CTLA Trunk Formula Costs Compared to Direct Costs: Data, Guidance, and Reasonableness

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Abstract

This article explores conceptual associations, CTLA guidance, and empirical real cost data within the context of the relationship between trunk formulas and real direct costs. Two CTLA trunk formulas are compared to real direct cost data within a cost approach of tree appraisal. The relevance and associations of trunk formulas to direct costs are explored. The conceptual associations that are explored pertain to reasonableness and guidance within the *Guide for Plant Appraisal*, produced by the Council of Tree and Plant Appraisers (CTLA).

Introduction

The presumed correlation of a strong relationship between trunk formulas (Trunk Formula Method and Trunk Formula Technique) and direct (acquisition) costs of trees has been a foundational assumption of tree appraisal which has not previously been examined in the literature. Trunk formulas have been included in all editions of the *Guide for Plant Appraisal* (the GPA) authored by the Council of Tree and Landscape Appraisers (CTLA) and previously by the International Shade Tree Committee (ISTC) and National Arborist Association (NAA). The formulas may be used as a surrogate calculation in tree appraisal to develop costs based on the assumption that extrapolating the unit cost of a nursery plant is directly proportional to the actual acquisition cost of a larger tree (CTLA 2019, p. 57). The prevailing historical conjecture among many older consulting arborists is that trunk formulas were developed and tested as "reasonable" against actual costs to transplant large trees. However, no documentation is available to refute or confirm this, which is another impetus for this research, data collection, and analysis.

Tree appraisal is the process of estimating the monetary value of trees. This article is limited to cost approaches. Costs are data, values are opinions. Cost approaches use cost data as a basis to estimate value. Trunk formulas, Trunk Formula Method (TFM) and Trunk Formula Technique (TFT), are commonly used within the cost approach. These two formulas were examined, specifically how they relate to direct costs. Other approaches, methods, and techniques exist for valuing trees; however, they are not within the scope of this article. Cost may be depreciated by various factors to reflect the appraiser's opinion of value. When the appraised tree is of a size commonly available from a nursery, nursery tree cost data may be used as a basis to estimate value. When the appraised tree is larger than commonly available nursery trees, trunk formulas are often used to develop a Reproduction or Replacement Cost.

Trunk formulas were developed in the early 1900's (Stone 1916, Felt 1929). These formulas, and current formulas, use the per square inch cost of diameter, or basic unit cost, of a commonly available nursery tree and extrapolate that cost for larger diameters to arrive at a basic cost (CTLA 2019, p. 54) which is used by the appraiser to estimate value. Trunk formulas may be used as a surrogate for direct cost when actual costs are not readily available.

Trunk formulas have been used in all editions of the *Guide for Plant Appraisal.* The 8th and 9th editions (CTLA 1992 and 2000) used Trunk Formula Method (TFM), which allowed for the use of wholesale, retail, or installed unit costs. TFM included depreciation factors of Species, Condition, and Location. TFM was used to develop a "Replacement Cost," the cost to duplicate or replicate the appraised tree.

The 10th Edition (CTLA 2019) made several changes and renamed 9th Edition Methods into three methods: Repair, Reproduction, and Functional Replacement. The Repair Method is outside the scope of this article. Reproduction and Functional Replacement Methods can use either direct cost or extrapolation techniques to arrive at a basic cost (CTLA 2019, p. 54). The 10th Edition introduced Direct Cost Technique (DCT), Cost Compounding Technique (CCT), and Trunk Formula Technique (TFT). The 10th Edition of the *Guide for Plant Appraisal* defines Direct Cost to be the acquisition cost of a larger tree with all costs associated with the project (CTLA 2019, p. 53, 56-57). Cost Compounding will not be discussed in this analysis.

TFT replaced TFM in the 10th Edition of the *Guide*. Functional Replacement Cost partially replaced the Cost of Cure Method. Depreciation factors of condition, functional limitations, and external limitations may be applied using TFT. The 10th Edition (p. 58) "advises against extrapolating planting [installation] and additional costs when applying TFT because of the weak relationship between those costs for a nursery tree and for a much larger tree." The installation cost is added at the end of the calculation in TFT as an additional cost, not extrapolated with the cost of the plant as within TFM.

