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Title: THE IMPACT OF NUTRIA (MYOCASTOR COYPUS) ON MARSH VEGETATION IN THE WILLAMETTE VALLEY, OREGON

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The relation of nutria (Myocastor coypus) feeding to total abundance, species composition, and seasonal use of the marsh flora on the William L. Finley National Wildlife Refuge was studied during 1969 and 1970. Nutria numbers were estimated by livetrapping. Food habits data were compiled from observations of feeding nutria. Phenology, distribution, and abundance of the marsh vegetation were systematically studied to estimate the availability of plant species. Ten one-milacre exclosure plots were used to evaluate the relation of nutria feeding to total abundance of vegetation.

Nutria densities on the refuge varied with water levels. During the winter high water periods densities were as low as 0.26 nutria per acre. During the summer nutria concentrated along permanent water areas when most ponds and streams went dry. Summer densities as high as 56.0 nutria per acre were found.

Of the 40 species of plants eaten by nutria the 15 most heavily used species accounted for 81.2 percent of the 438 observations.

Salix spp. accounted for 12.3 percent of the observations and was the most heavily used species. Other important food plants were *Ludwigia palustris* (9.3%), *Sparganium simplex* (8.9%), and *Bidens cernua* (7.5%). Forty-seven other plant species that occurred on the study area were not eaten.

Forage ratios were used to express the relation of a food item in the nutria's diet to its relative abundance in the environment. *Sagittaria latifolia*, *Polygonum hydropiperoides*, and *Polygonum hydropiper* had the highest forage ratios and were among the least available plants. Nutria feeding significantly reduced the total abundance of vegetation and the effects of feeding were greatest under the highest populations.

Nutria feeding is responsible for the disappearance of *Sagittaria latifolia* from the refuge. Other species are being affected to lesser degrees. The elimination of excess plant biomass, the rapid recycling of nutrients, and the creation of openings in dense vegetation are beneficial results of nutria feeding because they slow natural plant succession and the filling of the marsh.

The Impact of Nutria (*Myocastor coypus*) on Marsh Vegetation in the Willamette Valley, Oregon

by

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THE IMPACT OF NUTRIA (MYOCASTOR COYPUS) ON MARSH VEGETATION IN THE WILLAMETTE VALLEY, OREGON

INTRODUCTION

Nutria (*Myocastor coypus*) have been introduced from their native South America into many parts of the world (Ashbrook 1948). Most of these introductions were undertaken with the idea of establishing a valuable furbearer in the native fauna. However the possibilities of using nutria for the control of noxious vegetation have also been recognized. Nutria were introduced into Louisianna and Texas with this dual purpose in mind (Davis 1956, Kays 1956), but it soon became apparent that such values had been overrated when the animals spread over vast areas and were found to feed on agricultural crops (Texas Game and Fish 1959, Warkentin 1968).

Nutria have existed in the wild in Oregon since the early 1930's when the first known colony survived along the Nestucca River for several years (Kebbe 1959). Today nutria are abundant throughout western Oregon and in parts of central and northeastern Oregon (Mace 1970).

Since their introduction it has been assumed that these herbivorous mammals present a threat to Oregon's game habitat and cropland (Kebbe 1959, Ore. Game Comm. 1962). A warning is published each year by the Oregon Game Commission that nutria have increased to the point where they "...are now presenting serious threats to agriculture and wildlife" (Synopsis of Oregon Trapping Regulations, 1970-71 Season). The warning urges trappers to "...catch and destroy these animals at every opportunity." Each year the United States Fish and Wildlife Service attempts to control nutria populations on various public and private lands throughout the Willamette Valley.

Beyond the recent work by Peloquin (1969) on growth and reproduction there has been no research on nutria in Oregon. It is essential that further information be gathered on this species if public agencies are to effectively provide for their management.

For this reason I initiated a study of the effects of nutria on marsh vegetation. The objective of this study was to determine the relationship between nutria feeding and total abundance, species composition, and seasonal use variation of the marsh flora on the William L. Finley National Wildlife Refuge. This information may be helpful in evaluating the desirability of controlling nutria in the Willamette Valley. The effects of nutria on agricultural crops were not studied because nutria are not responsible for major crop damage on the refuge. The study was begun on 15 July 1969 and field work was completed on 20 December 1970.

STUDY AREA

The William L. Finley National Wildlife Refuge was selected as the study area because it contains a sizeable amount of marshland and a relatively isolated nutria population which is not subject to erratic human decimation. The refuge, located about 12 miles directly south of Corvallis, may be reached via U. S. Highway 99W (Figure 1). The refuge was established through a purchase of private land in 1964 to serve as a wintering area for the dusky Canada goose (Branta canadensis occidentalis) (U.S.F.W.S. 1969). Land is still being secured and eventually the refuge will encompass a total area of 5,370 acres.

The refuge extends from the eastern foothills of the Coast Range onto the Willamette Valley floor. Maximum change in elevation is approximately 250 feet with the majority of the area being flat to gently rolling. Much of the level land is planted to crops such as corn (Zea mays), Sudan grass and milo (Sorgum spp.), and rye grass (Lolium spp.) to provide a winter food supply for waterfowl. The upland areas are mostly regrowth Oregon Oak (Quercus garryana), Douglas fir (Pseudotsuga menziesii) and associated understory plants.

The refuge is divided by Muddy Creek which flows from south to north. It is the only stream on the refuge which does not normally go dry in the summer. Many small ponds and three large shallow

