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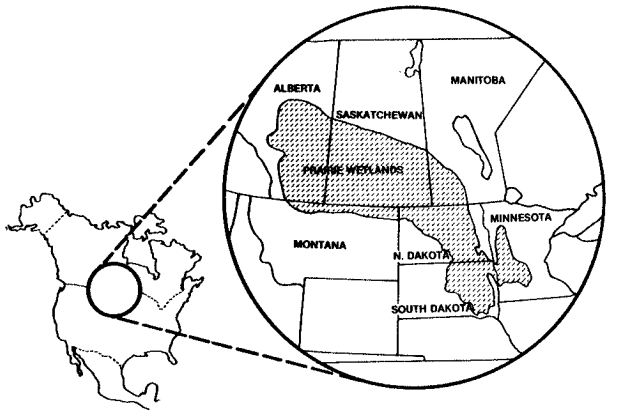

NORTH DAKOTA RESEARCH REPORT

The Fauna of The Prairie Wetlands: Research Methods and Annotated Bibliography

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ABSTRACT

The subjects of waterfowl, non-game birds, mammals, and poikilothermic vertebrates and invertebrates are briefly addressed. An annotated bibliography of selected published literature in support of these and other wetland-related topics is provided.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

THE FAUNA OF THE PRAIRIE WETLANDS: RESEARCH METHODS AND ANNOTATED BIBLIOGRAPHY

INTRODUCTION

The purpose of this report is to briefly review some of the current zoological research related to wetlands with a particular focus on the species associated with the Prairie Pothole Region. Subject areas to be addressed include waterfowl, non-game bird and mammalian use of wetlands, and cold-blooded vertebrates and invertebrates characteristic of this Region. This report is not intended to be a comprehensive treatment of these subjects but rather provide an exposure to some of the types of research recently or currently being conducted in freshwater wetlands. A selected annotated bibliography is included.

WATERFOWL

The Prairie Pothole Region is a major site for breeding and feeding of migratory waterfowl of the Central Flyway (Figure 1). In a given year, between 50% to 75% of North America's waterfowl are produced in this region (Upgren 1979). Most of the waterfowl research for this area has been conducted under the auspices of the Northern Plains Wildlife Research Center (U.S. Fish and Wildlife Service) at Jamestown, North Dakota. Consequently, the preponderance of literature reviewed below has been authored by personnel affiliated with this Center.

The importance of these wetlands to duck reproduction is underscored by several studies. Dwyer et al. (1979) studied home range characteristics of radio-marked mallards during the breeding season. They found a reproduction strategy that favors the use of several wetlands of diverse types, increasing potential options for meeting breeding requirements. Krapu et al. (1979) found that 66% of 53 nests initiated by radio-marked and

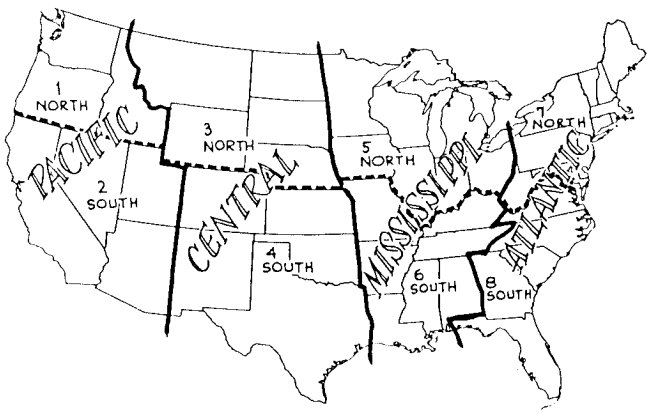

Figure 1. Flyway areas of the continental United States.

SOURCE: Shaw, S.P. and C.G. Fredine. 1956. Wetlands of the United States. U.S. Fish and Wildlife Service Circular 39, Washington, D.C. p. 20.

unmarked mallard hens were in wetlands among dense stands of emergent vegetation. Satellite photography was employed by Gilmer et al. (1978) to synoptically assess several habitat parameters deemed important to reproductive success. Pospahala et al. (1974) report a decline and subsequent low level of a mallard breeding population between 1959 and 1969, generally coinciding with a period of poor habitat conditions on the breeding grounds of the Prairie-Parkland Area in south-central Canada. Ruwaldt et al. (1979) observed a similar phenomenon on the potholes of South Dakota; densities of blue-winged teal (Anas discors), pintails (A. acuta), northern shovelers (A. clypeata), and green-winged teal (A. crecca) declined sharply on semi-permanent wetlands during the 1974 drought. Weller (1979) found that population fluctuations of blue-winged teal showed a significant positive correlation with water depth on ponds in northwestern Iowa from 1968-1974. He hypothesized that deeper water created additional feeding and loafing sites for territorial pairs in flooded grasses and sedges of temporary wetlands and around perimeters of deeper wetlands. Stewart (1971), studying waterfowl populations of the Turtle Mountains in North Dakota, estimated an average of 28,522 breeding pairs, producing 10,318 broods and 65,097 young for Class 3 to 5 wetlands (Stewart and Kantrud 1971). Kantrud and Stewart (1977) determined that of the total breeding population of twelve waterfowl species occupying pothole wetlands, 55% occupied seasonal and 36% occupied semi-permanent wetlands.

The importance of this habitat lies not only in its adequacy for reproduction but also as an essential food source. Bartonek and Hickey (1969) describe the food habits of canvasbacks (Aythya Valisineria), redheads (A. americana) and lesser scaup (A. affinis) collected on the potholes of southern Manitoba. They indicate a preference for invertebrates and Potamogeton tubers, both acquired in large degree from in or around potholes. Krapu and Swanson (1975) found that calcium content in major plant foods is far below requirements for egg production in pintails. The consumption of invertebrates by breeding hen pintails in tilled western North Dakota wetlands consisted of snails, fairy shrimp, and earthworms (Krapu 1974). Swanson and Meyer (1977) found that animal foods dominated the diet of laying female blue-winged teal. Snails comprised 38%, crustacea 14%, and insects 44% of the diet. Swanson et al. (1979) report that primary factors which influenced food selection among dabbling ducks were nesting chronology and food availability. Food availability was determined by the life cycle and behavior of invertebrates and current hydrological conditions within the wetland complexes. Anderson and Low (1976) sampled sago pondweed (Potamogeton pectinatus) in exclosurers and open plots and determined an average utilization of 60.5 g/m^2 foliage and 26.3 g/m^2 tubers by waterfowl between July 1973 and June 1974. Dirschl (1969) noted significant changes in the proportions of plant and animal foods consumed by lesser scaup and blue-winged teal over time, reflecting changes in the abundance of food items. Serie and Swanson (1976) examined the feeding ecology of breeding gadwalls on saline wetlands and ascertained that the major factors influencing food selection revolve around interactions among their physiological status, their anatomical and behavioral characteristics, and the abundance and behavior of food organisms as influenced by chemical and physical features of the environment. Siegfried (1973) found that foraging ruddy ducks (Oxyura jamaicensis) appeared to select areas relatively rich in midge larvae (Tendipedidae), especially Chironomus.

NON-GAME BIRDS

Although less important to man directly, a rich non-game avifauna is sustained by the pothole wetlands (Stewart 1975). Again, the primary attractant is the suitable habitat for food and reproduction.

Included in this group would be birds which utilize emergent vegetation for nesting (e.g., blackbirds) as well as shorebirds which satisfy dietary requirements along the shores of wetlands.

Bernstein and McLean (1980) found that the red-winged blackbird (Agelaius phoeniceus) preferred the cattail Typha

latifolia for nesting on Mentor Marsh, Ohio. They suggest that rigidity, easy nest accessibility, and wide spacing facilitate nest defense. Joyner (1978) studied this same species in Ontario, Canada and determined an exclusive use of canary reedgrass (Phalaris arundinacea) for nesting purposes. He indicates that blackbirds preferred nesting cover that was (1) close to water, (2) matured relatively early in the season, (3) had structural strength to support their nests. In terms of interspecific competition, Picman (1980) cites marsh wrens as a major cause of redwing blackbird nesting mortality in a brackish Canadian marsh.

The other blackbird species to frequent the pothole wetlands is the yellow-headed Xanthocephalus xanthocpehalus. Lederer (1978) studied the reproductive strategy of this species with respect to a fluctuating marsh habitat. He concluded that flexibility and opportunism characterize the selected strategy, and these features compensate for the unpredictability of the marsh situation.

Burger (1974) examined breeding adaptations of Franklin's Gull (Larus pipixcan) to a marsh habitat and ascertained that colony site selection was primarily tied to the cattail dispersion and density. In a related study, McColl and Burger (1976) found little impact on the water quality of the Agassiz National Wildlife Refuge from a colony of 30,000 nesting gulls. They suggested that the refuge was acting as a sink to runoff—particularly agricultural runoff.

In summary, Weller and Spatcher (1965) cite general habitat of the ancestral stocks (terrestrial versus aquatic), mode of locomotion (perches, walkers, swimmers, and flyers) and use of the major emergents (shoreward or water's edge) as primary factors in the evolution of nest-site selection among marsh birds. Furthermore, they suggest that the vertical height and resulting "layers" of vegetation, their robustness, and their relationship to water influence species use and, hence, species diversity.

MAMMALS

Mammalian species play an integral role in the ecology of the potholes. As predators, several mammals impinge directly on the population dynamics of waterfowl. As residents, such as the muskrat (Ondatra zibethicus), they rely on the wetland habitat for both food and shelter.

The impact of predation upon waterfowl is vividly illustrated by Duebbert and Lokemoen (1980). They controlled the major predators on a study site in South Dakota to determine impact on waterfowl nesting success. Those species controlled included red fox (Vulpes vulpes), striped skunk (Mephitis mephitis), raccoon (Procyon lotor), and badger (Taxidea taxus). The authors found a dramatic increase in mallard nests—from 37 in 1969 (at the inception of the study) to 1981 in 1972. They concluded that exceptionally high duck nesting densities and hatching rates occurred when predators were controlled. Eberhardt and Sargeant (1977) described the predation by mink (Mustela vison) families on prairie marshes. Avian species, primarily American coot (Fulica americana) and several duck species constituted 78% of the vertebrate prey. Other prey included pied-billed grebes (Podilymbus podiceps), yellow-headed and red-winged blackbirds, meadow voles (Microtus pennsylvanicus), and larvae of predaceous diving beetles (Dytiscus spp.). Sargeant (1978) studied red fox prey demands under laboratory conditions and concluded that ducks could represent a small part of the foxes' diet.

Fritzell (1978) found that building sites, wooded areas, and wetlands were the only habitats used by all raccoons on the prairie, regardless of age and sex. He indicates Class 3 and Class 4 wetlands (Stewart and Kantrud 1971) were in fact centers of raccoon activity. Muskrats are another mammal highly dependent upon the wetland habitat. Danell (1979) noted that muskrat feeding activities produced small open water areas of irregular shape within stands of emergent vegetation. He suggests that such areas may increase feeding options for waterfowl. MacArthur and Aleksiuk (1979) describe microenvironmental changes of the muskrat inhabiting the Delta Marsh in Saskatchewan. They determined that energy costs for thermoregulation are minimized through the construction and selective use of multiple shelters.

COLD-BLOODED VERTEBRATES AND INVERTEBRATES

Little is known about the herpetology, icthyology or invertebrate zoology of the Prairie Pothole Region. The importance of invertebrates in the diet of waterfowl has been amply substantiated (Bartonek and Hickey 1969; Krapu 1979; Krapu 1974; Krapu and Swanson 1975; Swanson and Meyer 1977). However, no in-depth descriptive work has been published on invertebrate fauna indigenous to these wetlands.

Peterka (1980) indicates important reptiles of the region include the plains garter snake (Thamnophis radix) and western painted turtle (Chrysemys picta). Dominant amphibians are typically the tiger salamander (Ambystoma tigrinum) and leopard frog (Rana pipiens). Fish are represented by the fathead minnow (Pimephales promelas) and three-spined stickleback (Culaea inconstans) (Held and Peterka 1974).

RESEARCH RECOMMENDATION

This brief literature review documents the past research emphasis on waterfowl ecology. Integration of this and other zoological work into a comprehensive study of the botany, chemistry, microbiology, and soils of prairie pothole wetlands would provide the first holistic approach into the intricacies and interrelationships of the pothole ecosystem.

