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A Framework for Environmental Risk Policy

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Executive Summary

Today's environmental concerns often involve invisible threats, such as the threat of global warming, the threat of ozone depletion, the threat of increasingly lower levels of air pollution, the threat of low-dose exposure to chemicals, and so on. Environmental problems today are often so subtle that they can only be quantified using epidemiological techniques or sophisticated computer models. While previous problems could often be controlled by relatively simple and low-cost technological solutions, the environmental issues that remain tend to be very complex, are as much behavioral as technological, and are often very expensive to address.

Architects of environmental policy in the 1960s and 1970s usually couched problems in terms of protecting the "general health." Almost everyone could be portrayed as a potential beneficiary of an environmental "clean up." Today, however, environmental initiatives are increasingly justified on the basis of protecting only a segment of the population, usually the most vulnerable, and especially children. In this context, some have proposed a risk-focused decision framework.

But a risk-focused framework for environmental policy poses new challenges, especially for low-level risks. The proliferation of safety measures aimed at small risks makes it difficult to compare potential safety investments. Making such comparisons is further complicated when complex mitigation measures are required, when risk-reduction measures only offer benefits to a small percentage of the population, and when other portions of the population might experience increased risks through unintended consequences or the indirect effects of regulations. Such complications make it difficult to insure that resources used to address risks will produce the desired outcome without introducing new risks or by shifting risk from one person or avenue of life to another.

Making sound public-policy decisions regarding environmental safety measures requires a net-benefit framework for portraying both the nature of environmentally conveyed health risks and the consequences of taking action to reduce them. It also requires an easily understood framework for choosing a risk-reduction strategy. Such an environmental-safety investment framework can help decisionmakers make sensible

choices regarding risk policy. It can also help individuals evaluate whether they're getting a net benefit from taxpayer resources invested in environmental risk reduction.

One solution to this problem might be a process of comprehensive comparative risk assessment, in which all risks and risk-reduction interventions are numerically assessed and ranked. But a comparative-risk approach has problems of timeliness and complexity, compounded by the subjective nature of risk. The "precautionary principle," favored by some environmental activists, offers an even less-attractive strategy for reducing risks, because it ignores the majority of relevant criteria that include realistic depictions of uncertainty regarding risks and intervention effects.

An alternative is a case-by-case evaluation of proposed risk-reduction interventions against a set of touchstones to insure that a proposed risk-reduction intervention is likely to:

- Save more lives on net, than it will take; and
- Outperform the natural risk-reduction benefits of leaving resources to circulate in a dynamic, market-based, knowledge-building economy.

Such a framework requires:

- A scientifically rigorous assessment of the best estimate of risk that reviews pertinent risk information and has transparent and meaningful peer review;
- A holistic evaluation of potential safety investments that considers risk-reduction, risk-shifting, risk-trading, and opportunity costs of investment; and
- A method for evaluating whether a resilient (adaptive) or interceptive strategy is more likely to secure a net risk reduction.

When applied to two recent, high-profile proposals to reduce environmental risk through regulation (the revised National Ambient Air Quality Standards of 1997 and the Kyoto Protocol of 1998), such a framework suggests these proposed risk-reduction measures are likely to do more harm than good.

The National Ambient Air Quality Standard revisions fail a simple test of providing a net health benefit when considerations of risk trading, risk shifting, and opportunity costs are considered.[1] The Kyoto Protocol also comes up short. Persistent uncertainties in our understanding of climate change suggest that taking interceptive actions to forestall the negative consequences of climate change are likely to cause near-term increases in risk; offer only questionable long-term reductions in risk while absorbing limited risk-reduction resources; and invite significant unintended consequences.

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[1] On May 14, 1999 the U.S. Court of Appeals in Washington D.C. invoked "non-delegation doctrine" to strike down certain aspects of EPA's 1998 revisions to the National Ambient Air Quality Standards for ozone and particulate matter. In *American Trucking Associations Inc.* v. *United States Environmental Protection Agency*, the U.S. Court of Appeals also pointed out (as we discuss below) that EPA's proposed ozone standard was crafted without due consideration of the tradeoff between ozone's harmful effects (as a lung irritant), and ozone's protective effects (from UV rays). The court also found that EPA's choice regarding retention of the older particulate standard in light of the proposed new fine particulate standard ($PM_{2.5}$) was arbitrary and capricious.

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Part 1

The Growing Focus On Risk and Safety

Today's environmental concerns often involve invisible threats, such as the threat of global warming, the threat of ozone depletion, the threat of increasingly lower levels of air pollution, the threat of low-dose exposure to chemicals, and so on. Environmental problems today are so subtle that they can only be quantified using epidemiological techniques or sophisticated computer models. While previous problems could often be controlled by relatively simple and low-cost technological solutions, the environmental issues that remain tend to be very complex, are as much behavioral as technological, and are often very expensive to address.

As a result, these problems often do not stimulate the kind of automatic public outcry that a phosphate-foaming river would. Environmental policy interventions must, therefore, rest on other grounds. In earlier days of environmental awareness, appeals could be made to protecting the "general health," where almost everyone could be portrayed as a potential beneficiary of an environmental "clean up." Today, however, environmental initiatives are increasingly justified on the basis of protecting only a segment of the population, usually the most vulnerable, and especially children.[2] In this context, some have proposed a risk-focused decision framework.[3]

But a risk-focused framework for environmental policy poses new challenges, especially for low-level risks that affect communities.[4] The proliferation of safety measures aimed at small risks makes it difficult to compare potential safety investments. Making such comparisons is further complicated when complex mitigation measures are required and when risk-reduction measures only benefit a small percentage of the population. Such complications make it difficult to insure that resources used to address risks produce the desired outcome without introducing new risks, or by shifting risk from one person or avenue of life to another.

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[2] Louis Freedberg, "Boxer Bill Would Make EPA Rules Fit Kids: Research on Effects of Pollutants on Children Called For," *San Francisco Chronicle*, April 17, 1997, p. A8. Since then, EPA Administrator Carol Browner created an "Office of Children's Health Protection" at the U.S. EPA, specifically devoted to weighing risks from a children's health perspective.

[3] American Law Institute, American Bar Association course description, available on the Internet at http://207.103.196.3/aliaba/cd37.htm, or from author upon request.

[4] Risks that are of an individualist nature, such as the risk of exposure to a chemical used in carpet manufacture, or the risk of a poor diet, can generally be addressed directly through individual choices.

These complicating factors result in a growing irrationality in America's risk-reduction investment choices. As risk analysts Tammy Tengs and John Graham have shown, America's public policy priorities bear little relationship to any rational ranking of risks and potential risk-reduction investments of tax dollars:

- To regulate the flammability of children's clothing, we spend $1.5 million per year of life saved, while some 30 percent of those children live in homes without smoke alarms, an investment that costs about $200,000 per year of life saved.[5]
- To regulate potentially carcinogenic benzene emissions during waste operations, we spend $19 million per year of life saved, while 70 percent of women over age 50 do not receive regular mammograms, an intervention that would achieve benefits that cost roughly $17,000 per year of life saved.[6]
- While we spent approximately $21.4 billion in 1994 on 185 life-saving interventions that averted approximately 56,700 premature deaths, spending that same amount of money based on priorities to maximize effectiveness could have saved an additional 60,200 people.[7]

Making sound public-policy decisions regarding environmental safety measures requires a net-benefit framework for portraying both the nature of environmentally conveyed health risks and the consequences of taking action to reduce them. It also requires an easily understood framework for choosing a risk-reduction strategy. Such an environmental-safety investment framework can help decisionmakers make sensible choices regarding risk policy. It can also help individuals evaluate whether they are getting a net benefit from the taxpayer resources invested in environmental-risk reduction. This policy study will explore the components that belong in such a framework.

