KAURI FORESTRY IN NEW ZEALAND
A PROTAGONISTS' VIEW

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ABSTRACT

Over the next decade the virtual cessation of timber extraction from virgin kauri forests is inevitable. If New Zealanders wish to use kauri timber in the future it will have to be taken from intensively managed regenerating stands designated for timber production, and from artificially established stands, probably in mixtures with suitable exotics, which will act as nurse crops and perhaps yield an intermediate crop.

This paper explores the various ways in which this might be done, reports on some recent and current experimental work in this field, and discusses a possible economic approach to kauri management.

INTRODUCTION

When considering management possibilities for kauri, two major problems become obvious. First, there are the technical aspects associated with growing the trees. Secondly, there is the economic viability of the operation.

It has long been recognised that the management of New Zealand indigenous trees was more difficult than that of exotic species, and that indigenous forest management could not satisfy New Zealand's demand for wood. Thus most state and private forest research has been directed toward exotics, particularly *Pinus radiata.* Radiata's early promise has been fulfilled many times over and today our pine plantations can produce all of our cellulose requirements, leaving a surplus to earn vital foreign exchange.

This country will never be short of wood, but when the quality of the wood is considered new problems emerge. Man does not live by bread alone but requires a variable diet for complete health. So, too, with timber.

Despite its great versatility, radiata pine cannot provide all of our wood needs. A finely built sideboard, made of pine and stained a mahogany colour, is a bit like making coffee out of acorns!

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It is strongly submitted that there is a place in our timber scene, and our economy, for timbers other than radiata pine, filling a place which pine cannot fill. These are special-use woods: the decorative timbers, the timbers with great strength, flexibility and durability. Kauri timber is well suited to many of these roles, especially boat building, turnery and veneer production.

GROWING NATIVE TREES

Because foresters did not understand the ecological requirements of the various native species, early attempts to grow them were not very successful. The plantation systems applied to European and North American conifers did not seem to work with New Zealand trees. The cost and the many difficulties involved meant that those few attempts at indigenous management which were made did not usually continue for long enough for real benefit to accrue.

The situation has now changed radically as shortages of quality timbers, both locally grown and imported, have become more apparent. The position of kauri in the market has now been considerably strengthened by the much higher and more realistic stumpages being paid for what is generally recognised as one of the world's finest softwoods. However, kauri is not only a timber of high intrinsic worth but also a tree capable of management in several different ways.

ESTABLISHMENT PHASE

While kauri will regenerate on a wide variety of sites, a good seed source is vital. Where regeneration is inadequate the stocking can be supplemented by planting, since seed is easy to collect and nursery production relatively straightforward (Dakin and McClure, 1975; Lloyd, 1978a).

Most difficulties occur in the field immediately following planting — or seed germination, if natural regeneration is being relied upon. Kauri is shade tolerant and, where natural forest processes prevail, seedlings usually sit beneath the canopy for 50 or 60 years (Lloyd, 1960). They grow extremely slowly and when light levels are high enough — usually following the breakdown of the nurse canopy — commence rapid growth.

The most useful breakthrough in the whole area of indigenous management will be to reduce this establishment stage from 50 to

10 years. This can be done by keeping the seedlings growing at a rapid rate from the time of planting or germination. To achieve this seedlings must have an adequate supply of nutrients, moisture and light, and for several years weed competition must be controlled.

At Hunua, in the Auckland Regional Authority's water catchment forests, south-east of Auckland, a wide variety of pilot experiments are being conducted, designed to find out as much as possible about the growth of kauri seedlings. Although much more work remains to be done, a standard procedure (given below) is followed when kauri is being planted into scrub-covered or forest sites, where natural regeneration is inadequate.

Seedlings between 40 and 70 cm tall are planted in the autumn, as soon as the ground is moist enough. Tentative results show that seedlings will benefit from having the planting holes dug some months before and, if the pH is below 5, lime should be added. If the site has not had kauri growing on it before, the addition of leaf mould, containing mycorrhiza, will be beneficial.

