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A methodology for the assessment of priorities and values in nature conservation

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Preface

This paper has been written as a first series of proposals, which I would hope to develop as a result of comments and suggestions made by those reading the paper.

The ultimate aim is to try to provide a basis for the assessment of the "conservation value" of various types of habitat outside the N.N.R./ S.S.S.I. series, and to make plain to others concerned with land use planning the logic behind such assessments.

Introduction

In common with all things which have no easily measured market value, the place of wildlife and wildlife conservation in our total "economy" tends to be somewhat vague. Attempts at conventional cost/benefit studies must always be imprecise, as the assumptions on which such studies are based are in themselves open to question. Such studies may be very useful when comparing two or more similar alternatives, but can not carry very much conviction when comparing circumstances which are not closely related. For example, the amount paid for licences to hunt, catch or photograph wild animals may be a useful means of comparing similar resources, such as two salmon rivers, but will be a less useful guide to the value of these resources as compared to other values, such as those obtained from a hydro-electric project.

In order to obtain some form of credible and generally acceptable assessment of the value of, for example, the wild plants and animals in a piece of woodland or a stretch of open moorland, it will be necessary to examine the habits, resources, ideology, and life-pattern of the animal which concerns us most - Man. Detailed assessments should then be related, if possible, to an overall conceptual framework, within which such assessments can be seen to be realistic. The construction of such a conceptual framework is not easy, as there are few direct points of definite knowledge which can be used as a foundation for it. This paper is an attempt to "rough out" a slightly clearer and more rational framework, which it is hoped can later be worked over in more detail.

In the Appendices at the end of this paper, three systems of valuation are set out, in as logical a fashion as possible, based on a number of premises which are described in the main chapters. Suggested values are also given to enable a "shadow price" to be calculated, as a means of relating these valuations to everyday market values such as the price of chocolates, motor cars, or shoes. Such values can not, by their nature, be very exact, but they can be used as a general indication, which may be better than completely ignoring such "intangible" values in one's calculations. These values will also change over the years, as values change in other parts of our society, and from one country or region to another, according to the standard of living and culture of the countries concerned.

A distinction is also drawn between the current value of the amenity afforded by a tree or a woodland full of bluebells, for example, and the value of a species threatened with extinction. As the latter can not be replaced once it is lost it must be valued on a separate scale, related in a much more tenuous way to current values, interest rates, etc.

The special position of National Nature Reserves and Sites of Special Scientific Interest is not considered in this paper, as the criteria for the selection of these have already been worked out. Such sites represent a special case, being in many instances, the best or the only examples of a certain type of habitat. They also form a national series; the value of the series being greater than the sum of its components.

1. Current value of wildlife to the nation

The wealth of a country is frequently expressed in terms of its Gross National Product, that of the United Kingdom being currently in the order of £40,000 millions. Sales of farm produce are valued at approximately £2,000 million, and about £900 million is spent on annual holidays each year. A figure of something like £5,000 million is spent annually on what may be loosely called "leisure", "entertainment", or "recreation", the exact figure depending on what one includes within this category.

The first, and largest, portion of most people's income is spent on essential items of food, clothing, and shelter; and people with larger incomes will have a larger margin for spending on "recreation"; although, as income rises, what is regarded as "essential" changes to some extent. As stated by Blai (1964); "until the prepotent needs are relatively satisfied the others do not emerge as consistent motivators of behaviour. The individual is dominated and his behaviour arranged only by unsatisfied needs. If hunger is satisfied it becomes unimportant in the current dynamics of the individual". It is evident for example that persons in the higher income brackets spend a considerable proportion of their income on purchasing houses in pleasant surroundings and with large gardens and/or on second homes in attractive parts of the country (and that the market for such properties is increasing as more people attain a higher personal income).

The margin available for spending on wildlife conservation (which has previously cost virtually nothing, and is now suffering accordingly) is likely to be considerably less than the amount spent on recreation, as, in most people's view, wildlife is regarded mainly as an aesthetic factor which contributes to one's enjoyment of a picnic or a ride in the countryside, etc.* It may, however, rise during the next few years as real incomes rise and people become less preoccupied with food, clothing, and shelter.

The value of wildlife to Man may be attributable to one or more of the following classes of benefit:-

A. Production	i.	actual	- meat, fish, etc.
	ii.	potential	- reserve of material for breeding
			- control of pest species
			- facilities for research work and training in scientific methodology

* The avoidance of global pollution and destruction of complete "life-support systems" is, to some extent, a different matter; and one which is in no way optional, as is the conservation of individual species or habitats.

b. Recreation

i. education - to broaden one's mind

ii. natural history studies, photography, etc.

iii. contribution to the landscape or character of a locality

The actual production value of wildlife in this country is not very great, as most plants and animals which are harvested commercially are cultivated and cared for in such a way that they can no longer be regarded as "wild". Even when, for example, deer are sold as venison, the value of the meat may be much less than the money paid for the privilege of stalking them; which must be classed as a recreational value.

The value of wild plants and animals as a reserve of material for breeding future food-producing crops is difficult to estimate. On a practical level it is rarely a major reason for the conservation of a population. Many species can be virtually ruled out as possible sources of food (although they may have other uses, e.g. for pest control, for ornament, or for fundamental research work), or they can be maintained in sufficient numbers and variety without special conservation measures. It is, however, a highly valid reason for conservation in general, and if the maximum variety of genetic material is to be maintained it is necessary to conserve more than the odd few individuals in one place. Where a species has, for example, a wide geographical or ecological range there is usually considerable genetic variation within the species, some being more tolerant of cold conditions, or more resistant to certain pests, etc.

The role of wildlife in controlling pest species is often a matter of some dispute. Under extensive systems of husbandry, such as most forms of forestry, the presence of a wide variety of insects and other organisms usually results in populations which are fairly stable in number, and the emergence of individual species as "pests" is unusual. In less natural or more intensive systems of husbandry, however, this mechanism is frequently insufficient to control pests, and sprays and other forms of protection may be necessary. As land-husbandry becomes more intensive the relative value of wildlife in this respect may, therefore, decline. On the other hand, its value for providing new means of "biological control" may increase considerably:- that is, using predatory species deliberately, rather than letting them come of their own accord.

Natural systems of plants and animals afford unique and valuable opportunities for fundamental research work and for the education of biologists, agronomists, silviculturists, etc., which is later reflected in the more efficient functioning of these scientists in their chosen careers; and the wider the range of conditions and organisms which is available for study the more numerous will be the opportunities for such study and research.

The educational aspects of wildlife may also be seen as a means of increasing one's understanding of the world at large and broadening one's mental horizons.

An interest in natural history frequently forms the basis of an absorbing hobby; a subject for photography; an excuse for getting soaked to the skin on remote oceanic islands; an interest in gardening; or merely taking the dog for a walk.

Even those of us who are not madly interested in wild orchids or stone curlews can scarcely fail to notice a wood full of bluebells or the herring gulls screaming and diving over a fishing port, and the character of many rural areas is dependent to a large extent on the wild plants and animals present; - heather moors, - grass covered dunes, - primrose-studded hedgerows, etc. The fact that these may depend to some extent on a past history of management as grouse-moors, stock-proof fences, etc. does not usually detract from their value, unless the hand of man is too obviously or heavily imprinted thereon. Wildlife is not, of course, the only factor involved in the "character" of a locality, but it can often be a very important one. Mutch (1968) found, for example, that, of visitors to four Forestry Commission forests, 8%, 6%, 6% and 1% respectively gave "nature studies" as the <u>prime</u> reason for visiting the forest.

If one forgets, for the moment, the actual and potential productive values of wildlife and considers only those aspects which may be broadly termed "recreational", it may be possible to relate these aspects in some way to the gross national expenditure on recreation. The productive values will, in most cases, be considerably less than the recreational values, and are more easily measureable in a direct way when they occur. To obtain an exact measure of the recreational value may be impossible. Even with the most sophisticated methods of interview-survey available to us it would be unrealistic to expect that one could separate and analyse people's motives and wishes to such an extent that one could say exactly how much of the value of a holiday or a country cottage was represented by the contribution of wild flowers, birds and other animals to be found there.

Using such figures as are available one could make a preliminary estimate that, of the £5,000 million or so, which is spent each year on luxuries such as holidays, beer, and television, about 1% might be attributable to the value of wild plants and animals in one form or another. There are numerous T.V. programmes, articles in magazines, pictures on calendars, etc., which have wildlife as their subject, as well as the robins in the garden, the honeysuckle in the hedge and the swans on the river. Such a figure of £50 million, if expressed as a capital sum on the basis of a 5% interest rate on capital, would represent a figure of £1,000 million, or about £17 per acre, on average, over the country as a whole. This is not, of course, a purchase price, but represents the sort of weight which should be given to wildlife conservation in day-to-day decisions on land-use planning.

The value of wildlife at any particular place will vary around this figure from nil to several hundred pounds per acre according to the criteria used in Appendix 2. Very roughly, it could be broken down into about five generalised classes:-

1)	$4\frac{1}{2}$ million acres of broadleaved woodland, limestone grassland, fen, water, dunes, and saltmarsh	£300 million
2)	11 million acres of heath, bog, and moor	£250 million

3)	21 million acres of pastoral farmland and conifer plantations	£300 million
4)	$18\frac{1}{2}$ million acres of arable farmland and temporary grass	£100 million
5)	5 million acres of urban land	£ 50 million
		£1,000 million

If one compares these values with the market values of land for agriculture, forestry, grouse-shooting, etc., they are, on average, much lower than agricultural land values and are roughly comparable with forestry and sporting values. On good quality arable land wildlife will be worth about 2% of the value of the land for growing crops, although this disparity could obviously be reduced if the use of the land were to change or if there were numerous hedges streams, and spinneys on the area. Similarly, the value of any one particular area may be greater than this if it lies within an area frequented by amateur bird-watchers, ramblers or parties of school children. In the cases of moorland and broadleaved woodland, these areas may frequently be more valuable to the community in their present condition than they would be if converted to pasturage or conifer plantations; although the interests of the private landowners may not coincide with those of the nation under the existing taxation and subsidy system.

The values arrived at by this approach do not seem unrealistic. One could, perhaps, argue that they should be slightly greater or slightly less. The intention here is to put forward the most logical and reasonable argument possible as a basis around which further detailed discussion can take place, and to form a footing upon which a method such as that in Appendix 2 can be developed with some degree of confidence.

A questionnaire recently circulated to 150 people, drawn in equal numbers from the fields of nature conservation, town planning, and landscape architecture, indicates that the above figures may be an underestimate. The response to the questionnaire gave a total of 80 completed forms, being divided almost equally between the three professional groups. Respondents were first asked what percentage of the Gross National Product they thought should be spent on the environment, including nature conservation, visual amenity, and recreational facilities. The mean figure for this was 4.24%, with a Standard Error of $\pm$ 0.51. The answers varied from $\frac{1}{2}$% to 16%, and a number of people felt unable to answer the question.

There was a greater degree of unanimity concerning the proportion of this amount which should be spent on nature conservation, as opposed to visual amenity or recreation. Only seven people thought the proportion should be less than 10% or more than 40%, and over half decided on values between 20% and 30%. The mean answers for the three groups were:-

Nature conservationists	26.78% $\pm$ 2.28
Town Planners	23.86% $\pm$ 2.50
Landscape architects	24.45% $\pm$ 1.92

As might be expected, the nature conservationists gave a slightly greater emphasis to wildlife than the other two groups of respondents, but the difference was not large enough to be statistically significant.

The differences between the three groups were greater when it came to the allocation of this amount between general conservation and the conservation of national and international rarities:-

	Protecting species threatened in other parts of the world	Protecting species uncommon in Britain	Conserving a variety of more common species
Conservationists	17.13% ± 2.61	15.26% ± 2.30	67.61% ± 3.36
Planners	24.50% ± 3.88	28.25% ± 2.87	47.25% ± 3.91
Landscapers	17.27% ± 2.66	22.64% ± 2.21	60.09% ± 3.65

Some of these differences are statistically significant, the town planners giving greater weight to rarities than the other respondents. The standard error of the planners' replies is also greater than that of the other respondents; possibly representing a greater variation in interest in wildlife in that group of people. These figures represent, on average, a contribution of about £80 million per annum to the conservation of wildlife in other parts of the world, and £320 million at home.

This questionnaire, which was intended to gauge informed professional opinion and was not, therefore, an attempt at a public opinion survey, indicates that the value of wildlife may be closer to 6% of the annual recreational expenditure than the 1% estimated on previous pages. The corresponding amount for visual amenity is about 13%, from the questionnaire. On this basis, the capitalized "value" of wildlife would average about £100 per acre and the visual amenity value about £200, giving a total of about £300 per acre between them. Such a value is equal to current market prices for good agricultural land.

2. Costs and values in resource utilisation

In simple cases, the value of a resource may be equal to the sum of a number of identical parts, regardless of their actual number. For example, a hundred metal bolts worth 2p each will be worth 200p in total, and three would be worth 6p. If, however, it were impossible to manufacture any more bolts of a particular size or type, the last few remaining in stock may come to have a greater value than 2p each due to their scarcity. This situation, which is illustrated in Fig. 1, applies to most natural resources, as they are not available in unlimited amounts. Thus, for example, a species of animal which becomes very rare will be reduced in total value as a species, but not in direct proportion to the reduction in numbers. If, for example, a population of 10,000 water fowl were reduced by 50%, its value to Man would not, in general, be reduced by as much as that. (The birds would still be almost as noticeable, if they continued to inhabit the same places; and, if conditions were favourable, they would recover in numbers over a short period of years).

