Long-term trends in waterfowl hunters, harvest, waterfowl use, and marsh habitat in the Crown Marsh - Long Point, Ontario

A proposal for the Long Point Waterfowlers' Association

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Executive summary

Long Point is an important staging area for waterfowl in eastern North America. Concentrations of waterfowl during autumn attract many hunters to this area, but public hunting opportunities are limited. The Long Point Waterfowl Management Unit (LPWMU) provides public hunting opportunities and is situated within a 1750 acre Great Lakes coastal marsh locally known as the Crown Marsh. Long-time waterfowl hunters of the Crown marsh are concerned about the quality of hunting and current habitat conditions. As a result, they have engaged the Long Point Waterfowl and Wetlands Research Fund (LPWWRF) to determine and quantify what historic changes have occurred in waterfowl-use, waterfowl harvest, hunter-use, and habitat conditions within the Crown Marsh at Long Point.

The specific objectives of this report are to assess: 1) historic trends in overall waterfowl harvest and numbers of waterfowl hunters at the LPWMU from 1961 - 2005; 2) trends in autumn and spring waterfowl abundance in the Crown Marsh (and several other major marsh complexes at Long Point) from 1971 to 2006; 3) changes in major habitat types and to estimate ratios of open water to emergent vegetation (habitat interspersion) in the Crown Marsh and Long Point Company Marsh (LPCM) during 1955, 1964, 1968, 1978, 1985, 1995, and 1999.

Hunter numbers and total harvest have both changed through time increasing from 1961 to the mid 1980s and decreasing thereafter. The potential reasons for these trends in hunter numbers are varied, but are probably largely related to Canada-wide changes in duck hunter numbers over the same period, but other less encompassing factors, such as changes in local hunting quality (e.g., reduced or difficult hunting opportunity, seeing fewer ducks, reduced harvest opportunities, etc.), also may be contributing factors. One measure of hunting quality, hunter success/harvest rate (kill per hunter) has remained relatively constant over time within the LPWMU, but other measures of hunting quality have changed. Our trend analyses suggested that autumn numbers of total dabbling ducks (all *Anas* spp), Mallard (*Anas platyrhynchos*), American Black Duck (*Anas rubripes*), and Redhead (*Aythya americana*) have declined substantially in the Crown Marsh from 1971 to 2005, which corroborates long-time LPWMU hunter observations. These results also may indicate habitat quality within the Crown Marsh have generally decreased, especially since the early to mid 1990s.

Habitat assessments using Geographic Information System analyses showed that broad habitat types (open water, emergent vegetation, dry land, and built-up/developed areas) within the Crown Marsh (and the LPCM) have changed and fluctuated dramatically from 1955 to 1999. Of particular interest, the ratio between areas of open water and emergent vegetation consistently

showed the largest changes between time periods. During 1955, 1964, and 1968 ratios of open water to emergent vegetation were consistent with habitat conditions considered optimal for marsh productivity and waterfowl use (approx. 50:50), but in 1978 (85:15) and 1985 (78:22) open water areas greatly increased relative to emergent vegetation. In 1995 and 1999, a period when Lake Erie water levels were relatively low, the Crown Marsh had relatively low ratios of open water to emergent vegetation (34:66 & 32:68, respectively), suggesting sub-optimal habitat interspersion and loss of potential waterfowl roost and feeding areas within the marsh.

Ratios of open water to emergent vegetation for the LPCM were similar to those of the Crown Marsh until 1985. However, in 1995 and 1999 ratios of open water to emergent vegetation in the LPCM (approx. 60:40) were much higher than those of the Crown Marsh and were close to a theoretical hemi-marsh condition (50:50). Comparison of these two marshes suggests that the habitat conditions in the LPCM generally were better for waterfowl during the mid to late 1990s. It also was interesting to note that autumn and spring numbers for all dabbling duck species and nearly all bay duck species have remained stable or increased from 1975 to present in the LPCM; autumn bay duck and Canvasback abundances plus spring Redhead numbers, however, declined during that time.

Habitat data were not readily available for years since 1999, but Lake Erie water levels have generally continued to decline and are slightly below long-term average levels. Thus, we speculate that habitat conditions within the Crown Marsh have continued to deteriorate (e.g., loss of water in shallow ponds, reduced size or total loss of open areas due to encroachment by emergent plants, particularly *Phragmites australis* and cattail) since the late 1990s and will continue to do so unless some directed marsh management is undertaken. To that end, we recommend creation of a specific, goal-orientated marsh management plan and that appropriate management activities begin in a timely manner to restore and/or create quality waterfowl habitat, enhance biodiversity, and increase hunting opportunity within the Crown Marsh – LPWMU.

Introduction

Long Point is one of the most important stopover sites for dabbling and diving ducks in North America. Abundant food resources and expansive emergent marsh habitats at this location attract tens of thousands of waterfowl each spring and fall. In turn, every autumn large numbers of waterfowl hunters are drawn to Long Point. Many of the marsh complexes at Long Point are either privately owned or leased by private hunting clubs (e.g., Long Point Company, Turkey Point Company, and Bluff's Hunting Club) or are designated as National Wildlife Area where waterfowl hunting is largely prohibited (Figure 1). The Canadian Wildlife Service (CWS) allows waterfowl hunting on limited sections of the Big Creek NWA, Long Point NWA - Thoroughfare Unit, and Hahn Marsh Unit. Thus, there is relatively little emergent marsh habitat available for public waterfowl hunting at Long Point.

The largest public hunting area at Long Point is the Long Point Waterfowl Management Unit (LPWMU) located in, what is known locally as, the Crown Marsh (Figure 1). The LPWMU was established in 1961 by the Ontario Ministry of Natural Resources (OMNR) to provide quality, yet controlled, sustainable hunting opportunities for waterfowl hunters. The Crown Marsh is owned by the government of Ontario, but the LPWMU is currently operated in a cooperative venture between the OMNR and the Ontario Federation of Anglers and Hunters (OFAH). Hunting Zones A and B of the LPWMU are both open for hunting a limited number of days (Monday, Wednesday, Friday, and Saturday) from late September – mid-December each year. At the end of each day, hunters are required to check-in at the LPWMU office where data are recorded on various aspects of their hunt (e.g., number of hunters per blind, number of hours hunted, and species-specific harvest).

The Crown Marsh is classified as a Great Lakes coastal marsh because it is characterized by an interspersion of emergent vegetation, mainly cattail (*Typha* spp), and open water areas that are directly and naturally connected to Lake Erie. As such, this wetland's productivity and plant/animal community characteristics and abundances are directly influenced by the short- and long-term hydrologic fluctuations of Lake Erie and the limnological regime of Inner Long Point Bay. The annual long-term fluctuations in Lake Erie water levels can cause shifts in plant, thus animal, communities along elevation gradients within these coastal marsh complexes (Wilcox et al. 2002). During periods of prolonged dry conditions, water levels recede and areas of higher elevation within coastal marshes become dry, allowing plants that are adapted to dry conditions to expand toward lower (typically lake-ward) elevations (Bedford 1992). This may reduce the amount or quality of habitat available for some waterfowl; conversely, it may provide increased habitat for other marsh obligate birds such as, rails, bitterns, marsh wrens (*Cistothorus palustris*), etc. (S. Timmermans, S. Badzinski, and J. Ingram; unpublished data). Low water conditions also may allow non-native, invasive plants, such as *Phragmites austalis*, to establish and create large, dense monotypic stands which are of limited use to waterfowl (Meyer 2003, Wilcox et al. 2003). During high water years, higher wetland elevations flood and plants better adapted to wet conditions become more prevalent. High water conditions also can influence habitat structure and quality for waterfowl through effects of wave action, localized emergent plant die-offs due to flooding, and creation of favorable habitat conditions for aquatic herbivores (e.g., muskrats [*Ondatra zibethicus*], Tundra Swans [*Cygnus columbianus*]). These natural disturbance factors may naturally expand or create new openings in stands of emergent marsh plants, effectively creating more or better feeding or resting areas for staging waterfowl. An optimal interspersion of open water to emergent plants, an approximate ratio of 50:50, can be an important habitat feature that can attract and maintain waterfowl use of a marsh (Weller 1987, Payne 1992).

Water levels of Lake Erie have been quite dynamic since the LPWMU was established in 1961 (Figure 2). During the early 1960s, Lake Erie water levels were near all-time lows, but steadily increased after the mid 1960s to reach all-time high water levels in the early/mid 1980s. After the mid-1980s, however, water levels have generally declined and currently are slightly below the Lake Erie long-term average. From 1961 – 2005, Lake Erie water levels generally were near or above long-term average levels (Figure 2). Because of the direct hydrologic link to Lake Erie, water levels in the Crown Marsh during autumn also could be considered average to above average from a historical perspective. Many of the current hunters began hunting the LPWMU in the early/mid 1970s and have thus witnessed and experienced a wide range of marsh habitat and hunting conditions. Specifically, they have observed annually fluctuating, but generally declining water conditions and associated changes in marsh plants and duck habitat (e.g., encroachment of terrestrial plants, invasion of undesirable, exotic marsh plants, loss of open water areas and development of expansive emergent plant monocultures). Hunters also believe that numbers of waterfowl and the quality of hunting in the LPWMU have declined over the past several decades. The Crown Marsh has had only limited habitat management since 1961. Based on these observations, there has been much discussion recently about undertaking some substantial habitat management to increase waterfowl-use and the quality of public hunting opportunities within the Crown Marsh.

Objectives

Recognizing the need for an objective and quantitative assessment of the current and historic state of the habitat and waterfowl-use in the Crown Marsh, The Long Point Waterfowlers' Association (LPWA) has engaged the Long Point Waterfowl and Wetlands Research Fund (LPWWRF) to determine what changes have occurred in waterfowl-use, waterfowl harvest, hunter-use, and habitat quality within the Crown Marsh and other major marshes at Long Point (Figure 2). Thus, the major objectives of this report are to assess:

1) trends in total harvest and total numbers of waterfowl hunters using the LPWMU from 1961 -2005;
2) trends in autumn and spring waterfowl abundance in the Crown Marsh and several other major marsh complexes at Long Point from 1971 to 2006;
3) long-term changes in habitat interspersion by calculating ratios of open water to emergent vegetation in the Crown Marsh and LPCM for the periods 1955, 1964, 1968, 1978, 1985, 1995, and 1999.

Methods

Trend analyses

We obtained data sets from the LPWMU office and the LPWA on annual numbers of total hunters and annual total harvest from 1961 to 2005. From those data we also derived an index of annual hunter success by dividing the total harvest (Hunting Zones A & B) by the annual total number of LPWMU hunters. We evaluated trends in these 3 variables over several time periods: 1) 1961-2005 (entire period of LPWMU existence), 2) 1971-2005 (coincides with aerial survey data on waterfowl abundance), 3) 1980-2005 (when Lake Erie had generally declining water levels), and 4) 1990-2005 (characterized by "low" water levels). To do this, we regressed these 3 response variables against YEAR (continuous variable / trend estimate) and $YEAR^2$ using ordinary least squares (OLS) regression analyses; the quadratic ($YEAR^2$) was included in models to determine if a non-linear relationship better accounted for annual variation in these data.

Data for waterfowl trend analyses were derived from counts obtained from aerial surveys flown by the Canadian Wildlife Service (1971, 1974, 1978, 1984 and 1988) and the LPWWRF (annually from 1991-2006). Surveys were flown mid-day (approx. 11:00 – 14:00 EST) during spring (approx. 1 March – 15 May) and autumn (approx. 1 September – 20 December). For more detail on survey methodology see Dennis et al. (1984) and Petrie (1998) or visit the

LPWWRF web site (http://www.bsc-eoc.org/lpbo/lpwwrfsurveys.html). We calculated annual abundance indices by averaging the number of birds counted within season- and species-specific survey windows. Survey windows included the period during autumn and spring when each species was present and most abundant at Long Point (see Figure legends for specific dates). We calculated abundance indices for the following species and waterfowl groups: Canada Goose (*Branta canadensis*), Mallard (*Anas platyrhynchos*), American Black Duck (*Anas rubripes*), American Wigeon (*Anas americana*), Green-winged Teal (*Anas crecca*), Canvasback (*Aythya valisineria*), Redhead (*Aythya americana*), Scaup spp (greater [*Aythya marila*] + lesser scaup [*Aythya affinis*]), Ring-necked Ducks (*Aythya collaris*), total dabbling ducks (sum of all preceding *Anas* spp plus Northern Pintail [*Anas acuta*], Gadwall [*Anas strepera*], Northern Shoveler [*Anas clypeata*], and Blue-winged Teal [*Anas discors*]), and total bay ducks (sum of all preceding *Aythya* spp). Abundance indices were first calculated for the entire Long Point Marsh complex and then for species in each marsh complex (MARSH) of interest (dabbling duck/goose analyses: Crown Marsh, Big Creek Marsh [BCM], LPCM, & Turkey Point Marsh [TPM]; diving duck analyses: Crown Marsh, BCM, LPCM, TPM, Lake Erie [south of Long Point shoreline], & Inner Long Point Bay [ILPB]). All abundance indices were log (Ln+1) transformed to minimize violations of linear model assumptions, and, as a result, trend estimates from statistical models (see below) can be interpreted as annual percentage changes in waterfowl numbers.

To estimate linear trends for waterfowl in each marsh complex from 1971 - 2006, we used season- (Autumn & Spring) and species-specific (see groups above) General Linear Models of the following form: Abundance Index $_{\mathrm{Ln}+1}$ = INTERCEPT + MARSH (categorical variable / accounts for marsh complexes having different bird abundances) + YEAR (continuous variable / trend estimate) + MARSH × YEAR (interaction term that tests if trends differ among marsh complexes). We ran site-specific OLS regressions models to estimate trends in species abundance when interaction terms were significant. We also estimated and reported seasonal trends in each species total abundance at Long Point. To do this, we used OLS regression analyses (Abundance Index $_{\mathrm{Ln}+1}$ = INTERCEPT + YEAR [continuous variable / trend estimate]) to obtain log-linear trend estimates for abundances of each waterfowl species during both autumn and spring at Long Point. For all trend analyses, we present the positive (+) and negative (-) YEAR slope / trend estimates (i.e., annual % increase or decrease in numbers of birds [± SE]), but indicate in bold print trends that are statistically significant ($P \leq 0.10$).

Habitat analyses

The LPWWRF provided detailed Geographic Information Systems (GIS)-based vegetation maps of the Crown Marsh and the LPCM originally digitized from air photos taken during 1955, 1964, 1968, 1978, 1985, 1995, and 1999 (for more detail see Wilcox et al. 2003). We grouped several habitat types used by Wilcox et al. (2003) into four broader habitat groups that were more appropriate for our analyses. These groups included: 1) open water (includes submerged vegetation and sparse floating and/or emergent aquatic plants), 2) emergent marsh vegetation (e.g., moderately dense to dense cattail [*Typhya* spp]), *phragmites* spp, bulrush [*Scirpus* spp], etc.), 3) dry land (e.g., meadow, wet meadow, wooded areas, etc.), and 4) built-up areas (e.g., parks, cottages, marinas, roads, dikes, etc.). We then used ArcMap3 software to estimate the total area (ha) of both the Crown Marsh and LPCM and the areas of these habitat types within the marshes during each of the seven time periods. Annual area estimates of open water and emergent vegetation and ratios between those two variables were presented in tabular form to show changes in interspersion of these two habitat types over time. We also used ArcMap3 to create annual digital maps of the Crown Marsh and LPCM showing the relative amounts and spatial distributions of the four major habitats. These maps were presented to visually assess marsh-specific shifts in vegetation communities, and to a lesser extent land-use practices, from 1955 – 1999.

Results

Hunter & harvest trends

Numbers of hunters using the LPWMU has changed greatly since the LPWMU opened in 1961. Hunter numbers increased from 1961 to the early/mid 1980s after which they substantially declined to present low levels; the number recorded in 2005 was the third lowest value in the history of the LPWMU (Figure 3). Because the magnitude of the total number of waterfowl shot each year is partly a function of the number of hunters in the marsh (Pearson Correlation: $r = 0.80$, $P < 0.01$), the total annual harvest showed the same general trend as did LPWMU hunter numbers. Harvest increased from 1961 to the late 1970s / early 1980s and decreased from the early/mid 1980s to 2005 (Figure 4). Because hunter numbers and harvest were correlated we were interested in knowing if a simple relative measure of hunter success (# birds killed per hunter) or harvest rate changed over time. Hunter success rate increased substantially from 1961 through the late 1970s, but since then has remained relatively stable or has only slightly decreased (Figure 5). Total hunters (Pearson Correlation: $r = 0.28$, $P = 0.07$) and total harvest

(Pearson Correlation: $r = 0.42$, $P < 0.01$) also were positively correlated with autumn Lake Erie water levels.

Trends in autumn waterfowl abundance from 1971 - 2005

Dabbling ducks

Abundances of some waterfowl species declined in the Crown Marsh from 1971 to 2005. Total dabbling duck, Mallard, and American Black Duck abundance during autumn declined substantially in the Crown Marsh from 1971 to 2005 (Figures 6, 7, & 8). In BCM, numbers of American Black Ducks also declined, but at a lower rate than in the Crown Marsh, whereas abundances of this species did not change appreciably in the TPM or LPCM (Figure 8). Numbers of total dabbling ducks, Mallard, and American Black Duck did not change substantially over the long-term in BCM, TPM, and LPCM, which were identical to Long Point wide long-term trends for these species (Figures 6, 7, & 8). Numbers of American Wigeon remained relatively stable over the long-term at Long Point and in the Crown Marsh, BCM, TPM, and LPCM (Figure 9). Abundances of Green-winged Teal increased substantially within the BCM, TPM, LPCM, and at Long Point, but no trend was detected in numbers counted in the Crown Marsh from 1971 to 2005 (Figure 10).

Diving ducks

Autumn abundance of bay ducks (sum of Canvasback, Redhead, Scaup, & Ring-necked Ducks) at Long Point has not changed appreciably from 1975 to 2005, but trends in numbers of bay ducks varied among marsh complexes (Figure 11). Autumn numbers of bay ducks have increased from 1975 to 2005 on Lake Erie, whereas abundances have decreased in the BCM and LPCM and remained stable in the Crown Marsh, TPM, and ILPB (Figure 11). Autumn numbers of Canvasback at Long Point have declined since 1975; declines also were observed in BCM and LPCM (Figure 12). Autumn Canvasback abundances have remained relatively stable over the long-term within the Crown Marsh, TPM, Lake Erie, and ILPB (Figure 12). Autumn Redhead numbers declined within the Crown Marsh and BCM, but numbers basically were stable in TPM, LPCM, Lake Erie, and ILPB from 1975 to 2005 (Figure 13); the Long Point-wide trend (-5%/year) was nearly statistical significant ($P = 0.11$) (Figure 13). Abundances of scaup in the Crown Marsh, BCM, TPM, LPCM, and ILPB did not exhibit strong increasing or decreasing trends, but numbers of scaup at Long Point have increased greatly and were primarily driven by major annual increases on Lake Erie over the past 30 years (Figure 14). However, there has been a large decline in scaup numbers over the past eight years at Long Point. Autumn Ring-necked Duck abundance at Long Point, and within six of its major marsh/wetland habitats, has remained stable from 1975 to 2005 (Figure 15).

Canada Geese

In general, numbers of Canada Geese counted at Long Point during autumn has declined over the past 34 years, but trends in abundances varied among the four marsh complexes we evaluated (Figure 16). Canada Goose numbers historically were low in the Crown Marsh and their numbers generally have not changed from 1971 to 2005 (Figure 16). Numbers of Canada Geese in TPM historically were higher than in the Crown Marsh, but goose abundance there also has not changed since 1971 (Figure 16). Numbers of Canada Geese decreased in the BCM, whereas their abundance increased substantially within the LPCM over the past 34 years.

