ECONOMIC ANALYSIS OF URBAN TREE REPLACEMENT DECISIONS

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Abstract. Urban forest managers often are required to make decisions about whether to retain or replace an existing tree. In part, this decision relies on an economic analysis of the benefits and costs of the alternatives. This paper presents an economic methodology that helps address the tree replacement problem. The procedures apply to analyzing the benefits and costs of existing trees as well as future replacement trees. A case study, involving a diseased American elm (*Ulmus americana*) is used to illustrate an application of the methodology. The procedures should prove useful in developing economic guides for tree replacement/retention decisions.

Key Words. Benefits; costs; tree removals.

A critical decision facing urban foresters, arborists, and planners involves deciding when an existing tree should be removed and replaced with a new planting. Tree removal decisions are often based on an evaluation of the tree's health and condition as well as safety concerns. A tree may be retained, but normally this requires a tree maintenance program and the expenditure of financial resources.

The decision to replace or retain an urban tree, for example, one with some health or structural problems, often comes under close public review, and urban foresters are frequently asked to provide detailed information that supports the decision. Many times this justification centers on an evaluation of the physical condition of the tree. While the physical characteristics are certainly important, a more comprehensive evaluation of whether the tree should be replaced or retained involves an analysis of the financial benefits and costs. Urban foresters and arborists could benefit greatly from having an economic procedure to evaluate and justify tree replacement versus retention decisions. This paper illustrates an easily applied economic methodology for assisting urban tree managers in making such decisions.

MEASURING THE BENEFITS OF URBAN TREES

The monetary benefits of urban trees are difficult to quantify because the trees provide numerous private benefits as well as public or social benefits (Miller 1997). For example, private benefits of urban trees can include enhancement of real-estate values, the tree's wood value, and climate modification that helps reduce a homeowner's heating or cooling expenses (Heisler 1986). The public benefits can include improved aesthetics (Dwyer and Schroeder 1993), reducing a community's noise and air pollution problems (Reethof and McDaniel 1978; Rowntree 1989), and enhancing biodiversity. Obviously there are a wide range of both public and private benefits, most of which are difficult to measure in physical terms, and usually even more difficult to evaluate in terms of dollars. The valuation of benefits associated with a particular tree is complicated because each specific tree has a different situation that causes benefits to vary from tree to tree (for example, a tree located in a city park versus a tree located on a home owner's property).

A number of studies have measured the physical contribution of urban trees in reducing house heating and cooling needs (Heisler 1986; McPherson and Rowntree 1993), air pollution (Akabari et al. 1992; McPherson and Nowak 1993), soil erosion (Rowntree 1989), and noise pollution (Cook 1978; Reethof and McDaniel 1978). Some studies have attempted to value these types of benefits using the impact the trees have on real-estate values (Weicher and Zerbst 1973; Li and Brown 1980; Anderson and Cordell 1988; Dwyer 1991). Other studies, such as Dwyer et al. (1989), use contingent valuation techniques (Loomis 1993) to measure the public's willingness to pay for urban trees located in park settings.

While these studies of urban forests are useful and have merit in describing physical and economic benefits in general terms, for the most part they cannot be directly applied to accurately estimate these values for a specific tree replacement or maintenance program, particularly because each tree's situation is different. Further, the difficulty and time and effort in applying these valuation techniques (e.g., contingent valuation) on a case-by-case basis make their use impractical.

The Council of Tree and Landscape Appraisers (CTLA) has developed a guide and formula approach to calculate individual tree values or benefits, *the Guide for Plant Appraisal* (CTLA 1992). This replacement-cost–based approach has been applied for some time and is generally accepted as a means to appraise trees for insurance claim cases and for tree casualty losses as defined by the Internal Revenue Service. The value has been used to estimate fair and just compensation for loss of a real property asset—trees. While the technique cannot account for all the indirect benefits of urban trees, it does attempt, as much as possible, to consider both private and public benefits of urban trees (McPherson 1992). For example, recently the CTLA formula was used to estimate the aesthetic benefits of trees in a cost-benefit analysis of a biological control program (Jetter et al. 1997).

