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Dispersal of Native and Nonnative Aquatic Plant Species in the San Marcos River, Texas

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ABSTRACT

The San Marcos River is a spring-fed system which originates from the Edwards Aquifer, south of Austin, Texas. Due to excellent water clarity, and consistent temperatures and flows, a diverse community of native and nonnative aquatic plants have developed, including *Hydrilla verticillata*. Samples were collected quarterly of floating plant fragments to determine biomass loadings, fragment counts and establishment of propagules. The biomass loadings and establishment will be discussed in this paper. Hydrilla fragment biomass loadings were significantly greater in March for site 1 (downstream of Spring Lake) due to the presence of a harvester on Spring Lake, which are the headwaters of the San Marcos River. Additionally, there was a significant increase in plant fragment biomass at site 3 which is located directly below several high recreational use areas on the San Marcos River for the September and June sampling periods. Hydrilla fragments collected from the river, transported to the LAERF and planted, were able to establish between 70 and 83% of all plants.

Key words: Hydrilla verticillata, hydrilla, East Indian hygrophila, *Hygrophila polysperma* propagule, fragments.

INTRODUCTION

The San Marcos River emerges from numerous springs originating from the Edwards Aquifer. The Edwards Aquifer extends over a major part of five Texas counties, Bexar, Com-

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al, Hays, Medina and Ulvalde. The San Marcos River (Hays Co.) begins at Spring Lake (4.05 ha) and culminates into the Guadalupe River, flowing approximately 112 km. Water clarity is excellent in Spring Lake, and the headwaters of the San Marcos River, and water temperatures and flows are generally consistent (Abbott and Woodruff 1986, Brune 1981). These environmental factors have resulted in a diverse and productive native aquatic plant community, including the endangered aquatic plant species Texas wild rice (*Zizania texana* Hitch.). Prior to the 1930s, four dams were constructed on the San Marcos River (Bradsby 1994) which reduced scouring effects due to flood events and altered the flows, thereby providing deeper areas for introduced submersed aquatic plant species to establish (Jenkins et al. 1986). Therefore, in addition to the desirable native plants, several introduced nonnatives have become established within Spring Lake and the San Marcos River, including East Indian hygrophila (*Hygrophila polysperma* Nees. T. Anderson), Eurasian watermilfoil (*Myriophyllum spicatum* L.), hydrilla (*Hydrilla verticillata* (L.f.) Royle), water hyacinth (*Eichhornia crassipes* (Mart.) Solms), water lettuce (*Pistia stratiotes* L.) and the emergent elephant-ear (*Colocasia esculenta* (L.) Schott). Stanton (1992) noted a general increase in introduced, nonnative aquatic plants with subsequent decrease in native populations. These introduced nonnative plant species have dispersed down the river, especially hydrilla and East Indian hygrophila, displacing native vegetation.

Hydrilla, a native of Southeast Asia and Australia, exhibits aggressive growth strategies, rapidly expanding to the surface and forming a dense canopy. Spring Lake are the headwaters for the San Marcos River with current estimates affirm hydrilla distribution to range from 71% to 86% of total lake populations (R. D. Doyle, pers. comm. 2000). Currently, a harvester is employed on Spring Lake to manage the hydrilla but other factors can also contribute to hydrilla fragmentation and dispersal down the river. Bradsby (1994) determined recreational activities on the San Marcos River to be related to season, location and time of day. Typical recreational activities are tubing, swimming, boating, and fishing. Recreation is related to season, with high use occurring during the summer months, especially holidays and weekends, and increased daily activities occurring in the afternoons. Breslin (1997) found that recreation negatively impacted the Texas wild rice, causing considerable visible damage. Although not mentioned in these papers, it can be assumed that recreational activities can also impact hydrilla, in addition to other aquatic plants, especially nonnatives, thereby releasing fragments. Recreation has also been noted as a major contributor to the decrease in native aquatic plant species and an increase in introduced plant numbers (Stanton 1992). Mumma et al. (1996) note's recreation could expedite the spread of nonnative plant species throughout a river. Aquatic plant communities can be impacted from recreational use, due to tearing or uprooting of aquatic plants with boat propellers, feet or paddles, allowing the more aggressive nonnative plants the opportunity to survive and spread (Kuss and Graefe 1985, Liddle and Scorgie 1980, Mumma et al. 1996). Nearly 80% of all native aquatic plants along the shorelines of the San Marcos River have been replaced by introduced nonnative plant species since the 1930s. These native plant declines can be attributed to harvesting by the commercial aquarium plant suppliers, aggressive competition with the nonnative introduced species and habitat destruction due to erosion, dredging and pollution (Young et al. 1973, Bradsby 1994).