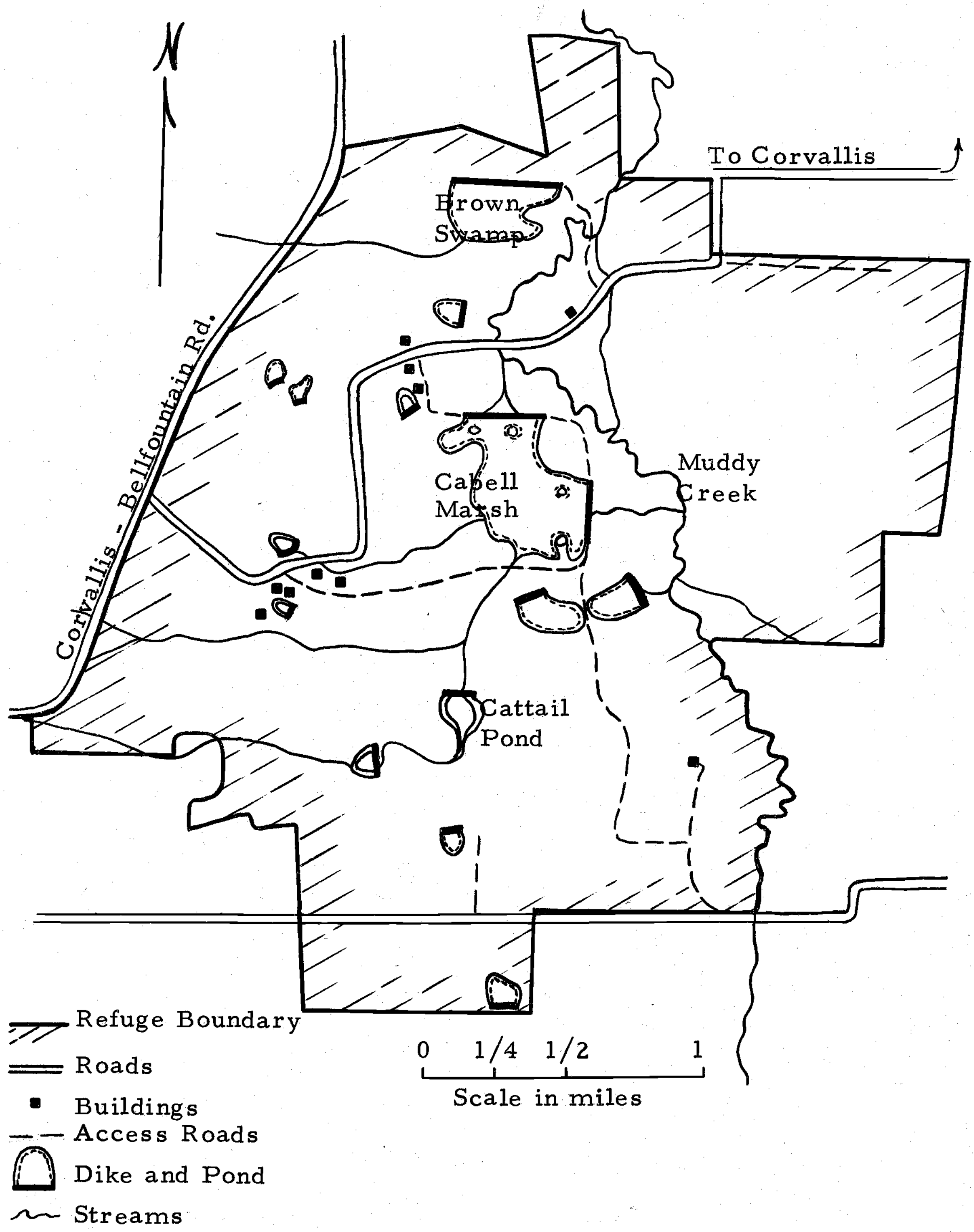

Figure 1. Map of the William L. Finley National Wildlife Refuge showing study areas.

marsh areas (Cabell Marsh, Cattail Pond, and Brown Swamp) are maintained by man-made dikes. Refuge management practices call for spring drainage of most of these ponds and marshes. These water areas typically remain dry until September or October when they begin to fill during periods of rainfall.

In the Willamette Valley about 70 percent of the total annual precipitation (ca. 40 inches) occurs during the period of November through March while only five percent occurs in June, July, and August (Bates and Calhoun 1970). Coupled with high rates of evaporation, climatic conditions are such that many bodies of standing water are greatly reduced in volume and surface area during the summer.

METHODS

Trapping

Live trapping for the purpose of estimating nutria numbers was accomplished by systematically trapping an area with 35 to 40 traps until no unmarked animals were captured. Traps were moved every other day to discourage trap addiction.

Two types of live traps produced by the Tomahawk Livetrap Co., Tomahawk, Wisconsin, were used in this study. Single-door traps, 9 x 9 x 24 inches, and double door traps, 9 x 9 x 32 inches were used in single and multiple sets on the shore and on floating wooden rafts. Double door traps were set with the back door closed. Carrots were used as bait. Near the end of the study some kill trapping was conducted with No. 1 1/2 single spring and No. 2 coil spring traps used in drowning sets.

Nutrias were weighed with a Forschner milk scale in traps in which they were caught. Animals were then removed, sexed, tagged, and released and the empty traps were again weighed. The weight of the empty trap was subtracted from the combined weights of the animal plus trap, and the calculated weight of the animal was recorded to the nearest 0.1 pound. One numbered, No. 3 monel metal ear tag (manufactured by the Salt Lake Stamp Co., Salt Lake City, Utah) was placed in the web of each hind foot of every animal captured. Tags of nutria previously marked were examined and replaced if necessary.

Nutria Food Habits

Feeding nutria were watched during each month of the year with 7 x 35 power binoculars and a 20 power spotting scope. A single observation of an individual nutria feeding on a single plant species, no matter the duration of the feeding time, was recorded as a single occurrence. Field sign of nutria feeding, such as recognizable pieces of plants found in the openings of nutria burrows, was recorded as a single occurrence only when the sign was fresh and definitely attributable to nutria.

The frequency of occurrence of each food item in the nutria's diet was expressed as a percentage by dividing the number of observations of nutria feeding on a particular plant species by the total number of observations for all species and multiplying by 100. Since the data for some months was rather meager it was convenient to calculate only the frequencies for the entire year and the four seasons. The latter values are most logical because they relate the data to the various phenological changes in the environment.

Vegetation Analysis

Phenology, distribution, and abundance of the marsh vegetation on the William L. Finley National Wildlife Refuge were systematically studied. During July 1969, reconnaissance maps were made of the Cabell Marsh and Cattail Pond study units using the intersection method described by Mosby (1969). These maps were reproduced in quantity and used in recording field observations.

Cabell Marsh and Cattail Pond were each arbitrarily divided into study units of approximately 3600 square yards to facilitate the recording of observations. Cabell Marsh had 82 such units and Cattail Pond had 24 for a total of 106.

Check lists of all plants present on each 3600 square yard study unit were compiled in the field during the months of August 1969 and August 1970. In addition to this, the locations of many plant species were recorded while gathering information on the phenological condition of the plants throughout the entire study period.

The frequency of occurrence of these plants was calculated as a ratio of the number of 3600 square yard study units on which a given species was found to the total number of units (106). The resulting ratio may be expressed as a decimal (frequency index) or converted into a percentage by multiplying the decimal by 100 (frequency percentage of occurrence). It must be recognized that for any single species the frequency percentage of occurrence may take a value from 0 to 100 percent. Since the entire study area was surveyed for each plant species these frequency data are a measure of availability of each species on the Cabell Marsh and Cattail Pond areas as a whole. Such availability data was numerically compared to food habits information to show food preferences and degree of utilization.

The refuge was visited at least twice each week throughout the study period in order to make regular field observations on phenological changes in vegetation and the distribution and abundance of plant species. Plant voucher specimens were deposited in the research collection of the Department of Fisheries and Wildlife, Oregon State University, and at the refuge headquarters.

Scientific plant names follow Peck (1961).

Exclosures

Ten one-milacre exclosure plots (seven on Cabell Marsh and three on Cattail Pond) were used to evaluate the relation of nutria feeding to total abundance of marsh vegetation. The plots were subjectively located during May 1970 to represent specific habitat types. The exclosures were square and measured 6.6 feet on each side and encompassed an area of 43.5 square feet (0.001 acre). Fencing was of two by four inch welded wire buried six to eight inches under ground and extending 42 inches above ground level. Unfenced plots (hereafter referred to as control plots) of equal size and representing similar vegetation were located within ten yards of each exclosure and left open to nutria feeding.

Vegetation samples were taken at 30 day intervals from one quarter of each exclosure and control plot from June through September 1970. Each plot was sampled in the progression: northeast corner, northwest corner, southeast corner, and southwest corner. Field records were kept as to sample location, date, water depth (if any), simple presence of species in the plots, average heights of the ten tallest individuals of each species, phenological stage of plants, and any indication of use by nutria in the control plots. The actual area sampled at each period was 3.13 square feet (1/8 milacre). Sampling frames 15 inches square were staked in the northeast and southwest corners of the one quarter milacre in both the exclosure and control plots at each sampling period.

All vegetation in each 15 inch square frame was clipped at ground level, separated by species and sealed in a plastic bag. Later that same day each clipped sample was weighed in its bag to the nearest 0.1 gram. By subtracting the known weight of the bag from the combined weight of the bag and sample the wet weight of the sample was obtained. Any sample of less than 2.0 grams was arbitrarily recorded as "trace" and discarded. The remaining samples were then air-dryed for a minimum of 30 days. Sample weights were recorded when they did not change from one weighing period to the next.

RESULTS

Nutria Populations

During this study 167 individual nutria were captured, tagged, and released. Recaptures totaled 271 for a total of 438 captures and recaptures. The principal trapping periods were late July through September 1969, February and March 1970, and August and September 1970. Trapping effort was concentrated on Cabell Marsh and Cattail Pond but other areas on the refuge were trapped when feasible.