METHODS

Examination of the kinds and relative abundance of selected invertebrates and vertebrates for a set of hydrologically similar wetlands would require a significant research effort. A proposal to accomplish this goal is found in Peterka (1980). A summary table (after Besser 1980) from that proposal is found in Table 1. This depicts the variety of methods one need employ to measure the broad spectrum of fauna encountered in the prairie pothole wetlands. The reader is directed to the citations within this table for additional detail on methodology.

Table 1. Methods to Measure the Relative Abundance of Fauna Characteristic of the Prairie Pothole Region.

Group	Season	Method (Reference listed where applicable)
1) Game birds		
a) Order Anseriformes Family Anatidae (Waterfowl)	Spring	Aerial counts/photos Direct observation Modified transect and flushing (Stewart and Kantrud, 1972) Breeding pair counts (Hammond, 1969; Stewart and Kantrud, 1973; Weller, 1979) Nest searches, success checks
	Summer	Brood counts (Observe numbers and species composition for any change.) Night lighting
	Fall	Aerial counts/photos Direct observation Modified transect and flushing
b) Order Gruiformes Family Rallidae (Rails)		Surveyed with non-game species
2) Non-game birds		
a) Order Podicipediformes, Pelecaniformes, Ciconiiformes, Falconiformes, Gruiformes, Charadriiformes, Strigiformes (Grebes; Pelicans and Cormorants; Herons and Bitterns; Hawks, Cranes, Rails and Coots: Shore birds and Gulls)	Spring, Summer, Fall	Aerial counts/photos Variable transects and strip census (Emlen, 1977; Stewart and Kantrud, 1972) Spot mapping
b) Order Passeriformes (Perching or Passerine birds)	Year round	Variable transects and strip census Spot mapping
3) Game mammals		
a) Family Cervidae White-tailed deer	Year round Winter	Ground census (Tracks, scats, and scrapes) Aerial count/photo
b) Furbearers Order Rodentia (Beaver and Muskrats)	Year round	Live trapping — catch/unit effort, mark & recapture Bank walk — locate dens/houses Aerial photos
Order Carnivora Family Mustelidae Mink and Weasel	Spring, Summer, Fall	Scent post (U.S. Dept. of Int., 1979) Live trapping — catch/unit effort, mark & recapture
Skunks	Spring, Summer, Fall	Scent post Nightlighting counts
Family Canidae Red Fox	Spring, Summer, Fall	Scent post Aerial counts/photos Ground Survey (Dens, tracks, scats)

Family Procyonidae Racoons	Spring, Summer, Fall	Bank walks — locate dens Nightlighting
4) Non-game mammals Orders Rodentia, Insectivora	Spring, Summer, Fall	Live trapping/grid system—with mark and recapture (Birney et al., 1976; French et al., 1976; Grant and Birney, 1979)
5) Cold-blooded vertebrates		
a) Amphibians Toads and Frogs	Spring, Summer, Fall	Trap netting—catch/unit effort (adult and tadpole) Mark and recapture—nightlighting/netting
Salamanders	Spring, Summer, Fall	Trap netting—catch/unit effort (adult and larval) Searches—density/area (Jaeger, 1980) Mark and recapture—nightlighting/grabbing
b) Reptiles Turtles	Spring, Summer, Fall	Mark and recapture—fyke nets (Vogt, 1980) Trap netting—catch/unit effort
Snakes	Spring, Summer, Fall	Trap netting (wire mesh) — catch/unit effort
c) Fishes Class Osteichthyes	Spring, Summer, Fall	Trap netting—catch/unit effort
6) Invertebrates		
a) Phylum Mollusca Classes Gastropoda, Bivalvia	Year round	Water column samples (Swanson, 1978b) Benthic samples—Ekman dredge, core sampler (Swanson, 1978c) (Benthic densities estimated via transect methods (Parker, 1979)
b) Phylum Arthropoda Class Insecta	Year round	Water column samples Benthic samples—Ekman dredge, core sampler
	Spring, Summer, Fall	Littoral zone traps (Swanson, 1978a) Net sweeps/light traps
Class Crustacea	Year round	Water column samples Benthic samples—Ekman dredge, core sampler
	Spring, Summer, Fall	Littoral zone traps

SOURCE: Besser, S. V. 1980. "Proposed Survey/Census Techniques." Page 25-27 in J. J. Peterka, "Census of Economically Important Fauna of Three Prairie Pothole Wetlands in South-central North Dakota," A Reseach Proposal, Department of Zoology, North Dakota State University, Fargo.

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The results of this census confirm the impressive number of coots wintering in the Mediterranean area. The author found that, where hunting pressure was heavy, wetlands, even those where the habitat was very good, supported a negligible number of waterfowl. He proposes that a waterfowl refuge system be established. He believes that lake Transimeno, the largest lake of Central and South Italy, almost 30,000 hectares, could easily become of international importance for species other than coot. The destruction and deterioration of wetlands must be brought to a stop. (In Italian with English summary.)

Anderson, D. R. and F. A. Glover. 1967. Effects of water manipulation on waterfowl production and habitat. Trans. N. Am. Wildl. Nat. Resour. Conf. 32:292-300.

This study was designed to: (1) determine the number of breeding birds, nesting ecology, brood size, total production, and the relationships between these factors for all important species of waterfowl, (2) record the progress of vegetation change on the study areas and its relationship to waterfowl production and ecology, and (3) understand the economic factors between the two areas.

The experimental area upon which water was applied early produced nearly three times as many ducklings per acre as the control area over a two year period. Flood-irrigation on the study areas apparently tended to replace low-growing saltgrass communities with sedges, rushes, and other plant species that provided more desirable nesting habitat for waterfowl. It was believed that the increased production resulted from the early water rather than the changes in vegetation.

Anderson, D. R., J. L. Laake, B. R. Crain, and K. P. Burnham. 1979. Guidelines for line transect sampling of biological populations. J. Wildl. Manage. 43:70-78.

The major advantage of the line transect sampling scheme is the relative ease of its implementation in the field once a proper design has been chosen. The problems encountered in the field are two-fold and interrelated: (1) defining the straight-line of travel, and maintaining it; (2) obtaining accurate measurements of distances and angles.

Conduct the survey in such a way as to maximize the probability that all objects on the centerline are found and be able to determine accurately the centerline of the transect once an object is found.

Survey design: transects should not be laid out too close together; lines should be spaced far enough apart that no object can be seen from more than one line. This will ensure statistical independence of distant line segments.

Anderson, M. G. and J. B. Low. 1976. Use of sago pondweed by waterfowl on the Delta Marsh, Manitoba. J. Wildl. Manage. 40:233-242.

Periodic sampling of sago pondweed (Potamogeton pectinatus) in exclosures and plots open to waterfowl activity on the Delta Marsh, Manitoba, indicated an average utilization of 60.5 g/m^2 (40.4 per cent of peak standing crop) foliage and 26.3 g/m^2 (42.9 per cent) tubers between July, 1973 and June, 1974. Intensity of use varied greatly among plots. Mallards (Anas platyrhunchos), canvasbacks (Aythya valisneria), and coots (Fulica americana) were the most commonly observed species on the study plots.

A surplus of submerged aquatic plant food evidently existed on the Delta Marsh at observed waterfowl population levels. However, heavy utilization of certain plots in 1973 resulted in a relative decrease (open vs. control plots) in the 1974 midsummer standing crops of those stands. It seems likely that heavy use of a single stand over several consecutive seasons might result in decreased plant production. Selection of more productive sites by feeding water fowl would eliminate such an effect.

Bailey, R. O. and B. D. J. Batt. 1974. Hierarchy of waterfowl feeding with whistling swans. Auk 91:488-493.

Swans did not appear to benefit from associations with ducks. Swans attracted ducks from the vicinity but there was little evidence that they were drawn to water bodies occupied by other waterfowl. Advantages of this behavior were more apparent for the ducks. Primarily the swans provided a readily gathered source of food.

The authors believe that interspecific dominance in the feeding zone was dependent upon mean body weight of each species.

Baldwin J. H. 1977. A comparative study of the sandhill crane subspecies. Pages 266-275 in C. B. Dewitt and E. Soloway (eds.), Wetlands ecology, values, and impacts: proceedings of the Waubesa Conference on Wetlands, Institute for Environmental Studies, University of Wisconsin-Madison.

This study defines and compares variation in the anatomy, physiology, and development of four of the six sandhill crane subspecies. Eggs from four of the subspecies: canadensis (Alaska), rowani (Alberta), tabida (Wisconsin and Idaho), and pratensis (Florida) were collected and transported to the International Crane Foundation where the chicks were hatched and reared under identical conditions.

Generally speaking, the rate of development increased with increasing latitude of the breeding grounds. The chicks from higher latitudes were capable of flight at an earlier age. Appendages, except for the wings, were shorter at higher latitudes (Allen's Rule). Overall body size decreased with increasing latitudes (reversing Bergman's Rule) for the migratory subspecies. The three wetland subspecies, rowani, tabida, and pratensis, exhibited faster rates and emphasis for height, tarsus, culmen, and midtoe growth.

The subspecific variations defined in this study lend evidence that each is a unique genetic unit.

Barontek, J. C. and J. J. Hickey. 1969. Selective feeding by juvenile diving ducks in summer. Auk 86:443-457.

The foods eaten by 49 juvenile canvasbacks and redheads were compared with the availability and abundance of potential foods in five potholes near Minnedosa, Manitoba.

Animal material comprised 57 per cent of the potential foods in dredge samples taken through two summers and over 99 per cent in net samples. The kinds and quantities of foods varied markedly among the potholes as well as within potholes during the two summers. Amphipods were abundant in two ponds during the first summer but disappeared during the second. Fathead minnows appeared on one pond and were believed responsible for reducing the standing crop of zooplankton.

Of the food taken by juvenile canvasbacks and redheads, 96 and 43 per cent respectively consisted of animal material. Trichoptera larvae with cases were an important food of both species, and they were apparently consumed in a proportion greater than found in the environment. Cladocerans, copepods, and phantom midge larvae were abundant in potholes, but they were conspicuously absent from the foods found in ducks. The close similarity between foods in ducks and dredge samples vs. net samples was expected for those bottom-feeding birds.

Bergman, R. D. 1973. Use of southern boreal lakes by postbreeding canvasbacks and redheads. J. Wild. Manage. 37:160-170.

Concentrations of predominantly male canvasbacks (Aythya valisneria) and redheads (A. americana) were studied on large lakes in southwestern Manitoba during summer and fall of 1969 and 1970. Peak numbers of both species occurred during the staging periods of late summer and early fall. Two lakes contained extensive beds of pondweeds (Potamogeton spp.), especially P. pectinatus and P. richardsonii, which apparently attracted canvasbacks. Food habits data from 14 adult canvasbacks indicated that P. pectinatus tubers and Potamogeton spp. rootstalks were preferred foods. Large numbers of redheads were observed on several lakes, including two bays of Lake Winnipegosis. One bay was intensively studied and found to have an almost continuous bed of Chara sp. and more restricted distributions of Ruppia occidentalis and P. pectinatus. Redheads were widely distributed throughout the bay although certain areas with relatively high occurrences of R. occidentalis and P. pectinatus were used most consistently. Food contents of 15 adult male redheads were comprised predominantly of vegetative parts of these three submergents. Human disturbance of summer-molting pochards appears to adversely influence their selection of molting lakes.

Berstein, N. P. and E. B. McLean. 1980. Nesting of redwinged blackbirds in cattails and common reed grass in Mentor marsh. Ohio J. Sci. 80:14-19.

During summer 1976, a study of habitat selection by the red-winged blackbird, Agelaius phoeniceus, was conducted on Mentor Marsh, chosen because of its unique geologic and botanical history. A swamp forest prior to 1959, the area is now a marsh composed of Typha latifolia, T. angustifolia, and Phragmites australis. Preferences of A. phoeniceus for each of these plants were investigated and T. latifolia was significantly most chosen. Presumed advantages include rigidity, easy nest accessibility, and wide spacing to facilitate nest defense. Additional features of habitat selected, such as available perches, proximity of open water, and edge effect were investigated. If rapid succession of monodominant stands of P. australis continues at the present rate, the nesting redwinged blackbird population may decrease sharply.

Boesh, D. F. 1973. Classification and community structure of macrobenthos in the Hampton Roads Area, Virginia. Mar. Biol. 21:226-244.