Trees are planted in groups of three, along a marked grid line and if necessary some of the shading plants are cut, so that overhead light is between 20 and 50% of full light. Plants are mulched with any available natural material. In spring the plants are fertilised with a long-lasting NPK fertiliser. It is possible that the addition of molybdenum may be beneficial. After the first year the seedlings are released from scrub competition which can be done by hand, or with chemicals which have a longer lasting effect. This releasing may be necessary again after three years. Final treatment comes at about age 5 when most of the scrub shading the seedlings is cut down to let in 60 to 90% of full light. Provided seedlings are well established by this stage they should continue to grow into small poles with no further treatment.

This method, slightly modified, could also be used if it is wished to establish kauri seedlings under a nurse provided by an exotic plantation species — *e.g., Pinus elliotti* or *Acacia melanoxylon.*

Once seedlings are established and growing at a reasonable rate, only one further releasing should be necessary — probably at about age 20. The most important factor is that the head of the tree must be kept in full light.

MANAGEMENT OF POLE STANDS

Results from silvicultural treatment of kauri pole stands indicate a favourable response to both thinning and the application of fertiliser.

It seems that a stocking of about 700 stems per hectare of pole sized trees (5 to 30 cm d.b.h.) is close to optimum; application of a nitrogenous fertiliser has been shown to boost growth following thinning even further.

Table 1 indicates the responses obtained from some of the treatments in an experiment at Hunua. These must be interpreted with care as it is almost impossible to find large enough areas of growth in order to properly replicate plot layouts. The Hunua plots were duplicated but variations in stocking, tree size, slope and soil type are too great to permit plot comparison. Instead, trees were randomly selected from each diameter class in the

TABLE 1: GROWTH RATES OF POLE KAURI

Stand Description and Location	*Treatment*	
Natural regeneration at Mangatangi—southern Hunua Range	Unthinned control	2174 stems/ha
	Thinned to:	1235 stems/ha
		740 stems/ha
		250 stems/ha
Dominant poles (20-25 cm dia. class) (in 1967)	Thinned to 740 stems/ha	+Nitrogen
		+Phosphate
		+N and P.
Small poles (0-5 cm dia. class) (in 1967)	Unthinned control	2174 stems/ha
	Thinned to:m	1235 stems/ha
		740 stems/ha
		250 stems/ha
	Thinned to 740 stems/ha	+ Nitrogen
		+Phosphate
		+N and P.
Plantation trees: plots established 1973		
Cornwall Park, Auckland	Planted 1926	346 stems/ha
Kirk's Bush, Papakura	Planted 1955	566 stems/ha
Scattered farm trees, Redshaw's farm, Paparimu	Naturally regenerating trees which were retained in 1965 when scrub was cleared and the area grassed. Annual application of molybdic superphosphate. Lime every three years.	

control plots and compared with trees as close to the same size as possible in the other plots. Future work may have to rely on a comparison of tree, rather than plot response, unless very even areas of pole regrowth can be found.

Despite these problems, the evidence presented indicates that silvicultural treatment considerably enhances the growth rate of kauri. Treatment has improved the growth rate of dominant trees (20 to 25 cm diameter class) by increasing periodic diameter increment between 170 and 290%. If the growth rates of the smallest trees in the stand (0 to 5 cm d.b.h.) are considered, the results are even more striking, with periodic diameter increments increasing 240 to 630%. Intermediate size classes exhibit similar patterns which fall between the two extremes.

This response is particularly heartening, indicating that, while the larger trees will grow faster, the smaller trees show an even better response. Thus there are prospects for the perpetuation of an all-aged stand with regular selection logging of dominant trees.