TFT can be used to develop either a Reproduction Cost or a Functional Replacement Cost (p. 54, 57-58). Functional Replacement costs are represented as a replacement of functional utility/benefits with something different, usually less than the original, resulting in implicit depreciation.

Approaches, methods, and techniques do not create value, but rather help the appraiser arrive at an opinion of value through a systematic process. When the appraisal problem and scope is similar, the ability to arrive at numeric values within a small range may exist within the same Assignment, Approach, and Method even when utilizing different techniques or methods. This process of using different techniques or methods to arrive at similar numeric cost values can be part of the reconciliation process to ensure reasonable and credible results.

This article explores the relationships between the development of various cost methods and techniques within tree appraisal. Cost approach valuations are opinions based on cost data. The transition from a cost to an opinion of value is not part of the scope of this paper. The application of depreciation is a methodology to reduce cost to an opinion of value. When depreciation is added, costs transition to an opinion of value. All calculations in this paper do not apply depreciation to ensure costs are comparable and devoid of opinion.

Objectives

The primary objective of this article is to compare trunk formulas with direct costs and determine if the data shows a strong or weak correlation for the use of these formulas as a surrogate calculation for direct costs. This article will examine the empirical evidence and analyze the data regarding the use of trunk formulas (TFM Installed Cost and TFT Installed Cost) as a surrogate calculation to determine if they are comparable to the acquisition cost of a larger tree as described in the *Guide*.

A secondary objective is to compare the results of the trunk formulas and direct cost data to assumptions and guidance within the 10th Edition of the *Guide for Plant Appraisal* to ascertain if they correlate. The assumptions and guidance examined are:

- Is it conceptually and empirically sound to extrapolate planting costs when applying trunk formulas?
- Can the cost of a nursery tree reliably be scaled to the cost of a large tree and conversely is the cost to acquire a large tree proportional to a nursery tree?
- Is the relationship strong or weak between those extrapolated costs for a nursery tree and for a much larger tree?

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- Do trunk formulas undervalue trees less than 10 inches and does the use of trunk formulas result in "unrealistically high" values for trees over 30 inches?

A third objective is to further examine the use of trunk formulas as a surrogate calculation and determine if the relationship to direct costs is strong enough to support and validate results of trunk formulas to deem them as reasonable and credible to be used as a "reasonableness test." The *Guide for Plant Appraisal* 10th Ed. (CTLA 2019) spends several pages discussing the need for appraisals to be reasonable and credible (p. 109-112); however, the *Guide* lacks guidance on reasonableness testing within the cost approach to value; market approaches, concepts and values are primarily discussed (p. 4, 109-112). The *Guide* states that "reconciliation brings together and resolves disparate indications of value or cost into a conclusion" (p. 105). The Guide further defines reconciliation as the 5th Step in the Tree Appraisal Process and "when necessary, is the final step in developing the assignment result." (p. 26). The *Guide* also states that "Plant appraisers should strive to produce reasonable and credible work products." (p. 109).

