Evaluation of moist-soil plant communities to water level management of Chautauqua National Wildlife Refuge.

Annual Report

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Table of Contents

Page

Introduction 3

Study Area 3

United States Fish and Wildlife Service Management Strategies 4

Methods 5

Results and Discussion
- South Pool 7
  - ZONE 1 7
  - ZONE 2 8
  - ZONE 3 9
  - ZONE 4 9
  - ZONE 5 10
  - ZONE 6 10
  - ZONE 7 11
- Setback Site 11
  - ZONE 1 12
  - ZONE 2 12
  - ZONE 3 12

Conclusions 13

Figures 15

Tables 19

Photos 29

References 36

Signature Page 37

Introduction

Long-term aerial inventories of waterfowl conducted by the Illinois Natural History Survey have identified Chautauqua National Wildlife Refuge (NWR), located in Mason County, Illinois, as the most important refuge in the Illinois River valley with respect to waterbird population numbers and use. The natural food base on refuges, such as Chautauqua NWR, is critical to the health of thousands of migrating waterfowl during fall and spring each year. The seed bank provided by moist-soil plants of the previous year can supply many bird species with the essential nutrition needed during the southward migration to wintering areas and the northward migration to nesting areas. With proper management of water levels at Chautauqua NWR, vast expanses of mudflats become available for the establishment of moist-soil plants. However, the most effective water management scheme for moist-soil plant establishment and seed production at Chautauqua NWR is currently unknown. We proposed to evaluate the vegetative response to water level management procedures implemented by the United States Fish and Wildlife Service (USFWS) for the lower compartment of Chautauqua NWR.

Study Area

The lower compartment of Chautauqua NWR, hereafter referred to as the south pool, was the primary study area for the moist-soil vegetation study (Figure 1). The south pool consists of approximately 2,300 acres (931 ha) of floodplain wetland, backwater lake, and bottomland forest habitat. A recurring problem in the south pool has been the inundation by the Illinois River during the growing seasons. Some years, such inundation has prevented drawdowns to expose mudflats that are critical for the germination of moist-soil plants while in other years inundation has destroyed developing plants. Through the expenditures of a Environmental Management Program Habitat Rehabilitation and Enhancement Project and funding through Midwest

Supplemental Appropriations improvements were made to the levee system and water control structures of the south pool. The levee was elevated to approximately 1 m (3 ft) over the flood stage of the Illinois River, or approximately 441.0 ft msl. The improvements protect the south pool from unnatural water level fluctuations of the river, and this pool can now be managed during most growing seasons.

For comparison with the south pool, a second study area, hereafter referred to as the setback site, was established outside of the setback levee on the west side of the south pool (Figure 1). The setback site is an unmanaged area that is subjected to fluctuating water levels of the Illinois River. The setback site is approximately 196 acres (79 ha).

United States Fish and Wildlife Service Management Strategies

In mid-June, the Illinois River was recorded at 441.5 ft above mean sea level (msl) and began to drop (Table 1). On July 13, 1999, the south pool and river water levels were 433.5 ft and 432.5 ft msl, respectively. The staff at Chautauqua NWR removed all stoplogs from the water-control structure, thereby dewatering the south pool. On July 19, 1999, a water level of 432.1 ft msl was achieved, stoplogs were returned to the water-control structure, and the drawdown was complete. Consequently, the south pool was subjected to a fast, mid-season, drawdown. The goal of refuge personnel was to maintain the water level of the south pool at approximately 432.0 ft msl throughout the growing season. This water level yielded approximately 1,500 acres (607 ha) of exposed mudflats for moist-soil plant germination. With little precipitation (Table 2), the river posed no threat of flooding, and the water level of the south pool was maintained at approximately 432.0 ft msl throughout the growing season (Table 1).

In early September, approximately 300 acres (121 ha) of the south pool were mowed in an effort to control willow (*Salix* spp.) growth (Figure 2, Photo 1). Vegetation along several established transects was destroyed, eliminating some sampling.

Methods

Twenty-four line transects were established for sampling the south pool (Figure 1). A point was randomly chosen within 24 320-meter (1,050 ft) sections along the north and south levees of the pool. From each point, transect lines extended directly north from the south levee or directly south from the north levee to open water (Figure 1). Using similar methodology, six transects were randomly chosen along the riverward side of the setback levee (Figure 1). From each point along the setback levee, transect lines ran perpendicular to the setback levee in a northwesterly direction (Figure 1).

In August, approximately one month after moist-soil plant germination, the transects were measured afoot, and a covermap depicting vegetative zones on each transect was produced (Figure 2, Table 3). Plant growth and species composition determined sample zones (Table 4). The number and locations of random plots were determined once the vegetation was established (Table 5). Three hundred plots with dimensions of 0.06 m^2 (0.67 ft^2) were considered physically possible to sample during the 1999 sampling season. The plots were divided among transects based on individual transect lengths and the area of each zone along a transect; therefore, the longer a transect, the more plots per transect, and the broader a zone, the more plots per zone (Table 5). Due to mowing and water fluctuations between covermapping and sampling, only 218 plots were monitored. Plots were monitored once, and the sampling period lasted approximately three weeks. GPS coordinates were recorded for each sample plot.

Sampling was initiated once the majority of the plants had matured, approximately 70 days after mudflats had been exposed and germination had begun. A plot frame was placed on the ground at random points along transects, and all the plants rooted within the frame were included in each sample (Photo 2). Specific vegetation within plots was monitored for species composition, stem density, and morphological characteristics. Measurements were collected from 19 moist-soil plant species considered to be of substantial value to waterfowl as food and cover (Table 6) (Low and Bellrose 1944; Mohlenbrock 1979; Fredrickson and Taylor 1982; Havera 1999). These 19 species represented 41 percent of those identified while covermapping (Table 2). Within each plot, one mature plant of each species with an inflorescence visually representative of an average plant was selected for measurement (Laubhan and Fredrickson 1992). Measurements included plant height, number of seed heads, average seed head height, and average seed head diameter (Figure 3). The representative plant of each species within a plot was collected for seed yield determination. The remaining mature plants of each species in the sample plot were counted and recorded to determine stem density. As the result of the overabundance of cocklebur (*Xanthium strumarium*) and willow, stem density and acreage of these species were generalized in order to recognize problem areas in need of management of these invasive species.

