Applying Modern Portfolio Theory to Timberland Allocation

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Abstract

Significant research has gone into developing models showing the appropriate mix of equity investments to optimize risk-adjusted returns. These optimal portfolios often have a mix of stocks, bonds, and cash. Increasingly, institutional investors are looking for other alternative investments to increase the return or lower the risk of their investment portfolios. Real estate assets, including timberland, are one of the asset classes that many institutional investors, particularly large pension funds, have used to improve their risk-adjusted returns. Due to low correlation between timberland investments and equity investments, timberland has a high probability of success in improving portfolio risk adjusted returns.

To gain insight into this issue, a Markowitz portfolio optimization technique was used to calculate the optimal mix of timber investments across geographies when mixed with traditional investments. The timberland asset class will be broken into three geographic components Pacific Northwest, Southeast, and Northeast. To compare the impacts addition of composite and regional timberland allocations, models were built using 1) equities only, 2) equities plus composite timberland returns, and 3) equities plus the three regional geographic timberland indices. A Markowitz portfolio optimization model was built using various combinations of these assets.

Keywords: timberland portfolio optimization, Markowitz, modern portfolio theory

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Introduction

Researchers and portfolio analysts have spent considerable effort developing models showing the appropriate mix of equity investments to optimize risk-adjusted returns. These optimal portfolios often have a mix of stocks, bonds, and cash, often including an international component used to reduce risk or boost returns. Increasingly, institutional investors are looking for other alternative investments to increase the return or lower the risk of their investment portfolios.

Timberland has been shown to have a low correlation with equities (Binkley et al 2001). As such, it is a good candidate for addition to an optimal portfolio to improve risk-adjusted returns. As stated by Markowitz (1952), "in trying to make variance small it is not enough to invest in many securities. It is necessary to avoid investing in securities with high covariances among themselves" Thus investments in timberland have a high probability for success in improving portfolio risk adjusted returns.

In addition, some research has shown that it improves overall portfolio returns in addition to reducing risk (Binkley et al 2001, Caulfield 1999). Most of the research published uses a single option for timberland investment (a composite timberland return). Little research has been published that shows the optimal mix of timberland investment across geographic areas of the United States. Caulfield (1999) states that, "Although research on timberland as a portfolio asset is potentially useful by TIMCOs for the construction of timberland portfolios, it is seldom employed to this end."

A Markowitz portfolio optimization technique was used to calculate the optimal mix of timber investments across geographies when mixed with traditional investments. The following asset classes were used 1) U.S. equities - Wilshire 5000 Total Return Index] and 2) Foreign equities [Morgan Stanley Europe Asia Far East Index –EAFE], 3) timberland. The timberland asset class is broken into three geographic components Pacific Northwest, Southeast, and Northeast. To compare the impacts addition of composite and regional timberland allocations, models were built using 1) equities only, 2) equities plus composite timberland returns, and 3) equities plus the three regional geographic timberland indices. A Markowitz portfolio optimization model was built using various combinations of these assets. The model was run for multiple iterations to create an efficient frontier. The capital market line was added and the optimal risk adjusted portfolio of traditional equities and geographic timberland investments were identified.

Data for the timberland asset classes will be obtained from the National Council of Real Estate Investment (NCREIF) Timberland Property Index. Data for this index is available quarterly back to 1987. However, the Northeast index values only start in 1994. In order to fully study the impact of regional timberland allocations the study looked at data from 1994 onward.

Methodology

Return data for U.S. timberland investments was obtained from the National Council of Real Estate Investment Fiduciaries (NCREIF). NCREIF produces a Timberland Property Index, which