Diameter Breast Height (cm)				*Tree Volume — Total Stem (m^3)*			
1967	*1978*	*c.a.i.**	*%c.a.i.*	*1967*	*1978*	*c.a.i.*	*% c.a.i.*
21.3	25.2	0.355	1.7	0.251	0.373	0.0111	4.4
24.6	31.3	0.609	2.5	0.345	0.585	0.0218	6.3
20.7	30.1	0.855	4.1	0.193	0.471	0.0253	13.1
24.4	31.9	0.682	2.8	0.271	0.605	0.0304	11.2
20.7	32.0	1.027	5.0	0.196	0.605	0.0372	19.0
22.9	30.3	0.673	2.9	0.267	0.500	0.0212	7.9
25.0	34.3	0.845	2.5	0.321	0.735	0.0376	11.7
4.6	5.55	0.086	1.9				
4.3	7.3	0.273	6.3				
4.3	7.5	0.291	6.8				
No trees in these plots in this size class							
4.4	9.2	0.436	9.9				
4.3	6.6	0.209	4.9				
4.9	10.9	0.545	11.9				
1973	1977			1973	1977		
30.9	34.1	0.8	2.6	0.482	0.599	0.029	6.0
18.3	22.2	0.98	5.4	0.128	0.206	0.020	15.6
31.7	35.6	0.98	3.1	0.525	0.670	0.036	6.9

* c.a.i. = current annual increment.

GROWTH OF KAURI IN PLANTATIONS

For some years the growth of some of the country's oldest plantations has been monitored. Measurements from some of these are included in Table 1, along with data from scattered kauri growing in open pasture. When the growth rates of the plantation trees are compared with those of the managed natural pole stands, they are seen to be similar.

— Diameter increment (current annual increment — c.a.i.) of the dominant trees in managed natural pole stands ranges from 0.61 to 1.03 cm.

— Diameter increment (c.a.i.) of planted stands ranges from 0.8 to 0.98 cm.

The most obvious problem with plantation trees established on open sites at relatively wide spacings (346 to 566 stems/ha) is that there is a strong tendency to retain lower branches for a much longer period and to develop multiple leaders. It would thus seem necessary to plant plantation kauri at very high densities (*ca.* 2000+/ha) or to plant them amongst an artificially established nurse crop.

MAXIMUM GROWTH RATE UNDER NATURAL CONDITIONS

Similar rates of growth to those obtained from managed stands have occasionally been recorded for naturally growing trees which have never received silvicultural treatment (Fig. 1).

(1) A 64.7 cm diameter kauri in the Hunua Ranges is aged 80 years (± 7) according to ring counts. Its rate of growth thus averages 0.81 cm annually.

(2) A pole kauri in the same area is 28.0 cm diameter. With 26 rings (± 5) the growth rate is 0.93 cm annually.

(3) A cross-section, taken from a tree felled in the southern end of the Hunua ranges in 1972, showed a fast growth rate for 94 years prior to felling. During this time it increased in diameter by 58.6 cm, an annual rate of 0.62 cm. This third tree differed from the first two in one significant way, for they have grown at a fast, relatively steady rate since they were small seedlings. The third tree took 105 years to grow to 7.2 cm diameter, a growth rate of 0.069 cm per annum.

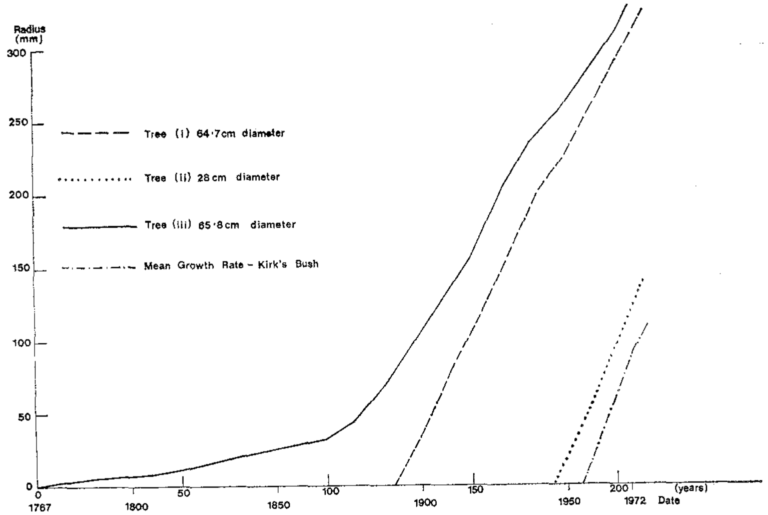

FIG. 1: *Growth rate of kauri trees (i), (ii), and (iii) grown under natural conditions. Kirk's Bush grown under plantation conditions.*