Twenty-four seed catchpans were also placed randomly throughout the study units for the duration of the sampling period (Figure 4) (Brock 1987). The pans were constructed from PVC. The top was covered with netting (2 cm^2, 0.8 in^2) to prevent rodent and bird entry. The bottom was covered in 3 layers: window screen (2 mm^2, 0.1 in^2), cheesecloth, and another layer of window screen. The multiple layers were used to prevent seed loss and still provide aeration for the collected seed. The pan was attached to wooden lathe with a piece of copper wire

(Figure 4). Seed collecting capabilities of the catchpans are being evaluated to determine their value to the estimation of seed production. The timing of collecting catchpans depended on the maturation and dispersal of seeds as well as the water levels of the south pool and the river. All of the catchpans were collected by November 18, 1999.

Laboratory analyses for determining seed production are currently in progress. Seeds from the representative plants will be removed from their foliage. All collected seeds, including those collected by the catchpans, have been air-drying for approximately two months and will be oven dried if necessary. Seeds will be weighed to the nearest 0.0001 g and stored in glass vials. The seeds will be used to estimate the average weight of seeds produced by an average- size plant. The seed yield data will be used to verify existing regression equations (Laubhan 1992; Laubhan and Fredrickson 1992; Gray et al. 1999a; Gray et al. 1999b) and to establish new equations for other species. Seed production of representative plants will be determined and extrapolated to seed production per species in each zone across the two study areas.

Results and Discussion

South Pool

Covermapping of the south pool revealed seven different vegetative zones (Figure 2, Table 3). Within the zones, at least 47 plant species were identified and recorded while covermapping (Table 4). One hundred eighty-six plots were sampled, and stem densities of the plants in each zone were calculated (Table 7). Analyses of seed production and waterfowl use-days are currently in progress.

ZONE 1

The zone representing the largest area was dominated by four willow species: *Salix amygdaloides*, *S. caroliniana*, *S. interior*, and *S. nigra* (Figure 2, Table 3). Over 43 percent of

the terrestrial portion of the south pool was willow habitat. This dominance was not evident through the density calculations because the size of the sampling frame did not allow a representative sample of willows to be depicted appropriately. Willow acreage for this zone was estimated by using covermapping observations and aerial infrared photos (Table 3).

Where the willows were the most dense, ground cover was present, but it was usually in minimal amounts [16 to 80 stems/m^2 (1.5 to 7.5 ft^2)] and generally did not reach maturity due to shading (Photo 3a). Many plots were covered with willow leaf litter, which contributed to the stunted growth of plants. In other areas of the zone, dense stands of teal grass (*Eragrostis hypnoides*), pigweed (*Amaranthus* spp.), rice cutgrass (*Leersia oryzoides*), and other moist-soil species occurred in canopy openings where sunlight penetrated the substrate. Teal grass yielded the highest stem density (725 stems/m^2, 68 stems/ ft^2) in these open areas (Table 7).

In an attempt to control willow growth, the refuge staff mowed more than 18 percent of the south pool including over 22 percent of zone 1 (Figure 2).

ZONE 2

Major plant species of the second largest zone were teal grass, rice cutgrass, nutgrasses (*Cyperus* spp.), arrowheads (*Sagittaria* spp.), and *Bidens*' (Figure 2, Table 3). Thirty-three percent of the total vegetated area of the south pool was comprised of these favorable duck food plants. Teal grass dominated in stem density (955 stems/m^2, 89 stems/ft^2), and rice cutgrass followed (85 stems/m^2, 8 stems/ft^2) (Table 7). Species of arrowhead (*S. calycina*), *Bidens* (*B. cernua*), and nutgrass (*C. erythrorhizos*) were mostly found in this zone.

Zone 2 had two subzones (Photo 4). Overall, both subzones were comprised of similar species: teal grass, arrowhead, and nutgrasses. However, one subzone near the south shoreline of the study area had a noticeably higher density of *Bidens* species than the subzone along the

north shoreline. This difference in *Bidens* composition may have been due to the variation in dewatering times of these two areas of the south pool. The south shore was the last area to have exposed mudflats; therefore, the plants colonizing the mudflats in this area were the last to germinate. Seed production of *Bidens* species is greater as a result of mid- to late-season drawdowns (Fredrickson and Taylor 1982).

ZONE 3

The third zone was comprised of approximately 146 acres (59 ha) (Figure 2, Table 3). Cocklebur and teal grass dominated this zone with densities of 292 and 394 stems/m^2 (27 and 37 stems/ft^2), respectively (Table 7). Most plots contained mature cocklebur with a mix of mature and stunted, immature teal grass plants. Other plants identified in the zone included pigweeds and nutgrasses. Willows existed in patches, but were not dominating the area yet, allowing cocklebur to flourish (Photo 3b).

This zone was primarily found on the firm, sandy soil of the north shore where dewatering occurred earlier and faster than other portions of the south pool. Optimal germination and production of cocklebur have been documented with mid- to late-season drawdowns (Fredrickson and Taylor 1982). Unfortunately, the drawdown of 1999 was favorable for cocklebur production.

ZONE 4

The fourth zone occupied approximately 105 acres (43 ha) of a mixture of teal grass and nutgrasses (Figure 2, Table 3). This habitat was scattered throughout the south pool, with the largest patch located between zone 1 and zone 3 on the north side (Figure 2). This entire area, > 70 percent of the 105 acres (43 ha), was mowed in early to mid-September prior to seed

production (Photo 3c). The mowed area was the only portion of this vegetation type falling within the sampling area; therefore, density measurements could not be calculated for this zone.

ZONE 5

Covermapping indicated that this zone consisted of approximately 56 acres (23 ha) of water smartweed and cocklebur (Figure 2, Table 3, Photo 3d). However, stem densities revealed that teal grass had the highest density (654 stems/m^2, 61 stems/ft^2) followed by rice cutgrass (77 stems/m^2, 7 stems/ft^2) (Table 7). Water smartweed and cocklebur had much lower stem densities, 27 and 8 stems/m^2 (3 and 0.8 stems/ft^2), respectively (Table 7). Teal grass and rice cutgrass grow in bunches of stems; therefore, more of these plants may be found over a smaller area than water smartweed or cocklebur. Water smartweed and cocklebur dominated the area, and their extensive coverage stunted the growth of some teal grass and rice cutgrass plants and shaded out other vegetation entirely. Multiple species of *Bidens*, including *B. cernua*, *B. frondosa*, and *B. connata,* were found in this zone. *Bidens cernua* exhibited the highest stem density (47 stems/m^2, 4 stems/ft^2) of the three *Bidens* species (Table 7).

