5 Risk Characterization

This section summarizes an initial assessment of the potential for plant breakage and reduced plant growth and vegetative reproduction for scenarios of commercial traffic increases in UMR Pools 4, 8, and 13.

Physical Damage to Submerged Aquatic Plants

The potential for physical damage to plants was assessed by comparing the values of current velocity and wave height calculated by the NAVEFF model with the screening criteria of 0.75 m/s for current velocity and 0.2 m for wave height for all 108 vessel types in all cells in Pools 4, 8, and 13 that were 1.5 m or less in depth. Cell depth is an output of the NAVEFF model and is determined by the flow conditions and bathymetry specified as input data for each pool.

The screening calculations were performed for the nine combinations of stage height and vessel location for each pool (Tables 9-11). The results demonstrate the increase in possible combinations of vessel type and cell number with increasing stage height. Due to constraints imposed by the bathymetry data on some of the pool cross sections, it was not possible to run all the vessel types using the NAVEFF model for all stage heights and sailing lines. Thus, in several instances (i.e., Pool 4, low stage; Pool 13, medium stage) the numbers in columns one and two vary in Tables 9-11. However, dividing the number of combinations of cell x vessel in the second column by 108 vessel types approximates the number of cells of 1.5-m depth for each stage height: 596 for low stage, 613 for medium, and 204 for high stage. The corresponding numbers for Pool 13 are 2,017 for low, 2,088 for medium, and 2,131 for the high stage height.

Table 9
Summary of Screening Assessment for Plant Breakage in Pool 4[1]

Stage/ Sailing Line	Number of Combinations Cells x Vessels	Number in Cells <1.5 m Deep	Number That Failed the Screen
Low Stage			
Left	1,193,134	64,012	342 (0.53)
Center	1,202,082	64,376	188 (0.29)
Right	1,195,641	64,064	224 (0.35)
Medium Stage			
Left	1,377,865	66,204	596 (0.90)
Center	1,377,865	66,204	340 (0.51)
Right	1,377,865	66,204	376 (0.57)
High Stage			
Left	1,440,613	22,032	304 (1.38)
Center	1,440,613	22,032	128 (0.58)
Right	1,440,613	22,032	164 (0.74)

[1] The number in parentheses is the percentage of cells <1.5 m deep that failed the screen.

Table 10
Summary of Screening Assessment for Plant Breakage in Pool 8[1]

Stage/ Sailing Line	Number of Combinations Cells x Vessels	Number in Cells <1.5 m Deep	Number That Failed the Screen
Low Stage			
Left	1,053,973	278,964	2,412 (0.86)
Center	1,053,973	278,964	1,500 (0.54)
Right	1,053,973	278,964	2,046 (0.73)
Medium Stage			
Left	1,070,821	381,024	3,372 (0.88)
Center	1,070,821	381,024	2,304 (0.60)
Right	1,070,821	381,024	2,772 (0.73)
High Stage			
Left	1,141,777	309,744	2,352 (0.76)
Center	1,141,777	309,744	1,338 (0.43)
Right	1,141,777	309,744	2,304 (0.74)

[1] The number in parentheses is the percentage of cells <1.5 m deep that failed the screen

Table 11
Summary of Screening Assessment for Plant Breakage in Pool 13[1]

Stage/ Sailing Line	Number of Combinations Cells x Vessels	Number in Cells <1.5 m Deep	Number That Failed the Screen
Low Stage			
Left	559,873	217,836	872 (0.400)
Center	559,873	217,836	528 (0.242)
Right	559,873	217,836	748 (0.343)
Medium Stage			
Left	625,321	225,504	808 (0.358)
Center	625,321	225,504	536 (0.238)
Right	609,661	212,328	760 (0.358)
High Stage			
Left	757,837	230,148	980 (0.426)
Center	757,837	230,148	524 (0.228)
Right	757,837	230,148	760 (0.330)

[1] The number in parentheses is the percentage of cells <1.5 m deep that failed the screen.

Of the possible number of cell x vessel combinations in Pools 4, 8, and 13, the numbers and percentages of combinations that failed either the current velocity or the wave height screening criteria were small. Less than 1.5% of the 1.5-m depth combinations failed the screen (Pool 4, high stage, left sailing line) for all combinations of stage height, vessel type, and sailing location across the three pools. For each pool, the greatest impacts resulted for vessels located at the left edge of the navigation channel, independent of pool stage height. In general, vessels operate in this portion of the navigation channel approximately 5% of the time.

The specific combinations of vessel type, sailing line, and stage height that failed the screening process could become the focus of a more detailed assessment. The cell identification number, the vessel type, and the NAVEFF model results (current velocity, wave height) for this screening exercise were recorded and saved as computer files. Analysis of these screening results indicated that the criterion that consistently failed the screening was wave height (>95% of all screening failures). The screening criterion was a wave height of 0.2 m; of the thousands of screening failures (Tables 9-11), the wave heights produced by the NAVEFF model calculations were less than 0.3 m. Thus, the wave height screening value was violated usually by small amounts. In more detailed assessments, the uncertainties associated with both the NAVEFF model computations and the screening criterion of 0.2 m should be examined to determine the probability that physical damage would be expected.

Decreased Growth and Vegetative Reproduction of Submerged Aquatic Plants

The impacts of traffic-induced sediment resuspension on plant growth and reproduction were assessed for one example cell selected from Pool 4 (115L7560), Pool 8 (145L6875), and Pool 13 (85L5300). The Pool 4 example location is 115 m left of the main sailing line at River Mile 756.0; the Pool 8 location is 145 m left of the sailing line at River Mile 687.5; and the Pool 13 cell is 85 m left of the sailing line at River Mile 530.0. Each cell is approximately 0.81 km (i.e., 0.5 mile) in length by 10 m wide and was selected because it was one that failed the physical screening for one or more vessel types, and the cell depth was ~1.5 m at high pool stage.

Light extinction coefficients

Time series of daily suspended sediment concentrations (mg/L) were constructed for each month in the May through September growing season for the 1992 baseline and the percentage increase in traffic scenarios. These concentrations were used to estimate daily values of light extinction coefficients. The suspended sediment concentrations were first converted to estimates of Secchi depth (m) using the regression equations for Pools 4, 8, and 13 (Table 4). The Secchi depths were then transformed to light extinction coefficients using the Giesen et al. (1990) equation (Figure 3). The monthly average values of the extinction coefficients are summarized for the selected cells in Tables 12-14.

The values estimated for suspended sediments associated with the 1992 baseline traffic data resulted in monthly average extinction coefficients that ranged from 3.08 to 4.24 m^{-1} in Pool 4 (2.62 to 3.00 m^{-1}); 2.96 to 4.59 m^{-1} in Pool 8 (3.30 to 3.84 m^{-1}), and 2.96 to 3.42 m^{-1} in Pool 13 (4.23 to 4.58 m^{-1}). The values in parentheses for each pool are estimated using the average monthly ambient suspended sediment concentrations (Table 5). Differences between the extinction values based on simulated 1992 traffic (Tables 12-14) and the coefficients reported in Table 5 result largely from different ambient suspended sediment concentrations reported for the particular cell within each pool in comparison to the reported monthly average value. The greatest difference was for the selected cell from Pool 13, which had an associated ambient suspended sediment concentration of 0.2 mg/L compared with values of 46-76 mg/L reported in Table 5.

Table 12
Summary of Pool 4 Monthly Average Light Extinction Coefficients (m^{-1}) Calculated for Different Traffic Increase Scenarios[1]

	Traffic Scenario				
	1992	**25%**	**50%**	**75%**	**100%**
May					
Mean	3.08	3.36	3.45	3.51	3.69
% Increase		8.98	11.93	14.03	19.64
June					
Mean	4.24	4.29	4.45	4.48	4.59
% Increase		1.40	4.93	5.73	8.39
July					
Mean	4.20	4.36	4.55	4.54	4.63
% Increase		3.75	8.37	8.15	10.40
August					
Mean	4.04	4.22	4.16	4.34	4.47
% Increase		4.49	3.05	7.56	10.72
September					
Mean	3.55	4.11	4.09	4.38	4.26
% Increase		15.76	15.09	23.12	19.86

[1] Percentage increases in average extinction coefficients compared to the 1992 reference values are also presented.

Table 13
Summary of Pool 8 Monthly Average Light Extinction Coefficients (m^{-1}) Calculated for Different Traffic Increase Scenarios[1]

Traffic Scenario					
	1992	25%	50%	75%	100%
May					
Mean	2.96	3.16	3.49	3.59	3.87
% Increase		6.56	17.98	21.39	30.81
June					
Mean	4.59	4.78	4.96	5.12	5.36
% Increase		4.03	7.91	11.33	16.62
July					
Mean	4.43	4.67	4.79	4.98	5.11
% Increase		5.51	8.30	12.55	15.44
August					
Mean	3.71	3.90	4.22	4.48	4.49
% Increase		5.08	13.78	20.82	21.16
September					
Mean	3.63	3.93	4.00	4.17	4.38
% Increase		8.26	10.04	14.70	20.72

[1] Percentage increases in average extinction coefficients compared to the 1992 reference values are also presented.

Table 14
Summary of Pool 13 Monthly Average Light Extinction Coefficients (m^{-1}) Calculated for Different Traffic Increase Scenarios[1]

	Traffic Scenario				
	1992	25%	50%	75%	100%
May					
Mean	2.96	3.17	3.23	3.87	3.39
% Increase		6.82	9.00	30.66	14.43
June					
Mean	3.31	3.57	3.83	4.08	4.24
% Increase		7.64	15.57	22.85	27.85
July					
Mean	3.38	3.59	3.77	4.14	4.28
% Increase		6.07	11.26	22.47	26.58
August					
Mean	3.42	3.40	4.02	3.82	4.10
% Increase		-0.54	17.60	11.66	19.92
September					
Mean	3.14	3.36	3.56	3.76	3.93
% Increase		6.96	13.20	19.77	25.03

[1] Percentage increases in average extinction coefficients compared to the 1992 reference values are also presented.

The increases in monthly light extinction coefficients across traffic scenarios demonstrate that a proportional increase in traffic intensity does not translate simply to the same proportional increase in light extinction. The light extinction coefficient is an exponent, so a small increase in it actually means an exponentially greater decrease in light availability. A 100% increase in traffic intensity produced, at most, a 28% increase in the average extinction coefficient (i.e., Pool 13, June). The results also reflect the monthly varying values of baseline traffic intensity and ambient suspended sediment concentrations. In Pool 4, the greatest relative increase in light extinction occurred for the months of May and September. In Pool 8, the greatest relative increase in light extinction occurred for the months of May and August. The greatest percentage increase in light extinction occurred for the months of June and July in Pool 13; these month-to-month differences were greater compared to Pools 4 and 8.