Trends in spring waterfowl abundance from 1975 -2006

Dabbling ducks

Spring abundances of total dabbling ducks at Long Point, and in four of its major marsh complexes, has not changed appreciably from 1975 to 2006 (Figure 17). Mallard numbers during spring also have remained relatively stable at Long Point and in the Crown Marsh, BCM, TPM, and LPCM over the past 31 years (Figure 18). Notably, in most years estimated abundances of dabbling ducks and Mallard in the Crown marsh during spring were stable and much lower than fall abundances. It was noteworthy that over time autumn abundances of both total dabbling ducks and Mallard declined and presently are approaching the lower spring abundance levels (e.g., dabbling ducks: $\text{Autumn}_{1971} = 4002$, $\text{Autumn}_{2005} = 341$; $\text{Spring}_{1975\text{-}2006\ \text{Ave.}} = 174$; Mallard: $\text{Autumn}_{1971} = 2937$, $\text{Autumn}_{2005} = 175$; $\text{Spring}_{1975\text{-}2006\ \text{Ave.}} = 80$) (Figures 6, 7, 17 & 18). Numbers of American Black Ducks staging at Long Point, and within the TPM and LPCM, during spring have remained relatively stable since 1975, but their numbers the Crown Marsh and BCM have increased over the same period (Figure 19). These trends in Black Duck numbers are different than those for autumn abundances because their numbers increased and remained stable in the Crown Marsh and BCM, respectively, from 1975 to 2006 (Figure 8). Similar to the seasonal use patterns observed for Mallard, the number of Black Ducks using the Crown Marsh during spring was generally lower than during autumn; because autumn use also declined over time, estimated numbers of Black Ducks counted in the Crown Marsh during fall and spring in recent years have become similar (e.g., $\text{Autumn}_{1971} = 820$, $\text{Autumn}_{2005} = 100$;

Spring $_{1975}$ = 10, Spring $_{2006}$ = 167) (Figures 8 & 19). Spring numbers of American Wigeon at Long Point and within the Crown Marsh, BCM, TPM, and LPCM remained relatively stable from 1975 to 2006 (Figure 20). In general, numbers of American Wigeon in the Crown Marsh during both autumn (Ave. $_{1971-2005}$ = 27) and spring (Ave. $_{1975-2006}$ = 12) were stable from 1975 to 2006 (Figures 9 & 20). Green-winged Teal abundances at Long Point have increased over the past 31 years, but detectable changes only occurred in the Crown Marsh and BCM (Figure 21). Despite their increase, numbers of Green-winged Teal historically counted within the Crown Marsh have been low and their estimated numbers were similar during both autumn (Ave. $_{1971-2005}$ = 15) and spring (Ave. $_{1975-2006}$ = 5) (Figures 10 & 21).

Diving ducks

Spring abundance of bay ducks increased at Long Point from 1975 to 2006 and was primarily related to increased use of ILPB, and a lesser extent Lake Erie, since the late 1990s; numbers of bay ducks generally have remained stable in the Crown Marsh, BCM, TPM, and LPCM from 1975 to present (Figure 22). Spring numbers of bay ducks in the Crown Marsh were, on average, higher in spring (Ave. $_{1975-2006}$ = 916) than in autumn (Ave. $_{1971-2005}$ = 44). No long-term trends were detected in numbers of Canvasback staging at Long Point, but spring numbers have increased on ILPB from 1975 to 2006; abundances were stable in the other major marsh complexes we evaluated (Figure 23). In general, use of the Crown Marsh by Canvasback was much higher (and less variable) in spring (Ave. $_{1975-2006}$ = 110) as compared to autumn (Ave. $_{1971-2005}$ = 7) from 1975 to 2006 (Figures 12 & 23). There was no detectable trend in Redhead use of Long Point from 1975 to 2006, but long-term changes in abundances occurred in several of the major marsh complexes (Figure 24). Spring Redhead abundance decreased at similar relative rates in BCM and LPCM, but increased substantially in ILPB; no trends were detected in the Crown Marsh or Lake Erie (Figure 24). Redhead numbers in the Crown Marsh, on average, tended to be higher in spring (Ave. $_{1975-2006}$ = 97) as compared to autumn (Ave. $_{1971-2005}$ = 6) (Figures 13 & 24). Spring counts of scaup have increased at Long Point since 1975 (Figure 25). No trends were detected in number of scaup in the Crown Marsh, BCM, or LPCM, but their numbers steadily increased on ILPB from 1975 to 2006 and also on Lake Erie since the early 1990s (Figure 25). On average, scaup numbers in the Crown Marsh were slightly higher in spring (Ave. $_{1975-2006}$ = 82) than in autumn (Ave. $_{1971-2005}$ = 13) (Figures 14 & 25). Spring abundance of Ring-necked Duck increased at Long Point and in two of its major marsh complexes from 1975 to 2006 (Figure 26). No trends were detected in spring numbers of Ring-necked Ducks using the Crown Marsh, LPCM, TPM, or Lake Erie (which essentially receives no use by this species), but use of BCM and ILPB by this species has increased since 1975 (Figure 26). Relatively few Ring-necked Ducks, on average, were counted in the Crown Marsh during fall (Ave. $_{1971-2005}$ = 2) and only slightly more were recorded on surveys during spring migration (Ave. $_{1975-2006}$ = 27) (Figures 15 & 26).

Canada Geese

Spring numbers of Canada Geese at Long Point have declined from 1975 to 2006 (Figure 27). Canada Goose numbers decreased in the BCM, but increased in the LPCM during the past 31 years (Figure 27). Spring abundance of Canada Geese in the Crown Marsh or TPM has not changed substantially since 1975. The Crown Marsh historically received very little use by Canada Geese during both spring (Ave. $_{1975-2006}$ = 4) and autumn (Ave. $_{1971-2005}$ = 13) migration (Figures 16 and 27).

Historic changes open water & emergent vegetation

Crown Marsh

Based on the annual area estimates of open water and emergent vegetation, we calculated ratios of open water to emergent vegetation to evaluate interspersion of these two habitat types and changes through time (Table 1). In the Crown Marsh during 1955, 1964, and 1968, ratios of open water to emergent vegetation fluctuated slightly but remained relatively constant around a ratio of 50:50, which is considered an optimal habitat ratio for waterfowl use. In 1978 and 1985, the ratio of open water to emergent vegetation in the Crown Marsh increased substantially, but ratios decreased greatly in 1995 and 1999 as abundance of emergent vegetation increased within the marsh (Figure 19 & Table 1).

Long Point Company Marsh

Ratios of open water to emergent vegetation in the LPCM followed similar patterns to those of the Crown Marsh from 1955 to 1985, but differed in 1995 and 1999 (Table 1). Ratios of open water to emergent vegetation were relatively constant and approximately 50:50 in 1955, 1964, and 1968. Similar to the Crown Marsh, in 1978 and 1985 the amounts of open water increased and emergent vegetation decreased in the LPCM, which caused the ratios of open water to emergent vegetation to increase substantially and thus deviate from a 50:50 ratio (Table 1). In 1995 and 1999, ratios of open water to emergent vegetation dropped to levels that were just slightly higher than 50:50, which were much higher than those for the Crown Marsh during those years. Thus, historically the LPCM generally had interspersion of open water and emergent marsh vegetation that approximated a hemi-marsh condition.

Discussion

Trends in LPWMU hunters and harvest

Long-term changes in numbers of hunters using the LPWMU largely reflect long-term dynamics of waterfowl hunters in Canada. For example, sales of migratory hunting permits in Canada rose from 380,059 in 1966 to an all-time high of 524,946 in 1978 (Bailey 2006a, b). However, recent estimates show that Canada has lost 62% of its waterfowl hunters since 1978; Ontario waterfowl hunters have declined by 58% since that time (Bailey 2006a). The precipitous decline in LPWMU waterfowl hunters since the late 1970s generally follows the same trends in hunter numbers at broader-scales within Canada and the United States. Declining NA duck populations, economic factors, changes in societal demographics and societal views toward hunting have played a major role in the NA decline of waterfowl hunters (Bailey 2006a). The highest numbers of hunters at LPWMU occurred from 1978 – 1984 (peak 1982), so other factors also likely played a role in the decline of hunters (and total harvest) in addition to broad-scale declines in waterfowl hunters.

Numbers of LPWMU hunters appeared to somewhat track North American breeding duck populations, as indexed by the Waterfowl Breeding and Population and Habitat Survey (US Fish and Wildlife Service 2006). For example, both numbers of LPWMU hunters and NA total breeding ducks increased substantially from lows in the early 1960s to relatively high levels in the early – late 1970s. The NA breeding duck population began to decrease substantially after 1979 to all time lows in the late 1980s / early 1990s after which it increased to all-time high levels in the late 1990s / early 2000s followed again by a decline to recent levels that are slightly below the long-term average (US Fish and Wildlife Service 2006). During the late 1970s to mid 1980s, when the NA duck population was declining and at all time lows, LPWMU hunter numbers were at historic high levels, but, in contrast to NA duck population, thereafter LPWMU hunter numbers only decreased continually to near all-time low levels in the early/mid 2000s. Changes in autumn abundances of popular hunted species within the Crown Marsh may better account for the decline in LPWMU hunters since the late 1970s. Our trend analyses confirm that autumn numbers of dabbling ducks (particularly Mallard and American Black Ducks) in the Crown Marsh were highest during the late 1970s – mid 1980s and have declined to current low levels (see Figures 6, 7, & 8). Declines in both LPWMU hunter numbers, thus total harvest, and autumn use of the Crown marsh by waterfowl, particularly dabbling ducks, also may be related to local habitat conditions that have changed since the late 1970s.

Habitat conditions may have partly contributed to changes in LPWMU hunter numbers and total harvest that have occurred within the Crown Marsh since 1961. Annual numbers of LPWMU hunters were positively correlated with annual autumn measures of Lake Erie water levels. This suggests that hunters may use annual water levels (via a visual assessment of how much water is in the marsh) as a deciding factor on whether or not to hunt, especially because this can affect accessibility to hunting areas/blinds and hunter-perceived quality of habitat for ducks. Results of our habitat analyses also show that open water area generally has declined, while emergent vegetation increased, in the Crown Marsh from the late 1970s to present, which is also the period corresponding to declining numbers of LPWMU hunters. These two trends suggest that hunter-use of the LPWMU is at least partly influenced by Lake Erie hydrology, likely through related factors that affect hunting opportunity/accessibility or hunting quality.

Waterfowl hunters often state that seeing ducks, preferably many ducks, and having opportunity to harvest ducks are two major components of hunting quality (National Duck Hunting Survey 2006). These aspects of waterfowl hunting are largely related to numbers of ducks using a marsh during the fall hunting season, which ultimately is related to marsh habitat quality or suitability and hunting pressure. Our trend analyses revealed that autumn mid-day use of the Crown Marsh by two of the most commonly harvested species, Mallard and American Black Duck, decreased substantially from 1971 to 2005. These declines in dabbling duck use probably has resulted in hunters seeing fewer ducks or reduced opportunities for them to harvest popular species and likely caused some to stop waterfowl hunting in the Crown Marsh. It was notable that in recent years, despite lower harvest due to fewer hunters, the number of ducks harvested per hunter has remained relatively stable over time in the Crown Marsh. This indicates that hunter success, another aspect of hunting quality, has not changed much in the Crown Marsh. Hunters may be spending more hours in the marsh in recent years to kill ducks, which to some could be perceived as a decrease in hunting quality. Annual totals of time spent hunting in the marsh were not readily available so we could not determine if hunter effort (or hunting pressure) has increased over time or correct hunter success or harvest rate for effort. Changes in these variables would be interesting to assess in future analyses.

Trends in waterfowl use of the Crown Marsh

The most pronounced and relevant result of our historic assessment of waterfowl trends was that mid-day use by dabbling ducks, particularly Mallard and American Black Duck, have decreased substantially from 1971 to 2005. This was especially noteworthy because total dabbling duck, Mallard, and Black Duck numbers generally were stable in the BCM, TPM, and LPCM during the same time. We also found that autumn-use of the Crown Marsh by Canada Geese was very limited and has not changed much since 1971. Redhead was the only bay duck (*Aythya* spp) for which we detected significant declines within the Crown Marsh over the past 31 years. We did not, however, find the same decreasing trends in spring numbers of total dabbling duck, Mallard, or Black Duck from 1975 to 2006. In contrast, spring numbers of Mallard were stable whereas total dabbling duck, Black Duck, and Green-winged Teal numbers increased from 1975 to 2006. Our findings suggest that autumn dabbling duck use, particularly Mallard and Black Duck, has decreased, but the factors explaining the apparent seasonal differences between trends are varied and complex.

It is not immediately clear, for example, why spring abundances of total dabbling ducks, Mallard, and American Black Duck in the Crown Marsh did not exhibit declining trends as did during autumn. We did find, however, that annual spring abundances of these birds were consistently lower than their autumn abundances and they exhibited generally stable long-term trends; also recall that autumn abundances generally declined over time and converged upon spring values in recent years. Seasonal differences in food availability and long-term responses of waterfowl foods to changing habitat conditions may provide an explanation for these waterfowl use patterns (i.e., assuming waterfowl numbers track changes in food in a marsh). Autumn food availability, thus marsh carrying capacity, generally is much higher than it is during spring due to major reductions caused by waterfowl consumption during autumn and early spring, seasonal plant senescence, over-winter die-off, and wave action (Badzinski et al. 2006, Schummer 2006). As a result, consistently higher numbers of birds in a marsh during autumn, as compared to spring, might be expected. Further, autumn food availability likely exhibits relatively higher annual variability, which combined with higher relative abundance, might allow detection of long-term annual changes in duck numbers during that season. Under intense feeding pressure, spring food levels in a marsh may be reduced to low and relatively constant levels (minimum threshold densities) each year (Badzinski et al. 2006). Given its relatively small size, these food conditions could exist in the Crown Marsh and thus duck numbers also may show long-term stability. The number of ducks counted during spring also may reflect the minimum optimal number of bird the marsh can support. Thus, if seasonal waterfowl numbers generally track annual average marsh carrying capacity, which is largely a function of food and space, it may be that differential seasonal trends in waterfowl abundances and the generally stable and/or relatively low spring waterfowl numbers we observed were still consistent with a general habitat quality decline (see below) in the Crown Marsh.

Habitat change in the Crown Marsh

A ratio of 50 percent open water to emergent vegetation, the "hemi-marsh" condition, is conducive to optimum marsh productivity and creates a state of habitat interspersion ideal for use by waterfowl and a multitude of other wetland-dependent birds and wildlife (Weller 1987). In managed marshes, when ratios of open water to vegetation approach 30 or 70 percent management action is typically taken to restore the marsh to a more optimal condition (Payne 1992). Proper habitat interspersion creates open water areas within a marsh for waterfowl to feed and provides day and night roost habitat (Weller 1987, Bookhout et al. 1989).

Our habitat analyses show that the Crown Marsh has undergone major changes and shifts in habitat types since 1955, most of which have been related to fluctuations in Lake Erie water levels. The ratios of open water to emergent vegetation in the Crown Marsh fluctuated slightly but approximated an optimal hemi-marsh in 1955, 1964, and 1968 (see Table 1). In 1978 and 1985, the ratios of open water to emergent vegetation (85:15 and 78:22, respectively) were well above the near optimal values observed in the 1950s and 1960s. During 1995 and 1999, open water area in the Crown Marsh decreased from high levels in 1985 and was largely replaced by emergent vegetation (e.g., cattail in lower marsh elevations and *Phragmites australis* in higher marsh areas [see also Wilcox et al. 2003]). As a result, ratios of open water to emergent vegetation indicated potentially sub-optimal habitat conditions for waterfowl and other marsh birds. Lake Erie water levels from 1999 to 2005 have generally remained stable and below the long-term average, so we speculate that the trend of emergent plants replacing open water area has continued. We also suspect that the distribution and amount of the invasive strain of *Phragmites australis* increased in the Crown Marsh since 1999 (see Wilcox et al. 2003). This is problematic because *Phragmites australis* can form large, dense monotypic stands that are of limited use to waterfowl and many other wildlife species inhabiting marshes (Meyer 2003). The generally declining habitat trends we observed in the past decade are not surprising given the limited amount of habitat management that occurred within the Crown Marsh. We suspect habitat conditions will continue to deteriorate if no habitat management is undertaken and especially if Lake Erie water levels continue to decline or remain at relatively low levels. If this occurs, the Crown Marsh may lose biodiversity and will become less attractive as a feeding area or a day/evening roost site for waterfowl and thus hunting opportunity and quality will further decline.

Habitat change in the Long Point Company Marsh

The LPCM also has experienced habitat changes since 1955, but that marsh was characterized by ratios of open water to emergent vegetation that, on average, were closer to a theoretical optimum condition during the periods we evaluated (see Table 1). The largest deviations from an optimal hemi-marsh occurred during 1978 and 1985 when ratios of open water to emergent vegetation were 87:13 and 90:10, respectively, which is the same period when the Crown Marsh had a large amount of open water. Ratios of open water to emergent vegetation for the LPCM were thus similar to those of the Crown Marsh until 1985. However, in 1995 and 1999 ratios of open water to emergent vegetation in the LPCM were much higher than those of the Crown Marsh and were close to (approx. 60:40) a theoretical hemi-marsh condition. Comparison of these two marshes suggests that the habitat conditions in the LPCM generally were better for waterfowl during the mid to late 1990s. It also was interesting to note that autumn and spring numbers for all dabbling duck species and nearly all bay duck species were stable or increased from 1975 to present in the LPCM. Autumn bay duck and Canvasback abundances plus spring Redhead numbers, however, declined in the marsh over this time and may be due to reductions in open water areas or larger scale changes in distributions that have occurred since zebra mussels invaded the lower Great Lakes (Wormington and Leach 1992, Petrie and Knapton 1999, Coordinated Canvasback Survey 1974 – 2005; unpublished data). Since 1995, cattail has replaced much of the open water areas in lower marsh elevations within the LPCM, while shoreline/open water areas and higher marsh elevations have been replaced with *Phragmites australis*. This phenomenon was similar to what occurred in the Crown Marsh during the same time (Wilcox et al. 2003).

The LPCM has been actively managed for decades, whereas the Crown Marsh has not, which may partly explain its relatively better habitat conditions. For example, currently two ponds are being created within a higher elevation of the marsh to reduce the amount of some *Phragmites australis* and to restore historic waterfowl habitat. Also, most channels and at least a portion of the open water areas are essentially dredged on an annual basis to increase water flow, marsh access, and suitability of habitats for waterfowl. Thus, we believe that habitat management in the LPCM has, at least partly, contributed to maintaining its near optimal habitat conditions.

Conclusions

Our historic assessments suggest that habitat condition / quality has deteriorated and autumn use by important waterfowl species has declined within the Crown Marsh, particularly over the past decade. We speculate that these trends will continue unless some form of habitat management is undertaken to create habitat more conducive to waterfowl use, especially if Lake Erie water levels continue to decline. We suggest that some, or all, of the following steps be taken to optimize waterfowl use and hunting opportunities within the Crown Marsh:

Management Recommendations

1) Enlarge and/or deepen some existing openings within the marsh, particularly those at lower marsh elevations closer to the lake to take advantage of existing water levels and seasonal fluctuations to maintain water levels; providing a range of water-depths will provide habitat for various waterfowl species (e.g., shallow areas for teal, deeper areas for larger dabbling ducks and possibly diving ducks, mainly Ring-necked Ducks)
2) Create new openings (in optimal sizes and depths depending on species of interest) in the lower marsh elevations to break-up large monotypic stands of cattail and *Phragmites australis*, which will increase habitat diversity and interspersion of open water / emergent vegetation.
3) Create new open water areas in higher marsh elevations to provide more useable habitat for waterfowl while also increasing hunting opportunities within the marsh. Depending on their location, these areas may be mainly dependent on water inputs from ground sources and/or Lake Erie – Inner Long Point Bay.
4) Strive to reduce large monotypic stands of *Phragmites australis* to increase wildlife value of marsh areas impacted by this exotic, invasive plant.
5) Create a Crown Marsh Management Committee to develop a specific goal-orientated management plan that optimizes hunting, conservation, and public interests. A monitoring program should be devised to evaluate effects of management activities. The committee should consist of biologists, academics, wetland managers, marsh users, and other parties interested in the management/rehabilitation of the marsh.

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Table 1. Changes in open water area, emergent vegetation area, and in the ratios (%:%) of open water to emergent vegetation in the Crown Marsh and the Long Point Company Marsh, Long Point, Lake Erie, Ontario, from 1955 to 1999.

