A PRELIMINARY REPORT OF ECOLOGICAL CHANGES WITH IMPOUNDMENT

in the

TINTAMARRE NATIONAL WILDLIFE AREA AND MISSAQUASH MARSH

by

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A Preliminary Report of Ecological Changes With Impoundment in the Tintamarre National Wildlife Area and Missaquash Marsh

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Abstract

Studies have been initiated to examine changes in waterfowl production, soil, water, vegetation, and invertebrate populations on a series of controlled waterlevel impoundments in the New Brunswick - Nova Scotia border area. The objectives are to (1) document changes in waterfowl production; (2) isolate those ecological factors responsible for changes in waterfowl production; (3) manipulate those factors so as to maintain optimum conditions; and (4) describe the best method of habitat management so that it can be applied elsewhere.

Preliminary results indicate some well defined trends in water chemistry, vegetation, invertebrates, and waterfowl production. In the water total alkalinity and specific conductance were found to be inversely related to the age of the impoundments. Vegetative succession is proceeding toward a sedge - cat-tail dominated marsh supporting fewer of the less aggressive but important waterfowl foods. Invertebrates of high food value to waterfowl decline in abundance as the age of the impoundments increases. New impoundments are characterized by a few important invertebrate taxa having a large number of individuals while old impoundments and natural marsh areas have a greater number of taxa of less importance and fewer individuals per taxa. The number of breeding pairs of waterfowl has remained nearly constant on the study areas; however, a progressively greater number of pairs has successfully nested as evidenced by a consistent increase in production since 1967.

Based on present data, drainage of impoundments at the age of five to six years is suggested. Removal of cat-tail and sedges, aeration of the soil and introduction of a terrestrial plant species which, upon reflooding, will provide a rapid release of nutrients and abundant detritus for invertebrates is recommended. Where several independently controlled impoundments exist, management should be scheduled in a manner that does not remove more than a fifth or a sixth of the impoundments from production in any one year.

More than 5,000 acres of potential waterfowl habitat has been acquired by government wildlife agencies in the New Brunswick - Nova Scotia border area during the last decade. Approximately 1,100 acres are under controlled water levels in seven man-made impoundments of varying age and size. A 275 acre natural marsh is situated adjacent to most of the impoundments and provides a good comparison of natural areas with man-made impoundments. That complex is being used for the study of ecological factors involved in the aging of marshes and for the experimental application and evaluation of habitat management techniques designed to establish and maintain optimum waterfowl production.

Our studies began in 1967 to measure waterfowl production and in 1972 to measure changes in soil and water chemistry, vegetation, and invertebrates that occur following flooding. The objectives of the studies are:

1. to document changes in waterfowl production,
2. to isolate those ecological factors responsible for changes in waterfowl production,
3. to manipulate those factors so as to maintain optimum conditions for the production of waterfowl, and
4. to describe the best method of habitat management for waterfowl production so that we can apply it elsewhere.

Literature Review

In the Atlantic Flyway, particularly eastern Canada, there have been few if any well documented studies of the effects of flooding on many ecological factors important to waterfowl production. Effective, economical marsh management practices for waterfowl production are not known with any degree of certainty. Most practices, including waterlevel manipulation, are based on experience rather than sound scientific principles (Lathwell, et al., 1969). It is widely agreed that upon creation of a new marsh a series of changes is initiated in factors such as soil, water chemistry, vegetation and invertebrates. It has been observed in many new marsh impoundments that waterfowl populations increase sharply upon initial flooding but begin to decline within a few years. Several explanations have been offered for that decline. Hartman (1949) believed that the basic cause of the decline in Wisconsin was the exhaustion or unavailability of soil nutrients needed to support attractive food and cover vegetation. In New York, Cook and Powers (1958), however, found during their study of marsh soils before and after flooding that an accumulation of nutrients rather than exhaustion occurred. Iron and manganese were found to reach potentially toxic levels. In either case, trial and error waterlevel manipulation has demonstrated that draining and soil aeration leads to enhanced vegetative growth. CHEMICAL REASONS WHY!!

Other workers have associated the decline in waterfowl populations with changes in vegetation. DiAngelo (1953) suggested that normal aquatic plant succession was responsible for the peak and subsequent decline of waterfowl populations on new areas. He correlated high early use of flooding projects with an abundance of pioneer plants, such as duckweeds (*Lemna* spp.), which are highly preferred waterfowl foods. As succession progressed, more stable rooted aquatics such as pondweeds (*Potamogeton* spp.) appeared, which did not produce as much food (Low and Bellrose, 1944). Griffith (1948), Sowls (1955), and Harris (1957) considered the amount and density of emergent cover to be an important factor in determining duck production. It may be inferred from the above studies that to produce attractive waterfowl habitat, management should be designed to control plant succession and soil fertility. what about water fertility?

In recent years aquatic invertebrates have been identified as potential controlling factors in waterfowl production. As primary consumers many are directly dependent upon aquatic vegetation but provide a higher protein food to ducks than vegetable matter. The importance of a high protein diet to downy young during the first two or three weeks of life has long been appreciated. More recently workers have suggested that a high protein diet is also essential to laying females and molting adults. Recent work has shown that such species as the pintail (Anas acuta (Linnaeus)) and mallard (A. platyrhynchos (Linnaeus)) on a high protein diet consistently lay two clutches of eggs, while on low levels of protein, there is either no attempt to lay or resulting clutches are small and/or infertile (Swanson, 1972). An earlier study by Holm and Scott (1954) suggested that relationship but perhaps did not fully appreciate the magnitude of its importance.

Studies of food habits and invertebrate ecology have shown that waterfowl are basically opportunists which feed upon the most abundant and available species of invertebrates. That fact has undoubtedly accounted for much of the success of manipulations of waterlevels and vegetation in the past. For example Burger (1966) obtained excellent success in brood production by impounding and flooding fields of millet at Remington Farms. Brood survival and invertebrate populations were both high following the first year of flooding. Unfortunately, studies were not undertaken to follow changes in invertebrate populations with time.

In the current study the dynamics of invertebrate populations in newly inundated impoundments is emphasized. At the same time the dependence of invertebrates upon vegetative succession and, in turn, upon soil fertility is recognized and examined. Both Krull (1970) and Swanson (1972) pointed out the dependence of invertebrates on vegetation type but inferred that the management of marshes for waterfowl food plants may, in fact, be managing invertebrate populations that are of high value to breeding areas for waterfowl.

