UNIVERSITY OF MANITOBA

A STUDY OF THE BREEDING HABITAT AND PRODUCTIVITY OF CANVASBACK AND REDHEAD DUCKS IN SOUTHWESTERN MANITOBA AND THE USE OF REMOTE SENSING IN THE INTERPRETATION OF HABITAT

BY

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ABSTRACT

During 1974 and 1975, the nesting ecology and productivity of canvasback (Aythya valisineria) and redhead (Aythya americana) ducks were assessed in southwestern Manitoba. Multispectral remote sensing imagery was tested as a means of identifying canvasback and redhead nesting habitat based on the interpretability of habitat components.

Although canvasback and redhead breeding densities were evenly distributed throughout the study area, pronounced productivity differences were recorded between a 6.4 km^2 study block and a series of roadside transects. Canvasback productivity averaged 1.36 juveniles/pair on the study block and 3.68 juveniles/pair on the transects. Lower canvasback productivity for the study block was attributed to: poor habitat conditions (few semi-permanent and permanent ponds), a high incidence of predation by raccoons (Procyon lotor), and interference by parasitic redheads which reduced canvasback clutch sizes. Reduced redhead productivity on the study block was due to a low number of nest initiations relative to breeding densities coupled with a high incidence of nest desertions.

Canvasback and redhead nesting ecology differed significantly for the following habitat parameters: pond size ($P < 0.01$); pond permanency ($P < 0.01$); emergent vegetation type ($P < 0.05$); and pond nesting potential ($P < 0.01$).

Nesting success for both species increased significantly for nests located on the more permanent ponds ($P < 0.10$), dominated by reed

marsh emergent vegetation ($P < 0.01$) and rated either 'Good' or 'Excellent' in terms of nesting potential ($P < 0.01$).

Wetland habitat parameters were successfully interpreted on Ektachrome (2448) and Aerochrome (2443) imagery. The combination of these two types of imagery enhanced the interpretation of habitat parameters, especially for pond size, pond cover type, emergent vegetation type and pond permanency. The Aerochrome infrared photography was superior to the Ektachrome format for delineating wet areas, land-water boundaries, stressed vegetation and separation between emergent species. Emergents such as cattail (*Typha latifolia*)/bulrush (*Scirpus acutus*), whitetop (*Scolochloa festucacea*)/sedge (*Carex atherodes*), willows (*Salix* sp.) and broadleaf forb-rush vegetation had distinctive spectral signatures.

INTRODUCTION

Migratory waterfowl populations have fluctuated at low levels throughout the prairies since the drought period of the late 1950's and early 1960's. Continuing loss of waterfowl habitat to agricultural land use practices and increasing hunting pressure have been primarily responsible for maintaining these low populations (Burwell and Sugden 1964, Kiel et al. 1972). Canvasback (Aythya valisineria) duck populations have not as yet recovered from the decimating effects of the drought (Trauger 1974).

Canvasbacks and redheads (Aythya americana) are diving ducks belonging to the subfamily Aythyinae. Both species are native only to the North American continent. They exhibit similarities in size, appearance, feeding behavior and habitat, particularly nesting habitat.

Two of the key factors affecting waterfowl populations are habitat quantity and quality. To assess these variables extensive field surveys are needed which are time consuming, repetitive, expensive and require several highly trained observers. A relatively new technique, remote sensing, is being tested in wildlife studies. Remote sensing means reconnaissance at a distance with the use of aerial photographs.

There are several possibilities whereby remote sensing can be combined with field studies. Much of the information on habitat quality and quantity could be extracted directly from remote sensing imagery with limited and selected input from field surveys. Field investigations can concentrate on gathering population data at reduced costs.

To utilize remote sensing to its best advantage in assessing habitat quantity and quality for specific waterfowl species, ecological studies must be intricate components of these investigations. Canvasback and redhead nesting ecology in relation to habitat availability, habitat components leading to successful nesting and the productivity of the two species is reported here. The hypothesis tested in this study is as follows: if canvasback and redhead nesting ecology, in particular successful nesting, is identified in terms of physical habitat components, can those components be interpreted and identified from remote sensing imagery.

The objectives of this study were: (1) to investigate the relationship between canvasback and redhead ducks in their use of nesting habitat; (2) to identify habitat components resulting in successful nesting; (3) to assess the productivity of these two species in Canada Land Inventory-Waterfowl Capability Class 2; and (4) to develop an interpretation key from remote sensing imagery for wetland habitat components.

LITERATURE REVIEW

CANVASBACK AND REDHEAD BREEDING ECOLOGY

Distribution of Breeding Populations

Stewart et al. (1958) described the density and breeding range of the canvasback while Delacour (1959) did the same for the redhead. Two-thirds of the canvasback and redhead breeding populations are located in the prairie pothole region of North Dakota, Manitoba, Saskatchewan and Alberta.

Trauger (1974) stated that the canvasback population during the 1950's exceeded 400,000 birds, decreased drastically during the drought of 1959 to 1962 and reached its lowest level during 1971-1972 at less than 200,000 canvasbacks (Figure 1). Redhead breeding populations have averaged 649,000 over the period 1955-74, ranging from a low of 387,000 in 1963 to a high of 927,000 in 1965 (Bellrose 1976).

Breeding Ecology

Intensive studies on the breeding ecology of canvasbacks and redheads have been pursued throughout their breeding range. Hochbaum (1944) assessed the requirements of canvasbacks and determined the significance of territorial spacing on the Delta Marsh of Manitoba. Olson (1964b) compared canvasback and redhead productivity and interactions on three types of habitat in Manitoba (prairie potholes, a large marsh and a lake). Stoudt (1971) studied the habitat requirements of the canvasback during the breeding season in the aspen

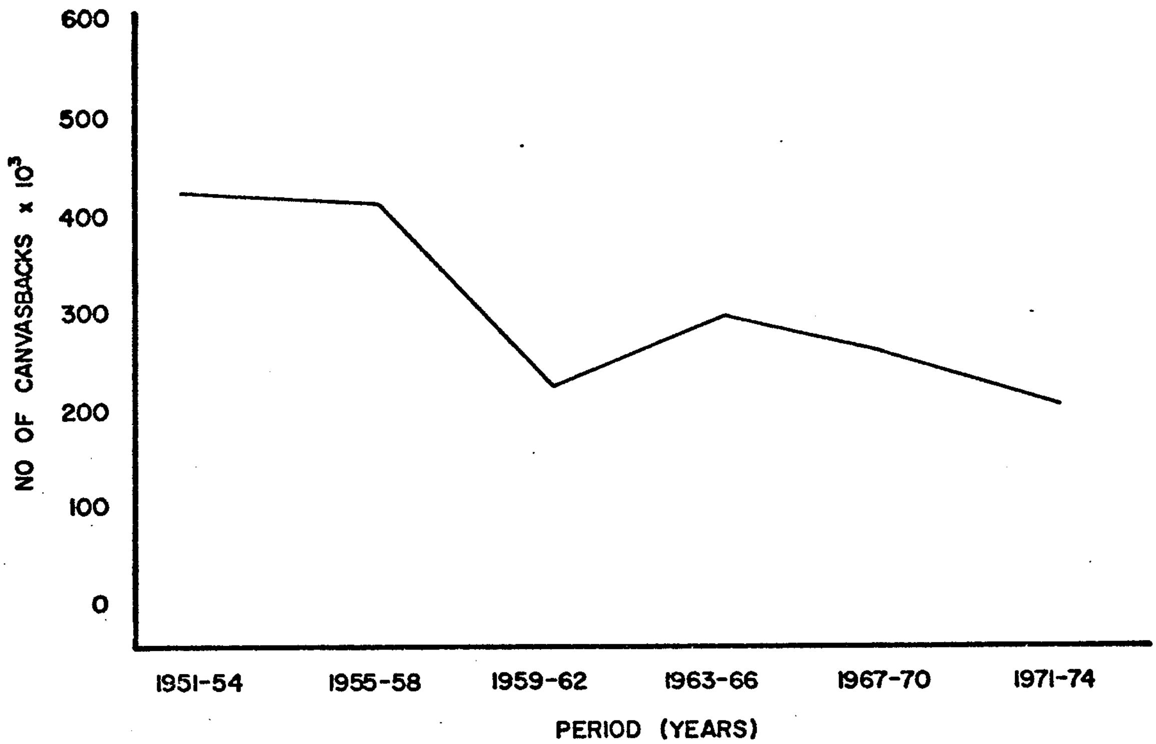

Figure 1. Canvasback populations wintering in the United States, 1951-1974. (Trauger 1974).

parkland of Saskatchewan. Sugden (1978) investigated the relationship between habitat characteristics, canvasback breeding populations and productivity on a Saskatchewan parkland study area. Low (1945) obtained ecological data for the redhead on the lakes, marshes and potholes of Iowa. Lokemoen (1966) studied the breeding behavior, habitat preferences and nesting success of the redhead on the potholes of western Montana. McKnight (1974) documented the nesting ecology of the redhead on the Fish Springs National Wildlife Refuge in Utah.

At Minnedosa, Manitoba, Dzubin (1955) observed that a pair of canvasbacks during the breeding season utilized an area consisting of several ponds. Different ponds were used for feeding, nesting, loafing or as waiting areas by the drakes. A waiting area was defined as a pond, group of ponds or part of a marsh where the drake awaits the hen during egg laying and early incubation. Dzubin (op. cit.) labelled this community relationship of ponds as a "home range" and estimated it to be in excess of 546 ha. (1300 ac.) for a pair of canvasbacks and at least 1344 ha. (3200 ac.) for a pair of redheads. In comparison the home range size for a pair of mallards (Anas platyrhynchos) was 294 ha. (700 ac.), for a pair of blue-winged teal (Anas discors) it was 105 ha. (250 ac.) and Poston (1974) found the home range of a pair of shovellers (Anas clypeata) averaged 32 ha. (76 ac.).

Canvasback and redhead ducks are described as overwater nesters, typically using emergent vegetation as nesting cover. These two species build their nests in clumps of cattail (Typha latifolia) or bulrush (Scirpus acutus) slightly above the water level and firmly attached to the surrounding vegetation (Kortright 1953). Investigations throughout the canvasback and redhead breeding range indicate the preference for cattail and bulrush cover located in ponds 2 ha. (5 ac.) and less in size (Table 1).

According to Low (1945), ponds smaller than 2 ha. (5 ac.) containing the preferred nesting cover that were at a distance greater than 0.4 km. (.25 mi.) from a larger body of water were not used for nesting. He also noted that nest densities were greatest where 10-25% of the pond contained open water and no nests were recorded where there were no openings. Olson (1964b) found pothole habitat to contain three times as many canvasbacks as redheads while the large marshes held up to five times as many redheads as canvasbacks.

Significant use of willows as a nesting substrate was recorded by Olson (1964b), Smith (1971) and Sugden (1978). Stoudt (1971) attributes high usage of willows as being indicative of high water levels when other preferred nesting cover was flooded.

Dwyer (1970) suggested that the presence of trees bordering the shoreline of a pond could impede the flight of diving ducks thereby discouraging the use of wooded ponds. Though canvasbacks tended to use open ponds to a greater extent than wooded ponds (Stoudt 1971), Sugden (1978) suggested that woody shore growth did not have much influence on pond use by canvasbacks except on very small ponds.

Although most of the literature indicates that canvasbacks and redheads initiate their nests over water, there is some evidence of dryland nesting, (Hochbaum 1944). Keith (1961) recorded that 50% of all redhead nests and 11% of canvasback nests were constructed on dry ground sites. McKnight (1974) documented extensive (72%) dryland nesting by redheads at the Fish Springs National Wildlife Refuge in Utah.

Table 1. Physical Characteristics of Canvasback and Redhead Nesting Ponds.

Preferred nesting cover	Pond size	Species studied	Location of study	Author
Sedge, bulrush, cattail	2.0 ha.	Redhead	Iowa	Low (1945)
Cattail, bulrush, baltic rush		Redhead	Montana	Lokemoen (1966)
Willows, cattail, whitetop	86% < 1.7 ha.	Canvasback	Saskatchewan	Sugden (1972)
Cattail, bulrush, whitetop		Canvasback	Saskatchewan	Stoudt (1971)
Cattail, willows	0.8 ha. or less	Redhead and Canvasback	Manitoba	Olson (1964b)
Cattail, bulrush, whitetop	98% less than 2.0 ha.	Canvasback	Manitoba	Stoudt (1974)
Bulrush, phragmites, cattail		Redhead	Utah	Williams & Marshall (1938)
Cattail, baltic rush		Redhead and Canvasback	Alberta	Keith (1961)
Willows, cattail, sedge		Canvasback	Alberta	Smith (1971)
Cattail	67% < 0.8 ha.	Canvasback	Manitoba	Dzubin (1955)
Bulrush, cattail whitetop	over 0.2 ha.	Canvasback, Redhead	South Dakota	Evans & Black (1956)

Low (1945), Lokemoen (1966), Sugden (1978), Stoudt (1974) and Olson (1964b) obtained water depth measurements at nest sites and found averages ranging from 22.4 cm. (8.8 in.) to 32.3 cm. (12.7 in.).

Factors affecting nesting success

Nesting success of canvasbacks and redheads can be influenced by weather, predation and parasitism. Because these two species prefer overwater nesting sites, flooding or drought conditions can have disastrous effects on nest success. Smith (1971) noted a nest success of 46% in the predrought years of 1952-1958; a 32% success rate during the drought (1959-1963) and a 64% nest success during the postdrought years of 1964 and 1965. Olson (1964b) reported a 22% nest success rate during the three year period 1959 to 1961.

Williams and Marshall (1938) recorded a 26% loss of redhead nests due to flooding at Bear River Migratory Bird Refuge in Utah. In Iowa, Low (1945) found a 56% rate of nesting success and attributed most nest losses to desertion and flooding. He concluded that recession of water from below some nests and the parasitic behavior of redheads caused most desertions. Weller (1959) documented redhead parasitism and found this species to be a semi-parasite, meaning part of the population nested normally, part parasitically and part laid their eggs parasitically early in the nesting season but later nested normally. He considered this an unfavorable trait since an average of only 10 to 15% of redhead eggs hatched successfully in the hosts nest. Olson (1964b) concluded that the amount of parasitism in canvasback nests was directly proportional to the number of redheads in the breeding population. Stoudt (1974) reported that over a 12 year period 57% of the canvasback nests at Minnedosa were parasitized by redheads.

Redhead parasitism on canvasback nests tends to decrease canvasback productivity and increase redhead productivity (Olson 1964b). Joyner (1976) recorded that redhead parasitism significantly reduced egg success of mallard, pintail (Anas acuta) and cinnamon teal (Anas cyanoptera) nests.

Olson (1964b) and Stoudt (1974) considered the raccoon as being the major predator of both canvasback and redhead nests at Minnedosa. They felt that the increasing abundance of this animal may cause a permanent reduction in the productivity of prairie nesting waterfowl. Kiel et al. (1972) suggested that both increased raccoon predation and increased pothole drainage are factors contributing to the decline of the canvasback at Minnedosa. Stoudt (1971) recorded a 68% nesting success for canvasbacks at Redvers, Saskatchewan. He attributed this high level of success to the area being relatively free of raccoons (Procyon lotor).

Cowan (1973) documented the increase and expansion of the raccoon range in Manitoba. He found raccoons to spend 62% of their time in and around potholes during the spring, summer and fall. Raccoon activity was centered on seasonal and semi-permanent wetlands (Fritzell 1978). After extensive investigation of raccoon predatory activities, Llewellyn and Webster (1960) concluded that as raccoon populations increased so did their damage to waterfowl nests.

Smith (1971) noted duck nesting success of 47% at Lousana, Alberta. Predators accounted for 56% of nest losses. He suggested that the high predation rates were influenced by increasing agricultural modifications of the landscape which reduced the amount of nesting cover.

Several authors have questioned and investigated the effects of human disturbance on waterfowl nesting success. Hochbaum (1944) observed that hens flushed from their nests frequently defecated on their eggs, thereby leaving a scent for predators to pick up. Keith (1961) conducted a series of tests with randomly placed chicken eggs. Some were smeared with duck feces, some placed by means of a long pole so that no human tracks led directly to them and others were placed with tracks leading up to them. He found no significant differences for predation rates between the three groups of eggs. Hammond and Forward (1956) were of the opinion that nest markers placed near located nests increased predation rates while eggs scented with duck feces incurred no more predation than those unscented. Stoudt (1974) recorded no appreciable differences in predation between disturbed and undisturbed nests (i.e. flushing vs. non-flushing of the hen from the nest). Olson (1964b) thought that activities of investigators at canvasback and redhead nests were not a major factor in nest success. Hammond and Forward (1956) and Stoudt (1974) concluded, if adequate care was taken when approaching and leaving a nest, losses to predators could be minimized.

Canvasbacks and redhead populations, as well as other waterfowl species, are feeling the effects of the man induced long term drought (Trauger 1974). The demands for increased agricultural production have demanded the reclamation of wetlands. Burwell and Sugden (1964) indicated the extent of pond loss in the United States and Canada. Kiel et al. (1972) monitored the changes in waterfowl habitat in the aspen parkland of Manitoba as influenced by agricultural practices. Canvasback nest destruction or desertion could be caused by plowing, mowing, burning or tree and brush removal from pond edges according to Stoudt

(1974). Kiel et al. (1972) found activities related to road building, land clearing and drainage caused physical disturbance to 120 ponds 93 times over a 16 year period. Land clearing and the removal of woody fringes from ponds is increasing the number of brush and tree piles. Raccoons use these brush and tree piles extensively for dens or day beds (Cowan 1973).

Drainage reduces the number of water areas available for breeding territories, nesting and brood cover. Evans and Black (1956) indicated that the drainage program in South Dakota was seriously reducing over-water nesting habitat. Incomplete drainage or partial filling of permanent or semi-permanent ponds can reduce their attractiveness to duck nesting by reducing pond size and permanence (Kiel et al. 1972). Goodman and Pryor (1971) estimated an overall net loss of 13% of wetland acreage in the prairie provinces with 11% of pond acreage totally drained in Manitoba. Drainage on a 1.6 km^2 (1 mi^2) area at Minnedosa caused a loss of 50% of the ponds over a two year period (Stoudt 1974). Olson (1964b) best states the effect of drainage on canvasback productivity as follows:

> "...drainage tends to increase the average size of the remaining wetlands even though decreasing the total amount of breeding habitat. Where this occurs the remaining nesting cover for both species is in the larger areas which contain proportionally more redheads and the result appears to be decreased canvasback production."

REMOTE SENSING

The field of remote sensing has been rapidly expanding from aerial photographic interpretation. Remote sensing involves the collection of data by systems which are not in direct contact with the objects or phenomena under investigation (Estes and Senger 1974).

The electromagnetic spectrum and the remote sensors available to image various segments of it are illustrated in Figure 2. Photographic remote sensing is limited to the ultraviolet, visible and near infrared portions of the spectrum between 360 millimicrons to approximately 900 millimicrons (Estes 1974). Multiband or multispectral imagery can be obtained by selectively filtering out various segments of the spectrum with either of the four basic film types: black and white; black and white infrared; colour or colour infrared. The black and white and colour films can be selectively filtered to monitor any part or parts of the ultraviolet or visible region of the spectrum (360-700 millimicrons). The black and white infrared and colour infrared emulsions are sensitized to the 700-900 millimicron range.

The use of aerial photographs for the study and mapping of wetlands is not new. Dalke (1937) emphasized the importance of aerial maps and ecological principles for mapping ecological zones such as submerged vegetation, floating-leaved species, rushes and cattail. MacConnell and Garvin (1956) utilized aerial photography for the interpretation of six wetland types.

A review of the literature by Eitel (1972) prompted him to make the following statements:

> "The most rapid and economical method for identifying, mapping and analyzing the wetland ecosystem is through remote sensing techniques. Ground surveys are slow, expensive and sometimes difficult because of the wetlands topography. Remote sensing methods provide useful research tools in the essential phases of wetlands investigations by rapidly assessing ecological conditions, furnishing insight for successful environment management and providing a benchmark for future comparative analysis".

Anderson (1969) mentions the need for a rapid, low cost method for monitoring the alteration, destruction and composition of marshlands.

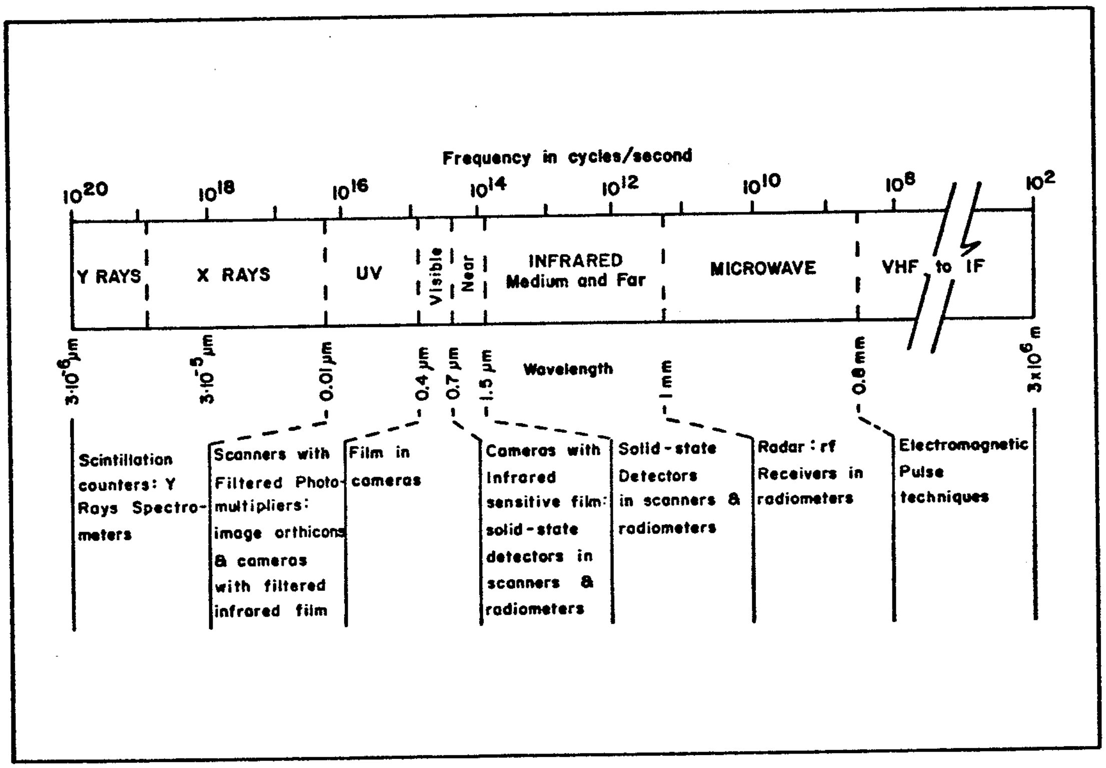

Figure 2. The electromagnetic spectrum and some sensors that image in it.

Olson (1964a), using black and white and colour aerial photography, was able to identify eleven wetland vegetative types in Maine. He suggested that a scale of 1:20,000 was adequate for broad ecological relationships but a scale of 1:15,000 or larger was necessary for identification of wetland species. His findings also showed that experience in wetland ecology was of more value than experience in air photo interpretation when it comes to accuracy of interpretation.

Parry and Turner (1971) found black and white infrared film very useful as a means of locating wetlands. Water appears characteristically black on infrared film because of its high absorption of solar radiation in the 700-900 millimicron range of the electromagnetic spectrum. Riemold et al. (1973) employed remote sensing techniques for identifying wetland plant communities and estimating primary production within a Georgia tidal marsh. Pestrong (1969) successfully tested multiband photography for the differentiation of vegetative types as an aid for the interpretation of geomorphology in the San Francisco Bay. Schneider (1968) considered colour aerial photographs well suited to water resource studies for monitoring and detecting changes in the hydrological regime of an area. Aerial multiband photography was successfully employed to inventory the marine coastal zone of New Jersey (Russell and Wobber 1972, Anderson and Wobber 1973). Marshlands in Nevada were evaluated using remote sensing imagery as a means of habitat inventory and quantification (Seher and Tueller 1973). Cowardin and Myers (1974) showed that multispectral aerial photography combined with limited ground truth produced specific signatures for the identification of wetland plant communities and plant species. Remote sensing imagery was utilized by Pakulak et al. (1973) to identify vegetation - landform units in a Canada goose nesting habitat study on part of the Hudson Bay coastal zone. Anderson (1969) investigated the feasibility of using imagery obtained from an aircraft for the analysis of water quality and marshland vegetation. He concluded that the characteristics of a marsh which are deemed important to waterfowl for food and protection such as reed (Scirpus sp.), cattail, three square (Scirpus americanus), yellow pond lily (Nymphoides peltatum) and wild rice (Zizania aquatica) are easily identified with Ektachrome infrared aerial photography.

Eyre (1971) recommended the combination of colour and colour infrared transparencies for estimating the loss of wetlands in Florida due to drainage for agriculture and industry. Olson (1964a) found no significant differences in interpretation accuracy of wetland vegetation between black and white and colour film. Seher and Tueller (1973) suggested that the colour film used by Olson (1964a) was inferior to the newer colour aerial film. Riemold et al. (1973) utilized Kodak Aerochrome infrared film 2443 for differentiation of wetland vegetative species. Pestrong (1969) also considered colour infrared imagery superior for interpretation of tidelands vegetation while normal colour photography was most useful for general interpretation. Because of its water depth penetration and excellent aquatic vegetation discrimination ability, colour film is ideal in water resource studies (Schneider 1968). Species differentiation by tonal contrast was more evident on colour infrared than on normal colour imagery (Anderson and Wobber 1973, Russell and Wobber 1972). According to Seher and Tueller (1973) plant identification was mapped most accurately by using colour and infrared photography simultaneously. For most marshland management problems they considered a scale of 1:10,000 adequate. Pakulak et al. (1973) were of the opinion that two types of colour infrared photography were best for detailed landform and vegetation analysis. Cowardin and Myers (1974) utilized black and white infrared, colour and colour infrared film to interpret twelve wetland plant communities and five aquatic species.

Anderson (1969) found colour film to be poor in the delineation of wetland plant communities. He felt that the sensitivity of this film to haze and the inability of filters to reduce this penetration resulted in the green tones of vegetation blending with each other thus causing poor species differentiation. While studying two species of wetland vegetation, pickerel weed (Peltandra virginica) and marsh salt grass (Spartina patans), Anderson (op. cit.) recorded rather large differences in their spectral reflectance curves in the near infrared while in the visible part of the spectrum these species were hard to differentiate. He indicated that this may also be true for other plant species and attributes these results as being indicative of the value of colour infrared photography in vegetative studies.

SUMMARY

The literature reviewed indicates the application of remote sensing techniques for the interpretation of wetland vegetation as well as for the habitat requirements and interactions between canvasback and redhead ducks. There has been very little research combining ecological studies of a specie or species with remote sensing. The intent of this study is to examine the nesting habitat preferences of two closely associated duck species with the use of remote sensing imagery. Canvasback and redhead nesting ecology will be studied in terms of eight gross physical habitat parameters. An analysis of these parameters will be undertaken to determine which factors within each parameter favor successful nesting. Data will be collected to assess the productivity of these species within the study area. A habitat interpretation key will then be developed for those parameters directly associated with canvasback and redhead nesting ecology.

This thesis has been divided into two parts, the first dealing with canvasback and redhead breeding ecology and the second with the application of remote sensing.

METHODS AND MATERIALS

STUDY AREA

The study area was located in southwestern Manitoba between the towns of Pilot Mound and Boissevain (Figure 3) approximately 176 km. (110 mi.) southwest of Winnipeg. This area was selected because it fell within the boundaries of the Canada Land Inventory (CLI) Land Capability for Waterfowl, Class 2 as described by Hutchison and Adams (1970). This habitat unit, class 2, was chosen because another waterfowl study utilizing remote sensing was in progress by the Canadian Wildlife Service comparing CLI classes 1 and 3 in western Manitoba and eastern Saskatchewan.

The region can be described as a mixed grass prairie that has been invaded by trembling aspen (Populus tremuloides). Light clay loam of the dark brown steppe and black earth transition zone, developed on glacial till, forms the dominant soil type (Ellis and Shafer 1943).

The topography is predominantly undulating with a few isolated rolling zones. Ponds or wetlands (natural depressions containing water part of, or throughout the year) are replenished by melting snow and rains. The 20 year average precipitation in the study area was 508

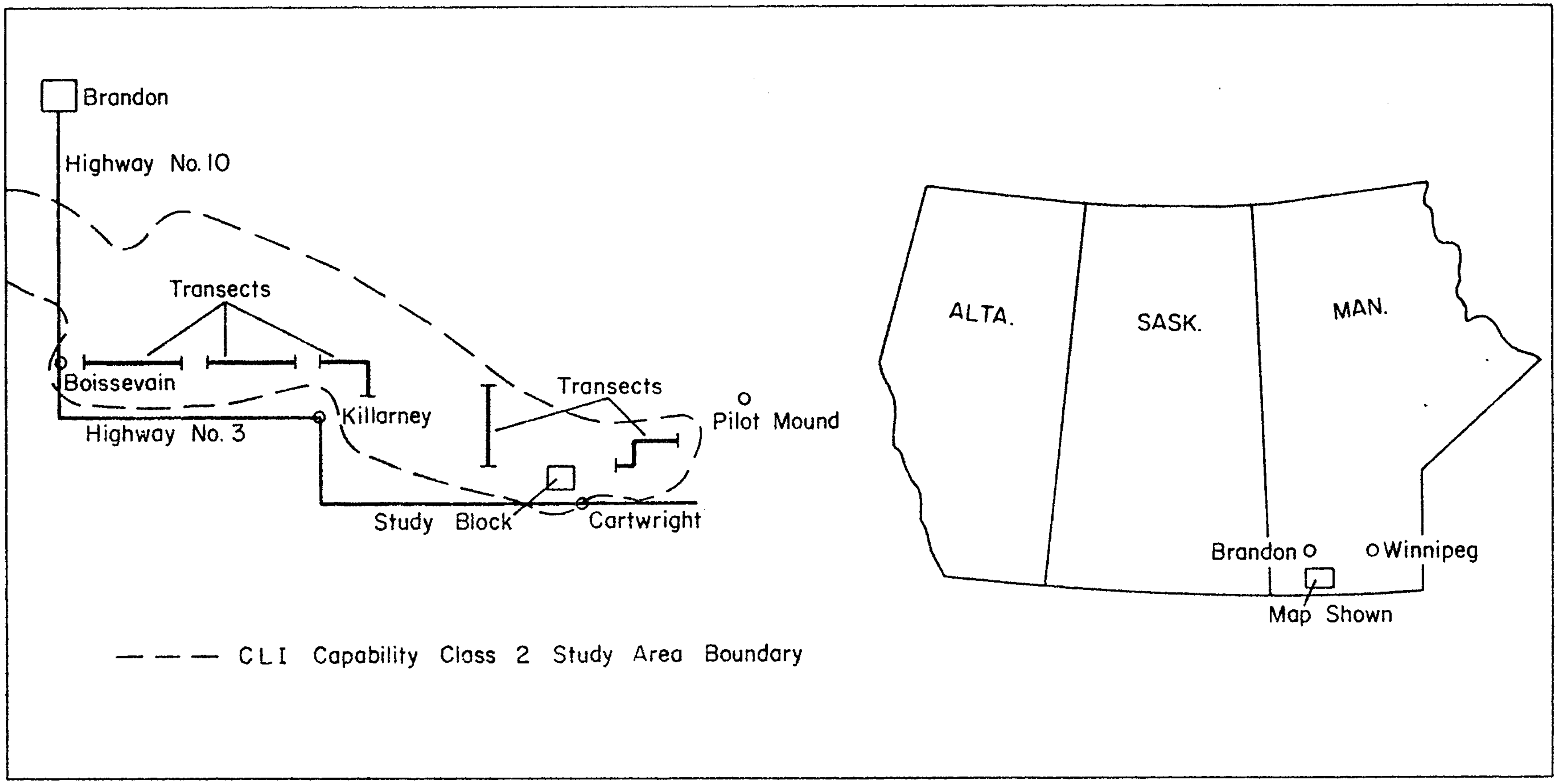

Figure 3. Location of study area, study block and transects.

mm. (19.9 in.) (Canada Department of Transport, Montly Record). Precipitation records between 1973-1975 for the towns of Boissevain, Killarney and Cartwright indicate above normal precipitation over the long term average (Table 2).

Field studies consisted of two components selected from CLI class 2; a study block, 6.4 km^2 (4 sq.mi.) in size located in township 2, range 15 west, composed of sections 10, 11, 14 and 15; and a series of 5 roadside transects totalling 46.4 km. (29 mi.) in length.

