A DYNAMIC MODEL OF RECREATIONAL USAGE

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SUMMARY

In recreation research, so-called "gravity" models have been applied to predict short term recreational usage of beaches, parks, tourists areas, etc., with some degree of success. Gravity models assume uaage of the recreational facility by individuals from the origin is a multiplicative function of the attractivensss of the facility, the distance between the origin and the facility, and the population size of the origin. Most versions of this model include exponents to be estimated empirically from usage data.

There have been a number of criticisms of these models in the literature. The models fail to take several psychological processes into consideration, such as perceptual and informational delays in tracking changes in site characteristics. Second, the meaning and stabliity of the empirical coefficients have been called into question, and the use of the same empirical constants for forecasting can be shown to be inadequate. Thus, the models have not played a large role in recreational planning. Most gravity models do not consider the substitutability of other recreational activities, and gives no insight into why people will drop one acitivty for another. They do not consider the complex tradeoffs and interactions among recreation facilities as conditions change over time. Finally, gravity models have not included factors associated with the larger socio-economic environment in which recreational behavior takes place. None of them consider, for example, the effects of increased fuel costs on recreational usage.

The reference mode for the present dynamic model represents the concerns of several leaders in the area of recreation and tourism at both the state and local level. The State of Michigan is going through a depressed era, feeling the effects of sagging car sales, unemployment, decreasing state funds, and inflationary fuel prices. Developing a reference mode, these leaders felt population would decrease, trip cost would continue to rise, appropriations for upkeep of the park system would decrease, distant parks would be underused, and attendance at more proximal parks would increase to high levels.

A dynamic model was formulated to describe a hypothetical recreational region beset with economic problems. The region was composed of two population centers and three to five large recreation facilities. The major variable dealt with the strength of the relationship between the recreationist's origin and the facility, somewhat similar to the approach used by Forrester[1] and Laird [2] The strength was a function of the perceived density over the desired density, the effect of trip cost, the perceived effects of maintaining the facility, as well as general physical characteristics of each facility. Perceptual and information delays were put into the model where appropriate.

The actual distribution of recreationists was accomplished in the model by normalizing each attractive strength value. Thus, at any time, the fraction of the recreational population going to a site was the ratio of the strength of the facility to the sum of the strengths in the total set of facilities. This method of defining relative strengths implies very specific reactions of the recreational system to increases or decreases in the total set of facilities[3].

Simulation runs were conducted over a time horizon of 50 years. During all but the first four years, the price of gasoline was allowed to increase exponentially, while state funds for maintaining the facilities were decreased over time to simulate severe economic conditions. The dynamics initially showed that the perceived population density of each facility (both in crowded and uncrowded conditions) determines the distribution of recreational usage patterns.

However, as the prices of gasoline rose, trip costs became the dominant factor. The attendance at proximal parks increase quite rapidly, but eventually with falling population and the remaining recreationists leaving the activity, attendance at even proximal locations declined. These baseline runs matched the qualitative characteristics of the original reference made quite well.

As mentioned, gravity models are limited as forecasting tools, and have not had extensive use for policy analysis. To illustrate the possible potential advantage of the present system dynamics approach to this same area, a simulation run was performed, starting with three recreational facilities in 1970 and systematically adding two more sites in either 1985, 1995, 2005, or 2015. The results showed that developing new urban parks at an earlier date decreased the likelihood of individuals giving up the activity because of trip costs. Opening up the parks at the same location at a later date had little positive effect.

These results were analyzed in light of the assumptions underlying the relative strength concept. A model of this type could never predict recreational behavior which demonstrated an hysteresis effect when new facilities were established or old ones shut down. This model could be used as a baseline to compare it with other models which assume that such psychological processes as boredom, curiosity, and attachment to specific locations are determiners of aggregate recreational behavior.

References

[1] Forrester, J. Urban Dynamics. Cambridge: MIT Press, 1969.

[2] Laird, M.W. Dynamic Migration Models. In Readings in Urban Dynamics. Vol. #1 (N.J. Mass. Ed.), Cambridge: Wright-Allen Press, 1974.

[3] Luce, R.D. Individual Choice Behavior, New York: John Wiley, 1959.

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Introduction

The motivation for developing this model came from an academic interest in the dynamics of recreational behavior as well as in responding to pressing recreational problems faced by state officials and tourist industry planners. The current energy picture and economic climate in midwestern United States appears to be relatively bleak. Michigan, for example, whose economic life revolves around the state of the automobile industry, is reeling from sharp declines in auto sales. The cost of energy, for the most part, has been increasing over the past eight years at a phenominal rate, not only increasing the cost of automobiles, but also affecting consumer choices and preferences for smaller and more economical cars.

Along with the decline of the automobile industry in Michigan, recreation and tourism has felt the pinch of rising gasoline prices and poor economic climate. State government, in particular, has had to scale down operations in the management of their state park system. According to the statements of some of the state officials, already there has been a profound change in recreational patterns across the region. People appear to be staying closer to home, and do not make as many recreational trips. There is a noticeable increase in the volume of recreationists utilizing public recreational facilities and going to tourist attractions in and around urban centers rather than traveling long distances.

Reference Mode

The specific implications and effects of the energy problem to recreational systems were communicated to the authors through conversations with officials responsible for operating the state park system in Michigan. Fig. 1 represents a reference mode having a time horizon of perhaps 30 to 50 years. As economic conditions worsen and the price of gasoline increases, the recreational population at an urban center will decline through emigration to another region or through a change to other recreational activities which do not require extensive travel costs. Responding to some preliminary empirical observations, state officials forecasted an initial increase in the volume of recreationists going to nearby parks followed by a steady decline usage.

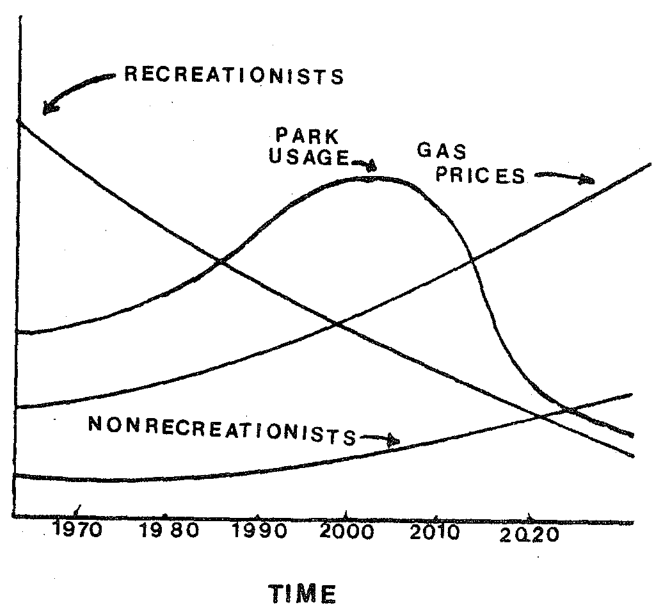

Fig. 1 Reference mode and time horizon for problem.

Current Recreational Usage Models

Much of the development of recreational models has been motivated by the need to predict the intensity of usage of regional recreational facilities and parks. For many years, geographers and regional economists have applied so-called "gravity models" to make predictions of recreational usage. The basic notions underlying gravity models and similar theoretical frameworks were developed in the nineteenth century, and are still being used successfully today in recreation research and applications.

The following equation gives the general form of the gravity model [1]:

$$U_{ij} = g\left(\frac{A_j^a \; P_i^b}{D_{ij}^c}\right) \qquad (1)$$

Where U = Number of recreational trips between i and j

g = Constant of proportionality, a scale factor

P = Population at origin i

A = The attractiveness of facility j

D = Minimum time-distance between i and j

a,b,c = Exponents

During the past few years, there has been a steady stream of papers dealing with various affects of fitting this model to empirical data. Table 1 shows a representative sample of these studies. For example, Malamud predicted the probability of an individual recreationist coming from a particular state

Table 1. Representative Sample of Recent Studies Using Versions of the Gravity Model.

Reactional application	Predictor variables	Authors
Freshwater fishing	Attractiveness, population, distance, opportunity	Freund and Wilson [2]
Ski trips	Quality of facility, income, age	McAllister and Klott [3]
Recreational home choice	Water, accessibility, amount of woods	Bell [4]
Las Vegas tourism	Distance, income, unemployment rate	Malamud [5]
Great Lake resort use	Distance	Wolfe [6]

or region by using a modified version of the basic model to take economic factors, such as average income, into consideration. The general form of the gravity model should also be very familiar to system dynamicists, although it should be noted that most geographers and other social scientists focus upon short term aspects of recreational behavior, and not upon long term dynamic relationships.

Concerning parameter estimation procedures used in this area to predict the number of trips per unit of time, again consider equation (1). The usual method of fitting the model to a set of data is to take the logs of both sides of the equation, and use multiple linear regression techniques to obtain estimates of a, b, c, and g. Although this method of predicting usage appears to be very useful on a short term basis, from a system dynamics point of view, one questions the meaning of the exponents themselves. The size of the exponents were not derived from rational first principles. For example, what does it mean to find that the exponent, b, associated with the size of the population at the ith urban origin, equals 3.564? That value has very little substantive meaning. Moreover, one should question the stability of the coefficients themselves over time, for if a new set of data were collected four years later, the coefficients most likely would change without giving the researcher insight into the mechanisms underlying those changes.

There are several other theoretical and practial limitations to these models. First, the models usually do not take into account the interaction effects and trade-offs among competing facilities. Secondly, the static gravity models ignore a number of important feedback mechanisms which change the behavior of the system over time. Although, for example, researchers are just beginning to empirically study the effects of perceptual and informational lags on recreational behavior, these are not included in a model of this type. Also, usually gravity models predict usage of recreational facilities for specific purposes. They do not take into consideration changes of interests, fads, and other similar factors. The model must also take into consideration the substitutability of other recreational activities as conditions change.

Purpose

The major goal of this paper then is to consider the potential dynamic aspects of recreational systems. The approach to modeling will be somewhat similiar in form to the gravity model, but here the stress will be those factors which determine the change in the system. Moreover, the present model will consider the impacts of the cost of energy and other economic factors on recreation in a more explicit manner. As mentioned earlier, although the gravity models are being used for predicting usage in the short term, their inadequacies as a forecasting tool prevent their application for widespread use in recreational planning. Currently we are only at the first stages of the modeling process. Nevertheless, every effort is being made to orient this dynamic version of the gravity model towards becoming a useful tool for long term recreational planning and policy analysis.

The Basic Relationships Revisited

The effort to integrate dynamic concepts into existing gravity model frameworks perhaps began with the work of Michael Laird [7] who applied the gravity model to predicting migration patterns within an urban system context. He noted that equation (1) can be abstracted and rearranged so that it takes the following form:

$$\text{Inflow} = \text{Labor Arrivals} = LA_{xy} = (LAN)\ (Lx)\ \frac{(LAMP)}{C^s_{xy}} \qquad (2)$$

L_x - NUMBER OF LABORERS IN CITY X
$LAMP_y$ - LABOR-ATTRACTIVENESS MULTIPLIER PERCEIVED AT POINT Y
C_{xy} - TOTAL COST OF MIGRATION FROM Y TO X
s - EMPIRICAL CONSTANT
LAN - LABOR ARRIVALS NORMAL

He suggested that attractiveness might be considered to be the benefits of a particular location and cost might essentially represent distances. Thus

$$\text{In flow} = \text{Labor Arrivals} = LA - (LAN)\ (L_x) \left[\frac{MLAMP}{MCOST}\right] \qquad (3)$$

MLAMP - AVERAGE LABOR ATTRACTIVENESS MULTIPLIER
MCOST - AVERAGE COST

The variable U, in equation (1) or in Laird's case inflow, I, appears to be motivated by a generalized benefit-cost ratio. This ratio can be absorbed into a single multiplicative effect, or again in the case of the present paper, two or more multiplicative effects. Laird felt that certain costs, such as transportation costs, were not significant factors affecting labor migration across cities. This may be still true today for urban migration, but perhaps not so for recreational systems. Nevertheless, although Laird was primarily concerned with the application of the gravity model to labor migration into and out of urban centers, his fundamental approach will be useful in considering recreational system dynamics, where each recreational facility has its benefits as well as costs.

