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STREET TREE MAINTENANCE: HOW MUCH SHOULD YOU SPEND NOW TO SAVE LATER?

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Abstract. Reducing the maintenance costs associated with street trees may increase initial costs for preventive treatments. Three measures are described to help you decide if investments in preventive measures are justified by future savings in reduced maintenance: present discounted values, internal rates of return, and service-life extension values. The measure you use will depend on your objectives and on the funding and accounting practices and philosophy of your organization.

Résumé. La diminution des coûts d'entretien associés aux arbres de rues peut augmenter les coûts initiaux pour les traitements préventifs. Trois mesures sont décrites afin de vous aider à décider si les investissements pour des mesures préventives sont justifiées par les économies *futures associées à la diminution des travaux d'entretien* requis: les valeurs présentes, le taux in terne de rendement, et les valeurs présentes, le taux interne de rendement, et les valeurs ajoutées service-vie. La mesure à utiliser dépendra de vos objectifs et de vos pratiques de financement et de comptabilité, de même que la philosophie de votre organisation.

Preventive measures may substantially reduce costs of street tree maintenance such as pruning roots, repairing sidewalks, and pruning branches for power line clearance or safety. For example, devices to control root damage to sidewalks have been commercially available for years. Planting stock that is slower growing or deeper rooting, or that is grown in deep containers may also reduce such damage. Managers, however, need some basis for judging whether preventive measures are worth their cost.

Cost-saving treatments cannot be rated categorically because maintenance costs depend on the species or varieties used, how they are grown and planted, the growing space and conditions provided, soil and drainage characteristics, and other site-specific factors. Three procedures, however, permit you to estimate how much to invest for future benefits: the discounted present value of future benefits, the internal rate of return, and service-life extension value (useful-life value). The first two methods are standard approaches used by economists for cost-benefit analysis (1). The third is a simple, common-sense approach. All three require reasonable estimates of costs and the duration and amount of expected benefits.

Present Discounted Value

Money is almost always worth more to economically rational people today than at some future date. Consequently, they will defer immediate use of their money only if compensated, usually by interest payments. In effect, a sum spent in the future is equal to a lesser sum spent now. The longer you must wait to use money, the less is its present discounted value. Time preference for the value of money can be expressed as a rate of interest (discount rate).

The influence of time on relative values is so great that economists insist that sums spent at different times be adjusted to their value at some common time before they can be compared with validity. Computations of present value are used extensively by economists and accountants to compare the worth of alternative investments when costs and benefits occur at different times. To obtain its present discounted value (PV), a future sum (FV) is discounted by a compound interest rate (r) using the formula

$$PV = \frac{FV}{(l + r)^N}$$

where N equals the number of years in the future.

Table 1 gives present values for each $100 that would be spent on maintenance for a range of future times and interest rates. For example, if \$500 of maintenance will be needed 10 years hence and the interest (discount) rate is 5%, the present value of that sum is \$305 (\$61 x 5). If something you can do now will delay the need for the \$500 of maintenance for another 5 years (i.e., for a total of 15 years), the present value of that amount wil be \$240 (\$48 x 5). In other words, at a 5% interest rate, spending \$500 in 15 years would be equivalent to spending \$240 now. If \$500 of maintenance would normally be needed in 10 years, you could (at 5%) afford to spend nearly \$305 on any measure that would permanently eliminate this maintenance cost. If, however, the maintenance reduction measure would only delay the \$500 expense so it occurred in 15 years, you could afford to spend only \$65 (the difference between \$305 and \$240) to postpone the maintenance.

Table 1. Present value per \$100 of future maintenance costs (rounded to the nearest dollar).

Maintenance interval (years)	*Interest rate (compound, annual)* 1%	2%	3%	4%	5%	6%	7%	8%	9%
5	\$95	\$91	\$86	\$82	\$78	\$75	\$71	\$68	\$65
6	94	89	84	79	75	71	67	63	60
7	93	87	81	76	71	67	62	58	55
8	92	85	79	73	68	63	58	54	50
9	91	84	77	70	65	59	54	50	46
10	91	82	74	68	61	56	51	46	42
11	90	80	72	65	59	53	48	43	39
12	89	79	70	63	56	50	44	40	36
13	88	77	68	60	53	47	42	37	33
14	87	76	66	58	51	44	39	34	30
15	86	74	64	56	48	42	36	32	28
16	85	73	62	53	46	39	34	29	25
17	84	71	61	51	44	37	32	27	23
18	84	70	59	49	42	35	30	25	21
19	83	69	57	48	40	33	28	23	19
20	82	67	55	46	38	31	26	22	18
21	81	66	54	44	36	29	24	20	16
22	80	65	52	42	34	28	23	18	15
23	80	63	51	41	33	26	21	17	14
24	79	62	49	39	31	25	20	16	13
25	78	61	48	38	30	23	18	15	15

Internal Rate of Return

Because choosing and justifying the interest rate is often difficult, an alternative to computing present discounted value is computing the rate of return that a contemplated investment would provide. You would prefer an investment returning 12% rather than one returning 8%, other things being equal.

