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COST-PRICE: A USEFUL WAY TO EVALUATE TIMBER GROWING ALTERNATIVES

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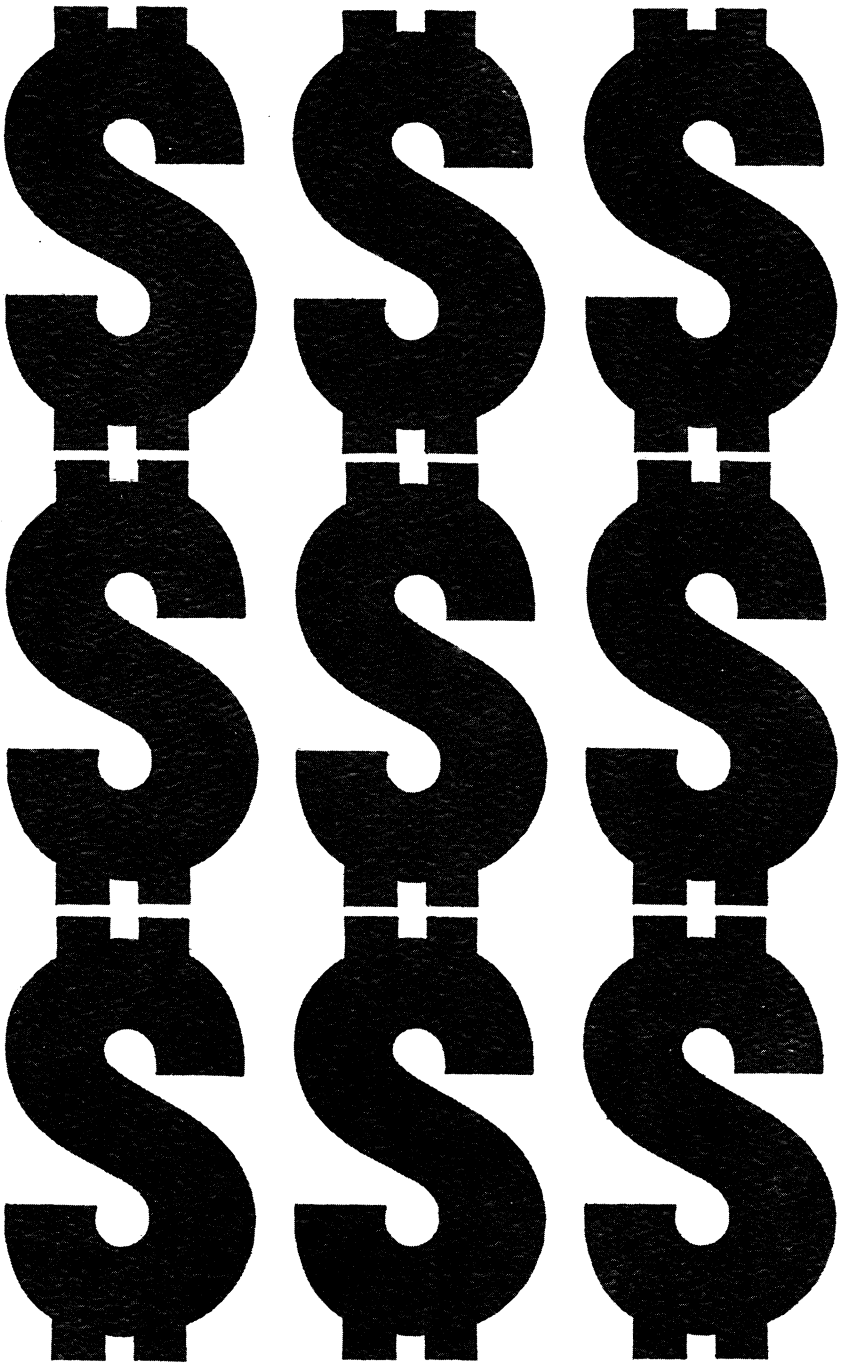

per cubic foot,

per cord,

or per thousand board feet.

North Central Forest Experiment Station
Forest Service
U.S. Department of Agriculture

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COST-PRICE: A USEFUL WAY TO EVALUATE TIMBER GROWING ALTERNATIVES

Allen L. Lundgren

INTRODUCTION

There are several ways to look at an investment. We can ask:

1. Will income be greater than cost?

2. At what rate will our invested capital increase?

3. What will we get back for every dollar we put in?

4. How long will it take to get our invested capital back?

5. What will it cost us to produce a unit of output?

These questions suggest several financial criteria to judge investments by:

1. Present net worth (or future net worth)

2. Internal rate of return

3. Benefit/cost ratio

4. Payback period

5. Production cost per unit of output

Each of these criteria measures an investment in a different way. All have their place in evaluating investment alternatives. The wise manager will not rely solely upon one criterion (that is, ask only one question about an investment); he will want answers to several questions and use several investment criteria, if possible, before making his final decision.

Many investment criteria are well known to forest managers and owners. Present net worth (with its related land or soil expectation value), internal rate of return, and benefit/cost ratio, have been widely used in forestry. Computer programs that calculate all three are available (Chappelle 1969, Lundgren and Schweitzer 1971). Payback period, widely used by business in practice, is not generally recommended as an investment criterion by economists, although it is recognized as one useful measure of an investment (Weingartner 1969).

One other investment criterion, the production cost per unit of output, has been available for decades but has not been widely used in forestry. For many purposes the cost of producing a unit of output may be a more useful guide for the forest manager than the traditional ones. In this paper this production cost per unit of timber output will be called "cost-price" (Lundgren 1966). This concept has been used by others: Kirkland (1915), Kittredge (1929), Hiley (1930, 1956), Buttrick (1943), Chapman and Meyer (1947).

This paper explains how this cost-price criterion is derived, shows how it can be used in making management decisions, and provides some charts useful in estimating the cost-price of timber for some general timber-growing activities. It also demonstrates how this criterion can be extended to nontimber outputs.

COST-PRICE: WHAT IT IS

The cost-price of growing timber is the price at which timber would have to be sold at some future time in order to earn a specified average rate of return on all the capital and resources used in growing the timber. Thus, it is the cost (including a return on invested capital) of producing a unit of output, usually expressed as dollars per cubic foot, per cord, or per thousand board feet. Cost-price may apply to actual past costs of production and yields of timber products, but this paper will be concerned primarily with calculating cost-prices for estimated future costs and yields.

The formula for calculating cost-prices is derived from the same discounting-compounding formulas used in other investment calculations, using the same concepts of discounted incomes and costs.[1/] The sum of discounted incomes for one rotation may include the sum of discounted incomes from the sale of different timber products at different times, the discounted value of other single incomes from nontimber sources at different times, and the discounted value of annual incomes.

To illustrate the concept of cost-price we will start with the simplest case. Assume that the only income will be from the sale of stumpage for a single product (measured in cubic feet)

1/ Procedures for compounding and discounting incomes and costs are widely available and will not be reviewed here. Interest rate tables are also available from many sources (for example, Lundgren 1971).

at the final harvest or rotation age. This we can represent by P_nV_n where P_n is the price in dollars per cubic foot at the rotation age n, and V_n is the volume in cubic feet per acre sold as stumpage at the rotation age n. Later we will show how this can be expanded to consider multiple products harvested at more than one time.

The sum of discounted costs for one rotation may include the sum of discounted periodic costs (including initial costs of stand establishment, timber stand improvement, timber sale costs, etc.), the discounted value of annual costs and expenses in growing the timber, and the net discounted value of the land used for growing the timber for one rotation. For our purposes we will assume that all discounted costs over the rotation can be represented by one symbol, C.

In general, the present net worth (PNW) is the sum of discounted incomes minus the sum of discounted costs. For our simple example:

$$PNW = P_nV_n(1+r)^{-n} - C,$$

where r is the stated interest rate.

It will be more convenient to express this in terms of future net worth (FNW) at the end of the rotation.

$$FNW = PNW(1+r)^n = P_nV_n - C(1+r)^n .$$

This is the basic formula used to derive the cost-price expression.

First we ask, "At what price (P_n) would the expected volume (V_n) have to be sold at the rotation age (n) in order to earn the stated rate of return (r) on the invested capital (C)?" At this price, future incomes would just equal compounded costs:

$$P_nV_n = C(1+r)^n ,$$

and FNW = 0.

From this we derive the formula for the cost-price (P_n):

$$P_n = C(1+r)^n \div V_n .$$

For example, suppose we expect to grow 1,200 cubic feet of merchantable timber per acre in 20 years, with a total discounted cost of $30 per acre, and wish to earn 6 percent on this $30/acre investment. The cost price would be:

$$P_n = \$30/\text{acre } (1.06)^{20} \div 1{,}200 \text{ cu ft/acre}$$

$$= \$96.21/\text{acre} \div 1{,}200 \text{ cu ft/acre}$$

$$= \$.0802/\text{cu ft.}$$

This tells us that if we can grow 1,200 cu ft of merchantable timber per acre in 20 years, and can sell it at $0.080 per cubic foot, then we will get just enough income ($96) at the end of 20 years to have earned 6 percent on our initial investment of $30 per acre. Including a return on our invested capital, it will have cost us $0.080 per cubic foot to grow this timber, hence the term cost-price. The cost-price is the break-even price.

