

COMPUTER ALGORITHMS FOR ASSESSING
REGIONAL RIVER RECREATION RESOURCES

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March, 1979

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CHAPTER 1

INTRODUCTION

The use of rivers for recreation is expanding rapidly. Increases of 50 to 100 percent per year are reported on rivers in nearly every part of the country (Hecock, 1977). In the case of the Illinois River in Oklahoma, estimates indicate that use has ballooned from 80,000 visitor days in 1971 to 250,000 in 1977. While data on other rivers in the region are not uniformly available, the evidence supports the contention that recreational river use in this region is high, and going higher.

This pattern of growth is related to the recent attention focused on rivers as recreational resources by Federal and State Legislation. Congress recently identified (1968) eight rivers to serve as a nucleus for a "National Wild and Scenic River System." Twenty-seven other rivers were subsequently designated for study as potential additions to the system. Twenty-nine additional rivers have been designated as study rivers. In addition to the National System, 24 states have authorized wild and scenic river or waterway systems. Another fifteen states are actively considering such programs. Oklahoma and surrounding states have actively engaged in developing waterways programs. Oklahoma's Rivers Act was passed in 1970.

Other factors are associated with the heightened interest in Rivers as recreational resources. These include the crowded conditions at other recreational facilities, the energy squeeze which

has focused attention upon close-to-home recreational opportunities, the back-to-nature movement in outdoor recreation, and an increasing focus on physical fitness in outdoor recreation. Presumably the efforts geared to the improvement of water quality in our nation's streams are of some relevance.

In spite of the burgeoning use, the heightened interest, and the legislative designations and support for river recreation, there is a surprising lack of useful knowledge concerning the recreational use of rivers available at either national or regional scales. It is impossible to obtain accurate estimate on the use of our rivers, and know even less about who the users are. The existing research is basically all the "case-study" variety, dealing with a single river or river segment. Moreover, focus is primarily on the "white-water" rivers, especially those in the West, and the management problems (use control, trash disposal, etc.) thereof. The great majority of these case studies lack uniformity and comparability. (Hecock, et.al. 1976) As a result it is difficult to paint an overall picture of use patterns.

Little has been done with respect to the recreational use of rivers in the context of total recreational use, or the total recreational resource base.

While analyses of entire river systems have been undertaken, especially in connection with proposals for state recreational waterway systems or as parts of proposals to include rivers in the National System, these attempts have generally concentrated on the

physical and cultural attributes of the rivers. Detailed study of rivers with respect to the distributions of demand over time and space, and alternative recreational opportunities has been lacking.

The research that is described in this report addresses the following shortcomings in our knowledge and capabilities to assess the River Recreation System.

1. lack of knowledge concerning the existing use of rivers;
2. lack of knowledge concerning river use in the context of other existing or potential recreational opportunities;
3. lack of knowledge concerning the recreational potential of rivers given the distribution of population and recreational resources;
4. lack of a capability to readily evaluate such a complex system and to simulate the subsequent effects of changes.

The purpose of the proposed research is to develop and extend knowledge regarding the recreational use planning of rivers. More specifically, it is intended that the following objectives will be accomplished:

1. modification of an existing computer program for evaluating recreational opportunities, reflecting the special character of rivers as recreational resources;
2. testing of the program in Oklahoma and surrounding regions;
3. evaluation of the capabilities of such a system.

To facilitate accomplishment of these objectives, the following procedures were undertaken and will be described in the report.

1. RECSAD, a computer program developed as an outgrowth of B - OKLA - 026 (Tweedie and Hecock, 1976) was evaluated and revised to take into consideration new ideas. RECSAD II is the product of this revision; adding considerable flexibility to its predecessor.
2. certain parameters of river use were obtained in order to establish values to be used in the model;
3. results of a run using RECSAD-II river recreation opportunities in Oklahoma, Arkansas and Missouri will be described;
4. river use data were obtained and will be described in order to assist in evaluating RECSAD-II;
5. the results of the project will be assessed.

The rest of this chapter is devoted to a review of RECSAD and other computer algorithms used in recreation planning. Recent modifications and the RECSAD-II option are also outlined. Chapter two describes and interprets the results of a RECSAD-II run, using rivers in southern Oklahoma, Arkansas, and Missouri. Chapter three reports the results of a test of accuracy of the simulation and describes resultant adjustments in the program. Chapter four is devoted to speculation about future conditions of the river recreation system, and then some conclusions.

Several appendices are included in this report. Appendix I provides a review of literature relating to recreational travel. Appendix II presents an annotated bibliography of computer appli-

cations in recreational planning. A large scale application of RECSAD II, camping opportunities in Oklahoma, is described in Appendix III. A description of computer programs developed specifically for this project are included in Appendix IV.

RECSAD

One of the by-products of an earlier OWRT-sponsored project (B-OKLA-026), was a computer program capable of assessing recreation supply and demand systems. The program and its operation are described and illustrated in full, Tweedie and Hecock (1976).

RECSAD (REcreation Supply and Demand) was designed for use in the evaluation of the adequacy of a single recreational facility, or a series of facilities serving regional demand. In addition, it was to be used to evaluate the regional recreational opportunities available to one or a series of population centers (Logsdon, et.al., 1978).

The program was designed in such a manner that users could select between two commonly used planning strategies (or models of recreational behavior) for evaluating population center opportunities or facility adequacy. First, the "standards" approach, whereby distances are regarded as invariant with respect to demand supply conditions up to a specified distance (often 25, 50, or 75 miles). This approach is commonly used by Federal agencies such as the Army Corps of Engineers or Bureau of Outdoor Recreation in the assessment of the value of a new facility, or by local planning

agencies to determine whether a given community has "sufficient" facilities within a "reasonable" distance according to some accepted "standard". In RECSAD this approach was simply referred to as the "fixed radius method".

Researchers and some state recreation planning agencies have been increasingly persuaded to treat distance as a variable factor in demand-supply assessment. Their notion is that even small increments of distance between users and facilities affects use and the amount of demand that is satisfied or fulfilled. Therefore an additional feature of the program allowed the user to select the "distance decay method", employing a locally-appropriate effect of distance on the demand-supply relationship.

The program addressed the spatial recreation system described by the location of a series of recreation sites and population centers. The system's population centers and recreation sites were "coordinatized" at any convenient scale using a coordinate system. An important feature of the program was its ability to cope with the "boundary problem" which is associated with the fact that a planning region may bear little resemblance to functional recreation regions. Therefore a distinction is made between the sites and population centers which are "of interest" (e.g. within the planning region) and all those sites and centers which have some relevance to evaluating system opportunities or adequacy.

RECSAD was designed to accommodate differences in available data and/or differences in a planner's inclination to emphasize

certain types of data. For example, recreation facility adequacy could be evaluated as if there is no difference in facility quality, or an "attractiveness" weight could be given to each recreation site. System adequacy could be evaluated in terms of regional population, number of participants, or in terms of estimated peak activity occasion levels. Demand could be adjusted to reflect economic, demographic, or other regional variations in population characteristics. Provisions for accomodating seasonal variations in participation were also included in the program.

The program was used to evaluate the impact or assess the utility of various planning strategies - new recreational sites, population growth, or redistribution, changes in participating rates and travel behavior.

Output from the program could be punched and utilized as inputs to computer mapping programs, descriptive statistics packages, or quantitative analytical programs.

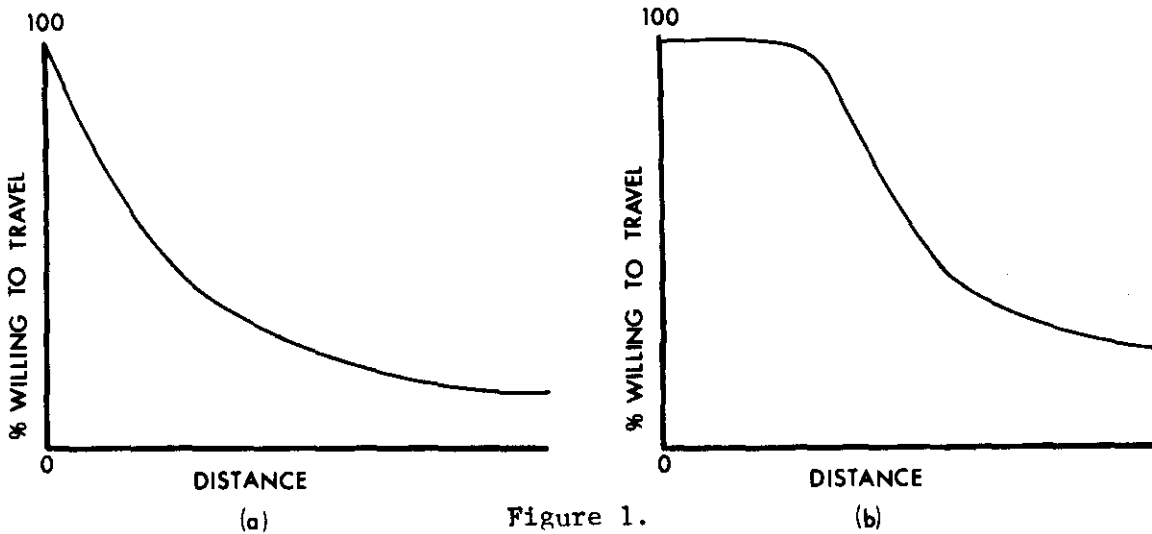
RECSAD to RECSAD II: An Evolution

While the original RECSAD program appeared to be satisfactory in many respects, it was determined that the distance decay method was unsatisfactory, and it was replaced by a new version called RECSAD II.

The model used in the original Distance Decay method assumed a very rapid decrease in user willingness to travel with a graduate increase in distance from the recreation site. The shape of the

distance decay curve used to calculate the probabilities of traveling a given distance between population centers and recreation sites is depicted in figure 1a. This model did not appear to reflect actual travel behavior.

Figure 1b shows the right half of the curve for the normal distribution. The shape of this curve would appear to be much more consistent with what is known about recreation travel behavior. (See Appendix I) Willingness to travel drops off gradually in the vicinity of the recreation site, then decreases rapidly as the distances involved become an impediment. As travel distances reach major magnitude, and increments to distance becomes less important in relative terms, the curve finally levels off at a low willingness level.



As indicated above, the basic curve has the shape of the right half of a normal curve, and represents the relationship between distance (on the x-axis) and the proportion of the population willing to travel a given distance (on the y-axis). These values start at 1.0 (at

distance = 0) and approach zero as distance increases.

Two conditions determine the position of these curves. First, the median distance to all recreation sites is calculated separately for each population center. Places that are far removed from most recreation sites, such as location in western Oklahoma, will have large median distances compared with places in the eastern part of the State. Second, willingness to travel with respect to the median distance is introduced as a constant proportion throughout the system. This value can be changed from one run to the next to simulate changes in travel costs or willingness to travel.

The result of these two conditions is that decay curves for specific population centers can be elongated or compressed, depending on the input conditions. Figure 2a shows the effect of dropping the proportion willing to travel the median distance from fifty (curve 1) to twenty-five percent (curve 2) with a median distance of 200 miles. This would depict a situation where high travel costs curtail travel in general.

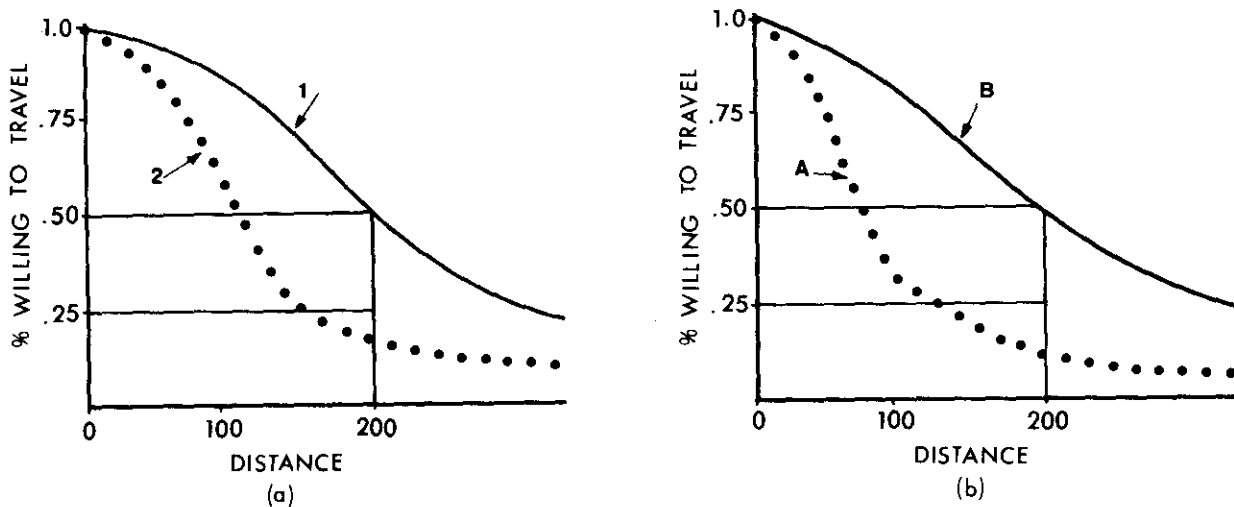


Figure 2.

Figure 2b is a comparison of two cities with different median distances. City A has a median distance of 100 miles compared with 200 miles for city B. In Oklahoma this would approximate the situation for Tulsa and Guymon. In each case 50% of the people are willing to travel the median distance, but because of differences in access to the recreation system residents of city B are willing to travel farther.

Since RECSAD is designed to assign all demand to recreation sites, curves depicting the number of users vs. distance travelled under differing conditions will intersect. Assuming a decreased willingness to travel as illustrated in Figure 2a, users will be forced into nearby recreation sites as depicted in Figure 3a.

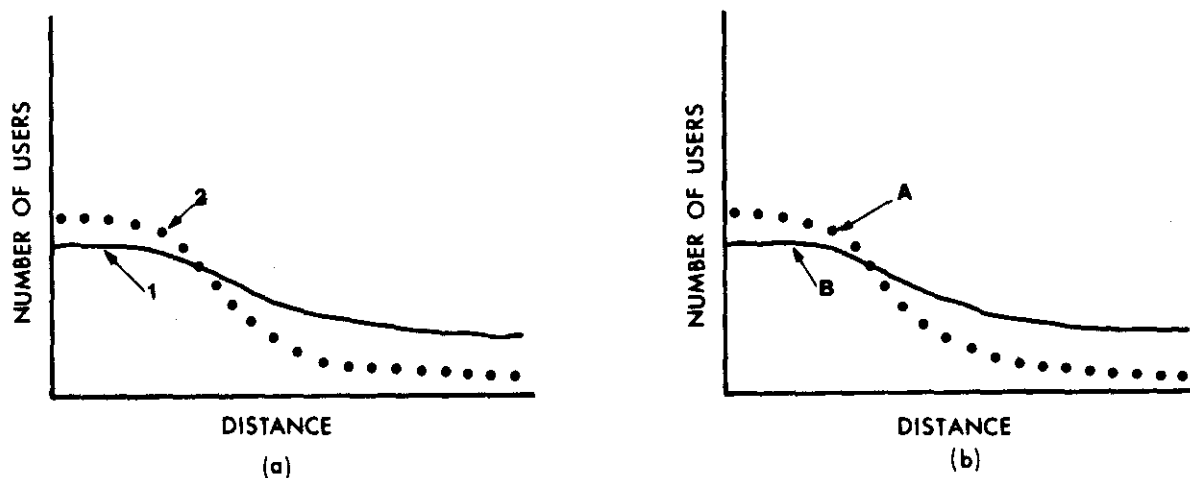


Figure 3.

Assuming that cities A and B have equal populations, figure 3b shows the number of users compared with distance travelled for the situation illustrated in figure 2b. People poorly served by the recreation system make a greater number of long distance trips.

Finally, both participation rates for specific population centers, and attractiveness of individual recreation sites, can be varied independently. These RECSAD options would influence the ideal shapes of the above curves. They have not been used in the present study.

The general mathematical equation for curves of the type illustrated in figure 1b is $Y = e^{-.5x^2}$. In RECSAD II this basic equation has been adjusted to allow for regional differences in willingness to travel due to relative abundance of recreational opportunities. For example, half of the river recreation opportunities in Oklahoma lie within about 100 miles of Tulsa, whereas for locations in the Panhandle the median distance to river recreation opportunities exceeds 200 miles. Under these circumstances it is reasonable to assume that western Oklahomans are willing to travel farther for river recreation.

This premise has been incorporated in the model by changing the basic equation to:

$$Y = e^{-.5 \left(\frac{D}{MDIST} * \sqrt{\frac{\text{LOG}(PCTMD)^2}{-.5}} \right)^2}$$

where D = distance between the population center and the recreation site.

MDIST = for each population center, the median distance to the set of recreation sites weighted by capacity (or thus the median distance to its recreation opportunities.)

PCTMD = the percent of the population willing to travel
the median distance.

MDIST is calculated separately for each population center.
PCTMD is input to the program and can be varied arbitrarily between
a high of 1.0 (everyone willing to travel the median distance) and
a low of 0.0 (no one willing to travel that far).

A simple example illustrates the use of this equation. (Figure 4)

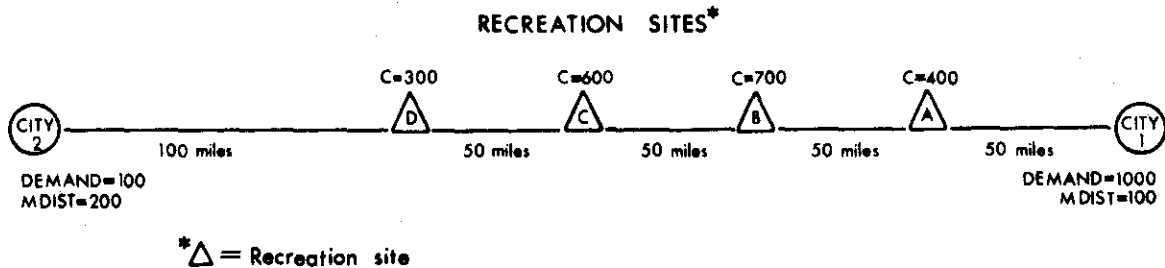


Figure 4.

Given two population centers, center A with a median distance
to the recreation sites of 100 miles (MDIST = 100) and center B
with a median distance of 200 miles. (MDIST = 200). Table 1
shows the proportion of the population from each center that is
willing to travel to recreation sites at selected distances, assuming
fifty percent of the population is willing to travel the median
distance (PCTMD = .50).

TABLE 1 (PCTMD = .50)

	Miles					
	50	100	150	200	250	300
Center A (MDIST = 100)	.84	.50	.21	.06	.01	-
Center B (MDIST = 200)	.96	.84	.68	.50	.34	.21

If only 25% of the population are willing to travel the median distance the probabilities decline accordingly. (Table 2)

TABLE 2 (PCTMD = .25)

	Miles					
	50	100	150	200	250	300
Center A (MDIST = 100)	.71	.25	.04	-	-	-
Center B (MDIST) = 200	.92	.71	.46	.25	.11	.04

In RECSAD II these values are adjusted according to the capacity of the recreation sites. A recreation site whose capacity is small relative to the demand at the population center should have limited appeal since it would be quickly overrun. By multiplying the probabilities by the ratio of the capacity of the recreation site to the demand at the population center ($ROOM = RFAC(J)/POP(I)$) the drawing power of the small recreation sites is reduced. While this procedure could also be used to increase the drawing power of large recreation areas, at present the program sets $ROOM = 1.0$ whenever capacity exceeds demand.

At this point RECSAD II has calculated a statistic that can be interpreted as the probability that residents at a specific population center are willing to travel to each specific recreation site, viewed in isolation from other sites. In a large problem (system) the sum of these values would be greater than 1.0, and consequently, using these values to assign users would result in considerable overcrowding.

In order to adjust the user flows from a specific population

center in proportion to the relative willingness to travel to each individual recreation site, the program now sums these values for all recreation sites. The number of users assigned to each site is then determined by that site's proportional contribution to the sum. These calculations are illustrated for the example in Figure 4 (Table 3).

TABLE 3
ILLUSTRATION OF SAMPLE CALCULATIONS

Pop Center	Rec Site	Prob	Room	Adjusted Prob	Proportional Prob	Users
1	A	.84	.4	.34	.405	405
	B	.50	.7	.35	.417	417
	C	.21	.6	.13	.155	155
	D	.06	.3	.02	.023	23
				<u>.84</u>		<u>1000</u>
2	A	.34	1.0	.34	.14	14
	B	.50	1.0	.50	.21	21
	C	.68	1.0	.68	.29	29
	D	.84	1.0	.84	.36	36
				<u>2.36</u>		<u>100</u>

City 1 is representative of places in eastern Oklahoma, with a relatively small median distance to the recreation sites. City 2 illustrates the situation in western Oklahoma. For city 1, 84% are willing to travel the 50 miles to recreation site A, but only 50% are willing to make the 100 mile trip to B. In contrast 84% of the residents of city 2 are willing to travel the 100 miles to park D, their nearest opportunity. People in city 2, with fewer local recreation opportunities, are more willing to make longer trips.

The effect of the adjustment for the size of the recreation

facility is illustrated for city 1. Site A can only accomodate 40% of the demand, site B can handle 70%, etc., and the probabilities are adjusted accordingly. The result is that site B attracts more users than site A (417 compared with 405) despite its greater distance. Obviously this is the intended effect. Residents of city 1 are forced to travel farther than they would prefer because the large demand overwhelms the nearest sites. For city 2, with its small demand, the capacity of the recreation sites is not a factor.

The assigned use for city 2 is much more evenly distributed than for city 1, since distance is a less important determinant. In the example 64% of the users from city 2 travel at least 150 miles compared with only 18% of these from city 1.

The use of RECSAD II for a large problem has been illustrated in the analysis of camping supply and demand in Oklahoma. (Logsdon, Appendix II).

CHAPTER 2

THE APPLICATION OF RECSAD II TO A RIVER RECREATION SYSTEM

In order to provide a test of the ability of the RECSAD II program to assist in the assessment of river recreation demand and flows, six rivers were identified as study rivers (figure 5a). These rivers are a subset of approximately 76 rivers in Oklahoma, Arkansas, Missouri, Illinois, Kansas, Tennessee, Louisiana, Iowa, and Mississippi and represent all of the major recreation rivers in these States.

In addition 120 population centers, defined by U.S. Postal Service three-digit Zip Code areas were utilized as population centers, or demand points for the test (figure 5b). Three-digit Zip Code areas were used in preference to other areal units such as counties or minor civil divisions because they offer a reasonable amount of aggregation, they have significance in terms of the functional organization of space, and provide a substantial amount of easily accessible population detail.

The extent of the study area was determined by drawing a generalized boundary extending approximately 500 miles from a point near the center of the study rivers. The need for such a large study area, including such a large number of rivers and population centers is linked to the fact that rivers in all directions from a population center figure in the apportionment of that center's demand. Therefore, while the six study rivers are the center of attention, rivers at rather great distances are "competitors" for purposes of this program, and must be taken into consideration. This is a boundary-setting problem which has been described previously in detail (Hecock and Tweedie, 1976).

Table 4 indicates the program inputs for an initial run of the

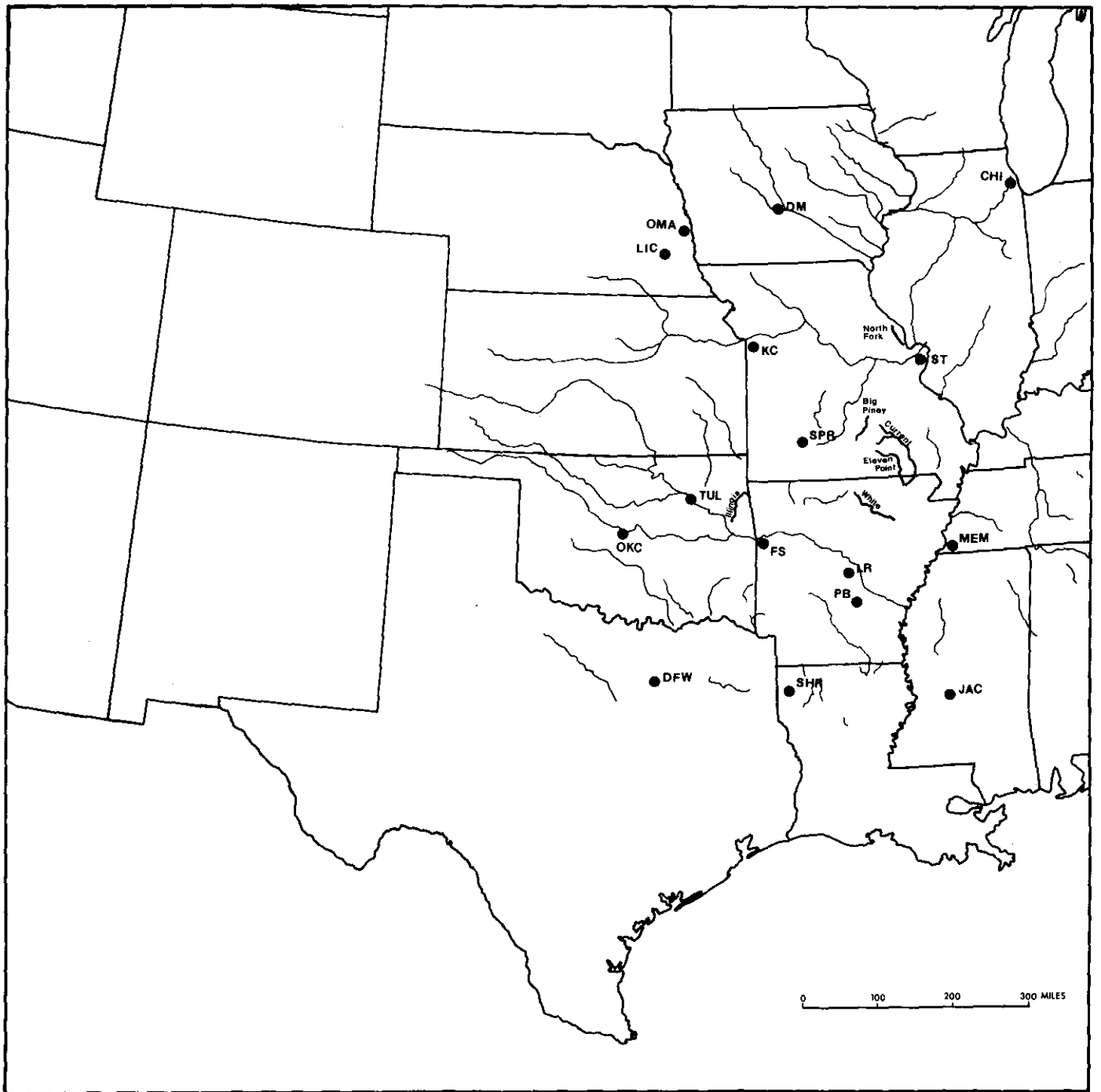


Figure 5a. Rivers Used In This Study.



