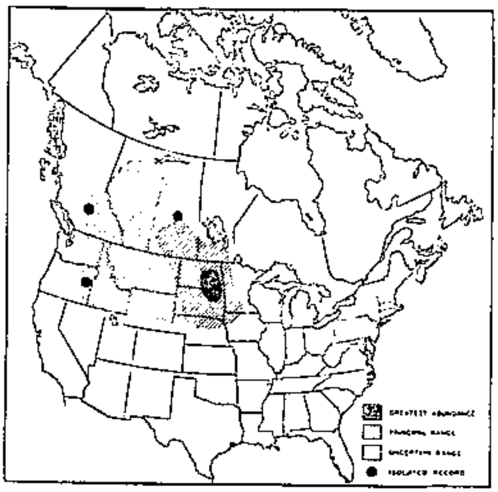

FIGURE 47.—Range of *Fluminea festucacea*.

Environment.—Shallow fresh-water ponds, bogs, marshes, and in moist soil; often thriving in considerable shade.

Propagation.—By division of root clumps or by seeds.

Related species.—Several other species of *Glyceria* occur in marshy places, but *G. striata* is the only one with a record of considerable use by ducks.

Fluminea festucacea: Whitetop (pl. 52; fig. 47).

Seeds of whitetop have been recorded from stomach examinations from only one locality, Oak Lake, Manitoba, but it may well be that within its limited range, the plant is used considerably, particularly in summer. Its seeds ripen and fall by mid-July, hence summer studies of the feeding activities of ducks in the northern prairie breeding grounds are necessary for a determination of this plant's true value.

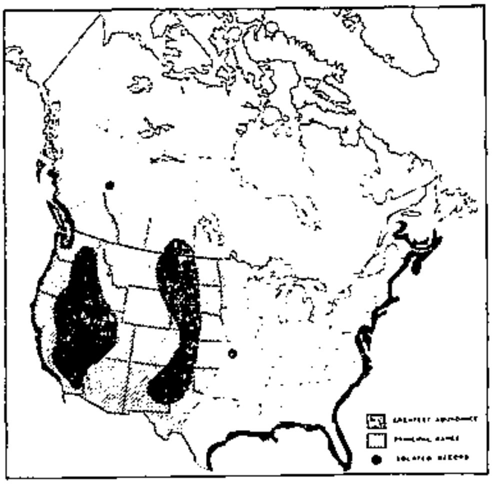

FIGURE 48.—Range of genus *Distichlis*.

Eragrostis: Lovegrass, tealgrass.

Though the genus *Eragrostis* is large and some of its species are plentiful in meadows or lowlands that are subject to seasonal inundations, the value of the group for duck food usually appears to be slight. The seeds or spikelets were found to be an important pintail food near St. Charles, Ark., and were recorded in small quantity from three other localities. Along the Illinois River the common species *E. hypnoides* is known by the name "tealgrass" and is considered a fair food for shoal-water ducks when the moist depressions in which it thrives are flooded in fall by high water.

FIGURE 49.—Range of *Spartina alterniflora*.

Distichlis: Saltgrass (pl. 53, fig. 48).

Value.—Locally fair.

Parts consumed. — The seeds (grains).

Identification.—In combination, the following features are fairly diagnostic: Creeping scaly rootstocks; numerous divergent, somewhat involute (in-rolled) leaves on erect branches; and short, dense panicles. These are rather rigid grasses and average about 1 foot in height.

Environment. — Saltgrasses grow on alkaline flats or in semidry salt marshes.

Propagation.—By means of rootstocks and probably by seeds.

Species.—*Distichlis spicata* is the common saltgrass of coastal marshes, whereas *D. stricta* and *D. dentata* are confined largely to inland alkaline areas of the West.

Hordeum pusillum: Little barley.

Though an annual grass of widespread distribution, little barley probably is ordinarily unavailable as food for ducks because it does not thrive on lands that are permanently marshy. Records of its use are confined to La Junta, Colo., where its grains were taken in large quantity by gadwalls and by baldpates (wigeons). The plants resemble small editions of cultivated barley and are also similar to *Hordeum nodosum*, except that the latter is perennial.

Leptochloa fascicularis: Sprangletop (pl. 54).

Limited stomach data and some field evidence indicate that the marsh or aquatic grass sprangletop may be of considerable local value as a duck food in Louisiana and in the lower Mississippi region. It thrives best in semidry marshes or dry lake beds. Its seeds are small but numerous and readily available. Further study of its consumption will be desirable.

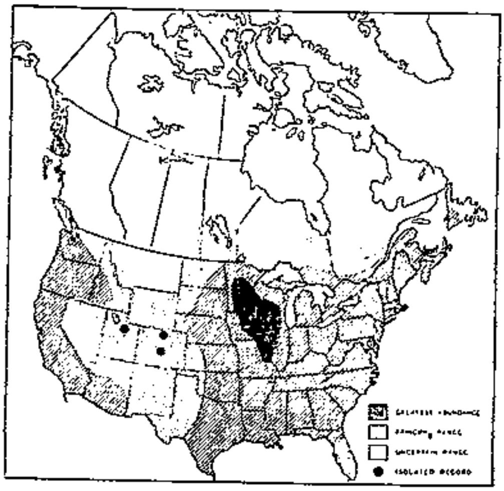

FIGURE 50.—Range of *Leersia oryzoides*.

Spartina: Cordgrasses (pls. 55–57 and 127, *B*; fig. 49).

Value.—Usually slight, locally fair.

Parts consumed.—The seeds (grains). The rootstocks of *Spartina alterniflora* are a valuable source of food for geese and also are eaten by brant.

Identification.—The compact, oblong-linear, one-sided spikes arranged alternately on the inflorescence are characteristic of the cordgrasses. The leaf margins are often involute (in-rolled).

Environment.—Members of the genus *Spartina* compose a very large proportion of the vegetation on brackish coastal marshes. *S. patens* furnishes most of the salt-meadow hay along the Atlantic coast, and *S. alterniflora*, known locally as tide grass, is usually restricted to the lower sections and outer borders of the marshes, where it is subject to regular inundation by the tides. In addition, two species inhabit meadows and marshes of the interior.

Propagation.—By perennial rootstocks in the useful species, and probably by seed.

Species.—*Spartina patens*, a slender, few-spiked form, and *S. alterniflora*, a somewhat coarser plant, dominate much of the marshland along the Altantic and Gulf coasts. In the same range occurs *S. cynosuroides*, which is a giant type with many spikes and grows commonly on the edges of sloughs, canals, and ponds. *S. spartinae* and *S. bakeri* are tufted plants of the Gulf region, the former distinguished by its erect and tightly appressed spikes and the latter by its large tussocks with long, narrow drooping leaves. *S. gracilis* and *S. pectinata* are the two inland species, the former, comparatively slender, being the more common occupant of alkali areas. *S. leiantha* is the Pacific coast representative.

Leersia oryzoides: Rice cutgrass (pl. 58; fig. 50).

Value.—Fair to locally good. This plant formed more than one-fifth of the food of 87 mallards collected during November in the flood plain along the Illinois River. Small quantities of the seeds of *Leersia virginica* and *L. lenticularis* also have been recorded from duck stomachs, but these species appear to be of only slight importance as duck foods.

Parts consumed.—The rootstocks and seeds (grains).

Identification.—The finely saw-edged leaves and the broad, flat spikelets are characteristic.

Environment.—Rich, moist soil in bottom lands of rivers, fresh-water marshes, and swamps. Rice cutgrass is particularly adapted to growth in marshes that dry out during the latter part of the growing season and are at times subjected to severe flooding.

Propagation.—By rootstocks or by seeds.

Zizania: Wildrice (pls. 59–61; fig. 51).

Value.—Excellent.

Parts consumed.—The seeds (grains).

Identification.—The partitioned cavity of the stem (pl. 61), the long rodlike seeds (pl. 60, *B*), and the differentiation of the inflorescence into separate staminate and pistillate portions (pl. 59, *B*) are distinctive. It is one of the best known of North American wild-duck foods and has been widely published upon (*8, 9, 17, 44, 76*).

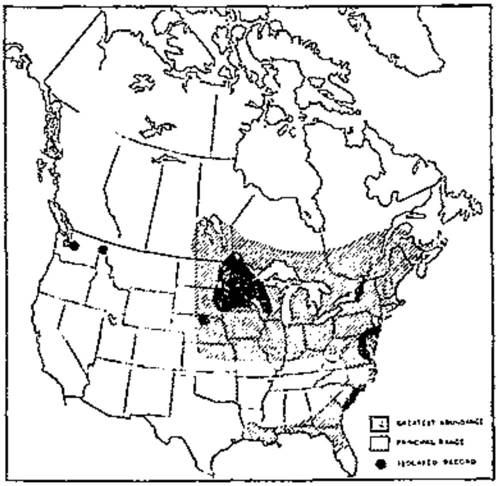

FIGURE 51.—Range of *Zizania aquatica* (including variety *angustifolia*.)

Environment.—Ideal conditions for wildrice growth include shallow fresh water a few inches to 2 or 3 feet deep, with sufficient circulation to prevent stagnancy, and a bottom composed of fairly deep muck or fine soft silt. Along the fresh-water sections of tidal streams it is often found thriving in marshes from which the surface water is drained completely twice a day during normal low tide.

The beds of the broad-leaved form of wildrice along the Potomac River extend downstream from the fresh-water section to a point where the salt content is equivalent to about 2 to 3.5 percent of normal sea salinity during the average growing season, but at the lower limit during dry seasons the plants are frequently destroyed by increased brackishness. Water brackish enough for the salt to be tasted may be considered unsuitable for the propagation of this fresh-water plant. Scofield (*76, p. 8*) states that when water is appreciably salty to the taste it is unsuited for the growth of wildrice.

Propagation.—By seeds, broadcast in fall or early spring.

Species.—*Zizania aquatica* is the larger form of wildrice with large leaves (frequently an inch or more wide) and with comparatively narrow grains. It is most abundant along the Atlantic coast but is locally common also in the interior as far north as the southern half of Minnesota and Wisconsin. *Z. aquatica* var. *angustifolia*, sometimes called northern wildrice (most abundant near the Canadian border, but extending southward to New York and Nebraska), is a smaller plant with comparatively narrow leaves (generally less than half an inch wide), thicker grains, and firmer, prominently nerved glumes that prior to maturity are usually nearly white.

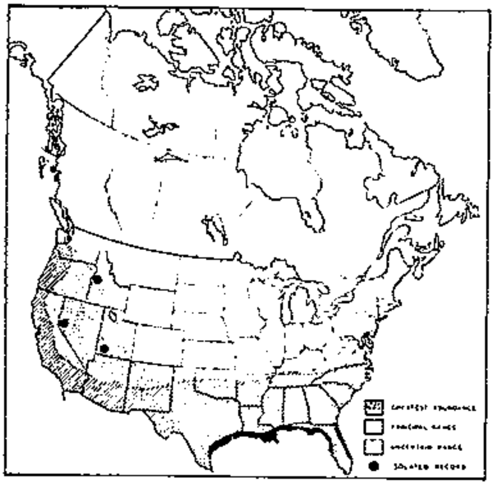

FIGURE 52.—Range of *Paspalum distichum.*

Zizania texana, a perennial species, with prostrate or decumbent stems, is known only from the vicinity of San Marcos, Tex., where it grows in rapidly flowing water. At present its value to ducks is unknown, but efforts are being made to ascertain its usefulness and adaptability to growth elsewhere.

Paspalum (pls. 62-63; figs. 52-53).

Value.—Locally fair to good and occasionally eaten in large quantities, more than 2,600 seeds of *P. boscianum* having been eaten by a mallard collected during December in eastern Louisiana.

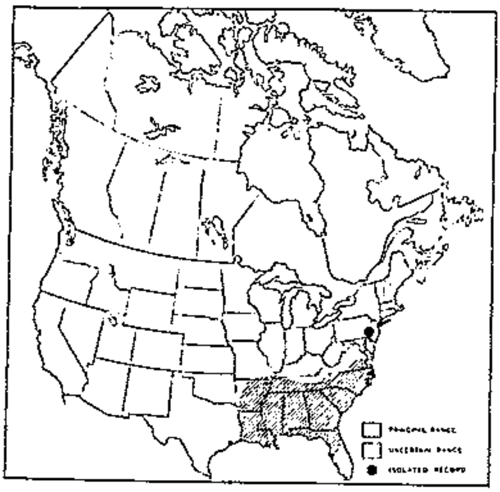

FIGURE 53.—Range of *Paspalum boscianum.*

Parts consumed. — The seeds (grains).

Identification.—*Paspalum* seeds (in their enclosing glumes) are usually somewhat hemispheric and are generally flattened on one side and convex on the other. Ordinarily they are broader (more nearly circular) than in the closely related grasses *Panicum* and *Echinochloa.*

Environment.—The species of *Paspalum* that are useful as duck food occur on moist ground or in marshes in the South. *P. boscia-*

num is of value principally in moist places that are flooded only after the end of the growing season. *P. distichum* grows either in moist places or shallow fresh water and at times has been found thriving in moderately brackish or alkaline soils.

Propagation.—By rootstocks or stolons, except in the case of *P. boscianum*, which requires seed planting.

Species.—*Paspalum boscianum* (pl. 63), known as bull paspalum, is a purplish or brownish annual species with brown seeds. *P. distichum*, known as knotgrass (pl. 62), and the closely related *P. vaginatum* have been recorded from Louisiana duck stomachs, and the former species is available for use in the irrigated alkali areas of the Southwest and California.

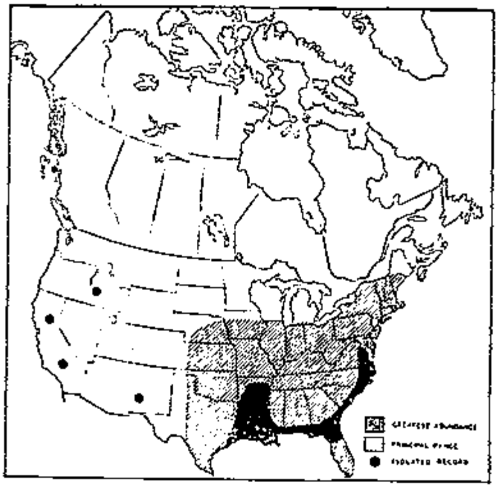

FIGURE 54.—Range of *Panicum dichotomiflorum.*

Panicum (pl. 64; fig. 54).

Value.—Fair.

Parts consumed.—The seeds (grains) in enclosing glumes.

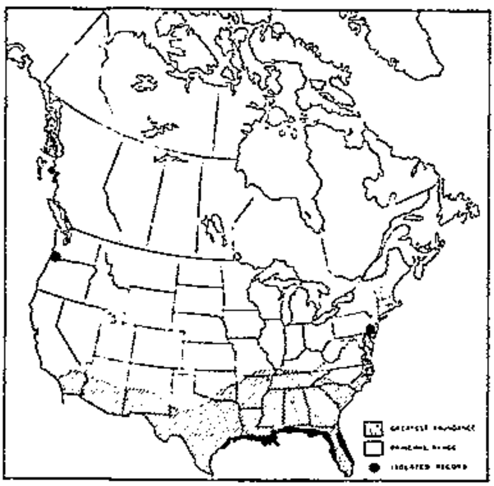

FIGURE 55.—Range of *Echinochloa colonum.*

Identification.—A large and diverse genus in which the seeds resemble those of *Paspalum* and *Echinochloa* but are generally biconvex, narrower, and pointed.

Environment.—*Panicum* habitats range from dry soil to aquatic (fresh-water) situations.

Propagation.—All the species valued as duck food are annuals and require planting by seed.

Species.—Various species of *Panicum* have been eaten in small quantity by ducks. Fall panicum (*P. dichotomiflorum*), which is comparatively outstanding in value, thrives particularly well in low places that are flooded after the end of the growing season. Maidencane (*P. hemitomon*), a common emergent aquatic or marsh plant in the South, flowers

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early and but rarely has any seeds at the time when northern ducks arrive. Switchgrass (*P. virgatum*) has widespread occurrence on the outer margin of marshes but is not significant as a duck food.

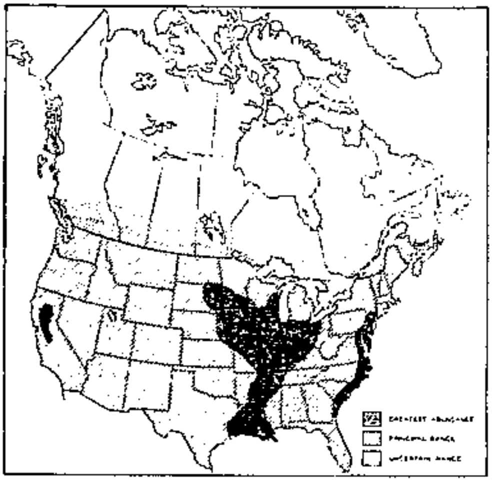

Figure 56.—Range of *Echinochloa crusgalli.*

Echinochloa: Wild millet (pls. 65–66 and 121, *A*; figs. 55–57).

Value.—Excellent.

Parts consumed.—The seeds (grains enclosed in glumes).

Identification.—Wild millets are rather coarse annual grasses with flat leaves and fairly dense panicles. The various species and varieties are diverse in appearance, particularly as regards presence and length of awns. The seeds resemble those of *Panicum* and *Paspalum* but have a more pronounced hump on the rounded back and a more tapering apex.

Environment.—Various moist or marshy places—generally in fresh-water situations but sometimes in the presence of mild brackishness or alkalinity. Wild millets are abundant rice-field weeds and thrive particularly well in soils that are submerged by a few inches of water during the early part of the growing season but are exposed later in the summer and autumn.

Propagation.—By seeds.

Echinochloa colonum (pl. 65, *A*; fig. 55).

This is occasionally an important duck food of the southern rice fields. It is a comparatively small species with rather narrow leaves and with smooth (awnless) spikelets arranged in about four rows on nearly vertical branches of the panicle.

Figure 57.—Range of *Echinochloa walteri.*

Echinochloa crusgalli (inclusive of varieties): Barnyard grass, Japanese millet, billion-dollar grass (pls. 65, *B* and *C*, 66, *A*, and 121, *A*; fig. 56).

The widespread, common type of wild millet sometimes called barnyard grass (*Echinochloa crusgalli*) is the most important species of its genus and ranks as one of the best duck-food plants of shallow marshes and moist soils. Usually the panicle appears bristly because of its awns or hairs but some varieties are nearly or quite smooth. In the Northern States a small seeded form (var. *mitis*), with short-awned fruit, predominates around the borders of marshes, and a nearly awnless form (var. *frumentacea*), known locally as Japanese millet and billion-dollar grass, is occasionally found escaped from cultivation along the borders of fresh-water areas.

Echinochloa walteri (pls. 65, *D*, and 66, *B*; fig. 57).

A large species that occasionally reaches a height of more than 9 feet in the Southeastern States and is usually hairy and long-awned. The seeds are smaller than in *E. crusgalli* and of less importance as a duck food. It frequently is abundant in mildly brackish parts of southern marshes and in the vicinity of the Great Lakes, and it is occasional along other inland fresh-water situations.

Other species of Echinochloa.

Echinochloa crus-pavonis of the Gulf region and *E. paludigena* of Florida have not yet been recorded as duck foods.

Setaria (Chaetochloa): Pigeongrasses (figs. 58–59).

Value.—Generally slight, but locally fair to good; apparently taken chiefly in temporarily flooded fields.

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FIGURE 58.—*Setaria lutescens*, × 4/5; seeds × 4.

Parts consumed.—The seeds (grains enclosed in glumes).

Identification.—The bristly, bottlebrush type of inflorescence is fairly distinctive. The seeds are strongly marked by many transverse wrinkles.

Environment.—Various moist places, such as meadows, cultivated fields, and grassy margins of ponds and lakes.

Propagation.—Chiefly by seed; *Setaria geniculata* by rootstocks.

Species.—The seeds of *S. lutescens* and *S. viridis* are the only ones that have been noted in duck stomachs. The former are larger and have been used more extensively.

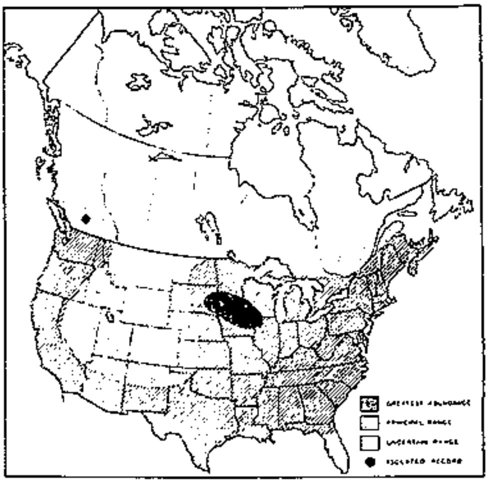

FIGURE 59.—Range of *Setaria lutescens.*

Cereal crops: Rice, corn, sorghum, barley, wheat, oats.

A large proportion of the grain eaten by ducks in certain localities has represented bait (particularly in the case of corn and wheat), but a far larger share of the grain consumption has resulted from gleaning activities by mallards and pintails in harvested fields.

The crops most frequently gleaned are rice, corn, and sorghum, though barley and alfalfa (a legume) have both been used in large quantities near the Salton Sea, Calif., by various species of shoal-water ducks. With few exceptions, stomach records of wheat and oats have been based on bait rather than on gleaned seed. In the Prairie States and Michigan, however, during rainy seasons ducks are frequently known to glean such grains (and buckwheat also) from stubble fields.

Oryza sativa: Rice (fig. 60).

Rice farming not only furnishes ducks with an abundant source of relished food (waste rice), but in addition it favors the growth of weeds that are excellent duck foods, notably wild millet, red rice, and smartweeds.

The chief centers of rice production are in eastern Arkansas, coastal Louisiana and Texas, and the Sacramento Valley of California, and each of these sections is recognized as an important duck-concentration area. Formerly the coastal sections of South Carolina and Georgia were particularly attractive to waterfowl because of their extensive rice plantations, but these passed out of existence about 25 years ago.

FIGURE 60.—Areas of rice production in the United States.

In Louisiana and Texas a considerable proportion of the rice consumed by ducks is the red variety. This is a weed very closely related to cultivated rice and is considered one of the worst rice-field pests in the United States because it ripens and shatters earlier than the cultivated rice. Although a good food, its dark color renders it objectionable to the American trade, which demands white rice. In many areas the feeding activities of mallards are reported to have been an important factor in controlling this weed.

Rice screenings have been used to some extent as bait in Louisiana and Arkansas, and in the Southeastern States small plots of cultivated rice have occasionally been planted and left unharvested to attract waterfowl—at present an illegal practice.

Zea mays: Corn.

Prior to the curtailment of the unsportsmanlike practice of baiting waterfowl on shooting grounds, corn was more widely used than any other cereal for this purpose. Consequently numerous stomach records have indicated the use of corn as bait in various parts of the country, but a number of records from Western States show that corn has been gleaned from harvested or hogged-off fields. Mallards are known to feed occasionally on standing corn in flooded areas.

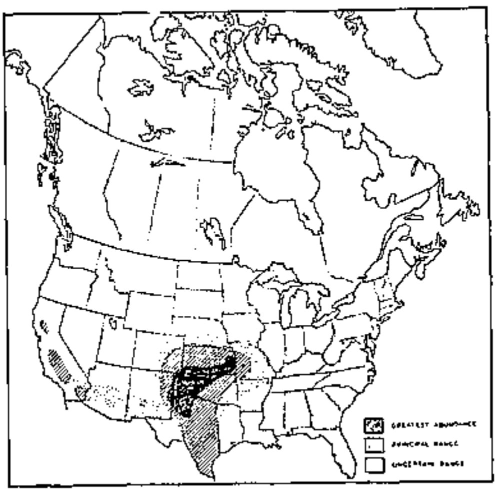

FIGURE 61.—Areas of grain-sorghum production in the United States.

Sorghum vulgare: Sorghum, Dwarf milo (fig. 61).

In the Panhandle sections of Texas and Oklahoma, sorghum is the main item of food of the thousands of mallards that concentrate there every winter. Their habit of feeding on sorghum has brought numerous complaints from farmers who have neglected to harvest and store the crop as soon as ripe, or who, because of weather conditions, have been unable to do so.

Ducks undoubtedly relish the grains of all kinds of sorghums, but the variety known as Dwarf milo appears best adapted to waterfowl use. The short stature of the plant is an asset if the crop is to be left in the field for ducks to harvest. It is also claimed that this variety is particularly tolerant of drought and neglect.

CYPERACEAE: CHUFA, BULRUSHES, SPIKERUSHES, SEDGES

Cyperus (pls. 67–69; fig. 62).

Value.—Excellent locally on flood lands; slight to fair, generally.

Parts consumed.—The tuberous structures of *Cyperus esculentus* (and possibly of other species) are used extensively in certain localities; the seeds (achenes) have frequently been taken in small quantities.

Identification.—The inflorescence (fruiting portion) usually consists of numerous rigid branchlets bearing flattened spikelets in either a spreading or sometimes a compact arrangement on a triangular (or rarely round) stalk. Usually there are three or more leaflike bracts radiating from the base of the inflorescence.

Environment.—Marshes, moist soils, and low areas subject to periodic inundation.

Propagation.—By tubers, corms, or rootstocks in the perennial species; by seeds in the annual.

Cyperus esculentus: Chufa, ground almond (pls. 67–68; fig. 62).

The tubers of chufas (often known by the name "ground almond") have provided much food to ducks in situations subject to seasonal flooding. In a series of gullets of 11 pintails and 3 mallards collected in the fall of 1935 at Catahoula Lake, La., nearly 94 percent of the total contents consisted of chufa tubers, most of the gullets containing more than 300 each. In the Illinois and Mississippi River bottoms excellent growths of chufa have been noted producing tubers in dry lake beds after the water had disappeared late in July (pl. 68, *B*); when submerged by fall rains they form valuable feeding grounds for shoal-water ducks. Nurserymen recommend that chufa tubers be planted in fairly sandy soils between April 1 and June 15 in the proportion of about 1 bushel per acre and at a depth of about 1 inch.

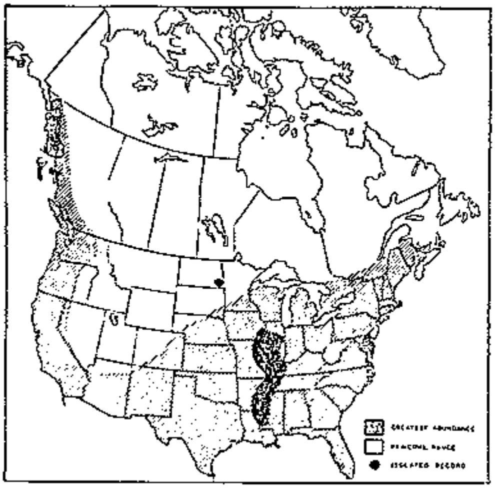

FIGURE 62.—Range of *Cyperus esculentus.*

Other species of Cyperus.

Seeds of *Cyperus strigosus* (pl. 69), *C. ferax*, *C. erythrorhizos*, *C. hochstetteri*, and numerous other species have frequently been used by ducks in small or moderate quantities in various parts of the continent, but they rarely constitute an important source of food. Seeds of *C. erythrorhizos*, however, were found to be an important winter food of 11 ducks of 4 species collected in the White River bottoms, Ark., in December 1936.

Eleocharis: Spikerushes (pls. 70–74; figs. 63–67).

Value.—Fair to good (locally excellent); the square-stemmed and the jointed spikerushes are of special value in the Southeastern and Gulf States.

Parts consumed.—The seeds (achenes). In *Eleocharis parvula* the tuberous structures on the roots are eaten.

Identification.—Spikerushes are characterized by unbranched, leafless stems (culms) topped by a single spike. The seeds bear a special caplike structure (the tubercle). Many species have a minutely reticulated seed coat.

Environment.—Most of the species of *Eleocharis* occur in moist, marshy situations, but several kinds grow emergent in shallow water and a few are normally submerged. Several species, including *E. palustris*, *E. parvula*, *E. albida*, *E. rostellata*, and *E. cellulosa* tolerate a moderate degree of brackishness or alkalinity, but on the whole the genus is more characteristic of fresh-water places.

Propagation.—The more valuable species are mostly perennial, and propagation by means of rootstocks is recommended in the absence of data on seed-germination requirements.

Eleocharis equisetoides and **E. interstincta**: Jointed spikerushes (pl. 70; fig. 63).

The jointed spikerushes are comparatively coarse, tall (2 to 3 feet high) species with larger seeds than most other members of the genus. The soft, cross-partitioned stems (pl. 70, *B*) are marked on the surface by encircling rings at fairly regular intervals. In *Eleocharis interstincta*, the rings (joints) are close together near the top of the plant (pl. 70, *A*); whereas in the closely related species *E. equisetoides*, the intervals between rings incline to be greater. Both species grow in fresh-water marshes of the Southeastern and Gulf States. *E. equisetoides* has proved to be a valuable duck food in the region extending from northern Florida to western Louisiana; it is somewhat tolerant of shade. *E. interstincta* is comparatively local in distribution and therefore is restricted in utility.

FIGURE 63.—Range of *Eleocharis equisetoides*.

Eleocharis quadrangulata: Squarestem spikerush (pl. 71; fig. 64).

The squarestem spikerush is an important fresh-marsh waterfowl food of the Atlantic and Gulf Coastal Plain, where its seeds have been found in the stomachs of nearly a dozen species of ducks. It is a rather robust plant with larger seeds than most other spikerushes and with four-angled (or rarely three-angled) stems 2 to 3½ feet high. It should not be confused with the less valuable slender, trianglestem spikerush (*E. robbinsii*). The square-stemmed species frequently produces small white tubers with a texture similar to that of the potato, and these are also of some value as a waterfowl food. The plant generally grows in water less than 18 inches deep, but it will withstand total emergence for considerable periods if the soil remains wet. Important beds have been found as far north as Delaware, but the seeds have been noted in greatest numbers in stomachs of black ducks, pintails, and teals collected along the Santee River in South Carolina and along the Gulf coast.

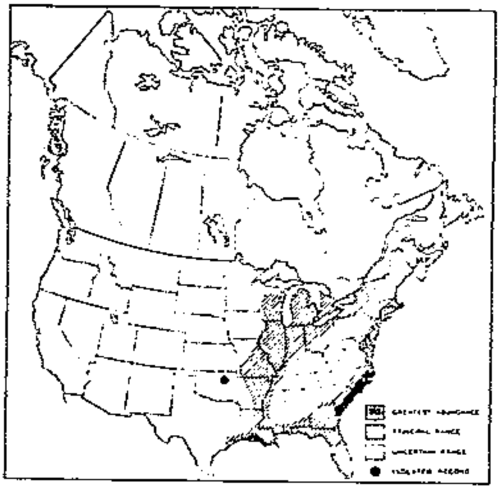

FIGURE 64.—Range of *Eleocharis quadrangulata*.

Eleocharis parvula: Dwarf spikerush (pl. 72, *A*; fig. 65).

The dwarf spikerush is a popular duck food in various regions and grows best on muddy margins or in very shallow water of moderately brackish or slightly alkaline areas. In favorable habitats it is frequently found floating on the water in large quantities after ducks have removed the tuberlike growths from the roots. It is a diminutive plant, about 3 inches or less in height, and is generally rather stout-stemmed, as compared with the hairlike stems of the slender spikerush (*Eleocharis acicularis*) (pl. 72, *B* and *C*). The latter is another small species that is also common but probably less valuable as a duck food. *E. parvula* may be propagated by means of its tubers or by transplanting groups of young plants.

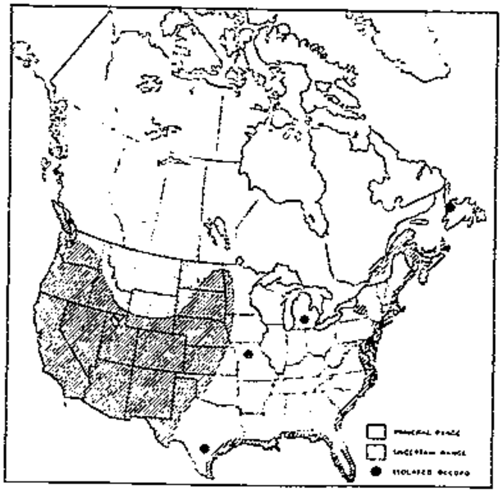

FIGURE 65.—Range of *Eleocharis parvula* and varieties.

Eleocharis palustris (inclusive concept): Common spikerush (pl. 73; fig. 66).

The common spikerush is probably the most widespread of the American species. It is round stemmed, grows on land or in shallow water, and is generally 1 or 2 feet high, but is extremely variable as to size and other characters. Its seeds are commonly found in duck stomachs, usually in small or moderate quantity. Blue geese also have been found feeding on the culms in the vicinity of Hudson Bay, and Canada geese are known to forage on it.

Other species of Eleocharis (pl. 74; fig. 67).

There are numerous additional species of *Eleocharis*, including *E. cellulosa* (the Gulf-coast spikerush) (pl. 74, *A*; fig. 67), *E. pauciflora*, *E. ovata*, *E. obtusa* (pl. 74, *B*), and *E. albida* (pl. 74, *C*), the seeds of which are known to be occasionally eaten by ducks. *E. cellulosa* and *E. albida* grow best on brackish soils, the latter from Maryland to the Gulf coast. *E. pauciflora* thrives in northern calcareous situations, and its thickened buds as well as the seeds have been eaten by shoal-water ducks in upper Michigan.

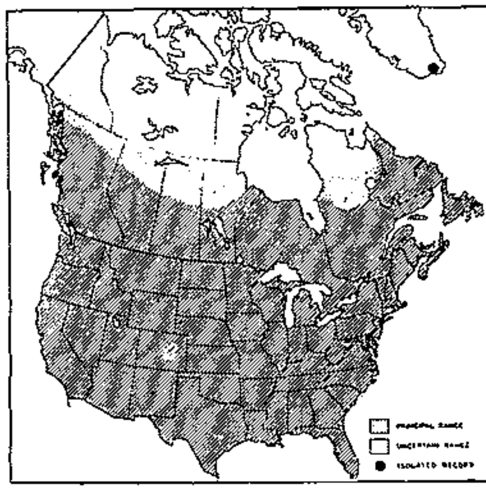

FIGURE 66.—Range of *Eleocharis palustris* (inclusive concept).

Scirpus: Bulrushes (pls. 75–83 and 137, *B*; figs. 68–78).

Value.—Good to excellent. Incidentally the rootstocks of some of the three-square bulrushes are excellent goose foods.

Parts consumed. — The seeds (achenes).

Identification.—The group is highly diverse, and some of its members cannot be satisfactorily distinguished from other Cyperaceae except by technical characters. The illustrations of species should aid in identifications in the genus. The most important bulrushes fit fairly well into the three following types: (1) Three-squares (triangular-stemmed and with leaves largely basal and inconspicuous); (2) round-stemmed bulrushes; and (3) leafy three-angled forms. Not all bulrushes fit definitely into these three types, and only the outstanding species are classed thus in the present treatment.

FIGURE 67.—Range of *Eleocharis cellulosa.*

Environment. — Various fresh-water, alkaline, or brackish marsh situations.

Propagation.—The valuable forms are perennial. All species can be propagated by rootstocks and a few by tubers. Seeds also can probably be used, but according to present meager information most of them require more than 1 year to germinate.

Type 1.—Three-squares

Stems (culms) triangular; leaves largely basal and not conspicuous; involucral bract solitary, erect, bayonetlike, appearing like an extension of the stem beyond the inflorescence; spikelets in a tight cluster.

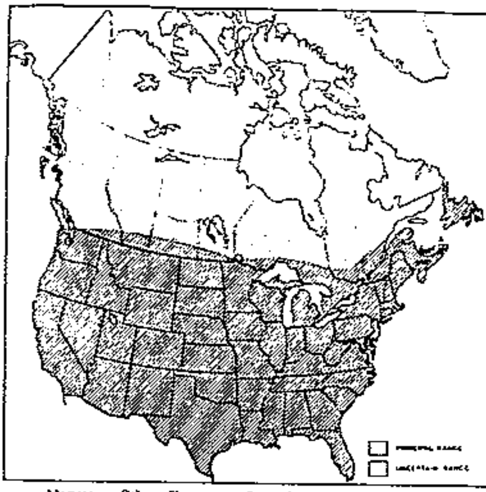

FIGURE 68.—Range of *Scirpus americanus*.

Scirpus americanus: Common three-square (pls. 75, *A* and *B*, and 76, *A*; fig. 68).

Value.—Good; usually a better seed producer than its near relatives.

Parts consumed.—The seeds (achenes).

Identification.—As compared with its close ally *Scirpus olneyi*, this species has rather firm stems with flat or shallowly grooved faces, and the involucral bract extends one to several inches beyond the cluster of large spikelets.

Environment.—Commonly on sandy soils on lake margins but often along streams or in marshes; sometimes emergent from water a foot or more deep. It grows in either fresh-water areas or in brackish or moderately alkaline places.

Propagation.—By rootstocks and probably by seed.

Scirpus olneyi: Olney's three-square (pls. 75, *B* and *C*, and 76, *B*; fig. 69).

Value.—Generally slight for ducks, because it often produces a poor crop of seeds and depends largely on vegetative reproduction; useful to geese and muskrats.

Parts consumed.—The seeds (achenes).

FIGURE 69.—Range of *Scirpus olneyi*.

Identification.—As compared with *Scirpus americanus*, the stems of Olney's three-square are soft and have deeply concave sides and a cluster of small spikelets near the tip.

Environment.—Various fresh-water or mildly brackish marshy situations, usually in rich soil. Maximum abundance of growth is attained in coastal marshes.

Propagation.—By rootstocks and possibly by seeds.

Other species of Scirpus related to type 1 (pls. 75–78; figs. 70–71).

Torrey's three-square (*Scirpus torreyi*) (pls. 75, *B*, *b*, and 77, *A* and *B*; fig. 70) is a northeastern species that resembles the common three-square (*S. americanus*) but differs in having a blunt tip on the involucral bract. Its value appears to be fair locally. *S. nevadensis* (pls. 75, *B*, *c*, and 78, *A*) is locally common on western alkali flats, but its use by ducks has not been noted. Its stems vary from triangular to roundish. *S. subterminalis* (water bulrush), a slender aquatic species, and S. *debilis*, a small tufted form (pls. 75, *B*, *a*, and 78, *B*) have been recorded locally or in limited extent.

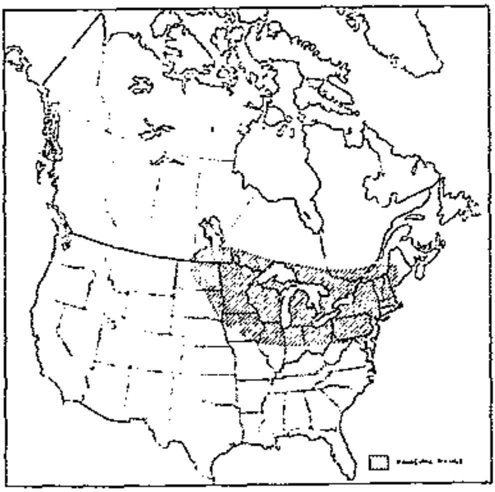

Figure 70. Range of *Scirpus torreyi*.

The swamp bulrush (*S. etuberculatus*) (pl. 76, *C*; fig. 71) has proved valuable locally, particularly in southeastern acid-water marshes having much humus; in northern Florida, it has been eaten frequently, especially by ring-necked ducks. This bulrush is rather intermediate between types 1 and 3: it is triangular-stemmed and somewhat leafy and has long spikelets arranged loosely on branchlets. Its height is usually 4 to 5 feet.

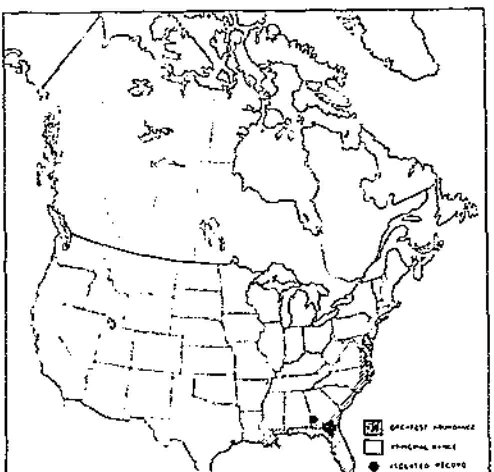

Figure 71.—Range of *Scirpus etuberculatus*.

Type 2.—Round-stemmed Bulrushes

Stems cylindrical; leaves basal and reduced; involucral bract solitary, erect, cylindrical and usually short; spikelets generally in loose, branching panicles though sometimes closely clustered.

Scirpus validus: Softstem bulrush (pls. 79, *B*, and 80, *A*; fig. 72).

Value.—Slight to fair; generally not abundant enough to be important.

Parts consumed.—The seeds (achenes).

Identification.—The stems of the softstem bulrush are bright green and also are distinct, as its name implies, in being soft and lax. The small spikelets (about one-fourth inch long) are usually a bright rusty brown.

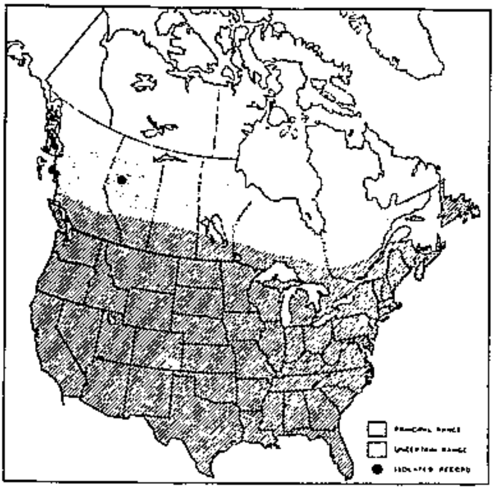

FIGURE 72.—Range of *Scirpus validus.*

Environment. — Fresh-water situations, usually in rich soil. Often this bulrush forms small patches in beds of *Scirpus acutus* or among other marsh growth. Because of its soft stem it does not withstand heavy wind or wave action so well as the other round-stemmed bulrushes; consequently it usually is restricted to more sheltered situations.

Propagation. — By rootstocks and probably by seed.

Scirpus acutus (S. occidentalis): Hardstem bulrush (pls. 79, *C*, and 80, *B*; fig. 73).

Value.—Generally good; excellent in the West. This is the most important of the round-stemmed bulrushes.

Parts consumed.—The seeds (achenes).

Identification.—The hardstem bulrush has fairly rigid, firm, dark-green culms, often 5 to 7 feet high, and has large spikelets (about half an inch long) with grayish brown scales.

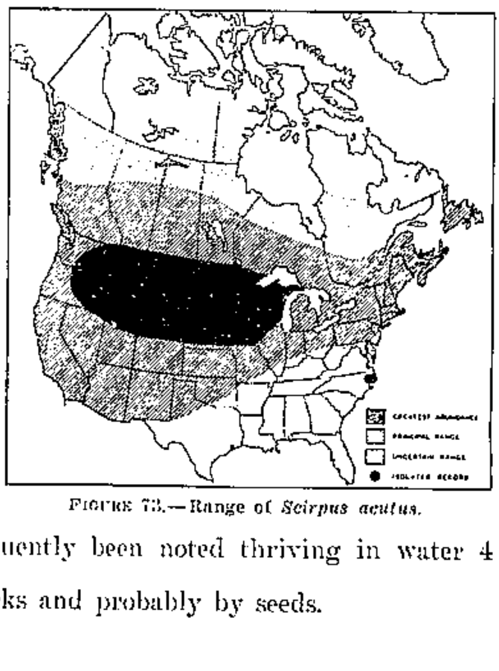

FIGURE 73.—Range of *Scirpus acutus.*

Environment.—This bulrush tolerates various kinds and qualities of soils, and though it is most commonly found in fresh-water areas, it also thrives in mildly alkaline or slightly brackish places. It grows either emergent from water or on wet land and is an excellent pioneer plant on hard-bottomed lakes, producing a buffer against wind or wave action and thus permitting aquatic plants to gain a foothold on bottoms otherwise unfavorable. In the latter situations it has frequently been noted thriving in water 4 feet deep.

Propagation.—By rootstocks and probably by seeds.

Scirpus heterochaetus: Slender bulrush (pl. 79, *D*; fig. 74).

Value.—Fair.

Parts consumed.—The seeds (achenes).

Identification.—Similar to the hardstem bulrush (*Scirpus acutus*) but has more slender stems and each spikelet is usually isolated on a separate branchlet of the panicle instead of being in clusters of two or more.

Environment.—Fresh-water lakes and marshes. In the upper Mississippi River bottoms, this is the most common of the round-stemmed bulrushes, almost entirely replacing *S. acutus*, which is more widespread and abundant in the adjacent upland lakes and marshes.

Propagation.—By rootstocks and by seeds.

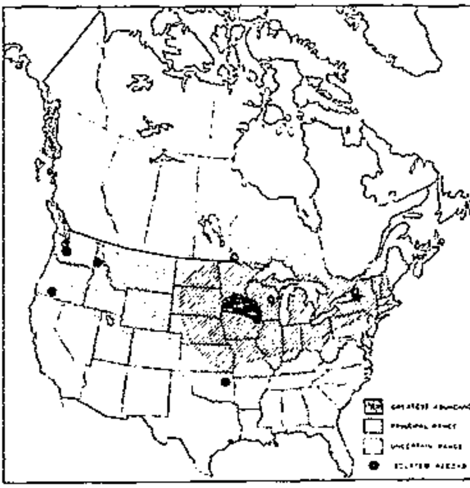

FIGURE 74.—Range of *Scirpus heterochaetus*.

Scirpus californicus: Southern bulrush (pls. 79, *A*, and 80, *C*; fig. 75).

Value.—Fair.

Parts consumed.—The seeds (achenes).

Identification.—The southern bulrush is a very tall species (often reaching a height of 12 feet) with diffuse panicles of many spikelets. It is the common large bulrush along southern coasts, including the South Atlantic (from South Carolina southward), the Gulf of Mexico, and California north to San Francisco Bay.

Environment.—Chiefly on rich soil in fresh-water marshes, but also thriving in open, sand-bottom lakes and in slightly brackish marshes.

Propagation.—By rootstocks and probably by seed.

FIGURE 75.—Range of *Scirpus californicus*.

Type 3.—Leafy Three-angled Bulrushes

Stems triangular; leaves several or numerous, generally conspicuous; involucral bracts usually 2 or 3, flat, leaflike and radiating from the base of the inflorescence; spikelets either clustered or in panicles.

Scirpus fluviatilis: River bulrush (pls. 81, *C*, and 137, *B*; fig. 76).

Value.—Slight, locally fair. The river bulrush depends principally on vegetative reproduction and rarely fruits well. The seeds have frequently been consumed by a variety of ducks but generally in small quantities. In most areas its exceedingly rank growth and harsh foliage make it an undesirable competitor with better duck foods.

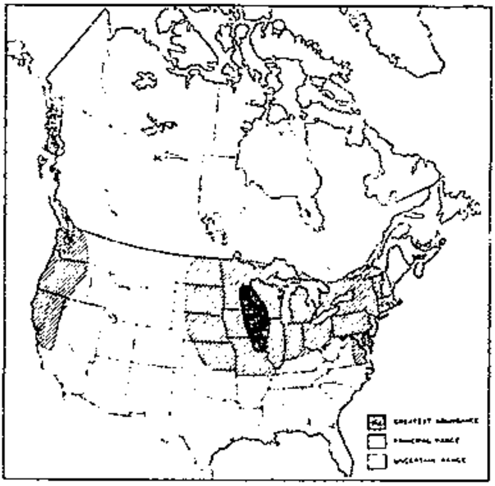

FIGURE 76.—Range of *Scirpus fluviatilis.*

Parts consumed.—The seeds (achenes).

Identification.—In this species the spikelets are disposed loosely on spreading branches of the panicle and the plant usually grows larger than its near relatives—often reaching a height of more than 5 feet.

Environment.—It thrives best in shallow fresh-water marshes of bottom-land lakes or streams and is most luxuriant in marshes that go dry during the latter half of the growing season.

Propagation.—By root-stocks or by the woody tubers. Ordinarily the encouragement of this species does not appear advisable.

Scirpus robustus: Saltmarsh bulrush (pls. 81, *A*, and 82, *A*: fig. 77).

Value.—Good to excellent in coastal marshes.

Parts consumed.—The seeds (achenes).

Identification.—The saltmarsh bulrush is the only three-angled, leafy bulrush that is widespread and abundant in coastal marshes.

FIGURE 77.—Range of *Scirpus robustus.*

Environment.—Brackish marshes that are flooded only by the higher stages of the tide. Along the Potomac River this bulrush extends upstream from the strongly brackish marshes at its mouth to a point where the salt content averages about 13 percent of normal sea salinity (varying from about 10 to 17) during the ordinary growing season. The finest beds along the eastern side of Chesapeake Bay were found to have a salt content varying from about 12 to 30 percent of normal sea salinity during the summers of 1935 and

1936, and during both seasons acid conditions prevailed in those marshes, as indicated by pH readings (footnote 13, p. 128) from 4.3 to 5.6 in the densest beds of this species.

Propagation.—By rootstocks or by seed.

Scirpus paludosus (S. campestris): Alkali bulrush (pls. 81, *B*, 82 *B*, and 83; fig. 78).

Value.—Good to excellent in western alkali areas. Wetmore (*87*) reported that on the Bear River marshes, Utah, although the seeds begin to mature in July and August, and many of them drop to the ground, a considerable proportion are held in the dry spikelets until the following spring or early summer, thus supplying a good source of food when the seeds of most duck-food plants are not available.

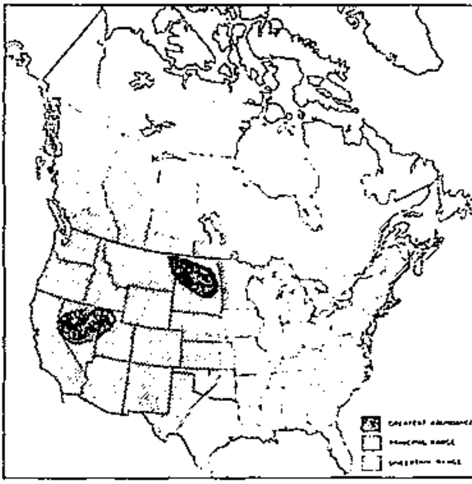

FIGURE 78.—Range of *Scirpus paludosus*.

Parts consumed.—The seeds (achenes).

Identification.—The alkali bulrush and the river bulrush (*S. fluviatilis*) are the principal inland species of type 3 (three-angled leafy species). The former is distinct in having thicker spikelets in dense clusters and its stems usually average about 3 feet, whereas the latter often attains a height of 5 feet. Both frequently have large, hard, tuberous growths on the rootstocks (not used by ducks).

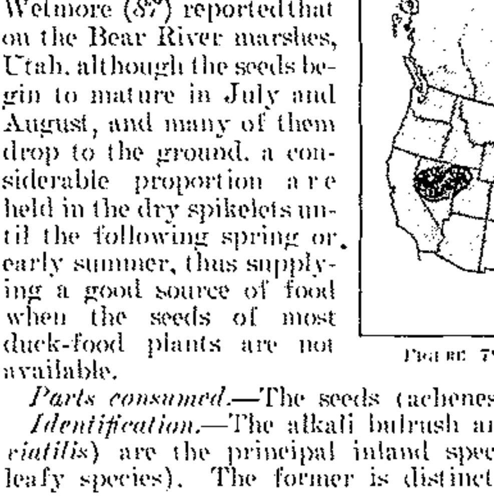

FIGURE 79.—Range of *Rynchospora corniculata*.

Environment.—Particularly abundant in alkaline areas of the Great Plains and Great Basin, often forming extensive stands there in shallow water or semidry marshes; also locally abundant in the brackish marshes of the New England coast.

Propagation.—By rootstocks, tubers, and probably by seed.

Other species of Scirpus related to type 3.

Scirpus cubensis, a southern small-seeded, cyperuslike species, has been taken by a large series of shoal-water ducks in one overflowed area in eastern Louisiana but apparently has not been of importance elsewhere. *S. atrovirens*, *S. cyperinus* (woolgrass) (pl. 137), and other related, minute-seeded species are frequent in fresh-water marshes and meadows but have no apparent food value for ducks.

Rynchospora corniculata (including **R. macrostachya**): Beakrush (pl. 84; fig. 79).

Value.—*Rynchospora corniculata* has large flattish seeds that have been much used by ducks in the Okefenokee Swamp, Ga., and in smaller quantity elsewhere along the Gulf and South Atlantic coasts.

Parts consumed.—The seeds (achenes).

Identification.—The stems (culms) are generally triangular and somewhat leafy; the seeds, like those of *Eleocharis*, have a beaklike cap (tubercle), but the inflorescence is not spikelike.

Environment.—Bogs, swamps, and coastal marshes.

Propagation.—With few exceptions the beakrushes are perennial and can be propagated by rootstocks or transplants as well as by seed.

Related species.—Various other species of *Rynchospora* have been used by ducks to a small extent. The beakrushes are generally of slight value to ducks, though fair locally in the Southeast.

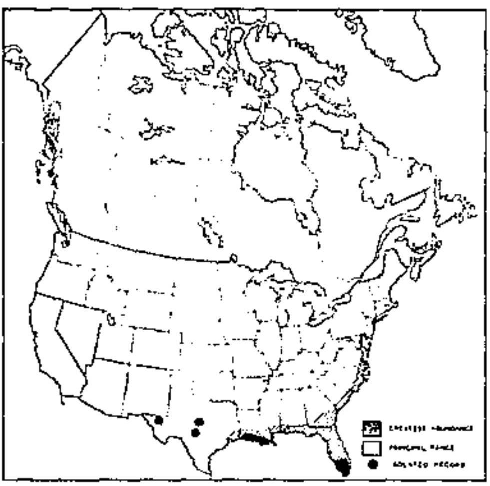

FIGURE 80.—Range of *Cladium jamaicense*.

Cladium jamaicense (**C. effusum**): Sawgrass (pl. 84, *B*; figs. 80-81).

Value.—Fair: used by ducks commonly in small or moderate quantity in the Gulf region.

Parts consumed.—The seeds (achenes).

Identification.—The long, slender, saw-edged leaves and the tall (5 to 9 feet), rigid stalks topped by elongated, plumelike inflorescences are typical. Sawgrass often forms almost impenetrable growths, and its leaves can inflict severe cuts.

Environment.—Usually in less than 3 feet of water in fresh or moderately brackish marshes, and at elevations less than 100 feet above sea level. It is the dominant plant in much of the Florida Everglades and is also abundant on the landward side of the Gulf coast marshes, where it withstands complete emergence for extended periods.

Propagation.—By rootstocks or by seeds; ordinarily not desirable for planting, because its rank growth is likely to choke out more valuable food plants.

Related species.—In the eastern half of the United States the seeds of *Cladium mariscoides*, a smaller species than sawgrass, have been found in duck stomachs occasionally in small quantities. A third

North American species, *C. mariscus* of the Pacific coast, has not given evidence of being of value as a duck food.

Carex: Sedges (figs. 82, 83, 86).

Value.—Generally slight to fair; in the northwestern parts of the continent the seeds are used considerably by ducks.

Parts consumed.—The seeds (achenes in perigynia).

Identification.—Sedge leaves are usually grasslike, but the inflorescences (fig. 86, *A*), if present, should be sufficient to identify the plants. The perigynium (seed container) is usually beaked (fig. 86, *B*) and thin-walled and is unique to this genus.

Environment.—Moist meadows, bogs, and marshes.

Propagation.—By rootstocks or by seed.

Species.—*Carex decomposita*, *C. rostrata* (fig. 83), *C. lupuliformis*, *C. riparia*, and *C. grandis* have each been recorded from duck stomachs 12 or more times, and numerous other species less frequently. According to field observations *C. lyngbaei* and *C. sitchensis* have been consumed freely by ducks on the coast of Washington, and mallards in midsummer have been noted feeding freely on the seeds of *Carex* (*stricta* type) in the upper Mississippi River bottoms. *C. lasiocarpa* (fig. 82) has been used in large quantities near Lake Puckaway, Wis.

