Habitat selection by breeding American black ducks (*Anas rubripes*) in northeastern Nova Scotia

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ABSTRACT

Habitat selection by breeding black ducks (*Anas rubripes*) was studied in Antigonish County, Nova Scotia during April-September 1990 and 1991.

Black duck pairs selected deciduous shrub ponds and sparsely vegetated ponds and avoided estuarine marsh and large lake habitat. Hens with broods preferred the deciduous shrub habitat while they avoided large lakes.

Black duck pairs appeared to use the distance to a brood-rearing pond as a cue in site selection. The closer a pond was to a suitable rearing pond the more likely it was occupied by a pair, regardless of food or cover resource availability. Black ducks, however, likely used site attributes such as the perimeter of the pond, the availability of aquatic invertebrates and the relative abundance of alder, willow and dead timber as cues in the selection brood-rearing habitat.

Black duck duckling survival, an estimate of recruitment, was the highest on preferred deciduous shrub ponds. Duckling survival was also higher on ponds with only one brood as opposed to ponds with several broods.

The most productive habitat for black ducks in the Antigonish study area were isolated, deciduous shrub ponds influenced by beaver activity. Black duck population numbers can be enhanced by managing local beaver populations.

ABREGE

Le choix de l'habitat par le canard noir (*Anas rubripes*) pour sa reproduction a été étudie dans le compté d'Antigonish en Nouvelle-Ecosse d'avril a septembre 1990 et 1991.

Les couples de canards noirs ont choisis les étangs bordes d'arbustes et d'arbrisseaux ainsi que les étangs ou la croissance aquatique est peu dense. Ils évitent par contre les estuaires marécageux ainsi que les grands lacs. Lors de la couvaison, ils préferent un habitat constitue d'arbustes et d'arbrisseaux alors qu'ils évitent les grandes étendues d'eau.

Il apparait que la distance entre les étangs est un critere de sélection important. Plus un étang est pres d'un autre étang, plus vite il est occupe par un couple et ce, sans se préoccuper de la nourriture ou des disponibilités de camouflage. Toutefois, les canards noirs utilisent les attributs possibles d'un emplacement tel que le périmetre de l'étang, la disponibilité des invertébrates aquatiques et, l'abondance relative des aunes, des saules et des arbres morts comme critere de sélection de l'environnement de son habitat de reproduction.

Selon un estime des individus, la survie des canards noirs était plus grande sur les étangs bordes d'arbrisseaux. Les étangs ou une seule couvaison a eue lieu

présentaient aussi un plus grand taux de survie que ceux ou plusieurs couvaisons avaient eues lieu. L'habitat le plus productif pour le canard noir dans le region d'Antigonish est un étang entouré d'arbutes, d'arbrisseaux, isolé et influence par l'activité des castors. Les populations de canards noirs peuvent donc etre augmentees en controllant les population locales de castors.

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PREFACE

The following is included in accordance with the regulations of the McGill University Faculty of Graduate Studies:

"The student has the option, subject to the approval of the Department, of including as part of the thesis the text, or duplicated published text (see below), of an original paper, or papers. In this case the thesis must still conform to all other requirements explained in Guidelines Concerning Thesis Preparation. Additional material (procedural and design data as well as descriptions of equipment) must be provided in sufficient detail (e.g., appendices) to allow a clear and precise judgement to be made of the importance and originality of the research reported. The thesis should be more than a mere collection of manuscripts published or to be published. It must include a general abstract, a full introduction and literature review and a final overall conclusion. Connecting texts, which provide logical bridges between different manuscripts, are usually desirable in the interests of cohesion.

It is acceptable for theses to include as chapters authentic copies of papers already published, provided these are duplicated clearly on regulation thesis stationary and bound as an integral part of the thesis. Photographs or other materials that do not duplicate well must be included in their original form. In such instances, connecting texts are mandatory and supplementary material is almost always necessary.

The inclusion of manuscripts co-authored by the candidate and others is acceptable but the candidate is required to make an explicit statement on who contributed to such work and to what extent, and supervisors must attest to the accuracy of the claims, e.g. before the Oral Committee. Since the task of the Examiners is made more difficult in these cases, it is in the candidate's interest to make the responsibilities of the authors perfectly clear. Candidates following this option must inform the Department before it submits the thesis for review."

The overall purpose of this study was to examine habitat selection by breeding black ducks. Data gathered from the study will hopefully be used as a springboard for a more experimental approach to black duck breeding habitat research and management. As habitat is altered to better suit the interests of man, black duck habitat selection studies are needed for predicting the effects of habitat manipulations on future population levels.

The study is divided into two sections to be published as separate papers, both of which will be submitted to the Journal of Wildlife Management. The co-authors of both thesis sections are my thesis supervisors, Rodger Titman and Norman Seymour. Dr. N. Seymour contributed to the formulation of the thesis' objectives and methodology. Dr. R. Titman contributed to the formulation of thesis hypotheses, the initial elaboration of methodology and revisions of drafts. I was responsible for all data collection and data analysis and interpretation. I was also resposible for the writing of all drafts.

In the first section I examine the habitat preferences of breeding black duck pairs and broods, highlighting possible reasons for their preference. The adaptive significance of habitat selection by black ducks will be discussed throughout the section. In addition, I will examine how black ducks pairs and broods choose their ponds and what habitat features are most important in influencing their decision.

In the second section I investigate black duck recruitment in different habitat types to determine which types of brood-rearing habitat are most productive for black ducks.

LITERATURE REVIEW

INTRODUCTION

The American black duck (*Anas rubripes*) is economically one of the most important waterfowl species in Atlantic Canada. Although black ducks have been on the decline for several decades (Feierabend 1984, Rogers and Patterson 1984), recent estimates suggest that population numbers, at least in the Atlantic flyway, are relatively stable (M. Bateman-CWS Sackville, N.B, pers. comm.). Nevertheless, the black duck in many parts of its range faces a plethora of environmental and ecological challenges, including habitat loss and degradation (Barske 1968), overhunting (Krementz et al. 1987) genetic swamping of black ducks by mallards (*Anas platyrhynchos*) through hybridization on shared breeding grounds (Rusch et al. 1989, Heusmann 1974, Brodsky and Weatherhead 1984, Ankney et al. 1987) and competition with mallards for quality breeding sites (Merendino et al. 1993).

As managers and researchers seek solutions to these complex problems facing the black duck population, important decisions that would arrest further black duck population decreases are hampered by the lack of a well developed data base (Kirby 1988). Particularly needed is research on black duck breeding habitat selection and its influence on reproductive success.

Habitat selection studies conducted on black ducks on relatively natural, unaltered breeding grounds are needed to assist waterfowl workers in predicting the effects of habitat management practices or alterations on recruitment in beleaguered black duck populations.

I have divided this literature review into two sections. The first section will touch on the basic theory and concepts of avian habitat selection. How breeding habitat is selected will be discussed using examples from the literature. Several theories of habitat selection and the effects of habitat selection on population dynamics will be presented.

In the second section I review studies on basic waterfowl breeding habitat requirements and habitat selection by pairs and broods and I concentrate particularly on habitat selection by black ducks.

HABITAT SELECTION

General theory - The choice of a habitat, in other words, a place to live and breed (Fretwell and Lucas 1970), is one that must be made by all animal species. Selection of specific habitats is presumably an adaptive behaviour designed to maximize survival and reproductive success (Partridge 1978).

Lack (1940, 1944) first proposed that the selection of a habitat was an innate reaction in response to certain stimuli in the environment. These stimuli indicate to the species which habitats contain the essentials for survival and production, for example food and shelter.

Critical resources, such as food and cover are termed ultimate factors (Hilden 1965) and are not always readily assessed at the time of habitat selection, such as when birds arrive on the breeding grounds in early spring. Insects may not yet have emerged and plants may still be senescent. The decision about where to settle must therefore be made using variables likely to indicate the future food supply and brood-rearing suitability and may not have any biological significance per se. These are proximate factors and they function to release immediate habitat selection behaviour (Hilden 1965).

Hilden (1965) believed that for birds, habitat selection is a two-stage process based on proximate factors in the environment at different levels of detail. The first stage is based on the stimuli released by general features of the environment such as landscape and terrain. The second stage involves the selection of a specific territory or site within the chosen environment. He suggested that the physiognomy of the vegetation is the stimulus for selection in many bird species as this will reflect integral ecological variables such as food resources, nest sites and song perches. At both levels, however, selection is dependent on whether certain key habitat characteristics (proximate factors) elicit the habitat selection response.

Current studies on avian habitat selection support Hilden's hypothesis and reveal that vegetation form and structure may be used as proximate factors in the selection of a breeding site. Knopf and Sedgwick (1992) reported that yellow warblers (*Dendroica petechia*) relied on the distribution of vegetation patterns in the selection of a nest site. Similarly, Munson (1992) suggested that dense woody vegetation is a key factor in the selection of a nest site by clay-coloured sparrows (*Spizella pallida*) and implied that nest cover may be more important in determining habitat selection for this species than food. To reduce the risk of nest predation, hermit thrushes (*Catharus guttatus*) were found to select nest sites in trees with good overhead cover and that were surrounded by a substantially greater density of small white firs (Martin and Roper 1988).

Birds may rely also on vegetation physiognomy as a predictor of future food supplies. A study conducted in the Chiricahua Mountains of Arizona revealed that vegetation structure and density were good indicators of food abundance as opposed to nesting cover and these variables are probably used by many of the resident bird species in habitat selection (Cody 1981). Similarly, Orians and Wittenberger (1991) suggested that nest site selection by female yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) was influenced by the structure of the marsh vegetation but more importantly by the distribution of food resources.

Physiognomy of vegetation can act as a cue indicating the presence of food for some bird species and cover for others. Most species, however, key on vegetation as a reflection of both food and cover because habitat selection is probably influenced by both of these ultimate factors. As Munson (1992) emphasized, influences of food and cover can vary from species to species but both likely operate simultaneously.

Although habitat selection is believed to be an innate response to particular environmental stimuli, other patterns of behaviour may be involved also. Imprinting and experience may be integral to the habitat selection process (Hilden 1965). For example, chicks may imprint on their surroundings and consequently become "devoted" to that breeding site, returning year after year to rear their young. Site tenacity, or homing has been well documented in waterfowl (Sowls 1955, Coulter and Miller 1968, Lokemoen et al 1990).

Experience also may modify habitat selection. For example, when a bird finds abundant food or nesting cover in a certain habitat type it will seek this type for future foraging or breeding. An example of this is birds visiting feeders during the winter months.

Testing for habitat selection - Habitat selection, as defined by Johnson (1980) is the disproportionate use of a habitat type in relation to its availability. For example, a habitat type is considered selected if it is available in relatively low quantities but is frequently used. Thomas and Taylor (1990) caution that without direct measurement of the availability of a particular resource only inferences can be made about resource preference.

Several statistical tests can be used to test for habitat selection (Neu et al. 1974, Johnson 1980, Alldredge and Ratti 1986, 1992, Thomas and Taylor 1990). The Neu et al. (1974) method, a comparison is made between the observed occurrence of individuals and the expected occurrence of individuals in a measured quantity of available habitats within the study area. This method is simple to use because usage and availability are compared for each habitat type across all individuals and individuals need not be identified.

Habitat selection and population dynamics - Not all bird species select habitat and many are able to use several habitat types. Rosenzwieg (1981) distinguished between two types of resource use behaviours: *opportunistic*, where resources are accepted in proportion to which they exist and *picky*, where certain resources are selected in proportions that are different from those available. Rosenzwieg (1981) goes further to define the ability to exploit resources as *generalist*, where fitness in one type of habitat equals the fitness in any other, and *specialist*, where fitness in one habitat type exceeds that in another habitat type. Rosenzwieg (1991) later argued that picky individuals will become more opportunistic as the population size increases indicating that habitat selection may be density dependent. These individuals may become less selective as the population increases. This phenomenon was observed several decades earlier by Svardson (1949) who reviewed the effects of population size on habitat selection in many territorial bird species. He concluded that optimal habitats were occupied first and as the population size increased, individuals settled in suboptimal habitats with fewer resources. Similar results were obtained by Nettleship (1971) who observed common puffins (*Fratercula artica*) first settle on the more productive slope habitat but as the population increased, pairs began to occupy less suitable habitat.

