Journal of Risk and Uncertainty, 3:369-379 (1990)


# Discounting and the Evaluation of Lifesaving Programs

MAUREEN L. CROPPER
*Department of Economics, University of Maryland; Resources for the Future, Washington, D.C. 20036*

PAUL R. PORTNEY*
*Resources for the Future, Washington, D.C. 20036*

**Key words:** discounting, latency, risk valuation

## *Abstract*

The evaluation of lifesaving programs whose benefits extend into the future involves two discounting issues. The intragenerational discounting problem is how to express, in age-$j$ dollars, reductions in an individual's conditional probability of dying at some future age $k$. Having discounted future lifesaving benefits to the beginning of each individual's life, one is faced with the problem of discounting these benefits to the present—the intergenerational discounting problem. We discuss both problems from the perspectives of cost-benefit and cost-effectiveness analyses. These principles are then applied to lifesaving programs that involve a latency period.

In evaluating a proposed regulation or making a public investment decision, it is standard practice to compare the discounted present value of costs and benefits of the project, i.e., to apply a benefit-cost criterion. Application of this criterion, however, often meets with resistance when benefits or costs take the form of lives saved. This is especially true when lives are saved or lost in the future, thus raising the question of whether these lives, or the monetary value of the corresponding risk reductions, should be discounted.

The problem of discounting human lives arises frequently in the context of environmental policy. Perhaps the most striking example is nuclear waste disposal, which may impose risks on generations thousands of years into the future. The time pattern of risks to human life is, however, important even in the context of shorter planning horizons. Many environmental programs—for example, those concerned with asbestos—reduce exposure to carcinogens with long latency periods. This implies that, while the costs of reduced exposure may largely be borne today, the benefits do not occur until the end of the latency period. Compared with a program that reduces an individual's risk of death today, a program that reduces that same person's risk of death at the end of a 20-year latency period saves fewer expected life-years. This fact has often been ignored in valuing the benefits of environmental regulations.

*The authors are, respectively, Associate Professor of Economics, University of Maryland and Senior Fellow, Resources for the Future; and Senior Fellow and Vice President, Resources for the Future. We thank the National Science Foundation for their support under grant DIR-8711083.

The purpose of this article is to clarify some of the discounting issues that arise in valuing health and safety programs. We identify two discounting problems that are frequently encountered in making environmental policy: 1) how to discount lifesaving benefits that accrue at some future point in a person's life; and 2) how to discount lifesaving benefits to members of future generations. The first problem, which we term the intragenerational discounting problem, arises in regulating substances that involve a latency period, such as pesticides, asbestos or radon. Reducing a person's exposure at age 20 to a carcinogen with a 20-year latency period does not begin to reduce the individual's conditional probability of death until the end of the latency period.[1] Lifesaving benefits that do not occur for 20 years must be discounted to the present so that they may be compared with the costs of reducing exposure in the current year.

The intergenerational discounting problem arises whenever substances are regulated that have long residence times in the environment. Nuclear waste is probably the most famous example of such a substance, but chlorofluorocarbons (CFCs) and greenhouse gases also come to mind.

We illustrate the distinction between intragenerational and intergenerational with a simple diagram (figure 1) that shows the time pattern of benefits resulting from a capital expenditure, for example, the construction of a safer nuclear waste disposal facility, that confers benefits to members of generations currently alive and to generations as yet unborn.[2] To simplify the problem, suppose that members of each generation live at most two periods and that these periods are 20 years long. Persons are 20 years old at the beginning of the first period of their lives and 40 at the beginning of the second period.[3]

For all persons near the facility, building a stronger depository reduces the conditional probability of dying at the beginning of period 1 and at the beginning of each subsequent period. At the beginning of period 1, the safer facility reduces the conditional probability of dying at age 40 for members of generation 1 ($D_{40}$) and the conditional probability of dying at age 20 for members of generation 2 ($D_{20}$). At the beginning of period 2, it reduces the conditional probability of dying at age 40 for members of generation 2 and the conditional probability of dying at age 20 for members of generation 3.