Within each month, the relative increase in light extinction coefficients with increasing traffic intensity is approximately linear for these pools (Tables 12-14). However, the variation introduced by the random selection of interarrival times and vessel types resulted in extinction values that are not simple multiples for successive scenarios of percentage increases in navigation traffic.

The results of increased traffic on suspended sediments produced increases in light extinction coefficients on the order of 1 to 28%, depending on the combination of month, pool, and traffic scenario (e.g., Tables 12-14). However, the value of the light extinction coefficient is an exponent in the equation which describes light attenuation within the water column in the plant growth models. Therefore, the impacts of these small increases in light extinction coefficients can be magnified when used in the plant models to examine the implications of increases in suspended sediments on growth and reproduction for wild celery (i.e., VALLA) and sago pondweed (i.e., POTAM).

Plant growth and biomass

The plant growth models for wild celery and sago pondweed were implemented for the selected locations (GIS cells) in Pools 4, 8, and 13. The time series of daily light extinction coefficients developed for each location and traffic scenario replaced the nominal values for the model days that correspond to the May through September growing season. For each representative plant species, simulations were performed for the four percentage traffic increase scenarios in addition to the 1992 baseline. The simulated values of total plant biomass, plant living biomass, tuber numbers (number/m^2), and tuber biomass (g dry mass/m^2) were summarized for the traffic scenarios.

Figures 23 through 25 illustrate the temporal growth dynamics of wild celery in Pools 4, 8, and 13 for the baseline and percentage increase traffic scenarios. The results of tow-induced increased suspended sediments and corresponding reductions in light availability have demonstrated impacts on plant growth for the selected cells in these pools. The severity of the modeled impacts was greatest in Pool 13, followed by Pool 4. Minimal impacts on wild celery were

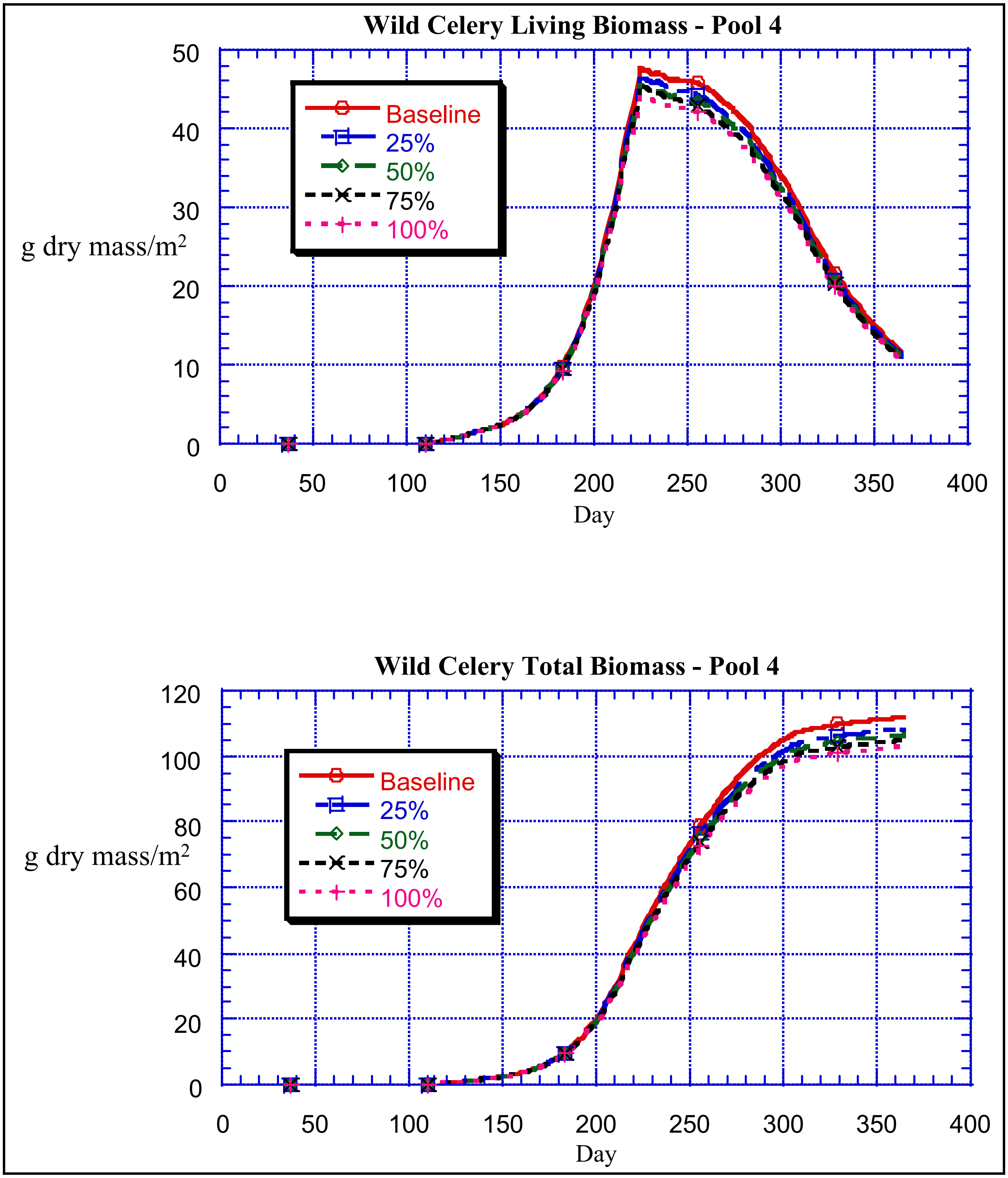

Figure 23. The growth (living biomass and total biomass) of wild celery in UMR Pool 4 for the baseline and percentage increase traffic scenarios. Climatological data pertaining to St. Paul, Minnesota, 10-year average (1985-1994) were used, water depth is 1.5 m, and Day 1 = January 1

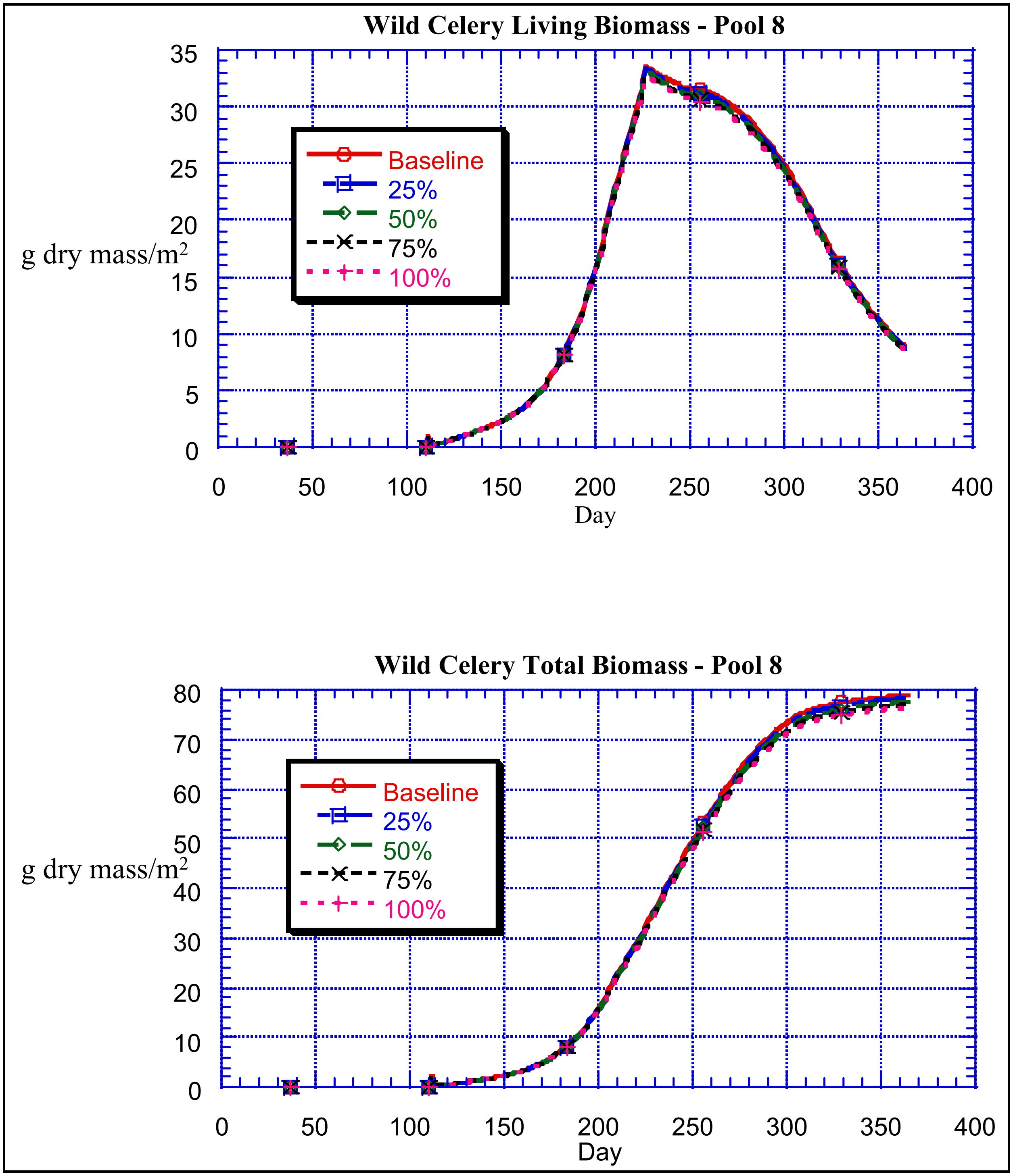

Figure 24. The growth (living biomass and total biomass) of wild celery in UMR Pool 8 for the baseline and percentage increase traffic scenarios. Climatological data pertaining to La Crosse, Wisconsin, 30-year average (1961-1990) were used, water depth is 1.5 m, and Day 1 = January 1