This habitat was found in patches along the south shoreline. Much of the water smartweed had established itself before the water had receded from the area, and despite its early germination, few plants produced seeds. Water smartweed prefers some water for optimum growing conditions; therefore, the dry conditions of this area possibly limited the amount of seed produced by this species while advancing the production of cocklebur and bur cucumber (*Sicyos angulatus*).

ZONE 6

The sixth zone was a 32-acre (13 ha) area along the south shoreline (Figure 2, Table 3). The soil was a peat-like substrate. The area consisted of species such as teal grass, nutgrasses,

rice cutgrass, and sprangletop (*Leptochloa fascicularis*) (Photo 3e). Teal grass exhibited the highest stem density (2,016 stems/m^2, 188 stems/ft^2) (Table 7). The most abundant species of nutgrass was *Cyperus erythrorhizos* with a stem density of 53 stems/m^2 (5 stems/ft^2) (Table 7). The vegetation in zone 6 was similar to zone 2; however, the limited amount of arrowhead and the occurrence of the peat-like substrate made the overall composition of zone 6 slightly different.

ZONE 7

The final zone of the south pool was comprised of spikerush (*Eleocharis palustris*), rice cutgrass, and *Bidens'* (Figures 2, Table 3, Photo 3e). The spikerush matured early and seed heads were formed in early to mid-August. Spikerush is considered a possible waterfowl food, but it is not preferred and has limited nutritional value; thus, the occurrence of spikerush was not recorded (Bellrose and Anderson 1943; Havera 1999). During covermapping, many of the rice cutgrass plants were recorded as unidentifiable seedlings. By the time sampling was finished, density calculations indicated that rice cutgrass had the highest stem density of this zone (904 stems/m^2, 84 stems/ft^2) (Table 7). Other species occurring in this zone included teal grass, *Bidens cernua*, and Walter's millet (*Echinochloa walteri*).

Setback Site

Covermapping of the setback site resulted in the designation of three different vegetative zones (Figure 2, Table 3). Within the three zones, 20 plant species were identified (Table 4). Thirty-two plots were sampled, and stem densities were calculated for each zone (Table 8). Analyses of seed production are currently in progress.

ZONE 1

The largest of the three zones was identified by its willow overstory (Figure 2, Table 3). Fifty-nine percent of the 192 acres (78 ha) of the setback site was willow habitat. As described earlier, density measurements do not represent the number of willows in this area due to the sampling method; however, covermapping observations and infrared photos provided ample information for an areal estimate of willows (Table 3).

Four subzones were defined by tree height and canopy closure (Photo 5). These subzones were comprised of willows ranging in height from < 0.3 to 1 m (1 to 3 ft), 1 to 2 m (3 to 7 ft), 2 to 5 m (7 to 16 ft), and > 5 m (16 ft) with some willows reaching 20 m (66 ft). When the willows were > 5 m (16 ft) tall, cocklebur and bur cucumber dominated the understory, and shaded out all the other vegetation (Photo 5). Cocklebur exhibited the highest stem density (48 stems/m^2, 4 stems/ft^2) followed by bur cucumber (4 stems/m^2, 0.4 stems/ft^2) (Table 8).

ZONE 2

Twenty-six percent of the setback site was comprised primarily of cocklebur and teal grass (Figure 2, Table 3). Cocklebur (358 stems/m^2, 33 stems/ft^2) dominated the zone with teal grass (240 stems/m^2, 22 stems/ft^2) as ground cover (Table 8).

ZONE 3

The third zone covered 22.5 acres (9 ha) or 15 percent of the setback site (Figure 2, Table 3). This zone was predominately teal grass and nutgrasses. Teal grass exhibited the highest stem density (4,318 stems/m^2, 402 stems/ft^2), while red-rooted nutgrass (*Cyperus erythrorhizos*) and cocklebur each exhibited stem densities of 75 stems/m^2 (7 stems/ft^2)

(Table 8). Other species in this zone included ferruginous nutgrass (*Cyperus ferruginescens*), pigweeds, and sprangletop.

Conclusions

The south pool of Chautauqua NWR was subjected to a fast, mid-season drawdown during the 1999 growing season. It was a very dry season; therefore, the water levels of the Illinois River and the little precipitation recorded for Havana, Illinois had little effect on the two study sites (R. Fisher, pers. comm.; USGS 1999).

The fast, mid-season drawdown yielded both desirable and undesirable plant species. Forty-seven plant species were identified through covermapping the two study sites. Eighteen of the 19 desirable plant species monitored were found across both study areas. The two most undesirable plants were willow and cocklebur.

The covermap of the two study sites during the 1999 growing season suggested that the managed area (south pool), where water levels were regulated for a mid-season drawdown, produced higher species diversity than the unmanaged area (setback site). The south pool had seven distinct vegetative zones, and approximately 47 species were identified through covermapping. Ninety-five percent (n=18) of the 19 desirable moist-soil plants being monitored occurred in the south pool. Teal grass, a good waterfowl food, was found to have the highest stem density in 5 of the 7 zones of the south pool (Bellrose and Anderson 1943). Rice cutgrass, an excellent food plant for ducks, had the second highest stem density in 4 of the 7 zones in the south pool, and the highest density in zone 7 (Bellrose and Anderson 1943). Willows have encroached upon 42 percent of the terrestrial habitat of the south pool. The willows ranged from <1 year (0.3 m, 1ft) to 5 years of age (5 m, 16 ft). Some vegetation was still able to germinate

and grow under the smaller willows through canopy openings. However, as the willows increased in height, the growth of ground cover vegetation became stunted or absent.

The setback site had three distinct vegetative zones and approximately 20 species were identified through covermapping. Only 11 of the 19 moist-soil plant species of interest occurred in the setback site. Cocklebur exhibited the highest stem density in 2 of the 3 zones of this area. Willows dominated 59 percent of the terrestrial habitat of the setback site, with trees ranging in height from 0.3 m (1 ft) (seedlings) to 20 m (66 ft) (approximate age unknown). Ground cover vegetation varied directly with willow height and canopy closure. Willows ranging in height from 5 to 20 m (16 to 66 ft) had understory vegetation of mostly cocklebur and bur cucumber and few, if any, waterfowl food plants.

Additional results and conclusions for the 1999 growing season will be available following the completion of the seed production analyses. Continued sampling in subsequent years will allow for comparisons of a variety of refuge management strategies and the plant species composition, stem density, and seed production that result.

