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Time Discounting by Certain Forest Landowners

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Pacific Northwest Forest and Range Experiment Station

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Bulletin No. 69

TIME DISCOUNTING BY CERTAIN FOREST LANDOWNERS

BY

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Experiment Station

New Haven: Yale University
1966

A Note to Readers
2012

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The many ways in which the author was helped by his wife, Margaret C. Flora, can be appreciated by other former graduate students.

Any conceptual oversights or expository difficulties are, of course, the sole property of the author.

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ABSTRACT

THIS study introduces time preference into the classical forest valuation apparatus and reports on an empirical examination of the feasibility of determining the role of time preference in subjective time discounting by woodland owners.

To this end, an analytical model for appraising forest investments is developed which incorporates both time preference and rates of return in alternative activities, and which substitutes the more general objective of utility maximization for the criterion of maximizing discounted net revenues.

The model demonstrates that distinction between time preference and alternative earning rates is appropriate when the difference between an initial outlay and the discounted value of expected net revenues is significant. The construction also reveals that time preference can be expected to bear on investment decisions for a person whose capital is limited or whose time priority is greater than the applicable rate of interest.

The model establishes that rotation lengths and choices between mutually exclusive investments can be resolved by comparing the relative levels of 'incremental time indifference' (utility) achieved, without discounting future values to a base year.

An empirical study of time discounting and capital market access, involving interviews with 50 major woodland owners in New England, is described. Responses indicated that, while in some cases economic motives did not influence initial purchase of forest properties, time and dollar revenues were relevant forestry decision variables for all 50. Time preference affected the time discounting paths of 19 of the 50.

It is concluded that, subject to certain questions of validity, empirical determination of subjective time discounting rates and identification of the influence of time preference are feasible and that a significant proportion of forest investors do not evaluate future financial returns in terms of compound interest.

INTRODUCTION

THE aim of this publication is to disabuse foresters of the prevalent notion that landowners necessarily discount future financial events according to compound-interest rates.

For more than 50 years, foresters interested in encouraging prudent land use have expressed concern about the generally low level of management on 'small' woodlands (15,20,41).* During most of the half-century, it was believed that if the forest landowner could be convinced that more intensive management would be profitable, he would undertake more refined practices (31, 32).

In time, steadily improving markets and a growing fund of management data made it evident that intensive cultural treatments could be attractive over relatively short periods on selected areas. Yet, the caliber of management adopted on these lands has not changed markedly (1,34,35).

More recently, attention has been fixed on the riskiness of forestry and the lack of forest credit as explanations of the failure of otherwise intelligent woodland owners to adopt 'acceptable' practices. Of late, both credit and forest insurance have become available to at least some landowners; however, no great interest has been shown in either of these innovations (13, 28).

Currently, research on adoption of innovations focuses on social and psychological factors (2, 26, 48). One of the latter group, time preference, is dealt with in this study.

Broadly defined, time preference is the preference for present over future income (21). The rate of time preference is an expression of *willingness* to trade incomes between periods, and is independent of one's *ability* to make the exchange. Time preference has been attributed by economics writers to a lack of foresight or willpower, inability to feel today the intensity of future wants, and uncertainty as to the length of one's life and the levels of future needs (4, 7, 18,27,37,46).

Some standard references on forest management and economics accompany their discussions of compound interest and discounting with a statement to the effect that the rate of time preference is very high for some persons. Such a person, it is held, discounts future costs and returns by a factor determined by his rate of time preference rather than by the going rate of interest (6, p. 69; 9, p. 297; 11, p. 156; 21).

*For list of references, see section on Literature Cited, p. 54.

Such statements leave unanswered the questions they arouse: Conceptually, can time preference really be separated from an individual's awareness of the ability of his capital funds to grow over time at the market rate of interest? Theoretically, is it to be expected that personal discounting is controlled by rates of time preference, or is it determined by other factors? Should it be assumed that a person discounts *either* at compound rates of interest *or* at rates of time preference, or is it theoretically plausible that both kinds of discounting are applied by the same person but to different spans of time? Can a theoretical framework be developed for answering these questions? On the empirical level, can the kinds and rates of discounting employed by woodland owners be discovered? Does anybody discount according to time preference?

This study develops a theoretical apparatus and an empirical procedure for answering these questions.. In the next section a theoretical construction for evaluating investment opportunities is suggested. This device incorporates both compound rates of interest and time preference. It indicates how time preference might affect investment decisions under various conditions of access to borrowing and lending opportunities, depending on the relative attractiveness of forestry and interest-bearing alternatives. Such a model is not presently available in the literature.

Subsequent sections report on a field investigation of the feasibility of determining the manner and rate of time discounting employed by individual forest landowners.

THEORETICAL DISCUSSION OF THE PROBLEM

IN THE introduction some questions were raised about the manner in which woodland owners appraise forest investments that involve significant waiting periods between initial outlays and final returns. Two distinct bodies of theory pertain to this problem. The first, investment theory, is employed both by economic capital theorists and by foresters interested in valuation theory. The second area, time preference theory, has been the sole domain of economists dealing with interest theory.

In this section, investment and time preference theories are merged, by starting with the "time-indifference map," a graphical device proposed by Irving Fisher in a noted treatise on interest theory (18). The time-indifference map will be subjected to certain special assumptions so that it can be used to explain choices between dollar incomes arising in more than two periods. Finally, the empirical work will be explained in terms of the device which has been proposed.

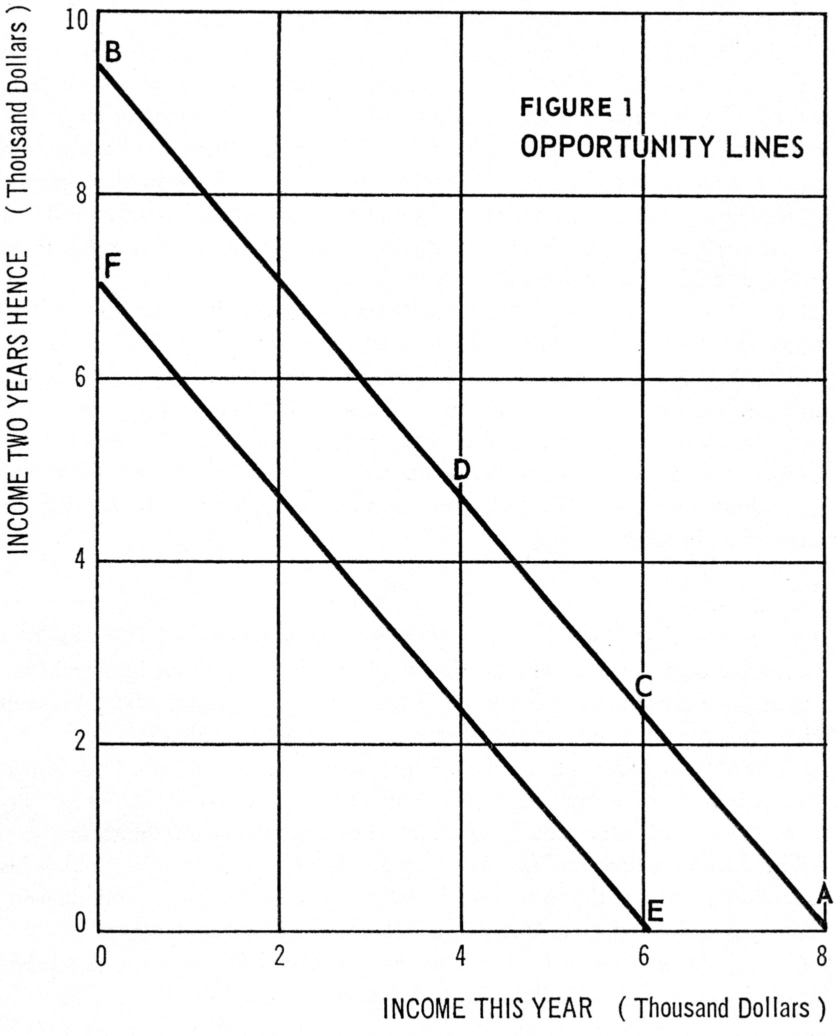
It will be shown that time preference can be separated conceptually from borrowing and lending opportunities; that time preference is the sole determinant of the discount path of some persons, a partial determinant for some, and irrelevant for others; and that both compound interest and time preference discounting may be applied by the same person, to different time spans.

FISHER'S OPPORTUNITY LINES

Figure 1 is a comparison of one's income in two different periods. The horizontal axis measures income this year. The vertical axis indicates income in some later year, say 2 years hence. Now, suppose that the individual whose income is to be plotted in figure 1 expects to receive $8,000 this year but no income 2 years from now. We must ignore other years because there are only two axes. His income situation is indicated by Point A.

Next, suppose that he can give up all or part of this year's income in exchange for more income in two years; that is, he can lend for two years. If he can lend at 8 percent interest, he can give up $8,000 now for about $9,350 later. In doing this, he would give up point A for point B, with no spendable income now and $9,350 in two years.

Since he may wish to lend only part of his income, some other combinations can be shown in figure 1. For example, if he lends $2,000, his funds this year



are reduced to $6,000, but he receives $2,330 in 2 years. This combination ($6,000, $2,330) is indicated by point C. Similarly, giving up $4,000 this year yields $4,660 in 2 years. The combination ($4,000, $4,660) is at point D. Any exchange between the 2 years can be shown in the same way. When plotted, the points fall on a straight line between A and B. The slope of this line is 1.166, reflecting 8 percent interest compounded for 2 years. A higher rate of interest would make the line steeper.

Borrowing, as well as lending, can be diagrammed. If this individual expects to receive $4,000 this year and $4,660 in 2 years, his financial situation is portrayed by point D. If he wants to borrow by giving up future income to obtain current income, and if he can borrow at eight percent interest, then he can move from D toward A along the straight line. For example, he can move from D ($4,000, $4,660) to C ($6,000, $2,330) by giving up $2,330 of future income for $2,000 additional income this year.

Point A has some relevance to forest valuation theory: it is the *present* (discounted) *value* of the income combination represented by points B, C, or D.

Other opportunity lines can be drawn as needed, for other income levels. Line EF, parallel to AB, is appropriate if one expects $6,000 this year and if exchange opportunities are available at 8 percent interest.

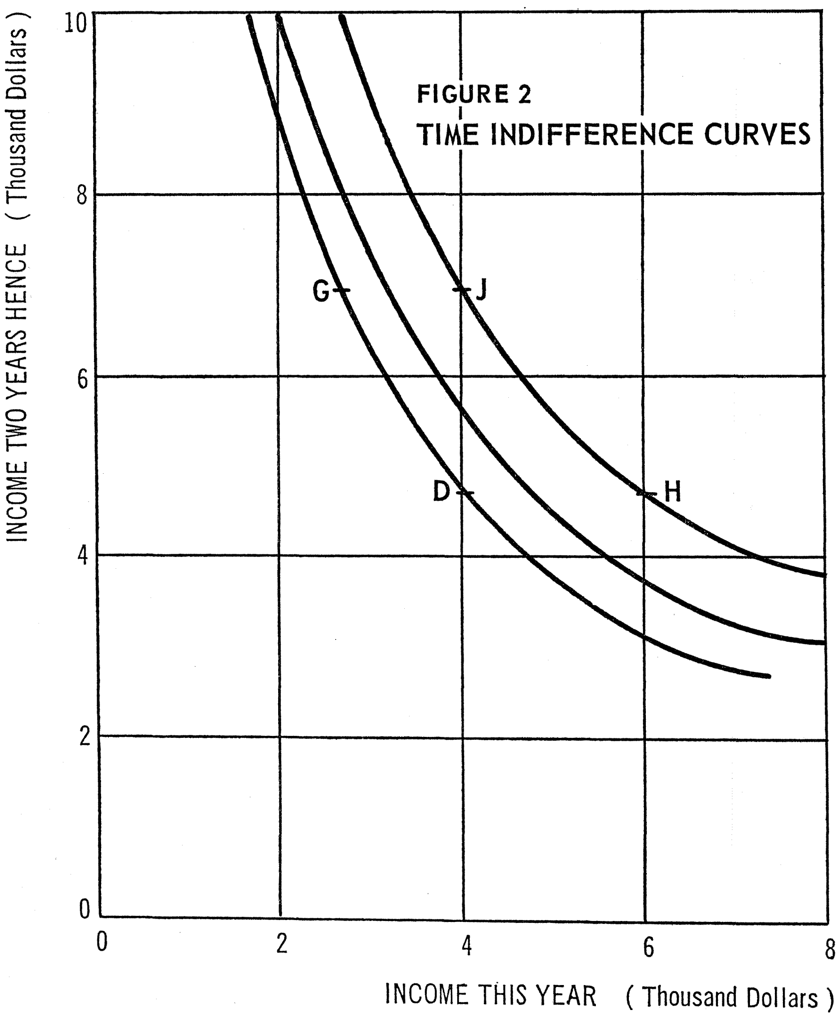
Observe that a move cannot be made from E to D unless a much steeper opportunity line can be obtained; that is, unless a higher interest rate can be obtained on funds lent.

Fisher's Time Indifference Curves

Figure 2 depicts the same individual's relative *preferences* for income in the 2 years. The curve intersecting point D connects income combinations between which this person is indifferent. That is, it is assumed that he is willing to give up some of this year's income if he is promised a sufficiently large additional stipend in 2 years, so that he moves from D to, say, G. He is indifferent between these two income combinations; they lie on the same indifference curve.

The slope of a time indifference curve at any point indicates how much his income in 2 years would have to be increased to compensate the individual for giving up an increment of this year's income; this is his *effective rate of time preference,* or his *marginal rate of income substitution* between the two years. Determinants of time preference were suggested earlier. However, the effective rate of time preference is not independent of expected incomes. As Heady (24, p. 425) points out:

> If the individual "believes" future returns to be high, he may put a relatively low value on the transfer (saving) of income from the present to the future. If he "believes" the future may give very low returns (or will result in a low value on assets carried into the future), he may place a relatively high value on saving. Or, exactly the reverse may hold true for other individuals.



