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Growth and decay: forest landowner impatience factor

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ABSTRACT

From saplings to mature stems, trees grow into new log-size classes expanding in both timber volume and monetary value. Forestland financial decay becomes discernible when timber revenues are discounted to their present-day value. Net present value (NPV) calculations require application of a financial discount rate moderated against the forestland's macroeconomic inflation rate. The discount rate is significantly determined by the forestland owner's 'impatience factor' uniquely guiding timber harvest rotation timing for each forestland investor. The importance of appropriately defining the impatience factor is discussed in this manuscript. A 15.78 hectare (39.0-acre) forested parcel value is considered, as viewed through the impatience factor lens for various investor classes to appreciate observed variability in discounted asset values and how it influences timber harvest rotation timing. Natural resource managers, investors, and advisors may find the techniques described here helpful in their timber management financial decisions.

INTRODUCTION

Forest biometricians and economists approach timber growth and decay from different perspectives. Biometricians articulate physical site characteristic through climate, biome, and tree species biology, leading to growth (Prodan 1968; Arney 2015). Economists seek net economic value growth but must address value decay as forestland assets are discounted through time (Dana and Fairfax 1980). Ultimately, these biometric and economic patterns are combined into time sensitive expressions of current value.

Monetary landscapes differ in value based on forestland owner characteristics: private individuals, Timber Investment and Management Organizations (TIMOs), indigenous people tribes or bands, or public entities. Forestland investors consider the time-value of money with respect to their opportunity cost of alternative investments (Hubbard and O'Brien 2015). Forestland owners' monetary preferences steer resource value decay rates as it is discounted from the future to today's value (Schlosser 2014; 2020).

Biologic growth and decay

Timber growth-and-yield characteristics are driven by physical land resources and the genetic materials present, or introduced, to forestland sites. Major driving forces include their location, resting at the core of productivity and being described as site index, temperature and degree growing days from sprouting (or planting) to their status as mature timber (Burkhart and Gregoire, 2005). These factors contribute to the expression of individual tree growth and potential timber merchantability (Husch et al. 1982; Brown et al. 2004).

Merchantability explains where core value conversion is focused, from stems on the stump to logs entering lumber mills. Computerized forest growth-and-yield programs have progressed since 1975 (Wykoff et al. 1982), transitioning from estimating forest stand total volume by species to include parameters such as diameter, height, crown competition factor, and other important measures (Arney 2015). The results allow market identification for specific products as projected into the future, addressing not an issue of total volume but of incremental log-segment grade changes.

Timber sellers in log markets located west of the Cascade Range in Oregon and Washington, USA, merchandize trees into logs which increase in volume as the trees grow. Log segments increase cubic meter measurements causing the log grade to shift into higher values per cubmic meter. Log grade value follows price increases as these grades progress through increasing small end diameter sizes facilitating recovery of pulp log segments, then to 4-sawmill, 3-sawmill, 2-sawmill, and potentially to 1-sawmill or SM and better log grades (NLRAG 2011; Schlosser 2020). Log grade differences are met primarily through larger log small end diameter as log lengths remain fixed. Each increase in log grade quality is met in the marketplace with higher value per thousand board feet (MBF), ceteris parabus. Log MBF measurements are analogous to cubic meter measures, but conversion is neither constant nor linear. These log markets administratively require log measurements in MBF units for all timber sold.

Economic growth and decay

All non-governmental owners must fund forestland management activities to pay property taxes, finance reforestation, provide protection, implement management, and pay infrastructure expenses, all while seeking positive financial returns on their forestland investment (Kimbel et al. 2010). The conversion of growing trees into financial revenue needs to be correlated with timber harvesting schedules timed to deliver value to landowners before biologic decay eliminates it; timing is important for determining timber NPV.

As biologic assets grow, merchandized tree stems can be harvested and sold as commodities. Optimal timber harvest timing for conversion of physical assets into dollars presents a challenge involving several opportunities. Forestland owners consider these options as trees mature to hold growing logs so that additional commodities or higher valued grades are grown. Those options broaden the range for financially wise decisions determining amounts of revenue to be generated now or into the future.

When timber is harvested, the landscape of opportunities is reduced to one option: the trees are converted to logs, delivered to a willing buyer, in exchange for payments. The next forest management step is reforestation, and the growth cycle is restarted. No more “when to harvest options” are available until the next rotation nears financially optimal timber harvest timing after several decades have passed.

Inflation, recession, appreciation and devaluation

While biologic cycles in tree growth begin with rapid growth rates eventually slowing down, its financial value keeps facing inconsistencies in economic realities (O'Conner and Orsmond 2007). Countries and regions go through large-scale inflationary periods and recessions (World Bank 2021; BLS 2021). Specific prices for round log commodities migrate through appreciation and devaluation cycles in response to the country's general economic vigor and consumer product demand.

When prices in the macroeconomy rise, the effect is called inflation. When the price of a certain commodity goes up in relation to the rest of the economy, it is called appreciation, and when its price goes down with respect to the rest of the economy, it is called devaluation (Frankel 2008; Hubbard and O'Brien 2015). The difference between inflation-versus-appreciation and depression-versus-devaluation is substantial.