There was a total of 230 ponds on the study block ranging from 50 to 63 per 2.6 km^2 (sq.mi.). The total wetland area averaged 61 ha. (153 ac.) per section or 24%. Land use on the block was estimated as follows: wooded and open pasture, 205 ha. (512 ac.) (20%); land under cultivation, 737 ha. (1843 ac.) (72%); roads, road allowances and railway right-of-ways, 62 ha. (154 ac.) (6%); and farmyards, 20 ha. (51 ac.) (2%). Mixed farming predominates throughtout the region with cereal crops, flax, rapeseed and beef cattle being the most important agricultural products.

WATERFOWL BREEDING POPULATIONS

Surveys of duck breeding populations were scheduled to begin during the first week of May but inclement wet weather delayed the 1974 census until mid-May. Both the transects and the study block were surveyed on a regular basis through June. Because weather can affect visibility no census was conducted during periods of precipitation or when winds exceeded 23-32 km./hr.. Ducks observed during a census were sexed and categorized as either single, paired, grouped or flocked. An indicated breeding pair index for all species was developed by combining single males and pairs.

Table 2. Precipitation (mm.) and Temperature (°C) Records for Cartwright, Killarney and Boissevain

	Cartwright						Killarney					
	1973		1974		1975		1973		1974		1975	
	Temp. °C	Precip. mm.	Temp. °C	Precip. mm.	Temp. °C	Precip. mm.	Temp. °C	Precip. mm.	Temp. °C	Precip. mm.	Temp. °C	Precip. mm.
Jan.	-11	5.1	-21	38.1	-13	27.9	15	tr.	-19	35.6	-13	30.5
Feb.	-11	20.3	-16	61.0	-15	15.2	-10	6.4	-13	33.0	-14	8.9
Mar.	1	9.4	-11	30.5	-11	58.4	2	3.0	-9	11.4	-9	43.2
Apr.	3	32.8	2	64.5	1	97.3	3	22.1	2	72.6	1	97.3
May	11	59.2	8	119.4	11	50.3	12	84.1	8	86.9	11	40.1
June	17	75.9	17	68.1	17	62.2	17	97.8	18	31.8	17	99.8
July	18	59.4	21	17.0	22	33.8	18	56.0	21	38.4	-	-
Aug.	19	60.5	16	86.9	17	51.3	21	45.2	17	107.2	-	-
Sept.	12	100.1	10	20.8	12	76.7	12	86.4	11	13.2	12	101.1
Oct.	8	25.7	7	20.3	6	56.6	9	36.3	8	17.8	7	43.9
Nov.	-8	52.3	-3	10.2	-2	40.6	-8	36.8	-2	2.0	-2	31.8
Dec.	-15	56.4	-8	30.5	-13	32.3	-14	27.9	-7	2.3	-12	15.2
Total		557.0		567.2		602.7		512.1		472.2		511.8

Table 2. (Continued)

	Boissevain						Boissevain	
	1973		1974		1975		20 yr. average	
	Temp. °C	Precip. mm.	Temp. °C	Precip. mm.	Temp. °C	Precip. mm.	Temp. °C	Precip. mm.
Jan.	-10	1.8	-20	35.6	-13	29.5	-18	28.2
Feb.	-11	19.8	-13	43.2	-14	9.1	-13	15.5
Mar.	2	3.6	-9	13.2	-10	40.1	-8	26.4
Apr.	3	29.0	2	67.8	1	131.1	3	32.8
May	11	103.1	8	75.4	11	34.8	11	63.5
June	16	98.6	17	21.8	17	59.4	16	92.7
July	17	78.0	21	49.5	22	87.9	19	59.4
Aug.	19	71.6	16	97.8	17	65.5	18	73.2
Sept.	12	89.4	-	-	12	105.2	12	39.1
Oct.	8	38.9	8	13.2	7	45.0	6	29.5
Nov.	-8	33.0	-2	tr.	-2	37.3	-4	24.9
Dec.	-14	33.3	-7	26.7	-11	18.8	-12	22.1
Total		599.9		444.2		664.7		507.2

Source - Mr. K. Prokop, Atmospheric Environment, Wpg. (Pers. comm.).

Two different procedures were necessary for the study block and the roadside transects. A map of all ponds within the study block was developed from 1964 panchromatic aerial photography obtained from the National Airphoto Library, Ottawa. Each pond was annotated, 1-230, and waterfowl observed were recorded with their associated pond. Two observers on foot visited each pond. Care was taken to "follow down" all flushed ducks and thereby eliminate possible replication of counts. As canvasbacks and redheads were of prime concern, their presence and numbers were recorded first. Binoculars (7x35) were used for all field observations. Flushing of ducks was minimized when the total pond surface area could be observed at a distance but was inevitable where a treed or tall residual fringe blocked the view of the water. An average time period of five days was required to survey the study block each time.

For the roadside transects similar mapping procedures were followed to include all ponds that had greater than 50% of their area within 0.2 km. (1/8 mi.) on each side of the road. Individual ponds were annotated, in the field, only if they were completely visible from the roadside. Those not visible were excluded from the surveys. All observations were taken from a vehicle driven slowly with frequent stops to search the ponds and surrounding vegetation with binoculars or a 25x spotting scope. During the 1974 field season all transects were censused within a one day period. The 1975 censuses were restricted to late afternoon or early evening periods.

POND STUDIES

The study block contained a matrix of ponds and land use practices. In order to assess the value or quality of these ponds for canvasback and redhead nesting various parameters required quantification as well as characterization. Ground truthing or cover mapping continued from late May until early August with notes being kept throughout the growing season. Individual ponds were classified according to permanency, emergent vegetation type, size, cover type, woody fringe, nesting potential, associated land use and basin disturbance.

Permanency. Ponds were assigned to one of six permanency types developed from the pothole classification systems of Stewart and Kantrud (1969, 1971) and Shaw and Fredine (1956). Permanency type 6 was altered from Stoudt (1971).

The six permanency classifications are as follows:

Type 1 - Ephemeral ponds. Shallow bodies of water in very slight depressions with no defined shorelines, also referred to as sheetwater.

Type 2 - Temporary ponds. Wet meadow vegetation dominates central area of pond basin.

Type 3 - Seasonal ponds. Shallow marsh emergents dominate central area of pond basin.

Type 4 - Semi-permanent ponds. Deep marsh species dominate central area of pond basin. Contains a defined open water zone.

Type 5 - Permanent pond. Deepest ponds, containing water when all others dry up.

Type 6 - Man-made dugouts or stockponds. Can exist in an overflow condition and take on the characteristics of a Type 4 or Type 5 pond.

Emergent vegetation types. Wetland vegetation was broadly defined by the dominant emergents found growing within each basin. A series of emergent vegetation descriptions developed by Adams (personal communication 1973) were used to identify emergent species most commonly found growing together. The six emergent types employed are as follows:

R - reed marsh. Containing tall deep marsh emergents such as cattail, bulrush and, or phragmites (phragmites communis).

S - broadleaf sedge-reedgrass marsh. Containing sedges (Carex atherodes), whitetop (Scolochloa festucacea), mannagrass (Glyceria grandis) or any combination of these.

F - broadleaf forb-rush marsh. Containing shallow marsh emergents such as arrowhead (Sagittaria cuneata), water parsnip (Sium suave), water plantain (Alisma triviale), smartweed (Polygonum sp.), burreed (Sparganium eurycarpum) or spikerush (Eleocharis palustris).

M - grass-rush meadow. Containing wet meadow vegetation such as narrow leaved sedges (Carex sp.), wild barley (Hordeum jubatum), northern reedgrass (Calamogrostis inexpansa), slough grass (Beckmannia szigachne), saltgrass (Distichlis stricta) or baltic rush (Juncus balticus).

H - herb-grass meadow. Containing wet meadow vegetation, in a disturbed condition, dominated by herbs such as dock (Rumex sp.), marsh ragwort (Senecio congestus), sowthistle (Sonchus arvensis), Canada thistle (Cirsium arvense), goosefoot (Chenopodium sp.), aster (Aster sp.), cinque-foil (Potentilla anserina) and grasses. Ponds disturbed by having brush or tree piles pushed into their center soon become vegetated by these species.

W - willows (Salix sp.), where they've become part of the wetland or are associated with any of the above types.

It was found that some ponds could not be adequately described by only one symbol and a maximum of up to 3 combinations proved sufficient. An example of the use of this system would be as follows: a pond containing a cattail and willow intermixed fringe encompassing an inner sedge zone would be described as a - WRS. A total of 16 different combinations described all of the ponds found within the study block.

Submergents growing in open water zones of ponds were identified (Hotchkiss 1967) and recorded.

Pond size: Pond areas, in hectares, were measured directly from 1975 aerial photographs with the use of an automatic planimeter (Manitoba Center for Remote Sensing). All ponds were separated into five size classes (Stoudt 1971; Smith 1971):

1. .04 - .22 ha. (.1-.5 ac.)
2. .23 - .42 ha. (.6-1.0 ac.)
3. .43 - .83 ha. (1.1-2.0 ac.)
4. .84 - 2.0 ha. (2.1-5.0 ac.)
5. greater than 2.0 ha. (>5.0 ac.)

Cover type: This classification system compares the extent of emergent vegetative cover to open water or dry ground. There are 4 categories based on cover interspersion in natural ponds as described by Stewart and Kantrud (1971):

Cover type 1 - closed stands of emergents with openings covering less than 5% of the pond area.

Cover type 2 - open water or bare soil covering 5 to 95% of the pond area with scattered dense patches or diffuse open stands of emergents.

Cover type 3 - central expanse of open water or bare soil surrounded by bands of emergent vegetation, averaging

2 meters (6 ft.) or more in width.

Cover type 4 - open water or bare soil covering more than 95% of the pond area.

Peripheral woody fringe. The percentage of shoreline of each pond bordered by tree and, or shrub growth was estimated while cover mapping and later rechecked on aerial oblique photographs that had been taken in May, 1974. Each value was assigned to 1 of 3 categories as described by Stoudt (1971):

Open - less than 25% woody growth.

Half open - 25 to 75% woody growth.

Closed - greater than 75% woody growth.

Nesting potential. Sugden (1972) and Olson (1964b) assigned nesting potential values to ponds as a means of assessing habitat quality for over water nesting ducks. Criteria for assigning nesting potential values for each pond were based on published descriptions of nesting habitat for canvasbacks and redheads by Stoudt (1971), and Lokemoen (1966). Factors considered were the species, amount and density of emergents, and the size and permanency of each pond. The five subjective ratings developed by Sugden (1972), reinforced by the author, and utilized in this study are:

Nil - no emergent cover suitable for nesting, lack of standing residual vegetation. Ephemeral or temporary ponds generally fall into this category. Also included are ponds that have been burned, hayed, plowed, filled, excessively grazed or trampled.

Poor - Flooded willows, sparse sedge or whitetop. Usually temporary or seasonal ponds or those affected by basin disturbance.

Fair - flooded willows mixed with sedges or grasses. Seasonal ponds with dense patches of sedge or small stands of relatively dense whitetop fall into this classification.

Good - seasonal or more permanent ponds containing small clumps of cattail, bulrush or extensive whitetop stands.

Excellent - semi-permanent or permanent ponds preferably less than 2 ha. (5 ac.) in size with dense stands of residual cattail or bulrush. Larger ponds could be included providing they contained intermittent small pools of open water within extensive dense stands of cattail or bulrush.

Land use and basin disturbance: The dominant land use or land management practice surrounding each pond was recorded as: cultivated land which included stubble, summerfallow or growing crops; grazed grassland including pasture interspersed with aspen groves; and ungrazed grassland.

Land use practices adversely affecting the quality of a pond basin were also monitored. Any one or a combination of the following disturbances were thought to make a pond undesirable for over water nesting ducks:

- mowed emergent vegetation during the previous late summer or fall.
- burning of vegetation during the fall or spring.
- grazing and trampling of emergents by livestock, destroying the density of standing residual vegetation.
- pond drainage resulting in the loss of habitat.
- pond filling, reducing permanency and destroying cover.
- plowing of pond basin removes cover and reduces pond permanency.

NESTING STUDIES

Intensive nest searches were carried out on the block aimed at locating as many of the canvasback and redhead nests as possible. Nest searches were initiated by mid-May and continued as long as new nests were being found. Two observers and a black labrador retriever searched all emergent vegetation located within wet pond basins. The dog was a valuable asset as she increased the efficiency of nest searches. Most nests were located by flushing a hen from cover or by observing a hen swimming out of cover into the center of the pond. Lone canvasback or redhead pairs observed on ponds under 2 ha. (5 ac.) during the breeding pair surveys were good indicators of ponds possibly containing nests.

Upon arrival at the nest site care was taken not to disturb the surrounding vegetation any more than necessary. Whenever possible nests were approached by wading from the open water so as not to make trails directly to the nest. If approach was through vegetation, care was taken to straighten and replace broken or displaced plants in order to cover any trails that a predator might follow. When leaving, all eggs within the nest were covered over by nest materials and down.

Data collected for canvasback and redhead nest were recorded on a waterfowl nest form developed for this study. The following information was collected:

- concealment vegetation - the dominant vegetation in which the nest was found.
- permanency, woody fringe, emergent vegetation type, nest potential of pond and basin disturbance.
- species incubating the nest.
- total number of eggs at that date.

- down-presence, absence and amount lining the nest.
- number of canvasback eggs and/or number of redhead eggs in a nest. Canvasback and redhead eggs exhibited differences in colour and size (Bellrose 1976).
- age of the eggs or stage of incubation. This was obtained by floating a couple of the eggs in the pond water beside the nest. The level at which a particular egg or eggs floated indicated how long they had been incubated as described by Westerskov (1950).
- number of eggs hatched. Data on the number of eggs hatching and not hatching were recorded for each nest incubated to term.
- predation. For each destroyed nest an attempt was made to identify the predator responsible. By examining the condition of the egg shell fragments and the nest structure coupled with Rearden's (1951) key, a nest predator was usually identified.

A nest search on a 3.2 km. (2 mi.) section of each transect during the first week of July 1975 was conducted. This was designed to assess the effects of human interference as related to predation rates and to determine nest density on the transects. Only those ponds monitored for breeding pairs were included in this nest search.

BROOD STUDIES

To determine productivity estimates for an area, several factors need to be know: a) breeding population i.e. number of indicated pairs; b) the percentage of those pairs that nested; c) the percentage of successful nests; d) the average brood size leaving the nest; e) the average number of juveniles fledged. This provides the basis for calculating the number of ducks produced per square kilometer of habitat or per nesting pair.

In order to monitor attrition of broods from successful nests it was necessary to mark them in some way. Female redheads and canvasbacks whose nests were still active after the third week of incubation were nest-trapped (Weller 1957) and nasal saddled (Sugden and Poston 1968) with numbered polyvinyl-chloride plastic strips for identification purposes. In addition a standard leg band was affixed to each bird. As long as the female remained with her brood and they could be located, juvenile mortality rates were recorded.

Hochbaum's (1944) and Southwick's (1953) descriptions of canvasback and redhead ducklings aided in distinguishing between downy ducklings of both species. Age estimates of ducklings were measured by employing the system proposed by Gollop and Marshall (1954).

All active canvasback and redhead nests prior to hatching were visited a day or two after the estimated date of hatching. All eggs were accounted for and their fate recorded.

Brood beatouts of all ponds containing water on the block were incorporated with late nest searches. These beatouts lasted until mid-August. Two persons and a dog started at one end of a pond, zig-zagged through the vegetation and met at the other end of the pond (Blankenship et al. 1953). All broods observed by this method were recorded.

To allow for the high mobility of canvasback and redhead broods (Evans et al. 1952) a 0.4 km. (0.25 mi.) buffer zone beyond the block was intermittently searched for dispersed saddled hens and broods.

Transect brood surveys were being conducted concurrently at weekly intervals. During 1974 surveys were carried out within a 1 day period, while in 1975, roadside surveys for broods were reserved for calm sunny evenings between 1800 and 2100 hrs.

Car door slamming or the honking of the car horn were employed to bring the canvasback and redhead broods out of cover in open ponds.

For all brood surveys whether beatouts or roadside transects the following data were recorded:

1. Number of ducklings per brood.
2. Species of each duckling where possible to distinguish.
3. Estimated age of ducklings.
4. Pond location.
5. Presence or absence of brood female.

REMOTE SENSING

Airborne imagery of the study block and transects was obtained on two flights - July 18, 1974, and July 25, 1975, between the hours of 900 and 1100 hrs. A Piper Apache aircraft equipped with a camera port was subchartered from the Canadian Wildlife Service. Photography in 1974 consisted of Ektachrome (colour) and Aerochrome (colour infrared) film while photography in 1975 was supplemented with black and white film. Specifications of these photographic missions are detailed in Table 3. All photographs were taken at an altitude of 1958.4 ± 17 m. above sea level using 70 mm Hasselblad 500 EL cameras (80 mm. focal length). Photo coverage was such as to provide 60% overlap between succeeding photographs to enable stereoscopic viewing. Photography was carried out by Mr. Garry Gentle, wildlife technician, Canadian Wildlife Service, Saskatoon, Saskatchewan. Processing of all exposed film was done by the National Airphoto Reproduction Center, Ottawa, Ontario. All film was processed as continuous strip transparencies.

Table 3. Film and Filter Specifications and Combinations Used in Aerial Photography of Wetland Investigations in Southwestern Manitoba.

Date	Scale	Camera	Film type	Filter	Exposure
7/18/74	1:15,840	1	Kodak Aerocolor (negative) 2445	HZ	f8-11/500 sec.
		2	Kodak Aerochrome Infrared 2443	W12 + CC20M	f5.6/500 sec.
7/25/75	1:15,840	1	Kodak Plus-X Aerographic 2402	W25A	f5.6-8/500 sec.
		2	Kodak MS Ektachrome Aerographic 2448	HZ	f4/500 sec.
		3	Kodak Aerochrome Infrared 2443	W12 + CC20M	f5.6/500 sec.

In addition, a series of 35mm oblique aerial photographs were taken throughout both field seasons from a Cessna 172 aircraft. Kodachrome 25 film plus a polarizing filter were employed.

IMAGERY ANALYSIS

The transparencies were stereoscopically viewed under various magnifications and the two power magnification was found most acceptable for the interpretation of wetland components. Those features or components under investigation in this study were: wetland size, dominant vegetative species, degree of open water, wetland permanency, woody fringe and agricultural disturbance factors. Wetland size was determined with the use of an electronic planimeter. The other features were tested for interpretability from the available photography with added information obtained through ground truthing. The several basic elements which aided in image interpretation were: size, shape, shadow, tone or colour, texture, pattern, site, association and resolution (Estes and Simonett 1975). The object of this analysis was to develop a descriptive photographic key of habitat components related to canvasback and redhead nesting ecology.

RESULTS AND DISCUSSION - PART 1

ASSESSMENT OF STUDY BLOCK HABITAT

Pond Studies

Mean pond density was 57.5 per 2.6 km^2 (mi^2) on the four sections and 50 per 2.6 km^2 on the five roadside transects. The lower pond density on the transects was probably due to the inclusion of only those ponds totally visible from the road; some transects extended into areas of a lower CLI capability class.

Pond size distribution by section on the study block is shown in Table 4. The average number of ponds in each size class was 46. This indicates relatively good dispersion of ponds in all size categories. Sixty-four percent of the ponds were .83 ha. (2 ac.) or less in size.

Overall habitat quality is best shown by pond permanency distribution (Table 5). Seventy-three percent of the ponds were considered as seasonal (permanency type 3) while only 9% were found to be semi-permanent (permanency type 4). There were no permanent ponds (permanency type 5) on the study block. Section 11 appeared to contain a better interspersion of pond permanency types than the other sections. According to Hutchison and Adams (1970), the limitations of this region are due to less than ideal distribution of wetlands and adverse topography which limits the development of permanency in ponds. This is an important factor in this study as canvasbacks and redheads have shown a preference for nesting on the more permanent ponds, (Stoudt 1974, Olson 1964b, Low 1945 and Lokemoen 1966).

Table 4. Distribution of Ponds by Size Class (ha.) and Section.

	Section					
Size Class	15	14	11	10	Total	% Distribution
.04-.22	12	10	6	17	45	20
.23-.42	7	12	8	16	43	19
.43-.83	18	15	13	13	59	26
.84-2.0	12	6	20	14	52	22
> 2.0	10	7	11	3	31	13
Total	59	50	58	63	230	100
%	26	22	25	27	100	

Table 5. Distribution of Ponds by Permanency and Section.

	Pond Permanency							
Section	1	2	3	4	5	6	Total	% Distribution
15	1	12	39	6	0	1	59	26
14	0	13	33	2	0	1	50	22
11	1	9	36	11	0	1	58	25
10	2	7	52	1	0	0	63	27
Total	4	41	162	20	0	3	230	100
%	2	18	70	9	-	1	100	

Pond permanency and its relationship to pond size is summarized in Table 6. The less permanent ponds dominate the smaller size classes, .83 ha. and less, whereas the more permanent ponds tend to be larger in size. Eighty percent of type 2 ponds were .42 ha. (1 ac.) or less in size, 64% of type 3 ponds were .83 ha. (2 ac.) or smaller while 95% of type 4 ponds were larger than .83 ha. (2 ac.) in size. This would normally have been expected as pond permanency is correlated to pond size (Millar 1971).

The largest number of ponds occurred in the open category classification 1 of woody fringe, that is those ponds whose perimeter was bounded by 25% or less woody vegetation (Table 7). Ponds located in pastureland consistently had a greater proportion of their perimeters treed (those in the half-open (2) and closed (3) categories) than ponds located in cultivated areas. Section 10, where 46% of the ponds were located in pasture land, had only 30% of the ponds denoted as open. Section 11 had 9% of its ponds in pasture land and conversely 86% of the ponds were considered open. The projection that wetlands located within cultivated areas are susceptible to man-induced alterations such as the removal of a woody fringe is substantiated.

Seventy-seven percent of the ponds within the study area were located in cultivated land while the remaining 23% were surrounded by pasture land (Table 8). Section 10 contained the most proportionate distribution between the two land use practices while the majority of ponds on section 11 were encompassed by cultivated fields.

Man-induced disturbances affected 49% of all wetlands within the study block (Table 9). Livestock grazing, mowing, burning and filling were the dominant disturbances. No ponds were affected by drainage. Seventy-two percent of the ponds on section 14 were disturbed while 31%

Table 6. Distribution of Ponds by Size Class (ha.) and Permanency.

	Pond Permanency							
Size Class	1	2	3	4	5	6	Total	% Distribution
.04-.22	2	23	20	0	0	0	45	20
.23-.42	2	8	33	0	0	0	43	19
.43-.83	0	6	52	1	0	0	59	26
.84-2.0	0	4	38	10	0	0	52	22
> 2.0	0	0	19	9	0	3	31	13
Total	4	41	162	20	0	3	230	100
%	2	18	70	9	-	1	100	

Table 7. Distribution of Ponds by Section and Woody Fringe.

	Woody Fringe				
Section	1	2	3	Total	% Distribution
15	37	11	11	59	26
14	28	10	12	50	22
11	50	7	1	58	25
10	19	27	17	63	27
Total	134	55	41	230	100
%	58	24	18	100	

Table 8. Distribution of Ponds by Land Use and Section.

	Land Use			
Section	Cultivation	Pasture	Total	% Distribution
15	43	16	59	26
14	44	6	50	22
11	55	3	58	25
10	36	27	63	27
Total	178	52	230	100
%	77	23	100	

Table 9. Distribution of Ponds by Man-induced Disturbance.

	Disturbance								
Section	Burning	Filling	Grazing	Drainage	Mowing	Plowing	Total	Undisturbed	% Disturbed
15	2	21	7	-	0	0	30	29	51
14	21	1	6	-	4	4	36	14	72
11	0	0	3	-	15	0	18	40	31
10	0	0	20	-	9	0	29	34	46
Total	23	22	36	-	28	4	113	117	
%	10	10	15	0	12	2	49	51	

on section 11 were affected. The effects of grazing were most evident on the shallower, seasonal and temporary ponds. Forbs, sedges, whitetop and mannagrass were grazed more extensively than either cattail or bulrush. The effects of pond filling were considered most disastrous in terms of irreversible damage to wetland habitat. When pushed into the central regions of wetlands tree and brush piles tend to reduce pond permanency and attractiveness to waterfowl, especially canvasback and redhead ducks (Stoudt 1971).

Sixteen different combinations of wetland vegetation were recorded (Table 10). The willow sedge type (WS) comprised the greatest frequency, 47 or 20%. Twenty-nine percent of the ponds contained cattail and/or bulrush (R). The broadleaf sedge - reedgrass complex (S) was evident in 75% of all wetlands while the broadleaf forb - rush marsh intermix (F) was found in 46%. Willows (W) were present in 33% of the wetlands.

On the study block 123 of 230 (53%) ponds were rated 'Fair', 'Good', or 'Excellent' for overwater nesting potential (Table 11). The highest rated ponds occurred on sections 11 and 15 while the poorest were found on sections 10 and 14. Sugden (1978) suggested that permanency was an important factor for higher pond nest potential ratings. Both sections 11 and 15 had a far greater number of wetlands rated semi-permanent than those on sections 10 or 14 (Table 5). The majority of ponds rated 'Nil' and 'Poor' were found in the smaller pond size classes of .42 ha. (1 ac.) and less (Table 12). Ponds rated 'Fair' dominated the .43-2.0 ha. (1.1-5.0 ac.) size classes. Those ponds rated 'Good' were more equally distributed in all size classes except the .04-.22 ha. (0.1-0.5 ac.) size class. A strong positive correlation

Table 10. Distribution of Ponds by Emergent Vegetation Types.

Emergent Vegetation Type[1]	Ponds No.	Ponds Percent
R	7	3
RS	20	9
RF	14	6
RSF	15	6
RSH	5	2
WS	47	20
WRS	6	3
WSF	25	11
SF	36	16
F	16	7
S	18	8
H	12	5
WF	1	-
WM	2	1
W	2	1
D	4	2
Total	230	100

[1]R - reed marsh
S - broadleaf sedge-reed grass
F - broadleaf forb - rush marsh
H - herb-grass meadow
W - willows
M - grass - rush meadow
D - drawdown

Table 11. Distribution of Ponds by Nesting Potential and Section.

	Nesting Potential					
Section	NIL	POOR	FAIR	GOOD	EXCELLENT	Total
15	5	17	23	14	0	59
14	9	12	21	8	0	50
11	12	11	13	16	6	58
10	6	35	18	4	0	63
Total	32	75	75	42	6	230
%	14	33	33	18	3	101[1]

[1]due to rounding.

Table 12. Distribution of Ponds by Nesting Potential and Size Class (ha.).

Size Class	NIL	POOR	FAIR	GOOD	EXCELLENT	Total
.04-.22	14	23	6	2	0	45
.23-.42	7	17	9	10	0	43
.43-.83	4	23	24	8	0	59
.84-2.0	4	8	21	14	5	52
> 2.0	3	4	15	8	1	31
Total	32	75	75	42	6	230

was evident when grouping ponds rated 'Fair', 'Good' and 'Excellent' as pond size increased (Figure 4).

Pond distribution in terms of permanency and nesting potential is depicted on Table 13. Those ponds rated 'Nil' and 'Poor' dominated permanency class 1 and 2 (ephemeral and temporary). The seasonal permanency class (type 3) contained a more equal distribution of ponds rated 'Poor', 'Fair' and 'Good'. The ponds considered as semi-permanent (type 4) were dominated by 'Good' and 'Excellent' nesting potential ratings.

Summary

Wetlands were well distributed in all size classes but not so in terms of permanency ratings. Only 9% were considered as semi-permanent and none were rated as permanent. Wetlands located in pasture land exhibited a higher proportion of woody fringe development than those located in cultivated fields. Wetland disturbance in the form of encroachment on pond fringes by the removal of the woody fringe occurred extensively on ponds located in cultivated fields. Almost half of the wetlands found on the study block suffered from some type of man-induced alteration. The highest frequency of ponds (20%) was labelled with the willow-broadleaf sedge-reedgrass vegetation type. Cattail and/or bulrush occurred in 29% of all ponds while the broadleaf sedge-reedgrass complex was an associate in 75% of the wetlands. Twenty-one percent of the wetlands on the study block were assessed as providing favourable canvasback and redhead nesting potential, i.e. those rated as 'Good' or 'Excellent'.

Wetland habitat quality on the study block was not optimum for canvasback and redhead ducks due to the following conditions: poor

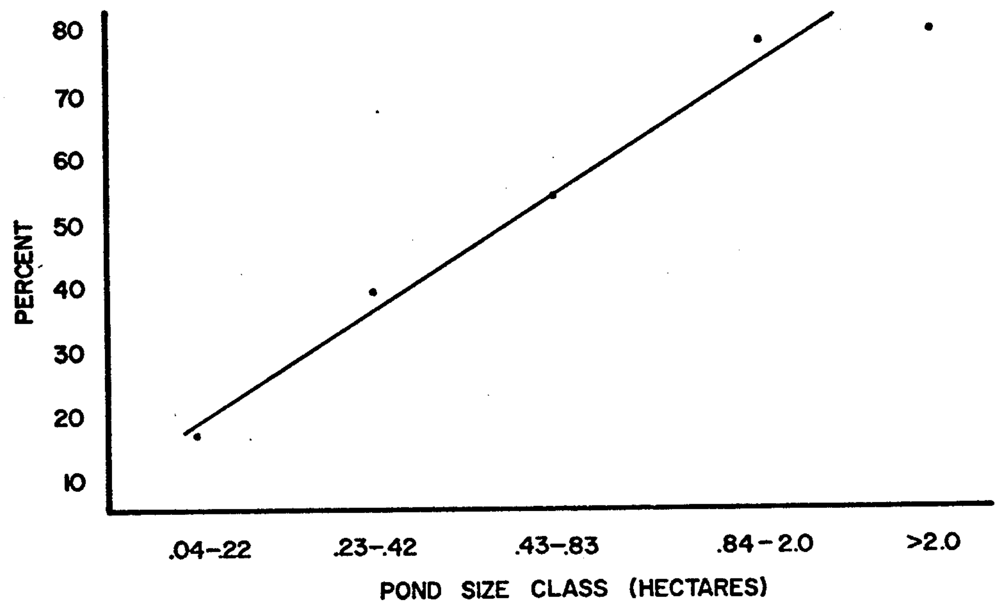

Figure 4. Percent occurrence of ponds rated 'Fair, Good and Excellent' within pond size classes (data from Table 11).

Table 13. Distribution of Ponds by Nesting Potential and Permanency.

	Nesting Potential					
Permanency	NIL	POOR	FAIR	GOOD	EXCELLENT	Total
1	4					4
2	25	16				41
3	3	58	71	30		162
4			3	11	6	20
5						
6		1	1	1		3
Total	32	75	75	42	6	230

interspection of semi-permanent and permanent ponds and a shortage of dense stands of residual emergent vegetation.

BREEDING DENSITIES, NESTING SUCCESS AND BROOD PRODUCTION

Canvasback and Redhead Breeding Densities

Canvasback breeding densities on the study block ranged from 2.50 indicated pairs per 2.6 km^2 (mi^2) in 1974 to 4.50 pairs in 1975. The roadside transect data yielded results of 3.86 indicated pairs in 1974 and 3.45 pairs in 1975. Breeding density levels for canvasbacks seemed to be most consistent for data obtained in early to mid-May (Table 14).

Mean redhead breeding densities were slightly higher than for canvasbacks. There were 3.50 redhead pairs on the study block in 1974 and 4.00 pairs per 2.6 km^2 in 1975. Redhead populations were slightly higher on the roadside transects, 4.00 pairs per 2.6 km^2 in 1974 and 4.62 pairs in 1975. It was found that the redhead breeding population levels were more reliable in late May to early June. Redheads are generally slower in their migration than canvasbacks (Bellrose 1976).

On the entire study area, canvasback breeding densities increased from 3.18 pairs per 2.6 km^2 in 1974 to 3.97 pairs in 1975. Redhead breeding densities also increased from 3.75 pairs to 4.31 indicated pairs per 2.6 km^2. The ratio of canvasback pairs to redhead pairs was 1:1.18 in 1974 and 1:1.07 in 1975.

The United States Fish and Wildlife Service, in conjunction with the Canadian Wildlife Service, conduct yearly surveys on selected transects throughout the prairie provinces to estimate waterfowl breeding populations. Over a 15 year period, an average breeding pair index of 3.73 and 3.39 per 2.6 km^2 for canvasbacks and redheads, respectively, were found on a 13.6 km. (8.5 mi.) transect near Boissevain, Manitoba.

