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CHANGES IN THE VEGETATION COVER IN A CONSTRUCTED WETLAND AT ARGONNE NATIONAL LABORATORY, ILLINOIS.

COURTNEY LYNN BERGMAN, KIRK LAGORY

ABSTRACT

Wetlands are valuable resources that are disappearing at an alarming rate. Land development has resulted in the destruction of wetlands for approximately 200 years. To combat this destruction, the federal government passed legislation that requires no net loss of wetlands. The United States Army Corps of Engineers (USACE) is responsible for regulating wetland disturbances. In 1991, the USACE determined that the construction of the Advanced Photon Source at Argonne National Laboratory would damage three wetlands that had a total area of one acre. Argonne was required to create a wetland of equal acreage to replace the damaged wetlands. For the first five years after this wetland was created (1992-1996), the frequency of plant species, relative cover, and water depth was closely monitored. The wetland was not monitored again until 2002. In 2003, the vegetation cover data were again collected with a similar methodology to previous years. The plant species were sampled using quadrats at randomly selected locations along transects throughout the wetland. The fifty sampling locations were monitored once in June and percent cover of each of the plant species was determined for each plot. Furthermore, the extent of standing water in the wetland was measured. In 2003, 21 species of plants were found and identified. Eleven species dominated the wetland, among which were reed canary grass (Phalaris arundinacea), crown vetch (Coronilla varia), and Canada thistle (Cirsium arvense). These species are all non-native, invasive species. In the previous year, 30 species were found in the same wetland. The common species varied from the 2002 study but still had these non-native species in common. Reed canary grass and Canada thistle both increased by more than 100% from 2002. Unfortunately, the non-native species may be contributing to the loss of biodiversity in the wetland. In the future, control measures should be taken to ensure the establishment of more desired native species.

INTRODUCTION

Wetlands are unique habitats with great intrinsic value that humans have not always recognized. For many years, wetlands were destroyed to make room for buildings and other developments. Unfortunately, this led to the destruction of approximately half of all wetlands in the continental United States in the past two hundred years [1].

The price of this destruction is high because the essential functions of the wetlands have been lost. Primarily, wetlands function as a filter, similar to a kidney, to purify contamination in the water introduced by natural causes or human influence. As water slowly flows through a wetland, the plant roots and stems absorb these contaminants [2]. Consequently, water leaving a wetland is typically cleaner than when it enters. Secondly, wetlands serve as habitat to many species of animals and plants. Wetlands support biodiversity because of the varied conditions found along the gradient from the uplands to water. Many species of animals and plants would not survive without wetlands. Some species are so specific to that habitat that the further destruction of wetlands endangers their continued existence [1]. Third, wetlands have the ability to stabilize water supplies. They act as a sponge that absorbs and holds excess water and decreases the frequency and magnitude of flooding events [2].

The federal government has passed legislation to prevent wetland loss. In 1990, President Bush modified existing legislation to prevent net loss of wetland habitat [3]. Before any land development, the United States Army Corps of Engineers (USACE) must determine if the development will interfere with the normal functioning of a wetland. The USACE classifies wetlands by the presence of three characteristics: hydric soils, hydrophytic vegetation, and wetland hydrology. Wetlands are flooded or saturated with water for at least two weeks during each growing season. This results in the formation of hydric soils because frequent flooding or

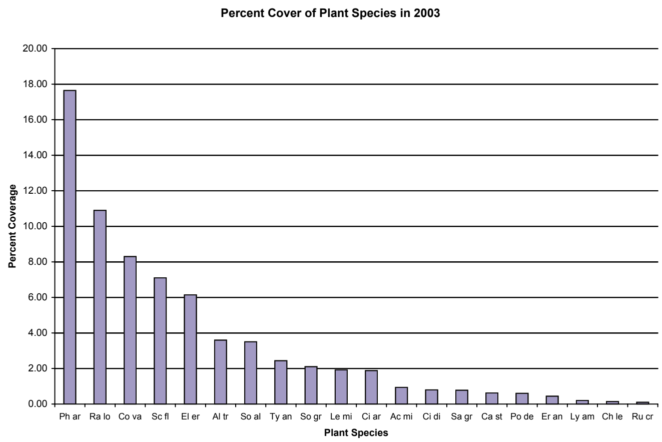

Figure 1: Percent cover of percent cover of plant species found in 2003. The plant species are arranged in descending order. Species codes are presented in Table 1.

