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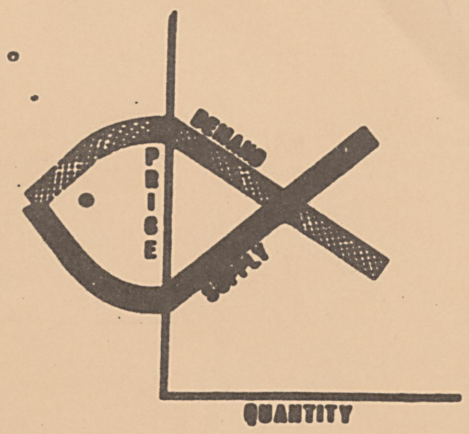

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Outdoor Recreation in Texas:

1968-2000

Volume II

by

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Texas A&M University

June 1, 1972

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U.S. NATIONAL MARINE FISHERIES SERVICE
ECONOMIC RESEARCH DIVISION

THE DEMAND FOR NON URBAN OUTDOOR RECREATION IN TEXAS: 1968-2000

VOLUME II

GRAVITY MODEL ESTIMATION FOR TEXAS OUTDOOR RECREATION

by

R. J. Freund

Texas Agricultural Experiment Station

Texas A&M University

Submitted in Partial Fulfillment

of

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1. Introduction

A simple "gravity" model [1/] for estimating the flow of travel for a particular outdoor recreation activity among geographical regions can be written as follows:

$$Y_{ij} = \frac{k\ A_j P_i}{B_i\ d_{ij}^2}$$

where

y_{ij} = no. of days of activity participation by individuals in (origin) region i spent in (destination) region j,

k = constant,

P_i = population in origin region i,

A_j = "attraction" of region j for participators in the activity,

B_i = "availability" in region i for participators in the activity, and

d_{ij} = distance from region i to region j.

It should be noted that this model is intended to describe the gravitational attraction of one body (the destination region j) on an originating body (region i). The B_i and P_i are the gravitational pull of the originating body while A_j is the gravitational pull of the destination body; d_{ij}^2 in the denominator illustrates the pull of gravity which is proportional to the square of the distance.

1/ For a more comprehensive statement and bibliography see "Operations Research in Outdoor Recreation" by Frank J. Cesario, Jr., Journal of Leisure Research, Vol I, No. 1, Winter 1969, pp. 33-52.

The simple gravity model as stated above can easily be generalized to allow for wider applications. Specifically in the estimation of recreation participation the following generalizations have been implemented in this model:

1. An allowance for several components of attraction. Each component is given a weight to indicate its relative importance.
2. The provision for several components of availability, likewise with provisions for different degrees of importance.
3. Provisions for an exponent different from "2" for distance since the desire to travel a certain distance for recreation does not necessarily diminish by the square of the distance.
4. The use of more than one aspect of origin population for determining the magnitude of flow from an origin.

The more general model as used in this application can be written as follows:

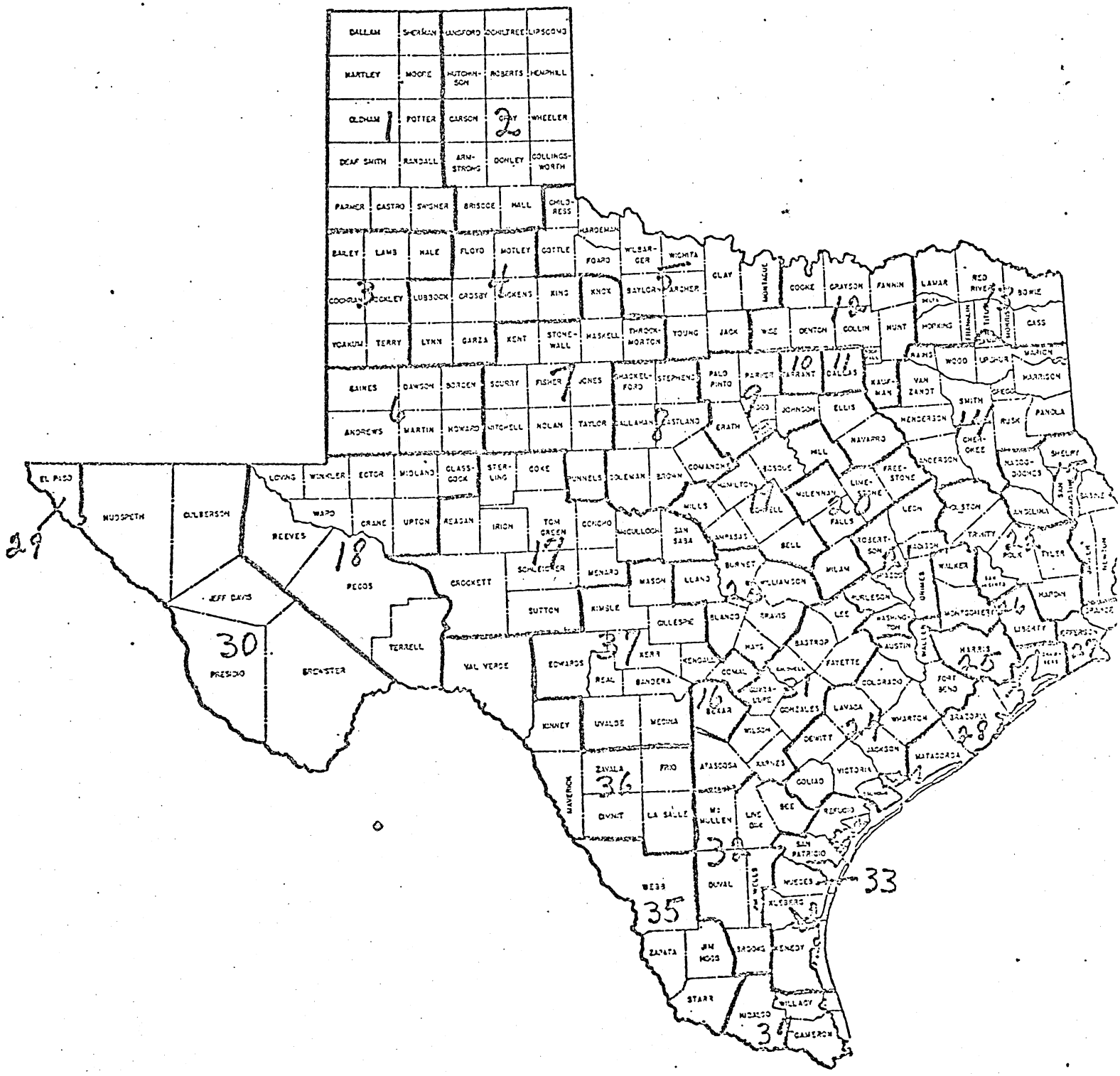
$$y_{ij} = \frac{k \; A_{1j}^{\beta_1} A_{2j}^{\beta_2} \cdots A_{pj}^{\beta_p} P_{1j}^{\gamma_1} P_{2j}^{\gamma_2} \cdots P_{qi}^{\gamma_q}}{B_{1i}^{\delta_1} B_{2i}^{\delta_2} \cdots B_{ri}^{\delta_r} d_{ij}^{\alpha}}$$

where the β, γ, δ are coefficients indicating the importance of attraction population, and availability variables and α is the "distance decay" coefficient.

It is of interest to note that the coefficients of this model are <u>elasticities</u>. That is, each coefficient indicates the percent change in participation associated with a one percent change in the relevant variable: attraction, population, etc.

FIGURE 1

Thirty-Seven Regions of Texas



Given a set of sample data points on participation at specific origin destination combinations and observed values of the A_j, P_i, and d_{ij}, estimates of the coefficients for the gravity model can be estimated by least squares using the log-linear model:

$$\log y_{ij} = \log k + \beta_1 \log A_{1j} + \ldots$$
$$+ \beta_p \log A_{pj} + \gamma_1 \log P_{1i} + \ldots + \gamma_q \log P_{qi}$$
$$+ \delta_1 \log B_{1i} + \ldots + \delta_r \log B_{ri} + \alpha \log d_{ij} .$$

For this particular study the recreation participation flows are estimated for seven major outdoor activities as follows:

1. Boating for pleasure in rural environments only.
2. Outdoor camping in rural environments only.
3. Fresh water fishing in rural environments only.
4. Fresh and salt water fishing rural environments only.
5. Hunting, all types, in rural environment only.
6. Picnicking in rural environments only.
7. Swimming, fresh and salt water, in rural environments only.

The recreational participation flows are studied for a 37 region subdivision of the state of Texas. A map of the 37 regions is given in Figure 1. Recreational flows from and to other states are not included in this study.

After obtaining a set of suitable equation estimates, recreation flow projections are obtained for specific future conditions by applying these equations to projection data provided by TP&W. Finally, these projections except for fresh and salt water fishing are compared to TP&W estimates of regional capacities for other activities.

2. Data Specifications

In this section are specified the variables to be used in this attempt to estimate a gravity model for outdoor recreation in Texas.

2.1. Activity participation - The variable to be analyzed and subsequently estimated for planning and policy purposes is the number of "people days" of participation for each of the activities in each of the 37 regions on trips whose total length is one, (not including overnight), two or three, and four or more days duration by individuals residing in each of the 37 aforementioned regions. The number of days of activity participation are obtained directly from the 1968 household survey using expansion factors appropriate for each region. It should be noted that the distinction between trips and vacations as specified in the schedule are not adhered to since for this type of analysis the total duration of the trip is seen to be of greater importance than the fact that annual leave may or may not have been used for the particular trip or vacation.

2.2 Demographic and socio-economic characteristics - Previous studies have indicated that socio-economic characteristics of individual households have a relatively small effect on the recreation participation of families. Since this particular model uses regional aggregations of data, the potential effects of such factors will be further dampened. Therefore, the only characteristics of the originating regions used in this model are:

1. The total region population according to the 1970 census,
2. Percent of the population of the region living in cities of 10,000 population or greater, and

3. The per capita buying power in dollars as obtained from the survey of buying power, 1969. This was used since recent regional data on income were not available during the estimation phase of this project.

2.3. The potential attraction of regions - Attraction is the pulling power of a particular region for individuals who want to participate in recreation activity. Attraction includes:

1. Environmental characteristics of the region, and
2. Facilities available for recreation.

Data on environment was obtained by Texas Parks and Wildlife staff from general descriptions of counties within a region as obtainable in any standard reference on Texas counties and by special measurement from large scale maps. Data on facilities available for recreation were obtained from the 1969 T.P.& W. inventory of recreational facilities. In Table 1 are given the 50 environment and facility variables used in this estimation of the model.

2.4. Availability - This factor is intended to indicate the attraction for an activity in and near the originating region. Often it is defined as a sum of "distance decayed" attractions for each region. Using the same notation as in section 1, it can be defined:

$$B_i = \sum_{j=1}^{37} d_{ij}^{\alpha} A_j$$

Since α is a quantity to be estimated, a preliminary estimate is usually used to compute availability.

Preliminary studies indicated that this availability quantity tended to measure total statewide rather than local recreation availability hence its use did not provide the desired results. For this reason availability was defined simply to be origin attraction. A further modification of the use of the

TABLE 1

REGIONAL ATTRACTION VARIABLES

Variable No.	Content	Scale
1	Miles River	100
2	Growing Season	2
3	Relief	2
4	Annual Rainfall	2
5	Acres of Hill Country	100,000
6	Acres of Piney Woods	100,000
7	Growing Season, Ratio of Destination to Origin	1
8	Mileage of Ocean Frontage	1
9	Mileage of Bay Frontage	10
10	Freshwater Boat Ramps	1
11	Saltwater Boat Ramps	1
12	Acres of Freshwater Lakes	10,000
13	Number of Freshwater Lakes	1
14	Miles Accessible Ocean Frontage	1
15	Miles Accessible Bay Frontage	10
16	Freshwater Slips and Stalls	100
17	Saltwater Slips and Stalls	10
18	Inland Campsites	1,000
19	Campsites on a Bay	10
20	Campsites on the Ocean	10
21	Fishing Quality Index	1
22	Yards of Freshwater Fishing	100
23	Yards of Bay Fishing	100
24	Yards of Ocean Fishing	100
25	Deer Index	10
26	Acres in Region	1,000,000
27	Leased Hunting Acres	1,000,000
28	Wildlife Management Acres	10,000
29	Inland Picnic Sites	1,000
30	Bay Picnic Sites	10
31	Ocean Picnic Sites	10
32	Yards of Swimming Pools	1,000
33	Yards of Freshwater Swimming	10,000
34	Yards of Bay Swimming	1
35	Yards of Ocean Swimming	100
36	Population Density	100
37	Waterfowl Rating	1
38	Quail Rating	1
39	Dove Rating	1
40	Turkey Rating	1
41	Squirrel Rating	1
42	Javelin Rating	1
43	Total No. Deer	10^7

Continued

Variable No.	Content	Scale
44	Total Small Game Index	1
45	Proportional Total Region Leased for Hunting	1
46	All Yards Swimming	1,000
47	All Yards Fishing	100
48	All Campsites	10
49	All Picnic Sites	10
50	All Boatramps	1

availability variable is given in Section 3.3.

2.5. Distance - A preliminary estimate of distance between centers of each pair of regions was computed by obtaining airline distances between the major population centers of the region and adding a 15 percent adjustment to obtain estimates of road mileage. This estimate was updated for each activity by obtaining, where available, the average distance traveled among origin - destination combinations obtained from household survey data.

3. Estimation

As previously indicated, the coefficients for the gravity model were estimated by using least squares on the logarithms of all variables. Obviously it was impossible to use all variables in the estimation process; a concensus of the various individuals involved in this project, personal opinions, examination of some simple correlations, and actual experimentation with various variable combinations were used to obtain a reasonably sized set of variables. A "stepdown" or "backward elimination" selection procedure was then used to delete, from each equation, variables which did not contribute materially to the estimating power of the equation. The final equation to be used for projections was chosen on the basis of statistical significances (not necessarily 5%), a "logical" subset of factors, and a minimum of "incorrect" coefficient signs. In addition it was found necessary to make some revisions and/or redefinitions of variables so as to make the model more reasonable. These are discussed in the following sections.

3.1. Participation - The 37 by 37 matrix of origins and destinations provides a possible 1,369 pairs of origins and destinations; this includes within region trips. Obviously, for any one activity and length of trip, only a relatively small number of these pairs actually show recreation participation. For some activities, the number of non-zero pairs is as little as 100 while

for others it may be over 500. The question remains how should the model estimation use the information from those origin destination pairs from which there was no participation. If none of these zero participation pairs are used, the model estimates may not reflect the reason for the absence of participation. On the other hand, the use of all combinations with zero participation will tend to dilute the effect of the non-zero participation data on the estimation procedure.

The solution used in this estimation procedure was to say that any origin-destination combination less than 100, 200 and 300 miles for one day, two or three day, or four and over day trips, respectively, was a "relevant" zero and data from such combinations were used in the estimation prodedure. All other origin-distination combinations with no participation were ignored. The computational procedure used to accomplish this was to define each "relevant zero participation combination" as having had 50 people days (a number sufficiently small to be able to be missed by the sampling procedure) and then to eliminate data from all pairs having actual zeroes in the estimation procedure.

A limited number of estimation runs were made using this scheme as well as the schemes where all or no zeroes were omitted. A comparison of the results of these runs indicated that this particular method of handling zero participation did result in better estimates of participation rates.

3.2. Distance - Distance is, of course, used to estimate the distance decay coefficient. This coefficient indicates how much recreation participation decreases as the distance from the origin increases. This would, for example, mean that with a unity distance decay coefficient, participation at a distance of 20 miles would be one-half that of 10 miles. It is intuitive that participation does not drop off that rapidly for low mileage trips. In other words, a family is normally indifferent, even in one day trips, among

trips of 10, 20 or possibly even 30 miles. On longer trips, this range of indifference may be even wider. To reflect this phenomenon all distances (as obtained in the previous section) were modified so that the minimum distance for 1, 2 or 3, and 4 or longer day trips were defined as being 20, 40 and 60 miles, respectively. These specific minimum values were obtained by preliminary studies and, in addition, have the advantage of appearing to be quite reasonable.

3.3. Availability - The basic gravity model implies that availability depresses recreational travel. The basic idea is that availability of recreational facilities near the origin will tend to make people participate in recreational activity at that origin. However, this particular application of the model is also intended to estimate participation within the originating region and the inclusion of availability would tend to provide a depressed estimate of such recreation as well. It is therefore reasonable to modify the model such that only the distance decay is increased by availability. This would then allow rather large participation in the originating region but would discourage travel of longer distances.