Table 14. Canvasback and Redhead Breeding Densities. (Indicated pairs[1]/2.6 km^2)

	1974			1975	
Survey Period	Canvasback	Redhead	Survey Period	Canvasback	Redhead
		Study Block			
May 16-25	2.50	6.25	May 6-9	4.25	2.50
May 26-June 4	2.50	3.50	May 13-16	5.00	1.50
June 17-24	1.25	4.00	May 21-24	4.50	2.75
			June 10-17	0.25	3.50
		Roadside Transects			
May 15	3.86	4.70	May 5-8	3.45	3.17
May 27	2.76	3.30	May 14-17	3.45	4.00
June 5	5.52	4.80	May 19-20	4.12	4.41
June 20	1.24	3.40	May 30-June 3	3.31	4.83
			June 17-21	2.34	4.41

[1]no. of single males plus pairs.

The ratio of canvasback pairs to redhead pairs was 1:1.15.

Dzubin (1969) stated that the optimum method for determining diving duck breeding populations was through a nest study. He felt that the large home ranges of these species, the congregation of lone males and pairs on deep ponds and the distorted sex ratios in all divers under estimated density of breeding birds on a study area.

Homing

Marked canvasback females exhibited a strong tendency to return to the same breeding area. Of the 10 adult canvasback females marked during the 1974 breeding season, 8 (80%) returned in the spring of 1975. Trauger and Stoudt (1974) recorded a strong homing instinct among adult canvasback females (75% returning), but not for redhead females. Only 2 of the 5 female redheads nasal saddled returned the following spring. Weller and Ward (1959) recorded very low return rates for hand-reared juvenile redheads.

Two of the 8 marked canvasback females utilized the same ponds for nesting in both 1974 and 1975. One female even went so far as to rebuild her previous years nest on the same site. Both females had been successful in their nesting attempts on those ponds during 1974. Both returning redhead females also selected the same ponds for nesting that had been successful on the previous year.

Nest density

A total of 33 canvasback and 20 redhead nests were located within the study block over the 2 nesting seasons. It was assumed that all canvasback and redhead nests were found.

Canvasback hens initiated 19 nests in 1974 and 14 nests in 1975. Eight of these in 1974 and 3 in 1975 were renesting attempts. This data indicated nest densities of 1.06 per km^2 ($2.75/mi^2$) for both years.

All canvasback pairs on the study block initiated a nest in 1974 while approximately 41% attempted nesting in 1975. Trauger and Stoudt (1974) and Olson (1964b) found that the urge to breed was weaker in yearling canvasbacks than in adults. Trauger and Stoudt (1974) found this especially true when habitat conditions in southwestern Manitoba were poor during the 1973 breeding season. Improved habitat conditions in 1974 within this study area could have been responsible for a higher incidence of nesting among canvasbacks.

Redhead data were difficult to analyze due to their erratic nesting behaviour - late migration and varying degrees of parasitism. Nine nests were located in 1974 and 11 in 1975. One nest in 1974 and 2 nests for 1975 were renesting attempts. Redhead nest density was $0.77/km^2$ ($2.0/mi^2$) for 1974 and $0.87/km^2$ ($2.25/mi^2$) for 1975.

Approximately 44% of the indicated redhead pairs on the study block initiated nests in 1974 and 45% attempted nesting in 1975. Weller (1959) concluded that only half of the redhead pairs he studied attempted to nest. He found redhead females to be involved in three types of egg-laying behaviour: normal; semi-parasitic - laying eggs in other nests and also incubating their own clutches; and parasitic - only laying eggs in other nests.

Redhead parasitism and clutch size

Redhead parasitism of canvasback nests was extensive. Of the 33 canvasback nests found on the study block plus the 7 nests recorded on a 16 km. (10 mi.) portion of the transects, 22 (55%) contained redhead eggs. Trauger and Stoudt (1974) reported that redheads parasitized 57%

of the canvasback nests in the Minnedosa pothole district. The average clutch size for 13 unparasitized canvasback nests was 7.2 eggs while the number of eggs per parasitized canvasback nest was 4.8 eggs for 22 nests (an average decrease of 2.4 eggs per canvasback nest). Several other studies (Table 15) recorded an average canvasback clutch size of 8.2 eggs per nest and 7.0 eggs per parasitized nest. The authors found reductions ranging from 0.7-2.2 canvasback eggs per nest due to redhead parasitism.

It was difficult to determine normal clutch sizes for redheads due to the degree of intraspecific parasitism among redhead females (Bellrose 1976). In 24 redhead nests examined, an average clutch size of 8.7 eggs per nest was recorded. The average clutch size determined by several other studies was 10.8 eggs per redhead nest ranging from 8.6-13.5 (Table 15). Redhead females deposited an average of 4.2 eggs per parasitized canvasback nest. Hochbaum (1944) found an average of 3.7 redhead eggs in 38 canvasback nests on the Delta marsh.

Nest success, predation and desertion

Canvasback nesting success was low for both years of this study (Table 16). A successful nest was one that produced at least 1 hatched young.

The greatest cause of nest loss was due to predation. Twenty of 33 canvasback nests (60%) were predated. This ranged from 63% in 1974 to 57% in 1975. The raccoon was the dominant predator and deemed responsible for destroying 18 of 20 predated canvasback nests. Two canvasback nests were destroyed by unidentified predators. One nest each year was deserted. Olson (1964b) and Stoudt (1974) attributed the majority of canvasback nest losses to the raccoon. Several other avian

Table 15. Canvasback and Redhead Clutch Size Data.

Canvasback		Redhead	
Mean no. of eggs/ unparasitized nest	Mean no of canvasback eggs/ parasitized nest	Mean no. of eggs/nest	Author
7.5	5.9	-	Sugden (1978)
9.9	7.7	11.4	Erickson (1948)
-	7.7	-	Olson (1964b)
8.0	7.3	-	Stoudt (1974)
8.0	6.6	10.8	Weller (1959)
8.0	-	10.1	Keith (1961)
7.7	-	10.0	Smith (1971)
-	-	8.6	McKnight (1974)
-	-	10.1	Lokemoen (1966)
-	-	12.5	Willaims and Marshall (1938)
-	-	9.8	Low (1945)
-	-	13.5	Wingfield (1951)
7.2	4.8	8.7	This study
8.0	6.7	10.8	Mean for all studies

Table 16. Fate of Canvasback and Redhead Nesting Attempts on the Study Block.

	Canvasback			Redhead		
	1974	1975	Total	1974	1975	Total
Nests initiated	19	14	33	9	11	20
No. predated	12	8	20	3	4	7
No. deserted	1	1	2	1	4	5
No. successful	6	5	11	5	3	8
% success	32	36	33(Ave.)	56	27	40(Ave.)

and mammalian predators were observed on the study area: common crows (Corvus brachyrhynchos), red-tailed hawks (Buteo jamaicensis), coyotes (Canis latrans), red foxes (Vulpes vulpes), striped skunks (Mephitis mephitis) and mink (Mustela vison).

Redhead nesting success varied greatly between each year of this study. Fifty-six percent nesting success was recorded in 1974 while it dropped drastically to 27% in 1975 (Table 16). Predation rates remained relatively constant, 33% in 1974 and 36% in 1975. The raccoon was responsible for all redhead nest losses.

Desertion rates were much higher among redheads than canvasbacks. Six percent of all canvasback nests were deserted while 25% were deserted by redheads. The desertion rate varied between the two years of this study, from 11% in 1974 to 36% in 1975. This increase in nest desertion in 1975 had a significant impact on the decline in nest success in that year. The overall high desertion rate by redhead females was probably due to the intraspecific parasitism of other redheads and declining water levels in July of 1975. Olson (1964b) and Low (1945) suggested that most nest desertions by redhead hens were attributed to the intrusion of parasitic redheads. Redhead females showing a general lack of broodiness had contributed to high desertion rates according to Lokemoen (1966). Weller (1959) was of the opinion that a low nesting drive was responsible for a large number of redhead nest desertions.

Hatchability

Hatchability of the eggs laid in 11 successful canvasback nests over the 2 year period was 59% (Table 17). Low hatchability rates for 1974 (43%) were partly attributable to the low proportion of redhead

Table 17. Canvasback and Redhead Clutch Size Composition and Hatching Success on the Study Block.

	Nest Data					
	Canvasback			Redhead		
	1974	1975	2 year Ave.	1974	1975	2 year Ave.
No. of successful nests	6	5	5.5	5	3	4
Total no. of eggs incubated	51	34	42.5	50	28	39
No. of canvasback eggs	39	21	30	-	-	-
No. of redhead eggs	12	13	12.5	50	28	39
No. of eggs/nest	8.5	6.8	7.7	10.0	9.3	9.8
Total no. of hatched young	22	28	25	41	17	29
No. canvasbacks hatched	20	20	20	-	-	-
No. redheads hatched	2	8	5	41	17	29
No. hatched/nest	3.6	5.6	4.5	8.2	5.7	7.3
No. canvasbacks hatched/ nest	3.3	4.0	3.6	-	-	-
No. redhead hatched/nest	.3	1.6	.9	8.2	5.7	7.3
% hatchability	43	82	59	82	61	74
% hatchability can. eggs in can. nests	51	95	67			
% hatchability red. eggs in can. nests	1	61	40			

eggs in canvasback nests hatching for 1974 (17%) as opposed to 1975 (62%). Hatchability of canvasback eggs in canvasback nests in 1975 was 51% and 95% in 1975. Stoudt (personal communication 1975) found high embryo mortality in many canvasback nests. He suggested the extreme interference by parasitic redheads to be responsible for low hatchability.

Since a high number of unhatched eggs (60% in 1974) were bacterially contaminated, it is possible that the floating method for aging eggs (Westerskov 1950) may have caused high embryo mortality. This prompted a series of laboratory experiments to investigate bacterial contamination by egg dipping. The experiments and their results are contained in Appendix A.

During the 2 year period of this project, 4.5 eggs per canvasback nest hatched. According to Bellrose (1976) 7.2 canvasback eggs hatch per nest.

Hatchability of redhead eggs laid in redhead nests appeared to have been much more successful than that for canvasback eggs. Redhead hatchability averaged 74%. Low (1945) recorded an 81% hatchability of redhead eggs in Iowa. Redhead females hatched an average of 7.3 young per nest during this study. In 1974, 8.2 eggs hatched per nest while 5.7 successfully hatched in 1975. Bellrose (1976) recorded 5.7 young hatching per successful redhead nest.

Brood size

Canvasback and redhead brood sizes were variable for each specie when compared to different districts of the study area, but there was very little overall differences in brood size (Table 18). The average canvasback brood size within the study block was 3.10, in a 1 km. wide

Table 18. Canvasback and Redhead Brood Size on the Study Block, Adjacent to the Study Block and on the Transects.

	Average Brood Size			
	Study Block	Outside Study Block	Transects	Overall Study Area
Canvasback	3.10(10)	5.55(22)	5.81(43)	5.37(75)
Redhead	4.66(6)	6.66(9)	5.54(35)	5.64(50)

( ) No. of brood observations.

Table 19. Canvasback and Redhead Brood Size by Age Class from Study Block and Transect Data.[1]

	Age Class			
	1	2	3	Source
Canvasback	6.70	5.36	5.13	This study
	6.33	5.90	5.31	Bellrose (1976)
Redhead	6.27	5.25	4.63	This study
	6.20	5.90	5.60	Bellrose (1976)

[1]Pooled 1974 and 1975 data.

buffer zone adjacent to the study block, 5.55, and for the roadside transects, 5.81. The overall canvasback brood size average for the study area was 5.37 (based on 75 observations). Olson (1964b) recorded an average canvasback brood size of 5.7 ducklings on pothole habitat.

Average redhead brood size on the study block was 4.66 ducklings, the area adjacent to the study block had an average of 6.66 ducklings per brood. Data from the roadside transects indicated a brood size of 5.54 ducklings. The overall redhead brood size for the entire study area was 5.64 ducklings based on 50 brood observations. Olson (1964b) found 5.1 ducklings per redhead brood on pothole habitat in southwestern Manitoba and 6.80 on the Delta marsh. He attributed the larger redhead broods to larger redhead populations on the Delta marsh and the subsequent increase in intraspecific parasitism.

In 1974, 17% of all canvasback broods contained 2.50 redhead ducklings per brood. In 1975, 31% of canvasback broods contained 2.30 redhead ducklings per brood.

Brood mortality

Seven dead downy young were found in or near nests on the study block. No readily recognizable cause of death was determined. Smith and Webster (1955) documented duckling mortality from a hailstorm in Alberta. Hailstorms occurred on the study block prior to the mortality observations and might have been partly responsible.

Canvasback and redhead brood mortality was monitored by aging and recording brood size. Gollop and Marshall (1954) developed a series of plumage subclasses from downy young to fully feathered juveniles. Brood size data are summarized in Table 19 for the three main age subclasses. The data from the study block were pooled with the transect data due to the low number of observations recorded on the study block.

Canvasback young exhibited a mortality factor of 23% (16 ducklings) from age class 1 to age class 3 (fledging). The greatest loss, 20%, occurred between age class 1 and 2. Redhead broods showed a decrease in size of 25% from age class 1 to 3. They were also susceptible to a higher mortality rate, 16%, between age classes 1 and 2. These results were similar to those of Bellrose (1976). Stoudt (1974) recorded juvenile mortality of 21% for canvasbacks and found losses minimal between age classes 2 and 3.

Brood mobility

Five marked canvasback hens and their broods moved 1.8 km. (1.1 mi.) from their nest sites while 3 redhead broods moved an average of 1 km. (0.6 mi.). Most of these movements were recorded off of the study block. Less than 50% of successfully hatched canvasback and redhead broods were located after they left the nesting ponds. Other marked hens and their broods were never found during repeated beatouts within the study block and on a 0.8 km. (0.5 mi.) buffer zone. Although it is rare for entire broods to be lost (Bellrose 1976), the high mobility of both species contributed to their not being located. Evans et al. (1952) reported canvasback broods to be much more mobile than redhead broods. They recorded canvasback broods spending no longer than 7 days on any one pond. Stoudt (1974) stated that the increased mobility of canvasback broods yielded a higher than normal juvenile mortality.

Net Productivity

Productivity estimates are based on the number of ducklings that reach flight stage or those reaching age class 3. The original intention of marking nesting females was an attempt to determine the exact number of ducklings fledged. Since less than 50% of the marked hens and their broods were located after hatching, this calculation was not possible. An alternate production estimate was obtained by multiplying the number of broods observed by the average size of age class 3 canvasback and redhead broods. This value was then converted into number of fledgings per km^2.

Productivity estimates within the various components of the study area varied (Table 20). Canvasback hens fledged 1.50 juveniles on the study block while 1.32 were fledged on the transects. Although no breeding population data were available for the buffer zone adjacent to the study block, monitoring of this area resulted in 8.6 canvasback young fledged per km^2. Based on the calculated average canvasback breeding population value of 1.23 pairs per km^2 for 1974, an estimated 6.98 fledgings per pair were produced on the buffer zone. This was substantially higher than recorded for the study block or transects. The buffer zone contained a great deal more brood ponds than the study block. Brood ponds were large, deep, open and had little emergent vegetation - much preferred by canvasback and redhead broods (Lokemoen 1966, Stoudt 1974).

The 1974 transect brood data were considered poor because they were collected during mid-day when brood activity was at a minimum. In 1975, evening surveys were conducted and significantly more broods were observed. Canvasback productivity on the study block was low again (1.22 fledgings/pair) but the buffer zone contained higher numbers of

Table 20. Estimated Productivity of Canvasback and Redhead Females.

	No. of broods observed	Ave. size class 3 broods	Max. no. fledged	No. fledged/ km^2	No. fledged/ pr.
Canvasback productivity					
1974					
Study Block	5	3.00	15	1.45	1.50
Buffer zone	9	5.60	50	8.58	6.98
Transects	8	4.60	37	1.97	1.32
1975					
Study Block	5	4.30	22	2.12	1.22
Buffer zone	11	5.27	58	9.96	6.49
Transects	28	5.40	151	8.04	6.04
Redhead productivity					
1974					
Study block	2	4.50	9	0.87	0.64
Buffer zone	7	6.30	44	7.57	5.23
Transects	2	7.50	15	0.80	0.43
1975					
Study Block	4	4.50	18	1.74	1.13
Buffer zone	3	5.33	16	2.75	1.65
Transects	27	4.60	124	6.60	3.54

fledged young, 6.49 per pair. The transects also produced high numbers of fledgings per pair, 6.04. Both the buffer zone data and the transect data were considered as reliable indicators of canvasback and redhead productivity.

The study block and transects yielded relatively low results for redhead productivity in 1974. Conditions similar to those recorded for canvasback productivity were felt to be responsible for low redhead results. The buffer zone data appeared much more realistic providing 5.23 juveniles fledged per hen. The 1975 data resulted in poorer redhead production on all three regions of the study area. Production varied from 1.13 fledgings per pair on the study block to 3.54 on the transects.

The number of redheads fledged per canvasback brood was unknown. Since canvasback productivity was higher than for redheads over both years of this study, the inclusion of this factor would have tended to reduce productivity differences between the two species.

Analysis of Transect Nesting Studies - 1975

Relatively high predation rates on the study block prompted an investigation into the effects of human disturbance on nesting success. During the first week of July 1975 a nest search was conducted on a 3.2 km. (2 mi.) portion of each of the 5 transects. This time period was selected as it coincided with the completion of initial canvasback nesting and the peak of redhead nesting based on the study block results. Habitat parameters were also recorded in order to obtain a larger sample of the nesting habitat utilization by canvasbacks and redheads. This provided an additional 4.0 km^2 (2.5 mi^2) of habitat investigated encompassing 122 ponds.

A total of 7 canvasback and 9 redhead nests were found. Of the 16 nests, 8 were active, 5 had successfully hatched, 2 were predated and 1 appeared to have been deserted. The assumption was made that due to the lush new growth at this time of the year, it was possible to have missed locating some early canvasback nests and these results would not provide accurate estimates of overall predation rates on the transects. Data did indicate combined nest density on the transects, 3.8 per km^2 ($6.3/mi^2$) to be similar to the study block, 3.8 per km^2 ($6.3/mi^2$) during 1975.

Nesting success on the study block averaged 32% in 1975. Of the nests having reached termination on the transects, 62% were successful. This value is only an estimate, but it is substantially higher than that found on the study block and may account for the higher productivity recorded on the transects (Table 20).

Summary

The number of canvasback pairs per 2.6 km^2 (mi^2) on the study area varied from 3.18 in 1974 to 3.97 in 1975. Redhead pairs showed a similar increase in population from 3.75 per 2.6 km^2 (mi^2) in 1974 to 4.31 during 1975. Canvasback females demonstrated a stronger homing instinct than redheads (80% vs. 20% respective return rate).

Canvasback nest density occurred at a rate of 2.75 per 2.6 km^2 for both years. Redhead nest density was 2.00 per 2.6 km^2 in 1974 and 2.25 per 2.6 km^2 in 1975.

Fifty-five percent of canvasback nests were parasitized by redheads. This resulted in a canvasback clutch size reduction of 2.4 eggs and an increase of 4.2 redhead eggs per parasitized canvasback nest. Canvasback clutch size (unparasitized) was 7.2 eggs per nest while redhead females laid 8.7 eggs per redhead nest. Nesting success for canvasbacks was 33% and 40% for redheads on the study block. Nest losses were due to predation and nest desertion. Canvasback nests tended to be quite vulnerable to predators with 60% of nest initiations being predated, while 35% of redhead nests were lost to predators. The raccoon was the dominant predator on both species nests. Canvasback females exhibited a stronger urge to complete incubation than did redhead females. Canvasback females deserted 6% of their nests while redheads deserted 25% of theirs. Hatchability of eggs found in canvasback nests was lower than those found in redhead nests, 59% vs. 74%, respectively. The lower hatchability of eggs laid in canvasback nests was partly attributable to unhatched parasitic redhead eggs. Canvasback hens hatched 4.5 young per successful nest while redhead females produced 8.2 young per successful nest.

Overall results for the study area yielded 5.37 young per canvasback brood and 5.64 per redhead brood. A mean value of 2.40 redhead juveniles were recorded per canvasback brood. Data for the study block showed 3.10 juveniles per canvasback brood and 4.66 per redhead brood. Brood mortality factors of 23% and 25% were documented for canvasbacks and redheads respectively, from post-hatching to fledging. Average brood mobility from the nesting pond was greater for canvasbacks, 1.8 km. vs. 1.0 km. for redheads. Canvasbacks fledged 1.50 juveniles per pair in 1974 and 1.22 juveniles in 1975 on the study block. Redheads fledged 0.64 and 1.13 juveniles per pair in 1974 and 1975, respectively, on the study block. Productivity for the remainder of the study area was 6.98 and 6.04 juveniles per canvasback pair in 1974 and 1975, respectively, while redheads produced 5.23 and 3.54 juveniles per pair for 1974 and 1975, respectively.

Reduced canvasback production of young on the study block was due to: a high incidence of redhead parasitism which reduced canvasback clutch size; and high predation rates by raccoons were believed to have been related to the canvasbacks preference for small nesting ponds. The smaller wetlands on the study block contained sparse emergent cover and were easily searched by raccoons.

Low redhead productivity on the study block was the result of: a low number of nest initiations in proportion to breeding pair densities and a high occurrence of nest desertions. Sugden (1978) speculated that a low nesting urge was inhibited at high population levels or low availability of nesting habitat. There was a lack of semi-permanent and permanent ponds on the study block. Nest desertions were related to a high incidence of intraspecific parasitism.

CANVASBACK AND REDHEAD NESTING ECOLOGY

The first objective of this study was to investigate the nesting ecology of canvasback and redhead ducks. This was accomplished by analyzing various habitat components recorded for each nest and nesting pond. Three subobjectives, directly related to the main objective were: (1) did the two species differ on nest site selection criteria on the study block?; (2) if they were different, were these differences attributed to the same variables during both years of the study, 1974 and 1975?; and (3) which habitat component(s) or variables(s) resulted in canvasback and redhead nesting success? To determine if there were any such differences, and their significance, the t-test statistic as described by Snedecor and Cochran (1973) was employed. Nest distribution for both species on each variable is illustrated in Figures 5-12.

Pond Size

Highly significant differences ($P < 0.01$) between canvasback and redhead nest distribution were found (Table 21). Both species used ponds in the .84-2.0 ha. (2.1-5.0 ac.) size class. Redheads showed a consistent preference for the larger ponds over .83 ha (2.0 ac.) (95% of nests) while canvasbacks also selected the smaller ponds less than .83 ha. (45% of nests). Olson (1964b) and Stoudt (1974) reported extensive canvasback use of smaller ponds and redhead preference for the larger ponds at Minnedosa. Canvasback hens selected larger ponds (over .83 ha.) 63% of the time in 1974 and 43% of the time in 1975. Significant between year (1974 vs. 1975) differences were found in choice of pond size for nest site by canvasbacks (Table 22). Increased use of larger ponds by canvasbacks may be due to high water levels in 1974 because of heavy spring rains in May (Table 2). However, no such differences were found for redheads (Table 23). Flooded vegetation in smaller ponds was unfavourable for nest location and forced females to larger ponds where peripheral emergent vegetation was less affected by flooding. In the spring of 1975 water levels returned to normal and nest locations by canvasback hens indicated their preference for the smaller ponds (Table 24) while redheads used ponds over .83 ha. (2.0 ac.) in size exclusively for their nests. Stoudt (1974) was of the opinion that canvasback females sought the seclusion of small ponds for nest as a redhead avoidance mechanism.

No significant differences were found between successful and unsuccessful nests (Table 25). Both species were most successful (52% of nesting attempts) when they nested in ponds between .84 ha. and 2.0 ha. in size (Figure 5). Eight nests found in the .43-.83 ha. (1.1-2.0 ac.) size class were unsuccessful. Forty percent of the ponds rated as

Table 21. t-test of Canvasback vs. Redhead Nest Distribution For 8 Habitat Variables (Study Block Data Pooled For 1974 and 1975).

Variable	Species	No. of Cases	Mean[1]	Std. Error	Level of Significance
Pond Size	Canvasback	33	3.36 ± 1.19	0.21	***
	Redhead	20	4.20 ± 0.52	0.12	
Pond Permanency	Canvasback	33	3.21 ± 0.42	0.07	***
	Redhead	20	4.00 ± 0.79	0.18	
Woody Fringe	Canvasback	33	1.45 ± 0.79	0.14	
	Redhead	20	1.40 ± 0.82	0.18	
Cover Type	Canvasback	33	2.82 ± 0.85	0.15	
	Redhead	20	2.95 ± 0.39	0.09	
Emergent Vegetation Type	Canvasback	33	3.30 ± 2.08	0.36	**
	Redhead	20	2.30 ± 1.66	0.37	
Nesting Potential	Canvasback	33	3.76 ± 0.79	0.14	***
	Redhead	20	4.45 ± 0.76	0.17	
Land use	Canvasback	33	1.76 ± 0.43	0.08	
	Redhead	20	1.80 ± 0.41	0.09	
Concealment Vegetation	Canvasback	33	3.70 ± 1.56	0.27	
	Redhead	20	4.05 ± 1.23	0.28	

[1]Mean ± standard deviation.

**Significant at the 5% level.

***Significant at the 1% level.

Table 22. t-test of Canvasback Nest Distribution For 8 Habitat Variables Between Years (1974 & 1975).

Variable	Year	No. of Cases	Mean[1]	Std. Error	Level of Significance
Pond Size	1974	19	3.68 ± 1.16	0.26	*
	1975	14	2.93 ± 1.14	0.20	
Pond Permanency	1974	19	3.16 ± 0.37	0.09	
	1975	14	3.29 ± 0.47	0.12	
Woody Fringe	1974	19	1.68 ± 0.88	0.20	**
	1975	14	1.14 ± 0.53	0.14	
Cover Type	1974	19	2.84 ± 0.83	0.19	
	1975	14	2.79 ± 0.89	0.24	
Emergent Vegetation Type	1974	19	3.58 ± 1.83	0.42	
	1975	14	2.93 ± 2.40	0.64	
Nesting Potential	1974	19	3.53 ± 0.70	0.15	**
	1975	14	4.07 ± 0.83	0.22	
Land Use	1974	19	1.63 ± 0.50	0.11	**
	1975	14	1.93 ± 0.27	0.07	
Concealment Vegetation	1974	19	3.16 ± 1.54	0.35	**
	1975	14	4.43 ± 1.28	0.34	

[1]Mean ± standard deviation.

*Significant at the 10% level.

**Significant at the 5% level.

Table 23. t-test of Redhead Nest Distribution For 8 Habitat Variables Between Years (1974 & 1975).

Variable	Year	No. of Cases	Mean[1]	Std. Error	Level of Significance
Pond Size	1974	9	4.22 ± 0.67	0.22	-
	1975	11	4.18 ± 0.40	0.12	
Pond Permanency	1974	9	4.00 ± 0.87	0.29	-
	1975	11	4.00 ± 0.77	0.23	
Woody Fringe	1974	9	1.44 ± 0.88	0.29	-
	1975	11	1.36 ± 0.81	0.24	
Cover Type	1974	9	3.00 ± 0.50	0.17	-
	1975	11	2.91 ± 0.30	0.09	
Emergent Vegetation Type	1974	9	2.22 ± 1.79	0.60	-
	1975	11	2.36 ± 1.63	0.49	
Nesting Potential	1974	9	4.33 ± 1.00	0.33	-
	1975	11	4.55 ± 0.52	0.16	
Land Use	1974	9	1.78 ± 0.44	0.15	-
	1975	11	1.82 ± 0.40	0.12	
Concealment Vegetation	1974	9	3.89 ± 1.27	0.42	-
	1975	11	4.18 ± 1.25	0.38	

[1]Mean ± standard deviation.

-non-significant

Table 24. Canvasback and Redhead Nest Distribution in 1974 and 1975 According to Pond Size (ha.).

	1974				1975			
Pond Size	Canvasback Frequency	%	Redhead Frequency	%	Canvasback Frequency	%	Redhead Frequency	%
.04-.22	1	5	-	-	2	14	-	-
.23-.42	2	11	-	-	3	21	-	-
.43-.83	4	21	1	11	3	21	-	-
.84-2.0	7	37	5	56	6	43	9	82
> 2.0	5	36	3	33	-	-	2	18

Table 25. t-test Results of Pooled Canvasback and Redhead Nest Success vs Pooled Unsuccessful Canvasback and Redhead Nesting For 8 Habitat Variables (1974 & 1975).

Variable	Group	No. of Cases	Mean[1]	Std. Error	Level of Significance
Pond Size	Unsuccessful	34	3.65 ± 1.12	0.19	
	Successful	19	3.74 ± 0.99	0.23	
Pond Permanency	Unsuccessful	34	3.38 ± 0.65	0.11	*
	Successful	19	3.74 ± 0.73	0.17	
Woody Fringe	Unsuccessful	34	1.44 ± 0.79	0.13	
	Successful	19	1.42 ± 0.84	0.19	
Cover Type	Unsuccessful	34	2.94 ± 0.74	0.13	
	Successful	19	2.74 ± 0.65	0.15	
Emergent Vegetation Type	Unsuccessful	34	3.47 ± 2.11	0.36	***
	Successful	19	1.95 ± 1.27	0.29	
Nesting Potential	Unsuccessful	34	3.76 ± 0.89	0.15	***
	Successful	19	4.47 ± 0.51	0.12	
Land Use	Unsuccessful	34	1.79 ± 0.41	0.07	
	Successful	19	1.74 ± 0.45	0.10	
Concealment Vegetation	Unsuccessful	34	3.62 ± 1.50	0.26	
	Successful	19	4.21 ± 1.27	0.29	

[1]Mean ± standard deviation.

*Significant at the 10% level.

***Significant at the 1% level.

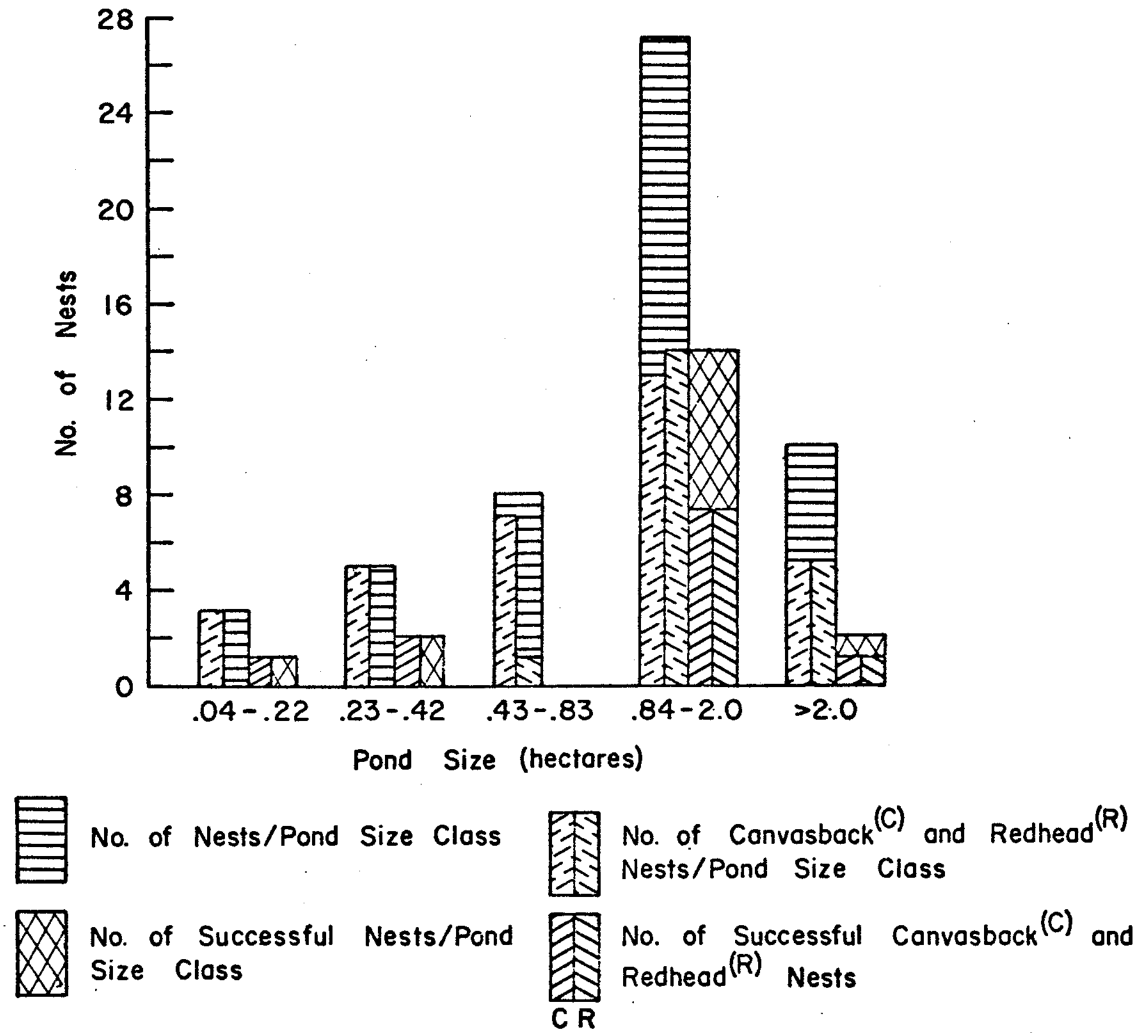

Figure 5. Canvasback and redhead nest distribution and nest success in relation to pond size (study block data pooled for 1974 and 1975).

