WETLANDS STATUS AND TREND ANALYSIS OF NEW YORK STATE MID-1980'S TO MID-1990'S

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EXECUTIVE SUMMARY

The results of this study document changes in wetland acreage and cover types from the mid-1980's to the mid-1990's in five ecological regions (ecozones) of New York, and characterize the main causes for those gains and losses.

Between the mid-1980s and mid-1990s, New York had a net gain of an estimated 17,619 acres of freshwater wetlands and associated open water.

An estimated 21,661 acres of wetlands and associated open water were lost between the mid-1980's and the mid-1990's, primarily as a result of urbanization and agriculture (Table 8). Approximately 39,280 acres of wetlands and associated open water were gained, primarily as a result of the reversion of agricultural land and from increased runoff resulting from hydrologic modifications of the landscape. In addition, 151,460 acres of wetlands changed from one wetland cover type to another, primarily as a result of increased water depths resulting from beaver activity and increased runoff, from agriculture, and from natural ecological successional processes.

There was a significant net gain of acres of wetlands in the Lake Plains ecozone. There were relatively minor net gains in the Appalachian Highlands, the Coastal Lowlands, and the Adirondack ecozones. There was a net loss of acres in the Hudson Valley ecozone.

1.0 INTRODUCTION

New York has a rich and diverse wetland resource. It has been estimated that there are between 2.25 and 2.4 million acres of freshwater wetlands. They range from the bogs and fens of the Adirondacks to expansive wetlands of the Lake Plain of western New York, and small potholes of Long Island. This resource provides a wide array of functions and benefits to the environment and the people of New York.

Despite the values wetlands provide, it is estimated that over half of New York's historic wetlands base has been lost to such activities as filling, draining, and dredging. In response to these historic losses, New York developed a multifaceted program to conserve its wetlands. This program includes an aggressive wetlands acquisition effort, wetlands management on certain publicly-owned land, regulation of certain activities that may have adverse impacts on wetlands, cooperative wetlands ventures with private landowners and other resource agencies, and wetlands research and education. The state adopted a freshwater wetlands protection law (Article 24 of the Environmental Conservation Law) in 1975 and a tidal wetlands protection law (Article 25 of the Environmental Conservation Law) in 1973. Article 24 provides protection measures for wetlands 12.4 acres in size or larger and certain smaller wetlands of unusual local importance. Section 404 of the federal Clean Water Act, which protects all wetlands as waters of the United States, has been implemented statewide since the late 1980s. Despite these programs and other federal, local, and private initiatives, it is generally believed that wetlands continue to be lost.

In order to improve wetlands conservation, basic information is needed about the current status of wetlands throughout the state, and the trends in wetlands gains and losses over time. Moreover, it is important to identify the principal causes to which any significant changes can be attributed. Furthermore, a mechanism for evaluating the success of wetlands conservation programs by periodically assessing changes in the wetland resource is needed. With such information in hand, targeted management and policy initiatives can be designed and implemented.

The purpose of this study is to provide a starting point for such a decision support system by: (1) determining the current status and trends of changes to freshwater wetlands in New York; (2) identifying the main causes behind the changes; (3) creating a benchmark for future assessments of status and trends in the state's wetlands resource base.

Technical challenges in such a study include availability and accuracy of maps, precision of interpretation, and assembly of a system to process and compare data (Appendices 1 and 2). Over and above these technical challenges, the power to resolve change on a statewide basis, even with perfectly accurate data, depends on the amounts and patterns of variability on the landscape, the resources available for the sampling effort, and the efficiency with which those resources are applied.

The precision of the results obtained in this study are discussed in a later section. However, in reviewing the results, it is well to remember that there are practical limits to the resolution that can be obtained from sampling. In an area the size of the state of New York (more than 31 million acres), resolving a landscape-category as small as 10,000 acres requires statistical precision on the order of one thirtieth of one percent. Such precision is rare in survey data, because the resources required to produce it are generally out of proportion to the goals of the study. For this reason, precision is addressed for mainly the major categories of state-wide wetland change. Nevertheless, estimates of change in smaller subdivisions are actually resolvable where variance is relatively small and the change analyzed is a difference in time between smaller areas.

2.0 METHODS

Usable aerial photographs from the mid-1980s and mid-1990s which could be rectified to national mapping standards defined the geographic extent of the sample area for this study. To enhance the precision of statewide estimates, a stratified-random design was used. Allocation of sampling units was approximately proportional to the land area of five ecological zones (ecozones). The ecozones were based on physiographic zones originally developed by Dickinson (1983). The ecozones used in this study included the Appalachian Highlands (Southern Tier), Adirondacks, Hudson Valley, Coastal Lowlands of Long Island, and Lake Plains of Lakes Erie and Ontario (Figure 1).

Aerial photographs from the mid-1980s and the mid-1990s were digitized and wetlands were mapped as to location based on their distinctive photographic signature. The wetlands identified were then classified to covertype according to DEC cover types (emergent, scrub-shrub, forested or open water). Wetland acreage and covertype from the two different time periods were compared, and the differences between the polygons were coded for cause of change. Results were then generated through geographic information system (GIS) comparison and analysis. A detailed discussion of site selection, aerial photography interpretation, and mapping standards are presented in Appendix 1. National map accuracy standards are described in Appendix 2.

Data collection focused on characterizing the wetland resource within the five ecological zones, and on a statewide basis, in order to address the following questions:

- What is the status of wetland gains and losses between the mid-1980's and mid-1990's for the Appalachian Highlands, the Adirondacks, the Hudson Valley, the Coastal Lowlands, and Lake Plain ecological zones.

- What are the causes of the gains and losses in wetlands, and of changes in covertypes?

- Are causes and rates of gains and losses different in wetlands larger (>)[1] and smaller (<)[2] than 12.4 acres?

The methods used here were algebraically equivalent to the formulas given in Frayer et al. (1983). However, for computational simplicity, the actual formulas used here were from commonly available sources as follows: Standard errors and confidence limits of the stratified estimates of change were

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1 > = equal to or greater than 12.4 acres.

2 < = less than 12.4 acres.

calculated according to methods in Thompson (1992). To calculate the Satterthwaite estimate of the degrees of freedom, an average sampling unit size was calculated from the overall sample and then divided into the size of each ecoregion to approximate the total possible number of sampling units per region. Optimal allocation of future sampling effort was calculated as proportional to the product of the size of each ecoregion times its standard deviation, assuming the cost of sampling to be equal in all regions (Snedecor and Cochran 1967). We follow Frayer et al. (1983) and Dahl and Johnson (1991) in using 90% confidence intervals and in displaying standard errors as percentages of the respective estimates. See Appendix 3 for further details.

3.0 RESULTS

3.1 Precision of Results

In Tables 1 through 18 estimates of wetland change are given as statewide totals and as literally hundreds of subdivisions as different combinations of ecoregion, wetland size category, and various causes of change are each considered. In general, the expectation that large changes are easier to resolve than small ones is born out by the size of the confidence intervals. Estimates of change >10,000 acres are usually significantly non-zero, i.e., the half-width of the nominal 90% confidence interval is less than the estimate itself and so the interval does not include zero, whereas a higher proportion of smaller estimates are non-significant. However, each process affecting wetlands acreage has its own variance, and estimates of change in some smaller (<1,000 acres) subdivisions of interest were actually resolvable.

Estimates of net change are less precise than estimates of losses and gains considered separately, because essentially the errors of losses and gains are combined in the net change estimates. For example, in Table 5, 7 of 12 estimates of net change >10,000 acres (absolute value) are significant, and only 1 of 12 net changes <10,000 acres are significant. This contrasts with the higher significance rates of the gains and losses shown in Table 16, where 21 of 22 estimates >10,000 acres are significant, as are 15 of 28 non-zero estimates <10,000 acres.

Tables 1 and 2 show both standard errors (as percent of estimate) and the 90% confidence interval half widths. Occasional references are given in the text to statistical significance, but often for clarity and brevity in the text, the reader is left to compare estimates with their confidence interval half widths in the tables.

Some of the tables and parts of the text discuss estimates in terms of percentages. Percentages are given in the tables to one or two decimal places. In the text, statewide estimates are given to a tenth of one percent, whereas estimates for ecoregions or other subunits are given as whole percentages. No precision estimates were made of these percentages, which are all derived from data presented, with confidence limits, in other tables.

The assumption of stratified random sampling may not have been strictly met by the procedures used here, in that the sampling units actually used were constrained by availability of useable imagery. Without the protection of true randomization, the estimates given here are subject to whatever biases may be inherent in the focus of the imagery data-gathering effort. For example, if an interest in a particular human activity caused aerial photographs to be concentrated in an unrepresentative portion of an ecoregion, then whatever trends existed in that small area would unduly influence the results. We inspected the distribution of effort with this possibility in mind, and the only apparent instance of potential bias that we noted was in the Hudson Valley ecoregion, where the available sampling units were primarily in the eastern half of the ecoregion. It is therefore possible that the apparent loss of wetlands in the Hudson Valley from the 1980s to the 1990s may have been extrapolated to too large an area and thus over-estimated by a factor of roughly two. In this case, questions of bias cannot be evaluated statistically without a much larger data set from which to sample.

Table No. 1 depicts the characteristics of wetlands within the five aggregated ecozones and statewide for New York. The following subsections present a brief analysis of the current status of New York's wetlands, followed by a more detailed examination of trends within the wetlands resource base from the mid-1980s to the mid-1990s.

3.2 Status of The Wetlands Resource in New York

3.2.1 Wetlands Abundance

Results of this study indicate that, as of the mid-1990s, there are about 2,397,000 acres of freshwater wetlands in the state, and that roughly 1,929,000 acres (80 percent) are larger than the 12.4 acres statutory size subject to the protections of Article 24 (Table 1).

The Lake Plains and Adirondack ecological zones have the highest concentration of wetlands in the state, with 13.1 and 11.2 percent of each ecozone, respectively, in wetland in the mid-1990s. In the other three ecozones, there is a lower percentage of the landscape in wetland: 4.4 percent in the Hudson Valley, 3.7 percent in the Appalachian Highlands and 2.3 percent in the Coastal Lowlands.

3.2.2 Wetlands Covertypes

For the purposes of this study, wetlands were characterized according to one or more of the following covertype classes. Table 2 summarizes the acreage and relative abundance of wetlands coverytpes in New York in the mid-1990s.

3.2.2.1 Forested Wetlands

Forested wetlands are characterized by woody vegetation that is six meters (20 ft.) high or taller. Typical wetlands plants in this category include red maples and green ash. O'Connor and Cole (1989) estimated that in the late 1970's most of the state's wetlands were forested. This study re-confirms that estimate. Based on mid-1990s data, 66 percent of the state's wetlands are in forest cover, encompassing about 1,582,000 acres of wetlands. The forested covertype is most common in the Adirondacks, where it accounts for 70 percent of all wetlands, and in the Lake Plain, where it accounts for 67 percent of all wetlands. Percentage of wetlands forested is least in the Appalachian Highlands (58 percent).

3.2.2.2 Shrub/Scrub Wetlands

Shrub/scrub wetlands include areas dominated by woody vegetation less than six meters tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of the wet conditions. Typical wetlands plants in this category include alder, dogwoods, and buttonbush. Shrub/scrub cover is the second most abundant covertype in New York, accounting for 18.8 percent, or about 451,000 acres, of the wetlands in the mid-1990s. This covertype is most common in the Appalachian Highlands, Lake Plain, and Hudson Valley, where it accounts for about 21-22 percent of all wetlands. Shrub/scrub wetlands are least common in the Coastal Lowlands, where only 3 percent of the wetlands are in this covertype.

3.2.2.3 Emergent Wetlands

Forested wetlands are characterized by erect, rooted, herbaceous wetland plants such as cattails, rushes, and sedges, which are present for most of the growing season in most years. They often have persistent plant material during the non-growing season as well. Emergent wetlands are relatively uncommon, accounting for only 10 percent, or about 239,000 acres, of the freshwater wetlands statewide in the mid-1990s. Emergent wetland as a covertype is most common in the Appalachian Highlands and Hudson Valley, where it accounts for about 11.5 percent of all wetlands. Emergent wetlands are the least common covertype in the Lake Plains and Coastal Lowlands, where only 8 percent of all wetlands are emergent.

3.2.2.4 Wetlands Open Water

Wetlands open water is that open water associated with other wetlands covertypes. It may support rooted, floating leaved plants, such as pond lilies, or free-floating plants, such as duck weed. This category does not include open water such as ponds, lakes, or streams not associated with other vegetated covertypes. Wetlands open water is the least common covertype, accounting for only 5 percent of wetlands in the state, or about 124,000 acres. Open water as a covertype is most abundant in the Coastal Lowlands, where it accounts for nearly 24 percent of all the wetlands. It is the least common covertype in the Lake Plains, where it accounts for about 3 percent of all the wetlands.

3.2.3 Ecological Zones

The acreage and relative abundance of wetlands varies greatly across the state, and is influenced by factors such as topography, climate, hydrology, and geology. Table No. 3 characterizes the acreage, size, and relative abundance of wetlands in New York according to the five ecological zones.

3.2.3.1 Lake Plain Ecozone

The Lake Plain ecozone encompasses 23.1 percent of the state's land area but as of the mid-1990s, it supports 39 percent of New York's freshwater wetlands. The Lake Plains is 13 percent wetland, in contrast to the statewide average of 7.2 percent. Due to the relatively flat topography in the Lake Plains ecozone, many of the wetlands are larger in size; 86 percent are >12.4 acres, as compared with the statewide average of 80 percent.

3.2.3.2 Appalachian Highlands Ecozone

The Appalachian Highlands ecozone encompasses 38 percent of the state's land area, but as of the mid-1990s, only 19 percent of New York's freshwater wetlands. It is about 4 percent wetland, in contrast to the statewide average of 7 percent. The Appalachian Highlands is characterized by rolling, hilly topography, and consequently many wetlands are defined by valleys and depressions and are not expansive. Only 67 percent are >12.4 acres, as compared with the statewide average of 80 percent.

3.2.3.3 Adirondack Ecozone

The Adirondack ecozone encompasses 23.4 percent of the state's land area, but as of the mid-1990s, 34 percent of New York's freshwater wetlands. It is 11 percent wetland, in contrast to the statewide average of 7 percent. Although characterized by high mountains and steep topography, the Adirondacks also has expansive peatlands and valleys, which allows for larger wetlands to develop. Approximately 85 percent of the wetlands in the Adirondack ecozone are >12.4 acres in size, as compared with the statewide average of 80 percent.

3.2.3.4 Hudson Valley Ecozone

The Hudson Valley ecozone encompasses 12.4 percent of the state's land area, but as of the mid-1990s, only 7 percent of New York's freshwater wetlands. It is 4 percent wetland, in contrast to the statewide average of 7 percent. The Hudson Valley is characterized by hilly topography, and consequently many wetlands are defined by valley and depressions, and are not expansive. Only about 59 percent are >12.4 acres, as compared with the statewide average of 80 percent.

3.2.3.5 Coastal Lowlands Ecozone

The Coastal Lowlands ecozone encompasses 3 percent of the state's land area, but as of the mid-1990s, only 1 percent of New York's freshwater wetlands. It is 2 percent wetland, in contrast to the statewide average of 7 percent. With many small potholes and stream-side wetlands, only about 60 percent are >12.4 acres in size.

3.3 Trends

Based on the present comparison of aerial photographs, there were a number of changes in the wetland resources of New York between the mid-1980's and the mid-1990's. Wetlands underwent changes in covertype and abundance due to a variety of causative factors.

3.3.1 Wetlands Abundance

Between the mid-1980s and the mid-1990s there was a gain of an estimated 39,280 acres of new freshwater wetland acreage statewide. Conversely, during this period there was a loss of an estimated 21,661 acres of wetlands, resulting in a net gain of 17,619 acres of wetlands (Table 4 and Appendix 3). The vast majority of the gains were in the Lake Plains ecozone, which experienced a significant net gain of 17,269 acres of wetlands. Minor net gains occurred in the Appalachian Highlands (2,422 acres). The Adirondack and Coastal Lowlands ecozones remained relatively unchanged, with very minor gains of <1,000 acres. The Hudson Valley experienced a net loss of 2,902 acres of wetlands. The total statewide gain, and the gain in the Lake Plains ecoregion, are significant (i.e., 90% confidence intervals do not include zero), whereas the estimates of change given above for the other ecoregions are not statistically significant (Appendix 3).

3.3.2 Wetland Covertypes

In addition to changes in wetland acreage, there were gains and losses in the amount and relative abundance of the four wetlands covertypes. Not all changes were attributed to gains and losses in acreage. Some of the shifts occurred as one covertype converted to another, such as wet meadows succeeding into forested cover, or shrub/scrub being flooded into wetland open water and emergent. Table 5 identifies the changes in wetland covertype between the mid-1980s and mid-1990s according to ecozone. Significant gains occurred in forested covertype (+55,748 acres, or about 4%) and open water covertype (+18,372 acres, or 17%). A significant loss occurred in the shrub/scrub covertype (-43,875 acres, or 9%) and a non-significant loss of 12,627 ± 28,838 was estimated for the emergent wetland covertype. The following summaries characterize shifts in covertype, and do not necessarily reflect gains and losses in acreage of that covertype.

3.3.2.1 Forested Wetlands

The largest acreage gain in forested wetlands occurred in the Lake Plain ecozone (38,808 acres), followed by the Appalachian Highlands (16,077 acres), and the Coastal Lowlands (1,685 acres). Forested wetlands as a covertype declined very slightly in the Hudson Valley (255 acres) and the Adirondack ecozone (567 acres).

3.3.2.2 Shrub/Scrub Wetlands

In the mid-1980s, shrub/scrub covertype made up 21 percent of the state's wetlands, but by the mid-1990s, had decreased to 19 percent through a net loss of 43,875 acres of shrub/scrub cover. Losses occurred in all ecozones, but were most dramatic, in terms of acreage, in the Lake Plains (18,123 acres or 8 percent) and the Adirondacks (15,308 acres or 12 percent). However in the Coastal Lowlands there was a loss of 2,008 acres, which accounted for 74 percent of the shrub/scrub covertype in that ecozone.

3.3.2.3 Emergent Wetlands

Emergent covertype acreage and relative abundance appeared to decline slightly statewide. Although the statewide estimate of change was not significant for this covertype, the estimate for the Lake Plains ecozone (-15,101 acres) did exceed the half-width of the 90% confidence interval and thus would be considered significant by the criteria used here.

3.3.2.4 Open Water Wetlands

In the mid-1980s, open water covertype made up 4 percent of the state's wetlands, but by the mid-1990s, had increased to 5 percent through a net gain of 18,372 acres of wetlands open water cover. Significant gains occurred in the Lake Plains (+11,684 acres) and Appalachian Highlands (+6,771) ecozones. Estimates for the other three ecozones could not be distinguished from zero.

3.3.3 Ecological Zones

Ecological zones experienced changes at different rates. Table 6 shows the rates of gain, loss and change in covertype relative to the percent of wetlands in and the relative size in the 5 ecozones. The Hudson Valley has only 7 percent of the state's wetlands, but suffered 20 percent of the losses during the study period. Conversely, the Adirondacks supports 34 percent of the state's wetlands, but experienced only 5.5 percent of the losses. The Lake Plains, with 39 percent of the wetlands, had 47 percent of the losses, and 70 percent of the gains. Table 7 summarizes the gains, losses, and changes in covertype in the five ecozones.

3.3.3.1 Lake Plains Ecozone

As discussed above, the Lake Plains was the most dynamic ecozone for wetlands during the period of the study, with 39% of the state's wetlands but nearly half of all wetland losses, 70 percent of all gains, and 43 percent of changes in covertype -- the greatest percent of each category statewide (Table 6). Figures 2a -2c and Table 7 illustrate the causes of these changes. Greatest losses were to urbanization (43 percent of losses), agriculture (38 percent), and aggregate mining (17 percent). Greatest gains were due to agricultural reversion (79 percent of gains). Greatest changes in covertype are due to plant succession (88 percent of changes). The Lake Plains had a significant net gain of 17,269 acres of wetlands during this study period (Table 4).

3.3.3.2 Appalachian Highlands Ecozone

The Appalachian Highlands also was a dynamic ecozone during this study period. It supports only 18.6 percent of the state's wetlands on 38.2 percent of the land area. However, it experienced 26 percent of all losses in the state, primarily from agriculture (87 percent of all losses in this ecozone). It also experienced 19 percent of the gain in wetlands in the state, primarily from modified hydrology (57 percent of gains in this ecozone) and agricultural reversion (42 percent of gains). The Appalachian Highlands had 29.1 percent of all the state's changes in covertype, primarily from plant succession (88 percent of all changes in this ecozone) and modified hydrology (9 percent). During the study period, the Appalachian Highlands had a non-significant, estimated net gain of 2,422 acres of wetlands. Figures 3a - 3c illustrate the causes of these apparent changes.

3.3.3.3 Adirondack Ecozone

The Adirondack ecozone was relatively stable during this study period. The Adirondacks supports 34 percent of the state's wetlands on 23 percent of the land area. However, it experienced only 4 percent of the losses, 5 percent of the gains, and 25 percent of the changes in covertypes. Losses were relatively minor (492 acres), and were attributed to agriculture (61 percent of losses), linear development (13 percent) and urbanization (25 percent). Gains (1,916 acres) were predominantly due to agriculture (46 percent) and modified hydrology (53 percent). Changes in covertype (34,477 acres) were due primarily to plant succession (80 percent), modified hydrology (11 percent), and beaver activity (9 percent). During the study period, the Adirondacks had a non-significant, estimated net gain of 724 acres of wetlands. Figures 4a - 4c illustrate the causes of these changes.