Fretwell and Lucas (1970) developed their "ideal free distribution" hypothesis stating that individuals will select habitats with the highest suitability, wherein the highest suitability means the individual's chances of breeding success are the best. An increase in the population results in a decrease in the suitability of the habitat, thereby forcing individuals to seek less populated habitats. The habitat distribution remains in equilibrium because the average success of individuals in the crowded, high quality habitat will be the same as the average success of individuals in a less dense but lower quality habitat.

Alternative models of habitat selection have been proposed, including Pulliam and Danielson's (1991) hypothesis of "ideal preemptive distribution". According to this model, individuals occupy a habitat with the best quality breeding site where reproductive success can be maximized. Because habitats vary in the quality of the breeding site, contributions of different habitat types to the overall population may be positive in "source" habitats, where recruitment exceeds mortality or negative in "sink" habitats, where mortality exceeds recruitment. The ability of an animal to discriminate among habitat types can thus influence its reproductive success.

The basic difference between the two distribution models is that the "ideal preemptive model" considers individual differences in reproductive success among breeding sites and habitats whereas the "ideal free distribution model" considers the average reproductive success in two habitats. The "ideal free distribution" assumes that individuals in the same habitat have the same reproductive success, whereas Pulliam and Danielson (1991) believe that differences in site quality should be accounted for within the same habitat.

HABITAT SELECTION BY BLACK DUCKS

Black duck breeding habitat selection - Early studies of black duck ecology seldom discussed habitat use in relation to habitat availability, i.e.; habitat selection. Although valuable baseline data were obtained, research centered on general descriptions of wetlands used by black ducks without testing hypotheses on selection or preference. Furthermore, some workers often elaborated only on nesting habitat and neglected wetland habitat used by pairs and broods altogether.

Stotts and Davis (1960) characterized in great detail nesting cover and materials used by breeding black ducks in Maryland but did not discriminate between wetland habitats used by pairs and broods. Coulter and Miller (1968) included a section on nesting cover in their study of black ducks in northern New England and described sedge meadow, bog and lake habitat only in the study area section without discussing how black ducks used the habitat.

More detailed research began to emerge on habitat types used by black ducks, especially with the publication of Barske (1968) "The Black Duck: Evaluation, Management and Research: A Symposium " in which the ecology of black duck populations in several parts of its range was examined. For example in New England and New York black ducks used shrubby marshes, wooded swamps and tidal marshes extensively for breeding whereas in the east-central United States researchers observed use of alkaline marshes, muskegs, bogs, lakes and ponds by breeding black ducks. Black ducks have been also reported to use estuarine tidal marshes in

Quebec (Reed 1975) and in the Atlantic provinces (Erskine 1987), where streams and rivers are heavily used also (Seymour 1984).

Only within the past decade, have workers using more intensive and rigorous scientific research, found evidence of preferential use of specific habitat types by waterfowl. Habitat selection has been documented for black ducks and for dabbling ducks in general. For example, Mulhern et al. (1985) studied wetland selection by mallards and blue-winged teal (*Anas discors*) in the prairie wetlands of Saskatchewan and reported that teal showed preferred larger wetlands with little vegetation, whereas mallards used wetland types in proportion to their availability. Conversely, in forested riverine areas, Gilmer et al. (1975) found that mallards made higher than expected use of nonpermanent wetlands, sand-bar ponds and ponds with shrub-covered shorelines. Similarly, the distribution of mallards, black ducks, and blue-winged teal in the Baie Noire marsh in Quebec was not random suggesting that waterfowl selected habitat (Courcelle and Bedard 1979). Ringelman et al. (1982) reported that black ducks in Maine preferred wetlands with abundant herbaceous emergent and shrub vegetation for breeding.

Breeding habitat requirements for black ducks - Black ducks and other dabbling ducks, have different habitat needs throughout the various stages of the reproductive cycle. All needs are often not provided by one type of wetland habitat necessitating the use of several habitat types during the breeding season to satisfy all breeding requirements (Patterson 1976, Dwyer et al. 1979, Mulhern et al. 1985).

Breeding pairs typically occupy one or more ponds during prelaying and laying and during these times the male defends from conspecifics the pond(s) as a territory (McKinney 1965). The defended pond serves as a rendez-vous spot for the male and female when she is off the nest and assures the pair of uninterrupted feeding time, pair bond activity and copulation (Seymour and Titman 1978).

The distribution of broods, conversely, is influenced by food and cover (Bengtson 1971). Foods high in protein, such as aquatic invertebrates, must be available for growing ducklings (Collias and Collias 1963, Sugden 1973). Likewise, adequate cover to escape from predators is critical for young ducklings as mortality is most prevalent during the first few weeks of life (Ball et al. 1975, Ringelman and Longcore 1982*a*, Orthmeyer and Ball 1990).

Habitat selection by breeding pairs - No evidence of habitat selection by black duck breeding pairs has been found. Ringelman et al. (1982) observed black duck pairs making heavy use of small, ephemeral ponds, although selection for this habitat type was not directly measured.

Breeding pairs of black ducks are territorial and distribution may be the result of this behavioural spacing mechanism (Dzubin 1969, Seymour and Titman 1978). For example, mallard pairs in Ontario did not use specific habitat types and were observed to be distributed evenly throughout marsh habitat (Patterson 1976, Godin and Joyner 1981).

Habitat selection by broods- Research on brood-rearing habitat selection by black ducks has revealed that hens in Nova Scotia select productive wetlands (Payne and McInnis 1983). Preference for rearing wetlands dominated by deciduous shrub and emergent vegetation was reported for black ducks in Maine (Ringelman and Longcore 1982*b*). In similar forested habitat Renouf (1972) reported rearing wetlands most often used by duck broods, including black ducks, were those created by beaver. In the boreal forest region of Quebec, Carriere (1990) observed black duck broods selecting shrub and patchy narrow-leafed emergent areas of rearing wetlands but data are based on a small sample of marked females.

Ponds rich in wetland vegetation offer ideal cover and food for broods. A mix of several vegetation types provide good lateral and overhead cover (Ringelman and Loncore 1982b), while herbaceous emergents like cattail (*Typha spp.*) and sedge (*Carex spp*) support high densities of invertebrates (Courcelles and Bedard 1979, Reinecke and Owen 1980, Kaminski and Prince 1981, Kaminski and Prince 1984). Although escape cover is essential, the abundance of aquatic organisms may be the most important variable influencing habitat selection by female black ducks (Parker et al. 1992).

For the closely related mallard, food is important. Talent et al. (1982) reported that mallard broods selected habitats with high densities of invertebrates. Godin and Joyner (1981), however, documented mallard broods in Ontario were attracted to large, open ponds where ducklings may be less accessible to mammalian predators. Rotella and Ratti (1992) reported that mallard broods in the prairies were habitat generalists because they used habitat types in proportion to their availability.

Cues used by waterfowl to select habitat - Selection of habitat by waterfowl is influenced by innate and learned responses to environmental stimuli, probably the vegetation. Structure and diversity of vegetation in a wetland were found to be key characteristics used in the selection of habitat by breeding black ducks in Maine, because they provide cues to the presence of ultimate factors, food and cover (Ringelman et al. 1982).

Kaminski and Prince (1984) and Courcelles and Bedard (1979) suggest that dabbling ducks use the interspersion of water and emergent vegetation as a proximate cue to habitats that support abundant foods.

The influence of habitat selection on reproductive success - Habitat selection is presumed to be adaptive so that breeding success and survival are highest in those habitat types selected. Habitat-specific reproductive success has been documented for several species of birds including puffins (Nettleship 1972), red-winged blackbirds (*Agelaius phoeniceus*) (Robertson 1972), and pied flycatchers (*Ficedula hypoleuca*)(Alatalo et al. 1985).

Breeding success in waterfowl is measured in terms of apparent duckling survival, and until recently, estimated as the mean number of class III ducklings (fledged ducks approximately 60 days old) divided by the average clutch size. Overestimates in survival and recruitment were suspected using this method because the loss of entire broods is not detected (Ringelman and Longcore 1982*a*). Most current waterfowl studies estimating duckling survival (or mortality), now employ a modified version of the Mayfield method (1961, 1975). This method was designed originally to estimate nest success by calculating the rate of egg loss over time of exposure to risk. Ringelman and Longcore (1982*a*) adapted this method to apply it to duckling survival data. Exposure to risk by a duckling is measured in duckling-days which is calculated as one-half of the length of time between observations. Furthermore, since duckling survival rates differ between Gollop and Marshall's (1954) age classes (Ringelman and Longcore 1982a, Orthemeyer and Ball 1990), overall survival is calculated as the product of the survival rate from class Ia-IIa ducklings (1-24 days old) and that of class IIb-III (25-60 days old). Ringelman and Longcore (1982 a) also assume independence between ducklings in a brood.

Although no one study has compared black duck brood survival among habitat types, separate studies may provide a basis of comparison. In a tidal marsh in the Chesapeake Bay area of Maryland, Stotts and Davis (1960) estimated black duck survival to be 91%. In similar habitat in the St. Lawrence estuary, Reed (1975), accounted for total brood mortality and reported that survival of black duck ducklings was as low as 34% . In the forested region of Maine, ducklings were reported to have an overall survival rate of 42% (Ringelman and Longcore 1982a). This was obtained by multiplying the survival rate of class Ia-IIa ducklings (61%) by the survival rate of class IIb-III ducklings (70%). The product of these rates reflects overall survival better because daily mortality rates of ducklings are not constant throughout the rearing period.

CONCLUSION

Although the black duck has been the subject of a species management plan wherein large acreages of wetland throughout its range are to be protected and managed, little research to date has focused directly on the what types of habitat are preferred by breeding pairs and broods. Studies from Maine suggest that black ducks show preference for large wetlands with abundant deciduous shrubs and herbaceous vegetation.

Habitat selection by breeding black ducks is a complicated process governed by instinctive and learned responses to environmental stimuli. How black ducks choose breeding sites is still unclear, however, researchers suspect that they are keying on proximate factors that reflect critical resources such as food and cover. In the current literature, the structure and diversity of wetland vegetation types are considered the most important habitat features that are assessed in site selection.

If black ducks are selecting specific habitat types, then the advantages of selection behaviour would be an increased reproductive success in the chosen habitat type. Black duck duckling survival data is sketchy with few studies reporting survival rates from different geographic locations, obscuring a possible relationship between rates and selected habitats.

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Section I. BREEDING HABITAT SELECTION BY BLACK DUCKS

ABSTRACT

Selection of habitat by pairs and brood-rearing female American black ducks (*Anas rubripes*) was studied in Antigonish Co., Nova Scotia in 1990 and 1991. Black duck pairs selected shrub-dominated and sparsely vegetated sites for pairing activities while females with broods broods chose only shrub-dominated sites. Pairs and broods selected the same habitat types in both years.

The only habitat characteristic important in predicting site use and use by pairs was the distance to brood-rearing site, which was negatively associated with pair site use. Black duck pairs chose sites that either served as the brood-rearing site or that were near a brood-rearing site. Long shoreline lengths, invertebrate biomass, area of alder/willow and coverage of flooded dead timber were associated with site use by females with broods.

INTRODUCTION

Forested and coastal wetland systems in Atlantic Canada have been changed drastically over the last several decades. How these habitat disturbances affect the breeding effort of the American black duck (*Anas rubripes*) remains unclear. To better understand how habitat changes affect population numbers, waterfowl managers and researchers in the maritime provinces have expressed a need for a deeper understanding of the breeding habitat requirements of the black duck. One of the specific objectives emerging from the Black Duck Joint Venture Steering Committee (1989) was to identify basic habitat features associated with breeding black ducks.

The black duck, a bird of eastern North America, breeds primarily in forested and coastal marsh habitat (Bent 1923). Earlier researchers suggested that black ducks breed virtually anywhere water occurred (Palmer 1976). Within the past decade, however, more detailed studies have revealed that breeding black ducks show preferences for specific types of habitat (Coulter and Miller 1968, Reed 1975, Ringelman et al. 1982). When habitat types are used disproportionately to their availability then their use is considered selective (Johnson 1980). Because wetlands differ in abundance of foods and accessibility to good cover, selecting certain habitat types for breeding may influence reproductive success (Cody 1985).

