5. DATA ANALYSIS

The study included the development of an improved and expanded data management system, which contains a wealth of information and allows for numerous analytical opportunities that can be used to evaluate wetland mitigation performance standards (e.g. Wetland Area Achieved) and measured attainment of NJDEP's NEPPS strategic goals. As part of this study, data analysis is primarily concentrated on the use of the study indicators themselves in hopes of identifying trends that may be useful in measuring the effectiveness of existing wetland mitigation in achieving a goal of a net gain in wetland area. However, we have explored a number of additional analytical options to illustrate the capabilities of the system. The following discussion serves to illustrate the analytical capabilities of the system, but is by no means exhaustive of all the possibilities.

5.1 Compensation Ratios

NJDEP has established a NEPPS strategic goal to improve wetland quality and function and achieve a net increase in wetlands through innovative techniques for the creation, enhancement and maintenance of New Jersey wetlands. Based upon the results of this study, mitigation was found, on average, to achieve the goal of wetland area created only 45% of the time, or a ratio of 0.45 acres of wetlands created for each 1.0 acres of mitigation proposed. This result suggests that current freshwater wetland mitigation practices are not resulting in a net increase in freshwater wetlands.

Compensation ratios were evaluated to determine to what extent the existing mitigation program offsets the permitted losses to wetlands. Compensation ratios are a comparison between the amounts of mitigation proposed/achieved in relation to the amount of wetland losses permitted in a single permit action. A compensation ratio achieved in excess of 1:1 is required to attain a net increase in wetland area. It is important to note that not all permitted losses require mitigation (some general permits do not require mitigation), and as such wetland losses at a program level would be expected to be greater than this analysis suggests. Additionally, wetlands replaced through mitigation may not be of comparable ecological value to wetlands lost.

A total of 75 files contained sufficient data regarding area of wetland impacts and were therefore used to calculate proposed and achieved mitigation ratios. Impacts authorized by NJDEP for these 75 files accounted for a total of 234 acres of wetlands lost. Corresponding mitigation approved by NJDEP for these sites was 324 acres. The majority of the mitigation proposed was wetland creation. Proposed ratios ranged from 0.55:1 to 3.96:1. By comparing the area of wetland impacts authorized with the amount of wetland mitigation approved, on a site-by-site basis, the compensation ratio approved by NJDEP was calculated to be 1.80:1 (Figure 4). For each acre of impact to wetlands approved by NJDEP, on average 1.80 acres of compensatory mitigation were required.

The total wetland area achieved through mitigation on these sites was only 187 acres. Achieved ratios ranged from 0:1 to 3.96:1. By comparing the average amount of wetland mitigation required with the actual amount of wetlands achieved through mitigation, on a site-by-site basis, the actual ratio of acres of mitigation wetlands achieved to those impacted was calculated to be 0.78:1. On average, for each acre of impact to wetlands approved by NJDEP, 0.78 acres were actually achieved through mitigation, a net loss of 22%.

Average proposed and achieved mitigation ratios were calculated by comparing the area of wetland impact authorized to the area of wetland mitigation approved or achieved on a site-by-site basis, rather than a comparison of total acres authorized to total acres approved or achieved. As a simplified example, suppose a study with two mitigation sites as follows: Site A, with 3 acres wetland impacts, 6 acres proposed wetland creation (2:1 ratio), and 2 acres achieved wetland creation (0.66:1 ratio); and Site B, with 2 acres wetland impacts, 8 acres proposed wetland enhancement (4:1 ratio), and 4 acres achieved wetland enhancement (2:1 ratio). To calculate the average proposed mitigation ratio, we would take the average of 2:1 and 4:1, for an average ratio of 3:1. To calculate the average achieved mitigation ratio, we would take the average of 0.66:1 and 2:1, for an average ratio of 1.33:1. Note that these results are different from the result one would get if all impacts, proposed mitigation acres, and achieved mitigation acres were totaled and the ratio of those totals reported (for our simplified case, the results for proposed and achieved mitigation would be 2.8:1 and 1.2:1, respectively).

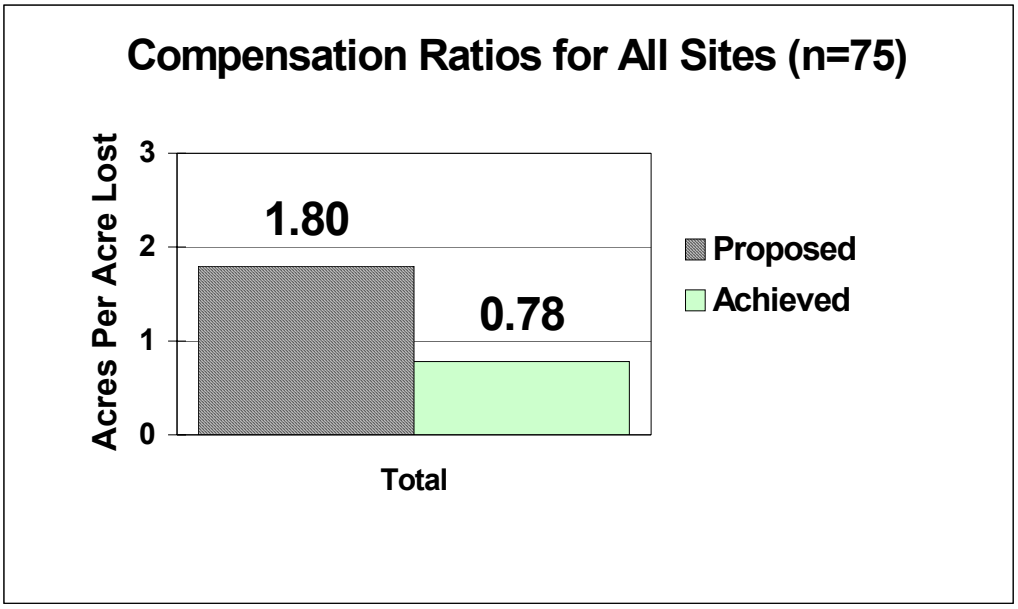

Figure 4: Comparison of Average Mitigation Compensation Ratios (Proposed vs. Achieved)

The results indicate that from 1988 to 1999 the wetland mitigation program in New Jersey resulted in a net loss in wetland area.

