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Effects of Recreation on the Submersed Aquatic Plant Community of Rainbow River, Florida

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ABSTRACT

Concurrent sampling of drifting plants and upstream recreational use on Rainbow River, a large spring-fed river in central Florida, showed the biomass of drifting (damaged) plants to be significantly correlated (r = 0.65 to 0.68) to upstream recreational activity. Intercorrelation among recreational user groups (boats, tubers, canoes) makes it impossible to attribute plant damage to a single type of recreational activity. Recreation was estimated to remove 0.000015 to 0.000034 percent of upstream plant biomass during each hour of peak recreational activity. In addition, quadrat sampling indicated that areas which received higher amounts of recreational use did not have significantly lower plant coverage or leaf densities. In Rainbow River, differences in submersed aquatic plant abundance are the result of factors other than recreational use.

Key words: Florida springs, plant damage, sagittaria, vallisneria, hydrilla.

INTRODUCTION

Many rivers formed by the large springs of central Florida (e.g. Silver Springs, Weeki Wachi Springs, Crystal Springs) have abundant submersed aquatic vegetation due to extremely high water clarity (Grice and Yentsch 1956, Rosenau et al. 1977, Duarte and Canfield 1990a), high nutrient concentrations (Rosenau et al. 1977, Duarte and Canfield 1990b, Mumma 1996), and stable water temperature and flow (Ferguson et al. 1947, Odum 1957a). One of the largest of these springs, Rainbow Springs (29°06'08" N., 82°26'16" W), has an average discharge of 20.1 cubic meters per second (USGS 1994) and forms Rainbow River, the third largest spring-river in Florida and the eighth largest reported in the world (Rosenau et al. 1977). Rainbow River is a valuable aesthetic, recreational, and economic resource to the local area and the entire state, attracting over 30,000 visitors each year (Pridgen et al. 1993, Holland and Cichra 1994). The primary recreational activities occurring on the river are motorboating, canoeing, and tubing, during which people float downstream on tire innertubes. During these recreational activities, people might tear or uproot submersed aquatic plants with their boat propellers (motorboats), feet (tubers), or paddles (canoes).

Since the mid-1980s, there has been increasing concern among riverfront property owners and the Florida Parks Service that recreation might be damaging the biological community of Rainbow River (Albert Gregory, Florida Department of Environmental Protection, Division of Recreation and Parks, pers. comm.). Recreation might also aid the spread of the exotic plant species hydrilla (*Hydrilla verticillata* (L.f.) Royle) throughout the river. The objectives of this study were to determine whether there is a relationship between recreational activity and damage (cutting and uprooting) of submersed aquatic plants, and if recreation causes changes in submersed plant areal coverage or leaf density.

MATERIALS AND METHODS

Sampling of damaged (uprooted or cut) aquatic plants samples was conducted below a high recreational use area (KP Hole County Park) while concurrently counting the

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number and type of upstream recreational users. A sample consisted of collecting all drifting vegetation collected in a 2-m wide by 1-m deep PVC framed net over a 60-minute period. The number of tubers, canoes, and boats upstream from the sampling point was continuously recorded in 15-minute intervals. Sampling was conducted during eight different sampling days during 1994, including a diurnal (24-hour) sample during Labor Day weekend. An attempt was made to sample on days of low, moderate, and high amounts of recreational activity. Sampling typically began at 8:00 a.m. Nets were set every two hours for a minimum of three sampling periods per day. The river was approximately 60 m wide and 1.5 m deep at this sampling site. The bottom of the net extended approximately 0.75 m below the surface of the water. Three nets were simultaneously employed along the width of the river. Thus approximately 10 percent of the stream width, 50 percent of the depth, and therefore five percent of the total cross-sectional area of the river was sampled.

