Agricultural Production and Technological Change

Advanced Producer Theory and Analysis: The Production of Perennials II

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AREC 705: Week 4

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Working Paper Overview

Working Paper.

Contributions – what question(s) is the paper addressing? –

Category – theoretical? empirical? case study? meta-study? –

Conclusions – what are the results? –

Context – what are related papers? who are the authors? –

Methods – what methods are used to analyze the problem? –

Working Paper Questions

General thoughts on the paper? –

What do you think about the framing of the paper? –

Thoughts on presentation of theory? –

Are there limitations to (or inaccuracies in) the conceptual framework? –

Are there trade-offs to this model vs. NPV? –

Can you think of any simple ways to adapt the model? –

Maximum Sustained Yield vs. NPV

To vulgarize and oversimplify, there has been a tradition in forestry management which claims that the goal of good policy is to have sustained forest yield, or even "maximum sustained yield" somehow defined. And, typically, economists have questioned this dogma.

(Samuelson 1976)

Maximum Sustained Yield vs. NPV

This apparent clash between economists and foresters is not an isolated one. Biological experts in the field of fisheries are sometimes stunned when they meet economists who question their tacit axiom that the stock of fish in each bank of the ocean ought to be kept as a goal at some maximum sustained level. Similarly, hard-boiled economists are greeted with incredulity if and when they opine that it may be optimal to grow crops in the arid plain states only until the time when the top soil there has blown away to its final resting place in the ears and teeth of Chicago pedestrians.

(Samuelson 1976)

Maximum Sustained Yield vs. NPV

Everybody loves a tree and hates a businessman. Perhaps this is as it should be, and perhaps after the profession of economics is 1,000 rather than 200 years old, the human race will be as conditioned to abhor economists as it has become to abhor snakes.

(Samuelson 1976)

Back to the working paper...

Consider a processing facility of a given size that is supplied a feedstock grown by a perennial crop in surrounding fields...

The manager's problem is:

$$\min \left[\begin{matrix} \text{farm gate} \\ \text{feedstock costs} \end{matrix} + \begin{matrix} \text{Feedstock} \\ \text{delivery costs} \end{matrix} + \begin{matrix} \text{Processing} \\ \text{costs} \end{matrix} \right] \text{ such that } \begin{matrix} \text{Feedstock} \\ \text{production} \end{matrix} = \begin{matrix} \text{Facility} \\ \text{capacity} \end{matrix}$$

Perennial Production: Age-yield

Production Q is the product of area planted L and per-unit productivity y, so that

$$Q = yL$$

Where y depends on the age-yield function $f(a)$ and the maximum/replacement age n.

$f(a)$ has the following properties:

$f(a)$ is continuous

$f(0) = 0$

$f(a)$ monotonically increases to a maximum, then monotonically decreases

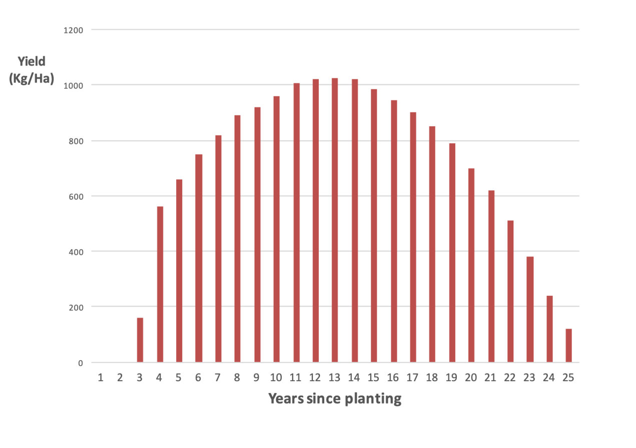
$$\lim_{a \to \infty} af(a) = 0$$

Perennial Production - Age-yield

In what cases is this MSY strategy reasonable?

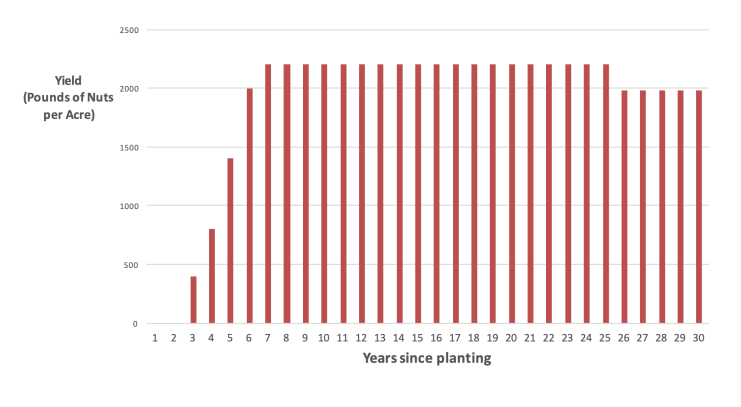
Are these assumptions realistic?