Inflation adjusted currency values are called real values associated with a stated benchmark date. The business currency converter within the US economy is published by the US Bureau of Labor Statistics (BLS) in the form of the Producer Price Index (PPI) (BLS 2021). The PPI value is published monthly approximately within two weeks of the end of each month and is representative of the index cost of goods for producers (BG-FRS 2015).

When trees are planted, annual property taxes are paid, and infrastructure maintained, the costs are all incurred in nominal terms to be offset by potential revenue at an indefinite future date. Ultimately, the non-governmental forestland owner's decision to invest in property and the forest is made with the anticipation of retrieving some future date value (Kimbell et al. 2010).

Inflation within a national economy is a shared feature: all investors participate within the same economic realities. While investor responses may be different, based on opportunities available to each investor, all respondents will adjust their rate of return expectations as the rate of inflation changes.

Opportunity cost

The interplay of two important factors - inflation in the economy and the landowner's specific impatience factor – serves as a significant key to placing costs and potential revenues into a meaningful and balanced context. The rate of inflation can be thought of as the economy's expansion rate, and the landowner impatience factor as perceived value decay. Discounting future values to current terms necessitates inflation to be lifted from projected future values for both willing buyers and willing sellers.

Natural resource management professionals integrate forest biometrics, site conditions, precipitation, and a host of directly related factors to anticipate biologic forces used to express forest maturity (Avery and Burkhart 2002). Forest economists recognize that landowners, investing money and silvicultural time, make decisions to boost their financial wellbeing in anticipation of eventual market timing to capture commodity value. Each investor approaches questions of profitability and the flow of capital in explicitly unique ways.

Impatience factor

Forestland investment decisions are viewed in relation to extended time horizons considered: decades and centuries, as opposed to days and months common in other financial investment arena. Forestland investors are generally macroeconomic inflation rate price-takers, seeking different levels only by changing venue. However, forestlands are location immutable, and the opportunities related to macroeconomic inflation rates are location dependent.

These investors weigh potential for financial returns against all other options with prospects moderated by perceived risks and their returns (Visco 1984). Investors face opportunity cost constraints in how they allocate their scarce financial assets (Ikonnikova et al. 2022) and how they use internal rate of temporal financial discounting to optimize their forestland investment decisions within the variable and everchanging macroeconomic inflation rate. This interaction gives understanding for impatience factor rate differences to traditional discount rates presented in this manuscript.

Conceptually, forestry investors apply the discount rate concept to make investment opportunity comparisons. Impatience factor rates accentuate the importance of extended time horizons and changed potential risks common to forestry investments. Traditional investors use discount rates as a means of investment comparison within similar investment categories. Resultant investments can be compared in this light.

While being risk adverse/tolerant and anticipating positive rates of return, investors incorporate local abiotic and biotic opportunities into their specific macroeconomic realities. Changes to time horizon decisions alter risks in any scenario. Higher impatience rates result in decisions favoring shorter timber rotation lengths. Lower impatience rates lead to longer timber rotation lengths and incumbent risks from natural disasters including wildfire losses. Concurrently, timber commodities will increase in value as the log grades increase (e.g., 4-sawmill log grades growing into 2-sawmill grades), so tradeoffs are made.

Impatience factor, when accepted as a unique and fully recognized phenomenon, can be viewed as a perceptual game changer within this temporally extended forestland investment horizon. As such, it alters the balance in the interplay of various perceived events to be differentially applied to potential commodity value shifts.

MATERIALS AND METHODS: FINANCIAL DECAY AND IMPATIENCE FACTOR

An investor's financial discount rate expresses the level of tolerance for receipt of delayed benefits. An investor's overall rate of discounting future returns to express them as current value becomes manifested as the product of the rate of inflation and the investor's impatience factor. This explains why the financial decay of the same asset, held by different investors in the same location, is managed in strikingly different ways.

Transactions evidence approach

Forestry entities rarely, if ever, publish the discount rate they apply to their forestland decision-making events. The transaction evidence approach (Levy 1985) can be applied to reveal the impatience factor behind harvesting decisions, though it can be misleading because non-financial conditions often influence, or even dictate, timber management activities on forestland properties.

Discount rates: inflation rate and impatience factor

Discounted future values are expressed as a multiplicative combination of inflation and the investor's impatience factor as decayed by time (0). As the rate of inflation in the macroeconomy changes, so does the investor's impatience factor. This approach recognizes the realities of the opportunity cost of capital (Keir and Keir 1993).

$$V_0 = \frac{V_n}{[(1+i)(1+f)]^n} \quad (1)$$

Where:

V_0 = present discounted value;

V_n = future value at year n;

i = annual inflation rate;

f = landowner’s annual impatience factor;

n = number of years to discount.

An investor’s impatience factor is flexible and moderates around the inflation rate. Timber management decisions exist in realities of rotation lengths measured against the horizon of decades, not months, which renders the interplay between the two phenomena significant.