This is accomplished by including an interaction term. Substituting for the coefficient of distance and (one) availability variable, insert the following elements into the equation:

$$\ldots \alpha \log d_{ij} + \delta_1 B_{1i} \log d_{ij} + \ldots \quad .$$

The effect of these elements can be seen by recombining as follows:

$$\ldots + (\alpha + \delta_1 B_{1i}) \log d_{ij} + \ldots ,$$

and rewriting in the multiplicative format produces

$$\ldots d_{ij}^{\alpha + \delta_1 B_{1j}} \ldots .$$

It should be noted that in this expression α and δ_1 would both be expected to be negative. It can, therefore, be seen that the absolute value of the distance decay function, that is, the rate at which travel decreases with distance is increased by a larger availability factor B_{1i}.

In this model, the above principle was applied using two factors as follows:

(1) The origin region quantity of the most relevant (see below) single facility for each activity, and

(2) The ratio of origin region over destination region quantity of this facility.

The use of (1) is self explanatory. Factor (2) exemplifies the idea that relative availability may be important, thus the corresponding coefficient would also be expected to be negative. The "most relevant" factors for the various activities are defined as follows:

(1) Boating and all boat ramps

(2) Camping: all campsites

(3) Freshwater Fishing: all yards fresh-water fishing

(4) All Fishing: all yards fishing

(5) Hunting: leased hunting acreage

(6) Picnicking: all picnic sites

(7) Swimming: all yards swimming.

It should be noted that preliminary analyses indicated that in some cases this second variable did not contribute significantly to the predictability of the equation hence it was not included.

4. Gravity Model Estimates

From the above lists of population characteristics, attraction and availability variables, and distances, selections of variables for use in the prediction of specific recreational activities were made on the basis of previous studies (see reports distributed June and October, 1971) as well as several other trial runs on different variable subsets.

The estimates of the coefficients and associated tests for statistical significance of the estimates for the seven types of recreation and three types of trips are given in Tables 2 through 8. Zero valued coefficients correspond to variables deleted. The statistical significance of remaining coefficients is provided by the "Students t" and statistical significance is indicated by (+) at 10% significance (*) at 5% significance and (**) at 1% or less significance. Other statistics such as R^2 or the residual mean square are provided but since these are measured in logarithmic terms they are extremely difficult to interpret.

In general the resulting estimating equations appear quite reasonable with respect to both the magnitudes and the directions of various effects. The major disturbing factor is that in many cases some of the "package" factors, that is, associated attractions turn out not to be statistically significant and/or the associated activity facilities are significant whereas the main facilities variables are not. This is due to the often encountered high correlation among these attraction factors, that is, they often appear together in roughly proportional quantities.

Individual equation sets will be briefly described below with particular reference to those factors which are not exactly as one would expect.

4.1. Boating - The equations for boating are pretty much as one would expect. It should be noted that boat ramps are not included in the variable set; this is due to the fact that slips and stalls are highly correlated with them and, if a choice has to be made, these tend to predict boating better. Even then, freshwater slips and stalls are never statistically significant due to the high correlation with acreages of freshwater lakes. Total population and percent urban population are correlated; this is the reason why the relative magnitude of the total population factor changes as percent urban population is included in the longer trips. The very high coefficients for purchasing power are probably to be expected but will cause a very large increase in projected boating where projected data imply a marked increase in purchasing power.

2.2. Camping - Since one-day trips do not include overnight stays no equation can, by definition, be estimated for such trips. In general the equations are pretty much as one would expect with physical characteristics of the destination regions being more important for the longer trips. The negative signs for freshwater boatramps and all yards fishing are somewhat unexpected. This is again due to the high correlation between these and various other factors that are included such as, for example, freshwater lakes, ocean frontage, and campsites. It is also quite possible that to some degree camping may be preferred on lakes where there are fewer boats and somewhat less fishing.

Again the high positive coefficients for purchasing power will provide a rather large increase in projected camping as real income increases.

TABLE 2

GRAVITY MODEL ESTIMATES

BOATING

No.	Index	Description	1-Day Coeff.	1-Day t	2/3 Days Coeff.	2/3 Days t	4+ Days Coeff.	4+ Days t
0		Intercept	-17.3435		-10.1403		-11.1465	
		Destination Attractions						
1	7	Growing Season, Dest./Orig.	.0	.0	.0	.0	2.0612	4.1311
2	12	Acres of Freshwater Lakes	.3174	1.9765	.4358	4.5813	.3867	6.4740
3	16	Freshwater Slips and Stalls	.0	.0	.0	.0	.0	.0
4	17	Saltwater Slips and Stalls	.0	.0	.1336	2.3576	.0944	2.6810
5	48	All Campsites	.5333	3.6418	.3871	4.3161	.2254	3.9853
6	49	All Picnic Sites	.0	.0	.0	.0	.0	.0
7	36	Population Density	.0	.0	.0	.0	.0	.0
		Origin Characteristics						
8	201	Total Population	.7819	3.6552	.2288	1.5490	.2664	2.7684
9	202	% Urban Population	.0	.0	.2304	1.7216	.1575	1.9178
10	203	Purchasing Power	2.4939	3.1179	2.1270	4.5731	1.8252	5.7370
		Distance Functions						
11	211	Distance (Adj.)	- 1.6514	-6.4412	- 1.1665	-6.9309	- .4506	-4.2679
12	306	Interaction, Total Boat R.	- .0056	-3.4222	- .0042	-5.5067	- .0040	-8.8565
		R^2 =	.3676		.2787		.2814	
		EMS =	5.5049		4.5581		2.8000	

TABLE 3

GRAVITY MODEL ESTIMATES

CAMPING

No.	Index	Description	1-Day Coeff.	1-Day t	2/3 Days Coeff.	2/3 Days t	4+ Days Coeff.	4+ Days t
0		Intercept			-10.7591		-24.3187	
		Destination Attractions						
1	3	Relief			.0	.0	.7458	4.5330
2	4	Annual Rainfall			.0	.0	1.4059	4.0122
3	5	Acres of Hill Country			.0	.0	.0	.0
4	8	Mileage of Ocean Frontage	No		.0	.0	.2229	3.2043
5	10	Freshwater Boat Ramps			- .2526	-2.6407	.0	.0
6	12	Acres of Freshwater Lakes			.3558	2.8564	.5005	5.6523
7	18	Inland Campsites	Equation		1.0775	5.7034	.5034	3.9587
8	19	Campsites on a Bay			.5205	4.4752	.0	.0
9	20	Campsites on the Ocean			.0	.0	.2871	3.7851
10	36	Population Density	Estimated		- .3282	-2.8780	- .3955	-5.2044
11	46	All Swimming			.1018	1.5587	.0823	1.9221
12	47	All Yards Fishing			- .1322	-1.4501	- .3251	-4.2236
		Origin Characteristics						
13	201	Total Population			.5108	3.7224	.3704	4.2743
14	202	% Urban Population			.0	.0	.0	.0
15	203	Purchasing Power			3.0167	6.0256	2.8261	8.7136
		Distance Functions						
16	212	Distance (Adj.)			- 1.6235	-9.3785	- .3149	-2.8153
17	307	Interaction, All Campsites			- .0012	-3.2764	- .0008	-3.9115
		R^2 =			.3551		.3040	
		EMS =			5.0656		3.4378	

2.3. Freshwater Fishing - As in most other equations the coefficients are generally what one would expect with some exceptions. The negative effect of growing season for one day trips is most likely a proxy for purchasing power which is known to be less in southern regions and, in the case of one day trips, is largely affected by those regions near the origin. This is further supported by the relatively low coefficient for purchasing power for one day trips. Various attempts at trying to eliminate this factor were unsuccessful.

Also disturbing is the negative sign for yards of freshwater fishing for one day trips. However, the positive factor for lakes and picnic sites, many of which are near fishing piers and barges, will probably overcome this problem.

The sign of the origin over destination interaction term with distance appears to be of the wrong sign in the longer trips; of course it may very well be that people with heavy local availability also like to travel farther distances for similar activities.

2.4. All Fishing - Again some of the signs are unexpected but in general the equations seem to be moderately satisfactory. Yards of freshwater fishing again has a negative sign for short trips but is compensated for a rather large coefficient for freshwater lakes. Ocean fishing for two and three day trips is probably compensated for by bay fishing and the high coefficient for miles of accessible ocean frontage. It is of interest to note that on the long trips picnic sites replace campsites as the auxiliary facilities variable; this is certainly not expected but again the rather large correlation between campsites and picnic sites should make the equation quite useful for prediction purposes.

TABLE 4

GRAVITY MODEL ESTIMATES

FRESHWATER FISHING

No.	Index	Description	1-Day Coeff.	1-Day t	2/3 Days Coeff.	2/3 Days t	4+ Days Coeff.	4+ Days t
0		Intercept	11.0679		-17.6034		-17.0382	
		Destination Attractions						
1	2	Growing Season	- 3.0409	-1.5233	.0	.0	.0	.0
2	7	Growing Season, Dest./Orig.	4.2078	2.1418	.0	.0	1.7988	3.5447
3	8	Mileage of Ocean Frontage	.2346	2.7882	.0	.0	.0564	1.7326
4	12	Acres of Freshwater Lakes	.4707	2.5957	.5050	4.7115	.3851	5.6916
5	18	Inland Campsites	.0	.0	.6966	4.3581	.6660	6.7303
6	22	Yards of Freshwater Fishing	- .4246	-2.6612	.0	.0	.0	.0
7	29	Inland Picnic Sites	1.5112	5.0752	.0	.0	.0	.0
8	36	Population Density	.0	.0	- .3445	-3.0749	.1217	-1.7515
		Origin Characteristics						
9	201	Total Population	1.0449	4.5784	.8091	5.9670	.4413	4.3306
10	202	% Urban Population	.0	.0	.0	.0	.2018	2.2773
11	203	Purchasing Power	1.2988	1.3349	3.1368	6.5975	2.6592	7.7425
		Distance Functions						
12	211	Distance (Adj.)	- 2.0257	-10.7140	- 1.4675	-8.9188	- .5179	-4.6808
13	306	Interaction, Yards. F.F.	- .0126	-1.4979	- .0256	-5.4809	- .0196	-6.3457
14	309	Freshwater Fish., Orig./Dest.	- .0028	-1.4298	.0018	1.9173	.0012	1.9778
		R^2 =	.4627		.3582		.3312	
		EMS =	4.8127		5.3783		3.4233	

TABLE 5

GRAVITY MODEL ESTIMATES

ALL FISHING

No.	Index	Description	1-Day Coeff.	1-Day t	2/3 Days Coeff.	2/3 Days t	4+ Days Coeff.	4+ Days t
0		Intercept	-12.1558		-16.1095		-18.7374	
		Destination Attractions						
1	7	Growing Season, Dest./Orig.	.0	.0	.0	.0	1.3905	2.6966
2	12	Acres of Freshwater Lakes	.6323	3.6772	.5245	4.9206	.3756	4.7121
3	14	Miles Accessible Ocean Frontage	.0	.0	.7312	2.5868	.9202	5.4413
4	22	Yards of Freshwater Fishing	- .5123	-3.4579	.0	.0	.0	.0
5	23	Yards of Bay Fishing	.5738	5.6433	.3056	3.4429	.0	.0
6	24	Yards of Ocean Fishing	.0	.0	- .7501	-2.2251	- .8112	-3.9800
7	36	Population Density	.0	.0	- .3798	-3.2715	- .1673	-2.3660
8	48	All Campsites	.8595	5.1801	.4071	4.1050	.0	.0
9	49	All Picnic Sites	.0	.0	.0	.0	.2915	3.3943
10	50	All Boat Ramps	.0	.0	.0	.0	.1028	1.8747
		Origin Characteristics						
11	201	Total Population	.6805	3.7218	.6130	4.5773	.4262	4.1652
12	202	% Urban Population	.0	.0	.0	.0	.2123	2.3506
13	203	Purchasing Power	2.2450	3.1506	3.1313	6.5182	2.7420	7.8814
		Distance Functions						
14	211	Distance (Adj.)	- 1.9187	-10.5384	- 1.5412	-9.4861	- .5654	-5.0803
15	306	Interaction, All Yards Fishing	.0	.0	.0	.0	- .0021	-2.4346
16	309	Interaction, A. F., Orig./Dest.	- .0025	-1.8217	.0	.0	.0	.0
		R^2 =	.4567		.3346		.3326	
		EMS =	4.8702		5.5497		3.6284	

4.5. Hunting - This set of equations makes large use of the environmental characteristics. This necessitated a somewhat unusual approach in that a different basic set of variables was used for selection for the one day trips than for the longer trips.

The resulting equations are generally quite reasonable. In this case, all coefficients can readily be explained although it is certainly true that the appearance and/or disappearance of variables as one goes to the longer trips is somewhat puzzling. It is also interesting to note that purchasing power has a lower coefficient in this activity than in most others.

4.6. Picnicking - The equations for picnicking for longer trips seem to fit much more poorly than those for the shorter trips. This could certainly be expected since picnicking is essentially a secondary activity, particularly for the longer trips. The negative coefficient for boatramps is somewhat unfortunate although it is normally offset by other factors. In general, although most other coefficients are of the appropriate sign, the equation may not be extremely useful for the reasons stated above.

4.7. Swimming - Swimming is another activity which is often secondary in nature, particularly for longer trips. It is of interest to note the interplay between the actual swimming variables and the associated activity variables. An attempt was made to estimate the equations using only associated variables as well as total swimming or using only the individual swimming variables. Neither equations fit the data as well but, on the other hand, the use of all variables does produce some rather confusing substitutions. It is of interest to note that the number of statistically significant coefficients increases markedly as the trips get longer which again reinforces the idea

TABLE 6

GRAVITY MODEL ESTIMATES

HUNTING

No.	Index	Description	1-Day Coeff.	1-Day t	2/3 Days Coeff.	2/3 Days t	4+ Days Coeff.	4+ Days t
0		Intercept	- 9.1048		-34.9076		-17.4341	
		Destination Attractions						
0A	2	Growing Season	----------		2.7343	2.1952	.0	.0
1	3	Relief	.4440	1.8548	.0	.0	.2904	3.3385
2	4	Annual Rainfall	.0	.0	- .8742	-2.7902	.0	.0
3	5	Acres of Hill Country	.0	.0	.1121	1.8103	.0	.0
4	6	Acres of Piney Woods	.0	.0	----------		----------	
5	7	Growing Season. Dest./Orig.	.0	.0	- 2.5819	-2.4572	- .8111	-1.6032
6A	9	Mileage of Bay Frontage	.1634	1.7763	.0	.0	.0510	1.4138
7	12	Acres of Freshwater Lakes	.0	.0	.1757	2.1219	.0	.0
8	26	Acres in Region	.8753	3.7278	.4078	2.1712	.1409	1.5910
9	28	Wildlife Management Acres	.2196	1.9799	.1071	1.7043	.0839	2.0923
10	44	Total Small Game Index	.0	.0	1.1734	1.6282	1.1027	2.7495
11	45	Proportion Acres Leased	.0	.0	.5292	2.3401	.4833	4.2012
		Origin Characteristics						
12	201	Total Population	.5901	2.5794	1.0558	7.3381	.6111	7.7961
13	202	% Urban Population	.4046	2.0924	.0	.0	.0	.0
14	203	Purchasing Power	1.3036	1.8549	2.2636	4.0311	1.4587	4.6762
		Distance Functions						
15	211	Distance (Adj.)	- 1.5574	-7.7595	- .9565	-6.4021	- .1319	-1.3876
16	306	Interaction, Ac. Leased	.0	.0	.0	.0	.0	.0
		R^2 =	.3343		.3810		.2694	
		EMS =	4.5179		3.9024		2.1927	

