Development of a Statewide Freshwater Wetland Restoration Strategy
Phase 1: Site Identification and Prioritization Methods

OUTCOME OF FRESHWATER WETLAND RESTORATIONS ORDERED BY THE RIDEM OFFICE OF COMPLIANCE AND INSPECTION

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EXECUTIVE SUMMARY

There is no accurate estimate of total wetland loss in Rhode Island but, given the extent of urbanization in the State, it is clear that losses have been significant. Rhode Island's remaining freshwater wetlands have been protected under State law since 1971, and currently there is increased interest in restoring destroyed or degraded wetlands. In 1999, the Rhode Island Department of Environmental Management (RIDEM), the U. S. Environmental Protection Agency (USEPA), and the Department of Natural Resources Science at the University of Rhode Island began development of a statewide freshwater wetland restoration strategy. This report is a product of that effort.

To date, freshwater wetland restoration in this State has been limited primarily to projects resulting from enforcement activities under the Rhode Island Fresh Water Wetlands Act. The outcome of these restorations has not been well studied, but may provide valuable guidance for future nonregulatory (i.e., proactive) and regulatory restoration efforts. With that in mind, during the spring and summer of 2000, we examined 413 files that were randomly selected from 30 years of complaints received by RIDEM concerning illegal alterations of freshwater wetlands. We then selected for further evaluation 26 sites where restoration of biological wetland had been attempted. We assessed the outcome of those restorations in the field and identified the wetland functions that the sites were performing using a methodology developed by the U.S. Army Corps of Engineers, New England Division, in 1995. Surrounding land use and land cover within 500 feet of each site were quantified using the 1995 RIGIS land use-land cover dataset and GIS software. Chi-square tests were performed to identify factors

contributing to the presence and extent of invasive plant species. A general overview of the regulatory actions taken by the RIDEM Office of Compliance and Inspection (OCI) between 1971 and 2000 is presented at the end of this report.

Twenty-three of the 26 restoration sites we visited had wetland hydrology and hydrophytic vegetation and were performing at least one wetland function. Wetland types created (typically wet meadow or marsh) usually differed from pre-alteration types (predominately forested wetland). At nearly half of the sites, high-density residential, commercial, or industrial development was the dominant type of land use within 500 ft. Most sites appeared to be capable of providing a water quality improvement function and valuable open space. Most sites also provided habitat for wetland-dependent wildlife, although surrounding land use practices often limited the quality of that habitat. Fewer sites provided downstream flood control, production export, or shoreline stabilization. Invasive plant species (*Phragmites australis* or *Lythrum salicaria*) were present at 52% of the restoration sites. Invasives were present more often at restoration sites surrounded by an abundance of high-density development. Ground cover of invasives ranged from less than 5% to more than 75%, and tended to increase with the age of the restoration.

Future nonregulatory and regulatory restoration attempts will benefit from realistic goals that are specific to individual sites. Some wetland types (e.g., marshes) may be re-created, while others (e.g., bogs, fens, or cedar swamps) may never be replaced. Restored wetlands in urban contexts should be expected to function differently, and to have different values, from those in rural contexts. Restored wetlands in highly urbanized landscapes will be less likely to provide high-quality wildlife habitat, to make significant contributions to State or regional biodiversity, or to be used for active recreation, but they can provide significant water quality improvement, flood abatement, aesthetics, and open space. Invasive plant species are likely to appear at restoration sites, and the probability of their appearance will increase over time. Long-term monitoring can help to assure that restoration goals are being met and that future degradation of restored wetlands is minimized.

Lessons learned from this review of OCI-mandated wetland restorations are applicable to both nonregulatory and regulatory restoration projects. Guidelines for planning, designing, or conducting either type of restoration might include:

1. Establish clear goals in terms of wetland type(s) and function(s) to be created; carefully design the wetland to meet those goals.

2. Thoroughly investigate site hydrology and set a target water regime.

3. Carefully consider the context of a restoration site when projecting what functions the wetland is likely to perform.

4. Where possible, maintain or re-create a naturally vegetated upland buffer around the wetland as part of the restoration process.

5. Maximize the benefits of restoration for wildlife by giving priority to large fill sites and sites that are contiguous to large, high-quality wetlands (proactive restoration only).

6. Establish a dense ground cover of desirable plant species as soon as possible after site preparation to reduce the chance that invasive species will gain an early foothold.

7. Monitor the site after construction to assure that restoration goals are being met and that degradation of site conditions is minimal.

8. Take steps immediately to rectify any problems and continue periodic monitoring.

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INTRODUCTION

It has been estimated that more than one-half of the original wetland area in the Lower 48 States has been destroyed since European colonization (Dahl 1990). The extent and causes of wetland losses in the Northeast are poorly documented, and there are no accurate estimates of total wetland loss in Rhode Island (Golet et al.1993). However, it is clear that losses have been significant, especially in urban and coastal regions. Federal, State, and local laws and ordinances now regulate land use in Rhode Island's remaining wetlands. Since 1971, inland wetlands have been protected under the Rhode Island Fresh Water Wetlands Act. The Act, administered and enforced by the Rhode Island Department of Environmental Management (RIDEM), prohibits any random, unnecessary, or undesirable alterations to wetlands. Violators are required to restore destroyed or degraded wetland. Restoration activities involving freshwater wetlands in Rhode Island have thus far been limited primarily to these enforcement actions. However, there is strong interest in nonregulatory or proactive wetland restoration (Murphy 1999, Murphy and Ely 2002), and currently RIDEM is collaborating with the University of Rhode Island's Department of Natural Resources Science and the U.S. Environmental Protection Agency in the development of a Statewide freshwater wetland restoration strategy (Miller and Golet 2000). This report is a product of this collaborative effort.

The Office of Compliance and Inspection (OCI), here considered to also include its predecessor Divisions (e.g., Divisions of Freshwater Wetlands, Water Resources, and Land Resources within the Departments of Natural Resources and Environmental Management), is responsible for enforcing the State's freshwater wetland regulations within RIDEM. OCI investigates alleged wetland violations, levies fines, orders appropriate actions to halt further damage, and, in many cases, orders wetland restoration. OCI may undertake a variety of enforcement actions, including warnings, Notices of Intent to Enforce (NOIE), Notices of Violation and Order (NOVAO), and orders to Cease and Desist (RIDEM 1998). Long-term monitoring of freshwater wetland restorations by OCI has been unfeasible due to a shortage of staff and the enormous number of complaints that must be investigated; OCI received 551 complaints and made 1,007 inspections in 2000 alone (Murphy and Ely 2002). There has been little research documenting the outcome of freshwater wetland restorations in general (Kusler and Kentula 1990). The primary objective of this study was to determine the outcome of restorations ordered by OCI. Specifically, we were interested in determining (1) whether wetland was created during mandatory restoration projects, (2) if the restored wetland was performing functions and values typical of natural wetlands, and (3) whether invasive plant species were a significant management issue in restored wetlands.

METHODS

File Reviews and Selection of Study Sites

During the spring of 2000, OCI had nearly 8,000 complaints on file concerning illegal alterations to freshwater wetlands since 1971. (Note: this figure does not include an undetermined number of unfounded complaints made between 1971 and the mid 1980's). We wished to examine only those complaints that resulted in the restoration of degraded or destroyed wetland. The 8,000 files were first stratified by decade and assigned a random number using Microsoft Excel Version 4.0. We then randomly selected 396 files from this dataset for review; an additional 17 complaint files recommended by OCI staff were also included (Table 1). Initially, data were collected from each file, regardless of the outcome (see Appendix A1 for a complete description of data collected). After reviewing a large number of files, we streamlined the review process and eliminated data collection for files that did not require restoration.

Sites were selected for a field visit only when the complaint file indicated that alteration had occurred within a swamp, marsh, wet meadow, fen, bog, or pond. Sites with alterations restricted to stream channels, floodplains, perimeter wetlands, riverbanks, or areas subject to flooding or storm flowage were not selected. In addition, the area of alteration had to be greater than 500 sq ft in size, the file had to have a record of compliance (indicating that restoration was completed to the satisfaction of OCI), and there had to be an adequate site description and directions to the site. Ultimately, 26 restoration sites were selected for study. Nineteen of those sites were selected randomly and seven were recommended by OCI staff. When landowner information in the file was current, we contacted the landowner prior to visiting the site. In other cases, permission to visit the site was requested after arrival or was not necessary.

Collection of Field Data

Sites were visited between 27 June and 24 October 2000. At each location, the outcome of the restoration was described (see Appendix A2 for a complete description of data collected in the field) and wetland functions and values were assessed using a technique developed by the U.S. Army Corps of Engineers, New England Division (USACE 1995). The CENED Highway Methodology functional assessment technique is a qualitative approach that identifies functions and values but does not weight or rank them. The wetland functions and values that we assessed, using selected CENED qualifiers, included floodflow alteration, water quality improvement, production export, sediment/shoreline stabilization, and heritage values (Appendix A3). Evaluation of a site's ability to provide wetland-dependent wildlife habitat was based primarily on water regime; CENED qualifiers were not applied. Seasonally flooded, semi-permanently flooded, and permanently flooded restoration sites (see Cowardin et al. [1979] for definitions) were considered capable of providing habitat for wetland-dependent wildlife, regardless of surrounding land use or land cover. Severely degraded sites were not considered capable of providing such habitat, despite an appropriate water regime. The presence of two invasive plant species, common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria),* was recorded and the percent cover of each was estimated using one of seven cover classes: 1-5%, 6-15%, 16-25%, 26-50%, 51-75%, 76-95%, and 96-100%. Overall wetland integrity was ranked high, medium, or low, based on the presence and extent of invasive plant species, surrounding land use-land cover types, and ongoing disturbance within the restoration area. This ranking was subjective, but consistent among the 23 sites evaluated.