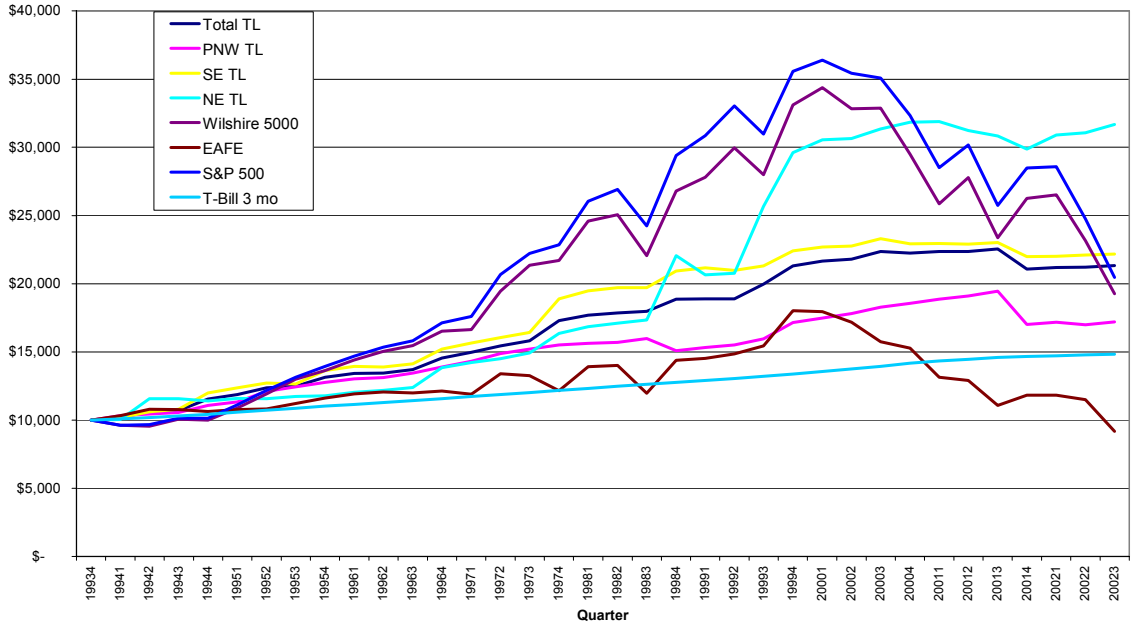
details quarterly performance results. This data includes a Total Timberland Index as well as three regional sub indices for Southeast, Pacific Northwest, and Northeast (NCREIF 2002).

Return data for U.S. stocks was derived from the Wilshire 5000 index. This index is the broadest index available for the U.S. equity market (Wilshire 2000). Quarterly returns with dividends reinvested were selected to match the return data for the NCREIF Timberland Property Index. For comparison purposes return data for the Standard & Poor's 500 Total Return Index was also obtained (Federal Reserve 2002).

Return data for international stocks was derived from the Morgan Stanley Europe Asia Far East Index. The MSCI EAFE Index is an unmanaged index of common stocks in Europe, Australasia and the Far East and includes dividends but is net of withholding taxes (Morgan Stanely 2002). To provide an estimate of the risk free rate for the same time period of analysis 3-month T-Bill rates were obtained (Federal Reserve 2002).

Recent equity and timberland performance has been quite variable. Equity asset values peaked in the first quarter of 2001 and have fallen substantially since that time (Exhibit 1). Similarly institutional timberland investments as evidenced by the NCREIF Timberland Property Index peaked between the first quarter of 2001 and the third quarter of 2001 depending on the region in question. Because of this recent behavior two different time periods were studied. The first period covers the 5-year period from first quarter 1994 through the fourth quarter 1998. The second period covers first quarter 1994 through third quarter 2002. The NCREIF Timberland Property Index covers the time period from first quarter 1987 through the present. However, the Northeast regional sub index is only available from first quarter 1994. Since the main purpose of this study is to look at the impact of regional allocations of timberland it was decided to start the analysis from this point.

Exhibit 1: Growth of $10,000 for Various Timber and Non-Timber Assets



Five Year Results

An analysis of the return over the 5-year period from January 1, 1994 through December 31, 1998 shows that the Wilshire 5000 index was the best performer of our mix of assets with a geometric mean return of 20.2%. This was followed by Northeast Timberland (16.1%), Southeast Timberland (15.0%), Total Timberland (12.9%), Pacific Northwest Timberland (8.3%), and the Morgan Stanley EAFE (7.3%). For comparison, the Standard & Poor's 500 Index outperformed all of these assets with a 22.2% geometric mean return and the 3-month T-Bill returned the least with a 4.9% geometric mean return.

While the timberland assets proved to under-performed the U.S. equity assets they did so with significantly less volatility. Standard deviations ranged from 2.3% for Pacific Northwest timberland to 6.7% for Northeast timberland with all except the Northeast falling below 3.8%. This compares favorably to the Wilshire 5000 Index and the Morgan Stanley EAFE both at 7.2%. This low volatility of returns is not surprising given the unique characteristics of institutional timberland investments. The biological nature of these timberland resources causes the total inventory, thus value of these resources to increase over time – breaking the return correlations (Whitaker et al, 1999).

