A RECREATIONAL USE SURVEY OF THE SAN MARCOS RIVER

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By

David D Bradsby

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A RECREATIONAL USE SURVEY OF THE SAN MARCOS RIVER

Approved:

B. G. Whiteside, Chairman

T. L. Arsuffi

G. Longley

Approved:

Dean of the Graduate School

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Finally, a thanks to and for the beautiful San Marcos River: "Long may you run".

INTRODUCTION

The San Marcos River is a unique ecosystem. Within its physically and chemically constant springfed waters live four threatened or endangered species: Texas wildrice (*Zizania texana*), the fountain darter (*Etheostoma fonticola*), the San Marcos gambusia (*Gambusia georgii*), and the San Marcos salamander (*Eurycea nana*). The survival of each species depends upon the continued flow of the San Marcos River and the wise use of this valuable resource.

The clear San Marcos River is also a recreational resource. Not only is the river a focal point for recreation by residents of San Marcos, it attracts visitors from throughout the state. During the past three decades two factors which will invariably affect the San Marcos River have occurred. First, the population of San Marcos and Hays County has increased significantly since 1960 (Greater San Marcos Economic Development Council 1993). The city population is expected to increase in the future, as is enrollment at Southwest Texas State University (SWTSU) which is located within the city (Greater San Marcos Economic Development Council 1993). Second, recreational participation is on the rise, especially water-based recreation (United States Forest Service 1979).

34%. By the year 2000, the amount of leisure time is estimated to be as high as 38% (Smith and Theberge 1987).

The United States Forest Service (1979) estimated that water-based and snow-based activities will have the greatest percentage of recreation participation through the year 2030. Water-based recreation constitutes a substantial portion of all recreational participation. Water resources are utilized for direct recreational uses such as swimming, boating, floating on inner tubes (tubing), and fishing, as well as for indirect activities such as sunbathing and picnicking.

Surveys have documented increased levels of use on many rivers in the United States ranging from 20% to 50% annually, and exceeding 100% in some instances (Lewis and Marsh 1977, Lime et al. 1978, Barrow et al. 1986, United States Bureau of Land Management 1990a). Nationally, angling participation has increased at a steady rate since 1955 (Manfredo 1986), and participation in swimming and other water-related activities has increased by approximately 15% since 1965 (Betz and Cordell 1989). The demand for rafting/tubing is projected to increase by approximately 23% from 1989 levels through the year 2000 and by 167% through the year 2040 (Cordell et al. 1989).

As water-based recreational participation increases, resultant impacts to the environment are expected to climb. Kraus (1984)

emphasized that recreation could "...pose a serious threat to many natural and wilderness areas." Reviews of the literature on the environmental impacts resulting from recreation have been prepared by Liddle (1975), Satchell and Marren (1976), Wall and Wright (1977), Manning (1979), Ream (1979), Hart (1982), Kuss and Graefe (1985), Price (1985), and Cole (1986). In general, these studies show that a small level of use can have large initial impacts, but that additional use causes proportionally less damage (Bell and Bliss 1973, Dale and Weaver 1974, Schecter and Lucas 1978). However, some investigations have indicated that water quality may degrade in a linear, more gradual fashion as a result of recreation (Schecter and Lucas 1978, McFeters 1975).

The majority of recreational impact studies have focused on terrestrial effects such as soil compaction, trampling of vegetation, and erosion (Cole 1986). Few studies detail the effects of water-based recreation to the aquatic environment. Activities which affect water quality may be direct, occurring on or in the water, or indirect, occurring on-shore or in the watershed (Liddle and Scorgie 1980). The water quality indices of prime concern with regard to recreation are nutrient enrichment, bacterial contamination, dissolved oxygen concentration, and suspended solids (Hammitt and Cole 1987). Recreational activity often leads to denuded streambanks; eroded shorelines can exaggerate the amounts of nutrients

reaching the stream. Little evidence exists associating water quality degradation to swimming (Nelson and Hansen 1984) or to dispersed recreation (Werner et al. 1985). Many of these studies deal with recreational participation in wilderness areas and address water quality as a secondary issue. However, a few have identified recreational activities as the cause of bacterial contamination and other changes (Varness et al. 1978, Taylor and Erman 1979). Suspended solids may be the most common factor affecting changes in water quality in recreation areas (Hammit and Cole 1987). Swimming, fishing, wading, and motorized boating have been identified as activities which can increase the turbidity of recreational waters (Liddle and Scorgie 1980, Hammitt and Cole 1987, Adams 1993). De-vegetated areas adjacent to the water can also lead to increased turbidity through erosion.

Impacts to the San Marcos River as a result of recreation have been documented by Jenkins et al. (1986). According to their study, environmental degradation is most severe along the stream bank. Recreational and waterfront use contribute to stream bank erosion primarily at river access and egress points. Litter is brought into the stream by active and passive river users. In addition, oils, heavy metals, and other toxins wash into the river from parking areas and roadways near the stream. Direct degradation to the vegetation of the river as a

result of recreation has been noted by Emery (1977), Vaughn (1986), and Staton (1992).

SAN MARCOS RIVER

The San Marcos River (Figure 1) originates from the Edwards Aquifer through a series of springs known as the San Marcos Springs. Average discharge from the springs for the period 1956 to 1992 was 166 cfs, with a minimum flow of 46 cfs on August 15-16, 1956 and a maximum of 451 cfs on June 12-15, 1992 (United States Geological Survey 1993). From the springs, the river flows approximately 64 km in a southeasterly direction to its confluence with the Guadalupe River. At the headwaters, a dam impounds the spring flow to create Spring Lake. The 18 ha reservoir is a part of Aquarena Springs, a commercial tourist attraction which was sold to SWTSU in 1994. Since uncontrolled access to Spring Lake is generally not available to the public, it was not included in the study. Between the San Marcos River's origin and its confluence with the Blanco River are several small dams which have changed the flow of the river and created large pools and backwaters. The dams were constructed prior to 1930 (Young et al. 1973) and have altered the ecology of the river by providing habitat for species adapted to slow-moving waters (Jenkins et

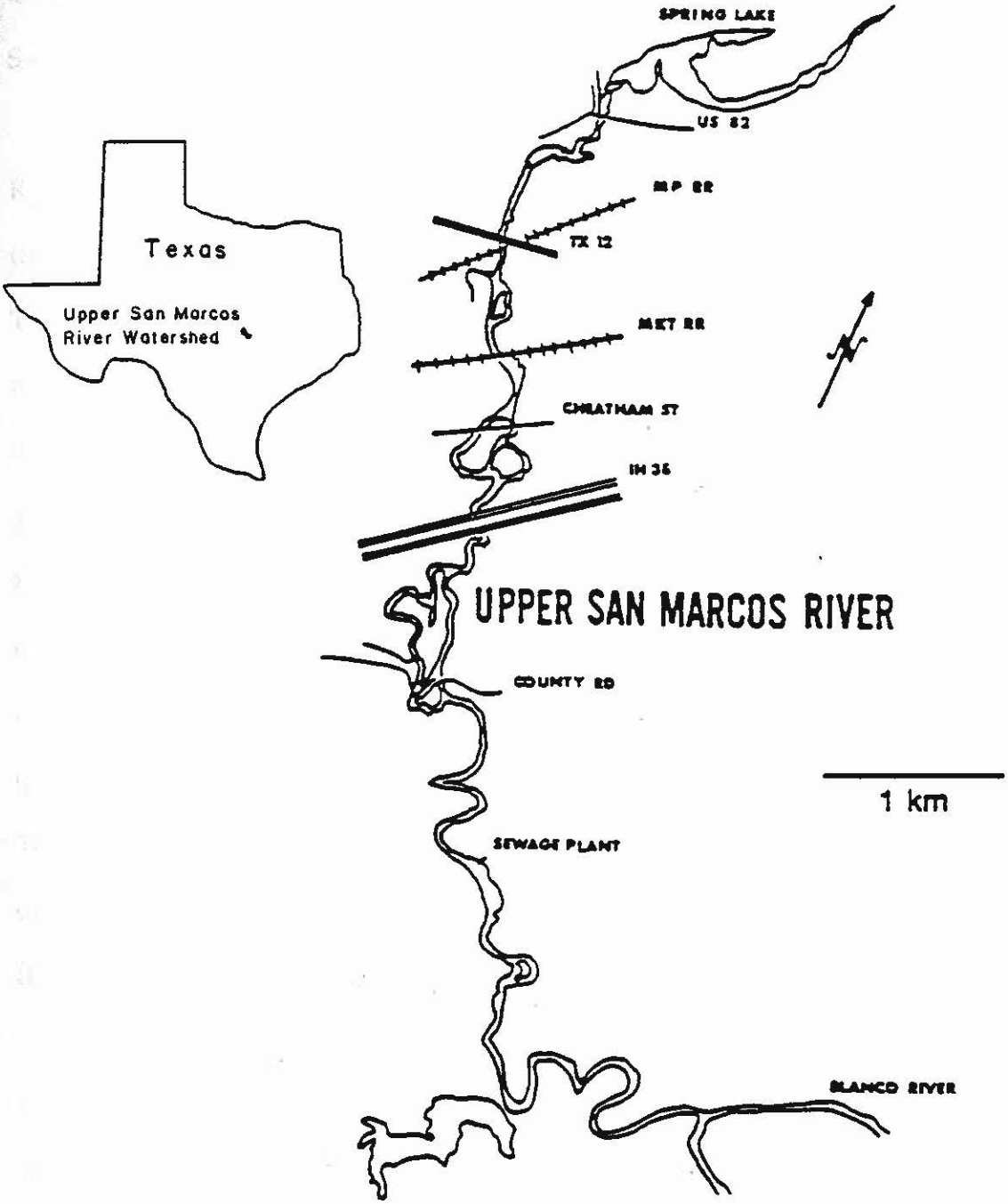


Figure 1. Map of the upper San Marcos River from Spring Lake to the Blanco River confluence.

al. 1986). Three small creeks and a sewage treatment plant empty into the San Marcos River upstream of the Blanco River confluence.

The study area encompassed the upper 2 km of the San Marcos River. This area extends from Spring Lake to the Interstate Highway 35 (IH 35) overpass and is the most heavily used for recreation (Figure 2). This section of the river resembles a springrun. Water flow in the upper reaches is moderate to rapid. The depth in the upper portions ranges from 0.6 to 4 m, while the width ranges from 5 to 15 m. The substrate is sand, gravel, and rubble, with a silt overlay in pools and slow-water areas (Espey, Huston and Associates 1975). In the upper portions of the river, the water temperature generally varies by less than 2° C throughout the year due to the large volume of 21.5° C springwaters which create the river. Water quality is classified as exceptional by the Texas Water Commission (1992). The chemical and physical consistency of the river has resulted in a high degree of endemism and diversity in the biota of the San Marcos River (United States Fish and Wildlife Service 1984).

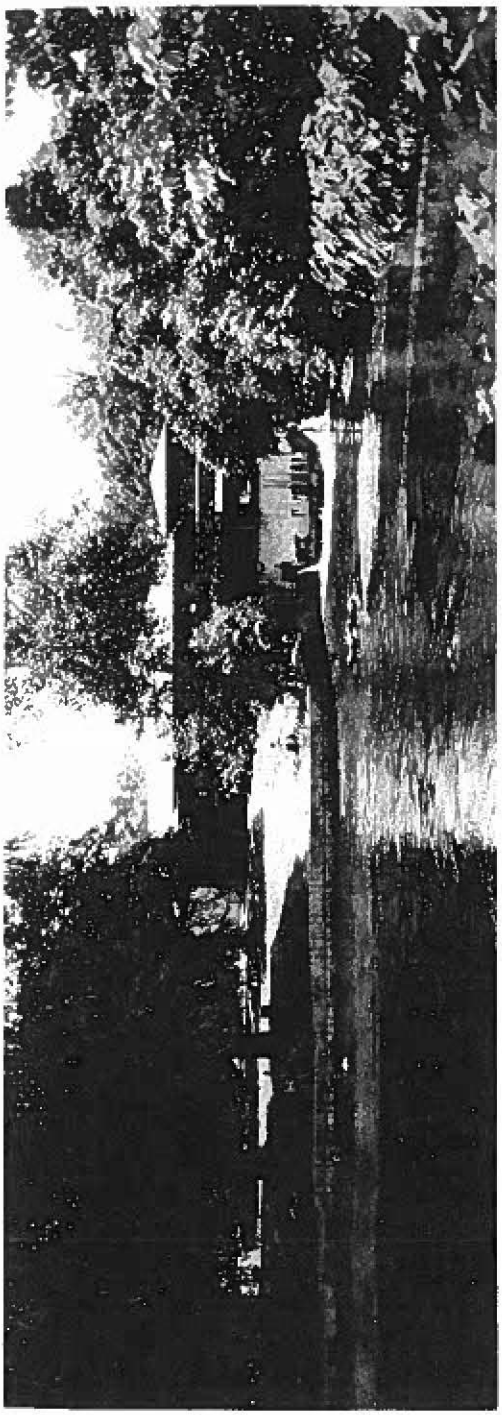
To undertake the study, the upper 2 km of the river was partitioned into 6 sections. Three criteria were used in the sectioning process: each section contained an attraction or node where recreationists congregate; each section had discrete boundaries; and each section was small enough

to allow accurate counting of the recreationists. The study area sections and their boundaries were:

1) Pepper's, from the Spring Lake dam to the US 82 bridge (Figure 3);
2) Sewell Park, from the US 82 bridge to the most downstream footbridge within the park (Figure 4);
3) City Park, from the downstream Sewell Park boundary to the railroad crossing adjacent to RR 12 (Figure 5);
4) Rio Vista Annex, from the railroad crossing adjacent to RR 12 to the next downstream railroad crossing (Figure 6);
5) Rio Vista, from the railroad crossing to the bridge at Houston Street (Figure 7); and
6) IH 35, from the Houston Street bridge to the IH 35 bridge (Figure 8).