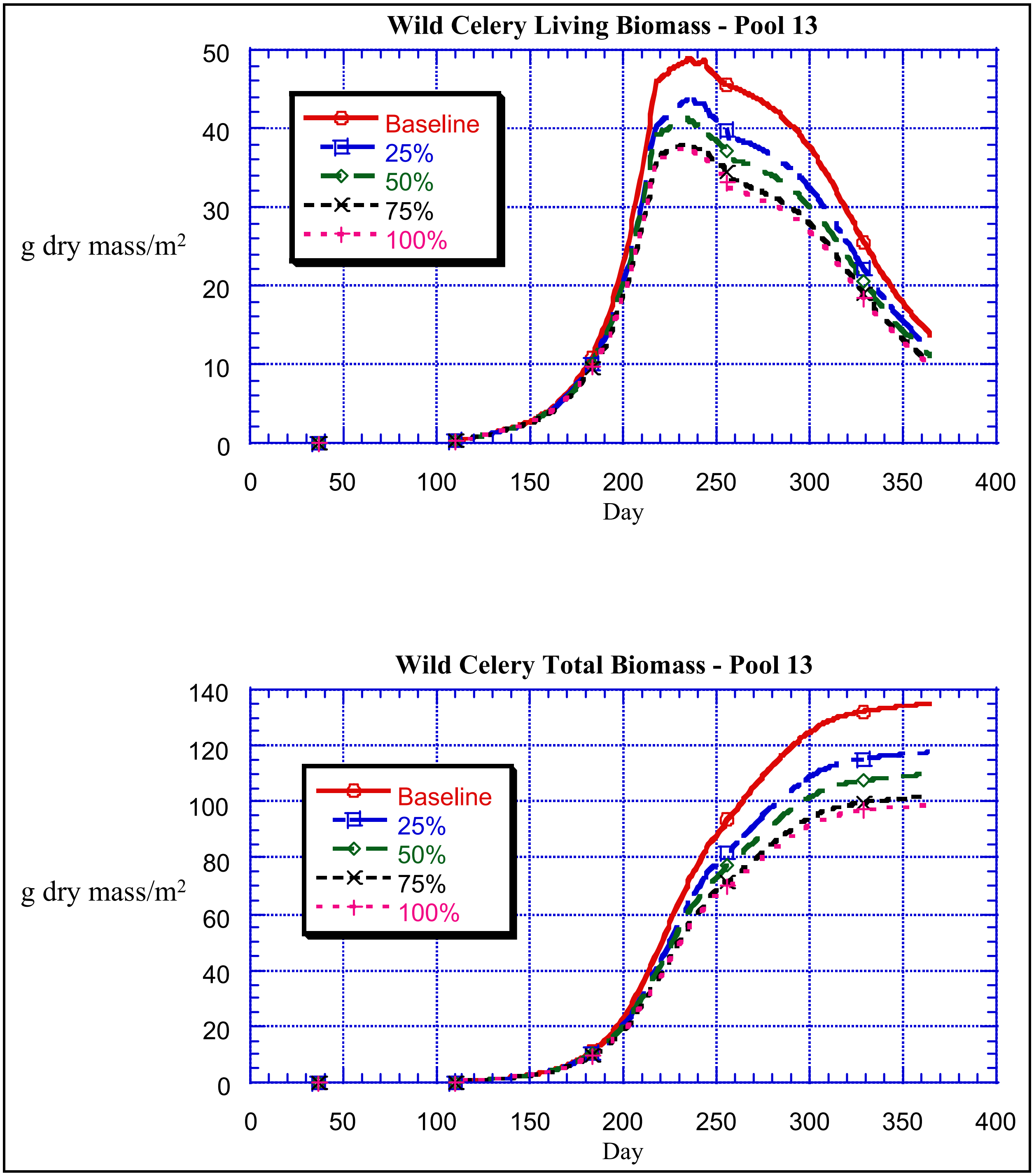

Figure 25. The growth (living biomass and total biomass) of wild celery in UMR Pool 13 for the baseline and percentage increase traffic scenarios. Climatological data pertaining to Moline, Illinois, 30-year average (1961-1990) were used, water depth is 1.5 m, and Day 1 = January 1

projected in Pool 8. The traffic-induced sediment resuspension appeared to exert its main impact during the latter part of the plant growth cycle (e.g., Figure 25).

The model results for total wild celery plant biomass (living + non-living) were summarized for the annual sum of daily values, the average daily value, and the maximum daily value (Table 15). Total annual plant biomass decreased by as much as 27% for a 100% traffic increase in Pool 13. Across the assessed scenarios, impacts ranged from 12-27% in Pool 13. Contrastingly, in Pools 4 and 8, the simulated traffic increases had less impact. Decreases in total plant biomass values ranged from approximately 1-8% compared to the 1992 baseline for Pools 4 and 8. The results indicated that a 25% increase in traffic did not translate into a corresponding 25% reduction in total biomass. However, the incremental decreases in total biomass were approximately linearly related to the increase in traffic; the incremental percentage decrease in biomass was nearly constant for each biomass measure with each 25% increase in traffic intensity (Table 15).

Table 15
Impacts on Total (Living + Dead) Biomass (g dry mass/m^2) of Wild Celery for the Percentage Increase Traffic Scenarios for the UMR-IWW System[1]

		Percent Traffic Increase			
Pool	**Baseline 1992**	**25**	**50**	**75**	**100**
Pool 4					
Annual Sum	14,564	14,126 (-3.0)	13,892 (-4.6)	13,706 (-5.9)	13,470 (-7.5)
Mean Biomass	39.9	38.7 (-3.0)	38.1 (-4.5)	37.6 (-5.8)	36.9 (-7.5)
Maximum Biomass	111.8	108.2 (-3.2)	106.5 (-4.7)	104.8 (-6.3)	103.1 (-7.8)
Pool 8					
Annual Sum	10,208	10,135 (-0.7)	10,039 (-1.7)	9,971 (-2.3)	9,907 (-2.9)
Mean Biomass	39.4	39.1 (-0.8)	38.8 (-1.5)	38.5 (-2.3)	38.3 (-2.8)
Maximum Biomass	79.0	78.3 (-0.9)	77.6 (-1.8)	77.0 (-2.5)	76.5 (-3.2)
Pool 13					
Annual Sum	17,371	15,228 (-12.3)	14,304 (-17.7)	13,263 (-23.6)	12,944 (-25.5)
Mean Biomass	47.6	41.7 (-12.3)	39.2 (-17.6)	36.3 (-23.7)	35.5 (-25.4)
Maximum Biomass	134.9	117.7 (-12.7)	109.8 (-18.6)	101.8 (-24.5)	98.9 (-26.7)

Values in parentheses are percent changes in production referenced to the 1992 baseline impacts.

Table 16 summarizes the corresponding projected traffic impacts on plant annual gross production, as well as on the mean and maximum values of daily plant living biomass for wild celery. The pattern of traffic impacts on gross production and living biomass essentially parallels the impacts recorded for total plant biomass. Percentage differences compared to the 1992 baseline scenario are of similar magnitude as the response of total biomass (i.e., Table 15). Again, the largest impacts were observed for the cell selected from Pool 13, and growth was reduced by ~10 to ~27% across the four increased traffic scenarios. Successively lesser impacts resulted for the simulations of traffic increases in Pools 4 and 8. Growth reductions were on the order of 0-4% in Pool 8, while corresponding impacts in Pool 4 ranged from ~3 to ~9% compared to the 1992 baseline simulations.

Table 16
Impacts on Annual Gross Production (g CO_2/m^2) and Living Biomass (g dry mass/m^2) of Wild Celery for the Percentage Increase Traffic Scenarios for the UMR-IWW System[1]

		Percent Traffic Increase			
Pool	Baseline 1992	25	50	75	100
Pool 4					
Gross Production	285.6	275.8 (-3.4)	271.3 (-5.0)	265.4 (-7.1)	260.5 (-8.8)
Mean Biomass	22.7	22.0 (-3.1)	21.7 (-4.4)	21.4 (-5.7)	21.0 (-7.5)
Maximum Biomass	47.6	46.4 (-2.5)	45.5 (-4.4)	45.4 (-4.6)	44.3 (-6.9)
Pool 8					
Gross Production	199.4	197.5 (-1.0)	195.3 (-2.1)	193.6 (-2.9)	192.0 (-3.7)
Mean Biomass	16.5	16.3 (-1.2)	16.2 (-1.8)	16.1 (-2.4)	16.0 (-3.0)
Maximum Biomass	33.5	33.4 (-0.3)	33.1 (-1.2)	32.8 (-2.1)	32.7 (-2.4)
Pool 13					
Gross Production	316.0	278.6 (-11.8)	257.6 (-18.5)	238.2 (-24.6)	230.4 (-27.0)
Mean Biomass	24.3	21.3 (-12.3)	20.1 (-17.3)	18.6 (-23.4)	18.2 (-25.1)
Maximum Biomass	49.1	44.2 (-10.0)	41.4 (-15.7)	38.0 (-22.6)	37.6 (-23.4)

[1] Values in parentheses are percent changes in production referenced to the 1992 baseline impacts.

The dynamics of sago pondweed living biomass and total biomass in Pools 4, 8, and 13 for the baseline and percentage increases in traffic are presented in Figures 26 through 28. The results indicate minimal impact of traffic on growth of sago pondweed in Pool 4 (Figure 26) and Pool 8 (Figure 27). However, modeled impacts on growth of this species were apparent for Pool 13 (Figure 28). The daily measures of total biomass (i.e., annual sum, average, maximum) demonstrated greater baseline production of sago pondweed compared to wild celery for Pools 4, 8, and 13 (Tables 15 and 17). As with wild celery, the largest impacts on sago pondweed from traffic increases were observed for Pool 13. However, the impact on sago pondweed growth was comparatively less than that for wild celery. The measures of sago pondweed total biomass were reduced from approximately 4-9% in Pool 13, compared with the 10-27% reductions simulated for wild celery in Pool 13. Modeled decreases in total sago pondweed biomass for Pools 4 and 8 were less than 3% of the 1992 baseline values across all four increases in traffic.

The impacts of simulated traffic increases on gross production and living biomass for sago pondweed are summarized in Table 18. The percentage changes in production and living biomass are approximately the same as those observed for total biomass. The greatest impacts occurred for Pool 13, with correspondingly lesser impacts in Pools 4 and 8, respectively. For all three measures summarized in Table 18 for all four traffic increase scenarios, the modeled impacts were less than 10% of the 1992 baseline values for production and living biomass.

Vegetative reproduction

The number and biomass of vegetative reproductive structures produced by the plant growth models during the growing season provides an indication of the potential impact of increased traffic on the availability of these structures to initiate plant growth in the subsequent year. Continued, significant reductions in the production of these vegetative reproductive structures might portend the disappearance of plant beds at affected locations within the UMR.