Figure 5b. Population Centers (3-Digit Zip Code Regions).

RECSAD II program for the estimation of user demand for, and flows to, the study rivers. The figures chosen for participation rates and willingness to travel were determined from a review of published and unpublished studies of river recreation use and users (as reviewed in Hecock, 1977).

TABLE 4
RECSAD II PROGRAM INPUT CONDITIONS

Number of Population Points	120
Number of Population Points of Interest	120
Number of Recreation Sites	74
Number of Recreation Sites of Interest	6
Scale (km or miles per inch)	80.000
Participation Rate (per 100,000)	1000.
Capacity Per Unit Facility	300.0000
Percent Willing to Travel Median Distance	0.25

The distinction between total recreation sites and "recreation sites of interest" is made because the total set of rivers influences the demand for, and flows to, the six study rivers ("recreation sites of interest"). The demand estimates for most of the remaining 70 rivers are probably incomplete to the extent that they may receive users from population points beyond the boundaries of the study.

The participation rate is a peak day participation, or maximum possible participation rate at any particular time.

In this application of RECSAD II capacities for the rivers are set artificially high which removes the effect of capacities in the

operation of the model. The rationale for this is based on the fact that capacities for most rivers are ill-defined, not well-understood, and not enforceable. (This is in contrast to the case of campgrounds where a finite amount of space is usually available, and capacities are rather easily estimated and enforced.)

Coordinates (X, Y) for Zip Code centers and major access points for each of the 76 rivers in the system were used as locational inputs to the program.

The results of this initial run of RECSAD II are summarized in Table 5. The model accounts for over 200,000 peak user days in the entire study area. In this run it is assumed that the origins of this demand are distributed in accordance with the distribution of population. Approximately 13 percent of this demand, about 28,000 users are received by the six study rivers. Of the 200,000 users approximately 50 percent travel 200 miles or less in order to obtain their river recreation experience.

TABLE 5
RECSAD II RESULTS

Total Demand Generated in Study Area	222651
Demand Satisfied by Study Rivers	78173
Percent of Study Area Demand Satisfied by Study Rivers	12.7

Distance (miles)	Trips	Percent	Cum, Trips	Cum, Pct
0.0 - 24.9	0.	0.0	222452.	100.0
25.0 - 49.9	4745.	2.1	217707.	97.9
50.0 - 74.9	3733.	1.7	213974.	96.2
75.0 - 99.9	10866.	4.9	203108.	91.3
100.0 - 124.9	15904.	7.1	187204.	84.2
125.0 - 149.9	16255.	7.3	170949.	76.8
150.0 - 174.9	18271.	8.2	152677.	68.6
175.0 - 199.9	19216.	8.6	133461.	60.0
200.0 - 224.9	19585.	8.8	113876.	51.2
225.0 - 249.9	17886.	8.0	95991.	43.2
250.0 - 274.9	18621.	8.4	77370.	34.8
275.0 - 299.9	16210.	7.3	61160.	27.5
300.0 and over	13196.	5.9	47964.	21.6

The amount of visitors received by each study river varies from about 4000 to over 5100 (Table 6).

TABLE 6
PREDICTED USE BY RIVER

River	Total Users
Big Piney (MO)	4939
Currant (MO)	4716
Eleven Point (MO)	4727
Illinois (OK)	4090
North Fork (MO)	5147
White (AR)	4533

For each river the number of users from each of the 120 population centers is obtained. Flows from selected population centers are presented in Table 7. According to this preliminary run of RECSAD II, St. Louis, Missouri contributes 9.7 percent of total users to the North Fork, but only 4.6 percent to the Illinois River in Oklahoma.

Using altered sets of input conditions, additional runs of RECSAD II were made. The specific inputs for each run are portrayed in Table 8. The number of population centers, number of rivers, the number of rivers of interest and the scale designations were the same in each run. Changes were limited to participation rates and willingness to travel in the belief that these are the critical variables with respect to regional flows of river recreationists.

TABLE 7

PERCENT OF TOTAL PEAK USE PREDICTED FROM SELECTED POPULATION CHANGES

Zip Code Number	381	386	631	639	641	722	741	Total Predicted Use
Place Name	Memphis (Tennessee)	Batesville (Mississippi)	St. Louis (Missouri)	Doniphan (Missouri)	Kansas City (Missouri)	Little Rock (Arkansas)	Tulsa (Oklahoma)	
Big Piney	3.8	1.1	8.3	.5	3.0	1.2	1.5	4939
Currant	4.7	1.4	7.4	.5	2.6	1.2	1.6	2470
Eleven Point	5.1	1.5	7.9	.5	2.2	1.2	1.3	4727
Illinois	3.3	1.1	4.6	.3	3.6	1.3	2.9	4090
North Fork	2.5	.7	9.7	.5	3.4	.6	1.2	5147
White	4.6	1.4	6.6	.5	2.7	1.3	1.9	4553

TABLE 8

SELECTED PROGRAM INPUTS FOR FIVE RECSAD II RUNS

Run	Peak Day Participation Rate (rate/10000 inhabitants)	Willingness To Travel Median Distance (percent)
1	1000	25
2	500	25
3	1000	10
4	1000	5
5	100	5

The results of the four additional runs are summarized in Tables 9 and 10. As expected, the relative amount of use predicted varies with each run and the patterns of distances traveled varies in accordance with the willingness to travel specified as inputs to the respective runs of the model.

TABLE 9

TOTAL PREDICTED PEAK USE, BY RIVER, FOR FIVE RECSAD RUNS

	RECSAD Runs				
	1	2	3	4	5
Big Piney	4939	2470	5020	4838	484
Current	4716	2358	4723	4533	453
Eleven-Point	4727	2364	4790	4660	466
Illinois	4090	2045	4033	3918	392
North Fork	5147	2574	5481	5508	551
White River	5433	2277	4506	4304	430
All Rivers of Interest	29052	14088	28553	27761	2776
All Rivers in System	222561	111325	222561	222651	22265

TABLE 10

PROPORTION OF TOTAL PREDICTED USE FROM EACH ZONE FOR EACH RECSAD II RUN

Distance Zone (miles)	Proportion of Total Use from Each Zone for Each RECSAD II Run (percent)				
	1	2	3	4	5
0- 25	2.1	2.1	3.1	3.8	3.8
26- 50	1.7	1.7	2.4	3.0	3.0
51- 75	4.9	4.9	6.9	8.3	8.3
76-100	7.1	7.1	9.8	11.5	11.5
101-125	7.3	7.3	9.6	11.1	11.1
126-150	8.2	8.2	10.3	11.4	11.4
151-175	8.6	8.6	10.2	10.8	10.8
176-200	8.8	8.8	9.6	9.6	9.7
201-225	8.1	8.1	8.1	7.7	7.7
226-250	8.4	8.4	7.8	6.9	6.9
251-300	7.3	7.3	6.2	5.1	5.1
301 and over	5.9	5.9	4.6	3.6	3.6

Flows from selected population centers to the study rivers are depicted in Tables 11a, b, and c. The amount of users a river receives from a given city depends upon the nearness of that city to the river, the participation level, the willingness to travel, the number of intervening or competing river recreation opportunities.

Total predicted flows of users for the Eleven Point River (Missouri) are depicted for each run in Figures 6a through 6e. Note that the varying program inputs produce flow maps which differ both in terms

TABLE 11a

PREDICTED FLOWS TO STUDY RIVER FROM MEMPHIS, BY RECSAD RUNS

	Amount of Total Use from Memphis to Specified River by Run				
	1	2	3	4	5
Big Piney	186	93	212	219	22
Current	220	110	280	315	32
Eleven Point	239	120	323	379	38
Illinois	134	67	123	109	11
North Fork	130	65	118	102	10
White	210	105	261	287	29
All Rivers	6656	3328	6656	6656	666

TABLE 11b

PREDICTED FLOWS TO STUDY RIVER FROM ST. LOUIS, BY RECSAD RUNS

	Amount of Total Use from St. Louis to Specified River by Run				
	1	2	3	4	5
Big Piney	408	204	477	499	50
Current	350	175	369	357	36
Eleven Point	372	186	409	407	41
Illinois	189	94	132	94	9
North Fork	499	250	667	771	77
White	300	150	286	256	26
All Rivers	13354	6677	13354	13354	1335

TABLE 11c

PREDICTED FLOWS TO STUDY RIVER FROM TULSA, BY RECSAD RUNS

	Amount of Total Use from Tulsa to Specified River by Run				
	1	2	3	4	5
Big Piney	75	37	72	65	7
Current	75	37	73	66	7
Eleven Point	63	31	54	45	4
Illinois	117	58	152	172	17
North Fork	60	30	51	41	4
White	85	42	89	86	9
All Rivers	3529	1765	3529	3529	353

of intensity and direction of flows. Ricky Jones, graduate assistant in geography, assisted in the preparation of Chapters 2 and 3.

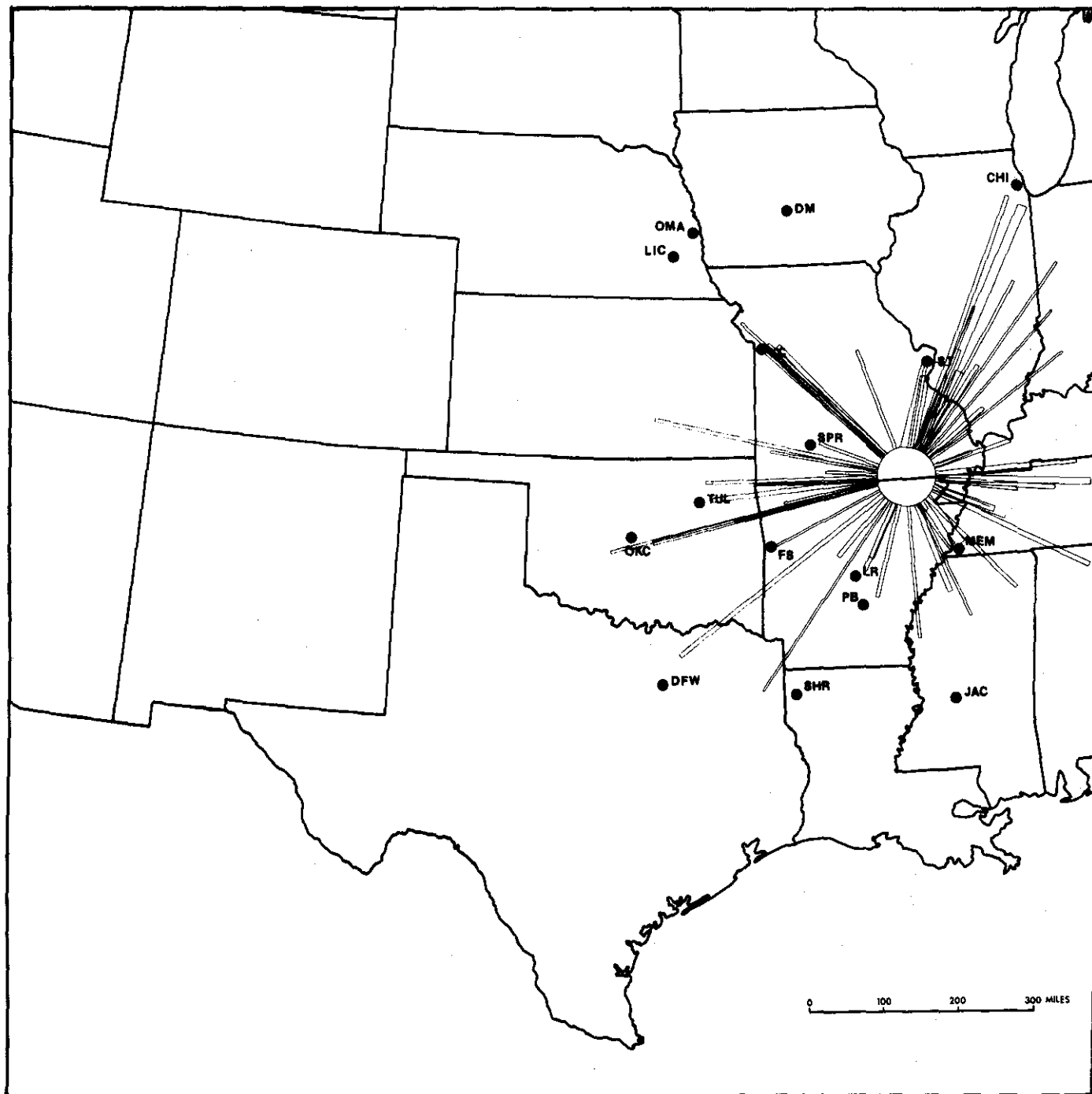


Figure 6a. Eleven-Point River, Predicted Travel, RECSAD Run #1.



Figure 6b. Eleven-Point River, Predicted Travel, RECSAD Run #2.

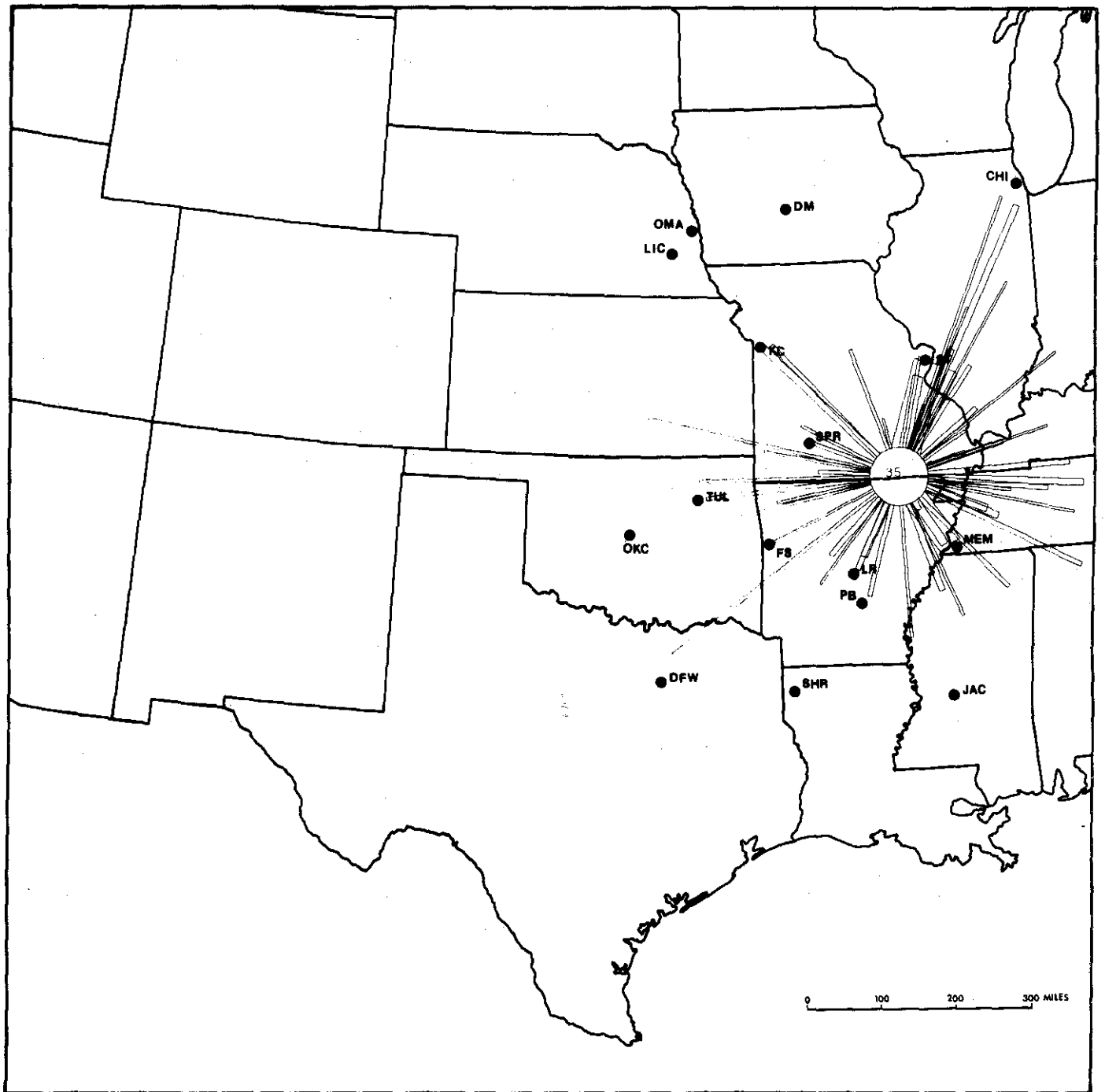


Figure 6c. Eleven-Point River, Predicted Travel, RECSAD Run #3.



Figure 6d. Eleven-Point River, Predicted Travel, RECSAD Run #4.

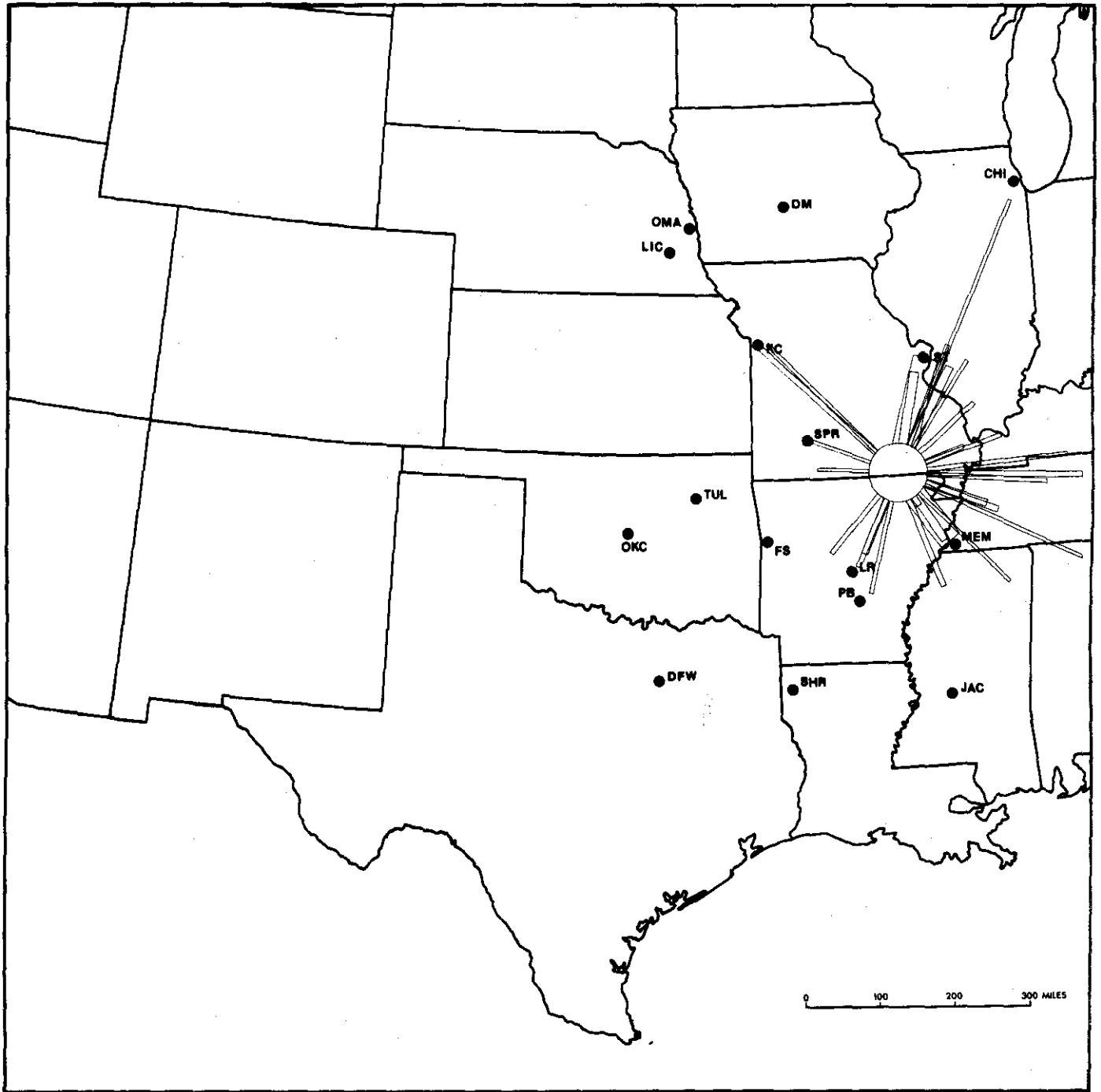


Figure 6e. Eleven-Point River, Predicted Travel, RECSAD Run #5.

Chapter 3

RECSAD AND REALITY: AN ASSESSMENT

In order to assess the capability of RECSAD II to accurately predict flows between population centers and rivers, data on visitor origins were obtained for the Study Rivers. These data were obtained through various means, in some cases river manager's files were used, while in other instances data were collected through the use of interviews.

Data for each river were summarized using ZIPDIST and compared with RECSAD Run #5 selected for the purpose because its overall predicted use levels were comparable to sample sizes obtained for the study rivers.

Table 12 indicates the distances traveled by 1730 river recreationists and the predicted travel characteristics of 2775 users using RECSAD II.

TABLE 12

PREDICTED AND EMPIRICALLY DETERMINED
TRAVEL BEHAVIOR OF RIVER USERS FOR SIX STUDY RIVERS

Miles Traveled	Six Study Rivers Percent of Total Users	
	Empirical Data	RECSAD Predictions
0 - 50 miles	13.2	6.8
51 - 100	6.6	19.8
101 - 150	27.8	22.5
151 - 199	22.8	20.5
200 - 249	15.0	14.6
250 and over	14.5	8.7
N =	1730	2775

While the results obtained are similar in broad outlines, RECSAD appears to underpredict usage originating close to, and far from, the

ivers. It should be noted that there is considerable variation among the rivers in terms of actual flows. (Table 13).

TABLE 13
 ACTUAL TRAVEL DISTANCES OF USERS OF STUDY RIVERS
 COMPARED TO RECSAD TRAVEL DISTANCES
 (Run 5)

Distance Zones (miles)	Predictions			Actual Travel			
	RECSAD II	11-Point	Current	North Fork	White	Illinois	Big Piney
0 - 50	6.8	5.3	1.7	8.1	53.1	15.9	27.0
51 - 100	19.8	7.01	7.24	6.2	10.2	11.6	1.5
101 - 150	22.5	16.2	56.6	5.4	20.4	16.6	43.0
151 - 200	20.5	40.1	9.0	29.3	6.1	28.8	7.5
201 - 250	14.6	7.2	10.3	33.2	2.0	20.6	12.5
250 and over	8.7	24.1	15.1	17.8	8.2	6.6	8.5
N =	2775	415			49	320	400

In order to assess the ability of RECSAD to provide reasonable predictions of flows, comparisons were made between actual and predicted flows between selected population centers and each study river. (Table 14).

TABLE 14

ACTUAL AND PREDICTED FLOWS BETWEEN
SELECTED POPULATION CENTERS AND STUDY RIVERS

River	(% of Total River Use From Selected Population Centers)						
	Memphis (TN)	Batesville (MS)	St. Louis (MO)	Doniphan (MO)	Kansas City (MO)	Little Rock (ARK)	Tulsa (OK)
Big Piney							
RECSAD #5	4.5	1.0	10.3	.8	3.3	1.2	1.4
Actual	0	0	14.8	0	1.5	0	0
Current							
RECSAD #5	7.06	1.77	7.95	.9	2.4	2.0	1.6
Actual	3.6	0	31.7	1.4	5.1	0	.3
11-Point							
RECSAD #5	8.2	1.9	8.9	.9	1.7	1.7	.7
Actual	14.4	2.4	14.5	1.4	5.3	0	1.0
Illinois							
RECSAD #5	2.8	1.0	2.3	.3	3.8	2.0	4.4
Actual	0	0	0	0	.1	.6	18.1
North Fork							
RECSAD #5	1.8	.4	13.9	.5	4.2	.4	.7
Actual	.8	0	3.5	0	13.9	0	0
White							
RECSAD #5	6.7	1.8	6.1	.7	2.6	2.3	2.1
Actual	4.1	0	0	0	0	8.2	0

The predicted and actual flows differ substantially from each other. Nevertheless, there are some general similarities, especially in the case of the 11-Point and the Big Piney Rivers.