'Good' or 'Excellent' occurred in the .84-2.0 ha. size class while only 17% were recorded in the .43-.83 ha. size class (Table 12). This suggests that pond size is very closely related to habitat quality and to canvasback and redhead nesting success.

In comparison, canvasback nests found on the transects were most often located in ponds over .83 ha. (2.0 ac.) in size as opposed to the study block preference for ponds less than .83 ha. in size (Table 26). Redheads remained consistant in selecting ponds over .83 ha. in size on the transects and the study block.

Pond Permanency

Canvasback and redhead nest locations were significantly different ($P < 0.01$) based on pond permanency (Table 21). Canvasback females preferred seasonal ponds (permanency type 3) whereas redheads selected semi-permanent ponds (permanency type 4) (Figure 6). This was also found in earlier studies by Stoudt (1974), Sugden (1978), Olson (1964b) and Dzubin (1955).

Both species were relatively consistent in pond permanency selection in each year of this study (Table 27). The between year differences in nest distribution for both species was not significant (Tables 22 and 23).

Significant ($P < 0.10$) differences were obtained between successful and unsuccessful nests according to pond permanency (Table 25). Both species were highly successful when nesting on semi-permanent ponds (permanency type 4) (Figure 6). Seventy-one percent of canvasback nesting attempts on these ponds were successful as opposed to a 23% success rate for nests initiated on seasonal ponds (permanency type 3). Redhead females exhibited a 43% nesting success on semi-permanent ponds

Table 26. Canvasback and Redhead Nest Distribution According to Pond Size (ha.) on the Transects and the Study Block - 1975.

	Pond Size					
	.04-.22	.23-.42	.43-.83	.84-2.0	2.0	Total
Transects						
Canvasback nests	2	-	1	2	2	7
Redhead nests	2	-	-	4	3	9
Nests/Pond Size Class	4	-	1	6	5	16
Percent nests/pond size class	25	-	6	38	31	100
Study Block						
Canvasback nests	2	3	3	6	1	14
Redhead nests	-	-	-	9	2	11
Nests/pond size class	2	3	3	15	2	25
Percent nests/pond size class	8	12	12	60	8	100

Table 27. Canvasback and Redhead Nest Distribution in 1974 and 1975 According to Pond Permanency.

	1974				1975			
Permanency	Canvasback Frequency	%	Redhead Frequency	%	Canvasback Frequency	%	Redhead Frequency	%
Ephemeral	-	-	-	-	-	-	-	-
Temporary	-	-	-	-	-	-	-	-
Seasonal	16	84	2	22	10	71	2	18
Semi-permanent	3	16	6	67	4	29	8	73
Flooded Stock ponds	-	-	1	11	-	-	1	9

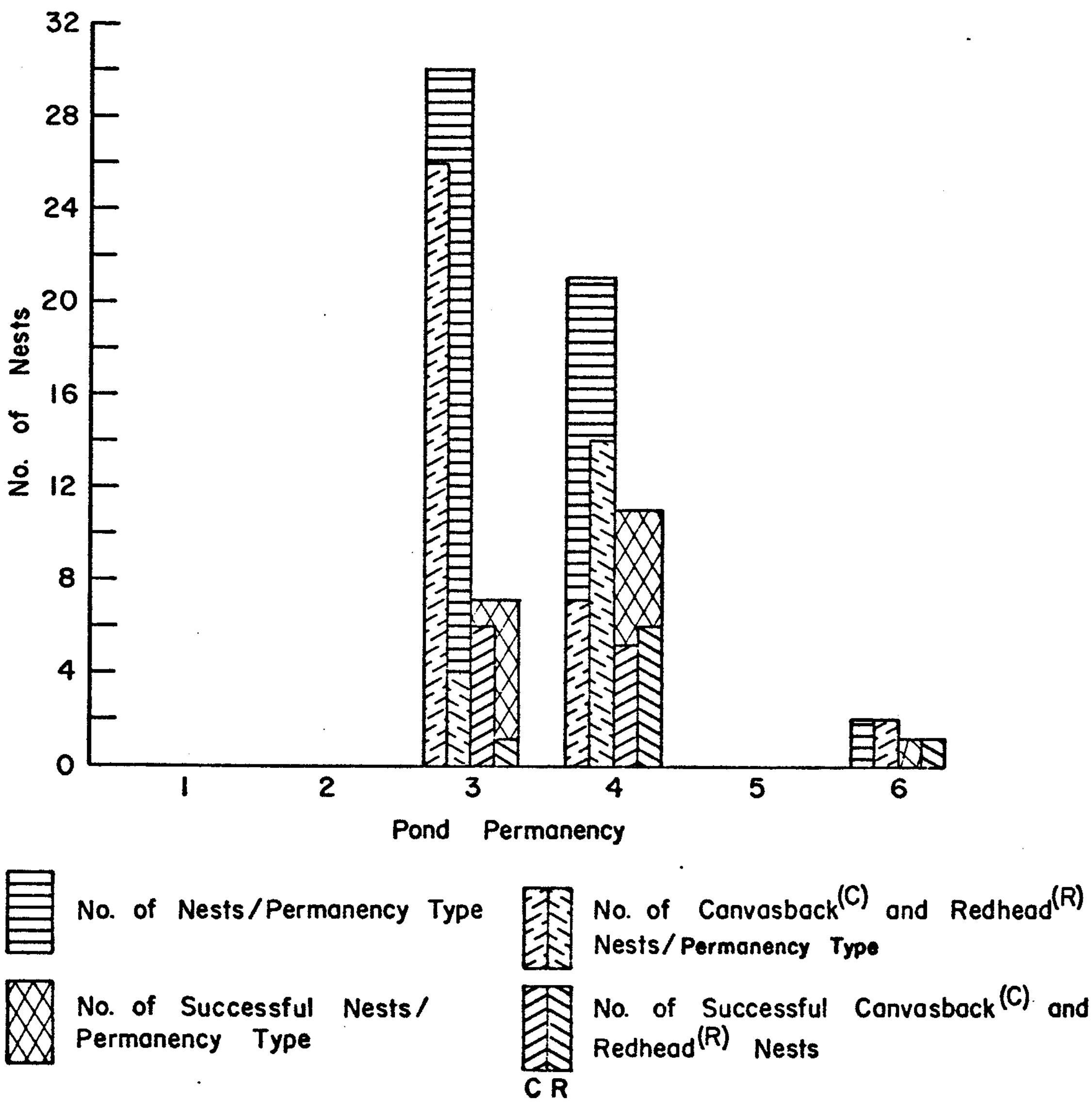

Figure 6. Canvasback and redhead nest distribution and nest success in relation to pond permanency (study block data pooled for 1974 and 1975).

as compared to a 25% nesting success on seasonal ponds. The lower nesting success rate for redheads was attributed to the high frequency of nest desertion. Redhead females deserted 25% of the nests that they initiated (Table 16). Bellrose (1976) documented a 37% desertion rate among nests failing to hatch and felt many were due to the intrusion of parasitic females. A high rate of desertion was also recorded by Low (1945) which he attributed to rapid fluctuations in water levels and intraspecific parasitism. Observations in this study of other redheads on ponds containing known redhead nests and the subsequent desertion of those nests suggested that intraspecific interference was directly related to some nest desertions.

On the transects, canvasbacks located 71% of their nests in either semi-permanent or permanent ponds (Table 28). Of the 122 ponds searched on the transects, 36% were classed as either semi-permanent or permanent while only 9% of the ponds on the study block were semi-permanent with no permanent ponds. The study block data indicated higher nesting success on semi-permanent ponds than for any others (Figure 6). As the transects contain a higher proportion of the more permanent ponds (type 3 & 4) (Table 28), it is suggested that this is positively related to higher productivity of both species on the transects as opposed to the lower productivity recorded on the study block.

Woody Fringe

No significant differences were found between canvasback and redhead nest site selection in regard to woody growth around ponds. Both species favoured ponds classed as open, that is less than 25% of the pond perimeter fringed by trees or willows (Figure 7). Seventy-three

Table 28. Canvasback and Redhead Nest Distribution According to Pond Permanency on the Transects and the Study Block - 1975.

	Pond Permanency[1]						
	1	2	3	4	5	6	Total
Transects							
Canvasback nests	-	-	2	4	1	-	7
Redhead nests	-	-	3	3	3	-	9
Nests/perm. type	-	-	5	7	4	-	16
Percent nests/perm. type	-	-	31	44	25	-	100
No. ponds/perm. type	4	20	53	29	15	1	122
% ponds/perm. type	3	16	43	24	12	1	100
Study Block							
Canvasback nests	-	-	10	4	-	-	14
Redhead nests	-	-	2	8	-	1	11
Nests/perm. type	-	-	12	12	-	1	25
Percent nests/perm. type	-	-	48	48	-	4	100
No. ponds/perm. type	4	41	162	20	-	3	230
% ponds/perm. type	2	18	70	9	-	1	100

[1] 1 Ephemeral
2 Temporary
3 Seasonal
4 Semi-permanent
5 Permanent
6 Stock ponds

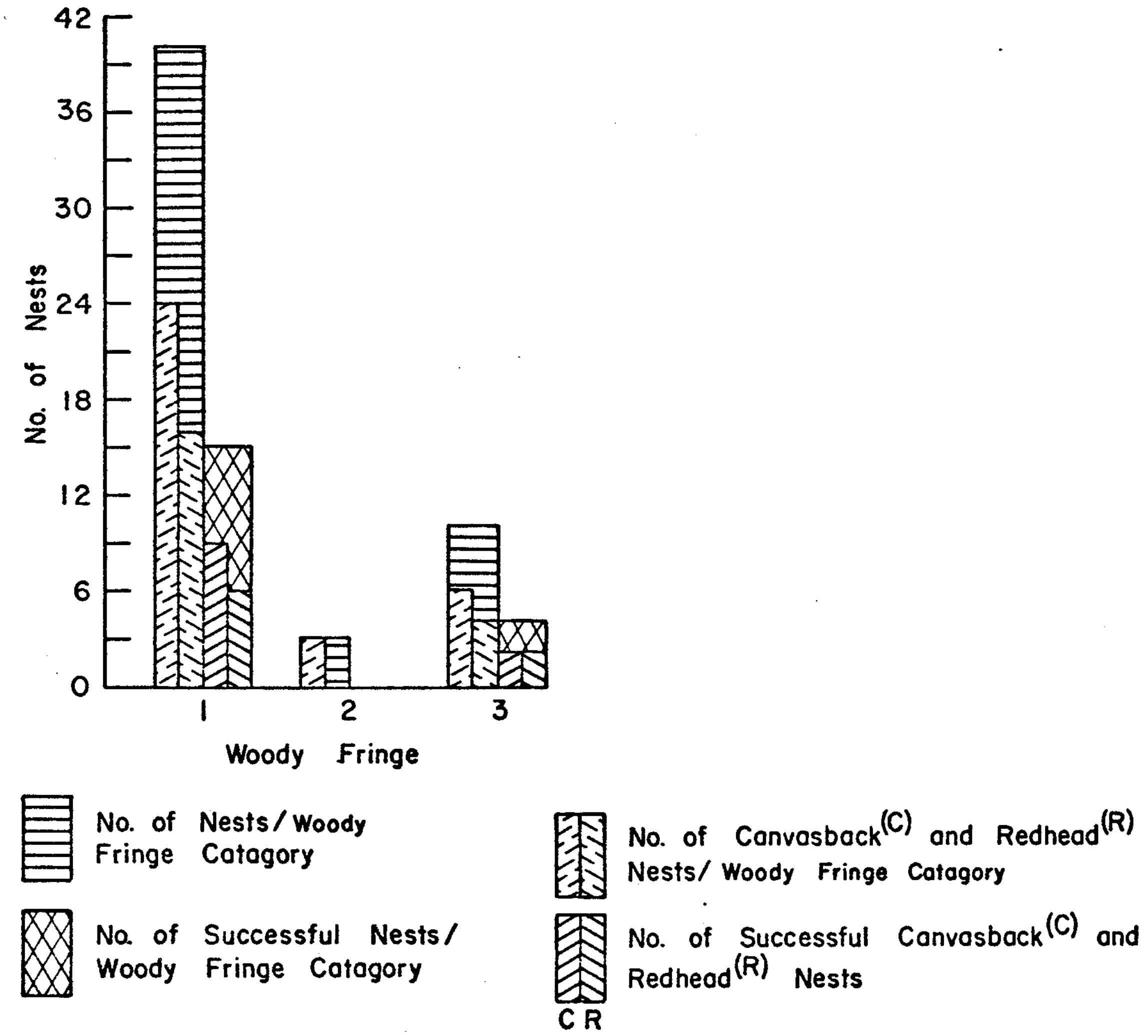

Figure 7. Canvasback and redhead nest distribution and nest success in relation to woody fringe (study block data pooled for 1974 and 1975).

percent of canvasback and 80% of redhead nests were located in those ponds categorized as open.

As shown earlier in Table 7, 58% of the ponds were considered open, 24% half-open and 18% closed. When this was analyzed as a nest to pond ratio (canvasback and redhead data combined), the following results were obtained: there was 1 nest for every 3.4 ponds in the open category; 1 nest for every 18.3 ponds in the half-open category and 1 nest for every 4.1 ponds categorized as closed. Thus woody growth around a pond is not necessarily a deterrent to canvasback and redhead nesting as suggested by Dwyer (1970). Sugden (1972) and Stoudt (1971) both concurred that a woody fringe is not a deterrent to canvasback nesting.

Canvasback females selected significantly ($P < 0.05$) more wooded ponds in 1974 than in 1975 (Table 22). Forty-two percent of canvasback nests were found in half-open and closed ponds in 1974 as opposed to only 7% in 1975 (Table 29). The high water levels of 1974 flooded much of the residual emergent vegetation typically used as a nesting substrate and forced canvasback females to utilize extensively flooded willows for nesting (Table 29). During times of high water levels Stoudt (1971) and Sugden (1978) recorded large numbers of canvasback nests in wooded ponds.

No appreciable affect on canvasback and redhead nesting success was attributed to the extent of the woody fringe. Thirty-one percent of those nests located on open ponds were successful while those found on half-open and closed ponds had a 37% success rate (Figure 7). Nests in open ponds were generally more successful than those in wooded ponds according to Stoudt (1974). Sugden (1978) found canvasback nesting success reduced in ponds containing tree growth and suggested that

Table 29. Canvasback and Redhead Nest Distribution in 1974 and 1975 According to Woody Fringe.

Woody Fringe	Canvasback Frequency	%	Redhead Frequency	%	Canvasback Frequency	%	Redhead Frequency	%
Open	11	58	7	78	13	93	9	82
Half-open	3	16	-	-	-	-	-	-
Closed	5	26	2	22	1	7	2	18

wooded ponds attracted avian predators. Stoudt (1974) discovered that redhead nests located in ungrazed woodlands had the poorest nesting success and felt that this was due to the cover provided for raccoons searching for food.

Both the transect and study block data are analagous in terms of nest distribution for tree growth around nesting ponds. Canvasbacks and redheads located 88% of their nests on open ponds on the study block and on the transects (Table 30). More than 3 times as many ponds on the study block were half open or closed in terms of tree growth than on the transects. This is probably related to the extent of tree clearing of pond fringes along the transects due to road construction.

Pond Cover Type

No significant differences between the two species were expressed by pond cover type (Table 21). Canvasbacks and redheads favoured cover type 3 ponds, those ponds containing a dominant central expanse of open water enclosed by a wide band of emergent vegetation (Figure 8). Sixty-four percent of canvasback and 85% of redhead nests were found in this cover type. Low (1945) observed that good interspersion of emergent vegetation with open water was an important criterion in the redheads' choice of nesting sites while Lokemoen (1966) found redhead preference for ponds with larger stands and wider bands of emergent vegetation. Both species were consistent in their choice of pond cover types between years (Table 31).

Nesting success for canvasbacks and redheads did not vary significantly on any of the pond cover types utilized. Nesting success varied from nil to 50% on the four cover types (Figure 8). Six nests were initiated on ponds (cover type 4) where only 5% of the total pond

Table 30. Canvasback and Redhead Nest Distribution According to Woody Fringe on the Transects and the Study Block - 1975.

	Woody Fringe[1]			
	1	2	3	Total
Transects				
Canvasback nests	6	1	-	7
Redhead nests	8	-	1	9
Nests/woody fringe class	14	1	1	16
Percent nests/woody fringe class	88	6	6	100
No. ponds/woody fringe class	106	10	6	122
% ponds/woody fringe class	87	8	5	100
Study Block				
Canvasback nests	13	-	1	14
Redhead nests	9	-	2	11
Nests/woody fringe class	22	-	3	25
Percent nests/woody fringe class	88	-	12	100
No. ponds/woody fringe class	134	55	41	230
% ponds/woody fringe class	58	24	18	100

[1] 1 Open (0-25%)
2 Half open (25-75%)
3 Closed (75-100%)

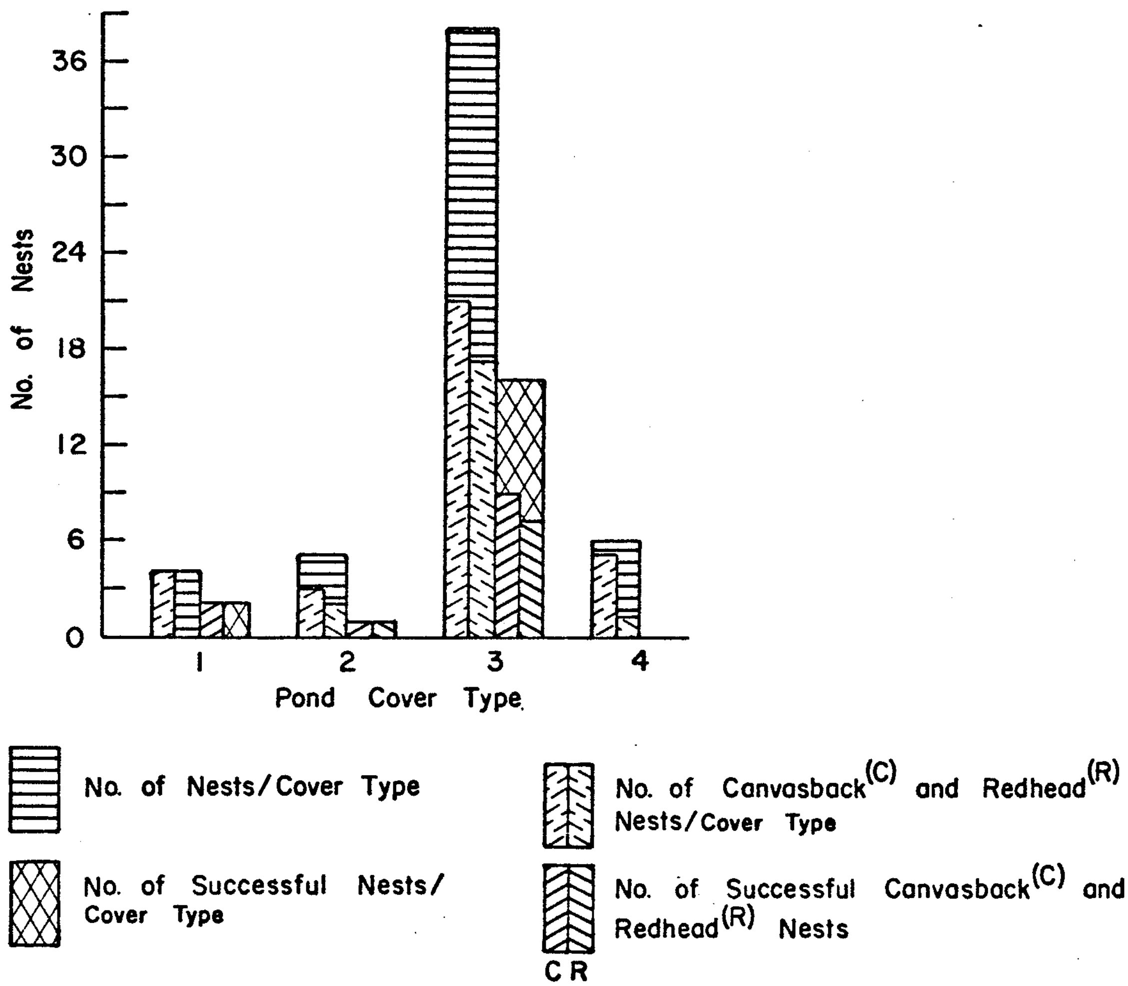

Figure 8. Canvasback and redhead nest distribution and nest success in relation to cover type (study block data pooled for 1974 and 1975).

Table 31. Canvasback and Redhead Nest Distribution in 1974 and 1975 According to Pond Cover Type.

	1974				1975			
Cover Type[1]	Canvasback Frequency	%	Redhead Frequency	%	Canvasback Frequency	%	Redhead Frequency	%
1	2	11	-	-	2	14	-	-
2	2	11	1	11	1	7	1	9
3	12	63	7	78	9	64	10	91
4	3	15	1	11	2	14	-	-

[1]percent of emergent cover to total pond area.
1. 95-100%
2. 5-95%
3. 30-60%
4. 0-5%

area contained emergent vegetation and none of these nests were successful. Nests located in sparse emergent cover were easy prey for predators. Higher emergent density provided better nest seclusion and resulted in lower predation rates.

Similar results for canvasback and redhead nest distribution in terms of pond cover type selection were found between the transect data and the study block data (Table 32). On the transects, 69% of the nests found were on cover type 3 ponds (emergent fringe encompassing an open water zone) and 76% of the nests on the study block were on the same type of ponds.

Emergent Vegetation Type

Canvasback and redheads were found to vary significantly ($P < 0.05$) in their selection of nesting sites based on emergent vegetation (Table 21). Redhead females located 70% of their nests in reed (R) or reed-sedge (RS) wetlands while canvasback hens utilized these two types for 42% of their nests (Figure 9). Canvasbacks used a greater variety of emergent vegetation types than redheads did. This could have been due to a number of factors. Firstly, canvasbacks selected smaller ponds (Figure 5) which are generally less permanent (Millar 1971). The less permanent ponds can undergo extreme water level fluctuations from full to flooded conditions in the spring to completely dry in mid-summer. The greater the water level fluctuation in a pond, the more diverse will be the vegetation found there (Stewart and Kantrud 1969) and therefore the more complicated will be the emergent vegetation description of this type of wetland. The opposite is also true where larger ponds tend to be more permanent there is less fluctuation in water levels and the emergent vegetation is more consistent. Secondly,

Table 32. Canvasback and Redhead Nest Distribution According to Pond Cover Type on the Transects and the Study Block - 1975.

	Pond Cover Type[1]				
	1	2	3	4	Total
Transects					
Canvasback nests	-	2	5	-	7
Redhead nests	-	3	6	-	9
Nests/pond cover type	-	5	11	-	16
Percent nests/pond cover type	-	31	69	-	100
No. ponds/pond cover type	2	19	58	43	122
% ponds/pond cover type	2	16	48	35	100
Study Block					
Canvasback nests	2	1	9	2	14
Redhead nests	-	1	10	-	11
Nests/pond cover type	2	2	19	2	25
Percent nests/pond cover type	8	8	76	8	100
No. ponds/pond cover type	5	33	82	110	230
% ponds/pond cover type	2	14	36	48	100

[1]percent of emergent cover to total pond area.

1. 95-100%
2. 5-95%
3. 30-60%
4. 0-5%

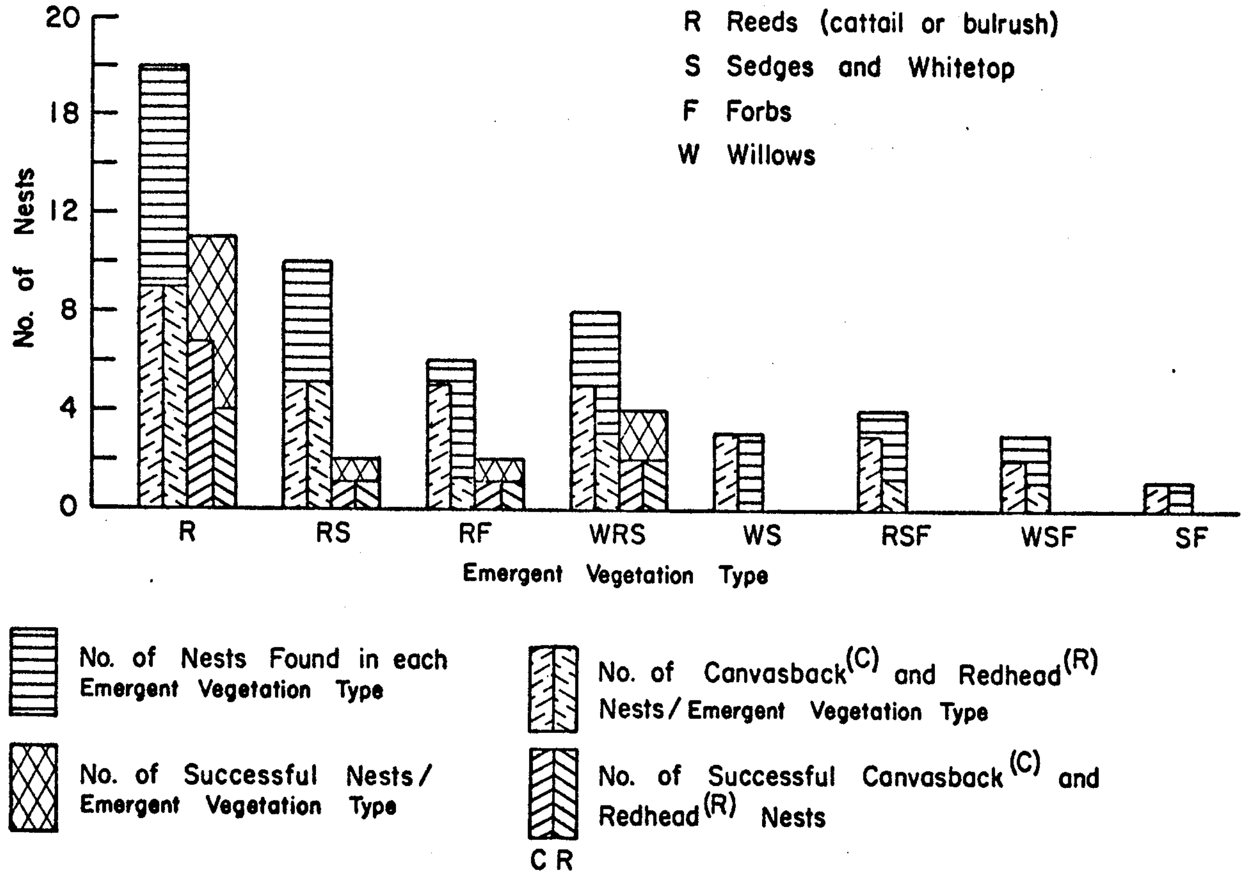

Figure 9. Canvasback and redhead nest distribution and nest success in relation to emergent vegetation type (study block data pooled for 1974 and 1975).

with the high water levels experienced in the spring of 1974, residual emergent vegetation in the smaller ponds was flooded and other vegetation such as flooded willows was utilized for nest concealment. The analysis of data on the use of wetland vegetation types by nesting canvasbacks between 1974 and 1975 were found to be non-significant (Table 22). Canvasback females made use of ponds containing willows (WRS, WS, WSF) for 47% of their nest locations in 1974 while only 7% of nests were found in such locations in 1975 (Table 33). In 1975 the changes were to ponds dominated by cattail (R, RF).

Redhead selection of nesting ponds related to emergent vegetation was much more consistent than for canvasbacks (Table 33). Since redheads tended to nest later and preferred the larger, more permanent ponds they weren't subject to being displaced from their normal nesting sites to the extent that canvasback females were.

Highly significant differences ($P < 0.01$) were found between successful and unsuccessful nests located on the various emergent vegetation types (Table 25). While 8 different emergent types were utilized for canvasback and redhead nesting, only 4 types produced successful nests (Figure 9). All successful nests were located on ponds containing some degree of cattail and/or bulrush cover. The majority of successful nests (58%) were located in pure reed marshes (R). Sixty-one percent or 11 nests located in these ponds were successful while the second highest success rate (50%) occurred on willow-reed-sedge (WRS) ponds.

Canvasback and redhead females consistently selected ponds containing cattail or bulrush for nesting on the transects, fifteen or 94% of all nests were found in reed (R) or reed-sedge (RS) ponds (Table 34). Data for the study block revealed significantly ($P < 0.01$) higher nesting success rates for canvasback and redhead nests found in ponds containing

Table 33. Canvasback and Redhead Nest Distribution in 1974 and 1975 According to Emergent Vegetation Type.

Emergent Vegetation Type[1]	1974				1975			
	Canvasback Frequency	%	Redhead Frequency	%	Canvasback Frequency	%	Redhead Frequency	%
R	3	16	5	56	6	43	4	36
RS	4	21	1	11	1	7	4	36
RF	1	5	1	11	4	29	-	-
WRS	5	26	1	11	-	-	2	18
WS	3	16	1	-	-	-	-	-
RSF	2	11	-	-	1	7	1	9
WSF	1	5	1	11	1	7	1	-
SF	-	-	-	-	1	7	-	-

[1]R - reeds (cattail or bulrush)
S - sedges and whitetop
F - forbs
W - willows

Table 34. Canvasback and Redhead Nest Distribution According to Emergent Vegetation Type on the Transects and the Study Block - 1975.

	Emergent Vegetation Types[1]							
	R	RS	RF	WRS	RSF	WSF	SF	Total
Transects								
Canvasback nests	2	5	-	-	-	-	-	7
Redhead nests	6	2	-	1	-	-	-	9
Nests/pond vegetation type	8	7	-	1	-	-	-	16
Percent nests/pond vegetation type	50	44	-	6	-	-	-	100
No. ponds/pond vegetation type	16	29	-	10	-	4	14	73
% ponds	13	24	-	8	-	3	11	
Study Block								
Canvasback nests	6	1	4	-	1	1	1	14
Redhead nests	4	4	-	2	1	-	-	11
Nests/pond vegetation type	10	5	4	2	2	1	1	25
Percent nests/pond vegetation type	40	20	16	8	8	4	4	100
No. ponds/pond vegetation type	7	20	14	6	15	25	36	123
% ponds	3	9	6	3	7	11	16	

[1]R - reeds (cattail or bulrush)
S - sedges and whitetop
F - forbs
W - willows

cattail and/or bulrush growth (Table 25), but only 60% of the nests on the study block were in these ponds in 1975. Lack of good nesting ponds on the study block may have caused both species to use other emergent vegetation types. The 10.2 km^2 (4 mi^2) study block contained 27 reed and reed-sedge ponds while the 4 km^2 (2.25 mi^2) of transect searched contained 45 of these ponds. The transects contained more of the preferred emergent vegetation types (R, RS) than the study block. This implied that canvasback and redhead nesting habitat quality was superior on the transects than on the study block.

