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MODELLING THE SPATIAL AND TEMPORAL VARIATION IN DENSITY OF BREEDING BLACK DUCKS AT LANDSCAPE AND REGIONAL LEVELS

By

Alan R. Hanson

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ABSTRACT

This thesis examined the ability of landscape-level descriptors of habitat to explain the observed distribution of indicated breeding pairs (IBPs) of American Black Ducks (*Anas rubripes*) in the Canadian Maritime Provinces of New Brunswick and Nova Scotia. and whether these relationships could then be used to produce spatially explicit waterfowl population estimates. Models were also developed to explain trends in Black Duck IBPs during the period 1990-99.

These were landscape-level models with an extent of 125.000 km^2 and grain sizes of 25 km^2 and 100 km^2. Data were obtained from the Canadian Soil Information Survey. Maritime Wetlands Inventory. ecological land classifications. provincial soil surveys. digital elevation models and topographical maps. Data on the chemical limnology of surface waters in survey plots were obtained from over 1.000 water samples collected during 1996-98. and from Environment Canada databases.

Variation in chemical limnology due to survey plot location was orders of magnitude greater than variation due to aquatic habitat type. although both factors were significant. Chemical limnology of surface waters was correlated to soil chemistry and other landscape-level attributes. The nature and spatial scale of wetland data made ecological land classification and soil data minor components of models.

The best predictive model for Black Duck IBPs included eight variables and had R^2 = 0.88. Black Duck IBPs were positively associated with maximum Golet Score. total number of lakes. total area of salt marsh. total phosphorous concentration of surface waters. stream density. and total number of buildings. and negatively associated with standard deviation of elevation and total length of roads. The Golet Score is a measure of a wetland's wildlife habitat value for a broad diversity of species. A univariate model based solely on Golet Score had R^2= 0.78. Data from plots surveyed during 1986-89. confirmed the importance of Golet Score as a predictor of Black Duck IBP distribution.

Increasing Black Duck populations in survey plots during the period 1990-99 were related to increasing stream density, decreasing variation in elevation, and hypothetically, greater numbers of beaver ponds. Logistic regression models were also developed to predict the presence of breeding Ring-necked Ducks (*Aythya collaris*), Common Mergansers (*Mergus merganser*), and American Green-winged Teal (*Anas crecca carolinensis*) in survey plots.

Keywords:

American Black Duck / Common Merganser / Ring-necked Duck / American Green-winged Teal / Habitat Models / Landscape Ecology / Chemical Limnology / Wetlands / New Brunswick / Nova Scotia

Coauthorship Statement

Versions of chapters contained in this thesis may, in the future, be submitted in whole or in part for publication. Dr. C.D. Ankney and Dr. R. Bailey of the University of Western Ontario will be listed as coauthors on these future publications because of their involvement in this work as academic supervisors.

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CHAPTER 1 – A GENERAL INTRODUCTION

INTRODUCTION

This chapter provides an overall introduction to this thesis which examined the ability of landscape-level descriptors of habitat to explain the observed distribution of breeding American Black Ducks (*Anas rubripes*) in the Canadian Maritime Provinces of New Brunswick and Nova Scotia, and whether these relationships could then be used to produce spatially explicit waterfowl population estimates. This research also investigated relationships between wetland biophysical form, chemical limnology, and ecological function.

Landscape-level analyses of wildlife-habitat interrelationships are characterised by large spatial scale and treatment of habitat units as part of a larger landscape mosaic (Conroy 1993). Wetland biophysical form describes a wetland in terms of both physical form (*e.g.*, surface morphology, presence of patterns, location in landscape) and dominant vegetation (*e.g.*, sedges, sphagnum moss, deciduous trees, shrubs). The Maritime Wetland Inventory includes 34 different wetland biophysical forms, *e.g.*, sphagnum bog and shrub swamp (Hanson and Calkins 1996). The ecological functions of wetlands include their role in hydrological (Bedford 1996) and biogeochemical processes (Gorham *et al.* 1998) as well as provision of wildlife habitat (Golet 1978).

Thesis Outline

This thesis has been written in manuscript style with Chapter 2 to Chapter 5 being independent documents. Chapter 1 presents a general introduction and Chapter 6 presents an concluding discussion. The outline of the thesis is as follows:

Chapter 1 discusses the rationale for the study and a general introduction to habitat selection by American Black Ducks, hereafter simply referred to as Black Ducks, as well as introductory discussions of wetlands and landscape ecology. Subsequent chapters contain detailed introductions to the specific ecological processes being examined in that chapter.

Chapter 2 describes landscape-level data that were used in the models. This includes data from the Canadian Soil Information Survey (MacDonald and Valentine 1992), the Maritime Wetlands Inventory (Hanson and Calkins 1996), and provincial ecological land classifications (Davis and Browne 1996; Ecosystem-Classification-Working-Group 1996).

Chapter 3 presents information on the chemical limnology of surface waters. Over 1,000 water samples were collected from within survey plots, with additional data being obtained from Environment Canada databases.

Chapter 4 presents data collected during breeding waterfowl surveys conducted by the Canadian Wildlife Service during 1986-1999 (Bateman and Hicks 1995; Collins 1999; Erskine *et al.* 1990). The methodologies used and limitations of these data are discussed.

Chapter 5 describes models created to explain the number of indicated breeding pairs (IBPs) of Black Ducks in survey plots during various time periods and at various spatial scales. Models created to explain the number of IBPs of Ring-necked Ducks (*Aythya collaris*), Common Mergansers (*Mergus merganser*), and American Green-winged Teal (*Anas crecca carolinensis*) are discussed. Models to explain trends in local Black Duck populations are also presented.

Chapter 6 discusses the potential for developing spatially explicit models of Black Duck populations based on available data and distribution models developed during this research.

BACKGROUND

Distribution Of Breeding Black Ducks

Surveys of wintering waterfowl by the U.S. Fish and Wildlife Service have indicated a decline of 68% in the American Black Duck (*Anas rubripes*) during the period 1955-1998 (Conroy *et al.* 1999). This mid-winter inventory counts an estimated 20-33 % of the total population (Heusmann 1999). To assess the status of breeding Black Duck populations, helicopter surveys have been conducted in eastern Canada since 1986 by the Canadian Wildlife Service and its partners in the Black Duck Joint Venture (BDJV). This survey was designed to detect a 10% population change over a 5 year period with 90% power and 95% confidence by surveying 200 plots over the entire range of the Black Duck (Bateman and Hicks 1995). Prince Edward Island (PEI) is not part of the overall BDJV helicopter-based Black Duck survey program. Surveys of breeding pairs and broods of Black Ducks were initiated in PEI in 1983, with 2 pair counts and 2 brood counts done by ground observation on approximately 75 wetlands. The very different nature of survey data precluded incorporating PEI into this study.

Black Duck indicated breeding pair (IBP) densities vary substantially among survey plots located throughout New Brunswick and Nova Scotia (Figure 1.1). In 1990 there were 0 to 37 IBPs per 100 km^2 (Bateman and Hicks 1995). The reason for variation in Black Duck densities among BDJV plots has never been determined. The magnitude of this variation raises many questions with respect to habitat selection by Black Ducks, and wetland function across the region. From the perspective of managing waterfowl populations, it suggests that spatially dependent models are required (Cowardin *et al.* 1995).

In recent years, many studies have quantified habitat use by breeding Black Ducks in eastern North America (Bowes and Kehoe 1994; Diefenbach *et al.* 1996; Diefenbach and Owen 1989; Hughson 1971; Lewis and Garrison 1983; Parker *et al.* 1992; Petrie 1998; Pollard *et al.* 2000; Ringelman *et al.* 1982; Seymour and Jackson 1996; Staicer *et al.*

1994). These studies have shown that, depending on the methods and location of the study, certain habitat characteristics are correlated with pair densities and reproductive success. These studies have, however, been spatially restricted and examined third and fourth order habitat selection, *i.e.* meso- or micro- scale, (Johnson 1980). A quantitative comparison of findings among studies is difficult because of different variables measured and different environmental conditions present. However, in a qualitative sense, common to all these studies was an increasing likelihood of Black Ducks using a specific wetland with increasing primary productivity and amount of emergent vegetation. The extrapolation of these studies to larger spatial scales is not practical because of the site specific and detailed nature of the data. The development of spatially explicit population models is often limited by the expense required to develop the database (Conroy *et al.* 1999; Rempel *et al.* 1997; Turner *et al.* 1995). The existence of the BDJV Survey and the Maritime Wetland Inventory affords a unique opportunity to examine habitat use by breeding Black Ducks at a landscape-level, *i.e.*, first and second order habitat selection, *sensu* Johnson (1980). An analysis of the distribution of breeding Black Ducks at several spatial scales will also address questions related to the spatial scale at which habitat selection may occur.

Mallards in Ontario, and Black Ducks in Nova Scotia, use highly productive wetlands in terms of nutrients, alkalinity, and conductivity (Merendino and Ankney 1994; Staicer *et al.* 1994). No differences have been documented in the types of habitats used by Black Ducks and Mallards in New Brunswick's upper Saint John River Valley (Petrie 1998). In eastern North America, Mallards use forested wetlands and beaver ponds, typically considered to be the exclusive domain of the Black Duck. In northern New York, there were no statistical differences in the types of habitats used by sympatric Black Ducks and Mallards, although there was a trend for Mallards to use more productive habitats (Dwyer and Baldassarre 1994; Losito and Baldassarre 1995). In Ontario, Mallards used the most productive wetlands, presumably because they have displaced Black Ducks from these habitats (Merendino *et al.* 1995). Mallards are absent from most of the waterfowl survey plots in New Brunswick and Nova Scotia. A component of this research was, therefore, to evaluate at a landscape-level, the conclusion that Black Duck's do not use the most productive habitats in Ontario due to the presence of Mallards (Merendino *et al.* 1993) and whether any specific habitat type can be managed to benefit breeding Black Ducks without the same benefits being accrued to breeding Mallards (Kirby 1988; Merendino *et al.* 1993).

Other waterfowl species are recorded during BDJV surveys, *e.g.*, Common Mergansers (*Mergus merganser*), Ring-necked Ducks (*Aythya collaris*), and American Green-winged Teal (*Anas crecca carolinensis*). The distribution of IBPs of these species will also be examined in relation to landscape-level habitat conditions.

Waterfowl Population Models

BDJV Surveys were designed to detection Black Duck population trends. In western North America, the Waterfowl Breeding Population and Habitat Survey has been conducted annually since 1955 (Baldassarre and Bolen 1994). This survey is conducted in May and covers 3.5 million km^2. Waterfowl and wetlands are counted from fixed wing aircraft along transects 0.40 km wide and up to 241 km long. A subsequent survey in July records number, age and size of duck broods, number of pairs still present and number of ponds remaining. The landscape-level waterfowl population and habitat data obtained from these two surveys are combined to produce estimates of fall populations. Although these surveys are costly, they provide the data required to annually formulate hunting regulations and foster the development of adaptive harvest management (Johnson *et al.* 1996).

Waterfowl harvest regulations and management actions in Atlantic Canada are based on population trend data provided by BDJV surveys and the National Harvest Survey (Cooch *et al.* 1978). Previous estimates of waterfowl populations in Atlantic Canada were based on simple extrapolation of survey data to larger geographic units, *e.g.*, provinces (Erskine 1987). The ability to produce regional waterfowl population estimates based on survey data and spatially explicit population models would allow management actions to be formulated in relation to total population estimates and not just indices of trends (Turner *et al.* 1995). By controlling for variation due to differences in habitat among BDJV plots, the power to detect trends may be increased. The development of a Black Duck production model based on habitat-specific pair densities could be used as a basis for models to predict the impacts of habitat alteration (*e.g.*, acid rain, climate change, habitat destruction) on regional Black Duck populations or other wetland-dependent wildlife. The utility of data collected during surveys designed for trend analysis for producing spatially explicit population models was evaluated.

Wetland Conservation

The global impacts of stratospheric ozone depletion and climate change captured public attention in the 1990s. However, the most important component of global change is human land use (Vitousek 1994). Wetlands have been lost at a proportionally greater rate than most other land-cover types, for example, 65% of Atlantic Canada salt marshes and 70% of wetlands in southern Ontario have been destroyed (Rubec *et al.* 1988). Remote sensing and geographic information systems (GIS) have allowed visual and quantitative interpretations of land-cover types and cumulative impacts of land-use change (Sader *et al.* 1995). Inventories of wetlands have long been used as a basis for conservation strategies designed to protect critical wildlife habitat (Tiner 1990). Wetlands have been classified according to several different systems of varying complexity (Cowardin and Golet 1995; Zoltai 1988). However, to fully understand the ecological impact of wetland habitat degradation and destruction, relationships between wetland biophysical form and ecological functions, such as wildlife habitat, must be determined (Bedford 1996; Novitzki 1995).

Landscape Ecology

The recent development of landscape ecology as a scientific discipline has resulted in an increased awareness of the importance of the appropriate spatial scale for analysis of ecological processes. Although the terms 'landscape' and 'landscape-level' are commonly used in a variety of scientific disciplines, there is no one universally accepted definition.

A landscape has been described as a mosaic of local ecosystems or land uses over an area several kilometres wide (Forman 1995). A region, by contrast, describes a broad geographical area with a common macro-climate and sphere of human activity, typically hundreds of kilometres in spatial extent. Specific to this discussion, Forman (1995, page 24) cited the Maritimes, as an example of a region.

Ecologists, however, think that there are many appropriate ways to define landscape depending on the phenomenon under consideration. Landscape-level does not confer a specific size, rather it refers to the mosaic of patches relevant to the ecological process under consideration (McGarigal and Marks 1995). An ecological definition of landscape is a matrix of habitats whose identity, scale, and spatial organisation are determined by the individuals that exploit it (Knight and Morris 1996). From both a geographer's and ecologist's viewpoint, to apply a landscape perspective is to treat 'large' areas as entities with intrinsic properties (Milne 1993). With respect to this study, analysis of wetland habitat and waterfowl populations at the spatial scale of survey plots (25 - 100 km^2) could be considered a landscape-level evaluation, which when repeated throughout New Brunswick and Nova Scotia, could be considered a regional analysis.

Although many studies of habitat selection by waterfowl have been conducted, most have not examined the spatial relationships of wetland habitat availability but rather have been conducted on a per wetland basis (*e.g.*, Diefenbach *et al.* 1996; Hudgins 1988; Paquette and Ankney 1996). In these previous studies the number of waterfowl using a specific wetland is related to habitat characteristics of that specific wetland. This study will relate the number of waterfowl to habitat characteristics at 25 km^2 and 100 km^2 spatial scales.

A spatial analysis of data from survey plots will investigate the appropriateness of the BDJV survey design in eastern Canada. The biotic components of wetlands are a product of hydrology and chemical limnology, which in turn are influenced by geographical, geological, and climatic factors (Zoltai 1988). The spatial scale at which wetlands are affected by geographical, climatological, and geological factors will also be examined.

OBJECTIVES

The main objectives of this study are:

1) Determine if landscape-level descriptors of habitat can explain observed distribution of Black Duck indicated breeding pairs in survey plots in New Brunswick and Nova Scotia.

2) Examine distribution of breeding Black Duck pairs at multiple spatial scales and determine if the BDJV breeding pair survey is appropriately designed.

3) Determine if landscape-level descriptors of habitat can explain temporal trends in local Black Duck populations in New Brunswick and Nova Scotia.

4) Determine if landscape-level descriptors of habitat can explain the observed distribution of indicated breeding pairs of Ring-necked Ducks, Common Mergansers, and American Green-winged Teal in New Brunswick and Nova Scotia.

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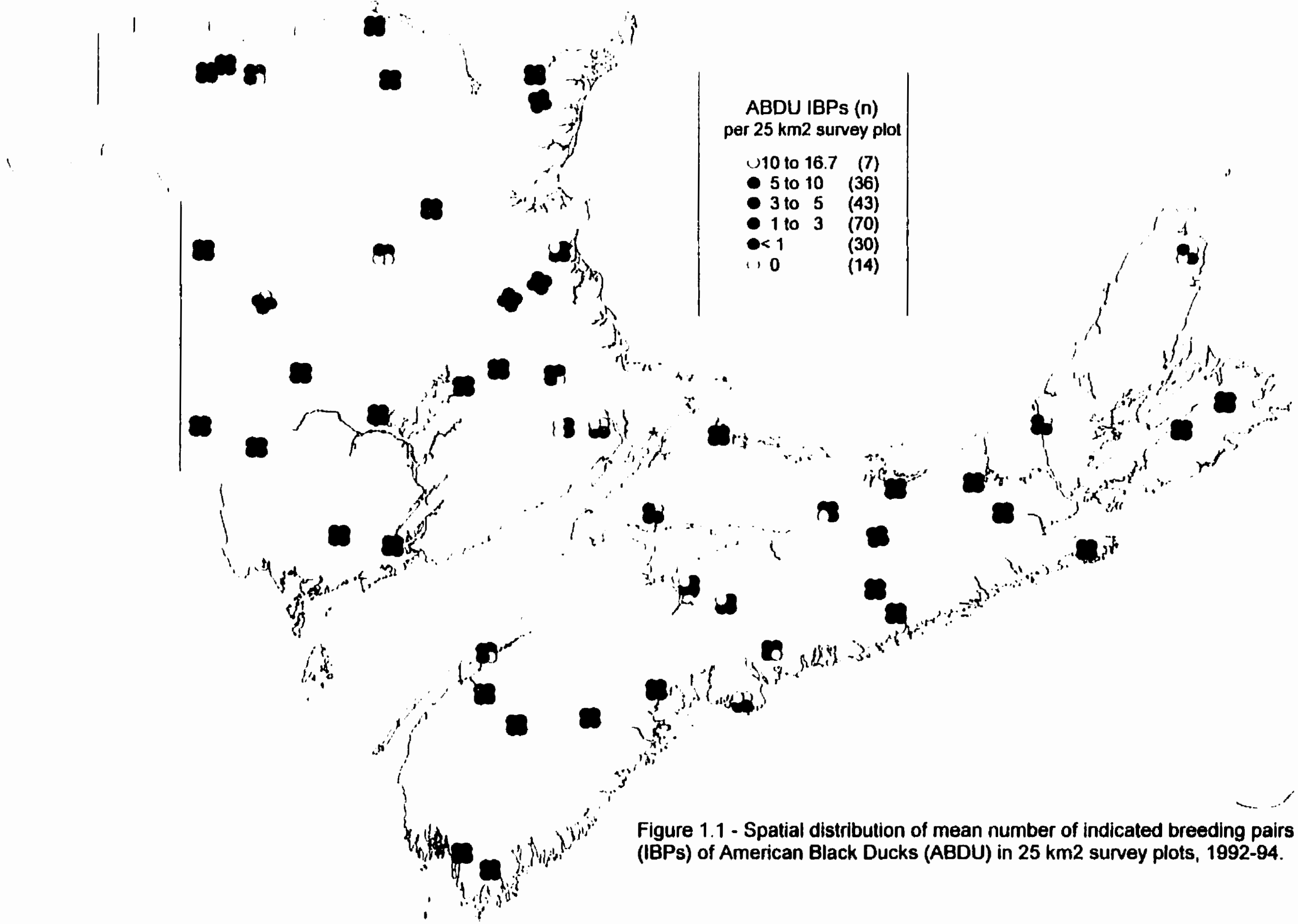

Figure 1.1 - Spatial distribution of mean number of indicated breeding pairs (IBPs) of American Black Ducks (ABDU) in 25 km2 survey plots, 1992-94.

CHAPTER 2 - A LANDSCAPE-LEVEL EVALUATION OF WETLAND HABITAT IN NEW BRUNSWICK AND NOVA SCOTIA

INTRODUCTION

This chapter presents information on landscape-level descriptors of wetland habitat that could potentially explain observed variation in the number of waterfowl observed in Black Duck Joint Venture (BDJV) survey plots in the Maritimes (Bateman and Hicks 1995. Erskine *et al.* 1990). The rationale for potentially including these variables in landscape level models of waterfowl distribution is discussed in Chapter 5 (Table 5.1).

Topographical mapping. landscape ecology and ecological land classification arise from a fundamental human need to reduce the complexity of the world into a pattern of homogenous blocks that can be readily understood. Although the inter-relatedness between land-related resources and life at large spatial scales has long been recognized. (*e.g.*, Gaia. Lovelock 1991). only recently has it developed into the discipline of scientific study known as landscape ecology (Forman 1990: Schreiber 1990: Zonneveld 1990). As human induced habitat change becomes global in occurrence and impact. an understanding of the dynamics of the biotic and abiotic components of ecosystems has become critical for managing land use and conserving biodiversity (Soulé 1986).

Concurrent with the emergence of landscape ecology (Forman 1995) and land-use studies (Rubec 1992: Rubec and Wiken 1983). wetland classification systems and inventories have been developed in Canada to conserve and manage wetland resources (Millar 1975: Warner and Rubec 1997: Zoltai and Vitt 1995). In the United States. similar efforts have been made to classify and inventory wetlands (Cowardin *et al.* 1979: Golet 1973: Golet and Larson 1974). In the United States. a national inventory program has been quite successful (http://mac.usgs.gov/mac/isb/pubs/factsheets/fs08099.html). In Canada. complete national coverage is lacking. Inventories have been conducted at provincial. or smaller scales (Cowell *et al.* 1995: Hanson and Calkins 1996: Ward *et al.* 1992).

With the development of landscape ecology principles and geographic information systems (GIS), the goals of wetland inventory programs have expanded. In Atlantic Canada, provincial governments are concurrently updating wetland inventories and forest inventories using the same images. Wetland inventories are now just one component of provincial land-use databases.

In order to understand wetland ecosystems, data on specific wetlands have to be merged with landscape-level hydrological, geographical, climatological, and geological data. Although the term landscape and landscape-level is used commonly in a variety of scientific disciplines, there is no one definition which all will agree to.

A landscape has been described as a mosaic of local ecosystems or land uses over an area several kilometres wide (Forman 1995). A region, by contrast, describes a broad geographical area with a common macro-climate and sphere of human activity, typically hundreds of kilometres in spatial extent. Specific to this discussion, Forman (1995, page 24) cited the Maritimes as an example of a region.

Ecologists think that there are many appropriate ways to define landscape depending on the phenomenon under consideration. Landscape-level does not confer a specific size, rather it refers to the mosaic of patches relevant to the ecological process under consideration (McGarigal and Marks 1995). An ecological definition of landscape is a matrix of habitats whose identity, scale, and spatial organisation are determined by the individuals that exploit it (Knight and Morris 1996). From both a geographer's and ecologist's viewpoint, to apply a landscape perspective is to treat large areas as entities with intrinsic properties (Milne 1993). With respect to this study, analysis of wetland habitat and waterfowl populations at the spatial scale of survey plots (25 - 100 km^2) would be considered a landscape level evaluation, which when repeated throughout New Brunswick and Nova Scotia, would be considered a regional analysis.

The desire to understand ecological processes at large spatial scales, and to determine what the appropriate spatial scale is for analysis, has led to the development of statistical procedures for spatial data (Isaaks and Srivastava 1989). Most natural ecological phenomena display spatial structure (Koenig and Knops 1998; Legendre 1993). Many statistical procedures common in ecological studies require samples to be independent. When samples are collected at different places or times, it is often the case that samples collected close to each other are more similar than those collected farther away or at a later time (Robertson 1987). This correlation has the effect of reducing the number of independent observations, and hence reduces the power of statistical tests (Brito *et al.* 1999). Assuming spatial dependence is more practical and realistic than assuming spatial independence (Rossi *et al.* 1992). The misapplication of simple statistical methods to spatial data may obscure more than it reveals. Past attempts to understand the importance of factors explaining ecological pattern may have in fact been only a ranking of these factors in order of their spatial autocorrelation strength (Lennon 2000).

The development of landscape ecology and geostatistical tools has allowed spatial autocorrelation to be thought of not as a statistical nuisance, but rather as a fundamental question about ecological phenomena (Isaaks and Srivastava 1989; Legendre 1993). Geostatistical tools that analyse autocorrelation were proposed early in the 20th century (Horne and Schneider 1995; Radeloff *et al.* 2000). Similar to the current discussion on the merits of null hypothesis testing (Cohen 1994; Johnson 1999), it should be stated that statistics can only corroborate or contradict ecological ideas; they cannot prove or disprove. Geostatistics are never a replacement for ecological reasoning (Cohen 1994; Rossi *et al.* 1992). Geostatistics are also not a replacement for traditional methods of exploratory data analysis such as univariate and bivariate summary data plots, Pearson product moment correlations, and simple tables of data (Rossi *et al.* 1992; Thomson *et al.* 1996). There are no true answers in geostatistics, only opportunity to gain more knowledge about the data and to improve one's models (Eastman 1999). The ultimate objective of work presented in this chapter is to summarise landscape-level descriptors of wetland habitat that may help explain the distribution of breeding waterfowl throughout New Brunswick and Nova Scotia.

METHODS

Black Duck Survey Plots

The geographic coordinates of the four corners of waterfowl survey plots were determined from 1: 50,000 National Topographic Series (NTS) maps on which the survey plot boundaries were drawn (Bateman and Hicks 1995, Erskine *et al.* 1990). The 10 km*10 km survey plot will hereafter be referred to as a PLOT. Within the PLOT, four 5 km*5 km quadrats were identified, which shall be referred to as PQUADs. For example, PQUADs 75A, 75B, 75C, 75D are the north-east, south-east, south-west, and north-west quadrats in PLOT 75, respectively. The geographic coordinates of PQUAD boundaries were also determined. Data were summarised for 100 km^2 PLOTs and 25 km^2 PQUADs for potential inclusion in landscape scale models of waterfowl distribution in the Maritimes.

Maritime Wetland Inventory

The Maritime Wetlands Inventory (Hanson and Calkins 1996) was initiated in 1981, prior to remote sensing, powerful personal computers, and geographical information systems utilised today. An ASCII file was originally created of all wetlands in New Brunswick and Nova Scotia greater than 0.25 ha, with custom BASICA programs to retrieve data. The location of each wetland was represented as a single point in the north-east corner of the wetland. The spatial extent and shape of the wetland was not represented digitally. The point data contained major systematic errors of omission in that the UTM zone and prefixes for the easting and northing (found at the corner of NTS maps) were not included in the database. Before being able to use the Maritime Wetlands Inventory (WI) as a geographic database, this information had to be added. This was done using algorithms based on the NTS Map and the easting and northing values that were in the database (Hanson and Calkins 1996).

Prior to using the WI database, the coordinates for wetlands were verified by mapping wetlands by county and also by watershed onto NTS 1: 500,000 digital maps using GIS software (SPANS 1999). Wetlands that were not within the proper county or watershed, were identified and their correct geographical coordinates determined by examining WI maps and 1: 50,000 NTS maps. Once the locational information in the wetland inventory database was verified, overlays onto polygons could be conducted (SPANS 1999).

Wetlands contained within survey plots were visually identified on the WI map sheets which allowed information attributed to individual wetlands to be summarised for survey plots. The boundaries of the waterfowl survey plots were drawn onto WI maps for New Brunswick and Nova Scotia (Hanson and Calkins 1996). Freshwater wetlands located within the survey plot were identified and information on these wetlands obtained from the WI database. This procedure was done visually using the WI maps because the point data format of the WI database could allow wetlands within the survey plot to be excluded if selection was done using GIS software. If greater than 30 % of the area of the wetland was within the survey plot, data for that wetland was included for the plot.

New Brunswick Soil Polygons

The New Brunswick Department of Natural Resources provided an overlay of WI wetlands (Hanson and Calkins 1996) onto provincial soil polygons, hereafter referred to as NB Polygons (Toner 1998). There are 9,934 different soil polygons in the province. These soil polygons range in size from 4.65 ha to 416 km^2, with mean size of 5.65 km^2. The overlay of wetlands onto NB Polygons resulted in approximately 1400 wetlands not being assigned to a polygon (Toner 1998). Many wetlands were not assigned NB Polygons because of their immediate proximity to large rivers, such as the Saint John River, or international boundaries (Toner 1998). Discrepancies between polygon boundaries and wetland location prevented assignment of a polygon in these cases. I assigned NB Polygons to these wetlands by examining the database and WI maps

Soil Landscapes of Canada

An overlay of WI wetlands onto Soil Landscapes of Canada polygons (SLC Version 2.2), hereafter referred to as SLC Polygons, was conducted (SPANS 1999). Wetlands that were not assigned a polygon were identified and WI maps and the database were consulted. Frequently wetlands were not assigned a polygon because the wetland's coordinates placed it slightly outside of the jurisdictional or coastline boundaries of New Brunswick in comparison to the polygons. In these situations, wetlands were assigned a soil landscape polygon based on their location on the WI map and the soil polygon that had been assigned to adjacent wetlands.

SLC Polygons are part of the Canadian Soil Information System (MacDonald and Valentine 1992) and are based on earlier mapping of Soil Landscapes of Canada (Anonymous 1989), which were recompiled at a scale of 1: 1 million. Within SLC Polygons there are 1 to 12 components. Location of components within SLC Polygons are not given. The first component covered, on average, 65% of the area covered by the SLC polygon. Each component had associated with it many categorical descriptors. A frequency distribution of categorical variables was summarised by PLOT and PQUAD using the percent area covered by the soil component as the weighting variable (PROC FREQ; SAS 1988). Each wetland therefore had 100 observations for each categorical variable. The value of this categorical variable could all be the same for the wetland or a combination of the various categories for that variable.

For example, Soil polygon 20183 is comprised of 3 components:

Component 1 covers 50% of the polygon area, and has a value of 'A' for vegetation.
Component 2 covers 25% of the polygon area, and has a value of 'B' for vegetation.
Component 3 covers 25% of the polygon area, and has a value of 'C' for vegetation.
A wetland in this soil polygon is assigned 50 observations for the value 'A', 25 observations for value 'B', and 25 observations for value 'C'.

Another example would be if Soil polygon 20184 is comprised of 4 components:

Component 1 covers 41% of the polygon area, and has a value of 'A' for vegetation.
Component 2 covers 27% of the polygon area, and has a value of 'A' for vegetation.
Component 3 covers 21% of the polygon area, and has a value of 'A' for vegetation.
Component 4 covers 11% of the polygon area, and has a value of 'A' for vegetation.

A wetland in this soil polygon is assigned 100 observations for the value 'A'.

Ecological Land Classification

Ecological land classification descriptions for PLOTS in Nova Scotia were assigned by plotting the location of PLOTS onto a 1: 640,000 scale map of the Natural History Theme Regions of Nova Scotia (Davis and Browne 1996a). This map is not available in digital format.

Wetlands in New Brunswick were assigned to ecological land classification units based on information associated with a provincial soil polygons (Ecosystem-Classification-Working-Group 1996). Data from the provincial ecological land classification system for New Brunswick were different from those for Nova Scotia. Information on New Brunswick Ecological Land Classification Units were summarised by PLOTs and PQUADs.

Wetlands in New Brunswick and Nova Scotia were assigned to National Ecological Framework Ecoregions and Ecodistricts based on information associated with SLC polygons (Ecological-Stratification-Working-Group 1995).

Land Cover and Surface Form Attributes

The number of buildings located within PLOTs and PQUADs was determined using the most recent 1: 50.000 NTS printed map available. In urban areas. where individual buildings were not identified on the map. this information was obtained from the local community development office. The total length of roads in survey plots was obtained using a map measuring wheel and 1: 50.000 NTS maps. Cart tracks. which are represented as black dashed lines. were not included in the total length of roads. This measurement is considered an index to road abundance as new forestry roads are constantly being built. some roads are allowed to revert to bush. and some become impassable due to bridge wash outs. Data on surrounding land cover and surface form were obtained from the SLC polygons and summary statistics generated for PLOTs and PQUADs (Table 2.1).

Elevation

SLC polygons contained categorical descriptors of slope gradient and topography. Summary statistics were calculated for each PLOT and PQUAD (Table 2.2).

Topographical information for survey plots was obtained using the GTOPO digital elevation model (DEM) created by the United States Geological Service. which was downloaded from their web site (http://edcdaac.usgs.gov/gtopo30/gtopo30.html). This DEM has an average distance of 700 m in the longitude direction and 950 m in the latitude direction between points. This grid spacing resulted in roughly 160 points per PLOT and 40 per PQUAD. An overlay of the point elevations onto the survey plots was then conducted (SPANS 1999). Summary statistics (mean. median. minimum. maximum. and standard deviation) of point data for each PLOT and PQUAD were then calculated (Table 2.2; PROC MEANS. SAS 1988).

NB Polygons were previously assigned mean elevations based on elevations for the polygon from topographic base maps (Toner 1998). Summary statistics (mean.

maximum, median) were then calculated based on the NB polygon assigned to the wetlands within the PLOT and PQUADs (Table 2.2).

NB Polygons contained information on slope classes where: Slope Class 0 < 0.5% gradient; Slope Class 1 = 0.5–1.5% gradient; Slope Class 2 = 1.5–2.5% gradient; Slope Class 3 = 2.5–5.0% gradient; Slope Class 4 = 5.0–9.0% gradient; Slope Class 5 = 9.0–15.0% gradient; Slope Class 6 = 15.0–30.0% gradient; and Slope Class 7 > 30.0% gradient (Table 2.2). The number of slope classes present in a NB soil polygon was used to create summary statistics. Each individual wetland was assigned to a NB Polygon, and therefore data were generated at the wetland level and summary statistics calculated for each survey plot (PROC MEANS; SAS 1988). For example, XSLOPV is the mean for the survey plot of the number of slope classes present in the soil polygon that the wetland is in (Table 2.2).

The modal slope category present in each soil polygon was also used to create summary statistics. Slope Classes were converted to percentage slope: 0 = 0.5 %; 1 = 1.0%, 2 = 2.0%, 3 = 3.75%, 4 = 7.0%, 5 = 12.0%, 6 = 22.5%, 7 = 30.0%. Data were generated at the wetland level and summary statistics calculated for each plot (PROC MEANS; SAS 1988). For example, XSM is the mean for the plot of the modal slope category for the soil polygon that the wetland is in (Table 2.2).

Soil Acidity

SLC polygons provided information on the calcareous class of parent material, with CALC0 to CALC3 representing increasing calcareousness of the soil (Table 2.3). NB polygons provided a measure of the acidity of the soil. Polygons were assigned a pH category based on the Forest Soil Unit that they were in (Colpitts *et al.* 1995; Toner 1998). NBPHC1 is the category with highest buffering whereas NBPHC4 is the most acidic (Table 2.3).

Soil acidity for Nova Scotia wetlands were derived by doing an overlay of the WI onto a digital map of the surficial geology of Nova Scotia (Stea *et al.* 1997). These maps are also available online (http://www.gov.ns.ca/natr/meb/pubs3.htm#maps). Surficial geology categories 'A' through 'P' were assigned acid buffering capacity ranks as follows: A = 1; B = 2; C = 3; D = 5; E = 3; F = 4; G = 2; H= 2; I = 2; J = 2; K = 2; L = 4; M = 4; N = 2; O = 2; P = WATER. The acid buffering capacity ranks are: 1 = very low; 2 = low; 3 = moderate; 4 = high; and 5 = very high. The assignment of acid buffering capacity was according to a scheme devised by Nova Scotia Department of Natural Resources staff (T. Horsman, R. Milton *pers. com*). The percentage of wetlands within the survey plot in each buffering capacity category is described by the variables NSPHC1 to NSPHC5 (Table 2.3).

A common soil acidity classification scheme for New Brunswick and Nova Scotia was derived by converting the NB soil pH categories into NS buffering capacity categories as follows: NB1 = NS5; NB2 = NS4; NB3 = NS3; and NB4 = NS2. A NB equivalent was not assigned to the extremely low buffering capacity NS1 category. The percentage of wetlands within the plot in each buffering capacity category was calculated (BVLO to BVHI, Table 2.3). The 5 categorical variables describing soil pH were reduced to a single quantitative variable estimating soil pH using the formula:

$$\text{SOILPH} = [(\text{BVLO}*4) + (\text{BLO}*4.5) + (\text{BMED}*5.5) + (\text{BHI}*6.5) + (\text{BVHI}*7.5)] / 100.$$

Soil Development, Drainage, Mode of Deposition, and Type

Categorical descriptors of surface material, rooting depth, and coarse fragment content were obtained from SLC polygons and summarised for PLOTs and PQUADs (Table 2.4). Coarse fragments were soil particles between 0.2 to 60 cm in size. Soil drainage descriptors were obtained from SLC Polygons and NB Polygons and summarised for PLOTs and PQUADs (Table 2.4). CanSIS categorical variables describing the parental mode of deposition of soils were summarised for PLOTS and PQUADs (Table 2.5).

CanSIS categorical variables describing soil types were summarised for PLOTS and PQUADs (Table 2.5).

Stream Length

Stream density (STREAM, Table 2.6) in most Nova Scotia survey plots was obtained from 1: 50,000 NTS digital topographical maps. A line (watercourse layer from digital NTS) onto area (survey plots) overlay was conducted (SPANS 1999). Watercourses greater than 25 m wide are represented by polygons, rather than lines, in the hydrology layer of the digital map. The length of these polygons therefore had to be measured on screen using the cursor. Digital maps were not available for some survey plots in Nova Scotia (PLOTs 29, 36, 38 and 39). Total stream length in these PLOTs was obtained using printed versions of the 1: 50,000 NTS maps and a map measuring wheel. There was close agreement between total stream length obtained using printed NTS maps compared to total stream length obtained using digital maps for five survey plots that were done using both methods (unpubl. data). Stream length was determined from hard copy maps for Nova Scotia survey plots that were surveyed between 1986-1989.

Digital NTS maps were not available for New Brunswick. Stream density in New Brunswick survey plots was therefore estimated based on values assigned to the NB soil polygon that the wetland was in (Toner 1998). Streams in NB Polygons were classified as being permanent or intermittent, with total stream length being the combination of the two categories. Stream density was calculated as the total length of permanent streams (metres) divided by soil polygon area (metres^2) * 1000. Each individual wetland was assigned to a NB Polygon, and therefore data were generated at the wetland level and summary statistics calculated for each plot (PROC MEANS: SAS 1988). For example, XISTOT is the mean for plot of the total length of intermittent streams present in the soil polygon that the wetland is in (Table 2.6). Stream length, stream density and other variables were summarised for PLOTs and PQUADs (Table 2.6).

Lake Area

Depending on their size, depth and amount of emergent vegetation, lakes may not be included in the Maritime Wetland Inventory (WI). All lakes in survey plots were identified on printed 1: 50 000 NTS maps. The area of the lake was determined using a PLACOM digital planimeter. The lake was measured three times and if all values were the same, this value was used. Occasionally these values were not the same, and in these cases, one or two additional measurements were taken, and the modal value was considered correct. Bays in lakes were measured as separate components to improve accuracy. Grid lines (1 km^2) on the NTS maps allowed for a rough visual verification of measurements. The number and total area of lakes were summarised for PLOTs and PQUADs (Table 2.6).

Total Number, Total Area and Types of Wetlands

The number, area and type of wetlands were summarised by PLOT and PQUAD (Table 2.7) based on data from the Maritime Wetland Inventory (WI). The WI describes wetlands according to eight classes and 34 sub-classes (Appendix A).

Vegetative Interspersion and Cover Type

The WI describes the vegetative interspersion of each wetland as low, medium or high (Table 2.8). The emergent cover is described according to eight categorical variables (Table 2.9). Categorical cover types were used to calculate a cover type score from which summary statistics were calculated.

Wetland Location in Watershed and Adjacent Habitat

The location of the wetland in relation to other wetlands and waterbodies is described in the WI according to juxtaposition and site type (Table 2.9). Wetlands are assigned one of eight juxtaposition classes (JP Class 1 - JP Class 8). These categorical variables were then used to calculate a juxtaposition score (JP Score) that ranged from 2.0 - 8.0. Summary statistics for juxtaposition scores were then calculated for PLOTs and PQUADs. Wetlands were also assigned to one of eight site types (SITE1 - SITE8). The WI also describes for each wetland the amount of adjacent habitat that is forested compared to open/agricultural. Summary statistics for these variables were calculated for PLOTs and PQUADs (Table 2.10).

Coastal Features

Data on coastal features were obtained for WI maps for plots that were located along the coast or located within 10 km of the coast. Coastal data were obtained for that coastal unit or a 10 km section of coastline. The WI identifies coastal features such as islands. marine habitats. estuarine habitats. saline ponds. and salt marshes (Table 2.10).

Canada Land Inventory Scores

A numerical Canada Land Inventory (CLI) score for each wetland was calculated based on the Canada Land Inventory suitability of habitat for waterfowl production class that the WI assigned each wetland (Table 2.10). Summary statistics were calculated for PLOTs and PQUADs.

Golet Wetland Evaluation System

The wetland evaluation system for New Brunswick and Nova Scotia (Table 2.11) is based on the Golet Scoring System (Golet 1978; Golet and Larson 1974). and consists of ten criteria and a relatively simple rating system (Hanson and Calkins 1996). Each criterion has specifications describing three or more possible categories into which a given wetland might be placed. Specifications were assigned ranks. ranging from one (lowest value) to three (highest value). A wetland receives a rank for each of the criterion. If. for any criterion. more than one specification could be applicable. the ranks for those specifications were averaged. Since some criterion are more important than others, each was given a fixed numerical value called a significance coefficient (Golet 1978; Golet and Larson 1974), ranging from 1 (least important criterion) to 5 (most important criterion). A sub-score is calculated for each criterion by multiplying the significance coefficient for that criterion by the rank given. Scores for all criteria are summed and a total Golet Score is obtained. This final score represents the wetland's relative wildlife value. The lowest possible total score is 36 and the highest is 108.

For some criterion, there are five categories of specifications and five corresponding ranks (3.0, 2.5, 2.0, 1.5, and 1.0). Other criteria had only three categories of specifications and ranks (3.0, 2.0, and 1.0), because the relationships or measurement ability was thought to be less refined (Golet 1978). A brief description of each criterion is found in Appendix B.

Summary statistics based on the Golet Scores of wetlands in PQUADs and PLOTs were calculated (Table 2.10).

Climate

Climate data were obtained from Environment Canada weather stations closest to the survey plots. If there was no weather station in the immediate vicinity of the survey plot, then data from the two nearest climate stations were averaged. Summary statistics were mostly based on data from 1983-1994. If the station ceased operation prior to 1994, and no other suitable data were available, then summary statistics were calculated on all data available (*e.g.*, Plot 59 used data from McAdam 1917-1976). Information on data used in the analysis is summarised in Appendix C, Table C.1. Summary statistics were calculated for PLOTs only (Table 2.12).

Principal Components Analysis

Principal component analyses (PCA) were conducted to possibly reduce the number of variables used in modelling Black Duck distributions (Proc PRINCOMP: SAS 1988).

Principal components were calculated using the correlation matrix and the eigenvectors were standardised. Although a multivariate normal distribution (*mnd*) is not required for PCA, the utility of PCA is enhanced if the variables are *mnd* (Tabachnick and Fidell 1989). Variables expressed as percentages were arcsine transformed and most other variables log10 transformed (Table 2.13) prior to PCA (Zar 1984). Variables had high W scores after transformation, indicating normal or near normal distributions (PROC UNIVARIATE; SAS 1988). To reduce the number of categories, and therefore increase the sample size in each category, derived variables were also created for inclusion in the PCA (Table 2.13).

Geostatistical Analysis

The location of the centroid of PQUADs was converted from latitude and longitude (decimal degrees) to Universal Transverse Mercator (UTM) easting and northing (metres) for Zone 20 (SPANS 1999). UTMs are cartesian coordinates from which distances between points can be calculated. Lag classes were established at 8,000 m intervals, with the maximum distance (range) being 160,000 m. Lag Class 1, compared all pairs of observations that were less than 8,000 m apart, and included a comparison among PQUADs within a given PLOT. Lag Class 2 compared all observations that were between 8,000 and 16,000 m apart, in essence it compared PQUADs to PQUADs in a contiguous PLOT. Lag Class 3 compared all observations that were between 16,000 and 24,000 m apart, *etc.* Most lag classes had hundreds of observations in them, with Lag Class 2 having the smallest membership (only 34 pairs of observations). It is recommended that each lag class be represented by at least 30-50 pairs of observations, although the greater the number of pairs of points, the greater the statistical reliability of each lag class (Rossi *et al.* 1992).

Omnidirectional (i.e. isotropic) correlograms were created using GS+ (Robertson 2000). Moran's I was used to measure spatial autocorrelation, with values close to +1.0 indicating a smooth surface, with each PQUAD containing values very similar to those in neighbouring PQUADs, and a value of -1 indicating a rough surface where neighbouring

PQUADs have very dissimilar values (Eastman 1999). Moran's I values near zero indicate no spatial autocorrelation. Variables with highly skewed distributions were log transformed prior to calculating Moran's I (Isaaks and Srivastava 1989).

RESULTS

Black Duck Survey Plots

As shown in Figures 2.1 and Figure 2.2. BDJV survey plots are located throughout Nova Scotia and New Brunswick in many geographical zones (Bateman and Hicks 1995; Davis and Browne 1996b; Ecosystem-Classification-Working-Group 1996; Erskine *et al.* 1990).

Ecological Land Classification

The origins of ecological land classification in Nova Scotia and New Brunswick can be traced to earlier forest classification schemes (Loucks 1962; Rowe 1972). Nova Scotia has an overall area of 54,940 km^2 and shoreline length of 7,400 km, and has been divided into a system of Natural History Theme Regions, Districts, Units and sub-Units (Figure 2.3; Davis and Browne 1996a). BDJV plots occur in many different Units, with little replication within Units or Districts (Table 2.14). Descriptions of the Regions, Districts, Units, and sub-Units in which the survey plots are located are given in Davis and Browne (1996a) and at http://museum.gov.ns.ca/mnh/nature/nhns/index.htm.

New Brunswick contains 71,960 km^2 and has a shoreline length of approximately 3,800 km. Recent efforts at ecological land classification for New Brunswick have created 7 EcoRegions and 35 EcoDistricts (Ecosystem-Classification-Working-Group 1996). The location of survey plots in relation to these zones is illustrated in Figure 2.4. The survey plots are located in many different EcoDistricts with little quantitative data being available for all zones (Table 2.15).

BDJV survey plots (Table2.16) were located in 10 different National Ecological Framework Regions (Ecological-Stratification-Working-Group 1995). Plots were located in 43 different National Ecological Framework Districts, however, summaries by district were not available. Summaries for regions are available at the following web site: http://www1.ec.gc.ca/~ecozones /default.htm.

The information contained within provincial ecological land classifications are useful descriptions of survey plots but are lacking in standard quantitative variables that are available for both provinces. The National Ecological Framework Regions are too broad to provide differences in landscape features among survey plots. The lack of replication among survey plots and lack of summary descriptions makes the National Ecological Framework Districts of limited value, compared to other variables, in understanding spatial variation among survey plots.

Land Cover

Land cover in survey plots was mostly in the mixed woods category (Appendix C, Table C.2), consistent with descriptions of the Acadian forest (Rowe 1972). Notable exceptions are the agricultural areas within PLOTs 34, 41, 42, 43, 44, 50 and 62. Coniferous forest is predominant in PLOT 53 where it probably reflects flat, poorly drained soils dominated by Black Spruce (*Picea mariana*). All wetlands in PLOT 65 were found on the coniferous forest land cover class, consistent with the Ecodistrict being dominated by Black Spruce, Balsam Fir (*Abies balsamea*), as well as White Pine (*Pinus strobus*) and Red Pine (*Pinus resinosa*) along the sandier river banks and ridges (Ecosystem-Classification-Working-Group 1996). There was little difference among plots in land cover.

Buildings and Roads

There was considerable variation in the total length of roads per PLOT, ranging from 0-137 km per 100 km^2 (Appendix C, Table C.3). There was considerable variation in the amount of roads within a given PLOT (Figure 2.5). The importance of roads to the forestry industry results in almost all PQUADs having roads present. Spatial autocorrelation in the total length of roads was minimal with Moran's I = 0.336 for among PQUAD comparisons (Lag Class 1) and considerably less for more distant comparisons (Table 2.17).

There was also considerable variation in the total number of buildings per PLOT, with 0 to 1415 per 100 km^2 (Appendix C, Table C.3). Within most PLOTs, there were similar number of buildings among PQUADs (Figure 2.6). Where survey plots bordered residential areas there were many buildings present. There was considerable spatial autocorrelation among PQUADs in the number of buildings present with Moran's I = 0.539 for Lag Class 1 and 0.343 and 0.257 for Lag Classes 2 and 3 respectively (Table 2.17).

Elevation

Most wetlands were found in SLC slope category 4 - 9% (Appendix C, Table C.4). Plots in the highest slope category were found in Cape Breton (PLOT 49) and northern New Brunswick (PLOTs 71, 74, and 75). PLOTs, located in the Carboniferous Basin, *e.g.*, 42, 53, 54, 55, 56, and 65 were in the lowest slope category. The surface form categories of rolling (SFM) or undulating (SFU) were most common (Appendix C, Table C.5). The domed bog category (SFO4) was uncommon, found only in PLOTs 53, 54, 55, 66 and 70. The level category (SFL) was found in many PLOTs and was most prevalent in PLOT 61 which has a large area of peatlands.

Median elevation within PLOTs ranged from 0 m above sea level (asl) to 475 m (Appendix C, Table C.6). The standard deviation of elevation of evenly spaced points within survey plots gave a direct measure of topography. PLOTs with high median elevations also had high standard deviation of elevation (Appendix C, Table C.6). PQUADs in north-western New Brunswick, Cape Breton, and along the bay of Fundy coastline had a lot of variation in elevation (Figure 2.7). There was considerable spatial autocorrelation in median elevation and standard deviation of elevation in PQUADs (Table 2.17).

Soil Development

The geological history of Nova Scotia and New Brunswick makes their bedrock lithology and soils very complex. The region has been: at the centre of colliding continents (Roland 1982): at the southern edge of glaciation (Pielou 1991): and inundated by ancient seas (Davis and Browne 1996b). The pH. available nutrients. and erodibility of soils all influence the fertility of wetlands within a watershed. The acid buffering capacity of soils has a direct impact on nutrient availability due to the leaching of nutrients from the upper soil horizons due to the naturally slightly acidic pH of precipitation.

Some soils in PLOTs 59. 60. 68. 72. 74 and 75 were classified as being weakly calcareous (CALC1). and PLOT 68 contained some soils classified as highly calcareous (Appendix C. Table C.7). All other PLOTs had either non-calcareous soils (CALC0) or the component contained water or rock (CALC#).

There was not much variation within survey plots of the buffering capacity of soils. Most PLOTs had all observations in the soil buffering capacity very low (SBCVL) and soil buffering capacity low (SBCL) categories. PLOTs such as 34. 40. and 41. however. had almost equal representation in soil buffering capacity low (SBCL). and soil buffering capacity high (SBCH) classes. PLOTs 42. 43. and 44. located in the Northumberland Plain EcoDistrict (Davis and Browne 1996a). had a high percentage of wetlands in soil buffering capacity high (SBCH) categories. PLOTs 74 and 75 which had some observations described as weakly calcareous (CALC1). also had among the highest values for soil pH (SOILPH). and a high number of observations in soil buffering category high (SBCH).

The derived variable which measured soil pH (SOILPH). ranged from 4.42 - 6.50 pH units (Appendix C. Table C.7). This derived variable allowed for a single quantitative description of soil pH to be used. and resolves discrepancies between provincial soil buffering categories. The spatial distribution of soil pH (SOILPH: Figure 2.8) corresponds with descriptions of the bedrock lithology and soils of the ecological land classification units that the survey plots are in, as well as with geological maps of New Brunswick (Ferguson and Fyffe 1985) and Nova Scotia (Donohoe *et al.* 1994). There was considerable spatial autocorrelation in soil pH (SOILPH) for Lag Classes 1-3 (Table 2.17).

The buffering capacity of bedrock and derived soils has been extensively studied in New Brunswick (Hawkins and Spavold-Tims 1984; Spavold-Tims 1986) and in Nova Scotia (Howell 1988; Underwood and Schwartz 1989). The sedimentary soils of the Carboniferous Basin are described as being acidic in New Brunswick, whereas they are of higher pH and fertility in the plots in Nova Scotia.

Plots were mostly classified as having mineral soil (MATSO, Appendix C, Table C.8). Some areas were classified as having acidic, hard rock, granite, surface material (MATR2), consistent with them being part of the South Mountain Batholith (PLOTs 26, 29) and the Granite Barrens EcoDistrict (PLOTs 26, 46). PLOTs also contained small areas of organic soils (MATOR). Spatial autocorrelation for MATOR was high for PQUADs within PLOTs and for the first 3 lag classes (Table 2.17).

The unrestricted rooting depth was predominantly in the 20-75 cm category (RTDPB, Appendix C, Table C.8). A shallow rooting depth would be indicative of thin soils overlying bedrock, or the presence of an orstein layer found in many areas (Davis and Browne 1996a; Ecosystem-Classification-Working-Group 1996). PLOTs in New Brunswick had an average of 27% of observations in the > 150 cm unrestricted rooting depth category (ROOTD), whereas the average for PLOTs in Nova Scotia was only 7%.

Soils in New Brunswick PLOTs had higher coarse fragment content compared to the Nova Scotia PLOTs (Appendix C, Table C.9). The average for New Brunswick PLOTs in CFRAGC was 22% whereas it was only 3% for Nova Scotia PLOTs.

The moist, temperate climate of New Brunswick and Nova Scotia results in the dominant soils being podzols (Colpitts *et al.* 1995; Davis and Browne 1996b; Ecosystem-Classification-Working-Group 1996). These soils are characterised by organic matter accumulating on the surface and organic acids leaching nutrients, iron and aluminum to deeper depths. Most of the PLOTs in New Brunswick and Nova Scotia had soils that were in category DW (dominantly Humo-Ferric Podzolic great group) and the closely related category DV (dominantly Ferro-Humic Podzolic great group (Appendix C, Table C.10). Besides podzols, the other major soil category was DU (dominantly Gleysolic order), which is a wet mineral soil. The more fertile soils in Nova Scotia were in category DI (dominantly Brunisolic Gray Luvisolic subgroup with inclusions of its gleyed subgroup). In New Brunswick, the most fertile soils were in the D3 category (Podzolic Gray Luvisolic subgroup). In general, the most fertile soils (DI) in Nova Scotia survey plots are somewhat more fertile than the most fertile soils (D3) in New Brunswick survey plots. However, the D3 soils of New Brunswick are more fertile than the DW podzols that predominate in Nova Scotia survey plots. The average for Nova Scotia PLOTs was 65% in the DW category whereas in New Brunswick, the average was 46% for the DW category and 23% for the D3 category. The other soils found in survey plots are in the Fibrosis (DX), Mesisol (DY), and Humisol (DZ) great groups, and can be described as organic soils, with increasing decomposition of the plant material (Anonymous 1976).

Parental Mode of Soil Deposition

The most commonly observed mode of deposition of soil materials was morainal (PMDM), which is described (Anonymous 1976) as sediment that has been transported beneath, beside, on, within, or in front of a glacier but not modified by any intermediate agent (Appendix C, Table C.11). Most of New Brunswick and Nova Scotia were impacted by at least four ice advances during the Wisconsin Glacial Stage (Pielou 1991; Roland 1982; Trenhalle 1990). The retreat of the last glacier was approximately 10,000 years ago, and therefore earlier modes of soil deposition would have been superseded by morainal. Many of the PLOTs in Nova Scotia had observations in the organic category

(PMDO) which is described as a layered sequence of three undifferentiated types of organic material (Appendix C, Table C.11). For New Brunswick PLOTs, the organic parental mode of deposition was separated into fibric sphagnum (PMD11), mesic sedge (PMD21), mesic woody sedge (PMD23), and mesic sphagnum (PMD25).

Soil Drainage

Overall, 45% of observations were in the well drained category (DRAINW), 23% of observations in the imperfectly drained category (DRAINI) and 12% in the poorly drained category (DRAINP, Appendix C, Table C.12). Poorly drained soils were common in PLOTs located in the Eastern Lowlands (Rowe 1972).

Lakes and Streams

Total stream density varied from 0.230 to 2.537 km/km^2 per PLOT (Appendix C, Table C.13). Stream density was relatively consistent among PQUADs within a given PLOT (Figure 2.9). Spatial autocorrelation in stream density was evident among PQUADs within a given PLOT with Moran's I = 0.3966 for the Lag Class 1 (Table 2.18). Moran's I was much smaller for subsequent lag classes.

The number of lakes varied from 0 to 82 per PLOT, while total lake area ranged from 0 to 17.325 km^2 per PLOT (Appendix C, Table C13). There was a weak negative correlation ($r^2 = -0.33$) between stream density and total area of lakes within PLOTs. The total number of lakes were similar for PQUADs within the same PLOT with Moran's I = 0.563 for Lag Class 1 (Figure 2.10, Table 2.18). PQUADs with the highest number of lakes were in the glaciated landscape of south-western New Brunswick and the Granite Barrens Ecodistrict in Nova Scotia (Davis and Browne 1996a). The total area of lakes was similar for PQUADs within the same PLOT with Moran's I = 0.515 for Lag Class 1 (Figure 2.11, Table 2.18). The PQUADs with the highest total lake area were also in the areas of New Brunswick and Nova Scotia that were most influenced by past glacial activity (Davis and Browne 1996a). Some areas in Nova Scotia, such as PLOTs 29 and 32 had very few lakes but still had large total lake area. There was substantive spatial autocorrelation in both the number of lakes and total lake area for lag class distances of up to 40 km (Table 2.18).

Wetlands

The number of wetlands per PLOT ranged from a low of 3 in PLOT 50 to a maximum of 187 in PLOT 38 (Appendix C, Table C.14). The number of wetlands in PQUADs were relatively consistent within PLOTs (Figure 2.12) with there being high spatial autocorrelation for Lag Classes 1 - 3 (Table 2.18). Survey plots with the highest number of wetlands were found along the eastern shore of Nova Scotia (PLOTs 26, 37 and 38), in glaciated south-western New Brunswick (PLOTs 57 and 58), and in the Carboniferous Basin of New Brunswick (PLOTs 66, 67, and 68).

Total wetland area followed a spatial pattern similar to that observed for total number of wetlands (Figure 2.13). Spatial autocorrelation was observed in Lag Classes 1 - 4 (Table 2.18). Total wetland area (SSIZE) in PLOTs ranged from 12.4 ha in PLOT 50 to 2124.8 ha in PLOT 31 (Appendix C, Table C.15). Most wetlands were relatively small, with the median size (MDSIZE) of wetlands per PLOT ranging from 0.6 to 8.0 ha. The range in maximum wetland size (MXSIZE) per PLOT was 5.4 to 794.1 ha.

Bog was the dominant class for 57% of all wetlands in PLOTs (Appendix C, Table C.14). Bogs were most common in PLOTs occurring in the Atlantic Interior Eco-Region in Nova Scotia and the Carboniferous Lowlands Region of New Brunswick (Tables 2.14-2.15, Figure 2.14). There was considerable spatial autocorrelation in the percentage of wetlands that were bogs with Moran's I values ranging from 0.705 to 0.213 for Lag Classes 1 to 6 respectively (Table 2.18). There was less spatial autocorrelation in the CanSIS variable describing surface forms that were bogs (variable SFBOG, Table 2.17). The second most prevalent wetland class was shrub swamp. The other common wetland classes were: open water, meadow, and deep marsh (Appendix C, Table C.14).

Whereas most wetlands were small, the number of sub-classes within a wetland was low, with the mean number of sub-classes (MNOCL) per PLOT being around 2 (1.43-2.67). Modal number of sub-classes (MONOCL) per PLOT was 1 or 2 (Appendix C, Table C.15).

The mean score (MCOV) for vegetative cover ranged from 2.67 to 5.61, with the modal score (MOCOV) being 4.5 (Appendix C, Table C.16). The majority of wetlands (69 - 100%) were classified as having low vegetative interspersion (INTER1, Appendix C, Table C.16). Most wetlands had vegetation cover greater than 95% of the area (CTYP1), as opposed to it occurring in a peripheral band (CTYP6; Appendix C, Table C.17).

The mean juxtaposition score (MJUXT) of wetlands in PLOTs varied from 2.67 to 5.16 (Appendix C, Table C.18). The modal score indicated that wetlands were in different juxtaposition classes. The juxtaposition classes of wetlands (JP1-JP7) differed among PLOTs (Appendix C, Table C.18).

Most wetlands (Appendix C, Table C.19) were classified as being located in the uplands of drainage systems, either isolated (SITE1), streamside (SITE2), or lakeside (SITE3). There were some wetlands located bottomland streamside (SITE6), with very few wetlands located bottomland deltaic (SITE7) and bottomland seaside (SITE8).

The habitat adjacent to wetlands was classified predominantly as forest (MFOR), with some open/agricultural land (MOPEN, Appendix C, Table C.19). There were no wetlands for which the adjacent lands were in the ocean or salt marsh categories, even though some of the PLOTs were located along the coast.

Coastal Features

Most survey plots were located inland and therefore did not have any coastal features associated with them (Appendix C, Table C.20). All coastal PLOTs, with the exception of PLOT 47, had salt marshes associated with them (SALTNO). PLOT 47 was located along the Bras D'Or Lakes. The maximum area of salt marshes (SALTHA) associated with PLOTs was 223.9 ha for PLOT 35. Coastal Plots did not have a lot of salt water ponds associated with them, with 2 being found in PLOT 44 and 4 in PLOT 50.

CLI Score

The mean CLI score (MCLI) for PLOTs was low, with the modal CLI score (MOCLIN) being zero (Appendix C, Table C.21). The CLI was a national program to rate the capability of the land to support various uses and natural resources. Almost all of Atlantic Canada was deemed as non-critical for waterfowl populations on a national scale. The basis for the waterfowl habitat capabilities assigned to the Atlantic Canada were the opinions of provincial and federal waterfowl biologists rather than any systematic evaluation (D. Dennis *pers. comm.*). The CLI data lacks the accuracy necessary for modelling waterfowl populations at a regional level.

Golet Score

The median Golet Score (MDSCOR) for wetlands in PLOTs ranged from 47.5 to 59.0 (Appendix C, Table C.21). There was considerable variation in median Golet Scores among PQUADs within the same PLOT (Figure 2.15). Moran's I value for Lag Class 1 was low compared to Lag Class 1 values previously reported for other variables (Table 2.18). It should also be noted that Moran's I values did not vary greatly among Lag Classes 1 - 6 (Table 2.18).

The maximum Golet Score (MXSCOR) ranged from 51 for PLOT 49 to a maximum value of 94 for PLOT 41. Similar to median Golet Score, there was considerable variation among PQUADs within the same PLOT (Figure 2.16). The spatial autocorrelation for maximum Golet Score was low (Table 2.18). The sum of Golet Scores (SSCOR) per PLOT ranged from a low of 150 for PLOT 50 to 9,958 for PLOT 37. The sum of Golet Scores represents two other previously summarised variables, namely, the average Golet Score and the total number of wetlands per survey plot.

Climate

Mean annual precipitation can be used an index to wet weather during the brood rearing season as well as an index to the effects of precipitation on releasing organic acids from peatlands into receiving waters, leaching soil nutrients from the upper soil horizons, and the flushing of nutrients from wetlands. The average daily minimum temperature in May (TMINMAY) could provide an index to cold temperatures that could affect duckling survival (Koskimies and Lahti 1964; Mauser *et al.* 1994; Steen and Gabrielsen 1988). The annual mean minimum temperature provides an index to ice-out and how quickly water temperatures would increase.

There was substantial variation in the mean annual total precipitation (PPYR) and mean daily minimum temperatures (TMINYR) among PLOTs (Appendix C, Tables C.22 & C.23). PLOTs with the highest number of days with snow in April (SNOWAPR) and May (SNOWMAY) were not necessarily PLOTs with the coldest temperatures during those months. Most of the PLOTs with high snow days in April and May were predominantly close to the moisture producing coast, but sufficiently inland, or elevated to have the colder air temperatures required for snow.

Principal Components Analyses

Geographical Features

A correlation matrix from a principal components analysis (PCA) of 12 topographical variables provided a summary of the relationships among these variables in PLOTs (Table 2.19). The derived soil pH (SOILPH) was positively associated with agricultural land cover (VEGA), hilly terrain (HILL) and steeper slopes (SLOPE). SOILPH was negatively associated with organic matter (MATOR), surface form bog (SFBOG) and total number of lakes (TOTLAK). A high coarse fragment content (CFRAGC) was associated with good drainage (DGOOD) and higher elevations (ELEVAV). The low number of PLOTs which had values for agricultural land cover (VEGA) limits meaningful interpretation of its correlation to other variables. Well drained soils (DGOOD) were associated with hilly terrain (HILL), steeper slopes (SLOPE), and higher elevations (ELEVAV). Poorly drained soils (DPOOR) were associated with organic matter (MATOR), and surface form bog (SFBOG). Surface form bog (SFBOG) was negatively associated with average elevation (ELEVAV), standard deviation of elevation (ELVSTD) and stream density (XSTM). There was a high correlation between the categorical variables describing slope (HILL and SLOPE) and the standard deviation of elevation (ELVSTD), a quantitative variable. There was a negative relationship between stream density (XSTM) and number of lakes in PLOTs, whereas there were positive correlations between stream density, mean elevation, and standard deviation of elevation. Streams occur in hilly terrain, whereas lakes are found in flat terrain, associated with the development of peatlands.

The first principal component accounted for 37% of the overall variation with PC1-PC3 accounting for 74% of the variation (Table 2.20). PCAs on subsets of variables had PC1 accounting for more of the overall variation, but this increase was not substantive in light of the reduced number of variables (unpubl. data). An evaluation of eigenvectors indicated that PC1 describes well drained soils of higher, hilly elevations with many streams versus poorly drained, organic soils in areas of bogs and lakes (Table 2.21).

Climate

A PCA was also performed on climatic data (Table 2.22). The number of days with snow in April (SNOWA) and May (SNOWM) was negatively correlated with various measures of minimum temperature. The total amount of precipitation during May and June (PPMJ) was weakly correlated with total annual total precipitation (PPYR). Annual total precipitation was more correlated with annual mean minimum temperature (TMNYR: R^2=0.58) than with precipitation in May and June (PPMJ: R^2= 0.420). The annual mean minimum temperature was highly correlated with mean minimum temperatures during April (TMNAPR), May (TMNMAY) and the growing season (TMNGS).

The first principal component accounted for 34% of the overall variation (Table 2.23). An evaluation of the eigenvectors indicates that PC1 describes decreasing snow with increasing annual maximum temperature and with increasing annual minimum temperature (Table 2.24). PC1 described the trend for PLOTs away from coastal influences to be colder in the winter, warmer in the summer, with less precipitation. PC2 describes increasing precipitation, with little relation to temperature or snow.

Aquatic Habitats

The number of wetlands per PLOT was positively correlated with the percentage of wetlands that were bogs, the total area of wetlands, and the total number and area of lakes (Table 2.25). The number of wetlands per PLOT decreased with increasing standard deviation of elevation and increasing stream density.

The percentage of wetlands that were bogs was negatively correlated with the percentage of wetlands that were shrub swamp, as well as stream density, average elevation and standard deviation of elevation. These relationships reflect the fact that shrub swamps are most often associated with streams. Streams were associated with higher and more incised elevations. Open water wetlands were also positively correlated with stream densities (Table 2.25). The number and total area of lakes were negatively correlated with the standard deviation of elevation.

The first principal component (PRIN1) describes a landscape which is flat with few streams but many wetlands, lakes and bogs (Table 2.26). PRIN1 accounted for 31% of the variation, with the second (PRIN2) and third (PRIN3) principal components accounting for 16% and 13% respectively (Table 2.27). Wetlands in this flat landscape are not hydrologically connected. PRIN2, in contrast, describes a landscape of higher elevations, with more streams, and shrub swamp wetlands that are hydrologically connected. PRIN3 describes a landscape with increasing number and size of lakes, located in higher elevations. Biplots of PC1-PC3 scores produced graphs with swarms of observations rather than PLOTs that were well separated in PC space.

DISCUSSION

Ecological land classification provides a useful hierarchical approach to describing the biophysical features of the landscape. The utility of these classifications is limited by them being narrative descriptions of spatially distinct entities. Classifications for New Brunswick and Nova Scotia are lacking standard quantitative variables that could be incorporated into statistical modelling (Davis and Browne 1996a; Ecosystem-Classification-Working-Group 1996). This problem is compounded for analyses that extend beyond provincial boundaries. The National Ecological Framework provides a system that is national in scope, however, the spatial scale of this endeavour was not compatible with the spatial level of my analyses. There are no categorical variables or descriptions of any kind available for Ecodistricts which precludes their use in modelling exercises (Ecological-Stratification-Working-Group 1995).

Provincial and National soil classification systems provide quantitative variables although they are limited in the types of biophysical features they describe. The usefulness of Soil Landscape of Canada data in GIS analyses is compromised by the fact that soil polygons are heterogeneous units comprised of components that are not georeferenced (MacDonald and Valentine 1992). Qualitative categorical variables traditionally used in mapping (*e.g.*, low, medium, and high) are less preferred for statistical modelling compared to continuous quantitative variables. This was illustrated by problems associated with interpreting qualitative categorical variables describing soil buffering capacities of New Brunswick soil polygons compared to a different qualitative system for Nova Scotia soil polygons.

Landscape-level topographical and geological variables, such as land cover classes and surface form classes, which potentially could reflect differences in habitat quality, showed little variation among survey plots. The information on surrounding land use from the Wetland Inventory also did not show much variation among plots.

The Wetland Inventory provided data at the smallest spatial scale of all the data sets. Plots that were on level terrain had a large number of wetlands and lakes. The Carboniferous Basin which occupies much of southeastern New Brunswick is an example of a of low-lying, flat area that has an extensive development of lakes and bogs.

Wetlands within survey plots were predominantly bogs. Bogs are the most numerous dominant class of wetlands in New Brunswick and Nova Scotia (Hanson and Calkins 1996). Bogs comprise 33% of the 33,351 wetlands in New Brunswick and 65% of the 33,328 wetlands in Nova Scotia. By land area, bogs comprise 50% of the 306,195 ha of wetlands in New Brunswick, and 71% of the 223,427 ha of wetlands in Nova Scotia. Shrub Swamps were the second most common type of wetland in survey plots, reflecting the fact that shrub swamps (primarily streamside alder swales) are the second most common form of wetlands in New Brunswick and Nova Scotia. Shrub swamps comprise 31% and 21% of the wetlands in New Brunswick and Nova Scotia respectively (19 % and 13% by area).

Many of the variables describing wetland features, such as vegetative interspersion and cover type, did not differ much among survey plots. The evaluation of wetlands as wildlife habitat in the Maritimes is based on Golet Scores. Wetlands are evaluated in terms of their value as wildlife habitat for a broad spectrum of species (Golet and Larson 1974). Golet Scores are based on many wetland features and hence are a good summary statistic for these data. The suitability of Golet Scores as a measure of wildlife habitat quality has not been thoroughly assessed. Although habitat quality can be measured both in terms of wildlife production as well as diversity, the two are not always strictly compatible (Wisheau and Keddy 1996). Whereas each species will have a specific set of habitat requirements, *i.e.* niche, no one wetland type will be optimal for all species. The broadness of the evaluation criteria reflects the emphasis on diversity. Previous work on a small spatial scale (14 individual wetlands) found no relationship between Golet Score and number of waterfowl broods (Hudgins 1988).

The relationships among variables in the principal components analysis of topographical features summarises information among plots as well as geological and ecological processes. The fact that soil pH was positively correlated with steeper slopes and higher elevation may reflect the presence of drumlins and/or the calcareous soils of northwestern New Brunswick. The negative correlation between average elevation and surface-form bog may reflect more of a cause and effect relationship. Principal components 1-3 (PC1 - PC3) based on 13 variables accounted for a major proportion of the variability in topographical data (74%). A PCA of 17 habitat variables describing small mammal habitat had PC1 - PC3 describing only 60% of the overall variation (Knight and Morris 1996). The PCA of wetland related variables produced PC1 - PC3 axes that accounted for 70% of the overall variation.

It should be stated, however, that the utility of PCA may be in exploring relationships among variables rather than as a variable reduction method. The use of principal components versus original variables may not provide improved modelling capabilities. Variables that may be highly correlated with Black Duck distributions may be a minor component on PC1 - PC3 axes. The use of PC scores also adds another level of complexity to understanding what landscape-level descriptors of habitat are important in explaining the distribution of Black Ducks. A thorough evaluation of the relationships between wetland inventory data, provincial soil polygons, climatic data, and CanSIS data, using PCA, for wetlands just in survey plots, would be of limited value.

The spatial autocorrelation observed for CanSIS data is consistent with the large spatial scale of the polygons. The presence of components within CanSIS polygons that are not geo-referenced limits the analysis of spatial autocorrelation with these data. Geographical variables such as elevation and soil pH had considerable spatial autocorrelation for Lag Classes 1-3 consistent with the large spatial scales of geological phenomena. The number/area of lakes and wetlands had spatial autocorrelation for Lag Classes 1-3, similar to that observed for other geographical features. Total lake area and total number of lakes had spatial autocorrelation for Lag Classes 1-4. The percentage of wetlands that were bogs and median Golet Score exhibited spatial autocorrelation for Lag

Classes 1-5, consistent with bogs occurring over large areas, where suitable conditions exist. The importance of spatial autocorrelation among PQUADs for topographical variables will be discussed in Chapter 5 relative to spatial autocorrelation in waterfowl densities. To understand the spatial variance of habitat variables previously described in this chapter, the observation points would have to occur at a regular interval (Isaaks and Srivastava 1989).

Spatial and statistical analyses of all wetlands (*ca.* 67,000) in Nova Scotia and New Brunswick, although outside the scope of this study, could be done with the information assembled for this study, and provide interesting insights regarding wetlands at a landscape-level. This work would further our understanding of wetland distribution and ecological function in New Brunswick (Toner 1998) and Nova Scotia.

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Variable	Description
VEGA	% of observations in cover category: Agriculture
VEGB	% of observations in cover category: Bog
VEGC	% of observations in cover category: Coniferous Forest
VEGD	% of observations in cover category: Deciduous Forest
VEGG	% of observations in cover category: Grassland
VEGM	% of observations in cover category: Mixed Forest
VEGR	% of observations in cover category: Marshland
VEGU	% of observations in cover category: Unvegetated
SFB04	% of observations in Surface Form - Domed Bog
SFB14	% of observations in Surface Form - Flat Bog
SFD	% of observations in Surface Form - Dissected
SFH	% of observations in Surface Form - Hummocky
SFL	% of observations in Surface Form - Level
SFM	% of observations in Surface Form - Stream Marsh
SFM06	% of observations in Surface Form - Rolling
SFR	% of observations in Surface Form - Ridged
SFS	% of observations in Surface Form - Steep
SFS01	% of observations in Surface Form - Stream Swamp
SFU	% of observations in Surface Form - Undulating

Table 2.1 - Variables describing land cover and surface form in waterfowl survey plots. based on Canadian Soil Information Survey data.

Variable	Description
SLOPEA	% of observations in Slope Category A (< 4%)
SLOPEB	% of observations in Slope Category B (4- 9 %)
SLOPEC	% of observations in Slope Category C (10-15 %)
SLOPED	% of observations in Slope Category D (16-30 %)
SLOPEE	% of observations in Slope Category E (31-60 %)
SLOPEF	% of observations in Slope Category F (> 60 %)
ELVAV	Mean elevation for plot (m asl)
ELVMD	Median elevation for plot (m asl)
ELVSTD	Standard Deviation of elevation for plot (m asl)
ELVMIN	Minimum elevation for plot (m asl)
ELVMAX	Maximum elevation for plot (m asl)
XELVX	Mean for plot of Mean Elevation (m asl) of NB Polygon
MXELVX	Maximum for plot of Mean Elevation of NB Polygon
MDELVX	Median for plot of the Mean Elevation of NB Polygon
XSLOPV	Mean for plot of number of slope classes present in NB Polygon
MXSLOPV	Maximum for plot of number of slope classes present in NB Polygon
MDSLOPV	Median for plot of number of slope classes present in NB Polygon
MOSLOPV	Mode for plot of the number of slope classes present in NB Polygon
XSM	Mean for plot of the mode of slope classes present in NB Polygon
MXSM	Maximum for plot of the mode of slope classes present in NB Polygon
MDSM	Median for plot of the mode of slope classes present in NB Polygon
MOSM	Mode for plot of the mode of slope classes present in NB Polygon

Table 2.2 - Variables describing elevation and slope in waterfowl survey plots.

Variable	Description
CALC0	% of observations in non-calcareous soil class (No CaCO3 detectable)
CALC1	% of observations in weakly calcareous soil class (1-5 % CaCO3)
CALC2	% of observations in strongly calcareous soil class (6-40% CaCO3)
CALC3	% of in extremely calcareous soil class (>40% CaCO3)
CALC#	non applicable (water. rock. ice)
NBPHC1	% of wetlands in pH category buffered (NB Data)
NBPHC2	% of wetlands in pH category slightly acidic (NB Data)
NBPHC3	% of wetlands in pH category acidic (NB Data)
NBPHC4	% of wetlands in pH category most acidic (NB Data)
NSPHC1	% of wetlands in soil buffering capacity category very low (NS Data)
NSPHC2	% of wetlands in soil buffering capacity category low (NS Data)
NSPHC3	% of wetlands in soil buffering capacity category moderate (NS Data)
NSPHC4	% of wetlands in soil buffering capacity category high (NS Data)
NSPHC5	% of wetlands in soil buffering capacity category very high (NS Data)
BVLO	% of wetlands in plot in very low buffering capacity soil category
BLO	% of wetlands in plot in low buffering capacity soil category
BMED	% of wetlands in plot in moderate buffering capacity soil category
BHI	% of wetlands in plot in high buffering capacity soil category
BVHI	% of wetlands in plot in very high buffering capacity soil category

Table 2.3. - Variables describing soil acidity and soil buffering capacity in survey plots.

Variable	Description
MATOR	% of observations in surface material category: Organic Soil
MATR2	% of observations in surface material category: Hard rock acidic
MATR4	% of observations in surface material category: Hard rock (unspecified)
MATSO	% of observations in surface material category: Mineral Soil
ROOT#	% of observations in Rooting Depth: Non- Applicable (rock or ice).
ROOTA	% of observations in Rooting Depth Category: < 20 cm.
ROOTB	% of observations in Rooting Depth Category: 20-75 cm.
ROOTC	% of observations in Rooting Depth Category: 75-150 cm.
ROOTD	% of observations in Rooting Depth Category: > 150 cm.
CFRAG#	% of observations in Coarse Fragment Content Category Non-Applicable
CFRAGA	% of observations in Coarse Fragment Content Category < 10 %.
CFRAGB	% of observations in Coarse Fragment Content Category 10-30 %.
CFRAGC	% of observations in Coarse Fragment Content Category 31- 65 %.
CFRAGD	% of observations in Coarse Fragment Content Category > 65 %.
DRAIN#	% of observations in Drainage Category - Non-Applicable
DRAINI	% of observations in Drainage Category - Imperfect
DRAINM	% of observations in Drainage Category - Moderate
DRAINP	% of observations in Drainage Category - Poor
DRAINR	% of observations in Drainage Category - Rapid
DRAINV	% of observations in Drainage Category - Very Poor
DRAINW	% of observations in Drainage Category - Well Drained
DR1	% of observations in Well Drained Category (NB Data)
DR2	% of observations in Moderately Well Drained Category (NB Data)
DR3	% of observations in Moderately Drained Category (NB Data)
DR4	% of observations in Imperfectly Drained Category (NB Data)
DR5	% of observations in Poorly Drained Category (NB Data)
DR6	% of observations in Very Poorly Drained Category (NB Data)
DR7	% of observations in Organic Soils Category (NB Data)
DR8	% of observations in Water Category (NB Data)

Table 2.4 - Variables describing surface material, rooting depth, coarse fragment content and soil drainage in survey plots.

Variable	**Description**
PMD11	% of observations in Mode of Deposition - Sphagnum Organic Material
PMD21	% of observations in Mode of Deposition - Mesic Sedge
PMD23	% of observations in Mode of Deposition - Mesic Woody Forest
PMD25	% of observations in Mode of Deposition - Mesic Sphagnum
PMDA	% of observations in Mode of Deposition - Alluvial
PMDC	% of observations in Mode of Deposition - Colluvial
PMDF	% of observations in Mode of Deposition - Fluvioglacial
PMDL	% of observations in Mode of Deposition - Lacustrine
PMDM	% of observations in Mode of Deposition - Morainal
PMDO	% of observations in Mode of Deposition - Organic
PMR	% of observations in Mode of Deposition - Bedrock
PMW	% of observations in Mode of Deposition - Marine
D#	% of observations in Soil Development Category Non Applicable.
D3	% of observations in Soil Development Category Podzolic Gray Luvisolic.
DI	% of observations in Soil Development Category Sombric.
DN	% of observations in Soil Development Category Sombric-Brunosolic.
DP	% of observations in Soil Development Category Dystric-Brunosolic.
DQ	% of observations in Soil Development Category Humic-Podzolic.
DR	% of observations in Soil Development Category Regosolic.
DU	% of observations in Soil Development Category Gleysolic.
DV	% of observations in Soil Development Category Ferro-Humic Podzolic.
DW	% of observations in Soil Development Category Humo-Ferric Podzolic.
DX	% of observations in Soil Development Category Fibrosol.
DY	% of observations in Soil Development Category Mesisol.
DZ	% of observations in Soil Development Category Humisol.

Table 2.5 - Variables describing parental mode of soil deposition and soil development in survey plots.

Variable	Description
STREAM	Total stream density (km/km^2) in survey plot
XISTOT	Mean for plot of total length (m) of intermittent streams in NB Polygons
MXISTOT	Maximum for plot of total length (m) of intermittent streams in Polygons
MDISTOT	Median for plot of total length (m) of intermittent streams in NB Polygons
XPSTOT	Mean for plot of total length (m) of permanent streams in NB Polygons
MXPSTOT	Maximum for plot of total length(m) of permanent streams in NB Polygons
MDPSTOT	Median for plot of total length (m) of permanent streams in NB Polygons
XISD	Mean for plot of intermittent stream density in NB Polygons
MXISD	Maximum for plot of intermittent stream density in NB Polygons
MDISD	Median for plot of intermittent stream density in NB Polygons
XPSD	Mean for plot of permanent stream density in NB Polygons
MXPSD	Maximum for plot of permanent stream density in NB Polygons
MDPSD	Median for plot of permanent stream density in NB Polygons
XSTM	Mean for plot of total stream density in NB Polygons
MXSTM	Maximum for plot of total stream density in NB Polygons
MDSTM	Median for plot of total stream density in NB Polygons
TOTLAK	Total number of Lakes in survey plot
MSIZEL	Mean Size of Lakes (km^2) in survey plot
SSIZEL	Total Area of Lakes (km^2) in survey plot

Table 2.6 - Variables describing stream length and number and area of lakes in survey plots.

Variable	Description
N	Number of wetlands
MSIZE2	Mean Size of Wetlands
SSIZE2	Total Area of Wetlands
MXSIZE2	Maximum Size of Wetlands
MDSIZE2	Median Size of Wetlands
OW	Number of Wetlands with Dominant Class = Open Water
DM	Number of Wetlands with Dominant Class = Deep Marsh
SM	Number of Wetlands with Dominant Class = Shallow Marsh
SFF	Number of Wetlands with Dominant Class = Seasonally Flooded Flats
M	Number of Wetlands with Dominant Class = Meadow
SS	Number of Wetlands with Dominant Class = Shrub Swamp
WS	Number of Wetlands with Dominant Class = Wooded Swamp
B	Number of Wetlands with Dominant Class = Bog
POW	Percentage of Wetlands with Dominant Class = Open Water
PDM	Percentage of Wetlands with Dominant Class = Deep Marsh
PSM	Percentage of Wetlands with Dominant Class = Shallow Marsh
PSFF	Percentage of Wetlands with Dominant Class = Seasonally Flooded Flats
PM	Percentage of Wetlands with Dominant Class = Meadow
PSS	Percentage of Wetlands with Dominant Class = Shrub Swamp
PWS	Percentage of Wetlands with Dominant Class = Wooded Swamp
PB	Percentage of Wetlands with Dominant Class = Bog
MNOCL	Mean Number of Wetland sub-Classes
MONOCL	Modal Number of sub-Classes
MDNOCL	Median Number of sub-Classes

Table 2.7 - Variables describing the number and type of wetlands in survey plots.

Variable	Description
INTER1	% of Wetlands with Low Vegetative Interspersion
INTER2	% of Wetlands with Medium Vegetative Interspersion
INTER3	% of Wetlands with High Vegetative Interspersion
MCOV	Mean Cover Type Score
MDCOV	Median Cover Type Score
MOCOV	Modal Cover Type Score
Cover Type 1	Vegetative cover occupies > 95% of wetland **COV = 4.5**
Cover Type 2	Vegetative cover occupies 76-95% of wetland in peripheral band **COV = 4**
Cover Type 3	Cover occupies 76-95% of wetland in dense patches or diffuse stands **COV = 6.0**
Cover Type 4	Vegetative cover occupies 26-75% of wetland in peripheral band. **COV = 7.5**
Cover Type 5	Cover occupies 26-75% of wetland in dense patches or diffuse stands. **COV = 9.0**
Cover Type 6	Vegetative cover occupies 5 – 25% of wetland in peripheral band. **COV = 4.5**
Cover Type 7	Cover occupies 5–25 % of wetland in dense patches or diffuse stands. **COV = 6.0**
Cover Type 8	Vegetative cover occupies < 5% of wetland. **COV = 3.0**
CTYPE1	% of wetlands in Cover Type 1
CTYPE2	% of wetlands in Cover Type 2
CTYPE3	% of wetlands in Cover Type 3
CTYPE4	% of wetlands in Cover Type 4
CTYPE5	% of wetlands in Cover Type 5
CTYPE6	% of wetlands in Cover Type 6
CTYPE7	% of wetlands in Cover Type 7
CTYPE8	% of wetlands in Cover Type 8

Table 2.8 - Variables describing vegetative interspersion and emergent cover type of wetlands in survey plots.

Variable	Description
JP Class 1	Hydrologically connected to other wetlands (different dominant class) or open water body within 1.6 km. **JUXT = 6.0**
JP Class 2	Hydrologically connected to other wetlands (same dominant class) within 0.4 km. **JUXT = 6.0**
JP Class 3	Wetland greater than 202 ha with greater than 3 or more wetland classes. **JUXT = 6.0**
JP Class 4	Hydrologically connected to other wetlands (different dominant class) or open water bodies from 1.6 - 5 km away. **JUXT = 4.0**
JP Class 5	Hydrologically connected to other wetlands (same dominant class) from 0.4 -0.8 km away. **JUXT = 4.0**
JP Class 6	Within 0.8 km of other wetlands (different dominant class) or open water bodies but not hydrologically connected. **JUXT = 4.0**
JP Class 7	No hydrologically connected wetland (same dominant class) within 1.6 km, or no other isolated wetlands (different dominant class) or open water body within 0.8 km. **JUXT = 2.0**
JP1	% of Wetlands with JP Class 1
JP2	% of Wetlands with JP Class 2
JP3	% of Wetlands with JP Class 3
JP4	% of Wetlands with JP Class 4
JP5	% of Wetlands with JP Class 5
JP6	% of Wetlands with JP Class 6
JP7	% of Wetlands with JP Class 7
MJUXT	Mean JP Score
MDJUXT	Median JP Score
MOJUXT	Modal JP Score
SITE1	% of Wetlands that are located: Upland Isolated
SITE2	% of Wetlands that are located: Upland Streamside
SITE3	% of Wetlands that are located: Upland Lakeside
SITE4	% of Wetlands that are located: Bottomland Isolated
SITE5	% of Wetlands that are located: Bottomland Lakeside
SITE6	% of Wetlands that are located: Bottomland Streamside
SITE7	% of Wetlands that are located: Bottomland Deltaic
SITE8	% of Wetlands that are located: Bottomland Seaside

Table 2.9 - Variables that describe juxtaposition and watershed location of wetlands in survey plots.

Variable	Description
MFOR	Mean Percentage of Adjacent Habitat that is Forest
MXFOR	Max Percentage of Adjacent Habitat that is Forest
MDFOR	Median Percentage of Adjacent Habitat that is Forest
MOPEN	Mean Percentage of Adjacent Habitat that is Open/Agricultural
MXOPEN	Mean Percentage of Adjacent Habitat that is Open/Agricultural
MDOPEN	Median Percentage of Adjacent Habitat that is Open/Agricultural
COASTAL	Total number of Coastal Habitat features
ESTUAR	Number of Estuarine Coastal Habitat Features
MARINE	Number of Marine Coastal Habitat Features
ISLAND	Number of Islands
SALTNO	Number of Salt Marshes
SALTHA	Total Area of Salt Marshes
PONDS	Total number of ponds
PONDSHA	Total area of ponds
MCLIN	Mean Score for CLI Class
MDCLIN	Median CLI Score
MOCLIN	Modal CLI Score
CLI Class 1	No limits to production **CLIN = 100**
CLI Class 2	Very slight limitations **CLIN = 80**
CLI Class 3	Slight limitations **CLIN = 70**
CLI Class 4	Moderate limitations **CLIN = 50**
CLI Class 5	Moderately severe limitations **CLIN = 30**
CLI Class 6	Severe limitations **CLIN = 20**
CLI Class 7	Almost no production **CLIN = 0**
MSCOR	Mean Golet Score
MXSCOR	Maximum Golet Score
SSCOR	Sum of Golet Scores

Table 2.10 - Variables that describe adjacent habitat, coastal features, CLI scores, and Golet Scores of wetlands in survey plots

Factor (Significance)	Rank 3.0	Rank 2.5	Rank 2.0	Rank 1.5	Rank 1.0
Wetland Classes (5)	> 5 classes Score 15.0	4 classes Score - 12.5	3 classes Score 10.0	2 classes Score 7.5	1 class Score 5.0
Dominant Class (5)	SFF, DM Score - 15.0	SM Score - 15.0	WS, SS Score 10.0	OW, B Score - 7.5	M Score - 5.0
Size Category (5)	200 + ha Score - 15.0	40+ - 200.0 ha Score - 12.5	10+ - 40.0 ha Score - 10.0	2+ - 10.0 ha Score - 7.5	0.25 - 2.0 ha Score - 5.0
Subclass Richness (4)	10 subclasses Score - 12.0	6 - 9 subclasses Score - 10.0	4 - 5 subclasses Score - 8.0	2 - 3 subclasses Score - 6.0	1 subclass Score - 4.0
Site Type (4)	Bottomland - Lakeside, Streamside, or Deltaic: Score - 12.0		Bottomland - Isolated, Seaside: Score - 8.0 Upland - Lakeside, Streamside: Score - 8.0		Upland - Isolated: Score - 4.0
Adjacent Habitat (4) 1) forest 2) agricultural/open 3) saltmarsh	Two or more habitat classes constitute > 90% of surrounding habitat Score - 12.0		One or more habitat classes constitutes 50 - 90% of surrounding habitat. Score - 8 or One habitat class constitutes > 90% of surrounding habitat. Score - 8		One or more habitat class constitutes 50% of surrounding habitat Score = 4.0
Cover Type (3)	Type 5: Score - 9.0	Type 4: Score - 7.5	Types 3 or 7: Score -6.0	Types 1, 2 or 6: Score - 4.5	Type 8: Score = 3.0
Interspersion (3)	High: Score - 9.0		Moderate: Score - 6.0		Low: Score - 3.0
Juxtaposition (2)	Type 1, 2 or 3: Score - 6.0		Type 4, 5 or 6: Score - 4.0		Type 7: Score - 2.0
Water Chemistry (1)	pH > 7.5: Score - 3.0		pH - 6.5+ - 7.5: Score - 2.0		pH < 6.5 Score - 1.0

Table 2.11 - Wetland Habitat Diversity (Golet) Scoring System for New Brunswick and Nova Scotia (Hanson &Calkins 1996).

Variable	Description
TMINYR	Annual mean minimum temperature
TMINGS	Mean minimum temperature (May. June. July and August)
TMINAPR	Mean minimum temperature April.
TMINMAY	Mean minimum temperature May
TMAXYR	Annual mean maximum temperature
TMAXGS	Mean maximum temperature (May. June. July and August)
TMAXAPR	Mean maximum temperature April
TMAXMAY	Mean maximum temperature May
SNOWYR	Annual mean number of days with snow
SNOWAPR	Mean number of days with snow in April
SNOWMAY	Mean number of days with snow in May
SNOWAM	Mean number of days with snow in April and May
PPMAY	Mean total precipitation in May
PPJUNE	Mean total precipitation in June
PPMY	Mean total precipitation in May and June
PPGS	Mean total precipitation in May. June. July and August
PPYR	Annual mean precipitation

Table 2.12 - Variables describing climatic conditions in survey plots

Variable	Description
LN	Log transformed (total number of wetlands)
AB	arcsine square root transformed (% of wetlands that are bogs)
AOW	arcsine square root transformed (% of wetlands that are open water)
ASS	arcsine square root transformed (% of wetlands that are shrub-swamp)
LMCLIN	Log transformed (mean CLI score)
LMNOCL	Log transformed (mean number of wetland sub-classes)
LMCOV	Log transformed (mean vegetative cover score)
LMJUXT	Log transformed (mean juxtaposition score)
LMSIZE	Log transformed (mean wetland size)
LMLK	Log transformed (mean lake size)
LTOTLAK	Log transformed (total number of lakes)
LSSIZEL	Log transformed (total lake area)
LXSTM	Log transformed (mean stream density)
LELVAV	Log transformed (mean elevation)
LELVSTD	Log transformed (standard deviation of elevation)
DPOOR	DRAINV + DRAINP
DGOOD	DRAINW + DRAINR
SFBOG	SFB04 + SFB14 + SFF13
SFHILL	SFD + SFR + SFS
SLOPE	SLOPED + SLOPEE + SLOPEF

Table 2.13 - Derived and transformed variables for use in principal components analysis of environmental descriptors of survey plots.

Plot	I.D.	Region	District	Unit	Sub-Unit
26	413A	Atlantic Interior	Quartzite Plains	Quartzite Barrens	Halifax
26	453	Atlantic Interior	Granite	Granite Ridge	
27	851	Atlantic Coast	Granite Barrens	Pennant Barrens	
28	460A	Atlantic Interior	Bays	Mahone Bay	
28	451A	Atlantic Interior	Granite	Granite Uplands	South Mountain
29	433	Atlantic Interior	Drumlins	Kejimikujik Drumlins	
29	412C	Atlantic Interior	Quartzite Plains	Mersey Meadows	Rocky Lake
30	452	Atlantic Interior	Granite	Shelburne Granite Plain	
31	412A	Atlantic Interior	Quartzite Plains	Mersey Meadows	Lake Rossignal
31	831	Atlantic Coast	Beaches and Islands	Tusket Islands	
32	451A	Atlantic Interior	Granite	Granite Uplands	South Mountain
33	451A	Atlantic Interior	Granite	Granite Uplands	South Mountain
33	422A	Atlantic Interior	Slopes and Ridges	South Mountain Slope	Bear River
34	720	Fundy Coast	Basalt Ridge		
34	610	Triassic Lowlands	Valley		
35	511A	Carboniferous Lowlands	Till Plain	Windsor Lowlands	Shubenacadie River
35	540A	Carboniferous Lowlands	Clay Plain	Comagun River	
36	423A	Atlantic Interior	Slopes and Ridges	Slate Ridges	Rawdon Hills
36	413A	Atlantic Interior	Quartzite Plains	Quartzite Barrens	Halifax
37	413B	Atlantic Interior	Quartzite Plains	Quartzite Barrens	Guysborough
38	413B	Atlantic Interior	Quartzite Plains	Quartzite Barrens	Guysborough
39	572	Carboniferous Lowlands	Rolling Upland	St. Mary's Fault Block	
40	572	Carboniferous Lowlands	Rolling Upland	St. Mary's Fault Block	
41	581	Carboniferous Lowlands	Hills and Valleys	Cumberland Hills	
41	311	Avalon Uplands	Hardwood Plateau	Cobequid Hills	
42	521A	Carboniferous Lowlands	Coastal Plain	Northumberland Plain	Northumb. Strait
43	521A	Carboniferous Lowlands	Coastal Plain	Northumberland Plain	Northumb. Strait
43	582A	Carboniferous Lowlands	Hills and Valleys	Pictou Valleys	Pictou Rivers
44	521B	Carboniferous Lowlands	Coastal Plain	Northumberland Plain	St. Georges Bay
44	312	Avalon Uplands	Hardwood Plateau	Pictou-Antigonish Highlands	
44	583A	Carboniferous Lowlands	Hills and Valleys	Antigonish Uplands	South River
45	571	Carboniferous Lowlands	Rolling Upland	Mulgrave Block	
45	583A	Carboniferous Lowlands	Hills and Valleys	Antigonish Uplands	South River
46	852	Atlantic Coast	Granite Barrens	Canso Barrens	
47	330B	Avalon Uplands	Fault Ridges	East Bay Hills	
47	512	Carboniferous Lowlands	Till Plain	Salmon River Lowland	
48	531	Carboniferous Lowlands	Stony & Wet Plain	Sydney Coal Field	
48	870	Atlantic Coast	Till Plain		
49	100	Plateau Taiga			
49	210A	Highlands	Plateau - Fir Forest	The Highlands	
50	522	Carboniferous Lowlands	Coastal Plain	Judique C. Lowland	
50	584	Carboniferous Lowlands	Hills and Valleys	Ainslie Uplands	

Table 2.14- Nova Scotia Natural History Theme units for survey plots. See Figure 2.3.

Region	District	Section	PQUAD								
1	1	2	74D	75A	75C	75D					
1	2	10	63A	63B							
2	1	1	74A	74C	74D	75A	75B				
2	1	2	73A	73B							
2	2	2	71D								
2	2	3	71A	71B	71C	71D	71D				
2	2	4	71B	71C							
2	3	1	72B	72C							
2	3	2	72B								
2	3	3	71A								
2	4	4	65A								
2	5	1	72A	72B	72C	72D					
3	1	1	75B	75C							
3	2	7	73A	73C	73D	74B					
3	3	2	63D								
3	4	2	61C								
3	4	3	62C	62D							
3	5	1	63A	63B	63C	63D					
3	5	5	61A	61C	61D						
3	6	2	51B	51C							
4	1	6	57A	57B	57C	57D					
5	1	1	62A	62B	62D						
5	3	2	60A	60B	60B	60C	60D				
5	4	4	64A	64B	64C	64D					
5	6	11	61B								
5	7	3	59B	59C	59A	59B	59D				
5	9	2	58A	58D							
5	10	1	59B								
5	10	2	58C	58D							
5	10	3	58A	58B	58C						
5	10	4	58B								
5	12	7	51C	51D	52A	52B	52C				
6	1	1	69A	69B	69C	69D	70A	70B	70C		
6	2	1	70A	70C	70D						
6	4	1	66B	66C	66D						
6	4	2	54D	66B							
6	4	4	53A	53B	53D	54A	54B	54D	67A		
6	4	5	53B	53C	53D	54B	54C	54D	55A	55B	55B
6	3	1	66B								
6	3	2	65B								
6	5	1	56A								
6	6	2	68A	68B	68D	68D					
6	6	3	67D	68C	68D						
6	6	4	66A	67B	67B	67C	67D				
6	7	1	52A	52D	53B	53B					
6	7	6	51A	51B	51C						
7	2	1	55A	55C	55D	56A	56B	56C	56D		

Table 2.15 - New Brunswick Ecological Land Classification for survey plots.

Region	District	PQUADs
117	481	74A 74D 75A 75B 75C 75D
118	484	72C 73A 73D 74A
118	485	71A 71A 71B 71C 71D 72A 72B 72C 72D
118	486	73A 73B 73C 73D 74B
118	487	74D 75A 75B 75C
118	488	64A 64B 64C 64D 65A 65B 65C 65D
118	489	61A 61A 61B 61C 61D 62C 63A 63B 63C 63D
118	490	62A 62B 62C 62D
119	492	63A 63B 63C
120	493	62D
120	494	60A 60B 60C 60D
121	495	59A 59B 59C 59D
121	496	51A 51B 51C 51D 52A 52B 52C 52D
121	497	59B
121	498	51A 51C
121	499	57A 57B 57C 57D 58A 58B 58C 58D
122	500	68A 68B 70A 70C 70D
122	501	69A 69B 69C 69D 70B 70C
122	502	56A 66B 66B 66C 66D
122	503	52D 53A 53B 53C 53D 54A 54B 54C 54D 55A 55B 55C 55D 66A 66B 66D
122	503	67A 67B 67C 67D 68A
122	504	42A 42B 42C 42D 43A 43B 43C 43D
122	505	55A 55C 55D 56A 56B 56C 56D
123	507	41B 41C 51B
123	509	34A 34D
124	510	32A 32C 32D 33A 33B 33C
124	511	28A 28B 28C 28D
124	512	28B 28C 29A 29B 29C 29D 32A 32B
124	513	33D 34D
124	515	30A 30B 30C 30D 31A 31D
125	516	27A 27B 27C 27D 30A 30B 31A 31B 31C 31D 46A 46B 46C 46D 47B 48B
126	517	35A 35B 35C 35D
126	518	34A 34B 34C
127	519	26A 26B 26C 26D 37A 37B 37C 37D 38A 38B 38C 38D
127	520	26A 26C 36A 36B 36C 36D
128	521	49B 49C 49D
128	522	50A 50B 50C 50D
128	523	48A 48B 48C 48D 47A 47B 47C 48B 48C
128	524	47A 47C 48D
128	525	44A 44B 44C 44D 45D
128	527	43B 44C 44D
128	528	41A 41B 41C 41D
128	529	45A 45B 45C 45D
128	530	41A 41B 40D
128	531	39A 39B 39C 39D 40A 40B 40C 40D 43C
129	532	49A 49B 49C 49D
129	533	49B 49C

Table 2.16 - Ecological Framework for Canada regions and districts for survey plots

			Moran's I Spatial Autocorrelation Statistic (Data Transformation Listed in Brackets)								
Lag Class	**Average Distance (m)**	**No Pairs**	**Roads** (Log + 1)	**No. of Buildings** (Log + 1)	**ELVSTD** (Square Root)	**ELVMED** (Square Root)	**Soil pH** (Raw Data)	**MATOR** (Sq. Root)	**SFBOG** (Sq. Root)	**Stream Density** (Log + 1)
1	5697	303	0.336	0.539	0.635	0.9	0.611	0.764	0.765	0.3966
2	13582	43	0.168	0.343	0.835	0.9	0.524	0.657	0.624	0.0007
3	20376	117	0.065	0.257	0.517	0.55	0.483	0.636	0.677	0.1782
4	28184	158	-0.166	0.086	0.236	0.25	0.134	0.361	0.436	0.1623
5	36213	137	-0.092	-0.026	0.133	0.1	0.194	0.089	0.229	0.1104
6	44266	168	0.053	0.395	-0.025	0.29	0.281	0.032	0.243	0.2909
7	51942	193	-0.001	0.401	0.217	0.09	0.168	0.144	0.182	0.0856
8	60068	182	0.004	0.142	0.108	0	-0.274	-0.146	-0.106	0.0727
9	68443	268	0.056	0.15	-0.001	0.23	-0.075	-0.088	-0.026	-0.2035
10	76027	344	0.04	0.146	-0.035	0.25	0.116	-0.083	-0.076	0.0125
11	84167	354	-0.13	-0.128	-0.105	0.01	0.322	0.093	0.089	-0.035
12	92150	410	-0.002	0.082	-0.009	0.07	0.302	0.088	0.054	0.0195
13	99993	463	-0.032	0.107	0.039	0.18	0.267	-0.03	-0.109	-0.0372
14	107583	338	-0.097	0.024	0.069	0.11	0.116	-0.215	-0.206	0.0923
15	116330	336	-0.28	-0.014	-0.072	0.08	-0.113	-0.236	-0.194	-0.1254
16	123802	394	-0.052	-0.074	-0.02	0.01	-0.114	-0.162	-0.079	-0.1247
17	132072	384	0.061	-0.13	-0.088	0.11	0.069	-0.096	0.008	0.0182
18	140081	468	-0.017	-0.046	0.071	0.33	0.113	-0.037	0.005	0.0544
19	147891	437	0.11	0.182	-0.128	0.23	0.068	0.002	0.006	0.0087
20	155752	357	0.113	0.06	-0.149	-0.1	0.027	-0.007	-0.018	-0.0469

Table 2.17 - Moran's I spatial autocorrelation statistic for topographic variables.

			Moran's I Spatial Autocorrelation Statistic (Data Transformation Listed in Brackets)						
Lag Class	Average Distance (m)	No. Pairs	Lake Area (Log + 1)	No. Lakes (Log + 1)	No. Wetlands (Log)	Wetland Area (Log + 1)	% Bogs (Raw Data)	Med. Golet Score (Raw Data)	Max. Golet Score (Raw Data)
1	5697	303	0.515	0.563	0.563	0.539	0.705	0.357	0.378
2	13582	43	0.345	0.51	0.531	0.731	0.764	0.223	0.144
3	20376	117	0.35	0.338	0.625	0.506	0.649	0.357	0.083
4	28184	158	0.423	0.328	0.228	0.056	0.414	0.322	0.105
5	36213	137	0.579	0.451	0.062	-0.037	0.345	0.323	0.164
6	44266	168	0.137	0.123	0.207	0.168	0.213	0.232	0.162
7	51942	193	0.204	0.141	0.372	0.274	0.093	0.176	0.271
8	60068	182	0.133	0.032	-0.163	-0.181	0.117	0.135	-0.069
9	68443	268	0.146	0.067	-0.049	-0.096	-0.026	0.087	0.171
10	76027	344	0.156	-0.044	-0.017	-0.059	0.055	0.099	0.248
11	84167	354	0.021	0.069	-0.213	-0.128	0.028	0.103	0.123
12	92150	410	0.316	0.15	-0.035	-0.091	0.21	-0.05	0.052
13	99993	463	0.259	0.226	-0.024	-0.013	0.224	0.062	0.076
14	107583	338	0.236	0.206	-0.053	0.031	0.203	-0.028	0.042
15	116330	336	0.004	0.078	-0.16	-0.146	-0.104	0.022	0.149
16	123802	394	0.004	0.043	0.009	0.053	-0.12	0.18	0.233
17	132072	384	0.098	0.002	-0.154	-0.016	-0.079	0.064	0.18
18	140081	468	0.019	-0.057	-0.097	0.114	0.044	-0.028	0.055
19	147891	437	-0.006	-0.131	-0.036	0.078	-0.215	-0.128	0.065
20	155752	357	-0.107	-0.167	-0.135	0.011	-0.104	-0.081	0.073

Table 2.18 - Moran's I spatial autocorrelation statistic for wetland related variables.

Variables	SOILPH	CFRAGC	VEGA	DGOOD	DPOOR	MATOR	SFBOG	SFHILL	SLOPE	TOTLAK	ELVAV	ELVSTD	XSTM
SOILPH	1	-0.0486	0.5027	-0.3107	-0.0641	-0.3906	-0.3421	0.2015	0.3636	-0.5686	-0.015	0.1404	0.3685
CFRAGC	-0.0486	1	-0.1167	0.4442	-0.296	-0.3309	-0.3731	0.1897	0.3264	0.0782	0.4298	0.3573	0.4383
VEGA	0.5027	-0.1167	1	-0.1527	-0.0973	-0.2849	-0.2636	0.1477	0.0913	-0.4519	-0.2347	0.1194	0.3539
DGOOD	-0.3107	0.4442	-0.1527	1	-0.6045	-0.3241	-0.3074	0.4299	0.339	0.3329	0.5293	0.5142	0.1955
DPOOR	-0.0641	-0.296	-0.0973	-0.6045	1	0.7144	0.6809	-0.3336	-0.3195	-0.1338	-0.3464	-0.4782	-0.1581
MATOR	-0.3906	-0.3309	-0.2849	-0.3241	0.7144	1	0.9516	-0.1992	-0.2482	0.1133	-0.2768	-0.4409	-0.3367
SFBOG	-0.3421	-0.3731	-0.2636	-0.3074	0.6809	0.9516	1	-0.2243	-0.2578	0.1746	-0.3346	-0.5008	-0.4348
SFHILL	0.2015	0.1897	0.1477	0.4299	-0.3336	-0.1992	-0.2243	1	0.7011	-0.0871	0.3025	0.6106	0.2609
SLOPE	0.3636	0.3264	0.0913	0.339	-0.3195	-0.2482	-0.2578	0.7011	1	-0.1383	0.3597	0.5584	0.3139
TOTLAK	-0.5686	0.0782	-0.4519	0.3329	-0.1338	0.1133	0.1746	-0.0871	-0.1383	1	0.0727	0.0139	-0.4576
ELVAV	-0.015	0.4298	-0.2347	0.5293	-0.3464	-0.2768	-0.3346	0.3025	0.3597	0.0727	1	0.5469	0.4353
ELVSTD	0.1404	0.3573	0.1194	0.5142	-0.4782	-0.4409	-0.5008	0.6106	0.5584	0.0139	0.5469	1	0.4383
XSTM	0.3685	0.4383	0.3539	0.1955	-0.1581	-0.3367	-0.4348	0.2609	0.3139	-0.4576	0.4353	0.4383	1

Table 2.19 - Correlation matrix from a PCA of topographical variables.

	Eigenvalue	Difference	Proportion	Cumulative
PRIN1	4.79432	2.20684	0.368794	0.368794
PRIN2	2.58748	1.06856	0.199037	0.567831
PRIN3	1.51892	0.37863	0.11684	0.684671
PRIN4	1.14029	0.45015	0.087715	0.772386
PRIN5	0.69014		0.053088	0.825474

Table 2.20 - Eigenvalues and amount of total variation explained by PC1 -PC5 from a PCA of topographical features.