Laboratory and Statistical Analyses

We obtained additional data for each site from 1997 digital orthophotography, the Rhode Island Soil Survey (Rector 1981), and the 1995 RIGIS land use-land cover dataset. Land use surrounding each restoration site was quantified using ARC/INFO and ArcView software and the 1995 RIGIS land use-land cover dataset. Approximate locations and sizes of each restoration site were digitized in ArcView and then a 500-ft buffer was created around each polygon. The RIGIS land use-land cover dataset was clipped to the 500-ft buffered area. We modified the RIGIS land use classes (Table 2) and, using ArcView, calculated the percentage of the land within the 500-ft buffer that each land use type comprised. Buffer and clip commands were also used to calculate the density of paved roads within this same area from the 1998 RIGIS roads-all dataset.

We used Chi-square tests to determine whether the age of the restoration, surrounding land use, or road density within 500 ft contributed to the presence or extent of invasive species. All statistical tests were performed using PC-SAS software and a significance level of 0.05, unless noted otherwise.

RESULTS

Outcome of Wetland Restorations

Twenty of the wetland restoration sites field-checked were located west of Narragansett Bay, one was on Conanicut Island in the Bay, and five were east of the Bay (Fig. 1). Twenty-three (88%) of the sites had wetland hydrology and hydrophytic vegetation and were performing at least one wetland function. High-density development (29%), wetland (26%), and upland forest (20%) were the predominant land use types within 500 ft of these restored wetlands (Table 3). At 11 of the sites, high-density development comprised more than one-third of the surrounding area and was the dominant land use type (Appendix A4). Wetland and upland forest were dominant at 6 and 3 of the sites, respectively, and low-density development predominated at 3 sites. Agriculture, disturbed open lands, and open water generally were rare. Other basic features of the 23 restored sites are presented in Appendix A5.

The majority of wetland types created after restoration were different from the pre-alteration wetland type (Fig. 2). Prior to alteration, most of the wetlands were forested. After restoration, most of the wetlands were either wet meadows or shallow marshes (i.e., emergent wetlands). Four of the restored wetlands were classified as forested. At two of those sites, the original vegetation had not been removed during alteration. At two other sites, willows, *Salix* spp., were dominant.

Invasive plant species, either the common reed, *Phragmites australis*, or purple loosestrife, *Lythrum salicaria*, were present at 12 (52%) of the restoration sites (Table 4). *Phragmites* was encountered at 10 of the sites (43%) and *Lythrum* at 4 (17%); the two species co-occurred at only two sites. Where invasive species were present, their combined cover ranged from less than 5% to more than 75%; 58% of the sites with invasive species had ≤15% cover (Fig. 3). Broad-leaved cattail, *Typha latifolia*, although not considered an invasive species, was encountered at 12 sites (52%), more than any other plant. Other plants that occurred frequently included willows, *Salix* spp. (48%); soft rush, *Juncus effusus* (43%); red maple, *Acer rubrum* (39%); and woolgrass, *Scirpus cyperinus* (35%). Appendix A5 identifies the dominant plant(s) at each site.

Wetland functions varied among the restoration sites (Table 5). Twenty sites appeared to be capable of performing a water quality improvement function (Fig. 4). Seventeen sites performed a heritage function by providing open space or aesthetic value. Sixteen sites were capable of providing habitat for wetland-dependent wildlife. Fewer sites contributed to downstream flood control (8), production export (3), or shoreline stabilization (2). Wetland integrity rankings were distributed nearly evenly among sites. Eight restoration sites were ranked high in overall integrity, 6 medium, and 9 low.

Factors Contributing to Presence and Extent of Invasive Plant Species

Three features of the restoration sites were considered when trying to explain the occurrence of invasive plant species (Table 4). The age of the restoration (X^2 = 2.07, df = 3,

$P > 0.50$) and road density within 500 ft ($X^2 = 2.66$, df = 3, $P > 0.40$) did not appear to be related to the presence or absence of invasive species. However, invasive plant species were more likely to be present at those restoration sites with a high percentage of high-density development around them ($X^2 = 9.81$, df = 3, $P < 0.05$). This relationship was even clearer when *Phragmites* data were analyzed independently ($X^2 = 11.60$, df = 3, $P < 0.01$).

The restoration sites reviewed ranged in age from 1 year to 20 years (Table 4). Older restorations were more likely to have greater cover of invasive plant species ($X^2 = 14.13$, df = 4, $P < 0.01$). Percent cover also tended to be higher when restoration sites were surrounded by an abundance of high-density development ($X^2 = 11.71$, df = 6, $P = 0.07$). High percent cover of *Phragmites* was especially likely at restoration sites with more high-density development in the vicinity ($X^2 = 17.80$, df = 6, $P < 0.01$).

DISCUSSION

Outcome of Wetland Restorations

The concept of restoration "success" is an elusive one; there are no standard criteria for judging success. Clear goals must be established prior to undertaking any restoration; without stated objectives, evaluating success is impossible (Tiner 1995). Simple re-creation of wetland (i.e., re-establishment of wetland hydrology or wetland vegetation) might be considered the least strict criterion of success. Re-creation of the same type of wetland that was lost may be a worthy goal, but that may be difficult or impossible to achieve, especially in the short term (Miller and Golet 2000). The re-creation of those specific functions that were lost has been recommended by some scientists (Larson and Neill 1987). Replacement of functions such as flood storage may be possible even without re-creation of the original wetland type.

Our review of restoration files indicated that OCI generally required fill removal and establishment of the original, or a wetter, water regime. Given the infant status of restoration science and OCI's exceedingly heavy workload, employment of a stricter standard for "success" may well be unfeasible at this time. For this reason, we intentionally avoided using the term "success," and instead focused simply on the "outcome" of restoration projects in this study.

Functioning wetland was re-created at 23 of the 26 restoration sites visited. Two of the sites lacked wetland hydrology, and livestock had removed all wetland vegetation at a third site. Wetland types that were created usually differed from pre-alteration types. Forested wetland, the most abundant wetland type in the State (Tiner 1989), was also the most commonly altered wetland type. The majority of forested wetlands were replaced with shallow marshes or wet meadows. OCI tended to target these types in order to better insure wetland hydrology. As long as there is no additional disturbance, forested wetlands may eventually redevelop at many of the restoration sites through natural succession.

Most of the restorations that we evaluated were small (<0.25 acres), because most illegal alterations were small. Although the importance of restoration of a small area may be questioned, the cumulative effect of many small restorations may be highly significant. The importance of an individual restoration (small or large) takes on added significance if the site is directly adjacent to existing wetland, particularly for functions such as wildlife habitat and open space. The significance of an individual restoration must be viewed in both spatial and temporal contexts.

Functions and Values of Restored Wetlands

The majority of restoration sites were considered capable of improving the quality of surface water or groundwater. Those sites were located in relatively shallow basins that were capable of storing surface water and that had constricted outlets, dense vegetation, or diffuse water flow to trap sediment and slow water movement, allowing biological, physical, and chemical removal or transformation processes to take place. The urban setting of many of the restoration sites provided the opportunity for water quality improvement due to increased runoff associated with impervious surfaces and inputs of sediment, nutrients, and other pollutants to the wetlands.

More than two-thirds of the restoration sites had the potential to provide habitat for wetland-dependent wildlife, although the quality of that habitat differed among sites. To be most meaningful, habitat assessment should be species-specific; one must use caution in generalizing about the wildlife habitat value of the restoration sites. Each site had a unique set of characteristics including, but not limited to, size, surrounding upland land use, the presence and extent of invasive plant species, water quality, and proximity to open water bodies and other wetlands, that influenced its ability to provide habitat for individual wildlife species. Any site with a seasonally flooded, semi-permanently flooded, or permanently flooded water regime was considered wet enough to support wetland-dependent species during some part of the year. Although 17 sites met this criterion, one site that was severely degraded was not considered to be providing wetland wildlife habitat. Most sites provided only low or medium quality habitat, due to the abundance of high-density development in the surrounding uplands or extensive cover of invasive plants.

It may be unfair to expect all, or even most, of the restoration sites to provide habitat for wetland-dependent wildlife because it is unlikely that those sites were providing such habitat prior to their alteration. The majority of alterations occurred in forested swamps where avian and mammal communities are composed principally of facultative species, which are also common to upland forests (Golet et al. 1993). In addition, the lack of suitable upland habitat around many of the sites would have limited their value to wildlife dependent on both wetland and upland habitat for survival (e.g., certain frogs and salamanders). Although few of the sites provided high quality wetland-dependent wildlife habitat, all of the sites provided some habitat for facultative species. Many of the sites we evaluated were the only natural habitats remaining in an otherwise heavily developed landscape.

Seventeen sites were considered to have one or more heritage values. Most of these sites provided natural open space in a heavily urbanized landscape. A few sites clearly had aesthetic value, due to the presence of flowering plants or plants such as red maple that turn vibrant colors in the fall. It is unlikely that any of the sites contributed significantly to biodiversity within the State, given their context or the presence of invasive species. Because all of the sites were privately owned, none was credited with public recreational or educational value.

Few sites contributed to downstream flood control, production export, or shoreline stabilization. Sites performing production export and shoreline stabilization were rare; only those sites that were adjacent to an open water body were considered to be effective at those functions. Wetlands performing flood control functions had to be effective at water storage and have a surface water connection to flood-prone property downstream. Many of the restoration sites were isolated from other wetlands and, therefore, their influence on downstream flood levels was negligible.