Under baseline conditions, the average number and biomass of tubers by wild celery was greatest in Pool 4, followed in order by Pools 8 and 13 (Table 19). The modeled impacts of increased traffic on the allocation of photosynthetically fixed carbon to these reproductive structures were minimal. The maximum values of tuber numbers and biomass were unchanged in Pools 8 and 13. Average number and biomass increased slightly with increased traffic in Pool 8 (Table 19). Minimal impacts were simulated in Pools 8 and 13. The greatest impacts were in Pool 4, and the projected decreases were less than 3% for average tuber number and biomass. Reductions in the maximum values of these measures ranged from 2-8% across the traffic scenarios in Pool 4.

The modeled impacts of increased commercial traffic on vegetative reproductive structures produced by sago pondweed are summarized in Table 20. No

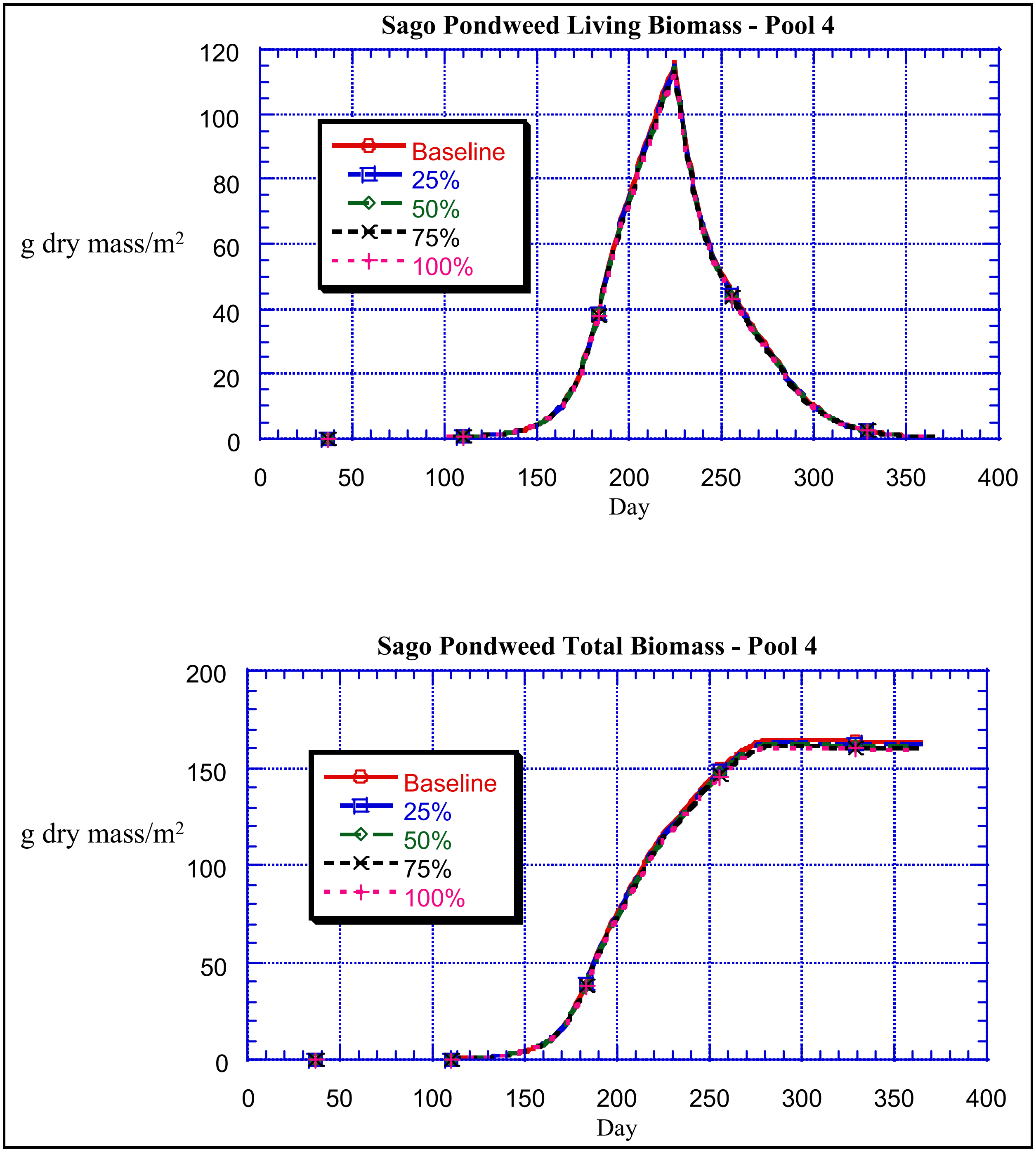

Figure 26. The growth (living biomass and total biomass) of sago pondweed in UMR Pool 4 for the baseline and percentage increase traffic scenarios. Climatological data pertaining to St. Paul, Minnesota, 10-year average (1985-1994) were used, water depth is 1.5 m, and Day 1 = January 1

changes in average or maximum numbers or biomass resulted for sago pondweed in Pool 4. In both Pools 8 and 13, the average number and biomass of

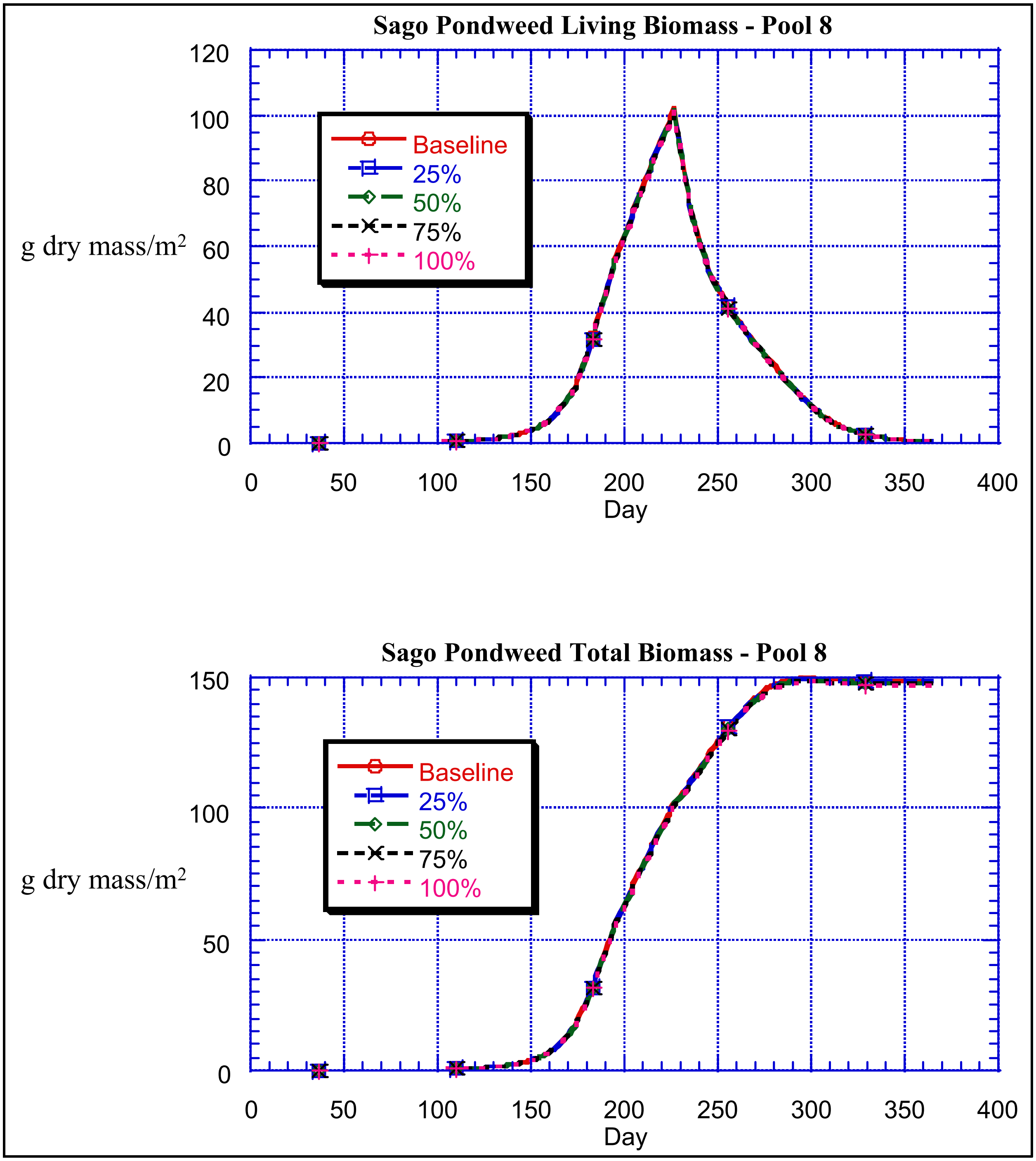

Figure 27. The growth (living biomass and total biomass) of sago pondweed in UMR Pool 8 for the baseline and percentage increase traffic scenarios. Climatological data pertaining to La Crosse, Wisconsin, 30-year average (1961-1990) were used, water depth is 1.5 m, and Day 1 = January 1.