Aquatic vegetation is diverse and abundant throughout the study area. Studies of the river's vegetation have been conducted by Hannan (1967), Young et al. (1973), Longley (1975), Espey, Huston and Associates (1975), Emery (1977), Terrell (1978), Emery and Guy (1979), Akridge and Fonteyn (1981), Vaughn (1986), Lemke (1989), Power (1990), and Staton (1992). In general, these studies have found the upper portion of the river

Figure 3. Pepper's study area on the San Marcos River, looking upstream. Pepper's, the most upstream study area, lies just below Spring Lake and includes a waterfall at the Spring Lake Dam. Pepper's Restaurant overlooks the river at this site. Access to the river is provided by a landing with steps leading into the river. The section has a deep pool, approximately 3.5 m in depth, at the falls. A cement landing provides easy access to the river, and parking is available within walking distance of the site. Property on the left is city-owned; property on the right is privately owned.



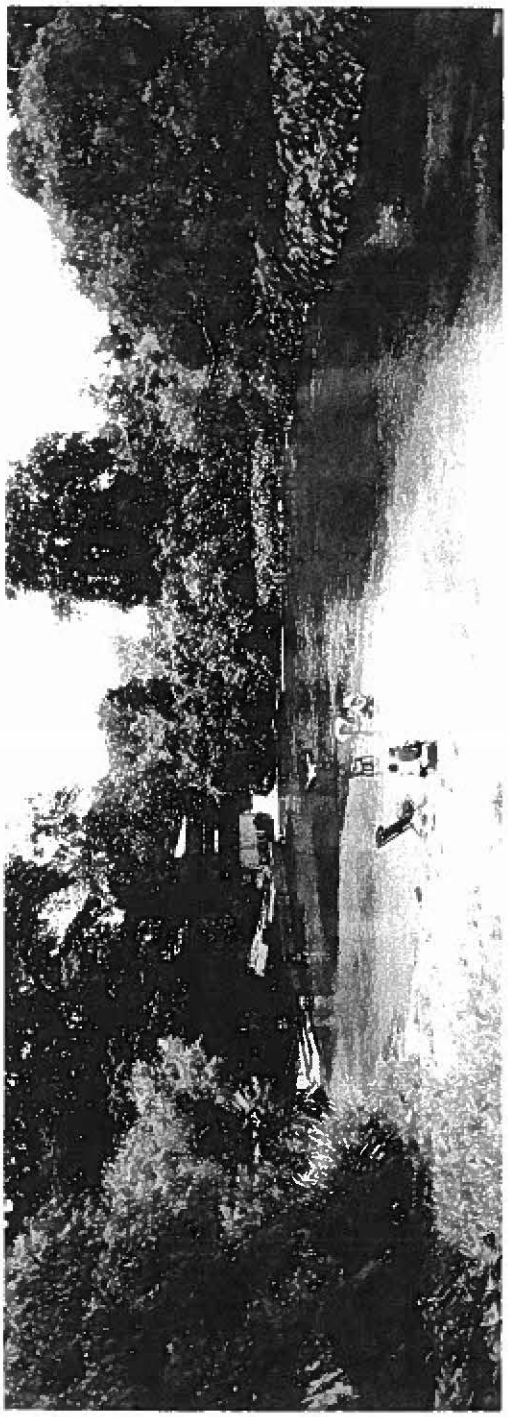
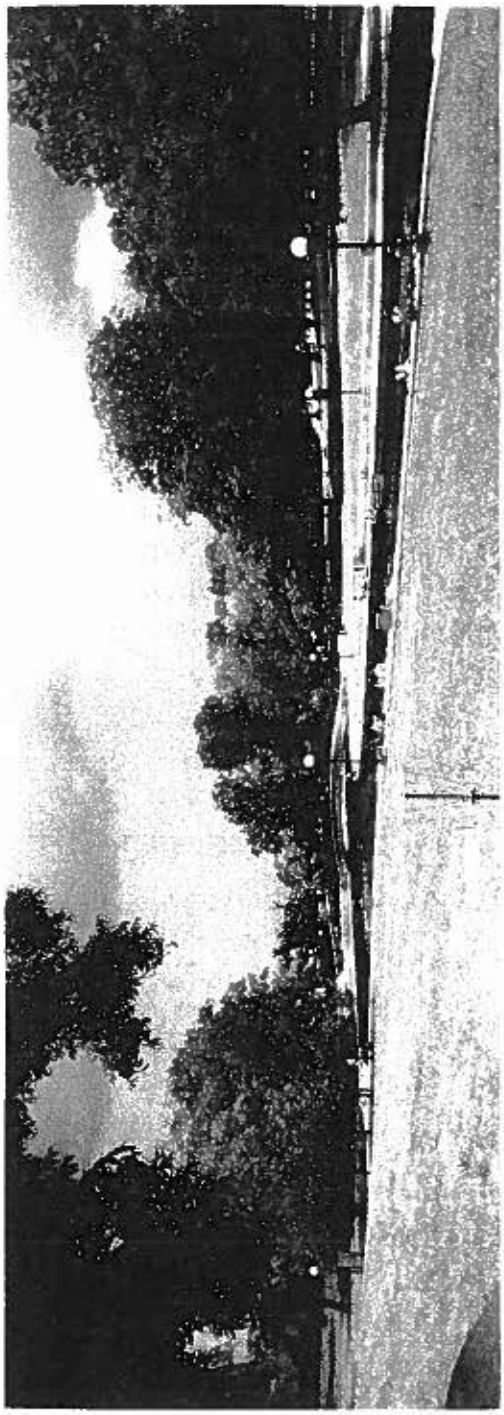


Figure 4. Sewell Park study area on the San Marcos River looking downstream. The river is channelized and a concrete wall and sidewalk line both sides of the river, providing numerous access points. In the downstream portion of Sewell Park, a meander has produced a pool, approximately 2.5 m deep, which is popular for swimming. The entire property is owned by the university.



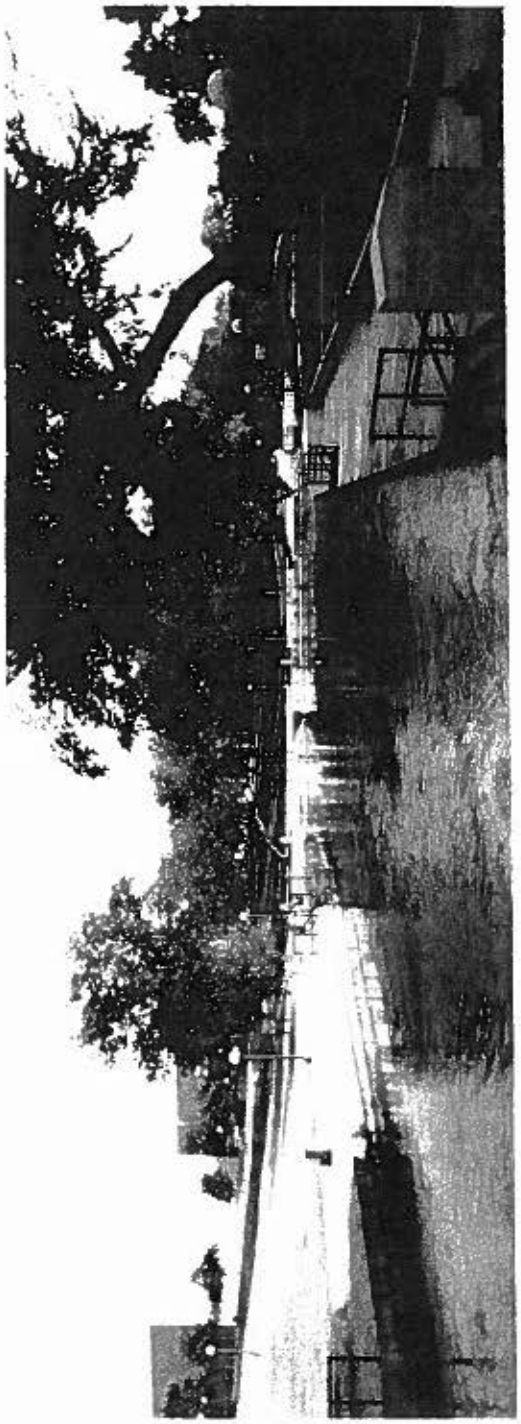
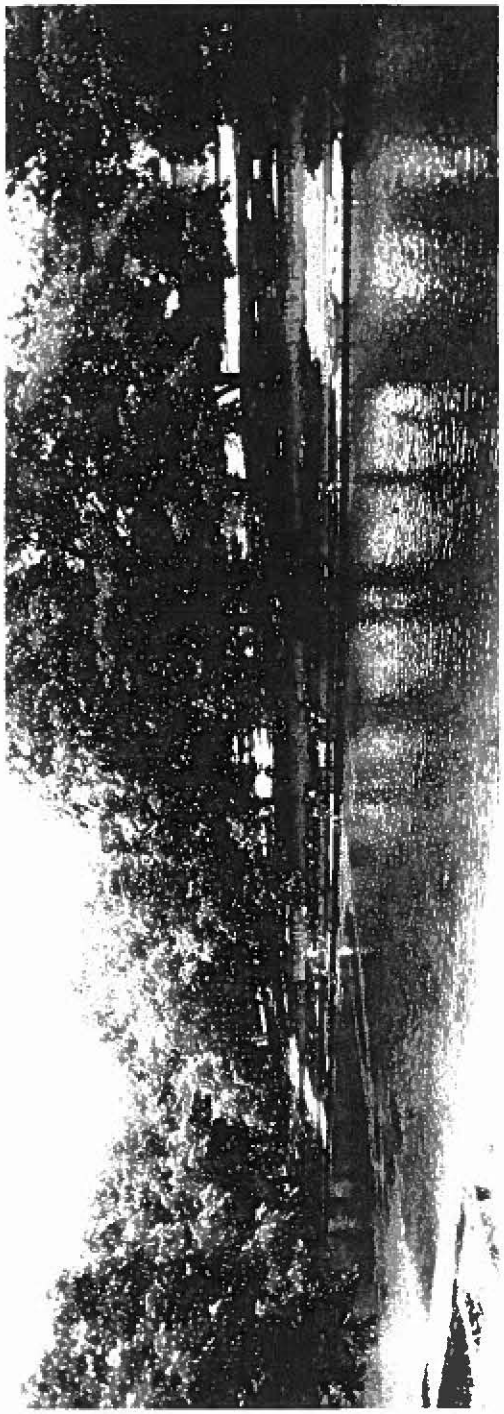


Figure 5. City Park study area on the San Marcos River. The river runs left to right. Portions of the river are channelized in the park. Cement landings provide access to the river on both sides. Additional access points, which lack structural support, have been established at other locations in this section. Aside from the area adjacent to the landings, the river is heavily vegetated. The entire property is owned by the city.



