Analysis of Historic Aerial Photographs to Assess Changes in Cover and Distribution of *Phragmites australis* at Wertheim National Wildlife Refuge, New York

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Summary

Historic aerial photographs were evaluated for use in mapping changes in the spatial distribution of *Phragmites australis* at Wertheim National Wildlife Refuge, on Long Island, New York. The most appropriate aerial photographs were growing season aerials taken by the New York State Department of Environmental Conservation in 1974 and 1989. These were compared with the distribution of *Phragmites australis* mapped in 2000 by the Conservation Management Institute (CMI). The CMI boundaries were slightly adjusted based on a review of aerial photographs and an aerial video taken in 2000 of the Refuge by NYSDEC.

In 1974, *Phragmites australis* covered approximately 155 acres. Coverage of *Phragmites* increased to 245 acres by 1989 and 335 acres by 2000. There were 128 patches in 1974, decreasing to 81 in 1989 and 51 in 2000 as patches coalesced. In the north portion of the Refuge, shorelines and islands within the main river have become dominated by *Phragmites australis*; while in the southern part of the Refuge, expansion has occurred on shorelines and ditches. From 1974 to 1989 the area covered by *Phragmites australis* increased approximately six (6.0) acres per year (2.5 ha/year). This rate increased to 8.2 acres per year (3.4 ha/year) from 1989 to 2000.

The expansion has been rapid, but comparable to other sites where similar studies have been completed. Further work should be done to address the relationship of *Phragmites australis* distribution and expansion to salinity levels and disturbance in the Refuge.

I. Introduction

A. Purpose of This Report

Phragmites australis or common reed is considered an invasive plant in wetlands due to its ability to form monotypic stands, thereby reducing diversity of other plant species. *Phragmites australis* is found in freshwater and brackish water conditions with low wave action, and can colonize both disturbed and pristine wetlands (Marks et al. 1993). This study documents changes in the distribution of *Phragmites australis* at Wertheim National Wildlife Refuge, in Suffolk County, New York from 1974 to 2000, using analyses of aerial photographs.

B. Wertheim National Wildlife Refuge

Wertheim National Wildlife Refuge is located on the south shore of Long Island in Suffolk County and in the Town of Brookhaven. Most of the 2,380-acre Refuge is in the Bellport USGS Quadrangle with a small portion in the east in the Moriches Quadrangle. The Refuge is bisected by the Carmans River, designated by New York as a Wild and Scenic River, which flows into Bellport Bay, the easternmost portion of Great South Bay. The Refuge contains extensive aquatic habitats including marine communities, intertidal and high salt marsh, freshwater tidal marsh, shrub swamp, and red maple-black gum swamp. The upland habitats include pitch pine-oak forest, coastal oak-heath forest, successional woodlands and shrublands, and open fields.

II. Methods

A. Data Sources

The Conservation Management Institute in Blacksburg, Virginia mapped vegetation through analyses of aerial photographs and field data from 1999 to 2001. The vegetation map produced by the Institute shows the distribution of twenty cover types, including *Phragmites australis*, mapped on to 1994 digital orthophotographs prepared by the New York State Department of Coastal Resources. Other data used in this study to assess *Phragmites* australis included National Wetland Inventory data (U.S. Fish and Wildlife Service 2003) and various GIS layers from the New York State GIS Clearinghouse and the Cornell University Geospatial Information Repository. These sources are listed in Section IV under web sites.

B. Aerial Photography

The U.S. Geological Survey database (Earth Explorer) was searched for historic aerial photographs as was the U.S. Department of Agriculture Aerial

Photography Field Office and the New York State GIS Clearinghouse. On reviewing some of these aerial photographs and similar studies in which *Phragmites australis* was mapped using historic aerial photographs (Barrett and Prisloe 1998; Winogrond 1997), it became apparent that the scale of aerial photographs had to be at least 1:20,000, and preferably 1:12,000 or greater, to allow for accurate delineation of *Phragmites australis*.

The best aerial photographs were available from the New York State Department of Environmental Conservation. These 1:12,000 color infrared aerial photographs were taken in August of 1974 and August of 1989. The NYSDEC aerial photographs were acquired as scanned TIFF images at 800 dpi with generous assistance from Fred Muschacke of NYSDEC.

Other available photographs were black and white, taken in the spring (leaf off). Black and white aerial photographs from 1980 were acquired from Aerographics in Smithtown, NY with help from Tom Rohan of Aerographics. Black and white positives (transparencies) at 1:20,000 were acquired from the U.S. Department of Agriculture Aerial Photography Office. The aerial photographs used in this study that cover the Refuge are listed in Section IV. C.