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5 Tammy O. Tengs and John D. Graham, Chapter 8, "The Opportunity Costs of Haphazard Social Investments in Life-Saving," *Risks, Costs, and Lives Saved: Getting Better Results from Regulation* (New York: Oxford University Press) 1996.

6 Ibid.

7 Ibid.

Part 2

A Framework For Environmental-Safety Investment

One proposed approach to improving risk-reduction investments is universal risk ranking (sometimes known as comparative risk assessment). Such ranking exercises may prove useful. However, it's unlikely that each new risk that arises can be explored and ranked in a timely or relevant manner.[8] Moreover, because risk preferences, exposures, and vulnerability vary by individual, there really is no purely objective way of ranking risks that applies uniformly for everyone. But where risk-reduction choices are made in a collective (public) context, the alternative—unranked risk-reduction investment—is clearly undesirable for reasons already discussed. Moreover, heightened emphasis upon the "precautionary principle" produces a constant pressure to regulate first and ask questions later.[9]

What is needed is an alternative to both the comparative-risk approach and the precautionary principle approach, a framework that evaluates proposed risk and safety measures and offers decision tools that are likely to provide net risk reductions. Such a framework requires:

- A scientifically rigorous assessment of risk that reviews pertinent risk information and has transparent and meaningful peer review;[10]

- A holistic evaluation of risks and potential safety investments by considering risk-reduction, risk-shifting, risk-trading, and opportunity costs of investment; and

- A method for evaluating whether a resilient (adaptive) or interceptive strategy is more likely to secure a net risk reduction.

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8 Richard J. McCann, *Putting Comparative Risk Assessment Into an Economic Framework*, Policy Study No. 229 (Los Angeles: Reason Public Policy Institute, August 1997).

9 The "precautionary principle," espoused by many environmental and public-health advocacy groups, suggests that when preliminary research indicates a potential risk, it is better to take action (usually regulatory) to eliminate the risk whether or not the exact nature of risk has been well characterized and quantified.

10 The best estimate of risk is one that actually reflects the risk, without adjusting for so-called "conservative" safety factors. For a discussion of the risk-distorting nature of such safety factors, see George M. Gray, *Key Issues in Environmental Risk Comparisons: Removing Distortions and Insuring Fairness*, Policy Study No. 205 (Los Angeles: Reason Foundation, May 1996).

A. Ensuring Accurate Depictions of Risk and Risk Reduction

> Understanding environmental risks involves a study of linkages and feedbacks in the natural world. Fragmenting the environment into artificial disconnected pieces; considering organisms in isolation; ignoring the interactions between organismal behavior and the organism's environment are inappropriate.
>
> A scientifically rigorous process to examine risks and risk-reduction measures must, therefore, look not only at single-medium impacts of a risk or a potential risk-reduction measure. That process must also look at all of the risk-related impacts such a measure might have, including the potential for risk-trading, risk-shifting, the opportunity cost of action, and the potential for proposed solutions to create risks through the economic impacts.[11] Our environmental policymaking process, however, rarely takes such a holistic view of risk nor of the impacts of regulation.

A recent example of the tendency for regulatory tunnel vision in risk-reduction measures gained visibility in the debate over automobile airbag requirements.[12] Rather than being "pure" in its risk-reducing impacts, the airbag requirement created new risks for a significant part of the population (smaller women) and posed a particular threat to children, the physically fragile, and the elderly. The initial cost estimates could never have encompassed the costs spent recently on modifying airbag technology, deactivating devices never intended to be deactivated, settling lawsuits, and so on. The additional risk posed by airbags and the additional costs of addressing these problems may not eradicate all of the safety gains stemming from their use. But this increased risk and cost should be taken off the bottom line of claims about increased safety stemming from airbag use to create, in effect, a "net-benefit" assessment of increased safety.

> Further, a scientifically rigorous process must be transparent and make full use of the checks and balances against error or bias that differentiate the scientific process from others. Genuine peer review and faithful representations of uncertainty must be preserved at every step along the evaluation pathway, not at just a few points, as is now typical of the political risk-assessment / risk-management process. Environmental risk-reduction policymaking is notorious for its failures to use rigorous peer review.

Consider the case of the recently revised National Ambient Air Quality Standards. When the proposals were floated, there was much talk of the need for scientific rigor. EPA representatives implied that the scientific rigor of the standards was a critical legitimizing factor. EPA Administrator Carol Browner, speaking at a conference in February 1997, characterized the science behind the proposed standards this way:

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11 Risk trading refers to the exchange of one risk for another, by the same individual. For example, the choice to drive instead of fly trades one type of risk for another. Risk shifting is the movement of a risk from one person or group to another. Thus, if one increased one town's fire-control budget while cutting another town's budget, one would simply shift the risk of fire, not reduce it. Opportunity cost refers to the fact that when you devote resources to a certain action, those resources are not simultaneously available for use in other ways.

12 National Motor Vehicle Safety Act, 15 USC 1381 *et seq;* Federal Motor Vehicle Safety Standard 208 as amended, 58 FR. 46551 (September 2, 1993). Standard 208 was recently revised in order to address this concern, allowing for the installation of an airbag deactivation switch.

In fact, I can safely say that this has been the most extensive scientific review and public outreach process ever conducted by EPA for public health standards....The science is clear and compelling.[13]

Mary Nichols, former EPA Assistant Administrator for Air and Radiation, also linked the soundness of the standards to the scientific rigor of the review process:

The result of these iterative, multi-year reviews is a solid scientific foundation upon which to build good policy. It really is the paradigm for, to use the phrase we hear so often, "sound science."[14]

But walking this talk seemed to give EPA difficulty. EPA likely fell short of either sound science or scientifically compatible thinking in picking the proposed standards. Indeed, the Clean Air Scientific Advisory Committee (CASAC) raised serious questions about the scientific rigor used to prepare the criteria documents and about the usefulness of the information generated by the review process for the purpose of selecting new air quality standards.[15]

In fact, CASAC's closure letters on ozone and particulates, sent to EPA Administrator Browner, conclude that the findings of the scientific studies reviewed in the documents were insufficient to warrant drawing any science-driven conclusion.

CASAC Chair George T. Wolff summarized the situation for ozone:

The panel concluded that there is no "bright line" which distinguishes any of the proposed standards (either the level or the number of allowed exceedances) as being significantly more protective of public health.

He goes on to say that:

Consequently, the selection of a specific level and number of allowable exceedances ***is a policy judgment***[16]

In other words, though CASAC found acceptable EPA's literature review regarding ozone, they concluded there was simply not enough scientifically convincing evidence in those papers to generate a scientifically driven recommendation.