Variable	PRIN1	PRIN2	PRIN3	PRIN4	PRIN5
SOILPH	0.154577	-0.487041	0.061017	-0.079449	-0.417169
CFRAGC	0.255736	0.175991	0.020682	0.474283	-0.003873
VEGA	0.106985	-0.446281	-0.06667	-0.180225	0.639623
DGOOD	0.280031	0.378638	0.005439	-0.064537	0.352783
DPOOR	-0.330409	-0.132348	0.3463	0.270916	-0.027373
MATOR	-0.346533	0.10794	0.464814	0.065333	0.172212
SFBOG	-0.360179	0.108911	0.41645	-0.027963	0.137449
SFHILL	0.281945	0.025386	0.432524	-0.402648	0.083732
SLOPE	0.297149	-0.019636	0.432774	-0.245294	-0.304325
TOTLAK	-0.065795	0.493062	-0.153218	-0.210484	0.008846
ELVAV	0.281866	0.226545	0.159663	0.348959	-0.205449
ELVSTD	0.362492	0.087739	0.18019	-0.102467	0.110027
XSTM	0.280873	-0.212356	0.161747	0.504759	0.298439

Table 2.21 - Eigenvectors for PC1 - PC5 from a PCA of topographical features.

	snowyr	snowa	snowm	Snowam	ppmay	ppjune	ppmj	ppgs	ppyr	tmxyr	tmxgs	tmxmay	tmnyr	tmngs	tmnmay	tmnapr
snowyr	**1.00**	0.87	0.70	0.87	-0.21	-0.27	-0.27	-0.15	-0.05	-0.36	0.17	0.04	-0.27	-0.17	-0.38	-0.32
snowa	0.87	**1.00**	0.75	0.99	-0.01	-0.16	-0.09	-0.02	-0.23	-0.45	0.25	0.12	-0.44	-0.26	-0.44	-0.48
snowm	0.70	0.75	**1.00**	0.81	0.15	-0.13	0.03	-0.10	0.08	-0.21	0.04	-0.10	0.00	0.00	-0.17	-0.19
snowam	0.87	0.99	0.81	**1.00**	0.02	-0.17	-0.07	-0.04	-0.19	-0.42	0.23	0.10	-0.38	-0.22	-0.41	-0.44
ppmay	-0.21	-0.01	0.15	0.02	**1.00**	0.60	0.92	0.68	0.40	0.19	0.01	0.02	0.15	0.06	0.12	0.11
ppjune	-0.27	-0.16	-0.13	-0.17	0.60	**1.00**	0.87	0.84	0.37	-0.06	-0.31	-0.20	-0.04	-0.14	-0.01	-0.01
ppmj	-0.27	-0.09	0.03	-0.07	0.92	0.87	**1.00**	0.84	0.42	0.09	-0.15	-0.09	0.07	-0.03	0.07	0.06
ppgs	-0.15	-0.02	-0.10	-0.04	0.68	0.84	0.84	**1.00**	0.25	-0.23	-0.17	-0.09	-0.34	-0.45	-0.33	-0.30
ppyr	-0.05	-0.23	0.08	-0.19	0.40	0.37	0.42	0.25	**1.00**	0.41	-0.31	-0.39	0.58	0.23	0.15	0.45
tmxyr	-0.36	-0.45	-0.21	-0.42	0.19	-0.06	0.09	-0.23	0.41	**1.00**	0.41	0.41	0.67	0.59	0.65	0.75
tmxgs	0.17	0.25	0.04	0.23	0.01	-0.31	-0.15	-0.17	-0.31	0.41	**1.00**	0.96	-0.24	0.05	0.05	-0.02
tmxmay	0.04	0.12	-0.10	0.10	0.02	-0.20	-0.09	-0.09	-0.39	0.41	0.96	**1.00**	-0.29	0.02	0.12	0.00
tmnyr	-0.27	-0.44	0.00	-0.38	0.15	-0.04	0.07	-0.34	0.58	0.67	-0.24	-0.29	**1.00**	0.82	0.76	0.83
tmngs	-0.17	-0.26	0.00	-0.22	0.06	-0.14	-0.03	-0.45	0.23	0.59	0.05	0.02	0.82	**1.00**	0.91	0.79
tmnmay	-0.38	-0.44	-0.17	-0.41	0.12	-0.01	0.07	-0.33	0.15	0.65	0.05	0.12	0.76	0.91	**1.00**	0.85
tmnapr	-0.32	-0.48	-0.19	-0.44	0.11	-0.01	0.06	-0.30	0.45	0.75	-0.02	0.00	0.83	0.79	0.85	**1.00**

Table 2.22 - Correlation matrix from a PCA of climatic variables.

	Eigenvalue	Difference	Proportion	Cumulative
PRIN1	5.45406	1.6127	0.34088	0.340878
PRIN2	3.84141	1.2286	0.24009	0.580967
PRIN3	2.61285	0.3689	0.1633	0.74427
PRIN4	2.24399	1.4581	0.14025	0.884519
PRIN5	0.78586	.	0.04912	0.933635

Table 2.23 - Eigenvalues and amount of total variation explained by PC1 -PC5 from a PCA of climatic variables.

	PRIN1	PRIN2	PRIN3	PRIN4	PRIN5
SNOWYR	-0.295713	-0.130452	0.333582	-0.099264	0.158777
SNOWA	-0.343067	-0.060859	0.337299	0.016883	-0.098104
SNOWM	-0.202419	-0.043982	0.47143	-0.128132	-0.048855
SNOWAM	-0.331216	-0.062237	0.372898	-0.000718	-0.090331
PPMAY	0.094608	0.356627	0.28427	0.219427	-0.114564
PPJUNE	0.075204	0.449453	0.058173	0.067507	-0.138601
PPMJ	0.096843	0.442659	0.203743	0.171735	-0.142641
PPGS	-0.044429	0.477175	0.002544	0.164253	0.017709
PPYR	0.199032	0.190837	0.269248	-0.184899	0.659929
TMXYR	0.322131	-0.132358	0.152443	0.262139	0.362997
TMXGS	-0.060089	-0.215564	0.088474	0.575073	0.159128
TMXMAY	-0.031598	-0.179526	0.006978	0.61757	0.034889
TMNYR	0.351128	-0.093773	0.242328	-0.21004	0.06066
TMNGS	0.302773	-0.202993	0.260561	-0.04547	-0.344892
TMNMAY	0.348515	-0.150598	0.158196	0.050345	-0.430131
TMNAPR	0.365794	-0.123784	0.180809	-0.023257	0.013031

Table 2.24 - Eigenvectors for PC1 - PC5 from a PCA of climactic variables.

	LN	AB	AOW	ASS	LMCLIN	LMNOCL	LMCOV	LMJUXT	LMSIZE2	LSSIZE2	LMLK	LTOTLAK	LSSIZEL	LXSTM	LELVAV	LELVSTD
LN	1.00	0.43	-0.20	-0.16	0.37	0.31	0.32	0.12	0.18	0.72	0.18	0.48	0.48	-0.32	-0.02	-0.44
AB	0.43	1.00	-0.49	-0.74	0.08	0.19	0.27	-0.32	0.10	0.34	0.35	0.39	0.56	-0.63	-0.40	-0.48
AOW	-0.20	-0.49	1.00	0.17	0.08	-0.09	-0.07	0.17	-0.15	-0.25	-0.08	0.09	0.08	0.32	0.11	0.42
ASS	-0.16	-0.74	0.17	1.00	0.08	0.22	-0.20	0.32	-0.04	-0.13	-0.34	-0.27	-0.45	0.40	0.36	0.20
LMCLIN	0.37	0.08	0.08	0.08	1.00	0.42	0.38	0.47	0.18	0.33	0.28	0.21	0.30	-0.12	-0.09	-0.34
LMNOCL	0.31	0.19	-0.09	0.22	0.42	1.00	0.24	0.12	0.24	0.36	-0.02	0.21	0.16	-0.18	-0.08	-0.30
LMCOV	0.32	0.27	-0.07	-0.20	0.38	0.24	1.00	0.44	0.06	0.24	0.25	0.39	0.56	-0.31	0.02	-0.07
LMJUXT	0.12	-0.32	0.17	0.32	0.47	0.12	0.44	1.00	0.07	0.11	-0.03	0.19	0.21	0.18	0.24	0.16
LMSIZE2	0.18	0.10	-0.15	-0.04	0.18	0.24	0.06	0.07	1.00	0.81	0.31	-0.03	0.07	0.02	-0.17	-0.47
LSSIZE2	0.72	0.34	-0.25	-0.13	0.33	0.36	0.24	0.11	0.81	1.00	0.33	0.26	0.34	-0.19	-0.13	-0.60
LMLK	0.18	0.35	-0.08	-0.34	0.28	-0.02	0.25	-0.03	0.31	0.33	1.00	0.01	0.53	-0.33	-0.33	-0.36
LTOTLAK	0.48	0.39	0.09	-0.27	0.21	0.21	0.39	0.19	-0.03	0.26	0.01	1.00	0.74	-0.46	0.07	0.01
LSSIZEL	0.48	0.56	0.08	-0.45	0.30	0.16	0.56	0.21	0.07	0.34	0.53	0.74	1.00	-0.53	-0.15	-0.20
LXSTM	-0.32	-0.63	0.32	0.40	-0.12	-0.18	-0.31	0.18	0.02	-0.19	-0.33	-0.46	-0.53	1.00	0.44	0.44
LELVAV	-0.02	-0.40	0.11	0.36	-0.09	-0.08	0.02	0.24	-0.17	-0.13	-0.33	0.07	-0.15	0.44	1.00	0.55
LELVSTD	-0.44	-0.48	0.42	0.20	-0.34	-0.30	-0.07	0.16	-0.47	-0.60	-0.36	0.01	-0.20	0.44	0.55	1.00

Table 2.25 - Correlation matrix from PCA of wetland features for wetlands in survey plots.

VARIABLE	PRIN1	PRIN2	PRIN3	PRIN4	PRIN5
LN	0.31	0.17	-0.04	-0.31	0.18
AB	0.35	-0.27	0.14	-0.17	0.00
AOW	-0.15	0.23	0.19	0.40	0.07
ASS	-0.23	0.32	-0.27	-0.13	-0.24
LMCLIN	0.20	0.35	-0.11	0.20	-0.36
LMNOCL	0.17	0.23	-0.20	-0.29	-0.41
LMCOV	0.23	0.27	0.22	0.08	-0.09
LMJUXT	0.01	0.50	0.04	0.16	-0.07
LMSIZE2	0.18	0.07	-0.46	0.16	0.39
LSSIZE2	0.32	0.14	-0.35	-0.07	0.38
LMLK	0.25	-0.08	-0.02	0.56	0.08
LTOTLAK	0.24	0.20	0.38	-0.24	0.14
LSSIZEL	0.33	0.13	0.34	0.16	0.11
LXSTM	-0.31	0.18	-0.19	0.10	0.29
LELVAV	-0.19	0.30	0.11	-0.32	0.38
LELVSTD	-0.30	0.14	0.36	-0.01	0.19

Table 2.26 - Eigenvectors from PCA of wetland features for wetlands in survey plots.

PCA	Eigenvalue	Difference	Proportion	Cumulative
PRIN1	4.98761	2.44374	0.311726	0.311726
PRIN2	2.54387	0.39448	0.158992	0.470718
PRIN3	2.14939	0.86202	0.134337	0.605055
PRIN4	1.28737	0.16834	0.080461	0.685516
PRIN5	1.11903	.	0.06994	0.755455

Table 2.27 - Eigenvalues from PCA of wetland features for wetlands in survey plots.

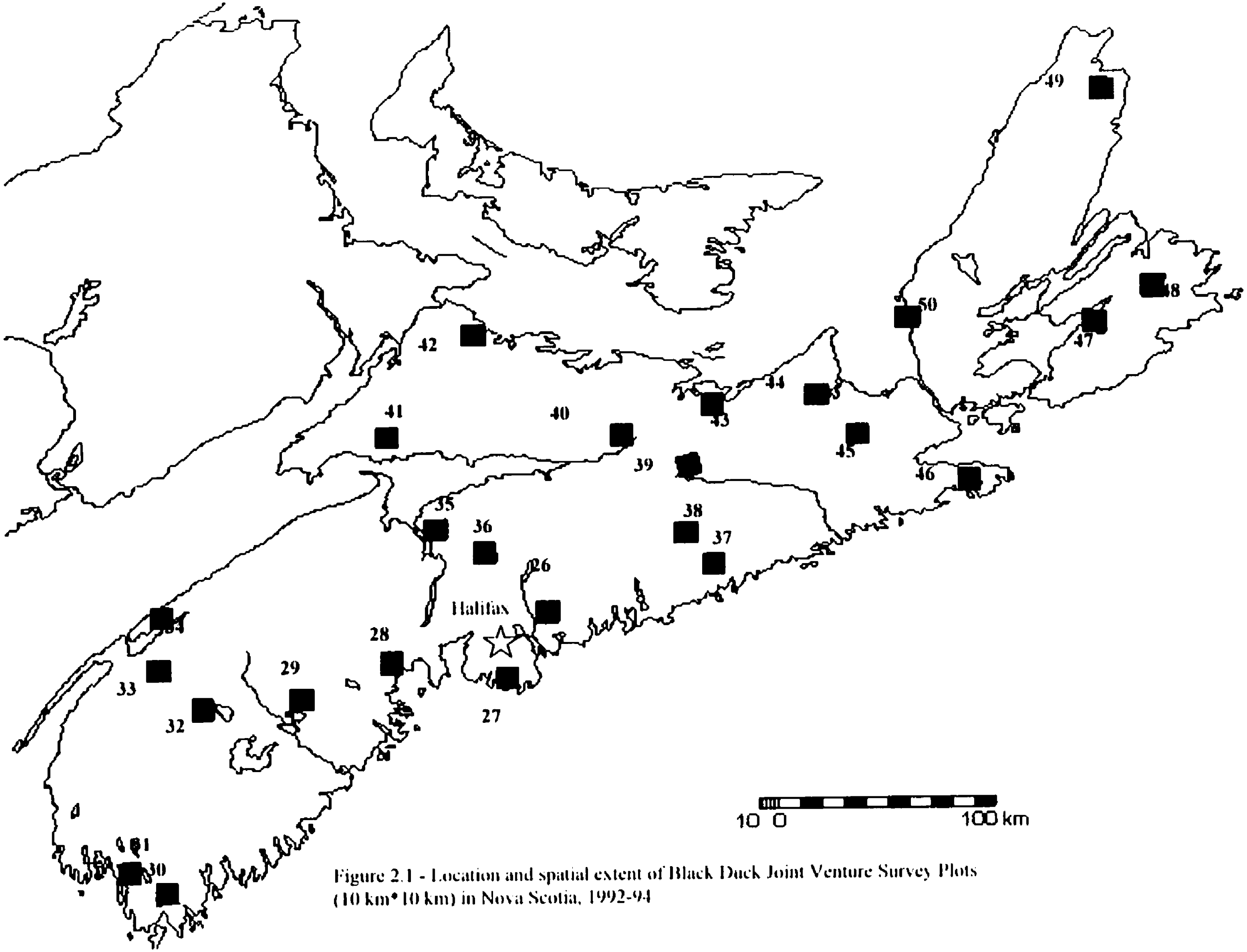

Figure 2.1 - Location and spatial extent of Black Duck Joint Venture Survey Plots (10 km*10 km) in Nova Scotia, 1992-94

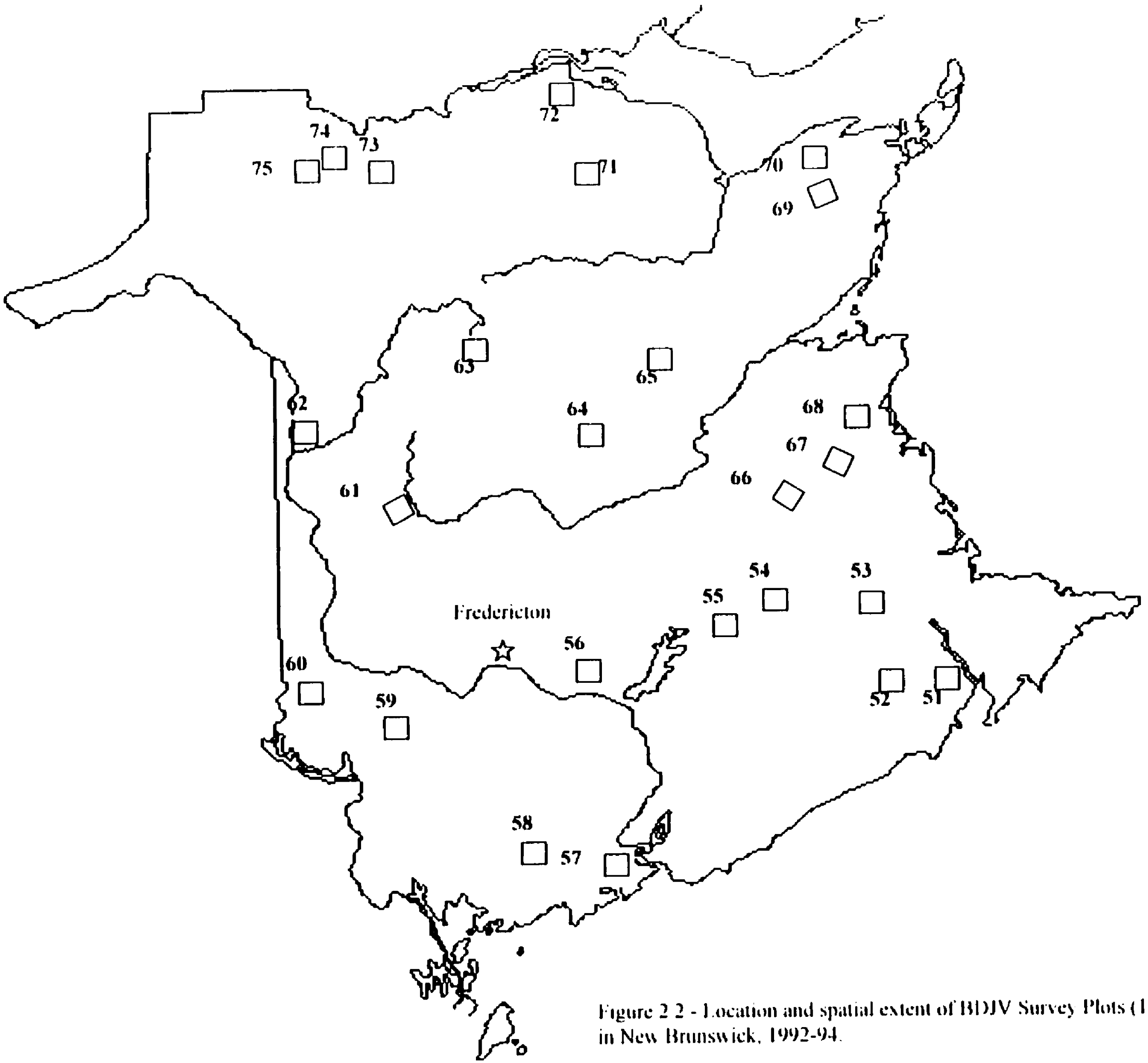

Figure 2.2 - Location and spatial extent of BDJV Survey Plots (10 km*10 km) in New Brunswick, 1992-94.

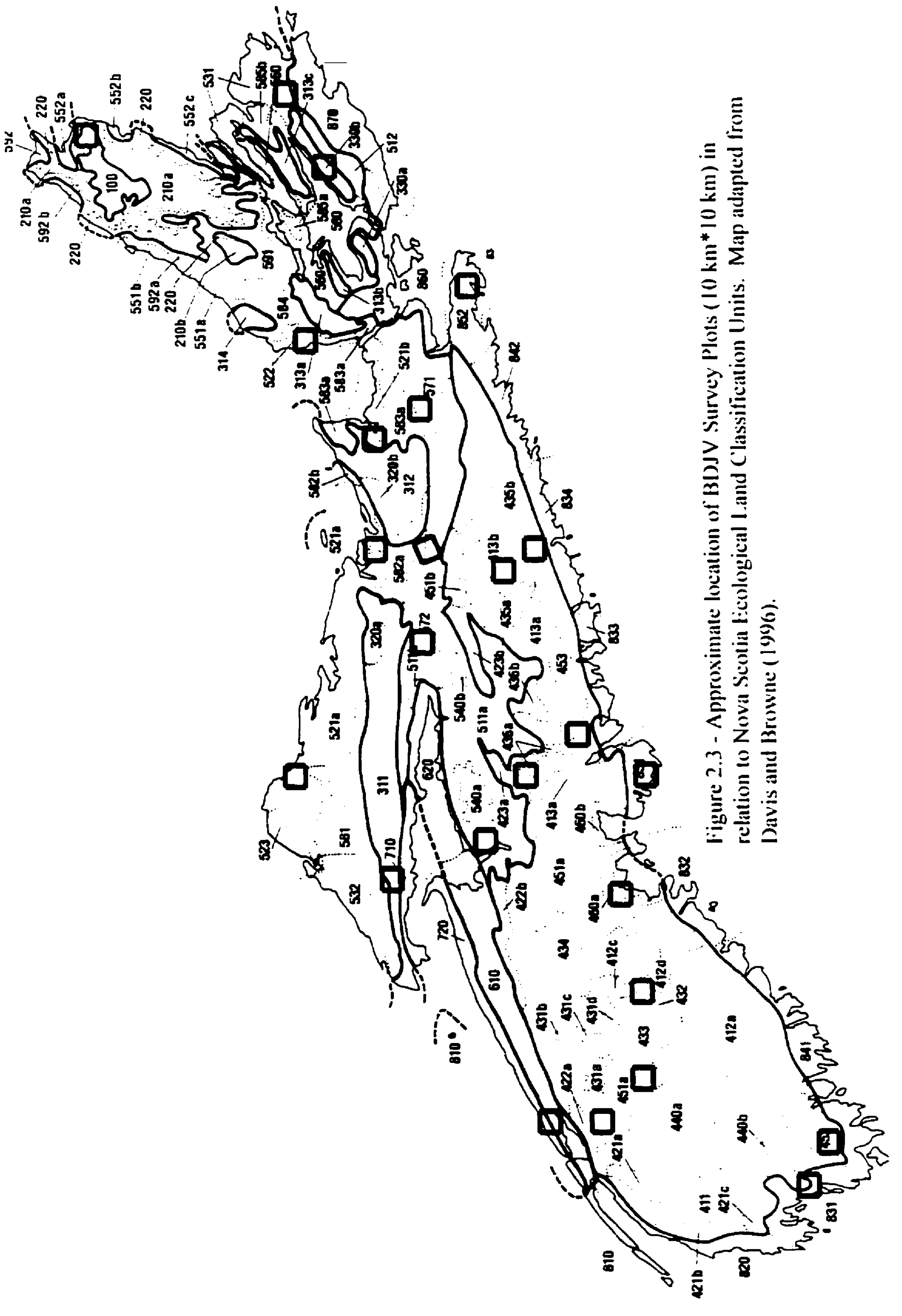

Figure 2.3 - Approximate location of BDJV Survey Plots (10 km*10 km) in relation to Nova Scotia Ecological Land Classification Units. Map adapted from Davis and Browne (1996).

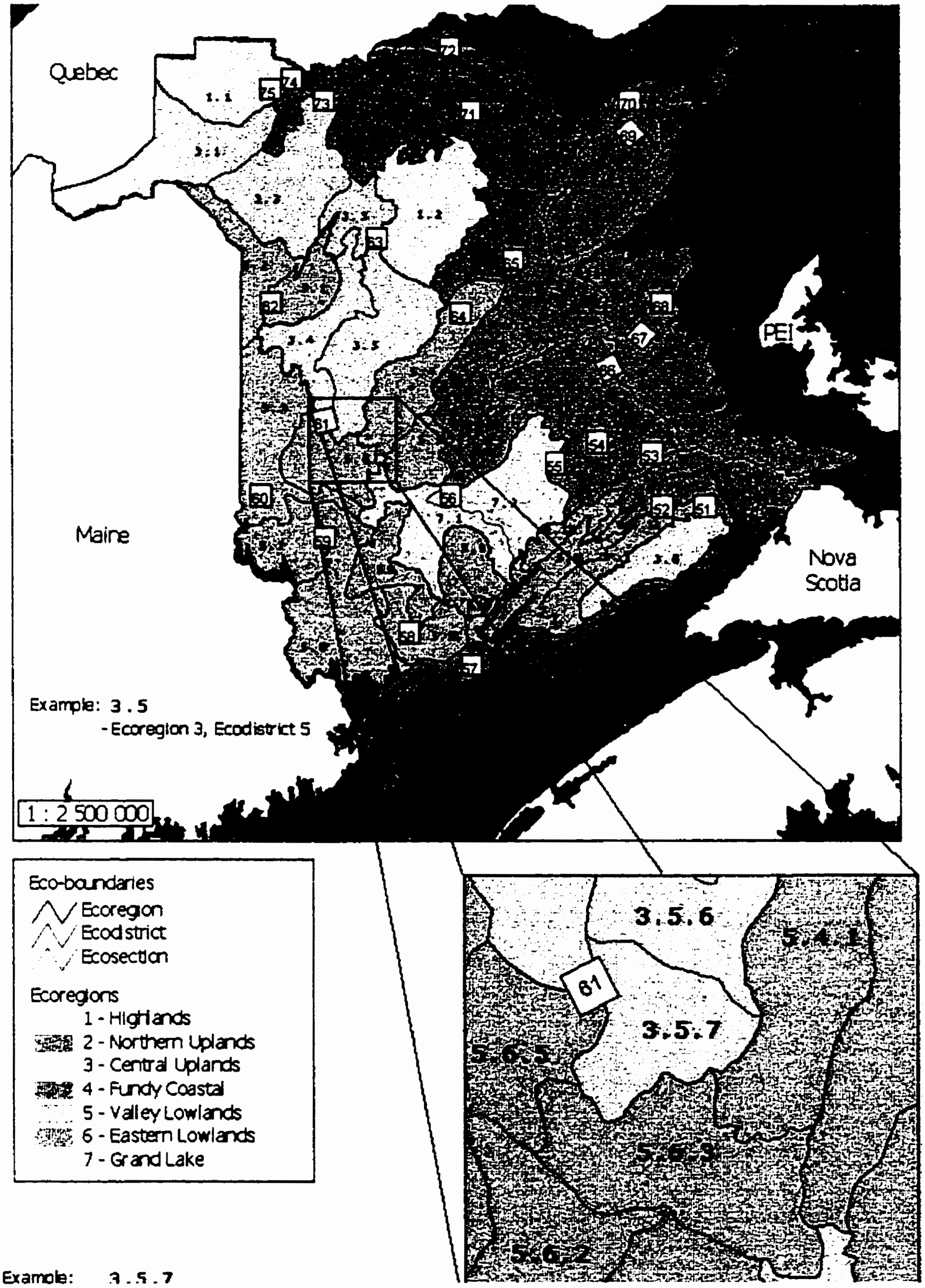

Figure 2.4 - Approximate location of survey plots in relation to New Brunswick ecological land classification units. Base map courtesy of V. Zelazny, NB-DNR&E. Survey plot numbers are indicated on map.

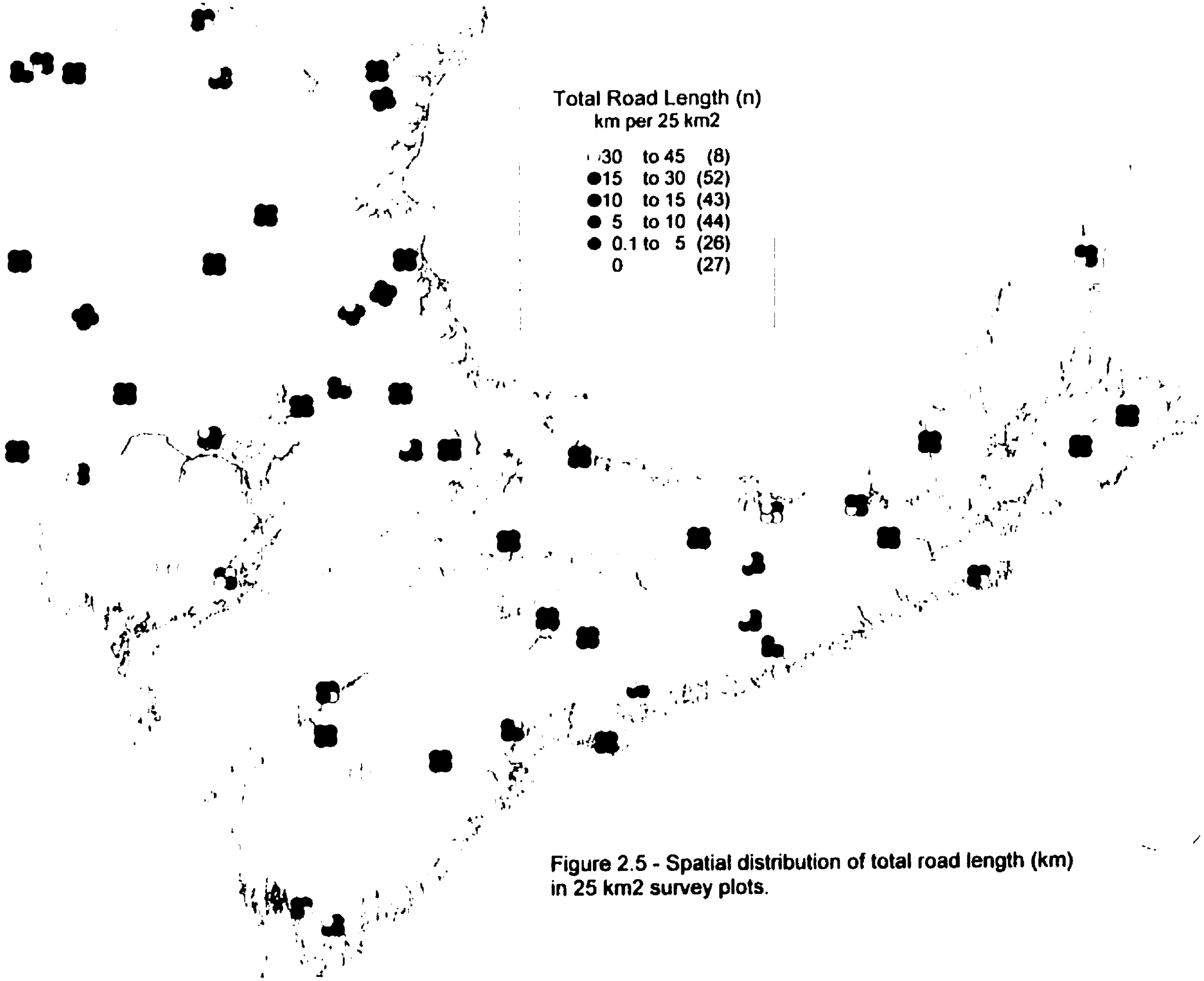

Figure 2.5 - Spatial distribution of total road length (km) in 25 km2 survey plots.

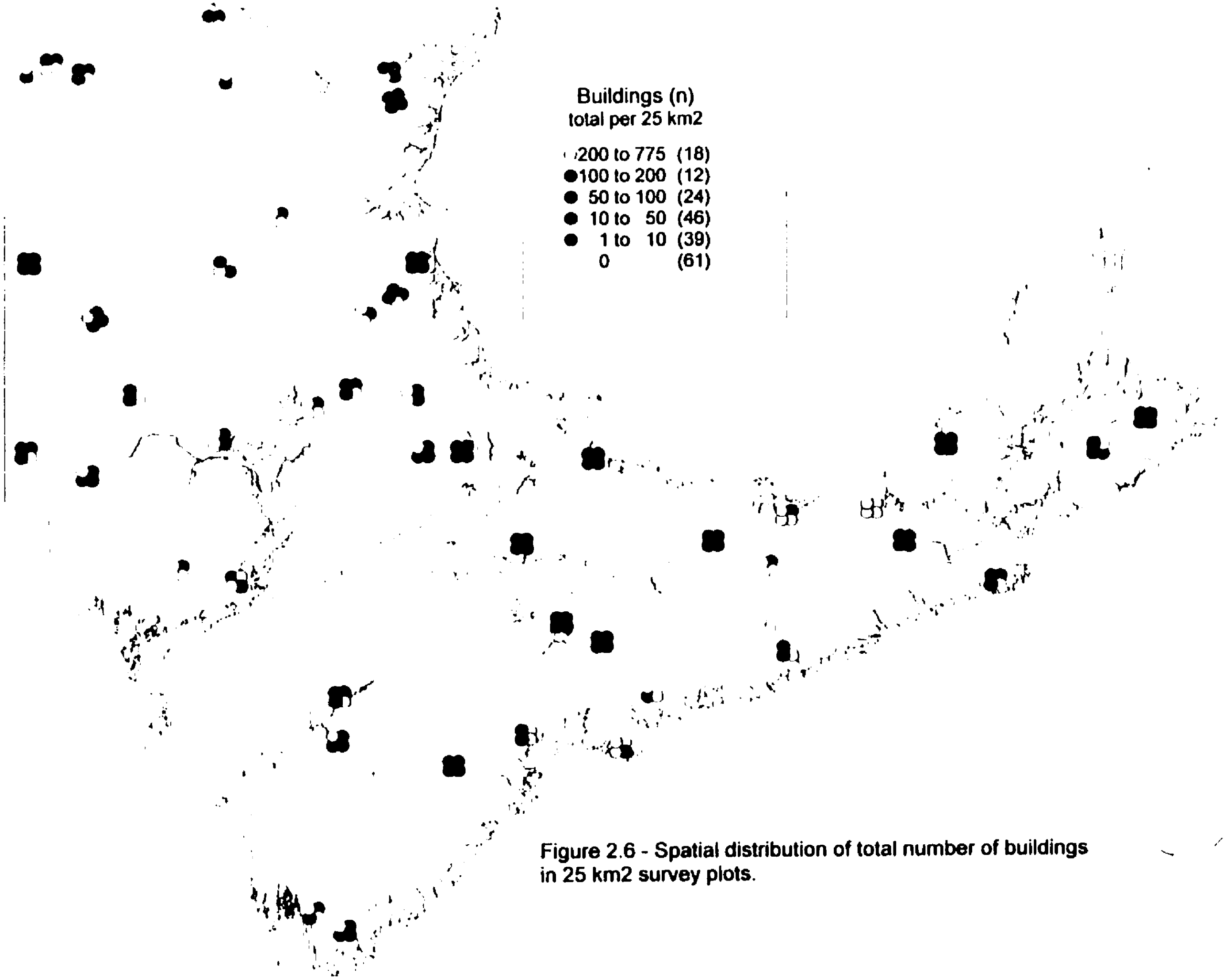

Figure 2.6 - Spatial distribution of total number of buildings in 25 km2 survey plots.

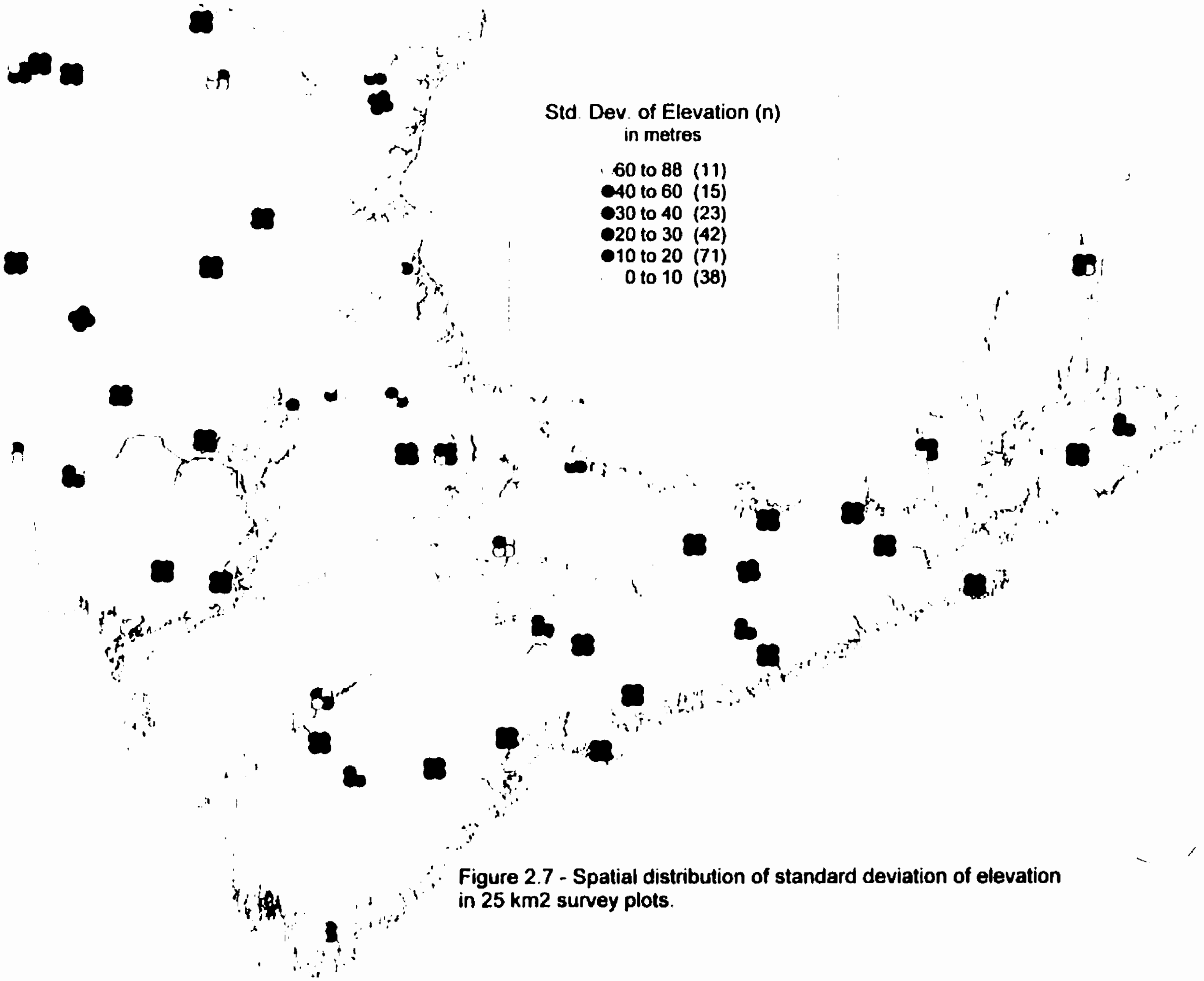

Figure 2.7 - Spatial distribution of standard deviation of elevation in 25 km2 survey plots.

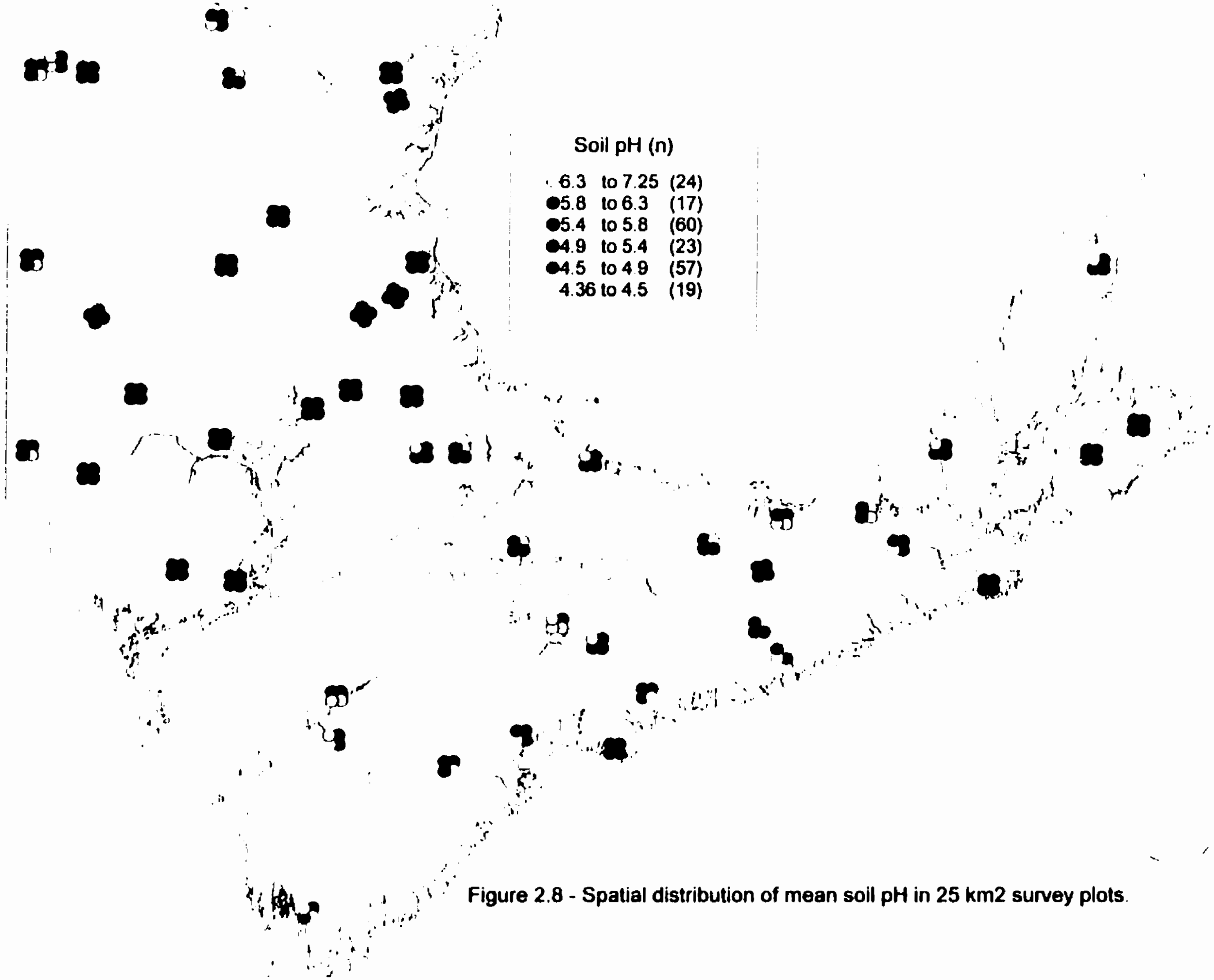

Figure 2.8 - Spatial distribution of mean soil pH in 25 km2 survey plots.

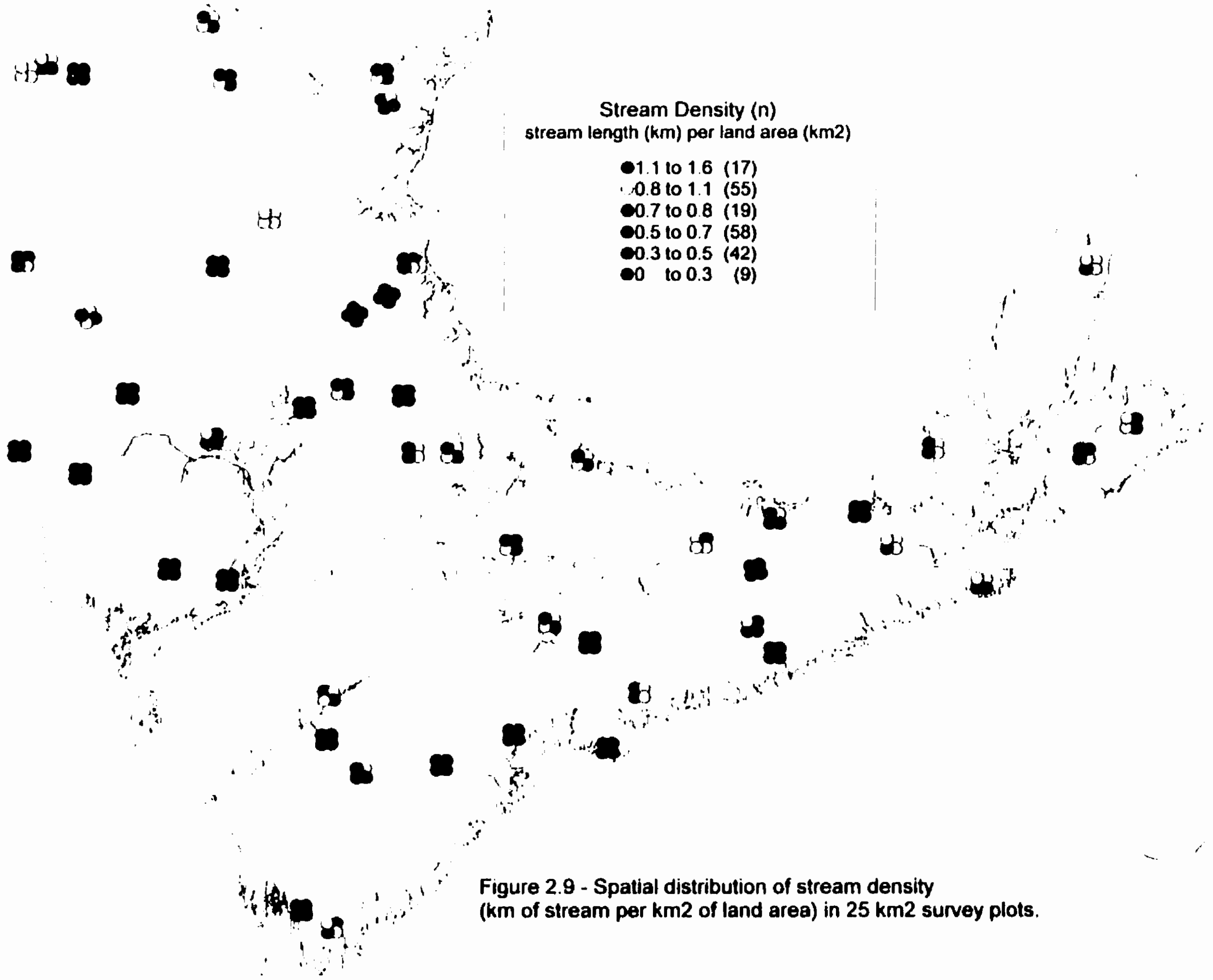

Figure 2.9 - Spatial distribution of stream density (km of stream per km2 of land area) in 25 km2 survey plots.

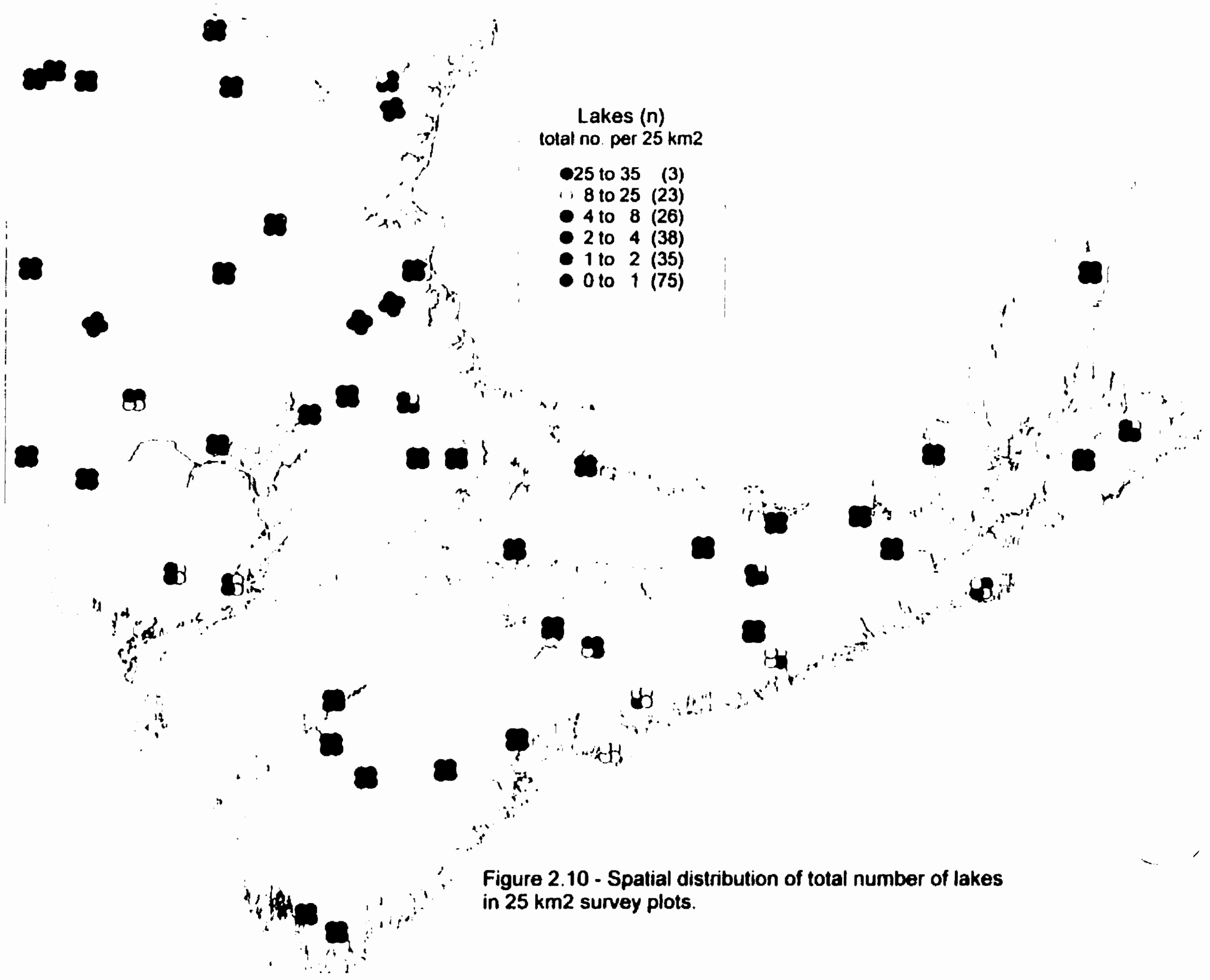

Figure 2.10 - Spatial distribution of total number of lakes in 25 km2 survey plots.

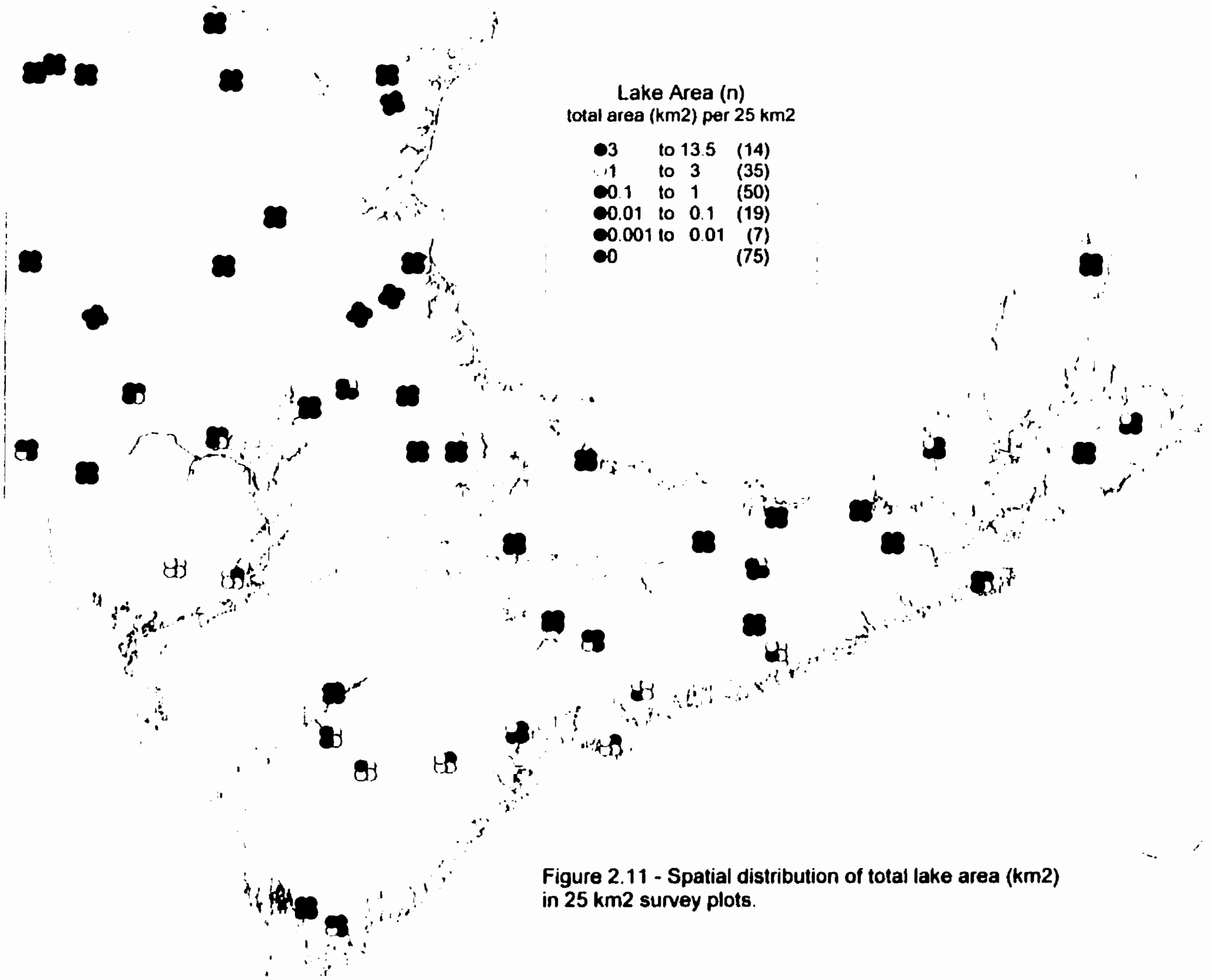

Figure 2.11 - Spatial distribution of total lake area (km2) in 25 km2 survey plots.

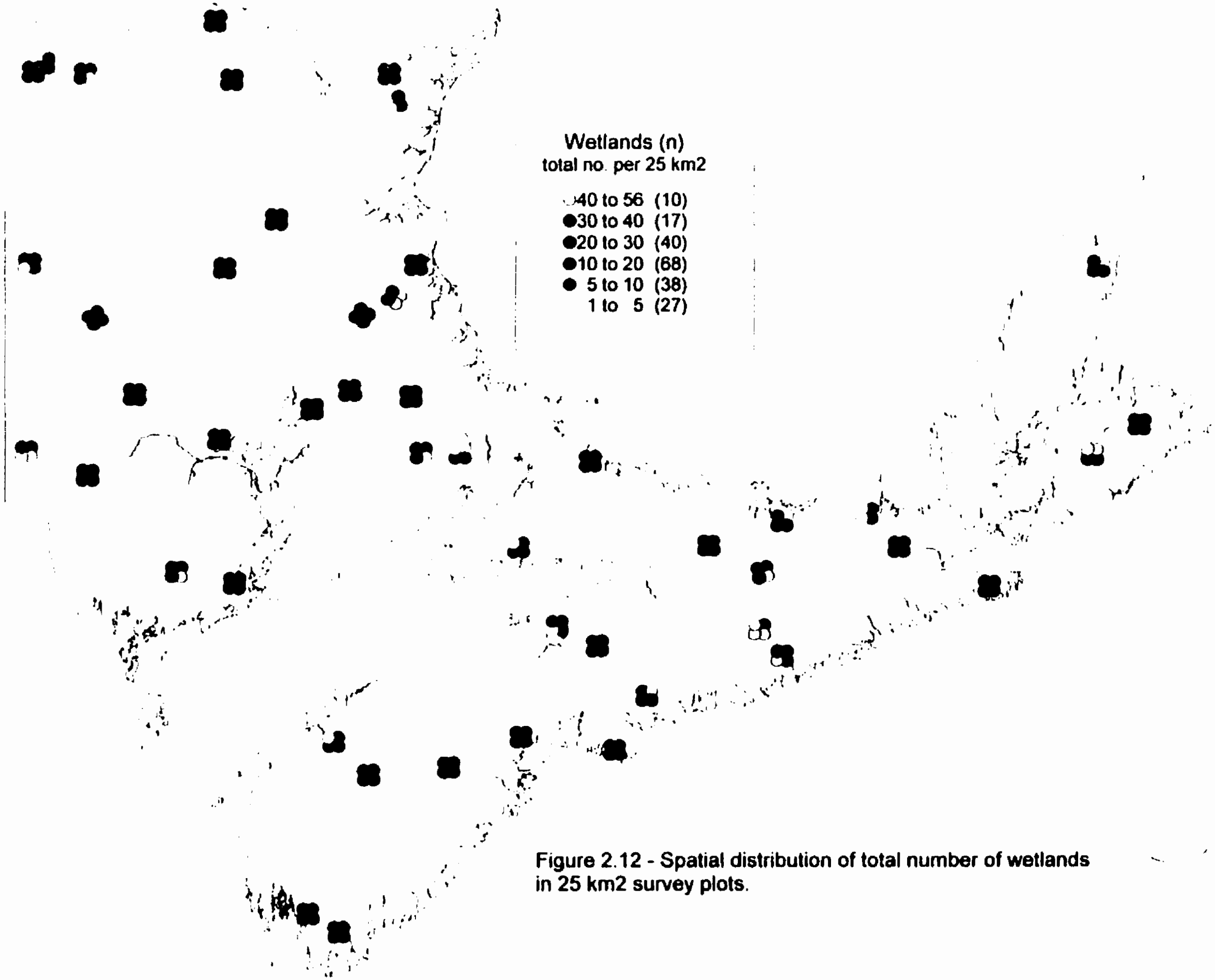

Figure 2.12 - Spatial distribution of total number of wetlands in 25 km2 survey plots.

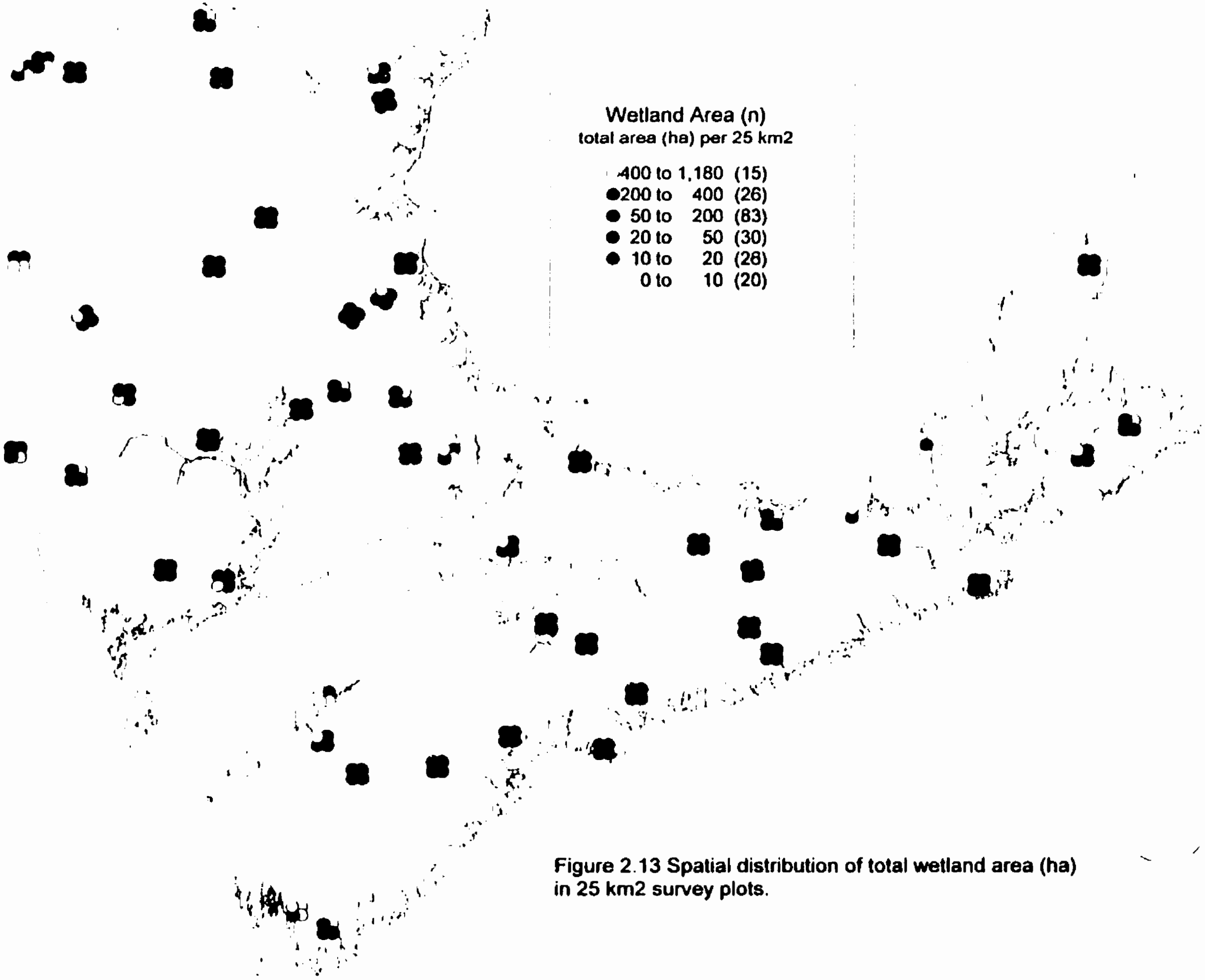

Figure 2.13 Spatial distribution of total wetland area (ha) in 25 km2 survey plots.

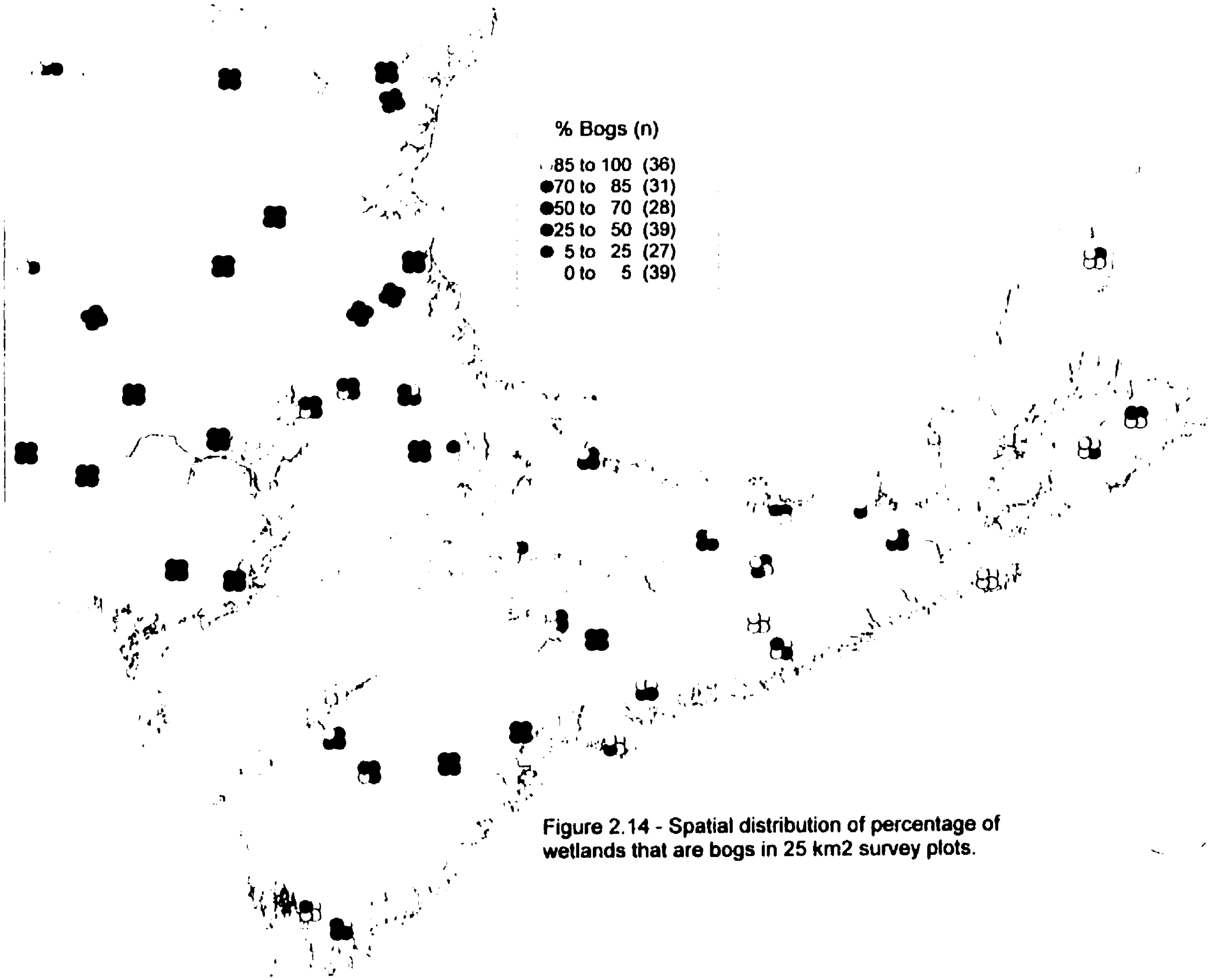

Figure 2.14 - Spatial distribution of percentage of wetlands that are bogs in 25 km2 survey plots.

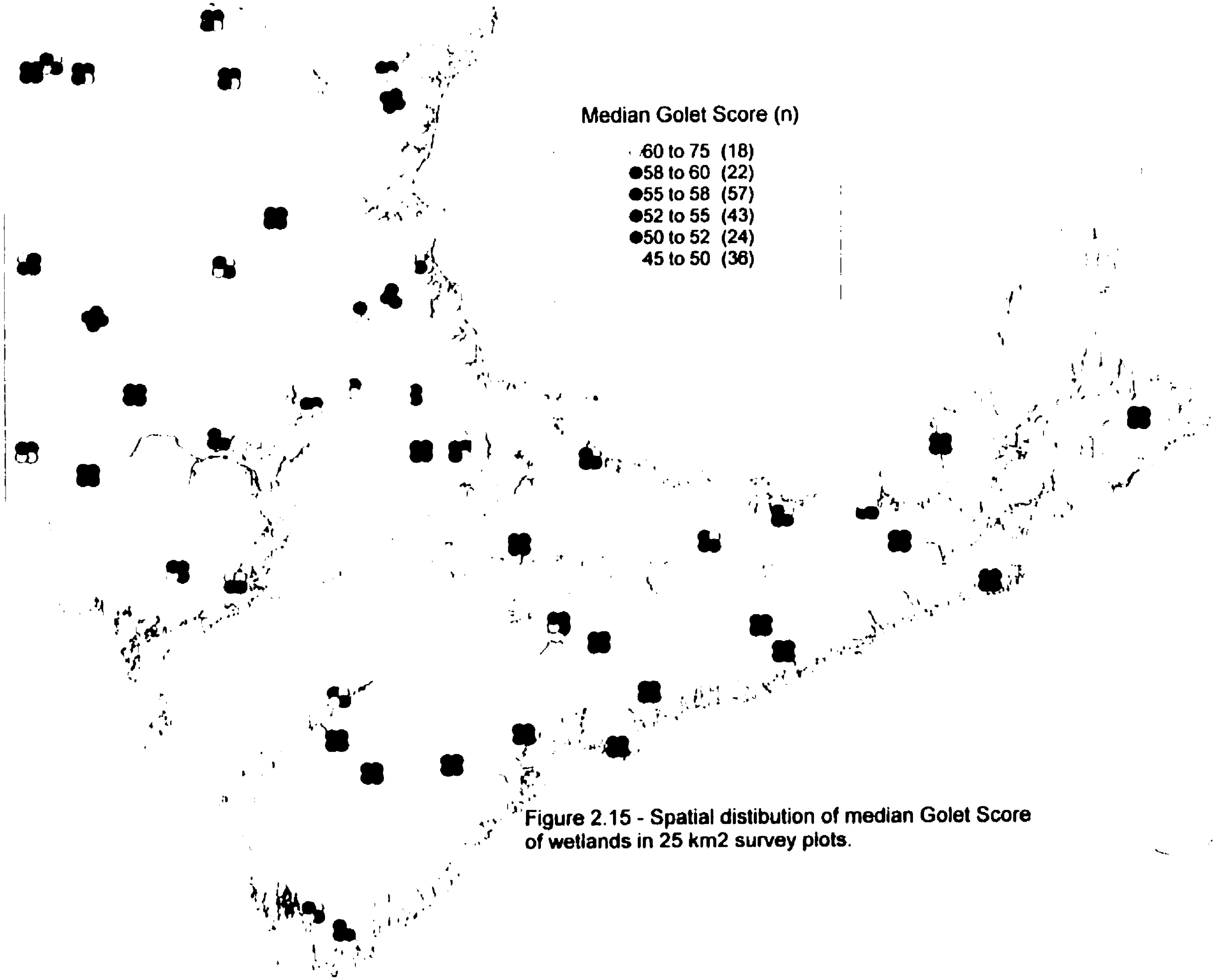

Figure 2.15 - Spatial distibution of median Golet Score of wetlands in 25 km2 survey plots.

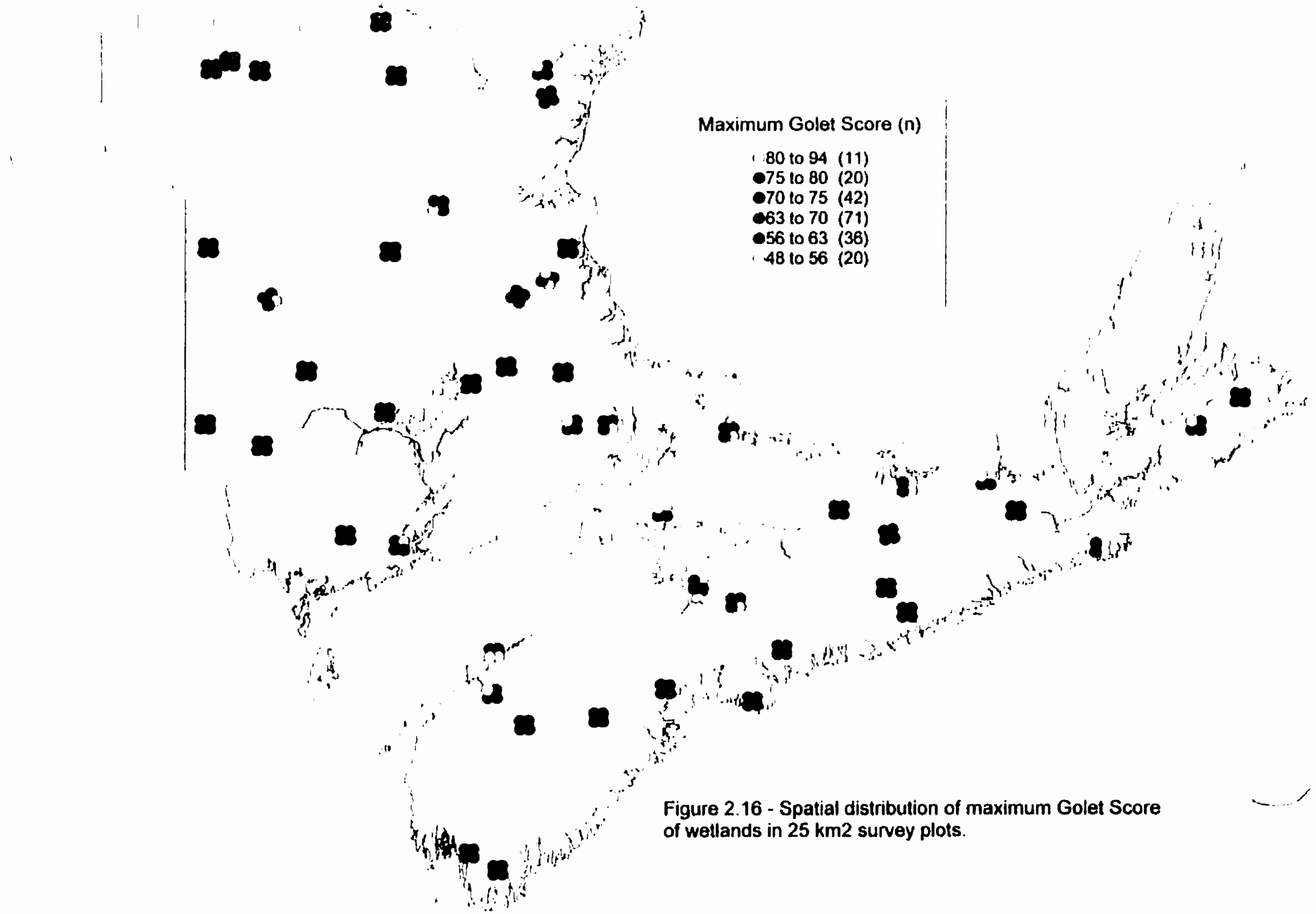

Figure 2.16 - Spatial distribution of maximum Golet Score of wetlands in 25 km2 survey plots.

CHAPTER 3 - A LANDSCAPE AND REGIONAL EVALUATION OF CHEMICAL LIMNOLOGY OF AQUATIC HABITATS IN THE MARITIMES

INTRODUCTION

The primary and secondary productivity and species composition of aquatic habitats are influenced by available nutrients and other aspects of chemical limnology (Mitsch and Gosselink 1986; Nicholson 1995; Wetzel 1983). The primary objective of this study was to determine the chemical limnology of surface waters in waterfowl survey plots located throughout New Brunswick and Nova Scotia (Bateman and Hicks 1995) as part of efforts to model American Black Duck (*Anas rubripes*) distributions. A secondary objective of this study was to examine variation in chemical limnology of surface waters among survey plots and among aquatic habitat types.

The chemical limnology of aquatic habitats is known to vary both spatially (Malmer 1992; Pienitz *et al.* 1997a; Pienitz *et al.* 1997b), and temporally (Jassby 1998; Stoddard *et al.* 1998). Spatial variation in the chemical limnology of lakes and rivers has been quantified for the Maritime Provinces (Clair *et al.* 1982; Spavold-Tims 1986; Underwood *et al.* 1986). The primary focus of these studies has been to document the impacts of acid deposition on aquatic ecosystems (Gorham *et al.* 1998; Howell and El-Shaarawi 1991). Other aspects of the chemical biogeochemistry of lakes and rivers, such as nutrient dynamics, has received little attention in Atlantic Canada. Unlike other regions where eutrophication is a concern (Carpenter *et al.* 1998; Glasgow and Burkholder 2000; Manny *et al.* 1994; Marion *et al.* 1994), oligotrophic conditions prevail throughout much of Nova Scotia (Melanson and Payne 1988).

Most examination of the chemical limnology of wetlands in northeastern North America has been done on small spatial scales (Hanson *et al.* 1994; Hanson *et al.* 1998; Longcore *et al.* 1998; Parker *et al.* 1992; Seymour *et al.* 1992; Staicer *et al.* 1994). Analogous to the situation observed for lakes, there can be large scale spatial variation in the chemical limnology of wetlands, *e.g.*, pH values from 3.6 to 5.2 for bogs and 4.0 to 6.0 for poor fens (Nicholson 1995).

Aquatic habitat types (*e.g.*, bog, fen, marsh, river, lake) have been shown to differ in many aspects of chemical limnology (Bridgham *et al.* 1998; Malmer 1992; Naiman *et al.* 1994). Recent work suggests that the vegetation and wildlife community of wetlands are affected by both pH and nutrient gradients, and that different wetland types may differ in which nutrient(s) limits primary productivity (Bedford *et al.* 1999).

Several researchers have demonstrated a positive relationship between aquatic nutrient status and aquatic bird abundance (Hoyer and Canfield 1994; Nilsson and Nilsson 1978; Sjoberg *et al.* 2000). Black Ducks use a variety of freshwater aquatic habitats, including marshes, beaver ponds, lakes, streams and rivers (Ringelman and Longcore 1982). Many aspects of a wetland's suitability as Black Duck habitat are related to water chemistry, *e.g.*, amount and type of emergent vegetation, primary and secondary productivity, presence of fish, water clarity. The density of breeding Black Ducks and their young have been correlated with many aspects of chemical limnology at a wetland-specific scale (Melanson and Payne 1988; Merendino and Ankney 1994; Parker *et al.* 1992; Seymour and Jackson 1996; Staicer *et al.* 1994). The chemical limnology of surface waters may therefore be an important landscape-level descriptor of breeding Black Duck habitat.

METHODS

Selection Of Sampling Sites

Water samples were collected in July and August, during 1996-1998, from areas within and adjacent to waterfowl survey plots (Figure 3.1). These 10km*10km plots surveyed during 1992-94, will be referred to specifically as PLOTs. All new sampling sites were established as Environment Canada water sampling stations (ENVIRODAT). Within constraints imposed by accessibility, water samples were assumed to represent the complete spatial area of the PLOT and range of aquatic habitats. The location from which water samples were collected was classified according to two separate schemes, station type (W1) and aquatic habitat type (W2). There were four different station types: wetland, river, lake, and peatland. Wetland, river, and lake are station types in the ENVIRODAT system. Because of well-documented differences in water chemistry of peatlands versus other types of wetlands, peatlands were not included in the wetland category, but kept as a separate category (National-Wetlands-Working-Group 1988). The small number of W1 classes resulted in relatively large sample sizes per station type. The other site descriptor used was aquatic habitat type (W2), which consisted of nine different classes. The previously described W1 classes of peatland, river and lake were used, as well as additional categories (beaver pond, emergent marsh, lacustrine marsh, riverine marsh, pond, and stream). The W2 classification scheme avoided combining potentially different systems into the same category, such as river and stream, or lacustrine marsh and emergent marsh.

Historical Water Chemistry Data

Based on geographical locations of sampling stations it was initially determined that sampling was not necessary in five plots. The ENVIRODAT database indicated that a large number of samples had already been collected there by other researchers. It was subsequently determined that samples would need to be collected from PLOT 68 because samples previously collected were not analysed for necessary parameters. Locations of sampling stations were plotted on 1: 50,000 National Topographical Series (NTS) maps to determine if they were within the study plot or in hydrological proximity. Water chemistry of these stations was then examined. Only data from stations for which samples were collected during mid-summer, within the last decade, and analysed for the appropriate parameters, were used. These requirements resulted in many stations and samples being discarded.

Collection of Water Samples

The number of water samples collected per plot, dates sampled, and mode of collection are listed in Tables 3.1 and 3.2. Samples were collected during July and August during the shortest time-period possible in order to avoid potential climatic or seasonal effects. Samples were not collected during spring, to avoid the potential impacts of spring run-off and rain on chemical limnology of these systems. It is also during July that broods utilise these wetlands. Maximum levels of ionic constituents can be observed during July in Maritime wetlands due to evaporative concentration and increased importance of groundwater inputs. Water chemistry of streams in Kejimikujik National Park (Plot 32) showed higher levels of ionic constituents and pH in late summer compared to spring (Gorham *et al.* 1998; Wood *et al.* 1991). Sampling was not done immediately after heavy rains or during high water flows.

Water samples for analysis of nutrients and ionic constituents were collected using one-litre, polyethylene bottles supplied by Environment Canada, Moncton, New Brunswick. Water samples for analysis of chlorophyll-a concentrations were collected in 500 ml polyethylene bottles provided by Environment Canada, Sackville. Sample bottles were triple rinsed with *in-situ* water prior to sample collection (except when sampling by helicopter). Grab water samples were collected from a depth of 0.5 m. Water samples were collected from the NS DNR helicopter using a sampling iron while 3 m above the water surface. The Coast Guard helicopter was equipped with pontoon floats and grab samples were collected. In 1996, water samples were collected from the helicopter using 3-litre polyethylene bottles and later transferred to one-litre and 500 ml sample bottles. All samples were placed on ice in coolers for transport back to the lab.

Laboratory Analyses

In 1996, 500 ml water samples were analysed for pH using a Fisher ACCUMET 156 pH meter. Conductivity was measured using a Radiometer CDM2e conductivity meter and reported as adjusted to 25 °C. Water samples (500 ml) were then filtered using vacuum pump filters and 4.8 micron glass-fibre filters. Methanol based extraction of chlorophyll-a, corrected for phaoephyton, was done (Marker *et al.* 1980). Analysis of 1996 data indicated that chlorophyll-a concentrations would not be a good predictor variable of waterfowl densities because of high within plot variation. Water samples were not collected for chlorophyll-a analysis in 1997 and 1998. Specific conductance and pH were measured in 1997 and 1998, using the one-litre samples submitted to Environment Canada Lab in Moncton.

The one-litre water samples were submitted to the Environment Canada Lab in Moncton, New Brunswick, for analyses. Standard methods were used for analysis of the following parameters: apparent colour, total nitrogen, acid neutralization capacity (ANC), dissolved sodium, dissolved magnesium, insoluble silicate, total phosphorous, dissolved sulphate, dissolved chloride, dissolved potassium, dissolved calcium, total organic carbon, specific conductance, pH, and dissolved inorganic carbon (Table 3.3). The lab is accredited through CSC/CAEL.

Statistical Analyses

Data Editing and Transformations

Water samples with specific conductance greater than 800 µS were deemed to be marine, and excluded from further analyses. Most water chemistry variables were log transformed (Table 3.3) prior to analyses. ANC was log-transformed after adding 6.5 to the observed value, in order to ensure that all ANC values were positive prior to log-transformation. Shapiro-Wilk statistics indicate that pH and the log-transformed variables had normal or near normal distributions given the large sample sizes (Table 3.3; PROC UNIVARIATE, SAS 1988).

General Linear Models

The statistical significance of variation in chemical limnology due to the categorical variables of location(PLOT), sample station type (W1), and aquatic habitat type (W2), was tested using the analysis of variance component of a general-linear model (PROC GLM: SAS 1988). General-linear models are robust to non-normal distributions (Zar 1984). A separate analysis was done for each water chemistry parameter. The relative importance of effects was expressed by representing the Type I sum of squares (SS) as a percentage of the corrected total sum of squares for the model. Whereas the order of variable entry will affect the value for Type I SS, separate models were run with location (PLOT) being the first variable entered and with location (PLOT) being the second variable entered.

Least squares mean (LSMs) and standard errors were estimated from models with location (PLOT) and aquatic habitat type (W2) as main effects. Least squares mean correct for unbalanced sampling design, *i.e.*, over or under representation of a given survey plot or aquatic habitat type in the overall design (SAS 1988). Graphical representation of LSMs are based on the anti-log of the means +/- one standard error. Shapiro-Wilk statistics indicate that the LSMs for water chemistry parameters for the 50 study plots had normal or near normal distributions (PROC UNIVARIATE: SAS 1988).

Principal Component Analyses

A principal component analysis (PCA) was conducted to determine relationships among water chemistry parameters and as a means by which to reduce the number of variables needed to describe differences in chemical limnology among PLOTs. Transformed variables were used because they were normally distributed. Principal components were calculated based on the correlation matrix. Principal component (PC) scores, standardised to unit variance, were computed for each observation.

The statistical significance of variation in principal components scores due to the location, sample station type, and aquatic habitat type was tested using the analysis of variance component of a general-linear model (PROC GLM: SAS 1988). ANOVA procedures for PC scores were the same as those previously described for individual water chemistry parameters.

Geostatistical Analysis

The location of the centroid of BDJV survey plots was converted from latitude and longitude coordinates (decimal degrees) to Universal Transverse Mercator (UTM) easting and northing coordinates (metres) for Zone 20 (SPANS 1999). UTM coordinates are cartesian coordinates from which distances between points can be calculated. Lag classes were established at 40,000 m intervals, with the maximum distance (range) being 360,000 m. Lag Class 1, compared 29 pairs of observations that were less than 40,000 m apart. Other lag classes had substantially more observations (72-153). It is suggested that each lag class be represented by at least 30-50 pairs of observations, although the greater the number of pairs of points, the greater the statistical reliability of each lag class (Rossi *et al.* 1992).

Omnidirectional (i.e. isotropic) correlograms were created using GS+ geostatistical software (Robertson 2000). Moran's I was used to measure spatial autocorrelation, with values close to +1.0 indicating a smooth surface, with each PQUAD containing values very similar to those in neighbouring PQUADs, and a value of -1 indicating a rough surface where neighbouring PQUADs have very dissimilar values (Eastman 1999). Values near zero indicate no spatial autocorrelation. Variables with highly skewed distributions were log transformed prior to calculating Moran's I (Isaaks and Srivastava 1989).

RESULTS

Comparisons of Location and Aquatic Habitat Type Variation

Characterizing the chemical limnology of aquatic habitats without replication in space or time may lead to inaccuracies. The chemical limnology of aquatic habitats are known to vary due to seasonal and short term climatic events (Jassby 1998). Water samples were collected from 25 aquatic habitats in July 1996, and again in August 1998 in PLOTs 51 and 53. There were differences in a limited number of chemical limnology parameters between the two years (Paired T-Test: Zar 1984). In Maine, significant between year differences were observed for pH, but not for other water chemistry parameters (Longcore *et al.* 1998). Differences between samples collected at different times may represent local conditions (*e.g.*, moose urine), short term conditions (rain events) and/or climatic conditions (wet versus dry summer). A pragmatic approach for synoptic comparisons is to leave this variation un-quantified and assume that the larger spatial patterns shown by the data supersede any uncharacterised temporal variability at the sampling points (Clair *et al.* 1982; Pienitz *et al.* 1997b; Underwood *et al.* 1987).

General linear models which included aquatic habitat type (W2), location (PLOT), and the interaction term, had model R^2 values that ranged from 0.441 for chlorophyll-a to 0.844 for pH (Table 3.4). The overall model was statistically significant for all parameters, $P = 0.0001$. Some historical water sampling stations were not analysed for all water chemistry parameters and therefore sample sizes vary among the specific parameters. Sample sizes for each model are presented (Table 3.4). There were significant effects of location (PLOT) and aquatic habitat type (W2) for all water chemistry variables with the exception of chlorophyll-a. There was a significant interaction between location and aquatic habitat type for many of the water chemistry variables. In models where location (PLOT) was the first variable entered into the model it explained a large percentage of the variation (Table 3.5). The notable exception was chlorophyll-a concentration. The percentage of variation explained by location (PLOT) ranged from a low of 11% for chlorophyll-a to 74% for dissolved inorganic carbon (DIC;

Table 3.5). The percentage of variation explained by aquatic habitat type (W2) in these models was 13% for chlorophyll-a and 3% for dissolved inorganic carbon. Type I SS values are affected by the order in which the variables are added to the model. Even when aquatic habitat type (W2) was entered into the model before location (PLOT). a large proportion of the variation was still explained by the effect of location.

Models including location (PLOT) and sampling station type (W1). were all statistically significant P = 0.0001 and had Model R^2 values that ranged from 0.287 for chlorophyll-a to 0.786 for pH (Table 3.6). The amount of variation explained by models which included sampling station type (W1 Models) was less than the amount of variation explained in models which included aquatic habitat type (W2 Models). Location (PLOT) was the variable in W1 Models which explained most of the overall variation (Table 3.7). similar to the W2 Models. Both W1 Models and W2 Models for chlorophyll-a. indicated that location (PLOT) was not important in explaining the observed variation.

LSMs were calculated using W2 Models which included location (PLOT) and aquatic habitat type (W2). These models were selected as they explained a higher amount of overall variation compared to W1 Models which included location (PLOT) and sampling station type (W1). Aquatic habitat type (W2) categories are also more ecologically meaningful. Sampling station type (W1) categories resulted in more within-category variation (Tables 3.8 - 3.14). LSMs for PLOTs correct for unequal representation of the aquatic habitat types among the survey plots. whereas LSMs for aquatic habitat types correct for unequal representation of plots among the aquatic habitat types.

There was considerable variation in LSM pH among plots (Appendix D. Figure D1). The amount of among-plot variation differed for the various parameters of chemical limnology (Appendix D. Figures D2 - D16). There was less variation among aquatic habitat types in LSM pH compared to variation among plots (Appendix D. Figure D17). The LSMs for other variables by aquatic habitat type are presented in Appendix D. Figures D18 - D32. Spatial and aquatic habitat type variation is addressed in the Results section.

Chemical Limnology

The correlation matrix from a principal component analysis highlighted relationships among water chemistry variables (Table 3.15). Increasing pH was associated with increasing Mg, K, and Ca. Conductivity is a measure of the concentrations of all ions and was therefore strongly positively correlated with measures of major ion concentrations, *e.g.*, ANC, Na, Mg, K, Ca. Apparent colour was positively associated with TOC, and negatively associated with pH, indicative that humic acids were responsible for the colour and acidity of most water samples. ANC was highly positively correlated with pH, conductivity, Mg, and Ca. Sodium (Na) was positively correlated with Cl, reflecting the importance of sea salt in the ionic composition of surface waters in Atlantic Canada (Underwood *et al.* 1987). Correlations among SO_4, K and Cl were also observed, consistent with a sea spray and marine silt soils. Magnesium was associated with K and Ca, indicative of well buffered bedrock and soils.

Total nitrogen (TN) was not highly correlated with any other variables. Total phosphorous (TP) was correlated with apparent colour and TOC, consistent with higher P content of soils from ombrotrophic wetlands (Bridgham *et al.* 1998).

A separate principal components analysis (PCA) was done for the 49 plots for which water samples were analysed for silicate. This PCA indicated that SIO_2 was most highly correlated with Ca (0.5581) followed by ANC (0.4550) and pH (0.3944). A PCA, based on the 355 locations for which chlorophyll-a concentration was measured, indicated that it was positively associated with TP (0.3279) and negatively associated with SIO_2 (-0.4416).

The eigenvalues for the correlation matrix indicated that the first four principal components accounted for over 85% of the variation, with the first principal component (PC1) accounting for 45% of the variation (Tables 3.16).

The structure of PC1 is one of increasing pH and major ions, combined with decreasing TOC and COLOR (Table 3.17). The PC1 axis will be termed the pH Axis. The second principal component axis (PC2) shows increasing TOC, COLOR , TP, and TN. The PC2 axis will be referred to as the Nutrients Axis. The PC3 axis indicates decreasing Na and Cl, with increasing pH and ANC and will be called the Salinity Axis. The PC4 axis has increasing TN and SO_4, while TP decreases and will be termed the Nitrate Axis.

Location (PLOT), aquatic habitat type (W2), and the interaction term explain a significant amount the variation in PC Scores (Table 3.18). Location explained 66, 50, 77, and 73% of the total variation in PC1-PC4 Scores respectively (Table 3.19). A GLM with location (PLOT) and aquatic habitat type (W2) as the main effects was used to calculate LSMs and standard errors (SE) for PC1-PC4 Scores.

Regional Variation in Chemical Limnology

Results from ANOVA of water chemistry parameters and principal component scores indicated that there were differences among PLOTs and among aquatic habitat types. Among PLOT variation in chemical limnology was four to five times greater than among aquatic habitat type (W2) variation (Table 3.5). There was considerable among PLOT variation in PC1-PC4 scores (Figures 3.2 - 3.9).

Surface waters with relatively high pH were observed in areas of neutral to basic soils (Figure 3.10). The PLOTs with the ten highest LSM pH values were in order of increasing pH: 43, 73, 68, 51, 71, 50, 75, 72, 62, and 74 (Appendix D, Figure D1). These PLOTs also had high PC1 scores (Figures 3.2 and 3.6). PLOTs 71-75 are located in northern New Brunswick in ecodistricts described as having bedrock and/or soils that are neutral to basic (Ecosystem-Classification-Working-Group 1996). PLOTs 43, 50 and 51 are coastal, with PLOT 51 also being in an area of gypsum deposits. PLOT 43 is located in the Carboniferous Lowlands of Nova Scotia in the Northumberland Plain, an area of sandstones, siltstones and gypsum (Davis and Browne 1996).

The PLOTs with the ten lowest LSM pH values were. in order of increasing pH: 31. 38. 46. 56. 32. 55. 30. 54. 37. 66 (Appendix D. Figure D1). PLOTs 30. 31. 32. are all in south-western Nova Scotia in Ecodistricts (Davis and Browne 1996) underlain by granitic bedrock with a thin covering of acidic soil (Figure 3.10: Table 2.14). PLOTs 37. 38. and 46 are found along the Eastern Shore of Nova Scotia on the Quartzite Barrens and Granite Barrens Sub-Units. PLOTs 54. 55. 56. and 66 are found in the Carboniferous Basin of New Brunswick in the Salmon River. and Grand Lake Ecodistricts (Table 2.15). These areas are underlain by easily weathered bedrock that produces deep acidic soils (Ecosystem-Classification-Working-Group 1996). Other PLOTs with LSM pH below 6.0 were. in order of increasing pH: 26. 27. 53. 40. 67. 58. 49. 28. 29. 33. 36. 48. and 39. PLOTs 53 and 67 are located in the Carboniferous Basin of New Brunswick The only other New Brunswick plot with LSM pH below 6.0 was PLOT 58 which is located on granitic soils in the Lepreau River Ecodistrict (Ecosystem-Classification-Working-Group 1996). In contrast to New Brunswick. most of the Nova Scotia plots with pH below 6.0. were located on granitic soils. PLOTs 26 and 27. are located on quartzite barrens and granite barrens. PLOTs 28. 29. 33. 36 and 40 are located in areas of high granite and quartzite. PLOT 48 is located in a stony wet till-plain with lots of bog development. PLOT 49 is located on the taiga plateau of Cape Breton which is blanketed by bogs (Davis and Browne 1996).

Spatial variation in acid-neutralizing capacity (ANC) was similar to that observed for pH (Figure 3.11). PLOTs 73. 43. 68. 51. 50. 71. 75. 72. 62. and 74 had the ten highest values for ANC (Appendix D. Figure D2). Many of the plots with low ANC had low surface water pH. The PLOTs with the ten lowest values for ANC were: 31. 38. 46. 56. 32. 55. 30. 54. 37. and 66.

Spatial variation in apparent colour probably reflected differences in inputs of organic acids (Figure 3.12). The surface waters in the majority of PLOTs (n=37) would be considered clear waters. The PLOTs with the highest values for apparent colour. were. in order of increasing magnitude: 60. 56. 33. 59. 55. 66. 53. 27. 67. and 54 (Appendix D. Figure D3). These plots had relatively low PC1 scores (Figures 3.2 and 3.6). PLOTs 53.

54, 55, 56, and 66, which had high apparent colour, are all located in the Carboniferous Basin of New Brunswick and have flat terrain, deep acidic soils, and extensive development of peatlands (Table 2.15; (Ecosystem-Classification-Working-Group 1996)). PLOT 27 is located on the Pennant Barrens Unit where bogs have developed in depressions on the granite plateau (Table 2.14; Davis and Browne 1996). PLOT 33 is located in the Granite Uplands Unit which is described as having many raised bogs. Data from the Maritime Wetlands Inventory (Hanson and Calkins 1996) indicates that plots with high values for apparent colour had extensive areas of peatlands. The total number of bogs and area in hectares, for plots with high values for water colour, are: PLOT 60 (7, 281 ha); PLOT 56 (30, 130 ha); PLOT 33 (26, 144 ha); PLOT 59 (35, 262 ha); PLOT 55 (68, 551 ha); PLOT 66 (66, 368 ha); PLOT 53 (49, 1246 ha); PLOT 27 (48, 91 ha); PLOT 67 (81, 549 ha); PLOT 54 (53, 1076 ha).

The PLOTs with the ten lowest values for apparent colour were: 75, 74, 50, 51, 72, 39, 62, 43, 64, and 52 (Appendix D, Figure D3). PLOTs with clear waters had significant relief, with many streams and rivers, and relatively few wetlands. The total number of bogs and area in hectares for PLOTs that had low values for apparent colour are: PLOT 75 (0, 0 ha); PLOT 74 (2, 2 ha); PLOT 50 (2, 10 ha); PLOT 51 (1, 0.4 ha); PLOT 72 (0, 0 ha); PLOT 39 (122, 495 ha); PLOT 62 (1, 2 ha); PLOT 43 (4, 9 ha); PLOT 64 (8, 22 ha); PLOT 52 (11, 21 ha). PLOT 39 which had clear waters did have a large number of bogs. However in PLOT 39 water samples were only collected from lakes and lacustrine marshes. This unbalanced design may have been responsible for pH being higher and colour being lower than if water samples had been collected from rivers and wetlands.

Total organic carbon in water samples had spatial variation, and a relationship with bogs, similar to that observed for colour (Figure 3.13 vs. Figure 3.12). This would be expected because of humic acids being responsible for the colour of surface waters in Atlantic Canada, and the correlation discussed earlier (Table 3.15). PLOTs with the highest total organic carbon, in order of increasing values, were: 42, 56, 55, 59, 27, 53, 66, 60, 54, and 67 (Appendix D, Figure D4). Plots with high TOC also had high PC2 scores (Figures 3.3

and 3.7). PLOTs with the lowest total organic carbon, in order of increasing values, were: 75, 52, 51, 74, 50, 39, 69, 64, 72, and 45.

Dissolved inorganic carbon (DIC) was measured only for water samples collected in 1997. Plots with high DIC had low TOC (Figure 3.14). DIC had similar spatial variation to that observed for ANC. The PLOTs with the highest DIC were 72 and 74 (Appendix D, Figure D5).

Those ions primarily responsible for determining pH, such as magnesium and calcium also showed spatial variance similar to that already discussed for pH and ANC (Figures 3.15-3.16). The magnitude of this variation was however much smaller than that observed for pH and ANC (Appendix D, Figures D6 and D7). Calcium concentrations in surface waters greater than 10 mg/L could be considered indicative of calcareous soils. High concentrations of calcium were observed in surface waters in PLOTs 62, 74, and 75, which are located in New Brunswick Ecodistricts 5.1, 5.1 and 1.1. These Ecodistricts have been described as having areas of calcareous bedrock and soils (Table 2.15: Ecosystem-Classification-Working-Group 1996).

PLOTs 35, 42, 43, 44, 50 had relatively high levels of potassium (Figure 3.17: Appendix D, Figure D8). These plots are all located in the Carboniferous Lowlands Region of Nova Scotia (Table 2.14: Davis and Browne 1996).

The conductivity of freshwater systems in Atlantic Canada can represent the influence of marine salts or minerals. The conductivity in PLOTs 74 and 75 (Figure 3.18: Appendix D, Figure D9) reflect high ANC (Figure 3.11). The high conductivity of PLOTs 43 and 50 reflect high concentrations of sodium (Figure 3.19: Appendix D, Figure D11) and chloride (Figure 3.20: Appendix D, Figure D12). PLOTs 44, 35, 50 and 43 had high concentrations of sodium and chloride indicative of their overlying Windsor Group formations that contain evaporites (Davis and Browne 1996). Sodium and chloride concentrations are indicative of distance to the coastline and differences in airborne inputs of sea salts. The maximum distance from salt water in Nova Scotia is *ca.* 75 km

(Underwood *et al.* 1986) and hence all of Nova Scotia is influenced by salt spray. It would appear that PC3, which describes decreasing Na and Cl with increasing pH and ANC, is also strongly influenced by distance from the coast. The lowest PC3 scores were observed in Nova Scotia and the highest scores observed in north-western New Brunswick (Figure 3.8).

High concentrations of sulphate in PLOT 50 may be due to evaporites or sea spray (Figure 3.21: Appendix D, Figure D13). Sulphate is the third most common ionic constituent of sea water after chloride, and sodium (Mitsch and Gosselink 1986).

PLOTs with high pH of surface waters and well buffered soils, such as PLOTs 50, 72,73,74, and 75, had some of the lowest values for total phosphorous (Figure 3.22: Appendix D, Figure D14). PLOTs 34, 42, 44 and 62 which were located in areas of known agricultural potential and fertile soils, had the highest total phosphorous values. Some PLOTs with high total phosphorous (e.g. 27, 61, 67, 68) were areas of high peatland development. This phosphorous may have been biologically unavailable due to being in an organic or colloidal form (Bridgham *et al.* 1998).

Plots with high total nitrogen (Figure 3.23: Appendix D, Figure D14) were found in coastal areas (PLOTs 30, 31 35, 43) as well as in the Carboniferous Basin of New Brunswick (PLOTs 54, 55, 56, and 66, Figure 3.23; Appendix D, Figure D15). Total nitrogen (TN) was not highly correlated to other water chemistry variables (Table 3.15). Plots with high concentrations of TN and high PC4 scores were found in the Carboniferous Basin of New Brunswick (PLOTs 53-56) and areas of high peatland development in Nova Scotia (PLOTs 30 and 31) as well as some coastal areas (Figures 3.5, 3.9 and 3.23).

Plots with high silicate concentrations (Figure 3.24; Appendix D, Figure D16) were found mostly in New Brunswick in areas of well buffered soils and high surface water pH. In contrast, most of the low silicate concentrations were found in Nova Scotia with the ten lowest means occurring in PLOTs 39, 46, 37, 48, 32, 35, 38, 26, 45 and 27

(Appendix D. Figure D16). The low silicate concentrations in Nova Scotia plots are consistent with the granite bedrock and low pH of surface waters in that province.

There was a lot of unexplained variation in chlorophyll-a concentrations (Table 3.5). hence samples were collected for chlorophyll-a analysis only during 1996 for a selected number of plots (Appendix D. Figure D17).

Spatial Autocorrelation Among Plots in Chemical Limnology

Most parameters of chemical limnology did not have substantial spatial autocorrelation beyond the first lag class (Tables 3.21 and 3.22). The average distance between the 29 pairs in Lag Class 1 was 27.000 m. Sodium (Na) and chloride (Cl) were exceptions with spatial autocorrelation evident up to Lag Class 4 (139.000 m) and reflected the importance of proximity to marine waters (Table 3.21). Surface waters in Nova Scotia had higher concentrations of Na/Cl compared to New Brunswick (Figures 3.22-3.23). Silicate (SIO_2) also had notable spatial autocorrelation up to Lag Class 4. Plots in New Brunswick had high SIO_2 concentrations coincident with high pH values (Figures 3.10 and 3.24).

Variation Among Aquatic habitats

The PC1 axis described increasing pH and other ions with decreasing apparent colour and TOC. Along the PC1 axis. negative scores indicate acidic dilute waters. whereas positive values indicate well buffered waters. Peatlands were the aquatic habitat type that had the lowest PC1 scores (Figure 3.25). These PC1 scores are consistent with univariate analyses where peatlands had the lowest pH . ANC. Ca. Mg. Na. Cl. and SO_4 (Table 3.8: Appendix D. Figures D17-D32). The PC2 axis described increasing TOC. apparent colour. TN. and TP (Table 3.17). Peatlands had positive PC2 scores (Figure 3.26). consistent with high colour. TOC and TN observed during univariate analyses (Appendix D. Figures D17-D32). The PC3 axis described decreasing Na and Cl with increasing ANC (Table 3.17) and all aquatic habitat types had similar PC3 scores (Figure 3.27). The

PC3 axis reflects a spatial pattern with all but one Nova Scotia plot having negative values (Figures 3.4 and 3.8). The PC4 axis described increasing TN and SO_4 with decreasing TP (Table 3.17). Peatlands were observed to have high TN in univariate analysis (Table 3.8) and PC4 scores (Figure 3.28). PC4 axis may describe spatial variation in water chemistry as indicated by the among plot variation observed in PC4 scores (Figure 3.5).

The mean pH for peatlands was 4.8, whereas the minimum was 3.9. Some wetlands in the peatland category were in fact fens, as evidenced by the fact that the maximum pH for the category was 6.7 (Table 3.8, Appendix D, Figure D17). Bogs typically have a pH of 4-5 whereas the pH of water from fens is 5-6 (National-Wetlands-Working-Group 1988; Nicholson 1995; Wood *et al.* 1991). Of the 65 wetlands that were classified as peatlands, 65% had a pH of 5.0 or less, and 90% had a pH of 5.4 or less. This distribution of pH indicates that very few fens were included in the peatland category. There were six wetlands classified as peatland with a pH of 5.7-6.1.

The range in water chemistry parameters for lakes was greater than any other aquatic habitat type. The water chemistry of lakes is known to be strongly influenced by the geology of their catchments (Howell 1988; Pienitz *et al.* 1997a; Pienitz *et al.* 1997b). The observed pH of lakes ranged from 3.2 to 7.9, with a raw mean of 5.6 (Table 3.8). A water sample collected from a lake that was surrounded by bog had a pH of 6.71. Conversely one sample collected from a lake had a pH of 3.2, and 16% of water samples collected from lakes had a pH of less than 5.0 (Table 3.8). Lakes could be characterised as clear and dilute (Table 3.8, Appendix D, Figures D17-D32).

Lake, lacustrine marsh, and pond had near zero PC1 scores with beaver ponds having slightly higher PC1 scores (Figure 3.25). Only peatlands had lower PC1 scores than lakes. Lakes had the lowest PC2 scores indicative of their clear and dilute nature (Figure 3.26).

Lacustrine marshes had slightly elevated levels of ionic constituents, nutrients, as well as ANC and pH, compared to lakes (Tables 3.8-3.9, Appendix D, Figures D17-D32). This trend was also observed for samples collected from the edge versus the middle of the same lake (unpubl. data).

Ponds, which are smaller in area and presumably shallower than lakes, had slightly higher levels of ionic constituents, nutrients, and pH compared to lake and lacustrine marsh. The same trends were clearly evident in PC2 scores (Figure 3.26) although less so with regard to PC1 scores (Figure 3.25).

There were three categories of lentic aquatic habitat types: river, riverine marsh, and stream. Rivers had larger water volumes than riverine marshes and streams and therefore had slightly lower concentrations of ionic constituents (Table 3.9 and 3.10, Appendix D, Figures D17-D32). All three lentic systems had similar (positive) PC1 scores, whereas, rivers had low PC2 scores compared to other lentic systems (Figures 3.25 and 3.26).

Beaver ponds were observed to have somewhat different chemical limnology compared to other aquatic habitat types (Tables 3.8-3.12, Figures 3.25-3.28, Appendix D, Figures D17-D32). Beaver ponds were observed to have low pH and low ANC with relatively high total nitrogen.

Emergent marsh had high PC1-PC3 scores. Emergent marsh had the highest PC2 scores indicative that this aquatic habitat type had high concentrations of nutrients. These high PC2 scores are consistent with high levels of TP, TN, and concentration of chlorophyll-a observed during univariate analyses. In contrast to other aquatic habitat types, emergent marsh had high LSMs for pH, ANC, Mg, Ca, K, conductivity, Na, Cl, TP, and TN (Tables 3.8-3.12, Figures 3.25-3.28, Appendix D, Figures D17-D32).

In watersheds with nutrient poor soils and resistant bedrock, the difference in chemical limnology between aquatic habitat types may not be as great compared to watersheds with fertile, easily eroded soils. Separate analyses were done for all plots, as well as plots which were nutrient rich (PC1 scores > above 0) and plots which were nutrient poor (PC1 scores < 0; Figures 3.29-3.31). A bi-plot of PC1 versus PC2 for low scores (Figure 3.31) showed less separation of aquatic habitat types than the bi-plot for high scores (Figure 3.30) or all plots (Figure 3.29). For mesotrophic (PC1 scores > 0) plots there were 27 pair-wise comparisons between aquatic habitat types that were significantly different for PC1 and/or PC2 scores (Table 3.20). For oligotrophic plots (PC1 scores < zero) there were only 21 pair-wise comparisons that were significantly different (Table 3.20). As will be discussed this indicates that differences among aquatic habitat types may be accentuated depending on the geological and geographical characteristics of the region.

DISCUSSION

Spatial Variation in Chemical Limnology

The relative amount of variation among plots represents differences in water chemistry due to large spatial-scale geological processes. Differences among aquatic habitats types represent smaller scale, hydrological and biological processes. No previous studies in Atlantic Canada have quantified variation in chemical limnology due to both spatial variation and aquatic habitat type.

The relative amount of spatial autocorrelation in chemical limnology among plots can provide insight into the relative importance of large scale geological and geographical processes to explain the observed variation in chemical limnology. Although autocorrelation statistics indicated that the extent of spatial autocorrelation was relatively limited, mapping the spatial distribution of water chemistry values indicated that for some plots and variables, there was considerable correlation between nearest neighbours. Whereas sample plots were not located equally in all geographic locations, geostatistics may not have provided a true representation of extent of spatial autocorrelation in chemical limnology in the Maritimes.

Plots with good soil buffering capability had high surface water pH (Figure 3.32). A linear regression between water pH and soil pH had an $R^2 = 0.44$ (Figure 3.33). There were plots, however, that were underlain by soils with poor buffering capacity, but had relatively high pH of surface waters. Surface water pH for plots with non-buffered soils ranged from 4.5 to 7.1. A decoupling of the relationship between soil and surface water pH may have arisen due to: 1) errors in assigning soil polygons to buffering capability categories; 2) the pH of water samples being influenced by atmospheric inputs; 3) surface and ground water flowing into the plot from other soil polygons; 4) anthropogenic inputs; 5) and/or the influence of biotic processes (e.g. peatlands).

Spatial variation in the pH of surface waters is studied more often than spatial variation of other aspects of chemical limnology. The among plot variation in pH observed in this study is similar to that previously reported for lakes in New Brunswick and Nova Scotia (Clair *et al.* 1982; Underwood *et al.* 1987). Plots with low pH of surface waters also had a high number of bogs and total area of wetlands, similar to previous findings in Nova Scotia (Gorham *et al.* 1998; Wood *et al.* 1991) and elsewhere in North America (Gergel *et al.* 1999).

Plots that had the highest calcium concentrations in water samples (Figures 3.16 and D7) had high estimated soil pH (Figures 2.8 and 3.33). Of the plots with the ten highest calcium concentrations, eight of them were also within the top ten for estimated soil pH .

The location of surface water with high total phosphorous (PLOTs 42, 44) coincided with areas known for soils with high agricultural potential. Agricultural activities can, in and of themselves, increase the amount of available nutrients through the use of fertilizers and production of manure. Phosphorous levels in surface waters can also be affected by local land use practices (forestry, cottage and housing development). Some PLOTs (e.g. 27) with high total phosphorous concentrations were areas with high residential development (Appendix C - Table C3).

Some plots with high total phosphorous concentrations in surface waters were areas of high peatland development. Bogs are thought to be phosphorous limited (Mitsch and Gosselink 1986). Total phosphorous in these surface waters may have represented organic/colloidal bound phosphorous with very little soluble reactive phosphorous (Bridgham *et al.* 1998). It was also interesting to note that some areas in north-western New Brunswick with surface waters of high pH had low total phosphorous. It has been previously suggested that the pH gradient does not necessarily parallel the gradient of increasing N and P availability, and should not be used as a surrogate for it (Bedford *et al.* 1999). Previous work on emergent wetlands in Ontario did not find a strong relationship between TP and alkalinity (Merendino and Ankney 1994), whereas work on human-impacted wetlands in Nova Scotia did (Staicer *et al.* 1994).

Variation in Chemical Limnology Among Aquatic Habitats

Seymour *et al.* (1992) provided data on total phosphorous, total nitrogen, pH and conductance of 35 dispersed wetlands, 10 lakes, and 15 river sites in the Antigonish watershed in Nova Scotia (near PLOT 44). Parker *et al.* (1992) provided data on pH from 79 wetlands in southwestern New Brunswick (near PLOT 58). Staicer *et al.* (1994) reported on the chemistry of 32 freshwater lakes in central and western Nova Scotia, many of which were known to be receiving anthropogenic nutrient inputs. These previous studies report water chemistry within the range of values observed in this study.