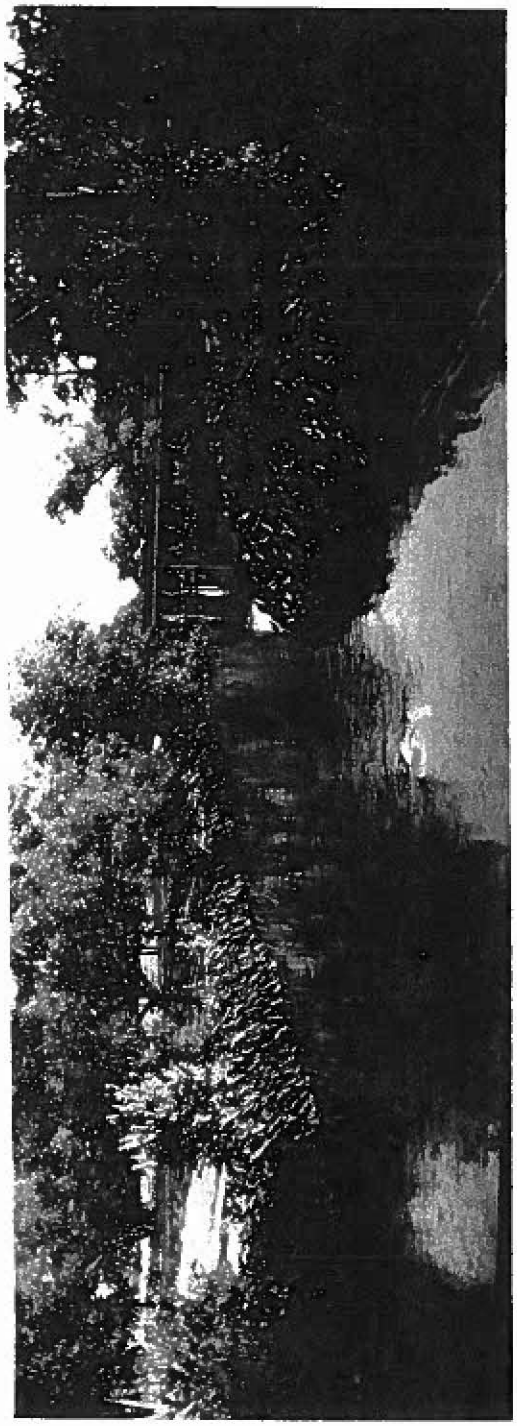
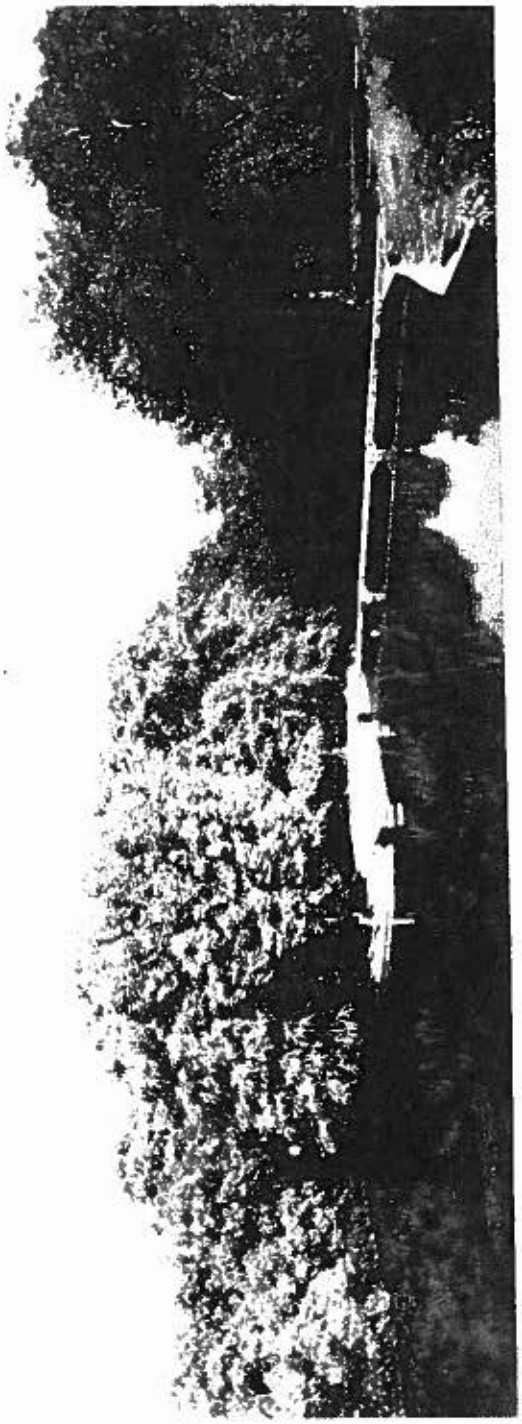


Figure 6. Rio Vista Annex study area on the San Marcos River. The upper photograph is looking downstream from the Ranch Road 12 bridge. Note the trail adjacent to the river. The entire property south (right) of the river is parkland owned by the city; the area across the river from the park is privately owned. The lower photograph shows the access area to the river from the park. Note the lack of vegetation or cover. Access to the river is limited by shoreline vegetation (south) and private ownership of the land (north). Most of the river at Rio Vista Annex is heavily vegetated. The confluence of Purgatory Creek and the San Marcos River is at this location.

Figure 7. Rio Vista Park study area on the San Marcos River. The upper photograph is looking downstream from the railroad trestle. The entire property south (right) of the river is owned by the city; property on the north side of the river is privately owned. The lower photograph is of Rodger's Dam showing the waterfall and backwater created by the dam. The popularity of this location can be attributed to several factors including covered pavilions, picnic areas, tennis courts and a swimming pool. Parking is limited at this site, but access is abundant.



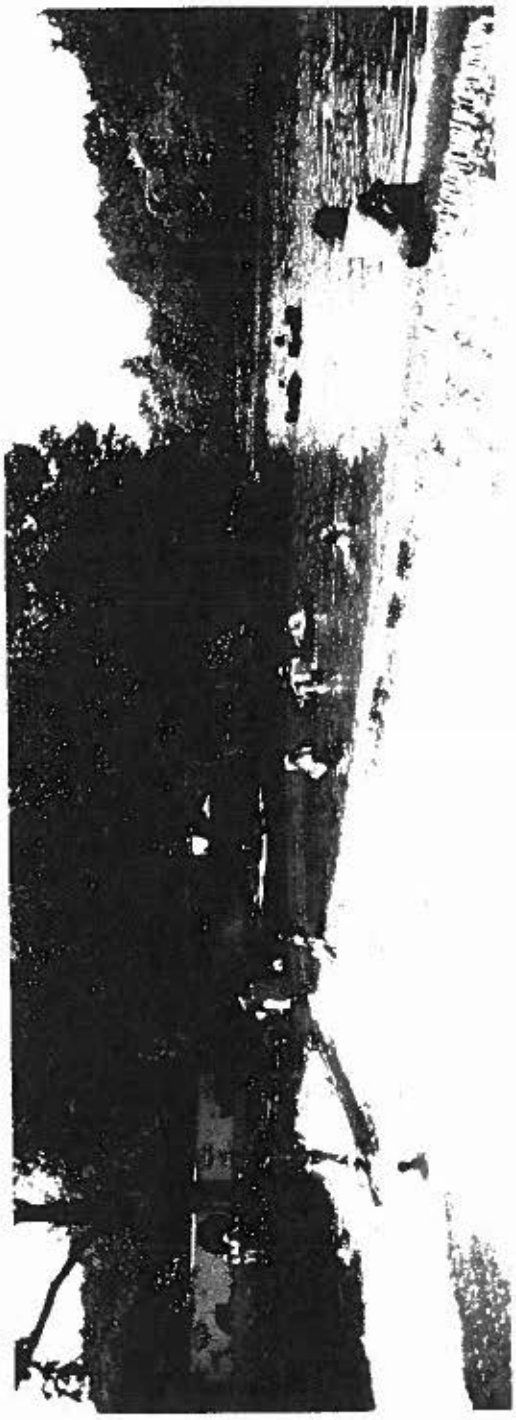
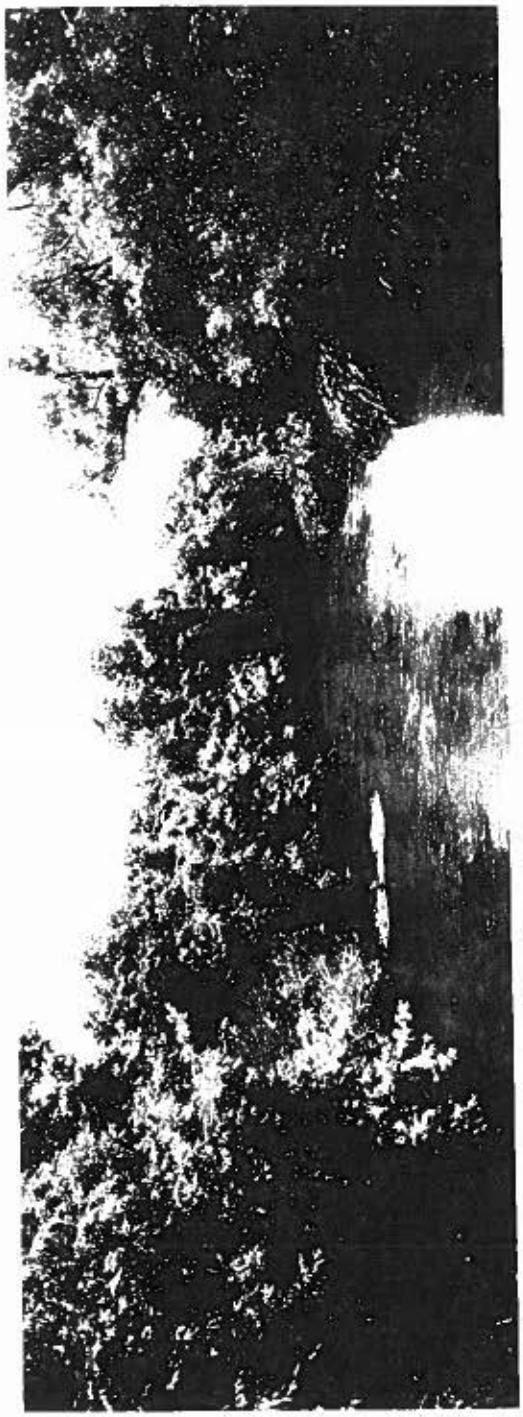
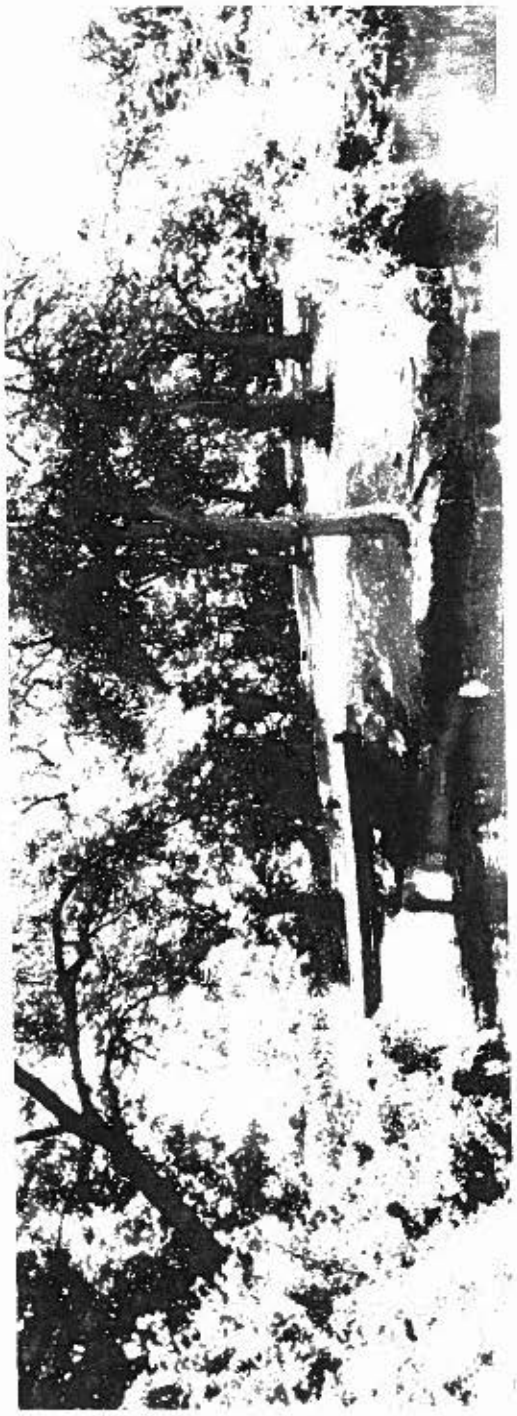


Figure 8. IH 35 study area on the San Marcos River. The upper photograph is from the Houston Street bridge looking downstream. A backwater slough (not pictured) is abutted by private and public lands. The lower photograph shows a pooled area and rope swing at a location popular for swimming and fishing. Access points are generally unimproved along shaded portions of the river. Most of the property adjacent to the river is parkland owned by the city.





to be vegetated with a mix of species including *Ludwigia repens, Elodea densa, Heteranthera dubia, Cabomba caroliniana, Vallisneria americana, Ceratophyllum demersum, Myriophyllum brasiliense, Colocasia antiquorum, Potomogeton illinoiensis, P. crispus,* and *Zizania texana.* Young et al. (1973) reported that approximately 80% of the native plants along the margin of the river had been replaced by exotic species since 1930. In the river, exotic plant species were introduced by commercial aquarium plant suppliers. Vegetational decline was attributed to harvesting by the plant suppliers, competition with introduced species, and habitat destruction due to erosion, dredging, and pollution (Young et al. 1973). Staton (1992) also noted a decrease in native species and an increase in exotics, and listed recreation among the causes of the decrease.

