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## ESTIMATION OF CONSUMER'S SURPLUS VALUES FOR LAND POLICIES

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**Changing social objectives and a greater variety of policy instruments require extra detail and fuller specification in analyses of land policies. Consumer's surplus remains an appropriate measure of net social benefit but surplus values must be estimated more carefully. The paper examines the application of four surplus concepts to policy problems and illustrates a methodology to estimate all four. The estimates for the different concepts can differ widely and the correct concepts have not always been advocated. The methodology appears useful where other estimation procedures have failed.**

### *Introduction*

Consumer's surplus has long been accepted as an appropriate measure of net social benefit. In his seminal contribution to the theory, Hicks (1943) identified and defined four surplus concepts. Several recent analyses of land use decisions have drawn on this contribution in their definitions, terminology and models. They follow this theory in arguing that an appropriate concept for one decision may be inappropriate for another. But they sometimes depart from the theory when they select a particular concept for an actual problem. And so far no empirical methodology is available to estimate all four concepts directly.

Land use policies remain concerned with the traditional issue of efficiency. But current interest has turned to the distributional and environmental consequences of land uses. For example, Olsen (1975) considered construction of a dam in a natural valley. There were reservoir-associated benefits for some consumers and valley-associated benefits for others. The latter benefits centred on option value—the premium that potential consumers of a good are willing to pay to ensure that it remains available. Woodfield and Cowie (1977) discussed consumer's surplus estimates as bases for resource pricing. Gluck (1975) contrasted the surplus in continued fishing of the Rakaia River with the lost surplus if fishing permits were withdrawn. Sanderson (1974) examined the effects of increased crowding on individual utilities. The same problem was investigated by Sinden and Smith (1975) but for natural rather than developed recreation environments.

The problems of continued use versus withdrawal, resource ownership, pricing and changes in the quality of a good have always existed. The associated policy tools of compensation and regulation have also long been known. But attempts to model these problems and estimate values are more recent.

\* I would like to thank, without implication, G. Olsen and D. R. Gallagher for their criticisms and encouragement and the formal but anonymous reviewers for their comments.

The objects of this paper are to indicate which concepts are appropriate for some specific land use problems and to present a methodology for estimation. The argument begins with a review of surplus theory including the definition of surplus concepts and a comparison of which have been applied and which should be applied. This theoretical review is followed by three applications of the methodology. The final discussion concerns the feasibility of the method, the validation of surplus estimates and the use of money and non-money measures of utility.<sup>1</sup>

The arguments concern particularly the withdrawal and 'forced' change in the quality of a good. One surplus concept (the quantity equivalent variation) seems appropriate where withdrawal is complete. But another (the price equivalent variation) seems appropriate where withdrawal just increases the price or decreases the quality of the good. These arguments differ from some recent analyses. The empirical methodology indicates that surplus values may differ considerably between concepts. Further, the applications show where the proposed methodology provides values where other methods have failed.

### *The Theory and its Application*

#### *The four surplus concepts*

The four concepts are distinguished by the direction and nature of the change in consumption of the good. For illustration, consider the following two polar cases. In one, the individual starts with no consumption and increases the quantity taken. In the other, he may start with some consumption but the quantity available to him is reduced to zero. In both cases, the surplus can be visualised as the change in income necessary to restore his initial level of satisfaction. Two concepts apply in each of these polar cases, depending on whether he can adjust his consumption after the change in income.

The four concepts are now defined following Hicks (1943).<sup>2</sup> Consider first a consumer who is not now consuming the good (Figure 1). *Quantity compensating variation*. The quantity compensating variation is the fall in income (tax) which just offsets a *rise in quantity* and leaves the consumer at his original level of satisfaction. No adjustment in consumption is permitted after the fall in income.

<sup>1</sup> This paper concerns surplus values for the individual and skirts the problems of aggregation. Nevertheless, the methodology follows conventional indifference theory. Thus as Currie, Murphy and Schmitz (1971) argue, the sum of the individual values represents aggregate market value when (a) the marginal utility of money is constant, (b) only the price (or quantity) of the relevant good is changing, and (c) the income elasticity of demand for the good is zero. The methodology may successfully value utility for the individual. But any success for groups of individuals requires that these three conditions be met.

<sup>2</sup> Currie, Murphy and Schmitz (1971) review all of Hicks's relevant work (Hicks 1942, 1943, 1956) and attribute eight concepts to him—rather than the four defined here. These four prescribe that a change in income must leave the consumer on his initial indifference curve. They follow the work (Hicks 1943) that underpins the current debate on land policies and rest on the current property rights situation—as described in footnote 6 of the present paper. The other four concepts allow the consumer to move to a new indifference curve and so rest on property rights that are inappropriate to the present discussion.