One important aspect of timberland as an alternative asset class in a portfolio optimization framework is its low or negative correlation to other assets. As shown below (Exhibit 2) the NCREIF Total Timberland Index correlation with other assets varies from negative 0.03 (with the Morgan Stanley EAFE Index) to 0.13 (with the T-Bill). Pacific Northwest timberland has negative correlations (from –0.45 to –0.31) with all except the T-Bill (0.38). Southeast timberland correlation has a low of negative 0.06 (with Morgan the Stanley EAFE) to a positive 0.10 (with the T-Bill). Finally, the Northeast timberland has the highest correlations with traditional equity assets (varying 0.38 to 0.46) and a negative correlation with the T-Bill (-0.37). By comparison the correlations between the Wilshire 5000 and the other two equity assets is between 0.81 (Morgan Stanely EAFE) and 0.99 (Standard & Poor's 500). Thus, all of these timberland assets make excellent candidates for inclusion in an optimal portfolio due to their relatively low correlations and high return characteristics.

Exhibit 2: Performance Data for Timberland and Equity Assets - 1994 to 1998

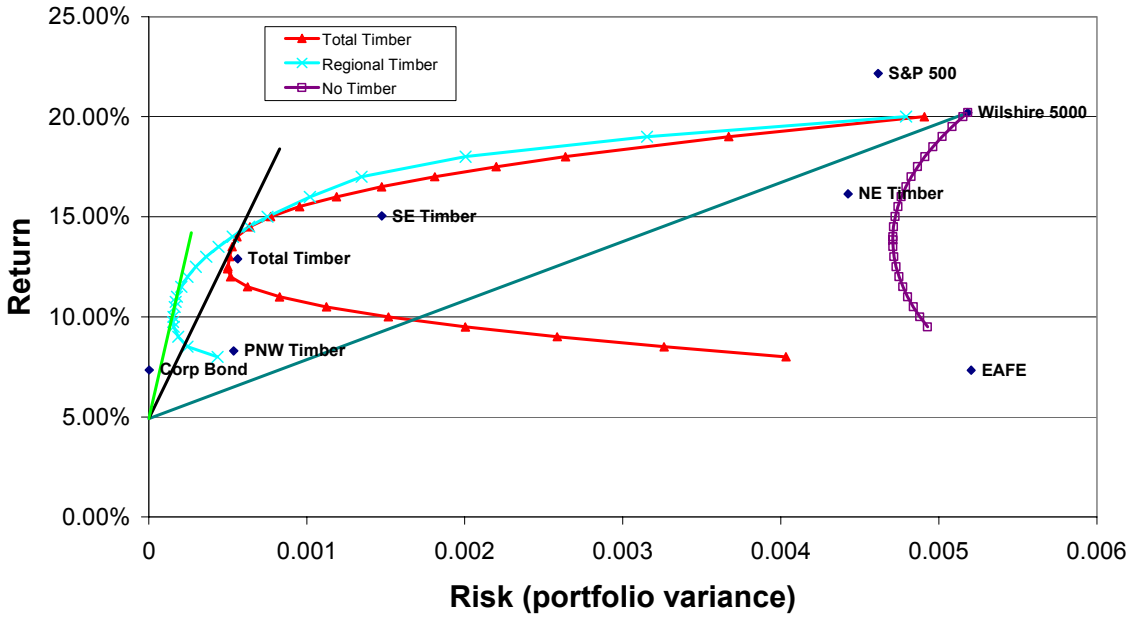
	Total TL	PNW TL	SE TL	NE TL	Wilshire 5000	EAFE	S&P 500	T-Bill 3 mo
Annual Return	12.9%	8.3%	15.0%	16.1%	20.2%	7.3%	22.2%	4.9%
Variance	0.0006	0.0005	0.0015	0.0044	0.0052	0.0052	0.0046	0.0000
Standard Deviation	2.4%	2.3%	3.8%	6.7%	7.2%	7.2%	6.8%	0.1%

Correlation Based on Quarterly Returns (1994.1 to 1998.4)

	Total TL	PNW TL	SE TL	NE TL	Wilshire 5000	EAFE	S&P 500	T-Bill 3 mo
Total TL	1.00							
PNW TL	0.15	1.00						
SE TL	0.97	0.03	1.00					
NE TL	0.32	(0.71)	0.33	1.00				
Wilshire 5000	0.08	(0.31)	0.03	0.38	1.00			
EAFE	(0.03)	(0.45)	(0.06)	0.46	0.81	1.00		
S&P 500	0.12	(0.32)	0.07	0.41	0.99	0.82	1.00	
T-Bill 3 mo	0.13	0.38	0.10	(0.37)	0.23	(0.20)	0.25	1.00

