Timber Inventory Uncertainty: Impact on Property Valuation

by Sam Radcliffe, Vice President

The value of a forest property is obviously heavily dependent on the volume and value of the property's standing timber. Most people familiar with the timberland space understand that timber inventory estimates have a certain amount of uncertainty associated with them. But appraisals are often read by non-technical users who assume that the reported timber volumes are empirical facts. Even seasoned users who know better often accept inventory estimates without question because, although imperfect, "they're the best numbers we have". These same seasoned users also may not understand completely the various sources of timber inventory uncertainty, or to what extent that uncertainty impacts property value estimates. The following is meant to provide a more complete understanding of how timber inventory estimates are made, why they are uncertain, and how that uncertainty affects property valuations.

The Inventory Process

Although timber inventory processes can vary a great deal, the "stratified random sample" is a common approach. The essential elements of this process are:

- The property is mapped to determine its total acreage and the acreage of each of several "strata". Strata are normally defined by timber types, e.g. spruce/fir sawtimber, northern hardwood poletimber, etc. Defining timber type attributes can include dominant species, tree size class, stand density, physiography, etc.
- A sampling design is developed, detailing the size of sample lots, the field measurements to be made, measurement techniques, coding, etc.
- An estimate is made of the total number of sample plots required, and the number of plots to be allocated to each stratum. The objective in this exercise is to minimize the "sampling error", to be discussed below. If the purpose of the inventory is to value the property, the objective might be to minimize the sampling error on the highest valuedproducts, which might result in disproportionately more sample plots being allocated to sawtimber strata.
- The target plots are laid out on the map. While this is treated as a random sample, for operational efficiency the plots are often laid out in a systematic fashion, i.e. on a grid.
- Armed with the GPS coordinates of each plot, timber cruisers navigate to each plot and make the prescribed measurements. Although timber volume is ultimately the variable of interest, it cannot be measured directly. Rather, tree diameters and heights aremeasured to indicate the fundamental geometry of the tree, which will ultimately be converted to a volume estimate. It is typical to measure or estimate multiple diameters and heights for a sample tree in order to identify the different timber products (sawlogs, pulp sticks, etc.) the tree could produce.
- Aside from the individual tree measurements, variables such as site quality, stand age, regeneration conditions, etc. are typically measured or observed before the cruisers move on to the next plot.
- The field measurements are converted to product volumes for each tree, which are then expanded to per acre, per stratum and per property total volumes. The conversion to product volumes depends on a volume model that can take many forms, such as volume tables, geometric functions, regression formulas, etc. The volume model should have been specified in the sampling design so as to assure that conforming tree measurements would be made. The expansion of individual tree volumes to the property as a whole depends on the acreage estimates for the sample strata.

Sources of Uncertainty

Many complicating details have been left out of this description. Suffice it to say that any process with this many moving parts will produce estimates that are not 100% accurate. The three general classes of error in a forest inventory include: sampling error, measurement error, and prediction error.

Unfortunately only one of these sources of error is readily measurable and commonly reported: the sampling error. As a statistical process, the inventory produces estimates of sample means, and each mean has an associated standard deviation from which the sampling error can be computed. The sampling error has two components: a confidence interval and a probability. The sampling error is often expressed as a percentage around the mean (confidence interval) at a given probability, e.g. "the average volume is 20 cords per acre + 10% at the 90% probability level."

107 Court St. Bangor, ME 04401
www.prentissandcarlisle.com

Translated: if the forest were repeatedly sampled, the resulting mean volume would be between 18 and 22 cords per acre 9 times out of ten. Note that the sampling error is random, dependent on the natural variation within the forest population, as well as the size of the sample. The other sources of error can be more problematic in that they can systematically introduce a bias to the inventory estimates.

Measurement error results when the measured and reported value (e.g. diameter) differs from the true value. Measurement error that results from a poorly calibrated instrument or a consistently incorrect application of procedures (e.g. always measuring diameter too high on the tree) will result in bias. It is the belief (or hope!) of many foresters that other measurement errors are random and therefore offset one another. Measurement error is difficult to identify and correct; most often inventory audits as a form of quality control are employed.

Prediction error is probably the least recognized and most insidious form of error. In my experience this is often the cause of wide discrepancies that are sometimes observed between two independent inventories of the same property. Prediction error originates in the volume models that are used to convert tree measurements to volume estimates and in the growth models that are used to update an older inventory.

It should first be recognized that the models themselves are usually constructed using sample data and so are subject to the normal sampling and measurement errors. Then statistical techniques, such as regression analysis, might be applied that produces further random error. So the model as constructed contains inherent uncertainty that contributes to prediction error.