The Concept of Strength

The primary characteristic of any given recreational facility, such as a state park, is its total attractive strength. From the author's empirical research findings and other sources, the total attractive strength is a function of (1) the density of recreationists at the facility, (2) the cost of transportation to and from the recreationist's point of origin, (3) the relative amount of funds used in maintaining the facility, and (4) the physical and environmental attributes of the facility itself. The strength, STRAI, of any particular park I, for individuals coming from urban center A at time, k can be represented by the following general equation:

```
STRAI.K=BASEAI*EDENAI.K*AEUPAI.K

BASEAI - NORMAL ENVIRONMENTAL ATTRACTIVENESS          (4)
EDENAI - DELAYED EFFECT OF RECREATIONAL DENSITY
ECAI -   EFFECT OF ROUND TRIP COSTS BETWEEN A AND I
AEUPAI-  ATTRIBUTED EFFECT OF UPKEEP
```

One should note, first of all, that the strength of a particular park or facility varies according to the origin of the recreationist. Although it is somewhat difficult to change the basic environmental characteristics of each park, changes can occur quite easily in the nature of the park due to increasing or decreasing maintenance and building funds. Likewise, various factors can change the park's population density. In both these cases, the effect on the distribution of people coming in or going out of the park is not instantaneous, and therefore perceptual and informational delays have been introduced into the model to account for this dynamic progress. It takes time for changes in recreational facilities to become known and diffused into the population.

Within a region, each recreational facility, such as a beach, will generate an attractiveness strength value for a given population of recreationists. It is assumed that aggregate choice and utilization of recreational locations, $L_1, L_2, \ldots L_3$, will be directly proportional to their relative strengths. Also to account for the interactive influences among recreational parks and facilities, which is unfortunately neglected in the gravity approach, an aggregate version of Luce's choice model was chosen to represent the "allocation of recreationists to facilities from a given urban origin[8]. Luce's model can be applied to recreational choice and behavior in the following manner. Consider urban center A. The fraction or recreationist going to park #1. FRECA1 can be expressed, according to the model as

```
FRECA1.K=STRA1.K/TOSTRA.K                                  (5)

FRECA1-  FRACTION OF RECREATIONISTS GOING TO #1 FROM A
STRA1 -  STRENGTH OF 1 PERCEIVED BY A
TOSTRA - TOTAL STRENGTH OF ALL LOCATIONS
```

The use of Luce's approach to the distribution of recreationists throughout a region has two important implications. First, from an empirical point of view, it assumes that the <u>ratio</u> of fractions associated with two locations will remain constant. This implies that when the recreational facilities are added or deleted from the total set of parks, the basic relationship between any given pair of parks remain the same. In essence, it appears that the system normalizes itself and adjusts for bigger or smaller set sizes. Thus, for example, if a new beach facility came into existence, increasing the original total set size N, the ratio of, for example, FRECA1 to FRECA2 would remain the same, regardless of the size of FRECA (N + 1) This constant ratio rule can be tested empirically from time series data representing situations where park systems were closed down or expanded.

The second implication of this approach to distribtuion recreationists throughout a region deals with the fact that the model explicitedly specifies the determiners of action toward <u>all</u> alternative recreation sites. To be a bit clearer, in the author's experience, many system dynamic models represent the allocation process by specifying in great detail all of the mechanisms that account for distributing resources (money, time, etc.) to all but one alternative. Everything is known about N-1 alternatives. The flow to the last alternative is usually calculated by subtraction, without much interest about why the flow of goods and materials go into the last sector. Using a strength concept, one has to model the factors which determine all alternatives, which becomes more intellectually challenging to accomplish

The Geographic Context of the Usage Model

In any particular state or region, there may be a number of large metropolitan areas and numerous state parks scattered around the area. Since this model is at the exploratory stage, it was thought best to limit the application of the model to a hypothetical region composed of a small number of parks and urban areas. The model could be expanded to represent the recreational behavior associated with as many as 120 parks and 17 or 18 cities, which may be more realistic, but at this stage, no more enlightening than a scaled down version of the model. Thus consider a region whose major population of recreationists are found in two urban centers, A and B. Five lakes are distributed around the region in a manner described in Fig. 2, and interpoint distances between each of the two cities and the lake facilities are shown in Table 2. I am assuming that the aggregate recreational activities represented in the model deals with the use of the beach and lake area for

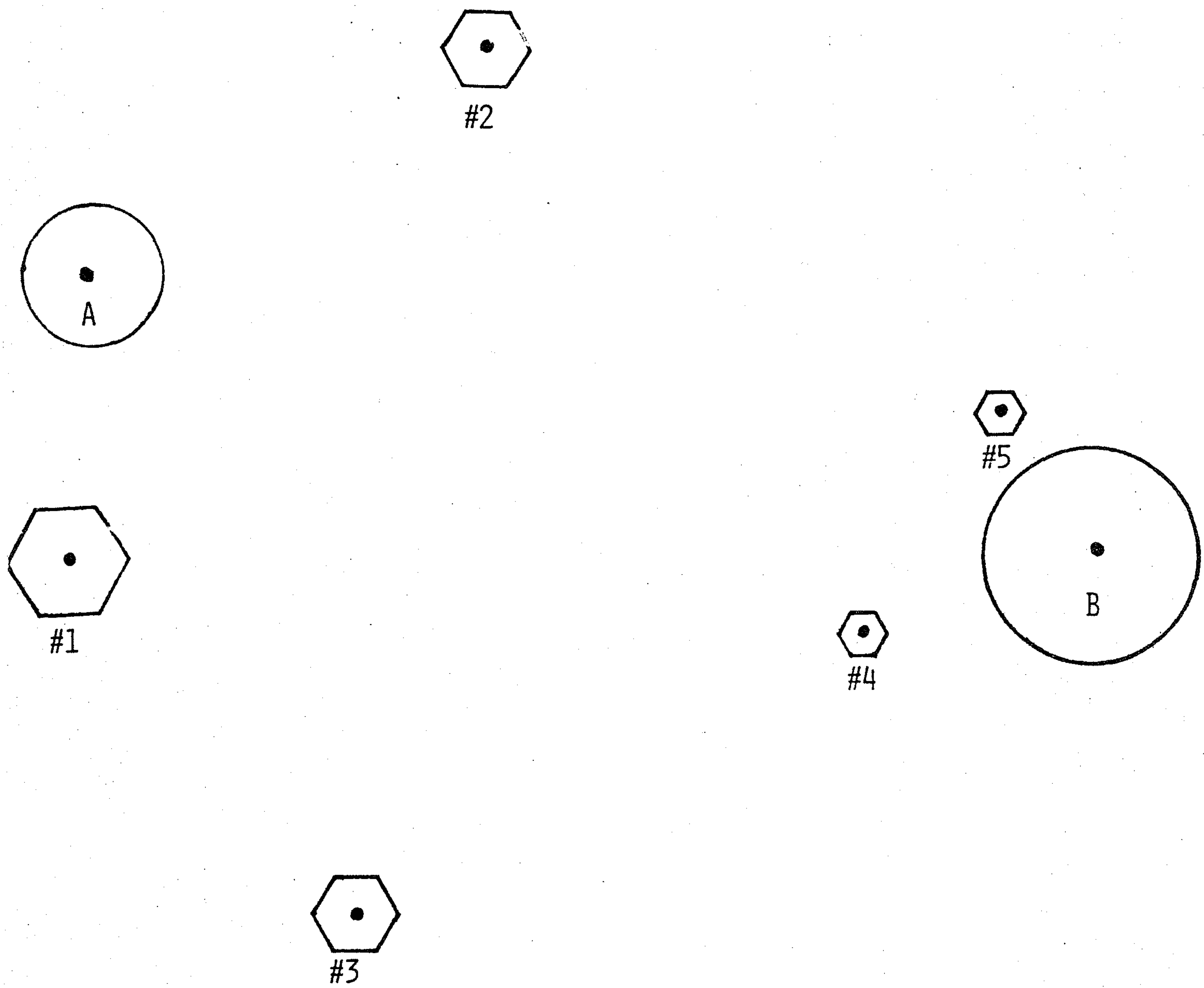

Fig. 2. Hypothetical region distributed in space and time, composed of two large urban centers and five lake and beach areas.

sunbathers, and water sports. The model can handle both aggregate or single recreational activities with little modification.

Table 2. Distance Between each Origin and Beach Facility.

	Recreational Lake				
City	1	2	3	4	5
A	17	33	48	60	64
B	70	52	56	15.5	11

Viewing Fig. 2, one can see that in this system, individual recreationists coming from origin B are fortunate to have two lake facilities nearby, and one would guess that recreationists from origin A would frequently utilize facility #1 which has a fairly large beach area. The gravity model would also indicate that one would not find many people from B going to park #1, due to the great distance between the two locations. The same would be true of individuals from A going to facilities #4 and #5.

The Structure of the Model

The model was developed by considering the factors which determine the strength of attraction of each recreational beach area. Let us take, for example, the portion of the model which specifically deals with the strength of attraction associated with park #1, which is closest to City A. As noted above, the attractive strength of #1 will be different for recreationists coming from A than for recreationists from B. Thus, two strength values must be calculated at any time k, one for A and one for B. Attractiveness, according to the model, is a function of four factors, namely (1) the facility's baseline environmental attractiveness, (2) the perceived density of the recreationists at the facility itself, (3) the cost of getting to the facility, and the perception of day-to-day conditions of the facility itself, i.e., potential for parking, restaurants, cleanliness of the beach, etc.

Concerning the first factor, with basic and normal environmental characteristics of the first facility, it is assumed that the perceptions of the environment are approximately the same for recreationists coming from both cities. However, I have included in the model the possibility that cities may differ with respect to types of recreationists, so that, for example, people from city A, who might be more inclined toward swimming may not appreciate the beaches as much as people from B who may be inclined toward sunbathing. The objective conditions of the water may be perceived and evaluated differentially.

The second factor deals with the population density of facility #1. It should be emphasized that most, if not all gravity models, ignore the possibility that the number and type of individuals at the park affect the facilities attractiveness. The populational term, P, in equation (1) refers to the size of the population at the origin, and if the population density enters into the model, it must do so through the attractiveness term. This dynamic model includes both the influence of the size of each urban population and particular concentration the recreational site. For those coming to park #1 from A, for example, the effect of population density is filtered through their own experiences and experiences of others. We have attempted to capture this filtering process of translating the actual densities observed or remembered recreational experiences through the smooth macro which introduces an informational delay into the system.

```
EDENA1.K=TABHL(EDNT1,ADENA1.K/DDENS,0,3,.5)
EDNT1=.7/.9/1.0/.76/.5/.3/.25
ADENA1.K=SMOOTH(DENS1.K,TDENA1)                      (6)
TDENA1=2
```

```
EDENA1 - EFFECT OF DENSITY AT A  (DIMENSIONLESS)
EDNT1 -  EFFECT OF DENSITY TABLE
ADENA1 - PERCEIVED DENSITY
DDENS -  DESIRED DENSITY
TDENA1 - TIME FOR DENSITY TO BE PERCEIVED    (YEARS)
```

The effect of population density at site #1 for the other origin, B, follows the same general pattern. It is assumed the perception delay time constant, TDENB1, would be larger then TDENA1, because people living in B, according to Fig. 2 live farther away from lake #1. It should take longer for changes in population density to defuse to these people on the average.

Population density must be defined in the model. Presumably, people react to short term population densities, as what one might observe on a single day.

```
DENS1.K=(POP1.K/ACRE1)*(1/365)                 (7)
```

```
DENS1 -  POPULATION DENSITY AT BEACH #1
POP1  -  RECREATIONISTS AT BEACH #1
ACRE1 -  SIZE OF BEACH    (ACRES)
```

The literature on the effects of population density and crowding on behavior is quite extensive (9,10,11). In general, there are no good figures on the size of the time lags and very little data about desired population densities. The desired population density DDENS was set at 60 people per acre, as a reasonable, initial estimate.

The next major factor in determining the attractive strength of facility #1 deals with the effect of trip costs. In this model, it is assumed that the dynamics of this factor is accounted for by changes in the price of gasoline. Total trip cost is a function of gas prices, total round trip distance, and the technical efficiency of transportation, i.e., average gas mileage. The effect of gasoline prices is represented by a table function COST. This function reflects the sensitivity to changes in total trip costs. Since we are assuming the bulk of those changes in costs are due to changes in the price of gasoline, the table reflects the elasticity of demand for gasoline. Figs. 3a and 3b show the shape of two table functions which vary along this dimension and were used in the simulation study. Presumably, the curve has been labeled as "inelastic" (3b) might be correlated with communities having a high average standard of living, while the latter curve might describe large urban populations where there are large numbers of unemployed and low income people.