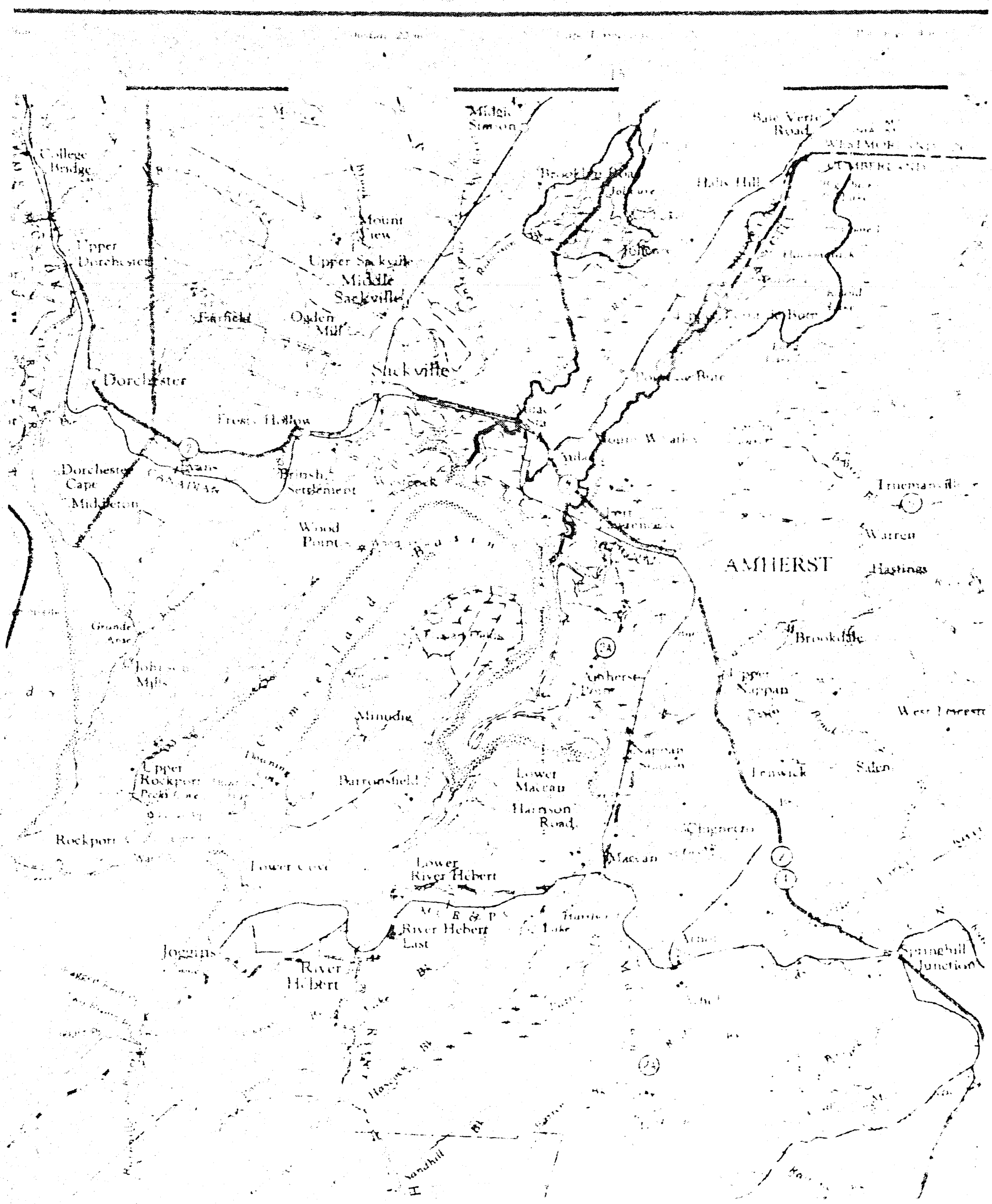
Description of Study Areas

The Tintamarre National Wildlife Area and the Missaquash Marsh were selected as study areas upon which to monitor changes in waterfowl production, vegetation, soil, water, and invertebrates that occur upon creation of new impoundments. Both study areas are located at the head of the Bay of Fundy, approximately seven miles northeast of the town of Sackville, in Westmorland County, New Brunswick. Contained within those areas is a contrasting variety of peatland and aquatic ecosystems, including several successional stages, a combination which appears to be unique in the Maritime Provinces. Associated with the wetland areas are spruce (Picea) and larch (Larix) forests, upland fields and previously drained or semi-drained marshland which was once partially used for agriculture.

The Tintamarre NWA is separated from the Missaquash Marsh by a distance of three miles (Fig. 1) and both were probably formed by the same geological processes. According to Ganong (1903) the lake basins within the study areas were originally part of an extensive shallow freshwater lake that formed the present Cumberland Basin at the head of the Bay of Fundy. As the land gradually settled the lake was inundated by the sea and the strong tidal currents rapidly eroded the soft permo-carboniferous sandstone substrate. The eroded silt was carried inland and deposited over the land as the tidal current lost velocity. The present natural lake basins were formed as the silt laden salt water met the outflowing freshwater and deposited its load of silt to form a natural drainage barrier. The resulting lakes consequently became situated at the head of a vast area of alluvial deposits which has since been diked from the sea to provide hay and pasture for cattle.

Eight individual marsh units were selected as study areas within the Tintamarre NWA and the Missaquash Marsh. Seven of the sites represent man-made impoundments having facilities for independent waterlevel control. The eighth is a natural marsh within the Tintamarre NWA. Table 1 summarizes size and date of flooding for each study area.

All impoundments were constructed in co-operation with Ducks Unlimited (Canada) and are located upon alluvial soil deposits bordering natural lake basins within the study areas. Impoundments 1 to 6 are located adjacent to each other within the Tintamarre NWA



Scale - 1:50,000

Tintamarre National Wildlife Area Missaquash Marsh

Figure 1. Location of the Tintamarre National Wildlife Area and the Missaquash Marsh

Table 1. Flooding dates and acreages of eight study sites in the Tintamarre National Wildlife Area and the Missaquash Marsh

Area	Date of flooding	Acres
Impoundment 1	January 1, 1972	40
Impoundment 2	April, 1971	65
Impoundment 3	June 1, 1971	80
Impoundment 4	April 1, 1970	45
Impoundment 5	April 1, 1970	25
Impoundment 6	September 1, 1969	25
Impoundment 7	September 1, 1965	800
Natural Marsh 8		275

and vary in size from 25 to 80 acres. Impoundment 7 is both the largest and the oldest of the man-made impoundments and is located on the Missaquash Marsh. The natural marsh area represents one of five natural lake basins within the Tintamarre NWA and may be described generally as a shallow mesotrophic water body.

Methods

A total of 90 soil samples was taken from the eight study areas between mid-July and mid-August, 1972. The samples were extracted in 3.0-inch diameter cores in water varying from 18 inches to 3 feet in depth. Soil in all major vegetation zones was sampled. Measurements of pH, phosphates, potassium, calcium and magnesium were obtained in pounds/acre from the organic and mineral layers of each sample.