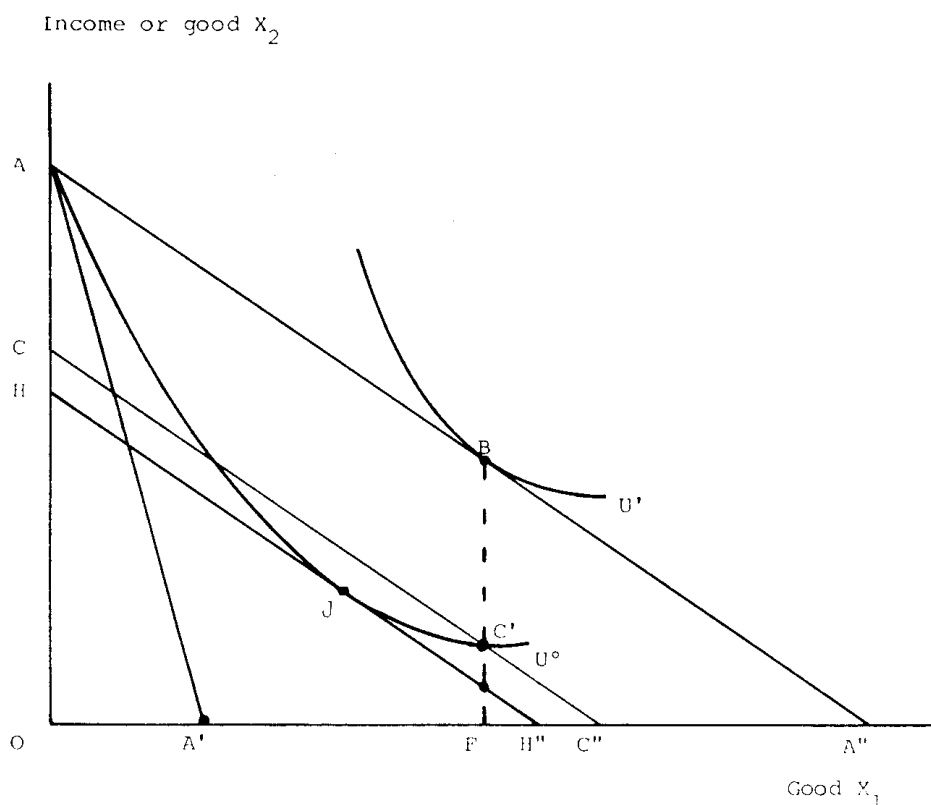


FIGURE 1—The quantity compensating ( $AC$ ) and price compensating ( $AH$ ) concepts of consumer's surplus. (The consumer starts at  $A$  and faces a fall in price or a rise in quantity).

The individual of Figure 1 faces the income and prices of the budget line  $AA'$ , is presently consuming zero quantity of the good  $x_1$  and so is at position  $A$ . The price of  $x_1$  drops to give the new budget line  $AA''$ . The individual reallocates his budget and consumption to move to  $B$  where he consumes quantity  $OF$  or good  $x_1$ . He is taxed by amount  $AC$  ( $=BC'$ ) to bring him back to his original indifference curve  $U^\circ$ . Amount  $AC$  is the required fall in income and so is the quantity compensating surplus.

*Price compensating variation.* Price compensating consumer's surplus is the fall in income (tax) which just offsets the effects of a fall in price to leave the consumer at his original level of satisfaction. The individual is permitted to change the quantity consumed after the fall in income.

The individual again faces budget line  $AA'$  (Figure 1) and starts at  $A$ . The price of good  $x_1$  falls to give the new budget line  $AA''$  and so he moves to  $B$ . Consider a tax of  $AH$  which gives the budget line  $HH''$ —parallel to  $AA''$ . He may change his consumption after the tax and so he moves from  $B$  to  $J$  on his original indifference curve  $U^\circ$ . The sum  $AH$  is the required fall in income and so is the price compensating consumer's surplus. Whenever indifference curve  $U^\circ$  is non-linear, and

convex to the origin, the price compensating surplus ( $AH$ ) is larger than the quantity compensating variation ( $AC$ ).

Now consider an individual who is consuming the good and so starts in a trading position such as  $B$  in Figure 2.

*Quantity equivalent variation.* The quantity equivalent consumer's surplus is the rise in income (subsidy) which offsets the effects of a fall in quantity and leaves the consumer at the same level of satisfaction. No changes in quantity consumed are permitted after the subsidy.

At  $B$  the individual consumes quantity  $OF$  of good  $x_1$ . The good is now withdrawn completely and so he is 'shifted up his budget line' to  $A$ .