USES OF COST-PRICE

Cost-price can be used to compare the economic efficiencies of alternative investments in much the same way as other investment criteria, such as discounted net worth, are used. We calculate the cost-price for each alternative and choose the one offering the lowest cost-price, if we wish to use that as our selection criterion. In this way we can compare the per-unit cost of growing timber on different sites, between different rotations, between different species, and for different cost levels, to cite some illustrations.

For example, jack pine (*Pinus banksiana* Lamb.) yield tables are available for well-stocked stands in the Lake States on site index (SI) 60 for a range of alternative rotation ages (table 1). Using the formula developed earlier,

Table 1.--Volume yields and average diameters of site index 60 jack pine[1/] and illustrative cost-prices[2/] for alternative rotation ages

Stand age	Volume per acre	Average d.b.h.	Cost-price per cord
	Cords	Inches	Dollars
20	8.3	4.0	9.58
30	17.7	5.9	7.32
40	25.6	7.5	8.24
50	31.1	8.7	11.07
60	34.6	9.7	16.22

1/ Unpeeled gross volume per acre in standard cords in trees 5.0 inches d.b.h. or more to a 4.0-inch top d.i.b., in well-stocked stands of jack pine in the Lake States. Interpolated from p. 29, Eyre and LeBarron (1944).

2/ Illustrative only; assumes discounted costs of $30 per acre and a 5-percent rate of return on this investment.

$P_n = C(1+r)^n \div V_n$, illustrative cost-prices per cord were calculated for each rotation age, assuming an initial investment of $30 per acre to cover all discounted costs and a 5-percent rate of return on this invested capital. These average cost-prices per cord were graphed to show the trend in cost-price with increasing rotation age (fig. 1). The marginal cost-price, the cost-price of each additional cord obtained by lengthening the rotation age 10 years, was calculated by dividing the total increase in cost per acre resulting from lengthening the rotation by 10 years by the additional cords obtained.

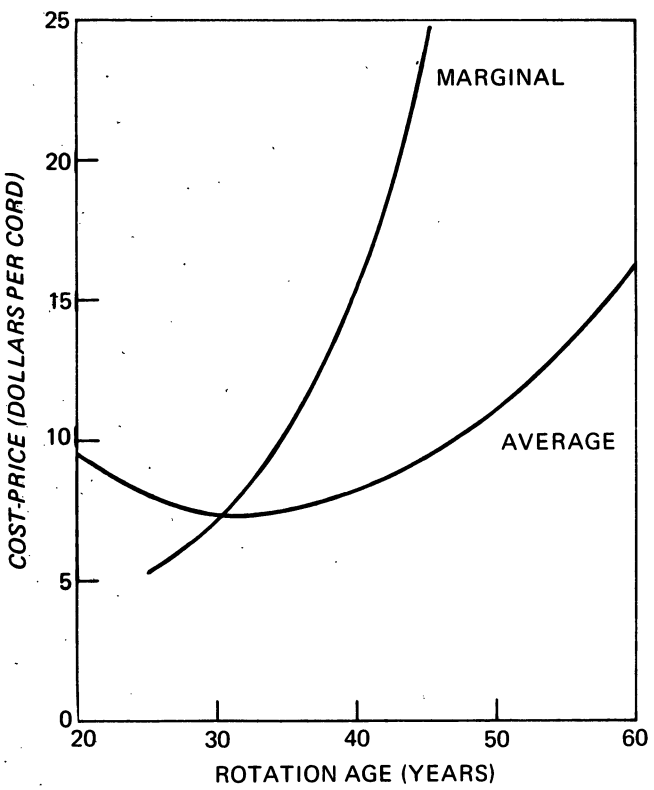

Figure 1.--Illustrative average and marginal cost-prices of growing jack pine pulpwood to different rotation ages on site index 60 land, earning 5 percent return on investment, for specified costs.

Note that the minimum cost-price occurs for a rotation of 30 years, $7.32 per cord. A rotation of 20 years produces less volume per acre, in smaller diameter trees, and at a higher per-unit price. It is clearly less desirable in terms of cost-price than a 30-year rotation. A 40-year rotation increases the cost-price by $0.92 per cord and therefore appears less desirable than the 30-year. However, the analyst or forest manager may decide that the additional volume per acre (an increase of almost 8 cords) and the increase in diameter (1.6 inches) may reduce logging costs or timber sales administration costs per cord, or increase the quality of the product sufficiently to offset this increase in cost-price. The marginal cost-price in going from age 30 to 40 is $10.30 per cord (taken at age 35) for the added 7.9 cords. The large increase in average cost-price of going from a 40-year to a 50-year rotation ($2.83 per cord) may be more difficult to justify. The marginal cost-price of each added cord is $24.24.

Cost-prices also can be used to compare the cost of growing timber on different sites. Again, we will use the jack pine yield table to illustrate this comparison for site indexes from 40 to 70 (table 2). The cost prices have been graphed (fig. 2) to better illustrate their relation to site index. For the rotation ages and costs used in these examples, it is obviously cheaper to grow wood on the better sites than on the poor sites. With such a graph one could establish a maximum cost-price as a cutoff point to determine the lowest acceptable site index on which to grow trees. For example, if $8 per cord were established as the upper limit on cost-price, then sites below SI 55 would not be acceptable because the cost to grow timber would be greater than $8 per cord.

It should be emphasized that these results are illustrative and would vary with the costs and yields assumed.

Several other useful graphs can be constructed from cost-price data. For example, graphs of cost-price over a range of site indexes can be constructed for several cost levels for any specified rate of return. This was done for jack pine using the rotation ages given in table 2 and a 5-percent rate of return, for costs per acre of $10, $20, $30, and $40 (fig. 3). Note that this graph also can be used to determine the maximum costs per acre one can incur on a given site for a specified cost-price of timber. For example, the most one can spend to grow jack pine for no more than $5 per cord, and earn 5 percent on invested capital, would be about $10 on SI 40, $14 on SI 50, $20 on SI 60, and $26 on SI 70.

Another useful graph for this purpose can be constructed for a single interest rate by plotting cost-price over discounted costs for each site index (fig. 4). From this graph one can quickly determine what the cost-price will be for any site and discounted cost combination. To invest $40 per acre to grow jack pine on site index 50, and earn 5 percent, for example, results in a cost-price of $14 per cord. Or, for any specified cost-price, one can quickly estimate the maximum investment per acre on a given site that will still earn a 5-percent rate of return.

These illustrations of how cost-price can be used in comparing alternatives and in providing information about investment alternatives should be enough to suggest other uses of this technique.

Table 2.--Rotation ages,[1] volume yields,[2] discounted costs,[3] and illustrative cost-prices for growing jack pine on a range of sites

Site index	Rotation age	Volume per acre	Discounted costs per acre	Cost-price per cord
	Years	Cords	Dollars	Dollars
40	45	17.2	20	10.40
50	40	20.0	25	8.70
60	35	22.0	30	7.50
70	30	23.1	35	6.70

1/ Rotation age (to the nearest 10 years) that produces trees that average at least 5.6 inches in diameter.

2/ Unpeeled gross volume per acre in standard cords in trees 5.0 inches d.b.h. or more to a 4.0-inch top d.i.b. in well-stocked stands of jack pine in the Lake States. Interpolated from p. 29, Eyre and LeBarron (1944).

3/ Assumed costs to reflect increasing cost of regeneration on better sites. A 5-percent return on investment is assumed.

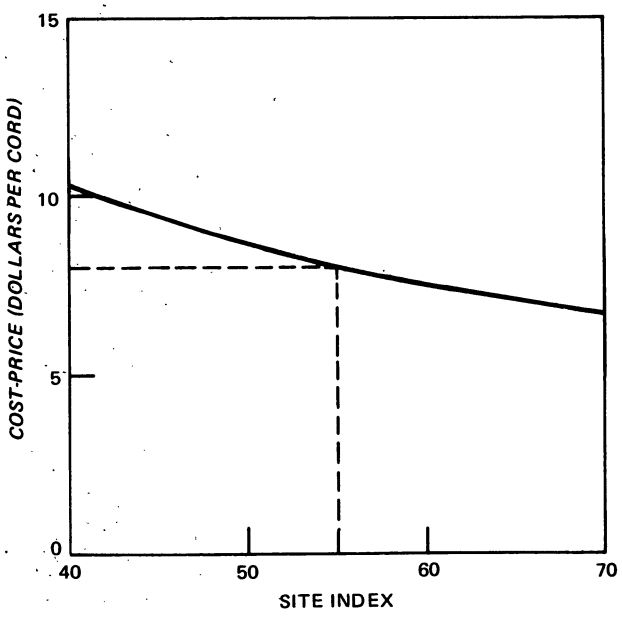

Figure 2.--Illustrative cost-price of growing jack pine pulpwood for a range of sites; costs vary with site, 5 percent return on investment.