The overall integrity of each restoration site was ranked high, medium, or low. Sites with high integrity (8) had <20% high-density development within 500 ft, little (<5%) or no invasive species cover, and no other obvious forms of degradation. Sites with medium integrity (6) typically had a moderate amount (20-50%) of high-density development within

500 ft, some invasive species cover but the plants were not dominant, and few, if any, additional disturbances. At low integrity sites (9), more than 50% of the surrounding land use consisted of high-density development, invasive plant species covered more than 75% of the area, or the site was severely degraded (i.e., contained trash or obviously poor water quality). The number of functions performed by the wetland had no bearing on its overall ranking for integrity.

Realism is necessary when trying to gauge what restoration can accomplish, and restoration goals should be appropriate to each project (Ehrenfeld 2000). Wetlands in highly urbanized landscapes cannot be expected to perform the same functions to the same degree that rural wetlands do. Because urban wetlands are more likely to receive greater inputs of stormwater runoff, sediment, nutrients, and other pollutants, and to be surrounded by heavily developed or fragmented upland habitats, they are less likely to provide high-quality wildlife habitat, to contribute to biodiversity, or to be used for diverse forms of recreation. However, other functions, including water quality improvement, flood abatement, and open space may take on increased social significance in an urban setting. The functional performance of wetlands restored under orders by OCI is dictated at least partially by the landscape setting or context in which the original wetland (and violation) occurred. In proactive restoration, functional performance can be controlled to some degree by conscious selection of sites within particular settings.

Invasive Species Problem

Invasive plants are part and parcel of the restoration process. Disturbed soil and altered water regimes associated with restoration activities can create conditions favorable to the establishment of *Phragmites australis* and *Lythrum salicaria*. Once established, these species are capable of dominating the wetlands they invade. Our results suggest that invasives may appear early on or years after restoration, but that abundance generally increases with age. The only factor we were able to identify that appeared to contribute to the presence of invasive plants was the amount of high-density development near the restoration site. Anthropogenic disturbances are becoming more important than natural ones in shaping many systems, and activities such as filling, altering water regimes, clearing vegetation, and water pollution are known to affect species composition and the diversity of plant communities in wetlands (Keller 2000). It seems likely that the restoration sites we studied that contained invasives were undergoing one or more forms of anthropogenic degradation. Increased stormwater runoff, sedimentation, and nutrient inputs all may help to create favorable conditions for the establishment and spread of *Phragmites* and *Lythrum*. Long-term monitoring and management are necessary to control these species at restoration sites. Unfortunately, this task often goes well beyond an enforcement setting. Responsibility for long-term monitoring and control may be somewhat easier to assign in proactive restoration projects.

Practical Problems in Assessing Restoration Outcomes

In some cases, it was difficult to be sure of the exact location of a restoration site described in a complaint file; in such cases, the outcome could not be evaluated. Complaint files from the 1970's were often incomplete, and sometimes lacked adequate directions to the site or descriptions of the pre-alteration wetland type. Landscape changes over the last 30 years, including the addition of roads, homes, and other structures, made directions, sketches, and pictures in other files obsolete. Many of the sites were small (<0.125 acres), and post-restoration vegetation dynamics made it difficult to identify site boundaries.

Some landowners were uncooperative and refused access to their land. Although complaint files indicated that these sites had been restored to OCI's satisfaction, landowners were wary of more wetland-related visits to their property. OCI recommended that we avoid several sites because of hostile landowners, and those sites were removed from the study.

Although the CENED (1995) functional assessment methodology is based on good science, it is also necessarily subjective. In addition, many of the qualifiers provided for evaluating each function often did not apply to a particular restoration site. At times it was difficult to separate the capabilities of the restoration site from those of contiguous wetland. Certain functions and values, such as heritage, floodflow alteration, and wetland-dependent wildlife habitat were particularly difficult to assess. In many cases, the restoration may have provided open space for a particular homeowner, but was not especially significant in a larger context. The CENED methodology does not indicate what scale to use when assessing wetland functions and values. To some degree, all of the restoration sites provided flood control, because runoff could enter the wetland and be retained there, instead of entering some other water body. However, in order to distinguish this wetland function from that provided by upland depressions, we decided that the wetland needed to store water and desynchronize flood events downstream. Generalizing about the value of wetland-dependent wildlife habitat was problematic due to the variability among sites and habitat needs of different species.

Guidelines for Future Restoration Projects

One of the objectives of this research was to develop guidelines that might be helpful in planning, designing, or conducting either nonregulatory or regulatory restoration of freshwater wetlands. The following are some possible guidelines.

1. Establish clear goals in terms of wetland type(s) and functions to be created; carefully design the wetland to meet those goals.

2. Thoroughly investigate site hydrology (hydrologic inputs and outputs, as well as groundwater levels) and set a target water regime. This will be necessary to produce the desired plant community and certain functions.

3. Carefully consider the context of a restoration site when projecting what functions the wetland is likely to perform. For example, restored wetlands in highly urbanized landscapes can be expected to be important for flood abatement, water quality improvement, open space, and aesthetics, but will likely have less value for wildlife habitat or biodiversity. Rural settings will be especially conducive to biodiversity, wildlife habitat, and a broad range of recreational opportunities.

4. Where possible, maintain or re-create a naturally vegetated upland buffer around the wetland as part of the restoration process.

5. Maximize the benefits of restoration for wildlife by giving priority to large fill sites and sites that are contiguous to large, high-quality wetlands (proactive restoration only).

6. Establish a dense ground cover of desirable plant species as soon as possible after site preparation to reduce the chance that invasive species will get an early foothold.

7. Monitor the site after construction to assure that restoration goals are being met and that degradation of site conditions (e.g., sedimentation, invasive species, water quality degradation) is minimal.

8. Take steps immediately to rectify any problems detected and continue periodic monitoring.

Table 1. Distribution, by decade, of complaint files reviewed.

Decade	*Randomly selected**	*OCI-recommended**	*Total*
1971-80	96**	0	96
1981-90	144	7	151
1991-00	156	10	166
Total	396	17	413

**Complaint files in use, missing, or otherwise unavailable were not included in this review.*
*** Complaint files numbered 1-290 were archived by OCI and not included in this review.*

Table 2. Codes used to describe land use within 500 ft of restored wetlands.

Land use code	*Definition (based on RIGIS classes)*
HI_DEV	High-density development, including medium/high-density residential, high-density residential, commercial, industrial, institutional, mixed urban land use, airports, railroads, and wastewater treatment facilities.
LO_DEV	Low-density development, including medium-density residential, medium/low-density residential, and low-density residential land use.
DST_OPN	Disturbed open land, including urban open space, waste disposal, power lines, developed recreational, cemeteries, vacant, and barren land.
AGRIC	Pasture, cropland, orchards, groves and nurseries, idle agriculture, confined feeding lots, and brushland.
UPL_FOR	Deciduous forest, evergreen forest, mixed deciduous forest, and mixed evergreen forest.
WATER	Reservoirs, lakes, and ponds.
WETLNDS	Forested and nonforested freshwater wetlands.

Table 3. Percentages of seven land use types within 500 ft of 23 restored wetlands.

*Land use**	*Mean*	*SE*	*Median*	*Min.*	*Max.*	*25th %ile*	*75th %ile*
HI_DEV	28.89	5.86	23.38	0.00	89.61	3.33	47.24
LO_DEV	12.82	3.24	7.64	0.00	48.09	0.00	21.18
DST_OPN	2.80	0.94	0.00	0.00	16.99	0.00	5.38
AGRIC	3.04	1.26	0.00	0.00	20.00	0.00	2.46
UPL_FOR	19.96	2.78	17.29	0.00	46.76	9.84	27.26
WATER	3.29	1.71	0.00	0.00	31.00	0.00	0.01
WETLNDS	25.51	2.48	26.75	8.32	47.00	14.47	34.76

**Land use codes defined in Table 2.*

Table 4. Abundance of invasive plant species at 23 restored wetlands and other features at each site that may have contributed to their presence and extent.

Site_ID	Age (years)	High-density development (% within 500 ft)	Road density (m/ha)	Invasives cover (%)*		
				Phragmites	Lythrum	Both
1107	14	43.16	45	86.5		86.5
1307	16	89.61	88	0		0
1473	13	74.28	39	3		3
2138	11	14.15	39	0		0
2150	11	58.83	30	10.5	38	63
2292	8	3.71	23	0		0
2771	6	0.00	37	0	10.5	10.5
453a	20	38.95	60	86.5		86.5
453b	20	38.95	60	86.5		86.5
89-27	9	0.44	50	0		0
89-72	11	7.34	87	0		0
89-94	5	8.81	33	10.5		10.5
90-93	6	45.67	62	10.5	3	20.5
91-88	6	50.59	27	10.5		10.5
914	18	2.19	45	0		0
92-80	3	3.81	32	0		0
93-226	6	0.00	39	0		0
95-84	1	29.11	76	0	10.5	10.5
95-35	3	36.26	119	3		3
95-259	2	46.13	65	0		0
95-525	3	64.93	69	3		3
95-642	2	0.00	39	0		0
96-130a	1	17.66	95	0		0

** Value (%) indicates the mid-point within the following cover classes: 1-5%, 6-15%, 16-25%, 26-50%, 51-75%, 76-95%, and 96-100%.*

Table 5. Functions performed (X) by 23 restored wetlands.*

Site_ID	*Flood abatement*	*Water quality improvement*	*Wetland wildlife habitat*	*Heritage functions*	*Production export*	*Shoreline stabilization*
1107	X	X	X	X	X	X
1307	X	X		X		
1473				X		
2138	X	X	X	X		
2150	X	X	X	X	X	X
2292				X		
2771		X				
453a		X	X	X		
453b	X	X	X	X	X	
89-27				X		
89-72		X	X	X		
89-94		X	X	X		
90-93		X	X	X		
91-88	X	X	X			
914	X	X	X	X		
92-80		X	X			
93-226		X	X			
95-84	X	X				
95-35		X	X	X		
95-259		X		X		
95-525		X	X	X		
95-642		X	X			
96-130a		X	X	X		