Recently, it has been considered useful to distinguish between (a) 'pure' time preference, arising when incomes are expected to be equal in the two periods, and (b) the discounting of the future utility of income due to declining marginal utility of income; that is, to the diminishing increments of satisfaction added in a given period by successive, equal units of income. For example, suppose that the individual's pure rate of time preference is zero, so that he would have no preference for present over future income if his expected income stream were constant, but that he expects to receive $1,000 this year and $2,000 next year. If his marginal utility of income declines, then he would be willing to give up more than $500 of next year's income for an additional $500 of income this year, since the $500 increment between $1,000 and $1,500 has more value to him than the $500 between $1,5°0 and $2,000.

It is always assumed that indifference curves are convex toward the origin. That is, they become steeper as they approach the vertical axis., This follows from the assumption that as one gives up increasing amounts of current income, he does so with growing reluctance, so that more and more units of future income must be promised to extract each additional unit of this year's funds. As one follows the indifference curve leftward from point D, each dollar given up out of hand (horizontal shift) requires an increasing number of dollars of promissory income (upward shift).

An infinite number of indifference curves can be developed, each representing a different amount of utility (satisfaction). Curves located in the upper right-hand corner represent more utility than those close to the origin, since it is assumed that one always prefers more income to less, in any period.

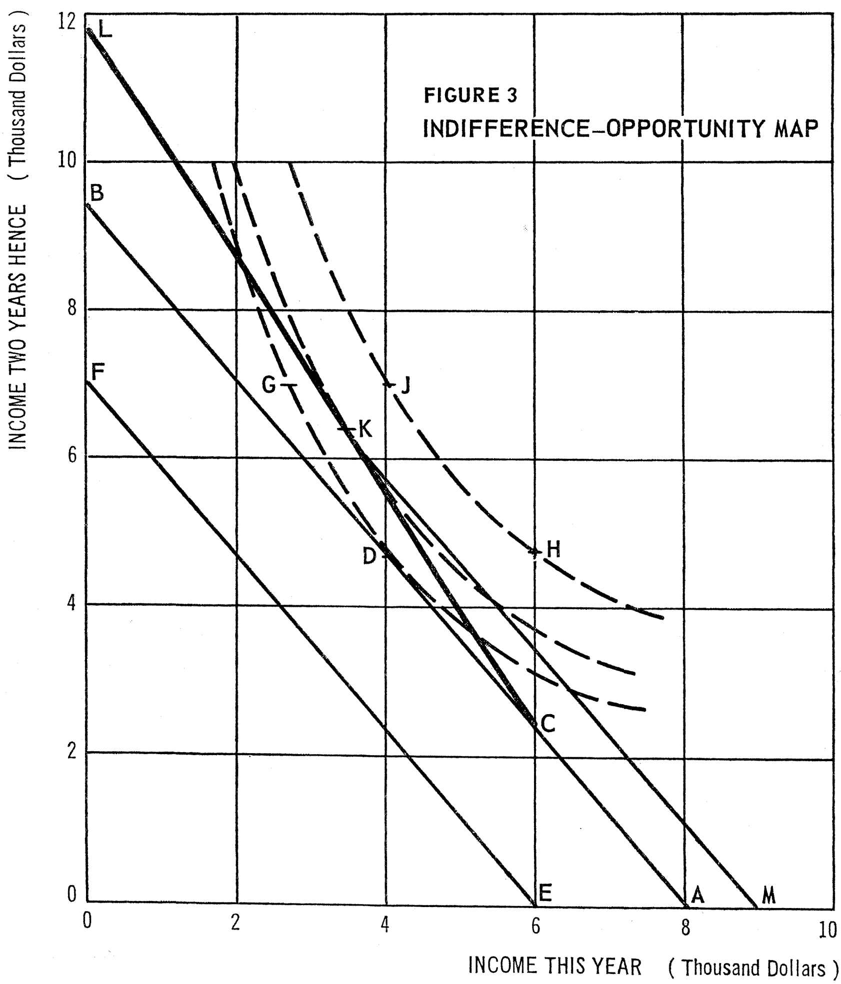
It is a characteristic of indifference curves that, even though the absolute amount of satisfaction attached to each curve is not known and even if the absolute difference in utility between two curves is unknown, still the utility difference between any two curves is everywhere constant.

In this connection, suppose that an individual with the time indifference map of figure 2 receives a bonus this year of $2,000. This moves him from point D to point H on a higher indifference curve. Theoretically, there is some sum of money which, if promised to him in 2 years, would be an exact substitute utility-wise.·for the $2,000 bonus this year. This sum, $2,340, can be determined from his time indifference map; it is the vertical difference between points D and J, where J is on the same indifference curve as H. Since J and H have the same amount of utility, this person is indifferent between the moves from D to J and D to H; he is indifferent about giving up $2,000 now to get $2,34° in 2 years. Indifference between these *increments* of income is important to the model developed later.

THE INDIFFERENCE-OPPORTUNITY MAP

In figure 3 the indifference curves of figure 2 have been overlaid on the opportunity lines of figure 1. Starting at point C, with $6,000 now and the prospect of $2,330 in two years, the individual in question may wish to shift his incomes, trading off one year's dollars against the other's. Whether he wants to do this or not can be seen from the relationship of his indifference pattern to his income-switching opportunities.

There is an indifference curve, not shown, through C that represents less satisfaction than the curve through D. D, representing $4,000 now and $4,660 later, is more attractive than C which designates $6,000 now and $2,330 later.



Since this person can move along the straight line toward D by lending, he will presumably do so.

Note that at D a time indifference curve is tangent to an opportunity line; satisfaction is greater at this point than at any other place on the opportunity line ACDB. In diagrams of this sort, maximum satisfaction is always reached at a tangency point.

If this person can borrow as well as lend, and if he is at some point like B, leftward of a tangency point, he will give up $4,690 of future income to gain $4,000 this year, thereby moving to D.

Suppose now that this person has an additional opportunity; not only can he borrow and lend at 8 percent, but also he can undertake forest management on some land he owns and, over a 2-year span, earn 30 percent on funds so invested. If he starts at point C, he can, by investing current income, moye to any point upward along the line CK. The slope of CK is greater than that of CB because CK represents a higher rate of interest.

Observe that he cannot move downward from K along the line CK, since forestry involves exchanging present funds for future funds, but never the opposite. Note also that, given an income combination represented by point C, an opportunity to lend and borrow at 8 percent, and the chance to 'lend' at 30 percent, this person will maximize his satisfaction by going into forestry, thereby moving along the line CK to its tangency with a time indifference curve at point K, giving an income distribution of about $3,5°0 now and $6,300 in 2 years.

COMPARISON OF CRITERIA

It has been mentioned that income maximizing and utility maximizing are apparently compatible objectives, insofar as figure 3 is concerned. However, the principle advanced in forest valuation theory, that one chooses that income distribution over time which maximizes present value of the investment (present net worth or discounted net value), requires some comment.

The present value of the income distribution represented by point K is equal to this year's income plus the future income discounted at the market rate of interest, here assumed to be 8 percent. Thus, the present value of point K is $3,5°0 plus $6,300 ÷ (1.08)2. The total is $8,900. It can be seen from figure 3 that this total present value can be determined graphically by drawing a straight line, KM, down to the horizontal (present-income) axis, parallel to the 8 percent lines AB and EF.

From figure 3 it can also be observed that any point on the forestry opportunity line CK above K has a higher present value than K, but any such point lies on a lower time indifference curve than does K. Therefore, if this individual is at point C and wishes to maximize satisfaction, he will give up $2,5°0 now to gain $3,97° ($6,300 - $2,33°) later; he moves to K. But if he wants to maximize present dollar value, he will put all $6,000 of this year's income into forestry to increase his income about $9,670 ($12,000 - 2,33°) later. This action corresponds to moving from C to L.

Clearly, the two criteria, maximum satisfaction and maximum present value, can conflict." Maximizing present value in dollar terms may not maximize satisfaction.

It will be assumed in this study, that individuals seek to maximize satisfaction and so strive to reach the highest possible time indifferent curve. This follows from the fact that indifference curves reflect desire, while present dollar value depends on opportunity.

CHOICE AS INFLUENCED BY OPPORTUNITY

To set the stage for later discussion, assume momentarily that the individual has an expected income distribution appropriate to point A in figure 4, and that he has just been given a bonus which moves him to point B. Now suppose that he is asked how large a stipend would have to be promised him in 2 years to cause him to give up his bonus this year.

If this person has no lending opportunities, he will demand that he be given enough later to permit him to reach the same time indifference curve as that which passes through point B. Thus, he would have to be offered the possibility of moving to point C before he would give up the difference between A and B.

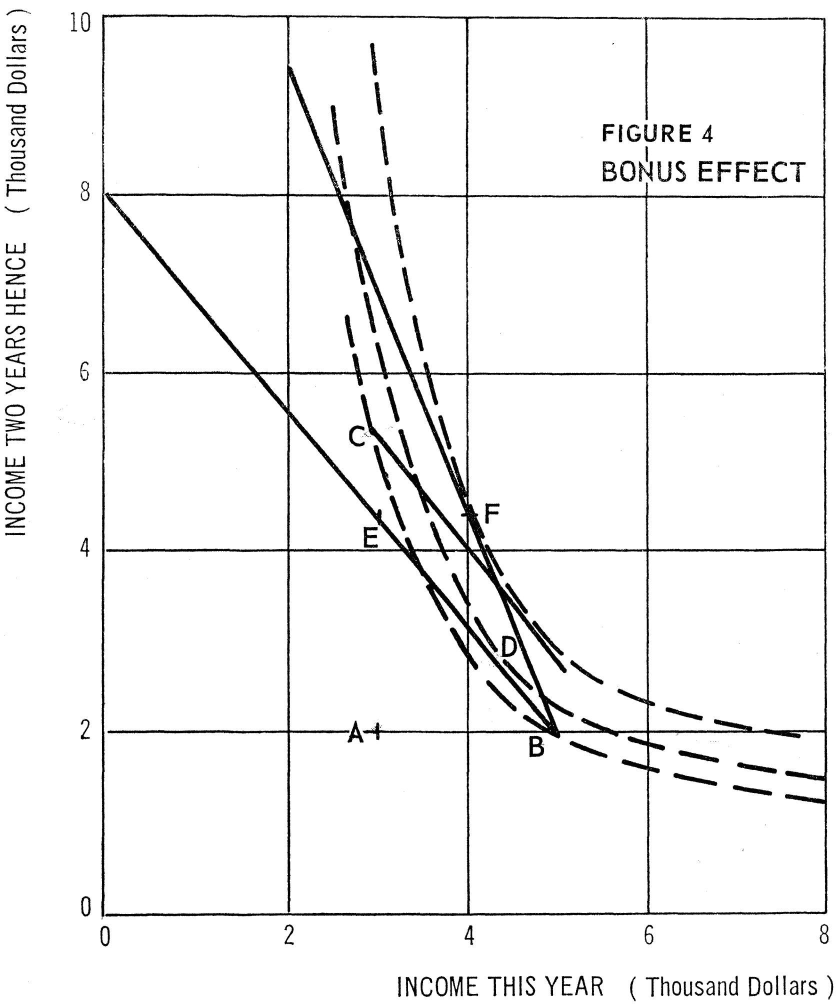
Suppose, however, that he is able to borrow and lend at 8 percent. Then from point B he can move to point D, as explained earlier. To compensate him for giving up his present bonus, he will now demand enough future income to permit him to reach the time indifference curve through D. He can do this from. point E, by borrowing, so he will demand the difference between points A and E for giving up this year's bonus. Evidently, when this individual has access to borrowing and lending, he requires a smaller future stipend for foregoing a current gain.

By a similar line of reasoning, if he can go into forestry from point B, and earn thereby a high rate of return along line BF, he will require sufficient future compensation to permit him to reach the time indifference curve through point F. In this case, he will not be content with being permitted to move to point E.

He will have to be offered the opportunity of moving to C before he will give up the bonus that takes him from A to B.

Extension to Several Periods

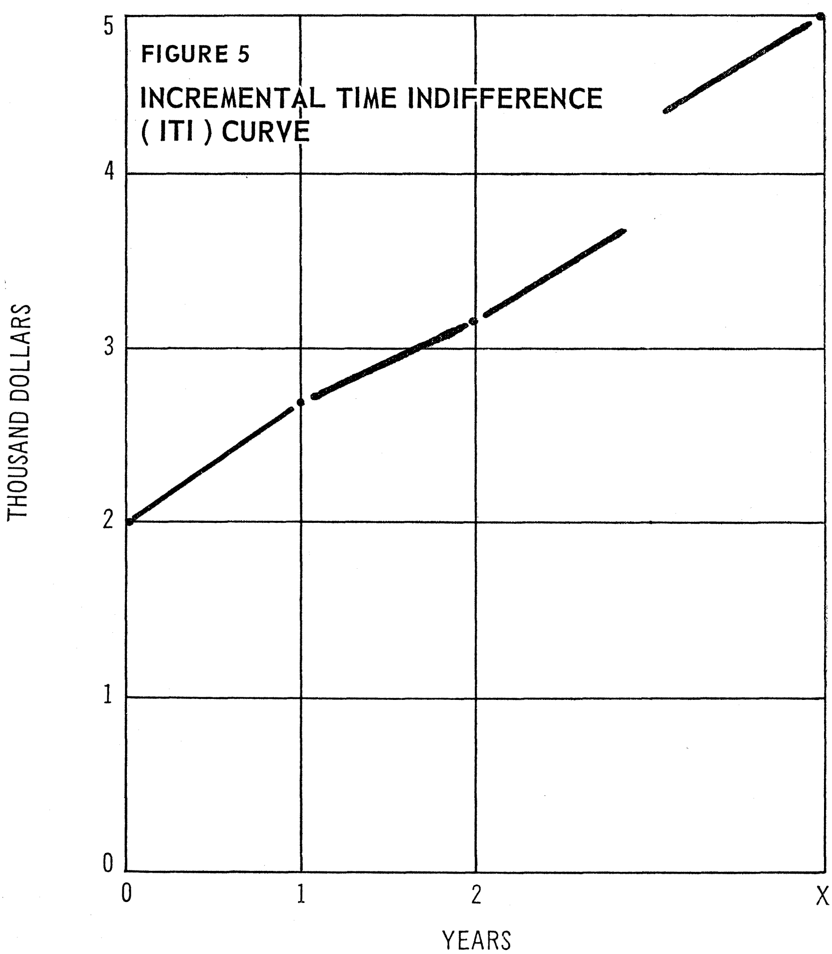
It is possible to develop a construction which extends the foregoing analysis to several periods. It will be assumed throughout that the individual is already



at some point A on the time indifference map, and that he has been offered the bonus during the present period which would move him to point B.

