Center for GIS

JUG BAY WILD RICE DELINEATION:
A HISTORICAL CHANGE ANALYSIS

Final Report

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Prepared for

Maryland Chesapeake Bay National Estuarine Research Reserve
Maryland Department of Natural Resources

Prepared by the Towson University Center for GIS

a Unit of the Division of Economic and Community Outreach

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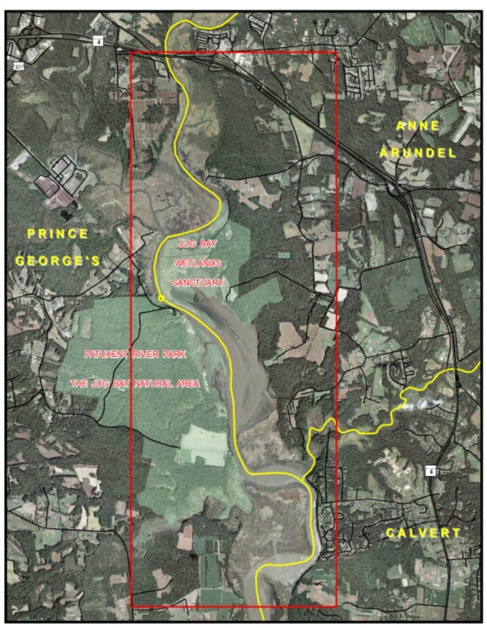
Background:

The Maryland Department of Natural Resources (MD DNR), through the Maryland Chesapeake Bay National Estuarine Research Reserve (CBNERR-MD) is engaged in an effort to protect and promote expansion of wild rice in the Jug Bay area of the upper Patuxent River. In order to evaluate the historical changes of the wild rice communities at Jug Bay, as well as the success of wild rice restoration and preservation efforts, CBNERR-MD employed the Center for GIS at Towson University (CGIS) to identify and delineate stands of wild rice based on aerial photography for four specific growing seasons.

Wild rice has historically been established in the Jug Bay area above the vicinity of Hall Creek on the Calvert County side, and Spice Creek on the Prince George's County side, where salinity levels below 5 parts per thousand permit its growth. Beginning in the late 1970's, a resident population of Canada Geese became established in the area. This population grew steadily, and by the mid-1990's, signs of their significant effect on the wild rice became apparent. Measures to protect the wild rice were initiated in 1999. These measures included installation of protective barriers, including 20,000' fencing to inhibit foraging geese, introduced wild rice plantings, applying herbicides to areas colonized by phragmites, and since 2001, a reduction of the resident Canada Geese population by about 2,500 birds. The areal extent of wild rice bottomed out around the year 2000. Since then, it has steadily rebounded. The study area for this project includes the marshes surrounding the Patuxent River and is bounded by the Rt. 4 bridge near Wayson's Corner in the north, and the southern limit of the Merkle Wildlife Management Area in the south (Figure 1).



A detailed delineation of marsh grass species was performed for the area during 2003. This study attempts to more fully document the reduction and rebound of wild rice in the area. A baseline is established with delineation for the 1989 growing season, prior to significant decline. The extent of wild rice is depicted near its minimum with a delineation of the 1999 growing season. The years 2005 and 2007 are included to document the rebound of the rice in recent years.

Note: This report was prepared by the Center for GIS at Towson University under Award No. NA07NOS4200134 from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

Data:

Completing this work required access to aerial photography of sufficient quality to distinguish the wild rice from the other marsh grasses. The rice is typically most identifiable during the first week of August, when it is in bloom. The Virginia Institute of Marine Science (VIMS) offered to share its library of black and white aerial photography that includes annual imagery for this study area dating back to the 1970's. Prior to the year 2000, VIMS has 9" x 9" hard copy prints of the images. Beginning in 2000, VIMS began receiving the imagery in data in digital (.tif) format. Members of the project team travelled to VIMS to review and select the imagery best suited to meet the project goals, in terms of target years and image quality. The team included Mr. Greg Kearns, staff biologist at the Patuxent River Park, Jug Bay Natural Area and subject matter expert regarding temporal and locational changes of wild rice within the study area. Images representing 1989 (9/28/89), 1999 (9/11/99), and 2005 (9/03/05) were selected. During this meeting, Mr. Kearns instructed the CGIS Project Manager on how to distinguish the wild rice from the other marsh grasses in the photos, based on color, texture and location.