ponding of water produces anaerobic conditions. As a result, wetlands support a predominance of plants that are adapted to grow in oxygen-depleted soil. A permit from the USACE is required before any activity takes place that will disturb an area classified as a wetland. Most disturbances must be mitigated through either avoidance and/or minimization of wetland impacts or replacement of lost wetland habitat [3].

In 1990, such a scenario occurred when the Advanced Photon Source (APS) at Argonne National Laboratory, Argonne, Illinois, was being planned. The proposed building area supported four wetlands, which totaled 1.5 acres. The construction was going to destroy three wetlands, and had the potential of causing harm to the fourth. The fourth wetland was fenced off and construction was not allowed within 50 feet to minimize impact. The USACE permitted the destruction of the other wetlands in exchange for the creation of a wetland of equal acreage. As a condition of the permit, the U.S. Department of Energy (DOE) was required to monitor the progress of the created wetland, Wetland R, for a period of five years to ensure the wetland retained wetland characteristics. This study extended from August 1991 until 1996. Researchers concluded from this study that wetland characteristics were retained, but non-native species were invading the wetland. Additionally, there was a recommendation for the creation of a buffer of native plants in the surrounding upland areas [4]. In 2002, the created wetland was re-evaluated to determine the status of vegetation, a similar study was conducted in 2003. The wetland was monitored to determine changes in the wetland since construction and to determine if the wetland was retaining wetland characteristics and supporting native plants.

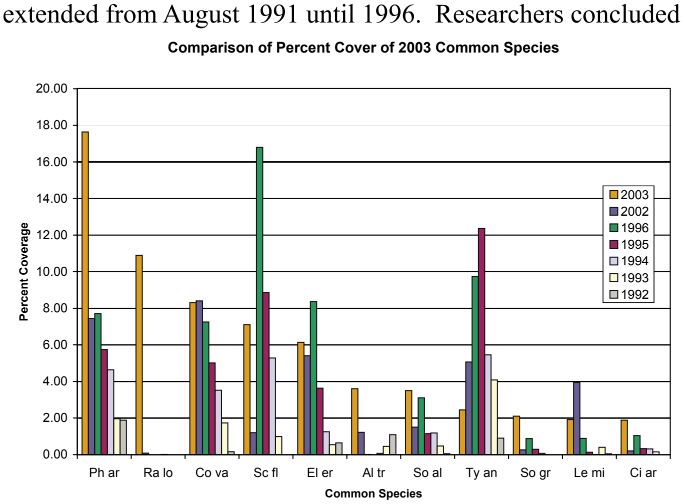

Figure 2. Percent cover of the common species found in 2003 compared to the percent cover of the same species in previous years. Species codes presented in Table 1.

MATERIALS AND METHODS

Wetland R was studied in 1991 through 1996 and again in 2002. To enable comparison to previous research, an approach similar to those of previous studies was used in the 2003 study. Wetland R is an area that is 160 meters in width and 80 meters in length. The northern uplands slope down to the water covered area of the wetland and then that slopes up to the southern upland. Previous researchers randomly determined the location