The overall patterns of flows are depicted in pairs of flow maps, Figures 7a through 7f and Figures 8a through 8f. Note that in these maps flows are scaled in such a way as to obtain total flow levels which are comparable from map to map. Once again there are a number of cases where there is rather close correspondence between predicted and actual flow maps. Nevertheless, there are several instances where the differences are great. In such cases, the problem seems to have to do with RECSAD's inability to account for intervening and com-



Figure 7a. Illinois River Observed Travel.

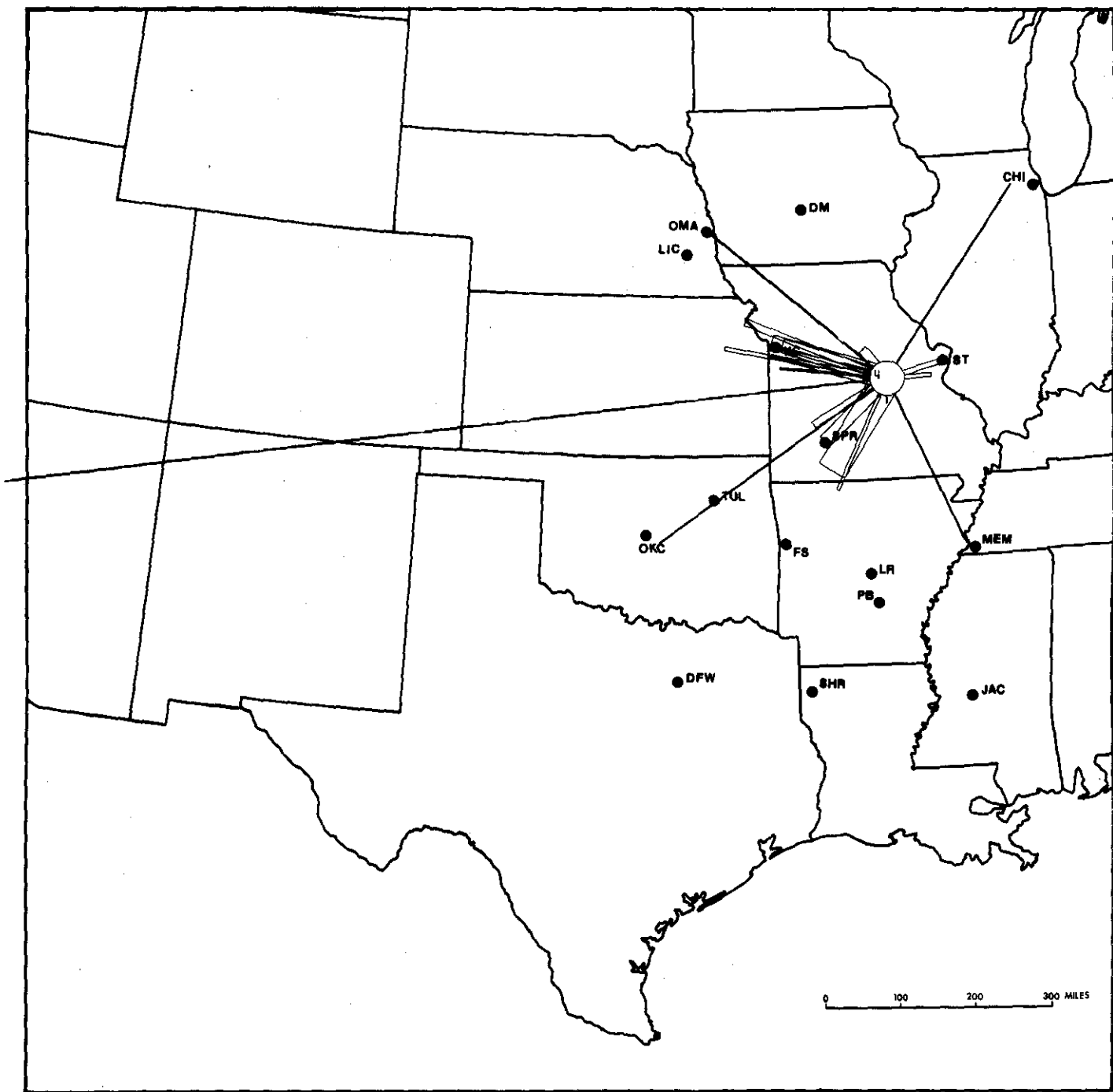


Figure 7b. North Fork River Observed Travel.

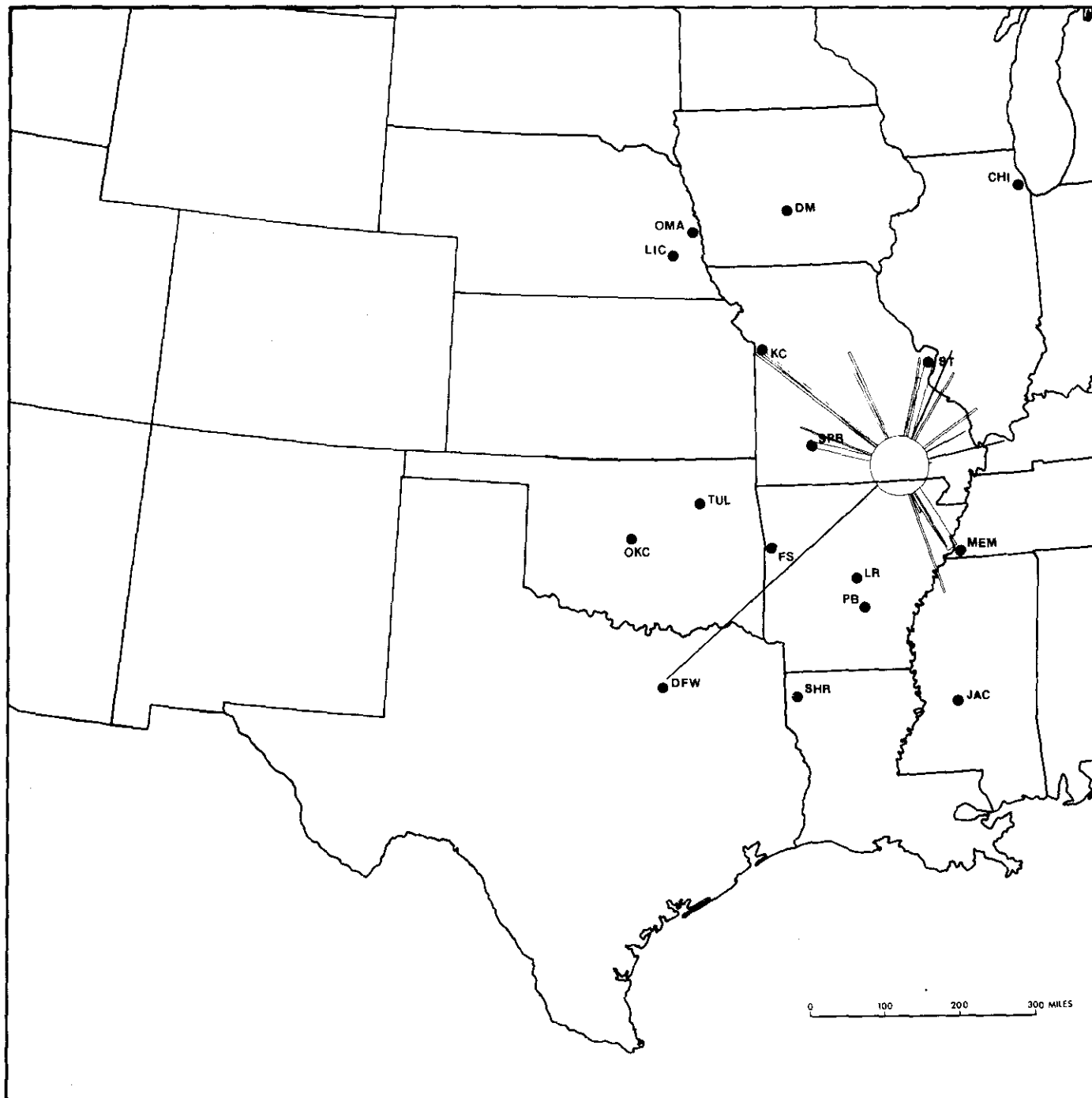


Figure 7c. Eleven-Point River Observed Travel.

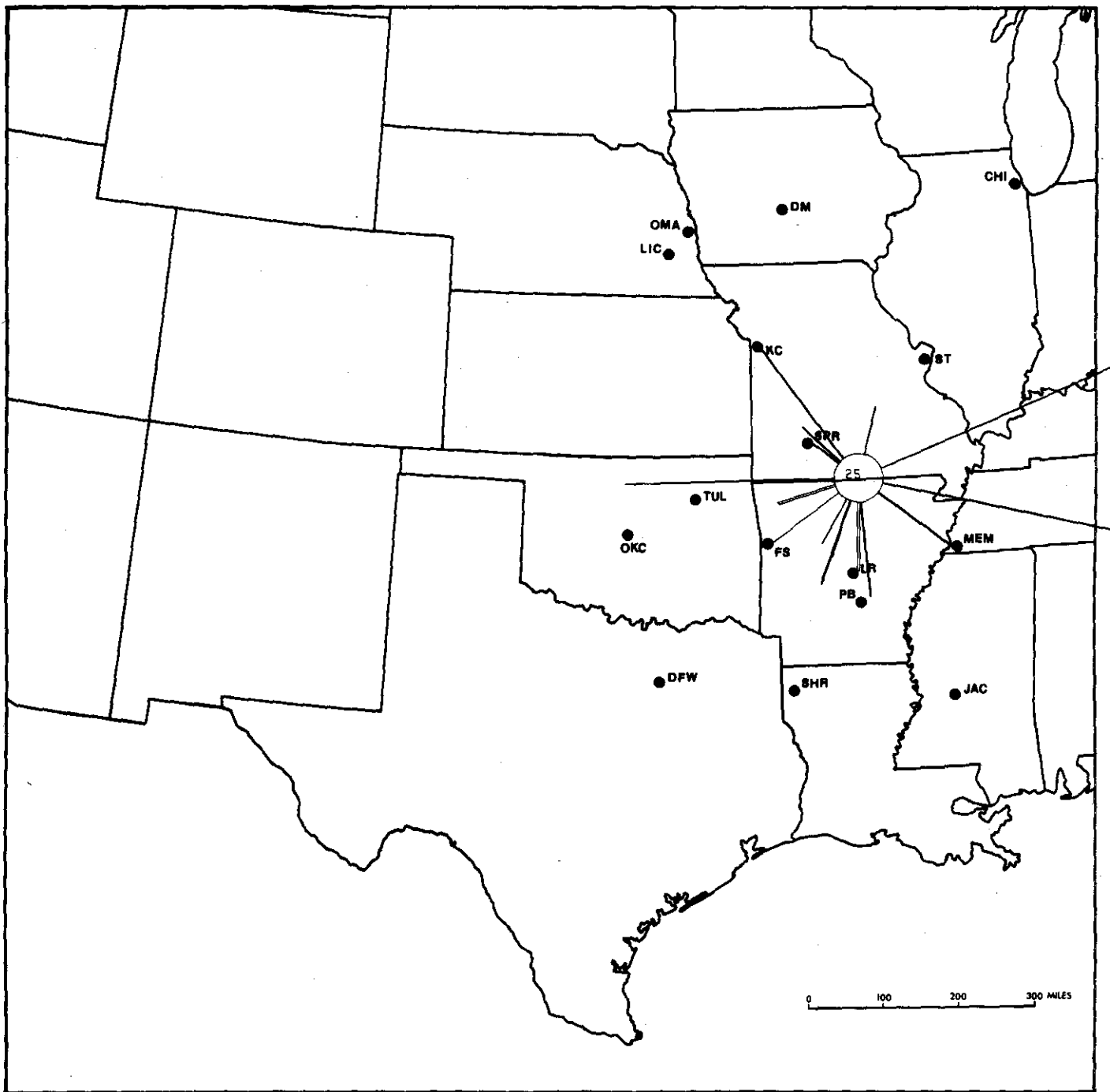


Figure 7d. White River Observed Travel.

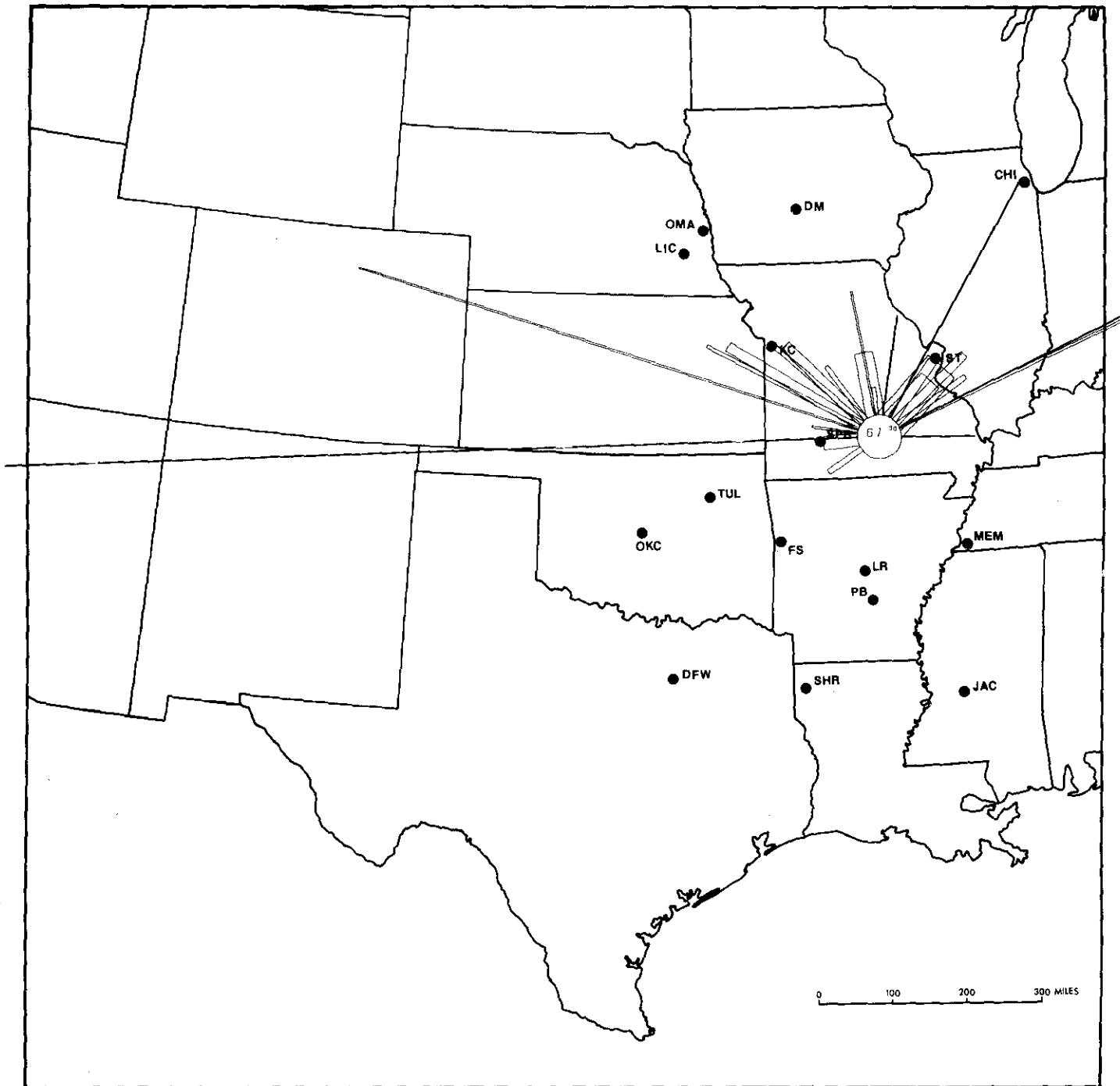


Figure 7e. Big Piney River Observed Travel.



Figure 7f. Current River Observed Travel.

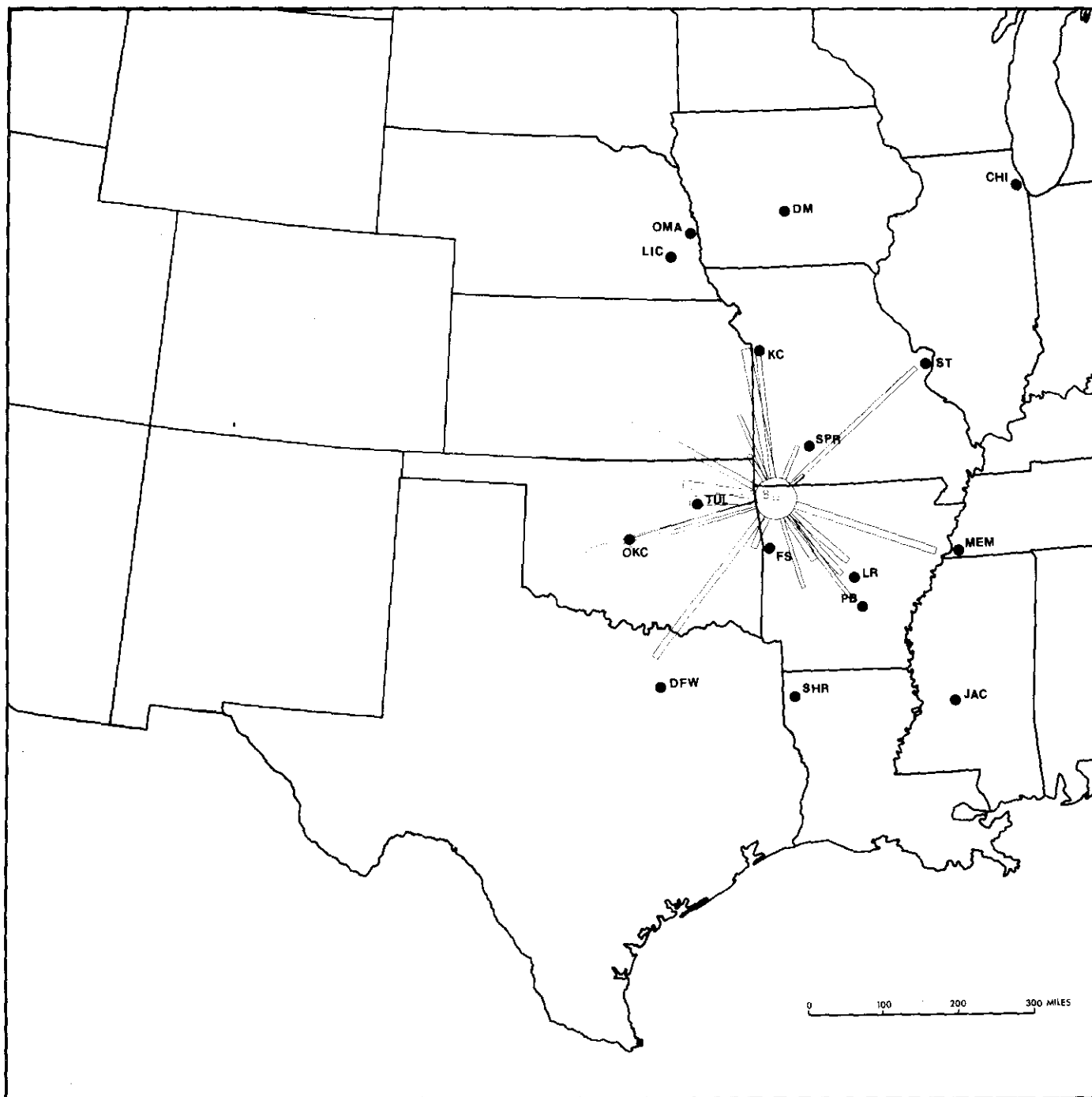


Figure 8a. Illinois River Predicted Travel.

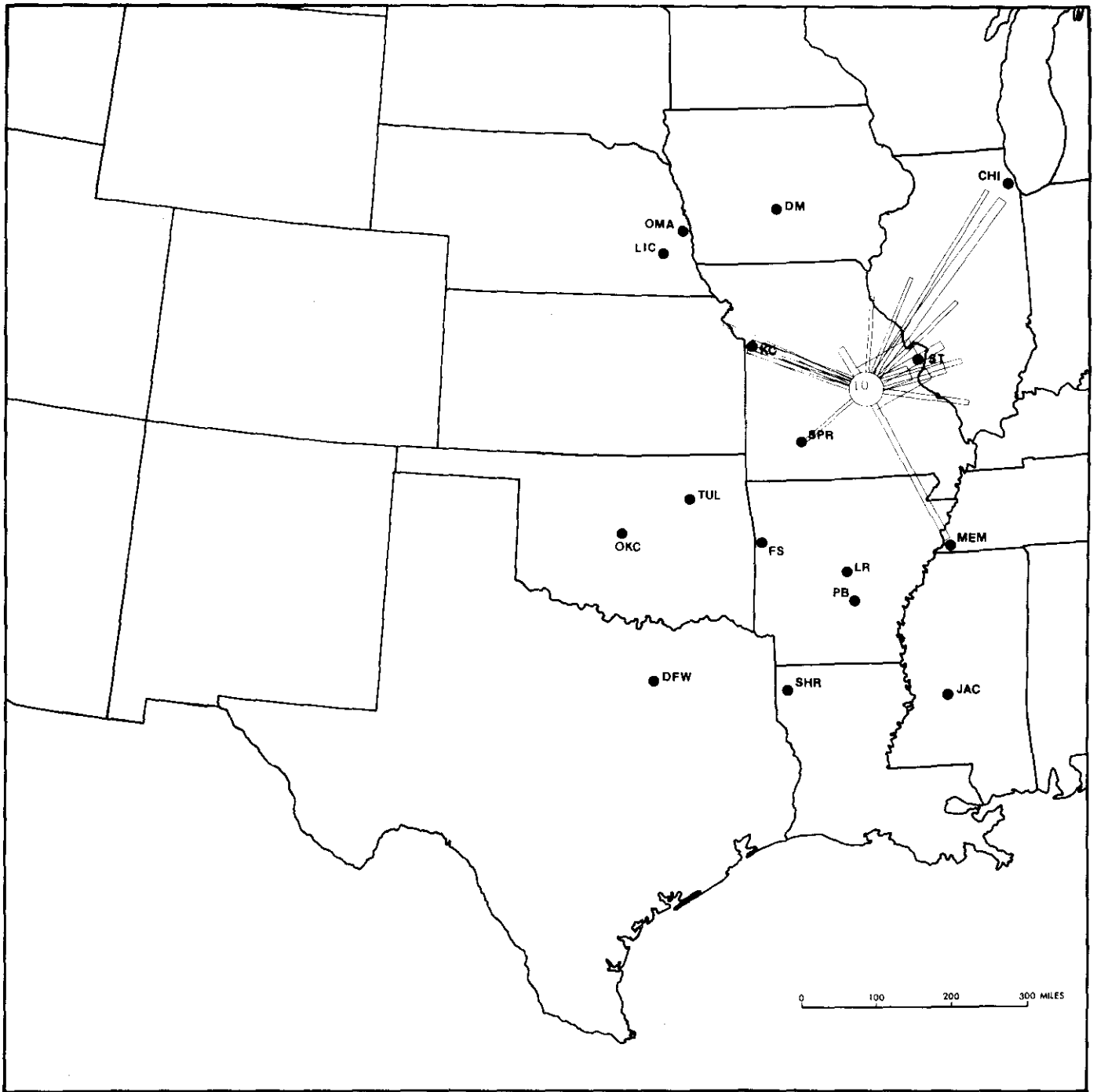


Figure 8b. North Fork River Predicted Travel.