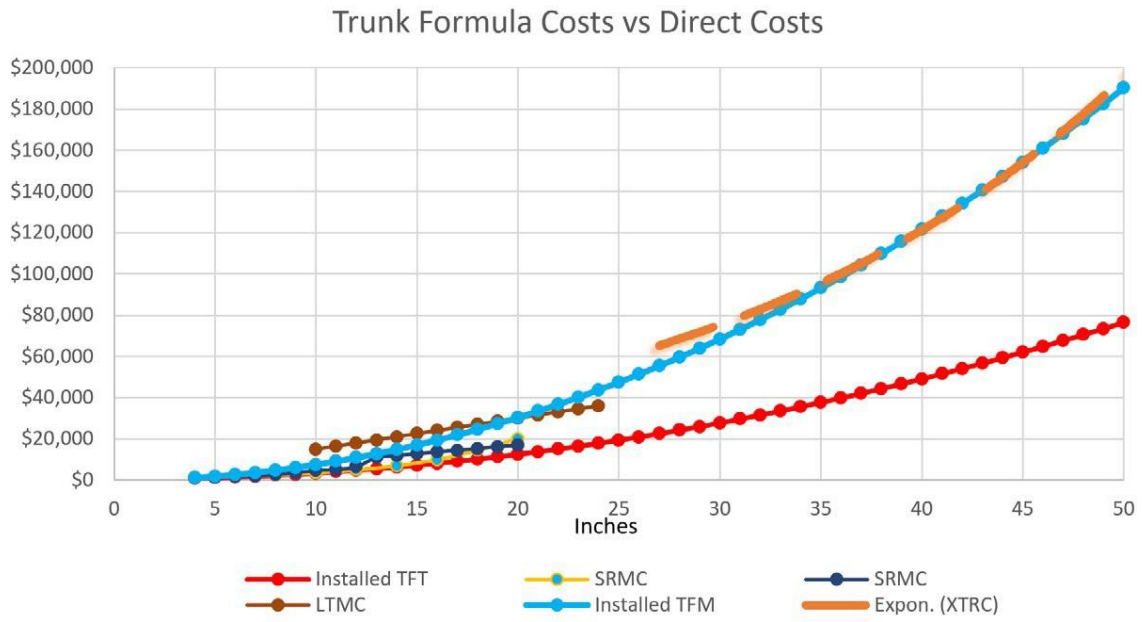
Methods

Tree installation cost data was gathered from various sources nationally (USA) including tree spade companies, large tree movers, and publicly available information. For the purposes of this study, a large tree was considered to be greater than 4 inches in diameter at dbh, and would require various mechanized equipment to move and install. Installed direct cost data from 4 to 50 inches diameter at breast height (DBH) range was gathered and analyzed. The tree installation shown in the following graph, include:

- Spade Tree Reproduction Cost (STRC – Yellow and Dark Blue dotted lines) was the cost to acquire and install a new tree with 55-100" truck mounted tree spades. The change in slope of the blue line is due to an increase in cost due to an increase in spade sizes.

- Large Tree Move Cost (LTMC – Brown dotted line) was the cost to acquire and transplant a new tree by digging and boxing prior to moving.

- Extra-Large Tree Relocation Cost (XTRC – Orange dashed line) was the cost to relocate trees from 27" to 90" DBH with specialized and heavy equipment using various techniques, commonly referred to as "Mega Moves".



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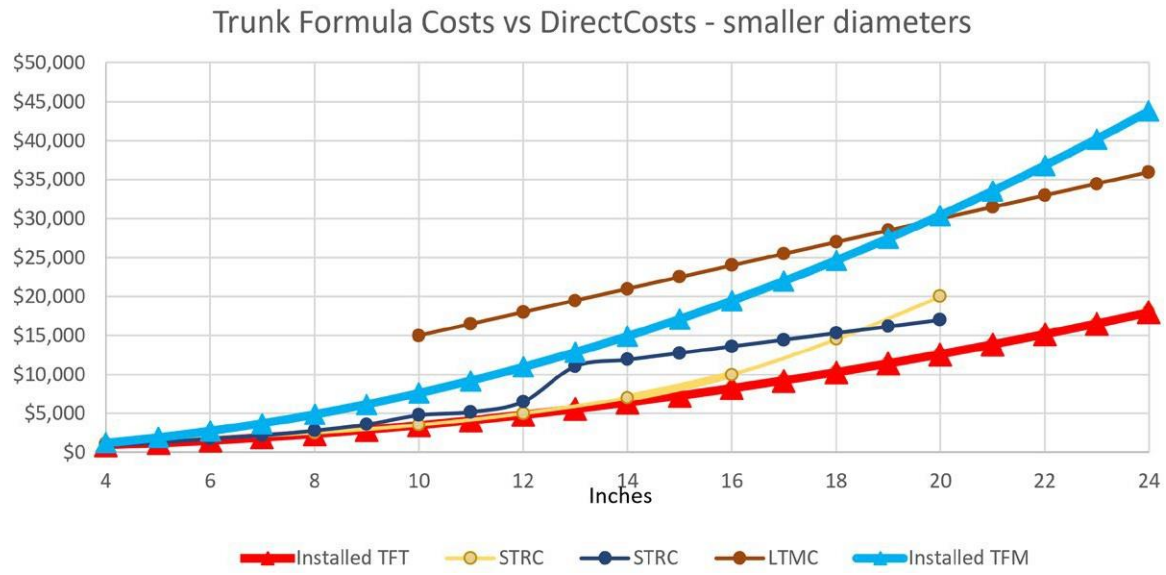