Assuming, for simplicity, that all costs of the facility are incurred at the beginning of period 1, the project will pass a benefit–cost test if the present value of the benefits of the risk reductions to all future generations exceeds the cost of constructing the facility. The

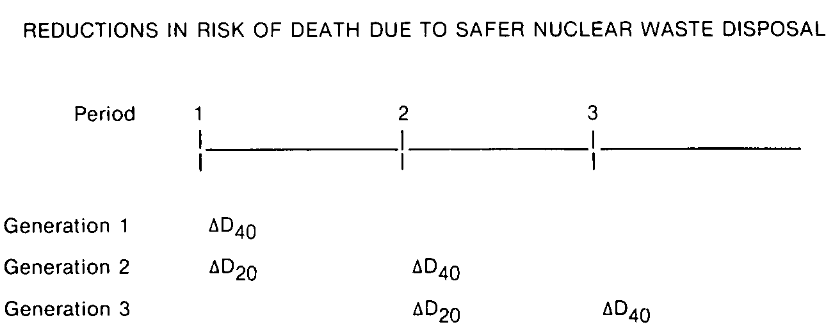


*Figure 1.* Changes in the conditional probability of death at age $t(D_t)$ due to safer nuclear waste disposal.

intragenerational discounting problem is to discount future lifesaving benefits for members of a single generation to the time of their birth.[4] In figure 1 this corresponds to discounting $\Delta D_{40}$ for members of generation 2 to the beginning of period 1. The rate at which members of each generation should be willing to discount their own future lifesaving benefits may be obtained from a life-cycle consumption–saving model, as we discuss in section 1 below. The intergenerational discounting problem is to discount the value of benefits to future generations to the present. In figure 1, having discounted the benefits to members of generation 3 to the beginning of period 2 (the intragenerational problem), one is then faced with the problem of discounting this amount to the beginning of period 1. This problem, which is clearly the more controversial of the two, is discussed in section 2.

As noted in section 2, it is difficult to avoid the conclusion that benefits to future generations should be discounted to the present, so long as three conditions hold: 1) individuals can be made indifferent to increases (decreases) in mortality risk if they are given (made to surrender) money payments; 2) there are alternative uses for lifesaving resources; and 3) capital investment yields a positive rate of return.

Many people, however, are uncomfortable with the notion that future lifesaving benefits should be discounted at a positive rate of interest, or even with the idea of monetizing lifesaving benefits. If the funds to be spent on lifesaving programs are fixed, so that the decision maker's problem is simply to allocate them among alternative programs,[5] then no monetization of benefits is required. The decision maker must, however, have a function that weights lives saved at different points in time. Assuming all costs are incurred today, the rate at which future lives saved are discounted is the rate implicit in this weighting function. We discuss the discounting implications of the cost-effectiveness approach to regulatory analysis in section 3.

We conclude the article by examining a class of environmental problems, namely, the regulation of environmental carcinogens, that raises intragenerational discounting questions because these carcinogens involve a latency period. How this latency period should be treated was the subject of a heated debate between the U.S. Environmental Protection Agency (EPA) and the Office of Management and Budget (OMB) in the case of asbestos regulation (U.S. House of Representatives, 1985). We argue that the positions of both the EPA and the OMB on the benefits of asbestos regulation were incorrect, and examine the implications of section 1 for the correct treatment of latency periods.

## 1. Intragenerational discounting issues

The question we address in this section is how lifesaving benefits that occur at different ages, to members of the same generation, can be expressed in a single year's dollars.[6] Equivalently, how much is an individual in the generation willing to pay at age $j$ for a change in his conditional probability of dying at some future age $k$?

A natural framework in which to answer this question is a life-cycle consumption model with uncertain lifetime.[7] In the life-cycle model, expected utility at age $j$, $V_j$, is the present discounted value of utility of consumption, $U(c_t)$, from $t = j$ to some maximum age $T$, weighted by the probability that the individual survives to age $t$, given that he is alive at age $j$, $q_{j,t}$,

$$V_j = \sum_{t=j}^{T}(1 + \rho)^{j-t}q_{j,t}U(c_t), \tag{1}$$

where ρ is the subjective rate of time preference.