TABLE 7

GRAVITY MODEL ESTIMATES

PICNICKING

No.	Index	Description	1-Day Coeff.	1-Day t	2/3 Days Coeff.	2/3 Days t	4+ Days Coeff.	4+ Days t
0		Intercept	11.1818		- .9733		- 5.0809	
		Destination Attractions						
1	2	Growing Season	- 3.0763	-2.0439	- 2.5262	-2.3772	- 1.6378	-2.1431
2	7	Growing Season, Dest./Orig.	.0	.0	.0	.0	1.0011	1.6310
3	12	Acres of Freshwater Lakes	.3181	1.8406	.2881	2.4490	.0	.0
4	29	Inland Picnic Sites	.0	.0	.0	.0	.3652	2.0026
5	31	Ocean Picnic Sites	.4175	3.3453	.2247	2.7201	.1722	3.2889
6	36	Population Density	- .2747	-1.5741	.0	.0	.0	.0
7	46	All Swimming	.0	.0	.1132	1.9117	.0	.0
8	48	All Campsites	.6622	4.3335	.3849	3.6738	.2183	1.8636
9	50	All Boat Ramps	- .3248	-2.5287	- .2313	-2.8406	- .0736	-1.8073
		Origin Characteristics						
10	201	Total Population	.6164	2.6597	.6186	4.4114	.3389	3.3701
11	202	% Urban Population	.4215	2.0267	.0	.0	.1559	1.9457
12	203	Purchasing Power	1.6629	2.0120	2.2214	4.2554	1.9237	5.1773
		Distance Functions						
13	211	Distance (Adj.)	- 1.7214	-8.7583	- .8933	-5.2840	.0	.0
14	306	Interaction, All Picnic Sites	- .0017	-2.6661	- .0016	-4.2422	- .0018	-7.8254
15	309	All Picnic Sites, Dest./Orig.	.0	.0	.0	.0	.0073	2.0379
		R^2 =	.4206		.2572		.2537	
		EMS =	4.8503		5.0127		2.7853	

TABLE 8

GRAVITY MODEL ESTIMATES

SWIMMING (ALL)

No.	Index	Description	1-Day Coeff.	1-Day t	2/3 Days Coeff.	2/3 Days t	4+ Days Coeff.	4+ Days t
0		Intercept	-20.8232		-14.0722		-14.2774	
		Destination Attractions						
1	7	Growing Season, Dest./Orig.	- 3.9608	-1.8755	.0	.0	1.0257	1.8310
2	8	Mileage of Ocean Frontage	.1554	1.5885	.1238	2.3120	.1392	3.8535
3	12	Acres of Freshwater Lakes	.0	.0	.2515	2.5086	.2789	3.7424
4	32	Yards of Swimming Pools	.0	.0	.0	.0	.1014	2.2831
5	33	Yards of Freshwater Swimming	.0	.0	.0	.0	.0	.0
6	35	Yards of Ocean Swimming	.3331	1.7414	.4287	4.8304	.2573	4.1180
7	36	Population Density	- .3388	-1.4530	.0	.0	- .1236	-1.6404
8	48	All Campsites	.0	.0	.2897	3.0722	.2810	4.0855
9	49	All Picnic Sites	.6986	3.7375	.0	.0	.0	.0
		Origin Characteristics						
10	201	Total Population	.8023	3.1126	.3405	2.2548	.4400	4.0105
11	202	% Urban Population	.0	.0	.2601	1.9173	.2024	2.0740
12	203	Purchasing Power	3.1949	3.4129	2.5215	5.2344	2.0137	5.3839
		Distance Functions						
13	211	Distance (Adj.)	- 1.5631	-6.0509	- 1.1057	-6.5140	- .3007	-2.5017
14	306	Interaction, Yards Swimming	.0	.0	.0	.0	.0	.0
15	309	Yards Swimming, Dest./Orig.	.0001	1.7166	.0001	3.5302	.0	.0
		R^2 =	.3242		.2844		.2582	
		EMS =	6.5635		4.7279		3.9031	

that swimming is a secondary activity and is more dependent on other facilities and activities.

5. Projections

The projections resulting from the application of the gravity model are obtained by applying the estimated gravity model coefficients to data sets which comprise projected values for population and attraction variables. The computer program which accomplishes this, provides as a by-product the current participation rates as well as participation rate estimates for current values of population and attraction; these can be used to compare projected versus current participation rates. This program is documented more formally in a separate report. This section deals entirely with a description of the output of the program; no comments on interpretation will be made since this requires intimate knowledge on Texas outdoor recreation.

The output of the computer program comes in four major sections as follows:

(1) Coefficients for the gravity model; these are printed so that they can be checked with the output of the estimation program to insure the appropriate coefficients have been used.

(2) A listing of the first 12 data sets labeled "data listing 0". This will normally be the data for origin region number one to the first twelve destination regions.

(3) Current data and estimates. This portion of the output consists first of a listing of the "adjustment factors" which are necessary to adjust for the multiplicative bias introduced by the use of least square on logarithms as well as the fact that projections using the

gravity model are provided for all origin-destination combinations (i.e. including those for which there was no participation observed in the household survey) which were not included in the estimation process. The listing of adjustment factors is followed by tables of current participation rate estimates as obtained by the 1968 household survey, and the current gravity model estimates.

All estimation and projection tables are in the form of a 37 by 37 table covering all origins/destination combinations with marginal totals for origin and destination totals and a grand total participation. Each table is completely documented with respect to the activity and the nature of the table. All participation rates are given in thousands of "people days". One table is provided respectively for one day trips, 2 or 3 day trips, 4 and up day trips, and total of all trips.

(4) Data listing for projections. This is labeled "Data listing 1" and is a listing of the first 12 observations of a particular projection; format is the same as given in Item 2 above; there is a title to indicate the type of projection data listed.

(5) Projections and comparisons. The projections and comparisons with current participation is provided in two sets of tables as described under Item 3 above. These are as follows:

a. Direct estimation. This set of tables is obtained by a direct application of the gravity model to a projection population and attraction data. They are adjusted by the adjustment factors described in Item 2 above.

b. The ratio of estimated projected participation to estimated current participation (two decimals assumed). A negative ratio indicates that there was a zero estimate for current participation hence the ratio is meaningless.

These tables are followed by a one page summary which compares the total destination recreation estimates with the TP&W supplied "Standards" and also provides a summary of origin total and per capita recreation participation estimates.

Thus the proper usage of the projections provided by this model must be tempered by the knowledge that these projections are the result of extrapolations using a regression model. Most standard references on regression warn against the use of extrapolations; these warnings are particularly relevant when one projects for situations that are completely different from the data used to estimate the parameters of the model. Thus, for example, a drastic change in the relative frequency of boatramps to the number and size of lakes, would provide highly unreliable estimates. Thus the projections are useful for generalized projections but are of more limited use, for example, for the projected effect of a single large new facility.

A RATIO CALIBRATION

AND

A "CASCADE" ESTIMATION PROCEDURE

FOR

TEXAS OUTDOOR RECREATION

REPORT TO

TEXAS DEPARTMENT OF PARKS AND WILDLIFE

SUBMITTED BY

TEXAS AGRICULTURAL EXPERIMENT STATION

JUNE 1, 1972

1. A "Cascading" Procedure

As a part of the work performed by Texas A&M in support of the state plan for outdoor recreation, two models for the prediction of rural outdoor recreation have been proposed and implemented. These are:

(1) The "econometric model" which uses individual household data to estimate the total participation in various recreation activities by individuals residing in each of the 37 regions, and

(2) The "gravity model" which uses aggregated data for recreation participation to estimate such travel among regions for recreation purposes.

The first model is expected, by definition, to provide more precise estimates of the recreation that "originates" in any one of the 37 regions but provides no method for allocating this recreational demand to the various "destinations", that is, regions in which the recreation actually occurs. The gravity model, on the other hand, estimates the amount of recreation involved in travel within and among regions. Total regional recreation, either origin or destination is simply obtained by summing the estimates of all origin-destination travel. Since each of these particular estimates is subject to some degree of variation, the resulting variance of the estimate of total recreation for any region may be quite large.

It seems intuitively reasonable to combine the better features of both methods by using the econometric model to estimate total origin recreation and then use the gravity model to allocate this recreation to the various destination regions. This particular procedure has been named "cascading"

the two models and has been implemented for this study.

Denote the econometric estimate for the number of "people days" of participation in an activity by individuals in region i by $\hat{y}_i$. Denote by $\tilde{y}_{ij}$ the number of people days participation in region j by individuals residing in region i as estimated by the gravity model. The gravity model estimate for the total participation by individuals residing in region i is thus

$$\tilde{y}_{i.} = \sum_{j=1}^{37} \tilde{y}_{ij} \quad .$$

It is assumed that $\hat{y}_i$ is a better estimate than $\tilde{y}_{i.}$, but there are no corresponding estimates $\hat{y}_{ij}$. The cascade estimate is then defined

$$\hat{y}^*_{ij} = \frac{\hat{y}_{i.}}{\tilde{y}_{i.}} (\tilde{y}_{ij}) \quad .$$

In other words, each origin/destination estimate is corrected or adjusted so that the total origin recreation:

$$\Sigma \hat{y}^*_{ij} = \hat{y}_i \ ,$$

the econometric estimate.

This particular procedure was implemented for the short trips (labeled two or three day trips) and long trips and vacations, (labeled four and over day trips). Due to the nature of the data, an econometric estimate was not made for one day trips and thus a cascading adjustment could obviously not be made for these trips. However, in order to make all estimates more internally consistent with the cascaded estimates, a parallel adjustment was made.

Denote the total econometric state-wide estimate for participation in all trips of longer than one day by $\hat{y}_{..}$, and the corresponding gravity estimate by $\tilde{y}_{..}$. The "cascaded" estimates for one day trips is then calculated

$$\hat{y}^*_{ij} = \frac{\hat{y}_{..}}{\tilde{y}_{..}} \tilde{y}_{ij} ,$$

where the $\tilde{y}_{ij}$ are the gravity estimates.

The resulting cascaded estimates are presented in a manner essentially identical to the presentation of the gravity estimates. A first page contains the econometric estimates and the TP&W supplied "standards". These are provided as a check to make certain that the correct cards have been provided. Then follow sets of origin destination participation tables for one day, 2-3 day, 4 and over day trips, as well as total of all trips. Then for all projections follow the table indicating percent change from current estimates of the various items in the table. The final page contains a comparison of the destination estimates with the TP&W supplied "standards" as well as a summary of origin total participation and per capita participation estimates.

2. A "Ratio" Calibration

It has been pointed out in the report describing the "cascading" process for calibrating the gravity estimates with the econometric model estimates, that estimates of recreation participation of individuals residing in a particular region as obtained by the gravity model are likely to have quite large variances. The cascade procedure is one attempt of reducing this variance by using, as a calibrating tool, the presumably better estimates from the econometric model.

The 1968 sample survey data provides another estimate of current recreation participation. Although these estimates are subject to sampling error, it can be supposed that these are better estimates than those obtained by the gravity model. Thus it is possible to calibrate the gravity estimates by using the ratio of 1968 survey estimates to 1968 gravity estimates for future projections for recreation participation. This procedure which will be referred to as the "Ratio" estimates, has been implemented and is presented to the Texas Department of Parks and Wildlife as an alternate method for their consideration.

It must be emphasized that no one of the three projections schemes can be absolutely preferred over the others. Each is subject to some uncertainties and each must be interpreted with care. For example, the ratio estimate cannot project recreation for any origin region showing non recreation in the 1968 household survey. A useful procedure is to compare the three estimates and make subjective judgements based on other knowledge of outdoor recreation to make adjustments where they are indicated.

The computer output for the ratio estimate projection is identical to that of the cascade projections; the unadjusted gravity model estimates included and are identical for both reports.

GRAVITY MODEL

AND

EXTENSIONS

FOR

ESTIMATION OF TEXAS OUTDOOR RECREATION

COMPUTER PROGRAM DOCUMENTATION

REPORT TO

TEXAS DEPARTMENT OF PARKS AND WILDLIFE

SUBMITTED BY

TEXAS AGRICULTURAL EXPERIMENT STATION

JUNE 1, 1972

1. Introduction

The Procedures for implementing the gravity model estimates for Texas Recreation Participation are performed by two programs as follows:

(1) The Estimation Program which uses various data generated by the Texas Department of Parks and Wildlife in Cooperation with other agencies to provide estimates for the gravity model, and

(2) The Projections Program which utilizes the estimated parameters for the gravity model together with projections data to forecast recreation participation. The projections program comes in two versions, one which calibrates forecasts by using Econometric Model estimates and one which uses an internal ratio estimate for a similar calibration. Details of the model concepts and description of statistical and forecasting procedures are discussed in other reports.

Several other programs were used in the development of the gravity model but in general these are concerned with the preparation of data or have been superseded by these two programs. Listings of the three programs are attached to this report; it should be noted that these are listings for specific runs of the model and minor changes in programs (as noted below) must be made for estimation and projection for different activities and/or different versions of the model which may be used. Data formats for the various input cards are reproduced in appendix 4 to this report.

2. The Estimation Program

The estimation program uses various input data regarding region characteristics, attractions, distances, and participation to estimate, by least squares

on logarithms, coefficients for a regression relating participation to various of these characteristics. Basically, the first part of the program develops a "variable pool" from which are selected, by a selection control card, the variables to be used in a particular regression. A "stepdown" or "backward selection" procedure is used to delete independent variables until all remaining coefficients are statistically significant at some predetermined level. One "run" of the program is required for each activity but a number of alternate models can be obtained in one "run" of the program. Regression parameter estimates are printed as well as punched, with the punched cards being directly usable for the projections program. It should be noted, however, that these punched cards have no model identification and must be kept in the appropriate order.

There are a considerable number of comments cards throughout the program which should be helpful in case the program aborts. Also there are checks to see that most data cards are in the appropriate order and the program aborts with an error message if this happens.

The required input for the estimation program is as follows:

(1) The "Master Distance Deck" containing initial estimates of distances among all 37 regions.

(2) The "POP" deck containing the population and income characteristics of the 37 regions. Only four of the variables of this card are normally read by the program; these are (1) total region population, (2) percent of population living in cities of 10,000 population or greater, (3) the percapita buying power, (4) population density.

(3) The "AT" deck containing, for each region, the various attraction variables as given on page 6 of the report describing the gravity

model. Fifty spaces are available in the array for attractions allowing for the generation of special attraction variables. Some of these variables are generated within the program.

(4) The "DD" deck, containing distance decay factors which are used to generate availabilities. Provisions are made for reading these factors even though they were not used in the latest version of the gravity model.

(5) The next two cards are control cards for the first selection of variables and performing the regression; necessary information and formats are given after line 90 on the attached listing. Selection indices refer to numbers (indices) of the particular desired variables from the variable pool; the identification of variables is given in a set of comments statements after line 165 on the attached listing. "IT" is the value of the "t" statistic, which if exceeded for all coefficients, stops the variable selection process.

(6) At this point follows the origin/destination deck for estimated participation followed by a "end card", a card with the letters "END" punched in columns 78, 79, and 80.

(7) Finally there may be additional sets of two cards (as in 5, above) specifying different variable selections and conditions for additional regression models.

Several modifications need to be made to the program for specific realizations of the model. These are as follows:

(1) If availabilities are to be generated as distance decayed attractions, statements performing this operation must be inserted after the comments card indicating "generate availabilities" (line 122).

(2) For most activities only rural participation is needed and this is implemented in the version of the program attached. If rural and urban participation is required, lines 157-159 must be changed since items ZZ(4), ZZ(5), and ZZ(6) contain urban participation.

(3) Lines 230-239 provide for the generation of the interaction of distances with an attraction variable as specified in the final report. The specific variable to be used must be programmed to be "AT1" for the origin and "AT2" for the destination quantity (lines 230 and 231) statement 133.

Finally it should be noted that a large number of executable statements are given in the program as comments. These are generally optional output statements which were used in debugging the program and may yet be useful for this purpose when other models are tried.

3. The Projections Program - Cascade

The projections program produces a set of projected origin-destination tables for the gravity model and cascade adjusted gravity estimates as described in other reports. A complete set of projections is supplied for any given set of population, attraction, standards, and econometric data. All of these must be present or the program aborts. Sets of projections data may be "stacked" so as to provide a large number of projections in one run of the program, however, separate runs of the program are required for each activity. The general nature of inputs to the program is very similar to that of the estimation program as the "head end" of the program is based on the equivalent portion of the estimation program. Description of equivalent data decks will not be repeated here.

The required input for the projections program is as follows:

(1) The "Master Distance Deck".

(2) The distance decay coefficients (equivalent to item 4 in the estimation deck).

(3) A specification of the number of independent variables and title information, format given after line 60 in the attached listing.

(4) The gravity model coefficient estimates; these are automatically available as punched output from the estimation program. If coefficients from other estimation procedures are to be used, they must be punched in the appropriate format which is described after line 76 and format statement 117. It should be noted that three sets of coefficients are read, one for each of the trip lengths. All three equations must have the same number of variables, although if a smaller number of variables are needed, coefficients can be entered with zero values. However, the intercept coefficient <u>must</u> always be the last coefficient.

(5) The data for current population, attraction, econometric estimates and standards, preceeded by a card containing 24 characters of desired identification. These decks are read by the REAT and ECRD subroutines.

(6) The origin-destination deck for estimated participation followed by an "END" card.