The upper curve in Fig. 1 has been drawn on the assumption that a reduction in numbers of 85% will halve the value of the resource. This may not be true in every case, but it seems to be a reasonable general assumption. The curve bears a close resemblance to graphs showing the effects of fecundity on the rate of natural increase of animals which produce single offspring (Cole 1954), and it also resembles the curve (Fig. 5) which relates total numbers of species of plants or animals to the area of habitat available to them. These similarities would appear to confirm the validity of the approximate form of this curve as there is an obvious relationship between the carrying capacity of a unit area of habitat and its value for conserving wildlife, or between the potential of a species to recover from a reduction in numbers and the value of those individuals which remain.

If, using this curve, the value of one individual unit is calculated, the lower curve can be drawn. This curve demonstrates very clearly that, although the total value of the resource decreases with a decrease in numbers, the value of one individual rises very steeply when more than 90% of the total has been lost. When 99% of the total resource has gone, the few units remaining may be very valuable, unless, of course, they are so rare as to be little more than an oddity. In the case of living creatures the point may be reached when so few individuals of a species remain that the population is unable to increase again, even if conditions improve, because it has become in-bred and genetically effete. Also, very small numbers are very vulnerable to hazards, such as an exceptionally cold winter, which could kill off so many as to leave too few individuals to breed. (If 98% of a large population is killed, there will still be a breeding nucleus left, but if 98% of a very small population is killed there may be only 2 or 3 individuals left - all of them old, of the same sex, or widely scattered.)

If a resource is used in such a way that it is not destroyed, but is, nevertheless, reduced in value, a different type of curve can be drawn (Fig. 2). The theory behind this is expounded by Roth (1967), in his book "Paying for Roads", and this graph was drawn using figures given in that book. The more the resource (in this case transport facilities) is used, the greater are the disadvantages (due to congestion) to each person, and, although more and more people continue to use the resource, until the point is reached where they obtain no net benefit thereby, the point of greatest total net benefit is reached long before usage reaches saturation point. An example of the application of this concept is given in Appendix 5.

Figs 1-4 illustrate the facts that:-

a) when a resource becomes scarce the value of a unit amount is likely to increase at a greater rate than normal, and

b) the "greatest value to the greatest number of people" is frequently obtained long before a resource is used to its maximum capacity.

These facts, taken in isolation, are not sufficient to enable a resource to be valued. Changes in personal income, amount of leisure time, personal mobility, or in habits or matters of taste can all affect the relative values of scenic or wildlife resources. Methods of valuing resources must, therefore, be of limited application only (i.e. they must compare resources in which only one or two factors are variable) <u>or</u> they must take account of a wide range of factors.

The "National Shade Tree Conference", which meets annually at the Ohio State University, has adopted a method of valuing trees in streets and public places which is based, primarily, on the size of the tree, with little reference to its prominence in the landscape. It can, therefore, only be used to value trees in similarly prominent positions, and would be of little use in Europe, where towns are not laid out as rectangular grids with all points of roughly equal prominence. A method adopted by the Federation of Swiss Parks & Public Gardens Departments for the "evaluation of ornamental trees" includes an assessment of the importance of a tree's position in the landscape. Four factors, in all, are assessed individually, and the scores for all four are multiplied together to give an overall score for the tree. This is then equated to a monetary value, rounded off to the nearest 10 Francs or so to avoid any spurious semblance of absolute accuracy. The methods given in Appendix 1 are based on 7 variables, each assessed more simply than in the Swiss method. This approach was developed at about the same time as the Swiss one, and without consultation, but has many similarities, as might be expected. The scores for each factor are again multiplied to obtain an overall score, this being a fundamental feature of the system.

This point may, perhaps, be worth illustrating by a few simple examples, as the business of multiplication seems to confuse many people who have read papers published on the subject of valuation. If one takes a tree planted in a town, and this is given scores for each of 7 factors, such assize, shape, position in the landscape, etc., these scores may be 1, 3, 2, 3, 3, 3, and 1 respectively. If these are added together the total is 16; if multiplied it is 162. If we then take a tree which is similar in terms of shape, position, etc., but scores twice as much for size, the scores will be 2, 3, 2, 3, 3, 3, 1. If these scores are added the total is 17; if multiplied, 324. If this tree is twice as conspicuous by virtue of its larger size it seems reasonable that it should score 100% more than the smaller tree, rather than only 6.25% more. On the other hand, if an area of heather moorland is valued at £1,000 for grouse-shooting and £400 as a wildlife resource these values are more or less independent and should be <u>added</u> to obtain a total value.

- i.e. interdependent variables should normally be multiplied, but independent variables should be added.

In some cases there may be several variables which are more or less independent, as far as their evaluation is concerned. For example, if one were to attempt to value a small woodland next to a house, close to a fairly busy road, and with a public footpath running through it, there would be several aspects to be valued before the overall value of the woodland to the community could be assessed:-

1. Value of timber production

2. Amenity value to persons passing by on the road

3. Amenity value to people living in the immediate vicinity

4. Amenity value to people walking along the footpath

5. Wildlife conservation value

There may also be other values, such as providing cover for pheasants, or shelter to buildings, crops, or livestock.

Several of these values may overlap to some extent, and one must be careful not to value the same thing twice. If one has already valued wildlife separately, for example, then one must value the trees in the woodland purely as a scenic feature, without further reference to their value as a habitat for animals and plants.

3. The question of size as a factor in the evaluation of sites for wildlife conservation

Other things being equal, a large site will be more valuable than a small site, as it can support a greater number of individuals of each species present. It may also be able to support a greater number of different species, particularly those animal species which feed on populations of other animals or on a restricted range of plant material. For example, Ward (1969) has shown that populations of certain insects which feed on juniper fruits are not present in areas with fewer than 100 juniper bushes.

The question, therefore, is not "Is a large site better than a small site?", but "How much more valuable is the larger site?".

It would be possible, in theory, to count all the individuals of every species present on a site and to evaluate these on some basis such as that given in Appendix 3. To the value obtained could be added any value which the site may have for research studies, educational use, etc. (Appendix 2). Usually, however, this will be impracticable and only a limited assessment of a few species will be possible, and in some cases (such as proposed new areas of water not yet created) even this may not be possible. Some workable concept of the value of habitat size is, therefore, required.

In most densely populated countries, such as Britain, there are likely to be greater numbers of small sites than of large sites, due to the fragmentation caused by an intensive pattern of land use. However, it may be sensible to examine, firstly, the case where there are equal numbers of sites in each class. In this instance the species which are present only in larger sites will have a relative value equal to that in column 3 below, using the assumptions embodied in Fig. 1 (see page 7).

Area of site	No. of sites	Relative value of each additional species
More than 1 unit	10	1.0
More than 2 units	9	1.1
More than 3 units	8	1.2
More than 4 units	7	1.3
More than 5 units	6	1.4
More than 6 units	5	1.6
More than 7 units	4	1.8
More than 8 units	3	2.2
More than 9 units	2	2.7
More than 10 units	1	4.2

The number of different species to be found on sites of different sizes follows a curve similar to that in Fig. 5. This curve is based on the assumption that a doubling of the area of a site gives a 20% increase in the number of species to be found on it. This is generally true at a fairly small scale, using units of about 1 sq. m. (e.g. Oosting, 1956). It also appears to be true at a larger scale, due partly to the inclusion of a greater range of ecological conditions within the site, and also to the maintenance of a sufficiently large population of plants and animals to support a more comprehensive range of predatory species, etc. Darlington (1943 and 1957) found that, in general, the numbers of species of various animal groups in islands in the West Indies doubles for every tenfold increase in area of land.

This can be expressed as:-

No. of species = no. of species per unit area x total area^c, where c is about 0.3.

A slightly more conservative figure (0.26) is involved in the assumptions adopted here.

If we use the curve in Fig. 5 and the relative values given in column 3 above it should be possible to calculate the relative value of the different sizes of site:-

Area of site	No. of sp.	Relative value of each additional species	Relative value of one site
over 1 unit	600	1.0	600
over 2 units	720	1.1	732
over 3 units	798	1.2	826
over 4 units	864	1.3	912
over 5 units	910	1.4	976
over 6 units	948	1.6	1037
over 7 units	992	1.8	1116
over 8 units	1037	2.2	1215
over 9 units	1065	2.7	1291
over 10 units	1092	4.2	1405

This takes no account of the increase in the numbers of individuals of a species, as separate from the number of different species. If the size of an area of, for example, an oakwood or wet heath is doubled, then the number of individuals of any species present is likely to be more or less doubled also. On the basis of the assumptions used previously (see Fig. 1) this will increase their value by about 25%.

A modified curve can, therefore, be drawn (Fig. 6), which should represent fairly accurately the relative values of different sizes of isolated sites containing similar types of habitat.

As can be seen, this is an almost perfect straight line at a slope of approximately 1 in 2. Thus, whilst the relative value of a site rises steadily with increasing size, under these circumstances the value per acre falls somewhat. If, for example, a 10 acre site were to be valued at £240, or £24 per acre, a 1 acre site would be worth £60 per acre:-

Area of site	Relative value of site (Nos. of species only)	Corrected value of site (Nos. of species and individuals)	Relative value per unit area
over 1 unit	600	600	60
over 2 units	732	882	44
over 3 units	826	1108	37
over 4 units	912	1332	33
over 5 units	976	1529	31
over 6 units	1037	1712	29
over 7 units	1116	1894	27
over 8 units	1215	2088	26
over 9 units	1291	2248	25
over 10 units	1405	2429	24

An example of the application of this concept is given in Appendix 6. Details of the actual numbers of species were not available, and would, of course, be required to verify or refute these figures. It is possible that the main increase in numbers of species takes place below the lowest size limit of 5 acres, or that the additional species gained by an increase in size are species which happen to be common in other types of habitat. If, however, the assumptions used here are generally correct, this approach does give a logical basis for assessment if detailed information is lacking.

The above calculations are based on sites which are assumed to be isolated from each other. Obviously, if two sites are very close together they may function as one unit. (Conversely, a single site which is long and narrow may have so little direct contact between its extremities as to resemble 2 or 3 smaller separate sites.) Where two or more areas of a particular type of habitat are in very close proximity their value may, therefore, be enhanced, if there is a shortage of larger sites. If, however, large sites are not unduly scarce, two widely separated sites of 200 acres each may be of greater value for wildlife conservation than a single 400 acre site. This reflects the fact that, under such circumstances, the advantages of having areas of habitat widely distributed outweigh the disadvantages arising from fragmentation.

In terms of practical land management, it may be easier to manage a large area of any one habitat satisfactorily, and this may influence decisions at a practical level. For example, a very small area of woodland may be unduly expensive to fence, acre for acre, in comparison with a larger area, and it may be more difficult to maintain a full range of age-classes of trees, such as is desirable for continuity of income from timber sales and for the maintenance of the greatest possible variety of woodland animals and plants.

4. The question of habitat diversity as a factor in the evaluation of sites for wildlife conservation

Following from the previous chapter, it is evident that, unless there is a scarcity of large units of a particular type, there is merit in having areas of habitat distributed as widely as possible. The corollary of this is that if one has an area of, say, 1000 acres it will be in the best interest of wildlife conservation to maintain as wide a diversity as possible of different habitat types within it:-

ponds, grassland, cliffs, woods, etc.

For example, if one had 1000 acres of woodland in a single block, the value of this for wildlife conservation would probably be reduced by only a small amount if 5 or 10% were felled. The creation of 50 or 100 acres of ponds or grassy glades may, on the other hand, have an appreciably greater value, so that the net effect is likely to be beneficial. Similarly, if the whole of a 1000 acre block of woodland were of one age, species, and density of tree cover, the conversion of part of the area to some other species, age class, or density would probably be beneficial. Some tree species may be better than others in creating suitable conditions for animals (Southwood 1961) or plants, which will influence the relative amount of each which would give optimal results. From the wildlife conservation point of view, a woodland containing

40% oak
10% ash
30% birch
15% Scots pine
5% Sitka spruce

would probably be more valuable than one containing different proportions of these species, such as:

10% oak
5% ash
5% birch
20% Scots pine
60% Sitka spruce

and would certainly be more valuable than pure spruce or pine, or even pure oak woodland, unless there were some particular reason for maintaining a pure crop. Similarly, some types of habitat may be of greater scarcity value than others, and should be given greater emphasis, accordingly.

In one particular locality there may be:-

old semi-natural oak woodland
young beech woodland
young pine woodland
rough grazing land, with some bracken and thorn
arable land
pasture
old fruit orchard
small ponds
streams
hedgerows
ditches
road-side verges

The sum value of these will be expressed in the total number of individuals of different plants and animals which occur there, with due weight given to the relative scarcity of each species, at both local and world-wide levels. Some indication of this value could be obtained by recording the abundance of different species of the more easily identified groups of organisms such as flowering plants and birds. Some indication can also be obtained using the premises given in previous chapters.

An additional premise would be that the number of species in an area is inversely proportional to the degree of human interference. This is not a factor which is easy to measure, and disturbance of only a part of an area will, of course, increase the diversity of conditions in the area as a whole. In the case of a habitat which is newly-formed, such as a newly planted woodland, or a freshly colonised spoil tip, there will normally be a gradual increase in the numbers of species, following a curve similar to the one in Fig. 5. Old areas of habitat with relatively little human interference tend, generally, to carry a greater diversity of species, therefore.

Similarly, habitats with more than one "layer" of vegetation tend to support a greater diversity of species. McArthur (1964) has shown that the diversity of bird species in any one type of habitat can be correlated directly with the number of layers of vegetation (herbs, shrubs, trees, etc.).

In general terms, therefore, an area which has a wide variety of habitat types will be of greater value than an area of uniform type, and habitats with a variety of age and structure and with only a limited amount of disturbance will be of greatest individual value to wildlife conservation.