Bogs can be identified in the field on the basis of the presence of plants such as red sphagnum (*Spaghnum rubellum*), leather leaf (*Chamaedaphne calyculata*), lamb-kill (*Kalmia angustifolium*), and larch (*Larix laricina*). Rich fens can be identified by the presence of graminoids such as blue-joint (*Calamagrostis canadensis*) and sedges (*Carex stricta, Carex bullata*) as well as heath shrubs such as spirea (*Spirea latifolia*) and hardhack (*Myrica gale*). Beaver meadows are fens that develop from abandoned beaver ponds (LePage and Keddy 1998). Field identification of fens can be problematic as they undergo successional change towards ombrotrophic conditions. Although the distribution of pH can be bi-modal for fens and bogs based on the presence or absence of groundwater inflow, the range of water chemistry reported for bogs and the use of the terms bog, poor fen, and rich fen indicates that there is a continuum between bogs and fens reflecting relative inputs of groundwater. The Maritime Wetlands Inventory does not have a separate wetland class for fens but rather includes them with bogs (Hanson and Calkins 1996). Based on water samples collected from peatlands during this study it would appear that most peatlands in the Maritimes are in fact bogs. It would appear that assigning water sampling sites to a peatlands category, which includes both fens and bogs, is a logistical necessity that does not introduce much error into the data.

Peatlands are very dilute in terms of cations, as evidenced by low ANC, magnesium, calcium, potassium, and sodium, and PC1 scores. High levels of total organic carbon and apparent colour are indicative of the role that organic acids have in defining the chemistry of bogs (Warner and Rubec 1997). These acids form during the decomposition of peat and are also present within *Spaghnum*. The highly stained tea-coloured water of many rivers and lakes in the Maritimes reflects the contribution of bogs to receiving waters (Gorham *et al.* 1998; Pienitz *et al.* 1997b; Smith 1966; Wood *et al.* 1991). The highly coloured water and high total organic carbon concentrations due to humic and fulvic acids were probably responsible for the high PC2 scores observed for peatlands. Emergent marshes also had high PC2 scores. This colour may have been due to humic acids created in adjacent peatlands and/or high total organic carbon concentrations due to high rates of primary productivity and carbon fixation.

In contrast to peatlands whose chemical limnology is very much influenced by biological processes and ombotrophy, lakes are very much influenced by the surrounding landscape, surficial geology, and atmospheric chemistry. Lake water chemistry was different from the chemistry of other aquatic habitat types. The applicability of lake water chemistry to processes such as potential primary and secondary productivity in adjacent wetlands should, therefore, never be assumed (Jones and Wedeles 1989).

Lentic systems had higher levels of ionic constituents (*e.g.*, magnesium, calcium, conductivity, sodium, chloride, silicate, and sulphate) compared to lacustrine systems.

Higher levels of minerals in rivers may be due to them transporting minerals originating throughout the watershed as well as erosion liberating minerals from the river bed itself.

Rivers had lower PC2 scores than lacustrine marshes and ponds. Lakes had lower PC2 scores than the other two lacustrine systems. It would, therefore, appear that PC2 scores (colour, nitrogen, phosphorous, total organic carbon) are reflecting differences in water volume of these different aquatic habitats. PC1 does not appear sensitive to the influence of water volume, compared to PC2. Overall, aquatic habitat types differed markedly in their PC1 and PC2 scores. Comparison of bi-plots of PC1 versus PC2 scores findings indicates that differences among aquatic habitat types may be accentuated depending on fertility of the wetlands.

Beaver (*Castor canadensis*) are the keystone species in many boreal and temperate riverine systems in eastern North America (Naiman *et al.* 1986; Nummi and Poysa 1997; Smith *et al.* 1991). Water chemistry of beaver ponds was observed to be somewhat different compared to that of other aquatic habitats. The water chemistry of beaver ponds changes after initial flooding with a resultant transfer of ions and nutrients from upland flooded soils to sediments that accumulate in the pond and downstream areas (Naiman *et al.* 1994). Nutrient dynamics and standing stocks change over time after initial flooding. The age of beaver ponds sampled in this study is not known. The low pH and ANC of beaver ponds was probably due to the release of humic acids from the soil upon flooding. Total nitrogen was also relatively high in beaver ponds.

Differences in water chemistry among aquatic habitat types has been most widely investigated in relation to the bog-fen gradient. Chemical gradients have received less attention in minerotrophic wetlands (Cowardin *et al.* 1979; Nicholson 1995). The transport and transformation of chemicals in wetlands involve a great number of interrelated physical, chemical, and biological processes (Mitsch and Gosselink 1986). Wetlands with different hydrologic characteristics have different biogeochemical processes and water chemistry. The chemical limnology of wetlands sampled in this study represent a broader spectrum of spatial area and aquatic habitat types than has previously been reported for the Maritimes. Spatial variation was more important than variation due to aquatic habitat type for the chemical limnology of surface waters in New Brunswick and Nova Scotia. However differences in the chemical limnology of aquatic habitat types may be important when dealing with ecological processes or species that are specific to a given aquatic habitat type. Therefore the use of ENVIRODAT station types which combine all wetland types into one category should be discontinued. Differences observed among aquatic habitat types in this study indicate that the chemical limnology of different minerotrophic wetland types warrants further study (Bedford *et al.* 1999).

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Plot	Year	Day	Month	Collection Mode	# Samples
26	96	27	August	CG Helicopter	28
27	96	27	August	CG Helicopter	24
28	97	9	August	Land	25
29	97	10	August	Land	19
30	97	14	August	Land	15
31	97	14	August	Land	6
32	NA			Historical	68
33	96	14	August	Land	29
34	96	2	July	Land	31
35	97	19	July	Land	20
36	96	21	July	DNR Helicopter	19
37	97	14	July	CG Helicopter	21
38	96	21	July	DNR Helicopter	23
39	97	14	July	CG Helicopter	11
40	96	21	July	DNR Helicopter	16
41	96	20	July	Land	30
42	96	30	July	Land	25
43	97	20	July	Land	17
44	NA			Historical	39
45	97	14	July	CG Helicopter	18
46	97	14	July	CG Helicopter	19
47	97	7	August	Land	12
48	97	7	August	Land	22
49	NA			Historical	43
50	97	8	August	Land	6

Table 3.1 - Sampling dates, collection mode, and number of water samples collected in Nova Scotia. CG Helicopter is Canadian Coast Guard Helicopter, whereas DNR Helicopter is Nova Scotia Department of Natural Resources helicopter.

Plot	Year	Day	Month	Collection Mode	# Samples
51	96	6	July	Land	14
52	96	7	July	Land	10
53	96	9	July	Land	21
54	96	17	July	Land	18
55	96	18	July	Land	21
56	96	11	July	Boat. Land	17
57	97	29	July	Land	23
58	NA			Historical	54
59	96	18	July	Boat. Land	17
60	96	17	July	Boat. Land	21
61	96	27	July	Land	25
62	96	28	July	Land	18
63	97	31	July	Land	19
64	96	20	August	Land	15
65	97	1	August	Land	16
66	97	1	July	Land	25
67	96	13	July	Land	26
68	98	20	August	Land	8
69	96	4	August	Land	20
70	96	5	August	Land	17
71	97	2	August	Land	15
72	97	2	August	Land	16
73	97	3	August	Land	8
74	97	4	August	Land	9
75	97	4	August	Land	13

Table 3.2 - Sampling dates. collection mode. and number of water samples in New Brunswick.

Variable	Log-Transformed	Description	Method	W Value
ANC	LANC	Acid Neutralising Capacity	2011	0.92
COND	LCOND	Specific Conductance	2041	0.91
Chl-a CONC	LCONC	Chlorophyll-a Concentration	-	0.85
COLOR	LCOLOR	Apparent colour	2011	0.95
CL	LCL	Dissolved Chloride	17209	0.97
CA	LCA	Dissolved Calcium	20110	0.96
DIC	LDIC	Dissolved Inorganic Carbon	2220	0.93
K	LK	Dissolved Potassium	19103	0.97
MG	LMG	Dissolved Magnesium	12107	0.93
NA	LNA	Dissolved Sodium	11103	0.92
SIO2	LSIO2	Insoluble Silicate	14109	0.91
SO4	LSO4	Dissolved Sulphate	16309	0.95
TN	LTN	Total Nitrogen	7601	0.99
TOC	LTOC	Total Organic Carbon	E004	0.97
TP	LTP	Total phosphorous	15413	0.96
PH	PH	pH	10301	0.97

Table 3.3 - Water chemistry abbreviations, method number, and W-value for normality

Dependent Variable	Overall Model						Type III SS		Type III SS		Type III SS	
	N	Model R^2	Model MS	Error MS	Model F-Value	Pr > F	W2 F-Value	W2 Pr > F	PLOT F-Value	PLOT Pr > F	W2*PLOT F-Value	W2*PLOT Pr > F
pH	1052	0.844	3.700	0.206	17.98	0.0001	24.91	0.0001	29.99	0.0001	2.79	0.0001
Conductivity	1052	0.749	0.428	0.043	9.87	0.0001	5.54	0.0001	20.33	0.0001	1.55	0.0001
Apparent Colour	1052	0.657	0.729	0.115	6.33	0.0001	9.52	0.0001	12.93	0.0001	1.23	0.0329
Sodium	1052	0.748	0.478	0.049	9.82	0.0001	7.33	0.0001	23.37	0.0001	1.64	0.0001
Magnesium	1052	0.798	0.496	0.038	13.07	0.0001	14.42	0.0001	21.83	0.0001	2.14	0.0001
Potassium	1052	0.618	0.311	0.058	5.35	0.0001	4.48	0.0001	8.96	0.0001	1.45	0.0004
Chl-a Conc.	359	0.441	0.288	0.154	1.87	0.0001	6.70	0.0001	1.11	0.3455	1.18	0.1708
Total Nitrogen	1048	0.713	0.336	0.041	8.18	0.0001	5.13	0.0001	18.86	0.0001	1.55	0.0001
ANC	1037	0.840	0.489	0.028	17.18	0.0001	16.22	0.0001	29.55	0.0001	2.33	0.0001
Silicate	1030	0.646	0.725	0.122	5.93	0.0001	30.20	0.0001	3.13	0.0001	1.94	0.0001
Total Phosphorous	999	0.620	0.532	0.105	5.07	0.0001	5.12	0.0001	9.19	0.0001	1.20	0.0550
Sulphate	1051	0.673	0.477	0.070	6.81	0.0001	3.72	0.0003	18.13	0.0001	1.76	0.0001
Chloride	1051	0.783	0.811	0.068	11.90	0.0001	2.69	0.0064	31.81	0.0001	1.45	0.0004
Calcium	1051	0.835	1.258	0.075	16.73	0.0001	13.51	0.0001	27.55	0.0001	2.05	0.0001
TOC	1047	0.674	0.390	0.057	6.80	0.0001	8.72	0.0001	14.23	0.0001	1.23	0.0331
DIC	540	0.812	0.986	0.070	14.05	0.0001	4.61	0.0001	23.71	0.0001	1.24	0.0861

Table 3.4 - Results from separate GLMs of chemical limnology variables for water samples collected from Black Duck Joint Venture plots. Variables in model were plot (PLOT), aquatic habitat type (W2) and interaction term.

Dependent Variable	Variable Entry: PLOT, W2, PLOT*W2 % Variation Explained By			Variable Entry: W2, PLOT, PLOT*W2 % Variation Explained By		
	PLOT	W2	PLOT*W2	PLOT	W2	PLOT*W2
pH	68	6	10	45	30	10
Conductivity	63	3	9	49	17	9
Apparent Colour	51	5	10	42	14	10
Sodium	62	3	10	56	9	10
Magnesium	66	4	10	46	24	10
Potassium	47	2	13	40	9	13
Chl-a Conc.	11	13	21	6	17	21
Total Nitrogen	59	2	10	56	5	10
ANC	72	4	9	49	27	9
Silicate	35	14	16	12	36	16
Total Phosphorous	47	4	11	36	15	11
Sulphate	51	3	13	48	6	13
Chloride	69	2	7	65	6	7
Calcium	72	4	8	45	31	8
TOC	54	4	9	44	14	9
DIC	74	3	5	50	26	5

Table 3.5 - Relative variation explained by plot (PLOT), aquatic habitat type (W2) and interaction term. Based on Type I sums of squares.

Dependent Variable		Overall Model					Type III SS		Type III SS		Type III SS	
	N	Model R^2	Model MS	Error MS	Model F-Value	Pr>F	W1 F-Value	W1 Pr>F	PLOT F-Value	PLOT Pr>F	W1*PLOT F-Value	W1*PLOT Pr>F
pH	1052	0.786	5.563	0.254	21.91	0.0001	44.00	0.0001	27.43	0.0001	2.19	0.0001
Conductivity	1052	0.691	0.639	0.048	13.35	0.0001	8.96	0.0001	21.25	0.0001	1.18	0.1158
Apparent Colour	1052	0.620	1.111	0.114	9.72	0.0001	25.64	0.0001	13.31	0.0001	1.54	0.0010
Sodium	1052	0.694	0.716	0.053	13.52	0.0001	13.52	0.0001	25.72	0.0001	1.43	0.0058
Magnesium	1052	0.738	0.741	0.044	16.81	0.0001	22.92	0.0001	22.60	0.0001	1.80	0.0001
Potassium	1052	0.540	0.440	0.063	6.99	0.0001	7.14	0.0001	11.17	0.0001	1.09	0.2732
Chl-a Conc.	359	0.287	0.325	0.166	1.96	0.0001	7.58	0.0001	1.27	0.2021	1.09	0.3365
Total Nitrogen	1048	0.661	0.503	0.043	11.58	0.0001	12.08	0.0001	21.84	0.0001	1.50	0.0019
ANC	1037	0.793	0.747	0.033	22.58	0.0001	30.33	0.0001	28.82	0.0001	1.99	0.0001
Silicate	1030	0.569	1.037	0.133	7.79	0.0001	58.00	0.0001	4.28	0.0001	2.44	0.0001
Total Phosphorous	999	0.560	0.778	0.108	7.19	0.0001	10.88	0.0001	10.11	0.0001	1.23	0.0769
Sulphate	1051	0.613	0.701	0.074	9.42	0.0001	6.28	0.0003	17.98	0.0001	1.88	0.0001
Chloride	1051	0.735	1.230	0.075	16.49	0.0001	3.13	0.0249	33.80	0.0001	1.11	0.2278
Calcium	1051	0.788	1.912	0.087	22.08	0.0001	23.61	0.0001	28.75	0.0001	1.49	0.0024
TOC	1047	0.636	0.594	0.057	10.35	0.0001	23.47	0.0001	13.64	0.0001	1.43	0.0056
DIC	540	0.782	1.453	0.074	19.73	0.0001	6.26	0.0004	28.20	0.0001	1.20	0.1628

Table 3.6 - Results from separate GLMs of chemical limnology variables for water samples collected from Black Duck Joint Venture plots. Variables in model were plot (PLOT), station type (W1) and interaction term.

Dependent Variable	Variable Entry: PLOT, W1, PLOT*W1			Variable Entry: W1, PLOT, PLOT*W1		
	% Variation Explained By			% Variation Explained By		
	PLOT	W1	PLOT*W1	PLOT	W1	PLOT*W1
pH	68	5	5	50	24	5
Conductivity	63	2	4	53	12	4
Apparent Colour	51	5	6	43	13	6
Sodium	62	3	5	60	4	5
Magnesium	66	3	5	51	18	5
Potassium	47	2	6	44	5	6
Chl-a Conc.	11	8	10	7	12	10
Total Nitrogen	59	2	6	58	3	6
ANC	72	3	5	52	22	5
Silicate	35	11	12	15	30	12
Total Phosphorous	47	3	6	39	11	6
Sulphate	51	2	8	47	6	8
Chloride	69	1	3	69	2	3
Calcium	72	3	3	49	26	3
TOC	54	4	6	45	13	6
DIC	74	2	3	56	19	3

Table 3.7 - Relative variation explained by plot (PLOT), station type (W1) and interaction term. Based on Type I sums of squares.

Parameter	Peatland/Bog (W2=B)					Beaver Pond (W2=BP)				
(units)	N	Mean	Min	Max	SE	N	Mean	Min	Max	SE
pH (pH units)	65	4.8	3.9	6.7	0.072	72	6.1	4.3	7.9	0.112
Conductivity (µS)	65	34.3	7.4	91.2	1.69	72	57.9	17.6	602	9.17
Chl-a (µg/L)	28	2.284	0.566	6.793	0.341	34	2.181	0.566	9.057	0.426
COLOR (colour units)	65	182	15	566	14	72	142	5	420	13
TN (mg/L)	65	0.25	0.05	0.95	0.022	72	0.31	0.04	2	0.033
ANC (mg/L)	64	-0.5	-5.5	10.3	0.34	72	15.7	-2.1	95.1	2.65
Na (mg/L)	65	2.3	0.1	8.7	0.20	72	3.1	0.7	75.5	1.04
Mg (mg/L)	65	0.41	0.05	1.39	0.030	72	1.04	0.22	6.53	0.139
SIO2 (mg/L)	65	2.36	0.03	18.8	0.34	69	3.77	0.3	8.5	0.25
TP (mg/L)	62	0.013	0.001	0.08	0.0018	72	0.019	0.001	0.09	0.0021
SO4 (mg/L)	65	3.86	0.16	27.6	0.58	72	4.41	0.16	20.1	0.48
Cl (mg/L)	65	3.27	0.15	12	0.32	72	3.99	0.18	110	1.53
K (mg/L)	65	0.22	0.05	1.2	0.022	72	0.32	0.04	1.94	0.036
Ca (mg/L)	65	0.88	0.1	3.77	0.087	72	6.17	0.64	36.2	0.918
TOC (mg/L)	65	19.0	4.3	54.1	1.31	72	15.9	1.2	52.4	1.23
DIC (mg/L)	27	1.3	0.4	4.2	0.18	32	5.1	1	24.5	1.05

Table 3.8 – Sample size, mean, minimum, maximum and standard error of chemical limnology variables for the aquatic habitat types: bog and beaver pond.

Parameter	Emergent Marsh (W2=EM)					Lake (W2=L)				
(units)	N	Mean	Min	Max	SE	N	Mean	Min	Max	SE
pH (pH units)	37	7.2	5.4	9.1	0.134	275	5.6	3.2	7.9	0.046
Conductivity (µS)	37	156.9	15.7	648.1	22.98	275	38.8	6.9	428	2.66
Chl-a (µg/L)	26	7.968	0.566	36.794	2.186	53	3.695	0.566	42.454	1.010
COLOR (colour units)	37	72	5	280	12	275	49	4	290	3
TN (mg/L)	37	0.28	0.04	0.98	0.038	274	0.18	0.01	0.9	0.008
ANC (mg/L)	37	30.5	0.2	119	4.95	266	3.8	-3	102	0.74
Na (mg/L)	37	13.5	0.6	114	3.53	275	3.3	0.3	57	0.27
Mg (mg/L)	37	2.78	0.24	14.6	0.549	275	0.59	0.11	7.83	0.053
SIO2 (mg/L)	37	2.81	0.05	13.8	0.48	267	1.14	0.03	6.6	0.06
TP (mg/L)	37	0.041	0.002	0.35	0.0110	245	0.012	0.001	0.9	0.0039
SO4 (mg/L)	37	9.72	0.19	76.1	2.74	275	3.62	0.2	55	0.28
Cl (mg/L)	37	18.35	0.45	179	5.36	274	4.95	0.27	105.9	0.48
K (mg/L)	37	1.14	0.07	6.3	0.285	275	0.32	0.05	2.5	0.015
Ca (mg/L)	37	11.02	0.25	42.2	1.667	275	1.97	0.13	31.4	0.262
TOC (mg/L)	37	9.5	0.5	34	1.27	274	6.4	0.5	27.3	0.26
DIC (mg/L)	8	7.0	1	11.7	1.33	173	1.7	0.2	26.7	0.27

Table 3.9 – Sample size, mean, minimum, maximum and standard error of chemical limnology variables for aquatic habitat types: emergent marsh, and lake.

Parameter	Lacustrine Marsh (W2=LM)					Pond (W2=P)				
(units)	N	Mean	Min	Max	SE	N	Mean	Min	Max	SE
PH (pH units)	85	5.8	3.9	7.7	0.088	27	6.4	5.4	7.5	0.113
Conductivity (µS)	85	61.1	7.8	709	10.32	27	92.3	16	642	24.39
Chl-a (µg/L)	43	4.318	0.566	18.114	0.667	6	2.925	0.566	7.359	1.136
Colour (color units)	85	77	5	350	8	27	61	5	250	11
TN (mg/L)	85	0.22	0.02	3.92	0.047	27	0.42	0.04	2.2	0.097
ANC (mg/L)	84	8.6	-1.9	224	2.88	27	12.9	-3.6	50.4	2.86
Na (mg/L)	85	5.6	0.5	95	1.29	27	9.4	0.8	88	3.36
Mg (mg/L)	85	0.82	0.15	12.7	0.162	27	1.27	0.25	5.6	0.236
SIO2 (mg/L)	85	1.47	0.05	6.92	0.15	26	2.21	0.08	7.5	0.41
TP (mg/L)	77	0.047	0.002	2.65	0.0343	27	0.045	0.001	0.6	0.0230
SO4 (mg/L)	85	4.52	0.34	95	1.17	27	5.69	0.8	55	2.00
Cl (mg/L)	85	7.69	0.36	84.3	1.60	27	13.52	0.3	123	5.03
K (mg/L)	85	0.48	0.05	5.1	0.083	27	0.66	0.06	2.5	0.114
Ca (mg/L)	85	3.87	0.2	43.9	0.821	27	5.28	0.19	36	1.419
TOC (mg/L)	85	9.7	2	28.4	0.73	27	7.7	1.4	24.9	1.13
DIC (mg/L)	25	5.9	0.1	55.9	2.27	21	4.5	0.9	14.1	0.85

Table 3.10 – Sample size, mean, minimum, maximum and standard error of chemical limnology variables for aquatic habitat types: lacustrine marsh and pond.

Parameter	River (W2=R)					Riverine Marsh (W2=RM)				
(units)	N	Mean	Min	Max	SE	N	Mean	Min	Max	SE
pH (pH units)	88	6.7	4.1	8.7	0.111	133	6.2	4.4	8.1	0.076
Conductivity (μS)	88	97.7	9.9	660	12.61	133	64.5	6.8	545.8	6.56
Chl-a (μg/L)	26	1.328	0.566	5.094	0.215	66	2.693	0.566	22.076	0.496
Colour (colour units)	88	63	4	400	7	133	104	4	420	8
TN (mg/L)	88	0.24	0.03	1.8	0.025	131	0.27	0.03	1.8	0.020
ANC (mg/L)	88	20.5	-4.4	158	2.91	131	14.0	-1.2	101	1.67
Na (mg/L)	88	7.2	1.1	91	1.63	133	4.5	0.7	81.2	0.75
Mg (mg/L)	88	1.36	0.29	5.42	0.122	133	1.17	0.25	6.13	0.101
SIO2 (mg/L)	88	3.84	0.2	8.87	0.22	133	3.87	0.1	9.37	0.18
TP (mg/L)	84	0.013	0.001	0.28	0.0038	131	0.036	0.002	2.1	0.0163
SO4 (mg/L)	87	7.80	0.68	82	1.47	133	5.08	0.23	106	0.90
Cl (mg/L)	88	9.91	0.53	138	2.56	133	5.65	0.26	158	1.30
K (mg/L)	88	0.62	0.08	15.2	0.172	133	0.40	0.03	2.4	0.031
Ca (mg/L)	88	8.86	0.33	57.7	1.174	133	5.47	0.5	39	0.600
TOC (mg/L)	86	7.6	1	33	0.70	132	12.1	1	40.8	0.73
DIC (mg/L)	47	5.7	0.3	40.2	1.16	48	3.3	0.4	27.2	0.67

Table 3.11 – Sample size, mean, minimum, maximum and standard error of chemical limnology variables for aquatic habitat types: river and riverine marsh.

Parameter	Stream (W2=S)				
(units)	N	Mean	Min	Max	SE
pH (pH units)	270	6.6	4.3	8.1	0.055
Conductivity (µS)	270	101.1	8.1	762	7.08
Chl-a (µg/L)	77	1.455	0.566	32.265	0.432
Colour (colour units)	270	68	5	420	4
TN (mg/L)	269	0.28	0.02	3.3	0.017
ANC (mg/L)	268	24.4	-1.8	183	1.99
Na(mg/L)	270	6.7	0.8	105	0.74
Mg (mg/L)	270	1.60	0.15	11.4	0.099
SIO2 (mg/L)	260	4.35	0.27	13.5	0.13
TP (mg/L)	264	0.012	0.001	0.4	0.0016
SO4 (mg/L)	270	8.92	0.25	275	1.53
Cl (mg/L)	270	8.81	0.28	175	1.03
K (mg/L)	270	0.56	0.03	19	0.075
Ca (mg/L)	269	9.96	0.24	80.1	0.810
TOC (mg/L)	269	9.2	0.7	48.3	0.45
DIC (mg/L)	159	7.4	0.3	45.3	0.77

Table 3.12 – Sample size, mean, minimum, maximum and standard error of chemical limnology variables for aquatic habitat type: stream.

Parameter (units)	Peatland/Bog (W1=B)					River (W1=R)				
	N	Mean	Min	Max	SE	N	Mean	Min	Max	SE
pH (pH units)	69	4.8	3.9	6.7	0.073	362	6.6	4.1	8.7	0.049
Conductivity (μS)	69	34.3	7.4	91.2	1.65	362	100.0	8.1	762	6.11
Chl-a (μg/L)	31	2.191	0.566	6.793	0.314	106	1.420	0.566	32.265	0.318
Colour (colour units)	69	185	15	566	13	362	67	4	420	4
TN (mg/L)	69	0.27	0.05	2	0.033	361	0.27	0.02	3.3	0.014
ANC (mg/L)	68	-0.4	-5.5	10.3	0.34	360	23.3	-4.4	183	1.64
Na (mg/L)	69	2.3	0.1	8.7	0.20	362	6.8	0.8	105	0.68
Mg (mg/L)	69	0.42	0.05	1.39	0.029	362	1.53	0.15	11.4	0.080
SIO2 (mg/L)	69	2.37	0.03	18.8	0.33	352	4.21	0.2	13.5	0.11
TP (mg/L)	66	0.01	0.001	0.08	0.0019	352	0.01	0.001	0.4	0.0015
SO4 (mg/L)	69	3.84	0.16	27.6	0.56	361	8.69	0.25	275	1.20
Cl (mg/L)	69	3.28	0.15	12	0.32	362	9.06	0.28	175	0.98
K (mg/L)	69	0.23	0.05	1.2	0.021	362	0.57	0.03	19	0.070
Ca (mg/L)	69	0.93	0.1	3.77	0.089	361	9.66	0.24	80.1	0.670
TOC (mg/L)	69	19.3	4.3	54.1	1.27	359	8.7	0.7	48.3	0.38
DIC (mg/L)	28	1.4	0.4	4.2	0.19	208	6.9	0.3	45.3	0.64

Table 3.13 – Sample size, mean, minimum, maximum and standard error of chemical limnology variables for sample types: peatland, and river.

Parameter	Lake (W1=L)					Wetland (W1=W)				
(units)	N	Mean	Min	Max	SE	N	Mean	Min	Max	SE
pH (pH units)	316	5.7	3.2	7.9	0.044	305	6.2	3.9	9.1	0.055
Conductivity (μS)	316	43.9	6.9	642	3.23	305	74.1	6.8	709	5.59
Chl-a (μg/L)	69	3.938	0.566	42.454	0.820	153	3.781	0.566	36.794	0.485
Colour (colour units)	316	53	4	350	3	305	101	4	420	5
TN (mg/L)	315	0.20	0.01	2.2	0.012	303	0.27	0.03	3.92	0.017
ANC (mg/L)	307	4.7	-3.6	102	0.73	302	15.5	-1.7	224	1.41
Na (mg/L)	316	3.9	0.3	88	0.38	305	5.6	0.6	114	0.71
Mg (mg/L)	316	0.66	0.11	7.83	0.052	305	1.27	0.15	14.6	0.102
SIO2 (mg/L)	307	1.23	0.03	7.5	0.07	302	3.19	0.05	13.8	0.13
TP (mg/L)	286	0.02	0.001	0.9	0.0040	295	0.04	0.001	2.65	0.0116
SO4 (mg/L)	316	3.78	0.2	55	0.30	305	5.34	0.16	106	0.61
Cl (mg/L)	315	5.71	0.27	123	0.61	305	7.38	0.18	179	1.06
K (mg/L)	316	0.37	0.05	5.1	0.023	305	0.48	0.03	6.3	0.044
Ca (mg/L)	316	2.29	0.13	36	0.271	305	6.01	0.21	43.9	0.459
TOC (mg/L)	315	6.7	0.5	28.4	0.28	304	12.0	0.5	52.4	0.50
DIC (mg/L)	198	2.1	0.2	26.7	0.28	106	4.6	0.1	55.9	0.69

Table 3.14 – Sample size, mean, minimum, maximum and standard error of chemical limnology variables for station types: lake and wetland.

Variable	PH	COND	COLOR	TN	ANC	NA	MG	TP	SO4	CL	K	CA	TOC
PH	1	0.6339	-0.5112	0.0357	0.856	0.2851	0.7549	-0.0376	0.2183	0.0787	0.4707	0.8316	-.4588
COND	0.6339	1	-0.3426	0.1716	0.7664	0.6778	0.8601	0.0056	0.4466	0.5252	0.6332	0.7782	-0.2755
COLOR	-0.5112	-0.3426	1	0.2506	-0.3991	-0.1937	-0.3522	0.5117	-0.3164	-0.1504	-0.2817	-0.3462	0.9194
TN	0.0357	0.1716	0.2506	1	0.149	0.1612	0.2035	0.1697	0.2728	0.1902	0.2116	0.1782	0.2924
ANC	0.856	0.7664	-0.3991	0.149	1	0.3276	0.88	0.0087	0.2531	0.1202	0.5087	0.9203	-0.3342
NA	0.2851	0.6778	-0.1937	0.1612	0.3276	1	0.5563	0.0645	0.416	0.9159	0.6785	0.3336	-0.169
MG	0.7549	0.8601	-0.3522	0.2035	0.88	0.5563	1	0.0432	0.3529	0.3762	0.6089	0.8621	-0.2937
TP	-0.0376	0.0056	0.5117	0.1697	0.0087	0.0645	0.0432	1	-0.2253	0.0196	0.151	0.0128	0.4943
SO4	0.2183	0.4466	-0.3164	0.2728	0.2531	0.416	0.3529	-0.2253	1	0.4337	0.3138	0.354	-0.2976
CL	0.0787	0.5252	-0.1504	0.1902	0.1202	0.9159	0.3762	0.0196	0.4337	1	0.5668	0.1258	-0.1368
K	0.4707	0.6332	-0.2817	0.2116	0.5087	0.6785	0.6089	0.151	0.3138	0.5668	1	0.4572	-0.2772
CA	0.8316	0.7782	-0.3462	0.1782	0.9203	0.3336	0.8621	0.0128	0.354	0.1258	0.4572	1	-0.2644
TOC	-0.4588	-0.2755	0.9194	0.2924	-0.3342	-0.169	-0.2937	0.4943	-0.2976	-0.1368	-0.2772	-0.2644	1

Table 3.15 - Correlation matrix from a PCA of chemical limnology of surface waters in BDJV survey plots.

	Eigenvalue	Difference	Proportion	Cumulative
PC1	5.87174	3.52314	0.451672	0.45167
PC2	2.3486	0.53859	0.180662	0.63233
PC3	1.81001	0.78595	0.139231	0.77157
PC4	1.02405	0.44785	0.078773	0.85034
PC5	0.5762	0.08831	0.044323	0.89466
PC6	0.48789	0.19409	0.03753	0.93219
PC7	0.29381	0.08908	0.0226	0.95479
PC8	0.20473	0.09062	0.015748	0.97054
PC9	0.11411	0.0291	0.008778	0.97932
PC10	0.08501	0.01362	0.006539	0.98586
PC11	0.07139	0.00897	0.005492	0.99135
PC12	0.06242	0.01237	0.004801	0.99615
PC13	0.05005	.	0.00385	1

Table 3.16 - Eigenvalue and proportion of variance explained by PC1-PC13 from a PCA of chemical limnology variables of surface waters in BDJV survey plots

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12	PC13
PH	0.3312	-0.1415	0.3032	-0.0603	-0.1106	0.0114	-0.1118	0.7245	0.2558	0.3567	-0.1423	0.0581	0.0928
COND	0.3722	0.1135	0.0171	-0.0317	0.2861	-0.0551	0.0055	-0.4916	0.6586	0.2843	0.0216	0.0553	0.0511
COLOR	-0.2301	0.4728	0.1715	0.0316	0.2754	-0.0481	0.2581	0.1685	-0.1400	0.4084	0.5395	-0.1851	0.0910
TN	0.0721	0.3663	0.0459	0.6498	-0.5103	-0.3136	-0.2506	-0.0618	0.0745	0.0230	0.0217	-0.0487	-0.0454
ANC	0.3525	-0.0378	0.3407	0.0167	0.0531	-0.0777	0.0127	-0.0516	-0.2242	-0.2262	0.4214	0.6529	-0.2024
NA	0.2807	0.2631	-0.3797	-0.2175	0.1348	-0.1334	-0.1641	0.2194	-0.0041	-0.0788	0.0534	-0.2197	-0.7016
MG	0.3761	0.0749	0.1742	-0.0183	0.1399	-0.1034	-0.0616	-0.2548	-0.6258	0.3647	-0.4228	-0.1339	0.0437
TP	-0.0359	0.4422	0.2603	-0.3677	-0.3134	0.6009	-0.3463	-0.1390	0.0196	-0.0322	-0.0072	0.0079	-0.0119
SO4	0.2156	0.0181	-0.2986	0.5452	0.1775	0.6849	0.1788	0.1035	-0.0664	0.0664	-0.0312	0.0999	-0.0606
CL	0.2149	0.2695	-0.5089	-0.1449	0.0990	-0.1249	-0.2871	0.1538	-0.1098	-0.1324	0.0933	0.2125	0.6215
K	0.3019	0.1802	-0.1353	-0.2298	-0.4880	-0.0278	0.7443	-0.0146	0.0070	-0.0610	-0.0488	-0.0193	0.0749
CA	0.3480	-0.0069	0.3331	0.1124	0.1939	0.0518	0.0112	0.0514	0.0310	-0.5655	0.1296	-0.5730	0.2150
TOC	-0.2069	0.4818	0.2012	0.0733	0.3375	-0.1115	0.1968	0.1700	0.1264	-0.2960	-0.5474	0.2838	-0.0385

Table 3.17 - Eigenvectors from a PCA of chemical limnology variables of surface waters in BDJV survey plots.

Dependent Variable	Overall Model						Variables					
	N	Model R^2	Model MS	Error MS	Model F-Value	Pr > F	W2 F-Value	W2 Pr > F	PLOT F-Value	PLOT Pr > F	W2*PLOT F-Value	W2*PLOT Pr > F
PC1	981	0.799	3.249	0.266	12.19	0.0001	11.47	0.0001	22.06	0.0001	1.92	0.0001
PC2	981	0.660	2.685	0.450	5.96	0.0001	8.81	0.0001	11.14	0.0001	1.25	0.0226
PC3	981	0.841	3.423	0.209	16.34	0.0001	2.95	0.0030	37.48	0.0001	1.64	0.0001
PC4	981	0.795	3.235	0.271	11.93	0.0001	1.31	0.2358	32.17	0.0001	1.21	0.0425
PC5	981	0.543	2.206	0.607	3.64	0.0001	2.59	0.0085	6.31	0.0001	1.54	0.0001
PC6	981	0.542	2.205	0.607	3.63	0.0001	1.33	0.2252	8.73	0.0001	1.16	0.0887

Table 3.18 - Results from separate GLMs of principal components scores from PCA of chemical limnology of surface waters in BDJV survey plots. Variables in model were plot (PLOT), aquatic habitat type (W2) and interaction term.

Dependent Variable	**Variable Entry: PLOT, W2, PLOT*W2**			**Variable Entry: W2, PLOT, PLOT*W2**		
	% Variation Explained By			% Variation Explained By		
	PLOT	W2	PLOT*W2	PLOT	W2	PLOT*W2
PC1	66	4	10	48	23	10
PC2	50	5	11	45	10	11
PC3	77	1	7	59	19	7
PC4	73	1	6	69	5	6
PC5	36	1	18	32	5	18
PC6	39	2	13	38	3	13

Table 3.19 - Relative variation explained by plot (PLOT), aquatic habitat type (W2) and interaction term in GLM of PC scores. Based on Type I sums of squares.

Wetland	Nutrient Poor Plots- Significant Differences Among PC1 and PC2 Scores									# Significant Differences
	B	**BP**	**EM**	**L**	**LM**	**P**	**R**	**RM**	**S**	
B	.	BOTH	PC1	BOTH	PC1	PC1	PC1	BOTH	BOTH	8
BP	BOTH	.	x	PC2	PC2	x	BOTH	x	BOTH	4
EM	PC1	x	.	PC2	x	x	x	x	x	1
L	BOTH	PC2	PC2	.	PC2	BOTH	BOTH	BOTH	BOTH	5
LM	PC1	PC2	x	PC2	.	x	PC1	PC2	PC1	3
P	PC1	x	x	BOTH	x	.	x	x	x	0
R	PC1	BOTH	x	BOTH	PC1	x	.	x	x	0
RM	BOTH	x	x	BOTH	PC2	x	x	.	x	0
S	BOTH	BOTH	x	BOTH	PC1	x	x	x	.	21

Wetland	Nutrient Rich Plots - Significant Differences Among PC1 and PC2 Scores									# Significant Differences
	B	**BP**	**EM**	**L**	**LM**	**P**	**R**	**RM**	**S**	
B	.	PC1	PC1	BOTH	BOTH	x	BOTH	PC1	PC1	7
BP	PC1	.	PC1	PC1	x	x	x	x	x	2
EM	PC1	PC1	.	BOTH	BOTH	PC1	PC2	PC1	PC1	6
L	BOTH	PC1	BOTH	.	x	PC2	PC1	BOTH	BOTH	4
LM	BOTH	x	BOTH	x	.	x	PC1	PC2	PC1	3
P	x	x	PC1	PC2	x	.	BOTH	PC1	PC1	3
R	BOTH	x	PC2	PC1	PC1	BOTH	.	PC2	PC2	2
RM	PC1	x	PC1	BOTH	PC2	PC1	PC2	.	x	0
S	PC1	x	PC1	BOTH	PC1	PC1	PC2	x	.	27

Wetland	All Plots - Significant Differences Among PC1 and PC2 Scores									# Significant Differences
	B	**BP**	**EM**	**L**	**LM**	**P**	**R**	**RM**	**S**	
B	.	PC1	PC1	BOTH	BOTH	PC1	BOTH	PC1	BOTH	8
BP	PC1	.	BOTH	PC2	PC2	x	BOTH	x	PC1	5
EM	PC1	BOTH	.	BOTH	BOTH	BOTH	BOTH	BOTH	BOTH	6
L	BOTH	PC2	BOTH	.	PC2	PC2	BOTH	BOTH	BOTH	5
LM	BOTH	PC2	BOTH	PC2	.	x	PC1	BOTH	PC1	3
P	PC1	x	BOTH	PC2	x	.	PC1	x	PC1	2
R	BOTH	BOTH	BOTH	BOTH	PC1	PC1	.	BOTH	PC2	2
RM	PC1	x	BOTH	BOTH	PC2	x	BOTH	.	PC1	1
S	BOTH	PC1	BOTH	BOTH	PC1	PC1	PC2	PC1	.	32

Table 3.20 - Number of significant differences among aquatic habitat type for PC1 and PC2 scores. Analyses were conducted on a subset of plots with PC1 Scores < 0 (nutrient poor), plots with PC1 Scores > 0 (nutrient rich) as well as complete data set

Lag Class	Distance Between Pairs (m)	No. Pairs	Moran's I ANC log(+6)	Moran's I pH	Moran's I Ca log	Moran's I Mg Log	Moran's I K log	Moran's I Cond log	Moran's I Cl log	Moran's I Na log
1	27201	29	0.538	0.565	0.5381	0.343	0.183	0.236	0.459	0.352
2	63217	72	0.084	0.132	0.1218	0.222	0.146	0.213	0.655	0.607
3	99317	117	0.368	0.202	0.2929	0.199	0.147	0.112	0.464	0.414
4	139474	129	0.018	-0.031	0.0341	-0.105	-0.027	-0.153	0.415	0.331
5	180330	138	0.003	-0.021	0.0192	-0.046	0.006	-0.048	0.226	0.19
6	217705	153	0.057	0.034	0.0962	-0.097	0.066	-0.059	0.143	0.103
7	261808	123	0.091	0.191	0.0871	-0.022	-0.094	-0.019	-0.264	-0.259
8	298923	107	0.065	0.079	0.0468	0.04	-0.193	0.019	-0.287	-0.271
9	342633	96	-0.168	-0.157	-0.1976	-0.075	-0.085	-0.014	-0.231	-0.17

Table 3.21 - Moran's I statistic for spatial autocorrelation for ANC and other water chemistry variables.

Lag Class	Distance Between Pairs(m)	No. Pairs	Moran's I Colour log	Moran's I TOC log	Moran's I K log	Moran's I SIO2 log	Moran's I S log	Moran's I TN log	Moran's I TP log
1	27201	29	0.616	0.575	0.183	0.591	0.136	0.41	0.591
2	63217	72	0.154	0.082	0.146	0.465	0.183	-0.088	0.116
3	99317	117	-0.033	-0.151	0.147	0.372	-0.028	-0.223	0.025
4	139474	129	-0.02	0.037	-0.027	0.348	-0.144	-0.021	0.039
5	180330	138	0.109	0.127	0.006	0.073	-0.046	0.123	0.025
6	217705	153	-0.269	-0.26	0.066	0.297	0.178	-0.072	-0.273
7	261808	123	0.06	0.079	-0.094	-0.013	0.02	-0.105	0.018
8	298923	107	-0.011	-0.014	-0.193	-0.205	-0.083	-0.07	-0.028
9	342633	96	-0.005	0	-0.085	-0.42	-0.086	0.07	-0.24

Table 3.22 - Moran's I statistic for spatial autocorrelation for apparent colour and other water chemistry variables.

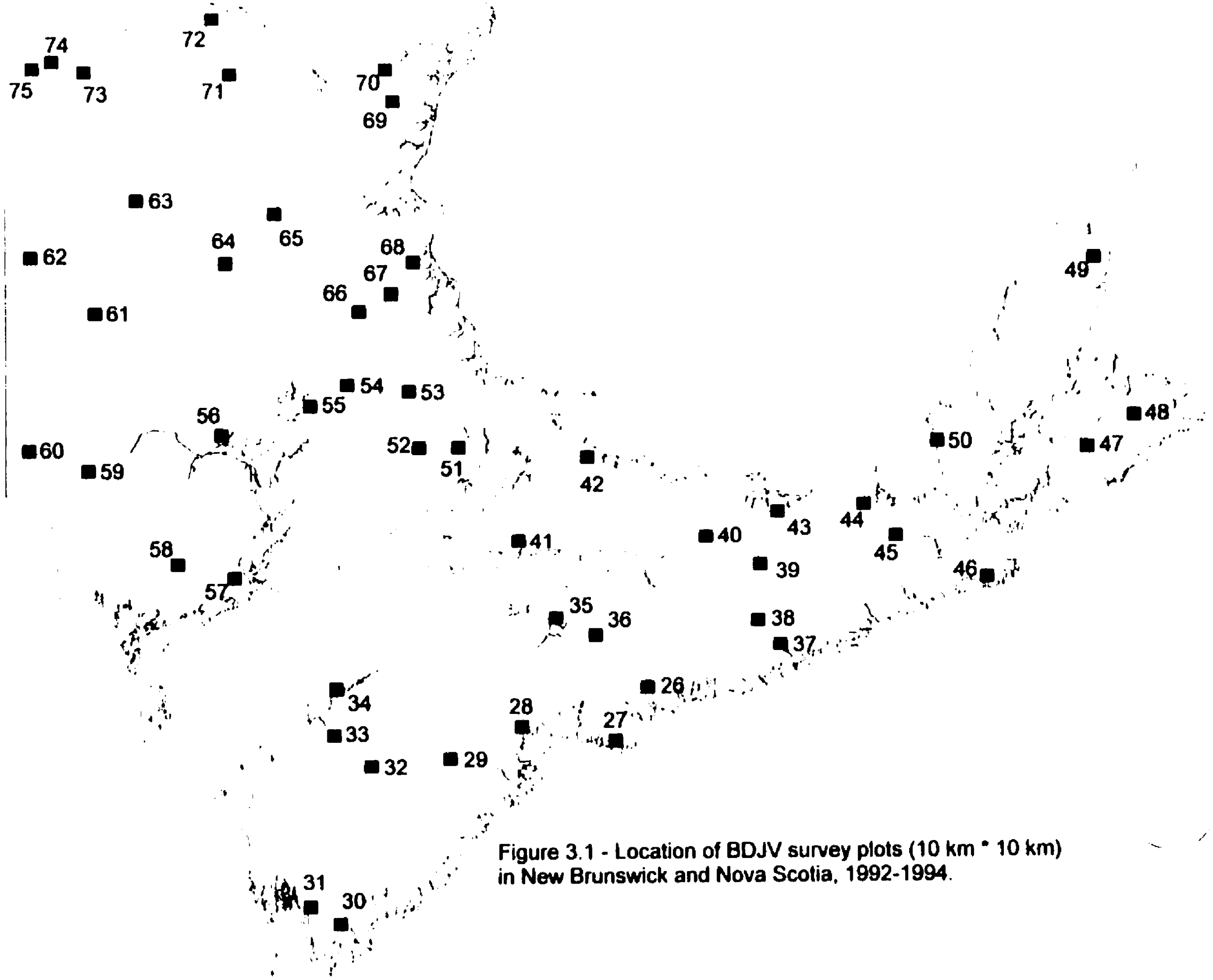


Figure 3.1 - Location of BDJV survey plots (10 km * 10 km) in New Brunswick and Nova Scotia, 1992-1994.

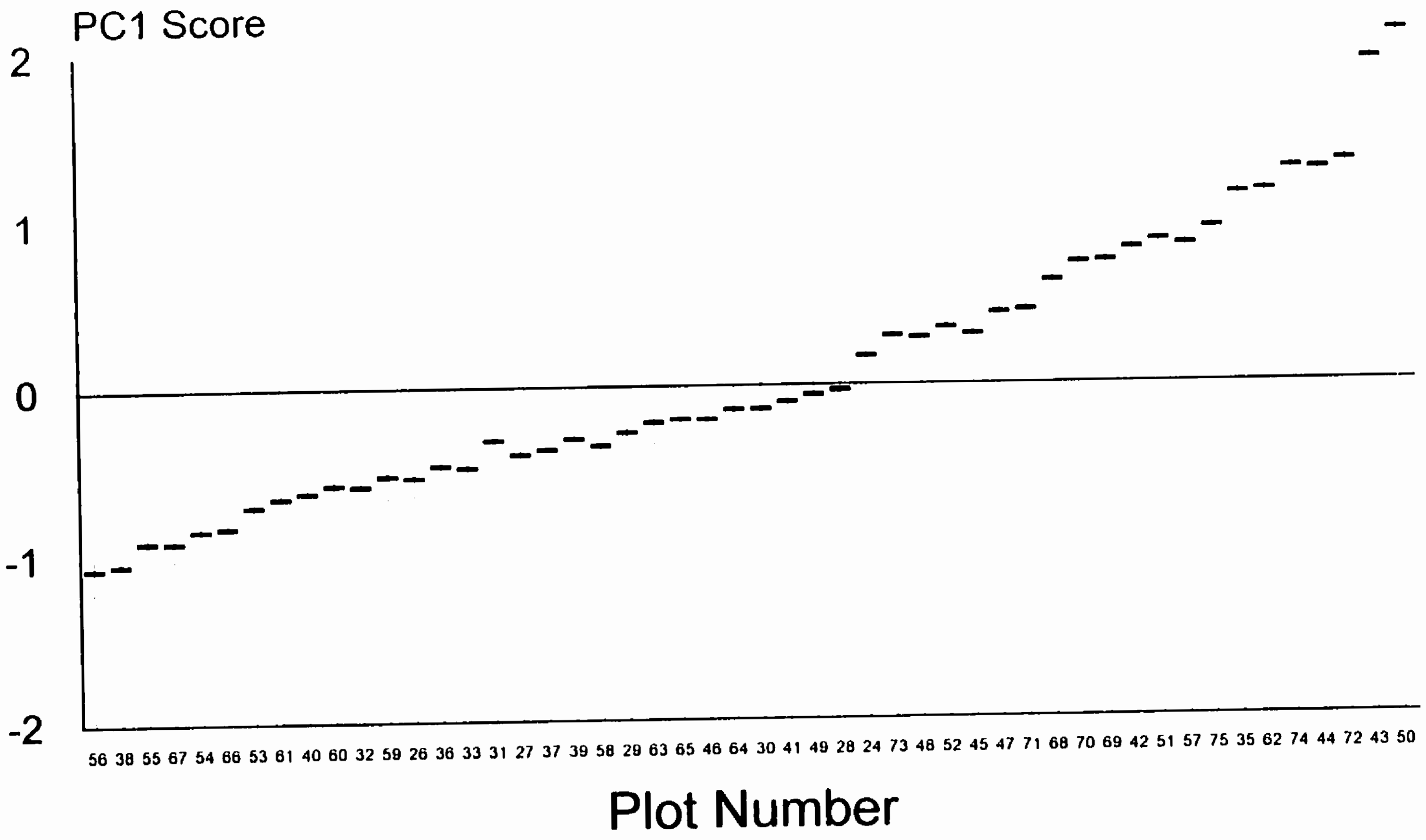


Figure 3.2 - Least squares mean and standard error of PC1 Score from PCA of chemical limnology of surface waters of survey plots.

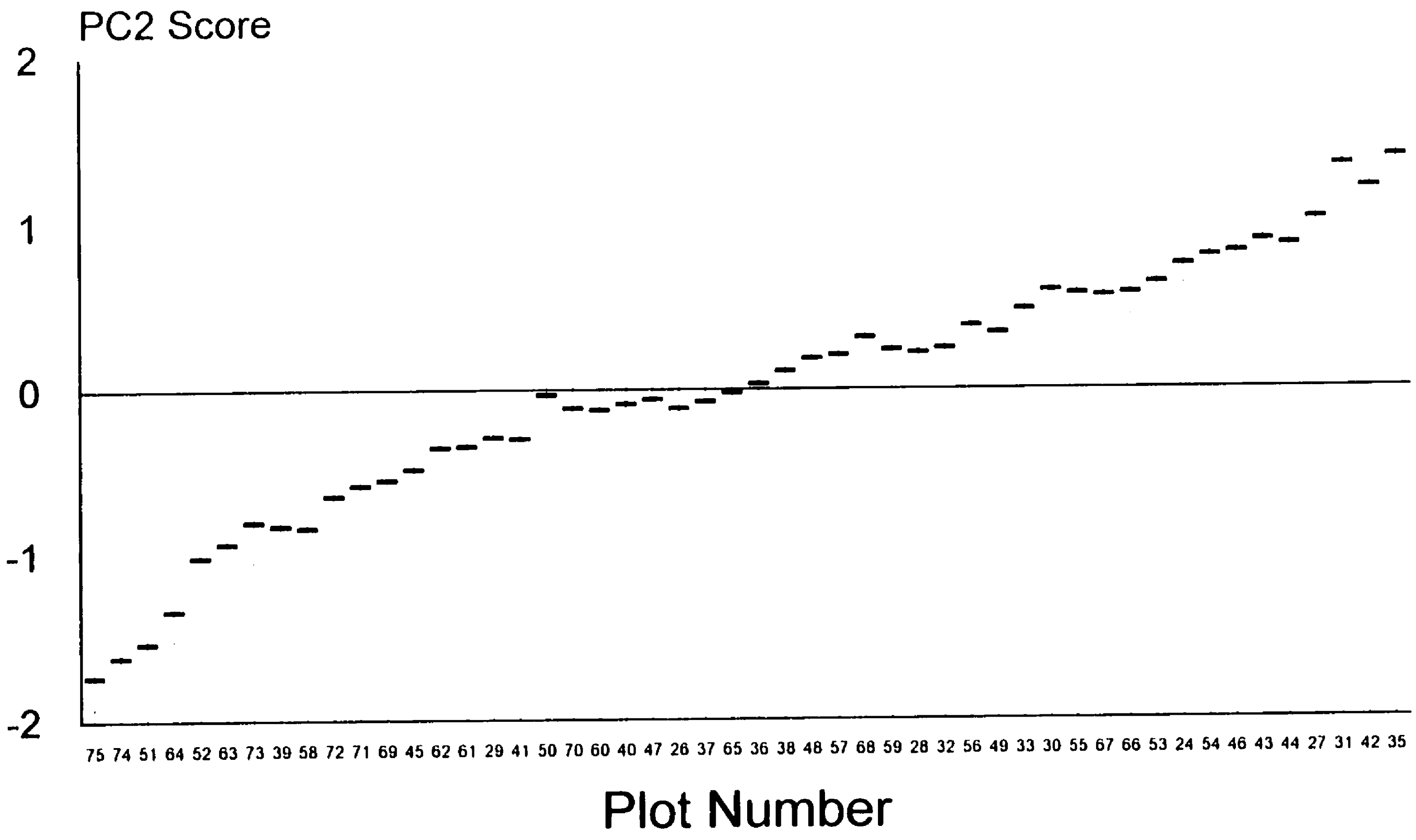


Figure 3.3 - Least squares mean and standard error of PC2 Score from PCA of chemical limnology of surface waters of survey plots.

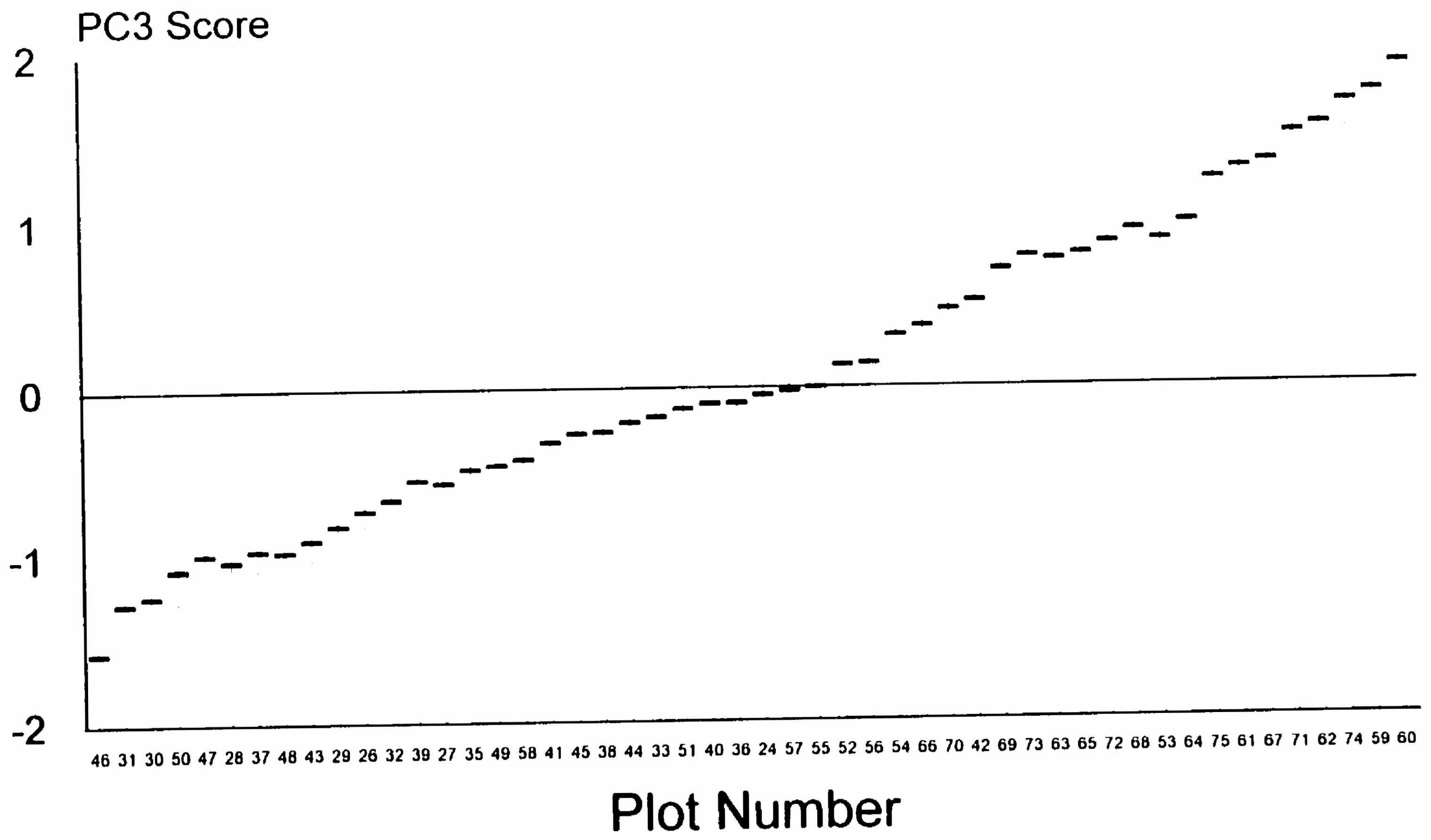


Figure 3.4 - Least squares mean and standard error of PC3 Score from PCA of chemical limnology of surface waters of survey plots.

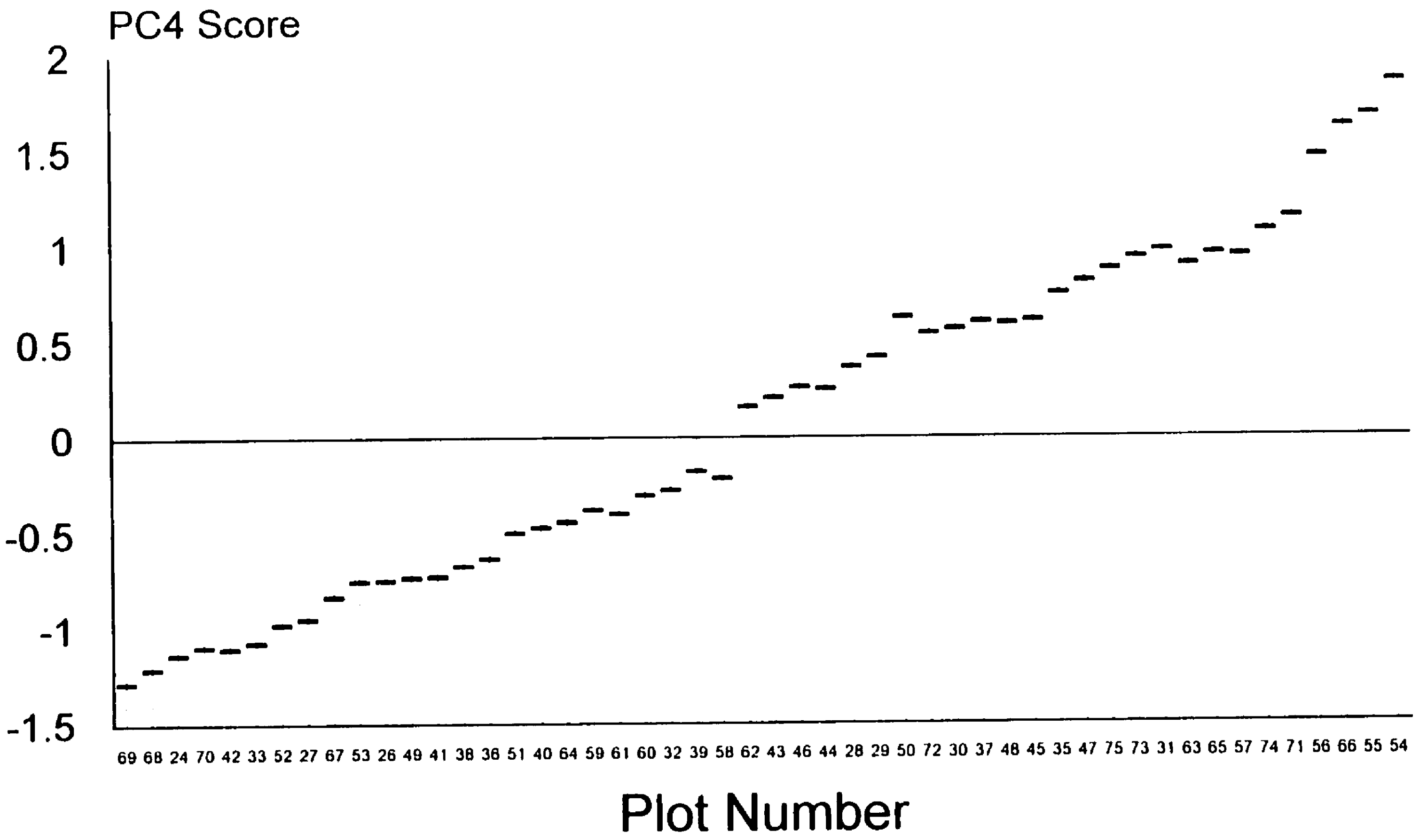


Figure 3.5 - Least squares mean and standard error of PC4 Score from PCA of chemical limnology of surface waters of survey plots.

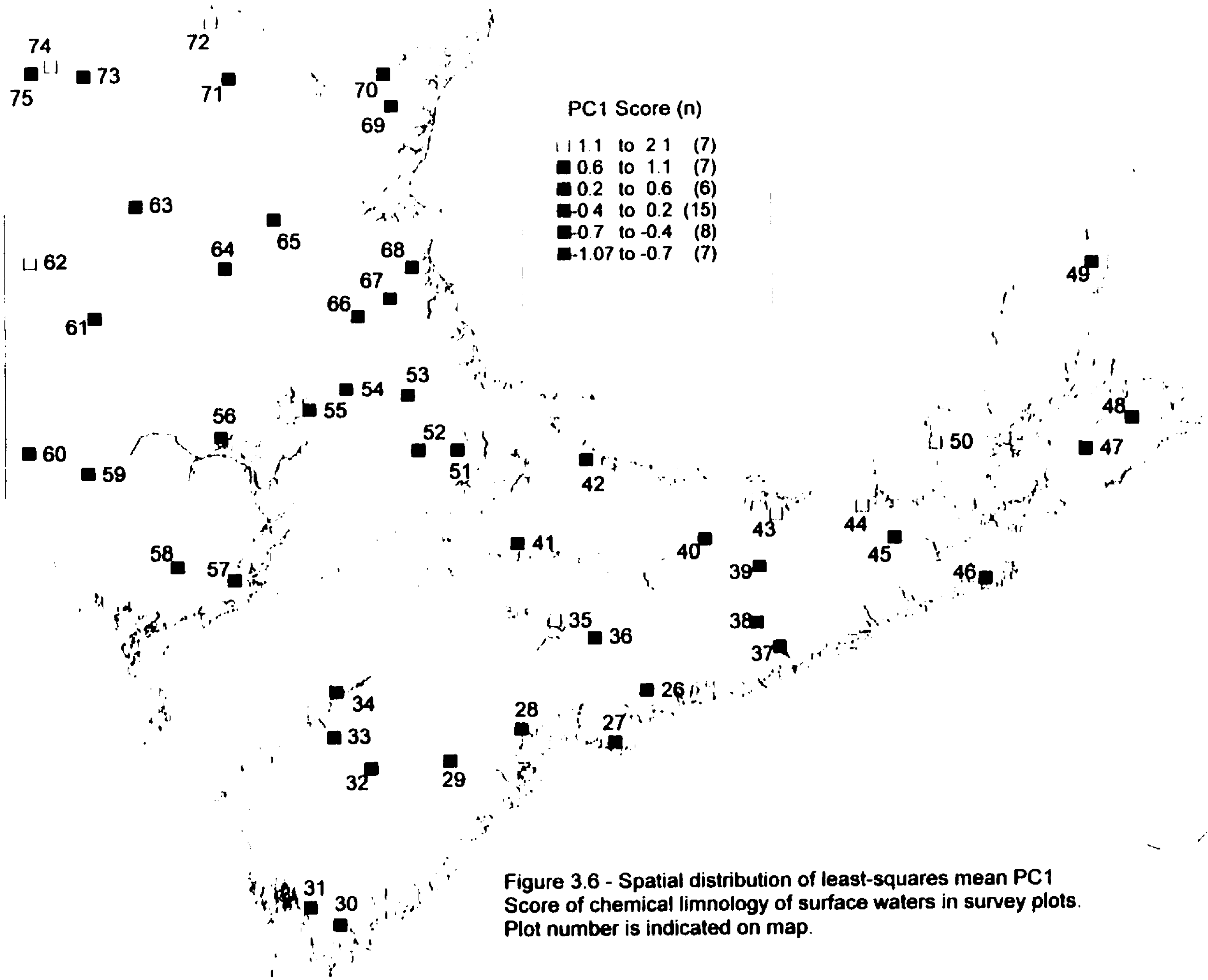


Figure 3.6 - Spatial distribution of least-squares mean PC1 Score of chemical limnology of surface waters in survey plots. Plot number is indicated on map.

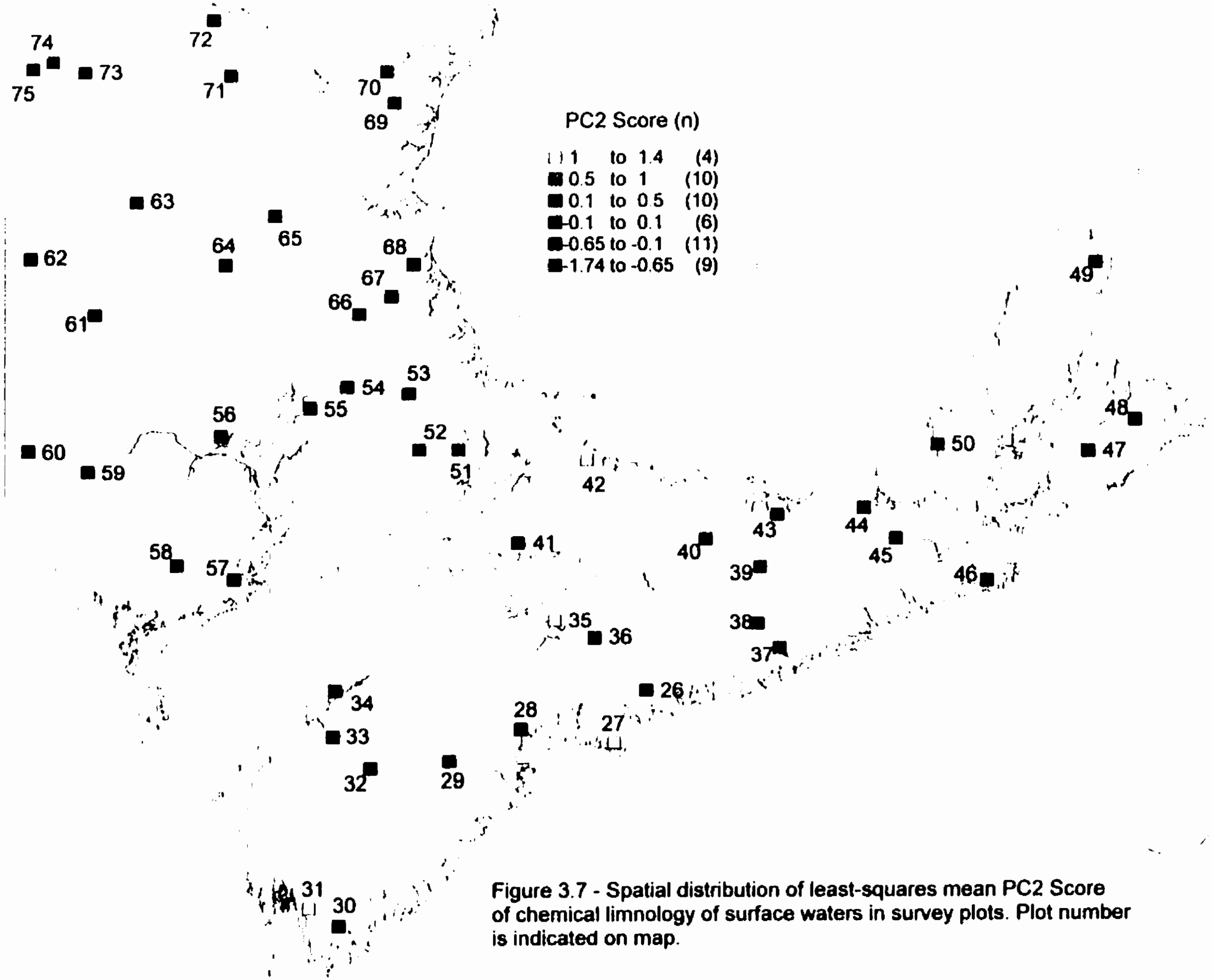
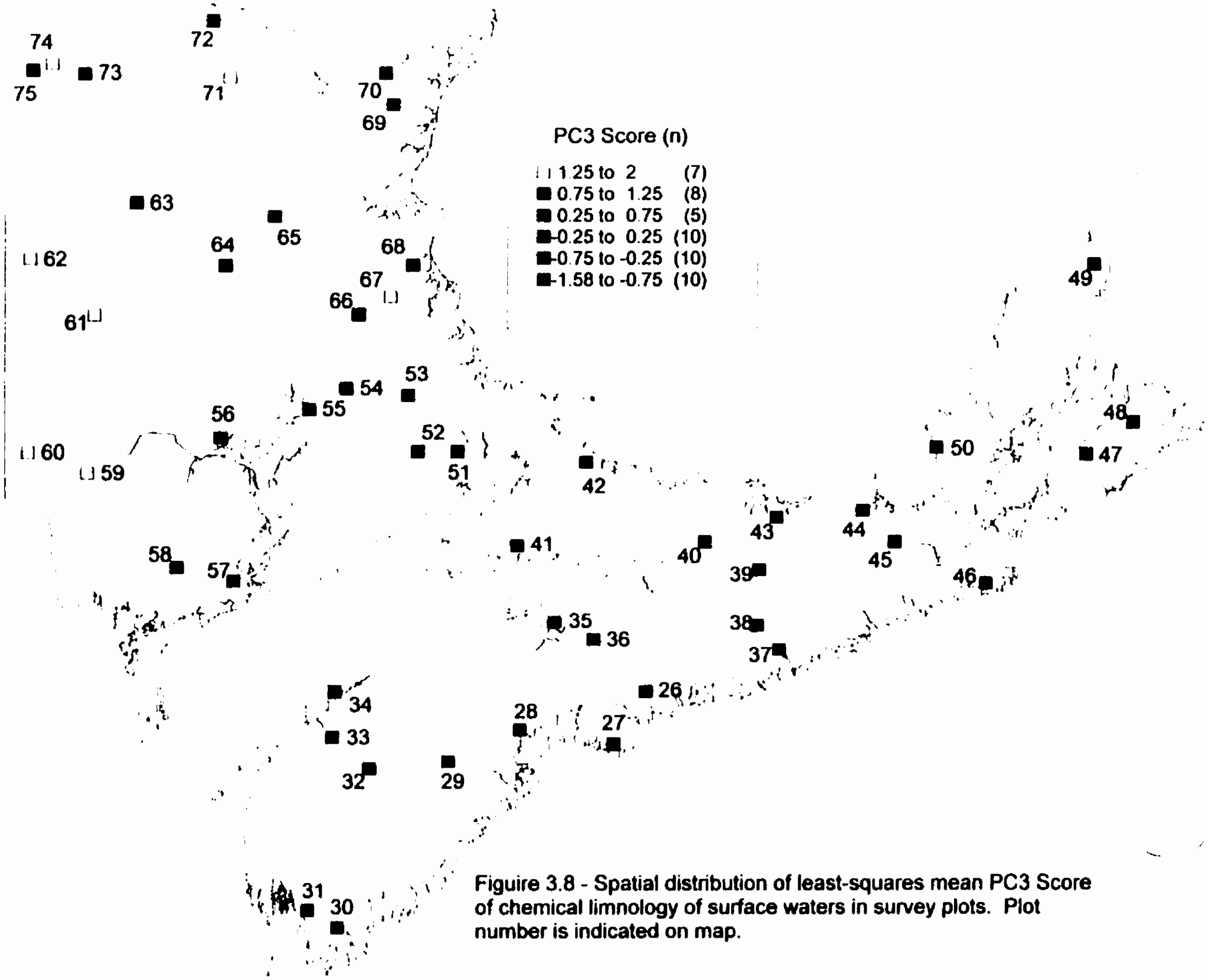


Figure 3.7 - Spatial distribution of least-squares mean PC2 Score of chemical limnology of surface waters in survey plots. Plot number is indicated on map.



Figuire 3.8 - Spatial distribution of least-squares mean PC3 Score of chemical limnology of surface waters in survey plots. Plot number is indicated on map.

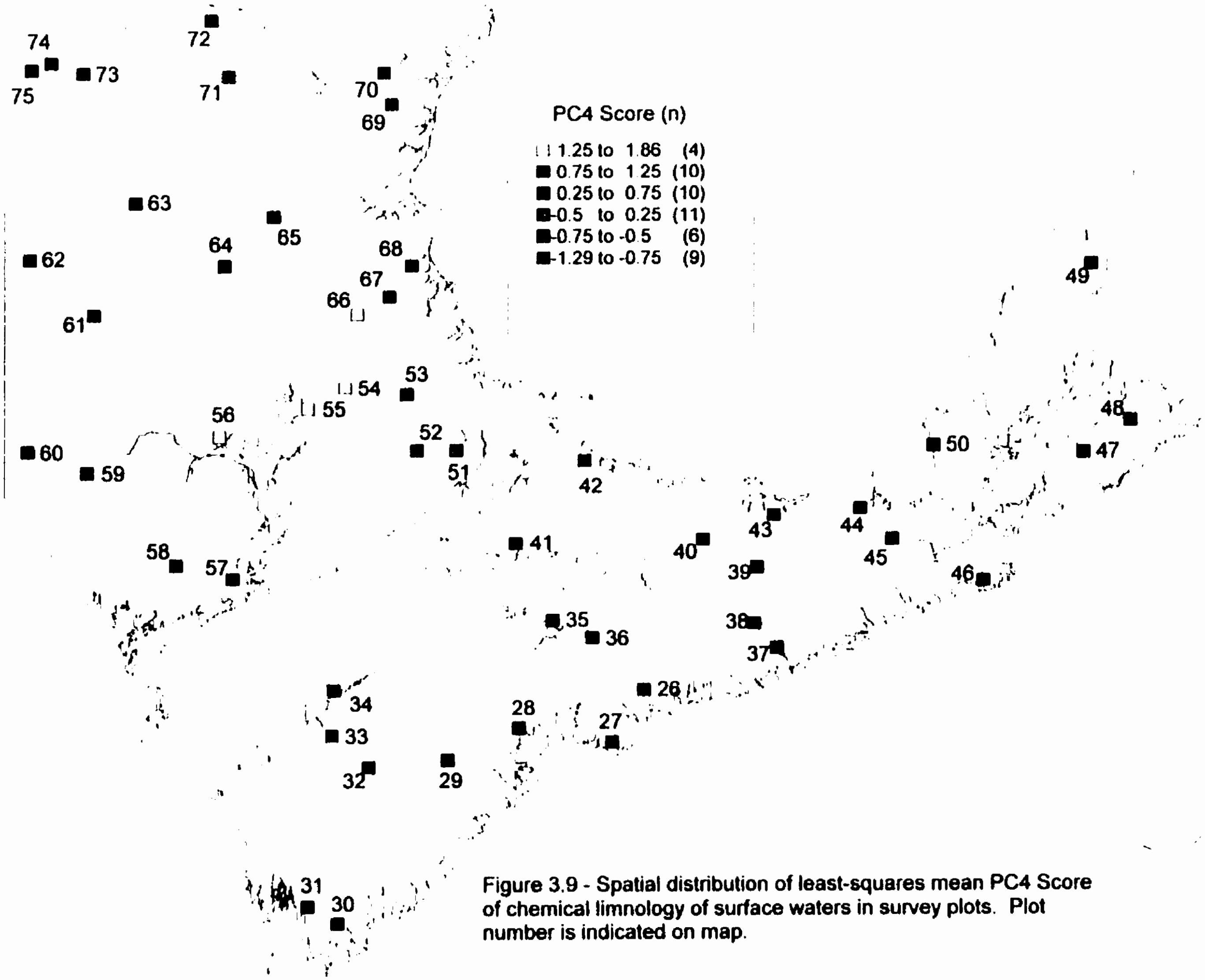


Figure 3.9 - Spatial distribution of least-squares mean PC4 Score of chemical limnology of surface waters in survey plots. Plot number is indicated on map.

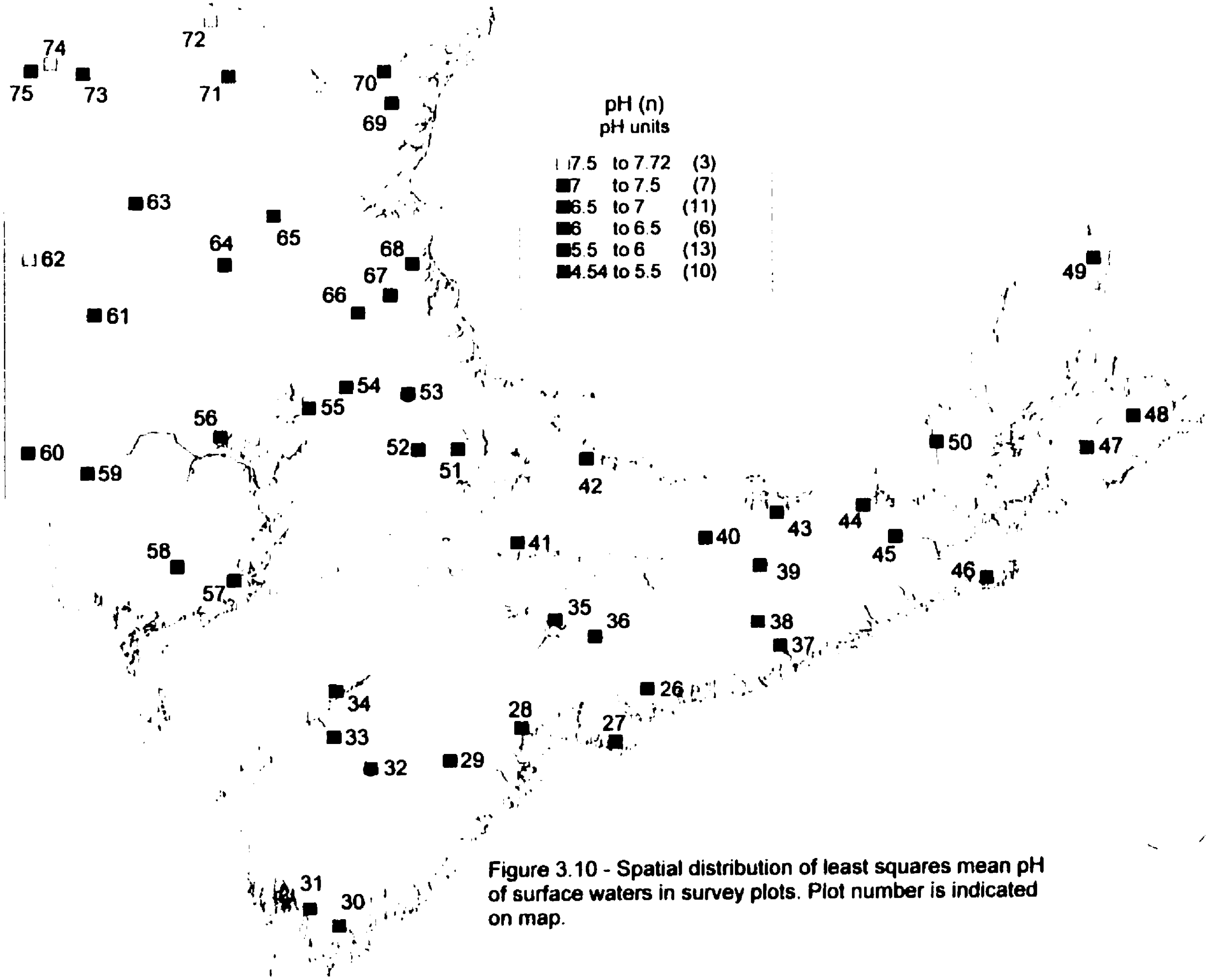


Figure 3.10 - Spatial distribution of least squares mean pH of surface waters in survey plots. Plot number is indicated on map.

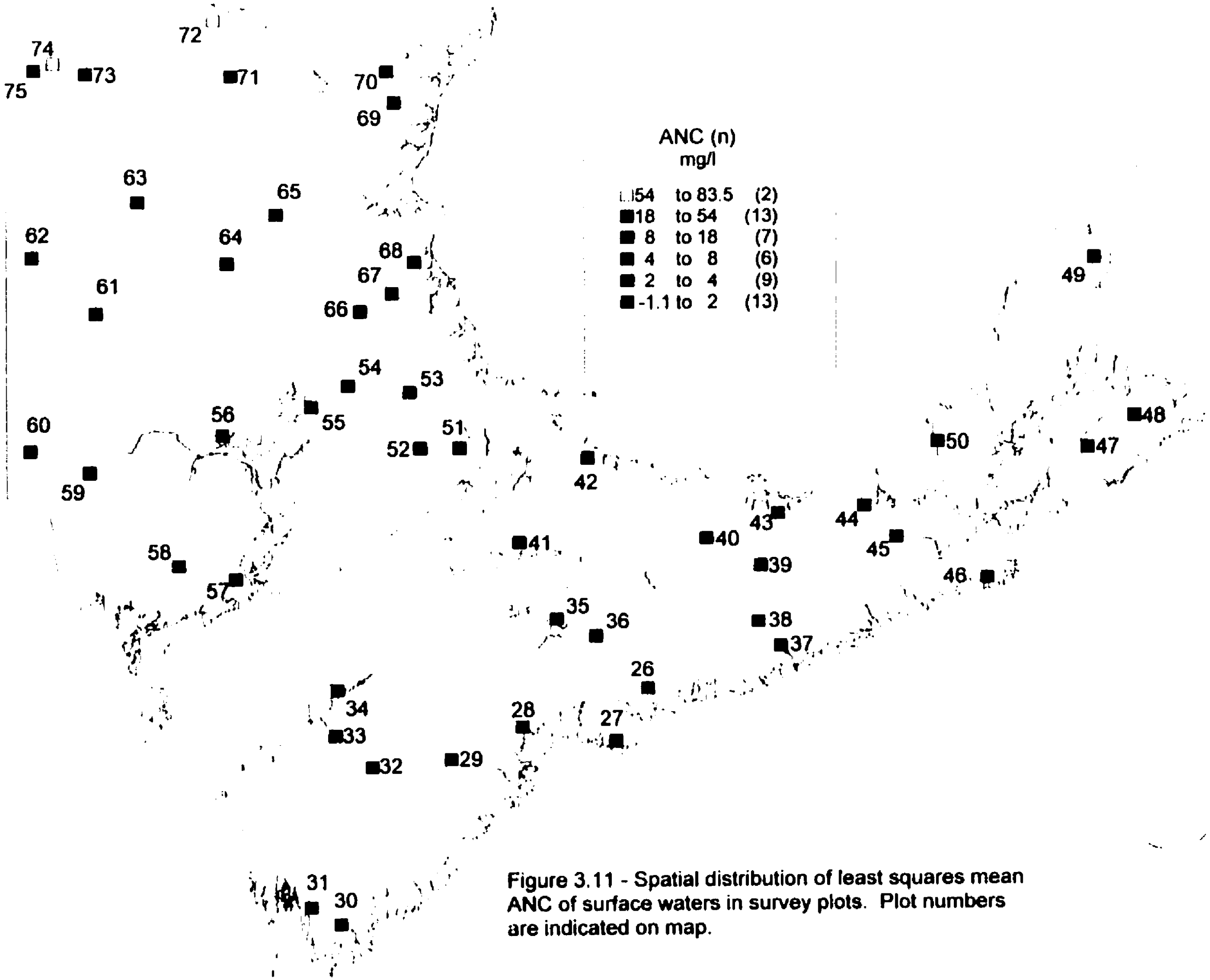


Figure 3.11 - Spatial distribution of least squares mean ANC of surface waters in survey plots. Plot numbers are indicated on map.

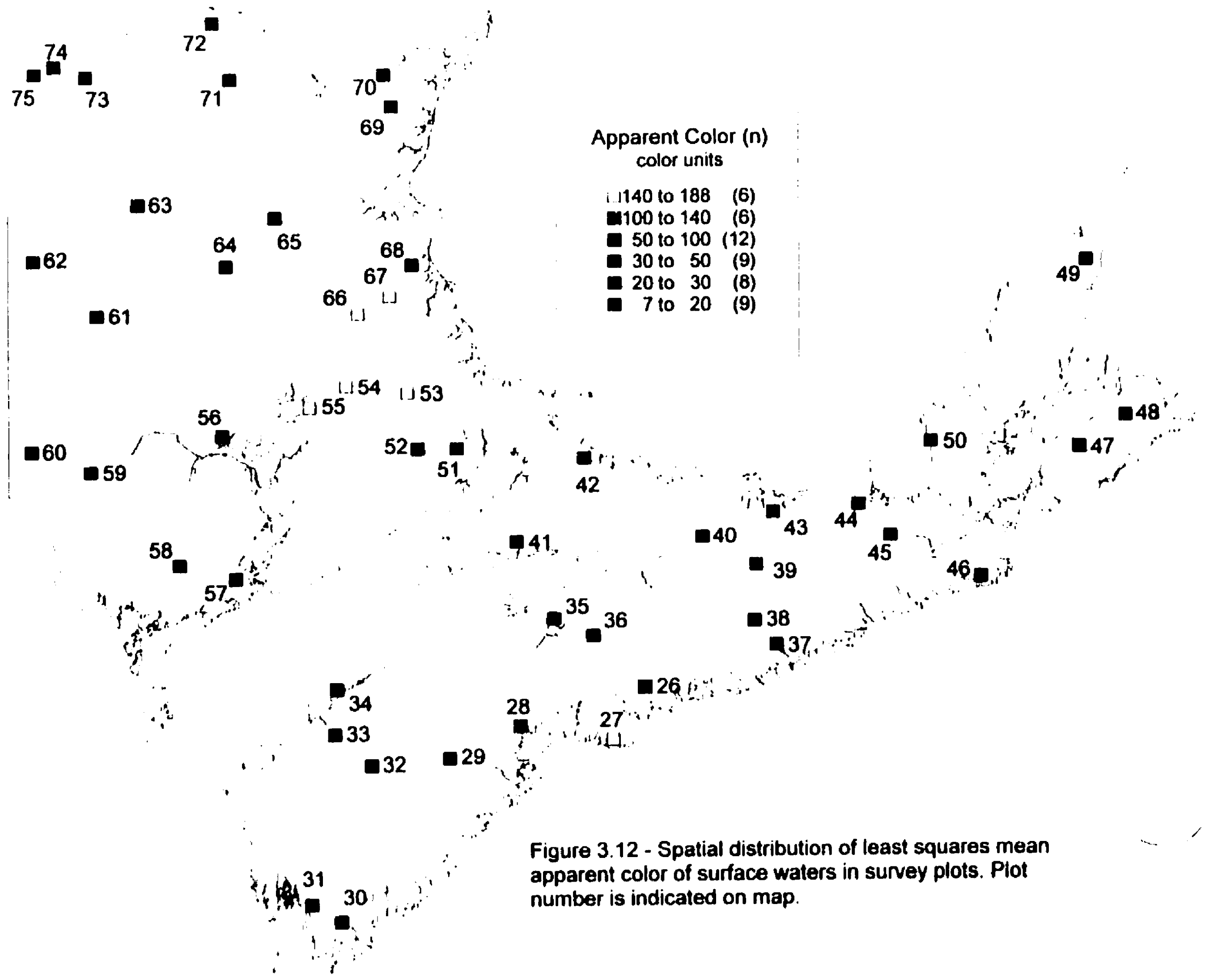


Figure 3.12 - Spatial distribution of least squares mean apparent color of surface waters in survey plots. Plot number is indicated on map.

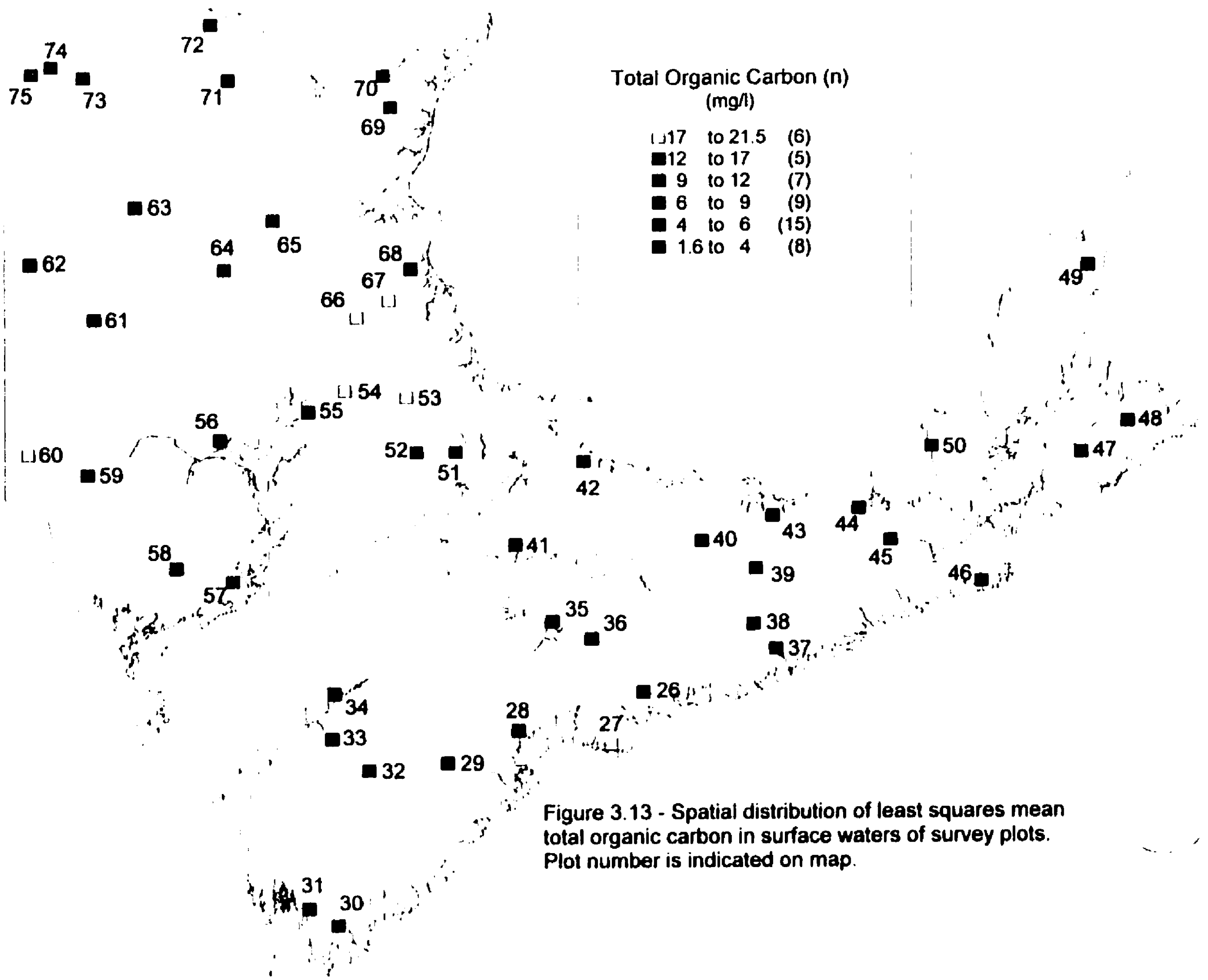


Figure 3.13 - Spatial distribution of least squares mean total organic carbon in surface waters of survey plots. Plot number is indicated on map.

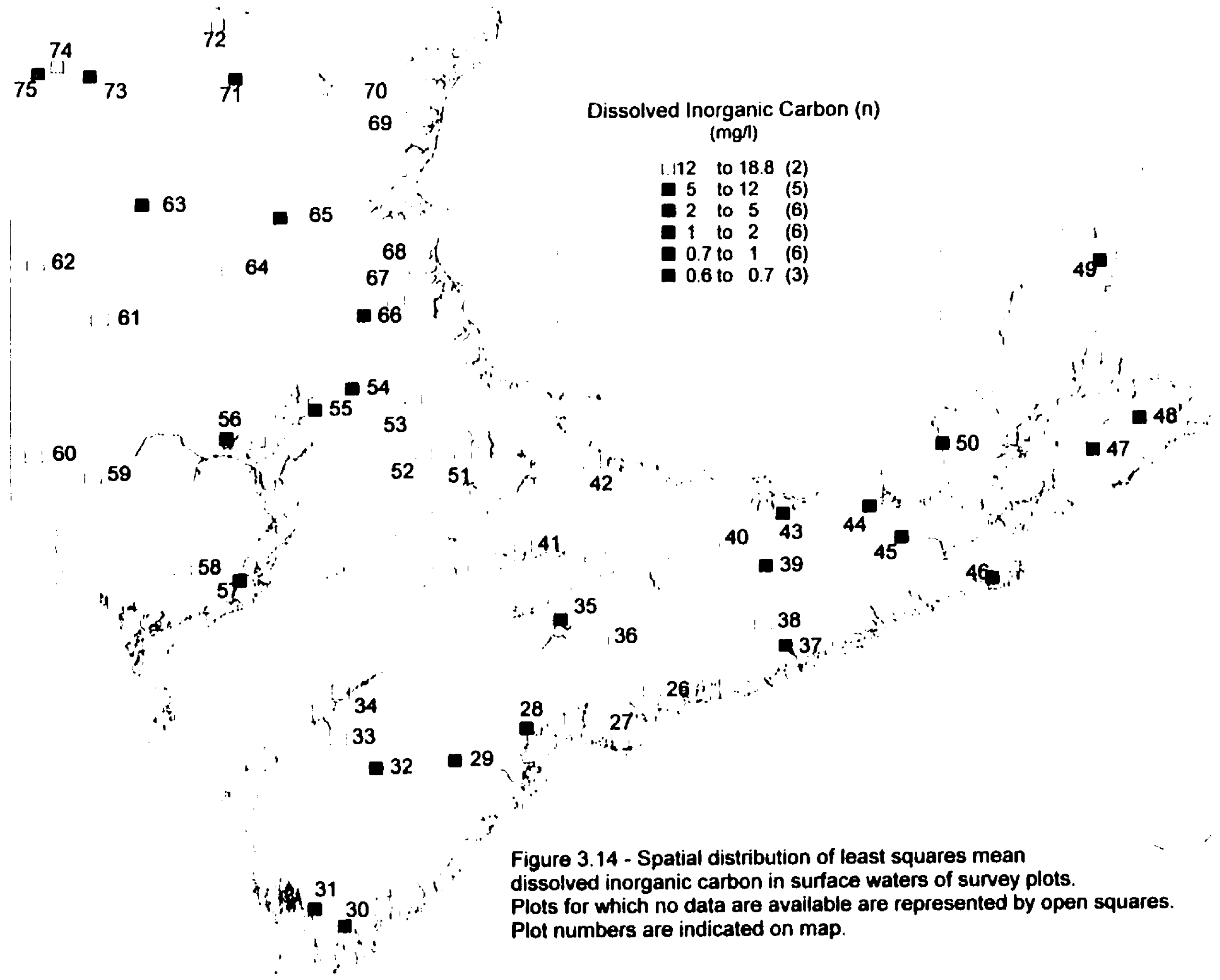


Figure 3.14 - Spatial distribution of least squares mean dissolved inorganic carbon in surface waters of survey plots. Plots for which no data are available are represented by open squares. Plot numbers are indicated on map.

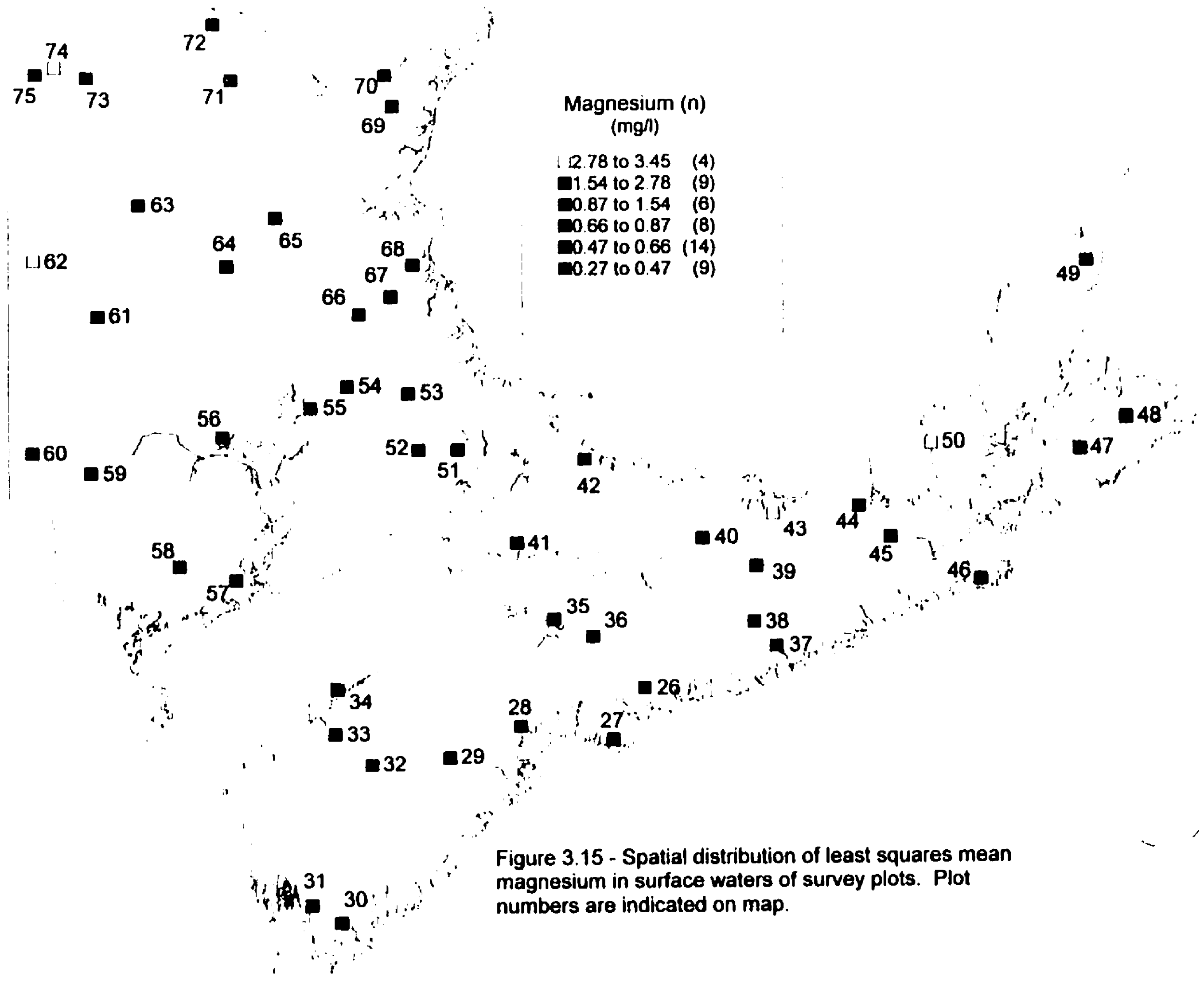


Figure 3.15 - Spatial distribution of least squares mean magnesium in surface waters of survey plots. Plot numbers are indicated on map.

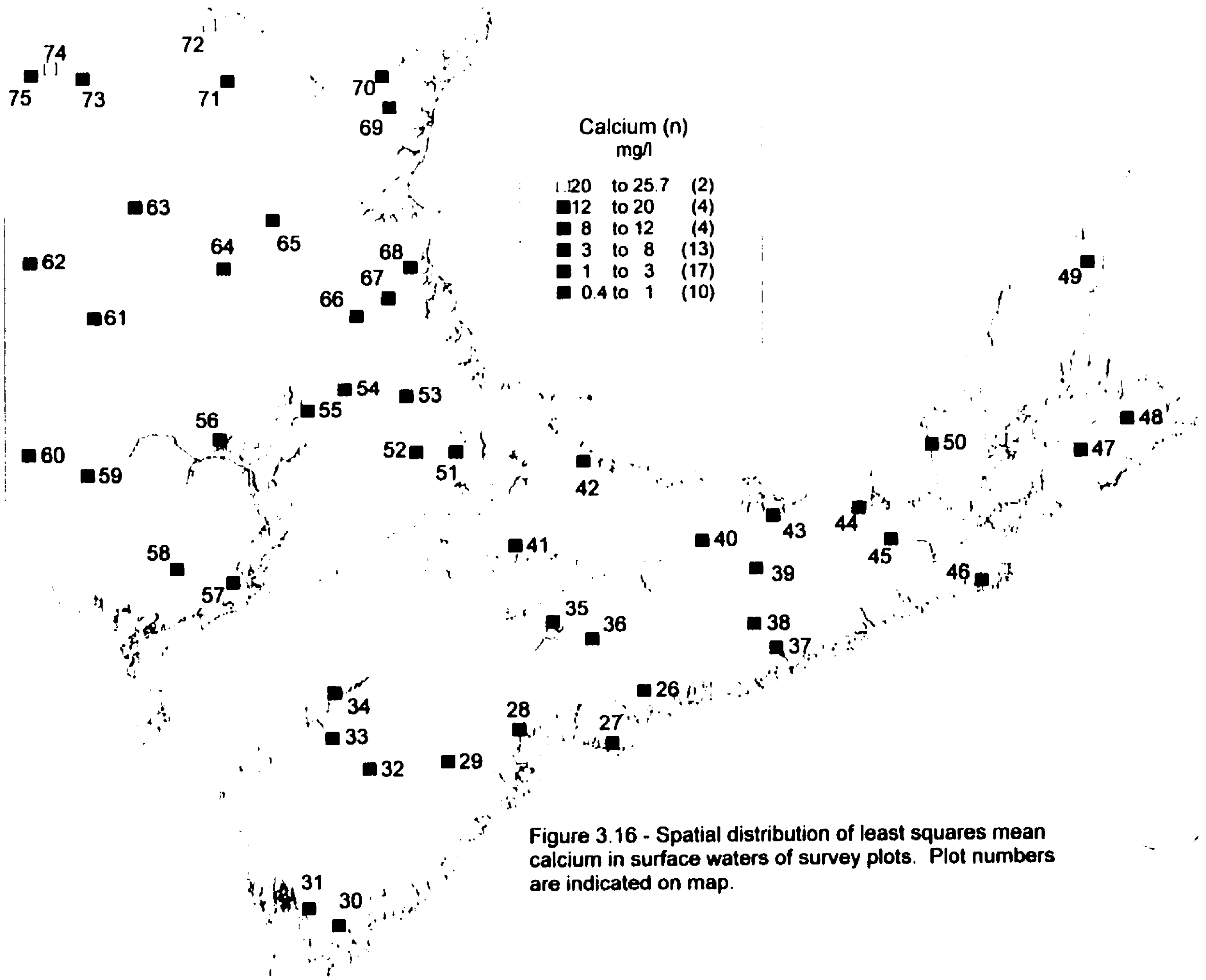


Figure 3.16 - Spatial distribution of least squares mean calcium in surface waters of survey plots. Plot numbers are indicated on map.

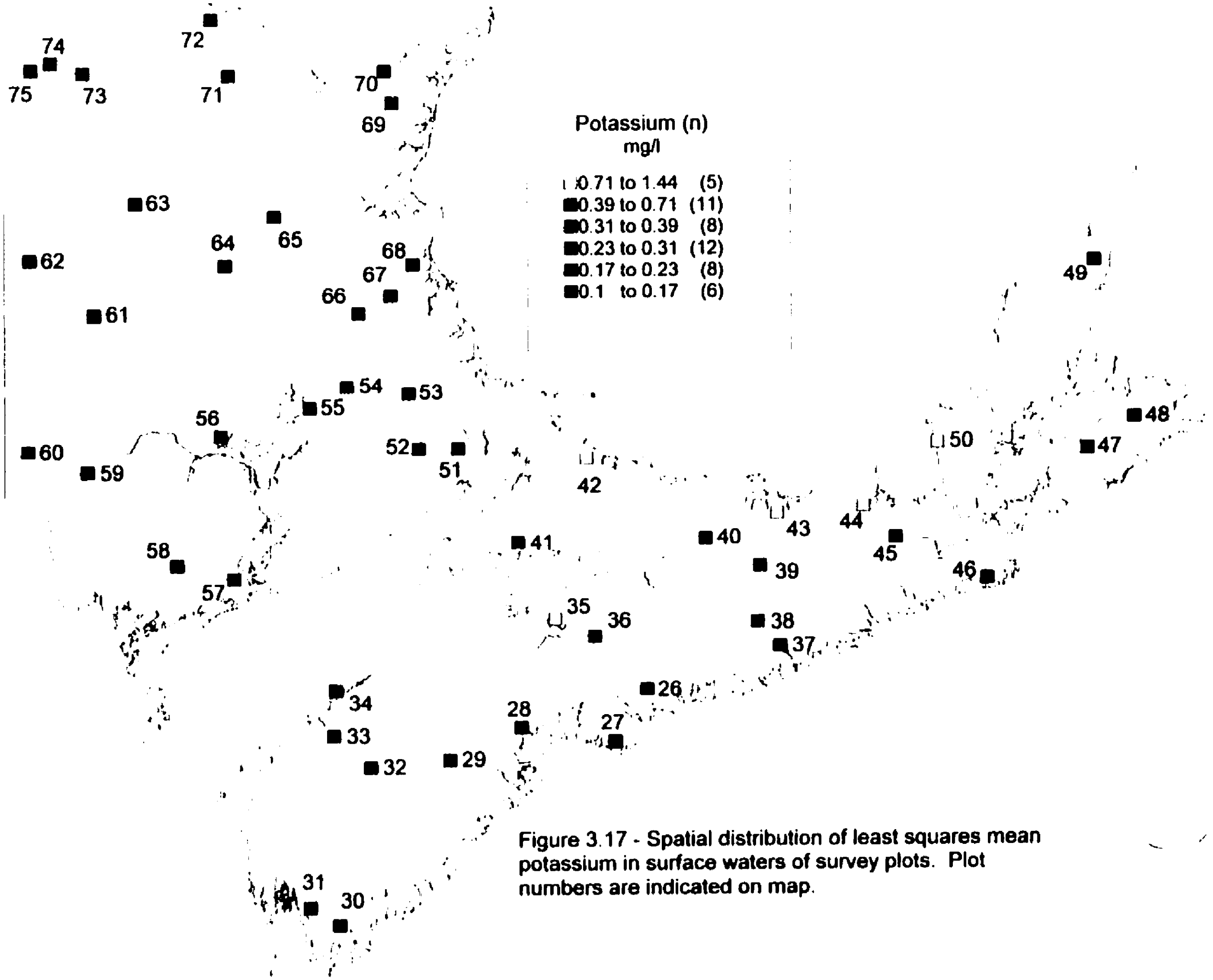


Figure 3.17 - Spatial distribution of least squares mean potassium in surface waters of survey plots. Plot numbers are indicated on map.

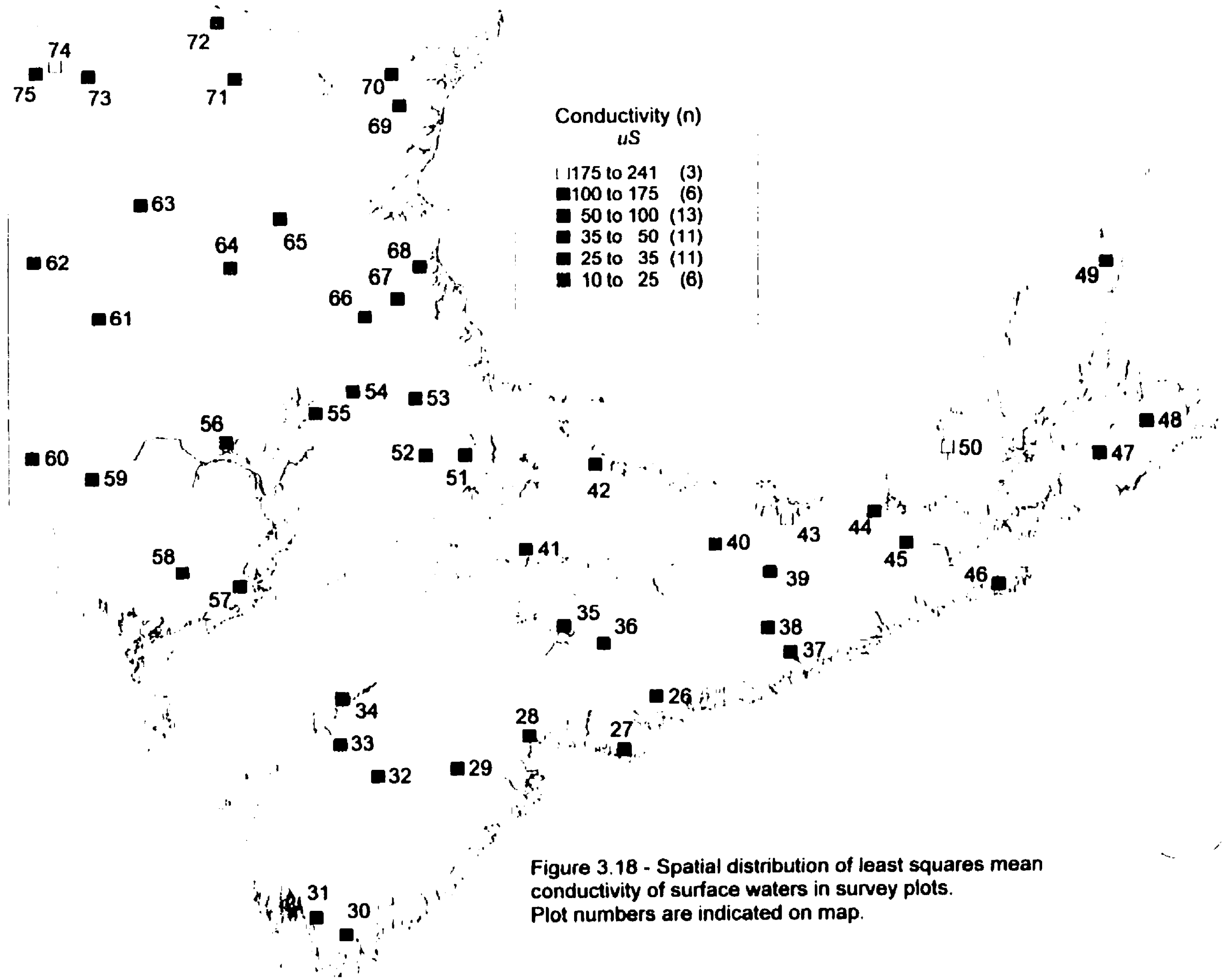


Figure 3.18 - Spatial distribution of least squares mean conductivity of surface waters in survey plots.
Plot numbers are indicated on map.