(7) Any number of population, attraction, econometric estimates and standards decks for desired projection; each must be preceeded by a card containing 24 characters of appropriate identification. The program will automatically terminate on an end of file.

4. The Projections Program - Ratio

This program is almost identical to the previous program except that it does not use the econometric estimates. Hence for steps 5 and 7 above, submit only the Population, Attraction, and Standards decks, preceeded by the identification card.

APPENDIX 1

LISTING OF GRAVITY ESTIMATION PROGRAM

```
C ****  GRAVITY MODEL ESTIMATION, SEPTEMBER 1971  *****
C      PROGRAM DEVELOPS UP TO 80 VARIABLES USING POP,AT,AV,MASTER
C    DISTANCE AND PARTICIPATION DECKS.   THEN, USING INFORMATION FROM A
C    NUMBER OF VARIABLES (ETC) CARD, FORMAT 10) AND
C    A SELECTION CARD ( FORMAT 351) CARD,
C    WITH DEPENDENT VARIABLE LAST, IT RUNS MAXI-MLR WITH STEPDOWN
C    TO ESTIMATE GRAVITY COEFFICIENTS
C****************
C    COEFFICIENTS ARE PUNCHED TO BE USED WITH THE PROJECTIONS
C    AND CASCADE PROGRAM
C ***********************************
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION T(20) , TM(20)
      DIMENSION  AQ(3)
      DIMENSION  DP(3,37,37), DS (37,37), POP (37,10), AT(37,50),
     2 AV (3,37,50 ), Z(350) ,
     1                    ID(20),ZZ(6),AVT( 7), DD(10,3)
      DIMENSION  R(20,21)
      DIMENSION          X(20),XBAR(20),XPX(21,21),XPY(20)
      DATA  AVT/'BOAT','CAMP','AFSH','FFSH','HUNT','SWIM','PICN'/
      DATA  END/3HEND/
      DATA  AQ/'1DAY','2/3D','4+D '/
      ALOG (YYY) = DLOG ( YYY)
      EXP ( YYY) = DEXP ( YYY)
      DEC  =  DLOG (100.0D0)
      DO 860 K=1,3
      DO  860  I=1,37
      DO  860  J=1,50
      AV ( K,I,J ) = 0.0D0
  860 CONTINUE
C**   READ   MASTER  DISTANCES
      DO  934 I=1,37
      READ (5,932) II, (DS(I,J),J=1,37)
  932 FORMAT  (I2,2X, 19F4.0/ 4X,18F4.0)
      IF (I.NE.II)GO TO  933
      GO TO  934
  933 WRITE  (6,935) II,I
  935 FORMAT  ('DISTANCE CARDS OUT OF ORDER',2I6)
      STOP
 934  CONTINUE
      DO 9045 I = 1,37
      READ (5,9028) II, (POP(I,J),J=1, 4)
 9028 FORMAT (4X, I4, 8X, F8.0, F8.3, F8.0, 24X, F8.0)
      IF (I.NE.II ) GO TO 9134
      GO TO 9045
 9134 WRITE (6,9334) II,I
```

```
 9334 FORMAT ('  POP CARDS OUT OF ORDER ',2I4)
      STOP
 9045 CONTINUE
      DO 9016 I=1,37
      DO 9015 K=1,5
      JJ=(10*K)-9
      JJJ=10*K
      READ(5,9010)II,KK,(AT(I,JK),JK=JJ,JJJ)
 9010 FORMAT (I3,3X,I4,10F7.3)
      IF(II.NE.I.OR.KK.NE.K) GO TO 9011
      GO TO 9015
 9011 WRITE (6,9012)I,II,K,KK
 9012 FORMAT( ' AT CARDS OUT OF ORDER',4I4)
      STOP
 9015 CONTINUE
C *** POP I4 IS POP DENSITY PUT IN AT 36
      AT ( I,36) = POP ( I,4)
C *** AT 44 IS TOTAL SMALL GAME INDEX
      AT (I,44) = 0.
      DO 9116 KK=1,6
      AT( I,44) = AT(I,44) + AT(I, KK+36)
 9116 CONTINUE
C *** AT 45IS PROPORTION ACRES LEASED
      AT (I,45)= AT(I,27) / AT(I,26)
C *** AT 46 IS ALL SWIMMING
      AT (I,46) = AT(I,32) + .1*AT(I,33) + 1000.*AT(I,34) + 10.*AT(I,35
C *** AT47 IS ALL YDS FISHING
      AT (I,47) = AT(I,22) + AT (I,23) + AT( I,24)
C  **** AT(48) ARE ALL CAMPSITES
      AT (I,48) =100.*AT(I,18) + AT(I,19) + AT(I,20)
C *** AT 49 IS ALL PICNIC
      AT (I,49)= 100.* AT(I,29) + AT (I,31)
C  AT 50 IS ALL BOATRAMPS
      AT (I,50) = AT(I,10) + AT(I,11)
 9016 CONTINUE
C  *****************
C 3.  READ DISTANCE DECAY COEFFICIENTS, 7ACTIVITIES AND 3 DAYS TRIP
C    FORMAT IS   3X,I2,3F6.3, THREE COEFFS PER CARD
C  *****************
      DO 352 II=1,8
      READ (5,345) I,(DD(I,J),J=1,3)
 345  FORMAT (3X,I2,3F6.3)
  352 CONTINUE
C   ****************
C 1. READ NO IND VARIABLES,ACTIVITY NO, AND MIN T, 2 DEC ASSUMED
C    ALSO A '1' IF MULTIPLE SELECTIONS FROM SAME DATA,
C      FORMAT IS 4I3)
C 2.READ SELECTION INDICES, FORMAT I3, MAXIMUM 20. DEPENDENT LAST
C  **************
 1111 CONTINUE
      READ (5,10,END=1112) NV,IAC,IT,IREP
   10 FORMAT  (4I3)
      AVX = AVT(IAC)
      READ  (5,351)  (ID(I),I=1,20)
  351 FORMAT  (20I3)
C ***************
C   ZERO ARRAYS  FOR REGRESSION ANALYSIS
C ***************
      NCT = 0
      YBAR = 0.0D0
```

```
      YSQ = 0.0D0
      M = NV + 1
      IMX = NV
      DO 7 I = 1,NV
      XPY(I) = 0.0D0
      T(I) = 0.0D0
      DO 7 J = 1,M
      XBAR(J) = 0.0D0
      XPX(I,J) = 0.0D0
    7 CONTINUE
C ***************
C   IF IREP.EQ.0  ZERO PARTICIPATION AND READ, IF NOT GO TO REG
C ***************
      IF ( IREP.EQ.1) GO TO 1150
C *********************
C   GENERATE AVAILABILITIES
C     DO 1971 I=1,37
C     WRITE (6,936) I,(POP(I,J), J=1,10)
C     WRITE (6,936)I,(AT(I,J),J=1,50)
C     DO 1971 K=1,3
C1971 WRITE (6,936) I, (AV (K,I,J) , J=1,50)
C 936 FORMAT('0',I3/5(1X,10F9.3/))
C     ********
C   DO APPROPRIATE TRANSFORMATIONS
C *************
      DO  920  I= 1,37
      DO  921  J=1,50
      AT  (I,J) = DLOG (AT(I,J)+0.1 )
  921  CONTINUE
      DO 922 J= 1,4
      POP ( I,J)  =  DLOG  ( POP(I,J) + 1.0D0)
  922 CONTINUE
  920 CONTINUE
      DO 9027 K=1,3
      DO 9027 I=1,37
      DO 9027 J=1,37
      DP  (K,I,J) = 0.0
 9027 CONTINUE
C  *********************
C     READ   ACTUAL  PART  AND  DIST
C      RURAL OR URBAN+RURAL SELECTION MUST BE PROGRAMMED
C      THE DP ARRAY HAS PROVISION FOR 1,2/3,AND 4+ DAY TRIPS
C    ALL OUT OF STATE PARTICIPATION IS IGNORED
C  *********************
 9340 READ (5,9040) I,J,(ZZ(K),K=1,6), XD, CHK
  111  IF (CHK.EQ.END)  GO  TO  1150
      IF(J.GE.38) GO TO 9340
C     WRITE(6,9040) I,J,(ZZ(K),K=1,6), XD, CHK
 9040 FORMAT(3X,2I4,2X,6F8.0,T64,F8.0,T78,A3)
C  *** RURAL ONLY
      DP ( 1,I,J) = ZZ(1)
      DP (2,I,J) = ZZ(2)
      DP (3,I,J) = ZZ(3)
      DS (  I,J) =XD
      GO TO 9340
C     ********************************
C     ********************************
C    GENERATE VARIABLE POOL
C  VARIABLES 1-50 ARE ATTRACTIONS
C            51 - 200 ARE AVAILABILITIES (3SETS)
```

```
C              201 - 210 ARE POP CHAR
C        211-2-3 ARE DISTANCES, MIN=20,40,60 RESP
C        214-5-5 ARE PARTICIPATION ADJ FOR MIN=50 FOR DIST LT 100*IAD
C         217-8-9 ARE ACTUAL PARTICIPATION
C         220-1-2 ARE PARTICIPATION - NOT LOG
C         223 IS TOTAL NON LOG PARTICIPATION
C.    ************************
C      ********************************
 1150 CONTINUE
      AQX = AQ(3)
      IS = ID (M)
      IF (IS.EQ.217.OR.IS.EQ.214) AQX=AQ(1)
      IF (IS.EQ.218.OR.IS.EQ.215) AQX=AQ(2)
      WRITE (6,410)AVX,AQX
  410 FORMAT ('1   ***  DATA LISTING ***',2A4,///)
      WRITE   (6,411)  (I,ID(I),I=1,M)
  411 FORMAT  ( 3( 4X, 10( I3,'(',I3,')'J/)//)
      DO 940 I=1,37
      DO 940  J=1,37
C **** DISTANCES *******
      DO 949 IR=1,3
      DMN = IR*20
      ZY  =  DS  (I,J)
      IF  ( ZY.LE.DMN )  ZY = DMN
C     ZZY = ZY + 15.
      ZZY = ZY
      Z ( 210 +IR) = DLOG (ZZY)
C   ** AVAILABILITIES, NOT USED ***
C     DO 948 IQ=1,50
C     Z ( 50*IR + IQ ) = AV ( IR,I,IQ)
C 948 CONTINUE
 949  CONTINUE
C ***** PARTICIPATION ******
      Z (223) = 0.0
      ZZX = 0.0D0
      DO 947 IR=1,3
      ZY = DP (IR,I,J)
      Z (216 + IR ) = DLOG ( ZY + 1.0 )
      Z (219+ IR) = ZY
      Z (223) = Z (223) + ZY
      XID = IR*100
      IF ( ZY.EQ.0.0.AND.ZZY  .LE.XID)ZY = 50.
      Z (213 + IR) = DLOG ( ZY + 1.0D0 )
      ZZX = ZZX + ZY
  947 CONTINUE
C ***** IF SUM OF ALL ADJUSTED PARTICIPATION IS ZERO SKIP TO 940 ***
      IF ( ZZX.EQ.0.0D0) GO TO 940
      DO 950 IR=1,50
      Z (IR) = AT (J,IR)
  950 CONTINUE
      DO  951  IR=1,10
      Z ( IR + 200 ) = POP ( I, IR)
  951 CONTINUE
C ********************************
C     END OF VARIABLE POOL GENERATION
C    ************************
C      ANY RECOMBINATIONS MAY BEPROGRAMMED HERE
C     USE Z(300 - 350)
C ********************************
C   Z 7 IS RATIO OF GROWING SEASON, DESTINATION OVER ORIGIN
```

```
      Z ( 7) = AT(J, 2) - AT(I,2 )
C   VARIABLES FOR DISTANCE INTERACTION,
C          FV IS ORIGIN, FW IS ORIGIN DIVIDED BY DESTINATION
      AT1 = AT( I,46)
      AT2 = AT( J,46)
      FV = DEXP (AT1)
      FW = DEXP( AT1 - AT2)
      Z(306) = Z(211)*FV
      Z(307) = Z(212)*FV
      Z(308) = Z(213)*FV
      Z(309) = Z(211) * FW
      Z(310) = Z(212) * FW
      Z(311) = Z(213) * FW
C   ************************
C   MULTIPLE LINEAR REGRESSION
C     ************
C    SELECT
C***************
      DO 451 II=1,M
  451 X(II)=Z(ID(II))
      XXX = X(M)
      IF (XXX.EQ.0.0D0) GO TO 940
      DO 40 L=1,M
      XBAR (L) = XBAR (L) + X(L)
      DO 40 K = 1,NV
      XPX(K,L) = XPX(K,L) + X(K)*X(L)
   40 CONTINUE
      YSQ = YSQ +  XXX * XXX
      NCT = 1 + NCT
C    **********
      IF  (NCT.GE. 50) GO TO 42
      WRITE  (6,41)  NCT, (X(K),K=1,M)
   41 FORMAT  (' ',I4,( /,'      ',10F8.4))
   42 CONTINUE
  940 CONTINUE
      YBAR = XBAR (M)
C    *****************
C      START REGRESSION CALCULATIONS HERE
C    *****************
   50 ZN = NCT
      DO 60 I = 1,NV
      DO 60 J = 1,M
      XPY(I) = XPX(I,M) - XBAR(I)*XBAR(J)/ZN
      XPX(I,J) = XPX(I,J) - XBAR(I)*XBAR(J)/ZN
   60 CONTINUE
      WRITE(6,67)
   67 FORMAT('1',10X,'XPX MATRIX & XPY')
      DO 70 I = 1,NV
      WRITE(6,65) (XPX(I,J),J=1,M)
   70 CONTINUE
C ************
C   CORRELATIONS
C ************
      SST = YSQ - YBAR*YBAR/ZN
      XPX (M,M) = SST
      WRITE  (6,610)
  610 FORMAT  ('0     CORRELATIONS *********')
      DO 61 I=1,NV
      XDG = XPX (I,I)
      DO  62 J=1,M
```

```
      R (I,J ) = XPX (I,J) / DSQRT ( XDG*XPX(J,J))
   62 CONTINUE
      WRITE (6,65) (R(I,K),K=1,M)
   61 CONTINUE
      CALL INVERT(XPX,NV,M,DET)
      DO  66  I=1,M
      XBAR(I) = XBAR (I) / ZN
   66 CONTINUE
      YBAR = XBAR(M)
      WRITE(6,68)
   68 FORMAT  (/////' ',10X,' DETERMINANT OF XPX, MEANS OF X S AND Y'/)
      WRITE(6,65) DET,(XBAR(J),J=1,M)
  681 WRITE(6,69)
 69   FORMAT('0',10X,'XPX INVERSE')
      DO 75 I = 1,NV
      WRITE(6,65) (XPX(I,J),J=1,NV)
 75   CONTINUE
   65 FORMAT (/ (5X, 8G14.7) )
      SSR = 0.000
      BSUM = 0.000
      DO 90 I = 1,NV
      BSUM = BSUM + XPX(I,M)*XBAR(I)
      SSR = SSR + XPX(I,M)*XPY(I)
 90   CONTINUE
      BO = YBAR - BSUM
      SSE = SST - SSR
      DFTOT = NCT - 1
      DFREG = IMX
      DFERR = DFTOT - DFREG
      REGMS = SSR/DFREG
      ERRMS = SSE/DFERR
      FTST = REGMS/ERRMS
C  ******************
C   CALCULATE T STATISTICS FOR COEFFICIENTS
C    OUTPUT STARTS HERE
C  ******************
      WRITE (6,106)  AVX,AQX ,ID(M)
  106 FORMAT  ('1  ACTIVITY = ',A4,',  ',A4,' TRIPS'//
     1 10X,' DEPENDENT VARIABLE IS ',I4,///)
      WRITE(6,105) NV,NCT
 105  FORMAT(' ',10X,'MULTIPLE  LINEAR REGRESSION '/
     116X,I2,' VARIABLES',2X,I3,' OBSERVATIONS'////
     210X,'ANALYSIS OF VARIANCE'//)
      N1 = DFTOT
      N2 = DFERR
      NA = IMX
      WRITE(6,110) N1,SST,NA,SSR,REGMS,FTST,N2,SSE,ERRMS
 110  FORMAT(' SOURCE',10X,'DOF',10X,'SS',16X,'MS',16X,'F'//
     1' TOTAL',12X,I3,6X,G13.7/
     2' REG.',13X,I3,6X,G13.7,6X,G13.7,6X,G13.7/
     3' ERROR',12X,I3,6X,G13.7,6X,G13.7////)
      R2  =  SSR/SST
      WRITE  (6,112)  R2
  112 FORMAT  (////' R- SQUARE = ',F6.4///)
      DO 100 I = 1,NV
      T(I) = XPX(I,M)/DSQRT(XPX(I,I)*ERRMS)
 100  CONTINUE
      WRITE(6,115)
 115  FORMAT (33X,'COEFFICIENTS',10X,'T-STATISTICS'/)
      WRITE (6,116) AVX,AQX, BO,(AVX,AQX,I,ID(I),XPX(I ,M),T(I),
```

```
      1 I=1,NV)
  116 FORMAT(' ',2X, 2A4          ,14X,F16.7/
     120(3X,2A4          ,2X,2I4,4X,2(F16.7,6X)/)//////)
  117 FORMAT ( 3I3, F12.6 )
      DO 120 I=1,NV
  120 WRITE ( 7,117) IAC, I, ID(I), XPX(I,M)
      WRITE ( 7,117) IAC, M, ID(M), BO
      IF(IMX.LE.1) GO TO 1111
      IMX = IMX - 1
      IX = 0
      TMIN = IT*IT
      TMIN = TMIN/10000.0D0
      DO 300 I=1,NV
      TI = T(I)*T(I)
      IF ( TI.EQ.0.0D0) GO TO 300
      IF ( TI.GE.TMIN ) GO TO 300
      IX = I
      TMIN = TI
  300 CONTINUE
      WRITE (6,118) IX, TMIN
  118 FORMAT ('0 DELETE VARIABLE ',I6, ' T-SQUARE = ', F10.5 )
      IF (IX.EQ.0) GO TO 1111
      DO 310 I=1,M
      TM(I) = XPX (IX,I)
  310 CONTINUE
      DO 320 I=1,NV
      DO 320 J=1,M
  320 XPX (I,J) = XPX(I,J) - TM(I)*TM(J)/TM(IX)
      DO 325 I=1,NV
      XPX( I,IX) = 0.0D0
      XPX(IX,I) = 0.0D0
  325 CONTINUE
      XPX (IX,IX) = 1.0D0
      XPX (IX,M) = 0.0D0
      IMY = NV - IMX
      WRITE (6,330) IMY
  330 FORMAT ( '1','STEPDOWN, STEP NO.',I4,///)
      GO TO 681
 1112 STOP
      END
      SUBROUTINE INVERT(X,N,M,D)
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION X(21,21)
      DATA ZERO/0.0D0/
      DATA ONE/1.0D0/
      D = ONE
      DO 3 L = 1,N
      P = X(L,L)
      D = D*P
      X(L,L) = ONE
      DO 1 J = 1,M
1     X(L,J) = X(L,J)/P
      DO 3 I = 1,N
      IF(I.EQ.L) GO TO 3
      P = X(I,L)
      X(I,L) = ZERO
      DO 2 J = 1,M
2     X(I,J) = X(I,J) - P*X(L,J)
3     CONTINUE
      RETURN
      END
```