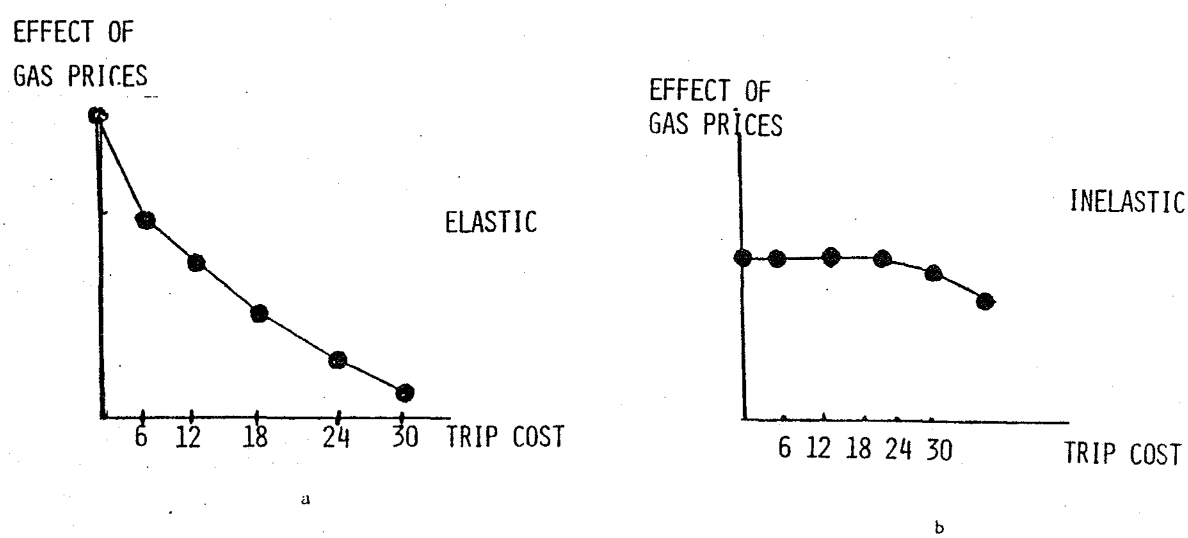

Fig. 3. The effect of trip costs on the strength of attractiveness.

The last factor deals with the recreationist's perception of the conditions at the site itself. Much of those conditions are related to how well the beach and bathrooms are kept up, roads maintained, etc. All of these activities depend upon annual expenditures from the state. The effect of upkeep, EUPK1, becomes a function of money expended on upkeep, MEOUK1. Dimensionally, this variable is in dollars per acre allocated from general funds to maintain the beach area at facility #1. It is assumed that the fraction of general funds expended on maintenance #1 (FEUPK1) would be in proportion to the size of the beach for larger beaches and require more funds to maintain.

The variable EUPK1, deals with the effect of funds on maintaining conditions at this particular beach. However, it, like density, takes time for recreationists to perceive changes in conditions, and we have recognized this effect by including another information delay into the model. Again, as in the lag in perceiving changes in population density, the average perception delay will differ for each urban center.

```
EUPK1.K=TABHL(EUPKT1,MEOUK1.K,0,20000,5000)
EUPKT1=.1/.6/.7/1.0/1.3                              (8)
MEOUK1.K=(GENFND.K*FEUPK1.K)/ACRE1
FEUPK1.K=CLIP(.43,.54,TIME.K,OPEN5)
```

```
EUPK1 -  EFFECT OF UPKEEP
EUPKT1 - EFFECT OF UPKEEP TABLE
MEOUK1- MONEY EXPENDED ON UPKEEP   (DOLLARS PER ACRE YEAR)
FEUPK1- FRACTION EXPENDED ON UPKEEP
GENFND- TOTAL GENERAL STATE FUNDS
```

Putting It All Together

The previously described four factors make up the strength of attractiveness for the first park. A equation (5) describes the application of Luce's choice model which determines the fraction of recreationists going from A to the first site. In a composite run, this fraction is multiplied by the size of the population, POPA, coming from A. This same process is continued for the other sites. The model does a lot of bookkeeping to keep track of site densities, and population shifts in the two urban centers.

Additional Sectors

The first additional sector deals with the dynamics of the populations living in the cities. For A, POPA refers to the size of the specific recreational population in that city, such as swimmers and beachcombers, etc. At this stage of the modeling process, the population dynamics are relatively simple (see Fig. 4). If conditions are bad enough, then recreationists do other activities closer to home and from the point of view of the model, they become part of the nonrecreationalist population POPNOA. At this stage we are assuming that emmigration away from the region represented in Fig. 2 is directly determined by general depressed economic conditions, and not directly due to recreational conditions. Further, it is assumed that people who leave A immigrate outside the region and do not go to B, and vice versa. In Michigan, for example, frankly very few people are thinking of leaving Detroit to go to Flint and vice versa.

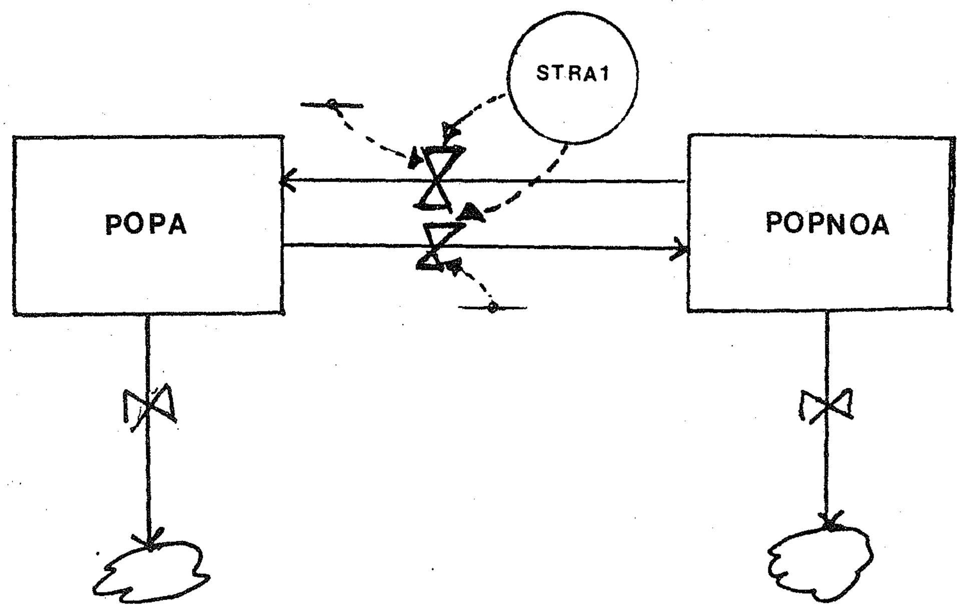

Fig. 4. The dynamics of shifts in recreational population.

The mechanism underlying the transition from POPA to POPNOA or POPB to POPNOB is based upon the assumption that if recreational conditions, as influenced by gas prices, are so bad that even the nearest beach has an extremely low strength score, than the rate of entering the non-recreational population, NORECA, increases rapidly. We arbitrarily set the value of STRA1 and STRB5 to .45 as a reference point. When, the strength of people living in A score below .45, they began looking for other forms of recreation and/or other activities closer to home. We also assumed that the non-recreationist will return back to those water activities when the attractiveness of the nearest beach goes beyond .45 in the opposite direction. However, we have assumed for the simulation model's parameters that these people return with less "vigor" so that the rate of return, RETRNA is less than for leaving POPA.

The last sector deals with inputs into the system, as represented by declining expenditures of funds for maintaining the beaches and the rising price of gasoline. We might add briefly that the scope of the model could be broadened to consider the dynamics of these factors, and other economic conditions, so that most or all of the mechanisms could be internalized and better understood. This would be vastly preferable to considering expenditures and gasoline prices as independent inputs as we have at this point in time.

In the model, gas prices and general funds are considered as level variables which push the system around, but are not pushed or pulled themselves. Figure 5 indicates that both variables decrease exponentially over time.

Figure 5. The dynamics of gasoline prices and general state funds.

SIMULATION RESULTS AND DISCUSSION

The initial simulation run was performed under baseline conditions set to observe the patterns of behavior displayed by recreationists coming from two moderate sized cities. The values of POPA and POPB, the number of recreationists in each city, were set at 112,500 and 150,000 respectively. The time horizon was set to range from 1970 to 2020, a span of 50 years. The rise in gasoline prices and the decline of general state funds was initiated in 1974 to correspond roughly with the year of the oil embargo. Also the first major set of simulation runs were performed using the table function, MV, which stands for the movable or elastic condition. The response of recreationists to the change in trip costs, as represented by this table function was the same for both cities. Finally, the effects of environmental characteristics was set at the same value for all five recreational facilities.

The analysis of the model began by attempting to reproduce the qualitative characteristics of the reference mode. Fig. 6 shows the time response of the three system variables used to describe the problem. The model predicts the decrease in recreationists over time, as well as an increase in non-recreationists. In addition, the park #5 located quite close to recreationists living in B. One can see a steady rise in usage, followed by an eventual decline, which matches the reference mode described previously. At this initial state of the modeling process, at least the model appears to possess face validity, which is a first step in the validation process.

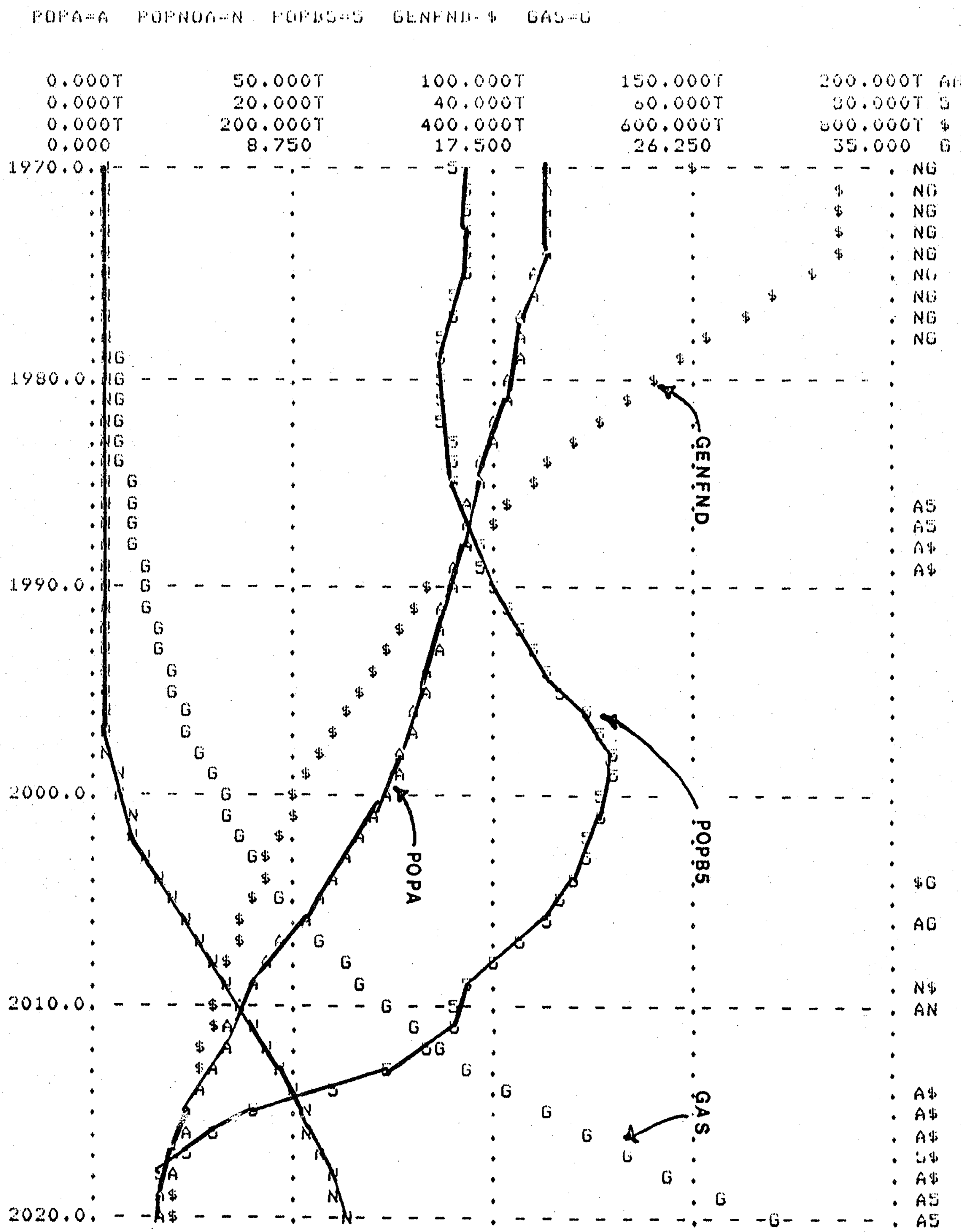

Fig. 6. The model's response for variables associated with the reference mode.

Fig. 7 shows what most recreational researchers would focus upon if this were a data set, patterns of usage over time. Those figures represent the total number of recreationists going to each park regardless of origin. What appears to be odd about these predictions is the low usage of beach number #1, which is nearest to A. This would contradict much of the thinking in recreational research circles, because frequently distance accounts for most of the variance in predicting usage when gravity models are utilized. Fig. 8 shows the fraction of recreationists going to each park from A. This figure indicates that the initial relatively low usage rate of #1 by recreationists from A changes drastically later, where almost 60 per cent of recreationists from that city go to that park.