The goal of this study was to determine the seasonality, amount and type of aquatic plant propagules being dispersed down the San Marcos River, in addition to viability of hydrilla fragments collected and planted at the Lewisville Aquatic Ecosystem Research Facility (LAERF).

METHODS

This study was conducted on the San Marcos River, San Marcos, Hays County, TX. This river is located approximately 48,280 m (30 miles) south of Austin, TX. Five sites were sampled five times each at five minute intervals. Sites were sampled on a quarterly schedule (March, June, September, December) reflecting seasonal trends (spring, summer, fall, winter) for three consecutive days resulting in a total of 15 replicates per site per sampling period. Site 2 was not sampled during September and December due to posted high bacterial counts in the river. The five sites were located down the river with site 1 located below the Spring Lake dam (Sewell Park); site 2 was 529 m (Hopkins foot bridge); site 3 was 1353 m (Cheatam Bridge); site 4 was 1796 m (I 35 Bridge); and site 5 was 2352 m (Capes Dam). Current velocities were measured daily at each site using a Montedoro-Whitney, Inc., flow meter (San Luis Obispo, CA) at 60% maximum depth (Chow 1959). The mesh sampling net was 6.1 m long by 1.22 m tall. Most sites ranged from 20 to 30 m across. Samples were collected by wading into the river, and holding the mesh sampling net into the flow for the specified timed interval. After completion of each timed event, the sample was removed from the mesh net and stored in labeled plastic bags until the sample was sorted to species, and dried. All samples were dried at 55C using a Blue-M forced air oven (General Signal, Atlanta, GA) for a minimum of 48 hours before weighing. Loading rates were calculated by multiplying the size of the net, the interval of time, the velocity of the specific site and the biomass to obtain plant propagule loading rate in g DW m^{-3}. The total biomass weight of sorted plants were averaged for all samples over the three-day sampling period. Average biomass was obtained for each plant species with comparisons being made between sites and season using a one way-ANOVA at $p < 0.05$. The Tukey's test was employed as a comparison of the means to distinguish significance.

During the June sampling period, samples were collected during the AM and PM time periods to determine daily fluctuations in plant fragments due to recreational usage of the river. In addition, 60 plant fragments of hydrilla were collected in March and June, transported to the Lewisville Aquatic Ecosystem Research Facility (LAERF) in Lewisville, TX to determine establishment. Thirty fragments were measured for total length, then planted into 0.946 liter containers of LAERF pond sediment and placed into 1845 liter fiberglass mesocosm tanks containing Lake Lewisville water. The plants were allowed a month to establish, then were harvested and processed into aboveground and belowground biomass and dried. Establishment was determined by production of roots.

TABLE 1. SPECIES LIST OF AQUATIC PLANT FRAGMENTS CAPTURED DURING THE ALL SAMPLING PERIODS ON THE SAN MARCOS RIVER, SAN MARCOS, TX. (N) REPRESENTS NATIVE PLANTS AND (E) DEPICTS EXOTIC PLANTS.

Scientific name	Common name	Exotic or Native
Cabomba caroliniana A. Gray	fanwort	N
Ceratopteris thalictroides (L.) Brongn.	water sprite	E
Ceratophyllum demersum L.	coontail	N
Colocasia esculenta (L.) Schott	Elephant ear, wild taro	E
Heteranthera dubia (Jacq.) Small	water stargrass	N
Hydrocotyle sp.	pennywort	N
Hydrilla verticillata (L.f.) Royle	hydrilla	E
Hygrophila polysperma (Nees. T. Anderson)	East Indian hygrophila	E
Ludwigia repens Forst.	water primrose	N
Myriophyllum spicatum L.	Eurasian watermilfoil	E
Nuphar sp.	yellow cow-lily	N
Pistia stratiotes L.	water lettuce	E
Potamogeton illinoensis Morong.	Illinois pondweed	N
Sagittaria platyphylla (Engelm.) J. G. Smith	grassy arrowhead	N
Vallisneria americana Michx.	water celery	N
Zizania texana Hitchc.	Texas wild rice	N

The additional 30 fragments were placed into another 1845 liter fiberglass mesocosm tanks containing Lake Lewisville water and allowed to free-float for thirty days, then planted into 0.946 liter containers of LAERF pond sediment and placed into the 1845 liter fiberglass tank. These plants were also allowed to establish for thirty days, harvested and processed into aboveground and belowground material, and dried.