The situation is much the same for CASAC's closure letter on particulates. After several rounds of corrections, CASAC eventually gave a "passing grade" to the Criteria Document and Staff Papers for their comprehensiveness. However, CASAC could find no clear indication of how to structure new standards: "There was no consensus on the level, averaging time, or form of a $PM_{2.5}$ National Ambient Air Quality Standard," indicated the CASAC closure letter. Instead, CASAC called for further research and a more-rigorous review process, lamented the haste imposed on their deliberations, and simply passed along the individual "preferences" of the members, most of which called for a less-restrictive $PM_{2.5}$ standard than

[13] Ibid.

[14] Mary Nichols, "Clearing the Air: EPA's Proposals on Ozone and Particulate Matter," *Environmental Manager*, Air and Waste Management Association, February 1997.

[15] CASAC was the official peer-review oversight panel for the NAAQS revision process.

[16] George T. Wolff, "CASAC Closure on the Primary Standard Portion of the Staff Paper for Ozone," November 30, 1995. (Emphasis by author)

that settled on by the EPA.[17] Wolff later summed up CASAC's findings, writing: "There does not appear to be any compelling reason to set a restrictive $PM_{2.5}$ National Ambient Air Quality Standard at this time."[18]

Despite the CASAC chairman's complaints about the peer-review process, and the extremely cautious findings of the peer-review committees, EPA went on to propose considerably tighter standards, characterizing them as having passed "peer-review upon peer-review," and portraying the findings of CASAC as strongly supporting its proposed standards.[19]

The current debate over climate change is another area in which the peer-review process is falling short of acceptable practices. Various authors have questioned the rigor of characterizations of the authoritative Second Assessment Report of the Inter-governmental Panel on Climate Change (IPCC). Portrayed as having survived the peer-review of 2000 scientists, in reality, few if any of those scientists reviewed the entire document nor the derivative "summary for policymakers" before the reports were issued.[20] Yet when speakers favoring rapid action on climate change speak, they tend to portray the situation as though all 2,000 scientists read and signed off on the total IPCC report, giving it the weight of their combined authority.

A holistic process also must recognize that resources are finite. All organisms, whether microbes or trees, operate in a finite slice of time, in which a finite range of actions and a finite pool of resources are available, necessitating, allocation of those finite resources. A tree, for example, has response mechanisms to deploy automatically a given unit of available energy, for growth in height, for growth in girth, for root growth, or for bark growth. Some available energy will go toward creating natural pesticides, some will go, perhaps, to make sap. Forests also have automatic processes that, over time, allocate resources in a way that optimizes both growth and safety.

Societies do not have such automatic allocation systems. Only by reviewing proposed risks and interventions with analytic rigor and a holistic perspective can we minimize unintended consequences and optimize risk-reduction resources. We must always keep in mind that poor investment decisions are not "harmless mistakes" but are a lost opportunity to realize genuinely increased safety or other benefits. Yet our environmental-risk regulatory regime rarely conducts such holistic analyses.

B. Ensuring Balanced Accounting

1. Accounting for Risk-trading and Risk-shifting

Like most of the actions taken to improve safety, actions intended to reduce environmental health risks are rarely pure in their effects. Choices have consequences, and it is a true Pollyanna who thinks that any significant action, risk-reducing or otherwise, can have purely positive consequences. While some safety improvement may be gained through the impact of a given risk-reduction measure, in many cases, the

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17 Ibid.

18 George T. Wolff, "The Particulate Matter NAAQS Review," *Journal of the Air & Waste Management Association*, vol. 46 (October 1996).

19 EPA Administrator Browner used this formulation in several presentations made in summer 1997 as the standards were being considered.

20 Richard A. Kerr, "The Right Climate for Assessment," *Science*, vol. 277, September 26, 1997; Dennis Wamsted, "Doctoring the Documents," *Energy Daily*, May 22, 1997; S. Fred Singer, Correspondence, *Nature*, vol. 382, August 1, 1996; "Coverup in the Greenhouse," *Wall Street Journal*, July 11, 1996; S. Fred Singer, *Hot Talk, Cold Science* (Oakland, California: Independent Institute, 1997).

unintended consequences of the measure can produce countervailing impacts that erase some or all of the perceived benefit.[21]

Part of the reason that risk-reducing measures are ambiguous is that risks themselves are often ambiguous. Even for a simple risk scenario, people do not face risks in the same way. Rather, each person has a highly individualized portfolio of risks of various types: environmental, nutritional, hereditary, social, and so on. Generally, we address risk issues by sectioning them off into risk areas: environmental risk, transportation risk, food safety, and so on.

The tendency to section off risks into easily manageable categories increases vulnerability to risks of unintended consequences such as those experienced with airbag regulations. In the most-extreme cases, this tunnel-vision approach can lead to actions that might ultimately cause more harm than good.

The tunnel-vision approach frequently overlooks the phenomenon that some call "death by regulation." Although regulatory costs and job losses are not often considered risk-relevant in themselves, they should be. The linkage between income and risk is subtle but intuitive. We know, for example, that people with large families face lower risks of suffering from severe depression or of becoming homeless due to economic dislocation.[22] We know that people with many friends are in less danger of becoming mentally ill than are "loners."[23] Having a strong social network lessens one's risk of mental illness. Likewise, we know that people's safety is related to people's income. Those with less income are proportionately less able to take the safety measures that higher-income earners can. Families with higher incomes can better withstand short-term health problems than those with less income. Families with higher incomes eat higher-quality foods, drive safer cars, live in safer neighborhoods, train their children for safer jobs, and so on.[24]

Peer-reviewed studies over two decades have examined the relationship between income and risk. The general conclusion of such studies is this: people use their disposable income to weave a personal safety net around themselves and their loved ones. The more disposable income they have, the tighter the weave of their personal safety net. The less disposable income they have, the looser the weave.

As systems engineer Ralph L. Keeney points out in *Estimating Fatalities Induced by the Economic Costs of Regulations*:

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21 Of course, there may be ancillary effects (both positive and negative) of a given action that do not relate to risk. For example, ozone reduction, which will be discussed later, has the ancillary benefit of providing greater visibility, which some people would value highly. But ozone-reduction regulations would also likely have negative impacts on the costs and availability of recreational activities such as motorhome camping, motorcycle touring, or powerboating, which other people would consider a negative impact on lifestyle. Such considerations would be important in a holistic regulatory analytical framework that looked beyond risk to total regulatory impact. However, classification of a regulatory effort as "risk-reducing" generally excludes considerations that do not relate directly (or indirectly) to health risk, either by congressional decree or by environmental agency interpretation of existing law.

22 Shelley E. Taylor, Rena L. Reppetti, and Teresa Seaman, "Health Psychology: What is an Unhealthful Environment, and How Does it Get Under the Skin?," *Annual Review of Psychology*, vol. 48, January 1, 1997, p. 411.

23 Ibid.

24 Ralph L. Keeney, "Estimating Fatalities Induced by the Economic Costs of Regulations," *Journal of Risk and Uncertainty*, vol. 14, 1997, pp. 5-23; Ralph L. Keeney and Kenneth Green, *Estimating Fatalities Induced by the Economic Impacts of EPA's Proposed Ozone and Particulate Standards*, Policy Study No. 225 (Los Angeles: Reason Public Policy Institute, June 1997); Aaron Wildavsky, "Richer is Safer," *The Public Interest*, vol. 60, (1980), pp. 23-29; William Kip Viscusi, "Mortality Effects of Regulatory Costs and Policy Evaluation Criteria," *Rand Journal of Economics*, vol. 25 (1994), pp. 94-109.