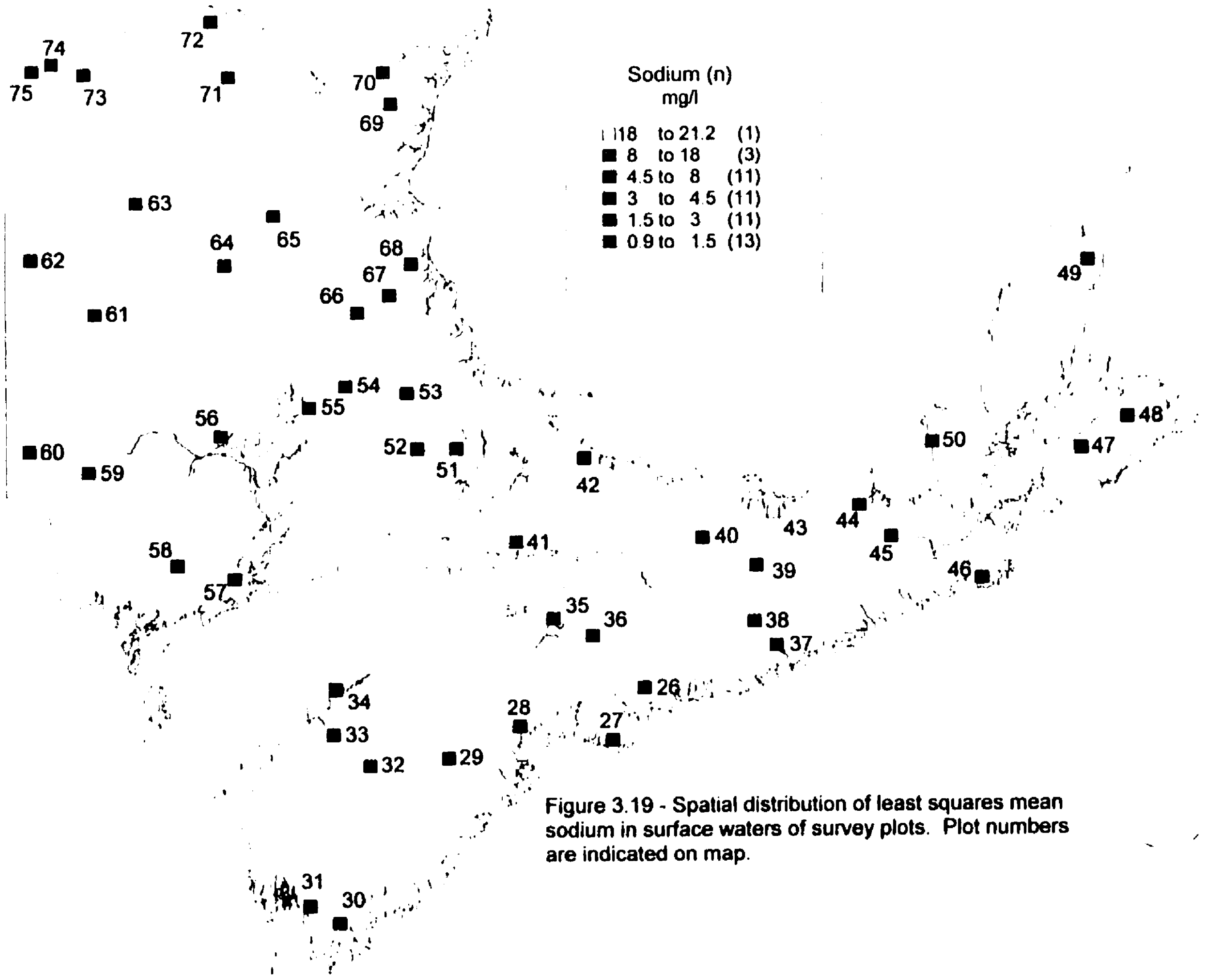


Figure 3.19 - Spatial distribution of least squares mean sodium in surface waters of survey plots. Plot numbers are indicated on map.

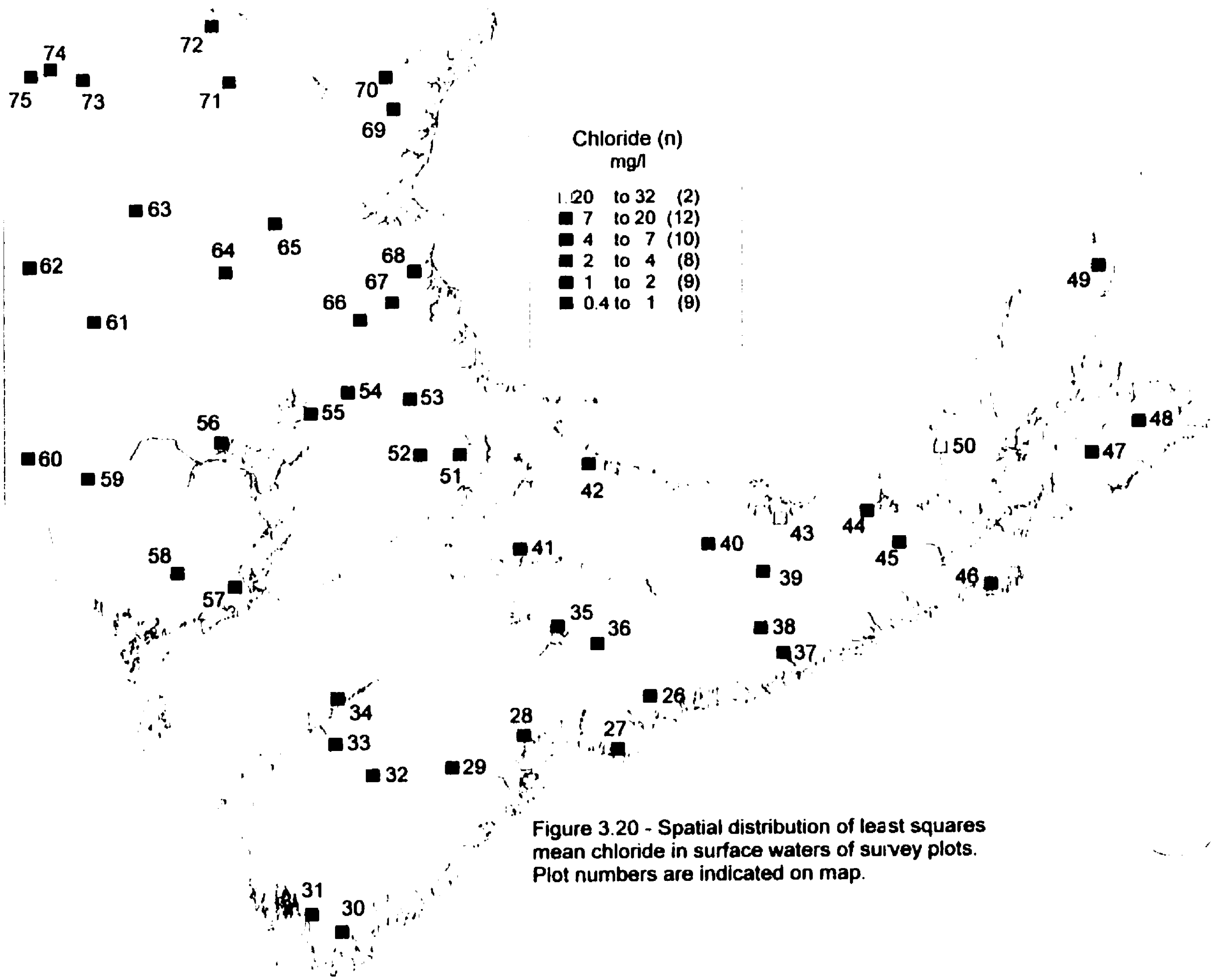


Figure 3.20 - Spatial distribution of least squares mean chloride in surface waters of survey plots. Plot numbers are indicated on map.

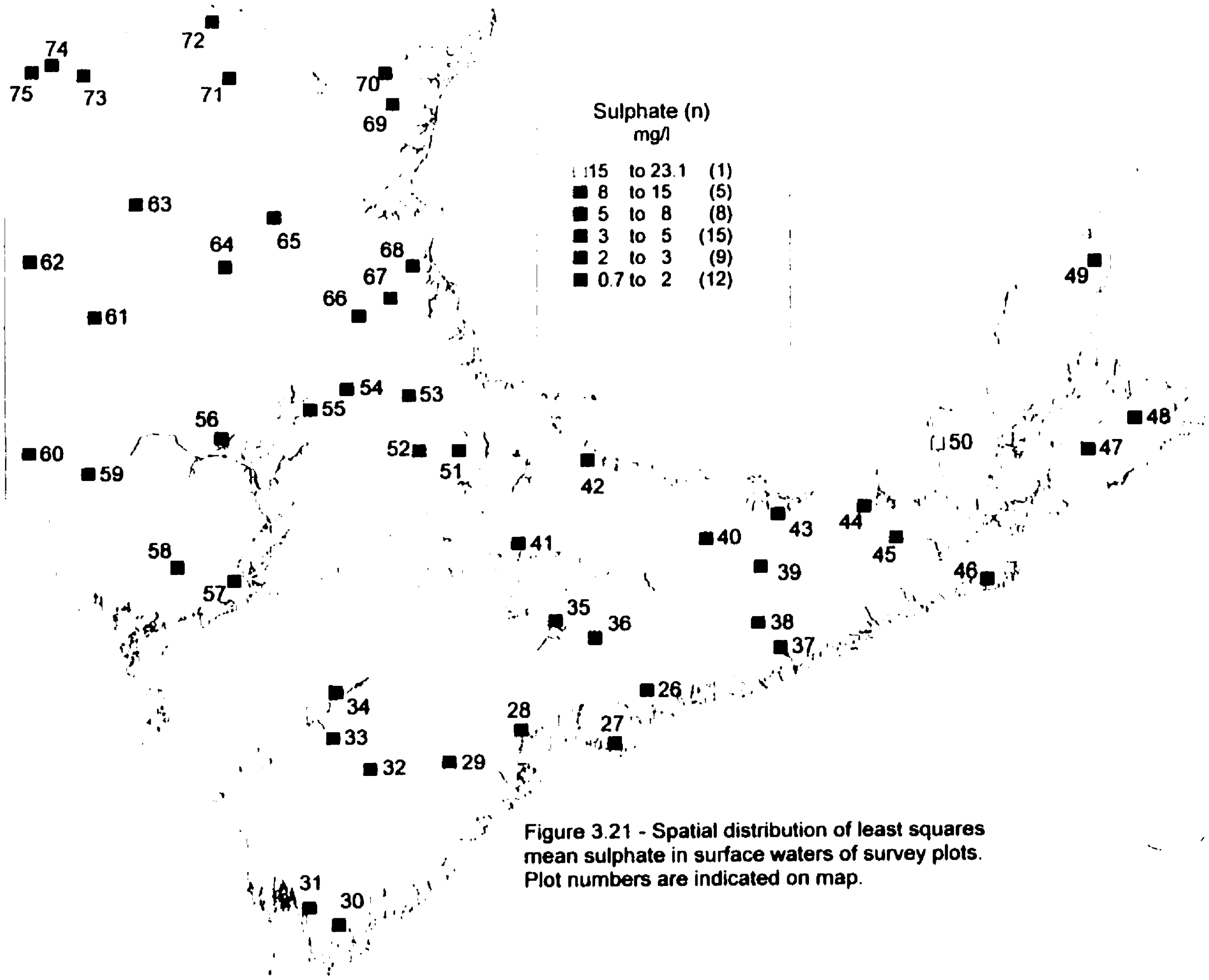


Figure 3.21 - Spatial distribution of least squares mean sulphate in surface waters of survey plots. Plot numbers are indicated on map.

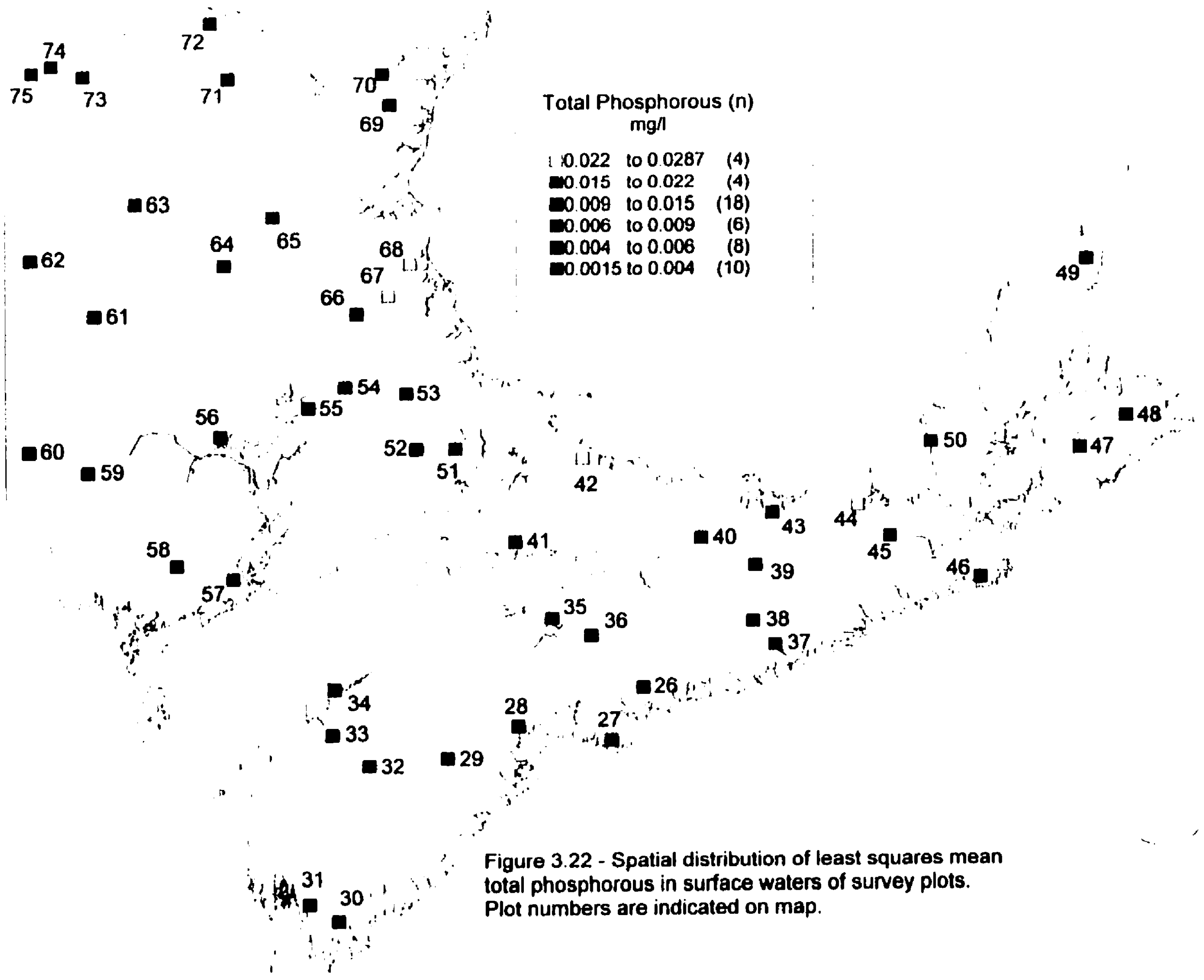


Figure 3.22 - Spatial distribution of least squares mean total phosphorous in surface waters of survey plots. Plot numbers are indicated on map.

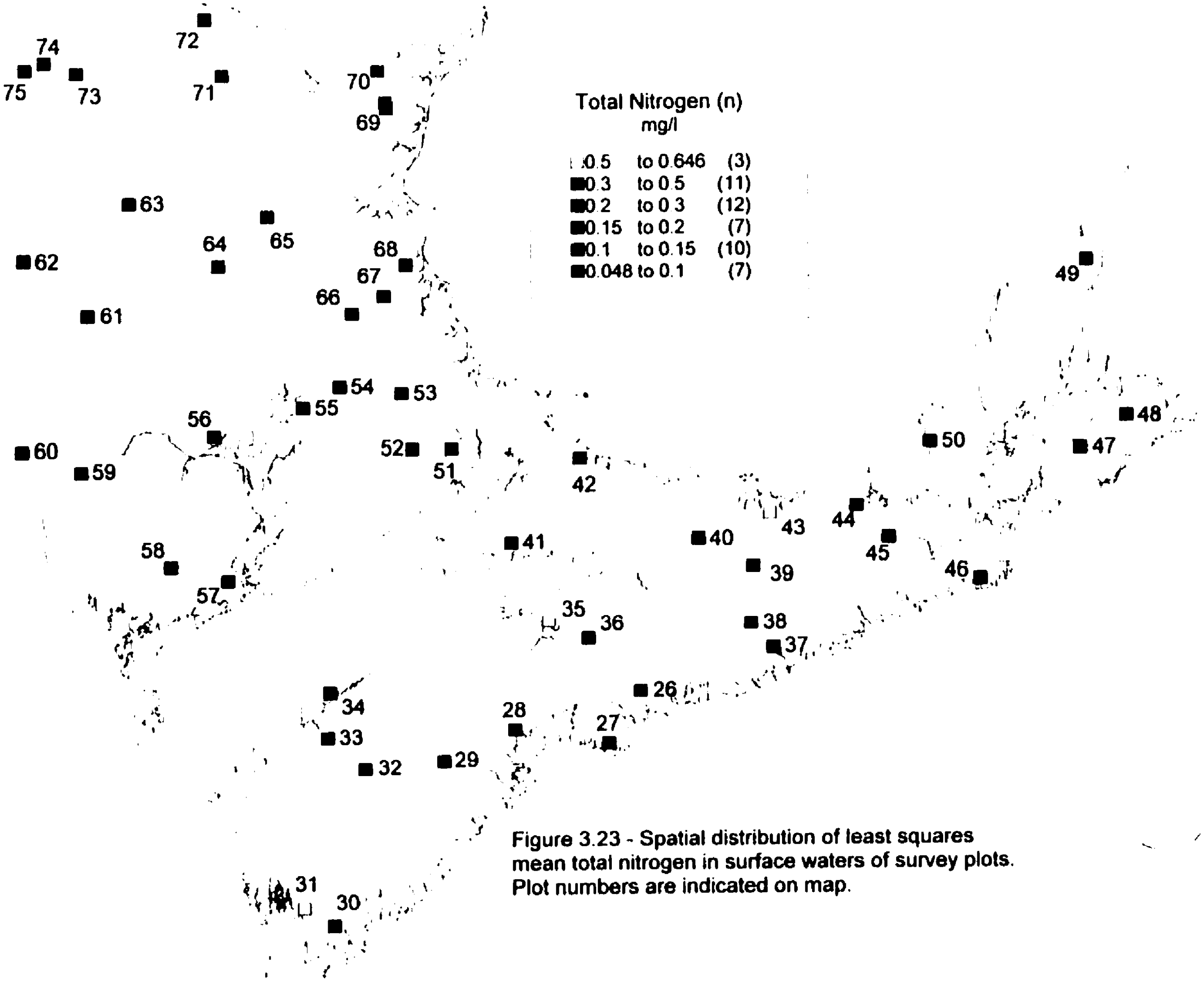


Figure 3.23 - Spatial distribution of least squares mean total nitrogen in surface waters of survey plots. Plot numbers are indicated on map.

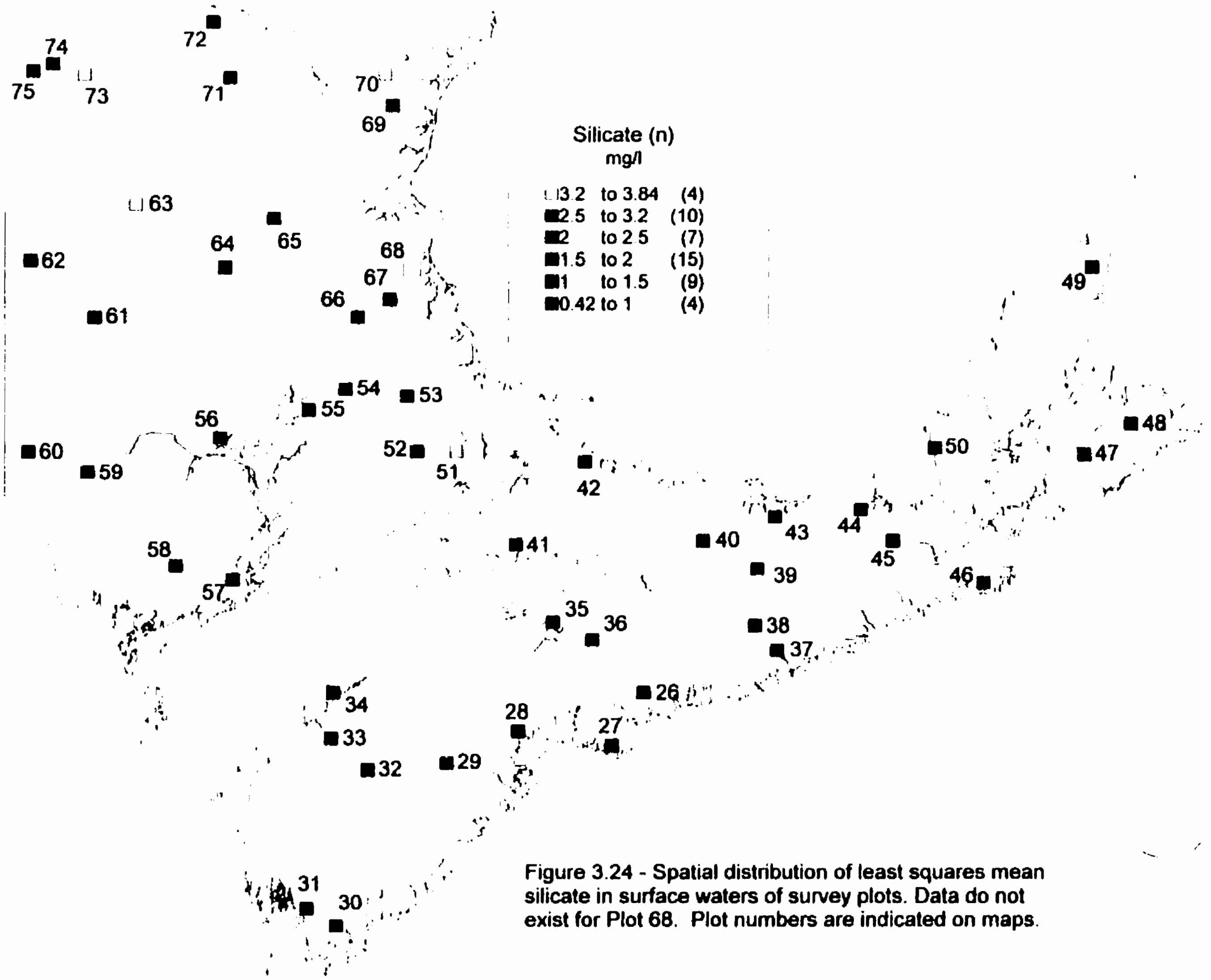


Figure 3.24 - Spatial distribution of least squares mean silicate in surface waters of survey plots. Data do not exist for Plot 68. Plot numbers are indicated on maps.

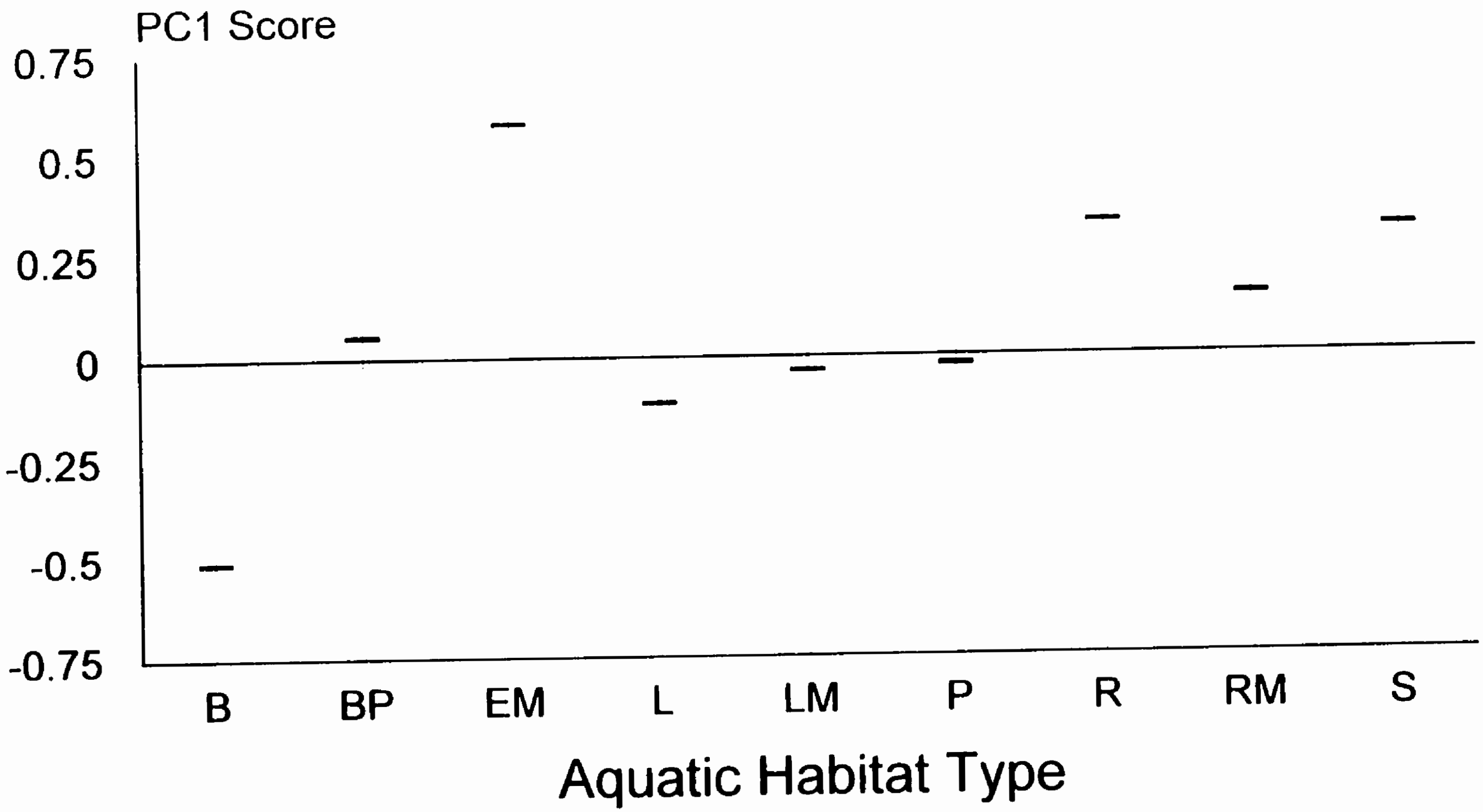


Figure 3.25 - Least squares mean and standard error of PC1 Score by aquatic habitat type from a PCA of chemical limnology of surface waters in survey plots. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

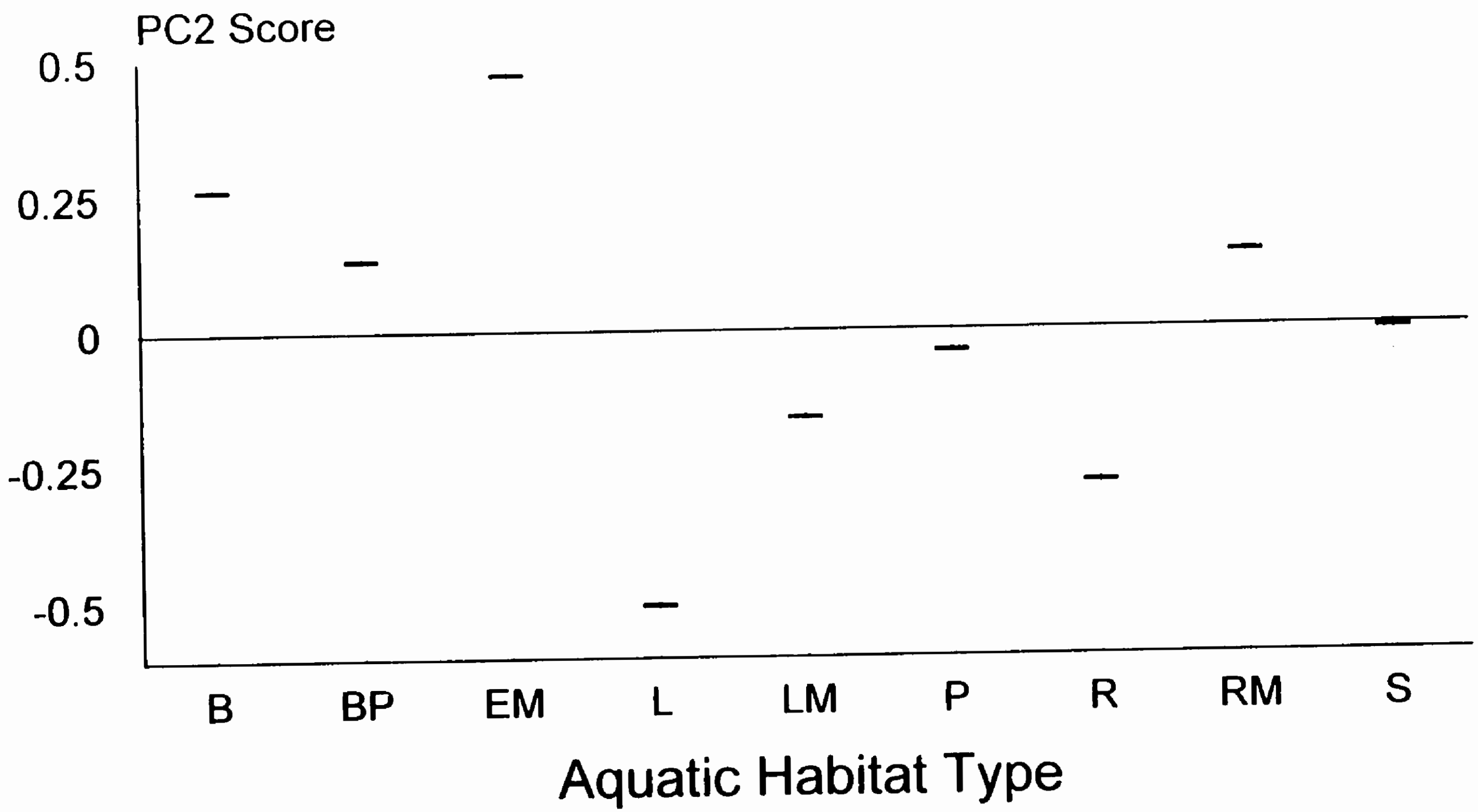


Figure 3.26 - Least squares mean and standard error of PC2 Score by aquatic habitat type from a PCA of chemical limnology of surface waters in survey plots. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

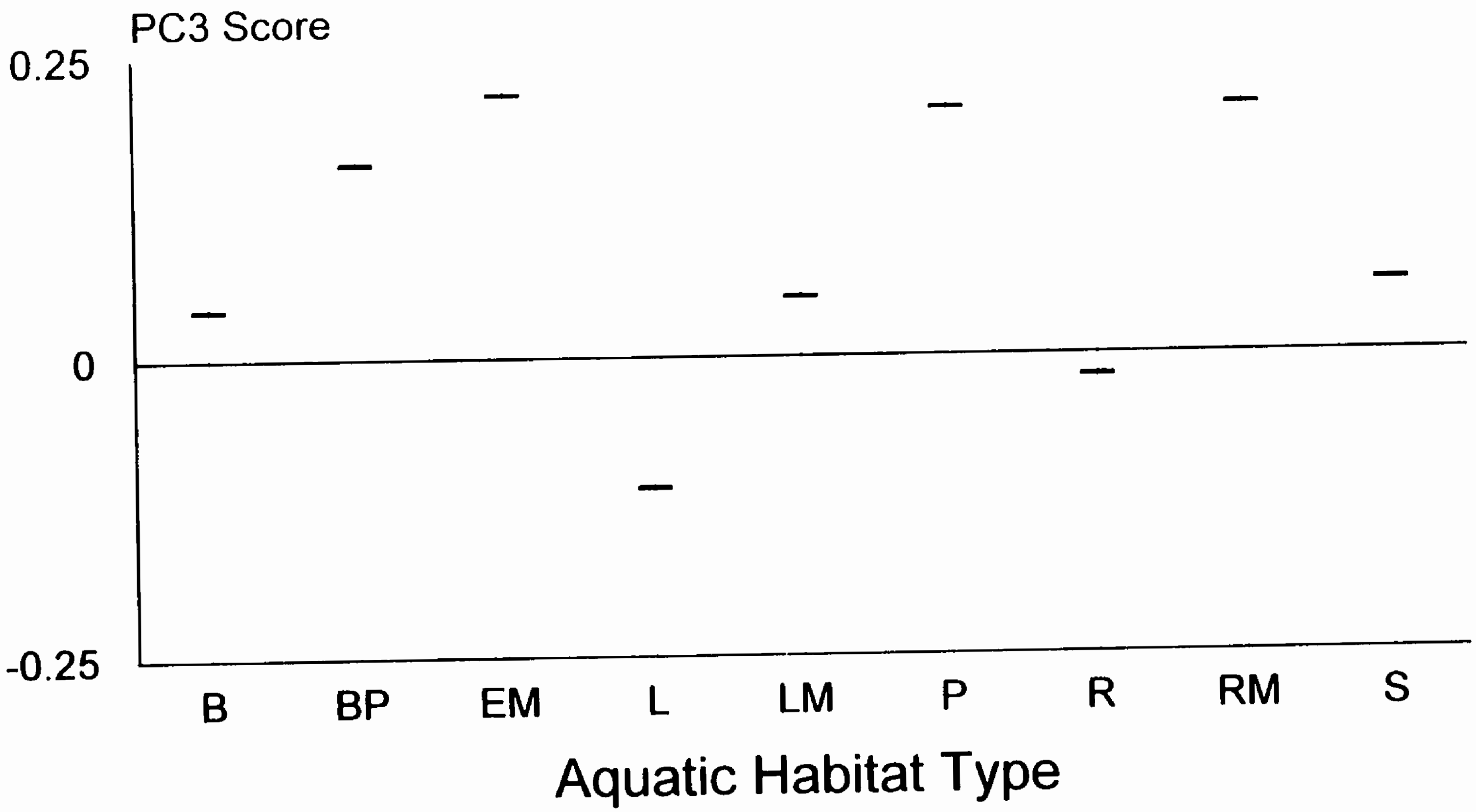


Figure 3.27 - Least squares mean and standard error of PC3 Score by aquatic habitat type from a PCA of chemical limnology of surface waters in survey plots. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

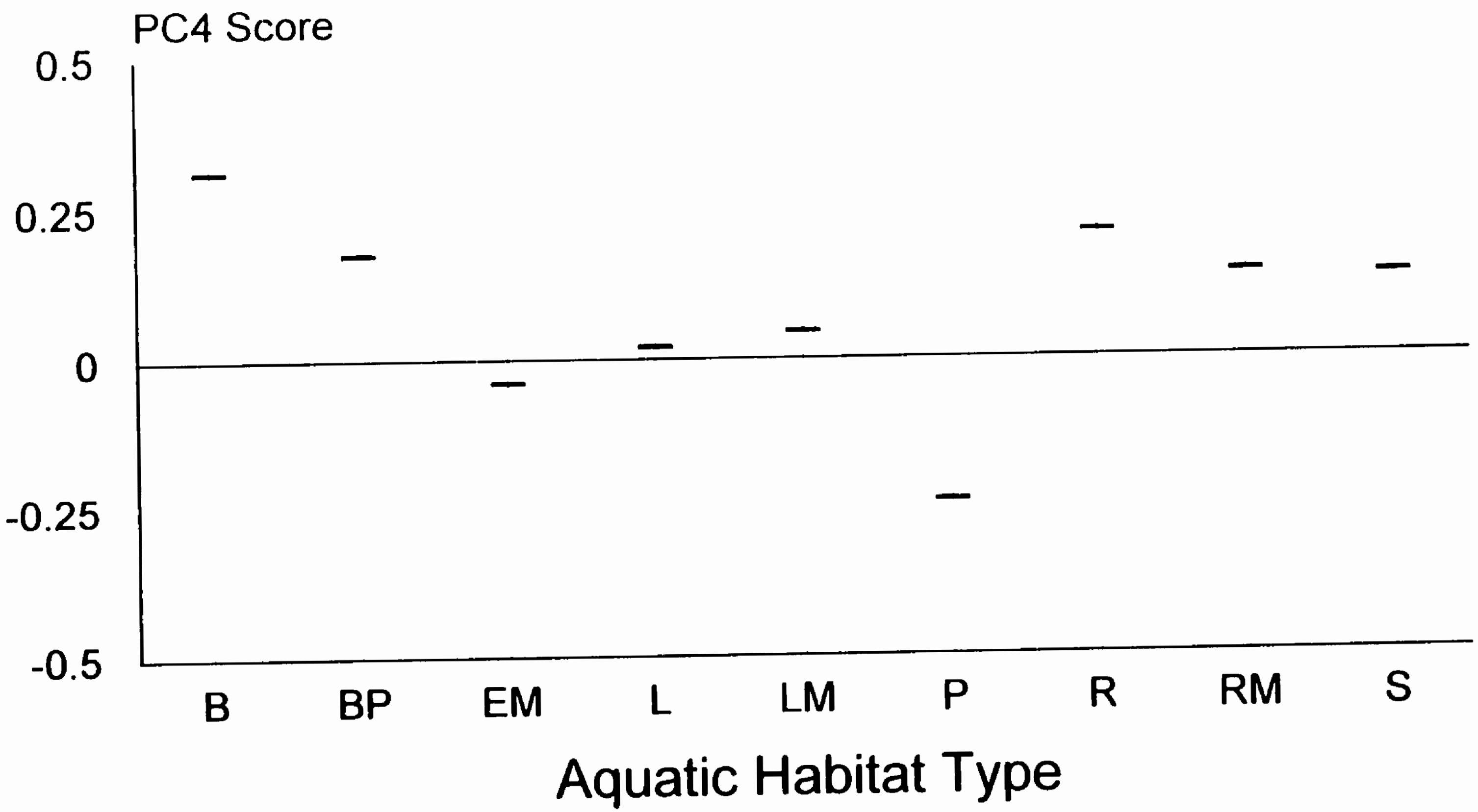


Figure 3.28 - Least squares mean and standard error of PC4 Score by aquatic habitat type from a PCA of chemical limnology of surface waters in survey plots . Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

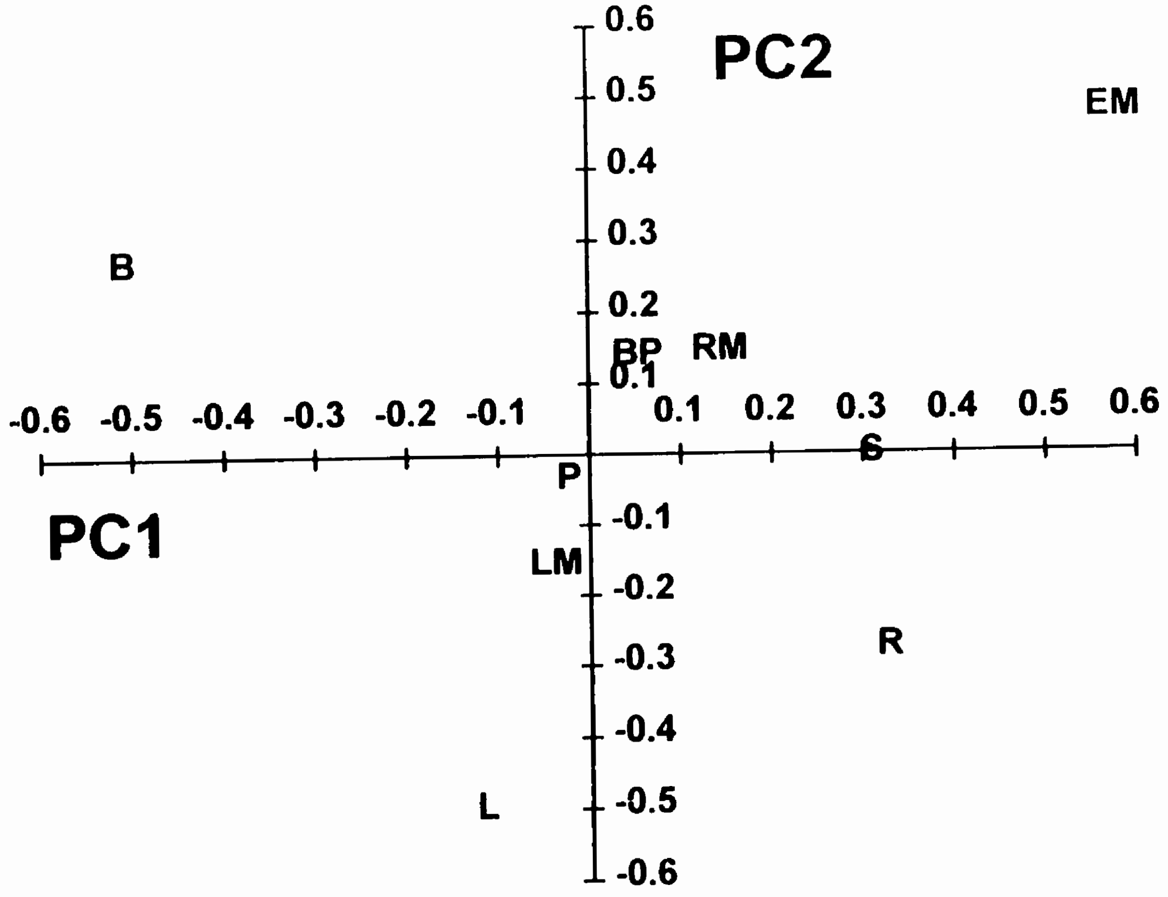


Figure 3.29 - Bi-plot of mean PC1 and PC2 scores of chemical limnology of surface waters by aquatic habitat type, data for all plots. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

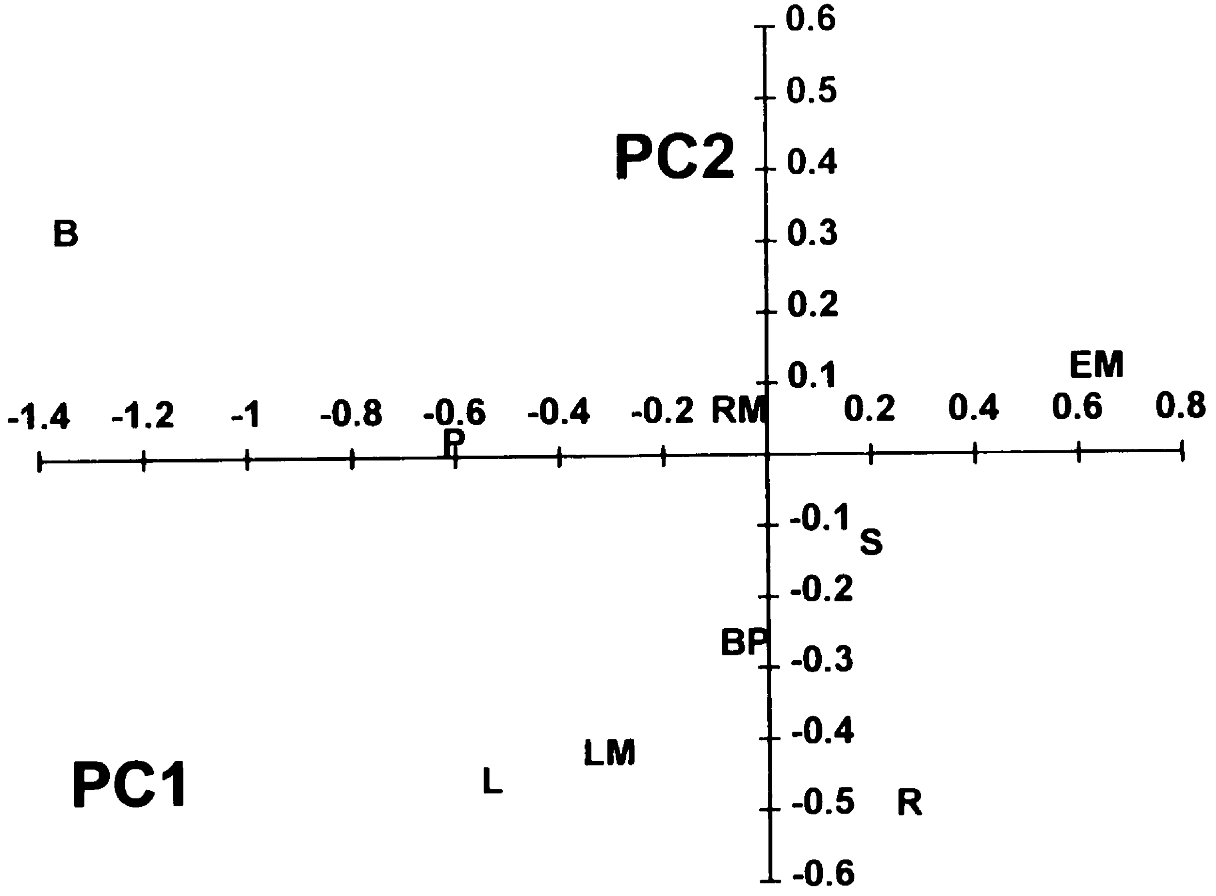


Figure 3.30 - Bi-plot of mean PC1 and PC2 scores of chemical limnology of surface waters by aquatic habitat type, data for mesotrophic plots only. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

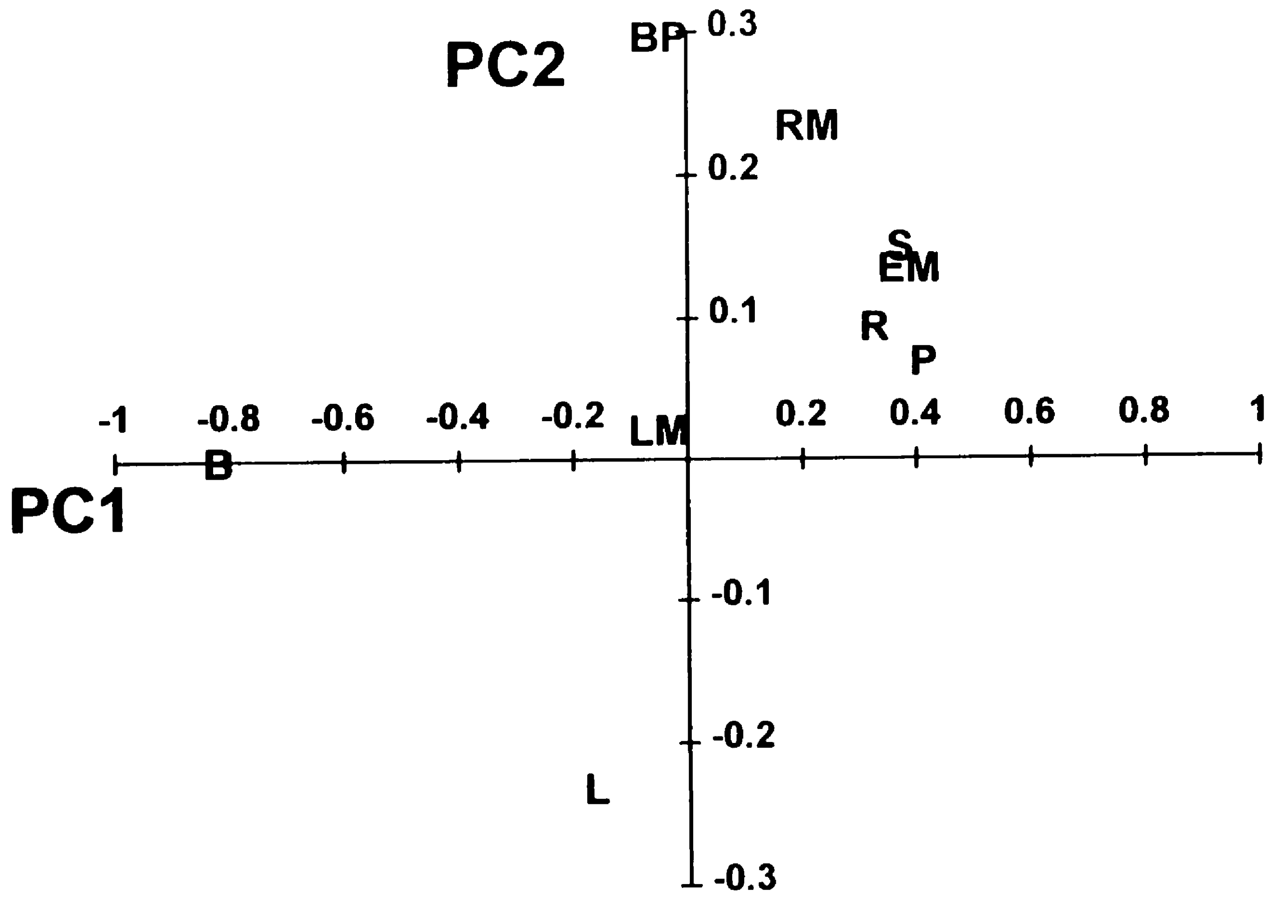


Figure 3.31 - Bi-plot of mean PC1 and PC2 scores of chemical limnology of surface waters by aquatic habitat type, data for oligotrophic plots only. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

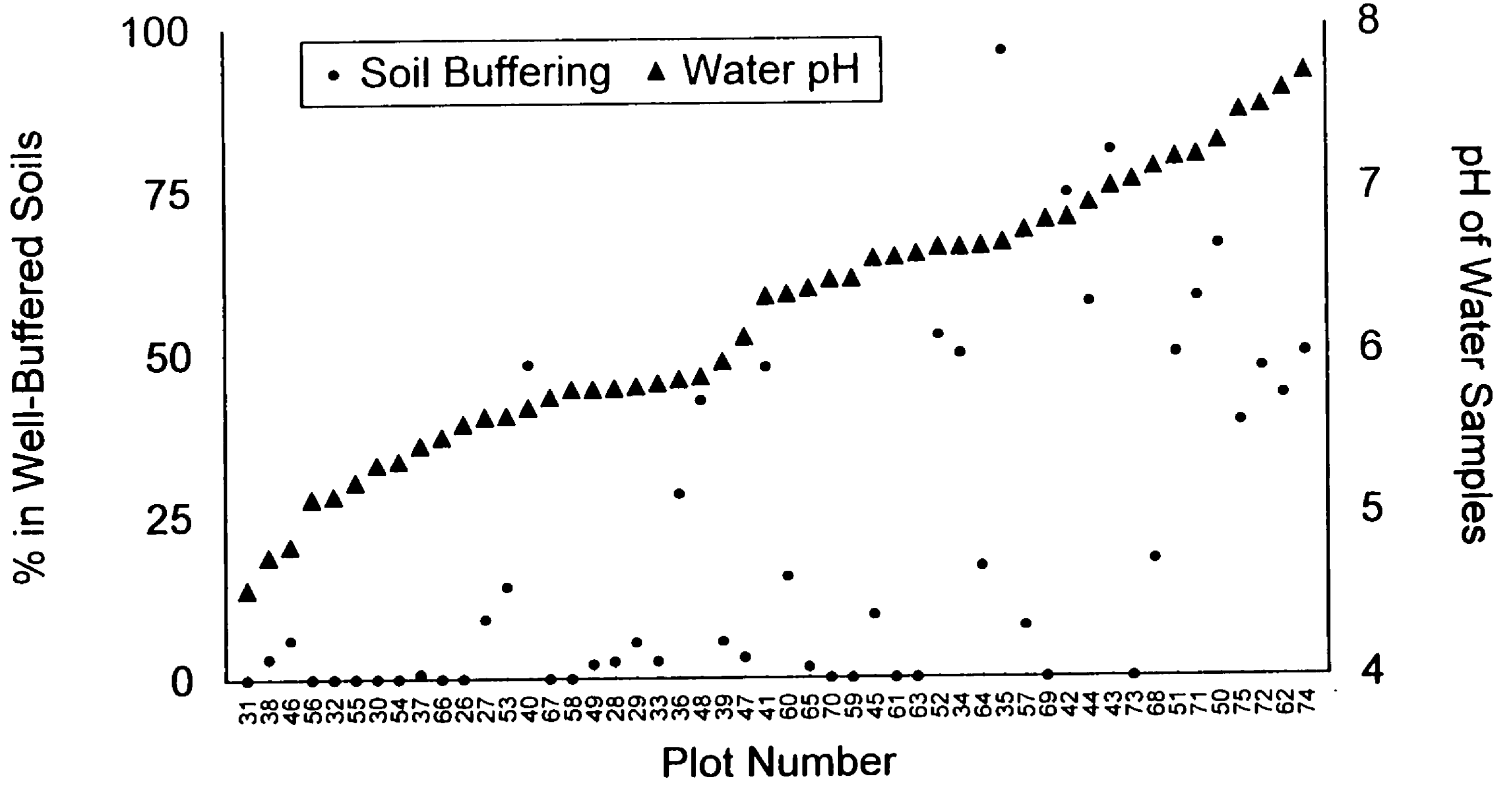


Figure 3.32 - Least squares mean pH of surface waters and percentage of wetlands in polygons with well-buffered soils.

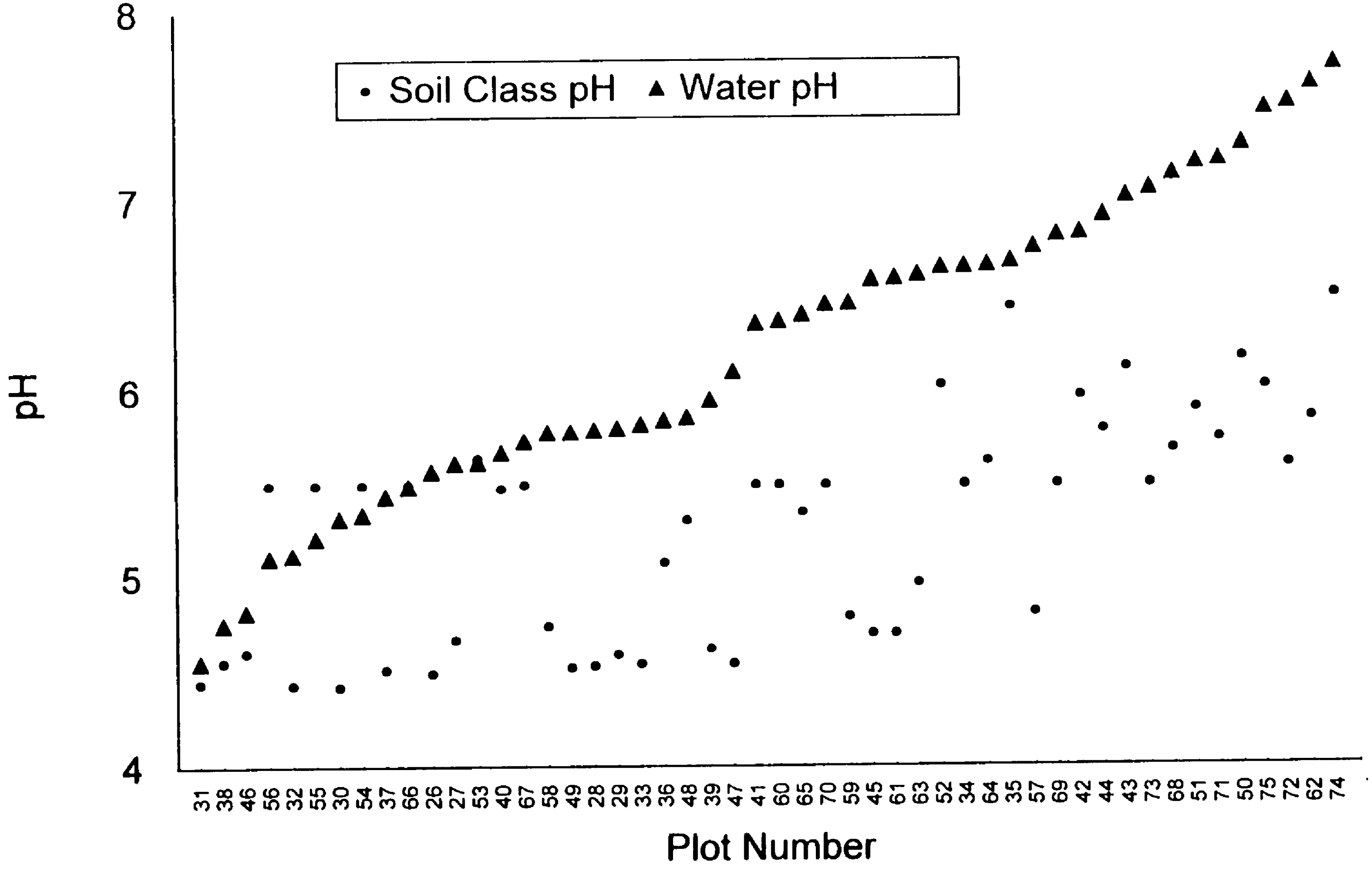


Figure 3.33 - Least squares mean pH of surface waters and estimated soil pH in survey plots.

CHAPTER 4 - BREEDING WATERFOWL SURVEYS IN THE MARITIMES

INTRODUCTION

This chapter describes results from annual surveys of breeding American Black Duck (*Anas rubripes*) populations in New Brunswick and Nova Scotia conducted by the Canadian Wildlife Service (CWS) during 1985-1999 (Bateman and Hicks 1995; Collins 1999; Erskine *et al.* 1990).

In western North America, the Waterfowl Breeding Population and Habitat Survey has been conducted annually since 1955 (Baldassarre and Bolen 1994; Johnson and Grier 1988). This survey is conducted in May and covers 3.5 million km^2. Waterfowl and wetlands are counted from fixed wing aircraft along transects 0.40 km wide and up to 241 km long. A subsequent survey in July records number, age, and size of duck broods, number of pairs still present and number of ponds remaining. The landscape-level waterfowl population and habitat data obtained from these two surveys are combined to produce estimates of fall populations. Although these surveys are costly, they provide the data required to annually formulate hunting regulations and management strategies.

Eastern Canada is not included in these surveys because of observational and logistical difficulties associated with forested habitats and low densities of breeding waterfowl (Chamberlain and Kaczynski 1965; Kirby 1980). Trends in waterfowl populations in eastern Canada have been monitored since 1954 using the Mid-Winter Inventory, which is conducted primarily along the Atlantic Coast of the United States. There is lack of consistency in the areas surveyed by the inventory (Eggeman and Johnson 1989), and efforts are underway to improve the design of the Mid-Winter Inventory (Conroy *et al.* 1988; Eggeman *et al.* 1997). In addition to questionable accuracy, another problem with these surveys is that they count individuals from different breeding populations. Because of various problems with this survey, the merits of continuing it have been questioned (Heusmann 1999).

The number of Black Ducks counted during the Mid-Winter Inventory declined from 600,000 during 1955-60 to 300,000 during 1981-1988 (Rusch *et al.* 1989). The Mid-Winter Inventory counts an estimated 20-33 % of the total American Black Duck (*Anas rubripes*) population during any given survey year. Concern over the decline in Black Ducks counted during the Mid-Winter Inventory highlighted the need for surveys of breeding populations (Grandy 1983). Surveys of breeding Black Ducks in Atlantic Canada were initiated in 1985 (Erskine *et al.* 1990).

Spatial autocorrelation and spatial analysis of survey data are often neglected components of survey data (Nummi and Poysa 1995; Paquette and Ankney 1996). The extent of spatial autocorrelation in survey data not only provides insight into factors responsible for observed population distributions (Legendre 1993), but can have practical implications with regard to survey design (McKenney *et al.* 1998), and statistical analysis (Brito *et al.* 1999).

This chapter describes results from annual surveys of breeding Black Duck populations in New Brunswick and Nova Scotia using helicopters during 1985-1999, and discusses the limitations of these data in estimating waterfowl populations and distributions.

METHODS AND MATERIALS

Breeding Waterfowl Surveys 1985 -1989

Sampling Design

Annual helicopter-based surveys of breeding waterfowl were conducted in New Brunswick and Nova Scotia during 1985 to 1989 according to a design by CWS (Erskine *et al.* 1990). In New Brunswick, the sampling design was for 5 km*5 km survey plots to be located on 1:50,000 National Topographic Series (NTS) map sheets in areas of 'good' Black Duck habitat. The NTS map sheets were selected at random. In New Brunswick, 25 plots were sampled in 1985 and 41 plots were sampled during 1986-1989. In Nova

Scotia, plots were located on randomly selected NTS map sheets and plots were located, ' using placement to include some wetlands- but not always good Black Duck habitat.' (Erskine *et al.* 1990). One plot with high duck densities was subsequently omitted from the surveys because of difficulties in obtaining accurate counts. In Nova Scotia, data were obtained from approximately 45 plots during 1986-1989.

Surveys

Surveys were conducted by CWS staff using helicopters (Bell 206B Jet Ranger), flying 15 - 30 m above ground level, with speed reduced to a hover when required. The pilot and navigator/observer sat in front with one or two primary observers in the rear seats. I participated in these surveys as a primary observer in 1988 and 1989. The navigator recorded all observations directly onto NTS map sheets with primary observers reporting waterfowl observations via the cabin intercom. All waterfowl observed were recorded by species, number and age/sex class.

Surveys were conducted in early May in order to maximise the proportion of Black Ducks seen as breeding pairs (Parker 1988; Parker 1989). Surveys were conducted in Nova Scotia during the second week of May, averaging about a week later than in New Brunswick. Pairs of Black Ducks represented 40-55% of the total groups observed (Erskine *et al.* 1990). Surveys were conducted throughout the day, with up to 9 hours of flying time per day.

Black Duck Joint Venture Surveys 1990-1994

Sampling Design

CWS analysis of data collected during 1985-89 indicated that a sample size of 200 plots across the Black Duck breeding range could detect a 10% population change in 5 years with 90% power and 95% confidence (Bateman and Hicks 1995). New Brunswick and

Nova Scotia were allocated 9 and 8 plots, respectively, of the 200 plots. These 10 km*10 km plots were randomly located.

In order to manage waterfowl populations at a provincial level, additional plots were surveyed by CWS in New Brunswick and Nova Scotia. In total, 25 plots were surveyed in New Brunswick and 25 plots were surveyed in Nova Scotia. This sample size could detect a 10% change in provincial populations in 10 years with 90% power and 95% confidence (Bateman and Hicks 1995). These additional plots were randomly selected from plots surveyed during 1985-89. Each old plot (5 km*5 km) made up one quarter of the larger 10 km*10 km plots. The 5 km*5 km quadrats will be referred to as PQUADs, whereas the larger 10 km*10 km survey plot will be referred to as PLOTs. PQUADs were given an alpha-numeric identifier consisting of the PLOT number and the letter A, B, C, or D depending on whether the PQUAD was in the NE, SE, SW or NW corner of the PLOT respectively. In 1992, the location of two PLOTs in New Brunswick were changed due to difficulties in getting an accurate count of high numbers of waterfowl.

Surveys

Nova Scotia surveys were flown by CWS staff during the first week of May during 1990-94 as they were during 1985-89. A separate crew flew surveys in New Brunswick during the first week of May in 1990. Group size composition suggested that there were many migrant birds in these counts, so the timing of the New Brunswick survey was delayed until the second week of May in 1991. During 1992-94, surveys in New Brunswick were not conducted until the third week of May. In 1993 and 1994, a survey crew conducted the New Brunswick surveys after completing the Nova Scotia surveys (Bateman and Hicks 1995).

Surveys were conducted according to the procedure described for the 1985-89 surveys with the exception that there was only one primary observer and one secondary observer.

Black Duck Joint Venture Surveys 1995

Sampling Design

Budget restrictions in 1995 resulted in only 10 and 9 plots being surveyed in Nova Scotia and New Brunswick respectively. These plots were selected at random from the 25 plots that were surveyed during 1992-94. Two plots that were selected at random were replaced with plots in closer proximity to the other selected plots to reduce among-plot travel time. Nova Scotia plots were flown between May 2-5 and New Brunswick plots were surveyed between May 10-12 (Appendix E - Table E1). Surveys were conducted as described previously for the 1990-94 surveys.

Black Duck Joint Venture Surveys 1996-1999

Sampling Design

Plots established during 1985-1989 and 1990-94 were incorporated into a redesigned survey that CWS initiated in 1996 (Collins 1999). Plots surveyed during 1996-99 will be referred to by their survey route numbers. Plots were 5 km*5 km and placed in one of four groups. Survey routes in two groups were surveyed in any given year on a rotational basis. Groups A and B were surveyed in 1996, groups B and C in 1997, groups C and D in 1998, and groups D and A in 1999. Nova Scotia surveys were flown the last week of April and first week of May; with New Brunswick surveys subsequently flown during the first and second week of May (Appendix E - Table E1). Surveys were conducted as described previously.

Data Interpretation

Location of Observations

The universal transverse mercator (UTM) coordinates of all waterfowl observations during 1986-1995 were determined using the 1: 50,000 NTS map sheets. The location of these observations were plotted onto Maritime Wetlands Inventory (WI) map sheets (Hanson and Calkins 1996). The wetland identification number was determined for observations that fell within the boundaries of wetlands included in the WI. Many waterfowl observations were located on lakes and rivers that were not included in the wetland inventory. The lack of digital maps precluded using this geo-referenced observational data in habitat models.

Determination of Indicated Breeding Pairs (IBPs)

The plumage of Black Ducks is sexually monochromatic which makes sex determination difficult during helicopter-based surveys. Various schemes have been used in different jurisdictions and years to determine indicated breeding pairs (IBPs) of Black Ducks (Bateman and Hicks 1995; Collins 1999; Erskine *et al.* 1990, Ross 1985). In developing models of breeding pair distribution, it is important that the number of IBPs represents only territorial, breeding pairs and does not include pairs that are still migrating. When using this survey data for trend analysis, it is not as critical to exclude pairs that may still be migrating as long as the proportion of pairs that are still migrating and included as IBPs is annually consistent. Most Black Ducks observed during the surveys were individuals of undetermined sex. IBPs of Black Ducks were determined using the observational data from the surveys and the following scheme:

1 Female = 1 IBP
2 Females = 2 IBP
1 Female with 1 Male = 1 IBP
1 Female with 2 or more Males = 1 IBP
2 Females with 1 or more Males = 0 IBP
1 Male with 0 or 1 Female = 1 IBP
1 Male with 1 Unknown = 1 IBP
1 Male with 2 Unknown = 1 IBP

1 Male with 3 or more Unknown = 0 IBP

1 Unknown = 1 IBP

2 Unknown = 1 IBP

3 Unknown = 0 IBP

Determination of IBPs for Other Waterfowl Species

For other species, breeding males could be differentiated from females based on plumage coloration. The protocol developed by the CWS Waterfowl Biologists Technical Committee, based on the presence of breeding plumaged males, was used to determine indicated breeding pairs (unpubl. report). For American Green-winged Teal (*Anas crecca*), Wood Ducks (*Aix sponsa*) and Mallards (*Anas platyrhnchos*), single males or males in groups of up to four individuals were considered indicative of one to four breeding pairs. A group of three males and one female, which was infrequent, was deemed to be a migrant flock and did not indicate a breeding pair. For Common Mergansers (*Mergus merganser*) the same protocol was used as for the dabbling ducks previously mentioned, with the exception that a group of three males and one female was considered indicative of three IBPs. Ring-necked Ducks (*Aythya collaris*) have a later breeding phenology than these surveys and hence there is a propensity for this species to be in pre-breeding flocks. Males (1-4 in number) were considered to be indicative of breeding pairs in flocks of various sizes. If there were more than four males in the flock, the flock was considered migrant and the number of IBPs was determined to be zero.

Visibility Correction Factor

Visibility correction factors are commonly used for breeding pair surveys done from fixed wing aircraft (Baldassarre and Bolen 1994). Visibility correction factors are not, however, applied to the helicopter-based BDJV breeding pair surveys (Bateman pers.com.). The USFWS uses helicopter surveys to provide their visibility correction factors for fixed wing surveys in the northeastern North America (Caithamer and Dubvosky 1996).

Geostatistical Analysis

The location of the BDJV survey plot centroid was determined and converted from latitude longitude (decimal degrees) to universal transverse mercator (UTM) easting and northing (metres) for Zone 20 (SPANS 1999). UTMs are cartesian coordinates from which distances between points can be calculated. For analysis of PQUAD data collected during 1992-94, lag classes were established at 8,000 m intervals, with the maximum distance (range) being 160,000 m. Lag Class 1 compared all pairs of survey plots that were less than 8,000 m apart, and would include a comparison among PQUADs within a given PLOT. Lag Class 2 compared all pairs of survey plots that were between 8,000-16,000 m apart. Most lag classes had hundreds of observations in them, with Lag Class 2 having the smallest membership with only 34 pairs of observations. Lag Class 2 compared PQUADs with PQUADs in a contiguous PLOT, e.g. PQUAD 74C versus PQUAD 75A. It is recommended that each lag class be represented by at least 30-50 pairs of observations, although the greater the number of pairs of points, the greater the statistical reliability of each lag class (Rossi *et al.* 1992).

Omnidirectional (i.e. isotropic) correlograms were created using GS+ (Robertson 2000). Moran's I was used to measure spatial autocorrelation, with values close to +1.0 indicating a smooth surface, with each QUAD containing values very similar to those in neighbouring PQUADs, and a value of -1 indicating a rough surface where neighbouring PQUADs have very dissimilar values (Eastman 1999). A Moran's I value of zero indicates no correlation. Variables with highly skewed distributions were log transformed prior to calculating Moran's I (Isaaks and Srivastava 1989).

Because the 25 km^2 PQUADs were located within the larger 100 km^2 PLOTs, a nested random effects model (Proc Nested; SAS 1988) was performed. This analysis determined the amount of variation in the mean number of Black Duck IBPs during 1992-94 that was explained by among PQUAD differences compared to among PLOT differences.

RESULTS

Black Ducks

During 1986-89, the mean number of Black Duck IBPs in New Brunswick survey plots ranged from 0 for Plot GP32 to 23 for Plot GP41 (Figure 4.1; Appendix E - Table E2). There was considerable annual variation in the number of IBPs recorded, with the standard deviation often 50% of the value of the mean (Appendix E - Table E2). The number of Black Duck IBPs in Nova Scotia plots was less than that observed for New Brunswick plots (Figure 4.1; Appendix E - Table E3). The number of IBPs ranged from 0 for Plot W12 to 7 for Plot C19. Annual variation in the number of IBPs recorded was also relatively high in Nova Scotia similar to that observed in New Brunswick (Appendix E - Table E3).

During 1990-1994, the survey design incorporated 5 km*5 km quadrats that were contained within 10 km*10 km plots (Figures 4.2 & 4.3). The timing and location of surveys in New Brunswick were modified in 1990 and 1991. A paired t-test indicated that the mean number of IBPs in New Brunswick survey plots with constant location for the period 1990-94 was significantly different than the mean values for 1990-91 and 1992-94 (Zar 1984; Appendix E - Tables E4 &E5). The location and timing of surveys for Nova Scotia plots remained consistent during the period 1990-94. Paired t-tests did not reveal any significant differences among time periods for Nova Scotia PLOTs (Appendix E - Tables E5 &E6). To eliminate annual variation that may have been due to differences in timing of surveys and to be able to include plots whose location changed, the mean number of IBPs during 1992-94 was used as the index of number of breeding Black Ducks for a survey plot. It should be mentioned that the use of this statistic neglects the considerable annual variation that was observed even during 1992-94.

The number of Black Duck IBPs among PQUADs varied considerably (Figure 4.2; Appendix E - Tables E4 & E6). There was considerable variation in the number of IBPs among PLOTs (Appendix E - Tables E5 & E7).

There was no significant difference in the mean number of Black Ducks in New Brunswick survey plots during 1986-89 compared to the mean of 1990-94 (paired t-test. Appendix E - Table E8). Surveys in New Brunswick have been subject to the most change over the years with respect to timing. methodology. and observers. In contrast. there was a significant difference between 1986-89 compared to 1990-94 for Nova Scotia survey plots. even though the methodology stayed the same. Changes in Black Duck populations and survey methodology/timing could potentially be responsible for the observed variation between survey periods. Changes in IBPs in plots between the two survey periods indicate that validating habitat-based population models using data from plots surveyed at different times could provide inaccurate parameter estimates.

Surveys conducted during 1990-99 have been analysed for trends (Collins 1999: Collins 2000: Figure 4.4). These tests for trends were based on estimating equation techniques for local populations developed for North American Breeding Bird Survey data (Link and Sauer 1998). The data for New Brunswick were partitioned into two subsets (1990-92 and 1993-98) due to the change in survey protocol described earlier (it should be noted that the analysis performed by Collins (1999) did not take into account the pattern of visits to the same plots over the years. although future analyses will). The estimate of trends for survey plots initiated in 1996 (Routes 56076-56091 and Routes 65051-65055) were based only on two years data. whereas plots that were initiated in 1990 were based on up to 8 years data (Appendix E - Tables E9 and E10). The population weight reflects local population density. Trend precision is a measure of how many times the survey was run and how evenly spaced in time the surveys were. Overall weight is the product of the population weight and the trend precision. Log slope is a measure of trend in the log scale. where the expected number of IBPs in the next year is the count in the current year times exponent (log slope). Log slope values outside of the range of between -1.0 and + 1.0 are given as range limit values and are indicated by an asterisk. Trend precision ranged from less than 1 for Routes initiated since 1996 to 170.22 for Route 56061.

The overall population trend for Black Ducks in Stratum1 (New Brunswick, Nova Scotia and Gaspé, Quebec) was an 8.3% change per annum, based on 58 local trend estimates (Collins 1999). Local trend estimates (Appendix E - Table E10) for Nova Scotia plots surveyed since 1990 (Routes 65026-650050) were negative for 4 of 25 plots (16%). Trends for Nova Scotia plots established in 1996 were negative for 2 of 4 plots (50%). In New Brunswick, more plots had negative trends compared to Nova Scotia plots. The local trend estimates (Appendix E - Table E9) for New Brunswick plots surveyed since 1990 (56051-56075) were negative for 7 of 24 plots (29%). In plots that were initiated in 1996, the local trend estimates were negative for 7 of 16 plots (44%). In addition to differences among plots in the direction of population change, there were also differences in the magnitude of this change.

Other Species

Although breeding pair surveys counted all waterfowl species, the usefulness of these surveys for other species is limited by the timing of the survey (*e.g.* Ring-necked Duck), low numbers observed (*e.g.* Mallard), and/or low visibility (*e.g.* Green-winged Teal).

Mallards and Wood Ducks were absent from most survey plots in New Brunswick and Nova Scotia (Appendix E - Table E12). Although Wood Ducks were observed infrequently, they were often found on the same plots as Mallards. Plots where Mallards were observed included Plot 42 which is an area of high agricultural activity along the Northumberland Strait, and Plot 58 which is located on the outskirts of a major urban centre, Sydney, Nova Scotia. Mallards were also observed in western New Brunswick in a region where Mallard populations have been increasing (Petrie 1998).

Ring-necked Ducks were observed on approximately 55% of the survey plots (Figure 4.5; Appendix E - Table E13). They are the second most abundant species of duck in the Maritimes based on population and harvest estimates (Erskine 1987; Levesque and Collins 1999). Timing of surveys is early for Ring-necked Ducks, and hence their distribution during surveys may not accurately reflect their distribution during the breeding season. Green-winged Teal were observed on approximately 50% of the survey plots (Figure 4.6: Appendix E - Table E13). Green-winged Teal are not as abundant as the Ring-necked Duck in previous population estimates (Erskine 1987) or harvest estimates (Levesque and Collins 1999). Common Mergansers were observed on approximately 50% of the survey plots (Figure 4.7: Appendix E - Table E14).

Local trends for Mallards were calculated for 8 routes in New Brunswick and Nova Scotia (Appendix E - Table E15). The trend was no change or positive for 5 routes. The overall trend for Stratum 1 was an increase of 43.2% per year based on a total of 10 routes. Estimated number of IBPs showed considerable variation during 1990-1994 and increased markedly in 1996 (Appendix E - Table E11). Local trends for Wood Ducks were calculated for 13 routes, with most routes having increasing populations (Appendix E - Table E16). For Stratum 1 there was an overall increase of 28.8%, although annual estimates of total IBPs varied considerably (Collins 1999).

Local trends for Green-winged Teal were calculated for 25 routes in New Brunswick and 14 routes in Nova Scotia (Appendix E - Table E17). Some routes had high positive slopes whereas others had substantive negative slopes, with 30 routes having no change or a positive trend. The overall trend for Stratum 1 was an increase of 19.3% per annum (Collins 1999). The estimated population of Green-winged Teal in Stratum 1 was variable during 1990-94 and increased when the new survey design was initiated in 1996 (Appendix E - Table E11). Of interest is that Route 65048 outside of Sydney, Nova Scotia had decreasing trends for Mallards, Wood Ducks, and Green-winged Teal (Appendix E - Table E17).

Local trends for Ring-necked Ducks were calculated for 28 routes in New Brunswick and 20 routes in Nova Scotia (Appendix E - Table E18). There was no change or a positive population trend in 38 of 48 routes, with the overall trend in Stratum 1 being a yearly increase of 11.8% (Collins 1999). Annual estimates of Ring-necked Duck IBPs for Stratum 1 remained relatively constant during 1990-1998, with an order of magnitude increase in 1999 (Appendix E - Table E11).

Local trend estimates for Common Mergansers were calculated for 21 routes in New Brunswick and 16 routes in Nova Scotia (Appendix E - Table E19). There was a negative population trend in 16 of the 37 routes, with the overall trend in Stratum 1 being a yearly increase of 2.6% (Collins 1999). Annual estimates of Common Merganser IBPs for Stratum 1 remained relatively constant during 1990-1999 (Appendix E - Table E11).

Spatial Autocorrelation

Moran's I statistic for spatial autocorrelation was calculated for the mean number of Black Duck IBPs observed in PQUADs during 1992-94 using an extent, *i.e.* active lag distance, of 160,000 m at 8,000 m intervals. Moran's I was 0.333 for Lag Class 1 where the average distance of separation between pairs of observations was 5,697 m (Table 4.1). The magnitude of spatial autocorrelation was slight for Lag Classes 2-4. Lag Class 5 had the highest Moran's I value.

Spatial autocorrelation was somewhat higher for Ring-necked Ducks compared to Black Ducks as evidenced by higher values for Moran's I statistic for Lag Classes 1-6 (Table 4.1). Moran's I for Lag Class 1 was 0.425. Spatial autocorrelation in the distribution of American Green-winged Teal IBPs was only evident for the Lag Class 1 with a Moran's I value of 0.239. For Common Merganser spatial autocorrelation was evident only in Lag Classes 1 and 2, with Moran's I values of 0.337 and 0.375 respectively.

Moran's I statistic for spatial autocorrelation was also calculated for mean number of Black Duck IBPs observed in survey plots during 1986-89. Extent, *i.e.* active lag distance, was established at 160,000 m at 20,000 m intervals. Greater distances for lag classes were used, compared to previous analyses, to ensure adequate sample size in each class and also because the survey plots were not nested within larger plots. The Moran's I value was 0.743 for the 10 pairs of survey plots in Lag Class 1, with the average distance between plots being 13,171 m (Table 4.2). The high amount of spatial autocorrelation in Lag Class 1 may result from the small number of observations. There was also spatial autocorrelation among the 35 plots in Lag Class 2 with a Moran's I value of 0.345. No trend in spatial autocorrelation was observed at further distances.

Trends in local Black Duck populations (data from survey routes) were also analysed for spatial autocorrelation using an active lag distance of 160.000 m at 20.000 m intervals. Moran's I statistic was similar for all lag classes (Table 4.3). The amount of spatial autocorrelation for trends in Black Ducks would appear to be less than that observed for the absolute number of IBPs. based on values observed for Moran's I statistic. This suggests that different landscape-level descriptors of habitat may be responsible for changes in local Black Duck populations compared to those responsible for the distribution of absolute numbers of Black Duck IBPs.

Results from the nested random effects analysis of variance for the mean number of Black Duck IBPs observed during 1992-94. indicated that 33% of the variation could be explained by among PLOT differences. whereas 67% was due to among PQUAD differences.

DISCUSSION

Breeding pair surveys for Black Ducks conducted by the Canadian Wildlife Service and its partners in the Black Duck Joint Venture during 1986-1999 were designed specifically for population trend detection (Bateman and Hicks 1995). The utility of these data in estimating local or regional populations will be influenced by how accurately the number of IBPs of waterfowl observed measure the actual population in the survey area. Adult waterfowl are highly mobile and able to fly in and out of survey plots. This mobility introduces variation in the number of IBPs observed during any given survey. Repeated surveys over a short period of time. using mark-recapture statistics. has identified this source of variation but has not led to development of correction factors (Parker 1988; Parker 1989). Visibility of waterfowl and methods used to calculate IBPs are also important sources of temporal variation.

The visibility of adult waterfowl. *i.e.*. the number of birds present that went undetected in relation to habitat type. during these helicopter-based surveys is not known. Although the visibility of territorial pairs is much greater than broods. the fact that it remains unquantified introduces the potential for survey results to be inaccurate representations of local breeding populations. Visibility correction rates have been calculated for brood surveys among different habitat types conducted by helicopter (Gabor *et al.* 1995). Some researchers have concluded that data collected from a single helicopter survey cannot be used to construct estimates of absolute species frequency or density (DesGranges and Darveau 1985). Others have stated that helicopter surveys of breeding waterfowl in the Boreal Forest give results comparable to those of ground surveys. with the qualifying statement that variability would mask small biases that could be present (Ross 1985). The visibility of large sized species is greater than small sized species during fixed wing surveys on the prairies. *e.g.*. ground-to-air corrections range from 10:1 for Green-winged Teal to 3:1 for the Mallard (Baldassarre and Bolen 1994). The 100 % visibility assumption for helicopter-based breeding pair surveys is most certainly suspect for small species such as Green-winged Teal if they do not flush upon approach of the helicopter.

The methods used to define IBPs and the timing of helicopter pair surveys in relation to breeding season phenology could also have an important impact on the number of IBPs reported for a survey plot (Parker 1988; Parker 1989). Timing of surveys in relation to breeding phenology will influence the number of IBPs observed because Black Duck plumage is sexually monochromatic. Single Black Ducks are defined to indicate one breeding pair. If they represent the territorial male, with the female unseen on the nest, then this conclusion is correct. However, if the male and the female are observed separately, they would incorrectly represent two IBPs. Two individuals observed together represent one IBP but if they are two males with the hens unseen on the nest, they really represent two IBPs. Group size analyses and multi-stage surveys have been conducted to investigate annual variation in phenology and determination of IBPs (Erskine *et al.* 1990; Parker 1989). There is, however, no accepted method by which to correct for annual variation in phenology therefore annual variation in determination of IBPs continues to contribute to annual variation in population estimates.

Annual variation in the number of IBPs counted during these surveys may indicate that the populations are relatively dynamic, or that surveys counted a variable proportion of the population each year. The use of the mean from three years data (1992-94) will simplify the determination of relationships between habitat factors and Black Duck breeding distributions, but should not obfuscate the fact that annual variation exists. High annual variation in IBPs will lead to habitat-based population estimates that will have large confidence limits.

An independent assessment of the distribution of Black Duck IBPs based on plots surveyed during 1990-94 can be done using data collected on spatially independent plots surveyed during 1986-89. The availability of two different data sets allows for an independent assessment rather than an assessment based on statistical techniques like the bootstrap (Beutel *et al.* 1999). It should be noted that these two data sets represent different time periods and that temporal changes in waterfowl populations could potentially confound this analysis.

Relatively low numbers of Mallards observed on the survey plots preclude a landscape-level analysis of their distribution and abundance. In Ontario and Quebec, Black Ducks and Mallards are currently sympatric or have been in the recent past (Ankney *et al.* 1987; Carriere and Titman 1999; Merendino and Ankney 1994). The low numbers of plots where Mallards occur in New Brunswick and Nova Scotia make any analysis of their spatial distribution anecdotal and would not elucidate reasons for changing Black Duck and Mallard populations in eastern North America. Aerial surveys of the Saint John River and associated floodplain wetlands indicate that Mallards are fairly common (Petrie 1998). Mallards are also present in various areas of the Maritimes where urban centres have been the source for populations to expand into adjacent agricultural areas, beaver ponds, and coastal marshes (Parker and Barrow 1989).

Although the Green-winged Teal is the fourth most prevalent species in the harvest in New Brunswick and Nova Scotia it did not occur in 60% of the PQUADs during 1992-94 and was not observed every year on another 25%.

Ring-necked Ducks are the second most prevalent species of duck in harvest estimates for New Brunswick and Nova Scotia. Although the timing of the survey is sub-optimal for Ring-necked Ducks, IBPs were observed on over half of the survey plots. Although Common Mergansers do not figure prominently in harvest estimates, they are killed during the hunting season because their diet includes fish (White 1957). Knowledge of the distribution and population of Common Mergansers is important in light of continued calls for a cull. Common Mergansers were observed on roughly half of the survey plots.

The estimated number of indicated breeding pairs of Black Ducks in Stratum 1 (NB, NS and the Gaspé region of Quebec) in 1998 was almost twice that estimated for 1994 (Collins 1999). Compared to the Prairie region of North America, the Maritimes do not experience great annual fluctuations in wetland habitat quantity and quality in early spring. Changes in IBPs observed over a 5–10 year period could be due to changes in habitat quantity and quality due to beaver activity (Payne and McInnis 1993) or hypothesized increasing Black Duck populations due to changes in survival rates (Francis *et al.* 1998.).

Harvest regulations have remained relatively constant in Atlantic Canada during the past decade, with harvest of Black Ducks decreasing somewhat during this time period. In the United States, restrictive hunting regulations were implemented in the mid 1980s and resulted in a dramatic decline in harvest (Francis *et al.* 1998.). The 8% increase in Black Duck populations in Stratum 1 may reflect increasing populations resulting from increased survival. Another explanation is that changes in population estimates reflect changes in which plots were surveyed within that given year. Evidence for this explanation is provided by the dramatic increase indicated in 1996 compared to earlier time periods. The new rotational survey design based on 5km * 5km plots was initiated in 1996. Another increase was indicated in 1998 and 1999 when new plots (Group D) were brought into the rotation (Collins 1999). If the true population of Black Ducks in the plots comprising Stratum 1 varied by an order of magnitude between 1990 and 1999, while habitat conditions remained unchanged, then habitat-based regional population estimates based on these plots could also vary by an order of magnitude.

Habitat-use studies are most informative when the distribution of individuals reflects habitat quality (Horne 1983). Large annual variation in waterfowl populations would indicate that either habitat conditions change markedly from year to year or that density does not always equate with habitat quality (Hobbs and Hanley 1990). Determining if relationships exist between habitat conditions and local trends in IBPs will help address this question.

When the BDJV surveys were designed in 1990, the statistical consequences of the number of survey plots were considered (Bateman and Hicks 1995). However, the consequences of spatial distribution of survey plots were not considered. The change from 5 km*5 km plots during 1986-1989 to 5 km*5 km plots nested inside larger 10 km*10 km plots changed the independence of the sampling plots. Fortunately, there was considerable variation in the number of Black Ducks IBPs among PQUADs within a given PLOT, with the majority of explained variance being due to among PQUAD variation, compared to among PLOT variation. Survey data indicate that potential statistical problems with the nested design were not as great as they could have been. From the overall perspective of spatial autocorrelation, Moran's I statistics for IBPs of Black Ducks, Ring-necked Duck, American Green-winged Teal, and Common Merganser indicates some spatial autocorrelation among PQUADs within the larger PLOT. The magnitude of this autocorrelation among PQUADs is not very high in absolute terms or relative to that observed for distances up to 40 km away.

The other spatial consideration with respect to sampling design of waterfowl surveys is plot size. Sampling unit size must be relevant to the ecological process under consideration (McGarigal and Marks 1995). In terms of Black Duck surveys and habitat modelling (see Chapter 5), the sampling unit should be roughly equivalent to the size of the home range (Beutel *et al.* 1999). The home range of Black Ducks is in the order of 1-3 km indicating that the 5 km*5 km PQUAD may be a more appropriate scale than the 10 km*10 km PLOT (Ringelman and Longcore 1982; Ringelman *et al.* 1982). The use of smaller spatial scales such as individual wetlands increases the probability that waterfowl distributions do not reflect habitat quality from the standpoint of breeding females or broods. Breeding pairs may be using wetlands in the early spring for loafing or for territorial reasons, with adjacent wetlands being most important for broods. Waterfowl surveys can now be recorded using laptop computers with integrated GPS units, allowing for the location of each individual waterfowl observation to be recorded (Butler *et al.* 1995a; Butler *et al.* 1995b). The completion of fully digital geo-referenced wetland inventories for New Brunswick and Nova Scotia will allow for future analyses of waterfowl distributions in relation to habitat characteristics at various spatial scales.

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Lag Class	Average Distance (metres)	No. Pairs	Moran's I ABDU log(+1)	Moran's I RNDU log(+1)	Moran's I AGWT log(+1)	Moran's I COME log(+1)
1	5697	303	0.333	0.425	0.239	0.337
2	13582	43	0.141	0.393	0.106	0.375
3	20376	117	0.247	0.23	-0.032	0.022
4	28184	158	0.206	0.343	-0.037	0.11
5	36213	137	0.363	0.343	0.116	0.028
6	44266	168	0.005	0.138	0.097	0.252
7	51942	193	0.118	0.062	0.099	0.183
8	60068	182	0.128	0.098	0.207	0.07
9	68443	268	-0.011	-0.018	0.025	-0.005
10	76027	344	-0.022	-0.04	-0.008	0.092
11	84167	354	0.001	0.009	0.004	0.027
12	92150	410	-0.071	0.176	-0.096	0.097
13	99993	463	0.09	0.02	-0.071	0.068
14	107583	338	0.113	0.143	-0.005	-0.16
15	116330	336	-0.114	-0.029	-0.109	-0.045
16	123802	394	0.079	0.088	-0.082	0.024
17	132072	384	-0.011	0.026	-0.094	-0.003
18	140081	468	-0.009	0.011	0.013	-0.111
19	147891	437	0.021	-0.052	-0.119	0.015
20	155752	357	-0.043	-0.059	-0.065	0.08

Table 4.1 - Moran's I spatial autocorrelation statistics for distribution of American Black Ducks (ABDU), Ring-necked Duck (RNDU), American Green-winged Teal (AGWT), and Common Merganser (COME) indicated breeding pairs (IBPs) in New Brunswick and Nova Scotia 1992-94. Active lag distance was 160,000 m, at 8,000 m intervals.

Lag Class	Average Distance (m)	Number of Observations	Moran's I
1	13171	10	0.743
2	31047	35	0.345
3	50763	42	0.163
4	70782	41	-0.032
5	89519	59	0.369
6	109997	51	0.063
7	130774	68	0.081
8	149402	56	-0.007

Table 4.2 - Moran's I spatial autocorrelation statistic for distribution of American Black Duck indicated breeding pairs in New Brunswick and Nova Scotia 1986-89. Active lag distance was 160.000 m. at 20.000 m intervals.

Lag Class	Average Distance (m)	Number of Observations	Moran's I
1	14351	18	0.1
2	30284	51	0.194
3	49581	58	0.012
4	70270	76	0.013
5	90030	125	0.049
6	109230	116	-0.205
7	129786	106	-0.04
8	149789	129	-0.025

Table 4.3 - Moran's I spatial autocorrelation statistic for distribution of trends in American Black Duck local populations in NB and NS during 1990-99. Active lag distance was 160.000 m at 20.000 m intervals.

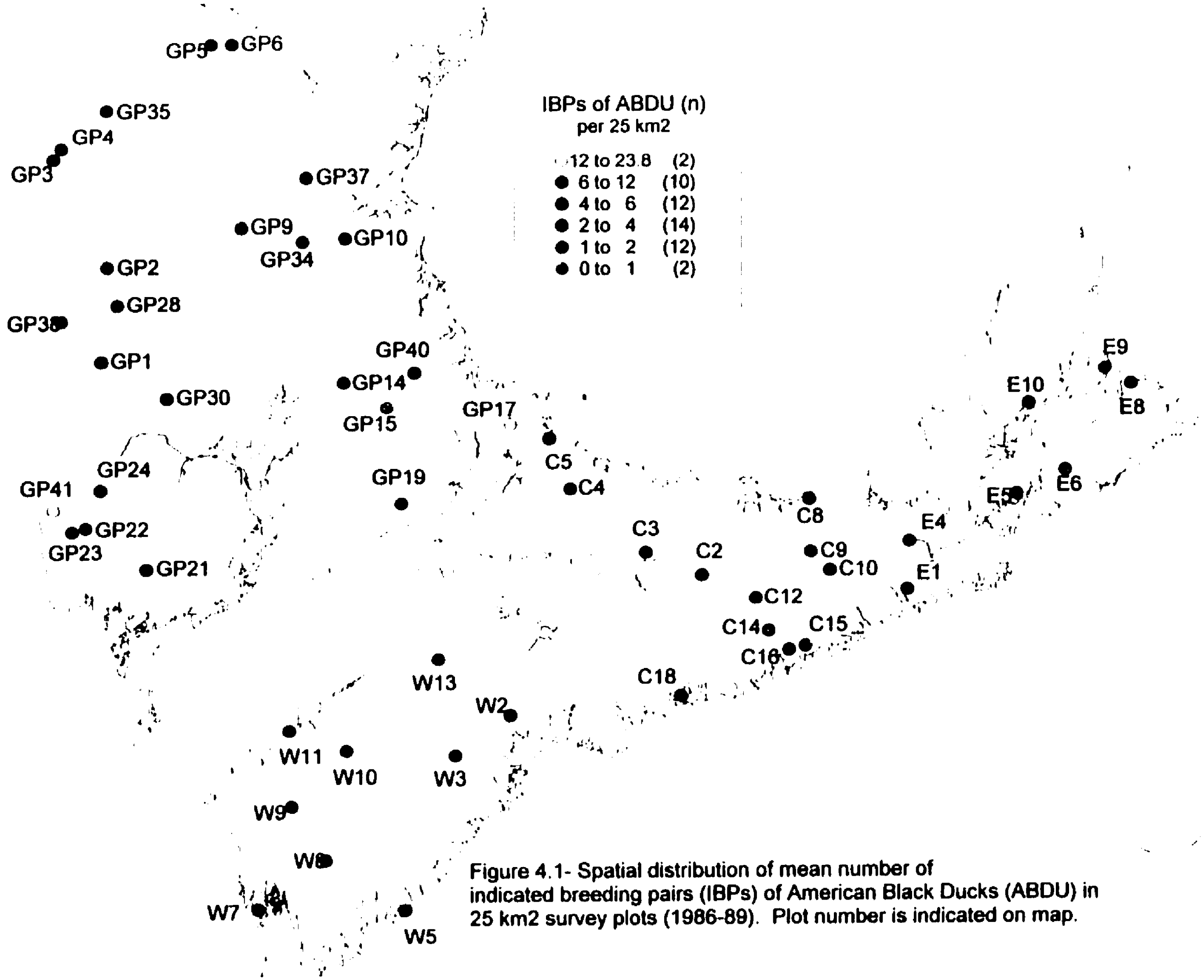

Figure 4.1- Spatial distribution of mean number of indicated breeding pairs (IBPs) of American Black Ducks (ABDU) in 25 km2 survey plots (1986-89). Plot number is indicated on map.

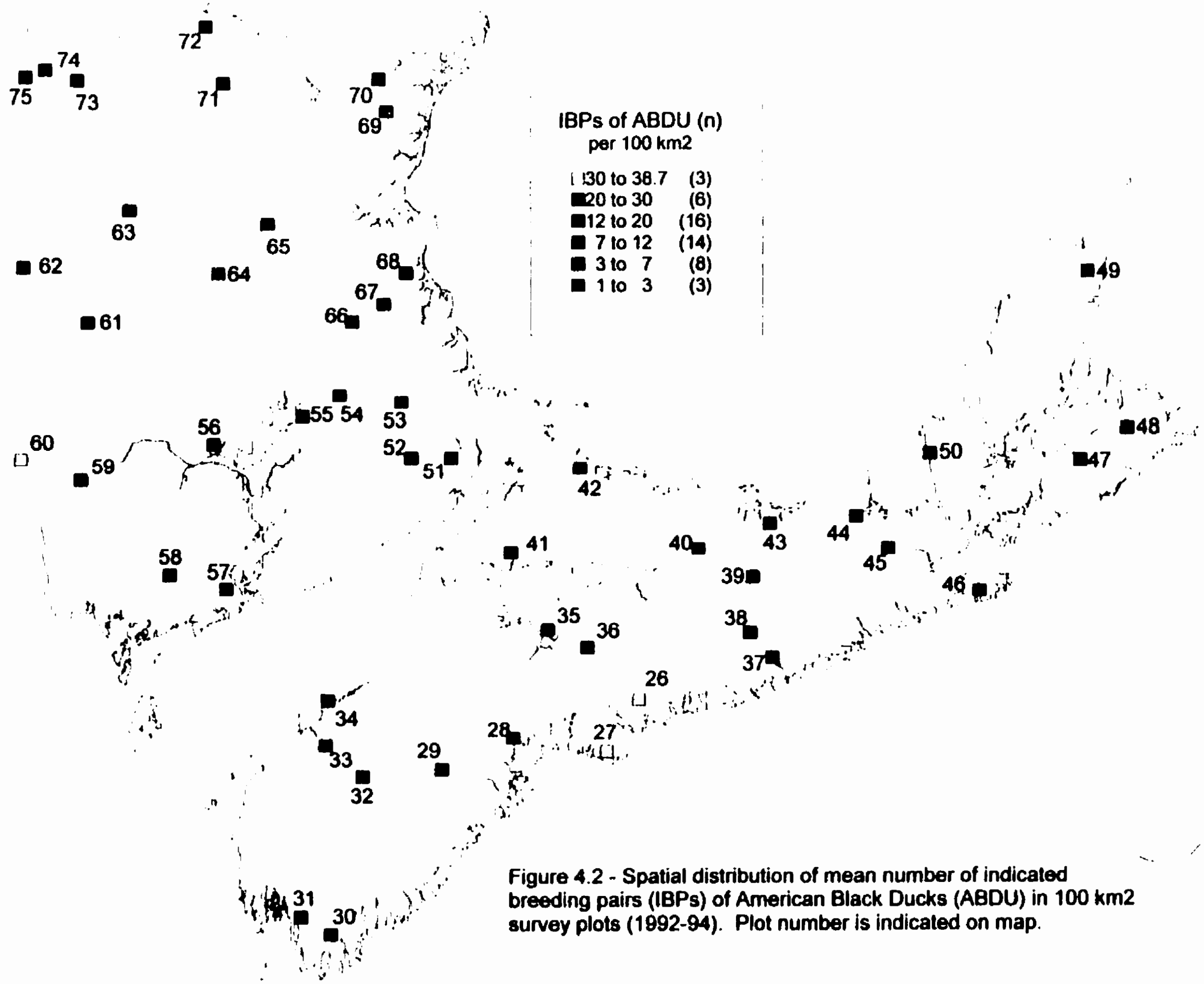

Figure 4.2 - Spatial distribution of mean number of indicated breeding pairs (IBPs) of American Black Ducks (ABDU) in 100 km2 survey plots (1992-94). Plot number is indicated on map.

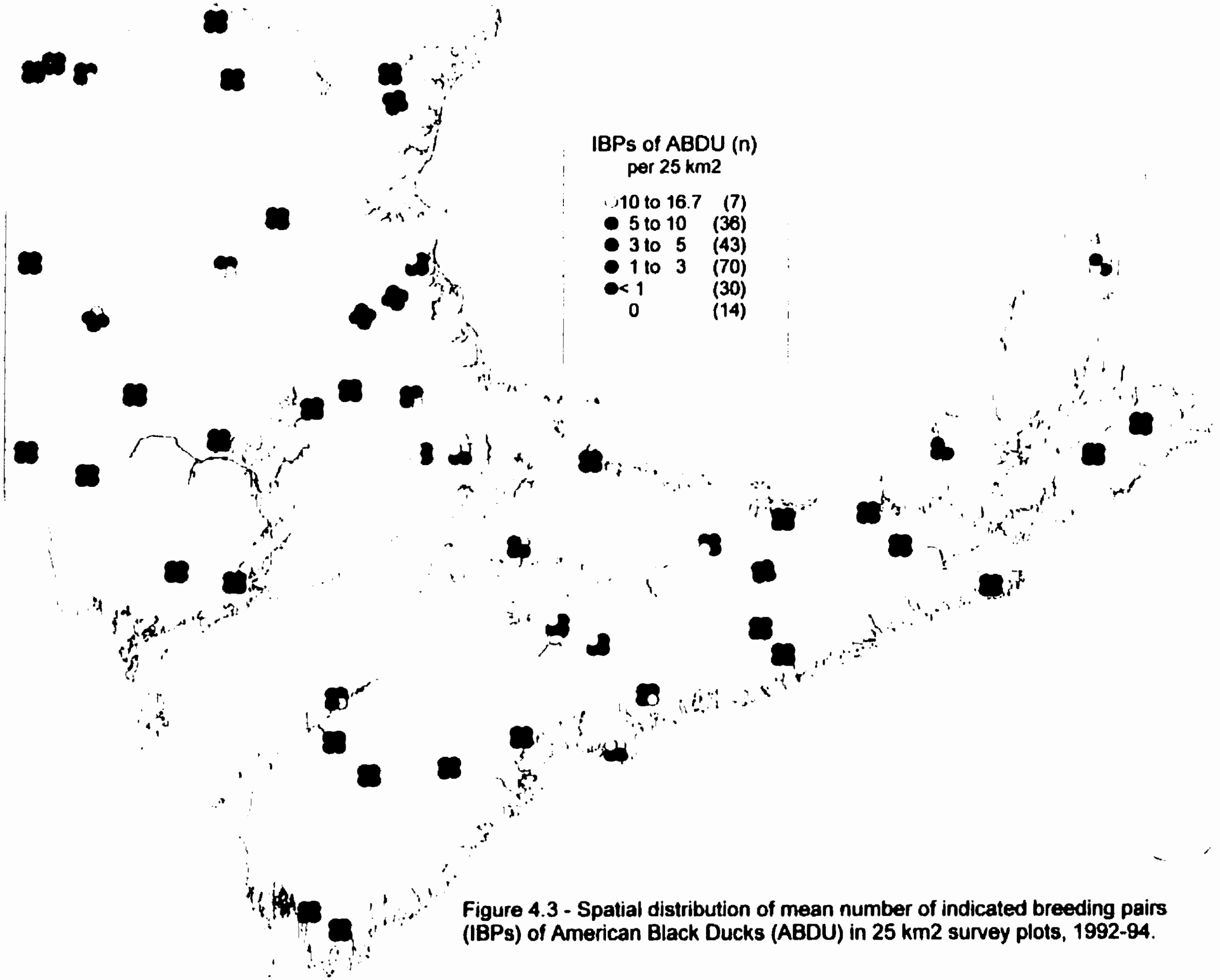

Figure 4.3 - Spatial distribution of mean number of indicated breeding pairs (IBPs) of American Black Ducks (ABDU) in 25 km2 survey plots, 1992-94.

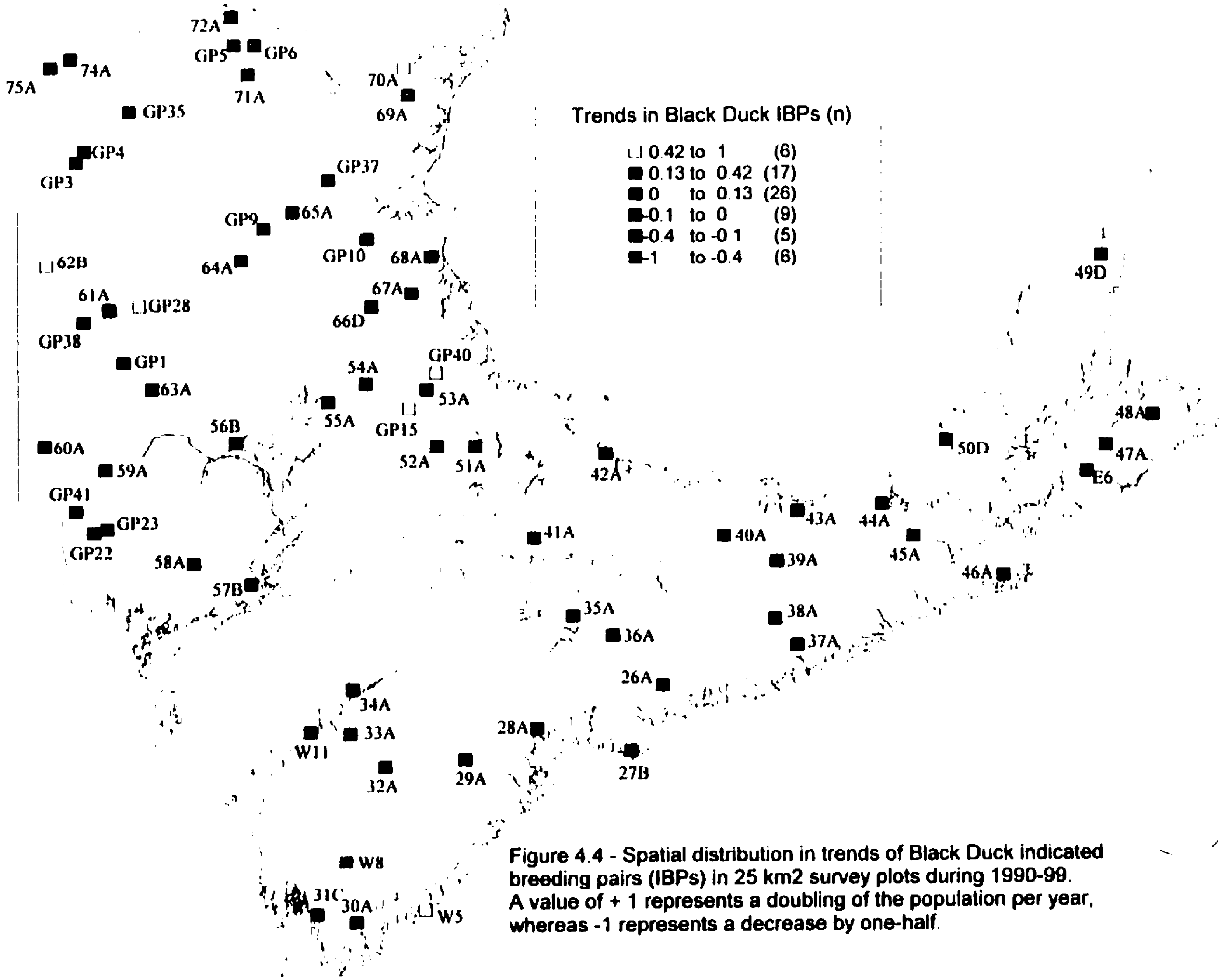

Figure 4.4 - Spatial distribution in trends of Black Duck indicated breeding pairs (IBPs) in 25 km2 survey plots during 1990-99. A value of + 1 represents a doubling of the population per year, whereas -1 represents a decrease by one-half.