The level of utility achieved depends on the individual's budget constraint. Suppose that the individual has wealth of $W_j$ at his current age, $j$, and earns $y_t$ at age $t, t = j, \ldots, T$, provided he is alive. If the individual can lend at the riskless rate $r$, but can never be a net borrower, he faces the budget constraints

$$W_j + \sum_{k=j}^{t}(y_k - c_k)(1 + r)^{j-k} \geq 0, \qquad j < t \leq, T, \tag{2}$$

which force him always to have nonnegative wealth. Other capital market assumptions, such as the availability of actuarially fair annuities, do not change the discounting results below (Cropper and Sussman, 1990).

A program to build a safer nuclear waste containment facility affects survival probabilities in the following way. Given that an individual is alive at age $j$, the probability that he is alive at age $k$ is the product of the probabilities that he does not die at ages $j$ through $k - 1$,

$$q_{j,k} = (1 - D_j)(1 - D_{j+1}) \ldots (1 - D_{k-1}), \tag{3}$$

where $D_k$ is the conditional probability of dying at age $k$, i.e., the probability that the individual dies at age $k$ given that he has survived to that age.

A health or safety program affects survival probabilities by altering the value of the $D_k$'s. A program to clamp down on drunken driving or to strictly enforce speed limits in a single year reduces $D_k$ for that year alone. A program that reduces an individual's exposure at age 30 to a carcinogen with a 20-year latency period reduces the conditional probability of dying at all ages after 50 ($D_{50}, D_{51}, D_{52}, \ldots$), while a program to increase the safety of a nuclear containment facility reduces $D_k$ beginning in the year the facility is built and at all subsequent ages. It should be emphasized that when the conditional probability of death is altered at age $k$, it affects the probability of surviving to ages $k + 1$ and beyond, $q_{j,k+1}, q_{j,k+2}, \ldots, q_{j,T}$, by virtue of equation (3).

The monetary value to an individual of a change in $D_k$, termed his willingness to pay (WTP), is the amount of money that can be taken away from him when $D_k$ is reduced that will keep his expected utility constant. WTP at age $j$ for a marginal change in $D_k$, $\text{WTP}_{j,k}$, is given by

$$\text{WTP}_{j,k} = -\frac{dV_j/dD_k}{dV_j/dW_j}dD_k. \tag{4}$$

The first term on the right-hand side of equation (4), the rate at which the individual is willing to substitute wealth for risk, is typically termed the value of life. Applying the Envelope Theorem to the Lagrangian function that corresponds to equations (1) and (2), $\text{WTP}_{j,k}$ can be written

$$\mathrm{WTP}_{j,k} = \left[(1 - D_k)^{-1}[U'(c_j)]^{-1}\sum_{t=k+1}^{T}(1 + \rho)^{j-t}q_{j,t}U(c_t)\right]dD_k.^{8} \tag{5}$$

Equation (5) states that the value to a person at age $j$ of reducing his conditional probability of death at age $k$ is the expected utility he would lose if he died at age $k$, divided by the marginal utility of consumption at age $j$.

The main insight that the life-cycle model yields for intragenerational discounting is that the individual's willingness to pay at age 20 for a change in his conditional probability of death at age 40 ($\mathrm{WTP}_{20,40}$) is what he would pay at age 40 for a change in his current probability of death, $\mathrm{WTP}_{40,40}$, discounted to age 20 at the consumption rate of interest. This can be seen by combining equation (5), evaluated at ages $j$ and $j + 1$, with the first-order conditions for utility maximization, to yield

$$\frac{\mathrm{WTP}_{j+1,k}}{\mathrm{WTP}_{j,k}} = \frac{U'(c_j)}{U'(c_{j+1})}(1 - D_j)^{-1}(1 + \rho) = 1 + \delta_j, \tag{6}$$

where $\delta_j$ is the consumption rate of interest at age $j$. If it is the case that the wealth constraint is not binding, then the consumption rate of interest equals the market rate of interest ($\delta_j = r$); otherwise $\delta_j$ may exceed the market rate of interest.[9]

Repeated use of equation (6) implies that the discount factor $\Gamma_{j,k}$ applied to $\mathrm{WTP}_{k,k}$ to yield $\mathrm{WTP}_{j,k}$ is the product of the annual discount factors $1/(1 + \delta_t), t = j, \ldots, k - 1$,

$$\begin{aligned} \mathrm{WTP}_{j,k} &= \Gamma_{j,k}\mathrm{WTP}_{k,k}, \\ \Gamma_{j,k} &= \prod_{t=j}^{k-1}(1 + \delta_t)^{-1}. \end{aligned} \tag{7}$$