To fulfil all requirements for black duck pairs and females with broods, a variety of habitats may be necessary (Spencer 1968, Patterson 1976, Mulhern et al.

1985). In the spring, pairs occupy ponds close to the nesting site and males defend these sites (Stotts and Davis 1960, Coulter and Miller 1968, Seymour and Titman 1978, Ringelman et al. 1982). Sites used by pairs are extremely variable (pasture pond, drainage ditch, managed marsh (Kirby 1988) but are usually visually isolated from adjacent territories of conspecifics and either support or be in close proximity to quality foods necessary for the laying female.

Unlike mobile, adult pairs, flightless ducklings require nearby cover to escape from predators and abundant, high-protein foods. Although food and cover are dependent on nearby aquatic vegetation, the abundance, structure and diversity of the vegetation may vary between sites used by pairs and broods. No research to date has tested for temporal and spatial habitat use by black ducks.

Little information concerning the quality of a site is available to pairs arriving on the breeding grounds in the spring. Indications of food and cover may not be immediately evident. The suitability of a breeding site must therefore be "evaluated" on the basis of certain habitat features early in the breeding season. The cues a female uses in selecting a breeding site remain unclear, although it is suspected that the physiognomy of the vegetation plays an important role (Courcelles and Bedard 1979, Ringelman et al. 1982).

The objective of this study was to determine whether black duck pairs and females with broods in northeastern Nova Scotia, select habitat or occupy it randomly. I test the null hypothesis that habitat types are used in proportion to their availability by pairs and broods. I also try to define the habitat characteristics used as cues in the selection of pair sites and brood-rearing sites by breeding black ducks.

STUDY AREA

This study was conducted in a 750 km^2 watershed in Antigonish County, northeastern Nova Scotia. Three rivers and their tributaries flow through forested and agricultural land and drain the watershed into a 20 km^2 estuary that opens into St. George's Bay on the outer St. Lawrence River. At the upper end of the estuary is a 1.5 km^2 saltmarsh cordgrass (*Spartina alterniflora*) tidal marsh similar to that described by Nixon and Oviatt (1973). The marsh consists of a network of narrow channels, inlets and shallow bays that are influenced by a tidal amplitude of not more than 1 m. Many small tidal pools and freshwater ponds are located at the marsh's periphery.

The remainder of the study area is made up of Acadian forest dominated by mixed stands of conifers (*Picea, Pinus*) and hardwoods (*Acer, Populus, Betula*). Lakes and freshwater wetlands are numerous and widely dispersed throughout the study area. Common freshwater emergent vegetation include cattail (*Typha* spp.), sedges (*Carex* spp.) and bulrush (*Scirpus* spp.). Flooded alder (*Alnus*), and willow (*Salix*) were present on many sites, particularly on wetlands influenced by beaver (*Castor canadensis*).

Important avian predators of black ducks, especially ducklings, in the study area are bald eagles (*Haliaeetus leucocephalus*), which have been observed in large numbers on the tidal marsh at the peak of the brood-rearing season (Maclean 1988), and gulls (Laridae). Mink (*Mustela vison*) have been known to prey heavily on black ducks, particularly incubating hens (M. Workman, pers. comm.). Snapping turtles (*Chelydra serpentina*) also are suspected to be an important predator of black duck ducklings.

METHODS

Habitat analysis - All brackish and freshwater wetlands in the study area were found using aerial (1:5000 ft) and topographic (1:10000m) maps. All known wetlands were considered sites (hereinafter also referred to as ponds) that were available for use by black duck pairs and broods. A wetland was defined as "land that has the water table at, near, or above the land's surface or which is saturated for a long enough period to promote wetland aquatic processes as indicated by hydric soils, hydrophytic vegetation, and various kinds of biological activity that are adapted to the wet environment" (North American Wetlands Conservation Council 1992). Each site was classified according to Cowardin et al.'s (1979) habitat classification system. This hierarchial system classifies wetlands based on the proportion of the dominant vegetation life form or substrate coverage. All study sites were categorized using the habitat types outlined in Table 1.1.

The features of all study sites were examined in detail from May to August of 1990 and 1991. It was assumed that all habitat variables measured were predictors of cues used by black ducks to select breeding sites. Efforts were made to select habitat variables that were appropriate and relevant to breeding black ducks. I used the "bird-centered view" (Knopf and Sedgewick 1992) to choose habitat variables that I hoped were the same characteristics as those perceived by black ducks as cues used in site selection. Also, my analysis included the application of multivariate statistics, which allowed for the dismissal of poor predictors from further analysis. I hope both of these efforts resulted in the finding of habitat variables that were not only statistically valid, but more importantly, biologically meaningful.

From May to mid-June, 16 physical and vegetation variables were measured at each site used by a pair. After leaf emergence (mid to end of June) to the end of August, 30 physical, chemical, floral and faunal characteristics were measured for all brood sites (Table 1.2).

The physical variables of distances to roads and dwellings, surface areas, perimeters and amounts of vegetation life forms were determined using 1:5000 ft aerial photographs. Distance to brood site, which was measured only for sites observed with a pair, was calculated as the closest distance from the site to a site observed with a conspecific brood. Percent cover of vegetation life forms was determined by on-site estimation and plant species were identified. The overstory density of vegetation life forms was estimated using a spherical densiometer (Lemmon 1956) in which three measurements taken from a vegetation life form stand were averaged.

Beaver activity was also noted for each site. A site was considered influenced by beaver if a beaver was observed on the site, a beaver dam or lodge was present or if signs of beaver foraging, such as chewed hardwood stumps were evident.

Water samples from 48 randomly chosen sites were collected from mid to late June 1990. Samples were analyzed by Environment Canada, Halifax, Nova Scotia using standard procedures (Environment Canada 1979). Specific conductivity, pH, total nitrogen (meq/L) and total phosphorus (meq/L) were measured.

Aquatic macroinvertebrates were sampled from 6 sites randomly chosen from each habitat class. Samples from one habitat class were collected on the same day so that the classes were sampled on consecutive days during the last week of June and the first week of July 1991. A sample collected from a site consisted of the total invertebrates collected throughout the water column using three collection techniques; sweepnet, activity trap and bottom corer.

To sample the water surface and subsurface, a series of three, 2m sweeps was made with a standard long-handled sweep net (mesh size was 0.5mm). Nektonic animals were collected using 24 hour activity traps consisting of a glass jar suspended horizontally (Murkin et al. 1983) and set midway between the substrate and the water surface. A single-core sampler (20 cm deep juice can, 12.5 cm in diameter) was used to collect benthic organisms. Invertebrates included in the sample were those that did not pass through a 0.5 mm sieve.

After, invertebrates were immediately preserved in a 10% ethanol solution and later counted and identified to family according to Pennak (1953). The sample was then oven-dried at 105°C for 24 h to estimate dry-weight biomass.

Pair and brood surveys- A breeding pair survey consisted of an aerial count for pairs and an aerial and ground count for broods. Aerial surveys were flown using a Nova Scotia Department of Lands and Forests helicopter with a pilot and two observers. We hovered for approximately 120 seconds over all water bodies in the study area at an altitude of 50 m above ground level.

Aerial pair surveys were flown in mid to late April in 1990 and 1991. A site was considered used by a breeding pair if a pair or lone drake or female was observed. Observations on the ground of territorial behaviour following the aerial survey confirmed that the site was being used by a pair.

A single aerial brood survey was flown 30 July 1990 but no brood surveys were flown for 1991 because all provincial helicopters were unavailable. Ground surveys of black duck broods began at the end of May and continued to mid-August in both years. Ground surveys for broods consisted of continuous observation from a natural, elevated vantage point using a 20x spotting telescope until a hen and her ducklings were sighted. To maximize sightings, ground observations coincided with times of peak activity; in the morning (sunrise-1030) and evening (1730-sunset) (Ringelman and Flake 1980). A site was considered used by a brood if a hen and her ducklings remained at the site for more than 24 h (Ringelman and Longcore 1982).

To permit individual identification, 35 black ducks were trapped on the tidal marsh in mid-April 1991 using a baited funnel-trap and marked with plastic nasal discs (Lokemoen and Sharp 1985).

Statistical analysis - To determine whether black duck pairs and broods select habitat I used a Chi-square goodness-of-fit test (Neu et al. 1974). I tested the null hypothesis that habitat types are used in proportion to their availability to pairs and broods. When resources are used disproportionately to their availability then use is selective (Johnson 1980). I used the Chi-square approximation because identification of individuals was not required, the number of habitat types in the study area (5) was small and the availability of the habitat types was known. The expected number of observations in each habitat type is based on each habitat type being used in proportion to its availability (Alldredge and Ratti 1986, 1992).

Each habitat type was subsequently analyzed using a Bonferroni z-statistic (Miller 1981) to determine which habitat types were not used according to their availability. Habitat types used more frequently than expected were considered selected whereas those used less frequently than expected were not preferred.

The relationship between habitat components and site use by pairs and broods was determined by examining differences (Mann-Whitney U test, $p<0.05$) (Sokal and Rohlf 1981) in habitat variables between used and unused sites. Data obtained in 1990 and 1991 were combined because differences ($p>0.1$) were not significant between years. Separate analyses were conducted for pair and brood sites. Variables that differed significantly were considered predictors of habitat selection (Knopf and Sedgewick 1992) and were subsequently entered as independent variables for subsequent analyses.

A stepwise forward discriminant analysis (Klecka 1975) was used to further identify habitat characteristics important in predicting site use by pairs and broods (Kaminski and Prince 1984). To prevent intercorrelation between variables, which could pose interpretive problems, one variable from an interrelated set of variables was entered in the analysis (Kaminski and Prince 1984). Independent habitat variables were log transformed (log [x+1]) (Ringelman and Longcore 1982) because habitat measurements were not normally distributed (Lillifors test for normality). The dependant categorical variable *usage* was considered as follows: (1) high use (used both years), (2) moderate use (used one year) and (3) no use (not used in either year).

RESULTS

Habitat selection- The study area contained 93 fresh and brackish wetlands that covered approximately 396 ha. The most abundant wetland habitat type in the study area was Estuarine Emergent (159.2 ha) although only four sites were sampled in this habitat. Most wetlands in the watershed were classified as Palustrine Unconsolidated Bottom (n=41) but they covered the smallest area (21.9 ha) (Fig.1.1).

Palustrine Unconsolidated Bottom and Palustrine Scrub-Shrub habitats supported the highest number of black duck pairs per hectare even though these types had the smallest surface areas (Fig.1.2). The highest density of broods was also found in the Palustrine Scrub-Shrub habitat whereas the lowest brood density was found in the Lacustrine Unconsolidated Bottom habitat.

Differences in the number of pairs observed in each habitat type between years were not significant (t-test, $p>0.1$) so pair numbers were pooled. The null hypothesis, that all wetland habitat types were used according to their availabilities was rejected ($X^2=176.3$, 4 df, $p<0.001$). Palustrine Scrub-Shrub and Palustrine Unconsolidated Bottom habitat types were preferentially used by pairs whereas Estuarine Emergent and Lacustrine Unconsolidated Bottom habitats were used less frequently (Table 1.3).

Brood data for the two years were pooled (t-test, $p>0.3$). The null hypothesis that all brood-rearing habitat types were used in proportion to their availability ($X^2=62.5$, 4 df, $p<0.001$) was again rejected. Broods selected only Palustrine Scrub-Shrub habitat type and used less frequently than the Palustrine Unconsolidated Bottom habitat type. All other habitat types were used according to their availability (Table 1.4).

Habitat characteristics- Twelve of 16 variables at pair sites were significantly different between used and unused sites (Mann-Whitney U test, $p<0.05$). By contrast, distances to roads and dwellings and area and percent coverage of ericaceous shrubs did not differ between used and unused sites. Used pair sites covered larger areas (ha) (4.5 ± 0.9 [SE], $p<0.001$) than unused sites (1.2 ± 0.2) and were closer (m) to brood-rearing wetlands (363.1 ± 60.4, $p<0.001$) than unused sites (1165.2 ± 87). Vegetation such as deciduous shrubs (alder/willow), flooded dead timber and persistent herbaceous vegetation covered larger areas on used pair sites ($p<0.05$).