		Year						
Marsh	Habitat Variable	1955	1964	1968	1978	1985	1995	1999
Crown	Open water (ha)	241	156	172	372	361	146	141
	Emergents (ha)	178	219	200	64	100	288	297
	Open water:emergents	58:42	42:58	46:54	85:15	78:22	34:66	32:68
Long Point Company	Open water (ha)	1431	1343	1428	2161	2387	1497	1451
	Emergents (ha)	1204	1140	1085	312	255	917	955
	Open water:emergents	54:46	46:54	57:43	87:13	90:10	62:38	60:40

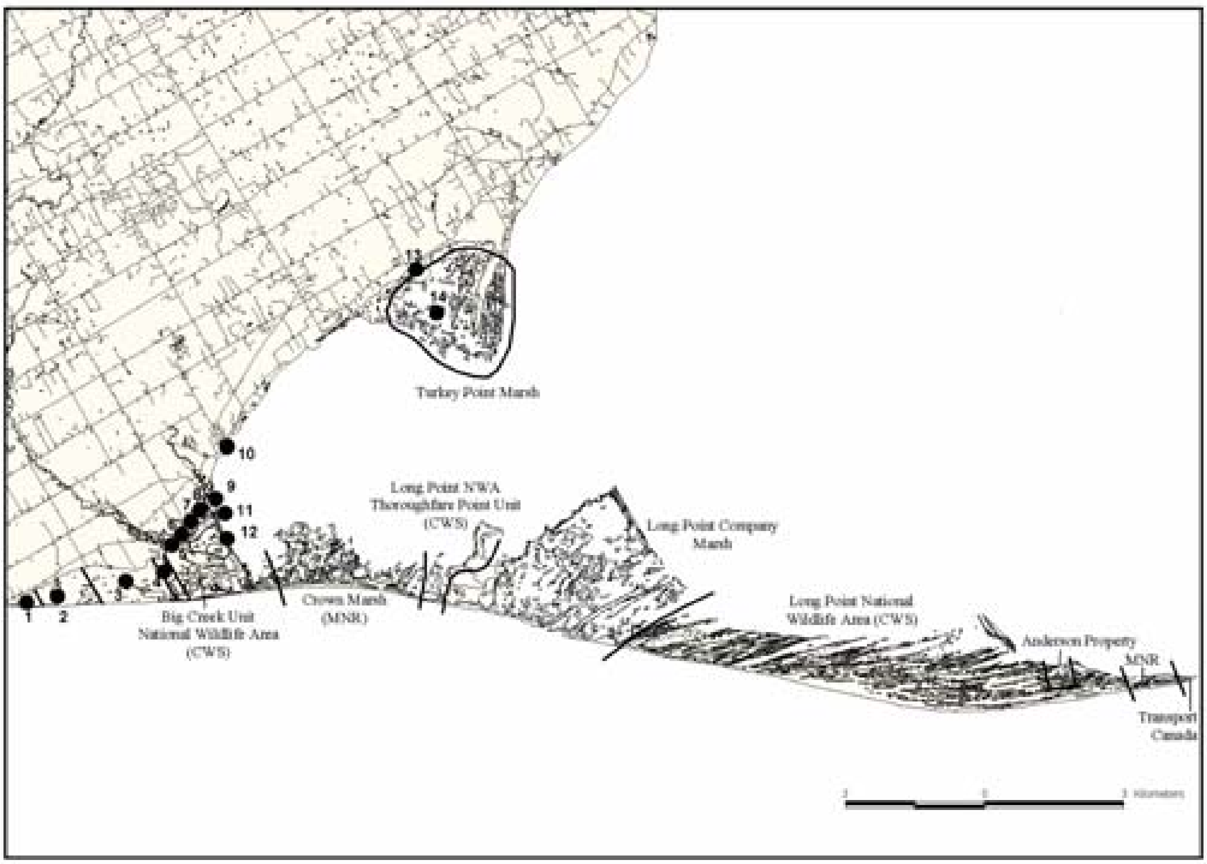


Figure 1. Locations of the Crown Marsh – Long Point Waterfowl Management Unit (WMU), Big Creek Marsh / National Wildlife Area (NWA), Turkey Point Marsh, and Long Point Company Marsh at Long Point, Lake Erie, Ontario. Approximate area of the marsh complexes are as follows: Crown Marsh = 1750 acres / 650 hectares; Big Creek Marsh = 3000 acres / 1215 hectares; Turkey Point Marsh = 3300 acres / 1335 hectares; and Long Point Company Marsh = 8600 acres/ 3480 hectares.

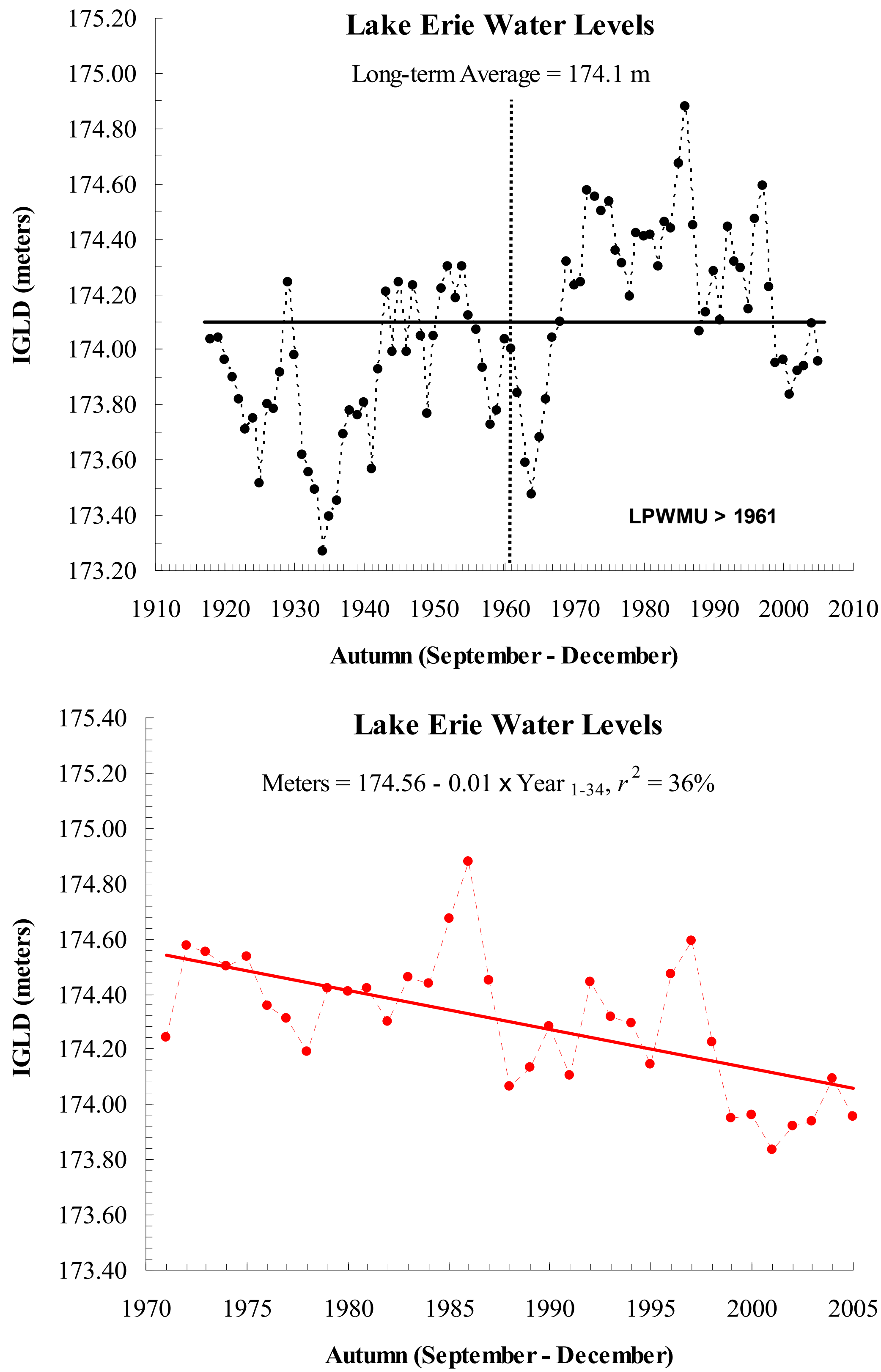


Figure 2. Long-term fluctuations in Lake Erie water levels from 1918 – 2005 and the general decline (shown in red) in autumn Lake Erie water levels since 1971. Data provided by the Canadian Hydrographic Service.

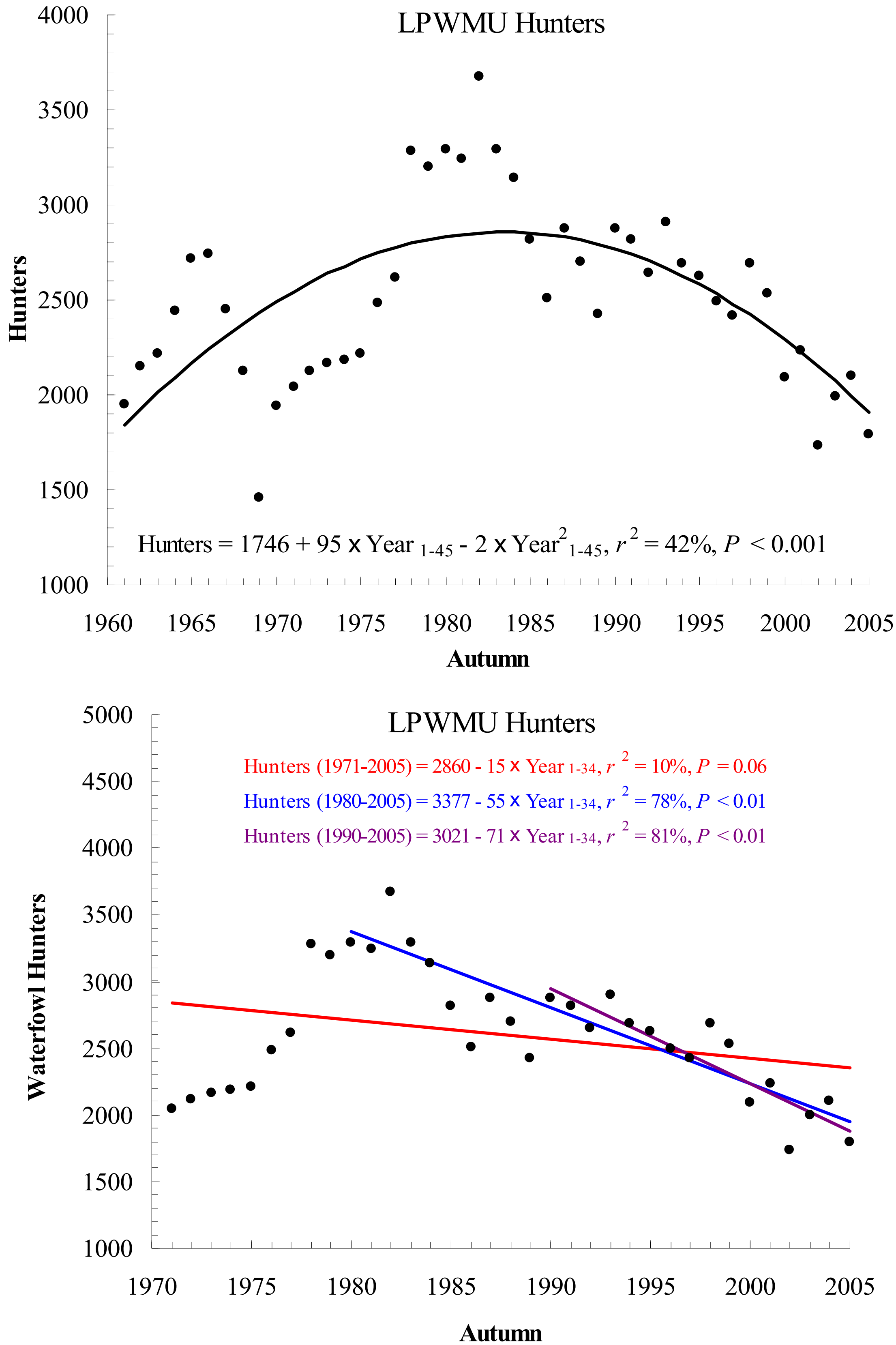
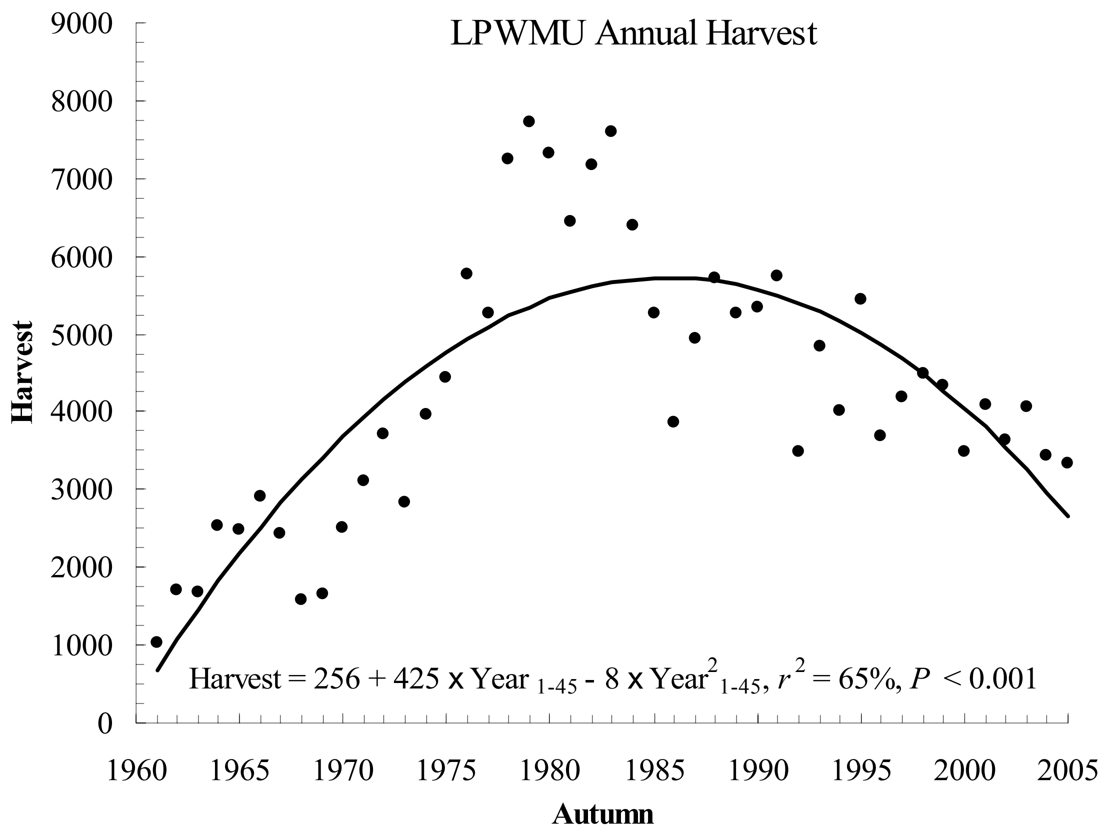


Figure 3. Trends in numbers of waterfowl hunters using the Long Point Waterfowl Management Unit (LPWMU) - Long Point, Lake Erie, Ontario from 1961 to 2005.



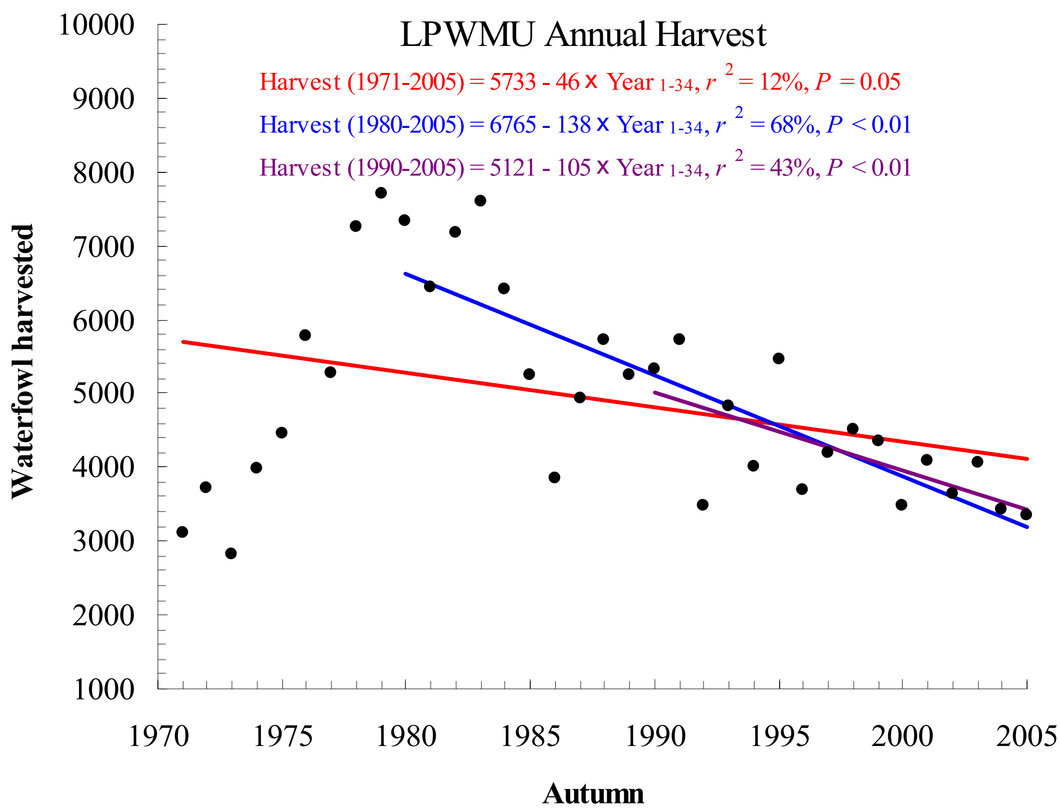


Figure 4. Trends in numbers of waterfowl harvested from the Long Point Waterfowl Management Unit (LPWMU) - Long Point, Lake Erie, Ontario from 1961 to 2005.

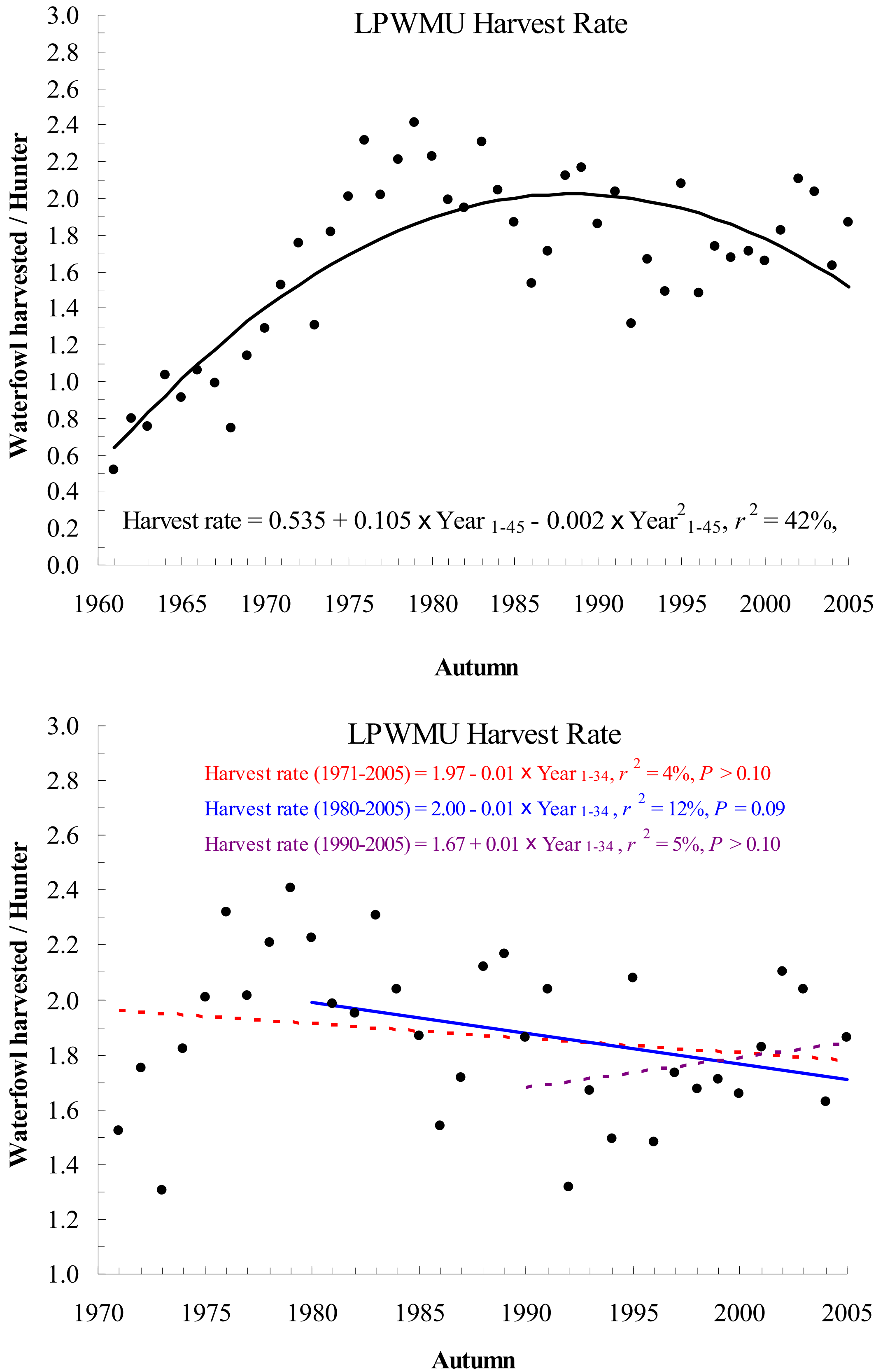


Figure 5. Trends in numbers of waterfowl harvested per hunter at the Long Point Waterfowl Management Unit (LPWMU) - Long Point, Lake Erie, Ontario from 1961 to 2005.

