RESIDENTIAL PREFERENCE: A PERCEPTUAL VIEW OF MELBOURNE

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ABSTRACT:

An understanding of the land-use/transport interaction,
although essential to a rational evaluation of urban and
regional policy, is frequently complicated by the
introduction of sophisticated mathematical techniques.
In an effort to make this interaction more visible to the
decision-maker, this paper places two of the more
advanced techniques, multinomial logit analysis and mental
maps, in a common framework of analysis and presentation.
In doing so it combines the strength of a rigorous
theoretical background with the simplicity of a visual
presentation. The paper outlines the theory and
development of the technique and illustrates its use
with reference to a case study of the residential location
preferences of residents of inner Melbourne suburbs.

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INTRODUCTION

An understanding of the ways in which transport in-
vestment, activity placement and residential location interact
is essential for a rational evaluation of urban or regional
policy alternatives. Frequently, however, the methods used
by planners to examine these interactions are complicated by
the introduction of sophisticated mathematical models. Al-
though such models may improve the explanatory power of the
planning method, such an improvement is frequently at the
expense of the comprehension of the method by the layman.

If one wishes to make the interactions clearly visible
to the decision-maker, who is frequently not cognizant of the
mathematical complexities involved in the modelling process,
then a clear, concise method for the presentation of results
and implications must be devised.

This paper attempts to provide such a method and,
at the same time, utilize two of the more advanced mathematical
techniques in location decision analysis; multinomial logit
choice modelling and the concept of mental, or cognitive, maps.
The approach is essentially three-staged as shown in Fig. 1.

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┌─────────────────────┐
│   PERCEPTION OF     │ ◄────────── Mental Maps
│      REGION         │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│   DECISIONS BASED   │ ◄────────── Multinomial Logit
│   ON PERCEPTIONS    │             Model
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│ VISUAL PRESENTATION │ ◄────────── Contour Maps
│     OF OUTCOME      │             or 3-D Terrain Model
└─────────────────────┘
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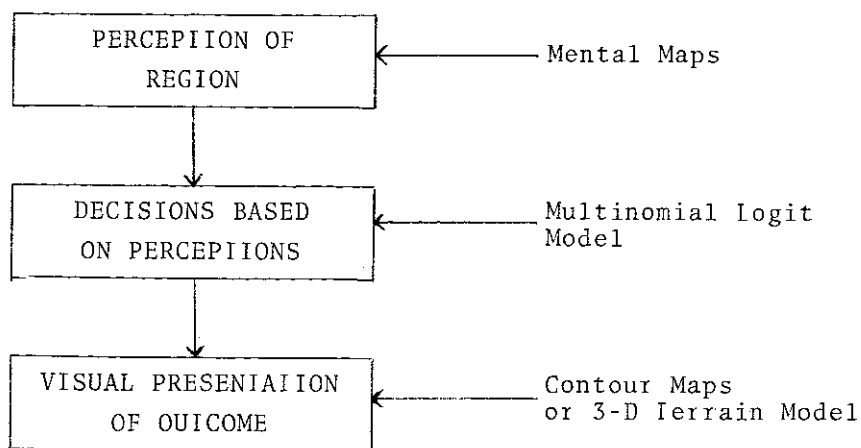
Figure 1. Structure of Proposed Approach

In this paper the model is developed in the context of urban residential location. However, the basic model structure as outlined in Fig. 1 could well be applied to problems involving regional development policies, decentralization, or facility location alternatives.

A THEORY OF CHOICE

A great deal of research in the areas of economics and psychology has been devoted to establishing a general theory of choice. Although many of the results have been conflicting, several general themes permeate all modern theories of choice. First, and foremost, is the concept that all choice decisions are probabilistic. This implies that a decision outcome can never be inferred with certainty. All that one can do is to assign a probability to that decision being made.

Secondly, choice decisions are not made between alternative objects but rather between the alternative sets of characteristics which those objects possess. This idea is expressed in the economic literature by Lancaster (1966) in his new approach to consumer theory, and in the psychological literature by Rosenberg (1956) as the cognitive summation theory of attitude.

Beyond these common principles, however, there exist a large variety of methods linking the characteristics of an object with the eventual choice of that object. One basic component of the psychological models of choice, which is generally not found in the economic models, is the realization that the choice process is composed of three separate, but interrelated, phases. Such a general choice model, as described by Golob, et al (1977) or Levin (1977), is shown in Fig. 2.

The economic theories of choice generally do not account for the second phase of the model, i.e. the subjective assessment of the decision-maker and the alternatives. Rather, they assume, or at least imply, that the choice behaviour of a decision-maker is directly related to the objective socio-economic characteristics of the decision-maker and to the objective physical characteristics of the alternatives.

On the other hand, the psychological theories of choice not only recognise but stress the overriding importance of the subjective transformation of characteristics of both the decision-maker and the alternatives. As important as the recognition of the three phases, is the realization of the linkages between elements of the three phases. Golob, et al (1977), in discussion of a model structure similar to that

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OBJECTIVE
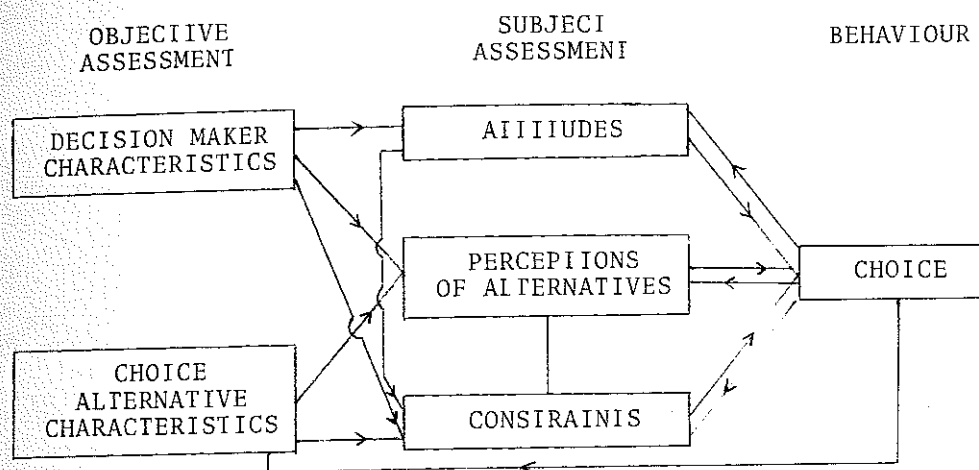ASSESSMENT

SUBJECT
ASSESSMENT

BEHAVIOUR

Figure 2. General Choice Model Structure

shown in Fig. 2, highlight many of the important linkages.
Whilst all of the linkages shown in Fig. 2 are shown to exist,
the relative strength and importance of such linkages is
believed to differ. Golob, et al (1977) conclude that the
most important linkage is that between the choice alternative
characteristics and the perceptions of the alternatives. Thus,
the decision-maker's subjective impressions of the characteris-
tics of the alternatives are critical in the overall choice
process. Although a characteristic may, in reality, be changed,
that change will not affect the choice decision unless the
perception of the characteristic also changes. Thus minor
changes that go unnoticed will not affect choice probabilities
nor will relatively major changes which simply don't come to
the attention of the decision-maker. Conversely, choice
probabilities can be changed without changing the alternatives
if one can instead change the perceptions of those alternatives
(for example, by information dissemination, advertising or
propaganda). Thus the realization of the choice process as
a three phase process has important policy and modelling
consequences.

From a modelling viewpoint, this process requires that
instead of using objective measurements of characteristics in
a model one must first obtain the subjective interpretations of
such characteristics. In some circumstances this is in-
evitable since it is impossible to obtain completely objective
measurements of a characteristic (e.g. comfort, convenience
in a mode choice decision). However it also requires that even

when objective measurements are obtainable (e.g. travel time), one must still transform this objective measurement into a subjective impression before using it in a model. For example, is a 20 minute trip really regarded as being twice as time consuming and onerous as a 10 minute trip?

Important as this subjective transformation is in the choice decision process, relatively little work has been performed to indicate the nature of such transformations in the context of mode choice modelling (e.g. Hensher and McLeod, 1975; Brown, 1977; Levin, 1977). What work has been done has concentrated on the variation in the perception of a single characteristic for a particular alternative (mode). In the context of spatial choice problems, however, the situation is a little different. Here one is concerned more with the variation in perception of characteristics over an urban or regional area. Fortunately, a well-established body of literature on this subject is available under the title of mental (or cognitive) maps (Gould and White, 1974; Morris, 1974; Crawford, 1977).

MENTAL MAPS

An individual's perception of his environment is moulded not simply by the physical environment itself, but also by the individual's level of knowledge of that environment. Where the level of knowledge is high, then the real environment and the individual's perception of that environment are likely to be similar. However, as the level of knowledge decreases so too does the similarity between real and perceived environment. Increasingly, subjective impressions, generalizations and biases play a more important role in the formulation of an individual's mental image of the environment. Just as the cartographic map can represent the real environment, so too a "mental map" can represent the perceived environment.