Considering only his indifference curves in figure 4, he is indifferent between receiving $2,000 (the difference between points A and B) now or $3,200 (C minus A) 2 years hence. These values can be plotted over time, as in figure 5. Similarly, he may be indifferent between $2,000 now and $2,700 next year; and between $2,000 now and $5,000 in year x, some time in the future.

These additions to income which are equal in satisfaction to $2,000 can be



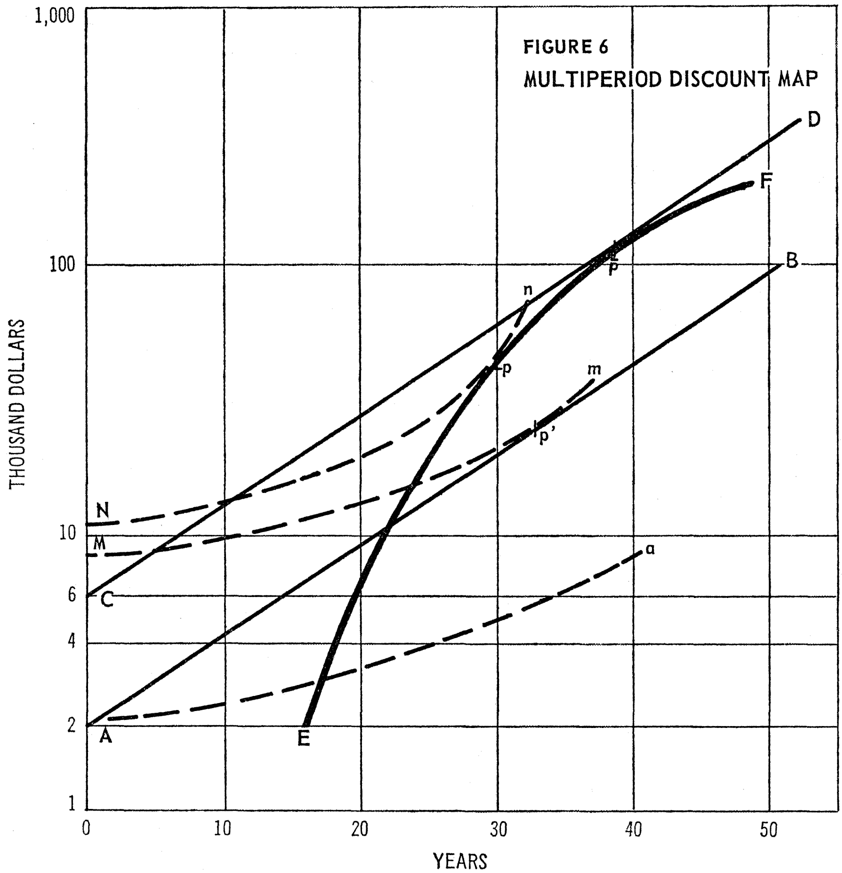
connected by a smooth curve if periods are sufficiently short and are adjacent in time. Such a curve of time-income increments toward which the individual is indifferent will be termed an *incremental time indifference* curve, and abbreviated ITI. It is incremental because it refers to increments of income rather than to total income. 'Incremental' rather than 'marginal' is used because discrete or 'lumpy' units of income are involved.

Just as with time indifference curves, a large number of ITI curves can be discovered, each corresponding to a different value of present income increment. Curves in the upper left-hand portion of the diagram represent greater satisfaction than do those below, as it is presumed that investors prefer more income to less, and income now to income later. Like indifference curves, ITI curves neither cross nor intersect. The distance in time over which the individual formulates subjective ITI curves can be supposed to be jointly determined by necessity (the need to deal with long-term projects) and facility (the ease with which reasonably uncertainty-free estimates of future events can be made).

The map of ITI curves can be expected to shift as different activities are considered, because utility can be said to be a function of other variables besides income and time, whose values may change as attention moves from one activity to another.

The extension of opportunity lines to several periods is somewhat easier to visualize. The $2,000 bonus (B minus A) of figure 4, if lent at compound interest, grows at an exponential rate over time. Thus, from an opportunity viewpoint, the present sum $2,000 is worth $2,000 plus 2 years' compound interest 2 years hence; it is worth $2,000 plus x-years' interest x years from now. If plotted with a logarithmic value axis, compound-interest opportunity lines become straight lines, as shown in figure 6. Again, an infinite number of compound-interest opportunity lines can be drawn, one for each point on the dollar axis.

In subsequent diagrams, the vertical (dollar) scale will be logarithmic. This is done for convenience, to make compound-interest borrowing and lending (opportunity) lines straight instead of curving upward at rapidly increasing rates. In order to show tangencies between ITI and opportunity lines, the ITI curves are shown as rising upward over time at an increasing percentage rate. There is no particular justification for this assumption. ITI curves which rise only gradually or rise at a decreasing absolute rate would give equally determinate results provided that a planning horizon is introduced. Curves which rise at a constant percentage rate seem unlikely unless one's innate preferences are structured like a compound-interest table. The ITI curves shown make tan-



gencies with other curves to be discussed presently; this provides a maximum number of possible kinds of discount paths for discussion.

The theoretical discussion would not change if the assumption about the shapes of ITI curves were removed. A linear vertical axis could be used. However, the analysis would be meaningless without tangency assumptions. In the absence of tangencies between ITI curves and compound-interest and/or forestry opportunity lines, investment planning would be simple all-or-nothing decisions.

Forestry opportunities are not generally considered to grow in value at a constant compound rate. In figure 6, the heavy solid line EF represents an investment opportunity in forestry, with \$2,000 invested initially. Assuming that sale of land is unacceptable, many kinds of forestry outlays cannot be retrieved, and value response does not occur, until some years later. This is reflected in the forestry curve. Curvature toward the right indicates less than a compound rate of value growth; this seems to be the usual case.

Graphic Review of Valuation Theory

The principles of forest valuation theory were discussed in connection with Fisher's two-period model. Since the mechanics of this theory form a part of the apparatus to be suggested, their operation in multi-period analysis is treated here.

It is a central tenet of valuation theory that rational investors seek to maximize the present (discounted) values of their portfolios (21, 22). In determining the rotation length of an investment opportunity in forestry, the investor would plan to carry the rotation until the current rate of return on his appreciated capital fund (achieved by holding the timber another year) drops to the rate of return offered by the best alternative investment in the same risk class.

This principle is indispensable to 'financial maturity' (12), 'maximum soil expectation value' (9, p. 239), 'forestry programming' (40), and 'capital budgeting' (10, 14). At the alternative rate of return, the present value of the enterprise is maximum, as illustrated in figure 6. The forestry value yield curve EF is analogous to the forest opportunity line BF of figure 4. However, the line of figure 4, involving only two periods, reflects only one rate of return. The value yield curve of figure 6, spanning many periods, grows at a variable rate. AB is an 8 percent compound-interest opportunity cost curve like AB in figure 3.

A large number of curves like AB could be drawn, each curve showing how an initial capital sum would grow through time. One such curve, CD, is the highest-possible of these opportunity cost curves which can be reached by the forestry value yield curve. Had the investor put \$6,000 into the alternative activity, it would eventually have achieved the value represented by point $\overline{P}$, about \$150,000. Therefore, the present value of the forestry activity is \$6,000. The maximum *net* value of the forestry venture is \$6,000 − \$2,000 = \$4,000. The relevance of these numbers as measures of present value are independent of the individual's ability to borrow (move leftward) along his opportunity cost curves, but he must be able to lend (move rightward) along them.

Systems analysts will recognize present value as an appropriate measure of relative worth only when forestry would fully employ the capital fund to the exclusion of any second project. Where several of a list of ventures involving different outlays may be undertaken, they must be ranked according to some other criterion. If the objective is maximum discounted net value of the total system, then the proper criterion is internal rate of return (29, p. 74).

Capital Market Imperfections

Of course, if perfect knowledge and capital mobility prevailed in a strictly competitive world, other investors would perceive at the outset the opportunity to secure the $4,000 net gain. Economic theory says that investors would then rush to take advantage of the apparent profit. Their demand for funds would raise the rate of interest (the slope of CD would steepen). The additional forestry effort would ultimately reduce prices through increased supply, and this would lower the actual position of EF below investors' expectations. Steepening of CD and lowering of EF would combine to move C, the present value point, down toward $2,000, wiping out profit.

Also, if outlays are not too 'lumpy,' the individual would himself find it profitable to borrow funds at the going rate of interest and employ them in forestry activities that are successively less attractive, until the forestry value yield curves like EF in figure 6 flatten out so that points A and C coincide. In fact, however, market imperfections do exist, outlays in forestry tend to be 'lumpy' because of fixed costs, dynamic elements like innovation occur, and some individuals are more hopeful than others, so that net gains are in fact anticipated if not realized (27).

Maximizing Satisfaction

It was explained with reference to the Fisherian analysis that maximizing satisfaction might lead to a different choice between spending and saving from that which would maximize discounted value. When the analysis is extended to several periods, as in figure 6, this point cannot be examined, since figure 6 presumes that the choice as to how much to invest out of current income has already been made. Only the invested portion is shown ($2,000 in the example). It is also assumed, for expository convenience, that only one outlay is made, and that this is followed some years hence by complete liquidation of the investment.

Figure 6 does indicate that the time of liquidation (harvesting in the forestry case) may be different when satisfaction is maximized than when present value is maximized. The level of satisfaction afforded by holding the initial sum $2,000 is indicated by the ITI curve Aa. This curve is analogous to the indifference curve BC in figure 4. The investor can achieve a higher level of satisfaction by entering forestry, moving along the forestry value yield curve, and reaching the highest-possible ITI curve at P. Point P corresponds to point F in figure 4. At the point in time relevant to P he would plan to terminate the forest rotation; this is earlier than if he maximized present value by carrying the rotation to point $\overline{P}$.

It is also evident that, on the basis of satisfaction, this investor will enter forestry rather than put his funds out at interest. The former course permits him to reach the ITI curve Nn, while the latter choice gets him only to the ITI curve Mm, which he touches at P′. Point P′ is analogous to point D in figure 4.

Possible Equivalence of ITI and Opportunity Curves

It is possible that the ITI curve and the opportunity line intersecting the vertical axis of figure 6 can be identical. This can be explained in terms of the two-period construction of figure 4. There are two requirements for this equivalence.

First, an individual whose initial income distribution is indicated by point A in figure 4 must be in subjective equilibrium at that point; that is, his opportunity line must be tangent to an indifference curve at A. Second, the bonus sum B – A must be small, so that the opportunity line through B diverges very little from the indifference curve through B. In this case, point E will lie very close to point C. The distance AC in figure 4 determines the ordinate of the ITI curve in figure 6 for the time interval of 2 years, and the distance AE establishes the ordinate of the opportunity line for the same point in time. If E and C are close together, then the two ordinates are nearly identical.

Of course, points C and E (figure 4) might be superimposed even if AB is very large. For this to be true for every pair of periods would require that a straight line connecting points B and C have a slope equal to $(1 + p)^n$, where p is the rate of interest appropriate to the opportunity line and n is the number of years involved. That this would be an exceptional instance is seen by moving point A to the left or right so that point C moves up or down the time indifference curve, or by moving point B to right or left. In short, a rather special combination of indifference curve and values of B – A in figure 4 would be required for superimposition to occur, if B – A is large.

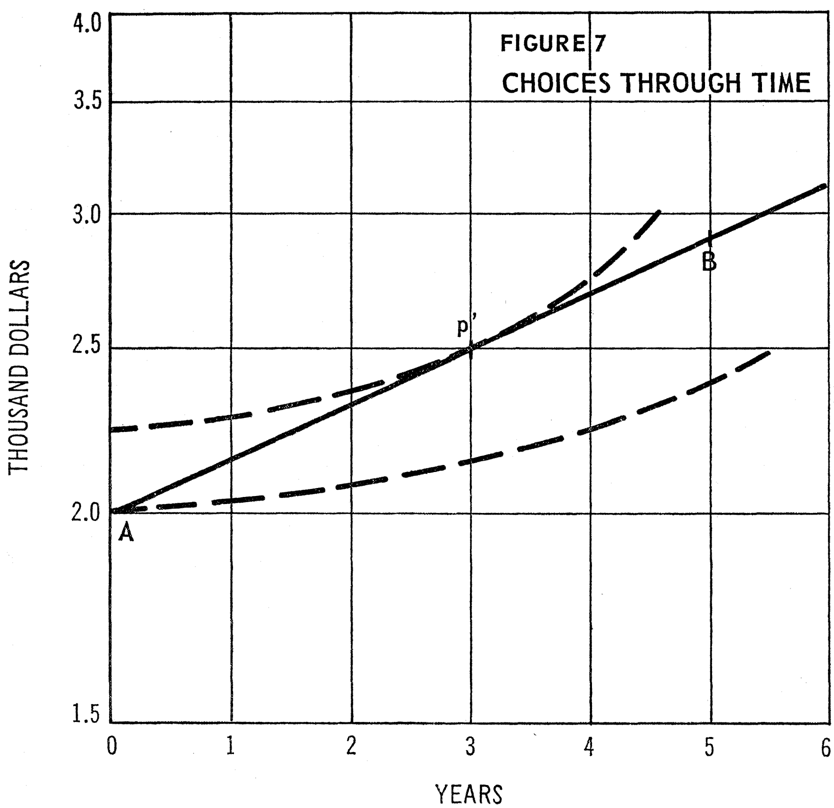
Interaction of ITI and Opportunity Curves: The Discount Locus

The failure of compound-interest opportunity curves to serve as criteria of satisfaction does not impair their analytical usefulness. While these curves do not provide a measure of subjective worth, they indicate opportunities to move between time-value points, possibly toward higher ITI curves, as suggested in the Fisherian discussion.