All distances were local and did not require extensive traffic control, long hauls, or any unique situations. The graph, data lines, and the trendlines were created by a computational mathematician to best fit the data as this was outside the author's professional purview. The trendline of Extra-large Tree Replacement Move Cost (XTRC) was plotted using the formula Y=76.067X2 - 0.0134x -0.0331. The graphs were calculated using individual series of data to develop exponential trendlines. Exponential trendlines are used when data contains all positive numbers of a real variable and can either fall or rise along the trendline. Exponential in this case does not refer to exponentiation or the repeated multiplication of numbers.

The direct cost data for smaller trees (<=24" DBH) includes the cost to acquire, move, and install a new tree. The direct cost data for larger trees (>=24" DBH) included the cost to move and install a tree of that size. Post-transplant care and establishment costs were not included in the cost data, and it is assumed that the cost data are lower than "all costs associated with the project" (CTLA 2020, p. 57). Therefore, it is assumed that the cost data is underestimated, and represents a minimum cost.

Trunk formulas were calculated using the average unit cost of several common species in the *Species Ratings and Appraisal Factors Guide* (RMC-ISA 2011) for the Largest Commonly Available Nursery Tree (LCANT) which was a 3" caliper tree at a purchase cost of $274.00 with an installation cost of $411.00. Trunk formula calculations were made for every whole number diameter in the range of 4-50" DBH. The trunk formula data sets included TFM Installed Cost using the installed tree cost divided by trunk area to arrive at a unit cost, which resulted in $96.9 per sq. inch (Installed TFM – light blue line) and TFT Installed Cost, in which the planting cost of the smaller tree was added in at the last step and used a sq. inch cost of $36.76 (Installed TFT – red line). TFM wholesale cost (uninstalled) was not used in the data sets, however of note, it matched very closely to the TFT number set. No depreciation was applied (all depreciation factors or limitations were rated at 100%).

Results

The TFM Installed Cost data (light blue line) was slightly higher than the direct cost of smaller trees (STRC - Dark blue & yellow line), with that difference increasing as the diameter increased to 20 inches. TFM and TFT Installed Cost was lower than the cost to purchase, move, and install (LTMC – brown line) boxed trees ranging from 10 to 20 inches in diameter; TFM Installed Cost became higher from 20 to 24 inches in diameter. A gap in direct cost data exists between 24 and 27 inches in diameter, however it can be assumed these costs are higher that TFM or TFT as the required equipment to move these sizes does not substantially differ from

moving trees 27 to 30 inches in which the direct cost is higher than TFM Installed Costs. The TFM Installed Cost correlation was unexpectedly robust within the Extra-Large Tree Relocation Costs (XTRC- orange dashed line) above 30 inches in diameter.

TFT Installed Costs (red line) showed a strong relationship with tree reproduction cost data below 10 inches in diameter. TFT Installed Costs resulted in lower costs than the direct cost data in all but the smallest diameters. At larger diameters, TFT Installed Cost numbers (red line) were roughly 60% lower compared to TFM Installed Cost (light blue line) and the Extra-Large Tree Relocation Cost (XTRC – orange line) within the range of 30" to 50" DBH.

Discussion of Data Results

When a reproduction or replacement cost is sought, direct costs or extrapolation (trunk formulas) can be used to arrive at a basic cost. Methods and techniques do not make, create, or define value, they only provide a systematic process, a calculation, for an appraiser to use as a basis to form an opinion of value. A similar replacement or reproduction cost may be attainable using different costs and within various techniques and methods as well as different approaches. Similarities in resultant costs allow the appraiser to bring together and resolve disparate indications of cost or value through the reconciliation process during the formation of an opinion of value.

If the cost results of replacing or reproducing the tree are similar using direct cost data and trunk formula calculations, then those costs may appear more credible if a strong correlation exists between the two results. The stronger the correlation of two calculation results, especially within a reconciliation process, the more reasonable and credible the result may appear to be. If the two results cannot be reconciled after "reviewing the data, methods, and calculations" (CTLA 2019, p. 30) then a problem may exist. However, different definitions of value may, and usually do, produce differing results which would not result in a correlation of dissimilar calculations.