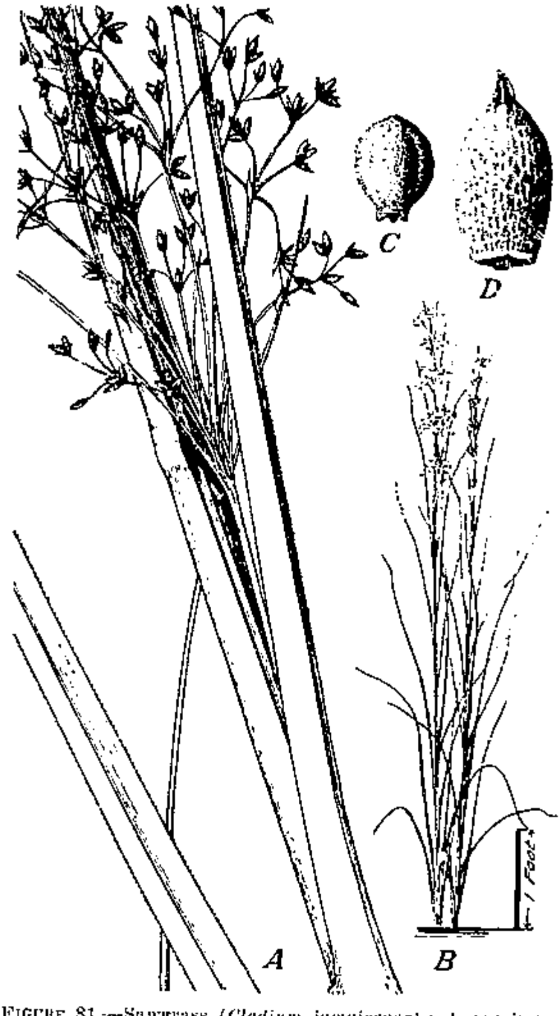

FIGURE 81.—Sawgrass (*Cladium jamaicense*): *A*, specimen, × 1/5, showing a small part of the inflorescence and the saw-edged leaves; *B*, whole plant; *C* and *D*, seeds × 8, *C*, with outer parts removed.

Much remains to be learned about the relative merits of the various sedges, as the genus is large, embracing more than 500 species in North America.

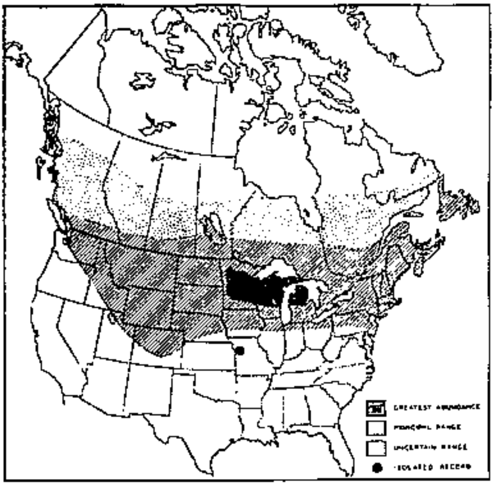

FIGURE 82.—Range of *Carex lasiocarpa.*

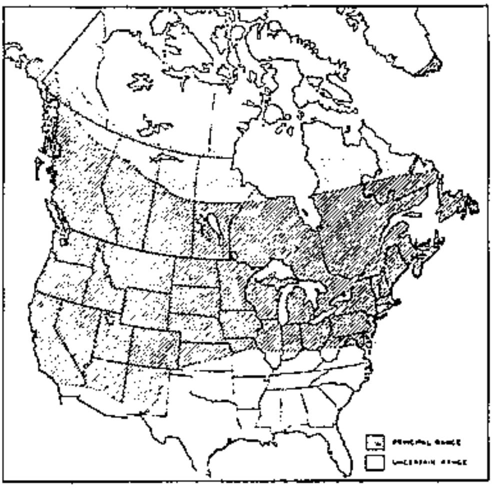

FIGURE 83.—Range of *Carex rostrata.*

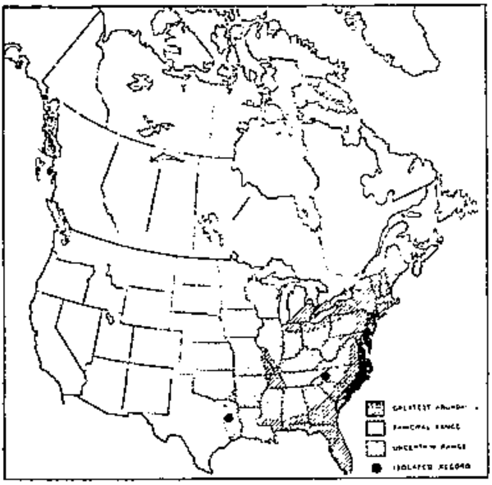

FIGURE 84.—Range of *Peltrandra virginica.*

Other genera of Cyperaceae.

Other genera of the Cyperaceae, including *Psilocarya*, *Fimbristylis*, *Dichromena*, and *Scleria* have been recorded from duck stomachs in quantities too small to be of consequence.

ARACEAE: ARROW-ARUM

Peltandra virginica: Arrow-arum, duck-corn (pls. 85, *A*, and 141, *B*; fig. 84).

Though arrow-arum is common in fresh-water or slightly brackish marshes and shallow lakes and though it produces an abundance of large rather fleshy seeds (berries), it has given little evidence of value to ducks other than a few wood ducks.

LEMNACEAE: DUCKWEEDS

Spirodela, Lemna, Wolffia, Wolffiella: Duckweeds (pl. 86; figs. 85, 87–90).

Value.—Fair to excellent; greatest utility in the lowlands of the Mississippi Basin.

Parts consumed.—The entire plants.

Identification.—Duckweeds are minute floating plants ranging in shape from oval or narrowly tongue-shaped to spherical. Stems and ordinary leaves are lacking, but some species have fine roots on the lower side. While these are true flowering plants, reproduction is usually accomplished by budding new plants (fronds) from clefts in the edge of the parent plants. This process results in the common colonial aggregations of two or more individuals. Hicks (*32*) reports that in Ohio, *Spirodela polyrhiza* is deeply pigmented when growing in mildly alkaline waters and that *Lemna minor* also frequently produces some red pigment under like conditions.

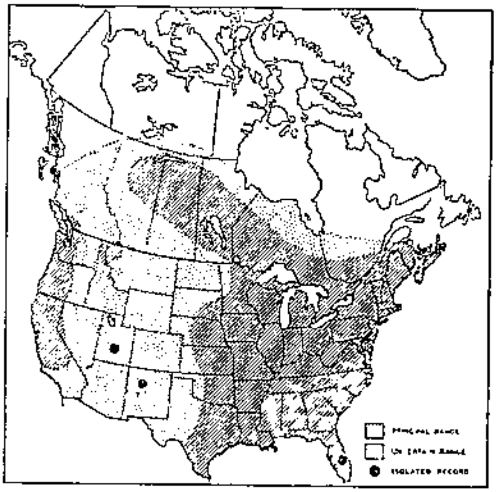

FIGURE 85.—Range of *Spirodela polyrhiza.*

Environment.—The surface of quiet, fresh water in sheltered ponds, swamps, and streams, often in dense shade. In the colder parts of their range these plants sink to the bottom of the water in fall and rise again to increase in size and numbers in spring.

Propagation.—By introduction of living plants transported in a moist condition.

Spirodela polyrhiza: Big duckweed (pl. 86, *A* and *F*; fig. 85).

The big duckweed is a rather coarse species with several roots on the lower side and with a thicker body than in duckweeds of the genus *Lemna*. It is roundish ovate in outline, nearly one-fourth inch long, and has a dark dot on the upper (green) side and usually is purplish on the lower side. Because of its wide distribution and local abundance it is used considerably by ducks. In Ohio, Hicks

(*32*) found it growing best in nearly neutral water, pH 6.3 to 7.5, but he also recorded it in water ranging from pH 5.9 to 7.9.

Lemna trisulca: Star duckweed (pl. 86, *B*; fig. 87).

The plant body of the star duckweed is thin and somewhat transparent and is ovate to lanceolate in shape. It is often more than one-fourth inch long, and frequently three or more individuals are found attached together in cross fashion. This duckweed grows either floating at the surface or submerged. Hicks (*32*) found that it thrives best in moderately acid waters, recording it from waters with a pH range of 4.9 to 7.3.

FIGURE 86.—*Carex rostrata*: *A*, specimens, × ⅓; *B* and *C*, seeds, × 8; *C*, seeds with outer cover (perigynium) removed.

Lemna minor: Duckweed (pl. 86, *C*; fig. 88).

Lemna minor is probably the most common of the duckweeds. It often completely covers small areas of still water and is valuable because of its abundance. The plant body, which is oval to elliptic in outline, is about one-eighth inch long and has a single, slender, white rootlet on the lower side. Hicks (*32*) reported that it tolerates a greater range of acidity and alkalinity (pH 4.4 to 7.9) than any other duckweed, but flourishes best in slightly acid water (pH 5.1 to 6.7).

Other species of Lemna.

Of the several other species of *Lemna*, probably all have some value as duck foods, but information on this point is incomplete.

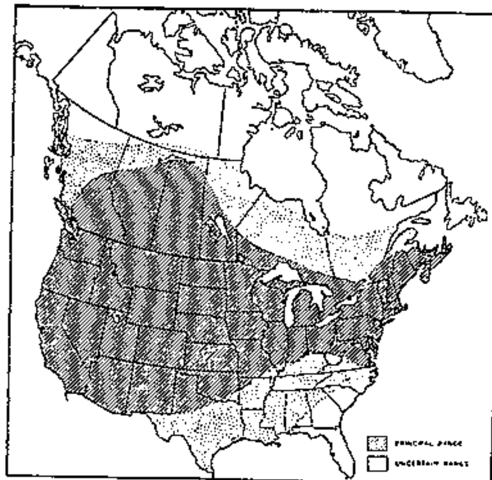

Figure 87.—Range of *Lemna trisulca.*

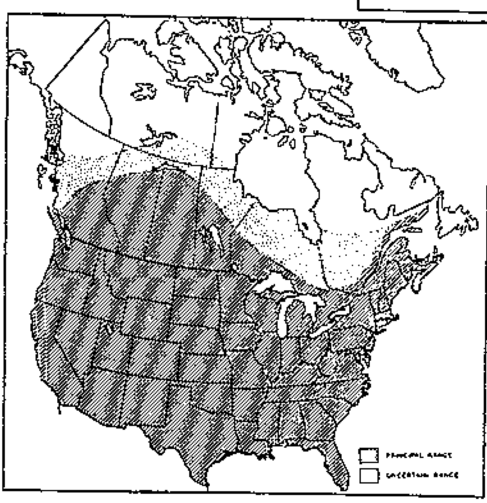

Figure 88.—Range of *Lemna minor.*

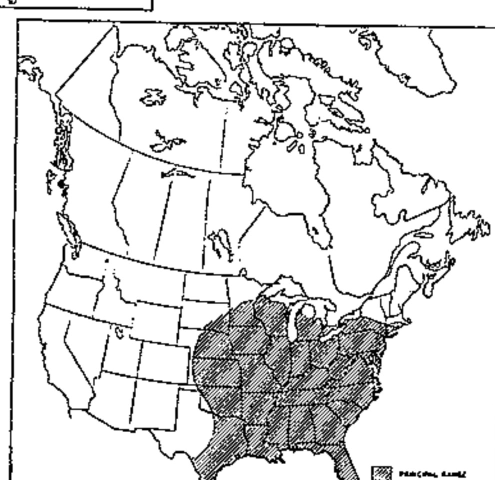

Figure 89.—Range of genus *Wolffia.*

Wolffia: Watermeal (pl. 86, *D*; fig. 89).

The tiny, globose, green bodies of watermeal are the smallest known flowering plants—about one thirty-second of an inch in diameter. Though both *Wolffia columbiana* and *W. punctata* have been noted in duck stomachs, they apparently are not nearly so important as the larger duckweeds. Hicks (*32*) found that these two species grow best in nearly neutral waters (pH 6.4 to 7.4).

FIGURE 90.—Range of *Wolffiella floridana.*

Wolffiella floridana (pl. 86, *E*; fig. 90).

Wolffiella has been recorded 35 times from duck stomachs, but in small quantities. The plants, which are narrow, tapering bodies about one-third of an inch long, are thin and somewhat transparent. Commonly several of them form starlike aggregations. Hicks (*32*) found this species in only moderately acid water (pH 4.8 to 6.8). Two other species of *Wolffiella* grow in California, but at present they are not of recognized duck-food value.

COMMELINACEAE: DAYFLOWER

A plant of the Commelinaceae, which appears to be an *Aneilema*, grows abundantly in the marshes near Charleston, S. C., and its seeds have been consumed by ducks. Further investigation of its value is planned.

PONTEDERIACEAE: PICKERELWEEDS, WATERSTARGRASS

Pontederia cordata: Pickerelweed (pls. 85, *B*, and 141, *B*; fig. 91).

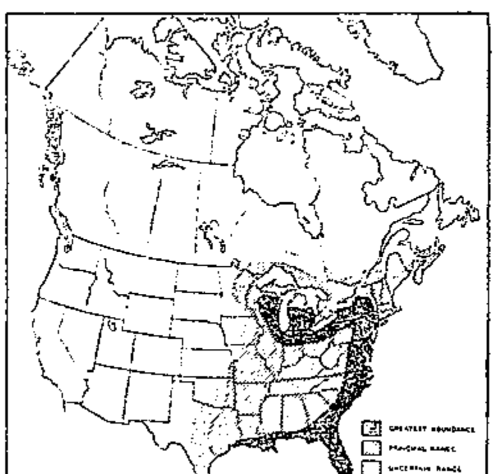

FIGURE 91.—Combined range of *Pontederia cordata* and *P. lanceolata.*

Value.—Slight to locally fair.

Parts consumed.—The seeds (utricles).

Identification.—Pickerelweed is distinct in its spike of bright blue flowers and in its lance-shaped or heart-shaped leaves with rounded bases (as compared with the pointed bases on leaves of *Peltandra* and some species of *Sagittaria* (pl. 40)).

Environment.—Usually in mucky soil in shallow ponds, streams, and marshes of fresh or slightly brackish water. Along the James

River, Va., this plant has been noted thriving in water with a salt content equivalent to about 2.5 percent of normal sea water during an average growing season.

Propagation.—By rootstocks or by seed.

Related species.—The narrow-leaved southern form of pickerelweed (*Pontederia lanceolata*) (fig. 91) is probably similar to *P. cordata* in having limited duck-food value.

Heteranthera dubia: Waterstargrass (pl. 133).

Waterstargrass is a common, widely distributed aquatic, but stomach studies have revealed only slight indications of its use by ducks. The plant has rather thick linear leaves and small yellow flowers, and ordinarily occurs in mucky bottoms.

The seeds of a related, broad-leaved species of *Heteranthera* (apparently *H. peduncularis*) formed the major proportion of the food of a pintail collected at Riverton, Kans.

MARANTACEAE: THALIA

Thalia.

Limited evidence at hand (three records) shows that thalia has some value as a duck food and that its merits deserve investigation. Two mallards, captured at St. Vincent Island, Fla., had eaten 144 and 2, respectively, of the large seeds; and the stomach of a lesser scaup duck, taken at Carlisle, La., contained one seed. Two species of *Thalia* occur in the Southeastern and Gulf Coast States.

MYRICACEAE: WAXMYRTLES, BAYBERRY

Myrica: Waxmyrtle, bayberry (fig. 92).

Value.—Slight to fair.

Parts consumed.—The seeds (nutlets).

Identification.—The plants are shrubby with resinous leaves and clusters of whitish, wax-coated globular "berries" borne on numerous short stalks along the branches.

Environment.—Moist ground in fresh or slightly brackish situations, chiefly near the coast.

Propagation.—By transplanting small specimens and probably by rooted cuttings or by seed. Barton (*3*) has shown that the seeds of bayberry (*Myrica carolinensis*) should be subjected to about 3 months of cold temperature to obtain successful germination; best results were obtained by stratifying these seeds between moist layers of granulated peat moss and storing them at temperatures of 5° C. Seeds may be planted outside late in fall and mulched or covered with boards—if planted too early they are likely to germinate and be killed before spring.

Species.—The bayberry (*Myrica carolinensis*) is usually a lower growing species and has larger fruit than the waxmyrtle. It thrives best on sandy ridges just back of coastal beaches, where it often aids greatly in anchoring shifting sand, but it grows also on the edges of marshes.

The waxmyrtle (*M. cerifera*) is most common along semishaded swamp borders near the coast north to Maryland, but it also thrives on the higher knolls in the open coastal marshes. It apparently has been used more frequently as a duck food than other species.

A western waxmyrtle (*M. californica*) is sometimes found on moist flats along the Pacific coast, but there is no evidence that it is sought by ducks.

BETULACEAE: ALDERS

Alnus: Alder.

Alder seeds have been eaten by ducks in a few northwestern localities, but in quantities too limited for the genus to be regarded as a source of duck food.

FIGURE 92.—Combined range of *Myrica cerifera* and *M. carolinensis*.

FAGACEAE: OAKS

Quercus: Oaks.

Value.—Excellent locally; mallards, black ducks, and wood ducks have fed considerably on oak mast in swamps of the South Central and Southern States.

Parts consumed.—The acorns.

Species.—The oaks that have small acorns and grow in or near low or swampy places are most valuable to ducks, but some of the species that produce large acorns also have been used to a lesser extent. The most useful species are southern red oak (*Quercus rubra*), water oak (*Q. nigra*), willow oak (*Q. phellos*), live oak (*Q. virginiana*), and pin oak (*Q. palustris*) and its near relatives.

URTICACEAE: WATER-ELM

Planera aquatica: Water-elm (figs. 93–94).

Value.—Generally slight or nil; locally (and periodically) excellent in the lower Mississippi region. As the fruit ripens and falls late in spring or early in summer, it is available for the northern ducks only under unusual conditions.

Parts consumed.—The seeds (nutlike fruits).

Identification.—The water-elm resembles the American hornbeam (*Carpinus caroliniana*) in the appearance of leaves and in general habits, but is distinct in its peculiar seed, which is covered by an irregular coat with fleshy fingerlike projections.

FIGURE 93.—Range of *Planera aquatica*.

Environment.—Borders of swamps and river bottoms subject to periodic flooding.

Propagation.—By transplanting seedlings or small trees as well as by seed.

POLYGONACEAE: SMARTWEEDS, DOCKS

Rumex: Docks.

Value.—Slight.

Parts consumed.—The seeds (achenes).

Identification.—The large rusty-brown spikes, consisting of whorls of winged dry fruits, are typical of docks. The sharply triangular seeds are also distinctive.

Environment.—Moist or marshy fresh-water or mildly alkaline places.

Species.—Dock seeds found in duck stomachs include *Rumex persicarioides* and *R. crispus* and some undetermined species.

Polygonum (Persicaria): Smartweeds (pls. 87–95; figs. 95–104).

Value.—Good to excellent.

Parts consumed.—The seeds (achenes).

Identification.—*Polygonum*, a genus of annual or perennial alternate-leaved herbs, may generally be identified by the thin, somewhat transparent, or rarely herbaceous, sheath (ocrea) that encases the stem for a short space above each joint. The black, or sometimes brownish, seeds and the spikes of pink or white flowers are also characteristic.

Environment.—Usually found in rich, moist soil or shallow marshes; a few species grow emergent or floating in water, and some are common on dry land. The genus is typically one of fresh-water situations, though the water smartweed (*P. amphibium*) and the marsh smartweed (*P. muhlenbergii*) tolerate mild alkalinity. The former is also often found thriving in moderately acid waters in the Northern States.

B5926M

FIGURE 94.—Branches and seeds of water-elm (*Planera aquatica*), × ⅔.

Propagation.—By rootstocks (in perennial species) and by seeds planted late in fall or kept in cold storage for several months at

FIGURE 95.—Range of *Polygonum lapathifolium.*

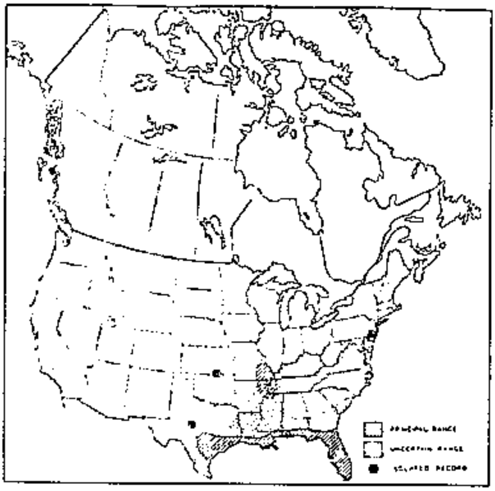

FIGURE 96.—Range of *Polygonum portoricense.*

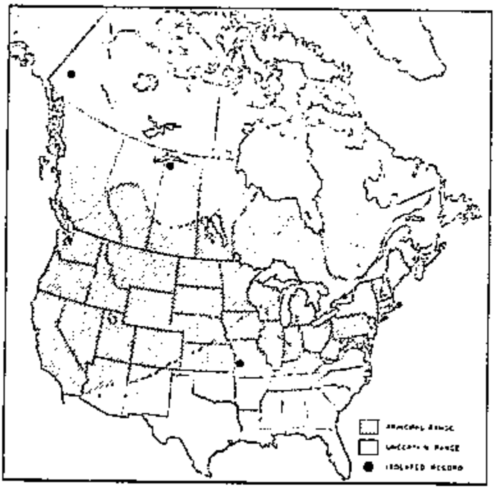

FIGURE 97.—Range of *Polygonum amphibium.*

near-freezing temperatures. Because the seeds of most smartweeds germinate slowly, stratification between moist layers of finely ground peat moss will probably be desirable.

Polygonum lapathifolium: Nodding smartweed (pls. 87–88, *A*; fig. 95).

Value.—Excellent.

Parts consumed.—The seeds (achenes).

Identification.—A rather tall (3 to 6 foot) common, annual species with densely flowered drooping spikes and flat, nearly circular seeds.

Environment.—Best growth occurs in moist, rich soil on exposed flats or near the water margin; common in shallow fresh or slightly alkaline marshes.

Propagation.—By seed.

Polygonum portoricense (*P. densiflorum*): Smartweed fig. 96).

Value.—Good.

Parts consumed.—The seeds (achenes).

Identification.—*Polygonum portoricense* is a rather coarse smartweed with long tapering leaves, dense flower spikes, and somewhat lens-shaped seeds.

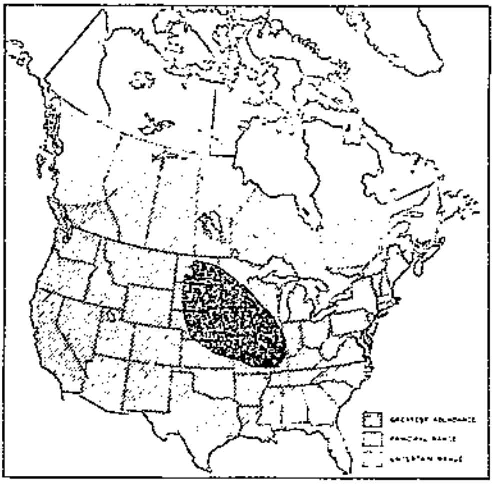

FIGURE 98. Range of *Polygonum muhlenbergii*.

Environment.—Swamps and marshes of the South Central and Gulf States. Luxuriant growths have been found along the swampy margins of the St. Francis River, northeastern Arkansas.

Propagation.—By transplanting rooted parts or by seed.

Polygonum amphibium: Water smartweed (pls. 89–90; fig. 97).

Value.—Good to excellent.

Parts consumed.—The seeds (achenes).

Identification.—The perennial water smartweed commonly grows semisubmerged in shallow water. The oval or short-cylindric spikes of pink flowers and the floating, shiny, elliptic or oblong leaves distinguish it from the closely related marsh smartweed (*Polygonum muhlenbergii*). The terrestrial form of *P. amphibium* (pl. 90) has a broad herbaceous sheath at each joint, and besides being quite different in general appearance it is usually sterile.

Environment.—Fresh, moderately acid, or mildly alkaline water.

Propagation.—By rootstocks or by seed. Germination experiments with seeds collected on August 28, 1935, in New York have been reported by Muenscher (*60*). At the time his notes were prepared for publication (early June 1936) he had obtained germination of 26 percent (after 45 days in the germinator) from seed that had been stored for 7 months in water slightly above freezing temperature

(1° to 3° C.). Up to June 1936, no seeds had sprouted when stored dry for 7 months at near-freezing temperature, when stored dry at ordinary room temperature, or when kept in water at room temperature.

Crocker (*13*) reported that by rupturing the coats of dry seeds of this smartweed he obtained a germination of 85 percent, but he does not record how long the seeds had been dry or at what temperatures they had been kept. Muenscher reported that seeds stored dry (and also wet) for 5 months in the manner above described failed to germinate after the seed coats had been opened and the seeds had been subjected to germinating conditions.

FIGURE 99.—Branch of water smartweed (*Polygonum muhlenbergii*), × ⅘, showing flower spikes; seed, × 8.

Polygonum muhlenbergii: Marsh smartweed (pls. 91 and 122, *B*; figs. 98–99).

Value.—Good to excellent.

Parts consumed.—The seeds (achenes).

Identification.—The marsh smartweed is closely related to the water smartweed (*P. amphibium*) but can be distinguished by the more elongate flowering spikes (usually 2 to 4 inches long in *P. muhlenbergii* and less than 1 inch long in *P. amphibium*). The leaves of the aquatic form of *P. muhlenbergii* (pl. 91, *A*) commonly have somewhat broadened or cordate bases and acute or acuminate tips, whereas those of its near relative are elliptic or oblong and are generally blunt-tipped.

Environment.—Fresh or mildly alkaline lakes (at depths less than 4½ feet) or marshy places. This plant is well adapted to withstand fluctuations of several feet in water level. A sterile form is often common on dry land and for reproduction depends chiefly on rootstocks. When flooded by shallow water it fruits abundantly. If this smartweed remains growing continuously in water for more than 2 years there usually is a decline in abundance of plants and also in production of seeds.

Propagation.—By rootstocks and probably by seed. Seeds kept both wet and dry at ordinary room temperature failed to germinate in the laboratory. Storing near the freezing point for several months in water or stratifying between layers of moist sand is apparently essential if the seeds are intended for spring planting. Late fall planting is probably preferable where cold-storage facilities are not available.

Polygonum pensylvanicum: Largeseed smartweed (pl. 88, *B*; figs. 100-101).

Value.—Good to excellent.

Parts consumed.—The seeds (achenes).

Identification.—The flowers of the largeseed smartweed are bright pink, in thick, erect spikes, and the seeds are the broadest of any of the circular, flat-seeded type.

Environment.—Fields, moist margins, and shallow fresh or moderately brackish marshes. Some of the finest plants have been noted on moist sandy margins of the tidal Potomac at a point where the salt content of the water is equivalent to about 18 to 25 percent of normal sea salinity during the average growing season.

Propagation.—By seeds.

FIGURE 100.—Flowering branch of largeseed smartweed (*Polygonum pensylvanicum*), × ⅛; seed, × 8.

Polygonum punctatum (P. acre): Dotted smartweed (pls. 92-93, *A*; fig. 102).

Value.—Good to excellent.

Parts consumed.—The seeds (achenes).

Identification.—The dotted smartweed is a perennial species with shiny black seeds (usually triangular) enclosed in sepals that are dotted with minute translucent glands; the flowers are whitish and are borne in slender spikes.

Environment.—Moist margins, in marshes and in swamps.

Propagation.—By transplanting or by seeds.

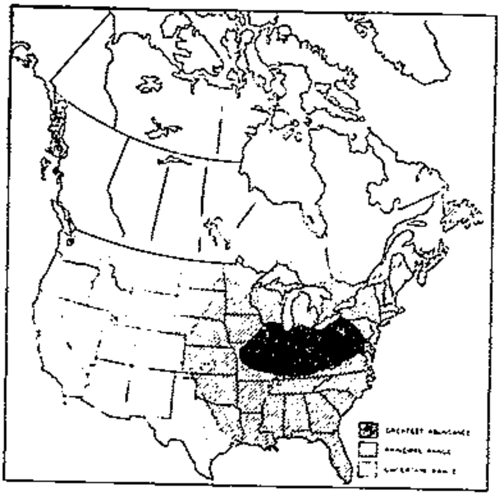

FIGURE 101.—Range of *Polygonum pensylvanicum*.

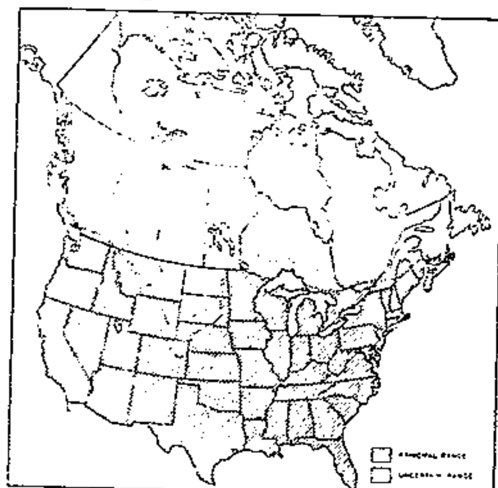

FIGURE 102.—Range of *Polygonum punctatum*.

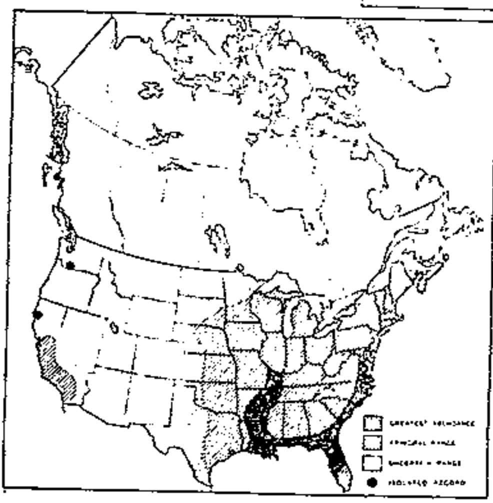

FIGURE 103.—Range of *Polygonum hydropiperoides*.

Polygonum hydropiperoides: Swamp smartweed (pls. 93, *B*, and 95, *A*; fig. 103).

Value.—Good.

Parts consumed.—The seeds (achenes).

Identification.—The swamp smartweed is a perennial plant with narrow leaves, fringed sheaths, slender, sparsely flowered spikes, and triangular seeds. This species resembles *Polygonum punctatum* but lacks the glandular dots on the structures (sepals) enclosing the small seeds and does not have the strongly peppery taste characteristic of many smartweeds.

FIGURE 104.—Range of *Polygonum persicaria*.

Environment.—Moist margins, marshes, and shallow water. It withstands considerable shade and grows under fresh-water or moderately acid conditions.

Propagation.—By transplanting or by seed. Seeding in fall is recommended unless cold-storage facilities are available for stratifying the seeds between layers of moist sand or finely ground peat moss.

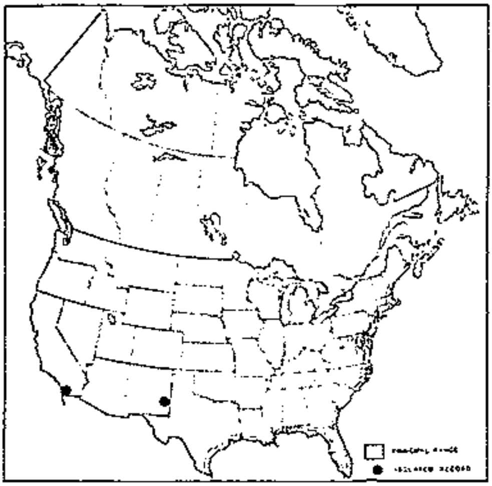

FIGURE 105.—Range of *Salicornia bigelovii*.

Other species of Polygonum (pls. 94–95, *B*; fig. 104).

Waterpepper (*Polygonum hydropiper*), ladysthumb (*P. persicaria*) (pl. 94; fig. 104), and tearthumb (*P. sagittatum*) (pl. 95, *B*) have fair local value as waterfowl food plants, and several other species have been used by ducks in small quantities.

CHENOPODIACEAE: GLASSWORTS

Salicornia: Glassworts, pickleweeds (pls. 96–97; figs. 105–107).

Value.—Locally fair to good. Large quantities of glassworts have been used by ducks along the Texas coast, and field observations indicate that the same is true locally along the Atlantic coast.

Parts consumed.—The seeds and adjoining parts.

Identification.—The young stems and branches of glassworts have a somewhat glassy appearance, which is due to their succulence and semitransparency. The plants are leafless, and the numerous joints of the stems are marked by slight constrictions.

FIGURE 106.—Range of *Salicornia rubra* (in the West) and *S. europaea* (in the East).

Environment.—Strongly saline or alkaline flats. According to Wiehe (*88, p. 333*), *Salicornia europaea* (pls. 96, *B*, and 97, *A*; fig. 106) of the coastal tide flats thrives best in situations that are flooded by high tides only once in 2 to 15 days. After a plant has become established, daily submergence by tides does not inhibit growth. On flats that are flooded every day a high percentage of the seedlings usually are killed. After they become well anchored in the mud, however, they can withstand daily submergence.

Propagation.—By seeds, or, in the case of *S. ambigua* (fig. 107) by rootstocks.

Species.—Stomach records indicate that *Salicornia bigelovii* (*S. mucronata*) (pl. 96, *A*; fig. 105), an annual coastal species with sharply pointed scales, has been used extensively by several species of ducks. In November 1935, W. S. Bourn noted a flock of about 50 black ducks feeding actively on glasswort (presumably *S. europaea*) near Cape May Courthouse, N. J.

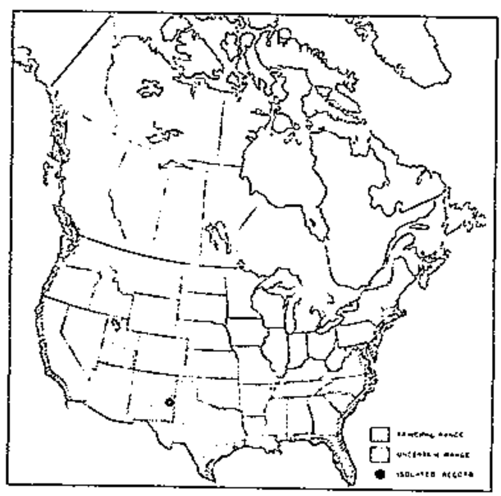

FIGURE 107. Range of *Salicornia ambigua*.

Salicornia rubra and *S. europaea* are annuals with blunt scales. The former is confined to the West and the latter to the East (fig. 106.) *S. ambigua* (fig. 107) is a perennial form. Apparently all species have duck-food value in localities where the plants form dense beds.

AMARANTHACEAE: WATERHEMPS, PIGWEEDS

Amaranthus- Pigweeds.

Seeds of pigweeds have been recorded from stomachs in several western localities, but the percentages involved were small.

Acnida cannabina: Tidemarsh waterhemp (pl. 98; fig. 108).

Value.—Locally fair to excellent. On the coast of Connecticut the tidemarsh waterhemp was found to make up about 65 percent of the fall and early-winter food of a series of 10 black ducks, and an equally large quantity had been eaten by various shoalwater ducks along the New Jersey coast. Several of the stomachs contained 1,300 to 1,600 seeds. This species produces thousands of seeds, and it is not unusual for a single plant to produce more than 2 quarts, unhulled.

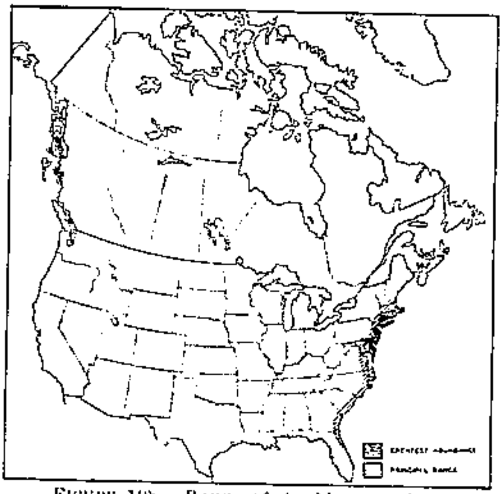

FIGURE 108.—Range of *Acnida cannabina.*

Parts consumed.—The seeds, with their enclosing membranes (utricles).

Identification.—The tidemarsh waterhemp is a stout pigweedlike plant 3 to 7 or more feet high, with dark reddish brown, oval, flat seeds of fair size (about one-eighth inch in diameter).

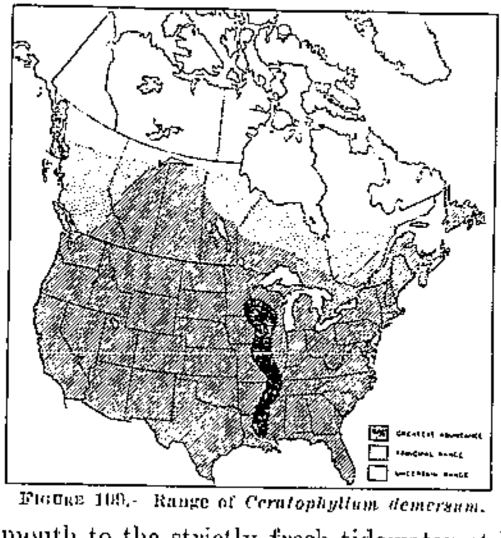

FIGURE 109.—Range of *Ceratophyllum demersum.*

Environment.—Fresh or brackish tidal marshes, particularly along the borders of tidal channels; thriving best on sandy muck in areas that are submerged only by the higher stages of the tides. It is often found growing with saltmarsh cordgrass (*Spartina alterniflora*) in brackish marshes and with three-square (*Scirpus americanus* and *S. olneyi*) in the fresher marshes. Along the Potomac River it extends upstream from the strongly brackish marshes at the mouth to the strictly fresh tidewater at Washington, D. C.

Propagation.—By seeds, preferably planted late in fall by raking them into wet soil. It is desirable to store the seeds (at temperatures near the freezing point) stratified between layers of moist sand. Seeds stored dry or in water have germinated fairly well also.

Related species.—*Acnida tuberculata* also has been recorded from duck stomachs, but it and other species have very small seeds and low value as compared with *A. cannabina.*

CERATOPHYLLACEAE: COONTAIL

Ceratophyllum demersum: Coontail, hornwort (pl. 99; figs. 2 and 109).

Value.—Generally slight to fair; locally excellent in the lower Mississippi region. In many places it is a serious competitor of more desirable plants.

Parts consumed.—The seeds (achenes) and leaves. Though coontail is widespread and often abundant, the production of seeds appears to be comparatively uncommon probably depending on high temperature in shallow water.

Identification.—The dense coontaillike tips of some branches and the forking of the whorled leaves (fig. 2, p. 20) should distinguish this plant. It never develops roots, although the basal ends are often buried in mud.

Environment.—Coontail is a submerged aquatic, free floating or anchored, and is essentially a fresh-water inhabitant. It thrives well either in dense shade or open-water areas. This plant, together with the duckweeds, usually forms the earliest dense growths of aquatic vegetation in ponds that have been scoured out by floods in the Mississippi Valley. It requires less light than most submerged seed plants and consequently often is found at greater depths than other species. In clear Florida springs it has been noted growing at a depth of nearly 30 feet.

Propagation.—By living parts, particularly the bushy tips. Plantings should be restricted to fresh-water areas where more valuable submerged species cannot thrive.

NYMPHAEACEAE: WATERLILIES, WATERSHIELD, SPATTERDOCKS

Nymphaea (Nymphozanthus): Spatterdocks, yellow pondlilies (pl. 130, *B*; figs. 110–111).

Value.—Generally slight, frequently choking out more valuable species; locally good in the case of *Nymphaea macrophylla*, which is an important food of ring-necked ducks in northern Florida.

Parts consumed.—The seeds.

Identification.—In the spatterdock (*Nymphaea*) the leaf is oval or elongate and its stalk is attached nearer the basal end of the blade than in the white waterlily (*Castalia*), which has almost circular leaves with stalks attached near the center. The flowers have about five bright yellow sepals and no conspicuous petals.

Environment.—Fresh- or acid-water ponds, lakes, and slow streams, at moderate depths (commonly less than 6 feet) and generally on fertile or mucky bottoms. In the Dismal Swamp, Va., the spatterdock has been noted growing successfully in water with an acidity of pH 5.

Propagation.—By rootstocks or by seed. The seed should be kept wet and should be planted late in fall or stored in water at low temperatures until spring.

Species.—*Nymphaea advena* of the East, *N. macrophylla* of Florida, and *N. polysepala* of the West have each been recorded from duck stomachs, generally in small quantity. A dwarf species, *N.*

microphylla, is often found in acid water, 6 to 10 feet deep, in northeastern lakes. Probably all the several other species of *Nymphaea* are fed upon to some extent by ducks.

Castalia:[7] Waterlilies (pl. 100; figs. 111–113).

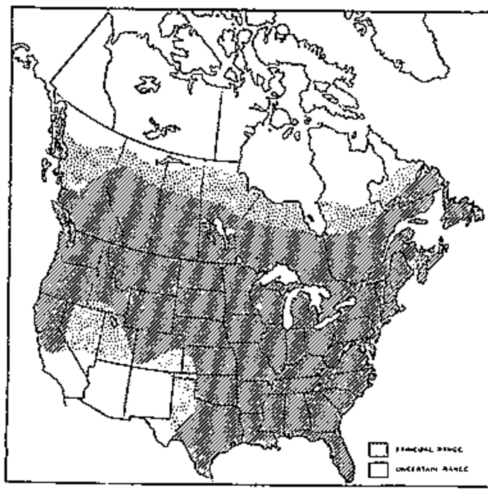

FIGURE 110.—Range of genus *Nymphaea*.

Value. — Generally fair; locally excellent in *Castalia flava* (*C. mexicana*); of greatest utility to ducks in the Gulf region.

Parts consumed. — The seeds and, in *C. flava*, the rootstocks and related parts.

Identification. — The leaves are nearly circular, and the flowers are showy, with numerous (25 or more) petals (fig. 111).

Environment. — Freshwater ponds, lakes, and slow streams at moderate depths and generally on fertile mucky bottoms.

Propagation.—By rootstocks or by seeds planted in fall or stored in water at low temperatures until spring. The fact that shade caused by the large floating leaves of waterlilies often retards the growth of more useful submerged plants should be given due consideration.

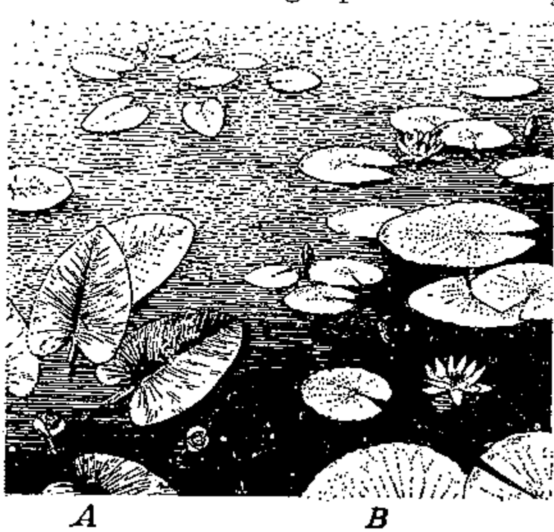

FIGURE 111.—*A*, Spatterdock (*Nymphaea advena*); *B*, waterlily (*Castalia tuberosa*).

Castalia odorata and **C. tuberosa:** Waterlilies (pl. 100, *C*; figs. 111–112).

Value.—Fair; seeds of both species have been recorded many times in stomach studies.

Parts consumed. — The seeds.

Identification.—The two common species of waterlily are very similar, but *Castalia tuberosa* generally has larger flowers and its leaves are usually less purplish underneath. *C. odorata* predominates in the acid waters of the East, and *C. tuberosa* in the calcareous waters of the Middle West.

[7] The name "*Nymphaea*" is now applied to this genus by some botanists but this bulletin follows the usage of current manuals.

Castalia flava (C. mexicana): Banana waterlily (pl. 100, *A* and *B*; fig. 113).

Value.—Locally excellent in the Gulf region.

Parts consumed.—The rootstocks, tubes, and seeds.

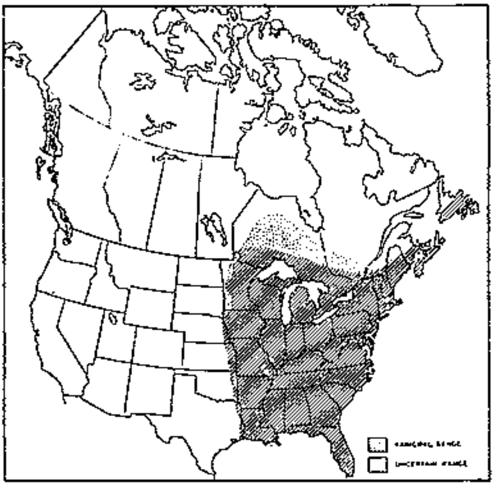

FIGURE 112.—Combined ranges of *Castalia odorata* and *C. tuberosa*.

Identification.—The yellowish flowers and the underground banana-like clusters of reproductive structures are fairly distinctive.

Environment.—Fresh or slightly brackish water at depths of one to several feet and on rather mucky bottoms.

Propagation.—By rootstocks, by the bananalike structures, or by seeds.

Other species of Castalia.

Probably other species of *Castalia* are used as duck foods, as there are many stomach records in which "*Castalia* sp." is listed. A species with very small seeds and bluish flowers (*C. elegans*) is locally abundant in important duck-feeding grounds of the fresher marshes along the Gulf coast.

Nelumbo pentapetala (N. lutea): American lotus (pls. 122, *B*, and 130, *A*).

The American lotus, known also as yonkapin, yockernut, and water chinkapin, is abundant locally in the Mississippi Basin and elsewhere, but stomach analyses indicate that its extremely hard, oval seeds are of practically no value as a duck food. It oftens chokes out valuable food plants.

FIGURE 113.—Range of *Castalia flava*.

Brasenia schreberi: Watershield (pl. 101; fig. 114).

Value.—Fair to excellent; of greatest utility to ring-necked ducks in Florida.

Parts consumed.—The seeds, usually in the small podlike fruits.

Identification.—The leaves of watershield are distinct in being complete small ovals (2 to 5 inches long) without any cleft and in having a coating of gelatinous material on the lower surface.

Environment.—Fresh- or acid-water ponds and lakes at moderate depths (usually less than 5 feet) and on bottoms of considerable fertility.

Propagation.—By rootstocks or by seed planted in fall or stored in water at low temperatures until spring.

Cabomba caroliniana: Fanwort (fig. 2).

Fanwort is related to watershield and is common in the South, but ducks do not appear to use it. It has finely divided leaves and is used commonly in aquaria.

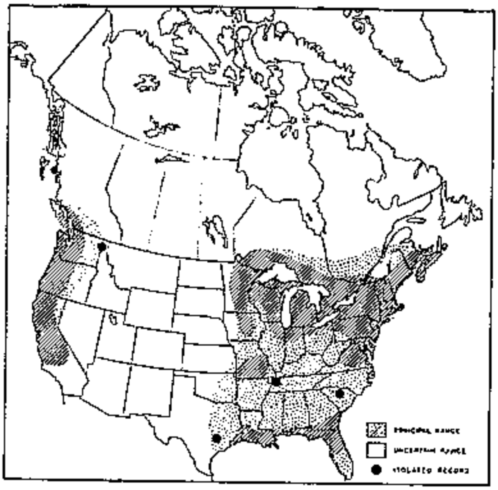

FIGURE 114.—Range of *Brasenia schreberi.*

RANUNCULACEAE: BUTTERCUPS

Ranunculus (subgenus Batrachium): White water buttercups (pl. 102; figs. 2, 115–116).

Value. — Apparently slight; used often but generally in small quantity. Since the seeds of water buttercups often mature early in summer, further food studies on the breeding grounds are necessary to determine their true value.

Parts consumed.—The seeds (achenes) and to a lesser extent, the leaves or other parts of the plants.

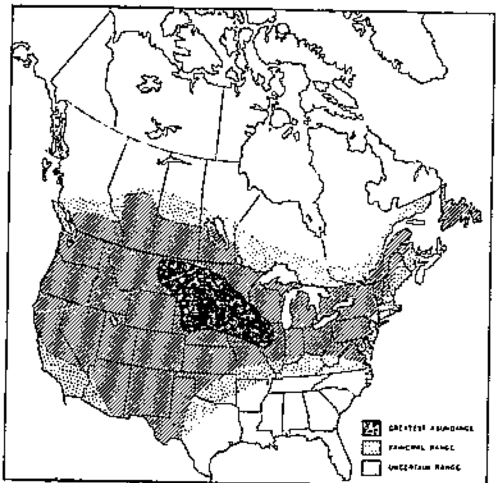

FIGURE 115.—Range of *Ranunculus circinatus* (including *R. subrigidus* and *R. longirostre*).

Identification. — White water buttercups are common aquatics with finely divided leaves and (in spring) with numerous white flowers just above the water surface.

Environment. — Fresh-water ponds or lakes at shallow or moderate depths (occasionally 4 feet or more). *Ranunculus circinatus* has been noted growing well in mildly alkaline waters on the Great Plains, and *R. aquatilis* (*R. trichophyllus*) in moderately acid lakes of the northern timbered regions.

Propagation.—By transfer of growing material or by seeds.

Species.—*Ranunculus aquatilis* and *R. circinatus* are the widespread white water buttercups, the former having fine, flaccid leaf divisions and usually a distinct leaf stalk, and the latter having coarser, more rigid leaves and no leafstalk. *R. circinatus* is particularly plentiful in many of the lakes of the Nebraska sand hills and in the upper Mississippi Valley.

Ranunculus (subgenera Halodes and Euranunculus): Yellow buttercups (pl. 103; figs. 117–120).

Though a number of the yellow-flowered species of *Ranunculus* have been used repeatedly, none has been recorded in significant percentages in duck-stomach studies. Most of them, however, mature their seeds early, and it seems probable that further information on food consumption by ducks during the nesting season and summer will show that the plants are of greater importance than is now apparent.

FIGURE 116.—Range of *Ranunculus aquatilis* and its varieties.

Species.—*Ranunculus cymbalaria* (pl. 103, *A*, and fig. 117) is a characteristic marginal plant in moist soil around alkaline lakes and ponds in the West. *R. flabellaris* (pl. 103, *C* and *D*, and fig. 118) and *R. purshii* (fig. 119) are amphibian forms, found either in water or on moist land. The latter species extends far northward, where it is available for northern ducks. Since these two buttercups adapt themselves to successful growth either in water (usually less than 4 feet deep) or on the exposed beds of water areas, they have a definite utility in situations unsuitable for the growth of most aquatic plants. *R. sceleratus* (pl. 103, *B*, and fig. 120) is a common and widespread marsh buttercup that produces an abundance of seed early in the growing season.

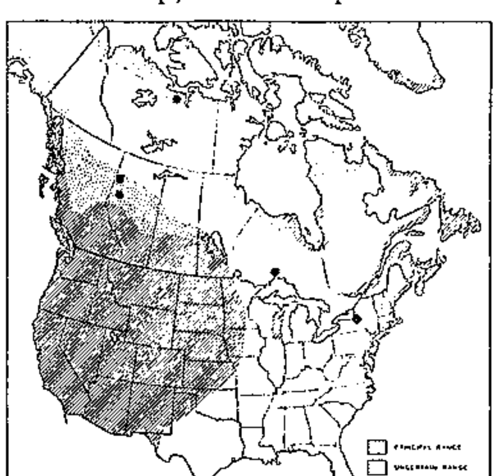

FIGURE 117.—Range of *Ranunculus cymbalaria* (including var. *alpina*).

HAMAMELIDACEAE: SWEETGUM

Liquidambar styraciflua: Sweetgum (figs. 121–122).

Value.—Locally fair in the lower Mississippi flood lands; slight or nil elsewhere.

Parts consumed.—The seeds.

Identification.—A tree having somewhat star-shaped leaves and hard, globular, pendant fruiting structures (fig. 122) in which the winged seeds are borne.

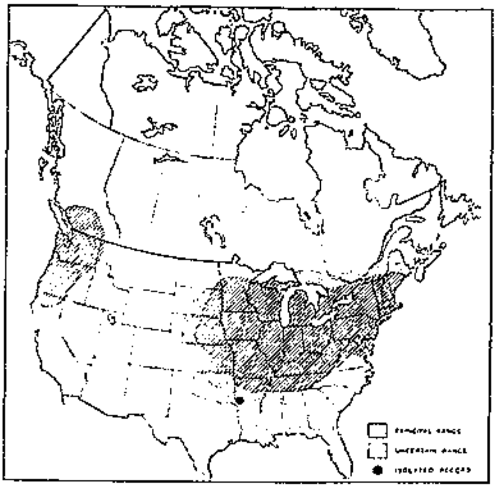

FIGURE 118.—Range of *Ranunculus flabellaris.*

FIGURE 119.—Range of *Ranunculus purshii.*

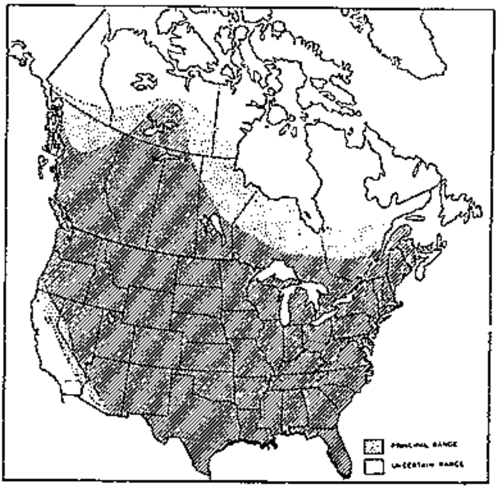

FIGURE 120.—Range of *Ranunculus sceleratus.*

Environment.—Bottom lands, slopes, and upland areas. Useful as a duck food only during flood stages in lowland woods.

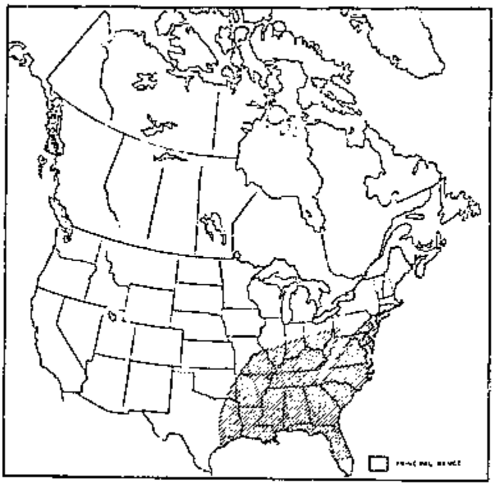

FIGURE 121.—Range of *Liquidambar styraciflua.*

VITACEAE: WILD GRAPES

Vitis: Wild grapes.

Value.—Slight; used frequently in small quantities in the lower Mississippi region.

Parts consumed.—The entire fruits or the seeds.

Species.—Of the numerous species of wild grape, several have been used in the lowlands of the Mississippi Basin. *Vitis cordifolia*, *V. cinerea*, *V. aestivalis*, and *V. rotundifolia* are common species of that region.

ONAGRACEAE: WATERPRIMROSES

Jussiaea: Waterprimroses (pl. 104; figs. 123–124).

Value.—Slight to locally fair. The creeping waterprimrose (*Jussiaea diffusa*) has proved to be of considerable value to ducks in the lower Mississippi region.

Parts consumed.—The seeds (in their podlike capsules).

Identification.—Prior to the development of flowers or fruit, some waterprimroses resemble smartweeds but are distinct in having no encircling sheath (ocrea) above the leaf attachment. All the waterprimroses are perennial, and their yellow flowers and cylindrical fruiting capsules readily distinguish them from smartweeds during later development.

Environment.—Mud or shallow water in marshy or swampy places. The species *J. grandiflora* and *J. diffusa* withstand fluctuations between a submerged (less than 4 feet deep) and an

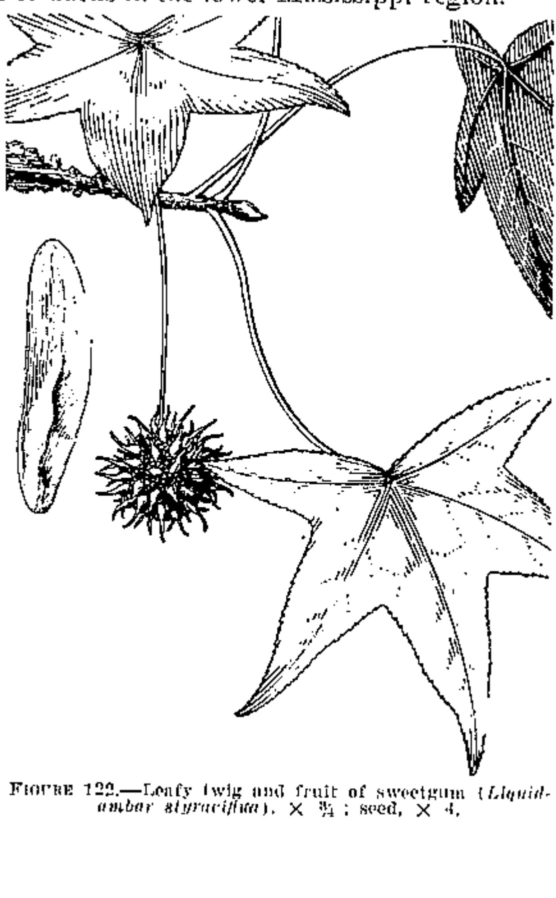

FIGURE 122.—Leafy twig and fruit of sweetgum (*Liquidambar styraciflua*), × ¾; seed, × 4.

emergent condition and are tolerant of considerable shade. A species of the open marshes, *J. leptocarpa*, has been found to be of local importance in the Southern States.