Common Name	Scientific Name	Wetland Status	Native	Code
Yarrow, Milfoil	*Achillea millefolium*	FACU	No	Ac mi
Large-flowered Water Plantain	*Alisma triviale*	OBL	Yes	Al tr
Common Fox Sedge	*Carex stipata*	OBL	Yes	Ca st
Ox-eye Daisy	*Chrysanthemum leucanthemum*	UPL	No	Ch le
Canada Thistle	*Cirsium arvense*	UPL	No	Ci ar
Pasture Thistle	*Cirsium discolor*	UPL	Yes	Ci di
Crown Vetch	*Coronilla varia*	UPL	No	Co va
Red-rooted Spike Rush	*Eleocharis erythropoda*	OBL	Yes	Eleo
Annual Fleabane Daisy	*Erigeron annuus*	FAC-	Yes	Er an
Small Duckweed	*Lemna minor*	OBL	Yes	Le mi
Common Water Horehound	*Lycopus americanus*	OBL	Yes	Ly am
Reed Canary Grass	*Phalaris arundinacea*	FACW+	No	Ph ar
Knotweed	*Polygonum*	FAC-	Yes	Poly
Eastern Cottonwood	*Populus deltoides*	FAC+	Yes	Po de
Long-beak Buttercup	*Ranunculus longirostris*	OBL	Yes	Ra lo
Curled Dock	*Rumex crispus*	FAC+	No	Ru cr
Grass-leaved Arrowhead	*Sagittaria graminea*	OBL	Yes	Sa gr
River Bulrush	*Scirpus fluviatilis*	OBL	Yes	Sc fl
Tall Goldenrod	*Solidago altissima*	FACU	Yes	So al
Lance-leaved Goldenrod	*Solidago graminifolia*	FACW-	Yes	So gr
Narrow-leaved Cattail	Typha angustifolia	OBL	Yes	Ty an

Table 1. The scientific name, common name, wetland status, status as a native, and code name of the plant species found in Wetland R in 2003. The 11 common species are presented in bold text.

of ten transects and randomly chose five sampling locations along each of the transects [5,6]. Figure 3 shows a diagram of the transects and sampling locations. The transects are 80 meters in length and perpendicular to a permanently established baseline that runs east to west and perpendicular to a second baseline that runs north to south. The fifty sampling locations were marked with flags and labeled with the quadrat letter and coordinates relative to the baselines. At the beginning of the summer, new flags replaced the old and missing flags in the same locations from 2002.

Quadrats were used to determine plant cover at each sampling location. For the sake of consistency, the 0.25 m^2 quadrat was positioned squarely south of each of the flags. Plant cover in each quadrat was determined once during the summer growing season. Data collection took place over three days: June 23, June 26, and June 27, 2003. The order of quadrat sampling was determined by randomly drawing quadrat numbers. The identity of each of the plant species found in the quadrats and the percent cover of the species in the 0.25 m^2 area was determined. The percent cover was determined using the "plant cramming" technique. "Plant cramming" is an ocular technique that mentally crams plants into a visualized section of a sampling section. When this is accomplished, the observer can determine the proportion of the sampling location that contains a certain plant species [7]. The particular technique used allowed percent cover to exceed 100% if the plants present in the sampling location overlapped each other within the boundaries.

Wetlands generally have such a variety of conditions represented in a small area that diverse groups of plants are able to inhabit them. Plant species differ in their ability to tolerate soil saturation and fit into five basic categories [8].

1. Plants that nearly always occur in wetland areas are in the obligate (OBL) category.
2. Plants that usually occur in wetlands, but occasionally occur in non-wetland areas, are in the facultative wetland (FACW) category.
3. Some plants are equally likely to occur in wetlands and non-wetlands and are in the facultative (FAC) category. The FAC category is further refined to indicate relative tolerance to inundation.
    a. FAC+ plants most frequently occur in wetlands
    b. FAC- plants less frequently occur in wetlands.
4. Plants that usually occur in non-wetlands, but occasionally occur in wetland areas are in the facultative upland (FACU) category.
5. Plants that nearly always occur in non-wetland areas are in the upland (UPL) category [8].

In addition, the areal extent of surface water was measured weekly between June 2, 2003 and July 9, 2003. The water extent was measured in relation to the plant sampling locations. A tape measure was used to measure how far standing water was from the sample location relative to the two baselines.