The CTLA approach is relatively easy to apply. The approach calculates a basic value for the tree then modifies this value given the tree's species, location, and condition. The condition adjustment accounts for the health, structural integrity, and environmental degradation aspects in determining the tree's value. The location factor attempts to account for the different private and public benefits of the tree. For example, a higher percentage location rating would be assigned to a tree whose shade reduces air-conditioning energy use for a privately owned building or to a tree that provides significant public amenity and aesthetic benefits in a public park.

Finally, the CTLA formula as it is normally applied appraises the value of the existing tree at present. In this study, we need not only the value of the existing tree but also the value or benefit of trees in the future. To use the CTLA formula this way, it is necessary to have a base value for future trees. To estimate future base values, we reviewed the base values used in the CTLA formula over the last 10 years. In this case, the values used were from the Rocky Mountain Chapter of the International Society of Arboriculture. On average, these base values have increased at the rate of 2.5% per year. In this study, this percentage rate is used to adjust base values for use in the CTLA formula valuation of future trees.

It should be emphasized that the CTLA formula measures the value of a tree as a real-property, capital asset. In this paper, we use this asset value as a estimate of the benefit value for an urban tree. Certainly there are shortcomings in using this asset value as a measure of the wide range of benefits an urban tree provides over time. Nevertheless, there are no other universally accepted economic benefit values for urban trees, and estimating economic values in specific cases would be difficult, at best. Thus, we use the CTLA valuations as proxies for the benefits provided by urban trees. In the future, if uniform, comprehensive economic measures of benefits become available, they would be applicable to the approach discussed in this paper.

ECONOMIC PERFORMANCE INDICATORS

Tree replacement/maintenance alternatives typically involve extended periods of time. For example, a decision to retain a tree may include a maintenance program that would last for 5 or 10 years, and the replacement tree may have a useful life of 100 years or more. The economic analysis of such long-term alternatives requires the consideration of the opportunity cost of capital, or interest, accrued over the investment period. Urban forestry expenditures, as any other private or public investment capital, should be expected to consider the opportunity cost of the investment (Zerbe and Dively 1994).

The procedures used to account for capital investments involve the use of various compounding and discounting formulas. These formulas are used to provide performance indicators for an investment. The most common indicators used in forest-type investments are present net value (PNV) and the land expectation value (LEV) (Davis and Johnson 1987). These indicators are based on present or discounted values. The present net value is the difference between the discounted benefits and discounted costs for a specific time period, or planning horizon. The land expectation value is the same except the discounting assumes the planning horizon is infinite. The LEV calculates the present net value, assuming the investment (replacement) recurs forever. For example, if the tree has a useful life of 50 years, the LEV assumes the tree is replaced in future years 51, 101, 151, etc. Tree species typically have different useful lives, and the LEV allows comparing them over a common time horizon, i.e., infinity.

There are several ways of presenting these economic performance indicators depending on the specific problem. The following formulas apply to the tree replacement/retention problem. Expression 1 applies to the existing tree retention portion of the analysis, and Expression 2 applies to the replacement tree, as

$$\mathrm{PNV} = \frac{[B_t - B_0] - \sum_{t=0}^{n} C_t(1+i)^n}{(1+i)^n} \qquad (1)$$

where

B_t = tree benefit (CTLA) at time t in the future

B_0 = tree benefit (CTLA) at present

C_t = cost at time t

t = time in years; year 0 is now

n = number of years of the investment or time period for tree maintenance/retention

i = discount rate or interest as a decimal, normally based on the best alternative guiding rate of return

$$\mathrm{LEV} = \frac{B_t - \sum_{t=0}^{N} C_t(1+i)^{N-t}}{(1+i)^N - 1} \qquad (2)$$

where N = number of years or useful life of the replacement tree. The other variables are as defined in Expression 1. Estimates of tree useful life or time to reach maturity can be found in silvics or dendrology texts (e.g., Harlow et al. 1996).