Benthic Macrofauna was sampled by grab at 16 stations in Hampton Roads and the adjacent Elizabeth River, Virginia. Sampling sites and species

were grouped by a classification strategy which basically consisted of the Canberra metric dissimilarity-measure and flexible and group average clustering. The sites were grouped into "associations" on the mud, muddy sand, and sand-bottoms, and those in the Elizabeth River. Species groupings distinguished a few species most frequent at restricted to muddy-sand and sand or solely to sand sites, ubiquitous species, epifaunal species which were microhabitat-restricted, and seasonal species. An analysis of numerically dominant species in the different associations indicated the relative importance of ubiquitous species and seasonally abundant species. Community-structure statistics (species diversity, species richness and evenness) showed definite spatial and temporal patterns. Diversity was high at sand and muddy-sand sites and low at mud and Elizabeth River sites. This spatial pattern was predominantly one of species richness. The applicability of "community concepts," the causes of substrate specificity, seasonality and species diversity, and the effects of pollution on community structure are discussed.

Brewster, D. A. and J. R. Caldwell. 1974. Wetland habitat changes in Saskatchewan, Canada, 1975. Naturalist 25(4):18-21.

Factors influencing wetland drainage include the drought of the 1930's, the Saskatchewan Department of Agriculture which may authorize a "Flood-control" program, back-flood irrigation schemes, and road-building. Waterfowl are faced with habitat destruction from causes other than drainage. These include the common practice of burning the vegetation in and around wetlands and filling depressions with earth.

If current practices continue, the critical point will soon be reached. Three problems face wildlife managers: they must calculate the amount of habitat required to sustain present populations, determine what is available, and predict the annual rate of loss.

Brewster, W. G., J. M. Gates and L. D. Flake, 1976. Breeding waterfowl populations and their distribution in South Dakota. J. Wildl. Manage. 40:50-59.

Grounds counts and random sampling techniques were used to census breeding waterfowl populations in South Dakota in 1973 and 1974. The estimated total of breeding pairs was 1,067,500 in 1973 and 439,000 in 1974. Drought conditions occurred concurrent with the reduced 1974 populations. Blue-winged teal (Anas discors) was the major species, followed by mallard (A. platyrhyncos), pintail (A. acuta), and gadwall (A. strepera). Less than 5 per cent of the total breeding pairs were diving ducks (Aythini). Redhead (Aytha americana) was the primary diving duck species. Striking differences in densities of breeding pairs occurred among the major physiographic regions of the state. Waterfowl densities were highest in the glaciated eastern half of South Dakota, particularly in the northern periphery of the Coteau des Prairies and in the major portion of the Coteau du Missouri. Over 75 per cent of the diving ducks were located on the Coteau des Prairies. The nonglaciated western half of the state had relatively low waterfowl densities but contained 20.7 per cent of the total breeding pairs in 1973 and 30.8 per cent in 1974.

Burger, J. 1974. Breeding adaptations of Franklin's Gull (Larus pipixcan) to a marsh habitat. Anim. Behav. 22:521-569.

The behavior and ecology of Franklin's gull were studied at Agassiz National Wildlife Refuge in northwestern Minnesota to determine the adaptations of the species for nesting in marshes. Two factors seemed to be important in colony site selection: cattail dispersion pattern and cattail density. Nest site selection was dependent on aggression and visibility. The distance between nests was directly correlated with visibility.

The breeding chronology of Franklin's gull is compressed when compared to that of other gulls. Possible selection pressures affecting this synchrony are discussed. The behavior of the marsh-nesting Franklin's gull is compared with that of typical ground- and cliff-nesting gulls; the possibility that the ancestral gull may have been a marsh nester is discussed.

Burton, B. A., R. J. Hudson, and D. D. Bragg. 1979. Efficiency of utilization of bulrush rhizomes by lesser snow geese. J. Wildl. Manage. 43:728-735.

Metabolizable energy (ME) and rate of passage of the rhizomes of three-square bulrush (Scirpus americanus) were calculated from experimental trials with caged lesser snow geese (Anser c. caerulescens.) ME was 1.43 kcal/g. Mean digestibility of rhizomes was 28 per cent. The rate of passage of the rhizome diet did not vary with the amount of food contained in the gastrointestinal tract. Mean retention time was relatively constant at 120 minutes. The internal organ dimensions of 90 hunter-killed geese were collected from October to April. Analysis showed no age or sex related differences. Gizzard size, small intestine length, and dry matter capacity were shown to increase significantly as the year progressed. The mean gut capacity was 28.8 g dry matter

Cammen, L. M. 1979. The macro-infauna of a North Carolina salt marsh. Am. Midl. Nat. 102:244-253.

Monthly samples were taken of the macro-infauna in a Spartina alterniflora marsh near Beaufort, N.C. A total of 32 tasa were collected; 19 of these were polychaetes and five were amphipods. Abundance was greatest in late winter and early spring and least in summer and early autumn. Numbers of individuals ranged from 2,200 to 15,500/m^2, and biomass ranged from 1.3 to 6.1 g ash-free dry weight/m^2. Four taxa made up an average of 96 per cent of the individuals and 85 per cent of the biomass collected each month; these taxa were the polychaetes Nereis succinea, Streblospio benedicti, and the family Capitellidae, and the Oligochaeta. Annual production of the macro-infauna was estimated to be 5.9 g ash-free dry weight/m^2, similar to that found in other North Carolina salt marshes. Production values for salt-marsh infauna were comparable to those found for salt-marsh epifauna.

Cook, A. and C. F. Powers. 1958. Early biochemical changes in the soils and waters of artificially created marshes in New York. New York's Fish and Game J. 5:9-65.

Shallow-water environments were studied over a 2-year period in six artificially-created marshes.

Marshes surrounded by good agricultural soils were more productive of food and cover plants than those surrounded by degraded lands. Soil analysis, except for certain of the trace elements, indicated that soils of marsh basins were more fertile, per se, than those of the continuous drainage areas. Excessive concentrations of soluble iron and manganese were noted. Strong thermal and chemical stratification was also noted.

Methods: To minimize sampling disturbances, soil samples were frozen immediately after being obtained. A plastic liner inside the coring device was used to collect the soil. Samples were analyzed for percentage of organic matter, pH, phosphorus, nitrate and ammonia nitrogen, calcium, magnesium, potassium, manganese, iron, and aluminum.

Denno, R. F. 1978. The optimum population strategy for planthoppers (Homoptera: Delphacidae) in stable marsh habitats. Can. Entomol. 110:135-142

The wing-morph composition of populations of planthoppers exploiting stable and temporarily uncertain resources was determined. In stable habitats like salt and fresh water marshes, the optimum population strategy of most planthoppers is to produce flightless brachypters which can efficiently use and remain on the immediate resource. Macropters, which can fly, are more adaptive and predominate in temporary habitats because they can emigrate and colonize new resources when conditions are no longer suitable.

Dirschl, H. J. 1969. Foods of lesser scaup and blue-winged teal in the Saskatchewan River Delta. J. Wildl. Manage. 33:77-87.

The food habits of adult lesser scaup (Aythya affinis) and blue-winged teal (Anas discors) were compared through analysis of monthly samples of gullet contents in an area of typical breeding in the Saskatchewan River Delta. Lesser scaup consumed an average of 66 per cent animal food and 34 per cent plant food whereas blue-winged teal used animal and plant foods in nearly equal amounts. Significant changes in the proportions of plant and animal foods occurred between months; they appeared to be correlated with changing abundance of food items. Major foods of lesser scaup were invertebrates and aquatic seeds abundant throughout the shallow eutrophic lakes of the Delta. Main foods of blue-winged teal were snails and seeds of emergent and other marsh plants associated chiefly with the lake shorelines. These differences in the diets reduce competition between the two species and contribute to their ecological separation within the habitat. Water levels constantly held high to increase duck nesting success will not diminish the food supply for scaup but, in the long run, will be detrimental to the food supply for teal

Downing, J. D. 1977. A comparison of the distribution of Aedes canadensis larvae within woodland pools using the cylindrical sampler and the standard pint dipper. Mosquito News 37:362-366.

Aedes canadensis (Theobald) were sampled in New Jersey pools over a 3-week period during the spring of 1976 to determine larval distribution. Replicate pools were divided into 3 concentric zones based on depth, and collections were taken with a cylindrical sampler and a standard pint dipper in each zone up to 14" deep. An analysis of variance on the data showed significant differences in distribution of larvae between the two sampling techniques. The cylindrical sampler data showed that Ae. canadensis larvae were equally distributed throughout the pools. Dipping collected the most larvae from the shallower zones of the pool and did not adequately sample the larval population in the deeper zones.

Duebbert, H. F. 1974. Nesting cover: a critical need for prairie ducks. Naturalist 25(4):25-27.

Quality of nesting cover has an important influence on nest site selection and hatching success of prairie ducks. During egg laying and incubation breeding hens of most species are closely associated with nest sites on land. Against current economic pressures on land the maintenance of adequate wetland and upland habitat to sustain a desirable waterfowl population presents a big challenge.

Present land use trends in the prairie pothole region indicate continued destruction and degradation of waterfowl production habitats. Fortunately, some habitats have been preserved by Federal, State, and private programs. Sound management plans are needed for implementation on private lands. Researchers, land managers, and administrators in key decision-making positions must work together to formulate practical programs to benefit the production of ducks. Prairie waterfowl are capable of high rates of reproduction if man provides the right environmental condition.

Duebbert, H. F. 1966. Island nesting of the gadwall in North Dakota. Wilson Bulletin 78:12-25.

An island nesting gadwall population was studied during 1955 and 1957 at the Lower Souris National Wildlife Refuge in North Dakota. This 7-acre natural island supported extremely high nest densities in both 1956 (78 nests) and 1957 (121 nests). Vegetation supporting the highest density of nests (80 per cent of all nests) was nettle (Urtica procera) and Canada thistle (Cirsium arvense). The island was separated from the nearest mainland by 2,000 feet of open water.

As the number of nesting pairs increased on the island to approximately 100, island home ranges appeared to break down and most of the pairs had at least part of their daily range up to 3 miles from the island. The intolerance between pairs seemed to have both sexual and topographic significance. Although there was much aggression between pairs, this did not prevent normal and highly successful completion of their individual reproductive cycles.

Nesting success for the 70 nests studied in 1956 was 85.7 per cent and for the 109 nests studied in 1957, 92.7 percent. The average clutch size of incubated clutches was 9.5 in 1956 and 9.7 in 1957.

In the 3 years following completion of this study, an interaction of low water levels and mammalian predation prevented the formation of high nesting densities on this island.

Edmondson, W. T. and G. G. Winberg, 1971. A manual on methods for the assessment of secondary productivity in freshwaters. IBP Handbook No. 17, Blackwell Scientific Publications, Ltd., Oxford. 358 p.

This handbook was issued by Section PF (Production

Freshwaters) of the IBP. Contents were derived from a working meeting held in Liblice, Czechoslovakia, 3-8 April, 1967. General headings include: (1) methods of collection, (2) methods of processing samples and developing data, (3) direct measurements of rates, (4) sampling and statistics, (5) the experimental field approach to secondary production, (6) laboratory measurements of processes involved in secondary production, and (7) methods for calculating productivity.

Erman, D. C. 1973. Invertebrate movements and some diel and seasonal changes in a Sierra Nevada peatland. Oikos 24:85-93.

The objectives of this study were to measure diel and seasonal changes in oxygen saturation, water temperature, water level, and aerobic limit in a Sierra Nevada peatland, and to study invertebrate migration in response to the diel changes. O_2 saturation, determined with an oxygen electrode at 2 cm, varied from a mid-afternoon minimum (35-44 per cent) to a maximum before sunrise (83-96 per cent), especially in July and August. This finding has not been previously reported for peatlands.

Aerobic limit was determined from redwood stakes that were stained when O_2 is absent. Minimum aerobic limit occurred in July (4.8 cm $\pm$ 0.43 cm) and maximum (18.8 cm $\pm$ 1.48 cm) occurred in November. The seasonal change in aerobic limit was not related to water level since the water table was at the surface each day.

Dipterans (Chironomidae and Heleidae) extracted from the peat showed no change in vertical distribution over a 24-hour period. But obligochaetes appeared to have a diel migration. Oligochaete vertical distribution was negatively correlated with surface water temperature ($r = -0.90$).

Fish, D. and D. W. Hall. 1978. Succession and stratification of aquatic insects inhabiting the leaves of the insectivorous pitcher plant, **Sarracenia purpurea**. Am. Midl. Nat. 99:172-183.