Propagation.—By transplanting rooted parts or by seeds.

Species.—Several species of *Jussiaea* are common in the South, and in addition to definite records of use of *J. diffusa* and *J. leptocarpa* by ducks, there are 17 stomach records of *Jussiaea* in which the species were not determined. Most water-primroses are creeping or decumbent, but *J. leptocarpa* is an erect, much-branched, hairy herb that commonly reaches a height of 2 to 4 feet.

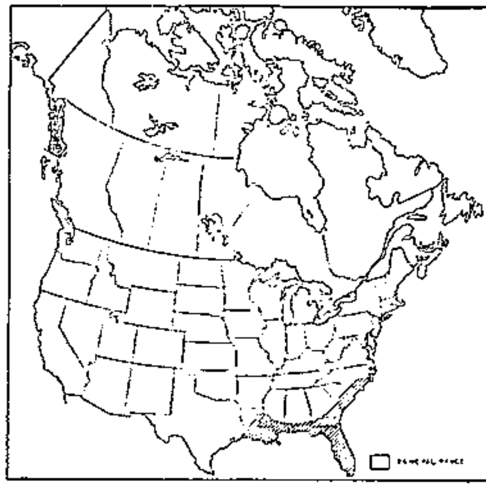

FIGURE 123.—Range of *Jussiaea grandiflora*.

HALORAGIDACEAE: WATERMILFOILS, MERMAIDWEEDS, MARESTAIL

Myriophyllum: Watermilfoils (pl. 105; figs. 2, 125–127).

Value.—Generally slight to fair; locally good.

Parts consumed.—The seeds (nutlets).

Identification.—The submerged leaves of species that are of value as duck food are somewhat featherlike in that they have many fine divisions in two ranks on a central axis. In some common species the leaves occur in whorls of four, five, and six, and in others they are opposite or alternate. In several kinds the fruiting part is emergent from the water and the leaves are usually smaller and less divided than on the lower part.

FIGURE 124.—Range of *Jussiaea diffusa*.

Environment.—Watermilfoils are essentially fresh-water aquatics that grow at various depths, sometimes at more than 15 feet, on either mucky or sandy bottoms. Several species withstand complete emergence as long as the soil remains moist.

Propagation.—By transplanting cuttings or by seed. Titcomb (*81*) reported that at the Mammoth Springs, Ark., fish hatchery, watermilfoil was easily propagated in ponds by simply covering a handful of the stalks with a shovelful of earth at intervals of 3 to 6

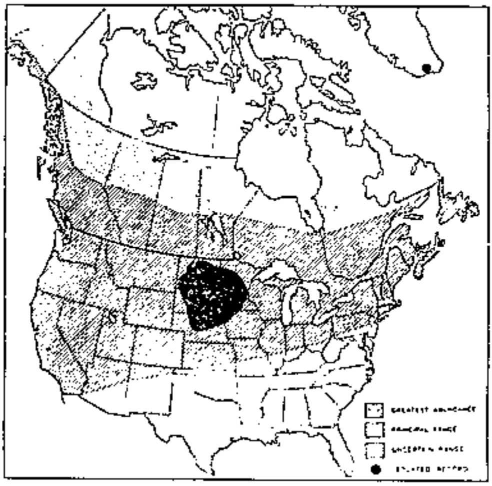

FIGURE 125.—Range of *Myriophyllum spicatum* (including M. *exalbescens*).

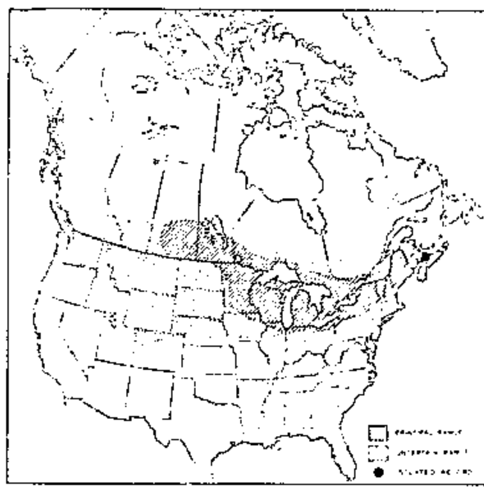

FIGURE 126. Range of *Myriophyllum verticillatum.*

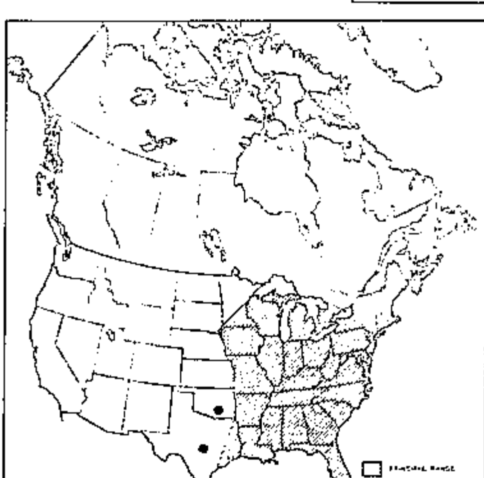

FIGURE 127.- Range of *Myriophyllum heterophyllum.*

feet. When this was done late in summer or early in fall a fine stand developed by the following spring.

Myriophyllum spicatum (M. exalbescens): Watermilfoil (pl. 105, *A*; fig. 125).

Myriophyllum spicatum is the most useful form of watermilfoil in western and northern parts of the United States, there being more than 225 records of its consumption by ducks, but the quantities of seed eaten average rather small. It is a common species, with emergent fruiting spikes and usually with reddish stems. The plant tolerates mild alkalinity and at times becomes dominant in shallow water in the North Central States.

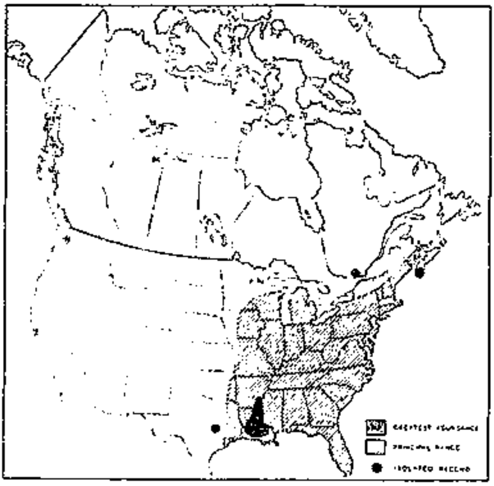

FIGURE 128.—Range of *Proserpinaca palustris*.

Other species of Myriophyllum.

Among the species for which there are records of use by ducks are *Myriophyllum scabratum*, with rough-surfaced nutlets and two types of leaves; *M. heterophyllum* (pl. 105, *C*; fig. 127) with conspicuous undivided leaves on the emergent fruiting spike; *M. tenellum*, which is practically leafless; and *M. verticillatum* (pl. 105, *B*; fig. 126), in which the large divided leaves are very flaccid.

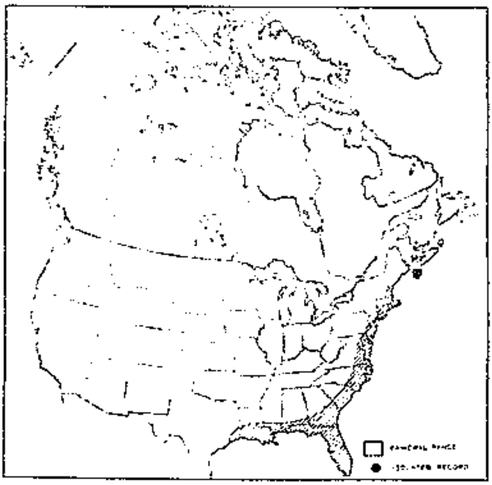

FIGURE 129.—Range of *Proserpinaca pectinata*.

Proserpinaca: Mermaidweeds (pl. 106; figs. 128–129).

Value.—Generally slight; locally fair; used many times in the South and East in small quantity.

Parts consumed.—The seeds (nutlets).

Identification.—Mermaidweeds are similar to watermilfoils, but the fruit consists of a triangular, bony, three-celled nutlet, whereas in the watermilfoils it is made up of four distinct and usually separable parts.

Environment.—Shallow fresh water of swampy places. *Proserpinaca palustris* tolerates considerable shade and both it and *P. pectinata* withstand fluctuations from a shallowly submerged (less than 3 feet) to an emergent condition.

Propagation.—By transplanting or by seed.

Species.—The two native species known to be used by ducks are *P. palustris* (including *P. amblygona*) and *P. pectinata.* In the latter (pl. 106, *A*) all the leaves are divided, whereas in *P. palustris* (pl. 106, *B*) the emergent leaves are merely serrate.

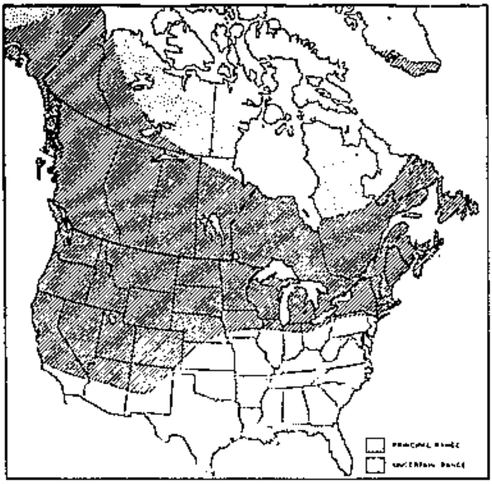

FIGURE 130. Range of *Hippuris vulgaris.*

Hippuris vulgaris: Marestail (pl. 107; fig. 130).

Value.—Generally slight: locally fair in the North and Northwest.

Parts consumed.—The seeds (drupelets).

Identification.—Marestail is normally a semisubmerged aquatic with emergent tips. Its whorls of unbranched, narrow, tapering leaves give the plant a bottlebrush appearance.

Environment.—Ponds, swamps, and lakes of shallow or medium depth; withstanding moderate alkaline and moderate acid conditions. When left totally emergent by receding waters, the plant continues to thrive as long as the soil remains moist.

Propagation.—By transplants or by seed.

Related species.—Northern species of *Hippuris* in Canada and Alaska are probably of considerable local value to ducks on the breeding grounds.

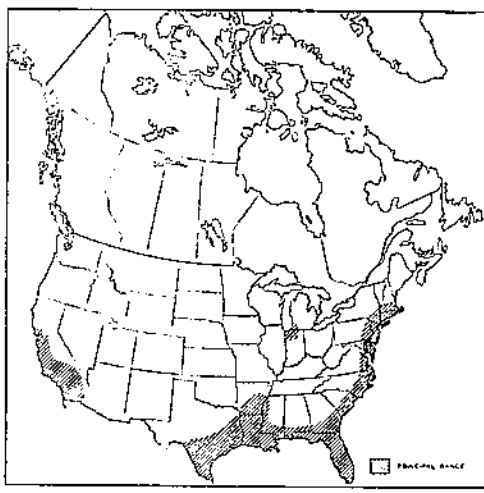

FIGURE 131. Range of *Hydrocotyle umbellata.*

UMBELLIFERAE: PENNYWORTS

Hydrocotyle: Pennyworts (pl. 108; figs. 131–133).

Value.—Generally slight; locally fair in the South and Southeast.

Parts consumed.—The seeds (merocarps).

Identification.—Pennyworts are creeping or floating perennial plants with roundish leaves, which are scalloped or lobed on the margins.

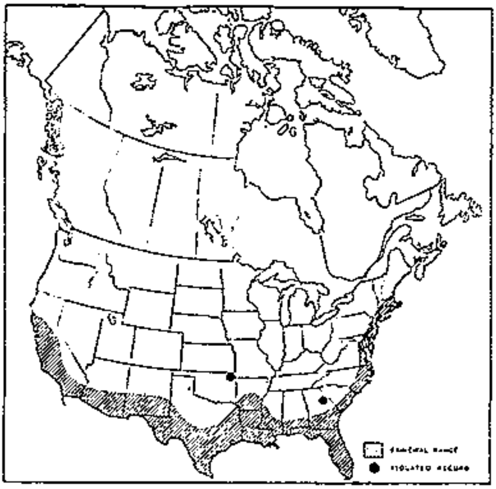

FIGURE 132.—Range of *Hydrocotyle verticillata*.

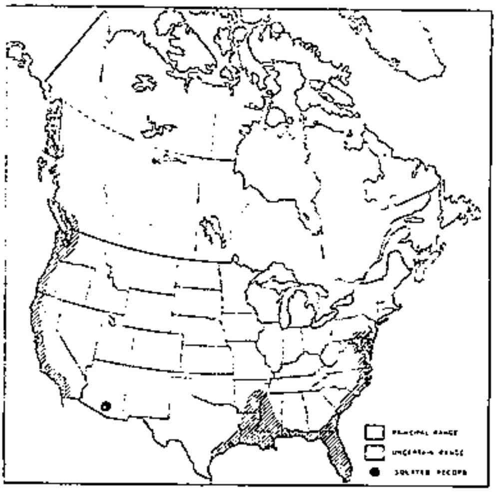

FIGURE 133.—Range of *Hydrocotyle ranunculoides*.

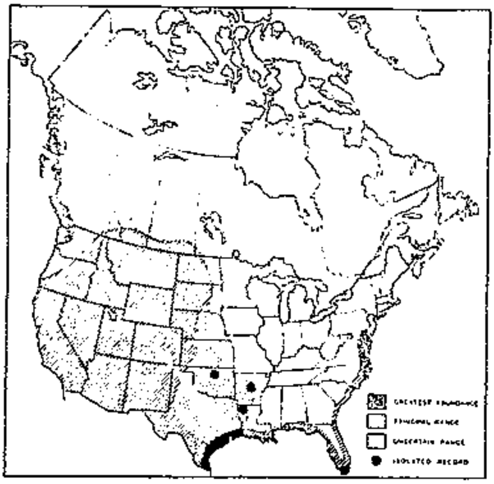

FIGURE 134.—Range of *Heliotropium curassavicum*.

Environment.—Diverse situations; often moist sandy places or swamps; sometimes growing in water with the upper parts floating (particularly in the case of *Hydrocotyle ranunculoides*). The species are tolerant of dense shade and sulphurous soils.

FIGURE 135.—Range of *Bacopa monnieria.*

Propagation.—By transplanting the creeping rooted stems or by seeds scattered on muddy margins.

Species.—The most common and most useful species are *H. umbellata*, *H. verticillata*, and *H. ranunculoides.* The many-flowered pennywort (*H. umbellata*) is distinct in its large terminal whorl (umbel) of seeds; the whorled pennywort (*H. verticillata*) has its seeds in series of whorls; and the water pennywort (*H. ranunculoides*) differs in having its leaf margins deeply cleft.

STYRACACEAE: SNOWBELLS

Styrax spp.: Snowbells.

The dry fruits of snowbell bushes have been consumed to a limited extent in the lower Mississippi region. *Styrax* is tolerant of dense shade and severe fluctuations in water level on periodically submerged woodlands, as in the lower White River bottoms of Arkansas, the Cache River bottoms of southern Illinois, and elsewhere.

CONVOLVULACEAE: DODDERS

Cuscuta: Dodders.

Dodder seeds have often been found in small quantity in duck stomachs from various regions. The fact that they are used is not surprising in view of their frequent occurrence as parasites on marsh plants.

BORAGINACEAE: HELIOTROPES

Heliotropium curassavicum (H. spathulatum): Heliotrope (fig. 134).

Value.—Generally slight; locally fair in the Gulf region.

Parts consumed. — The seeds (nutlets).

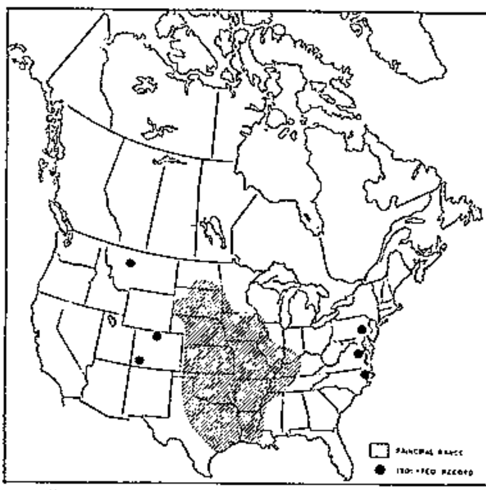

FIGURE 136.—Range of *Bacopa rotundifolia.*

Identification.—This perennial heliotrope is characterized by curved spikes of small white flowers and by narrow, alternate leaves, coated with a whitish bloom (glaucous).

Environment.—Chiefly brackish coastal beaches and alkaline flats of the West.

Propagation.—By seeds or by transplanting the perennial bases at the close of the growing season or early in spring.

Related species.—*Heliotropium indicum*, a larger species with bluish flowers, has been found many times in small quantities in duck stomachs from Avoyelles Parish, La. It is locally common on the lower Mississippi flood lands, often thriving in the dense shade of periodically submerged woodlands.

SCROPHULARIACEAE: WATERHYSSOPS

Bacopa: Waterhyssop (pl. 109; figs. 135–136).

Value.—Locally fair.

Parts consumed.—The seeds and other parts.

Identification.—Waterhyssops are semiprostrate, succulent plants with opposite, simple, unstalked leaves and small axillary flowers. The fruit consists of a globular or oval capsule containing numerous minute seeds.

FIGURE 137.—Range of *Cephalanthus occidentalis*.

Environment.—Moist flats along margins of ponds, and shallow water (less than 1½ feet deep); common along coasts and in the Mississippi Basin.

Propagation.—By transplanting rooted parts or by seed.

Species.—The roundleaf waterhyssop (*Bacopa rotundifolia*) has its greatest abundance in the middle and lower Mississippi Valley and the coastal waterhyssop (*B. monnieria*), a species with small narrow leaves (broadened toward the tip). is a common coastal plant that often forms mats in shallow brackish ponds. It was found that *B. rotundifolia* had been eaten in large quantities by a series of five green-winged teals, a pintail, and a ring-necked duck collected in eastern Arkansas. Many shoal-water ducks have been noted feeding on the beds of *B. monnieria* along the Gulf and South Atlantic coasts, and sportsmen and gun-club superintendents at a number of points in the Southeast speak highly of this species and have, to a limited extent, made efforts to increase the local supply.

LENTIBULARIACEAE: BLADDERWORTS

Utricularia: Bladderwort (pl. 132; fig. 2).

Bladderworts are submerged aquatics with finely divided leaves which often bear numerous small bladders. Though the plants occur commonly in duck-feeding areas, there are no definite records of their use. Field observations, however, indicate the possibility of a limited local value to ducks.

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RUBIACEAE: BUTTONBUSH

Cephalanthus occidentalis: Buttonbush (pl. 110; fig. 137).

Value.—Generally slight, locally fair to good; used a great deal in the lower Mississippi region, where it is extremely abundant.

Parts consumed.—The seeds (nutlets).

Identification.—A shrub commonly 5 to 10 feet high, with opposite, simple leaves and with flowers and seeds in compact spheres.

Environment.—Swamps or other low moist places. The buttonbush is particularly abundant in the shallow water along the borders of woodland lakes, where it withstands dense shade and severe fluctuations in water level.

Propagation.—By transplants or by seed.

COMPOSITAE: BEGGARTICKS, WATERMARIGOLD, GOLDFIELDS

Iva frutescens: Hightide-bush.

The hightide-bush (pl. 152, *B*) is a common plant in brackish coastal marshes, but its only record of usefulness as a duck food was from a Middlesex County, N. J., series of shoal-water duck stomachs in which the seeds formed a small percentage of the content. Hightide-bush is a shrubby plant, with thickish, mostly opposite, sharply toothed leaves. Along with the groundselbush (*Baccharis halimifolia*), it often takes over partially drained coastal marshes following mosquito-control operations (pl. 151, *A*).

Ambrosia artemisiifolia: Common ragweed.

Ragweed is prevalent in waste and cultivated places and is not normally an inhabitant of duck-feeding areas. It has furnished food in fair percentages, however, in several localities where the seeds have been washed into the water or where the ducks were feeding in fields.

Bidens: Beggarticks (pl. 111; fig. 2).

Value.—Generally slight or nil; occasionally fair.

Parts consumed.—The seeds (achenes).

Identification.—The marsh representatives of *Bidens* are medium-sized or large herbs with opposite leaves, usually yellow flowers and the oblong seeds of the beggarticks type. One species, *B. beckii* (pl. 111, *C*), is an aquatic with divided submerged leaves.

Environment.—Moist soil, marshes, lake margins, swamps, and (in *B. beckii*) open fresh water.

Propagation.—By seed.

Species.—*Bidens bidentoides*, *B. cernua*, *B. frondosa*, and *B. laevis* have been recorded from duck stomachs, and it appears probable that other species, including *B. comosa* (pl. 111, *A*) and *B. aristosa* (pl. 111, *B*) also are used. Though *B. beckii*, water marigold, is a locally common aquatic in northern lakes, there is no stomach-analysis evidence of its value as a duck food.

Baeria platycarpha: Goldfields.

Field observations indicate that goldfields, a small, golden-flowered, saltflat composite, is used by wigeons and other ducks in the vicinity of San Francisco Bay, Calif.

ANIMAL FOODS

Mollusks and insects are of outstanding importance in the animal food of game ducks. In the continental listing of food items (table 2) insects are represented as making up a slightly smaller proportion than the mollusks, but a larger series of summer stomachs might have reversed this ranking. Crustaceans and fishes also constitute important food elements in some sections. Several other groups of animals, including annelids, spiders (Arachnida), and frogs (chiefly Ranidae), have been identified frequently in the food but constitute a trivial part of the total. It is well to reiterate that the percentages of animal and plant food in the continental and regional food summaries (tables 2–10) are disproportionate, since whole classes of animals are contrasted with individual genera of plants. This results from the fact that in the original stomach analyses many of the recorded estimates of animal percentages were based on these inclusive groups and were not further subdivided.

MOLLUSCA: SNAILS, BIVALVES

(Pls. 112–114)

Two large classes of mollusks, the snails (Gastropoda) and the bivalves, or double-shelled mollusks (Pelecypoda), are of value in the animal food of game ducks. These mollusks reach their greatest importance in the coastal regions, but they also compose conspicuous proportions of the food in the eastern half of the United States and in both eastern and western Canada. Most of the bivalves eaten were species of little economic significance, but such important items as oysters (*Ostrea lurida*) from the coast of Washington were occasionally taken by a few of the diving ducks, particularly the greater scaup, a special study of which was made by McAtee in 1915 (ms. report, Biological Survey). The principal genera and a number of the useful species of mollusks that have been identified in the stomachs of game ducks are illustrated in plates 112–114.

In nearly all regions snails were found to be much more important to ducks than the bivalved mollusks, probably because of their much greater abundance in the habitats commonly occupied by game ducks. In the three coastal regions and in the lower Mississippi Valley snails ranked higher in the tabulations than any other forms of animal life. Many species were represented, and with the exception of those occasionally taken by greater scaups, most of them were either of small size or young individuals of larger species. The various species are usually restricted either to brackish or fresh water, but on the Gulf coast the neritina (*Neritina reclivata*) has often been found in both strongly brackish and strictly fresh waters. This important species seems to be of greatest use to waterfowl in the area of transition from fresh to brackish water in the territory extending from the mouth of the Mississippi River to Florida.

Along the Atlantic coast, all the way from New England to Florida, there are a number of important salt-water snails, including

Mitrella lunata, *Anachis avara*, *Nassarius vibex*, *N. obsoleta*, and *Melampus lineatus*, that are eaten by game ducks; and on both the North Atlantic and North Pacific coasts are found *Lacuna vincta*, *Littorina rudis*, and a few others. Among the fresh-water snails eaten are many species that also have extensive ranges, including *Gyraulus* (*Planorbis*) *parvus*, *Helisoma* (*Planorbis*) *trivolvis*, and *Stagnicola* (*Lymnaea*) *palustris*.

Propagation.—Much careful study of problems in the geographic distribution of mollusks is needed before definite recommendations can be made regarding the use of many species in improving waterfowl feeding grounds.

In important duck-nesting sections in the prairie-aspen belt of western Canada, Mozley (*59*) has made a detailed statistical study of the molluscan fauna of more than 300 small lakes and ponds. In that area—Manitoba, Saskatchewan, and Alberta, between 49°30′ and 56° north latitude—he found 10 species of snails and 2 species of small bivalves. He concluded that the distribution of mollusks is not a haphazard matter but the result of definite, complex reactions that are capable of measurement. For example, it was only in temporary ponds—those containing water about 1 or 2 months a year—that *Planorbis umbilicatellus* and *Planorbula campestris* were found.

Snails can be easily transferred in their natural waters, but if taken long distances they should be supplied with some form of vegetation from their native habitat to serve as food until released. Until more complete information is available it is safest to experiment only with those species that have the widest ranges and occur in the greatest variety of habitats.

INSECTA: INSECTS

(Pls. 115–117)

Insects are represented as constituting nearly a tenth of the total food of game ducks in the United States and Canada (table 2), a proportion that might have been greater had the summer months been more equably represented in the stomach material available. During the summer period in the waterfowl breeding range, insects form an especially large part of the food of both young and adult ducks. The feeding tendency of ducks at that season may be explained by the abundance and availability of insect life before much of the seed crop of useful plants has matured.

Many groups of insects, including caddisflies (Trichoptera), dragonflies (Odonata), brine flies (Ephydridae), and certain midges (Chironomidae), spend much of their life cycles in marshy or aquatic environments, and for this reason their larval, pupal, or nymph stages are available (often abundantly so) for consumption by ducks in summer. In addition numerous kinds of water bugs (Hemiptera) and water beetles (Coleoptera) spend their adult or larval periods in, on, or near water and thus become available prey for ducks.

Representative species from orders and families of insects that constitute valuable sources of duck food are illustrated in plates 115, 116, and 117. A list of the more important orders and families follows, in which those preceded by an asterisk (*) are groups of especial importance to game ducks:

Coleoptera: Beetles (larvae and adults).
- Carabidae: Ground beetles.
- *Haliplidae: Crawling water beetles.
- *Dytiscidae: Predaceous diving beetles.
- Gyrinidae: Whirligig beetles.
- *Hydrophilidae: Water scavenger beetles.
- Tenebrionidae: Darkling beetles.
- Scarabaeidae: Scarabaeid beetles.
- Chrysomelidae: Leaf beetles.
- Curculionidae: Snout beetles.

Hymenoptera: Ants, wasps, (larvae, pupae, and adults).

Trichoptera: Caddisflies (larvae).
- Rhyacophilidae.
- *Phryganeidae.
- *Mollanidae.
- Sericostomatidae.

Neuroptera: Alderflies.

Diptera: True flies (larvae and pupae).
- Tipulidae: Crane flies.
- *Chironomidae: Midges.
- *Stratiomyiidae: Soldier flies.
- Tabanidae: Horseflies.
- *Ephydridae: Brine flies.

Hemiptera: True bugs.
- Gerridae: Water striders.
- *Notonectidae: Back swimmers.
- Naucoridae: Creeping water bugs.
- Nepidae: Water scorpions.
- Belostomatidae: Giant water bugs.
- *Corixidae: Water boatmen.

Plecoptera: Stone flies.

Ephemoroptera: Mayflies.

*Odonata: Dragonflies, damsel flies.

Orthoptera: Grasshoppers, crickets.

Propagation.—The culture or propagation of insects for duck-food purposes is not ordinarily necessary. Mobility and fecundity enable insects to reach and populate practically all areas adapted to their specific requirements. In general, insect populations are plentiful throughout the temperate and north temperate parts of the continent, though certain kinds may be associated with particular regions. Brine flies (Ephydridae), for example, and some species of water boatmen (Corixidae) are most abundant in alkaline areas.

CRUSTACEA: CRUSTACEANS

(Pl. 118)

Crustaceans, with a percentage of 3.44, rank third among classes of animal foods consumed by game ducks (table 2). They are eaten in fair quantity in various parts of the continent, the highest percentages occurring in Canada (6.07 percent in the west and 9.81 percent in the east) and the lowest in the Gulf region (1.06 percent).

Plate 118 gives examples of the principal types of crustaceans used as duck foods and indicates in a small degree the extent of diversity of form in this large class. Orders of importance in the present study are as follows (italic letters in parentheses referring to their position on plate 118):

Branchiopoda: Fairy shrimps and water fleas (*B* and *C*).
Ostracoda (*G*).
Cirripedia: Barnacles (*A*).
Amphipoda: Beach fleas and scuds (*E* and *F*).
Isopoda (*D*).
Decapoda: Shrimps, crawfish, crabs (*H* to *M*).

Crabs and barnacles are restricted largely to seacoasts, but many forms of the crustaceans eaten by waterfowl occur inland in either fresh or alkaline waters. Much of the use of fresh-water shrimps by ducks has occurred in Western States, and many crustaceans of the smaller type have been consumed in inland waters. Crawfishes of various species occupy diverse habitats, ranging from coastal waters to inland lakes and streams, or in some instances their burrows are at a distance from open water. Some of the crustaceans eaten are of species that become destructive to aquatic vegetation (p. 139) and young fishes, but most of them subsist on organic debris or on small forms of life and in general are favored by environments in which organic material is present.

Propagation.—In most waters that are suitable for their existence, crustaceans are usually so widely distributed by natural means that attempts at propagation are unnecessary. The culture of scuds (*Gammarus* spp.), fresh-water shrimps (*Palaemonetes exilipes*), and crawfish (*Cambarus* spp.) occasionally has been practised by fish-culturists for many years. Methods for the propagation of these crustaceans as a source of food for fishes are discussed by Viosca (*83*). Comparatively little is known about the life histories of most of them. Reproduction is generally by means of eggs, and in some of the lower forms (*Cypris* and *Daphnia*) these have remained viable for about 25 years. Females of the majority of the higher forms—Malacostraca (which include the greater proportion of the kinds eaten by game ducks)—carry their eggs around on the under side of the abdomen or at the base of the thoracic legs until ready to hatch. In crawfishes, crabs, and related decapods, large numbers of eggs are produced and the young often remain with the mother for a short time after they have hatched. Most of them can be successfully collected in fine-meshed seines or dip nets and transported to favorable sites in containers of the same water in which found. It is obvious that the more egg- or young-bearing females that can be obtained the more rapid will be the reproduction in favored situations.

PISCES: FISHES

(Pl. 119)

Fishes are eaten by game ducks in six of the regions treated in this bulletin, but they attain a position of appreciable importance in three only. In western Canada they composed 1.58 percent of the total food (table 9); along the Gulf of Mexico, 2.86 percent (table 6); and in the Atlantic coastal region, 0.98 percent (table 3). In all parts of their range, however, mergansers are known to feed on fishes to a considerable extent, but in interior sections it is only under unusual circumstances that game ducks have been known to take this kind of food extensively.

Practically all the fishes eaten by game ducks are of the sluggish surface-feeding species, among which the top minnows, or killifishes (*Poeciliidae* and *Cyprinodontidae*), supply the greatest share. The species found to be of greatest significance are illustrated in plate 119, and their ranges are as follows:

The mummichog (*Fundulus heteroclitus*) occurs in fresh or brackish coastal waters from the Gulf of St. Lawrence to Texas. The salt-water killifish (*F. majalis*) is found in saline waters from Cape Cod to Florida. The fresh-water killifish (*Zygonectes diaphanus=F. diaphanus*) occurs in the fresh waters of coastwise streams from Maine to North Carolina. The mosquito fish, or top minnow (*Gam-*

busia holbrooki—formerly included with *G. affinis*), is found in fresh or brackish waters throughout the southern half of the United States, occasionally as far north as New Jersey. The sail-finned killifish (*Mollienesia latipinna*) thrives in fresh, brackish, or saline waters from South Carolina to Mexico. The broad killifish (*Cyprinodon variegatus*) occurs chiefly in brackish waters from Cape Cod to Texas. All are found in shallow waters and all are prolific breeders. Most of them lay eggs, but the mosquito fish (pl. 119, *D*) and sail-finned killifish (pl. 119, *E*) give birth to active young.

Among other fishes, the gizzard shad (*Dorosoma cepedianum*), a species practically worthless for human food, has been reported [8] to be of local importance to ducks in inland waters; and occasionally minnows (Cyprinidae), darters (Percidae), and sculpins (Cottidae) have been eaten in smaller quantities, especially in the interior regions.

Propagation.—Killifishes of the kinds shown in plate 119 have been successfully shipped for nearly a thousand miles by express. The fishes should be transported in large tin cans (with perforated tops) containing natural waters from the sites where collected. A small quantity of healthy aquatic vegetation placed in each can will aid in oxygenating the water. These fishes will reproduce readily when transferred to suitable situations.

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[8] TRAUTMAN, M. B. THE GIZZARD SHAD AS AN IMPORTANT FOOD FOR DUCKS IN THE INLAND LAKES AND RESERVOIRS OF OHIO. Ohio Dept. Agr., Div. Conserv., Bull. 13. n. d. [Mimeographed.]

PART 3.—PROPAGATION OF WATERFOWL FOOD PLANTS AND DEVELOPMENT OF FEEDING GROUNDS

The science of waterfowl-food culture is still in its infancy although much useful information has been published (see Literature Cited, p. 143) on the production of limited groups of valuable aquatic and marsh plants. Attempts to improve waterfowl feeding grounds in the United States received their greatest impetus as a result of the pioneer work of McAtee (*41*, *42*, *43*, *44*, *45*) from 1911 to 1918, which provided the basis for developing commercial sources of propagative parts of a number of important food plants.

Valuable data regarding the propagation of special groups of aquatic plants have been presented by a considerable number of earlier workers including Irmisch (*35*), Guppy (*27*, *28*, *29*), Morong (*57*), Sauvageau (*72*), Yorke (*91*), Pond (*68*), Glück (*25*), Fischer (*23*) and many others. More recently Mickle and Thomson (*51*), E. Moore (*53*), Arber (*2*), and Muenscher[9] (*60*, *61*) have contributed much helpful information on this subject.

CHOOSING PROPAGATIVE MATERIAL

Despite available information on the culture of duck-food plants, many attempts at propagation have resulted in failures, some of the causes of which are discussed on later pages (p. 116). One of the most frequent of these causes is neglect in considering the natural ranges of species or varieties that are used. These ranges often are dependent on climatic, soil, or water conditions that are quite different from those of the site to be improved.

Careful selection of seed stock, with due regard both to origin and to quality, is a cardinal principle in successful agriculture. For example, seed corn for use in the Northern States must be capable of resisting lower temperatures and maturing in a shorter growing season than the varieties used throughout the Gulf States; similarly, the durum wheats are best adapted for growth in the semiarid northern section of the Great Plains region, whereas the soft, red winter wheats are grown chiefly in the humid area eastward from Kansas to the Atlantic. It is just as important in aquiculture as in agriculture to give careful attention to sources of propagative materials to insure adaptable varieties or strains as well as suitable species. This cannot be overemphasized.

If propagative materials are properly handled it is usually best to obtain them from sources as near as practicable to the situation in which the planting is to be made, or from areas having nearly identical climatic and environmental conditions. Overlooking the im-

[9] W. C. Muenscher, of Cornell University, has recently conducted an extensive and valuable series of experiments on the storage, viability, and germination of the seeds of a large number of waterfowl food plants. While part of his findings were not published at the time of the preparation of this bulletin he kindly permitted the writers to use these data in the formulation of general conclusions regarding these matters.

portance of this has resulted in the planting of many species and varieties in regions or situations for which they are entirely unsuited. Reference to the range maps and the environmental data for the various species discussed (p. 19) should aid in reducing such mistakes.

AQUATIC TYPES

The truly aquatic plants, those that grow primarily submerged or floating, furnish by far the greatest proportion of the game-duck foods throughout the North American Continent. Most of these plants can be propagated successfully from seeds that have been properly harvested and stored. A large proportion can likewise be grown from leafy branch tips, as in the case of naiads, sago pondweed (pl. 120) and most of the broad-leaved pondweeds; or from the contracted, leafy stems commonly known as winter buds, such as are borne by some of the linear-leaved pondweeds (pl. 14). Many can be grown from the underground rootstocks, which sometimes produce equally valuable tuberlike buds or tubers such as those found on wildcelery (*Vallisneria spiralis*) (pl. 48) and sago pondweed (*Potamogeton pectinatus*) (pl. 8, *B* and *C*). An easy method of propagation in comparatively still waters is to transplant the entire plants, as in the case of the duckweeds (Lemnaceae); or long branches, as in the entirely rootless coontail (*Ceratophyllum demersum*) (pl. 99, *A*), the poorly rooted waterweeds (*Anacharis* spp.) (pl. 47), and the naiads (*Najas* spp.) (pls. 34 and 35).

MARSH TYPES

Several of the most important marsh or moist-soil duck-food plants are annuals and must be propagated from seed (or rarely by the transplanting of young plants). This group includes wildrice (*Zizania aquatica*), wild millet (*Echinochloa*, spp.), certain smartweeds (including *Polygonum lapathifolium* and *P. pensylvanicum*), and tidemarsh waterhemp (*Acnida cannabina*). A much greater number, however, are perennial and may be propagated either by seeds or rootstocks. In a number of species, including the duckpotatoes (*Sagittaria* spp.), chufa (*Cyperus esculentus*), and the saltmarsh and alkali bulrushes (*Scirpus robustus* and *S. paludosus*) the plants also bear tubers or propagative, tuberlike bodies (pls. 44, 68, and 83). The seeds of many perennial marsh plants germinate slowly and irregularly; therefore, where rapid production is desired it is recommended that rootstocks or tubers be used for propagation whenever practicable. This applies paticularly to such plants as the burreeds (*Sparganium* spp.) and many of the sedges (Cyperaceae).

DRY-SOIL TYPES

The use of dry-soil plants for duck foods may seem incongruous to many waterfowl students in the Eastern States and Canada. In parts of the western half of the United States, however, upland plants often furnish the major food supply for the most important species of shoal-water ducks. This is particularly the case in semiarid Southwestern States, where Dwarf milo or kafir from unharvested fields furnishes one of the principal foods. In the prairie States, various other cereals, including wheat, barley, oats, and to a greater extent corn, furnish attractive food for waterfowl. These plants, being annuals, can be produced by the usual agricultural practices.

In addition to cultivated crops, many smartweeds, pigeongrasses (*Setaria* spp.), and occasionally even ragweeds (*Ambrosia* spp.) are useful sources of duck food. Wild millet and chufa also are often found thriving in dry soils, but chufa must be flooded during the fall to make its tubers accessible as a duck food.

HARVESTING AND TEMPORARY FIELD CARE

The harvesting of propagative materials of most aquatic and marsh plants must be accomplished largely by manual methods. Seeds must necessarily be harvested at the time of ripening. This often is an irregular and gradual process, even in a single locality, and may necessitate traversing the beds several times during the season. For this reason it is impracticable to cite specific harvesting dates. In southern Maryland the seeds of wigeongrass (*Ruppia maritima*) may be found maturing from the middle of June until growth is stopped by fall freezes; likewise, in the same section, sago pondweed has been found fruiting throughout a period of more than 3 months, although the bulk of the seeds mature early in August. The northern (narrow-leaved) form of wildrice, which in northern Minnesota ripens over a period of about 2 weeks late in August and early in September, has been noted ripening about a month earlier when planted in central Illinois (pl. 121, *A*). Close watch therefore should be kept on all plants from which seeds are to be harvested. The period of maturity can be determined by the firmness and size of the seeds together with the time they begin to detach readily upon slight pressure from the fingers, or in the case of annual marsh plants, including wildrice and tidemarsh waterhemp, whenever a moderate jarring of the plant causes large numbers to fall. The maturity of bulrushes, spikerushes and related sedges, and other perennial marsh plants can usually be determined by the degree of ease with which the seeds can be removed from the spikelets or spikes when these are crushed in the hand. In general the later in the ripening season that harvesting can be successfully accomplished the better are the chances for obtaining productive seed.

In areas where pondweeds that produce thick-walled seeds have fruited heavily, huge windrows of the seeds are frequently found drifted up on the beaches after storms. If obtained before they have suffered prolonged, severe drying, these seeds have been found satisfactory for propagation. A fair percentage of sago pondweed seeds germinated after lying in such windrows for more than a year. A valuable supply can often be obtained with little work, merely by sifting the drifted seeds through screens with mesh of a size suitable to remove surplus debris.

A great variety of methods can be used in harvesting the seeds of tall marsh plants, depending on the situation in which they are growing and the particular species involved. The Indian method of harvesting wildrice—holding the fruiting parts over a canoe by means of a short stick and gently tapping the stalks with another stick until the ripe seeds fall—can at times be used (with canvas spread on the floor) for other plants, as tidemarsh waterhemp and the round-stemmed bulrushes (when dead ripe).

When harvesting seeds from large herbs or from woody plants with spreading branches, it may be practical to use a ground covering of canvas to catch the falling seeds. This may consist either of a single sheet 6 feet or more in diameter, slit from the outside to the center so that it can readily be drawn up under the plant, or two pieces of canvas can be laid on each side of the plant with their inner edges overlapping. This general method of harvesting can be applied on semidry or dry areas to such heavily fruiting plants as tidemarsh waterhemp (which may produce more than 2 quarts of seed per plant), oaks, and water-elm.

A cradlelike canvas trough 6 to 8 inches deep (pl. 121, *B*), constructed on a strong wire frame about 3 feet long and 16 to 18 inches wide at the top, can be equipped with shoulder straps and a belt and used effectively for harvesting in dry marshes or in water too shallow to permit the use of a boat. The trough is worn projecting in front of the wearer's waist and should be constructed so that the side held against the waist is short and nearly perpendicular. The shoulder straps should be attached so as to support the trough by both front and rear rims. An opening in one end of the bottom, equipped with a slide fastener operating from the under side, facilitates removal of the seed. Branches or tops of the plants bearing the ripened seeds should be held over this cradle and tapped or shaken gently to dislodge only ripened seeds. A pack sack may be worn on the shoulders and the seeds transferred to it from time to time to prevent the trough from becoming too heavy. A wire T that can be speared into the ground, to hold the pack sack upright while seeds are being transferred to it, is useful when the collector is working alone.

In dry marshes or meadows where the soil is moderately firm, ordinary agricultural equipment has been used successfully to harvest the seeds of alkali and saltmarsh bulrushes, wild millet, and smartweeds. Lightweight automobiles have been used in shallow marshes along the Gulf coast by equipping them with the wide-rimmed tractor wheels now on the market. Long wooden cleats are bolted to these wide rims to increase their width for use in the softer soils (pl. 146, *C*). Such equipment would often be useful in harvesting operations elsewhere.

Hand-operated hedge trimmers with vibrating sickles and equipped with sacks to catch the "trimmings," can be used for harvesting the fruiting tops of bulrushes and similar marsh plants. In some situations such trimming can be done directly into a shallow-draft boat or canoe.

After drying thoroughly for 1 to 2 weeks, the saltmarsh and alkali bulrushes and wild millet can be thrashed successfully in ordinary grain-thrashing machines. In small lots the dry heads can be flailed in grain sacks and the coarse debris removed by sifting.

Ordinary scythes, sickles, and rakes (frequently rakes alone) will suffice to procure unlimited quantities of the leafy stems of submerged plants for the transplanting of cuttings during the active growing season. Long-handled coke forks, silage forks, and potato hooks with closely spaced tines make useful tools for harvesting subterranean tubers.

In general it is recommended that the harvesting of rootstocks and tubers be carried on early in spring, before growth has started, in order to avoid the need for winter storage and the hazards that attend fall planting. Spring harvesting can be greatly facilitated if the location of the best beds is carefully marked during the previous fall, when the leafy parts of the plants are still evident. Some commercial dealers are reported to harvest considerable quantities of aquatic tubers through the ice by cutting out long blocks over the densest parts of previously marked beds and then digging out the tubers with long-handled coke forks. Dip nets can be used to gather the tubers that float to the surface during the operation.

Particular care should be taken while harvesting propagative materials of submerged plants to avoid drying during the period of collection and transportation. Leafy portions, seeds, rootstocks, and tubers should be kept thoroughly saturated with water until the time of shipment. Cans with tight-fitting covers (such as garbage pails or large lard cans) are satisfactory if the water is changed every 24 hours. When open containers must be used, they should be kept covered by a saturated piece of absorbent cloth. In warm weather the materials should be ventilated by using alternate layers of wet peat moss or Spanish moss to prevent fermentation; fine excelsior also may be used for this purpose if kept thoroughly wet. Small tubers or seeds handled in this manner should first be placed in cheesecloth to prevent loss among the packing materials. Seeds of marsh plants that normally ripen in a dry condition before falling into the marsh can be harvested without special precautions, but those that have thin or comparatively soft coats and retain considerable moisture up to the time they fall should be transferred to wet storage as soon as possible. A few days of severe drying will seriously injure such seeds as wildrice. The importance of avoiding delay in transferring freshly harvested materials to suitable storage cannot be overemphasized.

STORAGE AND GERMINATION

Recent storage and germination experiments with the seeds of a great variety of aquatic and marsh plants from the Northern and Central States indicate that the best results with nearly all species are obtained from seeds that have been stored in water at low temperatures. In the case of most of these plants, wet storage of thin-walled seeds is a necessity because prolonged drying was found to kill the embryos. In seeds with thick, firm coats germination was appreciably higher and much more uniform in samples that had been stored in water in refrigerators. The thick-walled seeds of sago pondweed, however, germinated well after lying exposed for more than a year in windrows on the margin of Arrowwood Lake, N. Dak. They were dry when collected and were kept in that condition until placed in jars of fresh water 5 weeks later. These seeds started sprouting 4 days after being immersed, and the bulk of them germinated in less than 10 days, although a few continued to sprout for more than 8 months. The seeds of many northern duck-food plants must have low-temperature storage or an out-of-door rest period at winter temperatures for a period of 3 to 6 months before successful germination can take place.

While treatment with sulphuric acid as reported by Fischer (*23*), and scarification or careful removal of seed coats—to reduce the physical handicap that the enclosed embryos must overcome before sprouting, and to permit more rapid absorption of water or oxygen—will shorten the time necessary for sprouting in some aquatic and marsh plants, as the burreeds, experiments with a number of other thick- and thin-walled seeds (various sedges (Cyperaceae), tidemarsh waterhemp (*Acnida*), and several pondweeds) showed that preliminary prolonged chilling also was necessary. It is probable that the great differences between the findings of Crocker (*13*), Fisher (*23*), and other early experimenters on the germination of the seeds of aquatic and marsh plants result from the lack of subjecting the seeds to a period of after-ripening at low temperatures before the germination tests were started or permitting the seeds to dry out prior to these tests. Seeds of the tidemarsh waterhemp and the waterchestnut, or water caltrop,[10] remained totally dormant or gave only a trivial percentage of germination after being held for more than a year in water that was regularly changed and kept at ordinary room temperatures; but at the end of 9 months portions of the same samples were transferred to a refrigerator for 3 months at temperatures of 36° to 38° F., and germinated well within a few days after being brought out to room temperatures again. Waterchestnut seeds that were subjected to only 1 and 2 months' refrigeration remained dormant, and 2 weeks of drying at room temperatures killed their embryos.

Many other experiments clearly demonstrate the futility of expecting many northern plants to continue reproduction by means of seeds when planted in warm southern waters, which are not subjected to the necessary period of low temperatures.

That prolonged low temperatures serve as the activating agent in producing a chemical change in the stored plant food, thereby converting it into a form that can be assimilated by the dormant embryo, was further shown by tests with saltmarsh bulrush and wildrice seeds from Maryland and Virginia. Placed in germination jars (2-quart jars of water that was changed twice a week) at ordinary room temperatures shortly after harvesting, these seeds remained permanently dormant even though part of the former were scarified or portions of the seed coats carefully removed; but similar material germinated well after being stored in water in a refrigerator for about 3 months. A temperature of 40° F. was sufficient for wildrice, and C. E. Chambliss, of the Bureau of Plant Industry, reported that samples of seeds of this plant stored for less than 2 months at about 50° germinated actively soon after being removed from the refrigerator and that samples kept at this temperature for 3 months sprouted in the refrigerator. Saltmarsh bulrush seeds, however, collected in Maryland, required much lower temperatures to produce the changes necessary for germination. Only those samples germinated successfully that had been frozen solid in ice at temperatures varying from 10° to 23° for a period of 2 weeks following a longer period of stor-

[10] Waterchestnut, or water caltrop (*Trapa natans*), is not a duck-food plant but a dangerous competitor species (see discussion under weed control, pp. 129 and 134).

age at 38° to 40°. On the other hand, embryos in seeds of the longleaf pondweed (*Potamogeton americanus*) from the vicinity of Washington, D. C., were all killed by a similar freezing treatment, although seeds germinated well when stored in water at a temperature of about 38° for 3 to 6 months. Fair but irregular germination of that species was obtained without refrigeration, and sporadic sprouting continued for more than 15 months.

Tubers and rootstocks of most aquatic and marsh plants likewise should be kept moist and stored at temperatures low enough to prevent destructive bacterial growth. Those of sago pondweed and other soft types may be stored in water or packed between layers of wet peat moss, Spanish moss, or saturated fine excelsior. Only one out of eight sago pondweed tubers (from Saskatchewan) that were dried for a month at ordinary room temperatures retained enough vitality to grow. Tubers of the flowering-rush (*Butomus umbellatus*) and rootstocks of the three-squares (*Scirpus americanus* and *S. olneyi*) sprouted well after being buried out of doors, some at a depth of 1 foot and others at about 3 inches, in moist, clayey garden soil near Washington, D. C., from the end of October until the end of the following March, although during much of that period they were frozen solid at the shallower depth. Tubers of chufa (*Cyperus esculentus*) may be stored successfully between layers of slightly damp sand in a cool cellar. The rootstocks of the hardstem bulrush (*Scirpus acutus*) grew very well after being packed in moist newspapers in a refrigerator, at temperatures of 32° to 38° F., from mid-October until early the following April.

When refrigerating facilities are not available for wet storage of aquatic seeds and tubers in the Northern and Central States, satisfactory fall and winter storage can often be accomplished by submerging specially constructed containers in fresh-water lakes and streams. Storage crates about 2 feet square can be constructed out of heavy hail screen (hardware cloth) of ¼- to ½-inch mesh and lined with smaller meshed cooper screen cloth. For seeds of the sago, longleaf, and other large pondweeds, 1⁄12-inch mesh (the size much used in window screens) is suitable for the lining, but a finer mesh is needed for species with smaller seeds.

Layers of the seeds about 3 to 4 inches deep should be separated by double layers of screen cloth (similar to that used for the lining) between which have been tacked narrow wooden cleats about 3 inches apart to permit a free circulation of water. The screen cloth should be bent around the ends of the cleats to prevent the seeds from working in between each pair of screens from the edges and filling the space between the cleats. To give added support, each set of these screen partitions should be so placed that the cleats will lie at right angles to those of the sets immediately above and below. The cleats should be just thick enough to insure water circulation between the layers of seeds. A layer of coarse excelsior would probably serve the same purpose as the cleats.

The storage crates should be carefully wired shut and then securely anchored below the ice level or in spring-fed streams that remain open all winter. Situations should be selected where floods or storms and shifting ice cannot cause damage.

Chambliss (*9*) states that wildrice can be stored in small quantities in garbage pails submerged in streams if the sides and tops of the pails are perforated sufficiently to permit water circulation. If the pails are lined with copper screen, much larger perforations or small windows can be used to facilitate freer circulation, thereby reducing the danger of fermentation without the loss of seed. The pails should not be more than three-fourths filled with seed and must be securely anchored and their tops carefully fastened.

Some commercial dealers in duck-food plants have piped the water of permanent hillside springs through concrete basements of winter-storage sheds. The entire basement is flooded just deeply enough to submerge the screened storage bins (which are reinforced outside with wood) and water is permitted to circulate through them as long as propagative materials are held in storage. Drains are provided so the water can be removed at any time. The water should enter at several points on the inlet end to insure thorough circulation. Care should be taken to avoid using containers so large that the water cannot circulate readily through the stored materials, or fermentation is likely to develop and cause injury.

Other dealers keep wildrice seed in sacks stored in ice houses. The sacks of rice are dipped in water and placed on the layers of ice and covered by a heavy layer of sawdust. They should be removed and dipped in a plentiful supply of fresh water at least once a week. Since the sacks rot rapidly under such conditions, they usually need to be replaced several times during a storage season. Each time the sacks are changed the wildrice should be freshly dipped, or water from a hose forced through it. The dangers of fermentation and desiccation are great, however, under this method, and submerged storage at low temperatures (32° to 36° F.) is preferable.

Under natural conditions it is probable that the seeds of most aquatic and marsh plants germinate during the first spring after they are produced. Some of the northern pondweed seeds have been noted sprouting in shallow ponds during early winter. The greatly delayed germination reported in laboratory experiments can usually be attributed to the fact that the seeds had been permitted to dry or else were not subjected to the necessary rest (after-ripening) period at low temperatures before the tests were begun.

SHIPMENT

The principal precaution to be taken in shipping propagative materials stored wet is similar to that for storage, namely, avoidance of drying and fermentation. Most of these materials can be successfully transported packed in moist peat moss, Spanish moss, or fine excelsior in light slat crates lined with burlap, or in ventilated bushel baskets. To prevent heating and fermentation, large lots of wet seeds should first be segregated in small cloth bags that are kept separated from each other by the packing material.

Leafy cuttings, young plants, and tender rootstocks can be shipped successfully if packed as follows: Spread a layer of wet peat moss about 1 inch thick on a long sheet of heavy waxed paper and scatter the plants thinly over it. Then roll the paper and its accompanying layer of plants rather loosely and ship in a closed container to prevent evaporation. These materials likewise can be transported in water when the extra weight is not prohibitive. As soon as the material arrives for planting it should be submerged in fresh water, which should be changed daily until planting is completed. The quickest practicable method of transportation should always be used. In warm weather if the time needed for shipment exceeds 3 to 5 days, some means of refrigeration should be provided.

Dry seeds can be shipped without special precautions.

PLANTING

Preliminary to planting, a study of each area should be made to serve as a guide in determining the correct procedure. It is thus possible to forestall the use of unsuitable places and to avoid the sowing of species that may already be abundant in the area proposed for development. Much money has been expended needlessly through lack of information on existing food resources; for example, the writers have seen many areas where wildrice from distant sources has been planted in dense beds of local wildrice, which the residents did not recognize or knew only as "water oats" or "wild oats." In the same manner, wildcelery and sago pondweed have sometimes been planted in unrecognized thrifty beds of the same species, and in one instance a fine bed of smartweed was mowed to prepare the area for planting with smartweed seeds. On a barren, northern lake that had a bottom composed of sand packed to almost rocklike firmness, more than $1,000 worth of aquatic plants was reported to have been sown, despite the fact that the bottom was too firm for any submerged seed plants to exist, and not one of the species planted could grow there. A preliminary survey would have prevented the waste of funds by indicating the futility of such plantings in that lake.

Some of the principal points requiring consideration before planting are indicated in the following modified questionnaire, which the Bureau of Biological Survey has prepared for correspondents requesting advice on improvement of their water areas:

1. Location and name of area; State, county, nearest town.
2. General character of area.
   - *a*. Is it a pond, lake, marsh, or stream?
   - *b*. Is it a natural area or a recent impoundment?
   - *c*. Size of area.
3. Water supply.
   - *a*. Source (i. e., spring, creek, etc.) and extent of flow.
   - *b*. Approximate depth; extent of shallow water (1 to 4 feet).
   - *c*. Is water clear, muddy, or stained?
   - *d*. Quality as to brackishness, freshness, alkalinity, or acidity.
   - *e*. Constancy of water level.
4. Type of margins; are there extensive mud flats or are margins sandy, stony, or wooded?
5. Type of bottom; hard or soft; sand, clay, or muck.
6. If plants are present, the most common marsh and aquatic species should be listed, or samples of those not recognized should be mailed in as pressed specimens for identification.
7. Additional comments.

The identification of established vegetation is essential not only to avoid unnecessary propagation of species that are already present but also to take advantage of existing plants as indicators that the place may be suitable or unsuitable for other species. Identification of materials can be obtained from botanists at State colleges or universities or from the Bureau of Biological Survey, but it is important that specimens be as complete as possible and that they be carefully pressed and dried before submission.