A fundamental assumption of trunk formulas is that they may be used as surrogate calculation in which the direct cost of a large tree can be estimated by calculating the extrapolation of nursery cost data when large tree acquisition data is unavailable. The data presented and analyzed in this paper shows a very strong correlation between all diameters of direct costs of extra-large tree data (dashed orange line) and TFM Installed Cost (light blue line). TFM Installed costs trend slightly higher than actual costs among the smaller diameters, however, the ability to depreciate down to value is always present, except within the data for large, boxed trees (brown line). TFT Installed Costs (red line) results are lower than TFM across the whole range of diameters and approximately 60% lower in extra-large tree direct costs (dashed orange line) greater than 30 inches.

The data shows a weak relationship comparing direct tree costs to TFT Installed Cost (red line) in all categories excepting the smallest diameter trees and does appear to validate it's use as a surrogate calculation to direct cost of a large tree due to the significantly lower resultant numeric costs, which are more significant in the extra-large tree diameters. Although TFT does not correspond to large tree direct costs within this data set, it is not to be inferred that TFT does not produce representative costs of the extrapolation of nursery tree costs or other costs.

Neither TFM Installed (light blue line) nor TFT Installed Costs (red line) were substantially lower than direct costs in diameters less than 10 DBH nor did either TFM or TFT Installed Costs result in higher numeric results in extra-large trees.

TFM Installed Cost provided the strongest correlation to direct cost across the range of costs examined in this paper, especially in larger trees (>27" DBH), in fact the correlation was surprising to the author when the computational mathematician presented the graph. TFT Installed Cost data showed a weak relationship to actual direct cost, except in smallest tree cost data (<14" DBH) and resulted in significantly lower (~60%) cost results for extra-large tree sizes.

The application of depreciation can reduce cost results downward to arrive at the appraiser's estimate of value. Some have criticized the high variation between the valuations produced by tree appraisers (Watson 2001). It is the appraiser's judgement on when and how to apply depreciation as value is an opinion. Professional opinions may vary widely, especially based on knowledge and experience, therefore differing opinions are not conceptually problematic. The development of differing costs may be reflective of different defined values, approaches, methods or techniques, which also are not conceptually problematic. Reducing the range of costs by not allowing for the extrapolation of installation costs may reduce the high variation of valuations produced by appraisers to some degree; however, it presents a conceptual problem related to the assumption within trunk formulas that extrapolating the unit cost of a nursery plant is directly proportional to the actual acquisition cost of a larger tree (CTLA 2019, p. 57) as seen within the data. Disallowing the extrapolation of installation costs within TFT results in a lower basic cost and may be nonrepresentative of acquisition costs and may restrict the appraiser range of reasonable costs from which an opinion of value is derived. Variation of valuations may better be reduced through training and education rather than restrictive formulas.

Another conceptual problem for tree appraisers is when basic cost cannot be adjusted upward to value such as in situations discussed by Cullen (2002). TFT Installed Costs were significantly lower than direct costs in most of the diameter range examined. Therefore, it would be mathematically impossible for the appraiser to arrive at a similar reproduction or replacement value as direct cost using TFT without an upward allowance or applying depreciation over 100% as discussed in the Cullen article. This conceptual problem would also present itself within the reconciliation process to an appraiser comparing cost results derived from direct cost and TFT. It is important to recognize that this conceptual assumption may only apply when relating trunk formulas to direct cost values and not to other definitions of value.

Discussion of 10th Edition Appraisal Assumptions and Guidance

The 10th Edition defines Reproduction Cost as "the cost to replicate or duplicate the item being appraised. Generally, this means estimating the cost of replacing the landscape item with one that is close to identical (i.e., the same species or brand, size, shape, and condition) and thereby providing all or most of the characteristics and benefits of the original" (CTLA 2019, p. 55). Additionally, the Guide states "where the appraiser is asked to estimate the cost of replacing a tree or restoring a site to some previous condition or utility, it may be appropriate to use cost methods without particular regard for market value or transactional behavior" (CTLA 2019, p. 12).