**Functions assessed using the U.S. Army Corps of Engineers Highway Methodology (CENED 1995).*

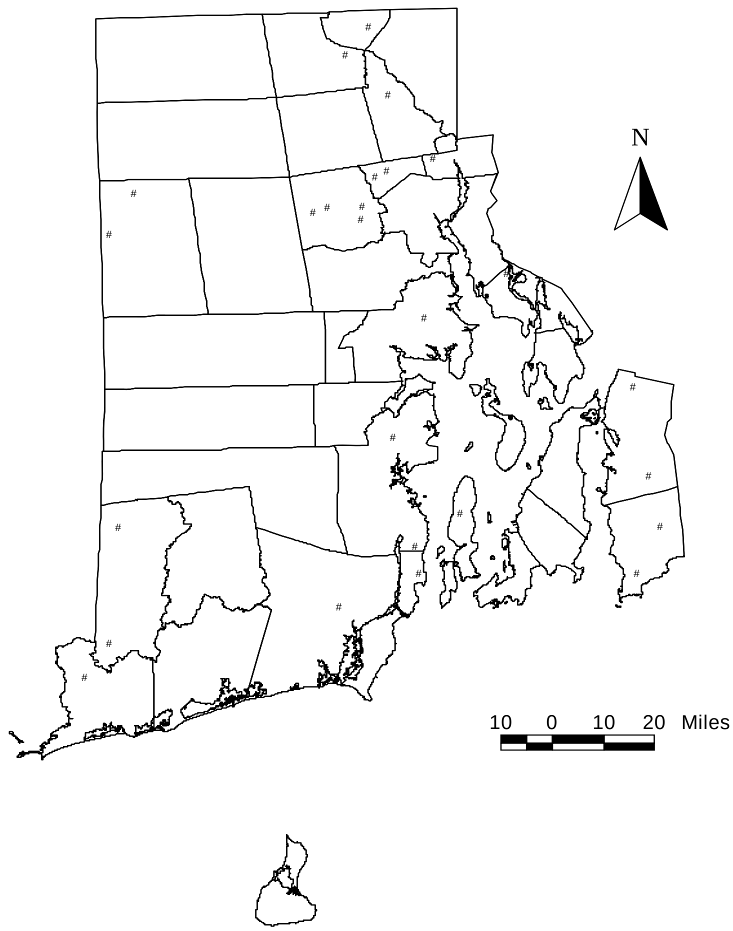

Figure 1. Locations of 26 freshwater wetland restoration study sites.

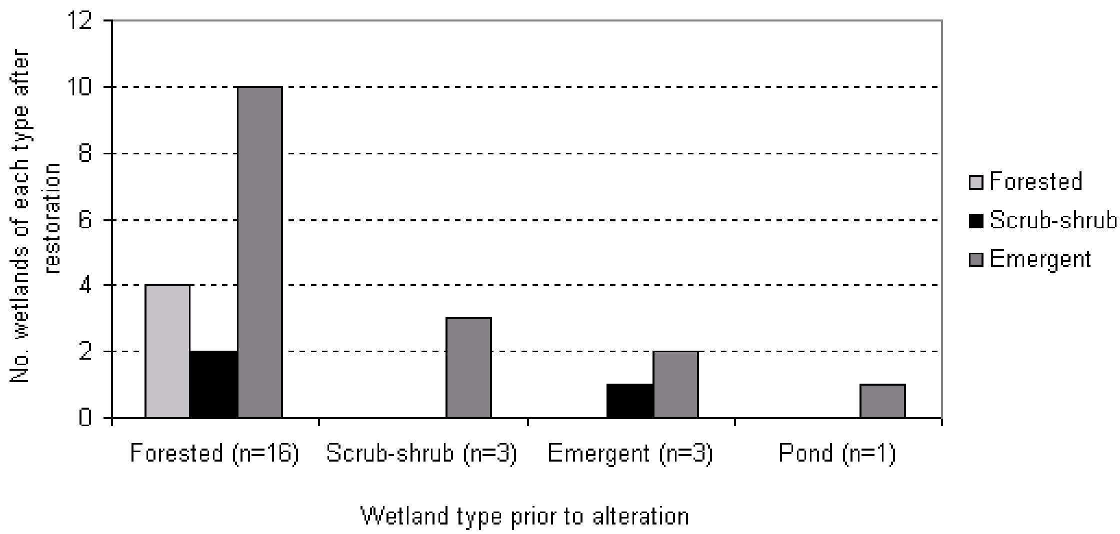

Figure 2. Comparison of wetland types prior to alteration and after restoration.

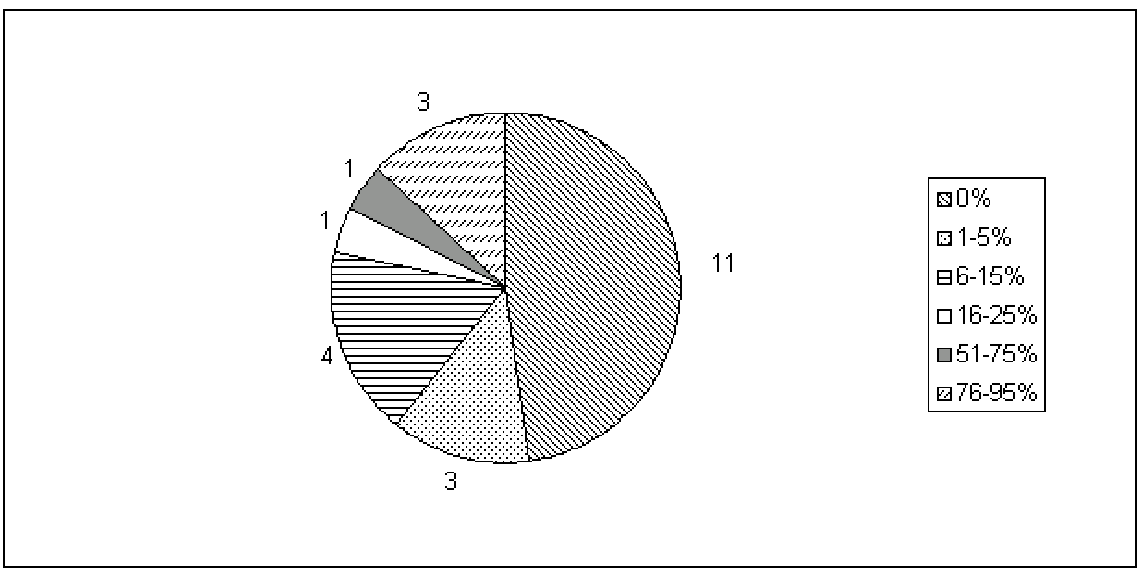

Figure 3. Number of restored wetlands with varying amounts of cover of invasive plant species (*Phragmites australis* and *Lythrum salicaria*).

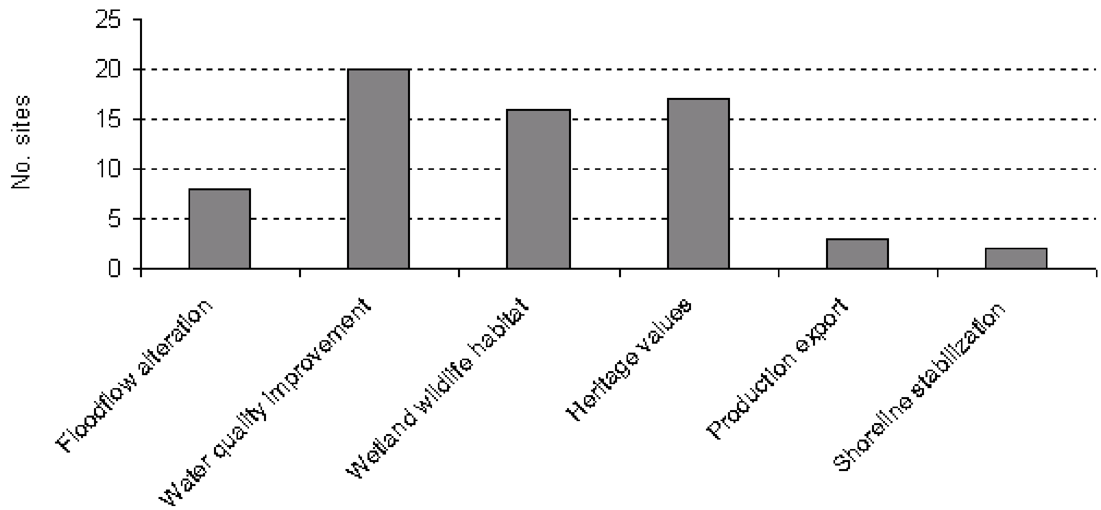

Figure 4. Number of restored wetlands with specific functions and values.

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APPENDIX A1.

Information collected from complaint files.