Consider an investor with an initial capital fund, $2,000, which he is planning to invest during the current year. He will do so if he can thereby reach a higher incremental time indifference (ITI) curve than the one intersecting the vertical axis at $2,000 in figure 7.

Suppose that he is asked to give up his initial capital fund on the promise of receiving a larger sum in 5 years. Presumably there is some receipt which is just large enough that he is indifferent between having it in 5 years and having $2,000 now.

Considering only his ITI curves (figure 7), this person would have to receive $2,400 in 5 years to compensate him for giving up $2,000 willingly. If, however,



he knows that he can borrow and lend at a rate of interest indicated by the slope of the opportunity line, 8 percent, then he can expect to be able to move to P' if he retains his fund. At P' he reaches a highest-possible ITI curve.

If he is to be persuaded to give up his $2,000, he must be offered an amount in 5 years which permits him to reach the same ITI curve as at *P'*. This amount is about $2,900, measured at B, since from B the individual can move leftward to P' by borrowing.

Points like B might be determined for a number of future years besides 5. If connected with a curve, they would represent a series of values between which the investor is indifferent, considering both his desires as measured by ITI curves and his opportunities as reflected in the opportunity curves and forestry value yield curves. At the risk of having developed a lugubrious terminology, these indifference loci will be termed *discount loci*.

Just as there are any number of ITI curves and opportunity curves connecting present with future values, so also are there any number of discount loci for any individual.

The relevance of discount loci is that they will be used in appraising *new* investment opportunities not now known to the individual. If the value yield curve of such a *new* opportunity touches a higher discount locus than the one passing through the point on the vertical axis appropriate to the outlay required for this opportunity, it will be undertaken. If two mutually exclusive projects involving the same outlay are being compared, that one will be chosen which touches the higher discount locus.

Discount loci are a rather special kind of indifference curve. They represent levels of satisfaction in the sense that an individual can attain a given level of satisfaction from any point along the same discount locus. It will be shown that in some cases the discount locus corresponds to an ITI curve; in some cases the locus follows an opportunity curve, so that the individual must borrow or lend to achieve the utility level appropriate to the locus; and in still other cases the discount locus would be expected to follow an opportunity curve over some time intervals and an ITI curve over others. The discussion is summarized in table 1.

DISCOUNT LOCI FOR VARIOUS CLASSES OF INVESTORS

Some general statements can be made about the shapes of discount loci for different persons, depending on their access to borrowing and lending and whether they consider forestry to be their 'best' opportunity, second-best, or do not consider it at all. These remarks will pertain primarily to persons for whom

TABLE I. DISCOUNT LOCI SUMMARIZED WITH REFERENCE TO FIGURE 8

Group	*Description*	*ITI Curve Attainable from Point A*	*Discount Path in Figure 8*
I	Steep ITI curves	Aa′	Aa′
II	Best opportunity exponential		
	Able to borrow and lend	Mm	AB
	Can lend but not borrow	Mm	AP′m
	Can borrow but not lend	Aa	AC′D′
III	Best opportunity in forestry; no other alternative	Nn	Nn
IV	Best opportunity in forestry; exponential alternative		
	Able to borrow and lend	Qq	AB
	Can lend but not borrow	Nn	Nn
	Can borrow but not lend	Qq	AB

point P lies to the left of point $\overline{P}$ (figure 6). Varying these assumptions involves the same analysis but broadens the spectrum of 'types' of loci without shedding additional light on the empirical results. Incidentally, the left-right relationship of P and $\overline{P}$ is the same whether the vertical axis is logarithmic or not.

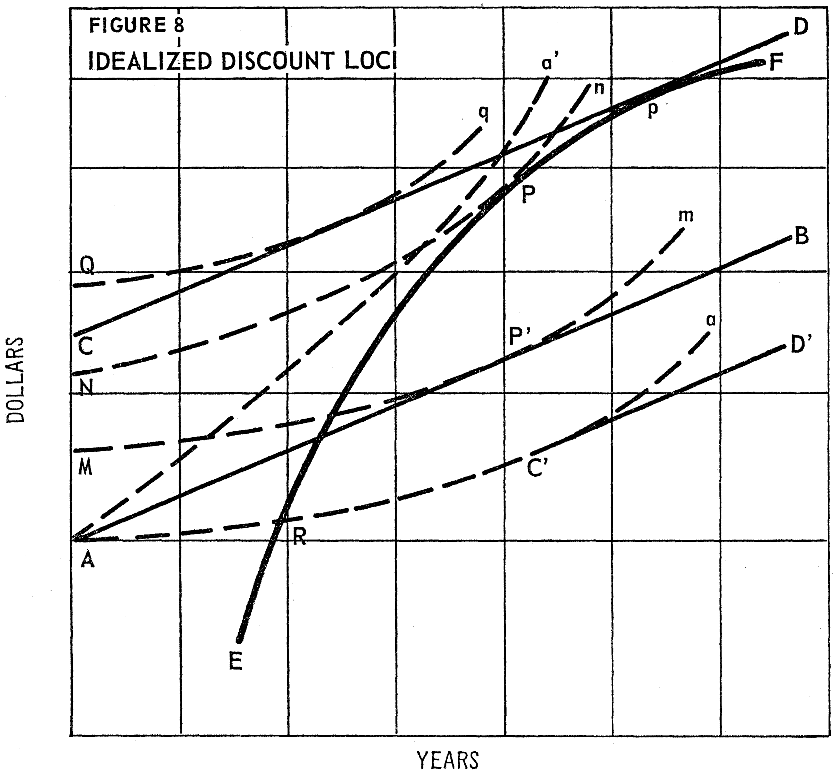
I. Steep ITI Curves

The first group of persons to be considered is that for which ITI curves are everywhere steeper than the compound interest opportunity lines and do not touch the forestry yield curve having the same intercept at point A. Such an ITI curve is illustrated by Aa′ in figure 8, where the relevant forestry value yield curve is EF. For these persons, the discount loci follow ITI curves solely.

II. Best Opportunity Exponential

The second group consists of persons who have varying degrees of access to borrowing and lending, and for whom forestry is unattractive. For those who can borrow and lend, the discount loci are exponential. The locus appropriate to the initial sum A in figure 8 is AB, as discussed previously.

It is reasonable to suspect, however, that the equivalence of discount loci and the going rate of interest as reflected in compound interest opportunity lines may not be applicable to some forest investors. First, they may be unwilling or unable to participate in the organized capital markets because of distrust of existing institutions, dislike of inflexible contractual arrangements, ignorance



of opportunity, lack of access, requirements for collateral, social pressure, family traditions, and the like.

Second, it is generally impossible to borrow against anticipated timber income if it is more remote than about 10 years (38). Third, the individual's time preference may be greater than the market rate of interest regardless of his time-stream of incomes. Such a person would borrow as much as institutions permit and still be willing to borrow more, but would lack future resources to exchange. Finally, his marginal rate of time preference may be lower than the rate of interest, even after lending all of his exchangeable current assets.

For those of this group who can lend at the going rate of interest but cannot borrow at all, the discount locus is AP′m, consisting in early years of a portion of the compound interest opportunity line and beyond P′ of a portion of the ITI curve which is tangent to AB. The inability of these persons to borrow prohibits them from moving leftward along AB to P' from points to the right of P'; the only way they can achieve the same level of satisfaction-the same ITI curve-as that which can be reached from point A is by receiving an amount which actually places them on the ITI curve.

For those who can borrow but cannot lend, the discount locus is *AC'D'*, by a similar line of reasoning.

III. Best Opportunity in Forestry; No Other Alternative

There may be some people who recognize an opportunity to profit from forestry, but consider themselves unable to enter the capital markets. Special attention is given to forestry as an alternative because one cannot move leftward along a forestry value yield curve.

For such a group, the discount loci are like Nn, following an ITI curve, since this same ITI curve can be reached by investing in forestry.

IV. Best Opportunity in Forestry; Exponential Alternative

Another group of investors might consider forestry the best outlet for their funds but also are able to borrow and lend at a lower rate of return than that offered by a forestry activity, provided that funds are retained long enough in the forestry venture.

The relevant discount locus is AB in figure 8. If such persons can borrow but cannot lend, the locus is still AB. If lending but not borrowing is possible, the locus is Nn, the ITI curve accessible by entering forestry.

FRACTIONAL BORROWING

Thus far it has been assumed that, when borrowing against a future income, the maximum sum that can be borrowed is determined by discounting the full future income. In the real world, however, future incomes provide such uncertain collateral that only a fraction of the futurity can be borrowed, while the full future value is demanded as collateral. Home loans are a common analogy, although business loans more correctly typify borrowing against value that is yet to be created.

The effect of restricted borrowing capacity is to shift the compound interest lines, like CD in figure 8, downward when borrowing is involved. This would mean that ITI curve Qq cannot be reached from point $\overline{P}$. Which ITI curve can be attained by borrowing depends, of course, on how far downward the borrowing line CD shifts. If the shift is great enough, borrowing becomes unattractive altogether. This means that, for persons to whom forestry appears the most attractive investment opportunity, no ITI curve above Nn can be reached. This conclusion holds only if P lies leftward of $\overline{P}$ (figure 8), since it is only in this situation that borrowing would be considered.

Fractional borrowing ability and limitations on subordinated obligations like second and third mortgages explain why an individual cannot invest his initial sum in forestry, borrow against the ultimate yield, invest the borrowed funds in forestry, borrow against that yield, and so on.

Theoretical Rationale for Determining Discount Loci

It has been explained that a new investment activity will be undertaken only if its value yield curve rises above the discount locus appropriate to the initial outlay required. When this new opportunity is undertaken, its rotation length is determined by tangency with a discount locus which is higher than that appropriate to the required outlay. Thus, in figure 9, the individual is presumed

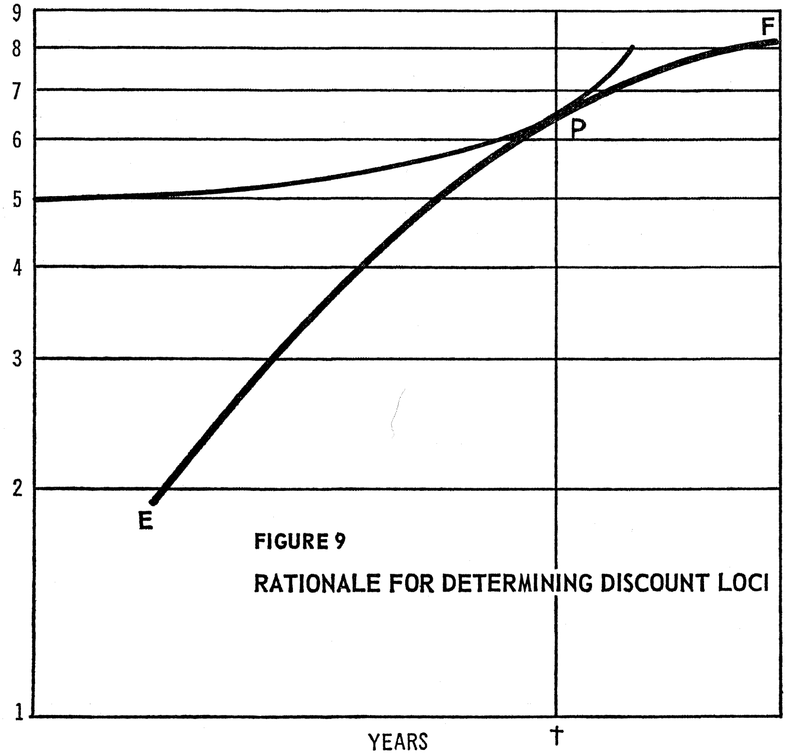


FIGURE 9
RATIONALE FOR DETERMINING DISCOUNT LOCI

to have an investment fund in the current year of $2,000. EF is the value yield curve of the new opportunity, tangent to a discount locus at P. The vertical intercept of the discount locus is at $5,000. The value difference $5,000 - $2,000 indicates that the ne\v enterprise is as valuable to this individual as if he had a *net* addition to his current income of $3,000.

The nature of the discount locus is discovered by proposing additions to the income stream, such as $3,000. Points on the discount locus are reve.aled by offering $3,000 and then determining how large a future increment is equal in value to $3,000. Such an increment is $4,5°0 ($6,500 - $2,000) at time t.

PLANNING HORIZONS

Two other elements in decision-making have thus far been ignored: Planning horizons and uncertainty. Worrell (47) has pointed out that for woodland owners who are unwilling or unable to recognize in their planning events occurring more than, say, 30 years hence, profit opportunities must be available within that time span in order to cause these owners to undertake forest management, regardless of whatever profit potential lies beyond the 3o-year horizon.

As time passes, the planning horizon moves forward, so that after 30 years, the benefits from waiting, say, an additional 20 years, are appreciated. Thus, if policy-makers anticipate a dearth of sawlogs 50 years hence and desire to encourage tree planting now, it may be necessary to offer profitable outcomes on the basis of 30-year-old pulpwood. Later, the disproportionate returns obtainable by holding the pulpwood on the stump until it grows to sawlog size in another 20 years can be usefully pointed out.

In the' time·discount model presented here, a finite planning horizon might be characterized by the abrupt termination of the ITI curves, opportunity lines, and discount loci at some point in time. More probably, the ITI curves assume infinite values in the period representing the planning horizon; that is, the ITI curves become asymptotic to a vertical line which intersects the time axis in that period.

UNCERTAINTY

Two kinds of uncertainty can be distinguished: that which attaches to the activity in question, such as future yields and prices· for standing timber; and that which surrounds 'outside' events that bear on the desirability of the activity, such as the length of life of the investor, the possibility of inflation, the investor's income stream, etc. The 'state of the world'-sort of uncertainty has been discussed as it influences the rate of time preference and thus the shapes of the ITI curves.