The formulas can be easily programmed into a spreadsheet format to make the calculations. In this study, a spreadsheet was designed using Microsoft Excel® to do the PNV and LEV calculations.

Both performance indicators assume the CTLA value represents the benefits provided by the tree. The PNV (Expression 1) measures the benefits of retaining the existing tree as the change in the tree's benefits ($B_t - B_0$) over the retention period (n). This change is represented by the difference in CTLA appraised values at the beginning (B_0) and end of the retention period (B_t). If the change is positive and greater than the total cost of maintenance (plus interest) over the retention period, $\left(\sum_{t=0}^{n} C_t(1+i)^n\right)$, then the tree should be retained. The net difference between the change in benefits and total costs (plus interest) is discounted to the present to give PNV. Likewise, the LEV (Expression 2) measures the replacement tree's future benefit (B_t) as the CTLA estimated value just prior to the time of the replacement tree's removal (N) in the future. If the LEV is positive, the benefits (value) of the tree are greater than the associated costs (tree establishment, maintenance, etc.) plus interest, then the replacement tree's management program is economically viable.

THE ECONOMICS OF THE TREE REPLACEMENT PROBLEM

There are two ways to view the economics of the tree replacement/maintenance problem. The first deals with the benefits and costs of retaining the existing tree only. The second considers the benefits and costs of retaining the existing tree as well as those of the replacement tree in the analysis. The two analysis approaches are outlined below using Expressions 1 and 2.

Existing Tree Only

Figure 1 illustrates a typical tree maintenance program for an existing tree. The parameters in Figure 1 are those shown in Expression 1 above. The tree is retained and the maintenance program applied if the PNV calculation is positive. In this case, the PNV is the discounted value of the net, or the difference between the change in tree benefits less the compounded value of the costs. Or in present value terms, if the present value of the additional benefits of retaining the tree are greater than the present value of the maintenance program costs, the tree should be retained. Otherwise, the tree should be replaced. Note that the existing tree's present and future values (B_0 and B_t in Figure 1) are calculated using the CTLA formula. The costs (Ct) are those associated with the maintenance program (pruning, insect control, etc.). The analysis here assumes the existing tree's removal costs are part of the establishment costs of the replacement tree.

The economic analysis here is based solely on the benefits and costs associated with retaining the exist

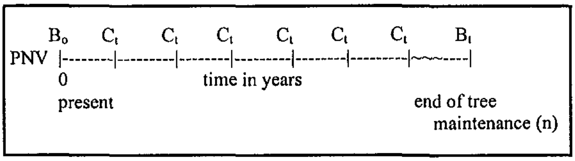

Figure 1. Timeline for the existing urban tree maintenance alternative, where *B* is tree benefits and *C* is periodic maintenance costs.

ing tree. This is a legitimate way of viewing the urban tree replacement problem and the way most managers would view the matter. However, one could also consider the benefits and costs associated with the replacement tree. The logic for considering the replacement tree lies in the possibility that the replacement tree could yield higher present net benefits (LEV) than the existing tree (PNV). If this was the case, the existing tree should be removed now and replaced even though its retention would yield positive net benefits. The analysis procedure for this approach is outlined next.