3.3.3.4 Hudson Valley Ecozone

The Hudson Valley ecozone had the greatest relative wetlands loss in the state. With only 7 percent of the state's wetlands on 12.4 percent of the land area, it experienced 20.4 percent of the losses (4,418 acres), 4 percent of the gains (1,516 acres), and 3.4 of the changes in covertype (5,143 acres). Greatest losses (2,612 acres, 59 percent) were to urbanization; 33.6 percent of all the statewide losses to urbanization occurred in this ecozone. Agricultural losses also occurred, accounting for 32 percent of the losses in this ecozone. Changes in coverytpe were mostly due to plant succession (56 percent of all causes in this ecozone) and to modified hydrology (31 percent). During the study period, the Hudson Valley had a non-significant, estimated net loss of 2,891 acres of wetlands; it is the only ecozone with a net loss of wetlands. Figures 5a - 5c illustrate the causes of these changes.

3.3.3.5 Coastal Lowlands Ecozone

Despite intense urbanization in this ecozone, the wetlands resource dynamics were relatively stable during this study period. The Coastal Lowlands support 0.9 percent of the state's freshwater wetlands on 2.9 percent of the state's land area. It experienced 1.1 percent of the losses (247 acres), 1 percent of the gains (354 acres), and 1.5 percent of the changes in covertype (2,329 acres). In this ecozone, aggregate mining had a significant influence on the dynamics of wetland change. It resulted in 49 percent of the losses (121 acres) and 53 percent of the gains (186 acres). Agriculture contributed to additional gains (41 percent of gains in this ecozone) and urbanization contributed to additional losses (50 percent). Most changes in covertype were due to plant succession (86 percent). During the study period, the Coastal Lowlands had a very minor, non-significant net gain of 107 acres of wetlands. Figures 6a - 6c illustrate the causes of these changes.

3.4 Causes of Change

Initially, the study was to explore four causes of changes to wetlands: agriculture, urbanization, linear development, and "other" causes, such as beaver activity. During the study, it became clear that there were additional major categories of causal factors that needed to be identified separately in the analysis and results. As a result, there are seven major causes of change included in this report. Table 8 summarizes gains, losses, and changes in covertype attributable to the seven causes.

3.4.1 Agriculture

Agricultural land is defined broadly as land used primarily for production of food and fiber. Agricultural activity is evidenced by distinctive geometric field and road patterns on the landscape and the traces produced by livestock or mechanized equipment. Examples of agricultural land use include: cropland, pasture, hayfields, orchards, vineyards, nurseries, ornamental horticultural areas, and confined feeding operations.

Agricultural impacts result when wetlands are drained and cultivated for growing crops, or when they are cut for hay or used for pasture. Additional impacts result from the elimination of wetland vegetation as farmers encroach into wetland areas to expand at the periphery of the cultivated fields when conditions allow. Additional impacts also may result when wetlands are flooded for ponds or when they are filled for structures such as barns.

Conversely, wetlands gains occur when previously-drained agricultural land is abandoned and drainage ditches fail, resulting in saturation or inundation of the historic hydric soils. Wetlands also expand when vegetation reinvades where cultivation at the periphery of fields wanes in response to high water levels in wet years. In addition, the creation of farm ponds is tallied as a wetland gain, although this category only accounted for five percent of all wetlands increases from agricultural activities.

Table 9 presents gains and losses from agriculture in all ecozones in the state. Statewide, there was a gain of 26,945 acres and a loss of 10,853 acres for a net gain from agriculture of 16,092 acres. Agriculture accounted for 69 percent of all gains and 50.1 percent of all wetlands losses in the state. An estimated 41 percent of gains from agriculture were in wetlands >12.4 acres in size and an estimated 44 percent of the losses to agriculture occurred in wetlands >12.4 acres. All ecozones had significant gains in wetlands from agriculture, but particularly the Lake Plains ecozone – an estimated 21,792 acres, with a loss of 3,850 acres, for a net gain of 17,942 acres of wetlands from agriculture. Significant losses to agriculture of the Appalachian Highlands and Hudson Valley out-paced the gains due to agriculture in those regions. Losses to agriculture were estimated as zero in the Coastal Lowlands and too variable to be distinguished in the Adirondacks.

3.4.2 Urbanization

Urban and suburban areas are characterized by intensive human use with much of the land covered by structures. Included in this category are cities, towns, and villages; strip development along highways; transportation, power, and communications facilities; and areas such as those occupied by shopping centers and industrial and commercial complexes.

Urban impacts to wetlands occur when wetlands are filled for residential, commercial, or industrial development or its supporting infrastructure. Other impacts, such as degradation of remaining wetlands from pollutants, invasion of exotics, habitat fragmentation, or human disturbance to habitat are not detected by the methodology employed in this type of status and trends analysis; only physical acreage losses are assessed. There were no gains attributed to urbanization in this study. Compensatory mitigation that might have occurred in response to permits issued under state, federal, or local regulatory programs would not have been discernable as compensatory mitigation using this study design, and consequently are not identified as gains in this category. Some changes in wetland cover types can be attributed to urbanization. These occur when stormwater detention basins are placed in forested or shrub/scrub wetlands.

Table 10 presents gains, losses, and covertype changes resulting from urbanization in all ecozones in the state. Statewide there was a loss of 7,766 acres of wetland to urbanization, accounting for 36 of all wetlands losses. Sixty-three percent of losses to urbanization (4,874 acres) were in wetlands >12.4 acres. Although all three of the statewide estimates of loss to urbanization were significant, the 90 percent confidence intervals of the estimates for individual ecozones all included zero. Nevertheless, it is clear from Table 10 that the main contributors to the statewide estimates were from the Lake Plains (4,362 acres) and Hudson Valley (2,612 acres). All other ecozones had very modest losses to urbanization. Covertype changes (non-significant) from urbanization occurred in a modest 148 acres, all of which occurred in the Lake Plains and Hudson Valley, and all of which occurred in wetlands >12.4 acres.

3.4.3 Linear Development

Linear developments are those that result from construction, operation, and maintenance of transportation corridors (e.g. highways, railroads) or utility corridors and rights-of-way.

Linear development impacts to wetlands occur when wetlands are filled for road beds, railroad beds, footings for utility towers, and right-of-way access roads. Road and railroad construction also can disrupt natural drainage, decreasing water flow into wetlands and resulting in a decrease in the size of a wetland. Conversely, gains in wetlands acreage can result when there is impaired drainage as a result of the placement of fill for roadbeds, which results in the impoundment of water behind the fill area. Increased water depths resulting from this same phenomenon also can result in changes in cover type.

Table 11 presents gains, losses, and covertype changes resulting from linear development in all ecozones in the state.

Significant losses to linear development occurred statewide (971 acres) and in the Lake Plains (280 acres) and Hudson Valley (359 acres) ecozones. All estimates of gains and covertype changes to this cause were non-significant. Thirty-eight percent of losses to linear development (369 acres) were in wetlands >12.4 acres.

3.4.4 Aggregate Mining

Aggregate mining impacts are those resulting from the mining of sand and gravel. The location and effects of aggregate mining are very strongly correlated with urban development and road construction, which are the primary markets for sand and gravel.

Losses from aggregate mining occur as material is excavated from the site, resulting in the elimination of the wetland due to back filling with unuseable soil materials. Impacts also occur from the disruption of local hydrology, because water is used heavily in processing the aggregate. Also noted were effects on agriculture, as farming was displaced by mining activities, allowing for some reversion of wetland on the abandoned agricultural fields.

Gains in wetland acreage from aggregate mining occur when mining pits are abandoned, fill with water, and wetlands vegetation invades, although more reclamation is for ponds, not wetlands. Other gains occur as a result of the modified drainage resulting from hydrologic changes precipitated by moving water around the mining sites for aggregate processing. Indirectly, gains would also occur as reversion of agricultural land as farming was abandoned in favor of aggregate mining on some fields; these gains, however, were credited as gains from agriculture, not mining.

Table 12 presents gains, losses, and covertype changes resulting from aggregate mining in all ecozones in the state. Significant statewide losses (2,023 acres) to aggregate mining were due mainly to the loss of 1,732 acres in the Lake Plains region. Seventy-five percent of the losses were in wetlands >12.4 acres. Estimates of gains and covertype changes due to aggregate mining were small and not statistically significant.

3.4.5 Modified Hydrology

Modified hydrology results from development in the watershed, which increases impervious surfaces and therefore increases runoff to low-lying areas. Water that otherwise would have percolated into the soil, and returned to the atmosphere through evapo-transpiration or entered the groundwater, is now directed to new or existing wetlands. Modified hydrology also results from increased agricultural drainage, which shunts water off the farm fields earlier in the spring, moving the water to other low-lying areas. These hydrologic modifications result in increased runoff to wetlands and surface waters.

Increased runoff results in increases in wetlands in two ways. Areas that previously were not sufficiently wet, now receive sufficient hydrology to maintain and support wetlands communities, either at low areas in the landscape, or adjacent to surface waters such as ponds and streams. In addition, existing wetlands are flooded more deeply, increasing the surface area of the wetland. However, in conjunction with increases in the size of existing wetlands, increased runoff results in changes in the community structure. As the water depths in the existing wetlands are increased, the cover type shifts toward communities more tolerant of deeper water levels. Typically, this results in a shift from forested and shrub/scrub towards emergents and open water. Table 13 presents gains, losses, and covertype changes resulting from modified hydrology in all ecozones in the state.

After agriculture, modified hydrology resulted in the largest gain in wetlands acreage in the state - a total of 11,832 acres, accounting for 30 percent of all wetland gains in the state. Nearly all of this gain (11,524 acres) occurred in small wetland areas <12.4 acres. None of the individual ecoregion gain estimates were significant, but the Lake Plains (5,569 acres) and Appalachian Highlands (4,568 acres) clearly made large contributions to the statewide estimate. Non-significant loss estimates to modified hydrology were due to small changes in a single sampling unit in each of two ecozones (Lake Plains and Appalachian Highlands).

The most notable effect of modified hydrology resulted from its influence on wetlands cover types. Overall there was a change in covertype on 16,378 acres of wetlands, 55 percent of which occurred on wetlands >12.4 acres. Modified hydrology accounted for 10.8 percent of all changes in covertype in the state. Significant changes were detected in the Appalachian Highlands (5,129 acres), the Lake

Plain (5,730 acres), the Adirondacks (3,621 acres), and the Hudson Valley (1,578 acres). Non-significant changes occurred in the Coastal Lowlands (320 acres).

3.4.6 Beaver Activity

Beaver affect wetlands by damming stream or wetland outlets, impounding water, and increasing water heights and the surface area of the impoundment.

Beaver activity results in increases in wetlands in two ways. In some situations, beaver dam a stream, impounding water behind the dam, which develops into a beaver pond with associated wetlands. In addition, existing wetlands are flooded more deeply, increasing the surface area of the wetland. However, in conjunction with increases in the size of existing wetlands, elevated water levels prompt changes in the community structure. As with increased runoff, discussed previously, beaver activity can result in increased water depths in the existing wetlands and cover type shifts toward communities more tolerant of deeper water levels – a shift from forested and shrub/scrub towards emergents and open water. There were no losses attributable to beavers as a result of this study. Table 14 presents gains, losses, and covertype changes resulting from beaver activity in all ecozones in the state.

In this study, beaver activity is responsible for 140 acres of gain in wetland acreage. Gains were detected in the Lake Plain (80 acres), Appalachian Highlands (35 acres), and Adirondacks (25 acres), and all occurred in wetlands <12.4 acres. Beaver were responsible for only 0.4 percent of gains in wetlands acreage in the state during this study period. However, there was a change in covertype in 8,020 acres of wetlands, 76 percent of which occurred in wetlands >12.4 acres. This change in covertype accounted for 5.3 percent of all covertype changes in the state. Greatest changes occurred in the Appalachian Highlands (3,773 acres) and Adirondacks (3,005 acres, non-significant). Non-significant changes also occurred in the Lake Plain (783 acres) and the Hudson Valley (458 acres). No beaver activity was detected in the Coastal Lowlands.

3.4.7 Plant Succession

The above described impacts can result in changes to plant community structure and covertype. The trend is toward drier conditions, and typically is manifested by emergents progressing toward shrub/scrub, and shrub/scrub progressing toward forested cover, over an extended period of time. However, natural perturbations such as floods, beaver activity, blow-downs, or other environmental disturbances can reverse this trend and create wetter habitat conditions such as open water or emergent plant communities. Table 15 presents gains, losses, and covertype changes resulting from these impacts in all ecozones in the state.

Change in plant community structure is not a causative agent in wetland gains or losses, but it was quantified in this study as a descriptor of the natural progression in plant species composition that results in changes in community structure and covertype.

Changes in plant cover type was prevalent within the period of time studied (mid-1980s to mid-1990s). Change in covertype occurred with a total of 124,032 acres with 72 percent occurring in wetlands >12.4 acres. Greatest changes in covertype were detected in the Lake Plain (57,472 acres), the Appalachian Highlands (33,990 acres) and the Adirondacks (27,695 acres). More minor changes occurred in the Hudson Valley (2,866 acres) and the Coastal Lowlands (2,009 acres). These changes are consistent with other trends in New York State towards increased forest cover.

4.0 A COMPARISON OF GAINS AND LOSSES FOR WETLANDS LARGER THAN AND SMALLER THAN 12.4 ACRES IN SIZE

New York's regulatory program has a statutory threshold of 12.4 acres, below which wetlands are not mapped nor regulated unless of "unusual local importance." A comparison of changes in wetlands larger than or equal to and smaller than 12.4 acres was made to determine if the regulatory program appears to have influenced rates of losses.

Based on this study, the proportion of wetlands losses in wetlands >12.4 acres is lower than the overall statewide proportion of wetlands >12.4 acres in size. Table 17 summarizes gains, losses, and net changes according to ecozone and wetland size. Statewide, wetlands >12.4 acres account for 80 percent of all wetlands, but losses in this population of wetlands account for only 53 percent of all losses. In the Lake Plains, this relationship is narrower, where 86 percent of the wetlands are >12.4 acres, and 71 percent of all losses occurred in these wetlands whereas the Appalachian, Adirondacks, and Coastal Plain the losses fall more disproportionately in the smaller wetland class (<12.4 acres).

Wetlands gains, however, appear to be occurring at a greater relative rate in wetlands <12.4 acres in size. Statewide, 20 percent of wetlands are <12.4 acres, but 71 percent of the gains occur in these smaller wetlands. In all ecozones except the Lake Plains, over 90 percent of the gains were in these smaller wetlands. Moreover, the acres gained in these small wetlands were more than twice the acres lost (Table 16).

In terms of cause of change, aggregate mining had a disproportionate disturbance to larger wetlands when compared to other causes of change. Although it only accounts for 9.3 percent of wetlands losses, 75 percent of the losses from aggregate mining were in wetlands >12.4 acres (Table 18). Sixty-four percent of the losses to urbanization were in wetlands >12.4 acres in size. Losses due to agriculture and linear development, respectively, were 43 and 38 percent of their losses occur in wetlands >12.4 acres.

These results imply that the Article 24 regulatory program has had a positive effect in reducing losses to wetlands in that there has been a significant net gain in wetland acreage. However, the inferences are indirect, at best. The state regulatory maps are outdated and it is believed that many wetlands >12.4 acres are not depicted on the regulatory maps and therefore not subject to regulatory jurisdiction. Additional comparisons of digital data from the regulatory maps and the study sites are needed to further clarify loss rates in regulated wetlands.

5.0 SUMMARY

The results of this study indicate that considerable changes have occurred in New York's wetlands resources from the mid-1980's to 1990's. Based on this study, it appears that:

- There was an estimated statewide net gain of approximately 17,619 acres of wetlands.
- There was a loss of approximately 21,661 acres of wetlands.
- Most of the acreage losses occurred in the Lake Plains and Appalachian Highlands ecozones.
- Most of the acreage losses resulted from agricultural conversion and urbanization.
- There was a gain of approximately 39,280 acres of wetlands.
- Most of the acreage gains occurred in the Lake Plains ecozone.
- Most of the acreage gains resulted from agricultural reversion and modified hydrology.
- Approximately 151,460 acres of wetland changed covertype.
- Most of the changes in covertype occurred in the Lake Plain ecozone.
- Most of the changes in covertype resulted from successional changes and modified hydrology.
- There were proportionately lower losses of wetland acreage in wetlands >12.4 acres than in those <12.4 acres, although the absolute acreage lost was about equal.
- Absolute gains in wetlands >12.4 acres was less than gains in wetlands <12.4 acres.

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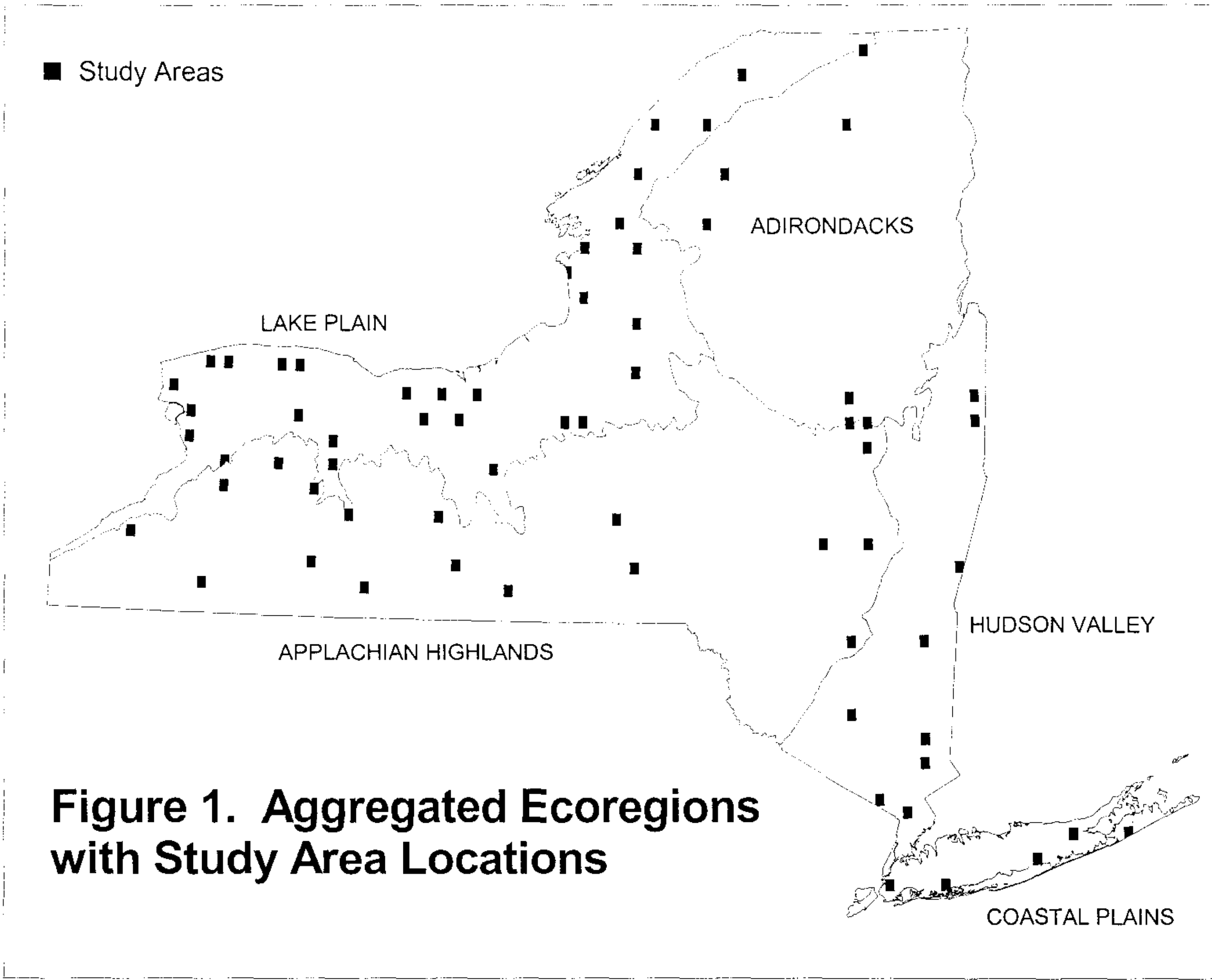
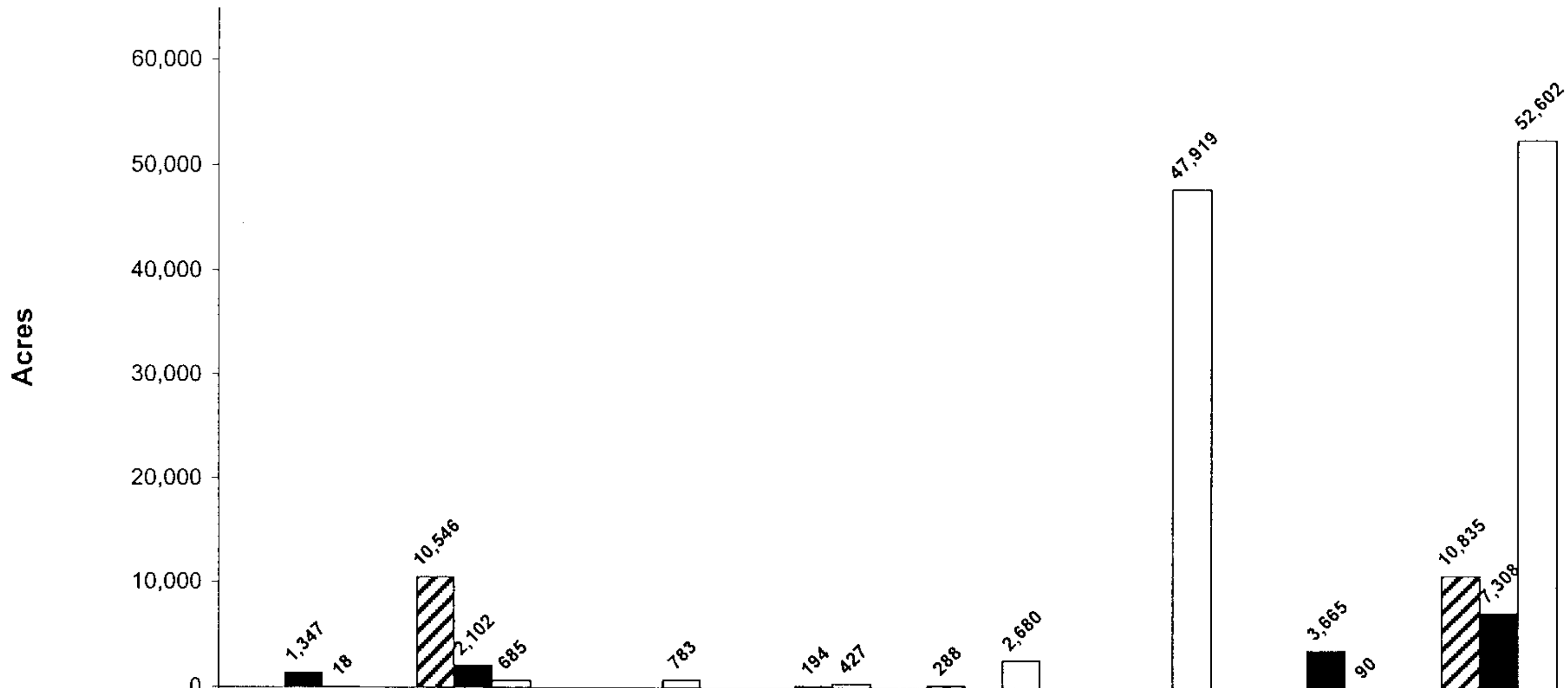