The study of mental maps was formalized in the exemplary works of Gould and White (1968, 1974). In a number of studies in various geographic locations, they considered the environment as perceived by the subjects of their experiments. Thus they considered Californian school-leavers' impressions of America, British school-leavers' impressions of Britain, a Negro child's impression of his immediate neighbourhood in Boston, and Swedish childrens' impressions of Sweden. As a result, they found that the mental maps retained by each subject were found to depend, basically, on the level of knowledge of the areas under consideration. The level of knowledge could, in turn, be expressed in a number of ways. For example, knowledge may depend on the length of residence in a certain area;

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the number of times a place had been visited or travelled through; the proximity of the area under consideration to the place of residence; the age of the respondent; the education and background of the respondent.

Two Australian studies employing mental maps are those of Morris (1974) and Crawford (1977). Morris, in her study of mental maps of Victoria, assessed the preferences of Victorian school leavers for various geographic areas in Victoria. Crawford considered the application of mental maps to the problem of growth centre development, in particular the Bathurst-Orange Growth Centre. He described applications of mental maps both at the level of regional attractiveness and at the local area design level.

All the above studies show the usefulness of mental maps in describing perceptions of regional areas. The present study differs in three aspects. Firstly, the study area will be a metropolitan urban area. Given the success of mental map approaches at both the regional level and the immediate neighbourhood level there is no reason to believe that they will not be just as applicable at the intermediate level of an urban area. Secondly, the charting of the mental maps, whilst of interest in themselves, will not be the major ob- jective of the study. The mental maps will subsequently be used as input to a modelling process to obtain residential preference ratings.

The third point of difference is perhaps the most fundamental. Previous mental map studies have requested subjects to rate particular geographic locations as, for ex- ample, a place to live. It is known, however, that the residential location decision is not based on a rating of the geographic location, per se, but on a rating of the various characteristics describing that location. This principle is espoused in the paper by Lancaster (1966) which embodies the "new approch to consumer theory." In the light of this recognition of a location being described in terms of characteristics, it seems reasonable to obtain mental maps of these characteristics in a spatial context as a basic first step to obtaining residential preference indicators. Obtaining mental maps of characteristics, rather than mental maps of geographic areas, has several advantages. Firstly, it enables the respondent to react to specific characteristics rather than to broad classifications such as geographic areas. As stated by Levin (1977), this feature promises more valid assessment of attitudes and perceptions. Secondly, it enables the contribution of each characteristic to the overall assess- ment of the area to be evaluated. Thirdly, it gives an

indication of the knowledge of specific characteristics of an urban area. Finally, it enables the effect of a change in one of the characteristics to be traced through to its final effect on residential preference.

A limited attempt to obtain mental maps of characteristics, or categories of characteristics, is described by Gould and White (1974) in their discussion of the work of Harris and Scala (1971). As will be seen later, the present study differs considerably in the way in which the mental maps of characteristics are combined.

The traditional representation of mental maps is in the form of contour maps. However, they can equally well be expressed in the form of a two dimensional matrix where the dimensions of the matrix correspond to the latitude and longitude of the geographical region under consideration and the elements of the matrix represent the respondents rating of the geographic area at a particular latitude and longitude. Thus,

$$S = \{S_{ij}\} \tag{1}$$

where S = perceived satisfaction with geographic region (i.e. a mental map)

S_{ij} = perceived satisfaction with geographic area at latitude i and longitude j

Extending this representation to the present study in which mental maps of characteristics are being considered, one can use a three dimensional matrix $\{S_{ijk}\}$ to represent a series of mental maps for the characteristics of the area, where S_{ijk} is the perceived satisfaction with characteristic k at latitude i and longitude j.

The manner in which this three dimensional matrix is collapsed into a two dimensional preference surface will depend on the choice process assumed to exist in the residential location choice process.

CHOICE PROCESS MODEL

Recent investigations into choice processes (particularly mode choice processes) have indicated that two basic categories of choice processes are possible. These have been termed "simultaneous" and "sequential" decision processes (Brand, 1973). Because these terms are used in many other contexts, however, the approaches have also been termed "rational" and "irrational" choice processes or, more correctly, "objective rational" and

"subjective rational" choice processes. The major distinction between the two approaches is that whereas the "rational" process results in a decision only after a full and thorough evaluation of all the attributes of all the alternatives, the "irrational" process results in a decision after an evaluation of only some of the attributes or some of the alternatives.

Thus although the "rational" process arrives at the optimal decision, the complexity of the operation required to arrive at this optimum may make the process too complex for human discrimination. As a result, the individual decision-maker may be forced to resort to an "irrational" decision process to make the process workable. Examples of "irrational" decision processes are satisfying (March and Simon, 1958) and elimination-by-aspects (Tversky, 1972).

Whilst these processes have particular advantages, especially when dealing with non-independent alternatives, the majority of research, at least in transport choice modelling, has concentrated on the rational choice process. Using the theory of individual utility maximization, several researchers have derived a choice model known as the multinomial logit model. This model may be derived using either a strict utility approach (Luce, 1959) or a random utility approach (Marschak, 1959) and may be expressed mathematically as

$$p(a) = \frac{e^{cU_a}}{\sum_{b=1}^{N} e^{cU_b}} \tag{2}$$

where $p(a)$ = probability of choosing alternative a

U_a = utility of alternative a

N = number of alternatives

C = sensitivity coefficient

The utility function U_a is generally assumed to be a linear additive function of the characteristics such that

$$U_a = \sum_{k=1}^{M} I_k \cdot S_{ak} \tag{3}$$

where I_k = importance of characteristic k in the choice process

S_{ak} = level of satisfaction with characteristic k for alternative a

M = number of characteristics

In considering spatial choice problems and recalling the representation of the mental maps of characteristics as a three dimensional matrix, equation (3) may be expressed as

$$S_{ij} = U_{ij} = \sum_{k=1}^{M} I_k \cdot S_{ijk} \tag{4}$$

and subsequently

$$S = \{I_k\} \cdot \{S_{ijk}\} \tag{5}$$

Equation (5) states that the overall mental map of a region is a weighted sum of the individual characteristic mental maps of the region. This formulation is a generalization of those of Harris and Scala (1971) and McHarg (1969) (who used a similar concept for the identification of feasible highway routes). In both those works the importance matrix was implicitly assumed to be a unit matrix.

The final step in the development of the area preference surface is to relate the mental map of a region to the probability of choice of sub-areas within that region. This may be done by combining equations (2) and (4). Thus

$$p(ij) = \frac{e^{cU_{ij}}}{\sum\limits_{b=1}^{i} \sum\limits_{d=1}^{j} e^{cU_{bd}}} \tag{6}$$

where $p(ij)$ = probability of choosing area with latitude i and longitude j

It should be noted that the denominator in equation (6) is a constant equal to the maximum expected utility from an area within the region (Ben-Akiva, 1977). Hence equation (6) may be rewritten as

$$P = k\{e^{cU_{ij}}\} \tag{7}$$

or

$$P = ke^{cS} \tag{8}$$

where P = area preference surface

$$k = \frac{1}{\sum\limits_{b=1}^{i} \sum\limits_{d=1}^{j} e^{cU_{bd}}}$$

Equation (8) defines the fundamental relationship in this model. It combines the features of both multinomial logit analysis and mental maps. Hence whilst having a sound theoretical background it also results in an easily understandable visual presentation of the model output.

An interesting sidelight to this model development is that if one applies it to a mono-nucleated city where the satisfaction with an area is inversely proportional to the distance from the city centre, e.g.

$$S_a = -t_a \tag{9}$$

where S_a = satisfaction with area a

t_a = distance from area a to city centre

then one obtains the classic density gradient model proposed by Clark (1951)

$$D_a = k \, e^{-ct_a} \tag{10}$$

where D_a = residential density of area a

= p(a) x total area population/area of a

The parameters k and c, as defined in this paper, may also be thought of in similar fashion to the parameters in Clark's model.

CASE STUDY OF INNER MELBOURNE RESIDENTS

To test the application of the theory described above, a study was conducted to determine the attitudes and preferences of people who had moved into the central city region of Melbourne during the period August through November 1975. The central city suburbs are, as shown in Figure 3, South Melbourne, Port Melbourne, Melbourne, Fitzroy, Collingwood, Richmond, Prahran and St. Kilda.