Trees that are attached to the land on a property (the usual situation of a tree being appraised) are not reproduced or functionally replaced unless they are installed at the site, which includes all costs including delivery, planting, warranty, and reasonable profit. Aftercare or establishment costs may or may not be included. The 10th Edition includes these costs in the Direct Cost Technique (CTLA 2019, p. 56) and the Cost Compounding Technique (CTLA 2019, p. 59). Trunk Formula Technique (CTLA 2019, p. 57) allows these costs to be added after extrapolation. The 9th Edition (CTLA 2019, p. 58) allowed these costs to be incorporated within the basic unit cost (cost/sq. in.) and extrapolated.

The 10th Edition (p.58) "advises against extrapolating planting and additional costs when applying TFT because of the weak relationship between these costs for a nursery tree and for a much larger tree." Trunk formulas are used to calculate a reproduction or replacement cost. The 10th Edition defines reproduction cost as "the cost to replicate or duplicate the item being appraised" (CTLA 2019, p. 55). When trunk formulas are used within a reproduction or replacement methodology it has been recognized as conceptionally sound and part of the acquisition cost to include installation costs when trunk formulas are used as surrogate calculation to estimate direct cost. DCT allows for installation costs to be included in the calculation. The inclusion of similar costs within trunk formulas may be required to arrive at similar cost estimates and to be conceptually sound between the two methodologies/techniques.

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The 10th Edition advises against extrapolation of planting costs based on a weak relationship between the extrapolation of a planted nursery tree and a much larger tree but does not provide any citations or reference for this guidance. The larger tree must be planted to be reproduced or replaced and planting costs are "an inherent and indispensable part of the total cost" (Cullen 2023) and are not an additional or optional cost when replacing or reproducing a tree in a landscape. Using the cost to plant a smaller tree may present further conceptual problems when the larger tree is being reproduced or replaced, especially if the implied depreciation is not described.

This conceptual complication of not extrapolating planting costs is also apparent if an appraiser attempts to arrive at similar reproduction or replacement cost as DCT using TFT. It may not be achievable and was not achievable within this data set. Similar cost results may be achieved using TFM. While Approaches, Methods, and Techniques cannot make value, conceptual problems may present themselves if the appraiser is numerically restricted when attempting to arrive at a conceptually sound and reconcilable replacement or reproduction estimate of cost which correlates to direct cost.

All recent editions of the *Guide* often confused trunk formula costs and values, especially related to trunk formula calculations, and expressed concern that installed and direct costs might overstate resulting appraised values. Trunk formula calculations result in a cost estimate derived from data, not a value result. Value is an opinion of worth. The 9th Edition states "the value of the trees based on trunk areas with diameters less than 10 in. (25cm) was often less than the cost of replacement. It is assumed value in this statement was more appropriately a "cost result." Conversely, for trees greater than 30 in. (75cm), tree values based on trunk area became unrealistically high" (p. 36). This latter statement stems from an article written by Chadwick (1975) regarding recommendations for improvements to the *Guide*. Chadwick stated that the number of trees over 40 inches in diameter appraisers "would be called upon to evaluate or appraise would be very small" and the "values now established for such trees by the present I.S.T.C. shade tree evaluation formula often become rather unrealistic" (Chadwick 1975). It is unclear how this statement of "rather unrealistic" has come to be interpreted as "unrealistically high" in various published sources especially as Chadwick did not clarify if trunk formulas became unrealistically high or low. He further recommended "to leave the evaluation to the good judgement of the experienced arborist or professional horticulturist." The data analyzed within this data set provided empirical evidence that neither trunk formula resulted in significantly lower values (costs) than the direct cost of replacement in trees less than 10 inches nor did the values (costs) result in "unrealistically high" costs of trees larger than 30 inches. If these costs are depreciated, the numeric values may be significantly lower than direct costs thereby negating this assumption.