Water samples were collected in mid-August and mid-September, 1972. Three sample sites were selected in each of the eight study areas based on vegetation density. Open water, sparse emergents and dense emergents were the vegetation densities identified and sampled in each study area. A total of 48 samples was collected at the water surface over the two sampling periods. Measurements of pH, alkalinity, specific conductance, dissolved chloride, calcium, magnesium, potassium, sodium and sulfate were obtained.

Vegetation was sampled during the summers of 1971 and 1972. The technique used is described in detail by Lamoureux and Zarnovican (1973).

Invertebrate populations were sampled in 1972 in three different vegetation zones in each of the eight study areas. Vegetation zones were identified on the basis of the density of the emergent plant growth. The three zones are described as follows:

A. Submerged and floating leaf aquatics - emergent vegetation was essentially absent. Pondweeds, duckweed, floating-leaf bur-reeds (*Sparganium* spp.), and bladderwort (*Utricularia* spp.) were characteristic of that zone.

B. Sparse emergents - emergent vegetation covered from 20 to 40 per cent with submerged and floating-leaf species occurring throughout. Soft stem bulrush (*Scirpus validus* Vahl), blue-joint (*Calamagrostis canadensis* (Michx.) Nutt.), spiraea (*Spiraea* spp.), burr-reed, and sedge (*Carex* spp.) were dominant emergent species which characterized that zone.

C. Dense emergents - emergent vegetation covered more than 75 per cent of the zone while submerged and floating-leaf aquatics were sparse or absent. The same species as found in zone B characterized that zone.

Four collection techniques were used to sample invertebrate populations within each vegetation zone described above. The techniques were activity traps, sweep nets, bottom core samples, and artificial substrates. Poor results were obtained by the latter two techniques and are not considered in this paper. Activity traps were set for one 24-hour period each week between June 1 and August 31, 1972. Sweep net samples were collected every second week during the same period. In the laboratory, invertebrates in each sample were separated, counted, and identified.

Waterfowl production has been measured annually since 1967 using a helicopter to count broods. Two surveys were conducted each year in late June and late July to obtain as close to a total count as possible. Breeding pair surveys have also been conducted annually from mid-March to May 31 to identify increases in numbers and establish the chronology of the breeding season. Information on food habits is limited due to low population levels that made the collection of large samples impractical.

Results and Discussion

Soil

Prior to flooding, the soil was a tidal silt which had been leached of salts and bases creating an acid condition at the surface.

Subsoils remained saline with a pH of about 7. In most sections, a distinct humus layer was present although mineral components were prevalent up to the surface. At the transition with peatland areas, the mineral soil was overlain by a layer of muck and peat up to two feet thick.

Examination of soil properties and changes which have occurred with flooding is incomplete. Based on the data collected to date, changes which may have occurred in soil chemistry as a result of flooding cannot be accurately identified. An initial examination of the top 8 to 10 inches of the soil profile has shown no obvious differences among areas of varying ages. That fact should not be unexpected when some basic factors of the total ecology of the area are considered.

All of the study areas exist in a cool, humid climate where there is a tendency toward progressive impoverishment of nutrients and bases. The underlaying bedrock is a soft permo-carboniferous sandstone with only trace amounts of base minerals containing Ca or Mg. At some time during the previous centuries the study areas were exposed to a tidal influence which deposited a thick layer of alluvial silt over the bedrock; however, with the gradual exclusion of the tide through both man-made and natural processes, a layer of varying thickness of organic matter was deposited over the silt in most of the study areas. Upon reflooding of the soil with fresh water, the pre-flood vegetation was gradually killed and decomposition proceeded at a much reduced level under anaerobic conditions. It is believed that rapid decomposition occurred entirely within the upper one inch of the organic layer. Changes within deeper sections of the soil profile were extremely slow, perhaps requiring decades or even centuries to detect. Future analyses of the top one inch of substrate in which decomposition is most active will better identify differences between study areas. Table 2 shows results of chemical analyses of the organic and subsoil layers within the eight study areas. All values are averages of measurements taken from a variety of vegetation types.

Table 2. Chemical analysis in pounds per acre of organic and subsoil layers in eight study areas

Study area	Organic					Subsoil				
	pH	P_2O_5	K_2O	Ca	Mg	pH	P_2O_5	K_2O	Ca	Mg
1.	5.2	27.4	177	792	300+	5.0	11.8	226	630	300+
2.	5.1	52.6	162	844	300+	4.9	22.7	220	687	300+
3.	5.3	27.2	155	1037	300+	5.0	6.9	350	825	300+
4.	5.3	29.1	163	784	300+	5.5	19.9	359	767	300+
5.	5.1	25.0	202	906	300+	4.8	14.0	213	823	300+
6.	5.6	42.0	308	711	300+	6.0	43.5	443	790	300+
7.	5.3	32.7	172	844	221	4.9	8.9	390	862	300+
8.	4.9	27.5	198	562	300+	4.9	36.6	423	541	300+

High levels of phosphorous and particularly magnesium reflect the former influence of the tide on the soil of the study area. It is possible that the high levels of those minerals may be limiting to some plant species; however, more must be learned about the tolerance of desirable aquatics before that can be determined. Values of pH are relatively low and can be attributed to a base-poor sandstone substrate and a slowly decomposing organic layer.

Water

Wide seasonal fluctuations in waterlevels were characteristic of the area prior to impoundment. Extensive flooding occurred in early spring but the watertable receded to a level that permitted pasturing of cattle or hay cutting from mid-summer to early fall.

Analysis of water samples collected from the study areas in August and September of 1972 demonstrated some well-defined differences in water chemistry between sites. Unlike the analyses of soil, some obvious trends can be observed in water alkalinity, specific conductance, dissolved chloride, and magnesium. The highest readings for those factors appear in the most recently flooded study areas and become progressively lower as age increases. Table 3 illustrates those trends in the various age classes. Values for impoundments flooded in 1970 and 1971 were averaged to give one value.

Dissolved potassium, sodium, and sulfates also suggest an inverse relationship with the age of the impoundment; however, irregularities in the trend are more common and probably can be explained by minor variations in water source, flushing activity and sampling error. Calcium levels show no trend and no attempt is made to explain variation at this time. Readings of pH are dependent in part on biological activity and present a highly cyclic pattern on a daily and seasonal basis; therefore, no trend is shown by the pH readings in Table 3.