C. Preparing Aerial Photographs for Interpretation

1. Scanning and Rectifying Images

Some aerial photographs were available digitally and others as prints. The hard copy versions were scanned and the digital versions printed, so photographs were available in both forms as follows:

1974 and 1989 1:12,000 DEC color infrared aerial photographs were scanned at 800 dpi as TIFF files and printed as standard aerial photographs (9” x 9”).

1980 1:12,000 black and white aerials were purchased from Aerographics as prints. These were scanned at 300 dpi as TIFF files

1961 USDA 1:20,000 positives (transparencies) were scanned at 600 dpi as TIFF files.

The scanned images were then rectified using ERDAS Imagine software. Control points were established at features that could be found in both the 1994 orthophotographs developed by the New York State GIS Clearinghouse and on each historic aerial photograph covering the Refuge. Two photographs were rectified for each year (1961, 1981, 1974, 1989) to cover the Refuge. These control points were generally road intersections, specific points along streams or along other waterways, or bridges.

During rectification, the software calculated a root mean square or RMS error. This error represents the degree of correspondence between the control points on the orthophotograph, which is a map, and the image being rectified, in this case, an aerial photograph (ERDAS 1999). The RMS was consistently less than one meter for these images.

2. Sources of Error in Alignment

The purpose of rectifying the historic aerial photographs was to convert the aerial photographs to maps that would align with the 1994 digital orthophotographs developed by the New York State GIS Clearinghouse. Despite the low RMS, there remained some offset in the aerials from these 1994 orthophotographs. In other words, the alignment between the historic aerial photographs and the 1994 orthophotograph was not exact. For 1989 and one of the 1974 aerials, this offset was between 5 and 10 meters. For the second 1974 aerial photograph (1455) the offset was over 20 meters. Despite repeated efforts, this offset could not be eliminated. In one case, an aerial was orthorectified. In that procedure, the digital elevation model was used to correct for any distortion or offset due to changes in topography. However, the result appeared to have a greater offset than rectification alone, so the procedure was not used further.

Polygons designated as *Phragmites australis* in the vegetation coverage developed by the Conservation Management Institute were converted into a separate ARCVIEW shapefile for the year 2000 *Phragmites australis* boundary. There is an approximately 5-7 meter difference or offset between the orthophotos they used, provided by the New York State Department of Coastal Resources and the current standard orthophotographs provided by the New York State GIS Clearinghouse. Both are based on 1994 photography.

D. Interpretation of Aerial Photographs and Digitizing *Phragmites Australis* Boundaries

The 2000 coverage was used as a starting point, since there is no field data for 1974 or 1989. So areas with *Phragmites australis* in 2000 were evaluated in both the 1974 and 1989 aerials to aid in identifying signatures for *Phragmites australis*. Some adjustments to the 2000 boundaries were made, based on an evaluation of a video from NYSDEC, taken in 2000 from a low-flying helicopter, and on signatures on the digital orthophotos. These adjustments resulted in a small (3-5 acres) decrease in the overall extent of *Phragmites australis* from that found by the Conservation Management Institute.

Boundaries of *Phragmites australis* were delineated, using ARCVIEW, on screen over the rectified 1974 and 1989 aerials. Patches of *Phragmites australis* generally appeared in the form of circular clones or as dense, reddish patches in the 1974 and 1989 aerial photographs. Where pattern and color were not sufficient a

magnifying (4x) stereoscope was used to identify patches of *Phragmites* based on height of the vegetation. Patches were delineated where *Phragmites australis* appeared to exceed 50% cover.[1] There were small patches, particularly along ditches, that may have been missed using this criterion, but these did not appear to represent more than a few acres in total area.

After several efforts, I abandoned using the 1961 and 1980 aerials to delineate *Phragmites australis* for those time periods. Both sets are black and white, taken in March and May respectively. While some authors have been able to discern *Phragmites australis* on black and white aerials, this proved difficult on the 1961 and 1980 aerials. Kiviat noted that dense and tall stands are generally recognizable but that mixed stands or stunted stands may not be (Erik Kiviat, personal communication). On overlaying the 1974, 1989, and 2000 boundaries on these, no discernible patterns or signatures could be consistently discerned.

III. Findings

A. Summary of Changes

1. Changes in Area

According to vegetation mapping by the Conservation Management Institute, there are approximately 1,315 acres of wetlands on the Refuge. Table 1 below shows the changes in area of *Phragmites australis* within the boundaries of Wertheim NWR over the period from 1974 to 2000. The number of patches has declined as patches or clones have coalesced, resulting in an increase in average patch size.

Table 1. Comparison of number of patches (N), minimum vs. maximum patch size, mean patch size, standard deviation and total area of *Phragmites australis* in 1974, 1989, and 2000.