These new residents were interviewed as soon as possible after they moved into the study area. This procedure was chosen for two reasons. Firstly, they had recently made
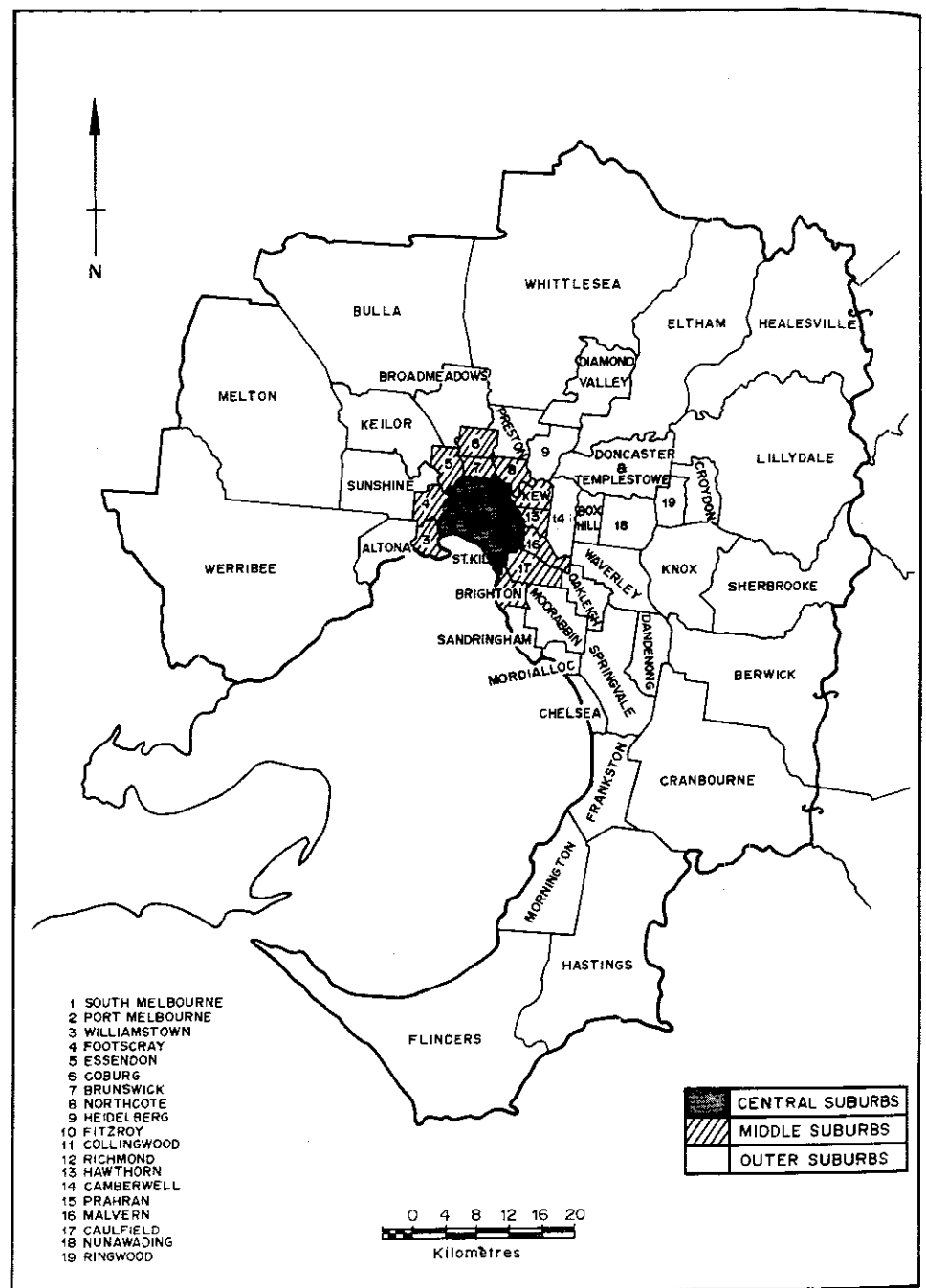
Figure 3   STUDY AREA

an overt decision to move and hence one may suspect that their
attitudes and actions were, at that time, closely related and
not subject to excessive cognitive dissonance.   Secondly, since
all residents in the study had moved at approximately the same
time, one may assume that the characteristics describing each
area under consideration would have been the same for all
study respondents.

The study took the form of a home interview question-
naire survey primarily aimed at establishing the respondents'
perception of how well a number of alternate locations would
have satisfied them with respect to a number of specific factors.
(Full details of the survey questionnaire are given in Young
(1976).) The factors considered are given in Table 1.

Table 1. Factors Included in Study of Residential Preferences

FACTORS	ABBREVIATIONS
Closeness to present workplace	Work
Closeness to shops	Shops
Closeness to public transport	Transport
Closeness to open country	Country
Closeness to bay beaches	Beaches
Closeness to parks, play areas, golf courses, ovals	Ovals
Closeness to entertainment	Entertain
Closeness to friends	Friends
Closeness to relatives	Relatives
Closeness to people of same age	Age
Closeness to people of same social level	Social
Closeness to people of same nationality	Nationality
Pedestrian safety	Safety
Traffic noise	Noise
Traffic congestion	Congestion
Tidiness of area	Tidiness
How well buildings are maintained	Maintain
How clean the air is	Air
Presence of trees, shrubs and grass	Trees
House type in the area	Home Type
Cost, rent or price, value for money	Cost

Respondents were asked to rate, by means of semantic
scales, the importance of each of these factors in their
residential location choice. They were also asked to indicate
how satisfactory they considered three suburbs to be (their
present one plus one each, with which they were familiar, from
the middle and outer suburbs) on the basis of each of these
factors.

A total of 261 questionnaires were administered to 244 households. Of these, 122 were renters and 122 were owners of the residences. This sample represented 16% of renters and 33% of owners moving into the area during the period of the study.

MENTAL MAPS OF CHARACTERISTICS

Translating theory into practice is usually associated with problems which are resolved by making approximations or assumptions. This study is no exception. It was mentioned earlier that a mental map is a representation of a person's perception of an area. Gould and White (1974) in the study of, for example, mental maps in Britain asked school leavers, from twenty-three schools in Britain, to rate, or more precisely rank-order, the ninety-two counties in Britain. Thus for each school leaver, Gould and White obtained an individual mental map based on rank order preferences. For each school, they then combined the rank order preferences of each school leaver at that school to obtain an average mental map.

The difficulty with the present study was that, as mentioned earlier, not all areas were rated by all respondents. Only three areas (one inner, one middle and one outer suburban area) were rated by each respondent and these areas varied from respondent-to-respondent. Thus complete individual mental maps did not exist. To obtain the average mental map of new inner suburban residents it was necessary to assume that they all perceive the urban area in a similar fashion. Hence, respondent B's perception of a particular area can be substituted for respondent A's perception of that same area when respondent A did not, in fact, rate that particular area. Thus the average mental map for all respondents may be obtained by calculating the average rating for each area from those respondents who rated that area and then constructing a composite map of these average ratings.

Mental maps constructed in this manner are shown in Figures 4 and 5 for two factors considered in the study; closeness to public transport and closeness to bay beaches. Each map is constructed for the combined group of owners and renters between whom there were no significant differences in ratings.

It can be seen that the mental maps so constructed appear to be reasonably consistent with intuition and knowledge of the Melbourne urban area. The public transport map shows a decreasing satisfaction with increasing distance from the central city area and from major railway corridors. The bay beaches map, as expected, shows a decreasing satisfaction with increasing distance from bay beaches.