Pairs were also more common on ponds modified by beaver ($p<0.001$) (Table 1.5).

Of the wetland sites in the study area (n=93), only 29% (27 of 30) were observed with a pair and a brood where 41% (38 of 93) supported a pair and no brood, 30% were apparently unused by either a pair or brood and no sites were observed with a brood and no pair. Over half (55%) of the sites used by pairs only were located within 1 km of a site supporting more than 1 brood. These sites were substantially closer to brood-rearing ponds (985.1 ± 142.7m, $p<0.05$) than sites not used by pairs. Sites used by pairs also had a lower proportion of open water (40.7 ± 4.9%, $p=0.001$) (Table 1.6) than sites not used by pairs.

Twenty-two of 28 habitat variables differed significantly ($p<0.05$) between used and unused brood sites (Table 1.7). Female black ducks with broods used sites that were larger (7.21 ha ± 1.7, $p<0.001$) than sites that were unused by broods (3.2 ha ± 1.1) and that had longer perimeters (1233 m ± 187.3, $p<0.001$) than unused sites (753 m ± 121.4). Sites used by broods were also farther from human dwellings (370 m ± 63.2, $p<0.01$) than sites not used by broods (207 m ± 78.5), although distances to roads were not important ($p>0.2$). A significantly greater diversity and abundance of vegetation life forms was found on sites used by broods ($p<0.001$). Except for floating-leafed vegetation ($p>0.05$), the area and percent of deciduous shrubs (0.44 ha ± 0.39, 21.6% ± 19.2), herbaceous vegetation (3.69 ha ± 9.92, 24.2 % ± 20.9) and flooded timber (0.18 ha ± 0.26, 8.82 % ± 13.56) were present on used rearing sites in greater area and proportion ($p<0.05$).

Cover for broods, was in part, provided by the overstory density of the vegetation life forms. Only cover density (%) of alder and willow was significantly greater on wetlands with broods (71.4 ± 5.0, $p<0.001$). Food, measured by invertebrate dry weight (mg), was greater on sites with broods (240.3 ± 98.5, $p<0.001$) than on sites without broods (97 ± 19.4).

A greater number of sites observed with broods was influenced by beaver activity (n=24) than used sites with no signs of beaver (n=2)($p<0.001$). Eighty-six percent of freshwater sites observed with a brood were influenced by beaver activity. All used brood sites with signs of beaver activity were classified as Palustrine Scrub-Shrub habitats, except for two that were Palustrine Emergent habitats.

Chemical variables were not different between sites used and unused by broods ($p>0.2$) except for total nitrogen, which was greater in brood-rearing wetlands (0.98 meq/L ± 0.16, $p<0.01$) than in wetlands not used by broods (0.64 meq/L ± 0.31).

The regression analysis revealed that the only variable important in predicting site use by pairs was the distance to a brood-rearing area (Table 1.7). Distance to a brood site was negatively associated with site use by pairs.

Discriminating brood site variables were site perimeter, invertebrate dry weight, the area of flooded alder/willow and the proportion of flooded timber coverage (Table 1.8). Length of wetland perimeter was the most important habitat characteristic in determining black duck brood use. The shoreline perimeter of sites used by broods was almost three times that of sites not used by broods. Invertebrate dry weight was the second most influential variable identified in site use by broods whereas the area of alder/willow and the proportion of timber were the most important vegetation components of used brood sites. Alder/willow overstory density exceeded that offered by herbaceous vegetation ($p<0.05$).

DISCUSSION

Habitat selection by breeding pairs- Black duck pairs were not randomly distributed throughout the Antigonish study area but were specific and consistent in their use of wetland habitat types. In both years 1990 and 1991, pairs selected Palustrine Scrub-Shrub (PSS) and Palustrine Unconsolidated Bottom (PUB) habitat types.

Deciduous shrub-dominated habitat, similar to the PSS habitat type, has been reported by Ringelman et al. (1982) to be preferred wetlands of black ducks breeding in Maine. Newly-flooded shrub habitat offers a pair ponds which are suitable for territory establishment since the abundant concealing vegetation isolates them from other pairs, allowing the male and female time for uninterrupted feeding and courtship activities (Seymour and Titman 1979). Flooded woody plants also afford good cover from predators and support higher densities of macroinvertebrate foods (Ringelman et al. 1982) that are particularly important to laying females (Swanson and Meyer 1973, Swanson et al. 1979).

Preference by pairs for PSS habitat type may have resulted from its suitability to support a brood as black ducks also selected PSS habitat to rear their young. By selecting this habitat type pairs not only fulfil their requirements for food and seclusion but can also ensure adequate food and cover resources for their future offspring. Female ducks that nest near good brood-rearing areas may be favoured by natural selection because females are better able to meet their high energy demands during egg-laying and risks to the brood during overland movement to rearing areas are minimized (Sedinger 1992).

Similar to forest-dwelling mallards (Gilmer et al. 1975), black duck pairs were able to exploit more than one type of wetland habitat as PUB habitat type was found to be used more than expected. Black duck pairs in Maine made extensive use of similar small ponds before broods hatched (Ringelman et al. 1982, Ringelman and Longcore 1982).

Preference by pairs for the poorer quality PUB habitat type may be influenced by the proximity of good feeding and rearing areas and the juxtaposition of the PUB sites. For example, PUB sites in the study area were only occupied by pairs if they were close to either the tidal marsh or a large emergent wetland (27 ha), two study sites known to support three or more broods (N. Seymour, pers. comm.), and isolated from nearby ponds. The close proximity of the PUB sites to large, quality rearing areas likely make them attractive to large numbers of breeding pairs, however, behavioral spacing mechanisms force them to singly occupy the isolated PUB sites, which effectively disperses the local breeding population (Dzubin 1969, Patterson 1976, Godin and Joyner 1981).

Lacustrine Unconsolidated Bottom (LUB) and Palustrine Emergent (PE) habitat types were used by pairs according to wetland availability. LUB habitats were avoided by pairs except for the use of an eutrophic lake that supported three pairs that defended a secluded, vegetated inlet of the lake. Sites belonging to the PE habitat type were not often used by pairs probably because of an overabundance of emergent vegetation, which often exceeded the ideal 50:50 cover to water ratio preferred by most dabbling ducks (Murkin et al. 1982).

Estuarine emergent (EE) habitat type was avoided by pairs during both years of the study. Pairs did not defend sites in this habitat type probably because sparse concealing vegetation was offered by the senescent *Spartina*. The tidal marsh site, referred to by Seymour and Titman (1978) as the "communal area", rarely supported territorial black duck pairs (N. Seymour, pers. com.)

Habitat selection by females with broods- Black ducks in the Antigonish study area selected only PSS habitat type for brood-rearing during both years of the study. Ringelman and Longcore (1982) report the selection of similar deciduous shrub ponds by black ducks for brood-rearing.

The selection of brood-rearing sites by dabbling ducks is thought to be made on the basis of food and cover availability (Bengtson 1971, Sedinger 1992), although some researchers suggest food is the important variable influencing wetland selection (Murkin and Kadlec 1986), particularly for black ducks (Erskine 1987, Parker et al. 1992).

All Palustrine Scrub-Shrub sites occupied by broods were altered by recent beaver activity (1-5 years). Beard (1953) and Renouf (1972) suggested that newly flooded beaver ponds were excellent at fulfilling the needs of waterfowl broods. Whitman (1987) reported that beaver ponds are the preferred black duck habitat in forested areas of eastern Canada. Natural drawdown in beaver ponds results in increased productivity (Brown and Parsons 1979, Kirby 1988) where submergent and emergent vegetation flourishes. Patches of herbaceous emergents provide a substrate for aquatic invertebrates (Krull 1970, Kaminski and Prince 1981, Murkin et al. 1982), a crucial protein source of developing black duck ducklings (Reineke and Owen 1980).

Beaver maintain relatively constant water levels throughout brood-rearing that keep plants and shrubs flooded. Foliage of alder and willow typically extend over the water and hang within centimetres of the water surface creating not only vertical cover but horizontal cover as well. Likewise, ducklings can take refuge from aerial and terrestrial predators in the tangle of fallen limbs, stumps and protruding roots provided by flooded dead timber.

Although black duck broods in the Antigonish study area preferred only PSS habitat, some broods occupied other habitat types in proportion to their availability. Estuarine habitats are generally productive for black ducks (Reed 1975), however, in this study brood density in the Estuarine Emergent (EE) habitat type was low. Black duck broods may not have been able to fully exploit this habitat type because of a lack of sites suitable for establishment of territories by pairs. No territories were found on the tidal marsh and the number of ponds in proximity to the marsh was limited. The number of ponds available to pairs arriving in the spring may be an important factor restricting the size of the breeding population (Godin and Joyner

1981).

A large number of studies reported in Kirby's (1988) review of black duck habitat use documented that black ducks throughout their range use extensively wetlands with abundant herbaceous emergent plants. PE habitat type, however, was used in proportion to availability by broods in the study area. Most sites that were dominated by emergent vegetation were impenetrable stands of hydrophytes (eg. *Typha*) that often dried before the brood-rearing period was over. These sites are frequently lost through succession. Conversely, PUB habitat, also used according to its availability, contained sites that were only sparsely, at best, covered by emergent vegetation. Most sites were small (<1 ha), with only a thin fringe of plants along the pond periphery offering black duck broods little food or cover.

LUB habitat type was the only wetland type used infrequently by broods. Sites belonging to this habitat type were similar in physiognomy to PUB sites except that they had larger surface areas. Sites with large open expanses of water are typically avoided by black duck broods because of a lack of cover and foods (Kirby 1988).

Cues used for site selection by pairs- Distance to brood site was the only habitat feature identified as a cue used by black duck pairs selecting a site. Dzubin (1969) postulated that mallard pairs occupied particular ponds because of their proximity to nesting cover or nesting sites.

Because occupied pair sites varied greatly, especially in vegetation type and coverage, no other characteristics emerged as cues suggesting that the quality of the pair site itself may not be a variable in the site selection process. Patterson (1976) concluded that pairs were distributed randomly throughout his study area regardless of pond fertility but that broods occupied more productive wetlands.

Pairs in the Antigonish study area seemed to have made one of two choices with respect to site selection; a site was chosen by pairs because it was adequate for courtship activities and it could support future offspring (distance to brood-rearing site is zero). Or, a site was chosen because it was adequate for courtship activities and it was in close proximity to a site that could support offspring (distance to brood-rearing site minimized). In the study area, all ponds (n=4) surrounding two large, vegetated rearing wetlands were occupied by pairs, however, ponds farther than about 1 km away remained vacant. In both instances, long overland movements to rearing wetlands were avoided, which could increase brood mortality (Ball et al. 1975, Rotella and Ratti 1992 but see Talent et al. 1982).

Pairs may thus focus on cues reflected by the brood site in the selection of the pair site. This suggests that cues used in pair site selection are too similar or identical to those used in site selection by females with broods.

Cues used for site selection by females with broods- Cues used by black ducks in the selection of a rearing site in order of significance were, wetland perimeter, aquatic invertebrate biomass, area of alder/willow and the percent coverage of flooded timber.

If pairs are choosing pair sites and rearing sites on the basis of the quality of the future rearing site, they are probably cueing in on certain habitat characteristics that are obvious in the spring before plant emergence. Wetland perimeter, which is evident to pairs arriving on the breeding grounds, was the most important habitat characteristic predicting site use by females. Patterson (1976) and Mack and Flake (1980) reported positive relationships between brood use and shoreline length. Because shoreline is often the site of abundant wetland vegetation, perimeter may be used by black ducks as a proximate factor that reflects available escape cover and foraging areas for broods.