As for the former kind of uncertainty, valuation theory suggests that a risk premium be added to the rate of discount, so that the discounted net worth is reduced for 'risky' projects. Since uncertainty of an event depends partly on its distance in time, one might logically assign a different risk premium to each point in future time. This is illustrated in figure 10 for only three points. The resulting discount path (locus ABCD in figure 10) may be smooth, but it is improbable that it corresponds to a compound interest growth line; that is, it would not be a straight line in figure 10.

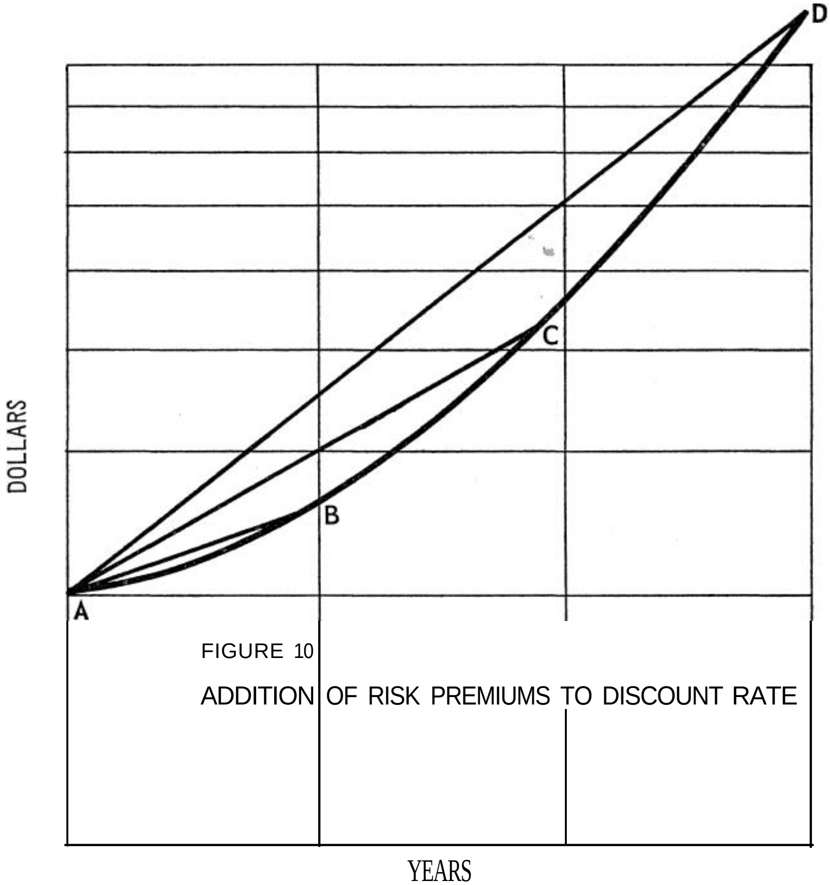


FIGURE 10

ADDITION OF RISK PREMIUMS TO DISCOUNT RATE

Another means of adjusting for uncertainty involves reducing the 'most likely' outcome by some arbitrary amount and then discounting to the present at a risk-free rate. This 'certainty equivalence' method is explained at length by Weintraub (45, p. 339 ff) and attacked by Hart (23), who points out that ". . . many people do things because of uncertainty that they would not do for any certainty whatsoever." He refers in this regard to cash holdings, differentiation of asset portfolios, and inventory policy.

If one is dissatisfied with a 'certainty equivalence' approach to uncertainty, the model proposed here is amenable to the introduction of stochastic uncertainty by adding a third axis to measure a variable called 'subjective probability' or, after Shackle (39), 'plausibility.'

In this case, investment opportunity curves become time-value-probability surfaces, as do the discount loci. Decisions are based upon tangencies between these surfaces, rather than between curves.

EMPIRICAL DETERMINATION OF DISCOUNT PATHS

THE intent of the first two sections is to suggest that, due to capital market imperfections, the individual's time preference may in many cases determine whether the forest-land owner embarks on forestry projects; that time preference should be considered when developing management plans which prescribe the rotation length; and that discount paths may not be exponential (compound interest) functions.

In this section is described an empirical examination of the valuation of investment activities by certain individuals, and the qualifications which must be placed upon the results.

USEFULNESS OF THE GRAPHIC DEVICE

It is appropriate to raise a question as to whether discount loci, or even incremental time indifference (IT!) curves, really exist in the mind of the investor. Introspection suggests that such curves are not formulated explicitly. However, the phenomenon of time preference has been generally recognized, and certainly some persons think in terms of alternative rates of return. Further, it is plausible that individuals can choose between a receipt of money today and receipt of some other sum tomorrow.

If three other conditions can be fulfilled, then discount loci are as valid conceptually as are indifference curves. Indifference curves have been determined empirically for certain commodities (44), though not without difficulty (19, 24). The three conditions are transitivity (33), consistency, and comparability (30).

TRANSITIVITY

Transitivity requires that if the decision-maker prefers three dollars to $2, and $2 to $1, then $3 must be preferred to $1. Considerable discussion on a mathematical level has revolved around weak versus strong ordering; that is, whether an adequate scale of preferences can be deduced from a situation in which the individual either prefers A to B or is indifferent between them. This is 'weak' ordering. Strong ordering calls for preference of A over B without the admission of indifference.

Strong ordering has been assumed with respect to the variables considered in this study. Thus, it is presumed that $2,102 is always preferred to $2,101, that high plausibility (certainty) is preferred to less, and that early income is preferred to later income. Admission of weak ordering does not destroy the analysis, since curves relating any two variables become 'zones' or families of curves, and surfaces relating the three variables become solids. However, weak ordering on the part of the decision-makers can cause indeterminateness in choices between investment activities.

Consistency

Consistency can be said to require that when an individual is presented with a choice-making situation, he will always make the same choice, provided that the state of the world remains constant.

Festinger (16) has observed that maximum certainty (and minimum decision time) occur when stimulus differences are greatest—in the choices of this study, when time spans and dollar values of the alternatives vary greatly. However, when points of indifference are sought, these variables have, by definition, values whose combined subjective impact is very little different between the two alternatives. As a consequence, an individual might report on one occasion that a net gain of $1,000 this year is worth to him a net gain of $2,200 in 10 years, but on other occasions to report the later value as, say, $1,900 or $2,250.

Where such choices can be made repeatedly under indentical conditions, this variance can be evaluated statistically, with, perhaps, the mean value taken as that most representative of the individual's preferences. In real-world experimental situations using substantial sums of money, the situation is complicated by the subject's ability to remember his previous choices, by fatigue, and by changes in the state of the world if a sufficient time span elapses between questioning periods.

The receipt of an array of replies that can be summarized statistically, or 'stochastic indifference,' is not in conflict with strong ordering of preferences as discussed in the previous section.

Comparability

Comparability requires that incomes arising in different periods be evaluated by the same utility function. Put another way, satisfaction from this year's income must be the same kind of satisfaction as that derived from income in another year. This condition does not seem restrictive inasmuch as choices are readily made between apples and oranges, savings accounts and new cars, and so on.

PRACTICAL RATIONALE FOR DETERMINING DISCOUNT LOCI

Given that discount loci can be formulated experimentally, what objective might this serve? First, hundreds of foresters are employed by the federal and state governments to assist in forest management planning on lands of the more than 4½ million private owners of commercial forest land in this country (42, p. 293). The advisory function can be pursued in two ways-by informing the landowner of the management alternatives available to him; or by learning the owner's objectives, cash and credit positions, and other decision-making constraints, and then selecting the n10st appropriate investment program for him. While the former approach lies more within the province of the forester, the large number of management variables (site, stocking, stand age, age of planting stock, plantation spacings, frequency and intensity of hardwood control, frequency and intensity of insect control measures, etc.) influencing the physical output of the land, together with the arbitrariness of price expectations, lead to an unworkably large number of possible management schemes.

In practice, then, it is desirable to follow the second course, learning something of the owner's primary purpose in land ownership, his expectations of the trend of general economic conditions, his planning horizon, his time preference, and the yields he expects from alternate investments-in short, his discount paths-to serve a screening function in rejecting from consideration large blocks of management proposals.

Second, forestry policy makers have suggested that stimulation of wood production is a desirable social end (3; 42, p. 103). Whatever the validity of the suggestion (43), this end has been sought through the 'Soil Bank' and 'A.C.P.' programs. Such encouragement, when directed at private owners through the provision of funds for tree planting and the like, can be effective in producing trees of sawlog size only if the owners' time preference and planning horizons, as reflected in the time discount functions discussed earlier, will permit it.

THE GROUP STUDIED

During the fall and winter of 1960-61, So major woodland owners in New England were subjected to questioning designed to reveal their approaches to time discounting. Major owners were selected for two reasons. First, a sample of given size would cover a maximum acreage upon which decisions are made. Second, it was felt that holders of substantial acreage are most apt to have developed a systematic outlook toward the future with respect to their land, and be most cognizant of timber and timberland values.

Corporate owners, partnerships, trusts, estates, fishing clubs, water companies, and municipalities were excluded from the sample, as were other types of ownership in which decision-making, risk-bearing, and/or profit-taking might be expected to be divided between two or more individuals.

Interviews were conducted in 10 of New England's 67 counties. Any county having less than 66 percent of its area in commercial forest land, as determined from U.S. Forest Service forest survey reports, was excluded from consideration. This eliminated from sampling such areas as Connecticut's Fairfield County, Cape Cod, and Massachusetts' island counties. Thus a random sample of 10 counties was drawn from a possible 45. The counties chosen were Windham and Tolland, Connecticut; Berkshire, Massachusetts; Bennington, Lamoille, and Essex, Vermont; Cheshire and Carroll, New Hampshire; and Cumberland and Oxford, Maine. Five major owners were selected in each of the 10 counties.

The study would have been conducted most easily had all the owners been, say, in a single state or in a block of several counties; however, it was felt that sufficient communication probably exists between owners in a single county that their actions and outlooks are not independent. This consideration is made more important by the fact that service foresters cover individual counties, and these persons undoubtedly constitute a major portion of the technical counsel utilized by woodland owners. Also, forestry and economic conditions differ within the New England states, so that results obtained from a block of adjoining counties could not be assumed representative of the region as a whole. Given a sample size of 50 individuals, the allocation of 5 to each of 10 counties was purely arbitrary.

Names of woodland owners were obtained from service (county) foresters in each of the states. The men were asked to provide a list of a half-dozen persons who had the most substantial woodland holdings in the county, subject to the ownership conditions mentioned earlier. It was assumed that the foresters would be aware of large holdings within their areas of responsibility, regardless of whether there had been personal contact with the owners of these holdings. Subsequent checking suggested this to be the case.

Undoubtedly there are persons whose holdings in anyone county are negligible, but whose properties in the aggregate amount to several thousand acres. Such persons might be overlooked by county foresters though they would be 'major' owners in the sense of this study. The solution to this omission would lie in a complete enumeration of New England forest landowners, developed by searching all town records. The cost of such an endeavor is made evident by the fact that there are 169 towns in Connecticut alone. A complete search was not attempted.

INTERVIEW PROCEDURE

Fundamentally, interviewing used the presentation of situation tests, each situation constituting a hypothetical but feasible set of circumstances. Questioning was of the sort, "Choose between a dollar today and two dollars tomorrow." Situations were varied, substituting different values for the 'two dollars tomorrow' until a 'tomorrow' value was found which caused the individual to be indifferent between 'a dollar today' and the 'tomorrow' value. The procedure was repeated for a total of three future points in time.

Questioning of this sort was not felt to be amenable to mail questionnaires, partly because of the large number of questions and the amount of explanation of the situations which was required, and partly because of a desire to minimize nonresponse (17). In all cases, prior contact was made with respondents by telephone to set up appointments and acquaint them with the kind of information sought. Initially, telephone calls were preceded by letters, but it was found after trial that telephoning, necessary in any case, was sufficient to obtain cooperation. In no instance was an interview refused. For mechanical reasons, one owner living in Florida was not contacted. In this case, the sixth owner in the county in order of size of holding was sought out.

The interview opened with a question ostensibly seeking the individual's reaction to the level of his property taxes and his opinion of a taxation scheme in force in New Hampshire in which the tax on timber (as separate from the land) is deferred until the time of cutting, at which time a fixed percentage of stumpage value is paid. Aside from the interviewer's casual interest in the matter, the primary purpose of this line of questioning was to establish rapport, create interest, and make it evident that the individual was being asked for information which he could in fact provide. It was hoped that any interpersonal tension would be relieved during this discussion.

At this time, probing was used to develop information on the owner's immediate objectives, the circumstances under which his land was acquired, his knowledge of technical aspects of forestry, his opinion of the market situation for forest products, whether he was participating in the A.C.P. or Soil Bank programs, whether he had been contacted by a service forester, and the level of n1anagement on his timberlands. Also sought was his occupation, a general estimate of his ability to meet forestry management expenses, and the acreage held.

Initially, probing was also employed in an effort to determine the individual's reaction to uncertainty; he was asked his opinion of the future trend of stumpage prices which he might face, the highest and lowest price levels which were expected to be possible in a particular year, and the 'odds' of its being between the upper and lower quartiles of the expected range. If forthcoming, answers would tend to confirm or refute the theoretical notion that uncertain future events are viewed in terms of a probabability density function. Similar work has been done by agricultural economists (25).

However, this portion of the study was abandoned after trial, as it was found that price expectations were not well formulated, so that response required considerable time for reflection, shortening the subsequent interest span. Also, there seemed little point in pursuing matters which apparently lay outside the frame of reference of most persons.