The 10th Edition states TFT is "based on an assumption that the cost of a nursery tree can be reliably scaled to the cost of a large tree. In many situations, this lacks empirical basis." and "An underlying inference is that the cost to acquire a large plant is directly proportional to the unit cost of the nursery plant" (p. 57). Additionally, the 10th Edition states "The CTLA advises against extrapolating planting and additional costs when applying TFT because of the weak relationship between those costs for a nursery tree and for a much larger tree." (CTLA 2019, pg. 58). This data set supports the assumption and inference of a weak relationship between TFT and the acquisition costs of a much larger tree, TFT results in a significantly lower cost result. The TFM data supports the assumption that the cost of a nursery tree can be reliably scaled to the acquisition cost of a large tree. The data shows the extrapolation of installation costs within TFM results in similar costs to the direct acquisition costs of large trees.

When planting and other costs are not extrapolated, the resulting basic cost is significantly reduced. A low numeric basic cost in trunk formulas can present real and conceptual problems for appraisers appraising trees. Appraisers have had concerns regarding low basic cost and have asked if depreciation factors could be rated above 100% (Cullen 2002). Advising against extrapolating planting and additional costs in trunk formulas restricts the scalability of nursery tree costs in large tree appraisal. When planting and additional costs are included while estimating cost using trunk formulas the cost estimate is more reliably scalable to approach

parity with direct acquisition costs. When the extrapolation of planting and additional costs are not included, it creates a lower basic cost which may be unrelated to direct cost.

Discussion of Reasonableness

The *Guide* states that "reconciliation brings together and resolves disparate indications of value or cost into a conclusion" (p. 105). The strong correlation of TFM to direct costs shows that disparate indications of cost within the data are minimal between these results. This correlation provides validation of the scalability of the cost of a nursery tree through formulaic extrapolation to be proportional to the acquisition cost of a larger tree. TFT did not show a strong correlation with direct costs and did not provide evidence of reliable scalability, additionally the disparate costs may affect the ability to reconcile the results when comparing the two. Due to this lack of a strong correlation, disparate costs, and divergent trendlines within the cost data, it can be interpreted as a lack of scalability in costs, thus TFT cannot be validated as a surrogate calculation for direct costs within this data set.

Appraisers may use two or more methods or techniques when appraising trees. Comparing the results of different methods and techniques can provide a "reasonableness test" within the final step of the tree appraisal process, reconciliation, to produce reasonable and credible estimates of value. In this same way, actual direct costs of large trees can be used as a reasonableness test to validate basic cost of large tree trunk formulas. The correlation of TFM and direct costs in this data set validates TFM as a reasonable and credible surrogate calculation for the acquisition costs of a large tree while that correlation is weaker within TFT which resulted in significantly lower cost results compared to direct cost.

Direct costs may present a logical, empirical, and sensible reasonableness test for trunk formulas when a correlation exists. The robustness of this correlation improves accuracy and credibility when "supported by relevant data and sound analyses" (p. 109). Additional cost data will further improve and perhaps redefine this correlation. Direct costs may be used as a reasonableness test for trunk formulas within the reconciliation process. When the cost data show a correlation and when reconciled against each other it can be used as a reasonableness test to ensure the result is both reasonable and credible. However, if the cost results are disparate then it may be the result of differing types of defined value or an inconsistency in the data, process, calculation, or some other factor. Results of trunk formula cost and actual direct cost may not or need not to always correlate. However, when they correlate strongly such as when using a trunk formula as a surrogate to direct cost it may be used to support the reconciliation process.

Conclusion

TFM Installed Cost showed a correlation to direct (acquisition) cost within this data set. As a result of the correlation within this data set, TFM may be considered a valid surrogate to direct cost data when appraising large trees for reproduction or replacement cost within a cost approach to value when market values or transactional behavior are not considered as part of the appraisal problem. TFM provides a sound conceptual and data supported basis for the foundational assumption of trunk formulas that the nursery cost of a tree can be reliability scaled up to the cost of a larger tree and correlates with direct costs of large tree acquisition. TFT installed cost had a very weak (significantly lower) relationship with, and did not correlate to, the actual direct cost data it is assumed to represent within the scalability of the cost of a nursery tree to the acquisition cost of a larger tree. It should not be inferred that TFT does not accurately represent an extrapolated cost estimate of a nursery tree to some other larger tree cost, only that there is a weak association with direct acquisition cost.