Unfortunately, the aquatic invertebrate biomass was sampled only throughout the brood-rearing period and not when pairs were assessing site quality in spring. Thus, I am uncertain whether pairs assessed ultimate factors, such as food resources, directly at the time of site selection or relied on other habitat characteristics as indicators of food abundance. Orians and Wittenberger (1991) hypothesized that female red-winged blackbirds assessed the production of insects on breeding marshes before nesting. My data, nevertheless, highlight an important correlation between site use by broods and availability of foods. Positive relationships have been found between waterfowl abundance and invertebrate abundance for dabbling ducks on the prairies (Murkin and Kadlec 1986) and in Ontario (Joyner 1980). Parker et al. (1992) suggested that the abundance of aquatic invertebrates was the most influential variable in wetland selection by black ducks. Selecting sites with abundant aquatic invertebrates ensures a protein-rich food for broods, which is crucial for black duck ducklings in meeting nutritional demands (Reineke 1979).

The area of flooded alder/willow and percent flooded timber were the only floral characteristics probably influencing site use by black duck broods. Both vegetation forms are the result of beaver activity and contribute to the vegetative structure of the wetland landscape in spring. Pairs can thus rely on the relative abundance and coverage of these woody plants as proximate factors that reflect potential food and cover (Ringelman and Longcore 1982, Ringelman et al. 1982).

All sites in the study area containing alder, willow and dead timber were influenced by beaver activity. Beaver maintain water levels which enables ducklings to exploit flooded vegetation (Renouf 1972) for food and cover. Reinecke (1977) (in Kaminski and Prince (1981)) reported high levels of invertebrates associated with 3 to 5-year-old beaver ponds. Furthermore, flooded alder and willow offered the best concealing protection as they had the highest overall overhead density. Flooded dead timber also helps camouflage black duck ducklings.

Management implications- Habitat of the black duck in the forested regions of its distribution can be managed by regulating numbers of beaver. Because shrub-dominated beaver flowages seem to be preferred habitats of black ducks in the study area, maintaining high numbers of beaver while avoiding economic damage to local residents, is probably the most efficient and cost-effective approach for black duck management. Unfortunately, much of the preferred black duck breeding habitat in the study area lies on private land where many land owners have dismantled beaver dams at the first signs of flooding. Education of land-owners about the conservation of black duck and beaver habitat along with monetary incentive programs should be top priorities for wildlife officials in the area.

As the mallard increases its distribution into traditional black duck range, wildlife managers should take special precautions when modifying wetlands to benefit breeding black ducks. To date, mallards that have been observed in the Antigonish study area occupied the larger emergent wetlands and the brackish tidal marsh. Rarely have mallards been observed on the smaller beaver flowages in Nova Scotia. Therefore, large budgets spent on creating and managing huge tracts of marshland may help promote the mallard cause in northeastern Nova Scotia. This could result in decreased black duck numbers as mallards generally outcompete black ducks on shared breeding grounds (Merendino et al. 1993). Once again, the restoration of deciduous shrub wetlands should be maintained.

Future research on black duck habitat management should focus on the experimental manipulation of pair sites. Several of the larger scrub-shrub and emergent wetlands in the study area could support substantially more broods, however, the number of black duck broods exploiting these sites is likely limited by the number of sites available to pairs. One or two small ponds close to these areas could be blasted with explosives in order to create sites for territorial pairs. This site could also serve as a study area for determining whether duckling survival is density dependent.

CONCLUSION

Black ducks are making "choices" with respect to wetland habitat type for pairing and brood-rearing activities in the Antigonish watershed. Territorial pairs selected both shrub dominated (PSS) ponds and sparsely vegetated (PUB) ponds. In most instances, pairs that used PSS ponds for courtship activities used the same pond to rear their broods, suggesting that deciduous shrub wetlands were the most productive ponds in the study area that fulfilled the needs of pairs and broods.

Pairs that used sparsely vegetated ponds used only those that were in proximity to a wetland that had the potential to become a brood-rearing site (ie. sufficient vegetative cover). In both instances, pair sites seem to be chosen with respect to the availability of quality rearing wetlands. By choosing sites that supply all requirements throughout the breeding cycle, black ducks may increase their reproductive success by reducing or eliminating interwetland movement, which can be energetically costly for pairs and could expose the brood to predators. Although pairs were found to prefer specific wetland habitat types in which sites were categorized by vegetation type and abundance, vegetation characteristics, per se, may not necessarily be important to breeding pairs. This is illustrated by the fact that two very different habitat types with varying amounts of vegetation coverage were selected. In addition, the only habitat characteristic probably used as a cue in site selection by black duck pairs was the proximity of the site to a brood-rearing pond, further evidence showing that breeding black ducks choose sites for pairing activities with the requirements of the brood "in mind". Dwyer et al. (1979) found that prairie mallard hens sought appropriate rearing ponds well before the brood-rearing period began.

Black duck broods were even more specific than pairs in selecting habitat because only shrub dominated (PSS) habitat was preferred. Shrub ponds, which were most often influenced by beaver activity, provided ducklings with an abundance of macro-invertebrates and good lateral and horizontal cover.

Black ducks in the spring probably used the pond perimeter, the abundance of alder and willow and the proportion of dead timber as cues because these wetland characteristics seem, from our perspective, obvious to ducks when selecting breeding sites. Perimeter reflects the availability of hiding and foraging places for vulnerable broods while the presence of alder, willow and dead timber indicates good dense cover from shrubs and trees flooded by beaver. Natural drawdown, periodic flooding and dewatering of flowages after abandonment by beavers, create productive wetlands that encourage the growth of herbaceous plants. Herbaceous vegetation, which was almost always present, but subdominant on shrub wetlands, support large amounts of aquatic invertebrates, the mainstay of a duckling's diet.

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Table 1.1. Habitat types evaluated for use by black duck pairs and broods on a 750 km^2 watershed in Antigonish Co., Nova Scotia, May-August, 1990-91.

Habitat type[a]	Description[b]
Estuarine Emergent	Influenced by oceanic tides with a salinity greater than 0.5%; >30% emergent vegetation coverage dominated by cordgrass (*Spartina alterniflora*)
Lalustrine Unconsolidated Bottom	>8ha with <30% vegetation coverage; substrate of organic material, mud, sand, gravel, cobbles
Palustrine Emergent	<8ha with >30% vegetation coverage dominated by cattail (*Typha*), bulrush (*Scirpus*), sedge (*Carex* spp.) and rushes (*Juncus* spp.)
Palustrine Scrub-Shrub	<8ha with >30% vegetation coverage dominated by alder (*Alnus*) and willow (*Salix*)
Palustrine Unconsolidated Bottom	<8ha with <30% vegetation coverage; substrate of organic material, mud, sand, gravel, cobbles

a - habitat types adapted from Cowardin et al. (1979) wetland habitat classification system

b - all habitat types except Estuarine Emergent are lentic habitats

Table 1.2. Habitat variables used to describe wetland sites in a 750 km^2 watershed in Antigonish Co., Nova Scotia, May-August, 1990-91.

Variable[a]	Description
Surface area[b,c]	Area covered by at least 0.1 m water (ha)
Perimeter[b,c]	Linear distance around the water body (m)
Dwelling distance[b,c]	Distance to nearest permanent human dwelling (m)
Road distance[b,c]	Distance to nearest road travelled at least twice per day (m)
Brood site distance[b]	Distance to nearest wetland used at least once for rearing (m)
Area of open water[b,c]	Area of water surface without vegetation (ha)
Percent open water[b,c]	Percent of water body without vegetation
Area persistent[b,c]	Area covered by herbaceous vegetation visible after senescence (ha)
Percent persistent[b,c]	Percent covered by herbaceous vegetation visible after senescence
Area ericaceous[b,c]	Area water surface covered by ericaceous shrubs (ha)
Percent ericaceous[b,c]	Percent water surface covered by ericaceous shrubs
Area alder/willow[b,c]	Area water surface covered by *Alnus/Salix* (ha)
Percent alder/willow[b,c]	Percent water surface covered by *Alnus/Salix*
Area flooded timber[b,c]	Area water surface covered by dead trees (ha)
Percent flooded timber[b,c]	Percent water surface covered by dead trees
Area herbaceous[c]	Area water surface covered by

	emergent herbaceous vegetation (ha)
Percent herbaceous[c]	Percent water surface covered by emergent herbaceous vegetation
Area floating-leafed[c]	Area water surface covered by floating-leaved vegetation (ha)
Percent floating-leafed[c]	Percent water surface covered by floating-leaved vegetation
Number life forms[c]	Number of vegetation life forms on water surface
Number life form patches[c]	Number of distinct life form areas on water surface
Alder/willow density[c]	Overstory density (%) of alder/willow
Herbaceous density[c]	Overstory density (%) of herbaceous vegetation
pH[c]	Water pH
Specific conductivity[c]	Specific conductivity of water sample
Total nitrogen[c]	Total nitrogen (mg) dissolved in 1 L water
Total phosphorus[c]	Total phosphorus dissolved in 1 L water
Invertebrate dry weight[c]	Sample consisting of total dry weight using three sampling methods

a - variables adapted from Ringelman and Longcore (1982)

b - variable considered in pair site analysis

c - variable considered in brood site analysis

Table 1.3. Observed and expected frequency of black duck pairs on different habitat types in a 750 km^2 watershed in Antigonish Co., Nova Scotia May 1990 and 1991.

Habitat type	No. pairs observed	No. pairs expected[a]	Area (ha)	N	Proportion pairs observed in each type	90% confidence interval[b]
Estuarine Emergent	9	49.5	159.2	4	0.073	$0.013<p<0.134$[c]
Lacustrine Unconsol. Bottom	11	32.9	105.2	6	0.089	$0.023<p<0.156$[c]
Palustrine Emergent	30	24.6	79.0	23	0.244	$0.144<p<0.344$[d]
Palustrine Scrub-Shrub	34	9.3	29.8	19	0.276	$0.317<p<0.108$[e]
Palustrine Unconsol. Bottom	39	8.9	6.8	41	0.317	$0.209<p<0.425$[e]
Total	123		395.8			

a - based on total pairs observed multiplied by proportion total area of the habitat type
b - according to a Bonferroni *z* statistic (Miller 1966 in Neu et. al. 1974)
c - used less than expected (avoided)
d - used in proportion to availability
e - used more than expected (selected)

Table 1.4. Observed and expected frequency of black duck broods on different habitat types in a 750 km^2 watershed in Antigonish Co., Nova Scotia, May 1990 and 1991.

Habitat type	No. broods observed	No. broods expected[a]	Area (ha)	N	Proportion broods observed in each type	90% confidence interval[b]
Estuarine Emergent	34	33.4	159.2	4	0.410	$0.271 < p < 0.549$[d]
Lacustrine Unconsol. Bottom	6	22.2	105.2	6	0.072	$0.006 < p < 0.139$[c]
Palustrine Emergent	15	16.6	79.0	23	0.181	$0.072 < p < 0.290$[d]
Palustrine Scrub-Shrub	24	6.3	29.8	19	0.289	$0.161 < p < 0.417$[e]
Palustrine Unconsol. Bottom	4	4.6	21.9	41	0.048	$0.016 < p < 0.080$[d]
Total	83		395.8			

a - based on total broods observed multiplied by proportion total area of habitat type
b - according to a Bonferroni *z* statistic (Miller 1966 in Neu et. al. 1974)
c - used less than expected (avoided)
d - used in proportion to availability
e - used more than expected (selected)

Table 1.5. Means for habitat variables and differences (Mann-Whitney) between used and unused sites by black duck pairs in a 750 km^2 watershed in Antigonish Co., Nova Scotia, May 1990 and 1991.

Habitat variable	Used	Unused	Level of Significance
Surface area (ha)	4.49	2.30	p<0.001
Perimeter (m)	791.00	389.05	p<0.001
Dwelling distance (m)	292.72	312.56	p>0.1
Road distance (m)	255.97	279.89	p>0.8
Dist. to brood site (m)	363.52	1634.89	p<0.001
Area open water (ha)	2.13	1.34	p=0.003
Percent open water	49.61	69.12	p<0.001
Area persistent (ha)	0.66	0.18	p=0.002
Percent persistent	13.74	9.38	p<0.05
Area ericaceous (ha)	0.09	0.11	p>0.1
Percent ericaceous	2.60	3.10	p>0.1
Area alder/willow (ha)	0.26	0.09	p=0.006
Percent alder/willow	14.13	6.83	p<0.001
Area flooded timber (ha)	0.09	0.01	p<0.001
Percent flooded timber	5.18	0.34	p<0.001

Table 1.6. Mean values for habitat variables and differences (Mann-Whitney) between used and unused sites by black duck broods in a 750 km^2 watershed in Antigonish Co., Nova Scotia, May 1990 and 1991.