A Comparison of Species Occurrence in the Different Sampling Years							
	Years Sampled						
Scientific Name	**2003**	**2002**	**1996**	**1995**	**1994**	**1993**	**1992**
Achillea millefolium	+	+	+	+	+	+	+
Agropyron repens			+	+	+	+	+
Agrostris alba			+	+	+	+	+
Alisma subcordatum			+	+	+	+	+
Alisma triviale	+	+	+		+	+	+
Ambrosia artemisiifolia elatior		+	+	+	+	+	+
Aster pilosus			+	+	+	+	+
Bidens frondosa			+	+	+	+	+
Carex cristatella		+	+	+	+	+	+
Carex stipata	+						
Chrysanthemum leucan-themum	+	+	+	+	+	+	+
Cirsium arvense	+	+	+	+	+	+	
Cirsium discolor	+	+	+				+
Convolvus arvensis		+					
Coronilla varia	+	+	+	+	+	+	+
Dactylis glomerata			+	+	+	+	
Daucus carota		+	+	+	+	+	+
Eleocharis acicularis			+	+	+	+	+
Eleocharis erythropoda	+	+	+	+	+	+	+
Erigeron annuus	+	+	+	+	+	+	+
Eupatorium serotinum		+	+	+	+	+	+
Festuca elatior		+	+	+	+	+	+
Leersia oryzoides		+	+	+	+	+	+
Lemna minor	+	+	+	+	+	+	+
Lycopus americanus	+	+	+	+	+		+
Melilotus alba			+	+	+	+	+
Penstamon digitalis		+					
Phalaris arundinacea	+	+	+	+	+	+	+
Phleum pratense			+	+	+	+	+
Poa compressa			+	+	+	+	+
Poa pratensis		+	+	+	+	+	+
Polygonum hydropiper			+	+	+	+	+
Populus deltoides	+		+	+	+	+	+
Potamogeton foliosus			+		+	+	+
Ranunculus longirostris	+	+			+		
Rudbeckia hirta		+					+
Rumex crispus	+		+	+	+	+	+
Sagittaria graminea	+	+	+	+	+	+	+
Scirpus fluviatilis	+	+	+	+	+	+	
Scirpus validus creber			+	+		+	
Silphium laciniatum		+					
Solanum carolinense		+					
Solidago altissima	+	+	+	+	+	+	+
Solidago graminifolia	+	+	+	+	+		
Sonchus arvensis		+					
Trifolium hybridum			+	+	+	+	+
Trifolium repens			+	+	+	+	+
Typha angustifolia	+	+	+	+	+	+	+
Typha X glauca			+	+	+		

Table 2. A comparison of the occurrence of the plant species found in 2003, 2002, and the common species in 1996 to previous years that Wetland R was sampled. The 2002 data was taken from Mejia (2002) and Murray (2002). The data from 1992-1996 was taken from Van Dyke (1996).

RESULTS

Table 1 presents the 21 species of plants found in the wetland in 2003, their associated wetland category, and their native status. In addition, four species were found but could not be identified; and two grasses were not identified, because their growth was not at sufficient maturity to allow identification. Eleven of these species were considered the most common and include reed canary grass (Phalaris arundinacea), long-beak buttercup (Ranunculus longirostris), crown vetch (Coronilla varia), river bulrush (Scirpus fluviatilis), red-rooted spike rush (Eleocharis erythropoda), large-flowered water plantain (Alis-

Scientific Name	2003	2002	1996	1995	1994	1993	1992
Ph ar	17.64	7.44	7.71	5.75	4.63	1.96	1.88
Ra lo	10.90	0.08			0.01		
Co va	8.30	8.40	7.25	5.01	3.52	1.73	0.16
Sc fl	7.10	1.20	16.80	8.86	5.28	0.99	
El er	6.14	5.40	8.36	3.63	1.25	0.54	0.64
Al tr	3.60	1.22	0.01		0.07	0.45	1.09
So al	3.50	1.50	3.10	1.15	1.18	0.47	0.05
Ty an	2.44	5.06	9.74	12.37	5.45	4.08	0.90
So gr	2.10	0.26	0.88	0.29	0.07		
Le mi	1.92	3.95	0.89	0.13	0.01	0.40	0.04
Ci ar	1.88	0.20	1.04	0.33	0.31	0.15	
Ac mi	0.94	0.22	0.23	0.15	0.23	0.04	0.02
Ci di	0.80	0.80	0.01				0.07
Sa gr	0.78	2.66	4.41	3.21	4.04	2.50	1.12
Ca st	0.62						
Po de	0.60		1.88	3.22	3.19	3.37	1.75
Er an	0.44	0.20	0.18	0.63	2.01	0.76	0.80
Ly am	0.20	0.92	0.10	0.07	0.04		0.01
Ch le	0.14	0.20	0.09	0.72	1.02	1.24	1.45
Ru cr	0.10		0.10	0.12	0.12	0.22	0.21