5.2 Replacement of Ecological Value

Within New Jersey, the NJDEP requires compensatory mitigation that is adequate to achieve the replacement of wetlands or State open waters of equal ecological value. Depending on the circumstances under which wetlands or State open waters are lost or disturbed, different types of mitigation may be acceptable. Generally, however, in-kind replacement is desirable to achieve replacement of ecological value. In-kind replacement generally refers to the creation, enhancement or restoration of the same type of wetland community (e.g. forested, scrub/shrub, emergent or open water) as that lost or disturbed by a permitted activity.

Nearly three times the area of open water was achieved through mitigation as compared with the amount proposed in mitigation plans subsequently approved by NJDEP. Open water represents 41% of all "wetlands" achieved through mitigation but only accounts for approximately 5% of the area lost or disturbed through permit action. This raises a question as to whether the requirement of replacing wetlands of equal ecological value is being met.

For purposes of this analysis we used type of wetland achieved as a surrogate for ecological value to further evaluate whether NJDEP's NEPPS goal of "improve quality and function and achieve a net increase in wetland resources" is being achieved. Table 11 provides a breakdown of compensation ratios by wetland type proposed. This analysis included only study sites that included information on the type of wetland impacted and mitigated. No credit was assigned if in excess of 100% of a particular wetland type was achieved. For example, a permittee proposed a total of 1 acre of mitigation consisting of 0.5 acres of forested wetland and 0.5 acres of open water, yet, they achieved 0.75 acres of open water only. The amount of open water proposed would therefore be applied to calculating the compensation ratio. In this case the compensation ratio achieved by type would be 0:1 for forested and 0.5:1 for open water.

Vegetation Type	**Total Impact** (ACRES)	**Total Mitigation Proposed** (ACRES)	**Proposed Compensation Ratio**	**Mitigation Area Achieved** (ACRES)	**Achieved Compensation Ratio**
Forested (n=31)	64.26	108.534	2.04	1.99	0.01
Shrub/Scrub (n=9)	6.93	9.01	2.78	2.18	0.91
Emergent (n=14)	17.63	22.74	1.85	10.54	1.29
Open Water (n=5)	4.6	4.116	1.07	0.71	0.28

Table 11: Summary of Compensation Ratios by Vegetation Type

The only wetland type where actual mitigation exceeded impacts was emergent wetlands (n=14), which achieved an average compensation ratio of 1.29:1 (Figure 5). However, this ratio still fell below the approved ratio of 1.85:1. Forested wetlands, in contrast, achieved the lowest average compensation ratio of 0.01:1. In a sample of 31 sites, of the 64 acres of forested wetland losses approved by NJDEP, 109 acres of forested wetland mitigation was proposed and only 2 acres of potential forested wetland was achieved through mitigation. Scrub/shrub wetland was found to achieve a compensation ratio of 0.91:1.

Although nearly three times the area of open water was achieved through mitigation in comparison to the amount approved by NJDEP, open water achieved a compensation ratio of only 0.28:1 based on a sample of 5 sites. This suggests that open water is being achieved in large part on sites that did not include open water in the approved mitigation plan and is therefore inconsistent with what was approved by NJDEP.

The results indicate that mitigation is not replacing wetlands in-kind and, as such, may not be adequate to replace wetland ecological values. See Photos 1 and 2 for examples of mitigation sites for which created wetland community types were inconsistent with those specified in the approved mitigation plans.

5.3 Effect of Wetland Type on Study Indicators

It was found that the type of wetland created through mitigation was generally inconsistent with the stated goals of the mitigation plan approved by NJDEP. This is particularly evident for forested wetlands. Of particular concern is that forested wetland was the most prevalent type of wetland mitigation proposed yet, only a small portion of sites resulted in potential forested wetland achieved. In contrast, although open water accounted for a very small proportion of wetland mitigation approved by NJDEP, nearly 40% of the total wetland type achieved through mitigation was open water.

The relationship between wetland type proposed and study indicators was examined to determine if wetland type proposed had any effect on the resulting study indicators. Data were analyzed for