Exceptions to this general rule will arise where a habitat becomes too small to support species which are uncommon in the area, and a balance must be found between the considerations mentioned here and those in Section 3.

Where habitats are concerned which have a large number of species in common, the relative value of a site will not be so greatly influenced by the proportions of each habitat present, as compared to a site with widely different habitat types. For example, half the species of animals and plants which occur on dry heathland may also occur on blanket bog, and the proportion of each habitat which is conserved will, to that extent, be of less significance than if each supported a completely different range of species. Similarly, the conservation of a local variant of a fairly common type of habitat will be important only if it has

a) species or varieties not found elsewhere,

b) value for research purposes,

c) educational value, or

d) aesthetic or other values.

5. Location and access as factors in site evaluation

It has already been stated (page) that the position of a site in relation to other, similar, sites can affect its value for wildlife conservation. Its position in relation to centres of population, public roads, schools, universities, etc., can also affect its value in various ways.

Let us consider a hypothetical case involving a site about 20 miles from a large city, where there are two opposing factors involved:-

a) the site contains a number of species which are vulnerable to disturbance if large numbers of people are present, and

b) the site would be highly attractive to large numbers of people if access were to be freely allowed.

The balancing of these two conflicting elements in an evaluation will be difficult. The first of these is concerned with the conservation of wildlife for:-

i) the maintenance of a reserve of genetic material in perpetuity, and
ii) the maintenance of a reservoir of wildlife at the present time which can "overflow" into surrounding areas.

The second element (b) is concerned with the conservation of wildlife for its recreational value, as mentioned in Section 1:-

i) education
ii) amateur naturalists
iii) general contribution to the character of the locality as a recreational area.

The freedom of access which should be permitted in such a case will depend on a great number of factors such as the configuration of the ground, the distribution of vulnerable species in relation to the main points of public access, the frequency of intensive public usage (e.g. mainly at week-ends), the main season of usage (e.g. mainly in the summer), the type of usage, etc. A certain amount of expenditure on footpaths, fencing, sign-posts, wardening, etc., may also affect the position considerably, and could help to reduce any conflict of interests. It is, therefore, extremely difficult to generalise on this topic beyond a certain level. The factors mentioned in other Sections will normally be relevant, in addition to the accessibility of the site and the individual characteristics of the site and its users.

If, on the other hand, a site has no particularly high value as a reserve of genetic material its main value may be for educational and recreational purposes, and in this case its accessibility will be of paramount importance in determining its value.

Accessibility to a particular site is fixed within certain limits, but may be affected by the construction of new roads, hotels, towns, field study centres, etc., as well as by changes in legal restrictions or ownership.

Referring back to the graph in Fig. 2, however, it is evident that the value of a site need not be directly proportional to the number of people who visit it, as the number of people who visit the site may, directly or indirectly, affect the value of each individual visit. A progressive reduction in the quality of the site or the quality of the recreational experience will have a similar effect to the loss of trees in a residential area (see Fig. 3), as far as its value is concerned. The attraction of the site will fall in a similar fashion to the number of trees on the housing site, and could be shown as in Fig. 8, using a $\log_e$ horizontal axis. The maximum net benefit in such a case is likely to be obtained when there are about 1/10th of the number of visitors which would devastate the site completely.

If the site also has a value for research work or on account of some rare species which is easily disturbed, the value of this may be similar to one of the curves, a, b, or c in Fig. 9. In such a case, the original curve (I) of total net value will be altered to II, III, or IV respectively, and it is evident that a clear choice should then be made between permitting a larger number of visits or restricting them almost completely. An intermediate policy, allowing a moderately large number of visits, could, under such circumstances, reduce the special qualities of the site without commensurate gain in its recreational value.

In attempting to carry out such a calculation it would be necessary to know:-

a) the number of visits which would completely destroy the value of the site for the conservation of wildlife

b) the value which people place on visits at the current level of usage

c) the actual level of usage at the present time

d) the value of the site for education, conservation of rare species, etc.

If exact figures for all of these factors are not available, as will often be the case, an informed estimate may still be useful.

The practical result of such an examination of a number of sites will be to show the levels of recreational use which would be most appropriate to each. Taken at a national level, it may be obvious that it would be worth spending money on improving access to a particular site in order to divert recreational pressures from more vulnerable sites where access should be restricted in some way.

6. The valuation of different species of wildlife

Moore (1969) considers certain species of wildlife to be of greater value than others, because of their interest or material value to Man. These species are those which are:

i. of known economic value, e.g. whales, herrings, bees

ii. valuable for the study of Man and his behaviour, e.g. apes

iii. "living fossils", which further the study of evolution

iv. species which give aesthetic pleasure, e.g. skylarks, primroses butterflies

v. species useful for the study and teaching of population ecology and ethology, e.g. colonial sea-birds

vi. species which have been studied intensively

vii. species which are evolving or are extending their previous range into different types of habitat.

The number of species represented by this list is only a very small proportion of all living species, and, generally speaking, they tend to be above average in size. Larger animals usually require a larger area of habitat to support a given population, and are, therefore, more vulnerable to any changes which reduce the area of available habitat. Consequently "there is a rough correlation between large size, scientific interest, aesthetic value, and need to conserve".

As Moore points out (and as has been stated in Section 4) one of the main aims of nature conservation is to maintain a wide diversity of species. Species which are very common will normally require little effort to conserve them, but species which are less common are likely to require more effort. If a wide variety of species is to be conserved, therefore, it is inevitable that more effort must go towards conserving the rarer species than the common ones. This does not mean to say that the rare species is more valuable than a common one, however. In fact, the reverse will usually be the case if one considers the species as a whole rather than a few individuals only. (This situation has been summarised in Fig. 1).

At a general level, therefore, the greatest effort should be directed towards the conservation of large rare species, and organisms of this type will be the most valuable, as individuals. At a more detailed level other factors should also be considered:-

1. the relationship of the species to other species in the area

2. any particular emotive value attached to the species

- in addition to the seven points listed previously.

The relationship of a species to other species is a very important factor in as much as the general importance of the species can not be assessed in total isolation. If one considers the oak trees in an oak woodland, for example, these will be more valuable than any horse-chestnut trees which happen to be growing there, as a greater number of insect, bird and plant species will be dependent on the oaks than on the horse-chestnuts (Southwood 1961). Similarly, a predator, such as a fox, which preys on a number of species is likely to be a more permanent and valuable part of an ecosystem than a very specialised species which preys on one species only, although the loss of either could have far-reaching repercussions under certain circumstances.

Some species may also have a particular emotive value over and above that which might normally be ascribed to them. For example, the almost extinct bald-headed eagle is a national emblem in the U.S.A., and nearer to home, the golden eagles and red deer of the Scottish Highlands symbolise the remote and rugged character of that region.

Another factor which may be important is one closely allied to item vii. above. Dr. Moore listed this point because evolving or expanding species are of particular interest to scientists, but there is also another side to this particular question. If one considers the need to conserve a wide Variety of genetic variation in a species, there will often be a case for conserving a range of old, stable, populations, as these will have had time to develop genetic qualities suited to the locality in which each local population is situated. A rapidly expanding population, on the other hand, is more likely to be of fairly uniform (though interesting) genetic constitution throughout its range. Certain species, such as wrens and kingfishers, are subject to drastic periodic "crashes" in population numbers during hard winters, in Britain. Recolonisation of their former habitats then takes place over a number of years from a very limited number of survivors, or by migration from other areas. In such cases, therefore, one could not say that a local population is likely to be of any particular value as a reservoir of genetic variability. On the other hand, a population of oak trees in a remote upland valley, where no "foreign" oak trees have been planted, is likely to have genetic features peculiar to that locality, and some of these features may be of value, directly or indirectly, to Man.

A rapid, if somewhat rudimentary method of valuing different species is given in Appendix 3.

7. <u>Land-use planning</u>

Very few parts of Britain (or indeed, of most other densely populated countries) are devoted solely or even primarily to wildlife conservation. Most of our wildlife occurs in areas which are managed primarily for food production, recreation, housing, or some other purpose, and these different types of land use vary in the degree to which they support any great range of wildlife. (See page 4). It is obvious, therefore, that the conservation of wildlife in Britain is strongly dependent on the proportions of different land use types, and will be vulnerable to changes in these, or to changes in land management within any one particular type. For example, the number and condition of hedgerows, ditches, and walls on agricultural land can be very important, as can the way in which a forest is managed, or the way in which a new reservoir is constructed, or the extent of conversion of marshland or heathland to intensive agricultural use.

It would be unrealistic to suggest that wildlife conservation should be the main object of management in many areas; but this does not mean that it should be ignored completely in such cases. Decisions as to the best type or pattern of land use are most likely to give the greatest benefit to the nation if they are based on all relevant criteria, rather than on one or two only. This will usually mean that the adoption of one uniform type of land use over a large area will not be the most satisfactory answer.

Figs. 11-12 illustrate this point in relation to the choice between two types of land use; agriculture and forestry. If the economics of food and timber production are considered in isolation there is likely to be an apparent advantage in having either 100% agriculture or 100% forestry. If, however, amenity and wildlife conservation are also considered, it is obvious that some sort of mixture of these two uses will give the best results. This is true in spite of the fact that amenity and wildlife have been given much lower values than food or timber production in the second example.

A study has recently been made of the effects of afforestation on wildlife in an area of about 80 square miles (20,000 hectares) in south-west Scotland (Helliwell 1971) and the change in populations of the various species of flowering plants, birds and certain mammals is summarised in Appendix 4. Using the sort of approach described in previous chapters, the afforestation of this area with Sitka spruce and Lodgepole pine can be said to result in a fall in the value of the vegetation from a figure of 2.1 points to a figure of 0.9 points, with a decrease in the value of the fauna from 4.7 points to 3.5 points.

The relative weighting of the fauna, as compared to the flora, is not very clear-cut. However, the national value of the plant species represented in this area is roughly equal to the national value of the animal species represented (using the method given in Appendix 3), but a greater proportion of the national population of the animal species is represented by this area than the proportion of the national population of plant species. The relative scores of each were, therefore, adjusted to give the fauna a proportionately greater emphasis.

The relative values of the flora and fauna arrived at by this means were:-

	Open hillside	Plantations	Total
Fauna	4,654	3,494	8,148
Flora	2,115	878	2,993
Total	6,769	4,372	

In this case, therefore, the afforestation of about one third of the area would give the greatest overall wildlife conservation "value". (The area studied was of particular interest for certain species of birds and mammals, and was not, in that respect, typical of other areas in South Scotland).

The fact that afforestation is proceeding to a greater extent than this is due to the fact that the main reasons for the planting are not connected with wildlife conservation.

Afforestation is occurring on a fairly large scale in upland Britain at the present time, involving something like 80,000 acres (33,000 hectares) per annum. It is, therefore, one of the most important current changes in land use, as far as wildlife conservation is concerned. The position in an area such as that referred to above can not be viewed in isolation, therefore. If afforestation is also occurring in neighbouring areas (as it is), the basis on which the species present have been evaluated will change as the species of open hillsides become scarcer and those of conifer plantations become more common. This will tend to reduce the amount of afforestation in any locality which is needed in order to obtain the optimum conditions for wildlife conservation.

If the afforested areas could be improved, from the wildlife point of view, then the optimum amount of afforestation would be raised accordingly. Steele (1971) makes some suggestions as to how this could be done.

The distribution of the afforested lanl would be a matter related to several factors:-

1. Practical considerations of management and costs, which tend to favour large compact units
2. The provision of shelter for farm animals, which tends to favour small units
3. Landscape considerations
4. The requirements of particular species of wildlife

Generally speaking, the species of the open hillside require fairly large areas of territory, which has traditionally been managed by grazing and burning for the production of grouse, deer, and sheep. The maintenance of large compact units would appear, therefore, to be most suitable unless shelter or landscape considerations are very strongly weighted against this. This conclusion may seem to contradict what was said in Chapter 5 regarding habitat diversity. When it is considered, however, that several of the species of particular value in this area (e.g. Golden eagle and feral goat) require large tracts of open hillside and that the burning and grazing of small areas of land surrounded by plantations is very risky or expensive, the logic of this conclusion will be evident, and is accommodated within the compass of the last paragraph in section 3.

Where (e.g. in arable or dairy farming areas) the question of muir-burning does not arise, and the majority of the species to be conserved do not require several square miles of territory, there will frequently be a stronger case for smaller woodlands, copses, and belts of trees; particularly if these are also visually suited to the landscape and there is only a small woodland acreage in the land-use pattern.

8. <u>The conservation of wildlife at local, regional and international levels</u>

When a species occurs in only one locality in the world the case for its conservation in that locality is fairly clear. When, on the other hand, a species is fairly common in some places but occurs elsewhere in smaller numbers, the picture is more complicated.

Referring again to the golden eagles in south-west Scotland; how valuable are they? Three pairs of golden eagles have bred in this region in recent years, having re-colonised the area since the 1940s by migration from further north, in the highlands, where several hundred birds are to be found.

The first point to consider (see p 17) is whether or not these three pairs represent a genetically distinct population. As they are the result of recent migration from elsewhere, this is unlikely:- nor would three pairs be a sufficient number to form a very stable isolated population.

Secondly, one must ask whether or not they represent a significant proportion of the total population of the species (see Fig. 1). Obviously they do not.

Have they, then, any value within the region for amenity, education, or other purposes? Yes -

i) The Galloway region has a moderate tourist trade, and the presence of species such as eagles is likely to enhance the "image" of the region, even if the birds are only rarely seen

ii) Some birds are occasionally seen and one pair has recently bred in the English Lake District, which is an area of great attraction to tourists, about 50 miles away across the Solway Firth.

If golden eagles are to re-colonise the Lake District they are most likely to come from Galloway, and the maintenance of this population as a "stepping stone" towards England (and Wales?) is of considerable importance.