Table 3: The average percent cover of the species found in Wetland R in 2003 compared to data from previous years in percents. The plant species are organized in descending order based on 2003 data.

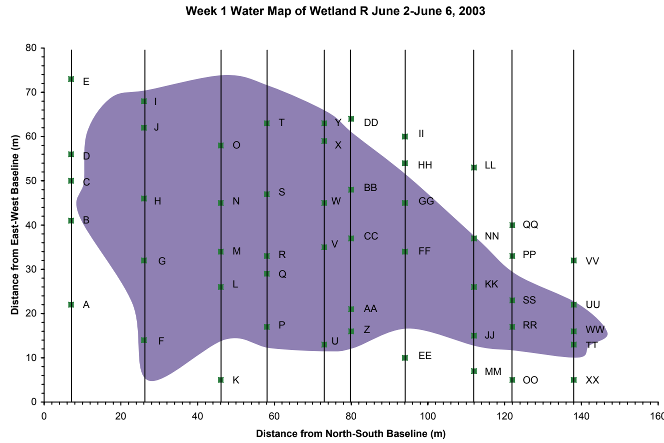

Figure 3: Water map for the week of June 2 – June 6. The measurements were taken on June 2, 2003 at 9:00 AM and June 4, 2003 at 11:45 AM. The top of the figure is north.

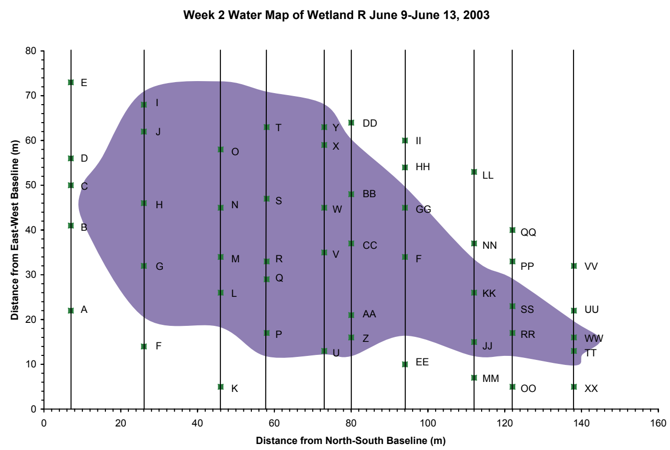

Figure 4. Water map for the week of June 8 – June 12. The measurements were taken on June 11, 2003 at 11:00 AM.

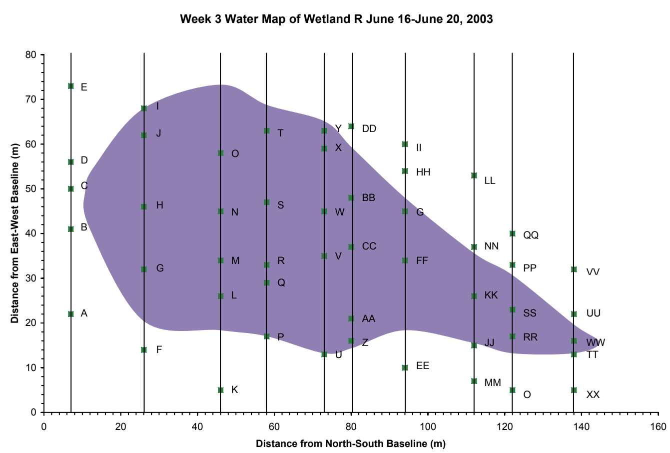

Figure 5. Water map for the week of June 16 – June 20. The measurements were taken on June 17, 2003 at 9:00 AM

ma triviale), tall goldenrod (Solidago altissima), narrow-leaved cattail (Typha angustifolia), lance-leaved goldenrod (Solidago graminifolia), small duckweed (Lemna minor), and Canada thistle (Cirsium arvense). Three of the common species (reed canary grass, crown vetch, and Canada thistle) are non-native, invasive species.