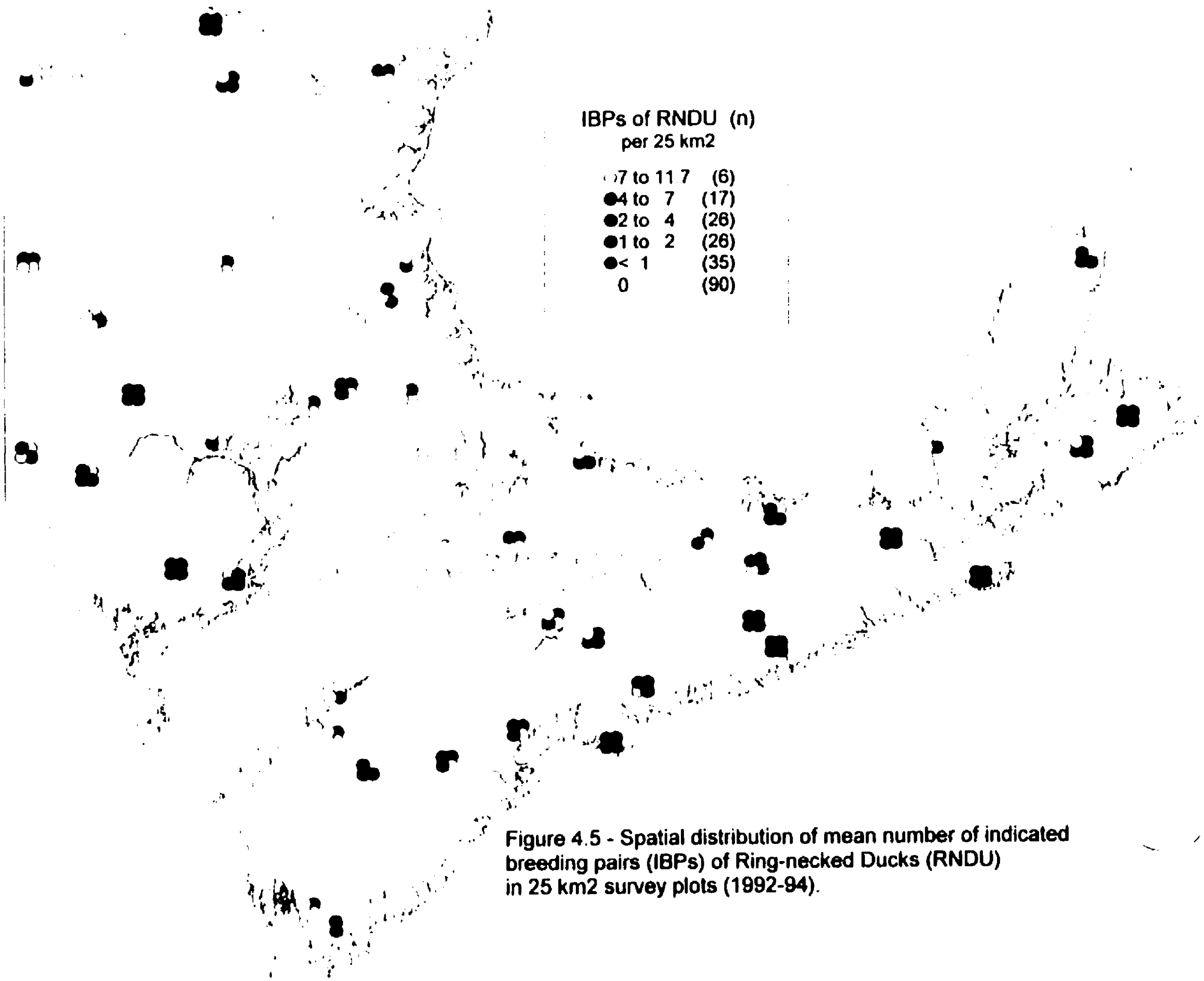

Figure 4.5 - Spatial distribution of mean number of indicated breeding pairs (IBPs) of Ring-necked Ducks (RNDU) in 25 km2 survey plots (1992-94).

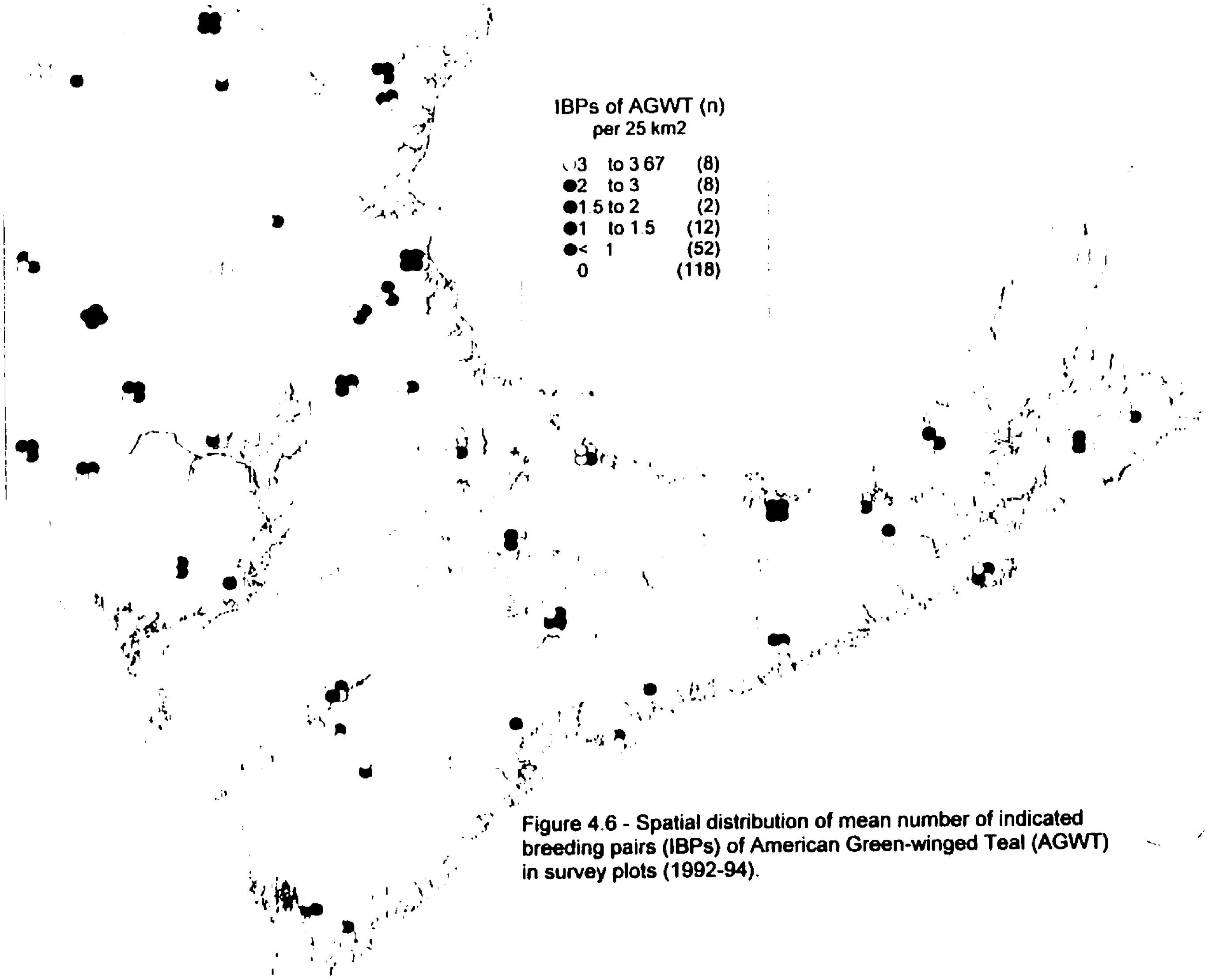

Figure 4.6 - Spatial distribution of mean number of indicated breeding pairs (IBPs) of American Green-winged Teal (AGWT) in survey plots (1992-94).

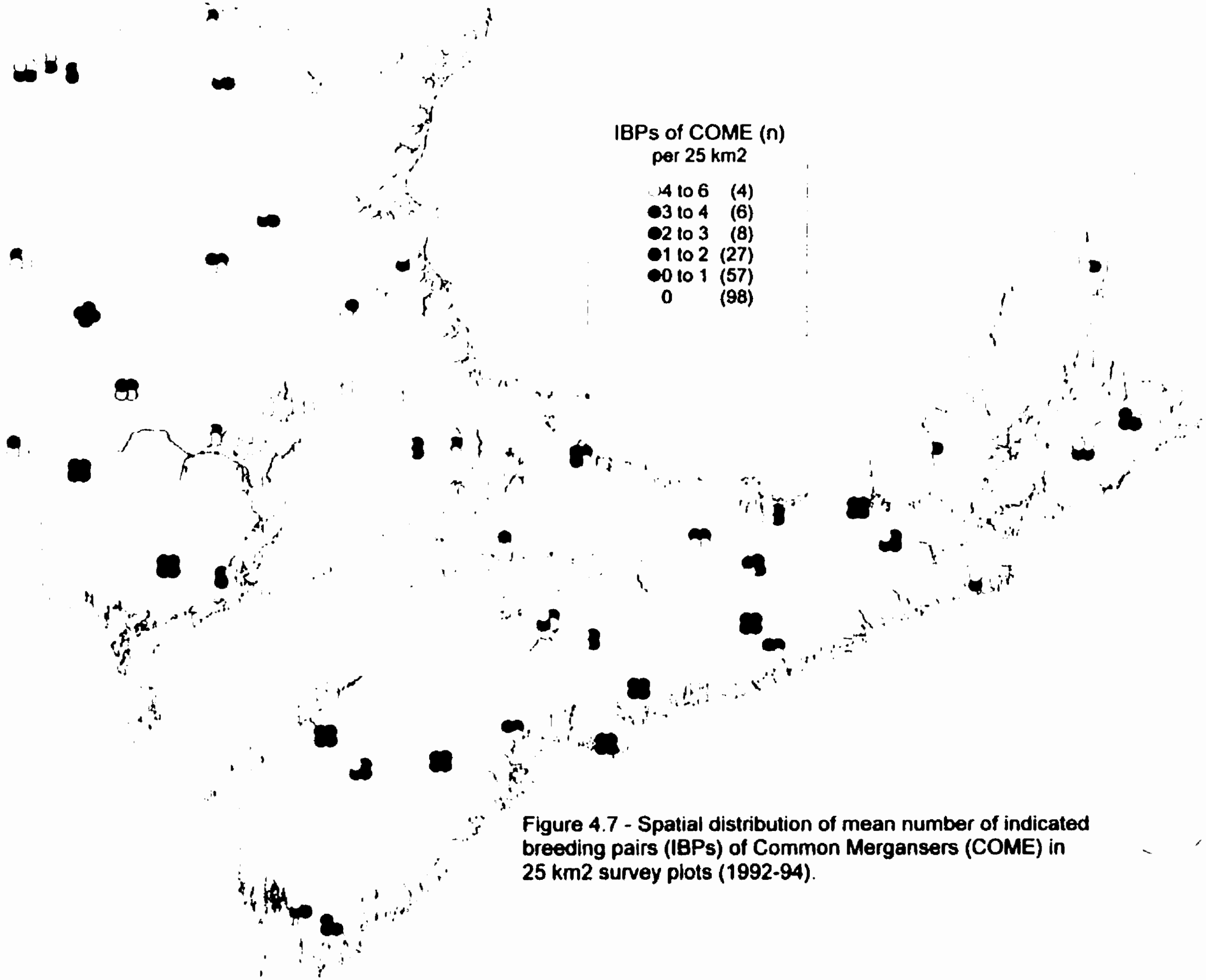

Figure 4.7 - Spatial distribution of mean number of indicated breeding pairs (IBPs) of Common Mergansers (COME) in 25 km2 survey plots (1992-94).

CHAPTER 5 – MODELLING WATERFOWL BREEDING PAIR DISTRIBUTIONS IN THE MARITIMES

INTRODUCTION

This chapter examines the ability of landscape-level descriptors of habitat to explain the number of indicated breeding pairs (IBPs) of American Black Ducks (*Anas rubripes*), Ring-necked Ducks (*Aythya collaris*), Common Mergansers (*Mergus merganser*), and American Green-winged Teal (*Anas crecca carolinensis*) observed in survey plots in New Brunswick and Nova Scotia during 1992-94 (Bateman and Hicks 1995). Data collected on Black Duck IBPs during 1986-89 (Erskine *et al.* 1990) in spatially independent survey plots were used to validate models that were derived using 1992-94 data. This chapter also investigates the relationships between landscape-level habitat conditions and trends in local Black Duck populations during the period 1990-99 (Collins 1999). For a detailed description of survey methodology and results see Chapter 4.

Black Duck Reproductive Ecology

The number of breeding pairs of Black Ducks in a given area reflects female philopatry, territoriality, habitat selection by the pair, and brood habitat selection by the female. Pairs are known to utilise territories of between 1 - 3 km^2 (Ringelman *et al.* 1982; Seymour 1990; Wright 1954), and females moving broods several kilometres is not uncommon (Ringelman and Longcore 1982; Seymour and Jackson 1996; Tufts 1986). Previous studies have shown that female Black Ducks will nest in a variety of habitats and locations (Coulter and Miller 1968; Krementz *et al.* 1992; Stotts and Davis 1960; Wright 1954); hence there is not strong selection of habitat based on nest site requirements.

Many species of waterfowl exhibit female philopatry, whereby the female returns to breed in the area where she was born or nested previously (Johnson and Grier 1988;

Anderson and Titman 1992). The degree of female philopatry varies, but can be very exact, with the female returning to nest under the same bush in consecutive years (Coulter and Miller 1968). Philopatry is more pronounced for females that successfully raise a brood than for females that are unsuccessful (Seymour 1991). Philopatry results in more females (all age classes) returning to areas where broods can be successfully raised, thereby reinforcing good decisions regarding habitat selection.

Differences in territorial behaviour among waterfowl species is correlated with differences in habitat type and body size (Anderson and Titman 1992; Nudds and Ankney 1982). Within a given species, such as the Black Duck, territorial behaviour can vary according to habitat type (Hughson 1971; Ringelman *et al.* 1982; Seymour 1990; Seymour 1992; Seymour and Titman 1978). Territoriality in Black Ducks, regardless of whether it ultimately reduces multiple paternity within broods, or competition for the food resources critical to nesting females and growing ducklings, makes the distribution of pairs and broods more uniform than it otherwise would be.

The need for more information on habitat use and habitat selection by Black Duck pairs and brood-rearing females was expressed by many at the Black Duck Symposium in 1968 (Addy 1968). Some believed that breeding habitats and nest sites of Black Ducks were so diverse that the presence of water was virtually the only characteristic known to be common to breeding sites (Palmer 1976). During the last 30 years, many studies have refined our knowledge of the habitat requirements of breeding Black Ducks (*e.g.*, Table 5.1). In these studies, certain environmental variables were correlated with habitat use and reproductive success of pairs and broods. These studies were, for the most part, conducted in different areas and in different years.

A shortcoming of such observational, correlative studies is that they do not prove cause and effect (Savard *et al.* 1994). If the same variables are not measured in all studies, then different variables can be significant even though they represent the same ecological process. For example, a study in New Brunswick (Parker *et al.* 1992) found increasing acidification of surface waters to be beneficial for Black Duck broods, whereas in most studies increasing acidification was detrimental (Rattner *et al.* 1987). The difference was that in the New Brunswick study, high acidity lakes were without fish, whereas circumneutral lakes had high fish populations which competed with ducklings for invertebrate prey. Another example related to acidity is that the influence of low pH can be offset by high nutrient availability, a situation most likely to occur due to direct or indirect anthropogenic nutrient inputs (Melanson and Payne 1988; Staicer *et al.* 1994). The problem with spurious correlations becomes more pronounced if variables are highly correlated with each other. Many parameters of chemical limnology are highly correlated with each other (Gorham *et al.* 1998). The significance of any one aspect of chemical limnology needs to be evaluated in terms of the biogeochemical process that it represents.

Wetland Productivity - Habitat Selection Factor versus Limiting Factor

A distinction needs to be made between a limiting factor and a factor that just influences habitat use. For example, although Krapu (Krapu 1979; Krapu 1981) and Reinecke (Reinecke 1977; Reinecke 1979) showed that invertebrates are an important food source for breeding Mallards and Black Ducks, there is still ongoing debate over whether food limits reproductive success of Black Ducks (Longcore *et al.* 1998; Porter 1993; Seymour and Jackson 1996). The fact that females take their young to wetlands high in invertebrate resources is what is important from the perspective of habitat selection (Ringelman and Longcore 1982; Seymour and Jackson 1996)

In two recent studies, wetland productivity did not correlate with brood size (Seymour and Jackson 1996; Longcore *et al.* 1998). The fact that wetland productivity was not correlated with brood size in a given study does not disprove the hypothesis that, *ceteris paribus* (all other thing being equal), increased food availability will increase duckling survival (Cox *et al.* 1998). Nor does it discount the fact that females take their broods to areas rich in invertebrates (Longcore *et al.* 1998; Seymour and Jackson 1996). It is interesting to note that mean brood size reported in Nova Scotia was 7.05 (Seymour and Jackson 1996), compared to 4.0 and 5.0 observed during two years of study in Maine (Longcore *et al.* 1998; Seymour and Jackson 1996). Variation in brood sizes indicates the importance of incorporating spatial and annual variation in population models (Conroy *et al.* 1995; McKenney *et al.* 1998).

The importance of wetland productivity can also be inferred from the observation that in Maine, Mallards and Black Ducks predominantly used wetlands located in agricultural landscapes, resulting in most broods being produced in agricultural areas (Longcore *et al.* 1998). Furthermore, two wetlands receiving anthropogenic nutrients had a high number of waterfowl broods observed on them, with high numbers of ducklings per brood.

Similar results were reported in Sweden, where higher densities of wild Mallard pairs and ducklings were observed on nutrient rich lakes versus nutrient poor lakes, and higher growth rates of human-imprinted Mallard ducklings were observed on lakes with above average phosphorous levels (Sjoberg *et al.* 2000).

Part of the debate about the importance of wetland productivity to Black Ducks arises from misinterpretation of Reinecke's work in Maine (Reinecke 1977; Reinecke 1979; Reinecke and Owen 1980). For example, Kirby (1988) stated, "Food quality and quantity do not seem to be limiting for either adult female (Reinecke and Owen 1980) or young (Reinecke 1977) Black Ducks in inland Maine or similarly productive freshwater wetlands". Seymour and Jackson (1996) stated, "....reproductive success of adult female black ducks (Reinecke and Owen 1980) and survival of ducklings (Reinecke 1977) are not limited by food in Maine".

It must be stressed and clarified that Reinecke's work showed that females lost weight during egg laying, and that the nutritional composition of invertebrates was not limiting waterfowl nutrition. Reinecke (1977), when discussing Black Ducks stated, "If food limits densities in Maine it operates through quantity rather than quality". Reinecke could not address the question of food-quantity limiting reproductive success in Black Ducks due to difficulties in quantifying invertebrate resources. The conclusion of Reinecke and Owen (1980) is that food quality does not limit the density of Black Ducks nesting in Maine.

Habitat Selection

The number of Black Ducks within a given area is often positively correlated with the amount of surface water such as wetlands, streams, and small lakes (Table 5.1). With increasing diversity of wetland type and shoreline irregularity, there is increased use by Black Duck pairs and broods. Wetlands with an irregular shoreline provide visual isolation which has been shown to be important to Black Duck pairs (Hughson 1971; Mendall 1949). Beaver ponds are known to be favoured habitat for Black Duck pairs and broods (Table 5.1). Beaver ponds have features such as emergent cover, flooded timber, abundant invertebrates and high primary productivity, that have been shown to be positively correlated with habitat use by pairs and broods (Table 5.1). Emergent cover and forested wetlands/flooded timber may be preferred by pairs and broods because they offer visual isolation and escape cover, as well as a higher abundance of invertebrates.

Salt marshes are also known to be an important habitat type for Black Duck pairs and broods. The mixing of nitrogen-limited marine waters with phosphorous-limited fresh water produces high primary productivity (Bertness 1999; Teal and Teal 1969). The tall emergent vegetation (*Spartina* spp.) in salt marshes also contributes to habitat suitability.

Female Black Ducks, *ceteris paribus*, prefer habitat with minimal human disturbance. The correlation between human disturbance, agricultural activities, anthropogenic nutrients, and fertile soils, may lead to a spurious correlation between habitat selection and human disturbance. This may explain why female Black Ducks selected habitats with increased human habitation in one study area (Conrad 1993).

Invertebrates are the chief food source of egg-laying female Black Ducks and young ducklings (Reinecke 1977; Reinecke 1979) and hence broods and pairs often select wetlands with high invertebrate abundance (Table 5.1). Invertebrates can be correlated with both chemical limnology and aquatic vegetation (Courcelles and Bedard 1979; Krull 1970; Reinecke and Owen 1980). Fish can reduce the population of invertebrates and therefore females will avoid utilizing wetlands where competition with fish for invertebrates would be high (Beattie and Nudds 1989; Cox *et al.* 1998). The relationship between invertebrate abundance and water chemistry can be confounded by high densities of fish.

Pairs and broods tend to avoid acidic surface waters because they are often oligotrophic with low availability of invertebrates (DesGranges and Darveau 1985). Calcium rich invertebrates, which are an important food for egg-laying females and growing ducklings, are absent from acidic wetlands (Rattner *et al.* 1987).

Modelling at a Landscape-Level

In recent years, many studies have quantified habitat use by breeding Black Ducks (Bowes and Kehoe 1994; Conrad 1993; Diefenbach *et al.* 1996; Diefenbach and Owen 1989; Hughson 1971; Krementz *et al.* 1992; Lewis and Garrison 1983; Parker *et al.* 1992; Petrie 1998; Pollard 1996; Ringelman and Longcore 1982; Staicer *et al.* 1994). These studies have shown that, depending on the methods and location of the study, certain habitat characteristics are correlated with pair densities and reproductive success. These studies have, however, been spatially restricted and examined third and fourth order habitat selection, *i.e.*, meso- or micro- scale (Johnson 1980). The extrapolation of these studies to larger spatial scales is not practical because of the site specific nature of the data. The development and utility of spatially-explicit population models are often limited by the expense required to develop the data base (Karl *et al.* 1999; Turner *et al.* 1995). To examine habitat use by breeding Black Ducks at the landscape-level (*i.e.* first and second order habitat selection, *sensu* Johnson 1980), variables need to describe the processes listed in Table 5.1 and be available for all of Nova Scotia and New Brunswick.

Statistical models can be viewed as parsimonious representations of the unattainable truth (Burnham and Anderson 1998). In recent years, many of the implicit assumptions of wildlife-habitat models have been elucidated (Beutel *et al.* 1999; Hobbs and Hanley 1990). Models were developed based on *a priori* hypotheses about habitat selection.

In this study, landscape-level will refer to the 5 km*5 km and 10 km*10 km survey plots (see Chapter 4). The spatial arrangement of habitat patches within survey plots was not measured. In most landscapes, total area of suitable habitat will be of greater importance than its spatial arrangement, especially for landscapes with a high proportion of suitable habitat (Andren 1994). From the perspective of bird populations, arbitrary topographic boundaries have little ecological relevance (McGarigal and Marks 1995), especially for adult ducks which are highly mobile.

From the perspective of flightless young Black Ducks, it should be noted that wetlands in the Maritimes tend to be hydrologically connected, thereby providing aquatic travel corridors. Black Duck broods have been observed to travel several kilometres along waterways to larger brood rearing areas (Ringelman and Longcore 1982; Seymour and Jackson 1996). This is in contrast to the Prairie pothole landscape, which is characterised by hydrologically isolated wetlands with females having to move broods overland between wetlands (Rotella and Ratti 1992). In the highly fragmented Prairie landscape, where little wetland habitat is left, spatial arrangement of habitat patches will be important (Andren 1994). A measure of the connectivity of habitat patches within survey plots was obtained from the Maritime Wetland Inventory which describes the juxtaposition of each wetland in relation to aquatic habitats (Hanson and Calkins 1996).

METHODS

Variable Selection

Landscape-level descriptors of habitat were developed and described in Chapter 2. Variables describing chemical limnology and waterfowl survey data were developed in Chapter 3 and Chapter 4 respectively. The term PLOT refers to 10 km*10 km plots surveyed during 1992-94, whereas the term PQUAD refers to 5 km*5 km plots that were nested within the larger PLOT.

Variables were log-transformed prior to analysis to improve normality and reduce heterogeneity of variance (Ott 1988). W values indicated normal or near normal distributions (Table 5.2). The square root transformation, which is often used for data with an underlying Poisson distribution, did not produce higher W values for IBPs than log transformation.

Global Models

Global models were developed from the over 100 habitat variables previously created. The number of structural parameters in global models did not exceed 10% of the sample size to minimise the potential of overfitting the model to the data (Burnham and Anderson 1998). Twenty variables were selected to be included in global models based on biological processes known to affect the distribution of Black Duck breeding pairs and broods (Table 5.1). Global models were also selected for Ring-necked Ducks, Common Mergansers, and Green-winged Teal based on factors known to affect the distribution of pairs and broods of these species at local spatial scales.

Variables selected for inclusion in global models are listed in Table 5.2, along with a reference to where in the thesis the variable is described in detail. If two similar statistics of the same variable are listed in Table 5.2 (*e.g.*, maximum Golet Score [MXSCOR] and mean Golet Score [(MSCOR]), only one of the variables would have been included in the global model. Reasons for which statistic was used to describe a variable are discussed in the Results section. The global model for survey data collected during 1986-89 (validation data) did not include any water chemistry related variables.

Total area of lakes (LSIZEL) was used in global models as a measure of total surface area of lakes. Total number of lakes (LTOTLAK) was included in global models because Black Ducks are known to use small shallow lakes in preference to large deep lakes (Table 5.1). Waterfowl are known to use lentic habitats: therefore mean stream density (LXSTM) was included in global models. The total number of wetlands (TOTAL) was included in global models because Black Ducks prefer spatially/visually isolated habitat (Seymour and Titman 1978). Total area of wetlands (LSSIZE) was included as a measure of total wetland habitat. Median size of wetlands (MDSIZE2) was included in models because Black Ducks prefer small emergent marsh wetlands. Large wetlands in the Maritimes tend to be large peatland complexes (Hanson and Calkins 1996).

Bogs. because of their acidic and oligotrophic nature. are not good habitat for Black Ducks compared to other wetland types (Table 5.1). The percentage of wetlands having bog as their dominant class (PB) was therefore included in global models. The variable describing the percentage of the area containing soil polygons in bog categories (LSFBOG) was also included in global models. LSFBOG provides a measure of presence of acidic and/or dystrophic conditions using a national database.

Either median Golet Score (MDSCOR). mean Golet Score (MSCOR) or maximum Golet Score (MXSCOR) were included in global models to represent a wetland's wildlife-habitat potential (Golet 1978). The median or mean score provides an index to the overall wildlife habitat potential of the survey area (PLOT or PQUAD) whereas the maximum score describes the best wetland. The median was used instead of the mean in order to minimize the effects of outliers in some models.

Standard deviation of elevation (LELVSTD) was included because streams in areas of steep topography would not be good habitat for Black Ducks because they would be quick flowing, have rocky substrates, and have highly variable water depths.

Total area of salt marshes in, and adjacent to, the survey plot (LSALTHA) was included in global models because Black Ducks are known to use salt marshes as pair and brood rearing habitat (Seymour and Jackson 1996; Seymour and Titman 1978).

The total number of buildings within the survey plot (LBUILD) was used as a measure of human habitation and disturbance. Black Ducks have been known to avoid areas of human habitation (Diefenbach and Owen 1989). The total length of roads within the survey plot (ROAD) was used in global models as a measure of human disturbance through the direct impact of the road (Findlay and Bourdages 2000) and as an index to forestry activities.

The minimum temperature during the growing season (TMINGS), which included the months of May, June, July, and August, was included in global models. Both primary and secondary productivity can be affected by temperature. The total precipitation during the growing season (PPGS) was included in global models because wetland hydrology and biogeochemistry can be affected by precipitation. Areas with a high amount of precipitation may have increased leaching of soil nutrients. Climatic factors are also important because the survival of ducklings can be reduced during periods of cold wet weather due to increased energy demands for thermoregulation and decreased food abundance (Cox *et al.* 1998; Mauser *et al.* 1994).

Total nitrogen and total phosphorous are the limiting nutrients in freshwater systems and therefore least-squares mean (lsm) total nitrogen (N1) and lsm total phosphorous (P1) were included in global models (Bedford *et al.* 1999; Mitsch and Gosselink 1986; Wetzel 1983). The lsm score for the first principal components axis (PCA1) and lsm score for the second principal components axis (PCA2) were included in the global model because they summarised a variety of aspects of chemical limnology of wetlands related to pH and nutrients respectively. All four water chemistry related variables (TN, TP, PC1, PC2) were included in global models for several reasons. Although PC scores summarise many aspects of chemical limnology, they can also make the interpretation of models somewhat more convoluted. From a logistical standpoint, if nitrogen and/or phosphorous concentrations add more to the explanatory power of the model than PC scores, it is less costly to analyse water samples for these parameters than for a whole suite. Lastly, it should be noted that historical data may not be available for all parameters included in the PC scores.

Variables associated with soil polygons that had no direct relationships with wetland ecology and habitat selection by waterfowl (*e.g.*, rooting depth) were not included in global models. Some soil attributes and wetland attributes, that may have been landscape-level descriptors of habitat, were not included in global models because they did not vary much among PQUADs or PLOTs (*e.g.*, calcareous class of soil, surrounding habitat cover for wetlands, CLI scores). Variables that were not available for both provinces were not included in global models; otherwise separate models would have had to be developed for New Brunswick and Nova Scotia.

Global models represented a parsimonious first step in modelling. The 20 variable maximum did not result in the omission of variables from global models that were felt, *a priori*, to be potentially important to the model. If global models did not adequately explain the variation among survey plots in number of breeding waterfowl, then an *ad hoc* approach could have been utilised if needed and explicitly stated (Burnham and Anderson 1998).

Model Selection

Log transformation of the mean number of indicated breeding pairs (IBPs) produced a distribution closer to a normal distribution compared to square root transformation. Count data often approximate a Poisson distribution and square root transformations will normalise these distributions. It should be noted that the mean number of IBPs during a three-year period is a continuous variable indicating density and not counts *per se*. Linear regression analysis was used for modelling (PROC REG, SAS 1988). Linear regression models are consistent with a parsimonious approach to modelling and a desire not to overfit the model to the data, compared to using generalised linear models with a log link function for a Poisson distribution (PROC GENMOD, SAS 1999). Bivariate scatter-plots and *a priori* knowledge of habitat selection by waterfowl suggested that the relationships between variables in the global model and response variables (*e.g.*, Black Duck IBPs) would be linear additive (Tabachnick and Fidell 1989).

In addition to the global model, lower order models were developed based on *a priori* knowledge of habitat selection by Black Ducks. Models with the 10 highest R^2 values for each model size were also computed in order to identify combinations of variables in higher order models that had high explanatory power (PROC REG / Selection = RSQUARE Best=10; SAS 1988). Aikake's Information Criterion for small sample sizes (AICc), was calculated using AIC values produced by PROC REG (SAS 1988) and the formula supplied by Burnham and Anderson (1998). AICc is recommended when the ratio between sample size and parameters is less than 40. Models did not include intercepts because most habitat variables were non-zero, positive values.

Suitability of models was determined based on Aikake's Information Criterion (AICc), R^2 values, and parameter estimates. Aikake's Information Criterion is based on information theory as opposed to traditional methods based on hypothesis testing (Edwards 1984) or newer Bayesian methods (Tucker *et al.* 1997). Conceptually, AICc is based on the Kullback - Liebler distance between the proposed approximating model and the unknown true model (Burnham and Anderson 1998). The smaller this distance, the less information is lost when using the approximating model compared to the true model. The lower the AICc score, the better the proposed model is. Based on Monte Carlo simulations, AICc scores have been shown to be more accurate in selecting the correct model compared to regression coefficients. AICc methods also offer the advantage of quantifying uncertainty in selecting the best model and model parameters, through the use of Aikake weights. AICc scores emphasise the selection of the most parsimonious model because the second term in the equation used to calculate AICc increases the AICc score by two times the number of parameters in the model. Use of AICc scores will reduce the risk of overfitting the model to the data. By *a priori* choosing the parameters to be included in the model. the process becomes one of fitting the data to the model.

The AICc score is only meaningful in comparison to other AICc scores: the absolute value. in and of itself. is irrelevant. Therefore. standard practice is to present the difference between a model's AICc score and the minimum AICc score of all models tested. This difference in AICc scores is denoted by Δ_i. The suitability of the various models was compared based on differences in AICc scores (Δ_i). There are no statistical means by that test the importance of differences in AICc scores. Burnham and Anderson (1998) have devised the following general rules based on experience gained from Monte Carlo simulations. If an alternative model has Δ_i less than 2. it should not be ruled out as potentially the best model. There is very strong evidence that the alternative model is not the best one if Δ_i is greater than 10. Differences in AICc values (Δ_i) between 2 and 10 have decreasing likelihood of being the best model (Burnham and Anderson 1998).

Logistic regression analysis was conducted using PROC LOGISTIC (SAS 1988). Separate analyses were done for the presence of Ring-Ducked Ducks. Common Mergansers. and Green-winged Teal in PQUADs. 1992-94. Logistic regression of positive local population trends in Black Ducks was also conducted (Collins 1999). There was a positive population trend for 48 survey plots. one plot had no change. and 20 had decreasing populations.

RESULTS

Black Ducks - PQUADs 1992-94

Both median Golet Score (MDSCOR) and maximum Golet Score (MXSCOR) were used in the initial global model. however. MDSCOR was subsequently removed from the global model because it was highly correlated with MXSCOR. Models incorporating MDSCOR had AICc scores slightly higher than models using MXSCOR. It was also felt that at the scale of 25 km^2. the wetland with the highest quality wildlife habitat (MXSCOR) would have greater influence on total IBPs compared to median wetland quality (MDSCOR). Models with total number of lakes (LTOTLAK) were used rather than total area of lakes (LSSIZEL). because the number of lakes within the quadrat would be more important than total lake area because Black Duck pairs prefer visual isolation from each other. AICc scores supported this decision with models including LSSIZEL having higher AICc scores compared to models including LTOTLAK. Total area of wetlands (LSIZE) was used rather than median wetland size (MDSIZE) because the two variables were highly correlated. Also median wetland size would only be important in context of total area of wetlands. For example. if there is only one wetland in Survey Plot A which is 5 ha in size. but Survey Plot B has 300 wetlands with a median size of 100 ha. the importance of small median wetland size is negated. Models with total wetland size (SSIZE) had lower AICc scores compared to median wetland size (MDSIZE).

The relative merits of various models are outlined below. The purpose of describing competing models of various sizes is the fact that data used to create these models for BDJV survey plots may not be readily available at provincial scales. Pragmatically. the best model is a trade-off between explanatory power and cost of data acquisition. Competing models are also presented because of model selection uncertainty (*i.e.* similar AICc scores: see Appendix F).

All models presented are statistically significant ($p < 0.05$). Lack of space precluded putting Model F and P values in the tables. The significance of parameter estimates are presented, although it has been stated that more is learned by estimation of the mean and variance of parameters than by testing hypotheses about their significance (Johnson 1999).

Maximum Golet Score (MXSCOR) was the best univariate model of Black Duck IBPs in 25 km^2 survey quadrats (Model 1,Table 5.3), with $\Delta_i = 91.29$ and $R^2 = 0.78$. There was little evidence to support total wetland area (LSSIZE), total stream density (LXSTM), total number of wetlands (TOTAL), or total number of lakes (LTOTLAK) as the best univariate model (Appendix F, Table F1). In the univariate model, and all subsequent models, Black Duck IBPs were positively correlated with the maximum Golet Score (MXSCOR).

The best bivariate model was Model 6 and incorporated total number of lakes (LTOTLAK) as well as maximum Golet Score (MXSCOR), with $\Delta_i = 60.52$ and $R^2 = 0.81$ (Table 5.3). The parameter estimate indicated increasing numbers of IBPs with increasing number of lakes. Based on AICc scores, there was little evidence to support other bivariate models as the best model (Appendix F, Table F1). Models based on total number or total area of wetlands were not as good as models incorporating measures of wetland quality (Golet Score), although their addition to MXSCOR did improve the amount of variation explained by the models.

The best three-variables model, Model 13, included total area of salt marsh (LSALTHA), as well as total number of lakes (LTOTLAK) and maximum Golet Score (MXSCOR) with $\Delta_i = 31.61$ and $R^2 = 0.84$ (Table 5.3). The parameter estimate indicated increasing numbers of IBPs with increasing area of salt marsh. There was little evidence to support any of other three-variables models based on AICc scores (Appendix F, Table F2).

The best four-variables model was Model 21 which included mean concentration of total phosphorous in surface waters (P1) as well as parameters included in the best three-variables model (LSALTHA, LTOTLAK and MXSCOR). The R^2 for this model was 0.8545 with Δ_i = 14.94 (Table 5.3). The parameter estimate for total phosphorous was 0.177 indicating increasing IBPs with increasing total phosphorous concentrations.

Two other models could also be considered the best four-variables model. Model 22 which included total wetland area (LSSIZE), total number of lakes (LTOTLAK), total area of salt marsh (LSALTHA), and total number of buildings (LBUILD) had R^2 = 0.8530 with Δ_i = 16.99 (Appendix F, Table F3). The parameter estimate for LBUILD was 0.0947 indicating increasing IBPs with increasing number of buildings in the plot. Model 23 included the standard deviation of elevation (LELVSTD) as well as the variables in Model 13 (LSALTHA, LTOTLAK and MXSCOR). Model 23 had R^2 = 0.8525 with Δ_i = 17.68 (Appendix F, Table F3). The parameter estimate for LELVSTD was - 0.1833 indicating increasing IBPs with decreasing standard deviation of the elevation.

Model 28 could be considered the best five-variables model, and included total wetland area (LSSIZE), total number of lakes (LTOTLAK), total area of salt marsh (LSALTHA), total number of buildings (LBUILD) and standard deviation of elevation (LELVSTD). These variables were included in the competing four-variables models previously discussed. Model 28 had R^2 = 0.8614 with Δ_i = 7.38 (Table 5.3). Parameter estimates for variables in these models were similar to parameter estimates in the lower order models.

Model 29 (Appendix F, Table F4) could also be considered the best five-variables model and included total number of buildings (LBUILD) as well as variables that were in Model 21 (LSALTHA, LTOTLAK and MXSCOR, P1). Model 29 had R^2 = 0.8602 and Δ_i = 9.10. Model 30 which had Δ_i = 12.48 and R^2 = 0.8578 included standard deviation of elevation (LELVSTD) along with variables from Model 21.

Model 35 was the best six-variables model and incorporated variables that were in the competing five-variables models, namely maximum Golet Score (MXSCOR), total number of lakes (LTOTLAK), total area of salt marsh (LSALTHA), total number of buildings (LBUILD), standard deviation of elevation (LELVSTD) and total phosphorous concentration (P1). Model 35 had $R^2 = 0.8657$ with $\Delta_i = 3.16$ (Table 5.7).

There was an increasing number of potentially best models with models that incorporated six or more variables (Appendix F, Table F5). Model 36 incorporated stream density (LXSTM) instead of total phosphorous concentration (P1). Model 37 (Appendix F TableF5) incorporated total wetland area (LSSIZE) instead of standard deviation of elevation (LELVSTD). Model 38 (Appendix F, Table F5) included total length of roads (ROAD) instead of total phosphorous (P1).

Model 45 was the best seven-variables model and included variables from the best six-variables model (Model 35) as well as stream density (LXSTM). Model 45 had $R^2 = 0.8682$ with $\Delta_i = 1.61$ (Table 5.3). Model 47 (Appendix F, Table F6) had similar values for Δ_i, but included total road length (ROAD) instead of stream density (LXSTM).

The model with the lowest AICc score was Model 62 which included eight-variables (Table 5.3). Model 62 had $R^2 = 0.8707$ with $\Delta_i = 0$ (Table 5.3). According to the parameter estimates for this model, there were increasing Black Duck IBPs with increasing maximum Golet Score (MXSCOR), total number of lakes (LTOTLAK), total area of salt marsh (LSALTHA), total phosphorous concentration of surface waters (P1), stream density (LXSTM), and total number of buildings (LBUILD). The number of IBPs was negatively associated with standard deviation of elevation (LELVSTD) and total length of roads (ROAD). The difference in AICc scores between the best seven-variable model compared to the best eight-variables model was 1.61 (Table 5.3). There were several other eight-variables models with $\Delta_i < 2$, which had various combinations of the previously discussed variables (Appendix F, Table F7).

Overall, inclusion of chemical limnology variables, added little predictive capability to models. However, some of the higher order models which had low Δ_i values included concentration of total phosphorous in surface waters (P1). For example Model 21, which included maximum Golet Score (MXSCOR), total number of lakes, total area of salt marsh (LSALTHA) and total phosphorous (P1), had Δ_i = 14.94 and R^2 = 0.8545. Model 22 which, instead of P1, included total number of buildings (LBUILD), had Δ_i = 16.99 and R^2 = 0.8530 (Appendix F, Table F3). The three-variables model (Model 13) which included only maximum Golet Score (MXSCOR), total number of lakes, and total area of salt marsh (LSALTHA) had Δ_i = 31.61 (Table 5.3).

Variables such as soil pH (SOILPH), mean PC1 score of chemical limnology (PC1), mean PC2 score of chemical limnology (PC2), mean total nitrogen (N1) and precipitation during the growing season (PPGS), added little predictive capability to models, and their parameter estimates were not significantly different than zero.

Black Ducks - PLOTS 1992-94

Analysis of Black Duck IBPs at the 100 km^2 PLOT spatial scale verified the importance of predictor variables that were previously shown to be important at the 25 km^2 PQUAD spatial scale (Table 5.4; Appendix F, Tables F9-F14). Mean Golet score (MSCOR) was used rather than median Golet score to allow extreme high values to influence the Golet Score statistic. Maximum Golet Score (MXSCOR) was not used as the Golet Score statistic for PLOTs because it was felt that a single wetland may not provide enough habitat for a 100 km^2 area. The same reasoning resulted in using total lake area (LSIZEL) rather than total number of lakes (LTOTLAK). Many small lakes in this larger survey area may not be as important as the total lake area in providing habitat for black Ducks. These *a priori* preferences were supported by lower AICc scores.

The best univariate predictor of Black Duck IBPs was mean Golet Score (MSCOR) which had Δ_i = 35.26 and R^2 = 0.9421 (Model 101, Table 5.4). The best bivariate model was Model 106 and included mean Golet Score (MSCOR) and total lake area (SSIZEL) with Δ_i = 21.93 and R^2 = 0.9576 (Table 5.4). The best three-variables model (Model 113) included mean Golet Score (MSCOR), total lake area (LSSIZEL), and total salt marsh area (LSALTHA) with Δ_i = 14.83 and R^2 = 0.9649 (Table 5.4).

The best four-variables model (Model 121) included concentration of total phosphorous in surface waters in the survey plot (P1) as well as mean Golet Score (MSCOR), total lake area (LSSIZEL), and total salt marsh area (LSALTHA) with $\Delta_i = 6.92$ and $R^2 = 0.9710$ (Table 5.4). Similar to models for PQUADs, Black Duck IBPs were positively correlated with these variables.

The best five-variables model was Model 126, and consisted of the positive influence of total number of buildings (LBUILD) being added to the four-variables found in Model 121 (LSSIZEL, MSCOR, LSALTHA, and P) with $\Delta_i = 3.83$ and $R^2 = 0.9746$ (Table 5.4).

The best six-variables model, Model 131, added the negative influence of standard deviation of elevation (LELVSTD) to the best five-variables model (Model 126) which had $\Delta_i = 3.24$ and $R^2 = 0.9762$ (Table 5.4).

The best seven-variables model (Model 136) added concentration of total nitrogen in surface waters (N1) to the variables previously listed for Model 131. Model 136 had $\Delta_i = 0$ and $R^2 = 0.9789$ (Table 5.4) and had the lowest overall AICc score. In Model 136 the number of Black Duck IBPs was positively correlated with mean Golet Score (MSCOR), total lake area (LSSIZEL), total salt marsh area (LSALTHA), concentration of total phosphorous in surface waters in the survey plot (P1), total number of buildings (LBUILD), and concentration of total nitrogen in surface waters (N1), in addition to being negatively correlated with the standard deviation of elevation (LELVSTD).

The best eight-variables model (Appendix F, Table F14) had a slightly higher AICc score than the best seven-variables model. There were several eight-variables models that had $\Delta_i < 2$ (Appendix F, Table F14). These could also be considered the best models because of the small differences in AICc scores.

Black Ducks – Survey Plots, 1986-89

The global model for Black Duck IBPs in survey plots that were surveyed during 1986-89 was similar to that created for PQUADs surveyed during 1992-94, because of the similar spatial scale of the survey plots. However chemical limnology variables were not included in these models because water samples were not collected in these plots. Model 201 which included only maximum Golet Score (MXSCOR) had $R^2 = 0.8765$ (Table 5.5). Model 201 could be considered the best overall model based on AICc scores, with $\Delta_i = 0.1$ (Appendix F, Tables F15 and F16). The parameter estimate for maximum Golet Score (MXSCOR) from Model 201 was 0.009 (Table 5.5), which is very similar to the parameter estimate of 0.008 from the univariate model based on data from 1992-94 (Model 1, Table 5.3).

Model 209 which included Maximum Golet Score (MXSCOR) and total number of wetlands (TOTAL) had the lowest AICc score ($\Delta_i = 0$) but the parameter estimate for (TOTAL) was not significantly different from zero (Table 5.5). Models including total wetland area (LSSIZE) were not as good as models which incorporated maximum Golet Score (Appendix F, Tables F15 and F16). Model 204, a univariate model based on total wetland area (LSSIZE), had $\Delta_i = 66.67$ and $R^2 = 0.8545$ (Appendix F, Tables F15). In bivariate models with total wetland area (LSSIZE) and maximum Golet Score (MXSCOR) the parameter estimate for LSSIZE becomes negligible compare to the parameter estimate for LSSIZE in the univariate model (Appendix F, Tables F15).

Ring-necked Ducks - PQUADs 1992-94

The best univariate model to predict the number of Ring-necked Duck IBPs in survey plots (25 km^2) during 1992-94, was based on the total number of lakes (LTOTLAK), and had $\Delta_i = 26.33$ and $R^2 = 0.58$ (Model 305, Table 5.6). Ring-necked Ducks use small lakes, and therefore the total number of lakes present in the 25 km^2 quad was thought, *a priori*, to better represent habitat availability than the total surface area of lakes (LSIZEL). Models using total surface area of lakes generally had higher AICc scores compared to models using total number of lakes (unpubl. data).

The best bivariate model (Model 309) included total wetland area (LSSIZE) as well as total number of lakes (LTOTLAK), with $\Delta_i = 4.61$ and $R^2 = 0.63$ (Table 5.6). Models which included measures of wetland quality (MXSCOR, MSCOR) had higher AICc scores compared to models which included measures of wetland quantity (Appendix F, Tables F17-F20). Stream density (LXSTM) did not add much predictive capability to models (Table 5.6) and in higher order models the parameter estimate was not significantly different from zero (Appendix F, Tables F17-F20).

Model 313, a three-variables model, could be considered the best parsimonious model with $\Delta_i = 2.24$ and $R^2 = 0.6388$ (Table 5.6). In this model there was a positive correlation between Ring-necked Duck IBPs and total wetland area (LSSIZE) and total number of lakes (LTOTLAK), and a slight negative correlation with the percentage of wetlands that were bogs (PB). In Model 321 there also was a negative relationship with PB.

Higher order models had slightly lower Δ_i values and higher R^2 values, but some parameter estimates were not significantly different from zero (Appendix F, Tables F17-F20). Model 321 was the best four-variables model and included the variables from Model 313 (LSSIZE, LTOTLAK, and PB) as well as soil pH (SOILPH). The addition of soil pH did not add greatly to the explanatory power of the model as evidenced by $\Delta_i = 1.03$ and $R^2 = 0.6448$ (Table 5.6).

The model with the lowest AICc score was a five-variables model (Model 328) with $\Delta_i = 0$ and $R^2 = 0.6503$ (Table 5.6). This model included a positive relationship with total length of roads (ROAD). in addition to the variables that were important in the lower order models. namely. a positive correlation with total wetland area (LSSIZE). and total number of lakes (LTOTLAK). and a negative correlation with percentage of wetlands that were bogs (PB). and estimated soil pH (SOILPH). Model 328 model was not considered the best overall model because the parameter estimate for the potentially spurious variable ROAD was not significant. As stated earlier. Model 313 should be considered the best overall model. with all parameter estimates being significant. and $\Delta_i = 2.24$ and $R^2 = 0.6388$. The relatively low R^2 for the best model could partly result from only 90 of the 200 PQUADs having Ring-necked Duck breeding pairs present.

Results from a logistic regression indicated that the presence of Ring-necked Duck IBPs could be predicted based on a positive relationship with total wetland area (LSSIZE) and total number of lakes (LTOTLAK) and a negative relationship with soil pH (Model 336. Table 5.7). The model had a correct classification rate of 86%. Logistic regression models with more variables. such as Model 337. had higher correct classification rates but also had higher AICc scores (Appendix F. Table F21). It should be noted that results from linear regression. *e.g.* Model 321. also indicated the importance of total wetland area. total number of lakes. and soil pH in understanding the distribution of Ring-necked Ducks.

Common Mergansers - PQUADs 1992-94

Linear regression models of Common Merganser IBPs observed during 1992-94 in 25 km^2 survey quadrats were not very accurate (Table 5.8. Appendix F Tables F22-F25). There were small incremental decreases in AICc scores and increases in R^2 values with increasing number of variables. Model 437 was a six-variables model and could be considered the best overall model with $\Delta_i = 0$ and $R^2 = 0.52$. with all variables having significant parameter estimates (Table 5.8). Model 437 included a positive relationship with median Golet Score (MDSCOR). total salt marsh area (LSALTHA). total lake area

(LSSIZEL), stream density (LXSTM), as well as a negative relationship with estimated soil pH (SOILPH) and mean PC2 score (PCA2). The most important variables in these models were total lake area (LSSIZEL) and stream density (LXSTM), which were positively correlated with IBPs of Common Mergansers. Information on wetland quality (MDSCOR) or quantity (LSSIZE) were not important in these models.

Common Mergansers were observed in only 102 of the 200 survey plots during 1992-94. Results from logistic regression (*e.g.*, Model 451) indicated that the presence of Common Merganser IBPs was positively correlated with total lake area (LSSIZEL), and stream density (LXSTM), and negatively correlated with soil pH (SOILPH) (Table 5.9). Model 451 had the lowest AICc score and a correct classification rate of 74% (Table 5.9; Appendix F Table F26).

Green-winged Teal - PQUADs 1992-94

American Green-winged Teal were observed in only 94 of the 200 survey plots. The absence, and low number of IBPs observed during surveys, precluded linear regression modelling. Logistic regression was used to predict the presence of Green-winged Teal in 25 km^2 survey plots (Table 5.10). Model 471, included seven variables and had a correct classification rate of 79% and $\Delta_i = 0$. Maximum Golet Score (MXSCOR), stream density (XSTM), the mean PC1 score from a PCA of chemical limnology of surface waters (PCA1), total phosphorous of surface waters (P1), total area of salt marshes (LSALTHA), and total number of buildings (LBUILD) were all positively correlated with the presence of Green-winged Teal in survey plots (Table 5.10). Variation in elevation (LELVSTD) was negatively correlated with the presence of Green-winged Teal. A three-variables model which included, stream density, salt marsh area, and variation in elevation had a 72.2% correct classification rate (Table 5.10). Model 470 included fourteen variables had a correct classification rate of 82%, but the same AICc score compared to Model 471 which included only seven variables (Appendix F Table F27).

Black Duck Local Population Trends

Linear regression based on habitat variables listed in Table 5.2 did not accurately predict local population trends in Black Duck survey plots. The global model which included 15 habitat variables, had an R^2 of only 0.23 (unpubl. data). Landscape-level descriptors of habitat could, however, predict which quadrats had increasing local populations using logistic regression.

Model 509 was the logistic model for trends in Black Duck IBPs with the lowest AICc score ($\Delta_i = 0$) and had a correct classification rate of 83% (Table 5.11). In this four-variables model, the presence of an increasing local Black Duck population was most affected by a positive relationship with stream density (LXSTM) and a negative relationship with standard deviation of elevation (LELVSTD). There were also slight positive relationships with total number of wetlands (TOTAL) and total road length (ROAD). Stream density is an important variable in this model. Although the parameter estimate was not statistically significant ($P = 0.06$), it was large in comparison to other parameters in the model (Table 5.11; Appendix F, Tables F28 and F29).

The main variables in other models that had comparatively low Δ_i values were again stream density (LXSTM) and standard deviation of elevation (LELVSTD, *e.g.*, Model 509). These models (Appendix F, Tables F28 and F29) also included a positive relationship with variables such as total number of lakes (LTOTLAK) and total number of buildings (LBUILD). Because of the correlation between total road length and total number of buildings, models were usually significant for one of these two variables (Table 5.11). Higher order models had higher correct classification rates but higher AICc scores because variables were adding only slightly to the predictive capability of the model (Appendix F, Tables F28 and F29). Many of the parameter estimates for variables in the higher order models were near zero. A linear logistic model (Model 501) that included 14 habitat variables had a correct classification rate (concordance) of 90.4% and $\Delta_i = 13.6$ (Appendix F, Tables F28 and F29).

DISCUSSION

Models of Black Duck Distribution

Linear regression analyses of the number of indicated breeding pairs in 25 km^2 PQUADs during 1992-94, 100 km^2 PLOTs during 1992-94, and 25 km^2 survey plots during 1986-89, all indicate that the single best landscape-level indicator of habitat potential for breeding Black Ducks is Golet Score (Golet 1978; Golet and Larson 1974; Hanson and Calkins 1996). The Golet Score ranks the suitability of a wetland as wildlife habitat for a broad diversity of species (see Table 2.11). The fact that a measure of wetland quality was a better predictor of Black Duck IBPs rather than wetland quantity, indicates that at a landscape-level, the distribution of Black Ducks is a result of wetland selection. It also suggests that all wetlands are not of equal value as Black Duck habitat. Although this fact has been proven many times at smaller spatial scales (Table 5.1), this is the first time it has been documented for Black Ducks at such a large spatial scale. Previous work on a small spatial scale (14 individual wetlands) found no relationship between Golet Score and number of broods (Hudgins 1988).

The best overall model for Black Duck IBPs in the 25 km^2 survey plots, as measured by AICc score, was an eight-variables model in which the number of Black Duck pairs was positively associated with maximum Golet Score, total number of lakes, total area of salt marsh in the immediate vicinity, stream density, total phosphorous concentration of surface waters, and the number of buildings. In this model the number of Black Duck pairs was negatively associated with standard deviation of elevation in the survey plot and total road length.

Black Duck IBPs were positively correlated with number of lakes, area of salt marsh, and stream density, consistent with Palmer's (1976) admonition that Black Duck breeding habitats are so diverse that the presence of water is virtually the only characteristic in common. All of those aquatic habitat types are known to be important for breeding Black Ducks (Table 5.1).

The chemical limnology of wetlands can be seen as a contextually important component of habitat selection. Given equal amounts of wetland habitat (*e.g.*, ponds, streams, lacustrine marsh) the more fertile areas with higher primary productivity should have more breeding pairs. The distribution of wetland habitat is, however, not uniform, so that chemical limnology adds little predictive capability to these landscape-level models. Chemical limnology may be important in explaining which wetlands are used within the 25 km^2 survey quadrat. It is worthwhile to note that total phosphorous was the aspect of chemical limnology that added the most predictive capability to the models. Although phosphorus is often the limiting nutrient in freshwater ecosystems, relationships are not always established between total phosphorous and waterfowl densities (Parker *et al.* 1992). Although water samples are routinely analysed for total phosphorous (TP), a more useful measure would be of phosphorous that is biologically available(*i.e.*, soluble reactive phosphorous). Total phosphorous concentrations in water samples collected from bogs may not represent the dystrophic conditions present (Bridgham *et al.* 1998).

In models with only two or three variables, a more general descriptor of chemical limnology (PCA2) was better than total phosphorous concentrations. This may have been due to PC2 scores representing differences among aquatic habitat types and geological conditions. Soil pH was not a good predictor of breeding pair densities. This may have resulted from more wetlands being in areas of low soil pH and the fact that Black Ducks may select individual wetlands with slightly higher pH in areas of generally low soil pH. Wetlands are referred to, euphemistically, as the kidneys of the environment, due to their role as filters for aquatic systems. Wetlands capture the nutrients and minerals present in running waters (Mitsch and Gosselink 1986). Although there was a relationship between soil pH and chemical limnology in the survey area, Black Ducks may use wetlands that have trapped sufficient nutrients so as not to be highly correlated with surrounding soil chemistry or mean water chemistry for plot. Beaver and beaver ponds are also known to dramatically influence the chemical limnology of riverine systems (Klotz 1998).

The number of Black Ducks was positively correlated with the number of buildings in the plot. Although previous researchers have found Black Ducks selected wetlands that were visually isolated from human dwellings (Diefenbach *et al.* 1996; Diefenbach and Owen 1989), Black Ducks will use productive wetlands that are close to human dwellings (Hanson *et al.* 1994; Hanson *et al.* 2000). Increased Black Duck densities may be associated with increased number of buildings because better soils in the area originally attracted human habitation (Conrad 1993) and/or anthropogenic nutrients increase the primary productivity of wetlands in the area (Staicer *et al.* 1994).

The most important negative relationship observed was that between Black Duck pair densities and the standard deviation of elevation. It should be noted that there was a positive correlation between stream density and variation in elevation. Flat terrain would allow for the development of more wetlands and lakes. Streams in areas of low relief are slow and meandering, allowing more sediments and nutrients to accumulate in them. High gradient streams in contrast have higher velocities, variable water levels, and rocky substrates. Low gradient streams are preferred by beaver (Beier and Barrett 1987; Bradt 1938; Craig 1990; Howard and Larson 1985) and hence there would be an expected negative correlation between the number of beaver ponds in a given plot and the standard deviation of elevation.

Parameter estimates for standard deviation of elevation were always significant with small coefficients of variation in linear and logistic regression models of Black Duck IBPs. In contrast, parameter estimates for stream density were sometimes not significant and had high coefficients of variation. Increasing stream density would probably be most important with respect to Black Duck habitat in areas of low variation in elevation. This could represent an ecological ceiling which linear regression models do not adequately characterise (Thomson *et al.* 1996). The use of a ratio variable (stream density divided by standard deviation of elevation) did not improve models (unpubl. data).

The number of indicated breeding pairs decreased with increasing number of roads. This may be a function of high road densities only being possible where there is low wetland density. It was also possible that roads may represent a disturbance factor. The parameter estimate for ROAD was, however, very low (-0.0047).

Spatial Scale of Analysis

With respect to the importance of predictor variables, results from linear regression analyses of survey data collected during 1992-94 at the 25 km^2 PQUAD scale gave similar results to analysing the data at the 100 km^2 PLOT scale. Appropriate predictor variables must be selected for the spatial scale of the analysis. For example, mean Golet Score was used rather than the maximum Golet Score for models at the 100 km^2 spatial scale of analysis because the probability that a single wetland could provide all the required habitat for 100 km^2 is much less than it is for a 25 km^2 area.

High R^2 values of PLOT models (n=50) compared to R^2 values of PQUAD models (n=200) could simply result from different sample sizes. Model 136, which had the lowest AICc score for analyses at the PLOT scale, had $R^2 = 0.9789$. Model 62, which had the lowest AICc score at the PQUAD scale, had $R^2 = 0.8707$. There is a higher probability of fitting the model to the data with a sample size of 50 PLOTs compared to a sample size of 200 PQUADs. The other reason for higher R^2 values for PLOT models compared to PQUAD models could relate to the reduced overall variation IBPs per PLOT (coefficient of variation = 63%) compared to IBPs per PQUAD (coefficient of variation = 92%).

Analysing data at the 100 km^2 scale would improve the accuracy of the model if presence of an IBP in a PQUAD resulted not from habitat conditions within that PQUAD but rather from habitat conditions in an adjacent PQUAD. Although analysing data at the PLOT level would overcome this potential problem, there still is the probability that presence of an IBP reflects habitat conditions in adjacent habitat outside of the PLOT. Inaccuracies due to location of observed pairs in relation to the habitat that they are selecting would appear to be minor based on high R^2 values for models developed.

From a theoretical basis, the smaller 25 km^2 quadrat is a better spatial scale for analysis because it is closer to the home range size of Black Ducks (Ringelman *et al.* 1982). It has been suggested that the spatial scale of habitat suitability index models should be the same as the home range of the study animal (Roloff and Kernohan 1999). With the exception of the period 1990-1995, surveys for breeding waterfowl in Atlantic Canada have been done at the 25 km^2 spatial scale during the past 15 years. Models potentially could be improved if all survey and habitat data were in digital format. Habitat surrounding waterfowl observations could then be summarised at various distances (e.g. 1, 3 and 5 km radii) using GIS.

Models of Ring-necked Duck Distribution

Ring-necked ducks were observed on only 110 of the 200 survey quadrats during 1992-94. Linear regression models were not very accurate in estimating the number of Ring-necked Ducks IBPs in PQUADs. The model with the best AICc score only had $R^2 = 0.65$. Results from logistic regression indicated that the presence of Ring-necked Duck IBPs could, however, be predicted based on total area of wetlands, total number of lakes and soil pH, with a correct classification rate of 86%. There was a slight negative relationship with soil pH and a strong positive correlation with total number of lakes, consistent with Ring-necked Ducks using ponds and lakes in areas of low to moderate pH (McAuley and Longcore 1988; Mendall 1958; Rempel *et al.* 1997).

Models of Common Merganser Distribution

Common Mergansers were observed in only 102 of the 200 plots surveyed during 1992-94. Predictive models of the number of indicated breeding pairs were not very accurate. However, a logistic regression model based on total lake area, total stream density, and soil pH had a correct classification rate of 74%. Similar to the logistic regression analysis for Ring-necked Ducks, there was a negative relationship between the probability of a Common Merganser IBP being present in the plot and soil pH. Common Mergansers will use areas of open water such as large lakes and rivers (Kerekes *et al.* 1994; Rempel *et al.* 1997; White 1957). The most important proximate component of habitat selection by Common Mergansers is the availability of fish (Cairns and Kerekes 2000; Erskine 1972; White 1957), which was not measured in this study. It is known, based on morpho-edaphic indices, that fish populations can be being positively correlated with pH and lake size (Ryder *et al.* 1974; Winkle and Hubert 1990). In oligotrophic south-western Nova Scotia, Common Mergansers were found only on lakes greater than 25 ha in size (Kerekes *et al.* 1994). New Brunswick has many large river systems and comparatively few lakes, while the converse is true for Nova Scotia. Separate models for Nova Scotia and New Brunswick, and incorporating a measure of the number of lakes greater than 25 ha may improve the correct classification rates for these models.

Models of Green-winged Teal Distribution

Green-winged Teal IBPs were not observed in 118 of the 200 plots surveyed during 1992-94. The presence of Green-winged Teal could be predicted based on wetland quality as measured by Golet Score, and stream density. Green-winged Teal were prevalent in coastal areas with low variation in elevation, high stream density, and surface waters with higher pH, and total phosphorous concentrations. Non-coastal areas described as having low variation in elevation, high stream density, and surface waters with higher pH, / total phosphorous concentrations, would probably also have a high density of beaver ponds. Green-winged Teal have been shown to be highly selective of beaver ponds for breeding habitat in northern Ontario (Rempel *et al.* 1997). It would also appear that Green-winged Teal are absent from the interior of Nova Scotia where surface waters have low pH. In comparison to what is known about habitat utilisation by breeding Green-winged Teal inland (Paquette and Ankney 1996), and by wintering Green-winged Teal in coastal areas (Genard and Lescourret 1992; Rave and Baldassarre 1989), there is little information about habitat-use by breeding Green-winged Teal in coastal areas.

Habitat Correlates of Black Duck Population Change

The role of habitat degradation and destruction in the decline of Black Ducks has been the subject of a long and often rancorous debate because of difficulty in ascertaining if these correlations reflect cause and effect (Ankney *et al.* 1987; Conroy *et al.* 1989; Petrie 1998; Rusch *et al.* 1989). The relationship between habitat conditions and Black Duck population change will be viewed as correlative in this discussion. Some may contend that improved breeding habitat conditions resulted in increased survival and subsequent recruitment into the breeding population. Others will assert that increased survival resulting from restrictive hunting regulations led to increased breeding populations that made use of increased availability of high quality breeding habitat.

The presence of increasing local populations was positively correlated with stream density and negatively correlated with variation in elevation. This relationship was also observed for the distribution of Black Duck IBPs. As stated previously, streams in areas of low relief would be slow and meandering, allowing more sediments and nutrients to accumulate, compared to high gradient streams which have higher velocities, more variable water levels, and rockier substrates. Low gradient streams are preferred by beaver (Beier and Barrett 1987; Bradt 1938; Craig 1990; Howard and Larson 1985; Retzer *et al.* 1956) and hence there would be an expected negative correlation between the number of beaver ponds in a given plot and the standard deviation of elevation.

During the period 1990-1999, the number of newly-flooded beaver ponds would be expected to have increased in New Brunswick and Nova Scotia with increasing beaver populations. In New Brunswick, the number of nuisance beaver reports increased from 54 in 1982 to a maximum of 378 in 1992 (John Blenis, pers. com., Table 5.12). In Nova Scotia, beaver were almost extirpated in the 1940s; however beaver populations have increased dramatically during the last 20 years (Mike Boudreau, pers. com., Table 5.12). In one small watershed in Nova Scotia, the area of aquatic habitat increased from 22 ha to 260 ha when beavers were re-introduced (Payne and McInnis 1993). In Minnesota, colonization by beaver increased the total flooded habitat in the landscape from 1 to 13%

(Johnston and Naiman 1990). In Maine, total wetland area increased 36% when beaver trapping was prohibited (McCall *et al.* 1996). It is therefore probable that Black Ducks increased in plots where there was an abundance of and/or increasing number of beaver ponds.

An air photo analysis of change in the amount of beaver pond habitat in survey plots would help elucidate the reasons for changes in local Black Duck populations. Habitat change can have a major impact on present distributions of wildlife and models developed from them (Knick and Rotenberry 2000). To understand waterfowl population dynamics and effectively manage waterfowl resources in eastern North America, the availability of wetland habitat should be monitored.

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Parameter (Reference)	Social Unit	Effect
Number of Wetlands		
(Goudie and Trimper 1990)	Pairs	Positive
(Conrad 1993)	Pairs	Positive
Number of Wetland Types		
(Goudie and Trimper 1990)	Pairs	Positive
(Patterson 1976)	Pairs	Positive
Total Stream Length		
(Ringelman and Longcore 1982)	Broods	Positive
Small Lakes (<10 ha)/Open Water		
(DesGranges and Darveau 1985)	Pairs	Positive
(Bordage *et al.* 1990)	Pairs	Positive
(Grenier *et al.* 1994)	Pairs	Positive
(Staicer *et al.* 1994)	Broods	Positive
(Bordage *et al.* 1990)	Broods	Positive
(Ringelman and Longcore 1982)	Pairs	Neutral
(Merendino and Ankney 1994)	Pairs	Neutral
(Merendino *et al.* 1995)	Pairs	Neutral
Surface Water Perimeter / Area		
(Diefenbach and Owen 1989)	Broods	Positive
(Patterson 1976)	Pairs	Positive
Shoreline Irregularity		
(Goudie and Trimper 1990)	Pairs	Positive
(Merendino and Ankney 1994)	Pairs	Positive
Beaver Ponds		
(Rempel *et al.* 1997)		
(Dwyer and Baldassarre 1994)	Broods	Positive
(Diefenbach *et al.* 1996)	Broods	Positive
(Ringelman *et al.* 1982)	Pairs	Positive
(Ringelman and Longcore 1982)	Broods	Positive
(Renouf 1972)	Broods	Positive
(McCall *et al.* 1996)	Pairs	Positive
(Merendino *et al.* 1995)	Pairs	Positive

Table 5.1 – Studies on factors affecting distribution of pairs and broods of Black Ducks and Mallards in forested regions.

Parameter (Reference)	Social Unit	Effect
Emergent Cover		
(Patterson 1972)	Pairs	Neutral
(DesGranges and Darveau 1985)	Pairs	Positive
(Dwyer and Baldassarre 1994)	Broods	Positive
(Patterson 1972)	Broods	Positive
(Carriere and Titman 1999)	Broods	Positive
(Ringelman *et al.* 1982)	Broods	Positive
(Staicer *et al.* 1994)	Broods	Positive
(Losito and Baldassarre 1995)	Female Mallards and Broods	Positive
Forested Wetlands / Flooded Timber		
(Dwyer and Baldassarre 1994)	Broods	Positive
(Diefenbach *et al.* 1996)	Broods	Positive
(Ringelman *et al.* 1982)	Pairs	Positive
(Ringelman and Longcore 1982)	Broods	Positive
(Losito and Baldassarre 1995)	Female Mallards and Broods	Positive
Disturbance		
(Conrad 1993)	Pairs	Positive
(Conrad 1993)	Broods	Negative
(Diefenbach and Owen 1989)	Broods	Negative
Salt Marsh		
(Reed 1970)	Broods	Positive
(Stotts and Davis 1960)	Broods	Positive
(Seymour and Titman 1978)	Broods	Positive
(Belanger and Lehoux 1994)	Broods	Positive
(Seymour 1991)	Pairs	Positive
(Seymour and Jackson 1996)	Broods	Negative
Presence of Fish		
(Hunter *et al.* 1985)	Broods	Negative
(Hunter *et al.* 1986)	Broods	Negative
(Parker *et al.* 1992)	Broods	Negative
(McNicol *et al.* 1987)	Broods	Neutral
(DesGranges and Hunter 1987)	Broods	Negative

Table 5.1 (continued) – Studies on factors affecting distribution of pairs and broods of Black Ducks and Mallards in forested regions.

Parameter (Reference)	Social Unit	Effect
Invertebrates		
(Courcelles and Bedard 1979)	Broods	Positive
(Patterson 1976)	Broods	Positive
(Reinecke 1977)	Broods	Positive
(Reinecke 1979)	Broods	Positive
(Diefenbach and Owen 1989)	Broods	Positive
(Erskine 1987)	Broods	Positive
(Melanson and Payne 1988)	Broods	Positive
(Parker *et al.* 1992)	Broods	Positive
(Hunter *et al.* 1984)	Broods	Positive
(Hunter *et al.* 1985)	Broods	Positive
(Joyner 1980)	Mallard Broods	Positive
(Staicer *et al.* 1994)	Broods	Positive
(Porter 1993)	Broods	Positive
(Sjoberg *et al.* 2000)	Broods	Positive
Total Phosphorous		
(Merendino and Ankney 1994)	Pairs	Positive
(Melanson and Payne 1988)	Broods	Positive
(Staicer *et al.* 1994)	Broods	Positive
(Longcore *et al.* 1998)	Broods	Positive
(Murphy *et al.* 1984)	Pairs, Broods	Positive
(Seymour and Jackson 1996)	Broods	Positive
(Sjoberg *et al.* 2000)	Broods	Positive
(McNicol *et al.* 1987)	Pairs	Positive
High Acidity		
(DesGranges and Darveau 1985)	Pairs/Broods	Negative
(Longcore *et al.* 1987)	Broods	Negative
(McNicol *et al.* 1987)	Pairs	Neutral
(Rattner *et al.* 1987)	Broods	Negative
(Haramis and Chu 1987)	Broods	Negative
(Hunter *et al.* 1985)	Broods	Negative
(Staicer *et al.* 1994)	Broods	Neutral
(Longcore *et al.* 1998)	Broods	Neutral
(Parker *et al.* 1992)	Broods	Neutral
(Merendino *et al.* 1995)	Pairs	Negative

Table 5.1 (continued) – Studies on factors affecting distribution of pairs and broods of Black Ducks and Mallards in forested regions.

Variable	Description	Details on Page No.	W
LTOTLAK	Log10 (total number of lakes)	23	0.87
LSSIZEL	Log10 (total area of lakes)	23	0.75
XSTM	Mean stream density	22	0.95
LELVSTD	Log10 (standard deviation of elevation)	20	0.94
BUILD	Total number of buildings	19	0.87
ROAD	Total length of roads (km)	19	0.91
LSSIZE	Log10 (total area of wetlands in ha)	24	0.95
TOTAL	Total number of wetlands	24	0.92
PB	Percentage of wetlands that are bogs	24	0.88
MDSIZE	Median size of wetlands	24	0.87
MXSCOR	Maximum Golet Score for a single wetland	25	0.98
MDSCOR	Median Golet Score for wetlands	25	0.97
MSCOR	Mean Golet Score for wetlands	25	0.63
LSALTHA	Log10 (total area of salt marshes)	25	0.31
LSFBOG	Log10 (% of wetlands on boggy soil units)	25	0.72
TMINGS	Mean min. temp. during growing season	26	0.94
PPGS	Total precipitation during growing season	26	0.96
SOILPH	Soil pH	22	0.88
N1	Log 10 (lsm nitrogen concentration)	94	0.96
P1	Log10 (lsm phosphorous concentration)	94	0.95
PCA1	Mean PC1 score for chemical limnology	94	0.92
PCA2	Mean PC2 score for chemical limnology	94	0.95

Table 5.2 - Habitat variables selected for inclusion in global model for Black Duck IBPs.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
1	MXSCOR	0.7801	91.29	0.007917	0.00029799	26.568	0.0001
6	MXSCOR	0.8134	60.52	0.006267	0.00039095	16.029	0.0001
	LTOTLAK			0.277728	0.0467291	5.943	0.0001
13	MXSCOR	0.8402	31.61	0.005766	0.00037303	15.457	0.0001
	LTOTLAK			0.300727	0.04353887	6.907	0.0001
	LSALTHA			0.228829	0.03982023	5.747	0.0001
21	LTOTLAK	0.8545	14.94	0.344308	0.04281377	8.042	0.0001
	MXSCOR			0.011018	0.00124777	8.830	0.0001
	P1			0.177951	0.04051392	4.392	0.0001
	LSALTHA			0.256597	0.03861206	6.646	0.0001
28	MXSCOR	0.8614	7.38	0.008674	0.00088415	9.810	0.0001
	LTOTLAK			0.326551	0.04102956	7.959	0.0001
	LSALTHA			0.199263	0.04016270	4.961	0.0001
	LELVSTD			-0.214116	0.04489946	-4.769	0.0001
	LBUILD			0.069703	0.01970999	3.536	0.0005
35	MXSCOR	0.8657	3.16	0.010883	0.00124079	8.771	0.0001
	LTOTLAK			0.348550	0.04142784	8.413	0.0001
	LSALTHA			0.212507	0.03998179	5.315	0.0001
	LELVSTD			-0.146702	0.05184056	-2.830	0.0051
	LBUILD			0.065989	0.01950528	3.383	0.0009
	P1			0.114717	0.04580503	2.504	0.0131
45	MXSCOR	0.8682	1.61	0.010156	0.00129024	7.872	0.0001
	LTOTLAK			0.374172	0.04329511	8.642	0.0001
	LSALTHA			0.212276	0.03971422	5.345	0.0001
	LBUILD			0.065682	0.01937533	3.390	0.0008
	LELVSTD			-0.197276	0.05794142	-3.405	0.0008
	LXSTM			0.341829	0.17954453	1.904	0.0584
	P1			0.107866	0.04564035	2.363	0.0191
62	LTOTLAK	0.8707	0	0.356445	0.04397709	8.105	0.0001
	MXSCOR			0.010131	0.00128143	7.906	0.0001
	LSALTHA			0.213328	0.03944451	5.408	0.0001
	LXSTM			0.357016	0.1784834	2.000	0.0469
	LELVSTD			-0.194355	0.0575625	-3.376	0.0009
	LBUILD			0.098425	0.02571173	3.828	0.0002
	ROAD			-0.004764	0.00248142	-1.920	0.0564
	P1			0.098357	0.04559581	2.157	0.0322

Table 5.3 - Best linear-regression models of Black Duck indicated breeding pairs (IBPs) in 25 km^2 survey plots (PQUADs).1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
101	MSCOR	0.9421	35.26	0.019466	0.00068912	28.248	0.0001
106	MSCOR	0.9576	21.93	0.016809	0.00086988	19.324	0.0001
	LSSIZEL			0.352639	0.08414240	4.191	0.0001
113	MSCOR	0.9649	14.83	0.015626	0.00088462	17.664	0.0001
	LSSIZEL			0.379714	0.07783529	4.878	0.0001
	LSALTHA			0.127188	0.04063761	3.130	0.0030
121	MSCOR	0.9715	6.92	0.0229	0.0036235	6.319	0.0001
	LSSIZEL			0.37619	0.0716087	5.253	0.0001
	LBUILD			0.10894	0.0311872	3.493	0.0011
	PI			0.25356	0.0882421	2.873	0.0061
126	MSCOR	0.9746	3.83	0.02307	0.0034618	6.664	0.0001
	LSALTHA			0.08884	0.0381635	2.328	0.0245
	LSSIZEL			0.39833	0.0690567	5.768	0.0001
	LBUILD			0.08085	0.0321407	2.515	0.0155
	PI			0.25644	0.0842957	3.042	0.0039
131	MSCOR	0.9762	3.24	0.01675	0.0033715	4.967	0.0001
	LSALTHA			0.10744	0.037833	2.84	0.0068
	LSSIZEL			0.44866	0.0801408	5.598	0.0001
	LXSTM			1.12918	0.4321967	2.613	0.0122
	LELVSTD			-0.36734	0.1152718	-3.187	0.0026
	LBUILD			0.08121	0.0314701	2.58	0.0133
136	MSCOR	0.9789	0	0.01388	0.0034065	4.075	0.0002
	LSALTHA			0.14964	0.0356316	4.2	0.0001
	LSSIZEL			0.5332	0.0774025	6.889	0.0001
	LXSTM			1.34857	0.4124059	3.27	0.0021
	LELVSTD			-0.46812	0.1131332	-4.138	0.0002
	ROAD			0.00288	0.0010408	2.768	0.0083
	NI			-0.29897	0.102775	-2.909	0.0057
144	MSCOR	0.9813	0.23	0.01296	0.0035947	3.606	0.0008
	LSALTHA			0.11291	0.0403547	2.798	0.0077
	LSSIZEL			0.45656	0.0775388	5.888	0.0001
	LXSTM			1.29811	0.4176686	3.108	0.0034
	LELVSTD			-0.36503	0.1204735	-3.03	0.0042
	LBUILD			0.06737	0.0309018	2.18	0.0349
	PCA2			0.06099	0.0444071	1.373	0.1769
	NI			-0.25589	0.1049834	-2.437	0.0191

Table 5.4 - Best linear regression models of Black Duck indicated breeding pairs (IBPs) in 100 km^2 survey plots (PLOTs), 1992-94.

Model	Variable	Model R2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
201	MXSCOR	0.876501	0.1	0.009	0.00047306	19.025	0.0001
209	MXSCOR	0.881987	0	0.010101	0.00085983	11.747	0.0001
	TOTAL			-0.004345	0.00284973	-1.525	0.1337
210	MXSCOR	0.878457	1.5	0.01018	0.00139799	7.282	0.0001
	LXSTM			-0.403215	0.44948138	-0.897	0.374
206	MXSCOR	0.876621	2.3	0.009248	0.00122323	7.56	0.0001
	LTOTLAK			-0.027704	0.12586833	-0.22	0.8267
207	MXSCOR	0.877134	2.1	0.00773	0.00254598	3.036	0.0038
	LSSIZE			0.041185	0.08112967	0.508	0.6139
213	MXSCOR	0.883366	1.7	0.009458	0.00120785	7.83	0.0001
	LTOTLAK			0.113765	0.14948046	0.761	0.4503
	TOTAL			-0.005825	0.00346042	-1.683	0.0987
212	LTOTLAK	0.882176	2.2	0.067715	0.12484216	0.542	0.59
	LSSIZE			0.252556	0.03853582	6.554	0.0001
	LSALTHA			0.109763	0.05274003	2.081	0.0427
211	MXSCOR	0.880643	2.9	0.008976	0.00123368	7.275	0.0001
	LTOTLAK			-0.024609	0.12507962	-0.197	0.8448
	LSALTHA			0.065243	0.05077115	1.285	0.2048
217	MXSCOR	0.8879	2.1	0.002678	0.00421546	0.635	0.5282
	LTOTLAK			0.003666	0.12461346	0.029	0.9767
	LSALTHA			0.05388	0.05057129	1.065	0.292
	SOILPH			0.614556	0.39390645	1.56	0.1253
218	MXSCOR	0.88596	3	0.009215	0.00122887	7.499	0.0001
	LTOTLAK			0.102052	0.14976093	0.681	0.4989
	LSALTHA			0.053075	0.05079718	1.045	0.3013
	TOTAL			-0.005239	0.00350238	-1.496	0.1412

Table 5.5 - Best linear regression models of Black Duck indicated breeding pairs (IBPs) in 25 km^2 survey plots, 1986-89.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
305	LTOTLAK	0.5841	26.33	0.518538	0.03101949	16.717	0.0001
309	LTOTLAK	0.6307	4.61	0.358328	0.04342342	8.252	0.0001
	LSSIZE			0.064663	0.01293412	4.999	0.0001
313	LSSIZE	0.6388	2.24	0.087137	0.01668303	5.223	0.0001
	LTOTLAK			0.358328	0.04342342	8.252	0.0001
	PB			-0.001084	0.00051470	-2.106	0.0365
321	LSSIZE	0.6448	1.03	0.376058	0.04410132	8.527	0.0001
	LTOTLAK			0.124896	0.02665663	4.685	0.0001
	PB			-0.001082	0.00051176	-2.114	0.0358
	SOILPH			-0.014235	0.00786658	-1.810	0.0719
328	LSSIZE	0.6503	0	0.134549	0.02707493	4.97	0.0001
	LTOTLAK			0.379294	0.04390497	8.639	0.0001
	PB			-0.00105	0.00050936	-2.061	0.0407
	SOILPH			-0.025016	0.00993355	-2.518	0.0126
	ROAD			0.003386	0.00192172	1.762	0.0797

Table 5.6 - Best linear regression models of Ring-necked Duck IBPs in 25 km^2 survey plots (PQUADs), 1992-94.

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardised Estimate	Odds Ratio
Model 336 $\Delta_i = 0$ Concordance = 86.0%						
LSSIZE	0.7498	0.2734	7.5222	0.0061	0.264441	0.472
LTOTLAK	3.5741	0.6100	34.3307	0.0001	0.781757	35.662
SOILPH	-0.4421	0.0939	22.1568	0.0001	-0.168271	0.643
Model 337 $\Delta_i = 5.9$ Concordance = 85.8%						
LTOTLAK	3.9025	0.7106	30.1633	0.0001	0.853596	49.528
MXSCOR	0.0126	0.0258	0.2402	0.624	0.056959	1.013
LSSIZE	0.7227	0.467	2.3951	0.1217	0.254896	2.06
SOILPH	-0.4695	0.2467	3.6232	0.057	-0.17871	0.625
PI	-0.0898	0.5493	0.0267	0.8702	-0.015215	0.914
PB	-0.00732	0.00628	1.3588	0.2437	-0.140607	0.993
LELVSTD	-0.4929	0.6257	0.6204	0.4309	-0.083627	0.611
Model 335 $\Delta_i = 27.8$ Concordance = 79.4%						
LSSIZE	-0.3193	0.1700	3.5278	0.0603	-0.1126	0.727
LTOTLAK	3.5354	0.5945	35.3648	0.0001	0.7732	34.308
PB	-0.00443	0.00546	0.6564	0.4178	-0.08496	0.996

Table 5.7 - Best logistic regression models for Ring-necked Ducks in PQUADs, 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
401	MDSCOR	0.3896	37.84	0.002791	0.00024769	11.269	0.0001
406	LSSIZEL	0.4689	12.05	0.322593	0.05013949	6.434	0.0001
	LXSTM			0.378612	0.04999964	7.572	0.0001
413	LSSIZEL	0.4873	7.1	0.339133	0.04978161	6.812	0.0001
	LXSTM			0.361308	0.04968179	7.272	0.0001
	PCA2			-0.044758	0.01685469	-2.656	0.0086
421	LSALTHA	0.5021	3.34	0.071617	0.02965307	2.415	0.0166
	LSSIZEL			0.348813	0.04934502	7.069	0.0001
	LXSTM			0.325632	0.05125796	6.353	0.0001
	PCA2			-0.056513	0.01734844	-3.258	0.0013
430	LSALTHA	0.5055	4.1	0.073548	0.02967446	2.479	0.014
	LSSIZEL			0.374395	0.05403274	6.929	0.0001
	LXSTM			0.414836	0.09255558	4.482	0.0001
	PCA2			-0.061566	0.01787513	-3.444	0.0007
	N1			0.043929	0.03796615	1.157	0.2487
437	MDSCOR	0.5207	0	0.004648	0.00184529	2.519	0.0126
	LSALTHA			0.087265	0.02995064	2.914	0.004
	LSSIZEL			0.286327	0.06257892	4.575	0.0001
	LXSTM			0.372949	0.13412538	2.781	0.006
	SOILPH			-0.048851	0.01780739	-2.743	0.0067
	PCA2			-0.05439	0.01721438	-3.16	0.0018

Table 5.8 - Best linear regression models of Common Merganser IBPs in 25 km^2 survey plots (PQUADs). 1992-94.

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardised Estimate	Odds Ratio
Model 451 $\Delta_i = 0$ Concordance = 73.7%						
LSSIZEL	3.4351	0.7803	19.3785	0.0001	0.430597	31.034
LXSTM	5.9721	1.874	10.1562	0.0014	0.334862	392.346
SOILPH	-0.3934	0.1043	14.2172	0.0002	-0.14975	0.675
Model 450 $\Delta_i = 3.2$ Concordance = 75.4%						
MXSCOR	0.035	0.0223	2.4544	0.1172	0.15795	1.036
LSSIZE	-0.5784	0.4199	1.8972	0.1684	-0.204004	0.561
TOTAL	0.0234	0.0189	1.5317	0.2159	0.146978	1.024
LSSIZEL	2.2093	1.0933	4.0833	0.0433	0.276945	9.11
LTOTLAK	0.8923	0.6087	2.1489	0.1427	0.195168	2.441
LXSTM	4.9172	2.0698	5.644	0.0175	0.275708	136.613
LELVSTD	0.0309	0.5887	0.0028	0.9581	0.005244	1.031
SOILPH	-0.6493	0.2234	8.4478	0.0037	-0.247129	0.522
PB	-0.00556	0.00561	0.9817	0.3218	-0.106646	0.994

Table 5.9 - Best logistic regression models of presence of Common Merganser indicated breeding pairs (IBPs) in 25 km2 survey plots (PQUADs). 1992-94.

Standardised Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
Model 471 $\Delta_i = 0$ Concordance = 79.0%						
MXSCOR	0.0484	0.0164	8.7411	0.0031	0.218559	1.05
LXSTM	5.0301	2.0935	5.773	0.0163	0.28204	152.946
LELVSTD	-2.1326	0.7023	9.2206	0.0024	-0.361835	0.119
PCA1	0.7465	0.2757	7.3344	0.0068	0.317429	2.11
P1	1.1853	0.5328	4.9485	0.0261	0.200897	3.272
LSALTHA	1.8034	0.7794	5.3535	0.0207	0.428308	6.07
LBUILD	0.4012	0.2152	3.4751	0.0623	0.194307	1.494
Model 472 $\Delta_i = 7.0$ Concordance = 76.5%						
MXSCOR	0.0267	0.0105	6.4569	0.0111	0.12055	1.027
LXSTM	5.1238	1.9118	7.1827	0.0074	0.287293	167.967
LELVSTD	-2.6681	0.6032	19.5655	0.0001	-0.452699	0.069
PCA1	0.69	0.232	8.8494	0.0029	0.293392	1.994
LSALTHA	2.0611	0.7781	7.0165	0.0081	0.489508	7.854
Model 473 $\Delta_i = 12.0$ Concordance = 74.5%						
LSALTHA	1.8487	0.7539	6.014	0.0142	0.439079	6.352
LXSTM	6.5219	1.8728	12.128	0.0005	0.365689	679.899
LELVSTD	-1.5962	0.3936	16.4503	0.0001	-0.270825	0.203
PCA1	0.4794	0.2109	5.1645	0.0231	0.203826	1.615
Model 474 $\Delta_i = 15.3$ Concordance = 72.2%						
LXSTM	6.9575	1.8726	13.8041	0.0002	0.390111	999
LELVSTD	-1.6513	0.3949	17.4871	0.0001	-0.280181	0.192
LSALTHA	2.0422	0.7598	7.2251	0.0072	0.485028	7.708

Table 5.10 - Best logistic regression models of presence of American Green-winged Teal in 25 km^2 survey plots (PQUADs), 1992-94.

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardised Estimate	Odds Ratio
Model 509 $\Delta_i = 0$ Concordance = 83.1%						
TOTAL	0.086	0.0354	5.9189	0.015	0.479405	1.09
LXSTM	9.1133	4.9173	3.4347	0.0638	0.420677	999
LELVSTD	-3.2877	1.1784	7.7835	0.0053	-0.485147	0.037
ROAD	0.2267	0.0759	8.9335	0.0028	1.020798	1.255
Model 504 $\Delta_i = 2.9$ Concordance = 85.8%						
TOTAL	0.0794	0.0411	3.7249	0.0536	0.442292	1.083
LTOTLAK	1.1046	1.1602	0.9065	0.341	0.215325	3.018
LXSTM	8.8845	5.4754	2.6329	0.1047	0.410118	999
LELVSTD	-4.5194	1.486	9.249	0.0024	-0.66691	0.011
ROAD	0.1388	0.0902	2.3672	0.1239	0.624728	1.149
LBUILD	1.0191	0.6448	2.4981	0.114	0.455225	2.771
SOILPH	0.182	0.2561	0.5052	0.4772	0.080864	1.2
Model 506 $\Delta_i = 4.5$ Concordance = 80.9%						
TOTAL	0.0628	0.0393	2.5482	0.1104	0.349971	1.065
ROAD	0.2198	0.0704	9.743	0.0018	0.989584	1.246
LELVSTD	-2.6909	1.1322	5.6489	0.0175	-0.397081	0.068
LTOTLAK	0.726	1.0587	0.4702	0.4929	0.141521	2.067
MXSCOR	0.0197	0.0192	1.0527	0.3049	0.096693	1.02
Model 503 $\Delta_i = 5.0$ Concordance = 86.1%						
TOTAL	0.0808	0.0418	3.7448	0.053	0.450536	1.084
LSALTHA	-0.6791	0.9079	0.5595	0.4545	-0.190186	0.507
LTOTLAK	1.0786	1.1733	0.845	0.358	0.210257	2.941
LXSTM	8.725	5.4911	2.5247	0.1121	0.402753	999
LELVSTD	-4.5837	1.4913	9.4478	0.0021	-0.676406	0.01
ROAD	0.1505	0.0922	2.6664	0.1025	0.677761	1.162
LBUILD	1.1307	0.674	2.8142	0.0934	0.505096	3.098
SOILPH	0.1875	0.258	0.5284	0.4673	0.083309	1.206
Model 501 $\Delta_i = 13.6$ Concordance = 90.4%						
LSSIZE	1.1928	1.1226	1.1289	0.288	0.376888	3.296
TOTAL	0.157	0.0712	4.8589	0.0275	0.874804	1.17
MDSCOR	0.1063	0.0835	1.62	0.2031	0.268179	1.112
MXSCOR	-0.1144	0.0711	2.5932	0.1073	-0.56128	0.892
LSALTHA	-2.0753	1.2983	2.555	0.1099	-0.581154	0.126
LSSIZEL	0.956	3.0131	0.1007	0.751	0.128175	2.601
LMSIZEL	-16.7743	7.8915	4.5182	0.0335	-0.886305	0
LTOTLAK	2.7319	2.0322	1.8072	0.1788	0.532544	15.362
LXSTM	8.0151	6.8259	1.3788	0.2403	0.369985	999
LELVSTD	-7.1118	2.4688	8.2979	0.004	-1.049455	0.001
ROAD	0.1481	0.1009	2.1544	0.1422	0.666698	1.16
LBUILD	3.222	1.3277	5.8892	0.0152	1.439331	25.079
SOILPH	0.4655	0.6045	0.5931	0.4412	0.206784	1.593
PB	-0.0228	0.0186	1.4971	0.2211	-0.424084	0.977

Table 5.11 - Best logistic regression models of presence of increasing Black Duck indicated breeding pairs (IBPs) in 25 km^2 survey plots (PQUADs), 1990-99.

Year	NB Complaints	NB - Live Trapped	NB - Dead Trapped	NS - Harvest
1982	54	26	0	
1983	86	48	0	
1984	108	86	0	
1985	118	72	0	3.864
1986	119	71	0	4.320
1987	153	103	0	6.079
1988	132	107	0	3.510
1989	126	132	0	2.400
1990	255	235	0	2.356
1991	281	444	0	2,769
1992	378	425	0	3.340
1993	360	293	20	4.801
1994	274	301	162	7,677
1995				6,090
1996				8.642
1997				6.385
1998				5.807
1999				4,126

Table 5.12 - Nuisance beaver reports in south-eastern New Brunswick 1982-1994 and Nova Scotia beaver harvest 1985-1999. Data courtesy of John Blenis, NB Dept. Natural Resources & Energy and Mike Boudreau, NS Department of Natural Resources.

CHAPTER 6 – CONCLUDING DISCUSSION: A MODELLING RETROSPECTIVE

INTRODUCTION

The purpose of this chapter is to discuss the results of a landscape-level evaluation of the distribution of breeding American Black Ducks (*Anas rubripes*) in the Canadian Maritime Provinces (New Brunswick, Nova Scotia). The thesis of this research was that landscape-level habitat descriptors could explain the observed distribution of breeding American Black Ducks, and other waterfowl. These relationships could then be used to produce spatially explicit waterfowl population estimates. This chapter discusses relationships observed between wetland biophysical form, chemical limnology, and ecological function. It also provides some concluding remarks regarding the objectives outlined in Chapter 1 and the limitations of the data and models derived.

DISCUSSION

Analysis of Aquatic Habitats

The development of computer based geographic information systems and the scientific discipline of landscape ecology has resulted in a larger spatial view of ecological processes (Conroy *et al.* 1995; Forman 1995). In most studies to date, wildlife-habitat inter-relationships were evaluated on a local scale, *e.g.*, a single wetland (Paquette and Ankney 1996). It is now apparent that much information can be gained about ecological processes by understanding the spatial scale at which these processes operate as well as the extent of spatial autocorrelation (Horne and Schneider 1995; Koenig and Knops 1998; Legendre 1993).

Studying ecological processes at multiple spatial scales is most often neglected because of a failure to understand its importance, or the required statistical resources and/or geo-spatial data are lacking. A landscape approach to ecological phenomena requires an integration of many diverse descriptors of the environment. The development of macro-scale wildlife and habitat conservation models has been, and will continue to be, limited by the availability and cost of obtaining the data required (Flather *et al.* 1992; Turner *et al.* 1995).

This study had to rely on existing data which potentially could describe the aquatic habitats of Nova Scotia and New Brunswick. The Maritime Wetland Inventory could be considered site-specific information as attributes are given for each specific wetland (Hanson and Calkins 1996). Some of these attributes do, however, describe habitat at a landscape-level. Juxtaposition describes the physical relation of the wetland to other aquatic habitats in the area. Land-cover variables also describe the surrounding landscape. There was, however, very little difference among wetlands in the surrounding land-cover, with most wetlands classified as surrounded by forested land. Provincial wetland inventories that are currently being developed for all three Maritime provinces (New Brunswick, Nova Scotia, and Prince Edward Island) are completely digital. Other cover types (*e.g.*, forest, agriculture) are available as separate layers. This will allow for various landscape features to be attributed to wetlands at various spatial scales, *e.g.*, land use immediately adjacent to the wetland, land use within a 2 km radius, land use within the watershed.

The Maritime Wetland Inventory treats wetlands as comprised of many hydrologically connected sub-classes. This approach becomes problematic for large wetlands that are comprised of many sub-classes. The character of a specific component of the wetland (geographic area) may be quite different from the overall wetland complex. New inventories should identify wetlands at the smallest homogeneous spatial unit. These wetlands could then be compiled spatially to represent a wetland complex. The numbering system for wetlands can also facilitate the identification of sub-units within wetland complexes. Analysis of wetlands at different spatial scales would also be facilitated using this approach.

Future wetland inventories should recognise that lakes, rivers, and streams, are also aquatic habitats, and that many wetland characteristics are influenced by hydrology. It is therefore critical that in future wetland inventories, hydrology layers are incorporated into digital wetland base-maps.

The hydrology of wetlands is very much affected by elevation and variation in elevation. The GTOPO digital elevation model (DEM) created by the United States Geological Service (http://edcdaac.usgs.gov/gtopo30/gtopo30.html) provided data at a relatively small scale, with approximately 160 points per 100 km^2. A visual comparison with topographic maps indicated an accurate description of elevation.

There is usually a trade-off between spatial extent and size of the sampling unit (grain) in most studies (Isaaks and Srivastava 1989). The Canadian Soil Information Survey (CANSIS) provides data that is national in spatial extent. However the grain size is rather large, with soil polygons being hundreds of square kilometres in size. Within these polygons there are 1-12 components that are not geo-spatially referenced. Problems relating to large grain size of CANSIS data could be resolved, to some extent, by making components spatially unique entities (*i.e.* grain size = component size).

Provincial soil maps provided information on soil chemistry that was of greater utility than CANSIS data. Soil mapping should provide quantitative measures of soil characteristics, because qualitative descriptors are not easily compared among provinces. Based on the grain of soil mapping both at national levels, and provincial levels, soil chemistry will only provide a relative indication of the chemical limnology of aquatic habitats within a given area. Many aspects of CANSIS data had questionable functional relationships with aquatic ecology, *e.g.* rooting depth, coarse fragment content.

The National Ecological Framework did not provide data at the grain size necessary to be useful in this project. New Brunswick and Nova Scotia ecological land classifications provided useful descriptions of relatively small spatial units but did not have any variables in common that could be used in creating a quantitative model for both provinces. Toner (1998) quantitatively examined the spatial distribution of wetlands in New Brunswick in relation to data from ecological land classification units and observed that wetland types were correlated with certain topographical features such as elevation and amount of surface water (lakes, rivers).

Environment Canada climate stations were usually located in close proximity to survey plots and provided the basic meteorological data that affects many ecological processes (*e.g.*,. temperature, amount of precipitation, snow cover). Data from these volunteer-based stations are essential if modelling of wetlands and other ecological processes is going to be done at local and landscape-levels.

Wetlands are products of many geographical and geological phenomena. The existence of a wetland inventory that describes many aspects of wetland biophysical form encapsulates many of these larger physical and chemical processes. Differences in water chemistry of two wetlands could be estimated if one wetland was a bog while the other one was an emergent wetland. In contrast, aquatic habitats such as lakes and rivers need a landscape context. In order to estimate differences in water chemistry between two lakes one would need to know the soils, geology, and vegetation of the watersheds that the two lakes were in. In the future, with GIS software and digital data becoming more widely available, landscape-level environmental data can easily become background layers in wetland inventories. A multi-attribute wetland inventory is the key to modelling wetland processes.

Evaluation of the Chemical Limnology of Aquatic Habitats

The primary and secondary productivity of aquatic ecosystems are known to be affected by the availability of nutrients (Mitsch and Gosselink 1986; Wetzel 1983). The logistical concern is how to do this at landscape and regional levels (Gorham *et al.* 1998; Jassby 1998; Pienitz *et al.* 1997).

The chemical limnology of water sample collected during this study quantified the spatial variation previously described in part by others (Clair *et al.* 1982; Gorham *et al.* 1998; Spavold-Tims 1986). This study has highlighted variation in chemical limnology among aquatic habitat types, which has recently been reviewed and quantified for other areas of North America (Bedford *et al.* 1999; Bridgham *et al.* 1998; Jonasson and Shaver 1999). This variation does not necessitate sampling effort be equally distributed among aquatic habitat types. It does, however, mean that this variation needs to be acknowledged, at both a sampling level and at an analysis level. At a sampling level, distinctions need to be made between wetland types (*e.g.*, bog versus emergent marsh). At an analysis level, it should be acknowledged that data from lakes may not be applicable to adjacent wetlands, especially if it is unknown whether it is a bog or an emergent marsh (Jones and Wedeles 1989).

The ability to do landscape-level analyses of wetland functions in the Maritimes is limited by the narrow range of chemical limnology parameters that have been summarised at large spatial scales. Most regional summaries published to date have only dealt with pH, presumably because of regional concern over the impacts of acid rain (Underwood and Schwartz 1989). Data collected during this study will be used in a regional summary of water chemistry of surface waters of the Maritimes.

Evaluation of Waterfowl Population Survey Data

Since breeding waterfowl surveys using helicopters were initiated in the Maritimes in 1986, the survey design has changed four times. Data collected during 1992-94 using consistent survey methods, provided the largest sample size. Data collected during 1987-89 on other survey plots provided data to verify models based on 1992-94 data. Data collected during 1995-99 on a reduced number of plots per year allowed for trend analyses for the entire period between 1990-99. It is hoped survey methods will remain consistent in future years in order to provide data on long term trends in Black Duck populations.

For the time period 1992-94, when survey methodology remained the same, there was annual variation in the number of Black Duck IBPs observed. For some plots the standard deviation was greater than the mean. To eliminate annual variation, the mean number Black Duck IBPs during 1992-94 was used as the single measure of Black Duck density during model development. This annual variation, which will be considered as a phenomenon separate from population trends, may have arisen from visibility bias, *i.e.*, all ducks are not seen on any given survey (Baldassarre and Bolen 1994) or inaccuracies in determining IBPs because of the timing of surveys in relation to nesting phenology and the fact that Black Ducks have sexually monochromatic plumage (Parker 1989). Regardless of the cause, the magnitude of annual variation in Black Duck IBPs observed during surveys would result in very large confidence intervals for habitat specific population estimates. This variation limits the utility of these population estimates from a scientific or conservation perspective.

The statistical effects of spatial autocorrelation were not considered when the survey plots were established in 1986, otherwise survey plots would have been spaced a minimum distance. When changes in study design were implemented in 1990, survey plots (100km^2) were still not separated by a minimum distance. Even worse, the new survey design incorporated four 25 km^2 survey plots nested within a larger 100 km^2 survey plot. Not only did this introduce the statistical effects of spatial auto-correlation into the data, it also introduced the potential for disturbance from the helicopter to influence the number of waterfowl observed in an adjacent plot. Although in reality the amount of spatial autocorrelation at the 25 km^2 survey plot level was minimal, the distance between plots should be considered when the survey is designed. Using geostatistical techniques such as Kriging to interpolate population data is facilitated by a uniform distribution of survey locations (McKenney *et al.* 1998).

Survey plots should also be chosen to represent the entire area and habitat types used by Black Ducks in the region of study. Complete geographical coverage is a good initial step in trying to survey all habitat types. However, to ensure that survey plots represent all habitat types an analysis of habitats within survey plots must be done as part of the survey plot selection process. Some of the more productive habitats for Black Ducks in the Maritimes, *e.g.*, salt marshes and floodplains are under-represented in the current survey plots. By surveying all habitat types, habitat specific distribution models could potentially provide a more accurate estimate of provincial Black Duck populations.

The size of the survey unit also needs to be evaluated as part of the survey design process. From the perspective of having a sampling unit approximately the same size as the Black Duck's home range, the 25 km^2 survey plot was preferable to the 100 km^2 survey plot (Beutel *et al.* 1999; Roloff and Kernohan 1999). A recent classification of wetlands as waterfowl habitat was conducted at a 2.5 km *2.5 km spatial scale (Rempel *et al.* 1997). The use of GPS and onboard computers to assign geographical co-ordinates to each observation during surveys, will facilitate analysis of data at multiple spatial scales (Butler *et al.* 1995).

Models of Breeding Black Duck Distributions

The best overall model for Black Duck IBPs, based on AICc scores (Model 62), explained 87% of the variation in the data. The difference between observed number of Black Duck IBPs in 25 km^2 survey plots and numbers predicted by Model 62 was highest for plots where large numbers of Black Duck IBPs were observed (Figure 6.1). The model was less accurate at predicting high numbers of IBPs compared to moderate or low numbers. Plots with high numbers of Black Duck IBPs could be considered outliers using statistical screening tools (Tabachnick and Fidell 1989). All plots were used in the model building exercise however, because the range of values observed in plots represents full reality. Plots with high numbers of Black Duck IBPs, such as 26 and 27, may represent the undue influence of migrating birds using coastal wetlands and large shallow lakes. There is also the possibility that local factors, such as wildlife habitat improvement or anthropogenic nutrients, could unduly influence the relationship between the amount of aquatic habitat, chemical limnology, and number of IBPs.

The spatial distribution of residuals for Model 62 was similar to the spatial distribution of Black Duck IBPs, with high residuals for survey plots where high numbers of Black Duck IBPs were observed (Figures 6.2 & 4.3). Positive values for residuals indicate that the observed number of IBPs was greater than the predicted number, whereas negative values for residuals indicate that the observed number of IBPs was less than the predicted number. The relationship between the observed number of Black Duck IBPs and residuals was pronounced with an $R^2 = 0.749$. It should be noted that a scatter-plot indicated that there was no relationship between residuals and predicted values of Black Duck IBPs ($R^2 = 0.07$), and that the assumptions of normality, linearity, and homoscedasticity for linear regression were met (Tabachnick and Fidell 1989).

There was spatial autocorrelation of residuals for the 25 km^2 survey plots within the larger 100 km^2 survey plot, *i.e.*, Lag Class 1 (Table 6.1) as was observed for Black Duck IBPs in Chapter 4. The degree of spatial autocorrelation for residuals was somewhat less than that observed for Black Duck IBPs (Table 6.1).

The data collected during 1986-89 (Parker 1989), allowed for an independent assessment of models developed using 1992-94 data. Although the number of IBPs in survey plots changed somewhat between the time periods of 1986-89 compared to 1992-94 (see Chapter 4), the similarity in relative AICc scores and parameter estimates, indicate that the maximum Golet Score (Model 201) is a good predictor of the density of breeding Black Ducks. Other parameters that were important for 92-94 survey plots were not important for 1986-89 survey plots. As was indicated by the high R^2 values for Model 201, there was little difference between observed versus predicted values (Figure 6.3). The number of IBPs in Plot GP41, an outlier, could not be predicted based on Model 201. Large numbers of birds used one lake in this plot because of water-level manipulations (pers. obs).

The use of the Golet Score as an index to Black Duck distributions facilitates thematic mapping of duck densities at various spatial resolutions and spatial extents because Golet Scores already exist for the entire provinces of New Brunswick and Nova Scotia in a geo-referenced format. Higher order models, including such variables as stream density, lake area, salt marsh area, would currently be difficult to use at provincial scales because digital data is not available (either due to the nature of the data or because of the costs involved in buying digital maps). A separate model for inland survey areas may provide a more accurate estimate of inland populations, however doing this would require two separate models and would detract from understanding the relative importance of coastal habitats to breeding Black Ducks. Having two separate models would be especially problematic for Nova Scotia, which is surrounded by marine water on three sides, has a shoreline length of 10,700 km, with the maximum distance from the coast being only 79 km. It should also be mentioned that local models, based on subsets of data can only be justified if there are ecological reasons for doing so. Otherwise there is a high probability of over-fitting the model to the data, rather than fitting the data to the model (Burnham and Anderson 1998). As discussed earlier, having an equal representation of survey plots in all habitat types facilitates creating habitat-based models.

The univariate Golet Score model is a crude approximation of reality, *i.e.*, actual number of Black Duck IBPs. This study could not determine if habitats are not used by Black Ducks because of low population numbers (Horne 1983) or due to habitat selection. However its ability to explain a considerable proportion of the variation in Black Duck IBPs among survey plots is important for wetland conservation. The importance of wetland quality, as measured by Golet Score, in determining Black Duck distribution at a landscape scale contradicts the argument that waterfowl habitat enhancement and conservation is not required for Black Ducks because there are lots of natural wetlands in New Brunswick and Nova Scotia. Black Duck distributions are more clumped than uniform across the landscape and Black Duck pairs will respond to favourable local conditions (Pollard *et al.* 2000). Wetlands should not be treated generically as wildlife habitat, *e.g.*, bogs have a very different ecological and wildlife habitat function compared to emergent marshes.

From this landscape-level analysis of Black Duck distributions in Atlantic Canada, it would appear that Black Ducks will tolerate human disturbance in order to utilise fertile wetlands. This current analysis of Black Duck distribution is consistent with that observed for Mallards where the two species are currently sympatric (Belanger and Lehoux 1994; Merendino and Ankney 1994).

Models of Trends in Local Black Duck Populations

Monitoring changes in habitat conditions is critical to understanding population dynamics. This is demonstrated by the fact that a model with four variables could predict with 83% accuracy which survey plots experienced increasing local Black Duck populations during 1990-99. Increasing local populations were most affected by a positive relationship with stream density and a negative correlation with variation in elevation. One plausible explanation is that increasing beaver populations resulted in more recently flooded beaver ponds being available. Without actually knowing if beaver ponds and habitat availability increased during this time period, it remains speculative that habitat conditions improved during this time period. This question is worthy of future study.

The total land area in forest cover was the only variable available to be used as a measure of habitat change in a recent effort at creating a continental population model for Black Ducks (Conroy *et al.* 1999). The disparity between what we know of Black Duck habitat selection at a local scale (Table 5.1) and what data is available to monitor habitat change at regional and continental scales is alarming. If changes in habitat quality and quantity are responsible for observed changes in wildlife populations then trend analysis of habitat is essential.

Models of Breeding Waterfowl Distributions

The inability to model the number of IBPs of Ring-necked Ducks, Common Mergansers, or Green-winged Teal in survey plots, highlights the significance of the explanatory power of the Black Duck models and lends support to the conclusion that the high predictive capabilities of the Black Duck models were not simply the result of large sample sizes and statistical power. The presence of one or more breeding pairs of Ring-necked Ducks within a 25 km^2 area was correlated with total wetland area, and total number of lakes. In contrast Green-winged Teal distribution was predicted by maximum Golet Score, stream density, chemical limnology of surface waters and presence of salt marshes. This information can be a starting point for any future development of models to explain the density of breeding pairs. In the absence of any other information, being able to predict the presence or absence of a species in a spatially defined area is useful.

Logistic models did not explain the presence of Common Mergansers with a high degree of accuracy. None of the habitat variables in the global model would be expected to be highly correlated with fish abundance, a critical component of Common Merganser habitat. A future analysis of the lake area data could determine the number of lakes in the plots that were greater than 25 ha. In the acidic lakes of south-western Nova Scotia, Common Mergansers were observed to only use lakes greater than 25 ha in size (Kerekes *et al.* 1994). Whether this relationship would hold true for the riverine dominated, well buffered systems of New Brunswick is unknown.

Estimates of Black Duck Breeding Pairs

The number of indicated breeding pairs of Black Ducks was estimated for 5 km*5 km grid blocks throughout Nova Scotia and New Brunswick based on the maximum Golet Score observed for wetlands in each block (Figures 6.4 and 6.5). The univariate model upon which these maps were based did not account for all variation in the data (R^2= 0.79), and did not include higher order terms. These maps do however indicate the relative importance of 5 km*5 km grid blocks as Black Duck breeding habitat based on freshwater wetlands. It can be seen that high densities of Black Ducks are estimated for many areas throughout New Brunswick but very few for Nova Scotia. In New Brunswick, areas of estimated high densities of waterfowl are found adjacent to the lower Saint John River system, and the coastal plain of Northumberland Strait. Highest estimated Black Duck densities in Nova Scotia are found in areas of fertile soils. Coastal areas in Nova Scotia did not have high estimated numbers of Black Ducks, presumably because of the prevalence of bogs. The limitations of the single variable model for producing population estimates are illustrated by the map for Nova Scotia.

