U.S. Timber Accounts, 1957 – 1997[1]

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Abstract

In the most comprehensive review of green accounting efforts in the U.S. to date, the National Academy of Sciences concluded that extending national income calculations to account for natural resources and subsequently for ecological services is a worthwhile and desirable goal. The study furthermore sees the creation of timber accounts as the next logical step in the implementation of Integrated Environmental and Economic Satellite Accounts (IEESA). This paper attempts to compute such a set of timber accounts for the continental U.S. from 1957 to 1997. Over this period, the monetary value of U.S. timber increased both at a nominal and real level. In computing these accounts, three different approaches were used: the method previously applied by the Bureau of Economic Analysis (BEA), a new method suggested by the National Academy, and the standard present-discounted value method. Given the available data, this paper concludes that the latter approach is most appropriate for implementing U.S. timber accounts.

Keywords

Green accounting; environmental accounting; comprehensive national accounts; timber accounts; IEESA.

I. INTRODUCTION

In 1992, the U.S. Bureau of Economic Analysis (BEA) began compiling Integrated Environmental and Economic Satellite Accounts (IEESA). However, Congress suspended its work after the publication of first results two years later.[2] In response to the Congress' request, the Department of Commerce asked the National Academy of Sciences to review the current state of environmental accounting in the U.S., which culminated in the publication of *Nature's Numbers* (Nordhaus and Kokkelenberg [6]). This study concluded that there were clear economic policy arguments for integrating environmental and economic accounts. Furthermore, it recommended that the BEA should continue working on its environmental accounts and saw the refinement of subsoil and timber value estimates as the next logical step in the implementation of the IEESA. Appendix C suggested a method for timber evaluation based on an unpublished manuscript which has been further developed in Vincent [12] as the "El Serafy variation."

This paper attempts to estimate both the asset value and net accumulation of timber in the United States by implementing the "El Serafy variation" as proposed by Vincent—hereafter referred to as the "Vincent method." It also seeks to compare it to two other well-known methods. One is a simplified version of the net price or net depletion method, used in previous BEA estimates (Howell [4]). This simplified net price method was pioneered in the most widely cited green accounting study *Wasting Assets* by Repetto *et al*. [7], and is hereafter referred to as the "Repetto method." The last approach is the well-known present discounted value (PDV) method.

[2] See Bureau of Economic Analysis [1] for an overview of BEA's activities as well as first estimates for mineral resources. U.S. Congress [11] directed BEA to stop any further work on its Integrated Environmental and Economic Satellite Accounts (IEESA).

II. PDV, REPETTO, AND VINCENT METHODS

PDV Method

The theoretically correct estimate for asset value V(t) of standing timber is the fundamental textbook approach of calculating the PDV of future income streams. In the case of forests, these income streams equal net stumpage price $p_s(t)$ times annual harvests q(t), where T = infinity, the discount rate is r, and the net stumpage price $p_s(t)$ equals market price p(t) minus extraction cost c(q(t)):

$$V(t) = \sum_{t=0}^{T} \frac{p_s(t)q(t)}{(1+r)^t}. \quad (1)$$

The corresponding net accumulation N(t) can be obtained by simply calculating the difference between asset value in the beginning and end of year t,

$$N(t) = V(t+1) - V(t). \quad (2)$$

To calculate the value of standing stock in a given year, however, requires the knowledge of paths for $p_s(t)$ and q(t) well into the future. In practice, T is chosen between 30 and 50 years, but it can sometimes still prove difficult to obtain these future price and harvest paths. Several shortcut formulas have been proposed to combat this problem.[3] Among them are the widely cited Repetto and the recently proposed Vincent methods.

Repetto Method

The original version of the net price method for forests, obtained as a simple extension of the net price approach for non-renewable resources, requires the knowledge of marginal extraction cost C'(q(t)):

[3] See Vincent and Hartwick [13], European Commission [3], and Vincent [12], among others.

$$N(t) = -[p(t) - C'(q(t))] [q(t) - g(t)], \quad (3)$$

where g(t) is the net natural growth, and q(t) – g(t) represents the net change in physical stock. Since it is difficult to obtain data on marginal extraction costs, most applied studies replace C'(q(t)) with average extraction cost c(q(t)), which results in

$$N(t) = -[p(t) - c(q(t))] [q(t) - g(t)]. \quad (4)$$

This is termed the "Repetto method," as it was used to calculate net depletion in *Wasting Assets* (Repetto *et al*. [7]). The corresponding formula used for the monetary valuation of timber stock simply involves multiplying the physical stock S(t) by the net stumpage price $p_s(t)$, again equal to average market price p(t) minus average extraction cost c(t):

$$V(t) = S(t)\, p_s(t). \quad (5)$$

The most important advantage of this approach is its minimal data requirement, but it is theoretically incorrect. In essence, the Repetto method would require the entire stock of standing timber to be cut down within one time period and sold at current market prices. For a single, managed forest stand in perfect rotation sustaining its annual harvest at a constant rate into perpetuity, this method underestimates the actual timber value, since it ignores future timber growth and undervalues all tree stands up to the optimal rotation age. In this study, however, the Repetto method overstates the actual timber value, since only a fraction of the total forest area in the U.S. is optimally managed, and old-growth forests are overvalued.