> *Regulatory costs are paid by individuals, which leaves them with less disposable income. Since individuals on average use additional income to make their lives safer and healthier, the regulatory costs lead to higher mortality risks and fatalities. Based on data from the National Longitudinal Mortality Study relating income to the risk of dying, approximately each $5 million of regulatory cost induces a fatality if costs are borne equally among the public. If costs are borne proportional to income, approximately $11.5 million in regulatory costs induces a fatality.*[25]

Though environmental advocacy groups and agencies generally dismiss such ideas as unconventional, the implications of this understanding are straightforward: less income, less safety. Nor is this relationship inherently unquantifiable. We can estimate the impact by determining how much a proposed action will cost an individual in terms of disposable income and then correlating that loss of disposable income with personal safety.

2. Accounting for Opportunity Costs

> *Risk-researcher Tammy Tengs and colleagues demonstrated in their study of the cost-effectiveness of risk-reduction measures undertaken by various governmental agencies that all investments in risk reduction do not yield equal results.*[26]

Table 1 shows the median cost of intervention for five regulatory agencies, each charged with reducing risk within its sphere of authority. To date, saving lives through environmental regulations has been, in the aggregate, more expensive than saving lives through other types of safety regulation, though some individual environmental measures may be highly cost-effective ways to reduce risk.

Table 1: Median Value of Cost/life-year Saved for Five Regulatory Agencies

Regulatory Agency	Median cost/ life-year saved
Federal Aviation Administration	$23,000
Consumer Product Safety Commission	$68,000
National Highway Traffic Safety Administration	$78,000
Occupational Safety and Health Administration	$88,000
Environmental Protection Agency	$7,600,000

Source: Tammy O. Tengs, et al., "Five-Hundred Life-Saving Interventions and Their Cost-Effectiveness," *Risk Analysis*, vol. 15, no. 3 (1995) pp. 369-389.

The average cost of a life-year saved in nonenvironmental interventions was about $64,000 in 1994 and probably hasn't changed significantly since then. If a proposed measure cost, say, $10 billion dollars

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25 Keeney, "Estimating Fatalities Induced by the Economic Costs of Regulations, pp. 5–23.

26 Tammy O. Tengs, et al., "Five-Hundred Life-Saving Interventions and Their Cost-Effectiveness," *Risk Analysis*, vol. 15, no. 3 (1995), pp. 369-389. In fact, Tengs et al. found that the most cost-effective risk-reduction interventions were generally medical, not regulatory. Medical risk-reduction interventions including things such as vaccinations, cancer screenings, hypertension screening and treatment often provide risk-reduction benefits at extremely low cost. The average cost of a life-year saved through medical interventions was $19,000 per life-year, considerably lower than other risk-reduction approach costs.

per year, we can see that the same amount of money spent on some of the demonstrated, cost-effective health and safety risk-reduction measures could hypothetically save the lives of 156,250 people per year (at $64,000/life-year saved), assuming returns on investment comparable to historically proven interventions. Of course, such high returns on risk-reduction investments are not likely to be maintained once the low-hanging fruit of risk reduction is plucked and more marginal risk-reduction measures are pursued. Still, if policymakers invest in collective risk-reduction activities, they should consider whether those safety investments achieve better values than those obtained by people on their own. They should also consider whether we are getting the biggest risk-reduction possible through available intervention pathways.

C. Evaluating the Safety-investment Strategy

As policy analyst Aaron Wildavsky points out, possible risk-reduction interventions lie along a spectrum from the resilient to the interceptive. Resilient approaches maximize our ability to cope with risk by maintaining a dynamic, market-based, knowledge-building investment strategy. Interceptive interventions emphasize specific risk-reduction investments that require certain actions and prohibit or restrict others.[27]

But how do we decide, for any given risk, whether an interceptive approach is more likely to provide a good return safety investments than a resilient approach?

Wildavsky also points out that uncertainties about the likelihood or extent of any given risk and uncertainties about the effectiveness of any intervention constrain risk-reduction decisions.[28] Figure 1 below shows how uncertainties about the nature and scope of a risk and uncertainties about intervention measures and their effects constrain strategy selection, favoring certain approaches over others.

Figure 1: Appropriate Strategies for Different Conditions

		Amount of Knowledge About What to Do	
		Small	Large
Predictability of Future Change	High	More resilience, less anticipation	Anticipation
	Low	Resilience	More resilience, less anticipation

Source: Adapted from Aaron Wildavsky's *Searching For Safety* (New Brunswick: Transaction Press, 1991), p. 122.

Employing both theory and empirical observation, Wildavsky observed that a strategy of interception is likely to be successful only in situations of excellent information. So, for example, for a power plant owner

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27 Aaron Wildavsky, *Searching for Safety* (New Brunswick: Transaction Publishers, 1991). Wildavsky used the terms "resilience" and "anticipation" rather than "resilience" and "interception." In adapting Wildavsky's framework to more recent risk-related issues, I've chosen to use "interception" because it corresponds better to common perceptions of how risk regulations work.

28 Ibid.

who knows that a particular part is going to burn out every 150 days an interception strategy of replacing the part every 149 days to prevent the risk may be cost-effective.

But where less information exists, more-resilient strategies are likely to succeed where interception is either infeasible or expensive. If a power plant had 8,000 critical pieces of equipment that, upon failure, would create a fire, but the plant owner did not know the failure rates of each piece, trying to intercept the risk by replacing pieces before they failed would be enormously costly. Further, trying to have backup systems on all 8,000 pieces would be technologically difficult and probably infeasible financially. Instead, a strategy of resilience, such as having a sophisticated fire-response system, is more likely to be a feasible and efficient way of dealing with this risk.

There are several reasons why resilience should be considered the default strategy. There is an unmistakable linkage between a society's resilient social and economic structures and its prosperity, safety, and environmental cleanliness.[29] This linkage stems, in part, from certain fundamental characteristics of resilient systems:

- Resilient systems build knowledge through research and build safety through efficient use of resources, enhancing the ability to respond over time to risks and to reduce risks.[30]
- Resources left in a resilient system of investment build diversity benefits, and safety benefits are both a specific benefit and an emergent benefit of the system as a whole.[31]
- Resilient approaches optimize use of local knowledge of specific and particular circumstances, since, with resources retained by individuals and firms in the social and economic system, people instinctively reduce risks, as they perceive them.
- Resilient approaches create "network benefits" by building knowledge at local levels which can then be brought into play in other areas. Research is a natural part of resilient systems.

Wildavsky illustrates these characteristics, drawing from the work of systems ecologists Kenneth E. F. Watt and Paul Craig. In one example, Wildavsky discusses the "omnivory principle," drawn from ecological studies:

> *The greater the number of kinds of resources utilized by a complex system, and the greater the number of pathways by which resources can flow to dominant system components, the less likely is the system to become unstable because of a supply failure or any single resource. This is the 'spreading the risk,' or insurance principle.*[32]

In another example, Wildavsky explains why a market-based system is more stable, and therefore, safer: the complexity and intricate nature of negative and positive feedback as conveyed through a market is a powerful stabilizing force, whether that market is financial or involves the way energy is distributed through

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29 Ibid.

