CHAPTER VIII- TN 17: A METHOD OF ALLOCATION OF RECREATION SUPPLY TO URBAN CENTRES

By W. Acar
(Introduction and Concluding Sections by J. Beaman)

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ABSTRACT

In some time around 1965 the Ontario Government started action focusing on providing the public with opportunities for outdoor recreation on a more equitable basis than was occurring without planned consideration of equity. Thus, there was a need for a simple model which could detect the areas of potential overload in the Province's recreation supply system, given the past trends of population and existing and planned supply.

Because of a strong interest in short-trip recreation, it was proposed that an allocation model be developed to study the opportunities for day trips and weekend trips from any of Ontario's urban centres within K-hour travel zones of the centres - K being 2 hours for day-use and 3 hours for weekend trips.

It was decided, for evaluation purposes, that the only supply to be considered effectively available to an urban-centred region was the amount lying inside its k-hour travel zone; and that the populations of the various urban centres compete for the use of the same opportunities in those areas where the travel zones overlap. Competition for a particular unit of supply was hypothesized to be defined by the pressures that centres would exert on "the supply they potentially have" and by a function of the travel times to a region where a supply is located, for which these centres compete.

The paper presents the assumptions just stated and describes the computational procedures developed.

It describes the computer algorithm which was prepared to allocate the supply of recreation opportunities in each destination region to urban centres in a way which is consistent with the competition and other effects hypothesized. The algorithm allows the generation of a measure of the supply per capita effectively available to the residents of the different urban centres.

An example that can be computed manually is presented, as well as the general mathematics of the simulation of the competition that takes place.

The computer programs developed have been tested extensively. It is equally possible to use them to study the allocation of supply using as little as 7 origins in 12 destinations or for much larger problems (e.g., 25 by 156). However, details on the programs are not provided. The reader is referred to published work by Acar (1974).

INTRODUCTION

The model described below was developed to answer a number of priority planning questions. These questions could not wait the completion of more sophisticated modelling efforts in which Ontario was involved (see Reference 33 and 34). For example, one planning question is the issue of whether more publicly supplied recreation opportunities should be placed near Toronto or whether such facilities should be placed in other areas which appear to be deficient in opportunities for recreation activities of a given type.

A continuing emphasis in Ontario has been the setting of objectives for the Outdoor Recreation Program (see Reference 30). Given the proposed objectives of the Province, it was possible to visualize an allocation of facilities which embodied these objectives. One possible allocation evaluation scheme being considered by Ontario is defined by the model presented in this paper. This scheme, by allowing examination of the existing distribution of user-days potentially available to participants in an activity, is designed to reflect the level at which all people in the Province of Ontario who desire to participate have access to particular kinds of facilities.

Rationale

A basic premise in the model presented is that participation rates can be used to calculate the number of participants in an activity that an area "should" generate. "Should" is used here to mean that it is possible to calculate the number of participants an area would generate if it were supplied with facilities in a way that reflects a standard that would be acceptable for all areas of the Province. For example, the number of participants which "should" be generated could be based on a standard defined using differentials computed by the analysis of variance. (See TN 12.)

No matter what formula is employed to calculate the number of participants an area "should" generate if appropriately supplied by opportunities, the approach proposed is to see how the number of potential participants in an area is related to the available supply of facilities. Ultimately, the object of this analysis is to see what pressure achieving a certain "standard" of participation would put on facilities available to an area within a particular distance of it.

Of relevance to the objective, then, is the principle of the K-hour travel zone. Because of interest in equity of opportunities for short-trip recreation, it is reasonable that only supply within two hours one-way travel from an urban centre be considered as available to that centre. In other words, for short-trip recreation, here it is considered that supply is "available" only if a destination is within two hours of an origin, one-way.