Nutria populations were estimated on the Cabell Marsh and Cattail Pond areas during the above trapping periods using a cumulative catch method (Overton and Davis 1969). Trapping periods varied from 14 to 22 days. Trapping was continued until no new animals were captured for at least three consecutive days. The particular trapping periods of late summer and late winter were selected because they represent the low and high respectively in water levels on the study area.

The nutria population on Cabell Marsh was estimated to be 41 animals during August-September 1969, 25 during February-March 1970, and 42 during August-September 1970 (Figure 2). On Cattail Pond populations were estimated to be 26 animals during February-March 1970 and 56 during August-September 1970 (Figure 3).

The water area on Cabell Marsh increased from about 10 surface acres during August 1969 to approximately 95 surface acres during

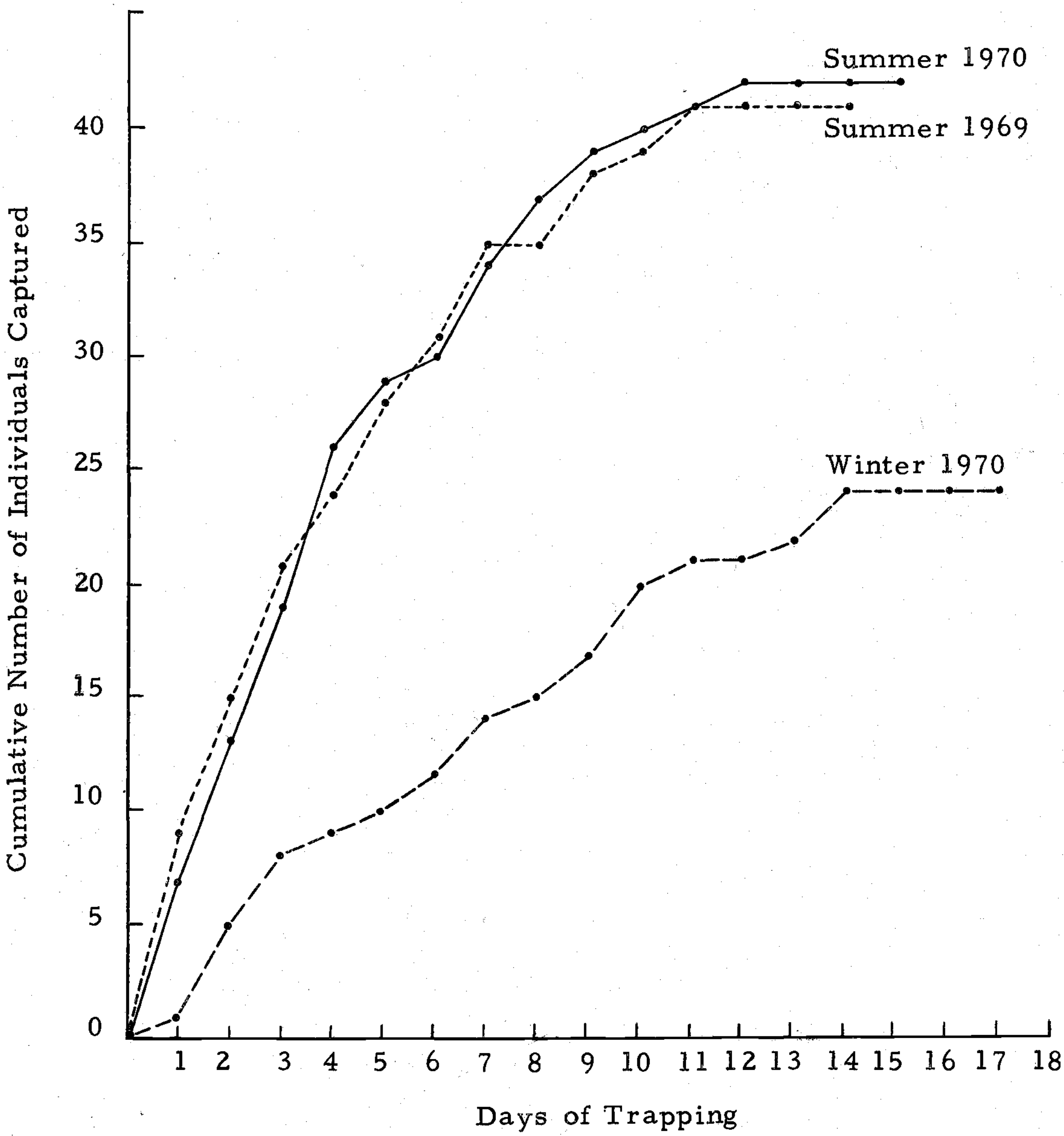

Figure 2. Nutria livetrapped from Cabell Marsh during 1969 and 1970.

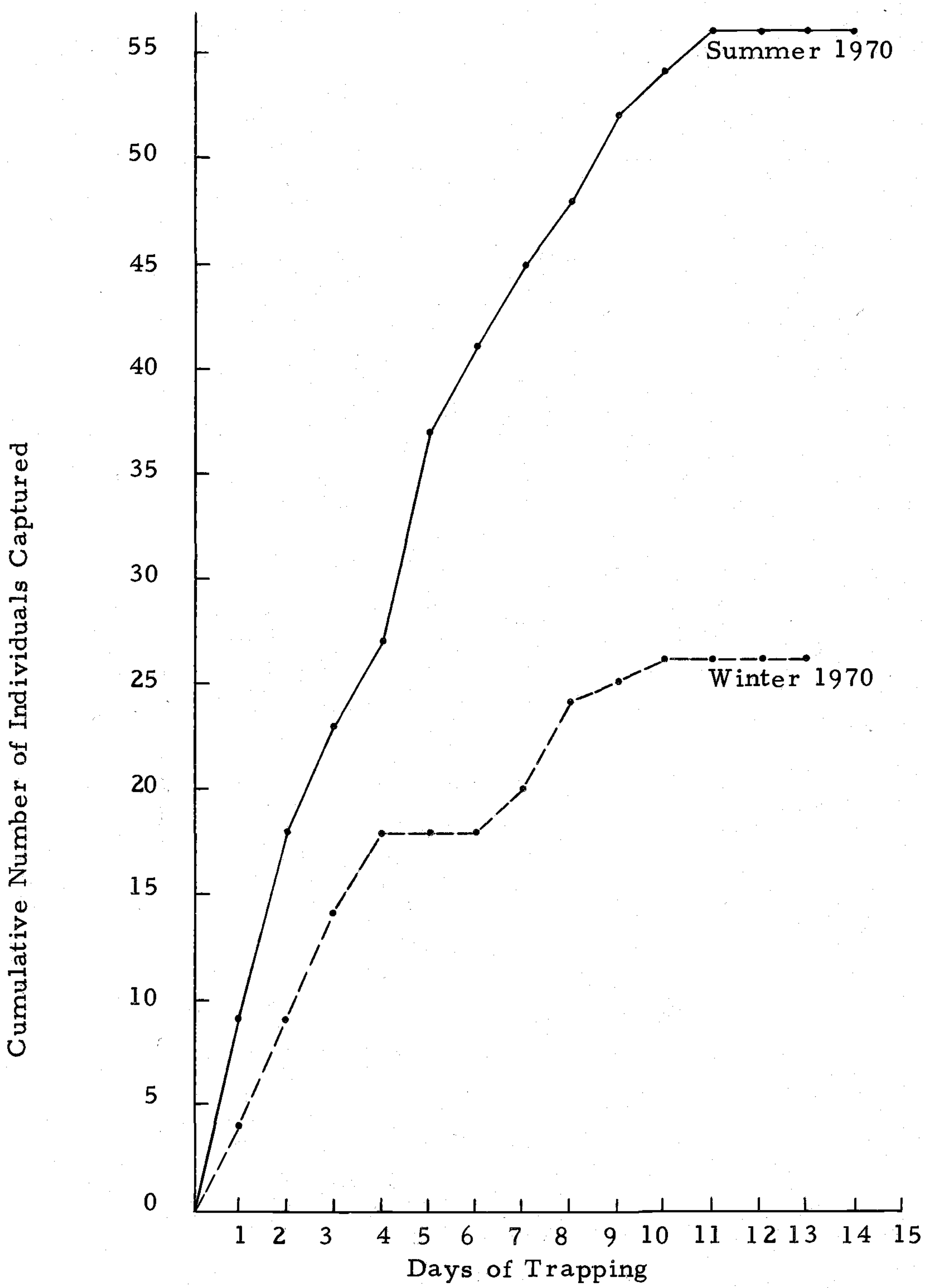

Figure 3. Nutria livetrapped from Cattail Pond during 1970.

