

Forest Resources

Introduction

Forest Growth and the Harvesting Problem

- Simple harvest problem
- Harvesting and replanting

Supply from Private Forests

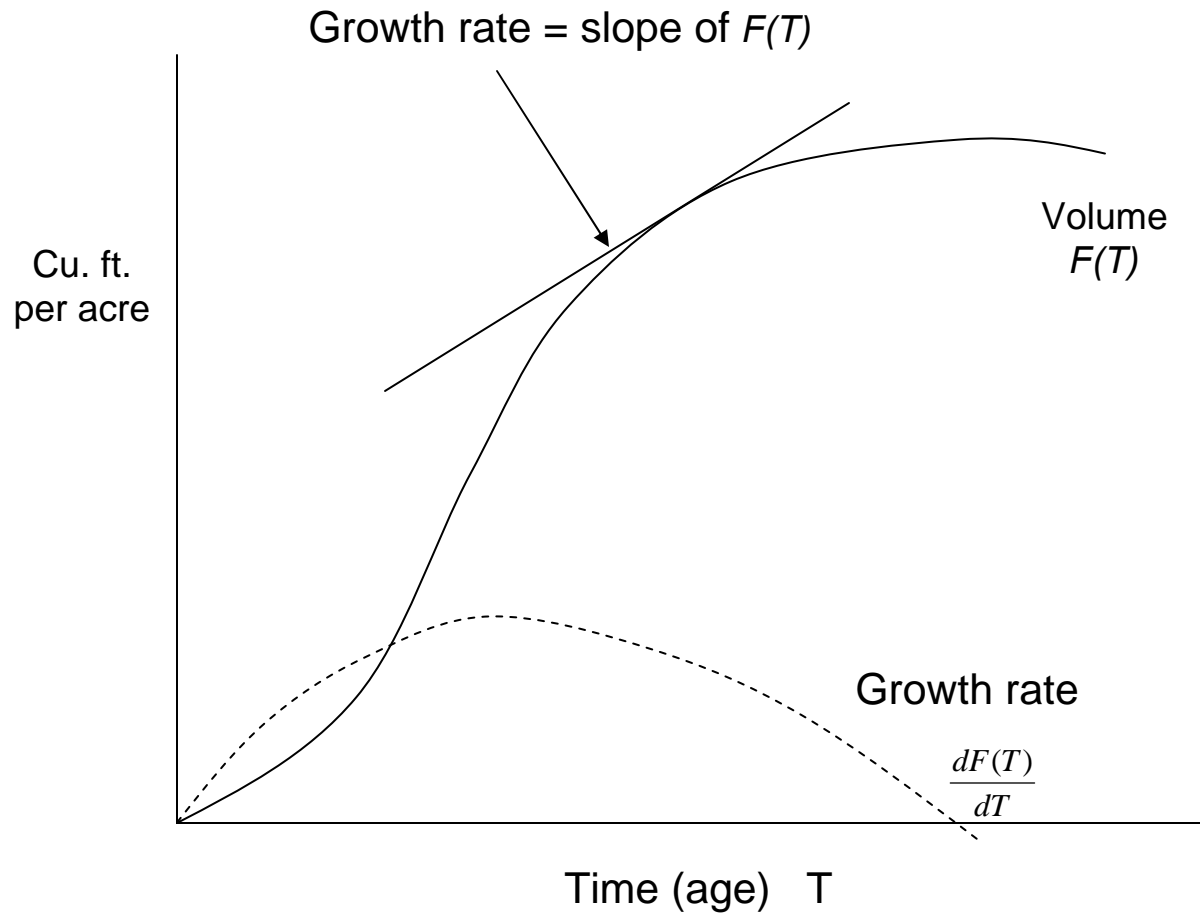
- Determination of rent and land use decision
- Comparative dynamics of the harvesting decision
- Total Timber supply.