Greenhouse experiments and field collections were used in investigating the ecological relationships of three species of Diptera, **Blaesoxipha fletcheri** (Aldrich) (Sarcophagidae), **Wyeomyia smithii** (Coguillett), (Culicidae) and **Metriocnemus knabi** Coquillett (Chironomidae), which inhabit the digestive fluid of the pitcher plant. Only newly opened leaves actively attract and capture insects. As the leaves age, the insect victims slowly decompose and the leaf fluid pH is lowered. Since the leaves of the pitcher plant are of different ages, each leaf differs in its ability to capture insects and in the degree of decomposition of its captured insects. The relative abundance of the insect inhabitants of a leaf depends on the leaf age because each insect species consumes captured insect remains at different stages of decomposition. The bouyant larvae of **B. fletcheri** feed upon newly captured insects floating upon the surface. As the victims decompose, free-swimming **W. smithii** larvae filter-feed upon the suspended particulate matter. Accumulated insect remains on the bottom of the leaf chamber provide food for **M. knabi**. Although all three species feed upon the remains of captured insects, they do so at different times and at different strate within the leaves.

Fowler, D. K. and B. S. McGinnes. 1973. A circular plot method of censusing post-breeding bird populations. Southeast Assoc. of Fish and Game Commissioners 27:237-243.

A circular plot method of censusing nongame birds on southern Appalachian forest recreation areas was devised and tested. Plot boundaries were de-defined with a range finder. Accuracy of the method was affected by the variability inherent in wild bird populations, rain and wind, dense vegetation, and complexity of the late summer period. Data are presented indicating significant differences in evening and morning bird activity and a significant within season decline in late summer bird population estimates. The census method used was judged satisfactory for a post -breeding bird census.

Methods included the use of 12 circular plots, 75 feet in radius, for population estimates. The center of each plot was marked with an 8-foot range pole and a 6-inch range finder was used to verify the imaginary plot boundaries. The average number of birds observed on the 12 plots during 10-minutes counting periods constituted one complete estimate. Bird density was calculated by dividing the percentage of an acre which a plot comprised into the mean number of birds per plot and multiplying this figure by 100 to given birds per acre for that particular count. The plots were systematically located along a compass bearing.

Fritzell, E. K. 1978. Habitat use by prairie racoons during the waterfowl breeding season. J. Wild. Manage. 42:118-127.

Raccoons were live trapped. Each animal was then anesthetized with phencyclidine hydrochloride (Seal and Erickson 1969). Numbered ear tags and a radio transmitter (Mech et al. 1965) were attached to each animal. Ages were determined by tooth wear (Grau et al. 1970) and visible reproductive characteristics (Sanderson 1950, 1961). Radial and ulnar ephiphyses of several animals that later died were x-rayed to confirm field age determinations (Sanderson 1961).

Multiple comparisons among sex-age groups and among months within groups were made by the Fisher significant difference procedure as suggested by Carmer and Swanson (1973).

Fritzell E. K. 1975. Effects of agricultural burning on nesting waterfowl. Can. Field-Nat. 89:21-27.

Agricultural burning in an intensively farmed region within Manitoba's pothole district is shown to affect the nesting activities of groundnesting ducks. All species, except blue-winged teal (Anas discors) preferred unburned nest cover, although success was higher in burned areas, where predators may have exerted less influence. Attitudes of farmers, burning chronology, and nest destruction by fires are also reported.

Gibbans, J. W. 1970. Terrestrial activity an the population dynamics of aquatic turtles. Am. Mid. Nat. 83:404-414.

A method of measuring terrestrial activity in aquatic turtles is presented. The importance of this activity is indicated in considering some aspects of the population ecology of the species involved. Based on captures in terrestrial pitfall traps, up to

30 per cent of the turtles inhabiting Carolina bay in South Carolina traveled onto land during an eight-month period of study. This suggests that terrestrial activity may be very important in the population dynamics of aquatic turtles. The trapping method revealed a directional trend in emigrating individuals and a random movement by immigrants. Individuals of at least four species moved back and forth between contiguous aquatic areas. Terrestrial activity could not be correlated consistently with any single environmental factor. Initial activity in spring and cessation in autumn are presumably influenced by temperature. Rainfall apparently provoked terrestrial movement in autumn but not during other parts of the year.

Gollup, J. B. 1974. Waterfowl and wetlands research of the future. Naturalist 25(4): 28-31.

Clear-cut policies and goals are necessary for intelligent management. Among the first of these, according to the author, should be a national land use policy for Canada and the United States. A basic ingredient should be a detailed inventory of the number, size, and type of wetlands by region. Various forms of leasing have been used in both Canada and the United States but economically feasible incentives for private landowners will be required if significant amounts of duck production habitat are to be maintained.

Research will have to detemine how many different uses for each bird there are; how many participants there will be in each; how they are distributed, and what does pleasure or satisfaction mean to different groups.

Gough, S. B. 1977. The growth of selected desmid (Desmidiales, Chlorophyta) taxa at different calcium and pH levels. Am. J. Bot. 64-1297-1299.

The growth of clonal isolates of **Closterium moniliferum** and **Cosmarium granatum** from hard waters and **Triploceras gracile** from an acid bog was examined at two different levels of calcium and pH. Low pH and low calcium favored the growth of **Triploceras**, whereas Closterium grew equally well at both calcium levels but preferred the higher pH. **Cosmarium** favored both high pH and a high calcium concentration. Each taxon was affected by an interaction of the parameters on the growth rates. The results from studies on these taxa do not completely support the generalizations generated by previous investigations on the chemical factors affecting the growth and distribution of desmids; the controlling influences may, therefore, involve a complex interaction of factors which are unique for individual taxa or groups of taxa.

Grinnell, F. and A.G. Smith. 1972. Pothole community management for livestock and wildlife in the intermountain region. J. Range Manage. 25:237-240.

Potholes are depressions of glacial origin occurring on the prairies of northern United States and in some of the intermountain glaciated valley. Intermountain potholes provide excellent wetland habitat for numerous species of migratory waterfowl, waders, game and nongame march associated birds. Most of the intermountain pothole areas are located on public lands and are important sources of water for grazing livestock. Grazing is a land use compatible with wildlife needs if ranges are not overgrazed or livestock concentrated around available watering sites. This study was made with the intent of presenting a management plan whereby wildlife and livestock could jointly occupy these pothole areas of the forest lands of the northern Intermountain Forest Region to the benefit of both. Ecological stability rather than environmental competition was the goal with application over wide areas of the intermountain west. The study identifies opportunities in designing range developments to complement waterfowl and other species of wildlife on glacial terrain.

Hammar, D. A. 1969. Parameters of a marsh snapping turtle population, LaCreek Refuge, South Dakota. J. Wildl. Manage. 33:995-1005.

Recapture of snapping turtles **(Chelydra serpentain)**, marked by attaching metal tags to a marginal shield, showed that movement occurred primarily within a single marsh unit. Mean distance moved between recaptures was 0.57 miles. Capture-recapture methods yielded an estimate of 2,145 adults or 1 per 2 acres. Predators destroyed 59 per cent in undisturbed nests. Inmigration contributed more to population maintenance and growth than did reproduction on the refuge. Annuli in bony structures may be useful to age turtles. Data from recaptures, captives, and annuli evaluations suggested individual growth follows a sigmoid curve.

Hanson, R.C. and A.S. Hawkins. 1974. Counting ducks and duck-ponds in prairie Canada: how and why. Naturalist 25(4):8-11

The annual nesting group inventory of waterfowl is the most extensive survey of wildlife populations ever conceived. The U.S. Fish and Wildlife Service coordinates the survey and provides much of the personnel and equipment. Waterfowl managers need this information to know how much breeding stock is on hand and the anticipated size of the duck crop. Hunting regulations are designed to remove only the surplus, but the surplus cannot be determined without first knowing the size of the population itself, information gained only through a major survey.

Harmon, K.W. 1970. Prairie potholes. Nat. Parks and Conservation Mag. 45(3):25-28.

A brief history of pothole information is given. Three million acres of prairie wetlands were estimated in 1968 for the Dakotas and Minnesota. Prairie potholes which contain only 10 per cent of the available duck nesting habitat in North America produce 50 per cent of the ducks in North America in an average year.

The article decrys the problem of wetland drainage and concludes that if people want wetlands and wildlife to remain a part of the prairie landscape, they will have to help pay for keeping these wetlands that usually provide no immediate income for the landowner.

Harris, S.W. 1954. An ecological study of the waterfowl of the potholes area, Grant County, Washington. Am. Midl. Nat. 52:403-432.

The vegetation of the potholes areas was arranged in zones along a moisture gradient. These zones

from dry to wet were: (1) no vegetation on high, dry, shifting sand dunes; (2) Psoralea on the windward faces of lower shifting dunes with sand dock and willows on the leeward faces; (3) saltgrass-Nevada clubrush meadows; (4) Baltic rush-sedge meadows; (5) bulrush-cattail; and (6) submerged aquatic plants.

The potholes area as a waterfowl winter range was acceptable to those species which are adapted to its winter climate, the mallard being the most abundant winter resident.

Permanent and temporary potholes (800-1,000), flooded flats, and creeks were used as territorial sites. Nesting sites depended upon available cover, wild rye grass, **Juncus**, and bulrushes being primarily used. Nearly two-thirds of all nests were within 30 feet of water. Six major cover types used by broods, in order of importance, were **Scirpus acutus, Juncus balticus**, open water, **Typha Latifolia, Scirpus americanus**, and **Salix** Nest predation by coyote, destruction of cover by cattle, and high breeding populations of coots were some apparent factors serving to limit duck populations in making nesting and brooding areas less desirable.

Have, M.R. 1973. Effects of migratory waterfowl on water quality at the Montezuma National Wildlife Refuge Seneca County, New York. U.S. Geol. Surv. Res. 1:725-734.

This study was done in response to the shellfish industry's concern that bacteria in effluent from the national wildlife refuges along the northeast coast of the United States may be adversely affecting the harvest of shellfish. A line graph shows inconsistent relationships between bird population at the Montezuma refuge and total coliform, fecal coliform, and fecal **Streptococci** counts. **Salmonella** were found in only one of the 17 samples of water taken within the refuge. Counts on nonpathogenic bacteria in the two major streams flowing into the refuge, Black Brook and White Brook, were greater than they were in water flowing out of the refuge. Specific conductance of water flowing out of the refuge was less than that of water flowing into the refuge, although the effluent had higher concentrations of phosphorus and nitrogen than the influent. A settling-pond effect in the quiet water of the refuge may help explain the improvement in the quality of water leaving the refuge. The study shows how its quality changes both chemically and biologically as water flows through the refuge. Further study is needed to determine the effects that a similar effluent would have on a coastal habitat of shellfish.

Hines, J.E. 1977. Nesting and brood ecology of lesser scaup at Waterhen Marsh, Saskatchewan, Can. Field-Nat. 91:248-255.

The nesting and brood ecology of the lesser scaup (**Aytha affinis**) was observed at Waterhen Marsh in central Saskatchewan. Most scaup nests were initiated during the first two weeks of June and the peak of hatching occurred during the middle two weeks of July. The mean clutch size was $9.70 \pm SE$ 0.21 ($N = 56$); if clutches of 13 and 14 are ommited, the mean becomes 9.47 ± 0.18 ($N = 53$). Several incidents of egg parasitism involving scaup were noted. Insular, well-concealed nest sites featuring plants (especially grasses) in the 21- to 60-cm height range were often selected. Twenty-eight (76 per cent) of 37 nests were successful. Striped skunks (**Mephitis mephitis**) and common crows (**Corvus brachyrhyncos**) caused most of the nesting failures. The high social tolerances exhibited by brooding scaup and the concentration of broods in areas of suitable habitat resulted in the formation of mixed broods. Redhead (**Aythya americana**) ducklings frequently joined these broods. Possible advantages of this creching are discussed.

Hoffman, R.H. 1970. Waterfowl utilization of ponds blasted at Delta, Manitoba. J. Wildl. Manage. 34:586-593.

Waterfowl use of 25 ponds blasted in Manitoba's Delta Marsh was studied from 1965-66. Greatest use of the ponds occurred during spring and early summer. In comparison to surrounding wetlands, there were greater fluctuations in annual abundance, less species diversity, and more breeding pairs per unit of shoreline on the ponds. Ducks stayed on the ponds a mean of 15.6 minutes per visit; 86 per cent of their time was spent on elevated soil. Blue-winged teal (**Anas discors**) comprised 56 per cent of the waterfowl counted. These ponds seemingly functioned as isolation and loafing areas for breeding pairs of dabbling ducks.