Owing to the imponderables involved, this must be one of the most difficult problems of evaluation which could present itself. If the species is able to spread, via this locality, and to become numerous in England and Wales, then one could value the future increase in the species and discount that value to the present day at some agreed rate of interest. For example, a £100,000 rise in the value of the species in 60 years' time would be worth about £6,000 at the present time, at a discount rate of 5%. (The calculation would be a little more complex than this, in fact, as the increase in the value of the species would occur gradually over the 60 year period, rather than suddenly at one particular point in time.) As the existence of the species as a whole is not in doubt at the present time, such a value plus any local "tourist attraction" value, appears to be a realistic estimate of the value of these three pairs of eagles (probably about £8,000 altogether).

In contrast to local occurrences of single species, a locally scarce habitat is more likely to have some distinctive features, as it will contain many species and at least some of these are likely to have characteristics peculiar to the locality. It may also contain some species not found elsewhere.

If a site does not contain any species or varieties of plants or animals of individual value, then the site itself cannot be held to be of any particular merit, unless it is valuable for education, research, or amenity; or unless the vegetation is essential for the prevention of erosion or deterioration of the soil. Sites which contain only common species can, in theory, be re-instated over a period of years, decades, or centuries, and are therefore of no particular individual value as reserves of genetic material whilst these species remain common.

In general terms, wildlife can be most effectively conserved when there are numerous and widespread areas of habitat suitable for it. If the area of the habitat is reduced, some species may be lost (Section 3), and if its geographical distribution is restricted there is also likely to be a loss of certain genetic types within the species which remain. The extreme example of reduction of habitat would be the conservation of a species in a zoo, botanic garden, or seed-store. In such circumstances it may be possible to maintain a few individuals under more-or-less un-natural conditions; and this may be a valuable aid to conservation. It can rarely, however, serve as a means of conserving a species for many years in the absence of a wild population, unless the zoo or collection is so large as to resemble the natural habitat in all important points; and, even under these conditions, many animals and plants may suffer a change in behaviour pattern and/or genetic constitution which would render them unfit for re-introduction to the wild state.

The ideal situation would be the other extreme, with large areas of natural and semi-natural habitats distributed in a more-or-less continuous fashion throughout the world. In the absence of this, the objective should be to maintain as wide a range of habitats as possible in as many different places as possible; balancing this objective with the need to have sufficiently large areas of each individual type of habitat and with the needs of other land uses.

Summary

1) Other things being equal, it is evident that priority should be given to the conservation of species which are rare,
of actual or potential material value,
or attractive to Man.
Very often these will be the larger species of animals, and those plants or animals which can survive only under a limited range of ecological conditions.

2) A wide distribution of habitats of different types should be maintained; and each of these should normally be of a diverse, rather than uniform, character.

3) Land-use planning should have some regard for nature conservation, even where other uses are of greater importance.

4) Access to areas which contain habitats or species which are vulnerable to disturbance may need to be restricted in some cases.

5) Undue fragmentation of wildlife habitats should be avoided.

6) Suggested methods are given for the comparison of one wildlife resource with another and for the attachment of notional monetary values to these resources.

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6) Suggested methods are given for the comparison of one wildlife resource with another and for the attachment of notional monetary values to these resources.

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Appendix 1

System for valuing trees and woods for amenity

(First published in the Arboricultural Association Journal 1(5), 128-131, 1967).

Valuation of Trees
(scale goes from 0 to 16,384 units:
equate 1 unit to £1/5 value)

UNITS

FACTOR	1	2	3	4
a. Crown area. Crown height (ft) x mean radius (ft.)	20-50 Sq. ft. small	50-200 sq. ft. medium	200-1,000 sq. ft. large	1,000-4,000 sq. ft. huge
b. Useful life expectancy. (years)	10-20	20-40	40-100	100-500
c. Importance of position in landscape or townscape	of little importance	of moderate local or some widespread importance	of great local or moderate widespread importance	of great and widespread importance
d. Presence of other trees.	large area densely treed	moderately well-treed area	some other trees of similar importance	no other trees of similar importance
e. Form	poor	fair	good	excellent
f. Species in relation to the setting	small growing trees of moderate suitability	small growing trees suitable to the setting or medium sized trees of moderate suitability	medium-sized trees appropriate to the setting, or large growing trees of moderate suitability	large growing trees of species appropriate to the setting
g. Special or historical value	no special value (i.e. most trees)	trees in avenues or other places forming features of vital importance to civic landmarks etc.		named tree of great local importance

Units for each factor to be multiplied together

Valuation of Woodlands

(scale from 0 to 16,384 units: equate 1 unit to £10 value)

	1	2	3	4
a. Area visible (acres) Length of perimeter (chains) x 0.25; or visible acreage if greater	0.5-1.5	1.5-5	5-20	20-100
b. Position in landscape	secluded	generally visible	prominent	very prominent
c. Average daylight viewing population (taken as 1% of population of urban areas: or 1 person per vehicle on roads)	(0-1) Remote rural	(1-20)	(20-100)	(100+) Near to one or more well-trafficked routes
d. Presence of other trees and woodlands (or other features of similar interest)	densely wooded	some other woods (usually with hedgerow trees or features)	hedgerow trees only: or few other woods or features only	no other woods, trees, or features of interest
e. Accessibility	no access to wood or land adjacent	access to land adjacent	access to wood, but difficult	readily accessible to large numbers of people
f. Species and state of crop	young plantation of 1 species: and derelict woodland	mixed plantation	semi-mature or natural woodland	mature or irregular woodland
g. Any special value	no special value (i.e. most woods)	local beauty spot	well-known beauty spot	feature of widespread fame or screening eyesore

Units for each factor to be multiplied together

Appendix 2

System for valuing wildlife habitats
(abstracted with some modification from an article first published in "Regional Studies" Vol. 3. pp. 41-47, 1969).

Factors to be evaluated	Parameters for assessment
1. Direct return	Capital value of licences or produce
2. Genetic reserve	Scarcity of habitat type Number of species present in habitat
3. Ecological balance	Number of species present in habitat Ubiquity of species present in habitat Area of land affected Value of agricultural land affected
4. Educational value	Scarcity of habitat type Number of species present in habitat Durability of habitat Accessibility
5. Research value	Scarcity of habitat type Accessibility Size of habitat
6. Natural history interest	Scarcity of habitat type Number of species present Accessibility
7. Local character	Scarcity of habitat type Number of conspicuous species Extent of habitat in the locality Numbers of people

Values for each of the 7 factors to be summed

1. Value of licences, etc.

2. Scarcity index (2) x no. of spp. x £B

3. No. of spp. x % of the locality covered by the habitat x area of the locality (hectares) x value of agricultural land affected (per hectare) x £C.

* 4. Scarcity index (4) x no. of obvious spp. x durability index x accessibility index (4) x £D.

* 5. Scarcity index (5) x accessibility index (5) x area (hectares) x £E.

6. Scarcity index (6) x no. of obvious spp. x £F.

7. Scarcity index (7) x no. of conspicuous spp. x % of locality covered by the habitat x annual number of "viewing days" x £G.

TOTAL: ______

* calculate values for each school or college separately, and sum.

Scarcity index (2) = % of the habitat within a 30 km. radius represented by the site in question + % of regional resource x 4 + % of total resource of that habitat in the British Isles x 8.

Scarcity index (4) = % of resource of that habitat within easy reach of students from any one school, college, or field centre. (1 km for primary schools, 5 km for secondary schools, and 20 km for colleges and universities)

Scarcity index (5) = % of resource of that habitat within reach of a research centre or university (i.e. about 80 km).

Scarcity index (6) = Scarcity index (2)

Scarcity index (7) = Scarcity index (2)

"No. of spp." = average number of species of flowering plants occurring in quadrats of 2 m x 2 m.

"No. of obvious spp." = total no. of species in the habitat which are illustrated in W. Keble Martin's Concise British Flora in Colour (Ebury Press 1965).

"No. of conspicuous spp."	= large, bright, or other notable species on an agreed list (see proposed list below).
Durability index	= estimated no. of students which could visit the area once per annum without undue harm to the site (maximum not to be greater than the actual no. of students available).
Accessibility index (4)	= the reciprocal of the distance (in kilometers) of the site from a school, college, or field centre.
Accessibility index (5)	= no. of research workers within 80 km of the site engaged in research on natural environment, divided by the no. of km from their research base.
Accessibility index (6)	= population within 1 km of the site, + population between 1 km and 8 km of the site/15 + population between 8 and 32 km of the site/250 + population between 32 and 160 km of the site/5000 +

Annual no. of "viewing days" = no. of "visitor days" per annum + resident population x 30.

Suggested values of £B-£G:-

£B = 1

£C = 1/10,000

£D = 1/50,000

£E = 20

£F = 1/1,000

£G = 1/2,000

"Conspicuous species" list:-

(Large, colourful, noisy, or attractive species which one may reasonably expect to see if present on a site).

Deer spp.
Feral goat
Squirrel spp.
Great crested grebe
Fulmar
Heron
Swan spp.
Goose spp.
Duck spp.
Moorhen/Coot
Buzzard
Eagle
Kite
Harrier spp.
Peregrine
Kestrel
Other birds of prey
Wood pigeon
Dove spp.
Oystercatcher
Curlew/whimbrel
Lapwing
Other wading birds
Gulls
Terns
Grouse spp.
Partridge
Pheasant
Capercaillie
Short-eared owl
Cuckoo
Kingfisher
Woodpeckers
Larks
Swallow/Swifts/Martins
Magpie
Jay
Dipper
Long-tailed tit
Ring ouzel
Wheatear
Wagtail spp.
Goldfinch
Raven
Rooks (nesting colony)
Bracken (if abundant)
Pasque flower
Kingcup
Globe flower
Monk's Hood
Red poppy
Welsh poppy
Water lilies
Meadow cranesbill
Bloody cranesbill
Balsam spp.
Gorse spp./Broom/Whin
Rest harrow
Blackthorn
Hawthorn
Cherry spp.
Meadowsweet
Rosa spp.
Whitebeams
Crab apple
Rose bay
Hedge parsley
Guelder rose
Honeysuckle
Ox-eye-daisy
Heather/heaths (if abundant)
Primrose
Oxlip
Cowslip
Bird's eye primrose
Woody nightshade
Foxglove
Silver-birch
Cow parsnip
Orchids
Bull-rush
Daffodil
Snowdrop/Snowflake
Iris/Flag
Crocus/Autumn crocus
Fritillary
Bluebell
White willow
Scots pine
Other trees

Appendix 3

Scoring system for valuing species

FACTORS	SCORES ½	1	2	4	8	16	32
No. of directly associated species		Very few e.g. Brent goose, Lloydia serotina	Few e.g. Primula vulgaris, golden eagle, knott, Acer pseudoplatanus.	Some e.g. Dactylis glomerata, green woodpecker, stoat.	Several e.g. Empetrum nigrum, blue tit, robin, Urtica dioica, badger.	Many e.g. Sorbus aucuparia, Acer campestre.	Very many e.g. Quercus robur, Betula verucosa.
Abundance (in Britain)		Very rare e.g. red kite, Lloydia serotina	Rare e.g. pine marten, Primula farinosa	Uncommon e.g. sparrow hawk, Rubus chamaemorus	Common e.g. badger, Phragmites communis	Very common e.g. chaffinch, wren, Urtica dicica.	
Conspicuousness	Not normally visible e.g. most small organisms such as many spp. of algae	Not conspicuous or e.g. Peltigera canina , Poa annua	Reasonably noticeable e.g. house sparrow, Heracleum sphondylium	Very conspicuous or attractive e.g. deer spp., Calluna vulgaris Primula farinosa, golden eagle			
Any material value (actual or potential)		No material value e.g. house sparrow, Heraclium sphondylium	Little material value e.g. Rubus spp., Vaccinium spp., coypu, Phragmites communis , Acer campestre	Some material value e.g. trout red deer, grouse, Pinus sylvestris			

Multiply the scores for each of the 4 factors together (species which appear to fall between the categories given may be allotted scores intermediate between those given).

On this basis Quercus robur would score 8,192, Calluna vulgaris about 320, the polecat about 30, and Lloydia serotina about 2.

It is suggested that this figure should be multiplied by £10,000 to give a "shadow price".

On this basis the "shadow prices" for a few representative species may be:-

Quercus robur	£81,920,000
Salix capraea	£30,000,000
Fagus sylvatica	£21,480,000
Calluna vulgaris	£ 6,400,000
Acer pseudoplatanus	£ 3,200,000
Red deer	£ 2,000,000
Tilia cordata	£ 2,000,000
Galium saxatile	£ 640,000
Ptarmigan	£ 480,000
Brent goose	£ 320,000
Polecat	£ 300,000
Primula farinosa	£ 80,000
Lloydia serotina	£ 20,000

These prices seem to be of the correct order of magnitude. For example one can imagine an industry or public body being asked to spend an extra £2 million to avoid exterminating a species of deer or £20,000 to safeguard a very rare plant.

In the case of deer or timber trees the values quoted above are not intended to include any commercial value from meat or timber, or values such as may be obtained from sporting rights. The inclusion of a factor for "any material value" in the assessment is intended solely as an expression of the fact that animals or plants which have some value or potential value as food, fur, timber, etc., are more likely to be deemed worth conserving than "useless" species; just as notably conspicuous or attractive species are likely to be valued more highly than inconspicuous or unattractive species.

Any value from actual sales of meat, etc., would be additional to those listed above.

