CHOOSING YOUR FUTURE:

THE ROLE OF IDEAS IN MANAGING TRADE-OFFS BETWEEN ECONOMIC AND ENVIRONMENTAL OBJECTIVES

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ABSTRACT

Environmental deterioration continues despite availability of policies and technologies that could reduce damage. Given the scale of human activity this creates a risk of environmental crisis. This thesis argues for revision of the dominant paradigm that provides the default assumptions used for theoretical and policy analysis that affects long-term economic and environmental outcomes. The paradigm extensions proposed include an environment that can be damaged by human activity, individuals with diverse beliefs and values, and an argument that the Earth is not yet in the industrial era but rather nearing the end of the transition to the industrial era. The proposed revised paradigm can be used to develop a theoretically sound strategy to reduce the risk of environmental crisis. The ideas-based strategy requires individuals to influence the beliefs and values of others to build support for government regulation and to establish norms to constrain damaging activity. The thesis argues that the paradigms and theories chosen by economists and other theorists are important influencers of economic and environmental outcomes.

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My mother's interest in my education provided me with the information that got me thinking about the success and failure of civilizations. My Dad taught me to think for myself at the dining table.

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Dyan de Silva, Glenda Taylor and Sally Major patiently produced and revised this document as it was written and rewritten. Tony Dowsett helped with the referencing and Anne French, Toby Easton and Claire Dale provided valuable editorial input.

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MATHEMATICAL GLOSSARY

UPPER CASE IS AGGREGATE

Lower case is individual

α	Output response to capital
β	Output response to labor
γ	Output response to environment
A	Aggregate activity
a	An activity
C	Aggregate eco-cost
c	Eco-cost for an individual
d	Environmental outcome as assessed by individual
E	Expected value
E	Environment stock
f	Relationship based on mathematical function
i	An individual
j	A specific possible outcome from an activity
K	Capital stock
L	Labor stock
m	Number of actors
n	Number of individuals
n	Social norm as assessed by individual
o	Outcome from activity
p	Personal norm for individual
Q	Total output
R	Self-repair capacity of the environment
s	Relative economic outcome as assessed by individual
SEU	Subjective expected utility
T_D	Environmental technology in causing damage
T_E	Environmental technology in production
T_L	Labor technology
T_K	Capital technology
T_Q	Economic technology
U	Aggregate utility
u	Individual utility
V	Direct economic benefit for all individuals
v	Direct economic benefit for individual
w	Weight in utility function
y	Importance of individual
z	Approval or disapproval value

PREFACE

As a twelve-year-old I read of the decline of the Roman civilization and wondered if ours would suffer the same fate. I have retained a life-long, though casual, interest in what makes civilizations succeed and fail.

The present effort can be traced back to some time in 1988 when a colleague and I, traveling on a plane late at night, were engaged in a wide-ranging discussion on the social, economic and environmental challenges we faced as a civilization. He suggested that I write my ideas on the subject in the form of a book. I managed to spend a few months at the end of 1988 and the beginning of 1989 trying to assemble an argument. Nothing of that effort remains but it provided the impetus for subsequently enrolling in an Economics PhD with the topic *The role of ideas in managing trade-offs between economic and environmental objectives*.

There were a few key starting points. I knew the environment was an emerging issue and could see that we were not managing it well. My observation that shifting from large cars to small cars would help the environment but reduce Gross Domestic Product (GDP) made me focus on trade-offs. My management consulting experience combined with my training in psychology and sociology provided the hypothesis that at the heart of the problem would be issues with ideas. I chose economics because it was the biggest gap in my knowledge of the relevant subject matter.

The rest was a combination of research and insight as I read, wrote and rewrote, gradually assembling the arguments that are included in this thesis. The most surprising thing for me at the beginning was that there was virtually no literature directly on the topic. Searches of the library catalogue and later the Internet using the keywords economy, environment, and idea in combination yielded zero relevant hits. More recently I have identified some research efforts that are directly relevant.

The reason for the lack of exploration of the role of ideas in managing economic and environmental outcomes is obvious with the benefit of hindsight. The topic requires thinking that combines a wide range of subjects including economics and the history of economic thought, psychology, sociology, history and environmental science. Young people are not likely to have the breadth of expertise or the patience to complete the task. Older people are often either domain specialists who are not interested in such cross-disciplinary projects or are captives of existing paradigms. Effective cooperation of complementary specialists to produce fundamental advances is rare. Straying beyond conventional discipline boundaries is a poor strategy if one is using a PhD as an entry to an academic career (Myrdall, 1973, pp. 59–60).

We observe a deteriorating environment and what seems to be insufficient effort to install remedies. Policy prescriptions and emerging environment-friendly technologies are available but not enough is being done to change the current alarming trends. The stakes are high and the risks are documented. There may be obstacles preventing a shared assessment of the risks or slowing our response.

My initial objective was to provide an effective diagnosis of the problem describing the obstacles to responding that would incorporate a role for ideas and offer a basis for more effective policy development and implementation. It was only as the work proceeded that I began to think more about strategies for change and paradigm shift.

Strategies involve planned allocation of resources to carry out actions to achieve desired objectives. Choosing a strategy requires identification and evaluation of strategic options. Implementation requires commitment of resources to some activities rather than others. Strategies that are not implemented cannot be successful.

A paradigm is a model of the world that guides and constrains the options considered in strategy development and evaluation. Our most important paradigms have been developed within academic disciplines during a period of economic growth that has been relatively unconstrained by availability of environmental resources. If more effective policy development and implementation is needed as environmental resources become constrained then adopting a revised paradigm may increase the range of solutions available.

I have learned from consulting to respond to an apparently insoluble problem by developing a better understanding of the problem rather than by widening the search for solutions. The presenting problem is slow implementation of remedies to prevent ongoing environmental damage. However, this is only the first layer of the problem. The problem statement in Chapter One provides more depth than is offered here. Chapters Two through Four describe the symptoms, the risks from failure to respond effectively and the current responses. The ideas-based strategy and proposed paradigm changes are specified in Chapters Six and Seven.

Much remains to be done. The current version of the argument is addressed to academics. A version that conveys the argument to potential managers and influential opinion-leaders is needed to implement the strategy.

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CHAPTER ONE

INTRODUCTION

...all scientific inquiry is, above all, an effort to simplify, by unifying what has long appeared as unrelated and disparate...

K. William Kapp 1961, p. vii

Environmental Issues

Global environmental issues arise when many actors cause small amounts of damage for a long time. Ongoing environmental damage is obvious, even to the most casual observer. We observe deterioration of our immediate physical environments and read reports on global environmental threats: for example climate change (Houghton et al., 2001, p. 13), water resource depletion (P. Simon, 1998, pp. 5-7; Ruttan, 1999, p. 5963), chemical (Tilman et al., 2001, p. 283) and biological contamination (Vitousek, 1994, pp. 1866-1869), deforestation (Prugh, 1999, p. 72), desertification (UNEP, 1993, p. 135), and species loss (Vitousek, 1994, pp. 1866-1869).

This thesis focuses on the role of ideas in the management of environmental issues. Many are global and the focus will be mainly on global issues. The analysis is also applicable to environmental issues caused by large numbers of actions at a national, regional or community level.

For globally dispersed environmental issues the course of development of the developing countries over the next few decades will be important. With more than three-quarters of the world's current population and all of the expected population growth (United Nations, 2001, pp. 480-483), the industrialization of the developing countries has the potential to have a significant impact on environmental outcomes. If development of the developing countries follows the same course as that of the developed countries, and uses the same technologies, then there may be a high risk of environmental crisis. The key environmental challenge in the developing countries is to ensure that they adopt an industrialization path that uses low damage technologies.

The developed countries have achieved population stability at population densities that are much lower than those in developing countries. They have largely completed their industrialization and have begun aggressive efforts to improve environmental outcomes. Per capita environmental impacts in the developed countries are much higher than current per capita impacts in developing countries. The challenge for developed countries is to achieve reductions in per capita environmental impacts to limit total growth in environmental damage.

Large-scale environmental damage is not new and past civilizations have left depleted environments. For example,

> the entire Mediterranean region shows the effects of siltation, overgrazing, deforestation, and erosion or salinization caused by irrigation. In Roman times, one could walk North Africa's coast from end to end without leaving the shade of trees; now it is a blazing desert. (Hawken, Lovins, and Lovins, 1999, p. 149)

Similar tales of destruction of environmental resources can be told about other peoples and regions (e.g., Flannery 1994, pp. 242-259; Goudie, 1994; Redman, 1992, pp. 41-48). The impersonal histories of environmental disasters make interesting reading but they are stories of events that happened to other people. We may comfort ourselves by noting that although the Mediterranean environment and many civilizations collapsed, civilizations in the west of Europe overcame resource limitations through a combination of innovation and the use of remote resources (Leonard, 1985, pp. 30-33).

As today's occupants of planet Earth we are the ones who need to respond to today's environmental challenges. We cannot take comfort in the potential for civilization to arise elsewhere because our civilization has only one planet and because we will face the risks from global environmental damage within our own lifetimes.

This chapter begins with a statement of the problem to be addressed. Conventional solutions have important deficiencies resulting in the examples cited at the beginning of this chapter. The approach highlights environmental constraints and focuses on environmental outcomes as objectives of societal management.

A simple societal model is introduced, with major roles played by businesses, governments and individuals. The chapter concludes with a summary of the disciplinary and methodological foundations chosen for the investigation, an introduction to the foundations of the solution proposed, and an outline of the thesis.

The Conventional Response

The conventional response to emerging environmental issues is to continue to maximize economic outcomes while relying on market signals to promote technological innovation and resource substitution (Nordhaus, 1992, p. 22; Norgaard, 1994a, p. 53). If unacceptable environmental damage occurs then policies such as taxes, permits and prohibitions are introduced to discourage damaging activities.

To date, the rate of technology and policy development and deployment has been too slow to arrest ongoing environmental deterioration. Hawken et al. (1999) argue that technologies to address many environmental issues are either already available or on the horizon. Important opinion-leaders, such as former President Bill Clinton, accept their argument:

> I urge you to all read a book, *Natural Capitalism*, by Paul Hawken and Amory and Hunter Lovins. It proves beyond any argument that there are presently available technologies, and those just on the horizon, which will permit us to get richer by cleaning, not spoiling, the environment. (Clinton in Hawken et al., 1999, back cover)

Having technologies does not automatically translate into using those technologies. Reviewing the prescriptions found in the literature reveals a variety of proposals that would help reduce environmental damage.

One such proposal is to value natural capital by encouraging recognition of its importance. Costanza et al. (1997) estimated that the global annual value of services from 17 important ecosystems in 1994 was US$33 trillion (p. 256). Patterson (2002) values primary ecological inputs for the same year at US$24.73 trillion (p. 474). For comparison, Patterson notes that this is almost as much as the global GDP for 1994, which the World Bank estimates as US$25 trillion (p. 474). Costanza et al. (1997) state that their ecosystem contribution is 1.8 times the Gross National Product (GNP) for the same period (p. 259). Having a measure of the value of environmental services creates an incentive for the "owners" of the environmental stocks to provide services to protect the value of their asset.

Governments act as owners of common environmental stock on behalf of their populations. Governments are expected to protect the value of the assets by regulating to prevent damaging activity. Various policy options have been proposed and adopted including shifting the tax basis from income onto activities that damage the environment, introducing tradable permits to restrict activity that is damaging in large amounts, preserving environmental resources via establishment of parks and species protection, restoring environmental amenities, and education to encourage environmentally beneficial shifts in personal and business activities.

Business is seen as having an important role. Hawken et al. (1999, pp. 13-21) argue that there are many opportunities for businesses to earn profits by deploying technologies that improve profitability and are much less damaging. Many businesses are successfully pursuing such win/win strategies where both the economy and the environment benefit.

While there are many situations where win/win strategies are available, there are others where businesses face a choice between profits or protecting the environment. In these situations businesses are encouraged to be socially responsible and consider the interests of the environment (Robèrt et al., 2002, p. 213). Individuals, including many in business and government, are also making valuable efforts to reduce environmental damage caused by their own activities or activities by others (e.g., Frey, 2002).

Speth (1992, pp. 209-213) describes six transitions: in demography, technology, economy, society, consciousness and institutions. A transition is required in all arenas to reach a sustainable society. The transition in demography is to reduce the growth rate of population and achieve stability as soon as possible. The technological transition requires transformation of technologies used in manufacturing, energy, transportation, building design and agriculture. Economic transformation will require prices to reflect ecological realities implying introduction of taxes on damaging activities and removal of subsidies for such activities.

The social transition Speth envisages would include funding flows to developing countries to generate environmentally sustainable employment opportunities and promoting social evolution towards societies that will be able to avoid excessive pressure on a deteriorating resource base. The consciousness transition depends on scientific research to identify solutions and the dissemination of information to build public support for change. Finally, institutional transition is needed to reach international agreements more quickly, to integrate environmental planning with other fields and to encourage efforts by local and private sector actors. Speth's six transitions highlight the conclusion that the required changes will not be achieved with business as usual but instead will require transformation of the Earth's societies over the next few decades.

Given the high stakes and the understanding of the challenge one would expect that policies would be aligned quickly to encourage environmental protection. It is therefore surprising that N. Myers and Kent (1998, p. xvi) and Pearce (1998, pp. 185-186) have found that subsidies are encouraging instead of discouraging activities that damage the environment. N. Myers and Kent conservatively estimate that almost US$1.5 trillion of environmentally and economically damaging subsidies are paid each year. The most important of these perverse subsidies are an estimated US$640 billion for road transportation, US$460 billion for agriculture and US$220 billion for water (p. xvii). N. Myers and Kent report that "a typical American taxpayer is paying at least [US]$2000 per year in perverse subsidies, and paying almost another [US]$2000 more for consumer goods and services with their increased prices, or through environmental degradation" (p. xviii).

An effort to raise awareness of the increasing risk of crisis was published in the Spring 1997 *Issues in Ecology.* A group of scientists stated :

> Based on available scientific evidence we are certain that:
>
> - Ecosystem services are essential to civilization
> - Ecosystem services operate on such a grand scale and in such intricate and little-explored ways that most could not be replaced by technology
> - Human activities are already impacting the flow of ecosystem services on a large scale. [bullet points per original] (Daily et al., 1997, para. 3)

Hawken et al. (1999) concluded "if current trends continue, humanity will dramatically alter or destroy virtually all of Earth's remaining natural ecosystems within a few decades" (p. 153).

Warnings about environmental crises are not new. For example, in *The Limits to Growth,* Meadows, Meadows, Randers, and Behrens (1972) argued that the trends in economic growth, resource depletion and waste accumulation will constrain economic growth and adversely affect human well-being within 100 years. The warning received widespread attention but the predicted crisis has not emerged yet. For example, almost all resources continue to be abundantly available and most commodity prices have not increased in real terms (Lomborg, 2001, pp. 137-138; Nordhaus, 1992, pp. 20-22, 28).

The topical environmental issue at the beginning of the 21st century is climate change driven by human activity. There is increasing recognition that over-abundance of harmful materials is at least as important a risk as depletion of useful ones (e.g., Tilman et al., 2001). The next environmental issue to attract widespread attention may be threats to ecosystems or fresh water shortages.

Environmental threats such as fires, weather extremes and diseases, or those listed above, may become hot topics, usually either because there is a mini-crisis or because an effective communicator captures the attention of opinion-leaders and the public. However interest soon wanes and people have come to accept news of environmental degradation as routine.

It is tempting to conclude from our continuing economic success, the apparent failure of predictions such as those by Meadows et al., and the seemingly inconsequential coming and going of environmental concerns, that humanity can continue to damage the environment and maintain our way of life. However, such a conclusion may not be justified.

To see why, consider a finite reservoir of water as a simple model of the environment. People take water from the reservoir. When the reservoir is half empty someone predicts that the water is coming from a finite reservoir and that it will run out. Some time later people are still successfully drawing water from the reservoir and so they conclude that the warning was wrong. If the reservoir is replenished, but at a rate slower than the rate at which water is taken, then the outcome will be the same, and the validity of the prediction is likely to be more difficult to discern.

The physical environment, like the reservoir, is a resource that is finite. One key difference is that a reservoir of water is visible, but it is more difficult to see the environment. The lack of clear understanding of environmental circumstances and the large scale of global processes relative to everyday lives means that the reduction of the water level in the environmental reservoir cannot be observed easily.

It is hard to detect a major shift in trends as a result of the warning by Daily et al. in 1997. Continuing with current responses may eventually reverse environmental depletion and so reduce environmental risks in the long-term. However, there may be important risks because of lags between the need for a response emerging, the need being identified, a response being developed, the response being implemented, and the response taking effect. Lags increase the risk of environmental crisis and motivate consideration of how they might be reduced.

Our level of concern over these medium-term risks will depend somewhat on how threatening they are to us as individuals. For reasons that will be explained in Chapter Three, medium-term will be used herein to refer to the period from 2010 to 2050 approximately. Therefore short-term is the next ten years and long-term is post-2050.

While few would prefer unsustainable development to sustainable development, there is very little effective policy or action to change the trends quickly. Will the current effort be enough or will additional effort be needed to avoid lags in responses that could allow destruction of important ecosystems? Chapter Four concludes that lags in responses are likely and that more effort to overcome them would be valuable.

Questions about global outcomes in the future cannot be answered by empirical analysis because it is not possible to run an experimental trial. One way forward is to rely on theoretical analysis, combined with data on the existing situation and trends.

The scientific forecasts of outcomes with existing trends remain uncertain but there is ample evidence that a change of course would be beneficial. Policies and technologies are available but are not deployed. The issue is implementation. Hawken et al. (1999) acknowledge this:

> While governments, NGOs, land trusts and other agencies strive mightily to conserve and restore living systems, they are not keeping up with the rate of destruction. It is our belief that we already know how to "invest" in natural capital – thousands of groups are doing it around the world. What we haven't learned is how to conduct our economy so that degradation first stops, and then reverses. (p. 159)

Reviewing the implementation section of several policy focused writings on the environment reveals a reliance on governments, businesses or individuals to change their behavior but little analysis of what will motivate them to do so (e.g., Beaton and Maser, 1999, pp. 85-88; Jepma and Munasinghe, 1998, pp. 83-118; Robèrt et al., 2000, pp. 198-204; Speth, 1992). There is a common logic used that goes as follows. There is an environmental problem. There is a technology or policy to address it. Governments (or businesses or individuals) need to take action. The environment will be repaired. The missing piece of logic is obvious when it is laid out this way; it is that the actors will take the action proposed.

In the absence of an adequate consideration of why actors will act the argument contains a "then a miracle occurs" step. Most policy writers implicitly recognize this. They defer to the resulting uncertainty about the environmental outcome by leaving out the claims implied by the last step of the argument, implicitly acknowledging that their policy prescriptions are incomplete.

Developing and implementing strategies to improve environmental outcomes begins with identification of the desired outcome. Next it is important to understand the current physical status and the expected physical status given existing trends. This allows the gap between the desired outcome and the expected outcome, given existing trends, to be identified. Analysis can be completed to identify and evaluate the options to close the gap and achieve the desired outcome. These options may be defined by alternative physical actions that could achieve the desired outcome. For example, one option to reduce global warming would be to substitute natural gas for coal in power generation. Strategic options are assessed using specified criteria, which might include for example the contribution to achieving the desired outcome, the expected ease and cost of implementation, and the impacts on important constituencies. Individual strategy development processes vary, depending on factors such as how much is known, what has already been decided and the objective of the strategy.

Choosing the preferred option or options is not the end of the strategic analysis because the means of implementation may also need to be chosen. Substituting natural gas for coal could be achieved using a variety of policies including taxes, quantity restrictions, subsidies and voluntary agreements. Again the range of options can be assessed against criteria and the preferred option chosen.

Even when an option has been chosen, for example to use taxes, there may be an issue of getting the enabling regulations introduced and enforced. Again, several options could be evaluated including leading existing governments, supporting alternative governments, and enlisting the support of gas producers to engage in vigorous lobbying.

The illustration involves three stages of strategy development: choosing a technology shift, choosing the policy instrument and choosing a method to introduce the policy instrument. In practice, strategy development may consider the three stages of strategy development together because difficulties with the second and third stages could imply a need to reconsider the first stage.

While these three stages are somewhat arbitrary they do illustrate the importance of bringing different perspectives to the development of environmental strategies. The first stage is in the physical domain and requires the expertise of environmental scientists, physicists, engineers, ecologists and other physical scientists. The second stage uses economic and policy tools while the third stage relies on managerial and social science. A successful strategy is only likely if appropriately skilled specialists are engaged at each stage and there are processes to link the specialists and stages together effectively.

Implementation involves the deployment or redeployment of resources by someone who controls those resources. Implementation is something that managers do when they follow an implementation plan. The implementation plan in this example of substituting natural gas for coal might lay out in detail how the manager will engage with both gas producers and governments to develop and enact the proposed regulations.

Absence of clear and detailed implementation plans that can be executed by managers who control the necessary resources increases the likelihood of implementation lags. For this reason, and because the trends appear to be potentially threatening, this investigation will begin with the working assumption that there is a need to reduce environmental damage and ask how, rather than whether, the response could be made more vigorous. Further evidence of the need for a more vigorous response will be introduced as the argument develops.

As noted above, environmental strategies may identify a desired physical outcome and some actions that would lead to the physical outcome. However, these strategies often stop short of laying out detailed implementation plans, identifying the manager who will implement the plan or considering how obstacles to implementation might imply modifications of other elements of the strategy.

Strategies may fail because managers lack power or lack the skills required to complete their task. They may also fail because of unforeseen events. However, good strategy development takes all these factors into account. If managers need to be replaced, retrained or given more power these steps will be included in good strategic plans. Similarly, good strategies anticipate events that would put desired outcomes at risk and include provisions to mitigate such events. Effective and innovative institutions that can develop strategies and manage change so that implementation proceeds as planned may be needed and some of the critical success factors for such institutions will be identified.

A Paradigm Problem?

Kuhn defines paradigms as "models from which spring particular coherent traditions of scientific research" (1970, p. 10) including law, theory, application, and instrumentation. He goes on to say that:

> The study of paradigms . . . is what mainly prepares the student for membership in the particular scientific community with which he will later practice. Because he there joins men who learned the bases of their field from the same concrete models, his subsequent practice will seldom evoke overt disagreement over fundamentals. Men whose research is based on shared paradigms are committed to the same rules and standards for scientific practice. (p. 11)

In my work as a strategy consultant I have found a very common pattern within organizations that are struggling; they have outdated paradigms. By this I mean that the members of the struggling organization have a set of theories and beliefs that were developed as an effective adaptation to their circumstances. Later, due to regulatory changes, globalization, technology change, competitor action, customer change or some other reason their adaptation is no longer effective. Successful ideas may persist even after they are no longer useful.

One important argument that will be developed in this thesis is that outdated ideas are a key reason why there has been insufficient action to reverse the trends that are damaging the environment. The currently dominant economic ideas, those that form the foundation for policy prescriptions, were developed when there were huge opportunities for economic development, great benefits from competition, and few environmental constraints (Norgaard, 1994a, p. 45).

Circumstances have now changed leading to the possibility that the ideas that were appropriate for managing the economy and the environment in the 19th and 20th centuries will be inappropriate in the current century, as the environment emerges as an important economic constraint. Dominance of ideas that have been successful in the past might be inhibiting consideration of alternative approaches and impeding the emergence of new ideas, just as Kuhn (1970, pp. 77-82) described.

This thesis focuses on the role of ideas. An idea is defined here as "a mental image or cognition that may occur without direct reference to perception or sensory processes" (Corsini, 1999, p. 466). Four kinds of ideas are used here: beliefs, values, theories and paradigms.

Ideas are relevant in two important arenas. The first arena is the choices, or decisions, made by actors in the environmental management process: the governments, businesses and individuals whose choices and resulting actions are the direct determinants of outcomes. In this arena the principal focus of this thesis is on the beliefs and values that influence choices of actors about activities that affect economic or environmental outcomes.

Individuals may act in ways that do not affect economic or environmental outcomes but that behavior is excluded from the definition of activity used here. Similarly only those actions by businesses that have economic or environmental consequences are included here as activity.

A belief is defined as "any proposition that is accepted as true on the basis of inconclusive evidence" (Colman, 2000, p. 84) or "an attitude of acceptance about the validity of a doctrine that may or may not be correct" (Corsini, 1999, p. 105). Probability statements can be used to describe degrees of belief in a proposition: "you can think of a probability as representing the individual's judgment concerning what will happen . . ." (Winkler, 1972, p. 16). In this thesis a belief is an expectation that if a condition is met, for example an individual carries out an activity, then a predictable outcome will occur with certainty or with a subjectively assessed probability.

A value is "a goal or standard considered especially worthy by an individual or a society" (Corsini, 1999, p. 1044). Values here do not have their conventional economic meaning of an individual's willingness to pay for benefits or to avoid costs (Pearce, 1993, p. 6). Values are used in this thesis to refer to the way that individuals assess outcomes. The approach of Ramsey (1926) will be followed: ". . . we act in the way we think most likely to realize the objects of our desires, so that a person's actions are completely determined by his desires and opinions" (p. 69). He goes on to say that "the theory I propose to adopt is that we seek things which we want, which may be our own or other people's pleasure, or anything else whatever, and our actions are such as we think most likely to realize these goods" (p. 69). What Ramsey refers to as the objects of our desires and the things that we want will be referred to here as values. Values are closely related to utilities because the expected utility of an outcome is the belief about the expected amount of the outcome multiplied by the value per unit of the outcome. Ramsey's opinions correspond to beliefs.

Beliefs and values influence the decisions that individuals make among possible activities. Individuals are assumed to choose an activity or activities to maximize subjective expected utility (SEU):

$$SEU(a) = \sum_j p(o_j)\ u(o_j)$$

where $p(o_j)$ is the individual's belief about the probability that outcome j will result from the activity a, and $u(o_j)$ is the value (or utility) that the individual places on the outcome j (Ramsey, 1926, pp. 62-79; Savage, 1954, pp. 73, 96-97; Von Neumann and Morgenstern, 1944, pp. 17-33; Winkler, 1972, pp. 16, 268-269).

Two individuals may both believe that an activity will cause a particular outcome but they may value the outcome differently. Similarly, individuals may value an outcome in the same way but have different expectations of the probability of the outcome.

The second arena for ideas is economic theory where the ideas of economists influence the beliefs and values of other actors and so have important indirect impacts on outcomes. Theory can mean "a plausible or scientifically acceptable general principle or body of principles offered to explain phenomena" (Merriam-Webster, n.d.). For theorists, theories are beliefs.

If ideas are important and the existing dominant paradigm is comprised of a set of theories this implies that it will be important to identify the existing dominant theories and test them to detect any that might be impeding our ability to manage the environment effectively. The key theoretical ideas that drive choices about activities that impact the environment are those that are used to manage the economy. Despite human diversity and pluralism, a small body of successful beliefs dominates management of the economy and environment.

The relevant aspects of the dominant paradigm can be summarized as a set of ten beliefs widely used by theorists who contribute to developing policies that affect the economy and the environment:

1. Individuals are rational and self-interested. They maximize subjective expected utility. Utility comes from consumption (Kamarck, 2002, p. 39; Samuelson and Nordhaus, 1989, p. 101).

2. The role of economic policy is to deliver the output to provide the consumption that individuals want. Production is constrained by capital and labor.

Production provides goods and services for consumption, and replenishes or increases stocks of capital and labor (Penz, 1986, pp. 12-23).

3. There are free gifts from the environment and free disposals may be made to the environment (Perrings, 1987, p. 5; Samuelson and Nordhaus, 1989, p. 24).

4. If activity damages the environment then prices or technology will remedy the problem; or property rights, taxes, tradable emission rights, quotas or prohibitions can be introduced to ensure adequate protection (Nordhaus, 1992, p. 22; Norgaard, 1994a, p.53; Prugh, 1999, p. 16; J. L. Simon, 1990, p. 440).

5. Economic activity is small relative to the potential of the environment. Technology will allow more efficient exploitation of the physical environment. If environmental stocks do become depleted then substitutes can be used (Prugh, 1999, pp. 16-17; Nordhaus, 1992, p. 23-28; Lomborg, 2001, pp. 159-160).

6. Business activity in competitive markets, whether carried out by corporations or individuals, is useful because it is an efficient way to deliver the goods and services that provide utility for individuals. Business activity should be constrained as little as possible to ensure efficiency (Eichner, 1983, p. 236; Mitchell and Simmons, 1994, pp. 4-6; Prugh, 1999, p. 17; Samuelson and Nordhaus, 1989, pp. 41, 43-44,).

7. Governments provide leadership. If environmental issues arise then governments have the obligation to resolve them (Woodwell, 2002, p. 432). Despite this, governments should minimize interventions that restrict the freedom of businesses and individuals to pursue their own interests (Eichner, 1983, p. 236; Samuelson and Nordhaus, 1989, pp. 773-775).

8. Beliefs and values are personal issues. "...Orthodoxy holds that people have an inalienable right to create their own values; accordingly any attempt to judge these values or replace them with others…is taken as anti-liberal and ultimately fascist" (Ophuls and Boyan 1992, p. 298).

9. Individuals cannot solve environmental issues. The best means to address environmental issues is socially responsible businesses (Robèrt et al., 2002) or government intervention (Saunders, 1999, pp. 273, 275).

10. The paradigm may not be perfect but its deficiencies are at the margin. Outcomes can be improved by making the world behave more closely to the way the paradigm assumes it should (Wiles, 1983, p. 67) and by selective use of environmental protection policies.

Conventional economic analysis implicitly assumes stationarity. A stationary process is one "whose properties are stable, in the sense that they are unchanged for any displacement along the time axis" (Malinvaud, 1970, p. 418). For example, if capital and labor have constrained output growth and continue to do so then the economic process may be stationary. However, if the environment becomes an important constraint then the production function may change so the process should not be treated as if it is stationary. If the process may not be stationary then it is important to be careful projecting the future from the past because some things will change while others will persist.

The theoretical beliefs listed above comprise part of the set of default assumptions commonly used for policy analysis. They are so dominant that they are frequently not specified, being taken as given by writer and reader alike. Particular analyses may vary one or more of these assumptions but usually most are retained.

Spash (1999) states that: " . . . to achieve social and environmental sustainability, there is a belief in the need to understand current approaches to economics and ecology but most importantly to develop a new paradigm" (p. 430). It is one thing to have a hypothesis that something is amiss but quite another to define the specific problems with the paradigm and develop an alternative. Consider the ten statements above. Which ones should be changed to get better environmental outcomes? Is one key theoretical belief wrong? Are there two or three?

The approach adopted is to focus on the roles that beliefs, values and theories currently play in affecting environmental outcomes and to develop an understanding of how changes in beliefs, values and theories could allow better outcomes. This thesis will argue that each of the ten statements summarizing the dominant paradigm contains a fundamental flaw and that by remedying those flaws theorists can gain a better understanding of the environmental challenge, understand how the current paradigm inhibits development of effective responses, develop a paradigm that is better adapted to current circumstances, and identify a strategy to reduce environmental damage and the risk of environmental crisis. The proposed revised list of theoretical beliefs is in Chapter Seven.

Despite these encouraging assertions the issue remains: Which elements of the paradigm should be changed? If the problem is a paradigm problem then developing a solution requires identification of the weaknesses in the existing paradigm and proposals for modification.

Managing a Trade-Off?

The dominant paradigm treats the environment as if it is a means to provide an economic end rather than as if it is an end in itself. The environment is assumed to provide free gifts of resources to the economy and to allow free disposals of the wastes generated by economic activity. Perrings (1987, p. 5) describes free gifts as things that can be provided by nature, and free disposals as the assumption that the economy can dispose of unlimited quantities of waste material without cost. Assuming free gifts and free disposals encourages maximization of economic output by avoiding any issues arising from effects on the environment. This need not be the assumed relationship between the economy and the environment.

The objective of sustainable development (Atkinson et al., 1997; Ekins, 1995; Faucheux, O'Conner, and van der Straaten, 1998; Heal, 1998; Pezzey, 1992; Prugh, 1999; Toman and Crosson, 1991; Toman, Pezzey, and Krautkraemer, 1994) proposes a revised relationship between economy and environment. Sustainability is an economic goal that recognizes that economic activity may cause environmental damage (Atkinson et al., 1997, p. 3). As an economic goal, sustainability involves maximizing output while limiting damage to the environment.

There are two broad versions of sustainability, distinguished by the outcomes they consider. Weak sustainability allows environmental damage provided that the overall capital stock does not decline. "This approach suggests that we could allow natural capital stocks to decline, provided manufactured capital stocks were rigorously built up to compensate. . . . Strong sustainability calls for independently maintaining the stocks of both manufactured capital and natural capital" (Prugh, 1999, p. 44). Both versions of sustainability involve continued maximization of output but they imply different environmental policies.

The approach here follows Common and Perrings (1992, p. 22) in considering economic and environmental outcomes as distinct from one another. The most important reason for a distinct focus on environmental outcomes is to allow consideration of the risk of an environmental crisis and the role that economic activity plays in increasing that risk. Humanity depends on the environment for survival as well as for wealth but the risk of environmental crisis is usually ignored in the cost-benefit analysis of economic initiatives (Pearce, 1976, p. 110).

In some circumstances an activity that maximizes economic output can also minimize environmental damage, for example a recycling business. In other circumstances something that would reduce economic output would also be environmentally damaging; for example burning forests to clear land for agriculture instead of harvesting the timber. For cases where environment and economic outcomes are both good or are both bad no trade-off is required. Many of our leaders believe that trade-offs are unnecessary. For example, former President Bill Clinton has said that "I have been convinced for years that it is no longer necessary to choose between growing the economy and preserving, and even improving, the environment" (Hawken et al., 1999, back cover).

Not everyone would be willing to join President Clinton in concluding that people will be able to rely on win/win solutions where both the economy and the environment can benefit. It is important to try very hard to find such solutions but also important not to ignore cases where there is a choice between achieving economic objectives and becoming wealthier, or pursuing environmental outcomes to avoid the risk of environmental crisis. This thesis is concerned with how cases where such trade-offs are required can be managed.

The approach options can be generalized as follows: the dominant paradigm, in which output is maximized and it is assumed that the environment will cope, in part due to human technology (J. L. Simon, 1990, part 7); sustainability, with the objective to maximize output subject to the constraint that damage to the environment is limited (Prugh, 1999, p. 44); win/win, which acknowledges distinct economic and environmental outcomes but assumes or concludes that the economy will operate in ways where both will benefit (Hawken et al., 1999, chap. 12); or trade-off, which requires managing trade-offs between distinct economic and environmental objectives (Common and Perrings, 1992).

The dominant approach does not consider environmental outcomes at all. Sustainability seeks maximization of output, subject to limiting environmental damage. Concluding that output growth is or is not sustainable does not highlight environmental outcomes or focus attention on environmental risks. The win/win approach de-emphasizes the practical issues of addressing difficult trade-offs by assuming that they need not exist.

The focus of interest includes consideration of environmental risks so economic and environmental outcomes are important and distinct objectives. There are situations where it is necessary to choose between economic and environmental objectives and in those situations someone must decide how much of each to choose. These are questions about societal objectives and it will be argued that the risk of crisis is sufficient to seek better environmental outcomes, even if this compromises some economic objectives.

In principle, managing this trade-off involves a few key steps. First, any win/win activity opportunities available can be exploited without any need to resort to trade-offs. In unregulated markets opportunities to get more profit and improve the environment are likely be rare, because profit-motivated businesses should have already exploited them.

Next, the win/lose activities are assessed to identify opportunities to improve environmental outcomes for the minimum cost (e.g., Barbier and Markandya, 1990; Faber and Proops, 1990). Decisions are then made about which opportunities to pursue and the preferred solutions are implemented. This idealized process may not be followed in practice because other processes, some of which will be discussed in this thesis, may be used to determine outcomes.

This thesis is mostly concerned with the decision-making and implementation stages of management of the trade-off. It will be argued that there are important obstacles preventing the development, adoption, and implementation of options to improve environmental outcomes. The arguments are developed to identify these obstacles and provide managers with some tools to help overcome them.

Establishing environmental outcomes as a distinct objective and recognizing that the economy and environment can affect one another implies rejecting the free gifts and free disposals assumption, which means that when a resource is used depletion of the resource and the accrual of wastes are considered. The effect of activity on environmental stocks differs from activity's normal effect on capital and labor. In general, more activity produces more capital and more labor but, in today's economy, activity often reduces environmental stocks as well.

Activity is no longer unequivocally good. With free gifts and free disposals more activity means more output, more consumption and more utility. Without free gifts and free disposals, activity may cause environmental damage so there will be an optimal amount of activity that gives the best combination of output and damage.

Activity is becoming large relative to the size of the environment (Pimentel et al., 1999; Vitousek, Ehrlich, Ehrlich, and Matson, 1986; Wackernagel et al., 2002). This means that activity can change the climate and deplete resources that are critical for agriculture. If there is a risk that new technologies and substitutes may not be sufficient to offset the effects on output of climate change, biological and chemical contamination, and land degradation, then environmental crisis becomes possible.

With assumptions that allow the possibility of crisis, the environment has standing and it becomes clear that growing activity forever to increase aggregate consumption without explicit consideration of environmental consequences has serious shortcomings as the goal of societal management. GDP growth is no longer the appropriate scorecard for societal performance.

Giving Standing to the Environment

Our experience of continuous economic progress during our lifetimes and our understanding of recent history lead us to think that we live in the industrial era. More complex classifications distinguish post-industrial society and the services, knowledge, information or communications ages from the industrial era (Bell, 1973, pp. 116-117). We may anticipate the biotechnology and nano-technology ages. Each classification is designed for a specific purpose and focuses on different aspects of the development process, depending on the backgrounds and purposes of the authors.

This thesis focuses on environmental issues. The classification of time periods selected emphasizes the relationship between human communities and their environments; in particular on the impact of the means of food production on potential population densities. Three eras are considered: hunting and gathering, agricultural, and industrial. The hunting and gathering and agricultural eras had relatively stable population densities with higher densities supported by agriculture (Ness, Drake, and Brechin, 1993, pp. 34-35). Hunting and gathering requires that the whole population be engaged in food production. Typically around 94% of the population is engaged in food production in agricultural economies while developed countries with industrial economies only need around 3% to 6% of the population engaged in food production (Ness et al., 1993, p. 37; US Census Bureau, 2001, p. 849). The industrial era is defined as a period of relatively stable population densities sustained by industrialized agricultural technology that allows a small percentage of the workforce to provide food for all.

Progress from one era to the next is referred to here as a transition. The transition from hunting and gathering to the agricultural era is described by Diamond (1998, pp. 105-

113). The transition from the agricultural era to the industrial era is referred to as industrialization or the industrial revolution. The increase in population density that accompanies industrialization is known as the demographic transition (Samuelson and Nordhaus, 1989, p. 883; Chesnais, 1992, part I). The first developed countries began their transition to the industrial era at the end of the 18th century. Developed countries have achieved industrialized agriculture and stable population densities and have therefore entered the industrial era.

Developing countries are those that remain in the transition to the industrial era. Population densities are projected to stabilize in developing countries around the middle of this century. Developing countries are still acquiring and deploying the technology and infrastructure required for industrial agriculture. With more that three-quarters of the world's population in developing countries, for the world as a whole the transition to the industrial era will end around 2050, having begun around 1800 (United Nations, 2001, pp. 480-483; Chesnais, 1992, chap. 2).

Industrial technologies are increasing environmental stocks and permitting a dramatic increase in population density. Chapter Three will develop a case that, when industrial technologies are fully deployed, population densities will be constrained by the physical environment, just as the environment constrained population densities in the hunting and gathering and agricultural eras.

Successful navigation of the end of the transition to the industrial era by developed countries does not necessarily mean successful navigation by the world as a whole. The developed countries have ended their transition with lower population densities than the developing countries had at the start of theirs (FAO STAT, n.d.; United Nations, 2001, p. 480). Also, the developing countries have been engaged in large-scale sales of their resource endowments, such as oil, timber, and minerals, to developed countries for decades (Boserup, 1981, pp. 188-190).

The issue the inhabitants of the Earth face now is how to ensure that the total environmental stock will be sufficient to sustain the expected global population as humanity navigates the end of the transition. The risk is that output may temporarily increase beyond the long run sustainable level, creating the potential for an environmental crisis that could cause so much damage that sustainable output might be below what would be achievable if a crisis was avoided. Giving the environment standing allows recognition of the potential for an environmental crisis and so provides an important foundation for management of the trade-off between economic and environmental objectives.

The standing for the environment implied by the argument above is as the provider of inputs that preserve humanity and improve human well-being. Some authors go further in arguing that the environmental as a whole or some subset of it such as trees or animals should have standing in its own right. (e.g., Barry, 1999, p. 14; Naess, 1973, p. 96). In this view, often associated with the phrase *deep ecology*, the environment should be preserved for its own sake. The argument presented in this thesis does not require an assumption of standing for the environment in this sense.

The Roles of Businesses, Governments and Individuals

Establishing the goal of improving management of the trade-off between economic and environmental objectives allows a fresh perspective on the activities of key types of actors: businesses, governments and individuals. The dominant paradigm prescribes aspects of the roles of each type of actor but in each case the prescribed role is found wanting in relation to the challenges posed by the risk of environmental crisis.

Advocates for change in the way the environment is managed often ask each type of actor to make their contribution, implicitly assuming that all that is required is an act of will (e.g., Goodland and Daly, 1990).

Businesses

In the dominant paradigm, businesses provide an efficient way to organize capital and labor to deliver the goods and services that provide utility for individuals (Samuelson and

Nordhaus, 1989, pp. 38-43). It follows that business activity should be constrained as little as possible (Eichner, 1983, p. 236; Prugh, 1999, p. 17). The argument against constraints is supported by the interpretation of Adam Smith's invisible hand as an assertion that the aggregate impact of individuals and businesses acting in their own interest will be in the interests of the community as a whole (Kamarck, 2002, p. 30).