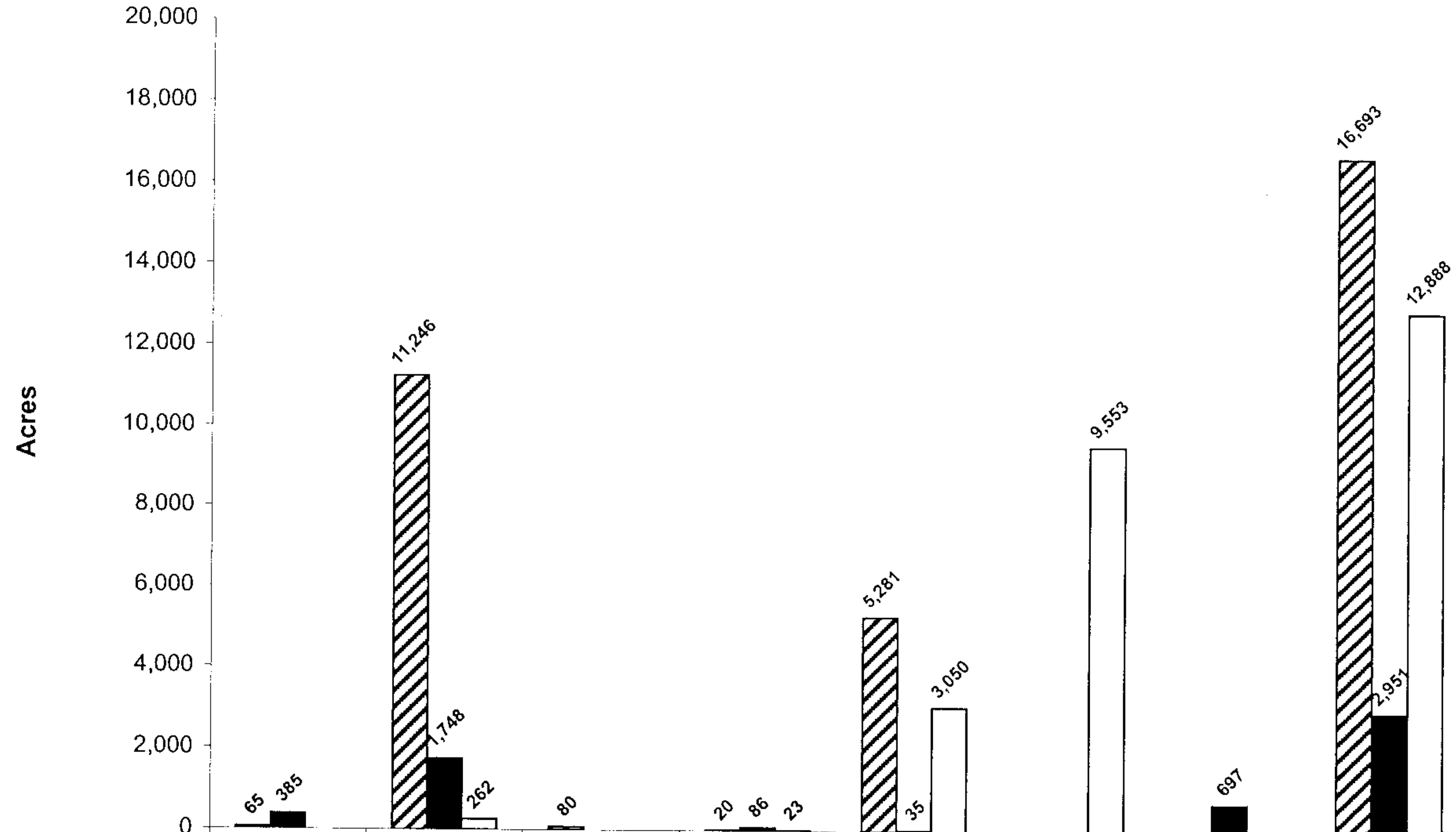
Figure 1. Aggregated Ecoregions with Study Area Locations



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained		10,546			288			10,835
Acres Lost	1,347	2,102		194			3,665	7,308
Acres Cover Change	18	685	783	427	2,680	47,919	90	52,602

Figure 2a. Wetland and open water gains, losses and changes in cover type in areas ≥ 12.4 acres due to various causative factors in the aggregated Lake Plain Ecoregion of New York between the mid-1980s and mid-1990's.

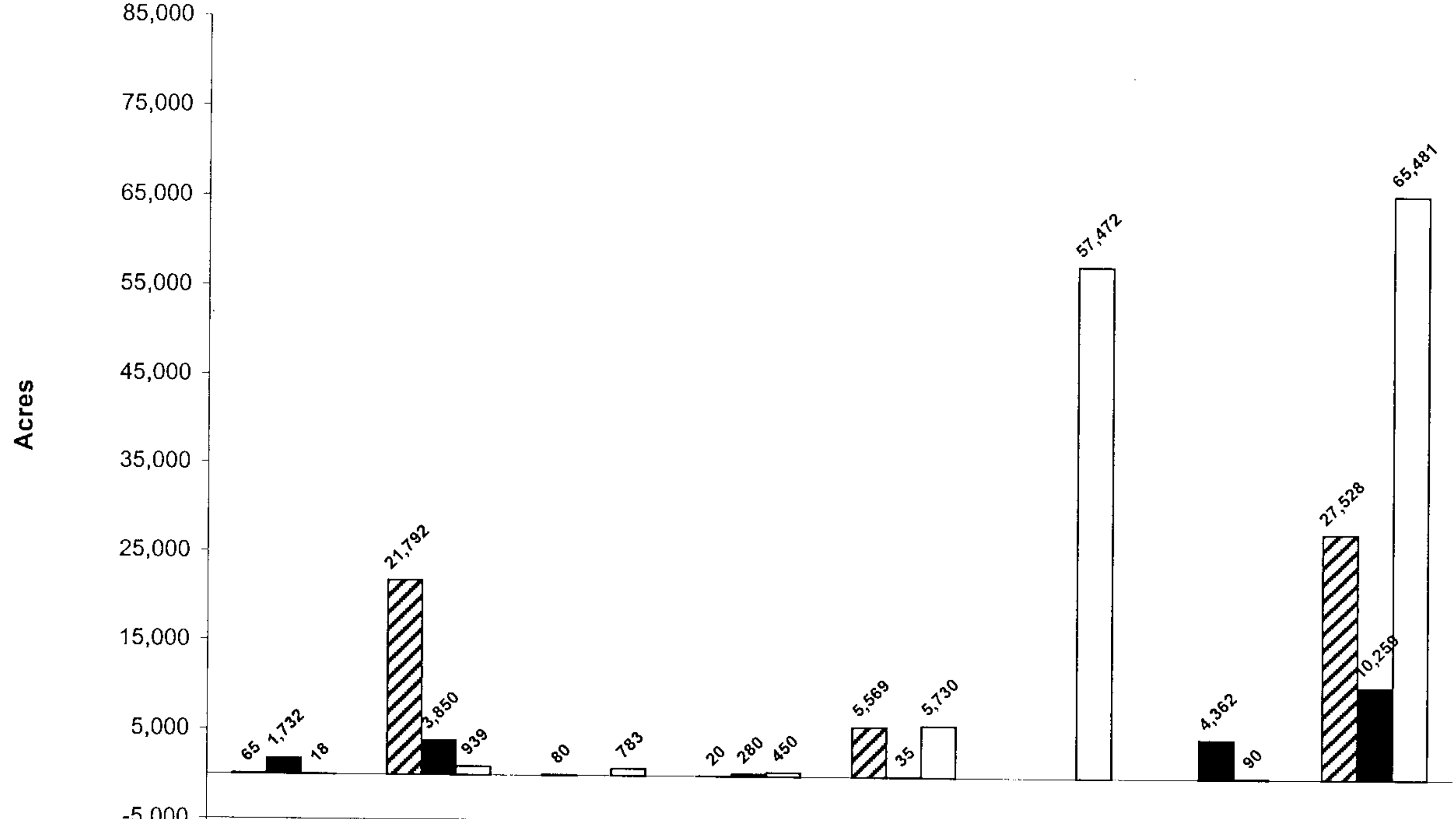
Projected acreages based on 31 sample areas (totaling 259,374 acres) taken from the aggregated Lake Plain Ecoregion (7,183,848 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
▨ Acres Gained	65	11,246	80	20	5,281			16,693
■ Acres Lost	385	1,748		86	35		697	2,951
□ Acres Cover Change		262		23	3,050	9,553		12,888

Figure 2b. Wetland and open water gains, losses and changes in cover type in areas < 12.4 acres due to various causative factors in the aggregated Lake Plain Ecoregion of New York between the mid-1980s and mid-1990's.

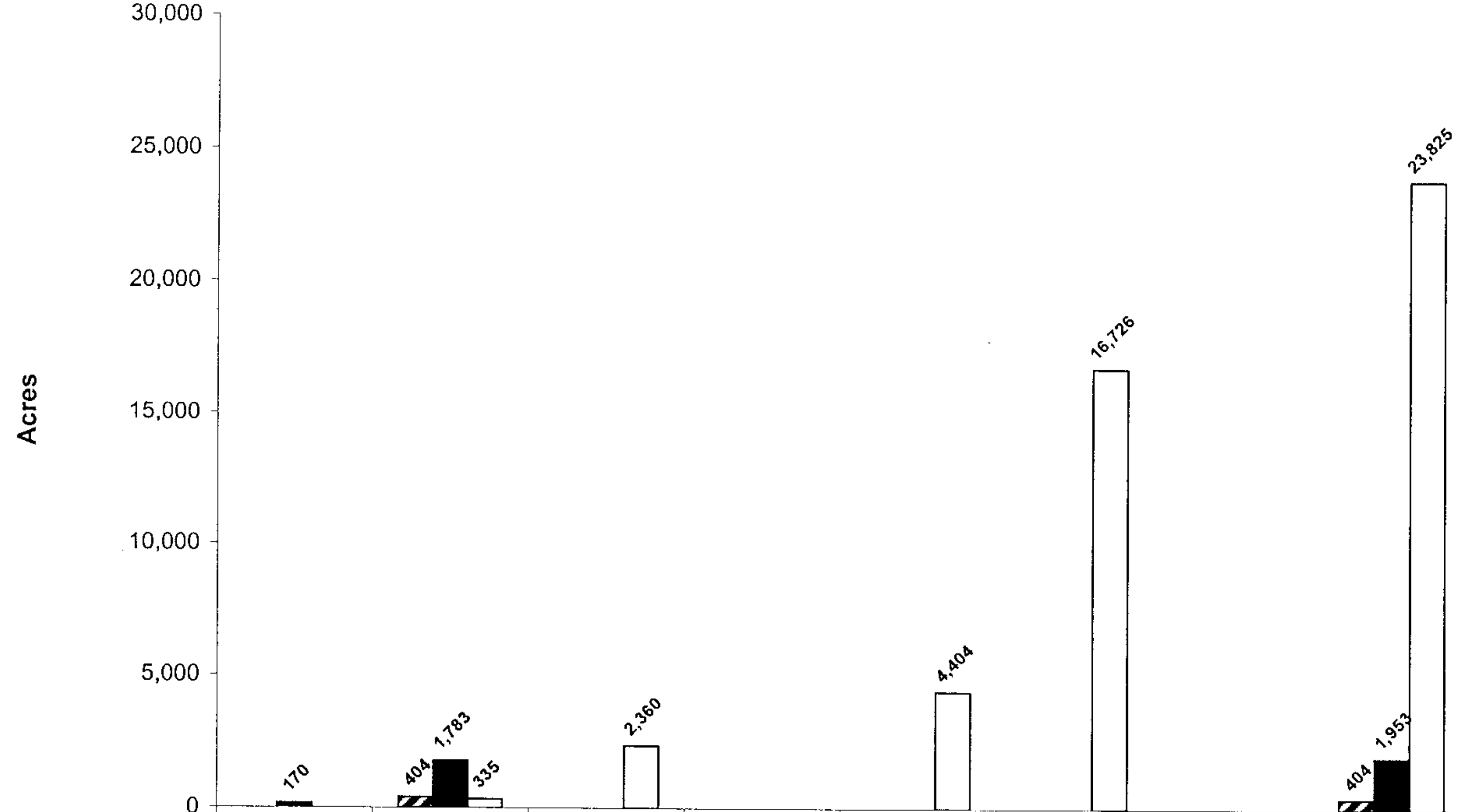
Projected acreages based on 31 sample areas (totaling 259,374 acres) taken from the aggregated Lake Plain Ecoregion (7,183,848 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained	65	21,792	80	20	5,569			27,528
Acres Lost	1,732	3,850		280	35		4,362	10,259
Acres Cover Change	18	939	783	450	5,730	57,472	90	65,481

Figure 2c. Wetland and open water gains, losses and changes in cover type due to various causative factors in the aggregated Lake Plain Ecoregion of New York between the mid-1980s and mid-1990's.

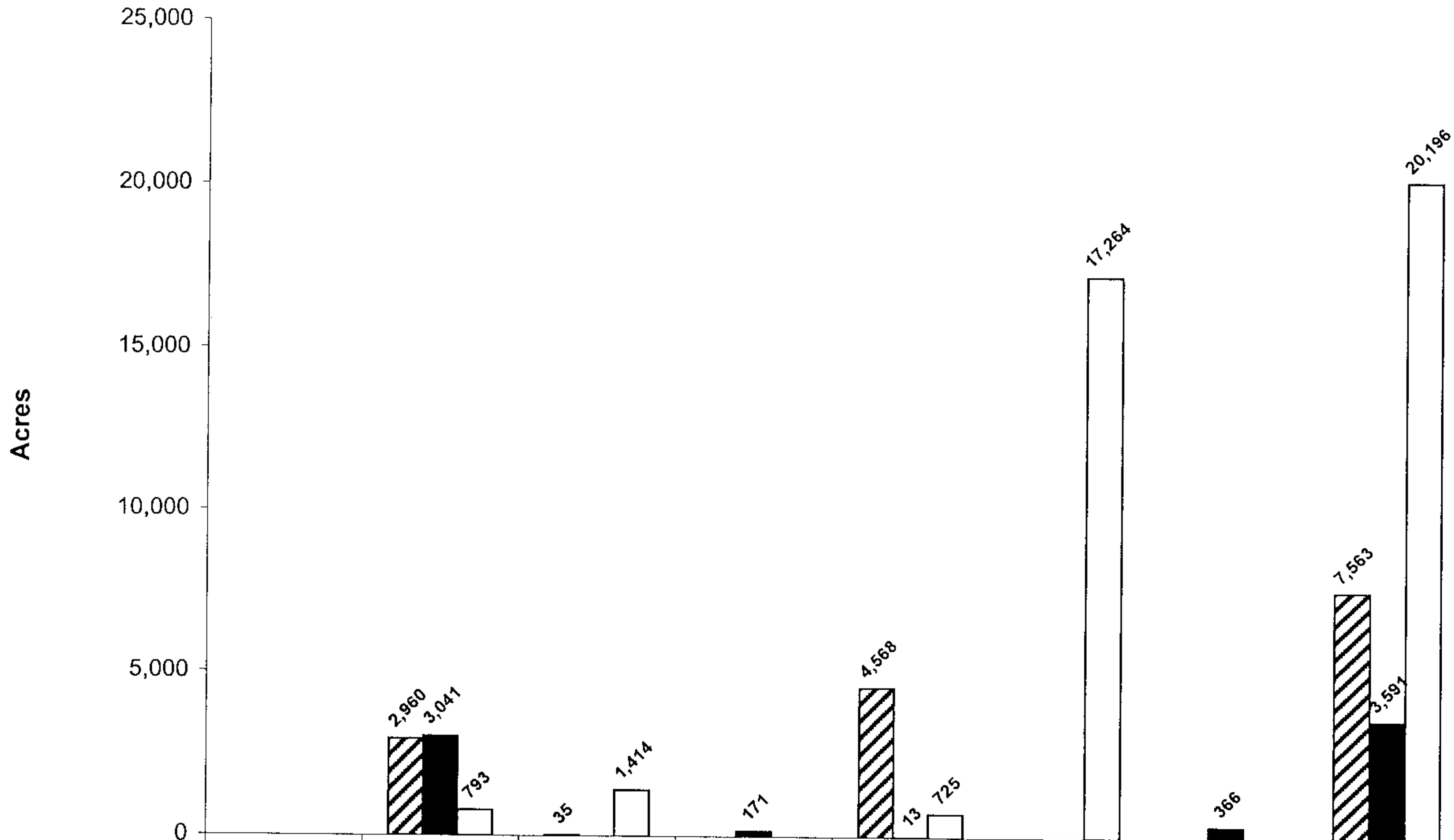
Projected acreages based on 31 sample areas (totaling 259,374 acres) taken from the aggregated Lake Plain Ecoregion (7,183,848 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained		404						404
Acres Lost	170	1,783						1,953
Acres Cover Change		335	2,360		4,404	16,726		23,825

Figure 3a. Wetland and open water gains, losses and changes in cover type in areas ≥ 12.4 acres due to various causative factors in the aggregated Appalachian Highlands Ecoregion of New York between the mid-1980s and mid-1990's.

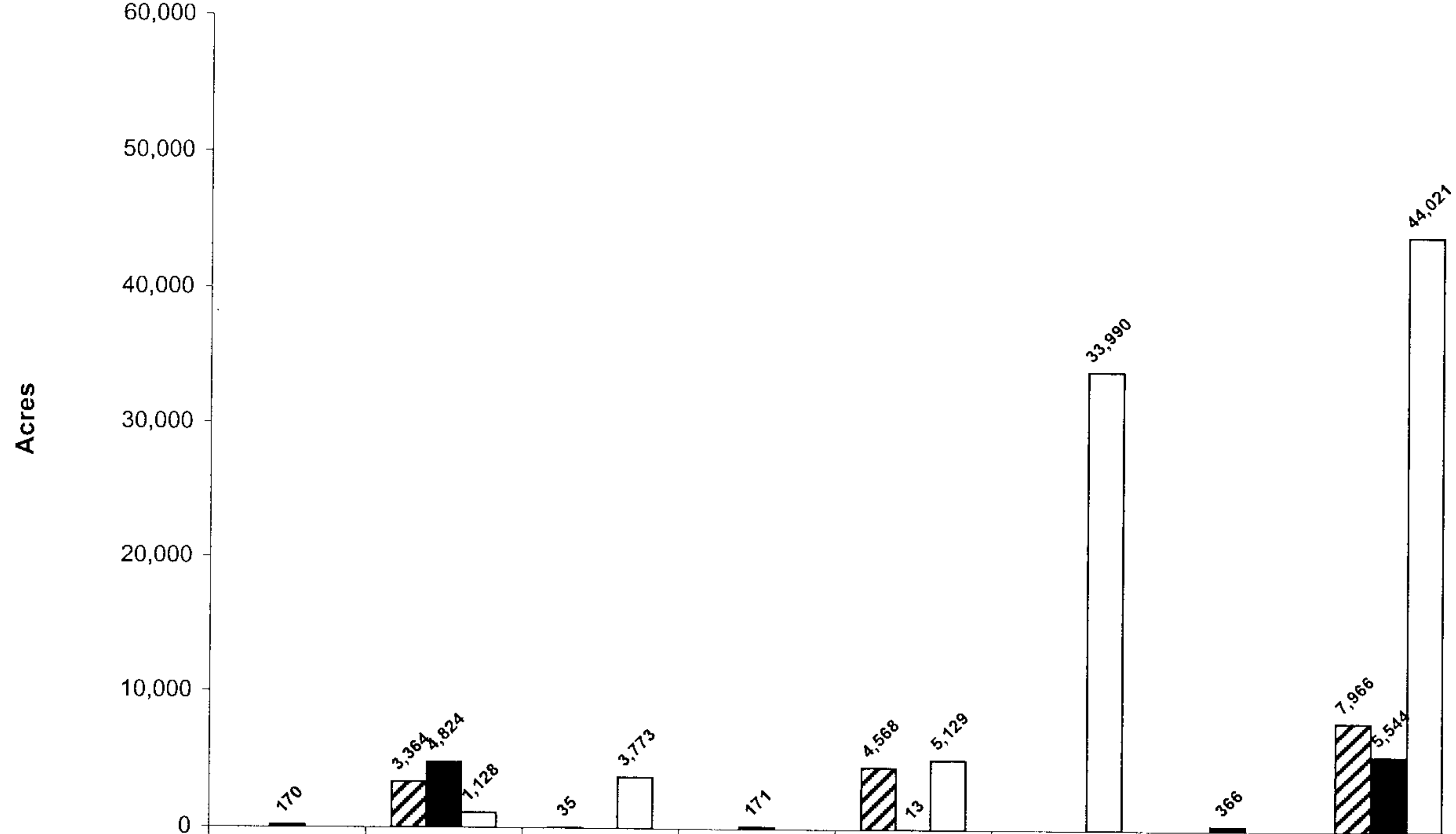
Projected acreages based on 19 sample areas (totaling 157,284 acres) taken from the aggregated Appalachian Highlands Ecoregion (11,889,736acres)



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained		2,960	35		4,568			7,563
Acres Lost		3,041		171	13		366	3,591
Acres Cover Change		793	1,414		725	17,264		20,196

Figure 3b. Wetland and open water gains, losses and changes in cover type in areas < 12.4 acres due to various causative factors in the aggregated Appalachian Highlands Ecoregion of New York between the mid-1980s and mid-1990's.