The third tree exhibits the classic natural growth pattern of kauri — very slow in sapling and pole stages, until the tree breaks through the nurse crop and gets its crown into full light. From that point on it grows quite rapidly. For comparison the growth of the kauri in plantation at Kirk's bush is also plotted on Fig. 1.

TIMBER QUALITY AND VALUE

Faster growth rates than those obtained from virgin stands are possible, which raises the question of timber quality. Will it be the same for fast grown, relatively small, trees as it is for the larger trees milled from virgin forests?

Unfortunately, very little information is available on this subject, which is surprising when kauri's place in the timber industry is considered. Hinds and Reid (1957) record physical and strength properties for test material obtained from the Waitakere Ranges, near Auckland. As this material was very slowly grown (10.2 rings per cm compared with the accepted average of 4), it is likely that it is atypical. These data are all that is available (J. M. Harris, pers. comm.) so there is a real need to obtain more information from a wide range of size classes, growth rates and sites.

When this is done it should be possible to comment on the timber qualities of faster grown kauri, and its value relative to timber from larger, slower grown trees.

A MANAGEMENT PROPOSAL

The research which has been done indicates that kauri can grow quite fast and diameter increments of 1 cm per annum are not impossible. The forest manager's real challenge is to overcome kauri's slow initial growth and keep the tree growing steadily from the seedling stage. There are no insurmountable problems, and our present level of knowledge is adequate to postulate a management regime for kauri.

It should be feasible to manage kauri on an 80-year rotation which will produce trees averaging 50 cm diameter breast height, on a sustained yield basis (Fig. 2). Although trees would be grown for 80 years, the stands would be selectively cut on a cycle which could be any length between 20 and 40 years. The expected yield on a 25-year cycle would be 160 to 190 m^3 of wood per hectare at each felling. Based on current stumpages the value

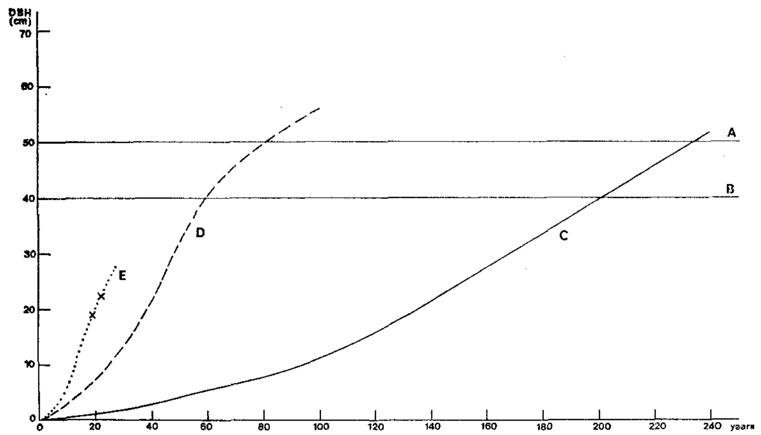

FIG. 2: *Calculated age-diameter growth curves for kauri in managed and unmanaged (natural) stands*

A. *Average tree diameter at time of selection logging.*
B. *Lower cutting limit. Trees smaller not removed unless thinning required.*
C. *Diameter growth rate in unmanaged stands.*
D. *Diameter growth rate in managed stands.*
E. *Actual growth rate Kirk's Bush, Papakura (planted 1956).*

of this should not be less than $6 000 and could be as high as $12 000.