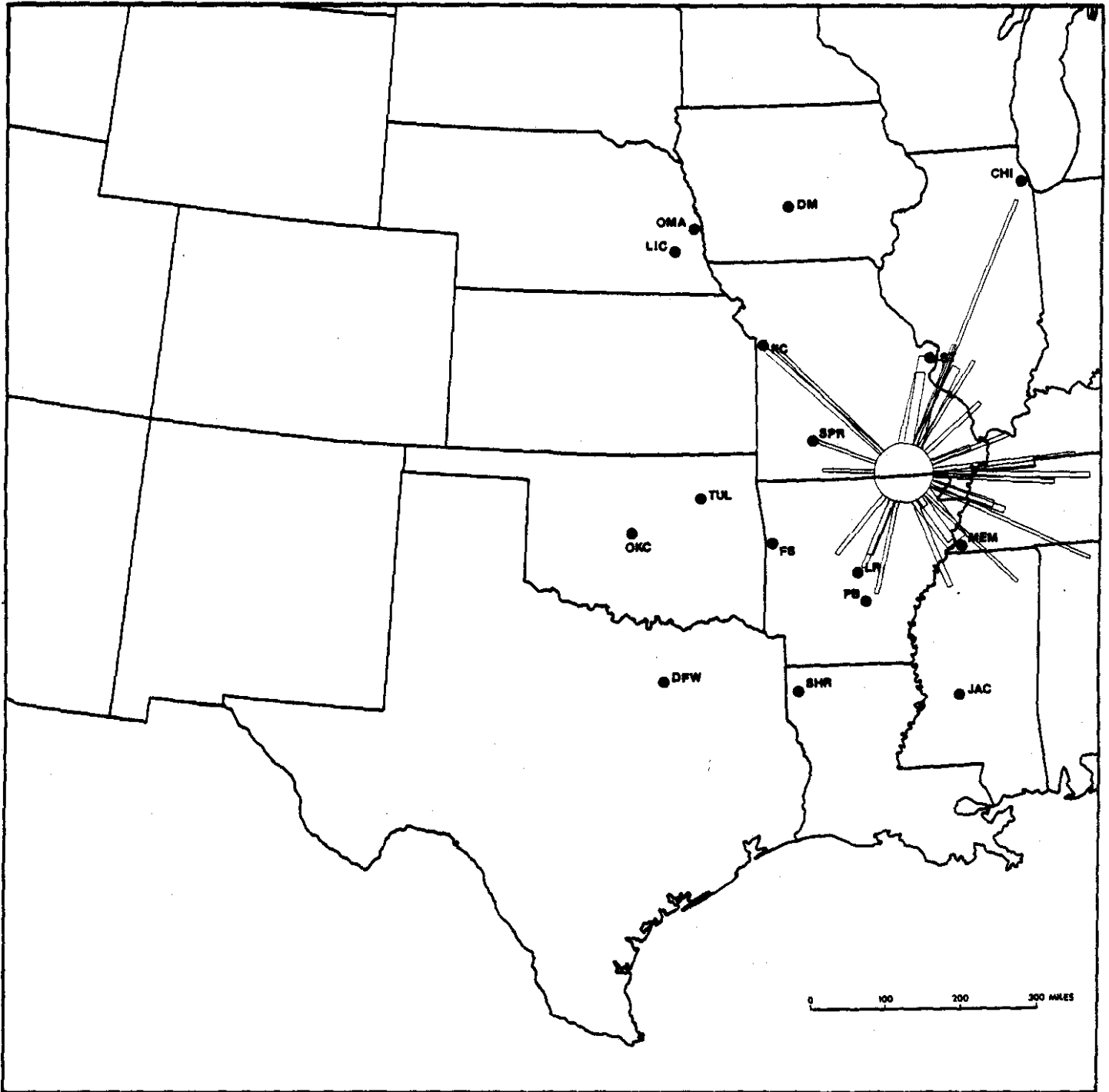


Figure 8c. Eleven-Point River Predicted Travel.



Figure 8d. White River Predicted Travel.



Figure 8e. Big Piney River Predicted Travel.

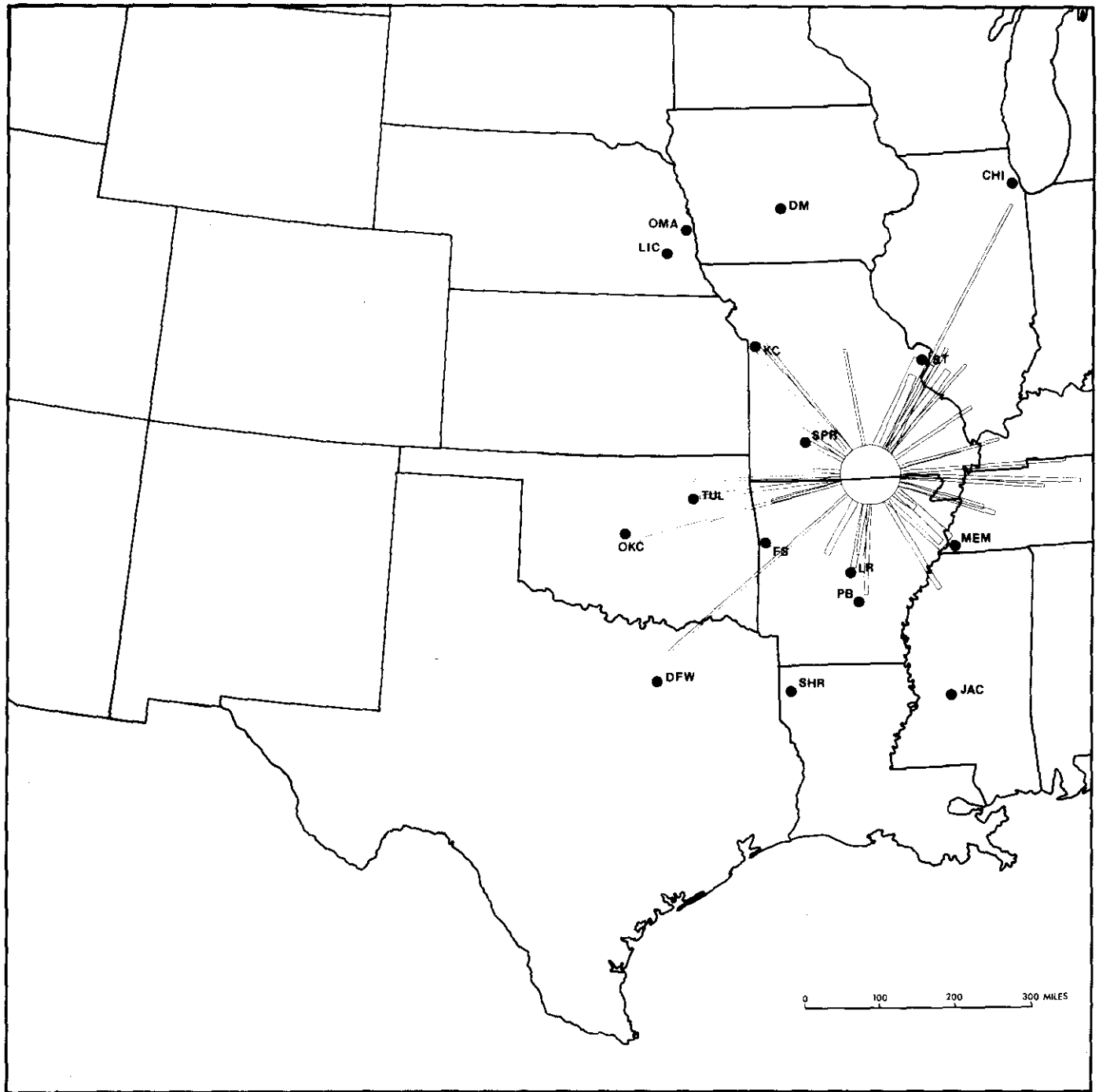


Figure 8f. Current River Predicted Travel.

peting opportunities.

Implications of Findings.

Based upon the evidence at hand, it appears that the goal of accurate prediction of recreation flows for rivers is an elusive one. While it appears that the RECSAD approach is capable of generating reasonable predictions in certain recreation supply and demand contexts, as in the case of camping for example (See Appendix 2), it is not able to accomplish this in the case of rivers. It remains to be seen, what, if anything can be done to enhance the ability of RECSAD II to achieve reasonable accuracies in predicting the flows of river recreationists.

Adjustments to the participation level does affect users flows predicted by RECSAD but only in a system where some recreation sites are overcrowded due to low capacities or a very large nearby population center. For rivers capacity, standards have not been established, and by their nature they are generally removed from large population centers. Thus in the present study changes in the participation rate merely caused constant proportional changes to all flows in the system.

Although the ATTRACT option of the program, whereby the attraction or drawing power of specific rivers can be enhanced, might be used to increase the flows to certain rivers, this is unlikely to substantially change the lack of sensitivity to intervening opportunities.

Differing assumptions concerning willingness to travel were also less effective in causing significant changes in flow patterns than had been expected. Indications are that using a low willingness to travel value positions most recreation opportunities in the relatively

insensitive right side of the decay curve where differences in distance involve only slight changes in the probabilities. On the other hand the use of high willingness to travel values appears to send users on longer trips than empirical evidence indicates. Clearly the positioning of the decay curve requires better calibration, which is difficult to do given the limited origin-destination data on recreation trips.

The other potentially useful area for future work would be to add a directional component to RECSAD whereby the program could calculate the direction of the closest opportunities for each population center and; then reduce the probabilities of users traveling to more distant sites in the same general direction. At this point in the development of the program, the principle investigators are unable to provide any additional insights into this particular problem.

Accomplishments of the Project

While it appears that this overall objective to develop a model which provides a high degree of accuracy in predicted recreation flows has eluded us, it is not difficult to point to solid accomplishments in this research project. As a by-product of this project, RECSAD II had achieved a substantial measure of success in modeling recreation supply and demand flows and simulating effects of future changes in willingness to travel in the context of camping in Oklahoma (See Appendix 2). Empirical data on river recreationists' origins have been obtained for six rivers in Oklahoma, Missouri, and

Arkansas. These data can be used in future attempt to revise RECSAD II or to develop different models for predicting recreation flows.

The research has also spawned a series of other computer program files which can be used in analyzing and portraying recreation systems (Appendix 4). ZIPMATCH was developed in order to match recreationists' five-digit Zip Codes to those contained in the LALZIP file. LALZIP was derived from the Census Bureau's PICADAD file and features zip codes, and the respective latitude and longitude coordinates for their centroids. ZIPDIST allows the user to analyze distance travelled using Zip Code inputs. FLOWPLOT draws flow lines between origin and destination points, with widths of the lines scaled in proportion to the amount of the flow between points. This latter program produces graphic output on a computer-driven plotter.

APPENDIX 1

A REVIEW OF LITERATURE ON RECREATION TRAVEL*

1. INTRODUCTION

There are conflicting views concerning the role of travel in the recreation experience, "...The concepts which have been developed, and to a lesser extent the usual transportation study data, are readily applicable to the case of outdoor recreation travel (Teidemann and Melstein, 1966)." At the other end of the spectrum is Wolf (1966) who states "there is no such entity as recreational travel. To comprehend the recreational use of our highways the stream of recreational travel on those highways must be broken down into its component parts and each studied separately". But most believe that travel is an important element in the decision-making process, and a number of models have been developed to portray it. "There have been discrepancies between estimated and empirical results but it appears that travel models are of adequate quality to be used for policy and planning purposes (Freund and Wilson, 1974)."

It is the purpose of this report to: (1) review existing empirical and theoretical recreational travel related studies; (2) ascertain the independent variables which help to explain recreational travel behavior; and to (3) evaluate the existing techniques used to model such behavior. The emphasis here is on recreational travel behavior although various demand and participation studies, which relate either directly or indirectly to recreational travel behavior, are also cited.

II. FACTORS AFFECTING RECREATIONAL TRAVEL BEHAVIOR

From the literature it appears that there are four broad categories of factors that are commonly linked to explanation of travel behavior. There are a number of characteristics which affect travel in the recreational experience. For the purpose of this report four categories are highlighted: (1) characteristics of access; (2) temporal characteristics; (3) characteristics of the facility; (4) user characteristics. "Though the effect of each have been considered individually (and sometimes collectively) by researchers, no study to date has established their relative importance, partly because human values are difficult to quantify (O'Rourke, 1974:142)."

* This was prepared by James Dunlap, Graduate Research Assistant, Department of Geography.

A. Characteristics of access:

"Keogh's study...provided evidence that 86 percent of drivers enjoyed the time spent traveling, but their reasons for selection were based on other considerations - 64 percent chose a particular route because it was fastest, 13 percent because there was less traffic, 8 percent because it was the most scenic, 6 percent because it was the cheapest, and 3 percent because it was the safest. The remainder had no alternative route available so could not make a choice (O'Rourke, 1974:146)."

The monetary cost of travel is one of the major expenditures for many recreational experiences according to Tiedemann and Milstein (1966). "Generally people who travel farther pay more for a given recreational experience than those traveling a shorter distance to the same facility (O'Rourke, 1974:145)." O'Rourke reviews studies done by Boggs and McDaniel, Seneca, and Mansfield. He concludes that priority is often given to this factor but believes further study is needed to establish its relative importance.

Van Lier (1977) also believes that the time spent traveling can be enjoyable and states that this factor may be responsible for the inertia of movement in Wolfe's (1972) model. Beaman (1974) examines this time/distance factor. Glascock and Born (1971) state that time and distance appear to be important reasons for the respondents in their study not participating more often. From a study done on reservoirs in Indiana, Matthias and Grecco (1969:69) conclude that "the difference in attraction rates substantiates the assumption that a trip is designed to be short as possible". O'Rourke (1974) reviews several studies done on the significance of journey time in the recreational experience, including those by Crew, Duffel, and Goodman and Keogh. He concludes that time is intimately connected to distance and that time may be the most significant factor in determining the distance a recreationalist will travel on certain types of trips. He also points out that time/distance measures have been given considerable attention in studies using gravity models. The U.S. Department of the Interior (1965) considers the significance of travel time to destination as well as round trip time. Mueller and Gurn (1962:38) conclude that "...leisure preferences are conditioned by location factors, that is, by time and distance required to reach the location where one can engage in the preferred activity". In regard to this characteristic Lentnek, Van Doren, and Trail (1974:79) state that "(t)he amount of time spent in transit is apparently a function of the amount of time spent at the site".

The scenic quality of the route is another factor considered by O'Rourke (1974). He cites a study done by Mansfield in which 36 percent of visitors to a certain area gave the highest priority to the natural attractiveness of their journey, with less emphasis

on the time requirements of the trip. He also reviews Houghton, Evans and Miles, and suggests that the literature merely confirms that recreationalists, drive on what they hope will be pleasant roads with scenic views.

Glascoek and Born (1971:10) reviewed a study by Myles which "reported that travel may be a pleasant part of the recreational experience..."

Hecock and Rooney (1974:45) state that "...where a person lives, to a large extent, determines the choices he has with respect to leisure pursuits". Regional location is important both from the supply and demand side. Regions with large populations have a high probability of being regions with a high demand for recreation. The sheer numbers of facilities and opportunities in certain regions affects the recreational travel behavior within that region. The U.S. Department of the Interior (1965:9) states that people in the West took vacations at a greater distance from home than people in other areas. According to Mueller and Gurin (1962) the West shows a higher proportion of people engaging in recreation away from home because of the better facilities in the region. They go on to say that camping, hiking and picnicking are also more common in this region. As stated earlier Hecock (1977) points to the regional differences in river recreation.

Stoevener and Guedry (1968:71-72) indicates that although the rural or urban residence of the recreationalist is a factor that is important, its significance has been lessened due to the increased homogeneity in our national culture and residence during childhood may be a more important consideration. They go on to say "(f)ormer rural residents may have developed different outdoor recreation use patterns, e.g., during childhood, and even though they are now urban residents, they may utilize their leisure time differently from the lifetime urban residents". According to Mueller and Gurin (1962) farmers are less likely to participate in certain recreational activities because of the nature of their profession and there is no indication that a home with a large yard in the suburbs restrict people from taking part in recreational activities away from home. "As expected there is more travel originating from more populous areas. It appears that individuals in urban centers tend to take longer trips (Freund and Wilson, 1974:248)." "The dominance of metropolitan areas as origins of boaters is clear... (Lentnek, VanDoren, and Trail, 1974:73)." Hecock (1977:280) points out that "(r)ivers showing the greatest use pressures are nearest large concentrations of population in the mid-west and East and close to the Pacific Coast". "...(S)ightseeing, driving, picnicking and particularly swimming are relatively more popular in the cities than in the surrounding areas (Mueller and Gurin, 1962:13)." Hauser (1962:48) found that the probability of people from large cities going camping is less than that of people residing in small cities. Thompson

(1967:527) uses city population as one of the assumptions for his study on Ontario parks and Freund and Wilson (1974:246) state that "(t)his variable (urbanization) seems to perform better than population density" in their gravity model.

B. Temporal characteristics:

Travel in the recreational experience has certain identifying characteristics which distinguish it from other forms of travel. The seasonal characteristics are discussed by the U.S. Department of the Interior (1965:8). They state that "(m)ore people began their vacations away from home in August, 37 percent, than in any other summer month... Twenty-two percent began their vacations in June, and 36 percent in July..." "The distribution of holidays through time is heavily peaked with a marked concentration in the short period of a few summer months: Hecock and Rooney (1974) point out the seasonal variations of participation for state recreational facilities in Oklahoma. Hecock (1977:280) states that "(r)ivers experience considerable season-to-season variability in use. Holiday weekends, such as Memorial Day, the Fourth-of-July, and Labor Day, may account for as much as one-quarter of total annual use on some rivers". He goes on to state that "(t)here are also some fairly predictable weekly and daily rhythms. Weekends account for as much as three-quarters of total weekly use. Most daily use is between 10 a.m. and 3 p.m." O'Rourke (1974:142) looks at studies done by Budde and Kousgaars, Houghton-Evans and Miles, Cracknell, Duffell, and Linde and concludes that "...recreational travel begins from a specific origin on days other than those committed to earning a livelihood and beyond that it is largely discretionary. Recreation traffic flow is, therefore, heavier at the beginning and end of the weekend (where there is a concentration of leisure time) and in summer, whereas commuter and other traffic experiences peak flows in the morning and evening throughout the week and does not exhibit seasonal variations". He also discusses a survey done by Wager which "...indicated that Sunday attendance may be five times as great as weekday attendance and visits in winter less than 20 percent of those in summer".

C. Characteristics of the facility:

According to the U.S. Department of the Interior (1965) the relative quality of site is an important characteristic in determining the satisfaction gained from a recreational experience. Their survey states (p.7) that "(o)f all reasons given for satisfaction, 28 percent were concerned with appreciation of the quality of the natural resource... The second most prevalent set of comments, 21 percent of all reasons given, related to developed facilities. People liked these facilities because they were attractive, clean and in good repair". There is a

considerable amount of literature on this subject. VanLier (1977:6) points out that the objectivity of these studies varies with the approach and the types of variables included, i.e., 'hard facts or measures of perception'. He goes on to write that according to Lintsen the perception of this characteristic differs considerably among different socio-economic groups. Shafer (1974:123) concluded that aesthetic quality is one factor that influences a person to camp at a specific site. Freund and Wilson (1974:241) use an attraction index to account for quality of site. Their study was based on the 1967-69 Texas Parks and Wildlife Department data. Although there has been considerable research on this characteristic and it has been used in several models, O'Rourke (1974:145) concludes that "(d)espite the success of these pioneering studies in the context in which they have been applied, it is patent and obvious that the attraction index has not been widely accepted, nor has the researcher been able to satisfactorily measure levels of preference attached by individuals to various experiences".

Thompson (1967:541) finds evidence to indicate that park size and attractiveness are related. This conclusion is based on his use of the traditional gravity model for analyzing recreational travel patterns to a sample of Ontario parks. The Michigan Outdoor Recreation Demand Study incorporated a capacity multiplier in a model they used to look at various recreation facilities (O'Rourke, 1974). Shafer and Thompson (1968) suggest that users traveled farther to campgrounds which had a large number of sites. There are two components of capacity.

Physical capacity deals with the amount of use an area can tolerate before the resource starts deteriorating (this is the easier to measure). Behavioral capacity is concerned with the population that can be tolerated before the recreational experience itself starts to deteriorate. A large facility may appeal to people but if it is operating near full capacity they may feel crowded and not have a good experience. The U.S. Department of the Interior (1965) deals with the lack of crowding as one of the factors given for user satisfaction. Ten percent of the respondents listed it as the most important reason for satisfaction.

According to O'Rourke (1974:124) "(t)he pattern of travel is a function of the structure of opportunities available to the recreationalist..." Hecock and Rooney (1974:3) state that "...the fact that participation and participation levels are linked to the availability of facilities is extremely well documented..." Cicchetti, Seneca, and Davidson (1969:89) discuss the importance of supply factors or facilities when trying to explain participation. McNeely and Badger (1967) use an availability factor in a regression analysis of recreation in Oklahoma, stating that this factor explained 75 percent of the variation in attendance. Ellis and Van Doren (1966) use an availability factor in their gravity model. Tiedemann and

and Milstein (1966) included indices of availability in a model they used on data from the Michigan Outdoor Recreation Demand Study.

According to Mueller and Gurin (1962) the lack of facilities was one of the reasons given by respondents for not engaging in more outdoor recreation activity. The facilities available for desired activities is an important factor when looking at regional differences in recreational behavior. A person desiring a recreational experience may in fact be looking for a set of activities, i.e., if a person cannot hike, camp, and picnic during the same outing they may be unhappy.

"An analysis of current vacation travel patterns indicates that additional facilities should be located primarily within one, or at most two, day's driving distance from the areas they are intended to serve. People will not normally travel a greater distance than that from the place where they are living. This is true even for upper income levels (Mueller and Gurin, 1962:54)." According to the U.S. Department of the Interior (1965) most people went on overnight recreation trips within their own Census Divisions and took their vacations at places within their own states or in neighboring states. Fifteen percent of their respondents ranked a convenient location close to home, or easy to get to, as an important factor for satisfaction with place of participation. Thompson (1967:527) states that "...traffic generated between a population area and a recreational area is directly related to the number of opportunities closer (in travel time) to the population area than the recreation area". The literature also seems to verify this for certain specific activities. From a study of boaters in Ohio, Lentnek, Van Doren and Trail (1974:71) concluded that "...activity-specialized boaters tend to choose the nearest lake that can be used for their activity..." Shafer (1974:122) writes that "...there are several factors that influence a person to camp at a specific park. Proximity to home is most important in some instances".

Proximity of the facility to an urban area has been shown to have an effect on the recreational behavior of people participating in certain activities. Hecock (1977:280) states that "(r)ivers showing the greatest use pressure are nearest large concentrations of populations..." According to Mueller and Gurin (1962:13) "...sightseeing driving, picnicking, and particularly swimming are relatively more popular in the cities than in the outlying areas".

D. Characteristics of the user:

"The paid vacation available to the male in the household appears to be the major factor in the travel decision. The percent of traveling

families increases as the number of weeks of paid vacation goes up (A Regional Study of Recreation Travel Behavior and Participation Patterns, 1975:17). It is not only the total amount of leisure available, but also how it is arranged, i.e., 2 day weekend, 3 day weekend, paid vacation, etc. According to Mueller and Gurin (1962) paid vacations are a concomitant of occupation and income that may affect outdoor activities. They conclude that these two variables, income and the availability of a paid vacation, are by far the most important determinants of travel oriented outdoor recreation. O'Rourke (1974:142) concludes that time available for recreation is a limiting factor on distance traveled. The U.S. Department of the Interior (1965:6) looks at time available for recreation and states that "...over half of the people with a favorite activity reported that lack of available time was the greatest factor in limiting their participation during the summer, fall, and spring, and nearly half said their favorite winter activity was also restricted by time." Thompson (1967:528) states that "(u)nquestionably the demand for recreational facilities will increase as an expanding population enjoys more leisure time while becoming more affluent and more mobile".

Income is one of the key factors in determining the travel behavior recreationists. This factor has a direct effect on the resources available to cover the monetary cost of travel and, the time available for such travel. "There is a steady increase in the percent taking recreational trips from the lowest income group to the highest income category... (A Regional Study of Recreational Travel Behavior and Participation Patterns, 1975:15)." Education and occupation are two other factors that are related to income and have been shown to influence travel behavior. The Regional Study of Recreation Travel Behavior and Participation Patterns (1975:17) states "(t)he level of educational attainment of the male in the household is strongly related to the decision to travel...Eighty percent of the college and higher educated groups travel while only 32 percent of grammar and 57 percent of high school graduates take recreational trips." "(T)he data on occupation of the head of the household indicates that white collar workers (professional, clerical and sales) travel more and take more trips per year as compared to those in blue collar occupations". Stoevener and Guedry (1968:68) discuss the high correlation between income, education and occupation.

Mueller and Gurin (1962:58) state that "(a)n analysis of leisure time patterns by socioeconomic characteristics show rising participation rates with increases in education and income for outdoor recreation and most other leisure time activities as well." They (Stoevener and Guedry, 1968:48) also conclude that "(c)ollege educated people, business men and professional people are more likely to engage in outdoor recreation away from home." "It has been demonstrated that the probability of a person becoming a camper increase with income, education and professional status (Thompson, 1967:541)." Studies done by Shafer, Fine and Werner,

and King (Glascock and Born, 1971:9-10) "implied that camping participants tended to have average incomes". Hecock (1977:282) points out that people who canoe are likely to be professionals, educated, and from higher income groups.

The Regional Study of Recreational Travel Behavior and Participation Patterns (1975:7) concluded that "(a)ll income groups will probably be forced to make adjustments in established recreation patterns in response to the energy - inflation unemployment situation. The lower middle income, the elderly, and others on fixed incomes who previously traveled are the groups whose recreation patterns may be drastically changed by the energy - inflation problems".

These social class differences reflect more than mere income differences. There is also a difference in life-styles and interest patterns. Mueller and Gurin (1962:10) think it is interesting "...that driving, hiking, picnicking, and nature and bird walks, which entail minimal expense and time, increase in frequency with income, whereas hunting, which is likely to involve more expense, equipment, and time is not income related". They (Mueller and Gurin, 1962:69) go on to say that "...(o)ver the past two decades the middle and upper income classes have been leaders in the trend toward a new life style, characterized by informal living. Outdoor recreation is part of this new life style".