Supply from Publicly Owned Forests

- Forest management on public lands: U.S.F.S. Policy.
- Forest management on state lands

Optimal policy: Benefits from standing forest services.

Forest growth



Simple Forest Harvesting Problem

1. Notation and Assumptions

T age of forest.

$F(T)$ volume per acre.

$\frac{dF(T)}{dT}$ annual growth per acre per year.

P price per unit for uncut timber (assumed constant over time)

r interest rate (assumed constant over time).

Assume: Forest will be harvested only once, and not replanted.

2. Harvest Rule for Single Harvest

Marginal benefit of waiting an additional year before harvesting is

$$MB_W(T) = P \frac{dF(T)}{dT}$$

Marginal cost of waiting an additional year is

$$MC_W(T) = rPF(T).$$

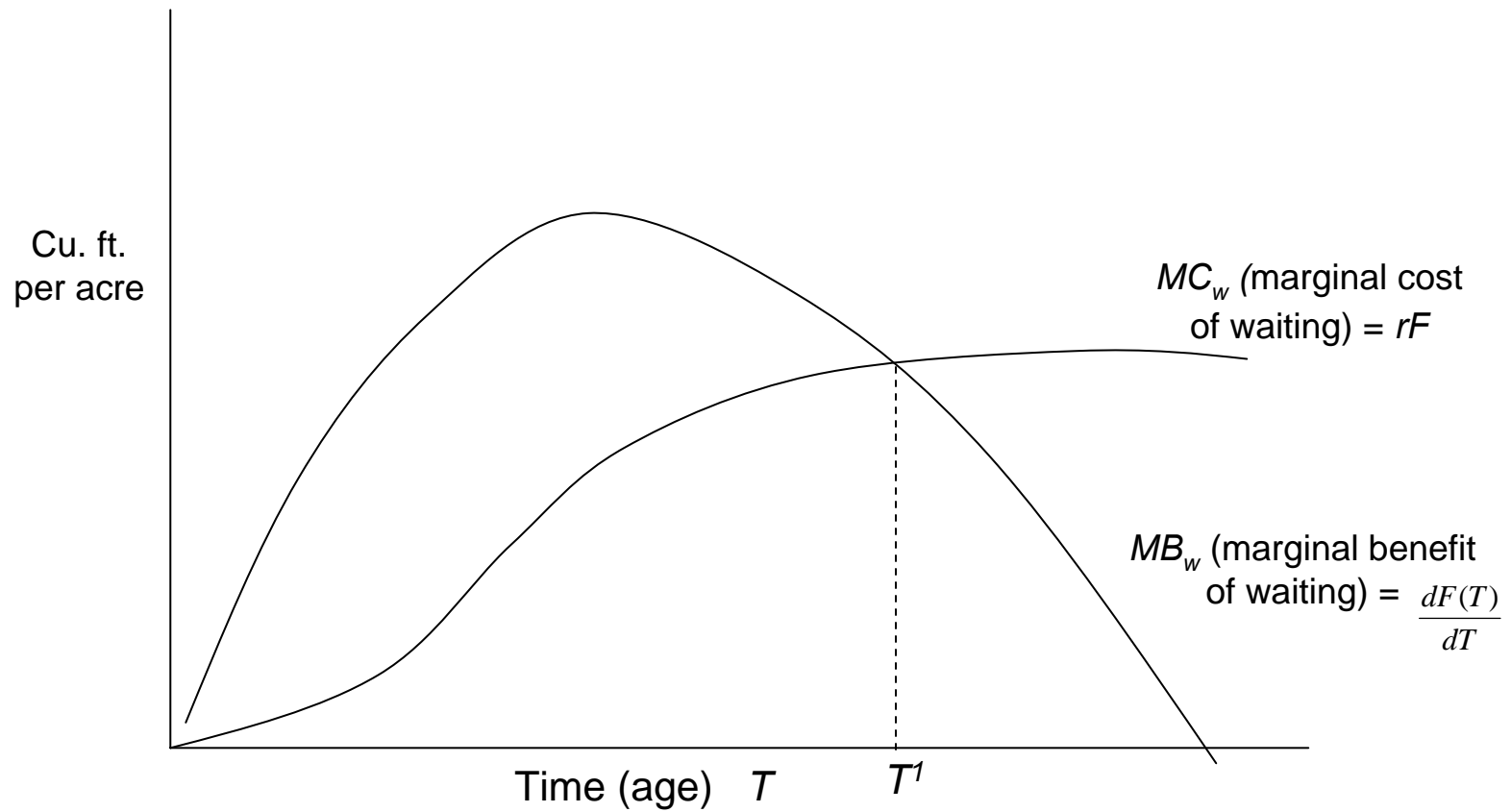
Profit maximizing forest owner harvests at age when $MB_W(T^1) = MC_W(T^1)$.