Table 2 presents the occurrence of the species in Wetland R in 2003 and in previous years. Additional species were found in previous years and are not shown in this particular table. Common fox sedge (Carex stipata) was found for the first time in the quadrats since the wetland was reconstructed. In addition, eastern cottonwood (Populus deltoides) and curled dock (Rumex crispus) was found in the wetland in 2003 and in the 1990s but were not observed in 2002.

Table 3 shows the mean percent cover, in descending order, of plant species in Wetland R that were observed in 2003. Figure 1 shows the percent cover for all species found in 2003. Figure 2 compares the percent cover of the common species in 2003 with the percent cover for those same species in previous years.

Figures 3 through 8 show the change in the extent of standing water during the six-week study period. The amount of water decreased from the first week through the fifth week and then increased into the sixth week after a period of significant rainfall. The area around quadrats M, N, R, and S was consistently covered by one meter of standing water. The west end of the wetland tended to dry up first and recede towards the eastern half of the wetland area. The areas that were consistently covered with standing water commonly contained Ranunculus longirostris, Scirpus fluviatilis, Eleocharis erythropoda, Alisma triviale, Typha angustifolia, and Lemna minor. The dry upland areas were mostly covered by the non-native species, Phalaris arundinacea and Coronilla varia. Observing areal water cover helped researchers observe what parts of the wetlands are more consistently covered with water.

DISCUSSION AND CONCLUSION

Three of the 11 most common species observed in 2003 were non-native species. Often, disturbed freshwater wetlands are the most susceptible to invasion by non-native plant species [2]. Without natural controls and with a tolerance for a wide range of soil conditions, non-native species are excellent competitors and usually crowd out natives in a relatively short amount of time [9]. The percent cover of reed canary grass and

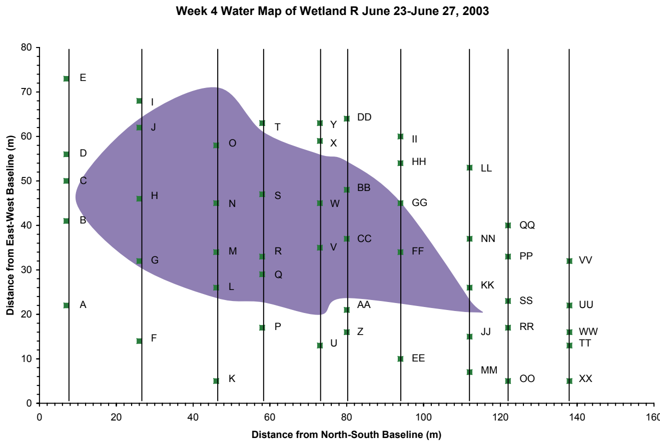

Figure 6. Water map for the week of June 23 – June 27. The measurements were taken on June 26, 2003 at 1:00 PM.

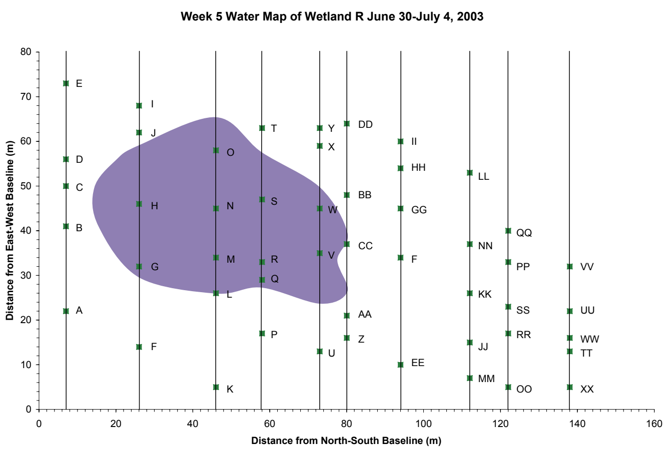

Figure 7. Water map for the week of June 30 – July 4. The measurements were taken on July 2, 2003 at 11:10 AM.