Vegetation collected in each net was removed, identified and sorted to species. Sagittaria (*Sagittaria kurziana* Glueck) and Vallisneria (*Vallisneria americana* L.) were further sorted according to the type of damage (cut and torn versus uprooted) which had occurred. Each sorted vegetation group was then weighed (wet weight). The total weight of damaged plant material collected in each net at the lowest recreational activity level of the day (typically between 8:00 and 9:00 a.m.) was subtracted from total plant weights collected from the corresponding net later in the day. By doing this, the change in the amount of damaged plants can be pooled from all sampling days. This method takes into account any possible day to day variation in ambient drifting plant abundance.

In addition to sampling damaged plants during various levels of recreational activity, a non-destructive sampling method was developed in order to determine whether recreational activity causes changes in submersed plant areal coverage and leaf density. Five plant beds in three different areas of the river were sampled during the spring (June 13 - June 29), summer (August 20 - October 4) and fall (December 6 - December 9) of 1994 and spring (April 18 - May 8) of 1995. The same plant beds were sampled throughout the study. The three areas were selected to include one area of low (headsprings), moderate (below State Park boundary), and high (below KP Hole County Park) recreational use. Only plant beds of predominantly sagittaria were sampled in order to achieve consistency among the sampled areas.

Each plant bed was sampled by identifying, counting and measuring individual plants within each of five randomly placed 0.25-m × 0.25-m PVC frame quadrats. All plants were identified to species. The percent areal coverage of all plant species within each quadrat was visually estimated by a single underwater observer. In addition, the number of individual leaves within each quadrat was counted for each species. Water depth at each quadrat location was also recorded.

Changes in mean total drifting (damaged) plant weight were correlated (Pearson correlation) with the total number of recreational users and the number of each type of recreational user (tubers, boats, and canoes) observed upstream while the nets were collecting plants, using combined data from all days and times. Mean plant areal coverage and mean leaf density were compared using 1-way analysis of variance among areas within each season to determine if aquatic plants responded to differences in the degree of recreational use. Statistical analyses were conducted using Statistical Analysis Software (SAS 1987). Unless otherwise stated, statements of statistical significance imply $P \leq 0.05$.

RESULTS AND DISCUSSION

Underwater observation of drifting plants confirmed that nearly all of the damaged plants floated at or near the water surface and all of these drifting plants were collected by the nets. Sagittaria comprised 89 percent by weight of all plants collected. Vallisneria and hydrilla were the next most abundant, each comprising 4 percent of the total weight. The composition of plant taxa collected with the nets was similar to the composition of plants found upstream of the sampling site (Figure 1), indicating that recreational activity is not selectively damaging any particular submersed plant species. Sagittaria was damaged about equally by cutting/tearing (53%) and uprooting (47%), while more of the vallisneria was damaged by tearing and cutting (95%) than by uprooting (5%).

Sampling days were separated into three low (maximum use of less than 10 users in any one 15-minute period), one medium (maximum use of between 10 and 25 users in any one 15-minute period) and three high (maximum use of 25 or more users in any one 15-minute period) recreational use days. During periods of low (August 25, 30, and December 1, 1994) and medium-use (August 11, 1994), the biomass of drifting plants did not significantly change throughout the day as recreational use on the river increased. This was true for all sampling days; representative low and medium-use days are shown in Figures 2 and 3. However, during all high-use days (July 2, 4 and September 4 and 5, 1994), the biomass of damaged plants significantly increased throughout