The second portion of the interview dealt with the matter of primary interest —estimation of discount paths. First, a situation was hypothesized in which the individual was to receive a lump-sum cash payment as a result of previous overcharges within the local property tax structure. He was then asked whether he would be willing to accept, instead, the same payment in 10 years. If the reply was 'no' (as it was in all cases), he was asked whether an amount equal to five times the initial figure, payable in 10 years, would motivate an exchange. If the answer was 'yes,' the objective of finding some future amount which makes the individual indifferent between receiving the later sum and the present amount was explained, and the respondent was asked to identify this future sum. Presumably this figure would establish a point like B (figure 7) on the discount locus through point A. In terms of the theoretical model, the individual is indifferent between the initial and the later amounts because he is able to reach the same ITI curve from either time-income position.

The same line of questioning was repeated for a time span of 5 years, and then for 2 years, so that the interviewee made three choice-type decisions. Each decision involved the same initial sum; thus each of the three time-value points presumably lay on a discount locus radiating from point A. Since there is only one discount locus intersecting any single point on the vertical axis, all three future values must be on the same discount path.

An exponential function $Y = ae^{rx}$ (or $Y = a(1 + r)^{x}$) can be fitted using only two points; that is, using two pairs of (x, y) coordinates, since only two parameters, a and r, must be established. If, then, it is desired to determine whether a series of points can be connected by an exponential (compound interest) curve, there must be more than two points. Four points—an initial value and three future values—were established for each individual interviewed. This provided enough points to permit a statement as to whether discount loci were exponential, but hardly permitted a statistical answer to the question of whether the loci were *significantly* different from exponential.

The same initial sum was used in the hypothetical situations presented to all those interviewed. This sum was $1,000. It was hoped that a figure could be found which was small enough to be a 'marginal' unit in the economic sense, yet large enough to be interesting. The initial sum chosen first was $500, but the first three persons interviewed indicated that this was so small a sum that they would be indifferent about receiving it now vs. some years hence. Evidently the smaller amount did not satisfy the 'interesting' criterion.

It seems probable that a thousand dollars is not an unduly large trial figure, since the intent of the study was to quantify a discount locus which the investor might use in appraising the present worth of an activity involving an outlay which is realistic but which is 'small' in the eyes of the investor. In forestry, a thousand-dollar expenditure would probably finance less than, say, the planting of 35 acres of seedlings. To a major woodland owner, such an amount may well appear small.

Once four points on a 'discount locus' were found, the same sort of questioning was repeated, but with a constraint on the individual's portfolio such that the monetary accrual would be used only in a forestry endeavor. The purpose of this part of the study was to employ a concealed device to determine what proportion of those interviewed actually considered forestry to be their 'best' opportunity; and for those for \vhom forestry was not best,' to determine how much less forestry was regarded in terms of future worth.

This portion of the inquiry was framed in a somewhat different context. It was hypothesized that a New England insurance foundation contemplated making cash payments to certain major woodland owners, for the purpose of furthering conservation through increased forest management. Payments would be free of obligation except that the money must be used in that forestry activity which the owner deemed most valuable to him. 'Forestry' was broadly interpreted to include road building, line running, pond construction, and fencing, as well as activities, such as cruising, pruning, and thinning, which are more customarily thought of as forestry. Purchase of additional land was specifically excluded.

It was then suggested that the individual would have a choice hetween taking the sum offered immediately, or of taking it later, with an additional stipend to compensate one for waiting. The forest management activity would not be performed until after receipt of the funds. It was explained that the budget of a philanthropic organization would he limited; and if some persons were willing to wait for a smaller compensation than the foundation could earn on its funds if invested elsewhere, then a larger number of individuals could be approached in the long run under the deferment plan.

This is not an unlikely framework. Most persons contacted were familiar with the Soil Bank and A.C.P. programs, under which landholders received federal funds for tree planting and timber stand improvement. Surveys inquiring into who might request such funds and how they would be used would have been a logical prelude to these programs.

UNCERTAINTY IN THE EMPIRICAL TESTS

Determination of points on the discount surface having other than full certainty would be of interest. However, alternatives would have to be presented whose subjective probability (plausibility) is known in measurable terms. At present, it is not even known whether decision-makers recognize uncertainty in a systematic manner when appraising alternate activities. Recent attempts to verify certain subjective probability models have not led to unassailable conclusions.

SUMMARY

Finally, it should be clear that this study cannot measure an absolute amount of satisfaction, nor measure a degree of belief (or probability), nor does it establish whether individuals implicitly discount to an index year. Even the model described in the previous section does not require discounting to a particular year in order to evaluate activities and their rotation lengths.

The study does establish a series of full-certainty income increments varying in time of occurrence, between which the individual is indifferent. These points constitute a special kind of indifference curve, which has here been called a 'discount locus.'

It is the point of tangency of a forestry activity's value-yield curve with the highest possible discount locus which determines its value and rotation length. The discount loci in fact comprise a discounting medium only if the individual does transpose subjectively uncertain possibilities into objective certainty equivalents and discounts these to a base year.

RESULTS OF THE INVESTIGATION

THE findings of the empirical inquiry can most readily be discussed as a number of distinct points.

Strong Ordering

Respondents were all able to report single values for the future sum which caused them to be indifferent between that sum and a thousand dollars now. This suggests that forest investors apply 'strong' ordering to future events.

Stochastic Indifference

This study sheds no light on the appropriateness of a stochastic indifference theory, since there was no opportunity to repeat the same line of questioning on successive occasions. Trials of this kind have been employed (8, 36) on the assumption of stochastic preference.

Granting the relevance of stochastic indifference, it nonetheless seems quite likely that if, on a particular occasion, a person chooses a value 10 years hence which he says is equal in utility to a thousand dollars now, and if this value is well above the mean of his distribution of indifference values for the tenth year, then his replies for 5 and 2 years are above the means for those years. Thus it would seem that choices for different years are probably not independent.

Marschak (33) suggests on the basis of work by psychologists that responses may differ but tend toward a constant 'correct' value as the number of trials increases. This approach is, of course, in contrast with the view of revealed preferences as random variables. The asymptotic behavior is held to be the result of a learning process. Acceptance of a 'learning process' theory would tend to invalidate the results of this study, since only a single trial was conducted. It can be argued in support of validity, however, that forest investment decisions are infrequent by nature, and that even if decisions would be different if oft-repeated, the presentation of learning situations in an empirical test would be of little descriptive value for decision-making.

Positive Time Discounting

It was found that, in all cases, time discount functions sloped upward over time, so that a greater premium was always required for waiting an additional unit of time for a given income accrual. While special utility may have attached to incomes in certain periods, it was not so great as to cause any person to be willing to wait an additional year for no additional premium.

It does not follow from this statement that investors necessarily required a higher *percentage rate of return* for longer waiting periods, but rather that they sought a higher *absolute* return. Examples of the upward-trending discount functions are shown in figures 12 and 13. These figures pertain to the loci determined when no constraints were imposed upon the investment activity. Apparently the marginal rate of time discount was positive for all individuals over a 1o-year span.

Of 50 interviewees, thirty-one reported that their discount loci corresponded to compound interest rates, within the linlits of their planning horizons. The rates of interest varied from 3 to 12 percent. Another five persons indicated that rates of compound interest were appropriate over the initial portions (2 or 5 years) of their loci, with other considerations determining the later portions. Figure 11 employs.a bar diagram to indicate the distribution of interest rates reported by these 36 individuals.

Figure 12 shows the discount loci determined for 13 of the 14 persons whose loci were not influenced by alternative rates of return as expressed by compound interest. The 14th had a very short planning horizon. Of the 14, 4 said that their replies strictly reflected the earning possibilities in forestry. The other 10 spoke about the uncertainties of life, the need for funds to tide them over, and other elements reflected in the ITI curves of the model presented in the first section.

The rather neat distinction between the groups of persons was facilitated first by the fact that all the respondents were willing to explain how they went about making choices between the income alternatives offered, and second because of a tnarked difference in the decision times required. Those who reported rates of interest did so promptly. On the other hand, those who replied in terms of forestry yields did not display much facility, and those whose reactions may be taken to reflect ITI curves required much thought in developing their answers, presumably because these values were never materialized froln time to time in terms of actual returns received or payments offered, as in the capital markets.

The apparent discount loci of the five persons who thought in terms of earning rates over the early years, and then referred to other factors, are shown in figure 13.

'BEST' INVESTMENT OPPORTUNITIES

In total, forestry figured in the discount loci of 10 persons; another 8 said that although they would use unforeseen income in other ways, the return they ex-

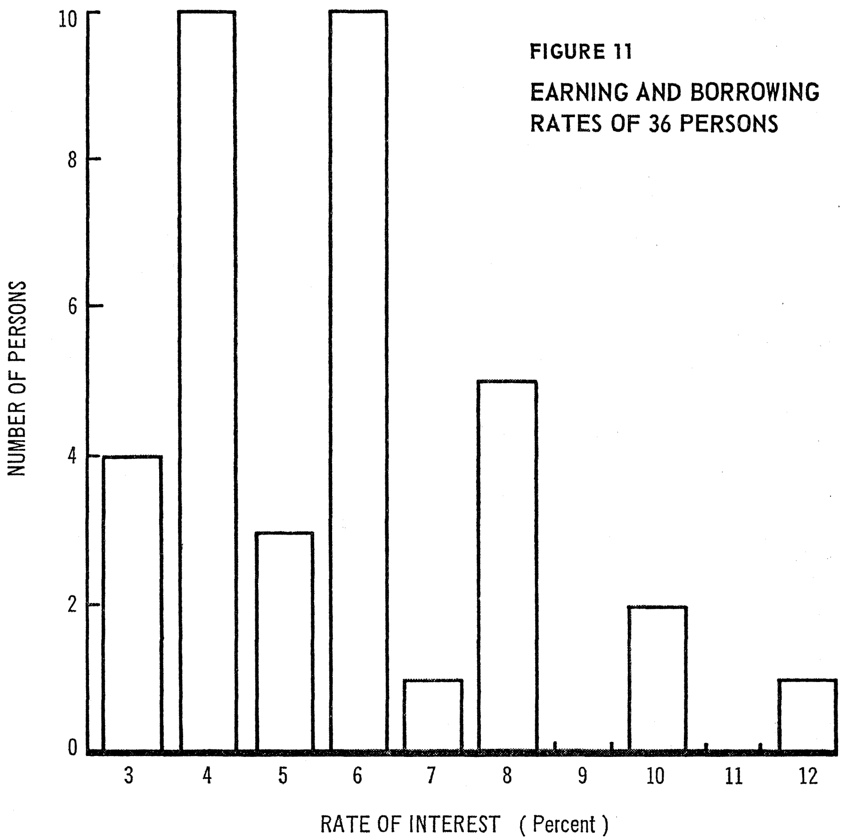


FIGURE 11

EARNING AND BORROWING RATES OF 36 PERSONS

pected was the same as they anticipated from their forestry works. Although 6 of the 18 did not indicate the rates of return they expected from forestry, the numerical data they gave suggested that, for the 18, expectations ranged from 4 to 17 percent. The mean expectation was 9 percent; the median was 7 percent.

Mortgages were mentioned by three persons as their 'best' opportunity. These three all anticipated a return of 6 percent. Stocks and bonds were mentioned by 12 persons, who expected returns varying from 4 to 10 percent, with a mean of 6 1/6 percent and a median of 5½ percent. Within this group, four specified their portfolios, which included utilities, municipal bonds, and mutual funds. These four reported yields having the same range as for the stock-bond group as a whole.

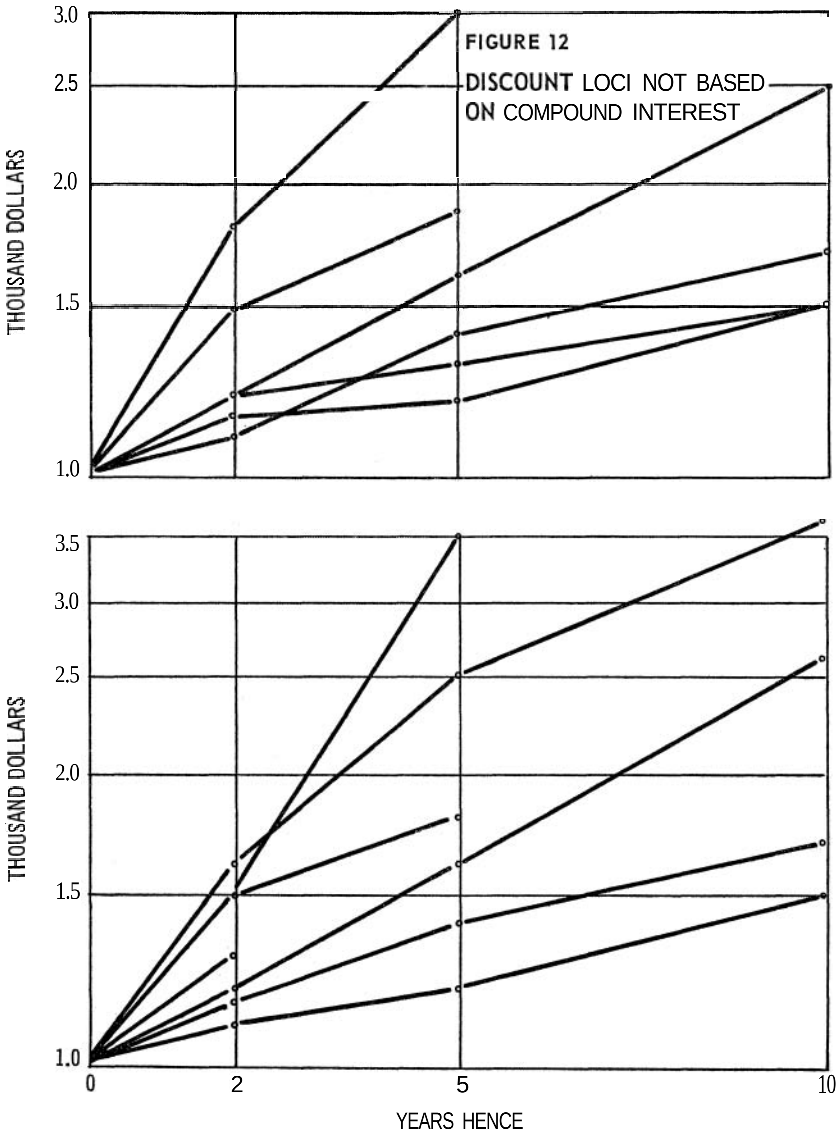
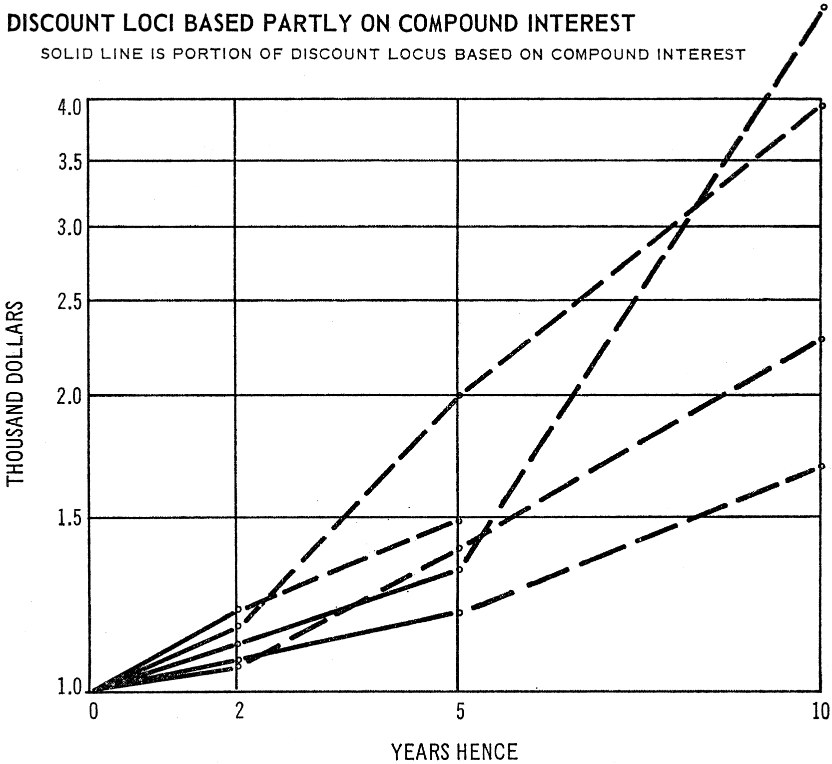