File Number _______

Classification:

_____Unfounded _____No Action _____Exempt _____Triage 1 _____Triage 2

_____Triage 3_____ N.O.I _____ N.O.V. _____Cease/Desist _____Cease/Restore

_____Application to Alter

Date of Complaint:______ Date of Violation: ___________

Wetland Type Prior to Alteration:

_____FO Swamp _____Shrub Swamp _____Marsh ____Wet Meadow_____Bog

___Fen _____Pond ____River _____Floodplain ____Riverbank _____Area

Subject to Storm Flowage _____ Area Subject to Flooding _____Perimeter Wetland

Vegetation list: ____

Nature of Alteration:

_____Filling _____Dredging _____Grading _____Draining _____Clearing

_____ Damming/Impoundments _______Other: ______________

Size of Alteration: _______________

Required Restoration:

____Remove fill _____Regrade _____Stabilize slopes _____Natural revegetation

____Planting in wetland ____Planting in upland _____Plant maintenance (1 year)

_____Plant maintenance (>1year) __Replant if necessary ___Other: _____

Restoration Performed:

____Fill removed ____Area regraded _____Slopes stabilized ____Area allowed to revegetate _____ Planting in wetland ____Planting in upland _____Plants maintained (up to 1 year) _____Plants maintained (> 1 year) _____Area replanted ___Other: _______

Number of Follow up Visits to Site: _____

Litigation_____

Date of Compliance: _________________

Date of Last Notation (in file): ______________

Location of Site (City or Town) ________________

Location of Site (Detailed): ____

Contact Information:

Land Owner: ___________________

Address: _______________________

Phone: ________________________

Included in File: ____Pictures ____Site plans ____Description of site ____Sketches ____Aerial

APPENDIX A2.

Information collected at restoration sites.

File Number ___________

Location ______________

Is it Wetland? ___ Yes ____ No

Size of Restoration site: _____________________ % WL ________ %UL ______

Wetland Type ________Water Regime _________Hydrologic Location _________

Dominant Species:____

Key Subordinate Species: ____

Ground Surface Covered by Invasives (%) ________________________________

% Cover of Phragmites _____________________ % Cover of Lythrum ________

Disturbance (Sedimentation, erosion, major storm runoff)

____

Illegal Alterations: ____

Wetland plantings present ________________Upland plantings present _________

Wildlife observations: ____

Surrounding Land Use/Cover Within 500 Feet

______Forest _____Low Res. _____Med Res. _____High Res. _____ Commercial

_______ Industrial _____Recreational ___Wetland

Is Restoration Adjacent to _______2 Lane Road ________ > 2 Lanes

Potential Wildlife Habitat in Restoration _____High ______Medium _____Low

Overall Wetland Integrity/ Quality _______High _____Medium _____ Low

Are Invasives Present in Upland? _______________________________________

Contiguous Wetland Type________________ Water Regime ___________________

Are Invasives Present in Contiguous Wetland? ______________________________

Potential Wildlife Habitat in Contiguous Wetland _____High ______Medium _____Low

APPENDIX A3.

Wetland functions assessed at 23 restoration sites, with qualifiers.
(Adapted from CENED [1995])

Wetland function/value	*Qualifiers*
Floodflow Alteration. This function considers the effectiveness of the wetland in reducing flood damage by water retention for prolonged periods following precipitation events and the gradual release of floodwaters.	-Wetland exists in a relatively flat area that has flood storage potential. -Wetland receives and retains overland or sheet flow runoff from surrounding uplands. -In the event of a large storm, this wetland may receive and detain excessive floodwater from a nearby watercourse. -Wetland outlet is constricted. -Wetland contains a high density of vegetation.
Water Quality Improvement. This function considers the effectiveness of the wetland in reducing or preventing degradation of water quality by trapping sediment or removing, retaining, or transforming nutrients entering the wetland.	-Overall potential for sediment trapping exists in this wetland. -Long duration water retention time is present in this wetland. -Wetland saturated for most of the season, ponded water is present in the wetland. -Dense vegetation is present. -Emergent vegetation or dense woody stems are dominant.
Wetland-dependent Wildlife Habitat. This function evaluates the effectiveness of the wetland to provide habitat for wetland-dependent species.	-Seasonally flooded, semi-permanently flooded, or permanently flooded water regime. -Wetland is not severely degraded.
Production Export. This function evaluates the effectiveness of the wetland to provide aquatic food chain support.	-Detritus development is present in this wetland. -Nutrients exported in wetland watercourses (permanent outlet present). -“Flushing” of relatively large amounts of organic plant material occurs from this wetland. -Indicators of export are present.

Sediment/Shoreline Stabilization. This function considers the effectiveness of the wetland to stabilize stream banks and shorelines against erosion.	-A distinct step between the open water body or stream and the adjacent land exists with dense roots throughout. -Wide wetland (>10 ft) bordering watercourse, lake, or pond. -Open water fetch is present. -Dense vegetation is bordering watercourse, lake or pond. -High percentage of energy-absorbing emergents and/or shrubs bordering watercourse or lake, or pond.
Recreation (Heritage Value). This value considers the suitability of the wetland to provide recreational opportunities.	-Wetland is part of a recreation area, park, forest, or refuge. -Fishing is available within or from the wetland. -Hunting is permitted in the wetland. -Hiking occurs, or has the potential to occur, within the wetland. -The watercourse, pond, or lake associated with the wetland is unpolluted. -Access to water is available at this potential recreation site for boating, fishing, or canoeing. -Accessibility and travel ease is present at this site.
Educational/Scientific Value (Heritage Value). This value considers the suitability of the wetland as a site for an “outdoor classroom” or as a location for scientific research	-Wetland contains threatened, rare, or endangered species. -Little or no disturbance is occurring in this wetland. -Potential educational site contains a diversity of wetland classes which are accessible or potentially accessible. -Off-road parking at potential educational site suitable for school bus access in or near wetland. -Site is currently used for educational or scientific purposes.

Uniqueness/Heritage (Heritage Value). This value considers the effectiveness of the wetland to provide special values, including overall health and appearance and its role in the ecological system of the area.	-Upland surrounding wetland primarily urban. -Upland surrounding wetland developing rapidly. -Two or more wetland classes visible from primary viewing locations. -Low-growing wetlands visible from primary viewing locations. -Half an acre of open water or 200' of stream is visible from primary viewing locations. -Wetland contains critical habitat for a state or federally listed threatened or endangered species. -Wetland is known to be a study site for scientific research. -Wetland is a natural landmark or recognized by the state natural heritage inventory authority as an exemplary natural community. -Wetland has local significance because it serves several functional values. -Wetland has local significance because it has biological, geological, or other features which are locally rare or unique. -Wetland is known to contain an important archeological site. -Wetland is hydrologically connected to a state or federally designated scenic river. -Wetland is located in an area experiencing a high wetland loss rate.
Visual Quality/Aesthetics (Heritage Value). This value considers the visual and aesthetic quality of the wetland.	-Multiple wetland classes visible from primary viewing locations. -Emergent wetland and/or open water visible from primary viewing locations. -Wetland dominated by flowering plants, or plants which turn vibrant colors in different seasons. -Land use surrounding the wetland is undeveloped as seen from primary viewing locations.

APPENDIX A4.

Relative abundance (%) of surrounding land use types and road density (m/ha) within 500 ft of 23 restored wetlands.*

SITE_ID	HI_DEV	LO_DEV	DST_OPEN	AGRIC	UPL_FOR	WATER	WETLNDS	RD_DEN
95-84	29.11	2.11	9.14	0.00	9.85	0.00	32.65	76
89-72	7.34	45.65	0.00	19.60	17.97	0.00	9.03	87
91-88	50.59	2.99	0.00	0.23	33.49	0.00	8.77	27
453a	38.95	0.00	16.99	0.00	25.14	0.00	16.03	60
453b	38.95	0.00	16.99	0.00	25.14	0.00	16.03	60
2150	58.83	0.00	5.30	0.00	22.42	0.03	8.85	30
92-80	3.81	12.63	0.00	0.00	46.76	0.00	35.49	32
96-130b	17.66	28.41	0.00	0.00	14.75	10.09	28.26	95
90-93	45.67	0.00	0.00	0.00	8.74	0.00	41.77	62
1473	74.28	0.00	3.84	0.00	9.80	0.00	9.80	39
95-259	46.13	0.00	5.64	0.00	10.89	0.00	37.23	65
914	2.19	48.09	0.00	10.41	15.91	0.00	21.58	45
1307	89.61	0.00	1.71	0.00	0.00	0.00	8.32	88
95-525	64.93	3.58	0.00	0.04	5.60	0.00	24.88	69
89-27	0.44	29.69	4.49	0.00	15.59	0.00	34.51	50
89-94	8.81	30.73	0.00	4.98	34.43	0.00	19.72	33
2292	3.71	18.77	0.00	13.89	21.82	11.12	30.32	23
93-226	0.00	11.69	0.00	1.45	39.64	0.00	47.00	39
1107	43.16	0.00	0.00	0.00	0.00	30.88	25.66	45
2771	0.00	12.49	0.00	14.76	42.75	0.00	29.20	37
2138	14.15	18.65	5.91	0.00	21.70	0.00	39.08	39
95-642	0.00	16.31	8.66	1.62	25.18	20.21	27.83	39
95-35	36.26	0.22	0.00	0.00	16.61	0.00	25.23	119

** Land use codes defined in Table 2.*

APPENDIX A5.
Site characteristics of 23 restored wetlands.