Given that the low correlations would make timberland a good candidate for inclusion in a portfolio, three cases are examined. First, a portfolio containing no timberland, second a portfolio containing the NCREIF Total Timberland Index, and third a portfolio excluding the Total Timberland Index but including the three NCREIF regional sub indices. In each case minimum variance portfolios were constructed across a range of required rates of return (Markowitz 1952). This "efficient frontier" of alternative portfolios provides the universe from which portfolio allocations should be made. Shown below are the results of this analysis (Exhibit 3). For comparison purposes the returns and volatility of the individual assets are included. The portfolio containing only equity assets provides an alternative with the highest overall returns. This portfolio also has the highest risk as measured by portfolio variance. Because of the extremely low correlations between these equity assets and the timberland returns, portfolios can be constructed that provide considerably better risk/return characteristics.

Exhibit 3: Minimum Variance Portfolios for Equity and Timber Investments - 1994 to 1998



The portfolio constructed using the Total Timberland Index has considerably less risk than the equity only portfolio. The minimum variance portfolio has a geometric mean return of 12.4% with a standard deviation of 2.23%. The portfolio constructed using the individual regional subindices yields a geometric mean return of 9.74% with a standard deviation of 1.24%.

Exhibit 4: Characteristics for Minimum Variance and Optimal Portfolios - 1994 to 1998

		No Timber	Total Timber	Regional Timber
Minimum Variance Porfolio	Return	13.84%	12.40%	9.74%
	Variance	0.0047	0.0005	0.0002
	Standard Deviation	6.86%	2.23%	1.24%
Optimal Portfolio	Return	20.20%	13.50%	10.75%
	Variance	0.0052	0.0005	0.0002
	Standard Deviation	7.20%	2.30%	1.30%
Optimal Portfolio Weights	Total TL	0%	90%	0%
	PNW TL	0%	0%	71%
	SE TL	0%	0%	2%
	NE TL	0%	0%	20%
	Wilshire 5000	100%	9%	6%
	EAFE	0%	1%	0%

The "separation principle" says that the investor can make two separate investment decisions. First, the investor selects the point on the efficient frontier at which to invest. Second the investor makes a choice of whether to leverage his investment to improve return by borrowing at the risk-free rate, or to reduce his risk by investing a portion of the investment in the risk-free asset (T-bills). Informed, risk adverse investors will buy a portfolio where the capital market line touches the efficient frontier since it provides the maximum return at the least amount of risk. Capital market line is formed using the geometric mean return for T-Bills (4.92%) over the same investment horizon and forming a line tangent to the efficient frontier. This tangency point is shown for each of the three investment portfolios and the optimal portfolio weights are indicated in Exhibit 4.

It can be seen from Exhibit 3 that for much of its length the efficient frontier formed with regional timberland allocations performs better than the one formed with the Total Timberland Index only. This implies that the total timberland index contains a sub optimal mix of timberland assets for optimal portfolios and would lead to incorrect decisions regarding optimal portfolio allocation. We observe this in the allocation example with allocation to the Total Timberland Index determined to be 90% but the sum of the more detailed allocations to the regional timberland sub indices totaling 94%.

Life of Index Results

Next we look at results over the life of the Northeast regional sub index (1994 through the third quarter 2002). Over this investment time frame the situation is quite different. Beginning in the first quarter of 2001 the equity indices fell quite spectacularly while the institutional timberland assets fell less dramatically. The geometric mean return for the NCREIF Total Timberland Index as well as most of the regional sub indices outperform our two equity investments the Wilshire 5000 and the Morgan Stanley EAFE Index as well as the benchmark Standard & Poor's 500 Total Return Index. However, the Pacific Northwest sub index is outperformed by the Wilshire 5000, and the S&P 500 Index.