Pond Nesting Potential

Highly significant ($P < 0.01$) differences were found between canvasback and redhead nesting sites based on pond nest potential ratings (Table 21). Canvasbacks located 61% of their nests in ponds rated as 'Good' while redheads selected those ponds for 40% of their nests (Figure 10). Ponds rated 'Excellent' contained 55% of all redhead nests and only 12% of canvasback nests. These results, as all the other on Table 21, were obtained by pooling canvasback data for 1974 and 1975 and comparing it to pooled redhead data. Habitat conditions were different between the two years. The spring of 1974 was abnormally wet while the spring of 1975 provided a return to more normal conditions. The changing habitat conditions have been considered responsible for discrepencies in the use of habitat variables by canvasbacks and redheads between the 2 years in this study. Canvasbacks differed significantly (P 0.05) on nesting sites based on pond nesting potential between 1974 and 1975 (Table 22) while redheads differed only slightly (Table 35). Canvasbacks used ponds rated 'Poor' and 'Fair' for 7 nests or 37% of their nesting attempts in 1974 as opposed to only 2 nests or

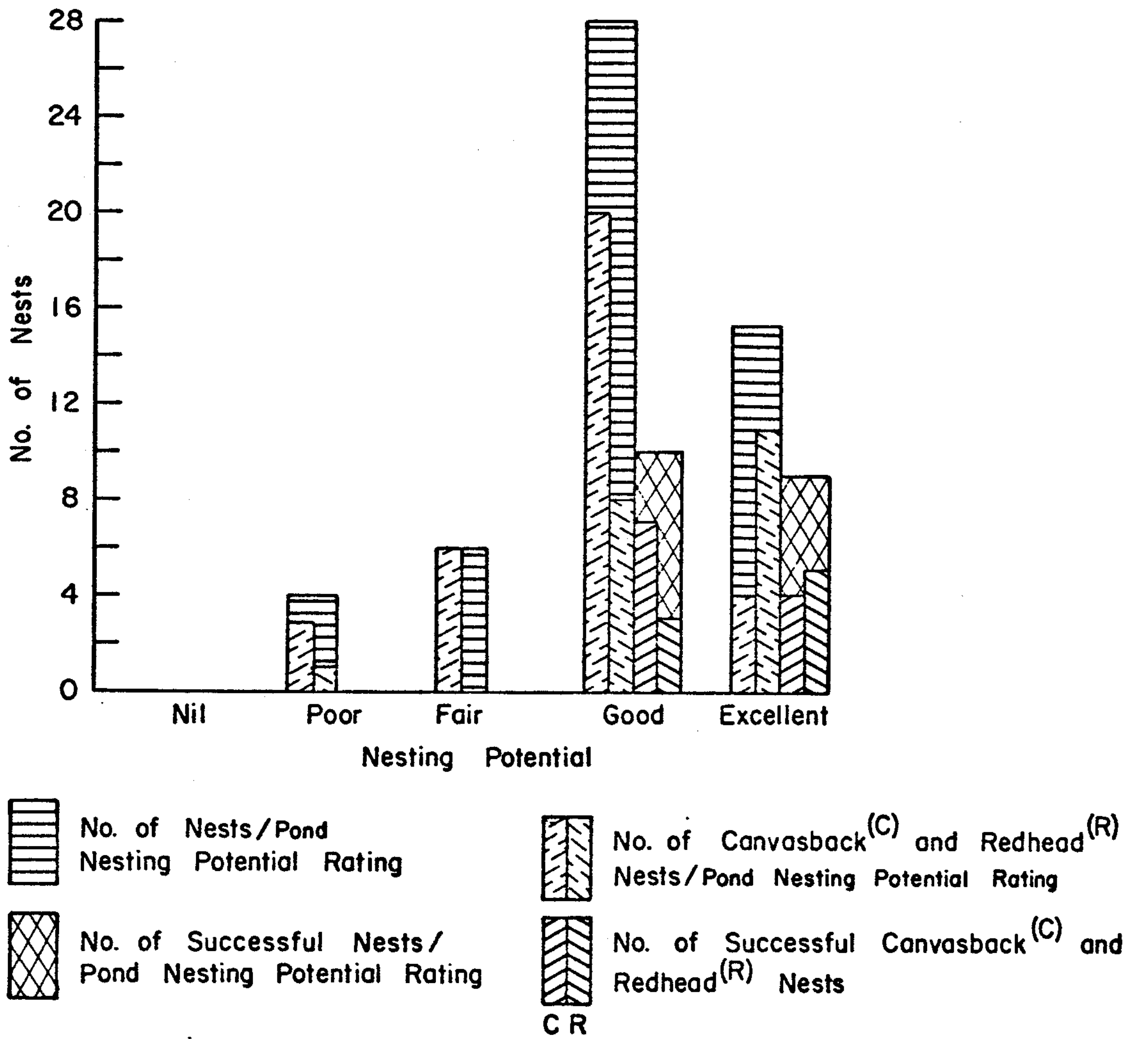

Figure 10. Canvasback and redhead nest distribution and nest success in relation to pond nesting potential (study block data pooled for 1974 and 1975).

Table 35. Canvasback and Redhead Nest Distribution in 1974 and 1975 According to Pond Nesting Potential.

	1974				1975			
Nesting Potential[1]	Canvasback Frequency	%	Redhead Frequency	%	Canvasback Frequency	%	Redhead Frequency	%
Nil	-	-	-	-	-	-	-	-
Poor	2	11	1	11	1	7	-	-
Fair	5	26	-	-	1	7	-	-
Good	12	63	3	33	8	57	5	45
Excellent	-	-	5	56	4	29	6	55

[1]Nil - no residual emergent vegetation.
Poor - flooded willows, sparse sedge or whitetop.
Fair - flooded willows mixed with sedges or grasses.
Good - small clumps of cattail, bulrush or extensive whitetop stands.
Excellent - dense stands of cattail or bulrush.

14% in 1975 (Table 35). These ponds generally contained willows which canvasback females turned to for use as a nesting substrate when other residual emergent vegetation was flooded (Stoudt 1971, Sugden 1978). Redhead females selected ponds rated 'Good' or 'Excellent' almost exclusively during this study. Only 1 nest was found in a pond rated as 'Poor' during 1974.

Canvasback and redhead nesting success was found to vary significantly ($P < 0.01$) according to pond nesting potential ratings (Table 25). No nests were successful in ponds rated 'Poor' or 'Fair' which contained 19% of nest initiations (Figure 10). Nesting success increased to 36% on ponds rated 'Good' and to 60% on those rated 'Excellent'. These results correlate favourably with the concept of nesting potential rating for ponds. Habitat quality is a key factor in terms of pond nesting potential ratings for ponds and was reflected in nesting success rates.

Canvasback and redhead females exclusively used ponds rated 'Good' and 'Excellent' for all their nests on the transects. Of all the ponds on the transect nest search area, 53 or 43% of the 122 ponds were considered to contain high quality nesting potential (Table 36). Canvasbacks and redheads utilized 30% of those ponds rated 'Good' and 'Excellent' for their nests in 1975. A corresponding preference for 'Good' and 'Excellent' rated ponds was found on the study block. Although only 48 of these ponds (21%) were found on the study block, canvasbacks and redheads nested on 48% of them. The higher percent use of the better rated nesting ponds expressed for the study block as opposed to the transect study area is not indicative of a greater nesting effort by the 2 species but of a lack of high quality nesting ponds on the study block (Table 36). Lack of good nesting habitat did

Table 36. Canvasback and Redhead Nest Distribution According to Pond Nesting Potential on the Transects and the Study Block - 1975.

	Pond Nesting Potential					
	Nil	Poor	Fair	Good	Excellent	Total
Transects						
Canvasback nests	-	-	-	3	4	7
Redhead nests	-	-	-	5	4	9
Nests/nesting potential type	-	-	-	8	8	16
Percent nests/nesting potential	-	-	-	50	50	100
No. ponds/nesting potential type	21(17)	26(22)	22(18)	32(26)	21(17)	122
Study Block						
Canvasback nests	-	1	1	8	4	14
Redhead nests	-	-	-	5	6	11
Nests/nesting potential type	-	1	1	13	10	25
Percent nests/nesting potential type	-	4	4	52	40	100
No. ponds/nesting potential type	32(14)	75(33)	75(33)	42(18)	6(3)	230

( ) - percent/nesting potential type.

not appear to have a detrimental effect on canvasback nesting intensity on the study block. More than 1 canvasback or redhead female or a combination of both were found nesting on the same pond within the study block and on the transects. Sugden (1978) reported multiple canvasback nests per pond not an uncommon occurrence on his Sasketchewan parkland study area.

The lack of high quality nesting ponds on the study block may have been a suppressing factor for redhead nest initiation. Sugden (1978) suggested that there may be a behavioral mechanism operating at high pair densities relative to habitat that suppresses nest initiation. The fact that approximately 2.7 redhead pairs per km^2 ($4.5/mi^2$) were recorded on the study block and only 1.5 nests per km^2 ($2.5/mi^2$) were found suggests that this mechanism may have been at work. The better nesting habitat on the transect supports this mechanism. The transect study area contained 2.2 redhead nests per km^2 ($3.6/mi^2$) compared to the 1.5 nests per km^2 ($2.5/mi^2$) on the study block. Lower redhead nest density on the study block probably accounted for lower redhead productivity than that recorded for the transects (Table 20).

Land Use

In their selection of nesting ponds, canvasback and redhead females maintained the same relative preferences for pasture land and cultivated land (Figure 11). Both species favoured nesting in ponds surrounded by cultivation. Over three times as many nests were found in cultivated areas than in those devoted to pasture. The surrounding land use of a pond is not a factor in nest site selection since the ratio of nests to ponds in both land use types was quite similar. The ratio of nests to ponds in pasture land was 1:4.8 while in cultivated

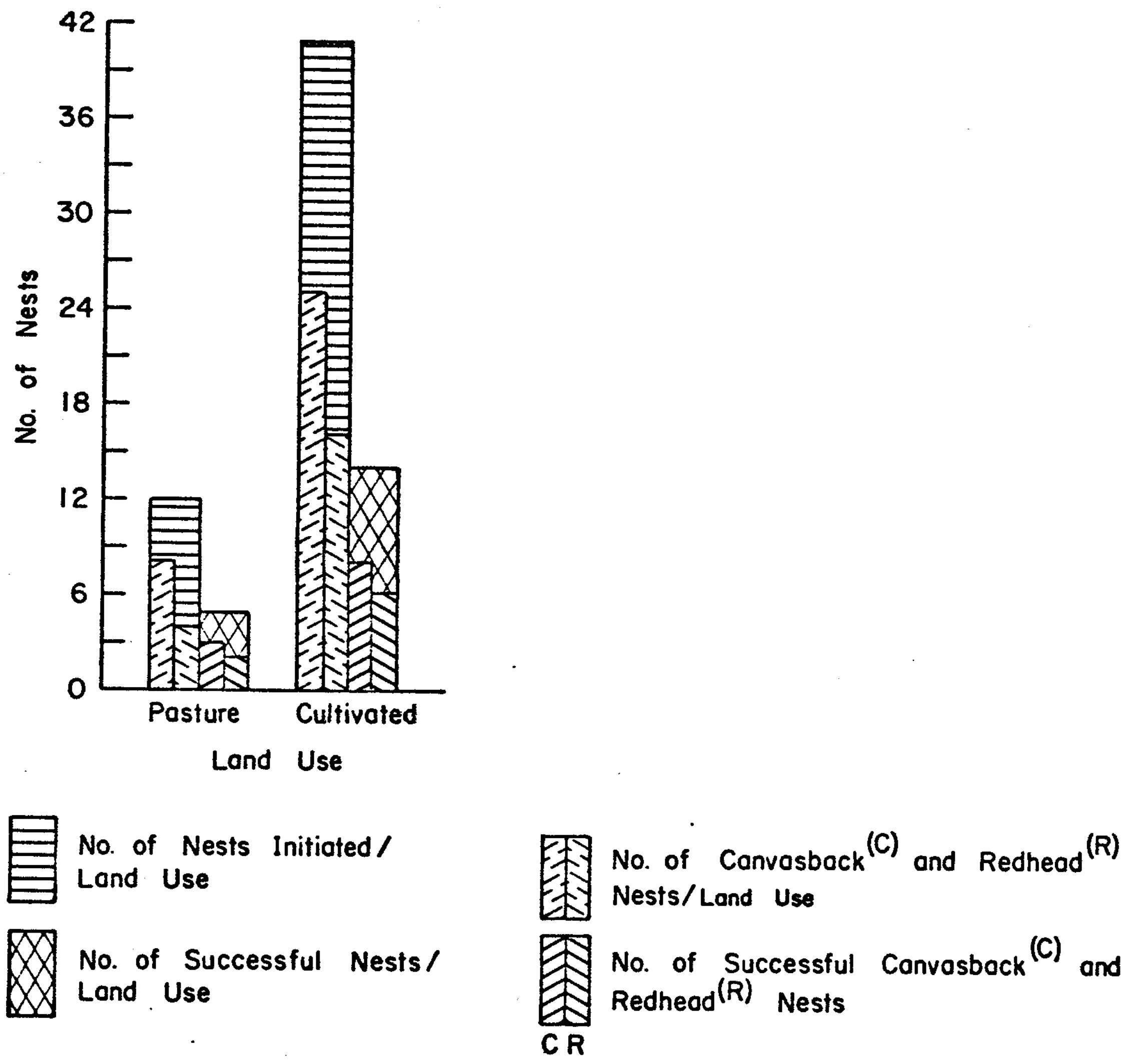

Figure 11. Canvasback and redhead nest distribution and nest success in relation to land use (study block data pooled for 1974 and 1975).

land it was 1:4.2 (Figure 11 and Table 37).

Significantly ($P < 0.05$) more canvasback nests were found in ponds surrounded by pasture in 1974 than in 1975 (Table 22). Seven of 19 nests (37%) were located in pasture land in 1974 as opposed to 1 out of 14 nests (7%) in 1975 (Table 37). As discussed under woody fringe, canvasbacks selected wooded ponds and utilized willows as a nesting substrate to a greater extent in 1974 than in 1975. Table 38 shows that twice as many ponds in pasture land were enclosed by a woody fringe as compared to ponds located in cultivated land. This possibly accounts for the higher use of ponds in pasture land by canvasbacks during the 1974 nesting season.

Canvasback and redhead nesting success did not differ significantly in pasture land or cultivated land. Nesting success was slightly higher for nests found within pasture areas (grazed grassland) than for those in cultivated land, 42% vs. 34%, respectively (Figure 11). Stoudt (1974) reported above average nesting success for pasture land and below average in cultivated land. He considered cover for predators to be reduced in actively grazed areas as opposed to land seeded in crop. Both canvasback and redheads shared the same degree of success when nesting in either land use type.

Canvasback and redhead females exhibited a preference for nesting ponds located in pasture land within the transects (Table 39). The opposite was recorded for the study block; most nests were found in cultivated areas. Since there were no significant differences for nesting success based on land use surrounding a nesting pond, this variable was considered of lesser importance in assessing nesting habitat quality.

Table 37. Canvasback and Redhead Nest Distribution in 1974 and 1975 According to Land Use Encompassing Each Pond.

	1974				1975			
Land Use	Canvasback Frequency	%	Redhead Frequency	%	Canvasback Frequency	%	Redhead Frequency	%
Pasture	7	37	2	22	1	7	2	18
Cultivation	12	63	7	78	13	93	9	82

Table 38. Distribution of Woody Fringed Ponds Between Pastureland and Cultivated Land Within the Study Block.

Woody Fringe	Pastureland	Cultivated Land
Open	19	115
Half-open	22	33
Closed	17	24
Total	58	172
Percent Open	33	67
Percent Half-open & closed	67	33

Table 39. Canvasback and Redhead Nest Distribution According to Land Use on the Transects and the Study Block - 1975.

	Land Use		
	Pasture land	Cultivated land	Total
Transects			
Canvasback nests	4	3	7
Redhead nests	8	1	9
Nests/Land use type	12	4	16
Percent nests/land use type	75	25	100
No. ponds/land use type	76(62)	46(38)	122
Study Block			
Canvasback nests	1	13	14
Redhead nests	2	9	11
Nests/land use type	3	22	25
Percent nests/land use type	12	88	100
No. ponds/land use type	52(23)	178(77)	230

Basin Disturbance

During this study, 26% of canvasback and redhead nests on the study block were found on ponds suffering some degree of disturbance. All but two of these ponds were affected by livestock grazing and trampling. The other nesting ponds had had their woody fringes bulldozed into a central location. Nesting success rates were similar for nests located in disturbed wetlands as opposed to those in pristine condition. These results suggest that grazing was not a significant disturbance factor in relation to canvasback and redhead nesting success.

Concealment Vegetation

Canvasback and redhead females exhibited similar preferences for vegetation selected as a nesting substrate or for nest seclusion. Fifty-six percent of all nests were found in cattails (Figure 12), a finding supported by earlier studies (Table 1). Twenty-eight percent of nest initiations were found in flooded willows and 80% of these occurred in 1974 during a time of high water levels (Table 40).

Canvasbacks used willows for nesting cover significantly more in 1974 (53%) than in 1975 (7%) (Table 22). Stoudt (1971) and Sugden (1972) noted extensive canvasback use of flooded willows when cattail cover was scarce. Sedge, whitetop and bulrush were only used to a limited extent. Although bulrush is a favoured emergent for nesting cover by both canvasbacks and redheads (Table 1) its low use in this study is best reflected in the scarcity of this emergent on the study block.

No significant differences were recorded for successful vs. unsuccessful nests in terms of this habitat parameter. Nesting success was highest when nests were located in cattails (45%) whereas nesting success was relatively poor in willows (27%) (Figure 12). Stoudt (1974)

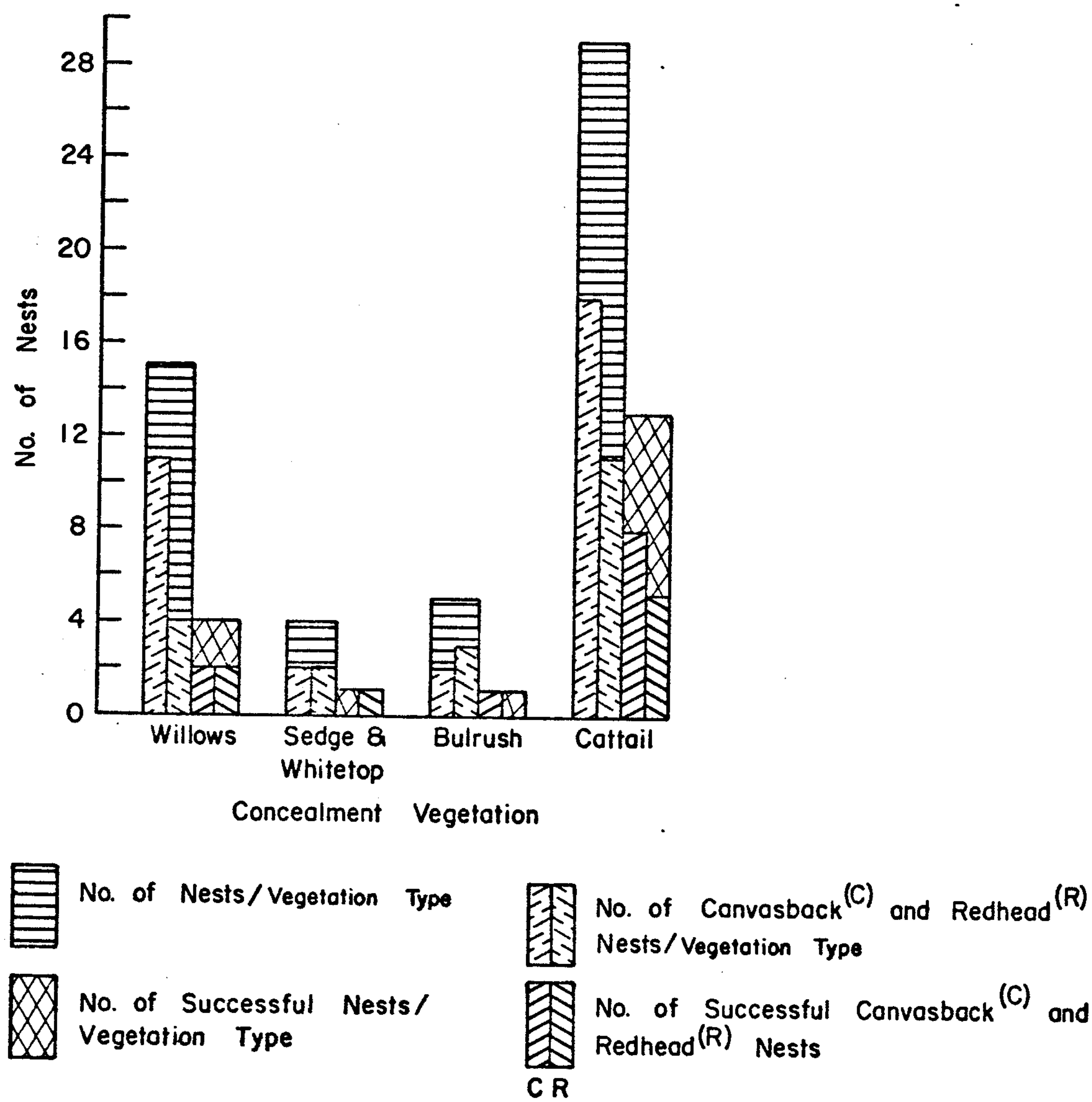

Figure 12. Canvasback and redhead nest distribution and nest success in relation to concealment vegetation (study block data pooled for 1974 and 1975).

Table 40. Canvasback and Redhead Nest Distribution in 1974 and 1975 According to Nest Concealment Vegetation.

	1974				1975			
Concealment Vegetation	Canvasback Frequency	%	Redhead Frequency	%	Canvasback Frequency	%	Redhead Frequency	%
Sedge or Whitetop	1	5	1	11	1	7	1	9
Willows	10	53	2	22	1	7	2	18
Bulrush	1	5	2	22	1	7	1	9
Cattail	7	37	4	44	11	79	7	64

and Sugden (1978) found above average canvasback nesting success in cattail and below average success in willows. Stoudt (1974) felt that nests in willows were highly vulnerable due to their being conspicuous while Sugden (1978) considered any type of woody growth to attract avian predators. Data of this study suggest that 71% of nests located in willows were predated while 38% located in cattails were destroyed.

Canvasback and redhead hens located all but one of their nests in cattails or bulrushes on the transects (Table 41). Hardstem bulrush contained 38% of all nests found on the transects while only 8% were found in this emergent on the study block. Bulrush cover was much more common on the transects than on the study block. Use of bulrush for nest concealment is probably related to its availability or abundance.

Twenty percent of canvasback and redhead nests on the study block were found in nesting cover other than cattail or bulrush while only 6% on the transects chose alternate concealment vegetation. As has been shown, nesting habitat on the study block is of poorer quality (Table 28, 34 and 36) and probably accounts for nests being found in less favourable locations (willows). When willows were used as a nesting substrate, success was below average (Figure 12). Consequently the higher use of willows on the study block could have been a contributory factor to the lower recorded productivity.

Summary

Canvasback and redhead nest site selection on the study block and the roadside transects are summarized on Table 42. In addition, those habitat components which resulted in successful nesting for both species on the study block, are included.

Table 41. Canvasback and Redhead Nest Distribution According to Concealment Vegetation Utilized on the Transects and the Study Block - 1975.

	Concealment Vegetation				
	Willows	Whitetop	Bulrush	Cattail	Total
Transects					
Canvasback nests	-	1	4	2	7
Redhead nests	-	-	2	7	9
Nests/concealment vegetation type	-	1	6	9	16
Percent nests/conceal. vegetation type	-	6	38	56	100
Study Block					
Canvasback nests	1	1	1	11	14
Redhead nests	2	1	1	7	11
Nests/concealment vegetation type	3	2	2	18	25
Percent nests/conceal. vegetation type	12	8	8	72	100

Table 42. Summary of Canvasback and Redhead Nesting Ecology, on the Study Block and Roadside Transects, and Nesting Success on the Study Block.

	Study Block		Transects		Study Block
	Preferred Nesting Habitat				
Habitat Components	Canvasback	Redhead	Canvasback	Redhead	Nesting Success for Both Species
Pond size	No preference	>0.83 hectares	>0.83 hectares	>0.83 hectares	>0.83 hectares
Pond permanency	Seasonal	Semi-permanent	Semi-permanent	Semi-permanent and permanent	Semi-permanent
Woody fringe	<25%	<25%	<25%	<25%	No influence
Pond cover type	open water >5% of pond area	open water >5% of pond area	open water >5% of pond area	open water >5% of pond area	>5% of pond area contained emergents
Emergent vegetation type[1]	R, RS, RF + WRS	R	R, RS	R	R
Associated land use	Cultivated land	Cultivated land	Pasture land	Pasture land	No influence
Pond nesting potential	Good	Excellent	Good and Excellent	Good and Excellent	Excellent
Nest concealment vegetation	Cattail and willows	Cattail	Bulrush	Cattail	Cattail

[1]R - reeds (cattail or bulrush)
S - broadleaf sedges and whitetop
F - broadleaf forbs and rushes
W - willows

Habitat requirements for the 2 species overlapped but significant differences were recorded on the study block for: pond size ($P < 0.01$); pond permanency ($P < 0.01$); emergent vegetation types ($P < 0.05$); and pond nesting potential ($P < 0.01$).

Nesting success on the study block varied significantly for: pond permanency ($P < 0.10$); emergent vegetation type ($P < 0.01$); and pond nesting potential ($P < 0.01$).

Net productivity for the roadside transects were substantially higher then for the study block. No evidence was recorded that human disturbance was responsible for poor nesting success on the study block. Sugden (1978) did not find that visiting canvasback nests increased nest losses through predation. Poor habitat quality on the study block was responsible for low productivity and superior habitat quality on the transects resulted in higher productivity.

Nesting habitat selection between the study block and transects for pond size and pond permanency were demonstrated by canvasbacks. Both of these habitat parameter differences were improvements in terms of habitat quality and nesting success. On the study block, female canvasbacks chose nesting ponds in all size classes whereas those on the transects preferred ponds larger than .83 ha. (2.0 ac.). More nests were successful on the larger ponds. Study block canvasbacks preferred seasonal nesting ponds as opposed to semi-permanent ponds on the transects. Nesting success was found to be significantly ($P < 0.10$) higher on semi-permanent ponds. Increased canvasback production on the transects was related to these changes in nesting habitat selection. The use of higher quality nesting habitat was in response to its availability. The transects contained 27% more semi-permanent and permanent ponds than did the study block. Sugden (1978) found nesting effort directly related to habitat availability, the number of semipermanent and permanent ponds available per canvasback pair. Redhead females, on the other hand, exhibited similar nest site selection criteria for both components of the study area. Increased availability of high quality nesting habitat on the transects may have reduced intraspecific encounters and subsequently reduced the number of redhead nest desertions. This would have lead to higher nesting success and higher productivity.

Canvasbacks and redheads have similar habitat requirements for nesting; thus encounters between the species were unavoidable. Redhead interspecific parasitism was an important factor in reducing canvasback clutch size and production but was not a factor in canvasback nest desertion. Redhead intraspecific encounters were related to habitat availability and to the rate of nest desertions. Canvasback females displayed a wide range of adaptability in nest site selection due to climatic and habitat factors. Raccoon predation of canvasback nests was the single most decimating element and was responsible for low canvasback productivity on the study block.

RESULTS AND DISCUSSION - PART 2

INTERPRETATION OF WETLAND HABITAT PARAMETERS FROM REMOTE SENSING IMAGERY

Pond size

Although wetland size can be accurately estimated in the field (Millar 1973a), all pond size measurements in this study were obtained directly from aerial photographs by using an electronic planimeter. Wetland boundaries were easily detected in regions dominated by agriculture. Generally changes in plant species from wetland to cropland or pasture provided an obvious change in colour tone or hue on the airphoto. Under stereoscropic vision, lowland areas usually contained some type of wetland development and were not seeded to crop except under very dry conditions. In the aspen parkland where wetlands have not been disturbed, wetland boundaries contain some degree of woody growth. In cultivated areas woody vegetation was detected by its rough texture, casting of shadows and relief (height) apparent under stereoscopic view.

Pond size measurements should ideally have been made from spring aerial photographs prior to new growth of emergent vegetation when wetland-upland boundaries are most obvious. Infrared photography produced the best results for imaging water bodies or wet areas. Parry and Turner (1971) found that the sensitivity of black and white infrared film to moisture content variations made this film extremely useful in the precise determination of land-water boundaries, particularily specific wetland areas. The less permanent emergent filled basins which became dry during mid-summer were more difficult to interpret than the deeper, open water ponds. Image features such as rough photographic texture and non-geometric patterns aided in interpreting these wetlands.

Pond Cover Type

The extent to which a wetlands surface area is covered by emergent vegetation was a simple visual calculation from an aerial photograph. The only difficulty encountered for this assessment was the ability to distinguish emergents from floating leaved plants or submergents. Ektachrome photography imaged both floating leaved vegetation as well as the submergents. Aerochrome imagery did not penetrate the water surface and only imaged the floating-leaved species. The ability to perceive height with the use of a stereoscope aided in the interpretation of emergent vegetation from floating leaved plants.

Not only did the pond cover type indicate the extent to which cover was available for over water nesting ducks but also provided clues to the permanency of each wetland. Generally, ponds containing dense stands of emergent vegetation occupying the entire basin were indicative of a shallow water regime and subsequently a low permanency rating (Stewart and Kantrud 1971). On the other hand, wetlands dominated by a central open water zone during mid to late summer were indicative of more stable water conditions and higher permanency ratings. These were relative conditions and could have been modified by other factors. High water levels, land use practices such as intense wetland grazing or alkalinity may alter normal cover types and give false preliminary indications of wetland permanency. The best indication of relative pond permanency was determined through the vegetation found within each pond. The interpretation will be discussed later.

Woody Fringe

Woody vegetation can be identified stereoscopically by: 1) height (trees and/or willows are generally taller than other vegetation); 2) shadows (because of their height, woody vegetation cast long shadows); 3) texture (because of branching and irregular spacing, a rough surface appearance is produced); and 4) location (woody vegetation is found along the outside edge of a pond although willows can occupy less permanent basins).

Dead or dying trees and willows appear grey on Ektachrome imagery while displaying a bluish tone on Aerochrome imagery. Extensive evidence of this characteristic was indicative of an increase in the water regime. Willows can withstand short periods of inundation and were found growing throughout some temporary and seasonal wetlands.

Associated land use

Two categories of land management practices surrounding wetlands were cultivated and not cultivated. Cultivated land was either in stubble, summer fallow, swath or growing crops depending on the time of the year. Land not in cultivation was either grazed grassland, ungrazed grassland or woodlots.

Interpretation of growing crops was based on colour tone and texture. Grain crops were successfully interpreted based on shades of green or magenta on the respective imagery. Oil seed and forage crops were identified from flower colouration (providing that the photography is taken at the appropriate time). Thaman (1974) reported that colour and colour infrared imagery were best for crop identification.

Multidate photography is suggested as the most reliable means for conducting crop identification surveys due to the changing signatures of cultivated crops on remote sensing imagery and the variable seeding times. Although no effort was made to interpret cultivated crops, their presence and type were recorded.

Pasture land appears less homogeneous in tone and has a rougher texture than seeded cropland. This was due to the wide variability and density of the vegetation growing in native pasture. The presence of livestock trails leading to and from water areas was a dominant feature in identifying this land use practice. Grazing intensity and time of the year were variables affecting the appearance of grazing areas. Grazing intensity was reflected in vegetation vigor and the extent of exposed bare ground. Aerochrome imagery was found to be superior for assessing vegetative vigor and the exposed bare ground due to the greater absorption of infrared radiation on bare ground.

Wetland disturbance

Wetland habitat can be eliminated or made unattractive to migratory waterfowl through man-induced disturbances. The most manifest of these practices, in particular those altering emergent nesting cover are: mowing of emergent vegetation, spring or fall burning of emergent vegetation; livestock grazing and trampling of wetland basins; wetland drainage (partial and complete) and wetland filling.

Mowing eliminates emergent residual vegetation for the following spring. Climatic conditions can affect the extent of this practice. Dry conditions provide opportunity for extensive mowing. The available imagery was taken during mid-summer and evidence of mowing was observed. During both years of this study water levels were fairly high and only the less permanent wetlands (temporary and some seasonal ponds) were mowed. Rows of swaths located in depressions were clues to wetland mowing. The swaths appeared beige in colour on Ektachrome imagery and white on Aerochrome imagery. Evidence of previous disturbance (mowing, plowing, cultivation) on presently inundated wetlands was visible in the form of striation-type patterns on the imagery.

Burning practices occur in two forms, fall and spring burning. Fall burning removes residual emergent cover and can be quite extensive when water levels are low, reducing the availability of overwater nesting cover the next spring. Spring burning destroys early upland duck nests. Both practices reduce the continually dwindling supply of nesting cover. These practices are of short term duration and are only evident prior to the new growth in the spring. Spring photography is ideal for assessing this practice. Lack of residual vegetation, charred remains of vegetation or lush early growth are obvious evidence of this practice.

Grazing and trampling of wetland vegetation can reduce a ponds attractiveness to waterfowl. The overall effect is the destruction or reduction of nesting cover for both upland and overwater nesting species. This disturbance was most severe in pasture areas where there was a shortage of semi-permanent and permanent ponds. Interpretation features which aided in identifying livestock grazing and trampling of wetland vegetation were: a discontinuous band of emergents, vegetation exhibiting stress characteristics, poor vigor and patches of dead vegetation within the wetland perimeter and livestock trails leading to the wetlands.

Wetland drainage on the study area took two forms, permanent and partial. Permanent drainage resulted in the complete removal of the wetland. More often was the practice of partial drainage which attempted to reduce the size of the wetland and also affected its permanency. The presence of drainage channels was readily interpretable from low level aerial photography. They are usually shallow, straight trenches leading from a higher point (wetland) to a lower one. Drainage channels either connect two or more wetlands or run from one wetland to a roadway ditch system. The spoil banks of these channels can either be vegetated or barren depending on how recent they are or on the subsoil characteristics.