30 Ibid.

31 Ibid.

32 Kenneth E. F. Watt and Paul Craig, as cited in Aaron Wildavsky, *Searching for Safety* (New Brunswick: Transaction Publishers, 1991), p. 114.

an ecosystem. Natural systems exhibit this complexity and rich feedback milieu, but so do economic systems. Quoting Kenneth E. F. Watt and Paul Craig again:

> *Systems of great complexity, with stability maintained by a lot of fast acting negative feedback loops are complex economies, with prices responding freely to trends in supply and demand. In such circumstances, we see very rapid introduction of new products, or replacement of old by new products.*

In yet another example, Wildavsky points out that ecological studies present cautionary findings with regard to poor specific risk-reduction investments:

> *We are specifically concerned with stability of the entire system in contradistinction to stability of each component of the system. That is, we understand that in biological, economic, or any other kind of systems, the former can be maintained at the expense of the latter. Putting this differently, if the goal adopted is to preserve stability of particular system components, the ultimate consequence can be decreased stability in the entire system.*[33]

Though proponents of a precautionary regulatory approach to safety tend to imply otherwise, a resilient investment strategy does not mean "do nothing," because "do nothing" is never a choice in a dynamic system. Taking a resilient approach will include continued research and actions that reverse various mistakenly adopted or no-longer-fruitful anticipatory measures that block the resilient process. This may include deregulation or replacement of less-market-based measures with more-market-based measures, or it may include public education to help put a given perceived risk into better perspective, so that the individuals can address risks more efficaciously. It may also include "mid-course" corrections, by making adjustments to specific risks, as they move from probabilities to tangible effects.

Departure from the resilient approach should require a demonstration by regulators, based on an assessment of evidence, that a proposed intervention will outperform the default path of resilience sufficient to warrant overriding people's individual choices, which are informed by their own preferences and their "local knowledge" of specific risk tradeoffs.

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[33] Ibid.

Part 3

Case Study I: The 1997 NAAQS Revision

In its 1997 proposal to tighten the nation's ambient air quality standards for ozone and particulate matter, EPA portrayed the risks of exposure and the benefits of action in a way that fell far short of the methodology discussed above.

Analysts differ regarding the rigor of: 1) EPA's risk-assessment methods for ozone and particulate matter; 2) EPA's rationale in framing the issue; 3) EPA's assumptions used in evaluating risk; and 4) EPA's methods for monetizing that risk. These controversies have been well covered in other studies.[34]

A. A Distorted Depiction of Risk and Risk Reduction

EPA's claims regarding premature mortality and respiratory illness caused by currently permissible levels of ozone and particulates came under fire from a variety of sources. In a Reason Public Policy Insitute study that evaluated these conflicting claims, Anne E. Smith, et al., found that while EPA's values for lives saved and disease averted were inflated, there was good reason to believe that currently permissible levels of ozone and fine particulates do cause some premature mortality and increased incidence of respiratory disease.

But after an extensive analysis of EPA methodology, Smith and her colleagues concluded that this risk was half as large (or less) than EPA had projected and that a more plausible range of premature mortality from exposure to particulate matter at the previous standard level is in the range of 1,000 to 6,000 lives annually (not 15,000, EPA's most-cited value). Smith, et al. also found that incidences of aggravated respiratory disease or distress are also only half of EPA's estimate, more likely in the range of 0 to 60,000, rather than the 74,000 cases claimed by EPA.[35]

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34 Kenneth Green, *Rethinking EPA's Proposed Ozone and Particulate Standards,* Policy Study No. 224 (Los Angeles: Reason Public Policy Institute, June 1997); Anne E. Smith, et al., *Costs, Economic Impacts, and Benefits of EPA's Ozone and Particulate Standards*, Policy Study No. 226 (Los Angeles: Reason Public Policy Institute, June 1997); Susan E. Dudley, "Comments on the U.S. Environmental Protection Agency's Proposed National Ambient Air Quality Standard for Ozone," prepared for the Regulatory Analysis Program, Center for Study of Public Choice, George Mason University. Available from Economists Incorporated's Web site: http://www.ei.com; Kenneth Chilton and Christopher Boerner, "Health and Smog, No Cause for Alarm," *Regulation*, no. 3 (1995), pp. 50-62.

35 Smith, et al., *Costs, Economic Impacts, and Benefits of EPA's Ozone and Particulate Standards.*

Smith, et al., concluded that a more plausible range of premature mortality from exposure to ozone is in the range of 100 to 300 lives annually, rather than the 470 premature deaths claimed by EPA.[36]

1. EPA's Ozone and Particulate Risk-ledgers

During the review period prior to adoption of the new standards, EPA portrayed the impacts of enacting new ozone and particulate standards in the following way:[37]

Table 1: EPA-postulated benefits of stricter ozone NAAQS
EPA-postulated benefits of reduced ozone exposure
• Approx. 470 fewer premature deaths/yr.
• Large but unquantified reduction in asthma
EPA-acknowledged liabilities of new standard
• Approx. $4 billion - $10 billion national cost /yr.

Table 2: EPA-postulated benefits of stricter particulate NAAQS
EPA-postulated benefits of reduced fine particulate exposure
• Approx. 1,000 - 15,000 fewer premature deaths/yr.
• Approx. 74,000 fewer cases of aggravated asthma/yr.
EPA-acknowledged liabilities of action
• Approx. $6.3 - $19 billion national cost /yr.

> But analysts outside EPA took a deeper look, finding that EPA's claimed benefits were inflated, while EPA had overlooked several liabilities and underestimated others.[38]

2. Ignoring Risk-trading

As policy analyst and economist Susan Dudley found in her analysis for George Mason University of the proposed ozone standard, the question of reducing ozone levels is not one of pure risk elimination but one of risk-tradeoffs.[39] It turns out that ground-level ozone is not a pure risk, because ground-level ozone has positive health impacts as well as negative. Specifically, like stratospheric ozone (which global treaties

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36 Ibid.

37 *U.S. EPA Regulatory Impact analysis for Proposed Particulate Matter National Ambient Air Quality Standard, and Regulatory Impact Analysis for Proposed Ozone National Ambient Air Quality Standards,* Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, December 1996.

38 Green, *Rethinking EPA's Proposed Ozone and Particulate Standards;* Smith, et al., *Costs, Economic Impacts, and Benefits of EPA's Ozone and Particulate Standards*; Dudley, "Comments on the U.S. Environmental Protection Agency's Proposed National Ambient Air Quality Standard for Ozone;" Chilton and Boerner, "Health and Smog, No Cause for Alarm."

39 Dudley, "Comments on the U.S. Environmental Protection Agency's Proposed National Ambient Air Quality Standard for Ozone.

protect), ground-level ozone protects people by screening out harmful ultraviolet rays that cause skin cancer (the most-common form of cancer), and cataracts, one of the most-common causes of visual impairment. Thus, from a holistic risk perspective, low-level ozone would count as a potential asset as well as a potential liability. How much of an asset would it be?

Dudley estimated that dropping the level of ozone in the lower atmosphere by the amounts that EPA predicts as a result of its proposed standard and using lower-bound estimates of the induced risk in order to be "conservative" would produce between 2,000 and 11,000 new cases of nonmelanoma skin cancer each year, between 130 and 260 cases of cutaneous melanoma each year, between 25 and 50 new melanoma-induced fatalities each year, and between 13,000 and 28,000 new cases of cataracts each year.