Appendix 4

Changes in plant and animal species following the afforestation of an area of land in south-west Scotland

A. Open Hill Land			B. Afforested Land	
Relative numbers	Score		Relative numbers	Score
		Blackbird	10	50
		Blackcap	6	38
1	238	Black grouse	3	346
		Blue tit	10	25
		Bullfinch	6	25
0.25	164	Buzzard	0.1	101
		Chaffinch	50	51
		Chiff-chaff	6	25
		Coal tit	60	45
1	42	Crow	0.5	32
0.25	17	Cuckoo	0.2	14
1	73	Curlew	0.1	26
		Dunnock	8	28
		Gardenwarbler	4	32
		Goldcrest	30	29
0.1	528	Golden eagle		
		Greenfinch	6	25
0.25	281	Hen harrier	0.5	367
2	33	Lapwing		
1	51	Mallard	1	51
65	60	Meadow pipit	16	36
0.25	221	Peregrine	0.1	136
		Pheasant	2	88
0.25	195	Raven	0.1	120
4	216	Red grouse		
1	88	Ring ouzel		
		Robin	10	30
		Siskin	4	54
10	32	Skylark	2	12
		Song thrush	6	38
		Sparrow hawk	1	44
2	33	Stonechat	4	36
		Tree pipit	8	56
		Willow warbler	40	33
4	36	Whinchat	10	50
		Whitethroat	4	22
		Wood pigeon	4	58
93.35	2,308		312.6	2,123
1	176	Blue hare	0.2	88
0.3	49	Brown hare	0.2	36
0.5	88	Fox	0.2	57
2	825	Goat (feral)		
2	1100	Red deer	0.5	680
		Red squirrel	5	78
		Roe deer	0.5	366
5.8	2,238		6.9	1,305

Relative numbers	Score		Relative numbers	Score
2	44	Adder	0.5	27
2	22	Lizard	0.5	14
2	42	Slow worm	0.5	25
6	108		1.5	66
150	13	Agrostis spp.	100	12
20	9	Anemone nemarosa	2	4
50	9	Anthoxanthum odoratum	100	12
		Betula spp.	10	5
30	11	Blechnum spicant	3	5
1000	26	Calluna vulgaris	10	5
150	13	Carex spp.	50	9
3	48	Carum verticillatum		
20	6	Cerastium spp.	3	3
5	4	Cirsium spp.	5	4
		Conopodium majus	2	3
1	14	Dactylorchis maculata		
50	14	Deschampsia flexuosa	200	22
10	30	Drosera rotundifolia	0.2	7
5	6	Endymion non-scripta	10	8
		Epilobium angustifolium	1	2
100	23	Erica cinerea	2	6
800	36	Erica tetralix	16	9
400	95	Eriophorum angusti-folium	8	24
300	119	Eriophorum vaginatum	6	29
100	12	Festuca ovina	10	5
20	6	Galium saxatile	30	7
1	33	Genista anglica		
20	6	Holcus lanatus	50	9
50	9	Juncus articulatus	3	3
10	5	Juncus effusus	30	7
20	24	Juncus squarrosus	2	11
30	7	Luzula spp.	30	7
1000	39	Molinia caerulea	100	17
100	92	Myrica gale	2	22
50	18	Nardus stricta	1	4
300	119	Narthecium ossifragum	6	30
30	7	Oxalis acetosella	300	17
10	8	Pedicularis spp.	0.1	1
5	23	Pinguicula vulgaris	0.1	5
10	5	Poa spp.	10	5
50	14	Polygala spp.	1	3
50	14	Polytrichum commune	100	17
400	19	Potentilla erecta	40	8
50	9	Pteridium aquilinum	100	12
3	3	Rumex spp.	3	3
1	2	Salix spp.	5	4
400	133	Scirpus caespitosus	8	33
1	2	Sorbus aucuparia	10	5
100	17	Sphagnum spp.	100	17

Relative numbers	Score		Relative numbers	Score
50	9	Trifolium repens	2	3
100	23	Vaccinium myrtillus	100	23
20	19	Viola palustris	50	27
2	3	Viola riviniana	20	6
6,077	1,156		1,641.4	430

Appendix 5.

Valuation of trees in a residential area

Using the method outlined in Appendix 1 and applying the concept referred to on page 7 to the amenity value of trees in a residential area, the curve in Fig. 3 can be produced (assuming that the houses are grouped in such a way that a reasonable number of trees can be retained). The actual number of trees and density of houses which is most appropriate in any one case will depend on a large number of factors including [illegible] question of privacy, recreational space, land prices and the exisiting character of the neighbourhood. Taking trees in isolation, however, it is evident that a density of 9 or 10 dwellings per acre is likely to give the greatest net benefit. Stated in tabular form this graph would be:-

No. of dwellings per acre	No. of trees per acre	Relative value per tree	Actual value per tree	Total value of trees per dwelling	Total value of trees per acre
1	32	25	25	800	800
2	26	27	54	754	1508
3	22	30	90	660	1980
4	19	32	128	608	2432
5	17	34	170	578	2890
6	15	37	222	555	3330
7	13	41	287	533	3731
8	11	46	368	506	4048
9	9	52	468	468	4212
10	7	60	600	420	4200
11	5	70	770	350	3850
12	4	82	984	328	3936
13	3	98	1274	294	3822

(Column 3 gives the relative value of one tree in relation to its scarcity and individual importance, as seen from a single dwelling. Column 4 gives this value multiplied by the number of houses on the site.)

If other factors are present which affect these values there will be a shift in the optimum number of dwellings per acre. In most instances, for example, trees in a residential area will also be visible to people living or travelling in adjacent areas, and the effect of this is demonstrated in Fig. 4. (This example assumes that the dwellings themselves are of no particular scenic merit or de-merit; or that this is assessed separately).

Curve "a" in Fig. [illegible] represents the fall in the amenity value of a wooded site, to persons outside the site, with progressive increases in the number of dwellings and the consequent felling of trees, in a position where a complete woodland cover is valued at £1,500. In this case, the curve drawn in Fig. 3 (shown here as curve I) is modified to give curve II, with an optimum number of about 6 dwellings per acre, instead of 10. If the "external" amenity value is greater, the optimal number of dwellings will decrease further, as in curves III and IV, levelling out at around 2 or 3 per acre, which is a sufficiently low density to allow the retention of a wooded external appearance to the site.

Appendix 6

Valuation of chalk grassland sites

Blackwood and Tubbs (1967) found the following number of areas of chalk grassland in England:-

Area of site	No. of sites
Over 5 acres	1225
Over 50 acres	294
Over 100 acres	143
Over 200 acres	67
Over 300 acres	41
Over 400 acres	30

Records of species numbers for each of these sites are not available, but if we assume that they follow a similar curve to that in Fig. 5 we can make a series of calculations similar to those on pages 10 and 11.

Area of site	Relative No. of species	Relative value of each addit- ional species	Relative value of site (Nos. of species)	Corrected value of site (spp. & individuals)	Relative value per unit area
over 5 acres	600	1.0	600	600	60
over 50 acres	1092	2.3	1132	2548	25
over 100 acres	1310	3.5	1677	3603	18
over 200 acres	1572	6.0	3249	5896	15
over 300 acres	1747	8.5	4737	8121	14
over 400 acres	1886	10.0	6127	10161	13

If, due to further "improvement" for agricultural purposes, some of the larger sites were to be broken up or were to disappear, leaving, say, only 3 sites over 400 acres and 10 sites over 300 acres, the position would be changed:-

over 5 acres	600	1.0		600	60
over 50 acres	1092	2.3		2548	25
over 100 acres	1310	3.5		3603	18
over 200 acres	1572	6.0		5896	15
over 300 acres	1747	20.0		10133	17
over 400 acres	1886	40.0		16537	21

In this case, the value of one 400 acre site would appear to be greater than two separate 200 acre sites.

Appendix 7

Valuation of habitat diversity

Referring again to the example of chalk grassland (page 11 and Appendix 6) we may examine the desirability of letting part of a site become colonised by woodland.

Assuming that woodland on chalk is about three times as common as chalk grassland, that it contains twice as many species of insects, birds, etc., and that none of these species (for the sake of this example) are found in any other habitat, we can summarise the position as in Fig. 7.

Obviously, if there are very few large woodlands and several large grassland sites, the relative values of the two habitats will be shifted from 2:3 to some different ratio, such as 3:1, if one is dealing with one of these large sites. The optimum proportion would then be 80% woodland, rather than only 30% with a steeper drop in value if the optimum percentage is not maintained.

Fig. 1. RELATIONSHIP BETWEEN THE NUMBER OF INDIVIDUAL UNITS AND THE TOTAL VALUE OF A RESOURCE WHICH IS BECOMING SCARCE.

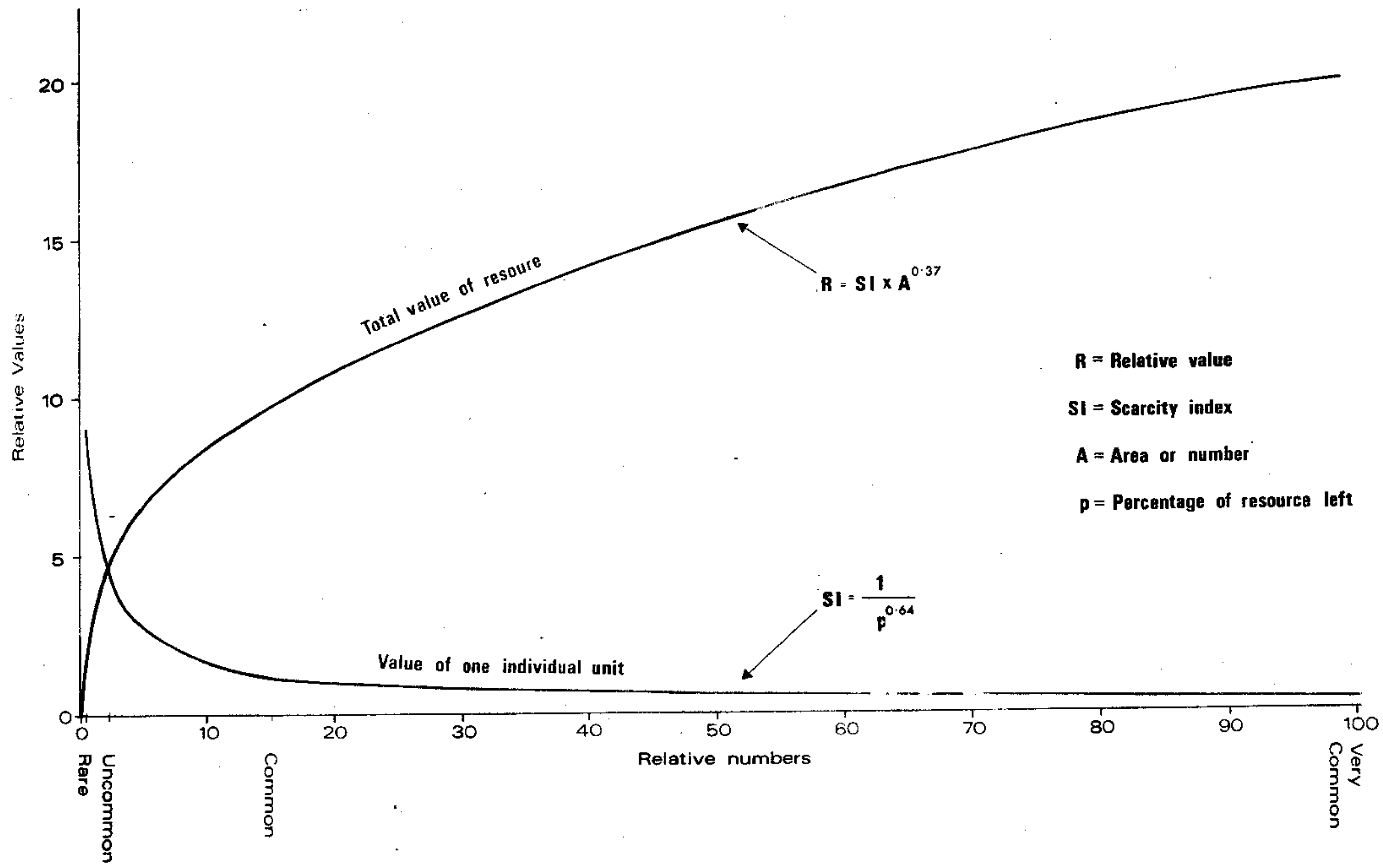


Fig.2. TOTAL NET BENEFIT RESULTING FROM INCREASED USAGE OF A FACILITY WHICH IS REDUCED IN VALUE THEREBY.