On the other hand, business activity is the proximate cause of a lot of environmental damage. Businesses extract, sell, and consume the fossil fuels that damage climate and they supply vehicles, roads, chemicals, and technologies. Businesses promote agricultural practices that may damage the productivity of land (Shiva, 1991, pp. 244-256). They supply the goods and services that are demanded by consumers, by other businesses, and by governments.

In the dominant paradigm businesses should be constrained as little as possible but may be regulated by governments if necessary. Observations that existing regulations are not reversing damaging trends and that new regulations are difficult to introduce have led to two further strategies to influence businesses: win/win and social responsibility.

The win/win approach involves the idea that businesses will or should find technologies and opportunities where both the economy and the environment will benefit (Hawken et al., 1999). The social responsibility approach argues that, either voluntarily or via social or customer pressure, businesses should refrain from activities that damage the environment (Robèrt et al., 2002, p. 13). Both strategies have worthwhile potential.

However, win/win and social responsibility are unlikely to provide sufficient impetus for change to avoid environmental crisis. Both the win/win and social responsibility arguments ultimately fail because they do not recognize the purpose as opposed to the functions of businesses. Businesses may serve functions of efficiently providing goods and services, providing employment or even preserving the environment. However, the purpose of businesses is to generate profits for shareholders. Boards of directors employ senior managers and shareholders employ directors. Businesses whose managers try to serve purposes that are not aligned with generating profits for shareholders are likely to founder in competition, be starved of capital or have management replaced for incompetence or breach of duty. Some companies that appear to or claim to be motivated by social responsibility are actually benefiting financially from their stance and so their strategies are more accurately described as win/win.

Win/win and social responsibility are frequently aligned with the interests of shareholders so there are many examples where business activities assist economic and environmental objectives simultaneously, for example recycling and more efficient industrial processes. It is much harder to find examples where businesses voluntarily sacrifice shareholder value to improve environmental outcomes.

This thesis will argue that win/win and social responsibility will not be sufficient and that business activities should be regulated more vigorously to limit environmental damage.

Governments

The dominant paradigm presumes that the market will ensure that the economic interests of individuals and businesses will be aligned with community economic interests so that under normal circumstances government intervention would not be necessary. In contrast, the argument above implies an increased regulatory role for governments. The dominant paradigm recognizes that there may sometimes be a need to introduce regulations in the form of property rights, taxes, tradable emission rights, quotas or prohibitions.

The difficulty is that the rate of introduction of regulations appears to be insufficient to reverse the trends that are damaging the ecosystems humanity depends on, as revealed by the issues listed at the opening of this chapter. Governments do not rectify the situation for several reasons that will be discussed further in Chapter Four. Governments are slow to regulate because they have a tendency to be followers, not leaders. Governments frequently follow business leadership because businesses are motivated, well resourced and organized. Businesses put immense effort into lobbying governments to protect their interests. For example, Hawken et al. (1999, p. 168) report that lobbyists spend US$100 million per month in Washington D.C., largely to protect business interests. Therefore when a proposed environmental protection policy is counter to the profit-maximizing interests of businesses, that policy is less likely to be implemented. The US has not ratified the Kyoto Protocol claiming implementation may hurt the US economy (White House, n.d.).

Individuals

In the dominant paradigm it is individuals who are the ultimate beneficiaries of economic activity. Consumer sovereignty implies that the purpose of economic management is to provide consumption utility to individuals (Penz, 1986, p. 12).

However, the individual in the dominant paradigm is anything but sovereign. It is usually assumed that the individual is motivated only by consumption utility and this cannot change. Such an individual is not going to be able to counter business interests to ensure implementation of regulations that will reduce environmental damage. However, neither businesses nor government institutions can be relied upon to prevent the consequences of environmental damage so a more potent role for individuals must be developed.

Individuals cannot achieve much acting alone under the current paradigm. What is needed is to find a way for individuals to work together to bring about regulatory change. Ensuring that individuals are informed, that they can make choices about matters that go beyond selecting the next form of consumption, and that they can act to alter economic and environmental outcomes will be important elements of the solution.

Disciplinary Foundations

The discipline of economics has made a important contribution to the theories that are used to manage the economy-environment interaction. Modern economics has many schools and approaches. Colander (2000) identifies a core of modern mainstream economics, used by the majority of economists today, that is distinct from a variety of heterodox economic schools. Colander makes a case for abandoning the use of the term neoclassical to refer to this core of modern mainstream economics. Colander argues that the term neoclassical is not appropriate because the modern mainstream approach can be distinguished from older approaches that also used the neoclassical label and because modern mainstream economists have explored a wide range of assumptions and approaches that are not consistent with the neoclassical approaches used until the 1930s.

The existence of numerous sub-disciplines, the variety of approaches used within modern mainstream economics, and the high rate of change in the subject means that it is difficult to pin down a set of assumptions or theories that form the core of modern economics. The approach used here is to identify a set of assumptions or theories that are widely used, explicitly or implicitly, as foundations for modern policy development. These are the theoretical beliefs listed above and labeled as the dominant paradigm. The list is not intended to be comprehensive or to summarize the core of modern conventional economics. Rather, it is a list of key assumptions that are frequently used in economics, business, and policy analyses, that affect the management of economy-environment interactions.

Economic analysis for current activity usually does not consider medium- and long-term environmental consequences. However, economic analysis that affects current economic activity may also affect medium- and long-term environmental outcomes. Analysts may not make explicit assumptions about the environmental impacts of the economic activity they encourage but this may lead to an implicit assumption that there is no impact. Analyses that examine small scale economic decisions may assume that the activity has a very small marginal effect on environmental outcomes that can safely be ignored, but if a very large number of such decisions are made the aggregate impact may be much more than marginal.

Environmental economics has emerged as a sub-discipline of economics that explicitly considers the environmental impacts of activity. Bennett (1999) writes that environmental economics focuses on the difficulties of making two assumptions he labels as neoclassical: that all goods can be individually owned, and that the full costs of production and consumption are reflected in market prices (p. 193). This thesis is consistent with environmental economics in considering costs of activity that are not reflected in market prices, which may be economic costs or environmental damage, and in dealing with goods that cannot be individually owned.

Public goods are goods that are not individually owned. They have two main properties, non-rivalry and non-excludability (Kaul, Grunberg, and M. A. Stern, 1999). Non-rivalry means that one person's use of the good does not limit the good or service's use by another person. Non-excludability means that one person or a group of people cannot prevent others from using the good or service. The environmental issues addressed in this thesis may involve public goods. For example, the global atmosphere can be polluted by anyone, regardless of pollution by others. However, the thesis is also concerned with damage caused by private owners using their own property, because their activity may affect other private owners and the environment.

Relatively unrestricted access to environmental public goods makes an important contribution to environmental damage. Kaul et al. (1999) conclude that public policymaking is inhibited in dealing with damage to environmental public goods by insufficient international policymaking, lack of involvement of non-state stakeholders in policymaking, and insufficient incentive for countries to cooperate (p. 451).

Public choice uses economic methods to analyze these kinds of political issues, in particular the *collective action problem* and the problem of aggregating preferences (McLean, 1987). The collective action problem arises in environmental issues because activity by large numbers of individuals can affect the quantity and quality of inputs provided by public goods (Bicchieri, 1993; Olson, 1965; Taylor, 1987). For example, some activity causes carbon emissions that are changing the global climate. In this case the collective action problem is that each individual has an incentive to continue the damaging activity, though most would benefit if everyone stopped, but there is no mechanism to cooperate to prevent the activity. The collective action problem is confronted in Chapter Six, because it inhibits the pro environment action by individuals that is proposed to lead governments. Processes that create preferences, or tastes, and the way preferences affect societal outcomes are also considered in the thesis.

This thesis differs from environmental economics in its approach to responding to environmental issues. According to Barry (1999) "environmental economics holds that the environmental problems facing society can be solved by a suitably regulated market and using the tools and reasoning of neoclassical economics" (p. 142). The thesis argues that while suitably regulated markets may be helpful, more is required. Although the tools and reasoning of economics can help to solve environmental problems, there are benefits available from using additional tools, in particular ideas about the ideas of individuals and theorists.

The approach adopted here is consistent with ecological economics. Ecological economics draws from or has intellectual antecedents in several other economic sub-disciplines including neoclassical economics, environmental economics, neo-Malthusian economics, and neo-Marxist economics, as well as ecology, socialism, political theory and moral philosophy (Spash, 1999; Prugh, 1999). Spash (1999) reports that in 1999 the International Society for Ecological Economics (ISEE) had almost 2000 members.

Robert Costanza (1991), the founding president of the ISEE, makes the case for the multi-disciplinary approach:

> Ecological economics goes beyond our normal conceptions of scientific disciplines and tries to integrate and synthesize many different disciplinary perspectives. One way it does this is by focusing more directly on the problems, rather than on the particular intellectual tools and models used to solve them, and by ignoring arbitrary intellectual turf boundaries. (p. 3)

Barry (1999) states that "ecological economics . . . differs from mainstream economics in that it seeks to base its theories and models on the insights of natural science as well as having roots in economic science" and "of central concern to ecological economics is the issue of the scale of the economy in relation to its ecological basis, something about which mainstream economics has little to say" (p. 147). The thesis builds on ecological economics in relying on natural science, irreversibility, limited substitutability of types of capital, uncertainty, scale and thresholds. It considers the long-term consequences of activity that damages the environment and the risk of a crisis if critical thresholds are crossed.

Pearce (1998) claims there is a moral tone in ecological economics arguments (pp. 313-314). Theorists may try to avoid moral issues by adopting a scientific stance, aiming to use positive analyses that describe the way things work and developing theories predicting that if certain steps are taken then certain results will follow. Theorists adopting this approach leave others to choose what to do with their theories. Other theorists may adopt a normative approach and advocate a course of action to achieve a desirable objective. Their recommendations may be about the choice of an objective or about the preferred way to achieve an objective.

The societal objective promoted by the dominant paradigm is to deliver the maximum amount of consumption to individuals. Theorists may accept this and go on to conclude that the best way to do this is to ensure that markets operate as efficiently as possible. If the societal objective is taken as given then the theorists may be able to construct theories about how best to conduct the economy.

McCloskey (1998) distinguishes persuasion from describing the economy, assessing the adequacy of economic theory, and studying the economist's role in the economy (p. xx). This thesis aims to persuade theorists and other individuals who play a role in managing the economy-environment interaction to adopt revised objectives and to use specified theories to develop strategies to achieve those objectives. In doing so it considers the nature of the economy-environment interaction from a theoretical and an empirical point of view, reviews the adequacy of existing descriptions of the economy-environment interaction, and examines the role of theorists in influencing outcomes.

Ecological economists question the choice of consumption maximization as the societal objective, arguing that more emphasis should be given to achieving better environmental outcomes. The thesis reviews some of the evidence and concludes that there is sufficient risk of environmental crisis that the societal objective should be adjusted to place more importance on environmental outcomes. It also develops a strategy that can be used by managers to accelerate the change in objective and to help implement specific initiatives to reduce environmental damage. In seeking to persuade theorists to adopt revised objectives and managers to use an ideas-based strategy it has moral, or normative, content.

The thesis also builds on approaches developed in behavioral economics and institutional economics. Behavioral economics has been described as "best characterized not as a single specific theory but as a commitment to empirical testing of the neoclassical assumptions of human behavior and to modifying economic theory on the basis of what is found in the testing process" (H. A. Simon, 1998). According to H. A. Simon the key neoclassical behavioral assumptions are, first, that motivations are given a priori in the form of a utility function that allows consistent choices among bundles of goods and services, and second, that actors always choose the alternative that yields the greatest utility (p. 221).

The thesis examines motivations other than consumption of goods and services but does not critically examine the second assumption. There is a large body of research showing that choices made by real individuals deviate from what would be predicted by the Subjective Expected Utility (SEU) model in some circumstances (e.g., Kahneman and Tversky, 1979; Tversky, Slovic and Kahneman, 1990). However, the SEU model provides both an approximation of real choice processes and a simple and robust way to develop the argument in this thesis, and it will be relied on throughout. The focus here is not on whether individuals actually make decisions in the way that decision theory says they should but rather on the values and beliefs that determine their choices.

Institutional economics considers a wide range of causes of economic phenomena. Samuels (1998) describes institutional economics as holistic and evolutionary. He lists principal themes including social change, social control, collective choice, the role of government, a theory of technology, the institutional or power structure of the society, an emphasis on the habits and customs of social life and a concern for values (p. 865). These themes are all relevant to the thesis topic. The ideas-based strategy proposed aims to use social processes to change values and customs (also referred to as norms), to change collective choices, and to achieve desirable environmental outcomes. It examines the roles of governments, businesses and technology choices in determining outcomes.

The argument draws on material from economic history, the history of economic thought, environmental science, sociology, psychology, and management. Combining material from a variety of disciplines reveals the important and useful role that ideas can play in managing trade-offs between economic and environmental objectives. Several theorists have called for such integrative efforts to help address environmental issues (e.g., Daly and Cobb, 1989; Etzioni, 1998; M. Jacobs, 1994).

The key foundations of the argument are a description of the economy-environment interaction which shows that environmental damage is a natural consequence of economic activity under current institutional arrangements, an argument that there is a risk of environmental crisis, a case that only individual action can reduce the risk of crisis, the specification of an extended utility function that includes motivations other than consumption, and an ideas-based strategy to overcome the collective action problem and accelerate implementation of initiatives to prevent environmental damage. These foundations combine to provide a tool that can be used by theorists, policymakers and managers to develop strategies to reduce the risk of environmental crisis.

The main argument is developed using methodological individualism (Danto, 1973, pp. 321-322). Methodological individualism uses explanations based on individual behavior. Methodological socialism uses explanations based on social phenomena. Arguments that rely on methodological socialism will be used only occasionally; for example in the concept of a community of action introduced in Chapter Seven. The analysis focuses on individuals who make decisions in circumstances that are affected by changing constraints. Etzioni (1998) introduces an alternative paradigm based on methodological socialism.

Methodological Foundations

Methodologies are generally developed within paradigms. So what does it mean to have methodological foundations where an important objective is a search for a revised paradigm? How can one choose methodological foundations without first deciding on the paradigm?

The methodological foundations are those that can guide and limit the search for a new paradigm. They are ideas that are even more fundamental than the paradigm choices. The basis for choice of these methodological foundations is pragmatic. The foundations are chosen to improve the prospects for having the revised paradigm widely adopted and achieving the objective of reducing the risk of environmental crisis.

Ideas

The focus of this work is on the role of ideas: values and beliefs, paradigms and theories. Values and beliefs directly affect the way that individuals behave, while paradigms and theories affect behavior indirectly by defining the way that individuals think about the way the world works and their roles within it.

Ideas provide a lens through which to examine the theories and data used for managing the trade-off between economic and environmental objectives. Where relevant, ideas are specifically included in the theoretical frameworks developed in this thesis.

Build on the Dominant Approach

The argument is pitched at those who are currently open-minded about the seriousness of environmental risks and policies to deal with them. Therefore environmental activists may not like some of the assumptions. The aim is to show that a change in the ideas used to manage economy-environment trade-offs is rational for those who currently use the dominant paradigm rather than offer an alternative and conflicting framework that may be easily rejected. Another way to explain this is that the aim is to persuade people so it is important to show the potential risks of working with existing ideas rather than simply asking people to accept different assumptions.

Self-Interested Individual

A key assumption throughout is that individuals are self-interested. Some proposals for change either explicitly or implicitly rely on actors abandoning self-interest so that they can be concerned about outcomes for others or for the environment (Mitchell and Simmons, 1994, p. 8). This approach is rejected because self-interest is so dominant in both theory and practice that attempting to overcome it is not likely to be successful. Furthermore, as will be argued in Chapter Two, the pursuit of self-interest is an important cause of environmental damage.

While maintaining the assumption that individuals are self-interested, alternative ways to think about what it is that self-interested individuals value will be explored, including the possibility that they may value outcomes for others or for the environment.

Minimum Sufficient Intervention

An important foundation of the approach is to identify the minimum sufficient intervention required to bring about the desired improvement in outcomes. The intervention should be minimal in two senses. First, it should be parsimonious in using the least amount of theoretical innovation required to achieve the objectives. Second it should require the least impact on the course of world history to reduce the risk of crisis.

Target Audiences

Economists and other theorists are influential in determining which ideas will be dominant. Therefore theorists are a key group who must be persuaded to adopt different ideas, so the argument must be credible to them. However, changing the ideas of theorists may not be sufficient because of the decades it would take for theorists to adopt new ideas and then disseminate them to the general population.

It will also be important to influence the general population, the individuals who have latent power in our plutocracy because they have the potential to lead political leaders. However, the general population is not likely to read and understand this thesis. The strategy involves influencing opinion-leaders who will influence the general population. Communicating with opinion-leaders requires an argument in a different form: shorter, more accessible and written in a different style. Therefore the strategy requires production of a popular version of the argument to influence opinion-leaders who, in turn, will influence the general population.

Effects and Outcomes

The thesis distinguishes effects from outcomes. An effect is "something that inevitably follows an antecedent" (Merriam-Webster, n.d.) whereas an outcome is "something that follows as a result or consequence" (Merriam-Webster, n.d.). When effect is used it will mean the result of an action. Outcome will be used to refer to a state of a variable of interest. Activity may have effects on more than one outcome. Outcomes may be affected by more than one action or may be unaffected by actions.

Mathematical Notation

Mathematical notation encourages rigor in definition of concepts, clarity in articulating the relationships among concepts and can, if used well, aid communication of arguments. Simple mathematics will be used to demonstrate and clarify some of the conclusions but the argument could be presented without the use of notation.

Foundations of the Solution

Idea Changes

A key distinguishing feature of this thesis is the focus on *the role of ideas* in managing trade-offs between economic and environmental objectives. The analyses of the relationship between the economy and the environment and of the roles of businesses, governments and individuals reveal some limitations of the ideas that comprise the dominant paradigm and suggest some directions for change, but are not sufficient to define a strategy for change.

The core of the argument is that several of the beliefs included in the dominant paradigm should be changed. Those ideas have been widely disseminated and accepted within modern societies and have effects that promote damage to the environment or prevent effective responses to environmental challenges. For each idea change proposed it will be argued that the idea is dominant, that the idea has become widely disseminated and that the idea's impact on behavior increases environmental damage or prevents effective responses to environmental issues.

The selection of the ideas chosen for change is justified by arguing that changes in a key few could reduce the risk of environmental crisis without having other effects that might be even more damaging. The ultimate criterion for retaining or rejecting ideas is their effect on the risk of environmental crisis. The purpose is management, not science. For each of the ideas chosen it will be demonstrated that, theoretically and empirically, the revised idea is closer to the truth than the currently dominant idea to be replaced.

The impacts of the proposed idea changes interact to create a powerful way to change our future. In Chapter Six the idea changes are used to develop a practical strategy to accelerate implementation of initiatives to reduce the risk of environmental crisis and in Chapter Seven the changes proposed are assembled to form a revised list of theoretical beliefs that are suggested as the basis for a revised paradigm.

From Economic Man to Ecological Individual

If businesses will not willingly sacrifice profits to protect the environment, and if governments follow the lead of businesses, then individuals must initiate the changes that will protect our environment. However, the dominant paradigm generally assumes that individuals are motivated only by utility from consumption (Kamarck, 2002, 39; Samuelson and Nordhaus, 1989, p. 101) and that, even if individuals did care about the risk of environmental crisis, no individual can achieve anything useful.

Here is a core problem that must be unlocked. The key to it is the restrictive characterization of the individual as a consumption utility maximizer known as economic man. Hargreaves-Heap and Hollis (1998) describe *economic man* as one who

> chooses the actions which satisfies his preferences better (or at least no worse) than any other. Here rationality is a means-to-end notion, with no questions raised about the source or worth of preferences. The rational economic man is a bargain-hunter, who never pays more than he needs or gets less than he could at the price. (p. 54)

Three key steps will be proposed to turn economic man into an ecological individual who has the potential to alter environmental outcomes. The first step is to add the potential for motivations beyond utility from consumption. The second is to allow the individual to change beliefs and values and the third is to overcome the collective action problem that discourages individual efforts to change environmental outcomes.

Assuming that an individual has diverse motivations and can be influenced by other individuals creates a potential for change that is absent in economic man. Social norms can be used to modify self-interest (Hunecke, Blöbaum, Mathis, and Höger, 2001, p. 845). While individuals may find it difficult to change themselves, they may be able to create, voluntarily and deliberately, the social circumstances that lead them to be changed by the social approval and disapproval of other individuals. This mechanism can be used to increase the value placed on environmental outcomes relative to the value placed on consumption. As an example of the kind of transformation of self-interest envisaged, people might come to value fuel efficiency, low emissions and recycling potential in cars instead of size, power and the prestige conveyed by design aesthetics and features.

Ophuls (1997) argues for a moral society where individuals can balance “their legitimate desire for independence against the inescapable fact of interdependence” (p. 276). Etzioni (1988) makes a similar point in proposing a decision-making model where “people pursue two irreducible ‘utilities,’ and have two sources of valuation: pleasure and morality” (p. 4). If such a moral society is needed, it may be difficult for political leaders to establish it. Dryzek (1987), focusing on moral persuasion as a tool of the elite, concludes that it cannot provide a foundation for ecological sustainability because the leadership cannot maintain their influence (pp. 160-161). Cheng (1997) is also pessimistic in his examination of the prospects for political leaders in Asia to use values as a tool for change. He concludes that “such a purpose would require long-term persistent effort and high sensitivity to cultural values. Neither virtue is possessed by most current political leaders” (p. 182). The approach adopted here is to have individuals effect the value changes, not the political leadership.

Extending the utility function to include values other than consumption may not seem particularly radical. People have been arguing for years that value changes are needed to protect the environment. However, it is radical in the sense that an individual with an extended utility function including consumption and compliance with social norms can no longer be understood within the dominant paradigm. Psychology and sociology become important.

Having an individual whose values and beliefs can evolve and respond to a changing environment is the key to developing a strategy to reduce the risk of environmental crisis, but it is not sufficient. It is also necessary to overcome the collective action problem: each individual will not act because that action alone will have no effect, even though if all individuals acted they could all be better off (Olson, 1965).

One element of the solution is to identify roles taken by individuals. *Managers* are individuals who act because they have some external motivation to contribute to the resolution of environmental issues. They act to influence other individuals, altering their values and beliefs and encouraging these other individuals to pass on their new values and beliefs to others. Managers may be paid, they may have existing strong activist beliefs, or they may get professional credit. A manager might be a member of government, a member of an activist group or simply a private individual who is concerned about environmental risk and is motivated to act to reduce the risk.

Opinion-leaders are influenced individuals who pass on the acquired values and beliefs to other individuals. Opinion-leaders may be media workers, activists, intellectuals, educators, parents or influential members of a drinking circle. The important thing is that they must be people whose views influence others.

Uncommitted individuals are in turn influenced by opinion-leaders, and may be directly influenced by managers. They acquire the values and beliefs that are transmitted to them and may make choices about activity that are influenced by the anticipated approval or disapproval of opinion-leaders. Uncommitted individuals respond to polls, vote, and purchase in accordance with their new values and beliefs.

These are distinct roles but individuals may have more than one role, perhaps in different aspects of their lives, and may shift from one role to another. The roles defined are chosen to describe the initiation and transmission of influence. Managers initiate, opinion-leaders transmit and uncommitted individuals provide the weight of numbers needed to change the course of a society.

Finally, there are *theorists*, some of whom are economists. Theorists acquire expertise as they develop, test, and debate theoretical ideas, which leads to the accrual of authority. The theorist who chooses to be a manager will focus on disseminating ideas and can be particularly effective due to his or her recognized expertise and authority. A theorist who chooses not to be a manager can still contribute to the strategy by developing ideas to be disseminated by other managers. A theorist who does not choose to pursue the strategy outlined in this thesis may develop and present competing or complementary ideas.

The strategy requires that managers influence other individuals who in turn lead governments. Opinion-leaders influence uncommitted individuals to increase their leadership of governments and change their damaging consumption behavior. Governments regulate businesses, businesses reduce their damaging activity and the risk of crisis is reduced. The conditions for these effects are explored more completely in Chapter Six. The role of theorists is further described in Chapter Seven.

Towards a Revised Paradigm

Paradigms and theories influence values and beliefs. In turn values and beliefs influence behaviors and the ways that the economy and environment are managed. The change in circumstances as environmental constraints become more important implies a change in the paradigm used to manage the economy and environment. The dominant paradigm was developed during the transition to the industrial era (Norgaard, 1994a, p. 45). It cannot be used to assess the risk of environmental crisis because it does not give the environment true standing. The paradigm must be generalized to help navigate the end of the transition.

In the generalized paradigm individuals get utility from sources other than consumption, and can learn and change. Further, economists and others who work with the dominant paradigm are not treated simply as scientists discovering and using laws describing how the world works. Rather, they are treated as actors in their own right, managers who can influence other individuals and thereby affect outcomes.

The purpose of the generalized paradigm is to facilitate communication of a way of looking at the coevolution of economy and environment that exposes potential to better manage the economy versus environment trade-off. The concepts included are those that assist in addressing the practical problem of reducing damage. The focus is on elaborating and understanding the levers that can be used to guide change.

Thesis Outline

Chapter One has specified the problem to be addressed and outlined the key elements of the solution proposed. It is intended to provide a roadmap of the remainder of the argument so that the reader has a good overall perspective of how each of the remaining chapters contributes to the story.

Chapter Two makes the case that environmental damage is a normal consequence of an unregulated market economy. The chapter begins by introducing a very simple economic model, using conventional assumptions. Building on the premise that environmental outcomes are important in their own right, the model is extended to incorporate a role for the environment. This is done by relaxing the free gifts and free disposals assumption to allow the possibility that the economy can affect the environment, and vice versa. Adding the assumption that the economy is large in relation to the environment allows several important conclusions to be drawn.

First, it is no longer certain that production or consumption activity will improve economic outcomes for the actor or for the economic community. Second, self-interested actors may find activities that are in their interests but are not in the economic interests of the community. Third, damage to the environment may proceed for some time without anyone's economic interests being harmed. Fourth, damage to the environment can continue when the economic interests of others, the economic interests of the community and sometimes even when the economic interests of the actors themselves are harmed by the activity. Finally, prices will only prevent environmentally damaging activity under some circumstances.

The overall conclusion of Chapter Two is that if the assumptions of the dominant paradigm are extended to include the environment and if individuals pursue their own consumption interests in a market economy then ongoing environmental damage will result.

Chapter Three begins by asking what will happen if economic activity continues to damage the environment. The emergence of environmental constraints may indicate that the Earth is nearing the end of the transition to the industrial era so that the future might not be a continuation of the past 200 years. Reviewing the implications of population and output growth for agriculture and climate change reveals that there is a risk that global environmental resources might become a serious constraint limiting output.

Three models of the future are introduced. In Model I the current economic progress continues forever, with economic output expanding as assumed within the dominant paradigm. Model II has the Earth emerging from a transition begun by the agricultural and industrial revolutions into an industrial era where population and output are relatively stable. Model III is a variant on Model II that involves *overshoot*, the expansion of population and output to unsustainable levels, followed by an enforced reduction to sustainable levels driven by insufficient environmental stocks. In Model III the sustainable population and resources might be lower than what might be achievable with Model II because of greater destruction of environmental stocks.

Many outcomes are possible. The conclusion drawn is that there is a risk of environmental crisis if the Earth continues with business as usual and so there is a need to consider ways to reduce the risk. In particular, Chapter Three concludes that the risk of an overshoot crisis is sufficient to warrant action to change the mix of activities and technologies so they are less damaging, and to protect environmental stocks.

Chapter Four asks what could be done to prevent damage and who is responsible for preventing ongoing damage. It begins with a brief examination of some characteristics of the risk of environmental crisis and then examines the potential for businesses and governments to reverse the trends that create this risk.

Three arguments for allowing business to continue with business as usual - win/win, social responsibility, and aligned interests - are examined. All three arguments are rejected, implying a need to constrain damaging business activity.

Reviewing the policy options available to constrain damaging business activity reveals that relying on market solutions is not likely to be very effective for the kind of damage being considered. Quotas and taxes are found to have potential. Quotas are the preferred policy because they are easier to set at the right level and, for given volume impact, are less likely to be resisted.

Governments are responsible for introducing policies to constrain damaging activities but business interests are powerful and likely to oppose regulations that threaten profits. Policy responses are likely to be delayed by scientific uncertainty, by the time needed to convince policymakers, and by the time taken to overcome opposition to the policies.

The chapter concludes that governments are responsible for managing the risk but that government regulations will be opposed by businesses if profit potential is threatened. In these circumstances there will be a contest between threatened profit-motivated businesses and environmentally motivated individuals to lead governments. Governments will only respond more vigorously to the risk of crisis if individuals lead them effectively and this will only happen if they are encouraged by a critical mass of public opinion.

Chapter Five examines the assumptions that are made by theorists about individuals. The chapter begins with the observation that the dominant paradigm assumes that individuals are motivated only by utility from consumption. Individuals can be modeled in a more complex way and this could provide a theoretical foundation for individuals to lead governments on environmental issues. Five proposals for changes to the individual's utility function are made; that consumption may be satisficed rather than maximized, that environmental outcomes may be valued, that utility from consumption outcomes relative to others is explicitly included, that individuals may be motivated by social approval or disapproval from others, and that individuals may have personal norms that they use to guide their own behavior.

In each case there is evidence that individuals do gain utility from the proposed utility sources. These changes would make it theoretically possible for individuals to have values that would motivate behavior that could lead governments to constrain the activity of businesses.

Chapter Six develops the strategy to accelerate implementation of initiatives to reduce the risk of an overshoot crisis. Self-interested individuals are assumed to be motivated by utility from consumption as well as the motivations introduced in Chapter Five.

The strategy involves managers influencing opinion-leaders who in turn influence uncommitted individuals to change their beliefs and values. The strategy can be used to introduce stronger government policies sooner than they would otherwise be implemented, to change consumption choices, to encourage less damaging technologies, and to reduce the likelihood or magnitude of overshoot at the end of the transition.

If the strategy is successful then individuals who act to change the values and beliefs of other individuals will have their own consumption behavior changed in due course, as the influence of others combines with more direct motivators to encourage them to act in ways that reduce damage.

Chapter Seven gathers the proposed changes to the assumptions of the dominant paradigm to articulate a revised paradigm that is capable of generating the strategy developed in Chapter Six. The first extensions add the environment as a constraint on production, allow damage to the environment and economic consequences of that damage, and relax the assumption of stationarity to allow changing states of the environment, the economy and technology in a long run analysis. These extensions allow the possibility that the Earth is in the transition to the industrial era, with a potential risk of environmental crisis.

The assumption of an ecological individual whose preferences can change allows the introduction of motivations other than consumption. A dynamic view of the economy-environment interaction has ideas, behaviors and outcomes coevolving to form a history that is influenced by the ideas people choose to adopt. The proposed revised paradigm is summarized. The chapter concludes with a discussion of the role of theorists and the impact of their choice of paradigm. Theorists generate and disseminate ideas that affect the economy-environment interaction.

Chapter Eight provides concluding comments. The revised paradigm can allow recognition of the potential for environmental crisis in a way that is economically meaningful. A strategy based on idea change can be used to reduce the risk of crisis. Finally, Chapter Eight points out the importance of the choices made by individuals in their roles as managers and opinion-leaders.

Conclusion

The Earth's managers have been more successful in achieving economic growth than at maintaining the quality of the environment. Economists have developed policy prescriptions that could reduce environmental damage but these have not prevented ongoing damage and persistent calls for more action.

The main idea of this thesis is to use ideas about ideas to identify an intervention strategy that can help managers accelerate the response to the risk of an environmental crisis. The key arguments made are: that environmental damage is a natural consequence of consumption-seeking activity by individuals and profit-motivated activity by businesses; that continuing with business as usual would mean accepting an increasing risk of an environmental crisis; that responses are available but there may be a need for a more vigorous response, now or in the future; that individuals can provide the impetus to accelerate the response and without individual action the response may not accelerate sufficiently; that the idea provided by the dominant paradigm that individuals are motivated only by consumption inhibits the development of strategies to accelerate the response; that assuming broader individual motivations can allow development of interventions to encourage pro environment behavior; and that a revised paradigm can be used by theorists and policymakers to develop and implement interventions that can help manage the trade-offs between economic and environmental objectives more effectively.

No one intervention will bring about sufficient change to reduce the risk of environmental crisis. The aims of this effort are to contribute to the intellectual foundations of a more effective approach and to advocate a simple intervention that is available for use by everyone who chooses to use it. At least the thesis may provoke dialogue about the importance of ideas in understanding and managing environmental issues.

CHAPTER TWO

THE MODEL

If it is agreed that economic output is a good thing
it follows by definition that there is not enough of it.
- Economic Report to the President, 1971, in Kaivo-Oja, 1999, p. 147

In this chapter a simple and conventional version of the dominant paradigm is introduced in a way that allows it to be developed to provide a pathway to the proposed management strategy. The overall framework is introduced, together with an important role for actors' activity choices. Aggregation of actors' activities leads to societal outcomes that, in principle, might be the subject of management focus.

The first objective of the modeling is to show what it means to manage trade-offs between economic and environmental objectives, and to identify tools a manager might use to achieve desirable outcomes. For the purposes of this thesis the desirable outcomes will be regarded as comprising three elements: community, economy and environment, collectively known as the *triple bottom line* (Jepma and Munasinghe, 1998). Each of these elements is a societal aggregate: community, the total utility for the individuals in the society; economy, the aggregate output of the economy; and environment, the flow of life-supporting services from environmental stock.

The elements of the triple bottom line interact with one another. The environment provides services to the economy, the economy provides utility to individuals in the community, and economic activity may cause damage to the environment. Choices made by the individuals in the community may affect the economy and the environment. Management is complicated further because with three objectives there are many combinations of outcomes that could be targeted and there may be disagreements among segments of the society about which is most important. Policies must reconcile the competing interests to set objectives, and must be based on an understanding of how the elements of the triple bottom line will interact to achieve the desired outcomes.

The second objective of the modeling is to examine the implications of the dominant paradigm that guides management of the economy-environment interaction and show why non-optimal outcomes are likely if the environment is constrained.

The third objective is to establish theoretical foundations that can be used in later chapters to extend the basic paradigm to allow a generalized paradigm that can assist managers to achieve better outcomes on the triple bottom line. Better outcomes would be more economic output, larger environmental stocks, more utility for the population, and a reduced risk of environmental crisis. The theoretical foundations introduced are chosen specifically because they allow the extensions that will be introduced in later chapters.

There are two parts to this chapter. The first part introduces the dominant paradigm and demonstrates that it is optimal if there are no environmental constraints. The second part shows that using the dominant paradigm if there are environmental constraints will lead to poor outcomes on the triple bottom line.

Each part is broken into four sections covering how individuals make decisions about activity, how individual decisions are converted into activity and aggregated across individuals, what outcomes result from the aggregated activity, and how trade-off management rules affect outcomes on the triple bottom line.

The Dominant Paradigm

Mainstream modern economics, sometimes called neoclassical economics, provides many of the assumptions of the dominant paradigm used for today's economic policy development (Söderbaum, 1998, p. 85). Modern economics is sufficiently flexible to accommodate varying many of the assumptions.

The development below builds on mainstream assumptions but emphasizes the role of individual activity, the decisions that individuals make about activity, and the aggregation of the effects of individual activities to produce societal outcomes. The form of the development has been chosen to allow subsequent generalization when the environment and the beliefs and values of individuals are included.

The assumptions introduced below, and others included in the ten elements of the dominant paradigm listed in Chapter One, do not constrain the potential of economic analysis to describe and explain economic and environmental phenomena. Economic analysis is very powerful and has been extended in many directions, including exploration of what happens when the assumptions listed are relaxed or modified. The important point here is not what mainstream analysis can or could do but rather how it is usually used. The ten elements of the dominant paradigm and the assumptions listed below form part of a default set of assumptions that are often used in economic analyses that produce policy prescriptions affecting economic and environmental outcomes.

One key objective of the following chapters is to bring these default assumptions from the background into the foreground, to show how some can contribute to sub-optimal policies in present circumstances, and to identify a revised list of default assumptions that can lead to better outcomes. The focus of the exposition in this chapter is on the "what" of the dominant paradigm. Discussion of why this paradigm takes the form that it does and why it has achieved dominance will be included in later chapters.

Individual Activity

The common determinant of the three elements of the triple bottom line is the behavior of individuals. If a manager is to affect outcomes on the triple bottom line then he or she must influence behavior. This thesis is concerned only with the subset of all behavior that is economically or environmentally relevant and that subset is referred to as *activity*. Activity may affect utilities, economic outcomes or environmental outcomes.

Following the definitions in Chapter One, assume that the individual maximizes SEU from an activity *a* where, as before:

$$SEU(a) = \sum_j p(o_j)\ u(o_j),$$

$p(o_j)$ is the individual's belief about the likelihood that outcome j will result from the activity a, and $u(o_j)$ is the value, or utility, that the individual places on the outcome j.

If the option to do nothing is available the individual will only choose activities where the SEU of the activity is positive and will select activities from among a range of possible activities to maximize the total SEU, constrained by money and time resources.

The SEU is ex ante. Unless otherwise specified the individual is assumed to have perfect foresight. The ex post utility that the individual receives is $u(o_j)$, the utility for the outcome j that actually results from the activity. In many instances the outcome from the activity is assumed known with near certainty so the SEU of the activity and the ex post utility from the activity are both approximately $u(o_j)$. In such cases the $p(o_j)$ values are 1, indicating that there is a strong belief that an outcome will follow from an activity.

In applications of the dominant paradigm used for management of economy-environment interactions, individuals are frequently assumed to gain their utility from consumption only (Kamarck, 2002, p. 39; Samuelson and Nordhaus, 1989, p. 101).

Production produces income. Income, in turn, provides consumption. Consumption may not follow immediately from activity so the utility resulting from activity may be discounted using the individual's discount rate. Utility components may be present values of a stream of future outcomes.

Where activity has a cost attached, usually in the form of labor and capital (time and money) the utility received is a net utility:

$$\begin{aligned} u(o_j) &= u(Benefit_j) - u(Cost_j), \\ &= u(Benefit_j) - u(Cost\ of\ labor_j) - u(Cost\ of\ capital_j). \end{aligned}$$

$Benefit_j$ is the gross utility experienced as a result of the activity. Labor may either be or include un-priced labor provided by the individual carrying out the activity. The cost of capital includes all cash inputs excluding the costs of labor.

Aggregating Activity in the Basic Model

Individuals choose activities to maximize their SEU. Utility is provided by consumption and activity is carried out to provide consumption. If the amount of utility is proportional to the amount of consumption then the total consumption output of the economy provides a measure of the aggregate amount of utility provided by the aggregate activity of the economy.

Aggregating the activity of individuals is very straightforward in the dominant paradigm. The mechanism can be understood by considering two actors who each have the opportunity to act. Assume that $u(o_j)$ is 1 for each of the actors. Each actor gets 1 for acting and 0 for not acting. The pay-off matrix for this simple situation is shown in Figure 2.1. The outcome will be that each actor will act, the total activity will be 2 units and the total utility will be 2.

		TWO	
		No Act	Act
ONE	No Act	0, 0	0 , 1
	Act	1, 0	1, 1

Payoffs for One, Two

Figure 2.1. Aggregation of activity in Cases I and II. Each actor gets 1 for acting and should act.

In the basic economic model, output maximization will provide the maximum amount of utility. The close link between activity and output is illustrated by the way these words are sometimes used interchangeably in describing the performance of an economy. However, for reasons that will become clear below, it is important to retain activity, consumption, output, and utility as separate constructs.

Capitalized variables represent aggregate quantities throughout this thesis. The maximization of output (Q) under the dominant paradigm can be described using the Cobb-Douglas production function:

$$Q = T_Q L^{\alpha} K^{\beta} .$$

T_Q is a parameter that represents the effectiveness of the technology of production; the amount of output produced for each unit of input. L and K represent the amounts of input of labor and capital respectively. The parameters α and β indicate how much the output changes with changes in the inputs. Output can be produced using different combinations of labor and capital.

Constraints on the short run availability of capital and labor are reflected in higher prices of these inputs as the total output of the economy increases. The mechanism for constraining the output in aggregate is the emergence of highest utility activity options whose SEU cost in capital and labor exceeds the SEU available from carrying out the activity.

Output takes the forms of consumption that provides utility directly and stocks of capital and labor that will serve as inputs to provide future consumption. Income provided as ownership of increased stocks of capital is a source of utility because the ownership represents a right to future consumption.

With inputs of capital and labor and outputs of utility-providing consumption together with stocks of labor and capital that provide for future consumption, the production function is like a perpetual motion machine that can produce ever-increasing amounts of consumption utility. Surpluses of production over immediate consumption allow increased stocks of capital and labor to support more production. Improvement in technology (T_Q) allows more effective production and provides a further source of growth.

In summary, the output of the economy is equal to:

$$Q = \sum_i \sum_a o_{ia},$$

which is the sum over all individuals of the outputs from the activities carried out by each individual. This model is additive. When environment is introduced, this property of additivity no longer adequately describes the aggregation process.

Outcomes

The simplest outcome is the environment. Inputs of raw materials from the environment are implicitly used in the production described by the production function but the usual, implicit assumption is that there are free gifts of inputs from the environment and free disposals of wastes to the environment. With the free gifts and free disposals assumption the environment is unaffected by activity.

The outcome for the economy is simply the total output, Q, described above. Some output is consumed but there is also an increase or reduction of the stocks of labor and capital:

$$L_1 = L_o + \Delta L_1$$

and

$$K_1 = K_o + \Delta K_1.$$

Capital and labor both have stocks at the end of each time period and flows during each time period.

The third element of the triple bottom line is community. The nature of community needs to be clarified. The simplest approach, consistent with that taken by Bentham (1789/1948) and implicitly assumed by economists, is to focus on what might be called a *community of interest*. In the community of interest the outcome for the community is equal to the sum of the outcomes for the individuals within the community. Utility comes from consumption and consumption is measured by the output that is created by activity. Therefore there is no separate outcome such as community utility that needs to be considered.