WHEN TO PLANT

The seeds, tubers, winter buds, and rootstocks of aquatic and marsh plants may be planted either in spring or as soon as harvested late in summer or in fall. Planting at any season has both advantages and disadvantages that depend primarily on local conditions.

The chief advantages of fall planting are that it minimizes the danger and eliminates the expense and work involved in storage, whereas spring planting commonly necessitates the use of materials that have been long stored and thus have undergone increased chances of injury by fermentation, heating, and drying. It has been shown that the seeds of a large proportion of the aquatic and marsh plants from the central and northern sections of the United States and Canada must undergo a rest period at low temperatures and in a wet condition to insure successful or uniform germination; under fall planting nature takes care of these requirements. Planting in fall can usually be done under more favorable weather and water conditions than in early spring and generally furnishes a more accurate picture of the water levels under which growth must take place, thereby permitting better selection of planting sites.

The advantages of spring planting are that the danger of destruction of the propagative materials after planting is lessened because the time during which waterfowl, muskrats, carp, and other vertebrates can devour or uproot the material before it starts growing is greatly reduced and that the possibility of damage by floods, either through sedimentation or scouring, is minimized and the hazard to tender species by deep freezing and to seedbeds by ice is eliminated.

If propagative materials are harvested in fall it may often be safest to plant half of them immediately after harvesting and the remainder the following spring unless it is certain that ideal storage conditions can be furnished for tubers, seeds, and rootstocks.

Leafy branch tips of many submerged species and entire plants of those that are free floating or poorly rooted can be successfully transplanted at almost any time during the active growing season.

HOW TO PLANT

Before any aquatic planting is started the area should be marked off to avoid duplication of plantings. Most submerged species should be planted in water 3 to 6 feet deep on moderately soft bottoms, and most marsh plants in water less than 2 feet deep. Wildrice and certain bulrushes will often thrive in water 3 to 4½ feet deep.

Planting should be so planned as to take advantage of the agency of prevailing winds and water currents in further disseminating seeds, to increase the extent of feeding grounds after the plants become established.

AQUATIC CUTTINGS

Leafy aquatic cuttings may be planted by molding balls of clay around the lower ends of groups of four or five shoots (6 to 12 inches long) and dropping them overboard on a moderately soft bottom.

These balls should be scattered at intervals of about 6 feet (see description of device for placing clay balls in firm soils in section below on planting tubers). Some dealers recommend the mere broadcasting of the cuttings, but much of the material is thus wasted through floating to the shore or drifting to other unsuitable situations. Unless the cuttings come in direct contact with the soil some species fail to develop rootlets or do so very slowly; for example, naiads have been kept in laboratory aquaria free from contact with soil for more than 7 months without developing rootlets, but as soon as the same cuttings were placed in contact with the soil they started producing them in a few days. When cuttings are planted in shallow water it is sometimes possible to save labor by embedding them directly in the bottom soil without using clay balls. Cuttings should be planted at the rate of about 3 to 5 bushels per acre.

If cuttings are to be planted on rather firm bottoms it may first be desirable to place them in contact with soil in a shallow retaining pond 1 to 2 feet deep until rootlets have begun to develop. They will then become anchored more rapidly in the new situation, and thus the chances of damage by wave action will be reduced. Leafy branches of sago pondweed often develop small propagative tubers among the leaves under such conditions (pl. 120.)

SEEDS

Aquatic seeding can be done by direct broadcasting of most saturated seeds. If the seeds are buoyant enough to float, however, they should be embedded in small clay balls (several to a ball) before broadcasting. A bushel of seed is enough to permit an average-sized handful to be broadcast at 9-foot intervals over an acre.

Dry seeds can be planted in marshes and moist margins by ordinary broadcasting. Whenever possible the area should be gone over with a disk, drag, or coarse rake before broadcasting and should be lightly raked afterwards.

TUBERS

Aquatic tubers should be embedded in small clay balls with the tip of the sprout projecting. The clay should be previously worked until it has the texture of soft putty, then a small ball of it held in the palm of one hand and a cavity pressed into it with the thumb of the other, after which the tuber should be inserted and the clay molded around the exposed surface. Such balls can be placed in bushel baskets in layers separated by pieces of burlap, and with a little practice each layer can be broadcast by using the layer of burlap beneath it as a crude bag (the burlap needs to be cut in squares somewhat wider than the diameter of the basket to make this possible). Care should be taken to avoid having the balls so wet that they stick together. When clay is not available some dealers recommend the use of mud balls wrapped in a double thickness of newspaper, using pieces 10 inches square and twisting the corners together.

About 1,200 tubers are enough to sow 1 acre if they are planted at intervals of 6 feet. When sowing the tubers of submerged plants, added assurance of success can be gained by embedding a few seeds of the same species in the outer portion of about half of the clay balls.

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In sowing firmer bottoms with either seeds or tubers that have been molded in clay balls, injury by currents or waves may be avoided before growth can start by using a device for placing them just below the surface of the soil. This consists of a piece of sheet-metal pipe about 3 inches in diameter and long enough to project 2 feet above the water level when the lower end is in contact with the bottom; it is equipped with a light plunger to force a hole large enough to receive the clay balls in the bottom soil. The plunger may be a light wooden or metal shaft about 2 feet longer than the pipe, with the lower end inserted into an oval piece of hardwood 2½ inches thick and 6 inches long. In firm sand the plunger may have to be more pointed, but the hole made by it should not be made deeper than necessary to hold the clay ball in place. A metal ring through which the pipe can be inserted may be hinged to the stern of the boat as an aid in using the "planter," and the pipe may be in short sections that can easily be fitted together to make it any desired length. The pipe should be forced slightly into the bottom soil before the plunger is inserted. After a hole has been made in the bottom soil, the plunger is removed and a single clay ball dropped through the pipe into the cavity. This method would take too much time for planting extensive areas, but could be used at strategic points.

In planting tubers of duckpotatoes, saltmarsh and alkali bulrushes, and other marsh plants, which grow in less than a foot of water, the operator may wear rubber boots and use a small spade. These tubers should be covered with 3 to 6 inches of soil.

Chufa and other tubers that develop in dry or semidry places can be broadcast on land that has previously been dragged, disked, or raked, if the broadcasting is followed with a similar treatment, or they can be planted at a depth of 1 to 2 inches by hand.

ROOTSTOCKS

Most rootstocks of aquatic and marsh plants should be set out where the water is shallow enough to permit planting by hand, the operator being equipped with rubber boots and a spade or hoe. The rootstocks should be placed in shallow trenches and covered with 3 to 6 inches of soil. Where currents are strong or wave action severe it would be helpful to fasten some of them down with small wire arches.

WINTER BUDS

Propagation by means of the contracted and modified leafy stems (pl. 14), which are commonly known as winter buds, can be accomplished by broadcasting them in water with a moderately soft bottom, or by fastening small clay balls to their lower ends to insure submergence and to hold them in the proper situation, particularly if the bottom is rather firm or the situation is subject to currents and wave action.

YIELDS AND FOOD VALUES

Little is known regarding the quantities of various wild-duck foods that can be produced in a specified water or marsh area, and reliable information is difficult to obtain for many species. This is because of numerous variable factors involved and the serious difficulty of making a complete harvest of submerged subterranean parts.

Investigations by Rickett (*69*, *70*) on two Wisconsin lakes have furnished some interesting facts regarding the quantity of the entire vegetative parts of a number of species produced on a definite area of lake bottom. Since seeds, rootstocks, and tubers commonly constitute the major portion of the plant eaten by ducks, however, these investigations did not furnish a reliable index to the quantities of actual waterfowl food produced. Rickett found that water composed an average of 87.7 percent of the total weight of 21 species of plants from Lake Mendota. Among these plants were sago pondweed, claspingleaf pondweed, or redheadgrass (*Potamogeton perfoliatus richardsonii*), naiads, muskgrass, wildcelery, coontail, duckweeds, wildrice, bulrushes, and other important aquatic and marsh species. In the plant zone in Lake Mendota (a mud-bottomed lake) the average yield was about 14,867 pounds per acre, wet weight, or 1,801 pounds dry weight of higher plants; while the yield from Green Lake, which has a deposit of fine marl on much of the bottom, averaged about 13,540 pounds, wet weight, and 1,590 pounds, dry weight, per acre. It is thus evident that the dry-weight yield of aquatic plants from a good shallow mud-bottomed lake compares favorably with that of ordinary wild hay produced on an upland area of equal size, in spite of the greater loss of weight that aquatic plants undergo in drying.

To determine the chemical composition of certain aquatic plants, including several important duck foods, representatives of a few genera have been analyzed by Schuette and Alder (*73*, *74*) and by Schuette and Hoffman (*75*). The genera on which they reported are *Cladophora*, *Myriophyllum*, *Vallisneria*, *Potamogeton*, *Castalia*, *Najas*, and *Chara*.

To be of much importance in a program designed to improve food conditions for waterfowl, analyses of the chemical composition of any item must be correlated with studies on digestibility and acceptability. In the absence of studies in the former field, the guide for the present must be largely the factor of acceptability.

Numerous types of livestock foods, including a considerable number of plants that are important for waterfowl, have been analyzed by the United States Department of Agriculture and State experiment stations. The averge percent composition and digestibility of these foods have been compiled in an extensive series of tables by Henry and Morrison (*31*).

A comparison of the food value of wildrice with other grains, as supplied by C. L. Langworthy and published by the Department of Agriculture (*8, pp. 20–21*), is presented in table 11. Most of the grains listed are at least locally important as wild-duck foods. Commenting on the table, the authors state:

Too much importance should not be placed on the variation in constituents as shown by figures like the above, since it must be remembered that a given constituent in any of the grains may vary to rather wide limits. For instance, the protein in common white rice varies from about 6 to 11 percent. So few analyses of wild rice are available that but little can be said regarding the range in the proportional amounts of the different constituents.

TABLE 11.—*Food value of wildrice compared with other grains*

Grain	Water	Protein	Fat	Carbohydrates	Ash	Fuel value per pound
Wildrice:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Calories*
Whole grain	9.5	12.9	1.0	75.2	1.4	1,625
Ground	13.0	10.9	.8	74.0	1.3	1,740
Parched whole grain	11.2	14.6	.7	72.3	1.2	1,020
Parched and ground	9.5	11.5	.8	76.9	1.3	1,800
Rice, polished	12.3	8.0	.3	79.0	.4	1,630
Barley, pearled	11.5	8.5	1.1	77.8	1.1	1,650
Wheat, cracked and crushed	10.1	11.1	1.7	75.5	1.6	1,685
Oats, rolled	7.7	10.7	7.3	66.2	2.1	1,850
Corn meal, unbolted	11.6	8.4	4.7	74.0	1.3	1,730
Hominy	11.8	8.3	.6	79.0	.3	1,650
Kafir	16.8	6.6	3.8	70.6	2.2	1,595
Buckwheat flour	13.6	6.4	1.2	77.9	.9	1,620

FACTORS THAT RETARD GROWTH, AND SUGGESTED REMEDIES

The many factors that retard or prevent the successful development of valuable waterfowl food plants may be roughly grouped in four classes—physical, chemical, biological, and economic. Efforts to remedy local situations can be directed (1) toward the elimination of the retarding factors, thus permitting optimum growth of desirable food plants; or, when this is impracticable, (2) toward the establishment of food plants that can withstand the prevailing unfavorable local conditions. Much information regarding methods of analyzing water samples—useful in determining the various chemical and physical conditions affecting the production of duck foods—has been published jointly by the American Public Health Association and the American Water Works Association (*1*). Needham and Lloyd (*62*), Ward and Whipple (*84*), and Welch (*86*) have presented good discussions of the manner in which aquatic organisms, including those that are valued as food for wild ducks, are affected by these and other factors.

PHYSICAL FACTORS

FLUCTUATING WATER LEVELS

No single factor is more potent in preventing the development of waterfowl feeding grounds than extreme or irregular fluctuations in the water level (pl. 122). In the United States the scarcity of aquatic and marsh vegetation resulting from this factor is most conspicuous in the flood plain of the Mississippi River from central Iowa to New Orleans, La., and along the lower parts of practically all the larger tributaries of that section of the Mississippi. The tremendous fluctuation, together with the scouring action of floods and the deposition of silt, which are discussed later (p. 123), make very uncertain most attempts to improve waterfowl feeding grounds in that region.

The periodic drying out of shallow upland lakes during the later half of the growing season is commonly noted, particularly throughout the central and western parts of the United States and Canada. Unless at least a few inches of water can be retained during the lowest stages, the successful production of truly aquatic plants there is almost impossible. Levels of lakes and streams that are converted into storage reservoirs for hydroelectric, irrigation, or flood-control purposes are often subject to annual fluctuations of 5 to 50 feet or more. If the fluctuation takes place during the growing season, the majority of the lakes become biological deserts so far as the production of wild-duck foods is concerned.

Tidal fluctuations affect the development of aquatic and marsh plants in a number of ways. Johnson and York (*36, p. 143*) have summarized the effects of tidal changes on plants as follows:

> We find that these are of most general importance in affecting, first, the amount of transpiration; second, the time available for gaseous interchange between the shoots and the air; and, finally in limiting the light-supply and hence the effective photosynthetic activities of littoral plants. Of secondary and only occasional importance are the effects on concentration of the soil-water at high levels, and the exposure of plants near mean low water to rains during low tides.

Thus the location of marginal beds of vegetation is closely related to tide levels (pl. 127, *B*).

Regular semidaily tidal fluctuations of less than 4 feet usually are not destructive to established beds of aquatic vegetation unless the beds are totally exposed for an extended period during abnormal low tides, due to winds or other causes.

Any program for improving waterfowl feeding grounds that have fluctuating water levels should first give consideration to the feasibility of stabilizing the levels. On many storage reservoirs shallow arms can be cut off from the main body of water by constructing low dams or revetted dikes equipped with spillways, thereby permitting the separate development of these stabilized areas without appreciably reducing the storage capacity. Small creeks can be diverted, dams constructed in high-water outlets, artesian wells drilled, and hydraulic rams or other pumping equipment installed to make adjacent water supplies available for restoring dry lakes and ponds. Sometimes the mere exclusion of livestock from thinly sedimented lake beds that overlie porous soils will remedy subsoil seepage caused by the hoofs breaking through the impervious clayey bottom. In areas where the tidal fluctuations are extreme (more than 5 feet), marshes that go dry at low tide but are flooded by the upper 2 to 3 feet of the normal high tides can sometimes be improved by impounding permanent water by means of revetted dikes equipped with tide gates or spillways. The gates should be constructed so that at least 1 foot of water will be retained at low tide, thereby permitting the development of submerged vegetation.

Many helpful suggestions and directions for installing dams, dikes, wells, pumping equipment, etc., have been published[11] (*4, 20, 24, 34, 40, 46, 52, 85*); among these, the following Farmers' Bulletins of the United States Department of Agriculture can be consulted: 1703, Reservoirs for Farm Use; 1279, Plain Concrete for Farm Use; 744, The Preservative Treatment of Farm Timbers; 1612, Propagation of Aquatic Game Birds; 1448, Farmstead Water Supply; 1404, Pumping from Wells for Irrigation; 864, Practical Information for Beginners in Irrigation.

In areas subject to irregular fluctuations where stabilization of water levels is not feasible, the improvement of natural feeding

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[11] UNITED STATES BUREAU OF FISHERIES. METHODS FOR THE IMPROVEMENT OF STREAMS. U. S. Bur. Fisheries Memorandum I-133, 28 pp., illus. 1935. [Mimeographed.]

grounds must be accomplished through the planting of foods that can survive these unfavorable conditions. A few good or excellent food plants and a number of species of lesser importance are suitable for propagation in such situations. Aquatic species should usually be limited to those that have a terrestrial form. Within the limits of their natural ranges the plants listed below are useful in improving feeding grounds in areas that fluctuate between a submerged and an emergent condition; some are limited to brackish, alkaline, acid, shaded, or other special ecological conditions. This, together with the ranges and comparative values, should be checked in the descriptive treatment of each species in the second part of this bulletin. They are listed in systematic order and therefore their position in this list does not indicate relative food values. Most of them require considerable moisture in the soil if they are left emergent, but those marked with an asterisk (*) can continue growth with very little moisture.

Pepperwort (*Marsilea vestita*).
Baldcypress (*Taxodium distichum*).
Burreeds (*Sparganium* spp.).
Longleaf pondweed (*Potamogeton americanus*).
Variableleaf pondweed (*P. gramineus*=*P. heterophyllus*), and other floating-leaved pondweeds.
Arrowgrass (*Triglochin maritima*).
Duckpotatoes, arrowheads (*Sagittaria* spp.).
Frogbit (*Limnobium spongia*).
Mannagrass (*Glyceria striata*).
Saltgrasses (*Distichlis* spp.).
Sprangletop (*Leptochloa fascicularis*).
Rice cutgrass (*Leersia oryzoides*).
*Panic grass, fall panicum (*Panicum dichotomiflorum*).
*Wild millets (*Echinochloa* spp.).
*Chufa (*Cyperus esculentus*).
Squarestem spikerush (*Eleocharis quadrangulata*).
Dwarf spikerush (*E. parvula*).
Slender spikerush (*E. acicularis*) and other spikerushes.
Common three-square (*Scirpus americanus*).
Hardstem bulrush (*S. acutus*).
Saltmarsh bulrush (*S. robustus*).
Alkali bulrush (*S. paludosus*) and other bulrushes.
Beakrushes (*Rynchospora corniculata*) (inclusive sense).
Sawgrass (*Cladium jamaicense*).
Pickerelweeds (*Pontederia* spp.).
*Pin oak (*Quercus palustris*).
*Overcup oak (*Q. lyrata*).
*Willow oak (*Q. phellos*).
*Water oak (*Q. nigra*) and other oaks.
Water-elm (*Planera aquatica*).
*Nodding smartweed (*Polygonum lapathifolium*).
*Water smartweed (*P. amphibium*).
*Marsh smartweed (*P. muhlenbergii*) and other smartweeds.
Glassworts (*Salicornia* spp.).
Tidemarsh waterhemp (*Acnida cannabina*).
Yellow buttercups and white water buttercups (*Ranunculus* spp., including *Batrachium*).
Creeping waterprimrose (*Jussiaea diffusa*).
Mermaidweeds (*Proserpinaca* spp.).
Marestail (*Hippuris vulgaris*).
Water pennywort (*Hydrocotyle ranunculoides*) and other pennyworts.
Roundleaf waterhyssop (*Bacopa rotundifolia*).
Buttonbush (*Cephalanthus occidentalis*).

EXCESSIVE DEPTHS

By far the greater proportion of submerged duck-food plants grow best in waters less than 10 feet deep. For this reason, it is recommended that when feasible most plantings of these species be made in water less than 7 feet deep. The depth at which the various species thrive is usually directly controlled by the amount of light reaching the bottom. Some few important species, however, require far less light than the majority and consequently are adapted for growth at greater depth. In some of the clearest lakes of spring streams satisfactory growths have been found at depths of 25 to 30 feet. Coontail has been noted by Kalmbach and Cottam thriving at depths of 29 feet in Wakulla Springs, Fla., and in the same area successful beds of wildcelery and the giant form of the southern naiad (*Najas guadalupensis*) have been found at depths of 22 to 25 feet. In upper Michigan and Wisconsin the northern naiad (*N. flexilis*) and watermilfoil (*Myriophyllum verticillatum*) have been found flourishing at depths of 18 to 20 feet in several of the clearer lakes.

Rickett (*69, 70*) reported that coontail grows at a greater depth than any other seed plant in Lake Mendota and Green Lake, Wis., in the former at a depth of nearly 6 meters and in the latter at 7 to 8 meters. He likewise reported that wildcelery, northern naiad, and watermilfoil thrive at depths of 5 to 6 meters, and in addition stated that the flatstem pondweed (*Potamogeton zosteriformis*) grows at similar depths. Muskgrasses (*Chara* spp.), while not seed plants, are known to be locally important as duck foods and have been found thriving at a depth of more than 30 feet in a limestone spring near Manistique, Mich. Wilson (*89*) reported that the pondweed *P. pusillus* grows at a depth of 6 meters in Silver Lake, Vilas County, Wis., and there even surpasses the depth of wildcelery and northern naiad. The plants growing at these depths are usually of dwarf size, although in Gogebic County, Mich., the writers occasionally found claspingleaf pondweed, or redheadgrass (*P. perfoliatus* var. *richardsonii*), and the whitestem pondweed (*P. praelongus*) fruiting at the surface of water 12 feet deep.

Since all these plants also grow in waters as shallow as 3 or 4 feet, they furnish a good selection for the development of diving-duck feeding grounds.

HARD BOTTOMS

Excessively firm sand, gravel, or rocky bottoms present a difficult problem in developing waterfowl foods. Practically nothing can be done with rocky- or gravel-bottomed areas (pl. 123, *A*) unless they can be covered with a sedimentary soil deposit. Sometimes silt-laden waters can be diverted over such barren areas until sufficient soil to permit plant growth has been deposited.

The initial plantings on firm sand bottoms (pl. 123, *B*) should be limited to the few species that can withstand such conditions. Usually wind and wave action add to the difficulties involved. Before plantings of submerged species are made, pioneer plantings of such wave-resistant forms as the firm-stemmed species of bulrushes—*Scirpus acutus* in the Northern States and Canada and *S. californicus* in the Southern States—should be made by transplanting rootstocks harvested in similar areas. These bulrushes can usually withstand depths to about 4½ feet. Once these are established and have retarded wave action sufficiently, such sand-resistant plants as the variableleaf pondweed (*Potamogeton gramineus*), the bushy form of northern naiad, wildcelery, and later the redheadgrass, sago pondweed and the related *P. filiformis* may be planted. In brackish waters the wigeongrass is more tolerant of firm sand than any other submerged food plant.

In planting all these species it is recommended that rootstock or tuber materials (obtained from firm sand-bottomed waters) be used and that they be set out in submerged shallow trenches 2 to 5 inches deep to avoid loss by wave action.

OOZE BOTTOMS

The semiliquid ooze bottoms of great depths raise an even greater problem in waterfowl-food development than the hard sand-bottomed water areas. Such bottoms are common in the open-water parts of many northern bogs. The actual water may be only a few inches deep, but frequently it overlies a tremendous depth of ooze that is not firm enough to serve as a substratum for the roots of most aquatic plants. This ooze commonly contains much raw peat or other poorly decomposed organic debris and often shows a decidedly acid reaction. As the bottom ooze gradually becomes denser with the accumulation of organic materials, among the first duck-food plants to become adapted for growth there are the spatterdocks, or yellow pondlilies (*Nymphaea microphylla* and *N. advena*). waterlily (*Castalia odorata*), watershield (*Brasenia schreberi*), floating-leaf pondweed (*Potamogeton natans*), ribbonleaf pondweed (*P. epihydrus*), largeleaf pondweed (*P. amplifolius*), floating burreeds (*Sparganium fluctuans* and *S. angustifolium*), and, on the borders, the sedge (*Carex filiformis*) and less commonly the arrowhead (*Sagittaria cuneata*).

TURBIDITY AND STAINS

By the exclusion or absorption of sunlight, excessive turbidity and stains are frequently responsible for the scarcity or total absence of duck-food plants in important areas. These conditions may be produced by physical, biological, chemical, or economic factors, or by any combinations of them. Most common among the causes of turbidity are prolonged suspension of clayey silt in running waters, particularly following heavy rains. This condition has been frequently found to destroy some of the finest beds of wildcelery, naiads, redheadgrass, and numerous other valuable duck foods in the Potomac River; and in much of the Missouri River and the southern Red River this turbid condition is permanent and precludes the growth of submerged vegetation. Wave action in shallow clay-bottomed lakes often brings similar results. When not too intense it can sometimes be remedied by planting marl-forming species, including muskgrass (*Chara* spp.), waterweed (*Anacharis canadensis*) and certain pondweeds (*Potamogeton* spp.). Possibilities for constructive work in the elimination of this type of turbidity are also offered in extensive erosion control, the construction of settling pools, and the creation of barriers to break up wave action.

The turbidity created by excessive industrial and domestic pollution is often a greater menace to the growth of submerged plants than the toxic conditions produced. The maximum turbidity in many tidal rivers is found at the point of mixture of the fresh and brackish waters, where a permanently cloudy condition is maintained by the resulting precipitation of dissolved materials. Submerged vegetation is often scarce in such sections.

In shallow mud-bottomed waters the feeding activities of various vertebrates, chiefly rough fishes and livestock, frequently cause destructive turbidity in valuable duck-feeding grounds. The elimination or exclusion of these vertebrates is the only solution to the problem.

The late-summer production of tremendous quantities of minute suspended algae has often been observed creating a harmful degree of turbidity over large areas. This subject is later dealt with in detail (p. 130).

Dark stains caused by dissolved materials absorb the sunlight and retard aquatic plant growth in the same manner as do materials that are held in suspension. These stains are occasionally caused by chemical pollutants but more commonly result from the leaching of dead organic materials, chiefly woody debris. The waters of many southeastern swamps are rendered totally unfit for the production of submerged vegetation by these organic brown stains. Lake Drummond, in the famous Dismal Swamp of southeastern Virginia (pl. 124, *A*), is a typical example of such conditions, although other unfavorable factors also are operative there. Acidity is a frequent but by no means universal accompaniment of these organic stains and may add to the problem of plant propagation.

Remedies for dark waters include flushing, draining, and the removal of woody debris, when feasible, and diversion of the principal sources of stained tributary waters. Before water impoundment is made in new areas, the need for eliminating from the basin all woody debris and other vegetable materials that may cause such stains cannot be overemphasized. In a large artificial lake constructed in a carefully cleared wooded basin in the town of Greenwich, Conn., the clear water and the resulting luxuriant growth of wildcelery, waterweeds, and pondweeds furnish a striking contrast to the barren dark-stained ponds created in uncleared or poorly cleared basins in the same locality.

The planting of duck foods in dark-stained or turbid waters, where most of the first-class food plants cannot thrive, should be limited to emergent species or those with floating leaves, and should be restricted to the shallowest parts. Within their natural ranges the following plants (arranged in systematic order) seem the most worthy of experimentation in stained waters:

Burreed (*Sparganium* spp.).
Ribbonleaf pondweed (*Potamogeton epihydrus*).
Pondweed (*P. pulcher*).
Largeleaf pondweed (*P. amplifolius*).
Floatingleaf pondweed (*P. natans*).
Arrowhead (*Sagittaria cuneata*).
Slender spikerush (*Eleocharis acicularis*).
Duckweeds (Lemnaceae) (when not too acid).
Pickerelweed (*Pontederia cordata*).
Water smartweed (*Polygonum amphibium*).
Marsh smartweed (*P. muhlenbergii*).
Yellow pondlily or spatterdock (*Nymphaea advena*).
White waterlily (*Castalia odorata*).
Watershield (*Brasenia schreberi*).
Mermaidweed (*Proserpinaca palustris*)
Featherfoil (*Hottonia inflata*) (pl. 124, *B*).

In brackish waters of a high degree of turbidity the muskgrasses (*Chara* spp.) seem better able to survive than any of the submerged seed plants.

ICE

The scouring action of ice masses in flowing waters following the spring breakup or the driving of ice into shallow areas by wind and waves at times cause severe damage to beds of submerged plants.

In certain types of shallow waters that freeze deep enough to include the bottom layer of mud, with its accompanying rootstocks, tubers, and seeds, "ice-lift" occasionally removes the entire bed. This usually occurs when there is a sudden rise in water level before the bottom layers have thawed sufficiently. The writers have noted the rootstocks of the white waterlily lifted from large beds by this type of ice action in such quantities that for many months the floating masses made boating impossible on shallow ponds. Sago pondweed beds covering scores of acres have been found similarly lifted from the bottom of shallow sluggish streams and carried away during a spring breakup. Increased depths, which prevent bottom soils from freezing, are the principal means of forestalling such damage.

WAVE ACTION

Wave action in large expanses of open water limits the growth of duck-food plants either through mechanical injury, especially in firm-bottomed water areas, or by turbidity in waters with mud or clay bottoms. The retarding of wave action may sometimes be accomplished by constructing groups of dredged islands, spoil banks of excavated channels, rock and willow breakwaters (see description below under means of retarding currents), use of wave-resistant plants, or lowering or raising the water levels. Earthen structures constructed to retard wave action should be planted with erosion-resisting vegetation, or protected by revetment when necessary.

The firm-stemmed species of bulrushes (*Scirpus acutus*, *S. heterochaetus*, and *S. californicus*) commonly withstand severe wave action in waters as much as 4½ feet deep; in water averaging less than 2½ feet deep, the following may be used within their natural ranges: Common three-square (*Scirpus americanus*), the giant form of the spikerush (*Eleocharis palustris*), baldcypress (*Taxodium distichum*), and marsh smartweed (*Polygonum muhlenbergii*).

CURRENTS

Strong currents often act as a deterrent to the successful establishment of aquatic and marsh plants, even though they prevail for only a minor part of the year. If other conditions are favorable, however, improvements can sometimes be made by constructing wing dams (pl. 125) or various types of rock fills to retard currents sufficiently to permit aquatic plants to thrive. The wing dams are constructed at right angles to the current and consist of a jetty about 8 to 10 feet wide of any desired height or length, built from layers of wire-bound bundles (about 1 foot thick) of sandbar willows alternated with layers of flat, thick pieces of limestone and topped with a heavy layer of these stones. The willow bundles are placed with their butts headed upstream. Such dams are often used to block side channels and act effectively in retarding currents in those situations also.

Wing dams have been in use along the upper Mississippi River for many years to control shifting sand in an effort to maintain a navigable channel. The major part of the river has too strong a current to permit the growth of aquatic vegetation, but immediately below the wing dams, where the current is retarded, various species of submerged plants grow successfully. Usually the longleaf pondweed and the waterweed are the first rooted plants to gain a foothold in such situations, but wildcelery, naiads, and a variety of other pondweeds are adapted for growth in those areas if sedimentation is not extreme.

SILTING

In addition to smothering valuable food beds, rapid sedimentation has completely filled in and ruined numerous important waterfowl lakes throughout the United States. Many more are in the late stages of destruction. Most of these lakes lie in bottom lands, where they are subject to the effects of floodwater silting (pl. 126), but many are located in upland areas, particularly in the western half of the United States, where overgrazing has caused an appalling degree of hillside erosion and completely destroyed many fine marshes or reduced them to only a minor fraction of their former size (pl. 153). Person (*65*) presents a good discussion of the need for attacking the erosion menace at its sources through lines of action that will retard the run-off and thereby increase the water absorption and infiltration of all soils that are subject to erosion.

The sediment in bottom land lakes comes from two principal sources: (1) Flood-plain silt, which commonly is derived from bank erosion along nearby bottom land channels during periods of severe flood (often merely representing a local transposition of heavy silt); and (2) hillside or distant upland silts, which are brought in by tributary streams. The latter class of silts may first be deposited at points remote from the lakes and then be transferred by later floods to points where damage to feeding grounds results.

Erosion resulting in the sedimentation of lake beds may be caused or accelerated by a great variety of factors, among which the following are often important: Deforestation, hillside cultivation, overgrazing, making highway cuts and related ditching, and construction of drainage ditches. The rate of erosion in a particular area usually depends on the quantity and character of the rainfall, type of soil, and slope of land. The original erosion may be in the form of sheet erosion, bank erosion, or gullying. Any plan to prevent or retard further erosion, with its resultant destructive sedimentation, should give consideration to all these factors.

The basis for permanent correction of erosion depends on three considerations: (1) A clear understanding of the specific causes of erosion in each area; (2) elimination of the factors found to be responsible; and (3) correction of the erosion already in progress. The last field involves a number of features, including the construction of many types of soil-saving dams and flumes, terracing, contour furrowing, riprapping, and proper plantings. These are discussed in detail in available departmental and other publications and need no elaboration here. A list of such publications can be obtained from the Department of Agriculture, Washington, D. C., and many of the States have also issued publications on the subject.

A lake bed filled with erosion silt can be restored only by the costly process of dredging, excavating, or to a limited extent by means of explosives; therefore, the time to attack this problem is at the first indication of its development.

In addition to the destruction of lakes by erosion sedimentation, many of the most productive lakes are gradually filling up with an accumulation of the organic debris that results from decay. This process is the natural consequence of a long and useful period of waterfowl-food production, and in its final stages can sometimes be partially remedied during dry seasons by the controlled use of fire in peaty beds as recommended by Pirnie (*67, p. 284*).

TEMPERATURE

The effects of various temperatures on the germination of seeds have been indicated in a previous section (pp. 107–110). In general it is safest to obtain all propagative materials from regions having temperatures similar to those in which the plantings are to be made. Southern species and varieties are likely to winter-kill in northern latitudes, and the seeds of northern aquatics that have been planted in southern waters are likely to germinate poorly. The pondweeds (*Potamogeton* spp.), which are by far the most important group of North American duck foods, are typically northern plants. A single lake in the North Central States may produce a greater variety of pondweeds than the entire southern half of the United States. About 40 species of pondweeds are listed in botanical manuals for the Northeastern States, whereas less than half that number are listed from the Southeastern States. Obviously most of the northern species are not adapted for growth in the warm southern waters.

Guppy (*28*) has demonstrated that temperature conditions are responsible for the infrequency of flowering and fruiting in certain aquatic plants. For example, he found that coontail requires almost tropical temperatures for the maturation of its fruit, although that species continues to thrive and spread by vegetative methods in cooler waters.

CHEMICAL FACTORS

EXCESSIVE SALINITY OR ALKALINITY

The great majority of waterfowl-food plants are adapted for growth only in fresh waters and soils. A fair number of marsh or moist-soil plants, however, and a few aquatic species that thrive in saline, alkaline,[12] or brackish areas, are important sources of duck foods.

The most common salts found in the alkali regions are sodium chloride (common salt), sodium carbonate (washing soda), sodium sulphate (Glauber's salt), sodium nitrate (Chile saltpeter), and magnesium sulphate (Epsom salt). The more abundant salts of ocean water (which contains an average of about 3.5 percent, or 35,000 parts per million, of solid matter) as reported by Dittmar (*15, p. 204*) are as follows: Sodium chloride (77.758 percent), magnesium chloride (10.878), magnesium sulphate (4.737), calcium sulphate (3.600), potassium sulphate (2.465), calcium carbonate (0.345), and magnesium bromide (0.217 percent). A simple method for determining the saltiness of coastal waters in the field, by means of chemical analyses, is described by Denny (14).

In the temperate ocean waters the eelgrass (*Zostera marina*) (pl. 30) is the only submerged duck-food plant that has been proved to be of great importance, although certain marine green algae are eaten extensively by waterfowl when better foods are not available. Re-

[12] In a popular sense the term "alkali" is applied to any soluble salt that is injurious to cultivated crops and most valuable grazing plants in the Great Plains and Great Basin. The present discussion is based on this concept, although from a chemical standpoint the term alkali should include only those substances that have basic properties.

cent analyses of the stomach contents of diving ducks, as well as field observations, indicate that a southern salt-water plant, shoalgrass (*Halodule wrightii*) (pl. 32), may be of considerable value, and field observations along the coast of Florida indicate that three other submerged plants of the saline Gulf coast waters may also be of some importance—manateegrass (*Cymodocea manatorum*) (pl. 31), halophila (*Halophila engelmannii*) (pl. 46, *A*), and turtlegrass (*Thalassia testudinum*) (pl. 49). In saline waters of the Pacific coast the surfgrasses (*Phyllospadix* spp.) are known at times to be used as food by diving ducks and are worthy of further study.

The wigeongrasses (*Ruppia* spp.) (pls. 27 and 28) are primarily brackish water plants and thrive best in waters containing less than four-fifths as much salt as normal sea water. They will continue to exist, however, in waters having a salt content considerably greater than that of normal sea water. *R. maritima* has been found alive in tidal pools that had been concentrated by evaporation to a chlorine content equivalent to 41,214 parts of ordinary salt (NaCl) per million parts of water, whereas the average chlorine content of Atlantic ocean water (19,538 p. p. m., based on Olsen, *64, p. 715*) is equivalent to only 32,210 p. p. m. of that salt. Metcalf (*50*) reported finding wigeongrass in an alkali lake in North Dakota that had a total salt content of 77,386 p. p. m., or more than twice that found in normal sea water.

Several species of muskgrasses (pl. 3) thrive in strongly alkaline or brackish waters and sometimes are eaten in large quantities by game ducks.

Two other submerged duck-food plants that withstand strongly brackish or alkaline conditions are the sago pondweed and the horned pondweed (*Zannichellia palustris*) (pl. 29), both of which thrive in water as brackish as that occurring in the upper half of Chesapeake Bay. Along the eastern shore of that bay it is not unusual to find eelgrass, wigeongrass, sago pondweed, and horned pondweed all thriving in the same area, in water with a chlorine content equivalent to about 13,000 parts per million of sodium chloride during the average growing season.

Another important duck-food plant that thrives well in moderately brackish and fresh water is the claspingleaf pondweed, or redheadgrass (*Potamogeton perfoliatus bupleuroides*) (pl. 25). In the Potomac River this plant extends downstream to a point where the eelgrass reaches its upper limits. During a normal summer season the chlorine content here is equivalent to 8,500 to 9,000 parts per million of sodium chloride, making the water slightly more than one-fourth as saline as average sea water.

As one progresses a few miles farther upstream two additional valuable duck foods, the wildcelery (*Vallisneria spiralis*) (pl. 48) and the southern naiad (*Najas guadalupensis*) (pl. 35), reach their lower limits in water that has a chlorine content equivalent to 6,000 to 8,000 parts per million of sodium chloride (during the average summer season). The southern naiad appears to be slightly better adapted for growth in waters with that degree of salinity than the wildcelery.

During years of heavy precipitation these plants make a greatly improved growth at these lower limits, as a result of the fresher condition of the water; but in periods of extreme drought they are destroyed by the increased salinity. Throughout ordinary growing seasons sudden fluctuations in the degree of salinity and accompanying changes in density of these waters cause the leaves and tender shoots of the redheadgrass to go through a number of periods of destruction and recovery. These fluctuations may result from temporary droughts, heavy rains, or strong winds that alter the normal tides. The injury apparently is brought about by the collapsing (discussion of osmotic pressure may be found in any textbook on botany) of the tender plant cells and a loss of their enclosed fluids when subjected to a rapid or extreme increase in salinity; and possibly by a bursting of the cells when the water is suddenly freshened around plants that have become adapted to growth under brackish conditions. The rootstocks and tougher parts of the stems appear to suffer little injury from these temporary changes.

The spiny naiad (*Najas marina*) (pl. 37) has a peculiar distribution in certain moderately brackish waters throughout the United States. It has been found growing luxuriantly in brackish waters of the salt-producing section in western New York, in moderately alkaline lakes of the Great Plains, in alkaline lakes of the Southwest, and in certain Florida spring streams that contain considerable quantities of magnesium and calcium in the form of chlorides and sulphates. Additional data, however, are needed concerning its specific requirements.

Wildrice (*Zizania aquatica*) (pl. 59) can withstand only a moderate degree of brackishness, and for this reason interior races of the species should not be planted in tidal waters. Along the Connecticut River, late in July 1936, the native form of wildrice extended downstream to a point where the water during high tide was a little more than one-fifth as saline as average sea water (chlorine content equivalent to more than 7,100 p. p. m. sodium chloride); during each ebb tide the water probably was appreciably fresher at that point. In mid-September 1936 the native wildrice was noted along the Delaware River at a point where the water at low tide was about one-sixth as saline as sea water (chlorine content equivalent to 5,320 p. p. m. sodium chloride). Along both these rivers this duck food reaches its lower limit of successful growth near the upper limits of the saltmarsh cordgrass (*Spartina alterniflora*) (pl. 55). At such points these two marsh grasses are commonly intermixed for a short distance, but the planting of wildrice should usually be avoided in marshes containing this cordgrass. In the Great Plains region wildrice has been noted only in fresh-water marshes or those with a very moderate degree of alkalinity.

The tidemarsh waterhemp (*Acnida cannabina*) (pl. 98), a valuable duck food of the northeastern tidal sections, withstands a great variation in salinity, thriving in strictly fresh or strongly brackish tide water if allowed periodical emergence during low tide (pl. 127, *B*).

In the western half of the United States and Canada, where alkaline soils are prevalent, a number of plant indicators of alkaline or brackish soils may be used to tell when moist soils contain too great a quantity of salts for the successful growth of most marsh duck foods. One of the most widespread and useful of these indicators is the saltgrass (*Distichlis stricta*. and in coastal areas the closely related *D. spicata*) (pl. 53), which grows abundantly on the moist flats bordering the alkaline or brackish marshes. Several species of glasswort (*Salicornia* spp.) (pls. 96 and 97) and sea blite (*Suaeda* spp.) (pl. 127) also are indicative of such conditions. Wigeongrass can often be used similarly to determine when water areas are too alkaline for the successful growth of most submerged fresh-water duck foods, although this plant is occasionally found in fresh waters.

In most alkaline regions the so-called black alkali (sodium carbonate) is considered more dangerous than white alkali (pl. 127, *A*). In its pure state this salt is white, like nearly all the other salts that cause alkaline soils, but dissolving organic matter from the soil gives it the black color. The nitrates act in a similar fashion and commonly take on a brown color. These salts produce a hard surface crust on the soil, which makes the seepage of water difficult and seriously interferes with plant growth. Although there is evidence that sodium carbonate may be more toxic than other salts occurring in alkaline regions, the hazard to plant growth in such soils appears to be more directly connected with the degree of concentration of the total salts present—the higher the concentration the more rapidly will the plant cells be destroyed or seeds prevented from absorbing sufficient water for germination.

From an agricultural standpoint it is generally considered that soils containing more than 1 percent of soluble salts if sulphates predominate, or 0.5 percent if carbonates, nitrates, or chlorides predominate, are unsuitable for crop production. The toxic effects of a particular salt may vary considerably, however, depending on its ratio to certain accompanying salts or other soluble compounds that may be present. The same facts can be applied to most terrestrial duck-food plants.

The freshening of alkaline situations can be accomplished only through continued flushing with fresh water, thereby causing these soluble salts to dissolve and gradually leach away.

In addition to the aquatic species already mentioned a considerable number of marsh or moist-soil plants that furnish fair or good grades of duck foods are adapted for growth on brackish or alkaline soils and can sometimes be used to improve feeding grounds in such areas. Within the limits of their natural ranges the following plants (listed in systematic order) are worthy of consideration:

Pepperwort (*Marsilea vestita*).
Arrowgrass (*Triglochin maritima*).
Saltgrasses (*Distichlis* spp.).
Sprangletop (*Leptochloa fascicularis*).
Gulf-coast spikerush (*Eleocharis cellulosa*).
Dwarf spikerush (*E. parvula*).
Common spikerush (*E. palustris*, *uniglumis* type).
Spikerush (*E. albida*).
Western scirpus (*Scirpus nevadensis*).
Saltmarsh bulrush (*S. robustus*).
Alkali bulrush (*S. paludosus*).
Glassworts (*Salicornia* spp.)
Tidemarsh waterhemp (*Acnida cannabina*).
Heliotrope (*Heliotropium curassavicum*).
Coastal waterhyssop (*Bacopa monnieria*).

Many other plants are tolerant of lesser degrees of alkalinity or brackishness and may frequently be used in moderately saline soils. Examples are wild millet (*Echinochloa walteri*), chufa (*Cyperus esculentus*), hardstem bulrush (*Scirpus acutus*), common three-square (*S. americanus*), Olney's three-square (*S. olneyi*), sawgrass (*Cladium* *jamaicense*), marsh smartweed (*Polygonum muhlenbergii*), and dotted smartweed (*P. punctatum*).

Gypsum (calcium sulphate) is sometimes found dissolved from the soil and deposited as a white crust on dry lake beds, where it is mistaken for alkali. Although it may be deposited in quantities great enough to prevent the successful growth of duck-food plants, it has been proved that it is not possible to dissolve enough of it to make it injurious to most plants.

Ordinary salt (sodium chloride), on the other hand, may be present in injurious quantities and leave no sign of a crust on the surface.

Even such a valuable compound as limestone (calcium carbonate), which is highly important to the growth of many useful food plants, may be deposited in such great quantities that it retards plant growth. This is clearly shown by the frequent scarcity of aquatic seed plants in the immediate vicinity of limestone springs and on certain marly lake beds.

Boron, in the form of borates, has been found in sufficient quantities in certain western irrigation waters, especially noticeable in volcanic sections, to be injurious to plant life. In parts of California, irrigation waters that contain more than 3 to 5 parts per million of boron are considered by Eaton (*18*) unsuitable for irrigating various cultivated crops. At present the effects of boron on aquatic and marsh duck foods are undetermined and merit careful study, particularly where its compounds accumulate through continued evaporation in western lake beds.

ACIDITY [13]

Acid conditions have a retarding effect on the growth of many aquatic and marsh plants, but are of much less importance in the development of waterfowl feeding grounds than is commonly believed. It is frequently found that many so-called acid waters (brown-stained) actually are neutral or moderately basic, and that their retarding effects on the growth of submerged duck foods are in reality due to the exclusion of sunlight by the dark stains leached from decaying woody debris. The most widespread acid conditions are encountered in the peat-moss-heath associations of certain northern bogs. There the peak of duck-food production has long been passed and waterfowl habitats are largely eliminated through the gradual filling in of former water areas with organic debris.

Acidity may affect the growth of plants by checking the work of nitrifying bacteria and thereby preventing the normal decay of humus, or by increasing the accumulation of carbon dioxide and accompanying toxic organic substances. Acidity also has been shown to have a definite effect on the availability of various soil salts to the plants. Certain salts that may not be toxic under normal conditions are reported to become injurious when concentrations are increased under acid conditions.

Hicks (*32*) has reported that the various species of duckweeds (Lemnaceae) (pl. 86) differ considerably in their tolerance either

[13] The strength of acidity and alkalinity (in the chemical sense) of a solution is measured by its hydrogen-ion concentration, which chemists express in pH valuations. These pH units are used in a manner similar to the degrees of temperature on a thermometer. The chemist uses pH 7 as the neutrality point, and when the pH value of a solution is lower than 7 it is tending to become acid but when the pH value is greater than 7 it is becoming alkaline (basic). Most ordinary fresh-water lakes have a pH range from about 6.5 to 8.5.

to acid or to alkaline conditions. He found that *Lemna minor* tolerated a greater degree[14] of acidity than any of six other species of duckweeds that he investigated.

The duck-food plants listed on page 121 for use in dark-stained waters are equally applicable for planting in moderately acid situations.

BIOLOGICAL FACTORS

UNDESIRABLE PLANTS AND THEIR CONTROL

No form of activity in the propagation of waterfowl food plants merits more careful attention than the effects of the growth of one species upon another. At present there probably is no branch in this field that is in greater need of additional investigation than that of adequate methods of controlling undesirable species and replacing them with plants that are of greater use in the waterfowl habitat.

Waterfowl food plants of various degrees of utility often are found in active competition with one another, to the detriment of the more useful species (pl. 130, *B*). There also is a formidable array of plants of practically no food value to wild ducks that compete actively with useful species and often take over huge areas completely, rendering them practically worthless as feeding grounds. These noxious plants may be roughly divided into three main groups: Aquatic seed plants, marsh seed plants, and algae. Under these headings serious consideration should be given to the following list, which includes species that have been found most detrimental to the growth of waterfowl food plants:

Aquatic seed plants

Waterlettuce (*Pistia stratiotes*) (pl. 128).

Water-hyacinth (*Eichhornia crassipes*) (pl. 144).

Alligatorweed (*Alternanthera philoxeroides*) (pls. 129 and 147, *A*).

American lotus (*Nelumbo pentapetala*) (pls. 122 and 130, *A*).

Waterchestnut, or caltrop (*Trapa natans*) (pl. 131).

Miscellaneous plants of little or no value, including bladderworts (*Utricularia*), waterstargrass (*Heteranthera dubia*), water spikerush (*Eleocharis prolifera*), and certain pondweeds that are normally sterile in North America (for example, *Potamogeton crispus* and *P. robbinsii*) (pls. 132–135).

Marsh seed plants

Cattails (*Typha* spp.) (pl. 150, *A*)—occasionally useful as goose forage.

Maidencane (*Panicum hemitomon*).

Giant cutgrass, or "whitemarsh" (*Zizaniopsis miliacea*) (pl. 141, *A*).

Cordgrasses (*Spartina* spp.—*S. alterniflora* sometimes valuable) (pl. 148, *B*).

Reed, or cane (*Phragmites communis*) (pl. 148, *A*).

Saltflat grass (*Monanthochloe littoralis*) (pl. 136).

River bulrush (*Scirpus fluviatilis*)—usually sterile and very rank, but occasionally a good food producer in the Northeastern States (pls. 81, *C*, and 137, *B*); the related woolgrass (*S. cyperinus*) also has little value and sometimes competes with better plants (pl. 137, *A*).

Sawgrass (*Cladium jamaicense*)—a fair to good duck food, but often so dense and rank as to choke out all other vegetation and convert shallow marshes into impenetrable jungles (fig. 81 and pl. 84, *B*).

Sedges (*Carex* spp.)—many species are fair in usefulness as duck foods but others take over semidry marshes to the exclusion of more valuable plants.

Sweetflag (*Acorus calamus*) (pls. 138 and 150, *B*).

Needlerush (*Juncus roemerianus*) (pl. 146, *A*).

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[14] Hicks reported that *Lemna minor* made its best growth in waters with a pH range of 5.4 to 6.8 and continued to exist in waters with a pH value of 4.5.

Blackrush (*J. gerardi*).
Lizardtail (*Saururus cernuus*).
Waterwillow (*Decodon verticillatus*).
Leatherleaf (*Chamaedaphne calyculata* and related heaths in northern bogs).
Mints (*Mentha* spp., *Stachys* spp., *Lycopus* spp., *Teucrium* spp.—chiefly in dry marshes) (pls. 139 and 140).
Saltmarsh fleabane (*Pluchea camphorata*) (pl. 151, *B*).

Algae

Green algae (Chlorophyceae) (pl. 147, *B*)
Blue-green algae (Cyanophyceae)

A number of species of algae at times become very destructive to submerged seed plants. This destruction arises chiefly from the exclusion of light (pl. 147, *B*) and the weighting down of the taller forms, but certain gelatinous algae often attach themselves to the plants in large quantities and injure them by retarding necessary exchange of gases between the plants and the water; and in the case of other species an actual toxic condition is apparently created by their decomposition.

The filamentous types of the green algae (Chlorophyceae), which are commonly known as pond scums and frequently form dense mats, either floating on the surface or blanketing submerged objects, are most destructive to submerged duck-food plants. The mats often become so thick that sunlight is almost totally excluded and the food plants weaken and disintegrate. In quiet water one of the most destructive blanketing types is *Rhizoclonium*, and along shores where wave action is great *Cladophora* is almost equally harmful. In shallow water and sunny situations, *Spirogyra*, *Oedogonium*, and *Zygnema* are among the common filamentous forms. A number of free-drifting, one-celled green algae also become so abundant as to retard submerged seed-plant growth by reducing the sunlight.

During the latter half of the summer it is common for huge numbers of minute blue-green algae (Cyanophyceae or Myxophyceae) to develop throughout warm lakes, and when this occurs the water is said to be "blooming" or "working." These minute suspended granules, which normally are scarcely visible to the naked eye, become so abundant during prolonged hot weather that they absorb a large proportion of the sunlight over the beds of submerged vegetation and gradually check plant growth. When concentrated by wind and wave action into fleecy masses these algae have a greenish-yellow color and soon form a slimy scum, which on decomposing gives off disagreeable odors, often resembling sewer gas. As this scum is driven in along the beaches and decomposition continues it takes on a conspicuous bluish-green color. During these final stages of decomposition adjacent submerged seed plants, including sago pondweed, have been noted sickening rapidly (near McGregor, Iowa) as though some active toxic substance was affecting their growth. Among the most common of these algae are *Microcystis aeruginosa*, *Coelosphaerium kutzingianum*, *Anabaena flos-aqua*, and *A. circinatus*. A number of gelatinous algae, especially *Rivularia* (one of the Cyanophyceae), attach themselves to many important species of aquatic food plants and gradually weaken them. Coontail is one of the few submerged seed plants that are fairly immune from this pest.

Four main lines of approach, or combinations of any of them, may be followed in a program of aquatic and marsh weed control: (1) Nature may be enlisted in carrying out the work by altering existing water levels or effecting kindred changes; (2) manual methods may be employed; (3) mechanical means may be utilized; or (4) chemical methods of eradication may be attempted. Each procedure has its limitations and advantages, depending on the species of plant and the character of the situation.

In order for control operations to be effective it is highly important that they be conducted at the proper time. Generally, mechanical and chemical control operations on plants that have a rather definite flowering and fruiting season should be put into practice at the peak of the flowering period or just after the blooming season is over but before any fruit has matured, because at that time the reserve of stored plant food is likely to be at its lowest ebb. This usually leaves a brief period for the work, but unless it is done then much effort and expense may be wasted.

Utilizing Natural Control

Many of the objectionable marsh or moist-soil plants become a serious problem only in the shallowest marshes or in those that go practically dry for extended periods. This condition can often be easily remedied by a slight permanent increase in the water level. A permanent depth of 2 to 3½ feet will gradually eliminate most of the objectionable plants. Therefore, the use of low dikes or dams equipped with gates to permit the regulation of the water level is often the most practical permanent measure of weed control.

Complete temporary drainage may likewise occasionally be of use, especially as a preliminary step toward mechanical methods of control. This method, however, is usually applicable only to the truly aquatic species and unless the soil can be thoroughly drained may actually stimulate the growth of noxious marsh plants.

Control through the exclusion of light can occasionally be accomplished on a limited scale. In the case of submerged species, this may be possible in certain areas through the creation of a temporarily turbid condition by means of small floating windmills designed to agitate soft-bottom soils. Experimental tests would be necessary. Such windmills can be constructed on inexpensive rafts and towed to any desired point. Light may be excluded from small patches in semidry marches and limited control obtained by using coverings of tar paper or similar weatherproof materials, but costs are usually prohibitive for wide use.

Carp may be used in spot control on small submerged patches when they can be confined to limited enclosures on soft soils, but they should not be introduced where their escape might become objectionable. Their use should preferably be limited to areas already accessible to carp. Control by this means should be started early in spring, before the plants have made appreciable growth.

Manual Methods of Control

Manual methods of weed control, or combinations of manual and mechanical means, are usually effective only on limited areas, but they have a definite place in arresting early infestations of undesirable plants and in clearing small ponds.

Early in the summer of 1935 a dense patch of the giant cutgrass (*Zizaniopsis miliacea*) (pl. 141, *A*) was discovered along the tidal Potomac River near Fort Belvoir, Va. Because of the danger of spread to adjacent wildrice beds, shortly after the flowering season the plants were all cut off by means of hand sickles just above the ground level. About 6 weeks later a second cutting was made and all the stunted leaves that had grown up after the first mowing were destroyed. A year later the photograph shown in plate 141, *B* was taken at this spot and not a trace of the plant remained. Pickerelweed from the surrounding beds was beginning to encroach on the bare mud that marked the site of the former patch. While severe winter weather may have aided in this elimination, the evidence seems to indicate the effectiveness of mowing.

The dangerous Eurasian waterchestnut, or water caltrop (*Trapa natans*) (pls. 142 and 143), which is becoming destructive to important submerged duck-food beds along the fresh waters of the tidal Potomac, has been successfully controlled in one of the upper beds (in the mouth of an adjacent tributary) by hand labor from a nearby C. C. C. camp. By use of forks and rakes the floating rosettes of this annual plant were pulled into shallow-draft boats and hauled ashore before the seeds had matured. Such work should always be begun at the uppermost beds to prevent reseeding by materials drifting in from farther upstream, and it is highly important that watch be kept during the following season to destroy any young plants developing from seeds of plants missed during the initial operations.

Hand-operated underwater saws now on the market can be used in the control of marsh or certain rooted aquatic plants. These saws consist of flexible narrow bands of steel with both edges toothed and weights attached at intervals of 3 to 5 feet. They are sold in short strips and can be fastened together in lengths as great as 100 feet if desired. A similar type of saw can be made from second-hand licker-in wire, such as that used in the combing process at cotton mills, and described by Gorman (*26*) as follows:

Licker-in wire is used in a combing process in cotton mills and can be purchased from any of the mill-supply houses at about 30 cents a pound, which averages 2½ cents per foot. This wire is similar to a single-edge saw and is 3/16 inch wide and 1/16 inch thick at the hilt. The teeth are right triangles, tapered to sharp points, and have a flat cutting edge. They are 1/8 inch deep and 1/4 inch on centers. The steel is not well tempered, and in short lengths the wire will break if bent abruptly, but in long lengths, such as those used in our work, no abrupt bending was necessary.