Scanned copies of the 1989 and 1999 images were ordered from the Air Photographics, Inc. Scans were taken at 12.5 microns. The source imagery was acquired at 12,000', 1:2,400 scale. For each of these years, four images along a north-south flight line were required to capture the entire study area. The four scanned images for 1989 and 1999 were mosaiced into a single image. To maintain consistency among the different years covered in the project, and because the rural nature of the study area offers a limited number of landmarks for georeferencing, the resulting images, as well as the 2005 imagery received from VIMS in digital (.tif) format were georeferenced (Maryland State Plane, NAD 83, Meters) to the 2007 imagery. Total Root Mean Square (RMS) error detail is provided in Appendix A. The source orthophotography for 2007 is the National Agriculture Imagery Program (NAIP). The NAIP imagery is true color, captured on 7/27/2007, and was collected at 1:40,000 scale, then scanned at 25 microns. This data was acquired from the MD DNR (http://dnrweb.dnr.state.md.us/gis/data/data.asp). True color NAIP imagery, which offers some advantages regarding ease of interpretation, is also available for 2005, but was rejected in favor of the VIMS imagery due to the presence of clouds and haze.

Data Creation Process:

Visual interpretation of the aerial imagery was performed, with polygons representing areas of wild rice digitized at an average scale of 1:2,000. The polygons represent and are attributed and symbolized as either monoculture or mixed stands of wild rice. The 2007 growing season was digitized first, with an on-line review meeting held upon completion to examine the results. Input was shared at this meeting, and the digitizing subsequently refined, separating the polygons to indicate either monoculture or mixed stands. After this initial feedback session, digitization for the 1989, 1999, and 2005 growing seasons was performed. An in-person review meeting between CGIS staff and Mr. Kearns was held to review the results. Large-scale plots were examined, with areas to be edited drawn in. A second round of edits to the wild rice polygons was made based on this review, with polygons added, deleted or edited.

Limitations:

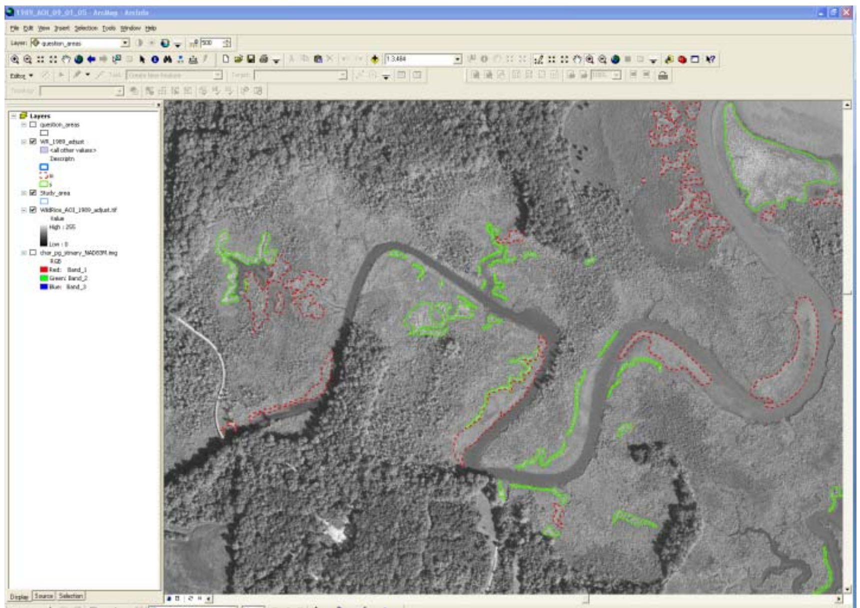
It was noted that color variation in the imagery made the wild rice difficult to distinguish in many areas where it appeared similar to other vegetation. This is particularly true in the delineations based on black and white imagery. Below are two examples from each year where there are similar shades of color and or textures representing solid and mixed stands of wild rice, while others of similar color or texture are not captured. Areas identified as either solid or mixed stands of wild rice are ultimately based on a combination of interpretation of the imagery, and Mr. Kearns familiarity with stands of wild rice in the Patuxent River Park Jug Bay Natural Area.