Exhibit 5: Performance Data for Timberland and Equity Assets - 1994-Q1 to 2002-Q3

	Total TL	PNW TL	SE TL	NE TL	Wilshire 5000	EAFE	S&P 500	T-Bill 3 mo
Annual Return	8.8%	6.2%	9.2%	13.4%	7.6%	-1.0%	8.3%	4.5%
Variance	0.0008	0.0010	0.0013	0.0048	0.0087	0.0068	0.0079	0.0000
Standard Deviation	2.8%	3.2%	3.6%	6.9%	9.3%	8.3%	8.9%	0.3%

Correlation Based on Quarterly Returns (1994.1 to 2002.3)

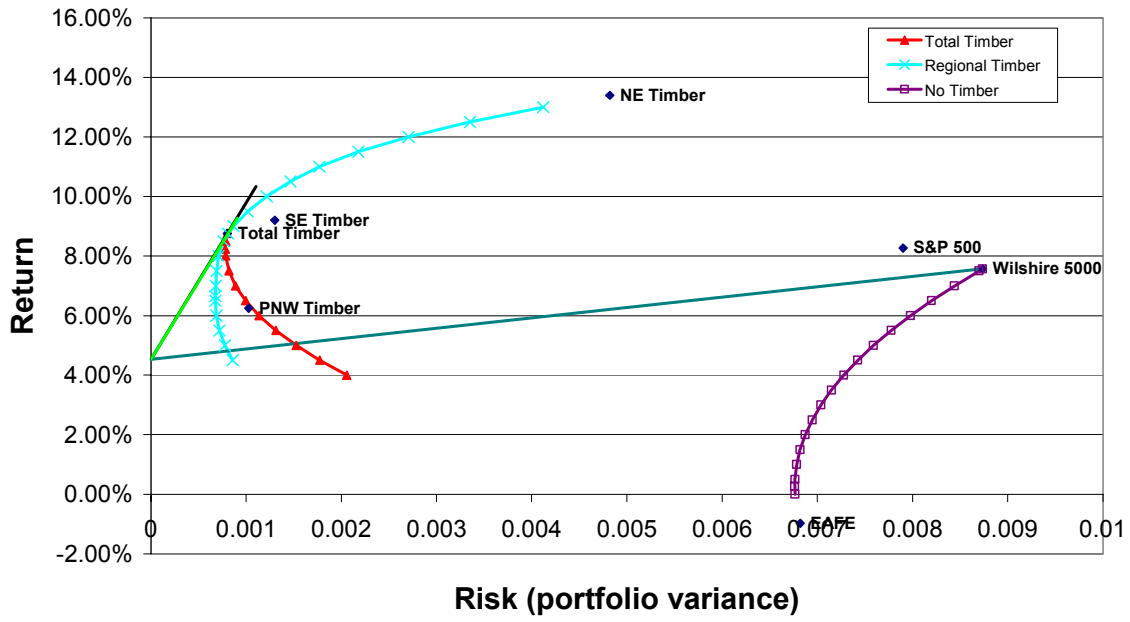
	Total TL	PNW TL	SE TL	NE TL	Wilshire 5000	EAFE	S&P 500	T-Bill 3 mo
Total TL	1.00							
PNW TL	0.60	1.00						
SE TL	0.91	0.35	1.00					
NE TL	0.53	(0.02)	0.38	1.00				
Wilshire 5000	0.19	(0.09)	0.21	0.24	1.00			
EAFE	0.19	(0.13)	0.14	0.44	0.83	1.00		
S&P 500	0.22	(0.08)	0.25	0.24	0.99	0.83	1.00	
T-Bill 3 mo	0.42	0.50	0.32	0.07	0.28	0.15	0.34	1.00

The standard deviation of returns also increased in almost every case. The one exception is the Southeast timberland sub index, which dropped from a standard deviation of 3.8% to 3.6%. The remainder increased by between 4% (Northeast timberland) to 38% (Pacific Northwest timberland) with the volatility of the equity indices increasing more on average than the timberland indices.

The other change in the data is that over this longer (almost 9 years) time frame the correlation between the timberland assets and the equity assets increased. While the correlations are higher they are still quite low and still provide diversification benefits. Shown below (Exhibit 6) are efficient frontiers for each set of investments. The inclusion of either the NCREIF Total Timberland Index, or the set of regional sub indices do prove to provide substantial diversification benefits. The investment portfolios that include timberland provide higher returns with significantly reduced risk. The all equity portfolio is *dominated* by the portfolio that includes combinations of the three timberland sub indices and the two equity indices.

It is also interesting to note that the portfolio that includes the NCREIF Total Timberland Index plus equities is *dominated* over its entire length except for the single point where the entire portfolio is comprised of timberland. This point is also the tangency point for the regional timber portfolio. This result is to be expected since the efficient market hypothesis would lead investors to select a mix of timberland investments that minimize portfolio variance in a mixed asset portfolio.