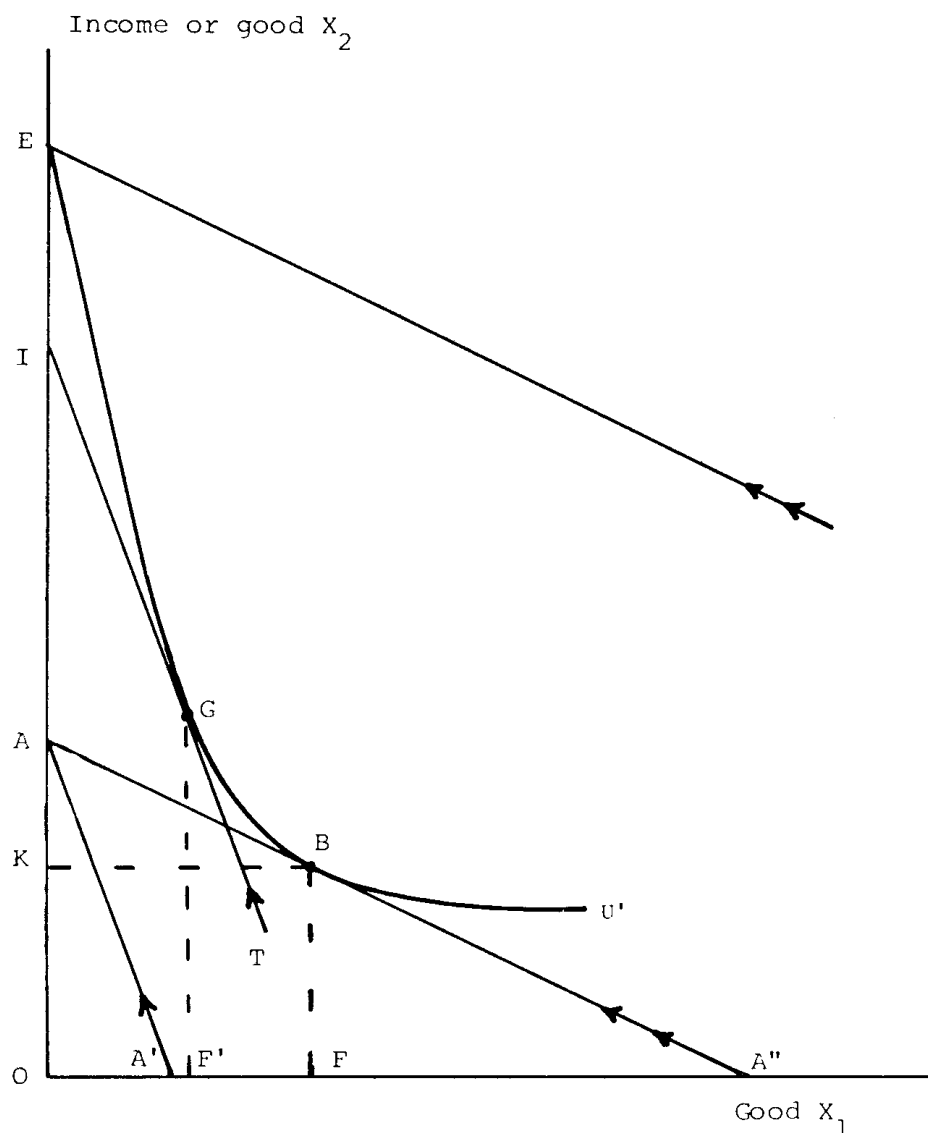


FIGURE 2—The quantity equivalent ( $AE$ ) and price equivalent ( $AI$ ) concepts of consumer's surplus. (The consumer starts at  $B$  and faces a rise in price or a fall in quantity).

Sum  $AE$  is required to return him to his original indifference curve  $U'$ . The amount  $AE$  is then the quantity equivalent variation.

*Price equivalent variation.* Price equivalent consumer's surplus is the rise in income (subsidy) which offsets the effects of a *rise in price* and leaves the consumer at the same level of satisfaction. Unlike the quantity equivalent variation, he is permitted to alter consumption after the subsidy.

The individual again starts at  $B$  in Figure 2 on budget line  $AA''$ . The rise in price gives a new budget line  $AA'$ . This rise must be high enough to eliminate all consumption of  $x$  and so he moves to  $A$  on the vertical axis.<sup>3</sup> Budget line  $IT$  has the same prices as  $AA'$  but, through the subsidy  $AI$ , has a higher budget. The individual can adjust his consumption along  $IT$  and so will move to  $G$  on his original indifference curve  $U'$ . Amount  $AI$  is therefore the rise in income which just offsets the effect of the rise in price. This is the price equivalent surplus. Figure 2 shows that the price equivalent variation ( $AI$ ) is less than the quantity equivalent variation ( $AE$ ) whenever indifference curve  $U'$  is non-linear and convex to the origin.

#### *Which concepts have been advocated?*

The attempts to apply different surplus concepts are partly a response to the changing objectives and issues of land policies. The current literature has mainly addressed the issues of withdrawal and property rights, as this review will indicate.

In their study of irreplaceable natural resources, Krutilla, Cicchetti, Freeman and Russell (1972) suggest that the 'price equivalent' measure applies where an individual is presently consuming a good but the rights to consume are withdrawn. Their 'price compensating' measure applies when the individual is not currently consuming the good and measures the surplus from further consumption.<sup>4</sup> This study was part of the option value debate which Olsen (1975) succinctly summarised. Following earlier writers, Olsen discussed two consumer's surplus concepts and developed arguments from Hicks's original contribution (1943) in the field. But Hicks's paper was entitled 'The Four Consumer's Surpluses' as a revision of an earlier paper (1942) in which he discussed only two concepts. Along with other participants in the debate, Olsen promoted the price equivalent variation. The price compensating version was advocated where the project provides more of an existing good, or a good that is not now consumed.

The current concern with who owns the environment and so who receives compensation has been analysed within the existing surplus framework. This problem also involves the distinction between withdrawal and continuation of a good. Krutilla and Fisher (1975) have reviewed and summarised several earlier studies that bear on this

<sup>3</sup> I am grateful to an anonymous reviewer for clarifying this point.

<sup>4</sup> Krutilla et al. (1972) used the labels of 'price equivalent' and 'price compensating'. Their 'price equivalent' concept is the quantity equivalent concept of the present paper.

problem. Consider, for example, the choice of concepts to analyse the balance of mining output and amenity benefits. If the miner has the rights to the property that provides the amenity benefits, then—to use their term—the ‘compensating variation’ is the appropriate measure of the surplus from the amenity benefits. Their diagram indicates that they mean the price compensating surplus. But now suppose the amenity rights are vested in the consumer and the miner will somehow destroy the amenity resource. Krutilla and Fisher (1975, p. 31) define the appropriate surplus here as the amount the consumer would accept in return for his right to consume, providing he is as satisfied after destruction as before. Their model indicates that this surplus concept is the quantity equivalent variation, even though the concept is under-defined and unnamed in the text. Krutilla and Fisher incorrectly rest their argument for just these two concepts on an earlier discussion by Mishan [1971, Ch. 48]. Mishan had in fact discussed all four concepts.

Gluck (1975) derived empirical estimates of consumer’s surplus for two policy situations, namely, continued fishing and the withdrawal of rights to fish. The surplus concept for both situations was termed ‘compensating variation’ whereas this concept could only fit the former policy problem. Nevertheless, Gluck’s survey questions followed the correct concepts. The question to elicit the surplus for continued use rested on the price compensation variation. The question for withdrawal rested on the quantity equivalent variation.

Even this brief review indicates that some writers use different terms for the same concept, some use the same term for different concepts, some use empirical methods which fail to follow the concept they advocate and some under-define their concept. Further, none of these writers recognises all four concepts. The general problem of which concept to use is now considered as an introduction to the assessment of the importance of errors in choice of concept in particular applications.

#### *Which concepts should be used?*

The choice between the concepts must always rest on the actual policy decision and will always require *ceteris paribus* assumptions. Consider a decision where a good is to be withdrawn. The theory indicates that both the price equivalent and quantity equivalent variations apply to this decision—as far as the decision has been specified. But, along with other writers on option value, Olsen refers just to the price equivalent variation. The theoretical specification and difference between the two concepts invites several questions. Does the role of the two equivalent variations need to be distinguished in practice and, if so, does one seem more relevant than the other? And is the price equivalent version more relevant—as Olsen (1975) implies? To choose the appropriate concept here, and more generally to choose between the four concepts, we need to look more closely at demand theory. The relevant theory and the four concepts are summarised into Table 1 to facilitate this choice.