The empirical significance of equation (7) is that, if one can extrapolate estimates of WTP for a change in conditional probability of death in the future ($\mathrm{WTP}_{k,k}$) from labor market or contingent valuation studies, then these estimates can be discounted using equation (7) to estimate WTP today for the future risk change ($\mathrm{WTP}_{j,k}$). For this to be successful, however, estimates of WTP for a change in current conditional probability of death must be age dependent and must reflect differences in income streams between cohorts. Returning to figure 1 for illustration, a contingent valuation study conducted in the year the waste disposal facility is built would estimate the value of a change in $D_{40}$ to members of generation 1 ($\mathrm{WTP}_{40,40}$). Before this can be discounted to estimate the value at the beginning of period 1 of a change in $D_{40}$ to persons in generation 2 ($\mathrm{WTP}_{20,40}$), one must adjust $\mathrm{WTP}_{40,40}$ for differences in lifetime earnings between generations 1 and 2.

## 2. Intergenerational discounting issues

Equation (7) indicates that, in the context of a life-cycle consumption model, rational individuals within each generation would discount future lifesaving benefits at the consumption rate of interest. This does not, however, solve the problem of how, in figure 1, a policy maker should discount the benefits to generation 3 from period 2 to period 1.

Suppose the planner combines the life-cycle utilities of members of each generation in a social welfare function. Let $P_t$ denote the population of generation $t$ and $\alpha$ the utility rate of discount. Assume social welfare is given by

$$S = \sum_{t=0}^{N} (1 + \alpha)^{-t} P_t V_{jt}(W_{jt}), \tag{8}$$

where $V_{jt}$ is, as in equation (1), evaluated for persons in generation $t$. If the planner's problem is to determine the initial wealth to be given to each generation $W_{jt}$, and the amount to be spent on lifesaving programs, it is hard to escape the fact that he will discount lifesaving benefits to future generations at the rate of return on capital. This is true even if $\alpha = 0$, i.e., even if there is no utility discounting. The reason is that resources not devoted to lifesaving programs for future generations can be invested at a positive interest rate so as to increase $W_{jt}$ for members of these generations.[10]

We hasten to add that the discounting of the dollar benefits of lifesaving does not imply that the planner is unconcerned about the welfare of future generations. If $\alpha = 0$, the utility of future generations will be higher than the utility of current generations, assuming that increasing consumption over time is technologically feasible. As long as consumption and survival probabilities are substitutes in the utility function, future generations can always be compensated for changes in their risk of death.

One problem, of course, is that the institutions necessary to guarantee that this compensation occurs may not exist. In an overlapping generations context, altruism might be sufficient to guarantee that compensating wealth transfers take place from one generation to another; however, there is evidence that people behave differently in a private context than they believe society should behave (Svenson and Karlsson, 1989). This implies that government programs may be required to enforce such compensation.

## 3. Cost-effectiveness analysis versus cost-benefit analysis

If a policymaker has a fixed budget to be spent on lifesaving programs, and if there are no alternative uses for the funds, then it is possible both to avoid monetizing the benefits of lifesaving programs (a necessity if there are alternative uses for lifesaving resources) and to avoid discounting future lives saved.

Suppose that a decision maker must choose among alternative lifesaving programs and that all program costs are incurred today. The benefits of such programs are evaluated by a function that ranks the expected number of persons alive at each age in the current and in future generations. This function might take the form

$$S' = \sum_{t=0}^{N} (1 + \alpha)^{-t} P_t \left[ \sum_{m=j}^{T} (1 + \rho)^{-m} q_{j,m}^{t} \right]. \tag{9}$$

The term in brackets is the discounted life expectancy at age $j$, for a person in generation $t$. It is the intragenerational objective function (1) with consumption omitted. Discounted life expectancy is weighted by the number of persons in generation $t$, $P_t$. $\alpha$ is the discount rate applied to life-years saved in future generations.