Vincent Method

An alternative shortcut formula for estimating timber values is the Vincent method:[4]

[4] This "Vincent method" was first proposed by Vincent and Hartwick [13] and further refined in Vincent [12]. It was also highlighted in Nordhaus and Kokkelenberg [6].

$$V(t) = \sum_{\tau=1}^{T-1} A(t,\tau)V_h(t,\tau), \tag{6}$$

where $V_h(t,\tau)$ is the value of timber stock per acre and age group τ at a given time t, and $A(t,\tau)$ is the corresponding area per τ. $V_h(t,\tau)$ is further defined as

$$V_h(t,\tau) = [p_s(T)q_h(T) + p_\ell(T)](1+r)^{-(T-\tau)}, \tag{7}$$

with the bare-land value $p_\ell(T)$ given as

$$p_\ell(T) = \frac{-C_s(T) + p_s(T)q_h(T)(1+r)^{-T}}{1-(1+r)^{-T}}. \tag{8}$$

$p_s(T)$ is the net stumpage price at the rotation age T, $q_h(T)$ is the harvest per acre, and $C_s(T)$ is the full rotation management cost. As in the case of the PDV method, net accumulation N(t) again equals the difference between asset value in the beginning and end of a given period.

Using the term "shortcut" formula for the original Vincent method is a misnomer, since it yields theoretically correct results and requires more data than the standard PDV method. "Shortcut," in this case, refers to the fact that the Vincent method can be applied using only present data, which is not possible for the PDV method. The PDV method as applied in this study uses highly disaggregated data split between four ownership groups, seven regions, and two timber types, for a total of fifty-six different categories. The Vincent method, however, goes one step further, requiring data split up by age groups. For any given age group, it is possible to assume that the per-acre harvest at the rotation age T, $q_h(T)$, is equal to the current per-acre harvest $q_h(t)$. This conclusion rests on the assumption that changes in the harvest rate for a given ownership group, region, and timber type are more likely due to shifts in the age structure within one of these fifty-six categories rather than changes in the harvest rate for any given age group.

In addition to future harvest data, the theoretically correct application of the Vincent method requires future stumpage price and full rotation management cost values to calculate

$p_s(T)$ and $C_s(T)$, respectively. In contrast to per-acre harvest rates, stumpage prices do show a clear positive trend over the time period in question. As proposed in Vincent [12], a quick fix to this problem is to reflect the change in stumpage prices by adjusting the discount rate r in the formula for $V_h(t,\tau)$ downward by the increase in stumpage prices. I used simple regression analyses to determine overall price increases between 1957 and 1997 in each of the fifty-six categories in order to make these adjustments in equation (7).

Any attempts to adjust for changes in the full rotation management cost would represent false accuracy since changes in $C_s(T)$ are hardly reflected in the results of formula (8), and even less so in (6) or (7). It can, therefore, safely be assumed that $C_s(T)$ equals $C_s(t)$ at the present time t.

III. U.S. TIMBER DATA

The U.S. Forest Service's Forest Inventory and Analysis program has continuously surveyed each of the 48 contiguous states between three and seven times within the last 65 years, resulting in the publication of roughly 240 individual state inventory reports.[5] The Forest Service's Pacific Northwest Research Station also maintains a central database with comprehensive physical timber data for the continental U.S. from 1957 to 1997 using continuous inventory methods.[6] Actual physical data are taken from the Forest Service's inventory reports and interpolated for the remaining years. No data are available for Hawaii, and no harvest data are available for Alaska. Hawaii's contribution to U.S. forests is minimal, but Alaska's forest cover is quite significant. Even without the area of the Tongass National Forest, Alaska had over 12.4 million acres of forestland in 1998.[7] This corresponds to 2.5% of the total forest area in the U.S.; 4.4% when adding the rough estimate for the total forest area in the Tongass National Forest. Interestingly, Alaska has shown a steadily declining forest area over the last half century, in contrast to the overall increasing trend in the continental U.S. However, since no set of harvest data was available and all three methods require them for their calculations, the state had to be ignored for this study.

Harvest q(t), forest area A(t), timber inventory S(t), and net natural growth g(t) data were compiled by seven regions as defined by the Forest Inventory and Analysis program: Northeast, North Central, Southeast, South Central, Intermountain or Rocky Mountain, Pacific Northwest, and Pacific Southwest (U.S. Forest Service [8]). The data were also compiled by four ownership

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5 Taken from an unpublished manuscript by Brad Smith, Forest Inventory and Analysis Dates of Statistics, U.S. Forest Service, Washington, D.C. (1999).