Demand can be viewed in terms of the questions that the consumer must answer in the particular market. In the first market situation the

TABLE 1

*The Choice between Four Concepts of Consumer's Surplus*

Nature of the market (1)	(2)	Appropriate measure of consumer's surplus (3)
	<i>Change in price</i>	
(i) Consumer is free to purchase any quantity at the given price. (price into quantity)	fall (a) Price compensating variation	rise (c) Price equivalent variation
	<i>Change in quantity</i>	
(ii) Consumer must take a given quantity, but is free to offer any price. (quantity into price)	rise (b) Quantity compensating variation	fall (d) Quantity equivalent variation

question is, what quantities shall I consume at the given prices? Here the consumer is a pure competitor in the market and is free to purchase any quantity at the given price. In terms of the above definitions, price compensating and price equivalent measures are appropriate (row (i) of Table 1). In the second market situation the goods are rationed and consumers are somehow compelled to take certain quantities. The consumer now assesses the maximum price that he will pay for a given quantity. His question is, what prices shall I pay for the given quantities? His willingness-to-pay now refers to some specific, fixed quantity of the good. The quantity compensating and quantity equivalent variations refer to this situation (row (ii) Table 1).

Option value exists when there is some possibility that the good may not be available in the future. This market situation involves a fall in quantity consumed or a rise in price and so one of two variations in column 3 of Table 1 is appropriate. Hicks himself (1943) provides some insight into the choice between the price equivalent and quantity equivalent variations and indicates that the policy problem will suggest the relevant variation. He writes as follows (p. 39):

. . . if the article is not merely outside the reach of this particular consumer, but is actually not being produced at all in one of the situations which are being compared,  $E_p$  (= price equivalent variation) ceases to be an important magnitude . . .  $E_q$  (= quantity equivalent), on the other hand, is an interesting magnitude. . .

And lower down on page 39,

. . . we do need to consider this case, when the article disappears altogether . . . and here we must have recourse to quantity-variations. . .

Thus the quantity variations are important in problems where quan-

tity is rationed. In general, the quantity equivalent variation may be as important as the price equivalent variation.<sup>5</sup>

Which measure then applies to a particular option value situation? The appropriate concept must depend on the particular policy issue. Consider, for example, the flooding of a natural area for a reservoir. The valley in its natural state is being completely removed—and not just priced out of reach. The appropriate measure for a good or activity in this specific environment seems to be the quantity equivalent rather than price equivalent variation. Some natural resources may be unique in some acceptable physical or biological sense, and the goods and activities they provide may have no effective substitutes. Withdrawal of these resources removes the goods completely. In this situation, the quantity equivalent variation also seems appropriate. On the other hand, the policy issue may involve a deterioration in a characteristic of a good at some location. But further quantities of the exactly same good may still be available but at a more distant location. Here the price of acquisition has risen and so the price equivalent variation seems relevant.<sup>6</sup>

The appropriate measure of consumer's surplus may depend on how the good is defined—as well as on the policy issue. Consider, for example, a good or activity like solitude. Any extra persons at the same site may completely remove the quantity available since solitude is an absolute state. The quantity equivalent variation may be relevant here.<sup>7</sup>

Hicks went on to suggest that the distinctions between the four variations might be 'a fiddling business'. But he did show that, when the income effect is positive but small, the magnitudes of the variations are in the following descending order: quantity equivalent, price equivalent, price compensating and, lastly, the quantity compensating varia-

<sup>5</sup> Various other contributors to the theoretical debate make substantial claims for particular concepts. Mishan (1971) promoted the price compensating variation when price falls and the price equivalent variation when price rises. He promoted other concepts when the consumer moves to a different indifference curve. Patinkin (1956) argued that Mishan's choice applies only for perfectly competitive markets. Mishan (1971, p. 328) dismissed the two quantity variations as unnecessary 'in ordinary circumstances'. These two variations were Marshall's (1930) definitions of consumer's surplus. However, my two quotes from Hicks indicate that Marshall's definitions may remain relevant to many land use problems—as Patinkin indicated.

<sup>6</sup> A reviewer questioned this choice of surplus concepts. The two equivalent variations were chosen when a good is withdrawn. Both variations return the individual to his original indifference curve—implying the inviolable right of the individual to the utility from the original consumption. But this implication rests on a particular system of property rights which, in turn, rests on a particular ethical judgment. The reviewer questions these basic judgments and so infers that perhaps other surplus concepts apply here. Without necessarily disagreeing, I have worked from the same bases as the earlier writers. Thus any different conclusions can be compared to their works because they involve identical assumptions. To question the underlying ethical judgments would add an extra dimension which is undesirable at this stage. But my own interpretation of current attitudes to property supports the positions of the earlier writers. Court decisions and legislation seem to justify the rights of the individual to the existing situation. Any forced changes must be justified, and often compensated, by the changer.

<sup>7</sup> I am grateful to G. Olsen (personal communication, 1976) for pointing this out.

tion. The graphical interpretation of Figures 1 and 2 permits further, more policy-oriented, conclusions. As argued above, more convex indifference curves lead to increased differences between price compensating ( $AH$  in Figure 1) and quantity compensating ( $AC$ ) surpluses. Similarly in Figure 2, more convex curves lead to an increased difference between quantity equivalent ( $AE$ ) and price equivalent surplus ( $AI$ ).

More convex curves may well be associated with the goods and services of unique natural resources.<sup>8</sup> Individuals may be willing to sacrifice large amounts of money for the first unit or to require greater and greater compensation for the withdrawal of more and more units of these resources. But goods with ready substitutes may have less convex curves because the first extra unit and last in withdrawal are more replaceable. Thus the difference in surplus estimates between two equivalent variations increases as the uniqueness of the resource increases (Figure 2). Equally, the concepts are identical and the difference disappears with a linear indifference curve ( $U'$ ).