Table 3. Average water chemistry data for August and September, 1972

Sample area	pH	Alk ppm	Sp.cond. umho/cm	Dissolved chloride	Ca	Mg	K	Na	Sulfate
1 (1972)	7.0	32.19	260	62	2.30	6.20	10.66	33.63	6.86
2 (1971) 3 (1971)	7.0	28.20	172	35	4.35	4.89	2.63	19.58	4.29
4 (1970) 5 (1970)	6.5	21.07	161	36	1.63	3.23	1.54	22.82	3.45
6 (1969)	6.5	13.80	112	22	1.10	2.50	3.18	14.00	5.47
7 (1965)	7.1	15.56	86	14	3.95	1.57	0.68	10.10	2.92
8 (natural marsh)	6.7	10.74	71	12	4.92	1.42	0.85	6.57	4.23

The high levels of dissolved nutrients shown to appear shortly after flooding are probably due to a release of soluble nutrients from the substrate and from pre-flood terrestrial vegetation. As the length of flooding increases decomposition slows down. It becomes anaerobic at depths below the soil surface and as dissolved nutrients are used up by developing flora and fauna, there is a gradual decline in nutrient levels. The end result is likely to be a somewhat stabilized condition similar to that present in the adjacent natural lake basins which contain a soft, electrolyte poor water.

Vegetation

Prior to flooding, vegetation within the man-made impoundments was composed primarily of dense grasses. Woody plants were absent over large sections, but became increasingly prominent near drainage ditches, old river channels and along the transition zone with peatland areas.

Dominant grasses were blue-joint, fresh-water cord-grass (Spartina pectinata Link), couch-grass (Agropyron repens (L.) Beauv.), and timothy (Phleum pratense L.). Woody plants included spiraea, speckled alder (Alnus rugosa (DuRoi) Spreng.), and larch (Larix decidua Mill.). Aquatic vegetation distinguished by a prominence of pondweeds with narrow, linear or strap-shaped leaves and arrowhead (Saggitaria spp.) occurred in drainage ditches and old river channels (Harries, 1968).

Upon flooding of the study areas with fresh water to average depths of 18 to 24 inches, the pre-flood vegetation was almost immediately affected. Terrestrial species were killed and initial decomposition was rapid. Those species tolerant of some flooding persisted for a time dependent upon their location within the study areas and subsequently upon the degree of flooding to which they were subjected. Spiraea, blue-joint, and fresh-water cord-grass were the dominant pre-flood species in all study areas except the natural lake basin designated as Number 8. All three species were tolerant to flooding and continue to persist in all study areas especially in the shallow or dry sites.

Succession following flooding proceeded rapidly toward a sedge (Carex rostrata Stokes) - cat-tail (Typha latifolia L.) dominated marsh. Sedge and cat-tail became established in all study areas during the first year of flooding and competed successfully with spiraea and blue-joint especially in the wetter sites. Cinquefoil (Potentilla palustris (L.) Scop.) was either absent or of minor importance during the first year; however, it became one of the most important and aggressive species in the second and third years of flooding. During the early stages of flooding, duckweed was an important species commonly associated with spiraea.

If flooding continues under present levels, unaltered by management, it is likely that cat-tail will spread over a major part of all study areas to the exclusion of most other species competing with it. Sedge will eventually dominate in the drier spots excluding both blue-joint and fresh-water cord-grass. Spiraea will continue to exist in favourable sites along the periphery of the dikes and in the drier locations within the impoundments. Cinquefoil will take over in deeper waters where rooting is possible. The trend over a large portion of the study area is obviously toward a vegetation type of low quality for waterfowl food and away from valuable plants such as the pondweeds, smartweed, and some other submerged and floating-leaf aquatics.

By plotting the number of species identified along the plant transects run in 1971 and 1972 against the age of the study areas (Fig. 2), the largest number of species is observed in areas between two and three years old. Since no data are available for areas between three and seven years old, it cannot be determined if a greater variety of plant species occurs in impoundments of that age class. It is possible that a downward trend begins shortly after the age of three years extending to the lower levels recorded in the seven year old study area and in the natural marsh as a result of interspecific competition. Table 4 is a list of the species identified along the line transects run in 1971 and 1972.