FIGURE 12
DISCOUNT LOCI NOT BASED ON COMPOUND INTEREST
THOUSAND DOLLARS
3.0
2.5
2.0
1.5
1.0
THOUSAND DOLLARS
3.5
3.0
2.5
2.0
1.5
1.0
0
2
5
10
YEARS HENCE

FIGURE 13

DISCOUNT LOCI BASED PARTLY ON COMPOUND INTEREST

SOLID LINE IS PORTION OF DISCOUNT LOCUS BASED ON COMPOUND INTEREST



One person reported his 'business rate' as 12 percent. Seven respondents felt that their best alternatives lay with banks, including savings and loan associations. These expected returns between 3½ and 4½ percent. One person mentioned series 'E' savings bonds. Four persons reported earning rates of 5, 6, 7, and 8 percent, in activities they did not choose to reveal. The average rate of interest reported by borrowers was 6 percent. All the borrowers indicated that they would obtain funds from banks, and would use collateral other than their forest land.

X

Fitting of Exponential Curves to Discount Loci

Of the 50 unconstrained loci, 31 were found to be wholly exponential. Five were partly exponential.

The question arises as to whether the 19 non-exponential curves can be approximated by compound interest curves in order that it might be said that all discount paths were *nearly* exponential in form. To this end, compound interest curves were fitted to each of the non-exponential loci.

Each exponential fitted curve was passed through the value-intercept equal to $1,000. A rate of interest was chosen for each curve such that the sum of the deviations of the logarithms of the actual time-value points around the curve was equal to zero. That is, a value of p was found for each person such that, for the equation $Y = A\ (1 + p)^t$, where Y is value at time t, A is present worth ($1,000), and t is the number of years, hence,

$$\log Y - \log A - (\log (1 + p))\ (t) = 0$$

For comparative purposes, linear functions were also fitted, passing through point A, with the sum of residuals of actual values about the line equaling zero. The linear curves appear as smoothly curving lines in figures 14, 15, and 16 because of the logarithmic vertical axis.

Examples of the fitted curves, both exponential and linear, are shown superimposed on selected discount loci in figures 14 to 16.

Fitting of curves had no relevance for 2 of the 19 persons, since 1 indicated that he would not postpone an income under any circumstances, and the other said that his planning horizon was shorter than 5 years.

For the 17 others, exponential curves produced a better fit in terms of the sum of residuals than the straight lines in only seven cases. In these seven cases, the mean residual was 87; that is, the average error encountered in employing a compound interest curve to describe these individuals' discount loci is $87, or nearly 9 percent of the present worth of any enterprise whose value is appraised by these loci. The average error is raised to 17.7 percent of present worth if compound interest loci are 'forced' to approximate the discount loci of all 17 persons.

It can be concluded that exponential functions are not appropriate to describe the discount loci of all the individuals interviewed. For 19 of the 50, compound interest calculations of present values of investment alternatives serve little purpose.

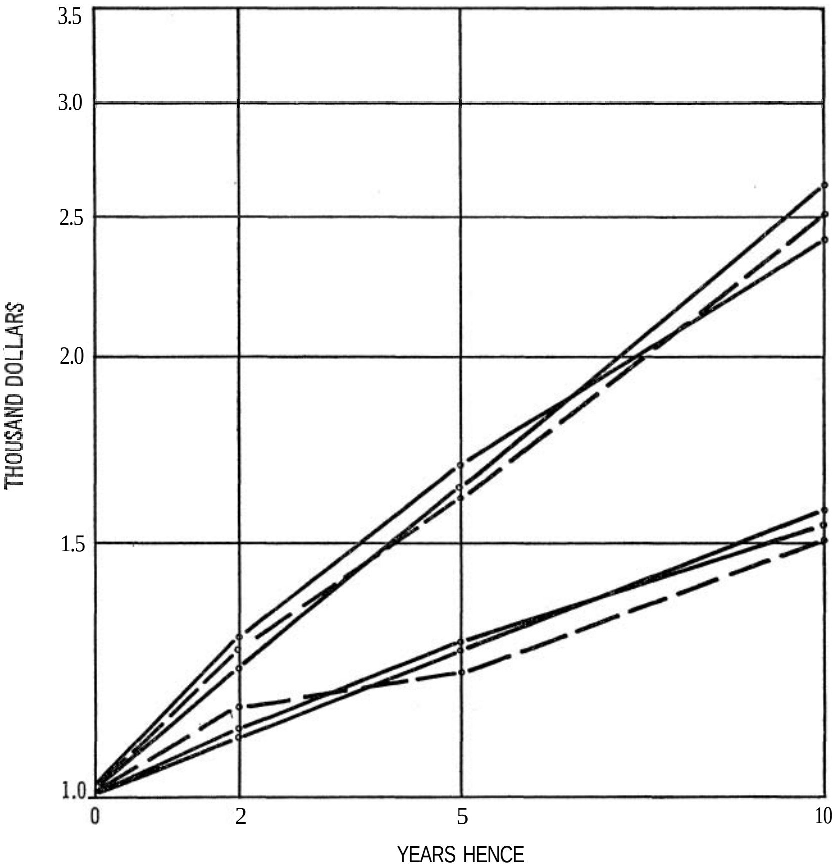
Forestry As a Best Investment

It has been reported that 18 of the respondents indicated that forest management was either the best investment available to them, or else equal in return to the best available. It is fair to ask whether these responses might have been different had the same questions been asked by, say, a representative of the New York Stock Exchange instead of by a forester. Fortunately, the 'restricted-to-

FIGURE 14

SELECTED DISCOUNT lOCl WITH FITTED EXPONENTIAL AND LINEAR CURVES

DASHED LINE: DISCOUNT LOCUS
STRAIGHT SOLID LINE: FITTED EXPONENTIAL CURVE
CURVED SOLID LINE: FITTED LINEAR CURVE

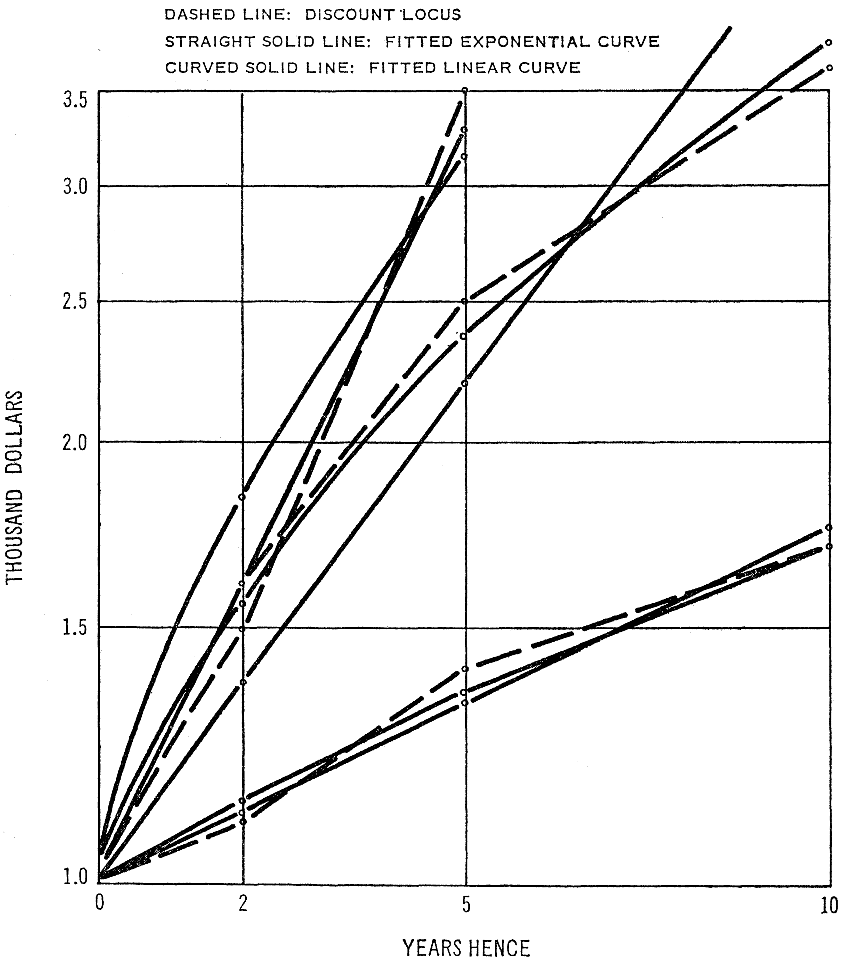


forestry' portion of the study gives some insight into the validity of such statements.

The theoretical remarks indicated that if forestry is indeed 'best',' then restriction to investment in a forestry activity involves no loss of satisfaction to the individual and no change in his discount locus. Response to the contrained

FIGURE 15

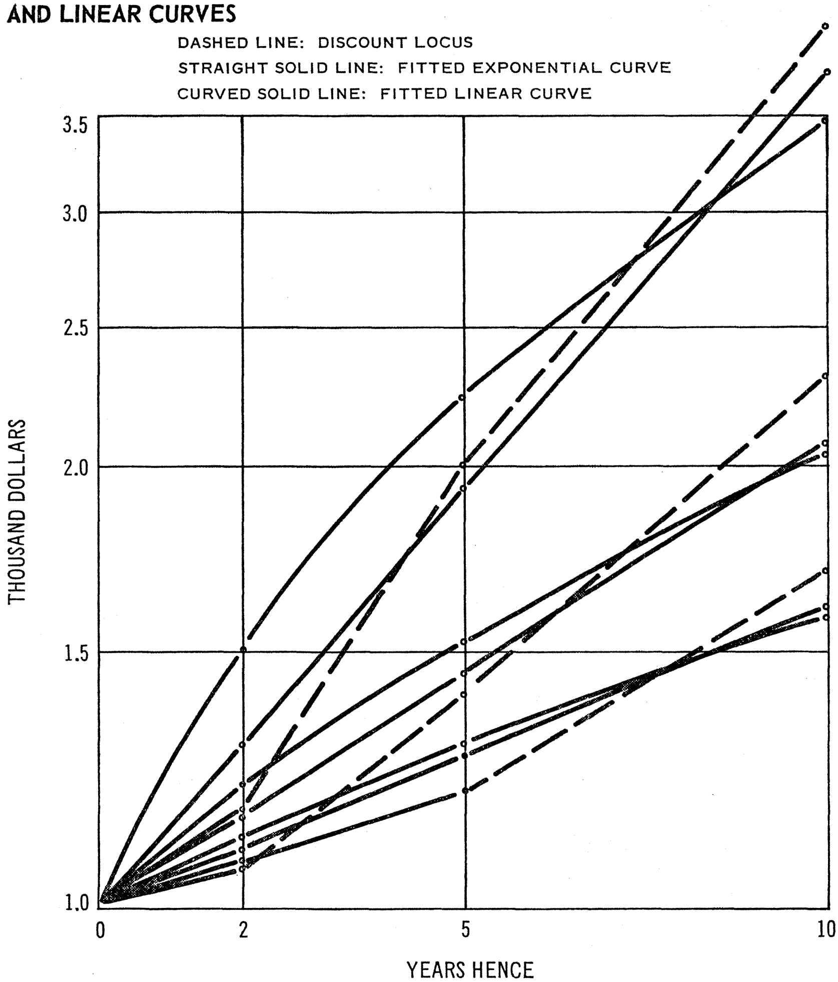
SELECTED DISCOUNT LOCI WITH FITTED EXPONENTIAL AND LINEAR CURVES



alternatives indicated that landowners' statements were apparently valid; for all of the 18, the restricted-to-forestry loci were identical with the 'unrestricted' loci. The mean return expected from forestry was 7.4 percent; the standard deviation of expected returns was 4.2 percent. The mean for all investment activities was 5.4 percent, with a standard deviation of 2.0 percent.