Hynes, H.B.N. and M.J. Coleman. 1968. A simple method of assessing the annual production of stream benthos. Limnol. Oceanogr. 13:569-573.

It is possible to calculate the annual production of stream benthic animals from data obtained from a series of good quantitative samples collected at intervals during the year. The method is explained and its limitations and shortcomings discussed. This seems at present to be the only simple and direct method of estimating production.

Joyner, D. E. 1978. Use of an old-field habitat by bobolinks and red-winged blackbirds. Can. Field-Nat. 92:383-386.

The habitat preferences of bobolinks (**Dolichonyx oryzivorus**) and red-winged blackbirds (**Agelaius phoeniceus**) nesting in a 15.4-ha field on the Luther Marsh Wildlife Management Area, Ontario were determined during 20 May - 30 June, 1977. Eight blackbird and 10 bobolink nests were found during the 6-week period. Red-winged blackbirds nested exclusively on monotypic stands of **Phalaris arundinacea** (Reed Canary-grass) which comprised less than 20 per cent of the 15.4 ha field. Blackbirds preferred nesting cover that (1) was close to water, (2) matured relatively early in the season, and (3) had the structural strength to support their nests. Bobolinks, in contrast, avoided **P. arundinacea** and used residual grasses and weeds for nest construction and cover. No definable relationship could be found between bobolink nesting behavior and the living vegetation in the field.

Jolly, G.M. 1965. Explicit estimates from capture-recapture data with both death and inmigration-stochastic model. Biometrika, 52:225-247.

The first purpose of this paper is to derive a general probability distraction designed to fit the majority of capture-recapture problems involving a "single" population. The word single denotes a population

covering an area within whose boundaries the animals are free to move and to mix with others of their kind, but which is regarded as a single area in respect of which parameters are to be estimated. A single population need not be homogeneous but may consist of different classes of animals behaving in different ways.

The second purpose is to show that extremely simple estimates of the parameters exist for a homogenous population subject to both death and inmigration.

Joyner, D.E. 1976. Effects of interspecific nest parasitism by redheads and ruddy ducks. J. Wildl. Manage. 40:33-38.

Of 809 duck nests found at Farmington Bay Waterfowl Management Area, Farmington, Utah, 290 were parasitized interspecifically, 264 by redheads (Aythya americana) and 62 by ruddy ducks (Oxyura jamaicensis). Pintail (Anas acuta) and cinnamon teal A. cyanoptera) nests most frequently incurred redhead parasitism, whereas cinnamon teal and redhead nests were most often parasitized by ruddy ducks. Mallard (A. platyrhynchos), pintail, and cinnamon teal nests parasitized interspecifically by ruddy ducks and redheads had significantly reduced ($P < 0.05$) egg successes. Egg success of cinnamon teal was significantly reduced ($P < 0.05$) through host egg displacement, primarily as a result of redhead parasitism. Egg displacement resulting from interspecific parasitism had a negligible effect on mallard, pintail, and redhead egg success. Redhead and ruddy duck interspecific parasitism did not decrease significantly ($P > 0.05$) host nesting success by increasing the occurrence of nest abandonment and nest predation.

Kantrud, H. A. and R. E. Stewart. 1977. Use of natural basin wetlands by breeding waterfowl in North Dakota, J. Wildl. Manage. 41:243-253.

Use of basin wetlands by breeding populations of 12 species of waterfowl was investigated in 1965 and during 1967-69 throughout the prairie pothole region of North Dakota. Data were obtained primarily by random sampling techniques. Of the total population occupying natural basin wetlands, 55 per cent occupied seasonal and 36 per cent occupied semipermanent wetlands. Seasonal wetlands contained 60 per cent of the population of dabbling ducks while semipermanent wetlands supported 75 per cent of the population of diving ducks. The proportion of basins that retained ponded water had a direct bearing on the value of each type of wetland to breeding waterfowl. Relative values of the more intermittant types of wetlands are greatly increased during years of ample precipitation.

Kempton, R. A. 1979. The structure of species abundance and measurement of diversity. Biometrics 35:307-322.

The structure of species abundance at a site may provide a better characterization of the environment than the list of named species. A diversity index is an attempt to give a one-dimensional description of this structure. Diversity measures which are based primarily on the pattern of abundance of those species with medium abundance and give undue emphasis to neither the very common or rare species found to be most consistent over years at the same site and give the greatest discrimination between sites. Different diversity indices may be given inconsistent orderings of a group of communities. A partial ordering on intrinsic diversity can, however, be defined for which all measures will give consistent results. Adopting a parametric distribution to describe the species frequencies allows efficient standardization for differences in sample size. If the log-series provides a good fit to all the communities under comparison, the ordering on intrinsic diversity is complete and given by the parameter x. Comparison is made between the species abundance distribution observed from a transect sample of forest trees when abundance is measured by the total number of individuals representing the species and by a measure of total biomass.

Kirsch, L. M. 1969. Waterfowl in relation to grazing. J. Wildl. Manage. 33:821-828.

A 4-year production study of upland nesting waterfowl on the Missouri Coteau area of North Dakota showed that pair numbers, nesting densities, and nest success were generally reduced by grazing. It is suggested that cover removal such as regular grazing and mowing be discontinued on acres managed primarily for waterfowl production and that management practices which create dense rank cover be substituted.

Klett, A. T. and L. M. Kirsch. 1976. Diurnal use of small wetlands by ducks. J. Wildl. Manage. 40:351-353.

Peak use of small Class 3 wetlands by blue-winged teal occurred in the early morning and evening, especially during the period when most of the birds were observed as segregated pairs. The data also suggested that differences in the diurnal distribution of some other dabbler species among various habitat types would be detected with a larger sample of observations.

The observations conclude that the present widely divergent views on pond use and pond occupancy are probably the result of varying sampling methods utilized by workers.

Krapu, G. L. 1974. Feeding ecology of pintail hens during reproduction. Auk 91:278-290.

Feeding ecology of breeding pintail hens was studied during a 3-year period in east central North Dakota. Invertebrates formed 56 per cent and 77 per cent of the diet of hens collected during follicle development and laying, respectively, but only 29 per cent during post-laying. Fairy shrimp, dipteran larvae, snails, and earthworms accounted for 95 per cent of the animal portion of the diet of 31 laying hens. Wheat and barnyard grass were the dominant food items in the diet of post-laying hens. Throughout the breeding season, pintails foraged primarily in detritus and sediments of shallow wetlands but occasionally fed at the water surface. Foraging occurs primarily on wetland habitats that characteristically undergo drying during summer and fall. Availability of the invertebrate foods consumed by pintail hens, therefore varies widely from year to year, depending on the extent of early spring flooding of shallow wetlands.

Breeding hens arrived with large subcutaneous and visceral fat reserves which were mostly depleted during the early nesting attempts. Loss of fat reserves increased the dependency of renesting hens on an available food source during the egg-laying period.

Krull, J. N. 1970. Aquatic plant macroinvertebrate associations and waterfowl. J. Wildl. Manage. 34:707-718.

An ecological study was conducted to determine the association of macroinvertebrates with 12 species of submerged aquatic plants common in central New York. The abundance and kind of animals associated with each plant species, and with their substrates were determined. An Ekman dredge was used to obtain the samples, which totaled 543 for the plants and 181 for the combined plant-substrate samples. These were taken in the shallows of five aquatic areas during the period of April-October, 1966. A total of 114 different taxonomic categories of animals was collected. Some plants harbored a larger biomass, greater numbers, and a greater toxonomic diversity than other hydrophytes. Three plant species harbored nearly 60 per cent of the animal species found. Macroinvertebrates appeared to be many times more abundant in vegetated areas than in nonvegetated areas. On the average, one g of animal life was found associated with 100 g of plant material. Hydrophytes believed to be poor waterfowl food plants almost assuredly are indirectly important to waterfowl production because they harbor large quantities of macroinvertebrates which furnish a source of animal protein.

Lammers, R. 1977. Sampling insects with a wetland emergence trap: design and evaluation of the trap with preliminary results. Am. Midl. Nat. 97:381-389.

A wetland emergence trap was designed to sample insects along a transect through three wetland plant communities. These plant communities were defined by optimal agglomeration (Orloci, 1967) of stratified random quadrats.

Traps were placed randomly in each plant community. The emergence trap was designed as a truncated cone. It is 1 m tall, accommodating the maximum height of most of the vegetation. Nitex monofilament nylon cloth was used as screening material.

Insects rose to the top of the trap, entered a funnel through holes cut in the funnel's side, and eventually fell into the bottle, perhaps stunned by alcohol fumes in the closed top.

Lederer, R. J. 1978. Fluctuation of a marsh habitat and the reproductive strategy of the yellow-headed blackbird. Great Basin Nat. 39:85-88.

The yellow-headed blackbird (Xanthocephalus xanthocephalus) nests in marshes and is dependent on emergent vegetation for nest sites. Fluctuating water levels from year to year cause an increase or decrease in the amount of emergent vegetation and affect the time required for the vegetation to become suitable for nesting. Nests built in marshes are very susceptible to wind, rainfall, vegetation growth, and predation. Many nests are abandoned before being used and the mortality of eggs and young is high. The reproductive strategy of the yellow-headed blackbird has been selected for flexibility and opportunism to compensate for the unpredictability of the marsh situation.

Lokemoen, J. T. 1973. Waterfowl production on stock-watering ponds in the northern plains. J. Range Manage. 26:179-184.

In a five-year study of stock-watering ponds in western North Dakota, pond size was found to be the major factor influencing duck use. As pond size increased, total pair and brood use per pond increased. Pairs used ponds as small as 0.1 acre in size, but broods were seldom seen on ponds of less than 1.0 surface acre. Dam-type ponds larger than 1.0 surface acre comprised only 29 per cent of all man-made ponds on the study area but received 65 per cent of the pair use and 87 per cent of the brood use. Utilization of fenced ponds by pairs and broods was not significantly different from utilization of unfenced ponds. Grazing rates of two to three acres per AUM and lower rates permitted the development of grassy shoreline cover preferred by pairs and brushy and emergent shorelines preferred by broods. Duck pairs were significantly more numerous on older ponds that had heavy deposits of sediment or were isolated from other wetlands. Broods were significantly more numerous on ponds with brushy shorelines and emergent vegetation than on those without. Broods were less numerous on turbid and newly constructed ponds. The most suitable stock-watering units for maximum waterfowl production were dam-type ponds of 1.5 surface acres, or larger, built in gentle to rolling terrain away from major sources of siltation.

Macan, T. T. 1961. Factors that limit the range of freshwater animals. Biol. Rev. 36:151-198.

All species are probably limited to places that offer refuges from predators, unless they live in waters which, because they are temporary or offer extremes of some factor such as salinity, harbor few or no predators. Some ciliates and cladocerans are limited to places where a particular food is plentiful, but most animals have a wide range. Data relating to lethal, optimal, and preferred temperatures are reviewed in this paper.

Adaption to mixohaline (brackish) water by a freshwater organism involves toleration by the tissues of a fluctuating concentration in the body fluid and the ability to get rid of unwanted ions. Calcuim appears to be favorable for all the species of some groups, and the less there is the fewer the species. Some protozoa are the only animals known to be affected by the concentration of hydrogen and hydroxyl ions.

Mac Arthur, R. A. and M. Aleksiuk. 1979. Seasonal microenvironments of the muskrat (Ondatra zibethicus) in a northern marsh. J. Mammal. 60:146-154.

Seasonal changes in the microenvironment of Ondatra zibethicus in Delta Marsh, Manitoba, Canada, are described. In winter, well-insulated, closely spaced resting and feeding shelters provided an equable microclimate moderated by the presence of open water in plunge holes. Group occupation of lodges during winter resulted in chamber temperatures that average 20°C above external air temperature. Daily fluctuations in winter lodge temperature reflected activity patterns of resident animals.

In summer, high lodge temperatures (25° to 30°C) appeared to favor the use of burrows and open nests by adults. Burrows provided the coolest, most stable microclimate in summer, with temperatures ranging from 8.5 to 20.5°C, depending on soil depth.