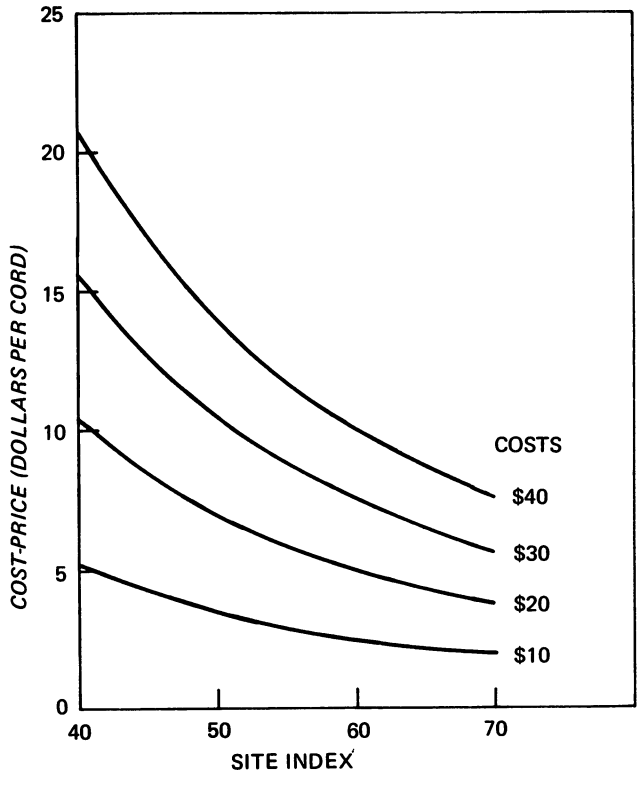

Figure 3.--Illustrative cost-prices for growing jack pine pulpwood for a range of site indexes and specified discounted costs per acre, to earn 5 percent.

One other useful modification of the cost-price concept can be made by rewriting our original cost-price expression in a slightly different form:

$$P_n = C[(1 + r)^n \div V_n].$$

Notice that the only change has been on the right-hand side to separate costs (C) from the remainder of the expression. The part of the expression in brackets can be considered as the cost-price per dollar of discounted costs. It is the reciprocal

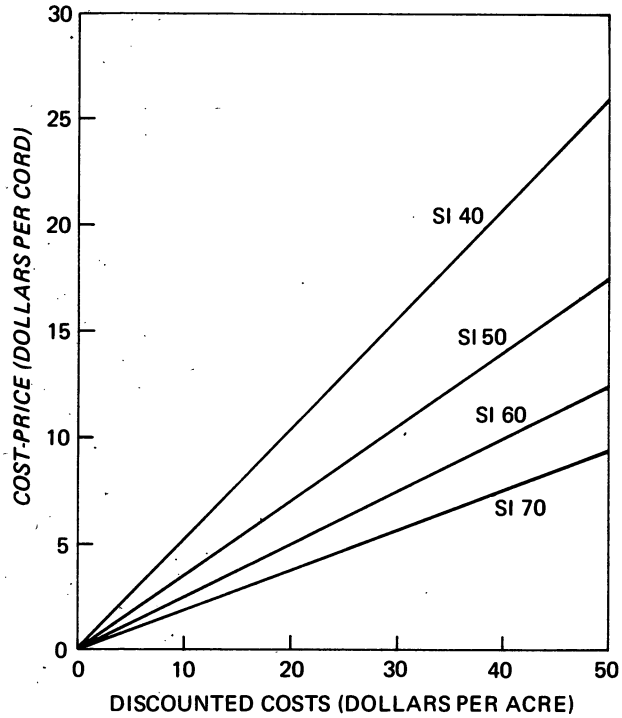

Figure 4.--Illustrative cost-prices for growing jack pine pulpwood for a range of discounted costs per acre and specified site indexes, to earn 5 percent.

of what I elsewhere have called the expectation value index (Lundgren 1966). We shall call this expression the cost-price index. One can easily determine V_n for a specified site index and rotation age n, and then compute the cost-price index for a range of interest rates r. For example, on a site index of 60 a fully stocked stand of jack pine will produce 22 cords of timber at age 35 years. The cordwood cost-price index would be:

r	$(1 + r)^{35} \div 22$
0.03	0.1279
.04	.1793
.05	.2507
.06	.3493
.08	.6720

The cost-price per cord for any specified sum of discounted costs is easily obtained by multiplying this cost-price index by the costs. Thus, for an interest rate of 5 percent and discounted costs of $30 per acre, the cost-price of growing jack pine on SI 60 would be $30(0.2507) = $7.52 per cord.

Tables of such cost-price indexes can be prepared for a given species for specified sites, rotation ages, and interest rates.

SOME GENERAL COST-PRICE CHARTS

It is evident that the formula used to calculate cost-price ($P_n = C(1 + r)^n \div V_n$) is not tied to any particular species, site, or unit of volume. In fact, it is a general formula applicable to a wide range of products and production situations. So, it is possible to construct charts to serve as general guides in evaluating production alternatives. Our examples will be confined to timber production, but it should be kept in mind that the output V_n may, with only slight modification, be number of deer, acre-feet of water, number of visitor days, or a number of other types of output.

By solving for the cost-price index for a range of specified yields and rotation ages, for a given interest rate, the information necessary to construct a useful type of chart is easily obtained. The cost-price index (in cents per cubic foot per dollar invested) for a given interest rate (say, 5 percent) can be plotted over a range of alternative rotation ages, for a range of specified final yields (fig. 5). From this type of graph, one can quickly determine the cost-price index for a given yield and rotation age. The cost-price index for timber expected to yield 3,000 cubic feet at 30 years would be 0.15 cents or $0.0015 per cubic foot per dollar invested, for this 5-percent graph. If the expected sum of discounted costs were $30 per acre, then the cost-price of this timber at 30 years of age would be ($0.0015/cu ft/dollar invested) ($30) = $0.045/cu ft.

Alternatively, one can specify the maximum acceptable cost-price index for a given rate of return and then determine the minimum volume output required for each rotation age. For example, suppose we wished to keep the cost-price below $0.05 per cubic foot, and our anticipated discounted costs were $25 per acre. Our cost-price index goal would then be $0.05 ÷ $25 = 0.2 cents per cubic foot per dollar invested. In order to earn 5 percent on our $25/acre invested funds we would have to obtain a final harvest of about 1,300 cu ft per acre at age 20, or 2,200 cu ft per acre at age 30 (fig. 5).

Similar graphs could be made for other interest rates and for other timber product outputs (cords, board feet). A set of general graphs for units of volume output, which can be cunits (100 cu ft), cords, or thousand board feet, for interest rates of 3, 4, 5, 6, 7, and 8 percent, is included in the appendix.

An even more useful general graph can be constructed for a given interest rate and rotation age by plotting cost-prices over discounted investment costs for a range of selected yields expressed either as total yield or as mean annual increment (fig. 6). On such a graph one can read directly the cost-price of growing timber for a

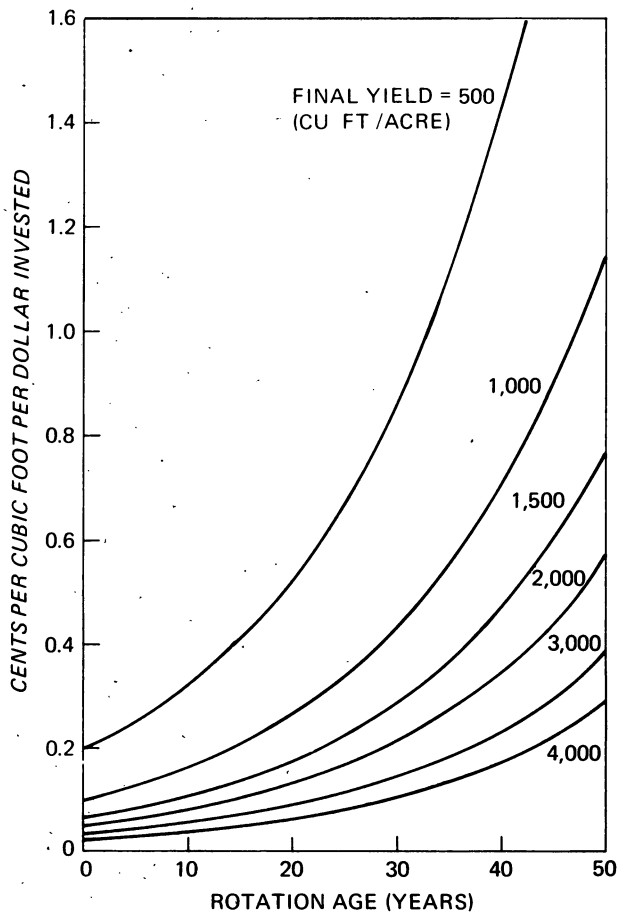

Figure 5.--Cost-price per dollar of invested capital for final yields from 500 to 4,000 cubic feet of timber per acre for rotation ages from 0 to 50 years, to earn 5 percent on invested capital.

specified discounted investment cost and yield for the rotation age and interest rate on which the graph is based. However, a large number of graphs may be required to cover a wide range of alternative interest rates and rotation ages. Such graphs are most practical for a fixed interest rate or for a fixed rotation age.

COST-PRICES FOR MULTIPLE PRODUCTS AND MULTIPLE TIME PERIODS

The cost-price formula given above applies to the simple case where we have only one product produced at one time that is measured in common units, and where each unit is sold for the same price or an average price per unit is applicable. Fortunately, this formula applies to many timber production alternatives where timber is managed in even-aged stands with a single final harvest or regeneration cut.