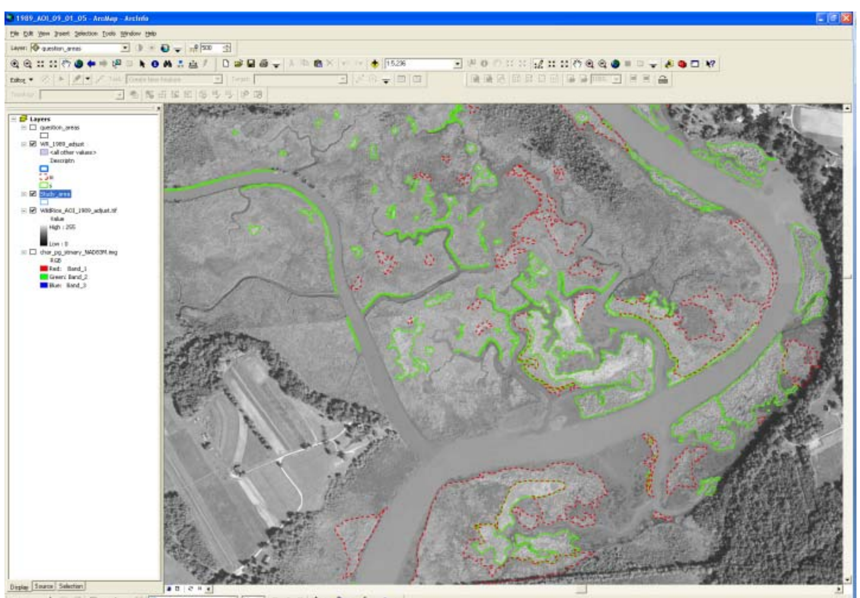
The spraying of marsh vegetation in the study area to remove phragmites had possibly occurred in 1999, prior to the acquisition of the aerial imagery. The lighter coloration resembling wild rice in some areas previously dominated by phragmites could by vegetation impacted by this spraying. Additionally it is believed that recent flooding in some areas may have left mud on vegetation along the shoreline that causes it to appear similar in color to wild rice.

Wild rice is most identifiable in aerial photographs during its flowering stage, which in the Jug Bay area is typically in the first week of August. However, this project depended upon available imagery for the study area, with the exception of 2007, acquisition dates that were not optimal.

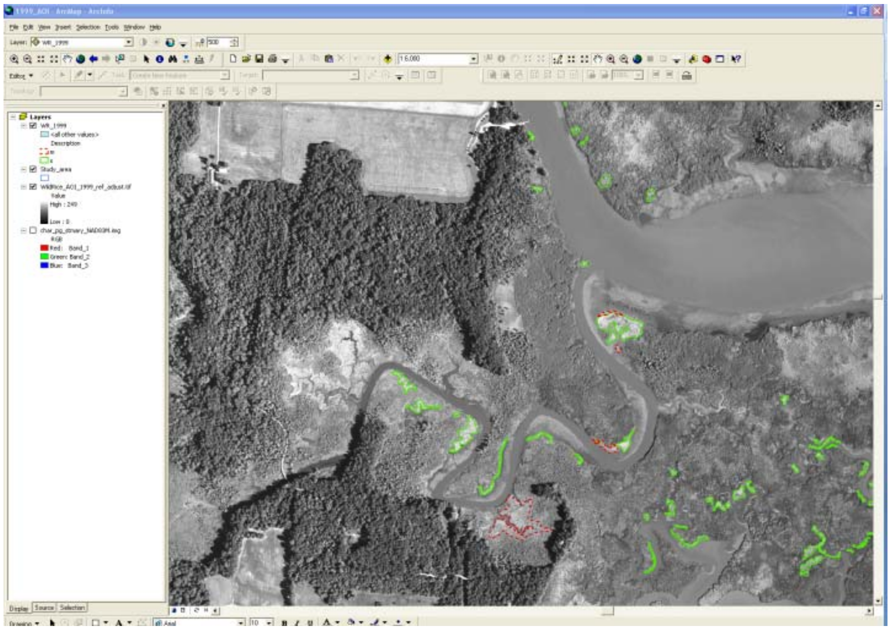
Imagery acquired after peak flowering stage does not prevent identification of the wild rice, but can increase the difficulty of interpretation. The imagery acquired from VIMS was captured on 9/28/1989, 9/11/1999, and 9/03/2005. The acquisition date for the NAIP imagery was 7/27/2007.