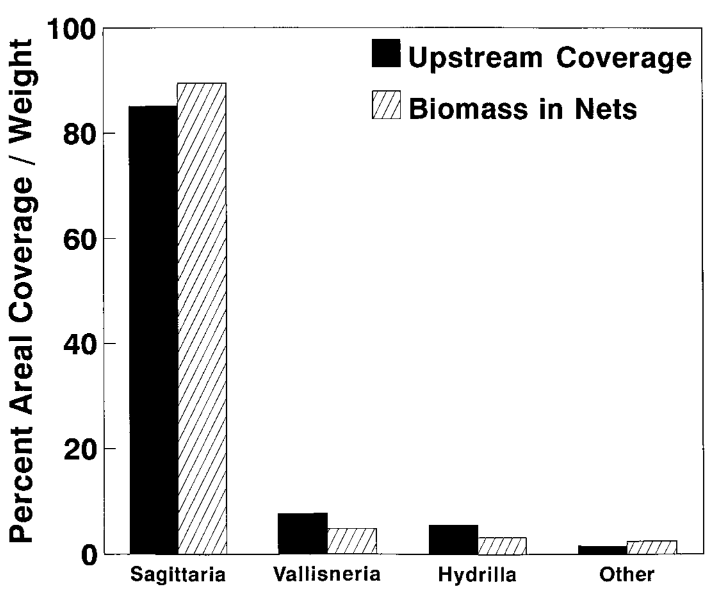

Figure 1. Percent composition by weight of submersed aquatic plants collected in nets (n = 34) and percent areal coverage of submersed aquatic plants (n = 21) upstream of the net sampling sites based on Mumma (1996).

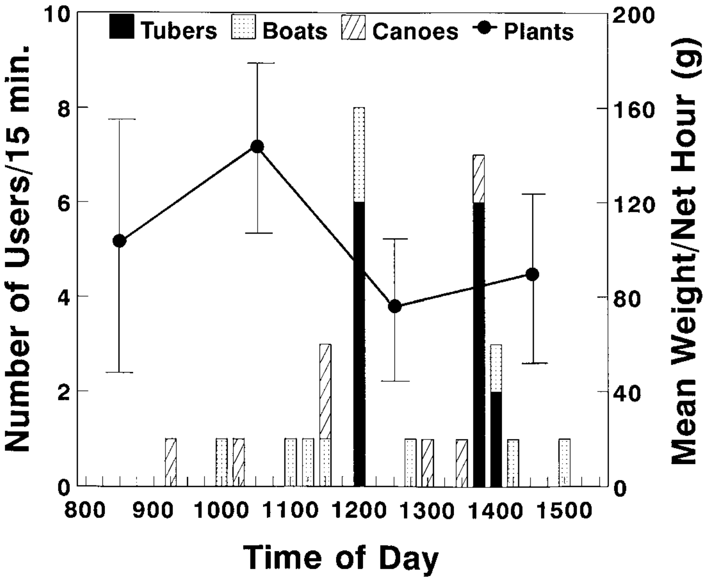

Figure 2. Relationship between wet weight of downstream drifting plants per net (3 nets) per hour and upstream recreational activity on a representative low-use day, August 25, 1994 on Rainbow River, Florida. Error bars represent one standard error.

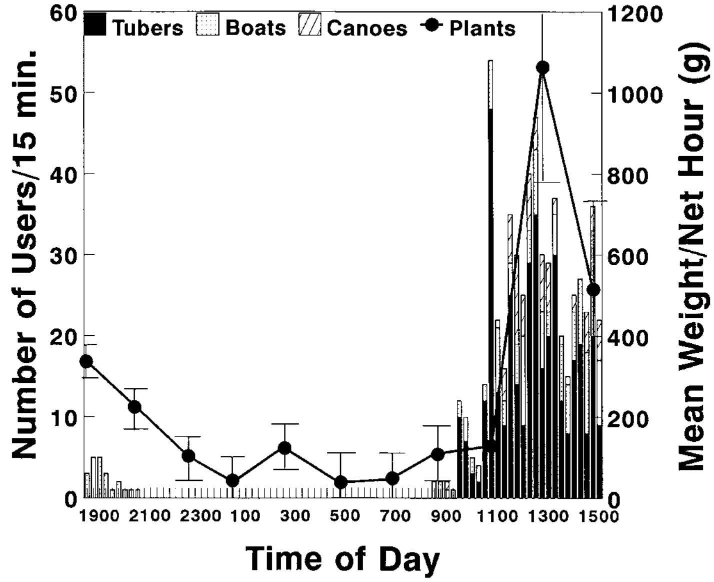

Figure 4. Relationship between wet weight of downstream drifting plants per net (3 nets) per hour and upstream recreational activity during a representative high-use period, September 4-5, 1994 on Rainbow River, Florida. Error bars represent one standard error.