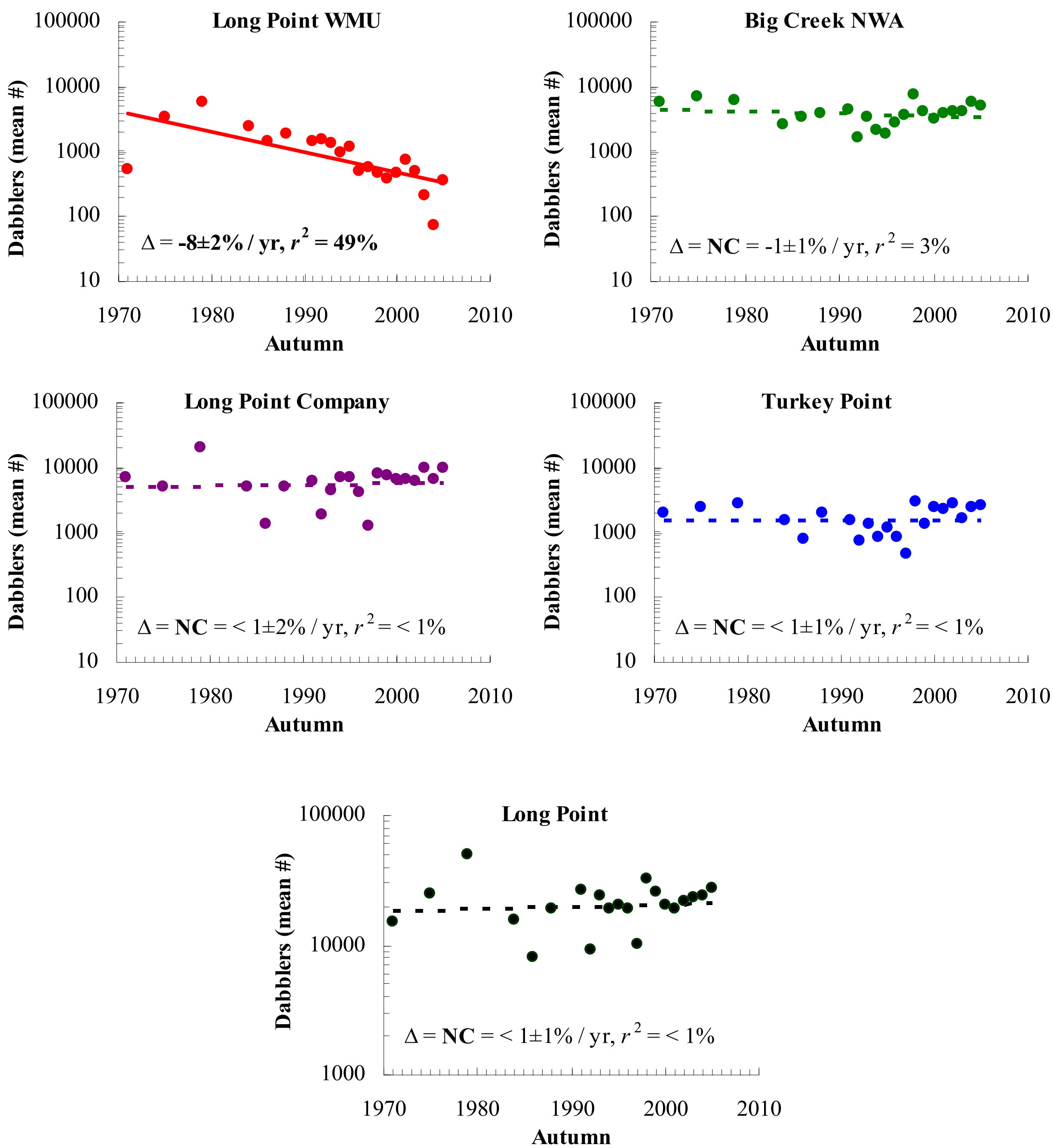


Figure 6. Changes in mean numbers of dabbling ducks* counted during the peak autumn migration period (1 October – 30 November) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented for dabbling ducks.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.

* Mallard, Black Duck, Wigeon, Gadwall, Pintail, Green-winged Teal & Blue-winged Teal.

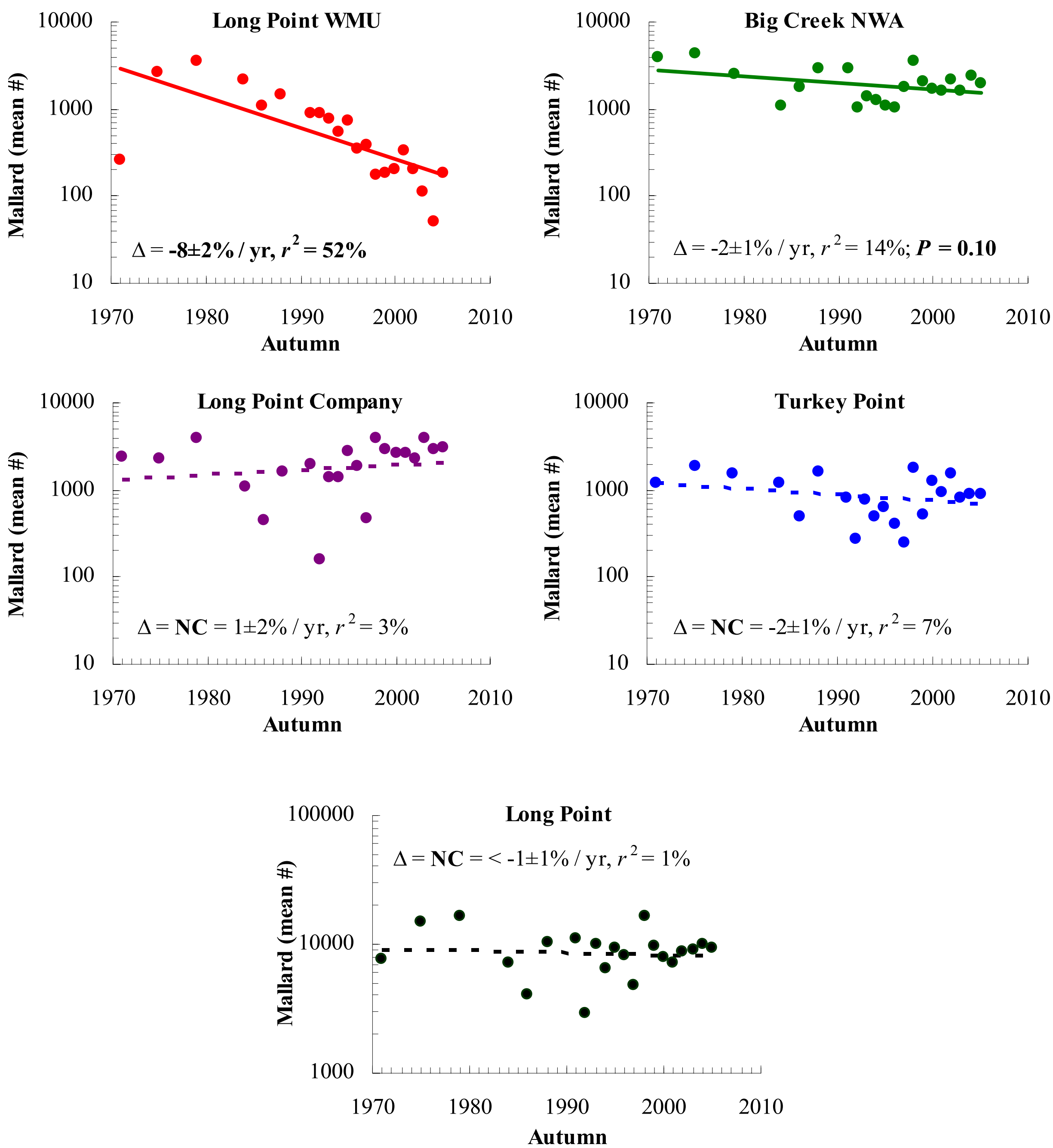


Figure 7. Changes in mean numbers of Mallard (*Anas platyrhynchos*) counted during the peak autumn migration period (1 October – 15 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.

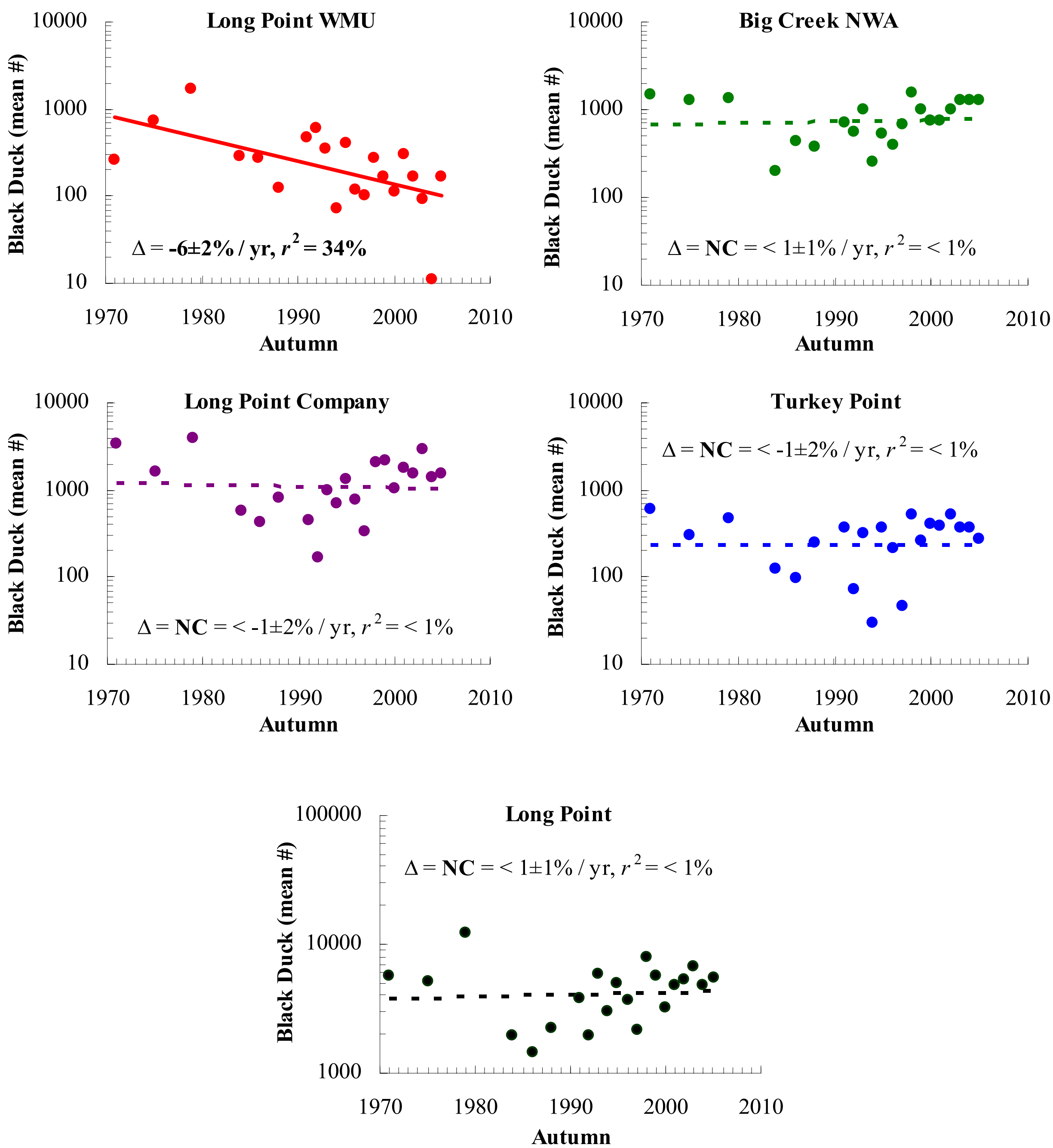


Figure 8. Changes in mean numbers of American Black Duck (*Anas rubripes*) counted during the peak autumn migration period (1 October – 15 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.

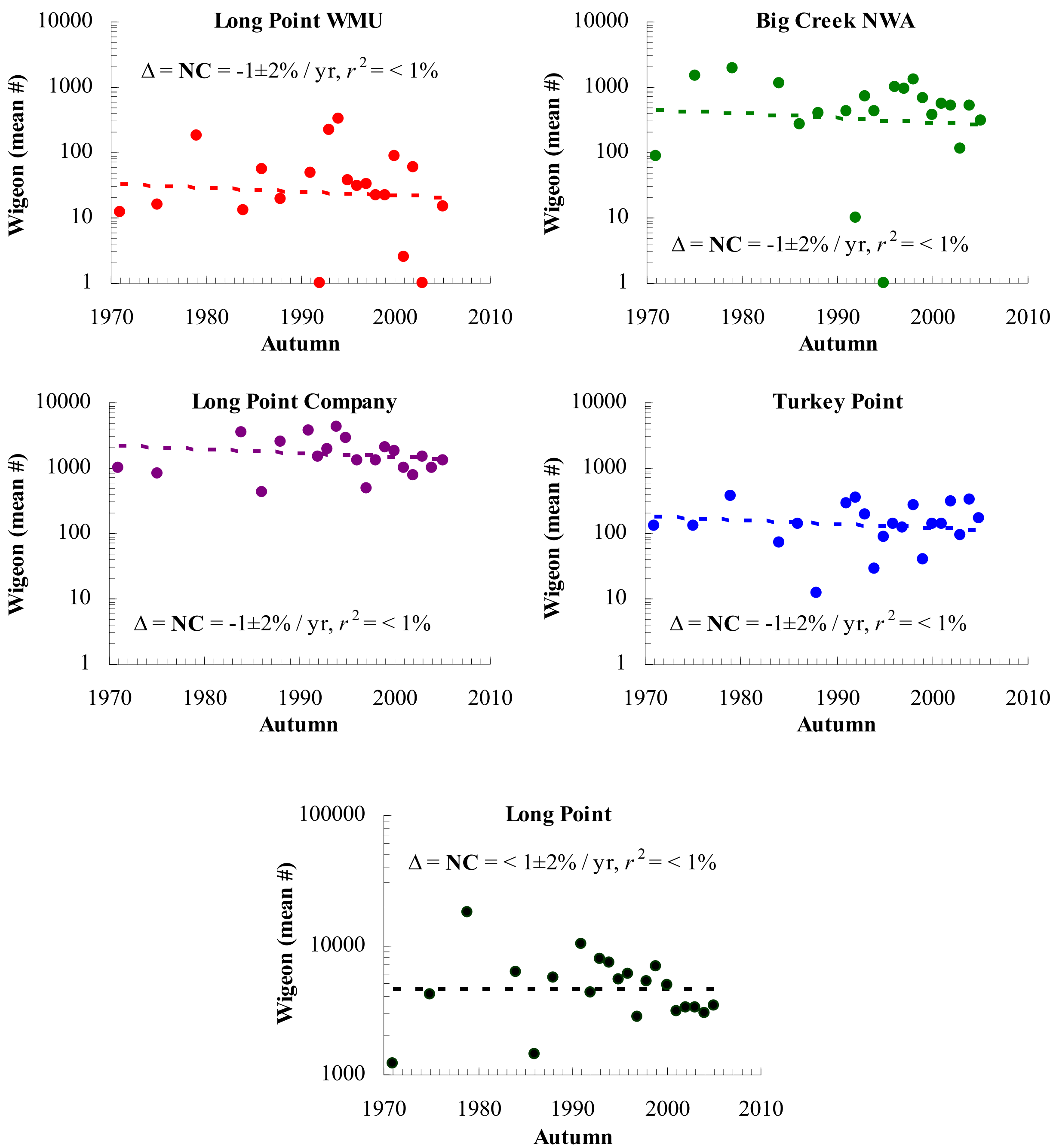


Figure 9. Changes in mean numbers of American Wigeon (*Anas americana*) counted during the peak autumn migration period (1 October – 15 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.

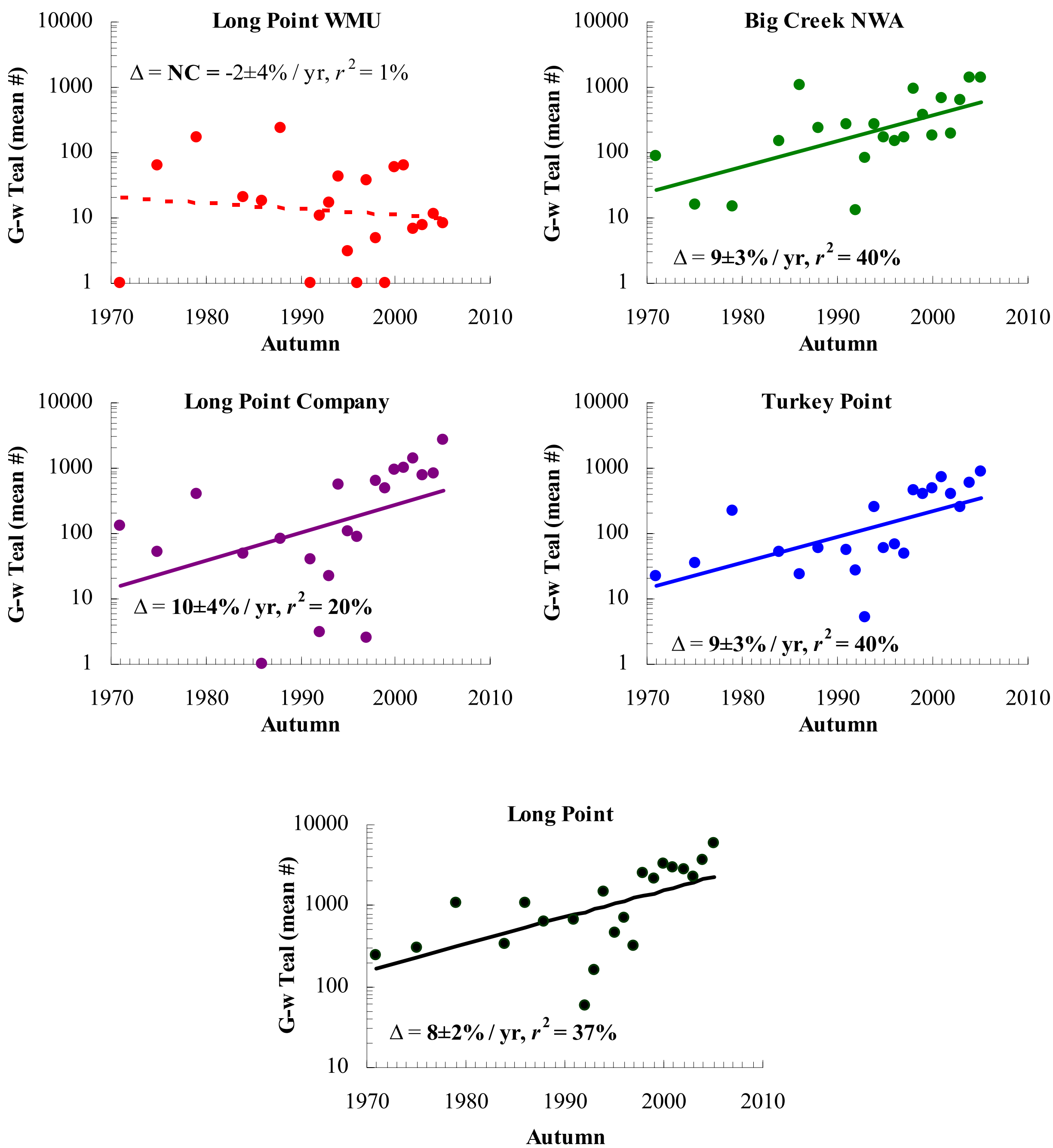
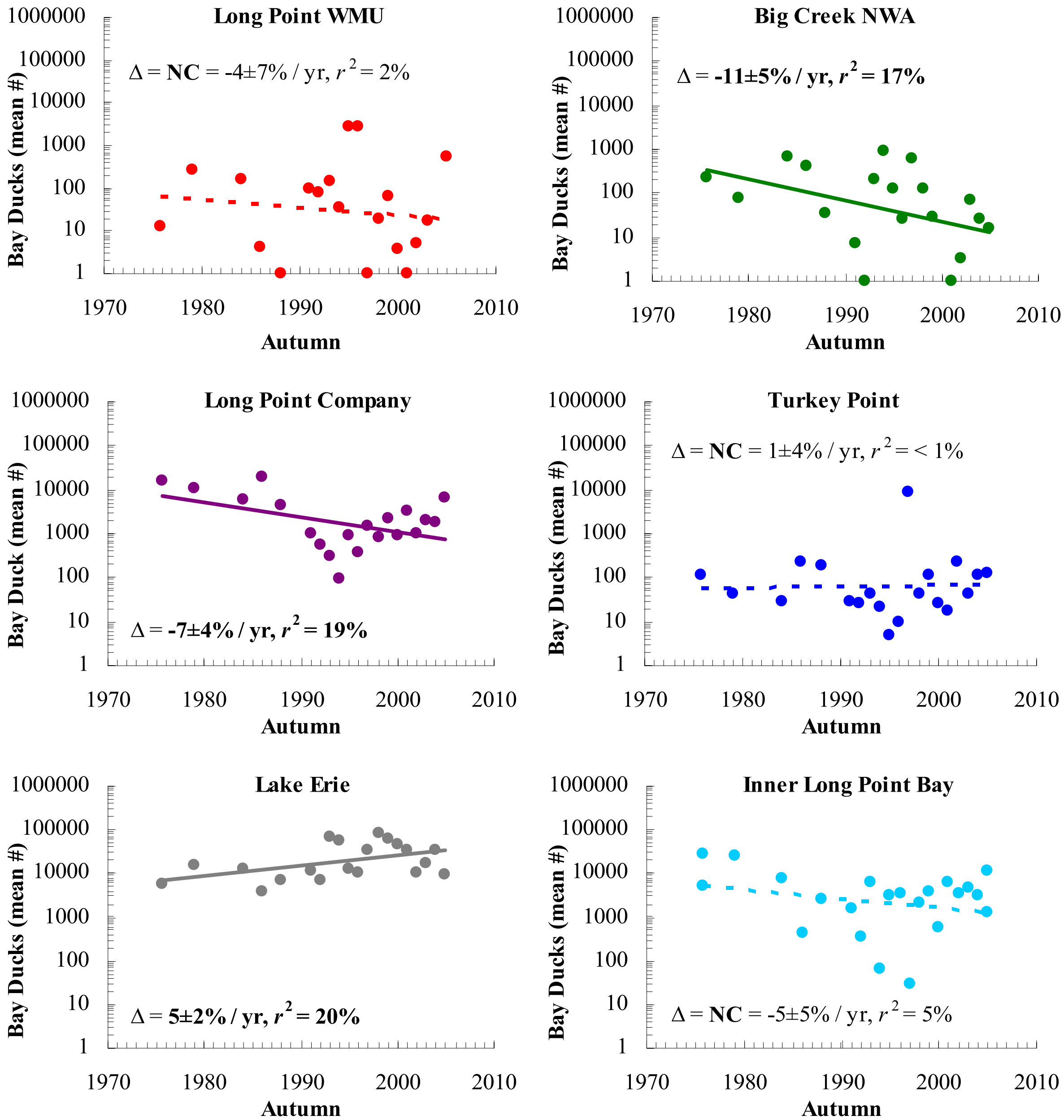


Figure 10. Changes in mean numbers of Green-winged Teal (*Anas crecca*) counted during the peak autumn migration period (1 October – 15 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.