One final question remains to be answered: Where will this kauri be grown? Two possibilities seem viable.

(1) There are 97 600 ha containing second-growth kauri in the Auckland region, of which 21 100 ha are controlled by the Forest Service (Lloyd, 1978b). It should be possible to place most of the Forest Service regeneration and a reasonable proportion of that in other tenures under sustained yield management. Assuming that 30 000 ha of kauri regeneration could be managed for timber production, then a 25-year cutting cycle would permit selection logging over 1200 ha per annum. This would yield a minimum of 180 000 m^3 of kauri timber, worth at least $7 million. It would not be possible to realize this rate of production for many years as most stands of regeneration are not, at present, fully stocked. A planting programme, aimed at bringing the stands up to full stocking within the next 50 years, would overcome this problem.

(2) Although it is not envisaged that large-scale kauri plantations be established, it is possible that small plantations could be set up:

  (a) On unstocked forest areas adjacent to natural kauri stands.

  (b) On other suitable sites in state, local authority and private forests.

  (c) As farm woodlots.

These plantations could be initiated using another species as a nurse, which itself would yield economic crops at intermediate stages in the cycle. Two possible species are *Pinus elliottii,* which has been found to make nitrogen available to underplanted *Agathis robusta* in Queensland (Richards, 1961) and *Acacia melanoxylon,* either separately or in mixture. Experiments using this technique are currently being carried out but no results are yet available.

ECONOMIC CONSIDERATIONS

Three distinct views of the relevance of the economist to problems of ecology and the environment can be found in the literature.

(1) "There is a group which argues that [ecological]/environmental problems are economic problems and that economic theory has the tools of analysis to solve [them].

(2) In contrast to this view, there is a second group who recognise in the life sciences a fundamental challenge to the application of economic theory. They tend to argue for the largely unfamiliar idea of 'stable states' with ecological criteria being substituted, in the main, for economic [ones].

(3) Between these two extremes is a third group who accept that there are limitations on the capacity of economics to prescribe policies [in these areas], but believe for the most part that the criteria should remain those of the economist . . . . " (Pearce, 1976, in Meister, 1977).

It is possible to grow kauri in rotations which by the standards of much commercial forestry are short (for example, *Picea abies* on an 81- to 120-year rotation in the U.S.S.R. (Tsurik, 1974) and *Quercus robur* on a 250-year rotation for veneer production in France (Roy, 1975)), but the question to be answered is, should we? That choices have to be made is the heart of the problem. We cannot, in any rational way, say no to using land for kauri forest and yes to using it for a radiata forest unless we know what the alternatives are and have some idea of the advantages and disadvantages of each alternative.

Deciding on the "best use" of the environment and the resources in it has three dimensions: physical (biological), economic and institutional. "Economists can contribute in determining the cost of alternative choices in terms of resource use and in determining the trade-offs between objectives given the different choices" (Meister, 1977). The economist's role thus is not that of a "god" dictating what must be done but rather as a member of a team appraising various alternatives in terms of what is economically desirable.

Comparisons through Time (Intertemporal Comparisons)

For the economist weighing up investment opportunities, particularly long-term investments, there is the problem of choice of discount rate. In its crudest form this problem can be reduced to the question, "What value should we put on a dollar of income next year compared with a dollar in the hand today?" The answer to this question is a measure of society's time preference. The discount rate, which is the weighting factor, is important on two counts. First, it allows comparisons to be made between projects with differing time profiles of expenditure and income and, secondly, it ensures that, by the standards of the day, the most efficient use is made of scarce resources.

The importance of the discount rate in determining the acceptability of a project can best be illustrated by an example. Suppose we have a project requiring a million dollar investment today giving a return of $2 000 000 in 7 years' time. At a 5% discount rate, the present value of the $2 000 000 return is $1.42 million, at a 10% discount rate $1.02 million, and at 15% a mere $760 000. Clearly at a 5% discount rate the project is very acceptable (since in present value terms we can expect a $420 000 profit from our $1 million investment). At 10% about the best that can be said is that we expect to get our money back, while at a 15% discount rate the project is unacceptable since we expect to lose $240 000.