Wetland filling by bulldozing the brush and/or woody fringe into the central region of a pond can reduce its ability to hold water. By so doing, a wetlands character becomes completely changed, its water regime is permanently altered and subsequently its vegetation. This practice was identified on aerial photos by the presence of islands, centrally located, either exhibiting dead or burned woody vegetation or as vegetated hummocks.

Emergent vegetation type

The vegetation found growing within a wetland was one of the principal factors as to its suitability for providing overwater nesting cover. Part 1 of this thesis examined canvasback and redhead nesting habitat requirements. Emergent vegetation interpretation from remote sensing imagery coupled with the knowledge of a waterfowl species nesting requirements would provide for a rapid qualitative and/or quantitative assessment of the wetland habitat for a particular region.

The six emergent vegetation types adopted for this study were: reed marsh; broadleaf sedge-reedgrass marsh; broadleaf forb-rush marsh; grass-rush meadow; herb-grass meadow and willow clumps. These six types singularily or in combination described all wetlands encountered during the course of this project.

Several factors affected the growth and appearance of emergent vegetation consequently altering their signature on aerial photographs. Vegetation density caused changes in tone and texture from pond to pond. A low density of vegetation resulted in a darker colour when exposed water or wet bare ground appeared through the canopy. The texture was also altered slightly in discontinuous stands of emergents.

The water regime or moisture stress (both excess or deficiency) caused tonal changes in the vegetation. Climatic factors had to be considered when interpreting emergent vegetation. Rapid drawdown within one wetland containing stands of cattail reflected a lighter colour on infrared imagery than another wetland where drawdown was not as rapid or as severe. Both wetlands appeared relatively the same on Ektachrome imagery. Wilting caused tonal changes resulting from moisture stress; the Aerochrome photography exhibited this change more readily than the Ektachrome imagery.

Vegetation diversity was another factor found influencing colour tone and texture. The less permanent ponds, those described as a broadleaf forb-rush marsh or a grass-rush meadow, contained many emergent species growing together and depending on dominance had a variable tone as indicated by Table 43.

Livestock grazing and trampling reduced plant vigor and subsequently altered their absorption and reflection of visible and infrared light.

Table 43. Interpretation Key for the Identification of Wetland Emergent Vegetation in Southwestern Manitoba from Multispectral Photography (July 25/75).

Emergent vegetation type	Vegetative species	Appearance E[1]	Appearance A[2]	Texture	Association	Examples[3]
R	Common cattail (*Typha latifolia*)	Dark green to mottled beige dependant on moisture stress	Reddish-brown to light brown dependent on moisture stress	medium	may establish itself in very temporary water or may persist for years in semi-permanent ponds (Millar 1976).	1B,3A,3B, 3C,4A,4B, 8B,8C.
	Hardstem bulrush (*Scripus acutus*)	Greyish-green	shades of brown dependant on plant species	medium	good indicator of relatively stable semi-permanent water conditions (Millar 1976)	2A,2B.
S	Broad-leaved sedge (*Carex atherodes*)	medium green	reddish-pink	smooth	dominant shallow marsh species indicative of ponds regularly drying up by mid-summer (Millar 1976)	3A,4A,7A.
	Whitetop (*Scolochloa festucacea*)	medium-light green	medium pink	smooth	frequently occurs where there is a longer period of flooding (Millar 1976)	1A,3C,6A, 8C.

Table 43. (Continued)

Emergent vegetation type	Vegetative species	Appearance E[1]	Appearance A[2]	Texture	Association	Examples[3]
F	Spikerush (*Eleocharis palustris*)	very dark green	very dark magenta	smooth	presence of this species in the shallow marsh zone indicates a longer period of flooding (Millar 1976).	3A, 5A, 5B, 7B.
	Water-plantain (*Alisma triviale*)	light yellow	very light pink	smooth	considered to be a disturbance species maintaining itself for several years after disturbance (Millar 1976).	5A, 5B, 6A.
	Mannagrass (*Glyceria grandis*)	light green	pink	smooth	common species to achieve dominance in moderately moist situations following disturbance (Millar 1976).	5A, 5B.
	Water parsnip (*Sium suave*)	light yellow	very light pink	smooth	shallow marsh species generally found associated with water plantain and mannagrass.	6A, 6B.
	Wild barley (*Hordeum jubatum*)	yellow	off-white	smooth	wet meadow dominant as well as a pioneering species (Millar 1976).	6C.

Table 43. (Continued)

Emergent vegetation type	Vegetative species	Appearance E[1]	Appearance A[2]	Texture	Association	Examples[3]
H/M	Herbs and grasses	light green	light pink	smooth	generally found on brush piles pushed into wetlands or as outer fringes of wet meadow zones, reliable indicators of low water levels.	6C, 7C.
W	Willows (*Salix* sp.)	grey to green dependant on moisture stress	light magenta to dark blue	rough	absence of willows from wet meadow zones of wetlands in the parkland region is a reliable indication that depressions have at one time been partially or entirely cultivated (Millar 1976).	1A,8A,8C.

[1]Ektachrome.

[2]Aerochrome.

[3]Plate number, wetland reference.

Pond permanency

The interpretation of pond permanency from remote sensing imagery was related to pond cover type, emergent vegetation and pond size.

Millar (1973b) found that open water zones within wetlands were a reliable indicator of some year-round flooding. Closed stands of emergents were found in shallow water, open stands in deep water and semi-open stands in intermediate depths (Stewart and Kantrud 1971). Ponds dominated by a central expanse of open water fringed by cattail, bulrush or whitetop were interpreted as the most permanent wetlands, semi-permanent (type 4) or permanent (type 5). These ponds were best described by pond cover types 2 and 3, where open water accounted for 5-95% of the wetland area (Stewart and Kantrud 1971). All of the ponds categorized as semi-permanent within the study block were larger than .83 ha. (2.0 ac.).

Seasonal ponds (type 3) were centrally dominated by shallow marsh emergents such as broadleaf sedge, whitetop, mannagrass, sloughgrass, smartweed or spkierush. These wetlands contained some open water and were best described by cover type 1 (closed stands of emergents with open water covering less than 5% of the wetland area). Fifty-five percent of the wetlands on the study block occurred in the .23-.83 ha. size class.

Temporary ponds (type 2) were dominated by wet meadow vegetation such as narrow leaved sedges, foxtail, northern reedgrass, baltic rush, dock and sowthistle. These wetlands contained no open water during mid-summer and the stands of emergents were closed (cover type 1). Eighty percent of the wetlands classed as temporary were .42 ha. or less in size.

Ephemeral ponds contained water for only short periods in the spring and were dominated by low prairie vegetation such as Kentucky bluegrass (*Poa pratensis*), switchgrass (*Panicum virgatum*), slender wheatgrass (*Agropyron trachycaulum*), goldenrod (*Solidago* sp.) and wolfberry (*Symphoricarpus occidentalis*) (Stewart and Kantrud 1971). All of these ponds were less than .42 ha. in size.

INTERPRETATION OF HABITAT PARAMETERS

The preceding discussion contains an explanation and description of wetland ecological parameters as well as their interpretation from aerial photographs. Table 42 provides an interpretation key and list of examples for emergent vegetation types as found within the study area. The following section comprises specific examples of the aforementioned parameters and their analysis on multispectral remote sensing imagery (Plates 1-8).

The area between the dotted lines on each figure represents the extent of overlap from one photo to the next. This region can be viewed under a stereoscope and this procedure is recommended as an aid in airphoto interpretation.

Plate 1

Wetland A

emergent type: WS, willows, slough sedge and whitetop.

woody fringe: 2, approximately 70% of the wetland fringe was wooded.

pond size: 3.03 ha. (7.21 ac.).

pond permanency: type 4, semi-permanent.

pond cover type: 2, approximately 50% of the wetland area is devoid of emergent vegetation.

wetland disturbance: none.

associated land use: upland area contained a cultivated crop of rapeseed.

comments:

A significant portion of the open water zone contains a dense covering of duckweed (*Lemna minor*) and open stands of variable density whitetop. The duckweed appears light yellow (Ektachrome imagery) and off-white (Aerochrome imagery). The whitetop interspersed in the open water zone appears light green (Ektachrome imagery) and light pink (Aerochrome imagery). The separation between whitetop and duckweed is much better and more discernable on the Aerochrome images than on the Ektachrome images. The tonal contrast in the infrared portion of the electromagnetic spectrum (.7-.9 millimicrons) is greater than that produced in the visible range (.4-.7 millimicrons). The light magenta toned vegetation (Aerochrome) or the medium green (Ektachrome) in the extreme western portion of this wetland is an example of a dense stand of sedge.

Inside the aspen (*Populus tremuloides*) outer fringe is an inner willow zone extending around 85% of the wetland. The mottled appearance of this band is due to an intermix of dead, dying and live

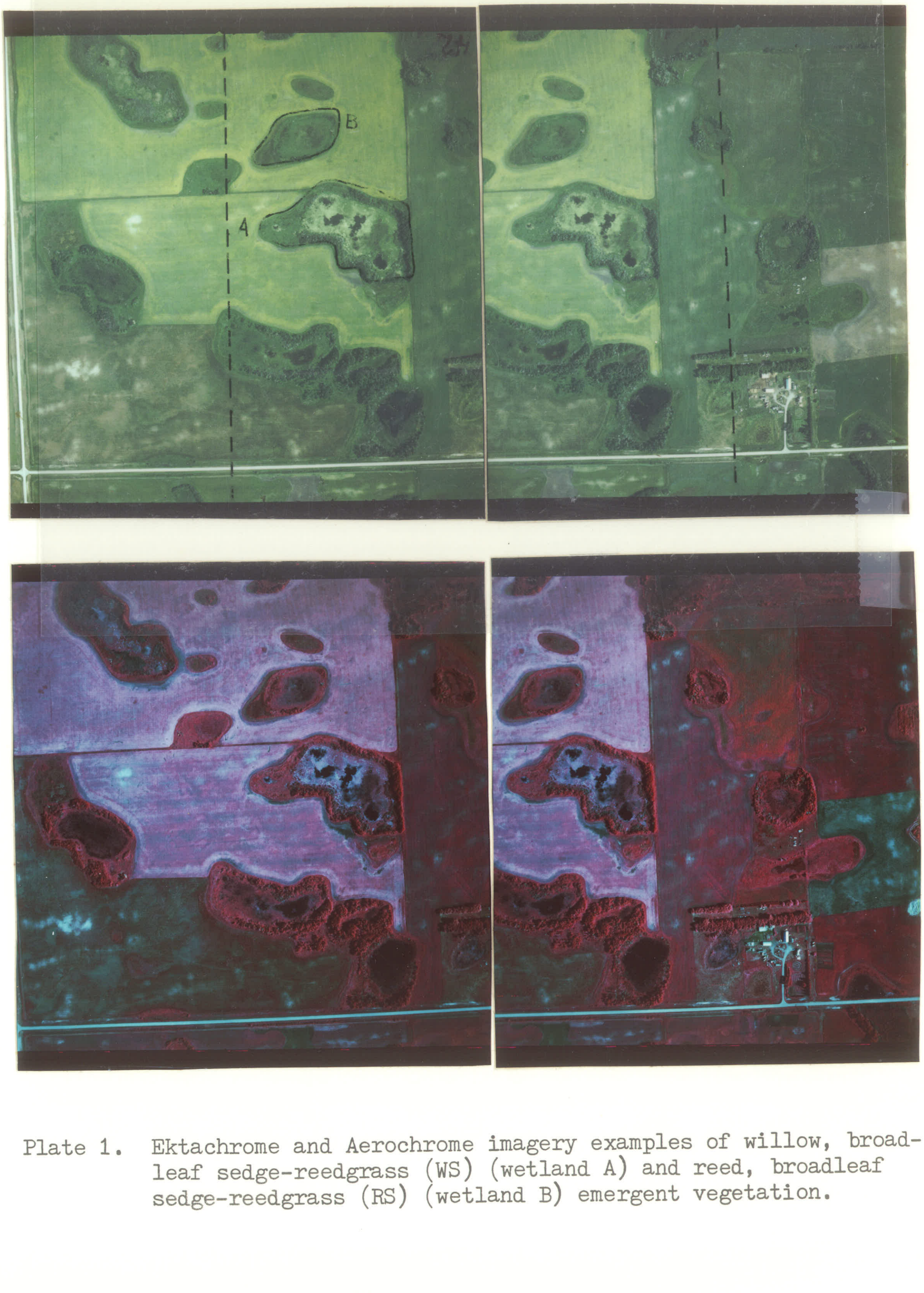

Plate 1. Ektachrome and Aerochrome imagery examples of willow, broadleaf sedge-reedgrass (WS) (wetland A) and reed, broadleaf sedge-reedgrass (RS) (wetland B) emergent vegetation.

willows. They appear grey to light green and rough in texture on Ektachrome imagery and light pink or bluish on Aerochrome imagery.

The upland area surrounding this wetland on 3 sides was seeded to rapeseed while the field to the west was seeded in a forage crop, an alfalfa-clover mixture. At this time of the year the rapeseed plant was flowering, hence the yellow (Ektachrome) or pale pink (Aerochrome) colour. Generally cultivated crops are uniform in tone and texture. On close examination the seeding rows are visible.

Wetland permanency ratings are subjective and vary, depending on water table fluctuations. During the period of this study, the region under consideration was experiencing high water levels and the permanency ratings of wetlands were assessed accordingly. This wetland with its intermittent open water zones and dominated by whitetop was considered to be a semi-permanent wetland.

Wetland B

emergent type: RS, cattail, slough sedge and whitetop.

woody fringe: 1, less than 25% of the wetland was treed.

pond size: 1.14 ha. (2.72 ac.).

pond permanency: type 3, seasonal.

pond cover type: 1, open water covered less than 5% of the wetland area.

wetland disturbance: none.

associated land use: surrounding upland seeded in rapeseed.

comments:

Four distinct tone-texture variations are evident within this wetland. The central zone contains standing water, scattered patches of duckweed and open stands of sedge and whitetop. The extent of the standing water phase (dark area) is more apparent on Aerochrome than on Ektachrome. The light coloured areas (pale yellow and off-white) are due to low density sedge and whitetop. The lightest patches are areas of high density duckweed mats. This zone was considered lighter in colour due to variations in vegetation density and species composition.

The next concentric zone was dominated by sedge and whitetop. The spectral signature for this intermix of vegetation was consistent and representative throughout the imagery.

The third zone or spectral anomoly occurs in three distinct locations, all tending to be peripherally located. The dark coloured, medium in texture vegetation is an example of cattail. It characteristically appears dark-green on Ektachrome and brownish-green on Aerochrome imagery.

The last unidentified feature is rough-textured and lies in the south-central fringe of the wetland. This small clump of trembling aspen is only a remnant of a once extensive treed fringe. These small treed clumps were left standing only because they were on the sites of stone accumulations from years of cultivation and stone picking. The uneven tree canopy, height variations and shadows account for the rough texture.

Lack of an open water zone and the presence of sedge as one of the dominant species within the central region implies that this wetland lacks permanency and hence was considered a seasonal wetland.

Plate 2

Wetland A

emergent type: R, hardstem bulrush and hybrid cattail.

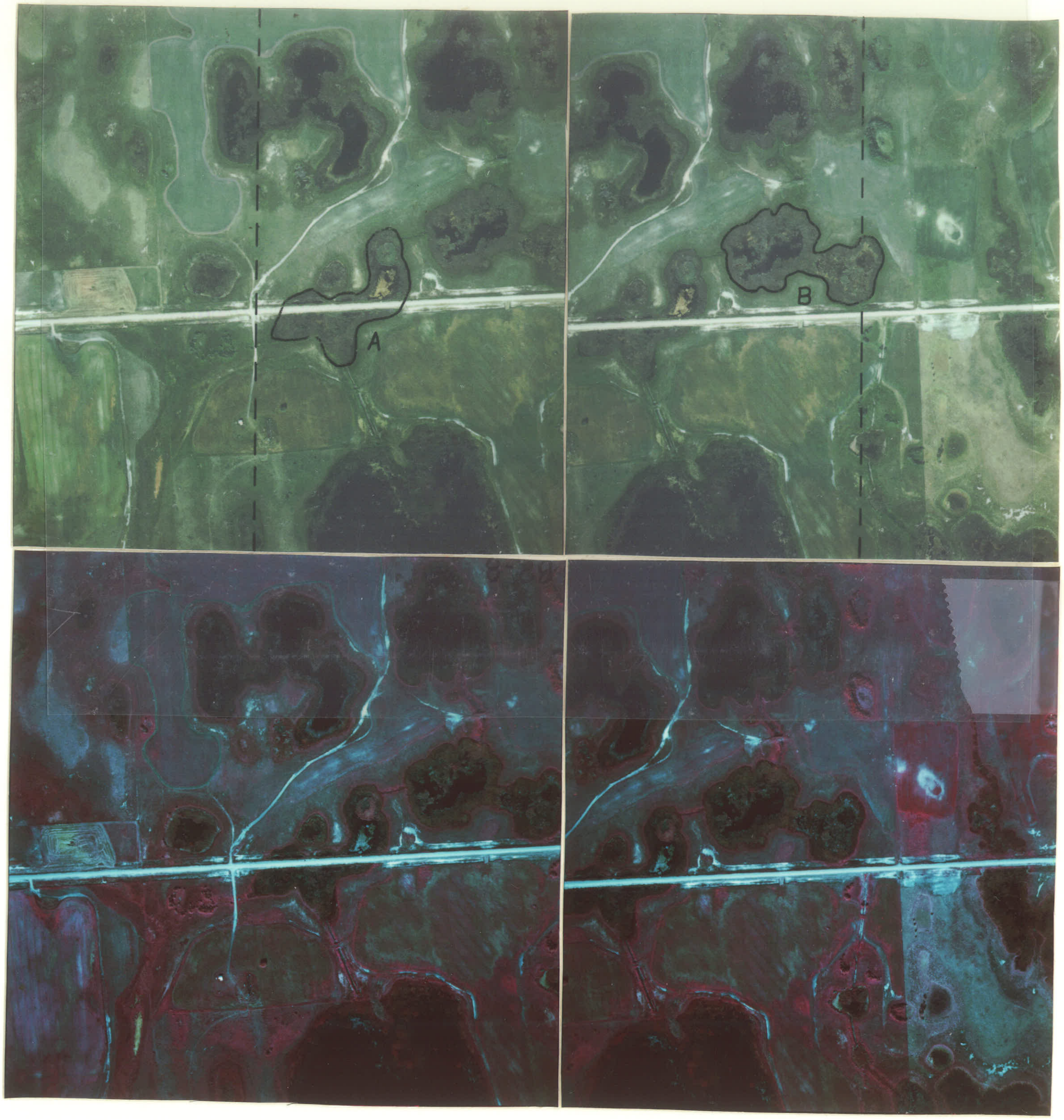

Plate 2. Ektachrome and Aerochrome imagery examples of reed (R) (wetlands A and B) emergent vegetation.

woody fringe: 1, there was no woody vegetation fringing this wetland.

pond size: 2.34 ha. (5.58 ac.).

pond permanency: 4, semi-permanent.

pond cover type: 2, approximately 60% of the wetland contained open water with scattered dense patches of emergents.

wetland disturbance: Two ditches interconnect this wetland with others.

associated land use: upland areas utilized as pasture.

comments:

There appears to be three types of aquatic vegetation growing within this wetland based on texture, colour and location. The continuous outer fringe was dominated by hardstem bulrush. It is medium in texture, greyish in colour on Ektachrome imagery and reddish-brown on Aerochrome.

The dense clump of emergent vegetation centrally located in the western portion of this wetland was hybrid cattail. It differs significantly in tonal properties from common cattail as illustrated in wetland B, Plate 1. Hybrid cattail reflects in a much lighter colour than common cattail on both Ektachrome and Aerochrome imagery. It contrasts to a greater degree on Aerochrome than on Ektachrome. The eastern portion of this wetland also contained smaller scattered clumps of hybrid cattail. The light-coloured vegetation (yellow on Ektachrome and off-white on Aerochrome) found in the open water zone directly west of the roadway was a dense covering of common bladderwort (Utricularia vulgaris).

The landowner(s) have an intricate ditch system in this area interconnecting a series of four wetlands. It is difficult to ascertain from these photos whether he is having much success in wetland drainage. It appears that the drainage pattern on both sides of the road is towards the roadway ditch system. In this case the landowner will probably ensure that during years of high water levels the excess water will not flood the upland areas but will be carried away via his ditch system to the roadway drainage network.

Wetland B

emergent type: R, hardstem bulrush and hybrid cattail.

woody fringe: 1, there was no woody vegetation fringing this wetland.

pond size: 2.70 ha. (6.45 ac.).

pond permanency: 4, semi-permanent.

pond cover type: 2, open water covered approximately 40% of this wetland interspersed with scattered clumps of emergent cover.

wetland disturbance: Two drainage ditches interconnect this wetland with 2 other wetlands.

associated land use: upland area maintained as pasture land.

comments:

This wetland was very similar to wetland A in this figure, but is almost exclusively dominated by hardstem bulrush. The only area containing hybrid cattail was in the vicinity of the ditch entrance to this wetland from the west. This patch of hybrid cattail is almost not detectable on the Ektachrome photo while it is slightly contrasted from the bulrush on the Aerochrome photo.

Patches of common bladderwort are present fringing the open water zone. In comparison between Plate 1 wetland A, common duckweed doesn't appear that much different in its textural and colour properties from common bladderwort. On Ektachrome imagery the duckweed appears slightly lighter than the bladderwort although this may be due to one or both of the following factors: vegetation density or change in sun angle (Stone 1956) although the latter shouldn't be a significant factor as both sets of photos were taken within a half-hour of each other.

The mottled appearance of the upland and the overall dull colouration is generally characteristic of heavily grazed areas. The mottled appearance is due to selective grazing by the livestock with removal of the more palatable species.

Plate 3

Wetland A

emergent type: RSF, common cattail, slough sedge, spikerush, water-plantain, marsh smartweed and sloughgrass.

woody fringe: 1, there was no woody vegetation surrounding this wetland other than a few small willow clumps.

pond size: 1.84 ha. (4.37 ac.).

pond permanency: 3, seasonal.

pond cover type: 1, less than 5% of the wetland contained open water.

wetland disturbance: Disturbance in the form of mowing is evident around this wetland by the concentric rings of dead vegetation visible on the imagery. Through ground inspection it was found that some of the drier portions of the cattail stands were being mowed as well.

associated land use: The surrounding upland regions had been seeded to rapeseed.

comments:

This wetland is part of a series of wetlands that can be termed overflow basins. During years of high water levels several wetlands

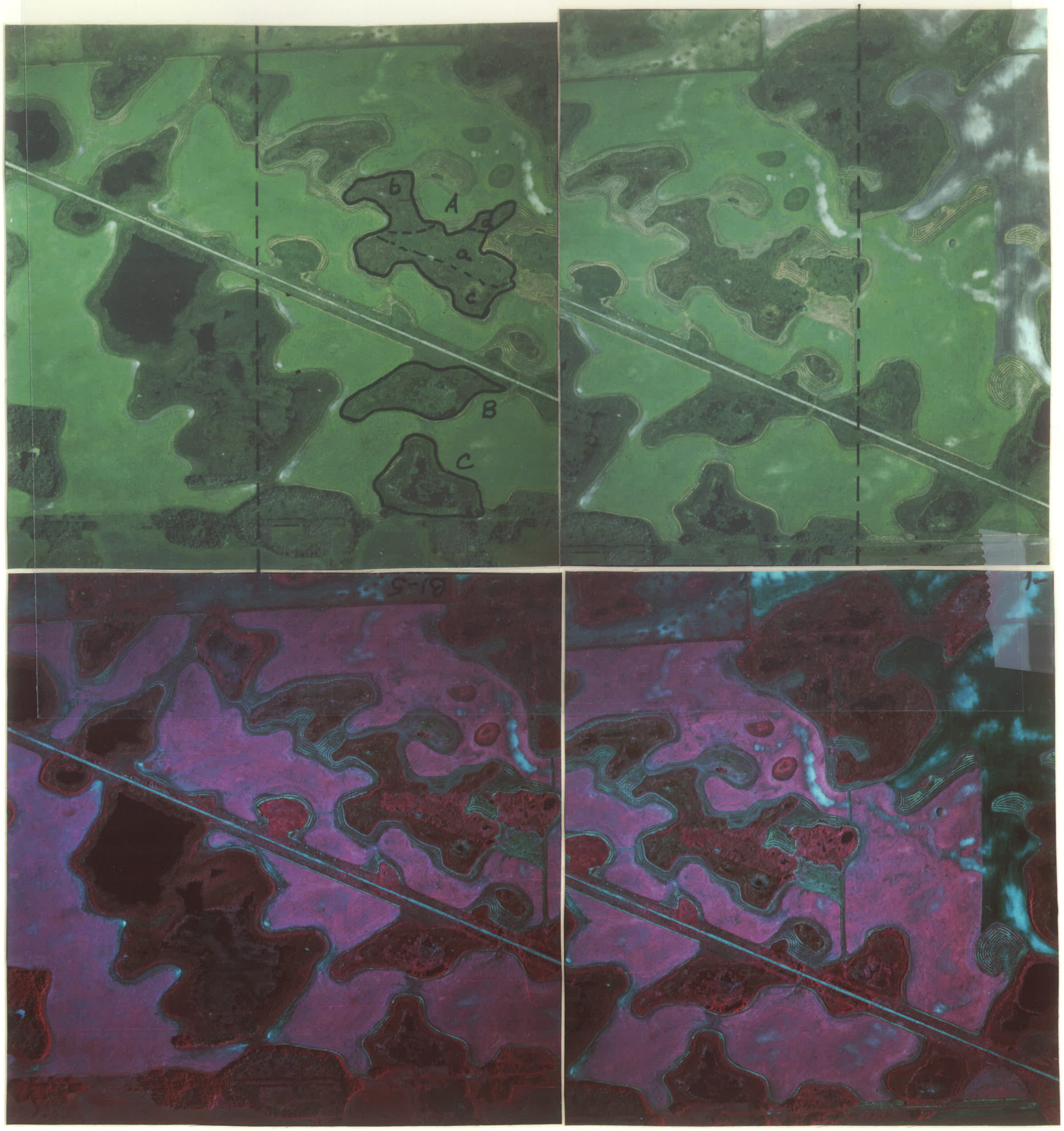

Plate 3. Ektachrome and Aerochrome imagery examples of reed, broadleaf sedge-reedgrass, broadleaf forb-rush (RSF) (wetlands A and B) and reed, broadleaf sedge-reedgrass (RS) (wetland C) emergent vegetation.

may appear as one large wetland but as the water recedes, they are evident as distinct basins with characteristics of their own. This pattern of overflow basins is present in a northwest direction from wetland A with visible signs of haying between each basin.

Upon examination of the imagery there appears to be 3 distinct types of vegetation based on tone-texture observations. The lightest colour annotated as Area a on the photograph, was identified as sedge. The darker toned peripheral regions of Areas b, c, and d were dominated by common cattail. The variable coloured central regions of b, c and d were composed of a variety of shallow marsh emergents. The darker toned central region of Area b was dominated by spikerush. The lighter central portion of Area c contained an intermix of water plantain, marsh smartweed, spikerush and sloughgrass. Area d was found to be similar to Area c. The rougher texture normally not associated with stands of sedge (Area a) - was due to the presence of low shrubs predominately willows.

Wetland B

emergent type: RSF, common cattail, slough sedge, whitetop and spikerush.

woody fringe: 1, approximately 10% of this wetland was fringed by woody vegetation.

pond size: 1.30 ha. (3.20 ac.).

pond permanency: intermediate between 3 (seasonal) and 4 (semi-permanent).

pond cover type: 2, approximately 10% of this wetland contained open water between dense stands of emergent vegetation.

wetland disturbance: none.

associated land use: surrounding upland was seeded to rapeseed.

comments:

Based on colour and textural variations on Ektachrome imagery, there appears to be 3 types of emergent vegetation growing within this wetland. An outer, dark mottled medium green zone was dominated by common cattail. The central light toned region was an intermix of slough sedge and whitetop. An intermediate located dark coloured discontinuous band was identified as spikerush.

Wetland C

emergent type: RS, common cattail, slough sedge and whitetop.

woody fringe: 1, less than 10% of the wetland perimeter was wooded.

pond size: 1.29 ha. (3.19 ac.).

pond permanency: type 4, semi-permanent.

pond cover type: 2, central open water zone compromising 35% of the wetland area with some interspersion of emergents.

wetland disturbance: none.

associated land use: cultivated rapeseed crop.

comments: outer emergent phase of dense, lush cattail. Open water zone contains diffuse clumps of whitetop-sedge intermix. The dark green tone (Ektachrome) and the dark reddish-brown tone (Aerochrome) as well as the uniform texture of the cattail fringe indicate healthy vegetative growth. This is also a general indication of stability in the water regime.

Plate 4

Wetland A

emergent type: RSW, common cattail, slough sedge and willows.

woody fringe: 1, approximately 10% of the wetland perimeter was wooded.

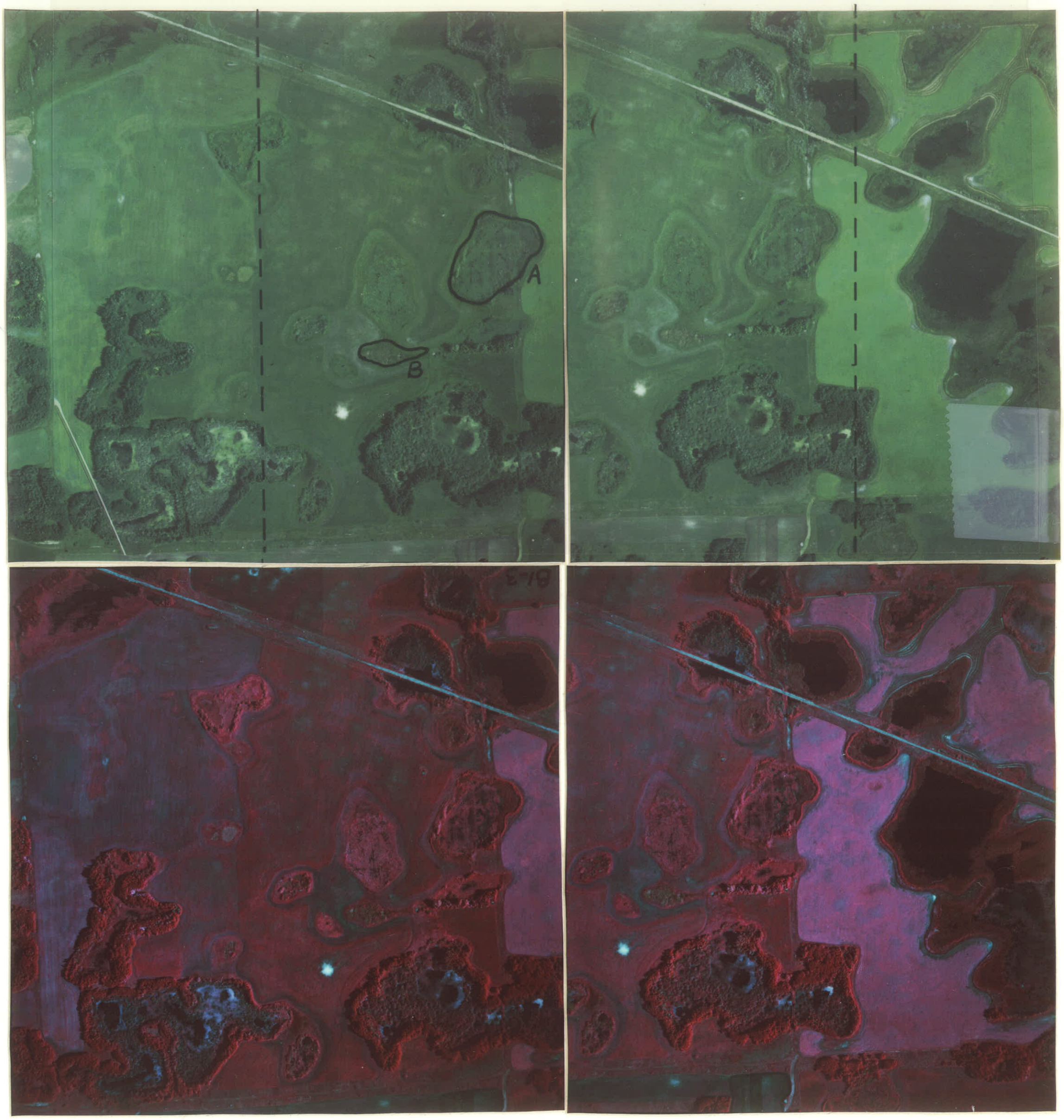

Plate 4. Ektachrome and Aerochrome imagery examples of reed, broadleaf sedge-reedgrass, willows (RSW) (wetland A) and reed, broadleaf forb-rush (RF) (wetland B) emergent vegetation.

pond size: 1.30 ha. (3.21 ac.).

pond permanency: type 3, seasonal.

pond cover type: 2, central open water zone comprises approximately 10% of wetland area between dense clumps of sedge and willows.

wetland disturbance: none at present, but the imagery exhibits north-south striations or rows evident within the sedge stands which might be an indication of mowing in drier years.

associated land use: cultivated crop of wheat.

comments:

The intermittent outer cattail fringe is not uniform or as dark in colour as was the cattail shown in Plate 3, wetland C. This was due to the effects of drawdown and the subsequent wilting of the cattail. The ensuing lack in vigor of the vegetation combined with the exposure of dead plant stocks has produced a slightly different spectral signature. The willow clumps in this wetland appear grey on the Ektachrome imagery and as light greenish-blue patches on the Aerochrome photos. This was due to a prolonged state of flooding at one time and the subsequent death of the willows.