The fauna of the upper San Marcos River is both diverse and specialized. Four endemic caddis fly species have been reported (Edwards and Arnold 1961, Longley 1975): *Protoptila arca, P. parce, Cheumatopsyche comis,* and *Metrichia nigretta.* In addition, the river is the northernmost extent of the caddis fly *Atopsyche erigia.*

Approximately 53 species of fish occur in the San Marcos River (Young et al. 1973, Longley 1975, Jenkins et al. 1986, Whiteside et al. 1994), including 25 species of minnows, 17 species of sport fishes, and 11 species

of rough fishes. About 25% of the fish species in the river are introduced species (Jenkins et al. 1986, Whiteside et al. 1994).

THREATENED AND ENDANGERED SPECIES

Texas wildrice

One of the plants that occurs in the upper San Marcos River is Texas wildrice (*Zizania texana*), established as an endangered species in 1976 (United States Fish and Wildlife Service 1984). An endemic species, the plant is found in the upper 2.4 km of the river, usually in deep or swift waters (Vaughn 1986). Texas wildrice is a perennial aquatic grass. It was first reported in 1892 by G. C. Neally as a variety of *Zizania aquatica* (Beaty 1975). Further investigation of the plant led to its being regarded as a new species, *Zizania texana*, by A. S. Hitchcock in 1933 (Beaty 1975). Several authors have reported a decrease in the abundance of Texas wildrice since 1932 (Silveus 1932, Beaty 1975, Emery 1967, Emery 1977, Vaughn 1986, Powers 1990). Suggested reasons for the decline include reduced sexual reproduction caused by plant isolation and by floating debris (Beaty 1975, Emery 1977), pollution, competition, and reduced river flow (Vaughn 1986). Staton (1992), Vaughn (1986) and Emery (1977) implicated recreational activity as another factor responsible for the decline of the

rice. Power (1990), however, felt that recreation was less of a detriment than had previously been reported.

The fountain darter

The fountain darter was first identified in 1884 (Jordan and Gilbert 1886) and was classified as endangered in 1970 (United States Fish and Wildlife Service 1984). Although the first specimens were taken below the Blanco River confluence, the fountain darter's range was limited to upstream of the San Marcos sewage treatment plant in recent years (Schenck and Whiteside 1976a). However, recent efforts have collected specimens of the darter from downstream of the plant (personal communication, Casey Berkhouse, United States Fish and Wildlife Service, San Marcos, Texas). The darters are found in vegetated areas and in backwater areas of limited flow (Schenck and Whiteside 1976b, Linam et al. 1993). Seasonal feeding activity appears to be lowest in the spring and highest in the fall. Also, fountain darters prefer to feed in the daytime (Schenck 1976).

The San Marcos gambusia

The San Marcos gambusia (*Gambusia georgei*) was first collected in 1882 by Jordan and Gilbert (Jordan and Gilbert 1886) and was classified as

endangered in 1980 (United States Fish and Wildlife Service 1984). Recognition of the fish as a distinct species was not made until 1968 by Hubbs and Peden (Hubbs and Peden 1969). Recent attempts to locate the fish have proven unsuccessful and Miller et al. (1989) indicated that the species may have been extirpated.

The San Marcos gambusia is restricted to shallow areas which are thermally constant and near flowing waters. Gambusia seem to prefer areas with mud bottoms and little aquatic vegetation, selecting areas shaded by overhanging vegetation or bridges (Hubbs and Peden 1969, Edwards et al. 1980, United States Fish and Wildlife Service 1984).

The San Marcos salamander

The San Marcos salamander, *Eurycea nana*, is a neotenic species endemic to areas near the San Marcos spring openings. The species was initially collected in 1938 and described in 1941 by S. C. Brown (Dowden 1968). The salamander was categorized as threatened in 1980 (United States Fish and Wildlife Service 1984). Recent collection efforts have located the salamander approximately 150 m downstream of the spring openings (Nelson 1993). Population estimates for the total number of San Marcos salamanders range from 21,000 to 54,000 individuals (Tupa and Davis 1976, Nelson 1993).

In Spring Lake, the San Marcos salamander inhabits areas adjacent to spring openings with a substrate of sand and gravel. Often, the San Marcos salamander is found near the aquatic moss *Leptodictyum riparium* and the filamentous blue-green alga *Lyngbya* (Dowden 1968, United States Fish and Wildlife Service 1984). The salamanders breed throughout the year in the vegetation, which provides protection from predators and serves as habitat for amphipods and insect larvae, the primary food of the salamander (Dowden 1968, Tupa and Davis 1976).

METHODS

To study the recreational uses of the San Marcos River, a study design was adopted which compensates for the difficulties associated with sampling stream systems. These difficulties include river length, recreational user mobility, and large numbers of access and egress points (Carlander et al. 1958, Malvestuto et al. 1978). The study design was modified from a roving creel survey described by Malvestuto et al. (1978), and involves the tandem use of counts and interviews. Survey days were chosen randomly by assigning numbers sequentially to the available survey days and selecting the days with a random number generator (Hewlett-Packard HP-11C programmable calculator). The survey schedule

is presented in Table 1. As recreational use of the river is highest in the summer months, the survey efforts were concentrated in the summer. For purposes of this study, the summer season extended from May through September. A total of 16 survey days were sampled in the summer months. The survey days consisted of 4 holidays, 6 weekend days and 6 weekdays. The fall months, October and November, had a reduced sampling schedule of 2 weekend days and 2 weekdays. For the winter season, 3 weekend days and 3 weekdays were sampled. The spring months, March and April, were sampled with 2 weekend days and 2 weekdays. Unfortunately, the data for the spring sample period were inadvertently destroyed.

The survey day was divided into three time periods: morning (9:00 a.m. to 12:00 p.m.), early afternoon (12:00 p.m. to 3:00 p.m.), and late afternoon (3:00 p.m. to 6:00 p.m.). Each of the 3-h intervals of the survey consisted of the following:

1) an activity survey;

2) a one-hour fixed point survey ; and

3) a questionnaire.

For each of the three time periods, the following procedures were followed. First, the activity survey was conducted by counting recreationists at each study site, starting at Pepper's and moving

Table 1. Study days for the recreational survey of the San Marcos River, 1984 - 1985.

Weekdays	Weekend Days	Holidays
Summer		
June 28, 1984	June 17, 1984	May 27, 1984
August 7, 1984	July 14, 1984	July 4, 1984
August 15, 1984	August 11, 1984	September 3, 1984
September 13, 1984	August 18, 1984	May 30, 1985
September 17, 1984	September 2, 1984	
June 28, 1985	June 16, 1985	
Fall		
October 16, 1984	November 18, 1984	
October 31, 1984	November 25, 1984	
Winter		
December 14, 1984	December 22, 1984	
December 26, 1984	January 13, 1985	
February 8, 1985	January 27, 1985	

downstream. Only recreationists in the river were counted and attempts were made to prevent double counts. The recreational users were segregated as to activity, and their number entered onto a data sheet (Figure 9). The amount of time required to get an accurate count of the recreational users varied with the number of users encountered at each site. In general, all six sections of the study area could be traversed in approximately 1 h.

Second, a 1-h count was taken of the number of recreationists on the river passing a fixed point, approximately 10 m downstream of the footbridge in City Park.

Third, during the remainder of the 3-h period, usually 20 to 30 minutes, the questionnaire was administered. The questionnaire consisted of 12 open-ended questions (Figure 10) and was designed to supplement the census data and to elicit information on the frequency, duration, time, and location of recreational use of the river. The questionnaire was administered randomly, generally to every fifth person encountered on the river. Due to time constraints, a limited number of questionnaires, 41, were completed for the study.

Data from the activity survey were compiled and analyzed to determine the activity with the highest level of participation; the study area location with the most recreational activity; the time period of the

Date-

Weather Conditions-

Location: # of :

	tubers	swimmers	anglers	boaters	dogs	misc
Pepper's time:						
Sewell Park time:						
City Park time:						
Rio Annex time:						
Rio Park time:						
IH 35 time:						

Comments:

Fixed Point:

start time- end time-

minutes :	5	10	15	20	25	30	35	40	45	50	55	60	Total
# people :													

Figure 9. Sample data sheet for recreational survey of the San Marcos River.

San Marcos River Questionnaire

1. How often do you use the river?

2. In what ways do you use the river? (i.e. swimming, boating, etc.)

3. During what months do you generally use the river?

4. When at the river, how long do you usually stay?

5. At what hours are you at the river?

6. When at the river, do you generally stay confined to one area or move from place to place?

7. What part of the river do you usually visit?

8. If you are not a local resident, how far did you have to travel to reach the river today?

9. Approximately how much money did you spend on items related to your visit to the river (i.e., tube rental, tackle, motel expenses, etc.)

10. In your opinion, what is the most important aspect of the San Marcos River?

11. Are you aware of the endangered species in the river?

12. Would you object to restrictions being placed on certain parts of the river in an effort to protect the endangered species?

Are you a student?

Please give your:
age-
sex-

Figure 10. Sample questionnaire for recreational survey of the San Marcos River.

survey day with the highest level of participation; and the season with the most recreational use. These numbers were expressed as a percent of the total number of recreationists counted during the activity survey.

Average use of the river on weekdays and weekend days was determined and compared. The fixed-point data were analyzed to determine time of day of the most activity and to compare weekday and weekend use.

Total recreational use of the San Marcos River for the summer of 1984 was estimated by determining the average recreational use of the river per survey weekday and survey weekend day, multiplying the respective averages by the number of weekdays and weekend days in the summer of 1984, and adding these two numbers. Values for holidays were included in the weekend data.

Additional information on recreational use of the river was obtained from the San Marcos Lions Club, a local organization which, as a fund raising activity, rents inner tubes for use on the San Marcos River. The tube rental facility is located in City Park. The Lions Club provided daily financial information for the summer of 1992. The rental facility was open only on weekends in May until Memorial Day. Following Memorial Day, it was open every day until Labor Day, with the exception of days when it rained (June 2, June 9, August 30, and August 31). The Lions Club

data was converted from amount of money collected per day to number of tubes rented by dividing the total amount of money collected by the tube rental rate. A ratio of 1:1 was assumed for tubes rented and number of tubers. This information was analyzed to determine differences in tuber demand on weekdays and weekend days. Numbers for total recreation use of the river for the summer of 1992 were also compiled.

Information about recreational use of the river was solicited from local recreation-oriented businesses. These included canoe liveries, the SWTSU outdoor program, and scuba shops. Conversations with employees at these businesses provided confirmation and insight into the use trends of the river. Information was supplied in narrative form and did not lend itself to detailed analysis.

Meteorological data for San Marcos, obtained from the United States Meteorological Station in San Marcos, were compared with the tube rental data. The climatological factors of interest were temperature and rainfall. Linear regression analysis was used to determine if recreational use of the river was correlated with temperature (Zar 1984, Feldman and Gagnon 1985). Data on precipitation was recorded nominally.