RESULTS AND DISCUSSION

Sixteen aquatic plant species, both nonnative and native were collected during the four sampling periods on the San Marcos River. Of these species, six were introduced plant species, with hydrilla comprising the greatest amount of biomass (Tables 1 and 2) for all sampling periods. Hydrilla was found in all samples, except one, for all the sampling periods. Hydrilla comprised the greatest percentage fragment biomass captured, ranging from 34% in December to 64% collected in September. The next greatest percentage collected was another nonnative aquatic plant, East Indian hygrophila ranging from 5.5% in September to 26.19% in December (Table 2). Although a variety of native plant propagules were also collected in the net, the biomass was generally lower and many of the fragments were not viable, consisting of just leaf material, especially for pennywort, grassy arrowhead, water celery and Texas wild rice.

Significant differences for nonnative (Figure 1A) and hydrilla (Figure 1B) were obtained for site 3 (1353 m) for the months of September and June as compared to the other sites. Site 3 is located directly below several high-use recreational areas (Lions Club and Sewell Park) on the San Marcos River which include such activities as tubing, swimming, boating and fishing. Additionally, hydrilla and many other aquatic plant species have topped out canopies, which could easily be impacted and fragmented by swimmers, boaters and recreational tubers. During the March and June sampling

TABLE 2. SPECIES LIST OF AQUATIC PLANT FRAGMENTS CAPTURED DURING THE FIVE SAMPLING PERIODS ON THE SAN MARCOS RIVER, SAN MARCOS, TX. NUMBERS INDICATE PERCENTAGE OF TOTAL PLANT BIOMASS LOADING AND (*) INDICATES ABSENCE FROM SAMPLE.

Scientific name	March 2000	June 2000	Sept. 2000	Dec. 2000
Cabomba caroliniana A. Gray	0.21%	1.32%	9.45%	19.31%
Ceratopteris thalictroides (L.) Brongn.	0.03%	0.2%	*	*
Ceratophyllum demersum L.	9.96%	5.10%	3.84%	11.70%
Colocasia esculenta (L.) Schott	0.03%	3.80%	2.24%	7.02%
Heteranthera dubia (Jacq.) Small	0.03%	<0.01%	*	*
Hydrocotyle sp.	0.15%	0.03%	0.01%	*
Hydrilla verticillata (L.f.) Royle	57%	53%	64%	34%
Hygrophila polysperma (Nees. T. Anderson)	18%	17.50%	15.5%	26.19%
Ludwigia repens Forst.	0.08%	0.11%	0.03%	*
Myriophyllum spicatum L.	0.05%	0.08%	0.03%	0.01%
Nuphar sp.	0.43%	*	*	*
Pistia stratiotes L.	0.09%	0.01%	0.05%	*
Potamogeton illinoensis Morong.	10%	8.10%	3.28%	1.04%
Sagittaria platyphylla (Engelm.) J. G. Smith	2.40%	8.50%	1.05%	0.32%
Vallisneria americana Michx.	0.69%	0.40%	0.63%	0.49%
Zizania texana Hitchc.	0.64%	0.060%	0.01%	*