It is easily verified that the optimal allocation of funds among lifesaving programs calls for equalizing the present value of future benefits per dollar spent. Formally,

$$\frac{(1+\alpha)^{-t} P_t \sum_{m=k+1}^{T} q_{j,m}^{t}}{\partial C / \partial D_k^t} = \frac{(1+\alpha)^{-t-1} P_{t+1} \sum_{m=k+1}^{T} q_{j,m}^{t+1}}{\partial C / \partial D_k^{t+1}} \tag{10}$$

where $\partial C/\partial D_k^t$ is the marginal cost of a change in the age-$k$ mortality rate for members of generation $t$, and the numerator of each expression represents the number of discounted expected life-years saved by each risk change. (To simplify the expression, we have set $\rho = 0$.) Equation (10) implies that, if $\alpha = 0$, future lives count equally with present lives, holding constant expected life-years saved.

An interesting question is whether, in their role as social decision makers, people believe that future and present lives saved should count equally, holding constant expected life-years saved. In other words, what value do they attach to $\alpha$? It is also of interest to know what value people attach to $\rho$, the rate at which future life-years are discounted within a generation.

Two recent studies shed light on these questions. Svenson and Karlsson (1989) asked students at the University of Stockholm to assign a number between 0 and 10 to the seriousness of a leakage of spent nuclear fuel in the years 3100, 4100, 10,000, 100,000, 1,000,000, and 2,000,000, assuming that the seriousness of such a leakage in the year 2100 equals 10. Approximately 30% of the 108 respondents did not discount the seriousness of future waste leakages at all. Among those who did, the mean value attached to an accident in the year 10,000 was 5, implying a value of $\alpha = 8.66 \times 10^{-5}$.

Over shorter periods, however, people may have higher values of $\alpha$. Horowitz and Carson (1990) report mean discount rates between 4.5% and 12.8% when respondents were asked to compare lives saved now versus lives saved 3 to 5 years into the future. It is not, however, clear to what extent respondents viewed these risks as applying to themselves or to others.

## 4. Regulations involving a latency period

We now apply the insights of the preceding sections to the regulation of environmental carcinogens—substances that are characterized by a lag (latency period) between exposure and effect. Since, by definition, cancerous cells do not appear until the end of the latency period, exposure to a carcinogen does not increase one's risk of dying of cancer until the end of this period. The latency period for asbestos is thought to be between 20 and 40 years, while for arsenic it is 30 to 50 years.

Figure 2 illustrates the effect of a 20-year latency period on the stream of benefits from reducing exposure to asbestos at the beginning of period 1. Assuming that this is accomplished by removing asbestos-containing materials from buildings, all persons who would have been exposed to asbestos will benefit, beginning at the end of their respective latency periods.[11] An important difference between the asbestos and nuclear waste examples is that there are no benefits from asbestos removal early in life to members of any generation ($\Delta D_{20} = 0$ in figure 2). Assuming equal $\Delta D_{40}$'s in both figures, fewer expected life-years are saved by removing asbestos than by building a safer nuclear waste disposal facility.

This fact, however, is often ignored in risk-benefit analyses, where the focus is on deaths avoided, regardless of their timing. An example of insensitivity to the approach recommended here is the EPA's original analysis of the benefits of prohibiting the manufacture of certain asbestos-containing products under the Toxic Substances Control Act (TSCA). In calculating benefits, the EPA assumed that the reduction in risk began on the date of exposure rather than at the end of the latency period. Assuming that 40 is the average age of exposure, this is equivalent to valuing lives saved using $WTP_{40,40}$. If, however, asbestos does not result in cancer until 20 years after exposure, then the program should be valued by discounting $WTP_{60,60}$ back to the present rather than using $WTP_{40,40}$.[12]

It should be emphasized that the difference between $WTP_{60,60}$, discounted to the present (the correct benefit measure), and $WTP_{40,40}$ is the result of two factors:

1. *Fewer life-years saved.* $WTP_{60,60}$ reflects the fact that only life-years beginning at age 60 are saved by asbestos removal; the years between ages 40 and 60 are not at risk.
2. *Discounting.* The life-years saved by asbestos removal do not start until age 60; hence they must be discounted to the present.