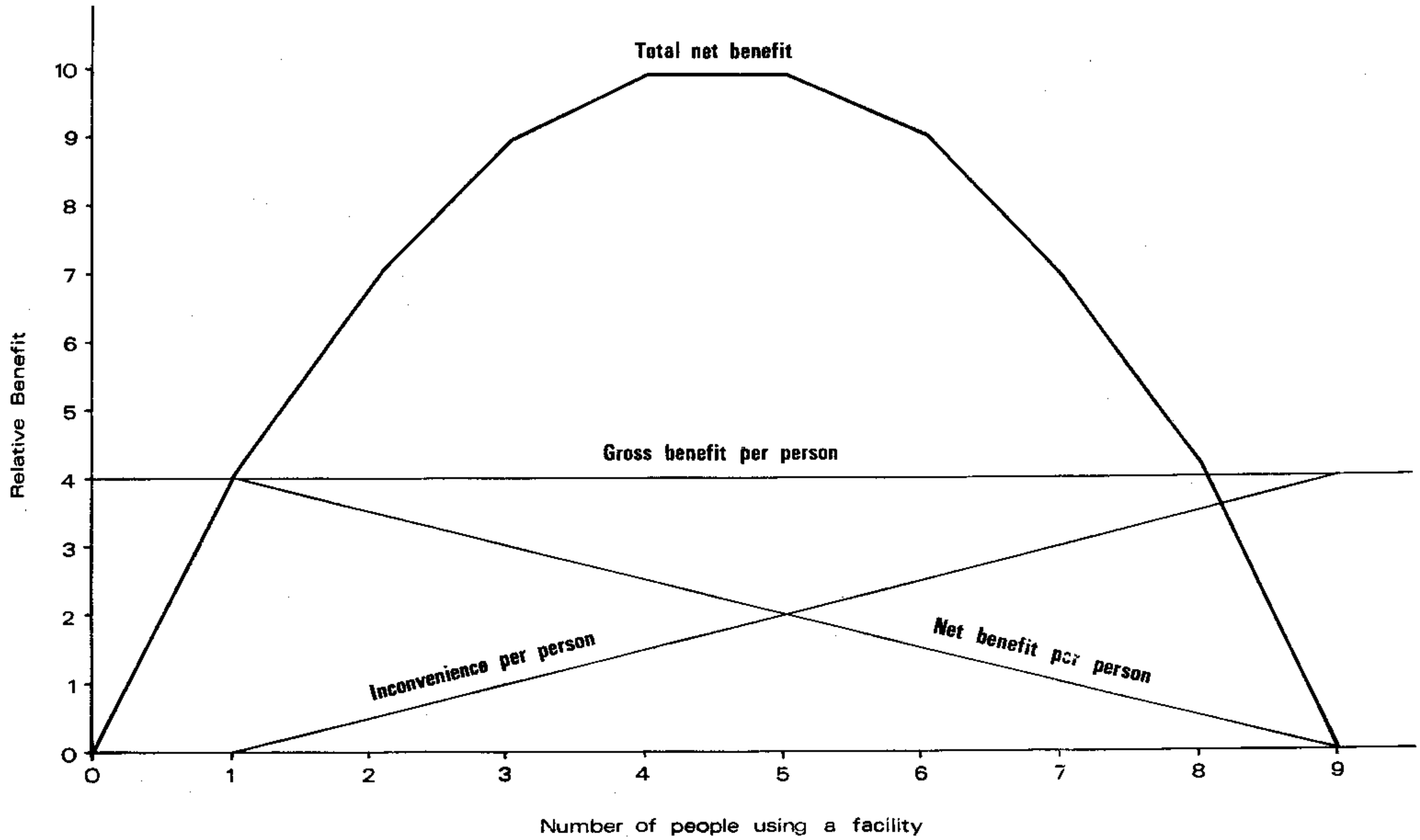


Fig. 3. AMENITY VALUE OF TREES IN A RESIDENTIAL SITE. (Internal site value only)

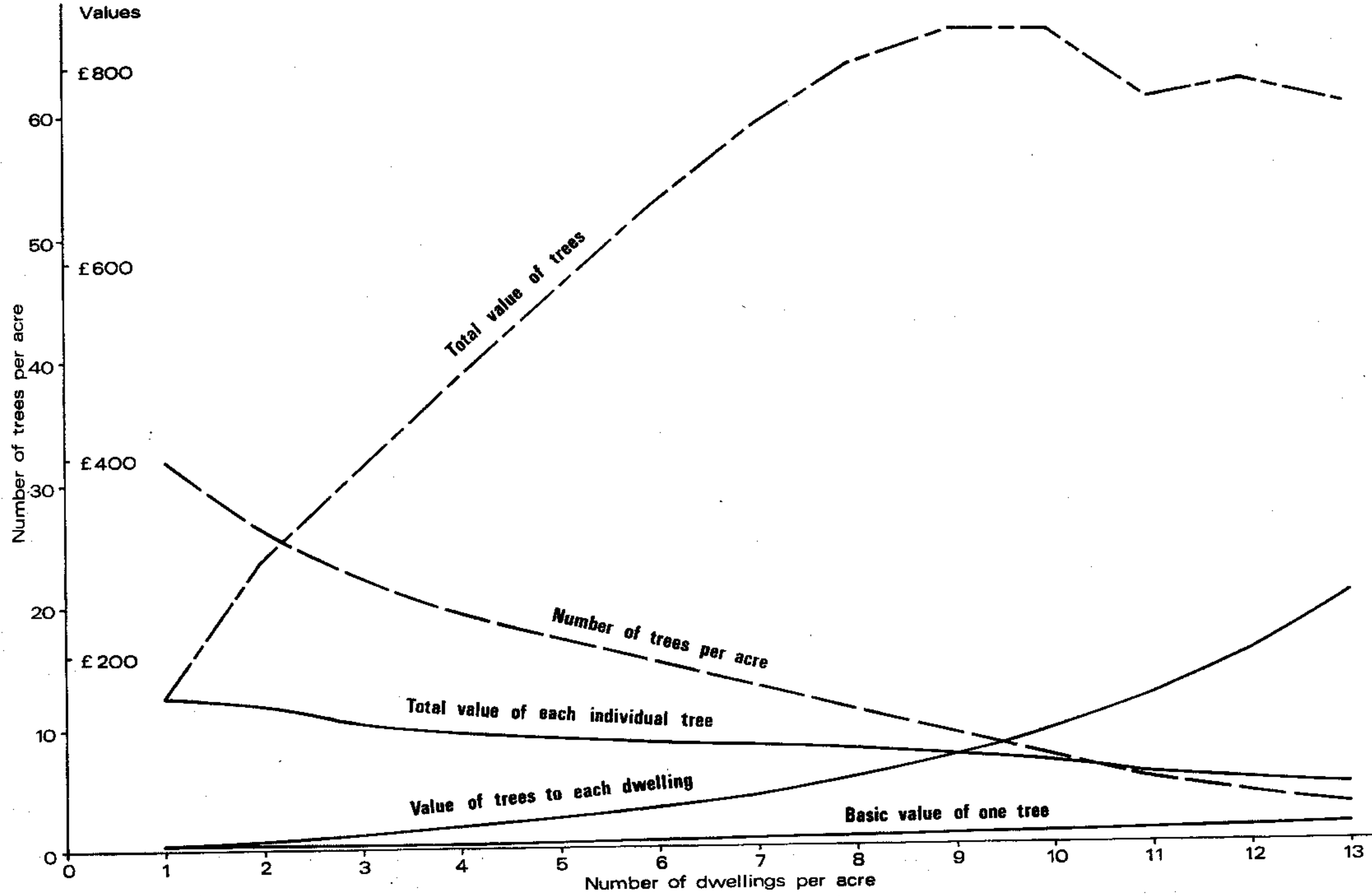


Fig. 4. AMENITY VALUE OF TREES IN A RESIDENTIAL NEIGHBOURHOOD
(Internal site value, plus value when seen from outside the site)

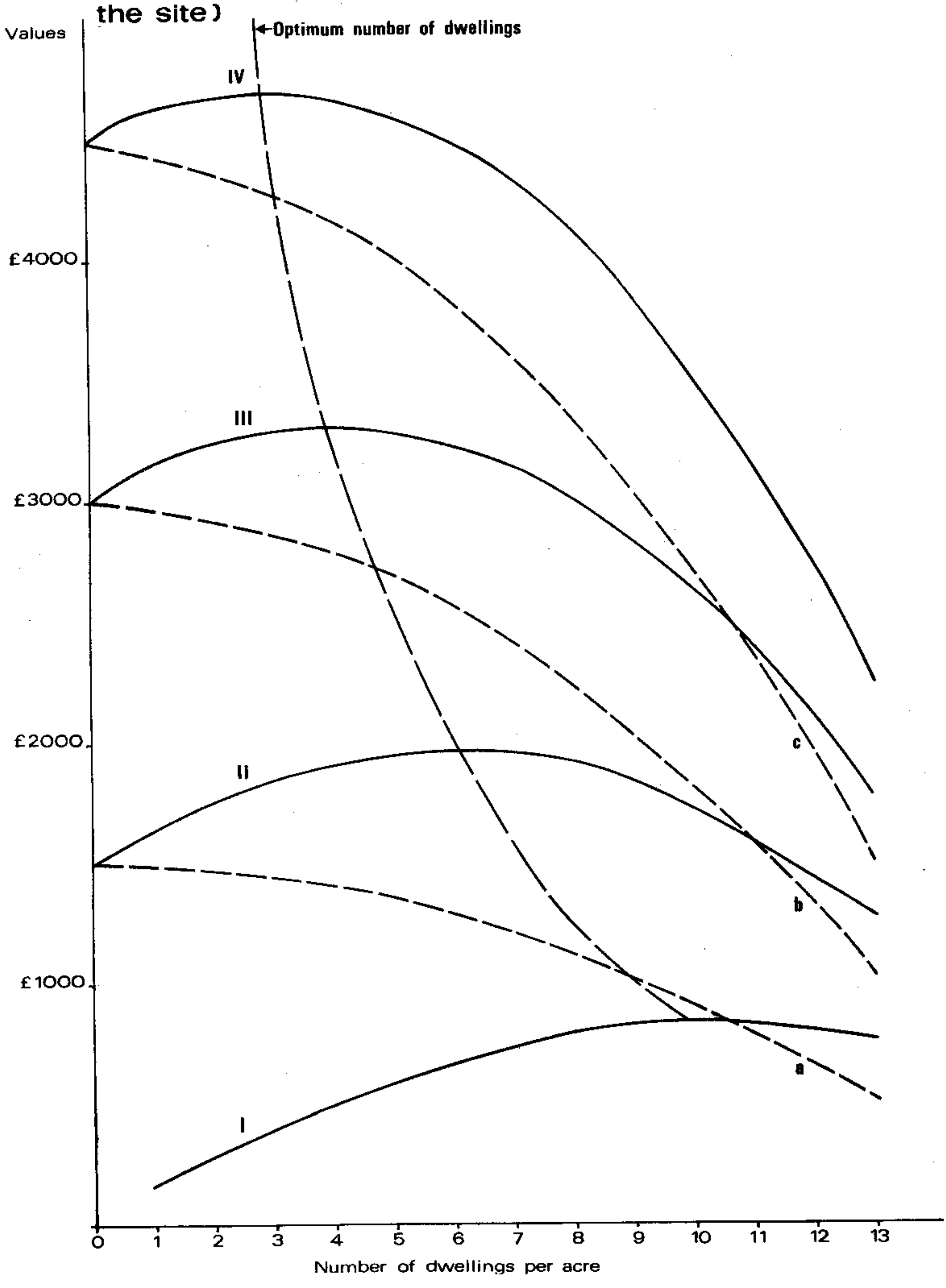


Fig. 5. RELATIONSHIP BETWEEN AREA OF SITE AND NUMBER OF SPECIES PRESENT

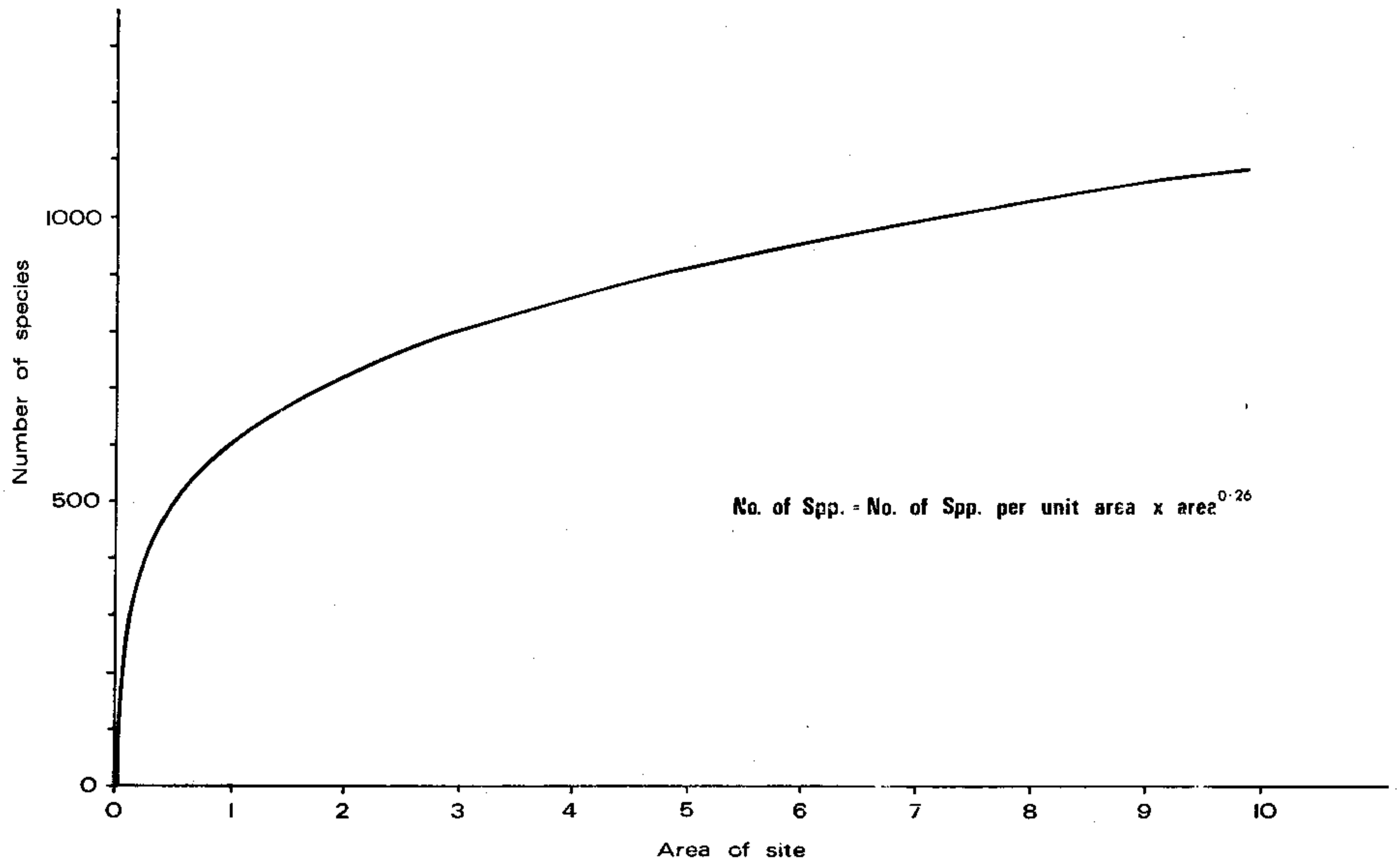


Fig. 6. RELATIONSHIP BETWEEN AREA OF SITE AND "CONSERVATION VALUE", ASSUMING EQUAL NUMBERS OF SITES IN EACH SIZE CLASS.