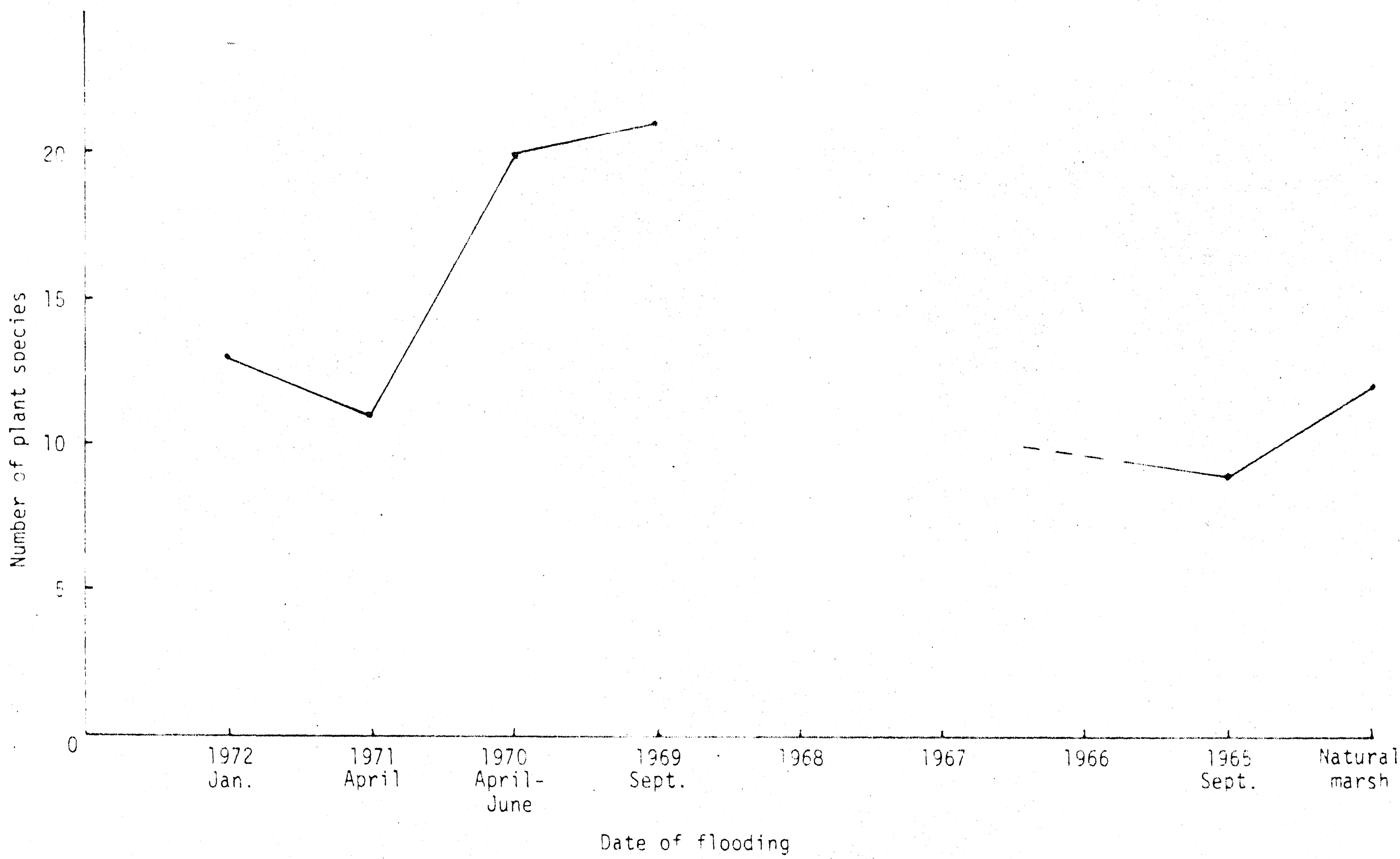


Figure 2. Variation in numbers of plant species with age of study areas

Table 4. Plant occurrence along line transects in study areas of differing age

Species	Jan. 1972 (1)	April 1971 (2 & 3)	Apr.-June 1970 (4 & 5)	Sept. 1969 (6)	Sept. 1965 (7)	Natural marsh (8)
Acorus calamus						x
Alisma triviale	x	x	x			x
Bidens cernua				x		
Bidens frondosa		x		x		x
Bidens sp.	x					
Calamagrostis canadensis	x	x	x	x	x	x
Callitriche palustris				x		
Callitriche sp.		x				
Carex lasiocarpa			x		x	
Carex rostrata	x	x	x	x		
Carex sp.	x		x			
Drepanoclodus sp.				x		
Eleocharis sp.			x			
Equisetum fluviatile			x			x
Equisetum sp.	x					
Galium palustre				x		x
Galium trifidum			x		x	x
Galium sp.				x		
Unidentified #1			x			
Unidentified #2				x		
Iris versicolor	x					
Lemna minor		x	x	x	x	
Lysimachia terrestris	x		x			
Lysimachia sp.		x	x		x	x
Nuphar variegatum						x
Potamogeton natans				x		
Potamogeton pusillus				x		
Potentilla palustris	x		x	x	x	x
Phragmites communis				x		
Sagittaria latifolia		x		x		
Scirpus validus					x	x
Sium suave			x	x		
Sparganium eurycarpum	x		x	x		
Spartina pectinata	x	x	x			
Spiraea latifolia	x	x	x	x	x	
Typha angustifolia			x			
Typha latifolia		x	x	x	x	x
Utricularia geminiscapa				x		
Utricularia vulgaris	x		x	x		

Invertebrates

Initial examination of the invertebrate data collected in 1972 indicates some interesting correlations between numbers of taxa and age of the study areas, vegetation density and plant species. A total of 47 taxa was considered in comparing the eight study areas but only 21 occurred in sufficient abundance to submit to statistical analysis.

As anticipated, the initial increase in invertebrates within the newly flooded marshes was exceptionally rapid. In the present study a relatively stabilized level in the number of taxa was reached in less than two years with about 90 per cent being reached by the end of the first growing season. In study areas ranging in age from 1.5 to 3 years, the number of taxa remained relatively constant; however, at some point between the age of three and seven years another increase appears to have taken place. The largest number of taxa were found in the oldest impoundment and were roughly comparable to those found in the natural marsh area. Table 5 and Fig. 3 list taxa identified and show their relationship to age.

An examination of the abundance of the 21 taxa for which a significant number of individuals was collected indicates that relatively few taxa reach their peak abundance in impoundments up to three years of age, ie. the majority of the invertebrate population in new impoundments is represented by few taxa having a large number of individuals. Older impoundments and natural areas have notably more taxa but fewer individuals. Impoundments flooded for less than one year, ie. flooded for one growing season, were found to contain the

Table 5. Invertebrate taxa identified in eight study areas

Taxonomic groups	Study areas							
	1	2	3	4	5	6	7	8
1. Dytiscidae	x	x	x	x	x	x	x	x
2. Hydrophilidae	x	x	x	x	x	x	x	x
3. Chironomidae	x	x	x	x	x	x	x	x
4. Haliplidae	x	x	x	x	x	x	x	x
5. Gyrinidae	x	x	x	x	x	x	x	x
6. Elmidae		x				x		x
7. Chrysomelidae	x							
8. Tipulidae	x	x	x	x		x	x	x
9. Culicidae	x	x	x	x	x	x	x	x
10. Ceratopogonidae	x	x	x	x	x	x	x	x
11. Corixidae	x	x	x	x	x	x	x	x
12. Gerridae	x	x	x	x	x		x	x
13. Belostomidae	x	x	x		x	x	x	
14. Notonectidae	x	x	x	x	x	x	x	x
15. Nepidae			x		x			
16. Noctuidae	x		x					
17. Libellulidae	x	x	x	x	x	x	x	x
18. Agrionidae	x	x	x	x	x	x	x	x
19. Aeshnidae		x	x	x	x	x	x	x
20. Psychomyiidae	x	x	x	x	x	x	x	x
21. Limnaephilidae		x	x	x			x	x
22. Leptoceridae								x
23. Phryganeidae						x	x	x
24. Baetidae					x		x	x
25. Ephemerellidae		x			x		x	x
26. Leptophlebiidae					x		x	
27. Planorbidae	x	x	x	x	x	x	x	x
28. Physidae	x	x	x	x	x	x	x	x
29. Lymnaeidae	x	x	x	x	x	x	x	x
30. Sphaeriidae	x	x	x	x		x	x	x
31. Erpobdellidae	x	x	x	x	x	x	x	x
32. Piscicolidae		x	x	x	x	x	x	x
33. Cladocera	x	x	x	x	x	x	x	x
34. Ostracoda	x	x	x	x	x	x	x	x
35. Copepoda	x	x	x	x	x	x	x	x
36. Gammaridae					x			
37. Talitridae		x		x	x	x	x	x
38. Oligochaeta	x	x	x	x	x	x	x	x
39. Nematoda	x			x				x
40. Eylaidae	x	x	x	x	x	x	x	x
41. Terbellaria						x		
42. Staphylinidae(T)								x
43. Arachnid (T)		x	x			x		x
44. Lepidoptera (T)		x	x	x	x		x	x
45. Cicadellidae(T)	x	x	x	x	x		x	x
46. Diptera (T)	x				x	x		x
47. Tettigoniidae(T)							x	
	30	34	33	31	34	32	36	39