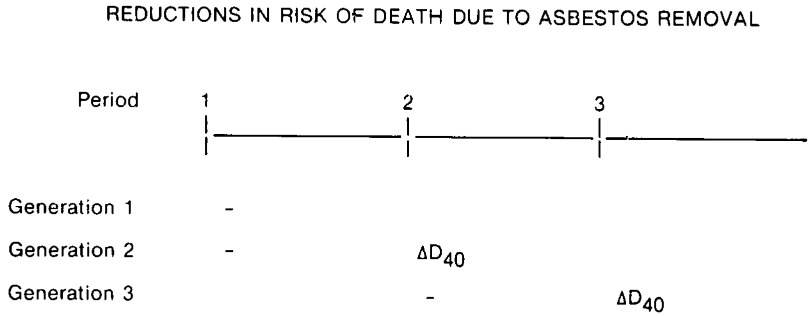


*Figure 2.* Changes in the conditional probability of death at age $t$($D_t$) due to asbestos removal, assuming a 20-year latency period.

Cropper and Sussman (1990) illustrate possible magnitudes for these effects. They calculate that, for a white male with an isoelastic utility function $[U(c) = c^{0.2}]$ and $r = \rho = .05$, $WTP_{60,60}$ is 70% of $WTP_{40,40}$. The fact that fewer life-years are saved thus reduces WTP by 30%. Discounting $WTP_{60,60}$ to the present implies that the correct benefit measure ($WTP_{40,60}$) is 26% of $WTP_{40,40}$.

One further observation about the control of environmental carcinogens should be made. We have illustrated this class of problems with the decision to remove asbestos from buildings, a case in which we assume all regulatory expenditures are made up front. For pesticide regulation, the cost of not using a pesticide (e.g., reduced crop yields) is incurred at the beginning of each time period. Here the correct decision rule is to compare the present value of benefits from not exposing people in period $t$, discounted to the beginning of period $t$, with period $t$ costs. Because the only people to benefit from pesticide regulation in period $t$ are people who are alive at that time, pesticide regulation is not really an intergenerational issue.[13] It does, however, involve *intra*generational discounting because of the latency period involved.

## 5. Conclusions

Regulatory decisions involving lifesaving will always be controversial; however, this controversy can be lessened if decision makers understand clearly the nature of the benefits that programs provide and use appropriate valuation techniques. We have emphasized the distinctions between 1) programs that reduce risk of premature mortality immediately; 2) those that reduce such risks but only after a latency period; and 3) those that provide risk reductions to individuals not yet born. While some programs might provide all three types of benefits, each is valued differently.

Even if the valuation techniques are correctly understood at the conceptual level, there remains the problem of empirical implementation. This will require at least two types of approaches. Programs to reduce risk of death immediately can be valued by hedonic wage techniques—by estimating a compensating wage differential received by workers in risky occupations. However, because compensating wage differentials reflect the preferences of persons who accept employment in risky jobs, they may not accurately value risk reductions for a randomly chosen person in the population. Contingent valuation studies (Jones-Lee, Hammerton, and Philips, 1985) may be needed to provide benefit estimates for a broader spectrum of the population.

Programs that reduce risk of death after a latency period can be valued by contingent valuation methods (Mitchell and Carson, 1986; Smith and Desvousges, 1987), i.e., by asking respondents about their willingness to pay today for a reduction in their conditional probability of dying 30 years hence. Alternatively, one can discount estimates of willingness to pay for a reduction in risk of death at the end of the latency period ($WTP_{k,k}$) to the present at the consumption rate of discount.

What policymakers need to know when making policies that affect future generations is the marginal rate of substitution between lives saved now and lives saved in the future.

This could be elicited via a contingent valuation survey in which respondents choose between future- and present-oriented lifesaving programs. Such a survey would provide information that could be used directly in a cost-effectiveness context, and is a necessary input into a benefit-cost analysis.