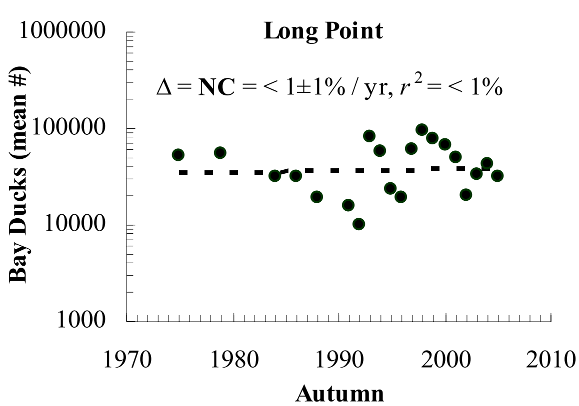
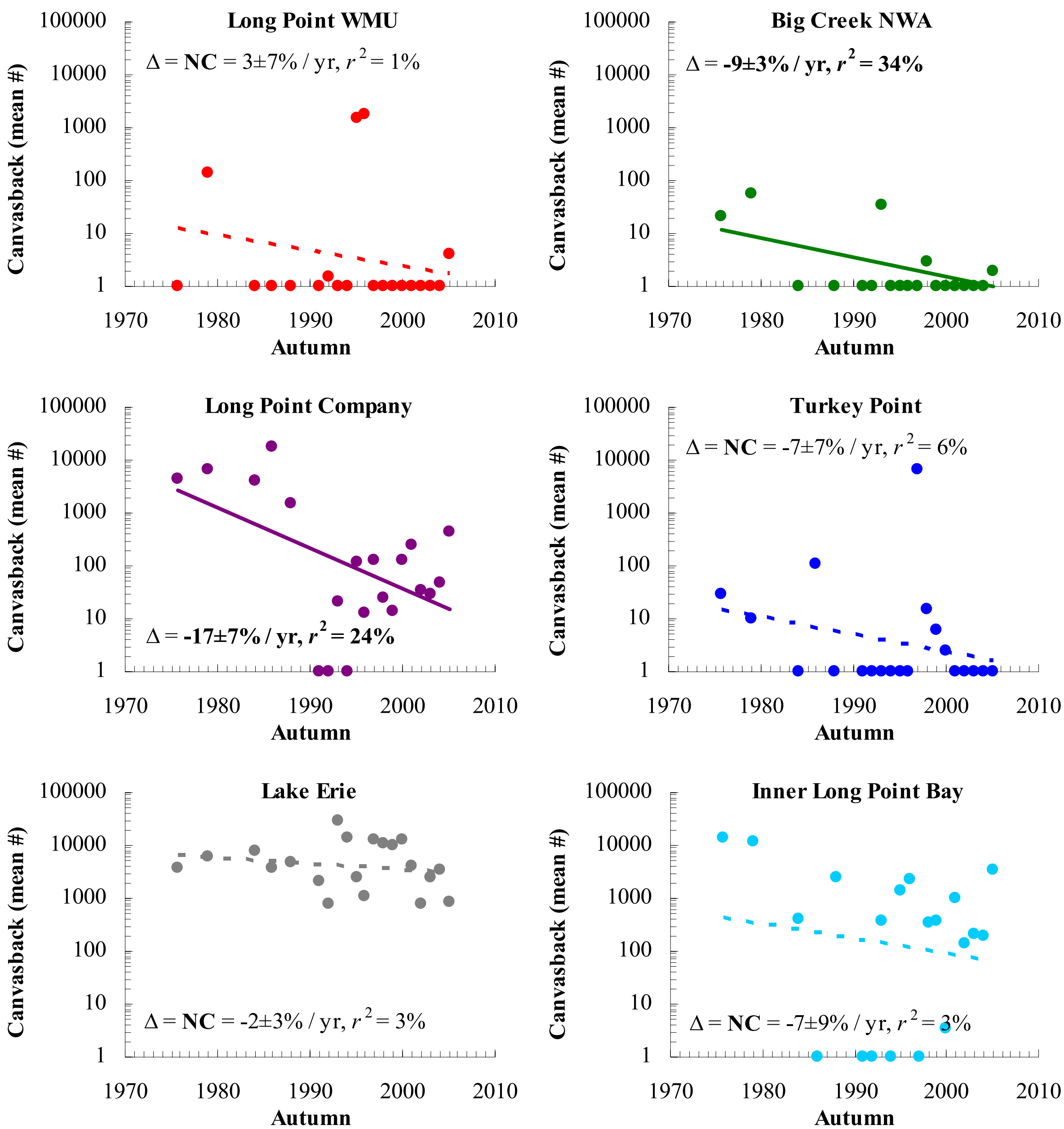


Figure 11. Changes in mean numbers of Bay Ducks* counted during the peak autumn migration period (1 October – 30 November) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$).

*Canvasback, Redhead, Scaup, & Ring-necked Duck.



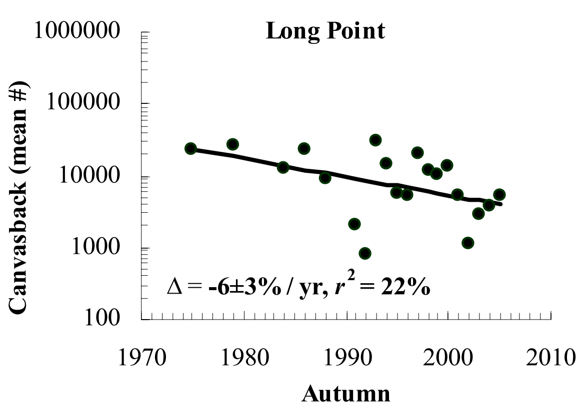
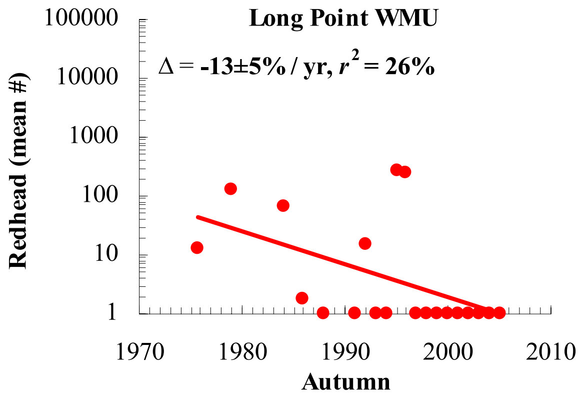
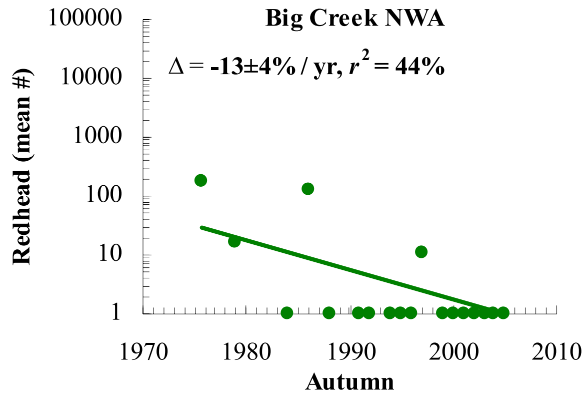
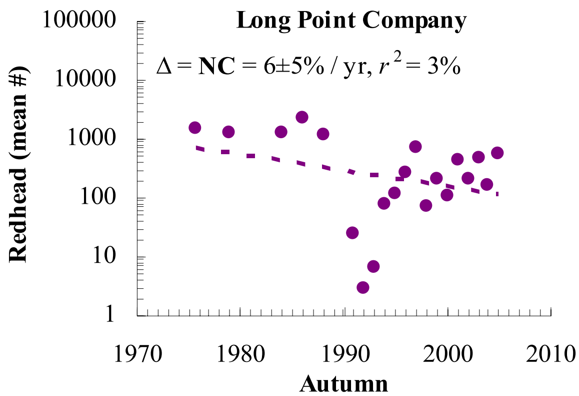


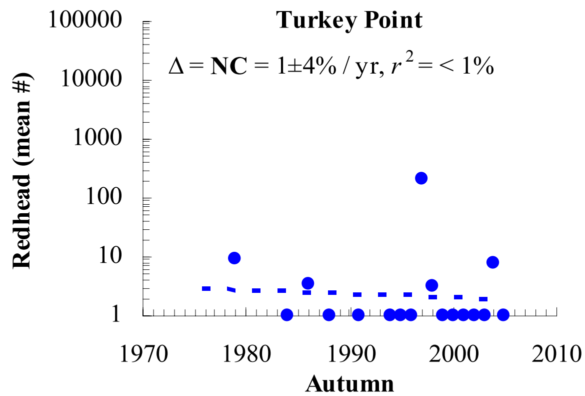
Figure 12. Changes in mean numbers of Canvasback (*Aythya vallisineria*) counted during the peak autumn migration period (1 October – 30 November) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

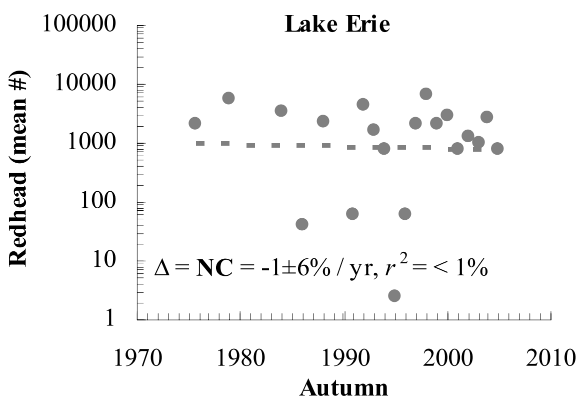
Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$).

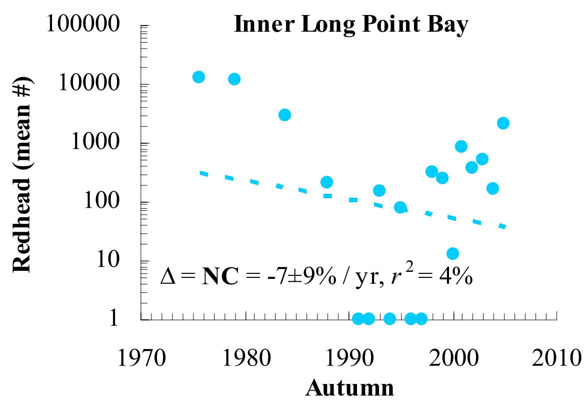












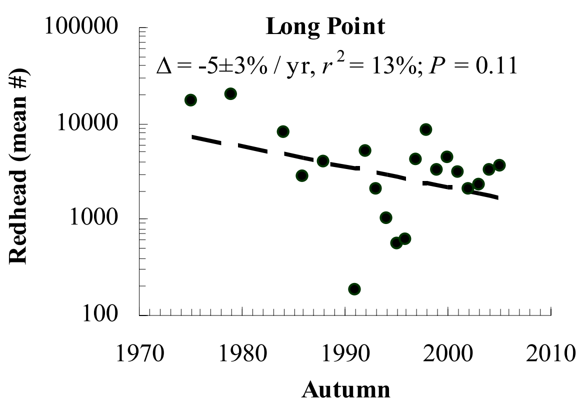
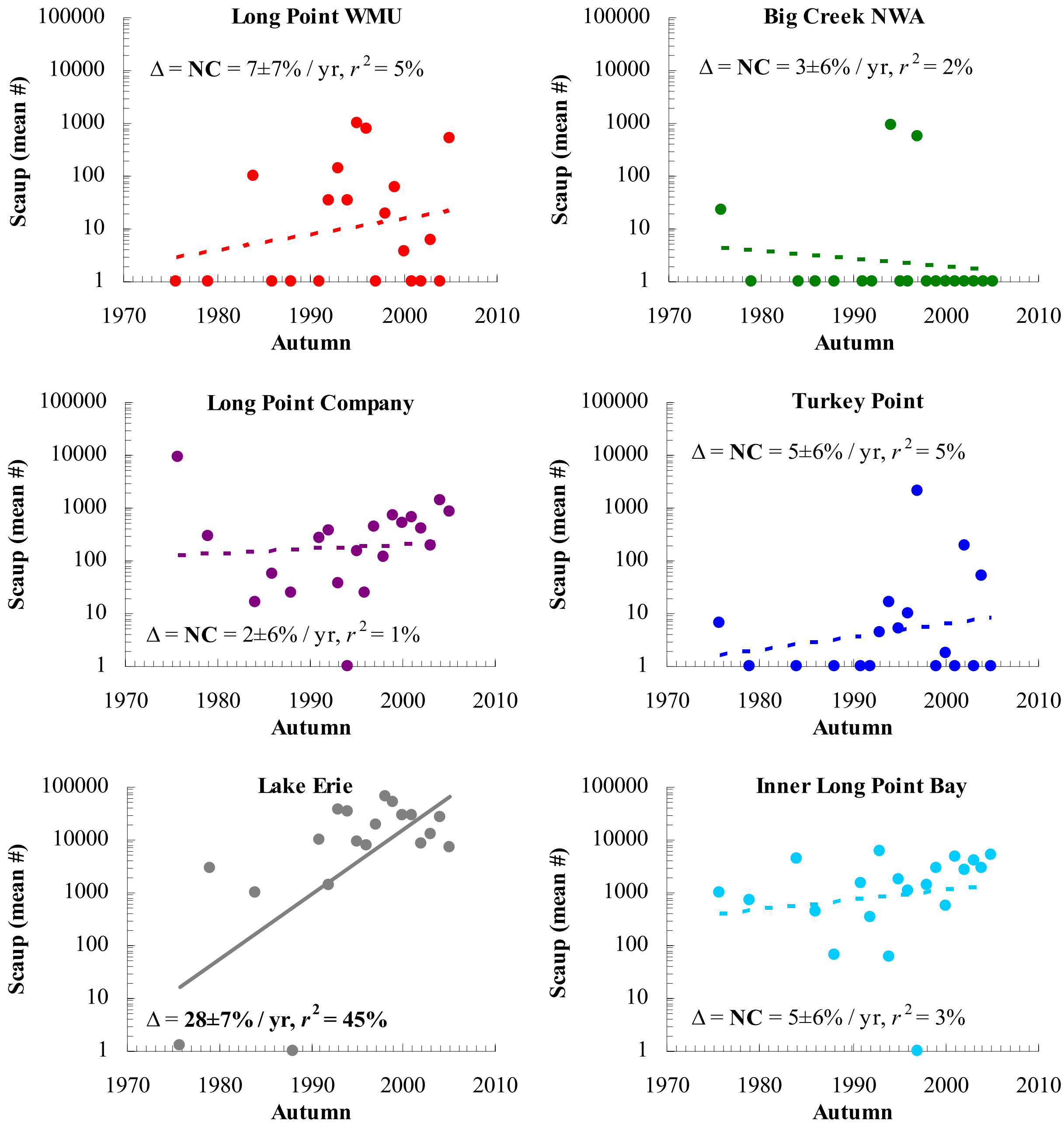


Figure 13. Changes in mean numbers of Redhead (*Aythya americana*) counted during the peak autumn migration period (1 October – 30 November) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$).



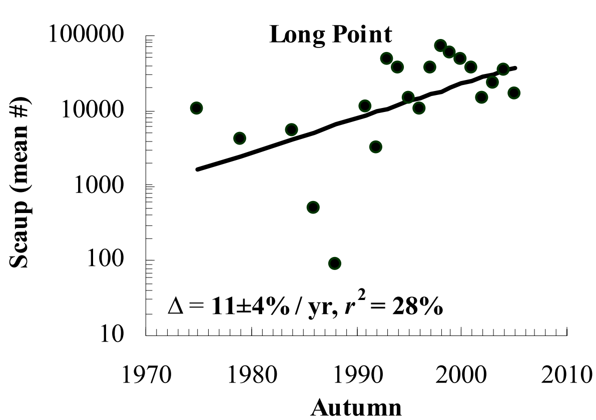
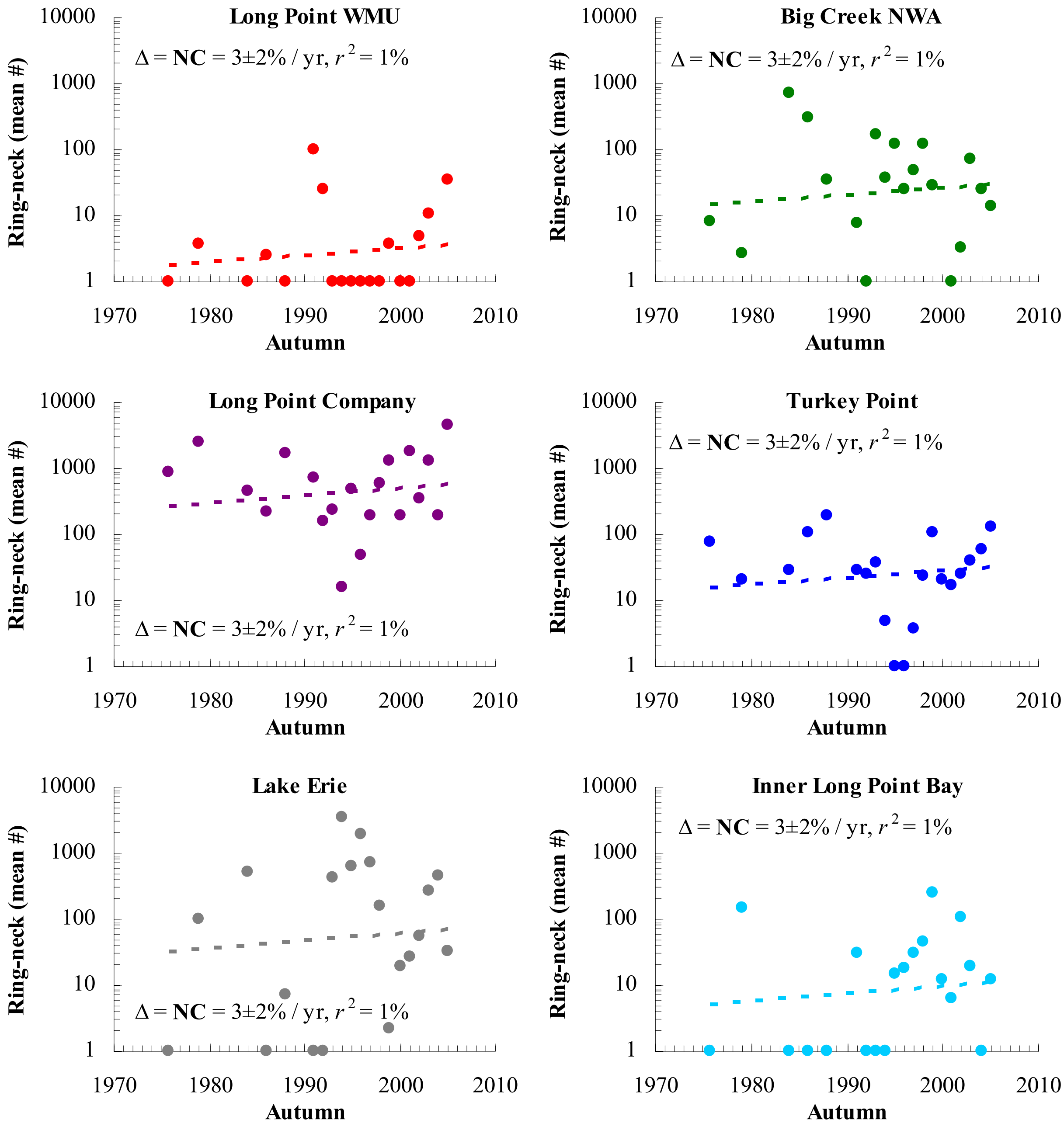


Figure 14. Changes in mean combined numbers of Lesser (*Aythya affinis*) & Greater Scaup (*A. marila*) counted during the peak autumn migration period (1 October – 30 November) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$).