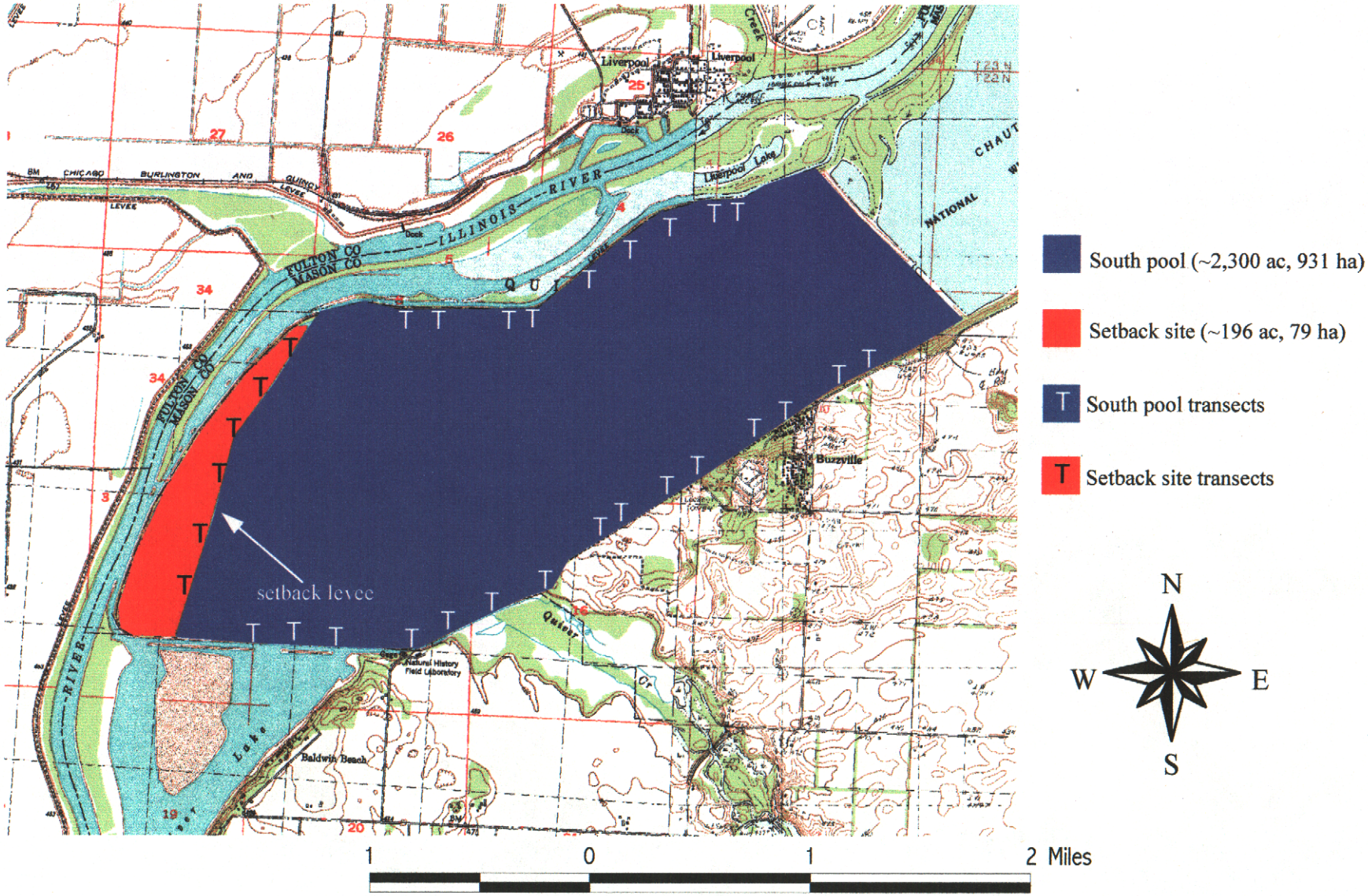

Figure 1. South pool and setback site study areas and transect locations for moist-soil plant investigations at the Chautauqua National Wildlife Refuge, summer-fall 1999.