Merchantability

Timber commodity values change on a sliding scale of log merchantability to be sold by weight as pulp logs or left growing to meet anticipated size requirements for higher quality and value sawlog scales (NLRAG 2011). Each sawlog commodity is marketable at price ranges to incentivize landowner’s delayed harvest timing decisions.

It is for this reason that any investor faced with this compelling choice needs to be aware of this intricate interplay amidst several considerations surrounding their ultimate decision. When the landowner’s impatience factor exceeds the current rate of inflation, harvesting decisions tend to favor relatively short timber stand rotation lengths.

IMPATIENCE BY OWNER TYPE

The owner’s impatience factor has been heuristically estimated as a response to the rate of macroeconomic inflation (0). Within the assumed macroeconomic inflation rate of 2.0%, forestland owner groups, detailed here, show an incremental decrease from the highest impatience factor troupe (TIMO), through all other named types to the lowest impatience factor group (federal forestland management). These rates are expressed in comparative context with recognition that any named category participant can be observed operating dissimilar to their named cast. These are stereotypical assignments of behaviour, but each decision is made one distinctive investor at a time.

Table 1. Investor impatience factor comparison when inflation is 2.0%/year.

Investor Type	Impatience Factor $(1 + f)$
Timber investment and management organizations	1.0250
State forestland management	1.0200
Non-industrial private forestland management	1.0150
Tribal nation forest management	1.0100
Federal forestland management	1.0075

Timber Investment and Management Organizations

As a group of investors, the TIMO's impatience factor for current consumption is the highest compared to other sellers in timber markets. TIMO businesses exercise decisions consistent with a high preference for current benefits over delayed returns (Hartwick and Olewiler 1998).

High impatience factor translates into purposefully aggressive management techniques. Oftentimes, this owner-cadre will favor relatively short harvest rotation lengths: when the value growth gets viewed as tipping the delicate balance between current and delayed benefits. This is heuristically determined to be at inflation rate times 1.25 (one and one quarter times the rate of inflation): 2.50% (0).

Using the approach identified in the denominator of 0, with the TIMO impatience rate, the rate of financial decay is 4.55% per year (0).

$$\frac{TIMO}{discount\ rate} = [(1.020)(1.025)]^n - 1 = 1.0455^n - 1 \quad (2)$$

or 4.55% annual rate of money decay.

The implied TIMO forestland investor, with a time-value of money discount rate of 4.55% per year will make timber harvest timing decisions using this guide.

State forestlands

States are publicly owned entities, and most state forestland management departments are formed under mandate to promote the value of public interests (Chasan 2000). These entities are closely linked to the need of generating revenue to fund schools (WaDNR 2021; Oregon Department of State Lands 2021). Simultaneously, they seek to promote job creation for industries within their state: logging operators, log truckers, lumber mills, shipping agents, foresters, and forest protection services. That emphasis on private sector job creation and tax revenue generation holds planning efforts to balance today's timber harvests with long-term sustainability of forests with wildlife, fisheries, and aesthetic considerations.

These state agencies, operating within these mandates, generally display their comparative impatience factor as being lower than their industrial forestry peers (0). State agency impatience factors act within the same context of the national economy, though generally set roughly on par with the macroeconomic inflation rate.

Using this 2.0% inflation example, state forestry management may operate with an impatience factor equal to 2.0% (0) times the inflation rate, or 4.04% per year (0).

$$\text{State forestry discount rate} = [(1.020)(1.020)]^{n} - 1 = 1.0404^{n} - 1 \quad (3)$$

or 4.04% annual rate of money decay.

States do not face the same financial obligations private and industrial forestland owners do. States pay no taxes for the properties they hold; they do not pay income taxes on the revenues they earn. The combined inflation rate and impatience factor generate a rate of monetary decay that justifies longer timber harvest rotation timing while also generating a continuous income flow.

Non-industrial private forestland owners

Private forestland ownership often comes with considerations of recreation through hunting or fishing, camping or aesthetics, non-timber forest products harvest, with thoughts of having "a natural and private place to be" (Majumdar et al. 2008). Non-industrial private forestland (NIPF) owners view non-commodity values to consider impacts on decisions associated with either spending time and money or receiving monetary gains from their activities (Markowski-Lindsay et al. 2016). Although not always revealed as monetary values, these considerations alter the effective personal discount rate in this context: NIPF impatience factor will normally be lower compared to their state and industrial cohorts.

A fundamental consideration that makes NIPF owners different is the responsibility to self-fund their activities: pay property purchase price, property taxes, conduct maintenance and protection. If landowners fail to support the costs of owning and managing the lands, they must subsidize the endeavor with revenue from other sources. Impatience factor within the NIPF cadre of owners appears highly variable.

NIPF impatience factor for monetary returns may be placed at three-quarters the rate of inflation. The example promulgated here (0), using 1.5% NIPF impatience factor (0), reveals a financial rate of monetary decay at 3.53% per year.

$$\begin{matrix}\text{NIPF}\\ \text{discount rate}\end{matrix} = [(1.020)(1.015)]^{\mathrm{n}} - 1 = 1.0353^{\mathrm{n}} - 1 \qquad (4)$$

or 3.53% annual rate of money decay.