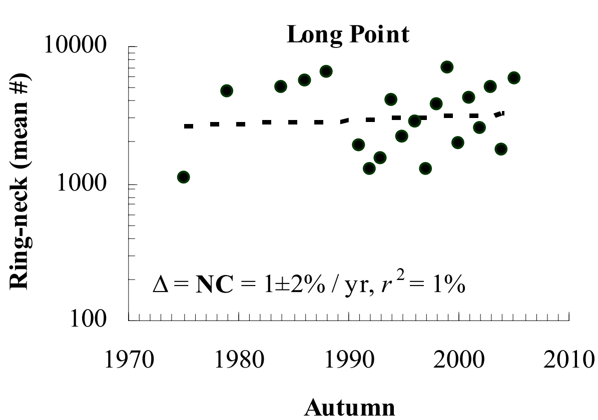


Figure 15. Changes in mean numbers of Ring-necked Ducks (*Aythya collaris*) counted during the peak autumn migration period (1 October – 30 November) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$).

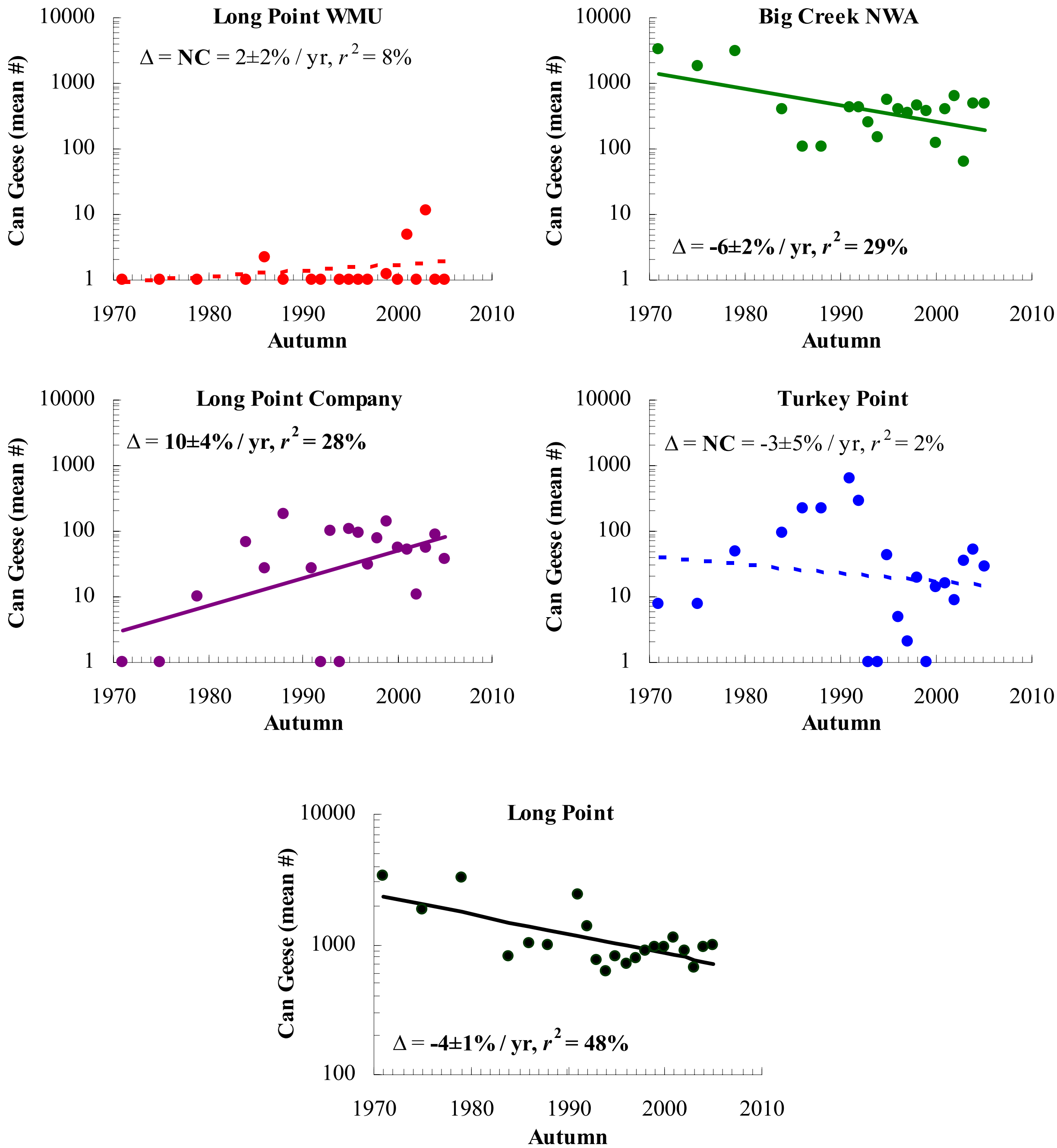


Figure 16. Changes in mean numbers of Canada Geese (*Branta canadensis*) counted during the peak autumn migration period (1 October – 15 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented for Mallard.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.

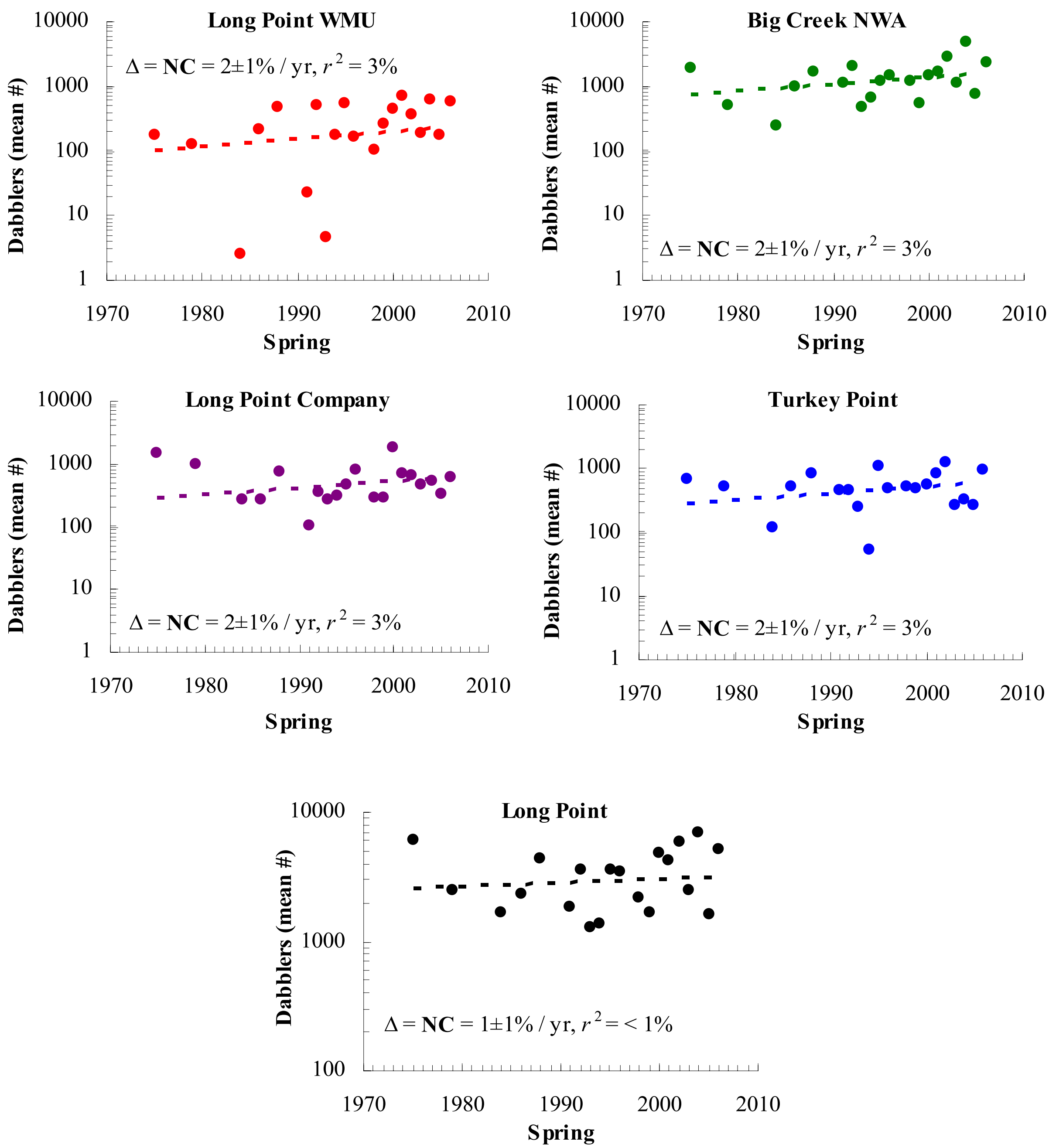


Figure 17. Changes in mean numbers of dabbling ducks* counted during the peak spring migration period (1 March – 15 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented for dabbling ducks.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.

* Mallard, Black Duck, Wigeon, Gadwall, Pintail, Green-winged Teal & Blue-winged Teal.

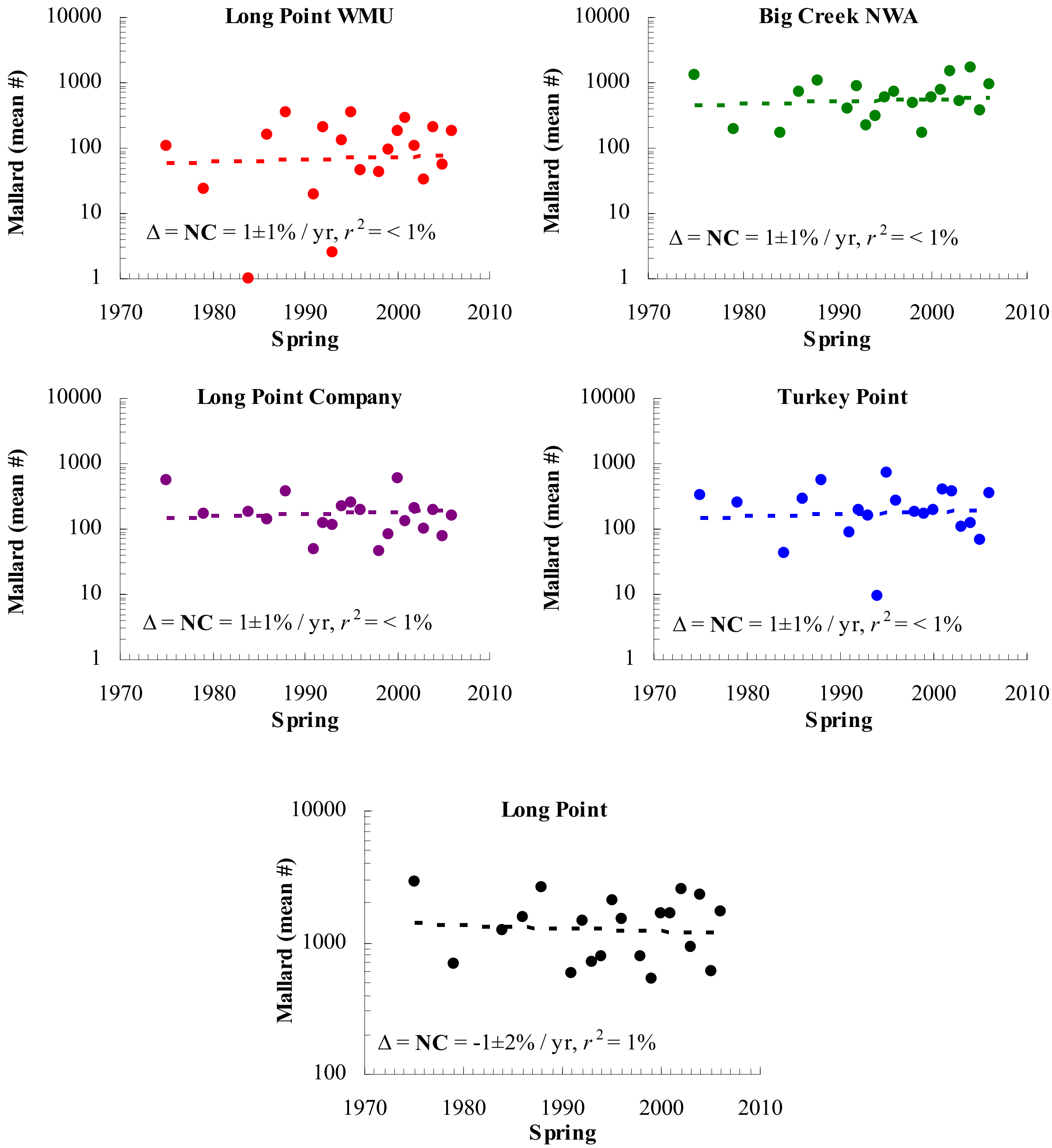


Figure 18. Changes in mean numbers of Mallard (*Anas platyrhynchos*) counted during the peak spring migration period (1 March – 15 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.

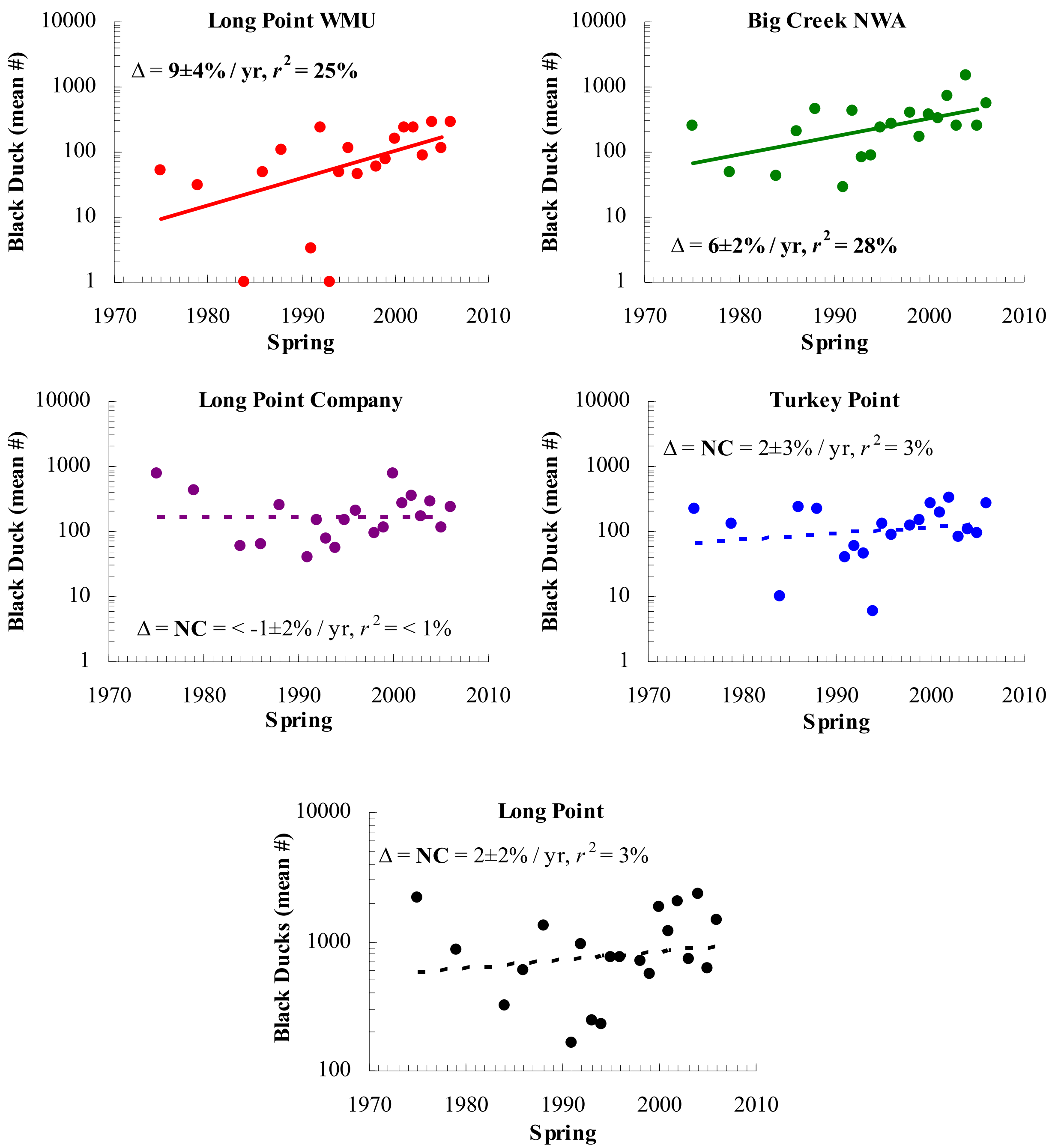


Figure 19. Changes in mean numbers of American Black Duck (*Anas rubripes*) counted during the peak spring migration period (1 March – 15 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.

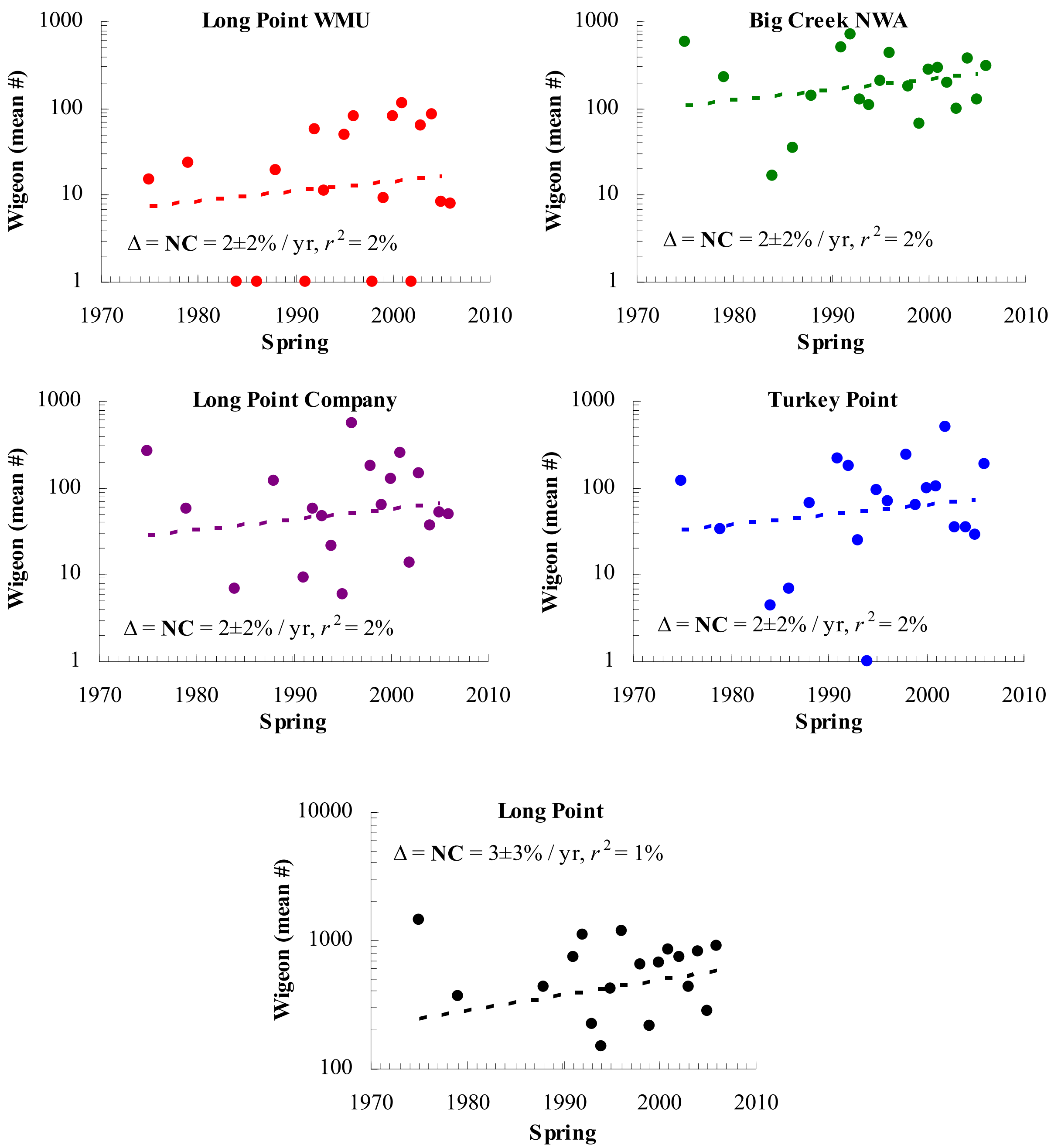


Figure 20. Changes in mean numbers of American Wigeon (*Anas americana*) counted during the peak spring migration period (15 March – 30 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.