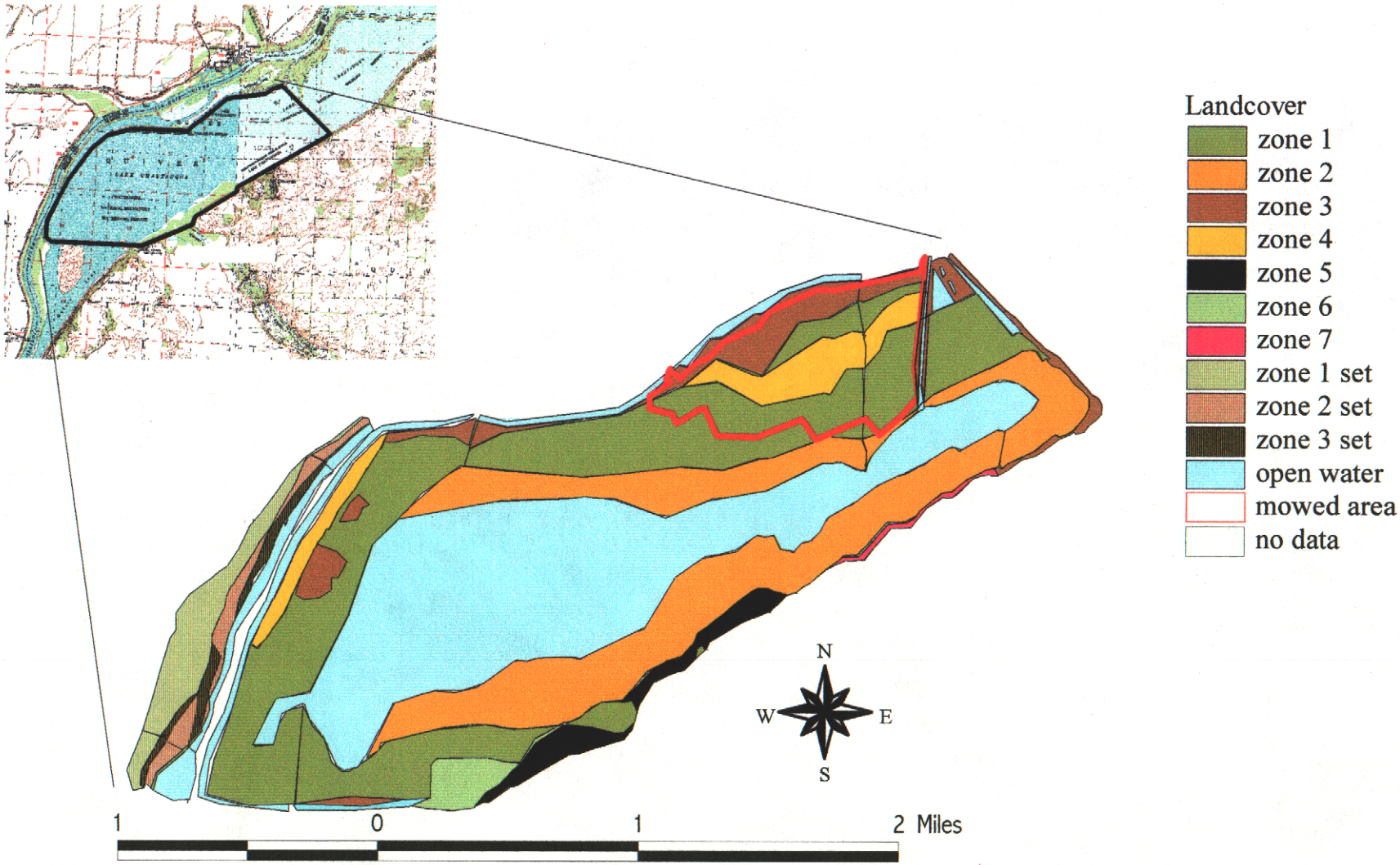

Figure 2. Cover map depicting zones of vegetation of the south pool and setback study sites at Chautauqua National Wildlife Refuge, summer-fall 1999.

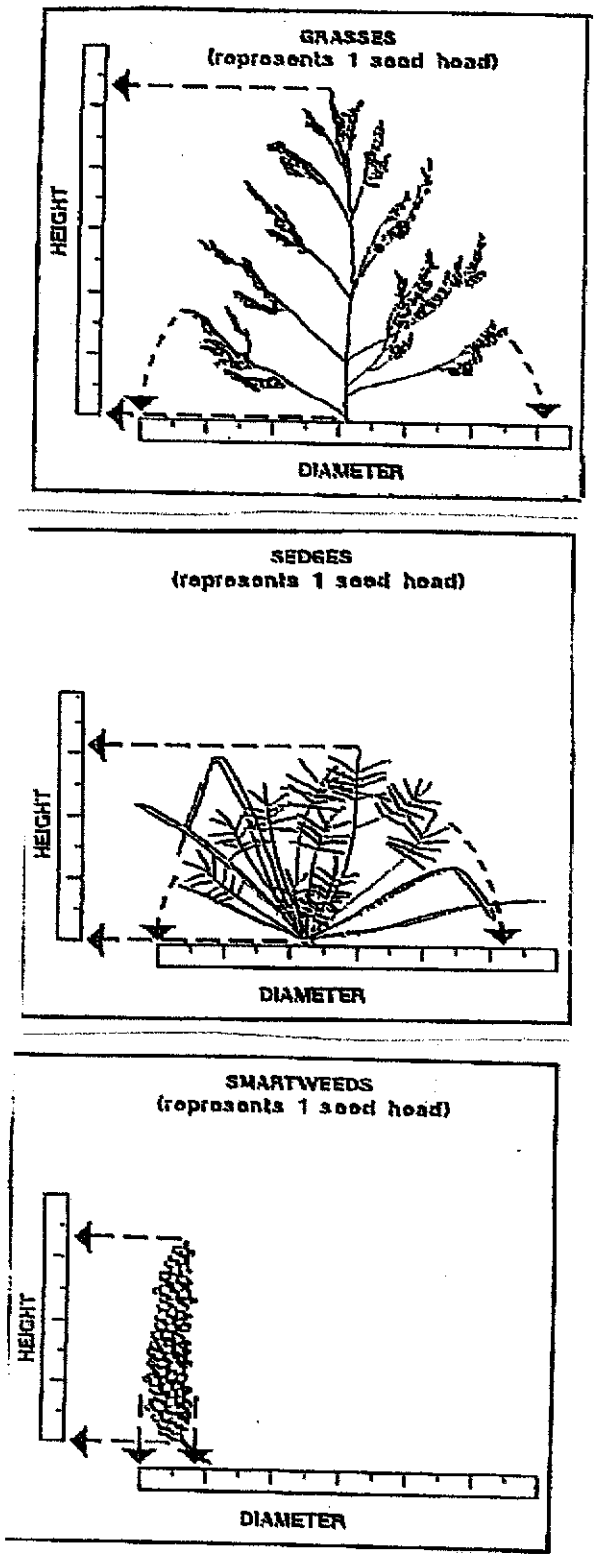

Figure 3. Measurements obtained from seed heads of moist-soil plants at Chautauqua National Wildlife Refuge, summer-fall 1999 (Laubhan 1992).