Methods of determining the appropriate discount rate of public sector projects are many and varied, though most are based on one of the following:

(a) Society's time preference.

(b) The government's borowing rate (the cost of government moneys).

(c) The rate of return on investment in the private sector (the opportunity cost of capital).

Support for each of these methods can be found in the literature. Public debate within New Zealand about the appropriateness of the various methods and the numerical value to be used in discounting has been virtually nonexistent since the late 1960s. Since 1971 public servants have been directed to use a discount rate of 10% — this rate being chosen as being the opportunity cost of capital. While a directive such as this may appear to simplify the problems faced by a researcher, it does in fact merely replace one set of problems with another set of equally serious ones.

The opportunity cost of capital approach, though widely accepted both here and overseas (Price, 1973; Arrow, 1976; Copeland, 1975, O'Dea *et al.*, 1979), suffers from a number of difficulties, the most obvious being how one determines the rate of return on private capital. As Arrow (1976) says, "In the private sector one can find a spectrum of rates, not only one." For this and a number of other reasons, such as imperfect capital markets (which mean that private sector's rate of return is hardly likely to be optimal in any economic sence), and claimed differences in public and private attitudes towards the future, the selection of 10% as the only discount rate has been severely criticised by some (Price, 1976; Arrow, 1976).

A number of writers have pointed out that methods of determining the discount rate based on society's time preference are the only ones which direct attention precisely at the problem of how governments should compare benefits which accrue to the community at different points of time. From a theoretical viewpoint, the society's time preference is the appropriate discount rate to use in public sector analysis.

Discount rates based on society's time preference are not without their difficulties. It has been claimed that measurement difficulties "are such as to preclude [their] use" (Battersby and Smallbone, 1971), though perhaps the greatest problem associated with society's time preference rates is that they are agreed by many to be low (Copeland and Rose, 1973; Arrow, 1976).

Low rates — a range of 2 to 8% is quoted by Copeland and Rose — can mean many more viable projects exist than there is finance to cary out. Criteria other than economic viability must then be used to decide which projects should have funds allocated to them.

A further problem is that, if the public sector uses low discount rates while the private sector uses high rates, low return public investment may displace higher return private investment. In this case the money cost of public investment will understate its social opportunity cost. Discussion of this problem (Fieldstein, 1964; Sen, 1967) can be found in the literature as can methods for coping with it. (Marglin, 1963; Harberger, 1969).

The cost of government borrowing has not found favour as a method of determining discount rates either in New Zealand or overseas. There are a number of reasons for this, chief among them being that inflation expectations influence the rate, and that not all government borrowing is on the open market.

Examination of the literature provides a number of reasons for serious disquiet about the use of 10% as the only discount rate. There is, however, no unanimity among writers as to what the discount rate should be. Rather the literature provides a powerful rationale for examining the viability of long-term public sector projects for a range of discount rates. Accordingly, in the following analysis, the relative profitability of growing kauri is compared with that of growing radiata pine at five discount rates — 2, 4, 6, 8 and 10%.

Comparison of the Direct Costs and Benefits of Radiata and Kauri Management

When comparing the profitability of two species having different rotation lengths such as radiata pine and kauri, the discount rate is only important so long as the timber from the species with the greater rotation length is worth more than that from the other species. If is not, then there can be no *prima facie* economic case for growing that species.

Based on current sales in the Northland area, the prices used in this analysis are:

Radiata pine — \$15.00 per m^3.

Kauri from 40-70 cm d.b.h. logs — \$60.00 per m^3 (I. Kippenberger, pers. comm.).

Table 2 sets out the assumptions made about the operations to be carried out in the two types of forests, their timing and their costs. In this table three pine rotations are equivalent to one kauri rotation.