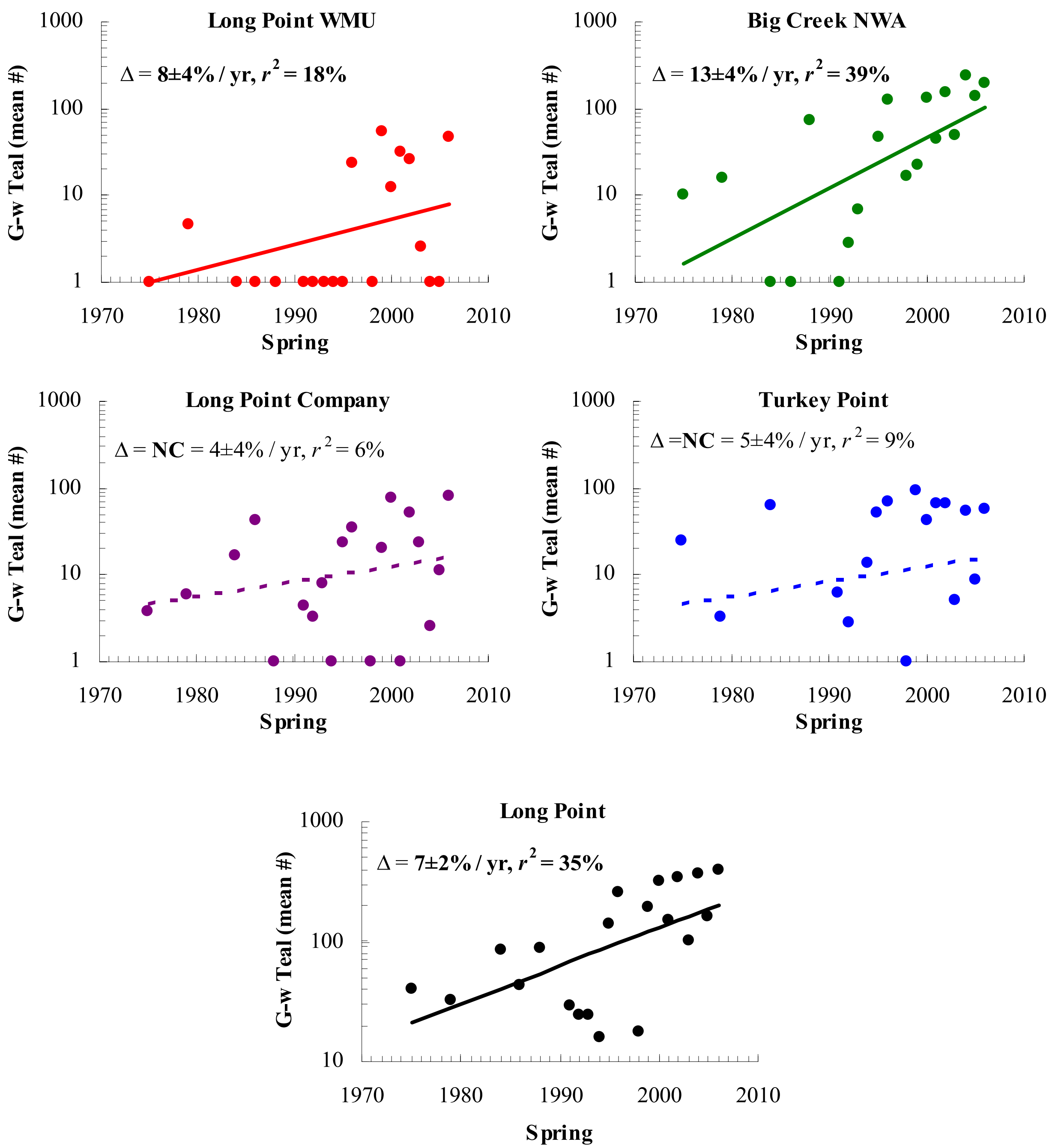
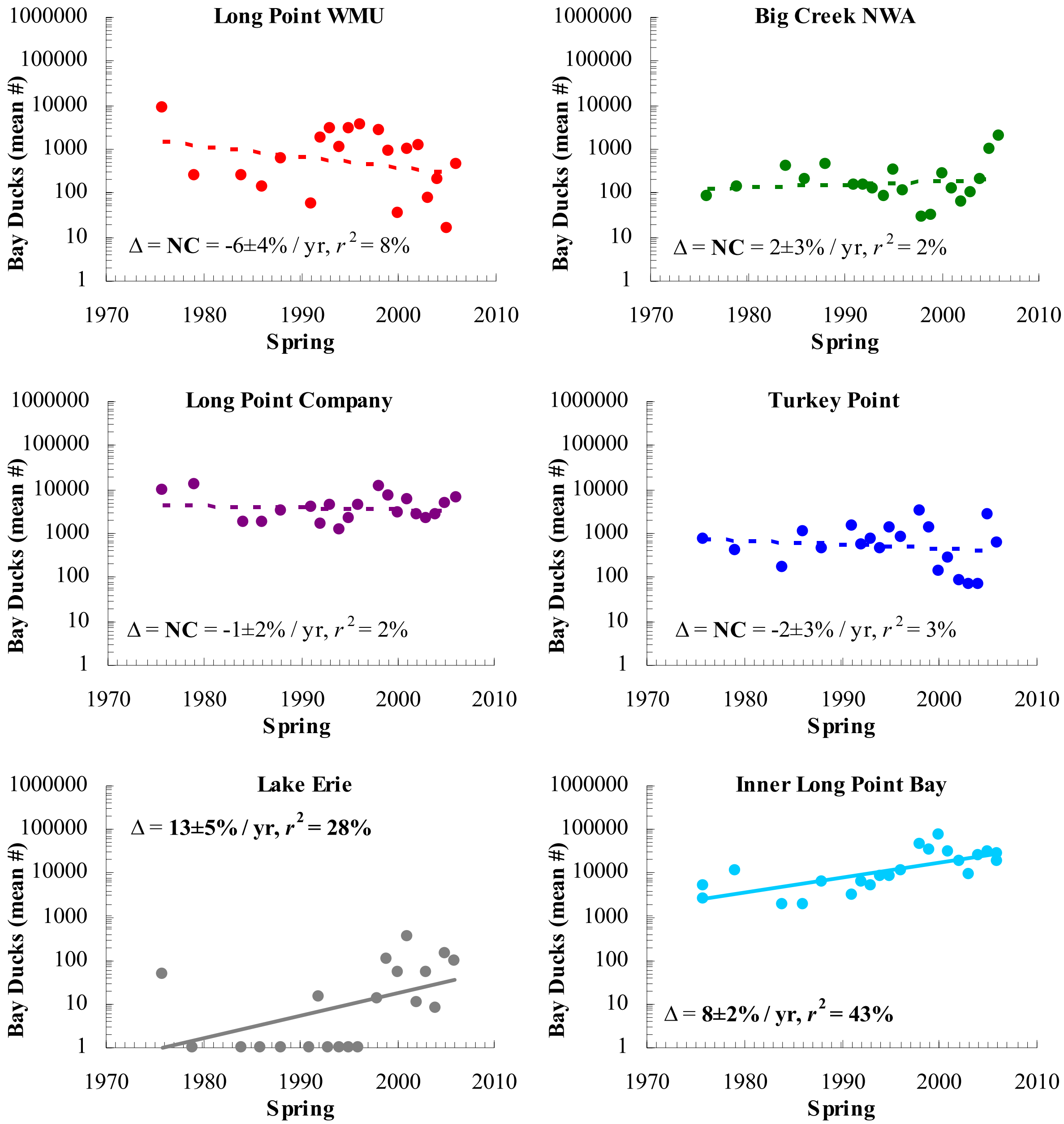


Figure 21. Changes in mean numbers of Green-winged Teal (*Anas crecca*) counted during the peak spring migration period (1 March – 30 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.



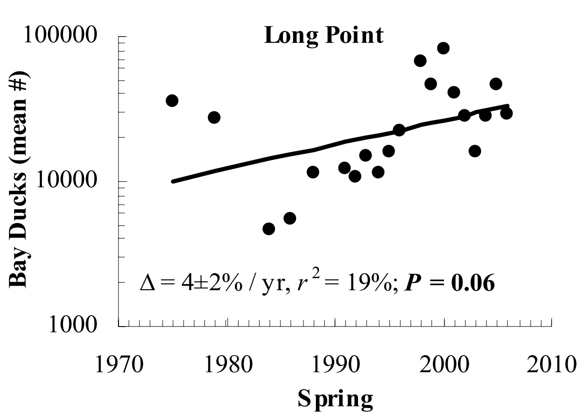
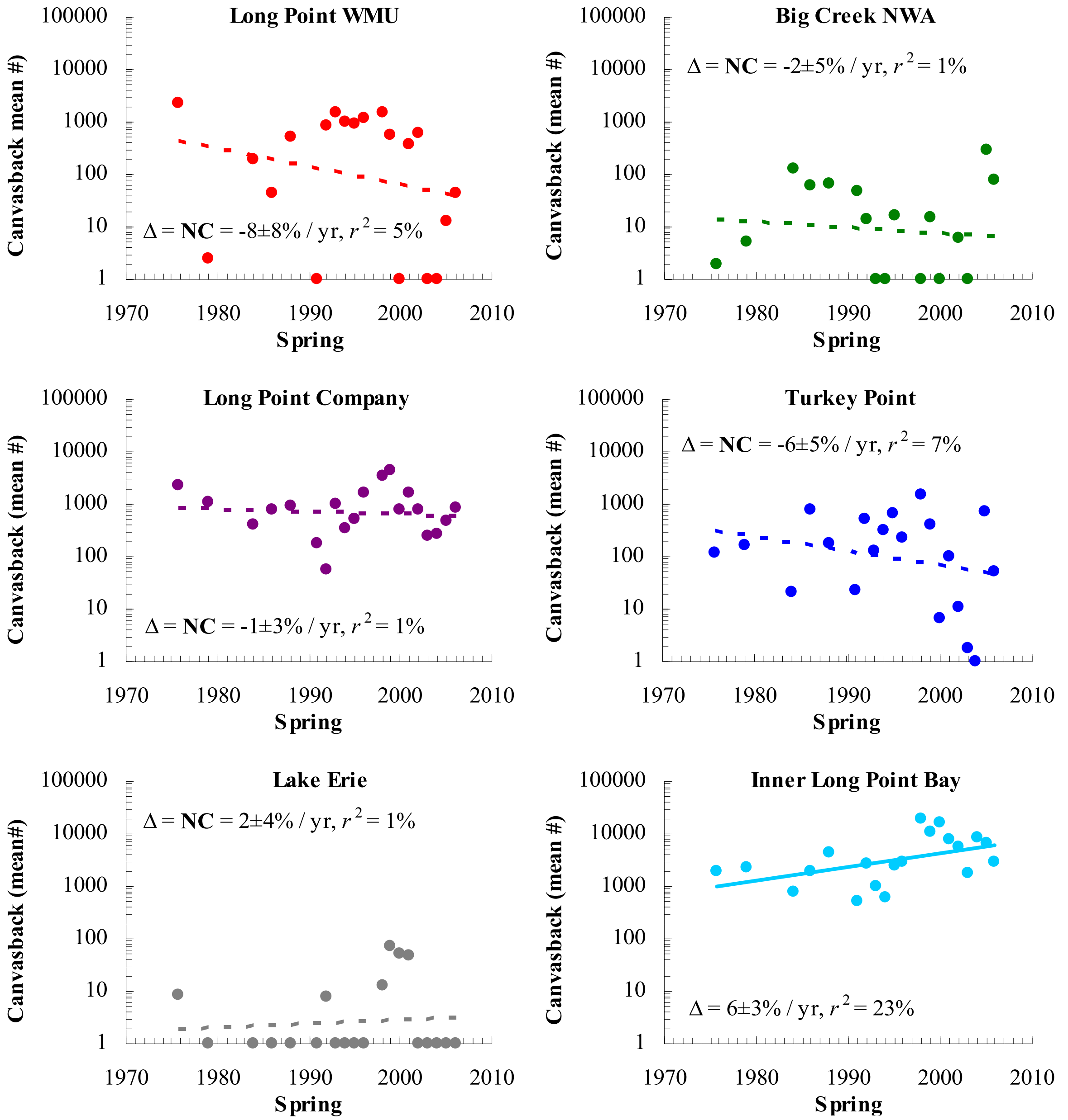


Figure 22. Changes in mean numbers of bay ducks* counted during the peak spring migration period (1 March – 15 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$).

*Canvasback, Redhead, Scaup, & Ring-necked Duck.



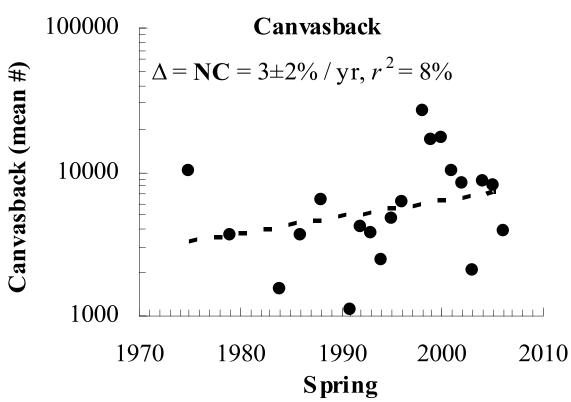
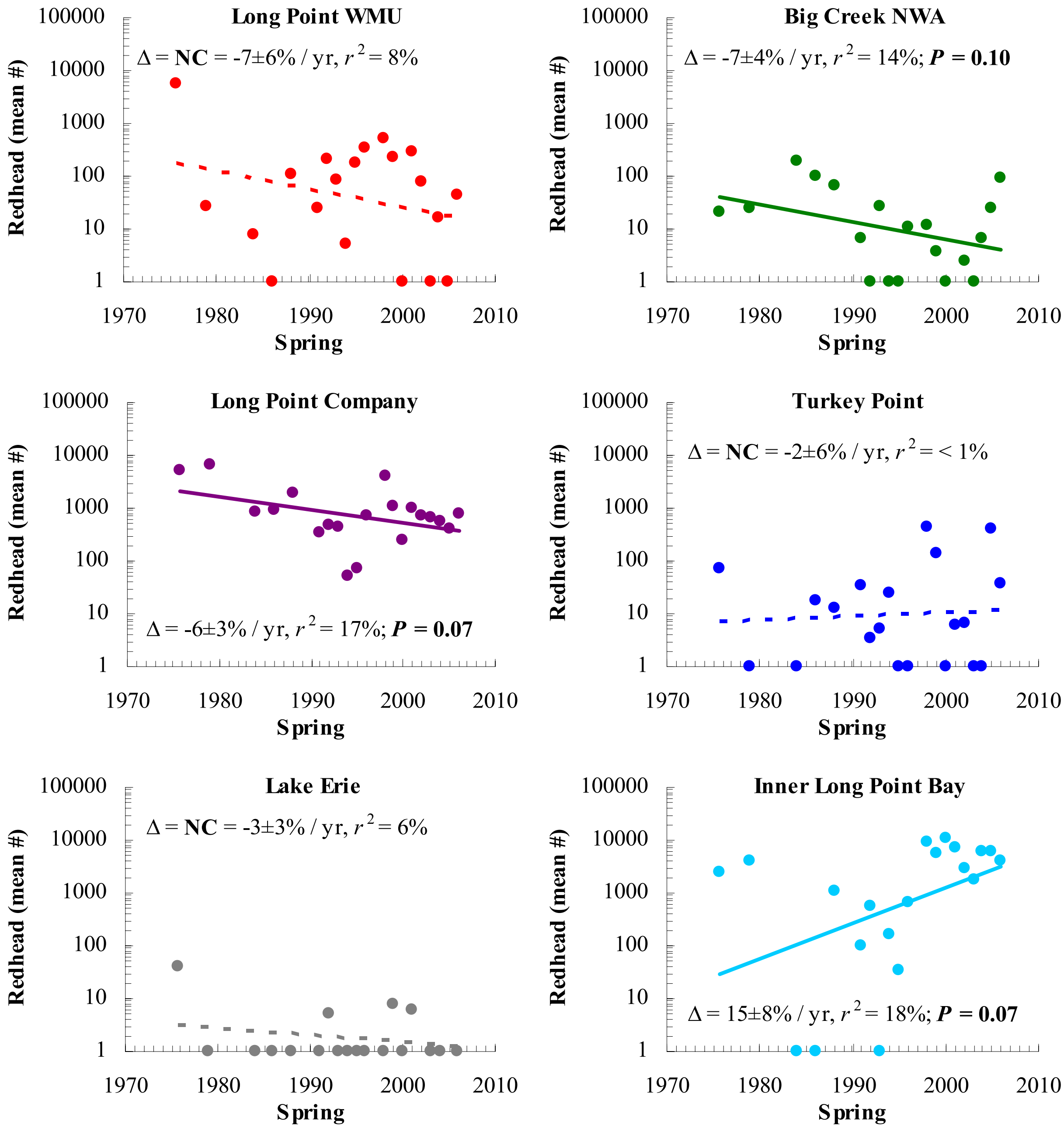


Figure 23. Changes in mean numbers of Canvasback (*Aythya vallisineria*) counted during the peak spring migration period (1 March – 15 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$).



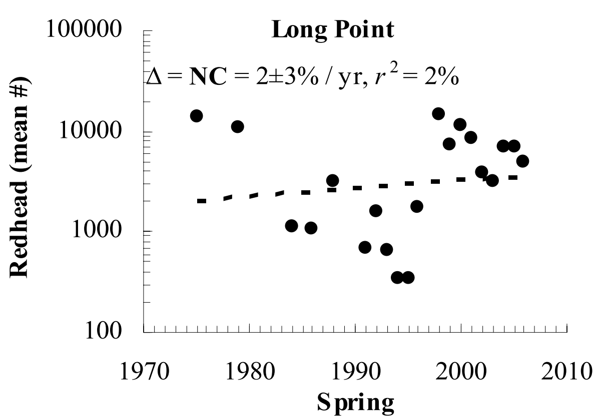
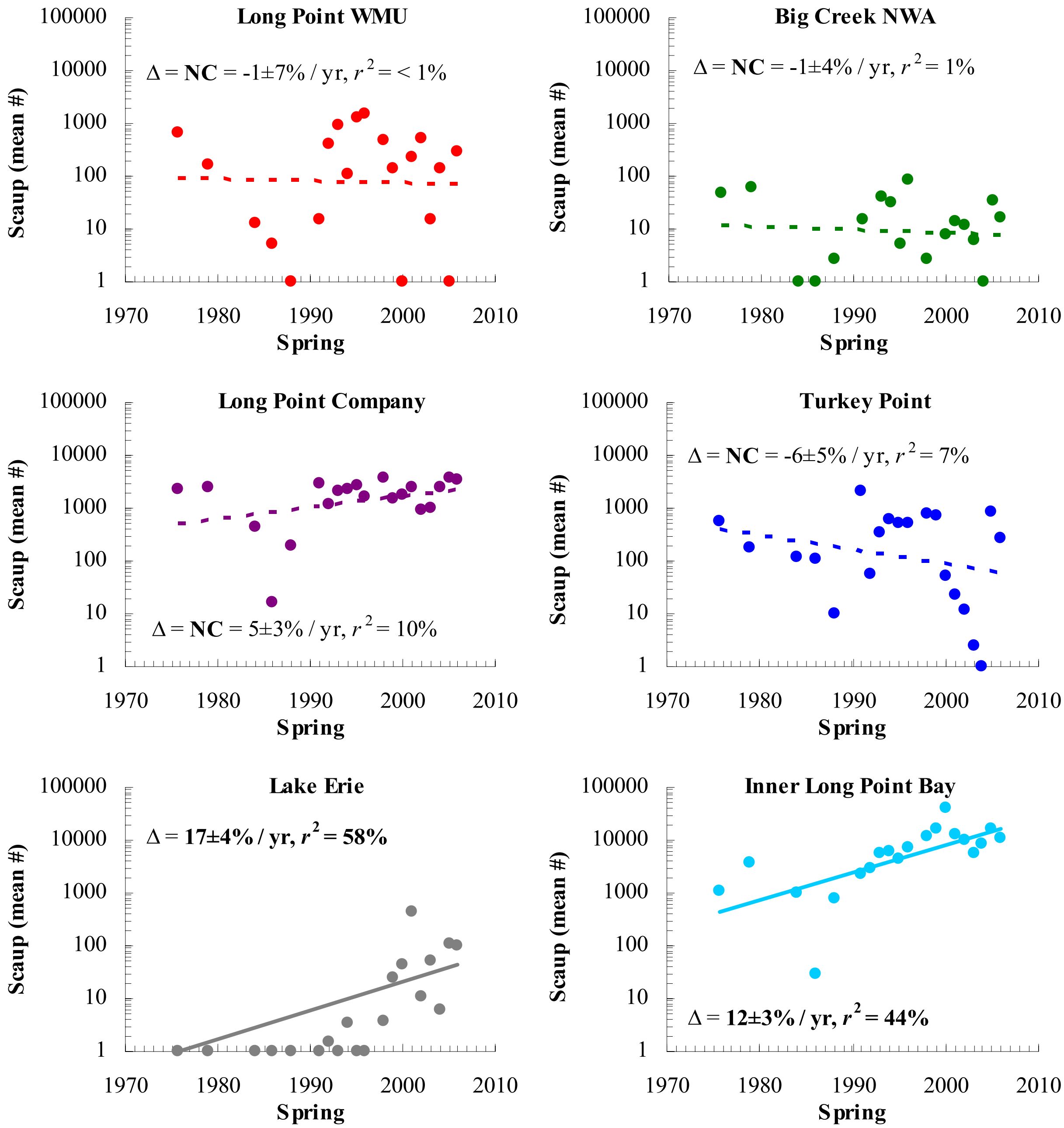


Figure 24. Changes in mean numbers of Redhead (*Aythya americana*) counted during the peak spring migration period (1 March – 15 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$).