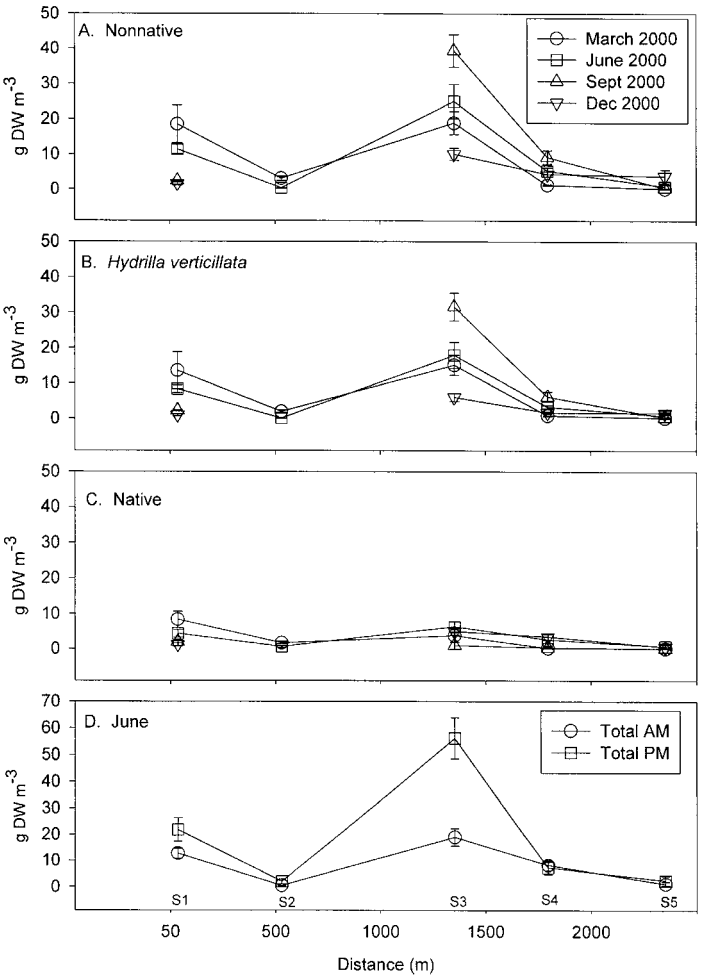

Figure 1. (A) Nonnative plant biomass loading (g DW m^{-3}) for four sampling periods on the San Marcos River, TX: (B) *Hydrilla verticillata* plant biomass loading (g DW m^{-3}) for four sampling periods on the San Marcos River, TX: (C) Native plant biomass loading (g DW m^{-3}) for four sampling periods on the San Marcos River, TX: and (D) Comparison between afternoon and morning total biomass loading (g DW m^{-3}) for the June 2000 sampling period. S # indicates site.

periods, site 1 which is located directly below the Spring Lake outfall, received significant amounts of fragment biomass as compared to the other sampling times. Site 1 is located directly below the outfall of Spring Lake which is randomly harvested as needed to control topped out hydrilla in the lake. The harvester was observed to be working during the March sampling period although it should be noted that most harvested plant material is collected by the harvester and deposited on the shore. Hydrilla and East Indian hygrophila were generally the only plant fragment biomass collected at site 5 (2352 m), except during the December 2000 sampling period which occurred after a minor flood event. Significantly reduced amounts of biomass reached site 5 indicating most fragments were dropping out before reaching this site probably becoming entangled on other plants, tree roots or debris, slowing the fragment progress down the river.

During the June sampling period, samples were collected during the AM and PM time periods to determine daily fluctuations in plant fragments due to recreational usage of the river (Figure 1D). Again, a significant increase in total propagule biomass were collected at site 3 during the afternoon time frame as compared to the morning hours, especially for the nonnative plant species hydrilla and East Indian hygrophila. Bradsby (1994) found afternoon recreational activities to increase in the river, and likewise Breslin (1997) found the most damage to Texas wild rice occurred between 2-3 PM.

Texas wild rice is only found in the upper 2.5 km of the San Marcos River (Breslin 1997) in addition to a small patch located near the outfall of Spring Lake. Fragments from other plant species, especially hydrilla can provide a potential threat to Texas wild rice due to floating mats of vegetation which interfere with reproductive structures, create shading of plants and slow flows (Power 1996, Beaty 1975). It was observed that hydrilla, East Indian hygrophila, and other aquatic plants would become entangled on beds of rooted aquatic plants, branches or roots of trees, rocks, shallow areas, and in some cases, forming huge floating mats that were detrimental to the established vegetation (Power 1996, Beaty 1975). As these fragments became stationary, eventually some became established, producing new colonies of vegetation. The establishment portion of this study found between 70% (June) and 83% (March) of all hydrilla fragments planted at the LAERF became established after one month growth. The average length for the hydrilla fragments at collecting and planting was 29 cm (June) and 39.9 cm (March). Establishment was determined by production of new roots, with the average weight of 0.42 g aboveground and 0.17 g belowground plant biomass (g DW pot^{-1}). Although the establishment portion of this study does not completely reflect the establishment of fragments found in the San Marcos River, it does provide information on % viability of hydrilla fragments from the San Marcos River. It should be noted that due to excellent water clarity and consistent temperature on the San Marcos River, hydrilla fragments are not exposed to high turbidity levels or temperature fluctuations found on many other aquatic systems therefore increasing fragment survival.

Aquatic plant fragments, especially hydrilla and East Indian hygrophila, are being created and released daily down the San Marcos River due to recreational usage, harvesting and environmental factors. Although this study gives a snapshot of the amount of plant material that is free-floating down the river, it provides information on propagule loading rates, types of propagules and effects of harvesting and recreational use on aquatic plant populations in the San Marcos River.

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