Site_ID	City/town	Size (sq ft)	Primary impact	Pre-alteration wetland type	Age (years)	Restored wetland type	Dominant plant species	Invasives cover class (%)	Water regime*
1107	Narragansett	2500	Filling	Scrub-shrub	14	Emergent	*P. australis*	76-95	SPF
1307	N. Kingstown	2500	Filling	Forested	16	Forested	*A. rubrum*	0	SF
1473	Johnston	20000	Filling	Forested	13	Forested	*Salix spp.*	1-5	TF
2138	S. Kingstown	5000	Filling	Scrub-shrub	11	Emergent	*J. effusus*	0	SF
2150	Pawtucket	60000	Filling	Emergent	11	Emergent	*L. salicaria*	51-75	SF
2292	N. Kingstown	4000	Filling	Emergent	8	Scrub-shrub	*Salix spp.*	0	SS
2771	Little Compton	7500	Filling	Forested	6	Emergent	*J. effusus*	6-15	SS
453-a	N. Providence	50000	Filling	Forested	20	Emergent	*P. australis*	76-95	SF
453-b	N. Providence	20000	Filling	Pond	20	Emergent	*P. australis*	76-95	SF
89-27	Jamestown	7200	Clearing	Forested	9	Forested	*Salix spp.*	0	TF
89-72	Lincoln	7200	Filling	Emergent	11	Emergent	*T. latifolia*	0	SF
89-94	Tiverton	10000	Filling	Forested	5	Emergent	*J. effusus*	6-15	SF
90-93	Johnston	15000	Filling	Forested	6	Emergent	*T. latifolia*	1-5	SF
91-88	Foster	100000	Filling	Scrub-shrub	6	Emergent	*T. latifolia*	6-15	SF
914	Barrington	20000	Filling	Forested	18	Scrub-shrub	*Cornus spp. /R. palustris*	0	SF
92-80	Foster	25000	Filling	Forested	3	Emergent	*T. latifolia*	0	SF
93-226	Little Compton	2000	Filling	Forested	6	Scrub-shrub	*R. palustris*	0	SF
95-84	N. Smithfield	25000	Filling	Forested	1	Emergent	*J. effusus*	6-15	SS
95-35	Westerly	20000	Filling	Forested	3	Emergent	*T. latifolia /S. cyperinus*	1-5	SF
95-259	Warwick	1500	Filling	Forested	2	Emergent	*S. cyperinus*	0	SS
95-525	Tiverton	7500	Filling	Forested	3	Emergent	*T. latifolia*	1-5	SF
95-642	Hopkinton	1800	Filling	Forested	2	Emergent		0	SF
96-130-b	Johnston	3500	Draining	Forested	1	Forested	*A. rubrum*	0	SF

**TF=temporarily flooded, SS=seasonally saturated, SF=seasonally flooded, SPF=semi-permanently flooded, PF= permanently flooded.*

APPENDIX B

Overview of OCI freshwater wetland enforcement actions, 1971-2000.

While reviewing complaint files to select restoration sites for field visits, much additional information regarding OCI enforcement actions was recorded. A summary of that information is presented here. Sample sizes vary among analyses because the process of file review was gradually streamlined, and eventually only those violations leading to restoration were selected for closer examination.

Findings

The number of freshwater wetland complaints on file at OCI increased steadily over the last 3 decades: 1,026 in 1971-80; 2,150 in 1981-90; and 4,693 in 1991-00. However, only in the early to mid 1980's did OCI begin to create complaint files for unfounded allegations of wetland alterations (H. Ellis, OCI; pers. comm., 2002); therefore, total complaint numbers for the 1970's and 1980's are underestimates of the actual totals. Among the 96 complaints that we reviewed for the period from 1971 to 1980, violations were addressed either through issuance of a Cease and Desist Order or Notice of Violation and Order (NOVAO), or through the violator's submission of an Application to Alter (Fig. B1a). During that decade, fewer than one-third (31%) of the complaints prompted restoration orders (Fig. B2), although all of the complaint files reviewed during this period involved confirmed alterations to freshwater wetlands.

Eight different regulatory actions were noted among 151 complaints reviewed for the period between 1981 and 1990 (Fig. B1b); a small number of additional cases were resolved through the submission of an Application to Alter. Ninety-seven percent of the complaint files that we reviewed during this period involved confirmed alterations. Far fewer complaints led to a Cease and Desist Order than in 1971-80. OCI responded to the great majority of complaints during this decade by issuing a NOVAO, and 70% of the complaints led to restoration orders.

Far more complaints were received between 1991and 2000 than in the previous two decades, and, as a result, OCI introduced four levels of triage, or prioritization of complaints, to manage this workload. Sixty-four percent of the complaints reviewed from this time period involved confirmed alterations to freshwater wetlands (Fig. B1c); 48% of the complaints led to restoration orders.

The percentage of restorations actually performed (i.e., those that were in compliance with OCI restoration orders) was similar among the three decades. Sixty-seven percent of required restorations were performed to OCI's satisfaction between 1971 and 1980, 83% between 1981 and 1990, and 75% between 1991 and 2000 (Fig. B2).

The amount of time between restoration orders and compliance ranged from less than 6 months to more than 10 years (mean = 36.2 months). Approximately 60% of all restorations were performed within 3 years of the original complaint (Fig. B3). The number of follow-up visits required by OCI staff to insure compliance ranged from 0 to more than 10 (Fig. B4). In 22% of the cases, compliance was achieved after one visit; in 54% of the cases, 2-5 visits were required.

In all years, alterations occurred both in "biological wetland" (i.e., swamp, marsh, bog, pond, or river) and "non-biological wetland" (i.e., perimeter wetland, floodplain, riverbank, area subject to flooding, or area subject to storm flowage). The bulk of alterations in each decade involved non-biological wetland (Fig. B5). Between 1971 and 1980, alterations of non-biological wetland were involved in 69% of the cases reviewed. Alterations of non-biological wetland occurred more frequently after 1980; 90% of the alterations reviewed from 1981-90 and 86% of the alterations from 1991-00 involved non-biological wetland. Approximately 60% of the alterations in each decade involved biological wetland.

Of all the alterations that led to restoration orders, filling (36%) was most common, and lowering of the water table (e.g., ditching) (1%) was least common (Fig. B6). Wetland types most frequently altered included perimeter wetland, forested wetland, riverbank, and floodplain (Fig. B7). Together, alterations to non-biological wetland accounted for 56% of the total. Sixty-four percent of the alterations to biological wetland and 72% of the alterations to non-biological wetland were less than 0.25 acres in size (Figs. B8 and B9).

Discussion

Enforcement of wetland regulations by OCI has grown increasingly complex over the last 30 years. During this time, the number of complaints concerning alleged alterations to wetlands has increased dramatically, and OCI has created an increasingly diverse series of responses in order to manage this workload. Three different types of responses were identified during this study between 1971 and1980, 9 between 1981 and 1990, and 12 between 1991 and 2000. Illegal alterations from 1971-80 were unlikely to result in wetland restoration; at that time, a Cease and Desist Order was the most common regulatory response. Restoration orders were issued at the highest rate (70% of confirmed alterations) during the 1980's, when there was both an increase in the rate of land development and stricter enforcement of the State's wetland regulations. The greatest number of complaints occurred during the 1990's, but more than one-third were unfounded. This high percentage of unfounded complaints may be explained in part by the public's using the Wetlands Act to try to halt development in their “backyard.” Restoration orders were issued for almost one-half of the violations that occurred in the 1990’s.

The frequency of alteration of non-biological wetland increased after 1980. Meanwhile, the frequency of alteration of biological wetland stayed relatively even over the three decades or dropped slightly during the last 10 years. These results suggest that increasing pressure is being placed on upland areas adjacent to wetlands as urbanization proceeds. The Governor’s Advisory Committee on Wetlands and Septic Systems recommended an increase in the size of the jurisdictional area around vegetated wetlands and standing water bodies from 50 ft to 100 ft in legislation submitted to the Rhode Island General Assembly in 1996-99, but the bill failed to pass in the House of Representatives each year.

While the number of restorations that were ordered varied among decades, the percentage of restorations that were actually performed remained similar. It is clear that regular monitoring of restoration projects is critical to guarantee compliance (2-5 visits for up to 3 years in most cases). The relatively high rate of compliance that has been achieved is due to the diligence of OCI staff. As the workload continues to increase, RIDEM needs to allocate sufficient resources to OCI to insure that compliance visits to restoration sites will continue.