February 1970, and dropped to a low of five surface acres during August 1970. Density of nutria compared to surface acres of water on Cabell Marsh varied from 0.26 nutria per acre during the winter to 4.1 nutria per acre in the summer (1969).

The much smaller Cattail Pond study area had approximately 10 surface acres of water during February 1970 and less than one surface acre during August 1970. Density of nutria per surface acre of water on Cattail Pond varied from 2.6 nutria per acre during the winter to 56.0 nutria per acre during the summer.

Tagging and recapturing has shown that the lower number of nutria per surface acre of water during the winter months can be attributed to movement of nutria to nearby temporary ponds and flooded fields. During the early summer when these temporary ponds dried up nutria concentrated along permanent ponds and streams.

Food Habits

Of the 90 species of vascular plants known to occur on the study areas 40 were actually seen being eaten by nutria (Table 1). Of these 40 species the 15 most heavily used species accounted for 81.2% of the 438 observations of feeding nutria and field sign. The 10 least used species accounted for only 2.0% of the observations. The most heavily used plant was *Salix* spp. which accounted for 12.3% of the observations. The three next most used species were *Ludwigia*

Table 1. Occurrence of Cabell Marsh and Cattail Pond plants in nutria food habits expressed as frequency of occurrence ( ) and percentage of observations.

Plant Species	Winter (Jan to Mar)	Spring (Apr to Jun)	Summer (Jul to Sep)	Fall (Oct to Dec)	Totals
Salix spp.	(13) 27.7 %	(7) 5.9 %	(23) 11.1 %	(11) 16.7 %	(54) 12.3%
Ludwigia palustris	-	(18) 15.3	(19) 9.2	(4) 6.1	(41) 9.4
Sparganium simplex	-	(7) 5.9	(32) 15.5	-	(39) 8.9
Bidens cernua	-	(5) 4.2	(28) 13.5	-	(33) 7.5
Eleocharis palustris	(1) 2.1	(15) 12.7	(11) 5.3	-	(27) 6.2
Polygonum hydropiperoides	(4) 8.5	(4) 3.4	(5) 2.4	(12) 18.2	(25) 5.7
Panicum capillare	(1) 2.1	(5) 4.2	(18) 8.7	-	(24) 5.5
Polygonum hydropiper	(2) 4.3	(8) 6.8	(7) 3.4	(4) 6.1	(21) 4.8
Veronica scutellata	(2) 4.3	-	(10) 4.8	(5) 7.6	(17) 3.9
Fraxinus latifolia	(4) 8.5	(2) 1.7	(7) 3.4	(3) 4.5	(16) 3.7
Spiraea douglasii	(3) 6.4	(5) 4.2	(3) 1.4	(3) 4.5	(14) 3.2
Agrostis palustris	-	(2) 1.7	(9) 4.4	(2) 3.0	(13) 3.0
Rumex crispus	(4) 8.5	(3) 2.5	-	(4) 6.1	(11) 2.5
Carex obnupta	(3) 6.4	(6) 5.1	(2) 1.0	-	(11) 2.5
Rorippa spp.	(2) 4.3	-	-	(7) 10.6	(9) 2.1
Sagittaria latifolia	-	(4) 3.4	(4) 1.9	-	(8) 1.8
Alisma plantago-aquatica	-	(5) 4.2	(3) 1.4	-	(8) 1.8
Veronica americana	(1) 2.1	(1) 0.9	(3) 1.4	(2) 3.0	(7) 1.6
Typha latifolia	(1) 2.1	(3) 2.5	(3) 1.4	-	(7) 1.6
Lupinus polyphyllus	(1) 2.1	(1) 0.9	(2) 1.0	(3) 4.5	(7) 1.6
Echinochloa crus-galli	-	(3) 2.5	(3) 1.4	-	(6) 1.4
Leersia oryzoides	-	(3) 2.5	(2) 1.0	-	(5) 1.1
Potamogeton spp.	-	(2) 1.7	(3) 1.4	-	(5) 1.1
Phalaris arundinacea	(2) 4.3	(1) 0.9	(1) 0.5	-	(4) 0.9
Rosa rubiginosa	-	(1) 0.9	-	(2) 3.0	(3) 0.7

Table 1. Continued

Plant Species	Winter (Jan to Mar)	Spring (Apr to Jun)	Summer (Jul to Sep)	Fall (Oct to Dec)	Totals
Ranunculus alismaefolius	-	(3) 2.5	-	-	(3) 0.7
Myriophyllum hippuroides	-	(2) 1.7	(1) 0.5	-	(3) 0.7
Solanum dulcamara	-	-	(1) 0.5	(2) 3.0	(3) 0.7
Pyrus sp.	(1) 2.1	(1) 0.9	-	-	(2) 0.5
Eleocharis obtusa	-	-	(2) 1.0	-	(2) 0.5
Ricciocarpus natans	-	-	-	(1) 1.5	(1) 0.2
Cyperus erythrorhizos	-	-	(1) 0.5	-	(1) 0.2
Carex vulpinoidea	-	(1) 0.9	-	-	(1) 0.2
Lemna minor	(1) 2.1	-	-	-	(1) 0.2
Ranunculus aquatilis	-	-	(1) 0.5	-	(1) 0.2
Conium maculatum	(1) 2.1	-	-	-	(1) 0.2
Myosotis laxa	-	-	-	(1) 1.5	(1) 0.2
Mentha pulegium	-	-	(1) 0.5	-	(1) 0.2
Senecio jacobaea	-	-	(1) 0.5	-	(1) 0.2
Cirsium arvense	-	-	(1) 0.5	-	(1) 0.2
Totals	(47) 100%	(118) 100%	(207) 100%	(66) 99.9%*	(438) 99.9*

* does not equal 100% due to rounding error.

palustris (9.3%), *Sparganium simplex* (8.9%), and *Bidens cernua* (7.5%). The total number of species consumed was highest during the late spring and early summer.

At least 47 other species of plants occurred on the study area (Table 2). Many of these species are probably eaten occasionally. However since these plants were not observed to be eaten, it must be assumed that they do not make up a significant portion of the diet.

The 47 species of plants which did not occur in the nutria's diet are arranged in five groups in Table 2. The plants in the first four groups are separated according to relative categories of abundance. Group V contains species that are probably unpalatable to nutria.

The species in group I are abundant throughout the year but they are probably not selected because of their coarse texture and because more palatable species are usually present.

The species in group II are of seasonal abundance. Most of these plants are present during the spring when a great number of other species are also in their full development. In addition several of these plants (*Briza minor*, *Geum macrophyllum*, *Dodecatheon hendersonii*, *Downingia elegans*, and others) are not found in great numbers at any one place.