With a 3.53% per year financial decay rate, NIPF timber harvest decisions will be targeted to longer rotation periods on each timber stand as compared to their already listed compatriots. NIPF owners often internalize the benefits of their investment to capture recreation, hunting or fishing, inter-generational asset transfers, and the pure enjoyment of owning forestlands. These values are not always articulated in dollars, they are priceless individual benefits of enjoyment.

Tribal forestland management

The history of forest management within tribal, indigenous people, and other aboriginal groups has cycled through tribal norms from time immemorial when a timber industry was not part of any economy (The American Indian Civics Project 1999; Pevar 2002), to times when European influences in North America initiated the conversion of forests into timber commodities (Prucha 1962; Library of Congress 2009). Across much of North America, since 1824 (Rice 2008; Buck 2008), aboriginal forestland management in the United States has been administered by the U.S. Department of the Interior, Bureau of Indian Affairs (Galloway 1995).

In the United States, Indian tribe forestland management experienced a watershed event with the US Supreme Court decision on Cobell, *et. al*, vs. Salazar (Secretary of the Interior) in 2010 (Cobell Settlement, 2010). All tribal allotment owners were offered payment by the US government for their share of fractionated interests in forest parcel allotments (Hall-Widdoss 2006), with the purchased forestland allotment title transferred to their tribal government.

Although economies-of-scale experienced by American Indian tribes/nations potentially means substantially increased financial returns on investments from tribal forest management departments, they also give new opportunities to fund non-timber related expenses such as improvements for fisheries habitat (Schlosser et al. 2011), mammalian territory expansion, culturally sensitive region protection, adaptogenic plant cultivation and propagation (Smith et al. 2002). Tribes have demonstrated adaptive financial return tradeoffs with culturally sensitive attributes achieved using forest management strategies (O'Brien 1989).

Indian tribes in this simplified stereotypic example, exercise economic impatience factors set within tradeoffs for financial capital, protection and expansion of culturally sensitive sites and plant communities, support of anadromous fisheries, and wildlife habitat augmentation. Although the impatience factor for economic returns is generally expressed as a rate lower than NIPF or state forestland owners, foregone resource gains in respect to other considerations could place it at much higher rates for specific purposes. The tribal impatience factor is estimated to be half the rate of inflation (0). In this example, with a demonstrative 2.0% inflation rate, the impatience factor may be 1.0%, and the resulting financial rate of decay would be 3.02% (0).

$$\begin{matrix}\text{Tribal nation}\\ \text{discount rate}\end{matrix} = [(1.020)(1.010)]^{n} - 1 = 1.0302^{n} - 1 \tag{5}$$

or 3.02% annual rate of money decay.

The projected 3.02% landowner rate of monetary time-value decay, as applied to forestry as macroeconomic inflation maintains at 2%, is realized with longer timber harvest rotation lengths than are normally seen with TIMO, state timberland management organizations, or the NIPF sector. Tribal forestry has demonstrated adaptive responses to achieve non-monetary goals through the management of their timberland resources (Wilkins 1997).

Federal forestland management

To extend this discussion to the federal forestland management sector, a national landowner collective outlook has been attempted. Management of federal forestlands in the USA has undergone a decisive change from earlier practices when timber harvesting on these lands used to be the primary source of rural jobs, lumber milling, and raw wood materials for the growing country (Ramage et al. 2017). Gifford Pinchot, the first Chief of the U.S. Forest Service, expressed his forest management paradigm as to "achieve the greatest good, for the greatest number in the long run" (Dana and Fairfax 1980; Clary 1986). For 75 years, that goal was consistently translated into jobs by harvesting timber, building roads, milling lumber, and supplying the raw lumber to erect houses and build the nation (Tobin 2013). People were put to work across several sectors and the greatest good was accomplished by harvesting timber from federal forests.

The shift in management focus revealed in the Pacific Northwest in 1990 with the listing of the Northern Spotted Owl (*Strix occidentalis caurina* Xántus 1859) as an endangered species (Fish and Wildlife Service 1990; USFS 2006). Federal forestlands in affected areas were removed from the leading status of timber suppliers, and the forest management paradigm shifted from its major focus on timber production to preservation of wildlife, fisheries, water quality, recreation, and aesthetics (Thomas et al. 1990; Sommers 2001; USFS 2005). Timber jobs and infrastructure development were greatly reduced, and so was the effective federal forest landowner's impatience factor based on transaction evidence approach estimates within the timber production realm (Levy, 1985).

The comparatively low impatience factor (0) is revealed as 0.75% times our example 2% inflation rate, to reveal a discount rate of 2.77% per year (0).

$$\begin{matrix}\text{Federal land}\\ \text{discount rate}\end{matrix} = [(1.02)(1.0075)]^{n} - 1 = 1.0277^{n} - 1 \qquad (6)$$

or 2.77% annual rate of money decay.