To understand why the model predicts low initial usage, Fig. 9 shows the population densities at each lake; while Fig. 10 indicates the predicted effects of increases in gasoline prices on recreationists for A. The first figure shows that the population density at #1 was low throughout the whole range of the forecast even when the majority of recreationists from A used the park. According to the model, densities that low are undesirable. The advantage park #1 had with respect to distance does not initially compensate for the density effect, so density during the earlier years dominate the dynamics of these recreationists. On the other hand, Fig. 10 shows a widening discrepancy between lake #1 and all the other recreational spots. Thus, as the price of gasoline increases, trip costs will dominate their behavior, bringing these individuals closer to home. Eventually, even areas close to home will be underutilized if the structure of the system remains the same.

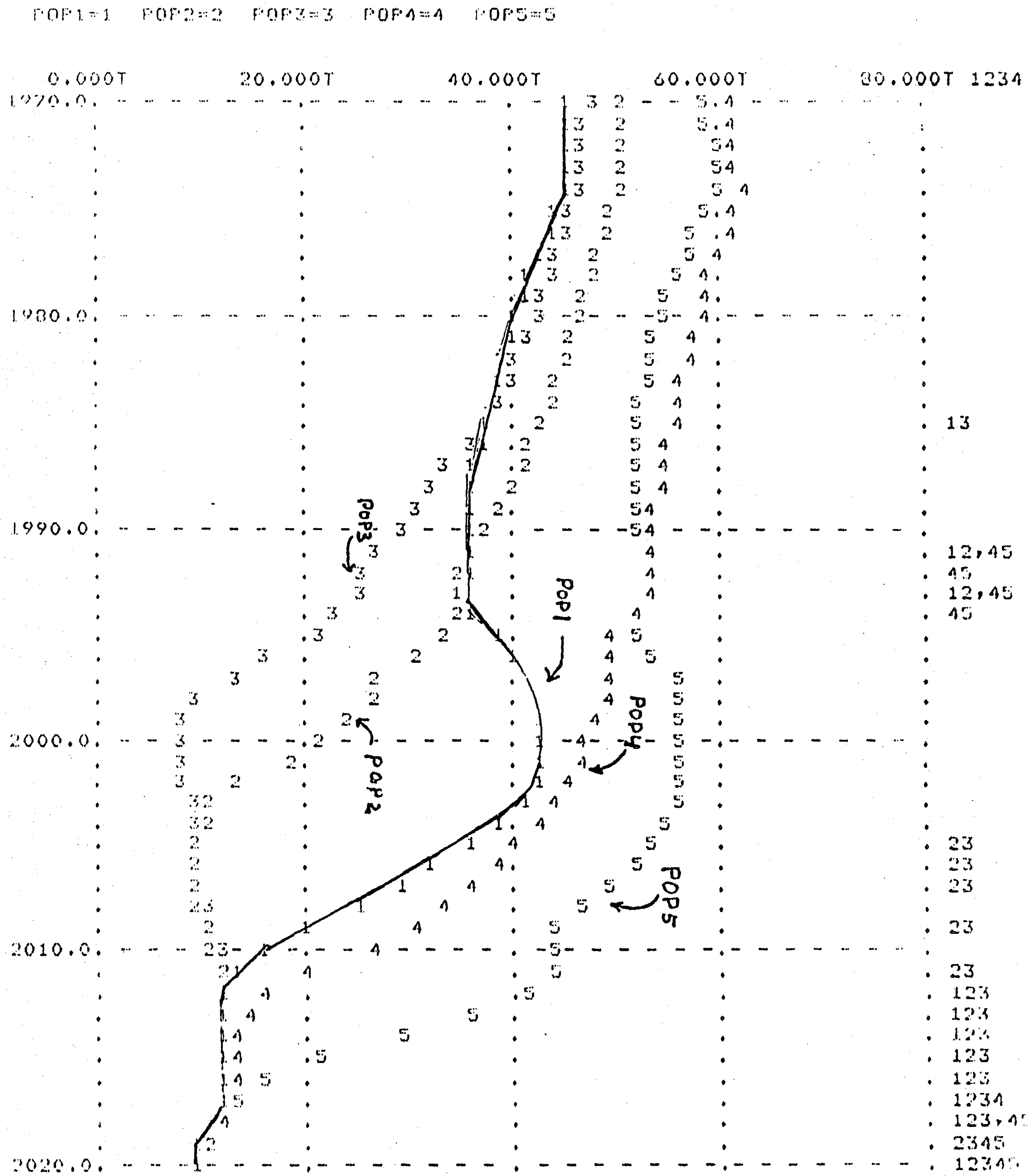

Fig. 7. Prediction of usage patterns of five regional parks.

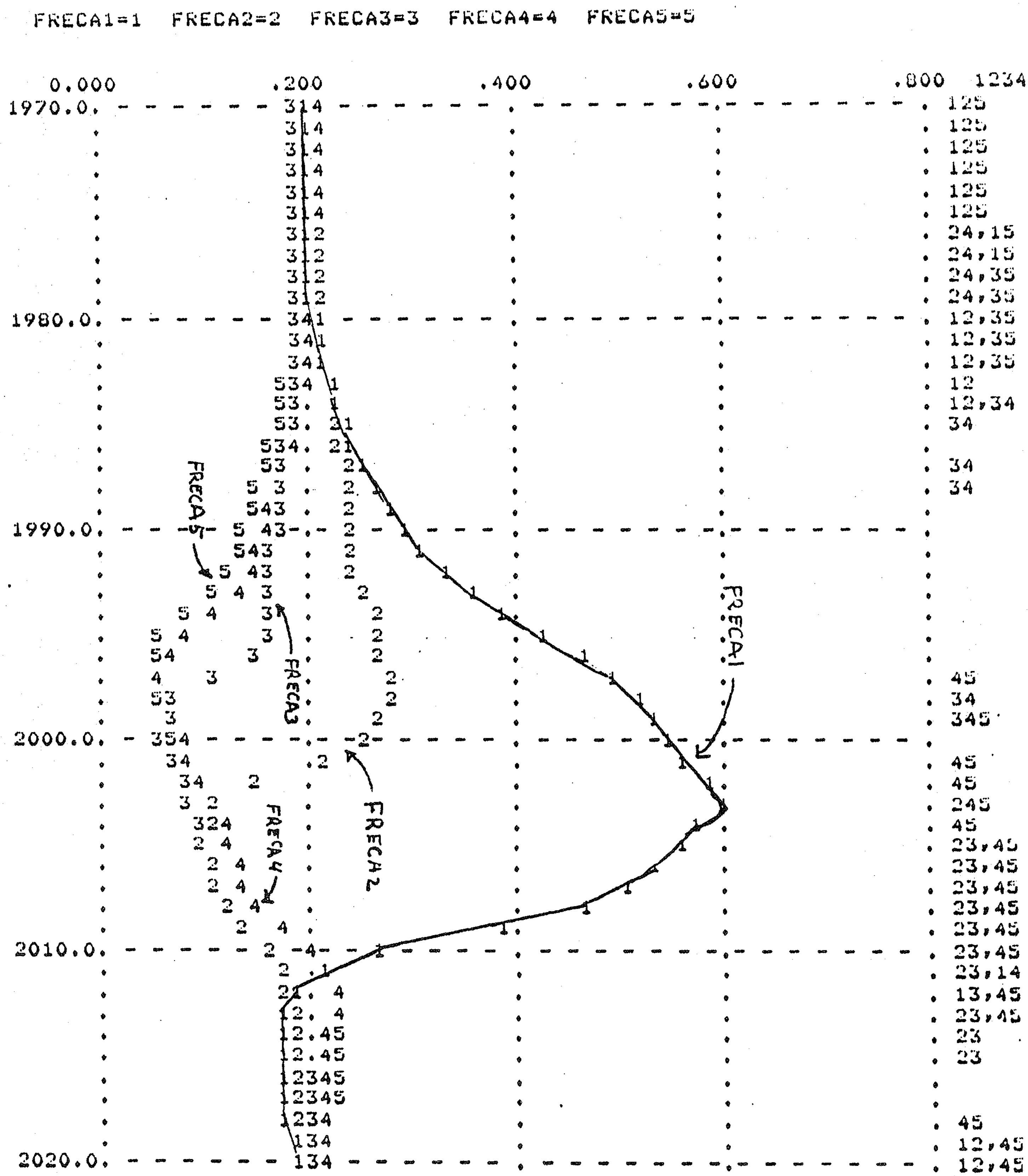

Fig. 8. Predicted fraction of recreationists from A going to each lake.

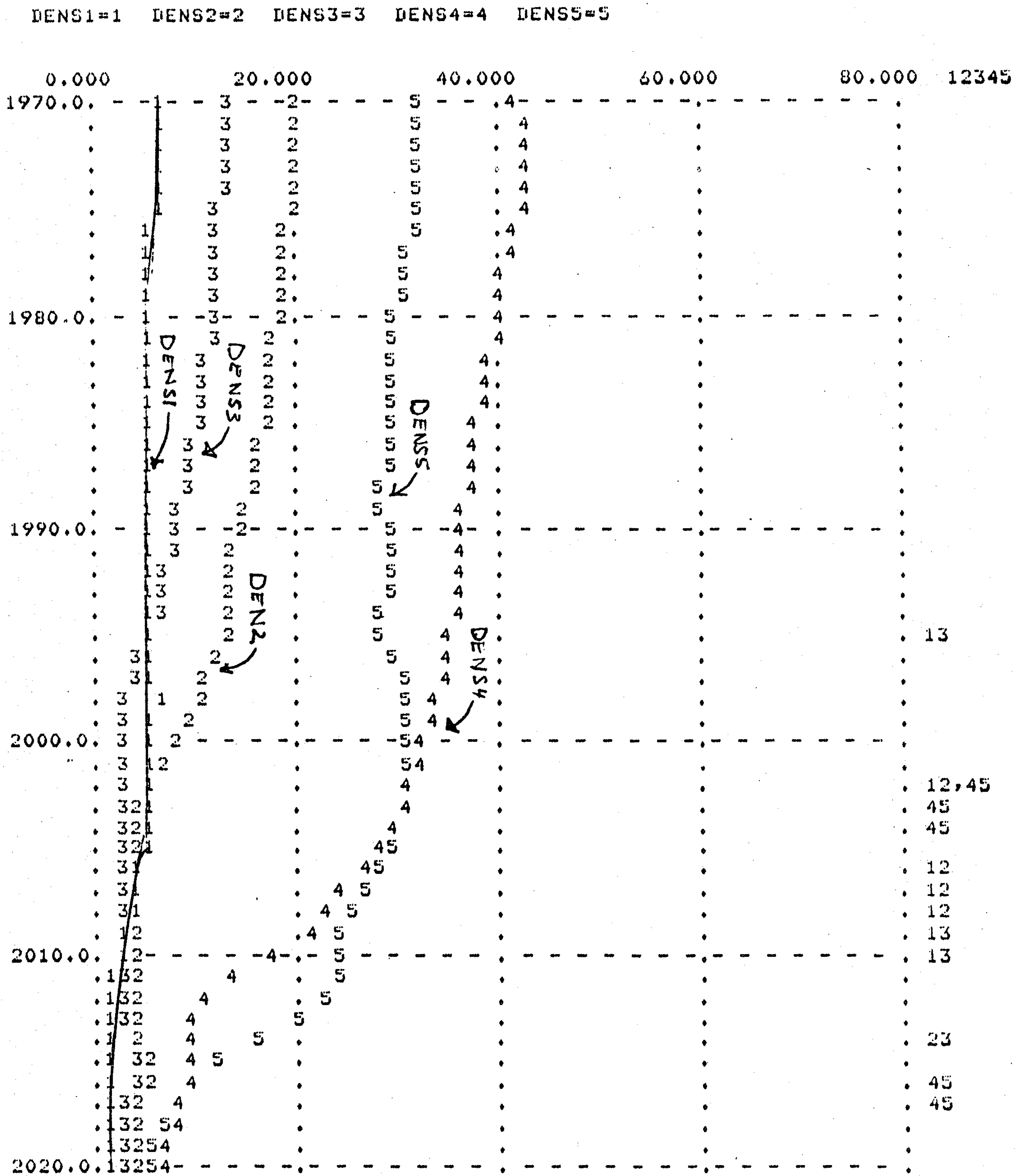

Fig. 9. Predicted population density of the park system.