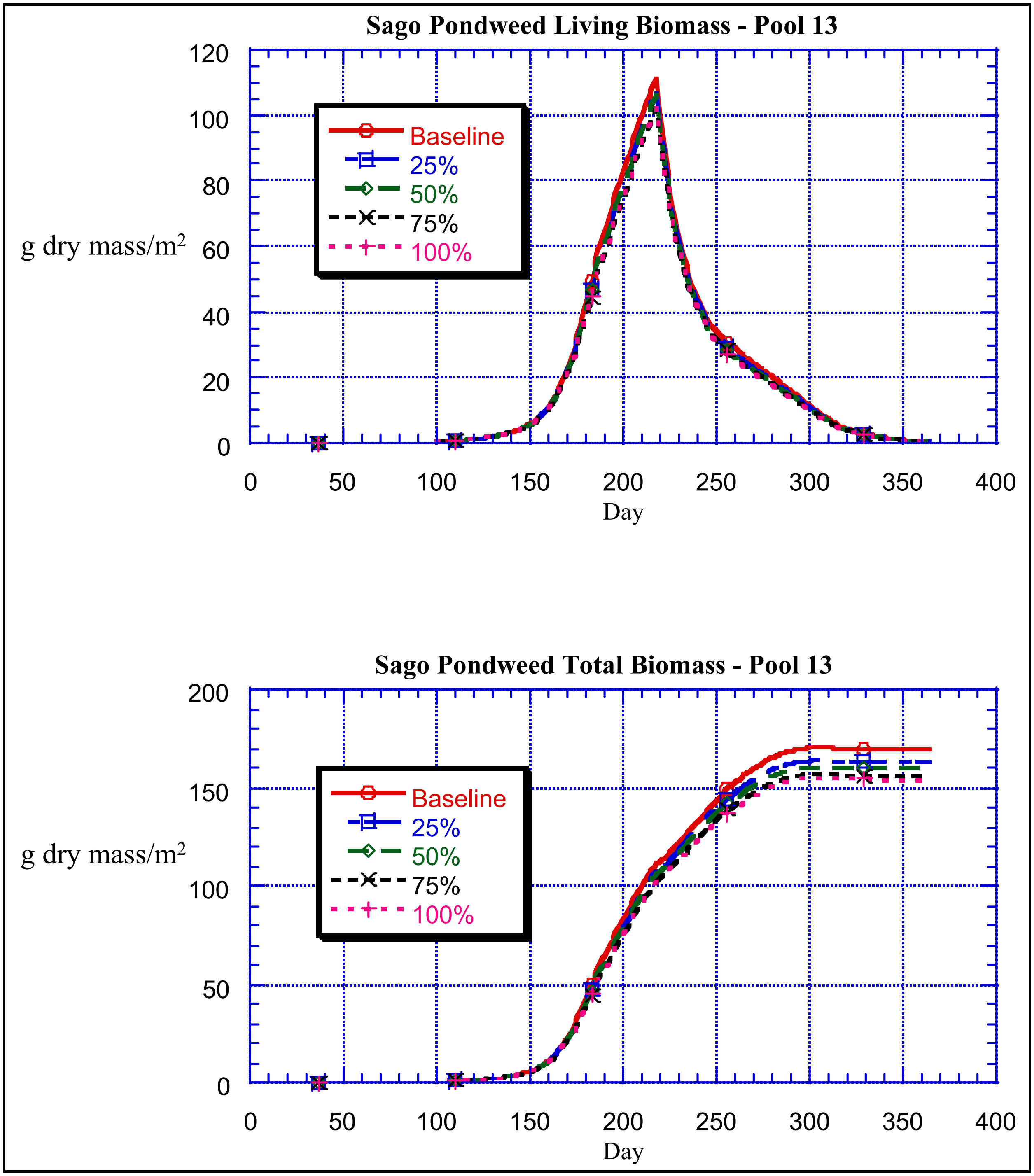

Figure 28. The growth (living biomass and total biomass) of sago pondweed in UMR Pool 13 for the baseline and percentage increase traffic scenarios. Climatological data pertaining to Moline, Illinois, 30-year average (1961-1990) were used, water depth is 1.5 m, and Day 1 = January 1

Table 17
Impacts on Total (Living + Dead) Biomass (g dry mass/m^2) of Sago Pondweed for the Percentage Increase Traffic Scenarios for the UMR-IWW System[1]

		Percent Traffic Increase			
Pool	**Baseline 1992**	**25**	**50**	**75**	**100**
Pool 4					
Annual Sum	25,905	25,660 (-0.9)	25,524 (-1.5)	25,378 (-2.0)	25,272 (-2.4)
Mean Biomass	71.0	70.3 (-1.0)	69.9 (-1.5)	69.5 (-2.1)	69.2 (-2.5)
Maximum Biomass	164.6	162.9 (-1.0)	162.3 (-1.4)	161.0 (-2.2)	160.5 (-2.5)
Pool 8					
Annual Sum	23,047	22,992 (-0.2)	22,925 (-0.5)	22,873 (-0.8)	22,820 (-1.0)
Mean Biomass	81.2	80.9 (-0.4)	80.7 (-0.6)	80.5 (-0.9)	80.4 (-1.0)
Maximum Biomass	149.8	149.4 (-0.3)	148.9 (-0.6)	148.6 (-0.8)	148.2 (-1.1)
Pool 13					
Annual Sum	26,910	25,922 (-3.7)	25,464 (-5.4)	24,804 (-7.8)	24,599 (-8.6)
Mean Biomass	73.7	71.0 (-3.7)	69.8 (-5.3)	67.9 (-7.9)	67.4 (-8.5)
Maximum Biomass	170.3	163.9 (-3.8)	160.4 (-5.8)	156.7 (-8.0)	154.9 (-9.0)

[1] Values in parentheses are percent changes in production referenced to the 1992 baseline impacts.

Table 18
Impacts on Annual Gross Production (g CO_2/m^2) and Living Biomass (g dry mass/m^2) of Sago Pondweed for the Percentage Increase Traffic Scenarios for the UMR-IWW System[1]

		Percent Traffic Increase			
Pool	**Baseline 1992**	**25**	**50**	**75**	**100**
Pool 4					
Gross Production	483.8	479.3 (-0.9)	476.8 (-1.4)	473.7 (-2.1)	471.4 (-2.6)
Mean Biomass	26.9	26.7 (-0.7)	26.5 (-1.5)	26.4 (-1.9)	26.3 (-2.2)
Maximum Biomass	116.2	115.1 (-0.9)	114.2 (-1.7)	114.2 (-1.7)	113.2 (-2.6)
Pool 8					
Gross Production	426.1	425.0 (-0.3)	423.7 (-0.6)	422.7 (-0.8)	421.5 (-1.1)
Mean Biomass	23.8	23.7 (-0.4)	23.7 (-0.4)	23.6 (-0.8)	23.6 (-0.8)
Maximum Biomass	102.9	102.0 (-0.9)	101.7 (-1.2)	101.4 (-1.5)	101.2 (-1.7)
Pool 13					
Gross Production	518.4	498.5 (-3.8)	488.8 (-5.7)	475.6 (-8.3)	470.7 (-9.2)
Mean Biomass	25.0	24.0 (-4.0)	23.7 (-5.2)	22.9 (-8.4)	22.8 (-8.8)
Maximum Biomass	111.2	107.0 (-3.8)	106.2 (-4.5)	102.6 (-7.7)	102.4 (-7.9)

[1] Values in parentheses are percent changes in production referenced to the 1992 baseline impacts.

Table 19
Impacts on Vegetative Reproduction of Wild Celery (i.e., Tubers) for the Percentage Increase Traffic Scenarios for the UMR-IWW System[1]

		Percent Traffic Increase			
Pool	Baseline 1992	25	50	75	100
Pool 4					
Average Number/m^2	129.2	128.9 (-0.2)	128.8 (-0.3)	127.7 (-1.2)	125.8 (-2.6)
Maximum Number/m^2	253.5	247.6 (-2.3)	246.6 (-2.7)	241.1 (-4.9)	234.6 (-7.5)
Average Biomass/m^2	11.5	11.5	11.5	11.4 (-0.9)	11.2 (-2.6)
Maximum Biomass/m^2	22.5	22.0 (-2.2)	21.9 (-2.7)	21.5 (-4.4)	21.0 (-6.7)
Pool 8					
Average Number/m^2	99.9	99.9	100.1 (+0.2)	100.1 (+0.2)	100.1 (+0.2)
Maximum Number/m^2	233.0	233.0	233.0	233.0	233.0
Average Biomass/m^2	8.97	8.97	8.98 (+0.1)	8.98 (+0.1)	8.98 (+0.1)
Maximum Biomass/m^2	21.0	21.0	21.0	21.0	21.0
Pool 13					
Average Number/m^2	97.5	97.5	97.3 (-0.2)	96.9 (-0.6)	96.5 (-1.0)
Maximum Number/m^2	233.0	233.0	233.0	233.0	233.0
Average Biomass/m^2	8.73	8.73	8.72 (-0.1)	8.68 (-0.6)	8.64 (-1.0)
Maximum Biomass/m^2	21.0	21.0	21.0	21.0	21.0

[1] Values in parentheses are percent changes in production referenced to the 1992 baseline impacts.

Table 20
Impacts on Vegetative Reproduction of Sago Pondweed (i.e., Tubers) for the Percentage Increase Traffic Scenarios for the UMR-IWW System[1]

		Percent Traffic Increase			
Pool	Baseline 1992	25	50	75	100
Pool 4					
Average Number/m^2	112.3	112.3	112.3	112.3	112.3
Maximum Number/m^2	330.1	330.1	330.1	330.1	330.1
Average Biomass/m^2	9.21	9.21	9.21	9.21	9.21
Maximum Biomass/m^2	26.3	26.3	26.3	26.3	26.3
Pool 8					
Average Number/m^2	114.2	114.2	114.5 (+0.3)	114.5 (+0.3)	114.5 (+0.3)
Maximum Number/m^2	319.6	319.6	317.1 (-0.8)	317.1 (-0.8)	317.1 (-0.8)
Average Biomass/m^2	9.39	9.39	9.41 (+0.2)	9.41 (+0.2)	9.41 (+0.2)
Maximum Biomass/m^2	25.7	25.7	25.5 (-0.8)	25.5 (-0.8)	25.5 (-0.8)
Pool 13					
Average Number/m^2	125.6	126.6 (+0.8)	127.9 (+1.8)	128.8 (+2.5)	129.3 (+2.9)
Maximum Number/m^2	349.6	346.6 (-0.9)	333.9 (-4.5)	330.9 (-5.3)	330.9 (-5.3)
Average Biomass/m^2	10.3	10.3	10.5 (+1.9)	10.5 (+1.9)	10.6 (+2.9)
Maximum Biomass/m^2	27.9	27.8 (-0.4)	26.9 (-3.6)	26.6 (-4.7)	26.3 (-5.7)

[1] Values in parentheses are percent changes in production referenced to the 1992 baseline impacts.

sago pondweed tubers increased slightly with increased traffic. However, the corresponding maximum values decreased by as much as 6% for the 100% traffic increase scenario in Pool 13.

Uncertainties

There are several sources of bias and imprecision associated with this initial assessment of commercial traffic on submerged aquatic vegetation in the main channel and main channel borders of the UMR-IWW System. These uncertainties are listed below.

- The physical criteria for plant breakage are based on a small number of experiments and publications. The 0.75-m/s current velocity and the 0.2-m wave heights may be pessimistic.

- The screening for physical damage does not address the potential impacts of continued and repeated exposure to current velocities and wave heights that are near, but fail to exceed, the threshold criteria for damage. It was assumed that each tow passage represents an independent event in relation to possible plant breakage.

- The plant growth models for wild celery and sago pondweed were calibrated using field data from the Netherlands and New York. It is possible that plant populations in the UMR-IWW System differ genetically from the calibration populations and/or possess adaptation mechanisms to other climates unknown to the authors of this report. These differences may cause the UMR-IWW System populations to behave differently than the calibrated model plant populations.