Wetland B

emergent type: RF, common cattail and spikerush.

woody fringe: 1, there was no woody vegetation within this wetland.

pond size: .36 ha. (.86 ac.).

pond permanency: type 3, seasonal.

pond cover type: 1, less than 5% of this wetland was comprised of open water or bare ground.

wetland disturbance: none.

associated land use: cultivated crop of wheat.

comments:

This wetland was dry and the cattail was in a wilted state. The combination of cattail, an understory of spikerush and the exposed ground produce the mottled signature shown. Cattail is still readily interpretable by its texture and mottled colour under stress conditions. The isolated dark patches exhibited are due to the exposed spikerush growing between the clumps of cattail.

Plate 5

Wetland A

emergent type: SF, mannagrass, water plantain and spikerush.

woody fringe: 1, no woody vegetation was identified within the boundaries of this wetland.

pond size: .86 ha. (2.04 ac.).

pond permanency: type 2, temporary.

pond cover type: 1, less than 5% of this wetland contained open water or exposed bare ground.

wetland disturbance: evidence of previous cultivation is visible in the form of east-west striations across the wetland.

associated land use: field maintained in a fallow state.

comments:

The two distinct clumps, dark green (Ektachrome) and dark red (Aerochrome) were found to be alkali bulrush (Scirpus paludosus). The outer fringe of this wetland was dominated by a wet meadow species, wild mint (Mentha arvensis).

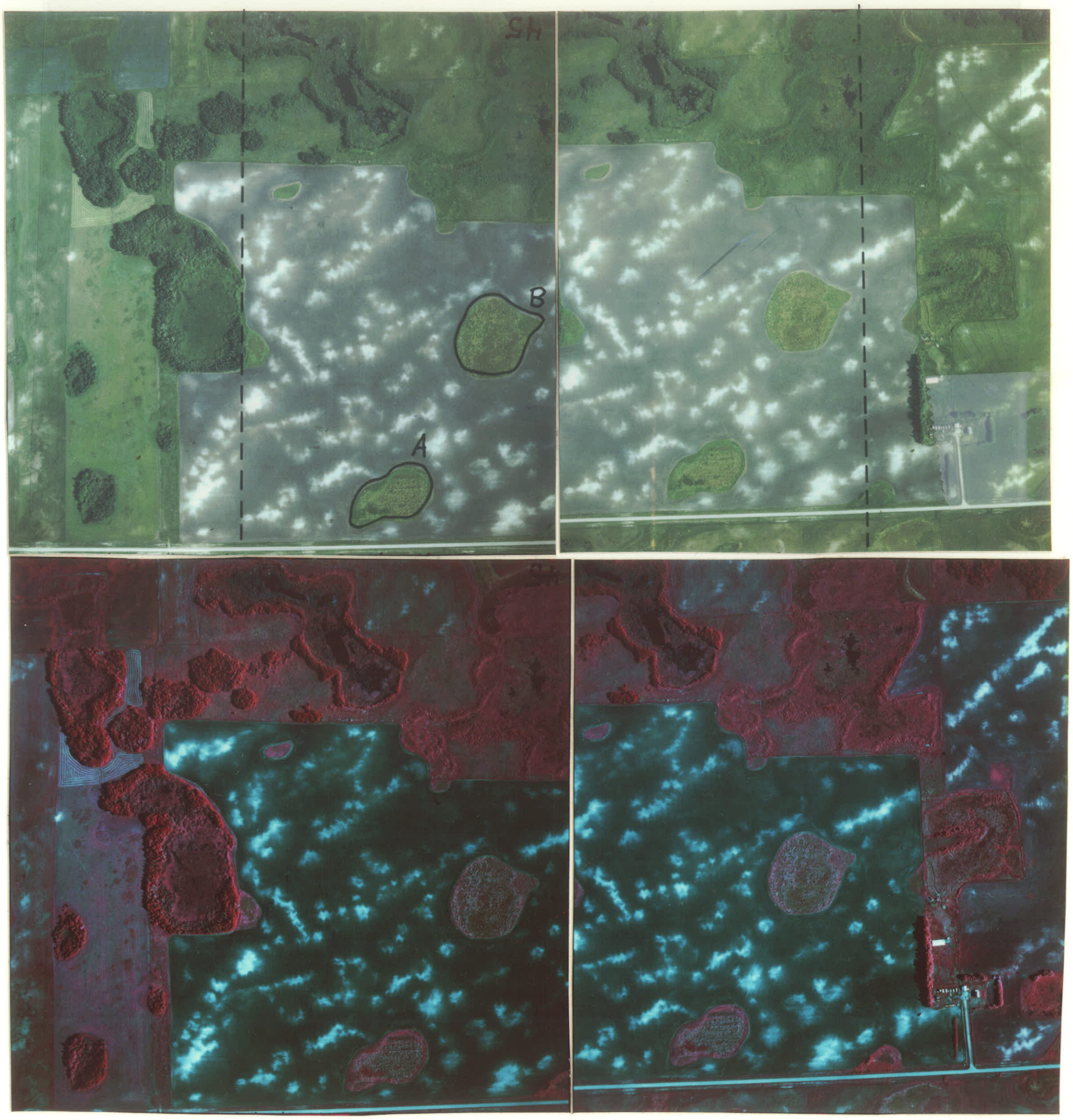

Plate 5. Ektachrome and Aerochrome imagery examples of broadleaf sedge-reedgrass, broadleaf forb-rush (SF) (wetlands A and B) emergent vegetation.

Wetland B

emergent type: SF, mannagrass, water plantain and spikerush.

woody fringe: no woody vegetation was identified within the boundaries of this wetland.

pond size: 1.53 ha. (3.63 ac.).

pond permanency: 2, temporary.

pond cover type: 1, less than 5% of this wetland contained open water or exposed bare ground.

wetland disturbance: although not as obvious as in the preceding wetland, there are signs of previous cultivation in an east-west pattern.

associated land use: field maintained in a fallow state.

comments:

The periodic cultivation of these 2 wetlands will do nothing to enhance there permanency or benefit to waterfowl. The agricultural working of these wetlands will cause a reduction in size and permanency by a levelling of the wetland from the outside inward. The frequency of cultivation, will determine the rapidity that this process will take place.

Plate 6

Wetland A

emergent type: RFS, softstem bulrush (*Scirpus validus*), mannagrass, water parsnip, spikerush and slough sedge.

woody fringe: 1, there was no evidence of woody growth associated with this wetland.

pond size: 1.02 ha. (2.42 ac.).

pond permanency: type 4, semi-permanent.

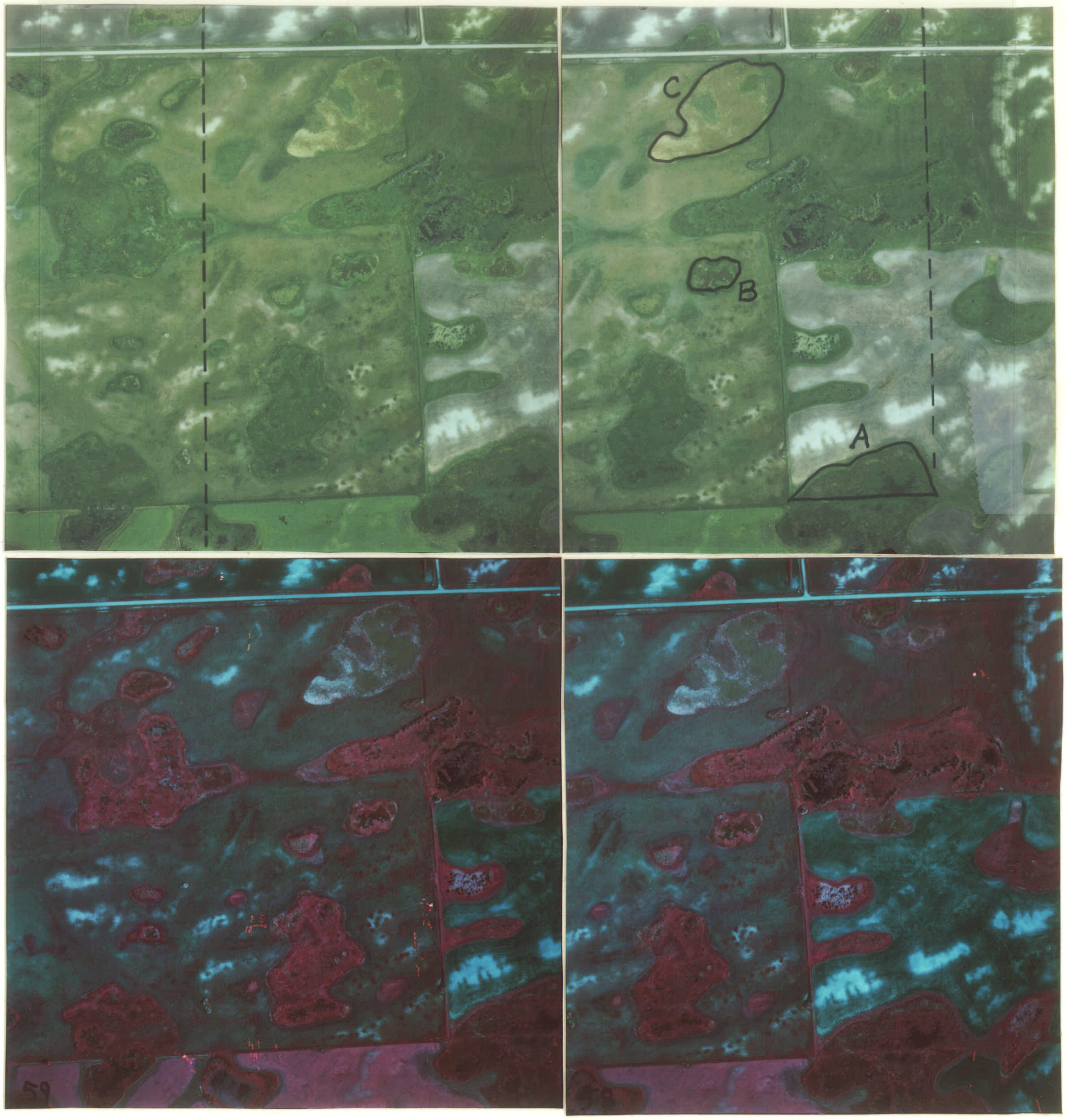

Plate 6. Ektachrome and Aerochrome imagery examples of reed, broadleaf forb-rush marsh, broadleaf sedge-reedgrass (RFS) (wetland A); broadleaf sedge-reedgrass, broadleaf forb-rush (SF) (wetland B) and broadleaf forb-rush marsh, grass-rush (FM) (wetland C) emergent vegetation.

<u>pond cover type</u>: 2, approximately 20% of the wetland contained open water.

<u>wetland disturbance</u>: none at present, but there was evidence of previous mowing and cultivation.

<u>associated land use</u>: upland maintained in a fallow state.

<u>comments</u>:

This wetland was part of a much larger wetland separated by a fenceline. Due to land use practices differing on either side of the fenceline each portion was considered separately. The adjoining wetland on the south side of the fenceline is fringed by low shrubs whereas this wetland has no shrub fringe. The establishment of woody growth has been controlled by periodic haying.

Two vegetation zones are visible in this wetland, an inner medium green (Ektachrome), medium magenta (Aerochrome) zone and a mottled light yellow to dark green (Ektachrome) or light cream to brownish-green (Aerochrome) outer fringe. The homogenous sedge zone is well delineated and appears darker in colour than previous examples of sedge-whitetop combinations. The outer zone is composed of softstem bulrush, spikerush, mannagrass and water parsnip. The darkest colour is due to the spikerush and bulrush. Although this fringe is narrow it could easily be confused and interpreted as cattail. The light colours are due to the combination of mannagrass and water plantain.

Wetland B

<u>emergent type</u>: SF, spikerush, mannagrass, nodding smartweed (<u>Polygonum lapathifolium</u>) and water parsnip.

<u>woody fringe</u>: 1, there was no woody fringe.

<u>pond size</u>: .53 ha. (1.25 ac.).

pond permanency: type 3, seasonal.

pond cover type: 2, approximately 50% of this wetland contained open water or was in a drawdown state.

wetland disturbance: none at present, but being a seasonal pond, it is probably susceptible to frequent haying.

associated land use: the upland area had been seeded in wheat.

comments:

This wetland contains 3 distinct colour tones on both types of imagery. The central zone, darkest in tone (dark green on both sets of photos) was dominated by spikerush. The lightest tone appearing as small isolated clumps were composed of water parsnip. The intermediate colour appearing as a discontinuous band surrounding the spikerush was dominated by mannagrass, nodding smartweed and water parsnip.

Wetland C

emergent type: FM, sloughgrass, shortawn foxtail (Alopecurus aequalis), water plantain and wild barley.

woody fringe: 1, there was no evidence of a woody fringe.

pond size: 1.20 ha. (2.86 ac.).

pond permanency: 2, temporary.

pond cover type: 1, less than 5% of this wetland was exposed bare ground.

wetland disturbance: the presence of the above mentioned species of vegetation are an indication of disturbance. In dry years this basin was cultivated as was evidenced by earlier aerial photography and land-owner interviews.

associated land use: the upland area had been seeded in wheat.

comments:

The lighter toned regions of the wetland were dominated by wild barley while the majority of this wetland was co-dominated by slough-grass and shortawn foxtail thus producing the beige tone (Ektachrome) and the light green tone (Aerochrome). The isolated medium green patches (Ektachrome) and the pink tone (Aerochrome) were islands of mannagrass.

Plate 7

Wetland A

emergent type: S, whitetop, slough sedge.

woody fringe: 1, less than 10% of this wetland contained woody growth.

pond size: 6.24 ha. (14.85 ac.).

pond permanency: 3, seasonal.

pond cover type: 2, approximately 60% of this wetland contained open water.

wetland disturbance: none at present. Frame 37 shows that this wetland is part of a much larger wetland with a fenceline on the west side and an old roadway on the north side segmenting the piece under study off from the rest. Lack of woody vegetation in this segment and a brush pile along the south-eastern boundary indicates clearing occurred at some time. Haying and cultivation were probably carried out when climatic conditions were favorable. The open water zone was probably maintained by periodic mowing of shallow marsh vegetation.

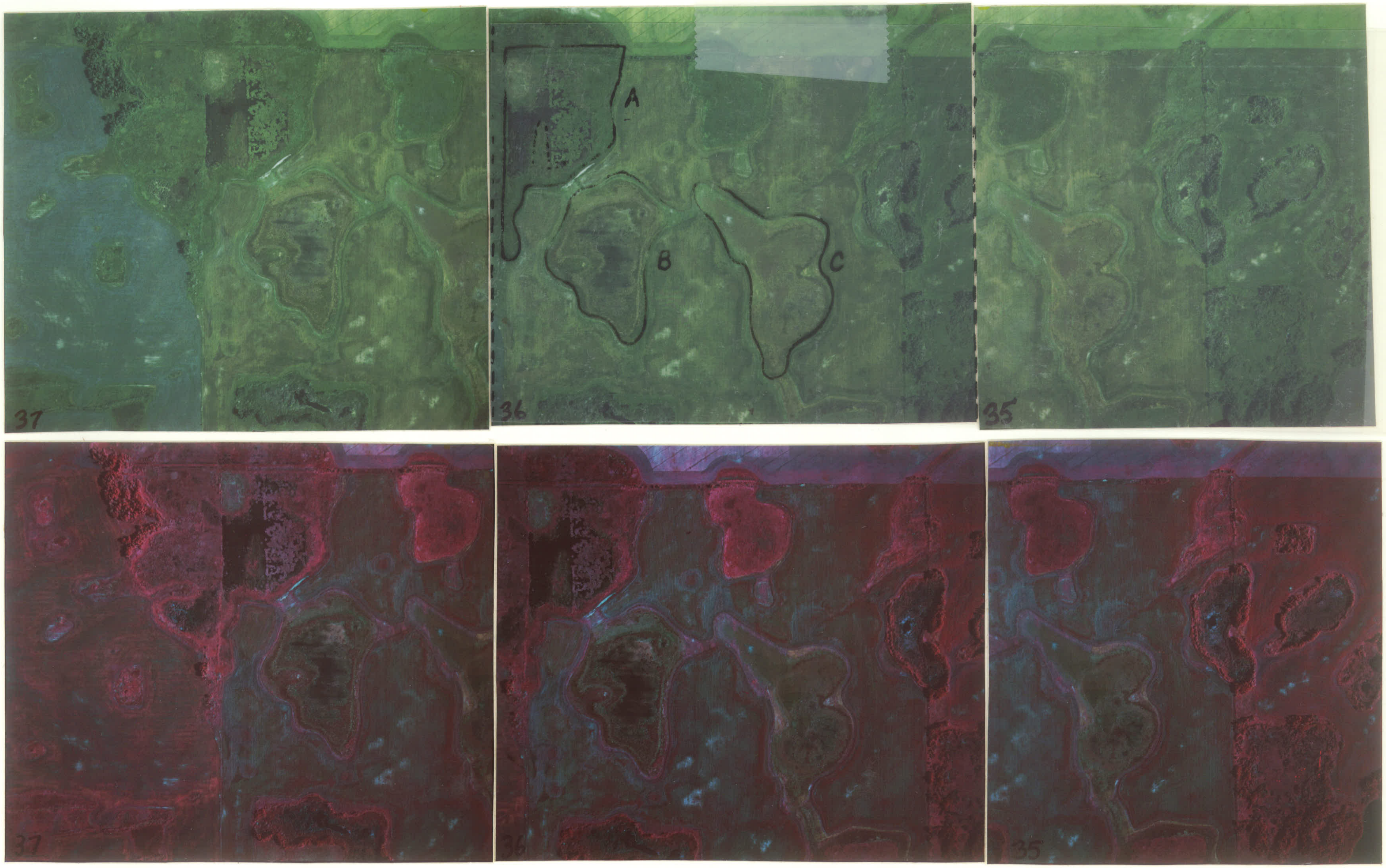

Plate 7. Ektachrome and Aerochrome imagery examples of broadleaf sedge-reedgrass (S) (wetland A); reed, broadleaf sedge-reedgrass, broadleaf forb-rush (RSF) (wetland B); and broadleaf forb-rush, grass-rush (FM) (wetland C) emergent vegetation.

associated land use: the upland area had been seeded in wheat.

comments:

The emergent phase of the open water zone was dominated by dense clumps of whitetop while the outer fringe was an intermix of whitetop and sedge. There is a distinct difference in tone between the whitetop and whitetop-sedge intermix. The homogeneous clumps of whitetop are much lighter in colour on both Ektachrome and Aerochrome imagery than the darker coloured whitetop-sedge intermix.

Area a contained a combination of shallow marsh and deep marsh emergents including sedge, spikerush, cattail and softstem bulrush. The medium-green (Ektachrome) and magenta (Aerochrome) account for the sedge while the brownish (Ektachrome) and dark green (Aerochrome) smudge were the resulting signature for the spikerush, cattail and softstem bulrush.

Wetland B

emergent type: RSF, common cattail, mannagrass, sloughgrass and spikerush.

woody fringe: 1, there was no evidence of a woody fringe.

pond size: 3.33 ha. (7.94 ac.).

pond permanency: 3, seasonal transitional.

pond cover type: 2, approximately 75% of the wetland was composed of open water.

wetland disturbance: none at present. This wetland had been cultivated prior to the high water levels of 1974 and 1975. The 1964 aerial photos showed this wetland and wetland 3 as being cultivated and only a slight indication of a basin depression.

associated land use: the upland area had been seeded in wheat.

comments:

The open water zone was dominated by common watermilfoil (Myriophyllum exalbescens).

The inner most emergent band was composed of cattail, mannagrass and spikerush. The pink tones in this zone (Aerochrome imagery) are due to the mannagrass while the overall darker colour of the cattail is due to the presence of spikerush. The predominately beige appearing zone found directly outside the previous zone was composed of slough-grass.

The discontinuous dark outer zone was dominated by spikerush.

Wetland C

emergent type: FM, water plantain, dwarf spikerush (Eleocharis parvula), spikerush and sloughgrass.

pond size: 4.51 ha. (10.74 ac.).

pond permanency: intermediate between 2 (temporary) and 3 (seasonal).

pond cover type: 2, approximately 20% of this wetland was open water or bare ground.

wetland disturbance: none at present, but had a similar history to wetland B.

associated land use: the upland area had been seeded to wheat.

comments:

A discontinuous fringe of spikerush along the eastern border of this wetland is readily discernable by its colour and association with the other forbs dominating this shallow wetland. The intermix of the tones from shades of beige on Ektachrome photography and light pink tones on Aerochrome imagery are consistant with the typical forb species found inhabiting wetlands in southwestern Manitoba.

Plate 8

Wetland A

emergent type: WS, willows and slough sedge.

woody fringe: 3, approximately 90% of this wetlands perimeter was wooded by trembling aspen.

pond size: 1.58 ha. (3.75 ac.).

pond permanency: 3, seasonal in a flooded state.

pond cover type: 3, central open water zone comprising 35% of total wetland area surrounded by continuous emergent fringe.

wetland disturbance: grazing and trampling by cattle.

associated land use: pasture.

comments:

The open water zone of this wetland is fringed by sedge and willows. The sedge is masked by the willow canopy and its presence is not readily interpretable on the imagery. The willow fringe is an intermix of live and dead vegetation. The greenish-grey colour on the Ektachrome photography makes it difficult to ascertain the live willow clumps from the dead ones. The Aerochrome imagery is much better for separating the dead willow patches from the live ones. The dead willows appear bluish-green in colour, a definite contrast from the live, pinkish coloured willows. The outer aspen fringe appears a very healthy dark green and magenta colour on the Ektachrome and Aerochrome imagery, respectively. The surrounding grassland pasture areas appear as a very light brown colour and a light blue colour on the imagery. These tones indicate the lack of healthy grassland species and suggest severe grazing pressure on this particular piece of farmland.

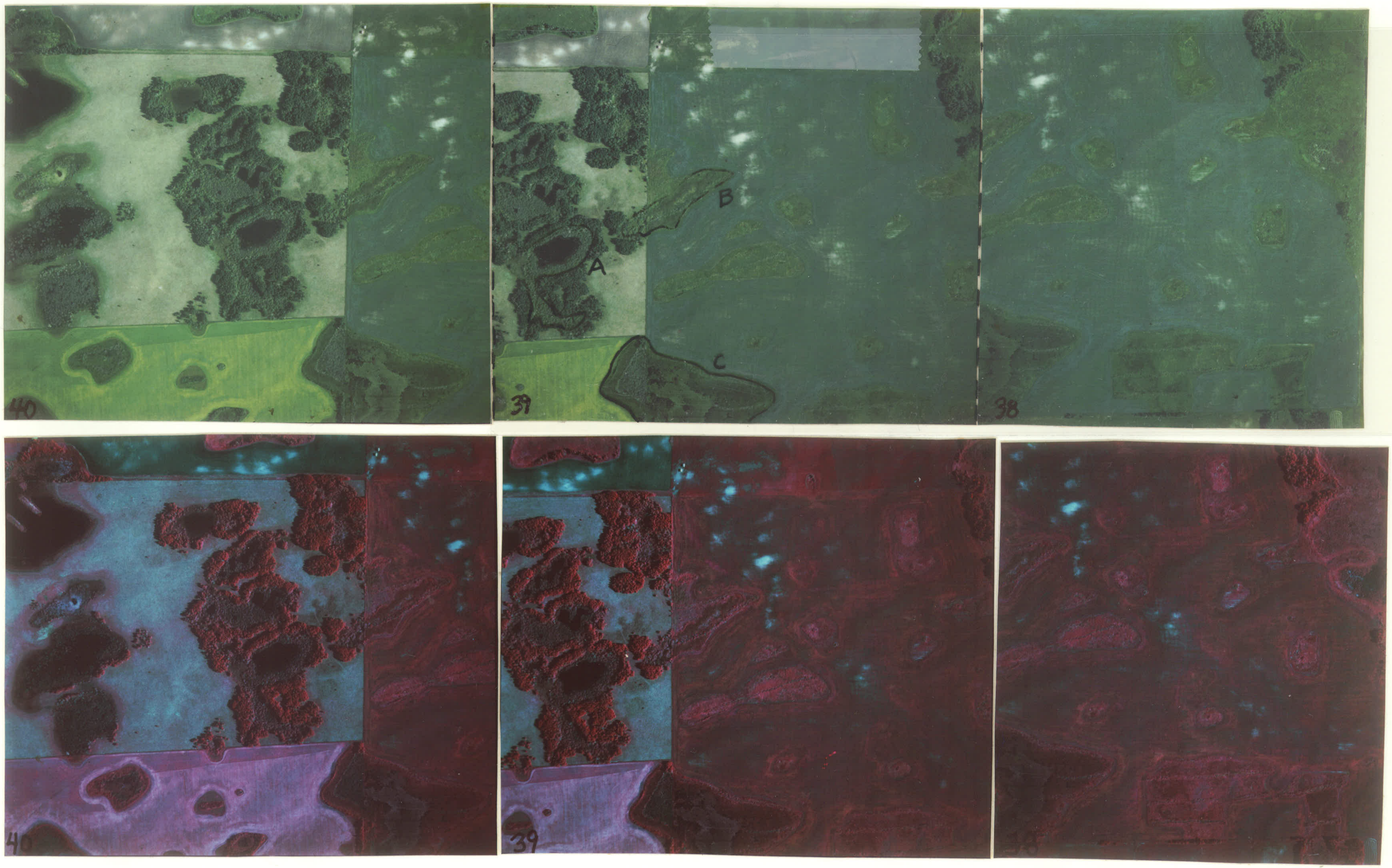

Plate 8. Ektachrome and Aerochrome imagery examples of willow, broadleaf sedge-reedgrass (WS) (wetland A); reed, broadleaf forb-rush (RF) (wetland B) and willow, reed, broadleaf sedge-reedgrass (WRS) (wetland C) emergent vegetation.

Wetland B

emergent type: RF, common cattail, spikerush, water plantain and water parsnip.

woody fringe: 1, less than 10% of this wetland was wooded.

pond size: .69 ha. (1.65 ac.).

pond permanency: 3, seasonal.

pond cover type: 2, approximately 20% of the wetland contains open water with interspersed clumps of emergent vegetation.

wetland disturbance: the brush and tree pile runs in a north easterly direction through the central aspect of this wetland. This practice is causing a decrease in the permanency of this wetland, thus the permanency 3 rating.

associated land use: the upland area was seeded to flax.

comments:

The central open water zones (light coloured areas on both sets of imagery) were dominated by water parsnip and water plantain. The dark coloured areas on either side of the brush and tree pile contained cattail and common spikerush.

Wetland C

emergent type: WRS, willow, common cattail and whitetop.

woody fringe: 2, although not entirely visible, approximately 35% of the wetland perimeter was wooded.

pond size: 5.89 ha. (14.03 ac.).

pond permanency: 4, semi-permanent.

pond cover type: 2, 60% of the wetland was open water with diffuse patches of whitetop found in the central portion of the basin.

wetland disturbance: brush and tree piles appear along the eastern portion of the wetland. The northwestern region of this wetland (region a) indicates a dense stand of dead or dying willows. The fenceline separates this region of the wetland from the rest (region b) and indicates clearing activities.

associated land use: upland seeded to flax on the eastern portion of the wetland while the western section was seeded in rapeseed.

comments:

The central zone of region a was dominated by flooded dead willows. The outer zone contained common cattail.

A diffuse stand of whitetop occupied the central deep marsh zone of region b. A dense stand of common cattail encompassed the central deep marsh zone.

Pond Nesting Potential

As was stated previously, the type and density of emergent residual vegetation can be used as an indicator of the overall quality of nesting habitat for overwater nesting ducks such as the canvasback and redhead. Although this type of assessment is best conducted on the ground, analysis can also be performed remotely from an aircraft or from aerial photographs. No vertical spring aerial imagery was obtained for this study but several oblique photographs were taken from a fixed-wing aircraft. These photos will be used to illustrate the various nesting potential ratings.

Examples of wetlands rated as Nil in terms of nesting potential are illustrated in Plates 9 and 10. This implies that there is no residual standing vegetation for overwater nesting ducks to utilize for nest construction and concealment. Wetlands considered as sheet-water are shown in Plate 9. An example of where the emergent vegetation was removed by mowing the previous summer, is shown in Plate 10.

Plates 11 and 12 are examples of wetland rated as 'Poor' for nesting. Although residual emergent vegetation is present, it is not of the species, density or location preferred by canvasback and redhead females. The two examples that illustrate this rating show wooded ponds containing flooded willows. Although willows are an adequate substrate for nests, the lack of emergent vegetation for nest construction materials in adequate density tends to down grade these wetlands. The removal of residual vegetation by fall burning can be readily interpreted from aerial photography (Plate 12). The appearance of a reddish tinge to willows is an indicator of this practice.

Examples of different wetlands providing 'Fair' nesting potential are illustrated by Plate 13 and 14. These wetlands generally contain a greater degree of residual vegetation but were limited by emergent species and water depth or wetland permanency. Plate 13 is a typical example of this classification. Flooded willows fringe the outer edge of the wetland while intermittent patches of sedge are found floating throughout the open water zone.

Plate 14 depicts a larger wetland containing extensive dense stands of sedge, however, sedge by itself does not provide adequate nest concealment in most cases for overwater nesting ducks.

Examples of wetlands rated as 'Good' and 'Excellent' are shown in plates 15-18 inclusive. These are the more permanent ponds containing

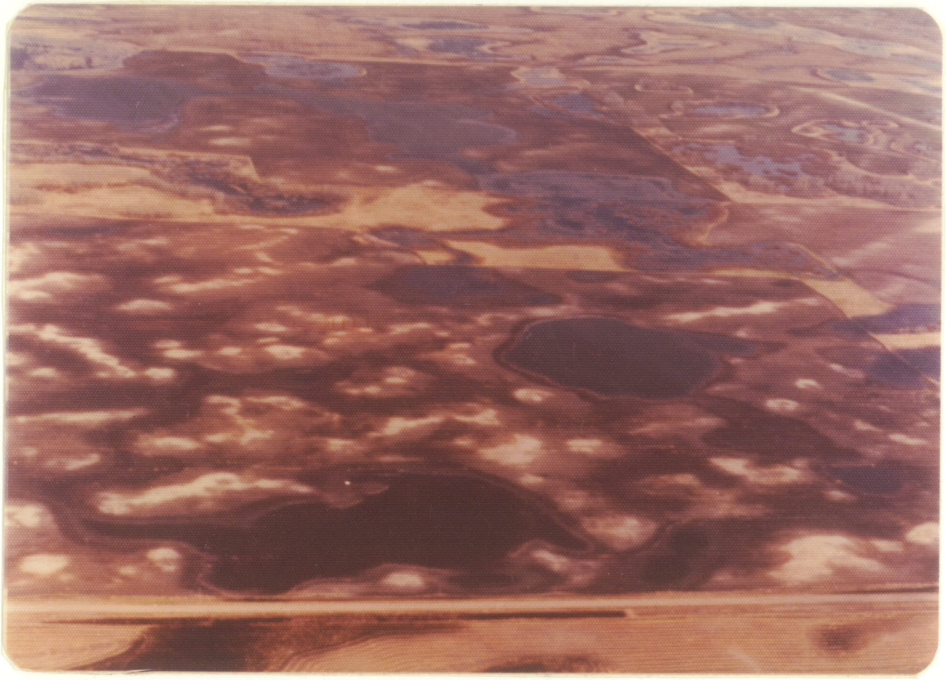

Plate 9. Wetlands located in fallow field (foreground) are examples of those rated 'Nil' in terms of nesting potential.