6 Richard Haynes from the Forest Service's Pacific Northwest Research Station provided the timber data sets derived from a forest sector-market analysis program.

7 With roughly 10 Million acres of forest land, the Tongass National Forest is the largest in the U.S., but is excluded from the overall forest area estimates of the Forest Service.

groups: national forests, other government, forest industry, and other private. In addition, harvest, inventory, and growth data were available by two timber types: softwood and hardwood. Stumpage prices $p_s(t)$ were taken from the same data set as the physical data but were only split into softwood and hardwood categories, not by ownership types. The softwood prices in turn were grouped by the seven regions, while hardwood prices were only compiled by "South" and "North." Assigning these two categories to the seven regions is relatively straightforward, except for the Intermountain region, for which I used an average between the South and North hardwood prices. All physical timber data were given in cubic feet, while price data were given in 1982 Dollars per board foot. I used the commonly applied conversion factor of 5.0 board feet per cubic foot nation-wide.[8]

Applying Vincent's method also requires data on rotation age, full rotation management cost, as well as harvest and area data by age group. I obtained rotation age data through the U.S. Forest Service's ATLAS model for timber projections. Due to the relatively small amounts of harvest in the national forest and other government ownership categories, these data could only be modeled for forest industry and other private owners. Because of their similarities in forest management, other private ownership data were used for the remaining two categories.[9]

I generated a set of full rotation management cost data from Moulton and Richards [5] as well as Dubois and McNabb [2]. Moulton and Richards compiled cost data per acre for three different management types by nine regions. Land in the national forest ownership category was assumed to only require passive management, which included minimal protection activities such as restricting grazing and allowing natural regeneration. The other three ownership categories were assumed to require active management, in the form of timber stand improvement and other

[8] As suggested by Richard Haynes.
[9] Based on unpublished data provided by John Mills from the Forest Service's Pacific Northwest Research Station.

silvicultural practices. Dubois and McNabb compiled cost trends for the South from 1952 to 1997 in two to nine-year increments. I used Dubois and McNabb's trend from the South in conjunction with Moulton and Richards' nation-wide data for 1990 to generate a data set for management cost, extrapolating the time series trend in the U.S. South to the entire country.[10]

Obtaining age group data posed a different kind of problem. The Forest Service had not collected age group data before the last round of inventories starting in 1992. There were, however, volume data available by diameter class for the six benchmark years 1953, 1963, 1977, 1987, 1992, and 1997.[11] The Forest Inventory and Analysis Database Retrieval System contains the latest inventory data for 45 states and enables the generation of diameter by age class data tables for the most recent inventory.[12] I compiled these matrices for the seven regions and then used them to convert diameter data for the six benchmark years to data by nine age groups spanning a decade each, with the last category consisting of all standing trees older than 80 years.

Applying the PDV method up to 1997 with a rotation age T of 50 years, requires harvest and net stumpage price data until 2046. Forest Service projections of timber data until 2050 served as the source for these data.[13] The projections are based on a physical timber model which generates data from 1972 through 2050. Between 1972 and 1998, when the actual physical data and the model overlap, the model very accurately predicts actual timber stocks. However, the

[10] As described in the discussion of the Vincent method above, full rotation management cost data have minimal effects on the final calculations. In fact, the management cost figures used do not result in significantly different timber value estimates than using values of zero.

[11] Data for the years 1953, 1963, 1977, 1987, and 1997 were taken from U.S. Forest Service [10]. 1992 data are from U.S. Forest Service [9].

[12] Most recent inventories can be obtained through the Forest Inventory and Analysis Database Retrieval System, http://fia.fs.fed.us/.

[13] Based on unpublished projection data from the ATLAS model for timber projections and the Oregon version of the Timber Assessment Market Model TAMM, provided by Richard Haynes from the Forest Service's Pacific Northwest Research Station.

model not surprisingly misses the forest sector's response to an unexpected large reduction of the federal harvest rate from 1991 to 1994 due to the spotted owl controversy in the Pacific Northwest. Hence, the necessary splicing of the two data sets was done over the five-year period between 1994 and 1998.

IV. MONETARY U.S. TIMBER ACCOUNTS

The three methods yield vastly different results. Estimates for 1997, the final year of the analysis, result in timber asset values of $438 and $578 Billion for the Vincent and Repetto methods, respectively. Both methods significantly overstate the theoretically correct value of U.S. timber of $305 Billion in 1997, obtained by applying the PDV approach (Table I).

The Repetto method's numbers correspond to the approach used by the BEA in its preliminary estimates for the IEESA, which obtains a current value estimate of $336 Billion for 1987 ($319 Billion in 1982 Dollars), the only year of its analysis.[14] This value is slightly higher than the value of $310 Billion obtained in Table I, which can be explained by the use of four different ownership categories and seven regions in this study; BEA's estimate only considers the breakdown between soft and hardwood.