In summary there is only a single bottom line for the dominant paradigm because environment is ignored and community is assumed to be equivalent to economy. The basic model is summarized in Figure 2.2.

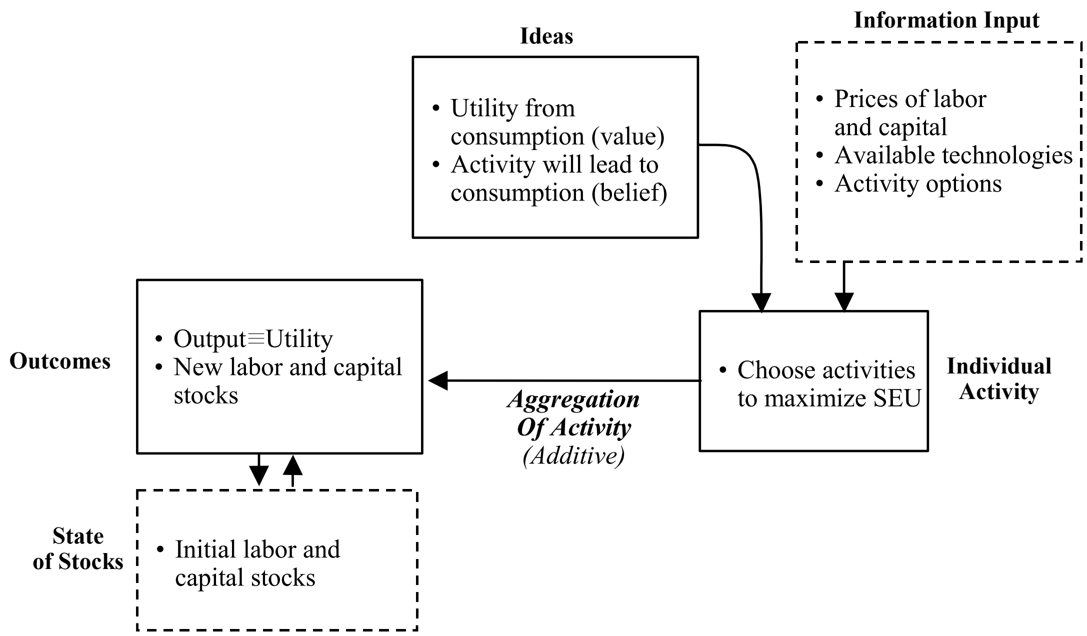


Figure 2.2. The dominant paradigm. Arrows show major effects. Dotted boxes show factors that affect and constrain ideas, behavior and outcomes.

Management

The manager's task is to maximize output because this will maximize utility. Growing the total output grows the total consumption utility too, in the form of population growth or increased consumption utility per capita. Environmental outcomes need not be considered.

Penz (1986) reports that the goal of policy in developed market economies "is the maximization of consumption in accordance with customer preferences, that is consumer sovereignty" (p. 10). Penz goes on to say that "consumer sovereignty, then, is not a goal that competes with other primary goals of economic policy, but rather is a core value that underlies the most important economic policy goals in liberal or social democracies" (p. 12).

In conclusion, consumer sovereignty is central in the dominant paradigm and is the optimal management strategy.

A Constrained Environment

Environmental constraints have been widely recognized during the latter part of the 20th century and are expected to become increasingly important as the 21st century progresses (Pearce and Turner, 1990; Prugh, 1999, p. 13-15). In this section the dominant paradigm will be extended to allow environmental constraints to be considered and the consequences of continuing to use consumer sovereignty as the management strategy will be examined. It will be shown that consumer sovereignty is no longer the optimal strategy in the presence of environmental constraints.

All that is required to generalize the dominant paradigm to allow for environmental constraints is to avoid the free gifts and free disposals assumption. Operationalizing this change in assumption is quite straightforward, requiring two modifications to the exposition above: introduce environment (E) as a third stock, alongside labor and capital,

$$E_1 = E_o + \Delta E_1,$$

and generalize the Cobb-Douglas production function to recognize environmental inputs as potential constraints on production (Nordhaus, 1992, p. 9)

$$Q = T_Q L^{\alpha} K^{\beta} E^{\delta}.$$

The first modification introduces the environment as a relevant outcome, and shows that the environment stock at the end of a period is equal to the stock at the beginning of the period plus the change in stock during the period. Environmental stock may change because resources are used for production or because the accumulation of wastes reduces the productivity of available resources. Usually, environmental resources such as fossil fuels, water and forests are distinguished from wastes such as carbon dioxide (CO_2), effluent and groundwater contaminants. The treatment here does not highlight this distinction. Environmental stocks are resources that provide inputs to production and if waste accumulation or invading species reduce output potential then environmental stocks have been depleted (Kaivo-oja, 1999, p. 141).

The second modification recognizes that the environmental stocks available affect the potential output resulting from activity. Environmental stocks have some similarities with capital. In general, capital provides a flow of inputs to production. Capital can take many forms including manufactured capital, human capital, social capital and natural capital. The term environmental stock is preferred here because it has a specific meaning.

Environmental stocks are resources that can provide production potential. Consider the simple case of an offshore fish population. The fish population may have been present for millions of years but it only becomes an environmental stock when a fishing boat and net are available to harvest it. It is the technology of fishing that converts the physical attribute, the fish population, into an environmental stock.

Environmental stocks are not physical quantities but rather are capitalized based on the potential flow of inputs to production and the expected duration of the flow. Therefore improvements in technology that enable more output from a given physical resource input may allow environmental stocks to increase while the physical resource is depleted. All other things being equal, damage to physical stocks will reduce environmental stocks.

Individual Activity

An individual's decision about activity is modified when the environment is assumed constrained. An individual with perfect foresight would be aware that activity could lead to outcomes for the environment. Here, the environment is assumed to be potentially constrained so it is assumed that activity reduces environmental stocks. Reduced environmental stock available for production in subsequent periods leads to a negative impact on future consumption possibilities.

The result for the individual is that the utility impact of activity, $u(o_j)$, now has two components: (a) The original utility, v_j, labeled the *prize*, that would result from activity in an unconstrained environment, and (b) a new utility component, c_j, labeled the *eco-cost*, that is the change in utility due to the reduction of future consumption resulting from the depletion of environmental stocks caused by the activity.

Now

$$u(o_j) = v_j - c_j.$$

As a result, the individual's evaluation of the activity can be rewritten as:

$$SEU(a) = \sum_j p(o_j)(v_j - c_j).$$

In what follows, there will be no need to preserve the possibilities that outcomes are uncertain or that more than one outcome from activity is possible. Therefore:

$$SEU\ (a) = v_a - c_a.$$

Aggregating Activity with a Constrained Environment

With a constrained environment, simple additivity is no longer an adequate means of aggregation. Establishing a method for aggregation with a constrained environment requires three steps: modeling the environment in a way that allows for the possibility that it is constrained, identifying the states, or *cases* of the economy-environment interaction and showing how aggregation is accomplished in each case.

The state of the environment, E_1, at the end of time period 1 depends on the state of the environment at the end of the previous time period, E_o, damage to the physical environment caused by activity during time period 1, the net self-repair capacity of the environment during time period 1, R_1, and any change in the productivity of each unit of physical input from the environment.

In the generalized production function the term T_Q represents the combined technologies used to exploit the inputs from labor, capital and environment. The impacts of technologies may be distinguished by noting that:

$$T_Q = f(T_L, T_K, T_E),$$

where T_L is the labor technology, T_K is the capital technology, and T_E is the environmental technology.

Changes in T_E are important because they increase the environmental stock even though the physical resource may remain unchanged. It is easy to identify examples of changes in T_E, a notable one being the exploitation of fossil fuels for food production. Fossil fuels and agricultural technologies have allowed a dramatic increase in the food production from each hectare of agricultural land. Total output increases have been facilitated by increases in T_E and by using a large proportion of global physical environmental stocks for human activity (Vitousek et al., 1986; Wackernagel et al., 2002).

Activity may use a flow of inputs enabled by an environmental stock. Oxygen is used for combustion. Land is used for agriculture. The activity may or may not result in depletion of stocks. In the case of oxygen there is usually no depletion of the environmental stock. In agriculture depletion is common, especially when land is irrigated or overused. Depletion is a flow that occurs during a time period and affects stocks. Depletion may result from use of resources or from accumulation of wastes.

The physical environment also repairs itself. Species stocks and degraded land may recover. Wastes may be chemically transformed or dispersed. However, the rate of recovery is constrained by the rate of the natural processes that enable it. The rate of recovery may reduce if physical environmental stocks are depleted excessively.

In the absence of intervention or changes in the productivity of environmental stocks, whether or not the environmental stocks are depleted depends on the rate of depletion in relation to the rate of self-repair. If the rate of self-repair, R, is assumed approximately constant then the rate of depletion is the critical variable. The rate of depletion depends on the level of activity and the depletion, or damage, technology, T_D:

$$\Delta E_1 = A_1 T_D + R_1$$

where A_1 is the aggregate level of activity in period one and T_D is usually negative. The depletion technology determines the impact of activity on depletion. Technologies referred to as environmentally friendly are those that have low or positive T_D values.

The impact of activity on environmental stocks is:

$$E_1 = E_o + A_1 T_D + R_1 .$$

The free gifts and free disposals assumption is appropriate when activity levels are low so that the environment is not depleted; that is, $R > AT_D$. This state is labeled *Case I* and referred to as *Free-Gifts/Free-Disposals.*

With a given level of T_D and growing activity levels there will eventually come a time when $R<AT_D$ so that physical environmental stocks begin to reduce. A reduction in physical environment stocks may or may not lead to a reduction in the available flow of inputs to activity, depending on the amount of reduction and on the nature of the environmental stocks. The amount of reduction of soil nutrients from irrigation may be sufficiently small that nutrient levels are not a constraint on the output from agricultural activity. With greater reductions, inputs of fertilizer may be needed to sustain output per hectare. The nature of forests means that some trees can be cut down without reducing the output from forestry activity. When all the trees are cut, however, the forest will not produce anything for a long time.

The case where environment stock is depleted but output is unaffected is *Case II*, or *Headroom* (see Figure 2.3). Headroom may be regarded as a latent economic problem because, although there is no reduction of output, there will be a reduction in the future when the stocks are depleted sufficiently.

If depletion is sufficient to affect output, so that further activity causes an eco-cost, then the environment has become a constraint on production. The mechanism for the constraint may take one of two forms: an increase in the inputs of capital, labor or environment required to achieve the same level of output from the activity, or a reduction in the availability of environmental inputs reducing the SEU available from the activity.

There are three Cases, labeled III, IV and V, where further activity, even at the same level, will lead to further depletion and to further reductions of output. These cases will be distinguished from one another below. Whether output is affected depends upon initial environmental stocks, E_o; the amount of activity, A; the technology used for the activity, T_D; the self-repair capacity of the environment, R; how long the activity is done for given $R<AT_D$; any change in T_E; and the nature of the environmental stocks, that is, the impact of partial depletion on output per unit of activity.

The final case, *Case VI*, occurs when environmental stocks have been depleted so much that A is reduced so that $R>AT_D$. The story so far is summarized in Figure 2.3.

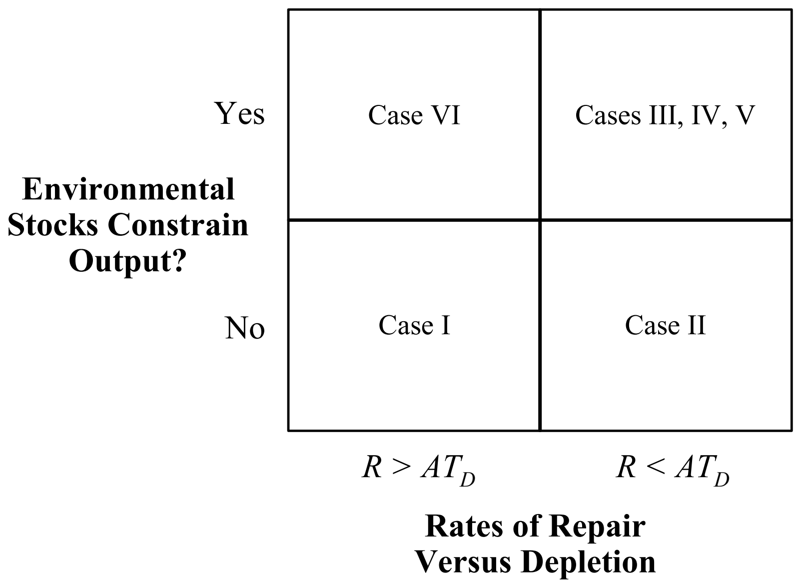


Figure 2.3. Cases of the economy-environment interaction. R is the self-repair rate for the environment, A is the aggregate amount of activity and T_D is the environment damage per unit of activity. T_E, the technological productivity of environmental inputs, is assumed constant.

An important conclusion can be reached at this point. History and the scale of activity matter if the environment is potentially constrained. If stocks reduce because damage cannot be offset by the self-repair capacity of the environment (or improved technologies) then activity will eventually lead to progression from Case II to higher cases. This may seem obvious but with the free gifts and free disposals assumption both history and scale can be ignored. The dominant paradigm assumes that history does not matter and the modern presumption of progress forever amounts to ignoring scale. These important points will be revisited in later chapters.

Aggregation of the effects of activity depends on the state of the environment. Aggregation under Case I is additive. Aggregation under Case II is also additive because the inputs and outputs are unaffected by the ongoing reduction in environmental stocks. Figure 2.1 describes aggregation for both Case I and Case II.

Beyond Case II the situation is very different because of the emergence of a future eco-cost resulting from the reduction of environmental stock.

The aggregate utility outcome, $U_{a,}$ from an activity is V_a-C_a. The V_a, or prize, occurs relatively quickly after the activity. It may be thought of as the direct benefit from developing a piece of land, collecting firewood or driving a car. Time distributions of outcomes and individual discount rates will vary among activities. The prize from the activity will usually come relatively soon because the activity is carried out to gain the utility and individuals value earlier outcomes more highly.

The eco-cost tends to emerge later. SEU maximizing individuals will also tend to choose activities that have a lot of V_a early and as little as possible C_a that might affect their utility outcomes.

Economists normally model individuals who have perfect foresight. However, they are usually working with analyses where individuals are seeking V_a and not considering C_a. It is not likely that those who introduced CFCs, cars and exogenous species were aware of the eco-cost their actions would encourage. Despite this, the analysis will continue to assume perfect foresight; the problem here is not knowledge, it is self-interest. It is sufficient to note that actors may underestimate the eco-cost of their activities.

Figure 2.4 shows all possible combinations of V_a and C_a. If the prize is less than 0 then the actor has no incentive to carry out the activity. If the eco-cost is less than 0, that is, there is an indirect economic benefit of the activity through a positive contribution to environmental stocks, then the economy benefits.

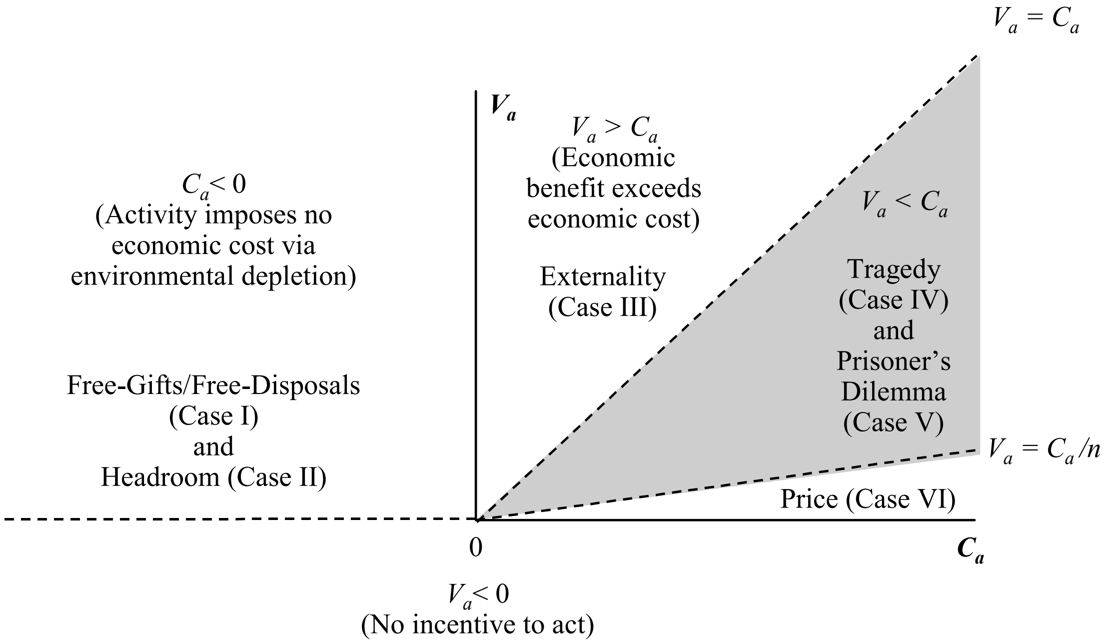


Figure 2.4. Value (V_a) and eco-cost (C_a) of activity. The number of actors who share the eco-cost equally is *n*.

If V_a>0 and C_a>0 then environmental depletion will occur if the actor acts. However, the environmental depletion will be in the economic interests of the total community provided that total utility is positive, that is, if V_a>C_a. Note that some individuals within the community will be incurring the eco-cost. This is labeled *Case III*, *Externality*.

Externalities arise when activities lead to costs or benefits that are imposed on Others (Turner, Pearce, and Bateman, 1994, p. 79). The externalities may be economic costs or adverse effects on individual non-economic well-being. The label externality is used here in a much more restrictive way than is conventional. The word is chosen because it does capture the essential feature of externality as used here which is an economic cost imposed on an Other, via the eco-cost of activity. Figure 2.4 also shows that the word externality as used here only applies when the activity is also in the economic interests of the community because the total prize is greater than the total eco-cost. Externality here means a negative externality and nothing worse.

Aggregation in Case III can be understood using the approach introduced in Figure 2.1. Figure 2.5 illustrates the Case III aggregation for two actors, where the total eco-cost (C_a) is less than the total prize for the individual (v_a). Assume as before that the prize for each unit of activity is 1 unit of utility. The eco-cost must be less, so let the eco-cost be 0.5 for each unit of activity, and assume it is shared equally between the two potential actors. The resulting pay-offs are shown for actors One and Two.

		Two	
		No Act	Act
One	No Act	0, 0	-0.25, 0.75
	Act	0.75, -0.25,	0.5, 0.5

Payoffs for One, Two

Figure 2.5. Aggregation of Activity in Case III. The prize for acting is assumed to be 1 and the eco-cost is assumed to be 0.5. If One acts alone then One's payoff will be 1+ (-0.5/2) = 0.75. Two will get -0.5/2= -0.25. If Two acts alone the outcomes will be reversed. If both act then each will get 1+(-1/2)=0.5. Each should act but each will be harmed by the actions of the other.

The result is that each actor will act, as in the other cases, but that the payoffs will be lower, with each actor only getting 0.5. In addition, each actor has an additional incentive to act. If One does not act, but Two does, then One will receive -0.25, his or her share of the eco-cost.

If the future aggregate economic cost of the environmental depletion (C_a) is greater than the "direct" benefit of the activity (V_a) then the activity is not in the economic interests of the community. This occurs in the shaded area of Figure 2.4. Additional activity within the shaded area would impose an economic cost on the community that is greater than the economic benefit to the community resulting from the activity.

Now consider the decisions made by actors about activity options within the shaded area of Figure 2.4. The individual actor maximizes using his or her own total utility, v_a- c_a.

Figure 2.6 shows how the total utility from the activity can be partitioned to arrive at the utility for the actor.

	Actor	Others	Total
Direct	v_a	$V_a - v_a$	V_a
Mediated Via Environmental Stock Depletion	c_a	$C_a - c_a$	C_a
Total	$v_a - c_a$	$(V_a - v_a) - (C_a - c_a)$	U_a

Figure 2.6. Partition of utility from an activity (U_a). V_a is the total prize and v_a is the prize for the actor. C_a is the total eco-cost and c_a is the eco-cost for the actor.

For many activities the direct economic benefit from the activity, V_a, will mostly go to the individual who carries out the activity, the *Actor*. V_a may also flow to *Others* as a result of the activity. The Others may be shareholders or employees of the company that made a product used for the activity. They may be members of a family sharing food cooked using the firewood.

Individuals are Actors at some times and Others at other times. Individuals might have the potential to be Actors because they could carry out an activity but in choosing to refrain from the activity they become Others. Individuals may be referred to as Actors because they have the potential to act but their choice to refrain from activity could make them an Other. Others may be Others because they are potential Actors who choose not to act, or because they do not have the opportunity to act. In a given community, an individual might operate as an Actor in one arena and also be an Other in a different arena.

For simplicity, assume, as before, that all the V_a goes to the Actor, that is, that $v_a = V_a$ for the actor. While the V_a is likely to be spread beyond the Actor, the recipients of the V_a may be treated as a relatively concentrated group with the Actor gaining an important share of the V_a.

The focus of this thesis is on those environmental issues caused by activities whose environmental effects are dispersed. Climate change is an example. A small group of Actors may benefit from the use of a car while the economic costs to Others of the resulting contribution to climate change are dispersed very widely. At some point the impacts of climate change may be large so that for using the car, the total eco-cost (C_a) may be greater than the total prize (V_a).

For activities that contribute to climate change, c_a/C_a, the proportion of the total economic cost mediated by environmental depletion that goes to the Actor, is very small. If n individuals share equally in the C_a then $c_a=C_a/n$. The line where the actor's benefit, v_a equals the actor's cost, C_a/n, is shown on Figure 2.4 for large n. At the other extreme, an Actor may get a large share of the eco-cost but nevertheless the amount that goes to Others is sufficient that for the Actor c_a is less than v_a so the activity provides a positive expected utility for the Actor.

The conclusion is that there is a potentially large class of activities, within the shaded area of Figure 2.4, which may provide positive utility to Actors but are not in the economic interests of the community as a whole because of the costs to Others. Environmental constraints make this possible. This case is *Case IV*. It corresponds to the tragedy of the commons (R. Hardin, 1982) and will be labeled *Tragedy*. Tragedy will occur if the environmental cost is greater than the direct benefit and the cost is shared sufficiently widely that the Actor's benefit remains greater than his or her share of the eco-cost.

The larger the number of Others who are sharing in the c_a, the lower the proportion that will go to the Actor, and the greater the likelihood that there will be a misalignment of individual and community economic interests. Any underestimation of C_a increases the likelihood of activity that is in the interests of the individual, but not in the economic interests of the community, by reducing the deterrent effect of the expected c_a for the Actor.

If the c_a is large enough to deter the activity, that is, $v_a < c_a$, then the activity will have been prevented. Case VI is labeled *Price*. It is similar to what happens without environmental constraints when the Actor is deterred from an activity because the Actor's costs of the activity exceed the benefit available. The difference here is that the expected future cost of environmental depletion is the source of deterrence.

In summary, if the amount of activity is small enough or the technology used is minimally damaging then the self-repair capacity of the environment will allow the free gifts and free disposals assumption. If the amount of activity increases continuously, eventually the self-repair capacity is not sufficient to prevent depletion. For a time, the depleting environment stocks do not imply a future economic cost because sufficient headroom remains to allow activity to continue as before. With continuing activity the headroom erodes further and the depletion begins to cause a future economic cost. The costs resulting from depletion are partly borne by the Actor; Others receive a negative externality.

Nothing has yet happened to prevent ongoing activity. Depletion continues until the future costs from depletion exceed the total benefit from the activity so the activity is no longer in the community's economic interest. The activity continues even then because the Actor's share of the cost is less than his or her benefit from the activity. The Actor gains, but at the expense of the community, which is a Tragedy. If the Actor gains a very large share of the cost or the cost becomes very high then the Actor will be deterred. The Price of activity is too high and the activity will not be carried out.

A potentially constrained environment has added three cases. Headroom, Externality and Tragedy are cases caused by ongoing depletion of environmental stocks by utility-maximizing Actors. As stocks deplete there is a shift from Headroom to Externality, from Externality to Tragedy and from Tragedy to Price. Avoiding this path implies remaining in Case I or else stopping the depletion of environmental stocks.

The existence of Tragedy is a great concern. Having consumption-motivated Actors who carry out activity that benefits them but harms both their economic communities and the environment is disturbing. Of even more concern is the conclusion that ongoing activity beyond a certain scale inevitably leads towards Tragedy.

However, there is a still more disturbing case than Tragedy, where consumption-motivated Actors carry out activities that harm their community economic interests, their environment and their own economic interests. Further, despite this harm to themselves, the Actors have a powerful incentive to continue their destructive activity.

So far, single Actors acting unilaterally have been the subjects of the analysis. However, many global environmental issues involve a large number of Actors.

Assume there are m Actors in a population of n individuals and each Actor may choose to act or not. Continue to assume that $v_a=V_a$ and $c_a=C_a/n$. Each Actor wants to act unilaterally so v_a must be greater than C_a/n and assume V_a is less than C_a. These assumptions place the activity option in the shaded area of Figure 2.4.

Now consider what happens when more than one Actor may act. Each Actor will act if and only if the expected utility from acting is greater than the expected utility from not acting. If the Actor does not act but the m-1 other Actors do act then the utility gained by the Actor will be:

$$u_a = -(m-1)C_a / n.$$

If the Actor does act then the utility gained by the Actor will be:

$$u_a = v_a - mC_a / n.$$

Therefore, acting dominates not acting because v_a is greater than C_a/n regardless of the number of Actors.

If each Actor carries out the same analysis and expects that each other Actor will do the same then each Actor will expect that the other Actors will act and should choose to act. If, for some reason, an Actor does not expect that the other Actors will act then that Actor should still act because v_a is greater than C_a/n.

Unfortunately, although the Actor will gain more utility by acting than by not acting, it is possible that $u_a < 0$:

$$u_a = v_a - mC_a / n$$

$$\Rightarrow u_a < 0 \ \mathit{if} \ v_a < mC_a / n$$

$$.\Rightarrow u_a < 0 \ \mathit{if} \ v_a / C_a < m / n$$

v_a/C_a is a benefit to cost ratio from carrying out the activity. The proportion of the population who act is m/n. If a large enough percentage of the population is able to act, and that proportion is greater than the benefit to cost ratio of the activity, then the utility for the Actors (and for Others) will be negative. This case, *Case V*, is known as the *Prisoner's Dilemma* (Campbell, 1985, p. 4-8), although "citizen's dilemma" might be more appropriate in this context.

		Two	
		No Act	Act
One	No Act	0, 0	-0.75, 0.25,
	Act	0.25, -0.75,	-0.5, -0.5

Payoffs for One, Two

Figure 2.7. Aggregation of Activity in Cases IV and V. Case IV is shown on the left hand side for Actor One. The prize for acting is assumed to be 1 and the eco-cost is assumed to be 1.5. If One acts then One's payoff will be 1+(-1.5/2)=0.25. One will act but the action will not be in the economic interests of the community. Case V is shown in the whole figure. If both actors act then each will get 1+(-3/2)= -0.5. Both will act to maximize their own SEU but acting is not in the actors' economic interests.

Aggregation in Cases IV and V is illustrated in Figure 2.7 for two individuals. Assume that V_a=v_a=1 and that C_a=1.5 so that C_a>V_a to establish the Tragedy. First consider the situation where only actor One has the opportunity to act so that only the left hand side of Figure 2.7 is operative. Actor One should act because the prize (v_a=1) is greater than the eco-cost (C_a/n=0.75). The outcome is positive for actor One but negative for the community as a whole. This is a Tragedy not a Prisoner's Dilemma because $v_a/C_a>m/n$ (1/1.5>1/2).

Now consider what happens when both actors may act. Now $v_a/C_a<m/n$ because 1/1.5<2/2 so it should be a Prisoner's Dilemma. The payoffs in Figure 2.7 confirm this conclusion. Acting dominates not acting for both actors but if they both act their payoffs are -0.5 each, which is worse that the 0 that each would get if they both refrained from acting.

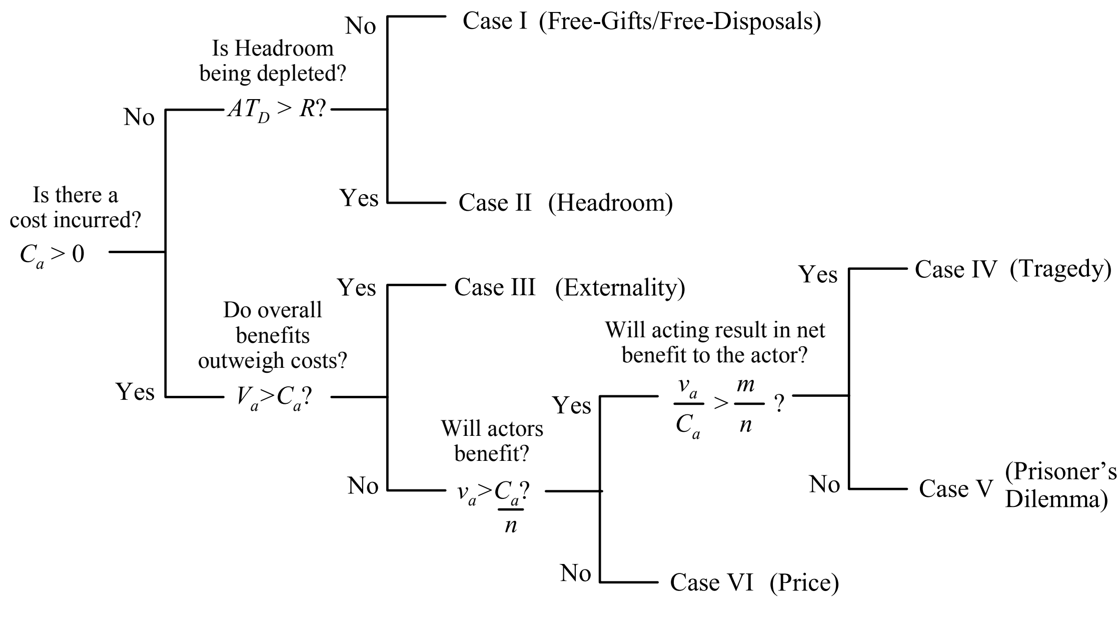


Figure 2.8. Conditions for Cases. V_a is the total prize and v_a is the prize for the actor. C_a is the total eco-cost. The number of actors is m and the number of individuals sharing the eco-cost equally is n. A is the aggregate amount of activity, T_D is the damage per unit of activity and R is the self-repair capacity of the environment.

Figures 2.8 and 2.9 illustrate the distinctions among the cases and are logically equivalent. Figure 2.8 shows the conditions for each of the cases while Figure 2.9

partitions the outcome space according to the conditions. For the purposes of Figure 2.9, V_a is arbitrarily assumed equal to 1.0 to establish a metric.

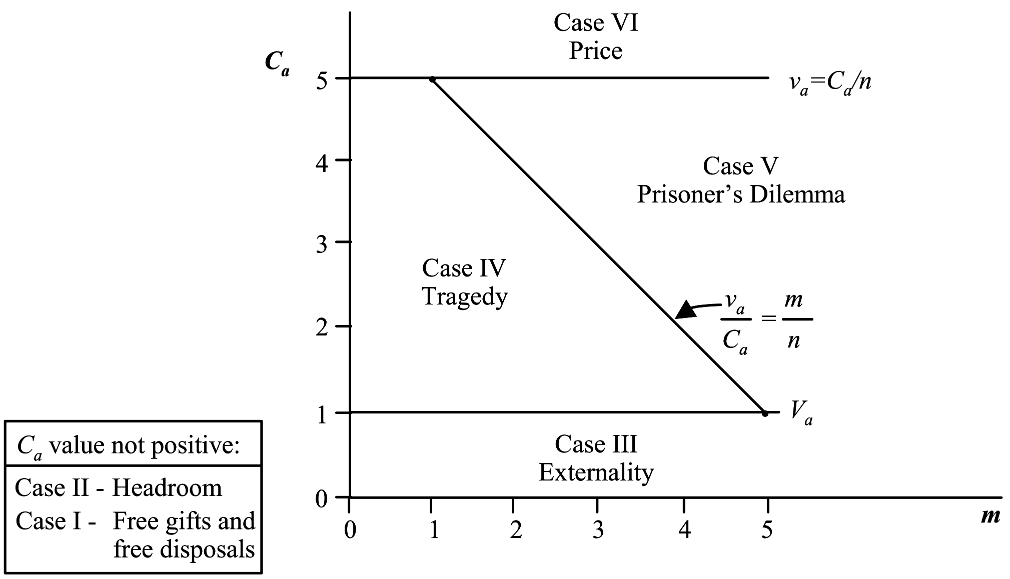


Figure 2.9. Outcome partition. V_a is the total prize and v_a is the prize for the actor. C_a is the total eco-cost. The number of actors is m and the number of individuals sharing the eco-cost equally is n. It is assumed that n = 5 and v_a = 1.

Actors with perfect foresight understand that they face a Prisoner's Dilemma and recognize that each Actor will be better off if they all refrain from acting. There are two important impediments preventing real life Actors from converting this insight into an agreement to refrain from action.

The first impediment is that the Prisoner's Dilemma arises as a result of a deterioration of the benefit to cost ratio for activity, resulting from accumulating environmental damage, with a background of a long history of beneficial activity. This history means that each Actor should presume that the other Actors will continue to act and faces the challenge of organizing an agreement not to act. Unilateral decisions to refrain from action are unlikely given that acting dominates not acting and that each Actor expects the other Actors to continue to act.

The second impediment is that, even when every Actor recognizes this very nasty situation, there is a huge coordination problem in organizing what, in practice, would need to be a global agreement not to act. Unilateral actions are pointless because defectors who choose to continue to act undermine coordination efforts, free riding on the restraint of the Others. As introduced in Chapter One, this is known as the collective action problem.

Solutions to the repeated prisoner's dilemma (e.g., Axelrod, 1985; Rapoport and Chammah, 1965; Taylor, 1987) rely on signaling by a small number of actors, usually two. With a large number of actors the problem becomes very difficult to solve. The practical response, articulated in different ways by Braybrooke (1985) and Black (1990), is not to solve the prisoner's dilemma itself but rather to transform the problem into a different problem: one that can be solved. That is the approach that will be used in this thesis. The direction of the solution of the large numbers prisoner's dilemma is indicated by R. Hardin (1985) who argues that individuals can influence one another and value outcomes for Others thereby motivating cooperation.

In the presence of environmental constraints, acting is in the interests of the individual but leads to adverse outcomes for the environment in Cases II through V and, in Cases IV and V, for the economy as a whole. The distinguishing feature of the Prisoner's Dilemma is that acting is individually rational but leads to outcomes that are not even in the economic interests of the Actors themselves.

Outcomes with a Constrained Environment

Outcomes on the triple bottom line with a constrained environment are very different from those that result with an unconstrained environment where Free-Gifts/Free-Disposals can be assumed.

The first step in determining the outcomes expected with a constrained environment is to identify which case or cases will eventuate. Is there a case that will predominate under the assumed conditions or is the outcome uncertain? Begin with Case I. If activity increases sufficiently Case II emerges. Ongoing activity in Case II is in the interests of individual Actors and so Case III will eventually emerge. Ongoing activity in Case III remains in the interests of individual actors so Case IV will emerge. Ongoing activity in Case IV is still in the individual economic interests of actors.

If many Actors can act and $v_a/C_a < m/n$ then Case V will emerge. If individuals can find some way to coordinate then they will combine to prevent activity in Case V. However, if coordination is unachievable then they will continue to act in Case V.

Activity in Case VI is not in the individual economic interests of Actors.

The conclusion is that if SEU maximizing individuals who get their utility from consumption are free to act, then the likely eventual outcome will be either Case IV or Case V, depending on v_a/C_a, m/n and the ability to coordinate.

With Cases IV and V the environment is damaged and damage is continuing. If the damage becomes sufficient that $v_a<c_a$ then activity will cease and the environmental stocks will begin to grow again. However, the result of the growth of environmental stocks will be a return to damaging activity. The consequence will be oscillation of activity options into and out of Case VI with seriously depleted environmental resources.

The outcome for the economy in Cases IV and V is correspondingly dismal. Despite the ongoing environmental damage, activity in Case III is Pareto-efficient. However, activity in Cases IV and V is not Pareto-efficient because, by definition, C_a is greater than V_a. Although some individuals benefit from the activity, the eco-cost of the activity is greater than the prize and that cost reduces the utility for other individuals.

The aggregate utility for the community is the sum of the utilities for the individuals within the community. Individuals continue to gain their utility from consumption so the outcome for the community is, as before, driven by the outcome for the economy. In Cases IV and V the economic outcome is not as good as it would be in Case III.

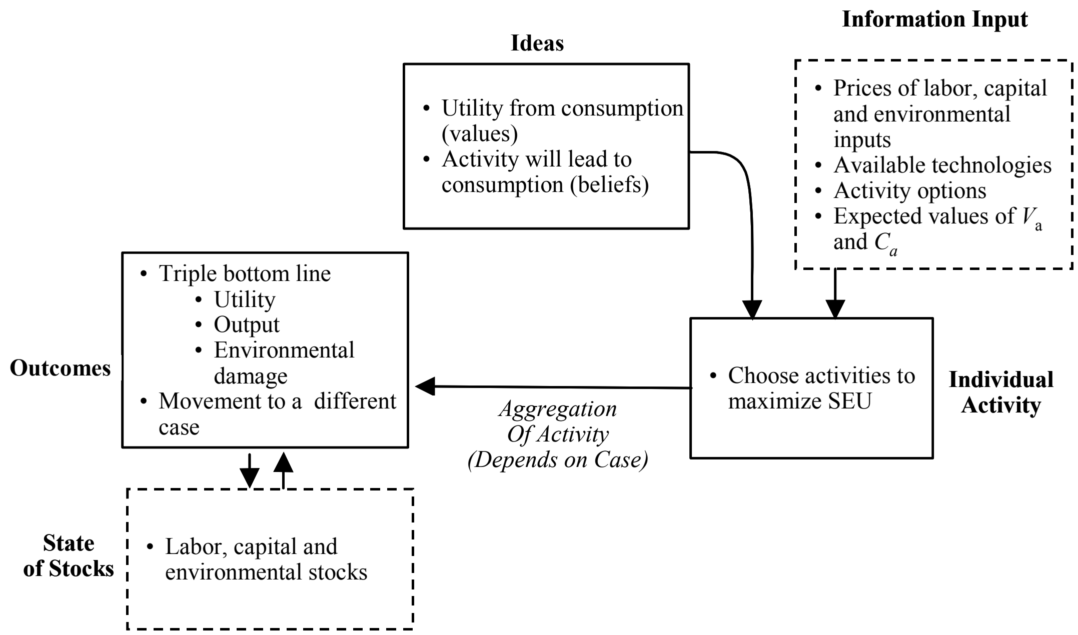


Figure 2.10. Extended paradigm with a constrained environment. Arrows show major effects. Dotted boxes show factors that affect and constrain activity and outcomes.

Figure 2.10 summarizes the paradigm extensions introduced to incorporate the potential for a constrained environment. The major changes are that the Actor considers the expected eco-cost as well as the prize, activity aggregation depends on the case, environmental stocks affect outcomes and are affected by outcomes, and the triple bottom line is needed to distinguish social, economic and environmental outcomes.

In conclusion, the outcomes expected assuming a constrained environment are worse than those expected with the assumption of an unconstrained environment.

__Management with a Constrained Environment__

The analysis above has explored the consequences of using conventional "free market" management when the environment is constrained. The outcome analysis portrays a situation where the environment is damaged, damage is continuing and the economic outcome is suboptimal. This raises the issue of what management strategies might lead to a better combination of outcomes.

Figure 2.11 summarizes the consequences for each of Actors, Others, the community, environment damage and the productivity of the environment, in each case.

Actors are assumed to care only about utility from consumption. In Cases I, II, III and IV, Actors choose to act and will gain an economic benefit from their activity. In Case V Actors may act but will not benefit economically and in Case VI self-interested Actors will not act. Individual Actors are economically harmed only in Case V.

The utility received by Others may be affected by activity carried out by Actors. Others' economic interests are harmed by activity in Cases III, IV and V. The community is the sum of the Actors and Others. Community economic interests are harmed by activity in Cases IV and V.

Environmental stock is depleted in Cases II, III, IV and V. In Case I the self-repair capacity offsets any environmental damage and in Case VI there is no activity so the environment is not damaged.

The environmental productivity column of Figure 2.11 assesses whether activity has an impact on the future economic productivity of the environment. Activity in Cases I and II does not reduce economic productivity, although ongoing activity in Case II will

		Outcome for				
Case	Label	Actor	Others	Economic Community	Environmental Stock	Environmental Productivity
I	Free-Gifts/Free-Disposals	Good	Good	Good	Good	Good
II	Headroom	Good	Good	Good	Bad	Good
III	Externalities	Good	Bad	Good	Bad	Bad
IV	Tragedy	Good	Bad	Bad	Bad	Bad
V	Prisoner's Dilemma	Bad	Bad	Bad	Bad	Bad
VI	Price	Good	Good	Good	Good	Good

Figure 2.11. Evaluation of outcomes from activity. Note that activity is deterred by price in Case VI.

eventually lead to economic productivity declining when Case III emerges.

Now examine the rows of Figure 2.11 instead of the columns. The analysis above established that the likely cases are IV and V if consumer sovereignty is the management objective. Consumer sovereignty has been established as the optimal management objective with an unconstrained environment. A different management objective is needed with a constrained environment.

Misalignment of individual and community economic interests in Case IV raises the possibility that community sovereignty might replace consumer sovereignty as the management objective. Community sovereignty would maximize the economic outcome for the community and would imply management intervention that would prevent activity in Cases IV and V. Case III might become the equilibrium case. Externalities would still occur but economic outcomes would be Pareto-efficient.