Given that K-hour travel zones are defined, allocation modelling would be simple if it were not for the fact that different urban centres compete for use of the same supply. Certain factors recognized as affecting park use are not considered in the allocation model. However, the works of Cheung (TN 1), Cesario (TN 4), Ross, et al. (TN 2 and TN 5), or Ellis and Kerr (Reference 33) do consider the effects of alternative facilities and/or attractivity of facilities on park use (see TN 1, TN 3, TN 4, TN 11, TN 33 and sources cited therein). Basically, in formulating an allocation model, it was considered wise to use a simplistic theory that did not attempt to consider elaborate interactions between supply units. A more complicated model might have resulted in more accurate results. But, the formulation of the allocation model had the immediate objective of supplying information to decision makers, as well as being a contribution to a growing literature on supply allocation models. The immediate needs for a decision-aiding model made it essential to place a limit on theoretical embellishments to the model.

Modelling Assumptions

One way to proceed to develop a model is to state assumptions and proceed to show how a model may be developed based on these. That is the approach taken here.

Assumption Al: The residents of an urban centre should not need to go beyond the K-Hour-Drive isochrone (i.e., outside the K-Hour Travel Zone) to receive a given level of service for day-use participation in a given activity.

This assumption embodies the policy that there is an intention to provide facilities for certain activities at a certain level of service within a certain distance of most residents of the cities of Ontario. This assumption is an assertion that Ontario, by using the model, is investigating the implications of accepting the view that its citizens should not recognize the disutility of travelling up to two hours one way and that its citizens should recognize infinite disutility for travel any further than this basic distance. This statement, of course, only refers to travel for day-use participation. The Province may indicate a different number of hours of travel as allowable for different activities and for overnight use of an area for a given activity.

Assumption A2: The population is homogeneous, across the province, with respect to those socio- economic variables affecting recreation participation.

This assumption is made so that a simple approach may be taken to determining the number of participants that "should be" generated by an area. The analysis of variance approach to calculating participation, alluded to earlier, allows one to associate different "ideal" or "standard" participation rates with different ages, sexes, etc. But examination of participation in Saskatchewan, where a sophisticated formula was used to take into account the variation in socioeconomic characteristics of the population in various cities, showed that only small differences, in the order of 10 percent at the largest, resulted from using this elaborate formulation rather than a simple participation rate. Given that one does not expect to be within 10 percent in this (or any) exploratory modelling effort, there is little merit in introducing such complexity into a model.

Assumption A3: The supply' of "facilities" for the activity being considered is homogeneous with respect to quality.

This assumption is also designed to facilitate competition modelling. But it also has distinct policy implications. It is readily recognized that there are better and poorer hunting areas, better and poorer picnicking areas, and that the problem of assessing quality, or what some authors call attractivity (see TN 1, TN 2, TN 4 and TN 9), is a problem which is receiving substantial consideration. (See Reference 24.)

Basically, the theoretical concern is that some participants in an activity receive a higher benefit from going to a good facility than others receive from going to a poor facility. The homogeneity assumption simply says from a policy perspective that all facilities will be "recognized to be" as of equal utility for the activity of concern. Thus, if this assumption is used in a given analysis, one is choosing not to acknowledge the difference between facilities as long as they meet the Province's basic standards for the given activity. At this point, assumption A3 is required to allow one to carry out modelling, at least until accurate attractivity measures have been assessed and adequately verified will it become possible to use these factors (given that implications of their use remain consistent with policy) in stimulating the competition and resulting al location.

Assumption A4: The concept of a "resistance to travel" may be used to define a function that indicates how areas, for which different population centres compete, should share the supply in destination units which they have in common.

This assumption is an interim approximation to reality accepted until some more appropriate approach can be taken. Basically, the general statement embodied in Assumption 4 is included here to serve as an introduction to a more detailed enunciation of a partition formula indicating how origins share supply units for which they compete this enunciation follows later in the text.

Assumption A5: It is possible to treat Southern Ontario as a limited number of supply units (destination units; e.g., 12 or 156) and a limited number of origin unit (e.g. 7 or 25).