APPENDIX 2

LISTING OF CASCADE PROGRAM

```
//$DATA
C    ******* GRAVITY  *****  PROJECTION AND PRESENTATION ****
C******** CASCADE AND NEEDS
C ** ** DATA PRESENTATION
C    MASTER DISTANCES
C   DISTANCE DECAY COEFF FOR AVAILABILITIES
C   NO. INDEPENDENT VARIABLES, ACTIVITY NO, 6 BLANKS, 28 CHAR IDENT
C   GRAVITY MODEL COEFFICIENT ESTIMATES
C   CURRENT POP AND AT PRECEDED BY 24 CHAR TITLE CARD
C    FOLLOWED BY A SET OF 1970 CAPACITIES CARDS ( STANDARDS)
C   CURRENT PARTICIPATION ( O/D TABLES )
C   END CARD
C   PROJECTED POP AND AT DECKS, PRECEDED BY 24 CHARACTER TITLE CARD,
C    FOLLOWED BY ECONOMETRIC ESTIMATES AND CAPACITIES ( STANDARDS)
C      THIS MAY BE REPEATED AS OFTEN AS DESIRED
C     ----------------------------------------
C      PROGRAM DEVELOPS UP TO 300VARIABLES USING POP,AT,AV,MASTER
C    DISTANCE AND PARTICIPATION DECKS.   THEN, USING INFORMATION FROM
C    A NUMBER OF VARIABLES CARD AND THE COEFFICIENT OUTPUTS OF THE
C    ESTIMATION PROGRAM, IT PERFORMS A FEEDBACK, PRINT THIS IN O/D
C    TABLE FORM, ADJUSTS ( CASCADES) FOR ECONOMETRIC MODEL AND
C    PROVIDES MARKET VACUUM USING GIVEN CAPACITY INFORMATION
C*****************
      DIMENSION  TYPE ( 5), LENTH ( 4),  F( 4),  AVT (  8)
      DIMENSION  ACT(4,38,38),EST(4,38,38),CD(4,38,38), XX(4)
      DIMENSION SCALE(4)    , BIAS(3)
      REAL*4  LOG, LENTH
      DIMENSION  DP(3,37,37), DS (37,37), POP (37,10), AT(37,50),
     2 X(3,21), AID(6) ,  XB(3,21) ,
     3 AV(3,37,50) , Z(350), IX (3,21), ZZ(6), AXT( 7), DD(10, 3)
      DIMENSION ESTM (4,38,38), XXM(4)
      DIMENSION POPM( 37,10), ATM(37,50),                ZM(350)
      DIMENSION  ECNT (2,42), STD (37)
      INTEGER  CD
      DATA SCALE/'THOU','X100','X100','THS '/
      DATA TYPE /'ACT ','EST ','CASC','*EST','*CAS'/
      DATA  LENTH /'1DAY','2-3D','4-UP','ALL '/
      DATA  AXT/'BOAT','CAMP','AFSH','FFSH','HUNT','SWIM','PICN'/
      DATA  END/3HEND/
      DEC = ALOG ( 100.)
      NCT = 0
C**   READ   MASTER  DISTANCES
      DO  934 I=1,37
      READ (5,932) II, (DS(I,J),J=1,37)
  932 FORMAT  (I2,2X, 13F4.0/ 4X,13F4.0)
      IF (I.NE.II)GO TO  933
      GO TO  934
```

```
  933 WRITE  (6,935) II,I
  935 FORMAT  ('DISTANCE CARDS OUT OF ORDER',2I6)
      STOP
 934  CONTINUE
C  ****************
C 3.  READ DISTANCE DECAY COEFFICIENTS, 7ACTIVITIES AND 3 DAYS TRIP
C     FORMAT IS   3X,I2,3F6.3, THREE COEFFS PER CARD
C  ****************
      DO 352 II=1,8
      READ (5,345) I,(DD(I,J),J=1,3)
 345  FORMAT (3X,I2,3F6.3)
  352 CONTINUE
C    ***************
C  1. READ NO IND VARIABLES,ACTIVITY NO., SIX BLANKS, AND START IN
C     IN COL.13 A 28 CHARACTER IDENTIFICATION
C     FORMAT IS 2I3,6X,7A4
C  *************
 1111 CONTINUE
      READ (5,10) NV,IAC, (AVT(I), I=1,8)
   10 FORMAT (2I3, 6X, 8A4 )
      M = NV + 1
C ****************
C  READ GRAVITY COEFFICIENT ESTIMATES *******
C     THERE ARE THREE SETS OF COEFFICIENTS
C       80 IS READ LAST IN PLACE OF THE DEPENDENT VARIABLE
C     --------------
      DO 368 K=1,3
      DO 368 ICC = 1,M
      READ (5,117) IA,I,IXT, XB (K,ICC)
  117 FORMAT ( 3I3, F12.6 )
      IF (IA.NE.IAC)  GO TO 369
      IF (I.NE.ICC) GO TO 369
      IX ( K,I) = IXT
      GO TO 368
  369 WRITE (6,364) I,ICC,IAC,IA
  364 FORMAT ('     CARDS FOR COEFF OUT OF ORDER ',4I4)
      STOP
  368 CONTINUE
      DO 365 I=1,M
      WRITE (6,366) AXT(IAC), I, (          IX(J,I), XB(J,I), J=1,3)
  366 FORMAT (  '  COEFF, ACT =',A4,I4, 3(  I6,F10.4))
  365 CONTINUE
C ****************
C  READ 1970 POP AND AT DATA
      READ (5,1165) AID
 1165 FORMAT (      6A4)
      IPP = 0
      CALL  READ  ( POP,AT,IPP )
C ***************
C  ** READ CURRENT ECMT AND STANDARDS
      WRITE(6,1178)AVT,AID
      CALL ECRD (ECMT,STD)
      DO 9027 K=1,3
      DO 9027 I=1,37
      DO 9027 J=1,37
      DP  (K,I,J) = 0.0
 9027 CONTINUE
      DO 25 I=1,4
      DO 25 J=1,38
      DO 25 K=1,38
```

```
      ACT (I,J,K) = 0.0
      EST (I,J,K) = 0.0
   25 CONTINUE
C  ***********************
C     READ   ACTUAL  PART  AND  DIST
C      READ SIZ PART - 1,2/3, AND 4+ DAYS FOR RURAL THEN URBAN
C    ALL OUT OF STATE PARTICIPATION IS IGNORED
C  ***********************
 9340 READ (5,9040) I,J,(ZZ(K),K=1,6), XD, CHK
  111  IF (CHK.EQ.END)  GO TO  1150
      IF(J.GE.33) GO TO 9340
 9040 FORMAT(3X,2I4,2X,6F8.0,T64,F8.0,T78,A3)
C     WRITE(6,9040) I,J,(ZZ(K),K=1,6), XD, CHK
      DP ( 1,I,J) = ZZ (1)
C  *** RURAL ONLY
      DP (2,I,J) = ZZ(2)
      DP (3,I,J) = ZZ(3)
      DS (  I,J) =XD
      GO TO 9340
C     ********************************
 1150 CONTINUE
C ***********************
C   GENERATE AVAILABILITIES
      CALL AVL (AV,AT,DP,DS,IAC)
C     DO 1971 I=1,37
C     WRITE (6,936) I,(PDP(I,J), J=1,10)
C     WRITE (6,936)I,(AT(I,J),J=1,50)
C1971 WRITE (6,936)I,(AV(I,J),J=1,50)
C 936 FORMAT(101,I3/5(1X,10F9.3/))
      CALL TRANS(AT,AV,PDP)
      DO 1155 I=1,4
 1155 F(I) = 1.0
      IN = 0
      WRITE (6,1160) IN
 1160 FORMAT ('1     DATA LISTING      ',I6,////)
      CALL EXT (DS,Z,AT,PDP,AV,EST,ACT,XB,IX,DP,NV ,IN ,F )
      DO 550 I=1,4
      F(I)= ACT(I,38,38) / EST (I,38,38)
  550 CONTINUE
      WRITE (6,551) ( F(I), I=1,4)
  551 FORMAT ( '0     ADJ  FACT  ' ///// 4F12.4)
C   ADJUST CURRENT ESTIMATES FOR LOG BIAS
      DO 561 J=1,38
      DO 561 K=1,38
      EST (4,J,K) = 0.0
      DO 561 I=1,3
      ESF = F(I) * EST(I,J,K)
      EST (I,J,K)= ESF
      EST(4,J,K) = EST (4,J,K) + ESF
  561 CONTINUE
      DO 55 I=1,4
      DO 55 J=1,38
      DO 55 K=1,38
      CD (I,J,K) =(ACT (I,J,K) + 500.)/ 1000.0
   55 CONTINUE
C  ** LITING OF CURRENT, ACT NO LONGER NEEDED
      ITYP =1
      ISC  =1
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
      DO 56 I=1,4
```

```
      DO 56 J=1,38
      DO 56 K=1,38
C   ** ACT WILL CONTAIN CURRENT CASCADED EST, EST WILL  HAVE GRAV EST
      XET= EST(I,J,K)
      ACT(I,J,K)=XET
      CD(I,J,K) = (XET + 500.) / 1000.
   56 CONTINUE
      ITYP = 2
      ISC = 1
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
      WRITE ( 6,1210) TYPE(2)
      CALL XNEEDS ( AVT, AID, EST , STD, IPX , POP)
C   CURRENT CASC
      CALL CASD ( ECMT,ACT)
      DO 571 I=1,4
      DO 571 J=1,38
      DO 571 K=1,38
      CD(I,J,K) = (ACT(I,J,K) + 500.) / 1000.
  571 CONTINUE
      ITYP = 3
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
C  ****************
C   1970 NEEDS
      IPX = 1
 1210 FORMAT ('1    ', A4)
      WRITE (6,1210) TYPE(3)
      CALL XNEEDS ( AVT, AID, ACT , STD, IPX , POP)
 1170 CONTINUE
       DO 1180 I=1,4
       DO 1180 J=1,38
       DO 1180 K=1,38
      ESTM (I,J,K ) = 0.
 1180 CONTINUE
C    START PROJECTIONS
      READ (5,1165, END=1000)   AID
       IPP = 1
      CALL READ ( POPM,ATM, IPP)
      CALL AVL  (AVM,ATM,DD,DS,IAC )
      CALL TRANS (ATM,AVM,POPM)
      WRITE (6,1178) AVT,AID
 1178 FORMAT('1  ECMT ESTIMATES (1975 AND LATER) AND STANDARDS' /
     1 /20X,14A4)
      CALL ECRD ( ECMT,STD)
      IN = 1
      WRITE (6,1160) IN
      WRITE (6,1185) AID
 1185 FORMAT    ( '    ' , 6A4)
C ****************
C       GRAVITY ESTIMATES
      CALL EXT( DS,ZM,ATM,POPM,AV ,ESTM,ACT,XB,IX,DP, NV ,IN ,F )
      DO 62 I = 1,4
      DO 62 J = 1,38
      DO 62 K = 1,38
   62 CD(I,J,K) = (ESTM(I,J,K)     + 500.)/1000.0
      ITYP  =2
      ISC = 1
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
C ****************
C    PERCENTAGE INCREASES
      DO 90 I = 1,4
```

```
      DO 90 J = 1,38
      DO 90 K = 1,38
      ACX = ACT (I,J,K)
      ACX = EST (I,J,K)
      IF ( ACX.LT.1.0 ) ACX = -ESTM(I,J,K) + 0.1
   90 CD(I,J,K) = ((ESTM(I,J,K) / ACX) *100. )  + 0.5
      ITYP = 4
      ISC = 2
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
C **************
C    NEEDS FOR GRAVITY MODE UNADJUSTED, IPX=1 IN COL 2 IN CARDS
      IPX = 1
      WRITE (6,1210) TYPE(2)
      CALL XNEEDS ( AVT, AID, ESTM, STD, IPX , POPM)
      CALL CASD ( ECMT, ESTM)
      DO 850 I=1,4
      DO 850 J=1,38
      DO 850 K=1,38
      CD(I,J,K) =  (ESTM (I,J,K) + 500. )/ 1000.
  850 CONTINUE
      ITYP = 3
      ISC = 1
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
      DO 87 I=1,4
      DO 87 J=1,38
      DO 87 K=1,38
      XCD = ESTM (I,J,K)
      ACX = ACT(I,J,K)
      IF (ACX.LT.1.0) ACX = -XCD + 0.1
      CD (I,J,K) = (XCD/ACX)*100. + 0.5
   87 CONTINUE
      ITYP = 5
      ISC = 2
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
C ********
C  NEEDS
C *** IPX=2 IDENTIFIES CASCADED PROJECTIONS AND NEEDS, COL 2 IN CARDS
      IPX = 2
      WRITE (6,1210) TYPE(3)
      CALL XNEEDS ( AVT, AID, ESTM, STD, IPX , POPM)
      GO TO 1170
 1000 STOP
      END
      SUBROUTINE READ (POP,AT, IPP )
      DIMENSION POP(37,10), AT(37,50)
      DO 9045 I = 1,37
      READ (5,9028) II, (POP(I,J),J=1, 4)
 9028 FORMAT (4X, I4, 8X, F8.0, F8.3, F8.0, 24X, F8.0)
      IF (I.NE.II ) GO TO 9134
      GO TO 9045
 9134 WRITE (6,9334) II,I
 9334 FORMAT ('  POP CARDS OUT OF ORDER ',2I4)
      STOP
 9045 CONTINUE
      DO 9016 I = 1,37
      DO 9015 K=1,5
      JJ=(10*K)-9
      JJJ=10*K
      READ(5,9010)II,KK,(AT(I,JK),JK=JJ,JJJ)
 9010 FORMAT (I3,3X,I4,10F7.3)
```

```
      IF(II.NE.I.OR.KK.NE.K) GO TO 9011
      GO TO 9015
 9011 WRITE (6,9012)I,II,K,KK
 9012 FORMAT( ' AT CARDS OUT OF ORDER',4I4)
      STOP
 9015 CONTINUE
C *** POP I4 IS POP DENSITY PUT IN AT 36
      AT ( I,36) = POP ( I,4)
C   SCALE ADJUST FOR PROJECTION AT
      IF ( IPP ) 9110,9216,9110
 9110 AT (I,15) = AT (I,15) / 10
      AT (I,16) = AT (I,16) / 100
      AT (I,17) = AT (I,17) / 10
C  ***************
 9216 CONTINUE
C **************
C *** AT 44 IS TOTAL SMALL GAME INDEX
      AT (I,44) = 0.
      DO 9116 KK=1,6
      AT( I,44) = AT(I,44) + AT(I, KK+36)
 9116 CONTINUE
C *** AT 45IS PROPORTION ACRES LEASED
      AT (I,45)= AT(I,27) / AT(I,26)
C *** AT 46 IS ALL SWIMMING
      AT (I,46) = AT(I,32) + .1*AT(I,33) + 1000.*AT(I,34) + 10.*AT(I,3
C *** AT47 IS ALL YDS FISHING
      AT (I,47) = AT(I,22) + AT (I,23) + AT( I,24)