- Concentrations of potentially different suspended sediments were assumed to exert the same reduction in light availability. No distinction was made between suspended sands versus suspended silts in their characteristic effects on underwater light fields. However, the nearshore algorithms for sediment resuspension were developed for the fine, cohesive sediments that are characteristic of the nearshore environment in the UMR-IWW System.

- Risks to plant growth and reproduction were estimated only for one cell of ~1.5-m depth in each of Pools 4, 8, and 13. Variability in sediment resuspension by the same vessel configurations for other cells of similar depth would result in different light extinction coefficients and presumably in different modeled impacts on plant growth and reproduction.

- It was assumed that the simulated impacts on sago pondweed and wild celery growth and reproduction are characteristic responses for other submerged aquatic plant species with similar phenology, biomass, and water column distribution in the UMR-IWW System.

- The current versions of the models do not calculate seed production and plant establishment from seeds. Recent literature on submerged aquatic plant population survival under adverse conditions indicates that seeds may play an important role.

Future revisions of the described assessment approaches will address these (and others yet to be identified) sources of bias and imprecision. Where possible, the impact of the specific sources of uncertainty on the estimated risks to plant breakage, growth, and reproduction will be quantified using methods of sensitivity and uncertainty analysis.

Probabilistic Risk Assessment

The main purposes of this preliminary assessment of hypothetical traffic scenarios were to (1) examine the efficacy of the overall approach and determine the feasibility of ecological risk assessment using the methods and models described, and if the methodology appears feasible, (2) to estimate the magnitude of impact of increased traffic on two plant species for selected locations with Pools 4, 8, and 13. The risk assessment described in this report represents a preliminary analysis where risks were characterized as single-value estimates or percentage changes in plant growth and vegetative reproduction. These analyses might be expanded in spatial extent by assessing more cells per pool to identify specific locations or areas within pools that might be at risk.

The next phase in assessing traffic impacts on submerged aquatic plants will be to incorporate the current methodology into a framework that characterizes risk in probabilistic terms. More detailed, probabilistic assessments will be performed for selected locations and traffic scenarios identified by the preliminary analyses. Parameters used in the calculations (e.g., suspended sediment concentrations produced by the NAVSED model, light extinction coefficients based on the regressions equations developed by Soballe, plant growth model coefficients) that are imprecisely known will be defined as statistical distributions. Monte Carlo simulation methods will be used to propagate these uncertainties through the model calculations to produce distributions of impacts on growth and vegetative reproduction in relation to specific traffic scenarios. These distributions of results can be used to estimate the probability of different magnitudes of impact in a manner consistent with probabilistic risk estimation.

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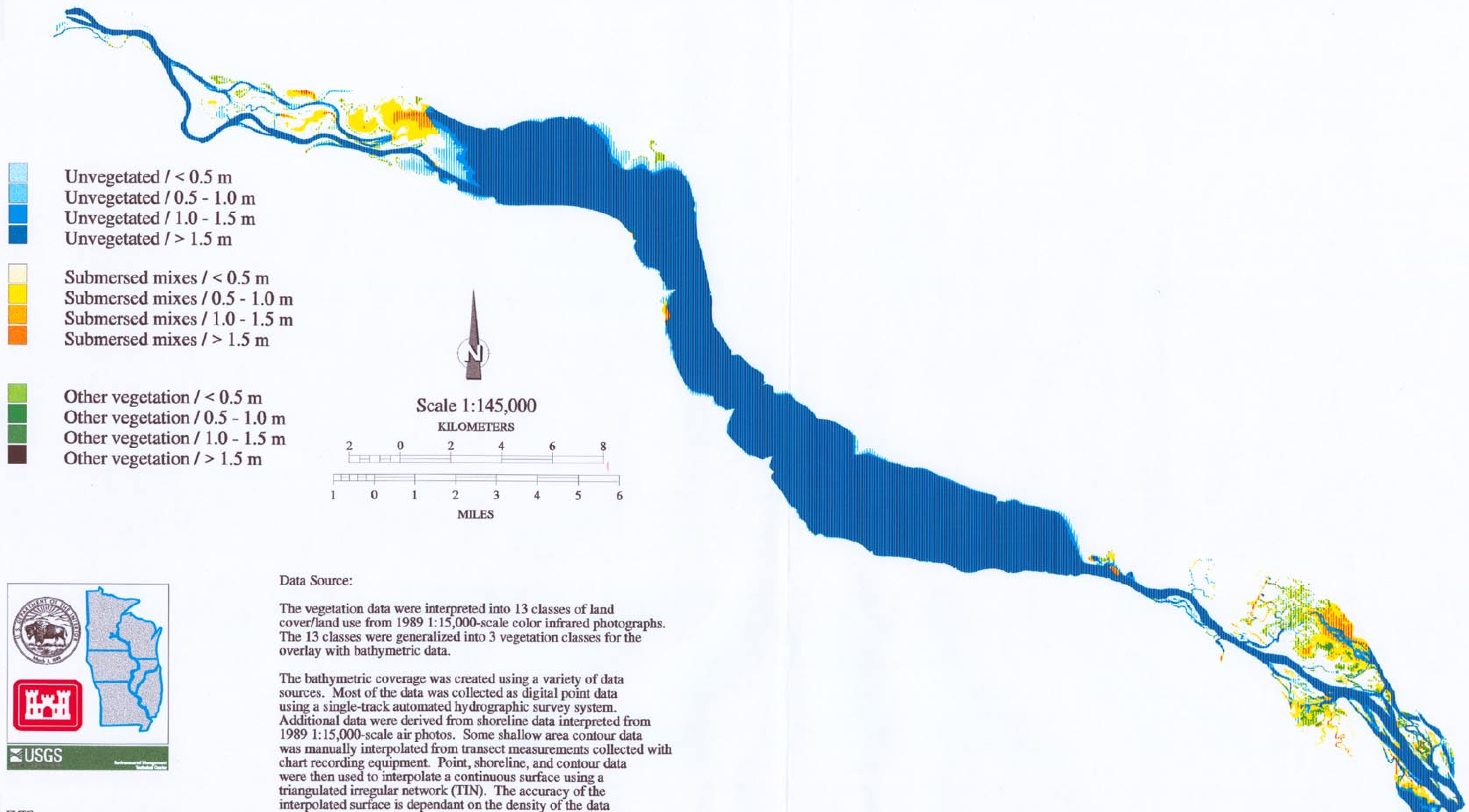
Appendix A
Submerged Aquatic Plant Coverage Maps for UMR Pools 4, 8, and 13

POOL 4 VEGETATION / BATHYMETRY



Data Source:

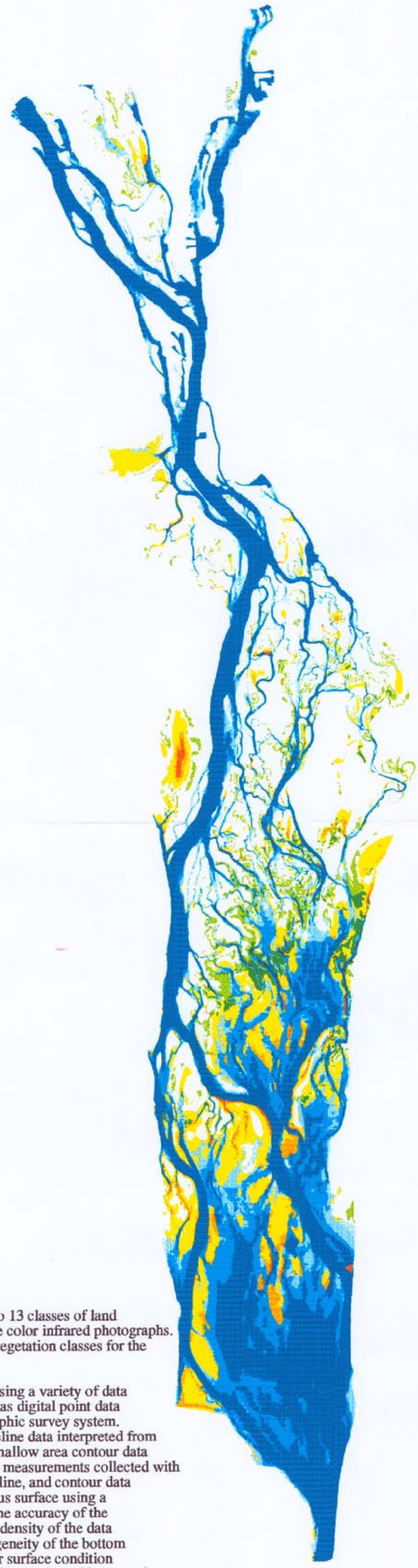
The vegetation data were interpreted into 13 classes of land cover/land use from 1989 1:15,000-scale color infrared photographs. The 13 classes were generalized into 3 vegetation classes for the overlay with bathymetric data.

The bathymetric coverage was created using a variety of data sources. Most of the data was collected as digital point data using a single-track automated hydrographic survey system. Additional data were derived from shoreline data interpreted from 1989 1:15,000-scale air photos. Some shallow area contour data was manually interpolated from transect measurements collected with chart recording equipment. Point, shoreline, and contour data were then used to interpolate a continuous surface using a triangulated irregular network (TIN). The accuracy of the interpolated surface is dependant on the density of the data used to create the surface and the homogeneity of the bottom surface. Water depths relative to a water surface condition exceeded 90% of the time was used for the overlay with vegetation data.

USGS

EMTC:
The Environmental Management Technical Center administers the Long Term Resource Monitoring Program for the Upper Mississippi River System, performing ecological monitoring and research on the river system.