(T) - terrestrial

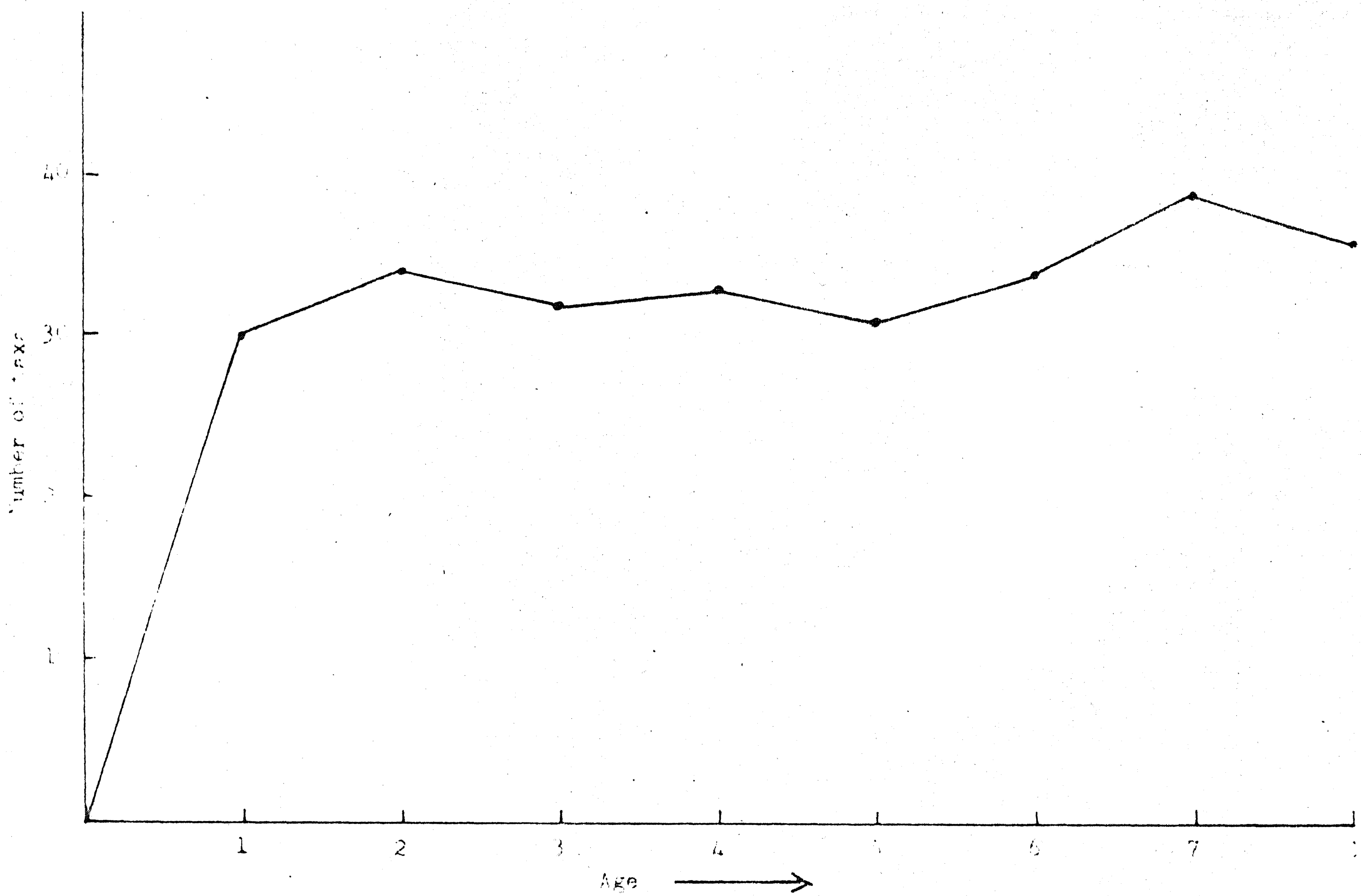


Figure 3. Relationship of the number of invertebrate taxa to age of study areas

highest numbers of individuals in the families Dytiscidae, Chironomidae, Corixidae, Planorbidae, and Culicidae. The families Gyrinidae, Aeshnidae, Physidae, and Lymnaeidae reached their peak abundance between one and three years while the remaining twelve taxa did not reach maximum abundance until a later period. The taxa Haliplidae, Erpobdellidae, Piscicolidae, Cladocera, Ostracoda, Copepoda, Talitridae, Ceratopogonidae, Libellulidae, Agrionidae, Sphaeriidae, and Oligochaeta were found to be most abundant in older impoundments and natural marsh areas. Table 6 lists taxa according to abundance and age class of study areas. Numbers of individuals noted are average values for each age class.

Vegetation density also appeared to have some influence on invertebrate numbers. Samples taken in the submerged and floating-leaf aquatic zones produced the smallest number of invertebrates while those taken in dense emergent zones contained the largest number. Low numbers in the submerged and floating-leaf aquatic zone closely correspond to findings in other studies. For example, Krull (1970) found relatively poor production of invertebrate fauna associated with such plant species as pondweeds which are characteristic of that zone. Sparse emergent, and dense emergent zones contained a notably higher number of invertebrates and were characterized by such plant species as sedge, cat-tail, spiraea and blue-joint. A total of 215,552 individual invertebrates was collected in the submerged and floating-leaf aquatic zone; 354,037 in the sparse emergent zone and 396,725 in the dense emergent zone. Plant succession is proceeding toward a dense emergent type, excluding submerged and floating-leaf aquatics that are generally

Table 6. Numbers of individuals in the characteristic taxa of the major age classes within eight study areas

Taxa	Age of marsh		
	1 yr. or less	1-3 years	7 yrs. or more
Dytiscidae	502	194	280
Chironomidae	62,946	10,530	9,052
Corixidae	7,344	631	1,292
Planorbidae	18,117	4,385	1,055
Culicidae	61	29	6
Sub-totals	88,970	15,769	11,685
Gryinidae	15	47	8
Aeshnidae	0	10	9
Physidae	130	939	228
Lymnaeidae	316	2,885	147
Sub-totals	461	3,881	392
Haliplidae	16	27	40
Erpobdellidae	18	59	201
Cladocera	8,470	4,897	14,477
Ostracoda	4,750	2,806	28,918
Copepoda	4,640	2,923	17,788
Talitridae	0	2	767
Oligochaeta	1,891	557	4,605
Ceratopogonidae	80	194	297
Libellulidae	3	14	18
Agrionidae	6	254	329
Sphaeriidae	1	1	109
Piscicolidae	0	1	28
Sub-totals	19,905	11,735	67,577

more desirable waterfowl foods. The sparse emergent zone as described in this study contains 20 to 40 per cent emergent vegetation with the remainder composed of open water and submerged and floating-leaf aquatics. The sparse emergent zone also supports a dense invertebrate population so that both food and cover are provided in an attractive combination for waterfowl. That suggests that the most attractive waterfowl marsh from the standpoint of food availability is one that contains large areas of sparse emergents.