C  **** AT(48) ARE ALL CAMPSITES
      AT (I,48) =100.*AT(I,18) + AT(I,19) + AT(I,20)
C *** AT 49 IS ALL PICNIC
      AT (I,49)= 100.* AT(I,29) + AT (I,31)
C   AT 50 IS ALL BOATRAMPS
      AT(I,50) = AT(I,10) + AT(I,11)
 9016 CONTINUE
      RETURN
      END
      SUBROUTINE AVL (AV,AT,DD,DS,IAC)
      DIMENSION AV(3,37,50), AT(37,50), DD(10,3), DS(37,37)
C    AV  =  SUM  (AT)  (DS**DD)
C ***********************
C     DO 860 K=1,3
C     DO  860  I=1,37
C     DO  860  J=1,50
C     AV ( K,I,J) = 0.0
C 860 CONTINUE
C     DO 9025  I=1,37
C     DO 9025  J=1,37
C     DIS = DS(I,J)
C     DO  9025 IAD=1,3
C     DMN = 20.*IAD
C     IF  (DIS.LE.DMN)  DIS=DMN
C     DIX = DIS
C *********
C   SPECIFY HERE ONLY THOSE AV NEEDED (IJ RANGE)
C     DO 9025 IJ=1,50
C ************
C     IJ = 12
C     AV ( IAD,I,IJ ) = AV (IAD,I,IJ ) + AT (J,IJ )*
C    1 (DIX ** (DD(IAC,IAD )) )
C9025 CONTINUE
```

```
      RETURN
      END
      SUBROUTINE TRANS (AT,AV,POP)
      DIMENSION AT(37,50), AV(3,37,50), POP(37,10)
C     ********
C    DO APPROPRIATE TRANSFORMATIONS
C ************
      DO  920  I= 1,37
      DO  921  J=1,50
      AT  (I,J) = ALOG (AT(I,J)+0.1)
C     IF  (AV(1,I,J).EQ.0.0) GO TO 921
C     DO 925 K=1,3
C     AV (K,I,J) = ALOG(AV(K,I,J) + 0.1 )
C 925 CONTINUE
  921  CONTINUE
      DO 922 J= 1,4
      POP (I,J) = ALOG (POP(I,J) +1.0  )
  922 CONTINUE
  920 CONTINUE
      RETURN
      END
      SUBROUTINE EXT(DS,Z,AT,POP,AV,EST,ACT, XB, IX, DP, NV ,IN,F)
C  DS= DISTANCES
C  Z = VAR POOL
C  AT = ATTRACTIONS
C  POP IS POPULATION ARRAY
C  AV IS AVAILLABILITIES -- CURRENTLY NOT USED
C  EST IS ARRAY FOR DEVELOPING GRAVITY EST
C  ACT IS ARRAY FOR ACTUAL PART
C  XB IS AARRAY FOR GRAVITY COEFFICIENTS
C  IX IS ARRAY OF INDEXING COEFFICIENTS
C  DP IS ARRAY OF ACTUAL PARTICIPATION
C  NV IS NO VARS IN GRAVITY MODEL
C  IN =0 CURRENT, =1 ALL OTHER RUNS
C  F ISARRAY OF LOG BIAS CORRECTIONS
C    GENERATE VARIABLE POOL
C  VARIABLES 1-50 ARE ATTRACTIONS
C            51 - 200 ARE AVAILABILITIES (3SETS)
C            201 - 210 ARE POP CHAR
C       211-2-3 ARE DISTANCES, MIN=20,40,60 RESP +  15
C       214-5-5 ARE PARTICIPATION ADJ FOR MIN=50 FOR DIST LT 100*IAD
C        217-8-9 ARE ACTUAL PARTICIPATION
C        220-1-2 ARE PARTICIPATION - NOT LOG
C        223 IS TOTAL NON LOG PARTICIPATION
C   ************************
      DIMENSIONDS(37,37),Z(350), AT(37,50), POP(37,10), AV(3,37,50),
     1 X(3,21), EST(4,38,38) ,ACT(4,38,38)
      DIMENSION XB(3,21), IX(3,21), DP(3,37,37),XX(4) , F(4)
      DEXP(WW) = EXP(WW)
      M = NV + 1
      NCT = 0
      DO 940 I=1,37
      DO 940  J=1,37
      Z (223) = 0.0
      DO 940 IR=1,3
      DMN = IR*20
      ZY  =  DS  (I,J)
      IF  ( ZY.LE.DMN )  ZY = DMN
C     ZZY = ZY + 15.
      ZZY = ZY
```

```
      Z ( 210 +IR) = ALOG (ZZY)
      ZY = OP (IR,I,J)
      IF ( IN.EQ.1) GO TO 949
      Z (216 + IR ) = ALOG ( ZY + 1.0 )
      Z (210+ IR) = ZY
      Z (223) = Z (223) + ZY
      XID = IR*100
      IF ( ZY.EQ.0.0.AND.ZZY  .LE.XID)ZY = 50.
      Z (213 + IR) = ALOG ( ZY + 1.0 )
C     DO 948 IQ=1,50
C     Z ( 50*IR + IQ ) = AV ( IR,I,IQ)
C 948 CONTINUE
 949  CONTINUE
      DO 950 IR=1,50
      Z (IR) = AT (J,IR)
  950 CONTINUE
      DO  951  IR=1,10
      Z ( IR + 200 ) = POP ( I, IR)
  951 CONTINUE
C ********************************
C     END OF VARIABLE POOL GENERATION
C    ***************************
C       ANY RECOMBINATIONS MAY BEPROGRAMMED HERE
C     USE Z(300 - 350)
      XPP =  EXP( POP(I,1)) / 1000.
C    Z7 IS RATION OF GROWING SEASON
      Z(7) = AT(J,2) - AT(I,2)
C * * * LEASED HUNTING ACRES
      AT1 = AT ( I,27)
      AT2 = AT(J,27)
      FV = DEXP ( AT1)
      FW = DEXP( AT1 - AT2 )
      Z(306) = Z(211)*FV
      Z(307) = Z(212)*FV
      Z(308) = Z(213)*FV
      Z (309) = Z (211) * FW
      Z (310) = Z (212) * FW
      Z (311) = Z (213) * FW
C     ************
C    SELECT
C****************
      DO 452 K=1,3
      DO 452 II=1,NV
      X (K,II) = Z ( IX(K,II))
  452 CONTINUE
      NCT = 1 + NCT
C    **********
      IF  (NCT.GE. 13) GO TO 42
      WRITE  (6,41)  NCT, ( X(1,K), K=1,NV)
   41 FORMAT  (' ',I4,( /,'      ',10F8.4))
   42 CONTINUE
      IF (IN.EQ.1) GO TO 206
      DO 205 II = 1,4
      XA = Z (219 + II)
      IF ( XA.EQ.0.0) GO TO 205
      ACT (II,I,J)  =  XA
      ACT (II,38,J ) = ACT (II,38, J) +  XA
      ACT (II,I,38 ) = ACT (II, I,38) +  XA
      ACT (II,38,38) = ACT (II,38,38) +  XA
  205 CONTINUE
```

```
  206 CONTINUE
C     ****************
C          PREDICT
C
      DO  49 K=1,3
      XX(K) =XB ( K,M)
      DO 48 IA = 1,NV
      XX ( K  ) = XX ( K ) + XB ( K,IA ) * X (K,IA)
   48 CONTINUE
      Y = ( EXP ( XX(K))) * F(K)
      EST ( K,I,J) =  Y
      EST (K,I,38) = EST (K,I,38) + Y
      EST (K,38,J) = EST (K,38,J) + Y
      EST (K,38,38)= EST  (K,38,38)+Y
      EST  (4,I,J) = EST  (4,I,J)  +Y
      EST  (4,38,J)= EST  (4,38,J)+ Y
      EST  (4,I,38)= EST  (4,I,38)+ Y
      EST  (4,38,38)=EST  (4,38,38)+Y
   49 CONTINUE
  940 CONTINUE
      RETURN
      END
      SUBROUTINE  WRITE  (CD,ITYP,IA,ACT,LENTH,TYPE,SCALE,ISC ,AID)
      INTEGER CD
      DIMENSION  CD (4,38,38),TYPE(5),LENTH(4),ACT ( 8) ,SCALE(4),AID(
C  *********
      DO  300 I=1,4
      WRITE  (6,200)  (ACT(IQ), IQ=1,8) ,( AID(IQ),IQ=1,6)
  200 FORMAT ( '1 GRAVITY MODEL    ,  ACTIVITY IS ',8A4,
     1 '  ESTIMATE FOR ',6A4)
      WRITE (6,201)          LENTH(I),TYPE(ITYP),SCALE(ISC )
  201 FORMAT('  ORIGIN/DESTINATION',4X,              '      TRIPS=',A4,4
     *'TABLE CONTAINS   ',A4,1X,A4/)
      WRITE(6,2021)
 2021 FORMAT(50X,'DESTINATION')
      WRITE(6,202)(IJ,IJ=1,24)
  202 FORMAT(/' ORIGIN', 24I5,/ )
      DO  290 J=1,37
      WRITE (6,203)  J,(CD (I,J,K),K=1,24 )
  203 FORMAT (3X,I2,2X,24I5)
 2031 FORMAT(/' TOTAL ',24I5)
  290 CONTINUE
      WRITE (6,2031)(CD (I,38,K),K=1,24)
      WRITE  (6,200)  (ACT(IQ), IQ=1,8) ,( AID(IQ),IQ=1,6)
      WRITE (6,201)          LENTH(I),TYPE(ITYP),SCALE(ISC )
      WRITE(6,2021)
      WRITE(6,206)(IJ,IJ=25,37)
  206 FORMAT(/' ORIGIN',13I5,4X,'TOTAL'/)
      DO 280  J=1,37
      WRITE (6,207)J,( CD (I,J,K ),K=25,38)
  207 FORMAT(3X,I2,2X,13I5,I7,4X,I2)
  280 CONTINUE
      WRITE (6,208)   ( CD (I,38,K),K=25,38)
  208 FORMAT(/' TOTAL ' ,13I5, I7////)
  300 CONTINUE
      RETURN
      END
      SUBROUTINE XNEEDS ( AVT, AID, EST, STD, IPX ,POP)
      DIMENSION POP (37,10)
      DIMENSION AVT(8), AID (6), EST(4,38,38), STD(37)
```

```
      WRITE (6,71) AVT,AID
   71 FORMAT ('0 NEEDS  ', 8A4,',',6A4 )
      WRITE (6,72)
   72 FORMAT ('0   REGION       PROJ  CAPACITY      DIFF      RATIO
     1ORIGIN TOT    PCAP      POP',// )
      STT = 0.
      DO 70 I=1,37
      XORIG = EST( 4,I,38) / 1000.
      EXS = EST  (4,38,I) / 1000.
      XPP = EXP ( POP(I,1)) / 1000.
      XPC = XORIG / XPP
      STC = STD (I) / 1000.
      STT = STT + STC
      XNT = XNT + STC
      VAC = EXS - STC
      RVAC = STC / EXS
      WRITE (6,73) I, EXS, STC, VAC, RVAC, XORIG,XPC,XPP
   73 FORMAT (' ',I10, 3F10.0, F10.3, F15.0 , 2( 2X, F10.5) )
C   STATEMENTS FOR PUNCHING CARDS
       WRITE (7,75) IPX, AVT(1), AVT(2), AID(1), AID(2), I, EXS, STC,
     1 VAC, RVAC, XORIG
   75 FORMAT (I2, 4A4, I4, 3F10.0, F10.3, F10.0)
   70 CONTINUE
      EXS = EST  (4,38,38) / 1000.
      VAC = EXS - STT
      RVAC = STT / EXS
      WRITE (6,74) EXS ,STT,VAC,RVAC
   74 FORMAT ('0 TOTAL     '  , 3F10.0, F10.3)
      RETURN
      END
      SUBROUTINE ECRD (ECMT, STD)
      DIMENSION  ECMT( 2,42), STD(37)
      DATA DSY/'S'/ , DLY/'L'/
C ****************
C     READ ECONOMETRIC MODEL PROJECTIONS
C ******************
      DO 57 I=1,7
      IN = 6*(I-1) + 1
      IM = 6*(I-1) + 6
      IF ( IM.GE.38) IM=38
      READ (5,1181) AX, ADD, AY,AZ,ICD, ( ECMT(1,J), J=IN,IM)
C **** AX=ACT, ADD=SHORT,LONG, AY=YEAR, AZ= HIGH,MED,LOW ******
 1181 FORMAT ( A4,A1,1X,A4,1X,A4,4X, I1, 6F10.0 )
          IF( DSY.EQ.ADD.AND.ICD.EQ.I ) GO TO 57
      GO TO 1176
   57 CONTINUE
      DO 58 I=1,7
      IN = 6*(I-1) + 1
      IM = 6*(I-1) + 6
      IF ( IM.GE.38) IM=38
      READ (5,1181) AX, ADD, AY,AZ,ICD, ( ECMT(2,J), J=IN,IM)
          IF( DLY.EQ.ADD.AND.ICD.EQ.I ) GO TO 58
       GO TO 1176
   58 CONTINUE
      DO 59 I=1,2
      WRITE (6,1182) AX,AY,AZ, ( ECMT( I,J), J=1,38 )
 1182 FORMAT('0',3A4,/, (8F10.0))
   59 CONTINUE
C ****************
C    READ STANDARDS PROJECTIONS
```

```
      READ (5,1183) AYI, IYI, STD
 1183 FORMAT ( A4, I4, 2X, 7F8.0 / ( 10X, 7F8.0  ))
      WRITE ( 6,1184) AYI,IYI,STD
 1184 FORMAT ( '01',A4,I5, 7F12.0/ ( 10X,7F12.0))
      RETURN
 1176 WRITE (6,1179) AX ,DSY,ADD,ICD,I
 1179 FORMAT (' ECMT OUT OF ORDER ',3A4,2I4 )
      STOP
      END
      SUBROUTINE CASD ( ECMT, ESTM)
      DIMENSION ECMT (2,42), ESTM( 4,38,38)
C  CASCADE PROCEDURE ----------
C    ONE DAY IS ADJUSTED BY RATIO OF ECONOMETRIC MODEL AND
C     GRAVITY MODEL ESTIMATES FOR 2/3 AND 4+ DAY TRIPD.  THE LATTER
C    ARE ADJUSTED BY RATIOS OF ORIGIN ESTIMATES OF THE TWO MODELS
C ****************
C  ONE DAY ADJUSTMENT
      RATIO = ( ECMT(1,38) + ECMT (2,38)) / (ESTM(2,38,38)        +
     1 ESTM (3,38,38)        )
C     WRITE (6,1190) RATIO
C1190 FORMAT (' ',F12.5)
      DO 89 J=1,38
      DO 89 K=1,38
      ESTM (1,J,K) = RATIO * ESTM (1,J,K)
      ESTM (4,J,K) = ESTM (1,J,K)
   89 CONTINUE
C ***********
C   CASCADE 2/3 AND 4+ DAY
      DO 88 I=2,3
      I2 = I - 1
      DO 88 K=1,38
      ESTM (I,38,K)=0.0
      DO 88 J=1,37
      FAC = ECMT (I2,J) / ESTM (I,J,38)
      FXS = FAC * ESTM (I,J,K)
      ESTM ( I,J,K) = FXS
      ESTM (4,J,K) = ESTM(4,J,K) + FXS
      ESTM ( I,38,K) = ESTM (I,38,K) + FXS
      ESTM (4,38,K) = ESTM(4,38,K ) + FXS
   88 CONTINUE
      RETURN
      END

CORE USAGE        OBJECT CODE=      440 BYTES,ARRAY AREA=        0 BYTES,TOTAL AR

DIAGNOSTICS        NUMBER OF ERRORS=        0, NUMBER OF WARNINGS=        0, NU

COMPILE TIME=      0.06 SEC,EXECUTION TIME=      3.88 SEC,   TAMU/WATFIV - VER 1
```