POOL 8 VEGETATION / BATHYMETRY



- Unvegetated / < 0.5 m
- Unvegetated / 0.5 - 1.0 m
- Unvegetated / 1.0 - 1.5 m
- Unvegetated / > 1.5 m

- Submersed mixes / < 0.5 m
- Submersed mixes / 0.5 - 1.0 m
- Submersed mixes / 1.0 - 1.5 m
- Submersed mixes / > 1.5 m

- Other vegetation / < 0.5 m
- Other vegetation / 0.5 - 1.0 m
- Other vegetation / 1.0 - 1.5 m
- Other vegetation / > 1.5 m

N

Scale 1:89,000

KILOMETERS

1 0 1 2 3 4 5 6 7 8

1 0 1 2 3 4 5

MILES

USGS

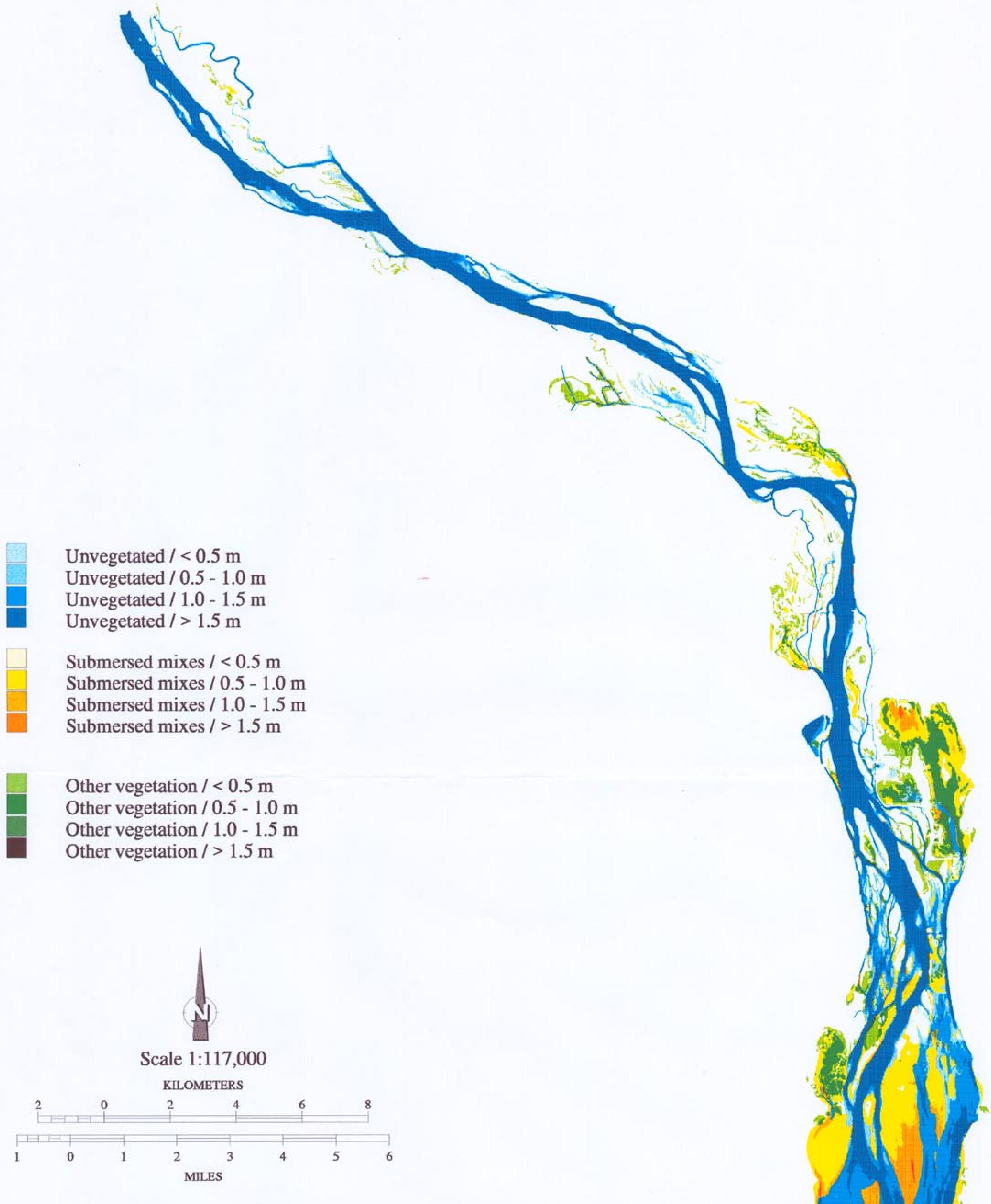
EMTC:
The Environmental Management Technical Center administers the Long Term Resource Monitoring Program for the Upper Mississippi River System, performing ecological monitoring and research on the river system.

Data Source:

The vegetation data were interpreted into 13 classes of land cover/land use from 1989 1:15,000-scale color infrared photographs. The 13 classes were generalized into 3 vegetation classes for the overlay with bathymetric data.

The bathymetric coverage was created using a variety of data sources. Most of the data was collected as digital point data using a single-track automated hydrographic survey system. Additional data were derived from shoreline data interpreted from 1989 1:15,000-scale air photos. Some shallow area contour data was manually interpolated from transect measurements collected with chart recording equipment. Point, shoreline, and contour data were then used to interpolate a continuous surface using a triangulated irregular network (TIN). The accuracy of the interpolated surface is dependant on the density of the data used to create the surface and the homogeneity of the bottom surface. Water depths relative to a water surface condition exceeded 90% of the time was used for the overlay with vegetation data.

POOL 13 VEGETATION / BATHYMETRY



Data Source:

The vegetation data were interpreted into 13 classes of land cover/land use from 1989 1:15,000-scale color infrared photographs. The 13 classes were generalized into 3 vegetation classes for the overlay with bathymetric data.

The bathymetric coverage was created using a variety of data sources. Most of the data was collected as digital point data using a single-track automated hydrographic survey system. Additional data were derived from shoreline data interpreted from 1989 1:15,000-scale air photos. Some shallow area contour data was manually interpolated from transect measurements collected with chart recording equipment. Point, shoreline, and contour data were then used to interpolate a continuous surface using a triangulated irregular network (TIN). The accuracy of the interpolated surface is dependant on the density of the data used to create the surface and the homogeneity of the bottom surface. Water depths relative to a water surface condition exceeded 90% of the time was used for the overlay with vegetation data.

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Appendix B
Plant Growth Model Parameters

Table B1
The Output Variable Listing for VALLA (for Wild Celery) and POTAM (for Sago Pondweed)

Abbreviation	Explanation	Dimension
DAVTMP	Daily average temperature	°C
DAYL	Day length	h
DDTMP	Daily average daytime temperature	°C
DTEFF	Daily effective temperature	°C
DTGA	Daily total gross CO_2 assimilation of the plant	$gCO_2.m^{-2}.d^{-1}$
DVS	Development phase of the plant	-
FGROS	Instantaneous CO_2 assimilation rate of the plant	$gCO_2.m^{-2}.h^{-1}$
GPHOT	Daily total gross CH_2O assimilation rate of the community	$gCH_2O.m^{-2}.d^{-1}$
IRS	Total irradiance just under the water surface	$J.m^{-2}.s^{-1}$
MAINT	Maintenance respiration rate of the plant	$gCH_2O.m^{-2}.d^{-1}$
NDTUB	Dormant tuber number	dormant tubers.m^{-2}
NNTUB	New tuber number	new tubers.m^{-2}
NTM	Tuber density measured (field site)	tubers.m^{-2}
NTUBD	Dead tuber number	dead tubers.m^{-2}
REMOB	Remobilization rate of carbohydrates	$gDW.m^{-2}.d^{-1}$
TEFF	Factor accounting for effect of temperature on maintenance respiration	-
TGW	Total live plant dry weight (excluding tubers)	$gDW.m^{-2}$
TGWM	Total live plant dry weight measured (field site)	$gDW.m^{-2}$
TRANS	Translocation rate of carbohydrates	$gCH_2O.m^{-2}.d^{-1}$
TREMOB	Total remobilization	$gDW.m^{-2}$
TW	Total live + dead plant dry weight (excluding tubers)	$gDW.m^{-2}$
TWGTUB	Total dry weight of germinating tubers	$gDW.m^{-2}$
WTMP	Daily water temperature	°C
TWLVG	Total dry weight of live leaves	$gDW.m^{-2}$
TWNTUB	Total dry weight of new tubers	$gDW.m^{-2}$
TWRTD	Total dry weight of dead roots	$gDW.m^{-2}$

(Continued)

Table B1 (Concluded)

Abbreviation	Explanation	Dimension
TWRTG	Total dry weight of live stems	$gDW.m^{-2}$
TWSTD	Total dry weight of dead stems	$gDW.m^{-2}$
TWSTG	Total dry weight of live stems	$gDW.m^{-2}$
TWTUB	Total dry weight of dormant tubers	$gDW.m^{-2}$
TWTUBD	Total dry weight of dead tubers	$gDW.m^{-2}$

Table B2
Relationship Between Development Phase (DVS) of Wild Celery, Day of Year, and 3 °C Day-degree Sum [Development Rate as a Function of Temperature (DVRVT) = 0.015; DVRRT = 0.040]

Developmental Phase Description	DVS Value	Day Number	3 °C Day-degree Sum
First Julian day number → tuber sprouting and initiation elongation	0 -> 0.291	0 -> 105	1 -> 270
Tuber sprouting and initial elongation → leaf expansion	0.292 -> 0.875	106 -> 180	271 ->1215
Leaf expansion → floral initiation and anthesis	0.876 - >1.000	181 - >191	1216 -> 1415
Floral initiation and anthesis--> induction of tuber formation, tuber formation and senescence	1.001 -> 2.000	192 -> 227	1416-> 2072
Tuber formation and senescence → senesced	2.001 -> 4.008	228 -> 365	2073 -> 3167
Senesced	4.008	365	3167

Note: Calibration was on field data from 1978 from Chenango Lake, NY (longitude 75 ° 50'W, latitude 42 ° 15'N; Titus and Stephens 1983) and climatological data were from 1978 from Binghamton (air temperatures) and Ithaca (irradiance), NY.

Table B3
Relationship Between Development Phase (DVS) of Sago Pondweed, Day of Year, and 3 °C Day-degree Sum (DVRVT = 0.015; DVRRT = 0.040)

Developmental Phase Description	DVS Value	Day Number	3 °C Day-degree Sum
First Julian day number → tuber sprouting and initiation elongation	0 -> 0.210	0 -> 77	1 -> 193
Tuber sprouting and initial elongation → leaf expansion	0.211 -> 0.929	78 -> 187	194 -> 1301
Leaf expansion → floral initiation and anthesis	0.930 - >1.000	188 - >195	1302 -> 1434
Floral initiation and anthesis--> induction of tuber formation, tuber formation and senescence	1.001 -> 2.000	196 -> 233	1435 -> 2077
Tuber formation and senescence → senesced	2.001 -> 4.033	234 -> 365	2078 -> 3193
Senesced	4.033	365	3193

Note: Calibration was on field data from 1987 from Zandvoort (longitude 5 ° 38'E, latitude 51 ° 54'N; Best 1987) and climatological data were from 1987 from De Bilt, The Netherlands.