#### *Applications of a Methodology*

Direct measurement of these surplus values for individual consumers requires indifference maps and budget lines. In a review of methods of indifference mapping, Sinden and Wyckoff (1976) suggest that only the models of utility estimation have provided entire maps with known utility intervals between curves. Estimation through the Ramsey model and utility functions is described elsewhere (e.g. Anderson, Dillon and Hardaker 1977 and Sinden 1974). This model is now applied to estimate surplus values for three policy problems. The structure of the maps for the model is discussed and then the necessary utility functions are presented or discussed without further consideration of the estimation procedure.

The first application is an attempt to estimate values for all four surplus concepts. The values indicate potentially large differences between the quantity equivalent and price equivalent variations. Estimation of option value through the price equivalent measure (the smaller of these two) may therefore seriously underestimate true option value. The second application is an attempt to estimate the lost surplus, and associated compensation, for withdrawal of the rural-way-of-life. The third relates to the utility losses of recreation with increases in crowding of recreation sites.

#### *Estimating all four surplus concepts*

The methodology was applied to estimate all four concepts for a policy problem on the Oregon-Idaho border (Sinden 1973). Reservoir construction in Hells Canyon would completely withdraw recreational facilities at the existing natural area. Following Figures 1 and 2, the

<sup>8</sup> The term 'unique' refers here to the perception of the consumer. The resource need not be physically or biologically 'unique' as long as the consumer perceives it as irreplaceable and useful.

good  $x_1$  was defined as a weekend of recreation at Hells Canyon. The good on the vertical axis ( $x_2$ ) was defined as a weekend in an alternative recreation activity. Good  $x_1$  is currently available and so the individual starts in a 'trading position' such as  $B$  in Figure 2. If this good is withdrawn completely, the individual will move back to  $A$ —*ceteris paribus*.

*Data collection.* Indifference maps were obtained for each subject for units of camping at Hells Canyon as  $x_1$  and camping at the Cascade Mountains as  $x_2$ . These two activities were real alternatives for the subjects at the time. The necessary utility functions (Table 2) were derived with the Ramsey model of utility estimation in the usual way (Sinden 1974).<sup>9</sup>

Data for the budget line were obtained by direct questioning. The marginal costs for travel, food, entrance fees, tolls and accommodation totalled \$40 for  $x_1$  and \$40 for  $x_2$ . The total budget for these two activities for the six weekends after the interview was \$200 for each family. An assumption was now introduced, namely all of this budget is spent only on the two activities. The assumption seemed realistic for the families in the survey and so the budget and cost data provided the price line  $AA''$  in Figure 2. The utility functions gave the empirical indifference maps. Together the price line and the map provided the graphical and mathematical means to identify points  $A$ ,  $B$ ,  $E$  and  $F$  and  $I$  and so to estimate consumer's surplus values of  $AE$  and  $AI$ . For family number 2, for example, with the utility function 2 in Table 2,  $OF$  represented two visits to  $x_1$ .

*Estimation of surplus values.* With units of  $x_2$  as a proxy for income, the values for the different surplus concepts can be read off the figure

TABLE 2  
*Utility Functions<sup>a</sup> for Two Subjects for Two Recreation Activities*

Subject	Utility function <sup>b</sup>	Coefficient of determination
1	$U = 19.3 + 8.7X_1 + 4.7X_2 - 1.6X_1^2 - 0.2X_2^2$	0.94
2	$U = 58.7 + 32.3X_1 + 14.2X_2 - 4.8X_1^2 - 0.6X_2^2$	0.84

<sup>a</sup> The functions were derived for one individual or subject in each family. The interview began with a series of factual questions on family data. These questions acted as a filter which allowed the interviewer to select the apparent decision-maker in the family. The games for the Ramsey model were directed to this person.

<sup>b</sup> The cross product terms ( $X_1X_2$ ) were insignificant in these models. The coefficients for the independent variables were significantly different from zero at the 1 per cent level or better.

<sup>9</sup> The utility functions and indifference maps were originally estimated to provide demand curves to estimate otherwise unpriced benefits (Sinden 1974). The present application to estimate four surplus concepts was undertaken to clarify and provide empirical content on the importance of different surplus concepts.

in units of days of  $x_2$ . Once the price of  $x_2$  is fixed, units of it could be converted directly into money terms.<sup>10</sup> Consider family 2 which is in some sense already endowed with two ( $OF$ ) units of  $x_1$  and at point  $B$  (Figure 2). If 'forced' to move back to  $A$ , an extra 5.5 days of  $x_2$  must be provided to exactly compensate for the loss of 2.0 days of  $x_1$ . The quantity equivalent variation is therefore 5.5 days.

Estimation of the price equivalent variation ( $AI$  in Figure 2) requires data on the increase in price of  $x_1$ . Precise information on the increase in travel cost to a comparable site was not available and so a new price of \$80 was arbitrarily selected for  $x_1$ . The original budget and this new price identify the price lines  $AA'$  and  $IT$ . Together with the indifference map, point  $I$  can be identified.<sup>11</sup> The price-equivalent variation was estimated by calculating  $AI$ —again in units of  $x_2$ . The amount of  $AI$  was 4.1 days.

The quantity compensating ( $AC$  in Figure 1) and the price compensating ( $AH$ ) variations can be calculated in a similar manner. The price line  $AA'$  now reflects a price of \$40 for both. The price line  $AA''$  is now applied to the indifference map and the optimal point  $B$  is identified. Points  $C'$  and  $J$  are then identified to define the price lines  $CC'$  and  $HH''$  which are parallel to  $AA''$ . The surplus values ( $AC$  and  $AH$ ) can now be read directly from the graph or calculated mathematically.

*The values themselves.* The following consumer's surplus values were obtained, all in units of  $x_2$ : quantity equivalent variation—5.5 days; price equivalent variation—4.1 days; price compensating variation—2.4 days; quantity compensating variation—2.2 days.

The order of these values follows the Hicks argument which was noted above. But the differences between them seem rather large. For example, the quantity equivalent variation is one-third larger than the price equivalent variation (5.5 versus 4.1 days), suggesting that estimation of the correct concept of consumer's surplus may be empirically important.