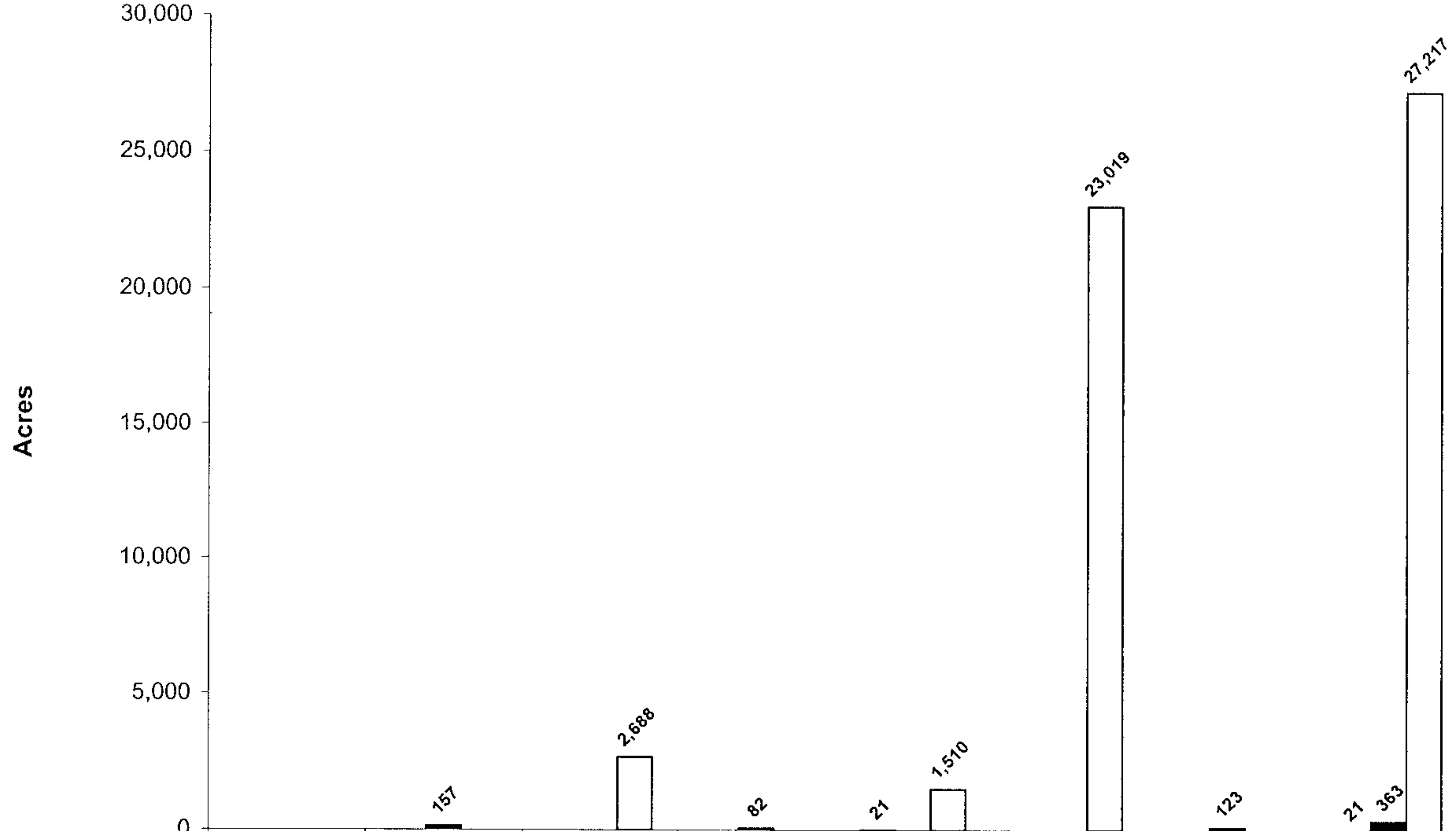
Projected acreages based on 19 sample areas (totaling 157,284 acres) taken from the aggregated Appalachian Highlands Ecoregion (11,889,736 acres)



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained		3,364	35		4,568			7,966
Acres Lost	170	4,824		171	13		366	5,544
Acres Cover Change		1,128	3,773		5,129	33,990		44,021

Figure 3c. Wetland and open water gains, losses and changes in cover type due to various causative factors in the aggregated Appalachian Highlands Ecoregion of New York between the mid-1980s and mid-1990's.

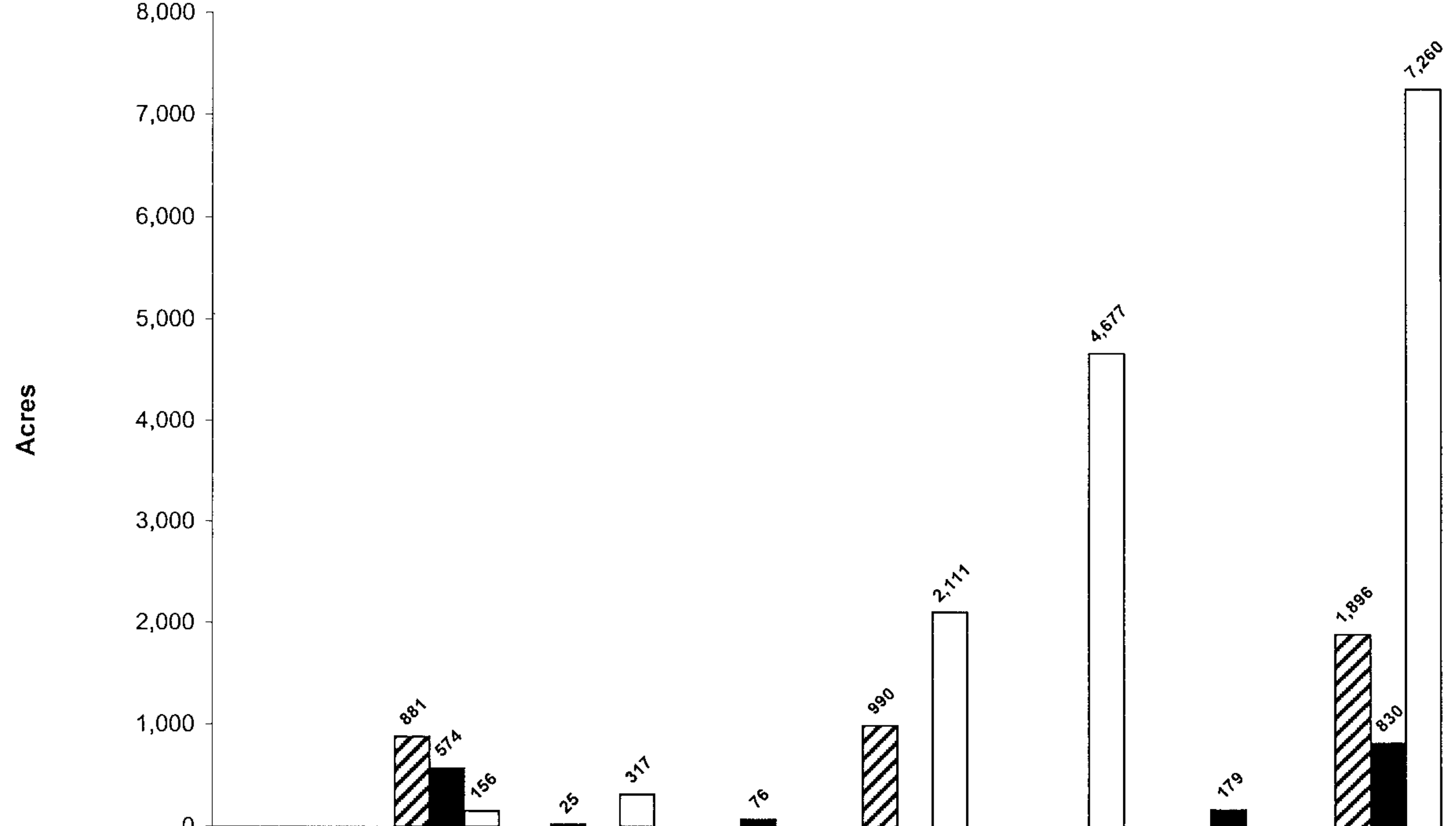
Projected acreages based on 19 sample areas (totaling 157,284 acres) taken from the aggregated Appalachian Highlands Ecoregion (11,889,736 acres)



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
☒ Acres Gained					21			21
■ Acres Lost		157		82			123	363
☐ Acres Cover Change			2,688		1,510	23,019		27,217

Figure 4a. Wetland and open water gains, losses and changes in cover type in areas ≥ 12.4 acres due to various causative factors in the aggregated Adirondacks Ecoregion of New York between the mid-1980s and mid-1990's.

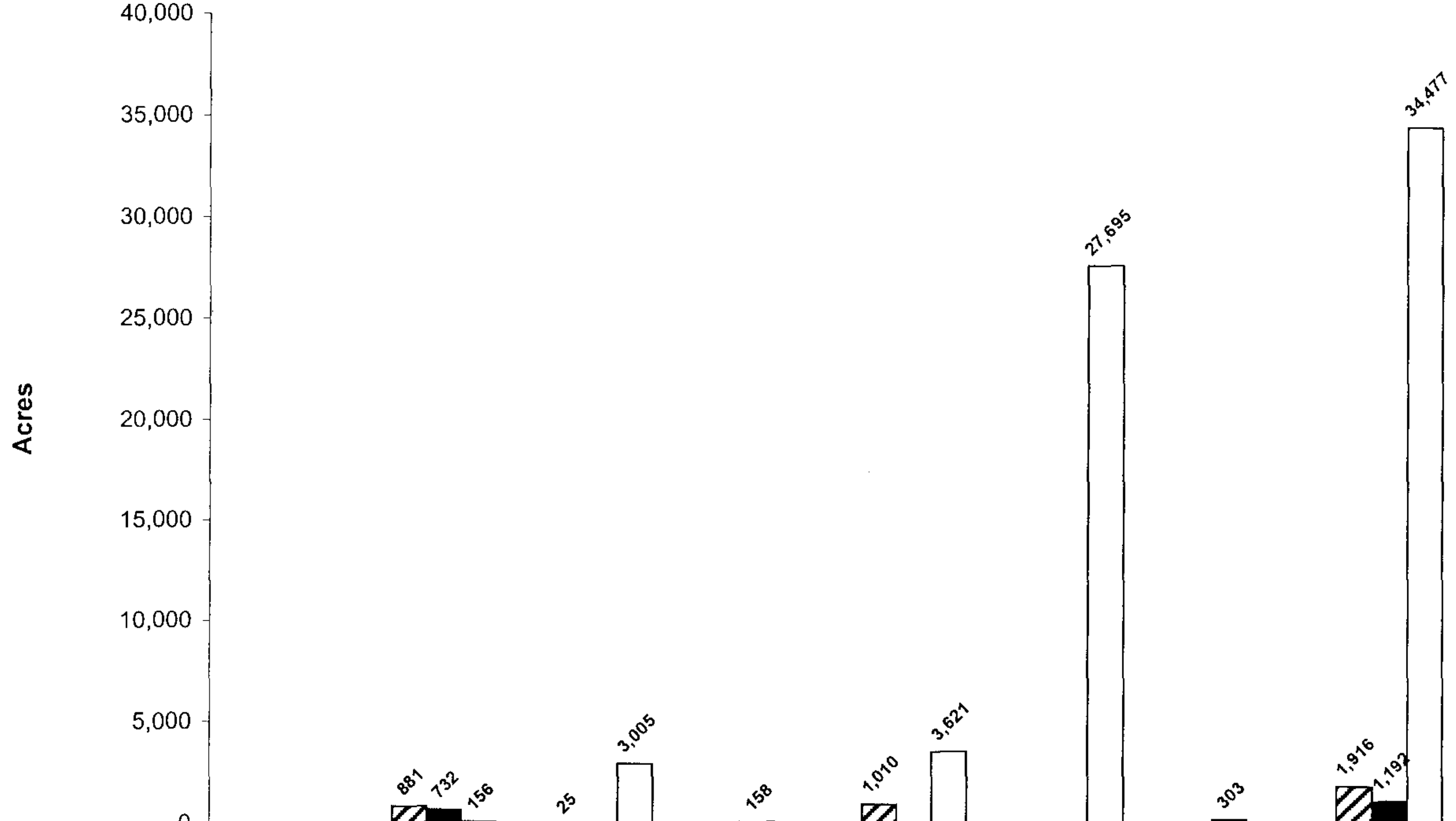
Projected acreages based on 7 sample areas (totaling 48,173 acres) taken from the aggregated Adirondacks Ecoregion (7,280,725 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained		881	25		990			1,896
Acres Lost		574		76			179	830
Acres Cover Change		156	317		2,111	4,677		7,260

Figure 4b. Wetland and open water gains, losses and changes in cover type in areas < 12.4 acres due to various causative factors in the aggregated Adirondacks Ecoregion of New York between the mid-1980s and mid-1990's.

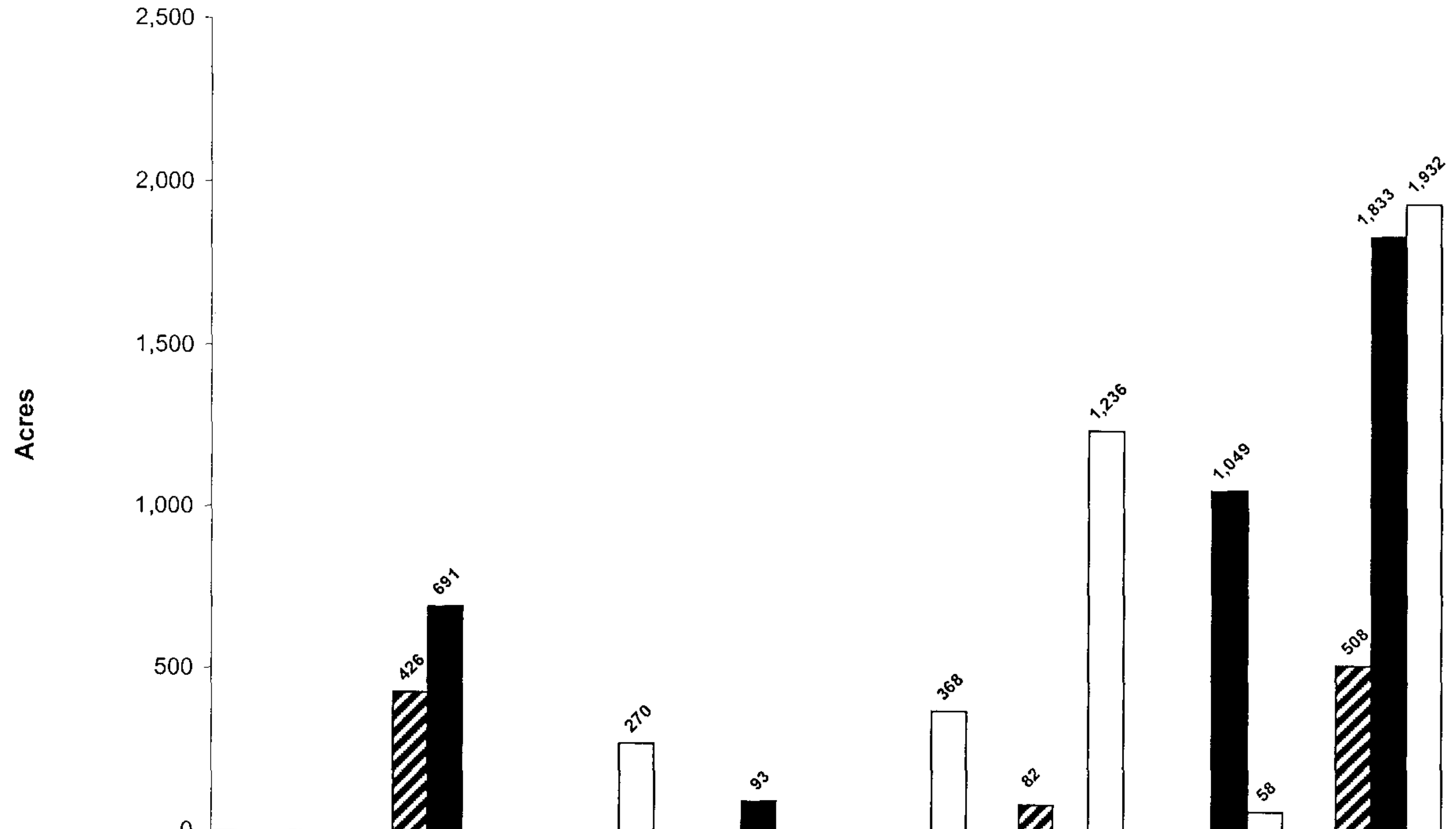
Projected acreages based on 7 sample areas (totaling 48,173 acres) taken from the aggregated Adirondacks Ecoregion (7,280,725 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained		881	25		1,010			1,916
Acres Lost		732		158			303	1,192
Acres Cover Change		156	3,005		3,621	27,695		34,477

Figure 4c. Wetland and open water gains, losses and changes in cover type due to various causative factors in the aggregated Adirondacks Ecoregion of New York between the mid-1980s and mid-1990's.

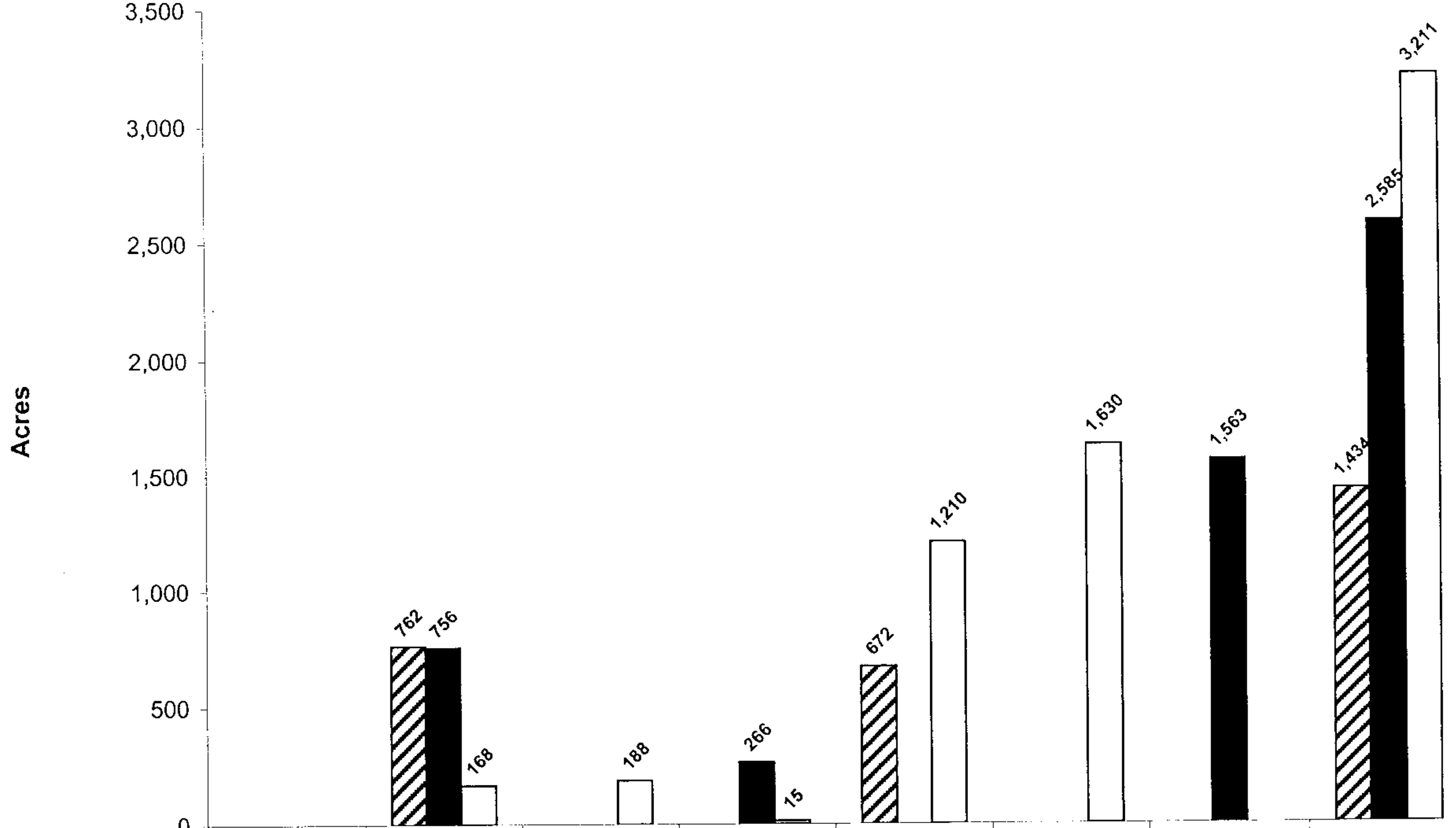
Projected acreages based on 7 sample areas (totaling 48,173 acres) taken from the aggregated Adirondacks Ecoregion (7,280,725 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained		426				82		508
Acres Lost		691		93			1,049	1,833
Acres Cover Change			270		368	1,236	58	1,932

Figure 5a. Wetland and open water gains, losses and changes in cover type in areas ≥ 12.4 acres due to various causative factors in the aggregated Hudson Valley Ecoregion of New York between the mid-1980s and mid-1990's.