APPENDIX 3

PROGRAM FOR GRAVITY PROJECTION WITH RATIO CALIBRATION

```
//$DATA
C    ******* GRAVITY  *****  PROJECTION AND PRESENTATION ****
C       **** RATIO ADJUSTMENTS
C ******* AND NEEDS
C ** ** DATA PRESTENTATION
C    MASTER DISTANCES
C   DISTANCE DECAY COEFF FOR AVAILABILITIES
C   NO. INDEPENDENT VARIABLES, ACTIVITY NO, 6 BLANKS, 28 CHAR IDENT
C   GRAVITY MODEL COEFFICIENT ESTIMATES
C   CURRENT POP AND AT PRECEDED BY 24 CHAR TITLE CARD
C    FOLLOWED BY A SET OF 1970 CAPACITIES CARDS ( STANDARDS)
C   CURRENT PARTICIPATION ( O/D TABLES )
C   END CARD
C   PROJECTED POP AND AT DECKS, PRECEDED BY 24 CHARACTER TITLE CARD,
C   FOLLOWED BY STANDARDS
C       THIS MAY BE REPEATED AS OFTEN AS DESIRED
C     ------------------------------------
C       PROGRAM DEVELOPS UP TO 300VARIABLES USING POP,AT,AV,MASTER
C    DISTANCE AND PARTICIPATION DECKS.   THEN, USING INFORMATION FROM A
C    A NUMBER OF VARIABLES CARD AND THE COEFFICIENT OUTPUTS OF THE
C    ESTIMATION PROGRAM, IT PERFORMS A FEEDBACK, PRINT THIS IN O/D
C    TABLE FORM, ADJUSTS ( CASCADES) FOR ECONOMETRIC MODEL AND
C    PROVIDES MARKET VACUUM USING GIVEN CAPACITY INFORMATION
C*****************
      DIMENSION  TYPE ( 5), LENTH ( 4),  F( 4),  AVT (  8)
      DIMENSION  ACT(4,38,38),EST(4,38,38),CD(4,38,38), XX(4)
      DIMENSION SCALE(4)    , BIAS(3)
      REAL*4  LOG, LENTH
      DIMENSION  DP(3,37,37), DS (37,37), POP (37,10), AT(37,50),
     2 X(3,21), AID(6) ,  XB(3,21) ,
     3 AV(3,37,50) , Z(350), IX (3,21), ZZ(6), AXT( 7), DD(10, 3)
      DIMENSION ESTM (4,38,38), XXM(4)
      DIMENSION POPM( 37,10), ATM(37,50),                ZM(350)
      DIMENSION  ECMT (3,38), STD (37)
      INTEGER  CD
      DATA SCALE/'THOU','X100','X100','THS '/
      DATA TYPE /'ACT ','EST ','RATI','*EST','*RAT'/
      DATA  LENTH /'1DAY','2-3D','4-UP','ALL '/
      DATA  AXT/'BOAT','CAMP','AFSH','FFSH','HUNT','SWIM','PICN'/
      DATA  END/3HEND/
      DEC = ALOG ( 100.)
      NCT = 0
C**   READ   MASTER  DISTANCES
      DO  934 I=1,37
      READ (5,932) II, (DS(I,J),J=1,37)
  932 FORMAT  (I2,2X, 19F4.0/ 4X,18F4.0)
      IF (I.NE.II)GO TO  933
```

```
      GO TO  934
  933 WRITE  (6,935) II,I
  935 FORMAT  ('DISTANCE CARDS OUT OF ORDER',2I6)
      STOP
 934  CONTINUE
C  ****************
C 3.  READ DISTANCE DECAY COEFFICIENTS, 7ACTIVITIES AND 3 DAYS TRIP
C     FORMAT IS   3X,I2,3F6.3, THREE COEFFS PER CARD
C  ****************
      DO 352 II=1,8
      READ (5,345) I,(DD(I,J),J=1,3)
 345  FORMAT (3X,I2,3F6.3)
  352 CONTINUE
C    ***************
C  1. READ NO IND VARIABLES,ACTIVITY NO., SIX BLANKS, AND START IN
C     IN COL.13 A 28 CHARACTER IDENTIFICATION
C     FORMAT IS 2I3,6X,7A4
C  **************
 1111 CONTINUE
      READ (5,10) NV,IAC, (AVT(I), I=1,8)
   10 FORMAT (2I3, 6X, 8A4 )
      M = NV + 1
C ****************
C  READ GRAVITY COEFFICIENT ESTIMATES *******
C     THERE ARE THREE SETS OF COEFFICIENTS
C       BC IS READ LAST IN PLACE OF THE DEPENDENT VARIABLE
C     --------------
      DO 368 K=1,3
      DO 368 ICC = 1,M
      READ ( 5,117) IA,I,IXT, XB (K,ICC)
  117 FORMAT ( 3I3, F12.6 )
      IF (IA.NE.IAC)  GO TO 369
      IF (I.NE.ICC) GO TO 369
      IX ( K,I) = IXT
      GO TO 368
  369 WRITE (6,364) I,ICC,IAC,IA
  364 FORMAT ('      CARDS FOR COEFF OUT OF ORDER ',4I4)
      STOP
  368 CONTINUE
      DO 365 I=1,M
      WRITE (6,366) AXT(IAC), I, (          IX(J,I), XB(J,I), J=1,3)
  366 FORMAT (   '  COEFF, ACT =',A4,I4, 3(  I6,F10.4))
  365 CONTINUE
C ******************
C  READ 1970 POP AND AT DATA
      READ (5,1165) AID
 1165 FORMAT (      6A4)
      IPP = 0
      CALL  READ  ( POP,AT,IPP )
C ***************
C  ** READ CURRENT ECMT AND STANDARDS
      WRITE(6,1178)AVT,AID
      CALL ECRD (ECMT,STD)
      DO 9027 K=1,3
      DO 9027 I=1,37
      DO 9027 J=1,37
      DP  (K,I,J) = 0.0
 9027 CONTINUE
      DO 25 I=1,4
      DO 25 J=1,38
```

```
      DO 25 K=1,38
      ACT (I,J,K) = 0.0
      EST (I,J,K) = 0.0
   25 CONTINUE
C  **********************
C     READ   ACTUAL  PART  AND  DIST
C      READ SIX PART - 1,2/3, AND 4+ DAYS FOR RURAL THEN URBAN
C    ALL OUT OF STATE PARTICIPATION IS IGNORED
C  **********************
 9340 READ (5,9040) I,J,(ZZ(K),K=1,6), XD, CHK
  111  IF (CHK.EQ.END)  GO  TO  1150
      IF(J.GE.38) GO TO 9340
 9040 FORMAT(3X,2I4,2X,6F8.0,T64,F8.0,T78,A3)
C     WRITE(6,9040) I,J,(ZZ(K),K=1,6), XD, CHK
      DP ( 1,I,J) = ZZ (1)
C  *** RURAL ONLY
      DP (2,I,J) = ZZ(2)
      DP (3,I,J) = ZZ(3)
      DS (  I,J) =XD
      GO TO 9340
C     ********************************
 1150 CONTINUE
C **********************
C   GENERATE AVAILABILITIES
      CALL AVL (AV,AT,DD,DS,IAC)
C     DO 1971 I=1,37
C     WRITE (6,936) I,(POP(I,J), J=1,10)
C     WRITE (6,936)I,(AT(I,J),J=1,50)
C1971 WRITE (6,936)I,(AV(I,J),J=1,50)
C 936 FORMAT('0',I3/5(1X,10F9.3/))
      CALL TRANS(AT,AV,POP)
      DO 1155 I=1,4
 1155 F(I) = 1.0
      IN = 0
      WRITE (6,1160) IN
 1160 FORMAT ('1    DATA LISTING      ',I6,////)
      CALL EXT (DS,Z,AT,POP,AV,EST,ACT,XB,IX,DP,NV ,IN ,F )
      DO 550 I=1,4
      F(I)= ACT(I,38,38) / EST (I,38,38)
  550 CONTINUE
      WRITE (6,551) ( F(I), I=1,4)
  551 FORMAT ( '0    ADJ  FACT  ' ///// 4F12.4)
C   ADJUST CURRENT ESTIMATES FOR LOG BIAS
      DO 561 J=1,38
      DO 561 K=1,38
      EST (4,J,K) = 0.0
      DO 561 I=1,3
      ESF = F(I) * EST(I,J,K)
      EST (I,J,K)= ESF
      EST(4,J,K) = EST (4,J,K) + ESF
  561 CONTINUE
      DO 55 I=1,4
      DO 55 J=1,38
      DO 55 K=1,38
      CD (I,J,K) =(ACT (I,J,K) + 500.)/ 1000.0
   55 CONTINUE
C  **LISTING OF CURRENT, ACT NO LONGER NEEDED
      ITYP =1
      ISC  =1
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
```

```
      DO 562 I=1,3
      DO 562 J=1,37
      ESTX = EST (I,J,38)
      IF ( ESTX.LT.100.) ESTX = 100.
  562 ECMT (I,J) = ACT(I,J,38) / ESTX
      DO 56 I=1,4
      DO 56 J=1,38
      DO 56 K=1,38
C   ** ACT WILL CONTAIN CURRENT CASCADED EST, EST WILL HAVE GRAV EST
      XET= EST(I,J,K)
      ACT(I,J,K)=XET
      CD(I,J,K) = (XET + 500.) / 1000.
   56 CONTINUE
      ITYP = 2
      ISC = 1
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
      WRITE ( 6,1210) TYPE(2)
      CALL XNEEDS ( AVT, AID, EST , STD, IPX , POP)
C   CURRENT CASC
      CALL CASD ( ECMT,ACT)
      DO 571 I=1,4
      DO 571 J=1,38
      DO 571 K=1,38
      CD(I,J,K) = (ACT(I,J,K) + 500.) / 1000.
  571 CONTINUE
      ITYP = 3
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
C  ***************
C   1970 NEEDS
      IPX = 1
 1210 FORMAT ('1    ', A4)
      WRITE (6,1210) TYPE(3)
      CALL XNEEDS ( AVT, AID, ACT , STD, IPX , POP)
 1170 CONTINUE
       DO 1180 I=1,4
       DO 1180 J=1,38
       DO 1180 K=1,38
      ESTM (I,J,K ) = 0.
 1180 CONTINUE
C    START PROJECTIONS
      READ (5,1165, END=1000)   AID
       IPP = 1
      CALL READ ( POPM,ATM, IPP)
      CALL AVL  (AVM,ATM,DD,DS,IAC )
      CALL TRANS (ATM,AVM,POPM)
      WRITE (6,1178) AVT,AID
 1178 FORMAT('1  ECMT ESTIMATES (1975 AND LATER) AND STANDARDS' /
     1 /20X,14A4)
      CALL ECRD ( ECMT,STD)
      IN = 1
      WRITE (6,1160) IN
      WRITE (6,1185) AID
 1185 FORMAT    ( '     ' , 6A4)
C ****************
C       GRAVITY ESTIMATES
      CALL EXT( DS,ZM,ATM,POPM,AV ,ESTM,ACT,XB,IX,DP, NV ,IN ,F )
      DO 62 I = 1,4
      DO 62 J = 1,38
      DO 62 K = 1,38
   62 CD(I,J,K) = (ESTM(I,J,K)     + 500.)/1000.0
```

```
      ITYP  =2
      ISC = 1
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
C ****************
C     PERCENTAGE INCREASES
      DO 90 I = 1,4
      DO 90 J = 1,38
      DO 90 K = 1,38
      ACX = ACT (I,J,K)
      ACX = EST (I,J,K)
      IF ( ACX.LT.1.0    ) ACX = -ESTM(I,J,K) + 0.1
   90 CD(I,J,K) = ((ESTM(I,J,K) / ACX) *100. )  + 0.5
      ITYP = 4
      ISC  = 2
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
C *************
C     NEEDS FOR GRAVITY MODE UNADJUSTED, IPX=1 IN COL 2 IN CARDS
      IPX = 1
      WRITE (6,1210) TYPE(2)
      CALL XNEEDS ( AVT, AID, ESTM, STD, IPX , POPM)
      CALL CASD ( ECMT, ESTM)
      DO 850 I=1,4
      DO 850 J=1,38
      DO 850 K=1,38
      CD(I,J,K) =  (ESTM (I,J,K) + 500. )/ 1000.
  850 CONTINUE
      ITYP = 3
      ISC = 1
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
      DO 87 I=1,4
      DO 87 J=1,38
      DO 87 K=1,38
      XCD = ESTM (I,J,K)
      ACX = ACT(I,J,K)
      IF (ACX.LT.1.0) ACX = -XCD + 0.1
      CD (I,J,K) = (XCD/ACX)*100. + 0.5
   87 CONTINUE
      ITYP = 5
      ISC = 2
      CALL  WRITE ( CD,ITYP, IB, AVT, LENTH, TYPE, SCALE, ISC,AID)
C ********
C  NEEDS
C *** IPX=2 IDENTIFIES CASCADED PROJECTIONS AND NEEDS, COL 2 IN CARDS
      IPX = 2
      WRITE (6,1210) TYPE(3)
      CALL XNEEDS ( AVT, AID, ESTM, STD, IPX , POPM)
      GO TO 1170
 1000 STOP
      END
      SUBROUTINE READ (POP,AT, IPP )
      DIMENSION POP(37,10), AT(37,50)
      DO 9045 I = 1,37
      READ (5,9028) II, (POP(I,J),J=1, 4)
 9028 FORMAT (4X, I4, 8X, F8.0, F8.3, F8.0, 24X, F8.0)
      IF (I.NE.II ) GO TO 9134
      GO TO 9045
 9134 WRITE (6,9334) II,I
 9334 FORMAT ('  POP CARDS OUT OF ORDER ',2I4)
      STOP
 9045 CONTINUE
```

```
      DO 9016 I = 1,37
      DO 9015 K=1,5
      JJ=(10*K)-9
      JJJ=10*K
      READ(5,9010)II,KK,(AT(I,JK),JK=JJ,JJJ)
 9010 FORMAT (I3,3X,I4,10F7.3)
      IF(II.NE.I.OR.KK.NE.K) GO TO 9011
      GO TO 9015
 9011 WRITE (6,9012)I,II,K,KK
 9012 FORMAT( ' AT CARDS OUT OF ORDER',4I4)
      STOP
 9015 CONTINUE
C *** POP I4 IS POP DENSITY PUT IN AT 36
      AT ( I,36) = POP ( I,4)
C   SCALE ADJUST FOR PROJECTION AT
      IF ( IPP ) 9110,9216,9110
 9110 AT (I,15) = AT (I,15) / 10
      AT (I,16) = AT (I,16) / 100
      AT (I,17) = AT (I,17) / 10
C   **************
 9216 CONTINUE
C **************
C *** AT 44 IS TOTAL SMALL GAME INDEX
      AT (I,44) = 0.
      DO 9116 KK=1,6
      AT( I,44) = AT(I,44) + AT(I, KK+36)
 9116 CONTINUE
C *** AT 45IS PROPORTION ACRES LEASED
      AT (I,45)= AT(I,27) / AT(I,26)
C *** AT 46 IS ALL SWIMMING
      AT (I,46) = AT(I,32) + .1*AT(I,33) + 1000.*AT(I,34) + 10.*AT(I,3
C *** AT47 IS ALL YDS FISHING
      AT (I,47) = AT(I,22) + AT (I,23) + AT( I,24)
C   **** AT(48) ARE ALL CAMPSITES
      AT (I,48) =100.*AT(I,18) + AT(I,19) + AT(I,20)
C *** AT 49 IS ALL PICNIC
      AT (I,49)= 100.* AT(I,29) + AT (I,31)
C    AT 50 IS ALL BOATRAMPS
      AT(I,50) = AT(I,10) + AT(I,11)
 9016 CONTINUE
      RETURN
      END
      SUBROUTINE AVL (AV,AT,DD,DS,IAC)
      DIMENSION AV(3,37,50), AT(37,50), DD(10,3), DS(37,37)
C     AV  =  SUM  (AT)  (DS**DD)
C ***********************
C     DO 860 K=1,3
C     DO  860  I=1,37
C     DO  860  J=1,50
C     AV ( K,I,J) = 0.0
C 860 CONTINUE
C     DO 9025  I=1,37
C     DO 9025  J=1,37
C     DIS = DS(I,J)
C     DO  9025 IAD=1,3
C     DMN = 20.*IAD
C     IF  (DIS.LE.DMN)  DIS=DMN
C     DIX = DIS
C ********
C   SPECIFY HERE ONLY THOSE AV NEEDED (IJ RANGE)
```

```
C       DO 9025 IJ=1,50
C ************
C       IJ = 12
C       AV ( IAD,I,IJ ) = AV (IAD,I,IJ ) + AT (J,IJ )*
C     1 (DIX ** (DD(IAC,IAD )) )
C9025 CONTINUE
        RETURN
        END
        SUBROUTINE TRANS (AT,AV,POP)
        DIMENSION AT(37,50), AV(3,37,50), POP(37,10)
C     ********
C    DO APPROPRIATE TRANSFORMATIONS
C ************
        DO  920  I= 1,37
        DO  921  J=1,50
        AT  (I,J) = ALOG (AT(I,J)+0.1)
C       IF  (AV(1,I,J).EQ.0.0) GO TO 921
C       DO 925 K=1,3
C       AV (K,I,J) = ALOG(AV(K,I,J) + 0.1 )
C 925 CONTINUE
  921  CONTINUE
        DO 922 J= 1,4
        POP (I,J) = ALOG (POP(I,J) +1.0  )
  922 CONTINUE
  920 CONTINUE
        RETURN
        END
        SUBROUTINE EXT(DS,Z,AT,POP,AV,EST,ACT, XB, IX, DP, NV ,IN,F)
C  DS= DISTANCES
C  Z = VAR POOL
C  AT = ATTRACTIONS
C  POP IS POPULATION ARRAY
C  AV IS AVAILLABILITIES -- CURRENTLY NOT USED
C  EST IS ARRAY FOR DEVELOPING GRAVITY EST
C  ACT IS ARRAY FOR ACTUAL PART
C  XB IS AARRAY FOR GRAVITY COEFFICIENTS
C  IX IS ARRAY OF INDEXING COEFFICIENTS
C  DP IS ARRAY OF ACTUAL PARTICIPATION
C  NV IS NO VARS IN GRRAVITY MODEL
C  IN =0 CURRENT, =1 ALL OTHER RUNS
C  F ISARRAY OF LOG BIAS CORRECTIONS
C    GENERATE VARIABLE POOL
C  VARIABLES 1-50 ARE ATTRACTIONS
C              51 - 200 ARE AVAILABILITIES (3SETS)
C              201 - 210 ARE POP CHAR
C       211-2-3 ARE DISTANCES, MIN=20,40,60 RESP +  15
C       214-5-5 ARE PARTICIPATION ADJ FOR MIN=50 FOR DIST LT 100*IAD
C        217-8-9 ARE ACTUAL PARTICIPATION
C        220-1-2 ARE PARTICIPATION - NOT LOG
C        223 IS TOTAL NON LOG PARTICIPATION
C    ************************
        DIMENSIONDS(37,37),Z(350), AT(37,50), POP(37,10), AV(3,37,50),
      1 X(3,21), EST(4,38,38) ,ACT(4,38,38)
        DIMENSION XB(3,21), IX(3,21), DP(3,37,37),XX(4) , F(4)
        DEXP(WW) = EXP(WW)
        M = NV + 1
        NCT = 0
        DO 940 I=1,37
        DO 940  J=1,37
        Z (223) = 0.0
```

```
      DO 949 IR=1,3
      DMN = IR*20
      ZY  =  DS  (I,J)
      IF  ( ZY.LE.DMN )  ZY = DMN
C     ZZY = ZY + 15.
      ZZY = ZY
      Z ( 210 +IR) = ALOG (ZZY)
      ZY = DP (IR,I,J)
      IF ( IN.EQ.1) GO TO 949
      Z (216 + IR ) = ALOG ( ZY + 1.0 )
      Z (219+ IR) = ZY
      Z (223) = Z (223) + ZY
      XID = IR*100
      IF ( ZY.EQ.0.0.AND.ZZY  .LE.XID)ZY = 50.
      Z (213 + IR) = ALOG ( ZY + 1.0 )
C     DO 948 IQ=1,50
C     Z ( 50*IR + IQ ) = AV ( IR,I,IQ)
C 948 CONTINUE
  949 CONTINUE
      DO 950 IR=1,50
      Z (IR) = AT (J,IR)
  950 CONTINUE
      DO  951  IR=1,10
      Z ( IR + 200 ) = POP ( I, IR)
  951 CONTINUE
C ******************************
C     END OF VARIABLE POOL GENERATION
C   ************************
C      ANY RECOMBINATIONS MAY BEPROGRAMMED HERE
C     USE Z(300 - 350)
      XPP =  EXP( POP(I,1)) / 1000.
C   77 IS RATION OF GROWING SEASON
      Z(7) = AT(J,2) - AT(I,2)
C * * * SWIMMING
      AT1 = AT ( I,46)
      AT2 = AT(J,46)
      FV = DEXP ( AT1)
      FW = DEXP( AT1 - AT2 )
      Z(306) = Z(211)*FV
      Z(307) = Z(212)*FV
      Z(308) = Z(213)*FV
      Z (309) = Z (211) * FW
      Z (310) = Z (212) * FW
      Z (311) = Z (213) * FW
C     ************
C    SELECT
C****************
      DO 452 K=1,3
      DO 452 II=1,NV
      X (K,II) = Z ( IX(K,II))
  452 CONTINUE
      NCT = 1 + NCT
C    **********
      IF  (NCT.GE. 13) GO TO 42
      WRITE  (6,41)  NCT, ( X(1,K), K=1,NV)
   41 FORMAT  (' ',I4,( /,'     ',10F8.4))
   42 CONTINUE
      IF (IN.EQ.1) GO TO 206
      DO 205 II = 1,4
      XA = Z (219 + II)
```

```
      IF ( XA.EQ.0.0) GO TO 205
      ACT (II,I,J)  =  XA
      ACT (II,38,J ) = ACT (II,38, J) +  XA
      ACT (II,I,38 ) = ACT (II, I,38) +  XA
      ACT (II,38,38) = ACT (II,38,38) +  XA
  205 CONTINUE
  206 CONTINUE
C     ******************
C          PREDICT
C
      DO  49 K=1,3
      XX(K) =XB ( K,M)
      DO 48 IA = 1,NV
      XX ( K  ) = XX ( K ) + XB ( K,IA ) * X (K,IA)
   48 CONTINUE
      Y = ( EXP ( XX(K))) * F(K)
      EST ( K,I,J) =  Y
      EST (K,I,38) = EST (K,I,38) + Y
      EST (K,38,J) = EST (K,38,J) + Y
      EST (K,38,38)= EST  (K,38,38)+Y
      EST  (4,I,J) = EST  (4,I,J)  +Y
      EST  (4,38,J)= EST  (4,38,J)+ Y
      EST  (4,I,38)= EST  (4,I,38)+ Y
      EST  (4,38,38)=EST  (4,38,38)+Y
   49 CONTINUE
  940 CONTINUE
      RETURN
      END
      SUBROUTINE  WRITE  (CD,ITYP,IA,ACT,LENTH,TYPE,SCALE,ISC ,AID)
      INTEGER CD
      DIMENSION  CD (4,38,38),TYPE(5),LENTH(4),ACT ( 8) ,SCALE(4),AID(
C  *********
      DO  300 I=1,4
      WRITE  (6,200)  (ACT(IQ), IQ=1,8) ,( AID(IQ),IQ=1,6)
  200 FORMAT  ( '1 GRAVITY MODEL     ,  ACTIVITY IS ',8A4,
     1 '  ESTIMATE FOR ',6A4)
      WRITE (6,201)          LENTH(I),TYPE(ITYP),SCALE(ISC )
  201 FORMAT('  ORIGIN/DESTINATION',4X,                '      TRIPS=',A4,4
     *'TABLE CONTAINS   ',A4,1X,A4/)
      WRITE(6,2021)
 2021 FORMAT(50X,'DESTINATION')
      WRITE(6,202)(IJ,IJ=1,24)
  202 FORMAT(/' ORIGIN', 24I5,/ )
      DO  290 J=1,37
      WRITE (6,203)  J,(CD (I,J,K),K=1,24 )
  203 FORMAT (3X,I2,2X,24I5)
 2031 FORMAT(/' TOTAL ',24I5)
  290 CONTINUE
      WRITE (6,2031)(CD (I,38,K),K=1,24)
      WRITE  (6,200)  (ACT(IQ), IQ=1,8) ,( AID(IQ),IQ=1,6)
      WRITE (6,201)          LENTH(I),TYPE(ITYP),SCALE(ISC )
      WRITE(6,2021)
      WRITE(6,206)(IJ,IJ=25,37)
  206 FORMAT(/' ORIGIN',13I5,4X,'TOTAL'/)
      DO 280  J=1,37
      WRITE (6,207)J,( CD (I,J,K ),K=25,38)
  207 FORMAT(3X,I2,2X,13I5,I7,4X,I2)
  280 CONTINUE
      WRITE (6,208)   ( CD (I,38,K),K=25,38)
  208 FORMAT(/' TOTAL ' ,13I5, I7////)
```

```
  300 CONTINUE
      RETURN
      END
      SUBROUTINE XNEEDS ( AVT, AID, EST, STD, IPX ,POP)
      DIMENSION POP (37,10)
      DIMENSION AVT(8), AID (6), EST(4,38,38), STD(37)
      WRITE (6,71) AVT,AID
   71 FORMAT ('0 NEEDS  ', 8A4,',',6A4 )
      WRITE (6,72)
   72 FORMAT ('0   REGION      PROJ  CAPACITY      DIFF     RATIO
     1ORIGIN TOT    PCAP     POP',// )
      STT = 0.
      DO 70 I=1,37
      XORIG = EST( 4,I,38) / 1000.
      EXS = EST  (4,38,I) / 1000.
      XPP = EXP ( POP(I,1)) / 1000.
      XPC = XORIG / XPP
      STC = STD (I) / 1000.
      STT = STT + STC
      XNT = XNT + STC
      VAC = EXS - STC
      RVAC = STC / EXS
      WRITE (6,73) I, EXS, STC, VAC, RVAC, XORIG,XPC,XPP
   73 FORMAT (' ',I10, 3F10.0, F10.3, F15.0 , 2( 2X, F10.5) )
C    STATEMENTS FOR PUNCHING CARDS
       WRITE (7,75) IPX, AVT(1), AVT(2), AID(1), AID(2), I, EXS, STC,
     1 VAC, RVAC, XORIG
   75 FORMAT (I2, 4A4, I4, 3F10.0, F10.3, F10.0)
   70 CONTINUE
      EXS = EST  (4,38,38) / 1000.
      VAC = EXS - STT
      RVAC = STT / EXS
      WRITE (6,74) EXS ,STT,VAC,RVAC
   74 FORMAT ('0 TOTAL     '  , 3F10.0, F10.3)
      RETURN
      END
      SUBROUTINE ECRD (ECMT, STD)
      DIMENSION  ECMT( 3,38), STD(37)
      DATA DSY/'S'/ , DLY/'L'/
C ****************
C     READ STANDARDS PROJECTIONS
      READ (5,1183) AYI, IYI, STD
 1183 FORMAT ( A4, I4, 2X, 7F8.0 / ( 10X, 7F8.0  ))
      WRITE ( 6,1184) AYI,IYI,STD
 1184 FORMAT ( '0',A4,I5, 7F12.0/ ( 10X,7F12.0))
      RETURN
      END
      SUBROUTINE CASD ( ECMT, ESTM)
      DIMENSION ECMT (3,38), ESTM( 4,38,38)
C  *** RATIO ADJUSTMENT PROCEDURE
      DO 9 J=1,38
      DO 9 K=1,38
      ESTM ( 4,J,K) = 0.0
      DO 9 I=1,3
      ESTM (I,J,38 ) = 0.0
      ESTM ( I,38,K) = 0.0
    9 CONTINUE
      DO 10 I=1,3
      DO 10 J=1,37
      DO 10 K=1,37
```

```
      ESTX = ESTM(I,J,K) * ECMT(I,J)
      ESTM (I,J,K) = ESTX
      ESTM ( I, J,38) = ESTM ( I, J,38) + ESTX
      ESTM ( I,38, K) = ESTM ( I,38, K) + ESTX
      ESTM ( I,38,38) = ESTM ( I,38,38) + ESTX
      ESTM ( 4, J, K) = ESTM ( 4, J, K) + ESTX
      ESTM ( 4, J,38) = ESTM ( 4, J,38) + ESTX
      ESTM ( 4,38, K) = ESTM ( 4,38, K) + ESTX
      ESTM ( 4,38,38) = ESTM ( 4,38,38) + ESTX
   10 CONTINUE
      RETURN
      END

CORE USAGE        OBJECT CODE=      440 BYTES,ARRAY AREA=        0 BYTES,TOTAL ARE

DIAGNOSTICS        NUMBER OF ERRORS=        0, NUMBER OF WARNINGS=        0, NUME

COMPILE TIME=      0.08 SEC,EXECUTION TIME=      3.55 SEC,    TAMU/WATFIV - VER 1
```