#### *Measuring surplus losses with increases in crowding*

Changes in some characteristic of a good often accompany increases in population—even though the good itself is still available. A case in point is the increase in crowding of recreation areas. Sanderson (1974) set out to estimate changes in consumer's surplus for changes in levels of crowding at some recreation sites in northern New South Wales. More specifically he investigated (a) the role of changes in utility as a

<sup>10</sup> I am grateful to an anonymous reviewer for indicating the suitability of units of  $x_2$  as a proxy. Another reviewer noted that the methodology applies only when the two goods are the sole possible choices.

<sup>11</sup> Natural scientists have claimed (Krutilla 1971) that Hells Canyon has unique biological features. Camping at the Canyon may therefore be an activity with no substitutes. A reservoir would destroy such features and completely withdraw this recreation activity. The quantity equivalent variation is therefore the appropriate surplus concept. Further, the price of the withdrawn activity rises from \$40 to infinity, and not to \$80—as a referee indicated. But to estimate and compare all four surplus concepts, I need a price less than infinity. The price of \$80 serves this purpose and should be so viewed.

rationing device and (b) the quantity of an alternative which compensates for any loss in consumer's surplus due to increases in crowding.

A measure of change in utility following an increase in crowding can be read off the maps or calculated mathematically. Consider the preferences of the subject of Figure 3 and his consumption of one day of  $x_1$ . Further, assume that on present trends there will be 20 persons at the site during the specified time period rather than the 10 as at present.<sup>12</sup> In the trading/no trading terms of Figures 1 and 2, the subject is at  $A$ ,  $B$  or  $C$  or some other such position depending on his consumption of  $x_2$ —the alternative activity. If the subject starts at  $A$  he requires compensation of  $Ca$  (1.75 days of  $x_2$ ) to keep him on the same indifference curve. Similarly, Figure 3 shows that compensation of  $Cb$  (2.5 days of  $x_2$ ) and  $Cc$  (3.5 days of  $x_2$ ) are required for these positions. The values of  $Ca$ ,  $Cb$ , and  $Cc$  are estimates of the quantity equivalent surplus or the loss in utility due to change in the crowding characteristic.

All subjects recorded losses in utility with increasing crowds. Further, the subjects exhibited increasing marginal disutility to crowds for the ranges of the data. With some assumptions, Sanderson (1974) then estimated the optimal level of crowding at the site. These estimates agreed closely with other estimates by other methods (Sinden and Smith 1975).

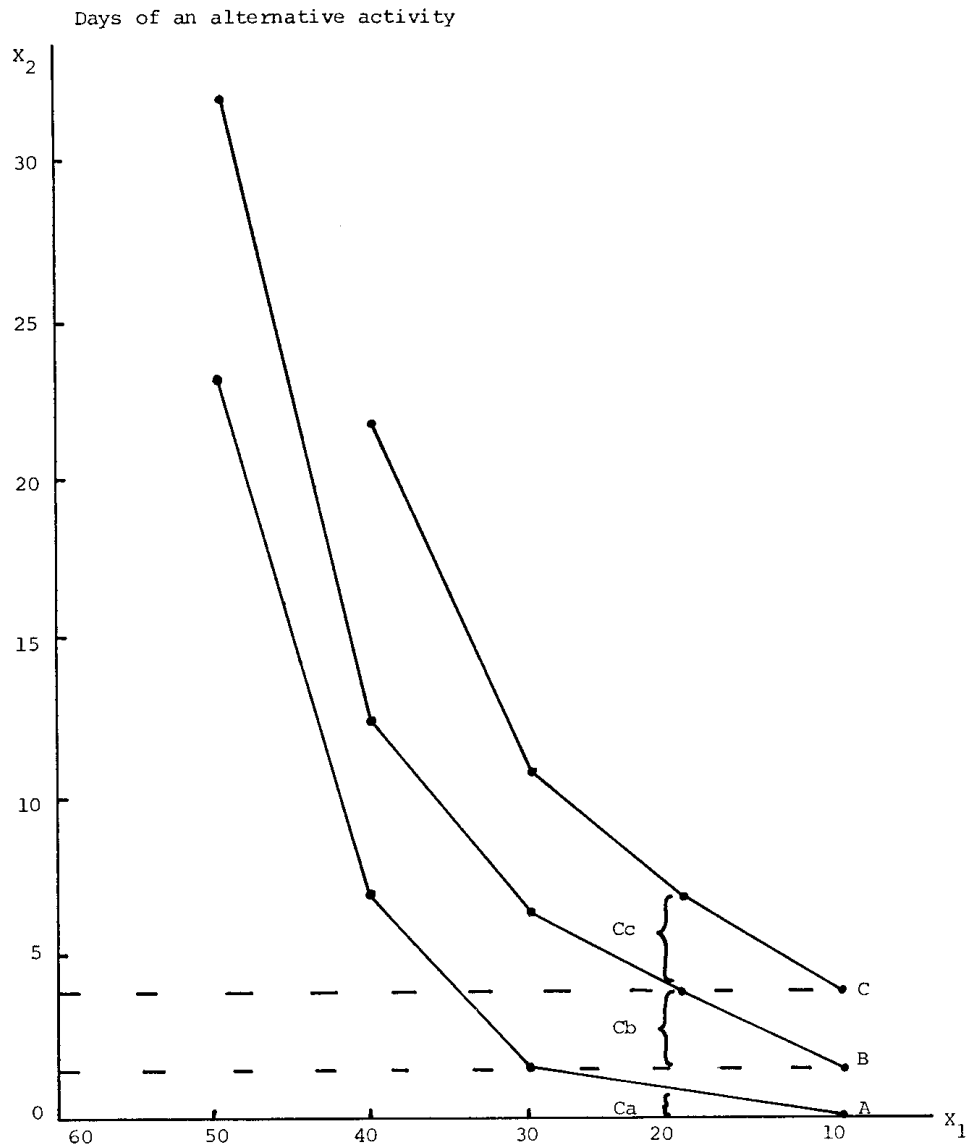
Information, with surplus estimates in days of an activity, may be useful where the same land use authority administers sites for both (all) relevant activities and where orders of magnitude rather than precise estimates are relevant for policy. These conditions are often satisfied with the accessible, highly crowded, picnic/day use sites of the Forestry Commission, National Parks and Wildlife Service and Department of Lands in New South Wales.