$$\text{Result: } P \frac{dF(T^1)}{dT} = rPF(T^1), \quad \text{or} \quad \frac{dF(T^1)}{dT} = rF(T^1)$$

Restatement of harvest age condition: Harvest when

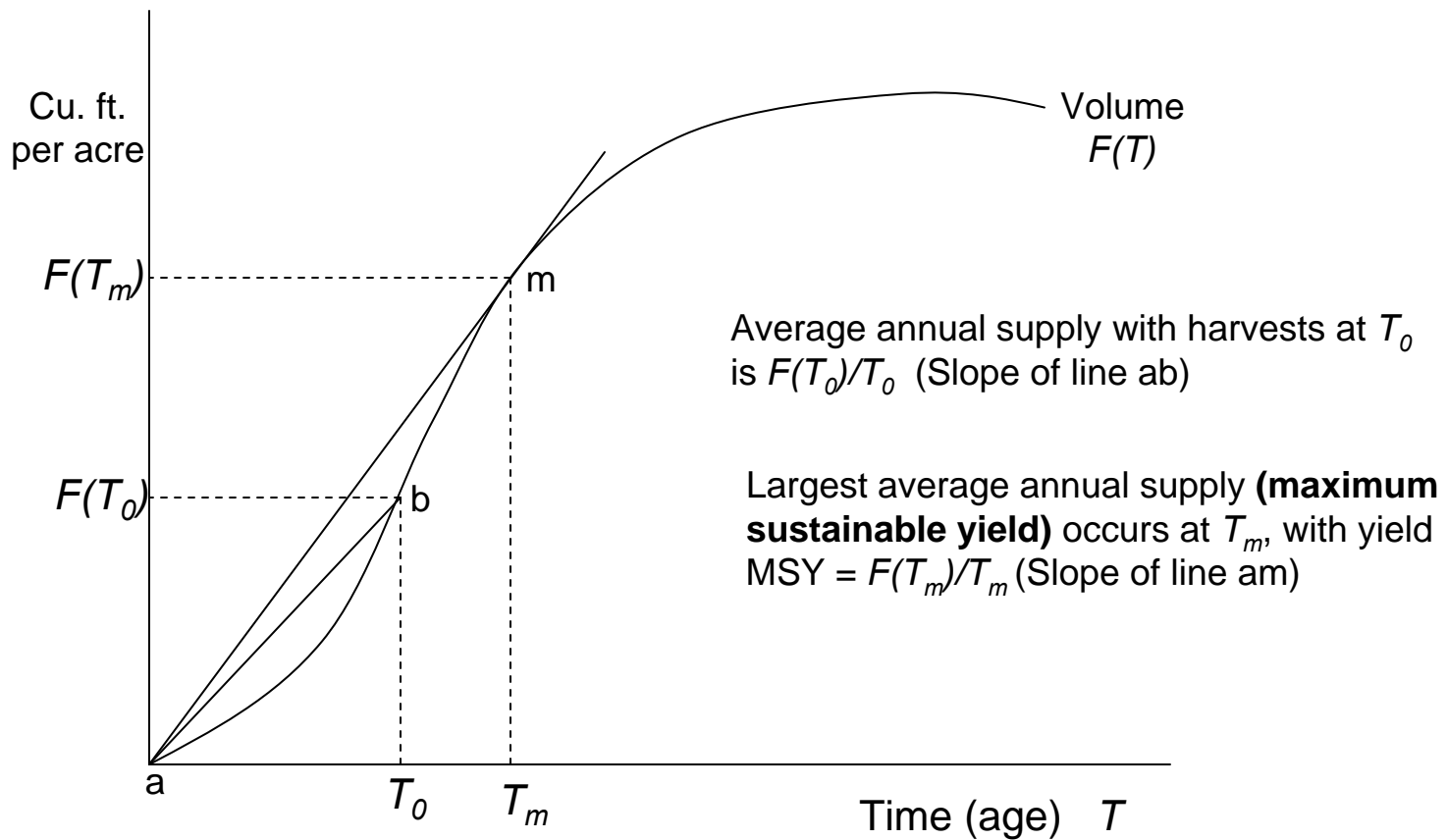
$$\frac{\frac{dF(T^1)}{dT}}{F(T^1)} = r, \quad (\% \text{ growth rate} = \text{interest rate.})$$