Both the Vincent and Repetto methods show similar overall trends. In general, Vincent's method results in asset value figures closer to the PDV method's estimates (Figure 1). However, the ultimate goal of U.S. timber estimates is the calculation of net accumulation numbers for subsequent integration in the IEESA flow accounts. Over time, only the PDV and Repetto methods prove stable, while the Vincent method jumps between $-7.7 and $26.1 Billion between 1985 and 1986, for instance; in the same years, the PDV method shows consistently stable results of $6.6 and 6.8 Billion (Table II and Figure 2). These fluctuations in the Vincent method highlight a peculiar feature of the data. Forest Service timber data are compiled by using actual inventory figures for six benchmark years and by linearly interpolating numbers for the years in between. This applies to all physical as well as stumpage price data sets except for harvest data, which were taken from a timber growth model for the years between inventories. All three

[14] Bureau of Economic Analysis [1]. Also see Howell [4] for a discussion of its methodology.

methods use the same price data set, but the PDV method exclusively relies on harvest data as its physical data input. Hence, it is the only method showing a relatively smooth asset value path that does not resemble the linear characteristics of the physical timber inventory (Figure 1).

The Repetto method should, therefore, show similarly unstable results for net accumulation. Nevertheless, it proves rather stable with net accumulation figures ranging between \$1.1 and \$4.5 Billion over the entire time period. This is due to the fact that the Repetto method as outlined in equations (4) and (5) relies on harvest data for the calculation of net accumulation, while asset calculations are based on physical inventory data. Calculating net accumulation by using equation (2) reveals this feature of the Repetto method, showing similar variations in net accumulation as the Vincent method (Figure 2). This internal inconsistency in the data renders the Repetto method inadequate for a set of consistent monetary timber accounts.

One unavoidable characteristic of both the PDV and Vincent methods is the dependence on discount rates (Figure 3 and Figure 4). Here, the Vincent method reveals another peculiar characteristic. Because of the correction for increasing prices, the actual interest rate for the case of $r = 2.5\%$ falls below zero in a few of the ownership and timber type categories, which results in negative estimates for the asset value in these particular groups. The asset values for $r = 2.5\%$, therefore, are lower than for $r = 5\%$ (Figure 4). This inconsistency with different interest rates and the Vincent method's sensitivity to fluctuations in physical area data, point to clear practical advantages of the PDV method.

Choosing between the two theoretically correct methods, the PDV method should therefore be given precedence in calculating both asset and net accumulation accounts. In Table III, total net change corresponds to net accumulation N(t), and the opening stock in any given year equals the asset value V(t). Reevaluation and capital formation are calculated with the standard accounting formula

$$V(t+1) - V(t) = \sum_{t=0}^{T} \frac{p(t+1)}{(1+r)^{t+1}} \cdot q(t+1) - \sum_{t=0}^{T} \frac{p(t)}{(1+r)^{t+1}} \cdot q(t). \qquad (9)$$

Adding and subtracting

$$\sum_{t=0}^{T} \frac{p(t)}{(1+r)^{t+1}} \cdot q(t+1), \qquad (10)$$

results in

$$V(t+1) - V(t) = \sum_{t=0}^{T} \left(\frac{p(t+1)}{(1+r)^{t+1}} - \frac{p(t)}{(1+r)^{t}} \right) \cdot q(t+1) + \sum_{t=0}^{T} \left(q(t+1) - q(t) \right) \cdot \frac{p(t)}{(1+r)^{t}}, \qquad (11)$$

where the first term on the right-hand side corresponds to the reevaluation and the second to the quantity change or capital formation. This breakup between reevaluation and capital formation changes is important for making natural resource accounts such as the IEESA fully compatible with the existing system of national accounts. It should be noted that the Vincent method naturally lends itself to such a split, and the formula can also be adjusted to accommodate the Repetto method.[15]

It should furthermore be emphasized that the problems of applying the Vincent method are not inherent to the method itself but rather are a feature of the data situation in the U.S. It is easier to predict future harvest rates than generate accurate present area data appropriate for the application of the Vincent method.

An empirical result of this study is that between 1957 and 1997, the monetary value of forests in the continental U.S. as calculated with the PDV method has shown a nominal increase between 2.1 and 3.4 percent annually, translating to increases between 0.4 and 1.7 percent in real

15 This split for the Repetto method has been performed in the IESSA Asset Accounts for 1987 in Howell [4].

terms. This is due to a continuous re-growth of U.S. timber stock throughout the last half a century—a trend that is predicted to continue for at least the next fifty years.

V. CONCLUSION

The Repetto method is advantageous with regard to its relatively few data requirements, and it enables a quick first approximation of timber values as demonstrated by Repetto *et al*. [7] for Indonesia. However, this method is theoretically incorrect and in praxis overstates the actual timber value in the U.S. Furthermore, some features of the available physical data make it internally inconsistent.