#### *Valuation of the rural-way-of-life*

Many land use decisions involve the sale of farms to the government. In consumer's surplus terms, these sales inevitably involve the following question. How much should be paid to ensure the farmer is as satisfied after the sale as before? Since the benefits of the farm are to be withdrawn, the annual money income must be estimated. But when farmers are offered an amount equivalent to their income they often do not agree to sell—implying that there are other unpriced benefits not recognised in the money income. Liesch (Liesch and Sinden 1976) attempted to value the unpriced benefits for this 'rural-way-of-life'. More specifically, he applied the conventional Hicksian arguments of Figure 2 to estimate the quantity equivalent consumer's surplus for the complete withdrawal of this rural-way-of-life.

The establishment of a National Park on the headwaters of the Macleay River, New South Wales, would completely displace some eight farms. Three of these farmers were absentee owners or away for a long period and so unavailable for interview. The other five were

<sup>12</sup> For simplicity in presentation, the budget lines are ignored.



Crowding: number of persons at a specific recreation site in a specific activity.

FIGURE 3—Estimation of changes in consumer's surplus due to increases in crowding.

interviewed through the Ramsey model of utility estimation to provide the necessary utility functions (after Table 2). The variable  $x_1$  was defined as the rural-way-of-life and coded as 1 = the farmers stay on their farms (and so have the rural-way-of-life) and 0 = they are moved off (and so do not have it). In the present 'trading' position of B in Figure 2 the farmer has the rural-way-of-life and so  $OF$  (the quantity of  $x_1$ ) equals 1. The variable  $x_2$  was defined as the activity that the farmers miss most while they live on their farms. This was invariably an overseas trip, an activity which none of the farmers had undertaken. Compensa-

tion must be estimated in money and can conveniently be the cost of providing these trips. Thus a separate sort of trip can be, and was, defined for each farmer. Variable  $x_2$  was therefore the annual quantity of such trips. The value of  $OK (=BF)$  is now 0 since no overseas trips ( $x_2$ ) had been undertaken. The utility functions provided the indifference 'curve'  $U$  through  $B$  and so located point  $E$ . The quantity  $KE$  is therefore the amount of  $x_2$  necessary to exactly compensate for the loss of the rural way-of-life ( $OF$ ).<sup>13</sup> The total quantity of trips ( $KE$ ) was closely related to the marital status of the farmer and the existence of friends nearby. Families with many close friends recorded the highest quantity.

The price per trip was obtained and the total cost of compensation for the lost way of life was calculated as the product of price and the number of trips ( $KE$ ). Full adjustment to a new way-of-life will take more than one year and, it was assumed, less than six years. Full compensation was estimated for year one, with equal annual decrements to zero compensation in year six. The total compensation for all five years was summed as a present value at 10 per cent.

The relationship of the total compensation values per farm family to the socio-economic characteristics of each family was examined to generalise the results to the three unavailable farmers. The following regression model was obtained:

$$(1) \quad V = 1575 + 16\,398 Z_1 + 52\,426 Z_2$$

(1.78)                      (5.79)

where  $V$  is value of total compensation per family (\$),  $Z_1$  is marital status (1 = married, 0 = single),  $Z_2$  is proximity of friends and relatives (1 = close, 0 = distant) and the  $t$  values are in parentheses. The coefficient of determination was 0.91. The model tests and supports the hypothesis that married farmers, with friends and relatives nearby, value the rural-way-of-life more highly than single farmers with no friends or relatives nearby. The model also assists validation of the results, as discussed below.

Data on the marital status and proximity of friends and relatives of the three absent farmers were obtained. They were inserted in the model to estimate the compensation for these farm families.

The total compensation for the rural-way-of-life, as a present value at 10 per cent, was \$49 300 as an average per family. Sensitivity analyses could readily be used to examine the effect of different costs per trip or compensation for more than five years or for a constant rather than a declining amount per year.

### *Discussion*

The objects of this paper have been to review the application of the

<sup>13</sup> The quantity equivalent variation is normally  $AE$  rather than  $KE$  since the budget can be reallocated to purchase  $AK$  more of  $x_2$  from the savings from lower purchases of  $x_1$ . The rural-way-of-life involves no money outlay for existing farm families and so  $AK$  cannot be purchased in exchange. For this reason, the quantity equivalent variation has been interpreted as  $KE$  rather than  $AE$ .

consumer's surplus concepts to some land use policy decisions and to illustrate a methodology to estimate surplus values. In this final discussion certain general features of the methodology and the use of surplus concepts are considered, namely, the practical feasibility of the method, the validation of the empirical results, the use of money and index units of utility and the use of surplus theory to guide choice of method and concept.

#### *Feasibility of the method*

Estimation of consumer's surplus values through indifference mapping offers several advantages over some other methods. In particular, analyses can be more detailed and each of the four concepts can be estimated. But how feasible is the method? Certain general aspects of the interview procedure are now considered.

The length of the interview procedure can be a major constraint. Originally, each utility function required some three hours to elicit (Sinden 1974) but Liesch and Sanderson improved the survey procedure to halve this length.

The notions of probability and the Ramsey game always required careful introduction. Subjects could readily nominate planning periods, their most preferred activities and current alternatives. But choices with probabilities of occurrence had to be introduced by the device of drawing marbles from bags. Each bag represented a prospect and the activity undertaken depended on the marble selected. This sort of simple introduction took one-third of the interview time.