TABLE 2: OPERATIONS AND THEIR COSTS

Operation	*Years Carried Out*	*Per Time Cost of Operation (\$/ha)*
RADIATA PINE		
Site preparation	0, 26, 52	252
Planting, fertilising, releasing	1, 27, 53	207
Aerial chemical release	2, 28, 54	35
Dothistroma pini spray	3, 29, 55	15
Thin to 750 stems/ha. Prune 0-2 m	5, 31, 57	240
Prune 2-4 m. *D. pini* spray	7, 33, 59	125
Thin to 300 stems/ha (waste)	8, 34, 60	85
Prune 4-6 m	9, 35, 61	90
Aerial fertilizer	10, 36, 62	113
Annual charges	1-76	54
Returns: 629 m^3 sawlogs at \$15/m^3	25, 51, 77	9,435
47 m^3 pulpwood at \$2.85/m^3		134
KAURI		
Site preparation	0	100
Planting	1	400
Releasing and fertilising	1-2	130
Releasing	3	75
Releasing	5	75
Thinning/Releasing	20	100
Aerial fertiliser	40	120
Release regeneration	45	75
Annual charges	1-79	60
Returns: 200 m^3 at \$60/m^3		12 000

TABLE 3: DISCOUNTED RETURNS ($/ha)

	Discount Rate				
Forest	*2*	*4*	*6*	*8*	*10*
Kauri:					
Costs	3 272	2 249	1 750	1 470	1 292
Return	2 511	541	120	27	6
Net return	– 761	–1 708	–1 630	–1 443	–1 286
Pine:					
Costs	4 062	2 704	2 029	1 653	1 408
Return	11 337	5 320	2 811	1 593	958
Net return	7 275	2 616	782	–60	–450

Table 3 sets out the discounted costs and benefits for the two types of forest at the five chosen discount rates.

Two points emerge from this table; the first is that, with the assumed prices, plantation kauri forestry cannot even make 2%. The second is that pine forests, with the prices assumed, fail to yield the 10% rate required by the government for public undertakings.

However, direct regimes such as the one whose economics has been considered are not the only, or even the most likely, way of establishing kauri. It is most likely that (as outlined in the first section of this paper) a nurse crop would be used to help establish kauri on bare ground. If it is possible to utilise a commercially valuable species for this purpose, such as *Acacia melanoxylon,* then the economics of kauri forestry could be improved. For this to occur, it would be necessary for the two species to have a synergic relationship. Unless the relationship was synergic a return of 4 to 5% from combined species forests compared with a 2% return from kauri forests would imply that still greater returns could be obtained by reducing the kauri component to zero and increasing that of the other species accordingly.

Once a kauri plantation is established it should be almost self-perpetuating. Trees should produce cones from about age 30, and, if secondary establishment in the stand is encouraged, by the time the original trees are harvested trees from the secondary establishment should be quite large. It should then be possible to manage the stand on a cutting cycle similar to that outlined in the management proposals for sustained or periodic yield.

Management of Existing Pole Stands, and of Plantation Kauri that has progressed toward an Uneven Aged Forest capable of Sustained or Periodic Yield

This type of management warrants consideration, not because it provides a rationale for planting new kauri forests (these must stand or fall in comparisons such as those of the direct or synergic regimes against returns from other uses for the land involved) but because:

(1) Establishment costs should be reduced.

(2) It reflects the type of management that may well be employed on existing second-growth stands.

(3) It is possible that such a system could result in increased volume production over that of a direct regime.

To the extent that production for a 75-year period increases in value over that from a direct regime, and the establishment costs are reduced, such a management system would improve the economics of kauri growing.

For example, were establishment costs to be reduced by ¾ to \$100/ha, then, assuming the same value of output (\$12 000/ha, now obtained in three equal amounts of \$4000 in years 25, 50, and 75) with all other costs assumed to be the same as for a direct regime, the return of kauri forestry improves from 2% to nearly 6%.