Fig. 4 Mental Map of Satisfact--ion With Closeness to Public Transport

Fig. 5 Mental Map of Satisfact-
-ion With Closeness to
Bay Beaches
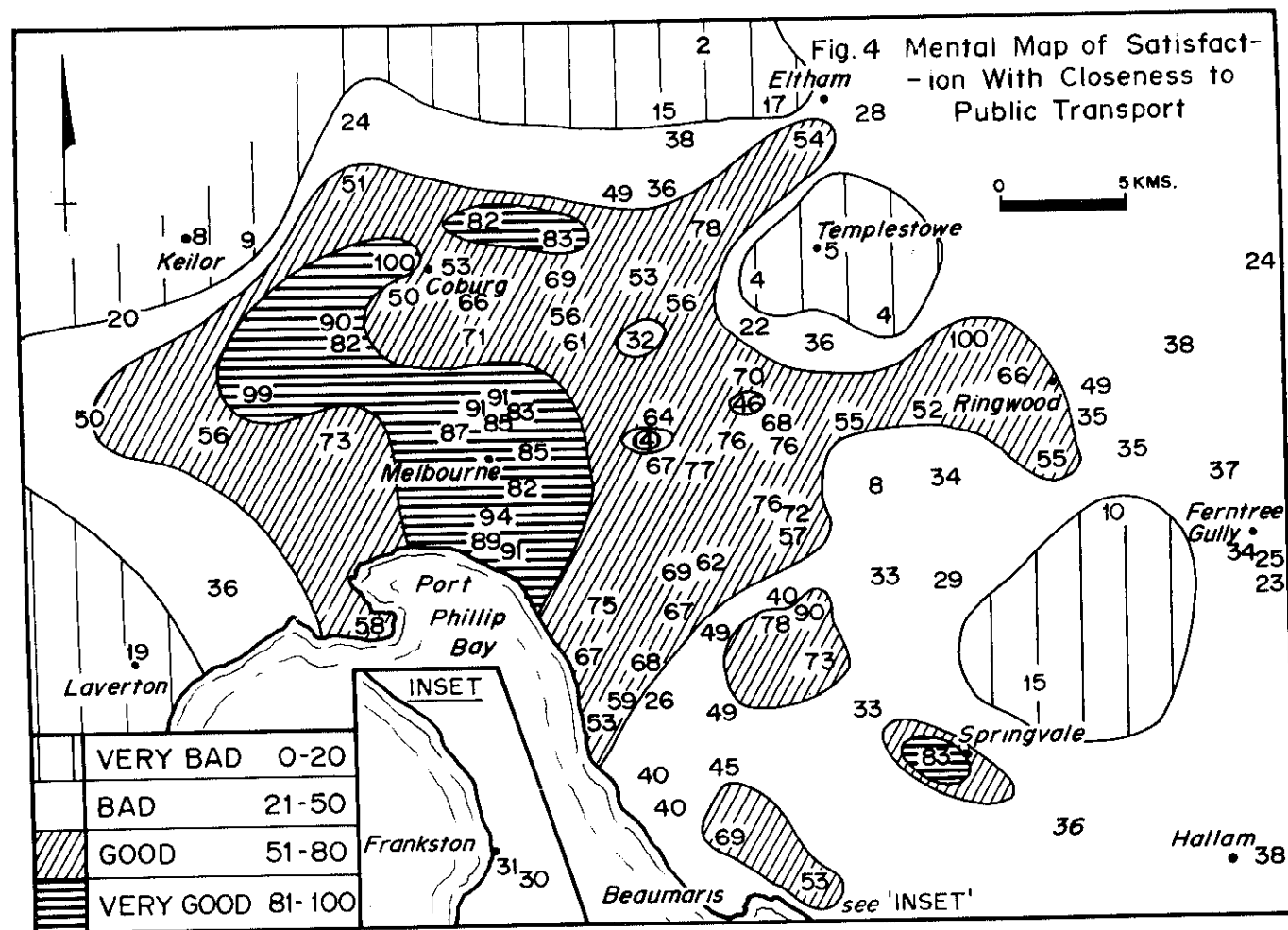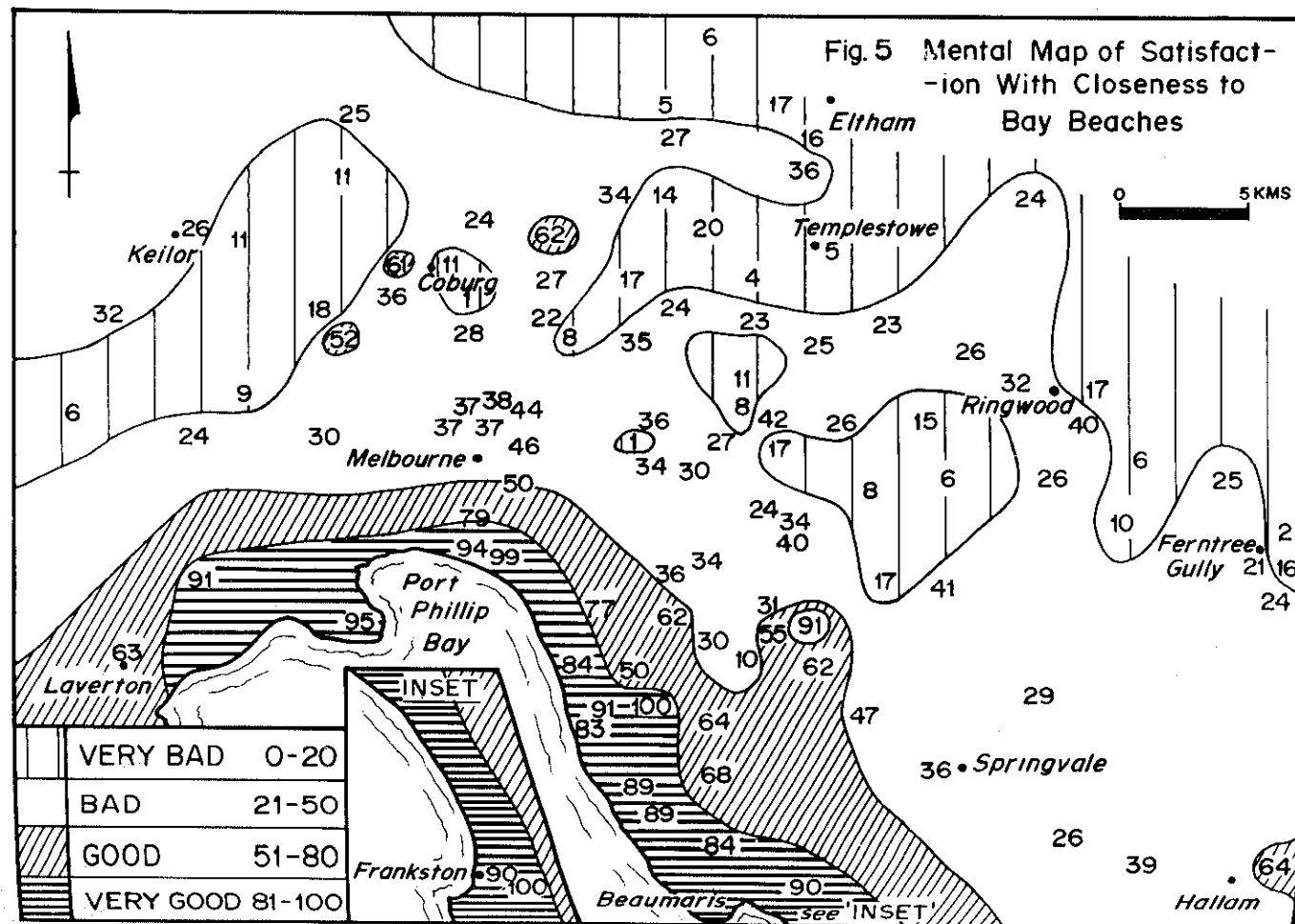
RESIDENTIAL PREFERENCE: A PERCEPTUAL VIEW OF MELBOURNE

Limited space in this paper prohibits the inclusion of the mental maps for all factors (see Young (1976) for further details). However, the general patterns which emerge include:

a) A radial pattern

(i)   the satisfaction with shops, public transport and entertainment decreases with increasing distance from the central city

(ii)   the satisfaction with open country, parks, pedestrian safety, traffic noise, traffic congestion, cost of housing and cleanliness of the air increases with increasing distance from the central city

b) An East-West distribution

Generally higher satisfactions were recorded in the east than the west for factors such as tidiness of the area, maintenance of buildings, presence of trees and shrubs and house type in the area.

c) An inland distribution

Satisfaction with bay beaches decreases with distance inland from Port Phillip Bay.

Polynomial Representation of Mental Maps

The mental maps as constructed above, although effective in representing the general distribution of satisfaction with a particular factor, had three distinct disadvantages. The first of these was the actual distribution of suburbs chosen by respondents. Whilst some suburbs were chosen quite often for evaluation by respondents there were other areas which did not attract a single response. Thus the tasks of interpolating and drawing contour lines in these areas was made quite difficult. Secondly, the unbalanced distribution of chosen areas also meant that while some suburbs' ratings were obtained from the average of a large number of responses, other suburbs' ratings were obtained from a single response only. If this response was extreme or atypical then the resultant mental map showed inconsistencies and discontinuities. Whilst such discontinuities, or fault lines, are indeed possible (see Gould and White (1974), pg. 191), it was felt that in the present study they were more the result of the data than of any underlying intrinsic cause.

Thirdly, since the mental maps were to be transformed into matrices for use in the subsequent modelling process, a simple computer-based process which eliminated the need for tedious hand calculations and contour map interpolations was desirable.

The solution to these three problems was to replace the hand-drawn mental maps of Figures 4 and 5 by polynomial surfaces fitted to the mental map data. The idea is similar to the terrain smoothing methods used in highway location studies such as GCARS (Turner and Miles (1969)). The basic objective of the method is to replace the observed mental map by a polynomial equation in terms of i and j (the coordinates of latitude and longitude within the urban area). This technique has several advantages. It makes interpolation at any point in the urban area very simple by merely requiring the substitution of the i and j coordinates in the polynomial equation. Secondly, the surface fitting process automatically gives more weight to those suburbs which receive a large number of respondent evaluations and less weight to single response (possibly extreme rating) suburbs. Thirdly, the expression of mental maps in polynomial form enables combinations of different mental maps to be performed in simple algebraic steps.

One decision that had to be made was the order of the polynomial to be used. In the GCARS terrain modelling exercise, little difference was found between polynomials of order six and higher order polynomials. To determine the order of polynomial to be used in this study, four measures of effectiveness were considered; changes in the residuals, correlation coefficient and F-ratio and visual observation of changes in the predicted surface as the order of the polynomial increased. Variations in the F-ratio and the correlation coefficient are shown for two factors, closeness to public transport and closeness to bay beaches, in Figures 6 and 7. It can be seen that as the order of the polynomial increases the degree of fit increases but at a decreasing rate. It can be seen that, like the GCARS study, increasing the order of the polynomial above six does not improve the analysis substantially. A sixth order polynomial was therefore used to mathematically describe the mental maps.