The above formula can be modified to account for multiple products and multiple harvest cuts over time. To do this, however, requires that some form of relative price index be used to relate different product prices at different time periods to the price for some standard product and time. To illustrate, suppose two products, pulpwood and saw logs, are expected from a single harvest cut at the end of a rotation (n years). Let P_{1n} and P_{2n} be the stumpage price for pulpwood and saw logs, respectively, with V_{1n} the volume in cords and V_{2n} the volume in thousand board feet (MBF). The cost-price equation would be:

$$P_{1n}V_{1n} + P_{2n}V_{2n} = C(1 + r)^n.$$

To calculate a cost-price, we establish a standard price (P), and express each product price as some proportion of that standard price. For our two products that means, $P_{1n} = k_1P$ and $P_{2n} = k_2P$. We can simplify things if we choose one of the product prices as a base price. For example, suppose we choose the pulpwood price (P_{1n}) as the standard, so that $P_{1n} = P$. Thus, $k_1 = 1.0$. We still have $P_{2n} = k_2P$. Here, k_2 expresses the value ratio of MBF/cord, so that k_2 cords are worth 1 MBF, or k_2 cords/MBF.

Substituting into the previous expression we have:

$$PV_{1n} + k_2PV_{2n} = C(1 + r)^n.$$

Then:

$$P(V_{1n} + k_2V_{2n}) = C(1 + r)^n$$

$$P = C(1 + r)^n \div (V_{1n} + k_2V_{2n}).$$

We can now use this formula to calculate the standard cost-price for this timber-growing example. To do this we must know the sum of discounted costs (C), the desired rate of return (r), the investment period (n), the volume of cordwood produced in the nth year (V_{1n}), the volume of saw logs produced in the nth year (V_{2n}), and the relative value of saw log stumpage prices in terms of pulpwood prices (k_2).

Suppose that a yield of 12 MBF of saw logs and 15 cords of pulpwood per acre is expected at 40 years; discounted costs are $60 per acre; we wish to earn 6 percent on our invested capital; and we expect that the sawtimber stumpage price in dollars per thousand board feet will be five times the pulpwood stumpage price in dollars per cord. That is, if the pulpwood stumpage price is $6 per cord, the saw log stumpage price will be $30 per MBF.

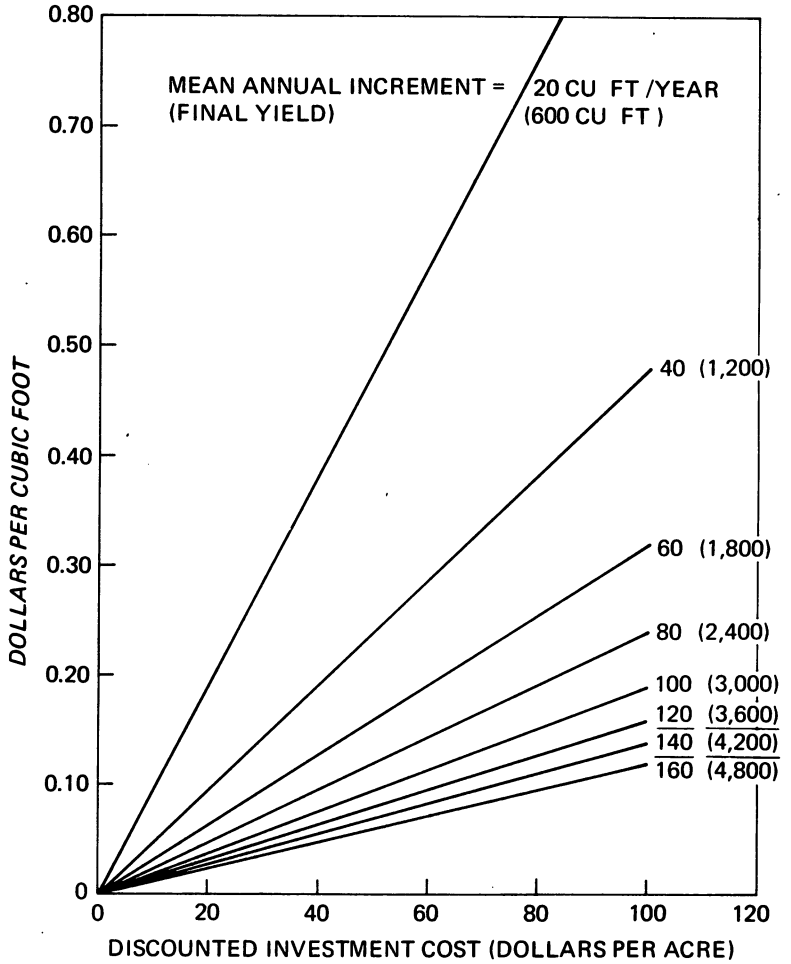

Figure 6.--Cost-price of growing timber to earn 6 percent on a 30-year rotation, for a range of mean annual increments and discounted investment costs per acre.

Thus, k_2 = 5.0 cords/MBF.

The calculated standard cost-price is:

$$P = \$60.00\ (1.06)^{40} \div (15 \text{ cords} + (5.0 \text{ cords/MBF})\ (12 \text{ MBF}))$$

$$P = \$60.00\ (10.286) \div (15 \text{ cords} + 60 \text{ cords})$$

$$P = \$617.16 \div 75 \text{ cords} = \$8.23/\text{cord}.$$

We know that the price of pulpwood $P_{1n} = P = \$8.23$/cord. We also know that $P_{2n} = k_2P$ = (5.0 cords/MBF) (\$8.23/cord), so that P_{2n} = \$41.15/MBF.

This tells us that if we grow 12 MBF and 15 cords of timber per acre in 40 years, and sell this timber at \$8.23/cord and \$41.15/MBF, then we will just earn 6 percent on an initial investment of \$60 per acre. If we get these yields and prices, our total income of \$617 will be just enough to pay off our compounded initial investment of \$60. These cost-prices are the costs of growing that timber, including a 6 percent return on invested capital.

This concept can be further extended to handle price relatives for different qualities of products (perhaps using, for example, a log quality index such as described by Herrick (1946) and McCauley and Mendel (1969)). It can be used to handle multiple harvest cuts over the rotation and different price levels over time that reflect the impact of tree size on product value or of stand characteristics on logging costs. In general:

$$\sum_{j=1}^{m} \sum_{t=0}^{n} P_{jt} V_{jt} (1 + r)^{n - t} = C(1 + r)^{n}.$$

Where P_{jt} is the price per unit of the jth product at a time t and V_{jt} is units of the jth product at time t. The left-hand side is thus the sum of discounted incomes for all the m products over the entire rotation to age n.

If each price is expressed in terms of a standard price (P), then $P_{jt} = k_{jt}P$, and we can write

$$P = C(1+r)^n \div \sum_{j=1}^{m} \sum_{t=0}^{n} k_{jt}V_{jt}(1+r)^{n-t}.$$

If desired, this can be simplified to:

$$P = C \div \sum_{j=1}^{m} \sum_{t=0}^{n} k_{jt}V_{jt}(1 + r)^{-t}.$$

AN EXTENSION TO NONTIMBER PRODUCTS

The concept of cost-price is not restricted to timber products. In the general formula given earlier, the term V_{jt} could be any output j at time t. For many nontimber outputs, such as deer harvested or man-days of recreation, an annual output may be expected. If these outputs are constant over time and we wish to calculate a constant cost-price over time we can modify the cost-price formula to simplify calculation. For annual outputs (v) and a constant cost-price (P) over time, the cost-price formula would be:

$$P = \frac{C}{v} \frac{r(1 + r)^n}{(1 + r)^n - 1}.$$

To illustrate, let v be 5,000 man-days of camping experience provided annually for 20 years by a sum of discounted costs (C) equal to $15,000, with a 5-percent rate of return. The cost-price per man-day of recreation would then be:

$$P = \frac{15,000}{5,000} \frac{.05(1.05)^{20}}{(1.05)^{20}-1} = 3(.080) = \$.24/\text{man-day}.$$

Obviously, graphs of the cost-price of annual output can also be constructed.

A WORD OF CAUTION

Any tool is subject to misuse. This seems to be particularly true of new tools. The analytical tool outlined in this paper, although not new to the forestry profession, may be new to a number of readers. Therefore, it is necessary to keep in mind the limitations of cost-price.

Cost-price is one excellent measure of an investment, but it is only one of several. The wise analyst will look at an investment from many viewpoints. He may calculate cost-prices, present net worth, future net worth, internal rate of return, and payback period. Each of these investment criteria provides an additional piece of information about the investment. Each enables the analyst to answer different kinds of questions about an investment than he otherwise could.

The cost-prices derived by the procedure outlined here are subject to all the limitations and uncertainties inherent in the underlying data. If physical outputs are not well known, cost-prices will be uncertain. If costs are known only within a wide range, then cost-prices will likewise be known only within a range of values. This problem is not unique to the cost-price criterion, but is common to other investment criteria as well.

Used with caution and restraint, cost-price provides an additional useful criterion for measuring an investment--the cost of producing a unit of output. Because it is measured in familiar units (for example, stumpage price per unit of output) it may well have a broader appeal to forest managers and resource analysts than other commonly used investment criteria.