Year	N	Minimum (acres)	Maximum (acres)	Mean (acres)	SD	Total (acres)	Proportion of total wetland in Wertheim NWR[2]
1974	128	<0.5	47.8	1.2	4.5	155.3	12%
1989	81	<0.5	43.2	3.0	7.1	245.2[3]	19%
2000	51	<0.5	58.5	6.6	12.0	335.3	25%

[1] Generally, *Phragmites* appeared to dominate the areas in which it grew on both the 1974 and 1989 aerials and on the NYSDEC helicopter video of the area.

[2] Based on mapping by the Conservation Management Institute in 2000 of 1,315.5 acres in wetland communities, including open marsh, shrub, and forested wetlands. The National Wetland Inventory figure is 1316.2 acres (U.S. Fish and Wildlife Service 2003).

[3] Approximately 7.3 acres of *Phragmites australis* that appeared in the 1974 aerial photograph were inundated with the creation of a pond in the east-southeast portion of the Refuge.

2. Comparison of Maps for Each Period

Six maps were created at a scale of 1:12,000 to allow for a comparison of the distribution of *Phragmites australis* for each period. The Refuge was split between north and south to arrive at this scale, which allows for easier visual inspection of changes in the distribution of *Phragmites australis*. The maps can be found following the reference section, and there are two for each year, one for the northern part of the Refuge and one for the southern part.

As described in II C. above, registration of aerials was not perfect. While this may affect the calculation of area in each year by only a minor degree, it makes overlaying each year onto another inaccurate. Therefore, Maps 1 and 2 show the distribution of *Phragmites australis* over the 1974 aerial photographs, and Maps 3 and 4 show the boundaries over the 1989 aerial photographs. For 2000 (Maps 5 and 6), the New York State GIS Clearinghouse orthophotographs were used.[4] A review of these aerials shows the following trends:

- Small patches in 1974 gradually coalesce into larger patches
- In the south, *Phragmites australis* seems to be expanding along ditches and shorelines.
- In the north, areas of open marsh along shorelines and islands, have become nearly completely dominated by *Phragmites*.
- *Phragmites* has grown up to the shrub and forested areas that transition between wetlands and upland forests.

B. Comparison to Other Studies

Winogrond (1997) evaluated changes in *Phragmites australis* at Stockport Flats, Tivoli North Bay, Iona Island Marsh, and Piermont Marsh, along the Hudson River in New York using aerial photographs from three periods between the 1960's and 1991. Expansion rates were estimated by dividing the change in area of *Phragmites* between aerial photographs by the number of years between photographs. Rates varied from 0.01 to 0.09 ha/year (0.09 to 0.22 acres/year) at Stockport Flats and Tivoli North Bay to 0.10 to 1.12 ha/year (0.24 to 2.71 acres/year) at Iona Island Marsh and 0.12 to 3.70 ha/year (0.29 to 8.95 acres/year) at Piermont Marsh. The rates of increase for the 1980 to 1990 period were higher than that of the 1960 to 1980 period. Winogrond also noted that the maximum rates of increase occurred in oligohaline (0.5-5.0 ppt) wetlands with lower rates in mesohaline (5-18 ppt) and freshwater (0-0.5 ppt) wetlands.

[4] While there is a slight (approximately 6 meter) offset in the boundaries of *Phragmites australis* delineated by the Conservation Management Institute on these orthophotographs, this difference is not noticeable at the scale of Maps 5 and 6.

By comparison at Werthiem, from 1974 to 1989 the area covered by *Phragmites australis* increased approximately six (6.0) acres per year (2.5 ha/year). This rate increased to 8.2 acres per year (3.4 ha/year) from 1989 to 2000.

Barrett and Prisloe (1998) compared the distribution of *Phragmites australis* mapped using 1965 and 1994 aerials along 31 sites in the tidal and fluvial reaches of the Connecticut River, as defined by The Nature Conservancy. They compared the portion of a given wetland, as defined in the National Wetland Inventory that was invaded by *Phragmites* in each period. They calculated the percent gain, or the difference in the proportion of a given wetland covered by *Phragmites australis* in 1994 minus that proportion in 1968. This percent gain varied widely between sites, from less than one percent to over 60%. When they compared sites along a salinity gradient, the lowest expansion occurred in the mesohaline and freshwater portions, with the greatest expansion in oligohaline wetlands. By comparison the percent gain at Wertheim NWR was seven (7%) from 1974 to 1989, six percent (6%) from 1989 to 2000, and 13% for the 1974 to 2000 period.

Rice et al. (2000) compared aerials from the 1930's, 1970's, 1980's, and 1990's for sites with various salinity levels in the Upper Chesapeake Bay. They calculated an intrinsic rate of increase to allow for comparisons between sites regardless of area differences. Their rates for the 1970 to 1980 period varied from 0.0037 to 0.0191 in freshwater marshes, 0.0451 to 0.1175 in mesohaline marshes, and 0.2123 in oligohaline marshes. For the 1980 to 1990 period, the rates were 0.0062 to 0.0129 in freshwater marshes, 0.016 to 0.0644 in mesohaline marshes, and 0.1221 to 0.1919 in oligohaline marshes. In addition, the rates of increase appeared to decrease or stabilize in marshes colonized prior to 1985, but not for those colonized since 1985.