Between November, 1973 and July, 1975, air temperatures in the marsh ranged from -39 to 34°C, while temperatures recorded from within shelters used by muskrats varied from -9 to 30°C. The range of mean temperatures (3° to 25°C) recorded from within occupied lodges and burrows during this period approximated the thermoneutral zone of this species. It is suggested that energy costs for thermoregulation are minimized through the construction and selective use of multiple shelters.

March, J. H., G. F. Marte, and R. A. Hunt. 1973. Breeding duck populations and habitat in Wisconsin. Wisconsin Department of Natural Resources Tech. Bull. No. 68.

Because of the need for up-to-date information on Wisconsin's breeding duck populations and habitat, a statewide survey was initiated in 1965. Subsequent surveys were run again in 1966, 1968, 1969 and 1970. Objectives of these five surveys were: (1) to provide reliable estimates of the size, distribution, and species composition of the duck populations breeding in Wisconsin from 1965 through 1970, (2) to inventory available habitat and determine occupancy of wetlands by breeding ducks, (3) to review sampling procedures in order to improve the results of future population censuses and habitat inventories.

This is a good publication on census methods.

Martien, R. F. and A. C. Benke. 1977. Distribution and production of two crustaceans in a wetland pond. Am. Midl. Nat. 98:162-175.

Annual production of the isopod, **Asellus obtuses**, and the amphipod, **Crangonyx gracilis** sp., in a small wetland pond in NW Georgia was estimated using the Hynes method. Both species were found in two distinct vegetation zones: a central **Cephalanthus occidentalis** zone and a marginal **Nyssa biflora** zone. Although growth in each species was relatively asynchronous, they each appeared to have one generation per year. Combined aufwuchs-benthos production in the Nyssa zone was 2.44 g/m^2 dry wt. for **Crangonyx** and 1.44 g/m^2 for **Asellus**,. Annual turnover ratios were 6.1 and 6.0 respectively Aufwuchs production in the **Cephalanthus** zone was 1.63 g/m^2 for **Crangonyx** and 0.65 g/m^2 for **Asellus**. Annual turnover ratios were 6.8 and 8.1, respectively. Benthos in Nyssa contributed by far the greatest crustacean production to this zone based upon standing stock values, but aufwuchs populations were the only significant source of production in the **Cephalanthus** zone.

Masters, M. J. 1971. The ecology of **Chytridium deltanum** and other fungus parasites on **Oocystis** spp. Can. J. Bot. 49:75-87.

Consideration of the population curves of **Oocystis crassa** and **O. lacustris** in Lake Manitoba during the summers of 1966 and 1967, and July, 1968, indicated that the aquatic fungus **Chytridium deltanum** was able in two instances to attack growing populations of these algae. This strongly suggested that the fungus was a parasite. However, in July 1965, in Cadham Bay, the fungus bloomed as the host population stopped growing and began to decline. Probably the host cells were slightly senescent at that time and thus, more susceptible to fungus attack. Consideration of the composition of the fungus population showed that during one epidemic at least, large numbers of zoospores were released every 7 to 9 days. This suggested a nearly synchronous development of the fungus population. It was also observed that zoospores, able to encyst and successfully infest one host, were sometimes unable to attack another potential host present at the same time. In 1966 and 1967 the fungus appeared a few days after the water had reached 25°C. Comparison of culture data for the algae and field studies indicated that **Chytridium deltanum** most commonly grew on the algae at temperatures above the optimum for the algae.

McColl, J. G. and J. Burger. 1976. Chemical inputs by a colony of Franklin's Gulls nesting in cattails. Am. Midl. Nat. 96:270-280.

Franklin's gulls nest at the Agassiz National Wildlife Refuge, northern Minnesota, after migrating from South America. Nutrient inputs by the gulls during 1971 were examined by comparison of water and sediment samples from two shallow pools. One pool was colonized by about 30,000 gulls nesting among cattails; the second pool contained cattails without a gull colony.

Large increases occurred in nitrogen and phosphorus concentrations of water in the immediate vicinity of the gull colony; peak concentrations were concomitant with the peak of gull nest-building and feeding activities (mid May and mid-July). About 36 per cent of the annual phosphorus input to the pool with the gull colony is attributable to the gulls.

However, there were no net changes in concentrations of nitrogen and phosphorus in water of either pool as a whole, i.e., nutrient concentration in inflow and outlet waters of both pools remained relatively constant throughout the year due to nutrient absorption by the pool sediments. The gull colony has little effect on the concentrations of sodium, potassium, calcium, and magnesium in the water. Outlet waters of both pools had higher potassium concentrations than inputs, due to release of potassium by the sediments to water, or by nutrient uptake by cattails and subsequent leaching of both living and dead cattails. The Refuge acts as a "sink" for nutrients in runoff from surrounding agricultural land.

Oetting, R. B. and J. F. Cassel. 1971. Waterfowl nesting on interstate highway right-of-way in North Dakota. J. Wildl. Manage. 35:774-781.

Six hundred and thirty acres of roadside were studied along 23 miles of Interstate 94 in Stutsman County, North Dakota to assess wildlife values of highway right-of-ways. The authors found 422 duck nests that had an overall success of 57 per cent in 1968, 1969, and 1970. Mammalian predators were responsible for 85 per cent of the destroyed nests.

To test the effect of mowing on duck nest initiation and success, alternate 1-mile blocks of the study area were not mowed in the fall of 1968. In 1969 and 1970, significantly more ducks chose unmowed vegetation in preference to mowed vegetation for nest sites. Mallards (Anas platyrhyncos), pintails (A. acuta), and gadwalls. (A . strepera) were especially responsive to unmowed vegetation. Success of duck nests in unmowed vegetation was 62 per cent compared with 51 per cent in mowed vegetation.

Sixteen per cent of the nests were unhatched by July 5, the beginning mowing date previously recommended by the North Dakota Highway Department. Wildlife killed by traffic did not increase when half the mile blocks were unmowed, and no significant difference was observed in build-up of snow between mowed and unmowed blocks in the winter of 1968-69. Of 182 motorists interviewed in the study area, 82 per cent had not noticed the unmowed rights-of-way. The authors strongly recommend no mowing of ditch bottoms or back slopes, minimal mowing of inslopes, and no mowing before July 20 to enhance waterfowl nesting and to reduce maintenance costs of highway rights-of-way in duck producing regions.

Owen, R. B. Jr. 1970. The bioenergetics of captive blue-winged teal under controlled and outdoor conditions. Condor 72:153-163.

The bioenergetics of caged blue-winged teal were studied under controlled and outdoor conditions with special emphasis on the effects of different variables on metabolism. Existence metabolism was different for males and females and was associated with the differences in weight of the two sexes.

Excretory energy varied curvilinearly and inversely with temperature, leveling off at temperatures below -20°C. This relationship was due to a drop in the amount of fecal material voided and to a decrease in the caloric value of the feces at these temperatures. Upper and lower lethal temperatures were not reached, but teal withstood ambient temperatures of -48° and + 50°C.

The caloric equivalent of a gram change in weight was 5.0 kcal/bird-day for indoor birds. For outdoor birds, the value varied between 2.9 and 7.0 with a yearly average of 5.3 kcal/bird-day.

Body weight, change in body weight, and molt correlated positively with metabolism. While temperature and photoperiod exhibited a negative correlation with metabolism. Changes in body weight were positively correlated with changes in available productive energy. Noctural activity increased sharply during premigratory periods.

Page, R. D. and J. F. Cassel. 1971. Waterfowl nesting on a railroad right-of-way in North Dakota. J. Wildl. Manage. 35:544-549.

A 21.5-mile section of the Northern Pacific Railway's main line right-of-way in the Missouri Coteau of North Dakota was studied to determine waterfowl production on both hayed and unhayed acreage. Overall nest success was 83 per cent. Nest densities were 9.6 nests per 100 acres on hayed areas and 55.6 nests per 100 acres on unhayed areas. The acres mowed for hay produced 0.64 duckling per acre, and the unmowed acres produced 3.93 ducklings for each acre. We suggest that for optimum waterfowl production, all annual cover removal be discontinued.

Picman, J. 1980. Impact of marsh wrens on reproductive strategy of red-winged blackbirds. Can. J. Zool. 58:337-350.

Marsh wrens destroy redwing eggs and young and are a major cause of redwing nesting mortality in a brackish water marsh in Delta, B.C. Redwing nesting success increases with distance of redwing nests from marsh wren nests. In spite of higher wren nest densities in 1977, wrens had a relatively smaller impact on redwing nesting success in 1977 than in 1976, when wren densities were lower.

Interference between redwings and marsh wrens has apparently evolved to reduce competition between these species through the spatial segregation of their nesting sites. As a consequence of different efficiencies of their interference mechanisms in vegetation of various densities, marsh wrens appear to be more successful in dense cattail whereas redwings are the more successful species in sparser vegetation.

Marsh wrens have an important effect on redwing reproductive strategy. Contiguous nesting by redwing females significantly reduces impact of wrens. Individuals failing to adopt this strategy have a negligible change of reproductive success. The hypothesis is proposed that marsh wrens may have influenced the evolution of a clumped pattern of nesting by redwings.

Pospahala, R. S., D. R. Anderson, and C. J. Henny. 1974. Population ecology of the mallard. II. Breeding habitat conditions, size of the breeding population, and productive indices. U.S. Fish Wildl. Serv. Resour. Publ. No. 115, Washington, D.C. 73 p.

This report provides information on mallard breeding habitat, the size and distribution of breeding populations, and indices to production. The information is primarily based on large-scale aerial surveys conducted during May and July, 1955-1973. The history of the conflict in resource utilization between agriculturalists and wildlife conservation interests in the primary waterfowl and breeding ground is reviewed. The numbers of ponds present during the breeding season and the midsummer period and the effects of precipitation and temperature on the number of ponds present are analyzed in detail. A decline and subsequent low level of the mallard breeding population between 1959 and 1969 generally coincided with a period of poor habitat conditions on the major breeding grounds. Spacing of birds in the "Prairie-Parkland Area" appeared to be a key factor in the density-dependent regulation of the population. Production indices in these northern areas appear to be a linear function of the size of the breeding population. Thus, the density and distribution of breeding ducks is probably regulated through a spacing mechanism that is at least partially dependent on measurable environmental factors.

Ruwaldt, J. J. Jr., L. D. Flake, and J. M. Gates. 1979. Waterfowl pair use of natural man-made wetlands in South Dakota. J. Wildl. Manage. 43:375-383.

Use of natural ponds and lakes, streams, stock ponds, and dugouts by pairs of waterfowl was examined in South Dakota in May and June 1973 and 1974. Densities of blue-winged teal (Anas discors), pintails (A. acuta), northern shovelers (A. clypeata), and green-winged teal (A. crecca) declined sharply on semi-permanent wetlands and stock ponds during the 1974 drought. Lack of water in ephemeral, temporary, and seasonal wetlands apparently decreased use of the remaining more permanent wetlands (natural or man-made) by these species.

Methods: Ground counts of waterfowl and wetlands were made in May and June on 476 quarter section plots throughout South Dakota Wetland numbers and hectares found on sample plots were expanded to provide estimates of total wetland numbers of hectares by major physiographic strata.

Schindler, D. W., A. S. Clark, and J. R. Gray. 1971. Seasonal calorific values of freshwater zooplankton as determined with a Phillipson Bomb calorimeter modified for small samples. J. Fish. Res. Board of Can. 28:559-564.

A modified temperature sensing circuit for Phillipson microbomb calorimeter allowed accurate calorific determinations on samples as small as 3 cal.

Calorific values of copepods from three lakes in eastern Ontario varied with species, developmental stage, lake, season, and year. No such differences were observed in calorific values for the few species of rotifers and caladocerans tested.

Similar calorific values were obtained for samples preserved by freezing, freeze-drying, and heat-drying, but preservation in formalin resulted in erroneously low calorific values.

Schroeder, L. D., D. R. Anderson, R. D. Pospahala, G. W. Robinson, and F. A. Glover. 1976. Effects of early water application on waterfowl production. J. Wildl. Manage. 40:227-232.