As well as the possibility of improving the direct return on kauri forestry, such management systems may also be important in maintaining a steady flow of indirect benefits. Because tree cover exists at all stages, the scenic value of the forest as well as its value for recreation and as a habitat for other native species should be greater than for a direct regime forest.

Indirect Benefits

The question arises as to whether or not there exist indirect benefits associated with the growing of kauri that could make up for the difference in return between kauri and radiata pine forestry. Unmarketable benefits are frequently claimed for forestry developments (Helliwell, 1974; Price, 1976). Some that would apply in this case are:

— Scenic and landscape values.

— Preservation of a biological heritage and a unique ecosystem.

— The establishment of a habitat for other plants and animals that more closely approximates the original one.

— Preservation of gene pools.
— Preservation of species associated with kauri forests.
— Provision of areas for native bush walks, nature study, art, etc.
— Increasing the range of forestry management options open to future generations.
— Maintenance of skills associated with management of native forests.

There exists a sizable body of literature attesting to the difficulty of both measuring and assigning monetary values to the benefits (and costs) associated with these and similar intangibles (Grayson, 1974; Clawson, 1975).

One method of approach, which avoids the problem of assigning values completely, is to ask: "What is the required annual value of any indirect benefits if this project is to meet a return of *x*% on the moneys invested in it?" A value judgement is then applied in deciding whether or not the indirect benefits are likely to be worth this amount, the project being then either accepted or rejected.

If this method is used, with a kauri log price of $60/m^3$, net indirect benefits amounting to $128.50/ha per annum are required to give a return of 10% on kauri forestry. (This amount is, of course, less for lower discount rates and Table 4 gives the amounts required for all five discount rates). Whether or not the indirect benefits of kauri forestry are worth this amount is a matter of personal opinion. There are indications that New Zealanders are beginning to place considerable value on their indigenous forests as witnessed by the Maruia declaration, the pressure to halt logging in Whirinaki State Forest, and the reported preference for indigenous forests for recreation purposes (Murphy, 1979). If artificially established or intensively managed natural pole stands are accepted as a substitute for virgin kauri

TABLE 4: ANNUAL MONETARY VALUE OF INDIRECT BENEFITS REQUIRED TO MAKE KAURI PLANTATION FORESTRY VIABLE AT VARIOUS DISCOUNT RATES ($/ha)

	Discount Rate				
	2	*4*	*6*	*8*	*10*
Total indirect benefits required over 80-yr period	761	1 708	1 630	1 443	1 286
Annual level of indirect benefit needed to produce his amount	19	69	95	115	128

forests, the indirect benefits from "plantation forests" will be greater than might otherwise be expected. Certainly there exist some situations where indirect benefits of $128/ha per annum would not appear an impossible target.

SUMMARY, AND A LOOK INTO THE FUTURE

This paper is in three parts. In the first part, evidence is shown that kauri is capable of management. In the second part, the place of the economist in determining the choice of tree species and the type of management employed is briefly reviewed and it is shown that re-establishing kauri on open areas is a costly, and much less economic proposition, than establishing radiata pine. In the third part, it is noted that kauri is, however, capable of providing many non-marketable benefits which must be taken into account if the true worth of re-establishing kauri forests is to be found, and it is suggested that inclusion of non-marketable benefits would justify at least some kauri forestry.

Because radiata pine has a very fast growth rate and is a versatile timber, it has attained a unique position in the New Zealand forestry scene. In spite of those things such as radiata's growth rate and the use of a high discount rate which push us towards a monoculture forestry situation, there are other reasons for growing a variety of species. A variety not only provides insurance against the failure of our major plantations because of disease, but also provides for those special-purpose requirements mentioned in the introduction of this paper.

Kauri has, by world standards, good growth rates and must be considered as one of the most important alternative species in the New Zealand forestry scene. It should, we believe, be given high priority in the Northland and Auckland regions.

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