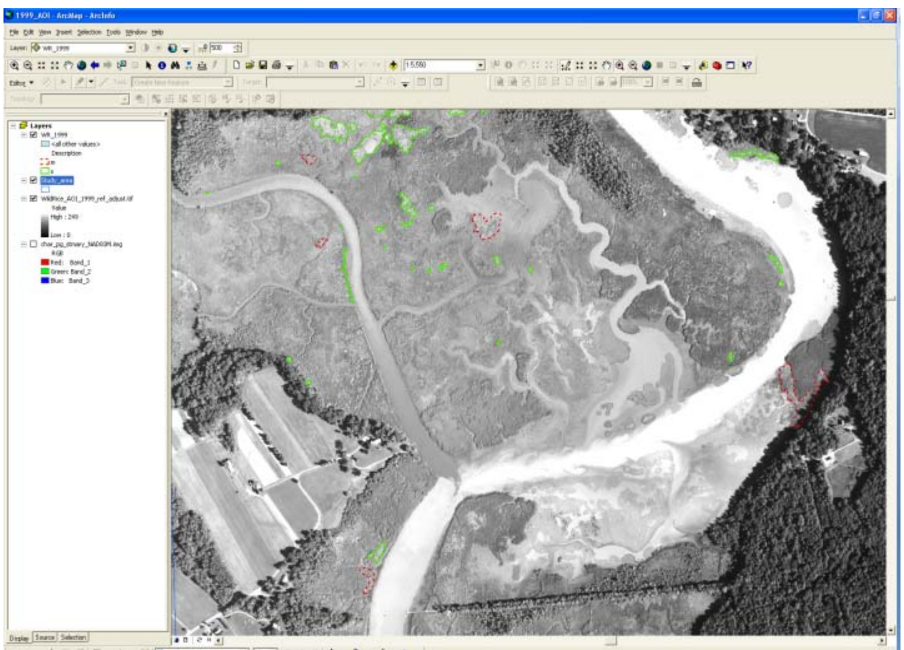
1989



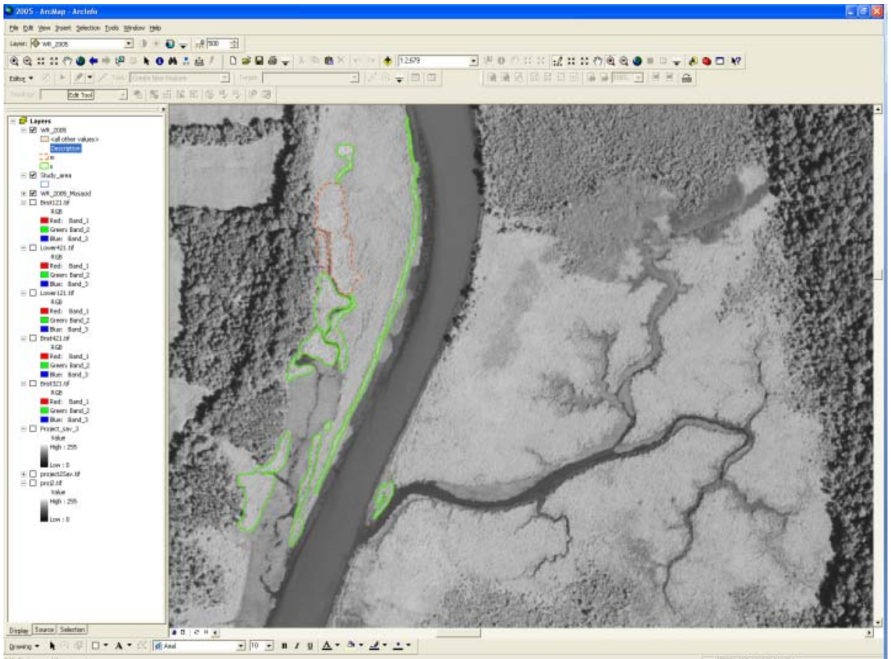


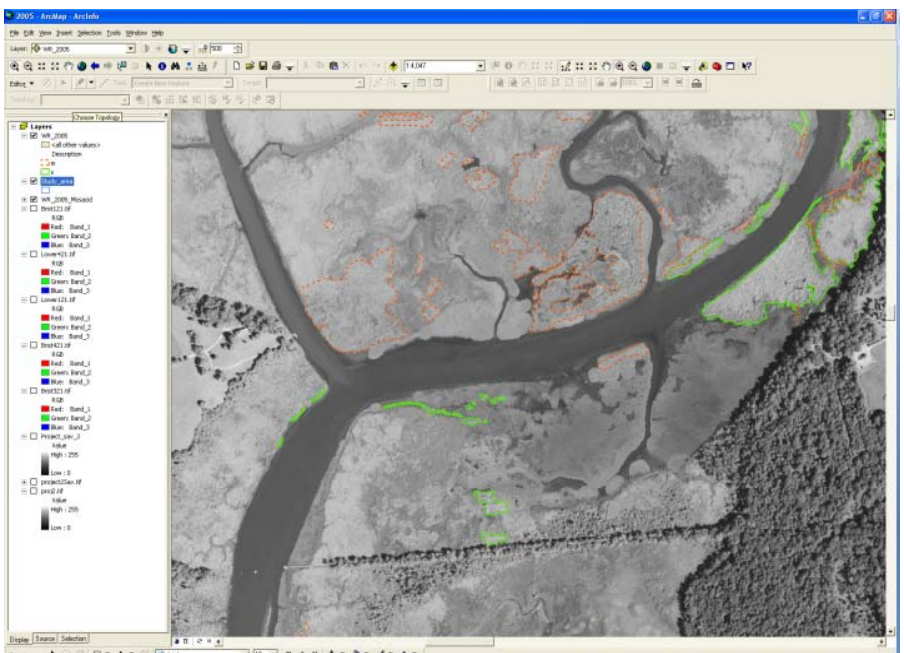
1999



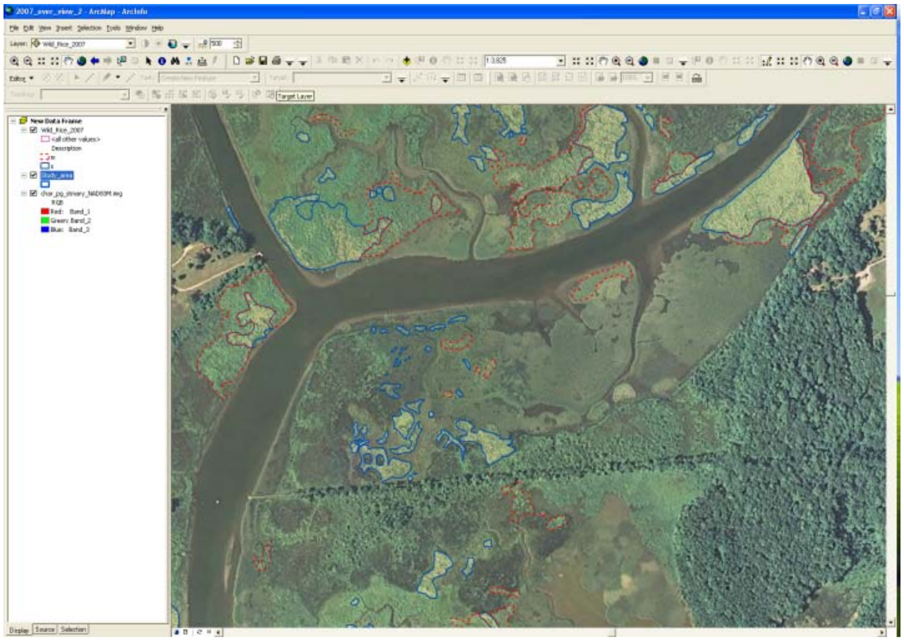


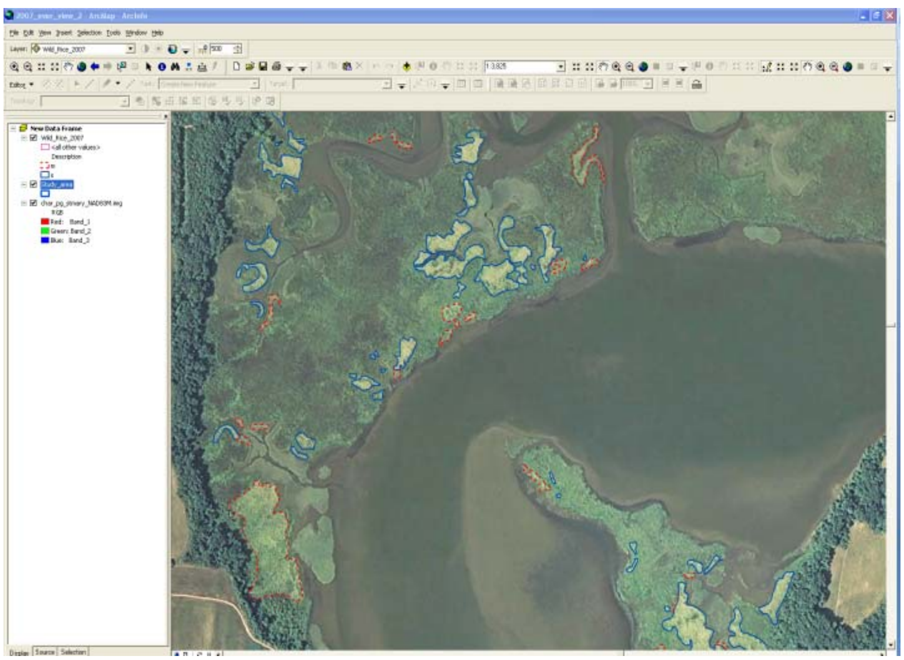
2005





2007





Results

Wild Rice Areal Coverage

Description	1989	1999	2003	2005	2007
Solid Wild Rice	583,053.79 m^2	110,894.62 m^2	278,043.18 m^2	408,335.97 m^2	621,979.62 m^2
Mixed Wild Rice	739,298.97 m^2	98,305.10 m^2	99,400.91 m^2	318,467.54 m^2	379,041.25 m^2
Total	1,322,352.77 m^2	209,199.72 m^2	377,444.09 m^2	726,803.51 m^2	1,001,020.87 m^2

Total Study Area 39,067,834.32 $m^{2)}$