Records of nests and broods on the Monte Vista National Wildlife Refuge, Colorado, suggested that waterfowl production was high in years when water was available prior to spring migration. If sufficient water was not available until after spring migration, low production could be expected. To test this hypothesis, we divided a 241-ha habitat unit on the refuge into 2 plots; the experimental plot was flood-irrigated 2 weeks before the peak of spring waterfowl migration and the control plot was flood-irrigated 2 weeks after the peak migration. This treatment was applied alternately to the plots during two 3-year periods and one 2-year period. Numbers of nests and production of mallards (Anas platyrhynches), pintails (A. acuta), shovelers, (A. clypeata), teals (A. discors, A. crecca, and A. cyanoptera), and gadwalls (A. stepera) were significantly greater ($P < 0.05$) on one plot when early water was applied. The inability to draw down water levels sufficiently on the other plot was believed to be the reason duck production was not significantly greater on both plots during years of early water application. Economic and management implications are presented.

Seber, G. A. F. 1962. The multi-sample single recapture census. Biometrika. 49:339-350.

The purpose of this paper was to set up a capture-recapture method for estimating the population parameters for a population in which there is both "inmigration" (including birth) and "death" (including emigration).

Sellers, R. A. 1973. Mallard releases in under-stocked prairie pothole habitat. J. Wildl. Manage. 37:10-22.

In 1969 and 1970, 821 and 653 female mallard (Anas platyrhyncos ducklings of genetically wild stock were released to increase the breeding population and production in pothole habitat near Minnedosa, Manitoba. Of the ducklings liberated in 1969, approximately 25 per cent returned in 1970 to breed on or within 5 miles of the 4-square mile release area; and about 9 per cent again returned in 1971. An estimated 20 per cent of the ducklings released in 1970 homed to the Minnedosa region in 1971. The mallard density on the core of the release area increased from approximately 12 pairs per square mile in 1969 to 66 $\pm$ 5 pairs in 1971 (the highest density ever recorded near Minnedosa). The density and percentage of marked hens decreased with distance from the core of the release area. The poor production among released hens was apparently not due to high breeding density nor to their inexperience in nesting, but was probably caused by insufficient nesting cover and severe nest predation. The date of liberation had no influence on prefledging survival; but a greater percentage of ducklings liberated in August 1970, remained on the release area after the opening of hunting (21 September) than did ducklings liberated in June and July, 1970.

Serie, J. R. and G. A. Swanson. 1976. Feeding ecology of breeding gadwalls on saline wetlands. J. Wildl. Manage. 40:69-81.

The feeding ecology of breeding gadwalls (Anas strepera) from saline wetlands in North Dakota was examined in relation to sex, pair mates, reproductive status, food availability, and wetland type during the spring and summer of 1971 and 1972. Esophagi of males and females contained 40.4 and 48.2 per cent animal food, respectively, between 17 April and 25 August. Animal foods consumed by paired females varied with reproductive condition and were independent of their mates. Invertebrates increased from 47.7 = 17.4 per cent in the diet during prelaying to 72.0 $\pm$ 18.4 per cent during laying and declined to 46.3 $\pm$ 30.0 per cent during postlaying. Aquatic insects dominated the diet during egg-laying and were selected disproportionately relative to their availability. Esophageal contents indicated that diversity of plant and animal foods in the diet varied inversely with specific conductance. Major factors influencing food selection of the breeding birds are discussed as interactions among their physiological status, their anatomical and behavioral characteristics, and the abundance and behavior of food organisms as influenced by chemical and physical features of the environment. The data suggested that these interrelated ecological factors act simultaneously to control the phenology of events and determine the foods utilized.

Siegfried, W. R. 1973. Summer food and feeding of the ruddy duck in Manitoba. Can. J. Zool. 51:1293-1297.

The food and feeding habits of adult and juvenile

rudy ducks (Oxyura jamaicensis) in southwestern Manitoba were studied during June-August 1971. Animal material predominated in the diets of the birds. The basic diets of adult males and females, as well as ducklings of all ages, were similar. Larval and pupal midges (tendipedidae, especially Chironomus) constituted the main food item. The quantity of grit in the gizzards increased with the age of the ducklings. There was no significant difference between the average quantities of grit retained by male and female adult birds. Ruddy ducks, of all ages, forage almost exclusively by diving and straining food organisms from the soft muddy ooze on the bottoms of ponds. Foraging ruddy ducks appear to select areas relatively rich in midge larvae.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-College Center for Environmental Studies, Fargo, North Dakota. 295 p.

This book documents available information concerning the status, past and present, of the breeding birds in North Dakota. Subjects that are treated in considerable detail include the geographical, ecological, and seasonal distribution of breeding populations. General headings include: (1) breeding birds of North Dakota, (2) environmental attributes of North Dakota, (3) environmental relationships of breeding birds, (4) species account, (5) literature cited, (6) appendix A - common and scientific names of plants referred to in text, (7) appendix B - synopsis of publications concerning breeding of birds of North Dakota, and (8) species index.

Stewart, R. E. 1971. Forests, wetlands, and waterfowl populations in the Turtle Mountains of North Dakota and Manitoba. Ph.D. Dissertation, Department of Zoology, North Dakota State University, Fargo.

Forests, wetlands, and waterfowl of the Turtle Mountains were studied from 1967 through 1970. Aspen is the dominant tree in all of the younger mainland stands but bur oak is dominant in one xeric mainland stand and in a narrow, exposed island stand.

Class 3 to 5 wetlands (seasonal, semi-permanent and permanent) and waterfowl were studied on 80 quarter sections of land, 60 on the U.S. side from 1967-1970, and 20 on the Canadian portion from 1969-1970. The number of Class 3 to 5 wetlands in the Turtle Mountains was estimated at 12,121 with 93,968 acres. Water chemistry determinations indicated wetlands had an average pH of 8.0, average alkalinity of 280 mg/l $CaCo^3$, and an average specific conductance of 630 mmhos/cm.

Fifteen species of waterfowl were encountered during breeding pair and brood surveys. Statistical estimates of pair, brood, and young density per section were made along with Highest Probability Density estimates of their precision, employing the Bayesian philosophy of statistics. An average of 28,522 breeding pairs were estimated to have used the Turtle Mountains and produced 10,318 broods (8.0 per section) and 65,097 young necked ducks had the highest importance values.

Stewart, R. E. and H. A. Kantrud, 1973. Ecological distribution of breeding waterfowl populations in North Dakota. J. Wildl. Manage. 37:39-50.

The distribution of breeding waterfowl populations on various wetland habitat types was investigated in North Dakota during 1967-69. Data were obtained by stratified random sampling techniques. The total acreage in North Dakota was estimated to be about 3.2 million acres. Natural basin wetlands comprised about 77 per cent of the acreage and 91 per cent of the number of wetlands in the state and were utilized by about 76 per cent of the state's breeding duck population. About 84 per cent of the statewide duck population occurred in the Prairie Pothole Region. Within the Prairie Pothole Region, seasonal (Class III) ponds comprised 36 and 23 per cent, respectively, of the total acreage and number of wetlands, and semipermanent (Clas IV) ponds and lakes comprised 18 and 3 per cent, respectively, of these totals. Agriculture has had drastic effects on the wetlands in this region as evidenced by the fact that natural basin wetlands with tilled bottom soils (chiefly Class II and Class III wetlands) comprised about 29 per cent of area but 52 per cent of numbers of all wetlands. In the Prairie Pothole Region, seasonal ponds and semipermanent ponds and lakes were utilized by about 48 and 27 per cent, respectively, of the total breeding ducks. Optimum environmental conditions for breeding dabbling ducks were present during years when large numbers and acreages of seasonal (Class III) pond basins contained surface water.

Stewart, R. E. and H. A. Kantrud. 1974. Breeding waterfowl populations in the prairie pothole region of North Dakota. Condor 76:70-79.

Populations of breeding waterfowl in the Prairie Pothole Region of North Dakota were censused from 1967 to 1969 through use of random sampling techniques. These populations fluctuated considerably due primarily to yearly variations in frequency, density, and area of basin wetlands with surface water.

Average population parameters for total breeding ducks included a frequency of 82 per cent on the quarter-section sample units, and a density of 44.5 pairs per square mile. The average projected population for the entire region was 1,619,000 pairs, including 1,450,000 pairs (89.6 per cent) of dabbling ducks, and 169,000 pairs (10.4 per cent) of diving ducks. Five primary species of ducks—the mallard, gadwall, pintail, blue-winged teal, and shoveler — comprised 83 per cent of the total breeding duck population. The mallard exhibited the highest average frequency (65 per cent) and the blue-winged teal the highest average density (13.9 pairs per square mile.)

During the period 1967-69, significant correlations occurred between fluctuations of the total breeding waterfowl populations and variations in the number of wetland basins containing surface water. Populations of dabbling ducks as a group showed high correlations with densities of wetlands of all types, and equally high correlations with densities of seasonal (Class III) and semi-permanent (Class IV) basin wetlands, in combination. Population fluctuations of total diving ducks were more closely related to changes in acreage of semipermanent (Class IV) ponds and lakes.

Stieglitz, W. O. 1972. Food habits of the Florida Duck. J. Wildl. Manage. 36:422-428.

Gizzards from 85 Florida ducks (Anas f. fulvigula) collected from November 1960 through December 1966 in two Florida counties were analyzed. Plant materials comprised 89.9 per cent of the total volume of all foods and animal matter 10.0 per cent. The most important foods by percentage of volume were spinynaiad (Naisa marina), 21.7; Tracey's beakrush (Rhynchospora traceyi), 18.3; dotted smartweed (Polygonum punctatum), 16.4; water pepper (Polygonum hydropiperoides), 10.1; shoalgrass (Diplanthera wrightii), 4.7; sawgrass (Cladium jamacicensi), 4.3; and muskgrass (Chara sp.) 3.3. Leading foods according to percentage frequency of occurrence were sawgrass, 70.9; waxmyrtle (Myrica cerifera), 62.8; spiny naiad, 36.0; Tracey's beakrush, 24.4; insects, 20.9; pigeongrass (Ruppia maritima), 15.1 and saltgrass (Distichlis spicata), 14.0. A comparison is made between feeding habits of the species in the dissimilar everglades and brackish marsh habitat types.

Stiles, G. F. and S. M. Smith. 1977. New information on Costa Rican waterbirds. Condor 79:91-97.

Over the years 1974 - 1977 the authors studied the distribution and abundance of seabirds, shorebirds, and other water birds in the Pacific slope of Costa Rica. These studies included three main phases: offshore voyages in small boats for seabirds; censusing waterbirds on certain freshwater marshes; and an intensive shorebird banding program.

Straskraba, M. 1965. Contributions to the productivity of the littoral region of pools and ponds. I. Quantitative study of the littoral zooplankton of the rich vegetation of the backwater Labicko. Hydrobiologia. 26:421-433.

During a quantitative study of the littoral zooplankton of a backwater, temperature as well as some chemical conditions were measured at monthly intervals for two years. At one station with a concentration of leaves of Nuphar, Hydrocharis, Myriophyllum, and Ceratophyllum near the surface, a remarkable vertical stratification of temperature and chemical factors was observed.

Crustacea exceeded numerically the Rotatoria, the mean ratios for the warm seasons ranging from 1.9 to 4.8:1, at stations with emergent vegetation, and from 5.0 to 13.0, at stations with submerged vegetation. A spring (May) maximum of the littoral species, mainly Chydorus, was followed by an increase of tycholimnetic Cladocera during June-September; followed by a fall maximum of littoral Cyclopidea. Two types of life cycles may be distinguished: The littoral species have mostly a well-defined spring maximum and a less-defined fall maximum, the tycholimnetic species, a summer maximum.

Swanson, G. A. 1978. A water column sampler for invertebrates in shallow wetlands. J. Wildl. Manage. 42:670-672.

This "short communication" describes a column sampler which is lightweight (2.5kg), quantitative, relatively simple to construct, and designed to operate in shallow water. Invertebrate samples are obtained by placing the cutting edge of the tube on the wetland substrate with the stopper removed and then firmly inserting the stopper and raising the water column. A picture of the device together with details concerning construction and use are provided in this article.

Swanson, G. A., M. I. Meyer, and J. R. Serie. 1974. Feeding ecology of breeding blue-winged teals. J. Wildl. Manage. 39:396-407.

A five-year investigation of factors influencing the selection of foods consumed by blue-winged teals (Anas discors) during the breeding season in the glaciated prairie region of south-central North Dakota showed that birds first arriving on the breeding grounds consumed a diet consisting of 45 per cent invertebrates. The proportion of animal foods in the diet increased to 95 per cent at the onset of the nesting season.

The quality and quantity of foods selected at any given time were influenced by the biological demands and morphological adaptations of the bird, the behavior and ecology of the invertebrates selected as foods, and the general nature of the aquatic ecosystems as determined by the hydrology and geology of the area and modified by land use and weather. Feeding activities changed significantly when food availability within the aquatic ecosystem changed.