Habitat variable	Used	Unused	Level of Significance
Surface area (ha)	7.21	2.11	p<0.001
Perimeter (m)	1233.02	421.45	p<0.001
Dwelling distance (m)	370.69	272.31	p<0.01
Road distance (m)	335.41	239.89	p>0.9
Area open water (ha)	3.03	1.45	p<0.001
Percent open water (%)	38.30	65.01	p<0.001
Area persistent veg. (ha)	1.24	0.19	p<0.001
Percent pers. veg. (%)	17.11	11.20	p<0.01
Area ericaceous veg. (ha)	0.06	0.11	p<0.05
Percent ericaceous veg.(%)	2.24	5.21	p<0.05
Area alder/willow (ha)	0.44	0.09	p<0.001
Percent alder/willow (%)	21.60	7.63	p<0.001
Decid. shrub density (%)	71.38	34.91	p<0.001
Area flooded timber (ha)	0.18	0.02	p<0.001
Percent flooded timber(%)	8.82	1.22	p<0.001
Area herbaceous veg. (ha)	3.69	0.26	p<0.001
Percent herb. veg. (%)	24.22	15.82	p<0.01
Herb. veg. density (%)	58.73	48.56	p>0.1
Area floating veg. (ha)	0.21	0.05	p>0.05
Percent flaoting veg.(%)	6.52	7.83	p>0.1
Number life forms	2.70	1.68	p<0.001
Number life form patches	5.32	2.60	p<0.001
pH	6.90	7.00	p>0.3
Specific conductivity	549.65	261.55	p>0.05
Dissolved nitrogen (mg/L)	0.98	0.57	p<0.01
Diss. phosphorus (mg/L)	0.13	0.12	p>0.2
Invert. dry weight(mg)	240.25	103.71	p<0.001

Table 1.7. Independent habitat variables identified by stepwise discriminant analysis predicting site use by black duck pairs in a 750 km^2 watershed in Antigonish Co., Nova Scotia.

Predictor variable	Stand. coefficient	Probability
Dist. to brood site	-0.53	p<0.001

Table 1.8. Independent habitat variables identified by stepwise discriminant analysis predicting site use by black duck broods in a 750 km^2 watershed in Antigonish Co., Nova Scotia.

Predictor variable	Stand. coefficient	Probability
Perimeter	0.376	p<0.001
Invert. dry weight	0.364	p<0.01
Area alder/willow	0.264	p<0.01
Percent flooded timber	0.229	p<0.01

Figure 1.1. Relative surface areas and the number of sites of different wetland habitat types in Antigonish Co., Nova Scotia (EE= Estuarine Emergent, LUB= Lacustrine Unconsolidated Bottom, PE= Palustrine Emergent, PSS= Palustrine Scrub-Shrub, PUB= Palustrine Unconsolidated Bottom).

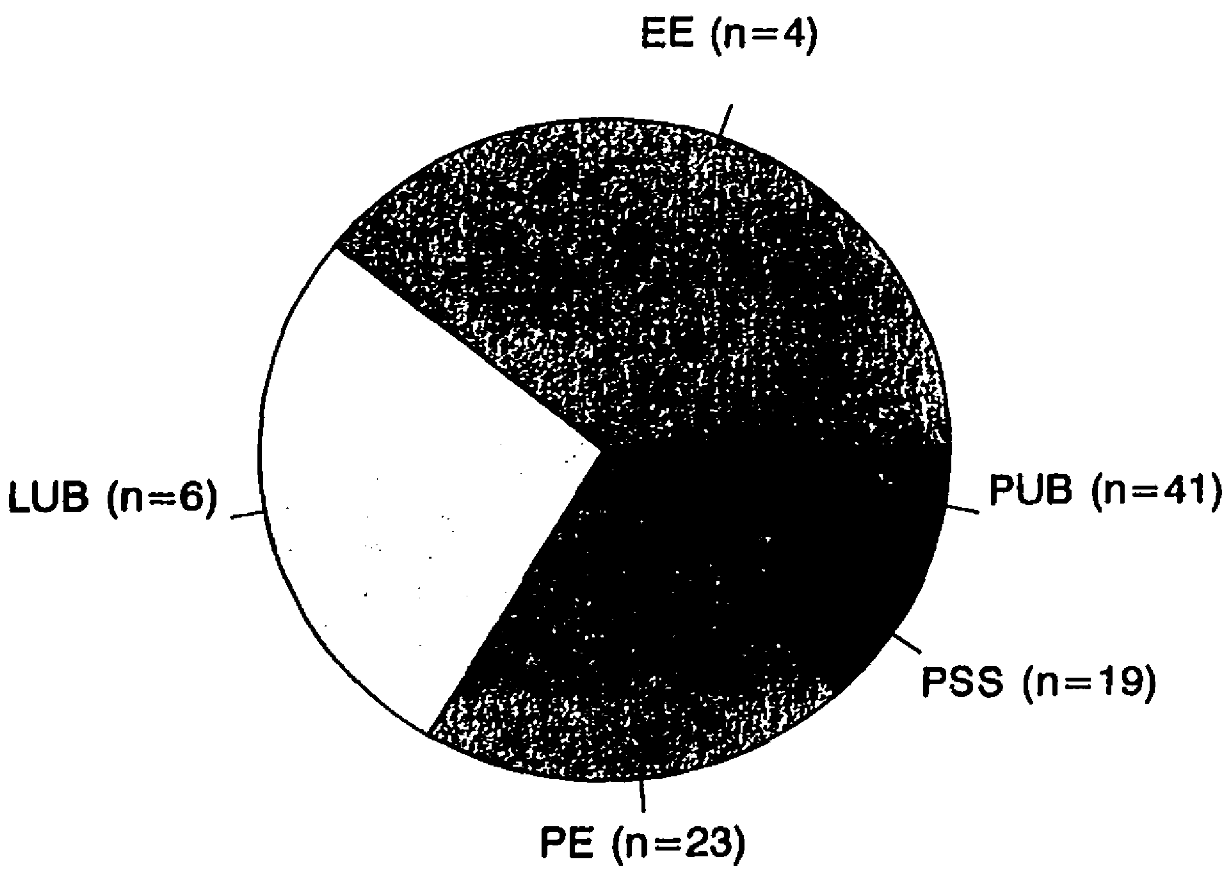
EE (n=4)
PUB (n=41)
PSS (n=19)
PE (n=23)
LUB (n=6)

Figure 1.2. Density of black duck pairs and broods in the different habitat types in Antigonish Co., Nova Scotia, 1990-91. (EE=Estuarine Emergent, LUB= Lacustrine Unconsolidated Bottom, PE= Palustrine Emergent, PSS= Palustrine Scrub-Shrub, PUB= Palustrine Unconsolidated Bottom).

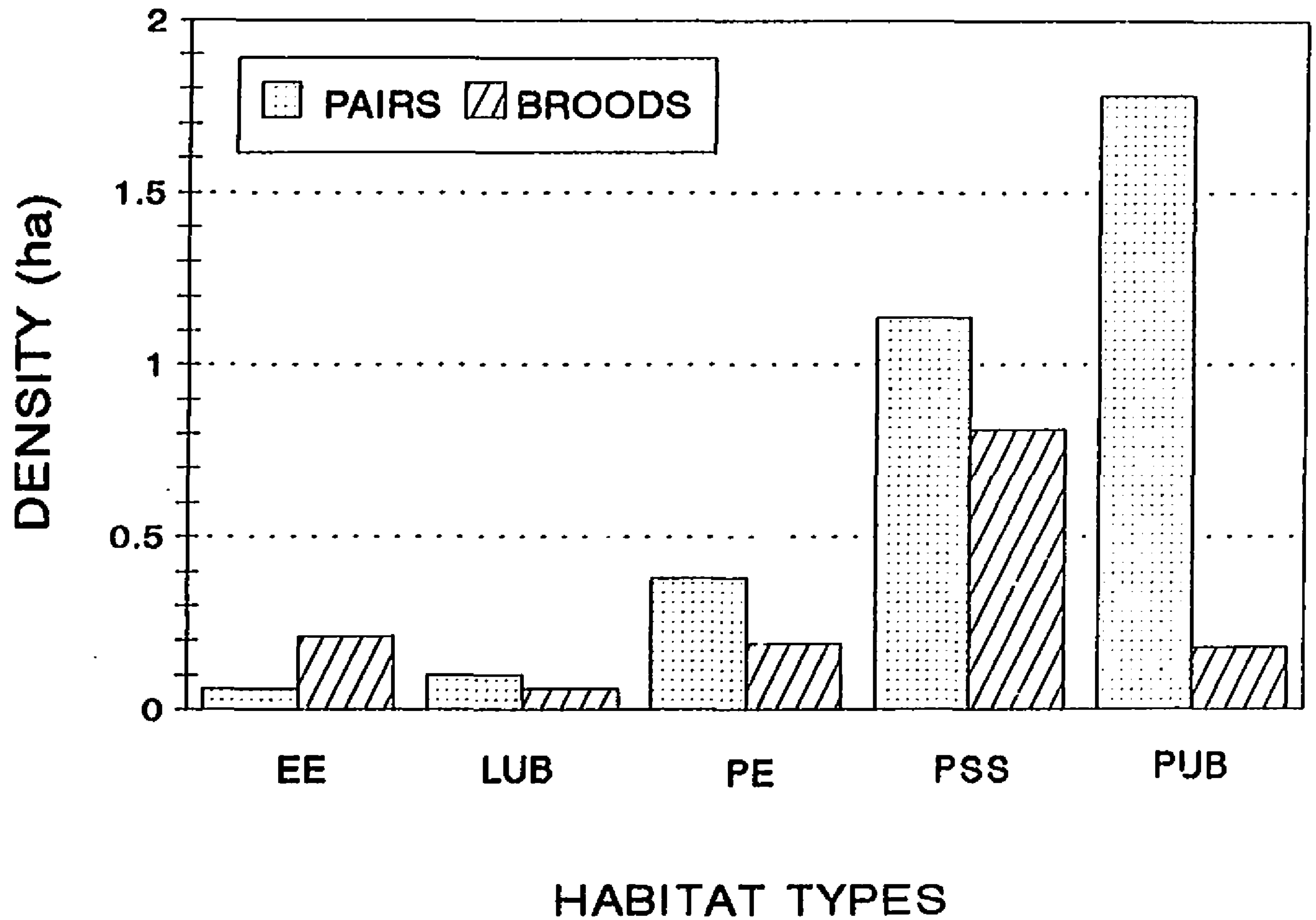

Fig.1.2 Density of pairs and broods in the different habitat types in Antigonish Co., Nova Scotia, 1990-91 (EE=Estuarine emergent, LUB=Lacustrine unconsolidated bottom, PE=Palustrine emergent, PSS=Palustrine scrub-shrub, PUB=Palustrine unconsolidated bottom).

Connecting statement

In the first section, the habitat preferences of black duck pairs and broods was studied. The cues black duck pairs and broods use in the selection of a site was also examined. In the following section, I studied the survival of black duck ducklings in different habitat types to determine if black duck productivity was influenced by wetland habitat type. I examined survival in the different habitat types and I compared duckling survival on sites with single broods with survival on sites with multiple broods.

Section II. The influence of wetland selection by brood-rearing females on black duck survival in different habitat types.

ABSTRACT

Survival rates of black duck duckling survival rates were used as an index of productivity in four different wetland habitat types in Antigonish Co., Nova Scotia in 1990 and 1991. The daily survival rate (DSR)(0.9829) of young ducklings (Class Ia-IIa) in the Palustrine Scrub-Shrub habitat type was greater than the DSR for ducklings using Estuarine Emergent (0.9600) and Unconsolidated Bottom (0.9579) habitats but not greater than ducklings using the Palustrine Emergent habitat (0.9760). Daily survival rates did not differ significantly ($p>0.05$) among habitat types for Class IIb-III ducklings. In all habitat types older ducklings (Class IIb-III) survived at greater rates than younger ducklings (Class Ia-IIa). The probability of a duckling surviving the entire brood-rearing period was highest in the Palustrine Scrub-Shrub habitat type (o.4682), which was the preferred brood-rearing habitat type in the study area. Deciduous shrub habitat, which was selected by broods, is the most important habitat type in the Antigonish study area.