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APPENDIX

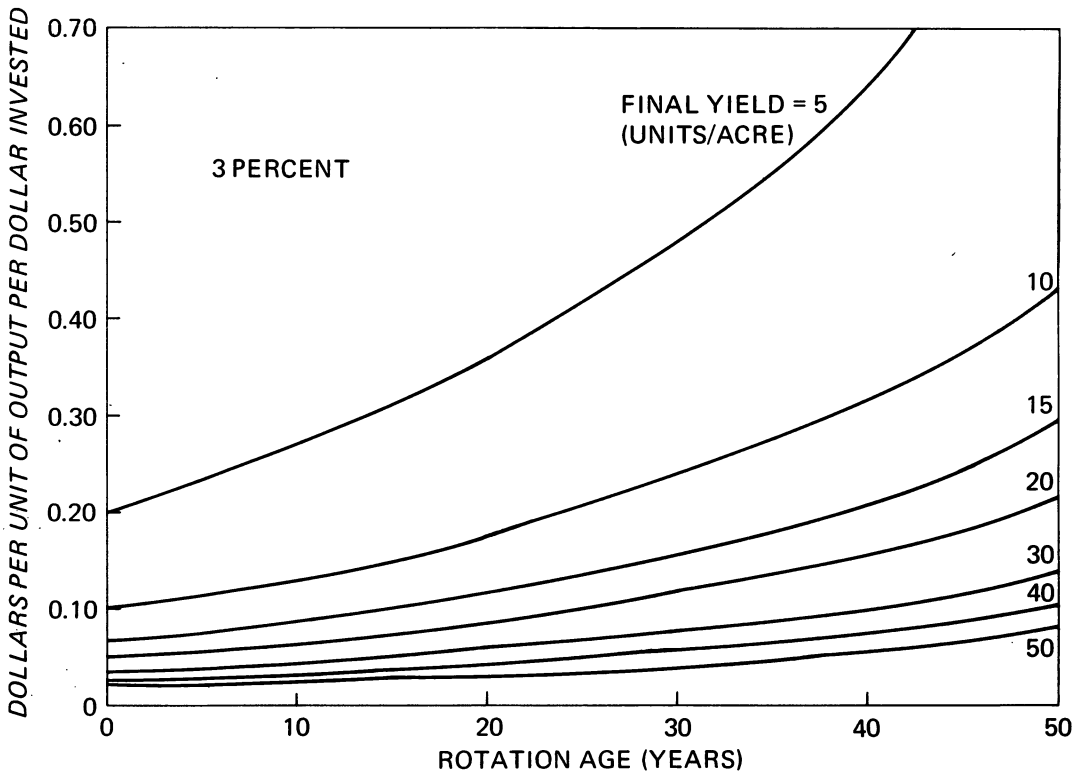
General Graphs of Cost-Price Indexes for Short and Long Rotations

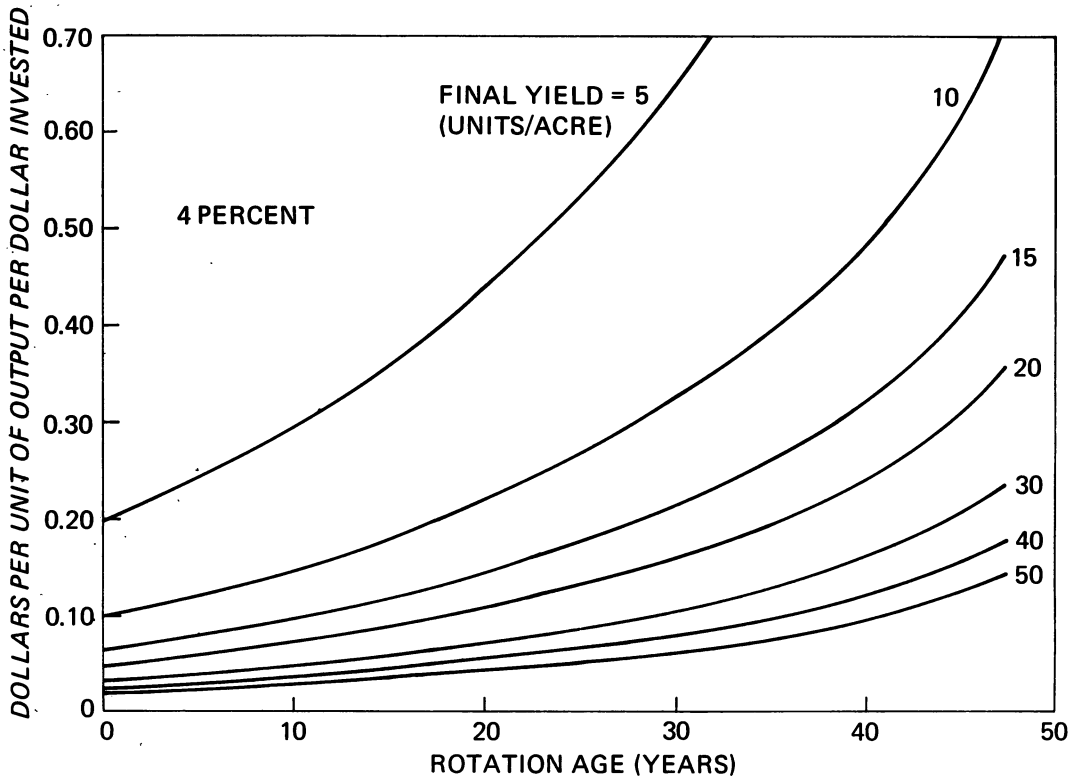
These graphs show cost-price indexes for a given interest rate for specified final yields, expressed as units of output per acre, for a range of rotation ages. These units may be cunits (100 cubic feet), cords, board feet, or other output harvested at the end of the rotation. There are two sets of graphs, one for short rotations (up to 50 years) and one for long rotations (up to 100 years). Each set contains one graph for each of six interest rates from 3 to 8 percent.

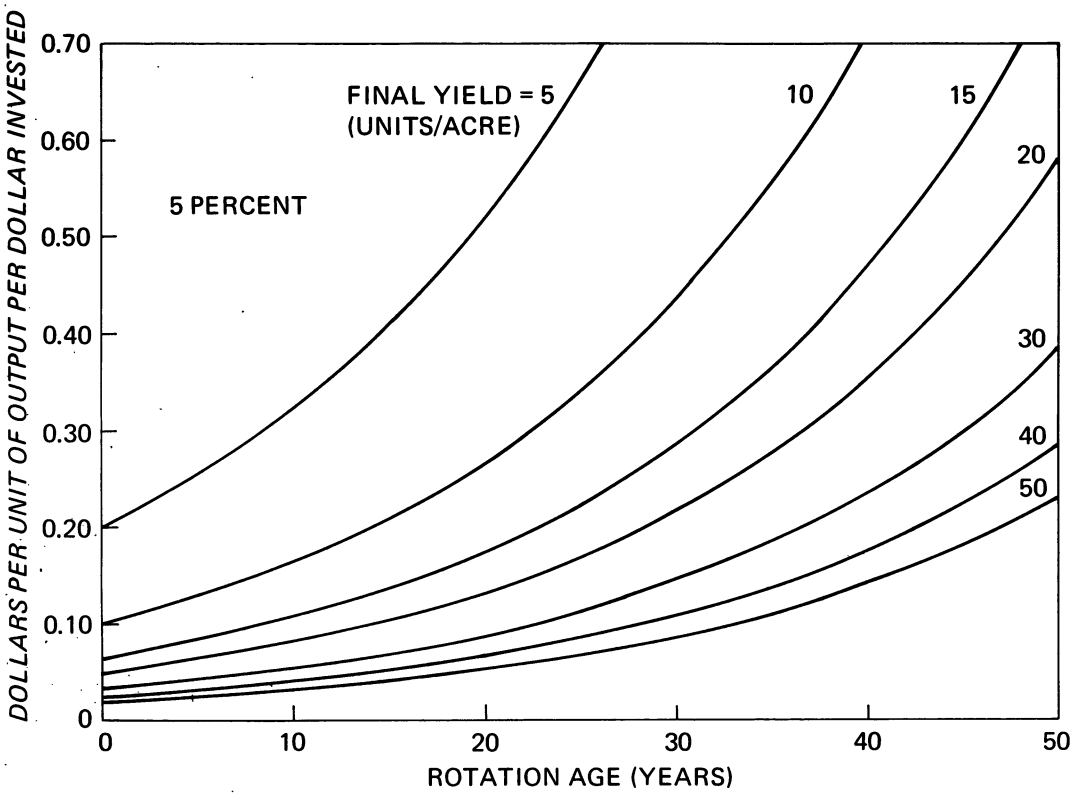
To estimate the cost-price of growing timber, obtain the cost-price index from the graph for the interest rate, rotation age, and final yield specified. Multiply this index by the estimated sum of discounted costs of growing this timber (the total dollars invested). This gives the cost-price per unit of product output.

For example, if we wish to earn 6 percent on our invested funds, and can expect to harvest 30 cords of timber per acre at the end of a 30-year rotation on our forest land, then the cost-price index is $0.19 per cord per dollar invested (fig. 10). If our expected total costs (discounted at 6 percent to age zero) were $20 per acre, then the cost-price of growing this 30 cords amounts to ($0.19/cord/dollar) ($20) = $3.80/cord. Similarly, if we had expected a yield of only 20 cords per acre, then the cost-price index would have been $0.28/cord/dollar, so the cost-price of this timber would have been $5.60/cord.