The projected 2.77% per year federal landowner financial discount rate serving as a response to situations mentioned could be the exemplified rate or even zero. Federal forestlands, under these conditions, are managed in a style comparable to national parks where there is no incentive to harvest timber for the sake of generating revenue or creating private sector jobs. National park forestland value is solely expressed in terms of non-monetary values for wildlife habitat, fisheries, water quality, aesthetics, and public opinion (Turner and Daily 2008). The time-value of money has been greatly reduced in importance for the federal forestland owner's timber harvest decision matrix.

DISCUSSION

Members of named forestland owner cadre, as discussed here, each view the financial management landscape from their unique perspectives. Through this approach, a forestland parcel is considered for its ability to generate financial value through the sale of timber products. All landowners in this scenario rely on the same biologic resource, but each comes with a differing time preference for money. This explains why open market competition for purchasing discrete forestland parcels occurs against the foreground of willing buyers entering purchase competitions with variable price points. Potential forestland buyers from a TIMO position may strategize with a relatively high discount rate, while the potential NIPF buyer may evaluate the same physical site, at the same time, using a comparatively lower rate. Their time-value of money approach defines their competitive property purchase reserve price (Rosenkranz and Schmitz 2007).

In all situations, timber harvest timing is only one characteristic to consider. Financial optimality must be comingled with non-monetary issues, taken one investor at a time.

Timber evaluated as a commodity

The Forest Resource Analysis System Software (FRASS) on-line demonstration site (D&D Larix 2023), featuring forestlands at the University of Washington's Pack Forest, in Pierce County, located on the west side of the Cascade Mountain range in the temperate forest biome (Smith and Smith 2012), was used to demonstrate time-value of money significance for driving timber harvest dates (0). This 15.78-hectare (39.0-acre) parcel contains seven (7) timber stands in various ages of development. Approximately 1.09 hectares of this parcel are represented by riparian zones, with 0.68-hectares located as open infrastructure (roads) taken out of commercial timber production consideration. This parcel has 15.10 hectares of forested lands, with 14.01 hectares considered as operable commercial timberland. All timber stands are dominated by Douglas-fir (DF) (Pesudotsuga menziesii var. menziesii (Mirb.) Franco) with other native timer species within this biome.

Table 2. Timber stand statistics (parcel 16N04E0416324016).

Stand ID number	Vegetation label	Site index (meters/feet)		Riparian zone hectares	Operable commercial timber land hectares	Total forested hectares on parcel
19008100	DF12	36.0	120	0.00	7.87	7.87
19008220	DF11	28.5	95	0.00	0.59	0.59
19808780	DF22	31.5	105	1.09	0.00	1.09
19838360	DF33	360.0	120	0.00	2.74	2.74
19899380	DF23	36.0	120	0.00	1.08	1.08
19899390	DF23	31.5	105	0.00	1.26	1.26
19969400	DF22	31.5	105	0.00	0.46	0.46
Totals:				**1.09**	**14.01**	**15.10**

The Forest Vegetation Simulator (FVS 2018) is used to project tree growth on this demonstration site. Site productivity is characterized by forestland site index (King 1966) measured on 50-year curves. Site index is a measure of soil productivity within the climate of the area (Burger and Kelting 1999), and is the average height, in feet and converted to meters for this analysis, that dominant and codominant trees of a given species grow in the specified number of years. The site index applies to fully stocked, even-aged, unmanaged stands.

Macroeconomic inflation rate for all portfolios was set at 2.0% per year. Monthly delivered log market prices were established through April 2021 within this marketing area (Puget Sound Delivered Log Market) and were combined with consistent costs for reforestation, road building, timber harvesting, log-trucking, timber harvest overhead and administration, and general management costs. The Real Price Appreciation (RPA) Forecast Tool (Schlosser 2020) was applied to all sort-and-grade price projections for this market area.

Property taxes were not levied for any of the landowner portfolios used here. Income taxes were not applied to the net revenues from periodic harvests scheduled. The only differentiating variable between portfolios is the impatience factor for each landowner class.

The FRASS approach

Highest and Best Use (HBU) is a financial performance metric used to describe the administration of an asset at its financially optimal management matrix (Brent and Steiner 2017). Determination of financial optimality is a requisite for standardized land appraisals in North America (USPAP, 2018) and Europe (IVCS 2017). This standard was redefined in the FRASS platform to determine timber harvest timing when attaining the forestland owner's financial optimality value and the corresponding timber harvest dates. One guiding metric of the FRASS Approach is identifying each landowner's impatience factor as a critical variable (Forest Econometrics 2023).

Biometric analysis

The FRASS Approach collects physical site conditions of tree species, size, age, and growth rates in each timber stand. These data are processed through forest biometric systems (FVS 2018) on each timber stand of each parcel. The timber stands are virtually grown to report periodic records for over 500 years. Multiple timber rotations of each timber stand are introduced broadening the analytical horizon to investigate multiple data connections into the future and their influence on financial optimality. Each data-dense array is compiled as a population distribution of tree records which are then virtually merchandised into log grades of each sort.

Economic market analysis

Delivered log market prices are analyzed for each sort and grade in the marketing area where properties are located. These data reveal real-price trends and cycles for each log sort and grade (Schlosser 2020). Real log prices are extrapolated into the future to match the dates of potential timber harvest events.