3. Ignoring Risk-shifting

As discussed above, some risk-modifying factors are indirect and relate to people's use of disposable income to purchase additional safety. We can estimate this impact by determining how much a proposed action will cost an individual in terms of disposable income and then correlating that loss of disposable income with their personal safety.

EPA first estimated the national cost of compliance efforts triggered by the new standards at $4 billion to $29 billion annually. However, EPA admitted that its figures calculated only partial compliance with the proposed standards. Other analysts estimated the full cost of compliance to be considerably higher. The Smith, et al. study represents the most-comprehensive cost study of the new standards to date, finding that costs more likely will range from $90 billion to $150 billion annually to reach full compliance with both new standards.[40]

Taking $40 billion as the annual cost of compliance for the new ozone standard (the middle of Smith's range of costs for the ozone standard alone) and calculating induced fatalities with a model developed by Ralph Keeney at the University of Southern California reveal a range of induced-fatality probabilities stemming from the income-risk relationship. Depending on whether one assumes that regulatory costs are borne equally by all households (the high end of the range), or proportionally with household income (the low end of the range), $40 billion (in 1990 dollars) spent each year to comply with the new standards will lead to induced fatality of 4,000 to 9,000 Americans each year.[41]

Taking $110 billion as the annual cost of compliance with the new particulate standard (the middle of Smith's range for full compliance with the particulate standard alone, incorporating a conservative assumption of overlapping control measures) and calculating induced fatalities with the Keeney model reveal the potential induced-fatalities stemming from the income-risk relationship. Depending on whether one assumes that regulatory costs are borne equally by all households (the high end of the range), or proportionally with household income (the low end of the range), $110 billion (in 1990 dollars) spent each year to comply with the new standards will lead to induced fatality of 10,000 to 25,000 Americans each year.[42]

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[40] Smith, et al., "*Costs, Economic Impacts, and Benefits of EPA's Ozone and Particulate Standards.*"

[41] Ralph L. Keeney and Kenneth Green, *Estimating Fatalities Induced by the Economic Impacts of EPA's Proposed Ozone and Particulate Standards,* Policy Study No. 225 (Los Angeles: Reason Public Policy Institute, June 1997).

[42] Ibid.

4. Ignoring Opportunity Costs

> As discussed earlier, it is not enough to simply ask how a given risk-reduction intervention performs compared to "doing nothing."

If the new air quality standards carry the $150 billion price tag calculated by Smith, et al., we must also ask what amount of risk reduction that same $150 billion might purchase the American people if used in risk-reduction interventions such as traffic safety improvement, which produce benefits of scale and centralization. About 44,000 people die each year in traffic accidents. Using the average National Highway and Traffic Safety Administration cost per death-averted of $78,000, we could reduce that death rate by half for only $3.4 billion, a small fraction of the estimated $150 billion cost of the new air quality standards.[43]

5. Balancing the Risk Ledger

> When we account for the benefits that EPA inflated, as well as the liabilities that EPA missed or underestimated, we see some sharp differences in the risk ledgers for the proposed actions. The biggest difference is that we now see liabilities of a magnitude large enough to erode the assets, requiring new ledger sections of "Net Assets of Action" and "Net Liabilities of Action."

Table 3: Balanced NAAQS-driven Ozone Reduction Risk-Ledger
HEALTH BENEFITS OF REDUCED OZONE EXPOSURE
• Unquantified, but likely reduced incidence of respiratory discomfort
• Approx. 100 – 300 less premature deaths/yr.
LIABILITY FROM REDUCED UV SCREENING BY OZONE
• Approx. 2,000 – 11,000 additional non-melanoma skin cancers/yr.
• Approx. 130-260 additional cutaneous melanoma cases/yr.
• Approx. 25 – 50 additional cutaneous melanoma deaths/yr.
• Approx. 13,000 – 28,000 additional cataract cases/yr.
LIABILITY FROM THE INCOME-RISK RELATIONSHIP
• Approx. 4,000 – 9,000 additional premature deaths/yr.
OPPORTUNITY COST OF MISALLOCATION OF FUNDS
• **Missed opportunity to save more lives at less cost through other more cost-effective risk interventions.**
NET BENEFITS FROM ACTION
• Unquantified, but likely reduced incidence of respiratory discomfort

[43] Naturally, the cost of averting risk from traffic hazard would increase as one picked off the cheapest interventions. The assumption that the cost of intervention would stay the same for the first half of the total number of people at risk may be optimistic, but the comparison is illustrative nonetheless.

NET LIABILITY FROM ACTION
• Approx. 4000 - 9000 additional premature deaths/yr.
• Approx. 2,000 - 11,000 additional non-melanoma skin cancers /yr.
• Approx. 130-260 additional cutaneous melanoma cases/yr.
• Approx. 25 - 50 additional cutaneous melanoma deaths/yr.
• Approx. 13,000 – 28,000 additional cataract cases/yr.
• **Missed opportunity to save more lives at less cost through other more cost-effective risk interventions.**

Table 4: Balanced NAAQS-driven Particulates Reduction Risk-Ledger
BENEFITS OF REDUCED PARTICULATE EXPOSURE
• Approx. 1,000 – 6,000 less premature deaths/yr.
• Between 0 – 60,000 less cases of aggravated respiratory disease/yr.
LIABILITY FROM THE INCOME RISK RELATIONSHIP
• Approx. 10,000 – 25,000 additional premature deaths/yr.
OPPORTUNITY COST OF MISALLOCATION OF FUNDS
• **Missed opportunity to save more lives at less cost through other more cost-effective risk interventions.**
NET BENEFITS FROM ACTION
• Between 0 – 60,000 less cases of aggravated respiratory disease/yr.
NET LIABILITY FROM ACTION
• Approx. 9,000 – 19,000 additional premature deaths/yr.
• **Missed opportunity to save more lives at less cost through other more cost-effective risk interventions.**

6. Evaluating the Risk-Reduction Strategy

Given the net liabilities inherent in the proposed revisions to the National Ambient Air Quality Standards, there is little need to look further in evaluating the wisdom of this policy. Were the net benefits positive, we would then have to compare the benefits of this investment to other available investments, and to assess whether our certainties and uncertainties gave us a good prospect for a positive policy outcome that could actually realize the benefits seen on paper, in light of real-world complexities.

Part 4

Case Study II: The Kyoto Protocol On Climate Change

A. Depiction of Risk and Risk Reduction

Fully implementing the Kyoto Protocol as currently delineated is unlikely to provide meaningful risk-reduction benefits, a view expressed by people cited as experts by proponents of the protocol at the 1997 Kyoto conference on climate change.