Simple harvest problem: harvest once, no replanting



r = interest rate
Price of timber = 1

Average Annual Timber Supply (per acre)



Harvesting and Replanting

3. Optimal Harvest Rule with Replanting and Re-harvesting

R (land rent) is opportunity cost of using an acre of land, \$ per acre per year.

Marginal cost of waiting an additional year to harvest now has two parts:

$$MC_w(T) = rPF(T) + R.$$

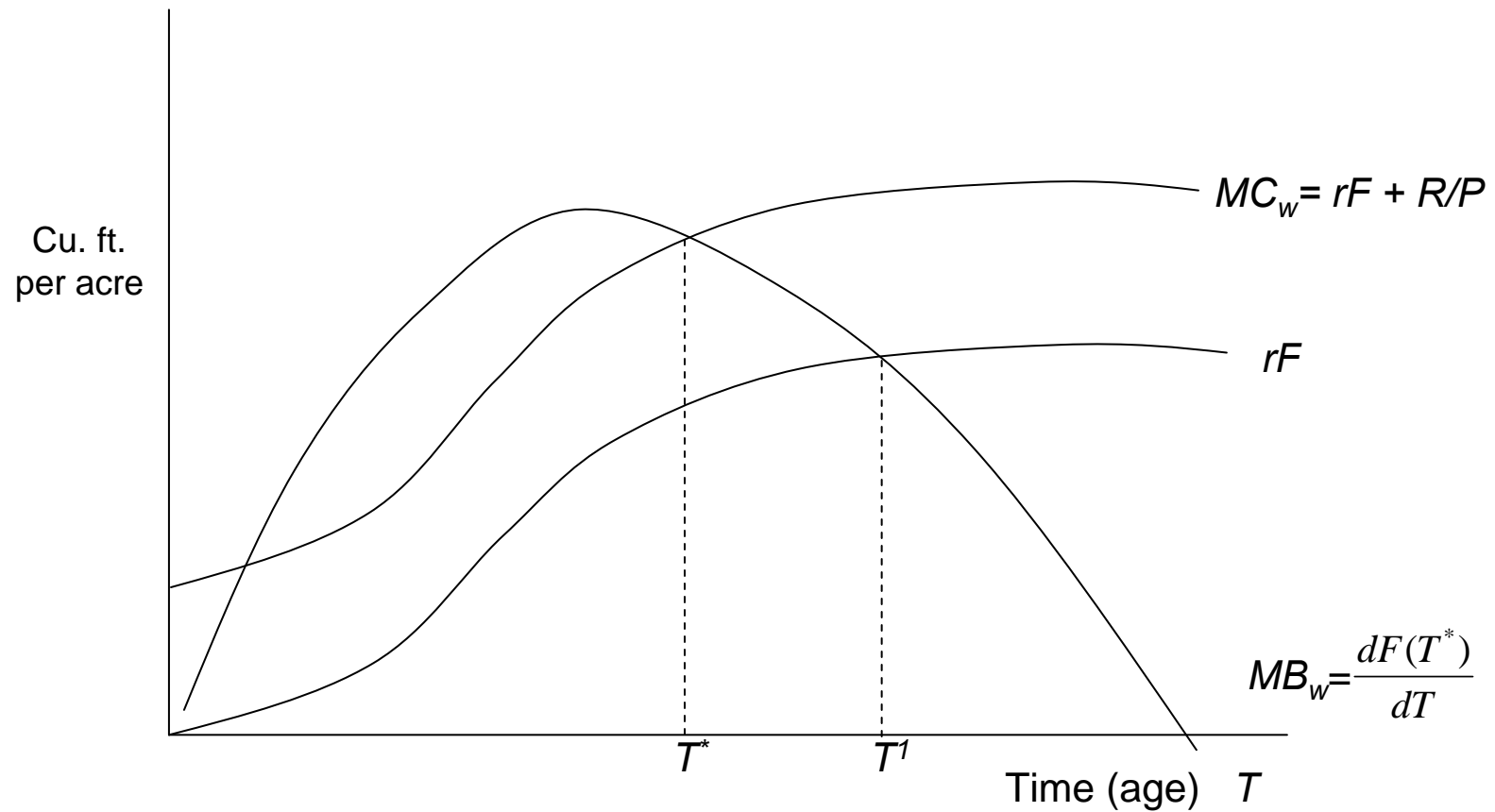
(Marginal benefit of waiting is same as before.)