The species in group III are generally common throughout the study areas but they apparently are not consumed. The species in group IV are rare on the study area and nutria probably come into contact with them only occasionally.

Table 2. Cabell Marsh and Cattail Pond plants that did not occur in nutria food habits.

Group I. Plants that are abundant but not eaten.

Epilobium adenocaulon	J. covillei
Juncus effusus	J. oxymeris
J. patens	J. sphaerocarpus

Group II. Plants that are seasonally abundant but not eaten.

Callitriche palustris	Barbarea vulgaris
Heleochloa alopecuroides	Geum macrophyllum
Camassia quamash	Dodecatheon hendersonii
Briza minor	Gratiola ebracteata
Cerastium spp.	Galium spp.
Brassica campestris	Downingia elegans
Barbarea orthoceras	

Group III. Plants that are common but not eaten.

Beckmannia syzigachne	Rumex acetosella
Potentilla gracilis	Rumex conglomeratus
Rubus spectabilis	Plantago lanceolata
Lupinus lepidus	P. major
Lindernia anagallidea	

Group IV. Plants that are rare and not eaten.

Spirodella polyrhiza	Amaranthus retroflexus
Polygonum lapathifolium	Callitriche hermaphroditica
P. punctatum	Bidens frondosa
Chenopodium album	Lindernia dubia

Group V. Plants that are probably unpalatable.

Urtica lyallii	Lamium amplexicaule
Amsinckia intermedia	L. purpureum
Myosotis versicolor	Lycopus americanus
M. macrosperma	Eryngium petiolatum
Prunella vulgaris	Lithospermum arvense
Mentha arvensis	

Species in group V are probably unpalatable to nutria for a variety of reasons. The members of the Boraginaceae have a sticky sap and are extremely hirsute. The members of the Labiatae are probably avoided because of their aromatic oils. *Urtica lyallii* and *Eryngium petiolatum* have stinging cells and spines respectively that may cause an animal to avoid them.

Phenology and Availability of Vegetation

The phenology of the various species of marsh plants that occur on the study area plays a major role in determining the availability of plants to nutria. During periods when few food plants are available the diet is more restricted than when greater numbers of species are available. As most plants mature they contain a higher percentage of lignified tissue and are probably not as palatable as young plants. Other plants decrease in palatability as they mature because of the development of spines, thorns, or other defenses.

Lippert and Jameson (1964) have recorded the phenology of several characteristic marsh plants in the Willamette Valley. Using some of the data which they presented and my own field observations, the phenology of a representative group of marsh plants on the study area was compiled (Table 3).

Submersed and floating aquatic species (*Ranunculus aquatilis*, *Potamogeton* spp., *Myriophyllum hippuroides*, *Lemna minor*,

Table 3. Phenology of representative marsh plants on the William L. Finley National Wildlife Refuge from data gathered during 1969 and 1970.

	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
+Ranunculus aquatilis	***--///-------
Potamogeton spp.	****----------
Callitriche palustris	***////-------
+Typha latifolia	***--///----------______________
Sagittaria latifolia	*****----/////
Sparganium simplex	***-------/////-_____________
+Eleocharis palustris	____****---//////-------______________
Rorippa nasturtium-aquaticum	****/////-
Camassia quamash	**///-
Cerastium spp.	***////-
Agrostis palustris	__________**-------////-----_____________
Panicum capillare	________ ***--///---______________
+Juncus effusus	____________****------/////----________
+Alisma plantago-aquatica	***/////////////-_______
+Eryngium petiolatum	***-////----
Bidens cernua	_______ ***---////---__________
+Ludwigia palustris	***--//////------_______
+Veronica scutellata	----_______****--//////----------------
Juncus sphaerocarpus	***--////---_______
Polygonum spp.	-----------//////////////--------------
Rumex spp.	----------/////////------------------
Carex spp.	-----////////////////////------------
+Salix spp.	___--------------------------____________
Fraxinus latifolia	____------------------------____________
Spiraea douglasii	_______------------/////---_____________

* first appearance, ----growth, //// flowering, ____present but dead or dormant

+ Information partially from Lippert and Jameson (1964).

Spirodella polyrhiza, *Callitriche palustris*, *C. hermaphroditica*) appear as early as February and March and are present until low water stages are reached in June and July. None of these species are abundant on the refuge ponds but they probably occur every year. *Ranunculus aquatilis*, *Callitriche palustris*, and *C. hermaphroditica* are the only members of this group that are known to flower and set fruit. The other species apparently do not have sufficient time to mature before late spring drawdowns leave them stranded to die. These species probably are maintained by overwintering rootstocks and turions.

Emergent species (*Typha latifolia*, *Sparganium simplex*, *Sagittaria latifolia*, *Eleocharis palustris*, *E. obtusa*, *Ranunculus alismaefolius*) begin growth typically in the latter part of March and most are present until November. *Ranunculus alismaefolius* matures and flowers by the end of March and is dead by the end of April. The other five species reach their maximum growth in July, have turned brown by late August and the dead stems are present well into the winter months. *Sparganium simplex* and *Eleocharis palustris* are two of the most common species on the study area and each typically forms large dense stands which contain no other species. *Eleocharis obtusa* is common but not abundant. *Typha latifolia* and *Sagittaria latifolia* are rare on the study area.

Several species (e.g. *Rorippa nasturtium-aquaticum*, *Camassia quamash*, *Cerastium* spp., *Barbarea vulgaris*) appear in late April and

May. Most of these species complete their reproductive cycle by June and they are rarely found after 1 July. All are abundant on the study area.

A large number of species (e.g. Agrostis palustris, Beckmannia syzigachne, Panicum capillare, Juncus effusus, Alisma plantago-aquatica, Eryngium petiolatum, Bidens cernua) appear in the period from March to early June.

These species typically reach their maximum development in late July and August after water levels have dropped to their lowest. They are dead or dormant by October but the dead stems may remain until the following spring.

The majority of the marsh substrate is vegetatively covered with a group of many species that are dominated by Ludwigia palustris, Veronica scutellata, Juncus sphaerocarpus, and Gratiola ebracteata. These species begin growth whenever the water is drained from their area. Thus on higher ground these plants begin growth in April while in the bottom of the marsh they may not begin growing until mid-June. The most abundant of these species, Ludwigia palustris and Veronica scutellata, may be found in various stages of growth throughout the year. Although most of the others are abundant, they are found only during their proper growing season.

Several species of Polygonum (P. hydropiper, P. hydropiperoides, P. lapathifolium, P. punctatum), Rumex (R. crispus, R. conglomeratus, R. acetosella), and Carex (C. obnupta, C. vulpinoidea) are present and abundant throughout the year. One or more species from these genera may be found in vigorous growing condition during any month of the year.

Woody species (Salix spp., Fraxinus latifolia, Spiraea douglasii, Rosa rubiginosa) may begin growth as early as February and they normally become dormant in late November. Although their maximum growth is during March to May these species are of course present throughout the year.

In order to compare food availability and food habits information it is necessary to quantify observational data. Indexes to availability of all food items which accounted for more than one percent of the nutria's diet are arranged in order of abundance in Table 4.

The indexes to availability are expressed as the number of plots on which each species was recorded on Cabell Marsh and Cattail Pond. The total of these observations is then expressed as a percentage of the maximum observations possible (106). Each species may range in value from 0 to 100 percent.

Forage Ratios

Forage ratios have been used as a method of expressing the relation of a food item in an animal's diet to its relative abundance in the environment (Hess and Swartz 1941, Takos 1947). The ratio, expressed as a decimal, is calculated by dividing the frequency of

Table 4. Occurrence and total availability (expressed as a percent) of major nutria food plants during 1969 and 1970.