## Notes

1. The conditional probability of dying at age $t$ is the probability that the individual dies between his $t$th and $t+1$st birthdays, assuming he is alive on his $t$th birthday.
2. Our assumption is that this new facility reduces the risk of a sudden and massive release of radioactivity that would result in acute fatalities.
3. This admittedly stylized approach enables us to avoid discussing the willingness to pay for risk reductions on the part of a two-year-old, for instance.
4. In the case of generations currently alive, benefits are discounted to the present.
5. This is probably not a bad description of the problem faced by the officials at a regulatory agency. While there is theoretically no limit on the amount of society's resources that the agency can commit to lifesaving in a given year, the agency's operating budget surely constrains the rulemaking it can do. This may have the effect of forcing the agency to adopt a cost-effectiveness approach.
6. To focus on the discounting issue, we assume that all persons in a single generation are identical. They are born in the same year, inherit the same wealth, face the same income stream and same probability distribution over the date of their death, and have the same tastes.
7. This model, originally developed by Yaari (1965), has been used to value changes in current risk of death over the life cycle by Arthur (1981) and by Shepard and Zeckhauser (1982, 1984). The discounting results presented here were obtained by Cropper and Sussman (1990).
8. See Cropper and Sussman (1990).
9. Viscusi and Moore (1989) estimate that individuals discount future lifesaving benefits at about 12%, a finding consistent with the fact that consumption is income-constrained.
10. For a discussion of discounting in a social planning context, see Dasgupta (1982). Cropper and Sussman (1990) obtain a similar result in the context of an overlapping generations model with altruism.
11. Unlike the nuclear waste example, benefits from removing asbestos do not extend to generations in the distant future if buildings containing asbestos would eventually have been torn down and replaced and if, upon demolition, the asbestos were captured and safely disposed of.
12. The OMB's solution to this problem also appears to have been incorrect. To take account of the latency period, the OMB also used $1 million as the value of statistical life. It then treated this sum, which corresponds to $WTP_{40,40}$, as occurring 20 years into the future and discounted it (rather than $WTP_{60,60}$) back to the present.
13. We are assuming that the effects of pesticide exposure are primarily carcinogenic, not teratogenic, and also that pesticide use will play no role in long-lived ecological damage.

## References

Arthur, W. Brian. (1981). "The Economics of Risks to Life," *American Economic Review* 71, 54-64.

Cropper, Maureen L. and Frances G. Sussman. (1990). "Valuing Future Risks to Life," *Journal of Environmental Economics and Management* 19, 160-174.

Dasgupta, Partha. (1982). "Resource Depletion, Research and Development, and the Social Rate of Discount." In Robert C. Lind (ed.), *Discounting for Time and Risk in Energy Policy*. Washington, DC: Resources for the Future.

Fuchs, Victor R. and Richard J. Zeckhauser. (1987). "Valuing Health—A 'Priceless' Commodity," *American Economic Review* 77, 263-268.

Horowitz, John and Richard T. Carson. (1990). "Discounting Statistical Lives," *Journal of Risk and Uncertainty*, this issue.

Jones-Lee, M. W., M. Hammerton, and P. R. Philips. (1985). "The Value of Safety: Results of a National Sample Survey," *Economic Journal* 95, 49-72.

Mitchell, Robert C. and Richard T. Carson. (1986). "Valuing Drinking Water Risk Reductions Using the Contingent Valuation Method: A Methodological Study of Risks from THM and Giardia." Paper prepared for Resources for the Future. Washington, DC: Resources for the Future.

Shepard, Donald S. and Richard J. Zeckhauser. (1982). "Life Cycle Consumption and Willingness to Pay for Increased Survival." In Michael W. Jones-Less (ed.), *The Value of Life and Safety*. Amsterdam, North-Holland.

Shepard, Donald S. and Richard J. Zeckhauser. (1984). "Survival Versus Consumption," *Management Science* 30, 423-439.

Smith, V. Kerry and William H. Desvousges. (1987). "An Empirical Analysis of the Economic Value of Risk Changes," *Journal of Political Economy* 95, 89-114.

Svenson, Ola and Gunnar Karlsson. (1989). "Decision-Making, Time Horizons, and Risk in the Very Long-Term Perspective," *Risk Analysis* 9, 385-399.

U. S. House of Representatives. (1985). *EPA's Asbestos Regulations. Hearing Before the Committee on Energy and Commerce, 99th Congress*. Washington, DC: U.S. Government Printing Office.

Viscusi, W. Kip and Michael J. Moore. (1989). "Rates of Time Preference and Valuations of the Duration of Life," *Journal of Public Economics* 38, 297-317.

Yaari, Menahem E. (1965). "Uncertain Lifetime, Life Insurance, and the Theory of the Consumer," *Review of Economic Studies* 32, 137-150.