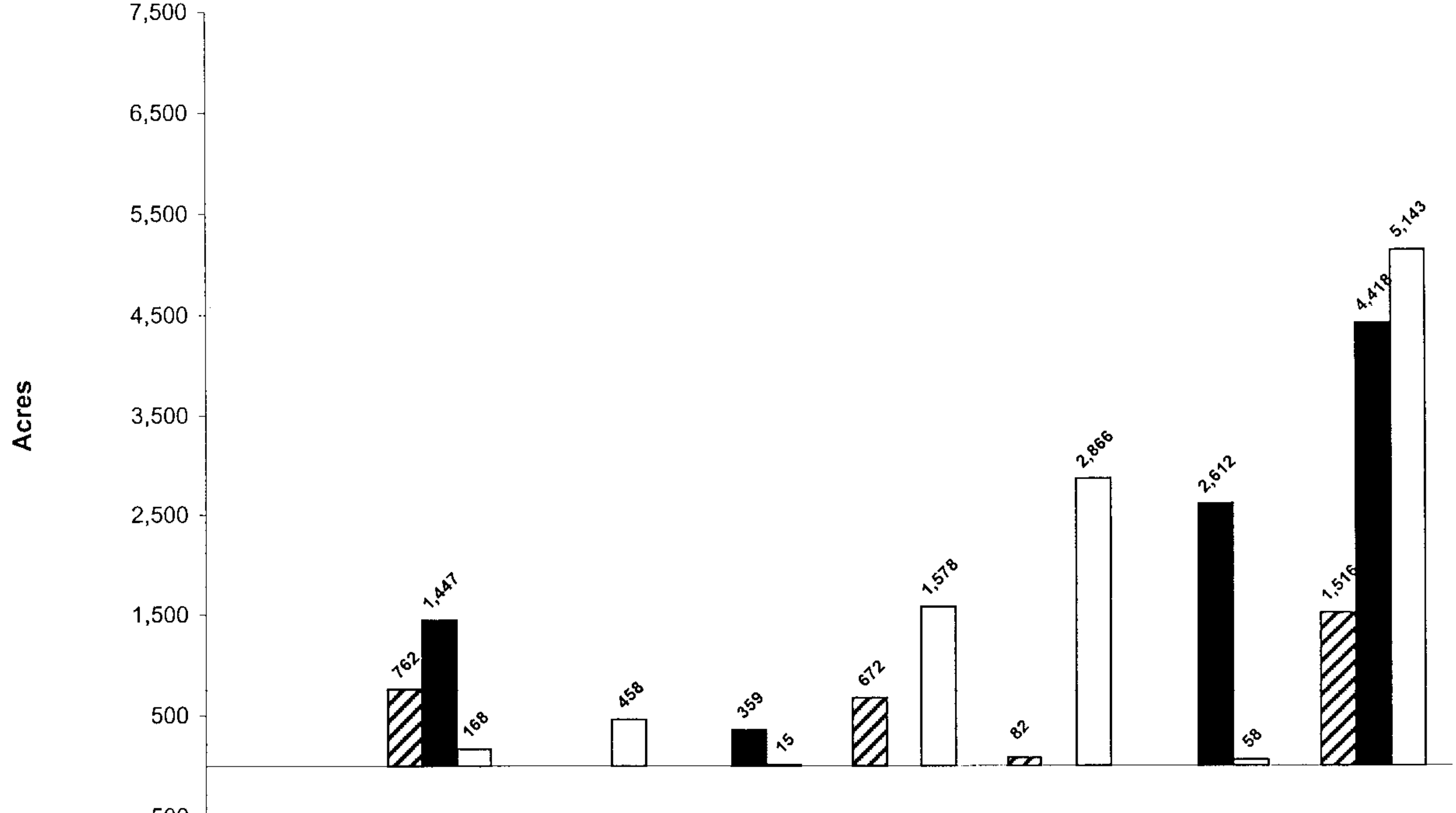
Projected acreages based on 9 sample areas (totaling 79,613 acres) taken from the aggregated Hudson Valley Ecoregion (3,853,965 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained		762			672			1,434
Acres Lost		756		266			1,563	2,585
Acres Cover Change		168	188	15	1,210	1,630		3,211

Figure 5b. Wetland and open water gains, losses and changes in cover type in areas < 12.4 acres due to various causative factors in the aggregated Hudson Valley Ecoregion of New York between the mid-1980s and mid-1990's.

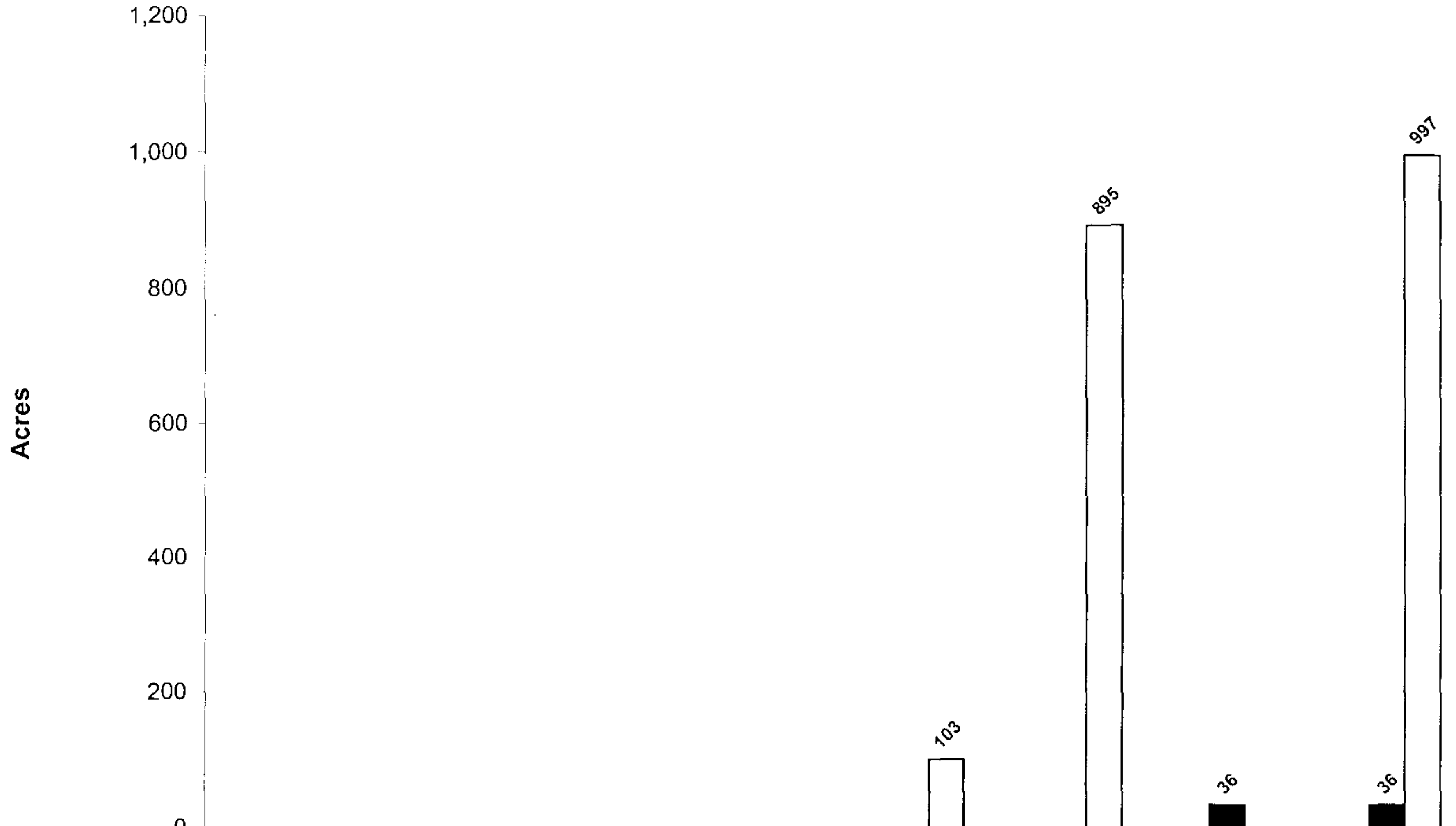
Projected acreages based on 9 sample areas (totaling 79,613 acres) taken from the aggregated Hudson Valley Ecoregion (3,853,965 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained		762			672	82		1,516
Acres Lost		1,447		359			2,612	4,418
Acres Cover Change		168	458	15	1,578	2,866	58	5,143

Figure 5c. Wetland and open water gains, losses and changes in cover type in areas due to various causative factors in the aggregated Hudson Valley Ecoregion of New York between the mid-1980s and mid-1990's.

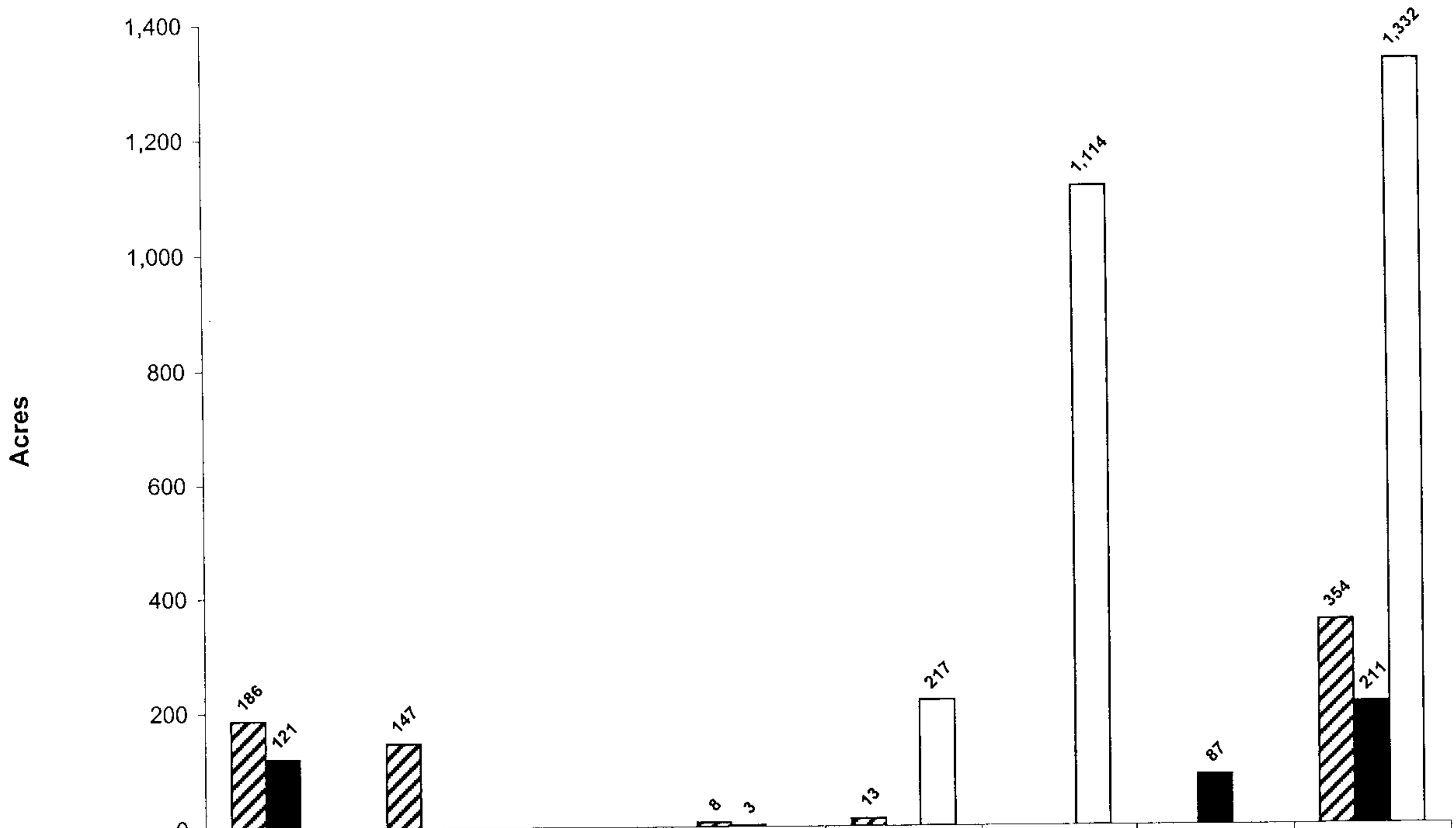
Projected acreages based on 9 sample areas (totaling 79,613 acres) taken from the aggregated Hudson Valley Ecoregion (3,853,965 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained								
Acres Lost							36	36
Acres Cover Change					103	895		997

Figure 6a. Wetland and open water gains, losses and changes in cover type in areas ≥ 12.4 acres due to various causative factors in the aggregated Coastal Plains Ecoregion of New York between the mid-1980s and mid-1990's.

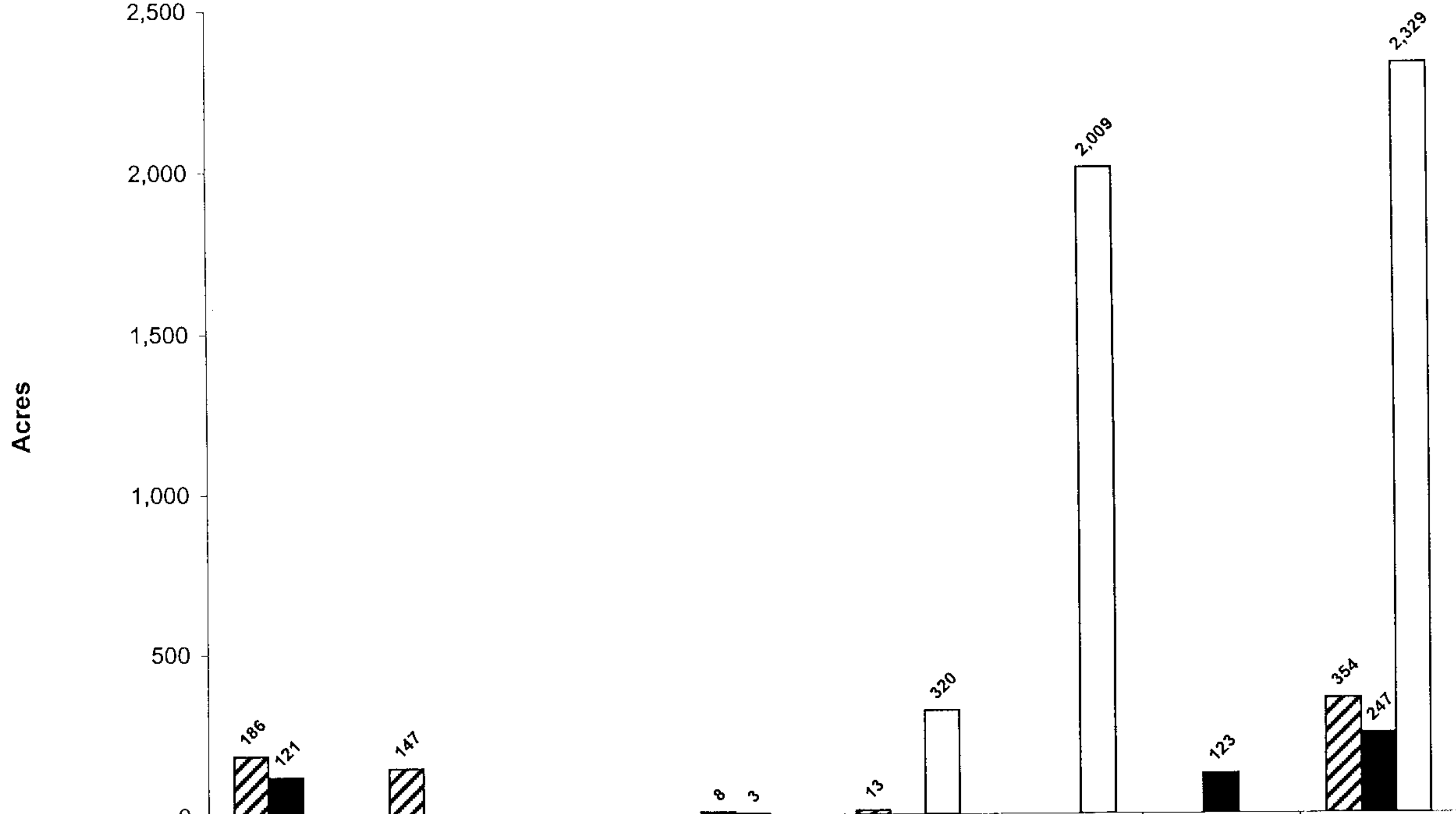
Projected acreages based on 5 sample areas (totaling 43,303 acres) taken from the aggregated Coastal Plains Ecoregion (908,205 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
▨ Acres Gained	186	147		8	13			354
■ Acres Lost	121			3			87	211
□ Acres Cover Change					217	1,114		1,332

Figure 6b. Wetland and open water gains, losses and changes in cover type in areas < 12.4 acres due to various causative factors in the aggregated Coastal Plains Ecoregion of New York between the mid-1980s and mid-1990's.

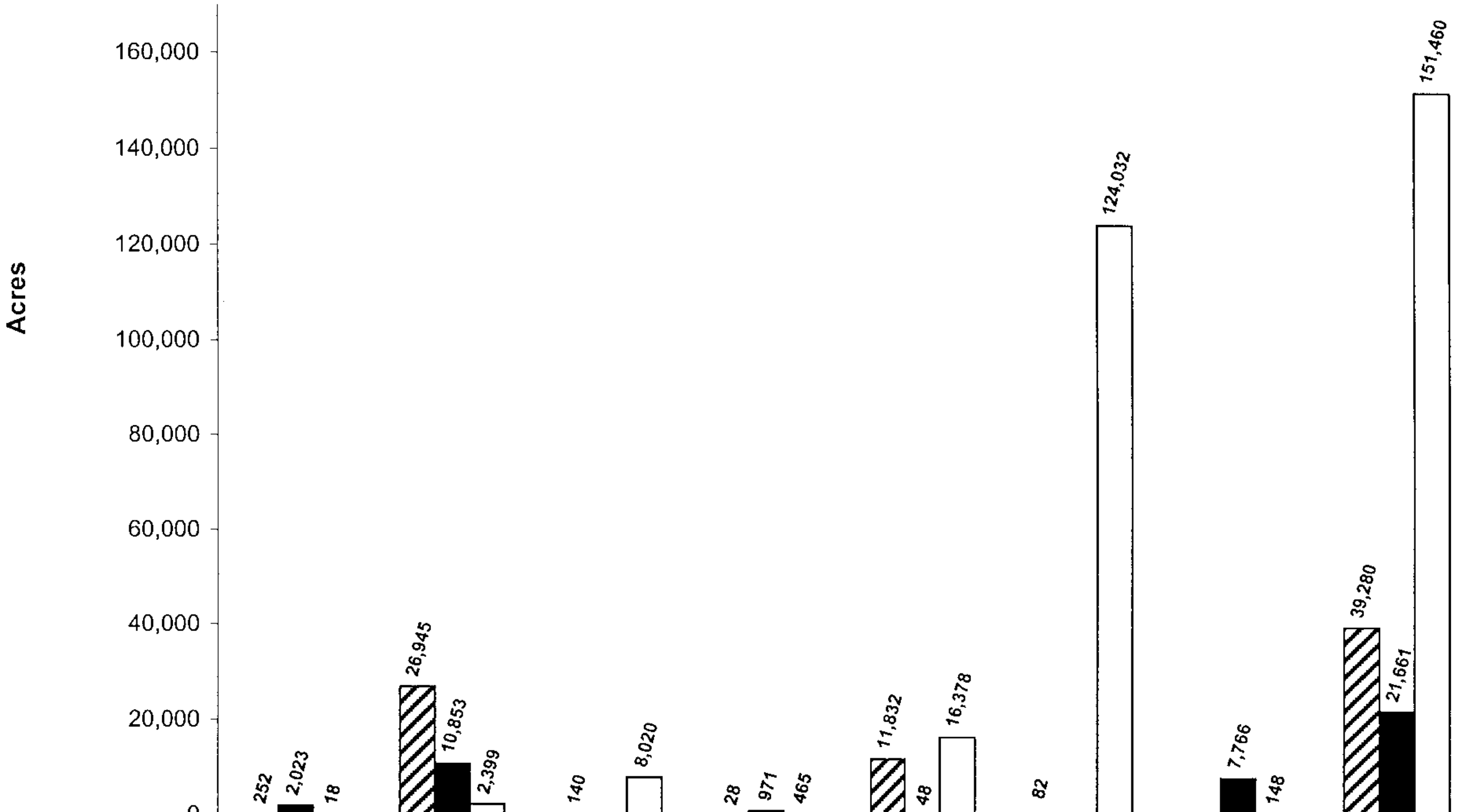
Projected acreages based on 5 sample areas (totaling 43,303 acres) taken from the aggregated Coastal Plains Ecoregion (908,205 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
▨ Acres Gained	186	147		8	13			354
■ Acres Lost	121			3			123	247
□ Acres Cover Change					320	2,009		2,329

Figure 6c. Wetland and open water gains, losses and changes in cover type due to various causative factors in the aggregated Coastal Plains Ecoregion of New York between the mid-1980s and mid-1990's.