Profit maximizing forest owner harvests chooses T^* to satisfy:

$$P \frac{dF(T^*)}{dT} = rPF(T^*) + R, \text{ or}$$

$$\frac{dF(T^*)}{dT} = rF(T^*) + R/P \quad (\text{F.1})$$

General problem: harvesting and replanting



r = interest rate
Price of timber = 1

4. The Land Use Decision and Determinants of R (land rent)

Notation: Subscripts ' f ' and ' a ' land uses, "forestry" and "alternative".

The return an acre of land can earn these two uses is denoted R_f and R_a .

The owner will: allocate the acre of land to forestry if $R_f \geq R_a$
allocate the acre to alternative use if $R_f < R_a$.

The resulting rent will be $R = \max(R_f, R_a)$.

5. What determines R_f ? (4 steps)

1. Harvesting the forest once at age T^* yields the net present value:

$$N = \frac{PF(T^*)}{(1+r)^{T^*}} - C.$$

C is planting cost, incurred at the start of each growing cycle.

N is present value receipts, discounted to start of growing cycle.

2. Harvesting and replanting at intervals of T^* years yields:

N (from first rotation), N after T^* years (from second rotation),

N after $2T^*$ years (from third rotation), . . . , etc.

The present value of this stream of future receipts is:

$$\begin{aligned} V_f &= N + \frac{N}{(1+r)^{T^*}} + \frac{N}{(1+r)^{2T^*}} + \frac{N}{(1+r)^{3T^*}} \dots \\ &= N \left(\frac{1}{1 - 1/(1+r)^{T^*}} \right). \end{aligned}$$

3. Combining steps 1 and 2, the value of the land for growing a forest is:

$$V_f = \frac{\frac{PF(T^*)}{(1+r)^{T^*}} - C}{1 - 1/(1+r)^{T^*}}.$$

(Note how V_f depends on P , C , r , and T^* .)

4. V_f and R_f are connected.

R_f is the maximum amount forest growers will pay per year to use the land.