During the spring and early summer, temporary and seasonal wetlands, if not severely disturbed, were of paramount importance to breeding blue-winged teals since they provided abundant and readily available, high protein, animal foods. Later in the summer when seasonal wetlands began to dry up, insects began to emerge in the semi-permanent ponds and lakes, and feeding intensity shifted to those more permanent waters. This trend, however, was reversed temporarily during the early summer following heavy precipitation that refilled shallow water areas and again stimulated invertebrate development.

Titman, R. D. and J. K. Lowther. 1975. The breeding behavior of a crowded population of mallards. Can. J. Zool. 53:1270-1283.

The breeding behavior of a population slightly in excess of 200 free-winged mallard ducks was observed during the breeding seasons of 1966 and 1967. These ducks frequented a 3.1 ha area at the Delta Waterfowl Research Station in Manitoba. The most notable behavioral abnormalities observed in this dense population were a great deal of strife, including fighting among males and females, and rape of females; a high frequency of nest parasitism; abandonment of nests; reduced broodiness of females; loss and abandonment of young; formation of large broods of mixed origin; and, renesting of hens already having produced a brood. Although egg production was high, productivity was low due to small hatch and to high morality of young less than two weeks old. Agressive behavior and rape within this population appeared to be responsible for mortality and reduced breeding success.

Van Velzen, W. T. 1972. Breeding-bird census instructions. Am. Birds 26:1007-1010.

The author suggests that each report should contain: (1) descriptive title of the area, (2) location, (3) continuity, (4) size of area, (5) description of plot, (6) edge description, (7) topography, (8) weather, (9) total number of man-hours devoted to censusing-cover-

age, (10) the breeding species found on the list in order of decreasing abundance, (11) total number of species, number of territorial males, and total density, (12) list of visitors to the plot, and (13) a remarks section in which such information as niche requirements of a given species, territorial size, and minor population fluctuations are given. An example is given.

Voigts, D. K. 1976. Aquatic invertebrate abundance in relation to changing marsh vegetation. Am. Midl. Nat. 95:313-322.

The relationship between invertebrate populations and vegetative cover was studied in several Iowa marshes during the peak of the avain nesting season. Shallow water with emergent and floating dead vegetation produced the most isopods, planorbid snails, and physid snails. Physid snails had another abundance peak in areas where submerged plants were found below dense free-floating plants. Midges reached greatest abundance in more open habitats somewhat protected from the wind. Amphipods were the most numerous invertebrate taxa and were most abundant in dense beds of submerged vegetation. Cladocera and copepods were most common in quiet pools with little vegetation.

Total invertebrate abundance increased as the emergent vegetation was replaced by submerged vegetation but maximum numbers occurred where beds of submerged vegetation were interspersed with stands of emergent vegetation. It is suggested that nesting marsh birds are attracted to marshes that produce the most invertebrates.

Voigts, D. K. 1973. An odonate emergence trap for use in marshes. Proc. Iowa Acad. Sci. 80:67-68.

A trap used in estimating emergence rates of Odonata over water in emergent vegetation is described. Is consists of a wooden frame lined with plastic screen and protected from muskrat damage by a covering of steel hardware cloth.

Vogl, R. J. 1973. Effects of fire on the plants and animals of a Florida wetland. Am. Midl. Nat. 89:334-347.

A total of 754 birds were recorded on a portion of a pond shore line during 63 visits for four months following a controlled burn, while 236 birds were observed on an adjacent and comparable, but unburned, shore line. Only five of the 35 bird species encountered were seen more often on the unburned site. Fire-induced bird and mammal injury or mortality was unobserved even though the burn resembled a wildfire. Birds showed no fear of the fire and some were attracted to the smoking landscape. Although some cold-blooded vertebrate mortality occurred, other reptiles survived, and alligators used the burned shore line almost exclusively. Mammal populations of burned and unburned areas appeared similar four months after the fire.

Animal responses are considered related to the fire removal of the heavy grass mat that otherwise covered the water and soils and the foods contained therein, and physically impaired new plant growth. Burning also produced an earlier, more rapid and far more productive growth of wet-prairie plants.

Weller, M. W. 1979. Density and habitat relationships of blue-winged teal nesting in northern Iowa. J. Wildl. Manage. 43:367-374.

Blue-winged teal (Anas discors) were censused on a 136-ha study area from 1962 to 1974 by use of pair counts and test numbers. Populations fluctuated between 20 and 111 pairs. Numbers showed a significant, positive correlation with water depth for the years 1968 to 1974, possibly because deeper water created additional feeding and loafing sites for territorial pairs in flooded grasses and sedges of temporary wetlands and around perimeters of deeper wetlands. Nest success was inversely related to both numbers of pairs and number of nests. Nest losses resulted almost entirely from predators. Nest and pair numbers were sufficiently well correlated that pair counts can be used on this area to estimate nesting effort when time does not permit nest surveys or when data on nest-site selection or nest success are unnecessary.

Weller, M. W. 1978. Management of freshwater marshes for wildlife. Pages 267-284 in R.E. Good, D. F. Whigham, and R. L. Simpson (eds.) Freshwater wetlands: Ecological processes and management potential. Academic Press, New York.

Although commonly practiced on wildlife management areas, marsh management is poorly founded in theory and as a predictive science. System or community-oriented management techniques are encouraged as most likely to meet diverse public needs, whereas species-specific management is more difficult, costly and limited in application.

What is most needed to advance marsh management theory and practice are experimental data gathered concurrently by a team of specialists in marsh plants, limnology, invertebrates, and vertebrates.

Areas of interest include: (1) habitat stimuli that attract wildlife to marshes (2) development of indices to wildlife production in marshes (3) diversity or heterogeneity of wetland areas in a complex essential to attract and maintain marsh wildlife (4) wetland:upland ratios conducive to preservation of typical prairie-wetland biotas (5) role of siltation, fertilizers and other man-made products in modifying productivity of wetland areas.

Weller, M. W. 1975. Studies of cattail in relation to management for marsh wildlife. Iowa State J. Sci. 49:383-412.

Greenhouse and field studies of the biology of cattail compared common cattail (Typha latifolia) with a robust hybrid of T. latifolia X T. angustifolia common to marshes of northwestern Iowa. Germination rates generally were inverse to water depth with maximum germination on one inch. Growth was directly related to water depth in most instances and hybrids grew taller than did common cattail but had stems of smaller average diameter. Rhizome shoot production also was inverse to water depths so that replacement-level production (rhizome to stalk ratio of 1:1) occurred in both species when water depths exceeded 15-18 inches. Experimental cutting demonstrated that flooding of cut stems kills plants. Plants survive only one year when so flooded. Size of open areas in cattail influence bird use, and management for maximum bird production requires maintenance of a 50:

50 cover-water ratio with interconnected and well-interspersed pools larger than 30 feet in diameter. Water-level manipulation and management of muskrat populations are regarded as the most natural, effective and inexpensive means of providing such cover.

Weller, M. W. 1974. North American prairie wetlands in relation to other waterfowl areas. Naturalist 25(4): 22-24.

In general, the ducks of the prairie potholes are more terrestrial and adaptable in nest sites and food than are ducks of other regions. This is a system selected for in the long evolutionary association of ducks and drought-prone prairie wetlands. It is obvious that the presence of diverse sizes of wetlands fulfills different needs for different species at various seasons. Conservation of waterfowl and other marsh life in North America and conservation of the unique prairie wetland region go hand in hand. These wetlands undoubtedly have many hidden economic benefits. The role of wetlands in maintenance of water table, in soil conservation through soil-moisture balance, and in maintenance of water quality through detozification or modification of nutrient levels have long been ignored. Many of the resources, of value for birds and other marsh wildlife, and for man will be gone before their values have been recognized.

Weller, M. W. and L. H. Fredrickson. 1973. Avian ecology of a managed glacial marsh. Living Bird 12:269-291.

The direct and vital role that vegetation plays in determining the use of an area by birds is most dramatically displayed in unstable habitats where birds have evolved adaptive responses to changing conditions. Marshes constantly undergo vegetative changes resulting from water fluctuations, which influence avian diversity and population size.

The major objectives of this study were (1) to record plant succession from the time of its establishment to its elimination by water and muskrats, (2) to measure avian succession, diversity, and population fluctuations dependent on the plant substrate, (3) to clarify typical marsh habitat cycles to allow optional use of natural systems in management of marsh wildlife, (4) to experimentally lengthen the typical habitat cycle to provide more uniform productivity, and (5) to better describe the form and function of a discrete, natural ecosystem.

All but cattail were eliminated within three years after the drawdown with cattail density steadily increasing. Concurrently, pool size and area of open water increased due to an increased muskrat population which utilized cattail for lodges and food. Bird populations changed dramatically in numbers and species, with the greatest number and species diversity present when 50 to 70 per cent of the open water was well-interspersed with emergent vegetation.

Weller, M .W. and C. S. Spatcher. 1965. Role of habitat in the distribution and abundance of marsh birds. Iowa Agricultural and Home Economics Experiment Station Special Report No. 43. Ames, Iowa. 31 p.

Severe drouth during the 1950's produced dramatic changes in the vegetation of midwestern glacial marshes, in the abundance and distribution of marsh birds. Changes in marsh habitat quality were studied in relation to bird populations in two small central Iowa marshes, Little Wall and Goose Lakes near Jewell.

During dry periods, only adaptable species such as redwinged black-birds were present. As water levels increased, densely vegetated areas were opened up by muskrat cutting, and yellow-headed blackbirds, coots, pied-billed grebes, and least bitterns became established and increased in numbers. Maximum bird numbers and diversity were reached when a well-interspersed cover-water ratio of 50:50 occurred.

Habitat changes permitted a measure of habitat preference and adaptability in several species. Evolution of nest-site selection seems to have been influenced by general habitat of the ancestral stocks (terrestrial versus aquatic), by mode of locomotion (perchers, walkers, swimmers, and flyers) and by use of the major emergents (shoreward or water's edge). The vertical height and resulting "layers" of vegetation, their robustness, and their relationship to water influence species use and, thereby, species diversity.

The viewpoint of marshes as transient seral stages is challenged because of their duration of life and because of the equally dramatic changes that may occur in surrounding terrestrial biomes.

Werner, E. E., D. J. Hall, D. R. Laughlin, D. J. Wagner, L. A. Wilsmann, and F. C. Funk. 1977. Habitat partitioning in a freshwater fish community. J. Fish Res. Board Can. 34:360-370.

The patterns of habitat utilization in the littoral zone fish community of two small southern Michigan lakes were examined. Abundance and habitat use of the fish were quantified by underwater transect censuses. The sunfishes (Centrarchidae) dominated the communities numerically and by weight with two species, the blue gill (Lepomis macrochirum) and largemouth bass (Micropterus salmoides) accounting for 85 per cent of the community biomass. Spatial (habitat) segregation of species was evident along gradients of depth (distance from shore), vertical height in the water column, and vegetational structure. Several species showed intraspecific differences in the spatial distribution of size-classes. Comparative analyses of habitat use in the two lakes suggest that small size classes are confined by predation to areas of dense cover and that within these areas, competition determines space utilization by different species. The patterns of habitat use are discussed in relation to the food habits and morphology of species in this community. Only one clear case of segregation of two species by food size occurs (bass and bluegill), most other species segregate predominantly by habitat. The rarer centrarchids show strong niche complementarily with the codominant bass and bluegill.

Yntema, C. L. 1970. Observation on females and eggs of the common snapping turtle Chelydra serpentina. Am. Midl. Nat. 84:69-76.

Records were kept on 255 female snapping turtles, Chelydra serpentina serpentina, and the eggs taken from them. The total number of eggs involved was

9,348. Statistical summaries were made of the following: length of carapace, weight of animal, eggs per animal, clutch weight, clutch weight/animal weight, weight per egg, diameter of egg, egg number/animal weight. A relation between length and weight was calculated and compared with previous studies. Clutch weight/body weight did not vary with size of animal. Larger animals tended to have larger eggs. A rough prediction for number of eggs in a female could be made by separating the females weighing less than 5 kg from those weighing 5 kg or more. The weight in kg of the smaller is multiplied by the factor of 9, the weight of the larger by 8. The resulting number plus or minus one third covers most of the observations made.

AUTHOR INDEX FOR BIBLIOGRAPHY