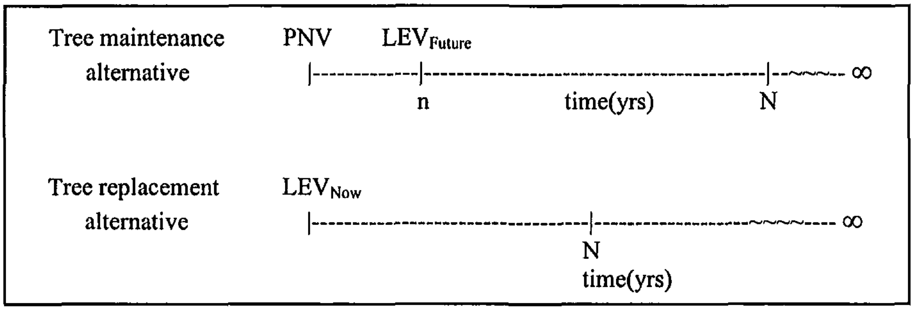

Figure 2. Timeline for the existing urban tree maintenance and replacement alternatives considering the replacement tree.

Existing Tree and Replacement Tree

Figure 2 describes the time line and performance indicator calculations for the existing tree maintenance and replacement alternatives. The LEV of the replacement tree is calculated using Expression 2 and represents the discounted net value of the benefits and costs of the replacement tree

The existing tree maintenance alternative now includes two present value components, the present net value of the existing tree (PNV) and the present net value of the replacement tree planted n years from now at the end of the maintenance program (LEV_{Future} discounted) or

$$PNV + \frac{LEV_{Future}}{(1+i)^n} \quad (3)$$

where n = number of years in the tree maintenance program.

If the tree is replaced now instead of at the end of an existing tree maintenance program, the present net value is given by LEV_{Now}. Thus, deciding which alternative is best from an economic standpoint amounts to whether

$$PNV + \frac{LEV_{Future}}{(1+i)^n} > LEV_{Now} \quad (4)$$

or

$$PNV > LEV_{Now} - \frac{LEV_{Future}}{(1+i)^n} \quad (5)$$

It should be noted that this last expression depicts an important economic principle related to the urban tree maintenance/retention problem. The net benefits of the maintenance program for the existing tree (PNV) must exceed the difference between the net benefits of planting the replacement tree now (LEV_{Now}) or later ($LEV_{Future}/(1 + i)^n$. Thus, the decision is not as simple as saying if the existing tree benefits exceed the costs of maintenance (i.e., a positive PNV), we should retain the tree.

In general, the longer the existing tree is maintained (i.e., n) the greater the difference in the right-hand side of Expression 5 and the higher the likelihood the best decision will be to replace the tree. Further, the higher the interest or discount rate used (i), the greater the compounded costs and the more likely the tree should be replaced. Otherwise, what is best will depend on characteristics of the tree, location, condition, and the specific maintenance and the replacement programs envisioned for the tree.

This approach of considering both the existing tree and replacement tree is also a legitimate way of viewing the replacement problem. It emphasizes the value or net benefits of the replacement tree in the analysis along with the benefits and costs of retaining the existing tree. While this emphasis is logical, it expands the necessary calculations and requires assumptions concerning the future tree conditions used in the analysis. The next section illustrates the two approaches applied to a case study problem.

CASE STUDY: AN AMERICAN ELM ON THE "OVAL" AT COLORADO STATE UNIVERSITY

The tree in question is an overmature, 173-cm (68-in.) dbh American elm (*Ulmus americana*) located in a historic parklike area of the Colorado State University

Table 1. American elm characteristics/ratings and CTLA benefit values (in U.S. dollars) for the tree now and at the end of the 8-year maintenance program.

Value/rating	Existing tree now	Existing tree 8 years from now
Base value[z]	\$36 per in^2	\$44 per in^2
Trunk area	2,076 in^2	2,110 in^2
Species rating	70%	70%
Condition rating	49%	43%
Location rating	60%	60%
CTLA value	\$15,380[y]	\$16,767

[z]Base values are expected to increase at the rate of 2.5% per year, or $36(1.025)^8 = \$44$.
[y]Calculated as \$36 per in^2 × 2,076 in^2 × 0.7 × 0.49 × 0.6 = \$15,380.

campus called the "Oval." There has been considerable controversy regarding the tree's removal and replacement. The university's landscaping department is considering retaining the existing tree for 8 years while applying an intensive tree maintenance program. After 8 years, the tree would be removed and replaced with a 6.4-cm (2.5-in.) American elm that is resistant to Dutch elm disease (DED).