Two correct alternatives are the PDV and Vincent methods. To be theoretically correct, both methods require the knowledge of future price and harvest paths, and the Vincent method requires the additional knowledge of future paths for full rotation management cost. However, through a few assumptions, the Vincent method's results can be approximated by using present data, which is not possible for the PDV method.

Nevertheless, the quality of physical forest data in the U.S. does not allow the Vincent method to calculate precise results due to its particular sensitivity to fluctuations in area estimates. It is easier to obtain future projections of quantity paths than accurate current area and inventory data. Hence, the PDV method should be used for calculating U.S. timber accounts (Table III).

In contrast to the almost universally held opinion that green accounting would inevitably result in downward adjustments to national income calculations, accounting for standing timber results in a small positive adjustment to net domestic product and its derivatives.

This paper would not qualify as a proper economic study if it did not end with a call for further research. Next to mourning the omission of Alaska with roughly 4.4% of the total forest area in the U.S., an of course much larger obstacle to appropriately portray the total benefits of forest capital to the economic welfare of the nation is the exclusion of non-timber forest services.

There is much more to a forest than its timber. Ecological services such as carbon sequestration, watershed protection, and recreational benefits most likely amount to much larger monetary values than the mere accounting for timber. Future work in this area should undoubtedly focus on creating a full set of forest accounts.

Tables and Figures

Table I Asset Value V(t) with PDV, Repetto, and Vincent methods, r = 5% (Million 1982 Dollars)

	PDV method (T = 50)	*Vincent method*	*Repetto method*
1957	$104,848	$118,286	$159,995
1958	$107,882	$120,111	$162,263
1959	$111,225	$121,917	$164,857
1960	$114,458	$124,083	$167,443
1961	$118,224	$125,513	$169,518
1962	$122,212	$128,519	$173,654
1963	$126,375	$136,379	$182,659
1964	$130,586	$144,546	$191,672
1965	$134,791	$151,956	$200,194
1966	$138,956	$159,540	$208,568
1967	$143,126	$168,521	$217,663
1968	$147,513	$175,007	$226,450
1969	$151,928	$182,500	$235,282
1970	$156,352	$189,675	$243,449
1971	$160,760	$204,715	$259,478
1972	$165,106	$219,466	$274,848
1973	$169,301	$235,099	$292,088
1974	$173,316	$249,078	$306,977
1975	$177,800	$263,957	$323,022
1976	$182,815	$277,476	$338,391
1977	$187,002	$270,579	$332,088
1978	$191,229	$264,790	$327,973
1979	$195,493	$256,476	$321,988
1980	$199,943	$251,078	$317,462
1981	$205,205	$243,602	$311,234
1982	$210,959	$234,740	$305,637
1983	$217,205	$230,526	$300,576
1984	$223,230	$221,118	$295,287
1985	$229,288	$217,565	$290,804
1986	$235,916	$209,888	$285,247
1987	$242,704	$236,012	$310,071
1988	$248,996	$260,395	$333,287
1989	$254,926	$285,486	$358,180
1990	$260,612	$311,450	$382,006
1991	$266,667	$335,789	$407,203
1992	$272,930	$347,253	$430,929
1993	$279,100	$365,041	$460,297
1994	$285,706	$384,804	$490,188
1995	$291,687	$400,979	$518,426
1996	$298,191	$420,539	$549,356
1997	$304,843	$437,568	$578,351

Table II Net accumulation N(t) with PDV, Vincent, and Repetto methods, r = 5% (Million 1982 Dollars)