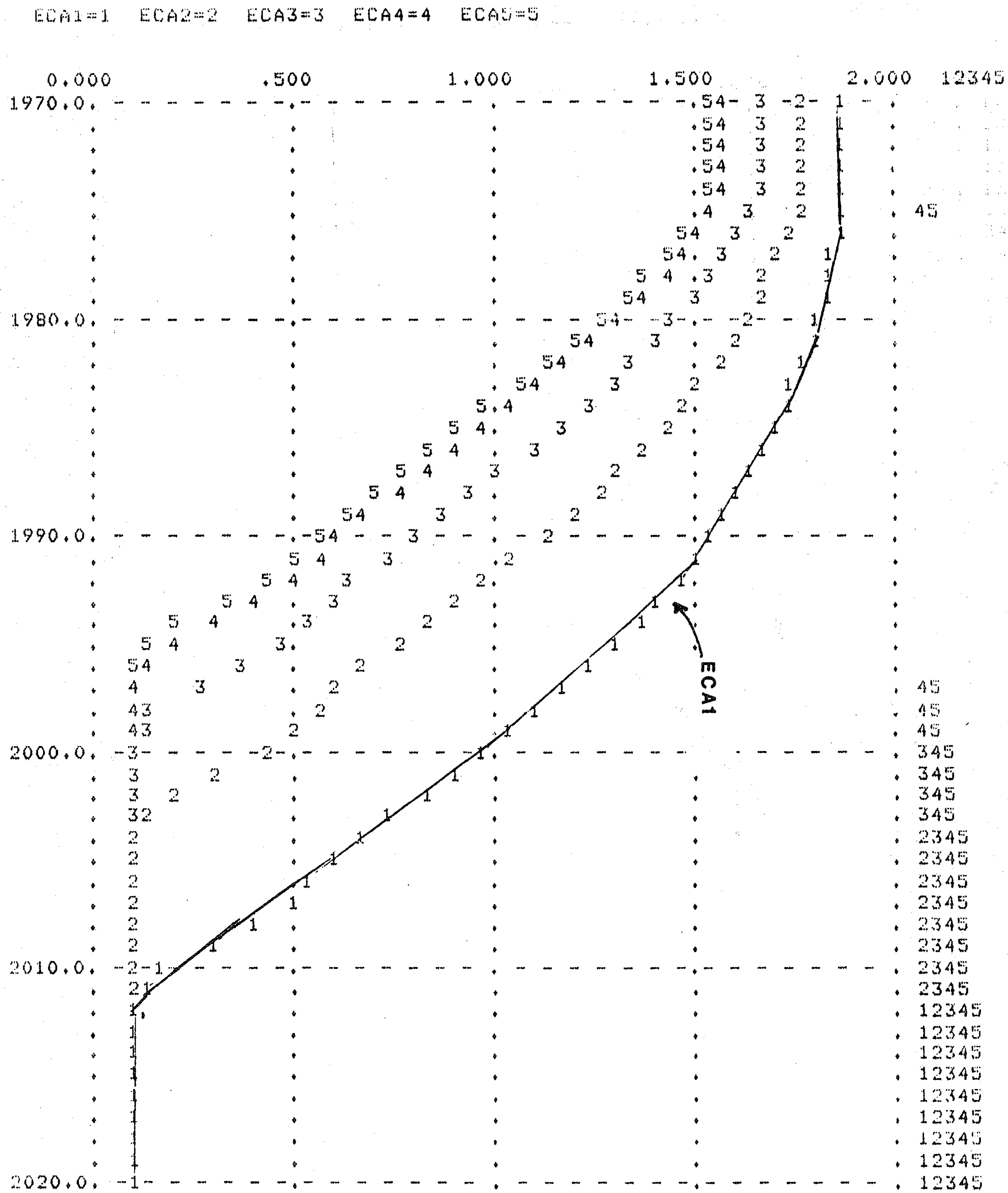

Fig. 10. Predicted effects of increases in the price of gasoline for each recreational facility.

High Density Conditions

In the model, the desired density was set to a daily figure of 60 people per acre. According to Fig. 9, this value is far above, even the densities at lake #4. A second set of simulation runs were undertaken to assess the impacts of "crowding" on the recreational patterns. The size of the recreational population at B, POPB was initially set at 1.2 million people. Given the original choice of parameter values for the number of acres involved, this certainly stressed the system.

The major question dealt with the direction of impacts on recreational behavior. Fig. 11 presents a very different qualitative picture of usage patterns. Comparing with Fig. 8, which represents low densities, one can note that the patterns have essentially been reversed; park #4 and park #5 are no longer popular, but #1 is. The dynamics are simple and actually similiar to the first case. Density determines initial choice, but as time goes on, energy costs have their delayed effect, causing the recreationists to stay nearer to home.

Introduction of New Parks

The next set of simulation runs were undertaken to test the logic of the model in more extensive ways and to consider recreational policy questions relevant to the model's scope and orientation. The introduction of new urban parks, for example, is currently being discussed as a desirable recreational alternative to traveling long distances. Additionally, there are questions which concern the impacts of closing some parks which no longer can be maintained. It would be of interest then, to orient the application of the model, or more realistic extension of the model, to forecasting those impacts.

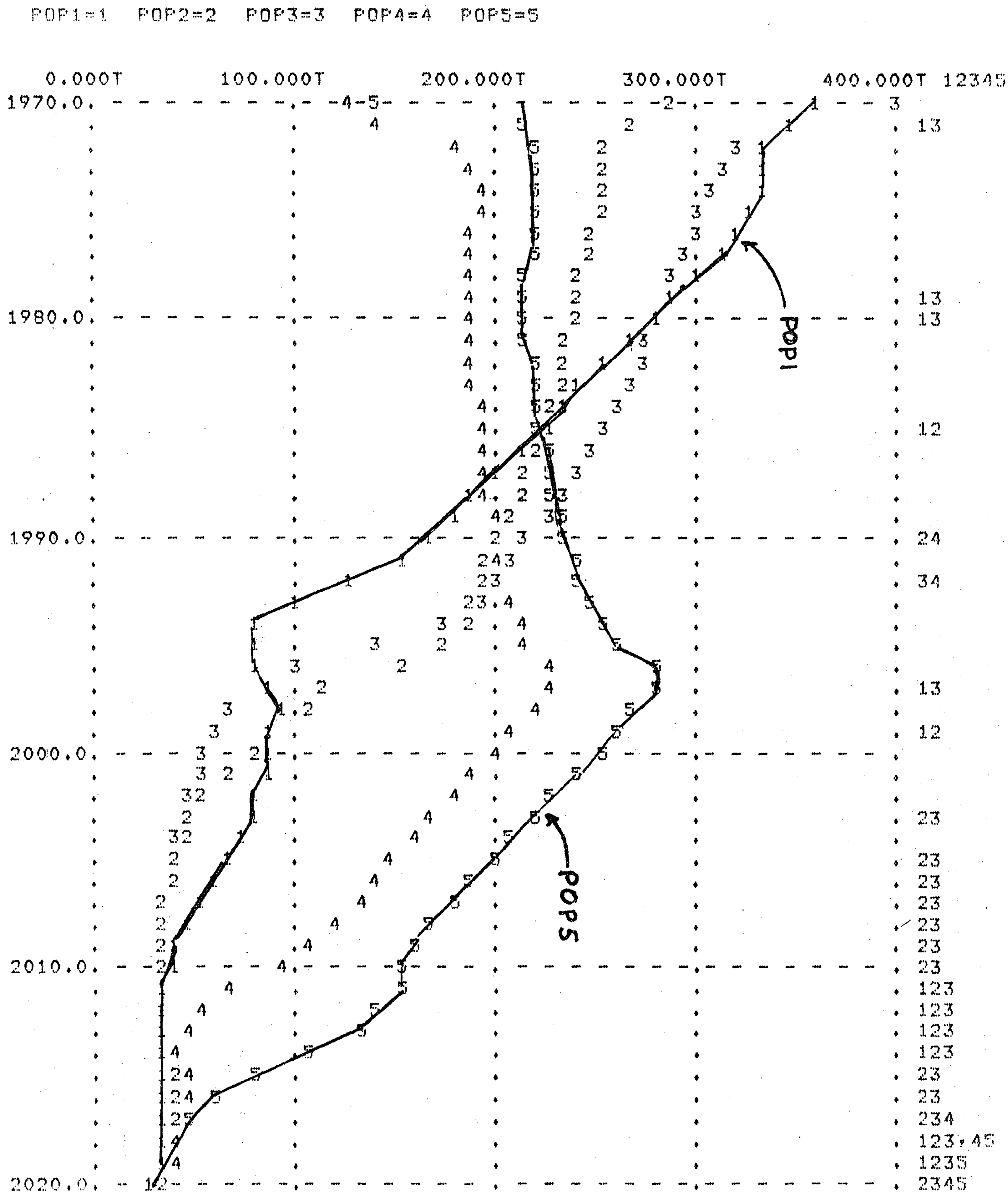

Fig. 11. Prediction of Usage Patterns (HIGH DENSITY)

The next simulation run was therefore designed to begin with only three active areas (numbers 1, 2, 3) and then two other facilities were introduced in either 1985, 1995, 2005, or the year 2015.

An example of impacts on the population densities of all relevant sites can be found in Fig. 12. This represents the result of opening these facilities relatively early in 1985. The model predicts profound effects on the usage of park #2, which prior to 1990, had been ranked first in usage. Then if #4, and #5 were introduced at that time, our runs showed people flowing to these areas, leaving #2 in large numbers. On the other hand, the model hypothesized that the same intervention at a later date would have less of an effect, both in terms of its influence on #2 and on the height of the density curves associated with facilities #4 and #5.

One way of evaluating the effects of coming "on line" at different stages of the decline in recreational interests is to compare the effects of the timing of the intervention on the final number of individuals in B, i.e., POPB, in the year 2020. Table 3 presents the model's predictions of the size of the recreationist population in comparison with the baseline conditions which is the case where all five facilities existed initially and remained intact throughout time. The first column displays this baseline condition, and the "never" column represents the opposite case where facilities #4 and #5 were never built. Two density conditions are presented in the table. From the standpoint of interventions to assist in keeping more recreationists active, the earlier these facilities were built, the better.

In terms of the impact of adding facilities, however, even though the size of recreationists population at B remained larger at the end of 2020, the model as constructed at this point, does display somewhat unrealistic behavior due to the

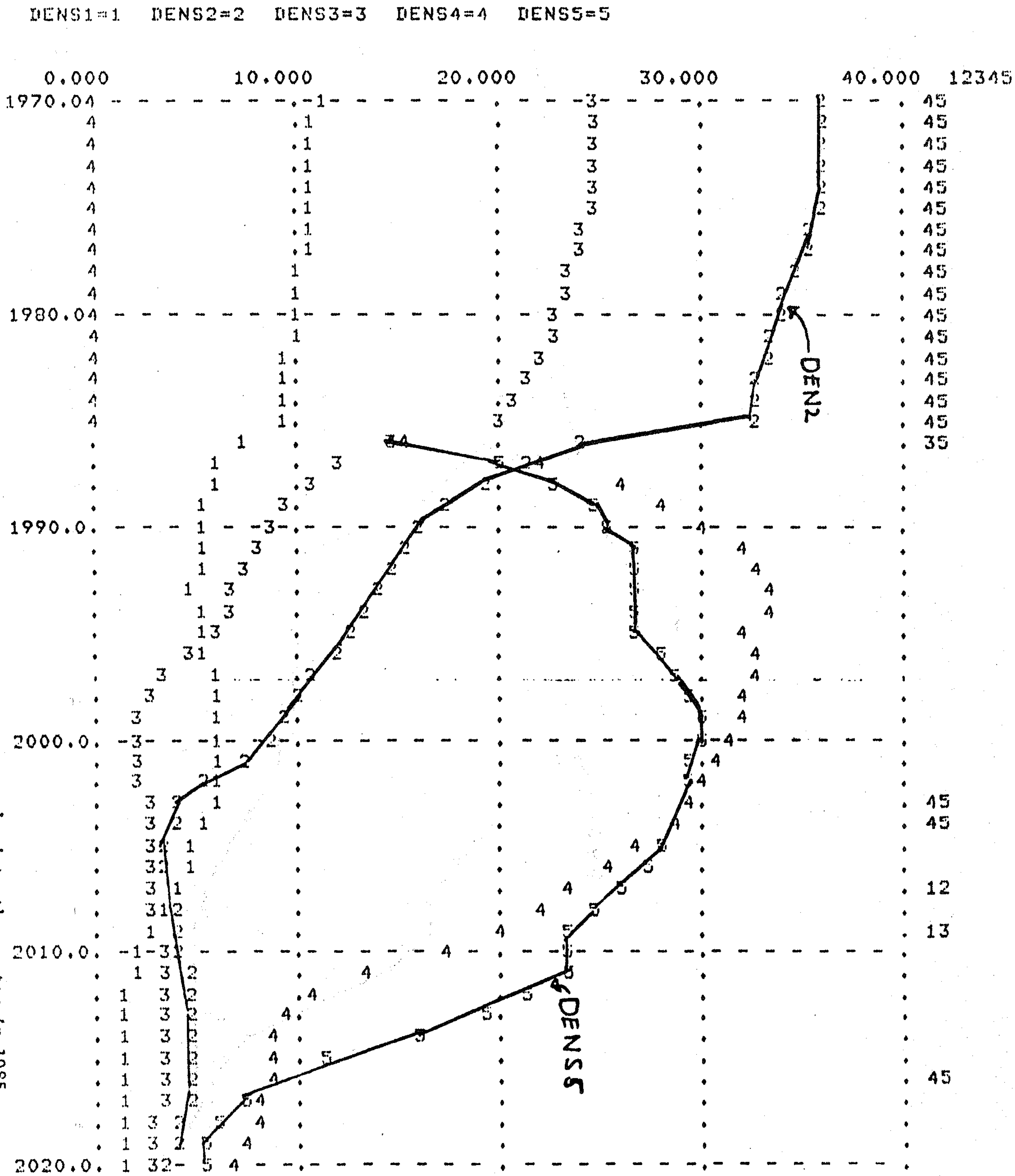

Fig. 12. The effect on population density after introducing two new parks into the system in 1985.