Existing Tree Only

Table 1 lists the base values and assumptions concerning changes in the elm tree's size and CTLA ratings. Over the 8 years, there will be an increase in the per-in^2 base value, a slight increase in trunk area, and a decline in the condition rating. The species and location ratings remain the same over the maintenance period. It should be noted that these future tree growth and condition ratings are estimates and are somewhat subjective. One can derive these estimates using past information from similar trees in the area and/or from growth (using an increment borer) and stress factor data for the existing tree. If there is a great deal of uncertainty concerning the future physical characteristics of the tree, it is probably best to test the sensitivity of the economic results using a range of future growth and condition rating possibilities.

Using the CTLA formula, tree values are calculated for the existing tree now (B_0) and at the end of the 8-year maintenance period (B_t). Over the 8 years, the tree benefits increase by US\$1,387 (\$16,767 (B_t) – \$15,380 (B_0)). In this case, the tree benefit increase is fairly substantial because the base dollar value per in^2 is rising at the rate of 2.5% per year, and this is a fairly large tree. Thus, even though there is a reduction in the tree condition rating, the CTLA calculation shows a higher value after 8 years. The combination of increase in per-in^2 value and increase in tree size more than offset the loss in value due to a decline in condition rating.

Table 2 shows the existing elm's maintenance schedule and costs. The total cost outlay is US\$900 over the 8 years. However, this total cost figure does not include the opportunity cost involved in using the limited financial resources for investing in this maintenance program. In this case, the landscaping department uses an interest rate of 7% per year. Using this rate, the total cost outlay plus interest is substantially more than US\$900 (\$1,267 in this case).

Table 2. American elm maintenance schedule, cost outlay, and compounded costs (in U.S. dollars) for the existing tree maintenance program

Year applied[z]	Treatment	Projected cost outlay[y]	Compounded cost (at 7% per year)
0	Minor prune	\$250	\$430[x]
1	Soil injection	\$100	\$161
3	Soil injection	\$100	\$140
5	Soil injection and minor prune	\$350	\$429
7	Soil injection	\$100	\$107
Total		**\$900**	**\$1,267**

[z]Year 0 represents the first year of the maintenance program; year 7 is the last year. The tree would be replaced, using this time scale, at the beginning of year 8. Costs are assumed to occur at the beginning of the year, and benefits at the end of the year.
[y]These projections should consider the rising costs of maintenance (inflation) over time in making the estimates. In other words, the figures should be a estimate of the cost outlay at that time in the future. Further, the possible increase in tree removal cost attributable to retaining the tree has not been considered here. If there are increased removal costs, from removing a larger and/or less sound tree, this additional cost should be included here as a cost to the retention program. Otherwise, the removal cost is considered as part of the establishment cost of the replacement tree.
[x]For example, the calculation is $250(1.07)^8 = \$430$.

Considering the existing tree only the present net value of this maintenance option is calculated using Expression 1, or

$$\text{PNV} = \frac{[16,767 - 15,380] - 1267}{(1.07)^8} = \$70$$

The positive PNV indicates that the benefits of retaining the elm are greater than the maintenance costs. It would be worthwhile to retain the elm. However, the increase in benefits and compounded cost figures are relatively close (US$1,387 versus $1,267) and are very sensitive to the assumptions concerning the interest rate, base value increase, and tree condition ratings.

The maintenance program considered here involved a certain set of treatments applied over 8 years. It should be noted that an expanded maintenance schedule or different treatments could be analyzed using this same approach. For example, we could expand this maintenance program beyond 8 years. In this case, the base value used in the CTLA formula will increase (it increases by 2.5% per year), but the rate of increase in trunk size will likely decline , as well as the condition rating. This will result in a marginal decrease in additional tree benefit values. At the same time, cost outlays plus interest will compound and will result in a marginal increase in additional costs. Thus, there will be a time when the maintenance program's costs exceed the net change in benefits.