By tying the hilts of two "licker-in" wires back to back at intervals of 8 or 10 inches, with cutting edges in opposite directions, a double-edged saw was made, capable of cutting in either direction of a sawing motion. In order to weight the saw and still allow it to take the contour of the lake bed, cast-iron tubes, 4 inches long, were slipped over the saw and leaded in place at intervals of 4 feet. Two 100-foot saws and one 50-foot saw were used in this work, long ropes being tied to each end.

The method of using the saw was as follows: Beginning at the downstream end, the saw was dropped to the bottom of the lake in the middle third, the ropes stretching to either shore. Usually five men were employed in the work, two operators on each shore and a man to observe the effect of the work and direct the shore men. Whenever the saw became entangled in roots or stumps in the bottom of the pond the party in the boat could disengage it by using a long hook. The shore men worked in pairs about 10 feet back from the water edge, each holding one end of a 1-inch water pipe 4 feet long to which the rope from the saw was tied. In narrow places, when the short saw was used, but one operator on each shore was employed. Frequent rests were allowed the operators at first, for the sawing motion was very tiresome until they became accustomed to it.

Sawing was done, of course, against the current, the growths rising to the surface as cut, and floating down stream. By purposely leaving untouched a belt of this aquatic growth across the lake, at a narrow place, down stream, the "floatage" was obstructed and collected in little islands that could then be conveniently dragged to shore.

Mechanical Means of Control

Mechanical means of control may involve the use of aquatic and marsh mowing machines, floating rakes (pl. 145, *B*), cables, crushing devices, and plows.

W. F. Kubichek reported that two mowings of a dense growth of cattails along Lake Mattamuskeet, N. C., had retarded that plant enough to permit a good growth of three-square to replace it during the following season. The first mowing was made at the time the plants were flowering, and this was followed by another mowing as soon as the plants had again reached a convenient cutting height (about 1½ to 2 feet). It is probable that the effectiveness of the work would have been further increased by a third cutting made after the remaining new growth had developed during the following spring.

Underwater mowing machines now on the market can mow at any depth down to 4 feet. These are operated by gasoline engines, which also supply the power for propelling the flat-bottomed boats on which they are mounted. These shallow-draft boats are driven by a stern paddle wheel, so that they can be operated with a minimum of interference from vegetation.

A crushing device for large-scale operations in removing dense beds of water-hyacinth (*Eichhornia crassipes*) (pl. 144), recently developed by the United States Engineers of the First New Orleans District, La., is described by Wunderlich (*90*). It consists of a self-propelled barge equipped with a conveyor and corrugated rollers that crush the plants. The crushed material is returned to the water as the barge progresses through the beds. Such equipment would be practicable only on extensive beds in water deep enough to float a fair-sized powerboat and should be correlated with other methods to complete the eradication. In many areas it would eliminate the use of costly toxic chemicals.

A smaller outfit, consisting of two pontoons equipped with an endless-chain conveyor, for use in narrow streams, has been developed by the same engineers. This device merely removes the plants from the water and deposits them on the banks where they soon die. Beds of waterlettuce (*Pistia stratiotes*) (pl. 128) can be handled in a similar manner.

With slight modification, an aquatic reaper for the removal of gross quantities of waterchestnut (pls. 131, 142, 143) or other aquatic plants attached to the bottom, might be constructed along the plan of the large kelp harvesters illustrated by Crandall (*12, p. 107*) and described briefly by Scofield (*77*). The harvester consists of a large shallow-draft boat with a submerged cutting apparatus and conveyor, somewhat like that of an ordinary grain reaper, mounted on the bow. The plants could be passed through a grinder or crusher and discarded in a single operation.

Mowers for marsh use have been developed to operate from lightweight automobile chassis equipped with special broad-rimmed, cleated tractor wheels. Mowers of this type have been used in New Jersey marshes in an effort to keep down the dense growths of reeds and cattails that followed mosquito-control drainage operations. Two cuttings a season were reported necessary to suppress these two undesirable plants.

A weed-crushing device developed by the Bergen County, N. J., mosquito-control workers is reported to be much more effective in controlling undesirable plants than the mowing implements previously in use. Peterson (*66*), of the Bergen County Mosquito Extermination Commission, has published a detailed description of its construction. It consists essentially of a light automobile chassis equipped with very wide-rimmed tractor wheels (combined width of rear rims 4½ feet) upon which are bolted a series of cleats made of angle irons about 8 or 9 inches apart and extending across the entire rim of each wheel. These cleats make a series of crimps in the crushed stems that was reported to result in a much greater retarding effect on later growth than was obtained by continuous mowing in the same area. To destroy the vegetation on the strip lying between the crushing wheel rims a detachable, cleated roller could be fastened in the rear and equipped with a frame so that any desired weight could be added. This type of a weed eradicator was constructed at a total cost of less than $500 and is worthy of serious consideration in any extensive program of giant-weed elimination in semidry marshes. Specifications for the construction of one of these reed crushers have been published (*66, p. 72*).

Chemical Control

The control of undesirable aquatic and marsh plants by means of chemicals as an aid to increasing the natural supply of waterfowl foods is still in the experimental stage, although chemicals have been used for many years in the control of the water-hyacinth (*37*) for maintaining navigation on southern waters, and in controlling algae in public water supplies (*30*). In recent years the value of chemical methods of controlling certain submerged seed plants as an aid to fish-cultural practices has been demonstrated by the Bureau of Fisheries (*80*).

During 1935 and 1936 the writers experimented with various chemicals primarily to determine their effectiveness in the control of waterchestnut on the tidal Potomac, and incidentally to note their effects on a number of worthless or low-grade marsh plants known to compete with more valuable waterfowl food plants. The chemicals were used in solutions applied with pressure sprayers, and in the case of those that could be obtained in the form of a fine dry dust the experiments were broadened to include dusting operations as well, after thoroughly mixing the toxic chemical dusts with various proportions of nontoxic dusts. The chemicals used were sodium chlorate, sodium arsenite, sodium chloride, copper sulphate, iron sulphate, zinc chloride, ammonium thiocyanate, calcium oxide (quicklime) and a commercial herbicide. Since, in excessive quantity, some of these chemicals are dangerously poisonous to fishes and other aquatic organisms, care had to be taken to prevent damage to valuable forms of animal and plant life, and in the case of the highly inflammable sodium chlorate, precautions were taken to avoid any fire hazard.

These experiments showed that in shallow waters (1½ to 4 feet deep at low tide) with an average tidal fluctuation of about 2¾ feet, sufficient to flush out of the beds twice a day in the isolated coves as well as in the main river, effective control of waterchestnut could be obtained if the proper solution was applied during the 12-day period immediately prior to the earliest maturity of the fruits. In the Washington section this usually is limited to about the first 12 days in July (in warm seasons it would doubtless be somewhat earlier and in cool seasons later). The most effective kill was obtained on calm, hot days by spraying at low tide during bright sunshine. A solution containing 1 pound of dry, powdered sodium arsenite and half a pound of sodium chlorate dissolved in 1 gallon of water sprayed on an area of 150 square feet (covered by a solid floating mat of the plant) produces a nearly total kill when not applied too early in the season (pl. 145, *A*). This spraying resulted in total disintegration of the beds in a little over 2 weeks. The powdered sodium arsenite was obtained at that time at 10 cents a pound in large quantities and the sodium chlorate at 6½ cents a pound.

Other chemicals were less effective unless used in concentrations great enough to be injurious to valuable aquatic life. The concentrations needed here would be too great to use in shallow lakes or other still waters, and further experimentation in such situations is necessary. Plants that appeared to be effectively controlled by earlier sprayings produced a new crop of rosettes and matured fruit late in the season, long after untreated beds had matured and disintegrated. Spraying was accomplished by means of 4-gallon hand-operated sprayers capable of developing a pressure of 90 pounds when fully charged. A medium-fine spray was found more effective than a very fine spray and was more easily controlled in the breeze. Submerged growths of wild celery, naiads, and several pondweeds did not appear to be affected by this spraying, and a good growth of the big duckweed (*Spirodela polyrhiza*) developed on the sprayed plots in a short time. In still waters, however, where currents do not carry away the spray solutions, the concentrations used in these experiments would probably be injurious to submerged plants.

Sodium arsenite must be used with due caution as it is a dangerous poison if taken internally by man, game, or livestock. It is likely to leave emergent soils sterile for a long time and for that reason is usually unsuitable for such situations in feeding grounds.

Sodium chlorate is inflammable, and care should be taken not only to keep fire or sparks away from this compound as used in the field but also from clothing that at any time may have been saturated with it.

In the control of water-hyacinth on navigable southern waters, officials of the United States Engineers Office at New Orleans, La., prepared their own sodium arsenite for use in spraying operations, as follows:

1. Six hundred pounds of white arsenic (arsenious oxide) and 600 pounds washing soda (sodium carbonate) are placed in a tank with about 600 gallons of water. This mixture is brought to a boil and kept boiling for 2 hours. It is then drained off and diluted to 9,600 or 12,000 gallons (depending upon the strength of solution desired), by the addition of the necessary amount of water. By using proportions, 1 pound of arsenic to 1 pound of soda, boiled in 1 gallon of water and diluted to 16 to 20 gallons of solution, any desired quantity may be mixed.

2. For spraying the solution over the hyacinths, a duplex Worthington pump (size 4½ by 2¾ by 4 inches) and 1-inch steam hose, 6 ply, with a Fuller nozzle, is used. This nozzle is used for the reason that it gives a very fine spray, which is desirable to avoid waste of material. The pressure on the hose is usually fifty pounds.

3. Upon warm sunshiny days, 1 gallon of the diluted solution is, ordinarily, sufficient to destroy 10 square yards of hyacinths. If the day is cloudy or cool, a larger quantity is necessary. Where the hyacinths are very tall, the spray does not reach the shorter plants, and the first application kills only the taller ones. A second application then becomes necessary in order to reach those not touched at first.

Control experiments with a variety of marsh plants indicate a tremendous variation in resistance to the same chemical solution for different species investigated. On semidry marshes in Dorchester County, Md., needlerush (*Juncus roemerianus*) (pl. 146) was effectively controlled by a single late-July spraying of ammonium thiocyanate (available in an impure form as a byproduct of the coke industry), but saltmeadow cordgrass (*Spartina patens*) showed little or no ill effects from its use. One gallon of the solution containing 1½ pounds of the crude chemical dissolved in water was found satisfactory for spraying 150 square feet of marsh. Since this chemical contains about 35 percent of nitrogen that becomes available to the soil it does not have the objectionable effects of sodium arsenite, which leaves the soil sterile a long time for many species. Its effect on animals is at present unknown and therefore the usual precautions should be taken. Sodium arsenite, dissolved in the proportion of 1 pound per gallon and sprayed on a similar plot, gave complete control of needlerush but showed little if any injury to the common three-square (*Scirpus americanus*), and a year later a luxuriant growth of saltgrass (*Distichlis spicata*) was encroaching on the plot. Copper sulphate sprayed at a similar rate gave a nearly complete kill of needlerush, but showed little effect on saltmeadow cordgrass and three-square. Both copper sulphate and sodium arsenite should be used with extreme care to prevent poisoning valuable plant and animal life. The saltmeadow cordgrass was effectively controlled by a solution containing 1½ pounds per gallon of sodium chlorate when used similarly. River bulrush (*Scirpus fluviatilis*) and beggarticks, or Spanish needles (*Bidens* spp.), were controlled fairly well by a solution of ammonium thiocyanate similarly used.

All chemical solutions should be carefully strained before pouring into a sprayer to avoid clogging the nozzle.

In general, chemical methods are too costly and have too many attendant hazards for the control of marsh weeds and should be used only where other methods are found impracticable.

Surber (*80*) reported that a commercial sodium arsenite weed killer containing 4 pounds of arsenious oxide (As_2O_3) per gallon had been successfully used in killing coontail, waterstargrass, waterweed, and certain pondweeds in shallow ponds for fish-rescue work in the upper Mississippi Valley. One gallon of this solution is equal to 1 part per million of arsenious oxide when mixed with 64,082 cubic feet of water. Effective control of the most submerged plants was obtained by Surber, without apparent injury to fishes, when this chemical was used in a concentration of from 1 to 1.7 parts per million of arsenious oxide in water (or roughly at the rate of about 1 gallon of the 4-pound solution to from 37,700 to 64,000 cubic feet of water). The solution was applied in its original concentration (or slightly diluted when the quantity was small) in a 3-gallon pressure sprayer. To avoid dangerous concentrations, accurate estimates of the volume of water to be treated must be made before spraying.

Fire may sometimes be used in the control of marsh plants. Various types of pressure torches, or fire guns using kerosene or light fuel oils, have been developed for weed control and are on the market.

Copper sulphate in weak solutions has been successfully used to combat algae. The treatment should begin before the algae have become abundant enough to be harmful. This chemical is very toxic to fish if used in excessive quantities. Hale (*30, p. 24*) indicates the killing dosage of copper sulphate for common fresh-water fishes, based on the experiments of Moore and Kellerman (*55, p. 11*) as shown in table 12.

TABLE 12.—*Killing dosage of copper sulphate for common fresh-water fishes (after Hale)*

Fish	Parts per million	Pounds per million gallons	Fish	Parts per million	Pounds per million gallons
Trout	0.14	1.2	Goldfish	0.50	4.2
Carp	.33	2.8	Perch	.67	5.5
Suckers	.33	2.8	Sunfish	1.35	11.1
Catfish	.40	3.5	Black bass	2.00	16.6
Pickerel	.40	3.5			

This subject needs further careful study, for the toxicity of a given dilution of copper sulphate is known to increase with a rise in temperature and decrease as the temperature falls.

Copper sulphate has been used most successfully in controlling surface algae by dissolving it in water and applying with a pressure sprayer. It has been found that submerged algae, however, can be controlled more effectively by towing burlap bags, each containing about 50 pounds of the crystals, suspended from the sides of a slowly moving boat. Moore and Kellerman (*54, 55*), Marsh and Robinson (*49*), Domogalla (*16*), and Hale (*30*) have presented valuable information regarding the use of this chemical. While there is great variation in the resistance of various types of algae to this treatment, most of the species that are injurious to duck-food plants can be controlled by a treatment of 1 to 4 pounds of the crystals per million gallons (or about 133,700 cubic feet) of water. If the water is very hard or contains a large quantity of organic matter, more of this chemical is needed to control the algae than would otherwise be required. A considerable number of large lakes in the United States are satisfactorily treated with copper sulphate each year. The writers were unable to discover any evident injury to aquatic seed plants in Bantam Lake, Conn., which has been successfully treated for a number of years, but excessive concentrations are known to be injurious to many seed plants and therefore great care should be taken in control work, especially in shallow waters.

ROUGH FISHES

In waters with moderately firm sandy bottoms, rough fishes may often be abundant but have little injurious effect on the aquatic vegetation. In the United States the destructiveness of the introduced European carp (*Cyprinus carpio*), however, is well known. The permanent turbidity of the water that results from its rooting in soft bottom soils often completely eliminates aquatic vegetation in important feeding grounds. Some of the plants are actually uprooted or eaten, but more may be destroyed when the roiled waters exclude the sunlight. The same effects have been noted to a lesser extent from the feeding activities of the native American carp (*Carpiodes* spp.), its near relatives the buffalo fishes (*Ictiobus* spp.), as well as a number of other members of the sucker family (Catostomidae), and the catfishes (Ameiuridae). In any broad program of carp eradication, however, the fact must be given due consideration that in many areas, from the standpoint of quantity production and total value, the European carp is becoming of foremost importance as a commercial fish.

Where there are no valuable fishes it is sometimes possible to poison with copper sulphate those that are destructive, but this chemical should be used rarely and with caution, for in concentrations great enough to kill fishes it is likely to be injurious to valuable plants. Derris, derived from the crushed roots of a tropical plant (*Derris elliptica*), is widely known among tropical peoples as a fish poison (*49*) and is worthy of careful experimentation in the control of rough fishes.

In lakes where bottom debris would not prevent the use of seines rough fishes can be successfully eliminated by seining, and often a fair market price can be obtained to offset the expense involved. Commercial seining during the winter season, in many Minnesota lakes, has successfully reduced the carp and other rough fishes to the point where they do little damage. This seining is conducted under the ice by special methods described by Klancke (*38*), at a season when the fishes usually bring a good price. In water areas where submerged debris makes seining impracticable, trap or fyke nets with long leaders and also pound nets can often be used satisfactorily, and under such conditions, or in water too deep for seining, gill nets may be useful.

In some situations rough fishes can be destroyed by lowering the water levels enough to permit freezing to the bottom; in other areas, by total temporary drainage. Such methods should not be used where an appreciable destruction of valuable fishes will result.

OTHER WILD VERTEBRATES

Muskrats (*Ondatra zibethica*) occasionally become a major factor in preventing the establishment of valuable marsh plants, particularly in areas where propagation is attempted on a small scale. There the muskrats may devour planted materials as fast as they get a start. At times it has been necessary to reduce their numbers appreciably in the Upper Mississippi River Wildlife and Fish Refuge, where they have been found destroying 30 to 50 percent of the wildrice before seed can mature. Wildrice is a favorite summer food of these fur animals along the upper Mississippi River.

Occasionally, by the construction of dams, beavers (*Castor canadensis*) alter water levels sufficiently to drown out useful beds of marsh plants, but more often their work increases the area of waterfowl feeding grounds.

Deer (*Odocoileus*) and moose (*Alces*) at times feed extensively on marsh and aquatic vegetation, and when abnormally abundant may occasionally injure early plantings, but such conditions are rare and need cause little concern.

In the case of all these animals, necessary control can usually be satisfactorily accomplished merely by relaxing existing restrictions on trapping and hunting.

Blackbirds and bobolinks (Icteridae) feed extensively on wildrice seeds, and the former often are abundant enough appreciably to reduce the supply that would later be available to waterfowl. In their feeding activities, however, they almost always shake off a considerable proportion of the seed and thus are instrumental in natural reseeding.

Waterfowl themselves at times become abundant enough on limited areas to reduce seriously the natural food supply or render the success of plantings difficult. This is particularly the case in protected situations where the birds concentrate in abnormal numbers. It is safest to prevent such concentrations on recently planted feeding grounds until the beds become well established.

INSECTS AND MISCELLANEOUS INVERTEBRATES

A great variety of insect pests are known to attack waterfowl food plants and occasionally thus become highly destructive. Examples are found in the reduced crops of wildrice due to the feeding activities of larvae of a minute moth, which destroys the immature rice seeds, and of certain fly larvae (Ephydridae and other Diptera), which damage the leaves and stems of many submerged plants. Occasionally the leaves of wildcelery in Potomac River beds are riddled by these larvae.

The greatest damage to marsh or aquatic plants is done by various leaf beetles (Chrysomelidae), snout beetles (Curculionidae), leaf- or stem-mining flies (Ephydridae, Scatophagidae, and others), midge larvae (Chironomidae), caterpillars (aquatic Pyralididae, particularly the Nymphulinae), caddisfly larvae (Leptoceridae and Hydroptilidae), froghoppers (Delphacidae), and grasshoppers (Acrididae and Locustidae). Comparatively little is known concerning practical methods of controlling many of these pests, and the cost of control would be prohibitive.

In addition to the insects, certain crustaceans occasionally become destructive to aquatic plants. Several species of crawfish feed to a great extent on submerged vegetation, and at least one of them, *Cambarus rusticus* (a species common in the lower Ohio River and its tributaries), is reported by G. C. Embody to be used to eliminate muskgrass, waterweed, naiads, pondweeds, blanket algae, and other aquatic plants from fishponds. Some plants, as watermilfoil and pepperworts apparently are not attacked by this species. A southern crawfish (*C. clarkii*) has been reported (by P. Viosca to the Biological Survey) to feed similarly in the vicinity of New Orleans, La., and another species (*C. hagenianus*) is frequently destructive to terrestrial plants in southern fields.

PLANT DISEASES

Very little is known concerning the diseases that affect aquatic and marsh plants, but from time to time they cause major catastrophes. During recent years the almost complete destruction [15] of the eelgrass beds along the entire Atlantic coast, by a pathological condition resembling a fungous disease furnishes ample evidence of the serious problems that occasionally develop in this field. The disappearance of this important marine food plant has resulted in a critical reduction in the North American brant population.

The effects of disease are noted frequently in many marsh plants, but usually these are not serious enough to cause a marked reduction in the food supply. Further careful study is needed in this field, however, since no practical means of control have as yet been formulated.

Until methods of disease control are developed, all attempts to combat the effects of waterfowl-food scarcity resulting from disease must be based chiefly on replanting destroyed beds with more resistant varieties or with species transferred from other areas. The Bureau of Biological Survey is experimenting in the reestablishment of the destroyed eelgrass beds by transplanting the same species from the Pacific coast, where at present it is uninjured; and also in the establishment of other salt-tolerant species, as wigeongrass, in the depleted areas.

ECONOMIC FACTORS

Some of the economic factors that retard the growth of marsh and aquatic plants are more or less indirect and have been discussed under previous headings (as silting, fluctuation of water levels, etc.), but several stand out conspicuously as attributable to man's bad judgment or to his efforts to gain a livelihood. Obviously much of this damage is unavoidable, but a great deal has been unnecessary. Foremost among these destructive forces are drainage, pollution, livestock overgrazing, and to a lesser degree, harmful methods of fishing. Each is here discussed briefly.

DRAINAGE

The reasons for drainage are manifold. Some drainage has been effected in a sound effort to improve agricultural lands. On the other hand, much of it has been the result of unwise promotional schemes, some of which have forced large numbers of farmers into bankruptcy and occasionally brought financial ruin to entire counties. Vivid illustrations are found in northwestern Minnesota. Bankrupt drainage districts have ruined farmers, investors, and waterfowl feeding

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[15] COTTAM, CLARENCE. THE PRESENT SITUATION REGARDING EELGRASS (ZOSTERA MARINA). U. S. Bur. Biol. Survey Wildlife Research and Management Leaflet BS-3, 7 pp. February 1935. [Mimeographed.]

grounds alike in nearly all parts of the country, but have been most in evidence in the Mississippi drainage basin.

Formerly productive marshes totaling hundreds of thousands of acres today lie barren of useful crops and valuable forms of wildlife. They usually become overgrown with dense tangles of reeds (pl. 148, *A*), willows (pl. 149, *A*), and cattails (pl. 150, *A*), and often become infested with thistles and other noxious weeds, the seeds of which are disseminated by the winds throughout the surrounding territory.

In recent attempts to abate the mosquito nuisance, a greatly expanded program of draining marshes by digging innumerable small ditches has destroyed large expanses of the important coastal feeding grounds of waterfowl and to a lesser extent valuable inland marshes (pl. 151). Near centers of population and in malarial sections, such work is justifiable but in areas remote from centers of human habitation it has brought much unnecessary destruction through overexpansion. When drained in this manner the coastal marshes commonly become densely overgrown with such worthless shrubs as baccharis and hightide-bushes (pl. 152). With proper planning and supervision effective mosquito control drainage can often be accomplished in tidal regions without the destruction of waterfowl feeding grounds. This can be effected through the installation of tide gates equipped with sills that maintain the minimum water depth necessary for aquatic plant growth (usually about 1 foot) but permit sufficient circulation to prevent the development of mosquito larvae.

Frequently the desired end can be attained just as effectively by stabilizing intermittent marshes, as described by Clarke,[16] or by submerging mosquito breeding places as by draining them, and as a result the areas may be actually improved for waterfowl. Submerging the areas permits those effective natural enemies of mosquitoes, the top minnows, or killifishes (Poeciliidae and Cyprinodontidae), to eliminate the larvae. One of the most effective of these fishes in the southern half of the United States is the mosquito fish (*Gambusia affinis*, inclusive concept). Descriptions of such methods of control are available in many publications (*33*, *56*, *82*).

The restoration of drained marshes is often made possible by the construction[17] of dams, dikes, and diversion ditches. The Bureau of Biological Survey is engaged in an extensive program of acquisition and restoration of such areas for waterfowl-refuge purposes at strategic points along the important migration lanes throughout the country.

POLLUTION

Pollution by large quantities of industrial or domestic waste has ruined important waterfowl feeding grounds in many parts of the United States. The lower Delaware River and the Illinois River are striking examples. Industrial wastes usually are more destructive than the wastes found in ordinary sewage, for they frequently contain large quantities of toxic chemicals, whereas domestic pollutants usually become ruinous to plant life only when abundant enough to cause excessive turbidity. In both classes of pollutants the

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[16] CLARKE, J. LYELL. MOSQUITO CONTROL AS RELATED TO MARSH CONSERVATION. Des Plains Valley Mosquito Abatement District, Lyons, Ill., 12 pp., illus. 1937. [Mimeographed.] Reprint of address entitled "Mosquito Abatement versus Wildlife Preservation." before the Chicago chapter of the Illinois Conservation Council, Oct. 21, 1937.

[17] See p. 117 for references to publications that are useful in such construction activities.

accompanying exclusion or absorption of sunlight is a highly destructive factor. Ordinary sewage in moderate quantity often acts as an actual fertilizer to aquatic and marsh plants when the waters do not become excessively turbid, but it is likely to be destructive to fishes through the reduction in the dissolved oxygen that usually is brought about by decomposition.

The most common forms of dangerous industrial pollution are paper- and pulp-mill wastes, tannery wastes, dye wastes from knitting mills, wastes from illuminating plants, wastes from the manufacture of corrosive chemicals, metal refinery wastes, oil emulsions from various sources, salt water from oil wells, and packing-house, cannery, and creamery wastes. The destructive effects of such materials can be eliminated only through the construction and proper operation of disposal or treatment plants at the sources of contamination.

Useful data regarding the construction of sewage-disposal plants have been published by many specialists in that field (*58*, *71*, *79*), and numerous publications on the subject of pollution have been issued by the Bureau of Fisheries. A good bibliography of the literature in this field can be found at the end of the recent valuable publication by Ellis (*19*).

GRAZING BY LIVESTOCK

It has already been pointed out that the presence of excessive numbers of livestock may cause objectionable erosion sedimentation, turbidity, and perforation of thinly sedimented bottoms of shallow basins that overlie porous soils In addition to these factors, direct destruction of valuable food plants through the feeding habits of cattle, horses, sheep, goats, and hogs is conspicuous in numerous waterfowl feeding and nesting grounds (pl. 153). A reduction in the numbers of grazing stock or their exclusion by fencing offers the only solution to this problem.

COMMERCIAL FISHING

Certain types of commercial fishing occasionally are injurious to submerged duck-food plants. The injury may result either from the use of fishing gear that tears out the rooting system, or from excessive seining, particularly during the early part of the growing season when the tender plants are easily broken. Regulation of fishing activities that interfere with growth will forestall this type of damage to waterfowl food plants.

SUMMARY

Much of the failure and wasteful expenditure that has attended efforts to improve food resources of game ducks is avoidable; the utilization of information being developed by research will reduce unnecessary error, expense, and disappointment. Success in increasing or improving food resources for game ducks requires information of the three types detailed in this bulletin: Data on the relative value of the various kinds of marsh and aquatic foods in any region; identification of the more important species utilized as food, and knowledge of their habitats and ranges; and principles of plant propagation and feeding-ground management.

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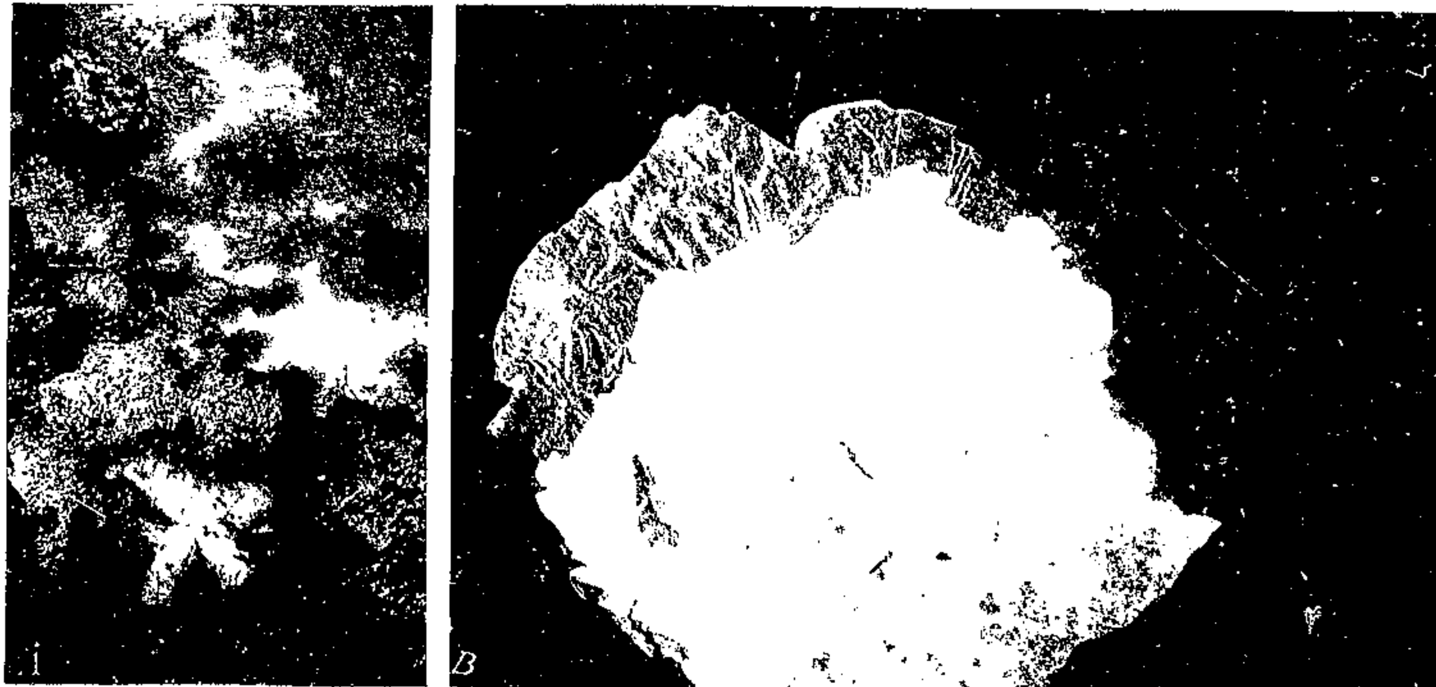
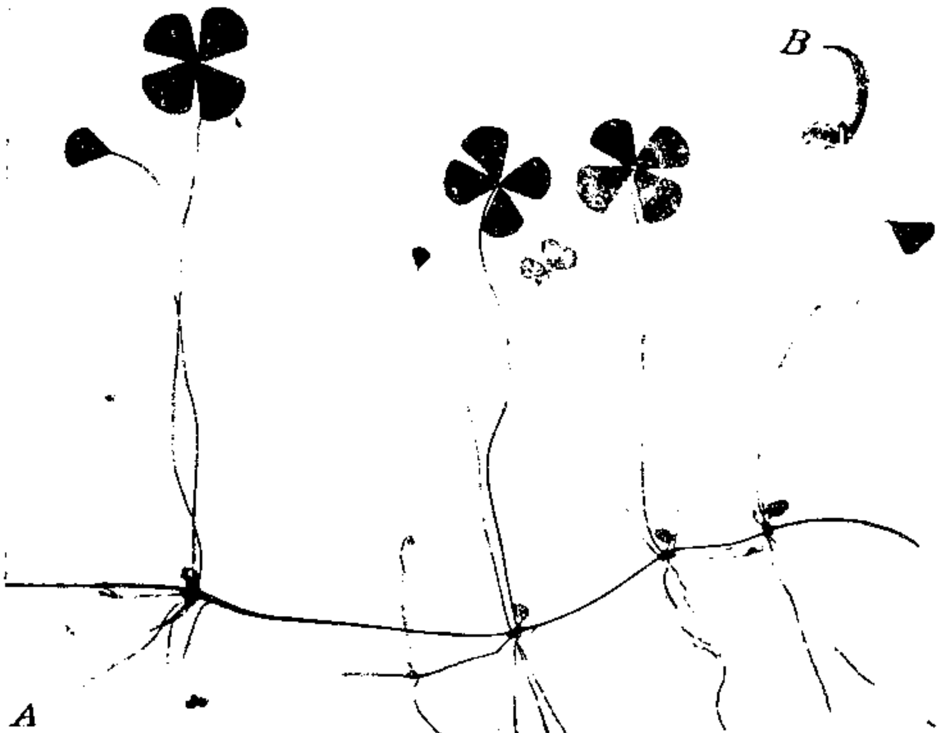


B43904; B6035M

A, Green seaweed (*Ulva* [*Enteromorpha*] *clathrata*), in Choptank River, Dorchester County, Md. *B*, Sea-lettuce (*Ulva lactuca*) (slightly reduced), from mouth of James River, Va.

Muskgrasses. × [illegible]: *A*, *Tolypella* sp., from [illegible], N. C.; *B*, *Chara* sp., from Potomac River, Md. *C*, Oogonium of *Chara*, × 10.

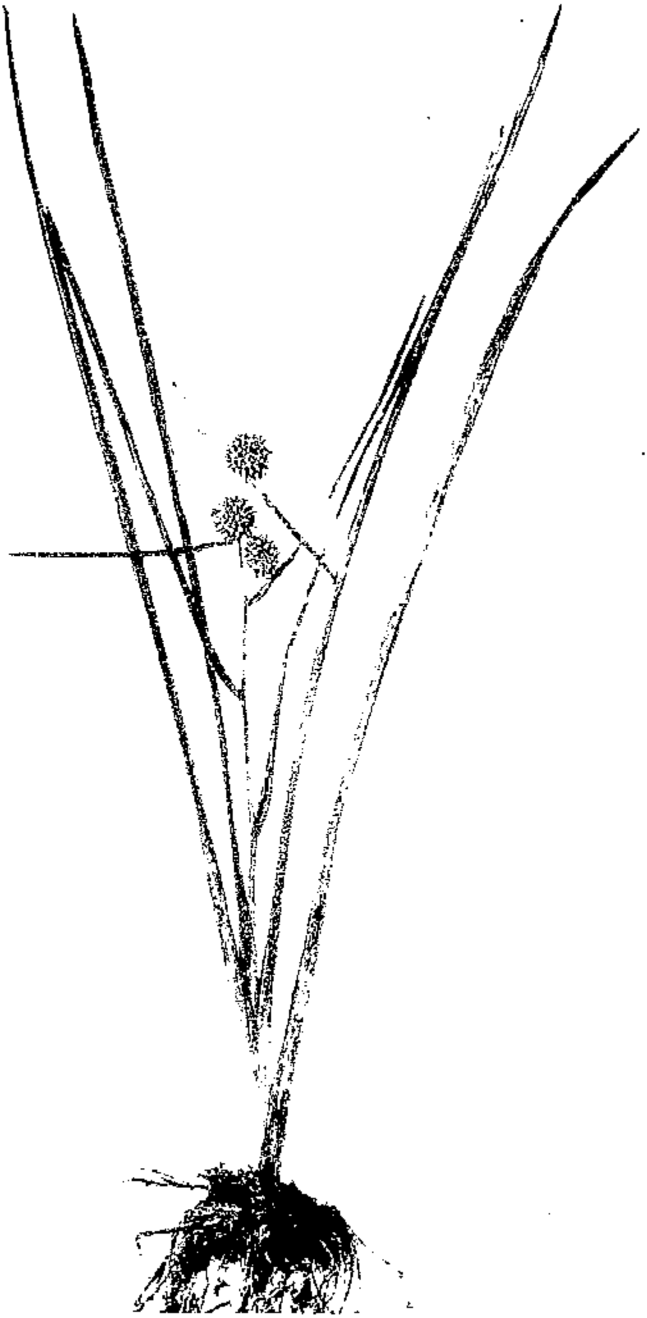


B60741M; B43750

A, Pepperwort (*Marsilea vestita*), × 2/3, from Stafford County, Kans. B, Sporocarp (fruiting structure), × 2½. C, Baldcypress swamp, Reelfoot Lake, Tenn., with blanket of duckweeds (*Spirodela* and *Wolffia*) covering water in foreground.

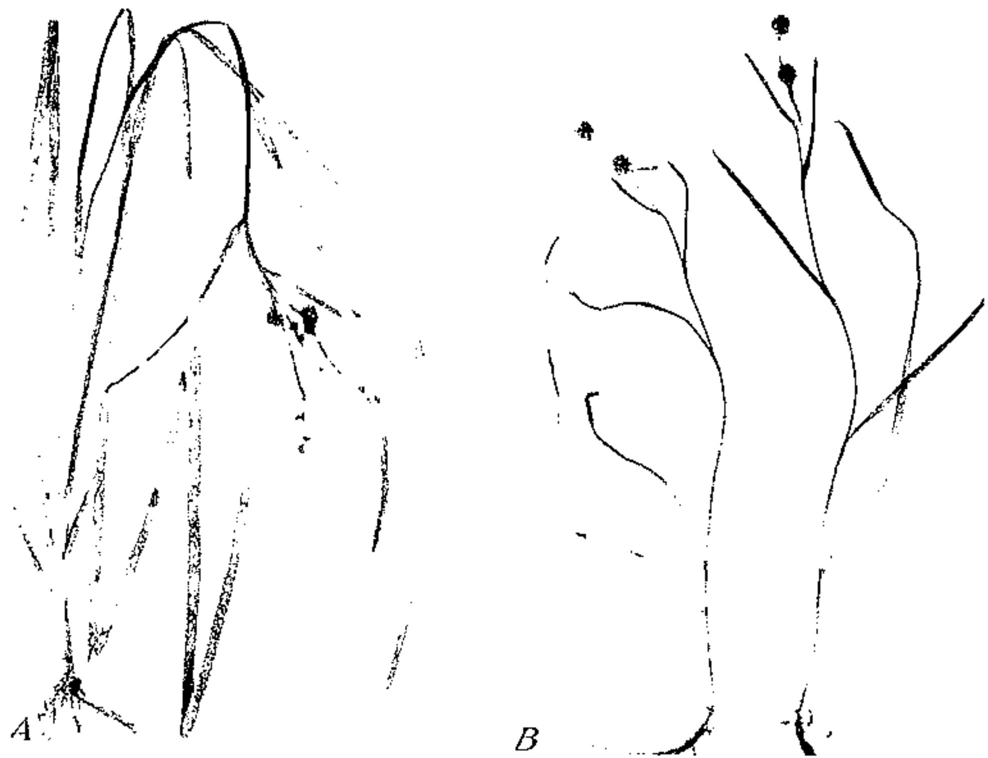
F6.44M

Giant burreed (*Sparganium* [illegible]). *A*, Specimen, [illegible], from Lake Gogebic, Mich. *B*, Six seeds of same relative size as in *A*. [illegible] *C*, Group of seeds, × 1[illegible] *a*, normal exterior; *b*, outer portion removed by digestion; *c*, cross section.



98491M

Burreed (*Sparganium chlorocarpum*), $\times \frac{3}{8}$, from Hampshire County, Mass.



B6043M; B6207M

Burreeds: A, *Sparganium fluctuans*, × 1/3, from Kennebec County, Maine. B, *S. minimum*, × 2/3, from Itasca County, Minn.

B0216M

Sago pondweed (*Potamogeton pectinatus*): *A*, Specimen, × ¼, from Mountrail County, N. Dak. *B*, Tubers from Detroit Lakes, Minn. *C*, Tubers from stomach of a canvasback taken at Oak Lake, Manitoba. *D*, Seeds, × 3½: *a* and *b*, specimens with outer parts removed; *c*, normal seed.

[illegible] *[illegible]* [illegible] Behr[illegible] [illegible], M[illegible]

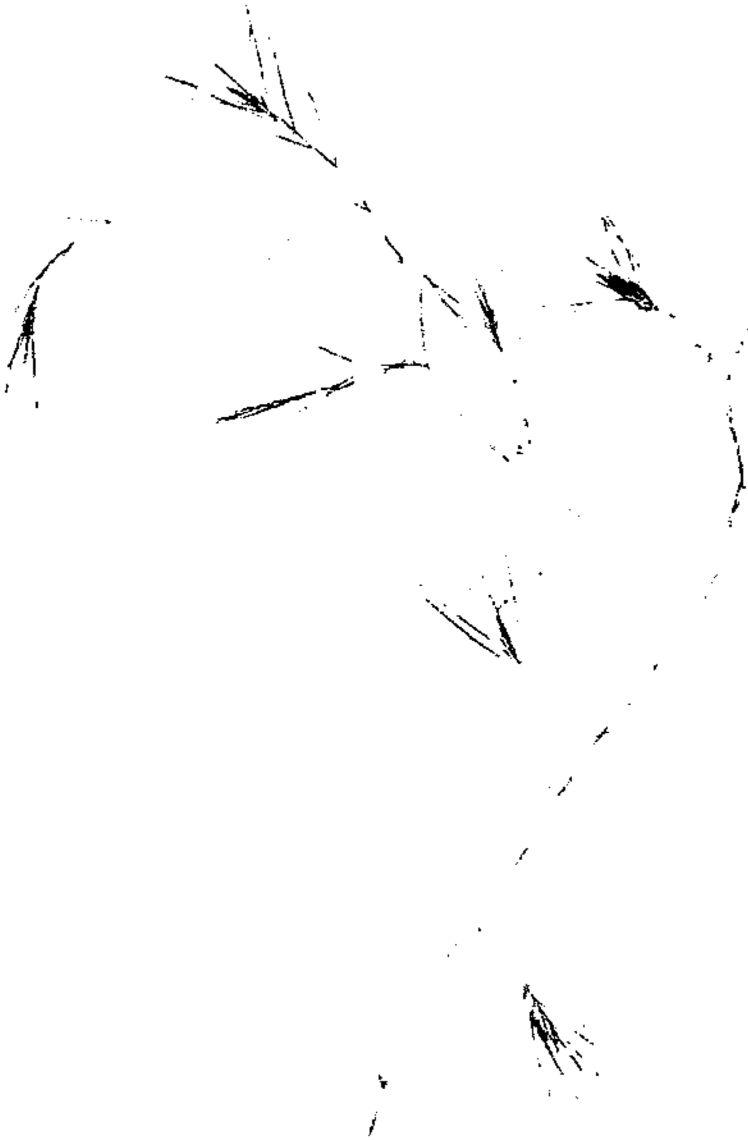
60:90M

Flatstem pondweed (*Potamogeton zosteriformis*), × 1, from the Mississippi River bottoms, Houston County, Minn.

Pondweed (*Potamogeton foliosus*): *A*, Plant, × [illegible], from Kenosha County, Wis. *B*, Seeds, × 3: *a*, side view showing wing or crest; *b*, cut surface showing interior. *C*, Bed of this pondweed in shallow tidewater of the Potomac River.

Pondweed (*Potamogeton pusillus* var. *polyphyllus*): *A*, Specimen, × ½, from Kennebec County, Maine. *B*, Branch and fruiting spike, × ½. *C*, Seed, × 3½.

Pondweed (*Potamogeton obtusifolius*), × ½, from Gogebic County, Mich.



Pondweed (*Potamogeton* [illegible]) from Walworth County, Wis.

Pondweed (*Potamogeton longiligulatus*), × [illegible], from Schoolcraft County, Mich.

Pondweed (*Potamogeton spirillus* [illegible]), from Lake Gogebic, Mich.

[illegible] M

Pondweed (*Potamogeton* [illegible] (*P.* [illegible])) from Franklin County, Maine.

56186M

Largeleaf pondweed (*Potamogeton amplifolius*), × [illegible], from Walworth County, Wis.

Longleaf pondweed (*Potamogeton americanus*): *A*, Specimen, [illegible], from the Mississippi River bottoms in northeastern Iowa. *B*, Fruiting spikes, × [illegible]. *C*, Bed of this pondweed in the Chesapeake and Ohio Canal, Montgomery County, Md.

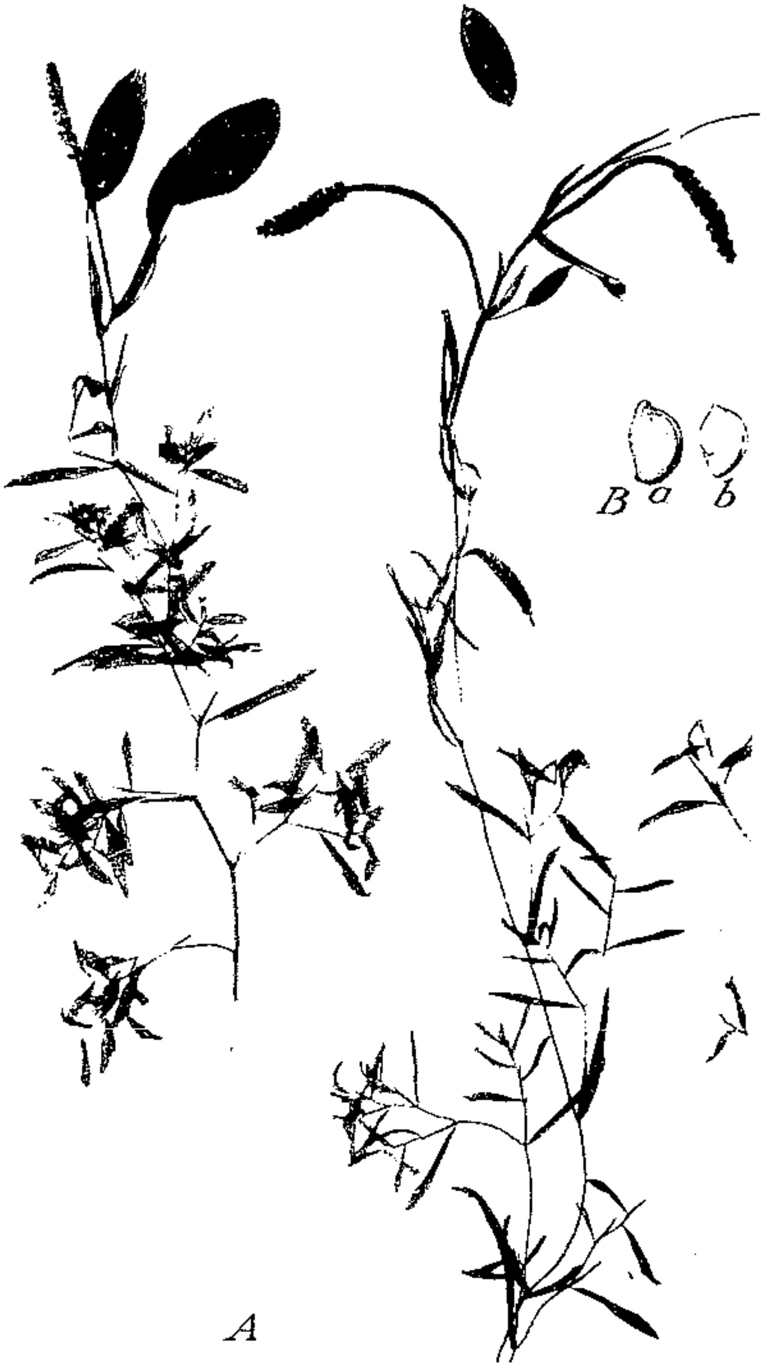
Floatingleaf pondweed (*Potamogeton natans*). *A*, Upper part of plant, × ½, from Hennepin County, Minn. *B*, Seeds, × 4: *a*, normal; *b*, with outer parts removed. *C*, Fruiting spike, × ½.

B6292M

Pondweed (*Potamogeton illinoensis*), × [illegible], from Walworth County, Wis., showing upper part of plant, with flower spike and typical stipules.

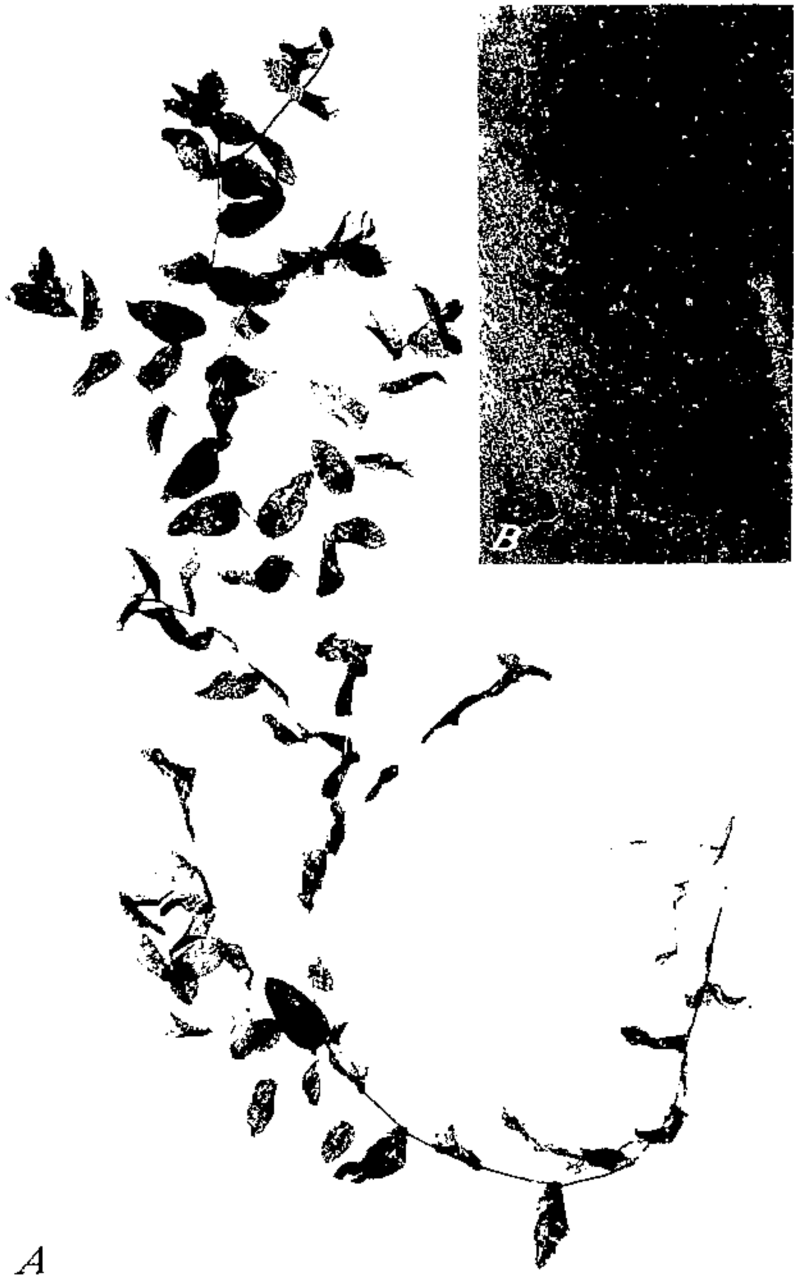
B8123M

Variableleaf pondweed (*Potamogeton gramineus*), × [illegible], large-leaved type, from Schoolcraft County, Mich.



B02566

Variableleaf pondweed (*Potamogeton gramineus*): *A*, Specimen, × [illegible], small-leaved type, from Schoolcraft County, Mich. *B*, Seeds, × 4: *a*, normal specimen; *b*, seed with outer covering removed by partial digestion.



Claspingleaf pondweed (*Potamogeton perfoliatus* var. *bupleuroides*): *A*, Specimen, [illegible], from the Potomac River. *B*, Dense growth in the Potomac at Morgantown, Md.

Whitestem pondweed (*Potamogeton praelongus*) × [illegible]. *A*, Fruiting plant, from Forest County, Wis. *B*, Branch from Freeborn County, Minn.

B656M

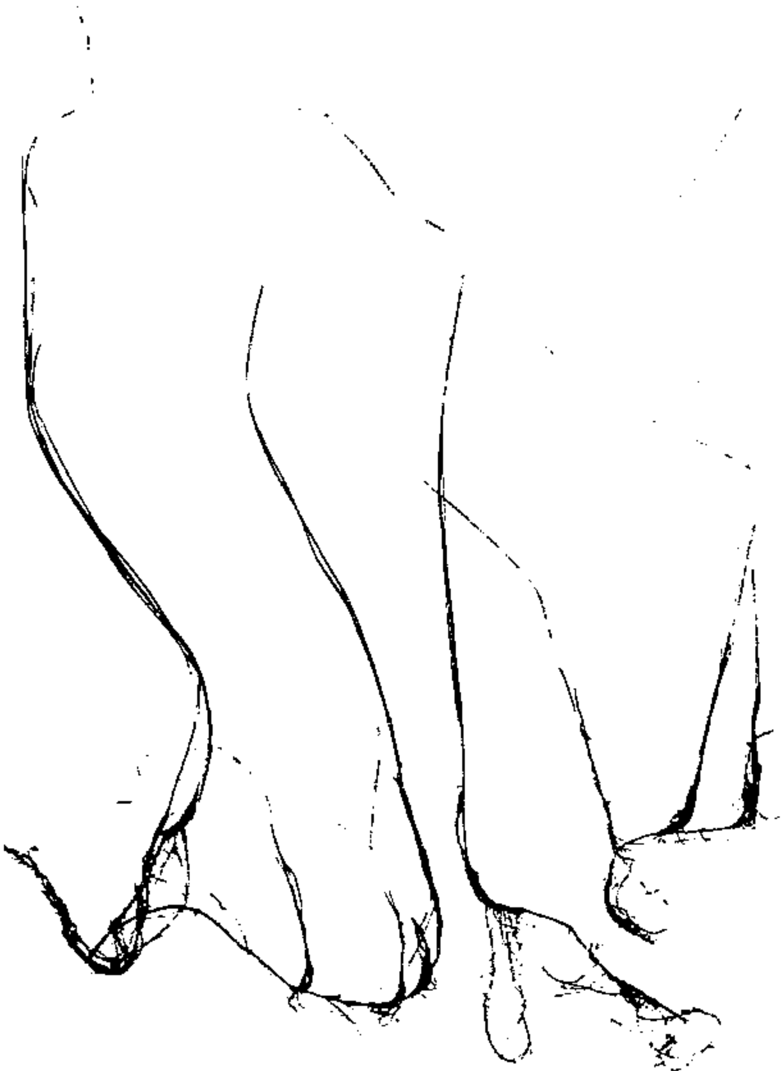
Wigeongrass (*Ruppia maritima*). *A*, Specimen, × [illegible], from Dorchester County, Md. *B*, Seeds, × 7—*a*, normal; *b*, with outer covering removed.

Wigeongrass (*Ruppia occidentalis*), × 3/8, from Garden County, Nebr.

Horned pondweed (*Zannichellia palustris*): *A*, Specimen, [illegible], from the Mississippi River bottoms, Goodhue County, Minn.; *B*, Seed, × 4.

Eelgrass (*Zostera marina*). *A*, specimen, × ½, from Hancock County, Maine. *B*, seed, × 5.

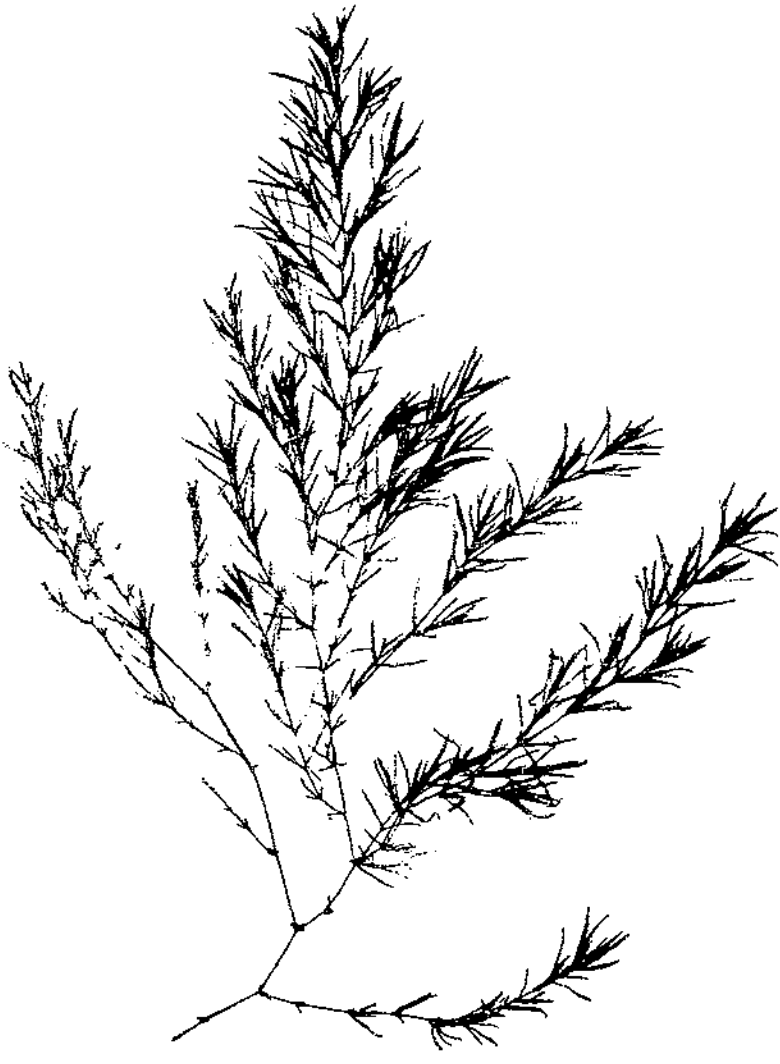
Manateegrass (*Cymodocea manatorum*), [illegible], from St. Marks Migratory Waterfowl Refuge, Wakulla, Fla.