In terms of the linear additive model, the estimated number of breeding pairs of Black Ducks would increase if there were lots of lakes in the area, lots of salt marshes, and high total phosphorous concentrations in surface waters. The parameter estimates for these variables were however low in comparison to that for maximum Golet Score in the best overall model (Model 62). As discussed earlier, imprecision in the estimates of IBPs in any given survey plot, and changing local populations on which the models were derived, contribute more to the imprecision of predicted numbers of IBPs than using the simple Golet Score model.

Future Models

This study has shown that Black Duck distributions and local population trends can be modelled based on landscape-level descriptors of habitat. Annual variation in the number of Black Ducks observed in survey plots reduces the precision of population estimates that can be derived from these models. The lack of digital habitat data limits the application of higher order models to provincial scales.

It is hoped that surveys conducted in future years using consistent survey protocols will provide more precise estimates of Black Duck densities in survey plots. If more precise estimates are not forthcoming then this uncertainty will have to be incorporated into models. The use of GPS and onboard computers will allow survey data to be compiled at various spatial scales using GIS in the future.

The completion of new digital wetland inventories complete with topographical base maps will allow habitat relationships to be explored at various spatial scales with relative ease. Habitat related data whether it be related to wetlands, river, lakes, chemical limnology, human disturbance factors or soil types should not thought of as separate entities. This study has illustrated that to understand regional wildlife populations we need to understand changes in the quality and quantity of habitat at large spatial scales. It is hoped that monitoring trends in wildlife habitat becomes an integral component of monitoring wildlife populations.

Conclusions

With regard to the main objectives, the following conclusions can be made:

1) Landscape-level descriptors of habitat could explain the observed distribution of Black Duck indicated breeding pairs. The best univariate model, based on survey data collected during 1992-94, explained 78 % of the variation and was based on maximum Golet Score. An analysis based on spatially independent survey data collected during 1986-89 confirmed the utility of the maximum Golet Score model (R^2=0.88).

2) Spatial autocorrelation analysis of the nested waterfowl survey plots used during 1990-95, indicated that Black Duck data from 25 km^2 survey plots nested within 100 km^2 plots could be treated as independent observations. Spatial autocorrelation was higher for many of the landscape-level descriptors compared to waterfowl data. The issue of spatial autocorrelation should be considered when designing any survey program.

3) Landscape-level descriptors of habitat could not accurately predict the magnitude of population change in Black Ducks during 1990-99. However, they could be used successfully in logistic regression. The best logistic regression model correct 83% of the time in predicting which survey plots had an increasing number of Black Ducks.

4) Landscape-level descriptors of habitat could not accurately predict the number of Ring-necked Duck, Common Merganser, and American Green-winged Teal in survey plots. They could be used with varying success in logistic regression models that predicted the presence of one or more breeding pairs. The best logistic regression models had correct classification rates of 86% for Ring-necked Duck, 74% for Common Merganser and 79 % for Green-winged Teal.

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Lag Class	Average Distance	Number of Observations	Moran's I ABDU	Moran's I Residual
1	5697	303	0.333	0.338
2	13582	43	0.141	-0.051
3	20376	117	0.247	0.145
4	28184	158	0.206	0.131
5	36213	137	0.363	0.360
6	44266	168	0.005	-0.049
7	51942	193	0.118	0.028
8	60068	182	0.128	-0.052
9	68443	268	-0.011	-0.189
10	76027	344	-0.022	0.032
11	84167	354	0.001	0.049
12	92150	410	-0.071	-0.125
13	99993	463	0.090	0.006
14	107583	338	0.113	0.073
15	116330	336	-0.114	-0.063
16	123802	394	0.079	-0.042
17	132072	384	-0.011	-0.034
18	140081	468	-0.009	-0.061
19	147891	437	0.021	-0.003
20	155752	357	-0.043	0.034

Table 6.1 - Spatial autocorrelation in number of Black Duck IBPs observed in PQUADs 1992-94 and residuals from best overall model (Model 62).

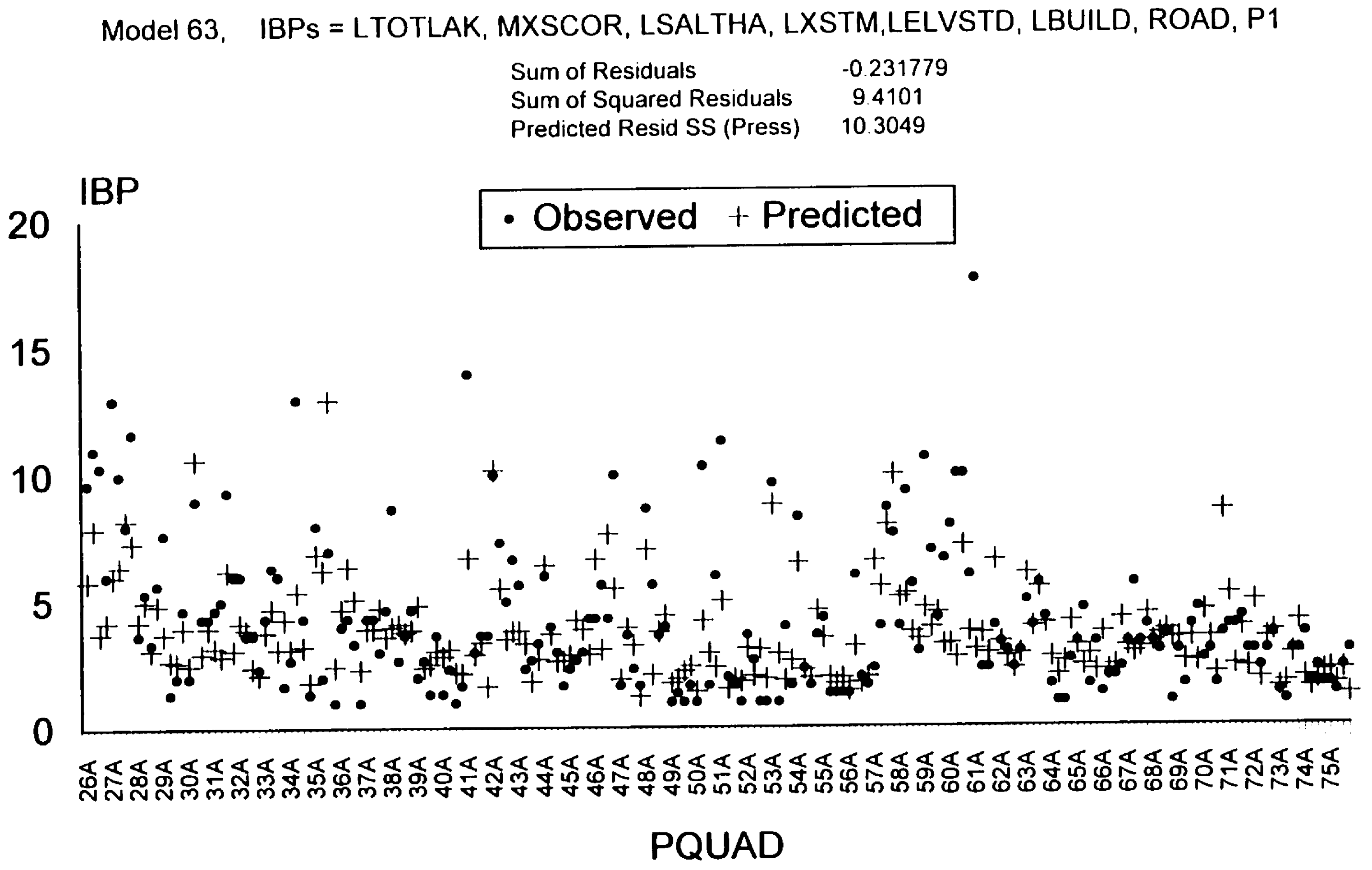

Figure 6.1 - Predicted versus observed number of Black Duck indicated breeding pairs (IBPs) in 25 km^2 survey plots (PQUADs) based on Model 63 which included eight-variables. See Table 5.3 for a complete description of model.

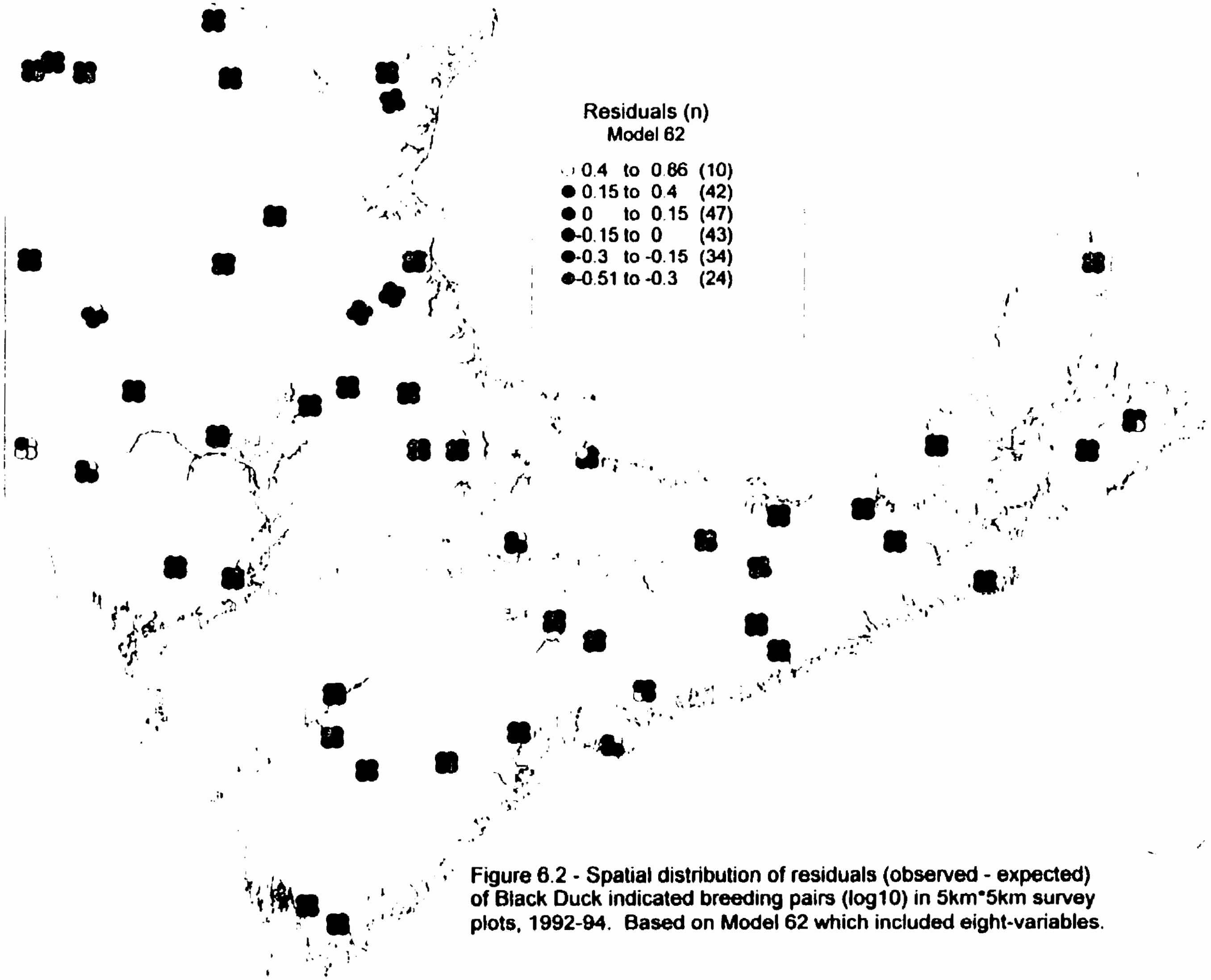

Figure 6.2 - Spatial distribution of residuals (observed - expected) of Black Duck indicated breeding pairs (log10) in 5km*5km survey plots, 1992-94. Based on Model 62 which included eight-variables.

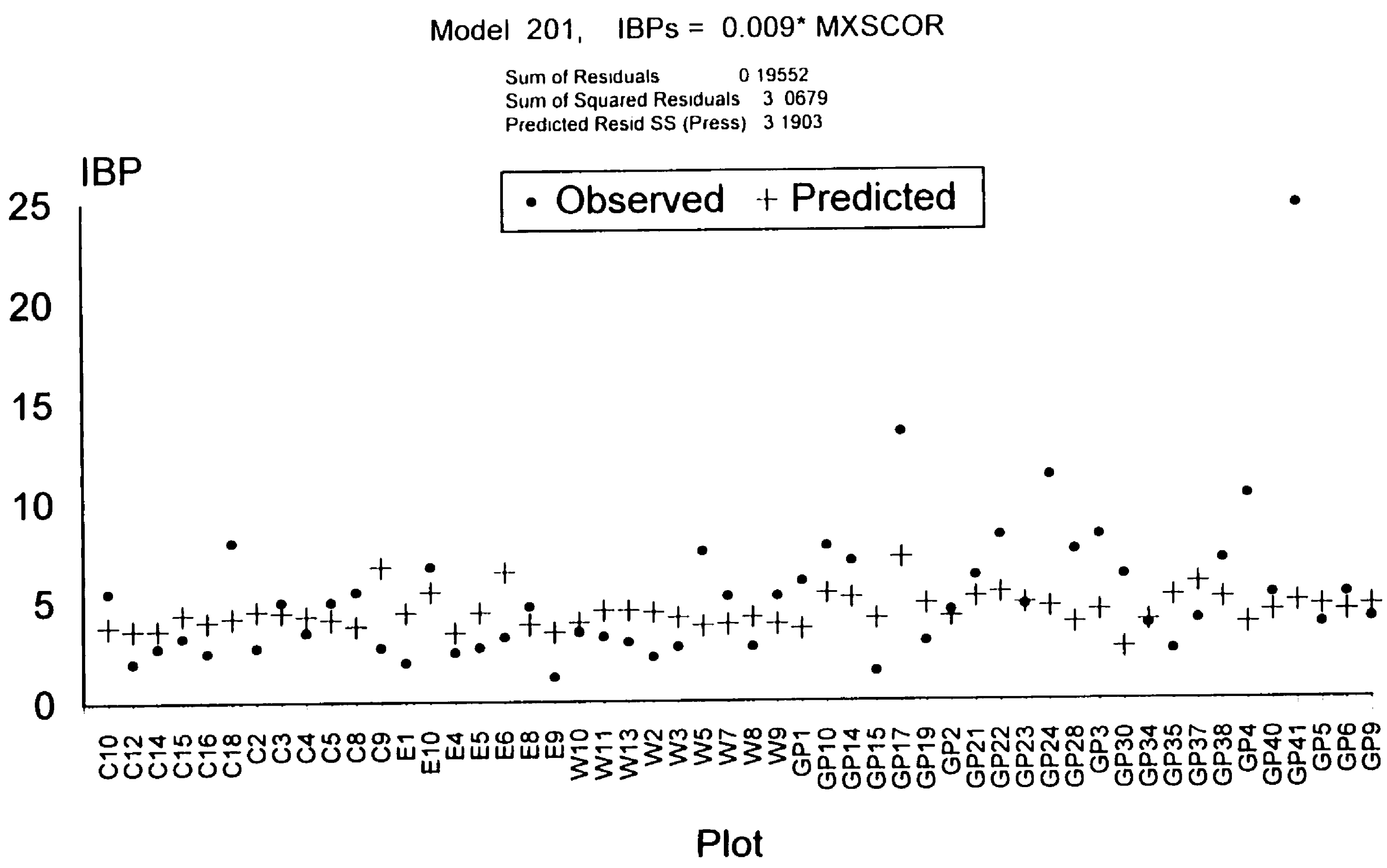

Figure 6.3 - Observed versus predicted number of Black Duck indicated breeding pairs (IBPs) in 25 km^2 plots, surveyed during 1986-89, based on Model 201. See Table 5.5 for a complete description of model.

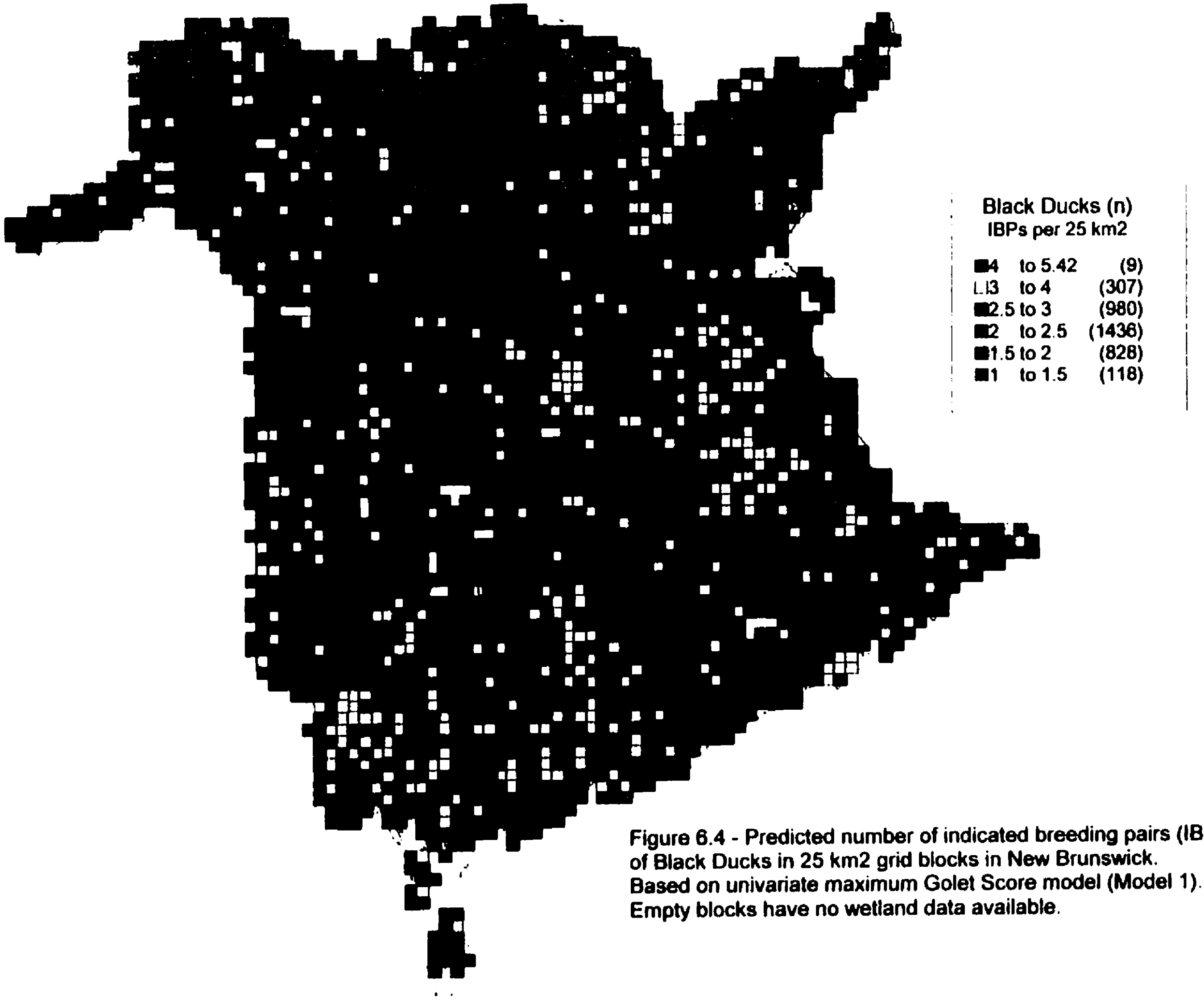

Figure 6.4 - Predicted number of indicated breeding pairs (IBPs) of Black Ducks in 25 km2 grid blocks in New Brunswick. Based on univariate maximum Golet Score model (Model 1). Empty blocks have no wetland data available.

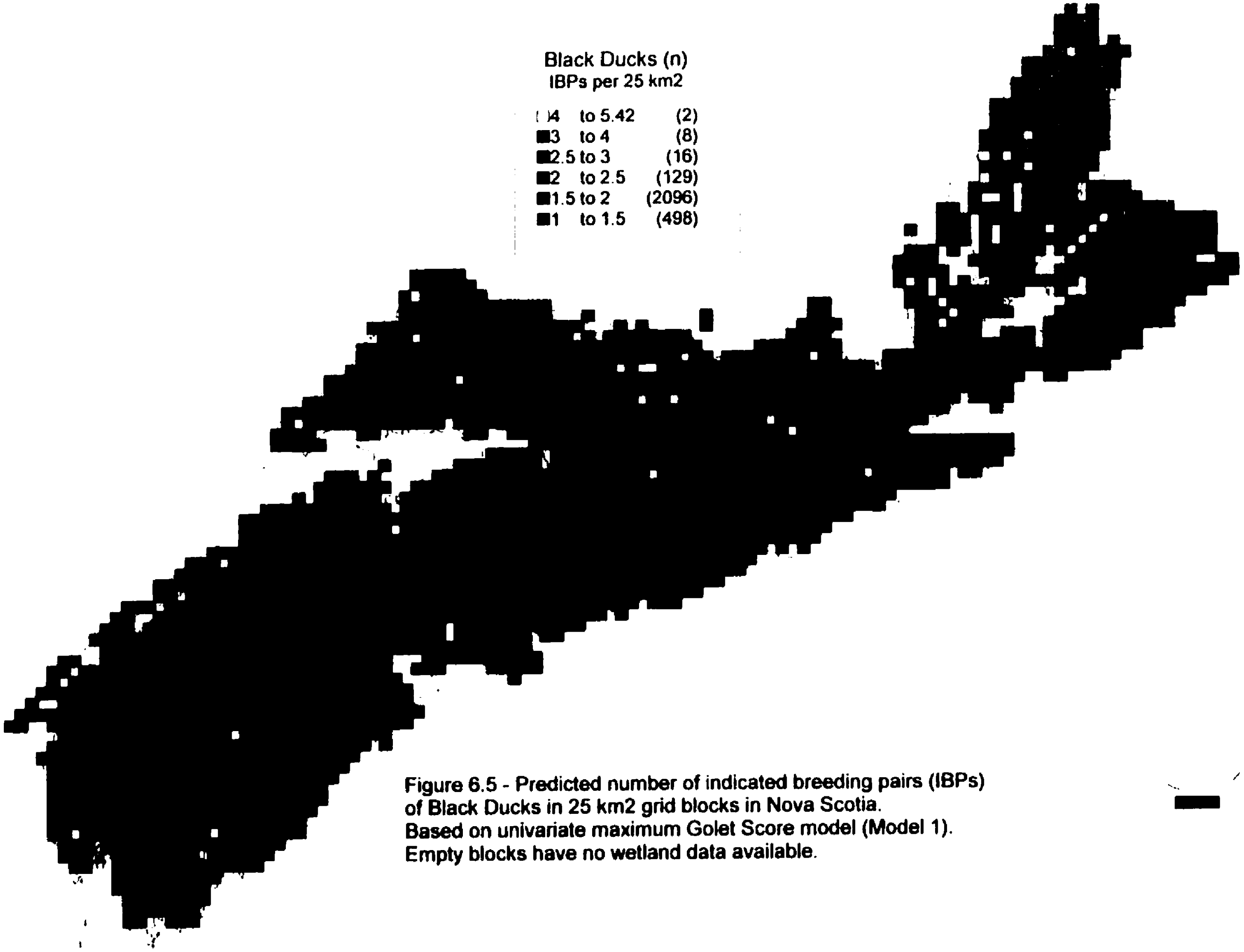

Figure 6.5 - Predicted number of indicated breeding pairs (IBPs) of Black Ducks in 25 km2 grid blocks in Nova Scotia. Based on univariate maximum Golet Score model (Model 1). Empty blocks have no wetland data available.

Appendix A

Description of Maritime Wetland Inventory Dominant classes and Subclasses

Within the 8 dominant wetland classes (underlined) there are 34 different wetland sub-classes (numbered).

A. OPEN WATER CLASS: refers to wetlands with water depths of one to three metres and consists of five subclasses:

1) **vegetated**: submergent, rooted aquatic plants growing to near the water surface. These plants may include: *Ceratophyllum demersum*, *Myriophyllum* sp., *Potamogeton* spp., *Utricularia* spp., *Ranunculus trichophyllus*.
2) **non-vegetated**: surface vegetation and near surface submergent vegetation is absent.
3) **floating leaved**: floating leaved non-rooted aquatics such as *Lemna minor*, *L. trisulca*, *Spirodella* sp., *Wolfia* sp., *Ricciocarpus natans* may be present.
4) **rooted floating leaved**: rooted aquatic vegetation with leaves floating on the waters surface such as *Erasenia schreberi*, *Nymphae odorata*, *Nuphar variegatum*, *Nymphoides cordatum*, *Potamogeton* sp., may be present.
5) **dead woody**: dead spars are abundant. This habitat is often the result of beaver activity, flowage areas of dammed waterways, or old sawmill sites.

B. DEEP MARSH CLASS: refers to wetlands that have an average water depth of 0.30 m to 1 m during the growing season. Emergent vegetation is usually dominant with surface and submergent vegetation present in open areas. It consists of nine subclasses:

6) **vegetated**: as described for Open Water class.
7) **non-vegetated**: as described for Open Water class.
8) **dead woody**: as described for Open Water class
9) **shrubby**: shrubs such as *Myrica gale* are present.
10) **robust**: robust emergents such as *Typha* spp. are present
11) **narrow leaved**: narrow leaved emergents such as *Sparganium sp.*, *Acorus calamus*, *Zizania aquatica*, and *Scirpus acutus* are present
12) **broad leaved**: broad leaved emergents such as *Caltha palustris*, *Sagittaria* spp., *Pontederia cordata* are present. These plants are less than 1 m tall and found in water up to 0.50 m deep.
13) **rooted floating leaved**: as described for Open Water class.
14) **floating leaved**: as described for Open Water class.

C. SHALLOW MARSH CLASS: describes wetlands with an average water depth of less than 0.15 m during the growing season. Surface water may be absent during mid to late summer. Floating leaved plants and submergents are often present in deeper water areas that are devoid of emergent vegetation. These wetlands are often dominated by emergent vegetation. This class consists of seven subclasses:

15) **non-vegetated**: a possible subclass applying to water collection in artificial structures such as gravel pits or water holding ponds where the substrate is comprised of rocks or gravel.
16) **dead woody**: as described for Open Water class.
17) **robust**: as described for Open Water class.
18) **narrow leaved**: as described for Deep Marsh class.
19) **broad leaved**: as described for Deep Marsh class.
20) **rooted floating leaved**: as described for Open Water class.
21) **floating leaved**: as described for Open Water class

D. SEASONALLY FLOODED FLATS CLASS : refers to extensive river floodplains where flooding to a depth of at least 0.30 m occurs annually during fall, winter and spring. During summer, the soil is saturated with surface water occurring in areas of lower elevation such as ox-bow ponds, drainage ditches and shallow depressions. This class incorporates vegetative components of the Meadow and Shrub Swamp, but its floodplain location makes it unique. Typically, emergent vegetation is dominant, but shrubs and scattered trees may be present. Seasonally Flooded Flats consist of two subclasses:

22) **emergent**: meadow emergents dominate with marsh emergents in wetter areas, especially along the watercourse.
23) **shrub**: shrubs such as *Alnus rugosa* or *Mryica gale* form the main vegetative component.

E. MEADOW CLASS: refers to wetlands dominated by meadow emergents with up to 0.15 cm of surface water during the late fall, winter and early spring. The soil is saturated during the growing season and the surface is exposed, except in shallow depressions and drainage ditches. Meadow consists of two subclasses:

24) **grazed**: most of the grasses and sedges are selectively removed by grazing livestock. Shrubby species such as *Spirea latifolia*, *Juncus* spp. and *Scirpus* spp. may persist.
25) **ungrazed**: refers to wetlands where meadow emergents such as *Calamagrostis canadensis*, *Phalaris arundinacea* may form tall, pure stands. Various components of shrub swamp may be scattered throughout. A meadow may be the result of flooding and subsequent draining of a pond either through the activity of beaver or man. Ungrazed meadows may become shrub swamps or wooded swamps if processes (flooding, ice

scour, or grazing) do not continuously remove deciduous plants that try to establish on the site.
26) **sedge**: areas of predominantly *Carex* spp., often times associated with washed out beaver ponds or along the edges of large acidic lakes.

F. **SHRUB SWAMP CLASS**: refers to wetlands dominated by shrubs where the soil is seasonally or permanently flooded with as much as 0.30 m of water. *Carex* spp. are often the ground cover under shrubs with meadow emergents occupying wetter areas. This class consists of three subclasses:

27) **slender**: tall slender shrubs such as *Acer rubrum* and *Alnus rugosa* are the dominant species of vegetative cover.
28) **compact**: compact shrubs form the main vegetative cover, e.g., *Myrica gale*.
29) **low sparse**: low sparse shrubs form the main cover, e.g., *Spiraea latifolia, S. tomentosa*.

G. **WOODED SWAMP CLASS**: refers to wetlands dominated by trees growing in a muck soil. The soil surface may be seasonally flooded with up to 0.30 m of water. Several levels of vegetation may be present including trees, shrubs, and herbaceous plants. In mature wooded swamps, differences in elevation may result in pronounced micro-habitats, where trees and shrubs occupy the drier areas. Whereas marsh emergents and ferns may occupy the ephemeral pools of standing water. There are two subclasses:

30) **Deciduous**: deciduous trees such as *Acer rubrum*, and *Fraxinus nigra* are dominant.
31) **Evergreen**: evergreen trees such as *Thuja occidentalis* are dominant.

H. **BOG CLASS**: refers to wetlands where the accumulation of *Sphagnum* moss as peat determines the nature of the plant community. Floating *Sphagnum* mats may encroach over the surface of any open water. This class consists of three subclasses:

32) **Woody**: evergreen trees such as *Picea mariana*, and *Larix laricina* are present.
33) **Shrubby**: low compact shrubs form the main vegetative component, e.g., *Chamaedaphne calyculata, Rododendron canadense, Kalmia* spp.
34) **Open**: refers to areas of the bog occupied by low creeping shrubs such as *Vaccinium* spp., as well as *Carex* spp. and *Cladonia* spp.

Appendix B -Description of Golet Scoring System Criteria

1. Wetland class richness

This criterion describes the number of wetland classes present in a wetland, where 2 ha is the minimum area recognisable as a separate class. As class richness increases, so does the likelihood for greater wildlife species richness. Wetland class richness is the broadest and single most important criterion for evaluation.

2. Dominant wetland class

Some wetland classes have greater value than others for wildlife diversity and production, and certain classes provide the only suitable habitat for some species highly valued by society (*e.g.*, waterfowl, rare species). Dominant life form of vegetation, water depth, and permanence of surface water are the major characteristics considered in ranking classes. The dominant class is the one that clearly occupies the greatest area. If two or more classes are co-dominant, the ranks are averaged.

3. Size Categories

Wetlands are ranked from largest to smallest, according to the general principle that as size increases, so does wildlife value ((Brown and Dinsmore 1986). Greater size usually results in greater insulation from human disturbance, greater habitat diversity and greater wetland longevity. In addition, wetlands larger than 40 hectares are of great value to flocks of migrating waterfowl.

4. Subclass richness

This variable also assesses habitat diversity. Just as particular life forms characterise subclasses, particular sub-forms characterise subclasses. A wetland's broad wildlife value increases as the number of subclasses increases. A wetland segment must be at least 0.5 ha in size to be recognised as a separate subclass.

5. Site Type

Bottomland wetlands are generally more valuable than upland wetlands because of greater soil fertility, more sustained surface-water levels, and longer geological permanence. Similarly, wetlands associated with open water bodies are usually more valuable than isolated ones. Using this rationale, site types were grouped into three categories for evaluation.

6. Surrounding Habitat Types

Freshwater wetlands bordered by forest, agricultural/open land, or salt marsh are more valuable to wildlife than those adjacent to intensively developed land. Furthermore, diversity in the surrounding habitat (e.g., freshwater and saltwater habitats) increases the possibility of wildlife diversity within the wetland. The percentage of the surrounding occupied by less intensively developed types and the number of different types present determine the rank for this criterion.

7. Cover type

This variable can be assessed in wetlands consisting of one or many wetland classes, although its value is most evident in evaluating deep and shallow marshes. Equal areas of open water and emergent vegetation (hemi-marsh) in a wetland will provide optimal habitat for waterfowl and marsh birds (Murkin *et al.* 1982; Weller and Spatcher 1965). Highest ranks are thus given to wetlands with nearly equal proportions of cover and water. Areas with nearly total cover or total open water receive low ranks. In addition, cover interspersed with water is deemed more valuable than a band of cover surrounding open water.

8. Vegetative Interspersion

A wetland receives a rank for this criterion according to which interspersion type it approximates. High ranks are associated with an abundance of edge between sub-form stands, small size of such stands, and a large number of different kinds of edge.

9. Wetland Juxtaposition

Habitat diversity is usually higher if the wetland is located near other wetlands, especially if the adjacent wetlands contain different classes or subclasses. Moreover, the diversity value increases if these wetlands are interconnected by streams. In such cases, wildlife (especially waterfowl) can move safely between wetlands to best meet their habitat requirements. Radio-telemetry studies indicate that female Black Ducks will use a series of wetlands located along streams (Ringelman and Longcore 1982).

10. Water Chemistry

Water chemistry influences the presence, abundance, and distribution of aquatic plants and invertebrates (Bendell and McNicol 1987; Schell and Kerekes 1989; Staicer *et al.* 1993) Specifications for pH classes were based upon Golet's (1973) data for 95 ponds and lakes in Massachusetts.

Appendix C - Summary Data of Ecological Descriptors of Survey Plots

Nova Scotia Plots			New Brunswick Plots		
Plot	**Station**	**Years**	**Plot**	**Station**	**Years**
26	Halifax A	1983-94	**51**	Baltimore	1983-94
26	Westphal	1983-94	**52**	Parkindale	1983-94
27	Timberlea	1946-63	**53**	Moncton	1983-94
28	St. Margaret's Bay	1983-94	**54**	Harcourt	1983-94
29	Bridgewater	1983-94	**55**	Wiggins Point	1983-94
30	Charlesville	1983-94	**56**	Acadia Forest	1983-94
31	Charlesville	1983-94	**57**	St John Airport	1983-94
32	Kejimkujik Park	1983-94	**58**	Hoyt-Blissville	1983-94
33	Bear River	1983-94	**59**	MacAdam	1917-76
34	Annapolis Royal	1983-94	**60**	Canterbury	1970-90
35	Summerville	1983-94	**61**	Juniper	1983-94
36	Mount Uniacke	1983-94	**62**	Aroostock	1983-94
37	Malay Falls	1983-94	**63**	Nictau	1983-94
38	Middle Musquodoboit	1983-94	**64**	McGraw Brook	1983-94
39	Trafalgar	1919-81	**65**	McGraw Brook	1983-94
40	Truro	1983-94	**66**	Acadieville	1983-94
41	Parrsboro	1983-94	**66**	Harcourt	1983-94
42	Pugwash	1983-94	**67**	Acadieville	1983-94
43	Lyons brook	1983-94	**67**	Harcourt	1983-94
44	Collegeville	1983-94	**68**	Kouchibouguac	1983-94
45	Collegeville	1983-94	**69**	Bertrand	1983-94
46	Deming	1983-94	**70**	Bertrand	1983-94
47	Sydney A	1983-94	**71**	Upsalquitch Lake	1983-94
48	Sydney A	1983-94	**72**	Charlo	1983-94
49	Ingonish Beach	1983-94	**73**	Kedgwick	1983-94
50	Port Hood	1983-93	**74**	S. Br. Kedgwick River	1983-94
			75	S. Br. Kedgwick River	1983-94

Table C.1 - Climate stations and years of data used in calculating summary climate statistics for plots.

Plot	VEGA	VEGB	VEGC	VEGD	VEGG	VEGM	VEGR	VEGU
26	0	7	0	0	0	93	0	0
27	0	1	0	0	0	99	0	0
28	0	9	0	0	0	91	0	0
29	0	0	0	0	0	100	0	0
30	0	30	0	0	0	67	3	0
31	0	17	0	0	0	83	0	0
32	0	7	0	0	0	93	0	0
33	0	10	0	0	0	90	0	0
34	17	9	0	0	0	74	0	0
35	4	4	0	0	0	92	0	0
36	0	8	0	0	0	92	0	0
37	0	10	0	0	0	90	0	0
38	0	10	0	0	0	90	0	0
39	0	8	0	0	0	92	0	0
40	5	2	0	0	0	93	0	0
41	14	2	0	0	0	84	0	0
42	23	0	0	0	0	77	0	0
43	3	0	0	0	0	97	0	0
44	39	0	0	0	2	59	0	0
45	0	0	0	0	0	100	0	0
46	0	5	0	0	0	95	0	0
47	0	10	0	0	0	90	0	0
48	0	18	0	0	0	82	0	0
49	0	4	0	16	0	78	0	2
50	10	0	0	0	0	90	0	0
51	2	0	0	0	0	98	0	0
52	4	0	0	0	0	96	0	0
53	0	33	56	0	0	11	0	0
54	0	20	17	0	0	63	0	0
55	0	21	0	0	0	79	0	0
56	0	10	0	0	0	90	0	0
57	0	0	0	0	0	100	0	0
58	0	4	11	0	0	85	0	0
59	0	0	0	0	0	100	0	0
60	12	0	0	0	0	88	0	0
61	1	0	0	0	0	99	0	0
62	10	0	0	0	0	90	0	0
63	0	0	0	0	0	100	0	0
64	0	0	0	0	0	100	0	0
65	0	0	100	0	0	0	0	0
66	0	7	0	0	0	93	0	0
67	1	4	0	0	0	95	0	0
68	3	0	0	0	0	97	0	0
69	5	0	0	0	0	95	0	0
70	2	17	0	0	0	81	0	0
71	0	0	0	0	0	100	0	0
72	2	0	0	0	0	98	0	0
73	0	0	0	0	0	100	0	0
74	0	0	17	0	0	83	0	0
75	0	0	0	0	0	100	0	0

Table C.2 - Summary by PLOT of land cover classes.

Plot	Total Roads (km)	Total Buildings
26	25	480
27	38	914
28	97	1240
29	46	116
30	24	107
31	33	102
32	0	0
33	57	308
34	82	780
35	44	294
36	37	157
37	33	276
38	21	0
39	29	3
40	57	55
41	50	165
42	56	268
43	137	1300
44	97	1415
45	33	79
46	23	143
47	43	92
48	79	405
49	9	0
50	58	234
51	56	179
52	37	135
53	43	40
54	54	4
55	53	2
56	69	15
57	71	828
58	0	1
59	11	33
60	54	40
61	47	306
62	72	322
63	38	20
64	16	2
65	21	1
66	16	25
67	57	25
68	44	127
69	42	76
70	30	110
71	26	2
72	45	193
73	41	53
74	20	10
75	33	12

Table C.3 - Summary by PLOT of total road length (km), and number of buildings.

Plot	Slope <4%	Slope 4-9%	Slope 10-15%	Slope 16-30%	Slope 31-60%	Slope > 60%
26	7	73	20	0	0	0
27	1	14	85	0	0	0
28	9	88	3	0	0	0
29	0	47	53	0	0	0
30	33	67	0	0	0	0
31	40	56	4	0	0	0
32	7	80	13	0	0	0
33	11	89	0	0	0	0
34	8	69	9	0	15	0
35	30	47	13	9	0	0
36	8	88	2	1	0	0
37	10	88	2	0	0	0
38	10	83	7	0	0	0
39	22	78	0	0	0	0
40	5	92	2	1	0	0
41	17	5	47	31	0	0
42	87	13	0	0	0	0
43	14	62	24	1	0	0
44	6	94	0	0	0	0
45	0	31	69	0	0	0
46	10	48	41	0	0	0
47	22	14	64	0	0	0
48	31	55	15	0	0	0
49	4	74	4	0	0	18
50	0	65	35	0	0	0
51	0	7	82	11	0	0
52	10	10	79	0	0	0
53	88	12	0	0	0	0
54	81	19	0	0	0	0
55	84	16	0	0	0	0
56	82	18	0	0	0	0
57	0	0	99	1	0	0
58	19	76	6	0	0	0
59	8	66	26	0	0	0
60	40	60	0	0	0	0
61	64	29	7	0	0	0
62	0	88	8	4	0	0
63	0	37	63	0	0	0
64	3	97	0	0	0	0
65	90	10	0	0	0	0
66	93	7	0	0	0	0
67	69	31	0	0	0	0
68	85	15	0	0	0	0
69	4	97	0	0	0	0
70	68	32	0	0	0	0
71	0	34	20	0	46	0
72	4	90	6	0	0	0
73	0	94	6	0	0	0
74	0	32	50	8	10	0
75	0	18	24	7	50	0

Table C.4 - Summaries by PLOT of slope classes.

Plot	SFB04	SFB14	SFD	SFF13	SFH	SFL	SFM	SFM06	SFR	SFS	SFS01	SFU
26	0	7	0	0	0	7	85	0	0	0	0	1
27	0	1	0	0	0	1	85	0	0	0	0	12
28	0	9	0	0	0	9	77	0	0	0	0	5
29	0	0	0	0	0	0	53	0	0	0	0	47
30	0	30	0	0	0	10	0	0	0	0	0	60
31	0	17	0	0	0	15	5	0	0	0	0	62
32	0	7	0	0	0	6	58	0	0	0	0	30
33	0	10	0	0	0	9	74	0	0	0	0	7
34	0	9	0	0	0	9	3	0	0	15	0	64
35	0	4	0	0	0	1	17	0	0	0	0	78
36	0	8	0	0	0	7	83	0	0	0	0	1
37	0	10	0	0	0	10	80	0	0	0	0	0
38	0	10	0	0	0	8	67	0	0	0	0	15
39	0	8	0	0	0	4	86	0	0	0	0	3
40	0	2	0	0	0	7	60	0	0	0	0	31
41	0	2	33	0	0	0	41	0	0	0	0	25
42	0	0	0	0	0	0	1	0	0	0	0	99
43	0	0	0	0	0	4	35	0	0	0	0	61
44	0	0	0	0	0	6	44	0	0	0	0	49
45	0	0	0	0	0	0	77	0	0	0	0	23
46	0	5	0	0	0	5	48	0	0	0	0	41
47	0	10	0	0	0	0	64	0	0	0	0	26
48	0	18	0	0	0	12	27	0	0	0	0	43
49	0	0	0	0	0	4	78	0	0	18	0	0
50	0	0	0	0	0	20	80	0	0	0	0	0
51	0	0	25	0	74	0	1	0	0	0	0	0
52	0	0	0	0	67	0	23	0	0	0	0	10
53	9	24	0	0	8	0	4	0	0	0	0	56
54	10	10	0	0	0	0	1	0	0	0	0	79
55	16	5	0	0	0	0	5	0	0	0	0	74
56	0	1	0	0	0	6	17	1	0	0	9	67
57	0	0	0	0	1	0	99	0	0	0	0	0
58	0	4	0	0	52	0	29	0	0	0	0	14
59	0	0	0	0	61	5	2	0	0	0	0	32
60	0	0	0	6	0	20	54	0	0	0	0	20
61	0	0	0	0	0	40	36	0	0	0	6	17
62	0	0	0	0	4	0	28	0	0	0	0	68
63	0	0	0	0	38	0	62	0	0	0	0	0
64	0	0	0	0	0	0	66	0	0	0	0	34
65	0	0	0	0	0	0	0	0	0	0	0	100
66	7	0	0	0	0	0	0	0	0	0	0	93
67	0	4	0	0	2	0	0	0	0	0	0	94
68	0	0	0	0	7	30	0	0	0	0	0	63
69	0	0	0	0	0	0	0	0	0	0	0	100
70	5	12	0	0	0	5	0	0	0	0	0	77
71	0	0	0	0	15	0	40	0	0	46	0	0
72	0	0	0	0	15	4	62	0	12	0	0	7
73	0	0	0	0	0	0	100	0	0	0	0	0
74	0	0	0	0	4	0	90	0	0	6	0	0
75	0	0	0	0	57	0	40	0	0	0	0	3

Table C.5 - Summary by PLOT of surface form classes.

PLOT	No. Points	Elevation Mean	Elev. Median	Elev. S.D.	Elev. Min.	Elev. Max.
26	170	76	75	29	23	172
27	147	42	39	22	1	91
28	143	51	56	25	1	95
29	168	103	103	14	82	144
30	153	24	26	13	1	60
31	159	33	32	14	1	60
32	156	123	121	25	85	174
33	156	140	148	33	30	205
34	140	84	71	63	1	215
35	150	31	30	16	1	79
36	152	127	131	29	57	186
37	150	55	58	23	1	114
38	163	138	142	15	91	174
39	161	183	182	21	148	245
40	165	165	163	34	90	270
41	171	123	123	72	9	264
42	163	26	23	15	1	74
43	165	60	60	31	1	182
44	173	54	42	39	1	213
45	170	154	152	17	114	198
46	136	27	26	18	1	89
47	150	116	119	42	18	182
48	167	54	61	25	1	96
49	160	320	331	89	138	475
50	95	54	54	40	1	162
51	165	132	123	73	7	333
52	171	125	122	30	56	233
53	171	99	100	11	61	122
54	175	106	108	10	60	123
55	167	64	66	15	18	89
56	166	56	54	30	1	130
57	171	73	65	26	5	159
58	157	187	183	26	148	286
59	165	167	152	37	119	259
60	165	155	152	10	145	209
61	172	294	274	32	260	396
62	176	185	183	44	122	330
63	158	266	271	32	204	335
64	172	243	245	44	122	345
65	174	134	138	34	60	200
66	169	92	91	10	68	121
67	171	53	54	9	30	71
68	174	18	18	11	1	40
69	173	56	57	17	20	91
70	168	44	43	14	16	73
71	165	327	345	61	182	426
72	176	110	109	56	23	226
73	176	344	339	47	214	460
74	174	212	213	40	122	335
75	176	256	255	50	151	396

Table C.6 - Summary statistics by PLOT of elevations (m asl) from USGS-DEM.

PLOT	CALC#	CALC0	CALC1	CALC1	SBCVL	SBCL	SBCM	SBCH	SBCVH	Soil pH
26	27	73	0	0	2	99	0	0	0	4.49
27	27	73	0	0	2	89	0	9	0	4.67
28	10	90	0	0	4	94	0	3	0	4.53
29	30	70	0	0	3	91	0	5	0	4.59
30	30	70	0	0	15	85	0	0	0	4.42
31	17	83	0	0	11	89	0	0	0	4.44
32	10	90	0	0	13	87	0	0	0	4.43
33	10	90	0	0	3	95	0	3	0	4.54
34	9	91	0	0	0	50	0	50	0	5.50
35	4	96	0	0	4	0	0	93	4	6.44
36	9	91	0	0	0	70	1	28	0	5.08
37	10	90	0	0	2	98	0	1	0	4.51
38	10	90	0	0	4	93	0	3	0	4.55
39	8	92	0	0	4	88	3	6	0	4.62
40	2	98	0	0	6	41	5	48	0	5.48
41	7	93	0	0	0	48	4	48	0	5.50
42	0	100	0	0	3	22	0	75	0	5.97
43	0	100	0	0	0	19	0	81	0	6.12
44	0	100	0	0	5	21	16	58	0	5.79
45	0	100	0	0	6	81	4	10	0	4.70
46	30	70	0	0	3	91	0	6	0	4.60
47	10	90	0	0	4	93	0	3	0	4.54
48	18	82	0	0	9	48	0	43	0	5.31
49	10	90	0	0	4	93	0	2	0	4.52
50	0	100	0	0	0	0	33	67	0	6.17
51	0	100	0	0	0	10	40	50	0	5.90
52	0	100	0	0	0	0	47	53	0	6.03
53	0	100	0	0	0	0	86	14	0	5.64
54	0	100	0	0	0	0	100	0	0	5.50
55	0	100	0	0	0	0	100	0	0	5.50
56	0	100	0	0	0	0	100	0	0	5.50
57	0	100	0	0	0	76	16	8	0	4.81
58	0	100	0	0	0	76	24	0	0	4.74
59	0	96	4	0	0	71	29	0	0	4.79
60	0	60	40	0	0	16	69	16	0	5.50
61	0	100	0	0	0	80	20	0	0	4.70
62	0	92	0	8	0	13	43	39	4	5.85
63	0	100	0	0	0	53	47	0	0	4.97
64	0	100	0	0	0	5	78	17	0	5.62
65	0	100	0	0	0	17	82	2	0	5.35
66	0	100	0	0	0	0	100	0	0	5.50
67	0	100	0	0	0	0	100	0	0	5.50
68	0	99	1	0	0	0	82	18	0	5.68
69	0	100	0	0	0	0	100	0	0	5.50
70	0	100	0	0	0	0	100	0	0	5.50
71	0	100	0	0	0	34	7	59	0	5.74
72	0	97	3	0	0	37	15	48	0	5.60
73	0	100	0	0	0	0	100	0	0	5.50
74	0	38	63	0	0	0	50	0	50	6.50
75	0	68	32	0	0	0	61	27	12	6.02

Table C.7 - Summary by PLOT of soil buffering variables.

PLOT	MATOR	MATR2	MATR4	MATSO	RTDP#	RTDPA	RTDPB	RTDPC	RTDPD
26	7	20	0	73	20	0	73	0	7
27	1	26	0	73	26	0	73	0	1
28	9	1	0	90	1	0	90	0	9
29	0	30	0	70	30	0	70	0	0
30	30	0	0	70	0	0	49	21	30
31	17	0	0	83	0	0	70	13	17
32	7	3	0	90	3	0	83	7	7
33	10	0	0	90	0	0	90	0	10
34	9	0	0	91	0	0	80	11	9
35	4	0	0	96	0	0	96	1	3
36	8	1	0	91	1	0	91	0	8
37	10	0	0	90	0	0	90	0	10
38	10	0	0	90	0	0	90	0	10
39	8	0	0	92	0	0	88	4	8
40	2	0	0	98	0	0	84	14	2
41	2	6	0	93	6	1	42	50	2
42	0	0	0	100	0	0	100	0	0
43	0	0	0	100	0	0	100	0	0
44	0	0	0	100	0	0	94	6	0
45	0	0	0	100	0	0	99	0	0
46	5	24	0	70	24	0	70	0	5
47	10	0	0	90	0	0	89	1	10
48	18	0	0	82	0	0	81	1	18
49	4	6	0	90	6	0	90	0	4
50	0	0	0	100	0	0	100	0	0
51	0	1	0	99	0	1	81	18	0
52	0	0	0	100	0	0	81	0	19
53	33	0	0	67	0	0	65	24	11
54	20	0	0	80	0	0	80	10	10
55	21	0	0	79	0	0	79	5	16
56	10	0	0	90	0	0	84	1	15
57	0	0	9	91	0	9	0	91	0
58	4	0	1	95	0	1	0	80	19
59	0	0	0	100	0	0	28	0	72
60	6	0	0	94	0	0	20	0	80
61	6	0	0	94	0	0	30	0	70
62	0	0	0	100	0	0	77	14	9
63	0	0	0	100	0	0	40	0	60
64	0	0	0	100	0	0	100	0	0
65	0	0	0	100	0	0	90	0	10
66	7	0	0	93	0	0	86	0	13
67	4	0	0	96	0	0	67	4	29
68	0	0	0	100	0	0	91	0	9
69	0	0	0	100	0	0	46	0	54
70	17	0	0	83	0	0	74	12	14
71	0	0	0	100	0	0	85	0	15
72	0	0	0	100	0	0	77	0	23
73	0	0	0	100	0	0	0	0	100
74	0	0	0	100	0	0	81	0	19
75	0	0	0	100	0	0	99	0	1

Table C.8 - Summary by PLOT of surface material and rooting depth classes.

PLOT	CFRAG#	CFRAGA	CFRAGB	CFRAGC	CFRAGD
26	27	0	73	0	0
27	27	0	73	0	0
28	10	5	85	0	0
29	30	45	25	0	0
30	30	3	67	0	0
31	17	15	54	13	0
32	10	26	64	0	0
33	10	1	89	0	0
34	9	49	40	3	0
35	4	79	17	0	0
36	9	10	80	0	0
37	10	2	88	0	0
38	10	0	90	0	0
39	8	2	90	0	0
40	2	37	62	0	0
41	7	9	48	36	0
42	0	96	4	0	0
43	0	55	45	0	0
44	0	41	59	0	0
45	0	20	79	0	0
46	30	3	68	0	0
47	10	0	90	0	0
48	18	0	82	0	0
49	8	0	74	16	2
50	0	100	0	0	0
51	1	0	81	18	0
52	0	0	100	0	0
53	33	0	67	0	0
54	20	0	80	0	0
55	21	0	79	0	0
56	10	6	84	0	0
57	9	0	1	90	0
58	5	0	0	95	0
59	0	0	42	58	0
60	6	0	94	0	0
61	6	0	40	54	0
62	0	0	86	14	0
63	0	0	63	37	0
64	0	0	100	0	0
65	0	0	90	10	0
66	7	0	93	0	0
67	4	6	90	0	0
68	0	36	64	0	0
69	0	0	65	35	0
70	17	46	37	0	0
71	0	0	85	15	0
72	0	4	96	0	0
73	0	0	60	40	0
74	0	0	74	26	0
75	0	0	48	52	0

Table C.9 - Summary by PLOT of coarse fragment classes.

PLOT	D#	D3	DI	DN	DP	DQ	DR	DU	DV	DW	DX	DY	DZ
26	20	0	0	0	0	0	0	7	0	66	0	7	0
27	26	0	0	0	0	0	0	1	0	72	0	1	0
28	1	0	0	0	0	0	0	9	0	81	0	9	0
29	30	0	0	0	0	0	0	0	0	70	0	0	0
30	0	0	0	0	0	0	0	11	0	59	0	30	0
31	0	0	0	0	0	0	0	33	0	50	0	17	0
32	3	0	0	0	0	0	0	9	0	81	0	7	0
33	0	0	0	0	0	0	0	9	0	81	0	10	0
34	0	0	0	0	0	0	8	0	0	84	0	9	0
35	0	0	55	0	0	0	0	26	0	16	0	4	0
36	1	0	0	0	0	0	0	12	0	78	0	8	0
37	0	0	0	0	0	0	0	10	0	80	0	10	0
38	0	0	0	0	0	0	0	8	0	82	0	10	0
39	0	0	0	0	0	0	0	16	0	76	0	8	0
40	0	0	23	0	0	0	4	17	0	54	0	2	0
41	6	0	3	0	0	0	0	6	20	64	0	2	0
42	0	0	11	0	0	0	0	24	0	65	0	0	0
43	0	0	33	0	0	0	0	17	0	50	0	0	0
44	0	0	34	0	0	0	6	0	0	59	0	0	0
45	0	0	0	0	0	0	0	0	0	99	0	0	0
46	24	0	0	0	0	0	0	5	0	65	0	5	0
47	0	0	0	0	0	0	0	25	0	65	0	10	0
48	0	0	0	0	0	0	0	13	0	69	0	18	0
49	6	0	0	0	0	16	0	4	70	0	0	4	0
50	0	0	35	0	0	0	0	20	0	45	0	0	0
51	1	0	0	0	0	0	0	0	0	99	0	0	0
52	0	13	0	0	0	0	0	1	0	86	0	0	0
53	0	9	0	0	0	0	0	56	0	2	9	24	0
54	0	56	0	0	0	0	0	24	0	0	10	10	0
55	0	45	0	0	0	0	0	35	0	0	16	5	0
56	0	58	0	0	0	0	4	26	0	1	9	1	0
57	9	0	0	0	0	0	0	0	0	91	0	0	0
58	1	0	0	0	0	0	0	19	0	76	4	0	0
59	0	14	0	0	0	0	0	21	0	65	0	0	0
60	0	60	0	0	0	0	0	34	0	0	0	0	6
61	0	0	0	0	0	0	0	18	10	66	0	6	0
62	0	3	0	6	0	0	0	10	5	76	0	0	0
63	0	0	0	0	0	0	0	0	55	45	0	0	0
64	0	0	0	0	0	0	0	3	0	97	0	0	0
65	0	0	0	0	0	0	0	0	0	100	0	0	0
66	0	30	0	0	0	0	0	4	0	59	7	0	0
67	0	45	0	0	0	0	0	5	0	46	0	4	0
68	0	43	2	0	0	0	0	36	0	19	0	0	0
69	0	40	4	1	4	0	0	0	0	51	0	0	0
70	0	7	0	1	0	0	0	46	0	29	5	12	0
71	0	0	0	0	0	0	0	0	54	46	0	0	0
72	0	2	0	0	0	0	0	9	46	43	0	0	0
73	0	40	0	0	0	0	0	0	34	26	0	0	0
74	0	63	0	0	0	0	0	0	21	16	0	0	0
75	0	32	0	0	0	0	0	5	50	12	0	0	0

Table C.10 - Summary by PLOT of soil development classes.

Plot	PMD11	PMD21	PMD23	PMD25	PMDA	PMDC	PMDF	PMDL	PMDM	PMDO	PMDR	PMDW
26	0	0	0	0	0	0	0	0	73	7	20	0
27	0	0	0	0	0	0	0	0	73	1	26	0
28	0	0	0	0	0	0	0	0	90	9	1	0
29	0	0	0	0	0	0	0	0	70	0	30	0
30	0	0	0	0	0	0	18	0	49	30	0	3
31	0	0	0	0	0	0	13	0	70	17	0	0
32	0	0	0	0	0	0	7	0	83	7	3	0
33	0	0	0	0	0	0	0	0	90	10	0	0
34	0	0	0	0	0	0	3	0	80	9	0	8
35	0	0	0	0	0	0	0	0	96	4	0	0
36	0	0	0	0	0	0	0	0	91	8	1	0
37	0	0	0	0	0	0	0	0	90	10	0	0
38	0	0	0	0	0	0	0	0	90	10	0	0
39	0	0	0	0	2	0	2	0	88	8	0	0
40	0	0	0	0	2	0	6	0	90	2	0	0
41	0	0	0	0	5	0	9	0	79	2	6	0
42	0	0	0	0	0	0	0	0	100	0	0	0
43	0	0	0	0	0	0	0	0	100	0	0	0
44	0	0	0	0	6	0	0	0	94	0	0	0
45	0	0	0	0	0	0	0	0	99	0	0	0
46	0	0	0	0	0	0	0	0	70	5	24	0
47	0	0	0	0	0	0	1	0	89	10	0	0
48	0	0	0	0	0	0	1	0	81	18	0	0
49	0	0	0	0	0	16	0	0	74	4	6	0
50	0	0	0	0	0	0	0	0	100	0	0	0
51	0	0	0	0	0	0	0	0	99	0	1	0
52	0	0	0	0	0	0	0	0	100	0	0	0
53	9	0	0	24	0	0	0	0	67	0	0	0
54	10	0	0	10	0	0	0	0	80	0	0	0
55	16	0	0	5	0	0	0	0	79	0	0	0
56	0	1	0	1	6	0	0	0	84	9	0	0
57	0	0	0	0	0	0	0	0	91	0	9	0
58	4	0	0	0	0	0	0	0	95	0	1	0
59	0	0	0	0	0	0	2	0	98	0	0	0
60	0	6	0	0	0	0	0	0	94	0	0	0
61	0	0	6	0	0	0	40	0	54	0	0	0
62	0	0	0	0	0	0	0	0	100	0	0	0
63	0	0	0	0	0	0	6	0	94	0	0	0
64	0	0	0	0	0	0	0	0	100	0	0	0
65	0	0	0	0	0	0	10	0	90	0	0	0
66	7	0	0	0	0	0	0	0	93	0	0	0
67	0	0	0	4	0	0	0	0	90	0	0	6
68	0	0	0	0	0	0	0	28	64	0	0	8
69	0	0	0	0	0	0	35	0	65	0	0	0
70	5	0	0	12	0	0	0	0	37	0	0	46
71	0	0	0	0	0	0	0	0	100	0	0	0
72	0	0	0	0	0	0	0	0	89	0	0	11
73	0	0	0	0	0	0	0	0	100	0	0	0
74	0	0	0	0	0	0	0	0	100	0	0	0
75	0	0	0	0	0	0	1	0	99	0	0	0

Table C.11 - Summary by PLOT of parental mode of deposition classes.

PLOT	DRAIN#	DRAINR	DRAINW	DRAINM	DRAINI	DRAINP	DRAINV
26	20	0	65	1	0	7	7
27	26	0	60	0	12	1	1
28	1	0	78	2	0	9	9
29	30	0	47	23	0	0	0
30	0	18	0	0	41	8	33
31	0	13	4	0	33	33	17
32	3	7	64	10	0	9	7
33	0	0	76	0	5	9	10
34	0	3	66	0	22	0	9
35	0	0	7	38	25	26	4
36	1	0	67	10	1	12	8
37	0	0	80	0	0	10	10
38	0	0	60	7	15	8	10
39	0	2	65	0	9	16	8
40	0	1	16	3	61	17	2
41	6	9	75	0	3	6	2
42	0	0	9	9	58	24	0
43	0	0	5	15	62	17	0
44	0	0	15	17	67	0	0
45	0	0	70	1	29	0	0
46	24	0	20	0	45	5	5
47	0	1	64	0	1	25	10
48	0	1	27	0	41	13	18
49	6	0	74	0	12	4	4
50	0	0	0	0	80	20	0
51	0	0	92	0	8	0	0
52	0	19	60	4	15	1	0
53	0	0	2	1	8	0	88
54	0	0	0	1	56	7	37
55	0	0	0	5	40	35	21
56	0	0	1	18	44	27	10
57	0	0	100	0	0	0	0
58	0	0	77	0	0	15	8
59	0	2	52	25	0	21	0
60	0	0	60	0	0	34	6
61	0	40	28	0	7	18	6
62	0	0	82	0	8	0	10
63	0	6	63	0	31	0	0
64	0	0	66	0	31	3	0
65	0	10	0	0	27	63	0
66	0	0	7	0	67	20	7
67	0	1	30	0	60	5	4
68	0	2	11	3	48	36	0
69	0	32	21	0	44	4	0
70	0	5	22	0	10	46	17
71	0	0	100	0	0	0	0
72	0	1	79	0	11	9	0
73	0	0	76	0	24	0	0
74	0	0	40	39	20	0	0
75	0	1	64	20	9	5	0

Table C.12 - Summary by PLOT of soil drainage classes.

PLOT	Stream Density	No. Lakes	Total Lake Area	Median Size	Max. Size	Mean Size
26	0.509	39	10.900	0.075	3.975	0.2795
27	0.386	49	9.875	0.100	1.675	0.2015
28	0.434	14	2.895	0.088	0.950	0.2068
29	0.230	8	8.750	0.800	3.050	1.0938
30	0.675	3	2.325	0.600	1.625	0.7750
31	0.489	5	7.450	0.200	6.200	1.4900
32	0.531	10	5.000	0.350	1.900	0.5000
33	0.842	9	3.225	0.150	1.325	0.3583
34	0.918	0	0.000	0.000	0.000	0.0000
35	0.710	3	1.150	0.475	0.525	0.3833
36	0.886	15	4.825	0.125	2.725	0.3217
37	0.517	35	17.325	0.075	12.000	0.4950
38	0.640	20	5.525	0.063	2.650	0.2763
39	0.600	16	2.675	0.075	0.675	0.1672
40	0.831	7	0.275	0.025	0.075	0.0393
41	1.105	6	0.725	0.113	0.275	0.1208
42	0.935	1	0.900	0.900	0.900	0.9000
43	0.975	2	0.075	0.038	0.050	0.0375
44	1.503	4	0.100	0.025	0.025	0.0250
45	0.927	11	1.775	0.150	0.425	0.1614
46	0.687	36	5.800	0.100	1.200	0.1611
47	0.678	11	1.625	0.050	0.600	0.1477
48	0.732	14	5.525	0.288	0.850	0.3946
49	0.826	17	1.275	0.050	0.425	0.0750
50	0.486	5	1.750	0.250	0.575	0.3500
51	1.179	0	0	0.000	0.000	0.0000
52	0.763	2	0.075	0.038	0.050	0.0375
53	0.844	8	0.131	0.001	0.075	0.0164
54	0.611	9	2.028	0.050	0.625	0.2253
55	0.777	2	0.45	0.225	0.375	0.2250
56	0.861	1	2	2.000	2.000	2.0000
57	0.726	82	9.925	0.018	3.950	0.1210
58	0.906	28	9.04	0.050	2.575	0.3229
59	1.311	8	7.95	0.750	2.300	0.9938
60	1.005	2	1.6	0.800	1.000	0.8000
61	2.537	0	0	0.000	0.000	0.0000
62	1.926	1	0.075	0.075	0.075	0.0750
63	0.867	60	11.054	0.025	2.875	0.1842
64	0.837	7	0.453	0.025	0.350	0.0647
65	0.962	2	0.076	0.038	0.075	0.0380
66	0.701	1	0.225	0.225	0.225	0.2250
67	0.625	1	0.175	0.175	0.175	0.1750
68	0.822	1	0.05	0.050	0.050	0.0500
69	0.955	1	0.075	0.075	0.075	0.0750
70	0.562	14	0.287	0.001	0.250	0.0205
71	1.090	18	0.14	0.001	0.075	0.0078
72	1.273	11	0.166	0.001	0.075	0.0151
73	0.944	5	0.005	0.001	0.001	0.0010
74	1.391	1	0.001	0.001	0.001	0.0010
75	1.204	3	0.227	0.001	0.225	0.0757

Table C.13 - Summary by PLOT of stream density (km/km^2) and lake area (km^2).

PLOT	WET	B	DM	M	OW	SFF	SM	SS	WS
26	135	106	2	0	15	0	0	12	0
27	55	48	0	0	7	0	0	0	0
28	77	42	1	2	4	0	0	28	0
29	92	61	0	3	6	0	0	22	0
30	84	61	0	14	1	0	0	7	1
31	54	48	0	1	1	0	1	3	0
32	89	53	0	4	0	0	0	31	1
33	38	26	0	0	0	0	0	12	0
34	7	1	1	1	2	0	0	2	0
35	27	17	2	3	1	0	0	4	0
36	81	52	2	19	1	0	0	6	1
37	133	118	0	0	10	0	0	5	0
38	187	179	0	0	1	0	0	7	0
39	144	122	0	1	4	0	0	17	0
40	64	10	1	11	7	0	0	35	0
41	26	1	1	7	3	0	0	14	0
42	59	9	4	8	3	0	1	32	2
43	37	4	2	9	11	0	0	11	0
44	19	1	0	1	8	0	0	9	0
45	52	19	1	1	2	0	0	29	0
46	67	67	0	0	0	0	0	0	0
47	96	87	0	1	6	0	0	2	0
48	62	47	0	0	9	0	0	6	0
49	45	44	0	0	1	0	0	0	0
50	3	2	0	1	0	0	0	0	0
51	20	1	2	4	5	0	3	6	0
52	36	11	1	9	0	0	4	11	0
53	73	49	1	9	0	0	3	11	0
54	66	53	0	3	1	0	0	9	0
55	92	68	0	12	0	0	11	0	1
56	44	30	0	11	2	2	0	1	0
57	102	34	7	4	19	0	0	38	0
58	104	56	0	0	8	0	0	40	0
59	82	35	0	16	16	0	1	9	5
60	33	7	4	12	5	0	0	7	0
61	43	14	13	2	1	1	0	13	0
62	24	1	7	2	4	0	0	10	0
63	108	23	12	13	34	0	2	25	0
64	42	8	6	0	2	0	0	25	1
65	61	16	7	2	0	1	0	34	1
66	111	66	9	2	0	0	0	33	1
67	129	81	20	2	0	2	0	24	0
68	73	47	4	1	0	0	0	21	0
69	41	21	2	0	2	0	0	16	0
70	40	24	1	2	1	0	0	12	0
71	59	7	9	3	2	0	0	38	0
72	70	0	35	10	19	0	0	6	0
73	30	0	8	1	1	0	0	20	0
74	24	2	7	3	1	1	0	10	0
75	34	0	14	3	1	0	0	16	0

Table C.14 - Total number and dominant class of wetlands in PLOTs.

Plot	N	MSIZE	MDSIZE	MXSIZE	SSIZE	MNOCL	MONOCL
26	135	2.0	0.9	43.8	271.4	2.27	2
27	55	1.9	1.1	15.5	101.9	1.60	1
28	77	3.7	1.7	40.0	286.4	2.12	2
29	92	6.0	2.2	115.9	550.9	2.03	2
30	84	14.5	3.7	346.3	1220.4	1.81	2
31	54	39.3	4.1	700.0	2124.8	1.80	2
32	89	7.3	2.8	94.0	646.0	2.01	2
33	38	4.6	2.6	18.5	173.1	2.13	2
34	7	2.7	1.1	8.1	18.8	2.29	2
35	27	17.2	2.5	124.7	463.9	2.44	2
36	81	4.4	1.7	99.2	355.6	2.17	2
37	133	2.0	1.2	11.1	264.5	2.13	2
38	187	5.2	1.5	118.0	969.2	2.07	2
39	144	4.5	2.0	40.0	647.7	2.19	2
40	64	2.2	1.1	20.9	141.2	1.97	2
41	26	18.2	0.8	263.7	472.3	1.73	1
42	59	8.1	2.9	94.1	478.8	2.39	2
43	37	1.6	0.7	9.0	60.3	1.95	2
44	19	1.4	0.6	5.4	26.5	1.89	2
45	52	7.1	5.2	43.7	368.8	2.19	2
46	67	6.3	2.8	100.4	420.9	2.04	2
47	96	5.6	2.0	75.0	541.7	2.20	2
48	62	13.7	7.0	77.0	851.0	2.31	2
49	45	1.5	0.8	8.1	68.5	2.00	2
50	3	2.5	2.4	7.2	12.4	1.60	1
51	20	2.4	0.8	16.6	49.7	1.43	1
52	36	2.5	1.6	12.5	90.8	1.89	1
53	73	16.3	4	201.6	1189.0	1.75	2
54	66	23.1	2	435	1525.1	2.18	1
55	92	6.8	2	156.5	629.6	1.68	1
56	44	5.3	2.4	50.6	244.3	1.65	1
57	102	9.1	3.6	91.6	924.0	2.67	2
58	104	6.5	1.6	101.8	673.2	2.24	2
59	82	11.6	3	201.6	952.9	2.01	2
60	33	29.2	2.4	681.9	1022.0	2.40	1
61	43	25.5	1.6	794.1	1124.0	2.16	2
62	24	2.0	1	7.6	47.3	1.54	1
63	108	10.6	1.6	790	1164.0	1.85	2
64	42	4.1	2	29.2	173.5	2.64	2
65	61	6.0	1.8	82.3	372.0	2.35	2
66	111	4.7	1.6	89.9	517.8	2.05	2
67	129	7.9	1.6	378.9	1033.2	2.28	2
68	73	8.4	2	148.3	612.1	2.23	2
69	41	8.3	2	103.6	348.0	2.07	2
70	40	20.4	4	158.4	814.0	2.38	2
71	59	3.9	2	26	227.6	2.08	2
72	70	16.5	8	88	1152.0	1.79	1
73	30	6.9	1.2	110	213.5	1.77	1
74	24	2.4	1	16.2	57.0	1.79	1
75	34	2.4	1.2	20.2	82.4	1.76	2

Table C.15 - Size and number of classes of wetlands in PLOTs.

Plot	MCOV	MOCOV	INTER1	INTER2	INTER3
26	5.16	4.5	97.04	2.96	0
27	4.83	4.5	100	0	0
28	4.64	4.5	93.51	3.9	2.6
29	4.52	4.5	91.21	7.69	1.1
30	4.68	4.5	95.24	4.76	0
31	4.58	4.5	100	0	0
32	4.50	4.5	93.26	5.62	1.12
33	4.78	4.5	94.74	5.26	0
34	4.71	4.5	85.71	14.29	0
35	4.61	4.5	92.59	3.7	3.7
36	4.76	4.5	95.06	3.7	1.23
37	4.76	4.5	100	0	0
38	4.53	4.5	98.93	1.07	0
39	4.59	4.5	98.61	1.39	0
40	4.48	4.5	96.88	3.13	0
41	4.50	4.5	92.31	3.85	3.85
42	4.55	4.5	69.49	30.51	0
43	4.34	4.5	97.3	2.7	0
44	3.87	4.5	100	0	0
45	4.70	4.5	94.23	5.77	0
46	4.50	4.5	100	0	0
47	4.55	4.5	96.88	3.13	0
48	4.43	4.5	100	0	0
49	4.47	4.5	100	0	0
50	4.50	4.5	100	0	0
51	4.50	4.5	100	0	0
52	4.50	4.5	100	0	0
53	4.50	4.5	97.26	2.74	0
54	4.52	4.5	98.48	1.52	0
55	4.52	4.5	100	0	0
56	4.60	4.5	97.83	2.17	0
57	4.90	4.5	87.25	12.75	0
58	4.75	4.5	95.19	4.81	0
59	4.81	4.5	100	0	0
60	4.59	4.5	85.71	14.29	0
61	4.50	4.5	88.64	11.36	0
62	4.50	4.5	95.83	4.17	0
63	4.64	4.5	99.08	0.92	0
64	4.61	4.5	80.95	19.05	0
65	4.50	4.5	72.13	26.23	1.64
66	4.51	4.5	92.79	7.21	0
67	4.50	4.5	94.57	5.43	0
68	4.50	4.5	90.41	9.59	0
69	4.54	4.5	95.12	4.88	0
70	4.50	4.5	80	17.5	2.5
71	4.50	4.5	77.97	22.03	0
72	4.54	4.5	100	0	0
73	4.50	4.5	86.67	13.33	0
74	4.50	4.5	79.17	20.83	0
75	4.54	4.5	88.24	11.76	0

Table C.16 - Vegetative cover score and vegetative interspersion of wetlands in PLOTs.

Plot	CTYPE1	CTYPE2	CTYPE3	CTYPE4	CTYPE5	CTYPE6	CTYPE7	CTYPE8
26	56.3	14.07	10.37	13.33	2.22	2.22	0.74	0.74
27	60	25.45	0	10.91	0	3.64	0	0
28	84.42	5.19	5.19	1.3	1.3	0	0	2.6
29	89.01	5.49	2.2	0	0	0	1.1	2.2
30	92.86	0	1.19	2.38	2.38	0	0	1.19
31	92.59	3.7	1.85	1.85	0	0	0	0
32	98.88	1.12	0	0	0	0	0	0
33	86.84	0	7.89	5.26	0	0	0	0
34	57.14	0	0	14.29	0	14.29	0	14.29
35	66.67	25.93	7.41	0	0	0	0	0
36	62.96	25.93	4.94	6.17	0	0	0	0
37	84.96	2.26	8.27	4.51	0	0	0	0
38	96.79	1.6	1.07	0.53	0	0	0	0
39	95.14	1.39	0	2.08	0.69	0.69	0	0
40	87.5	0	1.56	1.56	0	3.13	0	6.25
41	76.92	7.69	0	0	3.85	0	0	11.54
42	71.19	13.56	5.08	0	1.69	1.69	0	6.78
43	59.46	0	2.7	2.7	2.7	5.41	0	27.03
44	57.89	0	0	0	0	0	0	42.11
45	78.85	3.85	7.69	3.85	0	0	1.92	3.85
46	98.51	1.49	0	0	0	0	0	0
47	83.33	6.25	3.13	1.04	0	2.08	1.04	3.13
48	74.19	6.45	3.23	1.61	0	3.23	0	11.29
49	97.78	0	0	0	0	0	0	2.22
50	100	0	0	0	0	0	0	0
51	52.38	0	0	0	0	4.76	4.76	38.1
52	83.33	0	2.78	5.56	0	0	0	8.33
53	93.15	5.48	0	0	0	1.37	0	0
54	96.97	1.52	0	0	0	1.52	0	0
55	86.96	4.35	2.17	1.09	3.26	2.17	0	0
56	93.48	6.52	0	0	0	0	0	0
57	47.06	24.51	4.9	1.96	0	12.75	0	8.82
58	72.12	18.27	0.96	2.88	0	2.88	0	2.88
59	80.49	2.44	0	1.22	1.22	1.22	2.44	10.98
60	68.57	5.71	5.71	5.71	0	0	0	14.29
61	50	20.45	4.55	0	0	0	0	25
62	41.67	4.17	8.33	4.17	0	0	0	41.67
63	45.87	6.42	4.59	6.42	0.92	8.26	0	27.52
64	45.24	23.81	9.52	4.76	0	2.38	0	14.29
65	55.74	26.23	11.48	0	0	1.64	0	4.92
66	81.98	9.01	3.6	0	0	0	1.8	3.6
67	74.42	10.85	2.33	2.33	0	0	0	10.08
68	83.56	9.59	4.11	0	0	0	0	2.74
69	85.37	2.44	2.44	0	0	2.44	0	7.32
70	80	10	5	2.5	0	0	0	2.5
71	45.76	23.73	8.47	1.69	0	11.86	0	8.47
72	8.57	10	4.29	1.43	0	27.14	0	48.57
73	36.67	33.33	3.33	0	0	0	0	26.67
74	33.33	37.5	4.17	0	0	4.17	0	20.83
75	29.41	23.53	2.94	2.94	0	5.88	0	35.29

Table C.17 - Percentage of wetlands in vegetative cover type categories by Plot.

Plot	MJUXT	MOJUXT	JP1	JP2	JP3	JP4	JP5	JP6	JP7
26	5.60	6	23.7	59.26	0	0.74	3.7	9.63	2.96
27	4.84	4	9.09	36.36	0	5.45	9.09	36.36	3.64
28	4.49	4	36.36	5.19	0	2.6	3.9	35.06	16.88
29	4.76	6	41.76	15.38	0	0	0	19.78	23.08
30	4.07	6	25	23.81	0	0	3.57	2.38	45.24
31	4.22	6	20.37	24.07	0	1.85	1.85	18.52	33.33
32	5.01	6	53.93	11.24	0	1.12	3.37	15.73	14.61
33	5.47	6	71.05	2.63	0	13.16	0	13.16	0
34	5.14	6	57.14	0	0	14.29	0	28.57	0
35	5.33	6	44.44	25.93	0	0	0	25.93	3.7
36	5.43	6	22.22	48.15	1.23	2.47	3.7	22.22	0
37	5.23	6	36.09	25.56	0	0	0.75	37.59	0
38	5.10	6	25.13	31.55	0	0	0.53	41.18	1.6
39	3.17	2	11.11	13.19	0	3.47	6.25	0	65.97
40	5.19	6	3.13	60.94	0	4.69	1.56	25	4.69
41	5.31	6	42.31	23.08	3.85	0	3.85	23.08	3.85
42	5.15	6	27.12	33.9	0	0	5.08	30.51	3.39
43	4.00	2	29.73	10.81	0	8.11	8.11	2.7	40.54
44	3.05	2	0	10.53	0	31.58	0	0	57.89
45	4.46	6	13.46	36.54	0	11.54	5.77	5.77	26.92
46	5.67	6	88.06	1.49	0	2.99	0	1.49	5.97
47	2.75	2	11.46	1.04	1.04	3.13	2.08	7.29	73.96
48	3.48	2	22.58	3.23	0	6.45	4.84	11.29	51.61
49	3.29	4	2.22	0	0	0	2.22	57.78	37.78
50	2.67	2	0	0	0	0	0	33.33	66.67
51	4.48	6	38.1	14.29	0	9.52	4.76	4.76	28.57
52	4.72	6	41.67	16.67	0	0	5.56	13.89	22.22
53	4.33	4	23.29	12.33	0	6.85	6.85	31.51	19.18
54	3.70	2	19.7	9.09	0	1.52	3.03	22.73	43.94
55	3.57	2	21.74	14.13	0	6.52	0	0	57.61
56	3.30	2	19.57	4.35	0	8.7	6.52	2.17	58.7
57	5.33	6	51.96	25.49	0	0	1.96	9.8	10.78
58	4.35	6	28.85	23.08	0	4.81	4.81	3.85	34.62
59	5.61	6	71.95	13.41	0	0	2.44	7.32	4.88
60	5.03	6	40	25.71	0	2.86	0	17.14	14.29
61	4.86	4	45.45	2.27	0	4.55	9.09	34.09	4.55
62	4.92	6	41.67	12.5	0	12.5	20.83	4.17	8.33
63	5.39	6	59.63	13.76	0	0.92	3.67	18.35	3.67
64	5.14	6	42.86	16.67	0	0	23.81	14.29	2.38
65	4.66	6	19.67	26.23	0	3.28	16.39	21.31	13.11
66	3.75	2	10.81	17.12	0	0	7.21	24.32	40.54
67	3.64	2	14.73	9.3	0	0.78	6.2	27.13	41.86
68	3.70	2	13.7	12.33	0	2.74	8.22	21.92	41.1
69	4.00	2	0.33	0.61	0	0.11	0.17	0.11	0.94
70	3.45	2	0.5	0.11	0	0	0.22	0.17	1.21
71	5.12	6	1.32	0.83	0	0.11	0.33	0.33	0.33
72	5.60	6	2.09	1.05	0	0.11	0.33	0.22	0.06
73	5.60	6	0.55	0.77	0	0.06	0.22	0.06	0
74	5.33	6	0.72	0.17	0	0.11	0.28	0.06	0
75	4.24	4	0.44	0.11	0	0.33	0.55	0.11	0.33

Table C.18 - Juxtaposition scores and % of wetlands in juxtaposition categories by PLOT.

Plot	SITE1	SITE2	SITE3	SITE6	SITE7	SITE8	MFOR	MOPEN
26	24.44	48.89	26.67	0	0	0	92.96	6.30
27	40	30.91	29.09	0	0	0	73.64	26.36
28	53.25	27.27	18.18	0	0	1.3	96.10	3.90
29	49.45	26.37	23.08	0	1.1	0	98.91	1.09
30	51.19	23.81	25	0	0	0	100.00	0.00
31	57.41	25.93	14.81	0	0	1.85	100.00	0.00
32	31.46	52.81	15.73	0	0	0	100.00	0.00
33	15.79	68.42	15.79	0	0	0	100.00	0.00
34	28.57	28.57	28.57	14.29	0	0	64.29	35.71
35	37.04	44.44	11.11	7.41	0	0	90.74	9.26
36	22.22	35.8	41.98	0	0	0	95.68	4.32
37	37.59	36.09	26.32	0	0	0	98.87	1.13
38	44.39	43.32	12.3	0	0	0	96.26	3.74
39	68.06	25	6.94	0	0	0	99.31	0.69
40	32.81	62.5	4.69	0	0	0	100.00	0.00
41	7.69	76.92	15.38	0	0	0	86.54	13.46
42	42.37	44.07	13.56	0	0	0	78.81	21.19
43	48.65	2.7	48.65	0	0	0	86.49	13.51
44	47.37	0	52.63	0	0	0	81.58	18.42
45	32.69	44.23	23.08	0	0	0	90.38	9.62
46	98.51	1.49	0	0	0	0	100.00	0.00
47	77.08	12.5	10.42	0	0	0	95.31	4.69
48	43.55	16.13	37.1	0	1.61	1.61	100.00	0.00
49	97.78	0	2.22	0	0	0	100.00	0.00
50	66.67	0	33.33	0	0	0	100.00	0.00
51	42.86	57.14	0	0	0	0	88.57	11.43
52	44.44	55.56	0	0	0	0	94.44	5.56
53	67.12	32.88	0	0	0	0	97.67	2.33
54	83.33	15.15	1.52	0	0	0	100.00	0.00
55	80.43	18.48	1.09	0	0	0	100.00	0.00
56	58.7	34.78	6.52	0	0	0	96.74	3.26
57	19.61	50.98	26.47	2.94	0	0	99.02	0.98
58	42.31	41.35	16.35	0	0	0	100.00	0.00
59	17.07	62.2	20.73	0	0	0	90.12	9.88
60	25.71	68.57	5.71	0	0	0	92.00	8.00
61	38.64	61.36	0	0	0	0	100.00	0.00
62	8.33	91.67	0	0	0	0	91.67	8.33
63	17.43	73.39	9.17	0	0	0	100.00	0.00
64	26.19	66.67	7.14	0	0	0	100.00	0.00
65	37.7	62.3	0	0	0	0	100.00	0.00
66	65.77	33.33	0.9	0	0	0	100.00	0.00
67	72.09	27.91	0	0	0	0	100.00	0.00
68	68.49	31.51	0	0	0	0	100.00	0.00
69	58.54	39.02	2.44	0	0	0	100.00	0.00
70	62.5	37.5	0	0	0	0	100.00	0.00
71	30.51	69.49	0	0	0	0	100.00	0.00
72	22.86	74.29	2.86	0	0	0	95.00	5.00
73	3.33	96.67	0	0	0	0	99.17	0.83
74	16.67	83.33	0	0	0	0	100.00	0.00
75	23.53	73.53	2.94	0	0	0	100.00	0.00

Table C.19 - Percentage of wetlands in site type categories and mean score for forest cover and open cover by PLOT.

PLOT	COASTAL	ISLAND	MARINE	ESTUAR	PONDS	PONDSHA	SALTHA	SALTNO
26	0	0	0	0	0	0.0	0.0	0
27	21	17	2	2	0	0.0	0.0	0
28	9	4	1	2	0	0.0	1.0	2
29	0	0	0	0	0	0.0	0.0	0
30	7	0	0	2	0	0.0	108.4	5
31	7	0	0	0	0	0.0	104.0	7
32	0	0	0	0	0	0.0	0.0	0
33	2	0	0	0	0	0.0	13.7	2
34	12	1	1	1	0	0.0	152.3	9
35	17	0	0	1	0	0.0	223.9	16
36	0	0	0	0	0	0.0	0.0	0
37	0	0	0	0	0	0.0	0.0	0
38	0	0	0	0	0	0.0	0.0	0
39	0	0	0	0	0	0.0	0.0	0
40	0	0	0	0	0	0.0	0.0	0
41	0	0	0	0	0	0.0	0.0	0
42	8	0	1	1	0	0.0	39.2	6
43	10	2	0	6	0	0.0	30.0	2
44	11	1	0	5	2	5.0	27.0	3
45	0	0	0	0	0	0.0	0.0	0
46	36	24	1	8	0	0.0	20.7	3
47	1	0	0	1	0	0.0	0.0	0
48	0	0	0	0	0	0.0	0.0	0
49	0	0	0	0	0	0.0	0.0	0
50	8	0	0	0	4	115.7	41.1	4
51	3	0	0	0	0	0.0	62.6	3
52	0	0	0	0	0	0.0	0.0	0
53	0	0	0	0	0	0.0	0.0	0
54	0	0	0	0	0	0.0	0.0	0
55	0	0	0	0	0	0.0	0.0	0
56	0	0	0	0	0	0.0	0.0	0
57	0	0	0	0	0	0.0	0.0	0
58	0	0	0	0	0	0.0	0.0	0
59	0	0	0	0	0	0.0	0.0	0
60	0	0	0	0	0	0.0	0.0	0
61	0	0	0	0	0	0.0	0.0	0
62	0	0	0	0	0	0.0	0.0	0
63	0	0	0	0	0	0.0	0.0	0
64	0	0	0	0	0	0.0	0.0	0
65	0	0	0	0	0	0.0	0.0	0
66	0	0	0	0	0	0.0	0.0	0
67	0	0	0	0	0	0.0	0.0	0
68	0	0	0	0	0	0.0	0.0	0
69	0	0	0	0	0	0.0	0.0	0
70	0	0	0	0	0	0.0	0.0	0
71	0	0	0	0	0	0.0	20.7	3
72	11	0	7	3	0	0.0	1.5	1
73	0	0	0	0	0	0.0	0.0	0
74	0	0	0	0	0	0.0	0.0	0
75	0	0	0	0	0	0.0	0.0	0

Table C.20 - Coastal features for PLOTs.

Plot	MCLIN	MOCLIN	MSCOR	MDSCOR	MXSCOR	SSCOR
26	13.56	0	55.8	55	70	7538
27	12.55	20	52.6	52	65	2891
28	4.68	0	53.9	53	77	4150
29	5.11	0	54.4	54	72	5002
30	6.79	0	53.3	52	77	4481
31	4.07	0	53.9	55	67	2912
32	6.97	0	55.9	57	71	4974
33	7.89	0	57.7	57	71	2194
34	7.14	0	58.0	55	77	406
35	15.93	0	57.7	57	83	1559
36	15.19	0	55.7	54	81	4512
37	8.72	0	53.6	54	65	7123
38	6.42	0	53.3	53	72	9958
39	7.08	0	50.9	49	71	7331
40	15.47	0	54.3	55	64	3475
41	4.23	0	56.3	55	94	1464
42	36.10	70	58.7	57	83	3462
43	3.51	0	52.5	51	83	1944
44	2.63	0	51.1	51	62	971
45	8.27	0	56.2	57	74	2924
46	6.42	0	51.9	53	64	3478
47	1.04	0	50.3	49	67	4824
48	2.42	0	55.0	53	78	3413
49	5.33	0	47.9	48	51	2157
50	0.00	0	50.0	50	51	150
51	0.00	0	52.2	50	64	1097
52	6.39	0	53.6	54	76	1931
53	3.42	0	52.8	52	73	3855
54	2.27	0	51.5	47.5	79	3396
55	3.26	0	50.3	49	71	4624
56	5.43	0	50.7	49.5	76	2332
57	4.22	0	59.4	59	81	6055
58	7.79	0	54.8	55	72	5704
59	13.29	0	56.9	57	71	4665
60	26.57	0	57.9	57	77	2028
61	3.41	0	57.5	56	82	2532
62	6.25	0	55.8	56.5	71	1340
63	24.95	30	55.7	55	71	6072
64	8.57	0	59.9	59	76	2515
65	5.08	0	58.4	57	81	3560
66	8.20	0	52.7	51	76	5855
67	6.51	0	53.0	50	84	6833
68	4.93	0	53.1	51	72	3873
69	8.54	0	53.9	53	74	2210
70	9.50	0	54.9	51	82	2196
71	2.20	0	58.7	57	79	3464
72	4.86	0	57.4	58	74	4018
73	5.00	0	59.2	58.5	74	1775
74	1.25	0	57.9	58.5	66	1390
75	1.76	0	56.8	56	65	1932

Table C.21 - CLI Scores and Golet Scores for wetlands by PLOT.

PLOT	SNOWAPR	SNOWMAY	PPMAY (mm)	PPJUNE (mm)	PPGS (mm)	PPYR (mm)
26	3.79	0.67	114	104	399	1411
27	2.38	0.36	104	83	382	1259
28	1.33	0.17	118	104	412	1392
29	2.50	0.33	120	113	429	1528
30	1.00	0.00	106	116	420	1285
31	1.00	0.00	106	116	420	1285
32	1.45	0.08	105	98	391	1342
33	1.67	0.17	118	98	384	1344
34	1.88	0.09	78	83	329	1154
35	1.92	0.33	94	75	308	1042
36	3.00	0.58	124	100	415	1503
37	1.83	0.09	127	103	416	1534
38	1.50	0.08	103	105	415	1356
39	4.19	0.60	96	88	370	1378
40	3.33	0.33	98	90	367	1221
41	2.83	0.50	119	110	431	1305
42	2.92	0.33	97	90	357	1062
43	3.73	0.47	84	96	346	1227
44	2.17	0.25	116	108	420	1385
45	2.17	0.25	116	108	420	1385
46	2.25	0.25	120	118	435	1442
47	5.25	1.17	99	97	378	1510
48	5.25	1.17	99	97	378	1510
49	4.33	0.67	105	92	407	1756
50	2.33	0.00	74	85	327	1152
51	5.40	1.30	129	113	420	1363
52	3.36	0.42	107	116	389	1168
53	5.17	1.17	110	98	368	1093
54	5.30	1.10	116	95	405	1134
55	2.55	0.27	114	86	360	1053
56	4.17	0.75	115	103	425	1168
57	5.17	0.92	132	115	432	1358
58	3.30	0.30	121	91	396	1167
59	2.98	0.22	79	85	335	1112
60	4.90	0.30	106	105	396	1197
61	3.33	0.25	100	101	415	1144
62	2.08	0.08	104	99	424	1059
63	2.40	0.10	102	113	475	1147
64	4.33	0.08	127	106	444	1138
65	4.33	0.08	127	106	444	1138
66	3.90	0.72	116	93	387	1041
67	3.90	0.72	116	93	387	1041
68	3.25	0.50	121	91	391	1287
69	4.47	0.84	88	75	340	1102
70	4.47	0.84	88	75	340	1102
71	5.08	0.82	113	113	472	990
72	5.30	0.70	89	83	365	973
73	3.64	0.42	87	102	413	984
74	4.38	0.13	89	92	397	982
75	4.38	0.13	89	92	397	982

Table C.22 - Summary by PLOT of days with snow and total precipitation (mm).

PLOT	TMXYR	TMXMAY	TMXGS	TMINYR	TMINGS	TMINAPR	TMINMAY
26	8.6	12.1	17.7	1.4	10.3	-0.4	4.5
27	12.0	16.0	21.0	0.9	8.6	-1.5	3.1
28	11.4	15.0	20.4	0.9	8.6	-1.5	3.1
29	12.7	17.2	22.5	1.1	9.6	-0.3	4.1
30	10.4	12.3	16.5	3.4	9.5	1.9	5.3
31	10.4	12.3	16.5	3.4	9.5	1.9	5.3
32	11.7	16.9	21.7	1.0	9.5	-0.1	4.5
33	11.3	14.8	19.8	2.8	10.0	0.9	5.1
34	11.7	16.1	21.0	2.3	9.9	0.2	4.9
35	11.4	16.0	21.2	2.3	9.9	0.2	4.9
36	10.9	15.5	20.7	0.6	9.3	-0.6	3.8
37	11.0	14.4	20.1	0.2	8.6	-1.5	3.1
38	11.6	16.1	21.5	0.5	9.2	-0.7	3.8
39	10.3	14.2	20.2	-0.8	8.1	-2.7	2.2
40	11.1	15.8	21.0	0.3	9.5	-0.5	3.9
41	10.5	14.9	19.8	1.1	9.5	-0.1	4.4
42	10.9	15.6	21.1	1.9	11.5	0.1	5.8
43	11.2	15.9	21.4	1.4	10.6	-0.1	4.7
44	10.7	15.3	20.8	0.5	9.1	-1.2	3.5
45	10.7	15.3	20.8	0.5	9.1	-1.2	3.5
46	8.7	9.7	15.3	2.7	9.4	-0.2	3.4
47	9.9	13.2	19.3	0.8	8.8	-1.7	2.7
48	9.9	13.2	19.3	0.8	8.8	-1.7	2.7
49	10.2	13.1	19.4	1.6	9.6	-1.2	3.1
50	10.3	13.7	19.4	1.7	9.8	-0.8	3.7
51	10.2	15.8	21.0	-0.4	9.6	-1.8	4.1
52	10.5	16.4	21.4	0.5	10.3	-1.0	4.7
53	10.9	16.6	22.0	0.5	10.4	-0.8	5.0
54	10.4	16.6	21.8	-1.6	8.5	-2.3	3.2
55	10.9	17.0	22.0	1.0	11.0	-0.3	5.5
56	11.2	17.7	22.7	-1.4	8.6	-1.7	3.3
57	10.1	14.8	19.7	-0.3	8.9	-1.2	3.8
58	11.5	17.8	22.8	-0.2	9.9	-0.8	4.6
59	10.6	16.8	21.9	-1.4	9.1	-2.2	3.6
60	10.3	17.3	22.0	-1.5	8.9	-2.1	3.8
61	9.1	16.2	21.1	-2.5	8.4	-2.6	3.3
62	9.8	17.2	21.9	-1.6	9.6	-1.4	4.3
63	9.5	16.9	21.5	-3.8	7.2	-3.7	1.8
64	10.3	17.2	22.4	-2.0	8.7	-2.3	3.0
65	10.3	17.2	22.4	-2.0	8.7	-2.3	3.0
66	10.2	16.4	21.6	-1.4	8.9	-2.2	3.6
67	10.2	16.4	21.6	-1.4	8.9	-2.2	3.6
68	10.4	15.8	21.8	-0.5	9.7	-1.9	3.9
69	9.2	14.5	20.7	-0.5	9.1	-2.6	3.0
70	9.2	14.5	20.7	-0.5	9.1	-2.6	3.0
71	6.6	12.4	17.8	-3.7	6.7	-4.9	0.9
72	8.2	14.9	20.2	-2.1	8.6	-2.7	2.6
73	8.0	15.6	20.6	-3.8	7.3	-3.2	2.2
74	8.3	16.1	20.8	-4.0	7.2	-3.9	2.0
75	8.3	16.1	20.8	-4.0	7.2	-3.9	2.0

Table C.23 - Summary by PLOT of maximum and minimum temperatures (C°).

Appendix D

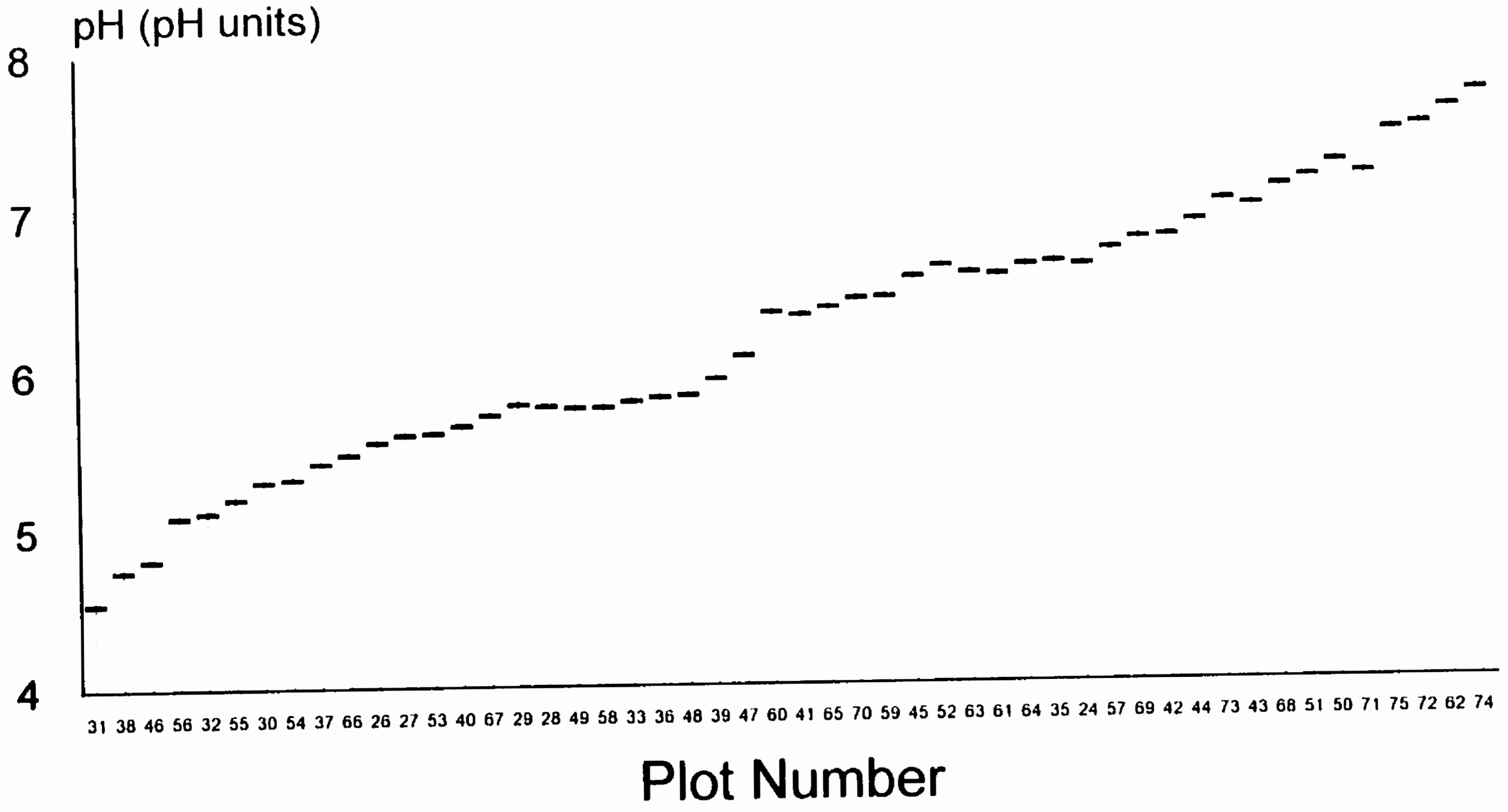

Figure D1 - Least squares mean and standard error of pH (pH units) of surface waters in survey plots.

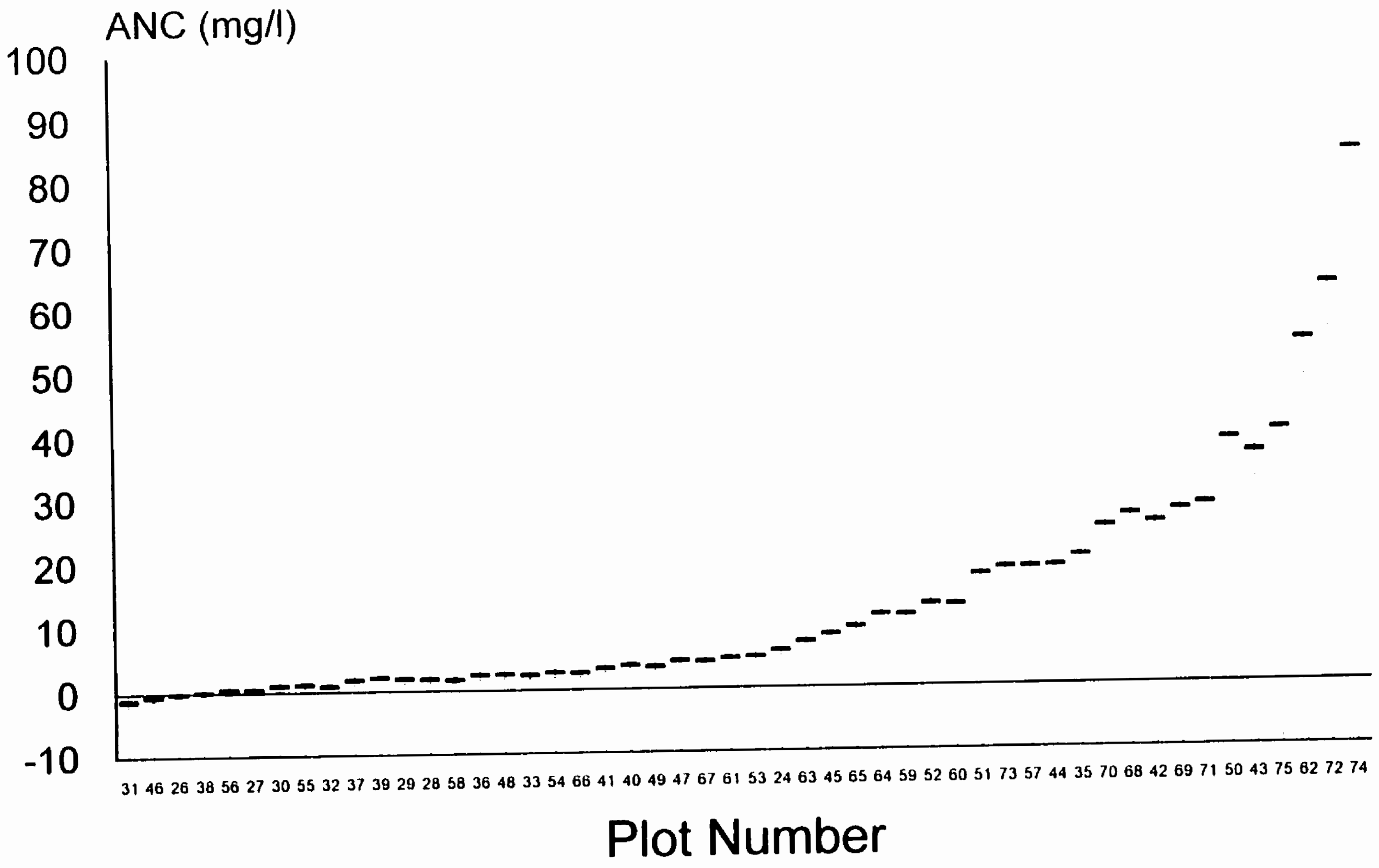

Figure D2 - Least squares mean and standard error of acid neutralising capacity (ANC; mg/l) of surface waters in survey plots.

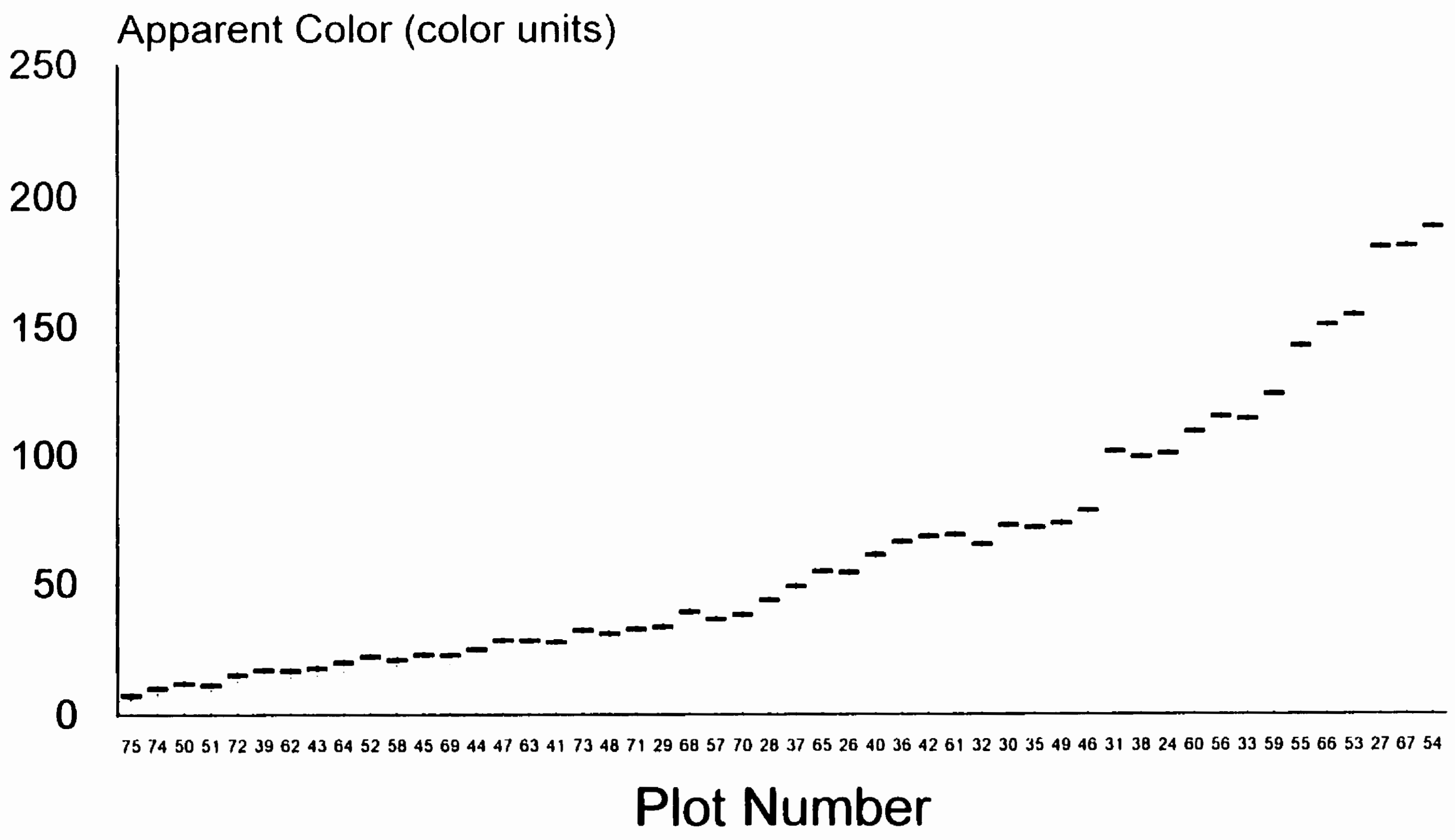

Figure D3 - Least squares mean and standard error of apparent color (color units) of surface waters in survey plots.

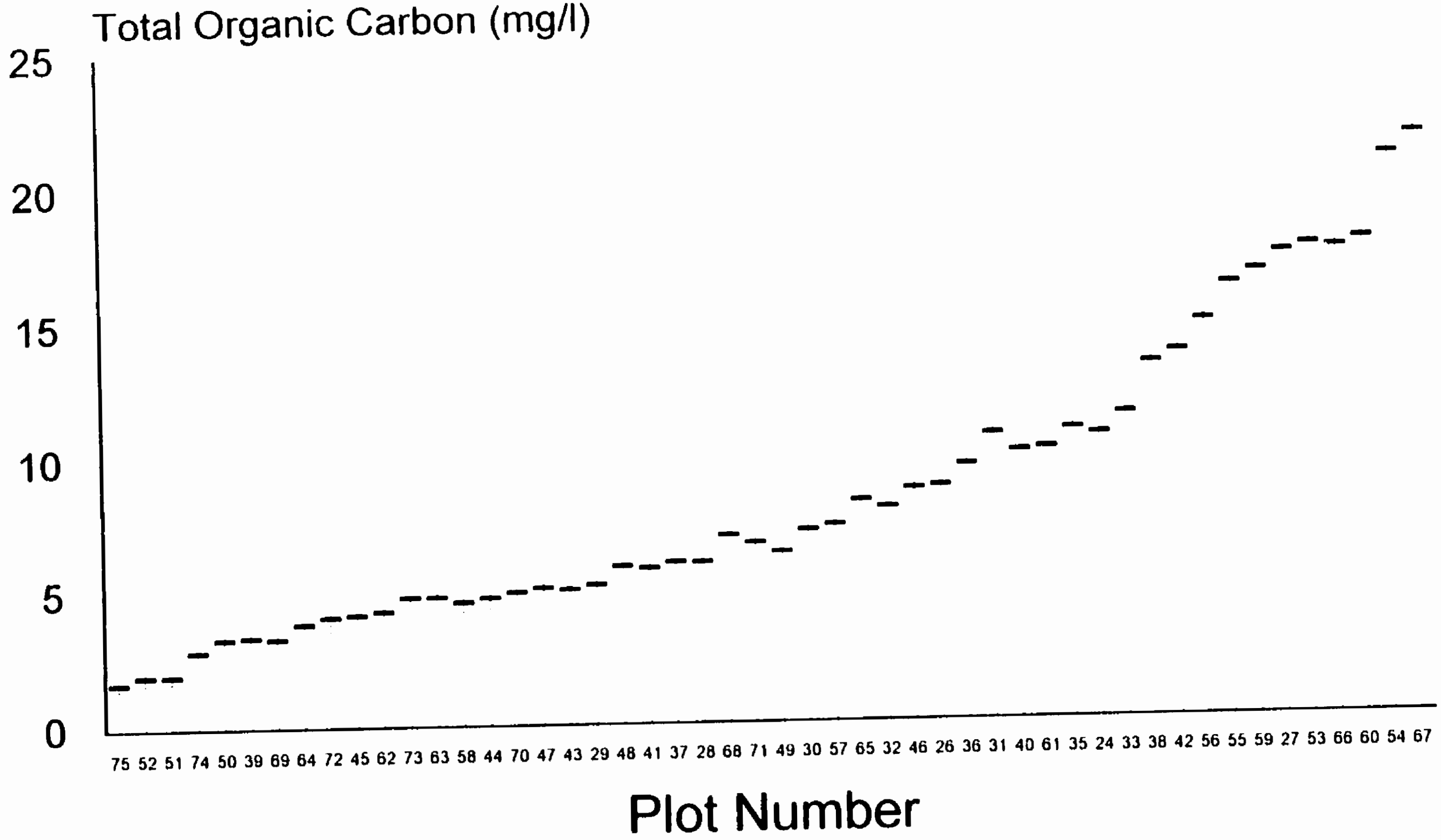

Figure D4 - Least squares mean and standard error of total organic carbon (mg/l) in surface waters of survey plots.