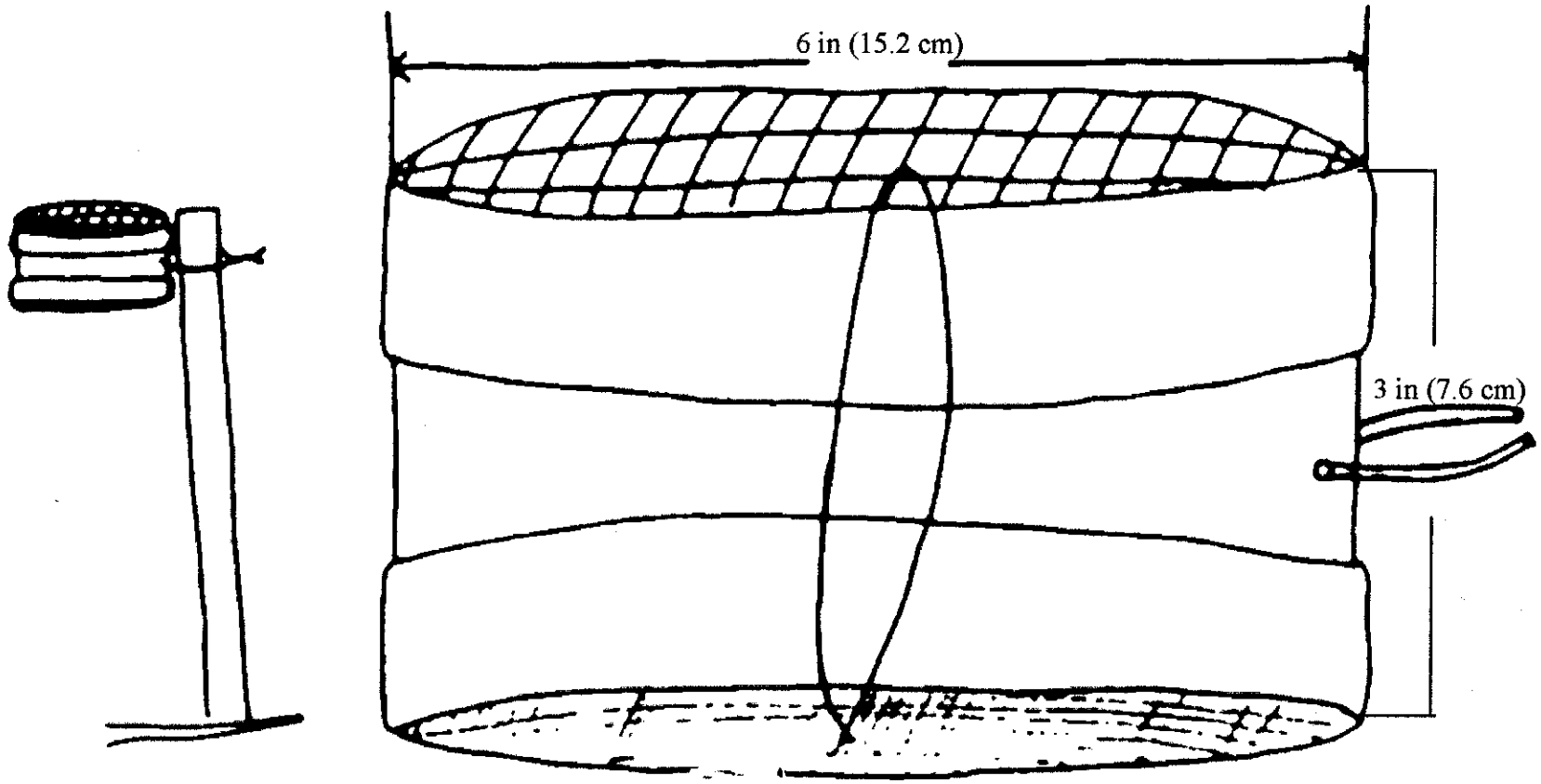

Figure 4. A diagram of seed catchpans used in determining seed yields of moist-soil plants at Chautauqua National Wildlife Refuge, summer-fall 1999 (Brock 1987).

Table 1. Water levels (ft msl) and management activities of the south pool at Chautauqua National Wildlife Refuge and the Illinois River (measured from south side of stop-log structure), summer-fall 1999 (R. Fisher, pers. comm.).

Date	South Pool	River	Management and Sampling Activities
19 Jun 1999	441.2	441.5	
30 Jun 1999	439.2	438.9	
06 Jul 1999	437.5	436.8	
13 Jul 1999	433.5	432.5	pulled all stoplogs
19 Jul 1999	432.1	431.7	held lake at approxmately this level
02 Aug 1999	432.2	431.5	
27 Aug 1999	431.7	431.5	
08 Sep 1999	431.7	431.4	
23 Sep 1999	431.7	431.4	
27 Sep 1999	431.4	431.4	began sampling
13 Oct 1999	431.9	432.1	first heavy frost
14 Oct 1999	431.9	432.1	let water in lake; finished sampling
20 Oct 1999	432.2	431.1	

Table 2. Monthly precipitation (inches) in Havana, Illinois, summer-fall 1999 (USGS 1999).

Month	Precipitation
June	2.9
July	3.5
August	2.8
September	1.0
October	0.1

Table 3. Aerial coverage of vegetative zones of the south pool and the setback site at Chautauqua National Wildlife Refuge, summer-fall 1999.

South Pool		Setback Site	
Zone	**Acres (ha)**	**Zone**	**Acres (ha)**
open water	789.8 (319.8)	open water	43.6 (17.7)
1	647.7 (262.2)	1	86.8 (35.1)
2	498.4 (201.8)	2	38.7 (15.7)
3	146.4 (59.3)	3	22.5 (9.1)
4	105.2 (42.6)		
5	56.5 (22.9)		
6	31.6 (12.8)		
7	8.3 (3.4)		
Total	2,284.0 (924.7)	**Total**	191.6 (77.6)

Table 4. Moist-soil plants recorded during cover mapping at Chautauqua National Wildlife Refuge, summer-fall 1999.

Scientific Name	Common Name	Site[a]
Amaranthus spp.	Pigweeds	SP, SS
Ambrosia spp.	Ragweed	SP, SS
Ammannia coccinea	Long-leaved ammannia	SP, SS
Bidens connata	Purple-stemmed swamp beggarticks	SP, SS
Bidens cernua	Nodding bur marigold	SP, SS
Bidens frondosa	Common beggarticks	SP, SS
Boehmeria cylindrica	False nettle	SP, SS
Cyperus erythrorhizos	Redroot flatsedge	SP
Cyperus esculentus	Chufa	SP
Cyperus ferruginescens	Ferruginous flatsedge	SP, SS
Cyperus strigosus	Straw-colored flatsedge	SP
Cephalanthus occidentalis	Buttonbush	SP
Echinochloa crusgali	Wild millet	SP, SS
Echinochloa walteri	Walter's millet	SP
Eleocharis palustris	Marsh spikerush	SP
Equisetum spp.	Horsetail	SP
Eragrostis hypnoides	Teal grass	SP, SS
Eragrostis pectinacea	Common love grass	SP
Euphorbia maculata	Nodding spurge	SP
Euphorbia supine	Milk purslane	SP
Forestiera acuminata	Swamp privet	SP
Galium spp.	Bedstraw	SP
Hibiscus laevis	Rose mallow	SP
Ipomoea lacunose	Small white morning-glory	SP, SS
Jussiaea repens	Creeping water primrose	SP
Leersia oryzoides	Rice cutgrass	SP, SS
Leptochloa fascicularis var. acuminata	Salt meadow grass/sprangletop	SP, SS
Lindernia dubia	Moistbank pimpernel	SP
Lippia lanceolata	Fog fruit	SP, SS
Panicum capillare	Witch grass	SP
Polygonum amphibium	Water smartweed	SP, SS
Polygonum lapathifolium	Nodding smartweed	SP
Populus deltoides	Cottonwood sapling	SP, SS
Sagittaria calycina	Arrowhead	SP, SS

Table 4. (continued)

Scientific Name	Common Name	Site[a]
Sagittaria latifolia	Arrowhead	SP
Salix amygdaloides	Peach-leaved willow	SP, SS
Salix caroliniana	Carolina willow	SP, SS
Salix interior	Sandbar willow	SP, SS
Salix nigra	Black willow	SP, SS
Saururus cernuus	Lizard's tail	SP
Scirpus fluviatilis	River bulrush	SP
Sicyos angulatus	Bur cucumber	SP, SS
Sida spinosa	Prickly sida	SP
Xanthium strumarium	Cocklebur	SP, SS

[a] SP=south pool; SS=setback site

Table 5. Transect length (m), number of vegetative zones per transect, and number of plots per transect for the south pool and the setback site at Chautauqua National Wildlife Refuge, summer-fall 1999.