If we were growing sawtimber on a 60-year rotation, expecting 40 thousand board feet at 60 years, and wished to earn 5 percent on our investment, then the cost-price index would be $0.43/thousand fbm/dollar invested (fig. 15). If our investment were $70/acre (sum of all costs discounted at 5 percent), then the cost-price of this sawtimber would be ($0.43/thousand fbm/dollar) ($70) = $30.10/thousand board feet.




DOLLARS PER UNIT OF OUTPUT PER DOLLAR INVESTED
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
FINAL YIELD = 5
(UNITS/ACRE)
10
4 PERCENT
15
20
30
40
50
0
10
20
30
40
50
ROTATION AGE (YEARS)


DOLLARS PER UNIT OF OUTPUT PER DOLLAR INVESTED
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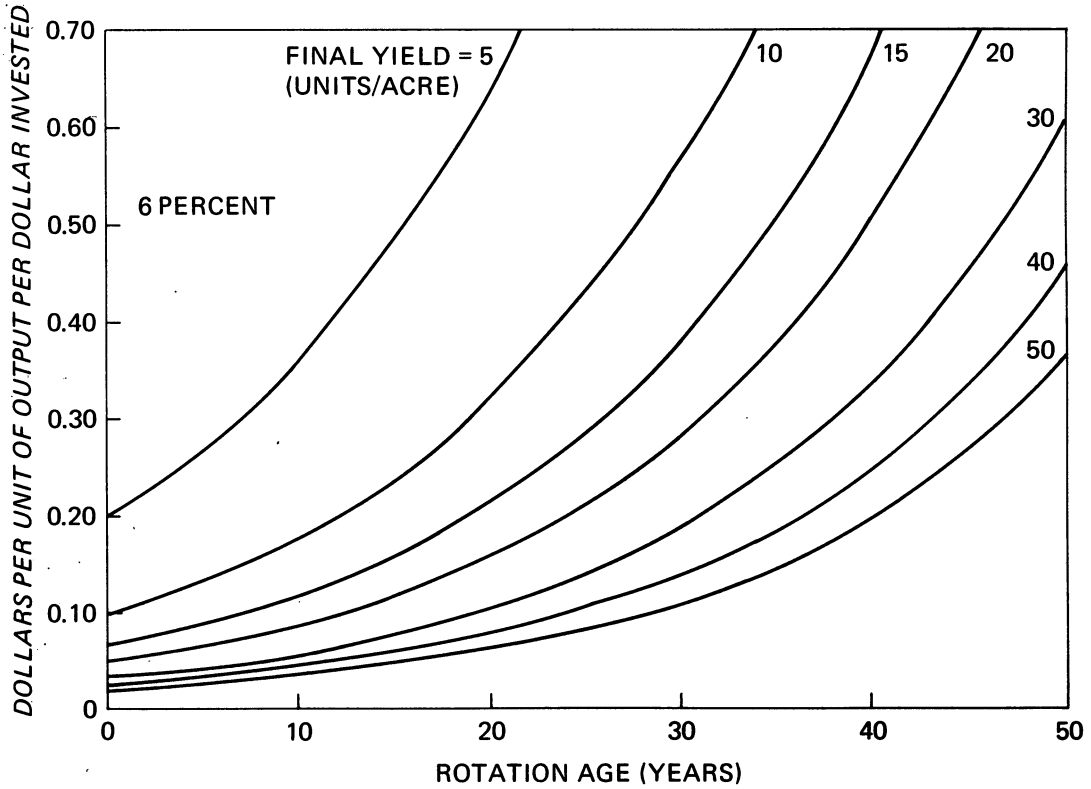
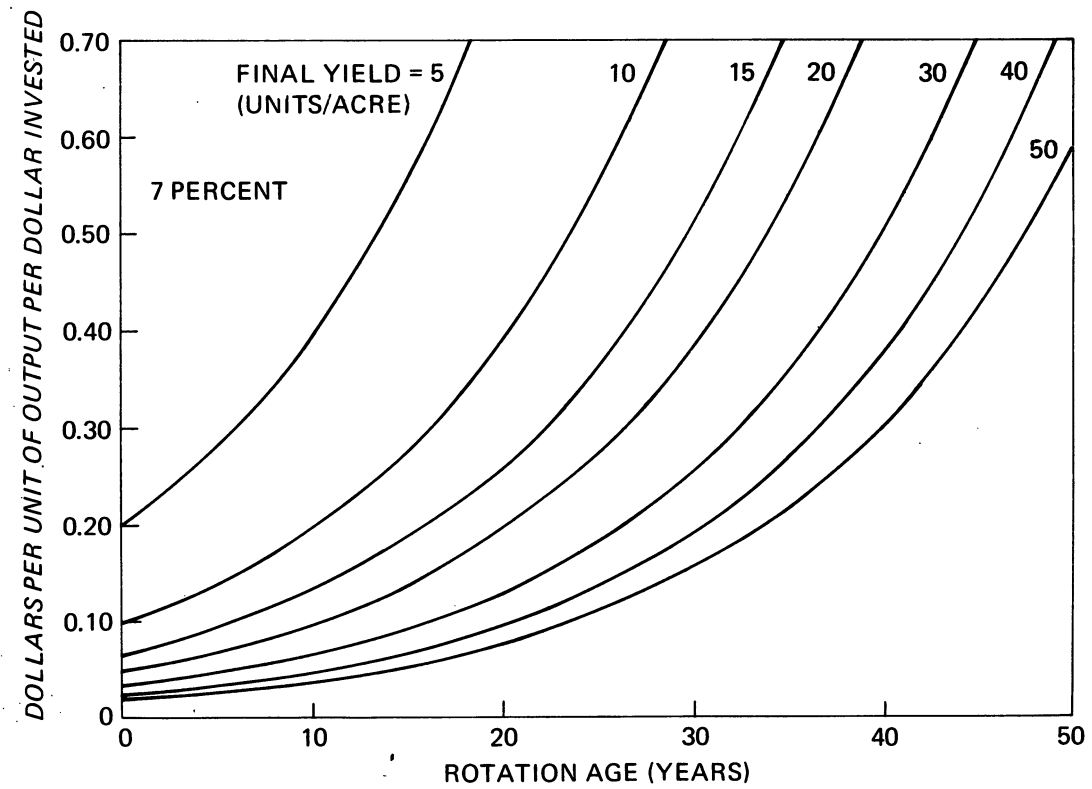
0.60
0.50
0.40
0.30
0.20
0.10
0
FINAL YIELD = 5
(UNITS/ACRE)
10
15
20
5 PERCENT
30
40
50
0
10
20
30
40
50
ROTATION AGE (YEARS)