The computational procedures that are defined in the discussion of the competition (and allocation) model involve dividing southern Ontario into origin and destination units. Supply is associated with destination units (clusters of townships), and population is associated with origins (cities and surrounding areas). This assumption embodies the idea that the population of southern Ontario is so highly concentrated in cities that for the purpose of calculating distance (and other manipulations that are described) populations may be considered to be concentrated at given points. It is also assumed that all the supply in a given unit is available at a point.

If one has dealt with problems where this kind of an approximation has been used, it will be realized that where population units are concentrated in cities this kind of an assumption works particularly well. Where the supply tends to be uniformly distributed within a supply unit and the distance functions do not tend to drop off in too much of a curvilinear manner over a supply unit, it may also be expected that the approximation does not result in problems. Thus, it may be understood that this assumption, as with other assumptions already stated, involves reasonable approximations to "reality" which are being made to operationalize a model that can be modified in later, more elaborate calculations.

Model Description

Consider counties, c, with facilities yielding up to A(c) opportunities. Let S(c,u,i) be the amount of A(c) allocated to a centre, u, in stage (iteration), i, of the allocation process. Also consider that the following two tables or matrices are specified: D(c,u) is an element of the array that gives distances from supply units c to a centre u. Pcnt(c,u) is an element of the array that gives the percent of the user-days of supply in c that is within the Z-hour travel zone of u.

Now it is claimed that an allocation consistent with the assumptions already given is achieved by a procedure. The procedure is called iterative because, as described below, one starts with an approximation and in successive steps, iterations, improves the approximations. Specifically, for each step, "i" (starting at i=0), one defines an equation for prorating supply in each c to each u:

$$(1)\ \mathrm{PRO}(c,u,i) = \frac{\mathrm{Pcnt}(c,u)p(u,i)/f(D(c,u))}{\Sigma_c\ \mathrm{Pcnt}(c,u)p(u,i)/f(D(c,u))}$$

The sum in the denominator only serves to normalize the proration so that all the supply of c (only supply within some u’s k-hour travel zone is being considered) is associated with some u. The formula is such that the sum of PRO(c,u,i) over u equals 1 for all c’s.

In the above p(u,i) is the pressure that a population places on the supply available to it: is the supply available per participant defined by:

$$(2)\ p(u,i) = \frac{\text{(population of u)(Average Per Capita Participation Rate for all u's together)}}{\Sigma_c\ \mathrm{PRO}(c,u,i)\ A(c)}$$

The sum in the denominator serves the same kind of normalization function as described for the denominator in Equation 1. In Equation 3, Equation is abbreviated using POP(u) for the population term and PPR for the per capita participation rate. The denominator is simplified to $\Sigma_c S(c,u,i)$.

$$(3)\ p(u,i) = \mathrm{POP}(u)\ \mathrm{PPR}/\ \Sigma_c S(c,u,i)$$

Now, Equation 1 indicates that the proportion of the supply in c allocated to u is inversely proportional to some function of distance (or travel time, should times be stored in the D(c,u) matrix), so Assumption A4 has been built into the allocation. Inclusion of P(c,u) and p(u,i) in Equation 1 indicates that supply is prorated in direct proportions to these variables. So the supply in c is allocated to u’s based on the amount of that supply included in each u's K-hour travel zone but “conditional” on the pressure that each population centre places on the supply available to it.

If all u's placed the same pressure on the supply available to them one can see that p(u,i) would cancel in Equation 1 resulting in:

$$(4)\ PRO(c,u,i) = \frac{Pcnt(c,u)/f(D(c,u))}{\Sigma_c\ Pcnt(c,u)/f(D(c,u))}$$

This indicates that each u is to receive a share of the supply in c reflecting how much of c's supply is in u's K-hour travel zone but conditional on how far c is located from u in comparison to c's distance from other u's.

At this point the reader can recognize that the kind of allocation being described is that discussed under Assumptions Al and A4. The effect of distance on the use of facilities is recognized. But if the population per unit of supply is high, the pressure on facilities is high for some u. A u with high pressure has "priority" compared to low pressure u's for being allocated supply *for which there is competition*. However, it may also be recognized that to calculate the PRO (c,u,i)'s, it is necessary to know the p(u,i)'s (the pressures) and vice-versa. But one does not know either.