The best fit sixth order polynomial surfaces for the mental maps of closeness to public transport and closeness to bay beaches are shown in Figures 8 and 9. The corresponding polynomial equations for each mental map are given in equations 9 and 10.
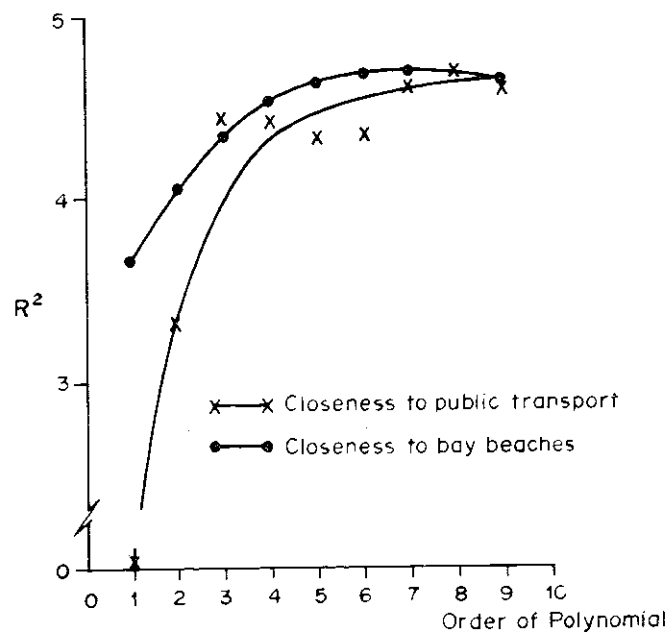
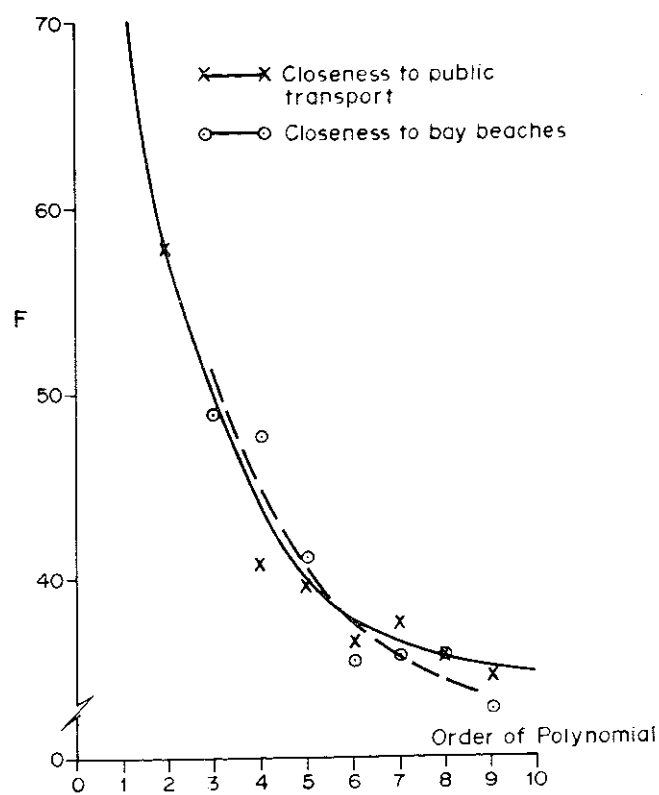Fig 6   Change in correlation coefficent with increasing order of polynomial

Fig 7   Change in F-ratio with increasing order of polynomial

$$S_{ij3} = - 127.19169 + 268.92652x + 320.27432y + 218.73746xy$$
$$- 78.70872y^2 - 128.73154x^2 - 47.44385y^4 + 57.80404xy^4$$
$$+ 47.63048x^3y - 2.6264c^2y^4 - 10.07402x^4y^2 + .8048x^6$$
$$- 5.0805y^6$$

$$\text{(9)}$$

$$S_{ij5} = 170.14029 - 274.47874x - 94.61756y + 258.61871x^2$$
$$+ 43.81979y^2 + 4.48847x^2y - 69.37533x^3 - 7.34912y^4$$
$$+ 47.42061xy^4 + 4.91584x^4y - 39.99746x^2y^3 + .2228x^6$$
$$- 7.37561y^6$$

$$\text{(10)}$$

where the origin for the co-ordinates is the top right-hand corner of figure 4, $x = i/10 = .2$ km; $y = j/10 = .2$ km.

From Figures 8 and 9 it can be seen that the basic features of the original mental maps are retained. The bay beaches mental map shows the same inland distribution, whilst the public transport map shows the predominant radial distribution with the influence of rail lines, especially the Dandenong corridor to the South-East. The major difference is that the maps exhibit much more regular contour variations with none of the isolated peaks and depressions shown in Figures 4 and 5.
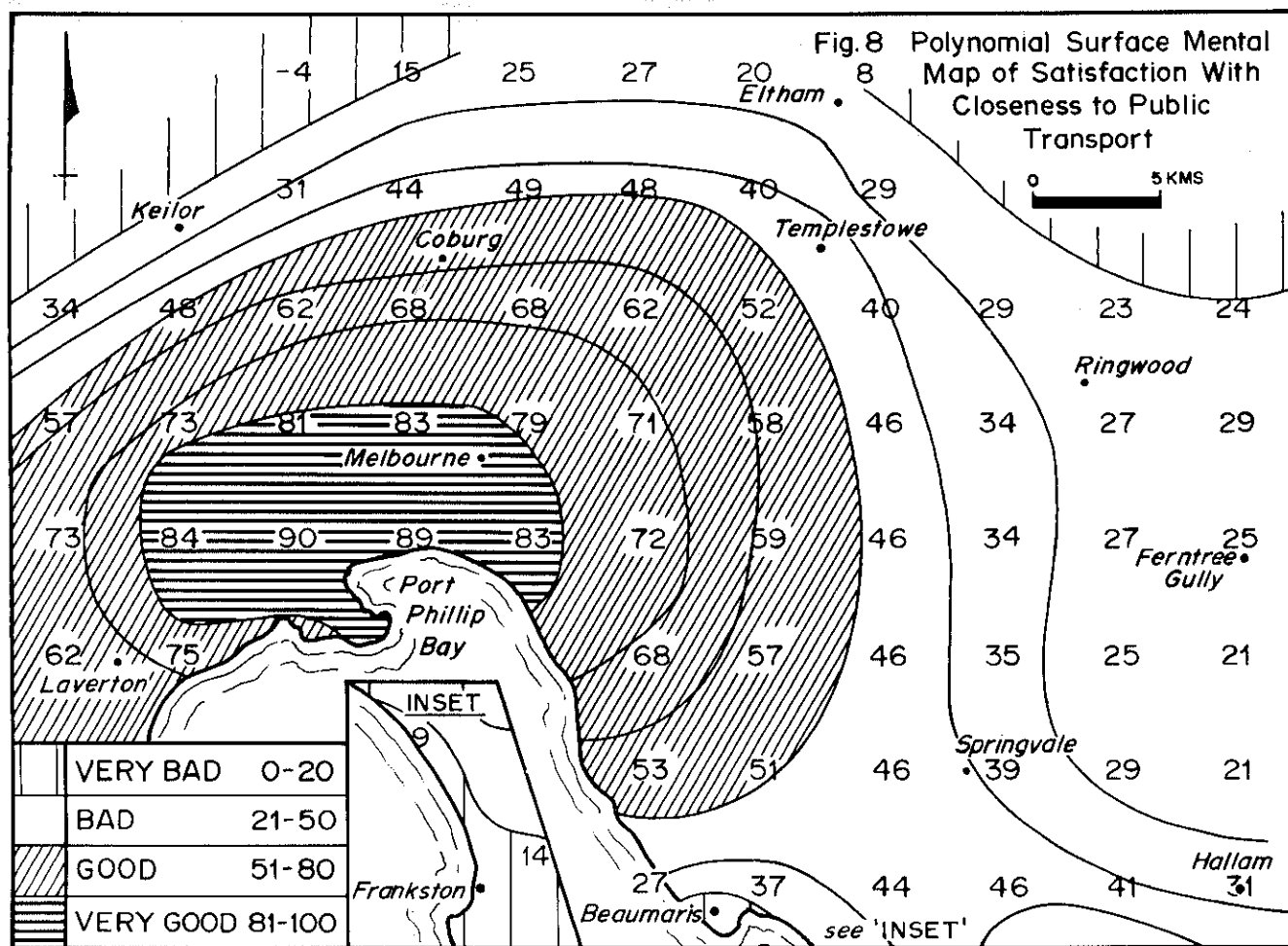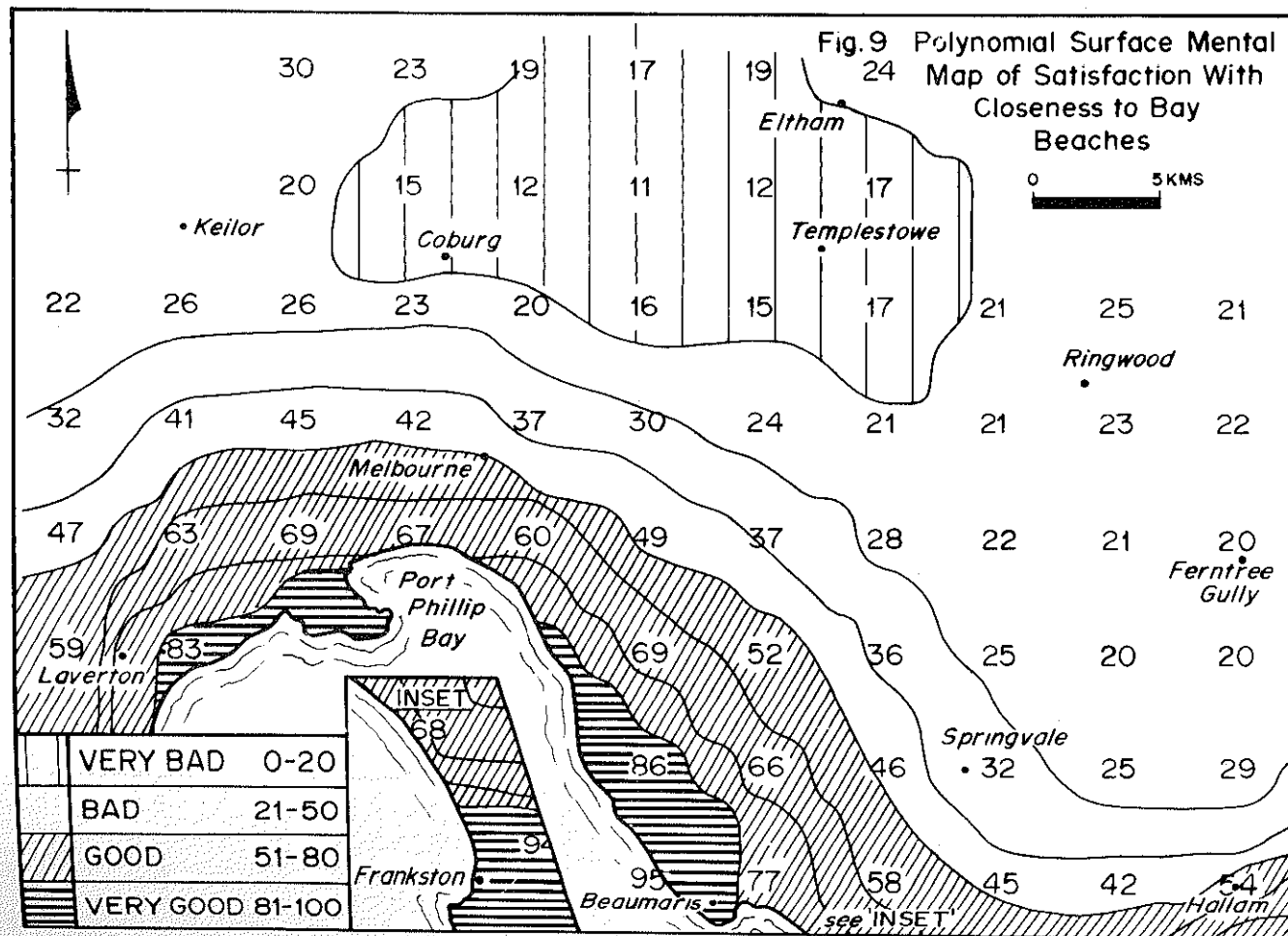
PERCEIVED UTILITY SURFACE