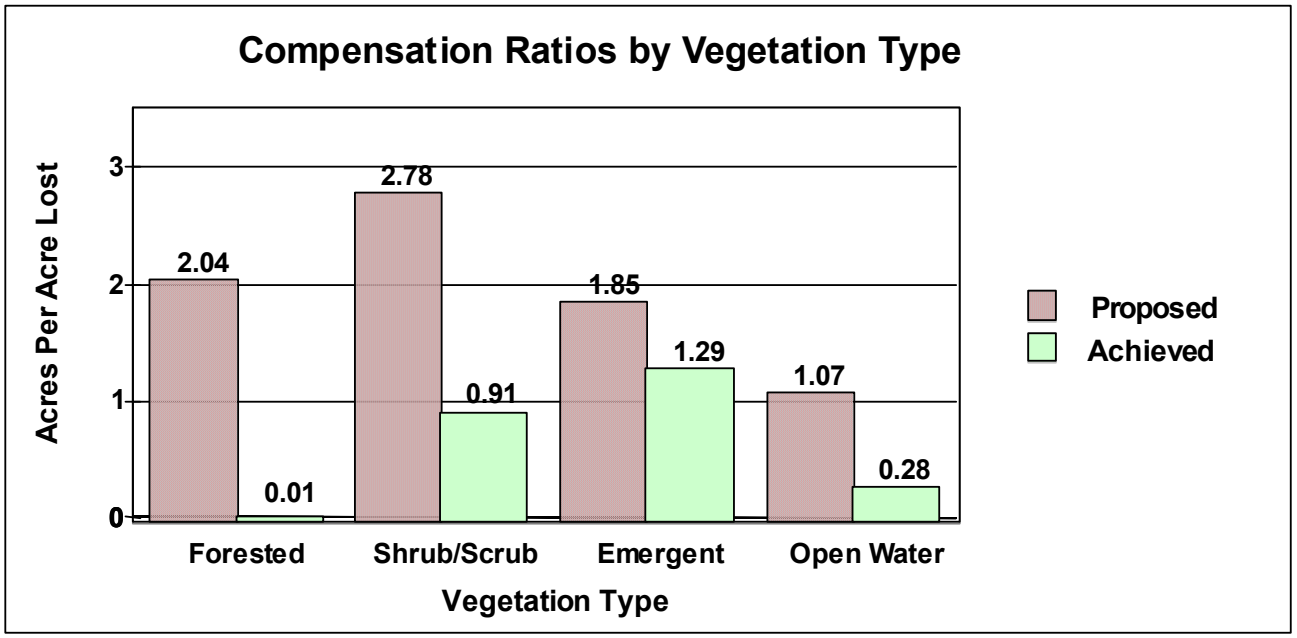

Figure 5: Comparison of Average Mitigation Compensation Ratios (Proposed vs. Achieved) by Vegetation Type

Mitigation Site ID = **123**

Wetland Achieved = **84.02%**
Concurrence Score = **37.84**
WMQA Index = **0.41**

Size (acres) = **13.20**

Wetland Type (acres)

	Impacted	Proposed	Achieved
Forest			
Shrub		2.90	0.55
Emergent		6.57	1.11
Open Water		3.73	9.42

Compensation Ratio (x:1)

Proposed	Achieved
2.09	1.75

Photo 1: Mitigation Site with Disproportionately High Amount of Open Water Created.

Although open water has many ecological benefits, it may not replace the wetland qualities lost through permitted disturbances.

Mitigation Site ID = **011**

Wetland Achieved = **36.63%**
Concurrence Score = **27.58**
WMQA Index = **0.30**

Size (acres) = **1.01**

Wetland Type (acres)

	Impacted	Proposed	Achieved
Forest	0.27		
Shrub			
Emergent	0.21	1.01	0.37
n Water			

Compensation Ratio (x:1)

Proposed	Achieved
2.11	0.77

Photo 2: Emergent Wetlands Created to Compensate for Impacts to Forested Wetlands.

In some cases, forested wetland losses are being compensated through the creation of other wetland types such as emergent wetlands.

only those study sites for which wetland type was specified in the approved mitigation plan. Figure 6 compares the average value for each study indicator based on the type of wetland proposed in the mitigation plan including forested, scrub/shrub, emergent and open water. Although statistical analysis was not performed on these data, there appears to be a reduction in all study indicators when forested wetland type is proposed.

The results of the analysis suggest that the type of wetland mitigation proposed may affect wetland mitigation status in terms of both wetland area and quality achieved through mitigation. The most prevalent mitigation type proposed, forested, has the lowest likelihood of succeeding. Open water in contrast is being created through mitigation at much greater rates than envisioned in mitigation plans approved by NJDEP.

5.4 Watershed Management Areas

New Jersey consists of 20 designated inland Watershed Management Areas (WMAs). Utilizing the spatial analysis capabilities of GIS, indicator values were plotted by WMAs (Figure 7) to determine if geographic factors may contribute to wetland mitigation status.

The highest Wetland Area Achieved was from WMA 5 (Hackensack) and WMA 7 (Elizabeth/Rahway), which each achieved in excess of 100%, although sample size was small for each (n=1). WMA 2 (Walkill) achieved the highest Concurrence score of 94% and WMA 17 (Maurice/Salem River) achieved the highest WMQA index score of 0.74. The highest overall scores were achieved in WMA 2 (Walkill) and WMA 17 (Maurice, Salem River, Cohansey). The lowest overall scores were achieved in WMA 19 (Rancocas Creek). Figure 8 shows the distribution of the number of study sites and the total area evaluated for each WMA. This study includes sites in all WMAs except WMA 1 (Upper Delaware River), WMA 4 (Lower Passaic, Saddle) and WMA 16 (Cape May). Although there was good representation among WMAs, sample size was small for some, particularly WMA 5 (Hackensack), WMA 7 (Elizabeth, Rahway, Woodbridge), WMA 14 (Mullica, Wading River), and WMA 19 (Rancocas). The majority of the study sites were located in WMA 9 (Lower Raritan), WMA 11 (Central