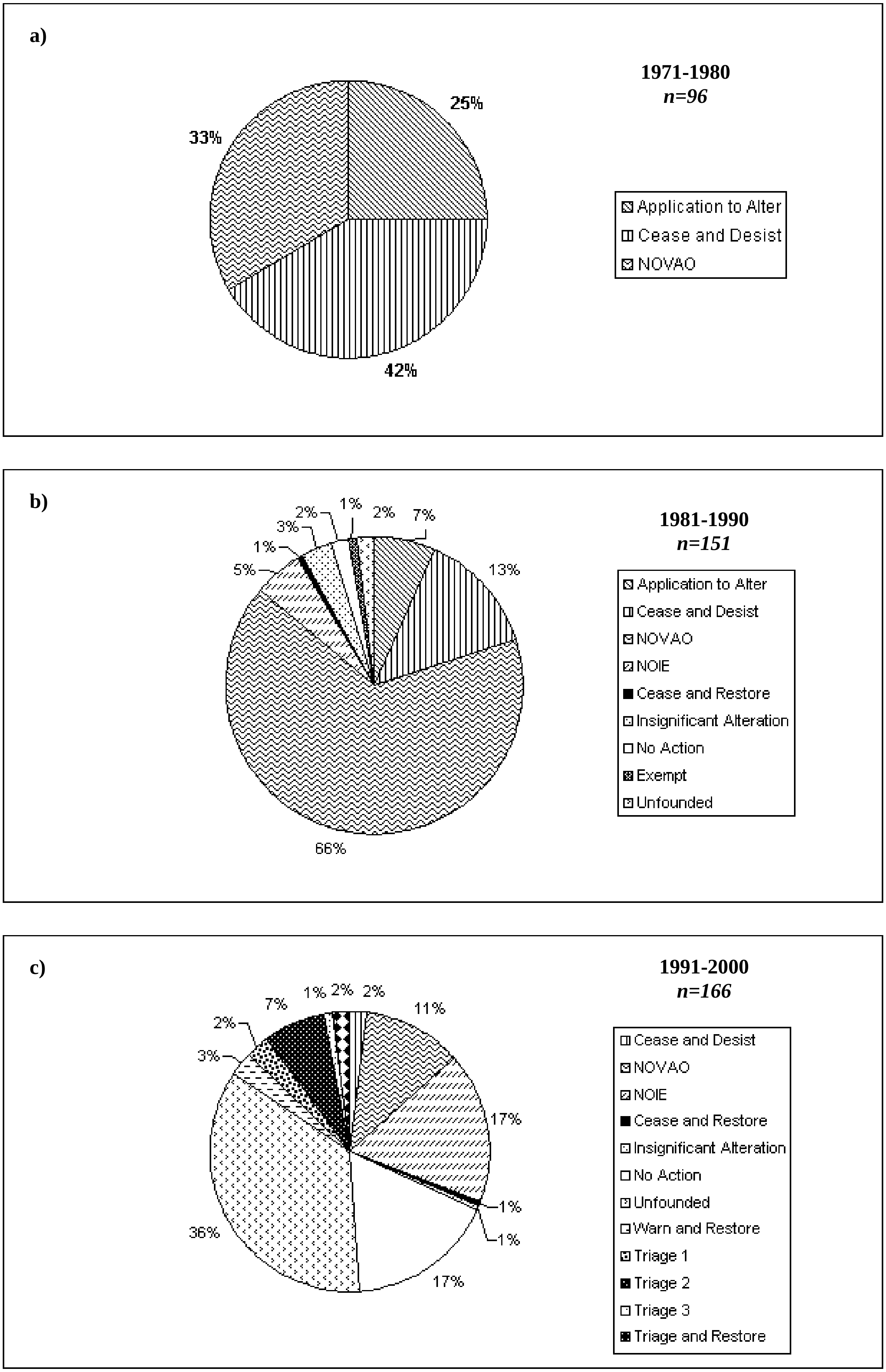

Figure B1. Regulatory actions initiated by OCI in response to freshwater wetland complaints, 1971-2000.

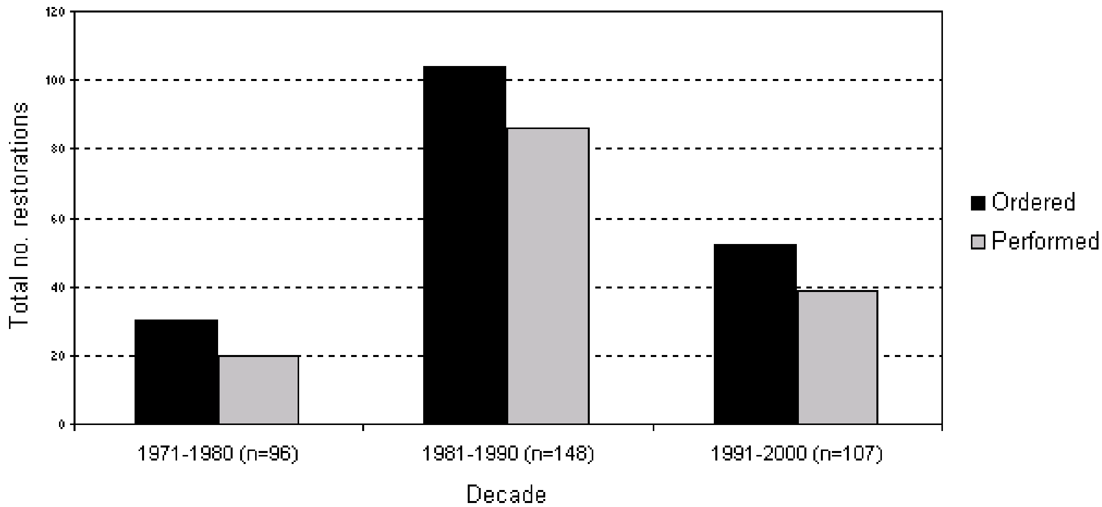

Figure B2. Total number of freshwater wetland restorations ordered and performedsatisfactorily during three decades. n= number of confirmed alterations.

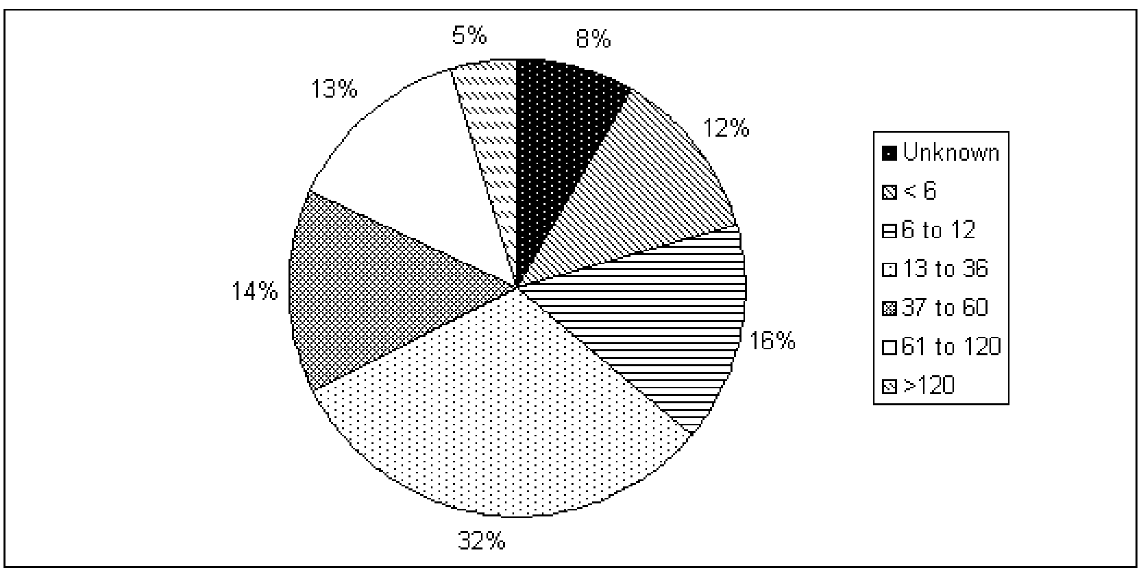

Figure B3. Time (months) between freshwater wetland restoration orders and compliance, 1971-00 (n=83).

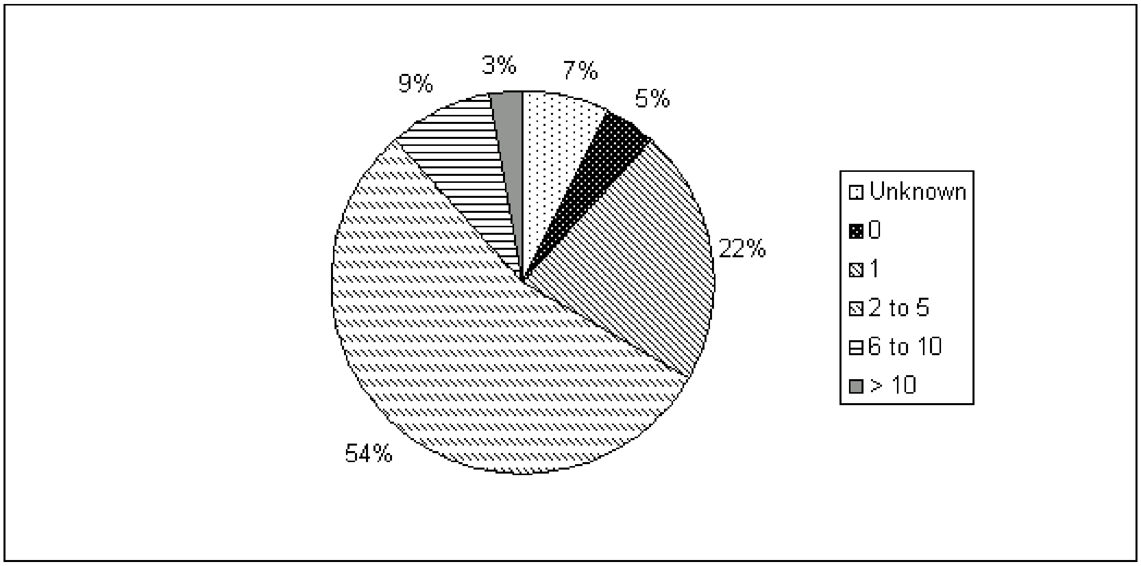

Figure B4. Number of follow-up visits by OCI staff before restoration compliance was achieved, 1971-00 (n=111).

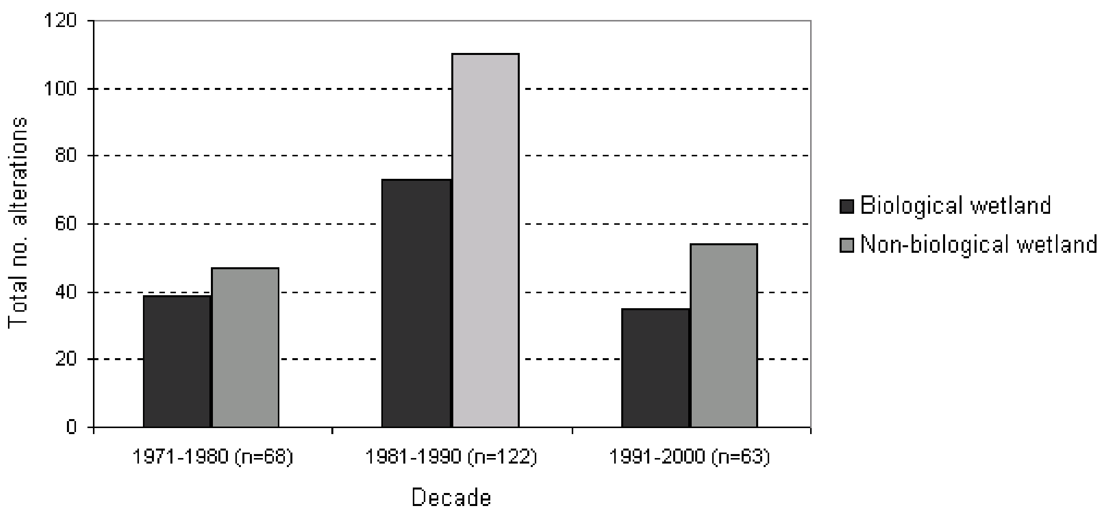

Figure B5. Total number of confirmed alterations involving biological and non-biological wetland during three decades. n= total number of alterations involving biological wetland, non-biological wetland, or both, that were reviewed during this study.