Shoalgrass (*Halodule wrightii*) [illegible], from Onslow County, N. C.

[illegible] County, N. C.

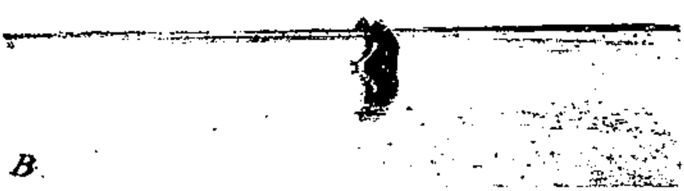
Northern naiad (*Najas flexilis*): *A*, Specimen, × [illegible], from the soft mud bottoms of the Potomac River; *B*, seeds, × 2—*a*, normal, *b*, with pericarp removed; *C*, Dense form of plant, × [illegible], from a firm sand bottom, Becker County, Minn.



B6166M

Southern naiad (*Najas guadalupensis*), coarse type, × ½, from Marion County, Fla.

A



B

B6014M; B43752

Southern naiad (*Najas guadalupensis*): *A*, Slender type, × 2/3, from Arlington County, Va. *B*, Dense beds in the Chautauqua Migratory Waterfowl Refuge, Mason County, Ill.

B6016M

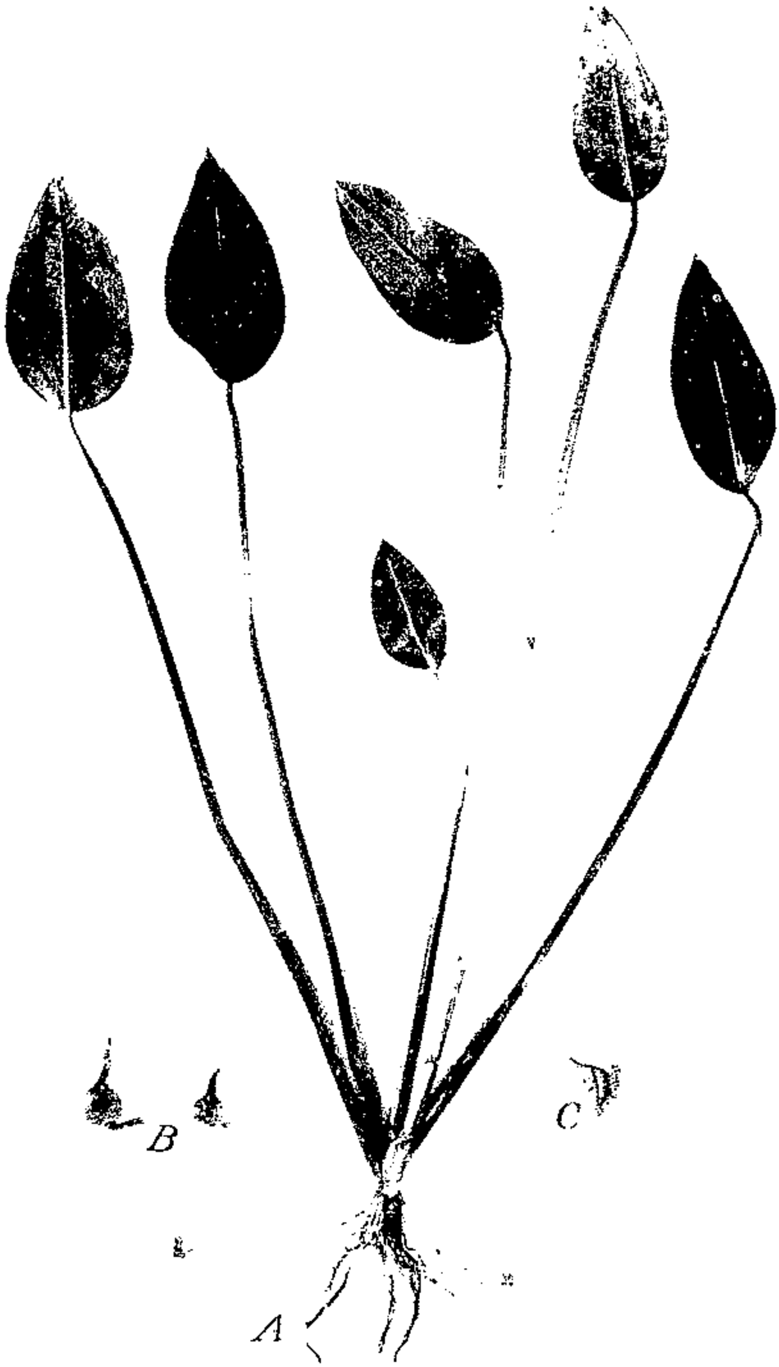
Spiny naiad (*Najas marina*), × ⅝, from Big Stone County, Minn.

Naiad (*Najas gracillima*) (× [illegible]), from Stafford County, Va.

86170M

Arrowgrass (*Triglochin maritima*): *A*, Specimen, × [illegible], from Little Narragansett Bay, Conn. *B*, Carpel and seeds, × 4.

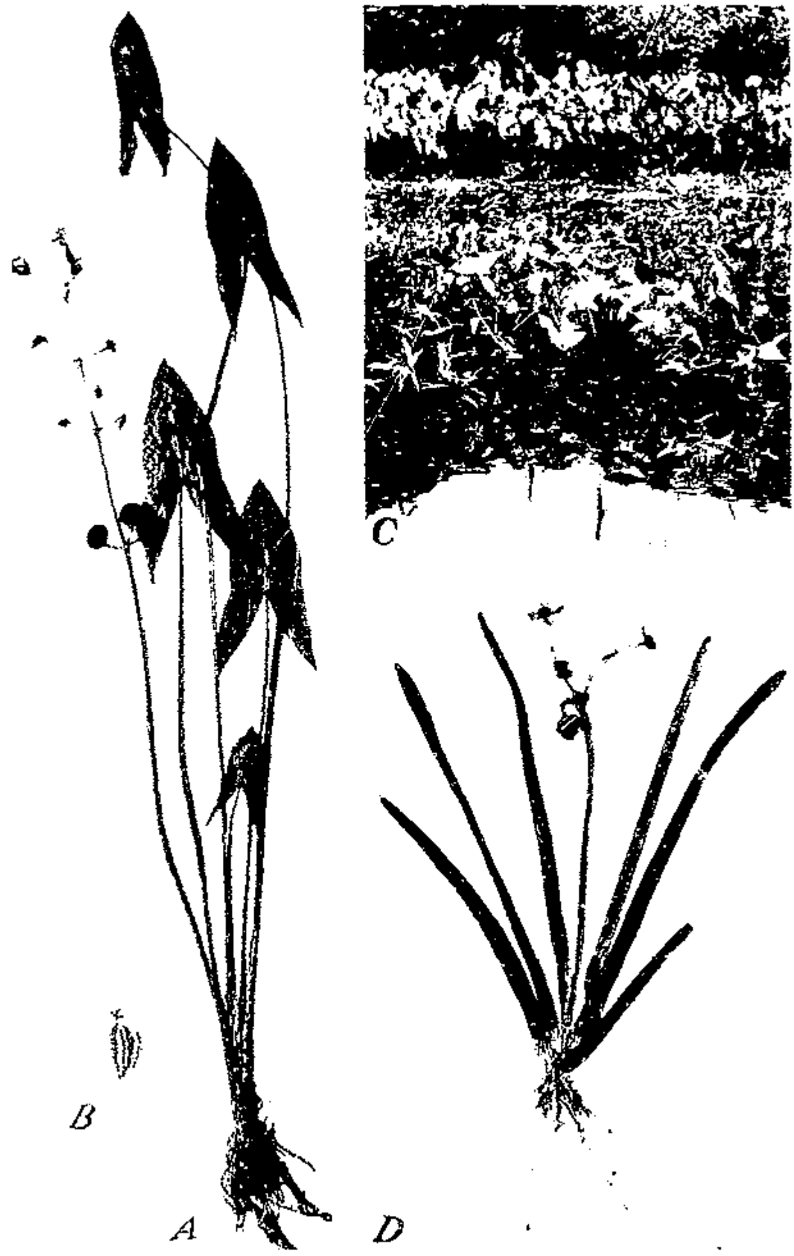
Arrow-headed leaves of four kinds of marsh plants, × 1/3: *A*, Arrow-arum (*Peltandra virginica*). *B*, Lophotocarpus (*Lophotocarpus calycinus*). *C*, Arrowhead (*Sagittaria latifolia*). *D*, Pickerelweed (*Pontederia cordata*).



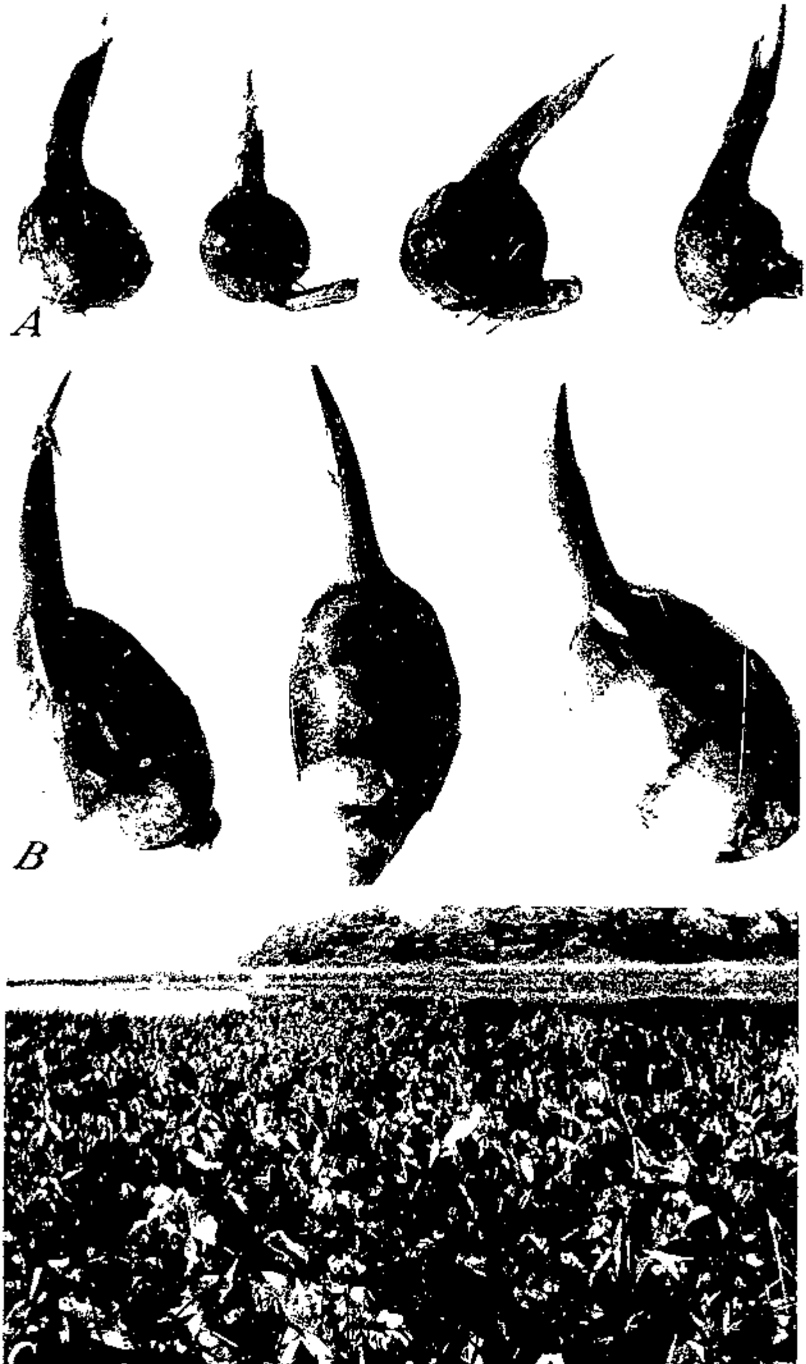
Delta duckpotato (*Sagittaria platyphylla*): *A*, Specimen, × [illegible], from tubers obtained on the Mississippi Delta, La. *B*, Tubers. *C*, Seed, × 1.

BL [illegible]EM; B43747

Arrowhead (*Sagittaria heterophylla*): *A*, Specimen, [illegible], from Allamakee County, Iowa. *B*, Marsh, principally of American lotus (*Nelumbo pentapetala*) with considerable *S. heterophylla* in the foreground and some *S. latifolia* in lower left corner, Crawford County, Wis.



A, Arrowhead (*Sagittaria cuneata*), × [illegible], from Prairie du Chien, Wis. *B*, Seed, × 4. *C*, Plants on the Upper Mississippi River Wildlife and Fish Refuge, Wis., with *S. latifolia* in the background (photograph by Herbert Graham). *D*, *S. subulata*, × [illegible], from Arlington County, Va.

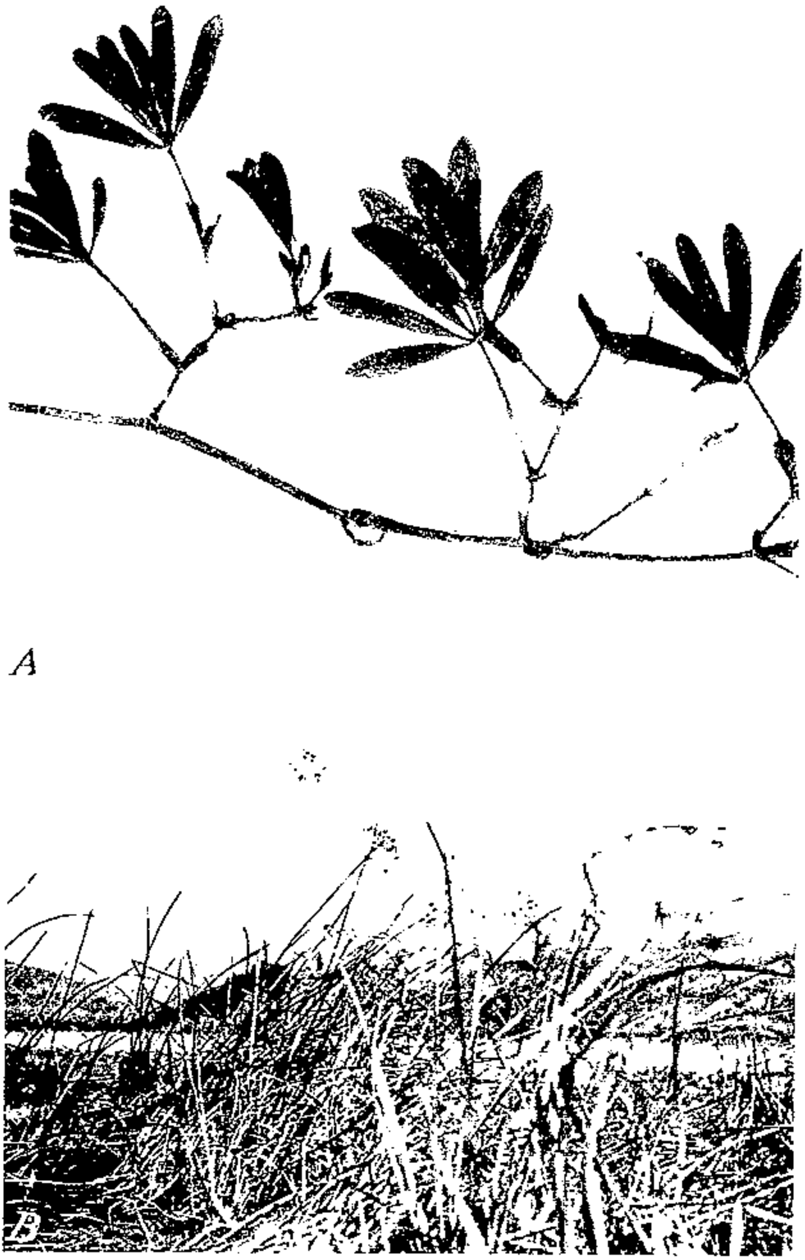


B6222M; B44682

A, Tubers of *Sagittaria platyphylla*, × 1. *B*, Tubers of *S. latifolia*, × 1. *C*, Marsh of *S. latifolia* in Franklin County, Vt.

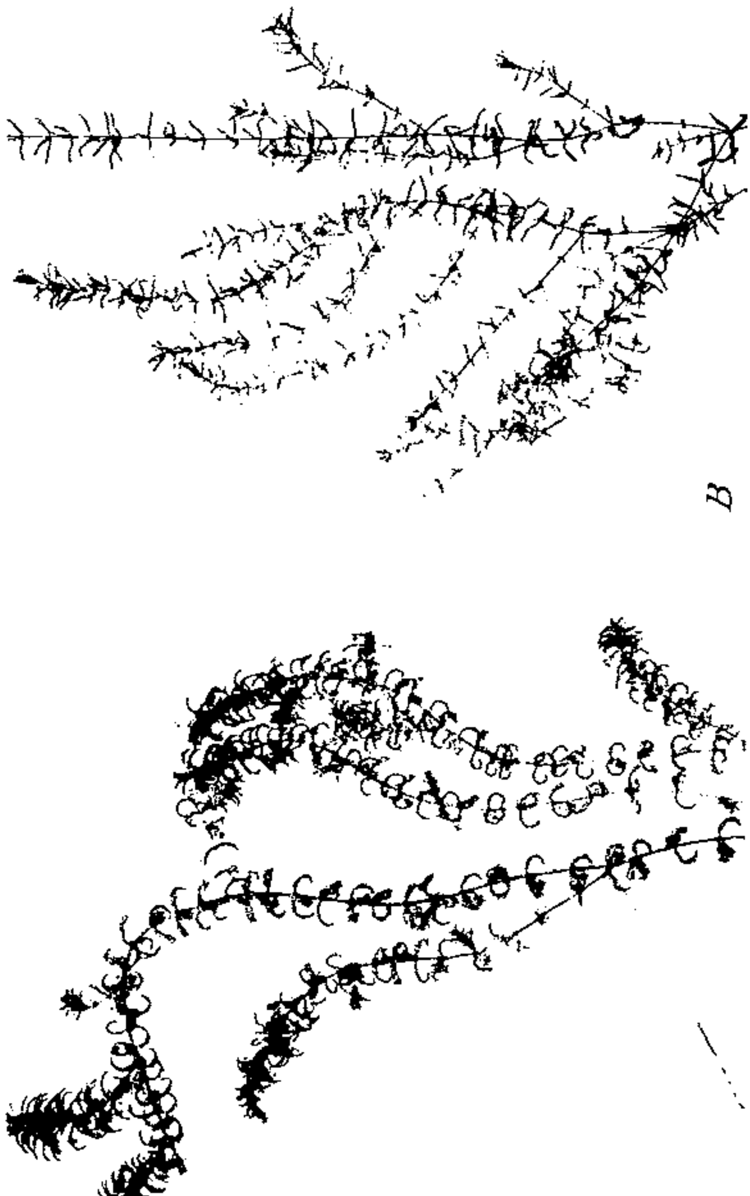
[illegible] B45751

Lophotocarpus (*Lophotocarpus calycinus*): *A*, Specimen, [illegible], from Keokuk, Iowa. *B*, Marsh in Chautauqua Migratory Waterfowl Refuge, Mason County, Ill.



B... M. 64,437

A, Halophila (*Halophila engelmanni*), × 1, from Titusville, Fla. *B*, Flowering-rush (*Butomus umbellatus*) in the southern part of Lake Champlain, N. Y.



Waterweeds: *A*, *Anacharis canadensis*, × [illegible], from Fairfax County, Va. *B*, *A. occidentalis*, × [illegible], from Keokuk, Iowa.

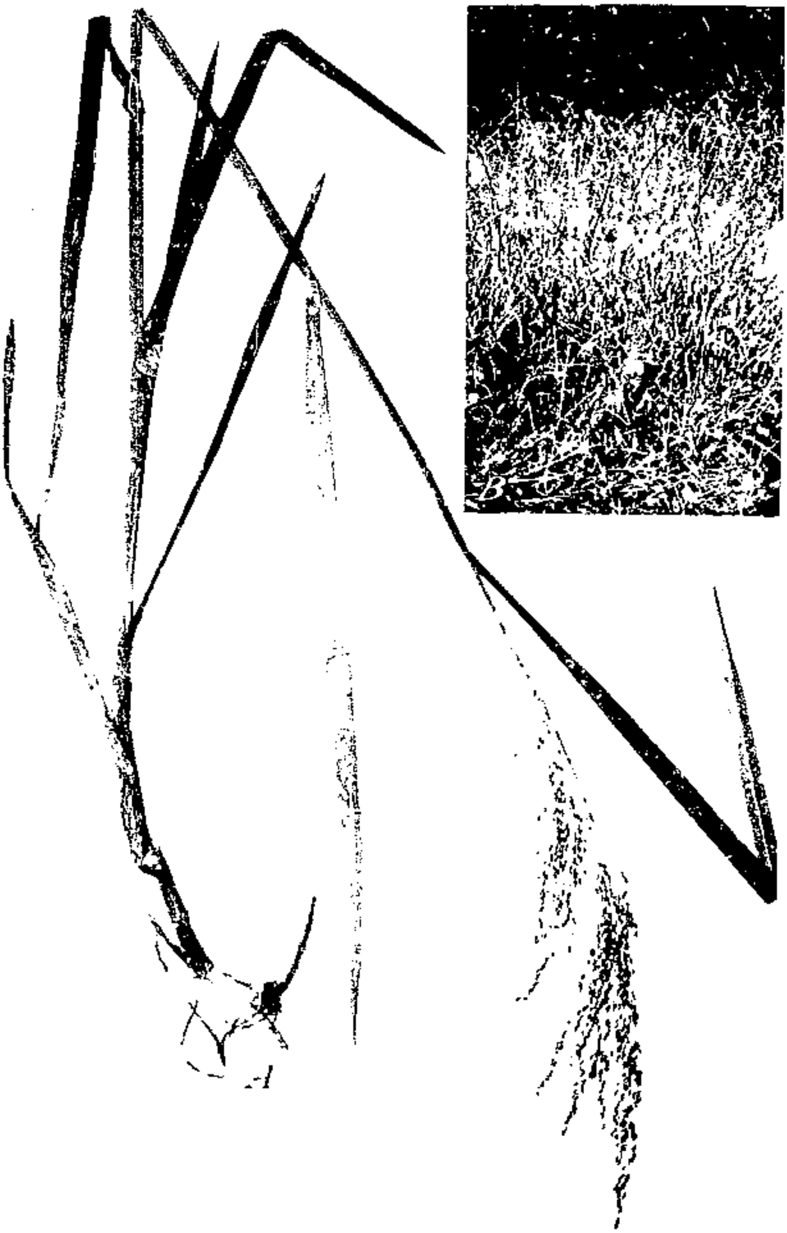
B6/73M, B6078M

Wildcelery (*Vallisneria spiralis*): *A*, Specimen with fruit and tubers, × ⅓, from Stafford County, Va. *B*, Seeds, × 5: *a*, normal; *b*, with outer covering removed. *C*, Northern form, × ¼, from Fairfax County, Va. *D*, Southern form, × ¼, from Seminole County, Fla.

TB 634 (1939) USDA TECHNICAL BULLETINS UPDATA
FOOD OF GAME DUCKS IN THE UNITED STATES AND CANADA
MARTIN, A.C., UHLER, F.M. 3 OF 4

Turtlegrass (*Thalassia testudinum*), × ¾, in winter condition, from St. Marks Migratory Waterfowl Refuge, Wakulla County, Fla.

Frogbit (*Limnobium spongia*).
A, Plant with emersed leaves, from Okefenokee Swamp, Ga. *B*, Smaller plant, with floating leaves, from Polk County, Fla. *C*, Fruits, from Yemassee, S. C.



Mannagrass (*Glyceria striata*): *A*, Specimen, [illegible], from Charles County, Md.; *B*, Growth in shallow water, Anne Arundel County, Md.

86229M

Whitetop (*Fluminea festucacea*), × [illegible], from Grant County, Minn.

The two principal species of saltgrass (*Distichlis*): *A*, Coastal form (*D. spicata*), × ½, from St. Marys County, Md. *B*, Seed, × 5. *C*, Interior form (*D. stricta*), × ½, from Socorro County, N. Mex. *D*, Seed, × 5. *E*, Marsh growth of *D. spicata* in Dorchester County, Md.

B62161

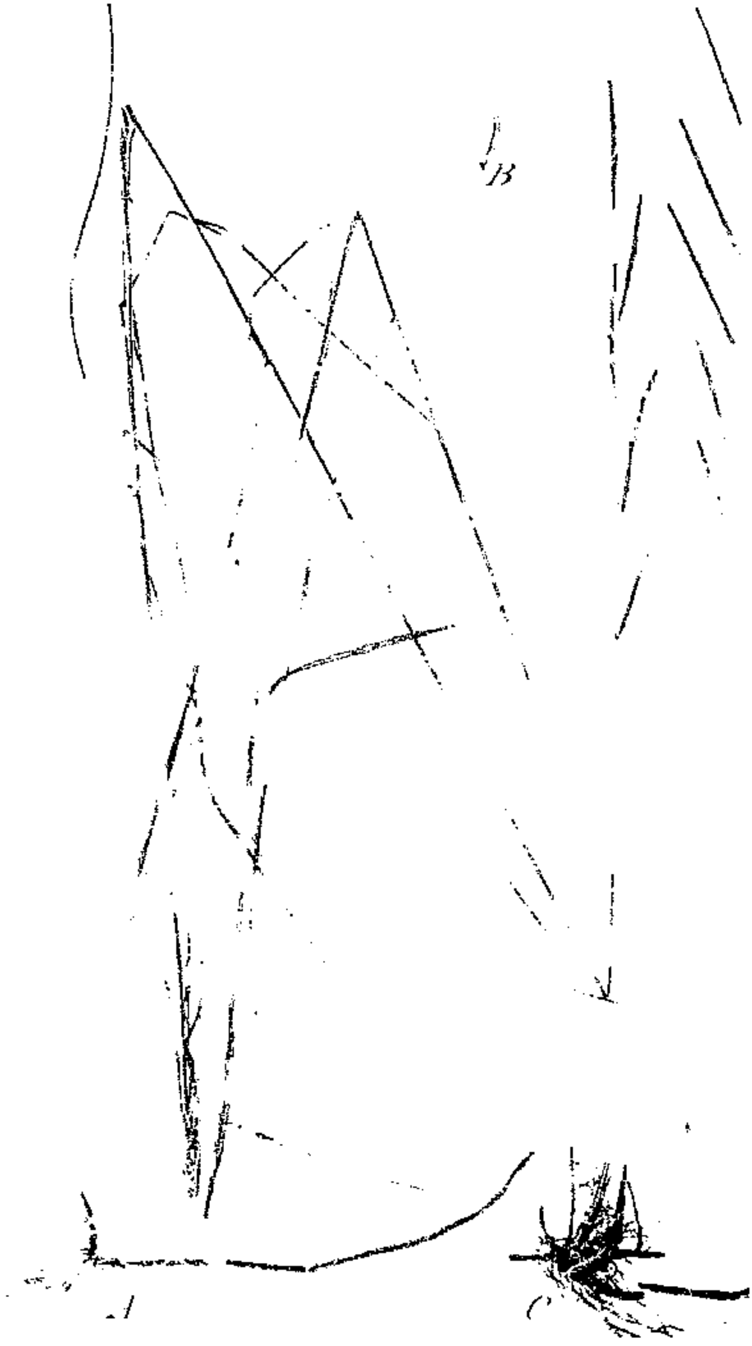
Sprangletop (*Leptochloa fascicularis*), × [illegible], from Vermilion Parish, La.

B5991M

Saltmarsh cordgrass (*Spartina alterniflora*), × [illegible], from St. Marys County, Md.

B44851

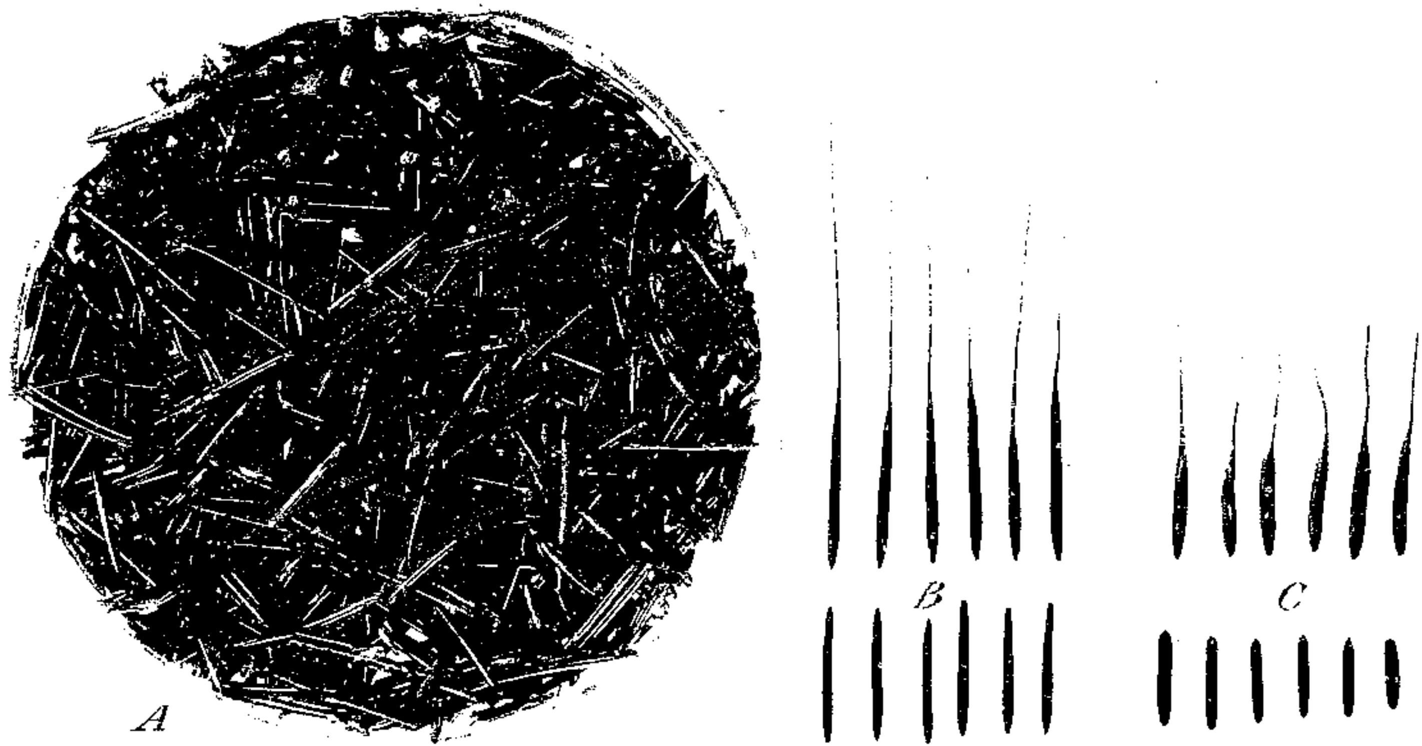
Clump of saltmarsh cordgrass (*Spartina alterniflora*) in the Choptank River, Dorchester County, Md.



Saltmeadow cordgrass (*Spartina patens*): *A*, Specimen [illegible] Princess Anne County, Md.; *B*, Seed, × [illegible]; *C*, Rootstocks, × [illegible].

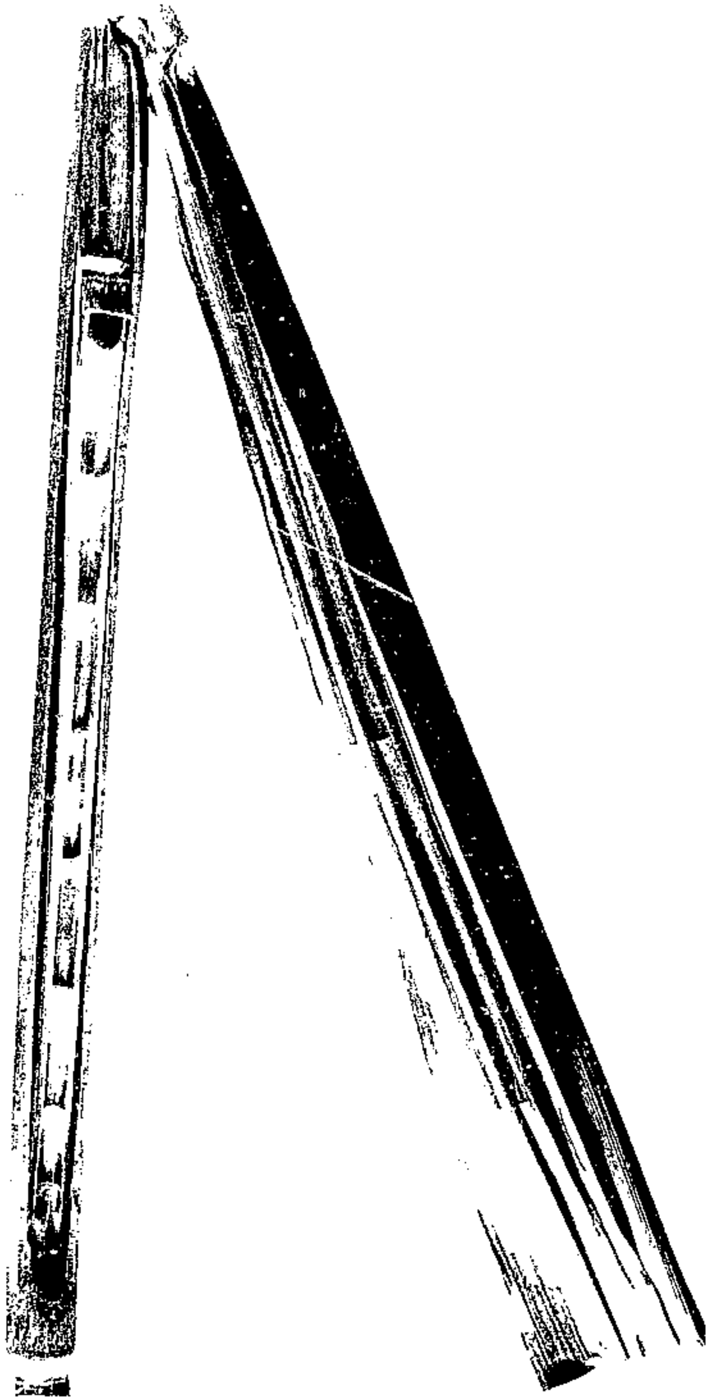
Cutgrass (*Leersia*) spp.: *A*, Southern cutgrass (*L. hexandra*), from Cameron Parish, La. *B*, Rice cutgrass (*L. oryzoides*), from the Mississippi River bottoms, Houston County, Minn. *C*, Roundfruit cutgrass (*L. lenticularis*), from the Mississippi River bottoms, Allamakee County, Iowa.

Wildrice (*Zizania aquatica*): *A*, Stand of broad-leaved form, Arlington County, Va. *B*, Panicles, × ¼, of the two principal types: *a*, broad-leaved; *b*, narrow-leaved (var. *angustifolia*) (photograph from Bureau of Plant Industry).



B6112M, E6277M

Seeds of wildrice (*Zizania*), × 1: *A*, Hulled, with a few oval seeds of pickerelweed (*Pontederia*), the gullet content of a black duck from Georgetown, S. C. *B*, Dried seeds of the broad-leaved form (*Z. aquatica*), from Arlington County, Va., in upper row unhulled, in lower, hulled. *C*, Dried seeds of the narrow-leaved form (*Z. a.* var. *angustifolia*), originating from northern stock but grown in Mason County, Ill.

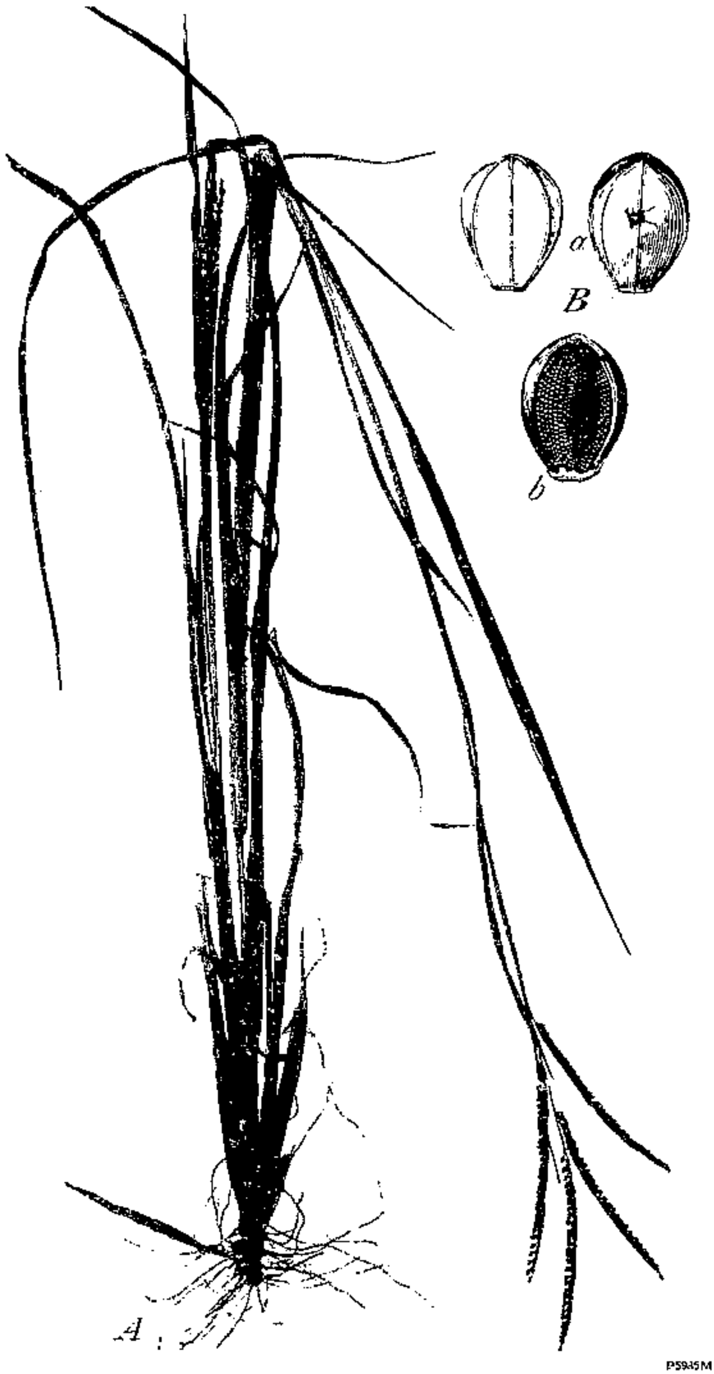


B6280M

Split stem of wildrice (*Zizania aquatica*) (slightly reduced), showing the distinctive partitions (pseudonodes).

B5933M

Paspalum (*Paspalum distichum*), $\times \frac{4}{5}$, from Socorro County, N. Mex.

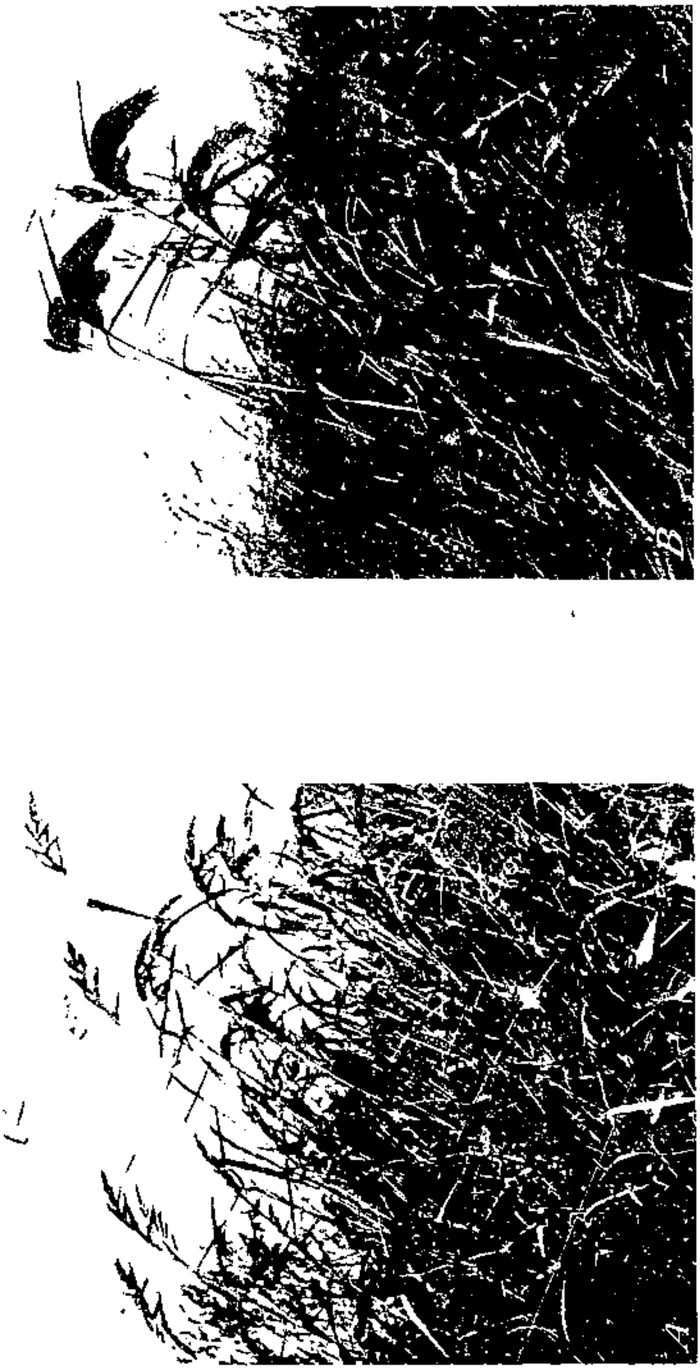


Bull paspalum (*Paspalum boscianum*): *A*, Specimen, × ½, from Arkansas County, Ark. *B*, Seeds, × 10—*a*, with glumes; *b*, without glumes.

B5934M

Fall panicum (*Panicum dichotomiflorum*): *A*, Specimen, × [illegible], from Arkansas County, Ark. *B*, Seeds, × 5—*a*, with glumes; *b*, without glumes.

Wild millet (*Echinochloa* spp.): *A*, *E. colonum*, from Lake Arthur, La. *B*, *E. crusgalli*: *a*, from Caddo Lake, La.; *b*, var. *mitis*, from Butte des Morts Lake, Wis.; *c*, var. *frumentacea*, from Scott County, Ill. *C*, Seeds of *E. crusgalli*, × 8. *D*, *E. walteri*: *a*, from Winnebago County, Wis.; *b*, from Potomac River, Arlington County, Va.; *c*, from Cameron Parish, La.

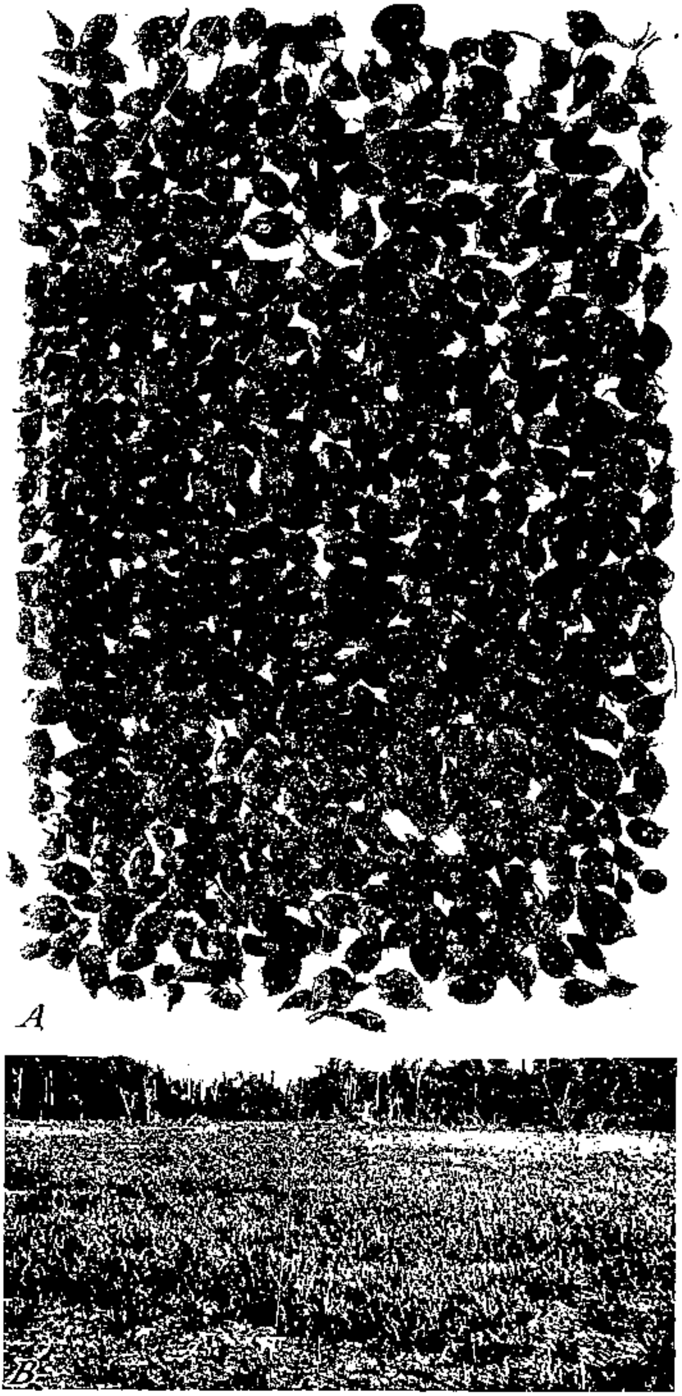


B43748, B43749

Wild millets in Winnebago County, Wis. *A*, *Echinochloa crusgalli*. *B*, *E. walteri*

B. & M. Photo

Chufa (*Cyperus esculentus*): *A*, Specimen, [illegible], from the Mississippi River bottoms, Allamakee County, Iowa. *B*, Base of a tuft of plants with tubers attached, × [illegible], from Arlington County, Va.

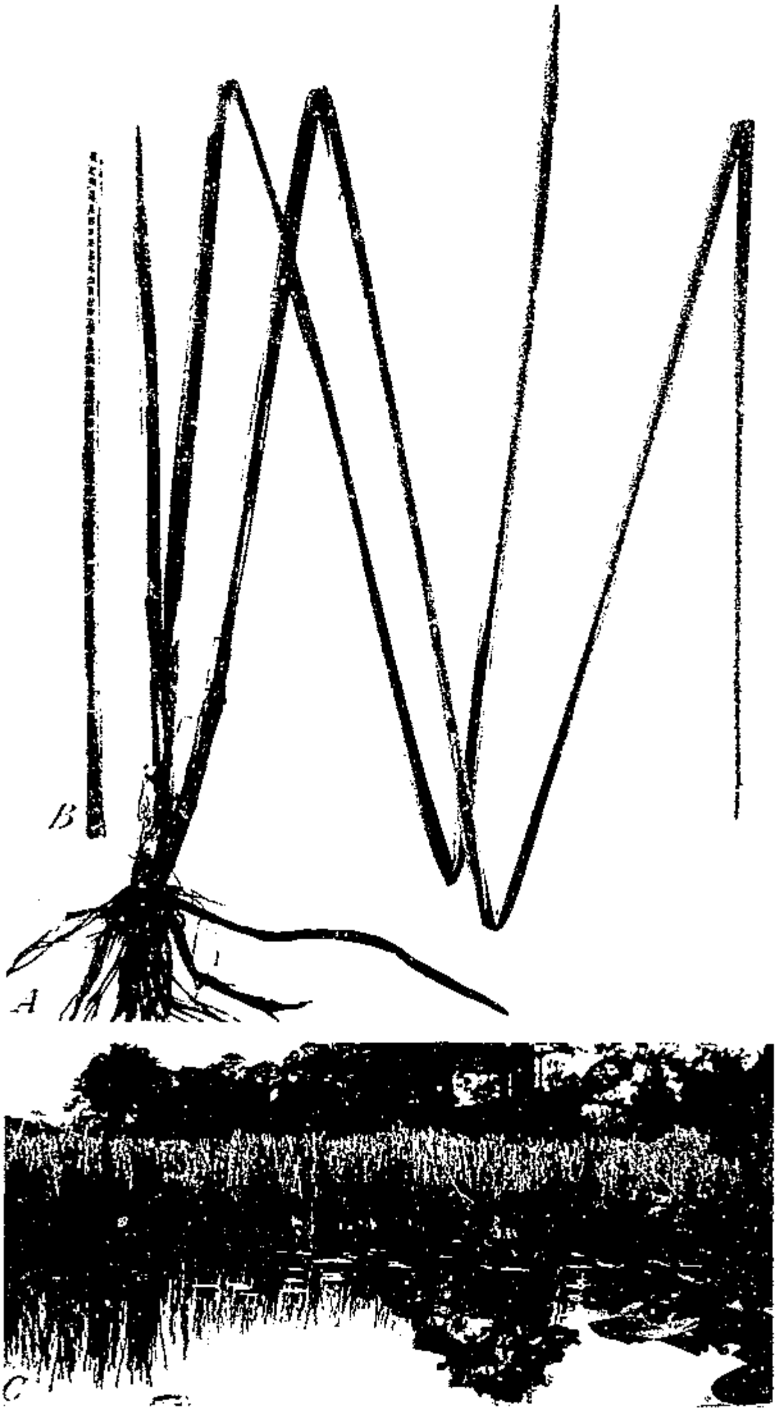


B5922M, B43.50

Chufa (*Cyperus esculentus*): *A*, About 700 tubers, $\times \frac{1}{2}$, removed from the gullet of a mallard taken at Catahoula Lake, La. *B*, Plants growing in dry lake bed, Schuyler County, Ill.

B5 96M

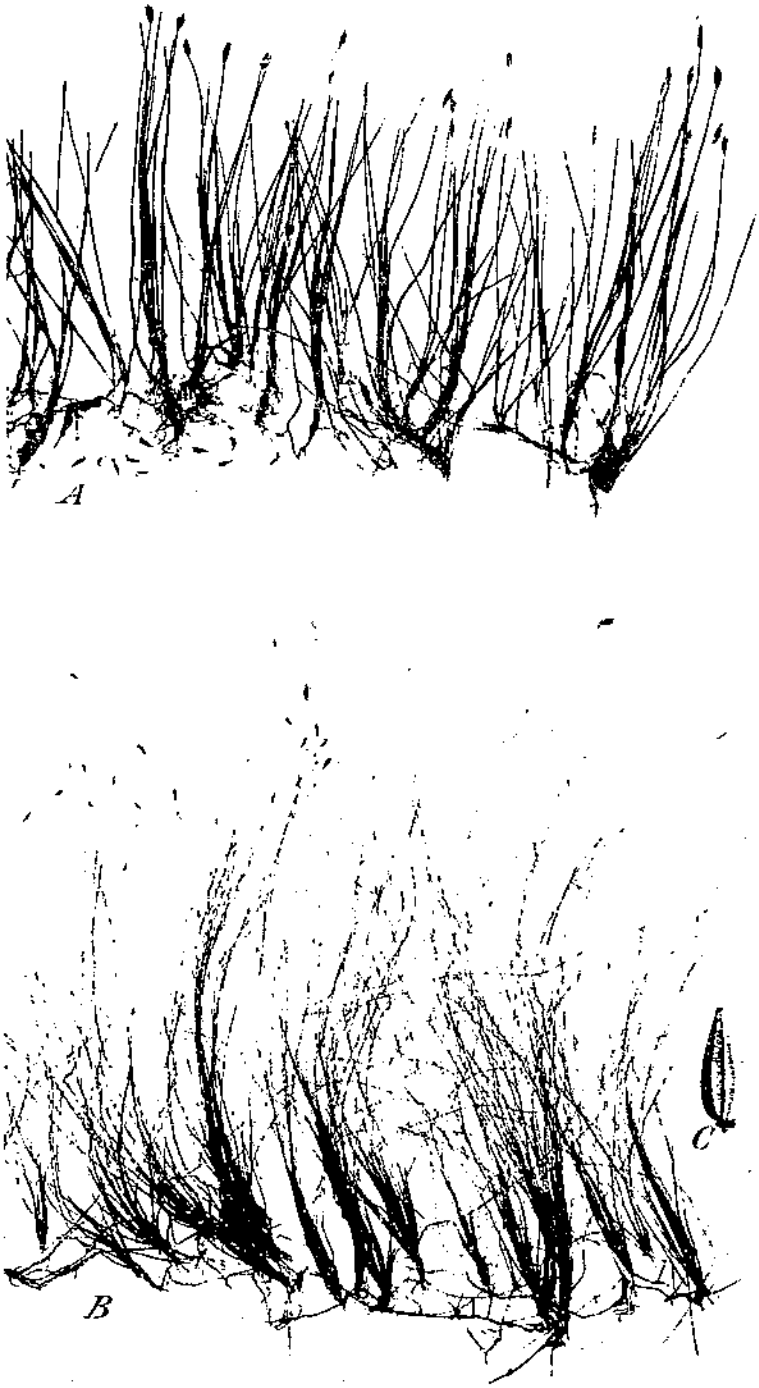
Cyperus (*Cyperus strigosus*), × [illegible], from Arlington County, Va.



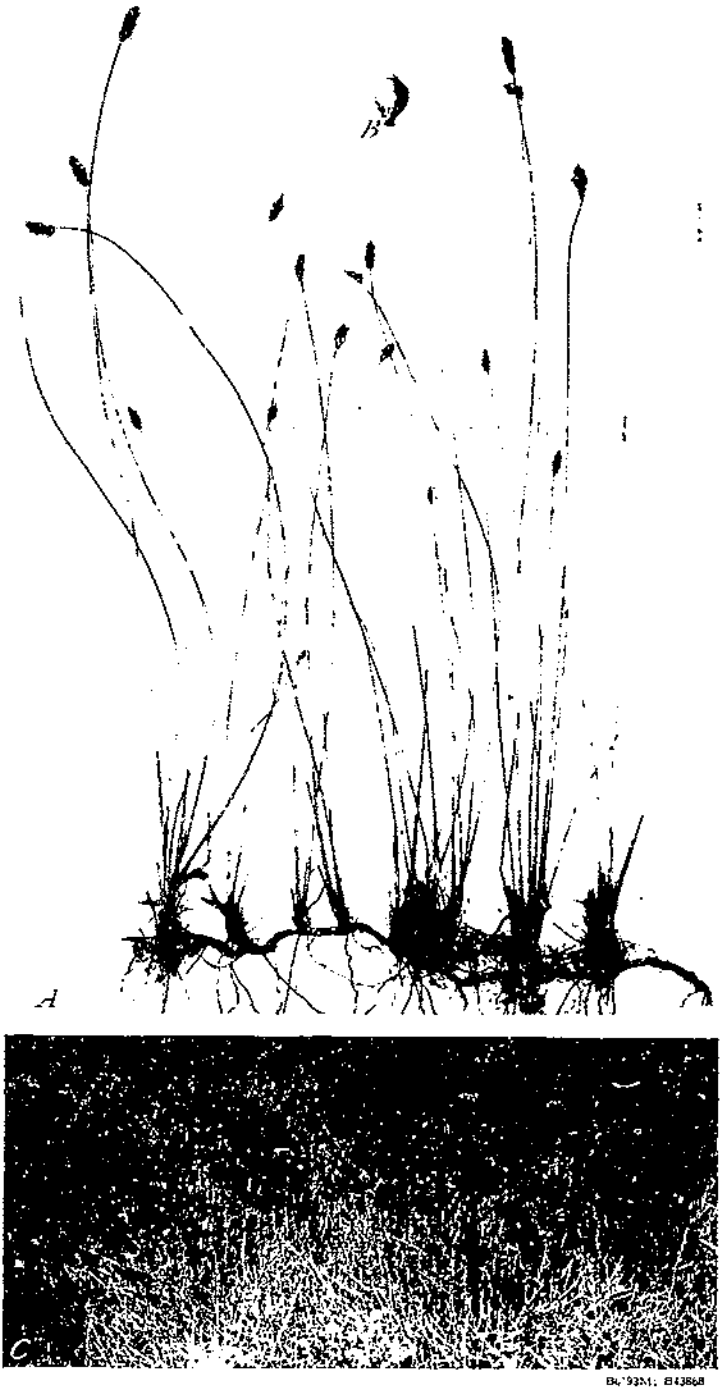
D7263M, D7262M

Jointed spikerush (*Eleocharis interstincta*): *A*, Specimen, and *B*, cut stem, both $\times \frac{1}{3}$, from Hendry County, Fla. *C*, Section of marsh from which specimen *A* was obtained.