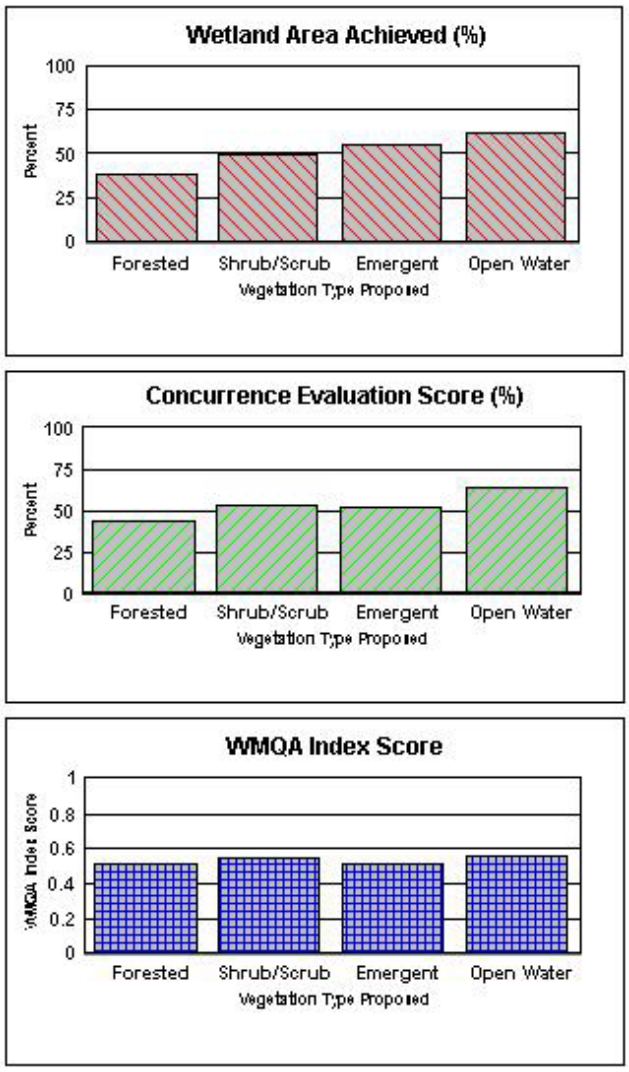

Figure 6: Changes in Study Indicators Based on Type of Wetland Mitigation Proposed

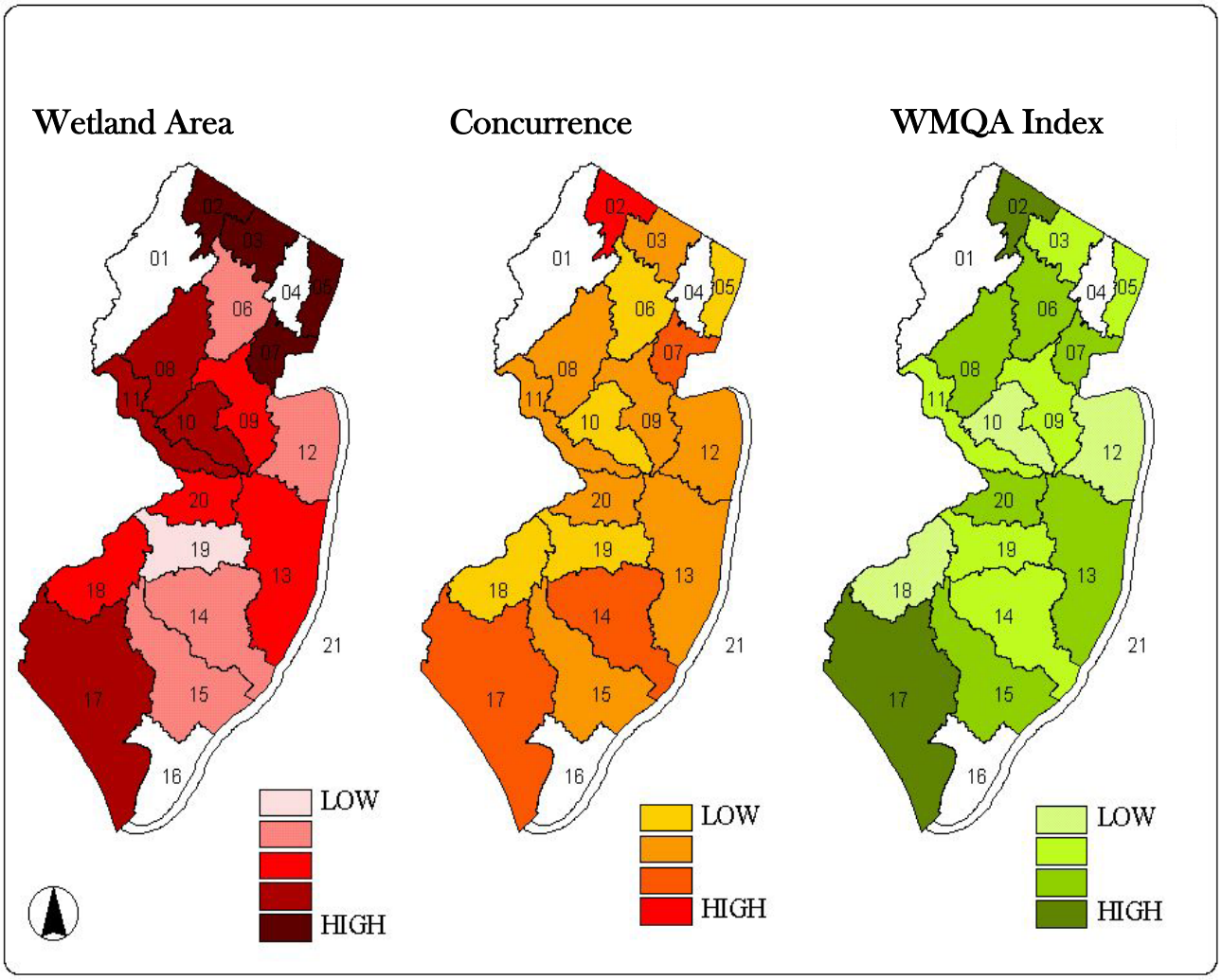

Figure 7: Spatial Analysis of Study Indicators by Watershed Management Areas (WMAs)