The internal rate of return is the compound interest rate that equalizes the present discounted value of costs and benefits. If applying a single treatment would avoid annual maintenance costs for N years, you would solve the following formula for the interest rate (r) at which the present value of the series of annual savings would exactly equal the cost of a single investment (I) made now:

$$\frac{\textbf{annual savings } ((1+r)^N-1)}{r(1+r)^N} = I$$

When investments postpone rather than eliminate costs, the present values of costs and benefits are needed to calculate internal rates of return. For example, if an investment (I) at the time a tree is planted would delay the usual costs of repairing sidewalk damage at 15, 20, and 25 years (treated as benefits (B) because they are avoided at the time usually needed) with costs (C) at 22 and 30 years, the generalized formula would be $B_{15} + B_{20} + B_{25} = I + C_{22} + C_{30}$. The specific formula would be that shown in Fig. 1. Again the internal rate of return is obtained by solving for r.

Although the general concept of internal rate of return is fairly straightforward, computation can be tedious, requiring repeated computations trying different interest rates until the correct one is found. Fortunately, successive approximation problems are readily solved using a computer. Hand-held calculators designed for business or financial applications usually have a special function key for determining the internal rate of return.

Fig. 1. Formula (example) for calculating postponed investments.

$$\frac{\text{15 year repair cost}}{(1+r)^{15}} + \frac{\text{20 year repair cost}}{(1+r)^{20}} + \frac{\text{25 year repair cost}}{(1+r)^{25}} = I + \frac{\text{22 year repair cost}}{(1+r)^{22}} + \frac{\text{30 year repair cost}}{(1+r)^{30}}$$

Figure 2. The internal rate of return can be calculated with this computer program for comparing alternative urban forestry investments. It is written in Microsoft BASIC for IBM PC and compatibles. (Trade names are used solely for information, and imply no endorsement by the U.S. Department of Agriculture.)

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1 REM IRR program - for examining interval rates of return for urban forestry
2 REM     investments, written by Al Wagar, PSW Forest & Range Experiment
3 REM     Station, P.O. Box 245, Berkeley, CA 94701, July 1986
10 DIM A(10),Y(10),C1(10),C2,(10),Y1(10),Y2(10)
15 INPUT"Amount of investment = $",I
18 INPUT"Number of years to consider = ",NY
20 PRINT"Are expected benefits or savings":PRINT"  a = annual:
22 PRINT"  p = periodic":INPUT"  b = both";B$
25 IF B$ = "a" OR B$ = "A" OR B$ = "b" OR B$ = "B" THEN 35
30 IF B$ = "p" OR B$ = "P" THEN 42
32 GOTO 20
34 REM
35 REM Enter present worth of annual benefits
38 INPUT"Estimated annual savings or benefits = $",E
40 IF B$<>"b" AND B$<>"B" THEN 130
41 REM
42 REM Enter present worth of periodic benefits or savings
43 REM Direct entry of periodic benefits
44 PRINT"Choose  1 = Direct entry of periodic benefits, or"
45 PRINT"        2 - Entry of periodic costs with and without investment"
50 INPUT  P
51 IF(P <> 1 AND P <> 2)THEN 50
52 K1=1:IF P=2 THEN 80
60 PRINT K1;:INPUT"Amt of benefit                 =  $",C1(1)
65 INPUT"       Yrs after investment ", Y1(1):S1=Y1(1)
67 K1=K1+1:PRINT K1;:INPUT"Amt of benefit (9999 to end) = $",C1(K1)
68 IF C1(K1) = 9999 THEN K1=K1-1:Y1(K1)=S1:GOTO 130
69 INPUT"       Yrs after previous benefit = ",Y1(K1):S1=S1+Y1(K1):Y1(K1)=S1
70 PRINT TAB(20) S1;"total"
71 IF S1>NY THEN K1=K1-1:PRINT"Exceeds analysis period":GOTO 18
75 IF K1<10 THEN 67
78 REM
79 REM Comparison of costs with and without investment
80 K1=1
81 PRINT"Pattern of costs avoided (or expected periodic benefits)":PRINT K1;
82 INPUT ". Cost (benefit)     = $", C1(1)
84 INPUT"    Yrs after investment =  ",Y1(1):S1=Y1(1)
85 K1=K1+1:PRINT K1;:INPUT ". Cost/benefit (9999 to end) = $",C1(K1)
86 IF C1(K1) = 9999 THEN K1=K1-1:Y1(K1)=S1:GOTO 90
87 INPUT"Yrs since previous cost/benefit =  ",Y1(K1):S1=S1+Y1(K1):Y1(K1)=S1
88 PRINT TAB(20) S1;"total":IF S1>NY THEN PRINT"Exceeds analysis period":GOTO 18
89 IF K1<10 THEN 85
90 K2=1:PRINT "Expected costs if investment made"
92 PRINT K2;:INPUT ". Cost                  = $", C2(1)
93 K2=1:INPUT "Yrs after investment = ", Y2(1):S2=Y2(1)
96 K2=K2+1:PRINT K2;:INPUT". Cost (9999 to end) = $",C2(K2)
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97 IF C2(K2)=9999 THEN K2=K2-1:Y2(K2)=S2:GOGO 130
98 INPUT"Yrs since previous cost = ",Y2(K2):S2=S2+Y2(K2):Y2(K2)=S2
99 PRINT TAB(20) S2;"total":IF S2>NY THEN PRINT"Exceeds analysis period":GOTO 18
100 IF K2<10 THEN 96
130 IV=.2:M = 1
133 IV+IV+(M*.001)
135 V= -I:IF B$="a" OR B$="A" OR B$="b" OR B$="B" THEN 140
138 GOTO 160
140 V=V+E*((1+IV)^NY - 1)/(IV)*(1+IV)^NY):IF B$="a" OR B$="A' THEN 300
160 JJ=0
165 JJ=JJ+1:V=V+C1(JJ)/((1+IV)^Y1(JJ)):IF JJ=K1 THEN 180
170 GOTO 165
180 IF P=1 THEN 300
182 JK=0
185 JK=JK+1:V=V-C2(JK)/((1+IV)^Y2(JK)):IF JK=K2 THEN 300
190 GOTO 185
300 IF ABS(V) < .01*I THEN 400
305 IF V<0 THEN M= -1
306 IF IV<0 THEN PRINT"Investment not recovered at any positive rate":GOTO 405
310 GOTO 133
400 PRINT"Internal rate of return is ";IV
405 INPUT"Make another run (y/n) ";C$
410 IF C$="n" OR C$="N" THEN 500
415 IF C$="y" OR C$="Y" THEN PRINT:PRINT:GOTO 15
420 GOTO 405
500 END
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Options for determining the internal rate of return are provided for in most financial software for personal computers. A program listing for calculating an internal rate of return adapted to urban forestry decisions is given in Figure 2. Table 2 gives some example scenarios and their rates of return, using that program. A graphical, linear interpolation method for estimating the rate in simple cases is given in (2).