The approach can be used to analyze when (the number of years of a maintenance program) the costs of maintenance begin to exceed the benefits. In this case, it is not many years beyond this 8-year program (about 10 years). However, this need not be the case in every situation. Each individual case will be different, depending on the tree values, change in tree characteristics, interest rate, and designated maintenance program.

Existing Tree and Replacement Tree

In this analysis, we assume the existing tree will be replaced with a 6.4-cm (2.5-in.) dbh, DED-resistant American elm with a projected useful life of 50 years (time to reach maturity based on tree species and site conditions). Table 3 describes the replacement tree's treatment schedule and costs. Note that the tree removal costs are part of the establishment costs of the replacement tree. Table 4 shows the benefit or tree values for the replacement tree at 50 years (for the LEV_{Now} calculation) and 58 years in the future (for the $\text{LEV}_{\text{Future}}$ calculation).

Using Expression 2, the LEV calculations are

$$\text{LEV}_{\text{Now}} = \frac{43,747 - 41,813}{1.07^{50} - 1} = \$68$$

$$\text{LEV}_{\text{Future}} = \frac{53,273 - 41,813}{1.07^{50} - 1} = \$403$$

Applying Expression 4

$$\text{PNV} + \frac{\text{LEV}_{\text{Future}}}{(1+i)^n} > \text{LEV}_{\text{Now}}$$

$$70 + \frac{403}{(107)^8} > 68$$

$$70 + 235 > 68$$

$$\$305 > \$68$$

In this case, considering the benefits and costs of the replacement tree, the decision remains the same—that is, retain the existing tree for 8 years then replace it with the DED-resistant elm. Replacing the existing tree now will not lead to greater present net benefits (US$68 versus $305). We would retain the tree even though the PNV of the existing tree (only US$70) is about the same as the LEV_{Now} of replacing the tree now (US$68). The *combination* of the existing tree retention and future tree replacement is greater (US$70 + $235, or $305).

It is interesting to note that the $\text{LEV}_{\text{Future}}$ value 8 years from now is 6 times greater than the LEV_{Now} value (US$403 versus $68). This is because of the increase in the base value used in the CTLA formula. Because this base value increases exponentially (i.e., it is compounded at 2.5% per year) it changes rather dramatically in 8 years (US$124 to $151 per in^2, Table 4). At the same time the total compounded costs for the replacement tree remains the same ($41813). This leads to a fairly large increase in the $\text{LEV}_{\text{Future}}$ compared to the LEV_{Now}. Because the existing tree maintenance program is fairly short (8 years), discounting to the present does not reduce $\text{LEV}_{\text{Future}}$ in a major way (US$403 to $235). In this case study, the best eco-

Table 3. Replacement tree establishment and maintenance schedule, cost outlay, and compounded cost (in U.S. dollars)

Year of occurrence	Activity	Cost outlay per occurrence[z]	Total cost outlay	Total cost outlay including interest (7%) after 50 years
0	Tree establishment including existing tree removal, replacement tree cost, and planting	$1,100	$1,100	$32,403
1–9	General maintenance (watering and fertilizer)	$20 per yr	$180	$3,587
10–46	Insect control every 2 yrs	$26 every 2 yrs	$468	$2,452
10–45	Pruning every 5 yrs	$100 every 5 yrs	$700	$3,371
Total			**$2,448**	**$41,813**

[z]To be consistent with the existing tree analysis, these replacement tree costs should be estimates of the actual cost outlay made in the future, that is considering inflation. In this example, they are average figures over the period (for example, $20 per year over years 1–9). If, instead, the cost outlays were based on today's costs they would need to be adjusted to include inflation by a percentage factor, similar to the adjustment in tree value. Thus, rising costs over time can be addressed by either using cost estimates that include the rising costs (inflation) or by adjusting today's costs by percentage factor to account for inflation. The latter approach is available in forest investment analysis programs such as Quick-Silver (Vasievich 1999) to individually adjust both benefit and cost figures considering inflation.

nomic decision is clearly to retain the existing tree and replace it later. It should be emphasized that other factors, such as safety, should also be considered in making the final decision.