Projected acreages based on 5 sample areas (totaling 43,303 acres) taken from the aggregated Coastal Plains Ecoregion (908,205 acres).



	aggregate mining	agriculture	beaver activity	linear development	modified hydrology	plant succession	urbanization	Total
Acres Gained	252	26,945	140	28	11,832	82		39,280
Acres Lost	2,023	10,853		971	48		7,766	21,661
Acres Cover Change	18	2,399	8,020	465	16,378	124,032	148	151,460

Figure 7. Wetland and open water gains, losses and changes in cover type due to various causative factors in All Ecoregions of New York between the mid-1980s and mid-1990's.

Projected acreages based on 71 sample areas (totaling 48,173 acres) taken from all New York State Aggregated Ecoregions (31,116,479 acres).

TABLES

Table No. 1. Characteristics of Wetlands in New York

	ECOLOGICAL ZONE											
	LAKE PLAIN		APPALACHIAN HIGHLANDS		ADIRONDACKS		HUDSON VALLEY		COASTAL LOWLANDS		ENTIRE STATE	
	mid-1980s	mid-1990s	mid-1980s	mid-1990s	mid-1980s	mid-1990s	mid-1980s	mid-1990s	mid-1980s	mid-1990s	mid-1980s	mid-1990s
% of wetlands forested	64.03%	66.98%	55.14%	58.45%	70.07%	69.94%	61.09%	61.99%	56.21%	63.91%	64.17%	66.02%
% of wetlands shrub/scrub	23.66%	21.30%	23.24%	21.96%	16.14%	14.25%	22.50%	20.93%	12.86%	3.27%	20.82%	18.83%
% of wetlands emergent	10.06%	8.27%	15.08%	11.56%	8.53%	10.79%	11.78%	11.50%	8.06%	8.15%	10.58%	9.97%
% of ecozone in open water (AR24)	2.25%	3.45%	6.54%	8.02%	5.26%	5.01%	4.63%	5.58%	22.87%	24.67%	4.44%	5.17%
% of ecozone in wetlands	12.87%	13.11%	3.73%	3.75%	11.22%	11.23%	4.49%	4.41%	2.31%	2.32%		
Projected acreages based on ratio of acreages in sample areas for each ecoregion to total acreages in ecoregion											**mid-1980s**	**mid-1990s**
acres of wetland in forest	592,121	630,929	244,436	260,513	572,602	572,035	105,659	105,404	11,793	13,477	1,526,610	1,582,358
Standard error (%)	(17)	(16)	(24)	(22)	(26)	(26)	(26)	(26)	(38)	(33)	(12)	(12)
90% C.I. Half-width	166,480	171,136	100,707	100,668	288,712	289,789	51,575	51,204	9,476	9,351	329,693	332,850
acres of wetland in shrub/scrub	218,764	200,640	103,007	97,887	131,851	116,543	38,908	35,592	2,698	690	495,227	451,353
Standard error (%)	(31)	(38)	(23)	(29)	(16)	(12)	(23)	(26)	(47)	(54)	(15)	(18)
90% C.I. Half-width	115,411	129,845	41,433	49,570	40,830	28,060	16,486	17,490	2,676	793	125,354	138,468
acres of wetland in emergent	93,048	77,947	66,838	51,531	69,711	88,286	20,375	19,554	1,692	1,718	251,663	239,036
Standard error (%)	(28)	(24)	(26)	(28)	(21)	(25)	(67)	(68)	(49)	(48)	(15)	(15)
90% C.I. Half-width	43,954	31,886	30,447	24,749	28,994	43,536	25,535	24,608	1,785	1,761	61,685	59,231
acres of open water (AR24)	20,801	32,485	28,982	35,754	42,983	41,007	8,007	9,496	4,798	5,202	105,572	123,944
Standard error (%)	(21)	(19)	(23)	(19)	(48)	(48)	(31)	(27)	(52)	(47)	(21)	(18)
90% C.I. Half-width	7,259	10,562	11,720	11,666	39,893	38,275	4,599	4,705	5,309	5,262	41,291	40,139
total acres of wetland	924,733	942,002	443,263	445,685	817,148	817,871	172,949	170,047	20,980	21,088	2,379,072	2,396,691
Standard error (%)	(15)	(15)	(20)	(21)	(19)	(19)	(27)	(26)	(25)	(26)	(9)	(10)
% of wetlands > 12.4 acres	76.05%	86.11%	66.95%	67.23%	85.00%	84.97%	59.68%	58.83%	60.18%	60.04%	76.10%	80.05%
% of wetlands < 12.4 acres	23.95%	13.89%	33.05%	32.77%	15.00%	15.03%	40.32%	41.17%	39.82%	39.96%	23.90%	19.95%
% of all wetlands in this ecoregion	38.87%	39.30%	18.63%	18.60%	34.35%	34.13%	7.27%	7.10%	0.88%	0.88%	**mid-1980s**	**mid-1990s**
acres of wetlands > 12.4 acres	703,278	811,201	296,760	299,632	694,552	694,979	103,222	100,034	12,627	12,661	1,810,438	1,918,505
Standard error (%)	(16)	(17)	(28)	(29)	(24)	(24)	(28)	(29)	(34)	(34)	(12)	(12)
90% C.I. Half-width	193,678	228,868	143,052	148,744	323,244	322,452	54,390	53,324	9,180	9,205	379,942	396,515
acres of wetlands < 12.4 acres	221,455	130,801	146,503	146,053	122,596	122,893	69,726	70,013	8,354	8,427	568,634	478,186
Standard error (%)	(40)	(9)	(14)	(14)	(20)	(20)	(28)	(27)	(27)	(26)	(17)	(8)
90% C.I. Half-width	151,136	20,746	36,437	36,000	47,490	47,264	36,770	34,906	4,888	4,686	160,613	66,159
total acres of wetland	924,733	942,002	443,263	445,685	817,148	817,871	172,949	170,047	20,980	21,088	2,379,072	2,396,691

Table No. 2. Acreage and Relative Abundance of Wetlands Covertypes in New York in the Mid-1990s

	Covertype							
	Forested		Shrub/Scrub		Emergent		Wetland Open Water	
NEW	acres	%	acres	%	acres	%	acres	%
Lake Plains	630,929	66.98%	200,640	21.30%	77,947	8.27%	32,485	3.45%
Standard error (%)	(16)		(38)		(24)		(19)	
90% C.I. Half-width	171,136		129,845		31,886		10,562	
Appalachian Highlands	260,513	58.45%	97,887	21.96%	51,531	11.56%	35,754	8.02%
Standard error (%)	(22)		(29)		(28)		(19)	
90% C.I. Half-width	100,668		49,570		24,749		11,666	
Adirondacks	572,035	69.94%	116,543	14.25%	88,286	10.79%	41,007	5.01%
Standard error (%)	(26)		(12)		(25)		(48)	
90% C.I. Half-width	289,789		28,060		43,536		38,275	
Hudson Valley	105,404	61.99%	35,592	20.93%	19,554	11.50%	9,496	5.58%
Standard error (%)	(26)		(26)		(68)		(27)	
90% C.I. Half-width	51,204		17,490		24,608		4,705	
Coastal Lowlands	13,477	63.91%	690	3.27%	1,718	8.15%	5,202	24.67%
Standard error (%)	(33)		(54)		(48)		(47)	
90% C.I. Half-width	9,351		793		1,761		5,262	
Entire State	1,582,358	66.02%	451,353	18.83%	239,036	9.97%	123,944	5.17%
Standard error (%)	(12)		(18)		(15)		(18)	
90% C.I. Half-width	332,850		138,468		59,231		40,139	

Table No. 3. Acreage, Size, and Relative Abundance of Wetlands in New York in the Mid-1990's

Ecozone	Acres of Wetland	% > 12.4 Acres	% of Ecozone in Wetlands	% of All Wetlands in this Ecoregion
Lake Plain	942,002	86.1%	13.1%	39.3%
Appalachian Highlands	445,685	67.2%	3.7%	18.6%
Adirondacks	817,871	85.0%	11.2%	34.1%
Hudson Valley	170,047	58.8%	4.4%	7.1%
Coastal Lowlands	21,088	60.0%	2.3%	0.9%
Entire State	2,396,691	80.0%	7.7%	

Table No. 4. Regional Trends in Wetlands Abundance Between the 1980s and the 1990s

Ecological Zone	Gains	Losses	Net Changes
Lake Plains	27,528	10,259	17,269
S.E. (%)	(26)	(30)	(45)
90% C.I. Half-width	11,867	5,142	13,210
Appalachians	7,966	5,544	2,422
S.E. (%)	(41)	(33)	(146)
90% C.I. Half-width	5,704	3,185	6,890
Adirondacks	1,916	1,192	724
S.E. (%)	(41)	(71)	(168)
90% C.I. Half-width	1,478	1,647	2,358
Hudson Valley	1,516	4,418	-2,902
S.E. (%)	(31)	(57)	(92)
90% C.I. Half-width	866	4,710	4,953
Coastal Lowlands	354	247	107
S.E. (%)	(55)	(61)	30
90% C.I. Half-width	417	322	626
State Total	39,280	21,661	17,619
S.E. (%)	(20)	(20)	(51)
90% C.I. Half-width	12,904	7,373	15,246

TABLE NO. 5. Changes in the Wetland Resources of New York from the Mid-1980's to the Mid-1990s According to Ecological Zone

Covertype/Ecozone	Acreage in Mid-80's	Acreage in Mid-90's	Change in Acreage
Forested wetlands statewide	1,526,610	1,582,358	+55,748
Standard error (%)	(12)	(12)	(22)
90% C.I. Half-width	329,693	332,850	20,916
Lake Plains	592,121	630,929	38,808
Standard error (%)	(17)	(16)	(29)
90% C.I. Half-width	166,480	171,136	19,192
Appalachian Highlands	244,436	260,513	+16,077
Standard error (%)	(24)	(22)	(29)
90% C.I. Half-width	100,707	100,668	7,972
Adirondacks	572,602	572,035	-567
Standard error (%)	(26)	(26)	(227)
90% C.I. Half-width	288,712	289,789	2,501
Hudson Valley	105,659	105,404	-255
Standard error (%)	(26)	(26)	(1111)
90% C.I. Half-width	51,575	51,204	5,266
Coastal Lowlands	11,793	13,477	+1,685
Standard error (%)	(38)	(33)	(50)
90% C.I. Half-width	9,476	9,351	1,809
Shrub/scrub Wetlands statewide	495,227	451,353	-43,875
Standard error (%)	(15)	(18)	(43)
90% C.I. Half-width	125,354	138,468	31,672
Lake Plains	218,764	200,640	-18,123
Standard error (%)	(31)	(38)	(77)
90% C.I. Half-width	115,411	129,845	23,577
Appalachian Highlands	103,007	97,887	-5,120
Standard error (%)	(23)	(29)	(128)
90% C.I. Half-width	41,433	49,570	11,389
Adirondacks	131,851	116,543	-15,308
Standard error (%)	(16)	(12)	(71)
90% C.I. Half-width	40,830	28,060	21,020
Hudson Valley	38,908	35,592	-3,316
Standard error (%)	(23)	(26)	(66)
90% C.I. Half-width	16,486	17,490	4,061
Coastal Lowlands	2,698	690	-2,008

Standard error (%)	(47)	(54)	(49)
90% C.I. Half-width	2,676	793	2,077
Emergnent Wetlands statewide	251,663	239,036	-12,627
Standard error (%)	(15)	(15)	(130)
90% C.I. Half-width	61,685	59,231	28,838
Lake Plains	93,048	77,947	-15,101
Standard error (%)	(28)	(24)	(57)
90% C.I. Half-width	43,954	31,886	14,603
Appalachian Highlands	66,838	51,531	-15,307
Standard error (%)	(26)	(28)	(36)
90% C.I. Half-width	30,447	24,749	9,459
Adirondacks	69,711	88,286	+18,575
Standard error (%)	(21)	(25)	(70)
90% C.I. Half-width	28,994	43,536	25,314
Hudson Valley	20,375	19,554	-821
Standard error (%)	(67)	(68)	(110)
90% C.I. Half-width	25,535	24,608	1,675
Coastal Lowlands	1,692	1,718	+27
Standard error (%)	(49)	(48)	(558)
90% C.I. Half-width	1,785	1,761	316
Open Water Wetlands statewide	105,572	123,944	+18,372
Standard error (%)	(21)	(18)	(33)
90% C.I. Half-width	41,291	40,139	10,156
Lake Plains	20,801	32,485	+11,684
Standard error (%)	(21)	(19)	(37)
90% C.I. Half-width	7,259	10,562	7,339
Appalachian Highlands	28,982	35,754	+6,771
Standard error (%)	(23)	(19)	(47)
90% C.I. Half-width	11,720	11,666	5,496
Adirondacks	42,983	41,007	-1,976
Standard error (%)	(48)	(48)	(142)
90% C.I. Half-width	39,893	38,275	5,436
Hudson Valley	8,007	9,496	+1,489
Standard error (%)	(31)	(27)	(63)
90% C.I. Half-width	4,599	4,705	1,751
Coastal Lowlands	4,798	5,202	+404
Standard error (%)	(52)	(47)	(56)
90% C.I. Half-width	5,309	5,262	480

Table No. 6. Relative Sizes and Percentages of Wetlands in Ecozones, with Changes in Covertype According to Ecological Zone

Ecozone	% of State's Land Area	% of State's Wetlands	% of Wetland Gains	% of Wetland Losses	% of Change in Covertype
Lake Plain	23.1%	39.3%	70.2%	47.4%	43.2%
Appalachian Highlands	38.2%	18.6%	20.3%	25.6%	29.1%
Adirondacks	23.4%	34.1%	4.8%	5.5%	22.8%
Hudson Valley	12.4%	7.1%	3.9%	20.4%	3.4%
Coastal Lowlands	2.9%	0.9%	0.9%	1.1%	1.5%

Table No. 7. Gains, Losses, and Changes in Covertype by Cause of Change According to Ecological Zone

ECOLOGICAL ZONE	Cause of change	Gains in Wetlands		Losses in Wetlands		Change in Covertype	
		Acres Gained	% of Ecoregion Gains	Acres Lost	% of Ecoregion Losses	Acres Cover Change	% of Ecoregion changes in covertype
LAKE PLAIN	aggregate mining	65	0.2%	1,732	16.9%	18	0.0%
	agriculture	21,792	79.2%	3,850	37.5%	947	1.4%
	beaver activity	80	0.3%			783	1.2%
	linear development	20	0.1%	280	2.7%	450	0.7%
	modified hydrology	5,569	20.2%	35	0.3%	5,730	8.8%
	plant succession					57,472	87.8%
	urbanization			4,362	42.5%	90	0.1%
APPALACHIAN HIGHLANDS	aggregate mining			170	0.8%	0	
	agriculture	3,364	42.2%	4,824	87.0%	1,128	2.6%
	beaver activity	35	0.4%			3,773	8.6%
	linear development			171	3.1%	0	
	modified hydrology	4,568	57.3%	13	0.2%	5,129	11.7%
	plant succession					33,990	77.2%
	urbanization			366	1.7%	0	
ADIRONDACKS	aggregate mining						
	agriculture	881	46.0%	732	61.4%	156	0.5%
	beaver activity	25	1.3%			3,005	8.7%
	linear development			158	13.3%	0	
	modified hydrology	1,010	52.7%			3,621	10.5%
	plant succession					27,695	80.3%
	urbanization			303	25.4%	0	
HUDSON VALLEY	aggregate mining					0	
	agriculture	762	50.3%	1,447	32.7%	168	3.3%
	beaver activity					458	8.9%
	linear development			359	8.1%	15	0.3%
	modified hydrology	672	44.3%			1,578	30.7%
	plant succession	82	5.4%		0.0%	2,866	55.7%
	urbanization			2,612	59.1%	58	1.1%
COASTAL PLAIN	aggregate mining	186	52.6%	121	48.9%	0	
	agriculture	147	41.4%			0	
	beaver activity					0	
	linear development	8	2.3%	3	1.3%	0	
	modified hydrology	13	3.7%			320	13.7%
	plant succession					2,009	86.3%
	urbanization			123	49.8%	0	

Table No. 8. Summary of Gains, Losses, and Changes in Covertype by Cause of Change

Cause of change	Gains in Wetlands		Losses in Wetlands		Change in Covertype	
	Acreage	Percent of All Gains	Acreage	Percent of All Losses	Acreage	Percent of All Changes
Aggregate Mining	252	0.6%	2,023	9.3%	18	0.0%
Standard error (%)	(53)		(37)		(64)	
90% C.I. Half-width	268		1,248		19	
Agriculture	26,945	68.6%	10,853	50.1%	2,399	1.6%
Standard error (%)	(23)		(19)		(35)	
90% C.I. Half-width	10,568		3,553		1,412	
Beaver Activity	140	0.4%	0	0.0%	8,020	5.3%
Standard error (%)	(45)		(0)		(38)	
90% C.I. Half-width	104		0		5,307	
Linear Development	28	0.1%	971	4.5%	465	0.3%
Standard error (%)	(75)		(27)		(79)	
90% C.I. Half-width	36		447		621	
Modified Hydrology	11,832	30.1%	48	0.2%	16,378	10.8%
Standard error (%)	(41)		(76)		(21)	
90% C.I. Half-width	8,219		62		5,621	
Plant Succession	82	0.2%	0	0.0%	124,032	81.9%
Standard error (%)	(99)		(0)		(14)	
90% C.I. Half-width	151		0		29,408	
Urbanization	0	0.0%	7,766	35.9%	148	0.1%
Standard error (%)	(0)		(43)		(62)	
90% C.I. Half-width	0		5,668		156	
Total	39,280		21,661		151,460	

Table No. 9. Changes in the Wetlands Resources in New York State from Agriculture

Ecozone - Wetland Size	Gains in Wetland Acreage	Losses in Wetland Acreage	Changes in Wetland Covertype
Lake Plains all wetlands	21,792	3,850	939
S.E. (%)	(29)	(28)	(74)
90% C.I. Half-width	10,623	1,795	1,169
wetlands >= 12.4 acres	10,546	2,102	685
S.E. (%)	(49)	(42)	(100)
90% C.I. Half-width	8,686	1,475	1,158
wetlands < 12.4 acres	11,246	1,748	262
S.E. (%)	(20)	(26)	(53)
90% C.I. Half-width	3,751	781	236
Appalachian Highlands all wetlands	3,364	4,824	1,128
S.E. (%)	(26)	(34)	(41)
90% C.I. Half-width	1,529	2,812	809
wetlands >= 12.4 acres	404	1,783	335
S.E. (%)	(93)	(42)	(100)
90% C.I. Half-width	651	1,309	581
wetlands < 12.4 acres	2,960	3,041	793
S.E. (%)	(28)	(41)	(46)
90% C.I. Half-width	1,454	2,166	637
Adirondacks all wetlands	881	732	156
S.E. (%)	(31)	(78)	(100)
90% C.I. Half-width	529	1,106	302

wetlands >= 12.4 acres	0	157	0
S.E. (%)	(0)	(99)	
90% C.I. Half-width	0	303	0
wetlands < 12.4 acres	829	574	156
S.E. (%)	(35)	(100)	(100)
90% C.I. Half-width	559	1,116	302
Hudson Valley all wetlands	762	1,447	168
S.E. (%)	(45)	(48)	(66)
90% C.I. Half-width	642	1,285	207
wetlands >= 12.4 acres	426	691	0
S.E. (%)	(44)	(51)	(0)
90% C.I. Half-width	347	658	0
wetlands < 12.4 acres	336	756	168
S.E. (%)	(58)	(50)	(66)
90% C.I. Half-width	362	698	207
Coastal Lowlands all wetlands	147	0	0
S.E. (%)	(46)		
90% C.I. Half-width	143	0	0
wetlands >= 12.4 acres	0	0	0
S.E. (%)			
90% C.I. Half-width	0	0	0
wetlands < 12.4 acres	147	0	0
S.E. (%)	(46)		
90% C.I. Half-width	143	0	0
Statewide all wetlands	26,945	10,853	2,390