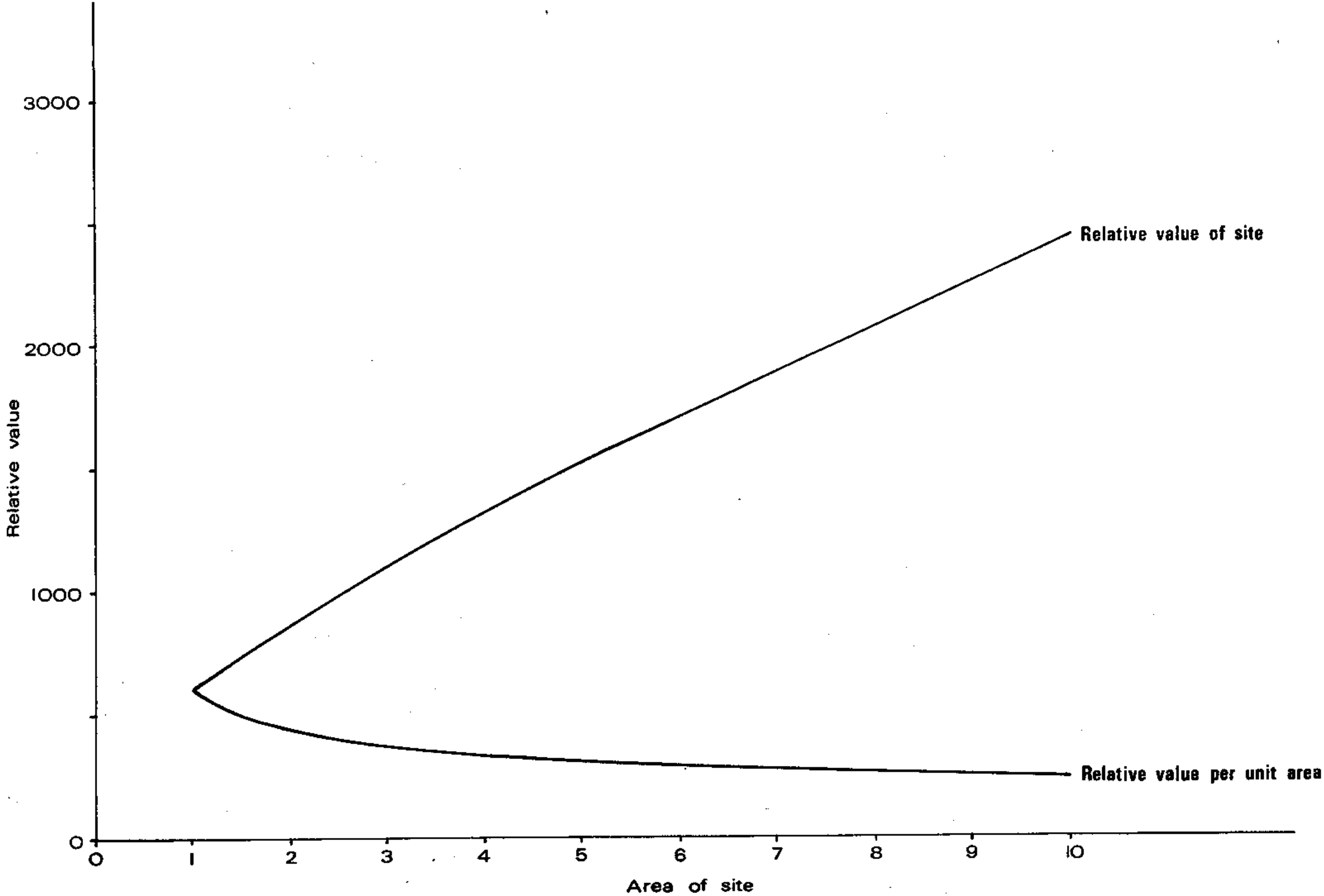


Fig. 7. EFFECT OF CHANGING PROPORTIONS OF DIFFERENT HABITATS ON ONE SITE ON THE VALUE OF THE SITE FOR WILDLIFE CONSERVATION.

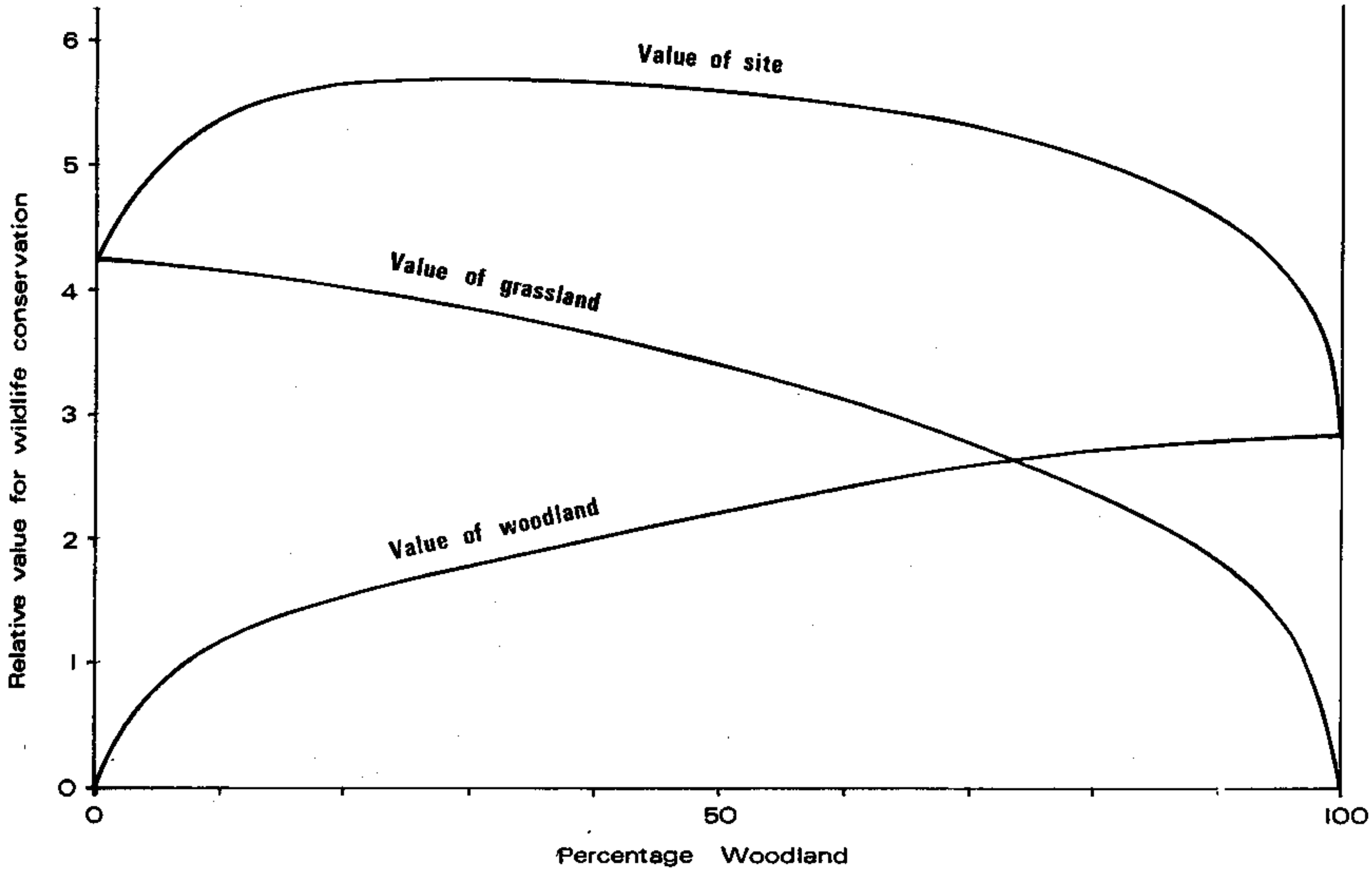


Fig. 8. EFFECT OF INCREASING USAGE OF A SITE ON THE NET VALUE OF THE SITE, WHERE USAGE DISTURBS OR DESTROYS THE BASIS OF THIS VALUE.

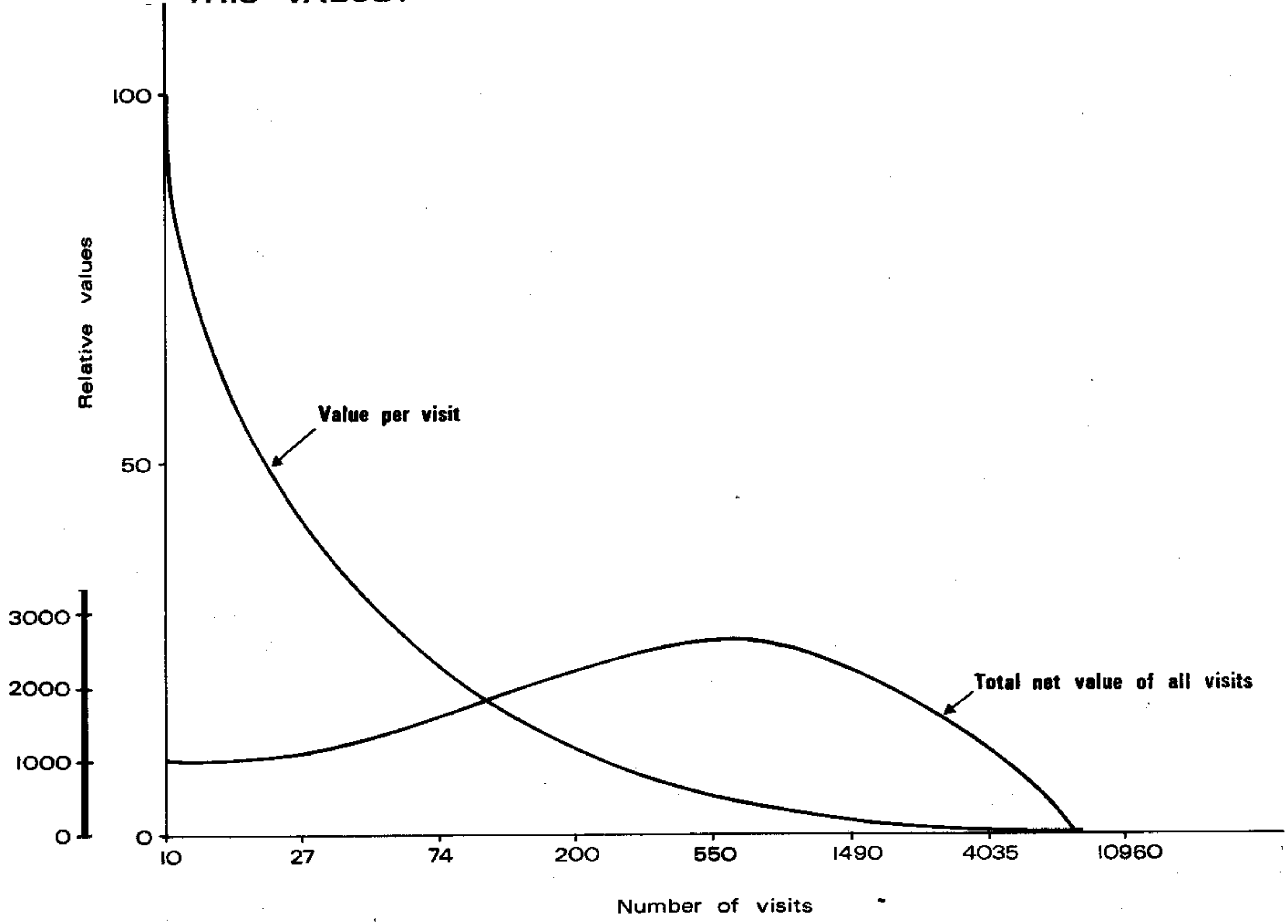


Fig. 9. EFFECT OF INCREASING USAGE OF A SITE WHERE MORE THAN ONE TYPE OF VALUE IS INVOLVED.