SUMMARY

The economic analysis is relatively straightforward and easy to apply because the monetary benefits are estimated using the CTLA formula approach and the necessary economic performance indicator calculations can be easily programmed into spreadsheet format or can be calculated using existing software (e.g., Vasievich 1999). However, the economic analysis does require detailed information for the existing tree and replacement tree, including tree characteristics now and in the future and the maintenance schedules and their costs. When a great deal of uncertainty exists regarding this information, it is important to do a sensitivity analysis, that is, varying the data and conditions to test the sensitivity of the analysis results to changes in the data and assumptions.

Table 4. Value/rating and CTLA values (in U.S. dollars) for the DED-resistant elm tree in the future.

Value/rating	50 years from today	58 years from today
Base value[z]	$124 per in^2	$151 per in^2
Trunk area	1,050 in^2	1,050 in^2
Species rating	70%	70%
Condition tating	80%	80%
Location rating	60%	60%
CTLA value[y]	$43,747	$53,273

[z]This is the current base value of $36 per in^2 adjusted by an increase of 2.5% per year for 50 years and 58 years, respectively.
[y]Note that the increase in CTLA values is due entirely to the increase in base values used in the formula. There is no difference in the tree's size or ratings. The tree just exists at different times in the future, 50 and 58 years, respectively.

There are two basic approaches that might be used to evaluate the tree retention/replacement problem. The decision maker could consider the existing tree only or both the existing tree and the replacement tree. Most urban forest managers would probably prefer to use the existing-tree-only analysis because it requires less information and the information used, for example tree condition and cost estimates, can be more accurately determined in the short term. Nevertheless, the long-term planning that pertains to the replacement tree is important and should be part of the overall process. This is particularly true when developing long-term general strategies for urban tree replacement guidelines. In these cases, the approach could be used on a broader scale to evaluate and compare the economic performance of a variety of tree maintenance and replacement alternatives.

The economic analysis procedures outlined here would appear to have merit for use in urban tree retention/replacement decision making. Along with other criteria, the procedures can be used to provide justification for selecting appropriate courses of action in managing urban forests.

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Résumé. Les forestiers urbains sont souvent appelés à décider si un arbre existant doit être conservé ou remplacé. Cet article présente une méthodologie économique qui dérive des indicateurs de performance applicables au problème de remplacement des arbres. La procédure s'applique à analyser les bénéfices et les coûts d'un arbre existant seulement tout comme à analyser à la fois ceux d'arbres existants et d'arbres de remplacement ensembles. Un exemple de cas impliquant des ormes d'Amérique (*Ulmus americana*) malades est présenté afin d'illustrer l'application de la méthodologie. La procédure devrait s'avérer utile pour développer une justification économique aux décisions de remplacer ou de conserver des arbres. La décision d'abattre un arbre est souvent basée sur une évaluation de la santé et de la condition d'un arbre tout comme de sa sécurité. Un arbre peut être conservé, mais normalement cela va exiger un programme d'entretien et l'allocation de ressources financières. La décision de conserver ou de remplacer un arbre urbain se fait souvent sous l'œil attentif du public et les forestiers urbains sont fréquemment appelés à fournir les informations détaillées qui justifient la décision. Même si les caractéristiques physiques d'un arbre demeurent certainement importantes, une évaluation plus soignée à savoir si un arbre doit être remplacé ou conservé devrait impliquer une analyse monétaire des coûts et des bénéfices. Cet article illustre une méthode économique facile d'utilisation pour assister les gestionnaires d'arbres urbains dans la prise de telles décisions.