A time period must always be nominated within which the overseas trips, for example, must be consumed. This period becomes the period within which choices are made for the Ramsey model. All the subjects in all three applications could specify a meaningful period for these choices. But the period had to be the same (one year) for all farmers in the application to the rural-way-of-life problem. The need for an identical period raised some difficulty because some farmers could readily plan for a whole year but others found this difficult. But the difficulty was eventually overcome by careful discussion with each subject.

The method proved feasible and even relatively straightforward after the probabilities and time periods had been discussed. The most difficult part of the methodology may well remain the formulation of the problem in terms of Figures 1 and 2 rather than the field interviews for the utility functions. Even so, the technique may be more suitable for intensive surveys of locally important problems than for rapid surveys of large numbers of people.

#### *Validating the results*

How well were the subjects motivated and can they be expected to reveal their true preferences? In other words, how valid are the surplus values from the methodology? For example, a reduction in crowding is

essentially a public good and so individuals may have little incentive to reveal their true preferences. The validity of the methodology or the results were tested in each of the three applications and the results are now considered.

No attempt was made to validate the values for the four concepts of consumer's surplus in the Hells Canyon example. But the values from the same methodology with the same and more subjects in another part of the same survey were tested for their predictive ability (Sinden 1974). In this part of the survey, utility functions were elicited and indifference maps and demand curves were also derived. The area under the curves provided monetary benefit values for each of five subjects for a particular recreation activity at a state park. A utility-maximising consumer will choose activities on the basis of such values. Valid results would therefore predict use. The study could not continue long enough to observe this subsequent use, and so consistent use trends between the immediate past and the future were hypothesised. Thus, valid results should explain immediate past use.

A dependent variable was defined as the quantity of the activity per subject at the state park over the past twelve months. The only independent variable was the value of the total benefit of the first day's use—as measured from the individual's demand curve. This independent variable was associated with 94.3 per cent of the variation of the dependent variable. The benefit values were significant at 1 per cent. This test was accepted as a successful validation of the methodology for this recreation problem. The same method was applied to the same subjects in the same way at the same time for the estimation of the four surplus values. The test indicates that the methodology may have been successful here.

Prior beliefs may suggest that true values are associated with some socio-economic characteristics of the subjects. A test of this 'internal consistency' between surplus value and characteristic is therefore a test of validity—although weaker than a prediction test. A test of internal consistency for the values of the rural-way-of-life was, in fact, presented earlier. Such values, Liesch and Sinden (1976) argued, should be related to certain family characteristics. A change in the characteristic should lead to a change in value. Equation (1) details the test and indicates the positive results. There was considerable consistency between subjects in the way values varied with characteristics—providing some support for the values themselves.

An earlier attempt to value the rural-way-of-life had been made through direct questions. The farmers had been asked, what is the minimum monetary amount you would accept to leave your farm? Despite appropriate qualifications for separate compensation for lost income and for levels of satisfaction, no answers could be obtained at all. The present methodology is therefore an improvement over this sort of direct question procedure. The figure of \$49 300 for the average compensation per family is one-third to one-half of the

existing market price of the land. For recent government acquisitions around growth centres a similar premium over market price had been paid.

Comparison of values with results from similar studies of the same problem is another way to validate the results. Although weaker than the internal consistency test, it does provide some justification for the results and the method. Sanderson's (1974) subjects provided information on the loss of utility with increased crowding. If all persons had identical responses then the total change in utility is the product of the utility change for the survey individual and the level of crowding.<sup>14</sup> The total utility for each level of crowding can therefore be estimated—in relative terms—and the optimal number of persons per site is that which provides the highest utility. Sanderson's data indicate an optimal crowding for picnicking of some 30 to 35 persons with a range of 22 to 38 persons if a fall in utility of up to 10 per cent is permitted. These results are almost identical with those of Sinden and Smith (1975) who investigated willingness-to-pay in time of travel. The latter results, from 95 households in Armidale, used time as the index of benefit. The optimal number of persons was 28 with a range of 16 to 36 for a loss of benefit of less than 12 per cent. Both surveys concerned the same sort of recreation and the subjects were drawn from the same population.

The tests seem to provide some justification for each of these three applications and alternative methodologies had failed completely for the rural-way-of-life problem. Perhaps the added introspection of the present method encourages preference revelation or perhaps the emphasis on quantity questions rather than the usual price questions discouraged free rides. But overall there seems sufficient justification for further use of the methodology and faith in the results.

#### *Converting utility to money*

Effective policy analysis requires the comparison and aggregation of individual preferences. The difficulties of making interpersonal comparisons of utility are well known and well documented. In the earlier study (Sinden 1973) the aggregation problem was circumvented. The utility functions were derived in the form of indifference maps and demand curves were derived from the maps. Then the consumer's surplus values in dollars can be taken from the appropriate areas under the curves and aggregated.

The forgone utilities of the rural-way-of-life were estimated as compensation values. These values are the cost of overseas trips and not the value of the utility from the trips. But this cost may be exactly the information needed for a decision when compensation is offered. Sanderson indicated how utility data themselves may be used directly in

<sup>14</sup> The assumption of identical preferences is, of course, open to question. But the same assumption is made by Sanderson (1974) and by Sinden and Smith (1975). Thus the results of the two studies can be compared—which is the present purpose.

land management decisions. The use of other measures of utility, namely units of a substitute good or of time, has also been illustrated.

### Conclusion

Consumer's surplus has long been accepted as an appropriate concept of net social benefit. But many non-economists and some agricultural economists may remain sceptical of the possibility of valuation and confused when formulating hypotheses concerning unpriced goods and services. How then can the concept assist in the formulation and analysis of land policies? And what might the present article contribute?

The intent of the paper has been to encourage more, and more relevant, use of the surplus concepts in analyses of land policies. The theoretical discussion has indicated the versatility of the concept with variations for the main types of policy issues. Hopefully, the applications of the methodology have indicated that valuations of otherwise unpriced goods (and bads) are possible. The methodology is one way to estimate surplus values as information for the increasing number and increasing intensity of debates on land policy.

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