Cocoa in Ghana



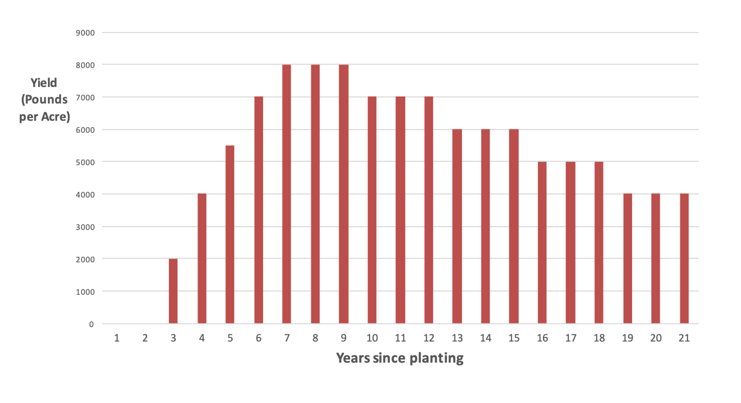
Mahrizal, Nalley, L. L., Dixon, B. L., & Popp, J. S. (2014). An optimal phased replanting approach for cocoa trees with application to Ghana. *Agricultural Economics, 45(3)*:291302. Source: Tregeagle & Simon (2018)

Almonds in California



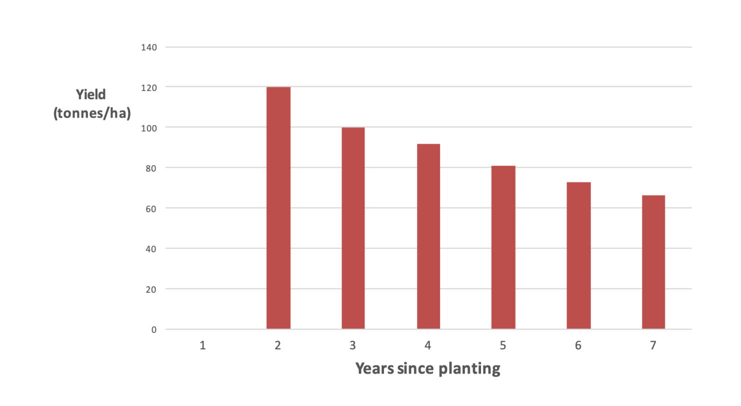
Klonsky, K., Livingston, P., & Tumber, K. (2016). Tree Loss Value Calculator - Almonds, Sacramento Valley. Source: Tregeagle & Simon (2018)

Blueberries in North Carolina



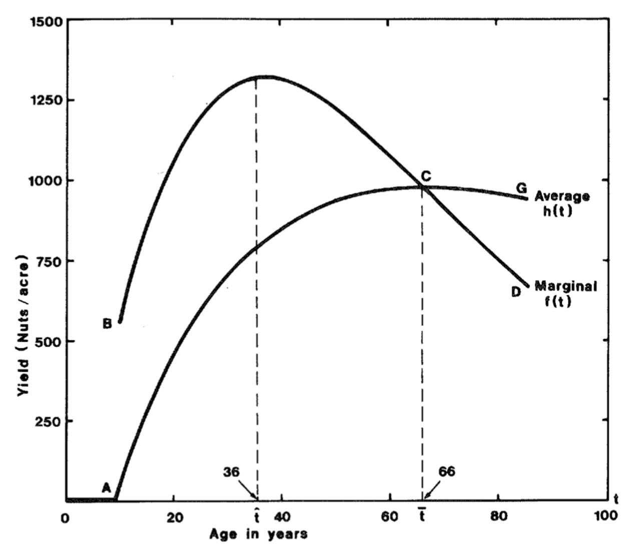
Safley, C.D., Cline, W.O., & Mainland, C.M. (2006). Evaluating the Profitability of Blueberry Production. Source: Tregeagle & Simon (2018)