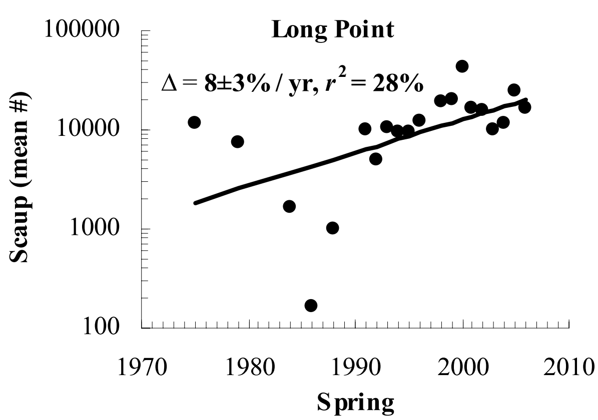
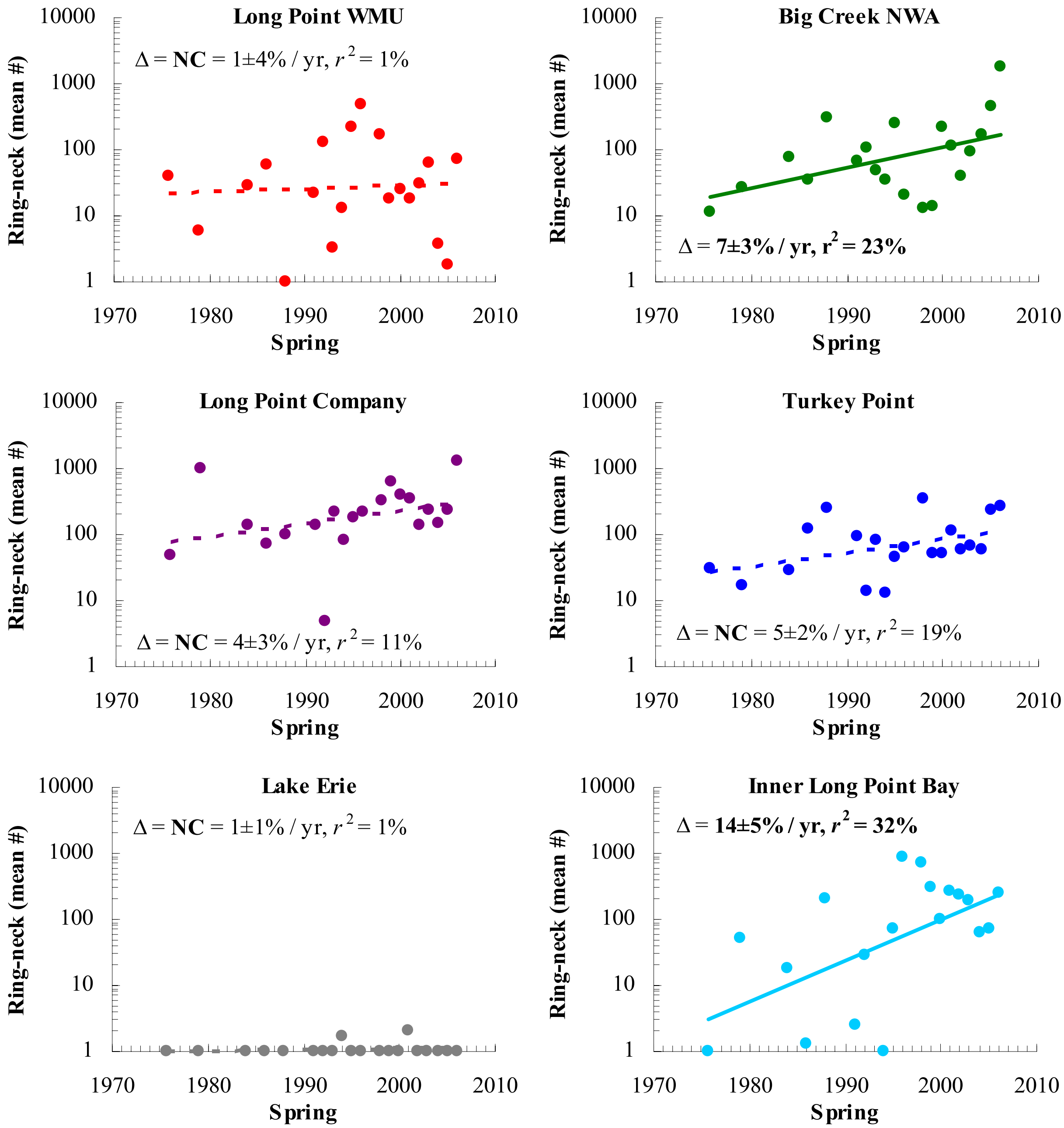


Figure 25. Changes in mean combined numbers of Lesser (*Aythya affinis*) and Greater Scaup (*A. marila*) counted during the peak spring migration period (1 March – 30 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$).



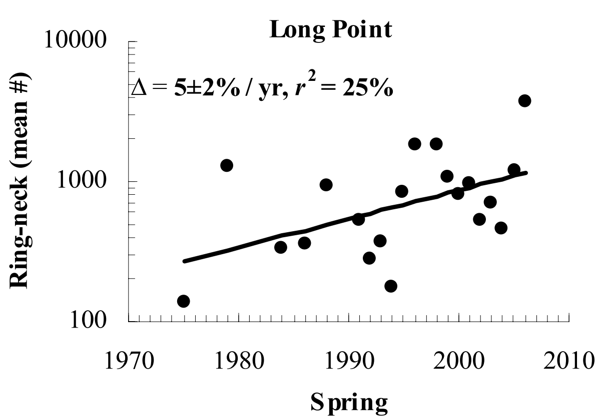


Figure 26. Changes in mean numbers of Ring-necked Ducks (*Aythya collaris*) counted during the peak spring migration period (1 March – 30 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$).

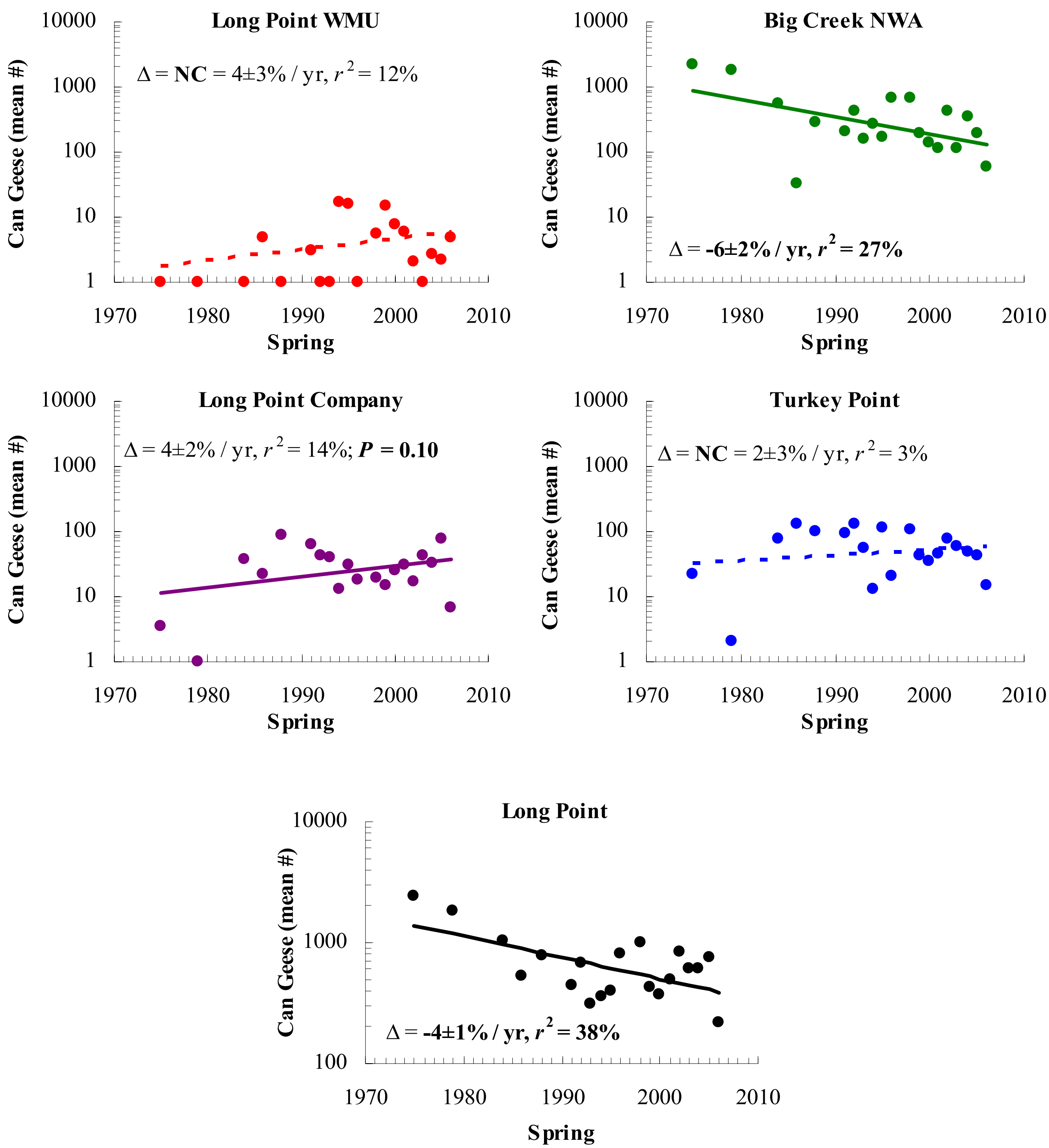
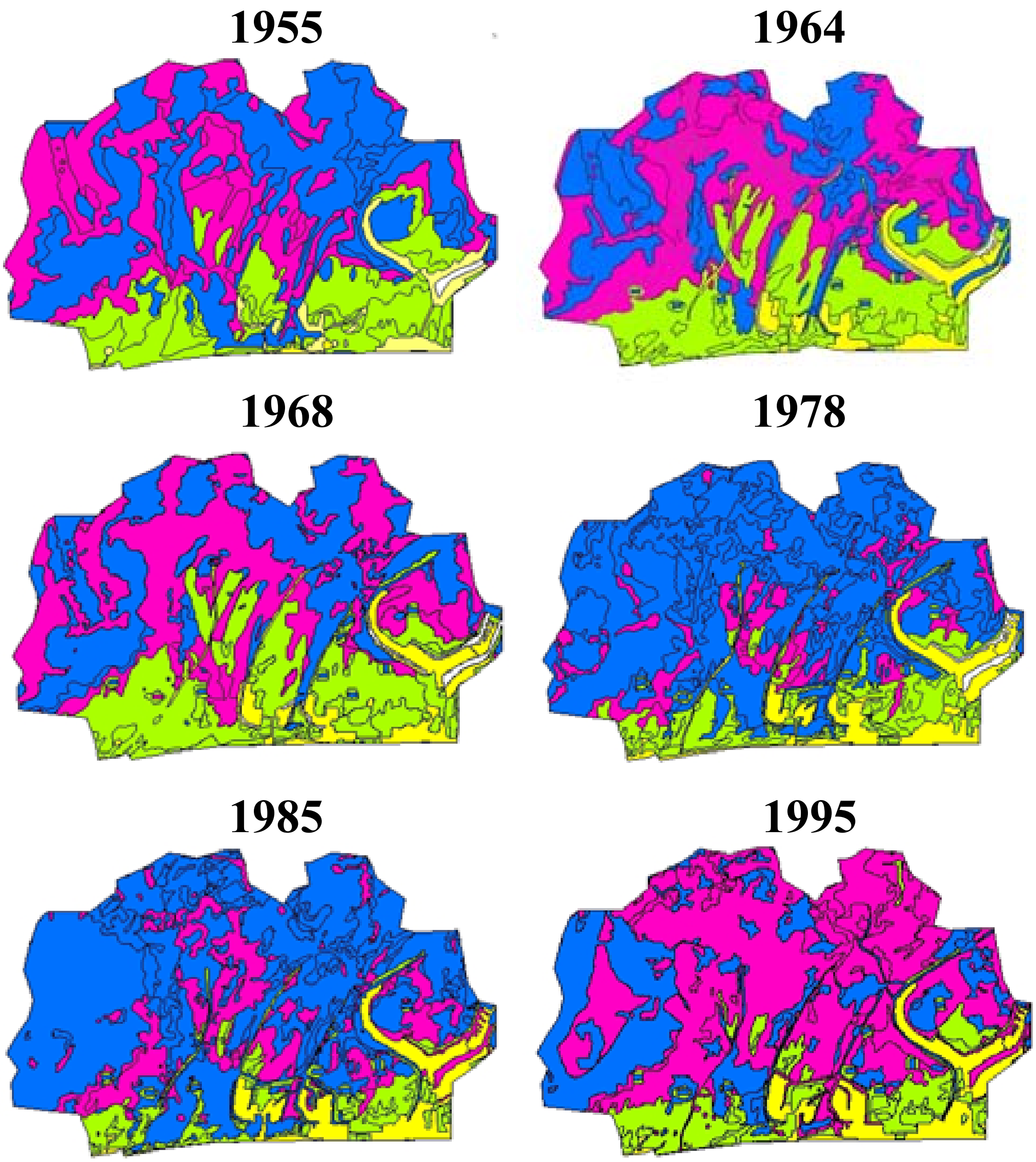


Figure 27. Changes in mean numbers of Canada Geese (*Branta canadensis*) counted during the peak spring migration period (1 March – 30 April) from 1971 to 2005 in 4 major marsh complexes at Long Point, Ontario; Long Point-wide trends are also presented.

Note: Solid lines indicate trends (Δ = % change [±SE] in numbers of ducks per year) that were statistically significant ($P \leq 0.10$) and dashed lines indicate no detectable change (**NC**) in mean numbers over time ($P > 0.10$). The SE (standard error) indicates precision of the trend estimate (smaller relative to the preceding trend slope is better / more precise). The r^2 indicates how well the trend line fits (explains variation) through the data points; a larger % variation explained = increasingly better model (line) fit.



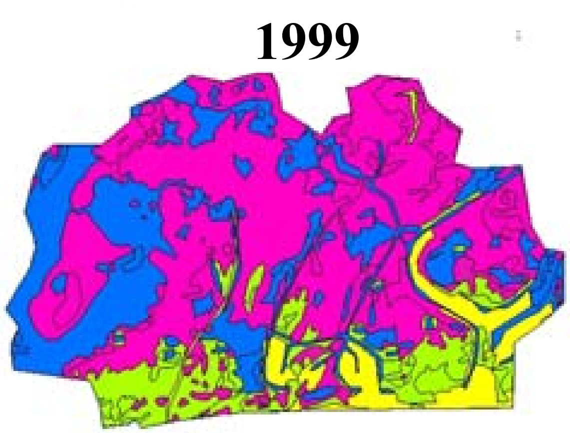
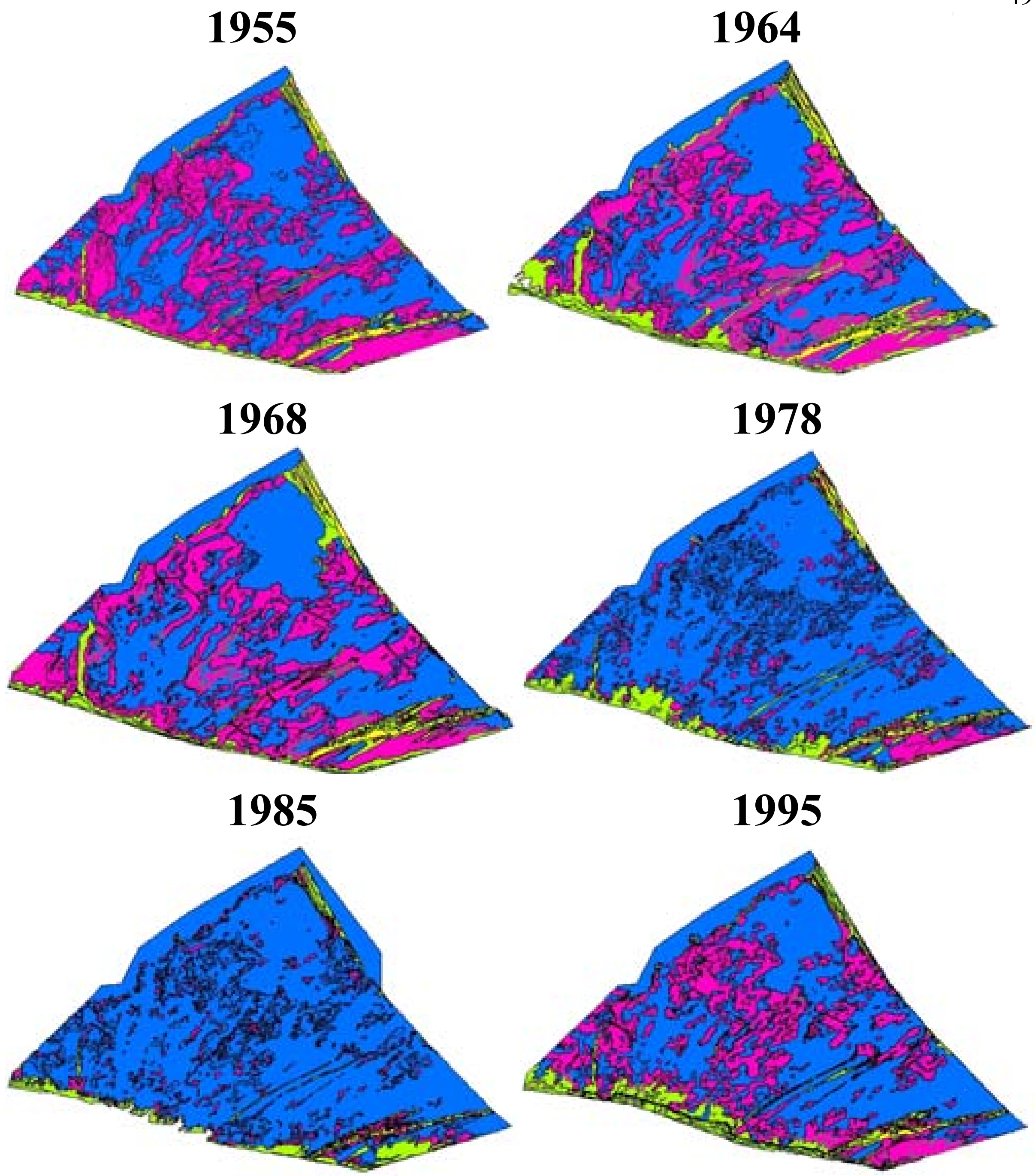


Figure 28. Changes in open water (blue), emergent vegetation (pink), dry land (green), and built-up areas (yellow) in the Crown Marsh during 1955, 1964, 1968, 1978, 1985, 1995, and 1999. North is toward the top of the page and years on are the north ends of the marsh.



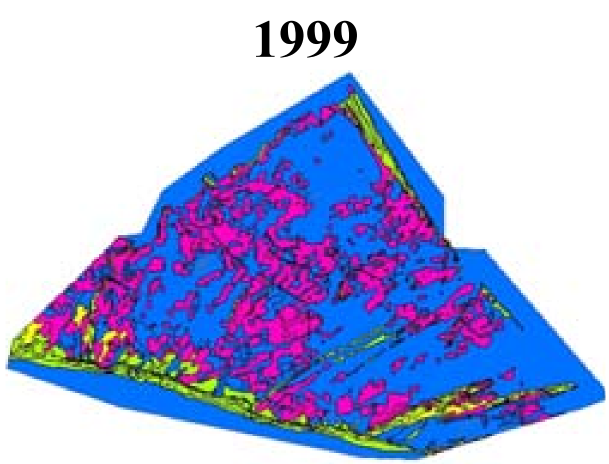


Figure 29. Changes in open water (blue), emergent vegetation (pink), dry land (green), and built-up areas (yellow) in the Long Point Company Marsh during 1955, 1964, 1968, 1978, 1985, 1995, and 1999. North is toward the top of the page and years on are the north ends of the marsh.