However, ongoing activity in Case III would lead to continuing damage to the environment and to a reduction in environmental productivity so, while Case III gives a better aggregate economic result than Cases IV and V, it does not address the issue of ongoing environmental damage. Ongoing environmental damage will lead to deteriorating economic circumstances. While each unit of activity in Case III is economically beneficial, it leads to environmental stock depletion and so contributes to a situation where future activity will be economically harmful.

Moving to Case II has the advantage that the environmental stock depletion contributes to a future rather than an immediate reduction in the consumption utility available from activity. In Case III environmental damage is sufficient that economic productivity is already reducing as a result of environmental stock depletion whereas in Case II the productivity reductions will occur in the future. Economic costs to others are also avoided by moving to Case II.

A management strategy that aimed to be in Case II might be labeled golden rule sovereignty because a strategy that protects outcomes for others also protects environmental productivity. Figure 2.11 illustrates this with the parallel entries in the two columns. The golden rule is prominent in many moral codes developed within the agricultural era including Hindu, Confucian, Zoroastrian, Buddhist, Jainist, Islam, Jewish, Greek and Roman. The Christian version of the golden rule is "Do unto others as you would have them do unto you." In several moral codes the phrasing is in the negative; for example the Confucian "What you do not wish others to do to you, do not do to them" (Wattles, 1987, p.106).

It is tempting to speculate that the golden rule was so prevalent in agricultural societies because it functioned as a mechanism to protect environmental productivity. This speculation is consistent with Spash's (1999) conclusion that "any new paradigm will need to include…a regard for the moral standing of others…" (p. 432).

The greatest protection for the environment would be achieved by managing to ensure Case I (Perrings, 1987). This management rule might be called environmental sovereignty. There are two immediate issues when considering environmental sovereignty as a management strategy. These are first that economic performance would be less than it could otherwise be, and second, that changing the management rule to something other than consumer sovereignty would be difficult to achieve.

The first issue might be addressed by a management rule that allows exhausting the available headroom and then moving to environmental sovereignty. The difficulty with such an approach is ensuring that the growth momentum created as the headroom is used up does not lead to ongoing activity within Case III. The golden rule is the management rule that would resolve this issue.

The second problem, changing the management rule, will be addressed in later chapters.

Conclusion

The first section of this chapter introduced the dominant free market paradigm that is the foundation of management of our economy and environment, and showed that consumer sovereignty is the optimal management rule within this paradigm.

The second section added some simple assumptions to introduce a constrained environment, and identified the consequences of continuing to use consumer sovereignty as the management rule. Allowing individuals to pursue their own economic interests in the presence of environmental constraints leads to poor outcomes on all elements of the triple bottom line: the economy under-performs its potential because activity with aggregate costs greater than aggregate benefits is carried out, the environment is depleted and continues to be depleted, and the community suffers because the net present value of total consumption is not maximized under the consumer sovereignty management rule.

The challenge that this poses is to develop and implement a revised paradigm that allows better outcomes. The task is articulated in Figure 2.12.

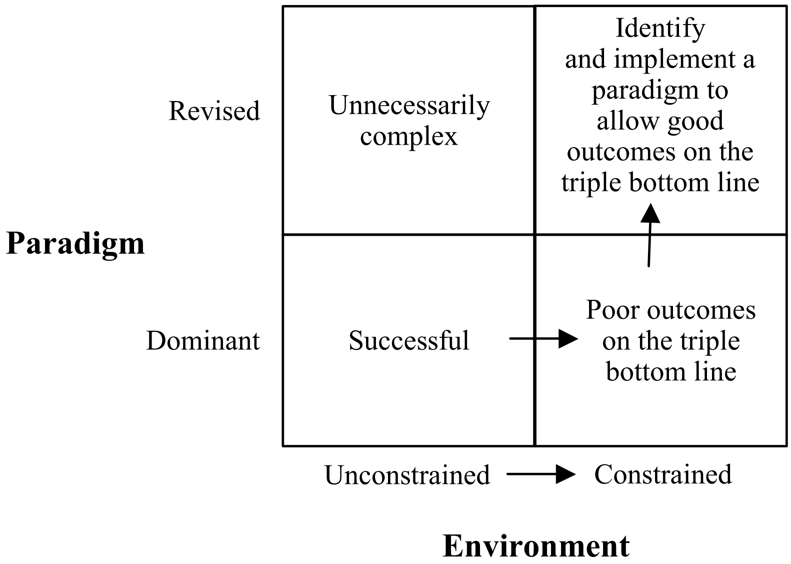


Figure 2.12. The paradigm challenge.

The revised paradigm will be developed through the remainder of this thesis. Chapters Three through Seven collectively conclude the modeling that has begun in this chapter. The modeling for the new paradigm has not been developed in this chapter because the rationale for the new paradigm can only be supported as the argument proceeds. An expanded version of Figure 2.10 will be presented in Chapter Seven.

Chapter Three assesses the impact of ongoing environmental damage in Cases II, III, IV and V to establish that there is a risk of environmental crisis.

CHAPTER THREE

ENVIRONMENTAL CRISIS

We are all in the same planetary boat. A few of us travel first class, while most are in steerage. But if the boat sinks we all drown together.
- Edward Kufuor in Goodland and Daly, 1992, p.128

A Risk of Crisis?

Chapter Two showed that consumption-motivated economic activity produces environmental damage. Despite ongoing erosion of environmental stock, economies continue to grow. There are several reasons for this. First, economies become less energy and materials intensive as per capita income grows so activities with less reliance on environmental stocks make up a larger proportion of total output. Second, many activities use eroding environmental stocks in Case II (Headroom) but there is no eco-cost so that economic output is not yet affected. Third, geographic expansion increases the physical inputs available, replacing the lost environmental stock. Fourth, technological innovation replaces the lost environmental stock by increasing the productivity of physical inputs. Fifth, as economic output becomes affected, substitutes are introduced.

One possible conclusion is that there is no need to worry about environmental stock erosion because effective environmental stocks will continue to grow via geographic expansion, technological innovation and substitution.

In *The Limits to Growth*, Meadows et al. (1972) warned that environmental constraints would limit the growth of population and output within 100 years; that is, by 2072. *The Limits to Growth* and the responses to it can be understood by distinguishing three aspects of the book: the evidence, the prescription, and the warning.

The evidence used by Meadows et al. to develop their conclusion was strongly criticised: for not including enough empirical data (Beckerman, 1972, p. 335); for assuming that only five to ten times currently known resources will be available when the ratio could be ten to 50 times (Heilbroner, 1973, p. 7); for assuming that only a four factor improvement in pollution would be achieved when it could be 40 or 400 (Heilbroner, 1973, p. 7), or a factor of 94 (Beckerman, 1972, p. 336); for claiming the results are not sensitive to small changes in assumptions when the changes might be large and testing indicates that the model is actually sensitive to assumptions about pollution growth (Ul Haq, 1973, p. 26); for using an aggregated model whereas the world is made of countries in different circumstances at different times so if there are difficulties for some, the world as a whole will "bumble along in the usual old way" (Beckerman, 1972, p. 339; Ul Haq, 1973, p. 27); for failing to consider the potential of kinds of resources not yet discovered (Ul Haq, 1973, p. 24); for failing to take account of technical progress (L. R. Brown, 1973, p. 15); for failing to recognize that humans are responding and will continue to do so (Ul Haq, 1973, p. 28), for being complacent about the social and political problems that would need to be solved to implement its prescriptions (Ul Haq, 1973, p. 30); and for not considering the costs of acting on the conclusions, given the risk that they are wrong (Beckerman, 1972, p. 335).

The prescriptions were "a crash program…aiming at both zero population growth and zero economic growth" (Heilbroner, 1973, p. 4). The prescriptions were also criticized strongly: because the steady state proposed is not feasible given the nature of economy-environment processes (Murray, 1973, p. 45); because increased output would be needed to provide adequate services to those already alive and to provide for inevitable growth (Heilbroner, 1973, p. 5); because if the stationary state was achieved there would still be serious environmental damage (p. 8); because it would be better to change the mix of production, focus effort on pollution, and continue with safe growth (p. 8); and because they do not address the social change required to mobilize technical responses (Heilbroner, 1973, pp. 11-12; Ul Haq, 1973, p. 29; Murray, 1973, p. 49).

Meadows et al. (1972) warned that:

> 1. If the present growth trends in world population, industrialization, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most

> probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity.
>
> 2. It is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future. The state of global equilibrium could be designed so that the basic material needs of each person on earth are satisfied and each person has an equal opportunity to realize his individual human potential.
>
> 3. If the world's people decide to strive for this second outcome rather than the first, the sooner they begin working to attain it, the greater will be their chances of success. (pp. 23-24)

Meadows et al. (1972) did not explicitly recommend zero population growth; they illustrate the consequences of zero population growth. What they say is that "we require that the number of babies born each year be equal to the expected number of deaths in the population that year….Such a requirement, which is as mathematically simple as it is socially complicated, is for our purposes an experimental device, not necessarily a political recommendation" (pp. 159-160).

Their modeling indicates that stopping population growth in 1975 would not be enough to prevent an overshoot crisis (p. 160) but that crisis would be prevented if, in addition, industrial investment was slowed to match depreciation of industrial capital by 1985 (p. 162). The authors acknowledge the implementation issue when they state that

> we can say very little at this point about the practical, day-by-day steps that might be taken to reach a desirable, sustainable state of global equilibrium….Before any part of the world's society embarks deliberately on such a transition, there must be much more discussion, more extensive analysis, and many new ideas contributed by many different people. (p. 180)

Meadows et al. call for further research and point out the difficult choices that must be made.

Most of the Meadows et al. conclusions seem reasonable. They argue that progress will not continue forever, that if the world continues with business-as-usual then the environmental constraints will lead to an overshoot crisis, and that taking action earlier rather than later will reduce the risk and magnitude of the crisis.

The warning can be right even if the evidence and prescriptions are not. Heilbroner's (1973) criticism illustrates this point. He is very critical of both the evidence presented and the prescriptions and yet he concludes that

> however "alarmist" the data on which their models are based, however naïve their call for social change on a scale that is beyond reach and by means they do not make explicit, one cannot fault their assertion that the exponential curves of growth, human and industrial, will sooner or later overtake the finite capabilities of the biosphere, bringing dreadful declines in population and the quality of life. (p. 10)

This is reinforced by Neurath (1994) who writes:

> Let me emphasize, because this point has been misunderstood again and again in all the discussions I have ever seen: this is *not a prediction* that the authors are making of things to come, *but a warning of what would happen if* mankind were to continue to grow its own numbers and its per-capita consumption at the rate at which they are growing now and have been growing for the last few decades. (p. 65)

Heilbroner (1973) argues that the real challenge is institutional and social, concluding that

> the social price of ecological control is a vast increase in the scope and penetration of regulatory authority, designed to enforce the necessary zero-growth behavior at the local level, on which our collective safety will depend at the planetary level. (pp. 11-12)

Heilbroner (1973) is pessimistic about the prospects for bringing about this change, concluding that

> whereas I have indicated some reason for optimism with regard to our technical capabilities for adaptation, I do not find it so easy to be sanguine with respect to our near-term ability to bring about the needed social and institutional changes, (p. 12)

and continues with the statement that

> our generation is unlikely to solve the technical problems that will guarantee the indefinite viability of the planet, and will surely not solve the social challenges that are indissolubly associated with mankind's survival. But, in the startled recognition that an ultimate ecological problem exists, it can set the stage for more decisive action by generations to follow. (p. 12)

Bertram Murray (1973), a zoologist, also accepted the warning:

> in biological and physical systems, then, the consequences of increasing growth are precisely those forecast in *The Limits to Growth* for human population and industrial growth. Although this forecast could be considered "theoretical," there is ample evidence from analogous systems to increase the probability of its correctness. Because of numerous factors, the accuracy of the forecast with respect to the *timing* of the collapse is more difficult to evaluate. Thus, we can be fairly certain that collapse will occur but less certain as to when. (p. 45)

Other critics did not accept the warning. For example, Beckerman (1972), criticized the work in a way that helps reveal why some accepted and others criticized the warning. He concludes that "although life on this Earth is very far from perfect there is no reason to think that continued economic growth will make it any worse" (p. 340).

While Murray's (1973) argument is based on the behavior of biological systems, Beckerman (1972) relies on economic arguments. He points out that the strongest criticisms have come from economists and criticizes scientists for being receptive to the warning. He explains economists' criticisms:

> the basic training of the economist includes a reluctance, derived from Alfred Marshall, to believe that nature proceeds in jumps . . . a tendency to think in terms of models that have negative as well as positive feedback; and a deep suspicion of the conclusions drawn from time series data. As regards the latter, since economics proper is about the logic of choice, economists are interested in the growth problem only in so far as it involves the choice that has to be made between consumption today and consumption tomorrow. (p. 342)

These arguments help reveal how the response to *The Limits to Growth* depends on the paradigms used by reviewers. Beckerman (1972) reveals that economists' training with continuous models leads them to expect the future to be a continuation of the past and to hold the view that natural processes do not proceed in jumps. This reasoning makes economists more likely to reject the warning. Murray's review relies on the analogy with biological populations that do overshoot the number that can be sustained by available resources and then collapse (Hern, 1990). This reasoning makes some biologists and some other scientists more likely to accept the warning.

A similar clash of paradigms can be seen in the debate following publication of Bjørn Lomborg's book *The Skeptical Environmentalist: Measuring the Real State of the World* (2001). Scientific American (Misleading Math, 2002) reported that:

> Lomborg's intention was to reanalyse environmental data so that the public might make policy decisions based on the truest understanding of what science has determined. His conclusion…was that…everything is getting better….Lomborg accuses a pessimistic and dishonest cabal of environmental groups, institutions and the media of distorting scientists' actual findings. (para. 2)

Scientific American (Misleading Math, 2002) published criticisms of Lomborg's book by four scientists. The titles of these criticisms convey a sense of the tone. They are: (a) *Global Warming: Neglecting the Complexities*; (b) *Energy: Asking the Wrong Question*;

(c) *Population: Ignoring Its Impact*; and (d) *Biodiversity: Dismissing Scientific Process*. Reading these criticisms, examining Lomborg's book (2001), and his response to the criticism (Lomborg, 2002) reveals that the criticisms are somewhat overstated and emotional (one reviewer described his review as angry) and that there is a tendency to focus not on the key arguments that Lomborg makes but rather on discrediting him as insufficiently expert and scholarly.

Lomborg (2001) is using the dominant paradigm and it leads him to focus on economic measures. For example, he reports an estimate of the total discounted cost of global warming of around US$5 trillion without considering that many of those likely to be affected by global warming are only minimally participating in the market economy. Further, the cost reported is a discounted cost. Perrings (1997) points out that discounting long-term future costs reduces the apparent danger and so reduces the likely response while at the same time eliminating the future costs from current decision-making (p. 181). The expected cost of climate change is calculated at around 1.5% to 2% of global GDP (Lomborg, 2001, p. 301) but discounting over a long time period means that future costs that might be more than US$1 trillion per annum do not have much impact on today's decision-making.

Further, Lomborg (2001) argues against taking much account of the risks of irreversible effects of climate change though he does acknowledge that such risks should be considered. His conclusion is that there are better ways to invest money (p. 317). Perrings (1997) points out that sustainable development implies that "if it is known that an action may cause profound and irreversible environmental damage which permanently reduced the welfare of future generations, but the probability of such damage is not known, then it is inequitable to act as if the probability is known" (p. 192). Lomborg's recommendations do ignore such risks, but not because he wants to be inequitable. Rather it is because the toolkit he is using is provided by the dominant paradigm, which requires decisions based on economic costs. Lomborg's critics do not believe that everything can be reduced to present dollar costs and benefits.

Lomborg (2002) himself believes that the motivations behind the Scientific American article extend beyond scientific debate, which may "account for the tone and the lack of balance of the feature as a whole" (p. 3). He quotes Stephen Schneider, one of the Scientific American authors, to clarify the rationale for these other motivations:

> On the one hand, as scientists we are ethically bound to the scientific method, in effect promising to tell the truth, the whole truth and nothing but – which means that we must include all the doubts, the caveats, the ifs, ands, and buts. On the other hand, we are not just scientists but human beings as well. And like most people we'd like to see the world a better place, which in this context translates into our working to reduce the risk of potentially disastrous climatic change. To do that we need to get some broadbased support, to capture the public's imagination. That, of course, entails getting loads of media coverage. So we have to offer up scary scenarios, make simplified dramatic statements, and make little mention of any doubts we might have. This "double ethical bind" we frequently find ourselves in cannot be solved by any formula. Each of us has to decide what the right balance is between being effective and being honest. I hope that means being both. (p. 3)

Lomborg's book and the reaction to it, much like the Meadows et al. (1972) document and corresponding reaction, illustrate the clash of paradigms. Lomborg (2001) is critical of the evidence used to support the argument that there might be an overshoot crisis. The scientists are concerned that there is a risk (p. 8), believe that Lomborg is using a paradigm that neglects factors they consider important (pp. 4,8) and respond vigorously to lessen the chance that Lomborg's argument will reduce commitment to change that they believe is necessary (p. 16).

Resolving the conflict requires deciding whether the process that might limit growth is best described by an economic or a biological paradigm. Three arguments can be advanced in favor of the biological view. First, Beckerman (1972), in another interesting illustration of paradigm clash, acknowledges that he knows very little about science (p. 328) and then goes on to criticise the arrogance of scientists for assuming that they are competent to comment on the economic problems of the environment (p. 329). Later, he points out that

> if there is an exponential growth in the demand for some resource, such as land, the supply of which is finite, then one day we shall run out of supplies of that resource. But this proposition has been true since the beginning of time; it was just as true in Ancient Greece, for example, as it is today. This did not prevent economic growth from taking place since the age of Pericles. (p. 332)

Beckerman (1972) is correct in concluding that economic growth has taken place since the age of Pericles but it has not been the continuous process he assumes. Redman (1992) reports that the history of Ancient Greece includes periods of "stable soils and population growth that might last from one to several hundred years, followed by rapid deterioration, and a long period of low population in the area, before a return to improved agrarian conditions" (p. 41). He concludes that

> it appears that the beginnings of soil erosion led in turn to the population aggregating into ever denser settlements and to intensification of farming practices on the remaining fertile land. These strategies were doubtless appropriate in the short-term, but in the long-term they resulted in even more serious erosion and more loss of soil fertility and agricultural potential. Today, where the astonishingly creative and innovative culture of ancient Greece flourished, we find eroded slopes and degraded vegetation. (p. 42)

The existence of episodes of environmentally influenced collapse of historical societies implies that human development is not necessarily a continuous process. If environmental constraints can affect the progress of other human societies there is at least a possibility that they may affect ours too.

Second, Gould and Eldridge (1977) argue that nature does proceed in jumps, they "believe that a general theory of punctuational change is broadly, though by no means exclusively, valid throughout biology" and go on to explain that "the general preference that so many of us hold for gradualism is a metaphysical stance embedded in the modern history of Western cultures: it is not a high-order empirical observation, induced from the objective study of nature" (p. 145).

Third, Vitousek et al. (1986), Pimentel et al. (1999) and Wackernagel et al. (2002) have completed different calculations that show that the scale of human activity is large relative to the total size of environment.

These three arguments may support the biological view that overshoot is possible but they do not establish that it will occur. A proponent of the dominant economic paradigm might acknowledge both points but argue that they do not apply in the world today because technology development will allow more efficient use of resources and the use of substitutes. If the rate of technology development is sufficient relative to the rate at which the physical environment is depleted and degraded then the environmental stocks available can grow at a rate equal to or greater than the rate of growth of the population.

Unfortunately, the issue cannot be resolved because there is not sufficient evidence about the prospective rate of technology development. In a 1984 review of the issue V. K. Smith and Krutilla conclude "confident judgements on the long-term maintenance of economic well-being with a constant or growing population, in the presence of finite natural and environmental resources, seem unwarranted based on what we know today" (p. 230). Krautkraemer reviewed the issue in 1998, concluding that

> the development of new materials that substitute for nonrenewable resources, improvements in extraction and processing technologies that allow the economical use of low-grade ores, and the greater efficiency of use of non-renewable resources are all likely to continue. The future is uncertain, and whether or not these mitigating factors will keep pace with increased demand for nonrenewable resources from a growing population and economic development remains to be seen. (p. 2103)

The lack of compelling evidence means that those who debate the issue tend to fall back on the ideas provided by their paradigms. The arguments are sometimes emotional, perhaps because individuals hold strong beliefs that are challenged. The beliefs they defend are provided by their paradigms but cannot be supported by compelling evidence so emotion is the result.

The green revolution, advances in information technology, and emerging energy technologies show how innovations can change our economic potential. With biotechnology, artificial intelligence, fusion, nanotechnology, faster-than-light travel and Star Trek transporters on the aspiration list, it is possible to envisage expansions of environmental stocks sufficient to ensure ongoing economic growth. This view of ongoing *Progress* provided by the dominant paradigm will be referred to as *Model I*. Despite challenges to Model I (e.g. Hubbert, 1993; Meadows et al., 1972; Meadows, Meadows, and Randers, 1992, pp. 7-13; Ophuls and Boyan, 1992, pp. 182-185) it is probably the dominant paradigm among western opinion-leaders.

Model I implies a stable and continuous future. It begins with the agricultural revolution, is driven by the industrial revolution, and comforted by Godel's Theorem, and goes on at least until the end of our children's children's lifetimes, which is further ahead than most of us dare to think.

Common (1995) summarizes the argument of Julian Simon, a key proponent of Model I, as being that energy is the key resource and if enough of it is available then material transformations can be used to produce anything that is needed, that human ingenuity leads to technological innovation, and that the threat of crisis is the trigger that leads to the ingenuity response (pp. 96-99).

If we believe in Model I we can relax. However, the question of risk management raises three important issues. Is there sufficient evidence to conclude that technology development will provide indefinite and uninterrupted environmental stock availability? If the outcome is uncertain, should management of the economy-environment interaction rely on an assumption of ongoing technological rescue? What are the consequences if assuming ongoing technological rescue turns out to be wrong? Common (1995) also points out that Model I might imply a human population of 20 billion people living happily underground on a biologically dead planet, a vision of the future that might not appeal to everyone (pp. 98-99).

To begin to unravel this, consider alternatives to Model I. The key feature of Model I is ongoing output growth, enabled by technology. Sustained growth is made possible by having sufficient ability to expand effective environmental stocks. To find an alternative model or models, consider the possibility that environmental stocks might really become a constraint on total economic output as the scale of human activity becomes large in relation to the size of the global environment. This might be caused by slower than hoped for technological development leading to a slower than hoped for expansion of effective stocks. It might also be caused by a large depletion of environmental stocks caused by depletion of important resources, or issues caused by overabundance of harmful substances such as greenhouse gases, heavy metals or invading species. In practice, a combination of the rate of technology innovation and environmental damage outcomes will determine the output potential.

Sustaining the population at current or increasing per capita consumption depends on the rate of population growth relative to the growth in output potential. The end of the demographic transition around the middle of this century will bring a reduction in the rate of population growth (United Nations, 2001, p. 480-483). Therefore, even if erosion of environmental stocks does constrain output potential, the stabilization of population may allow a soft landing. The soft landing would mean output growth could slow to match the reduced rate of population growth. With constrained environmental stocks, a change in output per capita, and therefore utility from consumption per individual, would be driven by the net effect of technological innovation and ongoing environmental stock depletion. This *Soft Landing* model will be referred to as *Model II*.

Like Model I, Model II relies on assuming sufficient technological innovation to offset environmental stock erosion. However, unlike Model I, Model II abandons the assumption that the future will be an extension of the recent past. It acknowledges the possibility of a state of the economy environment trade-off that is different from what we have today. Figure 3.1 illustrates the differences between Model I and Model II and introduces Model III.

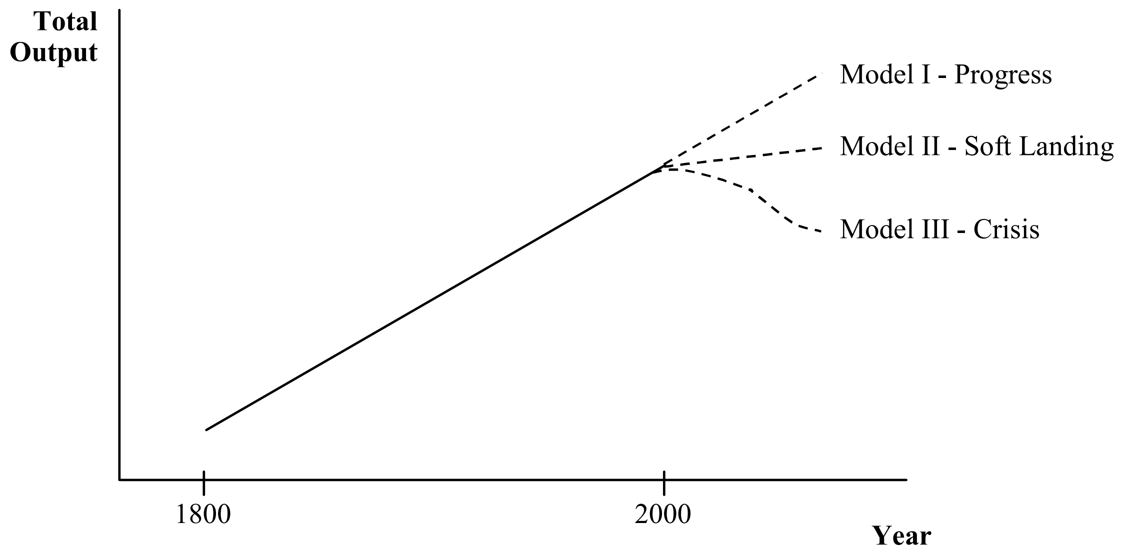


Figure 3.1. Alternative futures.

In Model III the rate of environmental stock depletion is so great that technological innovation is insufficient to sustain output so that output falls, as it appears to have done in Ancient Greece. If this happened there would be some combination of a reduction in GDP per capita and a reduction of population. *Model III* is labeled *Crisis*.

The crucial question addressed in this chapter is whether or not there is a need to be concerned about Model III. If the probability of Model III is very small then the risk management issue is not important. Establishing precise probabilities for these models is impossible a priori. It is conceivable that useable probability ranges for these models could be developed using analytic techniques but that task is not attempted here. Rather, the aim of this chapter is to establish that the estimated probability of Model III is not very small and that therefore humanity does face a risk management issue.

Moving from the dominant paradigm that predicts that progress will continue forever to consider the need for a paradigm where a risk of environmental crisis is acknowledged relies upon two arguments. The first is that Model I is not assured. The next section will argue that the current historical period may be a relatively short transition and that recent progress does not prove that progress will continue indefinitely.

The second argument is that if progress is not assured, then is not possible to be certain that a Soft Landing will occur. The third section of this chapter will review the outlook for demand for and supply of environmental stocks to develop some insight into the risk of crisis. In summary, the next section assesses Model I against Model II while the following section assesses Model II against Model III. The aim is to establish that Model I is not assured and that there is a risk of environmental crisis.

The Transition Hypothesis

Model I ultimately relies on technology. While substitutes may be used to sustain output growth, on a global scale they are finite and they require enabling technology. People no longer expect to discover an unknown continent but rather await advances in biotechnology, information technology, or nanotechnology to improve civilization.

Technologies determine the impact of activity on economic and environmental outcomes. If technologies change then the impacts of activity may change. There are three kinds of technological impact that are important. Economic technology (T_Q) is used in activity that combines inputs of capital, labor and environmental resources to produce the output that is measured by GDP. Other technologies, which may include economic technologies, combine with capital, labor, and environmental stocks in activity that produces the outputs that allow the population to survive. These include agricultural technologies, as well as those that protect health and safety. Damage technology (T_D) determines how activity causes damage to environmental stocks. If the economic and environmental technologies developed are effective enough and the damage caused by activity is low enough then it may be possible to have total damage that is small enough to be offset by the self-repair capacity of the environment.

For present purposes aggregate economic growth can be broken down into three factors; population growth, growth in agricultural output per capita and growth in nonagricultural output per capita. The reason for splitting agricultural from nonagricultural output is to distinguish the output that sustains the population from the output that provides the population with high consumption per capita.

The framework is shown in Figure 3.2. The plus indicates that agricultural output and nonagricultural output are added to get total output. The multiplications indicate that agricultural output per capita multiplied by population gives total agricultural output, and similarly for non-agricultural output.

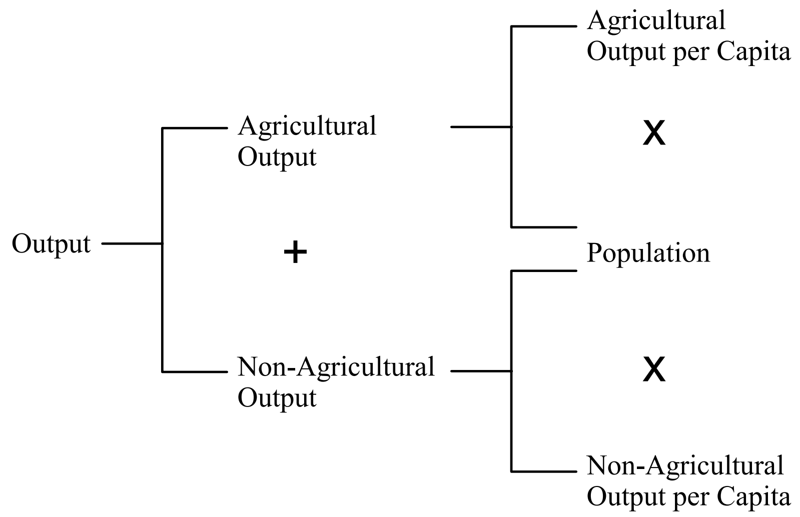


Figure 3.2. Composition of output

For the whole Earth, agricultural output per capita must fall within a narrow range. If it is too high then output will be wasted because each human is constrained in the amount he or she can eat. If it is too low then it will be insufficient to sustain the population.

Non-agricultural output per capita is not constrained in the same way. An individual who has sufficient food may have almost nothing else or may also have a house, a car, a plane, a boat and support from a sophisticated urban infrastructure. In a conventional economic analysis food is only a component of consumption per capita. Having better food may contribute to consumption per capita but this analysis will separate the provision of the food and other essentials that sustain life from the consumption component that provides utility beyond sustenance.

The kinds of technology distinguished above support different kinds of output. Environmental technology combines with some types of environmental stocks, notably productive agricultural land and climate parameters, to provide the agricultural output that sustains the population. Economic technology combines with other kinds of environmental stocks to provide the industrial outputs that sustain and grow non-food consumption per capita.

The damage technology and the self-repair capacity of the environment are important because they determine how the economic activity that provides output affects the levels of environmental stocks. If environmental stocks are large then growth can be sustained by drawing down the stocks (Cases I and II). If environmental stocks are not large in relation to the population then sustaining output growth depends on advances in economic and environmental technologies.

Agricultural land is an environmental stock only because people have agricultural technology to exploit it. The innovation of agriculture is described by Jared Diamond in his books *The Third Chimpanzee: The Evolution and Future of the Human Animal* (1992) and *Guns, Germs and Steel* (1998). Diamond describes the way development of a new environmental technology provided for a step-change in the population that could be supported on a given area of land.

Hunter-gatherers had very low population densities. Modern hunter-gatherer societies can only support around one person per square mile, or less than .01 persons per hectare, on the best land so it seems unlikely that the average for ancient hunter-gatherers would have been much higher. Assuming the whole land surface of the Earth to have been high quality, this would have allowed a maximum sustainable population of around 50 million people - the actual sustainable population with hunting and gathering technology would be much less. According to Norgaard (1994a) the total population between five and ten thousand years ago was approximately five million (p. 40).

For hunter-gatherers the key constraint on population density was the availability of animal and plant resources that could be hunted or gathered with the technology available. Wood and grass, the principal products of an undeveloped environment, cannot sustain humans. Agriculture is a much more efficient way to get food from land. By clearing a forest on fertile land to make a field, a farmer increases the food production potential of the same unit of land. The environmental stock increased. Huge growth in the food output per unit of land allowed a corresponding growth in population density; to at least 10 times the densities that are achievable with hunting and gathering (Diamond, 1992, p. 189).

Agriculture requires flat, fertile land with a good water supply. In many instances this would have been the land that was most productive for hunter-gatherers too, so conflict was inevitable. In the long run the agriculturalists had important advantages. Their greater population densities meant that they could provide more fighters per unit of disputed land (Diamond, 1998, p. 88). Hunter-gatherers must space the children they raise around four years apart so that they can be cared for in a mobile community whereas agriculturalists can support more children and have children more frequently (p. 89). Therefore, agricultural populations could recover more rapidly from adverse shocks.

Innovations in non-agricultural technology such as the wheel, pottery and writing allowed an increase in total output per person and a corresponding rise in consumption per capita. Hunter-gatherers and primitive agriculturalists produced little beyond the food required to sustain them. However with emergence of diverse technologies and the facility to store and defend possessions came growth in non-food output such as art, clothing, housing, and a wide variety of tools to further increase output.

Despite the development of manufactured output in the agricultural societies, population densities with agriculture are limited by the yields that can be achieved given land and water quality, crops available, growing technology and labor and energy sources. Each farmer, working with animals, could cultivate only a limited amount of land and could grow only a limited amount of produce on that land. The farmer had to feed his or her own family and provide seed for the next year's planting. What was available to support agricultural populations depended on how much activity the farming family could accomplish given the limitations of the technologies available.

In the agriculture era, birth rates were high with population controlled by episodic plagues, famines and wars. Petty described the situation in London in 1667: "In pestilential years, which are one in twenty, there dye one sixth of ya people of ye plague and one fifth of all diseases, the people which ye next plague of London will sweep away will be probably 120 thousand" (Cipolla, 1993, p. 132). These constraints kept world population relatively stable and below 300 million until the 18th century and the percentage of world population that was urban at a fairly constant 6% until the industrial revolution began at the end of the 18th century (Ness et al., 1993, p. 37).

The distinction between eras and transitions is fundamental to the argument being developed in this chapter. Thinking about long-term historical development tends to be dominated by classification of eras (e.g., Simmons, 1993). The hunter-gatherer era is followed by the agricultural era and now the industrial era. The transition from the hunter-gatherer era to the agricultural era is generally glossed over, partly because so little is known about it. This leads naturally to a view that the Earth has moved from the agricultural era to the industrial era, and is about to successfully enter the post-industrial era or the information age.

The agricultural era and the hunter-gatherer era were both characterized by relatively stable population densities that were constrained by environmental technology (Diamond, 1998, pp. 304-306). In contrast, the transition to agriculture was characterized by a rapid increase in population density (pp. 104-112, 304). Today, developed countries have experienced, and developing countries are experiencing, just such an increase in population density. This supports the view that the Earth as a whole is not yet in the industrial era but is still in the transition to the industrial era.

This conclusion, drawn by analogy with the transition to the agricultural era, is supported by theoretical analysis as well as by examination of the history of the last 200 years. The theoretical analysis says that sustainable growth in population density can only occur when there is a sustainable increase in environmental stocks, caused by development of environmental technology. This is what has been happening during the last 200 years.

The key technology change that enables the transition to the industrial era is substitution of energy from fossil fuels for human and animal energy in agriculture (Norgaard, 1994b). Using coal, oil and gas to provide energy has released agricultural workers from reliance on human and animal energy and allowed a huge increase in agricultural productivity. Changes associated with industrialization have led to dramatic improvements in agricultural productivity and created the potential for huge increases in population density. New crops such as potato and maize were introduced to Europe and these permitted higher yields or allowed crop choices to be fitted more closely to consumer preferences or land capabilities. Growing technologies ranging from irrigation and crop rotation to the application of pesticides and fertilizers have been combined with crop improvements through selective breeding, development of hybrids and genetic engineering to dramatically increase yields from a given area of land.

As a result, a much smaller proportion of the population is now required to produce food, around 3% to 6% in the developed countries (US Census Bureau, 2001, p. 849). Most of the population that was no longer needed for agriculture moved to cities and manufactured non-agricultural outputs that provided increases in consumption per capita. Others sought trade and colonization opportunities that established European influence over the rest of the Earth so industrial agriculture is becoming a global phenomenon. The increase in population density caused by industrial agriculture has combined with globalization to allow a huge increase in the scale of human activity.

One fundamental lesson that can be drawn from both the historical and the theoretical analysis is that development to date has not been a continuous, smooth process. In contrast, what we observe is long eras when change is very slow and relatively short periods of transition. Transitions are caused by technological innovations that increase the sustainable population.

The contrast between an era where environmental constraints limit population and a transition where populations grow rapidly is illustrated by Newman, Cossgrove, Kates, Matthews, and Millman (1990) who state that "the population of Europe rose and fell, seemingly in some relation to the available supply of food, prior to about 1800; but after 1800, fluctuations in local food supplies did not significantly affect population growth" (p. 219). The existence of periods of history where the role of environmental constraints differs means that the fundamental assumption of Model I, that of long-term continuous progress and output growth, unaffected by environmental constraints, must be called into question.

Figure 3.3 summarizes the history of eras and transitions to date and shows possible futures labeled as Model I and Model II. Projections from the recent past are inherent in many analyses of the risk of environmental crisis (e.g., Nordhaus, 1992; J. L. Simon, 1981, 1990). However, as argued above, in testing whether the future will be Model I or Model II, it is not reasonable to rely on projections of trends from within the last 200 years.

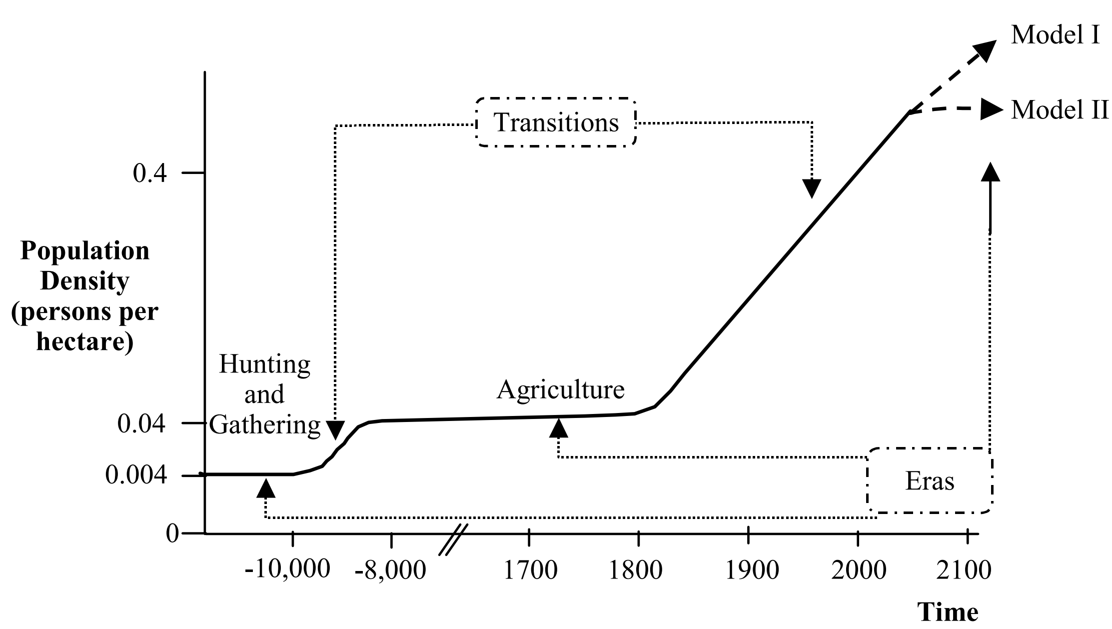


Figure 3.3. Transitions and Eras

The End of the Transition

Model II requires that the Earth is in the transition to the industrial era and that the transition will somehow end. But how will it end? Three factors are important in developing an understanding of how the transition will end. This section will introduce these factors and in so doing will further the argument for acknowledging that Models II and III should be considered as potential alternatives to Model I. The three factors to be considered are; emergence of environmental constraints on output, potential for ongoing advances in environmental technology, and the end of the demographic transition.

If the beginning of a transition is caused by development of environmental technologies that allow a rapid and large expansion of environmental stocks then the end of a transition should be characterized by the agricultural output expanding to the point where environmental stocks become a constraint again.

An important insight into the state of constraints can be gained by looking at the production functions used by economists. At its simplest, a production function models the way inputs are transformed to outputs using technology. The inputs used in the production function identify the resources that are assumed constrained. In modern economic analysis capital and labor are both treated as constrained. As shown in the first part of Chapter Two, growing a modern economy depends on being able to create a surplus of output over that required for consumption to allow the increases in capital and labor that in turn provide further output growth.

The production function focuses attention on the resources that are assumed constrained and ignores availability of abundant inputs. To illustrate, oxygen is needed to burn the fuels that sustain our industrialized society but oxygen is ubiquitous and abundant. During the transition to the industrial era it has been the rate of development of technology, the rate of accumulation of capital and the growth rate of population to provide labor and markets for the outputs that have constrained economic growth. Raw materials have been abundant and are extracted using capital and labor so it is capital and labor that constrain their supply.

In contrast, Petty, writing at the end of the agricultural era, had labor and land as constraints in his production function (Roncaglia, 1985). Ricardo, Malthus and others, also using land and labor as the constraints, wrote of diminishing returns in the productivity of land (Ekelund and Hébert, 1990, pp. 146-155) just at the time when technological advances were increasing those limits dramatically. Thus, the sustainable population density was increasing rapidly. As the end of the industrial transition approaches, some economists are re-introducing the environment as a constraint in their analyses, leading to the emergence of environmental economics and ecological economics as sub-disciplines within economics.

The second important factor that will influence how the transition will end is the potential for ongoing advances in environmental technology. If the Earth can continue to develop environmental technologies then it may be possible to continue to increase environmental stocks. Is a second green revolution possible? What is the potential from biotechnology? Can a cheap technology that will manufacture food from non-agricultural inputs be developed and disseminated? These are very difficult questions.

However, the third factor listed above, the end of the demographic transition, may mean that establishing the long-run potential of environmental technologies is not crucial to identifying the risks.