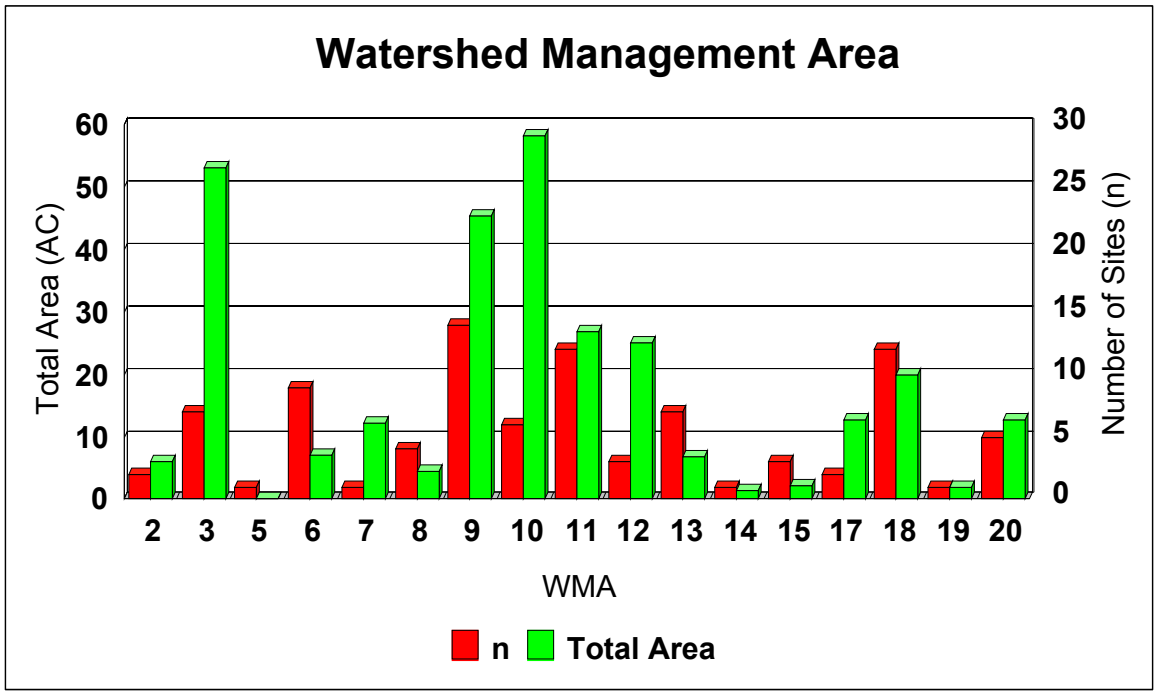

Figure 8: Number of sites and total area in each Watershed Management Area

Delaware), and WMA 18 (Lower Delaware). The majority of the mitigation area evaluated (acres) was located in WMA 3 (Ramapo), and WMA 10 (Millstone).

The high geographic variability in all indicator scores suggests that there may be localized factors that contribute to the suitability and success of mitigation sites in New Jersey. However, in some WMAs small sample size limits extrapolation of findings across the WMA. Additional study would be necessary to confirm these findings.

5.5 Wetland Size

The size of wetland mitigation sites evaluated in the field as part of this study averaged 3.49 acres with a range from 0.05 acre to 41.2 acres. Smaller sites are much more prevalent although the majority of mitigation area is contained in sites greater than 10 acres. Mitigation sites less than one acre in size accounted for 45% of the total sites included in this study. Sites with area of less than five acres account for 82% of all sites. However, in terms of area, ten sites (approximately 11% of sites) larger than 10 acres, accounted for approximately 60% of the total mitigation area evaluated.

The data were analyzed to determine if the proposed size of a mitigation site has an influence on either the quality or quantity of wetlands achieved through mitigation. The comparison between the size of a mitigation site and the study indicators suggested a small increase in all indicators as size of the mitigation site increases (Figure 9). Wetland Area Achieved ranged from an average of 33% of proposed wetland area achieved for sites less than 0.5 acres to 66% for sites greater than 10 acres in size. Concurrence Evaluation Score ranged from 37% for sites less than 0.5 acres to 51% for sites greater than 10 acres. WMQA Index Score exhibited the smallest increase from 0.44 for sites less than 0.5 acres to 0.67 for sites 5 to 10 acres. After the peak it decreased to 0.49 for sites greater than 10 acres (Figure 9).