To examine the relationship between flow of the San Marcos River and recreation, springflow data were gathered from the United States Geological Survey springflow gauge No. 08170000 at San Marcos. Stream

flow information for 1984, 1985, and 1992 was used. Linear regression was used to examine correlation between flow in the river and recreational use of the river for 1984, 1985, and 1992 (Zar 1984, Feldman and Gagnon 1985).

RESULTS

Total Numbers

A total of 4,470 recreationists was observed during the activity surveys on the San Marcos River; 14% in the morning, 55% in the early afternoon, and 31% in the late afternoon (Figure 11).

For the fixed-point recreational census 1,958 floaters (tubers, canoeists, kayakers, etc.) were counted; 14% in the morning, 70% in the early afternoon, and 16% in the late afternoon. An average of 114 recreationists passed the fixed-point per hour in the summer months during the early afternoon. For the late afternoon, an average of 27 recreationists passed by the point of the survey per hour while the morning period averaged 22 per hour during the summer months. The most recreationists to pass in a single hour was 287 in the early afternoon on Memorial Day 1985.

Based on the information provided by the Lions Club, a total of 26,874 tubers used the San Marcos River during the summer of 1992. This number does not account for tubes rented at other facilities or for privately

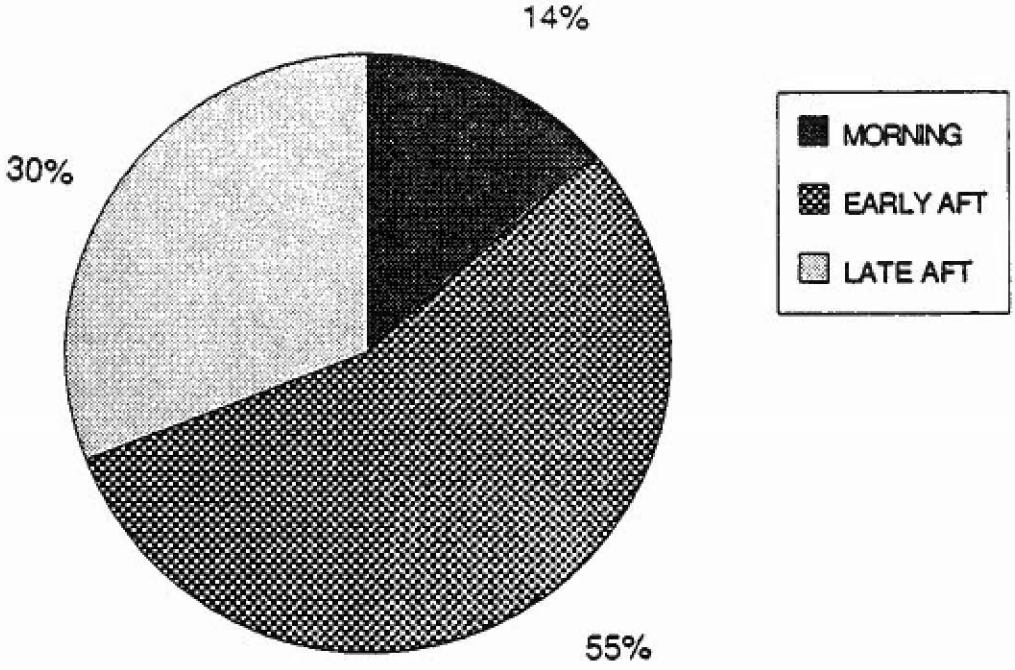


Figure 11. Recreational use of the San Marcos River by time of day, 1984-1985 (n=4470).

owned tubes. The revenue generated from the rental of these tubes approaches $85,000. Based on the average use for weekdays and weekends, the projection from the activity survey for total use of the river in the summer of 1984 is 18,309 for the period between Memorial Day and Labor Day.

By activity, the predominant recreational uses of the river were tubing (51%) and swimming (40%), while other recreational uses accounted for the remaining 9% (Figure 12). The most popular location on the river was Rio Vista Park, which attracted 37% of all users, followed by City Park (22%), Pepper's (15%), Rio Vista Annex (13%), IH 35 (9%), and Sewell Park (5%) (Figure 13).

Morning Activity and Location

Of the recreationists observed during the activity survey on the San Marcos River in the morning, 57% were swimming, 21% tubing, 7% fishing, 7% playing with a dog in the water, 5% boating, and 2% participating in other activities (Figure 12). The morning recreationists were attracted to the various locations in the following order: Pepper's (40%), Rio Vista Park (27%), City Park (13%), IH 35 (10%), Rio Vista Annex (7%), and Sewell Park (3%) (Figure 13).

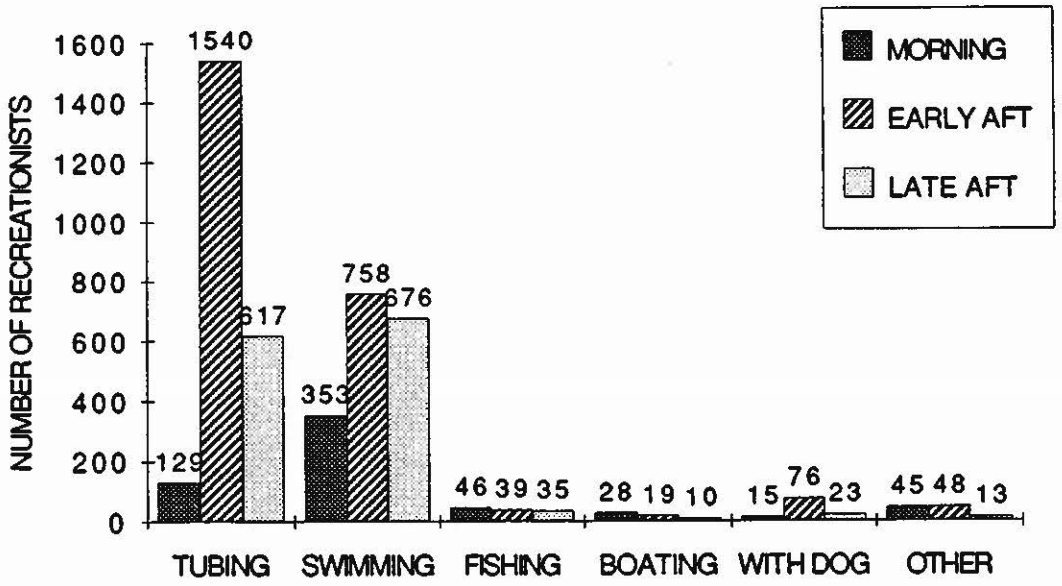


Figure 12. Recreational use of the San Marcos River by activity and time of day, 1984-1985. Total number of participants for each activity are given above the bars.

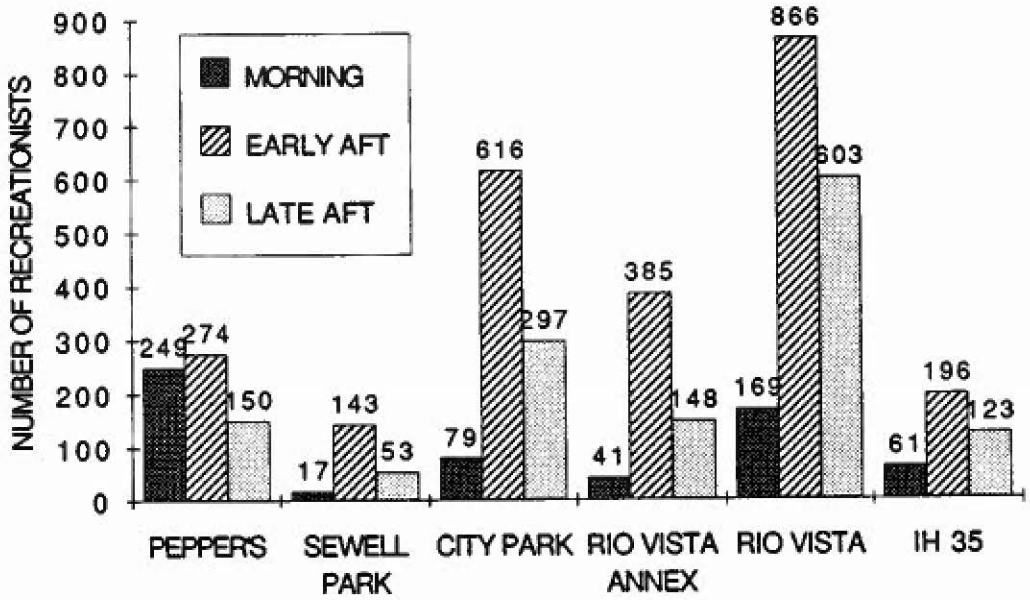


Figure 13. Recreational use of the San Marcos River by location and time of day, 1984-1985. Total number of participants for each activity are given above the bars.

Swimming was the predominant activity at Pepper's (91%), Rio Vista Park (44%) and IH 35 (30%) (Figures 14 and 15). Tubing was the predominant morning activity at City Park (47%) and Rio Vista Annex (71%) (Figures 14 and 15). Other morning activities generally had low levels of participation.

Early Afternoon Activity and Location

Of the recreationists observed during the activity survey on the San Marcos River in the early afternoon, 62% were tubing, 31% swimming, 2% fishing, 3% playing with a dog in the water, 1% boating, and 2% participating in other activities (Figure 12). The early afternoon recreationists were attracted to the various locations in the following order: Rio Vista Park (35%), City Park (25%), Rio Vista Annex (16%), Pepper's (11%), IH 35 (8%), and Sewell Park (6%) (Figure 13).

Swimming was the predominant early afternoon activity at Pepper's (67%) and at IH 35 (49%) (Figures 16 and 17). Tubing was the predominant activity at Sewell Park (53%), City Park (78%), Rio Vista Annex (88%), and Rio Vista Park (60%) (Figures 16 and 17).

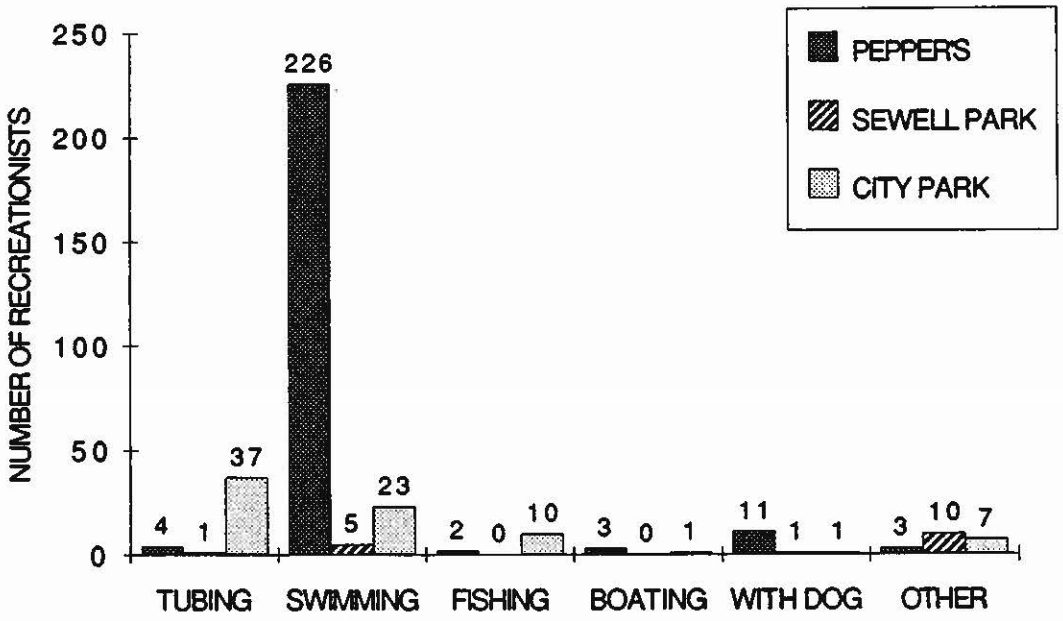


Figure 14. Morning recreational use of the San Marcos River by location and type of activity, 1984-1985. Total number of participants for each activity are given above the bars.