The world's population grew very slowly until around 1700, when mortality began to decline in the richer countries. Ness et al. (1993) claim that the major contributors to this decline were the extension of sanitation, a gradual rise in the Earth's temperature, trade expansion and the agricultural and industrial revolutions. In England and Wales mortality dropped steadily from around 30 per 1,000 in 1700 to reach around 10 per 1,000 in 1950. Fertility did not begin to decline until the middle of the 19th century and so population grew rapidly (p. 44).

This demographic transition is the means by which the increase in population density is occurring. In the transition from hunting and gathering to agriculture, population expansion was accomplished by increases in family sizes more than offsetting reduced life expectancy from disadvantages in nutrition and health. In the transition to the industrial era the population expansion is being accomplished by reductions in mortality that occur earlier than reductions in family size.

The demographic transition from high mortality and high fertility to low mortality and low fertility is essentially complete in the developed world but is ongoing in the developing world, leading to a large increase in population there. Combined mortality rates for Africa, Asia and Latin America were almost 40 per 1,000 until they began to decline slowly from 1920 through 1940 and then very rapidly from 1940 to 1970. Mortality declined much faster in the developing world than in the developed world because the methods used were acquired via technology transfer from developed countries. Birth rates in the developing world began to decline around 1960 but the rapid rate of mortality decline has led to rapid population growth (Chesnais, 1992).

Population growth is expected to be slowing when there are about 9.3 billion humans in 2050. The low and high estimates for 2050 are 7.9 billion and 10.9 billion respectively (United Nations, 2001, pp. 480-483). The combined population of Africa, Asia, Latin America and the Caribbean grew from 1.8 billion in 1950 to an estimated 4.9 billion in 1995, and is expected to be 8.1 billion by 2050. The rest of the world had 0.8 billion in 1950, 1.2 billion in 2000 and is expected to remain at approximately 1.2 billion until 2050 so all of the world's population growth in the next 50 years is expected to be in developing countries (United Nations, 2001, pp. 480-481). Over the 50 years from 2000 to 2050, global population density will have increased from 0.44 persons per hectare to 0.69 persons per hectare. Population is expected to stabilize after 2050.

The transition that began at the end of the 18th century will be ending by the middle of the current century, as the population stabilizes. The conclusion that population growth will slow around the middle of the century is very important. It means that the challenge for agricultural technology is not to provide ongoing increases in agricultural productivity but only to provide sufficient increases to accommodate the expected rapid population growth over the next 50 years and then to sustain the population as it grows more slowly after the middle of the 21st century.

Recall that the dominant paradigm leads to an expectation of a Model I future, where the Earth has entered an era of progress. Progress is expected to continue, fueled by a virtuous cycle of capital and labor growth, and sustained by ongoing technology development. In contrast, if the hypothesis of the transition is correct then development is not continuous and the Earth is in the last part of the transition to the industrial era. This implies that the Earth will be in the industrial era in around 50 years, with relatively stable population densities and relatively constant labor quantities. Environmental constraints may continue to increase as the end of the transition nears, and technologies that affect environmental productivity and environmental stock levels will become increasingly important.

The key issue therefore is whether or not the Earth will be able to successfully navigate the next 50 years. Success would mean depletion of environmental stock balanced by environmental technology development to allow the smooth landing of Model II. With a more stable population the Earth would enter the industrial era with population and environmental stocks approximately balanced. Note that in terms of the cases introduced in Chapter Two the Earth would be, on average, in Case 1.

The next parts of this chapter examine some global environmental constraints that may emerge over the next 50 years and tries to specify the challenge implied for development of environmental and damage technologies. The aim is to see if the risk of Model III is sufficient to justify management interventions. If it is not certain that the Earth will get to the Model II outcome over the next 50 years with existing ideas and management approaches (business as usual) then it would be valuable to consider what management interventions could increase the likelihood of Model II relative to Model III.

Model II Or Model III?

Technological advances in resource discovery and resource use have meant that real prices for many important resource inputs have declined over the past 30 years (Lomborg, 2001, pp. 137-138; Nordhaus, 1992, pp. 20-22; J. L. Simon, 1990, pp. 68-70). These price reductions show that factors such as technological development, substitution and capital formation have been more than sufficient to offset the economic effects of environmental constraints.

If the transition may be ending then projecting historical trends should be used with caution when assessing what might happen over the next 50 years. In assessing risks the focus will be on the life-sustaining attributes of the environment and on their ability to continue to sustain the flows of food and other life-sustaining inputs that will be needed to provide for the expanding population.

Agriculture

If availability of productive agricultural land might become a constraint that would indicate that the biological paradigm might be applicable and there might be a risk of a Model III outcome. In considering the ability of the environment to provide life-sustaining inputs, the critical issue is the availability and productivity of agricultural land in relation to the population that must be supported. Advances in agricultural technology (T_E) increase the productivity of agricultural land. Over the last 50 years agricultural output has increased dramatically via a combination of bringing new land into agricultural use and increasing the population sustained by each unit of land in use. Figure 3.4 shows the changes that have occurred from 1965 to 1995.

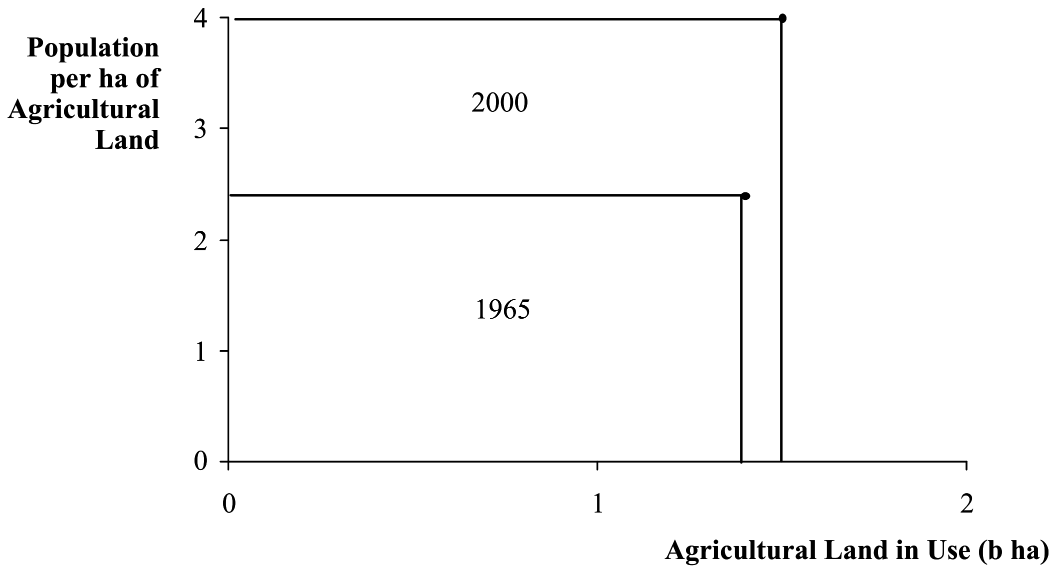


Figure 3.4. Agricultural output growth, 1965 - 2000. Data from FAO STAT (n.d).

The Figure shows that increasing productivity of land has been the major contributor to the food output increase, with land expansion playing a lesser role. The combined output growth has allowed an increase in population and in food per person. On a worldwide basis, per capita food production increased by 12% between the early 1960s and the early 1980s (WCED, 1987, p. 119). Over the same period, the cropped area per person declined by 30%. This huge productivity increase was achieved by developing new plant varieties, increased use of chemical fertilizers and pesticides, and more than doubling the irrigated area (WCED, 1987, p. 120). The rate of productivity growth between 1965 and 2000, measured in people supported per hectare, was 1.4% per annum.

Looking forward over the next 50 years, the change in agricultural output needed is approximately determined by the growth of the population. The agricultural output growth will be provided by further increases in agricultural productivity and by new land.

There is great uncertainty around key drivers of the adequacy of the future food supply; including the future rate of productivity growth (Federoff and Cohen, 1999), the long-term results of land degradation from factors like salination and desertification (de Vries, 2000), and the quality of new land that might be brought into production (Alexandratos, 1999). This uncertainty explains why Federoff and Cohen (1999) reported that at a colloquium on *Plants and population: Is there time?* there were “profound and sobering differences of opinion about humanity’s future ability to feed the human population while sustaining ecosystem services and preserving wildlands” (p. 5906).

Chesnais (1992) reported three estimates of the amount of land potentially suitable for agriculture. Two independent surveys, both done in the mid 1970s, agreed on a high estimate of approximately 3,400 m ha. The third estimate is 2,425 m ha. The higher estimates seem more credible. To get an estimate of current potential agricultural land it is necessary to take account of land losses through degradation and conversion to other uses such as urban development and roads. Estimates of the annual rate of land loss are shown in Figure 3.5.

The estimates vary widely. Figure 3.6 shows estimates of potential agricultural land for 2000 derived from Chesnais’ estimates, assuming an annual loss rate of 10 m ha. Food and Agriculture Organization (FAO) data on land under cultivation in 2000 is used to calculate the proportion in use for 2000 (FAO STAT, n.d.).

Authors	Covers cropland lost to:	Loss Rate (m ha per annum)	Comments
El-Beltagy (2001)	Irretrievably lost to production	6	
Buringh in Pierce (1990)	Erosion, Toxification, Desertification, Conversion	9	More high productivity than low productivity land lost
de Vries (2000)	Desertification, Urban sprawl	9	Business as usual case assumes doubling of historical loss rate for the future
Oregon State University (n.d.)	Degradation, Conversion	10	
Pimental et al. (1995)	World arable land losses	12	
University of Michigan (2002)	Desertification, Salination, Erosion, Roads/urban	19	Erosion less than 20% of losses
El Betagy (2001)	Degraded so that crop production is uneconomical	21	If land degradation is not stopped food yields in many parts of the world will decline

Figure 3.5. Summary of land loss estimates. Source of data is author, shown in List of References.

Assuming that all the land that is currently in agricultural use remains in use and that all the land that is suitable for agriculture could be used provides a best-case estimate of the amount of land available for agriculture. The estimated potential agricultural land is 3,189 m ha out of a global land area of 13,387 million (FAO STAT, n.d.). Figure 3.6 shows that the largest reserves of land are in Africa, South America and North America.

Alexandratos (1999) reports that historical productivity growth rates have declined from 2.8% per annum between 1961 and 1986 to 1.2% in 1986 to 1996 and notes that the slowdown has been partly caused by lack of demand, falling real prices, and policies to control growth of production and accumulation of surpluses. Alexandratos estimates that a growth rate of 1.1% per annum would be required to accommodate expected population growth from 1995 to 2030.

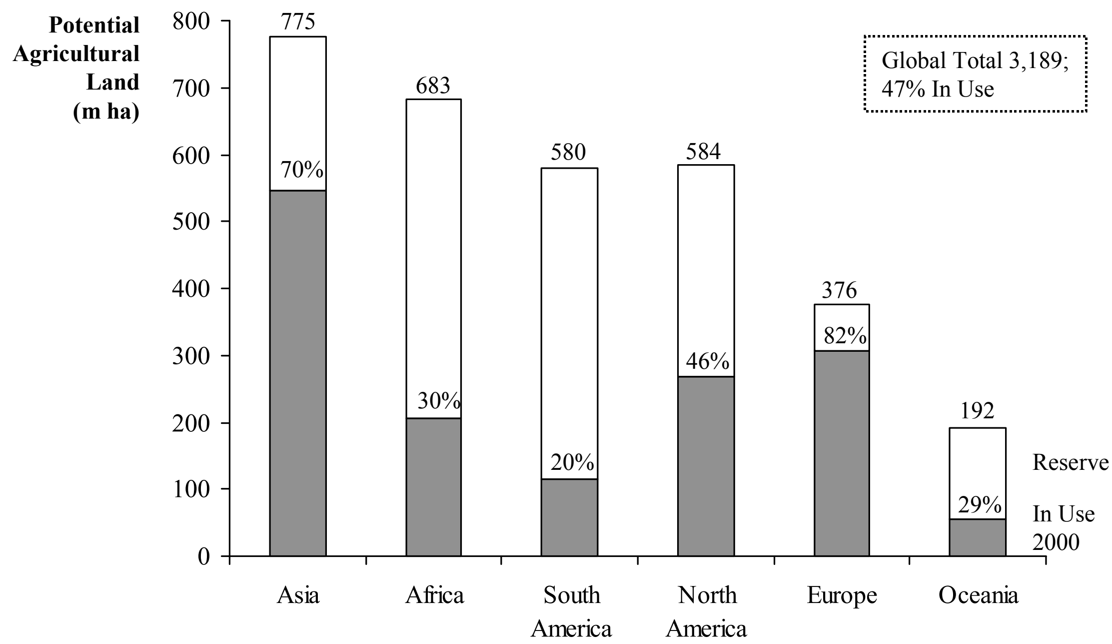


Figure 3.6. Estimated potential agricultural land and percent in use, 2000. Potential agricultural land based on Buringh (1975, as cited in Chesnais, 1992), estimates confirmed by National Research Council (1977, as cited in Chesnais, 1992). Projected to 2000 with a global loss rate of 10 m ha per annum. Total In Use data for 2000 from FAO STAT (n.d).

Projecting forward the productivity growth at 1.1% per annum for 50 years implies that the average population that can be supported per hectare of agricultural land used will increase from 4.0 persons to 7.0. This assumes that current rates of land loss and land added are maintained. On average, 700 persons would be supported by each square kilometer of agricultural land. With the global expected population of 9.3 billion in 2050 (United Nations, 2001, p. 480) there would be an increase in potential food per person by 27% relative to today. Even with the high estimate of population increase to 10.9 billion persons (United Nations, 2001, p. 483) there would be an increase of 9% in potential food per person. Based on this analysis, relying on technology seems a reasonable thing to do.

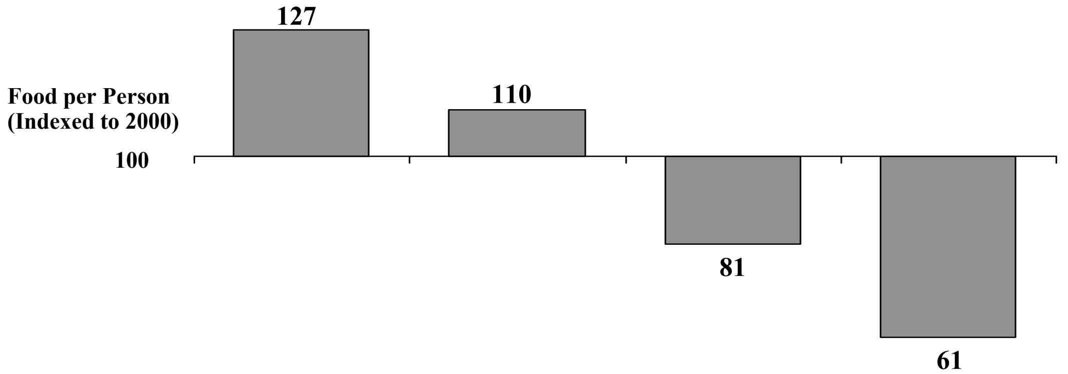
Agricultural land in use has been increasing each year by an average of about 4m ha and in 2000 was 1,497 m ha (FAO STAT, n.d.). If losses are approximately 10 m ha per annum this implies that 14 m ha of land must be being brought into production each year. If this rate of introduction of new land continues for the next 50 years it implies that 700 m ha of the available 1,712 m ha unused potential agricultural land will be required, leaving a reserve of 1, 012 m ha.

De Vries (2000) has used a similar approach to forecast regional availability of agricultural land for the next 25 years. De Vries uses a doubling of the rate of land loss as his base case because "increasingly more vulnerable lands are involved; 'doubling' is only an estimate but clearly within the range of degradation rates already observed" (p. 8). De Vries uses higher and lower loss rates for his analysis, as well: his low variant is continuation of the current loss rate.

If land loss rates increase then the rate of total land growth can be maintained by increasing the rate at which land is added to agricultural production. Assuming that the loss rate goes from 10 m ha per annum to 20 m ha per annum, and the addition rate also increases by 10m ha per annum, then at the end of 50 years around 1,200 m ha of the 1,700 m ha reserve land would have been brought into production.

The reserve land may be of lower quality than the land already in production. Ophuls and Boyan (1992) write "the best 50% of the land in use probably supplies 80% or more of the total agricultural output" (p. 50). They go on to say that "although there appears to be other land that could be developed, bringing into production any sizable quantity of new land would require enormous amounts of capital, vast expenditures of energy and above all, ecological expertise beyond any we now possess. Any production gains are likely to be ephemeral" (p. 51). Alexandratos (1999) reports that of the total unused land in developing countries "some 50% of it is under tropical forest, and large tracts are environmentally fragile, or suffer from other constraints, including lack of infrastructure, incidence of disease etc." (p. 5912).

Given that over two-thirds of this reserve land would be used it is likely that the productivity of the added land would be lower than the average productivity of the land already in use. To illustrate the impact of lower productivity it is assumed that 50% of the land added has half the average productivity of land in use.



Scenario:	Current Course	More Land Loss	Lost Land Not Replaced	Slow Productivity Growth
Each Year:				
- **land lost**	10 m ha	20 m ha	20 m ha	20 m ha
- **land added**	14 m ha	24 m ha	14 m ha	14 m ha
- **productivity**	1.1% growth pa	1.1% growth pa	1.1% growth pa	0.5% growth pa
- **new land productivity**	All achieves 100% of average productivity	Half achieves only 50% of average productivity	Half achieves only 50% of average productivity	Half achieves only 50% of average productivity

Figure 3.7. Agricultural scenarios. Numbers on bars are index of food per person with 2000 = 100. Potential agricultural land based on Buringh (1975), estimates confirmed by National Research Council (1977), as cited in Chesnais (1992). Projected to 2000 with a global loss rate of 10 m ha per annum. Agricultural land in use data for 2000 from FAO STAT (n.d).

Figure 3.7 shows four scenarios for the overall food supply outcome. The first one is the business as usual case with current land loss and addition rates and 1.1% per annum agricultural productivity growth that yields a 27% increase in average food per person. The second scenario has the higher rates of land loss and addition, and the lower productivity of added land. The outcome would be a 10% increase in potential food per person with the expected population, though there would be a reduction of 6% in food per person under the high population scenario.

The second scenario assumes that over two-thirds of potential agricultural land is brought into production over the next 50 years. However, there are competing uses for the land and other constraints that might limit the amount available for agriculture. Owners of some of the land may want to retain it as forest or wilderness. Some land may not be added to production because the transport costs of inputs and food are too high given the ability to pay of the likely consumers. The third scenario shows the outcome if the rate of new land addition cannot be increased above the current rate, on average, over the next 50 years. This would mean that only one-third instead of two-thirds of the reserve would be used. The result would not be acceptable with only 81% of the current food per person being available.

The future productivity growth rate is also uncertain. The gains of the last 50 years have been assisted by the Green Revolution but have come at a high cost in chemical and irrigation inputs and waste generation (Shiva, 1991; Tilman et al., 2001). Mann (1999) reviewed the prospects for sustaining or increasing the rate of improvement of agricultural productivity and found that agronomic and other constraints mean that it will be increasingly difficult to sustain linear yield increases. Many development paths are being pursued and some have potential. However, there may be limits to growing the productivity of crops, and funding has been reduced for the two international research agencies that led the productivity gains in rice, wheat and maize over the last few decades (pp. 310, 314).

When productivity is measured by people supported per ha of land the measure is affected by changes in the quality of the land as well as the technology used. Productivity growth includes the net effect of quality changes and technology changes. If land is being degraded but not lost to production (another form of T_D) and the quality of land is changing because of land losses and additions then any reduction in the average quality of land in use must be offset by additional productivity growth.

Future productivity growth rates will be affected by many factors including availability of water, effort applied, physical yield limitations, land quality mix and changes, and gains from biotechnology. De Vries' (2000) base case assumes approximately 0.7% yield growth per annum and his low case is approximately 0.5% yield growth per annum (p. 9).

The fourth scenario in Figure 3.7 uses De Vries' low productivity estimate. It is a worst-case scenario with a high rate of land loss, a low rate of new land introduction, and a low rate of productivity growth. The food potential per person would be 40% less than it is today. An increase to 1.5% productivity growth per annum for 50 years would be required to match today's per capita food levels with the expected population growth.

These scenarios show that there is sufficient land to feed the expected population of over nine billion provided that land losses are not too great or can be offset by introduction of high quality land, and provided that agricultural technology develops rapidly enough to provide for the growth in population and to offset any decline in the quality of land in use. The uncertainty is sufficient to imply that efforts to accelerate agricultural productivity growth should be combined with efforts to protect the quality of agricultural land.

Federoff and Cohen (1999) conclude their summary of the colloquium by pointing out that there is a lack of knowledge and of the institutions that are needed to develop and apply the required knowledge. They argue that success will depend on what is done now and in the immediate future, as "what is very clear is that there is no time to lose" (p. 5907). In the absence of effective action there may be an increasing risk of crisis.

Analysis of the agricultural challenge at a global level conceals important differences among regions. De Vries (2000) found that the Middle East, North Africa and South Asia will be severely land constrained by 2025 and that East Asia will be only a little better off. The implication is that food imports will be required to sustain the populations in these regions.

Latin America and the Caribbean are not land constrained and have potential to expand as food exporters. Sub-Saharan Africa is not land constrained in aggregate but human populations there are struggling to grow agricultural productivity. Average African food production decreased by 12% per capita between the early 1960s and the early 1980s and, combined with population growth, this led to a halving of the cropped area per capita. Fertilizer use per hectare was only 11% of the world average in 1984 (WCED, 1987, p. 119). Mink reported in 1993 that

> Agricultural intensification is taking place only in the sense that fallow periods are shortening….but in many areas, shortened fallow time is not accompanied by the introduction of new techniques that would permit yields to be sustained under this greater intensity. In part, this is because the greater intensity of land use is not generating surpluses for reinvestment in land productivity or other activities. Rather, the rapid rate of population growth is resulting in the mining of natural resources, as indicated by expansion into marginal areas and by stagnating yields. (p. 24)

The situation is not improving. The FAO has reported that the total number of undernourished people in Sub-Saharan Africa has increased significantly and that one third of the population was undernourished in 1997–1999 (FAO, 2002, p. 1). AIDS, conflicts, and famines further exacerbate the issue. It is hard to see how Sub-Saharan Africa will be able to effectively use the large share of agricultural reserve land that is found there.

Existing trends mean that food exports from the developed countries to the developing countries are likely to continue to be needed. In industrialized countries, availability of capital will allow further intensification of agriculture. Application of fertilizers and pesticides, irrigation, construction of greenhouses and development of new plants combined with good management techniques can deliver a lot more output from the same land. The Netherlands illustrates the potential for intensification when one considers the data on crop production per hectare. The FAO uses a value unit called the International Dollar (ID) to compute country and regional aggregates by using international commodity prices, resulting in the same price for a ton of wheat in whichever country it is produced. The Netherlands achieves ID$2,468 per hectare annually, which is almost five times the world average ID$515 (WATI, n.d.). Developed countries could adopt the kinds of technologies used in the Netherlands and would have access to the capital required. It remains to be seen whether they will use their land reserve to contribute to global food supply when there are competing demands on it for forestry and protection of wilderness, and those who will need food may not have a lot of money to spend.

The impacts of climate change are expected to vary among countries. Food production potential is expected to improve in the developed countries and erode in the developing countries (Rosenzweig and Hillel, 1998, p. 229). If local farmers in many developing countries have poor prospects for increasing productivity and the developed countries must fill the gap then the well-being of populations in the developing countries will depend on whether incomes are sufficient to afford the imported food, or other institutional arrangements are made to ensure that people have enough to eat. Alexandratos' (1999) conclusion reflects this concern:

> the problems of food insecurity afflicting many countries and population groups remain as severe as ever, regardless that price trends in world markets indicate once again an overabundance of food relative to effective demand at the global level. World market prices do not reflect adequately the problems of the poor and food insecure. (p. 5913)

Water is also important for agriculture. For example, Jackson et al. (2001) report that the Murray-Darling river basin contributes almost half of Australia's agricultural output and that salination and changes in the water table have reduced agricultural output by 20% (p. 1040). This has occurred on primarily private land with owners interested in maintaining economic returns. Pimentel et al. (1999) reviewed water resources noting poor management of both fresh water and groundwater supplies. Pollution is a serious issue. Ninety-five percent of water in the developing countries is polluted and sewage, disease organisms and chemical contamination mean that some polluted water cannot be applied to crops (p. 5). Ruttan (1999) reports that water scarcity is becoming an increasingly serious constraint on the growth of agricultural production. He states that 39 countries, plus Northern China and Western India, with a combined population of 1,066 million persons in 1990, will experience either absolute or severe water scarcity (p. 5963).

It will also be necessary to offset the consequences of biological degradation. Estimates of the number of species have grown from between five million and 30 million (Wilson, 1988, p. 5), to 35 million (Norgaard, 1994a, p. 15), up to even 100 million (Wilson, 1999, p. xiv). However, there are many recognized caveats around these higher estimates (Novotny et al., 2002, p. 843; Stork, 1997) and most experts in the field use a "working number" of 13.6 million (Wilson, 1999, p. xiv). Over-hunting, introductions of predators and parasites, and habitat destruction are causing extinctions. Extinctions are occurring so rapidly that Wilson (1999) claims that one fifth of species could be "doomed" by 2020 and Diamond reports that more than half of all species will be extinct or endangered by the middle of the 21st century (Diamond, 1992, p. 360).

The ultimate consequences of species losses and population reductions are often wide-ranging and delayed because of the interdependencies among them. For example, Diamond (1992) describes the effect of extinctions of just three big predators (jaguars, pumas and harpy eagles) on an island in Panama:

> ...the big predators used to eat medium sized predators like peccaries, monkeys and coatimundis, and medium sized seedeaters like agoutis and pacas. With the disappearance of the big predators, there was a population explosion of the medium sized predators, which proceeded to eat up the antbirds and their eggs. The medium-sized seedeaters also exploded in abundance and ate large seeds that had fallen on the ground, thereby suppressing the propagation of tree species producing large seeds, and favoring instead the spread of competing tree species with small seeds. That shift in forest tree composition is expected in turn to cause an explosion in hawks, owls and ocelots preying on those small rodents. Thus the extinction of three uncommon species of big predators will have triggered a rippling series of changes in the whole plant and animal community, including the extinction of many other species. (p. 360)

Similar stories can be told for many other regions of the world (e.g., Craig et al, 2000; Wilson, 1999).

A common concern expressed about the loss of species is that raw materials for potential pharmaceutical and breeding programs are being lost so potentially valuable new products will not be available. However, there may be a more important concern. Humans are still dependent on agricultural and forest production. In many cases production depends on pollination, seed distribution or protection from pests; functions that are often performed by undomesticated species. Species that are indirectly important to us are in turn dependent on others. Wholesale extinctions risk setting off ripple effects like the one described above that might seriously impact production.

Extinctions have attracted a great deal of attention but changes in populations of species may be economically more important. Species introductions provide a supply of new pests and weeds that must be controlled. New predators and parasites can disrupt ecological systems or reduce populations of organisms that support agricultural production. Bakker (1988) suggests that land bridges have played an important role in the mass extinctions that are documented in the geological record. Migrations of predators and parasites have had dramatic impacts on ecosystems. The recent ice ages and human migrations of historical times have caused an intermingling of species so local threats such as foot and mouth disease can quickly become global threats.

Daily et al. (1997) and Costanza et al. (1997) examine services provided to economic production by ecosystems and both conclude that they are economically important, that they are under threat, and that there are great uncertainties about the medium-term impacts of ongoing damage to these systems.

Land availability and quality, agricultural technology, climate, water, and ecosystem services are only a few of the many factors that will determine whether the Earth will be able to feed the expected population in 50 years time. Many other changes will take place between now and then, such as the aging of the population. The changing age distribution of the population will mean a greater proportion of the population will be looking for adult sized meals and a larger number of old people will need to be supported. It is not possible to say with certainty what the outcome will be but the evidence is sufficient to conclude that there is a risk of food shortfalls and that the risk is increasing as the population grows and physical environmental stocks are depleted.

The historical ability to develop agricultural technologies to access sufficient productivity growth to feed a rapidly growing population when physical environmental resources are abundant has been demonstrated. However, that past success cannot be used to conclude that technology will be able to provide enough food in the future, particularly when yields on much of the high quality land are already high and environmental stocks will be under pressure.

On balance, it looks as if achieving the agricultural productivity improvements required to support nine billion people in 2050 will be a huge challenge. Reliable and agreed figures for potential agricultural land and loss rates are not available. The lack of agreed planetary data and of widespread debate on the issue of the future quality and quantity of agricultural land is an important issue. Implications for management responses are considered at the end of this chapter and in Chapter Four.

Industrialization and Climate Change

Industrialization has allowed dramatic increases in total output per capita. The increase in agricultural productivity over the past 200 years has allowed labor to be diverted to industrial production, which has provided dramatic increases in total output. Most developed[1] countries have 400 to 450 cars per 1,000 persons, though the USA and Germany are closer to 500 and the United Kingdom less than 400 (US Census Bureau, 2001, p. 857). With similarly high penetrations of televisions, telephone lines and a wide range of labor saving household appliances (US Census Bureau, 2001, p. 858) together with adequate food, clothing, shelter and access to sophisticated medical support, the inhabitants of developed nations have benefited a great deal from their industrialization.

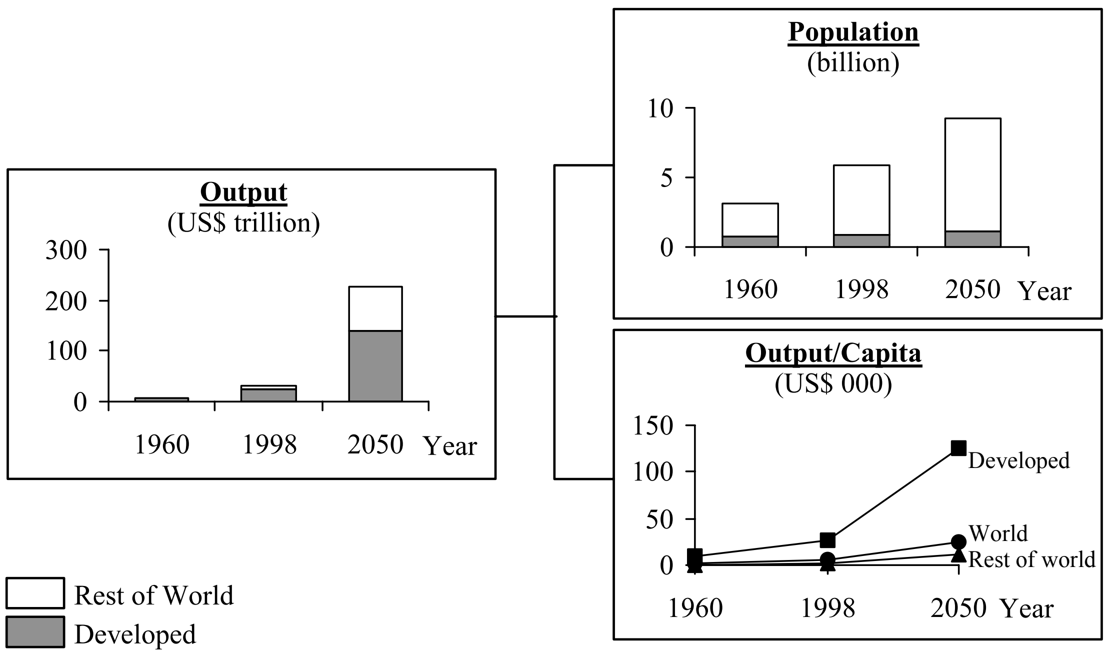


Figure 3.8. Composition of global output growth projected to 2050. Developed and Rest of World output growth trend from 1960 to 1998 used to project to 2050. Population data midpoint projection from UN. Data from United Nations (2001) and WDI Online (n.d.). All values in constant 1995 US$.

[1] Developed countries based on World Bank 2000 definition: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, the United Kingdom, and the United States of America. All other countries defined as Rest of World.

Now the same benefits are flowing to many individuals in the developing countries. The aggregate result of this is a dramatic increase in the total output of the Earth. Figure 3.8 provides data on total output growth for the Earth from 1960 to 1998 and projects these trends to estimate output growth to 2050. The figure shows that global output has more than quadrupled in the last four decades and would have to increase by over seven times the current amount to maintain that growth rate over the next five decades. This would be the expectation if the Model I projection of continued progress is correct.

The growth in income of developing countries is not likely, on its own, to reduce environmental damage (D. I. Stern, Common, and Barbier, 1994). Continuation of current economic growth rates would lead to output per capita growing to almost $US11,000 per annum in 2050 for each of the 8 billion people expected to be living in the rest of the world. That would be much less that the current US$27,000 per capita GDP in developed countries and much less than the more than US$125,000 per capita, which would result in developed countries in 2050, all assuming that current trends continue. The total output growth in the developing countries with current trends is greater than the total global output today. D. I. Stern et al. (1994) argue that income growth in developing countries will lead to increased environmental damage, with potential benefits from lower environmental damage per unit of output as economies grow being more than offset by the increase in output. If the technologies used to achieve future economic growth are as damaging as those used today then there will be a large increase in total environmental damage.

The dominant energy source for the recent output growth has been fossil fuels, in particular oil. Reserves of oil are being depleted and it is now getting harder to discover new sources of low cost oil and gas. There are several options for replacing oil, including some good long-term options, but all have undesirable features that reduce their attractiveness as substitutes for the next few decades. The major alternative fossil fuel, coal, is still abundant and could be used to provide energy for hundreds of years but coal releases more CO_2 per unit of energy produced than oil. Nuclear fission could provide a lot more energy but would also produce wastes that cannot yet be safely disposed of, as well as the risk of nuclear accidents. Nuclear fusion might resolve both these problems but is not expected to be commercially available for several decades. Hydroelectric power is becoming increasingly expensive in land lost through flooding and has limited capacity potential too. Other renewables (solar, wind, tide and biomass) look good as medium-term solutions but currently available versions are more expensive than coal.

Therefore, it is likely that fossil fuels will continue to be the main source of energy for several decades. As the developing countries with large populations industrialize there will be high demands for energy for industrializing agriculture, for transportation, for infrastructure development, and for electricity generation. Currently, annual per capita carbon emissions for the USA and Canada combined are 4.9 tons per annum, for the European Union 2.2 tons per annum and for China and India combined 0.4 tons per annum (Botteon and Carraro, 2001, p. 55).

China has a variety of energy options including natural gas, nuclear energy, hydroelectricity and wind energy (Neilson and McElroy, 1998, pp. 47-51). Despite this, China's development will be fossil fuel intensive as "coal, the most environmentally damaging of the fossil fuels, is the dominant source of primary energy in China, and will remain so at least for the next several decades" (Nielsen and McElroy, 1998, p. 11). Within two or three decades China will be the world's leader in carbon emissions, overtaking the US (Nielsen and McElroy, 1998, p. 4).

Reliance on fossil fuels means that concentrations of CO_2 and other greenhouse gases in the atmosphere will continue to increase. CO_2 is a natural waste product of animal respiration that is used by plants as a resource for photosynthesis and is diffused into and from the oceans in very large quantities. It is also produced as waste when trees or fossil fuels are burned to produce energy. When trees are cut the CO_2 released by burning or decomposition is offset by CO_2 absorbed for the re-growth of trees or other plants on the same land. Burning fossil fuels takes carbon from under the ground and releases CO_2 into the atmosphere. If this transfer is small it is either absorbed by the Earth's natural absorption capacity or it causes a small and unimportant increase in the concentration of CO_2 in the atmosphere.

However, when the transfer is large the effect is qualitatively different. Increased concentration of CO_2 in the atmosphere impedes radiation of infrared energy from the surface of the Earth into space, so the surface of the planet must warm to restore a balance between the incoming heat from the sun and the radiation of heat to space. In 1988 the Intergovernmental Panel on Climate Change (IPCC) was formed by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). The role of the IPCC is to "assess the scientific, technical, and socio-economic information relevant for the understanding of the risk of human-induced climate change" (About IPCC, n.d.). The IPCC does not conduct research directly, but compiles information from peer reviewed scientific and technical publications.

One of the major concerns of the IPCC is the concentration of CO_2 in the atmosphere, which has increased by 31% since 1750 and is now at a level that has not been exceeded in the last 420,000 years and possibly the last 20m years (Houghton et al., 2001, p. 7). Emissions of CO_2 from fossil fuel burning are the dominant cause of this increase in CO_2 concentration (p. 12). The IPCC projects that the CO_2 concentration will increase to between 540 and 970 ppm by 2100, implying growth of 90% to 250% over the concentration in 1750 (p. 12). The IPCC also reports that the observed temperature increase of 0.6°C over the 20th century will be followed by an increase of a further 0.8°C to 5.2°C over the 21st century (p. 13) with the outcome being strongly influenced by the course of human development. There is still a great deal of uncertainty about the geophysical and human consequences of climate change.

Three kinds of consequence of the human impact on the environment can be distinguished. The first is changes that are very likely or likely, based on established trends. These include increases in temperature, sea level, precipitation, cyclones, droughts in mid-latitude continental interiors and decreases in glaciers, sea ice thickness and extent (Houghton et al., 2001, pp. 4, 15).

The second is changes that will be influenced by the human response to emerging trends. An important example is the temperature increase, where the outcome will be affected by factors such as the rate of growth of populations and economies, and by technology choices (Houghton et al, 2001, pp. 14, 18). The human response will be explored more fully in later chapters.

The third kind of potential consequence is the risk of major climate discontinuities. One example of a potential climate discontinuity that has received a great deal of attention is the possibility of weakening or cessation of the Thermohaline Circulation (THC) in the North Atlantic Ocean. Warm waters flow north at the surface and cold deep waters flow south. Cessation of the THC and associated "atmospheric storm tracks would seriously affect the climate in northwestern Europe." Further "there is now a growing body of circumstantial evidence that the THC plays a dominant role for abrupt climate change" (Stocker, Knutti, and Plattner, 2001, pp. 278, 279).

Modeling shows that the THC can switch from its current state to a state where the circulation of water stops. The risk emerges at CO_2 concentrations of 2-4 times base levels and is greater with faster temperature changes. It has also been shown that the THC can shut down when CO_2 concentrations increase at a rate of 1% per year for 100 years. These changes in CO_2 are at the high end of the expected range over the next 100 years. The IPCC concludes that

> most models show weakening of the ocean thermohaline circulation which leads to a reduction of the heat transport into high latitudes of the Northern Hemisphere. However, even in models where the thermohaline circulation weakens, there is still a warming over Europe due to increased greenhouse gases. The current projections using climate models do not exhibit a complete shut-down of the thermohaline circulation by 2100. Beyond 2100, the thermohaline circulation could completely, and possibly irreversibly, shut-down in either hemisphere if the change in radiative forcing is large enough and applied long enough. (Houghton et al., 2001, p. 16)

The paleoclimatic records indicate that abrupt climate change events are common, with the most recent warming event occurring about 11,650 years ago (Stocker et al., 2001, p. 279) and the most recent cooling event 8,200 years ago (p. 280). The warming events are always abrupt, with temperature increases of 16°C within a few decades being observed in Greenland (p. 279). The cooling event may be longer, evolving over a timescale of 1,000-3,000 years, with the most recent cooling being attributed to a slowdown of the THC and producing a reduction of 7°C in Greenland temperature (pp. 279–280). For reference recall that CO_2 levels are currently at their highest level for at least 420,000 years, and possibly as much as 20 million years, and that concentrations could double over the next 100 years. The rate of temperature increase projected is unprecedented in the last 10,000 years.

It is known that the Arctic sea ice is an important contributor to the THC (Stocker et al., 2001, p. 287); that the climate models relied upon to conclude that the THC will not cease during the 20th century do not include glacier melt or sea ice effects (Houghton et al., 2001, p. 562; Stocker et al., 2001, p. 287); and that the last few decades have seen a 10 – 15% decrease in spring and summer sea ice extent, a 40% decrease in late summer and early autumn Arctic sea ice thickness, and a "considerably slower reduction in winter sea-ice thickness" (Houghton et al., 2001, p. 4).

Climate scientists are concerned about non-linearity of climate systems noting that "non-linear changes are not easily extrapolated from ongoing observed changes, they may have large amplitudes and they may occur as surprises" (Stocker et al., 2001, p. 277). Non-linear changes being studied include the collapse of large Antarctic ice masses potentially causing rapid sea level rise, desertification of entire land regions, thawing of permafrost and release of large amounts of radiatively active gases, as well as the collapse of the THC (p. 277). The models needed to understand these effects, and their interactions, are still being developed and the list of feedback mechanisms that will determine outcomes is not yet complete (p. 287).

Despite this uncertainty, Stocker et al. (2001) conclude that "there are few indications that an abrupt shut-down, a surprise, is a likely occurrence in the near future. It is also known that a slow-down of the THC moves the system close to thresholds – and this should be of sufficient concern to warrant intensified research into this topic" (p. 290). A slowdown may be occurring already. Sarah Hughes, an oceanographer, has recently reported that the flow of cold water southward from the Arctic has reduced by 20% since 1950 (Radford, 2001, para. 2).

The purpose of exploring the THC in particular and considering non-linear climate change more generally is not to predict any particular outcome but rather to establish that there is potential for climate changes that could have catastrophic impacts on humanity, that there is a great deal of uncertainty about these changes, and that climate changes may be discontinuous so they cannot be understood by simple projection of current trends.

Our understanding of the determinants of climate change and of the effects of humans on the environment is advancing rapidly. It is possible that the risks that will be recognized in the reasonably near future will be different from those recognized today, just as those recognized today are different from the risks of mineral scarcity that concerned many just a generation ago. The important conclusion is that there may be catastrophic environmental consequences of human activity that occur only when critical values of variables are exceeded.

Some of the human impacts on the environment are irreversible. This means that once a process is set in motion it may be impossible to reverse it, even if the dangers are understood. The only feasible responses may be to adapt to the changes or to implement further interventions designed to ameliorate the impact of the initial damage, but these interventions may have unanticipated effects too (Metz, Davidson, Swart, and Pan, 2001, p. 43).