Plant Species	Times Recorded Cabell (82 plots)*	Times Recorded Cattail (24 plots)*	Total (106 plots)*	Total Availability %
Ludwigia palustris	56	13	69	65
Bidens cernua	52	5	57	54
Fraxinus latifolia	32	16	48	45
Eleocharis palustris	35	10	45	43
Sparganium simplex	33	10	43	41
Agrostis palustris	30	6	36	34
Salix spp.	21	14	35	33
Veronica spp.	21	11	32	30
Panicum capillare	11	13	24	23
Spiraea douglasii	22	1	23	22
Rorippa spp.	13	8	21	20
Echinochloa crus-galli	19	2	21	20
Carex spp.	12	7	19	18
Polygonum hydropiperoides	13	2	15	14
Rumex crispus	11	4	15	14
Lupinus polyphyllus	9	5	14	13
Polygonum hydropiper	9	2	11	10
Alisma plantago-aquatica	6	3	9	9
Leersia oryzoides	8	2	10	9
Potamogeton spp.	5	4	9	9
Typha latifolia	4	2	6	6
Sagittaria latifolia	2	0	2	2

* number of 3600 square yard plots on each area

occurrence of a plant species in the diet by the availability of that food item on the study area. Forage ratios for all food items which accounted for more than one percent of the diet were calculated for the entire year (Table 5). Forage ratios were also computed for these same species for the spring and summer periods and for several species for the fall and winter.

Forage ratios may be interpreted only in broad terms. A ratio of 1.0 implies that the plant appears in the food habits in approximately the same proportion that it occurs in the habitat. When the ratio is less than 1.0 the plant is not being taken in proportion to its occurrence in the environment. Whenever the ratio is greater than 1.0 the plant is being selected from the environment in greater proportion than it occurs.

Only one species, Sagittaria latifolia, had a yearly forage ratio that approached 1.0. Yearly forage ratios for all other species were less than 0.5 indicating that these species are probably not over-utilized by nutria.

Sagittaria latifolia and Polygonum hydropiperoides were the only species that had a seasonal forage ratio of more than 1.0. However Salix spp. and Polygonum hydropiper each had forage ratios greater than 0.6 during at least one season. This information is interesting because Sagittaria latifolia rated as the least available of the major food plants and the two species of Polygonum were also among the least

Table 5. Forage ratios of major nutria food items.

Plant Species	Winter Jan to Mar	Spring Apr to Jun	Summer Jul to Sep	Fall Oct to Dec	All Year
Sagittaria latifolia	-	1.70	.95	-	.90
Polygonum hydropiper	.43	.68	.34	.61	.48
Polygonum hydropiperoides	.60	.24	.17	1.30	.40
Salix spp.	.84	.18	.34	.51	.37
Typha latifolia	.35	.42	.23	-	.27
Panicum capillare	-	.18	.38	-	.24
Sparganium simplex	-	.14	.38	-	.22
Alisma plantago-aquatica	-	.47	.16	-	.20
Rumex crispus	.61	.18	-	.44	.18
Veronica spp.	.21	.03	.21	.35	.18
Spiraea douglasii	.29	.19	.06	.20	.15
Ludwigia palustris	-	.24	.14	-	.15
Bidens cernua	-	.08	.25	-	.14
Carex spp.	.36	.33	.06	-	.14
Eleocharis palustris	-	.30	.12	-	.14
Leersia oryzoides	-	.28	.11	-	.12
Potamogeton spp.	-	.19	.16	-	.12
Lupinus polyphyllus	.16	.07	.08	.35	.12
Rorippa spp.	.22	-	-	.53	.11
Agrostis palustris	-	.05	.13	-	.09
Fraxinus latifolia	.19	.04	.08	.10	.08
Echinochloa crus-galli	-	.13	.08	-	.07

abundant food plants (Table 4). Salix spp. on the other hand ranked as the seventh most abundant food plant.

Many of the food plants that were readily available (e.g. Ludwigia palustris, Bidens cernua, Fraxinus latifolia) had relatively low forage ratios. This would seem to indicate that although these plants are often eaten they are not preferred foods.

Some plants of low availability (e.g. Leersia oryzoides, Potamogeton spp., Echinochloa crus-galli) also had relatively low forage ratios. There are two possible reasons for this: either the animals avoid the plants or the plants are rare enough that nutria do not often encounter them. Since several other plants of low availability (e.g. Sagittaria latifolia, Typha latifolia, Polygonum hydropiper) had relatively high forage ratios it is probable that such plants as Leersia oryzoides are simply not preferred foods and are therefore avoided by nutria.

The seasonal breakdown of the data reveals some interesting relationships that are dependent on phenological occurrences. In spring and summer, forage ratios were low--often below 0.2--because many plant species were available. In fall and winter, these ratios were generally higher--very few below 0.2--because fewer plant species were available.

Exclosures

The ten exclosure plots were established in a variety of vegetation types (Table 6). Dry weights of samples from all exclosures were compared with their respective control samples in Table 7. Using the data for each date in each plot as a sample, students *t* tests were performed on the paired data for Cabell Marsh (plots A-G) and Cattail Pond (plots H, I, J). The paired data for both areas are significantly different at the 99.9 percent confidence level (Cabell Marsh, *t* = 3.421, d.f. = 27; Cattail Pond, *t* = 4.025, d.f. = 11).[1]

The mean weights of the vegetation samples from the exclosure and control plots at their respective dates are graphed in figures 4 and 5. The difference in biomass between exclosure and control plots increases with time, due to the lack of feeding by nutria in the exclosures. The difference between exclosure and control plot weights on Cattail Pond are more than twice as great as they are on Cabell Marsh. This is due to the much higher nutria population on Cattail Pond.

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[1] Statistical procedure according to Snedecor and Cochran (1967).

Table 6. Plant species present in exclosure and control plots established during June 1970.

Plot	Location	Main Plant Species Present in Order of Abundance
A	Cabell Marsh	Eleocharis palustris Ludwigia palustris Bidens cernua Leersia oryzoides
B	Cabell Marsh	Ludwigia palustris Agrostis palustris Bidens cernua Eleocharis palustris
C	Cabell Marsh	Bidens cernua Echinochloa crus-galli Ludwigia palustris Gramineae (several spp.)
D	Cabell Marsh	Eleocharis plaustris Echinochloa crus-galli Ludwigia palustris Bidens cernua
E	Cabell Marsh	Ludwigia palustris Polygonum hydropiperoides Sparganium simplex Bidens cernua
F	Cabell Marsh	Ludwigia palustris Spiraea douglasii Bidens cernua
G	Cabell Marsh	Sparganium simplex
H	Cattail Pond	Sparganium simplex Panicum capillare
I	Cattail Pond	Eleocharis palustris Panicum capillare
J	Cattail Pond	Ludwigia palustris Eleocharis palustis Panicum capillare Sparganium simplex

Table 7. Weights of vegetation samples from exclosure and control plots A-J.