Further analyses of relationships between plants and invertebrates suggest additional correlations with plant species. The dominant plant species in each sample site were recorded. Although no attempt was made to record plant diversity at invertebrate sample sites, a relationship to the dominant life form of the vegetation was noted. In general, invertebrate fauna were most abundant in sites dominated by blue-joint grass. Depending upon the age of the impoundment and thus length of flooding, sample sites within the blue-joint grass zone were in varying stages of vegetative decomposition which suggests a highly attractive environment for invertebrates. Slightly lower levels of invertebrates were measured in zones characterized by sedges that have large leaf surface areas. Such species provide both food and shelter for several invertebrate taxa (Krull, 1970). Sample sites dominated by spiraea contained still fewer organisms but it is suspected that *Lemna* is an important controlling factor in that case. Krull (1970) found that *L. trisulca* harboured the largest number of taxonomic groups of organisms in his study of aquatic plant - macroinvertebrate associations. Furthermore, in the present study *Lemna* was found to be strongly associated with spiraea. Sample sites located in cat-tail produced the lowest number of invertebrates. Table 7 compares invertebrate numbers in various vegetation types.

Table 7. Total number of invertebrates collected in selected dominant vegetation types

Density of emergent vegetation	*Calamagrostis*	*Carex*	*Spiraea*	*Typha*
Sparse	43,605	40,839	21,449	19,033
Dense	64,197	61,664	N/A	17,469

Waterfowl use

Waterfowl production within the Tintamarre NWA and the Missaquash Marsh has shown a consistent upward trend since 1967 with the exception of the year 1972. In that year an abnormally cold, wet spring retarded breeding and caused high nest losses resulting in noticeably reduced brood counts. Table 8 shows waterfowl production data since 1967. The data suggest that production on the oldest impoundment, the Missaquash Marsh, has levelled off and it is anticipated that it will remain stable for several years before declining (Fig. 4).

In the natural marsh areas, the trend in production has been downward with the creation of nearby impounded areas. An apparent shift of broods from all of the natural marsh areas in the Tintamarre NWA to the nearby controlled waterlevel impoundments was noted in 1971. Table 9 illustrates that shift.

Table 8. Waterfowl brood records on eight study areas

Study area number	Date of flooding	1967	1968	1970	1971	1972	1973
Tintamarre NWA							
1	Jan., 1972					6	7
2	April, 1971				3	8	12
3	June, 1971				13	3	7
4	April, 1970			0	0	6	8
5	April, 1970			0	18	13	11
6	Sept., 1969			2	14	2	11
			Total	2	48	38	56
Missaquash Marsh							
7	Sept., 1965	44	62	91	108	74	109
Natural Marsh							
8				11	7	8	5

Breeding Birds: Breeding pair counts have been conducted on the study area since 1971. The objectives were to (1) measure increases in breeding pairs as impoundments were created and (2) record the chronology of the build-up of the breeding population. Maximum numbers of breeding pairs of black duck (*Anas rubripes* (Brewster)), observed on the study areas have remained relatively constant between 1971 and 1973. Blue-winged teal (*A. discors* (Linnaeus)) and pintail have increased over

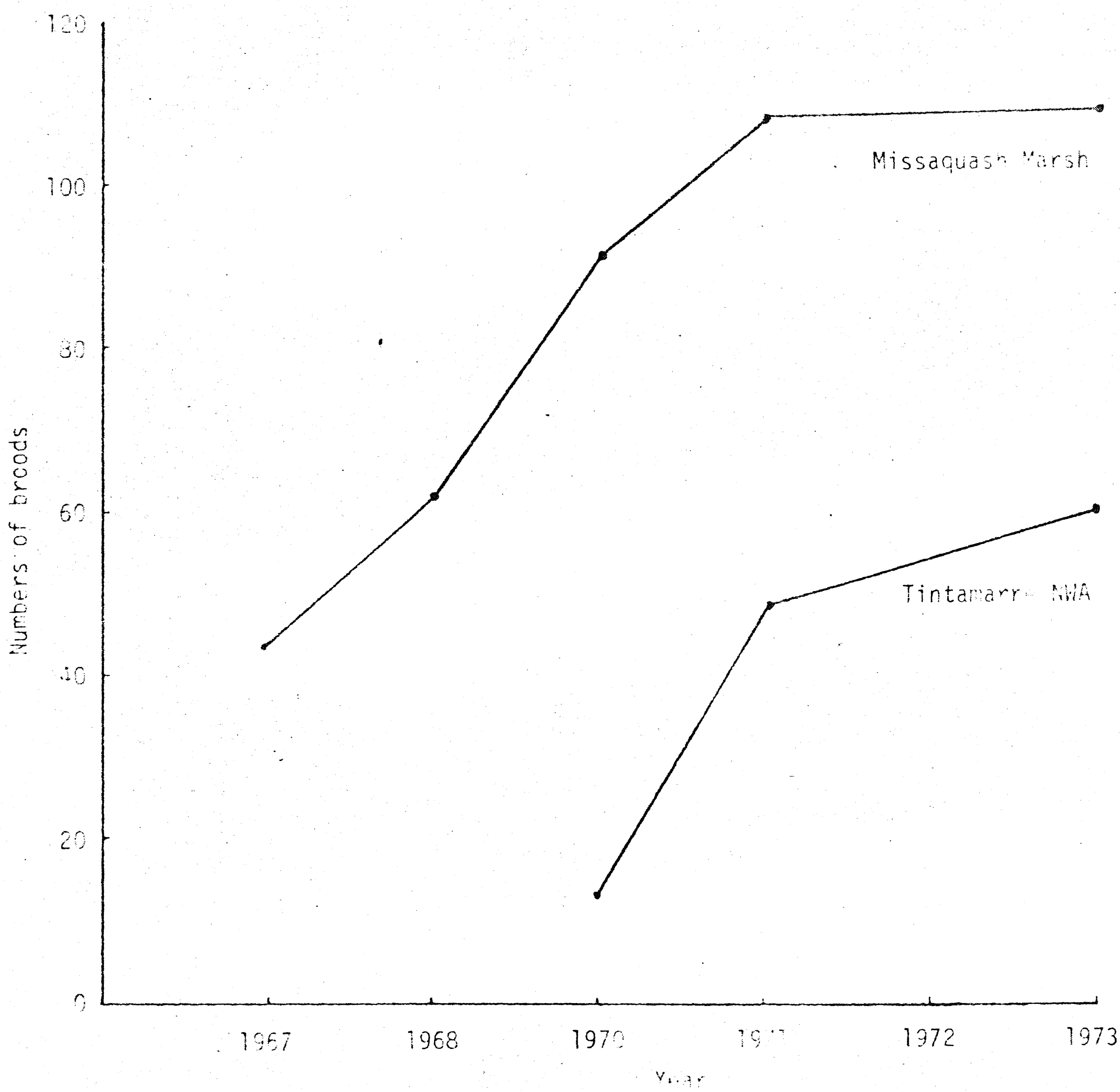


Figure 4. Waterfowl production in the Tintamarre National Wildlife Area and the Missaquash Marsh - 1967 to 1973