In the past, human populations have been able to respond to environmental catastrophes by simply moving away and developing elsewhere (Gottstein, 1999, p. 7). For example, the removal of the forests of Asia Minor to provide building materials and fuel for mineral processing led to soil erosion and silting of the harbors. The loss of safe harbors weakened coastal cities, and the arrival of malaria, which thrived in the swamps created by silting, made them uninhabitable. Those people and cities suffered but civilization moved to other places. Such opportunities to damage our environments and move on no longer exist because now there are few potentially productive places on Earth that are not already occupied by humans, and it will not be possible to move beyond the Earth in large numbers for many years, if ever.

The ability to change global landforms, the mix of species, and the climate makes humans an extremely powerful ecological force. This power is due to the scale and composition of human activity in relation to the size of the Earth. The consequences of the changes are uncertain, but there is no guarantee that they will be benign. The expected changes in climate may make it even more difficult to achieve the required agricultural productivity growth. The IPCC reports that increased heat waves, droughts, floods, soil erosion, the need to change crops to adapt to changing climate, steady increase of temperature, rising sea levels affecting coastal agriculture, extension of the range of tropical pest species, increasing frequency and intensity of storms, and shifts in rainfall patterns will make it more difficult to increase agricultural productivity at the required rate (McCarthy, Canziani, Leary, Dokken, and White, 2001, pp. 6-11). Offsetting these effects will be benefits from increased CO_2 levels, which promote plant growth, higher temperatures increasing agricultural potential in mid-latitudes and higher rainfall in some regions. Analysis by Rosenzweig and Hillel (1998) showed that when beneficial CO_2 effects were taken into account the net effect of climate change is to reduce predicted global cereal yields by between 1% and 8%, though the average masks a predicted decline in production in the developing countries combined with growth in expected production in the developed countries (p. 229). The IPCC concludes that it is difficult to predict the net impact of small increases in temperature on agricultural output but states that incomplete evidence indicates that larger increases would lead to “a slowing in the expansion of global food supply relative to growth in global food demand” (McCarthy et al., 2001, p. 11).

The argument is summarized in Figure 3.9. The dependent variable is agricultural output because agricultural output is required to allow the Earth to feed a population of 9.3 billion. Industrialization provides more productive agricultural technologies and the energy that improves the efficiency of labor employed in agriculture. Agricultural activity may damage agricultural land. Industrialization also encourages the use of fossil fuels for non-agricultural purposes, creating an aggregate activity level that is causing climate change. New land is brought into production to replace that lost by damage and to support the increasing population. Forest clearing will be needed to provide some of the new agricultural land, and will contribute to further climate change. Climate change has a detrimental effect on agricultural output. With limited availability of high quality potential agricultural land, the required improvements of agricultural technology become greater.

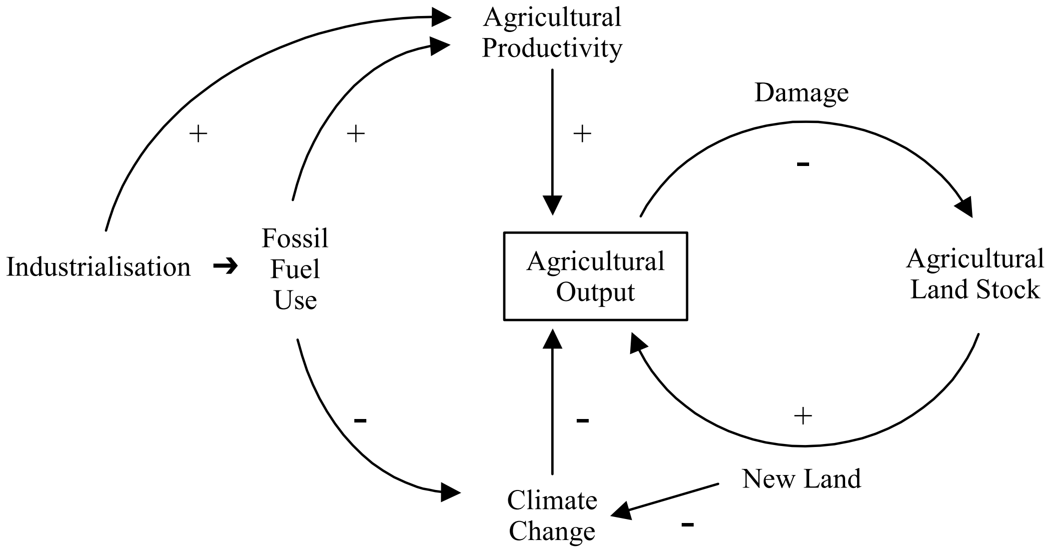


Figure 3.9. Drivers of agricultural output. The arrows show causal relationships. A '+' indicates that an increase in the variable at the source of the arrow increases agricultural output, and a '-' indicates the opposite.

Figure 3.9 helps clarify the nature of the global challenge posed by the emergence of environmental constraints. The principal objective should be to ensure the agricultural output that is required to sustain the population. Two things are required to achieve this: improve agricultural productivity and avoid or mitigate the adverse impacts of climate change. Increasing total output is revealed as a secondary objective.

This is the reverse of the situation in the recent past. For the last 200 years it has been possible to develop new agricultural land and improve agricultural productivity without being concerned about environmental consequences or constraints. This has allowed a primary objective of increasing output to provide improvements in consumption per capita.

Achieving the required agricultural output growth will depend on developing a detailed understanding of options and constraints. It may be important to limit fossil fuel use and other activities that cause climate change, to bring new land into production, to reduce damage to agricultural land, to develop and disseminate agricultural technologies that increase productivity and are robust in the face of climate change, and to slow population growth.

The Risk of Crisis

If the evidence of emerging environmental constraints supports the hypothesis of the transition and reduces confidence in a Model I outcome then there are three other possibilities to consider. First, a Model II outcome may occur so the population will stabilize at a level that is at or below the sustainable population. The second possibility is that the development process has already unleashed forces that will cause an environmental crisis and the Earth will inevitably face a Model III outcome. Third, the Model II and Model III outcomes may both remain possible at the beginning of the 21st century so which will occur depends on how the economy-environment interaction is managed over the next few decades.

The third possibility is pursued here. The data and arguments presented in the previous section imply that the first possibility is not assured. And if the Model III outcome is already inevitable then changes that improve environmental outcomes may diminish the magnitude of a Model III crisis.

A crisis will occur if the actual population is greater than the sustainable population at the end of the transition. The actual population that will need to be supported is uncertain but is an easily understood concept. Sustainable population is a more difficult concept. Essentially, the sustainable population is the number of people who can be supported given the amount of food that can be produced. The sustainable population depends on three things. The first is environmental stocks, including the amount and condition of land and the state of the climate. The second is available technologies including those that damage and repair the environment as well as those that use environmental inputs to produce agricultural output. The third is non-agricultural use of environmental stocks that would otherwise be available to produce agricultural output.

If the aim is to achieve a smooth Model II landing as the developing countries enter the industrial era under circumstances where environmental resources are constrained then what must be achieved? First, after the end of the transition the Earth as a whole must be in Case I, so that environmental stocks are not being depleted further. In any other case there is ongoing erosion of environmental stocks, which is not possible if the Earth is in the state that defines an era. To be more precise, any ongoing erosion of the physical environment must be offset by sustainable improvements in environmental technology or by natural, that is, non-crisis reductions in population.

Second, overshoot must be avoided (Ophuls and Boyan, 1992, p. 17). It would be possible to achieve sustainability by growing output as rapidly as possible, reaching the environmental constraints, waiting for population to drop and then stabilizing at the sustainable output level and population. However, this would be a Model III outcome not a Model II one and could hardly be called a smooth landing.

A Lesson from Transients

Ophuls and Boyan (1992, p. 42) point out that humanity is a living population and so must obey the same growth rules as other living populations, following a logistic curve with initial slow growth followed by a period of rapid growth then slower growth and finally a steady state. They also point out the risk that output growth will overshoot the level that would be sustainable in the long-term, leading to collapse.

It is not possible to examine historical evidence about the end of transitions but there is evidence that human populations have grown and then been constrained by limitations of environmental resources. These observations are called environmental transients here to distinguish them from transitions. This chapter has argued that if the Earth continues with business as usual then there is a risk of a Model III end to the transition to the industrial era. Transients can provide insight into the plausibility of this argument. Figure 3.10 shows transients, Model II and Model III transitions.

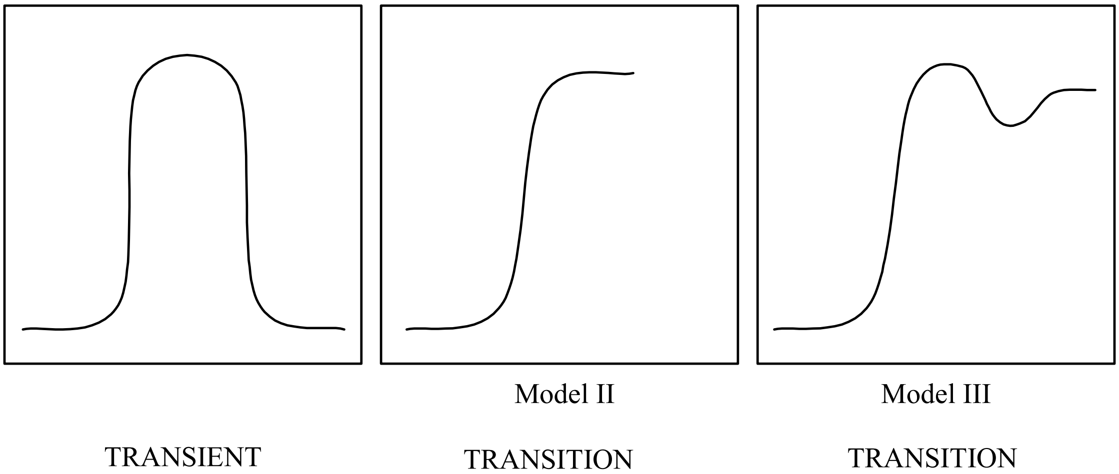


Figure 3.10. Transients and transitions. The horizontal axis is time and the vertical axis is output.

There is a close parallel between transients and transitions. In both cases the growth is caused by availability of unexploited environmental stocks. In both cases output may rise above the sustainable level. In both cases the resulting state must have net damage less than or equal to zero. The key difference is that environmental stocks after the transient are less than they were are the beginning whereas environmental stocks after a transition are likely to be greater than they were before the transition. In a transient, output growth is fuelled by discovery of physical environmental stocks, which are then depleted. The output growth is unsustainable. In a transition the sustainable output can increase because technological innovations like agriculture and industrialization that introduce new eras provide sustainable increases in environmental stocks.

An early example of a transient is provided by the arrival of humans into North America. As the glaciers retreated at the end of the last ice age some 12,000 years ago humankind expanded into the newly habitable land. Crossing from Siberia to what is now Alaska and passing through a narrow ice-free north-south corridor just east of the Rocky Mountains, these first Americans found a land where large mammals were abundant and unafraid of humans (Diamond, 1992, p. 341). Over the next 1,500 years these people spread throughout North and South America. Their artifacts have been found in all 48 contiguous states of the USA and as far south as Tierra del Fuego.

Martin (1973) reports that population densities of 0.39 persons per hectare were possible for the hunters who led the way through North America 12,000 years ago. Subsequent hunters behind the front faced more limited prey availability than those at the front so had lower population density.

With continuing hunting the preferred food species became scarce. Hunters switched to substitutes but the total supply of large mammals was finite. The North American mammoths, mastodons, camels, horses and giant ground sloths became extinct. Seventy-three percent of large mammal species in North America and 80% in South America disappeared (Diamond 1992, p. 342). Martin (1973) claims that this was not just a coincidence, arguing that the newly arrived hunters exterminated the large prey species and Diamond (1992, pp. 343-347) counters the key criticisms of Martin's theory, arguing that the hunters could spread rapidly enough and breed fast enough to account for the extinctions and pointing out that archeological evidence shows that mass killings have occurred whenever hunters have reached a land with animals naïve to humans.

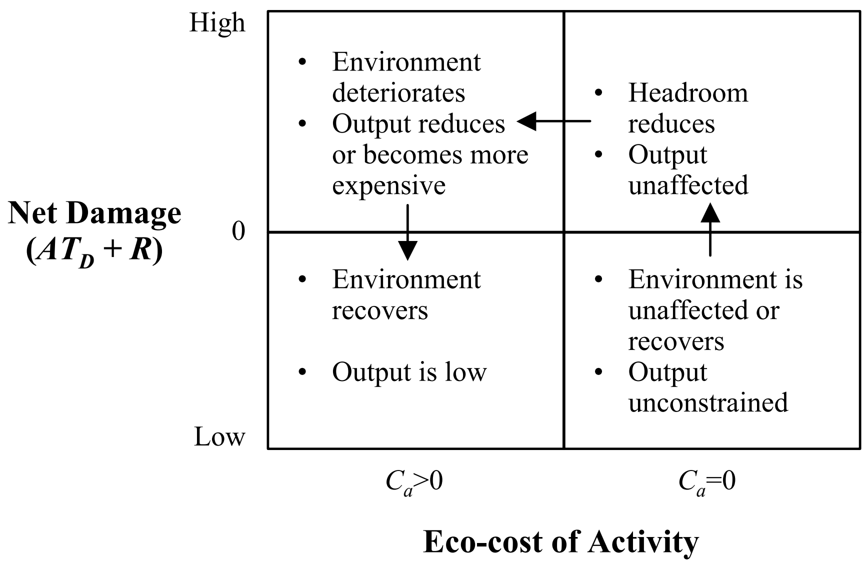


Figure 3.11. Dynamics of transients. A is total output, T_D is the damage technology, R is the self-repair capacity of the environment and C_a is the total eco-cost.

Consider the dynamics of environmental transients with this example as background. Figure 3.11 shows the state of the environment and the amount of damage being caused. Prior to arrival of the hunters, environment stocks are abundant. Net damage is unaffected by human intervention and assumed to be low. This initial state is shown on the bottom right of Figure 3.11 with damage low and environmental stock high. On arrival the hunters find very favorable hunting conditions and set about eating everything in sight. Population grows and the prey species begin to be depleted so the state moves to the top right of Figure 3.11.

With further hunting the populations of prey species reach levels where it becomes more difficult to hunt so more effort is required and eventually the sustainable population must reduce (top left). Finally, output drops to a level that allows recovery of environmental stocks (bottom left). If population does not fall precipitously or move on to exploit other geographic regions then a balance is reached where net damage is zero and environmental stock is just sufficient to sustain the population. If population does drop precipitously or move on then there may be a period where stocks and population are in balance. For North America the environmental stock at the end of this process was much lower than the stock at the beginning, indicated by the extinction of so many species.

There is a close parallel between transients and the end of transitions. In both cases the resulting state must have net damage less than or equal to zero. In both cases output may rise above the sustainable level. The key difference is that environmental stocks after the transient are likely to be less than they were are the beginning whereas environmental stocks after a transition are greater than they were before the transition. The technological innovations of agriculture and industrialization that introduce new eras can provide sustainable increases in environmental stocks.

The lesson from this examination of transients is that if the end of the transition to the industrial era does look like a transient then there is a risk of a Model III end to the transition. If output is maximized to provide the maximum consumption utility for consumers and there is population growth momentum, eco-costs and net damage, then damage is likely to continue, and if damage continues then it will erode the physical environmental stock. If technology development does not keep pace then eventually the output will fall until the demand for environmental stocks matches the supply. To achieve a Model II end to the transition the output reduction must be avoided by avoiding a situation where there is an eco-cost of activity and net damage is occurring.

Overshoot

Consumer sovereignty creates an incentive to maximize total output. To illustrate how overshoot occurs when output is maximized and the environment is finite, consider a very simple model. Output begins at one unit per period and is maximized. Output requires inputs of an environmental stock that is initially 100 units. Output growth is constrained by the rate at which capital and labor can be accumulated so that it grows at 10% per annum. Each unit of activity causes 0.5 units of damage and the self-repair capacity of the environment is 2 units per period. Reducing the environmental stock does not affect output.

The last assumption is an important one. It might correspond to harvesting prey species in North America that are easy to hunt, even when stocks are depleted, or it might represent harvesting a forest on flat accessible land. Alternatively it might correspond to extracting oil where the improvement in discovery and extraction technology offsets the increasing search difficulty as stocks become scarce. The path of output given these assumptions is shown in Figure 3.12.

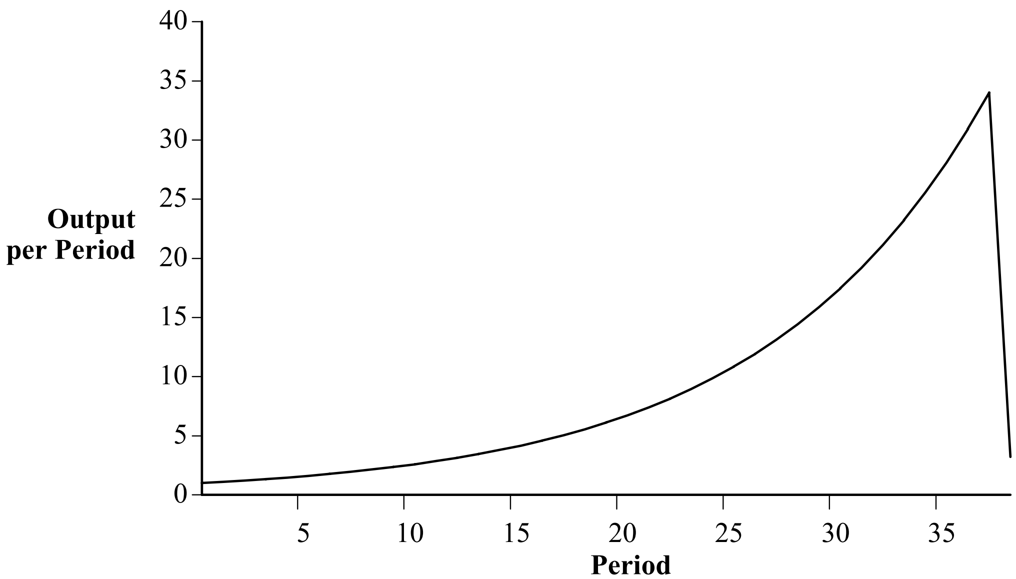


Figure 3.12. Overshoot (I). Output begins at one unit per period and is maximized. Environmental stock is initially 100 units. Output grows at 10% per annum. Each unit of activity causes 0.5 units of damage and the self-repair capacity is 2 units per period. Reducing the environmental stock does not affect output.

The assumptions lead to growth of output of 10% per year followed by a drop of output to zero when the environmental stock is exhausted. For the first 15 periods the amount of damage per period is less than the self-repair capacity and the stock is maintained. After that, the stock begins to erode. When the stock is gone output stops. There cannot be any price signal because the erosion of environmental stock does not affect the flow of inputs to activity. Note that the output is 34 in the last period before collapse while the sustainable output is only four.

The immediate reaction to this overshoot model is that it is so unrealistic that no lessons can be learned from it. The astounding thing is that just this appears to have happened to a human population in the relatively recent past.

Ponting (1991, chap. 1) and Flannery (1994, pp. 254-257) have documented the experience of Easter Island. When settled originally, in the fifth century A.D., Easter Island was covered with forest that provided materials for housing, canoes used for fishing, fuel for heating and cooking, material for making fishing nets, and protection of crop-land from erosion. The settlers prospered, growing from a very small number, perhaps 20 or 30, to a population of 7,000, or 0.43 persons per hectare, by 1550, and producing the statues for which the island is famous. In the course of that expansion the forest was easily harvested and was used for producing non-agricultural output: that is logs for rolling the statues to their place of erection. When the trees were eventually exhausted the population could no longer make nets and canoes for fishing, and agriculture deteriorated because of erosion and leaching of soil nutrients. When the first Europeans visited the island in 1722 they found a society of 3,000 people living in caves and squalid reed huts, engaged in perpetual warfare, with widespread slavery and cannibalism. The Easter Islanders did not slow the removal of trees soon enough and were unable to find substitutes when their primary resources had been depleted.

With the benefit of hindsight it is easy to say that the Easter Islanders should have anticipated the effects of their activities. It is also easy to picture a scenario of a few people pointing to the problem but being listened to only after it was too late to prevent a crisis given the population, intensity of use of forest, size of the remaining forest resource and availability of substitutes. The Easter Islanders had nowhere else to go because the island is 2,000 kilometers from the nearest inhabitable land.

Easter Island is not Earth. Though there are some parallels in relative uniqueness, population growth, and high intensity of resource exploitation, the Earth has many more options for substitution than the Easter Islanders had. Without access to a historical record it is not possible to know what debates took place and what policies were used prior to and during the crisis there. What is clear is that the Easter Islanders were not effective in avoiding their crisis because behavior changes that might have averted the crisis did not occur soon enough. It is possible to envisage that a modest change in behavior, if made soon enough, might have shifted the Easter Islanders onto a more benign path. More and more serious interventions would have been needed until finally the options to avoid the crisis disappeared entirely.

While deforestation was the principal cause of the overshoot in Easter Island, the deterioration of agriculture played an important role. Agricultural deterioration has a somewhat different characteristic to that portrayed on Figure 3.12 in that salination and leaching of nutrients reduces the productivity of the land so that output growth becomes more difficult. Figure 3.13 shows a revised model that represents agricultural

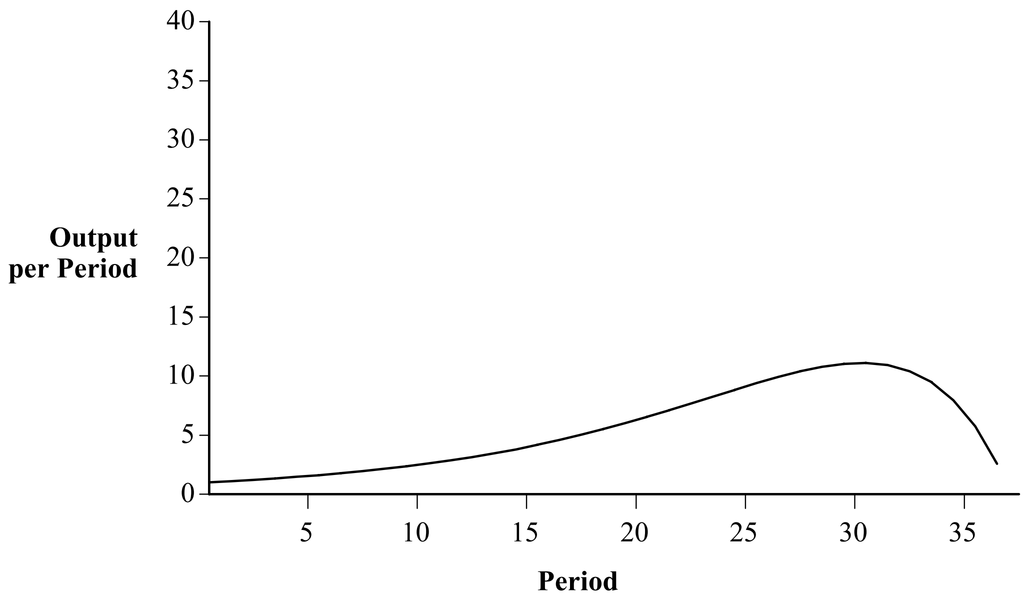


Figure 3.13. Overshoot (II). Output begins at one unit per period and is maximized. Environmental stock is initially 100 units. Output grows at 10% per annum. Each unit of activity causes 0.5 units of damage and the self-repair capacity is 2 units per period. Output per unit of activity reduces in proportion with the reduction of environmental stock.

deterioration more closely. The revision is that while activity grows as before, the output per unit of activity reduces in proportion with the reduction of environmental stock. There are two differences as a result of this change in assumption: the output grows more slowly and it declines gradually instead of precipitously. Overshoot still occurs because the sustainable output is only 4 units per period, as before.

The ability to produce output beyond the sustainable level is what drives the overshoot phenomenon. Therefore, the risk of overshoot depends on two things: emergence of environmental constraints and a management rule that maximizes short-term output, such as consumer sovereignty.

The Earth as a whole could face an overshoot risk if atmospheric changes resulting from industrial activities alter the climate, combining with land degradation to reduce sustainable food output. Or, if developing countries fail to industrialize successfully, the inputs needed for industrial agriculture might not be available to them so growth in population might exceed growth in agricultural output. Timings and outcomes are uncertain but the evidence implies a risk of an overshoot crisis that is worth understanding and managing.

The Crisis Threat

Overshoot would cause or, more accurately, would be an environmental crisis. Having insufficient environmental resource to support the population would lead to shortening time horizons. In these circumstances people might be more concerned about short-term survival challenges than longer-term requirements to preserve natural resources, leading to a more widespread pattern like the one observed in parts of Africa (Mink, 1993) and Easter Island. The recurrent floods and famines in parts of Asia and Africa illustrate the vulnerability of some parts of the world to crises caused by environmental constraints. In these circumstances populations tend to manage for the short-term. It is hard to be concerned about the effect of salination and desertification on agricultural output in five years time when there is a threat to food supplies today.

The outcome from a widespread threat to environmental resources depends on how constrained the options are. If population density is relatively low, manufactured capital is abundant and there are a lot of resources available, there would be little immediate threat. However, in developing countries, where population is dense and there is less natural and manufactured capital per person, the outcome from a serious threat might be some unfortunate combination of further erosion of environmental resources and a subsequent reduction of population.

If a crisis does emerge, the crisis itself is likely to reduce the ability to respond. More kinds of shared environmental resources would be depleted so there would be a tendency for more environmental resources to move to Cases IV, V and VI. In these cases it will be collectively rational to protect the environment. This beneficial effect is likely to be offset by stronger incentives to continue damaging activity in Cases IV and V, loss of output in Case VI and an increase in discount rates.

With an absolute shortage of resources, intense competition to exploit the remaining resources is likely to lead to social unrest and violence, as argued by Homer-Dixon (1999). He points out that environmental scarcity could plausibly produce five general types of violence: (a) local disputes caused by local degradation, (b) ethnic clashes arising from population migration, (c) civil strife (including insurgency, banditry and coups d'état), (d) scarcity-induced interstate conflict over resources such as water, and (e) North-South conflicts over mitigation of, adaptation to, and compensation for environmental problems. (p. 5)

Conflict would further reduce the ability to manage a crisis. With the detrimental impacts of climate change on agricultural productivity being concentrated largely in developing countries, trade liberalization would be very important in ensuring that sufficient supplies of food could be delivered to developing countries (Rozenzweig and Hillel, 1998, pp. 229-231). However, with high levels of conflict over scarce resources, trade liberalization is less likely so serious food shortages could eventuate. The result might be a significant population reduction, severe damage to the remaining resource and a long-term reduction in the carrying capacity of the Earth.

An environmental crisis caused by overshoot might evolve slowly and not be readily discernible. Norgaard (1994a) points out that countries such as Haiti, Somalia, and Ethiopia have "ethnic groups pitted against ethnic groups to control the remaining social order and natural resources, their people starving . . ." and that "Vietnam, Laos, Cambodia, and Afghanistan may have neither a cultural nor environmental basis on which to enter the race again . . ." (p. 184). Alternatively, slow development of an overshoot crisis might culminate in an acute period of conflict, starvation and disease.

Ophuls and Boyan (1992) summarize the reasons to avoid a crisis:

> The suffering and misery caused by a large overshoot of the carrying capacity will be enormous. Any large overshoot seems certain to erode the carrying capacity so severely that the surviving civilization will have rather limited material possibilities. And the opportunity to build the basic technological and social infrastructure of a high-level, steady state society may be irretrievably lost. (p. 17)

Response Options

There are two fundamentally different kinds of response advocated to meet this challenge. The first kind of response emphasizes development of industrial technologies. Biotechnology, nano-technology, information technology, fusion energy and other innovations are expected to provide improved total output per capita as well as the food and protection from disease and other dangers that will sustain the population. According to this approach the state of the environment is not particularly important to ensuring survival because the Earth will have a technological future.

The second kind of response is to try to protect the environment so that it is able to provide the outputs needed to sustain life. In this view, protecting the environmental resource is the key goal. Success in environmental protection will allow the developing countries to navigate the transition and successfully complete their entry to the industrial era. Then all will be able to enjoy the benefits from further developments in industrial technology in a safe and productive environment.

There are many potential futures depending on the current state of the world, which is not known for certain, and response strategies adopted. Five potential futures from the possible combinations of strategies are summarized below:

Progress is the future expected by those who are guided by the dominant paradigm. By continuing technological development and exploiting substitutes, it will be possible to overcome environmental constraints and restore the quality of the environment. The risk of environmental crisis is implicitly assessed as too low to be concerned about.

If progress is not expected to provide a safe future for the whole Earth then the developed countries may have a fallback response that can be labeled *elitism.* Elitism involves a technological future for the developed countries combined with a crisis for the rest of the world.

The political and moral implications of elitism as an environmental strategy are beyond the scope of this thesis. La Touche (1993) provides an account of the modern world that illustrates the characteristics and drawbacks of the elitism approach. There are, however, some practical issues with elitism as a strategy for coping with environmental threats. Problems in one part of the world can easily spill over to other parts. Destruction of the tropical forests, atmospheric and ocean pollution, diffusion of toxic wastes, transmission of disease, large-scale human migrations and increasing availability of weapons of mass destruction expose the well endowed countries to the consequences of outcomes for less well endowed neighbors and make it impractical to ignore outcomes for others.

A third possible future that could result from following a Model I driven strategy is labeled *technological failure*. In this outcome the strategy has been to attempt a technological solution based on progress, without a vigorous attempt to reduce damage, but the challenge has been too great. Technological failure will occur if increases in agricultural productivity are not sufficient to sustain the population and the environment deteriorates. The result would be Model III where the population must reduce to the sustainable level.

Environmental crisis is a future that might occur as a result of forces that have already been set in motion. Land is being degraded. The Earth is warming. Ecosystems are being damaged. At best the current course will not be changed for several years, if not decades. There may not be a serious attempt to protect our environment, possibly because of a belief in progress or possibly because it does not prove possible to assemble the political will. Or, too little may be done because of inability to deploy the resources and technologies required. The result would also be Model III but in this case without an over-optimistic reliance on technology.

Back-to-nature is a future that might be targeted by conservationists. Achieving this goal would require a shift from maximizing output to raise GDP per capita, to a goal of protecting the environment. Technological progress and output growth would both slow as effort is diverted to environmental protection. Back-to-nature is a low-tech solution to the environmental challenge that aims at a Model II future.

The analysis in the preceding sections provides some insight into how these potential futures can be reconciled. Technological failure and environmental crisis are undesirable futures that should be avoided if possible. However, the evidence presented in this chapter implies that it will not be easy to avoid crisis so relying solely on progress or on back-to-nature is not likely to be sufficient. Instead, technological development and capital investment should be continued but redirected to make better use of resources, reduce damage, and repair those aspects of the physical environment that will be needed to sustain the population.

The key objectives implied are to shift the mix of activities so that less damage is caused, to use damaging technologies less, to develop and deploy less damaging technologies, to defend physical stocks, and to make the social and institutional changes that are needed to support the changes. The changes will need to be made in the developing countries as well as the developed ones.

Specific initiatives will be difficult to define and implement because of the absence of agreed specific global triple bottom line targets that define trade-offs, the complexity of the interactions among activity mix, technology mix and conservation, and the absence of international institutions to develop agreed strategies.

Growing non-agricultural output remains desirable but only where it does not conflict with the objectives specified above. As De Bruyn (2000) observes, it is not economic growth itself that poses the risk, but rather the direction and quality of that growth (p. 38). These changes will not occur if consumer sovereignty remains the dominant societal management rule. Some other mechanism is required to ensure that consumer demand can be satisfied in a less damaging way.

There are many initiatives under way that are consistent with these goals. However, there is no shared vision to guide the effort, so initiatives are ad hoc, progress is slow, and the overshoot crisis risk continues to increase. Lack of awareness of the risks, the desire to wait for more evidence or low cost solutions, incentives that lead many to oppose changes, and inertia, impede development of a vigorous response.

Avoiding Crisis

If there is a risk of an overshoot crisis with business as usual then the strategic objective should be to shift to an improved path, as shown in Figure 3.14. Shifting to the improved

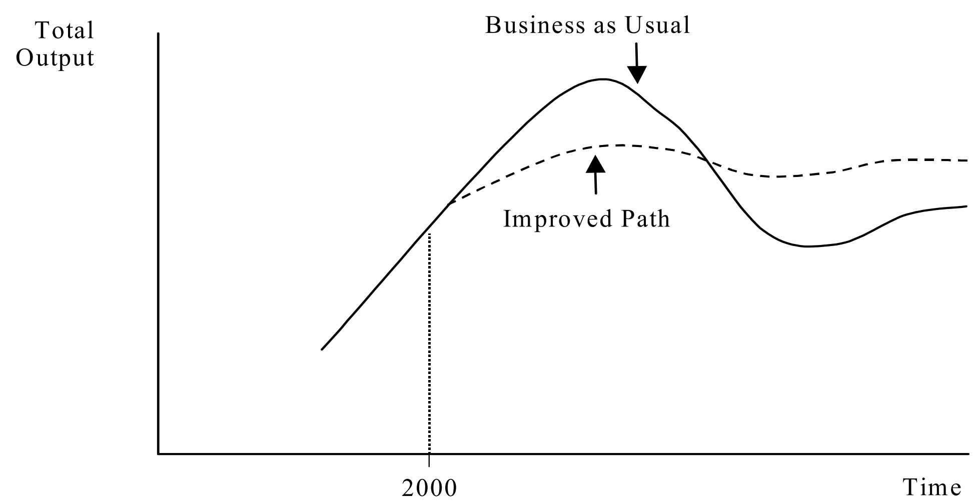


Figure 3.14. The strategy is to switch to an improved path.

path would reduce the peak output, reduce the size of the output decline during the crisis and allow a higher level of sustainable output during the industrial era.

To follow the improved path, policies must be introduced to provide protection against erosion of environmental stocks, not just to protect against the immediate economic consequences of environmental damage. However, there are many obstacles that prevent introduction of such policies.

Scientists disagree about the state of the environment, the impact of economic activity on the environment, and the impact of the state of the environment on economic potential. CFC's, global warming and AIDS were all subject to intense debate prior to being recognized and agreed as dangers by the scientific community. Formulating and implementing responses creates further lags. Environmental deterioration occurs over long periods. It is a bit like the story of the frog placed in warm water that is gradually heated. The frog does not get out and eventually dies because it never receives a sufficient signal of temperature change to jolt it into action. If the frog is dropped into hot water it jumps out immediately (Ehrlich and Ehrlich, 1993).

The easiest response to the risk of an overshoot crisis is to hope there will not be a problem or to hope that someone else will look after any problem that does emerge. One version of this response is provided by the observation that people in developed countries care more about their environments now that they are affluent and the perception that environmental deterioration in developed countries has been slowed. The argument goes on to say that if the benefits of progress are provided to the developing countries then they too will aspire to live in better environments and all will be well. The argument concludes that the pursuit of output growth is not environmentally damaging but rather promotes environmental protection.

There are two problems with the argument. First, it is not clear that people in the developing countries will ever be able to reach the levels of affluence that are enjoyed by people in developed countries (D. I. Stern et al., 1994; Pimentel et al., 1999; and see Figure 3.8). If growth of output per capita in the less developed countries continues at the rate achieved over the last four decades then the average per capita output will be only

US$11,000 per annum in 2050. To reach that level of income it is likely that infrastructure investment will be high, requiring large energy and materials inputs, with high environmental damage. Populations in the developed countries are demanding protection of their environments but their infrastructure is in place and they currently have an average output of US$27,000 per capita.

The second issue with the argument is that it assumes that the developing countries have the same opportunities as the developed countries enjoyed. However, the average population density of the developed countries now that their populations have stabilized is around 0.23 persons per hectare. The average population density of the developing countries is already 0.61 persons per hectare and is expected to be 1.05 persons per hectare by 2050. In 1960, when the developing countries were at an early stage of their demographic transition, their population density was 0.27 persons per hectare, already higher than the developed countries' density now (FAO STAT, n.d.; United Nations, 2001, p. 481). The developing countries are likely to complete their demographic transition with much lower levels of environmental stocks per person.

The need to change is being assessed continuously by a community of scientists, policy-makers and advocacy groups. Theories and research methods are being developed too, but they are not yet sufficiently developed to allow consensus on which risks are the most threatening, how threatening they are, and which responses will have the most beneficial impacts without creating worse problems elsewhere. Policies are being developed in the international arena, though as yet there has been very little action.

Introducing policies to redirect technological efforts and capital investment and to reduce damage will require effort by individuals, whether they are legislators, activists or individuals. If changes must be made in anticipation of a crisis rather than in response, then the level of understanding and commitment of the population will be important in determining whether or not sufficient change can be made quickly enough to avoid overshoot.

Given the obstacles that have been identified, changes in the path will only be created by people who are willing to invest their energy, perhaps in promoting changes or perhaps in changing their own behavior. But people will only invest their energy if they care about the outcome.

The basis for caring will differ among individuals (Hooker, 1963). Self-interested individuals would care because if a crisis comes sooner rather than later, and is global rather than regional, it may arrive at a time of their lives when they are least able to adapt and protect themselves. If such people are not aware that there may be a risk, or conclude that there is no risk because someone else will deal with it, or do not fear for their own futures, then they will not be concerned about the outcome.

Some people may care about the future for their children or grandchildren, or for the well-being of others who are close to them. Some will extend this caring for the well-being of others to everyone in their local community, their country, their cultural group, or to all humans. Some will extend it beyond humans to cute animals or to all animals. Some will care because they have religious, traditional or cosmological beliefs that promote a harmonious relationship with the natural world and do not sanction damaging it. Many will care for more than one of these reasons (Nash, 1989).

Conclusion

This chapter began with a discussion of warnings of environmental crisis, pointing out that the response to these warnings depends on the paradigm being used. Analysts who use the biological paradigm expect populations to overshoot the carrying capacity of their environments and have been receptive to the warnings. In contrast, analysts who use the mainstream economic paradigms have been more likely to reject the warnings. Mainstream economists have stronger beliefs that the future will be like the past and they have greater faith that technological advances will overcome environmental constraints.

The emergence of environmental constraints may indicate that the Earth is nearing the end of the transition to the industrial era so that the future might not be a continuation of the past 200 years. Global population growth is expected to slow around the middle of the 21st century and if current economic growth rates continue then the environment will need to provide for an expected population of 9.3 billion persons, consuming more than seven times as much output as is currently consumed.

Reviewing the implications of this growth for agriculture and climate change reveals that there is a risk that global environmental resources might become a serious constraint limiting output. There is a risk of increasing global output beyond its sustainable level to create an overshoot crisis. If such a crisis did occur it could lead to a reduced population and a lower sustainable output during the industrial era.

Reducing the risk of an overshoot crisis would require a change from aiming to maximize consumption to an objective of providing the food and other goods and services needed to sustain the population. Achieving this revised objective would imply effort to reduce damaging activity, to use technologies that are less damaging, to use environmental resources more efficiently, and to conserve the remaining physical environment.

Humans are the cause of environmental damage and the source of the threat of an environmental crisis. Our power over the environment and our vulnerability to its degradation means that we must be responsible for environmental management. In the past, nature has been viewed as able to protect itself and provide for us. That view is obsolete. Nature is not able to protect itself and may not be able to provide for us if it sustains too much damage. It is up to us.

The issue now is whether the response will be fast enough and strong enough to reverse recent trends so that the risk of an overshoot crisis will be reduced. If a crisis is avoided, the environment in 50 years might be more damaged than it is today. The choices made today will affect the way we will live in our old age and the way our children and grandchildren are able to live. Our choices will determine whether the environment will be robust, diverse, beautiful and safe, or vulnerable, uniform, ugly and dangerous.

Being ready and willing to do more is not enough. We must also be able to change. Developing a practical intervention to help reduce the risk of a Model III outcome by accelerating and strengthening the response is the subject of the remainder of this thesis.

CHAPTER FOUR

RESPONDING TO THE RISK

It is not enough to preach "we must do this, we must do that."
Such preaching is perhaps a necessary prerequisite to action,
but it does not necessarily produce the action required.

- Kenneth E. Boulding, 1991, p. 28

Chapters Two and Three argued that environmental damage is a consequence of self-interested activity and that the scale of such activity has created a risk of environmental crisis. This chapter examines what could be done to prevent damage, and who is responsible for preventing ongoing damage. It begins with a brief examination of some characteristics of the risk of environmental crisis and then examines the potential for businesses and governments to reverse the trends that create the risk. The chapter concludes that governments are responsible for managing the risk but that government regulations will be opposed by businesses if profit potential is threatened. In these circumstances there will be a contest between threatened profit-motivated businesses and environmentally motivated individuals to lead governments. Governments will only respond more vigorously to the risk of crisis if mass public opinion changes.

Risk Identification and Management

Common (1995, Chap. 3) reports that threats to sustainability which have large spatial extent, large temporal extent, large potential impact, high complexity, high levels of ignorance or uncertainty, and high intractability are the most difficult to manage. All of these characteristics apply to both climate change and threats to agricultural output. The management of these risks is complicated further because they interact with one another, have multiple decision-makers, and there is potential for strategic behavior.

Uncertainty

Risk can be distinguished from uncertainty. Risk arises when undesirable outcomes are possible whereas uncertainty arises when the probabilities of outcomes are unknown (Perrings, 1997, p. 183). Uncertainty restricts the use of conventional risk management approaches. For example, insurance may not be feasible: "All that may be known is that the probability of distant but potentially catastrophic outcomes is positive….it is impossible to insure commercially because there are insufficient data on which to estimate an expected value for future losses within acceptable levels of confidence" (p.179). Further, financial insurance payments may not compensate adequately for loss of life opportunities, while long time horizons and the scale of the issues imply that insurers may not have funds available to pay claims.