To obtain the perceived utility surface of the area, it is necessary to multiply the matrix of mental maps obtained in the previous section by the matrix of importances as shown in equation (5). The importance of each characteristic in the location choice decision is shown in Figure 10. These ratings were obtained, as stated earlier, from the respondents in the study by means of semantic differential scales. The values shown in Figure 10 are average importances for all respondents and do not allow for individual differences.

To obtain a perceived utility surface on the same scale as the previous mental maps, equation (5) was modified slightly to give equation (11):

$$S = \frac{I_k}{\displaystyle\sum_{k=1}^{M} I_k} \cdot \{S_{ijk}\}$$

$$\text{(11)}$$

Hence instead of obtaining a weighted sum of the satisfactions one obtains a weighted average. Although this procedure contravenes theoretical evidence (Golob and Dobson, 1974), it should, in this situation, make no difference since all alternatives have the same characteristics set size. It does have the advantage of making the mental maps and utility surface easily comparable. The resultant utility surface is shown in Figure 11. It should be noted that the utility values shown

Fig. 8 Polynomial Surface Mental Map of Satisfaction With Closeness to Public Transport

Fig. 9 Polynomial Surface Mental Map of Satisfaction With Closeness to Bay Beaches
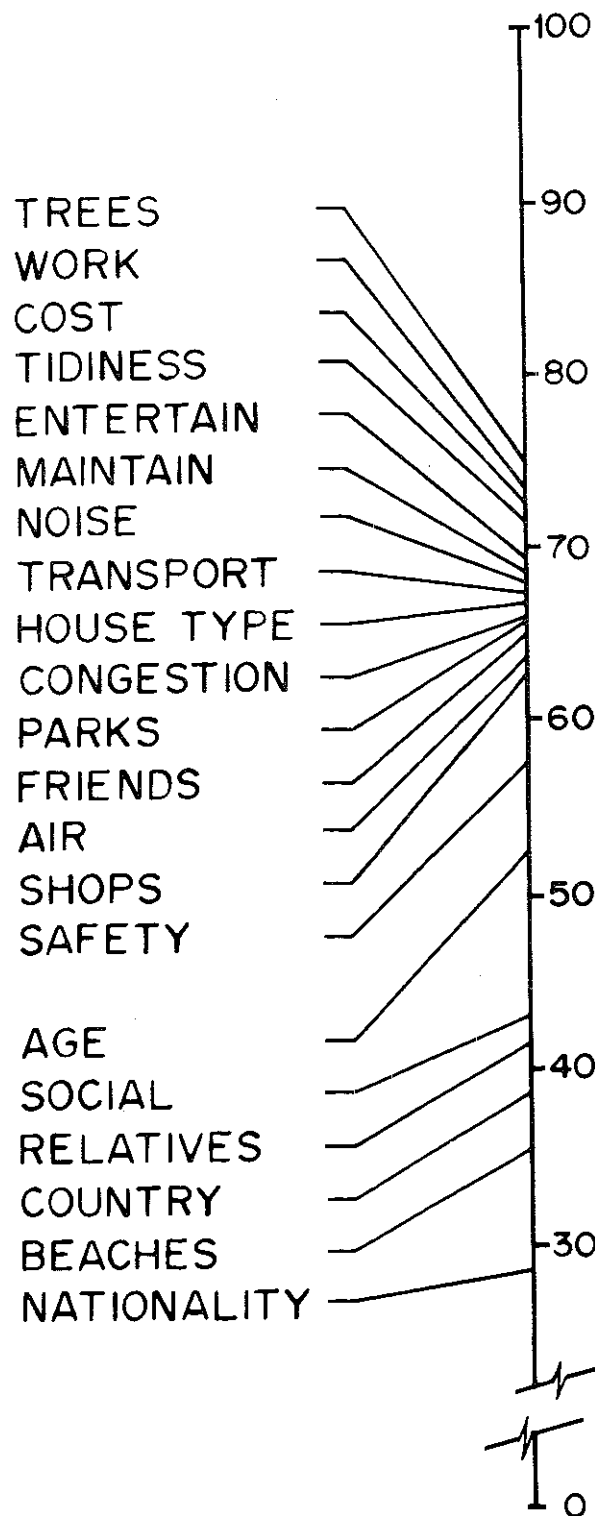
Figure 10   Importance Placed on Particular
             Factors by Respondents