Squarestem spikerush (*Eleocharis quadrangulata*): *A*, Specimen, × [illegible], from Fairfax County, Va. *B*, Marsh in Dorchester County, Md.

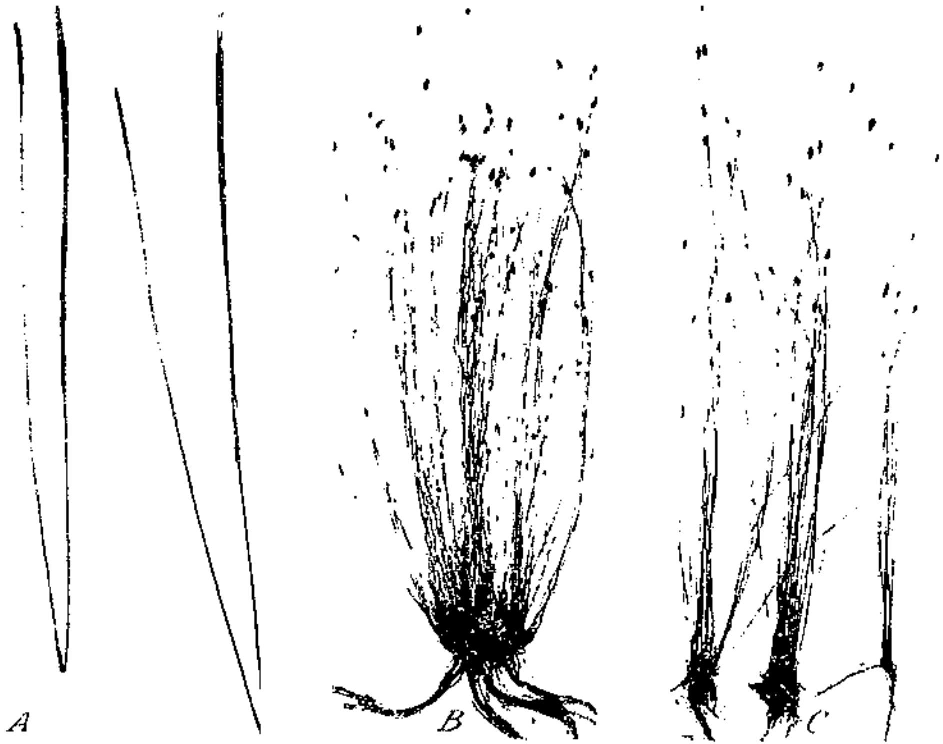


A, Dwarf spikerush (*Eleocharis parvula* var. *leptos*), × ½, from Socorro County, N. Mex. *B*, Slender spikerush (*E. acicularis*), × ½, from Keokuk, Iowa. *C*, Seed of the slender spikerush, × 20.



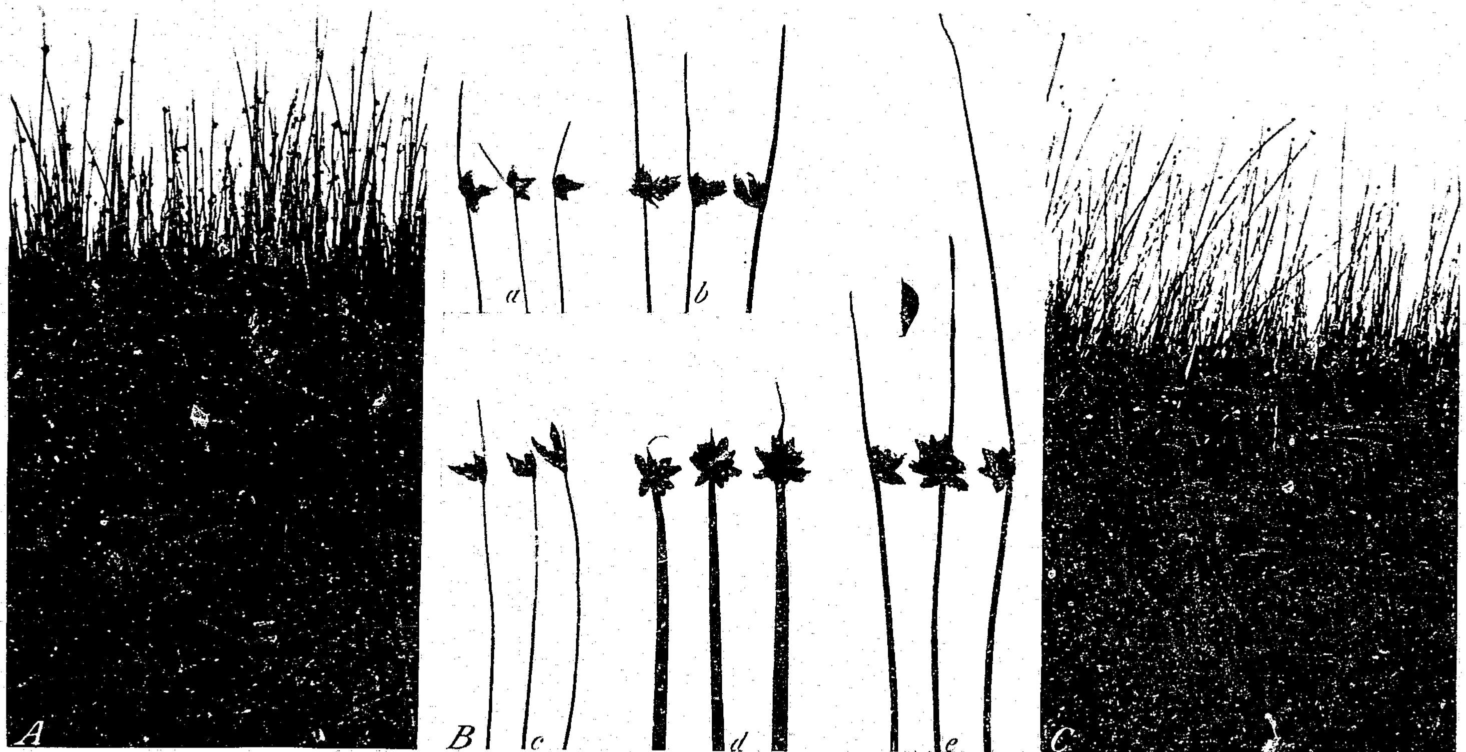
B4793M; B43868

Common spikerush (*Eleocharis palustris*): *A*, Specimen (*uniglumis* type), × ½, from a brackish marsh, Worcester County, Md. *B*, Seed, × 3½. *C*, Marsh in Charles County, Md.



B6,15M, B6,56M, U6,9LM

A, Gulfcoast spikerush (*Eleocharis cellulosa*), × 1/4, from St. Marks Migratory Waterfowl Refuge, Wakulla County, Fla., a species that tolerates a moderate degree of brackishness. *B*, An annual fresh-marsh spikerush (*E. obtusa*), × 1/4, from Keokuk, Iowa. *C*, A brackish-marsh spikerush (*E. albida*), × 1/4, from Charles County, Md.

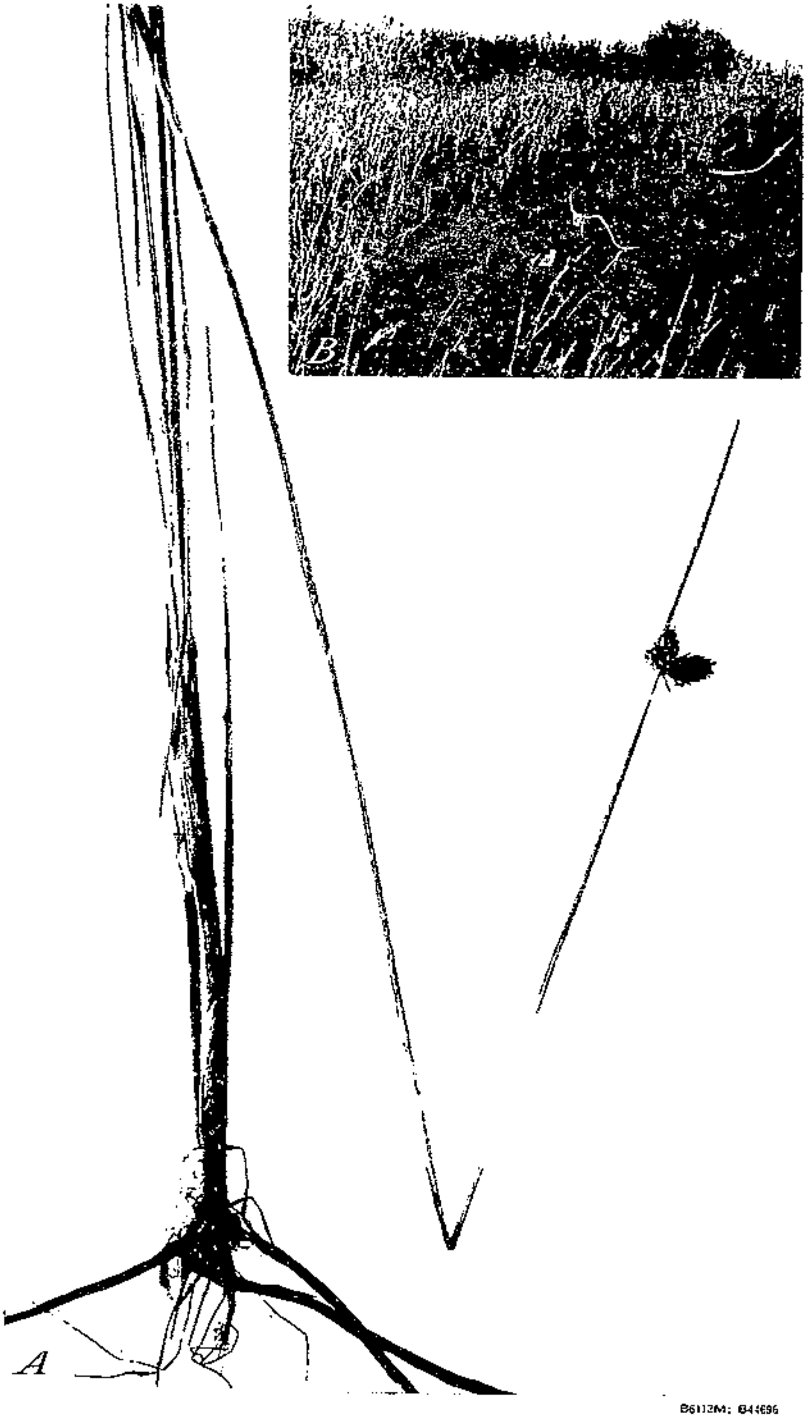


B42991; B6117M; B42881A

Three-squares and related bulrushes: *A*, Marsh of the common three-square (*Scirpus americanus*), Fairfax County, Va., showing typical extension of involucral leaves beyond spikelets. *B*, Specimens of plants, × ⅓—*a*, *S. debilis*, Washburn County, Wis.; *b*, *S. torreyi*, Burnett County, Wis.; *c*, *S. nevadensis*, Burke County, N. Dak.; *d*, *S. olneyi*, Dorchester County, Md.; *e*, *S. americanus*—center stalk, Princess Anne County, Va.; left and right, Arlington County, Va.; seed, × 2½. *C*, Marsh of Olney's three-square (*S. olneyi*), Dorchester County, Md.

B610M; B611M; B613M

A, Common three-square (*Scirpus americanus*), from Arlington County, Va. *B*, Olney's three-square (*S. olneyi*), from Princess Anne County, Va. *C*, Swamp bulrush (*S. etuberculatus*), from Okefenokee Swamp, Ga. (All × ⅓.)



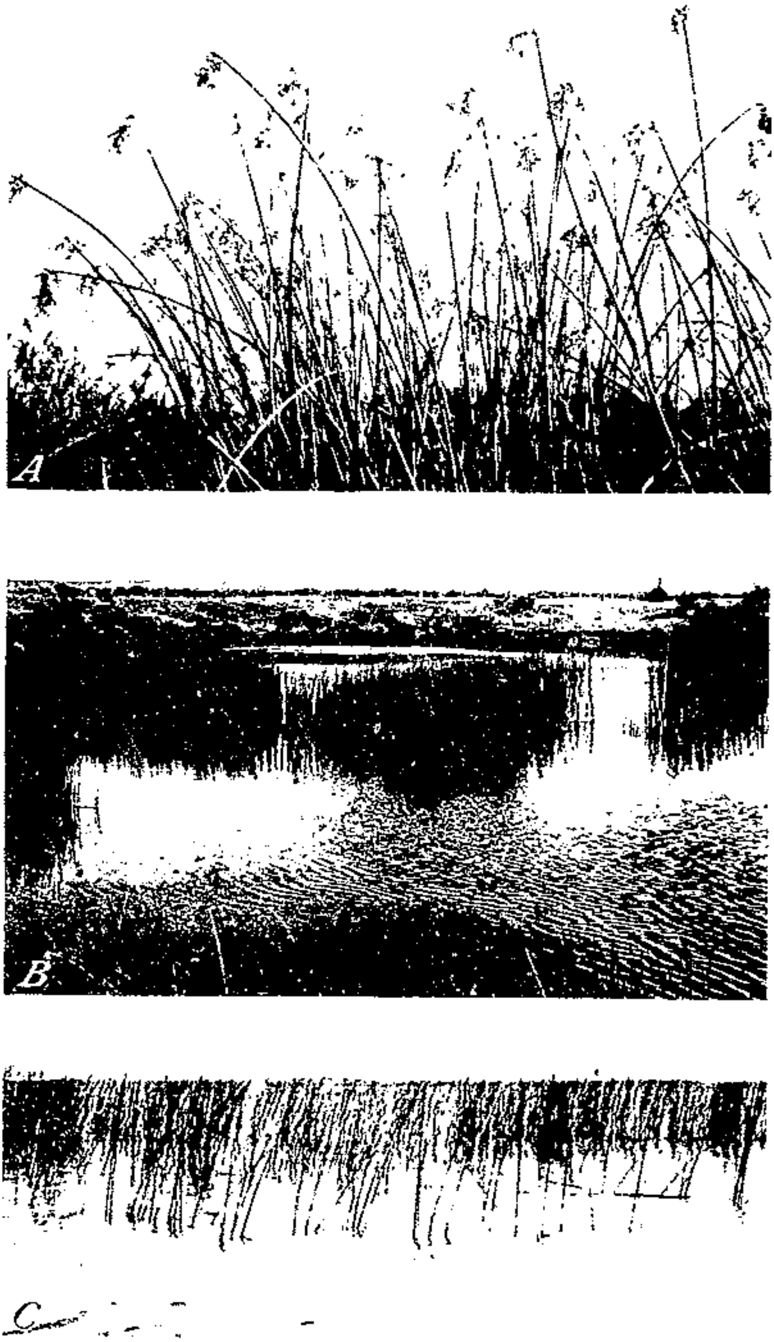
B6112M; B44696

Torrey's three-square (*Scirpus torreyi*): *A*, Specimen, × ½, from Burnett County, Wis. *B*, Marsh in Franklin County, Vt.

B6115M; B6116M

Bulrushes related to the three-square type, both × ½: *A*, *Scirpus nevadensis*, from an alkaline lake margin, Burke County, N. Dak. *B*, *S. debilis*, from Washburn County, Wis.

Round-stemmed bulrushes, × [illegible]: *A*, Southern bulrush (*Scirpus californicus*), Polk County, Fla. *B*, Softstem bulrush (*S. validus*), Nicollet County, Minn. *C*, Hardstem bulrush (*S. acutus*), Lake Mattamuskeet, N. C., with seed, × 1. *D*, Slender bulrush (*S. heterochaetus*), St. Louis County, Minn.



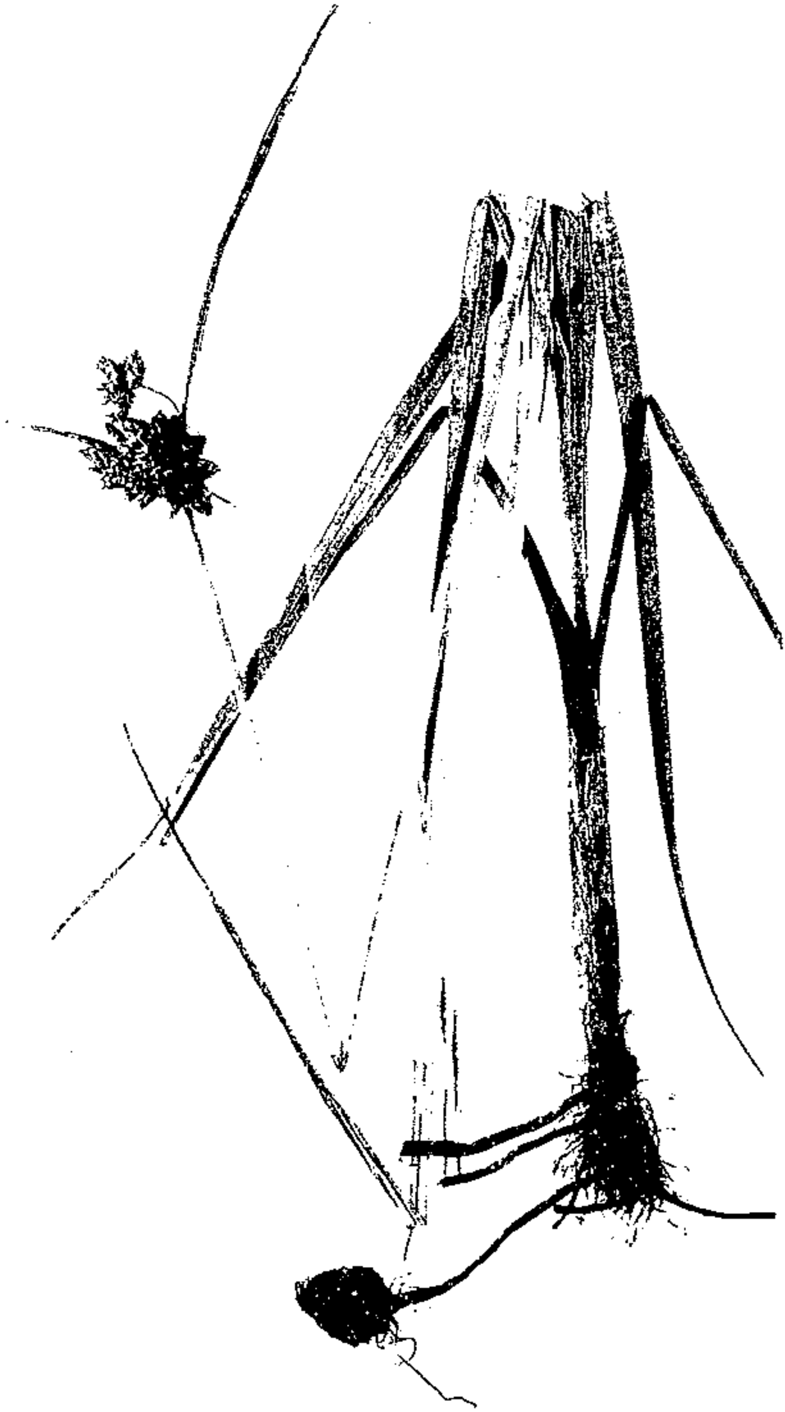
B75566M B.7135, B4347

Marshes of round-stemmed bulrushes: *A*, Softstem bulrush (*Scirpus validus*), in Becker County, Minn., showing typical lax stems and drooping inflorescence. *B*, Beds of hardstem bulrush (*S. acutus*), at Locomotive Springs, Kelton, Utah. *C*, Southern bulrush (*S. californicus*), on hard sand-bottomed lake, Marion County, Fla

Leafy three-angled bulrushes, all × [illegible]. *A*, Saltmarsh bulrush (*Scirpus robustus*): *a*, from Brevard County, Fla.; *b*, from Charles County, Md.; *c*, seed, × 1. *B*, Alkali bulrush (*S. paludosus*): *a*, from Garden County, Nebr.; *b*, from Socorro County, N. Mex.; *c*, seed, × 1. *C*, River bulrush (*S. fluviatilis*), from Arlington County, Va.

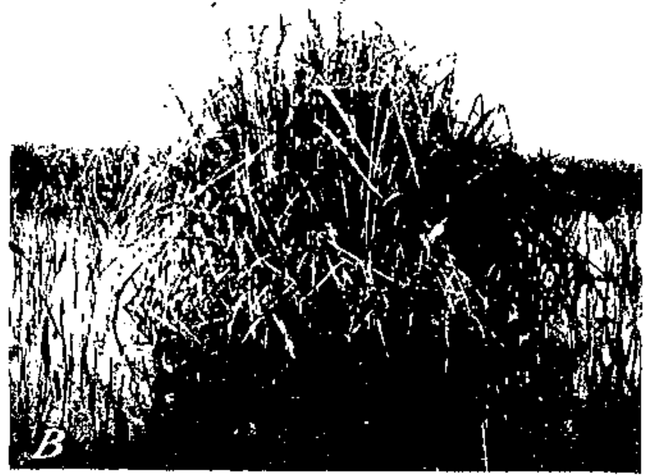
64526, B1093M

Marshes of leafy three-angled bulrushes: *A*, Saltmarsh bulrush (*Scirpus robustus*), Blackwater Migratory Waterfowl Refuge, Dorchester County, Md. *B*, Alkali bulrush (*S. paludosus*), Great Salt Lake, Utah.



DN 9M

Alkali bulrush (*Scirpus paludosus*), × ½, from Garden County, Nebr.

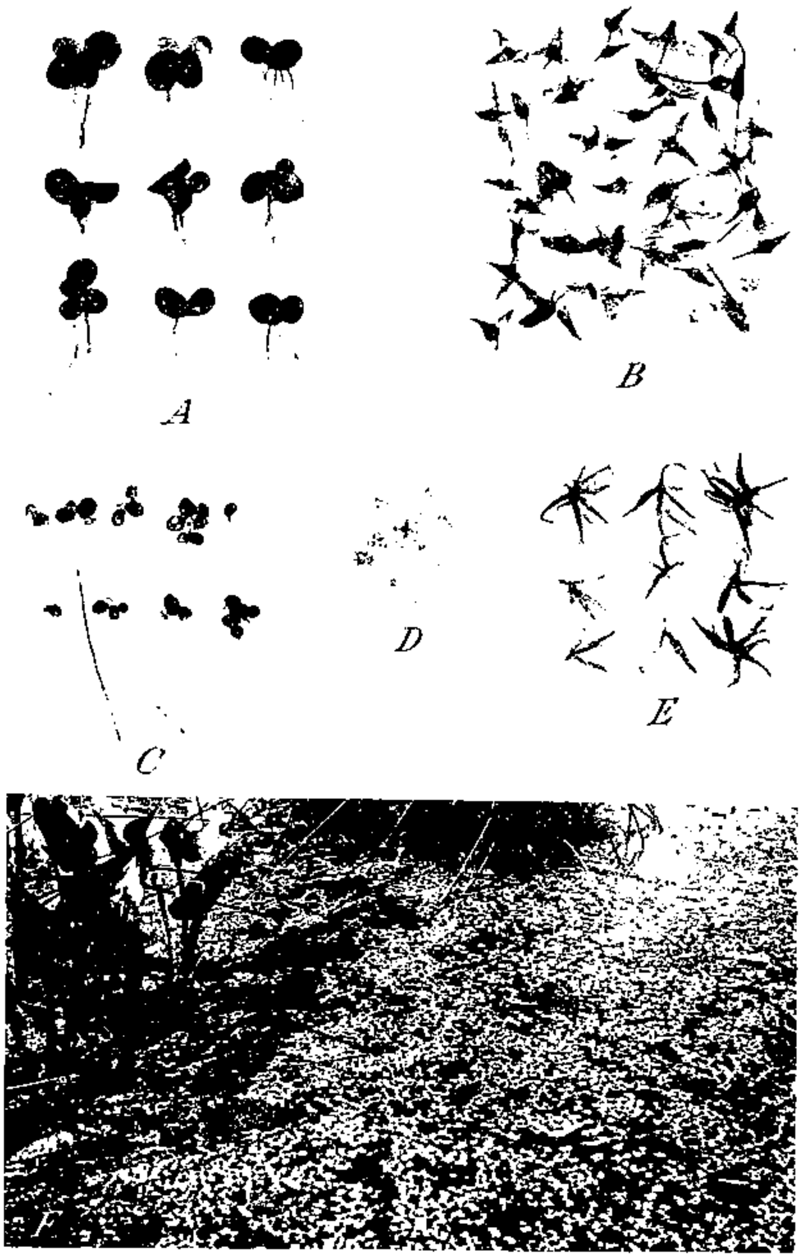


B5875M, E42135

A, Inflorescence of beakrush (*Rynchospora corniculata*), $\times \frac{1}{4}$, from Hardin County, Tenn. *B*, Clump of sawgrass (*Cladium jamaicense*) surrounded by arrowheads (*Sagittaria falcata*), Cameron Parish, La.

B42893, B42894

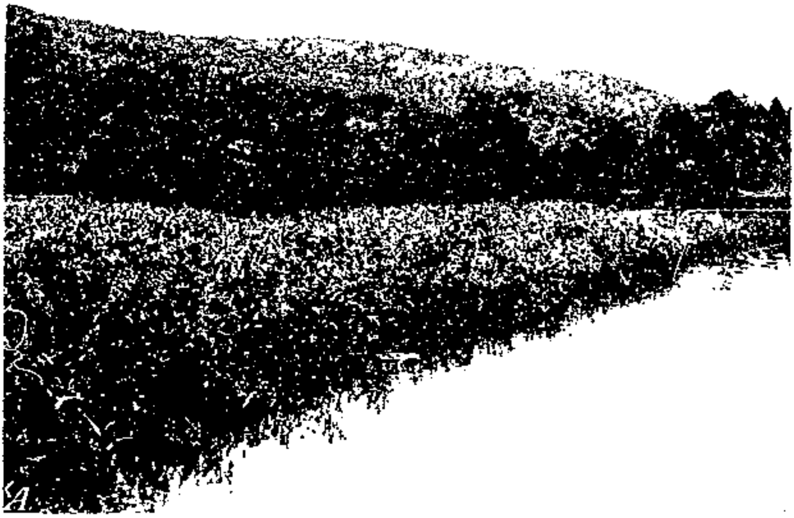
A, Clump of arrow-arum (*Peltandra virginica*); *B*, clump of pickerelweed (*Pontederia cordata*); both in Arlington County, Va.



B6037M, B4387

Duckweeds (Lemnaceae) (*A*-*E*, × 1): *A*, Big duckweed (*Spirodela polyrhiza*), and *B*, star duckweed (*Lemna trisulca*), both from Princess Anne County, Va. *C*, Duckweed (*L. minor*), Keokuk, Iowa. *D*, Watermeal (*Wolffia columbiana*), Morrill County, Nebr. *E*, *Wolffiella floridana*, Princess Anne County, Md. *F*, Big duckweed (*S. polyrhiza*) on a pond in Charles County, Md.

Nodding smartweed (*Polygonum lapathifolium*), × ⅓. Arlington County, Va.




B42133

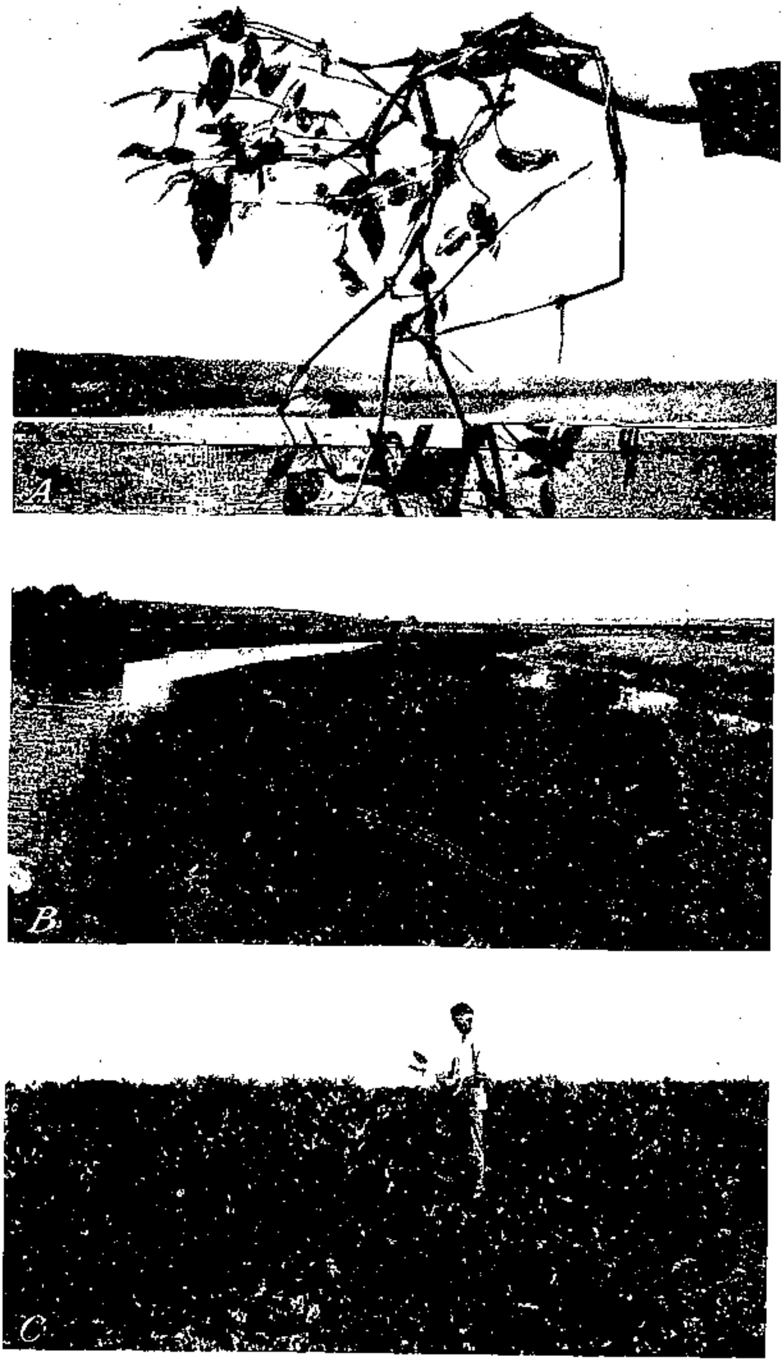
Smartweed beds: *A*, Nodding smartweed (*Polygonum lapathifolium*), Fairfield County, Conn. (photograph by A. L. Clark). *B*, Largeseed smartweed (*P. pensylvanicum*), Dorchester County, Md.

B6052M, B44679

Aquatic form of water smartweed (*Polygonum amphibium*): *A*, Specimen, $\times \frac{2}{5}$, from Delta County, Mich. *B*, Plants in flower, growing with hardstem bulrush (*Scirpus acutus*) in background, in lake near Calais, Maine.

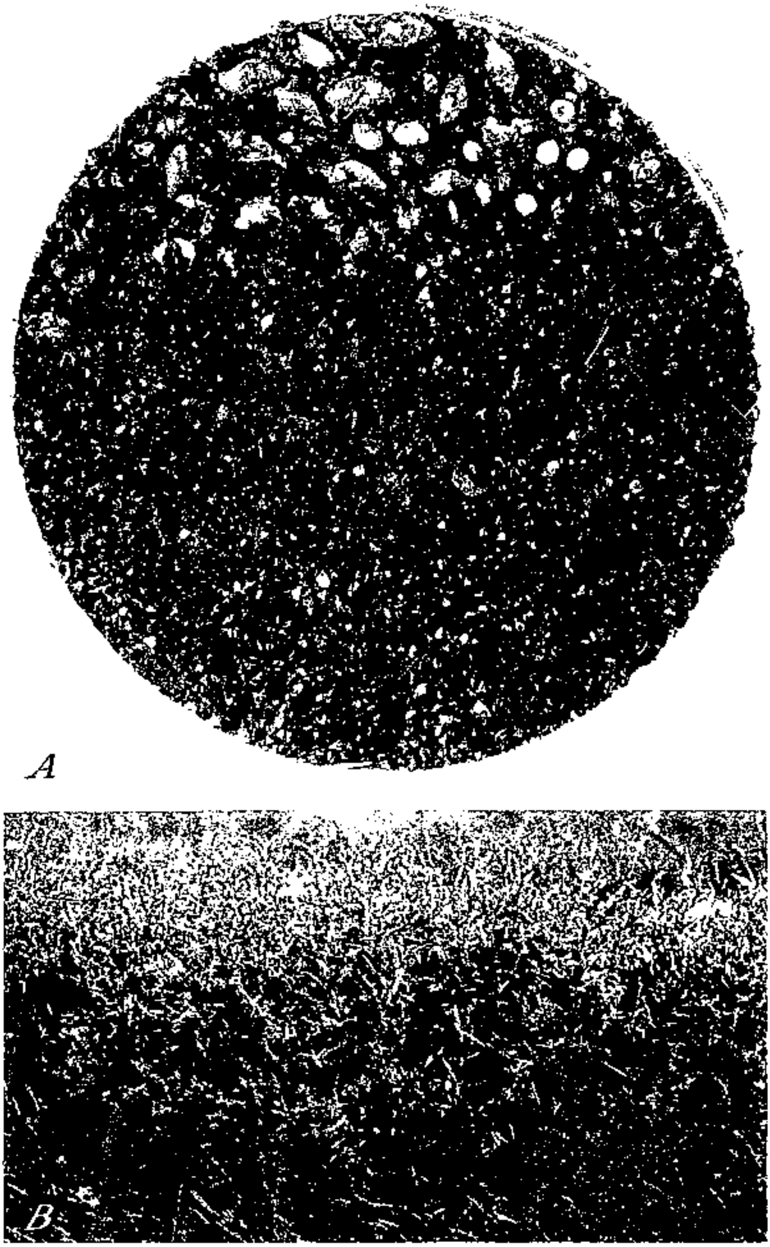
B5022M

Terrestrial form of water smartweed (*Polygonum amphibium*), × $^{3}/_{5}$, Door County, Wis.



B7567M; B7568M; B7569M

Marsh smartweed (*Polygonum muhlenbergii*): *A*, Specimen of aquatic form, showing swollen floating stems, taken from (*B*) bed of plants, Upper Souris River, N. Dak. *C*, Luxuriant stand in dry lake bed, showing survival value during drought, St. Charles County, Mo.



96181M; B44845

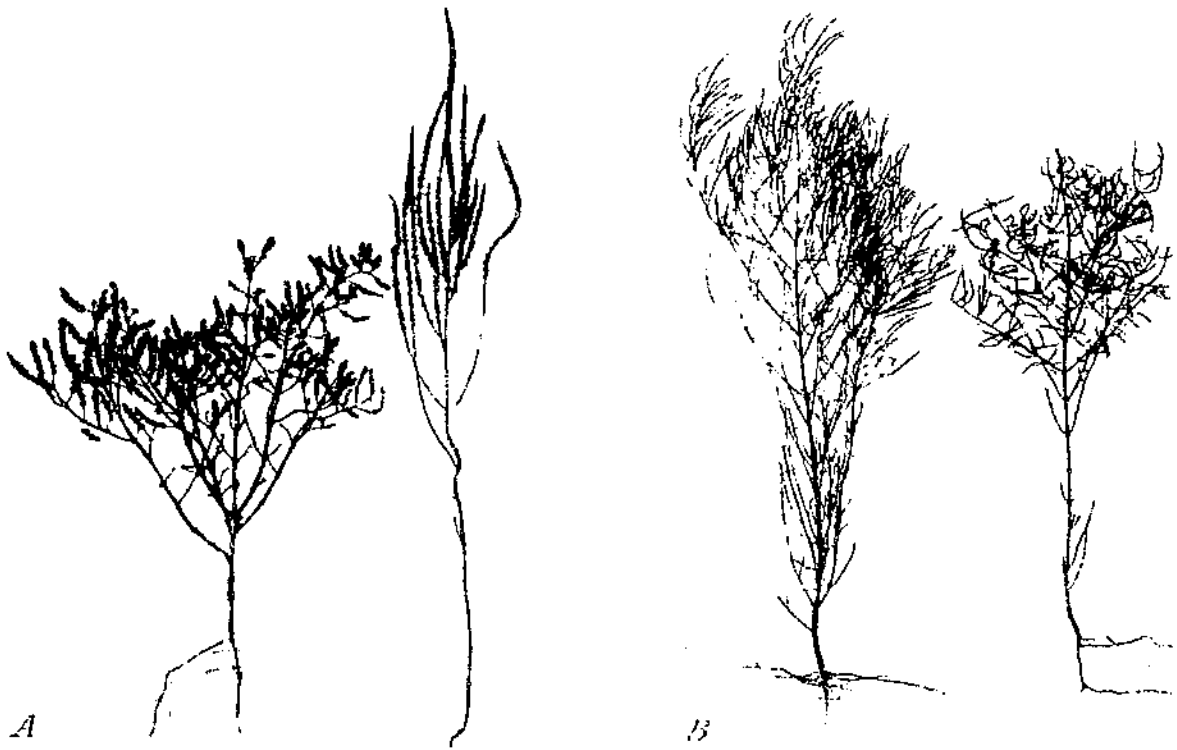
Dotted smartweed (*Polygonum punctatum*): *A*, More than 36,000 seeds (and a few mollusks), × 1, taken from the gullet of a black duck captured at Poplar Branch, N. C. *B*, Stand of the plants, Dorchester County, Md.

B6a3M; B6a2M

Specimens of smartweeds (*Polygonum*): *A*, Dotted smartweed (*P. punctatum*), $\times \frac{2}{5}$, Pepin County, Wis. *B*, Swamp smartweed (*P. hydropiperoides*), $\times \frac{1}{5}$, Arkansas County, Ark.

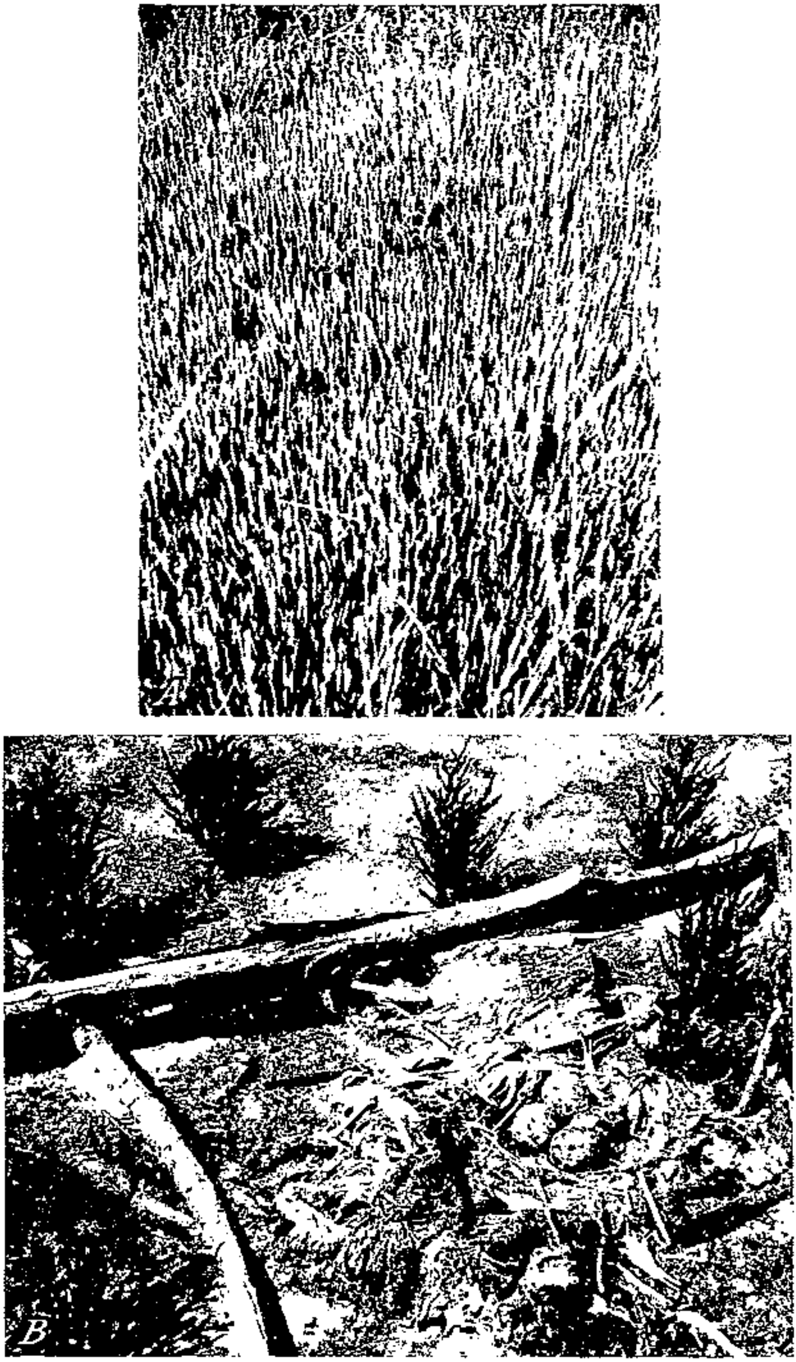
Ladysthumb (*Polygonum persicaria*), × [illegible], from Tazewell County, Ill.

Growths of smartweeds. *A*, Swamp smartweed (*Polygonum hydropiperoides*), Dorchester County, Md. *B*, Tangle of tearthumb (*P. sagittatum*), Arlington County, Va.



B---6M, B---7M

Specimens of glassworts (*Salicornia*), × ½: *A*, *S.* [illegible], Chaves County, N. Mex. *B*, *S. europaea*, Norfolk County, Va.



B4397S, B16196

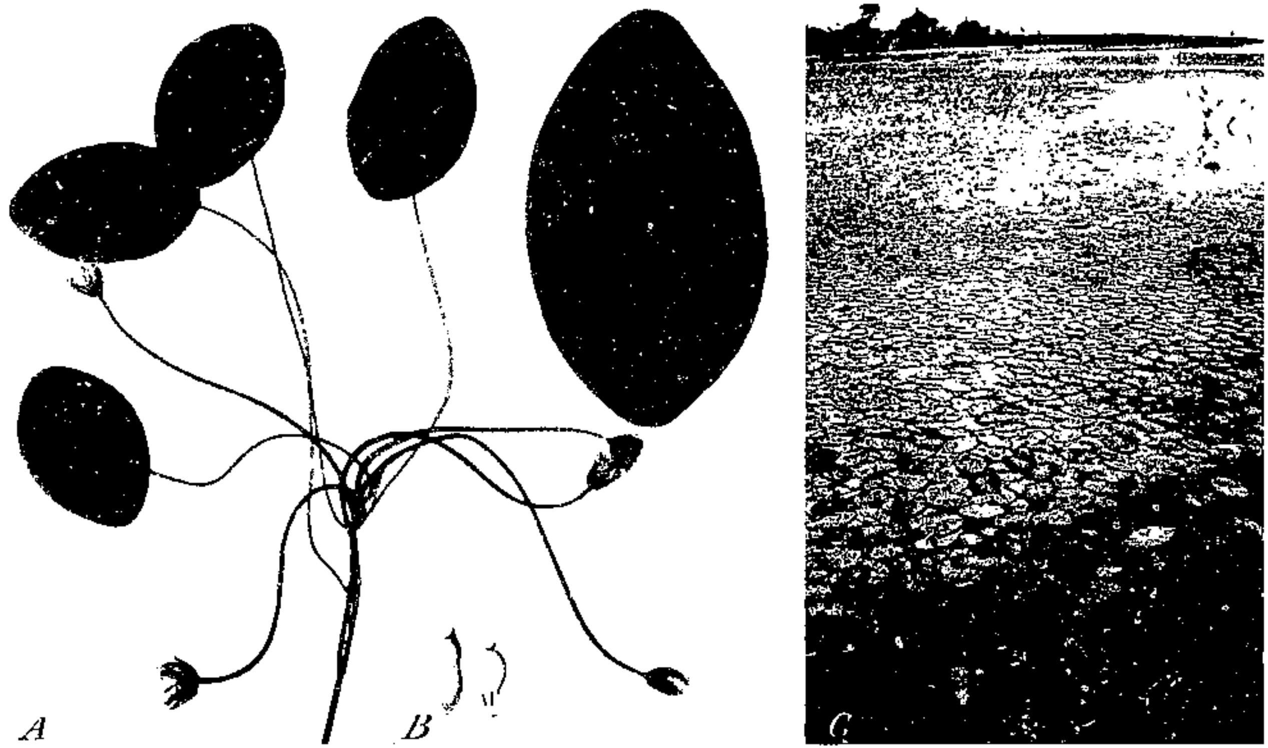
Characteristic growths of glassworts. *A*, Bed of young *Salicornia europea* in a salt marsh, Northampton County, Va. *B*, Scattered plants (*Salicornia* sp.) near nest of a killdeer, Bear River marshes, Utah.

Tidemarsh waterhemp (*Acnida cannabina*): *A*, Tide-flat growth along Potomac River, Arlington County, Va. *B*, Specimens, × 1/3: *a*, branch from pistillate plant bearing seed; *b*, branch from staminate plant.

BS(M): B5444

Coontail (*Ceratophyllum demersum*): *A*, Specimen, × [illegible], from Montgomery County, Md. *B*, An especially favorable habitat, Reelfoot Lake, Tenn., where its abundance made rowing difficult (duckweeds (*Wolffia* and *Spirodela*), spatterdocks (*Nymphaea advena*), and baldcypress (*Taxodium distichum*) also present. *C*, Seed of coontail with spiny appendages, × 2. *D*, Seed broken and exterior parts removed, × 4.

A, Banana waterlily (*Castalia flava*), specimen, × [illegible], grown from Lake Surprise, Tex., stock, showing several clusters of the bananalike hibernating bodies. *B*, Small rootstock, × [illegible]. *C*, Bed of waterlilies (*C. tuberosa*), Nicollet County, Minn.



Watershield (*Brasenia schreberi*). *A*, Specimen, × [illegible], from Hennepin County, Minn. *B*, Two-seeded and one-seeded fruits, × 1½. *C*, Extensive bed in Charcoal Creek, Franklin County, Vt.

White water buttercups, specimens, × [illegible]. *A*, *Ranunculus aquatilis* var. *capillaceus*, from Gogebic County, Mich. *B*, *R. circinatus*, from Hennepin County, Minn.

BF29M, 95776M, B5998M

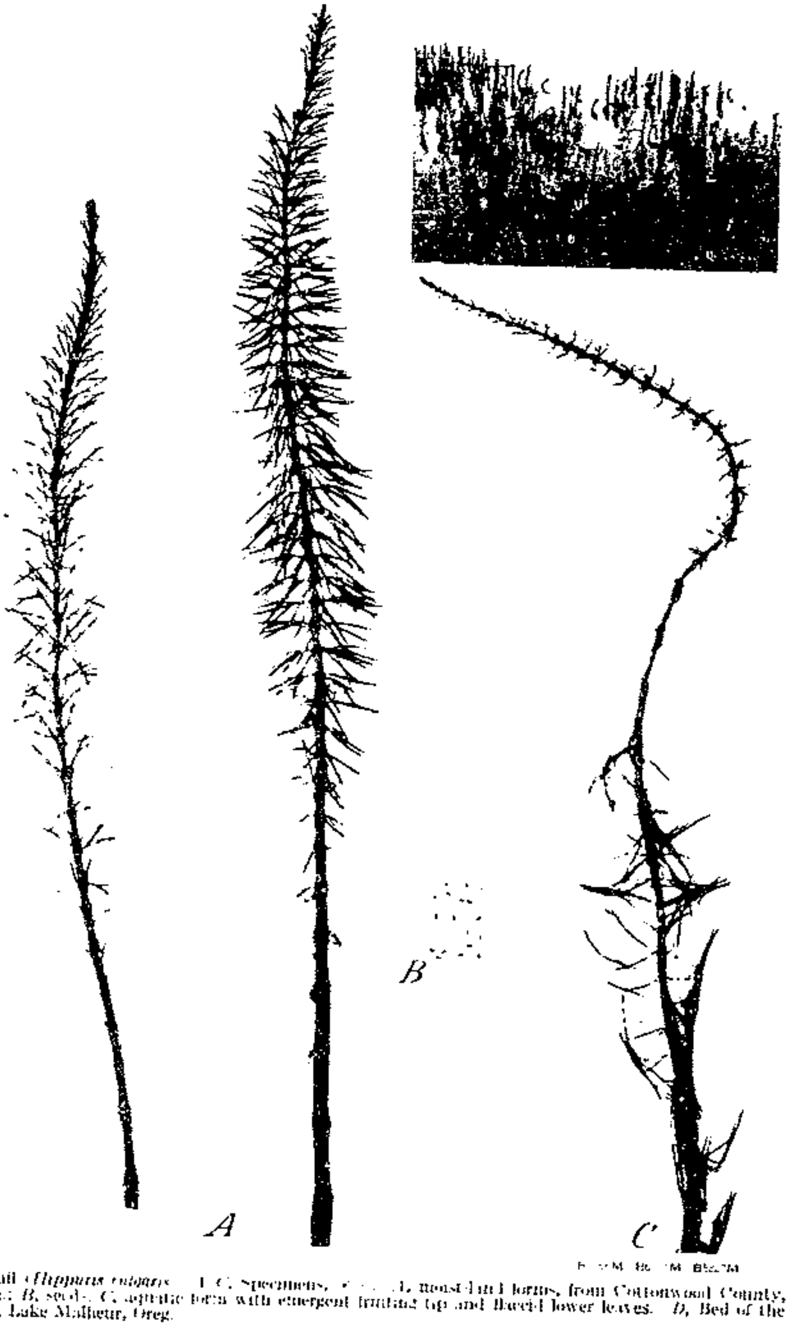
Buttercups: *A*, *Ranunculus cymbalaria*, × ¼, from Brown County, Minn. *B*, *R. sceleratus*, × ¼, from Charles County, Md. *C* and *D*, *R. flabellaris*, × ½, from Mississippi River bottoms, Buffalo County, Wis.: *C*, aquatic form, *D*, terrestrial form.

6632EM

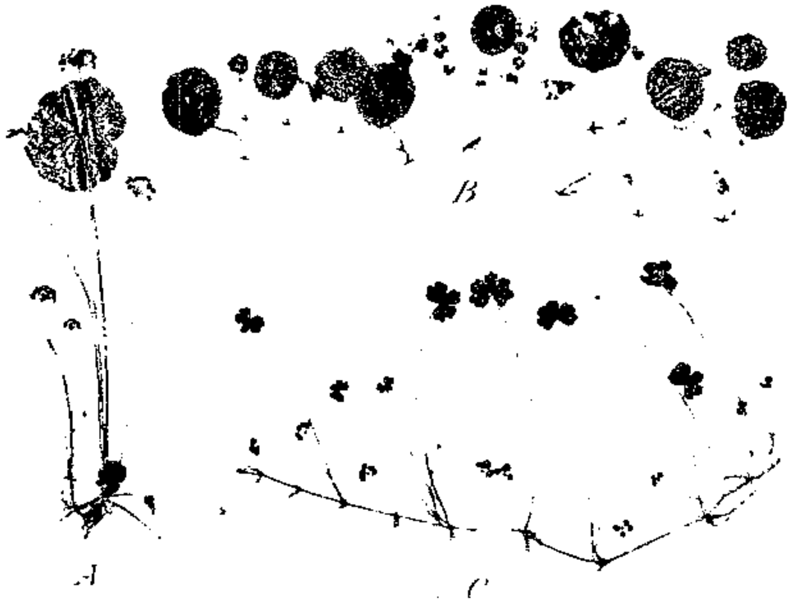
Creeping waterprimrose (*Jussiaea diffusa*), × 1/3, from Arkansas County, Ark.

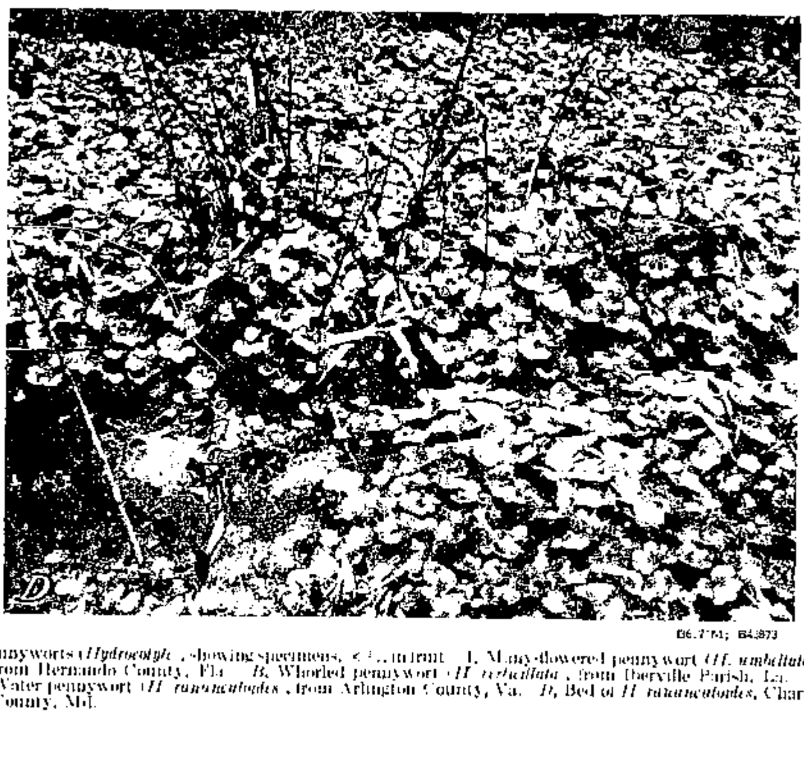
Watermilfoils, [illegible]: *A*, *Myriophyllum spicatum*, from Wright County, Minn. *B*, *M. verticillatum*, with winter buds, from Presque Isle County, Mich. *C*, *M. heterophyllum*, from Mobile County, Ala.

Mermaidweeds (*Proserpinaca*): *A*, *P. pectinata*, $\times \frac{1}{2}$, from Fort Myers, Fla. *B* and *C*, *P. palustris*. *B*, specimen, $\times \frac{4}{5}$, from Crawford County, Pa.; *C*, seeds, $\times 1\frac{1}{2}$.



Marestail (*Hippuris vulgaris*). A–C, Specimens, × [illegible]; A, moist-land forms, from Cottonwood County, Minn.; *B*, seeds; *C*, aquatic form with emergent fruiting tip and flaccid lower leaves. *D*, Bed of the plant, Lake Malheur, Oreg.





B6,774; B4,873

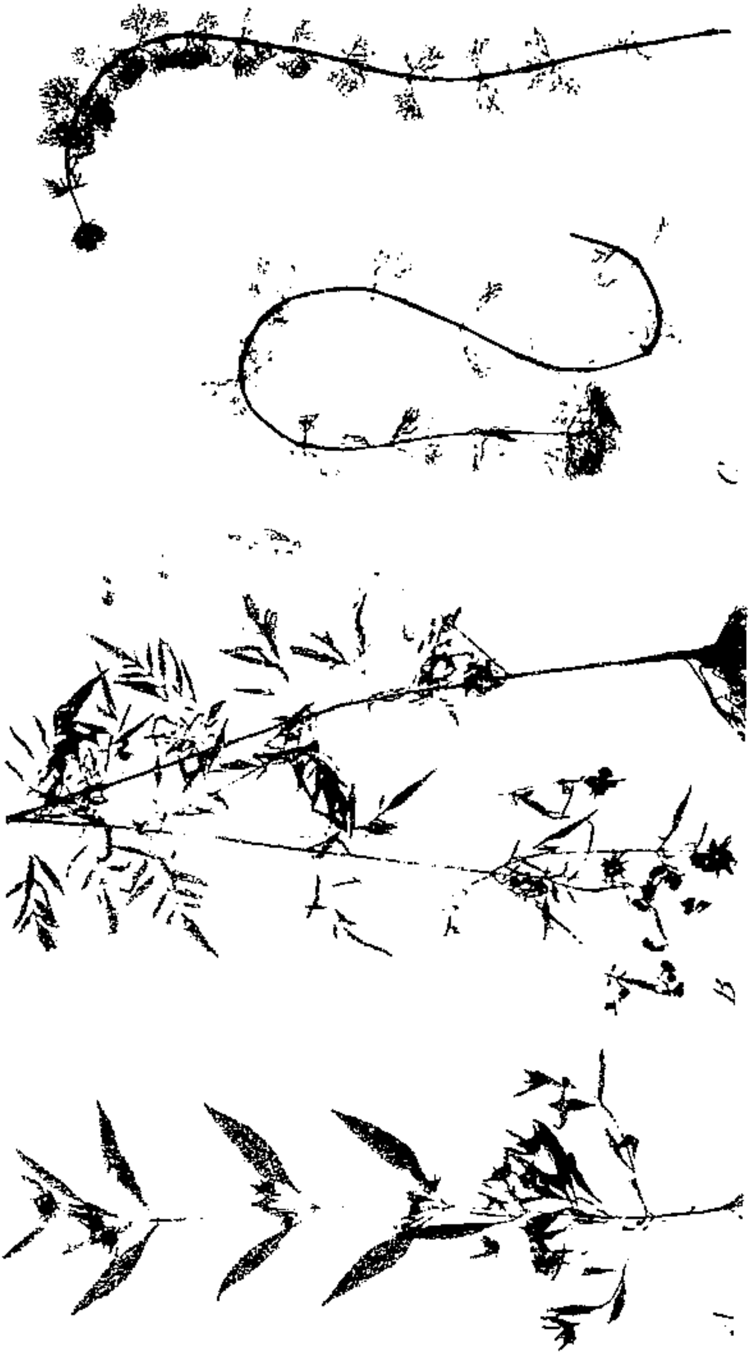
Pennyworts (*Hydrocotyle*), showing specimens, × ⅓, in front. *A*, Many-flowered pennywort (*H. umbellata*), from Hernando County, Fla. *B*, Whorled pennywort (*H. verticillata*), from Iberville Parish, La. *C*, Water pennywort (*H. ranunculoides*), from Arlington County, Va. *D*, Bed of *H. ranunculoides*, Charles County, Md.