Lovelace recalls that the automobile was originally developed for recreational purposes, and only later did it acquire other uses (O'Rourke, 1974:141). Driving for pleasure is still a major recreational activity. Wall (1972) concludes that the car is not only the main source of transportation to a recreation facility but that after the destination is reached it also tends to be the main focal point. As might be expected the family vehicle is the dominant mode of transportation on both long- and short-duration trips. According to the U.S. Department of the Interior (1965) 85 percent of all vacations away from home were taken by automobile, 91 percent of the overnight recreational trips, and 89 percent of the outings. "The car may be viewed as a catalyst of growth in outdoor recreation in that it has diminished the friction of distance between home and the recreation site, and has thereby encouraged participation in outdoor activities of all types (Wall, 1972:259)."

"Rogers concluded that the car not only stimulates recreational demand, but that its use varies with income: 'Low income car owners use their vehicles less frequently and over lower mileage recreation-ally: among them acquisition of a car depresses holiday taking, though the car is used most strongly at this income level as a family vehicle' (O'Rourke, 1974:147)." "Existing studies indicate the important recreational role of the car and all trends show that the recreation pattern of the future will be dominated by car-owners, even if their chosen activities do not always involve the use of a car (Wall, 1973:117)."

O'Rourke (1974:148) discusses the work done by Masser, Mansfield, Whitsum, and Vickermann on the level of car ownership and recreational travel and he concludes that "(s)ince it has been adequately established that car ownership does influence recreational travel, the need now is for a more thorough investigation as to whether this influence is primarily related to affluence or whether perception, motivation, or other factors are involved".

The literature verifies the importance of family life-cycle in the recreational experience. Wall (1973) discusses the importance of family life-cycle in his study of car owners. He also concludes that pleasure trips tend to be family activities (Wall, 1972:54). Stoevener and Guedry (1968:70) state that part of the increase in demand for outdoor recreation is due to its suitability for family groups. Sessoms' analysis of the British National Recreational Survey points out the influence of family life cycles in recreational patterns (O'Rourke, 1974:147). He states "...only 3 percent of the car-owning, trip-taking sample were alone: 33 percent consisted of husband and wife together; 17 percent were composed of husband and wife with other adults; and 45 percent were family groups of parents and children..."

Recreational activities are often family activities and especially outdoor recreational activities. According to the Mueller and Gurin (1962:25) survey the whole family of over 60 percent of the respondents enjoyed the same activities and two or more activities were engaged in by all or most members of the family. Being married or having children does not keep people from enjoying outdoor recreational activities and in many cases increases the probability of participation. A study done by Shafer (1974:114) on campers in northeastern New York State, states that over 90 percent of the respondents were single families or groups of families. Mueller and Gurin (1962:65) also point out that married couples with children are the most frequent campers among vacationers.

Children's age is another characteristic that should be considered. According to a survey done by the U.S. Department of the Interior (1965:10) "(m)arried couples with children less than 6 years old were the most active outing participants: 67 percent of this group took outings". The same study reports that married people with children less than 6 years old went on fewer overnight recreation trips and vacations away from home than those whose youngest child was from 6 to 11 years old. Stoevener and Guedry (1968:1970) state "(t)he age of the youngest child may act as a constraint on the activities of the family in much the same way as the physical limitations resulting from aging have been hypothesized to do". Shafer's (1974:147) study on campers points out that two-thirds of the families interviewed had children under 12 years of age and one-third to one-half of the families

had children between 12 and 18 years old. Masser (O'Rourke, 1974: 147) took into consideration children's ages in selecting households for his Birmingham study because he felt that the parents' leisure habits reflect in many ways their children's ages.

"Rogers notes the emergence of three phases in the life cycle which affects 'recreational idiosyncracies'. Constraints are fewest for the young adult who has a combination of physical capacity, disposable time, and an unencumbered income. In the family phase, when time and income are more heavily committed, recreation becomes informal, and the car becomes crucial. But, with increasing age, a phase of excess leisure and recreational passivity develops (O'Rourke, 1974:147)." ".(I)t does appear that some of the differences in outdoor recreational activity which exist now between younger and older people reflect differences in experience (hence interest) and acquired skill rather than in energy or physical ability to participate. As the generation which is young now grows older, it may well engage in outdoor recreation to a greater extent than the older age groups do now (ORRRC, 1962:24)." The ORRRC study states that the older people in our population also tend to have lower incomes and less education. Stoevener and Guedry (1968:70) suggest that the stage of life cycle reflects age, marital status, and children's age.

Table 1 summarizes the characteristics discussed this far. An attempt has been made to list the various groups of characteristics in the order of their relative importance. The variables within each group have also been listed in the order of their apparent significance. Each of these characteristics have been shown to influence recreational travel behavior. Most are factors that are being, and should be, considered in the decision making process, although at this point their relative importance is not clearly understood.

III. TECHNIQUES FOR MODELING RECREATIONAL BEHAVIOR

This section examines various techniques for modeling recreational behavior. Such techniques may often provide a valuable tool in the decision making process. "The purpose of a model or a simulation is to replicate some reality in mathematical form so that it can be studied under controlled conditions. The mathematical form, normally an equation or a set of equations, is considerably less complex than the real-world phenomenon it represents, thereby presenting an opportunity for intensive examination of the behavior of the model (The Ontario Research Council on Leisure, 1977:73)." Most models require information on at least some of the characteristics mentioned in the first part of this appendix. "The limitation in modeling is that the full spectrum of influences on a real situation can rarely be represented in the model. While this drawback especially applies to recreation, because of the importance of discretionary choice, individual perceptions and preferences in recreational behavior, modeling has still proven useful in research and planning (The Ontario Research Council on Leisure, 1977:73)."

The gravity model has been one of the most popular and frequently used techniques in the study of recreational behavior. These models borrow concepts from the physical sciences. The necessary computations are relatively simple and the results often have proven adequate for planning purposes. Gravity models have several variations, but they basically relate recreational travel to population, attractiveness of the recreational area, and distance/time. The standard formula for the gravity model is ...

$$I_{ij} = G \frac{P_i A_j}{TD_{ij}^b}$$

where I is the number of trips between origin i and destination j; G is the gravitational constant; P_i is the population of origin i; A_j is the attraction index of destination j; TD_{ij} is the minimum time/distance on route; b is a mathematically determined exponent.

Techniques such as the gravity model can be applied to a wide range of problems. "Most recreation uses of the gravity model have been...concerned with highway traffic flows to recreation destinations (The Ontario Research Council on Leisure, 1977:80)." "The model has been varied depending upon the problem under investigation and such variables as attractiveness of the recreation area (Van Doren, 1967), park capacity (Thompson, 1967), automobile ownership (Unger, 1967) and others (Carrothers, 1965; Lukermann and Porter, 1960;

Olsson, 1965; Clawson, 1968; Gordon and Edwards, 1973) have been used, while distance has on occasion been measured in time rather than kilometers (Crevo, 1963)" according to O'Rourke (1974:150). Acar (1973:7) considers the variables income, age, education, family, urbanization and travel time in what is termed an "efficient 'gravity' model". The computer generated model was based on the following assumptions: (1) no one travels beyond a certain travel zone, (2) the population is homogeneous, (3) the supply of recreation is homogenous and, (4) the resistance to travel to a particular recreation unit is inversely proportional to its distance from an urban center. They comment on the works of Cheung, Cesario, Ross, Ellis, and Ker and point out that they "...take into account the effects of alternative facilities and/or attractiveness of facilities on park visitation (Acar, 1973:6)".

Schulman and Grecco (1964) developed a gravity model based on observed data. To determine the total trips that would be attracted to a proposed recreational area they used a multiple regression model. The analysis was performed by a computer. The results from the multiple regression model were then fitted to the gravity model to examine the system of parks under consideration. The number of dwelling units in the county were used as a measure of recreational travel. Capacity, and the population within sixty miles of the park were other significant considerations. "It has been a recent practice to replace distance with travel time; however, in this study replacement was not deemed necessary (Schulman and Grecco, 1964:136)."

Freund and Wilson (1974) also used regression methods to implement a gravity model. They conclude that it is possible to use such techniques to estimate state-wide recreation travel. Such variables as attractiveness of destination, nearness to urban area, socio-economic characteristics of origin region (with emphasis on income), distance or travel time, and regional location were considered. They (Freund and Wilson, 1974:244) state that "(d)istance is a proxy for the time, effort, and cost involved in travel among regions".

"Thompson (1967) demonstrated the use of the (gravity) model in examining the flow of campers to parks in Ontario. He found that the attractiveness of a park is related to its situation. He also found that park size, and attractiveness were related; that the variables distance, population and capacity were significant in that order; that the volume of camper traffic generated appeared to vary with the size of city; and concluded that the gravity model had potential for the analysis of recreational travel patterns (O'Rourke, 1974:151)." Ellis and Van Doren (1966:60) discussing their gravity model, stated that "(i)t is assumed that campers would be attracted to a Michigan State Park according to its physical attributes, the number and quality of facilities available, and the recreational activities that can be

undertaken". They include an attraction index, time/distance measurement, origin characteristics and cost of travel in their model. The Ontario Research Council on Leisure (1977) discuss the importance of capacity, quality of site, and facilities available in representing attraction in the gravity model.

"The gravity model has been used successfully in the analysis of recreational travel patterns. It suffers however because of an assumed applicability throughout an entire system (Thompson, 1967: 35)." In discussing the shortcomings of the gravity model Van Lier (1977:3) states that "(b)oth statistically and conceptually it is impossible to separate the influence of origin, destination, and linkage on visit rates (or numbers) of outdoor recreational facilities". Thompson (1967:532) states that there are many problems associated with its use. These consist of: (1) human behavior involves more complex sets of forces than argument by analogy to a physical law will bring to light; (2) assigning an exponent of unity to population; (3) measuring the attractiveness of a recreational area; and (4) how well does distance measure the friction effect. The Ontario Research Council on Leisure (1977:78) states that "(t)he gravity model formula not only models the complete interaction, but also remains the same regardless of the structure of the particular system, or even the nature of the phenomenon itself. This feature of the model is at once a strength in that the model can be used for everything, but is also a weakness, in that interaction is not invariant with structure and the nature of the phenomenon."

"The gravity model, in seeking to explain the movement of people in spatially extensive areas, emphasizes distance and population size. Most research has sought to identify ranges of values for the distance exponent in the model. Bearing this in mind and considering the dissatisfaction expressed by other researchers, the gravity model seems destined to a lingering, but inevitable, demise in recreational studies (O'Rourke, 1974:152)."

Freund and Wilson (1974) in implementing an 'improved' gravity model to explain recreational travel and participation in Texas, found that 'a major task was to make physically observed measurements serve as proxies for parameters specified by the gravity model. In addition, they found it necessary to choose a reasonable set of meaningful predictor values'. Freund and Wilson (1974:241) concluded that it "...appeared to be of adequate quality to be used for policy and planning purposes, particularly when used in conjunction with other estimates". Van Lier (1977) states that most models are developed for a specific site and are not necessarily applicable to other sites. He develops a gravity model to overcome this limitation.

The inertia model is also a variation of the gravity model. As

pointed out by The Ontario Research Council on Leisure (1977) and Van Lier (1977), the model was developed by Wolf to compensate for the tendency of some gravity models to overestimate the number of short trips and to underestimate longer ones. The form is:

$$V_{ij} = K \frac{P_i P_j C_j^c}{D_{ij}^d} \cdot D_{ij} \frac{(\log D_{ij}/m)}{n}$$

in which the same variables (population P, capacity C, and distance D) are used but the distance function itself (or the description of the reaction of recreationist on distance) is transformed. Whether this type is more adequate to simulate reality still is to be proved for different forms of outdoor recreation (Van Lier, 1977:5)." This new approach uses a different recreation-to-distance-function based on the inertia of starting up and the inertia of movement. The starting up inertia is caused by the fact that some people may not want to make a trip of any length. The inertia of movement is caused by the fact that some people who indulge in lengthy trips, a still smaller minority finds travel itself so stimulating that the farther they go, the farther they want to go. Beaman (1974) analyzing research related to the inertia model suggested by Wolf, looks at five gravity functions. He concludes that there are cases in which (a) each new mile to be traveled offers more resistance than the last; (b) each new mile to be traveled offers less resistance than the last; and (c) each new mile to be traveled has a constant resistance. "The most important concept presented is that if an inertia model of travel behavior of the type Wolf describes is accepted, the decision to visit a given location must involve a reaction to distance in marginal rather than absolute terms (Beaman, 1974:220)." He (Beaman, 1974) believes that sightseeing and vacation travel may be heavily weighted toward decisions based on marginal utility considerations, but that most travel decisions involve both a marginal and an absolute component.

The systems model starts from a theoretical construct borrowed from the electrical engineering literature. This construct is then adapted to the recreation field by analogy. When looking at a systems model "...one can think of an electrical analog, where the origins act like current sources. The current (flow of campers) 'sees' various paths of differing resistance and distributes itself across the network in a minimum-energy fashion, eventually returning to the 'ground' via the park components. The flow at each park is thus determined by the relative resistance of all parks, all links, and the relative strengths of all origin sources (Ellis and Van Doren, 1966:60)". The Ontario Research Council on Leisure (1977:85) states that "(t)he system theory model is a mathematical model whose primary use is the prediction of attendance at a number of recreation sites or activity consumption

levels at various locations distributed over space. The model can be used to predict the traffic loadings on various transportation links such as highways to and from parks, as well". "These models require empirical studies to be refined and calibrated to some actual situation. They may however, still be formulated completely on a hypothetical basis (The Ontario Research Council on Leisure, 1977:75)."

The systems model offers more flexibility than some of the other models, but it is more difficult to construct and generally requires a computer. "The main benefits of the model over less complex models are its ability to retain relative accuracy when the study area becomes large, diverse in the resource type offered, or irregular in shape. It also has the ability to be formulated by the computer and solved for destination route flows in a single run (The Ontario Research Council on Leisure, 1977:85)."

The Ontario Research Council on Leisure (1977) considered capacity, relative attractivity, and time (resistance to travel) as input variables for the systems model. Their attractivity variable was derived from the sites physical attributes, improvements, relative cost to user, and desired activities available. "The construction of the model requires data to be available for some current year or recent past year on destination attendance, site characteristics, transportation link characteristics and origin area characteristics. Preferably, the origins of users of the recreation destination will also be available (The Ontario Research Council on Leisure, 1977:87)."

Ellis and Van Doren (1966) compare a systems model and a gravity model. They concluded that the systems model offered more flexibility and more clarification of demand. 'Wolf states that such a systems model would need to include an age index of socioeconomic cultural group, an education index, an occupation index, an income index and an attractivity measure based on perception.' Commenting on Ellis and Van Doren's study Beaman, Knetsch, and Cheung (1974:i) state that "(a)n important result of (their) article was the consideration of one model as better than another based on some criteria for measuring average error. This paper cast doubts on the Ellis-Van Doren findings by showing that if Van Doren's model had been parametrized efficiently and thus been as good as it actually could have been compared to Ellis' systems model probably would have shown both models to be equally good." I would agree with the statement by Ellis and Van Doren (1966:69) "(i)t would thus seem that the system theory model opens the door to a new and potentially useful area of research. It in no way obsoletes the gravity model, in our opinion, for modeling small simple systems, or for use by personnel with access only to smaller sizes of computers."

Another technique for modeling which requires considerable computer

time is regression analysis. "It should be remembered that regression equations cannot prove a causal relationship, but merely signify that some statistical relationship exists. This idea does not, however, diminish the utility to be derived from applying regression techniques, though like other statistical methods, the strength of interpretation depends on the validity of the hypotheses on which the models were based. In recreation research, regression equations are assuming increasing popularity in model development, and this trend is likely to continue (O'Rourke, 1974:153)." "...(M)odels, such as those based on regression techniques, exist only when empirical data are analyzed by the appropriate techniques. These models are normally structured by applying theoretical considerations in selecting variables, but they cannot be formulated at more than the most general hypothetical level without data to be manipulated (The Ontario Research Council on Leisure, 1977:74)." Such models work well only when adequate data are available.

Shaffer and Thompson (1968) used regression techniques in developing their mathematical model. They were concerned with the significance of site variables in determining campground use. They considered quality of site, capacity, nearness to potential user, and nearness to urban area among other variables. It was found that capacity and regional location were the most important factors in determining average total visitor-days at any one campground. 'Chung using regression techniques considered such variables as population size, accessibility, alternative recreation opportunities, and park attractiveness in determining recreational travel behavior (O'Rourke, 1974:153)'. Gibson and Reeves (1972) use multiple regression techniques to model attendance at campgrounds on the Arizona Strip. They utilized population of the state of origin, affluence of the state of origin (state per capita income), and the state's distance from the strip. This model, utilizing the three independent variables, has general applicability to campers and campgrounds throughout the country. "Campers as a group behave in a spatially rational manner, and the operation of the explainer variables employed in this model should have some relevance to several questions of policy with regard to establishing and maintaining camping facilities on federal lands (Gibson and Reeves, 1972:30)."

Johnson and Pankey (1968) develop a recreation-use prediction model through the use of regression equations. They considered such independent variables as socioeconomic characteristics, reservoir characteristics, distance, and time. The socioeconomic characteristics included age, education, income, property value, type of employment, urban-rural classification, number of automobiles/housing unit, and nativity. Reservoir characteristics included size (land area and water area), capital investment in recreational facilities, number of camp sites, number of boat-launching ramps, number of picnic

tables, number of flush toilets, number of pit toilets, and distance to the nearest inn or store. When quantifying distance they used road-miles. They also took seasonal variations into consideration. In addition they examined population density in each county and the availability of alternative recreation areas of the same general nature. They conclude that distance is probably the most important variable, after population, in predicting total use. They state that "...although we report models with socioeconomic variables, we stress alternative models which appear to have almost equally good explanatory power and which include more easily quantified variables (Johnston and Pankey, 1968:28)". They also conclude that it is unclear whether higher attendance leads to increased development or increased development attracts more users. Matthias and Grecco (1969) developed a prediction model by using nonlinear regression analysis. They looked at such variables as road distance, county population, and the influence of other similar facilities. Two regression curves were developed, one was used for counties that were closer to the park under consideration than any other and the other for when another park was closer. Together the two equations constituted the prediction model. "The method is able to predict future attendance with reasonable accuracy... Previously developed models required many socioeconomic and park characteristics variables which are difficult to measure and evaluate and extremely difficult to project. The model developed is probably as accurate and is much simpler to use. The model is adequate for advanced planning purposes and can be used to predict reservoir attendance and traffic volume estimates (Matthias and Grecco, 1969:68)." In a study of recreational boating in Ohio Lentnek, Van Doren and Trail (1969) developed a similar model in the form of:

$$f = ae^{-bd}$$

where:

- f = the rate of participation per million inhabitants,
- e = the natural base of the logarithms,
- a & b = parameters of functions, and
- d = time-distance measured in units of time zones.

"Nothing has been stated concerning the social, economic, demographic, or perceptual characteristics of the boating groups nor has any detailed evaluation been made of the boating activity opportunities and resources at the various lakes. The goal is a conceptualization of an analytical system, based on empirical evidence in one region which aids in understanding recreational behavior. The utility of such a system depends upon similar investigations in other regions which test the model. Hopefully, continued research will provide a basis for rationally planned recreational facilities (Lentnek, Van Doren and Trail, 1969: 121)."

"The intervening opportunities model assumes that the traffic generated between a population area and a recreation area is directly related to the number of opportunities in the recreational area, and is inversely related to the number of opportunities closer (in travel time) to the population area than the recreation area (Thompson, 1967: 527)." "Stated mathematically, the model is expressed as follows:

$$V_{ij} = V_i (e^{-LV} - e^{-L(V+V_j)})$$

where V_{ij} = trips originating in zone i and terminating in zone j

V_i = trip origins in zone i

V = number of possible destinations lying closer (travel time) to zone j

V_j = number of possible destinations in zone j

L = empirically derived factor varying with trip type

e = base of natural logarithms

(Thompson, 1967:534)." He points out that this model stresses the importance of regional location and mentions a number of studies which allude to such a model.

Linear programming is another computer-intensive modeling technique. "A linear programming model is one that is constructed with a number of algebraic relationships between quantities, normally having a certain number of constraining values, either a maximum or minimum value (The Ontario Research Council on Leisure, 1977:81)." The model is very sensitive to changes in the input values and when used in recreation the results must be interpreted with considerable care. The model can handle a large number of variables and several package routines are available which require various amounts of computer power. They discuss recreational studies that have been done using such programming and conclude that 'some recreation researchers and planners tend to be disturbed by its normative qualities and suspect that it is still questionable to require a specific linear function to be maximized or minimized in a field so responsive to qualitative factors (The Ontario Research Council on Leisure, 1977:81)'.

Greig (1977:ii) "...describes a new method of forecasting the change in numbers of visitors (and their origins) after a specific change in the recreational quality of a forest or any other rural area". He uses nonlinear programming techniques and concludes that quality of site characteristics and relative cost (including travel cost) are the main factors influencing a recreationalist's choice of a particular site.

A classification used by The Ontario Research Council on

Leisure (1977) is a comprehensive simulation model. These models require a substantial input and considerable computer time. "The purpose of a comprehensive simulation model of a recreation system is normally to go beyond the bounds of a simple origin-destination problem involving one activity or a set of activities (The Ontario Research Council on Leisure, 1977:89)." In one model discussed, they assume that recreation participation is based on availability of leisure and preferred activities. These characteristics are influenced by age, income, and family structure. They conclude that these models "...have had application only in the sense of guiding and contributing to research (The Ontario Research Council of Leisure, 1977:91)".

Table 2 provides a summary of the models discussed and the major variables used. Such techniques can provide a useful tool in the decision making process. It can be concluded that the appropriate technique depends on the particular situation under investigation. The data available, the accessibility of computer facilities, the expertise of the person analyzing the data, and the cost and time involved are also important considerations. The gravity model has been one of the most popular and frequently used in the analysis of recreational travel behavior.

IV. CONCLUSION:

The state of the art is such that the phenomenon of recreational travel behavior cannot be fully explained but certain independent variables can be and are being modeled in such a way as to provide a valuable tool in the decision making process. The variables discussed, though not quantified precisely, are an important element in this process. As expected the variables that are easier to quantify are the ones that have been used more frequently in modeling. Variables which deal with perception are difficult to quantify. Both tables show the importance of journey distance/time, facilities available for desired activities, and income. All of these variables are relatively easy to quantify.

There are various techniques available which adequately model recreational travel behavior. Models work best on a specific site where a homogeneous population is considered. The best model is the one that fits the data at hand. Facilities available, cost and time are also important considerations when considering the appropriate model.