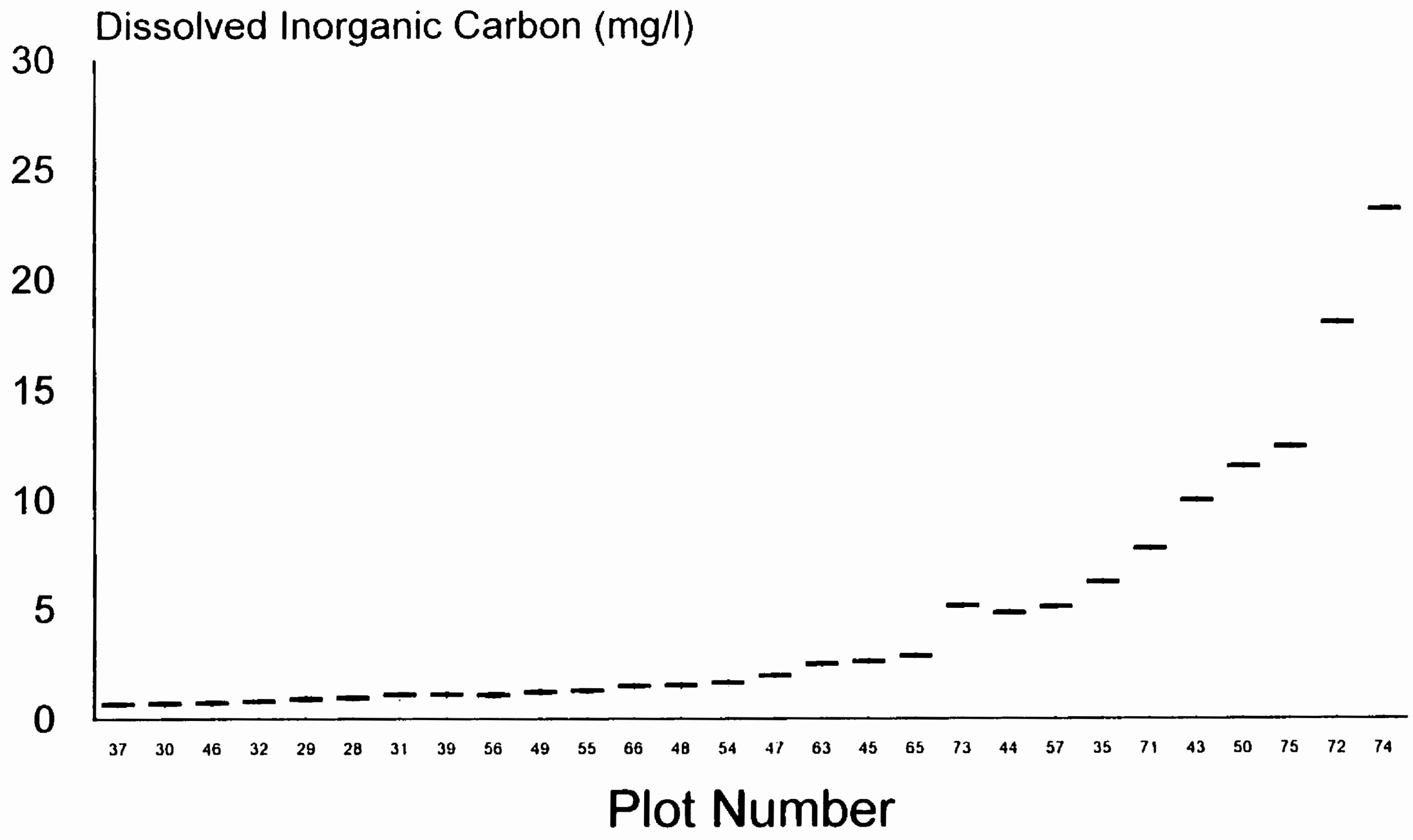

Figure D5 - Least squares mean and standard error of dissolved inorganic carbon (mg/l) in surface waters of survey plots.

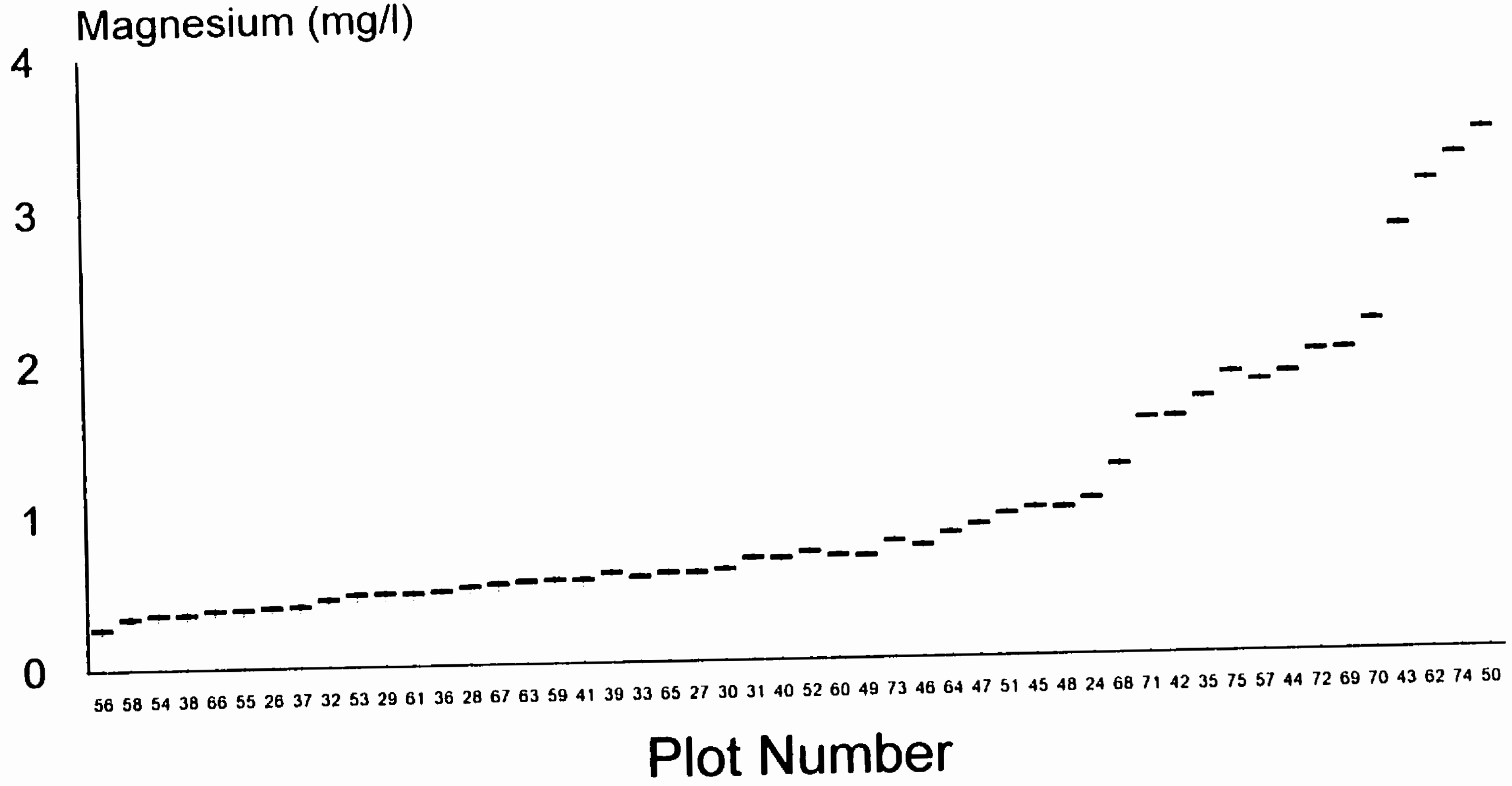

Figure D6 - Least squares mean and standard error of magnesium (mg/l) in surface waters of survey plots.

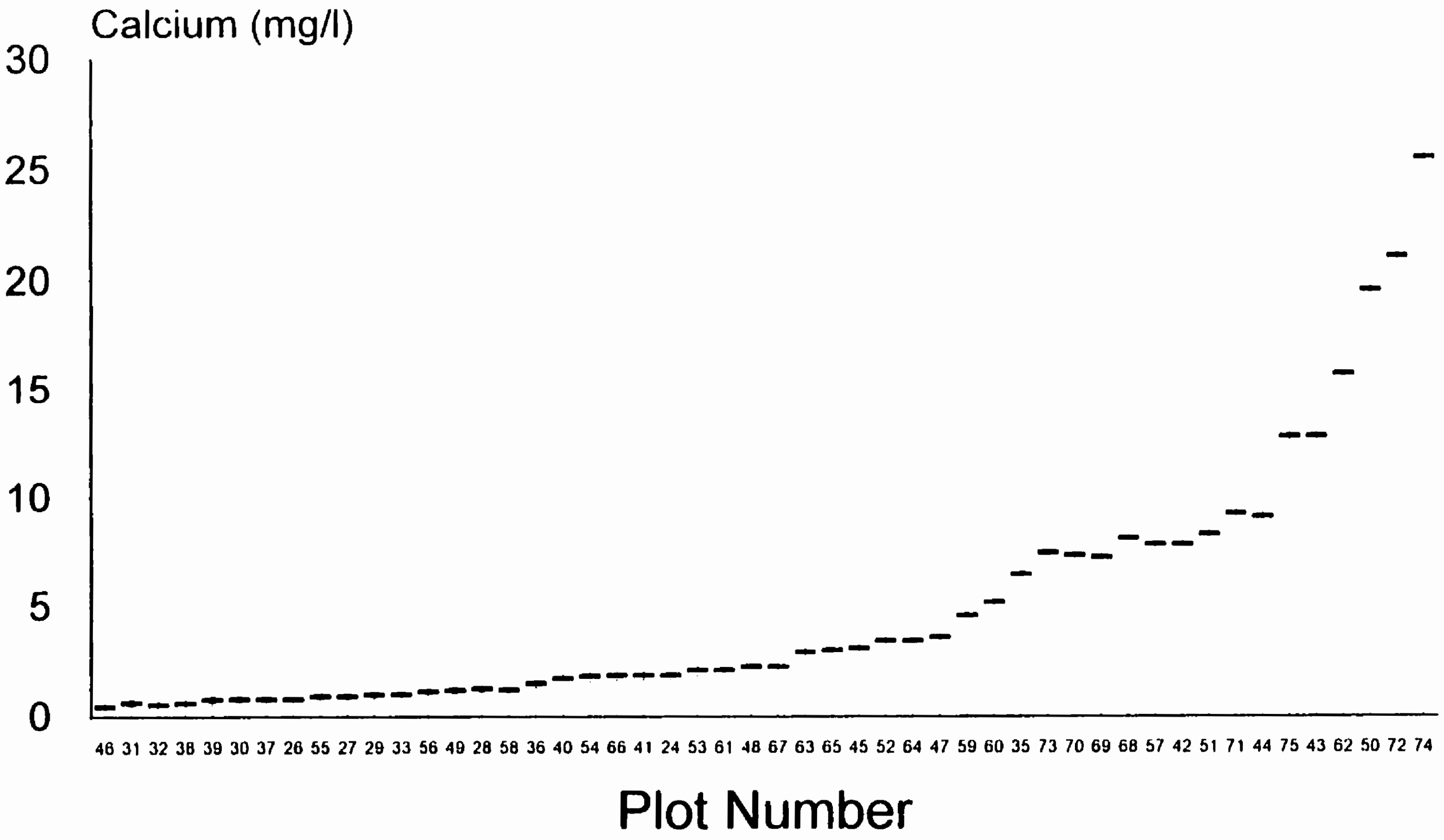

Figure D7 - Least squares mean and standard error of calcium (mg/l) in surface waters of survey plots.

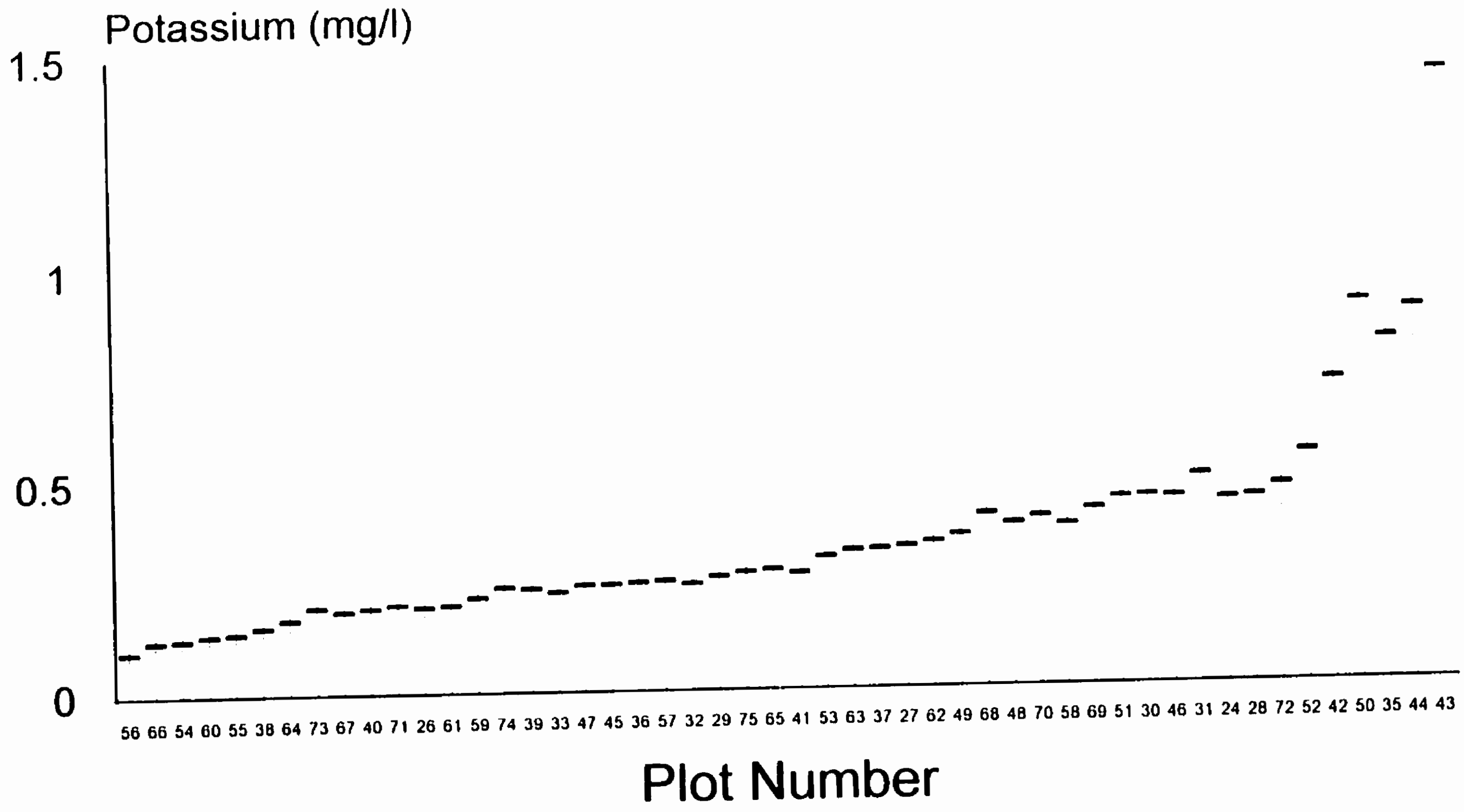

Figure D8 - Least squares mean and standard error of potassium (mg/l) in surface waters of survey plots.

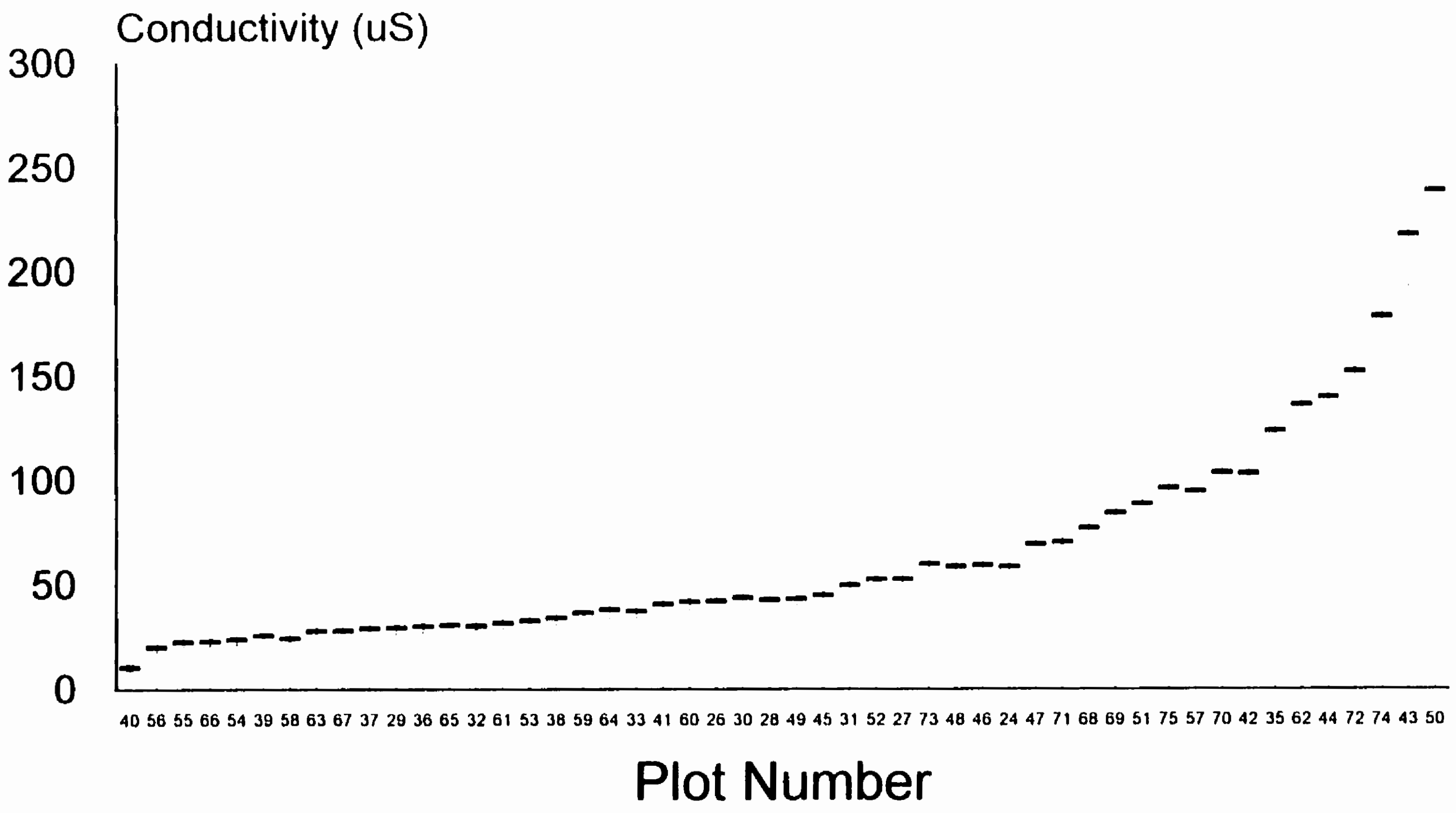

Figure D9 - Least squares mean and standard error of conductivity (uS) of surface waters in survey plots.

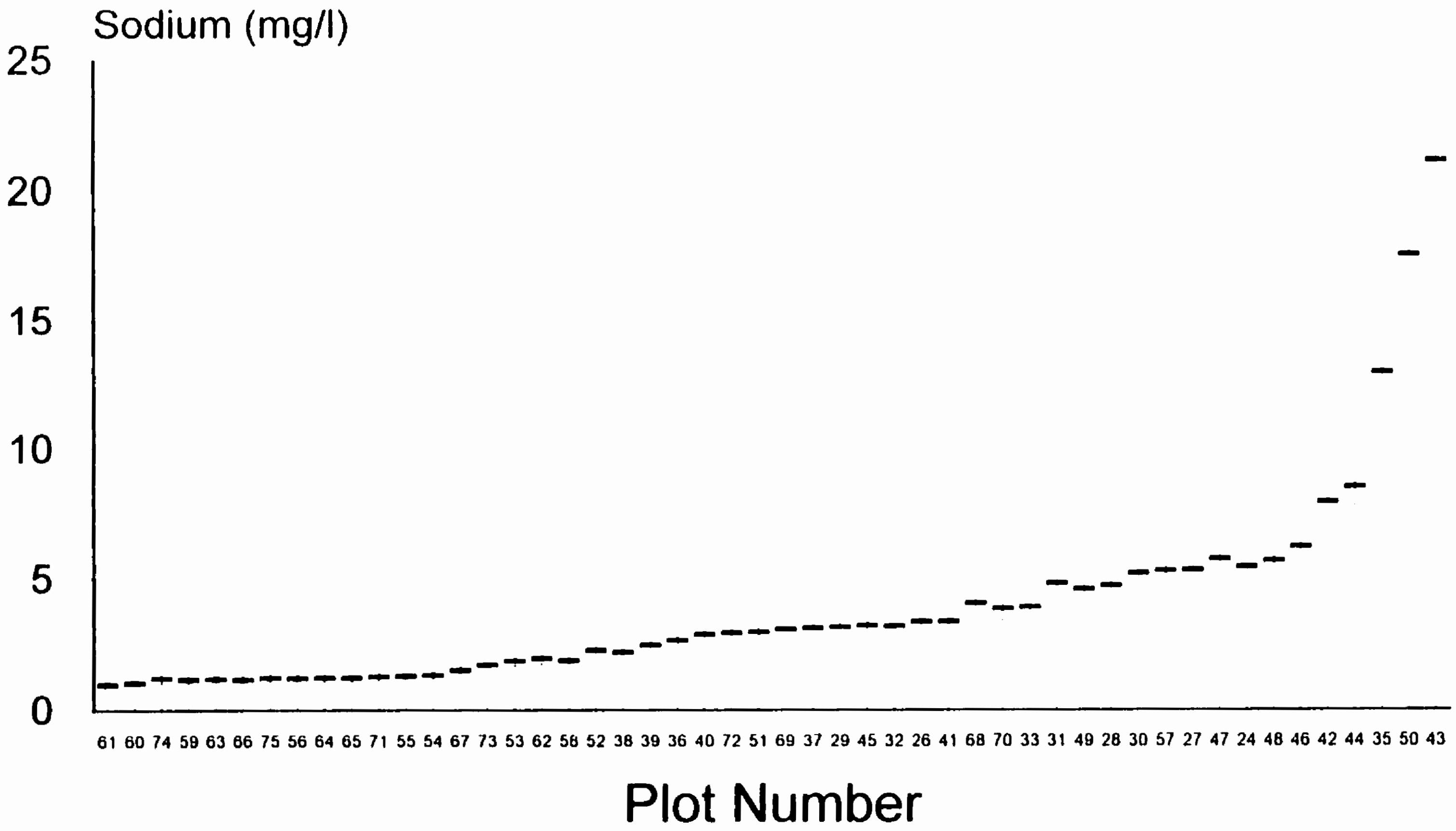

Figure D10 - Least squares mean and standard error of sodium (mg/l) in surface waters of survey plots.

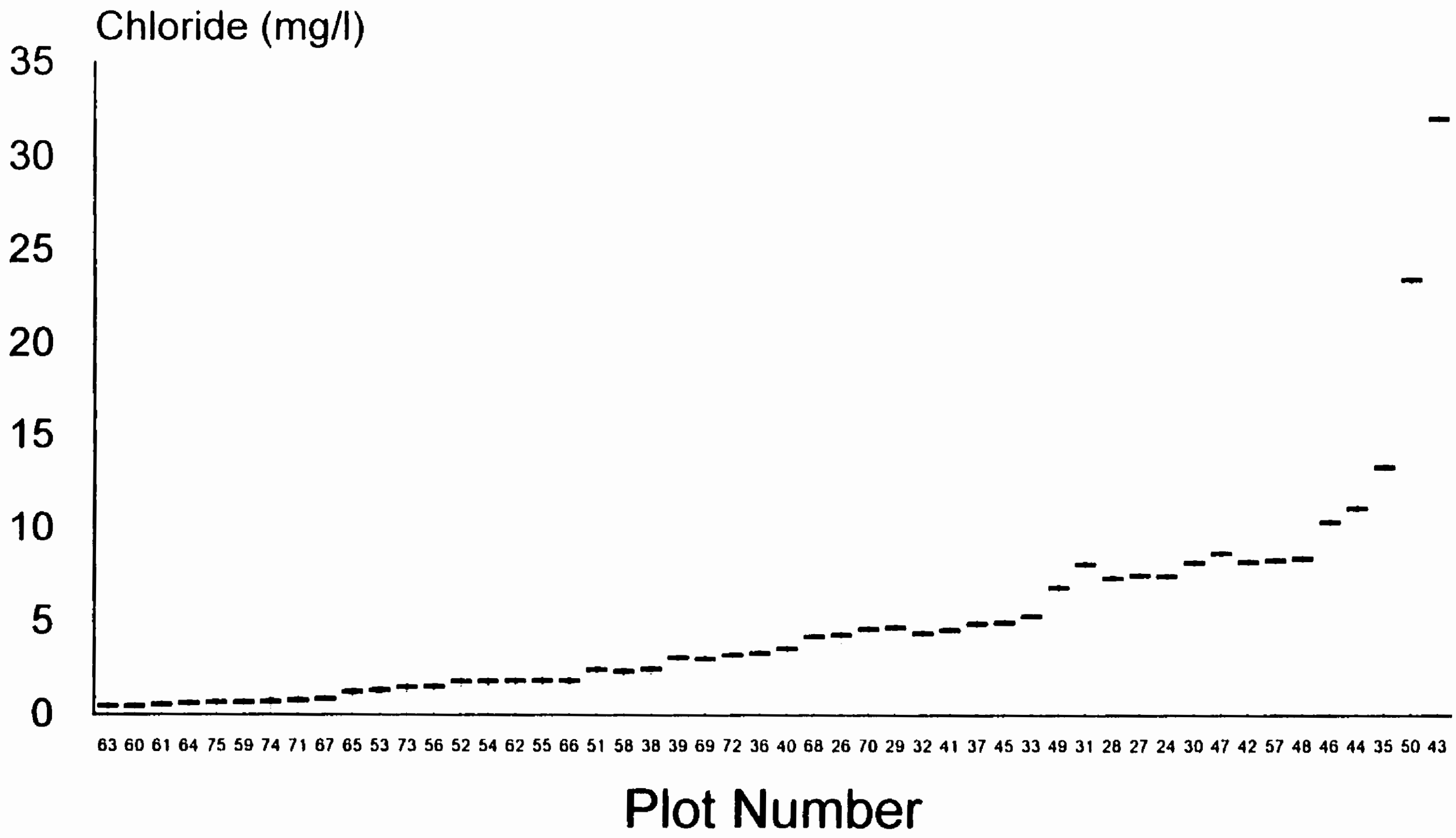

Figure D11 - Least squares mean and standard error of chloride (mg/l) in surface waters of survey plots.

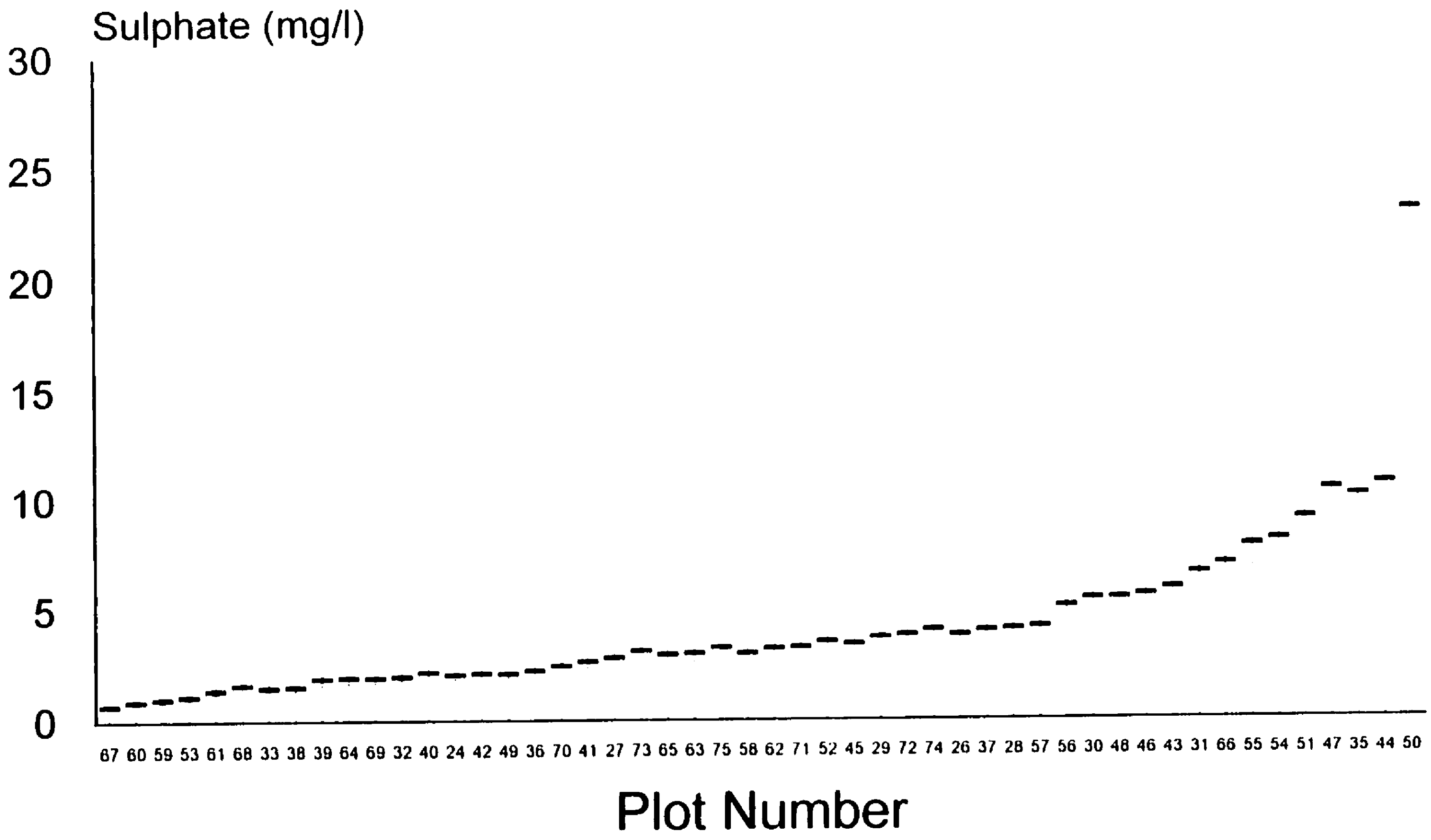

Figure D12 - Least squares mean and standard error of sulphate (mg/l) in surface waters of survey plots.

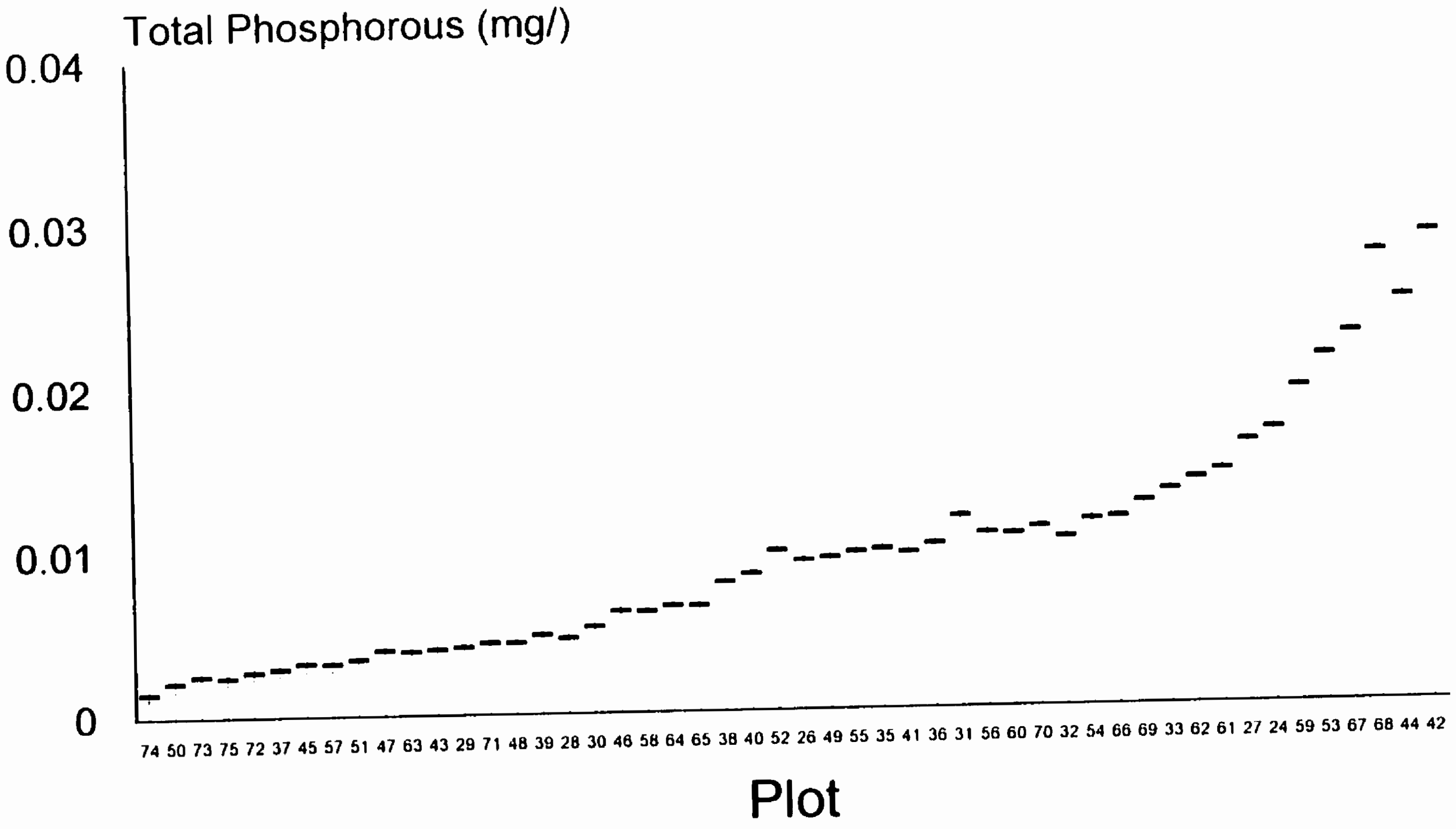

Figure D13 - Least squares mean and standard error of total phosphorous (mg/l) in surface waters of survey plots.

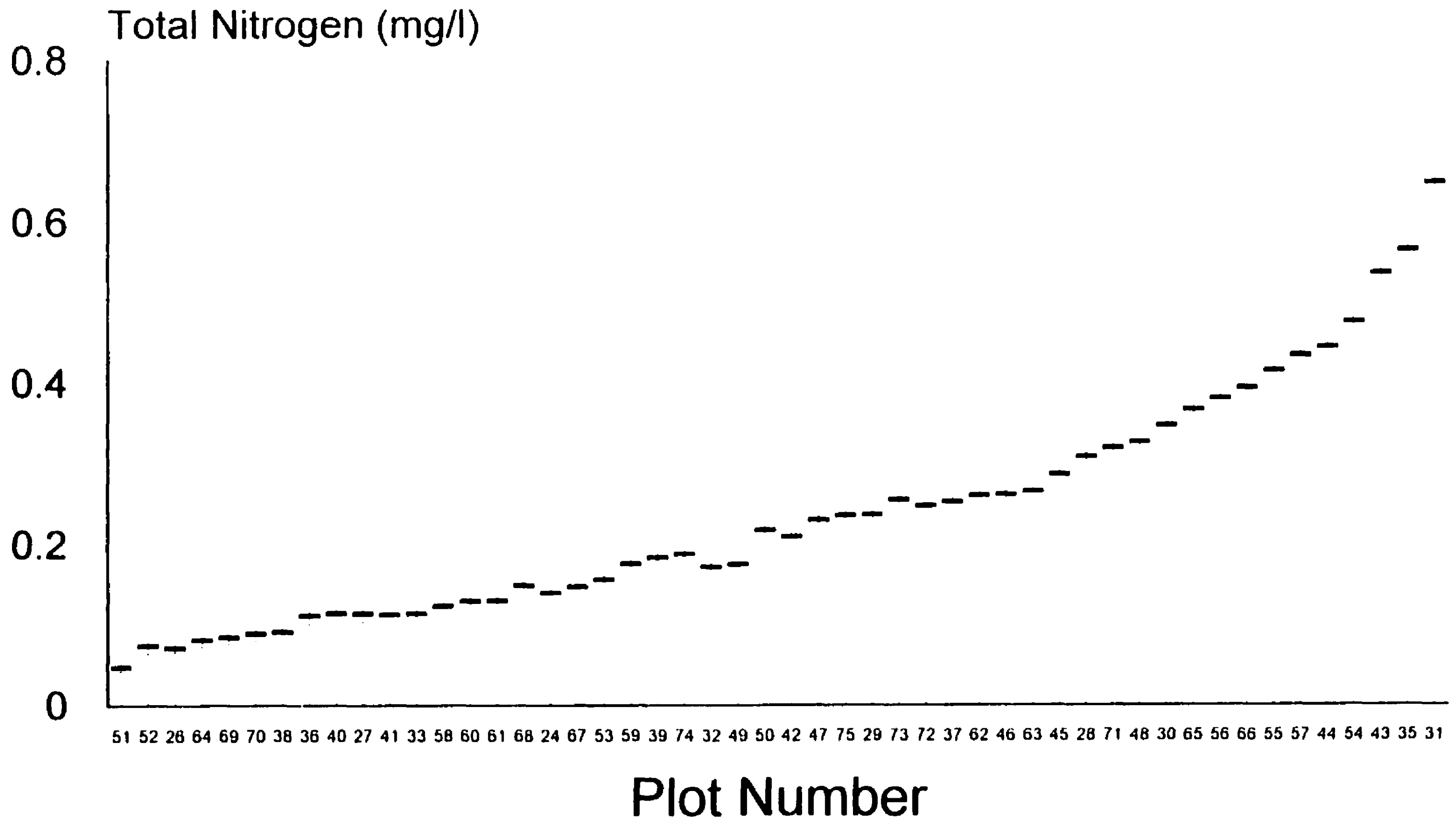

Figure D14 - Least squares mean and standard error of total nitrogen (mg/l) in surface waters of survey plots.

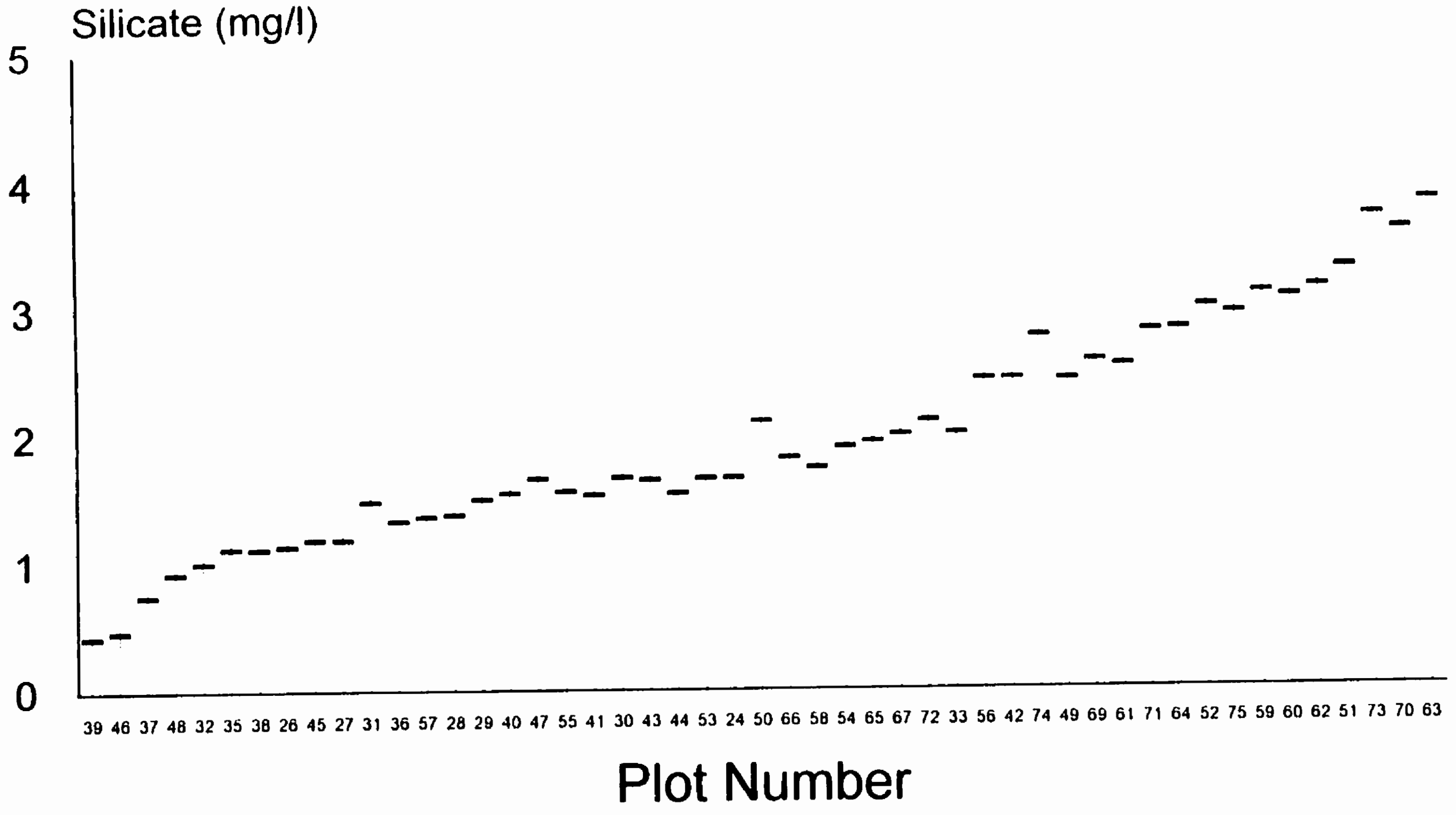

Figure D15 - Least squares mean and standard error of silicate (mg/l) in surface waters of survey plots.

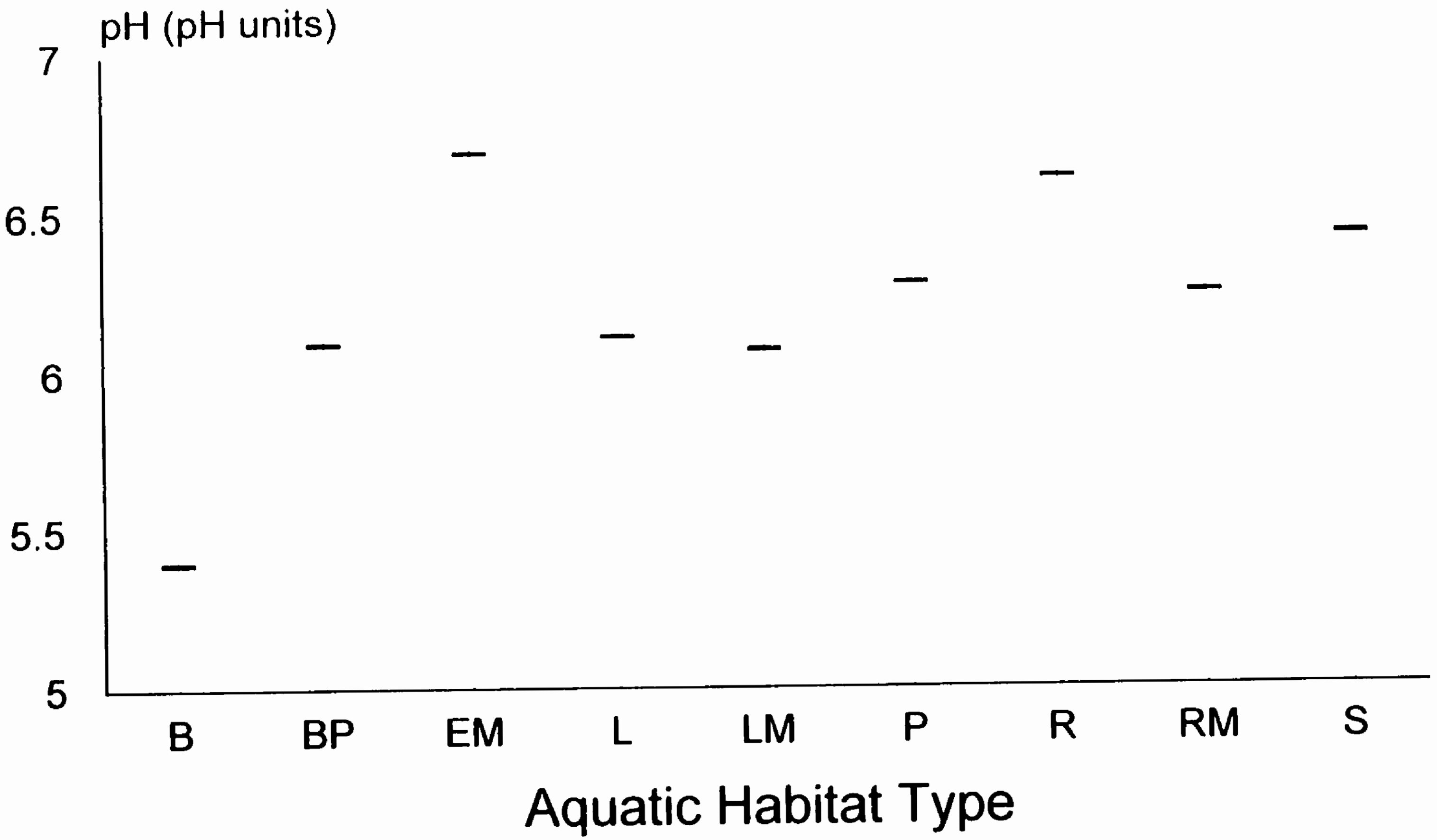

Figure D16 - Least squares mean and standard error of pH (pH units) of surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

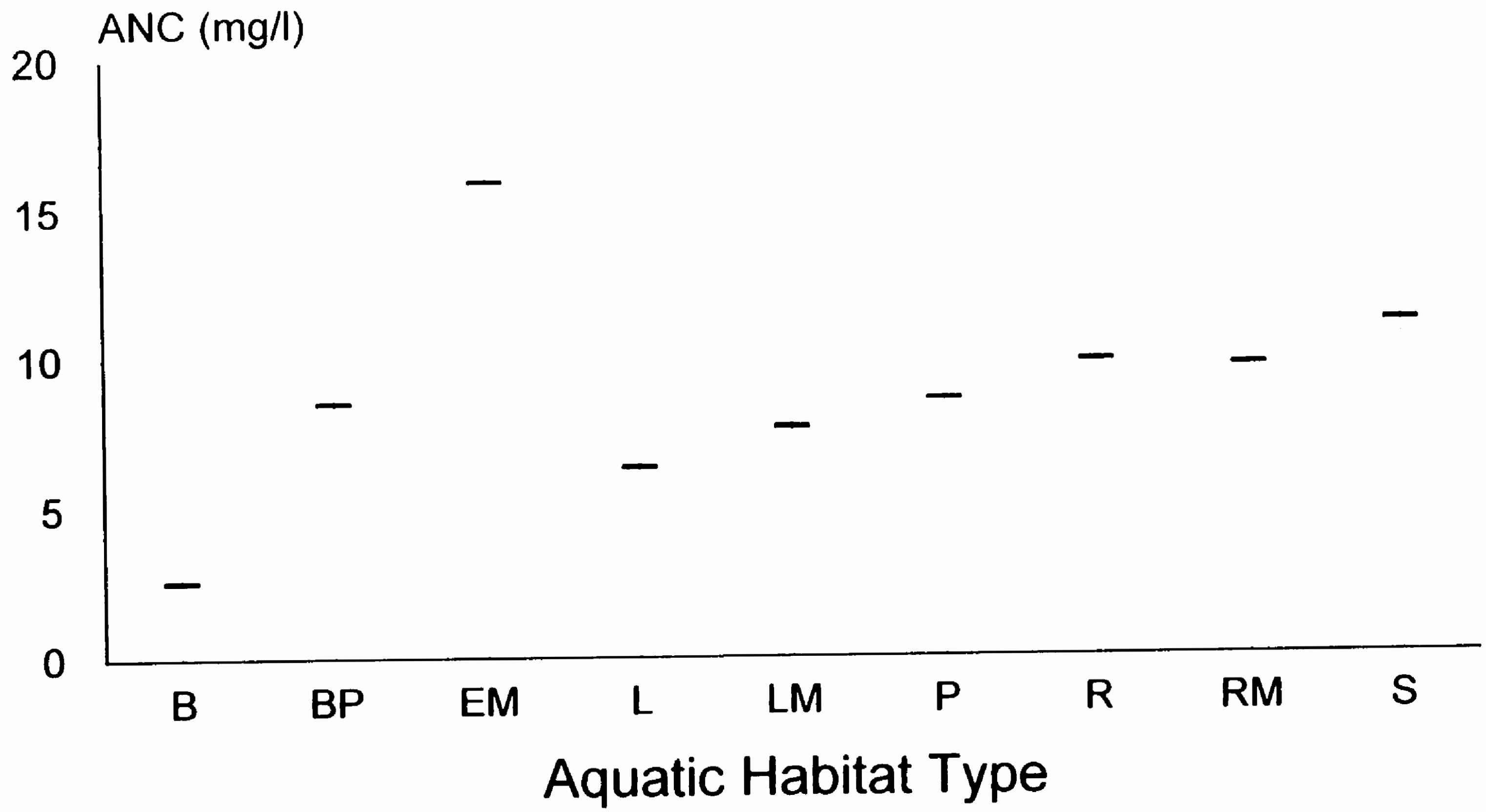

Figure D17 - Least squares mean and standard error of acid neutralising capacity (ANC; mg/l) in surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

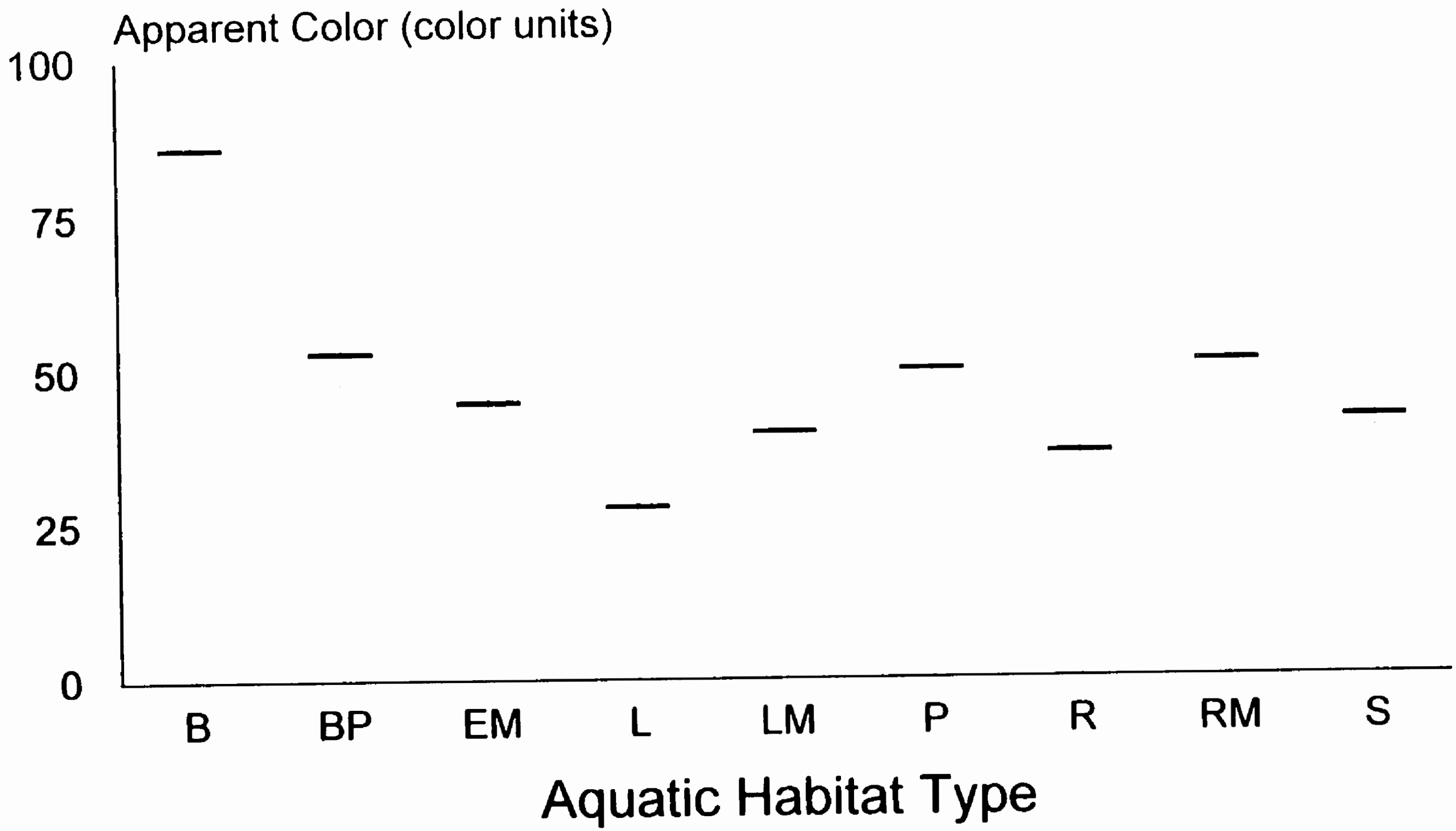

Figure D18 - Least squares mean and standard error of apparent color (color units) of surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

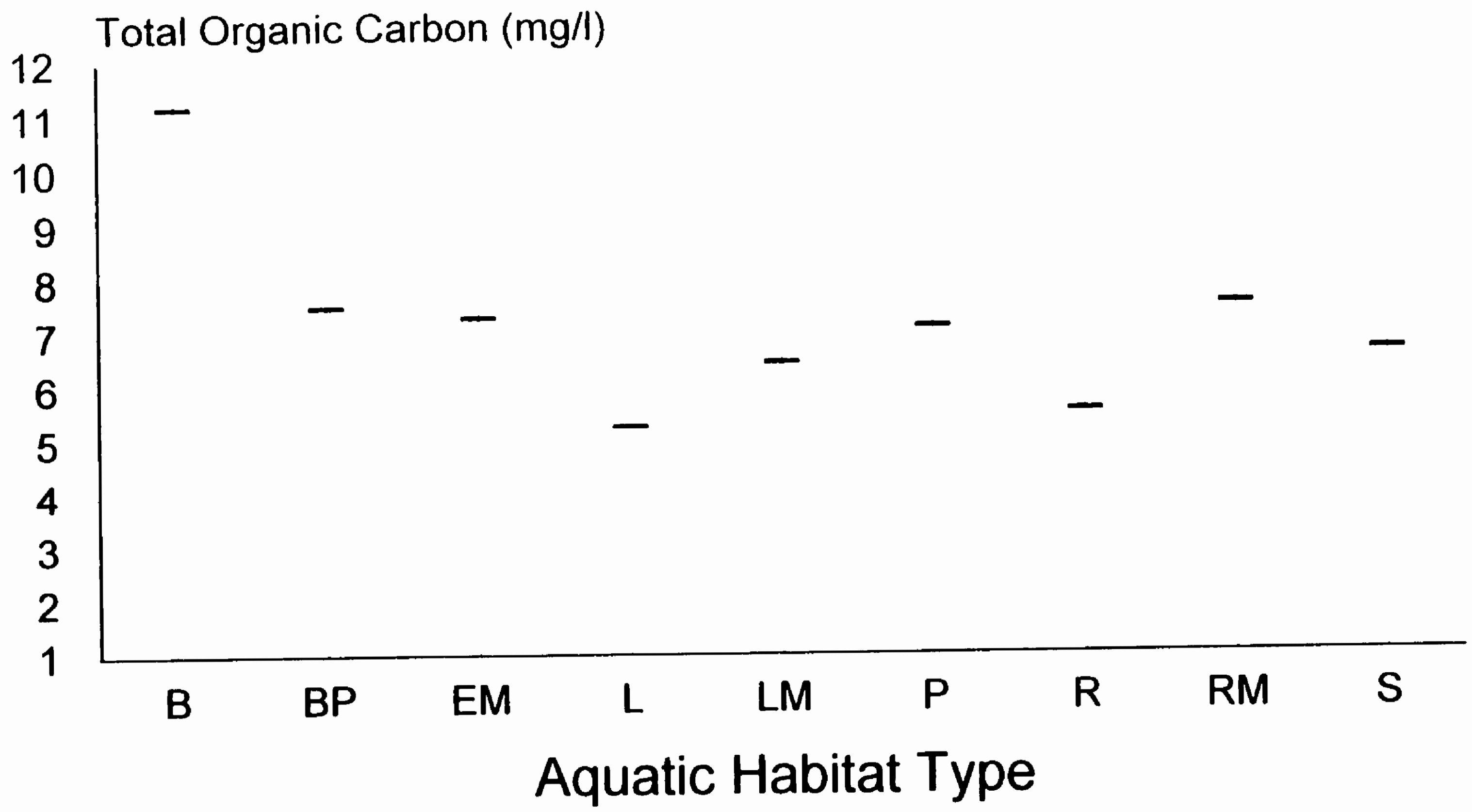

Figure D19 - Least squares mean and standard error of total organic carbon concentration (mg/l) in surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

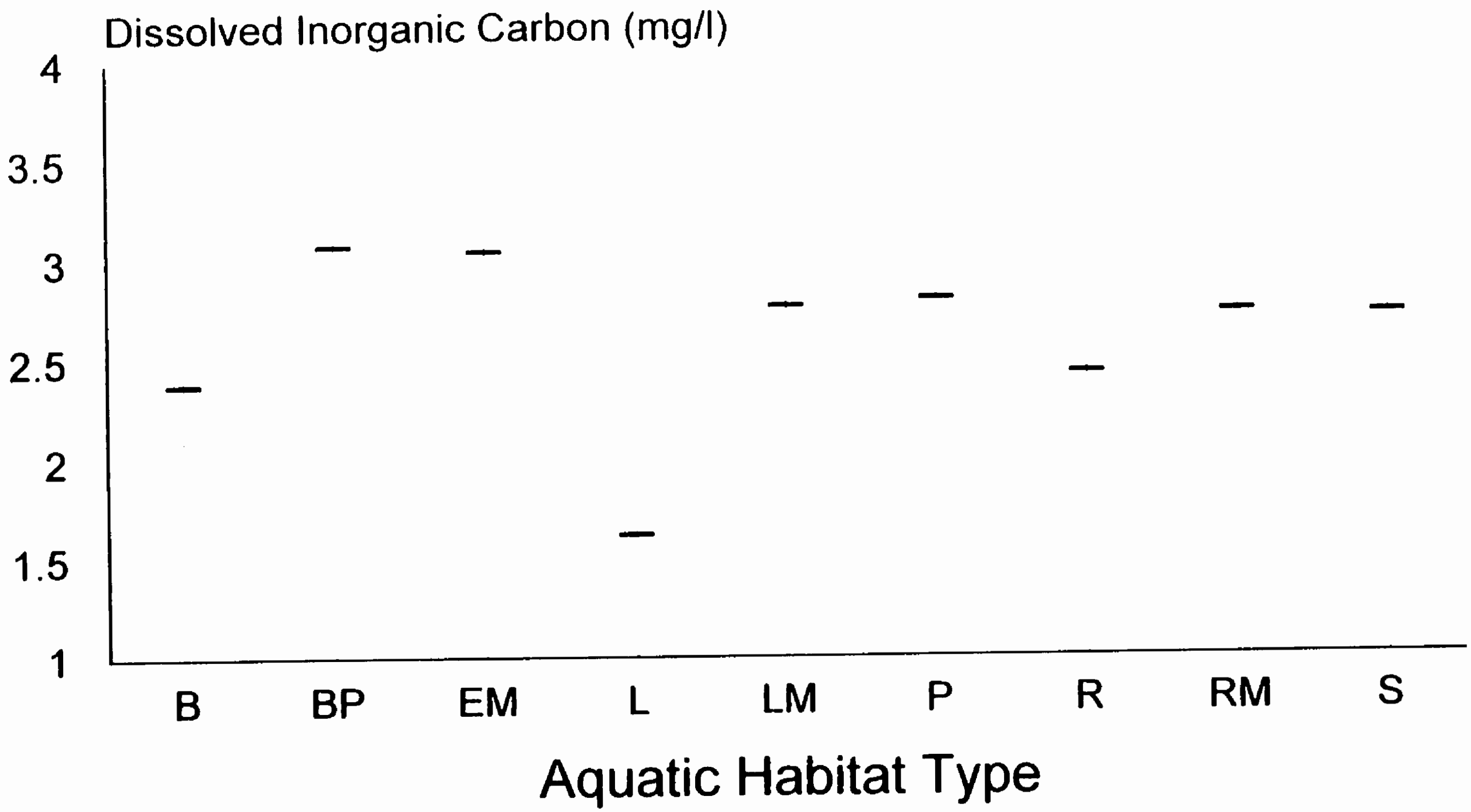

Figure D20 - Least squares mean and standard error of dissolved inorganic carbon (mg/l) in surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

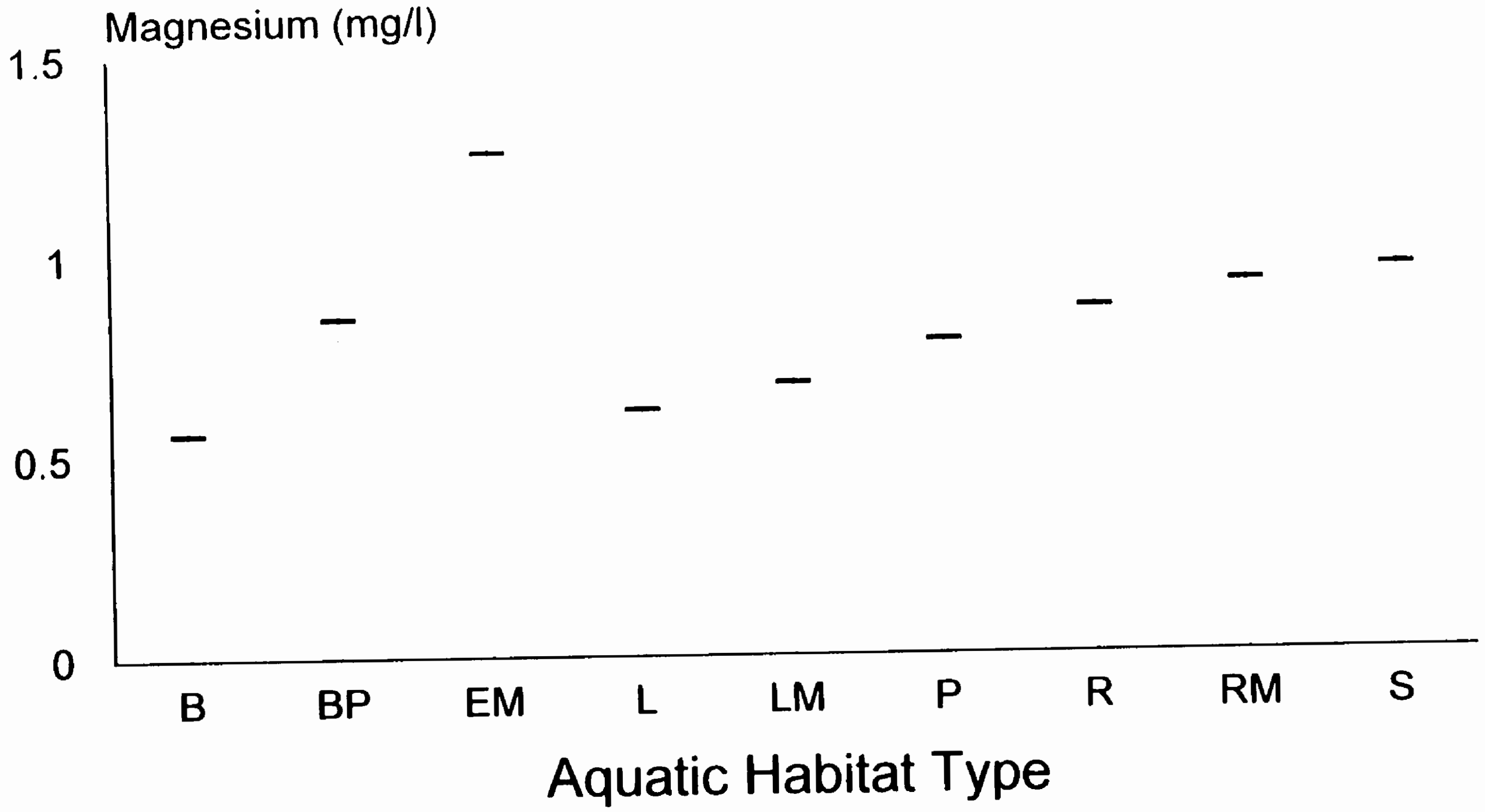

Figure D21 - Least squares mean and standard error of magnesium (mg/l) in surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

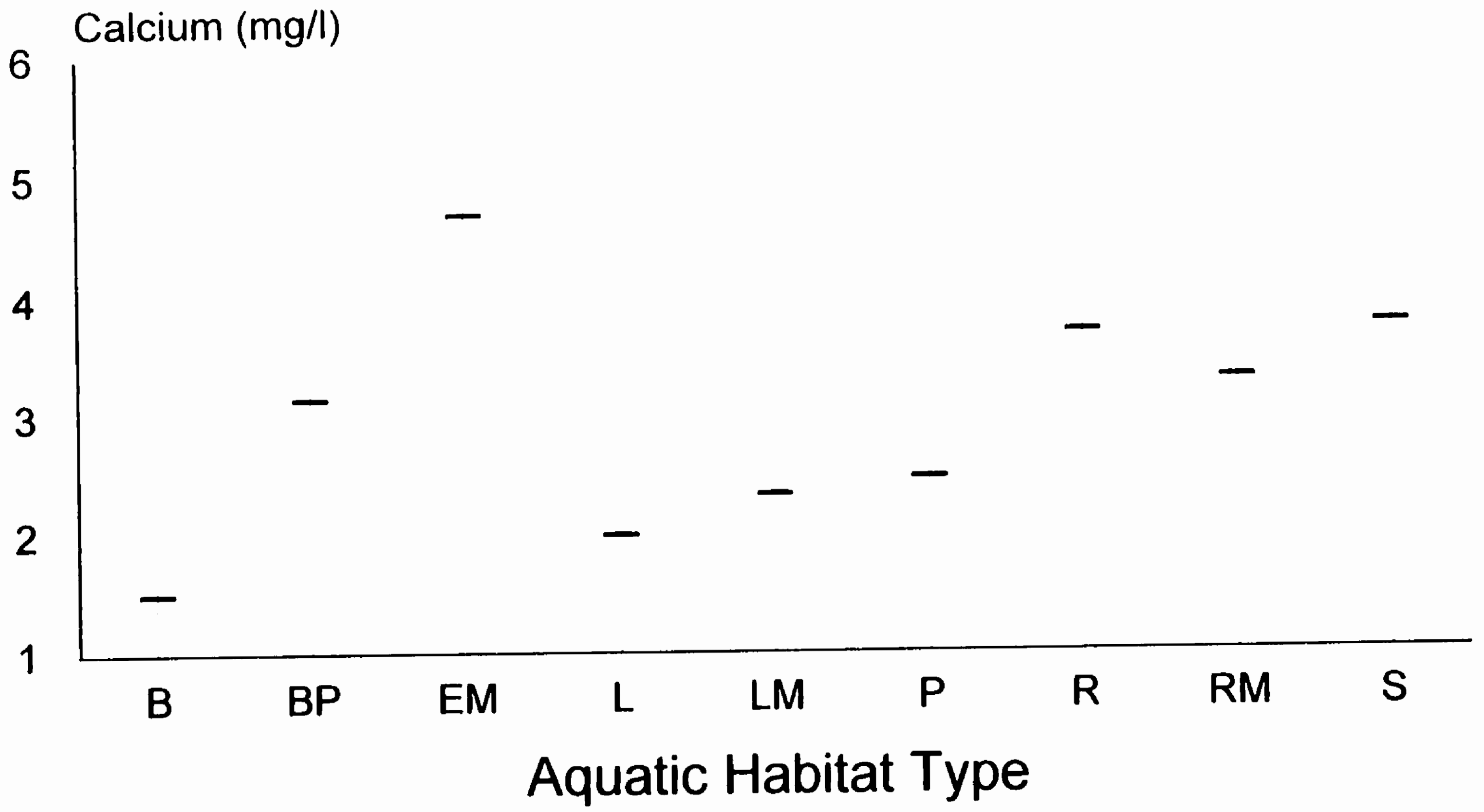

Figure D22 - Least squares mean and standard error of calcium (mg/l) in surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

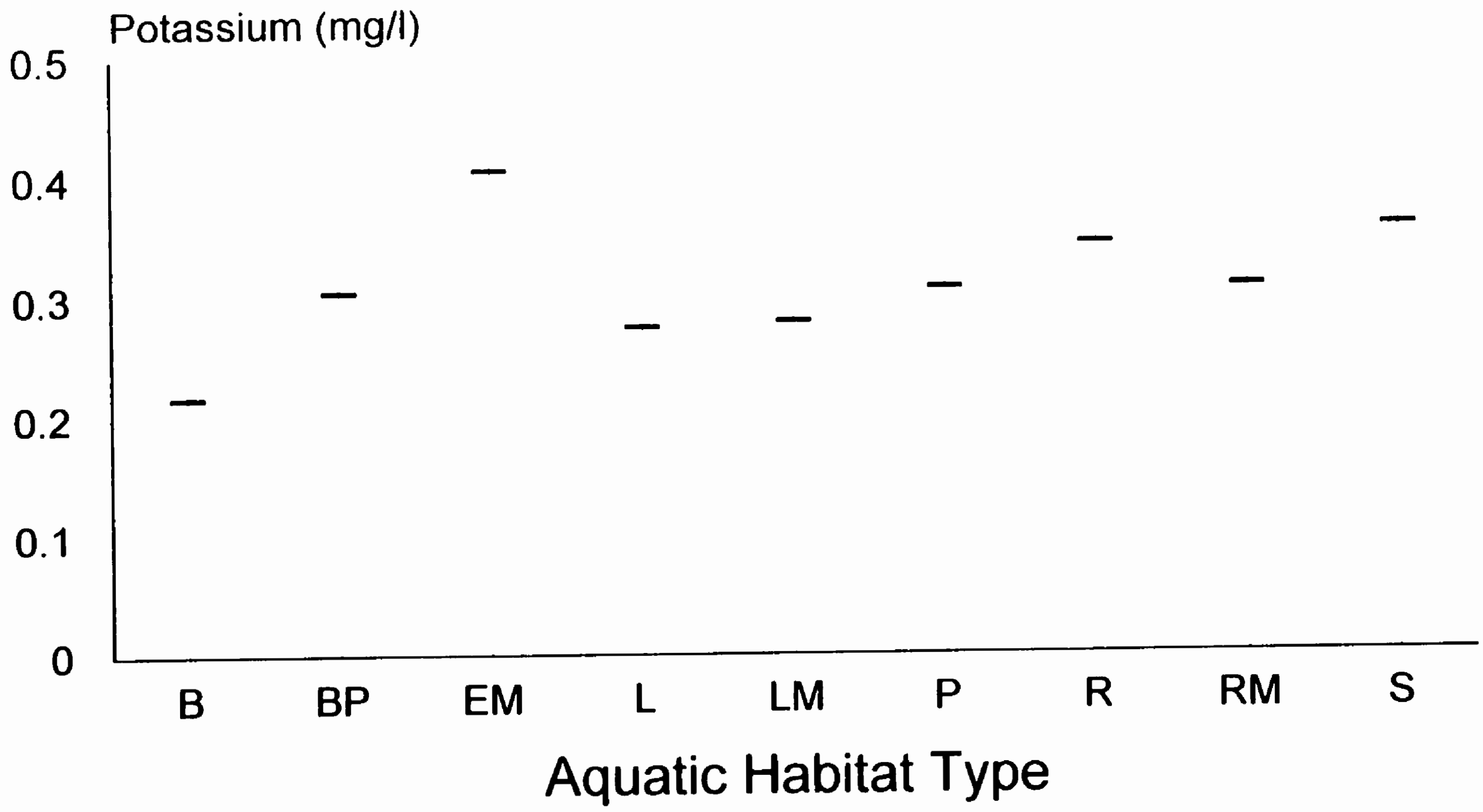

Figure D23 - Least squares mean and standard error of potassium (mg/l) in surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

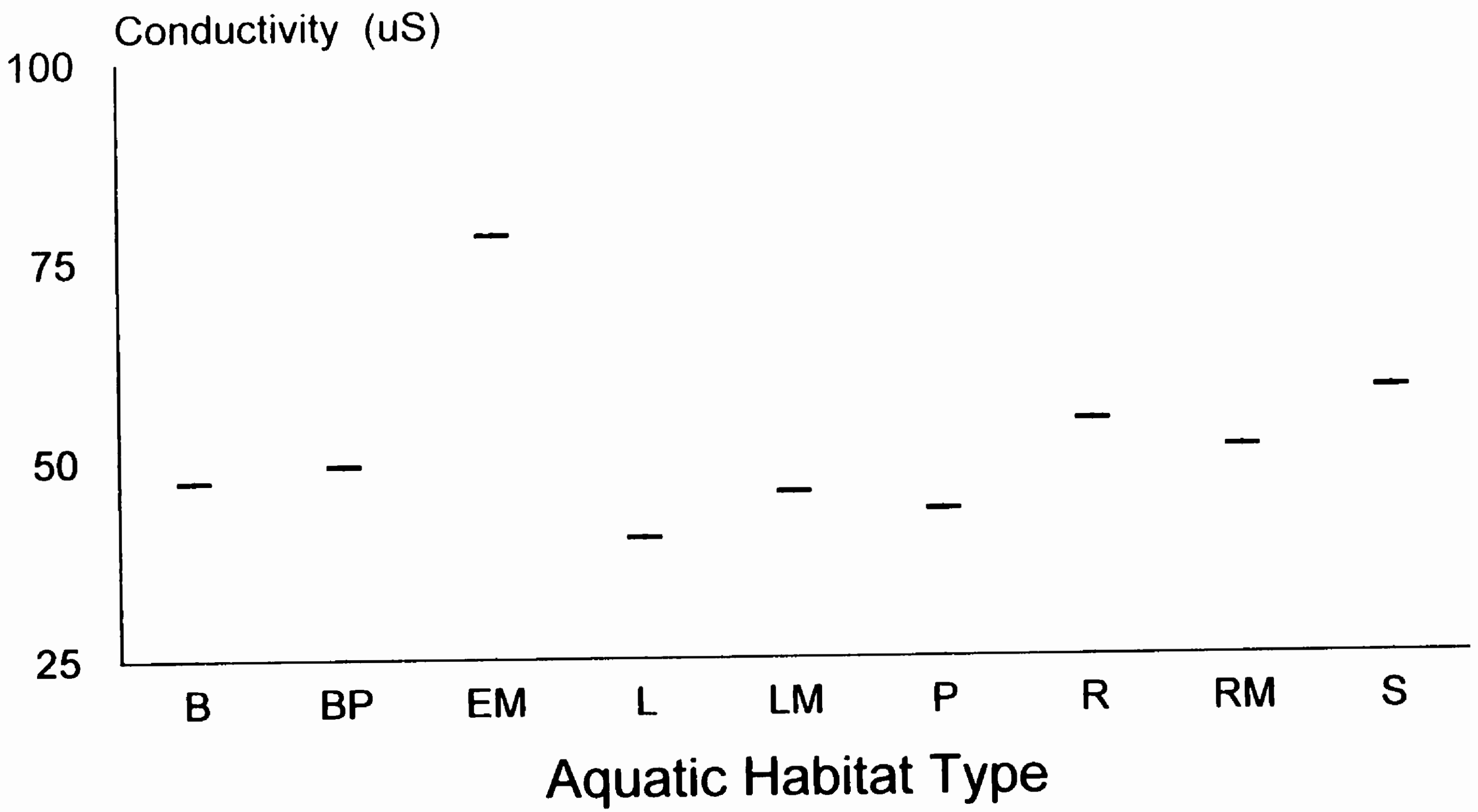

Figure D24 - Least squares mean and standard error of conductivity (uS) of surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

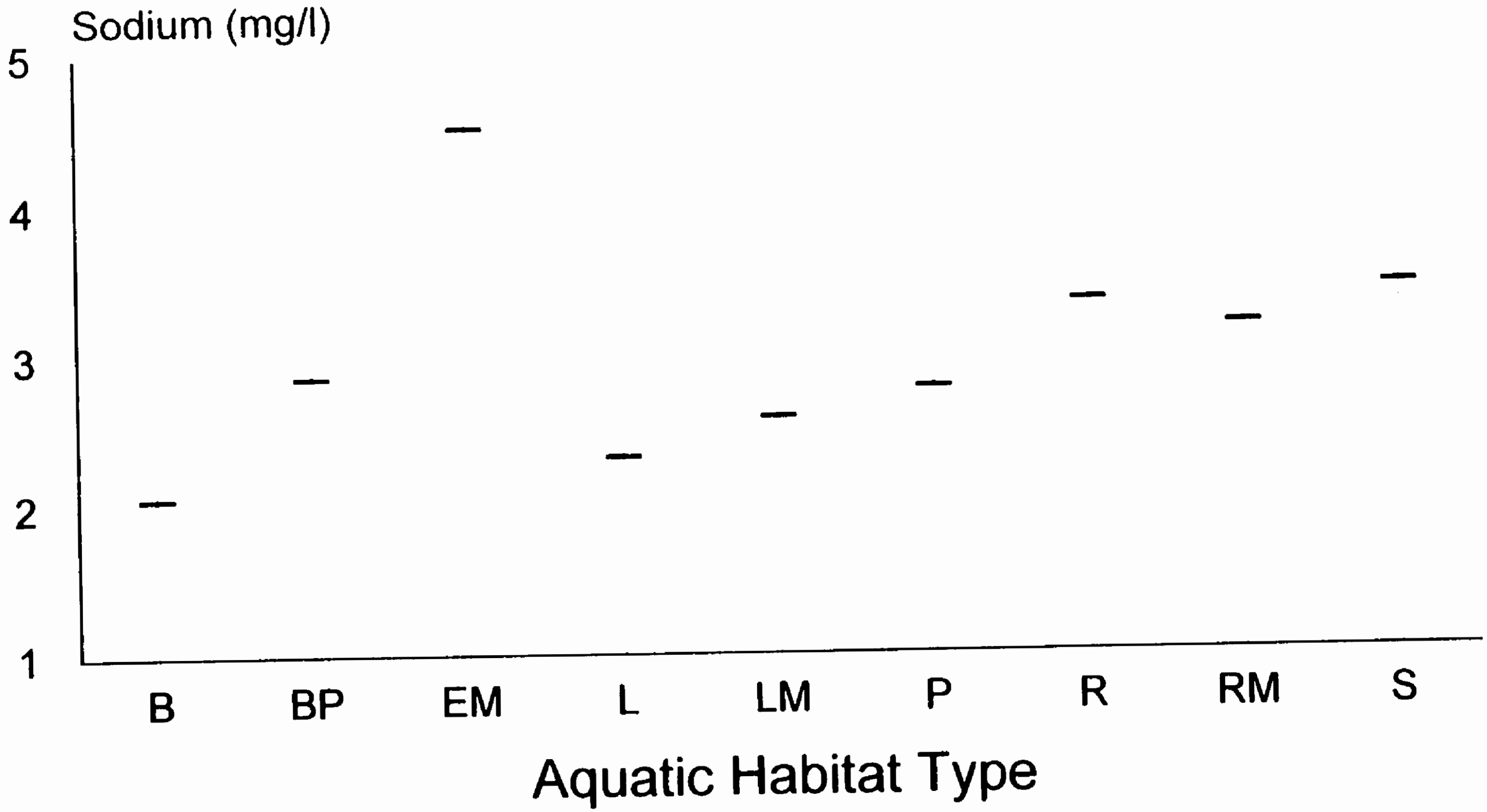

Figure D25 - Least squares mean and standard error of sodium (mg/l) of surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

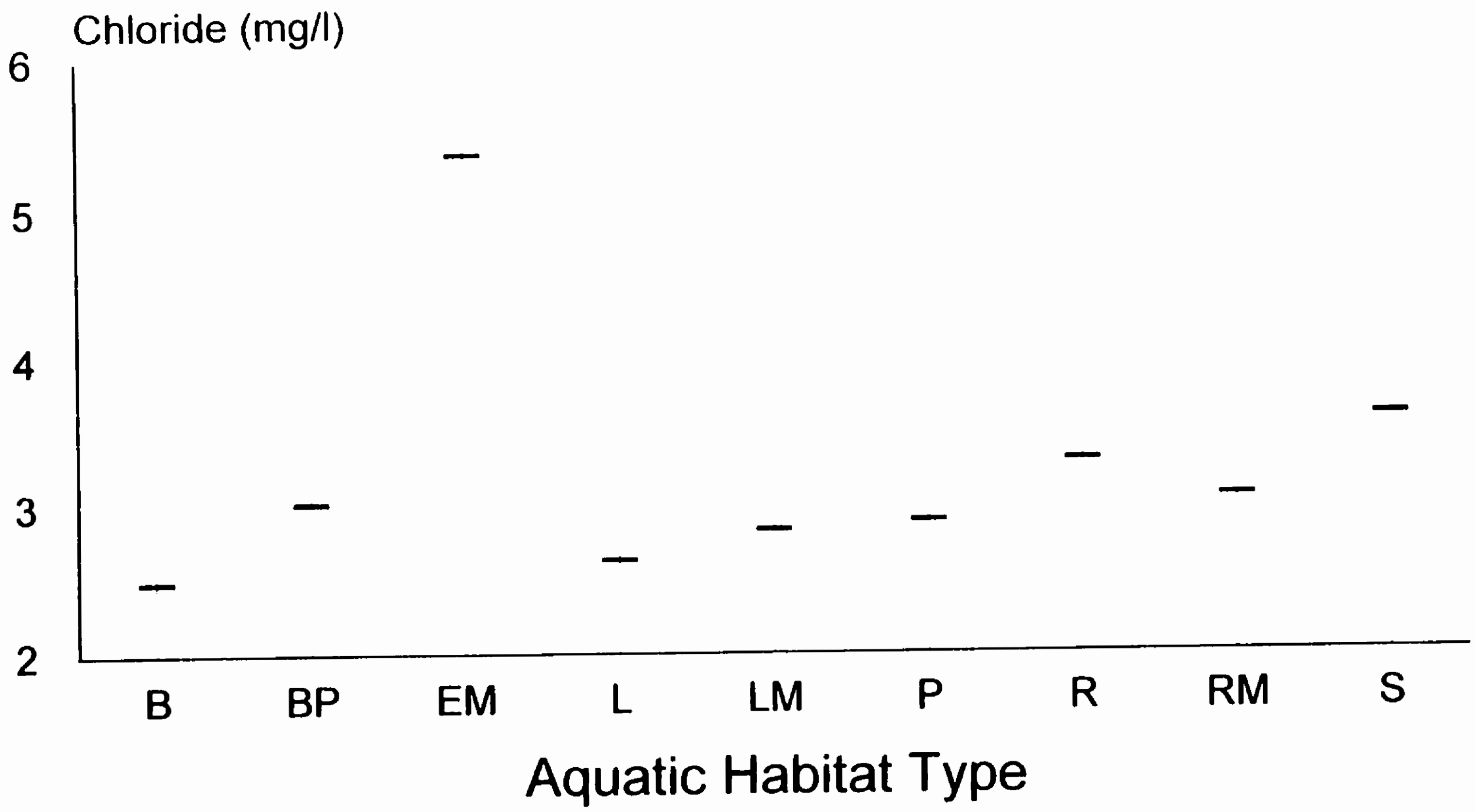

Figure D26 - Least squares mean and standard error of chloride (mg/l) in surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

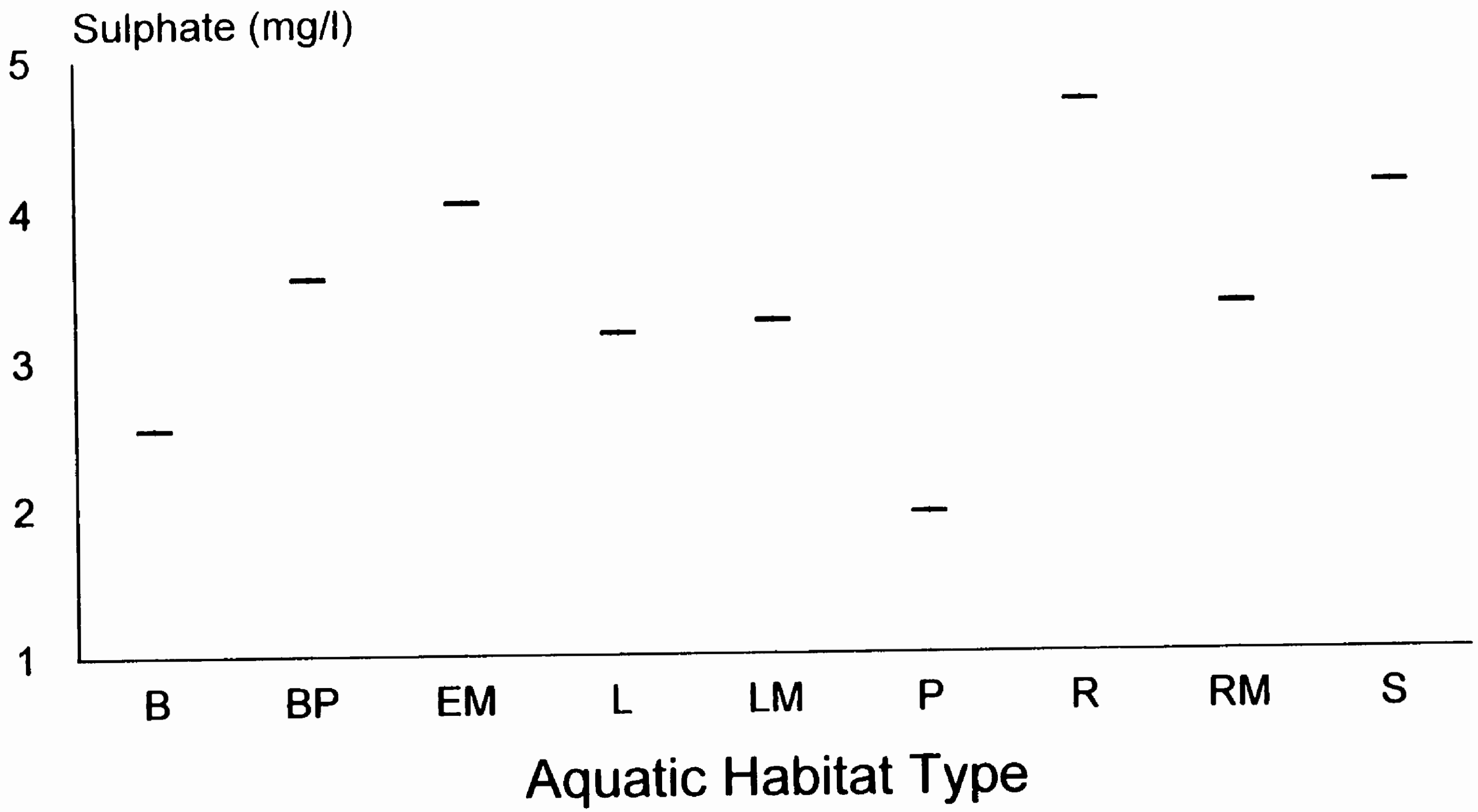

Figure D27 - Least squares mean and standard error of sulphate (mg/l) in surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

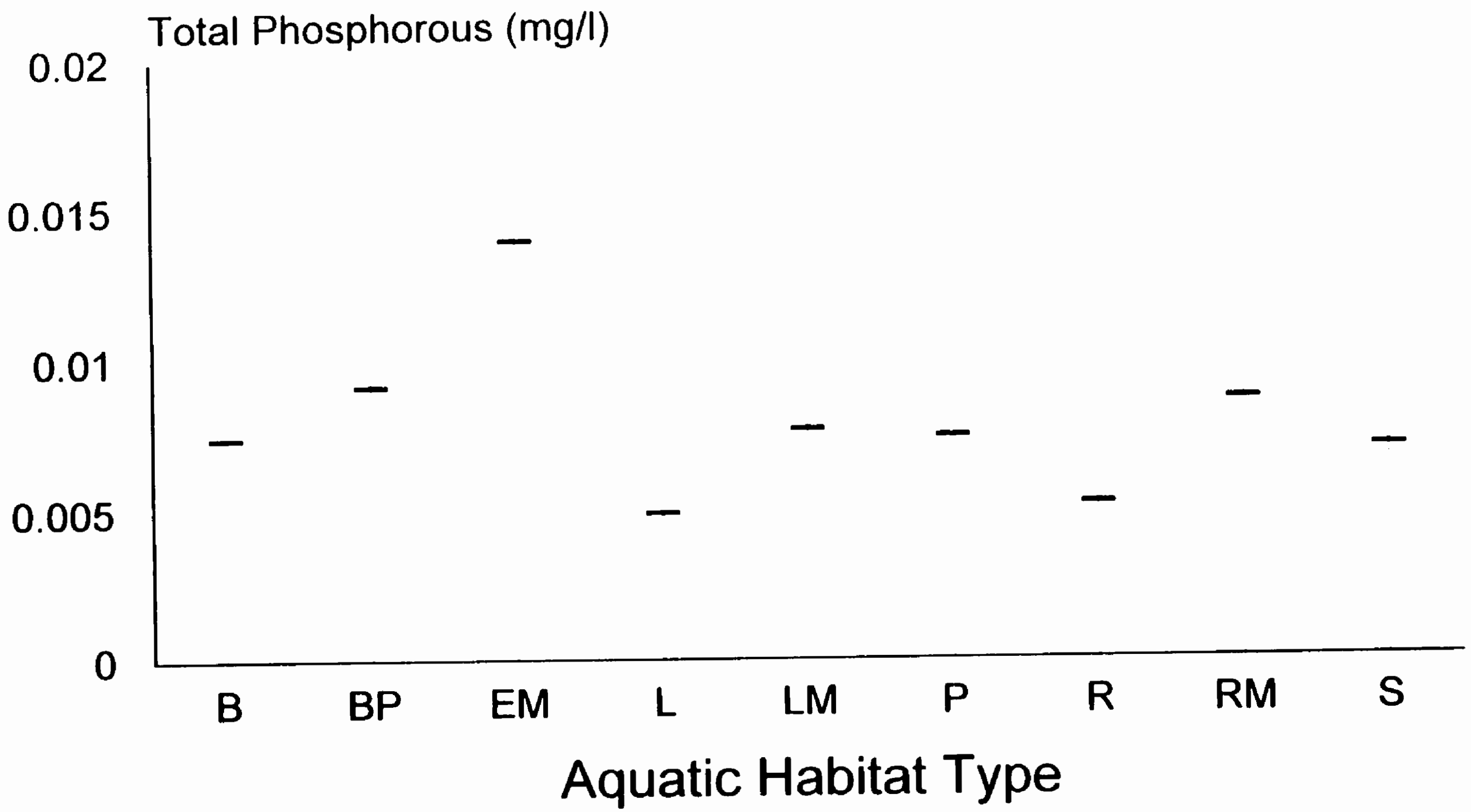

Figure D28 - Least squares mean and standard error of total phosphorous (mg/l) in surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

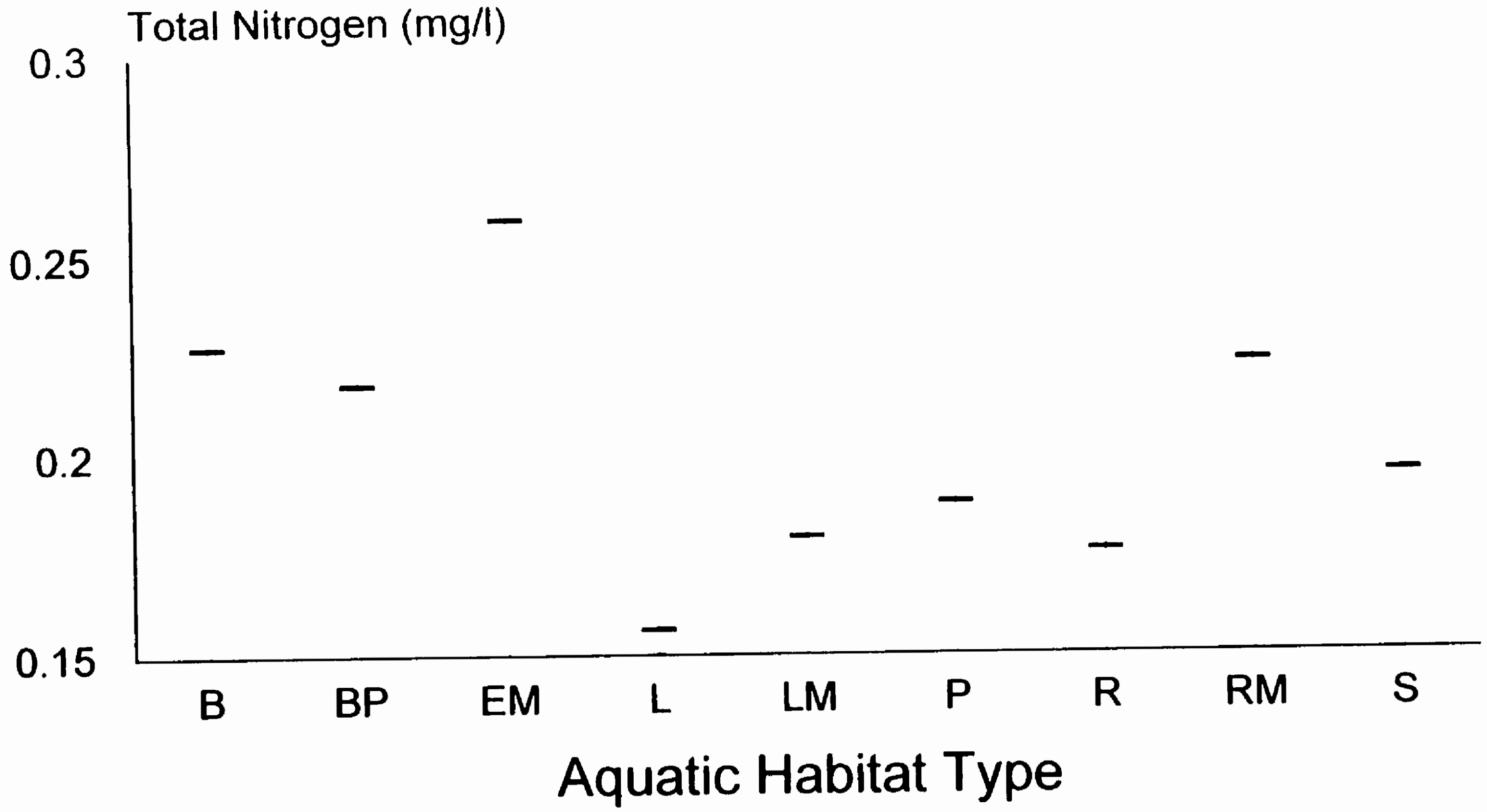

Figure D29 - Least squares mean and standard error of total nitrogen (mg/l) in surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

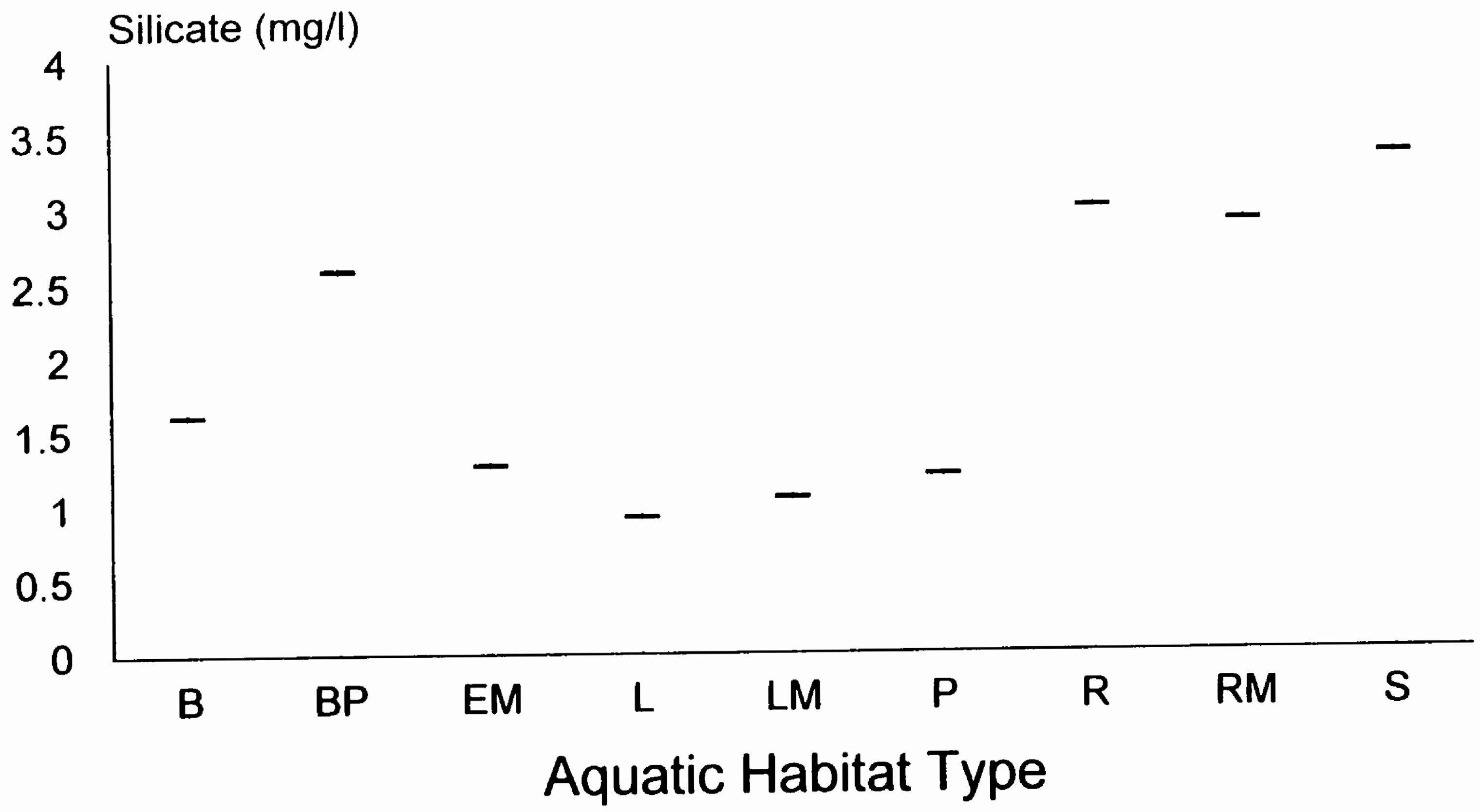

Figure D30 - Least squares mean and standard error of silicate (mg/l) in surface waters by aquatic habitat type. Abbreviations are: Bog/Peatland (B); Beaver Pond (BP); Emergent Marsh (EM); Lake (L); Lacustrine Marsh (LM); Pond (P); River (R); Riverine marsh (RM); Stream (S).

Appendix E - Waterfowl Survey Data 1986-1999

Year	Nova Scotia	New Brunswick
1985		May 15. 16
1986	May 5. 6. 14. 15. 20 .21	May 5. 6. 10
1987	May 11. 12 .13. 14. 15.	May 5. 8. 9
1988	May 5. 6. 7. 8. 13. 14	May 4. 5. 6. 7
1989	May 4. 5. 15. 16. 17	May 5. 9. 10
1990	April 30. May 2. 3. 4. 8. 9	April 30. May 1. 3.5. 8. 16
1991	April 30. May 1. 2. 5. 6. 8. 9. 10	May 8. 9. 10. 11
1992	May 1. 4. 5. 6. 7. 8. 9. 10. 11	May 13. 15. 16.17.18.19
1993	May 3. 4. 5. 7. 8. 9. 10. 11	May 14. 15. 16. 17. 18. 19
1994	May 2. 3. 4. 5. 7. 8. 9. 10. 11. 12	May 15. 16. 17. 18. 19. 20. 21
1995	May 2. 3. 4. 5	May 10. 11. 12
1996	May 2. 3. 5. 6.	May 9. 10. 14. 15
1997	May 3. 4. 5. 6	May 11. 12. 13. 15
1998	April 27. 28. 29	April 30. May 5. 6. 7. 8. 10
1999	April 30. May 1. 2	May 3. 4. 5. 6. 7

Table E1 - Dates of waterfowl surveys in New Brunswick and Nova Scotia 1985 - 1999.

Plot #	Name	Future No.	IBP 86	IBP 87	IBP 88	IBP 89	Mean 86-89	S.D. 86-89
GP1	Chainy Lakes	56076	6	3	6	4	4.75	1.50
GP2	Beaver Lake		2	4	5	2	3.25	1.50
GP3	Trafton Brook	56077	8	3	8	10	7.25	2.99
GP4	Sisson Branch Reservoir	56078	1	6	14	16	9.25	6.99
GP5	Charlo	56079	3	1	2	4	2.5	1.29
GP6	Three Corner Lake	56080	4	7	1	5	4.25	2.50
GP7	Youngs Brook	70A	5	7	5	5	5.5	1.00
GP8	Lake St.-Couer	69A	1	5	5	5	4	2.00
GP9	S. Br. Little Sevogle River	56081	5	2	3	2	3	1.41
GP10	Macs Lake	56082	4	6	5	12	6.75	3.59
GP11	Kent Lake	67A	1	3	5	5	3.5	1.91
GP12	McLean Lake	55A	5	1	3	4	3.25	1.71
GP13	Cranberry Lake		6	6	6	5	5.75	0.50
GP14	Lower Lake		3	5	7	9	6	2.58
GP15	Murphy Meadow Brook	56089	0	2	0	0	0.5	1.00
GP16	Gallagher Ridge	53A	5	5	2	7	4.75	2.06
GP17	Long Lake		10	17	8	14	12.25	4.03
GP18	Isaiah Corner	51A	5	9	8	9	7.75	1.89
GP19	Bennett Lake		1	2	2	3	2	0.82
GP20	Grand Bay	57B	2	4	8	6	5	2.58
GP21	McDougall Lake		7	2	3	9	5.25	3.30
GP22	Digdeguash River	56084	11	5	5	8	7.25	2.87
GP23	Stephenson Lake	56085	5	5	4	1	3.75	1.89
GP24	Deadwater Brook		11	9	14	7	10.25	2.99
GP25	Mud Lake	59A	12	15	13	15	13.75	1.50
GP26	First Adder Lake	63A	4	1	7	2	3.5	2.65
GP27	Juniper	61A	16	17	13	11	14.25	2.75
GP28	McKiel Lake	56088	5	8	6	6	6.25	1.26
GP29	Estey Lake	65A	1	4	0	4	2.25	2.06
GP30	Dumbar Falls		5	5	6	8	6	1.41
GP31	Charlo	72A	1	4	6	6	4.25	2.36
GP32	Whites Brook	73A	0	0	0		0	0.00
GP33	Restigouche River	74A	2	1	1	2	1.5	0.58
GP34	Crocker Lake		3	4	3	1	2.75	1.26
GP35	Lac du Petit-Vingt-Deux	56083	1	1	2	2	1.5	0.58
GP36	Lepreau	58A	2	5	4	2	3.25	1.50
GP37	Armstrong Lake	56086	1	5	1	4	2.75	2.06
GP38	Argyle	56087	5	7	7	4	5.75	1.50
GP39	Meadow Lake	66D	5	4	4	5	4.5	0.58
GP40	Bouctouche	56090	3	6	3	4	4	1.41
GP41	First Lake	56091	16	15	20	41	23	12.19

Table E2 - Indicated breeding pairs (IBPs) of Black Ducks in New Brunswick 25 km^2 survey plots during 1986-89 (unpubl data from (Erskine *et al.* 1990)).

PLOT	Name	Future No.	IBP 86	IBP 87	IBP 88	IBP 89	Mean 86-89	S.D. 86-89
C1	Salmon River Long Lake	26A	0	2	3	4	2.25	1.48
C10	Mitchell Lake		6	3	5	4	4.50	1.12
C11	Dunbar Lake	39A	0	1	0	2	0.75	0.83
C12	Smith Dam Flowage		1	1	1	1	1.00	0.00
C13	Como Lake	38A	4	2	2	2	2.50	0.87
C14	Mulgrave Lake		2	2	1	2	1.75	0.43
C15	Paul Morris Lake		2	2	5	0	2.25	1.79
C16	Halfway Brook Lake		1	4	0	1	1.50	1.50
C17	Quartz Lake	37A	3	6	4	1	3.50	1.80
C18	West Petpeswick		3	5	7	13	7.00	3.74
C19	Antigonish	44A	4	7	9	8	7.00	1.87
C2	Flat Iron Lake		1	1	1	4	1.75	1.30
C3	MacElmons Pond		1	4	5	6	4.00	1.87
C4	Weatherhead Lake		2	4	4	0	2.50	1.66
C5	Tidnish Bridge					4		
C6	Linden	42A	4	6	8	2	5.00	2.24
C7	Pine Tree	43A	0	0	2	2	1.00	1.00
C8	Lower Barney's River		3	3	6	6	4.50	1.50
C9	Eden Lake		1	1	3	2	1.75	0.83
E1	Seal Harbour		2	0	2	0	1.00	1.00
E10	Baddeck Bridge		6	8	4	5	5.75	1.48
E11	Little Judique Ponds	50D	3	3	11	5	5.50	3.28
E2	Duff Lake		2	0	1	0	0.75	0.83
E3	Admiral Lake	46B	3	2	1	4	2.50	1.12
E4	Campbell Lakes		4	1	1	0	1.50	1.50
E5	Cook Lake		1	2	3	1	1.75	0.83
E6	Lake Uist	65055	2	3	2	2	2.25	0.43
E7	Hay Lake	48A	8	5	12	3	7.00	3.39
E8	Kilkenny Lake		5	6	1	3	3.75	1.92
E9	Little Bras d'or South Side		0	0	0	1	0.25	0.43
W1	West Pennant	27B	2	0	2	6	2.50	2.18
W10	Mississippi Lake		0	5	1	4	2.50	2.06
W11	Marshalltown	65053	1	2	3	3	2.25	0.83
W12	Granville Ferry	34A	0	0	0	0	0.00	0.00
W13	Randall Lake		2	2	1	3	2.00	0.71
W14	Woodward Sanford Lake	35A	2	0	5	1	2.00	1.87
W15	Rawdon	36A	4	1	4	3	3.00	1.22
W2	Hennigar Lake		0	1	1	3	1.25	1.09
W3	Rhodenizer Lake		1	1	1	4	1.75	1.30
W4	Seven Mile Lake	29A	2	1	1	1	1.25	0.43
W5	Little Harbour Lake	65051	8	7	6	5	6.50	1.12
W6	Pubnico	31C	4	5	8	7	6.00	1.58
W7	Big Cook Island		6	1	5	5	4.25	1.92
W8	Second Lake	65052	1	1	3	2	1.75	0.83
W9	Barrio Lake		3	4	3	7	4.25	1.64
W9A	Central Lake - Keji	32A		2	3	0	1.67	1.25

Table E3 - Indicated breeding pairs (IBPs) of Black Ducks in 25 km^2 survey plots in Nova Scotia during 1986-89 (unpubl data from (Erskine *et al.* 1990)).