each sampling day as user activity increased (representative day shown in Figure 4). Also, the mean wet weight of damaged plants reached much higher levels, up to 1100 grams/net-hour on high-use days. The biomass of damaged plants peaked between 12:30 and 2:00 p.m., the time of highest recreational use, and then decreased (as recreational activity decreased), eventually returning to background levels (those observed during nighttime and early morning samples). Mean water velocity of the Rainbow River was 1 km/hr (Mumma 1996). At this rate, drifting plants damaged by upstream users would be captured in minutes by the nets. Drifting plants, damaged by users during the previous day, would exit the river within hours. Odum (1957b) monitored the abundance of downstream drifting plants in Silver Springs, Florida, and also found little difference in the abundance of drifting plants between early morning and late evening samples. In addition, no diurnal pulse in damaged plant abundance (due to recreation) was evident. This seems to be the case in Rainbow River, also, except when a large number of recreational users occur in a short period of time.

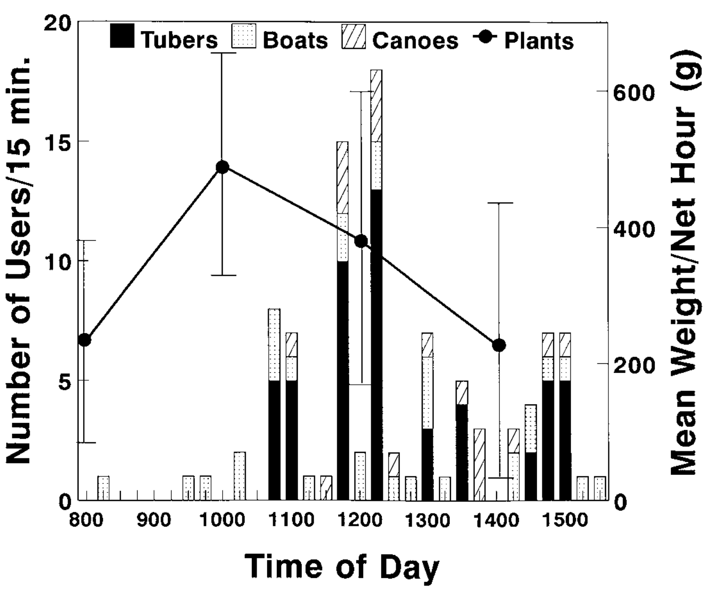

Figure 3. Relationship between wet weight of downstream drifting plants per net (3 nets) per hour and upstream recreational activity on a representative medium-use day, August 11, 1994 on Rainbow River, Florida. Error bars represent one standard error.

The biomass of damaged plants was significantly and positively correlated to the number of power boats (r = 0.68), canoes (r = 0.65), tubers (r = 0.68), and total number or recreational users (r = 0.53) observed on Rainbow River upstream from the nets. However, analysis of recreational user data reveals a high degree of correlation among the three principal user groups (boats to tubers, r = 0.95; boats to canoes, r = 0.99; tubers to canoes, r = 0.99). Intercorrelation among recreational user groups make it impossible to attribute plant damage to a single type of recreational activity.

The 2.8-km length of the river upstream of the net sampling site (KP Hole County Park) had a mean plant coverage of approximately 70 percent and a mean stream width of 50.7 m (Mumma 1996). Submersed plant biomass in this area ranged from 8.9 to 20.6 kg/m^2 (Duarte and Canfield 1990b). Thus, the total upstream submersed plant biomass ranged from 880,000 kg to 2,000,000 kg. The maximum damage rate to submersed plants of 1 kg/net hour represents a total maximum hourly removal rate of 30 kg/hour for the whole river width (three 2-m wide nets, 60-m river width). Therefore, the biomass of plants removed during the highest levels of recreational activity represents only 0.000015 to 0.000034 percent of total upstream plant biomass. In addition, due to the depth of the river, many plants are not accessible to damage by recreation. Furthermore, recreation intensity needed to