Multiple rotations

The Income Capitalization Approach (ICA), to determine the owner's asset value of forestland managed for timber production as the HBU, necessitates consideration of consecutive timber harvest rotations due to the transformative energy of time. The FRASS multi-faceted approach provides an extended and competent horizon for flexibility in timber management decisions. Time viewed here is a persistent variable applied to all calculations focused on variable lengths of each timber stand rotation, identifying the beginning of the second rotation, and all subsequent rotations after that. Pressure of time applied to the owner's decisions in the shape of fluctuating inflation, discount rates, costs, and potential revenues becomes explicative and convincing when articulated through NPV.

Current timber stand harvest characteristics are followed by the next timber stand as grown and merchandized at each 5-year period through the next 350-years. Finally, a third rotation is virtually projected to start after the second rotation is harvested. The third rotation value is determined using the Faustmann formula (Willassen 1998), also known as the Soil Expectation Value (SEV). It measures the NPV of perpetual timber production, following a constant rotation length and a constant silvicultural prescription. Analyses include over 3,500 possible value combinations per timber stand, with only one series acting as the true indicator of financial optimality, revealed as the HBU option.

The FRASS platform is used to consider financial optimality of each timber stand on this one 15.8-hectare parcel (0) using variability in the impatience factor parameters for each landowner type.

TIMO investors

Landowners of this commercial timberland management group may include vertically integrated operations holding timberlands and a lumber/pulp mill. These owners may be solely timberland management organizations strategizing harvest timing to fill domestic and international round-log demands. In some cases, these operations are closely held businesses, some are Subchapter-S Corporations. Others are publicly traded corporations competing for financial resources with all other financial rate of return opportunities.

Within the assumed macroeconomic inflation of 2.0% per year, the calculated economic discount rate is 4.55% per year (0). With this combination, ceteris paribus, timber harvest rotation timing tags comparatively short timber rotations (0). After the first rotation is harvested, each regenerated timber stand is harvested after 50 to 55 years. The perpetuity rotation lengths are found between 50 and 60 years on each timber stand. Rotation lengths are greatly influenced by each timber stand's site index (Appendix A).

Asset value determined through the ICA (USPAP 2018) combines all future revenue streams into a NPV total. This parcel nets $487,639, or $30,897/hectare. This would be the TIMO offer price breaking point for competitively bidding to purchase this parcel.

State forestland managers

As defined in this review, while macroeconomic inflation rate is 2.0%, state forestland management oversight will use the impatience factor of 4.04% time-value rate of money decay (0). When this discount rate is applied to this 15.78 hectare parcel, all other conditions held constant, timber harvest rotations extend to longer times, as compared to their TIMO associates (0).

The 2.0% impatience factor resulted in the same year of first timber stand harvest times on four of the timber stands, with timing delays of ten years on the other two. The second rotation timings alternated between the same periods until harvest, to an extension of 10 years. The final perpetuity rotations remained mostly the same, with two extending for an additional 10 years each.

The parcel value for the state forestland management operation is $587,418, or $37,219/hectare. This is approximately 17% higher than the TIMO owner's projected asset value.

NIPF investors

The NIPF class of investors has highly variable impatience factors. By ticking the discount rate down another half-point from the state forestland management organization, the NIPF 3.53% time-value of money decay is assumed (0). In this discounted cash flow prognosis (0), harvest timing was extended for between 5 and 10 years in each of the first, second, and third rotations. The resulting discounted cashflow for this ownership class is $761,120, or $48,225/hectare. This would be the NIPF reserve price breaking point for competitively bidding to purchase this parcel. This is approximately 56% higher than the TIMO investor's projected parcel bid price.

Tribe/tribal nation investors

Tribal forestland managers, when considered in the tribal/nation context, demonstrate a wide range of forestland ownership pressures, of which financial is oftentimes a secondary, albeit important consideration. The assumed impatience factor for this class is 3.02% time-value of money decay rate per year (0). This is 0.51 points lower than their NIPF associates, 1.02 points lower than their state compatriots, and 1.53 points lower than their TIMO competitors.

Given these guiding comparisons, timber harvest timing was extended by 5 to 20 years in each timber rotation as compared to their NIPF cohorts (0). Perpetuity rotation lengths were extended to 70 and 80 years each. Considering these financial controls, the discounted net present value of this parcel for the Tribal Nation is $1,067,716, or $67,651/hectare.

Federal forest managers

The supposed impatience factor for this forestland ownership class is 2.77% financial discount rate per year (0). This is 0.25 points lower than their Tribal Nation associates, and 1.78 points lower than their TIMO competitors.

Federal forestland managers in this scenario would harvest the current timber stands in the same years as their tribal nation compatriots, except for one (№19899390) which would be held for an additional 15 years. Most stands would be held for an additional 5 years each in the second rotation setting, with one held for an additional decade. The third rotation (into perpetuity) witnesses harvest entry extensions of 15, 20, and 25 years each, as compared to their Tribal Nation associates.