PQUAD	IBP 90	IBP 91	IBP 92	IBP 93	IBP 94	Mean 90-94	Mean 90-91	Mean 92-94
51A	13	5	7	11	13	9.80	9.00	10.33
51B	0	0	2	0	1	0.60	0.00	1.00
51C	1	0	1	0	1	0.60	0.50	0.67
51D	0	0	0	0	0	0.00	0.00	0.00
52A	0	0	3	3	2	1.60	0.00	2.67
52B	0	0	0	3	2	1.00	0.00	1.67
52C	0	0	0	0	0	0.00	0.00	0.00
52D	0	0	0	0	0	0.00	0.00	0.00
53A	6	7	12	7	7	7.80	6.50	8.67
53B	0	0	0	0	0	0.00	0.00	0.00
53C	3	1	3	3	3	2.60	2.00	3.00
53D	1	1	1	1	0	0.80	1.00	0.67
54A	7	3	8	10	4	6.40	5.00	7.33
54B	2	1	1	3	0	1.40	1.50	1.33
54C	0	0	0	2	0	0.40	0.00	0.67
54D	3	1	3	3	2	2.40	2.00	2.67
55A	4	3	3	4	3	3.40	3.50	3.33
55B	2	0	0	0	1	0.60	1.00	0.33
55C	1	0	0	1	0	0.40	0.50	0.33
55D	1	1	0	1	0	0.60	1.00	0.33
5690A	5							
5690B	28							
5690C	3							
5690D	0							
5790A	4							
5790B	5							
5790C	6							
5790D	3							
56A		1	1	0	0	0.50	1.00	0.33
56B		1	9	5	1	4.00	1.00	5.00
56C		1	0	0	3	1.00	1.00	1.00
56D		0	0	1	1	0.50	0.00	0.67
57A		1	2	1	1	1.25	1.00	1.33
57B		5	1	5	3	3.50	5.00	3.00
57C		5	10	6	7	7.00	5.00	7.67
57D		7	6	8	6	6.75	7.00	6.67
58A	3	4	1	5	3	3.20	3.50	3.00
58B	2	4	8	9	8	6.20	3.00	8.33
58C	2	8	4	5	5	4.80	5.00	4.67
58D	0	1	0	2	4	1.40	0.50	2.00

Table E4 - Indicated breeding pairs (IBPs) of Black Ducks in 25 km^2 survey plots in New Brunswick during 1990-94 (unpubl. data from (Bateman and Hicks 1995)).

PQUAD	IBP 90	IBP 91	IBP 92	IBP 93	IBP 94	Mean 90-94	Mean 90-91	Mean 92-94
59A	30	5	12	6	11	12.80	17.50	9.67
59B	8	2	8	4	6	5.60	5.00	6.00
59C	2	0	3	4	3	2.40	1.00	3.33
59D	9	1	8	6	3	5.40	5.00	5.67
60A	11	6	9	8	4	7.60	8.50	7.00
60B	20	7	9	9	9	10.80	13.50	9.00
60C	18	4	10	5	12	9.80	11.00	9.00
60D	7	4	2	5	8	5.20	5.50	5.00
61A	9	18	14	18	18	15.40	13.50	16.67
61B	3	4	0	1	3	2.20	3.50	1.33
61C	0	0	0	4	0	0.80	0.00	1.33
61D	1	2	0	5	4	2.40	1.50	3.00
62A	3	2	5	1	1	2.40	2.50	2.33
62B	0	1	2	1	3	1.40	0.50	2.00
62C	1	0	0	1	3	1.00	0.50	1.33
62D	1	0	0	1	5	1.40	0.50	2.00
63A	0	1	5	4	3	2.60	0.50	4.00
63B	2	3	4	2	3	2.80	2.50	3.00
63C	0	1	4	3	7	3.00	0.50	4.67
63D	0	5	1	5	4	3.00	2.50	3.33
64A	0	0	0	2	0	0.40	0.00	0.67
64B	0	0	0	0	0	0.00	0.00	0.00
64C	1	1	0	0	0	0.40	1.00	0.00
64D	0	2	3	1	1	1.40	1.00	1.67
65A	0	3	2	4	1	2.00	1.50	2.33
65B	2	3	4	4	3	3.20	2.50	3.67
65C	2	1	0	0	2	1.00	1.50	0.67
65D	0	1	2	2	3	1.60	0.50	2.33
66A	2	2	0	1	0	1.00	2.00	0.33
66B	0	1	1	0	2	0.80	0.50	1.00
66C	6	2	0	1	2	2.20	4.00	1.00
66D	1	0	1	1	2	1.00	0.50	1.33
67A	1	1	0	3	4	1.80	1.00	2.33
67B	2	4	4	5	5	4.00	3.00	4.67
67C	1	0	5	2	0	1.60	0.50	2.33
67D	6	1	2	5	2	3.20	3.50	3.00
6890A	8	2				5.00	5.00	
6890B	1	1				1.00	1.00	
6890C	3	0				1.50	1.50	
6890D	1	1				1.00	1.00	
68A			1	3	3	2.33		2.33
68B			0	5	1	2.00		2.00
68C			3	4	1	2.67		2.67
68D			0	0	0	0.00		0.00

Table E4 (cont'd) - Indicated breeding pairs (IBPs) of Black Ducks in 25 km^2 survey plots in New Brunswick during 1990-94 (unpubl. data from (Bateman and Hicks 1995)).

PQUAD	IBP 90	IBP 91	IBP 92	IBP 93	IBP 94	Mean 90-94	Mean 90-91	Mean 92-94
69A	1	1	1	2	3	1.60	1.00	2.00
69B	0	0	1	0	1	0.40	0.00	0.67
69C	0	0	3	3	3	1.80	0.00	3.00
69D	3	2	4	3	4	3.20	2.50	3.67
7090A	1							
7090B	1							
7090C	0							
7090D	1							
70A		4	3	2	0	2.25	4.00	1.67
70B		1	0	2	4	1.75	1.00	2.00
70C		0	1	0	1	0.50	0.00	0.67
70D		1	2	5	1	2.25	1.00	2.67
71A	1	0	3	2	4	2.00	0.50	3.00
71B		0	2	2	5	2.25	0.00	3.00
71C	1	0	3	2	5	2.20	0.50	3.33
71D	1	0	0	3	3	1.40	0.50	2.00
72A	0	3	2	3	1	1.80	1.50	2.00
72B	0	2	1	2	1	1.20	1.00	1.33
72C	2	1	2	2	2	1.80	1.50	2.00
72D	0	1	1	3	4	1.80	0.50	2.67
73A	0	0	1	0	0	0.20	0.00	0.33
73B	0	0	0	0	0	0.00	0.00	0.00
73C	3	1	4	2	0	2.00	2.00	2.00
73D	1	2	2	3	1	1.80	1.50	2.00
74A	1	0	0	5	3	1.80	0.50	2.67
74B	0	0	0	2	0	0.40	0.00	0.67
74C	1	0	2	1	1	1.00	0.50	1.33
74D	0	0	0	1	1	0.40	0.00	0.67
75A	0	2	2	0	0	0.80	1.00	0.67
75B	0	0	0	1	0	0.20	0.00	0.33
75C	0	4	0	4	0	1.60	2.00	1.33
75D	1	0	0	6	0	1.40	0.50	2.00

Table E4 (cont'd) - Indicated breeding pairs (IBPs) of Black Ducks in 25 km^2 survey plots in New Brunswick during 1990-94 (unpubl. data from (Bateman and Hicks 1995)).

PLOT	IBP 90	IBP 91	IBP 92	IBP 93	IBP 94	Mean 90-91	Mean 90-94	Mean 92-94
51	14	5	10	11	15	9.50	11.00	12.00
52	0	0	3	6	4	0.00	2.60	4.33
53	10	9	16	11	10	9.50	11.20	12.33
54	12	5	12	18	6	8.50	10.60	12.00
55	8	4	3	6	4	6.00	5.00	4.33
56	.	3	10	6	5	3.00	6.00	7.00
57	.	18	19	20	17	18.00	18.50	18.67
58	7	17	13	21	20	12.00	15.60	18.00
59	49	8	31	20	23	28.50	26.20	24.67
60	56	21	30	27	33	38.50	33.40	30.00
61	13	24	14	28	25	18.50	20.80	22.33
62	5	3	7	4	12	4.00	6.20	7.67
63	2	10	14	14	17	6.00	11.40	15.00
64	1	3	3	3	1	2.00	2.20	2.33
65	4	8	8	10	9	6.00	7.80	9.00
66	9	5	2	3	6	7.00	5.00	3.67
67	10	6	11	15	11	8.00	10.60	12.33
68	.		4	12	5	7.00	7.00	7.00
69	4	3	9	8	11	3.50	7.00	9.33
70	.	6	6	9	6	6.00	6.75	7.00
71	3	0	8	9	17	1.50	7.40	11.33
72	2	7	6	10	8	4.50	6.60	8.00
73	4	3	7	5	1	3.50	4.00	4.33
74	2	0	2	9	5	1.00	3.60	5.33
75	1	6	2	11	0	3.50	4.00	4.33

Table E5 - Indicated breeding pairs (IBPs) of Black Ducks in 100 km^2 survey plots in New Brunswick during 1990-94 (unpubl. data from (Bateman and Hicks 1995)).

PQUAD	IBP 90	IBP 91	IBP 92	IBP 93	IBP 94	Mean 90-94	Mean 90-91	Mean 92-94
26A	2	8	11	6	9	7.2	5	8.67
26B	7	8	10	7	13	9	7.5	10.00
26C	6	2	7	4	17	7.2	4	9.33
26D	9	2	8	3	4	5.2	5.5	5.00
27A	8	15	20	8	8	11.8	11.5	12.00
27B	7	11	11	6	10	9	9	9.00
27C	7	11	6	8	7	7.8	9	7.00
27D	11	5	6	10	16	9.6	8	10.67
28A	2	4	1	3	4	2.8	3	2.67
28B	2	2	3	4	6	3.4	2	4.33
28C	2	3	2	2	3	2.4	2.5	2.33
28D	4	6	3	4	7	4.8	5	4.67
29A	3	3	7	5	8	5.2	3	6.67
29B	0	0	0	1	0	0.2	0	0.33
29C	1	1	2	0	1	1	1	1.00
29D	2	2	6	1	4	3	2	3.67
30A	1	0	1	1	1	0.8	0.5	1.00
30B	6	8	10	7	7	7.6	7	8.00
30C	8	1	4	4	2	3.8	4.5	3.33
30D	2	4	4	3	3	3.2	3	3.33
31A	4	4	4	3	4	3.8	4	3.67
31B	3	10	6	3	3	5	6.5	4.00
31C	11	6	9	9	7	8.4	8.5	8.33
31D	6	4	2	5	8	5	5	5.00
32A	4	5	6	3	6	4.8	4.5	5.00
32B	0	2	1	4	3	2	1	2.67
32C	1	1	0	5	3	2	1	2.67
32D	0	1	0	3	1	1	0.5	1.33
33A	2	5	2	6	2	3.4	3.5	3.33
33B	6	1	5	4	7	4.6	3.5	5.33
33C	5	3	3	7	5	4.6	4	5.00
33D	2	2	1	0	1	1.2	2	0.67
34A	1	1	3	0	2	1.4	1	1.67
34B	12	6	7	18	11	10.8	9	12.00
34C	3	5	6	2	2	3.6	4	3.33
34D	0	0	0	0	1	0.2	0	0.33

Table E6 - Indicated breeding pairs (IBPs) of Black Ducks in 25 km^2 survey plots in Nova Scotia during 1990-94 (unpubl. data from (Bateman and Hicks 1995)).

PQUAD	IBP 90	IBP 91	IBP 92	IBP 93	IBP 94	Mean 90-94	Mean 90-91	Mean 92-94
35A	4	8	4	10	7	6.6	6	7.00
35B	0	0	3	0	0	0.6	0	1.00
35C	5	11	6	6	6	6.8	8	6.00
35D	0	0	0	0	0	0	0	0.00
36A	1	2	1	4	4	2.4	1.5	3.00
36B	3	5	4	3	3	3.6	4	3.33
36C	2	3	3	2	2	2.4	2.5	2.33
36D	0	1	0	0	0	0.2	0.5	0.00
37A	5	5	3	4	3	4	5	3.33
37B	2	1	6	1	3	2.6	1.5	3.33
37C	4	3	3	1	2	2.6	3.5	2.00
37D	3	1	6	2	3	3	2	3.67
38A	3	3	11	6	6	5.8	3	7.67
38B	3	3	2	2	1	2.2	3	1.67
38C	3	7	2	2	4	3.6	5	2.67
38D	5	7	4	3	4	4.6	6	3.67
39A	1	1	2	0	1	1	1	1.00
39B	3	3	2	2	1	2.2	3	1.67
39C	0	2	0	0	1	0.6	1	0.33
39D	0	1	1	3	4	1.8	0.5	2.67
40A	0	0	0	1	0	0.2	0	0.33
40B	1	1	1	2	1	1.2	1	1.33
40C	0	0	0	0	0	0	0	0.00
40D	1	0	0	0	2	0.6	0.5	0.67

Table E6 (continued) - Indicated breeding pairs (IBPs) of Black Ducks in 25 km^2 survey plots in Nova Scotia during 1990-94 (unpubl. data from (Bateman and Hicks 1995)).

PQUAD	IBP 90	IBP 91	IBP 92	IBP 93	IBP 94	Mean 90-94	Mean 90-91	Mean 92-94
41A	7	15	8	20	11	12.2	11	13.00
41B	7	2	1	3	2	3	4.5	2.00
41C	5	1	1	6	1	2.8	3	2.67
41D	0	0	4	4	0	1.6	0	2.67
42A	8	9	22	0	5	8.8	8.5	9.00
42B	5	3	10	5	4	5.4	4	6.33
42C	11	5	5	4	3	5.6	8	4.00
42D	1	4	9	3	5	4.4	2.5	5.67
43A	2	4	9	1	4	4	3	4.67
43B	4	3	3	1	0	2.2	3.5	1.33
43C	3	2	2	2	1	2	2.5	1.67
43D	1	1	2	3	2	1.8	1	2.33
44A	11	16	6	4	5	8.4	13.5	5.00
44B	3	2	4	1	4	2.8	2.5	3.00
44C	2	3	1	0	5	2.2	2.5	2.00
44D	2	1	1	0	1	1	1.5	0.67
45A	0	1	0	3	1	1	0.5	1.33
45B	1	4	2	1	2	2	2.5	1.67
45C	5	1	1	2	3	2.4	3	2.00
45D	4	1	2	3	5	3	2.5	3.33
46A	0	4	8	2	0	2.8	2	3.33
46B	0	7	5	4	5	4.2	3.5	4.67
46C	4	6	4	3	3	4	5	3.33
46D	3	7	8	10	9	7.4	5	9.00
47A	1	2	1	1	0	1	1.5	0.67
47B	6	2	1	2	5	3.2	4	2.67
47C	1	1	1	2	1	1.2	1	1.33
47D	1	1	1	1	0	0.8	1	0.67
48A	7	15	9	5	9	9	11	7.67
48B	4	4	4	6	4	4.4	4	4.67
48C	1	6	5	0	3	3	3.5	2.67
48D	8	8	2	4	3	5	8	3.00
49A	0	1	0	0	0	0.2	0.5	0.00
49B	0	1	0	1	0	0.4	0.5	0.33
49C	1	1	0	0	0	0.4	1	0.00
49D	0	1	0	1	1	0.6	0.5	0.67
50A	1	0	0	0	0	0.2	0.5	0.00
50B	10	13	13	10	5	10.2	11.5	9.33
50C	0	0	1	0	1	0.4	0	0.67
50D	7	5	5	3	7	5.4	6	5.00

Table E6 (continued) - Indicated breeding pairs (IBPs) of Black Ducks in 25 km^2 survey plots in Nova Scotia during 1990-94 (unpubl. data from (Bateman and Hicks 1995)).

PLOT	IBP 90	IBP 91	IBP 92	IBP 93	IBP 94	Mean 90-91	Mean 90-94	Mean 92-94
26	24	20	36	20	43	22.00	28.60	33.00
27	33	42	43	32	41	37.50	38.20	38.67
28	10	15	9	13	20	12.50	13.40	14.00
29	6	6	15	7	13	6.00	9.40	11.67
30	17	13	19	15	13	15.00	15.40	15.67
31	24	24	21	20	22	24.00	22.20	21.00
32	5	9	7	15	13	7.00	9.80	11.67
33	15	11	11	17	15	13.00	13.80	14.33
34	16	12	16	20	16	14.00	16.00	17.33
35	9	19	13	16	13	14.00	14.00	14.00
36	6	11	8	9	9	8.50	8.60	8.67
37	14	10	18	8	11	12.00	12.20	12.33
38	14	20	19	13	15	17.00	16.20	15.67
39	4	7	5	5	7	5.50	5.60	5.67
40	2	1	1	3	3	1.50	2.00	2.33
41	19	18	14	33	14	18.50	19.60	20.33
42	25	21	46	12	17	23.00	24.20	25.00
43	10	10	16	7	7	10.00	10.00	10.00
44	18	22	12	5	15	20.00	14.40	10.67
45	10	7	5	9	11	8.50	8.40	8.33
46	7	24	25	19	17	15.50	18.40	20.33
47	9	6	4	6	6	7.50	6.20	5.33
48	20	33	20	15	19	26.50	21.40	18.00
49	1	4	0	2	1	2.50	1.60	1.00
50	18	18	19	13	13	18.00	16.20	15.00

Table E7 - Indicated breeding pairs (IBPs) of Black Ducks in 100 km^2 survey plots in Nova Scotia during 1990-94 (unpubl. data from (Bateman and Hicks 1995)).

	Name	PQUAD	IBP 86	IBP 87	IBP 88	IBP 89	IBP 90	IBP 91	IBP 92	IBP 93	IBP 94	Mean 86-89	Mean 90-94	Mean 90-91	Mean 92-94
26	First Adder Lake	63A	4	1	7	2	0	1	5	4	3	3.5	2.6	0.5	4.00
29	Estey Lake	65A	1	4	0	4	0	3	2	4	1	2.25	2	1.5	2.33
31	Charlo	72A	1	4	6	6	0	3	2	3	1	4.25	1.8	1.5	2.00
32	Whites Brook	73A	0	0	0		0	0	1	0	0	0	0.2	0	0.33
8	Lake St.-Couer	69A	1	5	5	5	1	1	1	2	3	4	1.6	1	2.00
11	Kent Lake	67A	1	3	5	5	1	1	0	3	4	3.5	1.8	1	2.33
33	Restigouche River	74A	2	1	1	2	1	0	0	5	3	1.5	1.8	0.5	2.67
39	Meadow Lake	66D	5	4	4	5	1	0	1	1	2	4.5	1	0.5	1.33
36	Lepreau	58A	2	5	4	2	3	4	1	5	3	3.25	3.2	3.5	3.00
12	McLean Lake	55A	5	1	3	4	4	3	3	4	3	3.25	3.4	3.5	3.33
16	Gallagher Ridge	53A	5	5	2	7	6	7	12	7	7	4.75	7.8	6.5	8.67
27	Juniper	61A	16	17	13	11	9	18	14	18	18	14.25	15.4	13.5	16.67
18	Isaiah Corner	51A	5	9	8	9	13	5	7	11	13	7.75	9.8	9	10.33
25	Mud Lake	59A	12	15	13	15	30	5	12	6	11	13.75	12.8	17.5	9.67
20	Grand Bay	57B	2	4	8	6		5	1	5	3	5	3.5	5	3.00
E3	Admiral Lake	46B	3	2	1	4	0	7	5	4	5	2.50	4.2	3.5	4.67
C11	Dunbar Lake	39A	0	1	0	2	1	1	2	0	1	0.75	1	1	1.00
W12	Granville Ferry	34A	0	0	0	0	1	1	3	0	2	0.00	1.4	1	1.67
W15	Rawdon	36A	4	1	4	3	1	2	1	4	4	3.00	2.4	1.5	3.00
W9A	Central Lake - Keji	32A		2	3	0	1	1	0	5	3	1.67	2	1	2.67
C1	Salmon River Long Lake	26A	0	2	3	4	2	8	11	6	9	2.25	7.2	5	8.67
C7	Pine Tree	43A	0	0	2	2	2	4	9	1	4	1.00	4	3	4.67
C13	Como Lake	38A	4	2	2	2	3	3	11	6	6	2.50	5.8	3	7.67
W4	Seven Mile Lake	29A	2	1	1	1	3	3	7	5	8	1.25	5.2	3	6.67
W14	Woodward Sanford Lake	35A	2	0	5	1	4	8	4	10	7	2.00	6.6	6	7.00
C17	Quartz Lake	37A	3	6	4	1	5	5	3	4	3	3.50	4	5	3.33
E11	Little Judique Ponds	50D	3	3	11	5	7	5	5	3	7	5.50	5.4	6	5.00
E7	Hay Lake	48A	8	5	12	3	7	15	9	5	9	7.00	9	11	7.67
W1	West Pennant	27B	2	0	2	6	7	11	11	6	10	2.50	9	9	9.00
C6	Linden	42A	4	6	8	2	8	9	22	0	5	5.00	8.8	8.5	9.00
C19	Antigonish	44A	4	7	9	8	11	16	6	4	5	7.00	8.4	13.5	5.00
W6	Pubnico	31C	4	5	8	7	11	6	9	9	7	6.00	8.4	8.5	8.33

Table E8 - IBPs and means of Black Ducks in New Brunswick and Nova Scotia survey plots 1986-1994.

Route	Plot Number	Years of Data	Observation Periods	Population Weight	Trend Precision	Overall Weight	Log Slope
56051	51A	7	2	15.429	129.91	2.06174	-0.02246
56052	52A	5	1	5.5	23.32	0.5743	0.07748
56053	53A	8	2	11.75	31.38	1.09803	0.27292
56054	54A	7	2	9.714	64.91	1.18013	-0.01387
56055	55A	7	2	6.429	54.89	0.86437	0.17319
56056	56B	8	2	11.688	39.86	1.15266	-0.14106
56057	57B	7	2	8.071	46.17	0.92628	0.23529
56058	58A	8	2	6.438	18.47	0.61049	0.23503
56059	59A	7	2	16	65.22	1.6524	-0.04877
56060	60A	8	2	11.25	55.04	1.22603	0.01937
56061	61A	7	2	21.5	170.22	2.79749	0.03822
56062	62B	7	2	5.214	13.64	0.48526	0.59404
56063	63A	7	2	4.857	25.2	0.53937	0.23315
56064	64A	4	1	1.375	5.84	0.14367	-0.0974
56065	65A	7	2	3.286	7.69	0.29945	-0.02062
56066	66D	6	2	4.667	43.25	0.65126	0.21321
56067	67A	7	2	4.214	45.13	0.63058	0.16367
56068	68A	7	2	9.429	54.16	1.08363	0.08548
56069	69A	7	2	3.357	22.03	0.40501	0.23862
56070	70A	7	2	5.071	45.76	0.6991	0.45604
56071	71A	8	2	5.813	17.71	0.55847	0.15205
56072	72A	7	2	4.714	45.21	0.66851	0.04756
56074	74A	3	1	5	23.33	0.537	-0.08366
56075	75A	3	1	3	2	0.23834	0
56076	GP1	2	1	6.75	15.19	0.61095	-0.17688
56077	GP3	2	1	8.75	2.19	0.66967	-0.40547
56078	GP4	2	1	12.25	27.56	1.10876	0.15225
56079	GP5	2	1	7	15.75	0.63357	-0.85498
56080	GP6	2	1	6.5	1.62	0.49747	0.31016
56081	GP9	2	1	2.5	0.63	0.19133	-0.8473
56082	GP10	2	1	12.25	27.56	1.10876	0.09589
56083	GP35	2	1	2.5	0.63	0.19133	-1.00*
56084	GP22	2	1	15.75	35.44	1.42554	0.01058
56085	GP23	2	1	10.5	2.63	0.8036	-0.80235
56086	GP37	2	1	7	15.75	0.63357	-0.09589
56087	GP38	2	1	15	33.75	1.35766	0.18218
56088	GP28	2	1	10.75	2.69	0.82273	0.42488
56089	GP15	2	1	2.25	0.56	0.1722	0.69315
56090	GP40	2	1	6.25	1.56	0.47833	1.00*
56091	GP41	2	1	34.5	8.63	2.6404	0.02899

Table E9 - Local trend estimate parameters for Black Ducks from New Brunswick surveys 1990 - 1999 (unpubl. data from (Collins 1999)).

Route	Quad	Years of Data	Observation Periods	Population Weight	Trend Precision	Overall Weight	Log Slope
65026	26A	7	1	17.571	177.87	2.55715	0.12886
65027	27B	8	1	19.125	142.24	2.42437	0.11035
65028	28A	7	1	6.571	50.43	0.84386	0.22313
65029	29A	8	1	7.25	38.06	0.80821	0.06766
65030	30A	6	1	1.917	19.59	0.28027	0.10998
65031	31C	7	1	16.5	126.61	2.11883	0.11915
65032	32A	8	1	9.125	67.87	1.15673	0.14532
65033	33A	8	1	6.375	33.47	0.71066	-0.05621
65034	34A	6	1	2.25	26.25	0.35172	-0.13876
65035	35A	7	1	11.643	117.85	1.69437	0.10413
65036	36A	8	1	4.813	35.79	0.61005	0.0512
65037	37A	7	1	7.286	55.91	0.93559	0.06663
65038	38A	7	1	10.714	82.22	1.37586	0.10059
65039	39A	8	1	2.313	17.2	0.29314	0.08067
65040	40A	5	1	1.1	3.78	0.10871	0.06425
65041	41A	7	1	18	182.2	2.61952	0.04403
65042	42A	6	1	27.75	323.75	4.33791	0.16434
65043	43A	7	1	10.143	102.67	1.47608	0.13645
65044	44A	7	1	18	138.12	2.31145	0.05593
65045	45A	8	1	2.438	18.13	0.30899	0.21759
65046	46A	7	1	5.714	57.84	0.83159	0.08937
65047	47A	7	1	1.429	8.51	0.16633	-0.04713
65048	48A	7	1	17.429	133.74	2.23807	0.05036
65049	49D	4	1	0.875	5.69	0.10519	-0.24825
65050	50D	8	1	12.625	66.28	1.40739	0.06154
65051	W5	2	1	20.5	5.13	1.56893	0.603
65052	W8	2	1	5.5	1.38	0.42093	-1.00*
65053	W11	2	1	17.75	39.94	1.60656	0.06594
65055	E6	2	1	15.5	3.88	1.18626	-0.19416

Table E10 - Local trend estimate parameters for Black Ducks from Nova Scotia surveys 1990 - 1999 (unpubl. data from (Collins 1999)).

	Black Duck		Ring-necked Duck	
	IBP	SE	IBP	SE
1990	34286	6197	11330	2647
1991	30984	4122	9406	1844
1992	33516	4390	7847	1682
1993	32275	3960	7781	1899
1994	30834	3722	9510	2089
1995	32851	7275	10374	3897
1996	40964	3505	8689	2131
1997	40374	5152	11776	1962
1998	58165	7441	10640	2102
1999	56263	7112	18318	3466

	Common Merganser		Green-winged Teal	
	IBP	SE	IBP	SE
1990	5150	1079	5003	1433
1991	6363	1274	6224	1730
1992	4788	1128	4921	1408
1993	5907	1947	2882	959
1994	3746	983	4178	1041
1995	5187	1493	6224	1934
1996	9576	1989	8867	1994
1997	7103	1523	9907	2130
1998	6916	1979	8867	2010
1999	7290	2120	13832	2790

	Mallard		Wood Duck	
	IBP	SE	IBP	SE
1990	883	399	736	377
1991	968	441	830	468
1992	665	284	1729	652
1993	432	318	865	441
1994	432	243	1441	501
1995	346	345	3112	1275
1996	1419	725	1951	564
1997	1869	951	1308	646
1998	1241	429	2660	1355
1999	5047	1618	3738	1805

Table E11 - Estimated number of indicated breeding pairs and standard error of ducks in Stratum 1. 1990-99 (unpubl. data from (Collins 1999)).

Plot	Mall90	Mall91	Mall92	Mall93	Mall94	Wodu90	Wodu91	Wodu92	Wodu93	Wodu94
26	1	0	1	0	0	0	0	0	0	0
27	1	0	0	0	2	0	0	0	0	0
28	1	0	0	1	1	0	0	0	0	0
29	0	0	3	1	1	0	0	1	0	0
30	0	0	0	0	1	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	3
33	0	0	2	0	0	1	3	1	0	4
34	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	1	0	0
36	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	1	0	0	0	1
38	0	0	0	0	0	0	0	0	0	2
39	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0
41	0	1	0	1	0	0	0	0	1	0
42	2	0	2	1	0	2	4	8	1	10
43	0	0	0	0	1	0	0	0	0	5
44	1	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	1	4	0	2	0
46	0	0	0	0	0	0	0	0	0	0
47	1	0	0	1	1	0	0	0	0	0
48	3	5	1	0	1	1	0	2	0	0
49	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	2
52	0	0	0	0	0	0	0	0	0	0
53	0	1	1	1	1	0	0	5	0	0
54	0	0	0	0	0	0	0	0	0	1
55	0	0	0	0	0	0	0	0	0	0
56	0	0	2	0	0	0	0	0	0	0
57	0	0	1	0	0	0	1	0	6	1
58	0	0	0	0	0	0	0	0	0	3
59	4	1	0	0	0	3	1	4	0	4
60	2	2	1	1	2	3	1	1	5	5
61	0	1	0	1	0	1	0	0	0	0
62	0	0	0	0	0	0	0	0	0	0
63	0	0	1	0	1	0	0	0	1	1
64	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	1	1	0
66	1	0	0	0	0	0	1	1	0	1
67	0	0	0	0	0	0	0	4	0	0
68	0	0	0	2	0	0	0	0	3	1
69	0	0	0	0	0	0	1	0	0	0
70	0	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0	2	1
73	0	0	0	0	0	0	0	0	0	0
74	1	0	0	0	1	0	0	0	0	0
75	1	0	0	0	0	0	0	0	0	0

Table E12 - IBPs of Mallards and Wood Ducks in survey plots 1990-94

Plot	Rndu90	Rndu91	Rndu92	Rndu93	Rndu94	Agwt90	Agwt91	Agwt92	Agwt93	Agwt94
26	12	7	29	19	13	0	0	0	0	2
27	6	9	11	2	3	0	0	0	0	1
28	1	1	3	0	2	4	0	1	0	0
29	9	6	3	0	5	0	0	0	0	0
30	3	0	2	2	1	2	0	1	4	2
31	0	0	0	0	1	1	3	1	3	0
32	2	1	12	5	3	0	0	0	0	1
33	5	2	1	0	0	2	0	0	2	0
34	2	1	4	0	0	4	1	3	9	5
35	0	1	10	4	2	4	0	3	0	1
36	5	1	7	3	3	0	0	0	0	0
37	13	16	15	6	12	0	1	1	1	1
38	5	4	4	3	7	0	0	0	0	0
39	6	8	9	8	11	0	0	0	0	0
40	1	2	2	0	1	0	0	0	0	0
41	7	6	7	0	11	11	9	4	4	5
42	2	3	7	0	1	3	10	15	5	13
43	6	2	1	0	8	3	8	3	0	6
44	8	2	0	0	0	8	10	4	0	8
45	12	9	4	0	11	0	2	1	0	3
46	6	5	6	2	10	8	3	5	1	13
47	19	8	7	6	3	2	0	1	0	1
48	6	10	8	0	15	4	5	1	0	0
49	3	7	0	3	6	0	0	0	0	0
50	0	1	3	0	1	2	5	3	1	9
51	0	1	0	0	0	0	3	3	7	2
52	3	0	0	0	0	0	0	0	0	0
53	22	6	5	5	2	0	3	5	1	1
54	3	13	10	5	6	1	5	3	6	2
55	0	3	1	6	2	0	0	0	0	0
56	0	0	0	1	1	0	0	0	0	1
57	13	21	19	31	34	0	0	4	0	0
58	24	17	11	15	10	0	0	0	1	1
59	57	8	18	16	23	3	3	5	0	2
60	10	22	8	30	22	6	2	3	1	4
61	0	4	10	2	10	5	3	2	3	6
62	7	0	1	3	4	0	0	0	1	2
63	6	7	13	8	11	0	0	2	2	4
64	0	1	3	6	1	0	0	0	0	0
65	0	1	0	0	0	0	0	1	0	0
66	0	1	0	0	0	1	0	2	2	1
67	0	0	2	2	0	1	2	0	0	2
68	0	0	1	0	1	0	0	1	6	3
69	0	5	0	0	0	1	0	0	0	2
70	0	9	9	3	11	0	2	0	3	2
71	12	1	6	8	2	0	0	0	0	1
72	1	16	6	6	17	2	1	0	3	4
73	0	0	0	0	0	2	1	1	1	0
74	2	0	0	0	0	1	0	0	0	0
75	9	0	0	2	2	0	0	0	0	0

Table E13 - IBPs of Ring-necked Duck and Green-winged Teal in survey plots 1990-94.

PLOT	Come90	Come91	Come92	Come93	Come94
26	1	2	2	1	5
27	2	0	7	1	1
28	3	0	0	4	2
29	1	2	2	3	8
30	1	1	1	2	5
31	0	1	2	1	2
32	5	6	4	2	3
33	7	4	6	8	4
34	1	1	0	0	0
35	1	2	5	1	0
36	2	2	2	1	1
37	0	6	2	5	5
38	3	5	1	3	3
39	2	3	2	8	2
40	0	2	2	0	1
41	0	1	0	1	1
42	1	4	2	3	3
43	1	0	2	1	1
44	8	7	5	1	7
45	1	5	5	0	5
46	5	2	2	0	0
47	2	2	0	1	2
48	3	2	4	0	8
49	0	0	0	0	2
50	1	0	1	0	0
51	0	0	1	1	0
52	1	1	0	4	0
53	1	0	0	0	0
54	4	1	0	0	0
55	1	0	0	0	0
56	0	1	1	0	0
57	0	7	3	3	0
58	3	5	9	12	3
59	9	5	3	8	4
60	3	8	0	0	1
61	5	3	1	3	7
62	3	1	0	1	2
63	9	11	14	17	12
64	0	2	0	1	1
65	0	1	0	1	2
66	0	1	1	0	0
67	3	0	0	0	0
68	0	0	4	2	3
69	0	0	0	0	0
70	0	0	0	0	0
71	0	5	2	0	0
72	2	1	0	1	0
73	0	1	0	1	1
74	7	12	1	16	4
75	5	0	0	17	10

Table E14 - IBPs of Common Merganser in survey plots 1990-94

Route	Number of Observations	Survey Periods	Population Weight	Trend Precision	Overall Weight	Mallard Log Slope
56052	5	1	0.4	1.7	0.55338	0.02321
56053	5	1	0.8	1.6	1.09545	0.77337
65026	7	1	0.286	2.89	0.40587	0.0609
65028	7	1	0.286	2.19	0.40146	-0.00936
65029	8	1	0.25	1.31	0.34745	-0.09619
65030	6	1	1.167	11.93	1.65803	1.00*
65042	6	1	0.333	3.89	0.47676	0.6858
65048	7	1	0.571	4.38	0.80291	-0.15824

Table E15 - Local trend estimate parameters for Mallards in New Brunswick and Nova Scotia surveys 1990-99 (unpubl. data from (Collins 1999)).

Route	Number of Observations	Survey Periods	Population Weight	Trend Precision	Overall Weight	Wood Duck Slope
56056	5	1	0.4	1.7	0.41227	0.02321
56058	5	1	0.4	0.8	0.39327	0.5661
56059	7	2	1.429	6.42	1.48017	0.06127
56060	5	1	2.6	11.02	2.67976	0.53754
56062	5	1	0.8	1.6	0.78655	1.00*
56067	4	1	0.75	4.88	0.80895	0.92309
56072	4	1	0.75	4.88	0.80895	-0.10481
56091	2	1	2.5	0.63	2.3652	0.40546
65032	8	1	0.75	5.58	0.82385	0.15599
65033	8	1	0.875	4.59	0.92058	-0.18321
65035	7	1	0.429	4.34	0.49517	0.19967
65042	6	1	1.333	15.56	1.58419	0.34569
65048	7	1	0.429	3.29	0.47292	-0.45355

Table E16 - Local trend estimate parameters for Wood Ducks in New Brunswick and Nova Scotia surveys 1990-99 (unpubl. data from (Collins 1999)).

Route	Number of Observations	Survey Periods	Population Weight	Precision	Overall Weight	GWT Log Slope
56051	7	2	3.286	30.36	2.03173	-0.00831
56053	8	2	2.875	7.78	1.21632	0.57134
56054	7	2	3.286	28.96	1.98982	0.18622
56056	5	1	2.8	11.87	1.313	0.3958
56058	5	1	0.8	1.6	0.32159	0.25708
56059	7	2	2.143	7.53	0.9585	0.09028
56060	8	2	1.75	10.62	0.91627	0.09398
56061	7	2	2.571	16.63	1.37681	0.06246
56062	5	1	1.4	2.8	0.56279	0.46785
56067	4	1	1.25	8.13	0.67058	0.28467
56068	7	2	1.571	10.01	0.83682	0.14237
56069	4	1	0.5	2.13	0.23461	0.11976
56070	4	1	3.25	21.13	1.74351	0.23624
56071	5	1	0.4	0.8	0.1608	1
56072	4	1	2.25	14.62	1.20705	0.20332
56079	2	1	1.5	3.38	0.61419	-0.23105
56080	2	1	1.5	0.38	0.52455	0.69315
56082	2	1	1	2.25	0.40946	0
56084	2	1	1	2.25	0.40946	0
56085	2	1	1.5	0.38	0.52455	0.69315
56087	2	1	4	9	1.63785	0.3662
56088	2	1	1	0.25	0.3497	0
56089	2	1	1	0.25	0.3497	0
56090	2	1	1	0.25	0.3497	0
56091	2	1	1.5	0.38	0.52455	-0.69315
65031	7	1	0.857	6.58	0.48988	-0.13012
65033	8	1	0.375	1.97	0.18717	0.09619
65034	6	1	0.5	5.83	0.34543	0.02813
65035	7	1	0.286	2.89	0.1842	-0.59933
65041	7	1	5	50.61	3.22357	-0.16756
65042	6	1	7.167	83.61	4.95116	0.09658
65043	7	1	0.857	8.68	0.55261	-0.09326
65044	7	1	4.857	37.27	2.77601	-0.03698
65046	7	1	0.571	5.78	0.36841	0.17546
65048	7	1	0.429	3.29	0.24494	-0.87154
65050	8	1	1.75	9.19	0.87345	0.24608
65051	2	1	1	0.25	0.3497	0
65053	2	1	1.5	3.38	0.61419	0.23105
65055	2	1	7.5	1.87	2.62273	0.40547

Table E17 - Local trend estimate parameters for Green-winged Teal in New Brunswick and Nova Scotia surveys 1990-99 (unpubl. data from (Collins 1999)).

Route	Number of Observations	Survey Periods	Population Weight	Trend Precision	Overall Weight	RNDU Log Slope
56053	8	2	3.5	8.71	0.69427	0.02679
56054	7	2	8	69.96	2.97312	0.18054
56055	7	2	4.571	42.18	1.75998	0.12972
56057	7	2	7.286	34.02	1.88526	0.01913
56058	8	2	4.625	13.56	0.97405	-0.09312
56059	7	2	7.857	44.99	2.26313	0.0369
56060	8	2	8.625	47.25	2.42497	-0.04711
56061	7	2	7.286	50.61	2.34479	0.10336
56062	5	1	0.4	0.8	0.07393	1.0000*
56063	7	2	4	24.71	1.20207	0.38401
56064	6	2	2.333	11.13	0.61013	-0.21891
56065	5	1	0.6	1.2	0.11089	0.35076
56066	4	1	1.5	9.75	0.46419	0.54978
56067	4	1	2	13	0.61893	0.67776
56068	3	1	1	0.67	0.14789	-0.52244
56069	4	1	0.5	2.13	0.12357	0.76137
56070	4	1	3.75	24.38	1.16049	0.31838
56071	5	1	0.4	0.8	0.07393	0
56072	7	2	4.714	41	1.74577	0.17657
56076	2	1	3	6.75	0.57523	0
56078	2	1	4	9	0.76698	0.17028
56080	2	1	1.5	0.38	0.20452	0.69315
56082	2	1	7.5	16.88	1.43809	0.13516
56083	2	1	4	1	0.54539	0
56084	2	1	4.5	10.13	0.86285	0.41759
56086	2	1	2	4.5	0.38349	0
56088	2	1	3	0.75	0.40904	0.69315
56091	2	1	11.5	2.88	1.568	1.0000*
65026	7	1	2.857	28.92	1.17085	0.0563
65027	8	1	0.875	6.51	0.2935	0.06916
65028	7	1	0.857	6.58	0.29311	0.29459
65029	8	1	4.125	21.66	1.13372	0.29237
65032	8	1	0.25	1.86	0.08386	0.21603
65033	8	1	0.375	1.97	0.10306	-0.03178
65035	7	1	2.429	24.58	0.99523	0.01962
65036	8	1	1.125	8.37	0.37736	-0.02663
65037	7	1	4.429	33.98	1.51442	0.06647
65038	7	1	1.714	13.15	0.58623	0.12651
65039	8	1	4.5	33.47	1.50944	0.01480
65040	5	1	1	3.44	0.22471	0.25388
65041	7	1	7	70.86	2.86859	-0.01223
65042	6	1	2.333	27.22	1.056	0.58741
65046	7	1	0.857	8.68	0.35126	0.10635
65047	7	1	2.714	16.17	0.79931	0.06049
65048	7	1	3.143	24.12	1.07475	-0.07198
65050	8	1	0.75	3.94	0.20613	-0.23523
65052	2	1	4.5	1.13	0.61357	-0.22314
65055	2	1	4.5	1.13	0.61357	0.69315

Table E18 - Local trend estimate parameters for Ring-necked Ducks (RNDU) in New Brunswick and Nova Scotia surveys 1990-99 (unpubl. data from).

Route	Number of Observations	Survey Period	Population Weight	Trend Precision	Overall Weight	COME Log Slope
56052	5	1	0.8	3.39	0.41189	-0.03634
56056	3	1	0.667	0.44	0.33522	-0.83412
56058	8	2	1.75	4.89	0.89248	-0.08851
56059	4	1	2.25	9.56	1.1585	0.09249
56060	3	1	0.667	0.44	0.33522	-0.83412
56061	7	2	0.857	5.54	0.44773	0.19927
56062	5	1	1.6	3.2	0.8117	0.66269
56063	7	2	3.429	16.26	1.77102	0.07233
56064	4	1	1.25	5.31	0.64361	0.22505
56068	7	2	2.571	12.4	1.32897	0.29828
56072	7	2	1.286	11.82	0.6834	0.29896
56074	6	2	5.167	36.22	2.70831	0.00915
56075	2	1	1	0.25	0.50142	0
56077	2	1	3.5	0.87	1.75497	-0.28768
56078	2	1	9	20.25	4.5734	0.07438
56083	2	1	5.5	1.38	2.75781	-0.98083
56084	2	1	2	4.5	1.01631	0
56085	2	1	1.5	0.38	0.75213	-0.69315
56087	2	1	1.5	3.38	0.76223	-0.23105
56088	2	1	1.5	0.38	0.75213	0.69315
56091	2	1	4.5	1.13	2.25639	1
65026	7	1	0.286	2.89	0.15276	-0.16101
65027	8	1	0.625	4.65	0.32852	0.13199
65028	7	1	0.429	3.29	0.22561	-0.03164
65029	8	1	1.625	8.53	0.84217	0.09619
65032	8	1	1.875	13.95	0.98555	-0.21663
65033	8	1	1.875	9.84	0.97173	-0.09619
65036	8	1	0.5	3.72	0.26281	-0.30486
65037	7	1	1	7.67	0.52642	-0.12241
65038	7	1	1.857	14.25	0.97764	0.09251
65039	8	1	2.875	21.38	1.51117	0.2134
65040	5	1	1	3.44	0.51216	-0.05782
65043	7	1	1.143	11.57	0.61105	0.17546
65044	7	1	2.857	21.92	1.50406	-0.29263
65045	8	1	2	14.87	1.05125	0.21603
65046	7	1	0.429	4.34	0.22914	-0.86483
65055	2	1	3	0.75	1.50426	0

Table E19 - Local trend estimate parameters for Common Mergansers (COME) in New Brunswick and Nova Scotia surveys 1990-99 (unpubl. data from Collins 1999).

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
1	MXSCOR	0.7801	91.29	0.007917	0.00029799	26.568	0.0001
2	LSSIZE	0.7573	110.97	0.277724	0.01114413	24.921	0.0001
3	LXSTM	0.6444	187.4	1.725431	0.09086161	18.99	0.0001
4	TOTAL	0.5754	222.86	0.022953	0.00139769	16.422	0.0001
5	LTOTLAK	0.5712	224.84	0.809738	0.04973532	16.281	0.0001
6	MXSCOR	0.8134	60.52	0.006267	0.00039095	16.029	0.0001
	LTOTLAK			0.277728	0.0467291	5.943	0.0001
7	MXSCOR	0.7969	77.39	0.007922	0.00028706	27.596	0.0001
	PCA2			0.105026	0.02589609	4.056	0.0001
8	MXSCOR	0.7873	86.7	0.005387	0.00102058	5.278	0.0001
	LSSIZE			0.094052	0.03633481	2.588	0.0104
9	LTOTLAK	0.7856	88.22	0.267134	0.05223977	5.114	0.0001
	LSSIZE			0.219004	0.01556017	14.075	0.0001
10	MXSCOR	0.7825	91.09	0.010142	0.00151117	6.711	0.0001
	PI			0.071264	0.0474657	1.501	0.1349
11	MXSCOR	0.7823	91.34	0.007292	0.00053164	13.717	0.0001
	TOTAL			0.002544	0.00179461	1.417	0.1579
12	MXSCOR	0.7819	91.64	0.008878	0.00079437	11.176	0.0001
	LXSTM			-0.24849	0.190482	-1.305	0.1936

Table F1- Univariate and bivariate models of Black Duck IBPs in PQUADs. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
13	MXSCOR	0.8402	31.61	0.005766	0.00037303	15.457	0.0001
	LTOTLAK			0.300727	0.04353887	6.907	0.0001
	LSALTHA			0.228829	0.03982023	5.747	0.0001
14	MXSCOR	0.8157	60.1	0.00389	0.00099034	3.928	0.0001
	LSSIZE			0.135496	0.03472997	3.901	0.0001
	LSALTHA			0.240385	0.04361298	5.512	0.0001
15	LTOTLAK	0.8315	42.22	0.275984	0.04645585	5.941	0.0001
	LSSIZE			0.205334	0.01395825	14.711	0.0001
	LSALTHA			0.293575	0.04012081	7.317	0.0001
16	LTOTLAK	0.8297	44.26	0.275615	0.04474979	6.159	0.0001
	MXSCOR			0.006284	0.00037439	16.784	0.0001
	PCA2			0.103436	0.02377495	4.351	0.0001
17	LTOTLAK	0.8217	53.47	0.308414	0.04689424	6.577	0.0001
	MXSCOR			0.010263	0.00137198	7.48	0.0001
	P1			0.133868	0.04412893	3.034	0.0027
18	MXSCOR	0.8157	60.1	0.00389	0.00099034	3.928	0.0001
	LSSIZE			0.135496	0.03472997	3.901	0.0001
	LSALTHA			0.240385	0.04361298	5.512	0.0001
19	MXSCOR	0.8146	61.24	0.006637	0.00050434	13.159	0.0001
	LTOTLAK			0.303775	0.05180563	5.864	0.0001
	TOTAL			-0.002137	0.00184206	-1.16	0.2474
20	MXSCOR	0.8145	61.35	0.005294	0.0009555	5.54	0.0001
	LTOTLAK			0.262226	0.04872262	5.382	0.0001
	LSSIZE			0.039598	0.03548508	1.116	0.2658

Table F2 - Models (3 variables) of Black Duck IBPs in PQUADs. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
21	LTOTLAK	0.8545	14.94	0.344308	0.04281377	8.042	0.0001
	MXSCOR			0.011018	0.00124777	8.83	0.0001
	PI			0.177951	0.04051392	4.392	0.0001
	LSALTHA			0.256597	0.03861206	6.646	0.0001
22	LSSIZE	0.8530	16.99	0.168889	0.01473406	11.462	0.0001
	LTOTLAK			0.264339	0.04355239	6.069	0.0001
	LSALTHA			0.202032	0.04126998	4.895	0.0001
	LBUILD			0.09407	0.01755903	5.357	0.0001
23	MXSCOR	0.8525	17.68	0.009107	0.00090093	10.109	0.0001
	LTOTLAK			0.316174	0.04210863	7.509	0.0001
	LSALTHA			0.249226	0.03868357	6.443	0.0001
	LELVSTD			-0.183288	0.04531955	-4.044	0.0001
24	MXSCOR	0.8482	23.41	0.00585	0.0003654	16.009	0.0001
	LTOTLAK			0.295923	0.04256605	6.952	0.0001
	LSALTHA			0.196252	0.04020132	4.882	0.0001
	PCA2			0.074856	0.02325549	3.219	0.0015
25	MXSCOR	0.8465	25.67	0.010367	0.00166251	6.235	0.0001
	LTOTLAK			0.267763	0.04432998	6.04	0.0001
	LSALTHA			0.269184	0.04163184	6.466	0.0001
	SOILPH			-0.057425	0.02024124	-2.837	0.005
26	MXSCOR	0.8402	33.62	0.005864	0.00048924	11.986	0.0001
	LTOTLAK			0.307091	0.04822082	6.368	0.0001
	LSALTHA			0.22677	0.04045998	5.605	0.0001
	TOTAL			-0.000539	0.00173801	-0.31	0.7567
27	MXSCOR	0.8402	33.67	0.005916	0.00081299	7.277	0.0001
	LTOTLAK			0.298345	0.04512928	6.611	0.0001
	LSALTHA			0.229347	0.0399955	5.734	0.0001
	LXSTM			-0.035283	0.17007161	-0.207	0.8359

Table F3 - Models (4 variables) of Black Duck IBPs in PQUADs. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
28	MXSCOR	0.8614	7.38	0.008674	0.00088415	9.81	0.0001
	LTOTLAK			0.326551	0.04102956	7.959	0.0001
	LSALTHA			0.199263	0.0401627	4.961	0.0001
	LELVSTD			-0.214116	0.04489946	-4.769	0.0001
	LBUILD			0.069703	0.01970999	3.536	0.0005
29	MXSCOR	0.8602	9.10	0.010357	0.00124862	8.295	0.0001
	LTOTLAK			0.351407	0.04215319	8.336	0.0001
	LSALTHA			0.215348	0.04068107	5.294	0.0001
	P1			0.182022	0.03984359	4.568	0.0001
	LBUILD			0.054678	0.01943137	2.814	0.0054
30	MXSCOR	0.8578	12.48	0.011519	0.00125892	9.15	0.0001
	LTOTLAK			0.341042	0.04246191	8.032	0.0001
	LSALTHA			0.260894	0.03832298	6.808	0.0001
	P1			0.126499	0.04687975	2.698	0.0076
	LELVSTD			-0.110762	0.05208169	-2.127	0.0347
31	MXSCOR	0.8557	15.32	0.009454	0.00172703	5.474	0.0001
	LTOTLAK			0.324373	0.04537701	7.148	0.0001
	LSALTHA			0.26469	0.0390367	6.781	0.0001
	P1			0.162201	0.04219832	3.844	0.0002
	LSSIZE			0.043777	0.03349497	1.307	0.1928
32	MXSCOR	0.8557	15.38	0.00858	0.00092827	9.243	0.0001
	LTOTLAK			0.310258	0.04184791	7.414	0.0001
	LSALTHA			0.223835	0.04023611	5.563	0.0001
	PCA2			0.050162	0.02401527	2.089	0.038
	LELVSTD			-0.15129	0.04747519	-3.187	0.0017
33	MXSCOR	0.8556	15.49	0.008435	0.00095115	8.868	0.0001
	LTOTLAK			0.346557	0.04428319	7.826	0.0001
	LSALTHA			0.24943	0.03836623	6.501	0.0001
	LXSTM			0.384459	0.18633475	2.063	0.0404
	LELVSTD			-0.235904	0.05167791	-4.565	0.0001
34	MXSCOR	0.8550	16.38	0.011939	0.00168529	7.084	0.0001
	LTOTLAK			0.328934	0.04682596	7.025	0.0001
	LSALTHA			0.266657	0.04057189	6.572	0.0001
	SOILPH			-0.018583	0.02282119	-0.814	0.4165
	P1			0.158729	0.04691947	3.383	0.0009

Table F4 - Models (5 variables) of Black Duck IBPs in PQUADs, 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
35	MXSCOR	0.8657	3.16	0.010883	0.00124079	8.771	0.0001
	LTOTLAK			0.34855	0.04142784	8.413	0.0001
	LSALTHA			0.212507	0.03998179	5.315	0.0001
	LELVSTD			-0.146702	0.05184056	-2.83	0.0051
	LBUILD			0.065989	0.01950528	3.383	0.0009
	PI			0.114717	0.04580503	2.504	0.0131
36	MXSCOR	0.8644	5.15	0.008021	0.00093167	8.609	0.0001
	LTOTLAK			0.356123	0.04311696	8.259	0.0001
	LSALTHA			0.199878	0.03982875	5.018	0.0001
	LELVSTD			-0.26522	0.05089751	-5.211	0.0001
	LBUILD			0.069123	0.01954756	3.536	0.0005
	LXSTM			0.375285	0.18108863	2.072	0.0396
37	MXSCOR	0.8644	5.16	0.007127	0.00180527	3.948	0.0001
	LTOTLAK			0.315012	0.04419598	7.128	0.0001
	LSALTHA			0.218305	0.04018756	5.432	0.0001
	LBUILD			0.071519	0.02038186	3.509	0.0006
	LSSIZE			0.084726	0.03459161	2.449	0.0152
	PI			0.152792	0.0411126	3.716	0.0003
38	MXSCOR	0.8643	5.23	0.008872	0.00088231	10.056	0.0001
	LTOTLAK			0.308054	0.0416829	7.39	0.0001
	LSALTHA			0.20156	0.03985204	5.058	0.0001
	LBUILD			0.104813	0.02598249	4.034	0.0001
	LELVSTD			-0.202675	0.04488238	-4.516	0.0001
	ROAD			-0.005153	0.00251198	-2.052	0.0416
39	MXSCOR	0.8628	7.42	0.006475	0.00176882	3.66	0.0003
	LTOTLAK			0.303902	0.04386138	6.929	0.0001
	LSALTHA			0.202178	0.04010595	5.041	0.0001
	LBUILD			0.07783	0.02045752	3.804	0.0002
	LELVSTD			-0.1762	0.05200245	-3.388	0.0009
	LSSIZE			0.055437	0.03866011	1.434	0.1532
40	MXSCOR	0.8628	7.43	0.010383	0.00124001	8.373	0.0001
	LTOTLAK			0.331883	0.04306088	7.707	0.0001
	LSALTHA			0.216338	0.0404016	5.355	0.0001
	LBUILD			0.08881	0.02615224	3.396	0.0008
	ROAD			-0.004905	0.00253649	-1.934	0.0546
	PI			0.170105	0.04004379	4.248	0.0001

Table F5 - Models (6 variables) of Black Duck IBPs in PQUADs. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
45	MXSCOR	0.8682	1.61	0.010156	0.00129024	7.872	0.0001
	LTOTLAK			0.374172	0.04329511	8.642	0.0001
	LSALTHA			0.212276	0.03971422	5.345	0.0001
	LBUILD			0.065682	0.01937533	3.39	0.0008
	LELVSTD			-0.197276	0.05794142	-3.405	0.0008
	LXSTM			0.341829	0.17954453	1.904	0.0584
	PI			0.107866	0.04564035	2.363	0.0191
46	MXSCOR	0.8680	1.93	0.01089	0.00123348	8.828	0.0001
	LTOTLAK			0.330556	0.04235491	7.804	0.0001
	LSALTHA			0.213519	0.03974989	5.372	0.0001
	LBUILD			0.097233	0.0259039	3.754	0.0002
	LELVSTD			-0.141773	0.05160603	-2.747	0.0066
	ROAD			-0.004544	0.00249819	-1.819	0.0705
	PI			0.105938	0.04578997	2.314	0.0217
47	MXSCOR	0.8675	2.6	0.008203	0.00092703	8.849	0.0001
	LTOTLAK			0.338018	0.04354583	7.762	0.0001
	LSALTHA			0.202284	0.0394793	5.124	0.0001
	LBUILD			0.105521	0.02574063	4.099	0.0001
	LELVSTD			-0.255222	0.05064519	-5.039	0.0001
	ROAD			-0.005346	0.00248998	-2.147	0.0331
	LXSTM			0.389016	0.17954141	2.167	0.0315
48	MXSCOR	0.8670	3.41	0.008774	0.00198077	4.43	0.0001
	LTOTLAK			0.326844	0.04429446	7.379	0.0001
	LSALTHA			0.214989	0.03993497	5.383	0.0001
	LBUILD			0.073697	0.02026611	3.636	0.0004
	LELVSTD			-0.112386	0.05752125	-1.954	0.0522
	LSSIZE			0.052085	0.03819082	1.364	0.1742
	PI			0.112492	0.04573295	2.46	0.0148
49	MXSCOR	0.8667	3.78	0.00947	0.00169266	5.595	0.0001
	LTOTLAK			0.341908	0.04172798	8.194	0.0001
	LSALTHA			0.211433	0.03993982	5.294	0.0001
	LBUILD			0.066814	0.01949175	3.428	0.0007
	LELVSTD			-0.17042	0.05527367	-3.083	0.0023
	PPGS			0.000482	0.00039365	1.225	0.2219
	PI			0.144426	0.05177361	2.79	0.0058
50	MXSCOR	0.8665	4.17	0.007346	0.00180003	4.081	0.0001
	LTOTLAK			0.299644	0.04482749	6.684	0.0001
	LSALTHA			0.219017	0.03997668	5.479	0.0001
	LBUILD			0.101213	0.02642001	3.831	0.0002
	ROAD			-0.004413	0.00251779	-1.753	0.0812
	LSSIZE			0.079602	0.03453228	2.305	0.0222
	PI			0.143837	0.04121264	3.49	0.0006

Table F6 - Models (7 variables) of Black Duck IBPs in PQUADs. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
62	LTOTLAK	0.8707	0	0.356445	0.04397709	8.105	0.0001
	MXSCOR			0.010131	0.00128143	7.906	0.0001
	LSALTHA			0.213328	0.03944451	5.408	0.0001
	LXSTM			0.357016	0.1784834	2	0.0469
	LELVSTD			-0.194355	0.0575625	-3.376	0.0009
	LBUILD			0.098425	0.02571173	3.828	0.0002
	ROAD			-0.004764	0.00248142	-1.92	0.0564
	P1			0.098357	0.04559581	2.157	0.0322
63	LTOTLAK	0.8696	1.65	0.332938	0.04341595	7.669	0.0001
	MXSCOR			0.007773	0.00095466	8.142	0.0001
	LSALTHA			0.18795	0.04012507	4.684	0.0001
	LXSTM			0.425505	0.17982545	2.366	0.019
	LELVSTD			-0.22823	0.05270804	-4.33	0.0001
	LBUILD			0.099158	0.02586505	3.834	0.0002
	ROAD			-0.005792	0.00249017	-2.326	0.0211
	PCA2			0.042067	0.02414371	1.742	0.083
64	LTOTLAK	0.8695	1.87	0.331831	0.04349699	7.629	0.0001
	MXSCOR			0.007737	0.00096333	8.032	0.0001
	LSALTHA			0.206968	0.03939227	5.254	0.0001
	LXSTM			0.425398	0.18000223	2.363	0.0191
	LELVSTD			-0.242253	0.05099366	-4.751	0.0001
	LBUILD			0.116471	0.02643422	4.406	0.0001
	ROAD			-0.005454	0.00247912	-2.2	0.029
	PCA1			-0.038894	0.02312927	-1.682	0.0943
65	LTOTLAK	0.8693	2.1	0.353033	0.04625575	7.632	0.0001
	MXSCOR			0.008206	0.0019926	4.118	0.0001
	LSALTHA			0.214608	0.03968946	5.407	0.0001
	LXSTM			0.3309	0.17944676	1.844	0.0667
	LELVSTD			-0.163534	0.06354075	-2.574	0.0108
	LBUILD			0.072907	0.0201458	3.619	0.0004
	LSSIZE			0.04876	0.03799835	1.283	0.201
	P1			0.106002	0.04558724	2.325	0.0211
66	LTOTLAK	0.8691	2.44	0.323413	0.04265695	7.582	0.0001
	MXSCOR			0.00943	0.00168228	5.605	0.0001
	LSALTHA			0.212425	0.03969523	5.351	0.0001
	LELVSTD			-0.166205	0.05497741	-3.023	0.0028
	LBUILD			0.09857	0.02588353	3.808	0.0002
	ROAD			-0.004615	0.00249478	-1.85	0.0659
	PPGS			0.000498	0.0003913	1.274	0.2043
	P1			0.1365	0.05162995	2.644	0.0089

Table F7 - Models (8 variables) of Black Duck IBPs in PQUADs, 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
101	MSCOR	0.9421	35.26	0.019466	0.00068912	28.248	0.0001
102	LSSIZE	0.9248	48.35	0.413149	0.01682711	24.553	0.0001
103	LXSTM	0.8512	82.47	3.66287	0.28173979	16.745	0.0001
104	TOTAL	0.7233	113.51	0.012337	0.00109009	11.317	0.0001
105	LSSIZEL	0.6281	128.29	1.537439	0.16899220	9.098	0.0001
106	MSCOR	0.9576	21.93	0.016809	0.00086988	19.324	0.0001
	LSSIZEL			0.352639	0.08414240	4.191	0.0001
107	MSCOR	0.9527	27.49	0.019493	0.00062988	30.946	0.0001
	PCA2			0.151077	0.04627365	3.265	0.0020
108	MSCOR	0.9454	34.6	0.013997	0.00328837	4.257	0.0001
	LSSIZE			0.119706	0.07044332	1.699	0.0957
109	LSSIZEL	0.9329	44.97	0.269330	0.11245922	2.395	0.0206
	LSSIZE			0.367577	0.02490577	14.759	0.0001
110	MSCOR	0.9455	34.57	0.027219	0.00458954	5.931	0.0001
	P1			0.200502	0.11739608	1.708	0.0941
111	MSCOR	0.9433	36.53	0.018335	0.00134377	13.645	0.0001
	TOTAL			0.000953	0.00097197	0.980	0.3319
112	MSCOR	0.9437	36.19	0.022202	0.00250206	8.873	0.0001
	LXSTM			-0.563272	0.49530474	-1.137	0.2611

Table F8 - Univariate and bivariate models of Black Duck IBPs in PLOTs, 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
113	MSCOR	0.9649	14.83	0.015626	0.00088462	17.664	0.0001
	LSSIZEL			0.379714	0.07783529	4.878	0.0001
	LSALTHA			0.127188	0.04063761	3.130	0.0030
114	MSCOR	0.9538	28.6	0.010246	0.00331420	3.092	0.0033
	LSSIZE			0.177918	0.06842669	2.600	0.0124
	LSALTHA			0.141763	0.04843725	2.927	0.0053
115	LSSIZEL	0.9541	30.28	0.296415	0.09410524	3.150	0.0028
	LSSIZE			0.332966	0.02208215	15.078	0.0001
	LSALTHA			0.208337	0.04460989	4.670	0.0001
116	LSSIZEL	0.9639	16.29	0.306719	0.08011836	3.828	0.0004
	MSCOR			0.017176	0.00082154	20.907	0.0001
	PCA2			0.119070	0.04167597	2.857	0.0064
117	LSSIZEL	0.9640	16.21	0.390917	0.07954821	4.914	0.0001
	MSCOR			0.027387	0.00376983	7.265	0.0001
	PI			0.281002	0.09780627	2.873	0.0061
118	MSCOR	0.9593	22.27	0.017883	0.00115471	15.487	0.0001
	LSSIZEL			0.428608	0.09952086	4.307	0.0001
	TOTAL			-0.001387	0.00099344	-1.396	0.1693
119	MSCOR	0.9578	24.09	0.015570	0.00295220	5.274	0.0001
	LSSIZEL			0.338170	0.09101830	3.715	0.0005
	LSSIZE			0.029509	0.06713151	0.440	0.6623

Table F9 - Models (3 variables) of Black Duck IBPs in PLOTs, 92-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
121	MSCOR	0.9715	6.92	0.0229	0.0036235	6.319	0.0001
	LSSIZEL			0.37619	0.0716087	5.253	0.0001
	LBUILD			0.10894	0.0311872	3.493	0.0011
	P1			0.25356	0.0882421	2.873	0.0061
122	MSCOR	0.9710	7.81	0.026	0.0034431	7.552	0.0001
	LSALTHA			0.12488	0.0373636	3.342	0.0017
	LSSIZEL			0.4167	0.072537	5.745	0.0001
	P1			0.2751	0.0886977	3.102	0.0033
123	MSCOR	0.9694	10.59	0.01316	0.0012721	10.344	0.0001
	LSALTHA			0.08713	0.041442	2.103	0.041
	LSSIZEL			0.36216	0.0738777	4.902	0.0001
	LBUILD			0.08946	0.0347701	2.573	0.0134
124	MSCOR	0.9692	10.84	0.01965	0.0034535	5.689	0.0001
	LSSIZEL			0.3147	0.0744763	4.226	0.0001
	LELVSTD			-0.24427	0.119715	-2.04	0.0471
	LBUILD			0.11817	0.0323117	3.657	0.0007
125	MSCOR	0.9691	10.95	0.01404	0.00136	10.326	0.0001
	LSSIZEL			0.31113	0.0749098	4.153	0.0001
	LBUILD			0.09515	0.0340976	2.791	0.0076
	PCA2			0.08274	0.0410753	2.014	0.0498

Table F10 - Models (4 variables) of Black Duck IBPs in PLOTS, 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
126	MSCOR	0.9746	3.83	0.02307	0.0034618	6.664	0.0001
	LSALTHA			0.08884	0.0381635	2.328	0.0245
	LSSIZEL			0.39833	0.0690567	5.768	0.0001
	LBUILD			0.08085	0.0321407	2.515	0.0155
	P1			0.25644	0.0842957	3.042	0.0039
127	LSSIZE	0.9736	5.65	0.16516	0.038489	4.291	0.0001
	LSALTHA			0.11788	0.0390287	3.02	0.0042
	LSSIZEL			0.39092	0.0844638	4.628	0.0001
	LXSTM			0.92709	0.3173235	2.922	0.0054
	LBUILD			0.1084	0.0316296	3.427	0.0013
128	MSCOR	0.9735	5.98	0.02448	0.0034136	7.17	0.0001
	LSALTHA			0.10352	0.0376293	2.751	0.0085
	LSSIZEL			0.44647	0.0716671	6.23	0.0001
	ROAD			0.00226	0.0011054	2.04	0.0472
	P1			0.28387	0.0859058	3.304	0.0019
129	LSSIZE	0.9732	6.54	0.20044	0.0306428	6.541	0.0001
	LSALTHA			0.13765	0.0400128	3.44	0.0013
	LSSIZEL			0.29185	0.0743253	3.927	0.0003
	LBUILD			0.1183	0.0308732	3.832	0.0004
	N1			-0.24631	0.0894273	-2.754	0.0085
130	MSCOR	0.9726	7.57	0.01869	0.0034873	5.358	0.0001
	LSALTHA			0.1449	0.0370696	3.909	0.0003
	LSSIZEL			0.47495	0.0843407	5.631	0.0001
	LXSTM			1.23554	0.4564753	2.707	0.0096
	LELVSTD			-0.37889	0.1222125	-3.1	0.0033

Table F11 - Models (5 variables) of Black Duck IBPs in PLOTS. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
131	MSCOR	0.9762	3.24	0.01675	0.0033715	4.967	0.0001
	LSALTHA			0.10744	0.037833	2.84	0.0068
	LSSIZEL			0.44866	0.0801408	5.598	0.0001
	LXSTM			1.12918	0.4321967	2.613	0.0122
	LELVSTD			-0.36734	0.1152718	-3.187	0.0026
	LBUILD			0.08121	0.0314701	2.58	0.0133
132	LSSIZE	0.9759	3.92	0.08848	0.0575447	1.538	0.1313
	MSCOR			0.01764	0.0049075	3.595	0.0008
	LSALTHA			0.09968	0.0382534	2.606	0.0125
	LSSIZEL			0.35159	0.0745136	4.718	0.0001
	LBUILD			0.09272	0.0325925	2.845	0.0067
	P1			0.22369	0.0857339	2.609	0.0124
133	LSSIZE	0.9757	4.22	0.14698	0.0384941	3.818	0.0004
	LSALTHA			0.13209	0.038565	3.425	0.0013
	LSSIZEL			0.37935	0.0821701	4.617	0.0001
	LXSTM			0.70769	0.3278411	2.159	0.0364
	LBUILD			0.09786	0.0311638	3.14	0.003
	N1			-0.17843	0.0915687	-1.949	0.0577
134	MSCOR	0.9755	4.69	0.01975	0.0042997	4.592	0.0001
	LSALTHA			0.09465	0.0381572	2.481	0.017
	LSSIZEL			0.45505	0.0815166	5.582	0.0001
	LXSTM			0.52973	0.4117892	1.286	0.205
	LBUILD			0.07758	0.0320103	2.424	0.0195
	P1			0.24649	0.0840453	2.933	0.0053
135	MSCOR	0.9755	4.8	0.02528	0.0038726	6.529	0.0001
	LSALTHA			0.09169	0.0380001	2.413	0.0201
	LSSIZEL			0.3766	0.0708156	5.318	0.0001
	LELVSTD			-0.14926	0.1197617	-1.246	0.2192
	LBUILD			0.08217	0.0319625	2.571	0.0136
	P1			0.21015	0.0916462	2.293	0.0267

Table F12 - Models (6-variables) of Black Duck IBPs in PLOTS, 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
136	MSCOR	0.9789	0	0.01388	0.0034065	4.075	0.0002
	LSALTHA			0.14964	0.0356316	4.2	0.0001
	LSSIZEL			0.5332	0.0774025	6.889	0.0001
	LXSTM			1.34857	0.4124059	3.27	0.0021
	LELVSTD			-0.46812	0.1131332	-4.138	0.0002
	ROAD			0.00288	0.0010408	2.768	0.0083
	NI			-0.29897	0.102775	-2.909	0.0057
137	MSCOR	0.9784	1.21	0.01388	0.0034065	4.075	0.0002
	LSALTHA			0.14964	0.0356316	4.2	0.0001
	LSSIZEL			0.5332	0.0774025	6.889	0.0001
	LXSTM			1.34857	0.4124059	3.27	0.0021
	LELVSTD			-0.46812	0.1131332	-4.138	0.0002
	ROAD			0.00288	0.0010408	2.768	0.0083
	NI			-0.29897	0.102775	-2.909	0.0057
138	MSCOR	0.9779	2.39	0.01475	0.0033847	4.359	0.0001
	LSALTHA			0.13197	0.0382812	3.447	0.0013
	LSSIZEL			0.46884	0.0778113	6.025	0.0001
	LXSTM			1.23841	0.4196591	2.951	0.0051
	LELVSTD			-0.42249	0.1141331	-3.702	0.0006
	LBUILD			0.07712	0.0303834	2.538	0.0148
	NI			-0.21176	0.1009678	-2.097	0.0419
139	LSSIZE	0.9777	2.79	0.13954	0.0375367	3.717	0.0006
	LSALTHA			0.17373	0.0363244	4.783	0.0001
	LSSIZEL			0.51967	0.0827854	6.277	0.0001
	LXSTM			1.4012	0.4216397	3.323	0.0018
	LELVSTD			-0.25341	0.0999518	-2.535	0.015
	ROAD			0.00359	0.0010328	3.479	0.0012
	NI			-0.37149	0.1006458	-3.691	0.0006
140	MSCOR	0.9775	3.23	0.02121	0.004208	5.041	0.0001
	LSALTHA			0.10401	0.0370866	2.804	0.0075
	LSSIZEL			0.45852	0.0786557	5.829	0.0001
	LXSTM			0.92168	0.4401081	2.094	0.0422
	LELVSTD			-0.26452	0.1278554	-2.069	0.0446
	LBUILD			0.07751	0.0308799	2.51	0.0159
	PI			0.1571	0.091873	1.71	0.0945

Table F13 - Models (7-variables) of Black Duck IBPs in PLOTS, 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
144	MSCOR	0.9813	0.23	0.01296	0.0035947	3.606	0.0008
	LSALTHA			0.11291	0.0403547	2.798	0.0077
	LSSIZEL			0.45656	0.0775388	5.888	0.0001
	LXSTM			1.29811	0.4176686	3.108	0.0034
	LELVSTD			-0.36503	0.1204735	-3.03	0.0042
	LBUILD			0.06737	0.0309018	2.18	0.0349
	PCA2			0.06099	0.0444071	1.373	0.1769
	N1			-0.25589	0.1049834	-2.437	0.0191
141	MSCOR	0.9796	1.43	0.01251	0.0035956	3.479	0.0012
	LSALTHA			0.13196	0.0386673	3.413	0.0014
	LSSIZEL			0.51491	0.0787216	6.541	0.0001
	LXSTM			1.38755	0.4122227	3.366	0.0016
	LELVSTD			-0.41353	0.1222425	-3.383	0.0016
	ROAD			0.0025	0.0010874	2.301	0.0264
	PCA2			0.05197	0.0450665	1.153	0.2554
	N1			-0.32552	0.1049406	-3.102	0.0034
142	MSCOR	0.9796	1.47	0.0173	0.0045373	3.813	0.0004
	LSALTHA			0.14226	0.0361002	3.941	0.0003
	LSSIZEL			0.53487	0.0771553	6.932	0.0001
	LXSTM			1.18435	0.4356696	2.718	0.0095
	LELVSTD			-0.3869	0.1334912	-2.898	0.0059
	ROAD			0.00283	0.0010383	2.723	0.0094
	P1			0.1071	0.0942257	1.137	0.2621
	N1			-0.25805	0.1085707	-2.377	0.0221
143	MSCOR	0.9794	1.91	0.01949	0.0067909	2.87	0.0064
	LSALTHA			0.15573	0.0362322	4.298	0.0001
	LSSIZEL			0.5409	0.0778994	6.944	0.0001
	LXSTM			1.28687	0.4178427	3.08	0.0036
	LELVSTD			-0.47191	0.1133168	-4.164	0.0002
	ROAD			0.00323	0.0011039	2.925	0.0055
	LTMINGS			-0.34259	0.358516	-0.956	0.3448
	N1			-0.32897	0.1075639	-3.058	0.0039

Table F14 - Models (8-variables) of Black Duck IBPs in PLOTS. 1992-94.

Model	Variable	Model R2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
201	MXSCOR	0.876501	0	0.009	0.00047306	19.025	0.0001
202	LSSIZE	0.854479	8.5	0.283169	0.01636335	17.305	0.0001
203	LXSTM	0.749563	36.7	2.675962	0.21659104	12.355	0.0001
204	TOTAL	0.556273	66.47	0.023763	0.00297188	7.996	0.0001
205	LTOTLAK	0.735579	39.6	0.848386	0.07122656	11.911	0.0001
206	MXSCOR	0.876621	2.2	0.009248	0.00122323	7.56	0.0001
	LTOTLAK			-0.027704	0.12586833	-0.22	0.8267
207	MXSCOR	0.877134	2	0.00773	0.00254598	3.036	0.0038
	LSSIZE			0.041185	0.08112967	0.508	0.6139
208	LTOTLAK	0.855992	10.2	0.092997	0.12832232	0.725	0.472
	LSSIZE			0.25695	0.03973915	6.466	0.0001
209	MXSCOR	0.881987	-0.1	0.010101	0.00085983	11.747	0.0001
	TOTAL			-0.004345	0.00284973	-1.525	0.1337
210	MXSCOR	0.878457	1.4	0.01018	0.00139799	7.282	0.0001
	LXSTM			-0.403215	0.44948138	-0.897	0.374
211	MXSCOR	0.880643	2.8	0.008976	0.00123368	7.275	0.0001
	LTOTLAK			-0.024609	0.12507962	-0.197	0.8448
	LSALTHA			0.065243	0.05077115	1.285	0.2048
212	LTOTLAK	0.882176	2.1	0.067715	0.12484216	0.542	0.59
	LSSIZE			0.252556	0.03853582	6.554	0.0001
	LSALTHA			0.109763	0.05274003	2.081	0.0427
213	MXSCOR	0.883366	1.6	0.009458	0.00120785	7.83	0.0001
	LTOTLAK			0.113765	0.14948046	0.761	0.4503
	TOTAL			-0.005825	0.00346042	-1.683	0.0987
214	MXSCOR	0.877305	4.2	0.007973	0.00273283	2.917	0.0053
	LTOTLAK			-0.033197	0.12722784	-0.261	0.7952
	LSSIZE			0.042956	0.08217722	0.523	0.6035

Table F15 - Models (1-3 variables) of Black Duck IBPs in survey plots 1986-89.

Model	Variable	Model R2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
216	MXSCOR	0.882918	4.3	0.01071	0.00217912	4.915	0.0001
	LTOTLAK			-0.034203	0.12555908	-0.272	0.7865
	LSALTHA			0.065533	0.05080692	1.29	0.2033
	LELVSTD			-0.103672	0.10734452	-0.966	0.339
217	MXSCOR	0.8879	2	0.002678	0.00421546	0.635	0.5282
	LTOTLAK			0.003666	0.12461346	0.029	0.9767
	LSALTHA			0.05388	0.05057129	1.065	0.292
	SOILPH			0.614556	0.39390645	1.56	0.1253
218	MXSCOR	0.88596	2.9	0.009215	0.00122887	7.499	0.0001
	LTOTLAK			0.102052	0.14976093	0.681	0.4989
	LSALTHA			0.053075	0.05079718	1.045	0.3013
	TOTAL			-0.005239	0.00350238	-1.496	0.1412
219	MXSCOR	0.883298	4.1	0.010399	0.00183698	5.661	0.0001
	LTOTLAK			-0.031323	0.12512755	-0.25	0.8034
	LSALTHA			0.070611	0.05098305	1.385	0.1725
	LXSTM			-0.47279	0.45245802	-1.045	0.3013
215	LSSIZE	0.8172	27.4	0.243186	0.03932934	6.183	0.0001
	LTOTLAK			0.057687	0.12483135	0.462	0.6461
	LSALTHA			0.075053	0.0610122	1.23	0.2246
	LBUILD			0.051481	0.04585118	1.123	0.2671

Table F16 - Model (4 variables) of Black Duck IBPs in survey plots 1986-89.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
305	LTOTLAK	0.5841	26.33	0.518538	0.03101949	16.717	0.0001
302	LSSIZE	0.5037	61.67	0.143429	0.01009296	14.211	0.0001
304	TOTAL	0.4541	80.72	0.012912	0.00100365	12.865	0.0001
301	MXSCOR	0.4467	83.4	0.003794	0.00029932	12.676	0.0001
303	LXSTM	0.3300	121.67	0.781964	0.07898026	9.901	0.0001
309	LTOTLAK	0.6307	4.61	0.358328	0.04342342	8.252	0.0001
	LSSIZE			0.064663	0.01293412	4.999	0.0001
306	MXSCOR	0.6159	12.48	0.001438	0.00035519	4.049	0.0001
	LTOTLAK			0.39643	0.04245415	9.338	0.0001
312	LTOTLAK	0.6075	16.8	0.44266	0.03741655	11.831	0.0001
	LXSTM			0.257995	0.0750636	3.437	0.0007
308	MXSCOR	0.5052	63.11	-0.000773	0.00098568	-0.784	0.4341
	LSSIZE			0.169777	0.03509227	4.838	0.0001
311	MXSCOR	0.4925	68.16	0.001992	0.00051399	3.875	0.0001
	TOTAL			0.007338	0.00173503	4.229	0.0001
310	MXSCOR	0.4472	85.28	0.004417	0.00152583	2.895	0.0042
	P1			0.019953	0.04792616	0.416	0.6776
307	MXSCOR	0.4468	85.43	0.003794	0.00030005	12.645	0.0001
	PCA2			0.004409	0.02706814	0.163	0.8708

Table F17 - Models (1-2 variables) of Ring-necked Duck IBPs in PQUADs. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
313	LSSIZE	0.6388	2.24	0.087137	0.01668303	5.223	0.0001
	LTOTLAK			0.358328	0.04342342	8.252	0.0001
	PB			-0.001084	0.00051470	-2.106	0.0365
314	LSSIZE	0.6367	3.41	0.100796	0.02377253	4.24	0.0001
	LTOTLAK			0.371639	0.04380077	8.485	0.0001
	PI			0.03721	0.02058895	1.807	0.0722
315	LSSIZE	0.6367	3.44	0.102564	0.0246886	4.154	0.0001
	LTOTLAK			0.354155	0.04324273	8.19	0.0001
	SOILPH			-0.014272	0.00793552	-1.798	0.0736
316	LSSIZE	0.6362	3.71	0.090147	0.01961201	4.597	0.0001
	LTOTLAK			0.369666	0.04370815	8.458	0.0001
	LELVSTD			-0.045374	0.02634757	-1.722	0.0866
317	MXSCOR	0.6336	5.11	0.006118	0.00155504	3.934	0.0001
	LTOTLAK			0.359482	0.04325595	8.311	0.0001
	SOILPH			-0.057315	0.01856256	-3.088	0.0023
318	LSSIZE	0.6328	5.56	0.095194	0.03162133	3.01	0.003
	LTOTLAK			0.359163	0.04341751	8.272	0.0001
	MXSCOR			-0.000901	0.00085146	-1.058	0.2913
319	LSSIZE	0.6312	6.44	0.072511	0.02039505	3.555	0.0005
	LTOTLAK			0.355711	0.04382204	8.117	0.0001
	LXSTM			-0.057208	0.11481179	-0.498	0.6188
320	LSSIZE	0.6309	6.58	0.065005	0.01300267	4.999	0.0001
	LTOTLAK			0.357529	0.04358538	8.203	0.0001
	PCA2			-0.0075	0.02223358	-0.337	0.7362

Table F18 - Models (3-variables) of Ring-necked Duck IBPs in PQUADs, 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
321	LSSIZE	0.6448	1.03	0.376058	0.04410132	8.527	0.0001
	LTOTLAK			0.124896	0.02665663	4.685	0.0001
	PB			-0.001082	0.00051176	-2.114	0.0358
	SOILPH			-0.014235	0.00786658	-1.810	0.0719
322	LSSIZE	0.6446	1.12	0.122199	0.02570993	4.753	0.0001
	LTOTLAK			0.392974	0.04462159	8.807	0.0001
	PB			-0.001068	0.00051195	-2.086	0.0383
	P1			0.036453	0.02041935	1.785	0.0758
323	LSSIZE	0.6444	1.21	0.11314	0.02222068	5.092	0.0001
	LTOTLAK			0.391934	0.04455624	8.796	0.0001
	PB			-0.001093	0.00051201	-2.135	0.034
	LELVSTD			-0.045952	0.02611414	-1.76	0.08
324	LSSIZE	0.6413	2.96	0.121165	0.0335578	3.611	0.0004
	LTOTLAK			0.38175	0.04427093	8.623	0.0001
	PB			-0.001112	0.00051479	-2.161	0.0319
	MXSCOR			-0.000987	0.00084458	-1.168	0.2441
325	LSSIZE	0.6408	3.27	0.067289	0.03408897	1.974	0.0498
	LTOTLAK			0.343142	0.0437321	7.846	0.0001
	MXSCOR			0.003198	0.00213821	1.496	0.1364
	SOILPH			-0.041799	0.02003398	-2.086	0.0382
326	LTOTLAK	0.6406	3.37	0.378507	0.04393322	8.616	0.0001
	LSSIZE			0.119389	0.02694172	4.431	0.0001
	PCA1			0.036194	0.02492124	1.452	0.148
	P1			0.05576	0.02418033	2.306	0.0222
327	LSSIZE	0.6404	3.46	0.103975	0.02456797	4.232	0.0001
	LTOTLAK			0.377254	0.04442489	8.492	0.0001
	LXSTM			-0.108231	0.11589474	-0.934	0.3515
	PB			-0.00118	0.00052504	-2.247	0.0257

Table F19 - Models (4 variables) of Ring-necked Ducks IBPs in PQUADs. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
328	LSSIZE	0.6503	0	0.134549	0.02707493	4.97	0.0001
	LTOTLAK			0.379294	0.04390497	8.639	0.0001
	PB			-0.00105	0.00050936	-2.061	0.0407
	SOILPH			-0.025016	0.00993355	-2.518	0.0126
	ROAD			0.003386	0.00192172	1.762	0.0797
329	LSSIZE	0.6497	0.37	0.135716	0.02733355	4.965	0.0001
	LTOTLAK			0.370115	0.04405407	8.401	0.0001
	PB			-0.001073	0.00050954	-2.105	0.0366
	SOILPH			-0.02359	0.00966068	-2.442	0.0155
	LBUILD			0.031962	0.01932297	1.654	0.0997
330	LSSIZE	0.6489	0.81	0.126979	0.02580487	4.921	0.0001
	LTOTLAK			0.405859	0.04523767	8.972	0.0001
	PB			-0.001032	0.00051065	-2.022	0.0446
	PI			0.057952	0.0246421	2.352	0.0197
	ROAD			0.002841	0.00183698	1.547	0.1236
331	LSSIZE	0.6486	1	0.112687	0.02214986	5.087	0.0001
	LTOTLAK			0.403949	0.04511391	8.954	0.0001
	PB			-0.001074	0.0005105	-2.103	0.0368
	LELVSTD			-0.072562	0.03140873	-2.31	0.0219
	ROAD			0.002772	0.00183122	1.514	0.1317
332	LSSIZE	0.6481	1.26	0.114708	0.02218926	5.17	0.0001
	LTOTLAK			0.395202	0.04449768	8.881	0.0001
	PB			-0.001091	0.00051066	-2.137	0.0338
	LELVSTD			-0.06917	0.03070656	-2.253	0.0254
	LBUILD			0.026423	0.0185098	1.428	0.155
333	LSSIZE	0.6481	1.28	0.127389	0.02617412	4.867	0.0001
	LTOTLAK			0.394161	0.04441969	8.874	0.0001
	ROAD			0.004601	0.00201933	2.278	0.0238
	PCA2			-0.048708	0.02561035	-1.902	0.0587
	PI			0.08793	0.02871095	3.063	0.0025
334	LSSIZE	0.6476	1.56	0.093675	0.03646716	2.569	0.011
	LTOTLAK			0.365203	0.0448821	8.137	0.0001
	MXSCOR			0.00268	0.0021398	1.253	0.2119
	SOILPH			-0.037309	0.02002679	-1.863	0.064
	PB			-0.001002	0.00051501	-1.945	0.0532

Table F20 - Models (5 variables) of Ring-necked Duck IBPs in PQUADs, 1992-94.

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardised Estimate	Odds Ratio
Model 336 Δ_i = 0 Concordance = 86.0%						
LSSIZE	0.7498	0.2734	7.5222	0.0061	0.264441	0.472
LTOTLAK	3.5741	0.6100	34.3307	0.0001	0.781757	35.662
SOILPH	-0.4421	0.0939	22.1568	0.0001	-0.168271	0.643
Model 337 Δ_i = 5.9 Concordance = 85.8%						
LTOTLAK	3.9025	0.7106	30.1633	0.0001	0.853596	49.528
MXSCOR	0.0126	0.0258	0.2402	0.624	0.056959	1.013
LSSIZE	0.7227	0.467	2.3951	0.1217	0.254896	2.06
SOILPH	-0.4695	0.2467	3.6232	0.057	-0.17871	0.625
PI	-0.0898	0.5493	0.0267	0.8702	-0.015215	0.914
PB	-0.00732	0.00628	1.3588	0.2437	-0.140607	0.993
LELVSTD	-0.4929	0.6257	0.6204	0.4309	-0.083627	0.611
Model 337 Δ_i = 9.9 Concordance = 87.0%						
MXSCOR	0.0062	0.0296	0.0438	0.8343	0.027951	1.006
LSSIZE	1.1465	0.5357	4.5808	0.0323	0.404371	3.147
LTOTLAK	4.1379	0.7529	30.2075	0.0001	0.905084	62.673
LXSTM	0.2074	2.2377	0.0086	0.9262	0.011628	1.23
LELVSTD	-0.5334	0.7311	0.5323	0.4657	-0.090503	0.587
ROAD	0.0562	0.0335	2.8105	0.0936	0.27946	1.058
LBUILD	0.0498	0.3477	0.0205	0.886	0.024143	1.051
SOILPH	-0.7644	0.3187	5.7526	0.0165	-0.29096	0.466
PCA1	0.2372	0.3479	0.465	0.4953	0.100862	1.268
PCA2	0.171	0.4466	0.1466	0.7018	0.070496	1.186
PI	-0.2146	0.7361	0.085	0.7706	-0.036373	0.807
NI	-0.3738	0.9633	0.1506	0.698	-0.054261	0.688
PB	-0.00851	0.00806	1.1138	0.2912	-0.163368	0.992
Model 335 Δ_i = 27.8 Concordance = 79.4%						
LSSIZE	-0.3193	0.1700	3.5278	0.0603	-0.1126	0.727
LTOTLAK	3.5354	0.5945	35.3648	0.0001	0.7732	34.308
PB	-0.00443	0.00546	0.6564	0.4178	-0.08496	0.996

Table F21 - Logistic regression for Ring-necked Ducks in PQUADs. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
401	MDSCOR	0.3896	37.84	0.002791	0.00024769	11.269	0.0001
402	LSSIZE	0.3467	51.41	0.075895	0.0073852	10.277	0.0001
403	LXSTM	0.3579	47.96	0.519347	0.04931365	10.532	0.0001
404	TOTAL	0.3264	57.53	0.519347	0.04931365	10.532	0.0001
405	LSSIZEL	0.3151	60.86	0.488692	0.05107185	9.569	0.0001
406	LSSIZEL	0.4689	12.05	0.322593	0.05013949	6.434	0.0001
	LXSTM			0.378612	0.04999964	7.572	0.0001
407	LSSIZEL	0.4530	17.98	0.277484	0.0546634	5.076	0.0001
	LELVSTD			0.081552	0.01154607	7.063	0.0001
408	LSSIZEL	0.4487	19.54	0.254159	0.05707333	4.453	0.0001
	PI			-0.051628	0.0074552	-6.925	0.0001
409	MDSCOR	0.4472	20.06	0.00201	0.0002922	6.879	0.0001
	LSSIZEL			0.258511	0.05688104	4.545	0.0001
410	LSSIZEL	0.4327	25.26	0.301743	0.05498566	5.488	0.0001
	SOILPH			0.018535	0.00289376	6.405	0.0001
411	MDSCOR	0.4285	26.73	0.008752	0.00164104	5.333	0.0001
	SOILPH			-0.06173	0.01681201	-3.672	0.0003
412	LSSIZEL	0.4190	30.01	0.305761	0.05629019	5.432	0.0001
	N1			-0.1257	0.02112175	-5.951	0.0001

Table F22 - Models (1-2 variables) of Common Merganser IBPs in PQUADs. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
413	LSSIZEL	0.4873	7.1	0.339133	0.04978161	6.812	0.0001
	LXSTM			0.361308	0.04968179	7.272	0.0001
	PCA2			-0.044758	0.01685469	-2.656	0.0086
414	LSALTHA	0.4751	11.78	0.044516	0.02914815	1.527	0.1283
	LSSIZEL			0.325909	0.05001879	6.516	0.0001
	LXSTM			0.359261	0.05141784	6.987	0.0001
415	LSSIZEL	0.4727	12.69	0.325271	0.05013561	6.488	0.0001
	LXSTM			0.439105	0.07112105	6.174	0.0001
	ROAD			-0.001613	0.00134993	-1.195	0.2336
416	MDSCOR	0.4726	12.73	0.001945	0.00028691	6.779	0.0001
	LSSIZEL			0.276436	0.05600247	4.936	0.0001
	PCA2			-0.052346	0.01699206	-3.081	0.0024
417	LSSIZEL	0.4721	12.92	0.357723	0.05946482	6.016	0.0001
	LXSTM			0.412306	0.05865173	7.03	0.0001
	PB			-0.000371	0.00033805	-1.097	0.2738
418	LSSIZEL	0.4718	13.03	0.344516	0.05435293	6.339	0.0001
	LXSTM			0.506759	0.13259032	3.822	0.0002
	SOILPH			-0.007748	0.00742459	-1.043	0.298
419	LSSIZE	0.4716	13.13	-0.015714	0.01575329	-0.998	0.3197
	LSSIZEL			0.357494	0.0611406	5.847	0.0001
	LXSTM			0.454	0.09061827	5.01	0.0001
420	LSSIZEL	0.4707	13.48	0.297442	0.05446573	5.461	0.0001
	LELVSTD			0.077247	0.01150936	6.712	0.0001
	PCA2			-0.044049	0.01716082	-2.567	0.011

Table F23 - Models (3-variables) of Common Merganser IBPs in survey PQUADs. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter= 0	Prob > |T|
421	LSALTHA	0.5021	3.34	0.071617	0.02965307	2.415	0.0166
	LSSIZEL			0.348813	0.04934502	7.069	0.0001
	LXSTM			0.325632	0.05125796	6.353	0.0001
	PCA2			-0.056513	0.01734844	-3.258	0.0013
422	LSSIZEL	0.4899	8.18	0.361403	0.05447885	6.634	0.0001
	LXSTM			0.44061	0.09316839	4.729	0.0001
	PCA2			-0.048923	0.01735515	-2.819	0.0053
	N1			0.038636	0.03840013	1.006	0.3156
423	LSSIZEL	0.4883	8.79	0.351855	0.05371335	6.551	0.0001
	LXSTM			0.440162	0.13349237	3.297	0.0012
	SOILPH			-0.004726	0.00742433	-0.637	0.5251
	PCA2			-0.042995	0.01710591	-2.513	0.0128
424	LSSIZEL	0.4878	9.01	0.339301	0.04988501	6.802	0.0001
	LXSTM			0.385374	0.07375957	5.225	0.0001
	ROAD			-0.000618	0.00139692	-0.442	0.6588
	PCA2			-0.042436	0.01768683	-2.399	0.0174
425	LSSIZE	0.4878	9.01	-0.007022	0.01593685	-0.441	0.66
	LSSIZEL			0.354112	0.06036523	5.866	0.0001
	LXSTM			0.395643	0.09246795	4.279	0.0001
	PCA2			-0.043086	0.01730993	-2.489	0.0136
426	MDSCOR	0.4877	9.03	0.001728	0.00029753	5.808	0.0001
	LSALTHA			0.072622	0.03022763	2.403	0.0172
	LSSIZEL			0.295093	0.05587847	5.281	0.0001
	PCA2			-0.063604	0.01743148	-3.649	0.0003
427	MDSCOR	0.4875	9.13	0.00022	0.00077748	0.283	0.7773
	LSSIZEL			0.329843	0.05971629	5.524	0.0001
	LXSTM			0.325305	0.13653713	2.383	0.0181
	PCA2			-0.045399	0.01704518	-2.663	0.0084
428	LSSIZEL	0.4874	9.17	0.334106	0.05565727	6.003	0.0001
	LXSTM			0.336162	0.13295017	2.528	0.0122
	LELVSTD			0.006183	0.03031232	0.204	0.8386
	PCA2			-0.044533	0.01693171	-2.63	0.0092
429	LSSIZEL	0.4874	9.17	0.337506	0.05066168	6.662	0.0001
	LXSTM			0.352402	0.06900191	5.107	0.0001
	LBUILD			0.002704	0.01449938	0.186	0.8523
	PCA2			-0.045816	0.01782397	-2.57	0.0109

Table F24 - Models (4 variables) of Common Merganser IBPs in PQUADs. 1992-94.

Model	Variable	Model R^2	Δ_i	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
437	MDSCOR	0.5207	0	0.004648	0.00184529	2.519	0.0126
	LSALTHA			0.087265	0.02995064	2.914	0.004
	LSSIZEL			0.286327	0.06257892	4.575	0.0001
	LXSTM			0.372949	0.13412538	2.781	0.006
	SOILPH			-0.048851	0.01780739	-2.743	0.0067
	PCA2			-0.05439	0.01721438	-3.16	0.0018
430	LSALTHA	0.5055	4.1	0.073548	0.02967446	2.479	0.014
	LSSIZEL			0.374395	0.05403274	6.929	0.0001
	LXSTM			0.414836	0.09255558	4.482	0.0001
	PCA2			-0.061566	0.01787513	-3.444	0.0007
	N1			0.043929	0.03796615	1.157	0.2487
431	LSALTHA	0.5050	4.29	0.077131	0.030083	2.564	0.0111
	LSSIZEL			0.371034	0.05349112	6.936	0.0001
	LXSTM			0.455993	0.13177857	3.46	0.0007
	SOILPH			-0.007978	0.00743001	-1.074	0.2843
	PCA2			-0.054442	0.01744863	-3.12	0.0021
432	LSALTHA	0.5046		0.078132	0.03037056	2.573	0.0108
	LSSIZEL			0.350075	0.049363	7.092	0.0001
	LXSTM			0.376983	0.07279772	5.178	0.0001
	ROAD			-0.001401	0.00141059	-0.993	0.3217
	PCA2			-0.052314	0.01785643	-2.93	0.0038
433	LSALTHA	0.5030	5.11	0.077427	0.03126855	2.476	0.0141
	LSSIZEL			0.354991	0.05050733	7.029	0.0001
	LXSTM			0.352243	0.06811603	5.171	0.0001
	LBUILD			-0.008958	0.01506809	-0.594	0.5529
	PCA2			-0.05396	0.01789988	-3.015	0.0029
434	LSALTHA	0.5027	5.24	0.075155	0.0306302	2.454	0.015
	LSSIZEL			0.343453	0.05071268	6.773	0.0001
	LXSTM			0.330117	0.05221929	6.322	0.0001
	PCA1			-0.008257	0.01737356	-0.475	0.6351
	PCA2			-0.058267	0.01777035	-3.279	0.0012
435	LSALTHA	0.5022	5.42	0.072643	0.03007345	2.416	0.0166
	LSSIZEL			0.35625	0.05950106	5.987	0.0001
	LXSTM			0.349625	0.11841868	2.952	0.0035
	PCA2			-0.057032	0.01754331	-3.251	0.0014
	P1			0.003958	0.01759798	0.225	0.8223
436	LSALTHA	0.5021	5.45	0.071973	0.02985326	2.411	0.0168
	LSSIZEL			0.344773	0.0584162	5.902	0.0001
	LXSTM			0.320853	0.063173	5.079	0.0001
	PCA2			-0.057489	0.01894259	-3.035	0.0027
	PB			0.000046761	0.00035955	0.13	0.8967

Table F25 - Models (5 & 6 variables) of Common Merganser IBPs in PQUADs.

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardised Estimate	Odds Ratio
Model 451 $\Delta_i = 0$ Concordance = 73.7%						
LSSIZEL	3.4351	0.7803	19.3785	0.0001	0.430597	31.034
LXSTM	5.9721	1.874	10.1562	0.0014	0.334862	392.346
SOILPH	-0.3934	0.1043	14.2172	0.0002	-0.14975	0.675
Model 450 $\Delta_i = 3.2$ Concordance = 75.4%						
MXSCOR	0.035	0.0223	2.4544	0.1172	0.15795	1.036
LSSIZE	-0.5784	0.4199	1.8972	0.1684	-0.204004	0.561
TOTAL	0.0234	0.0189	1.5317	0.2159	0.146978	1.024
LSSIZEL	2.2093	1.0933	4.0833	0.0433	0.276945	9.11
LTOTLAK	0.8923	0.6087	2.1489	0.1427	0.195168	2.441
LXSTM	4.9172	2.0698	5.644	0.0175	0.275708	136.613
LELVSTD	0.0309	0.5887	0.0028	0.9581	0.005244	1.031
SOILPH	-0.6493	0.2234	8.4478	0.0037	-0.247129	0.522
PB	-0.00556	0.00561	0.9817	0.3218	-0.106646	0.994
Model 452 $\Delta_i = 9.0$ Concordance = 70.1%						
MXSCOR	-0.0189	0.00757	6.227	0.0126	-0.085192	0.981
LTOTLAK	1.6415	0.4276	14.736	0.0001	0.359035	5.163
LXSTM	2.9386	1.5232	3.7222	0.0537	0.164771	18.89
ROAD	-0.0541	0.0248	4.7488	0.0293	-0.269072	0.947
LBUILD	0.4973	0.2539	3.8359	0.0502	0.240871	1.644
Model 453 $\Delta_i = 11.7$ Concordance = 69.9%						
MXSCOR	-0.0164	0.00878	3.4947	0.0616	-0.074063	0.984
LTOTLAK	1.7037	0.4436	14.7522	0.0001	0.372644	5.494
LXSTM	3.4255	1.7848	3.6835	0.055	0.19207	30.738
LELVSTD	-0.2653	0.4804	0.305	0.5808	-0.045013	0.767
ROAD	-0.053	0.0249	4.5236	0.0334	-0.263491	0.948
LBUILD	0.5072	0.2545	3.9706	0.0463	0.245664	1.661

Table F26 - Logistic regression analysis of presence of Common Merganser IBPs in PQUADs. 1992-94.

Standardised Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate	Odds Ratio
Model 470 $\Delta_i = 0$ Concordance = 82.5%						
MXSCOR	0.0564	0.0287	3.8583	0.0495	0.254427	1.058
LSSIZE2	0.8043	0.4761	2.8538	0.0912	0.283669	2.235
TOTAL	-0.0434	0.0227	3.64	0.0564	-0.272338	0.958
LSALTHA	2.468	0.9405	6.8856	0.0087	0.586152	11.799
LTOTLAK	0.585	0.5484	1.1381	0.2861	0.127958	1.795
LXSTM	8.5477	2.6164	10.6735	0.0011	0.479276	999
LELVSTD	-1.7936	0.7354	5.9487	0.0147	-0.304322	0.166
ROAD	0.0168	0.0294	0.3282	0.5667	0.083688	1.017
LBUILD	0.3173	0.3249	0.9536	0.3288	0.153671	1.373
SOILPH	-0.5654	0.3173	3.1763	0.0747	-0.215211	0.568
PCA1	1.0611	0.3448	9.4693	0.0021	0.451159	2.889
PCA2	-0.0568	0.422	0.0181	0.8929	-0.023426	0.945
P1	1.2809	0.7177	3.1849	0.0743	0.217099	3.6
N1	0.6161	0.9092	0.4592	0.498	0.089424	1.852
PB	0.0122	0.00791	2.3807	0.1228	0.234352	1.012
Model 471 $\Delta_i = 0$ Concordance = 79.0%						
MXSCOR	0.0484	0.0164	8.7411	0.0031	0.218559	1.05
LXSTM	5.0301	2.0935	5.773	0.0163	0.28204	152.946
LELVSTD	-2.1326	0.7023	9.2206	0.0024	-0.361835	0.119
PCA1	0.7465	0.2757	7.3344	0.0068	0.317429	2.11
P1	1.1853	0.5328	4.9485	0.0261	0.200897	3.272
LSALTHA	1.8034	0.7794	5.3535	0.0207	0.428308	6.07
LBUILD	0.4012	0.2152	3.4751	0.0623	0.194307	1.494
Model 472 $\Delta_i = 7.0$ Concordance = 76.5%						
MXSCOR	0.0267	0.0105	6.4569	0.0111	0.12055	1.027
LXSTM	5.1238	1.9118	7.1827	0.0074	0.287293	167.967
LELVSTD	-2.6681	0.6032	19.5655	0.0001	-0.452699	0.069
PCA1	0.69	0.232	8.8494	0.0029	0.293392	1.994
LSALTHA	2.0611	0.7781	7.0165	0.0081	0.489508	7.854
Model 473 $\Delta_i = 12.0$ Concordance = 74.5%						
LSALTHA	1.8487	0.7539	6.014	0.0142	0.439079	6.352
LXSTM	6.5219	1.8728	12.128	0.0005	0.365689	679.899
LELVSTD	-1.5962	0.3936	16.4503	0.0001	-0.270825	0.203
PCA1	0.4794	0.2109	5.1645	0.0231	0.203826	1.615
Model 474 $\Delta_i = 15.3$ Concordance = 72.2%						
LXSTM	6.9575	1.8726	13.8041	0.0002	0.390111	999
LELVSTD	-1.6513	0.3949	17.4871	0.0001	-0.280181	0.192
LSALTHA	2.0422	0.7598	7.2251	0.0072	0.485028	7.708

Table F27 - Logistic regression analysis of presence of American Green-winged Teal in PQUADs. 1992-94.

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardised Estimate	Odds Ratio
Model 501 $\Delta_i = 13.6$ Concordance = 90.4%						
LSSIZE	1.1928	1.1226	1.1289	0.288	0.376888	3.296
TOTAL	0.157	0.0712	4.8589	0.0275	0.874804	1.17
MDSCOR	0.1063	0.0835	1.62	0.2031	0.268179	1.112
MXSCOR	-0.1144	0.0711	2.5932	0.1073	-0.56128	0.892
LSALTHA	-2.0753	1.2983	2.555	0.1099	-0.581154	0.126
LSSIZEL	0.956	3.0131	0.1007	0.751	0.128175	2.601
LMSIZEL	-16.7743	7.8915	4.5182	0.0335	-0.886305	0
LTOTLAK	2.7319	2.0322	1.8072	0.1788	0.532544	15.362
LXSTM	8.0151	6.8259	1.3788	0.2403	0.369985	999
LELVSTD	-7.1118	2.4688	8.2979	0.004	-1.049455	0.001
ROAD	0.1481	0.1009	2.1544	0.1422	0.666698	1.16
LBUILD	3.222	1.3277	5.8892	0.0152	1.439331	25.079
SOILPH	0.4655	0.6045	0.5931	0.4412	0.206784	1.593
PB	-0.0228	0.0186	1.4971	0.2211	-0.424084	0.977
Model 502 $\Delta_i = 7.6$ Concordance = 87.1%						
TOTAL	0.1186	0.055	4.6399	0.0312	0.660891	1.126
MDSCOR	0.023	0.0592	0.1509	0.6977	0.058049	1.023
LSALTHA	-0.7361	0.889	0.6856	0.4077	-0.206141	0.479
LTOTLAK	1.5595	1.2493	1.5581	0.2119	0.303996	4.756
LXSTM	5.5789	5.863	0.9054	0.3413	0.257527	264.779
LELVSTD	-5.118	1.7499	8.5539	0.0034	-0.755241	0.006
ROAD	0.1129	0.0941	1.437	0.2306	0.508072	1.119
LBUILD	1.7467	0.8381	4.3431	0.0372	0.780263	5.735
SOILPH	0.191	0.4273	0.1998	0.6549	0.084853	1.21
PB	-0.02	0.0144	1.9409	0.1636	-0.372376	0.98
Model 503 $\Delta_i = 5.0$ Concordance = 86.1%						
TOTAL	0.0808	0.0418	3.7448	0.053	0.450536	1.084
LSALTHA	-0.6791	0.9079	0.5595	0.4545	-0.190186	0.507
LTOTLAK	1.0786	1.1733	0.845	0.358	0.210257	2.941
LXSTM	8.725	5.4911	2.5247	0.1121	0.402753	999
LELVSTD	-4.5837	1.4913	9.4478	0.0021	-0.676406	0.01
ROAD	0.1505	0.0922	2.6664	0.1025	0.677761	1.162
LBUILD	1.1307	0.674	2.8142	0.0934	0.505096	3.098
SOILPH	0.1875	0.258	0.5284	0.4673	0.083309	1.206

Table F28 - Logistic regression models for presence of increasing local Black Duck populations in PQUADs 1990-99, with high concordance.

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardised Estimate	Odds Ratio
Model 509 $\Delta_i = 0$ Concordance = 83.1%						
TOTAL	0.086	0.0354	5.9189	0.015	0.479405	1.09
LXSTM	9.1133	4.9173	3.4347	0.0638	0.420677	999
LELVSTD	-3.2877	1.1784	7.7835	0.0053	-0.485147	0.037
ROAD	0.2267	0.0759	8.9335	0.0028	1.020798	1.255
Model 507 $\Delta_i = 1.5$ Concordance = 79.8%						
TOTAL	0.0884	0.0355	6.2175	0.0126	0.492742	1.092
ROAD	0.2137	0.0687	9.6728	0.0019	0.962276	1.238
LELVSTD	-1.6095	0.636	6.4043	0.0114	-0.237511	0.2
Model 504 $\Delta_i = 2.9$ Concordance = 85.8%						
TOTAL	0.0794	0.0411	3.7249	0.0536	0.442292	1.083
LTOTLAK	1.1046	1.1602	0.9065	0.341	0.215325	3.018
LXSTM	8.8845	5.4754	2.6329	0.1047	0.410118	999
LELVSTD	-4.5194	1.486	9.249	0.0024	-0.66691	0.011
ROAD	0.1388	0.0902	2.3672	0.1239	0.624728	1.149
LBUILD	1.0191	0.6448	2.4981	0.114	0.455225	2.771
SOILPH	0.182	0.2561	0.5052	0.4772	0.080864	1.2
Model 505 $\Delta_i = 3.1$ Concordance = 84.0%						
TOTAL	0.0605	0.0386	2.4589	0.1169	0.337385	1.062
ROAD	0.2389	0.0803	8.8556	0.0029	1.075545	1.27
LELVSTD	-4.1762	1.5048	7.7027	0.0055	-0.616273	0.015
LXSTM	9.8246	5.2669	3.4796	0.0621	0.453512	999
LTOTLAK	1.179	1.0929	1.1636	0.2807	0.229821	3.251
MXSCOR	0.00981	0.0208	0.2227	0.637	0.048114	1.01
Model 506 $\Delta_i = 4.3$ Concordance = 80.9%						
TOTAL	0.0628	0.0393	2.5482	0.1104	0.349971	1.065
ROAD	0.2198	0.0704	9.743	0.0018	0.989584	1.246
LELVSTD	-2.6909	1.1322	5.6489	0.0175	-0.397081	0.068
LTOTLAK	0.726	1.0587	0.4702	0.4929	0.141521	2.067
MXSCOR	0.0197	0.0192	1.0527	0.3049	0.096693	1.02
Model 508 $\Delta_i = 13.9$ Concordance = 66.9%						
TOTAL	0.055	0.028	3.8534	0.0496	0.306493	1.057
LXSTM	7.763	4.0534	3.668	0.0555	0.358348	999
LELVSTD	-1.4851	0.8201	3.279	0.0702	-0.219155	0.226

Table F29 - Logistic regression models for presence of increasing local Black Duck population in PQUADs 1990-99.

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