Jerry Mahlman, Director of the Geophysical Fluid Dynamics Laboratory at Princeton University, told the *Washington Post* that, "The best Kyoto can do is to produce a small decrease in the rate of increase."[44] In a post-Kyoto *Science* news brief, Mahlman says "it might take another 30 Kyotos over the next century" to cut global warming down to size.[45]

Bert Bolin, outgoing chairman of the United Nations Intergovernmental Panel on Climate Change, assessed the impact of Kyoto as a 0.4 percent reduction in greenhouse gas emissions compared to a no-protocol alternative and concluded: "The Kyoto conference did not achieve much with regard to limiting the buildup of greenhouse gases in the atmosphere."[46]

Robert Repetto at World Resources Institute acknowledges that the Kyoto Protocol is little more than a tiny step toward a distant end, rather than a significant step in itself: "Nobody thought in their wildest dreams that Kyoto would solve the climate problem…. If implemented, the achievement at Kyoto will be to get nations off a business-as-usual trajectory, and onto a path that peaks, and then starts going down."[47]

As Tom Wigley, a climate researcher at the National Center for Atmospheric Research in Colorado, puts it, "A short-term target and timetable, like that adopted at Kyoto, avoids the issue of stabilizing concentrations [of greenhouse gases] entirely."[48]

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44 Joby Warrick, "Reassessing Kyoto Agreement, Scientists See Little Environmental Advantage", *Washington Post*, February 13, 1998.

45 David Malakoff, "Thirty Kyotos needed to Control Warming," *Science*, vol. 278, December 19, 1997, p 2048.

46 Bert Bolin, "The Kyoto Negotiations on Climate Change: A Science Perspective," *Science*, vol. 279, January 16, 1998, p. 330.

47 Warrick, "Reassessing Kyoto Agreement, Scientists See Little Environmental Advantage."

48 Malakoff, "Thirty Kyotos needed to Control Warming."

In other words, benefits of the Kyoto Protocol are described more in political terms–as initiating a modest shift in energy-use patterns – than in terms of tangible environmental or risk-reduction benefits.

A short-term net-benefit assessment of the approach to climate change represented by the Kyoto Protocol suggests that proposed actions might well turn out to be risk-increasing. But there is also the long term to consider.

Given that significant climate change might have the potential to cause great increases in risks to human health, a discussion of the long-term policy implications of the Kyoto Protocol's "first step" is warranted. Yet assessment of long-term impacts is precisely where results are the least certain, since the scaling up of the modest and validated greenhouse effect to the level of global climate effects, including effects on oceans, ecosystems, mountains, rivers, groundwater, solar variation, greenhouse gas emissions, clouds, aerosols, water vapor, and historical variation, then trying to scale the impacts back down to the local and regional level, leaves us with a view which is best characterized as "through a glass, darkly."

One need not look beyond the landmark 1995 IPCC reports themselves (the often-thumped but rarely read bible of climate change) for expressions of that uncertainty.[49] Even a cursory review of the accepted uncertainties surrounding climate change shows a state of limited knowledge about what to do and a state of low predictability of the direction of change in risk.

Tides, waves, and storm surges could be affected by regional climate changes, but future projections are, at present, highly uncertain[50]

- Confidence is higher in hemispheric to continental scale projections of climate change than at regional scales where confidence remains low.[51]

- The global climate models used for future projections are run at fairly coarse resolution and do not adequately depict many geographic features (such as coastlines, lakes and mountains), surface vegetation, and the interactions between the atmosphere with the surface which becomes more important on regional scales.[52]

- Impacts are difficult to quantify, and existing studies are limited in scope. While our knowledge has increased significantly during the last decade and qualitative estimates can be developed, quantitative projections of the impacts of climate change on any particular system at any particular location are difficult because regional scale climate change projections are uncertain; our current understanding of many critical processes is limited; and systems are subject to multiple climatic and non-climatic stresses, the interaction of which are not always linear or additive. Most impact studies have assessed how systems would respond to climate changes resulting from an arbitrary doubling of equivalent atmospheric carbon dioxide concentrations. Furthermore, very few studies have considered greenhouse gas concentrations; fewer still have examined the consequences of increases beyond a doubling of

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49 Intergovernmental Panel on Climate Change (IPCC), *Climate Change 1995, The Science of Climate Change* (Cambridge, MA: Cambridge University Press, 1996), pp 44, 439.

50 Ibid, p. 41.

51 Ibid, p. 41.

52 Ibid, p. 44.

equivalent atmospheric carbon dioxide concentrations, or assessed the implications of multiple stress factors.[53]

Given these uncertainties, about the best that can be said regarding long-term risk-reduction benefits of a given approach is that *if* the risks of climate change are actually as large as the more extreme predictions of some climate models, and *if* our actions are successful at somehow eliminating those risks over the long term, *then* we may achieve a high level of risk reduction through those actions. However, these "ifs" encompass substantial uncertainty.

1. Ignoring Risk-shifting

One need not take extreme values in order to demonstrate that the impacts to people's risk profiles as a result of the costs of the Kyoto Protocol may be significant. Most moderate economic analyses with moderate assumptions show economic impacts of around a 2 percent reduction in U.S. GDP in order to bring U.S. greenhouse gas emissions to 1990 levels by the timeframe called for in the Kyoto Protocol.[54]

But for the sake of this analysis, let us make a few more optimistic assumptions about the Kyoto Protocol. Let us assume that the full cost of compliance with the Kyoto Protocol might only be $100 billion annually, half (or less than half) of typical estimates.

Using the model of induced fatality described earlier, we can model the impact of taking $100 billion out of people's own risk-reduction budgets and spending it elsewhere. Depending on whether one assumes that regulatory costs are borne equally by all households (the high end of the range), or proportionally with household income (the low end of the range), $100 billion (in 1990 dollars) spent each year to comply with the new standards would lead to induced fatality of 9,000 to 22,000 Americans each year.[55]

2. Ignoring Opportunity Costs

If the costs of the Kyoto Protocol amount to $100 billion dollars per year, we can see that the same amount of money spent on some of the demonstrated, cost-effective health and safety risk-reduction measures could hypothetically save the lives of many people if we would get returns on our investment comparable to historically proven interventions. As discussed earlier, such high returns on risk-reduction investments are not likely to be maintained as the low-hanging fruit of risk-reduction is plucked and as more marginal risk-reduction measures are pursued. Still, about 66,000 people die each year from job-related injuries and

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53 Ibid, p. 346.

54 For a range of economic estimates on the costs of various climate change scenarios with a discussion of assumptions, see Robert Repetto and Duncan Austin, *The Costs of Climate Protection: A Guide for the Perplexed*, World Resourses Institute Report (Washington, DC: World Resources Institute, 1997). For a recent low-end estimate of the costs of reducing greenhouse gases, see *Scenarios of U.S. Carbon Reductions*, a report of the Interlaboratory Working Group on Energy-Efficient and Low-Carbon Technologies (Berkeley, CA: Lawrence Berkeley National Laboratory, 1998). For a recent high-end estimate of the cost of reducing greenhouse gases, see *The Economic Risks of Reducing the U.S. Electricity Supply, CO_2 Control and the U.S. Electricity Sector*, a report by Resource Data International, Inc. (St. Louis, MO: Peabody Holding Company, July 1997). Finally, for a recent moderate estimate of the cost of reducing greenhouse gases, see WEFA Inc., *Global Warming: The Economic Cost of Early Action,* WEFA Report (Eddystone, PA: WEFA Inc, 1997).

55 The lower value in the range represents the assumption that regulatory costs will be divided among the population proportionately with household income, while the higher value in the range represents the assumption that regulatory costs will be borne equally by households regardless of income.

illnesses. If we use the average OSHA regulatory cost of $88,000 for each illness avoided, we could reduce by half these work-related injuries and illnesses at a cost of $2.9 billion, a fraction of the $100 billion that the Kyoto Protocol might require.