Using their formula for rates of increase, Wertheim experienced increase rates of 0.0304 from 1974 to 1989 and 0.0284 for 1989 to 2000, a slightly lower rate.

C. Recommendations for Further Work

Phragmites australis is considered to be most capable of invading disturbed areas. Therefore, selected areas where expansion has occurred could be evaluated to determine if some form of disturbance has or is occurring and the cause. Many of the tidal wetlands on Long Island have experienced disturbance from storm events, and the extent of disturbance is being mapped by NYSDEC (Fred Muschacke, NYSDEC, personal communication). In addition, based on other studies *Phragmites australis* appears to expand to the greatest extent in moderately saline marshes. The Conservation Management Institute assessed *Phragmites australis* and salinity. The results of that study could be compared with variations in expansion rates on a salinity gradient.

IV. References

A. Literature

Barrett, N. and S. Prisloe. 1998. Spatial patterns of expansion by *Phragmites australis* (Cav.) Trin. *Ex* Steud. Within the tidelands of the Connecticut River from 1968 to 1994. Report to The Nature Conservancy, Connecticut Field Office, Middletown, Ct.

ERDAS 1999. ERDAS Field Guide, 5th Edition, ERDAS, Inc. Atlanta, GA.

Marks, M., Lapin, B., Randall, J. 1993. Element stewardship abstract for *Phragmites australis.* The Nature Conservancy, Arlington, Virginia.

Rice, D., J. Rooth, and J.C. Stevenson. 2000. Colonization and expansion of *Phragmites australis* in Upper Chesapeake Bay tidal marshes. Wetlands, 20 (2): 280-299.

Winogond, H.G. 1997. Invasion of *Phragmites australis* in the tidal marshes of the Hudson River, A thesis submitted to the faculty of the Graduate School of Environmental Sciences, Bard College, Annandale-on-Hudson, NY.

B. Web Sites

Cornell University Geospatial Information Repository (CUGIR 1.5) 2003. Available at: http://cugir.mannlib.cornell.edu/index.jsp

New York Department of Environmental Conservation Tidal Wetlands Materials. 2000. Available at: http://www.dec.state.ny.us/website/dfwmr/marine/material.htm
The New York State GIS Clearinghouse 2003. Available at: http://www.nysgis.state.ny.us/welcome.htm

U.S. Department of Agriculture Aerial Photography Field Office 2003. Available at: http://www.apfo.usda.gov/orderingimagery.html#anchor324087

U.S. Fish and Wildlife Service 2003. National Wetlands Inventory Home Page. Available at: http://wetlands.fws.gov/

U.S. Geological Survey Earth Explorer 2003. Earth Resources Observation System Data Center. Available at: http://edcsns17.cr.usgs.gov/EarthExplorer/.

C. Personal Communication Sources

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D. Aerial Photographs

The table below lists aerial photographs used in this study. Those marked with an asterisk (*) were rectified and used in GIS mapping.

Table 2. Aerial photographs used in this study.

Date/Year	Photographs	Source	Scale	Type
17 May 1961	ASA-5AA-26, 27*, 28*, 29 and 30	USDA Aerial Photography Field Office	1:20,000	Black and white
23 March 1980	51-0140, 51-0141*, 51-0142, 52-0143*, 51-0144 and 0145 52-0153, 52-0154, 52-0155, 52-0156, 52-0157 and 52-0158	Aerographics, Inc.	1:12,000	Black and white
19 August 1974	1454, 1455*, 1456 1274, 1275*, 1276	NYSDEC	1:12,000	Color infrared
25 August 1989	31A-132, 133* and 134 32A-169*, 170 33A-177, 178	NYSDEC	1:12,000	Color infrared

Maps

The following maps (1:12,000) can be used to evaluate changes in the distribution of *Phragmites australis*:

Map 1. Boundary of *Phragmites australis* 1974
Wertheim National Wildlife Refuge - North
Map 2. Boundary of *Phragmites australis* 1974
Wertheim National Wildlife Refuge - South
Map 3. Boundary of *Phragmites australis* 1989
Wertheim National Wildlife Refuge - North
Map 4. Boundary of *Phragmites australis* 1989
Wertheim National Wildlife Refuge - South
Map 5. Boundary of *Phragmites australis* 2000
Wertheim National Wildlife Refuge – North
Map 6. Boundary of *Phragmites australis* 2000
Wertheim National Wildlife Refuge – South