Table 3. The Size of the B Population in 2020 as a Function of the Creation of Facilities #4 and #5.

Density	Year numbers 4 and 5 came "on line" (EO3)					
condition	1970	1985	1995	2005	2015	never
Low	31.01	29.79	23.62	13.17	12.00	12.02
High	142.10	140.60	129.50	90.40	79.30	79.40

constraints generated by the constant ratio rule, which was the basis for using the relative strength, rather than absolute strength to determine the number of people going to a given facility.

The constant ratio rule, which is a normalization of alternatives, means that the system can never display an hysteresis effect. Thus, no matter when the two facilities came into existence for any given origin O, the fraction of recreationists going to #5 or #4, FRECO4 and FRECO5, converged toward the trajectory of FRECO4 and FRECO5 found in the case where the two facilities were in existance from the start. Thus, for example, the values of FRECA5 generated in the condition where #5 came on line in 1985 began to quickly track the value of FRECA5 generated by the base case where all five parks were in operation. At 2020, in the case of the 1985 run, FRECA5 equaled .1946 while the value of the same variable generated on the base run was .1948, was hardly a difference, given the numerical precision involved.

Dynamically, the convergence process will take time to occur, and for example, in the case of the run where additional facilities came on line in 2015, the two fractions were far apart, but nevertheless rapidly converging.

The lack of an hysteresis effect implies behaviorally that the recreationist make very smooth adjustments to changing conditions and further, long term experience at one particular facility has no more effect on this process of adjustment than short term experience. Memory, emotional attachments, and experiences with specific locations would most likely generate an hysteresis effect. For example, a population of recreationists from B, who formed a strong attachment to lake #2 when the new lakes did not exist, and had gone to #2 year after year, might begin to switch towards lakes #4 and #5, but the usage rate associated with this population might be slower than a group of recreationists who had not gone to lake #2 for long periods of time, before numbers 4 and 5 opened.

The present model should be considered as a basis for comparison with models which deal realistically with psychological processes such as attachment, boredom, and curiosity. However, it does make a number of very clear empirical predictions though. For example, as the system begins to run down, the attractive strength of #5, for the case of individuals living in B, eventually converges towards the strengths of the other alternatives. When all 5 strengths converge to the same value, under those extreme conditions, the relative strength of 5, FRECB5, should equal all other fractions, implying a uniform distribution of recreationists across all five lakes. Statistically, that could be easily verified.

Lastly, with regard to the inputs into the system, the behavior of the system is not greatly affected by decreasing general funds for upkeep. It may have an impact upon the dynamics of individuals leaving the recreational population, but it will not modify the relative strengths, FREC. This is because the ordinal relationships among the effects of upkeep for each alternative, EUPK1, EUPK2, etc., remain the same over time.

However, the impact of rising gasoline prices drives the system at the moment, both in terms of this regional model, and unfortunately, in reality. Energy costs have been considered as exogenous inputs into this model. Why should those exogenous factors not be incorporated into a larger modeling effort? It is felt that regional recreational models should move in that direction as well as internally toward specifying the causal loop structure between the automobile, recreation, and tourism industries, and the supplies of energy. Those structural relations, which have been somewhat unclear in the past, may provide a little insight into ways to slow down the process displayed symbolically in the present recreational model.