A linear regression analysis was performed and determined that there is a positive correlation between Wetland Area Achieved and proposed size of the mitigation site ($r = 0.26$, $p<0.05$) (Figure 10). This suggests that on average, large sites are more conducive to increasing quantity

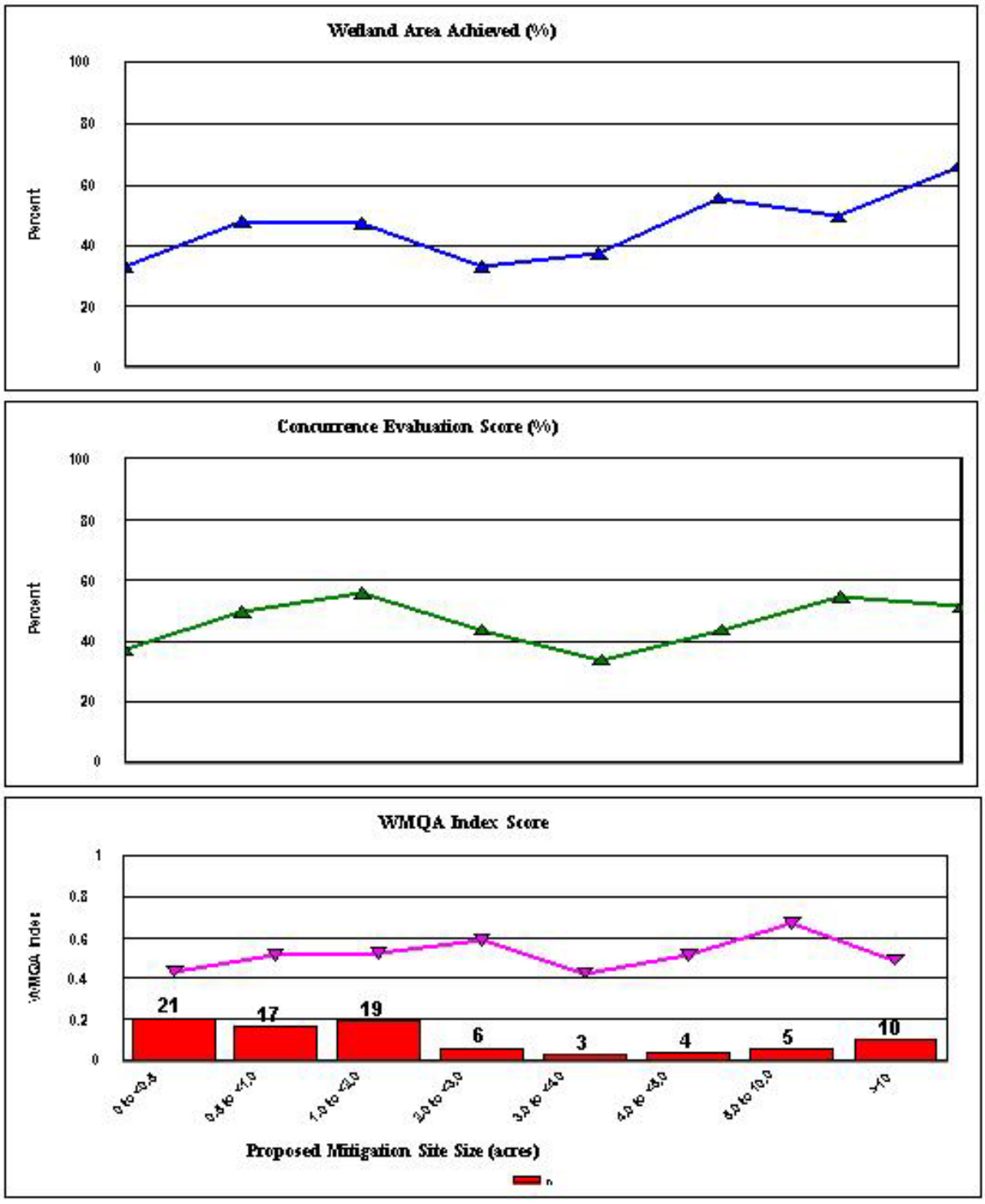

Figure 9: Distribution of Study Indicators by Size of Site

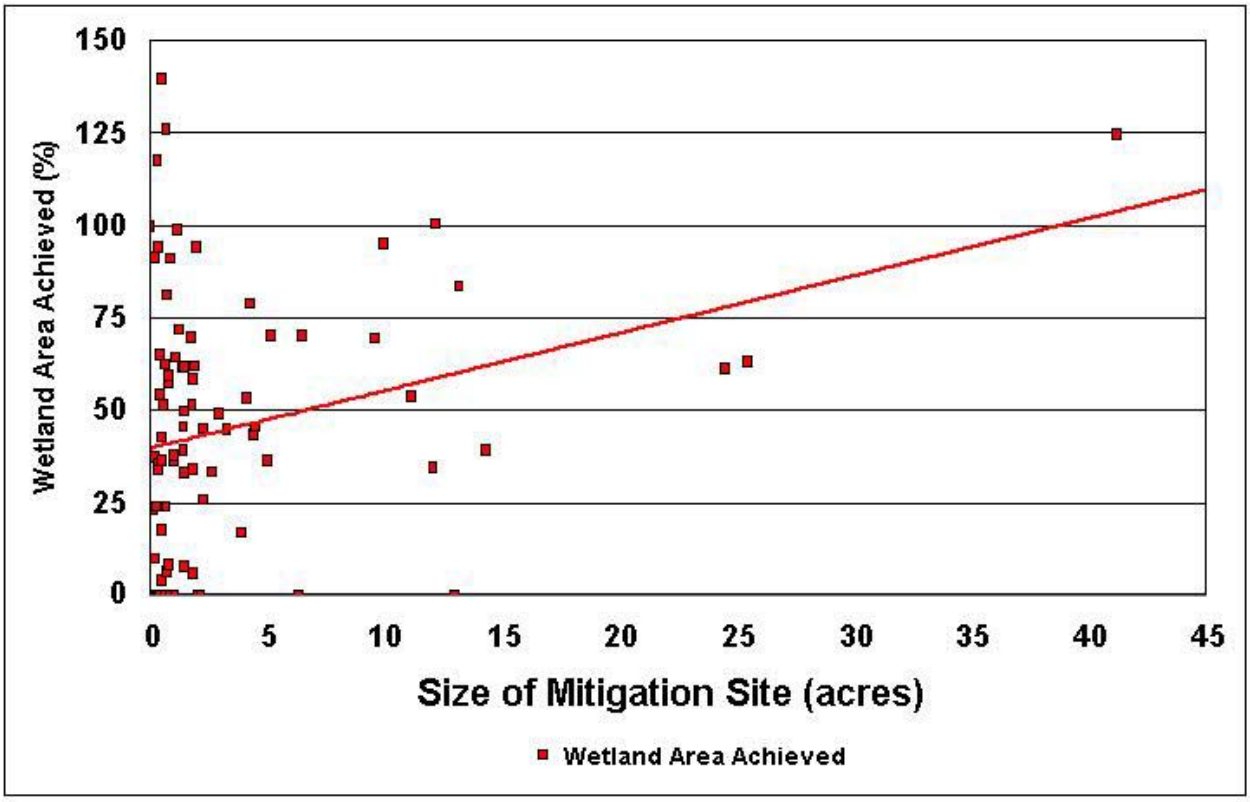

Figure 10: Linear Regression Analysis. Shows comparison between proposed size of site and percent wetland area achieved ($r=0.26, p<0.05$)

of wetlands achieved. However, the correlation is likely due to the single outlier on the right side of the graph (42 acres). There appears to be very little correlation for those mitigation sites smaller than 10 acres. Additional study of a greater number of larger mitigation sites would be necessary to test the hypothesis that the size of the mitigation site contributes to the attainment of goals. No significant correlation was found between Concurrence Evaluation or WMQA Index scores and size of site. Although it may be possible to increase success in terms of acreage created by increasing the proposed size of the site, this does not necessarily translate into increased compliance or improvements to the quality of mitigated wetlands.

5.6 Mitigation Site Age

The study included mitigation sites constructed during an eleven-year period from 1988 through 1999. The average site age was approximately 6 years old with good distribution of study sites among all age classes. The majority (97%) of study sites were in excess of two years of age.

The effect of age of the mitigation site on study indicators was explored to determine if there are any discernable trends in the quantity or quality of wetlands achieved during the study period. Figure 11 illustrates the changes in study indicators based upon age of site representing the period from 1988 (at right) to 1999. There was no improvement in study indicators detected during the study period.

The results of the analysis suggest there are not recent improvements in mitigation design and construction that would suggest a trend toward increasing attainment with goals. Improvement in these values may be expected in the future as NJDEP implements its performance-based standards for mitigation.

5.7 Mitigation Site Hydrology

The quality of hydrologic source was shown to be related to the quantity of wetlands achieved. Figure 12 illustrates the average Wetland Area Achieved, WMQA Index scores and the prevalence of invasive species for each of four dominant sources of hydrology including groundwater, sheetflow, stream diversion and stormwater.