When facing both risk and uncertainty it is difficult to decide how much to invest now to protect against the danger. Behavioral research shows that weak information is likely to be interpreted as reinforcing existing beliefs (Slovic, Fischhoff, and Lichtenstein, 1980, p. 211) leading to delays in recognition of emerging risks (Ophuls and Boyan, 1992, p. 202). For example, greenhouse gases and CFCs were accumulating in the atmosphere for decades before any concern was raised. Even when some scientists became concerned, there were disputes within the scientific community that caused further delays in response. When the risks were widely recognized there was additional time needed to develop technical and policy responses and for these responses to take effect.

Unexpected threats may complicate the response to risks already identified. These may be worst case outcomes from threats already identified, like changes to the THC or they may be complete surprises. Dumas (1999) examined risks from innovative technologies concluding that:

> Our natural tendency to overemphasize the advantages and undercount the costs, to "buy now and pay later," will get us into very deep trouble some day. Because we humans are the most capable species on earth, we are also the most dangerous. Our confidence that we can indefinitely avoid catastrophe while continuing to

> develop and use powerful and dangerous technologies is a lethal arrogance. We cannot keep winning a technological game of "chicken" with nature. (pp. 25-26)

The potential for scientists to discover offsetting risk-reducing mechanisms, for technological developments that can be used to reduce the risk, or for discovery of substitution opportunities creates an incentive to delay responses to emerging risks if the scientific information is uncertain. The greater the response required the more evidence the policymakers need before they will act. Gottstein (1999, p. 35) reports that there is a growing conviction that drastic changes will be required to cope with the present situation and avoid major catastrophes but is pessimistic about the potential to establish support for those changes because the studies needed require inter-disciplinary cooperation in an international context. He concludes that the information needed is scientific studies that report the origin of problems and potential solutions; examination of the options for action including the costs, benefits and risks; media communications to inform politicians and the public; and education of future leaders (p. 36).

Ozonoff (1999) points out that policymakers can make two kinds of error when assessing uncertain information about a risk. They may respond when the risk turns out to be unimportant or when a simple fix becomes available later (Type I error). They may decide not to respond when there is an important risk (Type II error). In making their decisions they will be affected by the information presented to them and by the outcomes for them of making each kind of error.

There are two management responses to uncertainty: obtain additional information to reduce the uncertainty; and adopt decision-making procedures that take account of the remaining uncertainty. Science can provide valuable information to reduce uncertainty. For example, Nordhaus (1994) estimated that the value of advancing by one decade the resolution of uncertainty about climate change policy was US$100 billion (p. 189). Perrings (1997) conveys the importance of information to reduce uncertainty in a non-financial way: "potentially catastrophic effects will, however, only seize the decision-maker's attention if the prospect of their occurrence excites minimal disbelief" (p. 187).

The information presented to policymakers is affected by the paradigms being used by those who are assembling the information. The differences between the dominant economic paradigm and the biological paradigm in this regard were explored in the previous chapter. Barret and Raffensberger (1999) distinguish two models of science used as inputs to environmental policy development: mechanistic science and precautionary science. Mechanistic science separates science from social issues, focuses on the harm caused by a few variables, minimizes Type I errors, and has peer review within the discipline. In contrast, precautionary science has a multidisciplinary approach, focuses on disruption of biological, ecological or social systems, minimizes Type II errors and has inclusive peer review processes. The existence of these two approaches to science creates further uncertainty because the stance of scientists towards the two kinds of error may not be explicit in information used by policymakers.

Despite the value of using science to reduce uncertainty, policymakers cannot rely on scientists to prescribe solutions:

> It cannot be the task of science, of course, to decide which risk society ought to take in order to reap which benefits, or in other words, which costs should be considered tolerable for gains of some sorts. This is a decision based on values which can only be taken by the public, or by the politicians representing the public, after understanding the results of a thorough and carefully explained cost-benefit analysis. Science cannot relieve politics from the responsibility for these value-based decisions (Gottstein, 1999, p. 9).

The Precautionary Principle

The precautionary principle has been proposed as a way to make decisions where there are high risks and high uncertainty. O'Riordan and Cameron (1994) summarize the precautionary principle as guiding a decision maker "to act *prudently* when there is *sufficient* scientific evidence and where actions can be justified on *reasonable judgements* of cost-effectiveness and where inaction could lead to potential irreversibility or demonstrate harm to the defenders and future generations" (p. 18). They go on to say “the notion in international affairs is mostly one of prevention, and justification of some action rather than to claim scientific uncertainty as a reason for delay” (p. 18).

The United Nations Conference on Environment and Development (UNCED) adopted the precautionary principle stating that:

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (Goklany, 2001, p. 5).

The precautionary principle implies an aversion to catastrophic risks, or the avoidance of Type II errors. It is consistent with behavioral research on attitudes to risk. Slovic et al. (1980) found that people are very averse to catastrophes, even if the probability is low, and that their judgments about risk are affected by the severity of the potential outcome and the number of people exposed to the risk. People are less concerned about more frequent, smaller losses of life (pp. 201, 209).

The precautionary principle offsets the understandable reluctance of policymakers to act when information is uncertain by creating an obligation to act to prevent catastrophic uncertain risk.

Perrings (1997) provides useful insight into what is involved in applying the precautionary principle to real decisions. He points out that a decision where information is uncertain may be divided into two components: one where there is risk but no uncertainty and one where there is a great deal of uncertainty. He recommends that policymakers should base their decisions on expected value maximization for the certain component but use the minimax decision rule for the uncertain component (p. 185). Minimax requires identifying the worst-case potential outcome and minimizing the maximum damage costs from that worst-case outcome. Translated simply into climate change this would imply using expected value to make decisions about temperature changes up to 2°C, which are very likely, while using minimax when managing the risk that temperature changes could be as much as 6°C. The minimax rule would imply minimization of the probability of worst-case outcomes which might result from larger temperature changes, like cessation of the THC.

Emergence of new scientific information would imply changes in the boundary between the certain component and the uncertain component of the expected outcome. If new observations are not surprising they will lead policymakers to revise upwards the judgment they make about their understanding of the system and so to use the expected value approach more. If observations are surprising then policymakers will become less confident of their knowledge and use the minimax approach more. Perrings (1997) points out that:

> It is a characteristic of the increasing flow of observations on the state of the global system that it does contain surprises. The emission of greenhouse gases is not new, but the notion that they might have the capacity to damage global life-support systems is….As our knowledge of the global system increases, so too does our uncertainty about the long-term implications of present economic activity. (p. 191)

Policymakers and theorists who are less well informed about the potential for catastrophic risks will also be likely to rely on the expected value approach.

Those using the dominant paradigm will be more likely to use the expected value approach because their theoretical beliefs make them less likely to recognize a risk of crisis. Lomborg's (2001) analysis of climate change, reported in Chapter Three, provides an example. Lomborg acknowledges that science has shown there is a risk of climate change leading to catastrophe but goes on to develop his recommendations using discounted costs and benefits as if the risk does not exist (pp. 300-317).

Several writers have pointed out that proponents of the precautionary principle sometimes focus on environmental risks without taking sufficient account of other important considerations. Goklany (2001) points out that there can be upward bias in the projected negative consequences of climate change because analysts do not take sufficient account of the potential for technological change and human adaptability (p. 7). Beckerman (2000) employs the dominant paradigm to project income growth trends and predict people will have very high incomes in the future so that losses due to global warming will be small in relation to expected wealth (p. 57). In addition, action taken to prevent environmental damage may have adverse consequences elsewhere (Goklany, 2001, p. 7; Gottstein, 1999, p. 35).

The precautionary principle's requirement that interventions be cost-effective may also weaken the response to environmental risks because it implies that only discounted economic costs should be included in the cost to be avoided. The costs of any intervention done now would be certain and undiscounted.

Goklany (2001) argues that correctly applying the precautionary principle would lead to: avoiding aggressive greenhouse gas controls that might retard economic development and cause hunger, poor health and higher mortality, especially in developing countries; to avoiding raising oil and gas prices because that would reduce the availability of food, require more land loss, and so create threats to biodiversity; reducing unnecessary subsidies for energy and other natural resources; increasing societal adaptability; and to continuing R&D into causes and impacts of climate change, into alternative energy sources, and into other ways to limit the build-up of greenhouse gas concentrations (pp. 86-88).

These arguments establish the need for caution in developing specific policies but it would remain valuable to accelerate change to reduce human activities that damage the environment, to ensure that activities are less damaging, and to develop technologies to allow the Earth's inhabitants to use environmental resources more sparingly and more efficiently. The precautionary principle implies a bias to act sooner rather than later, provided that the costs of doing so are not unreasonable.

Businesses: Restraint or Constraint?

One of the beliefs of the dominant paradigm is that businesses, whether operated by individuals or corporations, should be as free as possible to pursue opportunities for profit and that constraints on their activities are undesirable. Despite this, there are many regulations that constrain business activities to protect the health and safety of workers and consumers, to prevent and respond to externalities resulting from activity, and to protect the environment.

Business activities "are responsible, directly or indirectly, for most human impacts on the earth's ecosystems" (Capra and Pauli, 1995, p. vii). One response might be simply to expect businesses to refrain from damaging activity. If so, then analysis should show why businesses would choose to do so. This section will explore three widely held beliefs that are used to justify continued minimization of the constraints on business activity.

The first belief is that market forces will drive a search for win/win solutions so that businesses will find profit-making opportunities that involve environmentally beneficial or harmless solutions. The second is that businesses are or will become socially responsible and will voluntarily refrain from environmentally damaging activity. The third belief is that there is a natural alignment of interests between business and the community so unconstrained business activity will produce the best overall outcome for the community.

This section will argue that none of these beliefs provides protection from the potentially disastrous consequences of ongoing environmental damage and so it is important to be vigorous in ensuring adequate mechanisms are in place to constrain damaging activity. The important issue addressed here is the stance towards constraining business activity. The conventional stance, usually supported by one or more of the three arguments listed above, is that constraints should be minimized. This section argues that constraints ought to be expected, and their levels determined by taking account of effects on both economic and environmental outcomes.

During the early and middle stages of the transition there is a good case for minimizing constraints on business activity because the economy-environment trade-off is usually in Case I (Free-Gifts/Free-Disposals) or II (Headroom). However, towards the end of the transition Cases III (Externality), IV (Tragedy), V (Prisoner's Dilemma) and VI (Price) will be much more common. Being in Case VI ensures a search for new technologies or substitutes while activity in Cases IV and V should be constrained for economic reasons as well as to reduce environmental damage. It may be important to constrain some damaging activity in Cases II and III to reduce the risk of environmental crisis and to arrest trends that would lead to activity in Cases IV and V.

Win/win Solutions?

The first belief is that creative and well-managed profit-motivated businesses will find win/win solutions where activity is good for business and the environment simultaneously. For example, paper recycling reduces the need for landfills and conserves forests and at the same time reduces fiber and energy costs for businesses and paper costs for consumers.

Stephan Schmidheiny, Chairman of the Business Council for Sustainable Development, argues that there are two business arguments for caring about the environment: "First, if you don't, your business will lose out in the coming environmental shake-out. Second, as the division between environmental excellence and economic excellence blurs, there will be increasing profitability and competitiveness opportunities in eco-efficiency" (Schmidheiny, 1992, p. 22).

There is nothing inherently wrong with the view that businesses can improve profitability by being environmentally excellent, and that businesses that are not responsive to environmental concerns are likely to suffer as a result. However, while there are likely to be many win/win opportunities yet to be discovered, there are also many important win/lose situations where the combination of profit motive and innovation will not be sufficient to prevent serious ongoing environmental damage.

Profitable?	Damaging? Yes	Damaging? No
Yes	Business as Usual • Businesses will be quite happy to operate here	Win/Win (Case I) • Businesses will try to find activity here
No	Activity here is unattractive to business but may occur (e.g., Case V, loss leaders)	Community Service • Businesses have no incentive to act here

Figure 4.1. Business incentives

Figure 4.1 shows the Win/Win case where both economy and environment benefit from activity. This is Case I. Businesses have an incentive to find win/win opportunities. For such activities to be environmentally beneficial they must be substituted for other, more environmentally damaging, activities. These are the activities in the Business as Usual box. Profit-motivated businesses will only move activity to the Win/Win box if it is more profitable than the activity in the Business as Usual box. If the new opportunity is win/win but offers less short-term profit than existing activities or available alternatives then a profit-motivated business would not adopt it.

Relying on win/win solutions implies relying on businesses finding non-damaging activities that are the most profitable available. There may be some profit potential arising from the reduction in damage itself that could facilitate this; for example, if consumers are willing to pay more for a less damaging product or service.

Businesses will not necessarily take advantage of win/win opportunities because they focus their efforts on the most important profit opportunities. For example, Foreman (2002) reported that a joint project with citizen involvement for a unit of Dow Chemical found environmental benefits that produced savings of US$5.4 million with an annual rate of return of 180% but that the savings were not large enough to motivate management given the size of other opportunities available (pp. 165-167). Further, other units of Dow

Chemical and other companies approached declined to participate in an extension of the project.

A profit-motivated business that cannot find a more profitable opportunity in the Win/Win box would stay with the Business as Usual box. Many new opportunities that are profitable and damaging will fall in the Business as Usual box. Businesses would still have a strong incentive to carry out those activities.

There are potentially valuable activities in the Community Service box. A large reduction in damage might be achieved for a very small cost to profit. However, profit-motivated businesses have no incentive to operate in the Community Service box, just as they have no incentive to refrain from damaging activities in the Business as Usual box.

If a business did convert an opportunity that begins in the Community Service box to an opportunity in the Win/Win box there would be a profit gain for the company. This could happen if marketing efforts convinced customers to pay more for non-damaging activities. The business then could carry out profitable activity and avoid or reduce damage. But it would not be activity in the Community Service box.

In conclusion, there are win/win opportunities and businesses may have an incentive to seek them. However, there are also many activities that will fall into the environmentally damaging Business as Usual box and there is no disincentive to prevent businesses from carrying out these activities in the absence of a constraint. There is also no incentive for profit-motivated businesses to engage in activities that repair the environment, but are not profitable.

Social Responsibility

The second belief acknowledges that a lot of environmental damage cannot be stopped by profit-motivated businesses and demands that businesses voluntarily refrain from maximizing profit where their activities cause environmental damage. This view proposes that businesses should choose activities in the Community Service box of Figure 4.1.

Businesses are institutions, established by communities of human beings organized to achieve a common purpose. Most businesses exist solely for the purpose of creating value for their shareholders, providing products, services and employment, and competing with other businesses for sales and profitability in order to create value. Some businesses have other purposes in addition to the creation of shareholder value, depending on the motivations of their key stakeholders, especially shareholders. A business may have purposes to create employment, to improve the environment, to develop skills or to satisfy the owners' aspirations to be creative.

Purpose must be distinguished from function. Purpose is what motivates those who make decisions about the direction of a business. If a business does not meet its purpose or purposes then it will be dissolved. Function is the result of business activity. Businesses may serve functions such as providing necessary products and services, and providing employment.

Where shareholders choose motivations for a company other than profit it is not clear that the organization is a business; it may be more appropriately described as a not-for-profit or a charity organization, depending on the desired level of profitability. Regardless of the additional motivations, businesses with profit-motivated shareholders will not survive very long in competitive markets if they do not create shareholder value. Shareholders will take their capital to other businesses where the returns are better.

This is not to argue that businesses that seek environmental goals should not exist. There are investment funds such as the Jessie Smith Noyes Foundation (Tasch and Viederman, 1995) and firms such as The Bodyshop who pursue environmental goals, but for these organizations their environmental concern is consistent with, and promotes value creation for shareholders. This is the Win/Win box of Figure 4.1, not the Community Service box.

When an organization pursues both profit and environmental objectives in circumstances where a trade-off must be made (because the choice is win/lose rather than win/win) the effectiveness of the organization is likely to be greatly eroded. Organizations that pursue more than one objective frequently lose their way and can dramatically under-perform on one or both objectives.

The author has worked with many organizations that have both commercial and other objectives, mostly government owned enterprises. Developing shared internal understanding of how to trade off and manage the conflicting objectives is a common feature of strategy projects with such organizations. Almost all managers in these organizations come from either a commercial or a public service paradigm and lack the knowledge of the other paradigm that would allow them to reconcile and manage the two. This is in sharp contrast with purely commercial organizations where there is a clear understanding by managers that the purpose of the enterprise is to maximize shareholder value.

In developed economies directors have a legal responsibility to act in the interests of the company. Directors who choose to pursue activities that are contrary to the interests of the company expose themselves to great risk. Directors and managers who decided to spend significant funds to meet the environmental aspirations of a group of stakeholders, in circumstances that eroded or did not maximize shareholder value, would face howls of protest from shareholders and might risk legal action for breach of fiduciary duty.

In contrast to the view that businesses should be socially responsible, institutional constraints facing those who manage businesses mean that they must focus their efforts on maximizing profit. Not only are they constrained by legal obligations and supporting governance arrangements, but they also need to focus on profit to ensure survival of the business. Securing the profits needed for survival is not easy and requires sustainable economic advantage relative to competitors. Sustainable advantage is difficult to get and very valuable, and is not sacrificed lightly.

Businesses gain profit by selling products or services whose price per unit sold exceeds the cost per unit sold. Businesses seek sustainable advantage over one another in two arenas. First, they compete with other businesses to create value for customers and so win sales. If one competitor has a customer's volume then another competitor cannot have the same volume.

Second, businesses compete with one another for margin. Assume for the moment that the price for the product or service is the same for all participants because the product or service being provided is an undifferentiated commodity. In such a competitive market the price may be set by the marginal cost of the marginal producer. At a given price the unit profit for each producer will be determined by that producer's cost relative to the cost of the marginal producer so the lowest cost producers will earn the most profit per unit.

If the marginal producer leaves the industry or changes its costs so that the price changes the same rule will apply; the lowest cost producer will still earn the highest profit per unit. It is not the absolute cost that determines the profit per unit; it is the relative cost.

The same applies with prices. If one competitor can differentiate the product or service offered so that the customers are prepared to pay a price premium, then that competitor can earn an increment to profit per unit. Again, it is the relative price that is important, not the absolute price. The unit profit depends on relative cost and relative price.

Businesses must compete with other businesses for sales and profit per unit to create value and so they place a high value on relative success. It is not enough to reduce costs if the competitor is reducing costs too; the only thing that delivers sustainable profits is a sustainable cost or price advantage.

Businesses innovate to overcome relative cost and price disadvantages and build advantages, which drives what Schumpeter (1966) has called the process of "creative destruction." Some companies win and others lose but the overall result is more goods and services for consumers produced more efficiently. Seeking economies of scale to reduce relative cost and growing profits from businesses with existing relative advantage drive businesses to seek more sales.

Value destruction or bankruptcy will face businesses that lose in business competition. Managers and directors will lose their jobs. If pursuing competitive success is not compatible with choosing to avoid environmental damage then businesses that effectively pursue profitability will replace those that pursue environmental objectives.

Aligned Interests?

The third belief used to justify minimizing constraints on businesses acknowledges that businesses should maximize profit but states that in doing so they will act in the community interest.

This view is included in the dominant paradigm and derives ultimately from Adam Smith's famous passage from *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776/1898):

> …by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain; and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention. Nor is it always the worse for the society that was not part of it. By pursuing his own interest, he frequently promotes that of the society more effectually than when he really intends to promote it. I have never known much good done by those who affected to trade for the public good. It is an affectation, indeed, not very common among merchants, and very few words need be employed in dissuading them from it. (p. 345)

Smith appears to be arguing that the interest of the community is aligned with the self interests of business leaders and this is certainly the dominant interpretation of the passage. With business and community interests aligned there is no case for constraining individual activity, because that would harm community interests.

However it is not quite as simple as that. Elsewhere Smith (1776/1898) writes that merchants and master manufacturers are "an order of men, whose interest is never exactly the same with that of the public, and who accordingly have, upon many occasions, both deceived and oppressed it" (p. 203). He condemns the "mean rapacity of merchants and manufacturers, who neither are, or ought to be the rulers of mankind" (p. 377).

These statements raise the possibility that Smith recognized that there were circumstances where the interests of the community were not aligned with those of individuals or businesses. So what is the logical status of the dominant 20th century interpretation of the invisible hand as a license for unconstrained business activity?

There are three keys needed to unravel this; a clear definition of what is meant by community interest in this context, the distinction between economic and environmental outcomes, and the typology of cases introduced in Chapter Two.

Bentham proposed in 1789 that the community interests were merely the sum of all individual interests. This is an egalitarian assumption, with every individual weighted equally regardless of social status. Thus, the community is an artificial construct that finds value in that which is beneficial to a particular individual. (Ekelund and Hébert, 1990, p. 129).

However, to use Bentham's definition effectively it is important to distinguish between Actors and Others, especially in a Tragedy. The community of interest is comprised of one or more Actors as well as any number of Others, whose interests are affected by the activity of the Actors but who are not themselves making choices about levels of activity. Thus, while every individual affects the overall outcome for the community through valuation of their personal outcome, there are Actors who also affect the overall outcome for the community by altering the outcome enjoyed by other members of the community.

The community's interest in economic outcomes should be distinguished from the community's interest in avoiding damage and the risk of environmental crisis. Focus first on economic outcomes alone and consider the outcomes for the actors and the community as a whole for Cases II through V in turn. For Case II (Headroom) there are no economic costs for either Actors or Others. Activity is in the economic interests of the community. For Case III (Externality) there are economic costs for Actors and/or Others, the economic gains for Actors are greater than their economic costs and the net gains for the

Actors are greater than the total costs for the Others. The activity is in the economic interests of the community. The community has no basis to argue on economic grounds to constrain the activity of Actors. The outcome will be the best economically for the Actors and the community.

So for Cases II and III, and ignoring environmental damage for the moment, Smith's invisible hand is supported by the analysis here. But that is not the end of Smith's contribution. Evensky (1993) states that:

> By the end of his life, Adam Smith was no longer looking to the invisible hand to guide society to the conditions necessary for a constructive classical liberal state. Instead he called upon the visible hand of moral leadership from all individuals, and especially statesmen, to create those conditions and therefore that society. (p. 203)

Further, "in Smith's story ethics is the hero - not self-interest or greed - for it is ethics that defend the social intercourse from the Hobbesian chaos" (p. 204). What is this Hobbesian chaos? In 1651 Hobbes had argued that in the absence of some controlling society the individual pursuit of self-interest would lead to a *natural state* where there was a war of all men against all men

> And because the condition of Man is a condition of Warre of every one against every one; in which case every one is governed by his own Reason; and there is nothing he can make use of, that may not be a help unto him, in preserving his life against his enemyes; it followeth, that in such a condition, every man has a Right to every thing; even to one anothers body. And therefore, as long as this naturall Right of every man to every thing endureth, there can be no security to any man, (how strong or wise soever he be), of living out the time, which nature ordinarily alloweth men to live. (p. 64)

There is no inconsistency here; the two writers simply have different paradigms (Ophuls and Boyan, 1992, p. 205). Hobbes' experience was during the agricultural era prior to the industrial revolution. Hobbes deals with Cases IV and V while Smith's invisible hand argument is concerned with Cases I, II, and III.

Despite this important lack of generality and his clarification of the issue, Smith's invisible hand argument has been highly influential. It has been widely used to justify and promote the pursuit of economic gain by individuals and businesses. It has been helped in this by the dominant paradigm that assumes free gifts and free disposals and so focuses on Cases I and VI while ignoring Cases II through V. Modern economists have reviewed market mechanisms to conclude that the invisible hand argument will not always deliver optimal outcomes but this knowledge is only widespread among economic experts (Screpanti and Zamagni, 1993, pp. 350 – 352) and the invisible hand is still covered in standard texts, with footnotes about market failures.

Members of a community of interest may understand that their ex post outcomes can be affected by influencing the choices of potential Actors who are members of their community. In Cases I and II the economic outcomes for members of the community do not depend on choices made by others and so there is no need for such coordination. In Cases IV and V, a need for coordination emerges if the best available community outcomes are to be attained. This may lead to a *community of action*, where the members act to ensure the best outcome for the community. Communities of action are most important for Cases IV and V where economic outcomes for the community of interest are better if the behavior of Actors is constrained. Similarly, if the community faces a risk of environmental crisis, there may be a need for a community of action to prevent further environmental damage in Cases II or III.

In Case V the outcome depends on how many Actors choose to carry out the activity so the ex ante gains and costs may not be the same as the ex post gains and costs for the Actors. To illustrate this consider a two-Actor prisoner's dilemma. If One expects that Two will not carry out the activity then One will secure the most output by carrying out the activity. If One is correct and Two does not carry out the activity then One will get the highest payoff available.

If One expects that Two will not act but is incorrect then both actors will act and the outcome will provide the lowest payoffs available to both actors.

One might recognize that if the Actors could coordinate successfully they could avoid such mistakes and could get the best joint outcomes. When agreeing to coordinate in this way each Actor faces a risk that the other Actor will defect. This risk decreases if contracts are enforceable or if the game will be repeated, but increases as the number of actors increases. Coordination among businesses may require government facilitation because competition law usually prevents companies forming agreements to reduce output.

Consider these Case V potential outcomes from the perspective of the damage resulting. Activity is assumed correlated with damage so both outcomes that involve activity are more damaging than if neither Actor had acted, the choice that would give the Actors the best payoffs. As a result, it is in the economic interests of the Actors, the community economic interest, and the environment, for the Actors to coordinate successfully.

The conclusions of this section are presented in Figure 4.2.

		Is a Constraint Required to Get the Best Outcome?	
	Case	For the Economy	For the Environment
I	Free-Gifts/Free-Disposals	No	No
II	Headroom	No	Yes (unless willing to erode headroom)
III	Externality	No	Yes
IV	Tragedy	Yes	Yes
V	Prisoner's Dilemma	Yes (Unless coordination possible)	Yes (Unless coordination possible)
VI	Price	No	No

Figure 4.2. Constraint needs for each case.

Figure 4.2 shows the minimum that is required to get to the low activity outcome for each case. Case V requires coordination by the Actors or constraints on activity. Case IV requires that the community constrain individual activity in the economic interests of the community or to prevent damage. Constraining individual activity in the economic interests of the community will not work for Case III because the community benefits economically from the activity. In this case, and for Case II, the purpose of an intervention would be to prevent environmental damage.

Constraining Business Activity

The argument above demonstrates that it is vital for businesses to succeed in competition with one another in a market economy and that the resulting activity is likely to be environmentally damaging. Businesses are not free to choose to refrain from acts that improve their competitive position. They must be prevented from doing so when those acts would cause unacceptable damage.

In modern economies businesses really are solely motivated by profit. Contrast this with the organization of activity during the agricultural era. A peasant farmer must provide seed for the next crop and feed himself and his family. He or she must also provide for purchased inputs and other consumption, though the timing of these may be varied depending on the success of harvest. Taxes and rents ensure a surplus is targeted and can be varied, depending on the harvest, so that the farm can survive as a productive unit. The farmer in the agricultural era eats first. Food is the survival issue. Profit, in the form of rents and taxes, is secondary.

In contrast, shareholders eat last. A business gets its profit as a residual after paying for inputs and if profit is insufficient the business will cease to exist. Profit is the survival issue for businesses.

Policies to Constrain Damaging Activities

Policy responses advocated by modern economists (e.g., Baumol and Oates, 1988; Pearce and Turner, 1990) to constrain damaging activities can be classified into three categories; rely on existing market institutions, establish a market where one does not exist, and intervene in the market. In this section a description of the key characteristics of these policies will be followed by an assessment of their potential to address economic and environmental issues arising in each of the cases of the economy-environment interaction.

Policies are not relevant for Case I (no damage) and Case VI (activity deterred). Intervention is only needed where there are undesirable outcomes. The undesirable outcomes considered here fall into three categories: erosion of environmental stock (Cases II through V), economic costs to Others (Cases III through V) and economic costs to Actors themselves (Cases III through V).

This section considers the policy options and examines how they address each of Cases II through V. The potential of a policy depends on several factors: notably which case is being addressed, whether or not a property right exists and whether the eco-cost is widely or narrowly dispersed. It will be shown that the available policies can reduce environmental damage in some circumstances but that there are important areas where policy response options are insufficient.

Environment Protection Policies

The policy approaches proposed to protect the environment are divided into three categories, as shown in Figure 4.3. The first category advocates utilizing existing market institutions. This category involves no state intervention other than that required for effective market operations such as the existence and enforcement of contract law. The second category involves establishing a market, usually through assigning property rights that can then lead to solutions based in either of the other categories. The third category includes proposals to alter the way a market operates. The overall policy categorization is shown in Figure 4.3.

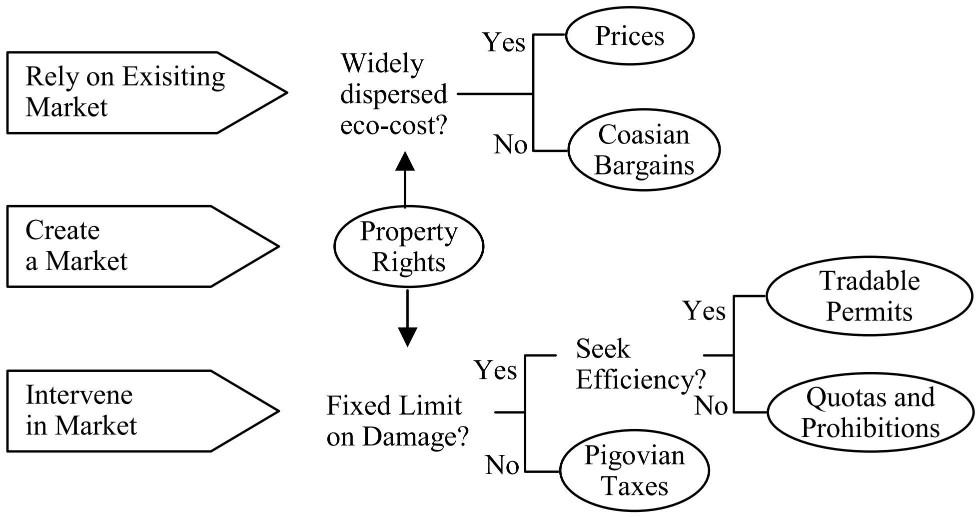


Figure 4.3. Economic policy options for environmental protection.

There are two types of policy proposal that rely on the existing market arrangements. The first advocates relying on price changes to signal the need for input substitutions and socio-technical innovations to maintain output in response to observed or anticipated environmental changes. The second argues for Coasian bargains, where Actors compensate Others who are harmed. These bargains are only effective when property rights are established and transaction costs are low, such as when the eco-cost is narrowly dispersed.

Policy proposals that require intervention in markets can be divided into two sub-categories. The first sub-category involves proposals to create markets where none currently exist. Establishing property rights where a resource has been used as a commons is used both for conventional resources such as land and for pollution sink capacity. In the former case some form of private ownership of the resource is conferred while in the latter case a right to exploit the resource or to emit pollution in the form of a quota or permit, that may be tradable, is given or sold to a market participant. Tradable quotas and permits will be considered here as a kind of regulation, rather than in the discussion of property rights because the crucial feature of these policies is that they impose fixed limits on output. Tradability only ensures that the output is limited in an economically efficient way.

The second sub-category of intervention in markets is discouragement or prohibition of activity that causes environmental damage of the proscribed form. Pigovian taxes seek to alter the incentives of market participants to encourage them to act in ways that reduce or eliminate environmental damage. Pigovian taxes are designed to include costs imposed on others via an externality as a tax on the producer or consumer. The aim is to ensure that the Actor faces the full social cost of an activity when choosing to carry out that activity (Dragun and O'Connor, 1993, p. 133).

Prohibitions, quotas and tradable permits regulate the quantity of activity or damage that is allowed. Prohibitions prevent all activity or damage within the target arena while quotas place a limit on the activity or damage. Tradable permits are quotas that can be traded among market participants to achieve the desired environmental result at the least economic cost.

The following analysis of each policy option will consider how effectively the policy addresses each of the cases and the likely outcome resulting from the introduction of the policy. This will allow development of a summary of the potential of current economic policy options to address environmental damage and its economic consequences.

Prices, Substitution and Socio-Technical Innovation

Price increases can occur when the cost or amount of inputs required to produce an output increases (Samuelson and Nordhaus, 1989, p. 95). This may occur because the environmental input is priced so production costs increase or it may occur because the environmental input is not priced but contributes less effectively to production so that more of other inputs are required to produce the same amount of output. It may also occur because scarcity increases the extraction cost of the environmental input. In all these cases the result is an increase in the cost, which creates upward price pressure.

Assuming the eco-cost of the activity is recognized, how much of the eco-cost is incorporated in the price depends on the circumstances. Because the eco-cost resulting from the activity occurs in future time periods, the impact on future productivity may not be factored into current prices. Current prices will only be affected if the productivity change is anticipated, at least some of the cost increase affects the price maker and competitive conditions allow the expected future cost increase to be factored into current prices.

When the price of the output increases there are several possible responses, depending on the circumstances. If there are substitutes whose price disadvantage prior to the price increase was less than the amount of the price increase then there will be a shift to the substitute (Samuelson and Nordhaus, 1989, p. 58). If there are no substitutes that are sufficiently closely priced then there will be a decline in volume of the output sold, depending on the price elasticity of demand (Samuelson and Nordhaus, 1989, pp. 451-2). These two effects may occur together, depending on production constraints on the output and the substitute.

The price change might also prompt socio-technical innovation to reduce the costs of the output or the substitute. Innovation may reduce costs rapidly, resulting in an increase of output despite some upward cost pressure from scarcity. This is particularly important in the case of renewable resources such as fishery stocks where scarcity may create even more incentive for a low cost producer to innovate or expand to increase production.

With this brief sketch of the price mechanism, the potential impacts that prices can have on environmental and economic outcomes can be identified for each case. For Case II (Headroom) prices can have no effect because there is no eco-cost; that is, the economic productivity of the environmental resource is unaffected by the erosion of environmental stock. For Cases III and IV prices might encourage a switch to substitutes in some circumstances but might not deter activity in others. Despite the price increase, the activity may still be in the economic interest of the Actor because v_a is greater than c_a (though not in the economic interest of the community in Case IV because V_a is less than C_a). For Case V (Prisoner's Dilemma) the outcome depends on which combined outcome the Actors find their way to. If Actors choose to carry out the activity, then prices will not have prevented environmental damage. If Actors can coordinate so that they choose not to carry out the activity then prices will have prevented damage. In most market economies communication to establish such coordination is regarded as anticompetitive, and is illegal. For Case VI prices effectively prevent activity.

A price increase may cause a switch to substitutes in any of Cases III through VI. This may take place quickly by altering the price relativities between competing inputs or outputs, or may have a delayed effect because the price rise stimulates development of previously undeveloped resources, exploration activity, technology development, or investment to enable use of a substitute.

A switch to substitutes may have the positive effect of reducing the environmental damage caused by the activity. However, the substitute will be chosen based on production cost potential. Therefore the impact on the total amount of environmental damage may be to reduce it or to increase it, depending on the nature of the substitute. The price mechanism does not encourage substitute choices that limit environmental damage, except that c_a might provide a price signal discouraging the choice of resources whose exploitation would increase the costs of the producer.

With continuing expansion of output, substitutions, erosion of environmental stocks and absence of other policies, there will be a tendency to continue substitution until Case VI is achieved for all the combinations of environmental resource and technology that can produce the output. At that point activity will be deterred. However, the point of activity deterrence may be delayed if the income constraint is not binding. Output prices may rise (V_a increases) making activity more profitable and providing even more incentive to increase production. This can happen with scarce resources such as ivory, whales, rare birds and animals.

The difficulties with reliance on the price mechanism are summarized in Figure 4.4.

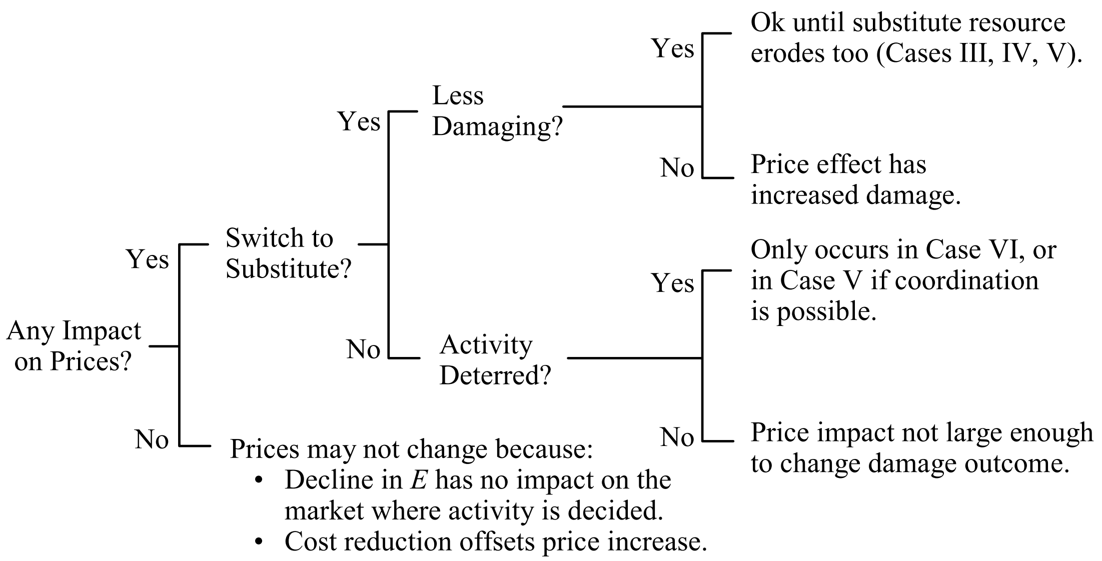


Figure 4.4. Relying on prices to deter damaging activity. E is the environmental stock. Case III is Externality, Case IV is Tragedy, Case V is Prisoner's Dilemma and Case VI is Price.

In response, the proponents of relying on price to address environmental issues (e.g., Lomborg, 2001; J. L. Simon, 1981, 1990) argue that substitutes and technological innovation can continue indefinitely. Barry (1999) is skeptical about uncritical reliance on the potential of technology:

> While there have been examples of successful technological solutions to environmental problems, this does not offer a strong position to suggest that past successes will be repeated in the future to deal with environmental problems of which we are only dimly aware. At the same time, past experience of technological solutions to environmental problems have demonstrated that they often cause other or worse environmental problems. (p. 144)

Coasian Bargains

A Coasian bargain is designed to respond to the externality that arises when one Actor's activity damages the interests of an Other. Coase (1960) pointed out that preventing an Actor's activity would cause economic damage to the Actor's interests, and the aim should be to seek ways to minimize the total damage rather than ways to prevent damage to Others. He cites several examples where the damage done by preventing activity could be greater than the damage done as a result of allowing the activity.

This places Coase's argument squarely into Case III, Externality. Coase's fundamental point is that the Actor engaged in damaging activity may be able to fully compensate the affected Other and still earn a greater reward from the activity than the total costs of the activity. The need to compensate the affected Other arises only if the affected Other has a right to prevent the activity.

There are two reasons why Coasian bargains may not prevent an Actor operating in Case III from damaging their environment. First, and most fundamentally, Coasian bargains focus only on maximizing utilities for the Actors and Others involved. Coase is not concerned with the level of environmental damage that might result from the activity. A successful Coasian bargain may improve the utilities for both parties but lead to an increase in damage. Coasian bargains in Case III may increase the prospects for Actors to damage their environments by enabling damaging activity that might otherwise not proceed.

Coase's proposal can also work for Case IV (Tragedy) or Case V (Prisoner's Dilemma) if Others compensate the Actor for forgoing activity the Actor has a right to carry out. This will work only if either the amount of damage is very concentrated, so that one Other can compensate the Actor for not acting, or if there is coordination among the Others affected to provide the payment to the Actor. The more widespread the eco-cost the greater the number of Others who must be coordinated and the less likely it is that a Coasian bargain can be achieved.

If such a Coasian bargain is struck in Case IV or V there may be a reduction in the amount of damage and improved payoffs, as the Actor forgoes damaging activity. While this is theoretically possible, it is not a perfect remedy because of the danger of strategic behavior on the part of the Actors considering activity. An Actor might develop a variety of proposals for activity only in order to extract compensation from those at risk of damage, and such behavior is likely to be resisted by threatened Others and by relevant authorities. It is hard to identify examples where Coasian bargains have prevented environmentally damaging activity, because those threatened in this way have generally sought remedies other than paying-off the Actor proposing the activity.

The second obstacle to reliance on Coasian bargains, affecting Cases III, IV and V, is that the kinds of environmentally damaging behavior this thesis addresses do not involve one Actor damaging another. Rather they involve large numbers of Actors, each of whose v_a seeking activity causes a small amount of damage to the interests of each of a large number of Others. In such circumstances Coasian bargains are simply impractical because of the transaction costs and coordination difficulties involved. There are few structural impediments to Coasian bargains. Contract law is robust and bargaining is widespread yet Coasian bargains are not being used very much. There are a few examples, perhaps even the purchases of rainforest acreage by environmental activists, but Coasian bargains have had little practical impact in preventing environmentally damaging activity.

Establishing a Property Right

Prices and Coasian bargains do not require any state intervention. Establishing property rights is an intervention that can prevent Case IV (Tragedy) and Case V (Prisoner's Dilemma).

If activity is damaging a shared environmental resource it may be possible to reduce or eliminate the damage by establishing a property right over the resource. The intervention may work because, instead of the Actors and Others sharing the eco-cost, the Actor with the property right gains the incentive to prevent the damage by getting all of the eco-cost and gains the ability to prevent the damage by having a right to control what activity takes place.

		Two	
		No Act	Act
One	No Act	0, 0	-0.75, 0.25
	Act	0.25, -0.75	-0.5, -0.5

Payoffs for One, Two

Figure 4.5. Prisoner's Dilemma. The prize for acting is assumed to be 1 and the eco-cost is assumed to be 1.5. If One acts alone then One's payoff will be 1+(-1.5/2)=0.25. Two will get -1.5/2= -0.75. If both Actors act then each will get 1+(-3/2)= -0.5. Both should act but acting is not in the Actors' economic interests.