TABLE 1
FACTORS AFFECTING RECREATIONAL TRAVEL BEHAVIOR

VS = very significant, S = significant, AS = apparently significant

VARIABLE	STRENGTH RELATIONSHIP TO TRAVEL FOR OUTDOOR RECREATION	RELATED TO THIRD VARIABLE	SOURCE
<u>Characteristic of Access:</u>			
journey distance/time	VS	availability of leisure	Beam(1974), Glascock & Born(1971), Matthais & Grecco(1969), Mueller & Gurin(1962), Lentnek, VanDoren, and Trail(1974), O'Rourke(1974), U.S.Dept. of the Interior(1965), Van Lier (1977), Wolf(1972)
monetary cost of travel	VS	time/ distance	O'Rourke(1974), Tiedemann & Millstein(1966)
scenic quality of route	S		Glascock & Born(1971), O'Rourke(1974)
amount of traffic on route	S		O'Rourke(1974)
is the route safe	S		O'Rourke(1974)
<u>Temporal Characteristics:</u>			
season	VS		A Regional Study of Recreational Travel Behavior and Partici- pation Patterns(1975), Hecock(1977), Hecock & Rooney(1974), O'Rourke(1974), U.S.Dept. of the Interior(1965), Wall(1973)
time of week	VS		Hecock(1977), O'Rourke(1974)
time of day	AS		Hecock(1977)
<u>Characteristics of Facility:</u>			
nearness to potential user	VS		Mueller & Gurin(1962), O'Rourke(1974), Shafer(1974), Thompson (1967), U.S.Dept. of the Interior(1965), VanDoren & Trail(1974)
facilities available for desired activities	VS		Cicchetti, Seneca & Davidson(1966), Freund & Wilson(1974), Hecock & Rooney(1974), McNeely and Badger(1967), Mueller & Gurin(1962), O'Rourke(1974), Tiedemann & Millstein(1966)
quality of site (relative)	VS	capacity (Thompson)	Freund & Wilson(1974), O'Rourke(1974), Shafer(1974), Thompson(1974), U.S.Dept. of the Interior(1965), Van Lier(1977)
nearness to urban area	S		Hecock(1977), Lentnek, VanDoren & Trail(1974), Mueller & Gurin(1962)
capacity, total behavioral physical % (crowding)	S		O'Rourke(1974), Shafer & Thompson(1968), Thompson(1967), U.S. Dept. of the Interior(1965)
<u>Characteristics of the User:</u>			
availability of leisure	VS	income occupation	A Regional Study of Recreational Travel Behavior and Partici- pation Patterns(1975), Mueller & Guedry(1962), O'Rourke(1974), Thompson(1967), U.S.Dept. of the Interior(1965)
income	VS	occupation education stage of life cycle	A Regional Study of Recreational Travel Behavior and Partici- pation Patterns(1975), Glascock & Born(1971), Hecock(1977), Mueller & Gurin(1962), O'Rourke(1974), ORRRC(1962), Stoevener & Guedry(1968), Thompson(1967)
education	VS	stage of life cycle	A Regional Study of Recreational Travel Behavior and Partici- pation Patterns(1975), Glascock & Born(1971), Hecock(1977), Mueller & Gurin(1962), ORRRC(1962), Stoevener & Guedry(1968), Thompson(1967)
occupation	VS	education	A Regional Study of Recreational Travel Behavior and Partici- pation Patterns(1975), Glascock & Born(1971), Hecock(1977), Mueller & Gurin(1962), Stoevener & Guedry(1968), Thompson(1967)
level of car ownership	VS	income	A Regional Study of Recreational Travel Behavior and Partici- pation Patterns(1975), O'Rourke(1974), U.S.Dept. of the Interior (1965), Wall(1972), Wall(1973)
family stage	VS	stage of life cycle	A Regional Study of Recreational Travel Behavior and Partici- pation Patterns(1975), Mueller & Gurin(1962), O'Rourke(1974), Shafer(1974), Stoevener & Guedry(1968), Wall(1972)
children's age	VS	stage of life cycle	O'Rourke(1974), Shafer(1974), Stoevener & Guedry(1968), U.S.Dept. of the Interior(1965)
stage of life cycle	S		O'Rourke(1974), ORRRC(1962), Stoevener & Guedry(1968)
regional location	S		Hecock(1977), Hecock & Rooney(1974), Mueller & Gurin(1962), U.S. Dept. of the Interior(1965)
rural	S		A Regional Study of Recreational Travel Behavior and Partici- pation Patterns(1975), Mueller & Gurin(1962), Stoevener & Guedry(1968)
urban	S		A Regional Study of Recreational Travel Behavior and Partici- pation Patterns(1975), Freund & Wilson(1974), Hecock(1977), Lentnek, Van Doren, & Trail(1974), Mueller and Gurin(1962), Stoevener & Guedry(1968)
city size	S		Freund & Wilson(1974), Hauser(1962), Thompson(1967)

TABLE 2

TECHNIQUES FOR MODELING

<u>MODEL</u>	<u>VARIABLE</u>	<u>REFERENCE</u>
gravity	journey distance/time	Acar(1973), Ellis & Van Doren(1966), Freund & Wilson(1974), O'Rourke(1974), Schulman & Gracco(1964), Thompson(1967)
	quality of site (relative)	Acar(1973), Ellis & Van Doren(1966), Freund & Wilson(1974), O'Rourke(1974), The Ontario Research Council on Leisure (1977), Thompson(1967)
	capacity	Ellis & Van Doren(1966), Schulman & Gracco(1964), The Ontario Research Council on Leisure(1977), Thompson(1967)
	facilities available for desired activities	Acar(1973), Ellis & Van Doren(1966), The Ontario Research Council on Leisure(1977)
	income	Acar(1973), Freund & Wilson(1974)
	nearness to potential user	Freund & Wilson(1974), Schulman & Gracco(1964)
	level of car ownership	O'Rourke(1974)
	monetary cost of travel	Ellis & Van Doren(1966)
	education, family stage, nearness to urban area, age	Acar(1973)
	city size, population of origin	Thompson(1967)
	regional location	Freund & Wilson(1974)
inertia	population, capacity, distance	Van Lier(1977)
systems theory	quality of site(relative)	O'Rourke(1974), The Ontario Research Council on Leisure(1977)
	journey distance/time, capacity, facilities available for desired activities, regional location	The Ontario Research Council on Leisure(1977)
	stage of life cycle, education, income	O'Rourke(1974)
regression analysis	population of origin	Gibson & Reeves(1972), McNeely & Badger(1967), Matthias & Gracco(1969), O'Rourke(1974)
	journey distance/time	Johnston & Pankey(1968), Lentnek, Van Doren & Trail(1969), Matthias & Gracco(1969)
	income	Gibson & Reeves(1972), Johnston & Pankey(1968), McNeely & Badger(1967)
	quality of site(relative)	Johnston & Pankey(1968), O'Rourke(1974), Shaffer & Thompson(1968)
	capacity	Johnston & Pankey(1968), McNeely & Badger(1967), Shaffer & Thompson(1968)
	nearness to potential user	Gibson & Reeves(1972), Shaffer & Thompson(1968)
	availability of leisure	McNeely & Badger(1967)
	education, occupation, level of car ownership, season	Johnston & Pankey(1968)
	accessibility, facilities available for desired activities	O'Rourke(1974)
	nearness to urban area, regional location	Shaffer & Thompson(1968)
	stage of life cycle, urban-rural	Johnston & Pankey(1968)
intervening opportunity	journey distance/time, facilities available for desired activities, regional location	Thompson(1967)
linear programming		The Ontario Research Council on Leisure(1977)
non-linear programming	quality of site, monetary cost of travel	Greig(1977)
comprehensive simulation	availability of leisure, facilities available for desired activities, income, family stage, stage of life cycle	The Ontario Research Council on Leisure(1977)

Appendix 2

AN APPLICATION OF RECSAD II TO A REGIONAL RECREATION DEMAND AND SUPPLY SYSTEM*

The changes which occur in the individual supply/demand relationship of each recreation site and population center combine to create shifts in that relationship for the overall recreation system. The recreation system pictured in Figure 1 and 2 is the recreation system for weekend camping trips in the State of Oklahoma.

RECSAD II Input

The three hundred forty-four population centers within the system are the centers of the 1970 Census County Divisions. Recognizing that competition for capacity can be expected from population centers outside of Oklahoma, the counties surrounding Oklahoma are included in the system, along with their accompanying recreation sites. This "boundary problem" is thereby compensated for to insure a more realistic view of travel patterns.

The 111 recreation sites within the system are identified as areas supplying the support facilities for weekend overnight camping opportunities. Because of the difficulty in defining boundaries of camping areas, identified campsites, as opposed to acres of land for camping, are used to determine capacity.

This information, on identified camp sites, both for tents and recreation vehicles, was obtained from the 1977 Oklahoma SCORP facility inventory, and Woodall's directory of camping.

Table 1 is an example of the input required by the RECSAD II program. An explanation of these input conditions follows.

TABLE 1

INPUT CONDITIONS	
NUMBER OF POPULATION POINTS	= 469
NUMBER OF POPULATION POINTS OF INTEREST	= 344
NUMBER OF RECREATIONS SITES	= 158
NUMBER OF RECREATIONS SITES OF INTEREST	= 111

* This was done as a part of Miles Logsdon's M.S. Thesis.

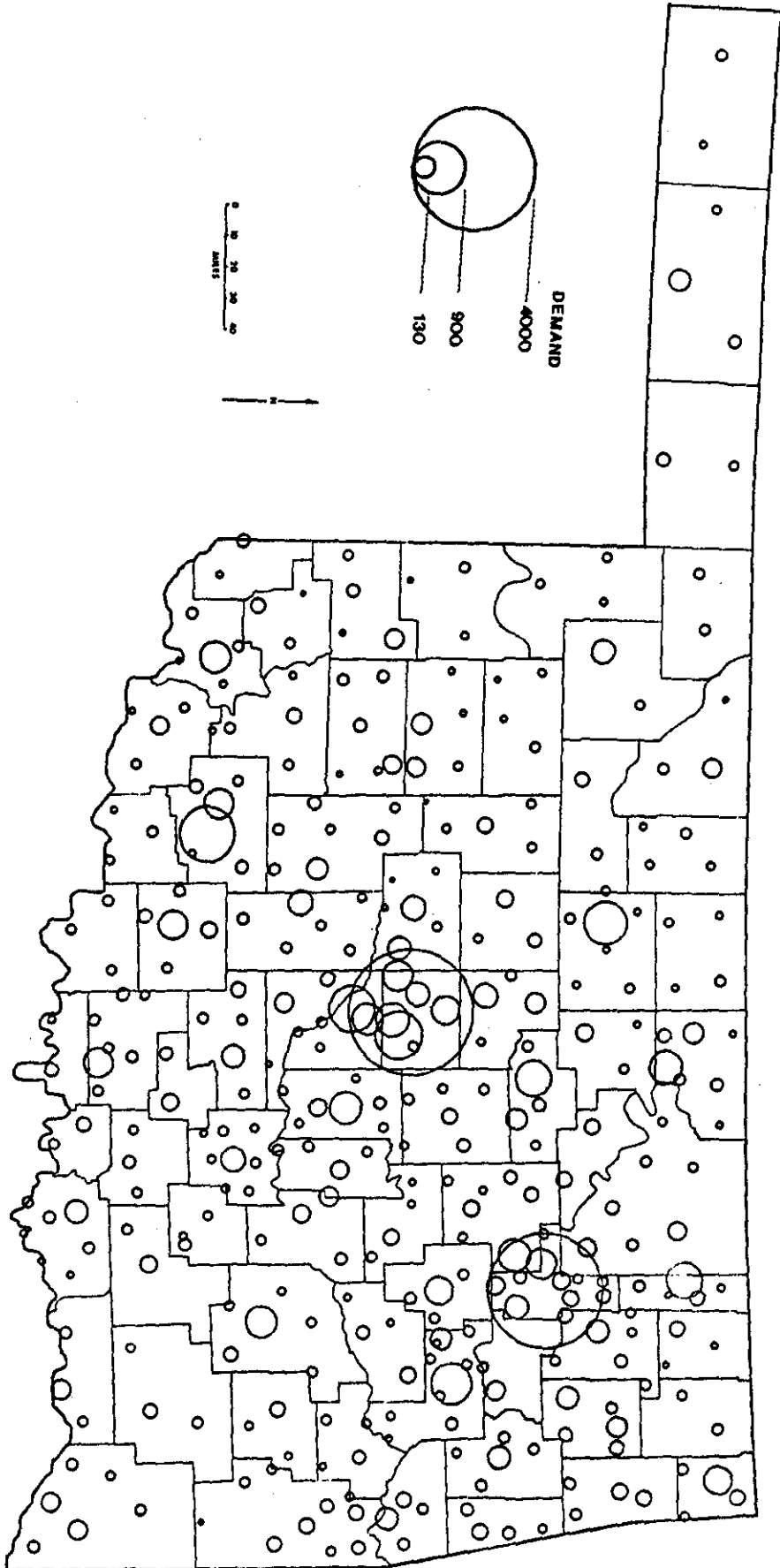


Figure 1. Demand for Weekend Camping Trips in Oklahoma.

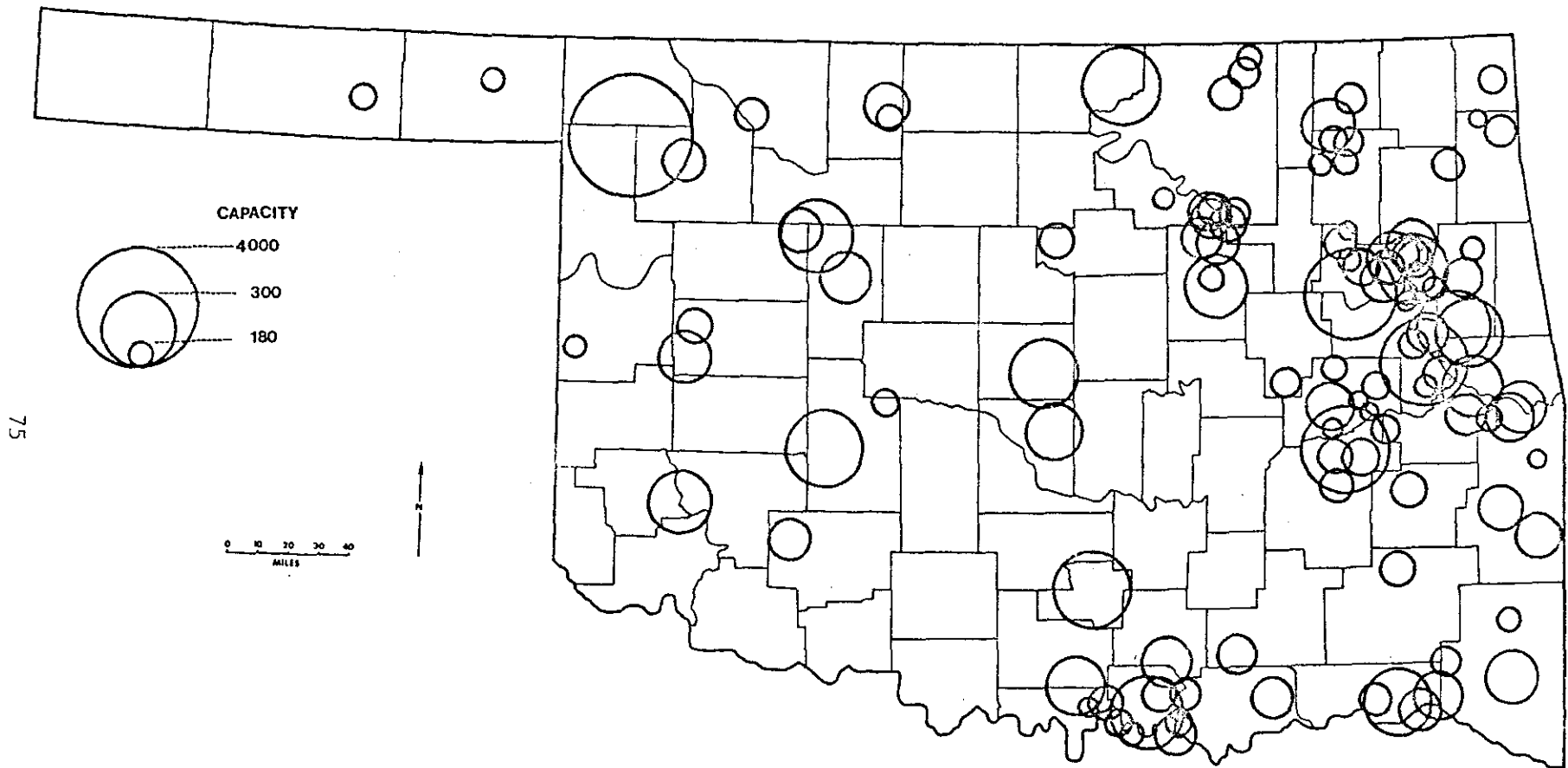


Figure 2 . Capacity for Weekend Camping Trips in Oklahoma.

SCALE (KM OR MILES PER INCH)	= 28.000
PARTICIPATION RATE (PER 100,000)	= 1200.
CAPACITY PER UNIT FACILITY	= 4.0000
PERCENT WILLING TO TRAVEL MEDIAN DIST	= 0.10

NPOP: Number of population centers. In this system, 344 are utilized.

NREC: Number of recreation sites to be analyzed. In this system, 111 are identified.

SCALE: Scale of source map in miles (or kilometers) per inch.

PARATE: The proportion of the population participating in the type of recreation activity under consideration; such an input may be obtained from local empirical studies or from regional or national averages such as those provided by the Bureau of Outdoor Recreation, or by various state recreation plans. In this discussion, a participation rate of 1.2 percent (1200 per 100,000) has been used.

CAPFAC: Daily facility capacity for each unit in the recreation site. Thus, a picnic table may have a maximum daily capacity of 12 picnic occasions, an acre of water = 1/2 a boating occasion, a front foot of beach = 1 swimming occasion, and so on. Such figures may be adjusted to conform to preferred local standards, or to local environmental carrying capacities. In this example, it is assumed that a campsite can accommodate 4 people.

Percent Willing to Travel Median Distance: as explained before, this is the percent of the population of each individual population center willing to travel the median distance to all recreation sites within the system. It is this value which will be varied to simulate changes in travel behavior.

Examples

A combination of factors influences the degree to which any recreation site is used. The factors of park capacity and park location act as key determinates in this evaluation.

To better illustrate the effects of the median distance decay curve and to assist in explaining the output of the RECSAD II program, four examples of park capacity and demand will be offered. These examples will illustrate the effects of decreased willingness to travel on individual recreation sites and population centers. The four examples include:

1. A large population center with good access to recreation areas;
2. A large population center remotely located from recreation sites;
3. A large recreation site near a large population center; and
4. A large recreation site remotely located from population centers.

The output of RECSAD II, using the median distance decay approach, is divided between reporting on the efficiency of recreation sites and evaluating the satisfaction at population centers. The terms used in the program will be explained along with a discussion of the example circumstances. The drawing power of each recreation site is assumed equal, governed only by its relative capacity. The explanation of these input conditions is found in the original documentation of the RECSAD program.

1. A large population center (Oklahoma City)

As the percent of the population willing to travel the median distance increases, the number of users finding an adequate recreational opportunity would also be expected to increase. Effective capacity is calculated by dividing the total capacity of a recreation site among the population centers which have users assigned to that site in proportion to the respective number of users from each population center. Table 2 shows the increases in effective capacity and, hence, fulfilled demand for the large population center of Oklahoma City, as willingness to travel increases. This population center is located near the center of the system with a median distance of 114 miles to all recreation sites within that system. Again, Figure 1 and 2 illustrates the distribution of population centers and recreation sites within this system.

TABLE 2

<u>% Willing To Travel</u>	<u>Occasions Of Demand</u>	<u>Effective Capacity</u>	<u>Capacity/Demand Ratio</u>	<u>Latent Demand</u>	<u>Median Distance</u>
10	4643	3712	.80	930	114
90	4643	4170	.90	473	114

Referring to Table 2 the demand from this center remains the same, as expected. The effective capacity, or the amount of recreation units used by this center increases. This would also be expected, because a larger percent of the population is willing to go farther and therefore occupy sites that before went unused.

The capacity/demand ratio indicates the relationship between the capacity available to the center and the demand from that center. A ratio above 1.0 indicates a surplus, while a value below 1.0 indicates a deficiency in supply. A 1.0 to 1.0 relationship is ideal.

Latent demand is a measure of unfulfilled demand occasions. It is a function of the distance from the population center to its recreation sites, and the demand of competing population centers for existing capacity. In this example, the amount of latent demand decreases as more people are willing to go farther.

2. A large remote population center (Guymon)

Located in the extreme western part of this recreation system, Guymon, a large population center for this area, has a longer median distance from recreation sites. Table 3 indicates the satisfaction of this population center as the willingness to travel increases.

TABLE 3

<u>% Willing To Travel</u>	<u>Occasions Of Demand</u>	<u>Effective Capacity</u>	<u>Capacity/Demand Ratio</u>	<u>Latent Demand</u>	<u>Median Distance</u>
10	134	107	.80	27	297
90	134	102	.77	31	297

In this circumstance, an increase in the willingness to travel had very little impact on latent demand or effective capacity. A higher willingness to travel caused greater competition from distant population centers at all recreation sites, resulting in slightly fewer opportunities being available to participants from this population center.

Again, the capacity/demand ratio indicates a deficiency of supply under both travel assumptions.

3. A large recreation site, near a large population center
(Little River State Park and Oklahoma City)

The measures used in quantifying the efficiency of recreation sites are quite simple. The capacity, as described before, is a fixed amount, depending upon the standard used to convert the sites' physical facilities into units of demand which they are capable of serving. The users are the number of demand occasions which would be willing to travel to this recreation site, given the selected willingness to travel. A capacity/use ratio is used to illustrate the crowding condition. A value above 1.0 would indicate a surplus of capacity, while a value below 1.0 would indicate overcrowded conditions.

As expected, the figures in Table 4 indicate that as the willingness to travel increases, the crowded conditions at this nearby recreation site decrease.

TABLE 4

Percent Willing To Travel	Capacity	Users	Capacity/Use Ratio
10	860	1310	.66
90	860	812	1.06

4. A large remote recreation site
(Boiling Springs State Park)

In this example the recreation site is remotely located from large population centers. As the percent willing to travel the median distance increases, the underused remote site becomes accessible to more users, and it experiences overcrowded conditions. The figures in Table 5 indicate this change.

TABLE 5

Percent Willing To Travel	Capacity	Users	Capacity/Use Ratio
10	464	410	1.13
90	464	507	.92

Existing empirical use figures for overnight camping at 20 recreation sites were found to correlate best with the assumption that 25% were willing to travel the median distance.

Referring again to figures 1 and 2 the relative supply/demand relationship for the camping recreation system can be seen. Focusing the attention on the adequacy of the recreation sites, figure 3 illustrates the capacity use ratio of all recreation sites at 25% willingness to travel level.

Table 6 summarizes the situation for Oklahoma and the surrounding states.

TABLE 6

	Parks in:		Total
	Oklahoma	Out of State	
Users from Oklahoma	26904	3786	30748
Out of State	3786	13577	52228

The cumulative travel distance for all users are shown in Table 7. Note, the average (median) travel distance is 100 miles.

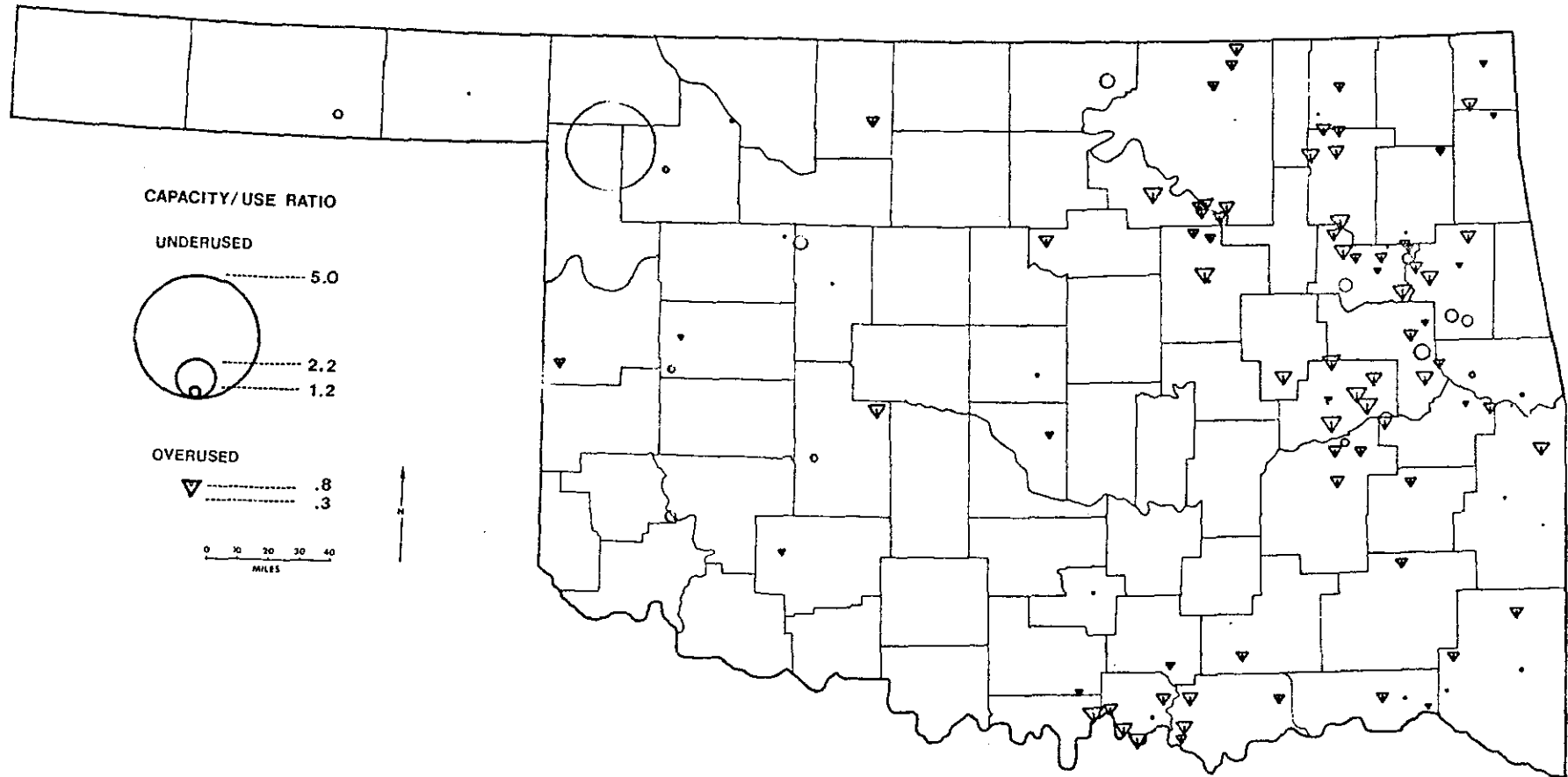


Figure 3. Capacity/Use Ratio--25% Willing To Travel.

TABLE 7
CUMULATIVE TRAVEL DISTANCE

Distance	Trips	Percent
25-49	77283	93.5
50-74	68670	83.0
75-99	54869	66.4
100-125	41512	50.2
125-149	30099	36.4
150-174	22705	27.5
175-199	15199	18.4
200-224	9811	11.9
225-249	5817	7.0
250-274	3985	4.8
275-299	2692	3.3
300-324	1293	2.2

The RECSAD model indicates that at the present willingness to travel, a majority of the recreation sites are overused. Underused sites, however, are clustered among overused sites. The large underused site near the panhandle, the Fort Supply Recreation Area, dominates the systems with a supply that is nearly twice that of any other site. When relying on reported data, consistency must be maintained, requiring the inclusion of this suspect capacity figure.

As expected most recreation sites in eastern Oklahoma are overused to some degree, while in western Oklahoma underused areas are more common. Since use is based on the willingness to travel the median distance, and the more remote population centers of western Oklahoma have a longer median distance, residents in the west are willing to travel to the more numerous sites in the eastern half of the state.