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APPENDIX 1 MODEL EQUATIONS

HERE ARE THE EQUATIONS OF THE MODEL WHICH HAVE BEEN MODIFIED TO TO PREDICT THE EFFECTS OF INTRODUCING TWO NEW PARKS NEAR B AT VARIOUS YEARS ON THE TIME HORIZON.

```
100=NOTE
101=NOTE                        RECLUCE
102=NOTE  RECREATIONAL MODEL USING LUCE'S CONST. RATIO ASSUMPTION
103=NOTE
104=NOTE              CONSTRUCTED BY RALPH LEVINE
105=NOTE               MICHIGAN STATE UNIVERSITY
106=NOTE
107=NOTE
108=NOTE                 POPULATION SECTOR
109=NOTE
110=NOTE
111=NOTE    RECREATIONISTS
112=NOTE
113=L POPA.K=POPA.J+(DT)(NDECA.JK+RETRNA.JK-NORECA.JK)
114=N POPA=POPAI
115=C POPAI=112.5E3
116=NOTE
117=NOTE EMIGRATION
118=R NDECA.KL=-NOUTA.K*POPA.K
119=A NOUTA.K=CLIP(LEAVEA,0,TIME.K,CHANGE)
120=C LEAVEA=.015
121=NOTE
122=NOTE CHANGE ACTIVITY
123=R NORECA.KL=NNOREC*POPA.K*ESTLVA.K
124=C NNOREC=.075
125=A ESTLVA.K=TABHL(ESTLVT,STRA1.K/NCUT,0,2,.2)
126=T ESTLVT=1.0/.9/.65/.35/.1/0/0/0/0/0/0
127=C NCUT=.45      (TURNING POINT)
128=NOTE
129=NOTE RETURN
130=R RETRNA.KL=NRETRN*POPNOA.K*ESTRTA.K
131=C NRETRN=.02  MAXIMUM RATE OF RETURN TO RECREATIONAL POP.
132=A ESTRTA.K=TABHL(ESRTT,STRA1.K/NCUT,0,3,.5)
133=T ESRTT=.1/.1/.1/.25/.65/.95/1.0
134=NOTE
135=L POPB.K=POPB.J+(DT)(NDECB.JK+RETRNB.JK-NORECB.JK)
136=N POPB=POPBI
137=C POPBI=150E3
138=NOTE
139=R NDECB.KL=-NOUTB.K*POPB.K
140=A NOUTB.K=CLIP(LEAVEB,0,TIME.K,CHANGE)
141=C LEAVEB=.015
142=NOTE
143=NOTE POSSIBLE ADDITIONAL PARKS NEAR B
144=R NORECB.KL=NNOREC*POPB.K*ESTLB5.K*DUMMY5.K+
145=X NNOREC*POPB.K*ESTLB2.K*DUMMY2.K
```

```
146=A DUMMY5.K=CLIP(1,0,TIME.K,OPEN5)
147=A DUMMY2.K=CLIP(0,1,TIME.K,OPEN5)
148=A ESTLB5.K=TABHL(ESTLVT,STRB5.K/NCUT,0,2,.2)
149=A ESTLB2.K=TABHL(ESTLVT,STRB2.K/NCUT,0,2,.2)
150=NOTE
151=R RETRNB.KL=NRETRN*POPNOB.K*ESRTB5.K*DUMMY5.K+
152=X NRETRN*POPNOB.K*ESRTB2.K*DUMMY2.K
153=A ESRTB5.K=TABHL(ESRTT,STRB5.K/NCUT,0,3,.5)
154=A ESRTB2.K=TABHL(ESRTT,STRB2.K/NCUT,0,3,.5)
155=NOTE
156=NOTE    NON-RECREATIONISTS
157=NOTE
158=L POPNOA.K=POPNOA.J+(DT)(NDCNOA.JK-RETRNA.JK+NORECA.JK)
159=R NDCNOA.KL=NOUTA.K*POPNOA.K
160=N POPNOA=PPNOAI
161=C PPNOAI=3E3
162=L POPNOB.K=POPNOB.J+(DT)(NDCNOB.JK-RETRNB.JK+NORECB.JK)
163=R NDCNOB.KL=NOUTB.K*POPNOB.K
164=N POPNOB=PPNOBI
165=C PPNOBI=5E3
166=NOTE
167=NOTE
168=NOTE
169=NOTE                GASOLINE PRICE SECTOR
170=NOTE
171=NOTE
172=L GAS.K=GAS.J+(DT)(NCGAS.JK)
173=N GAS=GASI
174=C GASI=.63
175=R NCGAS.KL=GASUP.K*GAS.K
176=A GASUP.K=CLIP(GASINC,0,TIME.K,CHANGE)
177=C GASINC=.085   RATE OF INCREASE IN PRICE OF GAS
178=NOTE
179=NOTE
180=NOTE
181=NOTE                GENERAL FUNDS SECTOR
182=NOTE
183=NOTE
184=L GENFND.K=GENFND.J+EXTRA2.J+(DT)(NDGEN.JK)
185=N GENFND=GENFDI
186=C GENFDI=600E3
187=A EXTRA2.K=PULSE(EXMONY.K,OPEN5,1000)
188=A EXMONY.K=GENFND.K*.25  EXTRA FUNDS FOR NEW PARKS
189=R NDGEN.KL=-DFND*GENFND.K*FLIP.K
190=A FLIP.K=CLIP(1,0,TIME.K,CHANGE)
191=C DFND=.05
192=NOTE
193=NOTE
194=NOTE
195=NOTE                PARK SECTOR
196=NOTE
197=NOTE
198=NOTE GENERAL PARAMETER VALUES - ALL PARKS
199=C DDENS=60
200=NOTE  MILEAGE EQUALS 18 MILES PER GAL. IN THIS EXAMPLE
201=C RMILE=.056  RECIPROCAL OF MILEAGE
```

```
202=NOTE
203=NOTE           PARK #1
204=NOTE
205=NOTE    BASELINE AND ENVIRONMENT
206=C BASEA1=.7
207=C BASEB1=.7
208=C ACRE1=20
209=C DISTA1=34     (ROUND TRIP)
210=C DISTB1=140
211=NOTE
212=NOTE    EFFECT OF DENSITY
213=A EDENA1.K=TABHL(EDNT1,ADENA1.K/DDENS,0,3,.5)
214=T EDNT1=.7/.9/1.0/.76/.5/.3/.25
215=A ADENA1.K=SMOOTH(DENS1.K,TDENA1)
216=A DENS1.K=(POP1.K/ACRE1)*(1/365)
217=C TDENA1=2
218=N ADENA1=60
219=NOTE
220=A EDENB1.K=TABHL(EDNT1,ADENB1.K/DDENS,0,3,.5)
221=A ADENB1.K=SMOOTH(DENS1.K,TDENB1)
222=C TDENB1=3.1
223=N ADENB1=60
224=NOTE
225=NOTE    EFFECT OF GASOLINE PRICES
226=A ECA1.K=MVA1*PUSHA+NOMVA1.K*PULLA
227=NOTE WHERE
228=C PUSHA=1     (ELASTIC CONDITION)
229=C ONE=1.0
230=C ZERO=0.0
231=NOTE AND
232=N PULLA=FIFZE(ONE,ZERO,PUSHA)
233=A MVA1.K=TABHL(COSTE,GAS.K*DISTA1*RMILE,0,30,5)
234=NOTE AND
235=A NOMVA1.K=TABHL(COSTNE,GAS.K*DISTB1*RMILE,0,30,5)
236=NOTE
237=A ECB1.K=MVB1.K*PUSHB+NOMVB1.K*PULLB
238=NOTE WHERE
239=C PUSHB=1
240=NOTE WHERE
241=N PULLB=FIFZE(ONE,ZERO,PUSHB)
242=A MVB1.K=TABHL(COSTE,GAS.K*DISTB1*RMILE,0,30,5)
243=NOTE AND
244=A NOMVB1.K=TABHL(COSTNE,GAS.K*DISTB1*RMILE,0,30,5)
245=T COSTNE=1/1/1/1/.95/.45/.45
246=T COSTE=2.0/1.5/1.0/.65/.45/.15/.10
247=NOTE
248=NOTE    UPKEEP
249=A EUPK1.K=TABHL(EUPKT1,MEOUK1.K,0,20000,5000)
250=T EUPKT1=.1/.6/.7/1.0/1.3
251=A MEOUK1.K=((GENFND.K+EXTRA2.K)*FEUPK1.K)/ACRE1
252=A FEUPK1.K=CLIP(.43,.54,TIME.K,OPEN5)
253=A AEUPA1.K=SMOOTH(EUPK1.K,TUPA1)
254=C TUPA1=2
255=N AEUPA1=1.0
256=A AEUPB1.K=SMOOTH(EUPK1.K,TUPB1)
257=C TUPB1=3.5
258=N AEUPB1=1.0
259=NOTE
```

```
260=NOTE    SUMMARY STATISTICS FOR PARK #1
261=A POP1.K=POPA1.K+POPB1.K
262=A POPA1.K=POPA.K*FRECA1.K
263=A POPB1.K=POPB.K*FRECB1.K
264=A STRA1.K=BASEA1*EDENA1.K*ECA1.K*AEUPA1.K
265=A STRB1.K=BASEB1.K*EDENB1.K*ECB1.K*AEUPB1.K
266=A FRECA1.K=STRA1.K/TOSTRA.K
267=A FRECB1.K=STRB1.K/TOSTRB.K
268=NOTE WHERE,
269=A TOSTRA.K=STRA1.K+STRA2.K+STRA3.K+STRA4.K+STRA5.K
270=A TOSTRB.K=STRB1.K+STRB2.K+STRB3.K+STRB4.K+STRB5.K
271=NOTE
272=NOTE             PARK #2
273=NOTE
274=NOTE    BASELINE AND ENVIRONMENT
275=C BASEA2=.7
276=C BASEB2=.7
277=C ACRE2=7
278=C DISTA2=66
279=C DISTB2=104
280=NOTE
281=NOTE    EFFECT OF DENSITY
282=A EDENA2.K=TABHL(EDNT2,ADENA2.K/DDENS,0,3,.5)
283=T EDNT2=.7/.9/1.0/.76/.5/.3/.25
284=A ADENA2.K=SMOOTH(DENS2.K,TDENA2)
285=A DENS2.K=(POP2.K/ACRE2)*(1/365)
286=C TDENA2=2.9
287=N ADENA2=60
288=A EDENB2.K=TABHL(EDNT2,ADENB2.K/DDENS,0,3,.5)
289=A ADENB2.K=SMOOTH(DENS2.K,TDENB2)
290=C TDENB2=3.1
291=N ADENB2=60
292=NOTE
293=NOTE    EFFECT OF GASOLINE PRICES
294=A ECA2.K=MVA2.K*PUSHA+NOMVA2.K*PULLA
295=A MVA2.K=TABHL(COSTE,GAS.K*DISTA2*RMILE,0,30,5)
296=A NOMVA2.K=TABHL(COSTNE,GAS.K*DISTA2*RMILE,0,30,5)
297=NOTE
298=A ECB2.K=MVB2.K*PUSHB+NOMVB2.K*PULLB
299=A MVB2.K=TABHL(COSTE,GAS.K*DISTB2*RMILE,0,30,5)
300=A NOMVB2.K=TABHL(COSTNE,GAS.K*DISTB2*RMILE,0,30,5)
301=NOTE
302=NOTE    UPKEEP
303=A EUPK2.K=TABHL(EUPKT2,MEOUK2.K,0,20000,5000)
304=T EUPKT2=.1/.6/.7/1.0/1.3
305=A MEOUK2.K=((GENFND.K+EXTRA2.K)*FEUPK2.K)/ACRE2
306=A FEUPK2.K=CLIP(.15,.18,TIME.K,OPEN5)
307=A AEUPA2.K=SMOOTH(EUPK2.K,TUPA2)
308=C TUPA2=2.9
309=N AEUPA2=1.0
310=A AEUPB2.K=SMOOTH(EUPK2.K,TUPB2)
311=C TUPB2=3.1
312=N AEUPB2=1.0
313=NOTE
```

```
314=NOTE     SUMMARY STATISTICS FOR PARK #2
315=A POP2.K=POPA2.K+POPB2.K
316=A POPA2.K=POPA.K*FRECA2.K
317=A POPB2.K=POPB.K*FRECB2.K
318=A STRA2.K=BASEA2*EDENA2.K*ECA2.K*AEUPA2.K
319=A STRB2.K=BASEB2*EDENB2.K*ECB2.K*AEUPB2.K
320=A FRECA2.K=STRA2.K/TOSTRA.K
321=A FRECB2.K=STRB2.K/TOSTRB.K
322=NOTE
323=NOTE               PARK #3
324=NOTE
325=NOTE     BASELINE AND ENVIRONMENT
326=C BASEA3=.7
327=C BASEB3=.7
328=C ACRE3=10
329=C DISTA3=96
330=C DISTB3=112
331=NOTE
332=NOTE     EFFECT OF DENSITY
333=A EDENA3.K=TABHL(EDNT3,ADENA3.K/DDENS,0,3,.5)
334=T EDNT3=.7/.9/1.0/.76/.5/.3/.25
335=A ADENA3.K=SMOOTH(DENS3.K,TDENA3)
336=A DENS3.K=(POP3.K/ACRE3)*(1/365)
337=C TDENA3=3.5
338=N ADENA3=60
339=A EDENB3.K=TABHL(EDNT3,ADENB3.K/DDENS,0,3,.5)
340=A ADENB3.K=SMOOTH(DENS3.K,TDENB3)
341=C TDENB3=3.6
342=N ADENB3=60
343=NOTE
344=NOTE     EFFECT OF GASOLINE PRICES
345=A ECA3.K=MVA3.K*PUSHA+NOMVA3.K*PULLA
346=A MVA3.K=TABHL(COSTE,GAS.K*DISTA3*RMILE,0,30,5)
347=A NOMVA3.K=TABHL(COSTNE,GAS.K*DISTA3*RMILE,0,30,5)
348=NOTE
349=A ECB3.K=MVB3.K*PUSHB+NOMVB3.K*PULLB
350=A MVB3.K=TABHL(COSTE,GAS.K*DISTB3*RMILE,0,30,5)
351=A NOMVB3.K=TABHL(COSTNE,GAS.K*DISTB3*RMILE,0,30,5)
352=NOTE
353=NOTE     UPKEEP
354=A EUPK3.K=TABHL(EUPKT3,MEOUK3.K,0,20000,5000)
355=T EUPKT3=.1/.6/.7/1.0/1.3
356=A MEOUK3.K=((GENFND.K+EXTRA2.K)*FEUPK3.K)/ACRE3
357=A FEUPK3.K=CLIP(.22,.28,TIME.K,OPEN5)
358=A AEUPA3.K=SMOOTH(EUPK3.K,TUPA3)
359=C TUPA3=3.5
360=N AEUPA3=1.0
361=A AEUPB3.K=SMOOTH(EUPK3.K,TUPB3)
362=C TUPB3=3.6
363=N AEUPB3=1.0
364=NOTE
365=NOTE     SUMMARY STATISTICS FOR PARK #3
366=A POP3.K=POPA3.K+POPB3.K
367=A POPA3.K=POPA.K*FRECA3.K
368=A POPB3.K=POPB.K*FRECB3.K
369=A STRA3.K=BASEA3*EDENA3.K*ECA3.K*AEUPA3.K
370=A STRB3.K=BASEB3*EDENB3.K*ECB3.K*AEUPB3.K
371=A FRECA3.K=STRA3.K/TOSTRA.K
372=A FRECB3.K=STRB3.K/TOSTRB.K
```

```
373=NOTE
374=NOTE            PARK #4
375=NOTE
376=NOTE
377=NOTE
378=NOTE     BASELINE AND ENVIRONMENT
379=C BASEA4=.7
380=C BASEB4=.7
381=C ACRE4=4
382=C DISTA4=120
383=C DISTB4=31
384=NOTE
385=NOTE     EFFECT OF DENSITY
386=A EDENA4.K=TABHL(EDNT4,ADENA4.K/DDENS,0,3,.5)
387=T EDNT4=.7/.9/1.0/.76/.5/.3/.25
388=A ADENA4.K=SMOOTH(DENS4.K,TDENA4)
389=A DENS4.K=(POP4.K/ACRE4)*(1/365)
390=C TDENA4=3.7
391=N ADENA4=60
392=A EDENB4.K=TABHL(EDNT4,ADENB4.K/DDENS,0,3,.5)
393=A ADENB4.K=SMOOTH(DENS4.K,TDENB4)
394=C TDENB4=2.0
395=N ADENB4=60
396=NOTE
397=NOTE     EFFECT OF GASOLINE PRICES
398=A ECA4.K=(MVA4.K*PUSHA+NOMVA4.K*PULLA)*NEW.K
399=A MVA4.K=TABHL(COSTE,GAS.K*DISTA4*RMILE,0,30,5)
400=A NOMVA4.K=TABHL(COSTNE,GAS.K*DISTA4*RMILE,0,30,5)
401=A NEW.K=CLIP(1,0,TIME.K,OPEN5)
402=NOTE
403=A ECB4.K=(MVB4.K*PUSHB+NOMVB4.K*PULLB)*NEW.K
404=A MVB4.K=TABHL(COSTE,GAS.K*DISTB4*RMILE,0,30,5)
405=A NOMVB4.K=TABHL(COSTNE,GAS.K*DISTB4*RMILE,0,30,5)
406=NOTE
407=NOTE     UPKEEP
408=A EUPK4.K=TABHL(EUPKT4,MEOUK4.K,0,20000,5000)
409=T EUPKT4=.1/.6/.7/1.0/1.3
410=A MEOUK4.K=((GENFND.K+EXTRA2.K)*FEUPK4.K)/ACRE4
411=A FEUPK4.K=CLIP(.09,0,TIME.K,OPEN5)
412=A AEUPA4.K=SMOOTH(EUPK4.K,TUPA4)
413=C TUPA4=3.7
414=N AEUPA4=1.0
415=A AEUPB4.K=SMOOTH(EUPK4.K,TUPB4)
416=C TUPB4=2.0
417=N AEUPB4=1.0
418=NOTE
419=NOTE     SUMMARY STATISTICS FOR PARK #4
420=A POP4.K=POPA4.K+POPB4.K
421=A POPA4.K=POPA.K*FRECA4.K
422=A POPB4.K=POPB.K*FRECB4.K
423=A STRA4.K=BASEA4*EDENA4.K*ECA4.K*AEUPA4.K*ONOFF4.K
424=A STRB4.K=BASEB4*EDENB4.K*ECB4.K*AEUPB4.K*ONOFF4.K
425=A ONOFF4.K=CLIP(1,0,TIME.K,OPEN5)
426=A FRECA4.K=STRA4.K/TOSTRA.K
427=A FRECB4.K=STRB4.K/TOSTRB.K
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428=NOTE
429=NOTE           PARK #5
430=NOTE
431=NOTE    BASELINE AND ENVIRONMENT
432=C BASEA5=.7
433=C BASEB5=.7
434=C ACRE5=5
435=C DISTA5=128
436=C DISTB5=22
437=NOTE
438=NOTE    EFFECT OF DENSITY
439=A EDENA5.K=TABHL(EDNT5,ADENA5.K/DDENS,0,3,.5)
440=T EDNT5=.7/.9/1.0/.76/.5/.3/.25
441=A ADENA5.K=SMOOTH(DENS5.K,TDENA5)
442=A DENS5.K=(POP5.K/ACRE5)*(1/365)
443=C TDENA5=3.8
444=N ADENA5=60
445=A EDENB5.K=TABHL(EDNT5,ADENB5.K/DDENS,0,3,.5)
446=A ADENB5.K=SMOOTH(DENS5.K,TDENB5)