Zusammenfassung Stadtforstleute werden oft mit der Frage konfrontiert, einen Baum zu entfernen oder ihn stehen zu lassen. Teilweise basiert diese Entscheidung auf einer ökonomischen Analyse der Vorzüge und der kosten für eine Alternative. Diese Studie präsentiert eine ökonomische Methodik, voraus sich Indikatoren für die Nutzungsansprüche ableiten, die für die Problematik des Ersetzens von Strassenbäumen anwenden lassen. Die Prozeduren sind dabei sowohl nur separat auf die Vorteile und die Kosten eines existierenden Baumes, wie auch die von stehenden und zu ersetzenden Bäumen gleichermaßen anzuwenden. In einer Fallstudie, bezogen auf erkrankte Amerikanische Ulmen (*Ulmus americana*), wurde die Anwendung dieser Methodik illustrativ dargestellt. Die Bestandteile der Methodik sollen sich nützlich erweisen bei der Entwicklung von ökonomischen Entscheidungsgrundlagen zum Ersetzen von Bäumen. Eine kritische Entscheidung, adressiert an Stadtforstleute, Baumpfleger und Planer, beinhaltet, den Zeitpunkt zu bestimmen, wann stehende Bäume entfernt und durch eine Neupflanzung ersetzt werden sollen. Ein Baum könnte erhalten werden, aber normalerweise erfordert das ein Pflegeprogramm und eine Auslage der finanziellen Resourcen. Die Entscheidung, einen Baum zu erhalten oder zu fällen, wird oft von der Öffentlichkeit beobachtet und die Stadtforstverwaltung wird regelmäßig nach den Details und Hintergründen, die eine solche Entscheidung rechtfertigen, gefragt. Oft konzentriert sich eine solche Entscheidung auf eine Bewertung der physischen Kondition eines Baumes. Während diese physischen Charakteristika sicherlich wichtig sind, so würde doch eine mehr umfassende Bewertung, ob ein Baum gepflegt oder gefällt wird, auch eine Analyse der monetären Vorteile und der Kosten beinhalten. Stadtforstleute und Baumpfleger könnten wirklich davon profitieren, wenn die ökonomischen Parameter Bewertung und Rechfertigung einer Baumfällung bzw. Pflege berücksichtigt werden. Diese Studie illustriert eine leicht anzuwendende ökonomische Methodik zur Unterstützung von Baumpflegern bei derartigen Entscheidungen.

Resumen. Los administradores del bosque urbano son con frecuencia requeridos para tomar decisiones en relación con mantener o remplazar un árbol. Este trabajo presenta una metodología económica que deriva indicadores de funcionamiento aplicables al problema del remplazo de los árboles. Los procedimientos se aplican para analizar solamente los beneficios y costos del árbol, como también el remplazo de los árboles. Se utiliza un caso de estudio, implicando olmos americanos enfermos (*Ulmus americana*), para ilustrar la aplicación de esta metodología. Los procedimientos deben probar económicamente la utilidad para justificar el desarrollo de decisiones remplazo/retención. Las decisiones de remoción de los árboles están con frecuencia basadas en la evaluación de la salud y condición del árbol, como también lo que concierne a seguridad. Un árbol puede ser retenido, pero normalmente requerirá un programa de mantenimiento y fuentes de financiamiento. La decisión para remplazar o retener un árbol urbano es vista de cerca con frecuencia por la opinión pública y los forestales urbanos son cuestionados para dar información detallada que justifique la decisión. Mientras las características físicas de los árboles son ciertamente de importancia, una evaluación más comprensiva de si el árbol debe ser retenido o reemplazado debería implicar un análisis de los beneficios y costo monetarios. Este trabajo ilustra una metodología económica fácil de aplicar para ayudar a los manejadores del árbol urbano a realizar tales decisiones.