Sugarcane in Brazil



Margarido, F. B. and Santos, F. (2012). Sugarcane Bioenergy, Sugar and Ethanol Technology and Prospects, Source: Tregeagle & Simon (2018)

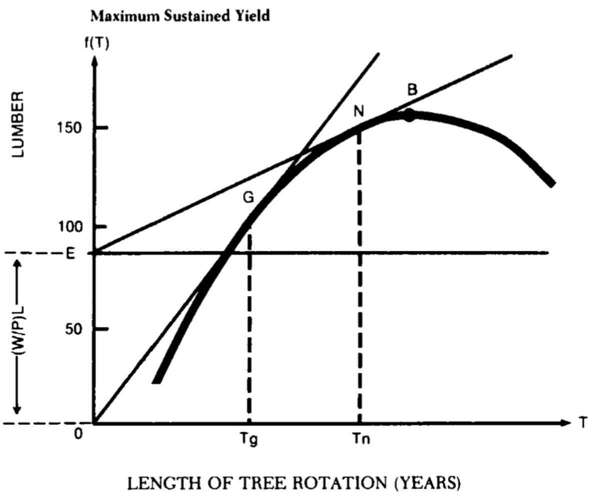
Coconuts in Sri Lanka



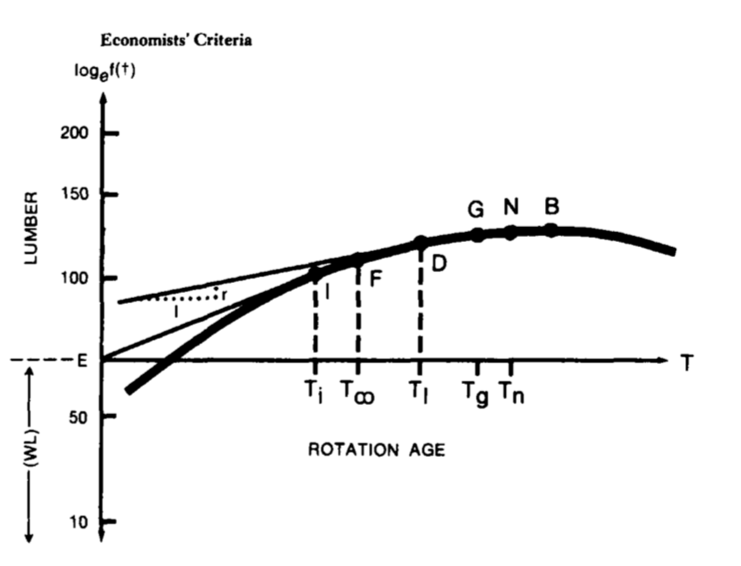
Tisdell, C.A. & De Silva, N.T.M.H. (1986).

Optimal Production from MSY: Samuelson (1976)

FIGURE 1



Optimal Production from NPV: Samuelson (1976)



Perennial Production - Land-yield

Yields per-unit of land y are estimated assuming a ‘balanced orchard’ – an equal proportion of land allocated to each age-class.

$$y(n) = \frac{1}{n}\int_0^n f(a)da$$

How would this work with 3-age classes?

Why use the ‘balanced orchard’? What does this accomplish?

Maximum Sustained Yield vs. NPV

This pattern... avoids any variability in supply because the replacement pattern is such that the age profile of the crop on the available land never changes.

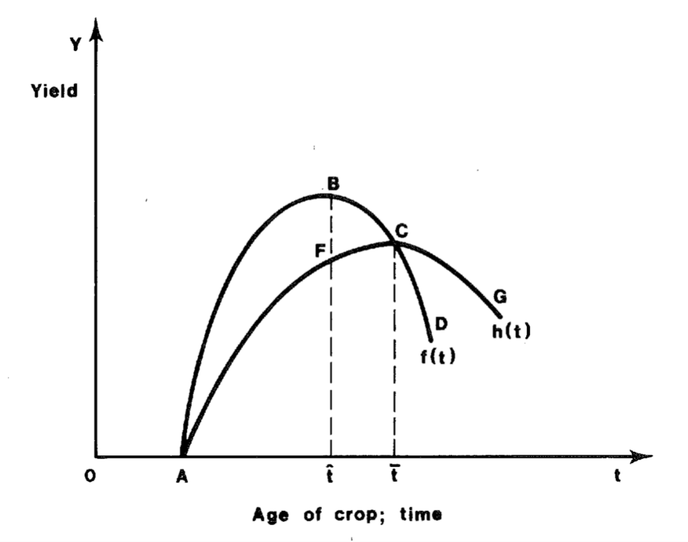
(Tisdell & De Silva 1986)

Maximum Sustained Yield vs. NPV

> *This pattern... avoids any variability in supply because the replacement pattern is such that the age profile of the crop on the available land never changes.*
>
> *(Tisdell & De Silva 1986)*

In other words...
this is the variance-minimizing and yield-maximizing orchard management solution.