on Figure 11 are on a 1 to 100 scale, where 1 represents completely unsatisfactory and 100 represents completely satisfactory.
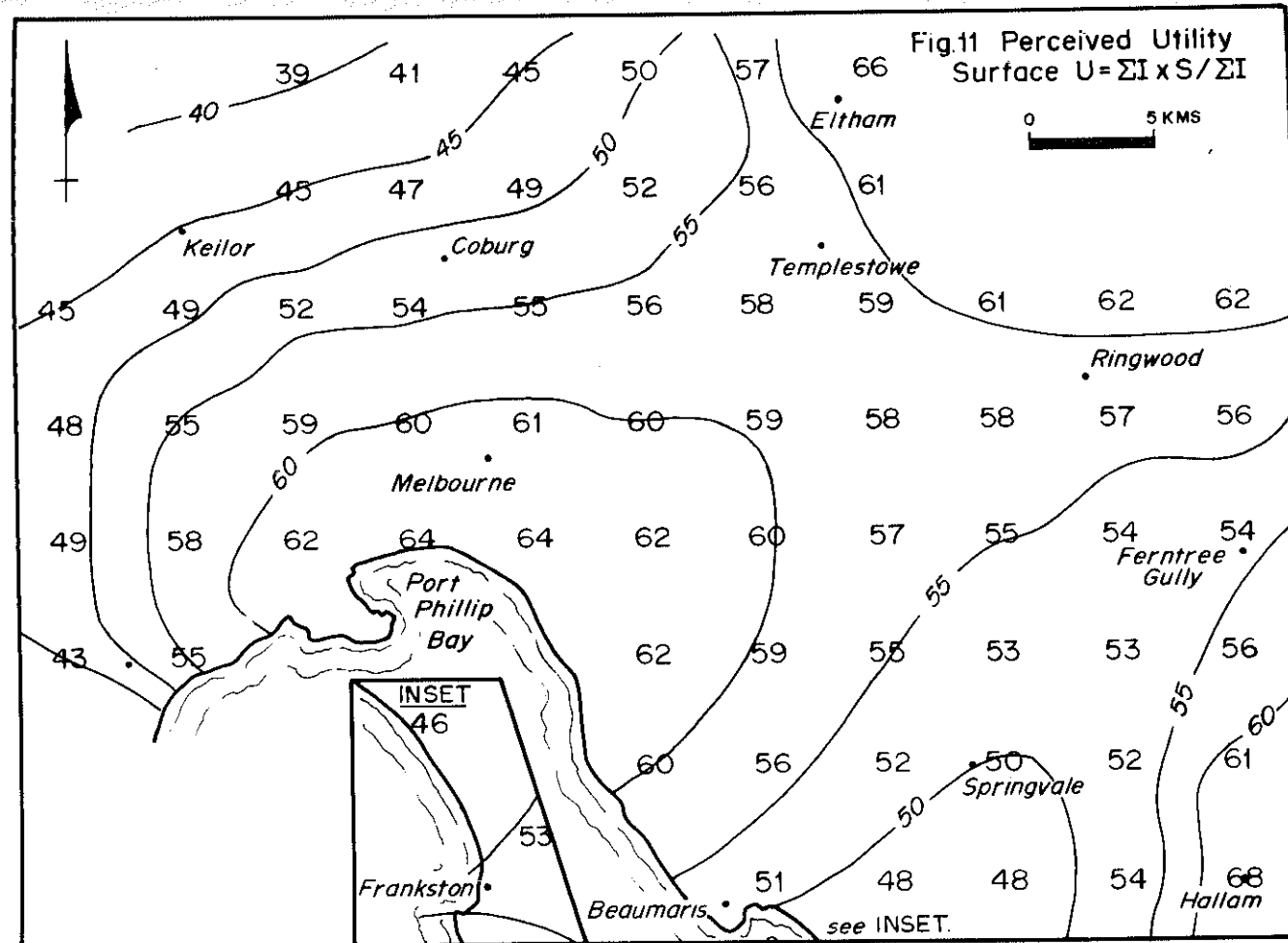
The most desirable areas, according to the respondents in the survey, are the inner suburbs and the Eltham area. This reflects the fact that many of the respondents were either students or young professional people who would be aware of and in sympathy with the environmental advantages of an area like Eltham, but who for practical reasons lived close to work or university in the inner city area. The most undesirable areas were the north-western suburbs and an area around Springvale and Dandenong (both industrial areas) in the south-east. Beyond Dandenong, desirability improved as one reached areas like Frankston and Berwick.
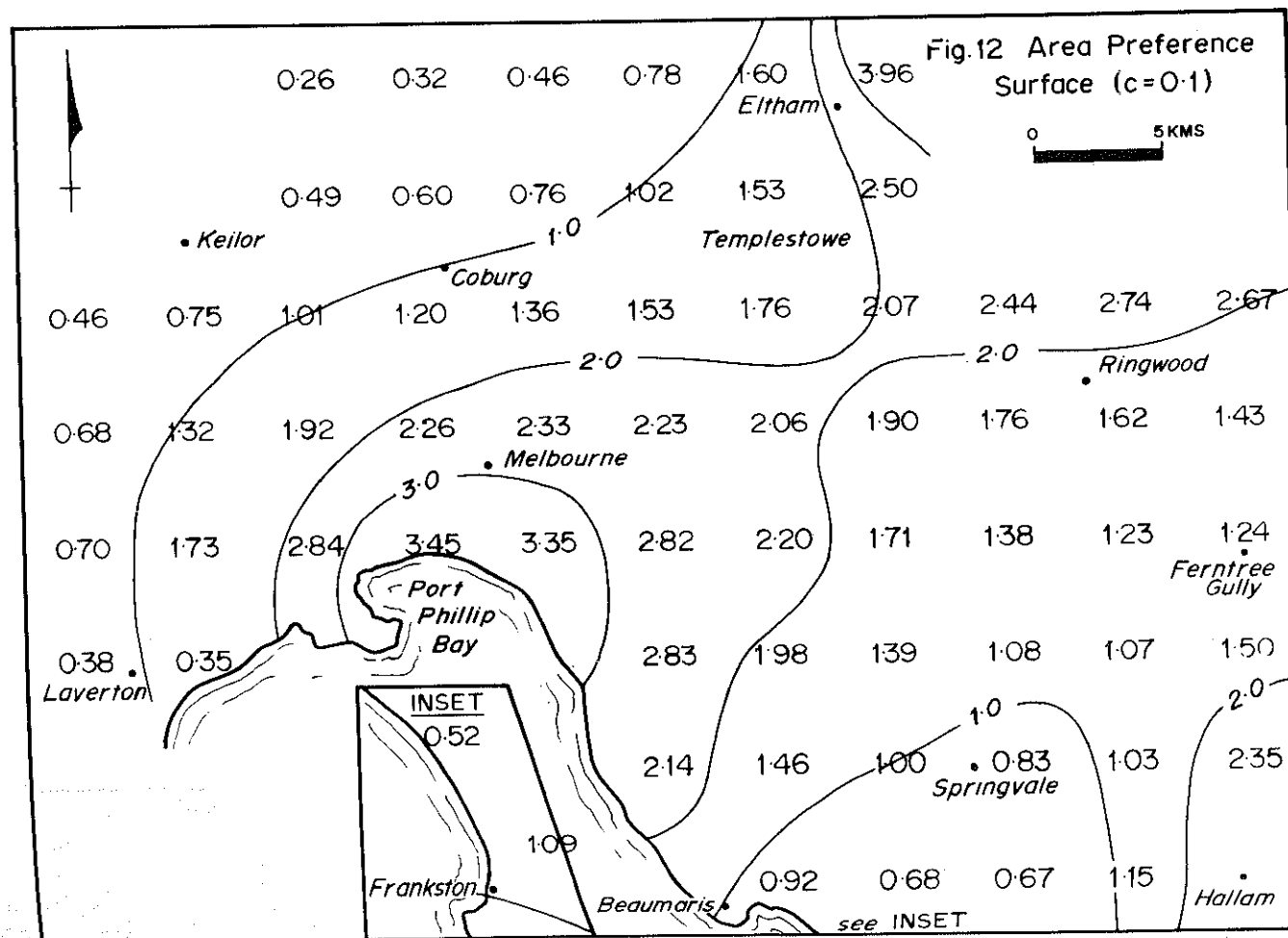
AREA PREFERENCE SURFACE

Whilst Figure 11 gives a good indication of how the urban area of Melbourne is perceived by the type of person in our survey, it does not indicate how such people would react to this perception in a choice situation. To convert the utility surface into an area preference (or choice) surface, one must apply equation (8), where S is defined in equation (11). Using values of C = 0.1, the resultant preference surface is shown in Figure 12. The elements of the preference surface matrix, as shown in Figure 12, represent the relative probabilities of a particular latitude/longitude combination being selected in a choice decision. Since the area of each location is constant, the elements also represent the residential density at that point.
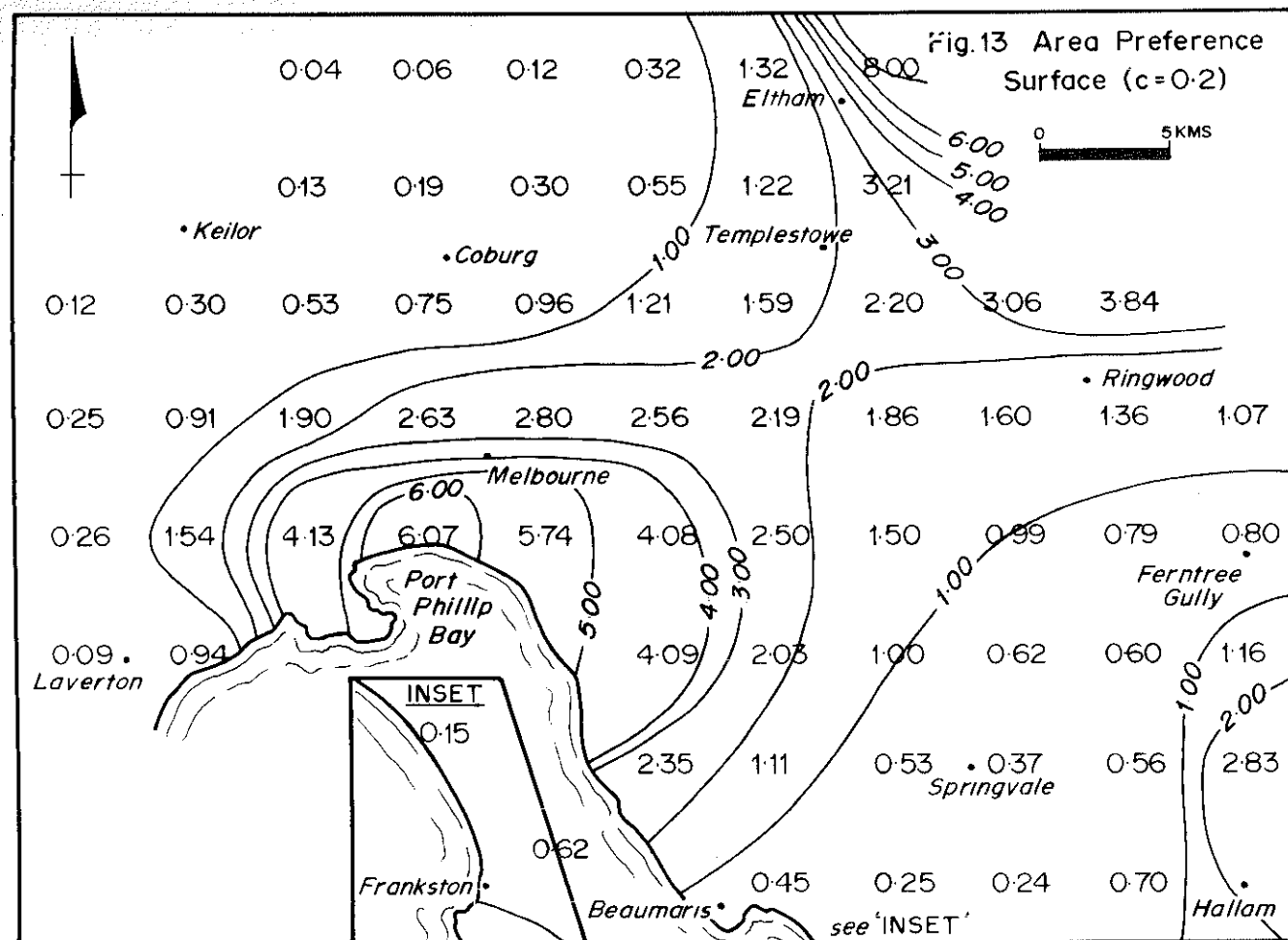
The contour lines on Figure 12 show the percent chance (or preference) people have of locating in that area of Melbourne. As can be observed the most attractive areas are around the central city, Eltham and East of Hallam. The least attractive areas are in the north-west and at Springvale/Dandenong.