APPENDIX 3

ANNOTATED BIBLIOGRAPHY OF COMPUTER APPLICATIONS IN RECREATIONAL PLANNING*

In the United States, many state and local agencies are actively involved in the planning and development of recreation system and facilities. A growing body of research has been undertaken to cater to the needs of planning bodies. An important feature of this research, is that it often involves an enormous quantity of information. Most planning exercises involve problems of allocating sets of conflicting activities among resources that are limited in both the spatial and temporal dimension. A common problem is one of deciding on the most efficient location of a recreation area for serving the needs of a scattered population with the constraint of a limited budget and limited areas available for the facility. Another problem is one of making predictions about the magnitude of use at one or several proposed facilities. Other kinds of problems involve the provision of substitute recreation activities when those that are most desired cannot be made available. All of these may require large data sets and many variables. To cope with both the problems of large data files and the computational complexities of some of the analytical models used a number of computer programs have been developed. Computer technology has also been applied to aid in the retrieval and storing of data.

The studies that are listed in this annotated bibliography are examples of those that either explicitly or implicitly make reference to the application of computers to recreation planning situations. The references have been classified into six categories:

- (1) Prediction of Use at Individual Parks
- (2) Prediction of Use at a Series of Recreational Areas
- (3) Simulation of a Recreation System
- (4) Intra-Park Behavior
- (5) Information Display and Retrieval Systems

*This bibliography was prepared with the assistance of Wong H. Sang, Research Assistant, Department of Geography, Oklahoma State University.

(1) PREDICTION OF USE AT INDIVIDUAL PARKS:

Cesario, F. J. (1969). "Operations Research in Outdoor Recreation."

Journal of Leisure Research, Vol. 1, No. 1, 1969, pp. 33-51.

This study attempts to predict recreation travel flows from several population centers towards a recreation site. An economic evaluation is made by estimating the primary economic benefits of outdoor recreation.

Walter, G. R. & J. A. Schofield (1977). "Recreation Management:

A Programming Example." Land Economics, May 1977, Vol. 53, No. 2, pp. 213.

An attempt is made to arrive at an optimal set of combinations of activities for satisfying a range of diverse activities. The technique of linear programming is applied to the case of Bowron Lake Provincial Park, British Columbia. The programming model also incorporates variables representing aspects of the natural environment, which might be affected by recreational development.

(2) PREDICTING USE AT A SERIES OF RECREATION AREAS:

Cheung, H. K. "A Day-Use Park Visitation Model." Journal of

Leisure Research, Vol. 4, 1972, pp. 139-156.

The relationship between use levels, population size, distance of population centers, attractiveness of recreational areas and alternative recreational opportunities is incorporated into a multiple regression analysis.

Elsner, G. H. (1972). "A Regression Method for Estimating the Level of Use and Market Area of a Proposed Large Ski Resort." Journal of Leisure Research, Vol. 3, No. 3, 1972, pp. 160-167.

An important part of recreational planning involves the estimation of the magnitude and spatial distribution of demand for the services that a recreational facility can offer. In this study, systems analysis is used for simulating use-levels and market areas for thirty six large ski-resorts in California. The results of the simulation were compared with observed values.

McKillop, W. (1975). "Wilderness Use in California: A quantitative Analysis." Journal of Leisure Research, Vol. 7, No. 3, 1975, pp. 165-178.

A regression model is used for analyzing the factors influencing wilderness use in twenty one Forest Service areas and three national parks during the 1968-71 period. The variables included were income levels, costs of travel, population levels of market areas and the availability of leisure time.

Murray, T., Rogers, P., Sinton, D., Steinitz, C., & R. Toth. (1971). Honey Hill: A Systems Analysis for Planning the Multiple Uses of Controlled Water Areas. Vol. 1, (Harvard University, Cambridge, Mass. Department of Landscape Architecture, Final Report.) 1971.

Research was aimed at focusing attention on the ways and means

of measuring non-monetary social and environmental costs and benefits and comparing them with costs and benefits measurable in dollars. Emphasis was on multiple uses of land and water resources for recreation. Data on the area was stored, analyzed and displayed using computer graphics developed by the investigators. The study developed sets of quality indices for visual quality, ecological damage, wildlife habitat etc. Grid areas were evaluated and ranked in terms of various uses, thus laying the basis for a planning evaluation process for site development. A simulation model was developed which allowed comparisons of the effects of implementing alternative recreation plans. Vol. 2 of the study contains appendices to Vol. 1.

Tweedie, S. W. & R. D. Hecock. "RECSAD: A Computer Program for Recreation Planning" Department of Geography, Oklahoma State University, The Oklahoma Water Resource Research Institute. 1974.

See discussion in Chapter 1 of this report.

(3) SIMULATION OF A RECREATION SYSTEM:

Krutilla, J. V. & A. C. Fisher. (1974). The Economics of Natural Environments: Studies in the Valuation of Commodity and Amenity Resources. Resources for the Future, Johns Hopkins University Press, Chapter 6.

A simulation model is used for evaluating the benefits from

environmental preservation.

Cesario, F. J. (1975). "A Simulation Approach to Outdoor Recreation Planning." *Journal of Leisure Research*, Vol. 7, No. 1, 1975, pp. 38-52.

Using a fictitious example, simulation techniques are applied towards solving the problem of planning recreation sites, making expansion decisions, determining the combinations of recreational activities and making forecasts of visitor responses to contemplated changes in various aspects of an outdoor recreation system.

Elsner, G. A. "Computer Management of Recreation Data: Terrain and Usage Studies for Land-Use Planning." In *Systems Analysis and Forest Resource Management, Proceedings of the Workshop on Syst. Anal. Gr. Soc. Amer. For.* pp. 351-367, (University of Georgia, Athens, Aug. 11-13, 1975).

Application of regression and computer simulation techniques for analyzing wilderness usage in terms of the origin, group size, stay duration, entry point and total daily volumes of wilderness users. The regression model is used for predicting the effects of expanded proposed recreation systems and the VIEWIT computer system helps in making rapid assessments of landscape and other vistas from different vantage points. It also makes possible the storage and retrieval of large amounts of data as well as providing cartographic capabilities for

displaying the results of all the analyses performed. VIEWIT is unique because it has been designed with the planner, and not the computer expert, in mind. No advanced computer programming knowledge is required.

Elsner, G. H. & R. A. Oliveira. (1973). Predicting Traffic Load Impact of Alternative Recreational Development. U. S. Forest Service, Pacific South West Forest and Range Experiment Station, Berkeley, California, Research Paper, 96, 1973. Traffic load changes due to expansion of recreation facilities may be predicted through computations based on estimates of drawing power of the recreational attraction, overnight accommodations, in-or-out terminals, probable types of travel, probable routes of travel and total number of cars in the recreation system. Once the basic model has been established, development alternatives may be simulated to provide percent change estimation of probable traffic load effects on each link in the system. Illustrative estimates are made for six alternatives in the Harney-Peak area of South Dakota.

Mednick, H. (1975). "A Markov Chain Model of Travel Patterns of U.S. Visitors to Ontario." Journal of Leisure Research, Vol. 7, No. 4, 1975, pp. 246-255.

A Markov-Chain Model is used as a basis for simulating the travel behavior of visitors making overnight stops among ten economic regions in the Canadian Province of Ontario.

Smith, V. K. & J. V. Krutilla. "A Simulation Model for the Management of Low Density Recreation Areas." Journal of Environment, Economics & Management, Vol. 1. (Nov.), pp. 187-201, 1974.

The use of level of a recreational facility, as indicated by user density, has important effects on the quality of the individual's recreational experience. The study attempts to measure the effects of alternative use levels on the expected quality of individual experience, in the Spanish peaks area in Montana, using a simulation model that approximates as nearly as possible the travel behavior of wilderness users.

(4) INTRA-PARK BEHAVIOR:

Bishop, B. W. (1970). "Stability of the Factor Structure of Leisure Activity: Analysis of Four Communities." Journal of Leisure Research, Vol. 2, 1970, pp. 160-170.

Recreational activities are pursued for several reasons that are essentially quite stable, regardless of the type of activity performed. The reported leisure activities of respondents in four communities were analyzed using factor analysis. Three dimensions of leisure behavior were used: active diversionary, potency and status.

Carls, F. G. (1974). "The Effects of People and Man-Induced Conditions on Preferences for Outdoor Recreation Landscapes." Journal of Leisure Research, 1974, Vol. 6, pp. 113-124.

It is important for a planner to know what effect people have on

each other within a recreation area. Such effects are often difficult to measure. In this study, samples of people (representing recreationists) were chosen for an experiment aimed at investigating the effect of people and man-induced conditions on preferences for outdoor recreation landscapes. Photographs of one hundred different landscape scenes were presented to the respondents for ranking on the basis of personal preferences. As the number of people in the scenes increased, preferences tended to decrease.

Ditton, R. B., Goodale, T. L. & P. K. Johnsen. "A Cluster Analysis of Activity, Frequency and Environment Variables to Identify Water-Based Recreation Types." Journal of Leisure Research, Vol. 7, No. 4, pp. 282-295, 1975.

An attempt is made to classify recreation activities using cluster analysis. Multiple measures on each individual's characteristics are used in developing typologies of recreation activities. Each activity type is spatially linked to an environment characteristic in the recreation area.

Hendee, J. C. & R. J. Burdge. (1974). "The Substitutability Concept: Implications for Recreation Research and Management." Journal of Leisure Research, 1974, Vol. 6.

From a theoretical standpoint, one recreational activity might substitute for another if it is capable of providing the individual with the same kind of satisfaction or that was

desired or expected from the first. In this study, factor analysis is applied towards classification of recreation activities on the basis of criteria that would facilitate the trade-off or substitutability one type of activity for another.

Kranz, P. "What Do People Do All." Behavioral Science, 15, 3, May, 1970, pp. 286-291.

Simultaneous developments in methodology and computer use are outlined which would make the field of time-budget research attractive to various types of behavioral studies. In a typical time budget, the researcher obtains the respondents list of activities for a day or a few hours. Computer techniques are then used to deal with the wealth of information provided. A specific computer program is described for use with an appropriately created semantic dictionary. The dictionary is created by a reiterative process and leads to the assignment of nominal data to descriptive words or phrases.

McKechnie, G. F. "The Psychological Structure of Leisure: Past Behavior." Journal of Leisure Research, Vol. 6, 1974, pp. 27-45.

The participants of leisure activities can be classified on the basis of the relationship between types of leisure activities and associated demographic and personality characteristics of the participants. Using the SPAN program of the BCTRY System of Cluster and Factor Analysis, personality and demographic characteristics of participants are related to the nature and

patterns of their leisure activities.

Nielsen, G. A., Jezeski, J., Emerson, C., D. Myrick, J. Suess, D. Stuart, and A. Williams. (1973). "Environmental Impact Assessment: the Gallatin Canyon-Big Sky Study." Journal of Soil and Water Conservation, 28 (5), 1973, pp. 208-210.

In determining the environmental impact of a proposed recreational development in Montana, baselines were established for assessing changes. The impact of traffic flow and fishing was examined. Thirty-one problems generated by human activity were examined.

Romsa, G. H. "A Method for Deriving Outdoor Recreational Activity Packages." Journal of Leisure Research, Vol. 5, 1973, pp. 34-46.

It is possible to identify groups of recreationists performing certain groups of activities together. An information statistic, '2 Delta I' is used for defining such groups.

Schmitz-Scherzer, R., Rudinger, G., Angleitner, A. & Bierhoff-Alterman, D. "Notes on a Factor Analysis Comparative Study of Leisure Activities in Four Different Samples." Journal of Leisure Research, Vol. 6, 1974, pp. 77-83.

The essential similarity of leisure activities is examined in terms of factor analysis. The study aims to develop a basic structure of leisure activity which could aid in developing categories of leisure activities on the basis of their ability to bring certain kinds of satisfactions. Factor analysis techniques are used.

Seneca, J. J. & R. K. Davis. "A Cross-Section Analysis of State Recreation Activity." Journal of Leisure Research, Vol. 8, No. 2, pp. 112-122, 1976.

The problem of the classification of leisure activities can also be approached from the point of view of the participant's perception of recreation activities. A sample of participants were asked to make judgements about the similarities between different recreation activities. The data obtained, being ordinarily scaled, was converted into ratio-scaled data using the technique of Nonmetric Multidimensional Scaling (NMDS).

Smith, S. "Similarities between Urban Recreation Systems." Journal of Leisure Research. Vol. 7, No. 4, pp. 270-281.

In an attempt to search for order and regularity in urban recreation systems, principal components analysis and discriminant analysis is applied. A Mahalanobis D^2 statistic was used to cluster the study cities into homogenous groups. Policy making implications include the possibility of developing uniform standards in the planning of recreation for similar groups of cities.

Tatham, R. L. & R. J. Dornoff. (1971). "Market Segmentation for Outdoor Recreation." Journal of Leisure Recreation, Vol. 3, No. 4, 1971, pp. 5-16.

This study represents an attempt at classifying recreational

activities into groups having certain characteristics attributes of recreational behavior patterns. Hierarchical clustering techniques are utilized for classifying segments of the recreational market. The procedure yields groups having relatively homogenous characteristics with respect to activity preferences and socio-economic criteria.

Tombaugh, L. W. (1970). "Factors Influencing Vacation Home Locations."

Journal of Leisure Research, Vol. 2, No. 1, 1970, pp. 54-63.

Recreational areas are threatened by expanding urbanization and activities that are dependent on wilderness locations.

This study discusses the competition existing between vacation home locations and other types of land-use, particularly recreational land use.

Wishart, D. Clustan 1A User Manual. St. Andrews, Fife, Scotland.

Computing Laboratory, University of St. Andrews.

An outline of computer programs available for using cluster-analytic techniques.

(5) INFORMATION DISPLAY AND RETRIEVAL SYSTEMS:

Elsner, G. H. "Campground Users: A Computerized Model for Summarizing

where they come from and How Long They Stay." U.S.D.A. Forest Service Research Note, PSW-258, 1971.

An information storage and retrieval system for market area information from data stored on campground permits.

Elsner, G. H. "Wilderness Management ... A Computerized System

for Summarizing Permit Information. U.S.D.A. Forest Service
General Technical Report PSW-2/1972.

A computerized system for analyzing information obtained
from permits. COUNTY converts ZIP mailing codes to origin-
of-visitor indices. TOTAL summarizes the information on the
total number of registered persons in a wilderness on a given
day. ORIGIN produces a summary of places of origin table,
by number of persons. LSTAY produces two distribution tables,
one on length of stay, and another by groups size.

Fraye, W. E. & D. B. Butts. (1974). "BUS: A Processing System
for Records of Backcountry Camper Use." Journal of Leisure
Research, 1974, Vol. 6, pp. 305-311.

A system of rapid data recall is outlined. Information is
provided on the spatial and temporal patterns of recreationists.
The system can be utilized for developing a reservation system
that controls visitor impacts on recreation areas. The
computer program was in FORTRAN IV and tested on a CDC 6400
computer.

Hodges, L. & C. S. Van Doren. (1972). "Synagraphic Mapping as a
Tool in Locating and Evaluating the Spatial Distribution of
a Municipal Recreational Facility." Journal of Leisure
Research, 1972, Vol. 4, 341-353.

A tool is developed for the rapid analysis of the geographical
distribution of recreational areas in a municipality. This

could be employed by planners and decision makers for evaluating disparities in recreational opportunities. Maps are generated for service radii of selected recreation centers, population densities and mobility indices for Dallas, Texas.

Loy, J. W. Jr. (1968). "An Information Retrieval System for Sport Sociologists." International Review of Sport Sociology. 1968, 3, 149-155.

A punched card system for information retrieval is described. The system is based on a type of edge-notched punched card, marketed under the trade-mark 'keysort'. The system is efficient, cheap and requires relatively little maintenance. The card format, storage system, mechanics, classification and coding system are described. Bibliographic data can be readily typed onto a card and the required coding punches are few and quickly made. It is a rapid and relatively open-ended system with the possibilities for adding new categories whether these are headings or sub-headings.

Nielson, J. M. & W. R. Catton, Jr. (1971). "Forest Recreation Propositional Inventory." Journal of Leisure Research, Vol. 3, No. 3, 1971, pp. 178-193.

An information retrieval system is described for the recovery of sociologically relevant information on forest recreation. The procedure involves the recording and storing of substantive, methodological, bibliographical and contextual information from published articles in the form of retrievable propositions.

APPENDIX 4

SUPPLEMENTARY COMPUTER PROGRAMS

In connection with this project it was necessary to develop the capability of analyzing and displaying origin/destination data efficiently through computerized methods. A series of computer programs were developed to handle this task. In the belief that these may have general utility to persons interested in spatial modeling of supply and demand or in developing graphics depicting flows of visitors, these programs are described and presented here.

The analysis of origins and destinations utilizing conventional places names is cumbersome and time-consuming. Researchers and others confronted with the need to maintain relatively detailed information on locations have come to rely upon U.S. Postal Service "Zip Codes." A good deal of census information is available by Zip Code. In addition, a large proportion of survey respondents can and will provide their home Zip Code. For those who cannot (or will not) it is a relatively simple matter to look up Zip Codes if home addresses or other locational data are obtained.

From the standpoint of preserving geographic detail Zip Codes at the three digit level are intermediate between county units and States. For the State of Oklahoma there are seventy-seven counties and only eleven three-digit Zip Code areas. Moreover, Zip Codes at the three-digit level make some sense from an areal functional organization standpoint. Zip Code areas usually have boundaries which are consistent with those of third-order market areas.

On the other hand, five-digit Zip Codes vary from a few blocks to several hundreds of square miles. Five-digit Zip Codes have little to do with the functional organization of space, especially in metropolitan areas where there are often a great number in a relatively small area.

Unfortunately there is no geographic logic in the numbering of Zip Codes beyond the fact that the first digit increases from East to West. In order to make the Zip Codes (either three- or five-digits) useful from analytical or graphics-display standpoints, it was necessary to merge a geographical reference system with the Zip Codes.

(1) The PICADAD Tape and Zip Code Reference Files:

The first requirement was to find geographical coordinates

for the zip codes. These are available for (most) five-digit Zip Codes on the PICADAD computer tape, available for \$80 from the U.S. Bureau of the Census. The PICADAD file contains a great deal of information that was extraneous to our purposes, so the required information, namely Zip Code, latitude, and longitude was extracted from the tape and arranged in ascending order by Zip Code. The resulting data set, called LALZIP, contained about 28,000 entries for the United States. The detail provided by five-digit Zip Codes was judged unnecessary for purposes of analyzing regional recreation flow patterns, so an additional file was created containing three-digit codes and coordinates for the entire USA. The 1970 population for these three-digit Zip Code areas was extracted from the Fifth Count computer tape of the US Census of Population and added to this three-digit file.

In order to utilize the five-digit Zip Code file in LALZIP, it was necessary to deal with a minor problem. The PICADAD tape does not include listings for each five-digit region within a metropolitan area. For example in the case of Tulsa, Oklahoma, only 74100 is listed. The next entry in the file is 74201. The effect is that all residents in a metropolitan area are aggregated to a single location with a large population rather than appearing as a cluster of many smaller population centers. For purposes of analyzing regional recreation flow patterns this aggregation seemed satisfactory and perhaps even desirable.

This does present a problem in matching a list of recreationists' five-digit Zip Codes to those in the LALZIP file. Program ZIPMATCH was written to solve this problem. To use the program, the recreationist data file is ordered by ascending Zip Codes and provided as input to the program. ZIPMATCH then assigns all recreationists to either their Zip Code (if it is in the file) or to the next smaller zip code that appears in the LALZIP file. For example, a user at 74074 would be assigned coordinates for zip code 74074, but a user from 74125 would be assigned to 74100.

Output from ZIPMATCH is in the form of a summary table showing the number of users from each five-digit Zip Code area (See Table 1). For example, in one sample over 2000 users were found to be located at only 145 five-digit Zip Code areas. Data summarized in this form can then be used for input for subsequent analysis such as computer mapping, (MAPLOT & FLOWPLOT) distance decay relationships (ZIPDIST), and comparisons with predicted use from a simulation model (RECSAD).

(2) Computer Mapping Programs and Problems:

Two computer mapping programs were developed in connection

with the project. The first, MAPLOT, draws graduate symbols scaled in proportion to the data values (or number of users) at the data points. The second, FLOWPLOT, draws flow lines between origin and destination points, with widths of the lines scaled in proportion to the amount of the flow between points. Both programs produce graphic output on a plotter.

Such output requires a frame of reference such as state or country boundaries or Zip Codes. These can either be coordinatized and drawn by the plotter on each map, or provided by preparing a transparent overlay through standard cartographic techniques. This overlay is then photographically combined with the computer map. Since computer maps look best when drawn at a large scale and photo-reduced, the latter approach was used.

In order to produce the computer maps it was necessary to convert the latitude and longitude for each Zip Code to x and y coordinates that could be used by the plotter. This process is complicated by the fact that it involves a conversion from spherical coordinates to rectilinear coordinates which must fit an existing base map. The Albers Equal Area projection, with standard parallels at 29°30' and 45°30' and centered on 95° west longitude, was selected because of its frequent use by the U.S. Census Bureau and other agencies.

The conversion was accomplished by first converting longitude and latitude into polar coordinates (R,P) on a flat surface, and then transforming these into Cartesian coordinates (X,Y) with the origin repositioned to be compatible with the plotter. The following equations and constants produced a reasonable fit for the United States map.

$$R = \sqrt{\left(\frac{2 K \cos (29.5)}{\sin (29.5) + \sin (45.5)}\right)^2 + \frac{4 K^2 (\sin 29.5) - \sin A}{\sin (29.5) + \sin (45.5)}}$$

$$\cos P = 1 - \frac{-2 (K \cos A \sin ((B-95)/2))^2}{R^2}$$

$$X = R \sin P + C$$

$$Y = -R \cos P + D$$

where:

$$A = \text{latitude of the Zip Code area}$$

B = longitude of the Zip Code area

K = a constant determined by the ratio between the radius of the earth and the radius of the sphere used to generate the map projection.

C,D = constants used to reposition the origin.

R,P = polar coordinates

X,Y = Cartesian coordinates

(3) Analysis of Distance Traveled (ZIPDIST):

Once latitude and longitude had been determined for both origins and destinations the following equation was used to calculate great circle, or airline distance between points.*

$$D = \sqrt{3.666 \left(\frac{\Delta\phi}{100}\right)^2 + 3.700 (\cos^2 \phi) \left(\frac{\Delta\lambda}{100}\right)^2}$$

where: D = distance in statute miles

ϕ = mean latitude of the two locations

$\Delta\phi$ = latitude difference in seconds

$\Delta\lambda$ = longitude difference in seconds

The use of straight line instead of highway mileage underestimates distances traveled. However, this error is fairly consistent in the sense that it effects all distance calculations proportionately. Its advantage in ease of calculation outweighs any loss of accuracy due to its use in the analysis.

The distances calculated by ZIPDIST can be used to analyze visitations by distance zones, or as an independent variable in a regression model.

*George A. James, Gordon R. Sanford, and Andrew Searcy, Jr., "Origin of Visitors to Developed Recreational Sites on National Forests", Journal of Leisure Research, (Spring 1972), p. 111.

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// EXEC FORTGCG
 //FORT. SYSIN DD *

PROGRAM RECSAD: MEDIAN DISTANCE DECAY VERSION

REQUIRED INPUT:

- 1) TITLE CARD:
 COL 1-5 TITLE
 11-78 ANY TITLE
- 2) CONDITIONS CARD
 COL 1-10 CONDITIONS
 11-15 NUMBER OF REC SITES
 16-20 NUMBER OF POPULATION CENTERS
 21-25 SCALE (MILES PER INCH)
 26-30 PARTICIPATION RATE PER 100,000
 31-35 CAPACITY PER UNIT FACILITY
 36-40 PERCENT WILLING TO TRAVEL THE MEDIAN DISTANCE
 41-45 PUNCH "1" TO LIST MATRIX OF USER FLOWS
 PUNCH "2" TO PRINT AND PUNCH MATRIX OF USER FLOWS
- 3) REC SITES CARD
 COL 1-9 REC SITES
 16-20 NUMBER OF REC SITES OF INTEREST
 21-80 FORMAT TO READ REC SITE DATA. MUST HAVE ONE I AND
 FOUR F TYPE FIELDS TO READ ID FOR REC SITE, X AND Y
 COORDINATES, CAPACITY, AND ATTRACTION.
- 4) REC SITE DATA: ONE REC SITE PER CARD CONTAINING ID CODE,
 X AND Y COORDINATES, CAPACITY, AND ATTRACTION.
- 5) POPCENTERS CARD:
 COL 1-10 POPCENTERS
 16-20 NUMBER OF POPULATION CENTERS OF INTEREST
 21-80 FORMAT TO READ POP CENTERS DATA. MUST CONTAIN ONE I
 AND 4 F TYPE FIELDS TO READ ID CODE FOR POP CENTER,
 X AND Y COORDINATES, POPULATION, AND STATUS. STATUS
 CAN BE USED TO VARY THE PARTICIPATION RATE FOR INDIVIDUAL
 CENTERS.
- 6) POPCENTER DATA CARDS: ONE CARD PER POP CENTER CONTAINING AN ID CODE
 X AND Y COORDINATES, POPULATION, AND STATUS.