V_f is the maximum amount forest owners would pay to use the land forever.

The present value of infinite stream of annual payments (R_f/r) must equal V_f .

Therefore, $R_f/r = V_f$, which implies $R_f = rV_f$.

Inserting the expression for V_f yields

$$R_f = r \frac{\frac{PF(T^*)}{(1+r)^{T^*}} - C}{1 - \frac{1}{(1+r)^{T^*}}}, \quad \text{or} \quad \frac{R_f}{P} = r \cdot \frac{\frac{F(T^*)}{(1+r)^{T^*}} - \frac{C}{P}}{1 - \frac{1}{(1+r)^{T^*}}} \quad (\text{F.2})$$

Factors affecting land use, harvest age, and timber supply

Effect of increase in:

	P	C	r
R_f rent on forest land	+	-	-
Acreage in forests	+	-	-
$MC_w (= rF + R/P)$	+	-	+
Harvest age, T^*	-	+	-
Average supply/acre: $F(T^*)/T^*$	-	+	-
Total supply/year	?	?	-

6. Example of analysis: How will a decrease in P affect land use, T^* and timber supply?

- (i) Land use depends on R_f . From equation (F.2), a decrease in P decreases R_f , and therefore decreases the acreage of land used for forest growing.
- (ii) Harvest age (T^*) depends on $MC_w = rF(T^*) + R/P$. From (F.2), a decrease in P will decrease R/P (because C/P increases,) lowering MC_w . When the marginal cost of waiting is decreased, forests are harvested later, i.e., T^* increases.
- (iii) Timber supply depends positively on the acreage of land in forest growing. It also depends positively on the yield per acre, $F(T)/T$, which depends on harvest age.
Assuming $T^* < T_m$, that is, the present value maximizing harvest age is less than the maximum sustained yield harvest age, an increase in harvest age will increase the yield per acre.
Therefore, a decrease in P reduces the acreage in commercial forestry, but increases the yield per acre, so the net effect on timber supply could be negative or positive.

Forest management on U.S.F.S forests

Maximum sustainable yield principle.

MSY can justify harvests, even though profit < 0.

USFS incurred losses on some forests & subsidized with other revenues.

GAO study, 1984:

Examined data on 3,000 timber stumpage sales in 1981 & 1982

USFS cost of sales include: mgt. cost on forest, road building, fire control, etc.

Nearly all sales in Rocky Mt., Intermountain, some Northern region forests lost money.

Forest management on U.S.F.S forests (cont.)

CRS 1984 study:

Compare revenue to costs, forest by forest, 1973-1983, report results by state.
Pacific states and deep south made money.
Intermountain, rocky mountain, east, southwest, and Alaska areas lost money.

CRS 1985 study:

Compare 1981 and 1982 operating revenue to costs, by region.
Rocky Mt. & Intermountain Regions lost money on average.

NRDC/Wilderness Society:

Study 1974-1978 and compare costs and revenues.
Identify forests that consistently lose money.
Acreage in 'losers' is 125 million acres, or 200,000 sq. miles, (roughly 1.25 times size of Calif.)

Forest management on U.S.F.S forests (cont.)