Optimal Production from MSY: Tisdell & De Silva (1986)



Perennial Production - Estimating Age- and Land-yield

$$f(a) = ??$$
$$y(n) = \frac{1}{n}\int_0^n f(a)da$$

How can we estimate these functions with data?

What data would we need?

Can we include control variables?

Perennial Production - Replacement Age

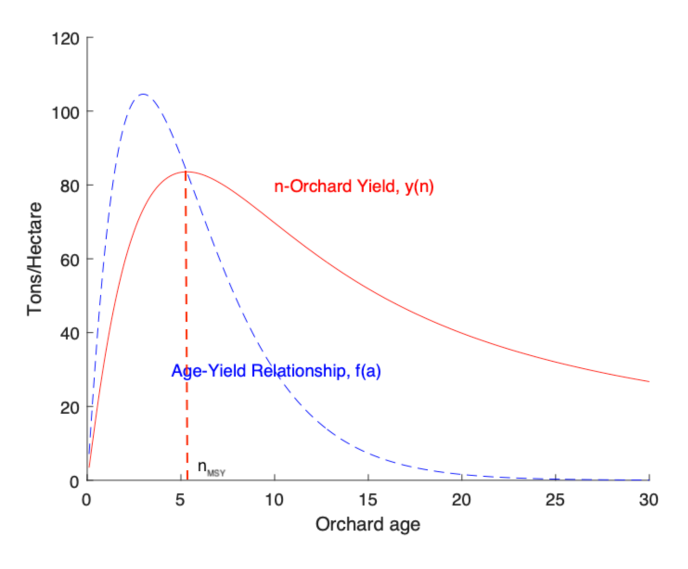
$$y(n) = \frac{1}{n}\int_0^n f(a)da$$
$$\frac{dy}{dn} = \frac{1}{n}\left(f(n) - \frac{1}{n}\int_0^n f(a)da\right) = \frac{1}{n}(f(n) - y(n))$$

Where $f(n)$ gives the yield of an additional n-aged tree,
and $y(n)$ gives the average yield of the balanced orchard with replacement age n.

Whether $y(n)$ is increasing or decreasing in n depends on the contribution of the marginal tree relative to the average n...

Increasing when $f(n) > y(n)$;
decreasing when $f(n) < y(n)$

Optimal Production from MSY



Perennial Production - Costs

$$
\begin{aligned}
\frac{C_n}{n} &= \text{annual replanting cost} \\
C_f &= \text{per-unit land costs, fixed relative to age} \\
L \cdot \left(\frac{C_n}{n} + C_f \right) &= \text{total growing costs} \\
C_D y(n) L^{\alpha} &= \text{delivery costs} \\
L = dA &= \text{density times growing region area} \\
C_p \left(y(n) L \right)^{\gamma} &= \text{processing costs}
\end{aligned}
$$

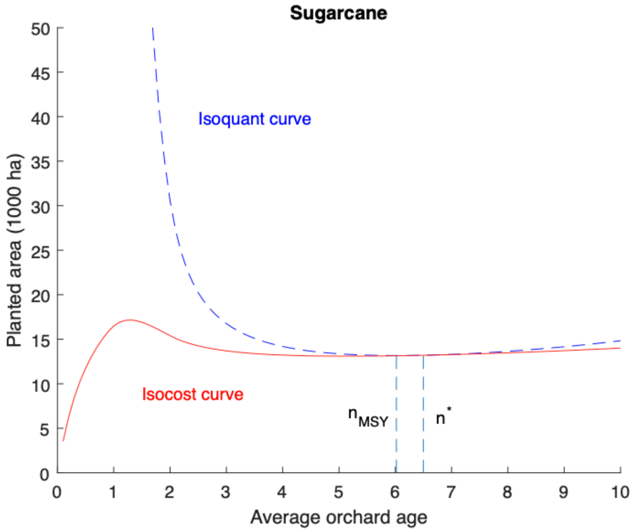
The Objective Function

Consider a processing facility of a given size that is supplied a feedstock grown by a perennial crop in surrounding fields...