Table 9. The shift in brood numbers from natural marshes to controlled waterlevel impoundments at the Tintamarre NWA

Natural marshes	1970							1971							
	Blk.	Gwt.	Bwt.	Pin.	Ring.	Wood	Total	Blk.	Gwt.	Bwt.	Pin.	Ring.	Wood	Unident.	Total
Large Lake	1		3				4								
Long Lake	1			1			2								
Front Lake (Study Area #8)	5	2	2			2	11	2	4	1					7
Paunchy Pond			1				1								
Beach Pond															
Sub-total	7	2	6	1		2	18	2	4	1					7
Impoundments															
1	- - - - Not flooded - - - -							- - - - - Not flooded - - - - -							
2	- - - - Not flooded - - - -								1		1		1		3
3	- - - - Not flooded - - - -							2	8		3				13
4															
5								5	4	6	2			1	18
6	1					1	2	2	4	7	1				14
Sub-total	1					1	2	9	17	13	7		1	1	48
Grand total	8	2	6	1		3	20	11	21	14	7		1	1	55

the same period while the number of American green-winged teal (A. crecca carolinensis (Gmelin.)) pairs has decreased. The total number of breeding pairs is roughly equal over the three year period although the species composition has changed. The increase in waterfowl production over the same period is undoubtedly a result of more breeding pairs remaining on the study areas to nest.

In normal years the peak number of breeding pairs of all species is reached by the third or fourth week of April. During the abnormal spring of 1972, peak numbers were not reached until the second week of May, a delay of three weeks from a normal season. The total number of pairs of all species in that year did not vary noticeably from the normal seasons of 1971 and 1973.

Food and Feeding Habits: The collection of data on food habits has been neglected due to low population levels which made collecting of birds impractical, although the importance of such data to habitat management is recognized. Spring food habits are particularly critical since that is a time of high energy requirements and a potentially limited food supply due to ice conditions. Some extensive general observations of feeding behaviour, particularly on the Tintamarre NWA, have suggested that waterfowl prefer recently flooded impoundments as feeding sites in the spring. Long established natural lake basins adjacent to controlled waterlevel impoundments in the Tintamarre NWA have been observed to receive consistently less feeding activity by waterfowl.

It is in impoundments of two to four years of age that both vegetative and invertebrate foods appear to be most attractive for waterfowl.

As indicated in this study and by other workers, vegetative succession moves from plants of high food value toward species of lower value. Likewise, in the current study it appears that the most desirable invertebrate foods for waterfowl occur in the largest numbers in marshes between one and three years of age. Long established natural areas and older man-made impoundments tend to provide more of the invertebrates considered to be less attractive to waterfowl. For example, the taxa Dytiscidae, Chironomidae, Corixidae, Planorbidae, Gyrinidae, Physidae and Lymnaeidae were found to be most abundant in study areas one to three years of age. Mendall (1949), Coulter (1955), Swanson (1972), Sugden (1969) and others have repeatedly identified representatives of those taxa as important waterfowl foods. Older impoundments and natural marsh areas tend to support more of the invertebrates less commonly used by waterfowl. Low priority food items in the taxa Erpobdellidae, Piscicolidae, Oligocheata, and others were most strongly associated with older impoundments in this study.

Examination of digestive tracts from waterfowl caught in muskrat traps during the spring season has provided some insight into food habits. Six birds have been obtained in that manner, three black duck, one mallard, one American green-winged teal, and one blue-winged teal. Both vegetable and animal matter were identified with the latter being most abundant. Invertebrates in the taxa Dytiscidae, Gyrinidae, Corixidae, Erpobdellidae, Gammaridae, Planorbidae, Lymnaeidae, Physidae, and *Pungitius pungitius* were among the animal matter found while bur-reed, bogbean (*Menyanthes trifoliata* L.), pondweed, sedge and various grasses composed the vegetable matter. Examinations of birds in the autumn have shown a predominantly vegetable diet as demonstrated in other studies; however, a bias is recognized in the data since all fall data were based on analyses of gizzards obtained from hunters.

Management Implications

At the present stage of the study, increases in waterfowl production on impounded areas have been documented. Further, some important ecological factors have been measured and speculations concerning their effect on waterfowl production can be made. In the coming year some manipulation of ecological factors will be undertaken to build and maintain optimum waterfowl populations and to develop effective methods of habitat management that can be applied to other areas in the Maritimes.

Based on present data, drainage of impoundments at the age of 5 to 6 years is suggested. Water quality at that age has reached a stage approaching the lower values of alkalinity and specific conductance found in natural marshes. A vegetation type has evolved that is low in quality as a waterfowl food. Valuable food plants such as pondweeds, smartweed and some other submerged and floating-leaf aquatics have been replaced over large sections by dense cat-tail and sedges. Invertebrate populations contain a wide variety of taxa that are less abundant and less attractive as waterfowl foods. Taxa such as Erpobdellidae, Piscicolidae, Oligochaeta, and Talitridae which are not generally considered important waterfowl foods have become abundant while families such as Dytiscidae, Chironomidae, Planorbidae, and Lymnaeidae that provide good food value have declined in numbers.

Drainage of impoundments at 5 years of age should be followed by removal of cat-tail and sedges, aeration of the soil and introduction of a terrestrial plant such as blue-joint grass which, upon reflooding, will provide a rapid release of nutrients and abundant detritus for invertebrates. In less than two years the impoundment should again reach its most desirable stage for waterfowl production providing large areas of sparse emergents in which may be found abundant invertebrate and plant foods.

Where several independently controlled impoundments exist, as in the Tintamarre area, management should be scheduled in a manner that does not remove more than one-fifth or one-sixth of the impoundments from production in any one year. Although management on a five year basis will remove some habitat prior to its reaching peak waterfowl production, it is believed that recovery following reflooding will thereby be more rapid. Adjacent flooded impoundments will provide alternative choices for waterfowl formerly dependent upon any impoundments temporarily drained.

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