Plot	Date of Sample	Dry Weights of Vegetation in Grams: Exclosure (1/8 milacre sample)	Control (1/8 milacre sample)	Difference (between excl. and cont.)
A	1 Jul	271.9	362.7	- 90.8
	31 Jul	195.6	178.8	16.8
	30 Aug	120.1	69.0	51.1
	28 Sep	149.8	147.3	2.5
	Totals	737.4	757.8	- 20.4
B	1 Jul	399.3	338.4	60.9
	31 Jul	172.4	95.1	77.3
	30 Aug	295.8	111.7	184.1
	28 Sep	138.6	92.7	45.9
	Totals	1006.1	637.9	368.2
C	2 Jul	375.8	152.1	223.7
	1 Aug	210.8	164.8	46.0
	31 Aug	128.2	131.3	- 3.1
	28 Sep	267.9	192.3	75.6
	Totals	982.7	640.5	342.2
D	2 Jul	140.0	128.0	12.0
	1 Aug	122.7	124.0	- 1.3
	31 Aug	48.3	102.5	- 54.2
	28 Sep	67.0	95.3	- 28.3
	Totals	378.0	449.8	- 71.8
E	2 Jul	193.8	151.7	42.1
	1 Aug	200.5	74.7	125.8
	31 Aug	193.9	29.8	164.1
	29 Sep	178.9	49.9	129.0
	Totals	767.1	306.1	461.0
F	2 Jul	189.2	166.2	23.0
	1 Aug	158.6	125.8	32.8
	31 Aug	148.0	60.1	87.9
	29 Sep	153.3	54.0	99.3
	Totals	649.1	406.1	243.0

Table 7. Continued

Plot	Date of Sample	Dry Weights of Vegetation in Grams: Exclosure (1/8 milacre sample)	Control (1/8 milacre sample)	Difference (between excl. and cont.)
G	2 Jul	138.2	156.3	- 18.1
	1 Aug	39.2	30.9	8.3
	31 Aug	111.0	74.1	36.9
	29 Sep	92.1	54.1	38.0
	Totals	380.5	315.4	65.1
H	3 Jul	39.9	24.9	15.0
	1 Aug	141.5	7.9	133.6
	1 Sep	91.0	30.5	60.5
	29 Sep	191.5	83.4	108.1
	Totals	463.9	146.7	317.2
I	3 Jul	111.1	85.3	25.8
	1 Aug	88.0	85.5	2.5
	1 Sep	161.3	76.0	85.3
	29 Sep	124.2	76.1	48.1
	Totals	484.6	322.9	161.7
J	3 Jul	371.9	283.2	88.7
	1 Aug	176.4	35.1	141.3
	1 Sep	221.7	19.8	201.9
	29 Sep	257.5	52.2	205.3
	Totals	927.5	390.3	537.2

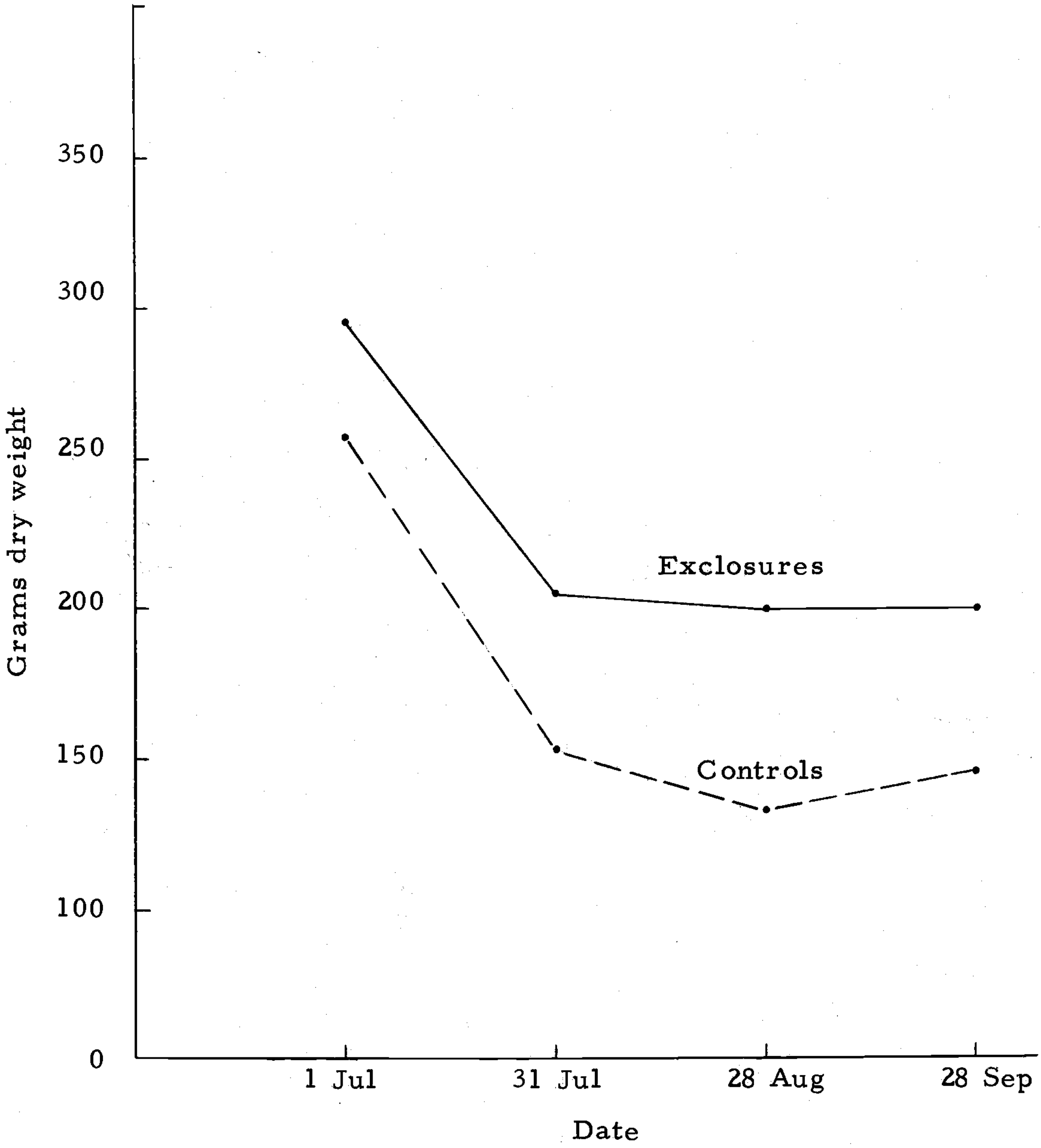

Figure 4. Mean weights of vegetation from 1/8 milacre samples of exclosure and control plots A-G on Cabell Marsh.