	Transect	Site	Length[a]	Zones/Transect	Plots/Transect
	1	south pool	3,903 (1,190)	4	25 (25 mowed)
	2	south pool	4,134 (1,260)	4	21 (12 mowed)
	3	south pool	3,777 (1,151)	4	22 (11 mowed)
	4	south pool	3,441 (1,049)	4	20 (14 mowed)
	5	south pool	2,631 (802)	3	16 (5 mowed)
	6	south pool	1,437 (438)	2	8
	7	south pool	1,329 (405)	2	8
	8	south pool	1,497 (456)	3	9
	9	south pool	2,013 (614)	2	11
	10	setback	1,101 (336)	3	8
	11	setback	1,164 (355)	2	7
	12	setback	1,113 (339)	2	7
	13	setback	765 (233)	3	5
	14	setback	570 (174)	2	3
	15	setback	333 (101)	2	2
	16	south pool	1,410 (430)	1	3
	17	south pool	567 (173)	2	4
	18	south pool	1,614 (492)	2	10
	19	south pool	1,980 (604)	3	13
	20	south pool	2,160 (658)	4	11
	21	south pool	2,043 (623)	2	12
	22	south pool	2,397 (731)	3	11
	23	south pool	1,887 (575)	2	6
	24	south pool	1,818 (554)	3	6
	25	south pool	1,590 (485)	2	9
	26	south pool	954 (291)	1	5
	27	south pool	1,131 (345)	2	7
	28	south pool	1,200 (366)	2	6
	29	south pool	870 (265)	2	5
	30	south pool	816 (249)	2	5
Total	30		51, 645 (15,742)		218 sampled (64 mowed)

[a] measurements in parentheses are in feet.

Table 6. The moist-soil plants monitored for seed yields at Chautauqua National Wildlife Refuge, summer-fall 1999, and their historical occurrence (x) at the Refuge. Also included are the duck species for which the plants provide major foods, the plant food rating for quality as a duck food, and if the plants are preferred (x) by waterfowl. Energy content (cal/g) of the plant seeds and the sites in which the plants occurred are also listed.

Species	Historical	Major Food[a]	Rating	Preferred[b]	Energy[c]	Site[d]
Amaranthus tuberculatus	x				4,542	SP, SS
Amaranthus rudis	x		fair	x	4,623	SP, SS
Bidens cernua	x				4,593	SP, SS
Bidens frondosa	x				5,177	SP
Cyperus esculentus	x			x	4,256	SP
Cyperus erythrorhizos	x	mall, gwt		x	5,196	SP, SS
Cyperus ferruginescens	x	mall, gwt	excellent	x	3,690	SP, SS
Cyperus strigosus	x			x	3,686	SP
Echinochloa crusgalli	x	mall, gad, pin, bwt, gwt	excellent	x	4,819	SP, SS
Echinochloa frumentacea	x	mall	excellent	x	4,531	
Echinochloa walteri	x	mall, pin, gwt	excellent	x	4,560	SP
Eragrostis hypnoides	x	gwt	good	x		SP, SS
Leersia oryzoides	x	mall, pin, gwt	excellent	x	4,470	SP, SS
Leptochloa fascicularis					2,834[e]	SP, SS
Polygonum amphibium	x	mall, pin, bwt, gwt				SP, SS
Polygonum lapathifolium	x	mall, pin, bwt, gwt	excellent	x	4,780	SP
Polygonum pensylvanicum	x	mall, pin, bwt, gwt	excellent	x	4,740	SP
Sagittaria calycina	x				5,150	SP, SS
Sagittaria latifolia	x	mall, gad	good	x	4,736	SP

[a]Major foods consumed by mallards (mall); green-winged teals (gwt); gadwalls (gad); northern pintails (pin); blue-winged teals (bwt).
[b]Bellrose and Anderson 1943.
[c]Havera 1999.
[d]SP = species identified in the south pool; SS = species identified in the setback site.
[e]Data represents *Leptochloa panicoides*.

Table 7. Densities (stems/m^2, stems/ft^2) of the common moist-soil plants of the south pool at Chautauqua National Wildlife Refuge, summer-fall 1999.

Species	Zone	Stems/m^2	Stems/ft^2
Amaranthus spp.	1	5.4	0.5
Bidens cernua	1	0.9	0.1
Cyperus erythrorhizos	1	138.6	12.9
Cyperus esculentus	1	5.7	0.5
Cyperus ferruginscens	1	5.1	0.5
Cyperus spp.	1	0.9	0.1
Cyperus strigosus	1	11.1	1.0
Eragrostis hypnoides	1	724.9	67.6
Leersia oryzoides	1	244.6	22.8
Leptochloa fascicularis	1	7.7	0.7
Lippia lanceolata	1	0.6	0.1
Polygonum pensylvanicum	1	0.6	0.1
Sagittaria calycina	1	12.0	1.1
Sagittaria spp.	1	0.6	0.1
Salix nigra	1	0.3	< 0.1
Salix spp.	1	0.9	0.1
Xanthium strumarium	1	10.9	1.0
Amaranthus spp.	2	7.3	0.7
Bidens cernua	2	16.8	1.6
Cyperus erythrorhizos	2	68.3	6.4
Cyperus esculentus	2	0.2	< 0.1
Cyperus ferruginscens	2	59.3	5.5
Cyperus strigosus	2	6.7	0.6
Echinochloa walteri	2	16.4	1.5
Eragrostis hypnoides	2	955.1	89.0
Leersia oryzoides	2	85.3	7.9
Leptochloa fascicularis	2	13.8	1.3
Polygonum amphibium	2	0.2	< 0.1
Polygonum pensylvanicum	2	0.2	< 0.1
Sagittaria calycina	2	33.8	3.2
Sagittaria latifolia	2	2.2	0.2
Salix spp.	2	0.4	< 0.1
Xanthium strumarium	2	0.8	0.1
Amaranthus spp.	3	12.5	1.2