Considering these managerial controls, the discounted net present value of this parcel for the Federal Forestland ledger is $1,319,930, or $83,631/hectare (Appendix E)

Inflation as a variable

The range of the impatience factor variables discussed here is dictated in consideration of the macroeconomic measurements of inflation. As inflation rates tend to fluctuate, so will individual landowner rates of value decay, guided by each uniquely defined impatience factor. These cannot be viewed as static measurements of expectations for a rate of return; they change influenced via the interplay of macroeconomic forces.

Investors in these typical owner categories will perform their economic roles, one investor at a time. The example of the Tribe/Tribal Nation was cited, but it is critical for the analyst to understand the specific nature of ownership as separate tribal members may hold timberlands as individuals. That person may perform akin to a NIPF investor. At the same time, the Tribal Nation may parallel decisions made by a state, or the federal forestland management agency. Still, the Tribal Nation may closely follow the pattern by national parks, where no timber harvest is planned on certain parcels. At the same time, a Tribal Nation ownership behavior may reflect vertical integration of forestland ownership with a tribally owned commercial lumber mill. Financial decisions may reflect end market considerations for lumber in line with their timber harvest timing decisions.

An exceptionally low inflation rate experienced in the USA after the great recession (2007-09), pushed investors into an unfamiliar *terra incognito* landscape especially challenging for forestland owners who place their hopes on converting standing trees as a biologic resource into financially attractive timber commodities, realized as capital in a turbulent reality of economic upheavals. It is critical for investors to be in a position enabling them to adopt informed decisions, especially at times when the macroeconomic inflationary tendencies drift into unfamiliar territory. Pursuing forestland investment returns, they need to coalesce tree growth parameters into reasonably predicted financial revenues to form modes of profitability unique to each investor.

CONCLUSIONS

The impatience factor, the way it is introduced here, is incorporated into the paradigm of investor discount rate calculation as a time-value concept. Integrating biometrics into this paradigm implies weighing tree growth variations when formulating various scenarios to consider potential volume of timber through its estimated growth into higher value commodities as determined by physical site characteristics.

While appreciated by the forestland manager and investor, the concept of impatience factor as an expression of time-value, present unique challenges of comingled financial timing considerations. Short duration investors will forego some inherent risks such as wildfire loss, or even land use regulatory changes. However, these investors also forfeit higher valued timber commodities because of needed tree growth time. In any scenario, the impatience factor conditions the owner's navigation through these specifically identified pieces of a puzzle.

Forestland owners seeking longer timber harvest durations, made available because of their lower impatience factor, will trade earlier revenues for longer rotation lengths as trees grow into higher value class logs, thus delaying financial returns to define their time-value equilibrium zone.

Although we labeled a range of impatience factor categories for different types of forestland owners, in the big picture these labeling nuances appear inconsequential when delivering the message of how diversified forestland ownership and management options play out when articulating a unique investment profile. Forestland ownership, as an investment category, incorporates sciences of biometrics, econometrics, land use planning, marketing, and macroeconomics to financially optimize timber harvest timing through multiple rotations.

These all-encompassing determinations define the long-term profitability of each investor on each timberland site at specific points in time. This manuscript explains why several disparate investors approaching the same timber parcel, on the same day, will enter with different reserve prices for competitive bids to purchase the forestland parcel.

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CONFLICT OF INTERESTS

The author declares no conflict of interest.

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Appendix A. TIMO harvest value summary.

Stand Info		**Current Rotation**		**Next Rotation**		**Third Rotation Into Perpetuity**		**Total Present Value**	
Stand ID Number	Operable Commercial Timber Land Hectares	Harvest Year	Net Present Value	Rotation Length (years)	Net Present Value	Rotation Length	Soil Expectation Value (Present Value)	Stand Value	Value Per Hectare
19008100	7.87	2045	$210,644	50	$35,048	50	$16,961	$262,653	$33,369
19008220	0.59	2065	$6,701	55	$1,143	55	$495	$8,339	$14,018
19838360	2.74	2030	$112,103	50	$17,637	50	$8,535	$138,275	$50,545
19899380	1.08	2035	$25,629	50	$6,192	50	$2,996	$34,817	$32,102
19899390	1.26	2045	$25,080	55	$4,270	60	$2,007	$31,356	$24,834
19969400	0.46	2055	$10,423	55	$1,209	60	$568	$12,200	$26,679
Total Value based on Operable Commercial Timber Land Hectares:							**14.01**	**$487,640**	**$34,807**
Value per Hectare (Forested Hectares):							15.09		**$32,315**
Value per Hectrare (Entire Parcel):							15.78		**$30,902**
Bare Land Value (Entire Parcel SEV):							**15.78**	**$210,560**	**$13,343**

Appendix B. State harvest value summary.