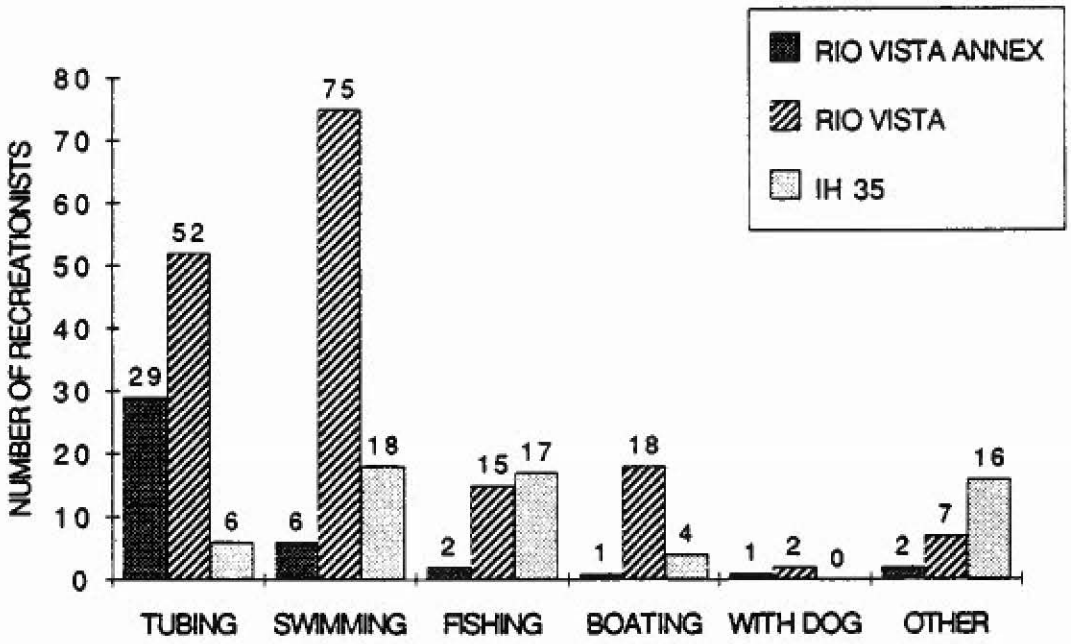


Figure 15. Morning recreational use of the San Marcos River by location and type of activity, 1984-1985. Total number of participants for each activity are given above the bars.

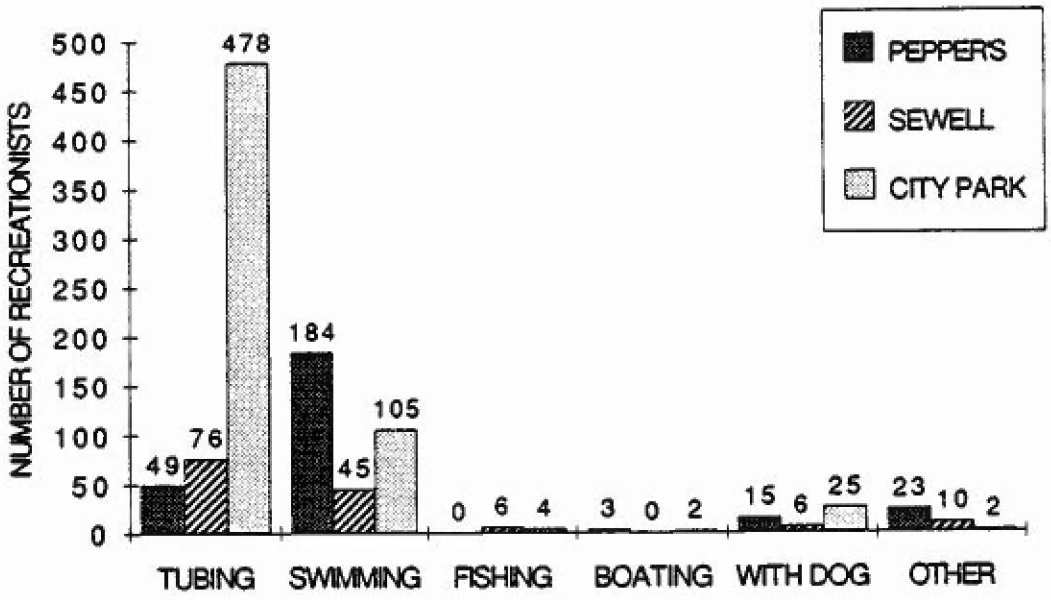


Figure 16. Early afternoon recreational use of the San Marcos River by location and type of activity, 1984-1985. Total number of participants for each activity are given above the bars.

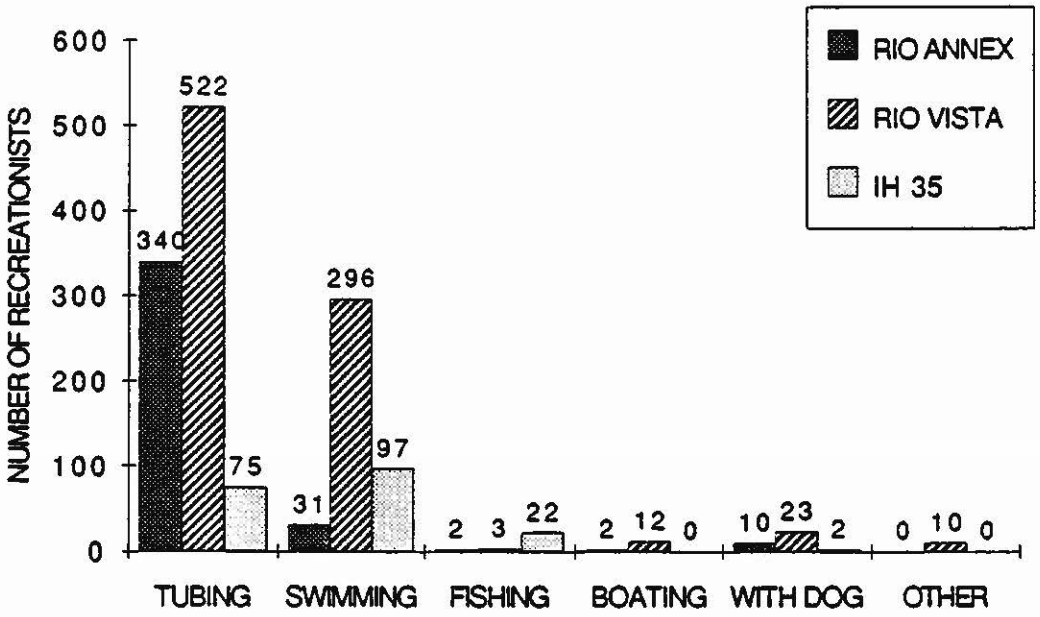


Figure 17. Early afternoon recreational use of the San Marcos River by location and type of activity, 1984-1985. Total number of participants for each activity are given above the bars.

Late Afternoon Activity and Location

Of the recreationists observed during the activity survey on the San Marcos River in the late afternoon, 49% were swimming, 45% tubing, 3% fishing, 2% playing with a dog in the water, 1% boating, and 1% participating in other activities (Figure 12). The late afternoon recreationists were attracted to the various locations in the following order: Rio Vista Park (44%), City Park (22%), Pepper's (11%), Rio Vista Annex (11%), IH 35 (9%), and Sewell Park (4%) (Figure 13).

Swimming was the predominant activity at Pepper's (81%), Sewell Park (58%), Rio Vista Park (58%), and IH 35 (47%) (Figures 18 and 19). Tubing was the predominant late afternoon activity at City Park (61%) and Rio Vista Annex (78%) (Figures 18 and 19). Other late afternoon activities generally had low levels of participation.

Seasonal Variation

The loss of the spring data hampered efforts to compare seasonal variation in river use. However, the remaining data show that summer is the season of the most intense recreational activity. This contention is supported by conversations with employees of recreational businesses operating within San Marcos. In the summer months, the frequency, duration, and amplitude of recreational experiences increases.

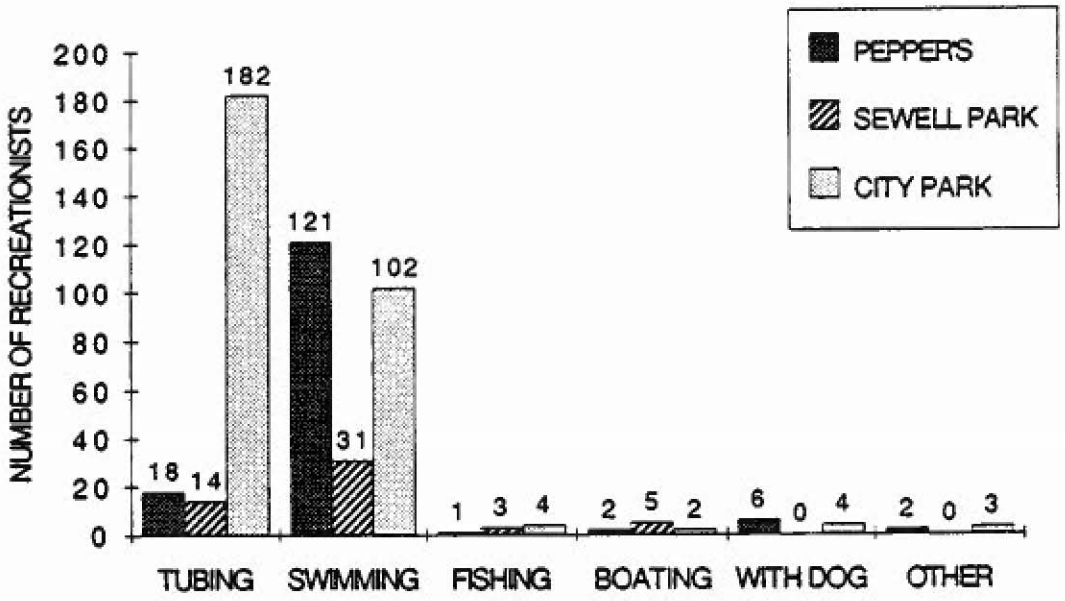


Figure 18. Late afternoon recreational use of the San Marcos River by location and type of activity, 1984-1985. Total number of participants for each activity are given above the bars.

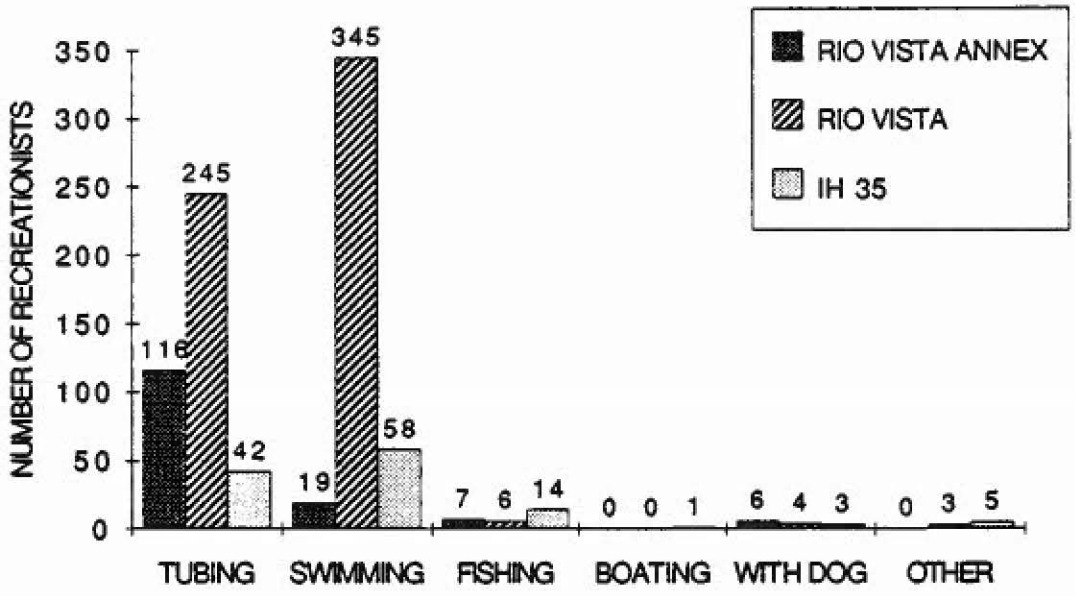


Figure 19. Late afternoon recreational use of the San Marcos River by location and type of activity, 1984-1985. Total number of participants for each activity are given above the bars.

Additionally, a wider variety of activities are pursued. Data from the fall survey season showed a decline in recreational activity on the river. During the winter months, use of the river for swimming and tubing essentially disappeared. It would be expected that during the spring season, recreational use of the river would gradually increase and would ultimately surpass fall levels.