	PDV method (T = 50)	*Vincent method*	*Repetto method*	*Repetto method using N(t) = V(t+1) – N(t)*
1957	$3,033	$1,826	$1,423	$2,268
1958	$3,343	$1,806	$1,662	$2,594
1959	$3,233	$2,165	$1,517	$2,586
1960	$3,766	$1,430	$1,882	$2,075
1961	$3,988	$3,007	$2,023	$4,136
1962	$4,163	$7,859	$2,094	$9,005
1963	$4,211	$8,167	$2,178	$9,013
1964	$4,206	$7,410	$2,170	$8,522
1965	$4,165	$7,584	$2,199	$8,374
1966	$4,170	$8,980	$2,162	$9,095
1967	$4,387	$6,486	$2,469	$8,788
1968	$4,415	$7,493	$2,482	$8,832
1969	$4,424	$7,175	$2,540	$8,167
1970	$4,407	$15,039	$2,595	$16,029
1971	$4,346	$14,752	$2,752	$15,370
1972	$4,195	$15,633	$2,797	$17,240
1973	$4,014	$13,979	$2,923	$14,889
1974	$4,485	$14,878	$3,633	$16,045
1975	$5,014	$13,520	$4,457	$15,368
1976	$4,188	-$6,897	$3,873	-$6,303
1977	$4,227	-$5,790	$3,443	-$4,115
1978	$4,264	-$8,314	$3,085	-$5,984
1979	$4,449	-$5,398	$2,860	-$4,526
1980	$5,263	-$7,475	$3,285	-$6,228
1981	$5,754	-$8,862	$3,273	-$5,597
1982	$6,246	-$4,215	$3,251	-$5,061
1983	$6,025	-$9,408	$2,491	-$5,289
1984	$6,058	-$3,553	$1,990	-$4,483
1985	$6,628	-$7,677	$2,082	-$5,557
1986	$6,787	$26,124	$1,698	$24,824
1987	$6,293	$24,382	$1,382	$23,216
1988	$5,930	$25,091	$1,139	$24,893
1989	$5,687	$25,964	$1,084	$23,826
1990	$6,054	$24,338	$1,590	$25,197
1991	$6,264	$11,464	$1,968	$23,726
1992	$6,169	$17,788	$2,423	$29,368
1993	$6,606	$19,763	$3,377	$29,890
1994	$5,981	$16,176	$3,875	$28,238
1995	$6,504	$19,560	$3,835	$30,930
1996	$6,652	$17,029	$4,255	$28,995

Table III U.S. Timber Accounts from 1957–1997, using the PDV method with r = 5% and T = 50 years (Million 1982 Dollars)

	Opening Stock	*Change*		
		Reevaluation	*Capital formation*	*Total net change*
1957	$104,848	$2,054	$979	$3,033
1958	$107,882	$2,161	$1,182	$3,343
1959	$111,225	$2,247	$986	$3,233
1960	$114,458	$2,447	$1,320	$3,766
1961	$118,224	$2,549	$1,439	$3,988
1962	$122,212	$2,680	$1,483	$4,163
1963	$126,375	$2,706	$1,505	$4,211
1964	$130,586	$2,751	$1,455	$4,206
1965	$134,791	$2,737	$1,428	$4,165
1966	$138,956	$2,821	$1,349	$4,170
1967	$143,126	$2,810	$1,577	$4,387
1968	$147,513	$2,882	$1,533	$4,415
1969	$151,928	$2,898	$1,526	$4,424
1970	$156,352	$2,901	$1,506	$4,407
1971	$160,760	$2,782	$1,564	$4,346
1972	$165,106	$2,673	$1,522	$4,195
1973	$169,301	$2,511	$1,503	$4,014
1974	$173,316	$2,412	$2,072	$4,485
1975	$177,800	$2,284	$2,730	$5,014
1976	$182,815	$2,137	$2,051	$4,188
1977	$187,002	$2,434	$1,793	$4,227
1978	$191,229	$2,711	$1,553	$4,264
1979	$195,493	$2,999	$1,451	$4,449
1980	$199,943	$3,258	$2,005	$5,263
1981	$205,205	$3,588	$2,166	$5,754
1982	$210,959	$3,918	$2,328	$6,246
1983	$217,205	$4,296	$1,729	$6,025
1984	$223,230	$4,696	$1,362	$6,058
1985	$229,288	$5,082	$1,546	$6,628
1986	$235,916	$5,517	$1,270	$6,787
1987	$242,704	$5,241	$1,051	$6,293
1988	$248,996	$5,015	$915	$5,930
1989	$254,926	$4,717	$970	$5,687
1990	$260,612	$4,490	$1,564	$6,054
1991	$266,667	$4,250	$2,014	$6,264
1992	$272,930	$4,046	$2,124	$6,169
1993	$279,100	$3,885	$2,721	$6,606
1994	$285,706	$2,532	$3,450	$5,981
1995	$291,687	$2,559	$3,945	$6,504
1996	$298,191	$1,717	$4,935	$6,652
1997	$304,843	.	.	.