The manager's problem is:

$$\min \left[\begin{array}{c} \text{farm gate} \\ \text{feedstock costs} \end{array} + \begin{array}{c} \text{Feedstock} \\ \text{delivery costs} \end{array} + \begin{array}{c} \text{Processing} \\ \text{costs} \end{array} \right] \text{ such that } \begin{array}{c} \text{Feedstock} \\ \text{production} \end{array} = \begin{array}{c} \text{Facility} \\ \text{capacity} \end{array}$$

Optimal Production for a Processor



The Objective Function

1. How did they develop these isoquant and isocost curves?

2. What are the two issues that arise from this figure regarding an interior solution to the optimization problem?

3. How do they address/solve these two issues?

Comparative Statics from Theory

$\mathbf{x}$	$\frac{\mathbf{dn^*}}{\mathbf{dx}}$	$\frac{\mathbf{dL^*}}{\mathbf{dx}}$
Q	(< 0)	$(> 0) \Leftrightarrow y''(n*) < 0$
C_f	(< 0)	(< 0)
C_n	(> 0)	(> 0)
C_D	(< 0)	(< 0)
α	(< 0)	$(< 0) \Leftrightarrow L > e^{-1/(\alpha-1)}$

Table 1: Signs of comparative statics of n^* and L^*.

Comparative Statics from Simulations

1. What parameters from the cost min problem do the authors estimate from data?

2. What parameters are unknowns?

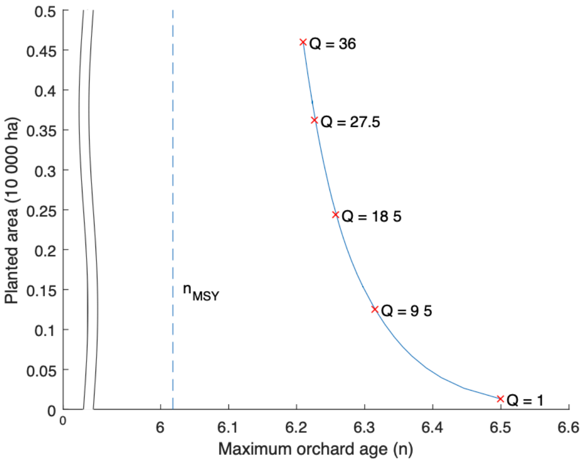
3. Given that they are using parameter values from the lit how do they estimate comparative statics?

Parameter Values

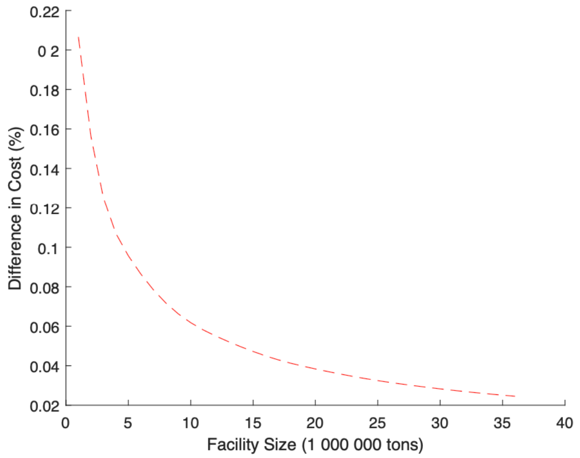
	Parameter	Min Value	Calibration	Max Value
Yield	t_1	0	1	2
	t_{max}	$t_1 + 1$	2	$t_1 + 5$
	t_T	$t_{max} + 7$	13	$t_{max} + 13$
	f_{max}	60	120	180
Cost	C_f	1129.84	2259.67	3389.51
	C_n	784.85	1569.69	2354.54
	C_D	0.13	0.26	0.40
	α	0.75	1.50	2.25
Capacity	$\bar{Q}$	1 000 000	19 000 000	37 000 000

Table 3: Support for random parameters used in cost minimization. The parameters are drawn from a uniform distribution centered on the Brazilian calibration