Service-Life Extension Values

Another way to determine how much you should spend on maintenance prevention measures is to consider that the benefit produced by delaying maintenance for a year is worth the maintenance cost divided by its normal service life. For example, if $500 of maintenance work normally is needed every 15 years, each year of service-life is worth approximately $33. If a protective measure will extend the service life by 5 years, the savings will be $165 ($33 × 5). Therefore, you could justify spending up to this amount on protective measures. If a measure extends the maintenance interval by only 3 years then only a $99 cost ($33 × 3) is justified. Expressing benefits as service-life extension values provides a different, but useful, perspective on cost thresholds for protective measures. Service-life extension values are easily calculated without formulas, but do not consider individuals' preference for present over future values. The amount you can justify spending increases rapidly and in direct proportion to how much an expenditure extends normal maintenance times.

Choosing A Method

The measure of economic efficiency you should use depends on your objectives and on the funding and accounting practices and philosophy of your organization. How does it evaluate budgets and allocate funds among departments? Does it support an increase in current spending to reduce future expenditures on repairs? How does it allocate funds between maintenance, repair, and capital improvement? Even if your budget requests are not analyzed and funded by comparing savings with costs, you still should analyze your own priorities using some economic efficiency

Table 2. Internal rates of return for selected treatment scenarios.

Scenario	Return (%)
1. A single investment now of $10 per tree will eliminate annual costs of $6 for 10 years.	58.9
2. A single investment now of $20 per tree will eliminate annual costs of $6 for 10 years.	27.0
3. A $20 investment every 10 years will eliminate annual costs of $6. (Note reducing cost by $6 per year is equivalent to eliminating an annual cost of $6.)	27.0
4. A $10 investment now will eliminate a $30 cost in 5 years and an additional $30 cost in 10 years.	30.4
5. A $20 investment now will eliminate a $30 cost in 5 years and an additional $30 cost in 10 years.	17.1
6. When a period of 45 years is considered, a $100 investment per tree now will delay for 5 years a $300 cost normally occurring in 15 years, with additional $300 costs occurring every 8 or 9 years instead of every 5 years.	10.2
7. Same as scenario 6 except that recurring costs are $400.	11.9
8. Same as scenario 6 except that recurring costs are $500.	13.3

criteria.

If allocation of funds is based, in whole or part, on standard economic analysis, use present discounted value or internal rate of return. If your organization's budget analysts use an interest rate to compare costs and savings, use that rate and present discounted values. Alternatively, you might want to use the interest rate your city pays for borrowing operating funds until the tax revenues roll in, the rate it pays on bond issues, or the average commercial rate for borrowing money. If allocation of funds is determined (or influenced) by where returns on investments are greatest, use the internal rate of return for your analyses. If alternative budget allocations are compared by using a nonstandard economic method, you may want to use the service-life extension method because it is simpler to do, to comprehend, and to explain.

Showing some measure of the economic efficiency of alternative expenditures in your budget might greatly help you gain support for budget requests.

Literature Cited

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