DOLLARS PER UNIT OF OUTPUT PER DOLLAR INVESTED
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
FINAL YIELD = 5
(UNITS/ACRE)
10
15
20
30
40
50
6 PERCENT
0
10
20
30
40
50
ROTATION AGE (YEARS)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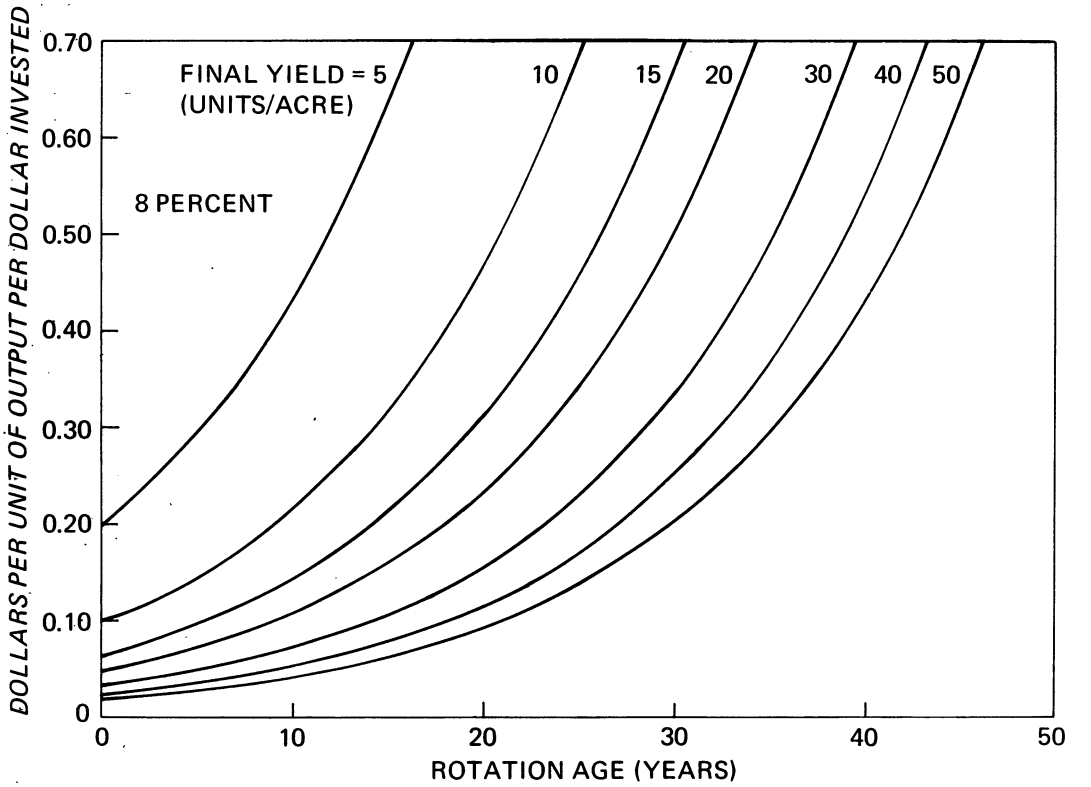
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
FINAL YIELD = 5
(UNITS/ACRE)
10
15
20
30
40
50
7 PERCENT
0
10
20
30
40
50
ROTATION AGE (YEARS)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0.60
0.50
0.40
0.30
0.20
0.10
0
FINAL YIELD = 5
(UNITS/ACRE)
10
15
20
30
40
50
8 PERCENT
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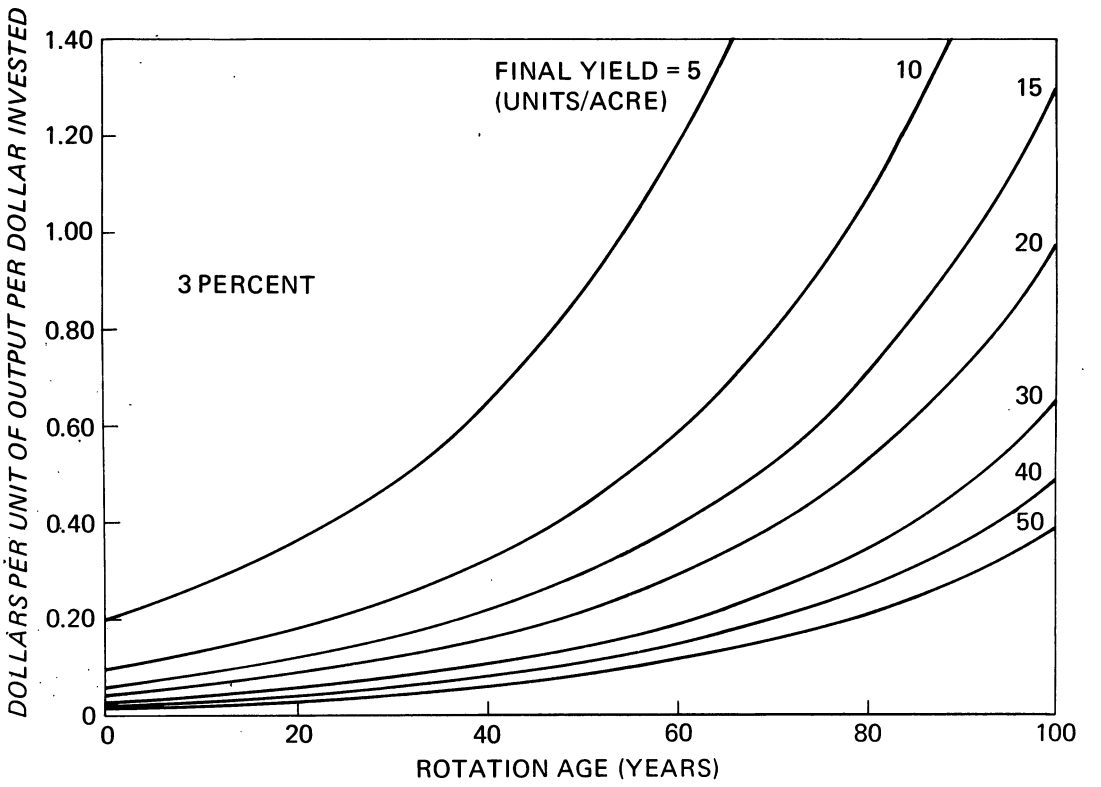
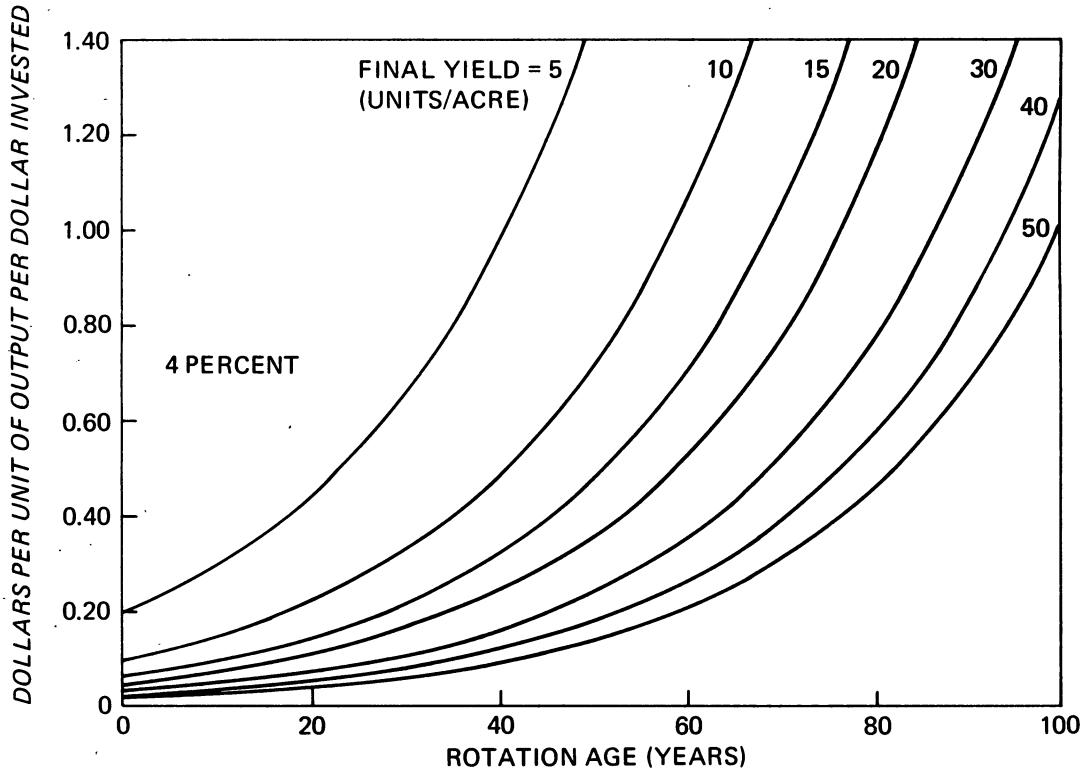
10
20
30
40
50
ROTATION AGE (YEARS)