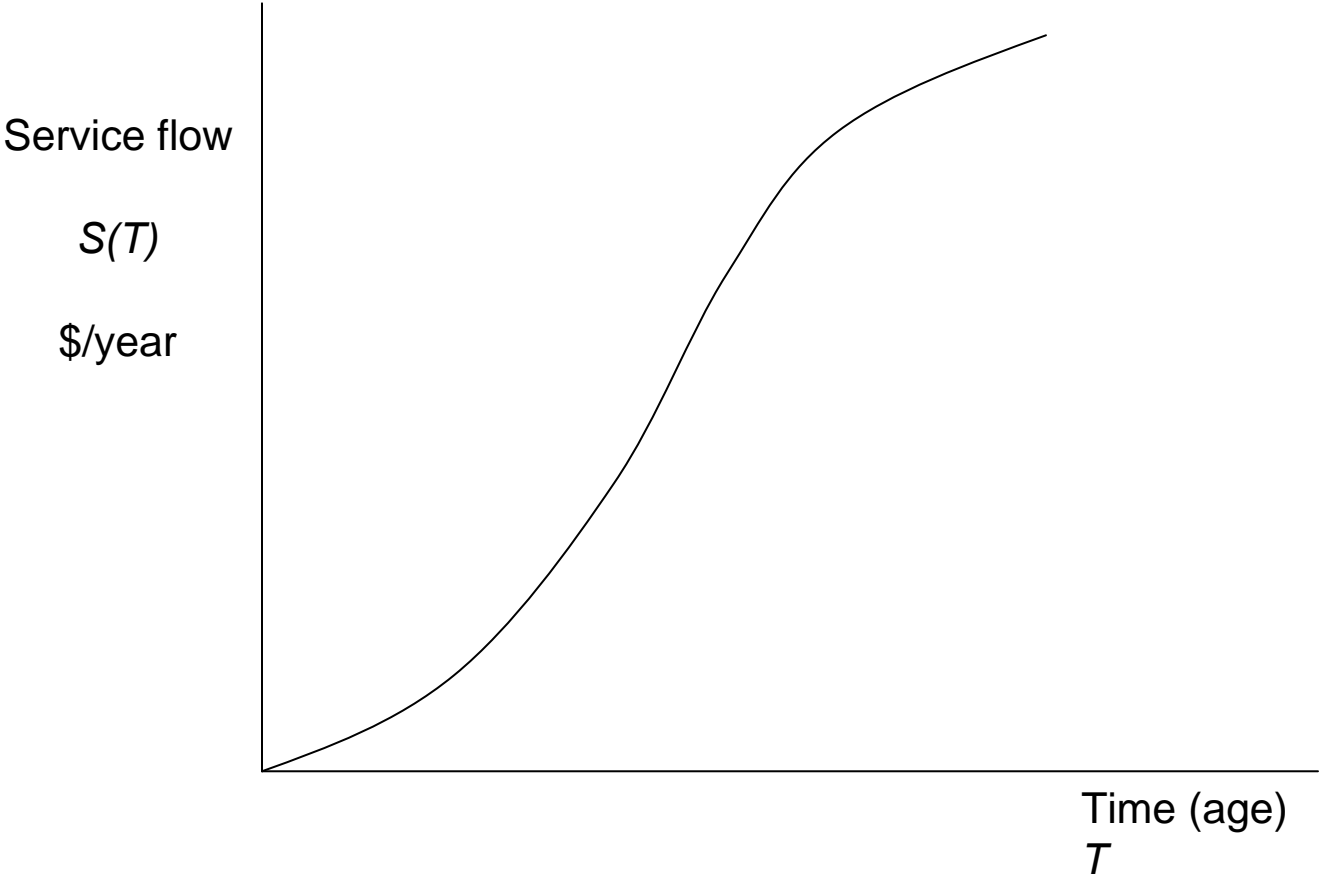
CRS 1994 study:

Examine USFS procedures for reporting costs of timber sale program. Concludes cost information is flawed and USFS is not responsive to recommendations to change accounting procedures. Over period 1989-1993 the large majority of national forests lost money on timber