Exhibit 6: Minimum Variance Portfolios for Equity and Timber Investments – 1994-Q1 to 2002-Q3



The minimum variance portfolio for the mix of assets that include the NCREIF Total Timberland Index has a minimum variance where the portfolio consists of only timberland and provides a return of 8.23% with a standard deviation of 2.8%. The optimal portfolio for this mix of assets includes 100% timberland with the standard deviation increasing only to 2.83% while the return increases to 8.76%. This was determined as before by finding the tangency portfolio but this time using a revised risk free rate of 4.65% for this time interval.

The minimum variance portfolio that includes the regional timberland sub indices has a geometric mean return of 6.65% with a standard deviation of 2.6%. The optimal portfolio for this mix of assets returns 8.75% with a standard deviation of 2.85%. In stark contrast the minimum variance portfolio that includes no timberland returned only 0.27% and had a standard deviation over 3 times higher (8.22%). Similarly, the standard deviation of the optimal no timberland portfolio is over three times higher than the regional timberland mixed asset portfolio while providing a lower return (7.57% versus 8.75%).

Exhibit 7: Characteristics for Minimum Variance and Optimal Portfolios – 1994-Q1 to 2002-Q3

		No Timber	Total Timber	Regional Timber
Minimum Variance Porfolio	Return	0.27%	8.23%	6.65%
	Variance	0.0068	0.0008	0.0007
	Standard Deviation	8.22%	2.80%	2.60%
Optimal Portfolio	Return	7.57%	8.76%	8.75%
	Variance	0.0087	0.0008	0.0008
	Standard Deviation	9.35%	2.83%	2.85%
Optimal Portfolio Weights	Total TL	0%	100%	0%
	PNW TL	0%	0%	40%
	SE TL	0%	0%	38%
	NE TL	0%	0%	19%
	Wilshire 5000	100%	0%	3%
	EAFE	0%	0%	0%

As can be seen from Exhibit 7 above, the optimal regional timberland allocation totals 97%. This is made up of 40% Pacific Northwest timberland, 38% Southeast timberland, and 19% Northeast timberland. The remainder of the assets (3%) are allocated to the Wilshire 5000 Index.

On closer examination of the data that makes up the NCREIF Total Timberland Index and its sub indices we find that the mix of timberland investments reported in the index does not match the regional portfolio allocation derived here. The market value weighted components of the NCREIF index are $2,617.2 million Southeast (70%), $916.8 million Pacific Northwest (25%), and $203.4 million Northeast (5%).

Conclusions

It is clear from the examples provided that adding timberland to a portfolio of equity assets improves the risk return profile of the portfolio. It also points out the importance of portfolio rebalancing since the allocation to timberland, and the allocation to each regional timberland sub index changes depending on the time period selected.

Thomson (1997) studied the impacts of holding mixed asset portfolios containing timber over long time periods. Rather than using actual reported timberland returns he constructed theoretical timber return benchmarks for Douglas fir and Southern pine using historical timber prices. Results of this study showed that optimal timber allocation varied substantially period to period with timber allocations over 50% common in the 1943 to 1957 period (Thomson 1997). The allocation to Douglas fir and Southern pine also varied over time. This confirms the importance of portfolio rebalancing to match new risk and return expectations over time.

As discussed in Markowitz (1952), one "should combine statistical techniques and the judgment of practical men." No attempt to make adjust the variance or expected return values in this purely theoretical discussion. However, adjustments may be warranted. For example it is unlikely that the Morgan Stanley EAFE index will continue to produce negative results for the next 5 years. In addition, some issues exist with the use of quarterly NCREIF Timberland Property Index results. The NCREIF Timberland Property Index is an appraisal-based system. Since most appraisals happen at year-end the index may underestimate the true volatility of these timberland

investments (Lutz 2001, Lowery 2002). Use of these methods to determine actual portfolio allocations should take these issues into consideration.

The methods used here could be extended to provide insight into broader issues of portfolio allocation. To provide easy to understand insight into the timberland allocation issue only two non-timberland assets were included in the portfolio mix. This analysis could be extended to include more financial assets in the investment mix. For example, one could include various other standard equity U.S. indices (e.g. Russell 2000, Nasdaq Composite, S&P 500, S&P MidCap 400 Index, S&P SmallCap 600) as well as corporate or U.S. Treasury bonds. It could also include more diversity in the international exposure by including the Morgan Stanley Emerging Markets Free Index, or by including various country indices (e.g. FTSE 100, Nikkei 225, Hang Seng, Xetra Dax, Cac 40, TSE 300). Including these other equity indices would more closely match the investment universe of the institutional investor and provide more insight into the appropriate regional timberland and non-timber portfolio allocations.

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