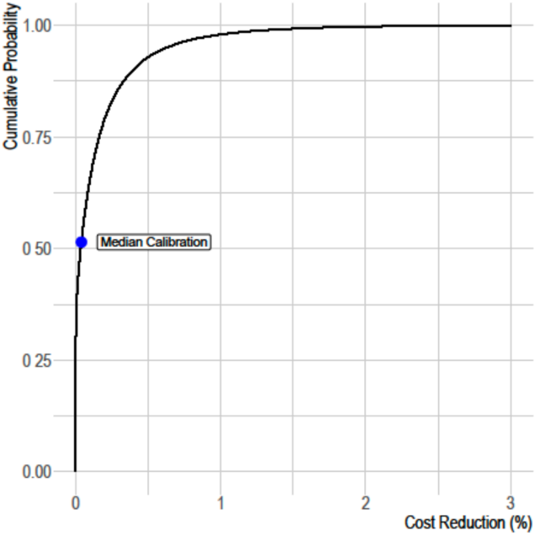
Comparative Statics (fig 3)



Comparative Statics (fig 4)



Comparative Statics (fig 5)



Samuelson Paper Overview

Samuelson, P.A. (1976). Economics of Forestry in an Evolving Society Economic Inquiry, XIV, 466–492.

Contributions – what question(s) is the paper addressing? –

Category – theoretical? empirical? case study? meta-study? –

Conclusions – what are the results? what method for determining optimal harvest length does Samuelson recommend? –

Context – what are related papers? who are the authors? –

Methods – what methods are used to analyze the problem? –

Samuelson Paper Questions

Samuelson, P.A. (1976). Economics of Forestry in an Evolving Society Economic Inquiry, XIV, 466–492.

How does maximum gross sustained yield differ from maximum sustained net yield and MSY? –

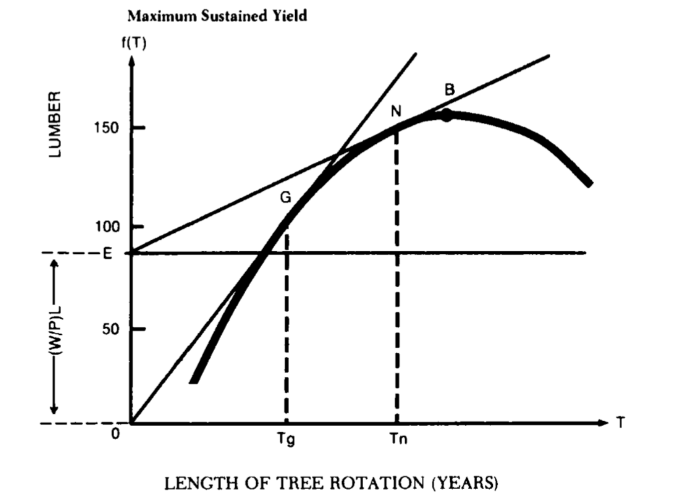
What is missing from the non-Faustmann NPV approaches to optimal replacement time? –

What are challenges to the assumptions underlying all of these models? (what are the assumptions?) –

Fundamentally, what is the Faustmann solution to optimal forest management? –

Optimal Production from MSY: Samuelson (1976)

FIGURE 1



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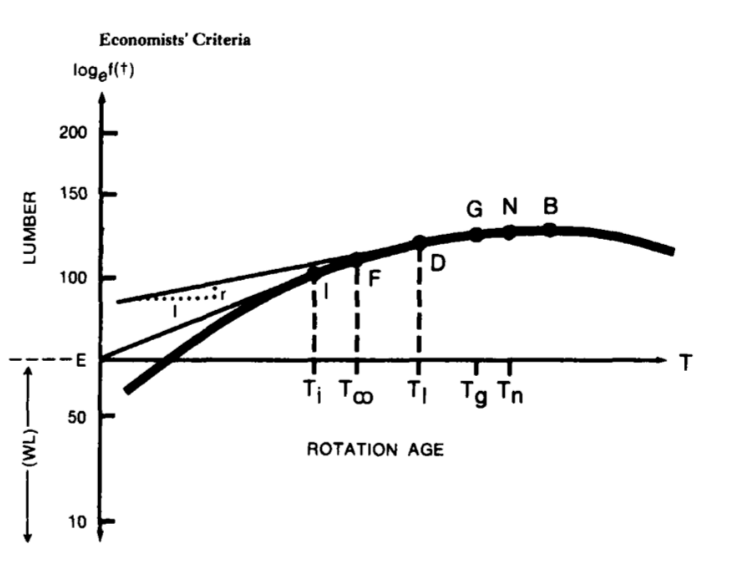

Faustmann Solution

Samuelson, P.A. (1976). Economics of Forestry in an Evolving Society Economic Inquiry, XIV, 466–492.

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