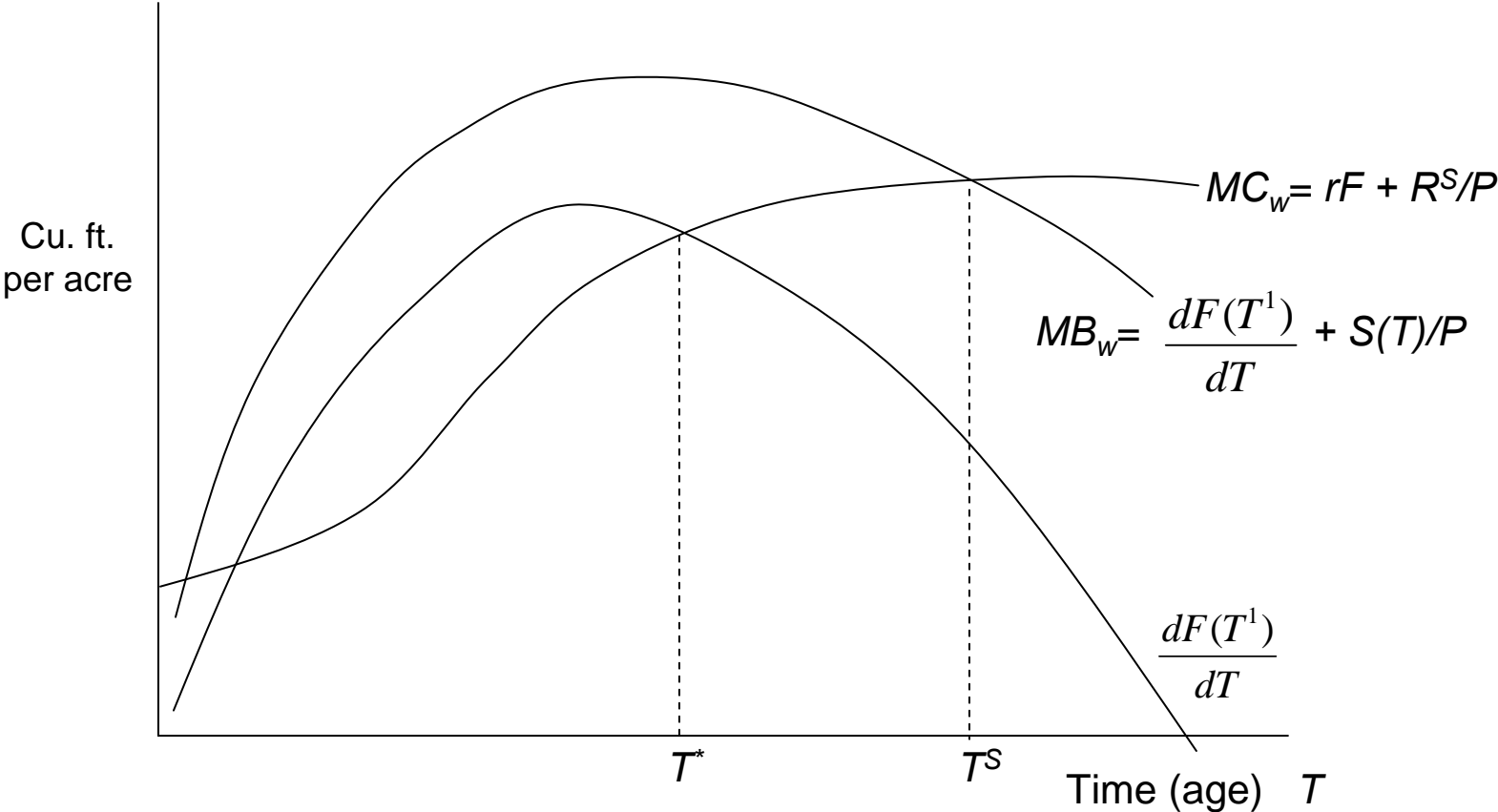
GAO 2001 study:

Again concludes that USFS data on timber sale costs are unreliable due to accounting deficiencies. Based on possibly deficient data, it appears that USFS timber sale program lost \$125 million in FY1998. All but 2 out of 10 FS regions lost money.

Service Flow from a Standing Forest



Optimal Harvest Age when Service Flow is Recognized



r = interest rate
 Price of timber = 1
 R^S = rent when $S(T)$ is recognized.