The inherent uncertainty in the model is amplified if the population on which the model is based differs from the population currently being sampled. Tree geometry varies by site quality, age, stand density, species, topography, etc. A volume model that is not multi-variate will predict the volume of the average tree over a wide region, which may not fit the specific forest being inventoried.

Volume models require precisely defined inputs, e.g. "height to a 3.5 inch diameter inside bark". Prediction error can be generated when the model receives input other than that for which it is calibrated, e.g. "height to a 4 inch diameter outside bark", resulting in erroneous volume estimates. This sort of mix-up often occurs as a result of measurement error, when the cruiser measures trees according to market specs rather than the intended specs of the volume model. Of course this mismatch between inventory specs and market specs raises other issues in the context of valuation, which will be discussed below.

Often a current inventory is not available – the most recent fieldwork may have been conducted a year ago, or as many as 10 years ago. In that case the old field-generated inventory must be updated for growth and harvest that took place during the interim period. The growth model suffers all of the same prediction error problems as the volume model, but with the growth model these errors get compounded each year of the projection period. Harvest volumes used to update inventories are not sample-based and are not modeled – they are usually a 100% enumeration of the volumes that were removed. They are subject to measurement error (e.g. bad mill scale) and again the market specs for products may not be the same as the inventory specs, causing an "apples and oranges" problem when adding growth and subtracting harvest.

Uses of the Inventory Appraisal

Now that the reader has been persuaded to forever look at inventory estimates with a jaundiced eye, the bad news – the appraiser is often handed an inventory that suffers to varying degrees from all of these levels of uncertainty. How does that uncertainty work its way into the estimate of total property value?

One of the fundamental tasks in timberland appraisal is calculation of the property's Gross Timber Value (GTV, also referred to as Timber Capital Value). GTV is simply the retail value of the property's current standing timber. It is estimated by multiplying current inventory estimates by current market stumpage prices. Care must be taken that the prices and inventory volumes are on the same volumetric basis. For example, in the Lake States, pulpwood is commonly sold by the "100-inch cord" which is approximately 4% more volume than a standard cord. In the case where the inventory is reported in standard cords, either the inventory or the prices should be adjusted downward before calculating GTV.

Given the uncertainty surrounding inventory estimates, and the further difficulty of estimating market stumpage prices for a variety of products, even under the best conditions GTV estimates should be considered to have an "uncertainty range[1]" of at least ±10-20%.

GTV plays a role in all three of the standard appraisal approaches used in valuing timberland: cost, comparable sales, and income. Each approach produces an indicated value and the appraiser reconciles these values to develop a final estimate of market value. In the cost approach, total property value is indicated directly as a multiple of GTV. For example, in the Lake States, investment grade properties often sell in the range of 60-80% of their GTV.

Assuming a GTV uncertainty range of ±15% and a timber value multiplier (TVM)[2] of 70%, the property value indicated by the cost approach has an uncertainty range of approximately ±10% (.15 X .70).

107 Court St. Bangor, ME 04401
www.prentissandcarlisle.com

In the comparable sales approach, the subject property is compared to other sold properties for a variety of attributes, one of which is timber value indicated by GTV. If the subject property contains greater (less) timber value than a comparable sale, then the comparable's price is adjusted upward (downward). One formulation of the adjustment amount is [(subject GTV/ acre – comparable GTV/Acre) X TVM]. If it is assumed that (1) the comparable GTV is its "true" value, and (2) there are no other adjustments to be made, then it can be shown that the uncertainty range of the indicated subject property value is the same as the uncertainty range around the GTV estimate, i.e. ±10-20%. If the assumption regarding the comparable GTV is relaxed, the uncertainty range around the indicated value could be much wider.

The income approach is based on a discounted cash flow model where cash flows are projected for a finite period (typically 10-30 years), and a reversion value is estimated in the final year of the projection. The reversion value and all of the annual cash flows are discounted to the present at a risk-adjusted discount rate[3] for timberland. Importantly, the reversion value is often estimated using a cost approach which depends directly on the final year estimate of GTV. Typically the largest cash flow stream in a timberland DCF is the timber harvest revenue. Timber inventory, growth and harvest are projected throughout the period using some form of model that is subject to prediction error. A simple DCF model illustrates the impact on net present value of uncertainty in the inventory and growth estimates. Here are the features of our model:

- 15 year projection
- 5% discount rate
- Constant real prices
- Uncertainty range on initial inventory of +15%
- Annual growth equal to 3% of inventory, with a uncertainty range of ±15% (2.55% - 3.45%)
- Harvest equal to 90% of growth
- Annual expenses starting at 25% of stumpage and remaining fixed throughout the projection
- A Timber Value Multiplier of 70% on the reversion value

This simple model results in an approximate ±20% uncertainty range around the indicated property value from the income approach. The interval widens as the uncertainty around the initial inventory and growth estimates increases, but it changes little in response to changes in the discount rate, harvest rate, expense rate or Timber Value Multiplier.