Table 7. (continued)

Species	Zone	Stems/m^2	Stems/ft^2
Cyperus ferruginscens	3	1.4	0.1
Cyperus spp.	3	1.4	0.1
Eragrostis hypnoides	3	394.4	36.8
Xanthium strumarium	3	292.2	27.2
Amaranthus spp.	5	13.0	1.2
Bidens cernua	5	47.0	4.4
Bidens frondosa	5	1.0	0.1
Cyperus erythrorhizos	5	59.0	5.5
Cyperus esculentus	5	8.0	0.7
Cyperus ferruginscens	5	57.0	5.3
Cyperus spp.	5	1.0	0.1
Echinochloa walteri	5	25.0	2.3
Eragrostis hypnoides	5	654.0	61.0
Leersia oryzoides	5	77.0	7.2
Polygonum amphibium	5	27.0	2.5
Polygonum spp.	5	3.0	0.3
Salix spp.	5	1.0	0.1
Xanthium strumarium	5	8.0	0.7
Amaranthus spp.	6	4.6	0.4
Cyperus erythrorhizos	6	52.6	4.9
Cyperus ferruginscens	6	6.9	0.6
Cyperus strigosus	6	11.4	1.1
Eragrostis hypnoides	6	2,016.0	187.9
Leersia oryzoides	6	41.1	3.8
Leptochloa fascicularis	6	38.9	3.6
Sagittaria calycina	6	34.3	3.2
Xanthium strumarium	6	6.9	0.6
Bidens cernua	7	164.0	15.3
Cyperus erythrorhizos	7	80.0	7.5
Cyperus esculentus	7	4.0	0.4
Cyperus ferruginscens	7	16.0	1.5
Echinochloa walteri	7	108.0	10.1
Eragrostis hypnoides	7	304.0	28.3
Leersia oryzoides	7	904.0	84.2
Sagittaria latifolia	7	44.0	4.1

Table 8. Densities (stems/m^2, stems/ft^2) of the common moist-soil plants of the setback site at Chautauqua National Wildlife Refuge, summer-fall 1999.

Species	**Zone**	**Stems/m^2**	**Stems/ft^2**
Amaranthus spp.	1	2.1	0.2
Bidens cernua	1	1.1	0.1
Eragrostis hypnoides	1	1.1	0.1
Sicyos angulatus	1	4.3	0.4
Xanthium strumarium	1	48.0	4.5
Amaranthus spp.	2	17.5	1.6
Cyperus ferruginscens	2	1.5	0.1
Eragrostis hypnoides	2	240.0	22.4
Xanthium strumarium	2	357.8	33.3
Amaranthus spp.	3	22.9	2.1
Cyperus erythrorhizos	3	75.4	7.0
Cyperus ferruginscens	3	48.0	4.5
Echinochloa crusgali	3	2.3	0.2
Eragrostis hypnoides	3	4,317.7	402.4
Leptochloa fascicularis	3	29.7	2.8
Salix spp.	3	6.9	0.6
Xanthium strumarium	3	75.4	7.0

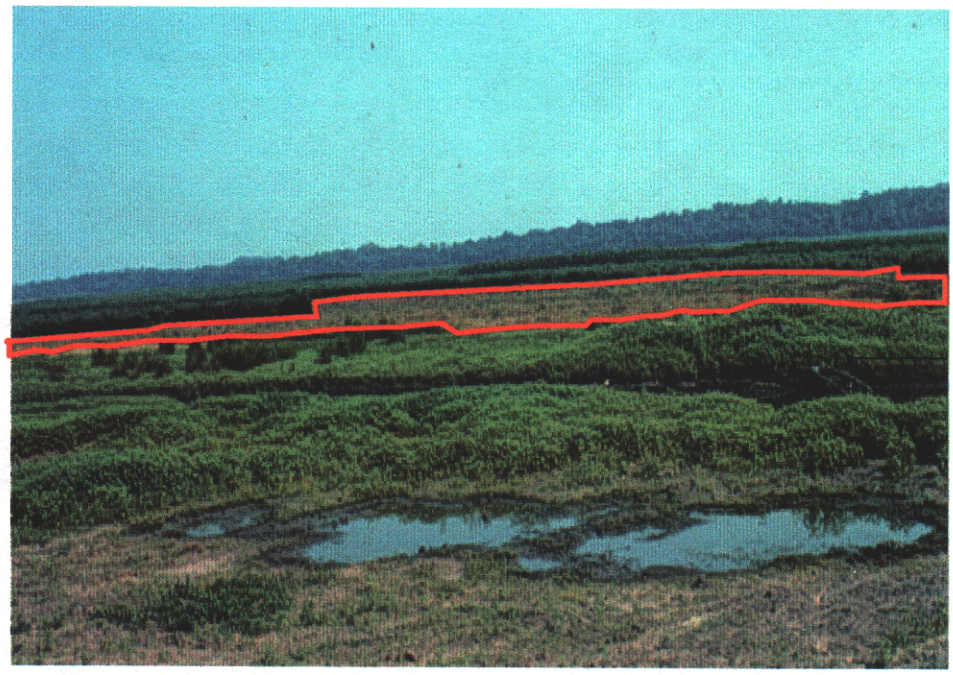

Photo 1. Area mowed for willow control in the south pool at Chautauqua National Wildlife Refuge, summer-fall 1999: (top) mowed area enclosed in red; (bottom) close-up of mowed vegetation.

Photo 2. Frame (0.06 m^2, 0.67 ft^2) used to sample moist-soil plants at Chautauqua National Wildlife Refuge, summer-fall 1999.

a.

b.

Photo 3. Vegetative zones of the south pool at Chautauqua National Wildlife Refuge, summer-fall 1999: a) zone 1; b) zone 3; c) zone 4; d) zone 5; e) zone 6; f) zone 7.

c.

d.

Photo 3. (continued)

e.

f.

Photo 3. (continued)

Photo 4. Subzones of Zone 2 of the south pool at Chautauqua National Wildlife Refuge, summer-fall 1999: (top) vegetation along the south shoreline of the pool; (bottom) vegetation along the north side of the pool.

Photo 5. Zone 1 of the setback site at Chautauqua National Wildlife Refuge, summer-fall 1999: (top) subzones of willows; (bottom) understory consisting of cocklebur (*Xanthium strumarium*) and bur cucumber (*Sicyos angulatus*).

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