FIGURE 16

SELECTED DISCOUNT LOCI WITH FITTED EXPONENTIAL AND LINEAR CURVES



ITI Curves

It was theorized in an earlier section that some persons (those who cannot borrow against forestry outcomes) would discount along incremental time indifference (ITI) curves in the restricted instance. For those persons who could borrow in the unrestricted situations but could not do so in the restricted activity, the constrained discount loci shed some additional light on the shapes of the ITI functions. There were 13 of these people in addition to the 12 whose .unconstrained loci apparently followed ITI curves either partially or entirely.

While best-fit exponential curves were found to be poor indicators of the shapes of the discount loci, they offer a useful index of the *relative* time-slopes of the non-exponential discount loci for use in comparison with the slopes of exponential discount loci.

When exponential curves were fitted to the discount loci of all persons who discounted along ITI curves either in the unrestricted or restricted situations, it was evident that, in general, ITI curves were steeper than the compound interest rates of return available to investors with market opportunities.

It would be expected, then, that persons who discount along ITI curves (i.e., according to time preference) would place lower present values on activities involving deferred payoffs. That is, persons who do not have access to borrowing in the capital markets are less interested in forestry, even though their personal rates of time preference are no different from those of persons who do have access.

ACCESS TO CAPITAL FUNDS

If the discount loci found empirically are interpreted in the light of the model outline in this study and validated against verbal comments by the interviewees, then it must be concluded that of the 50 respondents, 6 persons could and would borrow against expected future incomes in the normal course of their affairs. An additional four would borrow only in the restricted-to-forestry situation in order to earn elsewhere at a better rate than in forestry; however, these four planned to use something other than their forest assets as collateral.

This would be a rational course for any person who allocates his incomes between periods until the increments of utility afforded by the expectation of the last dollars in each period are equal. A sum which can be spent only on forestry implies a large income in the period in which the forestry project reaches fruition. This person would endeavor to allocate income away from that period and into other periods, which he can do by borrowing, perhaps followed by investment in enterprises offering returns in different periods.

The discount loci suggested that 13 could not borrow; however, there were a number of persons whose utility maximization would not involve borrowing in any case, so that no general statement can be made about the number of persons restrained from borrowing.

It is perhaps significant that, although two persons said outright that they needed immediate funds, neither of these complained about his inability to borrow. Although this result is in contrast with an abundant literature citing the need for forest credit, it may reflect the particular economic status of the group interviewed in that they were major landowners and in general had more than average assets.

PLANNING HORIZONS

Fifteen persons clearly had planning horizons of less than 10 years. Of these, three were shorter than 5 years and one was less than 2 years. Nothing can be said about the horizons of the remaining 35 persons.

The mean 'fitted' rate of time discount for those with short horizons was 10.8 percent; for the others, 6.6 percent. Standard deviations were, respectively, 8.0 percent and 3.2 percent, which suggest considerable overlap between the two groups.

APPRAISAL OF UNCERTAINTY

Each of the 10 persons who indicated that he would invest in some forest-oriented activity if he had additional liquidity was asked whether he felt that forestry offered special risk or uncertainty when compared with other investments, and whether this influenced his decisions in any way. The same questions were addressed to 10 other persons, chosen systematically, who did not name forestry as a 'best' activity.

None of the 20 persons felt that forestry was more risky than the other investments which they undertook. It has been noted that these 'other' activities ranged from savings accounts to mortgages. While this result was surprising, it must be interpreted in the light of the objectives of the investments in landownership and in forestry, as the meeting of these objectives may not be influenced by those factors, such as fires and sharp price fluctuations, which are generally considered to make forestry an uncertain undertaking. Also, investors may believe that those factors which make forestry uncertain would have an equal effect on any other activity.

CIRCUMSTANCES AND OBJECTIVES OF LANDOWNERSHIP

While no formal questioning was directed toward the reasons why these persons had acquired forest land, the history of their tracts and their management invariably came up in informal discussion.

Eight persons had inherited their land with a sawmill, and it was still used to provide a continuous wood supply for the milL Eleven more had purchased the land themselves to support a sawmill. Two tracts were inherited with a farm. At the time of the study, one of these was under management for current timber income while the other was inactive. Three ownerships were held after they were logged over by the owner because of a lack of opportunity to sell the land; these tracts were being logged over periodically by the owners. Two holdings were being held for future logging. *Two* woodlands had been acquired in connection with a visitor-oriented business and were retained to protect the 'atmosphere' surrounding the business. Ten more tracts were held for the stated purpose of selling off the timber as stumpage; none of the 10 apparently envisaged selling the land. Rather, it was felt by some of these persons that cutting can be carried out on a Io-to-20-year cycle. Two of these 10 anticipated rapid increases in land values. All of the 38 holdings just listed were characterized by resident owners whose current investment motives were apparently dominated by economic considerations.

Four more individuals said that they sought deferred income, either after their retirement or for their heirs. Five, including two mentioned above, were awaiting rapid changes in real estate values, largely on the basis of an increasing population and demands for recreation.

Finally, IS reported aesthetic motivation. It will be noted that the total number of owners discussed here is greater than the number interviewed since some persons reported two objectives having equal weight.

Of the 15 who cited aesthetic reasons for their original land acquisition, 7 appeared to be sharply cognizant of economic opportunity in their present management outlook. This seemed to be a sequential relationship; land was purchased as a 'retreat' for recreational purposes, and later the owners began to seek out opportunities to realize income from the land.

It also appeared that, in general, nonresident owners had acquired their holdings in single large blocks in one purchase, whereas the woodlands of the resident owners were purchased piecemeal over a number of years.

SIZE OF FOREST LAND HOLDINGS

Acreage held varied from ISO to 33,000 acres. The mean ownership was 3,720 acres; 80 percent of the woodlands fell between 500 and 5,000 acres. The Forest Service has estimated that, for the New England states, the average private holding comprises 114 acres, with only one-half of one percent of the ownerships having between 500 and 5,000 acres (42, p. 552).

Summary

Based on the data collected, certain conclusions can be drawn about the specific group dealt with. It is not felt that the data are sufficiently representative of any well-defined segment of the forest economy to permit extending these conclusions to some larger group.

The first four of these conclusions require the model as an analytical tool; the remainder are independent of the expository device.

a. For a majority (31 of 50), the fundamental principles of valuation theory involving profit maximization and a borrowing-or-lending rate of interest were strictly applicable.

b. For a substantial fraction, time preference was a total or partial determinant of the time discount locus.

c. For those persons whose discount loci do not depend on alternative earning rates, the discount loci cannot usefully be approximated by an exponential (compound interest) function. A fitted exponential curve does serve as an index of the *relative* rates of discount employed by different persons.

d. In those instances in which a determination could be made, incremental time indifference (ITI) curves were appreciably steeper than the earning rates offered by alternative investments.

e. The mean return expected from investments was 5.4 percent, which is somewhat lower than rates frequently suggested as appropriate to industrial investments.

f. A significant fraction of those interviewed apparently did not consider borrowing to be an opportunity which they were free to exercise.

g. Nearly a third (fifteen) had planning horizons shorter than 10 years. Intuition to the contrary, no relationship was observable between this characteristic and individuals' ages, investment activities, or cooperation with the A.C.P. program. Apparently short planning horizons need not preclude forest management practices.

h. The persons interviewed apparently did not regard forestry ventures as 'risky' relative to other investments which they might have pursued. However, replies on this matter were highly suspect of bias, as the questions were asked by a forester.

i. Distinction must be made between motivation which induces land acquisition and that which underlies subsequent management. A major motive for forest land ownership in this group involved economic returns; it was more of a factor in management than in acquisition. Aesthetic values accounted for a significant fraction of both management practices and original acquisition.

j. While the average age of those interviewed might be termed 'late middie', no relationship is notable between the size of holding and age, or between the rate of time discounting and age.

k. Cooperators in the A.C.P. program, in which the Department of Agriculture makes payments for timber management practices, are not different in any observed manner from noncooperators.

1. Neither a high rate of time preference nor limited access to capital markets necessarily precludes land ownership and forest management.

CONCLUSIONS

THE two objectives of this study were to develop an analytical model in order that the theoretical relevance of time preference to discount. theory might be examined, and to determine whether the type and degree of time discounting employed by individuals can be found empirically.

TIME DISCOUNTING MODEL

It was possible to devise a time discounting model which incorporates both time preference and opportunities to borrow and lend. It is· suggested as a framework for describing decision-making processes as they relate to the time variable; no suggestion is implied that investors actually do or should employ the modeL In its simplest form, the model relates two variables-dollar value and time-in terms of satisfaction (utility). It is compatible with the introduction of two additional variables-psychic income from specific activities and uncertainty.

The construction pertains to gains which arise only once during the span of time under consideration. Thus a portion of the apparatus is an *incremental time indifference* curve, or ITI curve, which connects time-value points between which the individual is indifferent as to receiving anyone of them. The ITI curve reflects his rate of time preference; each curve represents a different level of utility.

Also employed is a curve illustrating the growth of a capital fund at compound interest. The *compound interest opportunity* line indicates one's ability to realize in any single period the cash value of his investment; it may also show the time-value path along which it is possible to borrow against a future fund, where the future fund is assumed to accrue in an instant, and borrowing is assumed to exhaust entirely the credit offered by this fund.

Also utilized is a curve determined by the value growth of an initial outlay in a forestry enterprise. It is presumed that the yield will be realized at a single point in time. The *forestry value yield* curve is interesting in that it represents a 'lending' path, but in no case is it a 'borrowing' path.

Infinite numbers of the three kinds of curves can be developed, with each curve appropriate to a different initial fund. It is assumed that, given an initial capital fund, the objective of the individual is to employ that fund in that activity which permits him to reach the highest level of satisfaction; that is, the highest possible ITI curve.

CONCLUSIONS

DISCOUNT LOCI

The model makes it clear that, conceptually, time preference can be distinguished from the value productivity of capital funds. It also suggests the manner in which different kinds of investors might discount future values to a base year, as prescribed by valuation theory.

For persons who have access to capital markets and who can make their investment outlays in small units, the model is not particularly interesting since ITI curves coincide with compound interest opportunity lines which constitute their discount paths, or discount loci.

For those whose investment outlays are in large 'chunks,' as seems to be the case frequently in forestry because of high fixed costs associated with such investments, the ITI curves are not coincident with opportunity lines, but the discount loci are still along the compound interest paths so long as the investor can borrow and lend in the capital markets.

Some persons may have ITI curves that are sufficiently steep as not to contact either forestry value yield or opportunity curves, where these curves pass through the same initial points as the ITI curves. Others may not conceive of themselves as having investment opportunities. For both groups, the discount loci follow ITI curves. For the former group, forest management would be unattractive because of the high rate of discount applied to future yields.

On the basis of the model, all other persons can be expected to discount along paths which are made up of segments of ITI curves and opportunity curves.

DISCOUNTING VERSUS MAXIMIZING

On the basis of the model, it appears that in order for persons to rank con1peting investment opportunities, it is not a necessary assumption that future costs and returns are discounted to a base year; rather, they can be evaluated in terms of the highest-ranking discount locus which each activity can achieve.

EMPIRICAL OBSERVATIONS

The empirical portion of the study involved interviewing So persons who represented the five largest forest landholdings in each of 10 randomly-selected New England counties. These persons were presented with hypothetical situationswhich involved their choosing between accepting one thousand dollars now or taking a larger sum at some specified future time. A series of such choices n1ade possible the formulation of a single discount locus for each person.

FEASIBILITY OF EMPIRICAL STUDIES

On the basis of the interview results, it is concluded that, for persons for whom time and income are variables affecting satisfaction, it is feasible to establish discount loci. The conclusion is subject to considerable qualification.

First, the conclusion is relevant only for future incomes that are free of uncertainty. Second, these incomes must be mutually exclusive: choices were of the 'either-or' variety, between sum A now *or* sum B later.

Third, no positive statement can be made as to the validity of the results of the experimental work; it cannot be established that the discount functions which individuals reported are different from the 'true' subjective functions on which decisions are based. They might be different because the respondent does not know the 'true' values and so reports only estimates of them; because bias is unintentionally introduced by the interviewer or by the interview situation; or because intentional misrepresentation is actuated by particular motives of the respondent.

Validity cannot be tested by repetition of the trials because of respondents' memories of earlier replies. Individuals' replies cannot be examined critically in the light of actual behavior because their weighting of noneconomic objectives and subjective appraisal of expected costs and returns cannot be determined; if they could, behavior would merely set a boundary on the rate of time discount.

It is the opinion of the writer that, because the situations offered were not 'loaded' with emotional or motivational content, replies were sufficiently valid to justify the conclusions drawn here.

ADEQUACY OF THE MODEL

It was concluded that time discounting practices of woodland owners could be explained in terms of the framework provided by the model, inasmuch as responses by 50 persons could all be classified and interpreted in terms of market access, as suggested by the model.

This is perhaps not the only model which the data could fit, nor is any conclusion made here that this decision model is in fact employed. Further, time discounting may be obscured by a complex of overriding objectives and values. It is suggested, however, that both time preference and market opportunity are plausible variables and that they probably interact in determining the valuation placed by investors on costs and returns which vary in their times of occurrence.

VARIATION OBSERVED IN APPROACH TO DISCOUNTING

The respondents' replies indicated that some woodland owners have no access to non-forestry investment activities. Such persons discounted according to their rates of time preference. In terms of the model, their discount loci were along ITI curves. Others had access to borrowing and lending opportunities and appraised investments in terms of alternative rates of return. Still others had varying combinations of market access and regard for forestry as an investment; their discount paths were consistent with those suggested by the model.

IMPORTANCE OF A TIME PREFERENCE DISCOUNTING MODEL TO FORESTRY

Apparently the outlook toward long-term investments of nearly 40 percent of the major woodland owners interviewed was influenced to some degree by time preference. It is the writer's opinion that this percentage would be substantially larger had persons possessing holdings closer to the average size for the region been contacted, due to the greater probability of capital market imperfections surrounding 'smaller' owners. If this is so, then time preference may have a considerable bearing on forest management decisions in New England.

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