In summary, the typical error levels present in timber inventory and growth estimates can by themselves lead to a measurable uncertainty in appraised property values. Some simple valuation model exercises using realistic assumptions resulted in the following approximate uncertainty ranges on indicated property values by the three standard appraisal approaches:

Cost: ±10%
Comparable Sales: ±15%
Income: ±20%

Conclusions

The income approach generates the highest uncertainty because of the "magic of compounding". The cost approach generates the least uncertainty because only a portion of the inventory value predicts property value.

Most users of timberland appraisals understand that they are complicated analyses that depend on many market factors, assumptions and appraiser judgment. Many think that the timber inventory is a firm bedrock that provides some comfort in the face of all of those uncertain market elements. To the contrary, we have shown that even "good" inventories by themselves create significant uncertainty in the final appraised values.

This is not to suggest that timberland appraisals are worthless or should be abandoned. They are after all based on "the best information available" in most instances. But we offer these suggestions and best practices for appraisers and appraisal users:

- The timberland appraiser should have some field inventory experience, but more importantly should have or be able to draw upon the expertise required to "look under the hood" of inventory estimates. Often, some of the problems with inventory estimates can be corrected by re-processing field data, but this is not a minor undertaking.
- A timberland appraisal report should, at a minimum, summarize the source of the inventory estimates and provide some opinion on their adequacy. If the inventory sampling errors are available, they should be reported.
- In almost every appraisal, the assumed accuracy of the inventory should be stated as an Extraordinary Assumption[4].
- The quality of the forest inventory should be a consideration in selection of the discount rate for the income approach. Cash flows that are dependent on a more uncertain inventory should be discounted more steeply. Note that this will not narrow the uncertainty range on a percentage basis, but by lowering the net present value it will narrow the absolute uncertainty range.
- Upon engagement, appraisers should reserve the right to withdraw from an assignment if the condition of the inventory is such that it could lead to a misleading estimate of property value.

107 Court St. Bangor, ME 04401
www.prentissandcarlisle.com

- Appraisal clients must understand the nature and impact of inventory uncertainty. Many readers of an appraisal would be surprised to learn that simply because of inventory uncertainty the appraised value could have a 10-20% uncertainty range.
- Institutional investors, lenders, and asset managers should have clear guidelines regarding the minimum inventory requirements for valuation.
- The value uncertainty should be explicitly considered in deciding whether the cost of a fresh inventory is justified during acquisition due diligence.
- Given the unavoidable uncertainty in timberland appraisals, appraisal clients should consider whether the appraised value ought to be stated as a range rather than a point estimate. A follow-on to this would be reconsideration of acquisition and lending guidelines that are appraisal-driven. Perhaps a concept such as "Reliable Minimum Estimate" as used in statistics could be adopted for valuation.

---

[1] As used here, the term "uncertainty range" is analogous to a statistical confidence interval, but it includes not only the sampling error but also the estimated impact of other error types.

[2] The Timber Value Multiplier was described in our 2010 Q2 newsletter. Please contact sjradcliffe@prentissandcarlisle.com for a copy.

[3] The timberland discount rate was discussed in our 2013 Q2 newsletter, available at http://prentissandcarlisle.com/assets/PCnwslttr_2QTR-13.pdf

[4] From USPAP: Extraordinary Assumption: an assumption, directly related to a specific assignment, as of the effective date of the assignment results, which, if found to be false, could alter the appraiser's opinions or conclusions.

Comment: Extraordinary assumptions presume as fact otherwise uncertain information about physical, legal, or economic characteristics of the subject property; or about conditions external to the property, such as market conditions or trends; or about the integrity of data used in an analysis.

Learn more about P&C at http://www.prentissandcarlisle.com

Subscribe to our Timberland Investing News Feed at: http://scoop.it/t/timber-invest

This report is intended to be an unbiased and accurate source of information on timber markets and timberland investments. However, timber market conditions and the forest products industry vary greatly within and across regions and depend on a substantial number of factors that this publication does not cover. Therefore, anyone using information published in this report for any specific purpose, sale or contract does so at his or her own risk. Information included in this report and provided by other sources is believed to be reliable and accurate. Prentiss & Carlisle assumes no responsibility for errors or omissions.

107 Court St. Bangor, ME 04401
www.prentissandcarlisle.com