DOLLARS PER UNIT OF OUTPUT PER DOLLAR INVESTED
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0
FINAL YIELD = 5
(UNITS/ACRE)
10
15
20
30
40
50
3 PERCENT
0
20
40
60
80
100
ROTATION AGE (YEARS)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0
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15
20
30
40
50
4 PERCENT
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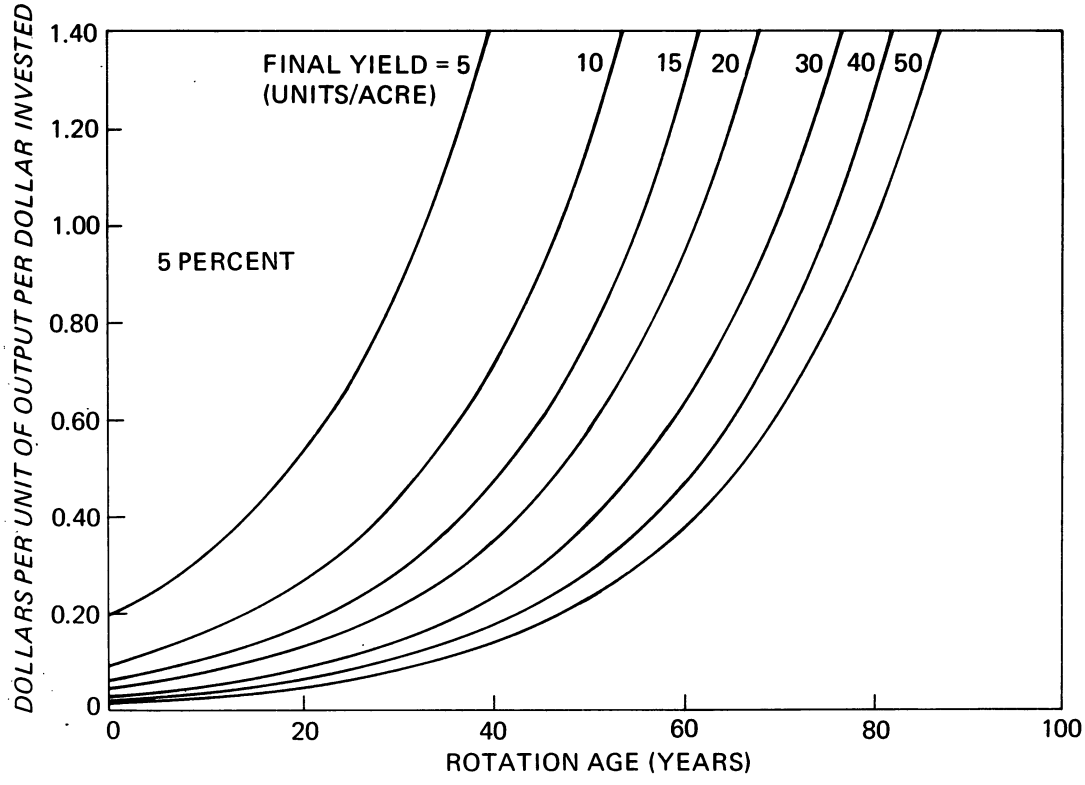
20
40
60
80
100
ROTATION AGE (YEARS)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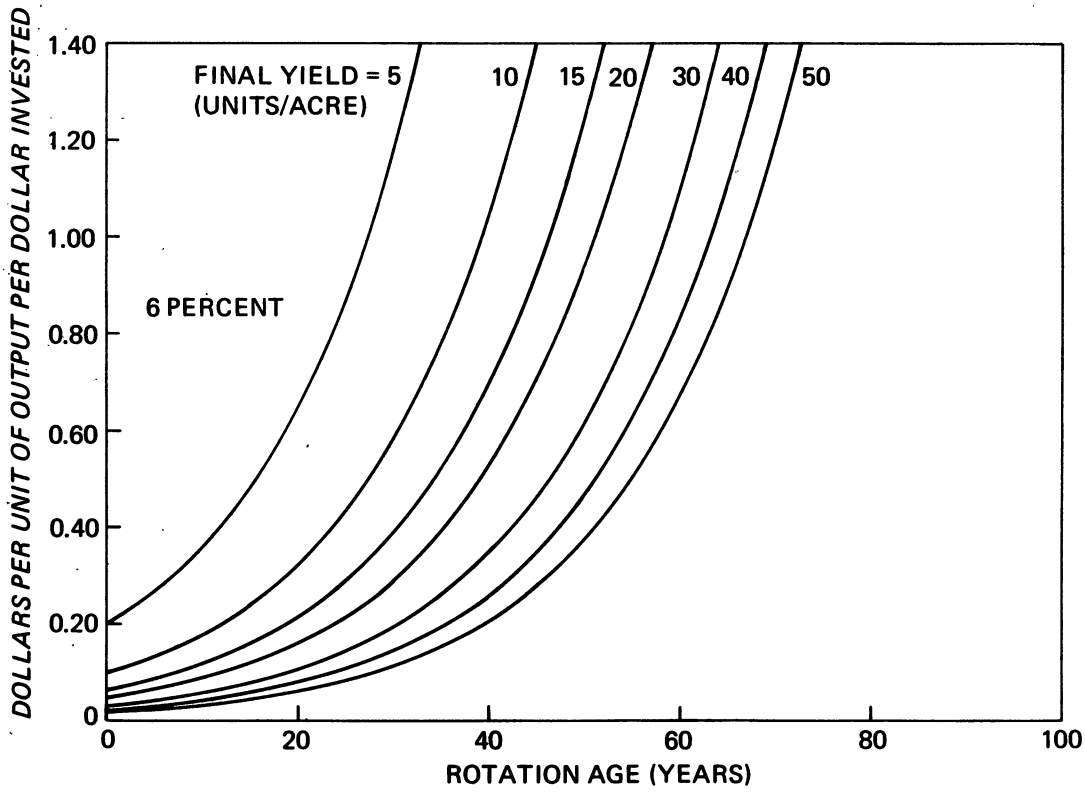
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0.60
0.40
0.20
0
FINAL YIELD = 5
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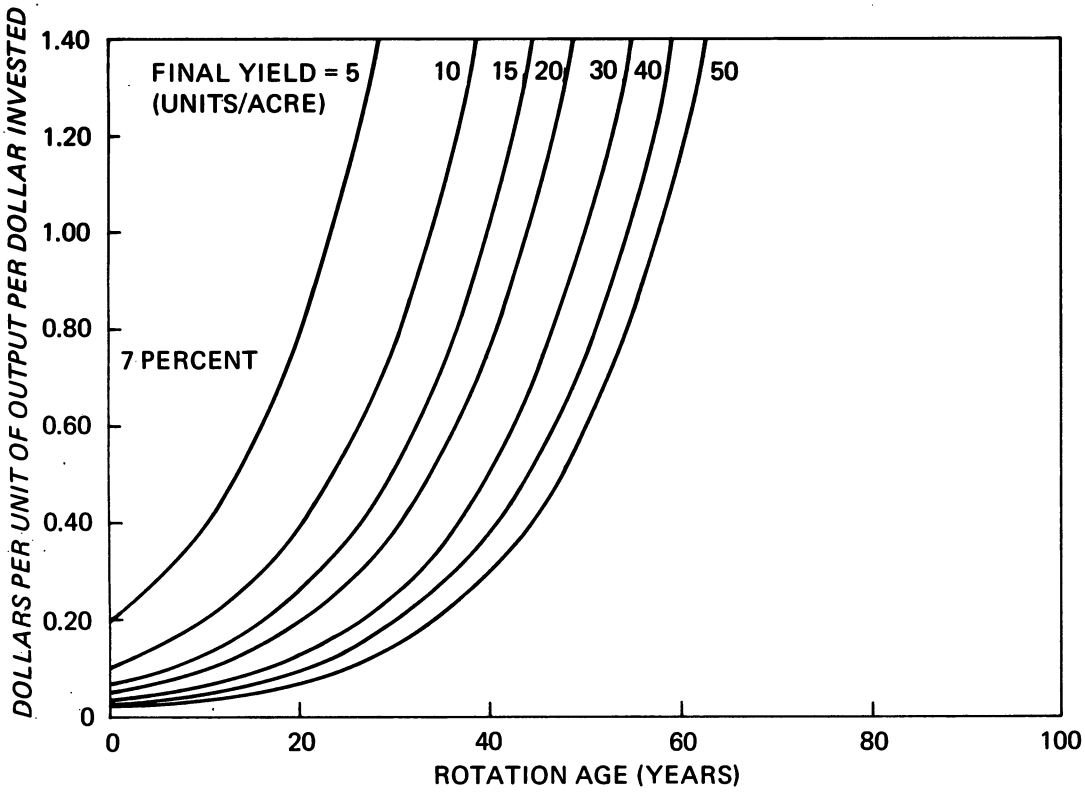
10
15
20
30
40
50
6 PERCENT
0
20
40
60
80
100
ROTATION AGE (YEARS)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10
15
20
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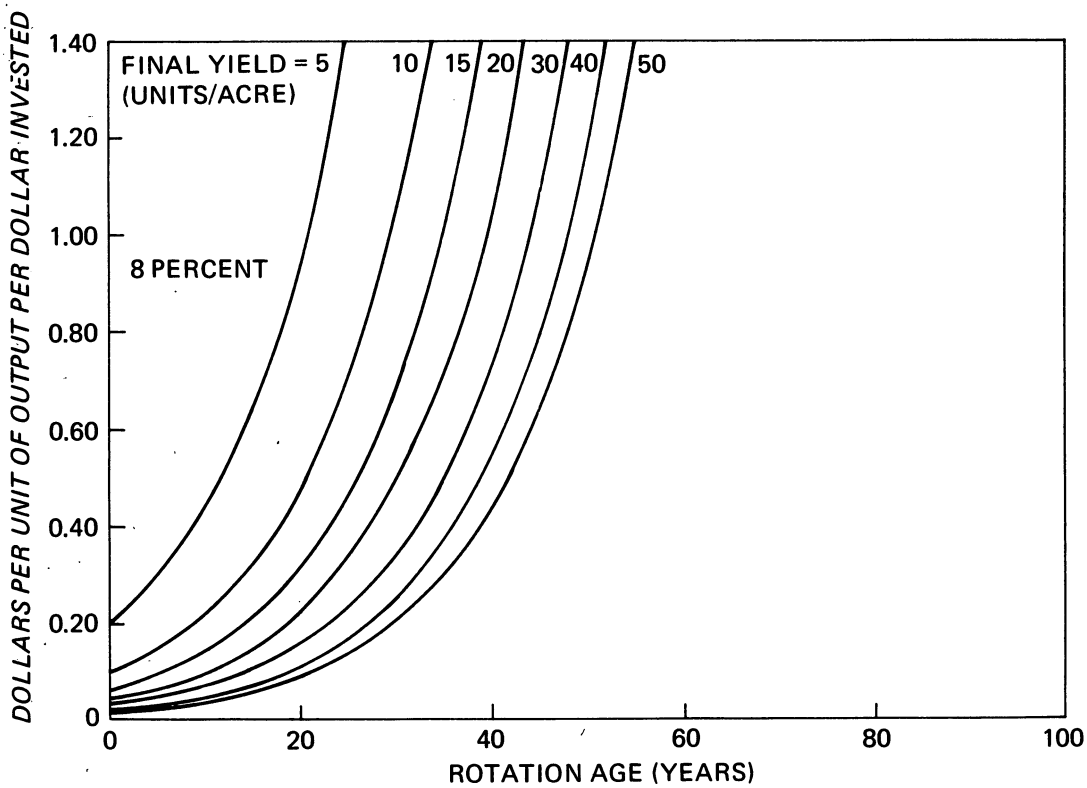
50
7 PERCENT
0
20
40
60
80
100
ROTATION AGE (YEARS)



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