S.E. (%)	(23)	(19)	(35)
90% C.I. Half-width	10,568	3,553	1,412
wetlands >= 12.4 acres	10,950	4,733	1,020
S.E. (%)	(46)	(25)	(74)
90% C.I. Half-width	8,572	2,009	1,261
wetlands < 12.4 acres	15,943	6,120	1,378
S.E. (%)	(15)	(24)	(31)
90% C.I. Half-width	3,995	2,519	735

Table No. 10. Changes in the Wetlands Resources in New York State from Urbanization

Ecozone - Wetland Size	Gains in Wetland Acreage	Losses in Wetland Acreage	Changes in Wetland Covertype
Lake Plains all wetlands	0	4,362	90
S.E. (%)		(62)	(81)
90% C.I. Half-width		4,586	124
wetlands >= 12.4 acres	0	3,665	90
S.E. (%)		(63)	(81)
90% C.I. Half-width		3,911	124
wetlands < 12.4 acres	0	697	0
S.E. (%)		(60)	
90% C.I. Half-width		706	0
Appalachian Highlands all wetlands	0	366	0
S.E. (%)		(71)	
90% C.I. Half-width		448	0
wetlands >= 12.4 acres	0	0	0
S.E. (%)		(0)	
90% C.I. Half-width		0	0
wetlands < 12.4 acres	0	366	0
S.E. (%)		(71)	
90% C.I. Half-width		448	0
Adirondacks all wetlands	0	303	0

S.E. (%)		(66)	
90% C.I. Half-width		389	0
wetlands >= 12.4 acres	0	123	0
S.E. (%)		(100)	
90% C.I. Half-width		240	0
wetlands < 12.4 acres	0	179	0
S.E. (%)		(100)	
90% C.I. Half-width		348	0
Hudson Valley all wetlands	0	2,612	58
S.E. (%)		(78)	(100)
90% C.I. Half-width		3,767	107
wetlands >= 12.4 acres	0	1,049	58
S.E. (%)		(81)	(100)
90% C.I. Half-width		1,586	107
wetlands < 12.4 acres	0	1,563	0
S.E. (%)		(75)	
90% C.I. Half-width		2,187	0
Coastal Lowlands all wetlands	0	123	0
S.E. (%)		(100)	
90% C.I. Half-width		262	0
wetlands >= 12.4 acres	0	36	0
S.E. (%)		(100)	

90% C.I. Half-width		77	0
wetlands < 12.4 acres	0	87	0
S.E. (%)		(100)	
90% C.I. Half-width		185	0
Statewide all wetlands	0	7,766	148
S.E. (%)		(43)	(62)
90% C.I. Half-width		5,668	156
wetlands >= 12.4 acres	0	4,874	148
S.E. (%)		(50)	(62)
90% C.I. Half-width		4,091	156
wetlands < 12.4 acres	0	2,892	0
S.E. (%)		(44)	
90% C.I. Half-width		2,295	

Table No. 11. Changes in the Wetlands Resources in New York State from Linear Development

Ecozone - Wetland Size	Gains in Wetland Acreage	Losses in Wetland Acreage	Changes in Wetland Covertype
Lake Plains all wetlands	20	280	450
S.E. (%)	(100)	(34)	(83)
90% C.I. Half-width	34	159	631
wetlands >= 12.4 acres	0	194	427
S.E. (%)		(40)	(87)
90% C.I. Half-width	0	132	624
wetlands < 12.4 acres	20	86	23
S.E. (%)	(100)	(42)	(100)
90% C.I. Half-width	34	61	39
Appalachian Highlands all wetlands	0	171	0
S.E. (%)		(78)	
90% C.I. Half-width	0	232	0
wetlands >= 12.4 acres	0	0	0
S.E. (%)			
90% C.I. Half-width	0	0	0
wetlands < 12.4 acres	0	171	0
S.E. (%)		(78)	
90% C.I. Half-width	0	232	0
Adirondacks all wetlands	0	158	0

S.E. (%)		(65)	
90% C.I. Half-width	0	199	0
wetlands >= 12.4 acres	0	82	0
S.E. (%)		(100)	
90% C.I. Half-width	0	160	0
wetlands < 12.4 acres	0	76	0
S.E. (%)		(100)	
90% C.I. Half-width	0	147	0
Hudson Valley all wetlands	0	359	15
S.E. (%)		(51)	(100)
90% C.I. Half-width	0	339	28
wetlands >= 12.4 acres	0	93	0
S.E. (%)		(78)	(0)
90% C.I. Half-width	0	134	0
wetlands < 12.4 acres	0	266	15
S.E. (%)		(59)	(100)
90% C.I. Half-width	0	290	28
Coastal Lowlands all wetlands	8	3	0
S.E. (%)	(100)	(100)	(0)
90% C.I. Half-width	17	7	0
wetlands >= 12.4 acres	0	0	0
S.E. (%)			

90% C.I. Half-width	0	0	0
wetlands < 12.4 acres	8	3	0
S.E. (%)	(100)	(100)	
90% C.I. Half-width	17	7	0
Statewide all wetlands	28	971	465
S.E. (%)	(75)	(27)	(79)
90% C.I. Half-width	36	447	621
wetlands >= 12.4 acres	0	369	427
S.E. (%)		(36)	(85)
90% C.I. Half-width		227	614
wetlands < 12.4 acres	28	602	38
S.E. (%)	(75)	(37)	(71)
90% C.I. Half-width	36	376	46

Table No. 12. Changes in the Wetlands Resources in New York State from Aggregate Mining

Ecozone - Wetland Size	Gains in Wetland Acreage	Losses in Wetland Acreage	Changes in Wetland Covertype
Lake Plains all wetlands	65	1,732	18
S.E. (%)	(69)	(42)	(65)
90% C.I. Half-width	76	1,223	20
wetlands >= 12.4 acres	0	1,347	18
S.E. (%)	(0)	(51)	(65)
90% C.I. Half-width	0	1,164	20
wetlands < 12.4 acres	65	385	0
S.E. (%)	(69)	(41)	
90% C.I. Half-width	76	266	0
Appalachian Highlands all wetlands	0	170	0
S.E. (%)		(100)	
90% C.I. Half-width	0	295	0
wetlands >= 12.4 acres	0	170	0
S.E. (%)	(0)	(100)	
90% C.I. Half-width	0	295	0
wetlands < 12.4 acres	0	0	0
S.E. (%)	(0)		
90% C.I. Half-width	0	0	0
Adirondacks all wetlands	0	0	0

S.E. (%)			
90% C.I. Half-width	0	0	0
wetlands >= 12.4 acres	0	0	0
S.E. (%)			
90% C.I. Half-width	0	0	0
wetlands < 12.4 acres	0	0	0
S.E. (%)			
90% C.I. Half-width	0	0	0
Hudson Valley all wetlands	0	0	0
S.E. (%)			
90% C.I. Half-width	0	0	0
wetlands >= 12.4 acres	0	0	0
S.E. (%)			
90% C.I. Half-width	0	0	0
wetlands < 12.4 acres	0	0	0
S.E. (%)			
90% C.I. Half-width	0	0	0
Coastal Lowlands all wetlands	186	121	0
S.E. (%)	(69)	(100)	
90% C.I. Half-width	276	257	0
wetlands >= 12.4 acres	0	0	0
S.E. (%)			

90% C.I. Half-width	0	0	0
wetlands < 12.4 acres	186	121	0
S.E. (%)	(69)	(100)	
90% C.I. Half-width	276	257	0
Statewide all wetlands	252	2,023	18
S.E. (%)	(53)	(37)	(64)
90% C.I. Half-width	268	1,248	19
wetlands >= 12.4 acres	0	1,517	18
S.E. (%)	(0)	(46)	(64)
90% C.I. Half-width		1,177	19
wetlands < 12.4 acres	252	506	0
S.E. (%)	(53)	(38)	
90% C.I. Half-width	268	333	

Table No. 13. Changes in the Wetlands Resources in New York State from Modified Hydrology

Ecozone - Wetland Size	Gains in Wetland Acreage	Losses in Wetland Acreage	Changes in Wetland Covertype
Lake Plains all wetlands	5,569	35	5,730
S.E. (%)	(66)	(100)	(37)
90% C.I. Half-width	6,186	59	3,587
wetlands >= 12.4 acres	288	0	2,680
S.E. (%)	(98)		(34)
90% C.I. Half-width	480	0	1,527
wetlands < 12.4 acres	5,281	35	3,050
S.E. (%)	(68)	(100)	(46)
90% C.I. Half-width	6,112	59	2,359
Appalachian Highlands all wetlands	4,568	13	5,129
S.E. (%)	(71)	(100)	(41)
90% C.I. Half-width	5,661	23	3,641
wetlands >= 12.4 acres	0	0	4,404
S.E. (%)			(48)
90% C.I. Half-width	0	0	3,633
wetlands < 12.4 acres	4,568	13	725
S.E. (%)	(71)	(100)	(46)
90% C.I. Half-width	5,661	23	578
Adirondacks all wetlands	1,010	0	3,621

S.E. (%)	(70)		(39)
90% C.I. Half-width	1,364	0	2,775
wetlands >= 12.4 acres	21	0	1,510
S.E. (%)	(100)		(59)
90% C.I. Half-width	41	0	1,718
wetlands < 12.4 acres	990	0	2,111
S.E. (%)	(70)		(65)
90% C.I. Half-width	1,356	0	2,656
Hudson Valley all wetlands	672	0	1,578
S.E. (%)	(57)		(47)
90% C.I. Half-width	718	0	1,369
wetlands >= 12.4 acres	0	0	368
S.E. (%)			(49)
90% C.I. Half-width	0	0	333
wetlands < 12.4 acres	672	0	1,210
S.E. (%)	(57)		(54)
90% C.I. Half-width	718	0	1,221
Coastal Lowlands all wetlands	13	0	320
S.E. (%)	(93)		(57)
90% C.I. Half-width	26	0	388
wetlands >= 12.4 acres	0	0	103
S.E. (%)			(61)

90% C.I. Half-width	0	0	134
wetlands < 12.4 acres	13	0	217
S.E. (%)	(93)		(64)
90% C.I. Half-width	26	0	295
Statewide all wetlands	11,832	48	16,378
S.E. (%)	(41)	(76)	(21)
90% C.I. Half-width	8,219	62	5,621
wetlands >= 12.4 acres	309	0	9,065
S.E. (%)	(90)		(27)
90% C.I. Half-width	474		4,132
wetlands < 12.4 acres	11,524	48	7,313
S.E. (%)	(42)	(76)	(28)
90% C.I. Half-width	8,165	62	3,531

Table No. 14. Changes in the Wetlands Resources in New York State from Beaver Activity

Ecozone - Wetland Size	Gains in Wetland Acreage	Losses in Wetland Acreage	Changes in Wetland Covertype
Lake Plains all wetlands	80	0	783
S.E. (%)	(58)		(69)
90% C.I. Half-width	78		910
wetlands >= 12.4 acres	0	0	783
S.E. (%)			(69)
90% C.I. Half-width	0		910
wetlands < 12.4 acres	80	0	0
S.E. (%)	(58)		
90% C.I. Half-width	78		0
Appalachian Highlands all wetlands	35	0	3,773
S.E. (%)	(100)		(55)
90% C.I. Half-width	60		3,587
wetlands >= 12.4 acres	0	0	2,360
S.E. (%)			(70)
90% C.I. Half-width	0		2,883
wetlands < 12.4 acres	35	0	1,414
S.E. (%)	(100)		(80)
90% C.I. Half-width	60		1,951
Adirondacks all wetlands	25	0	3,005

S.E. (%)	(100)		(73)
90% C.I. Half-width	49		4,261
wetlands >= 12.4 acres	0	0	2,688
S.E. (%)			(71)
90% C.I. Half-width	0		3,696
wetlands < 12.4 acres	25	0	317
S.E. (%)	(100)		(100)
90% C.I. Half-width	49		616
Hudson Valley all wetlands	0	0	458
S.E. (%)			(67)
90% C.I. Half-width	0		575
wetlands >= 12.4 acres	0	0	270
S.E. (%)			(100)
90% C.I. Half-width	0		502
wetlands < 12.4 acres	0	0	188
S.E. (%)			(100)
90% C.I. Half-width	0		351
Coastal Lowlands all wetlands	0	0	0
S.E. (%)			
90% C.I. Half-width	0		0
wetlands >= 12.4 acres	0	0	0
S.E. (%)			

90% C.I. Half-width	0		0
wetlands < 12.4 acres	0	0	0
S.E. (%)			
90% C.I. Half-width	0		0
Statewide all wetlands	140	0	8,020
S.E. (%)	(45)		(38)
90% C.I. Half-width	104		5,307
wetlands >= 12.4 acres	0	0	6,101
S.E. (%)			(42)
90% C.I. Half-width			4,493
wetlands < 12.4 acres	140	0	1,919
S.E. (%)	(45)		(61)
90% C.I. Half-width	105		2,020

Table No. 15. Changes in the Wetlands Resources in New York State from Succession

Ecozone - Wetland Size	Gains in Wetland Acreage	Losses in Wetland Acreage	Changes in Wetland Covertype
Lake Plains all wetlands	0		57,472
S.E. (%)			(23)
90% C.I. Half-width	0		22,200
wetlands >= 12.4 acres	0		47,919
S.E. (%)			(25)
90% C.I. Half-width	0		20,336
wetlands < 12.4 acres	0		9,553
S.E. (%)			(25)
90% C.I. Half-width	0		4,021
Appalachian Highlands all wetlands	0		33,990
S.E. (%)			(17)
90% C.I. Half-width	0		10,306
wetlands >= 12.4 acres	0		16,726
S.E. (%)			(33)
90% C.I. Half-width	0		9,713
wetlands < 12.4 acres	0		17,264
S.E. (%)			(22)
90% C.I. Half-width	0		6,445
Adirondacks all wetlands	0		27,695

S.E. (%)			(36)
90% C.I. Half-width	0		19,392
wetlands >= 12.4 acres	0		23,019
S.E. (%)			(32)
90% C.I. Half-width	0		14,290
wetlands < 12.4 acres	0		4,677
S.E. (%)			(67)
90% C.I. Half-width	0		6,044
Hudson Valley all wetlands	82		2,866
S.E. (%)	(100)		(56)
90% C.I. Half-width	152		2,981
wetlands >= 12.4 acres	82		1,236
S.E. (%)	(100)		(76)
90% C.I. Half-width	152		1,737
wetlands < 12.4 acres	0		1,630
S.E. (%)			(42)
90% C.I. Half-width	0		1,288
Coastal Lowlands all wetlands	0		2,009
S.E. (%)			(46)
90% C.I. Half-width	0		1,991
wetlands >= 12.4 acres	0		895
S.E. (%)			(51)

90% C.I. Half-width	0		982
wetlands < 12.4 acres	0		1,114
S.E. (%)			(43)
90% C.I. Half-width	0		1,020
Statewide all wetlands	82		124,032
S.E. (%)	(99)		(14)
90% C.I. Half-width	151		29,408
wetlands >= 12.4 acres	82		89,794
S.E. (%)	(99)		(17)
90% C.I. Half-width	151		25,220
wetlands < 12.4 acres	0		34,238
S.E. (%)			(16)
90% C.I. Half-width			9,181

Table No. 16. Changes in the Wetlands Resources in New York State from All Causes

Ecozone - Wetland Size	Gains in Wetland Acreage	Losses in Wetland Acreage	Changes in Wetland Covertype
Lake Plains all wetlands	27,528	10,259	65,490
S.E. (%)	(26)	(30)	(20)
90% C.I. Half-width	11,867	5,142	22,050
wetlands >= 12.4 acres	10,835	7,308	52,602
S.E. (%)	(47)	(36)	(23)
90% C.I. Half-width	8,669	4,502	20,082
wetlands < 12.4 acres	16,693	2,951	12,888
S.E. (%)	(24)	(20)	(23)
90% C.I. Half-width	6,677	1,010	5,086
Appalachian Highlands all wetlands	7,966	5,544	44,021
S.E. (%)	(41)	(33)	(13)
90% C.I. Half-width	5,704	3,185	10,158
wetlands >= 12.4 acres	404	1,953	23,825
S.E. (%)	(93)	(44)	(25)
90% C.I. Half-width	651	1,504	10,383
wetlands < 12.4 acres	7,563	3,591	20,196
S.E. (%)	(44)	(37)	(19)
90% C.I. Half-width	5,738	2,314	6,794
Adirondacks all wetlands	1,916	1,192	34,477

S.E. (%)	(41)	(71)	(37)
90% C.I. Half-width	1,478	1,647	24,898
wetlands >= 12.4 acres	21	363	27,217
S.E. (%)	(41)	(100)	(32)
90% C.I. Half-width	1,478	702	16,825
wetlands < 12.4 acres	1,895	830	7,260
S.E. (%)	(100)	(100)	(66)
90% C.I. Half-width	41	1,612	9,248
Hudson Valley all wetlands	1,516	4,418	5,143
S.E. (%)	(31)	(57)	(43)
90% C.I. Half-width	866	4,710	4,101
wetlands >= 12.4 acres	82	1,833	1,932
S.E. (%)	(100)	(60)	(54)
90% C.I. Half-width	152	2,030	1,953
wetlands < 12.4 acres	1,434	2,585	3,211
S.E. (%)	(32)	(56)	(38)
90% C.I. Half-width	864	2,700	2,261
Coastal Lowlands all wetlands	354	247	2,329
S.E. (%)	(55)	(61)	(46)
90% C.I. Half-width	417	322	2,274
wetlands >= 12.4 acres	0	36	997
S.E. (%)		(100)	(52)

90% C.I. Half-width	0	77	1,112
wetlands < 12.4 acres	354	211	1,332
S.E. (%)	(55)	(62)	(42)
90% C.I. Half-width	417	280	1,204
Statewide all wetlands	39,280	21,661	151,460
S.E. (%)	(20)	(20)	(13)
90% C.I. Half-width	12,904	7,373	32,714
wetlands >= 12.4 acres	11,341	11,493	106,573
S.E. (%)	(45)	(26)	(15)
90% C.I. Half-width	9,815	5,002	26,494
wetlands < 12.4 acres	27,888	10,168	44,887
S.E. (%)	(19)	(22)	(15)
90% C.I. Half-width	10,036	3,747	11,888

Table No. 17.	Changes in Wetlands by Ecozone and Size of Wetland										
Ecological Zone		percent of wetlands	Gains			Losses			Net Change		
			>=12.4	<12.4	Total	>= 12.4	<12.4	Total	>=12.4	<12.4	Total
Lake Plains	acres	86.1%	10,835	16,693	27,528	7,308	2,951	10,259	3,527	13,742	17,269
	percent		39.4%	60.6%		71.2%	28.8%				
Appalachians	acres	67.2%	404	7,563	7,966	1,953	3,591	5,544	-1,549	3,971	2,422
	percent		5.1%	94.9%		35.2%	64.8%				
Adirondacks	acres	85.0%	21	1,895	1,916	363	830	1,192	-342	1,065	724
	percent		1.1%	98.9%		30.4%	69.6%				
Hudson Valley	acres	58.8%	82	1,434	1,516	1,833	2,585	4,418	-1,751	-1,151	-2,902
	percent		5.4%	94.6%		41.5%	58.5%				
Coastal Lowlands	acres	60.0%	0	354	354	36	211	247	-36	144	107
	percent		0.0%	100.0%		14.7%	85.3%				
State Total	acres	80.0%	11,341	27,939	39,280	11,493	10,168	21,661	-152	17,771	17,619
	percent		28.9%	71.1%		53.1%	46.9%				

Table No. 18. Distribution of Losses According to Cause and Size of Wetlands (condensed from Tables 9-13)						
Cause of Loss	Wetlands >=12.4		Wetlands <12.4		Total Wetlands	
	acres	% in wetlands >= 12.4	acres	% in wetlands < 12.4	acres	% of losses
Aggregate Mining	1,517	13.2	506	5.0	2,023	9.3
Agriculture	4,733	41.2	6,120	60.2	10,853	50.1
Linear Development	369	3.2	602	5.9	971	4.5
Urbanization	4,874	42.4	2,892	28.4	7,766	35.9
Modified Hydrology	0	0.0	48	0.5	48	0.2
Total	11,493		10,168		21,661	

APPENDICES

APPENDIX 1. SURVEY PROCEDURES

Study Design

The study consisted of five main elements: (1) sample site selection; (2) aerial photography acquisition and interpretation; (3) ground truthing; (4) map generation and comparison, and data analysis; and (5) report preparation.[3]

Definition of Wetlands

In general terms, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. The single feature that most wetlands share is soil or substrate that is at least periodically saturated with or covered by water. The water creates severe physiological problems for all plants and animals except those that are adapted for life in water or in saturated soil. Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this study, wetlands are defined as those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Sample Site Selection

The study was based on a stratified random sample of wetlands from two time periods: 1985± 1 year, and 1995± 1 year. It required locating aerial photography of suitable chroma, quality, scale and season to meet the criteria of the project goal. The Department of Environmental Conservation (DEC) was consulted throughout the performance of the project so they could approve the statistical sampling, the methodology for determining status and trends, and aerial photography selected for the project. Results from the early stages of the pilot study indicated that photographs from the National High Altitude Photography (NHAP) program were available for the designated time periods and provide a suitable photobase.