Class Ia-IIa ducklings belonging to broods occupying sites with other broods survived at lower rates (0.9605) and survival probability (0.4267) than ducklings belonging to broods occupying isolated, dispersed sites (0.9765, 0.5231). No differences for grouped or isolated broods in either daily survival rate or survival probability were detected for Class IIa-III ducklings. Sites supporting many young

broods may attract not only breeding pairs, but also predators, creating a "sink" where predators can reduce black duck production. Black ducks that are able to discriminate between wetland habitats may be able to gain reproductive advantage by choosing rearing ponds that fulfil duckling requirements.

INTRODUCTION

If habitat selection is an adaptive behaviour then individuals should select habitat that enhances reproductive success (Partridge 1978, Orians and Wittenberger 1991). The availability of good rearing habitats becomes increasingly important for black ducks, especially as quality wetlands become more scarce across eastern Canada. In the past, researchers have commented most on the role of nesting habitat types in the breeding success of black ducks (Stotts and Davis 1960, Coulter and Mendall 1968, Coulter and Miller 1968, Reed 1975). Although good nesting cover is essential for breeding success, attributes of brood-rearing sites are thought to directly affect the survival of the brood (Sedinger 1992). Missing from the current data base on black duck habitat selection is the importance of the quality and type of brood-rearing habitat and its capability to support optimal numbers of ducklings from hatching to fledging.

We determined whether black duck survival is influenced by brood-rearing habitat type. I predicted that duckling survival would vary with brood-rearing habitat type and that survival would be greater in preferred habitats than in other habitat types.

STUDY AREA

The study area was the same as that described in Section I.

METHODS

Survival rates of black duck ducklings, in contrast to the number of ducklings in age-class III broods, were used as an index of productivity because this method reduces the chances of overestimating production by incorporating total brood loss into the calculation (Ringelman and Longcore 1982).

To determine survival rates of ducklings, intensive observation of black duck broods on ponds in each habitat type was conducted from the last week in May to the end of August 1990 and 1991. Efforts were made to follow marked broods, however, females colour-marked on the tidal marsh in early spring evidently left the study area to breed elsewhere. Instead, the unique combination of age-class and number of ducklings per brood permitted the identification of individual broods (Ringelman and Flake 1980). Broods observed on the tidal marsh occupied exclusive, specific bays and inlets of the marsh (N. Seymour, unpubl. data). This behavioural trait helped to prevent further confusion with identification.

Broods used in the survival analysis were only those where observations began with the Class Ia (1-7 days of age) development stage (Gollop and Marshall 1954) and continued to Class III (43-55 days of age). Observation effort was intensified at the beginning of the brood-rearing period so that entire brood losses could be noted. Omitting total brood losses from brood survival probability calculations results in overestimation of black duck productivity (Reed 1975, Ringelman and Longcore 1982). Although it is possible that entire brood mortality occurred on brood sites, survival estimates in habitats within the study area were low compared to results reported in the literature suggesting that survival estimates obtained in this study are at least conservative.

Survival data were divided into two age-class intervals, Class Ia-IIa (1-27 days of age) and Class IIb-III (28-55 days of age) (Ringelman and Longcore 1982). Only broods sighted at least twice in each composite age class interval were used to calculate survival rate.

All sites observed with a brood were revisited every 6-12 days, however, multi-brood sites were visited approximately every 4-6 days (ie. tidal marsh). Brood observations began one half-hour before sunrise and 3.5 hours before sunset. Observation periods lasted until the brood was sighted, counted and aged according to Gollop and Marshall (1954).

A separate analysis compared survival of broods on isolated sites and broods that were on the same site (referred to as grouped broods). A large proportion of black ducks breeding in the study area used the tidal marsh and an inland emergent marsh as rearing wetlands, which served as the sites for the grouped broods. Isolated broods were single broods encountered on dispersed sites on any habitat type.

Duckling daily survival rates were calculated using the Mayfield method (1961, 1975) that was modified by Johnson (1979) and Ringelman and Longcore (1982b). This method estimates duckling survival only for the period during which the brood is observed. This permits direct comparison of the survival rates of ducklings in different broods from different habitat types. The length of time between observations, which reflected the risk to the duckling, was termed exposure and was measured in duckling days. A reduction in brood size on subsequent visits to rearing sites was assumed to indicate duckling mortality.

Survival probability or period survival rate (PSR), which was calculated as the daily survival rate over the observation period, was found separately for Class Ia-IIa and Class IIb-III ducklings. Overall PSR (Class Ia-IIa) was also calculated. The calculation was performed by multiplying the survival probability of Class Ia-IIa ducklings by the survival probability of Class IIb-III ducklings because younger ducklings experienced lower survival than older ducklings (Ringelman and Longcore 1982). This method results in a lower overall PSR than the PSR's for the intervals.

RESULTS

A total of 36 black duck broods was observed on 4 different habitat types in the study area in 1990 and 1991. Because the number of broods observed in the Lacustrine Unconsolidated Bottom and the Palustrine Unconsolidated Bottom habitat types were inadequate for statistical analysis, data for these two types were combined and a new habitat type, Unconsolidated Bottom (sites with <30% vegetation coverage) was formed.

Daily interval survival rates and overall daily survival rates in each habitat type were not different between 1990 and 1991 (Mann-Whitney U test, $p>0.3$) so data for both years were combined. In all habitat types the daily survival rate for younger ducklings (Class Ia-IIa) was lower than that for older ducklings (Class IIb-III) ($p<0.05$,) .

Differences in daily survival rates among the four habitat types were found to be significant for Class Ia-IIa ducklings (ANOVA, $p<0.01$) but not Class IIb-III ducklings ($p>0.6$) (Table 2.1). Overall daily survival rates calculated for ducklings from Class Ia to Class III also did not differ from one habitat to the other ($p>0.4$). The daily survival rate for younger ducklings in the Palustrine Scrub-Shrub habitat type was greater than the survival rate in Estuarine Emergent and Unconsolidated Bottom habitat types ($p<0.01$) but not for the survival rate for ducklings occupying the Palustrine Emergent habitat type ($p>0.7$).

The period survival rate (PSR) for the brood-rearing period over both years in all habitats throughout the study area was 0.343. Considering survival probability within the habitat types, Palustrine Scrub-Shrub yielded the highest overall survival probability (0.4682), followed by Palustrine Emergent (0.3682), Estuarine Emergent (0.2015) and Unconsolidated Bottom habitat type (0.180) (Figure 2.1).

In all habitat types, older Class IIb-III ducklings had a greater survival rate (0.680) than Class Ia-IIa ducklings (0.491, $p<0.01$). The highest survival for older ducklings was in the Palustrine Scrub-Shrub rearing sites (0.7590), although ducklings in the Estuarine Emergent (0.6893), Palustrine Emergent (0.7110) and Unconsolidated Bottom (0.6586) had similar chances of survival ($p>0.3$). Younger ducklings reared on Palustrine Scrub-Shrub wetlands had the highest chances of survival (0.6076) which were much greater than for ducklings reared on Estuarine Emergent sites (0.332) and Unconsolidated Bottom sites (0.318, $0.1<p<0.05$).

Survival rates were compared for isolated broods (1 brood/site) and wetlands with multiple broods (>1 brood/site) (Table 2.2). Class IIb-III daily survival rate and overall daily survival rates of ducklings did not differ between broods that were isolated and on a wetland and those that were grouped (t-test, $p>0.4$). Class Ia-IIa broods, however, had a daily survival rate of 0.9765 on isolated wetlands which was slightly greater (0.9600) than for broods on a multi-brood rearing site ($0.1<p<0.05$).

The overall survival probability of a duckling reared on an isolated wetland was estimated to be 36% whereas that of a duckling raised on a site with more than one brood was estimated at 32%. Younger ducklings had a higher overall chance of survival on isolated sites (52%) than at grouped sites (43%) ($0.1<p<0.05$) but for older ducklings survival on isolated sites (68%) was lower than on a grouped site (69%) (Figure 2.2).

DISCUSSION

Duckling survival in different habitat types- Survival of black duck duckling seems influenced by wetland habitat type, but only for younger ducklings. Young ducklings (ClassIa-II) with the highest survival were reared on deciduous, shrub ponds (Palustrine Scrub-Shrub), which were preferred breeding habitat of black ducks in my study area. Habitat variables that influence food and cover affect duckling survival through effects on growth and exposure to predators and may cause black ducks to select brood-rearing habitat that will ensure adequate foods and cover.

Survival of young ducklings (Class Ia-IIa) was most favourable in the Palustrine Scrub-Shrub habitat type because of its abundance of aquatic invertebrates associated with accompanying patches of herbaceous vegetation and its dense horizontal and vertical cover provided by alder (*Alnus*) and willow (*Salix*). According to Parker et. al. (1992) the availability of invertebrates is the most important variable in black duck brood site selection and may thus be the most influential resource affecting duckling survival. Quality, high protein foods are particularly important to younger ducklings, which are vulnerable to exposure and have the highest mortality during the first weeks of life (Ball et al. 1975, Talent et al. 1983, Orthemeyer and Ball 1990, Savard et al. 1991). McAuley and Longcore (1988) reported that the survival of young ring-necked ducks (*Aythya collaris*) was dependant on the abundance of invertebrates.

The presence of escape cover is also important to young broods. From hatching to 14 days of life, ducklings are particularly susceptible to predation and inclement weather (Sedinger 1992). Survival did not differ among habitat types for older ducklings probably because resources found on preferred habitat such as invertebrates and dense cover are not as critical for the older, less vulnerable Class IIb-III ducklings. For example, older ducklings also supplement their diet with increasing amounts of vegetable matter (Reinecke 1979), which is more accessible than aquatic invertebrates. Older ducklings also employ other predator escape methods such as flying or diving, rather than hiding in wetland vegetation, an anti-predator strategy used by many young ducklings (Savard et al. 1991).

Estimates of duckling survival examined on a habitat type basis show good agreement with data reported from studies on specific habitat types in other geographic regions. The overall duckling survival for ducklings reared on Palustrine Scrub-Shrub habitat was 0.440, which is close to the 0.420 survival estimate found in similar deciduous shrub habitat in Maine (Ringelman and Longcore 1982). Reed (1975) reported duckling survival in estuarine habitat to be as low as 0.340% which is comparable to 0.320 found in the Estuarine Emergent habitat type in Antigonish Co.

Duckling survival in isolated and grouped broods- Class Ia-IIa ducklings on isolated ponds had a higher survival probability than broods grouped on the same wetland. Savard et al. (1991) also reported that Barrow's goldeneye (*Bucephala islandica*) and bufflehead (*B. albeola*) duckling survival was higher on ponds with single broods than on ponds with several broods implying density-dependent mortality. Sites supporting more than one brood may attract large numbers of predators such as bald eagles (*Haliaeetus leucocephalus*), gulls (*Laridae*) and mink (*Mustela vison*) which prey on young ducklings. Maclean (1988) reported that bald eagles, which gather in groups of up to twenty on the Antigonish tidal marsh during brood-rearing, preyed on black duck ducklings. Sites with grouped broods may act as predator "sinks" where mortality may eventually exceed productivity in years of heavy predator pressure (Pulliam and Danielson 1991). Increased predation on an annual basis could eventually seriously curtail black duck recruitment even on wetlands with good food and cover.

Management implications- The aims of black duck habitat management should include the conservation of Palustrine Scrub-Shrub wetlands for brood-rearing. Black duck recruitment is highest on deciduous shrub wetlands, which should be maintained by proper beaver population management.

Large impoundments should be discouraged in black duck habitat management because these may not only concentrate broods but they could also become favourite foraging grounds for predators. Likewise, hunting pressure may also be increased by concentrating broods where ducklings may not have had a chance to leave their natal pond before the start of the hunting season. Local black duck population numbers may be enhanced by maintaining large numbers of isolated beaver ponds in forested regions of the northeast.