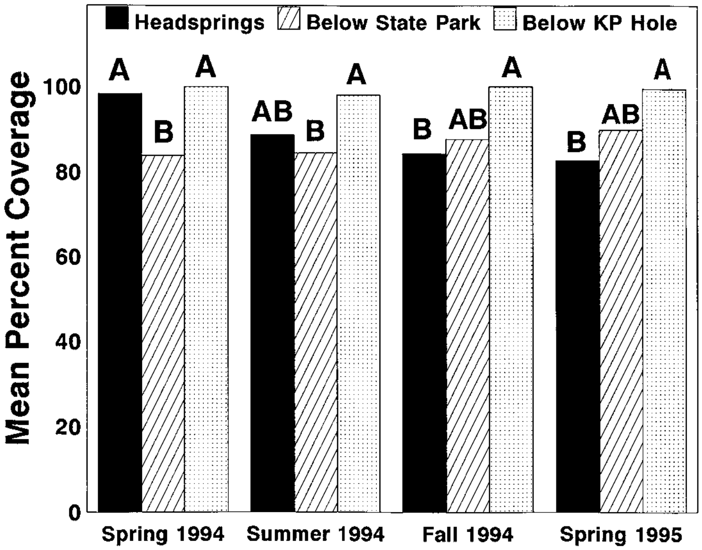

Figure 5. Mean percent coverage of submersed aquatic plants (n = 25) among three areas over four seasons in Rainbow River, Florida. Areas within each season with the same letter are not statistically different.

achieve this rate of plant damage only occurs a few hours of the year (Holland and Cichra 1994). Although recreational activity was correlated to damaged submersed aquatic plants, the amount of damage is insignificant in comparison to the total biomass of plants in the river.

Mean areal plant coverage and leaf density was highest below the KP Hole County Park over all four seasons (Figures 5 and 6). If recreational activities on the river decrease plant abundance, then the area below the KP Hole County Park (the area which received the highest levels of recreational activity) would be expected to have had the lowest areal coverage and leaf densities rather than the highest. In addition, mean plant coverage was not found to significantly differ over time at the KP Hole County Park, despite the intense seasonal use of this area.

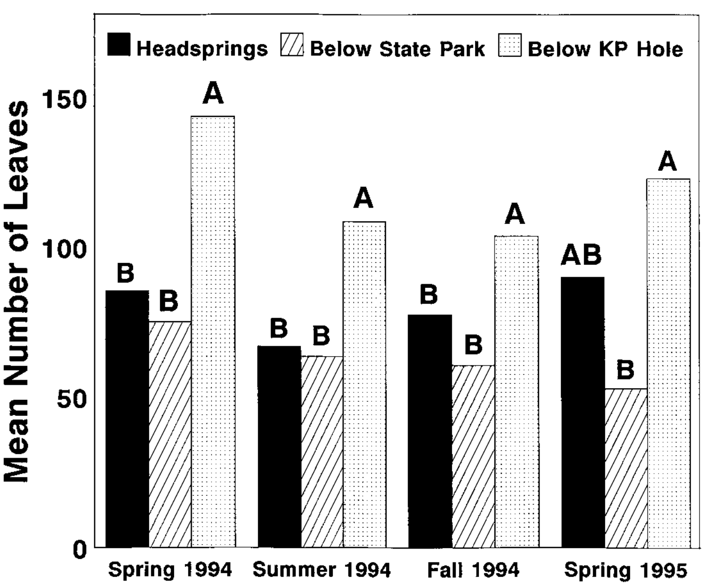

Figure 6. Mean number of leaves (n = 25) per 0.25 m^2 quadrat of submersed aquatic plants among three areas over four seasons in Rainbow River, Florida. Areas within each season with the same letter are not statistically different.

Studies have shown that water depth and substrate type strongly influence aquatic plant communities (Hynes 1972, Steward 1991). Water depths below the KP Hole County Park were significantly less than those recorded in the headsprings or below the state park boundary. Observations revealed that this area has a sandy substrate type. Perhaps the combination of shallower water, swifter current, and sandier substrate has created natural conditions more conducive to growth of sagittaria. Hence, in Rainbow River, differences in submersed plant coverage and leaf density seem to be the result of factors other than recreation.

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