Extrapolating installation costs provides a conceptually and empirically sound methodology when using trunk formulas to estimate the acquisition cost of a larger tree from nursery tree cost data when acquisition costs are unavailable. A reproduction or replacement tree must be installed on site, whether real or conceptual, and planting costs may not be considered an additional or optional cost. Cullen provides an argument that they are "an inherent and indispensable part of the total cost" (Cullen 2023). When using trunk formulas as a surrogate calculation to estimate the cost of a large tree acquisition, extrapolation of planting and additional costs may be

needed to arrive at a similar cost as direct cost. Adding the cost to plant a nursery tree after the extrapolation of the unit nursery tree cost does not correlate to the basic cost of the acquisition of a larger tree within this data set.

This correlation of the extrapolation of nursery tree costs and for the acquisition cost of a larger tree is a fundamental assumption of trunk formulas in which the "cost of a nursery tree can be reliably scaled to the cost of a larger tree" and the inference that "the cost to acquire a large plant is directly proportional to the unit cost of the nursery plant." If a correlation does not exist, the conceptual foundation of trunk formulas as a surrogate calculation to estimate direct costs when data is unavailable breaks down. Furthermore, if the extrapolation of installation costs is not performed, the cost of acquisition (direct cost) may be unattained, especially when using TFT. This presents another conceptual problem; if the basic cost of TFT is lower than and not representative of acquisition cost, the appraiser has no upward allowance to apply when using TFT as a surrogate calculation.

The 10th Edition does not recommend installation costs to be extrapolated within TFT due to "the weak relationship between these costs for a nursery tree and for a much larger tree" (CTLA 2019 p. 58). This relationship is confirmed in the data, as the data shows TFT cost results become significantly lower (approximately 60% lower) in large tree data compared to direct costs. However, the data does confirm the assumption that "the cost of a nursery tree can be reliably scaled to the cost of a large tree" within TFM while TFT does not appear to reliably scale the cost a nursery tree to the acquisition cost of a large tree. The assumption of a "weak relationship between those costs for a nursery tree and for a much larger tree" is not supported in this data for TFM but is supported for TFT.

Reconciliation is Step 5 of the Tree Appraisal Process in the *Guide*. Using two methods or techniques provides the appraiser a reasonableness test within the reconciliation step which is the final step in developing the assignment result. The *Guide* provides guidance that tree appraisals be "supported by relevant data and sound analyses" (p. 109). The *Guide* states that "reconciliation brings together and resolves disparate indications of value or cost into a conclusion" (p. 105). The results of the data support the use of TFM as a surrogate calculation to direct cost due to the strong correlation of trendlines to arrive at a reasonable and credible reproduction or replacement cost estimate. The strong correlation of trendlines provides similar indications of cost and thus provides a credible and reliable process for the basis of reconciliation. The relationship within this data set between direct costs and TFM is strong enough to support and validate the use of TFM as a surrogate calculation to estimate the direct (acquisition) cost of larger trees due to the extrapolation of installation costs. As a result of this strong relationship and lack of disparate costs results, direct costs may be used as a reasonableness test for TFM when estimating basic cost to produce a reasonable, logical, and credible result. TFT, lacking the extrapolation of installation costs, did not show a strong correlation to direct costs and TFT's use as a surrogate calculation for direct cost of large trees is not supported within the data due to the disparate cost results.

It is not to be inferred that TFT is not reasonable, nor does it result in a less logical or credible result. The result of TFT calculations may be applicable to different appraisal questions other than that of a surrogate calculation for acquisition costs of a large tree. TFT results in a different cost result which may not correlate to direct cost of large trees but rather to the cost result of the extrapolation of a nursery tree cost or other definitions of value.

Final Notes

The author strongly encourages additional research, data collection, and analysis of similar cost data to develop more extensive data sets. Additional research will bolster the empirical evidence to provide a more solid basis of support for current usage and future changes to CTLA trunk formulas, if needed, as well as creating a more robust "reasonableness test" for trunk formula usage. The author also recommends CTLA re-examine guidance provided in the *Guide* and to provide data and/or citations to support any future guidance and recommendations. The *Guide* provides guidance while stating a "lack of empirical evidence" in many instances

and then provides specific guidance without citing data. The empirical evidence in this paper and others can support future CTLA guidance with relevant data and sound analyses to ensure assumptions and guidance are conceptually tested.

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