447=C TDENB5=1.5
448=N ADENB5=60
449=NOTE
450=NOTE    EFFECT OF GASOLINE PRICES
451=A ECA5.K=(MVA5.K*PUSHA+NOMVA5.K*PULLA)*NEW.K
452=A MVA5.K=TABHL(COSTE,GAS.K*DISTA5*RMILE,0,30,5)
453=A NOMVA5.K=TABHL(COSTNE,GAS.K*DISTA5*RMILE,0,30,5)
454=NOTE
455=A ECB5.K=(MVB5.K*PUSHB+NOMVB5.K*PULLB)*NEW.K
456=A MVB5.K=TABHL(COSTE,GAS.K*DISTB5*RMILE,0,30,5)
457=A NOMVB5.K=TABHL(COSTNE,GAS.K*DISTB5*RMILE,0,30,5)
458=NOTE
459=NOTE    UPKEEP
460=A EUPK5.K=TABHL(EUPKT5,MEOUK5.K,0,20000,5000)
461=T EUPKT5=.1/.6/.7/1.0/1.3
462=A MEOUK5.K=((GENFND.K+EXTRA2.K)*FEUPK5.K)/ACRE5
463=A FEUPK5.K=CLIP(.11,0,TIME.K,OPEN5)
464=A AEUPA5.K=SMOOTH(EUPK5.K,TUPA5)
465=C TUPA5=3.8
466=N AEUPA5=1.0
467=A AEUPB5.K=SMOOTH(EUPK5.K,TUPB5)
468=C TUPB5=1.5
469=N AEUPB5=1.0
470=NOTE
471=NOTE    SUMMARY STATISTICS FOR PARK #5
472=A POP5.K=POPA5.K+POPB5.K
473=A POPA5.K=POPA.K*FRECA5.K
474=A POPB5.K=POPB.K*FRECB5.K
475=A STRA5.K=BASEA5*EDENA5.K*ECA5.K*AEUPA5.K*ONOFF5.K
476=A STRB5.K=BASEB5*EDENB5.K*ECB5.K*AEUPB5.K*ONOFF5.K
477=A ONOFF5.K=CLIP(1,0,TIME.K,OPEN5)
478=A FRECA5.K=STRA5.K/TOSTRA.K
479=A FRECB5.K=STRB5.K/TOSTRB.K
480=NOTE
481=NOTE
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482=NOTE
483=NOTE                    CONTROL CONSTANTS
484=NOTE
485=C DT=.2
486=C PLTPER=1
487=C LENGTH=1970
488=N TIME=1970
489=C OPEN5=1970
490=C CHANGE=1974
491=NOTE
492=NOTE PLOT CARDS FOR A
493=PLOT POPA=A,POPNOA=L/GAS=G/GENFND=$
494=PLOT DENS1=1,DENS2=2,DENS3=3,DENS4=4,DENS5=5
495=PLOT ECA1=1,ECA2=2,ECA3=3,ECA4=4,ECA5=5
496=PLOT POP1=1,POP2=2,POP3=3,POP4=4,POP5=5
497=PLOT STRA1=1,STRA2=2,STRA3=3,STRA4=4,STRA5=5
498=PLOT FRECA1=1,FRECA2=2,FRECA3=3,FRECA4=4,FRECA5=5
499=NOTE
500=RUN
OK-
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APPENDIX 2

LIST OF VARIABLE DEFINITIONS

THIS IS AN ABBREVIATED SET OF DEFINITIONS OF VARIABLES IN THE MODEL, INCLUDING THE SET OF SWITCHING FUNCTIONS USED TO CONTROL THE TIME OF INTRODUCING DECREASES IN GENERAL FUNDS, THE INTRODUCTION OF NEW PARKS, AND THE RESPONSES TO CHANGES IN TRIP COSTS MADE BY RECREATIONISTS FROM A AND B.

NAME	DEFINITION
ACREL	AREA OF BEACH AT FACILITY L (ACRES)
ADENAL	PERCEIVED DENSITY OF L BY POPA (PEOPLE/ACRE/DAY)
ADENBL	PERCEIVED DENSITY OF L BY POPB (PEOPLE/ACRE/DAY)
AEUPAL	ATTRIBUTED EFFECT OF UPKEEP OF L BY POPA
AEUPAB	ATTRIBUTED EFFECT OF UPKEEP OF L BY POPB
BASEAL	BASIC ATTRACTIVENESS OF L BY POPA
BASEBL	BASIC ATTRACTIVENESS OF L BY POPB
COSTE	EFFECT OF TRIP COSTS TABLE, ELASTIC CASE
COSTNE	EFFECT OF TRIP COSTS TABLE, INELASTIC CASE
CHANGE	DATE WHEN GAS PRICES AND GENERAL FUNDS CHANGED
DDENS	DESIRED DENSITY (PEOPLE/ACRE/DAY)
DENSL	POPULATION DENSITY AT PARK L
DISTAL	ROUND TRIP DISTANCE BETWEEN A AND L (MILES)
DISTBL	ROUND TRIP DISTANCE BETWEEN B AND L
DFND	NORMAL DECREASE IN FUNDS CONSTANT
DUMMYL	SETS NEAREST PARK TO B FOR INTRODUCTION OF NEW PARKS
ECAL	EFFECT OF ROUND TRIP COSTS GOING FROM A TO L
ECBL	EFFECT OF ROUND TRIP COSTS GOING FROM B TO L
EDENAL	EFFECT OF DENSITY OF L ON RECREATIONISTS FROM A
EDENBL	EFFECT OF DENSITY OF L ON RECREATIONISTS FROM B
EDNTL	EFFECT OF DENSITY AT L TABLE
ESRTT	EFFECT OF STRENGTH ON RETURNING TABLE
ESTLVA	EFFECT OF STRENGTH ON LEAVING POPA FOR POPNOA
ESTLVB	EFFECT OF STRENGTH ON LEAVING POPB FOR POPNOB
ESTLVT	EFFECT OF STRENGTH ON LEAVING TABLE
ESTRTA	EFFECT OF STRENGTH ON RETURING TO POPA
ESTRTA	EFFECT OF STRENGTH OF NEAREST L ON RETURNING TO POPB
EUPKL	EFFECT OF UPKEEP AT L
EUPKTL	EFFECT OF UPKEEP AT L TABLE
EXMONY	EXTRA MONEY FOR MAINTAINING NEW PARKS
EXTRA2	ADDS EXTRA FUNDS FOR TWO NEW PARKS AT TIME EQUALS OPENS
FEUPKL	FRACTION OF FUNDS EXPENDED ON UPKEEP OF L
FLIP	SETS TIME FOR GENERAL FUNDS TO START TO DECREASE
FRECAL	FRACTION OF RECREATIONISTS GOING TO L FROM A
FRECBL	FRACTION OF RECREATIONISTS GOING TO L FROM B
GAS	PRICE OF GASOLINE ($/GALLON)
GASI	INITIAL PRICE OF GAS
GASINC	VALUE OF GASUP
GASUP	NORMAL RATE OF INCREASE IN PRICE OF GAS
GENFND	GENERAL STATE FUNDS ALLOCATED FOR PARKS ($)

GNFNDI	INITIAL LEVEL OF GENERAL FUNDS
LEAVEA	VALUE OF NOUTA AFTER TIME EQUALS CHANGE
MEOUKL	MONEY EXPENDED ON UPKEEP OF L ($/ACRE/YEAR)
MVAL	EFFECT OF ROUND TRIP COSTS FROM A TO L, ELASTIC CASE
MVBL	EFFECT OF ROUND TRIP COSTS FROM B TO L, INELASTIC CASE
NCGAS	NET CHANGE IN PRICE OF GAS
NCUT	REVOLVING POINT OF STRAL FOR LEAVING OR RETURNING TO POPA
NDCNOA	NET MIGRATION RATE FROM POPNOA OUT OF REGION
NDECA	NET MIGRATION RATE FROM POPA OUT OF REGION
NDGEN	NORMAL DECLINE IN GENERAL FUNDS
NEW	SETS EFFECT OF TRIP COSTS TO ZERO FOR TIME LESS THAN OPEN5
NNOREC	NORMAL EXCHANGE RATE BETWEEN POPA AND POPNOA
NOMVAL	EFFECT OF TRIP COSTS FROM A TO L IN INELASTIC CASE
NOMVBL	EFFECT OF TRIP COSTS FROM B TO L IN INELASTIC CASE
NORECA	NET EXCHANGE RATE BETWEEN POPA AND POPNOA
NOUTA	NORMAL EMIGRATION OUT OF A
NOUTB	NORMAL EMIGRATION OUT OF B
NRETRN	NORMAL RATE OF RETURN TO ACTIVITY
ONE	VALUE OF PULLA OR PULLB
OPEN5	DATE WHEN FACILITIES #'S 4 AND 5 OPEN
POPL	NUMBER OF RECREATIONISTS AT PARK L
POPA	POPULATION OF RECREATIONISTS AT ORIGIN A
POPAI	INITIAL LEVEL OF POPA
POPAL	NUMBER OF RECREATIONISTS FROM A GOING TO L
POPB	POPULATION OF RECREATIONISTS AT ORIGIN B
POPBI	INITIAL LEVEL OF POPB
POPBL	NUMBER OF RECREATIONISTS FROM B GOING TO L
POPNOA	POPULATION OF NON-RECREATIONISTS AT ORIGIN A
PPNOAI	INITIAL VALUE OF POPNOA
POPNOB	POPULATION OF NON-RECREATIONISTS AT ORIGIN B
PPNOBI	INITIAL LEVEL OF POPNOB
PULLA	SETS INELASTIC CONDITION FOR A
PULLB	SETS INELASTIC CONDITION FOR B
PUSHA	SETS ELASTIC CONDITION FOR A
PUSHB	SETS ELASTIC CONDITION FOR B
RMILE	RECIPROCAL OF MILEAGE
RETRNA	RATE OF RETURN FROM POPNOA TO POPA
RETRNB	RATE OF RETURN FROM POPNOB TO POPB
STRAL	STRENGTH OF L FOR POPA
STRBL	STRENGTH OF L FOR POPB
TDENAL	TIME FOR DENSITY OF L TO BE PERCEIVED (YEARS)
TOSTRA	TOTAL ABSOLUTE STRENGTH OF ALL FACILITIES FOR POPA
TOSTRB	TOTAL ABSOLUTE STRENTTH OF ALL FACILITIES FOR POPB
TUPAL	TIME FOR EFFECTS OF UPKEEP TO FILTER FROM L TO POPA
TUPBL	TIME FOR EFFECTS OF UPKEEP TO FILTER FROM L TO POPB
ZERO	VALUE OF PULLA OR PULLB

CLASS II DOCUMENTATION STANDARDS FOR SIMULATION MODELS

1. ACCESS TO MODEL:

Name of Model: RECLUCE, a Dynamic Recreational Usage Model

Name and current address of the senior technical person responsible for the model's construction: Dr. Ralph L. Levine, Dept. of Psych. Michigan State Univ. East Lansing

Who funded the model development? University Funds

In what language is the program written? DYNAMO

On what computer system is the model currently implemented? CDC CYBER 750

What is the maximum memory required to store and execute the program? ______

What is the length of time required for one typical run of the model? 3-5 minutes

Is there a detailed user's manual for the model? Not available yet.

2. PURPOSE OF THE MODEL:

For what individual or institution was the model designed? For use by State Department of Natural Resource Officials

What were the basic variables included in the model?

Price of gasoline, maintenance funds, number of park visitors, population density, number of non-recreationists.

Over what time period is the model supposed to provide useful information on real world behavior?

40-50 years

Was the model intended to serve as the basis of:

- an academic exercise designed to test the implications of a set of assumptions or to see if a specific theory would explain historical behavior ______
- communication with others about the nature and implications of an important set of interactions ✓
- projecting the general behavioral tendencies of the real system ______
- predicting the value of some system element(s) at some future point in time ✓

3. MODEL SPECIFICATION AND THEORETICAL JUSTIFICATION:

Provide two diagrams illustrating the extreme behavior modes exhibited by the major model elements:

If they are not included in the body of the paper indicate where the reader may find:

a model boundary diagram that indicates the important endogenous, exogenous and excluded variables ______

a causal influence diagram, a flow diagram, the computer program and definitions of the program elements ______

Is the model composed of:

simultaneous equations ______

difference or differential equations ✓

procedural instructions ______

Is the model deterministic ✓ or stochastic ______

continuous ✓ or discrete ______

4. DATA ACQUISITION

What were the primary sources for the data and theories incorporated in the model?

Data Conversations with state officials.

Theory Gravity models of recreational usage, Luce's theory of individual choice behavior.

What percent of the coefficients of the model were obtained from:

measurements of physical systems ______

inference from social survey data ______

econometric analyses ______

expert judgment 40

the analyst's intuition 60

What was the general quality of the data? Sparse

5. PARAMETER ESTIMATION

If they are not given in the publication, where may the reader obtain detailed information on the data transformations, statistical techniques, data acquisition procedures, and results of the tests of fit and significance used in building and analyzing the model? ______

6. MODEL PERFORMANCE AND TESTING

Over what period was the model's behavior compared with historical data? ______

Plans are being made to obtain time series data for that analysis.

What other tests were employed to gauge the confidence deserved by the model? ______

Thus far, I have only tested the model against reference modes.

Where may the reader obtain a detailed discussion of the prediction errors and the dynamic properties of the model? See author. Also read Luce, Individual Choice Behavior, New York: Wiley, 1959.

7. APPLICATIONS

What other reports are based upon the model? None so far

Name any analysts outside the parent group that have implemented the model on another computer system. None

List any reports or publications that may have resulted from an evaluation of the model by an outside source. None

Has any decision maker responded to the recommendations derived from the model?

Not yet

Will there be any further modifications or documentation of the model?

Where may information on these be obtained? We are only at the beginning stages of the modeling process, RECLUCE will be modified considerably in the future to include more realistic psychological processes, such as attachments to particular locations, curiosity, and novelty. No, RECLUCE will not be left alone.