Statistics

	1989 Mono	1989 Mixed	1989 Total
Polygon Count	402	129	531
Minimum Size	7.12	35.151	7.12
Maximum Size	76,469.54	79,632.16	79,632.16
Sum	583,053.79	739,298.97	1,322,352.77
Mean	1450.38	5,730.99	2,490.31
Standard Deviat	5898.71	13,442.70	8,579.76
	1999 Mono	**1999 Mixed**	**1989 Total**
Polygon Count	211	58	269
Minimum Size	2.51	118.85	2.51
Maximum Size	7,826.94	9,923.36	9,923.36
Sum	110,894.62	98,305.10	209,199.72
Mean	525.57	1,694.91	777.69
Standard Deviat	1,004.52	2,235.64	1,449.28
	2003 Mono	**2003 Mixed**	**2003 Total**
Polygon Count	111	9	120
Minimum Size	93.54	743.75	93.54
Maximum Size	26,334.51	52,940.99	52,940.99
Sum	278,043.18	99,400.91	377,444.09
Mean	2,504.89	11,044.55	3,145.37
Standard Deviat	4,368.61	15,540.69	6,389.53
	2005 Mono	**2005 Mixed**	**2005 Total**
Polygon Count	62	109	271
Minimum Size	0.091	37.24	0.091
Maximum Size	42,295.64	46,336.42	46,336.42
Sum	408,335.97	318,467.54	726,803.51
Mean	2,520.59	2,921.72	2,681.93
Standard Deviat	5,703.56	6,343.09	5,972.27
	2007 Mono	**2007 Mixed**	**2007 Total**
Polygon Count	436	178	614
Minimum Size	4.9	33.69	4.9
Maximum Size	56,727.25	76,358.03	76,358.03
Sum	621,979.62	379,041.25	1,001,020.87
Mean	1,426.56	2,129.45	1,630.33
Standard Deviat	4,669.05	6,512.43	5,279.88