Stand Info		**Current Rotation**		**Next Rotation**		**Third Rotation Into Perpetuity**		**Total Present Value**	
Stand ID Number	Operable Commercial Timber Land Hectares	Harvest Year	Net Present Value	Rotation Length (years)	Net Present Value	Rotation Length	Soil Expectation Value (Present Value)	Stand Value	Value Per Hectare
19008100	7.87	2045	$238,035	50	$50,576	60	$33,469	$322,080	$40,919
19008220	0.59	2065	$8,350	55	$1,863	65	$1,119	$11,332	$19,049
19838360	2.74	2040	$125,052	50	$19,402	60	$12,839	$157,293	$57,497
19899380	1.08	2045	$30,669	50	$6,980	60	$4,619	$42,268	$38,973
19899390	1.26	2045	$28,341	60	$6,798	60	$3,789	$38,929	$30,832
19969400	0.46	2055	$12,369	60	$2,021	60	$1,126	$15,516	$33,930
Total Value based on Operable Commercial Timber Land Hectares:							**14.01**	**$587,418**	**$41,928**
Value per Hectare (Forested Hectares):							**15.09**		**$38,928**
Value per Hectare (Entire Parcel):							**15.78**		**$37,225**
Bare Land Value (Entire Parcel SEV):							**15.78**	**$282,020**	**$17,872**

Appendix C. NIPF harvest value summary.

Stand Info		**Current Rotation**		**Next Rotation**		**Third Rotation Into Perpetuity**		**Total Present Value**	
Stand ID Number	Operable Commercial Timber Land Hectares	Harvest Year	Net Present Value	Rotation Length (years)	Net Present Value	Rotation Length	Soil Expectation Value (Present Value)	Stand Value	Value Per Hectare
19008100	7.87	2050	$284,683	65	$83,851	70	$51,875	$420,409	$53,411
19008220	0.59	2070	$10,932	55	$2,827	75	$2,537	$16,296	$27,393
19838360	2.74	2055	$153,718	65	$27,044	70	$16,731	$197,493	$72,192
19899380	1.08	2045	$34,678	65	$12,466	70	$7,713	$54,857	$50,580
19899390	1.26	2060	$36,218	60	$8,257	70	$6,768	$51,243	$40,585
19969400	0.46	2065	$15,767	60	$2,777	70	$2,277	$20,821	$45,531
Total Value based on Operable Commercial Timber Land Hectares:							**14.01**	**$761,120**	**$54,327**
Value per Hectare (Forested Hectares):							15.09		**$50,439**
Value per Hectare (Entire Parcel):							15.78		**$48,233**
Bare Land Value (Entire Parcel SEV):							**15.78**	**$398,601**	**$25,260**

Appendix D. Tribal nation harvest value summary.

Stand Info		**Current Rotation**		**Next Rotation**		**Third Rotation Into Perpetuity**		**Total Present Value**	
Stand ID Number	Operable Commercial Timber Land Hectares	Harvest Year	Net Present Value	Rotation Length (years)	Net Present Value	Rotation Length	Soil Expectation Value (Present Value)	Stand Value	Value Per Hectare
19008100	7.87	2050	$330,143	65	$134,045	70	$125,099	$589,287	$30,293
19008220	0.59	2075	$14,749	65	$5,160	75	$5,651	$25,560	$17,333
19838360	2.74	2065	$192,097	65	$40,117	70	$37,439	$269,653	$39,896
19899380	1.08	2045	$39,235	65	$19,443	70	$18,145	$76,824	$28,616
19899390	1.26	2065	$45,685	75	$15,738	80	$14,029	$75,453	$24,216
19969400	0.46	2090	$22,529	75	$4,447	80	$3,964	$30,940	$27,404
Total Value based on Operable Commercial Timber Land Hectares:							**14.01**	**$1,067,716**	**$76,211**
Value per Hectare (Forested Hectares):							15.09		**$70,757**
Value per Hectare (Entire Parcel):							15.78		**$67,663**
Bare Land Value (Entire Parcel SEV):							**15.78**	**$588,532**	**$37,296**

Appendix E. Federal forest management harvest value summary.

Stand Info		Current Rotation		Next Rotation		Third Rotation Into Perpetuity		Total Present Value	
Stand ID Number	Operable Commercial Timber Land Hectares	Harvest Year	Net Present Value	Rotation Length (years)	Net Present Value	Rotation Length	Soil Expectation Value (Present Value)	Stand Value	Value Per Hectare
19008100	7.87	2050	$355,624	70	$178,782	90	$190,319	$724,725	$92,074
19008220	0.59	2075	$16,903	75	$7,793	100	$9,149	$33,846	$56,895
19838360	2.74	2065	$214,761	70	$55,532	90	$59,116	$329,408	$120,412
19899380	1.08	2045	$41,743	70	$25,613	90	$27,265	$94,621	$87,244
19899390	1.26	2080	$56,555	80	$19,743	95	$20,651	$96,949	$76,784
19969400	0.46	2090	$26,797	80	$6,639	95	$6,945	$40,380	$88,302
Total Value based on Operable Commercial Timber Land Hectares:							**14.01**	**$1,319,930**	**$94,213.35**
Value per Hectare (Forested Hectares):							15.09		**$87,470.44**
Value per Hectare (Entire Parcel):							15.78		**$83,645.69**
Bare Land Value (Entire Parcel SEV):							**15.78**	**$727,769**	**$46,119.71**