APPENDIX 4

Data Format

Distance Decay Cards

Cols	FMT	CONTENT
1-2	A2	"D"
3-5	I3	Activity
		001 Boating
		002 Camping
		003 Fishing (ALL)
		004 Hunting
		005 Picnicking
		006 Swimming
		007 Fishing (Fresh)
		008 Fishing (Salt)
6-23	3F6.3	(1) Exponential decay coeff., 1 day trips
		(2) Exponential decay coeff., 2-3 day trips
		(3) Exponential decay coeff., 4 and over day trips

Data Format

"PØP" Deck

Col's	FMT	Description
1-8	I8	Region
9-16	F8.0	Year
17-24	F8.0	Pop., adj. to base used for grav.
25-32	F8.3	% Urban
33-40	F8.0	Purch. power, per capita
41-48	F8.3	Pop. density, new
49-56	F8.0	p.c. Income
57-64	F8-0	Family Income
65-72	F9.3	Pop. dens., adj to gravity
73-80	F8.0	Pop., new

NOTE: (1) The population figures used in gravity estimation are somewhat different from data provided in August by TPW. Thus all projections are based on an "adjusted" population obtained by multiplying the TPW projections by the ratio of the two population estimates. (2) Projected per capita purchasing power is projected income multiplied by ratio of current purchasing power to current income. (3) Only the first four fields are used by the gravity programs.

Data Format

"AT" Decks

Col's	FMT	Description
1-3	I3	Region
4	I1	0 = 1970, 1 = 1975, 2 = 1980, 3 = 1990, 4 = 2000
5	I1	1 = Low, 2 = Med, 3 = High, (1970 = 0)
6-9	3X	
10	I1	Card No. (1-5)
11-80	10F7.3	Ten attraction variables per card, in order given in Table 1 of Final Report

Data Format

Econometric Model Estimates

Col's	FMT	Description
1-4	A4	Activity designation
5	A1	S = Short (2/3 day) trips
		L = Long (4+ day) trips
7-10	I4	Year
12-19	A8	High, Medium, Low
20	I1	Card No. (1-7)
21-80	6I10	Econometric estimates, six per card; regions 1-37, followed by total state-wide estimate; last four fields of card 7 contain trash.

NOTE: No econometric estimates exist for <u>all</u> fishing.

Data Format

Coefficient Decks

Col's	FMT	Description
1-3	I3	Activity No.
		1 Boating
		2 Camping
		3 All Fishing
		4 Freshwater Fishing
		5 Hunting
		6 Swimming
		7 Picnicking
4-6	I3	Coefficient No. (1 to M)
7-9	I3	Coefficient index as picked from variable pool, last coefficient is B_o and has index of dependent variable
10-21	F12.6	Coefficient

Standards Deck

Col's	FMT	Description
1-4	A4	Date and level
7-8	I2	Activity identification, coded as in household survey
10	I1	Card No. (1-6)
11-66	7I8	Standards (Capacities), last card has only two entries

Note: Standards used for fishing were not supplied by TP&W and have col's 1-8 different. This does not affect programming.