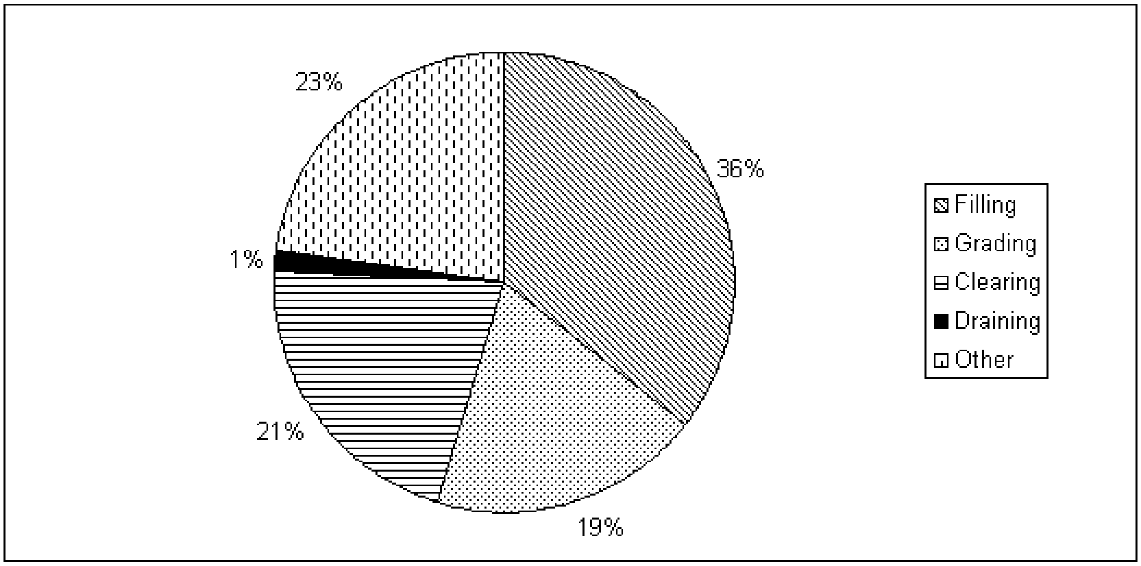

Figure B6. Types of alterations to wetlands where restoration was ordered, 1971-00 (n=258).

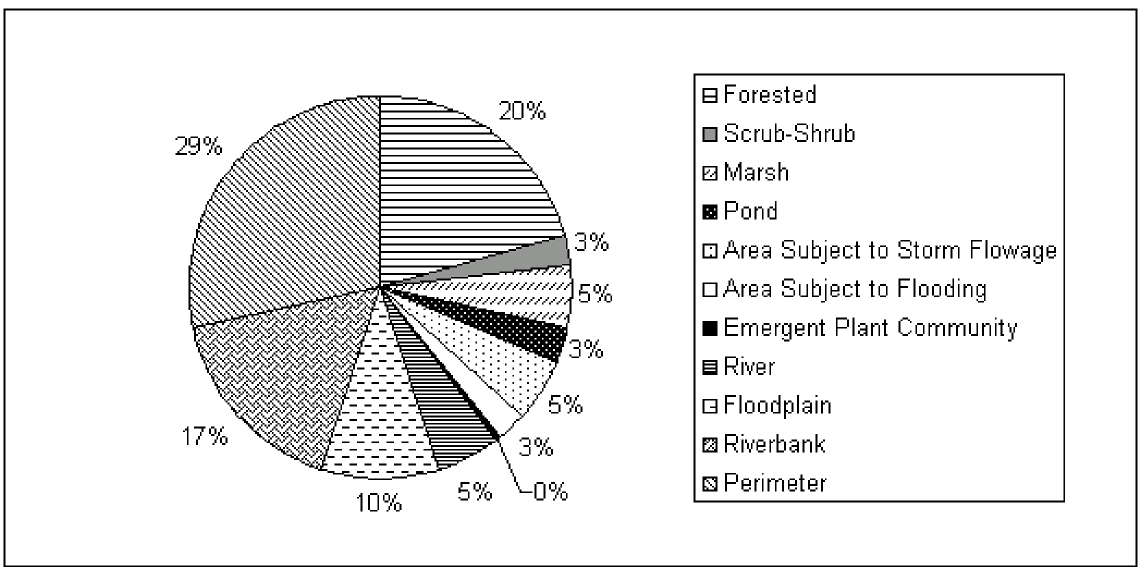

Figure B7. Wetland types altered in enforcement cases requiring restoration, 1971-00 (n=240).

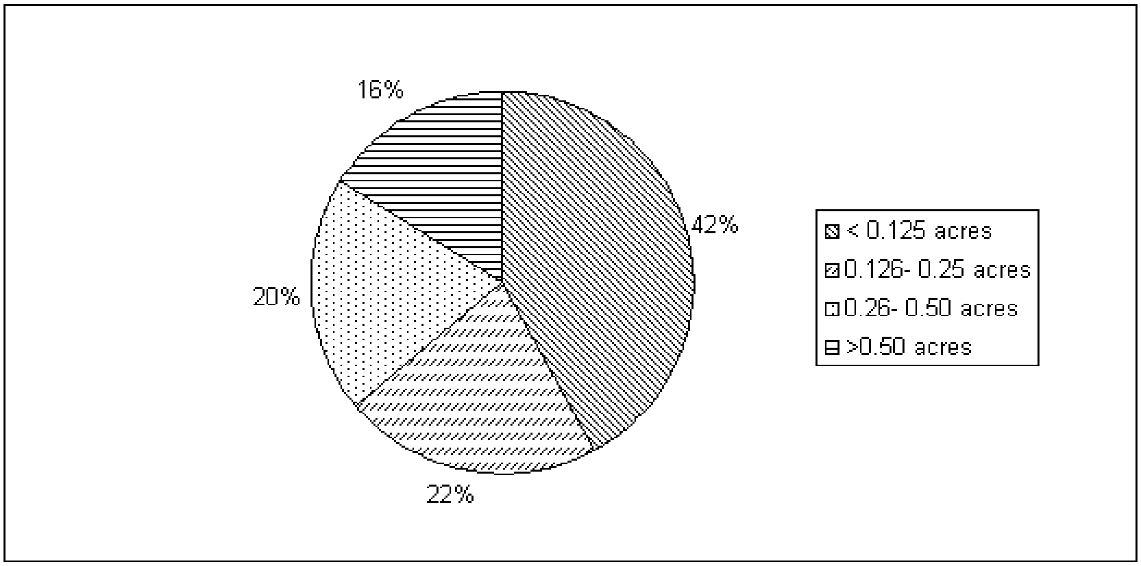

Figure B8. Sizes of alterations to biological wetland in enforcement cases requiring restoration, 1971-00 (n=50).

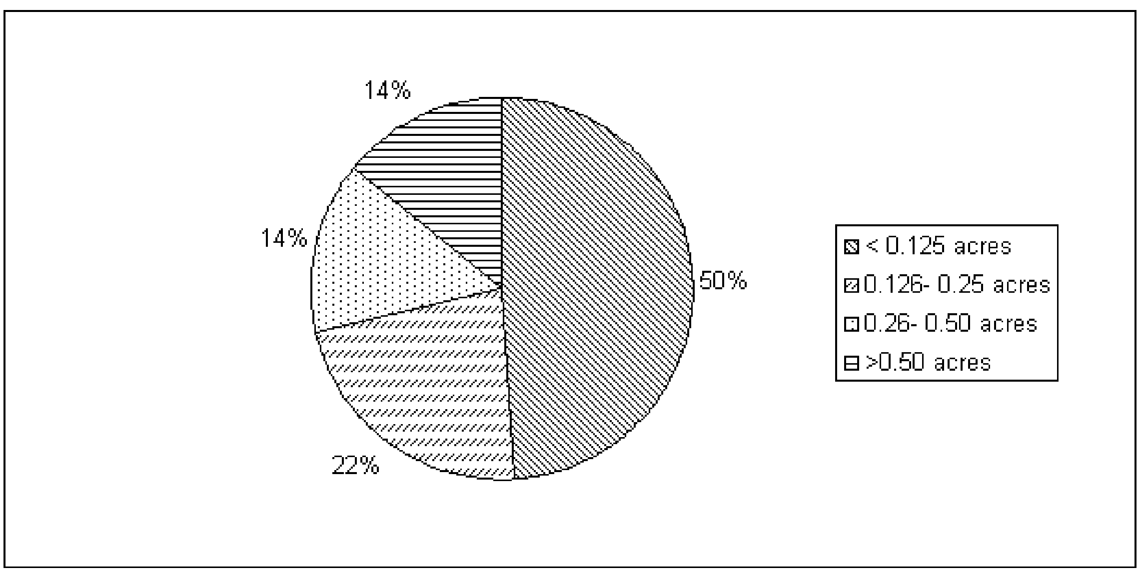

Figure B9. Sizes of alterations to non-biological wetland in enforcement cases requiring restoration, 1971-00 (n=49).