3. Balancing the Risk Ledger

When we account for the lack of demonstrable near-term risk-reduction benefits from the Kyoto Protocol approach to climate change policy; the risk-reduction liabilities of the income-risk relationship; and lost opportunities to use proven risk-reduction interventions, we find higher liabilities than benefits for the near term. Given the long-term uncertainties involved, even putting the speculative benefits into the risk-ledger does not contribute much more information to evaluate whether we are on the right track:

Table 5: Balanced Kyoto Protocol Risk Ledger

KYOTO PROTOCOL RISK-REDUCTION BENEFITS —NEAR TERM[a]	
• Reduced risk of harm from changing weather patterns:	NONE
• Reduced risk of harm from extreme weather events:	NONE
• Reduced risk of harm through famine avoidance:	NONE
• Reduced risk of harm through disease prevention:	NONE
• Reduction in other proposed climate change hazards:	NONE
• Reduced risk of harm through avoided economic impacts of climate change:	NONE
KYOTO PROTOCOL RISK-REDUCTION BENEFITS —LONG TERM[b]	
• Reduced risk of harm from changing weather patterns:	NONE – HIGH
• Reduced risk of harm from extreme weather events:	NONE – HIGH
• Reduced risk of harm through famine avoidance:	NONE – HIGH
• Reduced risk of harm through disease prevention:	NONE – HIGH
• Reduction in other proposed climate change hazards:	NONE – HIGH
• Reduced risk of harm through avoided economic impacts of climate change:	NONE – HIGH
KYOTO PROTOCOL RISK-REDUCTION LIABILITIES —NEAR TERM[c]	
• Induced fatalities from income-risk relationship:	Approx. 9,000 – 22,000/yr.
KYOTO PROTOCOL OPPORTUNITY COSTS —NEAR TERM[c]	
• Lives not saved through other risk-reduction investments:	Approx. 0 – 3.5 million/yr.
• Resources not available for other social uses:	$100-200 billion/yr.

NOTES:

a) These values derive from the consensus scientific view that Kyoto compliance, of itself, will produce no environmental benefit, as discussed above.

b) This range of values flows from the consideration that if the pessimistic scenarios of climate change as discussed in the IPCC reports on climate change are true, and if the anticipatory approach is effective, averted risks could be significant.

c) Induced fatality values calculated by author using income-risk relationship as modeled in Ralph L. Keeney and Kenneth Green, *Estimating Fatalities Induced by the Economic Impacts of EPA's Proposed Ozone and Particulate Standards,* Policy Study No. 225 (Los Angeles: Reason Public Policy Institute, June 1997); "Lives not saved" values are calculated by author from values in Tammy O. Tengs, et al., "Five-Hundred Life-Saving Interventions and Their Cost-Effectiveness," *Risk Analysis*, vol. 15, no. 3 (1995), pp. 369-389.

4. Evaluating the Risk-reduction Strategy

Because of substantial uncertainties in the underlying science of climate change, we are unable to tell, from the long-term perspective, whether an action such as the Kyoto Protocol will secure long-term, net risk reductions. In the near term, the Kyoto Protocol clearly has liabilities that exceed its potential benefits.

Finally, the magnitude of the uncertainties in the underlying science of climate change suggests that acting in an interceptive way would most likely waste limited risk-reduction resources, since such actions are more likely to miss the mark than to hit it.

Part 5

Conclusion and Recommendations

Given the complex nature of environmental problems, the "precautionary principle" offers a poor strategy for reducing risks. One solution to this problem might be a process of comprehensive comparative risk assessment, in which all risks and risk-reduction interventions are numerically assessed and ranked. But a comparative-risk approach has problems of timeliness and complexity, compounded by the subjective nature of risk.

An alternative is a case-by-case evaluation of proposed risk-reduction interventions against a set of touchstones to insure that a proposed risk-reduction intervention:

- Saves more lives on net, than it will take; and
- Outperforms the natural risk-reduction benefits of leaving resources to circulate in a dynamic, market-based, knowledge-building economy.

Such a framework requires:

- A scientifically rigorous assessment of the targeted risk that reviews pertinent risk information and has transparent and meaningful peer review;
- A holistic evaluation of potential safety investments that considers risk-reduction, risk-shifting, risk-trading, and opportunity costs of investment; and
- A method for evaluating whether a resilient (adaptive) or interceptive strategy is more likely to secure a net risk reduction.

When applied to two recent, high-profile proposals to reduce environmental risk through regulation (the revised National Ambient Air Quality Standards of 1997 and the Kyoto Protocol of 1998), such a framework suggests that both proposed risk-reduction measures are likely to do more harm than good.

The National Ambient Air Quality Standard revisions fail a simple test of providing a net health benefit when considerations of risk trading, risk shifting, and opportunity costs are considered. The Kyoto Protocol comes up short in the underlying science. Persistent uncertainties permeating our understanding of climate change suggest that taking interceptive actions to forestall the negative consequences of climate change are likely to cause near-term increases in risk; and cannot ensure long-term reductions in risk, while absorbing limited risk-reduction resources; and inviting significant unintended consequences.

To improve our nation's risk-reduction investment strategy, policymakers should:

- Expand the scope of risk and regulatory analysis to include both the direct elements of risk and the indirect elements, such as risk shifting, risk trading, and opportunity costs. The recent appeals court decision opened the door for considering direct risk shifting as it pertained to ozone reduction and the potential increase in UV exposure, But further expansion would probably require revision of the Clean Air Act, as the recent court decision upheld earlier decisions forbidding such considerations;

- Improve agency practice of environmental-risk assessment, most notably by removing the extensive use of "safety factors" and worst-case scenarios that tend to inflate perceived risks;

- Insure a peer-review process throughout the entire process of risk evaluation and regulatory analysis, with binding authority to require revisions and re-analysis of findings;

- Broaden the selection of peer reviewers to include qualified individuals from fields that can help quantify and consider risk shifting, risk trading, and opportunity costs;

- Separate control of the peer-review process from the agency preparing to promulgate a rule, eliminating any potential conflict of interest;

- Require analysis demonstrating that an interceptive approach to managing a particular risk is likely to outperform a resilient approach. Such analysis might require the development of new analytical tools; and

- Require regulatory impact analyses to compare the risk-reduction gained through a proposed measure to a range of other available risk-reduction options such as investment in medical research, automobile safety, aviation safety, occupational safety, and so on.

About The Author

Dr. Kenneth Green is Director of the Environmental Program at the Reason Public Policy Institute. Dr. Green has published peer-reviewed policy studies on climate change, air quality and environmental risk including: *A Plain English Guide to the Science of Climate Change, Rethinking EPA's Proposed Ozone and Particulate Standards, Estimating Fatalities Induced by Economic Impacts of EPA's proposed Ozone and Particulate Standards (co-authored), Looking Beyond ECO, Defending Automobility,* and *Checking Up on Smog Check.* Green received his doctorate in environmental science and engineering (D.Env.) from UCLA in 1994, joined RPPI soon after, and now works from his home-office in Central Texas.

Other RPPI Studies

Kenneth Green, Richard McCann, Steve Moss, and Roy Cordato, *Climate Change Policy Options and Impacts*, Policy Study No. 252 (Los Angeles, Reason Public Policy Institute, February 1999).

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