Table B4
Parameter Values for VALLA (Values Listed Are Those Used for Calibration, and Ranges Are in Parentheses)

Parameter	Abbreviation	Value	Reference
Morphology, Development and Phenological Cycle			
First Julian day number	DAYEM	1	
Base temperature for juvenile plant growth	TBASE	3 °C	calibrated
Development rate as function of temperature	DVRVT* DVRRT	0.015 0.040	calibrated
Fraction of total dry matter increase allocated to leaves	FLVT	0.718	1, 2
Fraction of total dry matter increase allocated to stems	FSTT	0.159	1, 2
Fraction of total dry matter increase allocated to roots	FRTT	0.123	1, 2
Plant density	NPL	30. m^{-2}	1
Wintering and Sprouting of the Tubers			
Dormant tuber density	NDTUB	233. m^{-2}	3 (4)
Initial dry weight of a tuber	INTUB	0.090 g DW. $tuber^{-1}$ (0.002 - 0.120)	3, 4
Relative death rate of tubers (on number basis)	RDTU	0.018 d^{-1} (0.015 - 0.021)	5
Growth of the Sprouts to the Water Surface			
Relation coefficient tuber weight-stem length	RCSHST	12 m. g DW^{-1}	6, 7
Relative conversion rate of tuber into plant material	ROC	0.0576 g CH_2O. g DW^{-1} d^{-1}	6
Critical shoot weight per depth layer	CRIFAC	0.0091 g DW. 0.1 m plant $layer^{-1}$ (0.0091 - 0.041)	3, 4
Survival period for sprouts with negative net photosynthesis	SURPER	23 d	8,9

(Continued)

Table B4 (Continued)			
Parameter	**Abbreviation**	**Value**	**Reference**
Light, Photosynthesis, Maintenance, Growth and Assimilate Partitioning			
Potential CO_2 assimilation rate at light saturation for shoot tips	AMX	0.0165 g CO_2. g DW^{-1} h^{-1}	10
Conversion factor for translocated dry matter into CH_2O	CVT	1.05	11
Water depth	DEPTH	1 m	user def.
Initial light use efficiency for shoot tips	EE	0.000011 g CO_2 J^{-1}	11
Reduction factor to relate AMX to water pH	REDAM	1	
Thickness per plant layer	TL	0.1 m	12
Daytime temperature effect on AMX as function of DVS	AMTMPT*	0 -1	10
Reflection coefficient of irradiance at water surface	RC	0.06	13
Plant species specific light extinction coefficient	K	0.0235 m^2 g DW^{-1}	10
Water type specific light extinction coefficient	L	0.43 - 0.80 m^{-1}	1
Reduction factor for AMX to account for senescence plant parts over vertical vegetation axis	REDF	1.0	user def.
Dry matter allocation to each plant layer	DMPC*	0-1	10
Daily water temperature (field site)	WTMPT	-, °C	user def.
Lag period chosen to relate water temp. to air temp., in case water temp. has not been measured	DELAY	1 d	user def.
Total live dry weight measured (field site)	TGWMT	-, g DM m^{-2}	user def.

(Continued)

Table B4 (Concluded)			
Parameter	**Abbreviation**	**Value**	**Reference**
Induction and Formation of Tubers			
Translocation (part of net photosynthetic rate)	RTR	0.247	5
Critical tuber weight	TWCTUB	14.85 g DW m^{-2}	1, 3, 5
Tuber number concurrently initiated per plant	NINTUB	5.5 $plant^{-1}$ (0.002 - 15)	4, 1
Tuber density measured (field site)	NTMT	55-233 .m^{-2}	4
Senescence			
Relative death rate of leaves (on DW basis; Q10 =2)	RDRT	0.021 d^{-1}	1
Relative death rate of stems and roots (on DW basis; Q10=2)	RDST	0.021 d^{-1}	1
Harvesting			
Harvesting	HAR	0 (0 or 1)	user def.
Harvesting day number	HARDAY	304 (1 - 365)	user def.
Harvesting depth (measured from water surface; 1-5 m)	HARDEP	0.1m<DEPTH	user def.

1. Titus & Stephens 1983; 2. Haller 1974; 3. Korschgen & Green 1988; 4. Korschgen et al. 1997; 5. Donnermeyer & Smart 1985; 6. Bowes et al. 1977; 7. Van der Zweerde 1981; 8. Titus & Adams 1979b; 9. Best 1987; 10. Titus & Adams 1979a; 11. Penning de Vries & Van Laar 1982a, 1982b; 12. Titus et al. 1975; 13. Golterman 1975.
* Calibration function.

Table B5
Parameter Values for POTAM (Values Listed Are Those Used for Calibration, and Ranges Are in Parentheses)

Parameter	Abbreviation	Value	Reference
Morphology, Development and Phenological Cycle			
First Julian day number	DAYEM	1	
Base temperature for juvenile plant growth	TBASE	3 °C	calibrated
Development rate as function of temperature	DVRVT* DVRRT	0.015 0.040	calibrated
Fraction of total dry matter increase allocated to leaves	FLVT	0.731	1
Fraction of total dry matter increase allocated to stems	FSTT	0.183	1
Fraction of total dry matter increase allocated to roots	FRTT	0.086	1
Plant Density			
Plant density	NPL	30. m^{-2}	2
Wintering and Sprouting of the Tubers			
Dormant tuber density	NDTUB	240. m^{-2}	1, 2
Initial dry weight of a tuber	INTUB	0.083 g DW. $tuber^{-1}$ (0.022 - 0.155)	1 (3, 4)
Relative death rate of tubers (on number basis)	RDTU	0.026 d^{-1}	3
Growth of the Sprouts to the Water Surface			
Relation coefficient tuber weight-stem length	RCSHST	12 m. g DW^{-1}	5, 6
Relative conversion rate of tuber into plant material	ROC	0.0576 g CH_2O. g DW^{-1} d^{-1}	5
Critical shoot weight per depth layer	CRIFAC	0.0076 g DW. 0.1 m plant $layer^{-1}$	1, 5
Survival period for sprouts with negative net photosynthesis	SURPER	27 d	1

(Continued)

Table B5 (Continued)			
Parameter	**Abbreviation**	**Value**	**Reference**
Light, Photosynthesis, Maintenance, Growth and Assimilate Partitioning			
Potential CO_2 assimilation rate at light saturation for shoot tips	AMX	0.019 g CO_2. g DW^{-1} h^{-1}	7
Conversion factor for translocated dry matter into CH_2O	CVT	1.05	8
Water depth	DEPTH	1.3 m	user def.
Initial light use efficiency for shoot tips	EE	0.000011 g CO_2 J^{-1}	8
Reduction factor to relate AMX to water pH	REDAM	1	1
Thickness per plant layer	TL	0.1 m	9
Daytime temperature effect on AMX as function of DVS	AMTMPT*	0-1	1
Reflection coefficient irradiance at water surface	RC	0.06	10
Plant species specific light extinction coefficient	K	$0.095m^2$ g DW^{-1}	1
Water type specific light extinction coefficient	L	1.09 m^{-1}	1
Reduction factor for AMX to account for senescence plant parts over vertical vegetation axis	REDFT	1.0	user def.
Dry matter allocation to each plant layer	DMPC*	0 -1	1
Daily water temperature (field site)	WTMPT	-, ^oC	user def.
Total live dry weight measured (field site)	TGWMT	-, g DM m^{-2}	user def.
Induction and Formation of Tubers			
Translocation (part of net photosynthetic rate)	RTR	0.19	1, 11
Critical tuber weight	TWCTUB	7.92 g DW m^{-2}	1,2,3,4,5
Tuber number concurrently initiated per plant	NINTUB	8 $plant^{-1}$ (7-12)	1 (4, 5)
			(Continued)

Table B5 (Concluded)

Parameter	Abbreviation	Value	Reference
Induction and Formation of Tubers			
Tuber density measured (field site)	NTMT	400 -440 .m^{-2}	3
Senescence			
Relative death rate of leaves (on DW basis; Q10 =2)	RDRT	0.047 d^{-1}	1
Relative death rate of stems and roots (on DW basis; Q10 =2)	RDST	0.047 d^{-1}	1
Harvesting			
Harvesting	HAR	0 (0 or 1)	user def.
Harvesting day number	HARDAY	304 (1 - 365)	user def.
Harvesting depth (measured from water surface; 1-5 m)	HARDEP	0.1m<DEPTH	user def.

1. Best 1987; 2. Sher Kaul et al. 1995; 3. Van Wijk 1989; 4. Spencer & Anderson 1987; 5. Bowes et al. 1977; 6. Van der Zweerde 1981; 7. Van der Bijl et al. 1989; 8. Penning de Vries & Van Laar 1982a, 1982b; 9. Titus et al. 1975; 10. Golterman 1975;11. Wetzel & Neckles 1986.
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13. ABSTRACT *(Maximum 200 words)*

This study presents an initial assessment of the potential ecological risks by commercial navigation traffic on submerged aquatic plants that grow in the main channel and the channel borders of the Upper Mississippi River-Illinois Waterway (UMR-IWW) System. The assessment addresses the possibility of plant breakage resulting from increases in current velocity or the momentum imparted by wake waves associated with the passing of commercial vessels. This part of the assessment is based on results of an experimental study on plants to various currents in flumes. The assessment also examines the possibility that commercial-vessel-induced increases in suspended sediments might diminish available underwater light enough to impair photosynthesis, growth, and vegetative reproduction of submerged aquatic plants. This part of the assessment is based on results of simulation models on growth of submerged aquatic plants. The species selected to represent contrasting characteristic life forms of the submerged aquatic vegetation in the UMR-IWW are American wild celery, a noncanopy former, and sago pondweed, a canopy former.

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The risk assessment methodology described in this report is being developed to assess the potential ecological impacts associated with the anticipated growth of commercial traffic navigating the UMR-IWW System for the period 2000-2050. In the absence of actual traffic projections, the present assessments evaluate risks posed by hypothetical 25, 50, 75, and 100% increases in traffic intensity compared to traffic intensity determined from the 1992 lockage records.

The assessment indicates that impacts of direct physical forces on aquatic vegetation up to a rooting depth of 1.5 m can be expected in less that 1.5% of the possible combinations of vessel type, location in relation to sailing line, and pool stage height. More than 95% of the impacts most likely stem from secondary wave heights exceeding the 0.2-m criterion. The assessment also indicates that across the scenarios the decreases in wild celery peak biomass are expected to be highest in UMR-Pool 13 (up to 12%) and lower in the Pools 4 and 8 (1-4%). The expected impacts on the average tuber (vegetative propagule) biomass are low, i.e. a decrease of maximally 3%. Expected impacts on sago pondweed peak biomass and tubers are less than on wild celery.

The current, initial ecological risk assessment methodology will be incorporated into a framework that characterizes risk in probabilistic terms in a following phase.

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