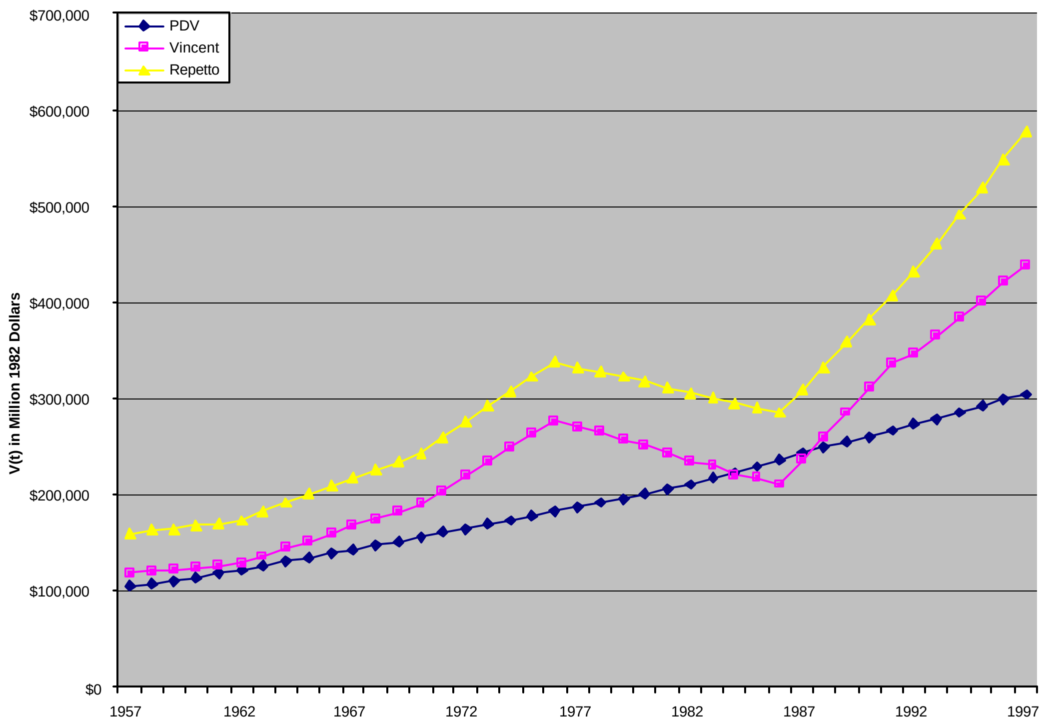

Figure 1 Asset Value V(t) with PDV, Vincent, and Repetto methods, r = 5% (Million 1982 Dollars)

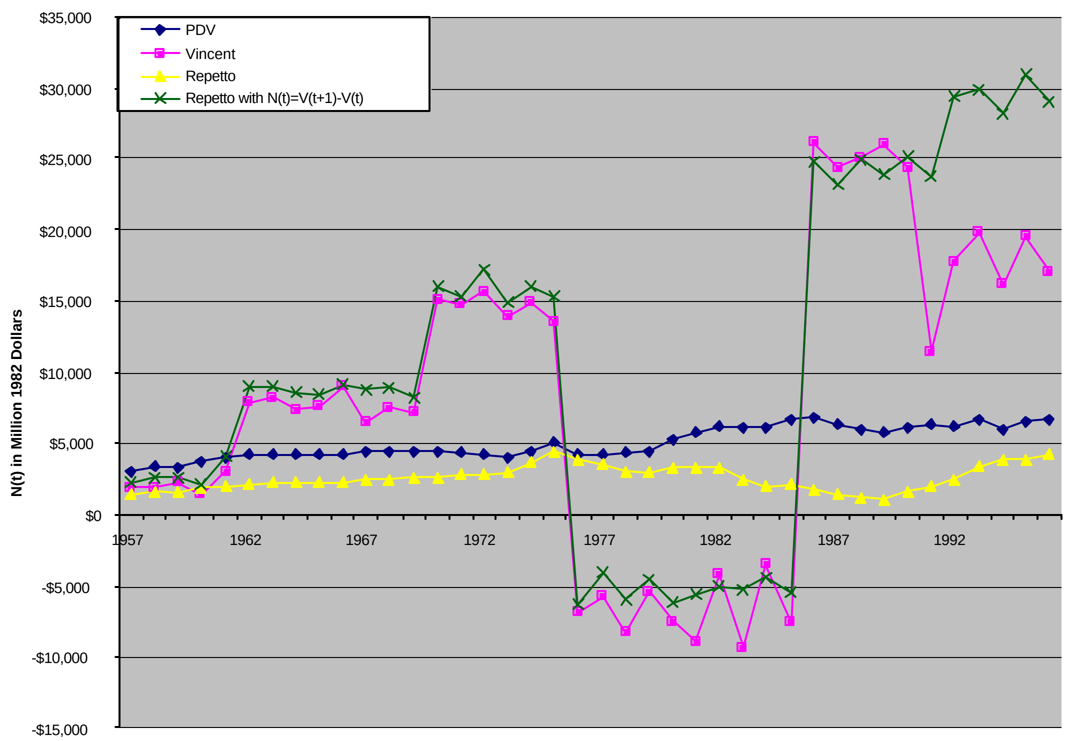

Figure 2 Net Accumulation N(t) with PDV, Vincent, and Repetto methods, r = 5% (Million 1982 Dollars)