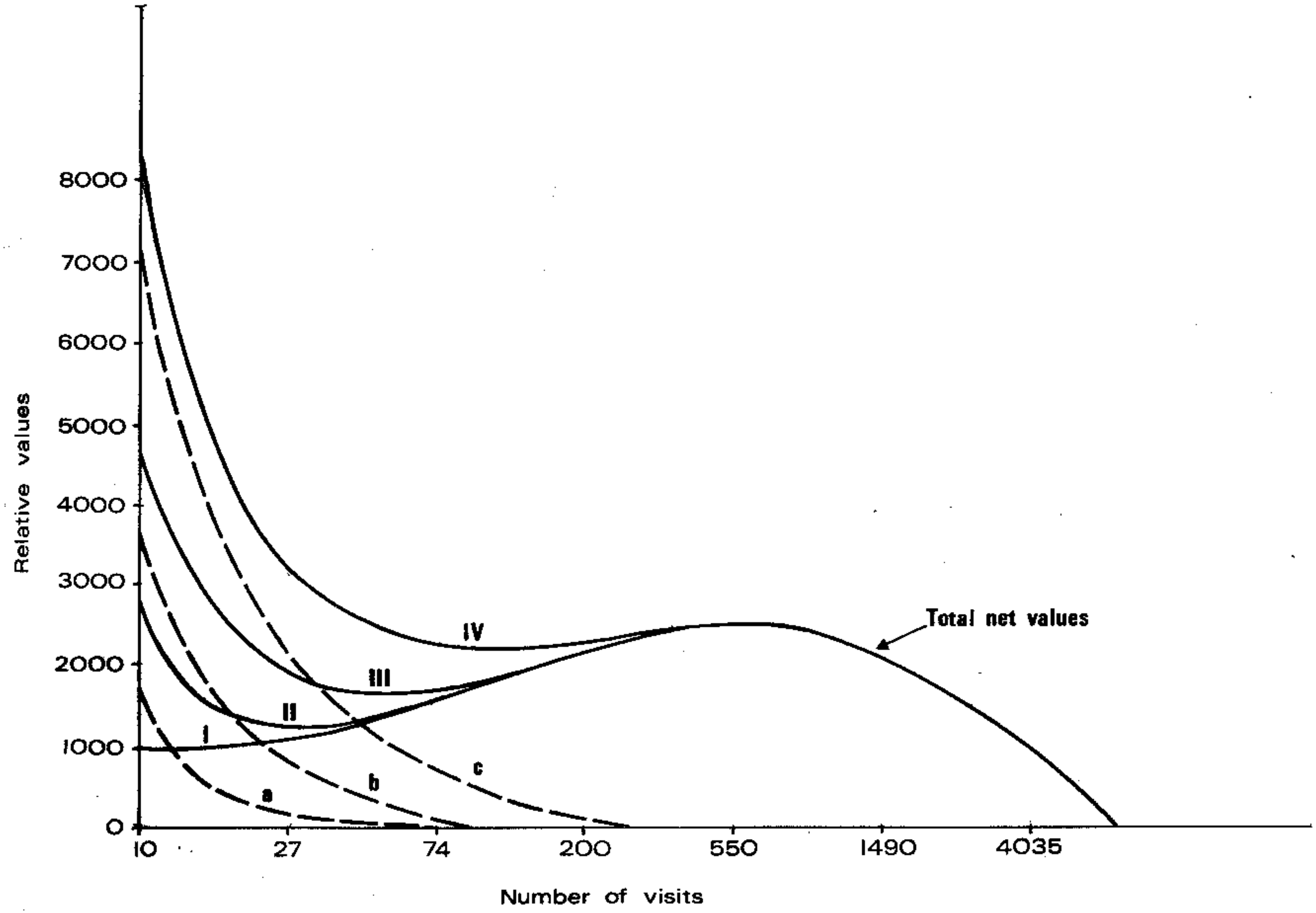


Fig. 10. EFFECT OF GALLOPING HORSES ON CHALK GRASSLAND. (After Perring, 1967.)

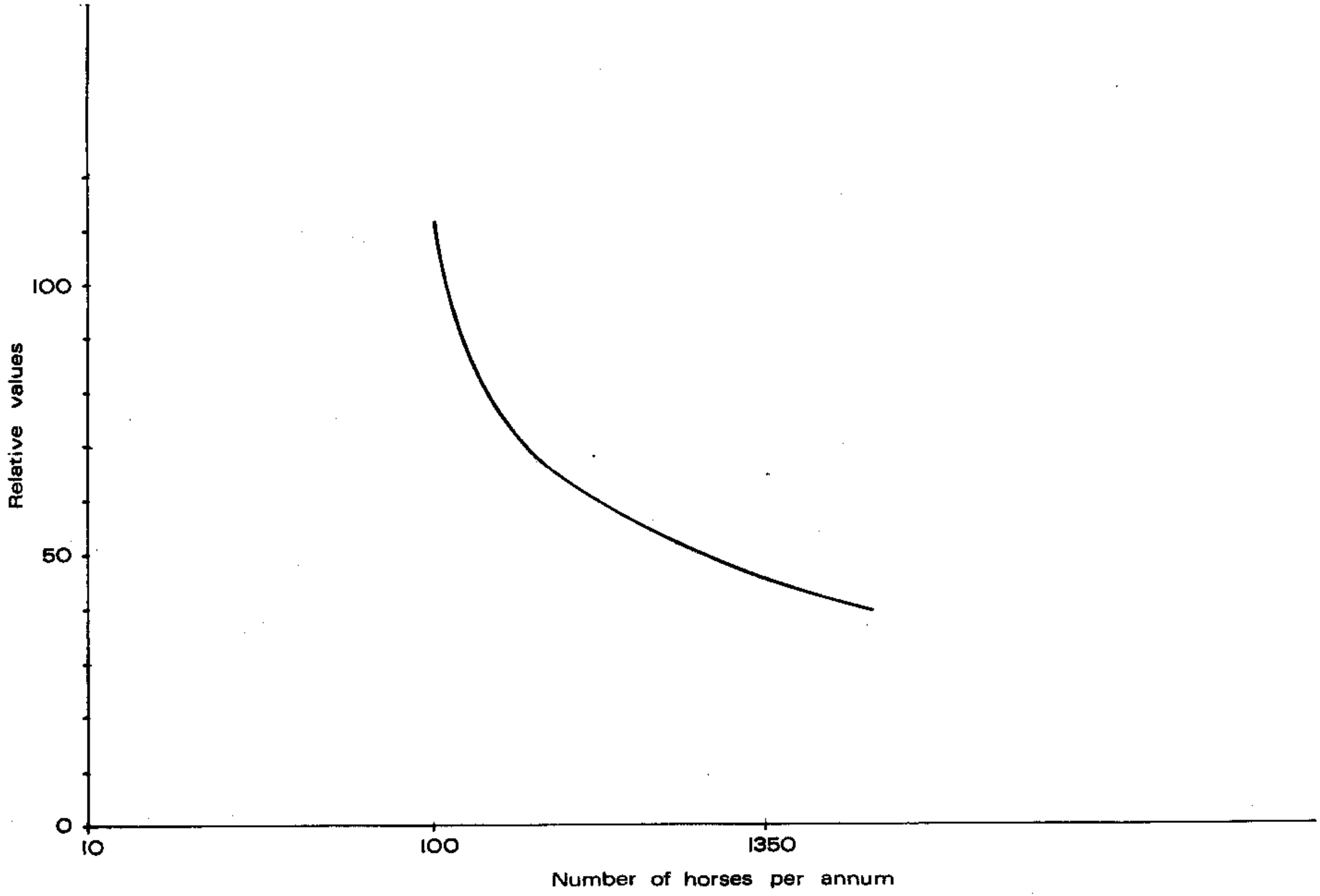


Fig. 11. VALUE OF VARYING AMOUNTS OF WOODLAND AND AGRICULTURAL LAND

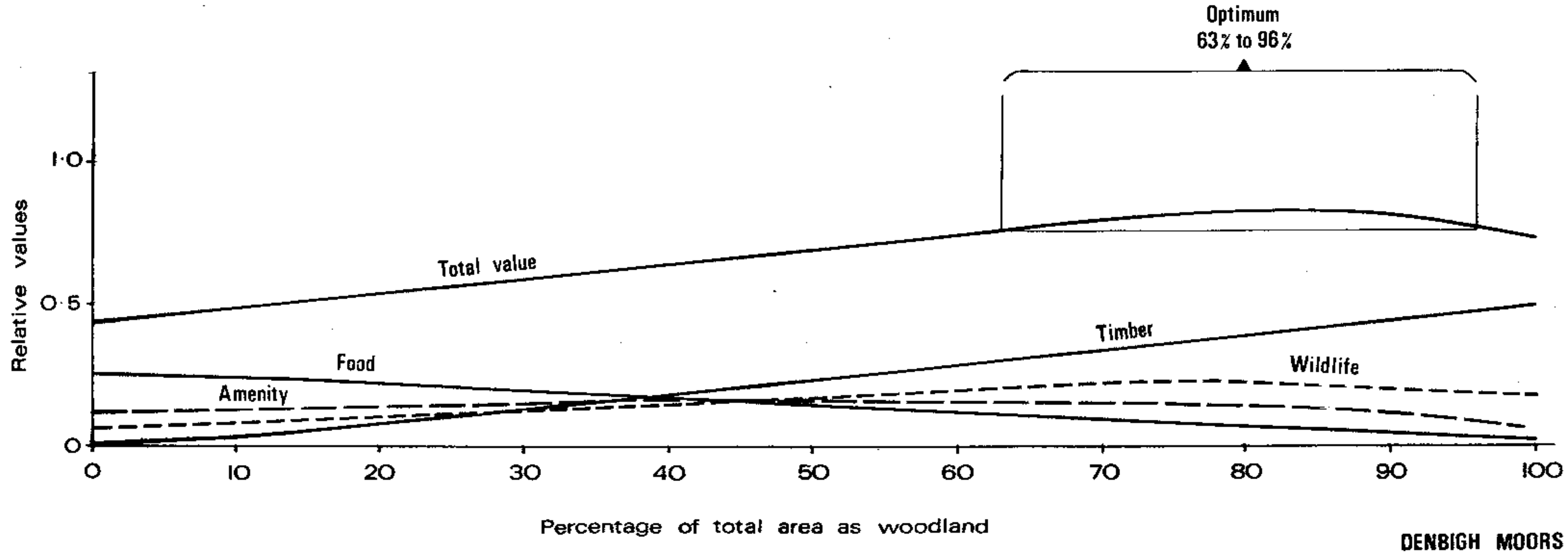
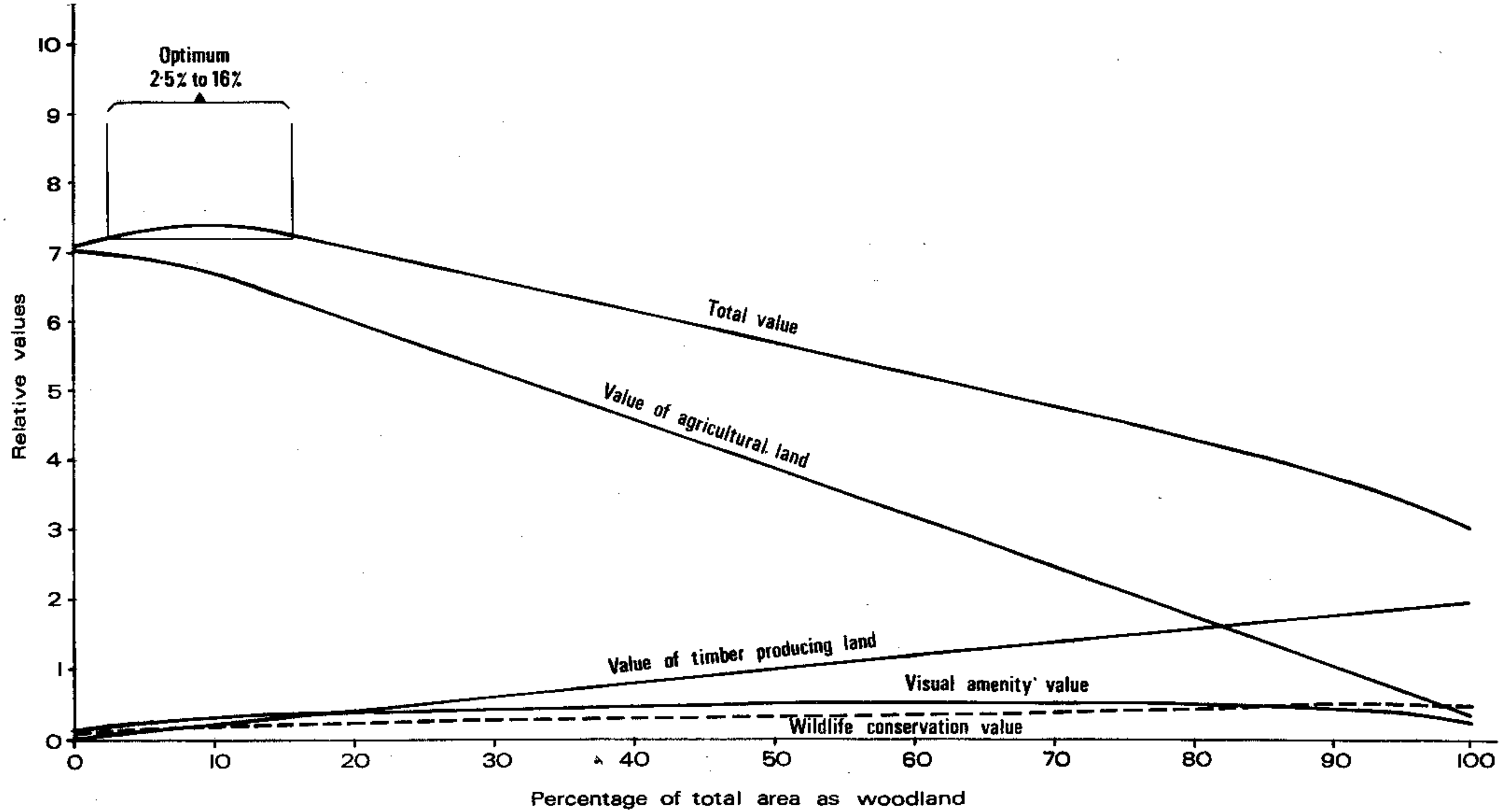


Fig.12. VALUE OF VARYING AMOUNTS OF WOODLAND AND AGRICULTURAL LAND



HAMPSHIRE