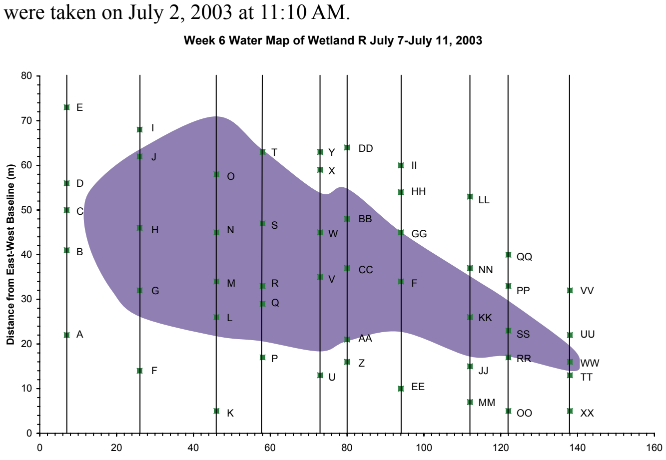

Figure 8. Water map for the week of July 7 – July 11. The measurements were taken on July 9, 2003 at 11:00 AM.

Canada thistle increased dramatically from 2002. Reed canary grass percent cover has been increasing gradually since 1992, but from 2002 to 2003, the percent cover more than doubled. Canada thistle was generally the same low percentage in 1992, 1993, 1994, 1995, and 2002. If this trend continues, these two species may pose a threat to biodiversity in Wetland R by decreasing area available to other, native, species. In June 2003, herbicide was applied to the wetland to try to control the reed canary grass. The reed canary grass began to slowly thin, however, the herbicide may have had some adverse affects on native vegetation. The percent cover of crown vetch, a non-native upland plant, did not increase from 2002, however, the upland should receive some control treatment or the crown vetch may become more widely established.

The wetland may benefit from a controlled burn in the near future to dispose of accumulated plant litter. In many areas, Wetland R is littered with the remains of narrow-leaved cattails from previous years. The coverage of cattails has decreased from the previous year, but without a burn, the litter will persist and prevent colonization by other species. Unfortunately, most of the areas of soil saturation or water cover are dominated by river bulrush and narrow-leaved cattail. These two species are aggressive and tend to create monocultures, causing a reduction in diversity in wetlands. There are two obligate species, grass-leaved arrowhead and long-beak buttercup, that are of particular interest because they are less aggressive native plants. Less aggressive plants can encourage diversity in wetlands. Unfortunately, there was a substantial decrease in grass-leaved arrowhead from last year. However, long-beak buttercup coverage has increased from previous years and seems to be thriving.

The presence or absence of desired wetland plants is an excellent indicator of wetland quality. Plants respond to environmental conditions such as soil quality, quantity and quality of water, and topography. Plants tolerant of the specific conditions in a wetland will succeed and the species type, abundance, and diversity will indicate the quality [3].

Wetland R has maintained wetland characteristics and supports native plant species. Monitoring should continue to ensure that Wetland R continues to maintain wetland characteristics. In the future, control measures should be taken to ensure the establishment of more desired native species. Planting native plants, herbicidal treatments on non-native, invasive plants, and controlled burns to reduce litter will encourage native plant growth and increase biodiversity in the wetland. The relative abundance of non-native and native species, should be observed closely to ensure the wetland performs optimally to nurture quality and biodiversity. Animal use of the wetland could also be monitored to determine overall biodiversity of Wetland R and its importance to the ecology of the area.

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