Plate 10. Wetland in foreground rated 'Nil' in terms of nesting potential due to lack of emergent residual vegetation (mowed previous summer).

Plate 11. Series of wooded wetlands located in pastureland rated 'Poor' in terms of nesting potential.

Plate 12. Wetlands A and B are examples of wetlands rated 'Poor' in terms of nesting potential.

Note: reddish tinge of willows, evidence of fall burning in these basins.

Plate 13. Wooded wetland was rated 'Fair' in terms of nesting potential.

Note: mottled areas in open water zone, this was evidence of residual sedge.

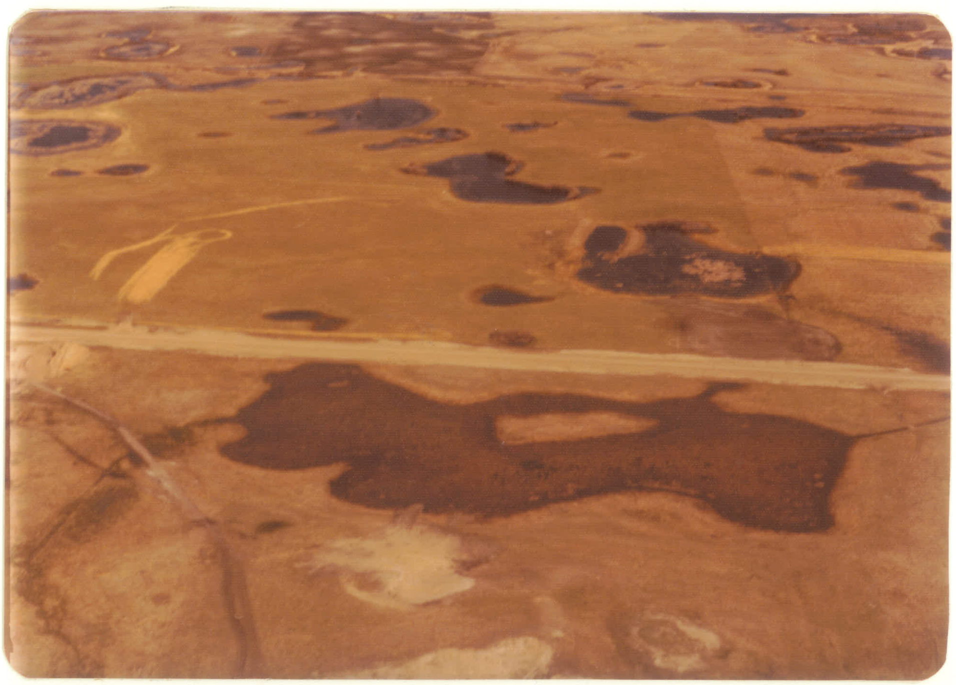

Plate 14. Wetland in foreground rated 'Fair' in terms of nesting potential.

Note: dense patches of residual sedge throughout basin.

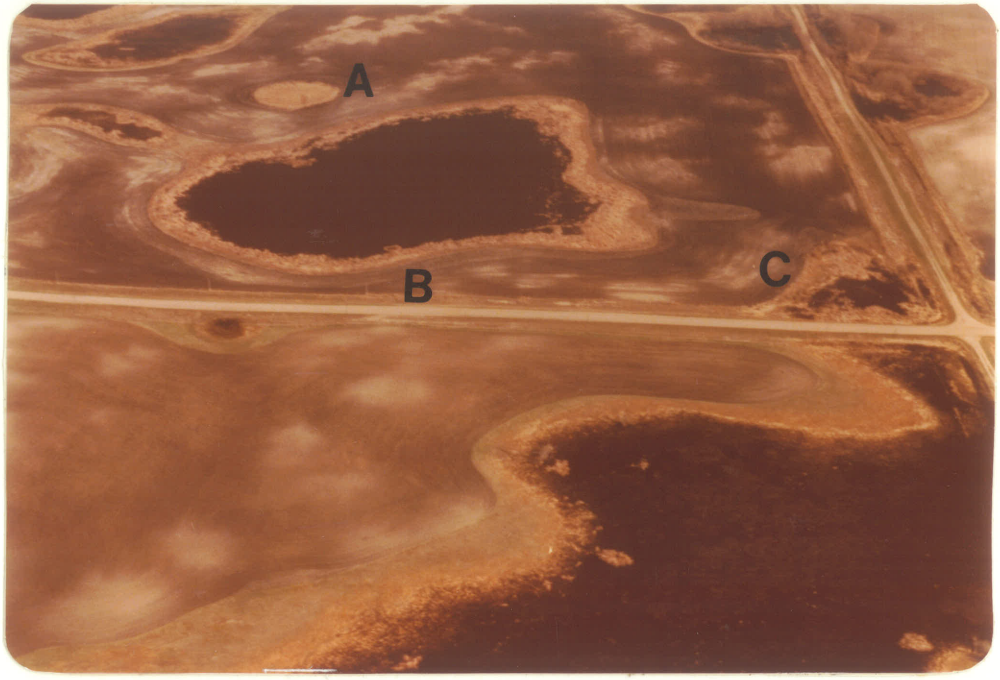

Plate 15. Wetland A was rated as 'Good' while B and C were considered 'Excellent' in terms of nesting potential.

Note: dense stands of cattail in all 3 wetlands.

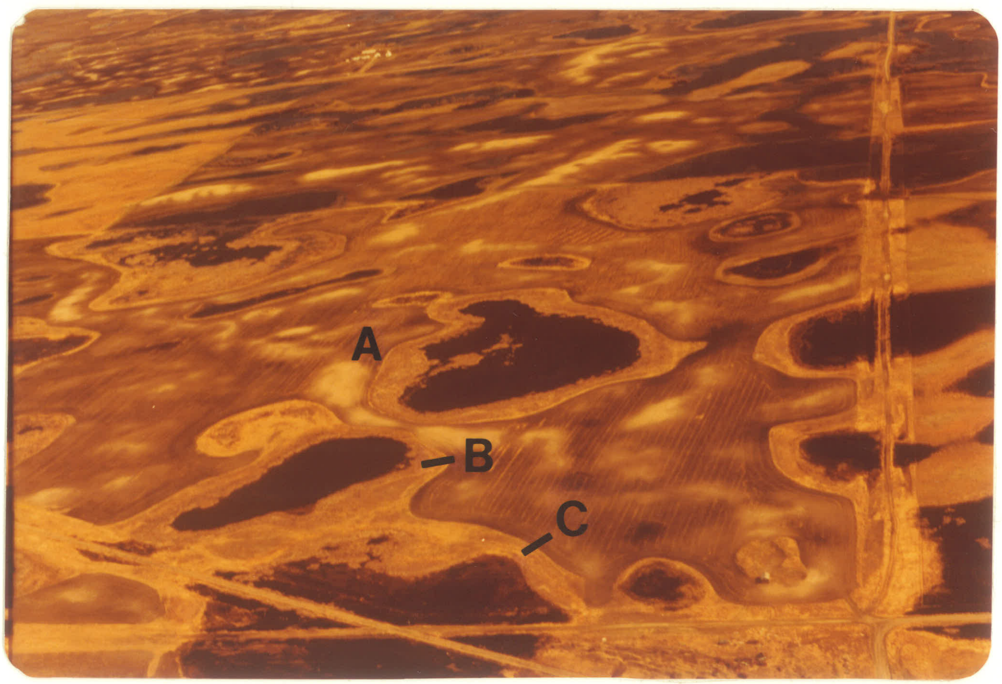

Plate 16. Wetlands B and C were rated 'Excellent' and wetland A was rated 'Good' in terms of nesting potential.

Note: dense residual fringe of cattail in wetlands A, B and C. Dense patches of residual whitetop in open water zone of wetland C.

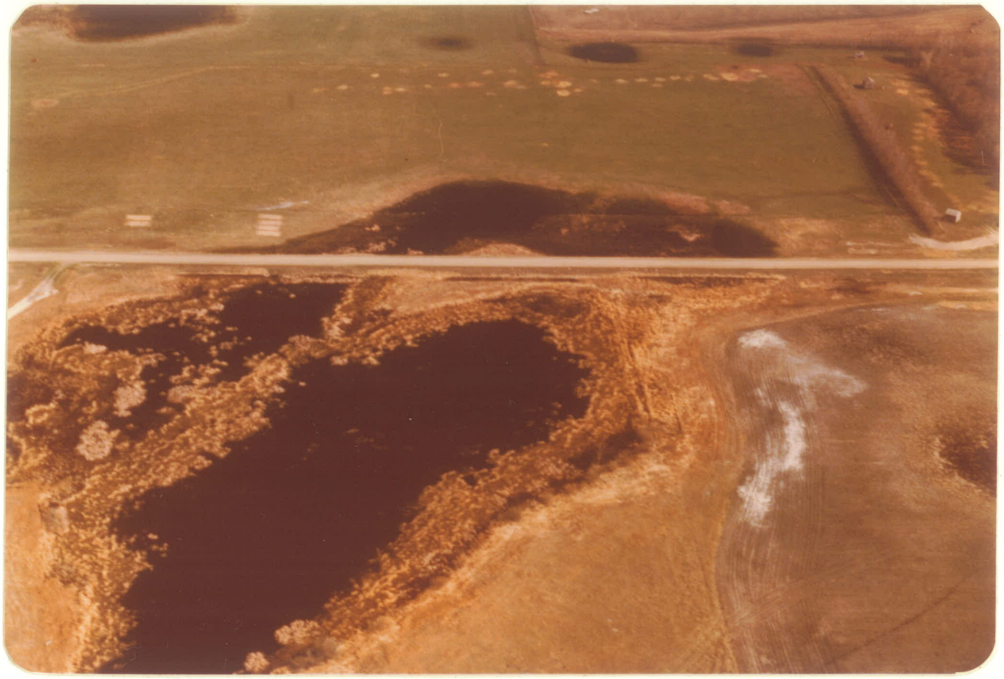

Plate 17. Wetland in foreground rated 'Excellent' in terms of nesting potential.

Note: Dense emergent fringe of residual whitetop interspersed with clumps of hardstem bulrush.

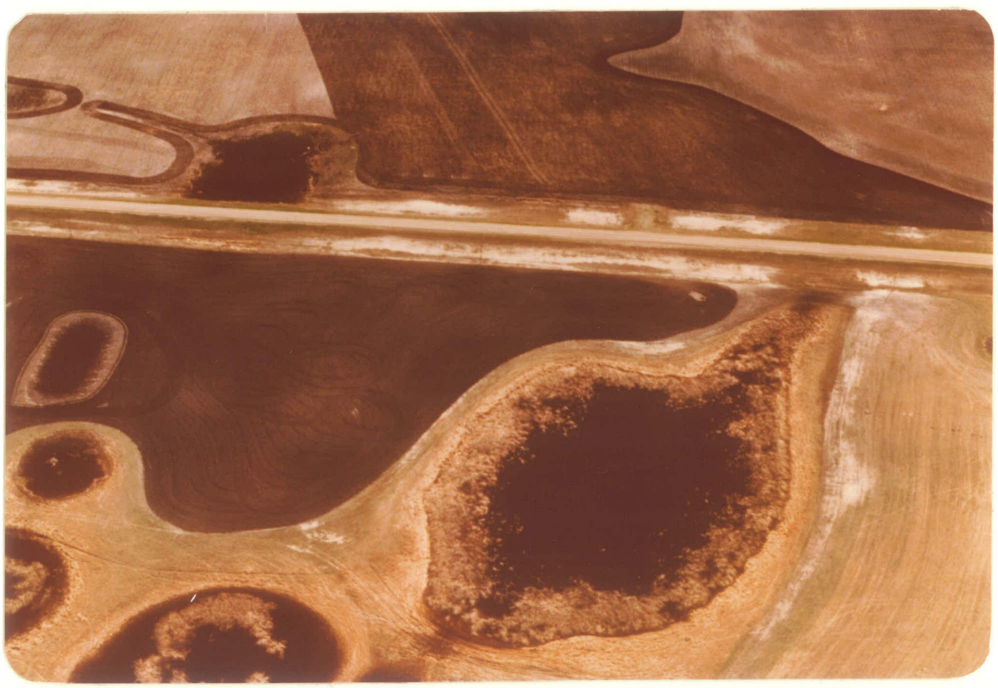

Plate 18. Larger Wetland rated 'Excellent' in terms of nesting potential.

Note: dense emergent fringe of hardstem bulrush.

dense stands of preferred nesting vegetation such as cattail, whitetop and bulrush. Plate 15, wetland A was rated 'Good' only because of the dense stand of cattail and its small size while its permanency was questionable. Wetlands B and C received ratings of 'Excellent' due to the dense continuous fringe of cattail, high permanency ratings and intermediate sizes.

Plate 16 shows 3 examples of high quality canvasback and redhead nesting habitat. All of these wetlands contained cattail as the dominant emergent. Wetland C contained an inner intermittent zone of whitetop scattered throughout the open water zone. Wetland A was rated as 'Good'. This wetland was limited from a higher rating due to its excessive size - 3.34 ha. (7.95 ac.). Wetland B was rated 'Excellent' because of its smaller size, 1.00 ha. (2.40 ac.), high permanency rating (semi-permanent) and its dense continuous fringe of cattail. Wetland C was rated as 'Excellent' also because of size, .97 ha. (2.32 ac.), permanency (semi-permanent) and the availability of high quality concealment and nesting vegetation in the form of cattail and whitetop.

Another wetland rated 'Excellent' is illustrated in Plate 17. This wetland was larger than 2.11 ha. (5.0 ac.) but was broken up into smaller open water pools by residual emergent whitetop. The lighter toned clumps of vegetation located fringing the open water pools were hardstem bulrush.

Plate 18 shows a permanent hardstem bulrush wetland approximately 1.47 ha. (3.50 ac.) in size and rated as 'Excellent'.

The preceding photos have indicated the key factors to look for in order to assess the quality of nesting habitat for canvasback and redhead ducks. These key factors are: (1) presence or absence of residual emergent vegetation; (2) wetland size; (3) wetland permanency; (4) species and abundance of emergent vegetation. Oblique photographs are not the best medium for this type of interpretation because of distortion whereas vertical photography would have been much better.

SUMMARY AND CONCLUSIONS

The hypothesis of this study has been accepted. The results have shown that canvasback and redhead nesting habitat parameters can be accurately interpreted with the use of remote sensing imagery. It is imperative that the investigators be familiar with wetland ecology, the topography of the region in question and recent climatic conditions.

The following is an assessment of the interpretability of the 8 habitat parameters under investigation in this study:

1) Pond size: The use of an electronic planimeter is the most accurate means for obtaining this measurement providing that exact wetland boundary interpretations were acquired. Wetland boundaries were in close association with the inner edge of upland cultivation or the most central extent of tree growth on wooded ponds. Aerochrome imagery was superior to the Ektachrome imagery for interpretation of water and wet areas, particularly within totally vegetated wetlands.

2) Pond cover type: The proportion or percent of emergent vegetation to total pond area as well as its distribution was more readily interpretable on the Aerochrome imagery. Ektachrome imagery would penetrate the water surface and provide images of submerged vegetation or bottom features. This caused problems in differentiating between open water and emergent vegetation. Water and wet areas on Aerochrome imagery were highly reflective, providing a clear and sharply contrasting signature.

3) Woody fringe: Trees and willows were successfully interpreted by image features such as location, rough texture and the presence of

shadows. Quantitative measurements for the percentage of shoreline on each pond fringed by woody growth were estimated from the imagery.

4) Associated land use: The interpretation of agricultural land management practices were based on the uniformity of colour tone and photographic texture. Cultivated crops tended to be uniform in colour and texture whereas grazed grassland, ungrazed grassland or woodlots tended to be non-homogeneous for both criteria. Crop interpretation was most successful for those species that were flowering (rapeseed and flax). Some cereal crops were variable in appearance from one location to another and the anomaly was attributed to extreme variations in seeding times.

Variances in spectral signatures for pasture land were directly related to grazing intensity. The presence of stockponds, undisturbed tree fringes, and animal trails leading to wetlands or stockponds were clues for identifying grazed grasslands.

5) Wetland disturbance: Several land use practices were identified as harmful to the optimum development and maintenance of wetland habitat. In particular, certain agricultural activities were considered detrimental to canvasback and redhead nesting habitat: mowing of emergent vegetation, spring or fall burning of wetland basins, wetland drainage, basin filling and excessive grazing or trampling of emergent vegetation.

The presence of swaths or hay bales located in depressions or wetland basins indicated mowing activities. Mid-summer imagery does not provide a record of the overall extent of this practice. As mowing is an on-going activity throughout the summer months, fall imagery would be more efficient for a complete assessment.

Mid-summer imagery is of no value for assessing spring or fall burning practices. Spring colour imagery is recommended for recording this evidence. Generally, black-toned basins with sporadic clumps of residual vegetation and/or scorched willows provide an indication that burning has taken place.

Drainage practices were interpreted by the presence of straight narrow channels interconnecting two or more wetlands or a wetland with a roadside ditch.

Basin filling was identified by dead tree piles or raised central regions of wetlands, giving an island effect, covered with disturbance vegetation.

Livestock grazing and/or trampling of emergents was identified when the vegetation exhibited any of the following characteristics: poor vegetative vigor; having more exposed dead stocks than live vegetation (when this was not related to declining water levels); and when ponds were located in grazed grasslands.

6) Emergent vegetation type: The 6 emergent vegetation types selected for this study exhibited spectral differences when assessed on Aerochrome and Ektachrome imagery. Interpretation accuracy was enhanced when homogeneous stands of emergent vegetation were encountered. Tonal contrast between emergent species was greater on Aerochrome imagery than on Ektachrome imagery. Interpretation problems were encountered when: several species co-dominated a wetland; stress conditions altered the natural appearance of vegetation; tall emergents provided a closed canopy on lower story co-dominant species; and when sparse vegetation density occurred in open water zones.

Broad spectral differences were found between reed marsh emergents and broadleaf sedge-reedgrass species. The broadleaf forb-rush type, within itself, exhibited the greatest variations in spectral signatures. The diversity of species and variability in their physical structure was deemed responsible. The grass-rush meadow type and the herb-grass meadow type were somewhat difficult to interpret. Ecological characteristics aided in their differentiation. The willow vegetation type was unique in textural and tonal properties and provided little difficulty in interpretation.

7) Pond permanency: The accuracy in interpretation of the previous 6 habitat parameters, in particular, pond size, pond cover type, wetland disturbance and emergent vegetation determined the degree of precision in establishing recognition signatures for pond permanency. In most cases, a wetland was best described by a combination of vegetation types. The emergent vegetation dominating the central region of a wetland or fringing the open water zone tended to best describe its permanency. Any available imagery from previous years was considered of vital importance for providing additional information in regard to this parameter.

Typically, wetlands interpreted as exhibiting a central open water zone and dominated by reed marsh vegetation were placed in a semi-permanent or permanent category. Wetlands dominated by broadleaf sedge-reedgrass vegetation were in most cases, considered seasonal in nature. An extensive open water zone fringed by a dense continuous stand of whitetop was judged as semi-permanent. Grass-rush emergents were indicative of temporary permanency. Herb-grass vegetation was considered representative of temporary or ephemeral wetlands, generally areas of previous or present agricultural disturbance. Willow vegetation was indicative of fluctuating water levels and was associated with other emergents, providing a more reliable source for evaluating permanency.

8) Pond nesting potential: As canvasback and redhead ducks are initially early nesters, an assessment of nesting potential required an inventory of residual emergent vegetation. No vertical spring imagery was available, instead colour aerial obliques were obtained. The colour photographs were excellent for interpreting the extent of residual sedge, whitetop, cattail and bulrush vegetation.

RECOMMENDATIONS FOR MANAGEMENT

The use of remote sensing imagery for assessing wetland habitat quality and quantity in terms of specific waterfowl species has been shown to have practical applications. It provides a permanent record of wetlands and their associated habitat features. In this respect remote sensing is a valuable tool for monitoring changing physical and climatic conditions if conducted on a year to year basis.

Multispectral imagery (colour plus colour infrared) is recommended for habitat investigations. The colour format provides the interpreter with a familiar view of ground features while the colour infrared imagery is best suited for actual interpretation of habitat components.

Mid-summer remote sensing imagery is recommended for: assessing relative wetland permanency (sequential year to year imagery will enhance interpretation of this parameter); identification of emergent vegetation; pond cover type classification; estimating the extent of woody vegetation fringing wetlands; assessing the impact of agricultural land use practices on wetland basins and associated upland nesting cover.

Spring colour aerial photography is recommended for interpreting pond nesting potential and spring or fall burning practices. Fall remote sensing imagery would be ideal for inventorying haying practices.

The techniques developed in this study indicate the broad regional approach to habitat assessment for species specific requirements and are directly applicable throughout the aspen parkland as well as the mixed prairie region. These methods of assessing and interpreting wetland habitat quantity and quality have been developed for their practical application purposes. Biologists having an understanding of wetland ecological principles and who conduct periodic ground spot checks will maintain high interpretation accuracy.

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APPENDIX

APPENDIX A - EGG DIPPING STUDIES

During the 1974 nesting season 30 out of 92 eggs or 33% of the eggs incubated by canvasback and redhead hens did not hatch. Inspection of several of these unhatched eggs showed signs of bacterial contamination. Could the floating of eggs in slough water, to determine age of the embryo (Westerskov 1950), have resulted in contamination and low hatchability? Unfortunately during the first season, eggs floated from each nest were not marked and consequently no check was made of the difference in hatchability between floated and untouched eggs.

Stoudt (personal communication 1976) indicated low hatchability in his canvasback study at Minnedosa but he did not consider that floating the eggs in slough water was responsible. He considered extreme disturbance by parasitic redheads as a possible reason for a high percent of unhatched eggs in canvasback nests. Hatchability was much lower in canvasback nests than in redhead nests (43% vs 82% respectively), those canvasback nests not parasitized suffered equally low hatchability in 1974. These results prompted a series of laboratory and field experiments on the effects of different types of water on floating eggs. Field studies consisted of marking canvasback and redhead eggs that were floated during the 1975 nesting season.

Two objectives of laboratory experiments, utilizing unwashed domestic (Pekin) duck eggs, were: (a) to determine the effect on hatchability of dipping eggs in slough water as opposed to disinfected tap water and (b) to determine the effect on hatchability due to temperature difference between the eggs and the dipping water.

Experiment 1 consisted of 5 treatment lots of 40 eggs in each (Table 44). Two lots of eggs were incubated for 4 hours to bring them to incubation temperature (warm eggs) before dipping them in cold slough or disinfected tap water at 13°C, two lots of cold eggs were dipped in cold slough or tap water whereas the fifth lot was the untreated control. All five lots of eggs were incubated. Fertility, hatchability and contamination were recorded at 28 days.

Experiment 2 also consisted of 5 treatment lots of 40 eggs in each but all of the eggs were incubated for one week before dipping. Also cold slough water at 13°C as well as warm slough water at 39°C were used for dipping. Similarly cold disinfected tap water at 13°C and warm disinfected tap water at 39°C were used. The fifth control lot of eggs was not dipped. All eggs were incubated and fertility was checked at 13 days whereas hatchability and contamination were recorded at 28 days. Results of both experiments are summarized in Table 45.

The cold water temperature of 13°C was selected as an average pond temperature during the nesting season. The warm water temperature of 39°C was considered the average egg temperature during incubation thereby removing any effect due to temperature difference.

Results from experiment 1 (Table 45) show that dipping warm eggs in either cold slough water (lot 2) or cold disinfected tap water (lot 4), reduced hatchability 48% and 18% respectively when compared with the control (lot 5). Also results bear out the expectation that slough water would result in greater microbial contamination than disinfected

Table 44. Pekin duck eggs laboratory dipping treatments.

Treatments	Description of Treatments
	Experiment 1
1	Cold eggs dipped in cold slough water at 13°C
2	Warm eggs (incubated approx. 4 hrs.) dipped in cold slough water at 13°C.
3	Cold eggs dipped in cold disinfected[1] tap water at 13°C.
4	Warm eggs (incubated approx. 4 hrs.) dipped in cold disinfected tap water at 13°C.
5	Control eggs.
	Experiment 2
6	Warm eggs[2] dipped in cold slough water at 13°C.
7	Warm eggs dipped in warm slough water at 39°C.
8	Warm eggs dipped in cold disinfected tap water 13°C.
9	Warm eggs dipped in warm disinfected tap water 39°C.
10	Control.

[1] Active ingredient in "clean egg 404" disinfectant used is chlorine.

[2] Warm eggs indicates that all eggs in Experiment 2 were incubated one week before being subjected to treatments.

Table 45. Fertility and Hatchability of Pekin Duck eggs by egg dipping treatments.

Treatments	No. Eggs Set	No. Infertile	No. Fertile	No. Hatched	Percent Hatchability of eggs	
					Total	Fertile
			Experiment 1			
1	40	4	36	28	70	78
2	40	4	36	9	23	25
3	40	3	37	30	75	81
4	40	7	33	18	45	55
5	40	7	33	24	60	73
			Experiment 2			
6	40	3	37	26	65	70
7	40	7	33	21	53	64
8	40	3	37	21	53	64
9	40	2	38	30	75	79
10	39[1]	5	34	22	56	65

[1] Due to egg breakage in transport, some lots had fewer than 40 eggs.

tap water which was evident at hatching. Placing warm eggs in cold slough water would be expected to cause contraction of the egg contents and a suction effect through the pores of the shell thereby drawing the slough water and its microflora into the egg. A similar effect with lesser depression of hatchability in lot 4 may have been due to suction of some microorganism into the egg from the shell of the unwashed eggs. Lots 1 and 3 indicate that dipping cold eggs in cold water had no detrimental effect on hatchability as there is not likely to be any movement into the egg. The most drastic effect resulted from dipping warm eggs in cold slough water.

Results of experiment 2 show less effect of dipping treatments on hatchability. It was not known if these eggs underwent any treatment such as washing before they were received for this experiment. It may be that 1-week-old embryos are less susceptible to the effects of dipping in cold slough water (lot 6) or tap water (lot 8). The lowest hatchability resulted from dipping warm eggs in cold disinfected tap water which may have resulted from bacterial contaminants from the shell being sucked into the eggs.

The results of the experiments indicate that for determining age of embryo, dipping incubated eggs in water at approximately the same temperature as the eggs will minimize embryo mortality due to microbial contamination even if slough water is employed.

Field results for 1974 indicated an embryo mortality factor of 60%. This loss was attributed to bacterial contamination. For the 1975 nesting season, disinfected tap water was carried as the dipping medium. A grease pencil was used as the marking agent.

The results from the 1975 transect nest search also included an analysis of embryo mortality for unhatched eggs found in successful canvasback and redhead nests. This data were treated as the field treatment control as none of these eggs had been dipped.

The 1975 study block data showed a 10% embryo mortality rate due to bacterial contamination for eggs floated in disinfected tap water (Table 46). Twenty-two percent of the field treatment control eggs (transects) died as a result of bacterial contamination.

No results were available for comparing dipped eggs to those not dipped because the marking agent was worn off during incubation or was undetectable after hatching.

The mortality rate for 1974 was abnormally high compared to the 1975 treatment control. Using disinfected tap water as a dipping medium instead of slough water could reduce embryo mortality (Table 46).

Table 46. Embryo Mortality of Unhatched Eggs Recovered from Successful Canvasback and Redhead Nests Located on the Transects and Study Block (1975).

	Transects				Study Block			
Cause of Mortality	Redhead eggs	Canvasback eggs	Redhead[1] eggs	Total	Redhead eggs	Canvasback eggs	Redhead[1] eggs	Total
Infertility	-	1	2	3	-	-	-	-
Bacterial Contamination	-	-	2	2	-	1	-	1
Cessation of Incubation	-	2	2	4	4	1	5	9
Total				9				10

[1]Redhead eggs found in canvasback nests.

APPENDIX B - LIST OF PLANT SPECIES

Scientific Name	Common Name
Agropyron trachycaulum	slender wheatgrass
Alisma triviale	water plantain
Alopecurus aequalis	shortawn foxtail
Aster sp.	aster
Beckmannia szigachne	sloughgrass
Calamogrostis inexpansa	northern reedgrass
Carex atherodes	slough sedge (broadleaf)
Chenopodium sp.	goosefoot
Cirsium arvense	canada thistle
Distichlis stricta	saltgrass
Eleocharis palustris	spikerush
Eleocharis parvula	dwarf spikerush
Glyceria grandis	mannagrass
Hordeum jubatum	wild barley
Juncus balticus	baltic rush
Lemna minor	duckweed
Mentha arvensis	wild mint
Myriophyllum exalbescans	common watermilfoil
Panicum virgatum	switch grass
Phragmites communis	phragmites
Poa pratensis	kentucky bluegrass
Polygonum coccineum	marsh smartweed
Polygonum lapathifolium	nodding smartweed
Populus tremuloides	trembling aspen
Potentilla anserina	cinquefoil
Rumex sp.	dock
Sagittaria cuneata	arrowhead
Salix sp.	willow
Scirpus acutus	hardstem bulrush
Scirpus paludosis	alkali bulrush
Scirpus validus	softstem bulrush
Scolochloa festucacea	whitetop
Senecio congestus	marsh ragwort
Sium suave	water parsnip
Solidago sp.	goldenrod
Sonchus arvensis	sowthistle
Sparganium eurycarpum	burreed
Symphoricarpus occidentalis	wolfberry
Typha glauca	hybrid cattail
Typha latifolia	common cattail
Utricularia vulgaris	common bladderwort

APPENDIX C - LIST OF BIRDS AND MAMMALS

Birds

Scientific Name	Common Name
Anas acuta	pintail
Anas clypeata	shoveller
Anas cyanoptera	cinnamon teal
Anas discors	blue-winged teal
Anas platyrhynchos	mallard
Aythya americana	redhead
Aythya valisineria	canvasback
Branta canadensis	canada goose
Buteo jamaicensis	red-tailed hawk
Corvus brachyrhynchos	common crow

Mammals

Canis latrans	coyote
Mephitis mephitis	striped skunk
Mustela vison	mink
Procyon lotor	raccoon
Vulpes vulpes	red fox

APPENDIX D - GLOSSARY OF TERMS

Anomaly - In general, a deviation from the norm (Reeves et al. 1975).

Cover type - A subjective classification system representing differences in the spatial relation of emergent cover to open water or exposed bottom soil (Stewart and Kentrud 1971).

Electromagnetic spectrum - The ordered array of known electromagnetic radiations extending from the shortest cosmic rays through gamma rays, x-rays, ultraviolet radiation, visible radiation, infrared radiation and including microwaves (Reeves et al. 1975).

Habitat - A set of ecological conditions required by any one species.

Imagery - The products of image forming instruments (analogous to photography) (Reeves et al. 1975).

Infrared, photographic - Pertaining to or designating the portion of the electromagnetic spectrum with wavelengths just beyond the red end of the visible spectrum, generally defined as from 0.7 - 1.0 millimicrons or the useful limits of film sensitivities (Reeves et al. 1975).

Interpretation key - A systematic listing of the observable distinguishing characteristics of an element of a landscape (Reeves et al. 1975).

Multispectral - Generally used for remote sensing in 2 or more spectral bands such as visible and infrared (Reeves et al. 1975).

Parasitism, redhead - A behavioral trait in which females of this species lay their eggs, at varying degrees, in nests of other redheads or in the nests of other species (Bellrose 1976).

Photographic interpretation - The act of examining photographic images for the purpose of identifying objects and judging their significance (Reeves et al. 1975).

Remote sensing - In the broadest sense, the measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is not in physical or intimate contact with the object or phenomenon under study (Reeves et al. 1975).

Sensor - Any device which gathers energy, electromagnetic radiation or other, and presents it in a form suitable for obtaining information about the environment. Aerial cameras use natural or artificially produced electromagnetic radiation external to the object or surface being sensed (Reeves et al. 1975).

Signature - Any characteristic or series of characteristics by which a material may be recognized (used in the sense of photographic spectral signatures (colour reflectance)) (Reeves et al. 1975).

Spectral signature - Qualitative measurement of the properties of an object at 1 or several wavelength intervals (Reeves et al. 1975).

Stereoscope - A binocular optical instrument for assisting the observer to view 2 properly orientated photographs to obtain the mental impression of a 3-dimensional model (Reeves et al. 1975).

Texture - The visual impression of roughness or smoothness created by some objects. In a photo image, the frequency of change and arrangement of tones. Some descriptive adjectives for texture are fine, medium and coarse (Reeves et al. 1975).

Tone - Each distinguishable shade variation from black to white. Different objects reflect, emit and transmit different amounts and wavelengths of energy. Differences recorded as either tonal, colour or density variations of an image. The colour contrast between an image and its background (Reeves et al. 1975).

Wetland or pond - A depression in the land which is normally covered with shallow water for at least a portion of each year and, in an undisturbed state, supports wetland vegetation (Millar 1976).