[illegible]

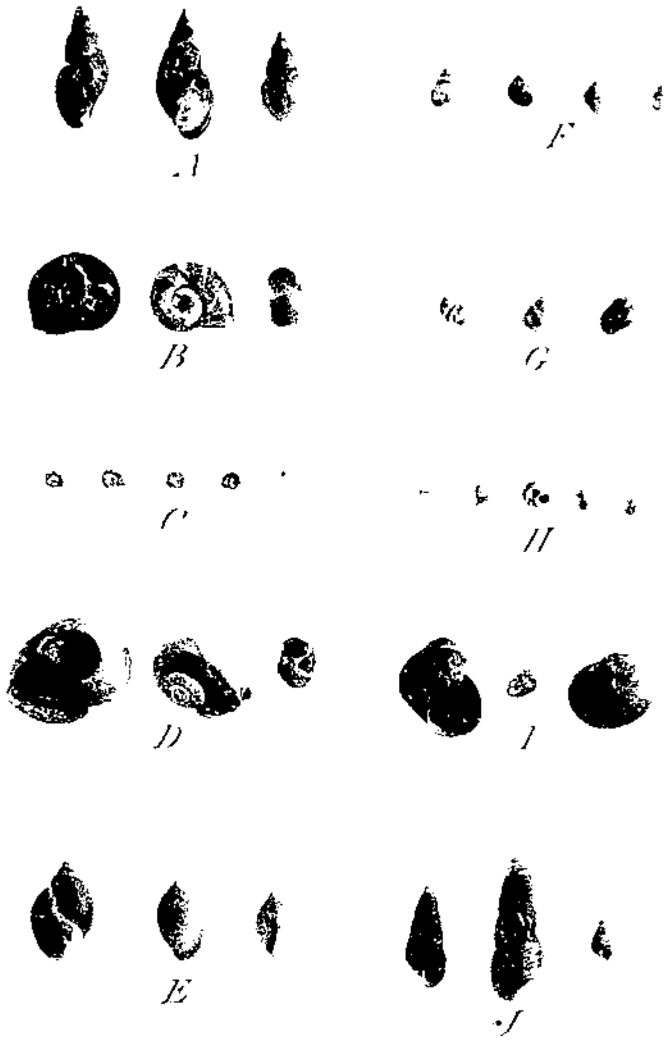
Waterhyssops (*Bacopa*). × 1. *A*, Coastal waterhyssop (*B. monnieria*), from Calcasieu Parish, La. *B*, Roundleaf waterhyssop (*B. rotundifolia*), from the Mississippi River bottoms, Jackson County, Iowa.

B65-M, B1629, B5685

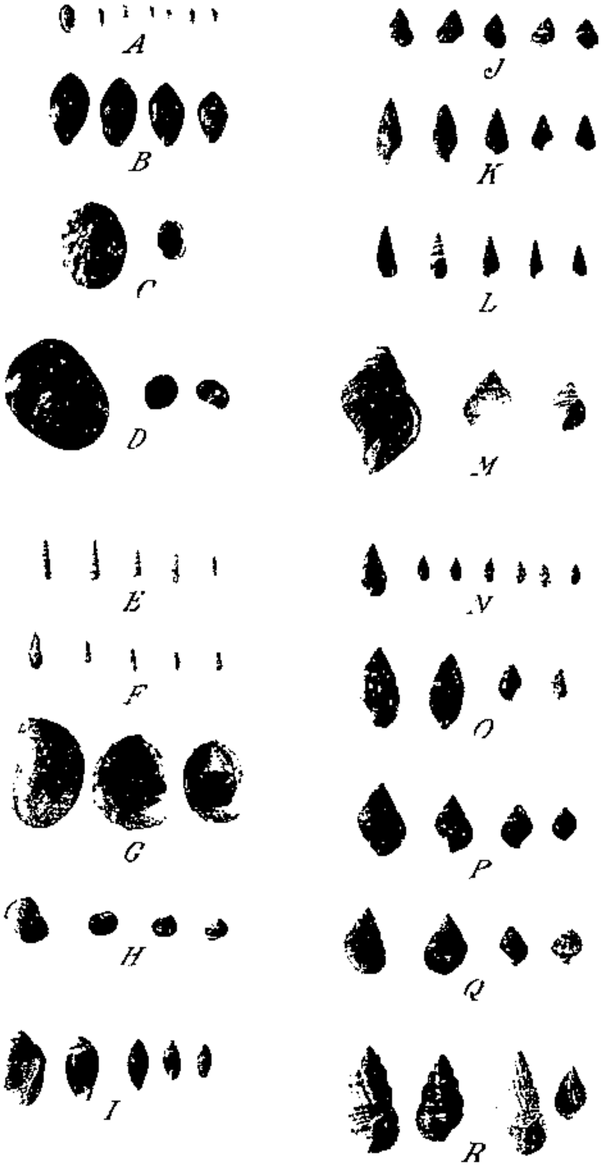
Buttonbush (*Cephalanthus occidentalis*): *A*, Specimen, × ½, collected in July, Arlington County, Va.; *B*, Fruits from same bush (*C*), collected the following February; *D*, Favorable buttonbush habitat in a gum swamp, Johnson County, Ill.



A, Beggarticks (*Bidens cernua*), from Buffalo County, Wis. B, Beggarticks (*B. aristosa*), from Prince William County, Va. C, Watermarigold (*B. beckii*), from Schoolcraft County, Mich. All × $\frac{1}{4}$.



Fresh-water snails (Gastropoda), all × ¾, used as food by waterfowl. *A*, Pond snail (*Stagnicola (Lymnaea) palustris*); *B*, three-coiled snail (*Helisoma (Planorbis) trivolvis*); *C*, *Gyraulus (Planorbis) parvus*; *D*, terraced snail (*[illegible]*); *E*, tadpole snail (*Physa gyrina*); *F*, *Amnicola [illegible]*; *G*, flood shell (*Fluminicola nuttalliana*); *H*, round-mouthed snail (*Valvata tricarinata*); *I*, *Vivipara [illegible]*; *J*, *Goniobasis virginica*.

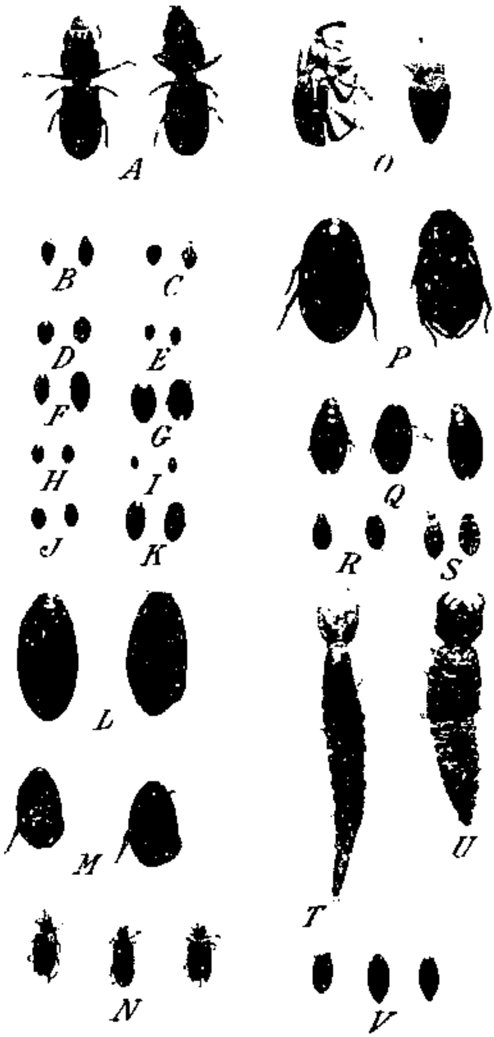


H. · M.

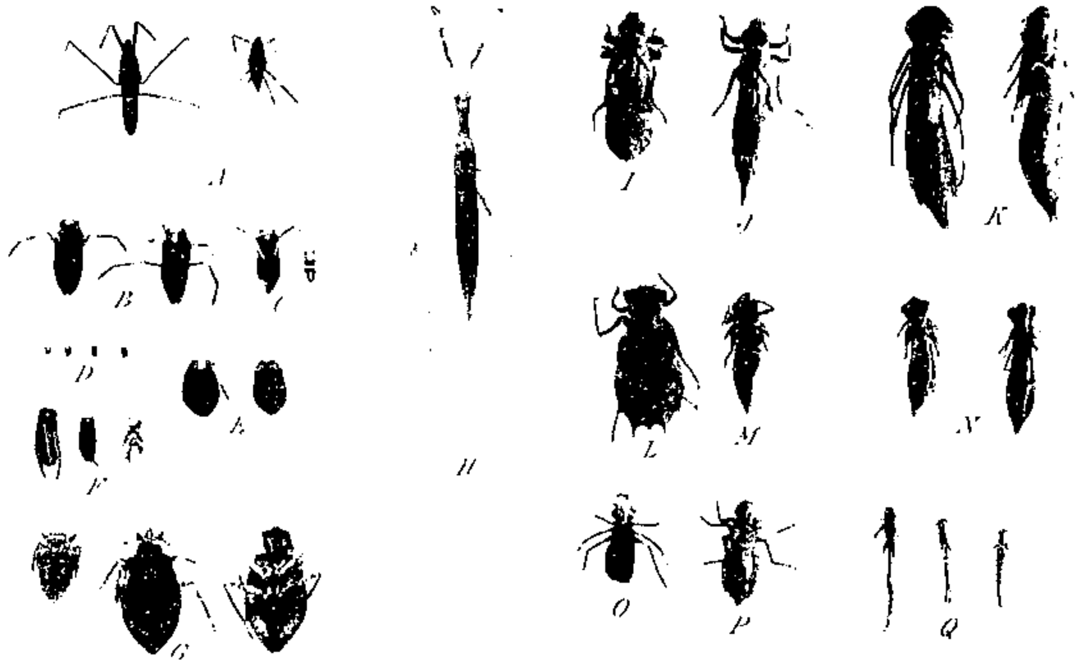
Salt-water snails (Gastropoda, all × 2), used as food by waterfowl: A, *Acteocina canaliculata*; B, *Melampus lineatus*; C, tortoise-shell limpet (*Acmaea testudinalis*); D, *Neritina reclivata*; E, *Turbonilla* sp.; F, *Odostomia* sp.; G, arched slippershell (*Crepidula fornicata*); H, periwinkle (*Littorina saxatilis*); I, *Olivella* (2 on left, *O. biplicata*; 3 on right, *O. mutica*); J, *Lacuna vincta*; K, *Cerithium variabile*; L, *C. minimum nigrescens*; M, wrinkled purpleshell (*Thais lamellosa*); N, *Alia* (left specimen, *A. carinata*; others, *A. lunata*); O, *Anachis avara*; P, *Nassarius obsoleta*; Q, *N. vibex*; R, *Nassarius* (2 on left, *N. mendicus*; 2 on right, *N. trivittata*).

B[illegible]M

Bivalve mollusks (Pelecypoda; all × 1), eaten by diving ducks: A, Little blue mussel (*Mytilus edulis*); *B*, ribbed mussel (*Modiolus demissus*); *C*, rock cockle (*Paphia staminea*); *D*, [illegible]; *E*, Morton's cockle (*Cardium mortoni*); *F*, nut shell (*Nucula proxima*); *G*, *Gemma gemma*; *H*, small seed-shell (*Pisidium occidentale*); *I*, large seed-shell (*Sphaerium stamineum*); *J*, oysters (*Ostrea lurida*); *K*, bent-nosed clam (*Macoma nasuta*).



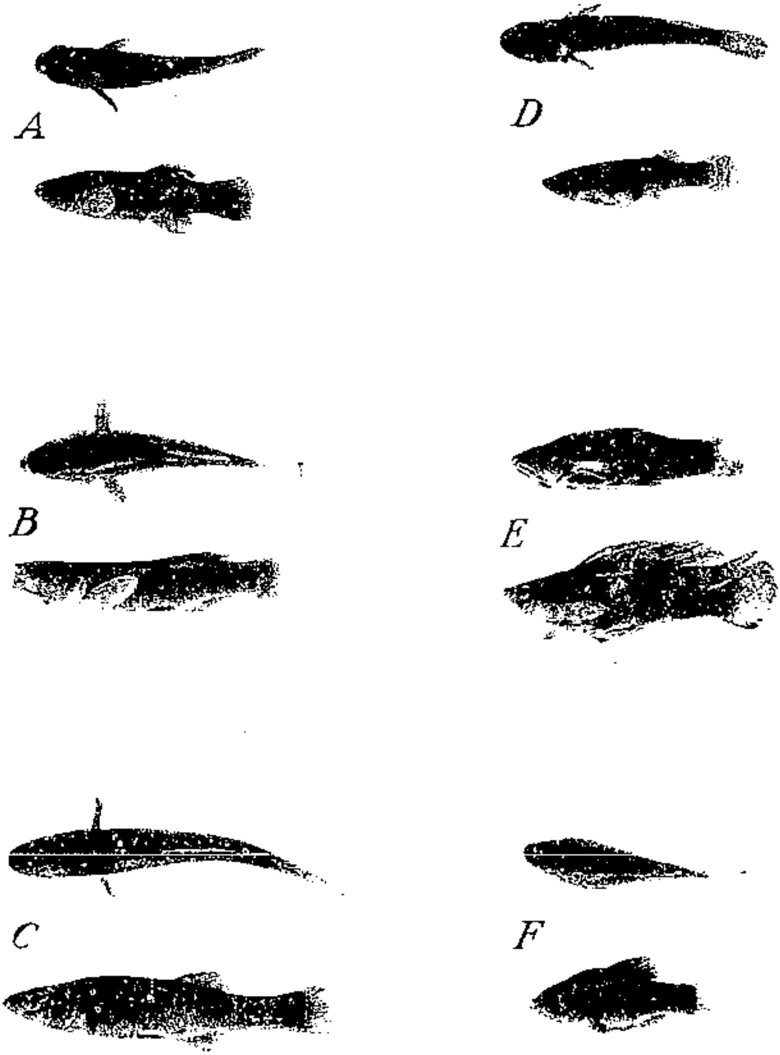
Beetles (Coleoptera), × 1, commonly eaten by game ducks: *A*, Ground beetles (*Scarites subterraneus*); *B* and *C*, crawling water beetles (Haliplidae)—*B*, *Haliplus connexus*; *C*, *Peltodytes 12-punctatus*.—*D* to *M*, diving beetles (Dytiscidae)—*D*, *Colpius inflatus*; *E*, *Canthydrus bicolor*; *F*, *Hydrocanthus iricolor*; *G*, *Laccophilus decipiens*; *H*, *Hydrovatus compressus*; *I*, *Bidessus affinis*; *J*, *Coelambus inaequalis*; *K*, *Deronectes griseostriatus*; *L*, *Colymbetes sculptilis*; *M*, *Thermonectes basilaris*.—*N*, Long-horned leaf beetles (*Donacia subtilis*); *O*, snout beetles (*Sphenophorus aequalis*); *P* to *S*, water scavenger beetles (Hydrophilidae)—*P*, *Hydrophilus obtusatus*; *Q*, *Tropisternus lateralis*; *R*, *Berosus striatus*; *S*, *B. infuscatus*.—*T*, larva of predacious diving beetle (*Cybister fimbriolatus*); *U*, larva of water scavenger beetle (*Hydrous triangularis*); *V*, whirligig beetles (*Gyrinus analis*).



True bugs (Hemiptera) (A–H, × 1), and nymphs of dragonflies and damsel flies (Odonata) (I–Q, × 1), eaten by game ducks: A, Water striders (*Gerris remigis*) (left, adult; right, nymph); B, C, and D, back swimmers (*Notonecta*): B, *N. irrorata* (left, ventral; right, dorsal); C, *N. uhleri* (left, adult; right, nymph); D, *Plea striola*; E, creeping water bugs (*Pelocoris femoratus*) (left, dorsal; right, ventral); F, water boatmen (*Arctocorixa* spp.) (right, ventral; others, dorsal); G, giant water bugs (*Belostoma* sp.) (left, nymph; center, dorsal; right, ventral); H, water scorpion (*Ranatra* sp.); I–P, dragonfly nymphs: I, *Gomphus externus*, J, *G. notatus*, K, *Anax junius* (left, dorsal; right, ventral); L, *Epicordulia princeps*; M, *Cordulegaster* sp.; N, *Aeschna* sp. (left, dorsal; right, ventral); O, *Neurocordulia obsoleta* (ventral, labium raised); P, Libellulinae (ventral, labium lowered); Q, damsel fly naiads (Coenagrioninae).

Nymphs, larvae, or pupae of aquatic insects eaten by ducks, all × 7/8. *A–C*, Mayfly nymphs (Ephemerida) – *A*, *Ecdyonurus* sp.; *B*, *Siphlonurus* sp.; *C*, *Ephemerella invaria*. *D–F*, stone-fly nymphs (Plecoptera) – *D* and *E*, *Pteronarcys* sp.; *F*, perlid. *G*, larvae and pupae of caddisflies (Trichoptera), with cases (below) from which removed; *H–K*, various types of caddisfly larval cases; *L*, crane-fly larvae and pupae (*Tipula* spp.); *M*, midge larvae (*Chironomus tentans*); *N*, horsefly larvae (*Tabanus atratus*); *O–Q*, soldier-fly larvae (Stratiomyidae) – *O* and *P*, *Odontomyia* spp.; *Q*, *Stratiomyia* sp.; *R*, brine-fly pupae (*Ephydra* sp.).

Crustaceans eaten by game ducks. A–G, Order other than Decapoda, all × 7: A, barnacles (*Balanus glandulosa*); B, fairy shrimps (*Apus* sp.); C, water flea (*Streptocephalus* sp.); D, *Idothea baltica*; E, beach fleas (*Orchestia grillus*); F, scuds (*Gammarus fasciatus*); G, ostracods (*Cypris pellucida*). H–M, decapod crustaceans, all × [illegible]: H, crawfish (*Cambarus virilis*); I, fresh-water shrimp (*Palaemonetes exilipes*); J, green crab (*Carcinides maenas*); K, yellow shore crab (*Hemigrapsus oregonensis*); L, mud crab (*Neopanope texana sayi*); M, mud crab (*Hexapanopeus angustifrons*).

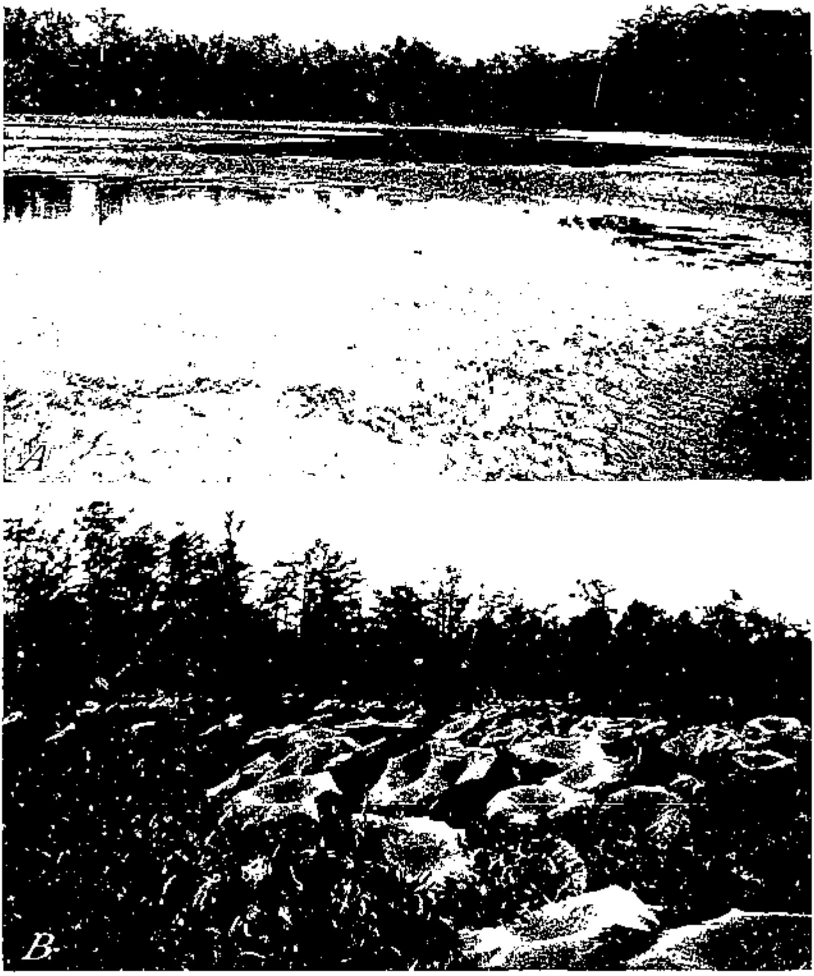


85973M

Common killifishes, or top minnows (Cyprinodontidae and Poeciliidae), all × ½, eaten by game ducks: *A*, Mummichog (*Fundulus heteroclitus*); *B*, salt-water killifish, with mouth open (*F. majalis*); *C*, fresh-water killifish (*F. diaphanus*); *D*, mosquito fish (*Gambusia affinis holbrookii*); *E*, sail-finned killifish (*Mollienesia latipinna*), female above, male below; *F*, broad killifish (*Cyprinodon variegatus*).

Coarse form of sago pondweed (*Potamogeton pectinatus*) from Arlington County, Va., showing the small tubers that developed among the leaves after this branch was torn from its rootstocks and placed in shallow water in contact with the soil; such branches are useful for propagation.

A, "Just another marsh" to the casual observer, but in reality a food haven for wild ducks. Biologist shown examining northern wildrice that had been planted on the margin of a dense bed of wild millet, smartweed, wapato, and lophotocarpus in the Chautauqua Migratory Waterfowl Refuge, Mason County, Ill. *B*, Harvesting cradle for gathering the seeds of wildrice, tidemarsh waterhemp, and other tall marsh plants.



B4°277, B7310M

A, Barren, semidry lake bed in the bottomlands along the White River, Monroe County, Ark. Lakes that are subject to extreme fluctuations in water level and are usually dry during the latter part of summer can be greatly improved by planting chufa (*Cyperus esculentus*) around the borders and marsh smartweed (*Polygonum muhlenbergii*) in parts that retain water longest. *B*, Similar lake bed in the bottom lands at the mouth of the Ohio River, Ballard County, Ky., with an excellent crop of marsh smartweed and scattered plants of American lotus (*Nelumbo pentapetala*=*N. lutea*).

B43567; B40245

A, Boulder-covered margin of Devils Lake, N. Dak., often a major obstacle to the development of waterfowl food plants on northern lakes. Sometimes a layer of silt can be washed over such margins and make the propagation of food plants possible. *B*, Barren, firm sand margin of a northwestern lake, a type difficult to improve for waterfowl, though susceptible of gradual improvement by planting hardstem bulrush (*Scirpus acutus*) and other wave-resistant species.

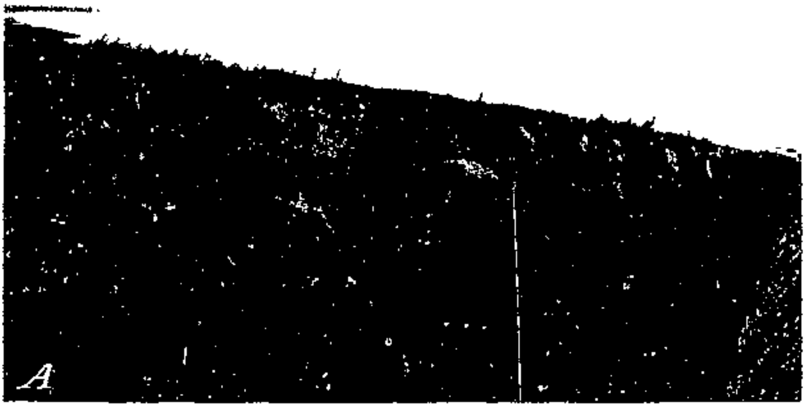
B43918;

A, Decaying cypress stumps on the margin of Lake Drummond in the Dismal Swamp, Norfolk County, Va. The acid condition and the intense organic stains that characterize the water of this barren lake prevent the development of most aquatic plants. *B*, Featherfoil (*Hottonia inflata*) growing in similar waters of Dragon Swamp, northwest of Saluda, Va. (photograph by C. E. Smith). This plant is worthy of experimental plantings in such waters, for shoal-water ducks were found to feed on it actively in a game sanctuary at Bridgeport, Conn.

P1969.

A, Wing dams projecting into the left side of the Mississippi River below Homer, Minn., which, though constructed to aid in maintaining a navigable channel, often served also to retard the current sufficiently for the development of valuable beds of aquatic plants. *B*, Barges loaded with bundles of willows and flat rocks, for use with the aid of a floating derrick in the construction of a wing dam (photograph by H. W. Graham).

A, Sediment deposited in a former duck marsh during a single heavy rain in Buffalo County, Wis., from erosion that could have been controlled on an adjacent hillside. *B*, Bank erosion along the mouth of the Zumbro River, Wabasha County, Minn., the silt from which, originating during flood seasons, completely destroyed neighboring waterfowl feeding grounds. *C*, Silt-filled bed of Pile Lake, adjacent to the mouth of the Zumbro River, which 8 years before this photograph was taken was a fine bottom-land lake.



B45173 B44691

A, Semidry, alkali-encrusted bed of Horsehead Lake, Kidder County, N. Dak., with a dense mat of sea blite (*Suaeda depressa*) in the foreground. Such alkali flats can sometimes be improved by planting glassworts (*Salicornia* spp.). *B*, Exposed tidal margin near the mouth of Mianus River, Conn., showing a band of sea blite (*Suaeda americana*) with a background of saltmarsh cordgrass (*Spartina alterniflora*). Such margins in this area could be improved by planting tidemarsh waterhemp (*Acnida cannabina*).

B. S. M. 84346

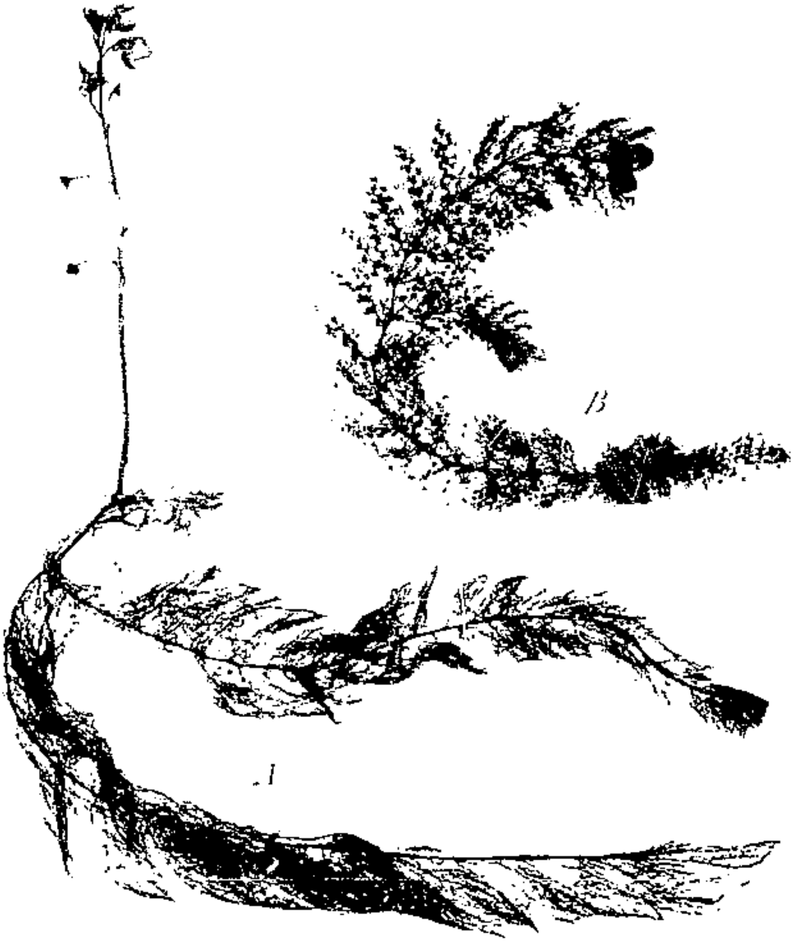
A, Floating rosette of waterlettuce (*Pistia stratiotes*), $\times \frac{3}{4}$, at times a menace to waterfowl food plants in the Gulf States. *B*, Dense, floating mat of waterlettuce interspersed with duckweeds (*Lemna* sp.), Marion County, Fla.

Alligatorweed (*Alternanthera philoxeroides*), × ½, an aquatic amaranth that has become a serious menace to waterfowl food plants in the Southeastern and Gulf States.

A, American lotus (*Nelumbo pentapetala* (*N. lutea*)) in the Illinois River bottoms, Fulton County, Ill., a beautiful aquatic plant, but often a serious menace to the growth of valuable waterfowl food plants—its bonelike seeds have rarely been found in duck stomachs. *B*, Low tide in a bed of yellow pondlily, or spatterdock (*Nymphaea advena*), which has eliminated a valuable growth of wildcelery in Fairfax County, Va.; although the seeds are occasionally eaten by ducks, the plant is likely to be more of a liability than an asset in many waterfowl feeding grounds.

B43552, 43557

A, Distant view of floating beds of waterchestnut (*Trapa natans*) on the Potomac River, mouth of Oxon Run, Prince Georges County, Md., from which point this plant has infested the entire length of the fresh-water section of the tidal Potomac in about 15 years. *B*, Edge of dense bed of waterchestnut in Prince Georges County, Md., July 30, 1930, which has almost entirely crowded out formerly valuable beds of wildcelery and other waterfowl food plants.



A, Common bladderwort (*Utricularia vulgaris*) from Allamakee County, Iowa. *B*, Branch with bladders and winter buds from Nicollet County, Minn. Stomach examination has not indicated that this plant has any value as a duck food—at times it becomes abundant enough to retard the growth of valuable submerged plants—but there is some evidence that it may be useful in the natural control of mosquito larvae.

B92:2M

Waterstargrass (*Heteranthera dubia*). Stomach examination indicates that this submerged plant, which resembles the pondweeds, is rarely eaten by ducks. Locally it is an active competitor of wildcelery, sago pondweed, and other valuable duck food plants.

E6083M

Muckweed (*Potamogeton crispus*) from the Potomac River, Prince Georges County, Md., an introduced European pondweed the presence of which is a fair indicator of domestic pollution; in North America it rarely produces seed and appears to be of little, if any, value as a duck food; locally it has been found crowding out valuable submerged plants.

B5999M

Robbins pondweed (*Potamogeton robbinsii*) from Schoolcraft County, Mich., a rigid-leaved submerged plant of little, if any, value as a duck food; it rarely produces seed and frequently crowds out more valuable species, particularly in northern lakes.

Saltflat grass (*Monanthochloe littoralis*) from the southeast side of Nueces Bay, Tex., a grass of the southern coasts of California, Texas, and Florida that rarely produces seeds but usurps flats that could support more useful species.

A, Woolgrass (*Scirpus cyperinus*), worthless as a duck food, competing with the more valuable pickerelweed (*Pontederia lanceolata*) in a semidry marsh along Savannah River, Jasper County, S. C.; a slight permanent increase in water level would retard the former and increase the latter. *B*, Tangle of river bulrush (*S. fluviatilis*) (see also pl. 81, *C*) in the Mississippi River bottoms near Sabula, Iowa, a species that rarely produces important quantities of seeds and depends chiefly on its woody-tubered rootstocks for reproduction; it is of little value as a duck food in most sections (photograph by H. W. Graham).

Sweetflag (*Acorus calamus*) with fruit, from a tidal marsh in Arlington County, Va. (see also pl. 150, *B*).

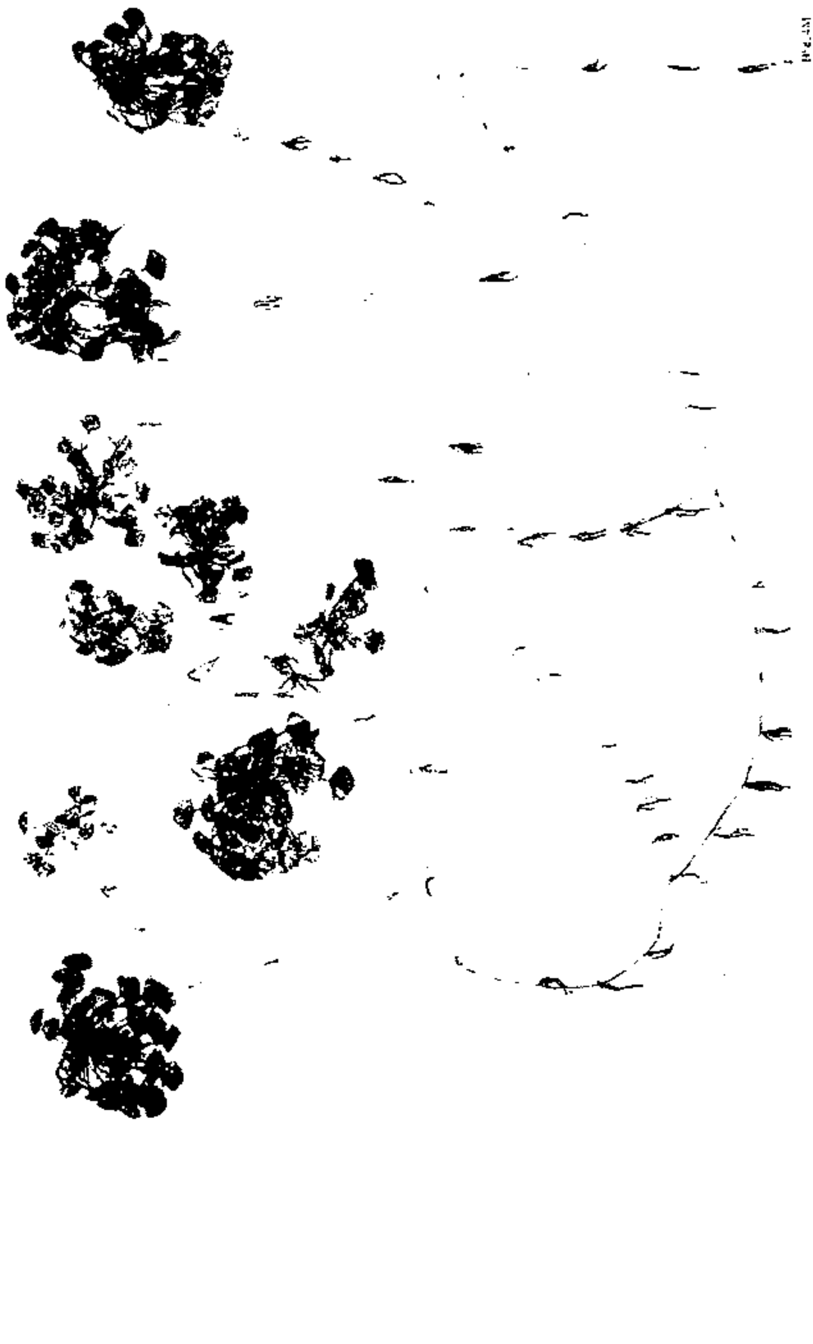
A, American germander (*Teucrium canadense*) from border of Potomac River, Arlington County, Va. *B*, Inflorescence of betony (*Stachys tenuifolia* = *S. aspera*) from the same area. These coarse mints and several related species are often abundant in semidry marshes but have practically no value for waterfowl.

86215M

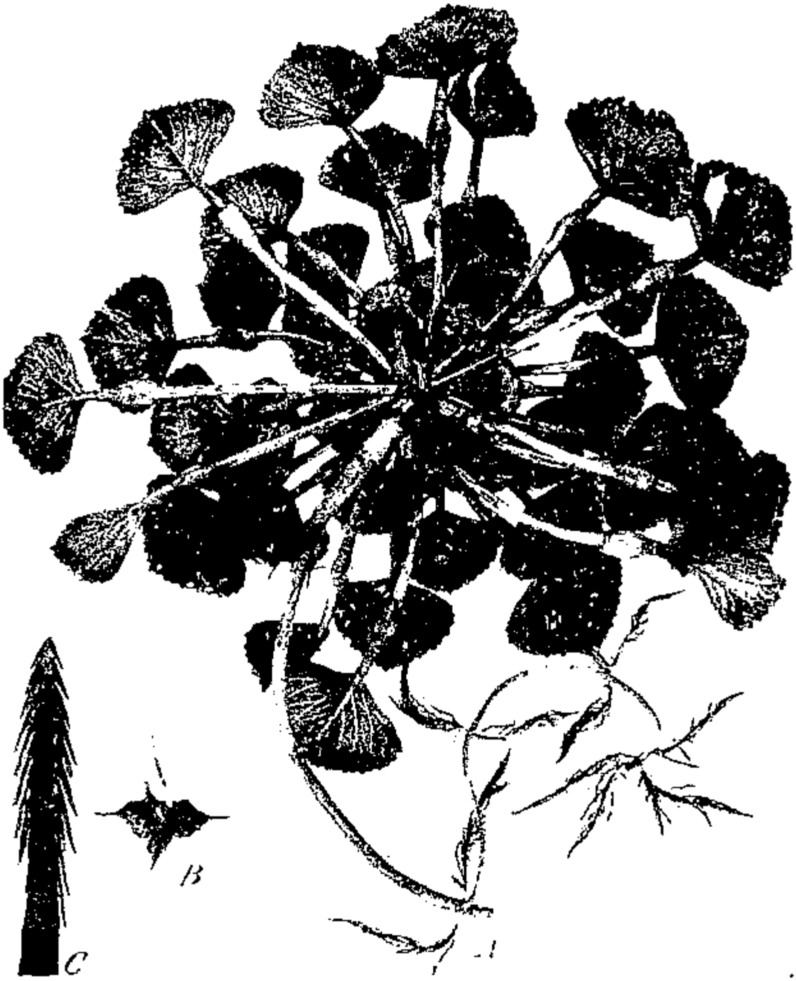
Wild mint (*Mentha canadensis*) from Round Lake, Delta County, Mich., a plant that is of little value to ducks and often competes with useful food plants in shallow marshes.

B43303, B4467

A, Dense patch of giant cutgrass (*Zizaniopsis miliacea*) along Dogue Creek, Fairfax County, Va., prior to experimental control by mowing early in July and again at the end of August 1935. *B*, Same site about 1 year after it had been mowed; no trace of the former growth remained, and pickerelweed (*Pontederia cordata*) was encroaching from the surrounding bed; arrow-arum (*Peltandra virginica*) in foreground.



Large plant of waterchestnut, or caltrop (*Trapa natans*), from the tidal Potomac, showing nine floating rosettes and stems bearing submerged leaves. This plant was more than 11 feet long and its largest rosette 18 inches wide.

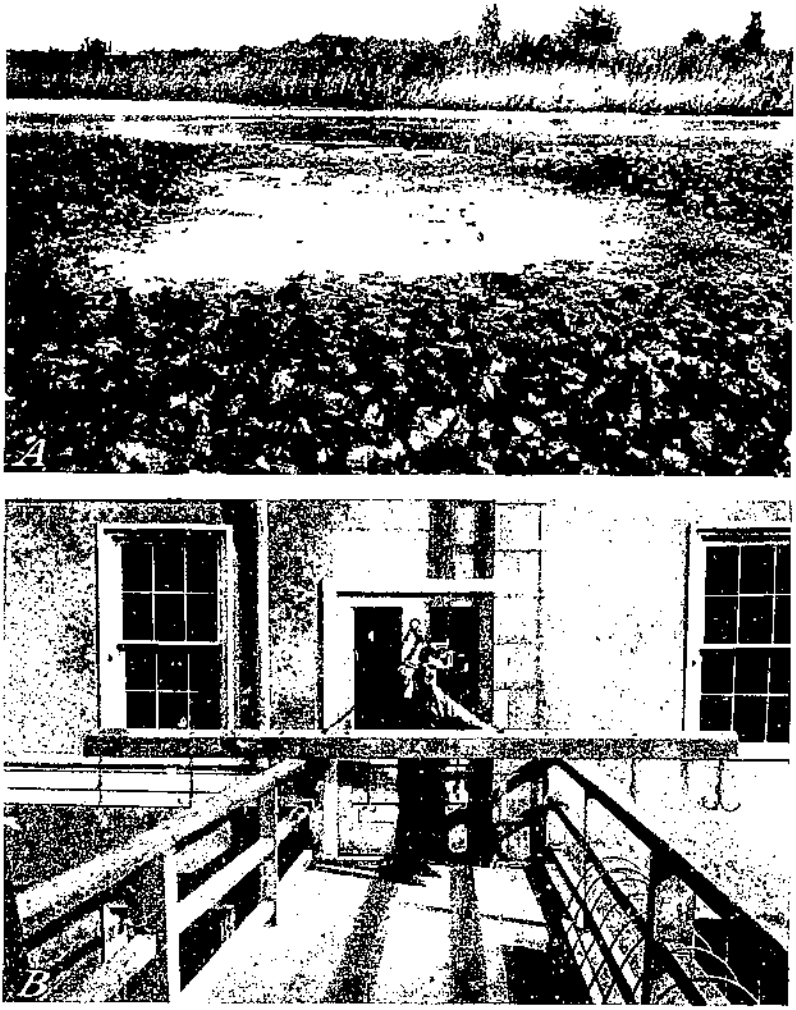


F-N 5M B6634M, B0756M

A, Waterchestnut (*Trapa natans*) from Arlington County, Va. Fruiting rosette, × ¼, with a few submerged leaves. *B*, Sprouting fruit, about × ½. *C*, Barbed tip of fruit spur, about × 12.

B43568; B43707

A, Upper end of Lake Monroe, near Sanford, Fla., choked with a solid mat of water-hyacinth (*Eichhornia crassipes*). *B*, Water-hyacinth on the St. Johns River, Lake County, Fla., March 29, 1936, floating rafts of which often drift for many miles and rapidly spread this aquatic pest.



B4372, B45697

Experimental control of the waterchestnut (*Trapa natans*) along the tidal Potomac: *A*, Rectangular clearing (in center) resulting from spraying with a solution of sodium chlorate and sodium arsenite, July 11, 1935, 2 weeks before the photograph was taken. *B*, Floating rakes developed for removing the plant growth: End of rake shown in lower right corner has rigid curved tines; rake in center has crow's-foot hooks suspended on stout chains; both types to be pulled by tractor pulley operating from the land.

F6056M; B43924

A, Needlerush (*Juncus roemerianus*) in fruit, from Dorchester County, Md.; this saltmarsh plant has no duck food value and often chokes out useful species. *B*, Dense needlerush marsh near Charleston, S. C., with no valuable food plants remaining. *C*, Light automobile equipped with special gear for traversing marshes—useful in operations for the control of undesirable marsh plants and in planting propagative materials (photograph by J. C. Salyer).

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FOOD OF GAME DUCKS IN THE UNITED STATES AND CANADA
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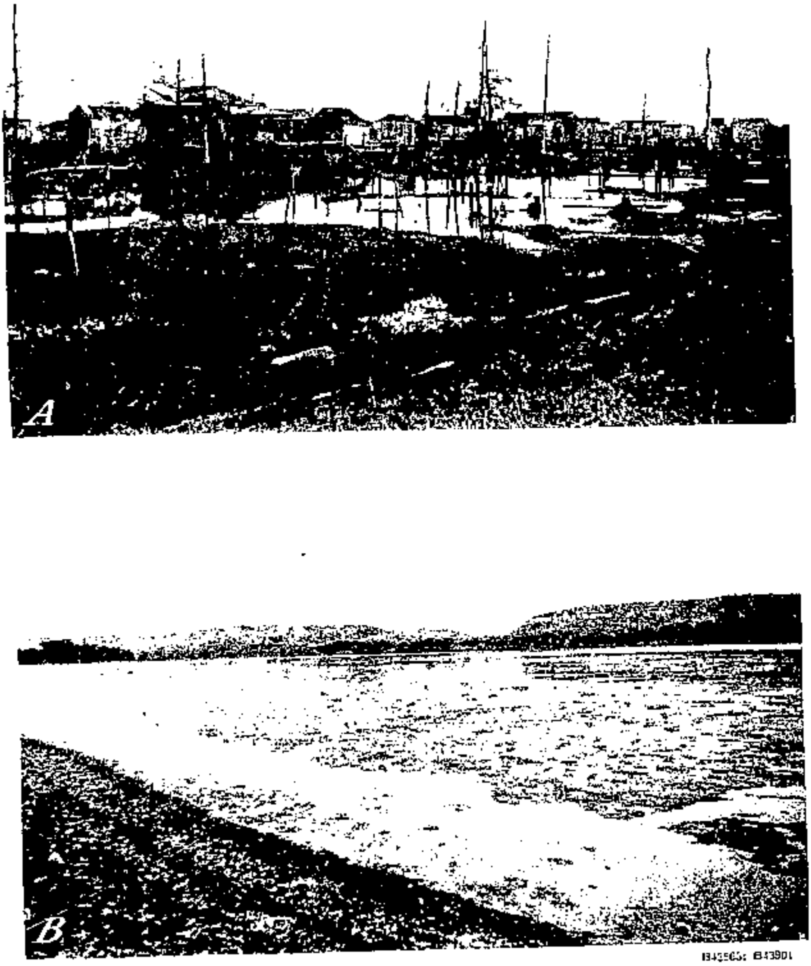
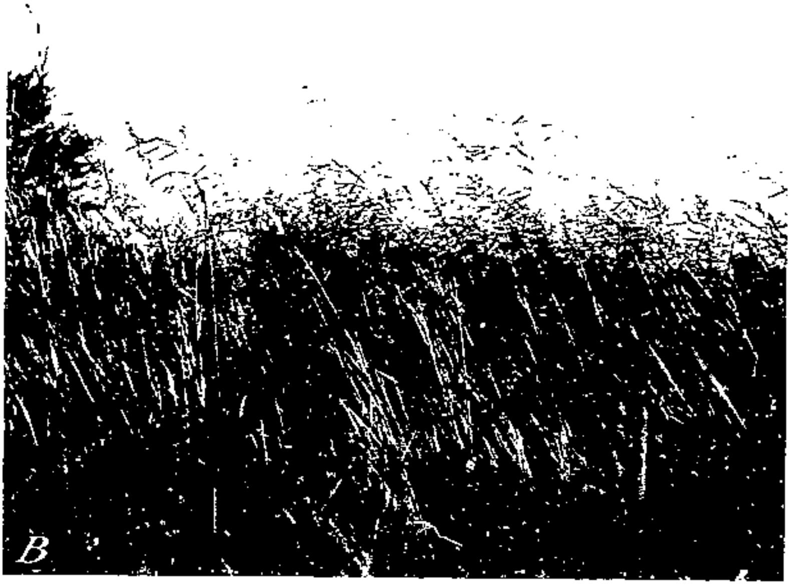


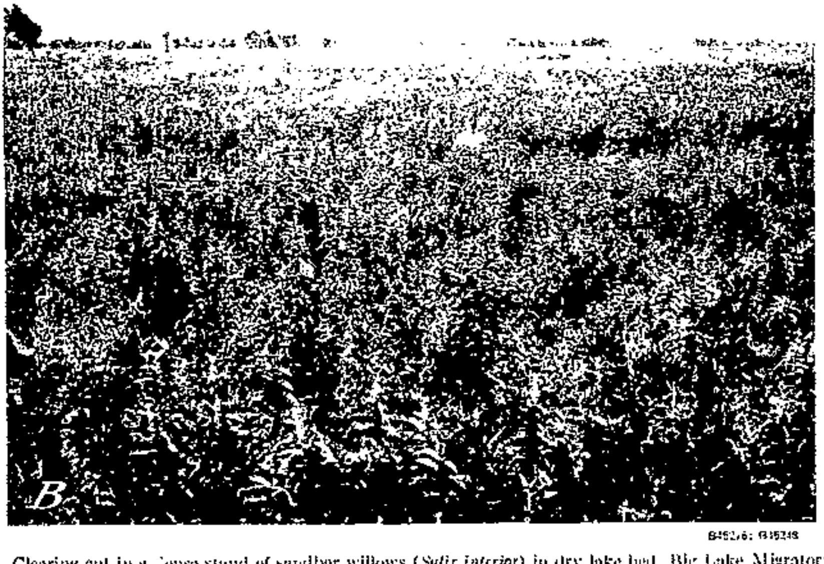
B43565; B43901

A, Floating beds of alligatorweed (*Alternanthera philoxeroides*) (see also pl. 129) along Lake Pontchartrain, near New Orleans, La., in winter condition and choking out all submerged vegetation. *B*, Floating mats of filamentous green algae on Sturgeon Lake, in the Mississippi River bottoms, Dakota County, Minn. These algae frequently become so dense that they exclude sunlight, thereby injuring the growth of valuable submerged food plants.



B17553; B4399

A, Reed, or cane (*Phragmites communis*), along mouth of Bear River, Utah, a species worthless as a waterfowl food and often found crowding out valuable food plants. *B*, Prairie cordgrass (*Spartina pectinata* = *S. michauxiana*) in the Mississippi River bottoms, Trempealeau County, Wis., a coarse grass of semidry marshes and low meadows that frequently chokes out valuable food plants; the closely related big cordgrass (*S. cynosuroides*) is often equally undesirable in many brackish marshes.



B452/6; B35248

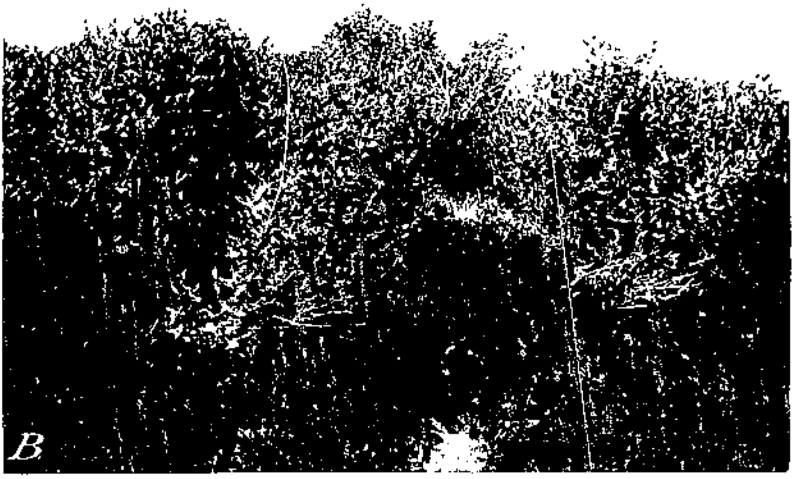
A, Clearing cut in a dense stand of sandbar willows (*Salix interior*) in dry lake bed, Big Lake Migratory Bird Refuge, Mississippi County, Ark., to permit the production of smartweeds, chufa, and other useful duck foods. Willows are often a major obstacle to the development of waterfowl food resources. *B*, Dry marsh in the Mississippi River bottoms, Trempealeau County, Wis., with all valuable food plants crowded out by worthless mints (*Teucrium* and *Stachys*) and nettles (*Urtica*) (see also pl. 139).

B42879; B43867

A, Cattail (*Typha angustifolia*), the growth of which has choked out a valuable stand of wildrice along the tidal Potomac in Arlington County, Va., leaving only remnants of pickerelweed (in the foreground), which also is being eliminated. *B*, Heavy growth of sweetflag (*Acorus calamus*), a plant that has practically no value as a waterfowl food and has crowded out nearly all other vegetation in this marsh in Charles County, Md.

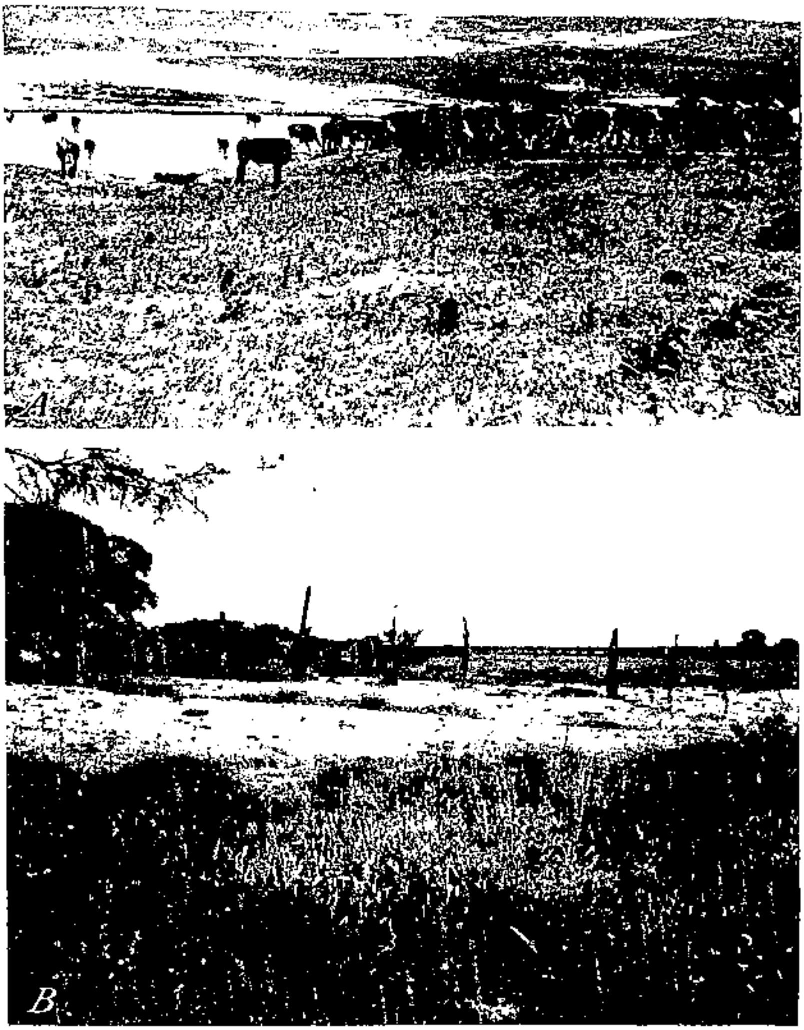
B4469; B44942

A, Site of a formerly good duck marsh in New Haven County, Conn., destroyed by mosquito drainage ditches, along which hightide-bushes (*Iva frutescens*) are starting to develop. *B*, Undesirable vegetation—groundselbushes (*Baccharis halimifolia*) in background and saltmarsh fleabane (*Pluchea camphorata*) in foreground—encroaching on a drained brackish marsh along the eastern shore of Chesapeake Bay.



B44941; B43966

A, Groundselbushes (*Baccharis halimifolia*), which have choked a drained tidal marsh in Dorchester County, Md., a relatively valueless shrub that often develops in brackish marshes drained in mosquito-control operations. *B*, Hightide-bushes (*Iva frutescens*), which have replaced a valuable growth of saltmarsh bulrush (*Scirpus robustus*) along a drainage ditch through a brackish marsh in Somerset County, Md.



B50129; B42150

A, Waterfowl desert in Garden County, Nebr., created by overgrazing in a former duck-breeding area. *B*, Erosion silt filling a formerly fine duck marsh in the San Simon Valley, N. Mex., as a result of overgrazing on the adjacent Peloncillo Mountains.

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