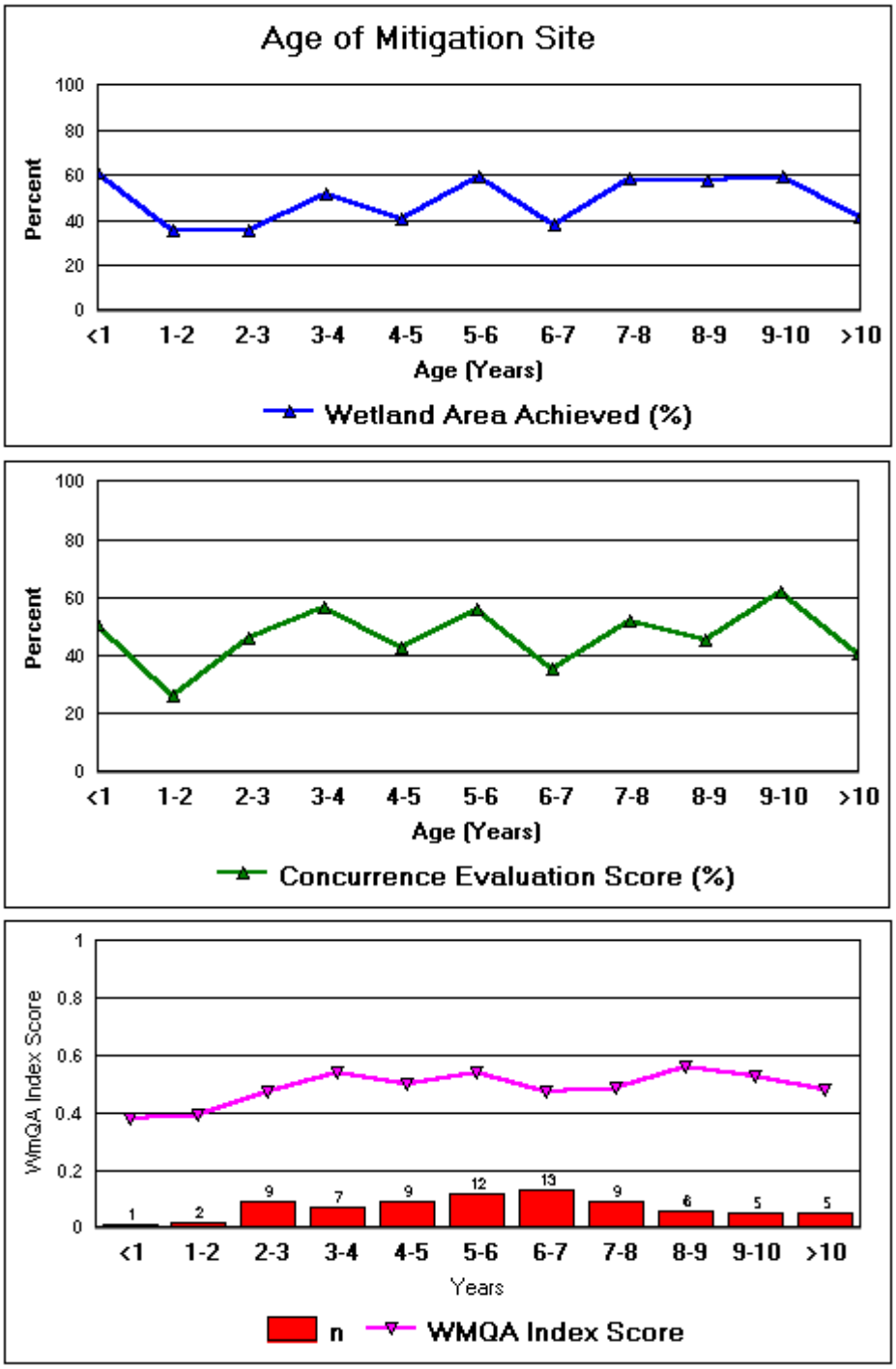

Figure 11: Distribution of Study Indicators by Age of Site

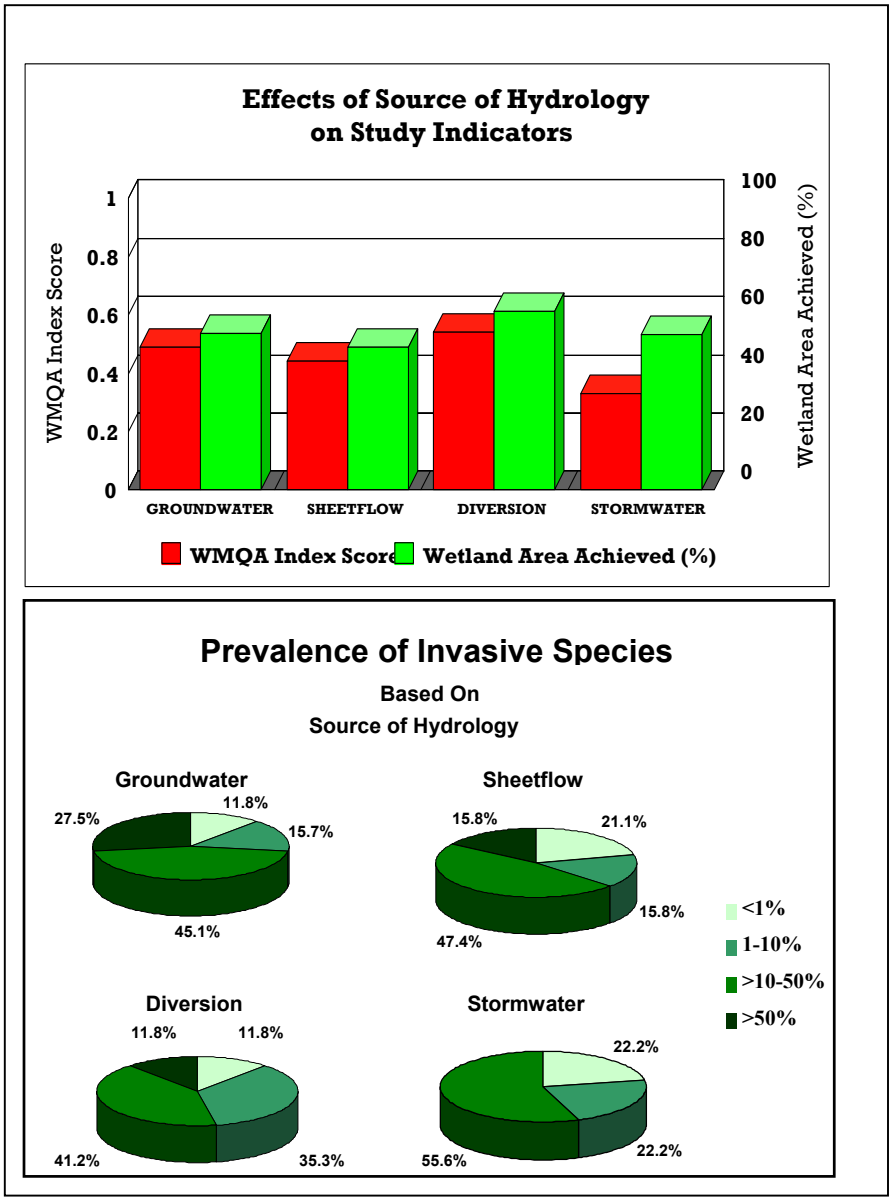

Figure 12: Effects of Hydrology on Study Indicators (top chart) and Effect of Source of Hydrology on Prevalence of Invasive Species (bottom chart)

The data suggest that source of hydrology does have a bearing on the attainment of study goals. We found that although Wetland Area Achieved remained relatively constant among sources of hydrology, stream diversion resulted in the highest average score of 61%, well above the mean value of 45% when all sites are combined. In terms of WMQA Index Score, stormwater-driven wetlands scored substantially lower than wetlands with other sources of hydrology. Stormwater-driven mitigation wetlands were also found to be more likely to have in excess of 50% cover of nuisance and invasive vegetation than mitigation wetlands driven by other sources of hydrology. This suggests that stream diversion as a source of hydrology is more likely to result in improvements to wetland mitigation quantity, and stormwater results in detriments to the quality of the wetlands achieved.