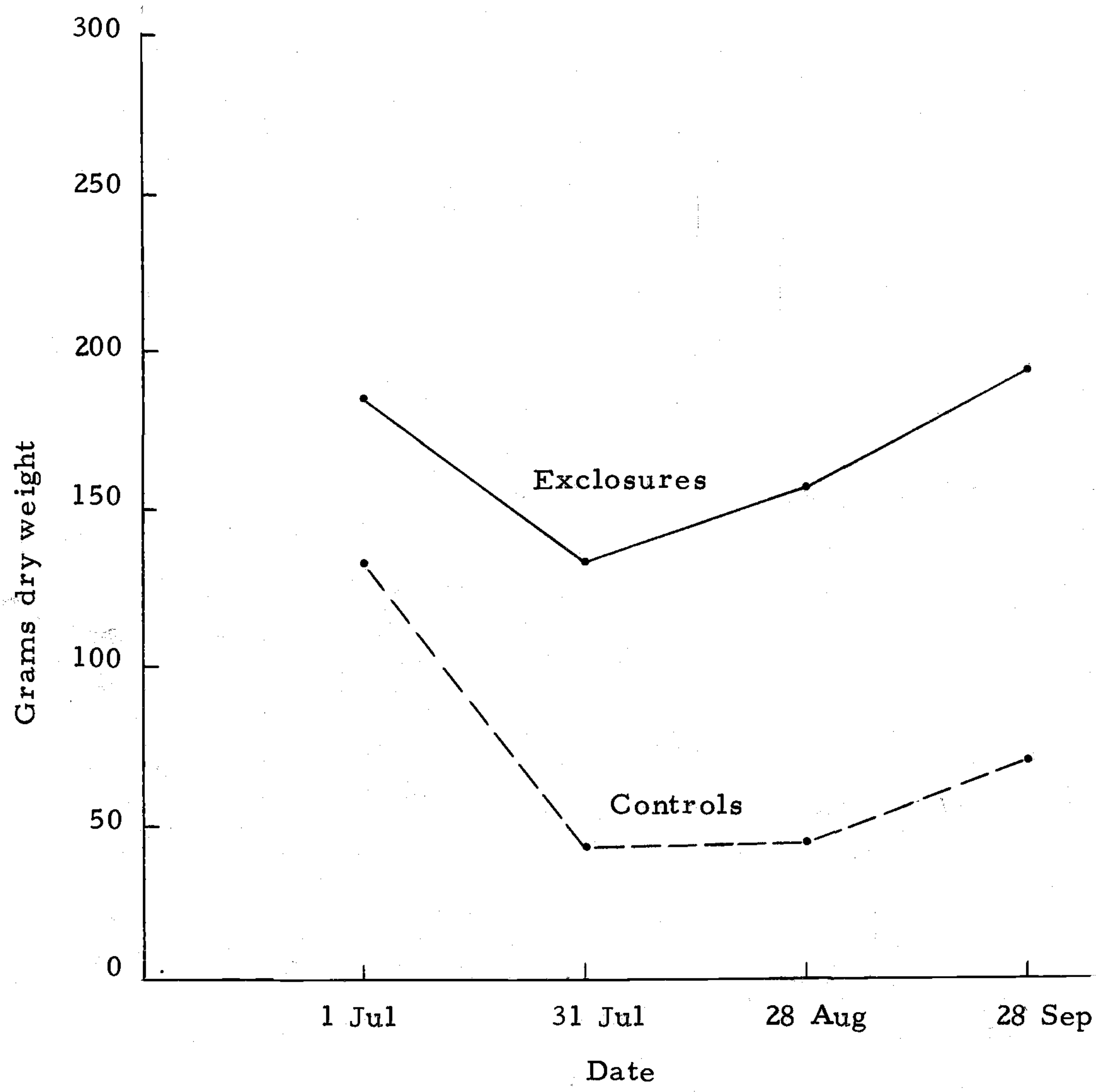

Figure 5. Mean weights of vegetation from 1/8 milacre samples of exclosure and control plots H, I, and J on Cattail Pond.

DISCUSSION

Although Ashbrook (1948) concluded that the nutria "... is not too particular in selecting a menu.", it is apparent that nutria do prefer certain species of food plants. Takos (1947) came to the conclusion that muskrats (Ondatra zibethica) feed on the most abundant and conveniently obtained foods. While this is essentially true for nutria, a few major food items are of rather limited occurrence on my study area.

Various species of Typha, Sagittaria, and Sparganium have been listed as the three major food plants of nutria by numerous North American and European authors (Atwood 1950, Dozier 1951, Ehrlich 1962, Ehrlich and Jedynak 1962, Ehrlich and Spielberg 1960, Guenther 1950, Harris and Webert 1962, Hillbricht and Ryszkowski 1961, Laurie 1946, Swank and Petrides 1954). A majority of these authors have pointed out that in areas with high nutria populations, Typha, Sagittaria, Sparganium, and Potamogeton are the first plants to disappear. Ehrlich (1962), Ensminger (1955), Harris and Webert (1962), and Waldo (1958) have found that such vegetation usually recovers by the following year. Hillbricht and Ryszkowski (1961) disagree and say that over-utilized vegetation does not return even after several years.

Sagittaria latifolia and Typha latifolia, which were once common on the refuge (Marshall 1950), have now been very nearly eliminated.

It appears that the pressure of nutria feeding has been very great on Sagittaria latifolia and the species is probably rare for that reason.

Although early and prolonged drawdowns are probably responsible for the rarity of Typha latifolia on Cabell Marsh, drawdowns are not normally practiced on Cattail Pond and the species is also rare there. All of the seven observations of nutria feeding on Typha latifolia were recorded about a single, small clone of plants that grew in an area of high nutria activity on Cattail Pond. The clone was entirely eliminated by nutria feeding during the period of July 1969 through February 1970 and the species did not reappear on the site during the summer of 1970. Nutria feeding is at least partially responsible for the general decrease in Typha latifolia on the refuge.

Most authors (Ehrlich 1962, Ehrlich and Jedynak 1962, Harris and Webert 1962, Hillbricht and Ryszkowski 1961, Ryszkowski 1966) agree that nutria tend to concentrate their feeding activities and that this creates openings along trails and feeding areas. I have observed this same thing with individual nutria returning to the same feeding area day after day even when seemingly better forage was nearby.

Hillbricht and Ryszkowski (1961) found increased numbers of nitrophilous and poisonous plant species in the openings created by nutria. They inferred that the increases in numbers of such species were due to excess deposition of fecal material and a lessening of competition through removal of other species. Most of the species of plants on my study area which are rarely or not at all eaten by nutria have various types of defense. These defenses include thorns, spines, chemical irritants and poisons, heavy epidermal layers of trichomes, aromatic and volatile oils, and sappy exudates. Whittaker and Feeny (1971) point out that such defenses as these are possibly characters that developed as protection against herbivores.

I have found many of these types of plants on my study area. The plants are not concentrated in any particular area and I do not feel that their presence on the area is the direct result of nutria feeding. However, it is entirely possible that extremely high nutria populations could overgraze the more palatable plants thereby allowing these resistent species the opportunity of becoming dominant members of the plant community. Such changes in species composition have been recognized and attributed to overgrazing by both domestic and wild animals in many plant communities (Taylor 1936).

Several minor activities of nutria could affect vegetation when the animals concentrate in small areas. Excessive burrowing may create openings in dense vegetation. The habit of establishing permanent trails creates long, narrow openings. However these activities (together with the recycling of nutrients through feeding) are probably beneficial due to a slowing of natural plant succession, a decrease in the filling of the marsh, and the opening of dense vegetation stands (Hillbricht and Ryszkowski 1961).

Many of the plants in the nutria's diet are relatively abundant on the study area. These species apparently are able to maintain their abundance in a variety of ways. Many annual species germinate and reach maturity in a very short time in the spring when a large number of species are present in great abundance. As the season progresses the number of species that are in growing condition declines and feeding pressure is greater on the remaining species. Several species which mature early in the summer are apparently not adversely affected by the intense late summer grazing. Many species may even be benefited by the removal of their own excess tissue (Taylor 1936).

Phenological changes and seasonal succession have various effects on animals. The most obvious effect is the variation in seasonal abundance of food plants. For the nutria this means that during the spring and early summer there are many species of plants available in the young succulent growth stages. At this time nutria are the least specialized in their food habits.

As the season progresses there are fewer and fewer species of plants available for consumption by nutria. Many species have completed their reproductive cycle and are in advanced stages of decomposition. Most of the species that are present are mature and at this time their tissue is tough and mostly lignified material and is therefore unpalatable. At this later time feeding pressure is restricted to small areas because nutria tend to concentrate near water during the dry season (Kays 1956). When water levels rise in the fall, nutria populations spread out, many plants begin to grow again, and feeding pressure is not concentrated.

It appears that only one species, Sagittaria latifolia is disappearing from the refuge because of nutria feeding. Typha latifolia may also be reduced by nutria feeding. However, it is probable that the elimination of excess plant biomass, the rapid recycling of nutrients, and the creation of openings are beneficial results of nutria feeding because they slow natural plant succession and the filling of the marsh. On the whole it is highly improbable that nutria feeding will create any major ecological changes in the marshes of the Willamette Valley.

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