One can proceed to find a solution iteratively. An initial estimate of the pressures can be obtained by assuming that all u's get all supply within their K-hour travel zone. So according to Equation 3:

$$(5)\ p(u,o) = \frac{POP(u)\ PPR}{\sum A(c)\ P(c,u)}$$

where the PRO(c,u,i)'s have been set to 1 reflecting the approximation described above.

Now, the zero value of the subscript i in p(u,0) indicates that the values defined by Equation 5 are initial estimates of the p(u,i)'s. If these are substituted into Equation 1, one may write the equation for the first iteration:

$$(6)\ PRO(c,u,l) = \frac{(Pcnt(c,u)\ p(u,0)/f(D(c,u))}{\Sigma_c\ Pcnt(c,u)/f(D(c,u))}$$

Thus one gets estimates of the PRO(c,u,1) and these may be substituted into Equation 3 to get revised estimates of the p(u,l) which can be substituted into Equation 1 to get revised estimates of the PRO(c,u,2). This procedure can obviously be repeated indefinitely with each cycle of computation, i, being called an iteration. What one wants is that this process moves toward a unique set of values which are the ideal allocations. Thus, at each iteration one can test to see if the solution is changing in such a way that a final set of values will differ by some small amount from the current “best” values. When the solution is not changing, one has the desired allocation related estimates. These pressures indicated are the information that is provided to planners or managers so they have insight into the relative deprivation of some areas compared to others.[1]

A manager, by looking at a series of pressure values, say 7, 5, 4.5, 4.4, 4, 3.8, 3.7, could conclude that there was a definite need to put in facilities to increase the opportunities to the area with a pressure of 7. The manager may, however, wish to have the allocation program run a number of times with different alternative development plans to see which results in the most desirable pressure values or which ones results in an acceptable set of pressures at a minimum cost. Incidentally, such runs would be made using projected population so that the solutions (pressures) arrived at would be appropriate to the time when facilities were actually in place.

<u>An Example</u>

Some readers may find the preceding easier to follow if given an example. So before

[1] The allocation program used was written in the Fortran computer language and is no longer available. Regardless, details regarding insuring that there is a unique solution etc. have not been pursued. See Acar 1974 for such matters.

going on to cover some special points, consider two urban centres A and B with populations 100,000 and 50,000 respectively. Assume that these centres are served by three supply areas each offering 1,000,000 user-days of activity in the way indicated in Table 1. Also for the sake of simplicity assume D2 ±B = 2D2 .o and for convenience use MUD to indicate millions of user-days (1,500,000 user-days = 1.5 MUD).

As described earlier, to begin allocation one allocates to both A and B all supply that they could possibly have a claim to: (1) is entirely allocated to A, (3) to B, and (2) is allocated 100% to A and 50% to B (is over allocated). So assuming PPR = 1, initial pressure estimates are:

p(A,0) = 100,000/2000 = 50.00
p(B,0) = 50,000/i500 = 33.33
and substituting these into Equation 1 (or using Equation 8)
PRO(A,2,0) = 50.00/(50.00 + 8.33) = .857
PRO(B,2,0) = 8.33/(50.00 + 8.33) = .143

The other PRO( )'s need not be calculated because the way the example was set up they are equal to one or zero depending on which u the supply being considered has been totally allocated to.

Now, proceeding to iteration one using the initial values that have been established and using Equations 7 and 8 one finds for iteration 1:

TABLE 1: PERCENT OF SUPPLY IN THREE REGIONS INCLUDED IN THE K-HOUR TRAVEL ZONES OF TWO CITIES

		Supply Areas		
		1	2	3
Cities	A	100	100	0
	B	0	50	100

p(A,1) = 100.000/1000(1 + .857) = 53.85
p(B,1) = 50,000/1000(1 + .143) = 10.94
PRO(A,2,1) = 53.85/(53.85 + 10.94) = .831
PRO(B,2,1) = 10.94/(53.85 + 10.94) = .169

Carrying out a second, third, etc. iteration does not change the pressures much. About 1.83 MUD are allocated to A and 1.17 to B meaning, in the general sense, that the pressure on the supply of A is about 5 times as high as on the supply allocated to B.