CONCLUSION

Black duck survival varied with habitat type, where the greatest survival of ducklings were on preferred shrub-dominated habitat of Palustrine Scrub-Shrub. The availability of an abundance of aquatic invertebrates and dense concealing cover probably contributed to the high duckling survival found in Palustrine Scrub-Shrub habitat. Survival was slightly higher on isolated ponds compared to ponds with more than one brood. Predator density may increase with the number of broods present on the pond as predators try to increase their catch per effort by foraging on sites with more potential prey. The most productive and therefore important black duck rearing habitat is that which was preferred by black ducks, isolated deciduous shrub ponds. Black ducks are able to increase their reproductive success by making specific choices about where to breed instead of occupying habitat randomly.

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Table 2.1. Number of black duck broods, losses, interval survival rates and overall survival rates in different habitat types in Antigonish Co., Nova Scotia, 1990-91.

		Class Ia-IIa[1]			Class IIb-III[1]			
Habitat type[2]	No. broods	Total exposure (duck.days)	Total losses[3]	Interval survival rate	Total exposure (duck.days)	Total losses	Interval survival rate	Overall survival rate
E.E	13	1149	46	0.3329	835	11	0.6893	0.2288
U.B	5	428	18	0.3130	338	5	0.6586	0.2061
P.E	7	667	16	0.5180	580	7	0.7110	0.3682
P.S.S	11	1283	22	0.6276	1126	11	0.7590	0.4763

[1] brood age-class system according to Gollop and Marshall (1954).
[2] E.E= Estuarine emergent, U.B= Unconsolidated bottom (wetlands with <30% coverage), P.E= Palustrine emergent, P.SS= Palustrine scrub-shrub.
[3] total number of ducklings lost.

Table 2.2. Number of black duck broods, exposure, losses, interval survival rates and overall survival rates of ducklings belonging to isolated and grouped broods in Antigonish Co., Nova Scotia, 1990-91.

Habitat type[2]	No. broods	Class Ia-IIa[1] Total exposure (duck.days)	Total losses[3]	Interval survival rate	Class IIb-III[1] Total exposure (duck.days)	Total losses	Interval survival rate	Overall survival rate
Grouped	13	1149	46	0.3321	835	11	0.7091	0.2355[c]
Isolated	23	2378	56	0.5262	1314	23	0.6100	0.3220[c]

[1] brood age-class system according to Gollop and Marshall (1954).
[2] Grouped= >1 brood per site, isolated= 1 brood per site.
[3] total number of ducklings lost.

Figure 2.1. Percent overall survival and percent survival of Class Ia-IIa and Class IIb-III black duck ducklings in four habitat types in Antigonish Co., Nova Scotia, 1990-91 (EE=Estuarine Emergent, UB= Unconsolidated Bottom, PE= Palustrine Emergent, PSS= Palustrine Scrub-Shrub).

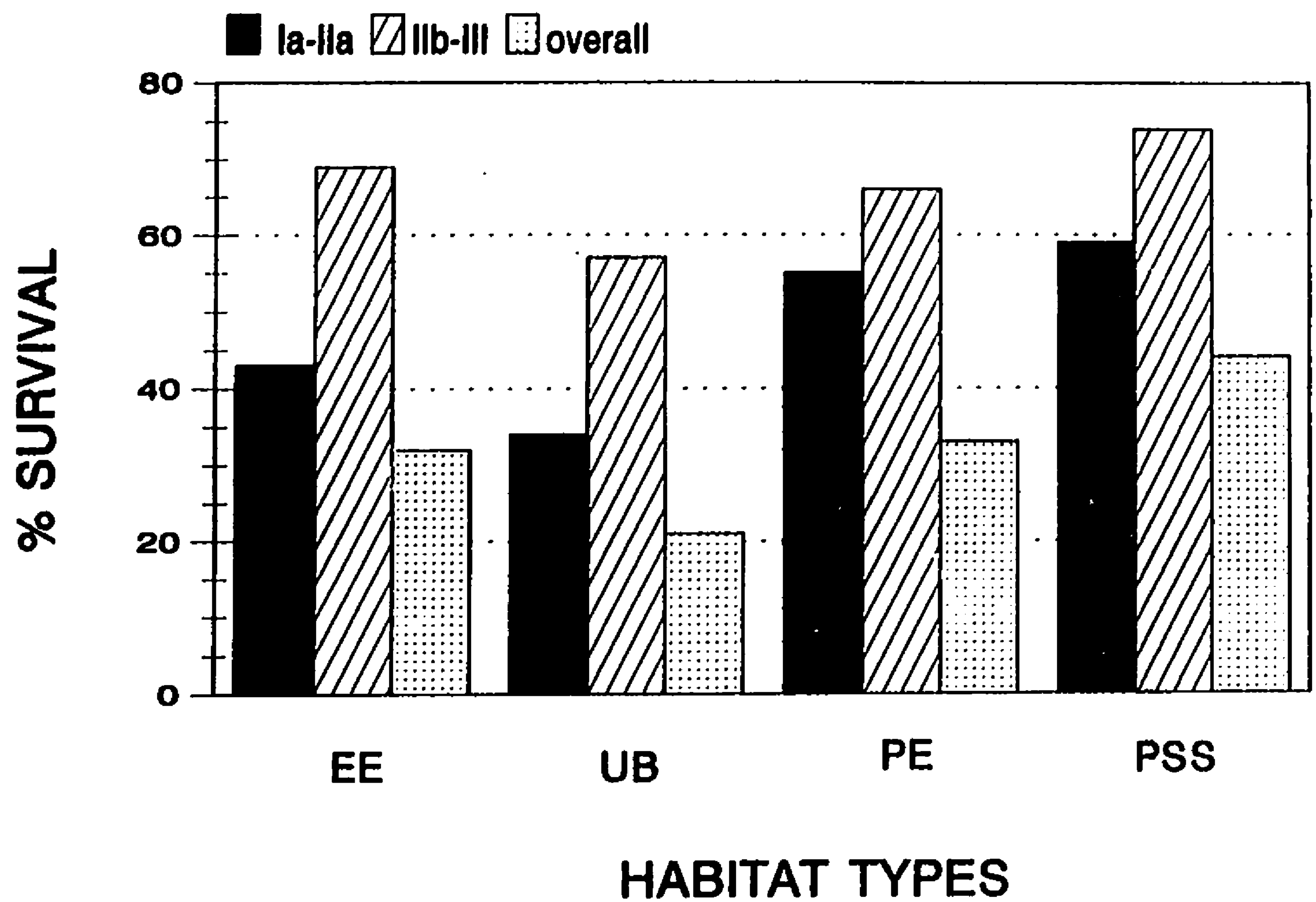
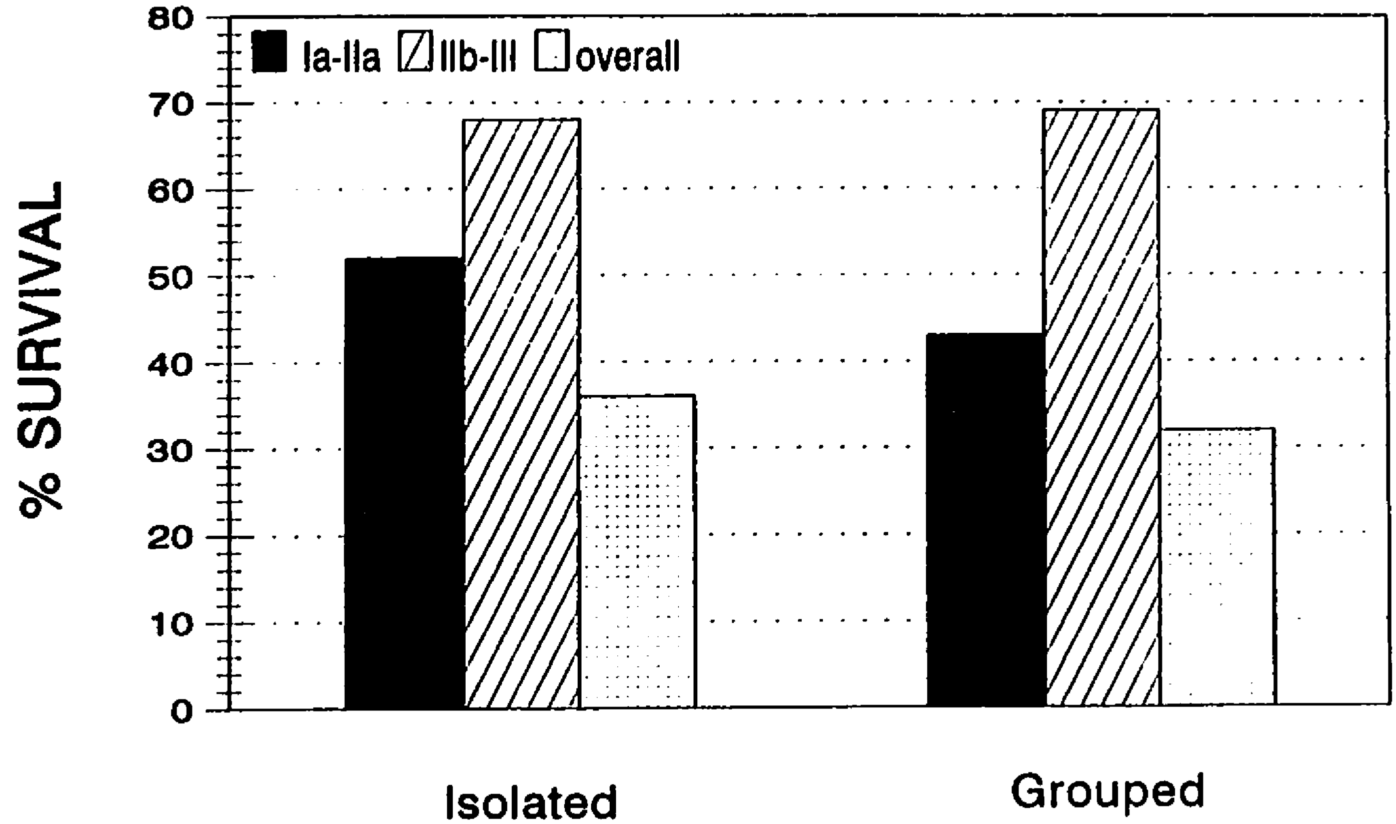

Ia-IIa
IIb-III
overall
80
60
40
20
0
% SURVIVAL
EE
UB
PE
PSS
HABITAT TYPES

Figure 2.2. Percent overall survival and percent survival of Class Ia-IIa and Class IIb-III black duck ducklings belonging to isolated and grouped broods in Antigonish Co., Nova Scotia, 1990-1991.


% SURVIVAL
80
70
60
50
40
30
20
10
0
Ia-IIa
IIb-III
overall
Isolated
Grouped

GENERAL CONCLUSION

Breeding black ducks are not distributed randomly throughout northeastern Nova Scotia but preferred certain types of habitat for the courtship and brood-rearing phases of the breeding cycle. By discriminating among different habitat types black ducks use habitat types that offer a relative abundance of critical food and cover and hence enhance reproductive fitness.

Quality brood-rearing areas probably serve as a primary attractant to pairs arriving on the breeding grounds. Females may choose ponds that serve as both courtship and rearing site, however, the need for isolation and uninterrupted feeding time may force a pair to seek a nearby isolated pond, regardless of the quality of food or cover.

Black duck females probably use the structure of the wetland vegetation landscape in the selection of a brood-rearing site. Flooded woody vegetation, often a result of beaver activity, seems to be an important cue in the selection of a brood-rearing site. Physical attributes of a wetland seem to play a role, whereby sites with long and variable shorelines, indicating good opportunities for foraging and hiding, are preferred.

Survival of black duck ducklings is influenced by habitat type, suggesting that habitat selection plays an adaptive role for breeding black ducks. Black ducks with the highest reproductive fitness occupy ponds that are isolated with a good coverage of overhead cover. This type of habitat needs to be preserved to ensure the continued survival of the black duck in the northeast.