Summary

A pattern of a decreasing then increasing area of wild rice within the study area can be seen over the 18 year study period. In 1989 it was estimated that there were over 1,322,000 m^2 (326 acres) of wild rice. In 1999 this declined to approximately 209,000 m^2 (51 acres). This was followed by a slight increase in 2003 to approximately 377,000 m^2 (93 acres). By 2005 a significant increase to nearly 726,000 m^2 (179 acres) was estimated. By the end of the study period there was an estimated 1,001,000 m^2 (247 acres) of wild rice with in the study area. This demonstrates a 479% increase in the estimated coverage area of wild rice in an over an 8 year period.

Appendix A

1989 RMS Error Report Details

X Source	Y Source	X Map	Y Map
7.000827	4.772872	424823.504785	123756.644262
8.743772	16.786481	425069.341274	126704.812075
13.379164	18.094307	426159.794351	127075.433230
17.358708	18.078461	427098.159863	127120.468868
6.951005	-24.141703	425492.824850	116539.486575
8.536877	-24.165466	425895.052841	116572.033921
18.455378	-22.832411	428333.806802	117198.446605
9.299883	-17.127414	425907.284650	118378.602837
10.514716	-18.224584	426242.771447	118137.108419
9.451656	-14.091142	425872.342957	119141.873255
16.746416	-18.653403	427798.072507	118196.507730
15.897593	-18.102663	427575.150467	118308.846396
7.418046	-7.662633	425207.966082	120682.044567
15.137863	-6.199256	427077.858967	121224.517648
14.350032	-2.519743	426796.514723	122121.499516
11.518629	1.599306	426004.389155	123067.221760
11.541270	1.896534	426006.505826	123146.067751
13.176159	9.581095	426251.754463	125040.347281
11.835843	9.647005	425925.656878	125035.918112
7.528641	12.638117	424834.973951	125691.988806
16.450021	6.269306	427109.023306	124303.526134
5.570188	3.875799	424489.639568	123504.908439

Total RMS Error: 2.42958

Transformation: Adjust*

1999 RMS Error Report Details

X Source	Y Source	X Map	Y Map
6.340540	4.379561	424823.353390	123756.438758
6.567147	-18.539312	425907.510823	118378.868743
18.020289	17.191493	427098.641551	127120.513886
13.404583	-20.287487	427574.697587	118308.102800
5.416464	-9.439453	425203.116180	120451.299378
16.211644	5.232277	427107.338481	124302.883296
15.005439	-3.212364	427150.606224	122317.475517
9.132538	16.516983	425070.849499	126706.200873
5.618947	6.012882	424595.510011	124115.379120
2.906874	10.626542	423779.732624	125111.443418
15.285249	-15.497060	427781.922685	119503.419016
5.969644	-20.093268	425839.558949	117982.726131
7.517715	12.409720	424828.119402	125691.764364
7.062483	-15.385543	425871.356106	119140.444916
13.949141	17.500525	426161.152327	127074.783062

Total RMS Error: 2.36840

Transformation: Adjust*

*The adjust transformation optimizes for both global LSF and local accuracy. It is built upon an algorithm that combines a polynomial transformation and TIN interpolation techniques. The adjust transformation performs a polynomial transformation using two sets of control points, then adjusts the control points locally to better match the target control points using a TIN interpolation technique (Source: ESRI.com).