In addition to its primary objectives, the study was intended to conform to the following accuracy requirements:

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[3] This study is designed to be a quantitative measure of the areal extent of wetlands in New York. It will provide no indication of wetland quality (function or value) outside of the diminishing area (acreage) of wetlands, by category.

1. The maps showing the wetland boundaries for the two time periods (mid-1980's and mid-1990's) would meet national map accuracy standards (see Appendix 2); no more than 10 percent of the points can deviate by more than 40 feet from true position.

2. The study would evaluate, depending on available funds, randomly selected quarter portions of 5-10 percent of New York, an estimated 49 to 97 quads.

3. The resulting data would be processed so the state-wide estimate of change in wetland acreage between the mid-1980's and the mid-1990's would be as precise as possible.

The design for the study consisted of a stratified random sample, using 1:24,000 U.S. Geological Survey (USGS) topographic quadrangle (quad) maps as the basic sampling unit There are 968 USGS quads in New York. A total of 69 quadrangles (7.1 percent) were used in the study.

The sampling rationale and protocol are as follows:

1) Each of the ecozones in New York, as defined in Dickinson (1983) and Will et. al. (1982), was analyzed, using the acreages reported in O'Connor and Cole (1989), and other appropriate sources, to determine the best estimate of that ecozone's proportional contribution of freshwater wetland acreage to the total freshwater wetland acreage in New York. These 12 ecozones were aggregated to five larger ecozones prior to the final analysis when it became apparent that some smaller ecozones were similar with respect to wetland types, landscape feature, and general characteristics, and that sample sizes in those smaller ecozones were insufficient to render statistically significant or meaningful results by themselves (Figure 1).

2) In order to allocate samples based upon population size (i.e., acres of wetlands) within an ecozone, each ecozone's proportional contribution of freshwater wetland acreage[4] was multiplied by 49 (5 percent of the total number of USGS Quads in New York), to determine the number of sample quads as a goal to sample for that ecozone.

3) Sample quads were selected in each ecozone by digitally overlaying the USGS quad map on the ecozone and assigning sequential numbers to the quads, starting in the upper left (northwest) corner of the ecozone and proceeding from left to right (west to east) across and down the ecozone (to the south). Using a random number generator, the assigned number of quads was selected within each ecozone. In the event more that 25 percent of a quad fell within a major area of open water not reasonably susceptible to filling (e.g., Lakes Erie, Ontario or Champlain), an additional quad was randomly selected within the same ecozone and portions of that quad (in 25-percent increments) were analyzed for wetland gains or losses.

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[4] The percent of the state's total wetland acreage in each ecological zone was estimated from DEC's mapped regulatory wetlands database.

4) To ensure adequate representation of the wetlands resource across an ecozone, the five aggregated ecological zones were subdivided to include representative sub-ecozones. Figure No.2 illustrates the 12 ecological zones used to stratify the samples within the five aggregated ecological zones. Figure Nos. 2 and 3 depicts the location of the areas selected for study.

5) Because U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) maps were used to assist in determining the general type, location and extent of wetlands in the selected quads, USGS quads initially selected by the above procedure were referenced to the appropriate NWI quads, and those quads were examined to determine if they would provide suitable wetland type, location and extent information. If it was determined that the NWI quad was not suitable (e.g., based on aerial photography too removed in time from the study period, or obvious inaccuracies in wetland mapping), another USGS quad was randomly selected and its corresponding NWI quad examined for suitability as baseline information.

Aerial Photo Acquisition and Interpretation

The study required locating mid-1980's and 1990's aerial photography of suitable chroma, quality, scale and season. Results from the early stages of the pilot study indicated that photographs from the National High Altitude Photography (NHAP) program were available for the designated time periods and provided a suitable photobase. Aerial photography interpretation was conducted using standard (Wolf 1983) and more specialized (Howard 1970) methodologies and photointerpretation guidelines established by the U.S. Fish and Wildlife Service National Wetland Inventory (1995).

Prior to beginning interpretation, the following materials were collected for each sample quad: USGS topographic maps; USDA soil survey data, as both paper maps and, where available, as vector data downloaded from the Cornell CUGIR Work Group of the Mann Library; and NWI maps. The various paper maps and aerial photographs were then scanned, photo-rectified, and geographically linked and refined. The available image data were then viewed and compared.

Photo interpretation followed rigorous guidelines developed using dual computer monitors. Initially, water drainage patterns and water bodies were digitized onto aerial photographs by visually comparing the aerial photo on one screen to the USGS contour map on the other screen, to which it was geographically linked and synchronized. The contour elevations from USGS maps were used to verify the drainages on the aerial photo. For quality control purposes, drainages and water bodies were examined again by using paired stereoscopic photographs under a mirror stereoscope. After digitizing the drainages and water bodies, the remaining different types of wetlands were digitized using dual computer monitors and geographically linked aerial photographs and maps. The geographically referenced system displayed aerial photographs on the left screen and USGS topographic contour maps, NWI maps, and soil maps on the right screen. A cursor could be used on one screen/map to simultaneously show the geographic position of that exact feature on the screen/map on the other monitor.

Map Generation and Comparison

NHAP and NAPP aerial photographs were scanned at a resolution of 300 dpi and imported into Erdas Imagine 8.3.1 and rectified using USGS 7.5-minute quadrangles as ground control. In sample areas where the topographic relief was more pronounced, USGS 7.5-minute DEMs (digital elevation models) and internal camera geometry specifications obtained from USGS were used to orthorectify the digital scans of the aerial photographs to remove distortions. This procedure resulted in digital aerial photographs with a horizontal accuracy tied to the accuracy of the USGS 7.5-minute maps used as ground control. This meets National Map Accuracy Standards (NMAS) for 1:24000 scale data with horizontal positional accuracies of approximately 40 feet, and a pixel resolution of 3.0 meters.

Wetland areas were then identified, digitized, and coded as to wetland type (i.e., trees, shrubs, emergent, or open water) on top of the digital aerial photographs using both Erdas Imagine 8.3.1 and ArcView 3.1. Vector data for identified wetlands in the sample areas were converted to the ARC/INFO GIS format for mid-1980's and mid-1990's sample periods. This allowed for a visually linked and scaled comparison of mid-1980's aerial photographs with mid-1990's aerial photographs to identify wetland changes and the causes of these changes. The GIS polygons for the two sample time periods were then combined to produce a composite GIS layer which allowed areas of change from one time period to the next to be identified.

Once the areas of change from the mid-1980's to the mid-1990's were identified, they were then coded in ArcView as to the category of change (i.e., wetland gain, wetland loss, or wetland cover type change) which occurred, and the causal factor of the change (e.g., agricultural, urban/suburban) was identified and coded. All of the sample areas falling within each New York ecozone were then projected into the New York Transverse Mercator (NYTM) projection/grid system based on the North American Datum of 1927 (NAD-27), and combined into a single GIS layer. The GIS layer for each wetland was trimmed to fit exactly within the ecozone boundaries. All acreage calculations were made from these ecozone-bounded sample areas.

As applied to the USGS 7.5-minute quadrangle topographic map, the horizontal accuracy standard requires that the positions of 90 percent of all points tested must be accurate within 1/50th of an inch (0.05 centimeters) on the map. At 1:24,000 scale, 1/50th of an inch is 40 feet (12.2 meters). The vertical accuracy standard requires that the elevation of 90 percent of all points tested must be correct within half of the contour interval. On a map with a contour interval of 10 feet, the map must correctly show 90 percent of all points tested within 5 feet (1.5 meters) of the actual elevation.

The wetlands were mapped according to the following steps:

1) The aerial photographs were visually examined to determine where wetlands might occur by their distinctive photo signature while comparing them with USGS topographic mapping, NWI mapping and soils mapping.

2) After the wetlands were digitized onto one set of aerial photographs, the photographs were re-examined under the stereoscope. The wetlands were then identified as to habitat type (open water, emergent, scrub-shrub or forested) and coded for GIS purposes.

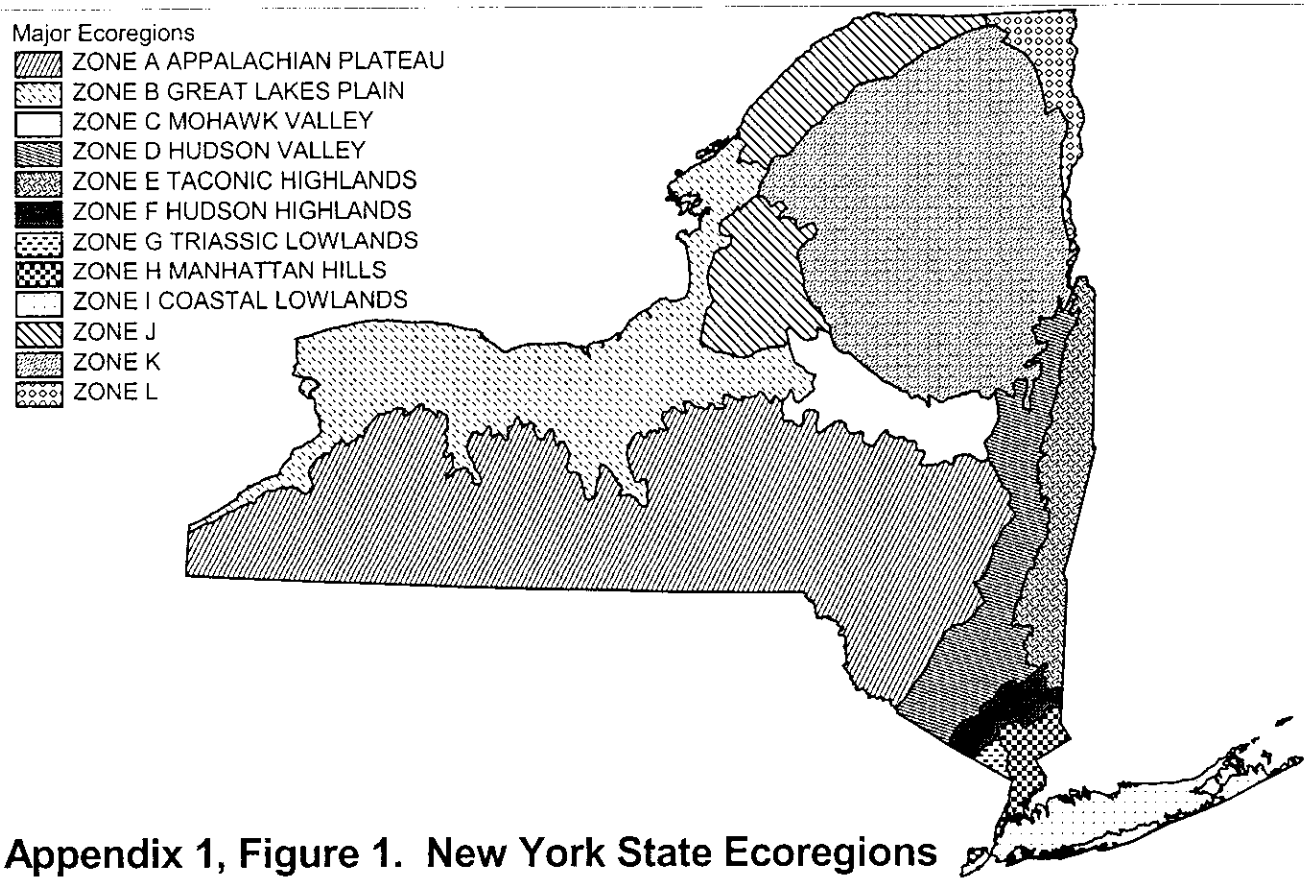
3) Once both sets of aerial photographs (1980's and 1990's) were digitized with appropriate wetland polygons and wetland category codes, the acres where habitat change from the mid- 80's to the mid-90's time frame occurred were coded for the cause of the change as follows:

   a. Urban/suburban development
   b. Linear transportation and utility projects
   c. Agriculture conversion or reversion
   d. Beaver activity
   e. Modifications in runoff
   f. Aggregate mining

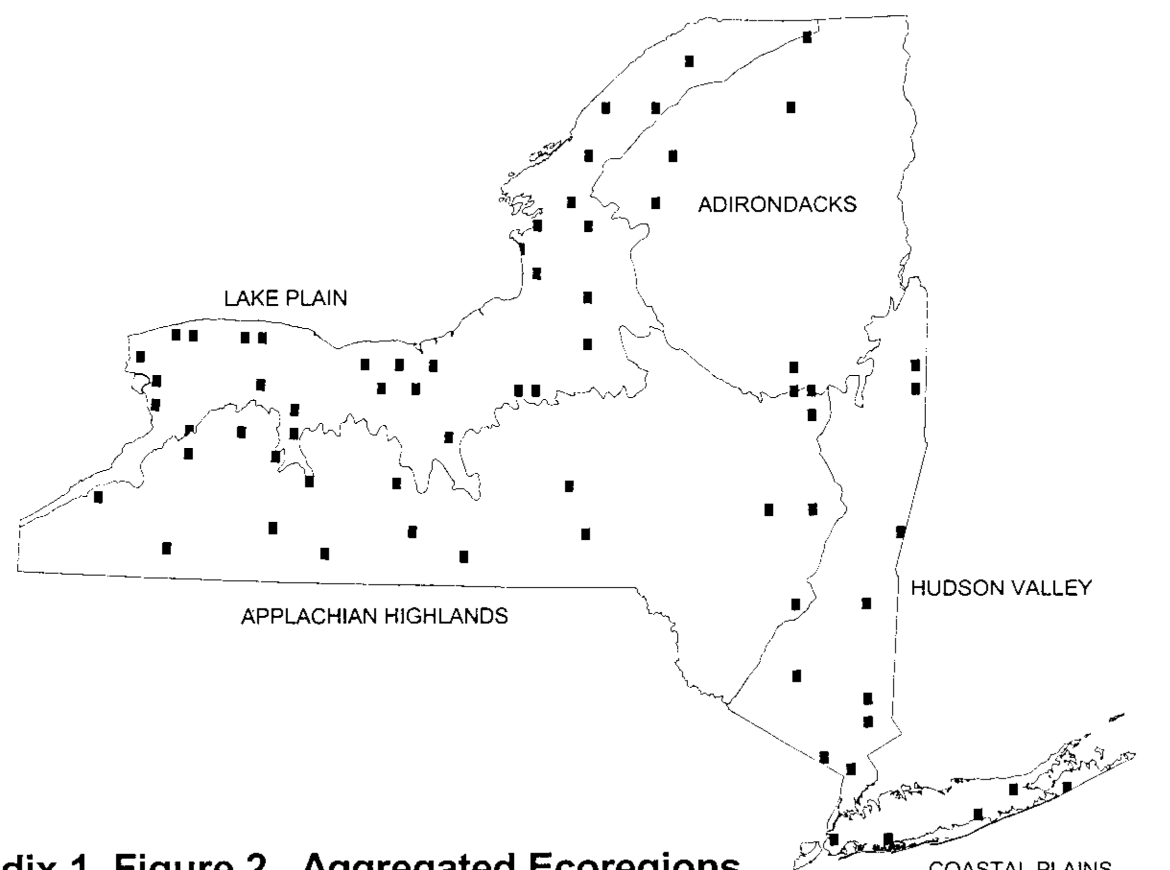
4) The cause of change data were tabulated and the appropriate graphics and tables were generated using Excel.

Ground Truthing and Other Quality Control Measures

Preliminary ground truthing was conducted to assist in developing photointerpretation keys. In addition, ground truthing was used during the study to confirm the vegetation indicators and boundaries of wetlands. A more complete listing of quality control measures is included in Appendix Table 1-1. In addition, as photo interpretation proceeded and tentative boundary lines were drawn, randomized ground truthing was conducted to determine the accuracy of photo interpretation and mapping techniques.



Appendix 1, Figure 1. New York State Ecoregions



Appendix 1, Figure 2. Aggregated Ecoregions

Appendix 1, Table 1-1. Summary of Quality Control Measures

Interpretation of Aerial Photography	1. Identify all variations in photographic tone and color, pattern, topographic location and texture. 2. Identify all variations that are likely wetlands. 3. Identify wetland areas as to habitat cover type and map as polygons. 4. Correlation (separate individual) reviews 10% of identifications made in Steps 1, 2 and 3 for accuracy. 5. Steps 1, 2 and 3 are checked by ground truthing using 1987 Corps of Engineers Methodology. 6. Mapped polygons are corrected as necessary. 7. Correlation rechecks with a 10% survey. 8. Corrections are made as necessary and final product is prepared.
Coding of Cover Type, Gains and Losses, and Cause of Change	1. Coding of cover type will be verified by ground truthing within 3 locations in each of the 4 habitat cover types found in each of the 5 ecozones. 2. Correlation re-verifies the correctness of the coding on a 10% random sample for each cover type within each ecozone. 3. Gains and losses and causes of change verified in the same ground truthing manner as for 1 and 2, above.
Digital Transfer of Data	1. Ninety percent (90%) of all map products and interpreted overlays were within the specified limits of National Map Accuracy Standards.

APPENDIX 2. United States National Map Accuracy Standards

With a view to the utmost economy and expediency in producing maps that fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, the Federal Government has defined standards of horizontal accuracy. For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as bench marks, property boundary monuments; intersections of roads and railroads; corners of large buildings or structures (or center points of small buildings). In general, what is well-defined will also be determined by what is plottable on the scale of the map within 1/100 inch. Thus, while the intersection of two roads or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would not be practicable within 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. This class would cover timber lines and soil boundaries. For reference the web site location for United States National Map Accuracy Standards is http://rmmcweb.cr.usgs.gov/public/nmpstds/nmas647.html.

APPENDIX 3. Statistical Methods and Sampling Design

The sampling design was nominally stratified-random with proportional allocation. Each mapped area was given a random number, and sampling units were chosen in order. Occasionally, aerial photos were not available and another randomly numbered area was picked. Other times, photos were available but not useable, in which case the mapped area immediately north of the chosen one was used. The resulting allocation of effort was approximately proportional to the area of each ecoregion (Table 3-1).

For purposes of estimating change in each ecoregion, we used each sampling unit as an independent estimate of the relative change, as was done by Frayer et al. (1983). The average of these individual ratios of difference to area sampled gives an estimate of the overall change, and the standard deviation of the ratios leads directly to estimates of precision.

Standard errors and confidence limits of the stratified estimates of change were calculated according to methods in Thompson (1992). To calculate the Satterthwaite adjustment to the degrees of freedom, an average sampling unit size was calculated from the overall sample and then divided into the size of each ecoregion to approximate the total possible number of sampling units per region.

An Example - Net Wetland Acreage Change from 1980s to 1990s

All the constants and statistical parameters necessary to compute the confidence limits of net wetland change are given in Table 3-1. The overall standard error of estimated wetland change between the 1980s and 1990s is 9,110 acres. The effective number of degrees of freedom is 54, such that the nominal 90% confidence limit can be calculated as 1.674 times the standard error of estimate, or ± 15,246 acres. The half-width of the confidence band is thus slightly smaller than the estimate, which by totaling the acreages of change from Table 3-1 is + 17,619 acres.

Table 3-1. **Constants and parameters used in calculating confidence limits on overall net wetland change**

Ecoregion	Area (acres)	Approximate Number of possible sampling units (N)	Sample size (n)	Estimated Change in Total Wetlands (acres)	Standard Deviation (acres)
Adirondacks	7,280,725	904	7	724	3,211
Appalachian Highlands	11,889,736	1476	19	2,422	17,323
Coastal Plains	908,205	112	5	107	657
Hudson Valley	3,853,965	478	9	-2,902	7,989
Lake Plain	7,183,848	892	33	17,269	44,899
Totals	31,116,479	3,862	73	+17,619	

Design of Future Sampling

Optimal allocation of future sampling effort was calculated as proportional to the product of the size of each ecoregion times its standard deviation, assuming the cost of sampling to be equal in all regions (Snedecor and Cochran 1967).

The high variability among sampling units in the statistical population of quadrangle maps suggests that a large increase in sampling effort would be necessary to refine the precision of the net total wetlands change estimate to a small number of acres. In simple random sampling, it takes a hundred-fold increase in effort to reduce confidence intervals to one tenth their current width. In stratified sampling, the allocation of samples can be optimized such that a given increase in effort can produce a slightly greater increase in precision. Using the ecoregion size data and the estimated standard deviations in Table 3-1, optimal allocation of the sampling units in the five ecoregions would be in the ratio 3:17:1:8:44, as given in Table 3-2. Thus, for the same effort, the number of sampling units for the Lake Plain region would increase from 33 to 44. This proportional increase reflects the combination of large size and high variance in this ecoregion. With allocation proportional to the ratios in Table 3-2, a 100-fold increase in sampling effort would reduce the width of the nominal 90% confidence interval to about ± 1400 acres, which is less than one tenth of the ± 15,246 acres calculated in this study. Such a massive sampling may not be realistic, but the width of the confidence interval could be shrunk to roughly ± 10,000 acres by only doubling the present effort.

Further increase in precision might be possible by decreasing the within-stratum variance. This would have to be done by re-stratification, such that the new strata were less heterogeneous as to trends in wetland acreage. Investigation into the feasibility of such a scheme is beyond the scope of the present study.

Table 3-2. Optimal allocation of sampling units among ecoregions rounded to nearest integer, assuming a total sample of 73

Ecoregion	Area (acres)	Approximate Number of possible sampling units (N)	Optimal sample size (n of 73)
Adirondacks	7,280,725	904	3
Appalachian Highlands	11,889,736	1476	17
Coastal Plains	908,205	112	1
Hudson Valley	3,853,965	478	8
Lake Plain	7,183,848	892	44

REFERENCES - See main text.