When, by using the allocation approach, it has been found that there is a 5 to 1 pressure differential, the question is: So what? If the area with high pressure is still adequately supplied with facilities according to some standard then no action is required. If it is not, then as suggested elsewhere in this paper, other supply may be introduced into the system in any number of ways and the resulting allocations tested. However, in this case it is obvious that to lower the pressure at A without also lowering B one should add to supply area 1. Still, if supply area 1 is near urban land it may be cheaper to add sites to area 2 (if land there is cheaper.)

<u>Technical Points About Improvements to and Possible Modifications to the Model Defined</u>

The kind of issues that arise in actually using the model are numerous. A few of the important ones which the reader may wish to note are:

(1) As already mentioned (Footnote 1 and in the text) a "convergence criterion" must be specified so that iterations can be stopped when a solution is good enough. For this and other technical matters (e.g. the necessity of intra-iterational loops, etc.), see Acar (1974).

(2) By merely calculating allocation based on the factors in Equation 1 and 3, there is no guarantee that some areas will not be above their saturation limit, in terms of some standard

of a maximum number of persons per unit of recreation supply. Correcting for this involves reallocating users in a way consistent with the general procedure. Whenever the "load" of any one c is larger than allowed, then the additional people can be "channeled" to other c's. For further information on this point, see Acar 1974 and Ker (1973, 1974).

(3) A distance function must be chosen.

Regarding the latter, it should be noted that sensitivity to change in the distance function is relevant in considering resistance of distance as an impediment to travel. Runs of the allocation model have been made that use different distance functions. These runs have produced measures of allocation with only minor differences. Thus, the model has been found to be only mildly sensitive to different distance functions. This mild sensitivity can be understood by noting the similarity of a variety of functions of distance over a broad range of distances (see Figure 1 of TN 14, and Ker 1974).

CONCLUSION

The method of stating assumptions that define a model that is used to aid analysis of a planning problem has not gained wide acceptance in planning outside of highly quantitative planning circles. However, if it is recognized that in this paper the object of defining a simulation model is to use it to generate a measure of goodness of allocation of the supply of facilities for participating in an activity, then the merits of the exercise may be clearer.

Care should be taken not to reject this approach because of objections to some modelling assumptions. The assumptions postulated do not necessarily define a behavioural system, but rather a method of measuring allocation that is consistent with the proposed objectives of Ontario. It must be recognized that whether or not people behave in a certain way is not fundamentally the point at issue; assumptions that reflect objectives or policy should not be confused with behavioural assumptions.

A method of deriving a useful measure of pressure of recreation supply has been defined. There is a need to be concerned about how assumptions used in deriving the measure may be interpreted. If this simulation of competition is an appropriate yardstick against which Ontario may measure the opportunities it provides to different groups of its citizens, it is imperative that the user understand that yardstick. Accepting the model may result in accepting a supply of opportunities at a certain level as good, whether or not people use these opportunities. (That the opportunities or facilities are under or over used when an allocation is good may only reflect the fact that people do not behave as if travel up to K–hours has no disutility.)

The relevance of policy and its dominance over behavioural considerations in this formulation is brought out clearly when one reviews the development of the model's definition. An arbitrary time of driving, namely two or three hours, is accepted as having no disutility. No particular weights that degrade a visit are introduced to suggest that current policy might value opportunities at one–hour distance over service near the desirable limit of travel. On the other hand, examination of the supply framework used here (see TN 16) shows that the Province of Ontario is seriously considering a policy that takes into account the standard work week and degrades supply that is primarily available only during the work week. The model is more a policy planning model than a model for predicting. But it is a quite acceptable policy planning tool, given the state of the art in outdoor recreation planning and the equalitarian objectives of Canadian governments.