Fishing and boating have a relatively stable demand throughout the year. Activities which require contact with the water are more dependent upon weather conditions and are therefore segregated to the warmer months of the year. Participation in all activities is influenced by weather conditions to some extent. Observation indicated that rain was a major detraction to recreational use on the river, regardless of the season.

Weekend vs. Weekday vs. Holiday

Weekday and weekend use were compared for the activity survey data and the tube rental data. Due to the limited use of the river during other times of the year, comparison of weekday and weekend use was restricted to the summer months. Based upon the activity survey data, weekday use averaged 56 recreationists per day. On weekends the numbers increased to an average of 461 recreationists per day. For the three holidays of the summer, use was approximately the same as for a

weekend day, with an average of 475 people. However, the number of recreationists using the river on Labor Day of 1984 was low due to rainy conditions. The highest use for any single day, 753 recreationists, was recorded on July 4, 1984. For the tube rental data, average weekday use was 2.6 times higher than weekday use as determined by the activity survey. Tube rentals averaged 148 tubes per weekday, with a range of 6 to 723 (n=68). Weekend rentals averaged 494 tubes with a daily range of 28 to 998 (n=37). For the three summer holidays, average daily tube rental was 432. Again, inclement weather reduced the amount of recreational use of the river on Labor Day. The rental facility was closed on rainy days.

Supplemental Rental Data

From June 1, 1985 through October 31, 1985, the SWTSU Outdoor Center rented a total of 90 canoes and 250 tubes. From November 1985 through May 1986, a total of 190 canoes, 30 kayaks and 90 tubes was rented by the Center (Jenkins et al. 1986). There is no breakdown available as to the time or place of use of the rented equipment.

From May 1985 through October 1985, the Amkon Canoe Company reported canoe rentals of approximately 20 canoes per weekend and 32 to 40 canoes for the remainder of the week. The company also rented

approximately 40 tubes per week at the peak of the season (Jenkins et al. 1986).

Goynes Canoe Livery rented approximately 2,400 canoes in 1983 and 1984 and 1,200 canoes in 1985 (Jenkins et al. 1986). Most of these canoes were used downstream of the study area (Tom Goynes, Martindale, Texas, personal communication).

Hydrologic Data

Flow in the summers of 1985 and 1992 was higher than mean summer flows for the period 1956 through 1989, while flows in the summer of 1984 fell below the mean values (Figure 20). No pattern of recreational use related to flow in the river was observed and no correlation was evident (r^2=.001).

Meteorological Data

No correlation was detected between air temperature and recreational use based upon the tube rental data for the summer of 1992 (r^2=.076). Observation indicated increased recreation use on days when the temperature approached 32° C. On days with precipitation, activity on the river was sparse.

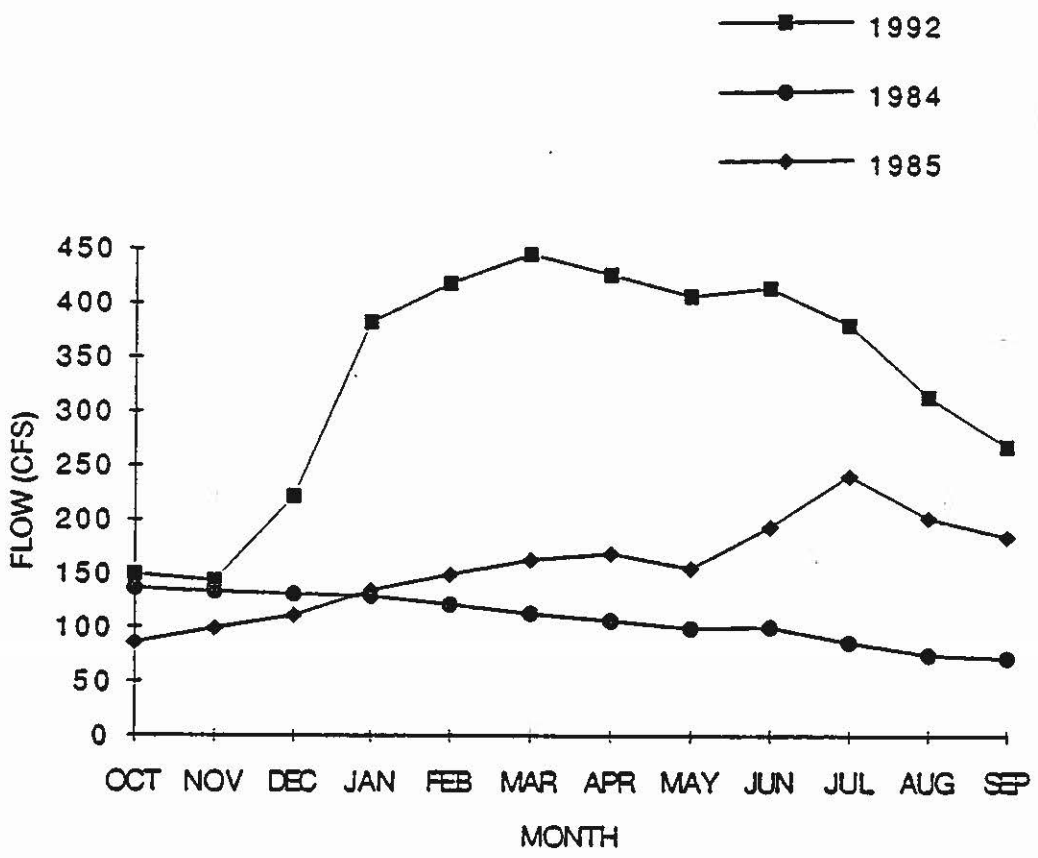


Figure 20. Mean monthly flows of the San Marcos River at United States Geological Survey gauge 08170000 for the years 1984, 1985, and 1992.

Questionnaires

Few questionnaires were completed due to difficulties in soliciting people to participate in the interview process and the limited amount of time allotted to conduct the interviews. Although the questionnaire was designed to be quickly administered, it generally took over 15 minutes for completion. However, conversations with persons involved with various aspects of recreation on the San Marcos River and personal observation support the limited amount of information gathered with the questionnaires.

A total of 41 questionnaires were completed during the study. Twenty-six of the respondents were male with an average age of 26 years, ranging from 10 to 72. For female respondents, the average age was 24 years, with a range of 18 to 31. The average age for all respondents was 25.

Seventy-six percent of those that completed the questionnaire were from San Marcos. Of the 10 out-of-town respondents, six traveled from Austin and one each traveled from Houston, Galveston, Dallas, and San Antonio.

Eighty-eight percent of the respondents limit their use of the river to the summer months and the rest utilize the river year-round. Sixty-eight percent of the respondents visit the river more than 10 times per

annum, and 56% of the respondents use the river several times per week during the summer months.

Seventy-eight percent of those interviewed arrived at the river in the early afternoon, 5% arrived at the river prior to noon, and 17% arrived in the late afternoon. The length of time that users stayed at the river varied, with some overlap between time periods; 63% reported that they remained at the river for 2 to 3 h; 27% stayed 4 to 5 h; and 10% remained for more than 6 h.

Tubing and swimming were identified by all of the respondents as activities in which they normally participated. Fishing was the only other activity to be mentioned by more than 10% of the respondents.

No clear consensus was obtained on the most popular location. Preferences were Sewell Park (22%), City Park (22%), Pepper's (20%), Rio Vista Annex (10%), Rio Vista Park (10%), and IH 35 (5%). The rest of the respondents had no site preference. Site preference may have been a function of the location of the respondent at the time the questionnaire was given.

Fifty-six percent of the respondents had at least a limited knowledge of the endangered species present in the river, and 72% of the respondents did not object to the incorporation of management practices on the river to protect the endangered species.

For 58% of those interviewed, the most important aspect of the San Marcos River was the environmental aesthetics, in particular the cleanliness of the water. For the male respondents, social interaction was listed by 50% as an important attribute of the recreational experience. Female respondents were more attracted by the aesthetics of the river.

DISCUSSION

Time of Recreational Use

Recreational use of the San Marcos River is segregated over time and space. This study showed that use of the San Marcos River is highest in the summer months, especially on weekends and holidays. Similar results have been reported in other studies (Lime et al. 1978, Hammitt et al. 1983, Field and Martinson 1986) which have found that water-based recreation is primarily a summertime activity with most use occurring between the Memorial Day and Labor Day weekends. High recreational use during the summer months can be attributed to favorable weather conditions during the summer (high temperatures and low precipitation) and time off from school or work.

The United States Bureau of Land Management (1988) reported that outdoor recreational use is heaviest on weekends and holidays, with holidays associated with long weekends receiving the most use. Similar

use patterns occur on the San Marcos River. The activity survey found a ratio of weekday to weekend use of 1:8 while the tube rental data showed a 1:3 ratio. The activity survey included all recreational users observed on the river, whereas the tube rental data was specific to tubers. Average holiday use during the study period was similar to that found for weekend use. The Fourth of July had high levels of river use in 1984 and in 1992. In 1992, the holiday was on a Saturday. However, for many people, either Friday or Monday was a day off work. The additional time off work, combined with favorable weather conditions, contributed to the high levels of recreation for July 3 - 6, 1992.

The degree of seasonal demand for recreation varies with the activity. Tubing is strictly a summertime activity. Swimming for recreation is limited to the summer months, while swimming for exercise on the river occurs in every season except winter. Fishing and boating are most popular in the summer months, with limited but stable activity the remainder of the year.

Use of the San Marcos River varies over the course of the day. Field and Martinson (1986) reported that the majority of water-based recreation occurs on daily cycles with variation throughout the daily cycle by activity. The current study supports this contention. Combined activity totals show that the early afternoon period has the highest recreational use with

a gradual reduction in the late afternoon. Morning activity, in general, is limited. The major recreational pursuits are swimming and tubing which account for 91% of the recreational use of the river. Although participation in swimming is influenced by temperature (Field and Martinson 1986), it is the most popular activity in the morning. Tubing is the activity of choice in the early afternoon, similar to observations from other studies (Haberlein and Vaske 1977, Hammitt et al. 1983, Shelby and Stein 1984, Shelby and Heberlein 1986). For the late afternoon period, swimming once again dominates. The closure of the Lions Club Tube Rental facility at 7:00 p.m. probably reduces the amount of tubing later in the day. Fishing occurs primarily in the early morning and early afternoon, with some activity throughout the day. Fishing and scuba diving were the only activities observed at night. It is surmised that the anglers are influenced by the habits of their prey as well as by the disruptive activities of other recreational users. In general, fishermen on the river are at areas and times isolated from tubers and swimmers. The number of dogs brought to the river was highest in the early afternoon, when the most recreationists were at the river. Boating on the San Marcos River appears to be more prevalent in the morning, with a slight reduction into the late afternoon.

Location of Recreational Use

Based upon the activity survey, Pepper's (Figure 3) attracts 15% of the recreational users of the upper San Marcos River. A deep pool, approximately 3.5 m in depth, at the falls attracts swimmers, snorkelers, and scuba divers. Observation and conversations with scuba divers indicate that this site is used to the exclusion of other areas for night scuba diving. In addition, Pepper's is the starting point for many float trips down the river. A cement landing provides easy access to the river, and parking is available within walking distance of the site.

Based upon the activity survey, Sewell Park (Figure 4), wholly owned by SWTSU, attracts 5% of the recreational users of the upper San Marcos River. In the downstream portion of Sewell Park, a meander has produced a pool, approximately 2.5 m deep, which is popular for swimming. Instream use at Sewell Park is the lowest of the study areas. Access to Sewell Park is restricted to students, faculty, and staff of SWTSU and their guests, although this rule is infrequently enforced. It appears that the river is of secondary importance and that most of the visitors to Sewell Park are content to remain on shore. In many ways, Sewell Park is utilized as a beach. Hecock (1970) reported that beaches are popular for water and non-water recreation activities, with many users spending the majority of their visit out of the water. The park's shallow and narrow

river channel limits swimming. Tubing in Sewell Park is transient in nature; tubers generally float through this section of the river and do not originate or terminate their float in the park. Canoe and kayak use is occasionally heavy, as Sewell Park is the location for SWTSU canoe and kayak classes.

For many tubers, City Park (Figure 5) is the starting point of their trip down the river. City Park, with 22% of the total recreational use, contains the Lions Club Tube Rental facility and ample parking. Cement landings provide access to the river on both sides. Additional unimproved access points have been established at other locations in this section. The shallow nature of the river at the park, the absence of aquatic vegetation near the banks, and a concrete landing on the east side of the river make this site popular for swimming.