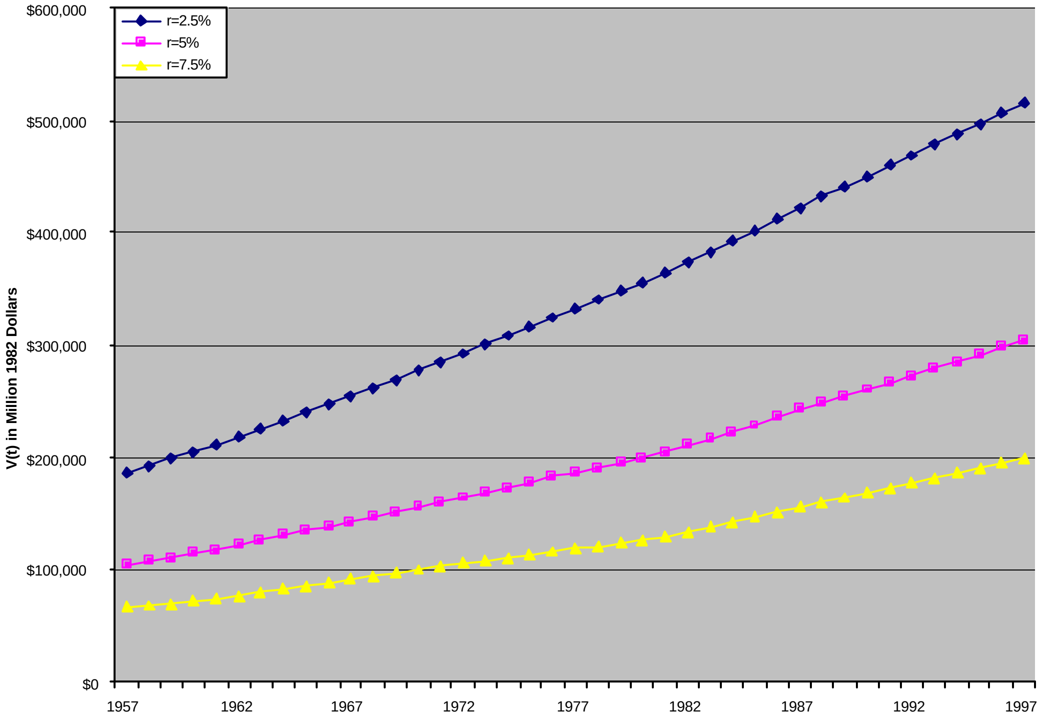

Figure 3 Asset Value with PDV method, T = 50, and varying interest rates (Million 1982 Dollars)

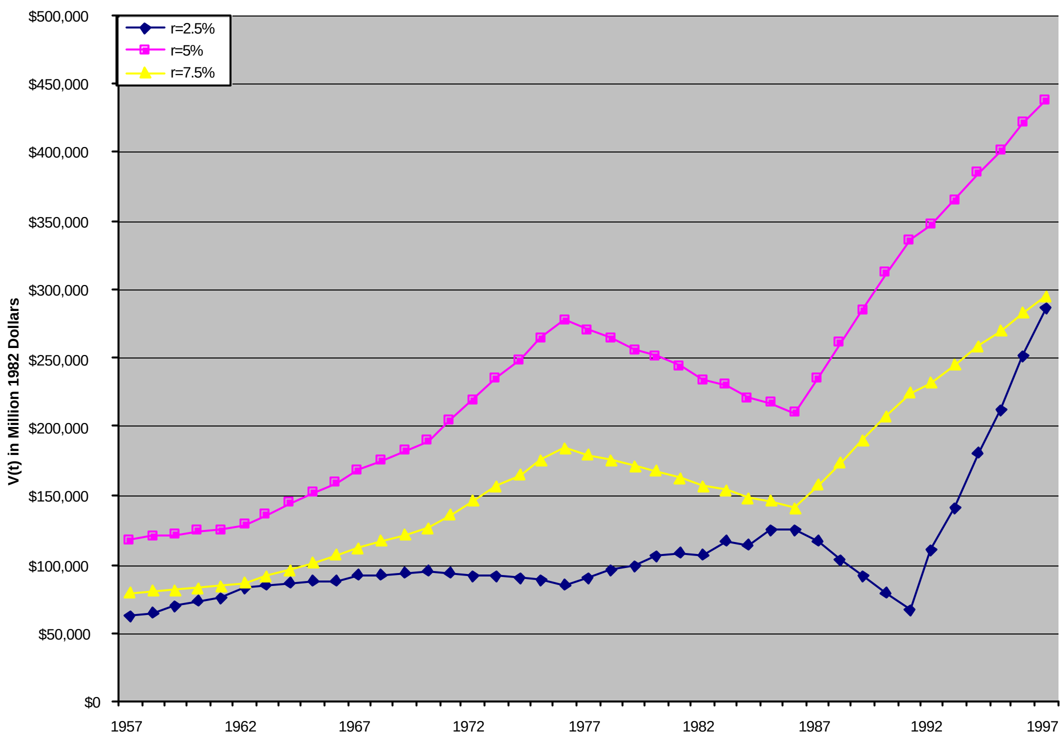

Figure 4 Asset Value with Vincent method and varying interest rates (Million 1982 Dollars)

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