REAL*4 TITLE(17)
 REAL*4 FMTR(15),FMTP(15)
 DIMENSION USERS(500,200),CUM(13),IDPOP(500),IDREC(200)

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DIMENSION SDIST(660)
DIMENSION PX(500),PY(500),POP(500),EFFCAP(500)
DIMENSION RX(200),RY(200),RFAC(200),ATRACT(200),PR(200),RPOP(200)
DIMENSION CUR(200),DIS(200)
DATA RPOP/200*0./,EFFCAP/500*0./,CUM/13*0./,CUR/200*1./
IEND=0
LOOP=0
SUM1=0.
SUM2=0.
SUMD=0.
1000 READ (5,1000) TITLE
    FORMAT (10X,17A4)
    WRITE (6,1000) TITLE
C
C
C      READ PARAMETERS
1010 READ (5,1010) NREC,NPOP,SCALE,PARATE,CAPFAC,PCTMD,MATRIX
    FORMAT (10X,2I5,4F5.0,15)
    IF (PARATE.EQ.0.0) PARATE=100000.
    IF (CAPFAC.EQ.0.0) CAPFAC=1.
    CAL=ALOG(PCTMD)
    AFACT=SQRT(CAL/(-.5))
C
C
C      READ REC SITE DATA
1030 READ (5,1030) NRSS,FMTR
    FORMAT (15X,15,15A4)
    IF (NRSS.EQ.0) NRSS=NREC
    DO 10 I=1,NREC
    READ (5,FMTR) IDREC(I),RX(I),RY(I),RFAC(I),ATRACT(I)
    IF (ATRACT(I).EQ.0.0) ATRACT(I)=1.0
    RFAC(I)=RFAC(I)*CAPFAC
    SUM1=SUM1+RFAC(I)
    10 IF (I.EQ.NRSS) SUMA=SUM1
C
C
C      READ POP CENTER DATA
2000 READ (5,1030) NPSS,FMTP
    IF (NPSS.EQ.0) NPSS=NPOP
    WRITE (6,2000)NPOP,NPSS,NREC,NRSS,SCALE,PARATE,CAPFAC,PCTMD
    FORMAT (///,2X,' INPUT CONDITIONS'//
    X 17,' NUMBER OF POPULATION POINTS      ='//15//
    X 17,' NUMBER OF POPULATION POINTS OF INTEREST ='//15//
  
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X T7, NUMBER OF RECREATIONS SITES           =, I5, /
X T7, NUMBER OF RECREATIONS SITES OF INTEREST =, I5, /
X T7, SCALE (KM OR MILES PER INCH)           =, F8.3, /
X T7, PARTICIPATION RATE (PER 100,000)       =, F9.0, /
X T7, CAPACITY PER UNIT FACILITY             =, F9.4, /
X T7, PERCENT WILLING TO TRAVEL MEDIAN DIST  =, F9.2)

DO 20 I=1, NPOP
  READ (5, FMTP) IDPOP(I), PX(I), PY(I), POP(I), STATUS
  IF (STATUS.EQ.0.0) STATUS=1.0
  POP(I)=POP(I)*(PARATE/100000.)*STATUS
  SUM2=SUM2+POP(I)
20 IF (I.EQ.NPSS) SUMB=SUM2

C
C
C   ROUTINE TO FIND MEDIAN DISTANCE FOR EACH POP CENTER

  HALF=SUM1/2.0
  DO 28 J=1, NPOP
    ACCUM=0.0
    DO 22 I=1, NREC
      DIS(I)=SQRT((PX(J)-RX(I))**2+(PY(J)-RY(I))**2)
      DIS(I)=SCALE*DIS(I)
    22 IF (DIS(I).EQ.0.0) DIS(I)=.001
  C - LOOP TO FIND SHORTEST DISTANCES
    DO 26 KK=1, NREC
      DO 23 I=1, NREC
        IF (DIS(I).LT.0.0) GO TO 23
        DTEMP=DIS(I)
        NCLOSE=I
        K=I
      GO TO 24
    23 CONTINUE
    24 DO 25 II=K, NREC
      IF (DIS(II).LT.0.0) GO TO 25
      IF (DIS(II).GE.DTEMP) GO TO 25
      DTEMP=DIS(II)
      NCLOSE=II
    25 CONTINUE
    ACCUM=ACCUM+RFAC(NCLOSE)
    IF (ACCUM.GE.HALF) GO TO 27
    DIS(NCLOSE)=-DIS(NCLOSE)
    26 CONTINUE
    27 SDIST(J)=DIS(NCLOSE)
    28 CONTINUE

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C
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 C

THIS SECTION ASSIGNS ALL POPULATION TO REC SITES

```

29 DO 40 I=1,NPOP
   SDP=SDIST(I)/AFAC
   SUMPR=0.
   DO 30 J=1,NREC
   D=SQRT((PX(I)-RX(J))**2+(PY(I)-RY(J))**2)
   D=SCALE*D
   DIS(J)=D
   U=-0.5*(D/SDP)**2
   ROOM=RFAC(J)/POP(I)
   IF (ROOM.GT.1.0) ROOM=1.0
   PR(J)=EXP(U)*CUR(J)*ROOM
30 SUMPR=SUMPR+PR(J)
   DO 35 J=1,NREC
   PR(J)=PR(J)/SUMPR
   USERS(I,J)=POP(I)*PR(J)
   RPOP(J)=RPOP(J)+USERS(I,J)
   XD=0.
   DO 33 K=1,13
   CUM(K)=CUM(K)+USERS(I,J)
   XD=XD+25.
   IF (DIS(J).LT.XD) GO TO 35
33 CONTINUE
35 CONTINUE
40 CONTINUE
   SUM3=0.
   DO 45 J=1,NREC
   SUM3=SUM3+RPOP(J)
45 IF (J.EQ.NRSS) SUMC=SUM3
  
```

C
 C
 C
 C

AFTER INITIAL ALLOCATION, THIS SECTION CALCULATES C/U RATIOS
 AT REC SITES, EFFECTIVE CAPACITY, AND C/D RATIOS AT POP CENTERS.

```

2005 WRITE (6,2005)
   FORMAT ('1', ' REC SITE', 6X, ' CAPACITY', 9X, ' USERS', 5X, ' C/U RATIO', /)
   SUM4=0.
   DO 50 J=1,NREC
   CUR(J)=RFAC(J)/RPOP(J)
   IF (J.GT.NRSS) GO TO 49
   WRITE (6,2010) IDREC(J), RFAC(J), RPOP(J), CUR(J)
2010 FORMAT (I9, 2F14.0, F14.2)
  
```

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CARD
0171      49 DO 50 I=1,NPOP
0172          TMCP=USERS(I,J)/RPOP(J)*RFAC(J)
0173          IF (TMCP.GT.USERS(I,J)) TMCP=USERS(I,J)
0174          SUM4=SUM4+TMCP
0175      50 EFFCAP(I)=EFFCAP(I)+TMCP
0176          DO 55 I=1,NPSS
0177      55 SUMD=SUMD+EFFCAP(I)
0178          WRITE (6,2011) SUMA,SUMC
0179      2011 FORMAT (//,'SUMS:',/,3X,'IN REGION',F12.0,F14.0)
0180          WRITE (6,2012) SUM1,SUM3
0181      2012 FORMAT (/,3X,'TOTAL',F15.0,F14.0)
0182          WRITE (6,2015)
0183      2015 FORMAT ('1','POP CENTER',8X,'DEMAND',5X,'EFF. CAP.',5X,'C/D RATIO
0184          X',6X,'MED DIST',,'LATENT DEMAND',/)
0185          DO 60 I=1,NPSS
0186          CDR=EFFCAP(I)/POP(I)
0187          XLATNT=POP(I)-EFFCAP(I)
0188          WRITE (6,2020) IDPOP(I),POP(I),EFFCAP(I),CDR,SDIST(I),XLATNT
0189      2020 FORMAT (I11,2F14.0,F14.2,F14.0,F14.0)
0190          50 CONTINUE
0191          WRITE (6,2024) SUMB,SUMD
0192      2024 FORMAT (//,'SUMS:',/,5X,'IN REGION',F12.0,F14.0)
0193          WRITE (6,2025) SUM2,SUM4
0194      2025 FORMAT (/,5X,'TOTAL',F15.0,F14.0)
0195
0196          C
0197          C
0198          C
0199          SUM6=0.0
0200          SUM7=0.0
0201          SUM8=0.0
0202          SUM9=0.0
0203          DO 65 I=1,NPSS
0204          DO 65 J=1,NRSS
0205      65 SUM6=SUM6+USERS(I,J)
0206          K=NPSS+1
0207          DO 66 I=K,NPOP
0208          DO 66 J=1,NRSS
0209      66 SUM7=SUM7+USERS(I,J)
0210          L=NRSS+1
0211          DO 67 I=1,NPSS
0212          DO 67 J=L,NREC
0213      67 SUM8=SUM8+USERS(I,J)
0214          DO 68 I=K,NPOP
  
```

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```

CARD
0214 DO 68 J=L,NREC
0215 68 SUM9=SUM9+USERS(I,J)
0216 WRITE(6,2026)SUM6,SUM7,SUM8,SUM9
0217 2026 FORMAT ('1',4X,'IN-REGION USE OF IN-REGION PARKS =',F16.0,/,
0218 + T6,'OUT-OF-REGION USE OF IN-REGION PARKS =',F14.0,/,
0219 + T6,'IN-REGION USE OF OUT-OF-REGION PARKS =',F12.0,/,
0220 + T6,'OUT-OF-REGION USE OF OUT-OF-REGION PARKS =',F10.0)
0221 C
0222 C WRITE DECAY SUMMARY TABLE
0223 C
0224 WRITE (6,2030)
0225 2030 FORMAT (///,7X,'TRAVEL DISTANCE SUMMARY',//,10X,'DISTANCE TRIP
0226 +S PERCENT CUM TRIPS CUM PCT',/)
0227 XD=0.
0228 PREV=CUM(1)
0229 DO 70 K=1,13
0230 DIFF=PREV-CUM(K)
0231 PCT=100.0*DIFF/CUM(1)
0232 PCENT=100.0*CUM(K)/CUM(1)
0233 WRITE (6,2040) XD,DIFF,PCT,CUM(K),PCENT
0234 2040 FORMAT (8X,F10.3,2(F10.0,F10.1))
0235 XD=XD+25.
0236 PREV=CUM(K)
0237 70 CONTINUE
0238 C
0239 C IF (MATRIX.EQ.0) GO TO 79
0240 C
0241 C LOOP TO WRITE AND PUNCH FLOW MATRIX
0242 C
0243 WRITE (6,300)
0244 300 FORMAT ('1',10X,'FLOW MATRIX',/)
0245 DO 78 J=1,NRSS
0246 WRITE (6,301) IDREC(J)
0247 301 FORMAT (///,20X,'FLOWS TO REC SITE',I5)
0248 DO 78 I=1,NPSS
0249 IF (MATRIX.EQ.2) WRITE (7,303) IDREC(J),RX(J),RY(J),IDPOP(I),PX(I)
0250 + PY(I),USERS(I,J)
0251 303 FORMAT (2(I5,2F6.2),F6.0)
0252 WRITE (6,302) IDPOP(I),USERS(I,J)
0253 302 FORMAT (9(I6,F6.0,2X))
0254 78 CONTINUE
0255 C
0256 79 IF (LOOP.EQ.1) GO TO 90

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    LOOP=1
  C
  C     RESET VALUES NEEDED FOR ADJUSTMENTS
  C
    DO 80 I=1,NPOP
  80 EFFCAP(I)=0.0
    DO 81 J=1,NREC
    CUR(J)=(CUR(J)+1.0)/2.0
    IF (CUR(J).GT.1.0) CUR(J)=1.0
    IF (CUR(J).GE.1.0) GO TO 81
    IEND=1
  81 RPOP(J)=0.0
    DO 82 K=1,13
  82 CUM(K)=0.0
    IF (IEND.EQ.0) GO TO 89
    GO TO 29
  89 WRITE (6,310)
  310 FORMAT (///,10X,'ADJUSTMENT NOT RUN; ALL CAPACITY/USE RATIOS ARE
    +ONE OR GREATER')
  90 STOP
    END
  //GO. SYSIN DD *
  TITLE RECSAD FOR STUDY RIVERS
  CONDITIONS 74 120 80 100 300 .05 2
  REC SITES 6(I3,13X,2F7.3,2F7.0)
  654 17.1 6.1 1
  639 17.2 5.6 1
  654 17.6 5.6 1
  744 15.8 5.3 1
  633 17.2 7.0 1
  726 16.9 5.4 1
  35433.292 88.076 19.923 2.968 1
  REST OF REC SITE DATA CARDS
  76032.788 97.729 13.046 2.384 1
  POPCENTERS (I3,13X,2F7.3,F7.0,F2.0)
  35634.577 86.970 20.621 4.129 266891
  REST OF POP CENTER DATA CARDS
  76233.216 97.106 13.500 2.739 119004
  //
  
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// EXEC FORTGCC
//FORT. SYSIN DD *

      FLOWPLOT PROGRAM

REQUIRED INPUT: (FORMATS CAN BE CHANGED TO FIT THE DATA)
  1) TITLE CARD (FORMAT 101)
  2) PARAMETER CARD:
      COL 1-5  ZIP CODE OF REC SITE LOCATION (DESTINATION)
           6-10 X COORDINATE OF REC SITE
           11-15 Y COORDINATE OF REC SITE
           16-20 CAPACITY OF REC SITE
           21-25 LARGEST CAPACITY OF ALL REC SITES IN SYSTEM
           26-30 MAXIMUM SIZE OF CIRCLE (REPRESENTING CAPACITY) TO BE
                  PLOTTED AT LARGEST REC SITE
           31-35 WIDTH OF FLOW BAR PER USER
           36-40 FLOW BAR CUTOFF. FLOWS MUST BE GREATER THAN THIS
                  VALUE TO BE PLOTTED
           41-45 PUNCH "1" TO SURPRESS NUMBERS AT END OF FLOW BAR
  3) 'READ CONTROL' CARD
      COL 1-5  NUMBER OF READ UNIT FOR FLOW DATA (5 FOR CARDS)
           6-10 PUNCH "1" TO GET LIST OF FLOWS ON PRINTOUT
           11-70 FORMAT TO READ FLOW DATA. MUST HAVE ONE I AND 3 F FIELDS
                  TO READ ZIP CODE (AS INTEGER), X AND Y COORDINATES, AND FLOW.
  4) FLOW DATA CARDS. ONE CARD FOR EACH FLOW CONTAINING ZIP CODE
      OF ORIGIN, X AND Y COORDINATES OF ORIGIN, AND FLOW
  5) END OF FILE CARD. PUNCH -1 IN COLUMNS 2-3.

PROGRAM PRODUCES A PLOT SHOWING:
  1) A CIRCLE AT THE REC SITE SCALED TO CAPACITY
  2) BARS CONNECTING POP CENTERS WITH REC SITES (ORIGINS WITH
      DESTINATIONS) WITH WIDTH SCALED IN PROPORTION TO NUMBER OF USERS.

      DIMENSION TITLE(15),FMT(15)
      CALL PLOTS

      READ,WRITE AND PLOT TITLE
  10 READ (5,101,END=90) TITLE
  101 FORMAT (15A4)
      WRITE (6,201) TITLE
  201 FORMAT ('1',10X,15A4)
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IF (FLOW.GE.10.0.AND.DIFFX.LE.0.0) XOFF=.2
W=FLOW*WIDPER
IF (DIFFX.EQ.0.0) GO TO 40
PHI=ATAN(DIFFY/DIFFX)
IF (DIFFX.LT.0.0) PHI=PHI+3.1416
IF (DIFFY.LT.0.0.AND.DIFFX.GT.0.0) PHI=PHI+6.2832
GO TO 50
40 PHI=1.5708
IF (DIFFY.LT.0.0) PHI=4.7124
50 DIST=SQRT((XE-XC)**2+(YE-YC)**2)
IF (DIST.LT.RAD) GO TO 65
DX=(W/2.)*SIN(PHI)
DY=(W/2.)*COS(PHI)
X1=XC-DX
Y1=YC+DY
X2=XE-DX
Y2=YE+DY
X3=XE+DX
Y3=YE-DY
X4=XC+DX
Y4=YC-DY
WH=W/2.
IF (RAD.LE.WH) GO TO 55
B=SQRT(RAD**2-(W/2.0)**2)
A1=B*COS(PHI)
A2=B*SIN(PHI)
X1=X1+A1
Y1=Y1+A2
X4=X4+A1
Y4=Y4+A2
55 CALL PLOT (X1,Y1,3)
CALL PLOT (X2,Y2,2)
IF (W.EQ.0.0) GO TO 60
CALL PLOT (X3,Y3,2)
CALL PLOT (X4,Y4,2)
60 XX=XE+XOFF*COS(PHI)
YY=YE+YOFF*SIN(PHI)
IF (NOMUM.EQ.1) GO TO 70
CALL NUMBER (XX,YY,.14,FLOW,0.,-1)
GO TO 70
65 XX=XE-XOFF*COS(PHI)
YY=YE-YOFF*SIN(PHI)
CALL NUMBER (XX,YY,.07,FLOW,0.,-1)

```

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CARD
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```

    GO TO 70
68  XX=XC-.2
    CALL NUMBER (XX, YC, .14, FLOW, 0., -1)
70  IF (LIST.NE.1) GO TO 30
    WRITE (6, 204) IZIP, XE, YE, FLOW
204  FORMAT (16, 2F8.2, F6.0)
    GO TO 30
80  CALL PLOT (25., 0., 999)
    GO TO 10
90  STOP
    END
    SUBROUTINE CIRCLE (XPT, YPT, RAD)
    DP=0.
    X1=XPT+RAD*COS(DP)
    Y1=YPT+RAD*SIN(DP)
    CALL PLOT (X1, Y1, 3)
    DO 40 J=1, 36
    DP=DP+.175
    X1=XPT+RAD*COS(DP)
    Y1=YPT+RAD*SIN(DP)
    CALL PLOT (X1, Y1, 2)
40  CONTINUE
    RETURN
    END
//GO.FT99F001 DD UNIT=3350, SPACE=(TRK,(5,10)), DISP=(NEW,KEEP),
// DCB=(RECFM=FB, BLKSIZE=1920, LRECL=96),
// DSN=PLOT.ACT14328.SWT9, VOL=SER=DASD40
//GO.SYSIN DD *
FLOWMAP OF 1978 SAMPLED USERS FOR ILLINOIS RIVER
744 15.8 5.3 66 137 1.0 .01 1 1
5 1(13,13X,2F7.3,F5.0)
48643.872 84.330 21.531 1.041 1
55445.000 93.312 16.016 1.645 1
    REST OF FLOW DATA CARDS
90833.776118.184 -1.179 -6.008 1
-1
//
  
```

111

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 12345678901234567890123456789012345678901234567890123456789012345678901234567890

CARD
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```
// EXEC FORTGCG
//FORT.SYSIN DD *
C PROGRAM ZIPMATCH
C
C REQUIRED INPUTS: (NOTE: FORMATS CAN BE CHANGED TO FIT SPECIFIC DATA)
C 1) USERS ZIP CODES ARRANGED IN ASCENDING ORDER (FORMAT 100)
C 2) A SEPARATE FILE CONTAINING ALL POSSIBLE THREE DIGIT ZIP
C CODES (001-999) AND THEIR LATITUDE AND LONGITUDE. SOME OF
C THESE ENTRIES ARE NOT REAL ZIP CODES AND THUS LATITUDE AND
C LONGITUDE WILL BE BLANK. THESE ENTRIES MUST INCLUDED IN
C THE FILE TO PREVENT THE PROGRAM FROM "BOMBING" WHEN A USER
C PROVIDES AN ERRONEOUS ZIP CODE (DATA READ BY FORMAT 101)
C
C THE PROGRAM READS THREE DIGIT ZIP CODES, GROUPS USERS FROM THE SAME
C ZIP CODE AREA, LOOKS UP THEIR LATITUDE AND LONGITUDE IN A REFERENCE FILE,
C CONVERTS LATITUDE AND LONGITUDE TO X AND Y COORDINATES FOR USE BY A
C PLOTTER (ORIGIN IN LOWER LEFT), OUTPUTS ZIP CODE, LATITUDE, LONGITUDE,
C X,Y, AND FREQUENCY.
C
C THE FOLLOWING INCLUDES A LIST OF THE PROGRAM AND SAMPLE INPUT
C
100 READ (5,100) IZIPT
100 FORMAT (3X,13)
9 KOUNT=1
10 READ (5,100,END=49) IZIP
IF (IZIPT.NE-IZIP) GO TO 50
KOUNT=KOUNT+1
GO TO 10
49 KEY=1
50 READ (1,101) KZIP,XLAT,XLONG
101 FORMAT (13,2X,F6.3,F7.3)
IF (KZIP.LI-IZIPT) GO TO 50
CALL CONVRT(XLAT,XLONG,X,Y)
WRITE (7,200) IZIPT,XLAT,XLONG,X,Y,KOUNT
200 FORMAT (13,F6.3,3F7.3,15)
IF (KEY.EQ-1) GO TO 96
IZIPT=IZIP
GO TO 9
90 STOP
END
SUBROUTINE CONVRT(XLAT,XLONG,X,Y)
C
```

00000000111111111222222222233333333334444444445555555556666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890

CARD
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0088

C SUBROUTINE CONVERTS LATITUDE AND LONGITUDE TO X AND Y
C

RE=7920000./162300.
R1=(2.*RE*COS(.51487))/(SIN(.51487)+SIN(.79412))
SLAT=XLAT
SLONG=XLONG
SLAT=SLAT/57.2958
DEN=SIN(.51487)+SIN(.79412)
R=SQRT((R1**2)+((4.*RE**2)*(SIN(.51487)-SIN(SLAT)))/DEN)
DIFF=(SLONG-95.0)/2
DIFF=DIFF/57.2958
COSTH=1.-((2.*(RE*COS(SLAT)*SIN(DIFF))**2)/R**2)
THETA=ACOS(COSTH)
IF (DIFF.GT.0) THETA=-1.0*THETA
X1=R*COS(THETA)
Y1=R*SIN(THETA)
X2=Y1
Y2=-X1
X=X2+15.
Y=Y2+70.
RETURN
END

//GO.FT01F001 DD DSN=U12489A.ZIP3D.DATA,DISP=SHR
//GO.SYSIN DD *

021
123
123
138

REST OF USER THREE DIGIT ZIP CODES

740
990

//
SAMPLE OF ZIP CODE, LATITUDE AND LONGITUDE REFERENCE FILE (THE DATA SET
IS CALLED ZIP3D.DATA IN THIS PROGRAM, AND IS READ FROM UNIT 1)

001
002

REAL ZIP CODES BEGIN AT 010

010 42.259 72.560
011 42.097 72.587

REST OF ZIP CODE, LATITUDE AND LONGITUDE FILE

000000001111111112222222222233333333333444444444455555555555666666666677777777778
 123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890

114

```

CARD
0001 // EXEC FORTGCG
0002 // FORT.SYSIN DD *
0003 C PROGRAM ZIPDIST
0004 C
0005 C REQUIRED INPUT: (NOTE: FORMATS MAY BE CHANGED TO FIT SPECIFIC DATA)
0006 C 1) ZIP CODE, LATITUDE & LONGITUDE OF REC SITE (DESTINATION) (FORMAT 99)
0007 C 2) ZIP CODE, LATITUDE & LONGITUDE AND NUMBER OF USERS FROM EACH
0008 C THREE DIGIT ZIP CODE AREA (ARRANGED IN ASCENDING ORDER BY ZIP
0009 C CODE) (FORMAT 102)
0010 C
0011 C PROGRAM CALCULATES AIRLINE DISTANCES BETWEEN POINTS AND OUTPUTS ZIP CODES
0012 C OF REC SITES, POPULATION CENTERS, DISTANCE AND FLOW BETWEEN POINTS.
0013 C
0014 C ISUM=0
0015 C READ (5,99) IDREC,RLAT,RLONG
0016 C 99 FORMAT (I3,F6.3,F7.3)
0017 C 10 READ (5,102,END=90) IZIP,KOUNT,XLAT,XLONG
0018 C 102 FORMAT (I3,I5,F6.3,F7.3)
0019 C ISUM=ISUM+KOUNT
0020 C DIFLAT=(RLAT-XLAT)*3600.
0021 C DIFLON=(RLONG-XLONG)*3600.
0022 C PHI=((RLAT+XLAT)/2.)/57.2958
0023 C DIST=SQRT((3.666*(DIFLAT/100.)**2)+(3.700*(COS(PHI))**2)*(DIFLON/1
0024 C +00.)**2)
0025 C WRITE (6,200) IDREC,IZIP,DIST,KOUNT
0026 C 200 FORMAT (' TO ',I5,' FROM ',I5,F7.1,' MILES, USERS = ',I5)
0027 C WRITE (7,300) IDREC,IZIP,DIST,KOUNT
0028 C 300 FORMAT (2I6,F7.1,I5)
0029 C GO TO 10
0030 C 90 WRITE (6,201) ISUM
0031 C 201 FORMAT (//,' ISUM = ',I6)
0032 C STOP
0033 C END
0034 C //GO.SYSIN DD *
0035 C 64539.773 94.837
0036 C 260 1240.141 80.687
0037 C 392 3532.323 90.164
0038 C
0039 C REST OF USER FLOW DATA
0040 C
0041 C 918 31132.826117.126
0042 C //
  
```