Recreationists in City Park appear to be a mixture of local and out-of-town users. It is surmised that out-of-town users of the river are attracted by the tube rental facility, the proximity of parking, and the ease of access to the river. Local users seem to use City Park as an access point to the river for tubing and for swimming. Observation indicates that the footbridge which transects the river is often used for fishing.

Rio Vista Annex (Figure 6) attracts 13% of the recreational users of the upper San Marcos River. At this site, access to the river is limited by

shoreline vegetation and by private ownership of the land. One area in the park provides river access. Beginning in 1985, the Rio Vista Annex area was refurbished with a playscape and other amenities. These changes probably attract more people to the greenbelt of the river, and secondarily contribute to river recreational use. The low use of this area is attributable to the absence of access points, the narrowness of the river channel, and the position of the area with regard to the starting and stopping point for most tubers on the river. Fishing at Rio Vista Annex is often confined to the confluence of Purgatory Creek and the San Marcos River, or to the creek proper.

Rio Vista Park (Figure 7) attracts 37% of the recreational users of the upper San Marcos River. Although the highest percentage occurs in the late afternoon (44%), swimmers and tubers utilize the park throughout the day. The popularity of this location can be attributed to several factors including two covered pavilions, picnic sites, tennis courts, and a swimming pool. In addition, Rodgers Dam influences the river flow in this section. Tubers and swimmers congregate in the backwater and repeatedly ride the rapids over the dam. The waterfall and resultant rapids at the dam are also popular for kayakers.

Rio Vista Park is often the most downstream extent of recreational trips on the upper San Marcos River. Tubers find it easy to return to

from other recreational activities contributes to the use of the IH 35 site for fishing.

Demographics

The average age of recreationists on the San Marcos River is 25 years, with a median age of 23 years. The average recreationist's age is slightly higher than might be expected on a river with uses dominated by swimming and tubing. Other studies (Hammitt et al. 1983, Field and Martinsen 1986) have demonstrated that swimming and tubing are activities that appeal mostly to teenagers and young adults, while canoeists and fishermen tend to be older (Heberlein and Vaske 1977, United States Department of the Interior 1980). The relatively high age may be due in part to a willingness for older recreationists to answer the questionnaire from which the age was calculated, and the use of the San Marcos River by the local populace. The median age for Hays County in 1987 was 25 years (San Marcos Chamber of Commerce 1988).

Smith and Theberge (1987) reported that age has a consistent relationship to outdoor recreational participation. Recreational participation tends to decline with age and the degree of decline varies with the activity type. Participation in strenuous activities declines more rapidly than other activities. Although the most popular activities on the

San Marcos River are not particularly arduous, most of the people recreating on the river are young. National studies (United States Department of the Interior 1979) have demonstrated that among demographic variables, age has the most value in predicting participation in various recreational activities.

Even though the median age for Hays County residents is expected to increase in the future, the aging of the population is not expected to diminish recreational participation in San Marcos. According to the 1990 Texas Outdoor Recreation Plan (Texas Parks and Wildlife Department 1990), participation in outdoor recreation for the region encompassing the San Marcos area surpasses the state average. In particular, water-related activities have high participation rates. Projected participation is expected to increase into the year 2000. The San Marcos Chamber of Commerce (1988) listed the population of San Marcos at approximately 34,659 permanent residents and 20,530 students and the population of Hays County at 69,200. Projected numbers for the year 2000 indicate a growth in the permanent population of San Marcos to over 50,000. Increases are expected in the student population as well, and the county population is predicted to reach 94,700. The use of the river by local residents and continued growth of the student population will provide a steady source of river recreationists.

Although gender differences in recreational participation have leveled over the past 20 years (United States Department of the Interior 1979), rates of participation remain lower for females than for males. Males participate more than females in such activities as boating, fishing, and outdoor games, while females in the western United States participate about equally as men in swimming (Smith and Theberge 1987). Hammitt et al. (1983) observed more males tubing in Appalachian streams than females. Although sex-related differences in preferred activity or location were not obtained in the present study, observation indicated that participation in all activities is higher for males than for females. Relatively few all-female groups were seen on the river, whereas many male-only groups were observed.

Most of the recreational users of the San Marcos River are from the San Marcos area. Of the questionnaire respondents, 75% were from the city. Based on the projected use of the river for the summers of 1984 and 1992, the number of out-of-town recreationists was 4,577 and 6,719, respectively. Results from a visitor study of the Yakima River Canyon (United States Bureau of Land Management 1988) found that visitors to the canyon generally stayed 2 to 6 h if they were from local towns, while visitors from further distances stayed longer. The majority of users of the

San Marcos River stay at the river for less than 6 h, which suggests that most of the use is local in origin.

It is suspected that the origination of most out-of-town visitors to the river is from within a 97 km radius, or 1-h drive, of San Marcos. Both Austin and San Antonio lie within the prescribed area. Of the out-of-town visitors to the river interviewed, 60% were from Austin. The paucity of visitors from San Antonio can be explained by the number of water-based recreational options which are closer to San Antonio than the San Marcos River. The community supply function, as defined by Cordell and Bergstrom (1991), implies that a closer recreational opportunity will be utilized more often than one at a greater distance, although Peterson et al. (1985) cautioned that changes in consumer tastes and preferences could affect the influence that distance has in predicting demand. Chubb and Chubb (1981) and Siehl and Szwak (1986) anticipate an increasing dominance of recreational use near the place of residence in the future. Projected energy shortfalls could limit travel to distant recreation sites, and Chubb and Chubb (1981) predicted that recreation venues within a tank of gas of the user will thrive. The Bureau of Land Management (1990b) projected that vacation travel to major destinations will decrease in the near future and utilization of closer recreational resources will increase.

Out-of-town respondents to the questionnaire spent an average of $15.44 for expenses related to their trip to the San Marcos River. In contrast, local users of the river often spent nothing. Since the questionnaire indicated that 25% of the users of the river are from out-of-town, and the Lions Club information showed a total of 26,874 tubers using the river in the summer of 1992, the total amount spent on recreation for the summer of 1992 was at least $103,733.64. Based on the use projections for the summer of 1984, the out-of-town expenditures were $70,672.74.

In 1983, food stores, eating and drinking establishments, and auto repair services in San Marcos showed substantial market penetration (Fisher 1984). Market penetration is the extent to which a product or service sells in a given market. For the food-related businesses, market penetration is due to the location of the city on a major travel corridor, IH 35; the importance of tourism to the economy of San Marcos; and the large number of students in the city. Gasoline service stations in the San Marcos area had a relatively low market penetration, possibly because most tourism to the city originates within a 97 km radius.

Water quality and quantity

Aesthetics and water quality were the prime attractants of the San Marcos River identified by questionnaire respondents. A survey of San Marcos residents conducted in 1981 rated the city's scenic beauty and the San Marcos River as the top two benefits of the city and gave highest priority to protecting the natural beauty of the city as well as the San Marcos River, its water quality and supply, and its environmental, cultural, and recreational resources (Freese and Nichols, Inc. 1983). According to the San Marcos Master Plan, the City should recognize that the environmental and cultural resources of San Marcos are an integral part of, and are largely responsible for, the quality of life enjoyed in San Marcos, and that the protection of those resources need not be incompatible with economic and population growth (Freese and Nichols, Inc. 1983).

The greatest threat to the water quality and threatened and endangered species of the San Marcos River may also be the biggest threat to recreational use of the river. Flow in the river is threatened by demands for water from the Edwards Aquifer. As evidenced by legislation (Senate Bill 1477) enacted by the 73rd Texas Legislature in 1993, efforts are under way to reduce the amount of water pumped from the aquifer. However, increased diversions from the aquifer and/or a return of

drought conditions could significantly reduce the flow of the river. The results of the present study did not find a correlation between flow in the San Marcos River and recreational use based on the tube rental data. Other studies indicate that such a relationship exists in streams utilized for recreation. Brown et al. (1992) examined several studies and found a nonlinear relation of recreation to flow in each. In general, recreational quality increases with flow to a point, and then decreases with subsequent increases in flow. Minimum, optimum, and maximum flow values differ with the river or activity being examined.

Although a correlation between flow in the San Marcos River and recreational use was not detected, the projected total numbers of recreationists for 1984 (low flow) and 1992 (high flow) differ markedly. Based only on tube rental data, the 1992 summer season surpassed the use of the river in 1984 by 8,565 recreationists even though the use figures for 1984 included all recreationists. Anecdotal information and observation during the summer of 1984 indicated that reduced flows of the river resulted in a reduction in recreational activity. It is suspected that many of the river recreationists choose to go to rivers with flows more conducive to recreation or forego water-based recreation altogether when flow is below a level suitable for recreation.

Negative aspects of the recreational experience on the San Marcos River associated with reduced flows include increased coverage of emergent vegetation, poorer water quality, and an overall decline in aesthetic parameters. At high flows, tubers are able to float the river; at reduced flows, tubers are more inclined to propel themselves down the river, disturbing the substrate and damaging the vegetation. It is surmised that low flows in the river would lead to increased habitat destruction due to increased contact with the substrate and vegetation by tubers and swimmers alike.

Determinations have been made as to the minimum flows required to protect the species of the San Marcos River (Espey, Huston and Associates 1975), and additional studies are planned (personal communication, Ken Saunders, Texas Parks and Wildlife Department, San Marcos, Texas). Espey, Huston and Associates (1975) determined that a minimum flow of 75 cfs was required to protect the endangered species of the river. Flows sufficient for protecting habitat may not be adequate to support recreational use of the river. Methods exist for determining the minimum flows required to preserve flows needed for recreation. Hyra (1978) indicated that for tubing, a depth of 0.3 m and a width of 1.2 m is the minimum requirement, with a depth of 0.15 m necessary for canoe and kayak traffic. Corbett (1990) derived an equation related to average annual

stream flow to determine minimum flows needed for canoeing. The final form of the equation based on a fit for 45 data points is:

$$Q_{MIF} = 7.52\,(Q_{AAF})^{.582}\,.$$

In this equation, Q_{MIF} is the minimum instream flow for recreational boating and Q_{AAF} is the average annual flow. Application of Corbett's equation to the San Marcos River produces a minimum flow value of 146 cfs.

These methods were developed on streams considerably different from the San Marcos River, and their applicability to the San Marcos River remains untested. On the San Marcos River, the flow needed to provide suitable depths and velocities will vary according to the hydraulic conditions of each particular cross section of the river. Any study to determine the minimum flows required for recreation will need to be site-specific for the San Marcos River.

CONCLUSIONS

This study documented the recreational use patterns of the San Marcos River and showed that recreational use of the San Marcos River occurs primarily during the summer months, with most use on weekends and holidays. Swimming and tubing dominate use of the river,

accounting for 91% of the observed activity. Other activities often take place at times and locations segregated from the influences of swimmers and tubers. Use of the river is lowest in the morning, peaks in the early afternoon, and gradually diminishes in the late afternoon; is partitioned among specific locations; and appears to migrate downstream over the course of the day. The most popular locations on the river are Rio Vista Park and City Park.

Recreational users of the San Marcos River are typically young adult males who live in San Marcos. Out-of-town users generally originate from within an hour's drive of San Marcos. Local users of the river spend very little money for the recreational experience, which typically lasts 2 to 3 h. The most important aspect for recreational users of the San Marcos River is the environmental aesthetics, particularly the water quality. Awareness of the endangered species present in the river is high.

Of the threatened and endangered species of the San Marcos River, the fountain darter and Texas wildrice inhabit the portion of the river which receives the most recreational pressure. Impacts to Texas wildrice have been documented (Emery 1977, Vaughn 1986, Staton 1992) and habitat destruction resulting from recreation could have detrimental effects to the darter. Due to amount of activity, swimming and tubing are the two pursuits which pose the biggest threat. Impacts associated with

these activities include vegetation removal and soil compaction at access and egress points of the river, increased turbidity, and vegetation damage and removal in the river.

Stream flow is the critical element for the survival of the threatened and endangered species of the San Marcos River, and for its continued recreational use. At reduced flows, tubers and swimmers are more likely to come into contact with the substrate and vegetation of the river which results in increased habitat destruction and which diminishes the recreational experience. As flows lessen, recreational use of the river declines. At some as yet unidentified minimum flow, recreational use of the river would cease altogether. In order to provide for continued use of the San Marcos River as a recreational resource, and to protect the species of concern of the river, studies need to be conducted to determine the requisite flows needed to protect the biota in the San Marcos River and to maintain the river as a recreational resource.

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