To illustrate the effect of the sensitivity coefficient c, a new area preference surface was constructed with c = 0.2. The resulting map is shown in Figure 13. As might be expected, when the sensitivity coefficient increases peoples' sensitivity to differences in the utility gained from living in each area increases. In terms of the actual preference surface, the peaks become higher and the troughs lower. The shape of

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Fig.11 Perceived Utility Surface $U = \Sigma I \times S / \Sigma I$

Fig. 12 Area Preference Surface (c = 0.1)

Fig.13 Area Preference Surface (c = 0.2)

the surface is more evident in the three dimensional perspective drawing shown in Figure 14.

Obviously, the choice of sensitivity coefficient has a large impact on the actual distribution of choice resulting from a perceived utility surface. No attempt has been made in this paper to estimate this sensitivity coefficient. One possible technique would be to match the density distribution obtained from the model with an observed density distribution of the population in question (e.g. young, married, professional couples with no children). Adjustment of the coefficient to achieve maximum agreement of the density distributions may result in a valid estimate of the sensitivity coefficient. Further research is needed on this problem.

USE OF THE MODEL

The model as outlined in this paper has several uses. Firstly, it can be used to estimate the area preferences of a particular group in the community. This group may be defined on the basis of socio-economic classification or by present residential location. Such information would be most useful in migration studies such as those performed by Maher (1978). Alternatively such information could be collected on a regional basis to assist in the planning and prediction of impact of the development of growth centres (Young and Richardson, 1977).

Secondly, since the areas are described in terms of the characteristics of the area, individual mental maps may be constructed to help isolate the perceptions, and misperceptions, of individual factors. Such information would be most useful in a marketing campaign to help promote particular locations.

Thirdly, since each characteristic is considered individually then changes in each characteristic, which may result from a change in the physical environment (e.g. an improved transport system, a new regional centre), may be traced through the model to assess their impact on the overall area preference surface.

Finally, and most importantly, since the output of the model is in visual form, either as a contour map as in Figure 13 or as a perspective drawing as in Figure 14, or as a physical terrain model, the uses of the model can be communicated to the decision-maker with maximum effectiveness. No knowledge of the mathematics and equations is necessary for the decision-maker to appreciate the effect of his policy decisions. In this regard, the model is ideally suited to use with an interactive computer graphics display.

Fig. 14 Three Dimensional View of Area Preference Surface (c=0·2)
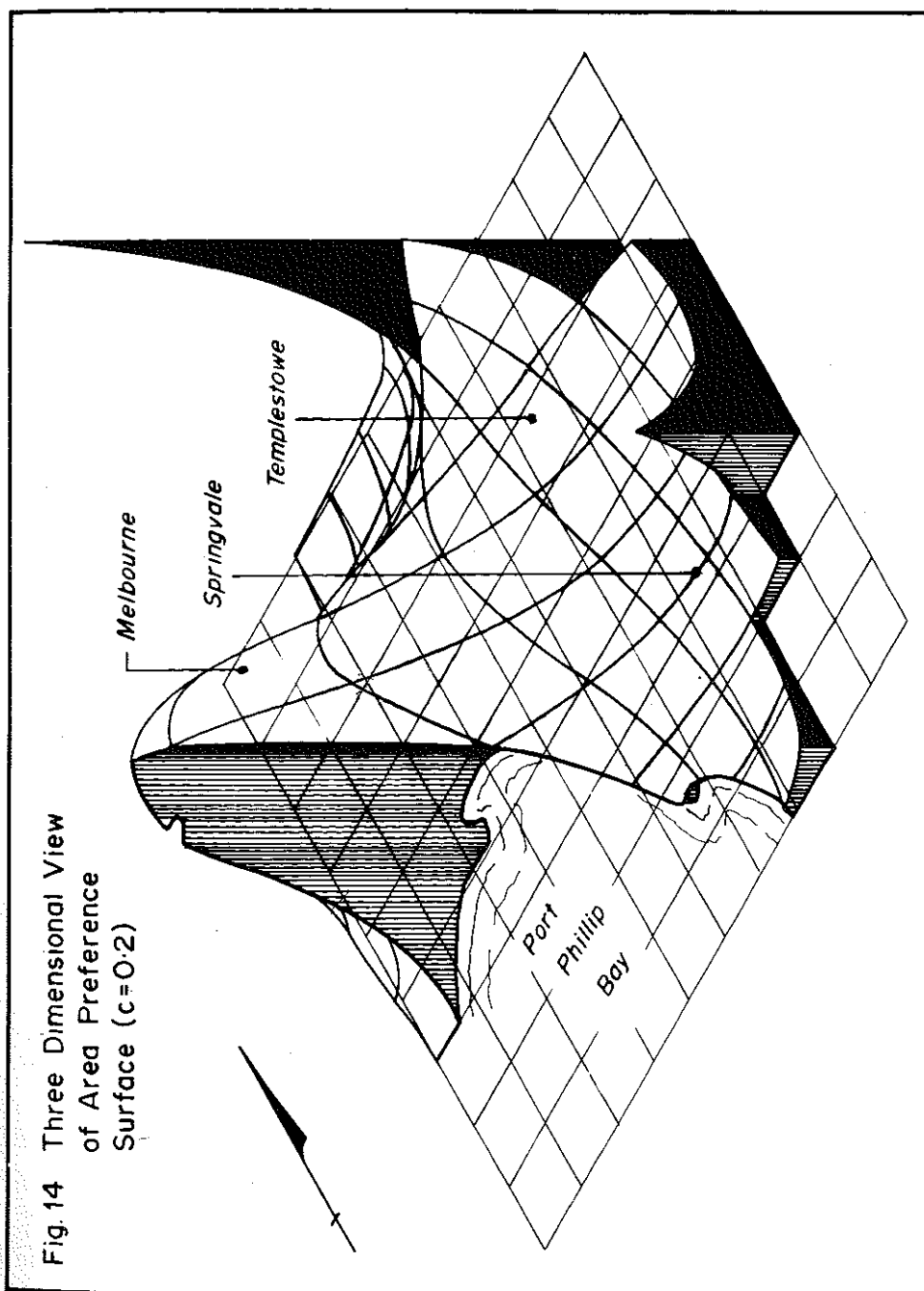
CONCLUSION

Ihe technique described in this paper combines the features of multidimensional mental maps and multinomial logit choice theory. In doing so it enables the presentation of the results to be made in an easy-to-understand visual manner. Such a technique should insure maximum comprehension of the effect of transport or land use policy on residential location choice.

Ihe model is demonstrated using data collected from a survey of new residents of inner Melbourne suburbs. It is shown to produce a logical, consistent perceptual view of Melbourne by people in the study. Further research is shown to be needed in the choice of a sensitivity coefficient for use in the model.

Ihe model is believed to be particularly useful in bridging the gap between planner, technologist and decision/ maker in the land-use/transport planning task.

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