To illustrate how introducing property rights can reduce environmental damage, consider Case V where there is activity, with a non-exclusive property right, that is damaging the environment. Consider a game where V_a =1 and C_a=1.5 for each unit of activity. This generates the Prisoner's Dilemma case as shown in Figure 4.5.

In Chapter Two it was shown that there is a good chance that the outcome of this game will be for both Actors to choose to act.

Now consider what happens if One alone is given the property right and receives all payoffs. If One chooses two units of activity the utility will be -1. Choosing one unit of activity provides a utility of -0.5 and choosing not to act provides a utility of 0. Case V has been transformed to Case VI and activity is deterred.

Granting a property right may also prevent Case IV, Tragedy, where activity is in the interests of the Actor but not in the interests of the community. In Case IV the activity proceeds because the eco-cost is shared sufficiently widely that the Actor is not deterred. In some circumstances establishing a property right may mean that a greater share of the eco-cost would accrue to the Actor, possibly enough to deter activity thereby creating

Case VI. In other circumstances the Actor's share of the eco-cost would still be too low to deter activity and the Actor would have the property right but would still engage in activity that damages the environment and the community's economic interests.

In Case IV the eco-cost can be transferred to future generations despite existence of a property right (Pearce, 1998, p. 23). Consider an Actor who is making a decision about an economic improvement that will cause some irreversible damage to the environment. The activity might be an irrigation project, which will double the land's productivity for the first 20 years, until the accumulated results of salination and erosion combine to make the land unproductive. Assume that the hypothetical farmer-actor is aware of the medium- and long-term consequences of the development.

The situation can be illustrated with V_a=v_a=1 for years one to 20 and V_a=0 thereafter; C_a=c_a=0 for years one to 20 and C_a=2 thereafter. With an original payoff of 1 each year, the payoff if the farmer proceeds with the investment will increase to 2 for years 1 to 20 and then reduce to 0 for each year thereafter. The incremental effect of the project will be to increase the payoff by 1 each year for the first 20 years and reduce it by 1 each year thereafter.

Economic actors discount future payoffs. Assuming a typical financial discount rate of 10% and a cost for the irrigation project of 3 the net present value of the project is 4.2. This is made up of the project cost, a positive component of 17.2 for the first 20 years and a negative component of 10 thereafter. It is economically rational for the farmer to proceed with the irrigation project despite its destruction of the productive capacity of the land.

The result is that the farmer can gain the benefit of the development during the period of the farmer's economic life but the economic and environmental damage is exported to future generations. Instead of the farmer bequeathing land with a permanent productive value of 1 per annum, the next generation inherits a desert. This is an example of Case IV, where a property right already exists. It is consistent with observations of the deterioration of privately owned agricultural land reported in Chapter Three (Jackson et al., 2001, p. 1040).

Competition may exacerbate this phenomenon. If other farmers are achieving cost reductions via introduction of irrigation projects or other innovations then prices may drop, leaving the farmer-actor with no choice but to pursue the unsustainable development project.

A property right has no impact at all on Cases II or III. For Case II a reduction of headroom will not be prevented by a property right because, regardless of whether the property right is owned or not, V_a is greater than C_a because C_a=0. The same is true in Case III because V_a is greater than C_a.

Prohibitions, Quotas, and Tradable Permits

Prohibitions, quotas, and permits are designed to limit output by regulation. A prohibition is a special type of quota, where the amount of activity allowed is nil. Tradable permits are another special type of quota, where a market is created in permits to ensure that the restriction on output is applied in the most economically efficient way.

Quotas are effective when a certain amount of use of environmental resources may be acceptable but if use increases beyond a certain point (i.e., $AT_D>R$) then damage will occur. Quotas are used for renewable resources (input or production quotas) or where the environment has a limited, possibly local, capacity to absorb pollution without damage (pollution permits).

Quotas and permits are licenses to use environmental resources or to pollute, which are property rights. Tradable permits are especially popular among some economists because they can limit environmental damage to a desired level and be efficient (Greenwald, 1994, p. 322; Saunders, 1999, pp. 273, 275).

Pareto-efficiency exists when there are no possible trades among market participants that would make both parties to the trade better off without making another party worse off (Samuelson and Nordhaus, 1989, p. 966). Tradable permits achieve this because, if a tradable permit is worth more to another Actor than to the holder then both parties will have an incentive to trade so that the Actor who ends up with the permit or quota is the one who has the greatest net payoff. The amount of damage is held to the pre-determined limit. That is, the tradable permit allows the greatest available total payoff given the policymakers' limitation on damage that determines the volume of permits issued.

Unlike the policy initiatives discussed above, quotas can address Case II as well as Cases III, IV and V. Quotas are likely to encourage substitution, so the net effect on environmental stocks will depend upon which inputs and technologies are used by the substitute. Quotas may be designed to address damage specifically, so they are more likely to be implemented in a way that is sensitive to environmental damage itself, not just to the economic outcomes. They can also be raised or lowered if circumstances change.

Pigovian Taxes

As a damage-preventing policy, a Pigovian tax seeks to remove the incentive to carry out the damaging activity. A tax imposed on the output may deter activity. A tax directly on damage may reduce the incentive to choose the activity, or may create an incentive to find a way to reduce the level of damage without limiting activity or output.

Taxes are especially attractive to some economists because they rely on the profit motive to guide the choice made by potentially taxed Actors between engaging in the taxed activity and so paying the tax, or changing their activities to avoid the tax. Theoretically at least, taxes leave Actors with greater freedom of action than they have with quotas. If it is less expensive to switch to a substitute, or to develop a technology to reduce or avoid damage, then a tax will encourage an Actor to do so.

Imposing a tax addresses Cases II through V, provided the tax is large enough to change the choice by the Actors. If the tax is not large enough to change choices then it will cause an increase in costs, and therefore prices, and the analysis applied to prices above will apply. The result could be that those who can afford the cost of the tax provide revenues to the government, all appears to be well because the polluter is paying, but the damaging activity continues. Schelling (1992) points out that "a carbon tax sufficient to make a big dent in the greenhouse problem would have to be roughly equivalent to at least a dollar per gallon on motor fuel" and that such a tax is unlikely to be ratified by the Senate. A tax low enough to be acceptable would be ineffective as a greenhouse policy (p. 11).

If a Pigovian tax is large then the Actors may have an incentive to cheat. A large tax will only have the intended effect if cultural constraints or effective enforcement prevent cheating.

Between 1987 and 1994 the countries of the European Union introduced many market based environmental policy instruments such as taxes. This was done because of increased awareness of the potential of markets, recognition of the limitations of governments and of command and control systems of regulation, increased concern that existing regulations were not adequately coping with environmental problems, and a desire to have polluters pay for the costs of the damage caused by their activities. Ekins (1999) reviewed the European Union experience with taxes and other market-based instruments, pointing out that they have the potential to replace income or corporate taxes. He also concluded that a desire to avoid eroding the competitiveness of businesses led to a tendency to adopt voluntary agreements or exempt environmentally intensive sectors of the economy, resulting in failure to achieve the original objective of a reduction in damaging activity.

Policy Potential

Figure 4.6 summarizes the applicability of each of these policies that respond to adverse economic and environmental outcomes resulting from activity to the cases identified in Chapter Two.

<table>
<tr><th rowspan="2">Policy</th><th colspan="4">Case</th><th rowspan="2">Conclusion</th></tr>
<tr><th>II
Headroom</th><th>III
Externality</th><th>IV
Tragedy</th><th>V
Prisoner’s Dilemma</th></tr>
<tr><td rowspan="2">Prices, Technology, and Substitution</td><td rowspan="2">No Effect (C_a=0)</td><td colspan="2">Activity not deterred</td><td>Activity deterrence requires coordination, which is usually illegal</td><td rowspan="2">Price deters activity for Case VI</td></tr>
<tr><td colspan="3">May switch to substitutes</td></tr>
<tr><td>Coasian Bargaining</td><td>No Effect (No risk to interests)</td><td>May increase damaging activity</td><td colspan="2">May prevent activity if C_a is concentrated or Actors coordinate</td><td>Not effective for dispersed issues</td></tr>
<tr><td>Establish Property Rights</td><td colspan="2">No effect ($V_a > C_a$)</td><td>Prevents activity if Actor given property right gets a large enough share of C_a</td><td>Shifts to Case VI</td><td>May not be feasible for dispersed issues</td></tr>
<tr><td>Quotas, Prohibitions, and Tradeable Permits</td><td colspan="4">Can prevent activity. May switch to substitutes</td><td>Preferred option</td></tr>
<tr><td>Pigovian Taxes</td><td colspan="4">Can prevent activity but only if large enough. May cause switch to substitutes or development of technology</td><td>If large enough to prevent activity may as well be a quota</td></tr>
</table>

Figure 4.6. Potential for economic policies to reduce damaging activity. V_a is the total prize and C_a is the total eco-cost.

The first conclusion that can be drawn from Figure 4.6 is that the market solutions (prices, Coasian bargains and property rights) are not likely to be effective for dispersed environmental problems. For Cases II and III, where the erosion of environmental stock is not harming community economic interests, the market provides the economically correct solution. However, as shown above, this solution accepts ongoing erosion of environmental stock so that as economic growth proceeds there is a shift to Cases IV and V. The market solutions only work well for Cases IV and V if Actors and Others are concentrated, which is not the case for the dispersed environmental issues that are the focus of this thesis.

The exception to this is property rights, which can be very useful for Case V and for Case IV if the Actor given the property right gets a large enough share of the C_a. This will not always occur and it may not always be feasible to award property rights, especially where damage is caused by widely dispersed activities.

Pigovian taxes only deter damaging activity if they are large enough to reduce v_a below c_a. Variation in v_a and c_a makes it difficult to set taxes at the right level. Despite this, taxes may be useful for Cases II and III because they encourage switching to substitutes and development of technology, which may lead to development in a less damaging direction without deterring activity that is in the economic interests of the community. They may also provide revenue that can be specifically targeted to improving environmental outcomes (Schelling, 1992, p. 14).

Quotas, including prohibitions and tradable permits, are the preferred option. They can prevent activity for all cases and so reduce the need to be sure which case applies when designing an intervention. The policymaker is able to set a quota level and ensure that the targeted level of activity and damage results, whereas for other policies there is a great deal of uncertainty about the outcome, because of variations in V_a and C_a.

Baumol and Oates (1979) examine a wide range of options for policy intervention concluding that "direct controls and regulations…dominate environmental programs in the United States and other countries" (p. 323). This observation is consistent with the practical implications of the analysis here. The issue is whether sufficient regulations are being imposed. Economists, including Baumol and Oates, acknowledge the role of direct controls but would prefer to see a wider range of policies adopted.

Government Response

The argument above establishes that constraints on damaging activity are needed to protect the economic interests of the community in Cases IV and V, and to protect against a risk of environmental crisis in Cases II, III, IV and V. In the absence of such constraints, communities will under-perform their economic potential and may face environmental crisis. It concludes that direct controls, that is, quotas, are the preferred form of regulation, though other instruments can be useful in particular circumstances. The remainder of this chapter will examine the prospects for introduction of constraints on damaging activity, identifying obstacles and examining the roles of governments, businesses and individuals in creating and overcoming the obstacles.

Andrews (1999) lists several reasons why governments have an important role in environmental management including: governments assign and enforce property rights; governments define and enforce the rules of markets; governments protect public health and safety; governments protect environmental assets from tragedies of the commons; governments provide collective goods that markets do not; and government actions have environmental impacts themselves (pp. 1-3). He goes on to conclude that: “questions about the proper management of the environment are fundamentally entwined with questions about the proper ends and means of governments themselves” (p. 4).

Those who seek stronger controls over damaging activity look to governments to be more vigorous in establishing such controls. For example, Woodwell (2002) argues that:

> conservation has become, not the preservation of biodiversity, honorable as that may be, but the preservation of the functional integrity of the human environment. That purpose is the central purpose that we assign to the governments that we establish in democracies to define and defend the public interest. (p. 432)

The need for governments emerges when large groups form. Small groups of actors who can communicate with one another may be able to establish coordination to prevent environmental and other risks without any outside assistance (Axelrod, 1985; Bicchieri, 1993; Olson, 1965; Taylor, 1987). However, when the group is large, communication is difficult, and trust is absent, there is a strong incentive for individual members of the group to pursue their own interests to the detriment of Others. One defector encourages others to defect and coordination is difficult to sustain. In the society Hobbes (1651/1962) described, with limited resources, each individual would attempt to secure as much as possible for themselves. In response to this individuals should form a social contract and agree to pass power to a sovereign who would impose coordination so that individuals’ freedom to act could be constrained in their own interests.

Hobbes was writing during the agricultural era, before the agricultural revolution of the 18th century, when dominant technologies were mature, land in production was limited, and a large investment of labor was needed to bring more, lower quality land into production. Feudal struggles for resources and power had been common in the period leading up to his writing so it is reasonable to expect that the eco-cost was greater than the prize for many decisions about potential activities.

Later, when technological development accelerated, discovery of the rest of the world provided imported wealth, and energy costs declined due to fossil fuels, environmental stocks increased in what are now the developed countries and so the amount of headroom increased dramatically. The need for constraints imposed by governments declined.

Government constrains activity?	**Transition**	**Era**
No	OK	Risk to environment and economy from damage
Yes	Risk to country because of relative economic underperformance	OK

Figure 4.7. Government's activity constraint choice.

The argument is summarized in Figure 4.7. As a general rule, during an era governments must focus on constraining activity, or there is a risk to both economic and environmental outcomes. However, during a transition governments should avoid constraining activity because regulation would lead the economy to under-perform relative to its potential, and there is abundant headroom. More importantly, national economies would under-perform relative to other national economies and countries risk military or economic domination if they fall behind in the race to industrialize (Kennedy, 1987).

Chapter Three argued that the Earth as a whole is in the process of moving from a transition to an era. This implies a need for governments to increase constraints on damaging activity. However, there is a strong argument, established during the transition, that governments should minimize constraints on economic activity. Eichner (1983) summarizes the argument:

> The economic system can be viewed as a self-regulating mechanism, one that requires little or no interference by the government to insure the best possible results. Indeed, government intervention is likely to impair the economy's

> performance since any decisions based on the dynamics of the political system will probably be inferior those made impersonally by the market. From the largely self-regulating nature of a market economy, it then follows that the role of the government in economic matters can, and should, be sharply limited. (p. 236)

Magaziner and Reich (1982, p. 331) claim that many people believe that economic problems arise from too much interference in the market and that there should be less rather than more economic intrusion. If there is a strong belief that governments should intervene less, combined with a need for governments to intervene more, then a political contest will be needed before governments can fulfill their role of constraining damaging activity.

Government Leadership

The rulers envisaged by Hobbes were not followers because they did not need to submit themselves for election and they often had a great deal of power, so they could afford to act as leaders. This is not to say that there are no leaders among modern governments, nor to say that modern governments have not been prepared to show leadership at times, even when re-election prospects were threatened as a result. The argument is that in modern circumstances there is a tendency for governments to be followers rather than leaders.

In modern plutocracies governments must offer themselves for re-election every three or four years. Politicians gain their consumption opportunities and self-esteem from their success in election contests, so are highly motivated to win elections. Media and polls ensure that ideas that are of interest to the electorate are widely discussed and that politicians have the opportunity to understand the views of the electorate. In these circumstances a politician may have to choose between following public opinion to win the approval needed for election, or leading public opinion and taking the risk that the electors will not follow. Most politicians are clever enough and self-interested enough to take the role of followers on most important issues (Stimson, Mackuen and Erikson, 1995).

So if governments are not the leaders in our modern societies then who is? Note that the focus of the question is leadership on issues that are relevant to managing the economy versus environment trade-off.

Businesses provide a great deal of leadership of the management of the trade-off between economic and environmental objectives. Like other actors, businesses act in their own self-interest. As shown above, businesses will be quite happy to support the environment provided it is profitable for them, but in win/lose games, where a choice must be made between economic and environmental outcomes, businesses should seek their economic goals at the expense of environmental goals.

Economic man only gets utility from economic outcomes. Real people have more diverse motivations. In contrast businesses really are like economic man; motivated only by profit. The need to satisfy capital markets and discount rates mean non-economic outcomes and outcomes more than a few years in the future are not important to businesses.

Business Opposition to Regulation

If environmental stocks, for example, water supplies or pollution sinks, are provided free to the market then those stocks are likely to be used in preference to labor or industrial capital to avoid financial costs. The result may be that depletion of the stock is detected, leading to an attempt to introduce policies to constrain the damage. However, when an Actor is gaining free use of an environmental resource that has become scarce, and there are moves to limit that use, the Actor is likely to resist the policy.

Quota or tax policies to limit environmental damage may harm businesses in one or more of four ways. First, current or potential volume of business may be limited by the policy. Second, businesses may need to increase investment in pollution abatement or resource use efficiency to maintain volume or growth given the restrictions imposed. Third, businesses may have to pay taxes or purchase permits or quotas. Fourth, if businesses pay for capital equipment or for quotas they will have an increased asset base but competitive conditions may prevent them from earning any extra income to provide a return on the increased investment.

This section examines the impact that constraints on damaging activity would have on profit-motivated businesses. The potential for opposition that might delay or prevent policy introductions motivates consideration of the ways that policies might differ in their impacts on business Actors. Choosing policies that are less likely to be opposed increases the likelihood of being able to implement constraints without delay. The examination of policy potential showed that policies that rely on the market are unlikely to be very effective for environmental issues that involve dispersed eco-costs. Therefore this section will focus on the likelihood of business opposition to quotas and taxes. It is assumed that policymakers wish to achieve a reduction of damaging activity and that the amount of reduction desired is known from scientific and policy analysis.

For Cases II through IV both quotas and taxes will be opposed by businesses because in all cases the prize for the Actor is greater than the eco-cost so the policy will prevent businesses from carrying out profitable activity.

For Case V, quotas will be in the interests of actors because the prize is less than their share of the eco-cost and competition law will usually prevent them from agreeing to reduce production. An example of this is introduction of quotas for a fishery with depleted stocks. Current participants may agree to volume restrictions because each recognizes that without volume restrictions they will all get reduced payoffs.

Quotas may be easier to implement than taxes (Congleton, 1996, p. 36; Connelly and G. Smith, 1999, p. 174). Quotas are widely understood and can be established independent of market forces and economic factors. However, they may not be the most cost-effective method. They do not provide an incentive for initiatives to do better than the targeted level of damage, and they may be difficult to enforce (Connelly and G. Smith, 1999, p. 173).

Governments may be attracted to taxes to increase revenues and because the tax creates an incentive for businesses to innovate to do better than the targeted level of damage. Taxes have three important drawbacks that may increase business opposition to their introduction. First, a tax that prevents a targeted amount of activity will still be paid on the remaining activity (Congleton, 1996, p. 21).

The second drawback of taxes is that they may be imposed by national governments on businesses that are exposed to international competition. Unless taxes are uniform across countries, a business that is taxed will be disadvantaged relative to competitors who are not taxed. The result may be closure of the taxed business and migration of activity to untaxed businesses in other countries (Ekins, 1999, Pt. 4.1). Quotas may not produce this undesirable result because in some industries it is possible to withdraw high cost capacity without damaging the competitive position of the capacity that remains.

All of these impacts will be worse if they are not also imposed on competitors. The result can be a Prisoner's Dilemma where each country avoids tough environmental standards, fearing the flight of capital abroad and the loss of national economic competitiveness (Bennett, 1999, p. 196).

The third drawback of taxes is that it is difficult to anticipate the tax level that will produce the desired reduction of damaging activity. A tax that is set too high will discourage activity that governments have decided is acceptable and will impose an unnecessary additional cost on activity that continues. Business lobbying to avoid the tax or to reduce its size may lead to taxes that are too low to produce the targeted reduction of activity. Governments may have an incentive to accept a tax that is too low because they gain revenues and the tax may be easier to implement. It is difficult to set the tax just right. Taxes can be reset but there is a risk that politics and economics will determine the level, rather than the environmental risk that motivated the intervention. Further, if businesses are exposed to international competition it will be difficult to set the tax rate higher than it is in other countries.

Three conclusions can be drawn. First, profit-motivated businesses are likely to oppose the introduction of quotas or taxes, except in Case V where intervention may be in their interest. Second, businesses have an incentive to lead governments to prevent policies that will reduce their profit. Third, taxes are likely to be opposed more than quotas, for a given target volume impact.

Business Actors that are opposed to introduction of a policy to protect environmental stocks are in a strong position to lobby policymakers. They may be highly motivated. A permit scheme, tax or regulation may have a material effect on an Actor's business economics, threatening profits or even the viability of the business. They may have access to resources to commission research, fund lobbying, influence policymakers by making contributions to political parties or individual politicians, and conduct media campaigns. Business leaders have access to policymakers and politicians. Through industry associations, threatened businesses can combine their resources to have greater effect.

Schmidheiny (2002) argues that the effectiveness of businesses in ensuring their freedom of activity is becoming a cause for concern

> Alert citizens begin to question with growing concern whether these processes are still socially controlled or even controllable. Is it practical and feasible for our society and the government institutions acting on its behalf to monitor processes of business innovation for their compatibility with basic ethical standards?…Globalization is another cause for concern in that businesses could escape government controls, and consequently social oversight, since politics and legislation and application of the law are still the primary responsibility of national governments, even in this age of globalization. There is little that nation states can do to control international activities compared with dynamic and powerful companies. (p. 322)

Congleton (1996, p. 219) points out that businesses locate where opposition to their activities is least effective while Beck (1995) points out that the activity that causes concern is difficult to prevent because everyone is already doing it. No one can be blamed, no one should be expected to stop, and it cannot be a crime.

Impact of Business Opposition

Business opposition to efforts to constrain damaging activities is very effective. This section reviews the impact of business opposition and assesses overall risks to the regulatory response. Failure to overcome business opposition to policy introduction has important consequences. Three will be briefly discussed: implementation failure or delay, weaker policies, and misdirected technology. The last part of the section reviews assessments of national environmental policies and considers the prospects for governments to introduce effective damage constraining policies.

Opposition to regulatory policies may lead to implementation failure or delay. Emergence of scientific evidence implying the need for a constraint on business activity sometimes stimulates competing scientific studies that counter the initial findings or increase uncertainty. In consequence, policies may be introduced in response to evidence of an emerging crisis rather than in anticipation of damage. Fishing and species protection are examples. Fish stocks are usually plummeting and causing economic hardship before permit policies are introduced. It is only when fishing interests themselves are threatened that action is taken. Similarly, species must be endangered and the population must be aroused before protection steps are taken. Well-managed organizations do not operate in this way; they seek to anticipate risks and control their futures.

Connelly and G. Smith (1999, pp. 160-161) point out that regulators can be captured by industries as a result of the circulation of personnel. Relationships that are too close encourage a soft approach to anticipatory regulation. The resulting delays may mean that businesses are constrained only after the damage to the environment has been done.

Opposition may also lead to policies that are weaker than what is needed. Kaimowitz and Segura (1996) reviewed the lessons from environmental reform efforts in Costa Rica. They concluded that

> when government has really been interested in ensuring significant results within a short time period it has tended to use subsidies, taxes and restrictions. However, when there has been only a weak interest in making serious progress it has relied almost exclusively on educational activities and persuasion. (p. 451)

Howlett (2002) reviewed the evolution of environmental policy in Canada and concluded that institutionalized voluntarism is used when the issues are large and constraints are high (p. 29). If the lesson from Costa Rica is correct this would be relatively ineffective. Howlett reported that efforts to replace regulation with market and tax-based financial incentives and to promote industry self-regulation have been unsuccessful. Lack of fiscal capacity led to failure to implement incentives. The self-regulation approach "to do more with less" emerged, but "very few of these arrangements were ever created and the difficulties in assessing their impact and efficacy, as well as legal issues concerning their status vis-à-vis existing laws, have led to few recent efforts towards their expansion" (pp. 36-37).

Bulkeley (2001) examined Australia's response to climate change concluding that "the dominant resource-based coalition has sought to restrict the intervention of the state in determining climate responsibilities though regulatory or fiscal measures by promoting voluntary measures" and that "the resource-based coalition, including state and non-state actors, has sought to channel the influence and control of the state to serve their interests" (p. 443).

Business interests opposing regulation may weaken policies by proposing voluntary constraints or self-regulation. If businesses expected voluntary constraints or self-regulation to limit their activities as much as regulations would, then efforts to establish voluntary constraints would not be worthwhile.

A third consequence of opposition is misdirection of technology relative to what would be optimal with effective management of the trade-off between economic and environmental outcomes. From an environmental point of view, good technologies are those that lead to reduced damage and larger environmental stocks. Economically good technologies lead to increased economic output for a given amount of economic input. Profit potential alone provides a strong motivation to find economically good technologies but there is no comparable mechanism to encourage adoption of environmentally good technologies. Lafferty and Meadowcroft (2000) report that governments of the major developed countries are unwilling to confront domestic opposition or to commit the financial resources to support technology transfer to developing countries. They report that governments "routinely note their hands are tied because the relevant technology is owned by the private sector" (p. 437).

Opposition to policies is not the only obstacle to implementation of effective constraints on damaging activity. Ineffective bureaucratic processes may also impede regulation. However, if businesses were supportive of policy changes to constrain their activities then one would expect that damage reduction policies would be widespread and effective.

One way to assess the overall progress toward effective constraints on damage is to review the reported progress of countries. Lafferty and Meadowcroft (2000, pp. 415-417) assessed the response of countries to environmental challenges. They described the Netherlands, Norway and Sweden as *enthusiastic*: consistent efforts to develop a new paradigm for environmental policy and an emphasis on international environmental diplomacy, and solidarity with developing countries. Australia, Canada, Germany, Japan, the United Kingdom and the European Union were described as *cautiously supportive*: official support for sustainable development as a national and international goal but an uneven pattern of initiatives. The USA was described as *disinterested*: sustainable development largely understood as a problem for the developing world and sustainable development not taken up by key government agencies.

Andrews (1999) provides an historical explanation for the US stance:

> Throughout American history, the United States' dominant policies have been to promote the economic exploitation of natural resources, beginning with the seemingly inexhaustible abundance of the North American continent and expanding more recently – through the economic power of transnational corporations and capital markets – to include the accessible assets of the entire planet. The United States has not been unique in this: European trade and

colonization began it, and most other governments have done likewise. But as the world’s largest single market for material and energy resources, and a leading exporter of both production technologies and consumer lifestyles, its policies have been prominent influences and are central to any solution. (p. 353)

Despite these mixed stances, the scorecard for these developed countries is not impressive. Lafferty and Meadowcroft (2000) report that the Dutch and the Germans are falling back from prior commitments (pp. 169, 430); that in most developed countries total greenhouse gas emissions increased between 1990 and 1997; and that per capita greenhouse gas emissions also increased, although emissions per unit of GDP have fallen (p. 403). Most of these countries failed to meet the United Nations Commission on Environmental Development (UNCED) objective of stabilizing emissions by 2000 (p. 439).

Kaimowitz and Segura (1996) concluded on the basis of their research in Costa Rica that “environmental policies which threaten key economic sectors are unlikely to be adopted, even when interest groups apply substantial pressure to do so” (p. 451). Indications are that this conclusion could be applied equally to other developing as well as to the developed countries. Beck (1995) states the conclusion more dramatically, claiming that “the regulating system for the ‘rational’ control of industrial devastation is about as effective as a bicycle brake on a jetliner” (p. 2).

The evidence seems to indicate that, despite widespread efforts to reduce damage, business interests are able to exert sufficient power to enable them to continue with a close enough approximation to business as usual to allow large-scale damage such as greenhouse gas emissions to continue. Under the circumstances, it would not be wise to simply rely on governments to respond effectively to the challenge posed by the risk of environmental crisis. In *The March of Folly* Barbara Tuchman (1984) investigated the causes of important follies in history: failures of leadership to respond effectively to critical challenges. She describes best practice:

> the overall responsibility of power is to govern as reasonably as possible in the interest of the state and its citizens. A duty in that process is to keep well

> informed, to heed information, to keep mind and judgment open and to resist the insidious spell of wooden-headedness. If the mind is open enough to perceive that a given policy is harming rather than serving self-interest, and self-confident enough to acknowledge it, and wise enough to reverse it, that is a summit in the art of government. (p. 32)

Having examined several historical instances of folly Tuchman concluded that governments fail frequently and that when they do:

> in the first stage, mental standstill fixes the principles and boundaries governing a political problem. In the second stage, when dissonances and failing function begin to appear, the initial principles rigidify. This is a period when, if wisdom were operative, re-examination and rethinking and a change of course are possible, but they are rare as rubies in a backyard. Rigidifying leads to increase of investment and the need to protect egos; policy founded upon error multiple, never retreats. The greater the investment and the more involved in it the sponsor's ego, the more unacceptable is disengagement. In the third stage, pursuit of failure enlarges the damages until it causes the fall of Troy, the defection from the Papacy, the loss of a trans-Atlantic empire, the classic humiliation in Vietnam. Persistence in error is the problem. (p. 383)

Tuchman's work implies that it may be difficult to get the current generation of leaders, who follow the dominant paradigm, to rethink their positions. A more promising approach may be to provide them with stronger incentives to encourage introduction of damage constraining policies and with resources to make policy introduction easier.

Leading Governments

The argument above establishes that governments are responsible for the introduction of regulations to prevent damaging activity but that governments may be led by profit-motivated businesses that are, in the logic of the dominant paradigm, opposed to regulation of their damaging activities. If governments can be led to prevent introduction of regulations then it must also be possible to lead them to introduce regulations.

The widely held belief that government intervention in economic activity should be minimized is an additional obstacle to policy introduction (Magaziner and Reich, 1982, p. 331). Outcomes to date are at best mixed and there is no reason to be confident that they will improve if the Earth's leadership continues with business as usual. If these were the only forces affecting the outcome then it is unlikely that effective constraints on damaging activity could be introduced.

Scientists have identified damaging activity and pointed out that unless current trends are changed there is a risk of environmental crisis. Ecological economists and others have responded to the scientific findings and assembled arguments supporting greater government intervention. Individuals are affected by this new information and have become very concerned about environmental outcomes. They have formed Green political parties and activist groups that join with scientists and some economists in calling on governments to take more action. These groups promote constraints on damaging activity and combine to counter the efforts of profit-motivated businesses to resist constraints.

The result is that businesses and their organizations line up against individuals and their organizations in a contest to lead governments. Outcomes will depend on the strength of influence of those whose interests are threatened by the policies versus the strength of influence of those who wish to see damage constraining policies introduced.

Widespread acceptance of sustainable development has led to it being used by governments, businesses and environmental groups to forge close links between economic and environmental concerns (Lafferty and Meadowcroft, 2000, p. 48). Sustainable development has the advantage, from the environmental perspective, of being a principle that forces consideration of environmental issues.

The policymakers who must decide are influenced by their starting paradigm, which is likely to be the dominant paradigm, and by the forces exerted by the two sides. Their decisions may be affected by the likelihood that any costs arising from their decisions are likely to be incurred early and imposed on organizations with the capacity to fight back, whereas any benefits are likely to occur later and be widely dispersed among people who may not appreciate them. Policymakers may have personal incentives to favor policies that provide near term benefits for those who are important to them but have widely dispersed costs in the more distant future (Ozonoff, 1999, pp. 102-103).

Forces opposing regulation can mount a variety of strategies and arguments. Beck (1995) points out that the way environmental issues are described and communicated can assist opposition to policy introduction. He identifies two stages in ecological conflict. In the first the threats are identified and acknowledged. In the second, when the threats have become established everyone seeks to avoid accountability by placing themselves on the good side: "a policy of lip service to ecology becomes indispensable" (p. 9). Beck also says that "the surplus of possibilities for doom permits one to play a game of transpositioning in the public dramatization of risks, a game in which someone else's blacker black can whitewash one's own black" (p. 8). He also illustrates the way dialogue about over-abundance of pollutants can be converted into a need for more products by noting that forest destruction in Germany can be described not as a result of speed, trucks or coal-fired power plants but rather the lack of catalytic converters on cars. He concludes that scientific language can be used to "set the switches for social (in)action" (p. 11).

Access to policy forums may be provided preferentially to business interests. For example, Lafferty and Meadowcroft (2000) reported that the Australian Bureau of Agricultural and Resource Economics offered seats on its Board to any organization that contributed $A50,000 and that major corporations were heavily represented but environmentalists were not (p. 43).

Having access to financial resources also provides business interests with the opportunity to influence decisions directly. Congleton (1996) reports that campaign contributions by environmental and anti-environmental interest groups affect voting by politicians. Business interests may also gain advantage by being able to mobilize skilled researchers and advocates (p. 18). Foreman (2002) reports that citizens who get involved in contests to lead governments may be less skilled, and often are unpaid (p. 164).

One particular argument by actors threatened with policies that would prevent activity is especially powerful. Utilities for individuals are, in general, threatened by declines in GDP per capita that could be mediated by reductions in V_a through restrictions of activity or imposition of taxes. When actors argue that a policy is bad for business policymakers must take note because most individuals understand that their own utilities are threatened if the incomes of businesses are threatened. The presumption that governments should avoid constraining the profit-making activities of businesses increases receptiveness to this argument.

A few important individuals have interests that encourage them to behave like businesses in the contest to lead governments. Some very powerful and influential people are in positions where they are gaining a great deal of utility from the value created by businesses. Those few individuals have a greater disincentive than most to encourage choices that promote environmental outcomes at the expense of utility derived from business profits. Poor people who may have less to lose from looking after their environments are also likely to have fewer resources and less influence. This effect occurs both within countries and between countries.

Other arguments that reduce the response to damaging activity are that humans are adaptable and so will find solutions to environmental issues, and that the discovery of new technologies will allow the consequences of current damage to be managed in the future. Davidson (2000) highlights what he calls "three fallacies of the current mainstream economic and technological model" that are used to "avoid the responsibility of being prudent stewards of our natural resource endowment" (pp. 7-11). The first of these is *Marie Antoinette Economics* where environmental outcomes are ignored. He uses as an example an economist who argued that there is little need to worry about climate change because agriculture only represents a very small component of the US economy. Davidson points out that people can only eat food so agriculture needs to be protected as a separate goal from output. The second fallacy he calls *Custer's Folly:* the expectation that technological developments will save humanity by allowing development of substitutes for damaged or depleted resources may not apply to essential natural resources such as air, fresh water, oceans, forests and eco-systems, at least for the critical next few decades. The third fallacy is *Not Beating the Wife as Much as Before* which is where successes in environmental protection are used to support the conclusion that enough is being done.

The argument that nature will take care of us would have been advanced in the past but there seems to be widespread recognition now that environmental issues are important challenges that must be managed by people, and high levels of environmental consciousness are revealed by surveys (e.g., Richardson and Rootes, 1995, p. 249). Wapner (1995) reports that a survey in the USA in 1990 found that 74% agreed that protecting the environment was so important that "requirements and standards cannot be too high and continuing environmental improvements must be made regardless of cost" (para. 24).

Organizations of individuals have been developed to encourage the introduction of regulations and other initiatives to improve environmental outcomes. Green parties have gained an average of almost 5% of the vote in European elections they have contested and have secured ministerial posts in five European countries (Müller-Rommel, 2002, pp. 5, 7). While developing their political strength the green parties were able to take positions opposing dominant economic interests but once they gained power the Greens needed to compromise with coalition partners (Müller-Rommel, 2002, p. 10). Poguntke (2002) argues that the Greens had very little success in their core objectives, most notably their opposition to nuclear power (pp. 141-142). Further, they had to establish policies in a range of non-environmental arenas, while competing parties developed environmental policies, so that there is a risk that the electorate perceives the Greens as not being distinct from other parties.

Activist groups have also been developed to channel the desire of individuals to promote better environmental outcomes. Wapner (1995) reported that international activist organizations have affected outcomes on a wide range of environmental issues by influencing government policy, constraining businesses, and supporting and empowering local community efforts.

Existing initiatives by organizations of individuals have had important impacts by raising awareness of environmental issues, getting environmental issues established on domestic and international political agendas, and getting some damage reducing policies introduced. However, green political parties and activist groups are constrained by the need to broaden their agendas and compromise their opposition to business interests in order to grow their support. In doing this the organizations reduce their differentiation from other organizations, risk losing the support of their original members, and limit the impact they can have on environmental outcomes.

Despite this limitation of organizations, it is vital to recognize that individuals have immense latent power to influence governments. Stimson et al. (1995) examined the impact of public opinion on government policy in the US. They concluded that politicians monitor opinion polls and translate large-scale public opinion changes into large-scale policy changes very rapidly. This finding implies that if mass public opinion shifted strongly to support environmental objectives then governments would follow the lead.

The conclusion that influencing mass public opinion is the best lever to lead governments is supported by Foreman (2002), who states that "the government could not be relied on to achieve protection unless aided by an empowered and attentive citizenry" (p. 148). Andrews (1999) agrees: "The enduring challenge for American environmental policy, in short, is to build and maintain public support for effective governance of the environment: for managing the environment by managing ourselves" (p. 372).

However, there is less evidence that government can lead public opinion effectively, so it would not be wise to rely on environmental policymakers to lead opinion so that the citizenry can then lead other policymakers. Stimson et al. (1995) did not find evidence that opinion responded to policy (p. 559). L. R. Jacobs (1992) reported that internal competition within government limited the development of apparatus for manipulating the public, though he did note, with concern, that constraints on government leadership of public opinion might erode, creating the potential for future manipulation (pp. 212-213).

In conclusion, when business interests are powerful enough, and individuals do not oppose them effectively, businesses are likely to delay, dilute, or prevent the introduction of regulations that threaten profits, leading to continuing stock depletion. Despite the difficulties, governments are responsible for ensuring that the trade-off between economic and environmental objectives is managed effectively and it is important to find a way to mobilize them more effectively. If pursuit of economic outcomes is creating a risk of environmental crisis then remedying this situation is one of the most important roles for governments. Governments will follow individuals if individuals want environmental damage reduced because governments respond to public opinion.

Government Effectiveness

Changing mass public opinion so that individuals lead governments may be a necessary condition for implementing regulations to limit damage and to shift the mix of technologies, but it may not be sufficient. Governments must also establish policy and implement the changes. Organization effectiveness is a very large topic and only a few observations will be offered here.

The contest to lead governments will be resolved in the political arena: "In the end, whether public policies exacerbate or moderate the relationship between politics, pollution and prosperity reflects the political balance between the interests of individual voters and the pressures of economic and environmental interest groups" (Congleton, 1996, p. 27).

Governments have a responsibility to be effective referees in the contest. This means ensuring that the issues are recognized, that appropriate institutions are established to ensure that the trade-offs between economic and environmental objectives can be managed, and that those institutions are effective in formulating, implementing and enforcing policies.

Getting the issues recognized means acknowledging: the risk of an overshoot crisis and the importance of managing ecological resources; the need for a shift in the mix of activities and technologies in both developed and developing countries; and the inevitability of political conflict that will lead to removal of existing rights to damage the environment. Governments will need to reconcile the competing interests to get the best outcomes available and should prepare all parties to expect that the result is not likely to be a continuation of business as usual.

Opschoor (1996) explains intervention failures as resulting from rigidities due to entrenched division of labor between administrative organizations, insufficient integration between agencies and departments, lack of instruments or mandates sufficiently strong to achieve policy objectives, and lack of instruments or powers to ensure policy implementation within the economic processes (p. 333).

Existing government institutions have been established to manage in circumstances where economic growth is the primary objective and there is a conflict between the interests of the constrained resources, capital and labor, to appropriate the rents resulting from the growth. As environmental constraints have emerged, environment ministries and departments have been added to the apparatus of governments. However, van der Straaten (1998) states that: "in many cases the short-term interests of labour and capital are barriers to the implementation of environmental policies. An institutional basis is lacking in Western countries for the discussion and solution of the distributional effects of environmental policies" (p. 82). For example, there is no forum to decide which economic activity improves well-being and which just grows GDP, how much damage reduction could be gained by shifting the mix of activities and technologies, who will gain and who will lose as a result of mix changes, and how mix changes could be effected.

Kaul et al. (1999) suggest that reform of current institutions needs to ensure better North-South representation in governance of international organizations, forums that include transnational organizations of individuals alongside governments and businesses, an actor such as a United Nations institution that can represent future societies, and inclusion of appropriate disciplines and stakeholders in issue oriented international organizations (p. xxxi).

The institutions developed will need to include staff from a variety of disciplines, working together to develop plans that have economic, environmental and social objectives. They will need to have agreed criteria to develop recommendations and make decisions on issues where the science may remain uncertain. This implies a larger role for governments in economic planning, required because unconstrained market activity will lead to ongoing damage, as shown in Chapters Two and Three.

Beck (1995) proposes several institutional changes that would discourage damaging activity. He argues for: changing the burden of proof so that businesses must justify their activities rather than beginning with a presumption that a business has a right to operate, requiring insurance of the risks of new technologies to reveal that many are uninsurable, and ensuring that those who cause damage are liable to affected parties for the damage caused, using as examples polluter compensation of tourist enterprises and local population (pp. 5-6).

These initiatives have disadvantages that would need to be overcome. Changing the burden of proof could be weakened by capture of regulators. Insurers have responded to the uncertainty of environmental risks by shifting coverage from activities carried out during the insured year to covering damage discovered during the insured year, thereby avoiding exposure to and coverage of distant uncertain risks (Bennett, 1999, pp. 192-193). Businesses can avoid liability by establishing shell companies. Bennett reports for example that the average fleet size for oil supertankers is 1.7 (p. 198). Congleton (1996) summarizes the situation

> Proposed institutional reforms should analyze incentives for the exercise of undesirable and desirable discretion along the chain from voters to final environmental policies. Not all institutional or rule changes are politically, legally, or behaviorally feasible. Would that we all simply did what was best in all circumstances. (p. 26)

Government institutions would need to operate very effectively to accomplish the transformation that would be required. Walters (2002) examined the characteristics of public service organizations that were successful innovators. Fitz-enz (1997) assessed the characteristics of the best human asset managers and Kotter (1998) summarized the reasons why efforts to transform organizations frequently fail. There is considerable overlap among the prescriptions of the three authors and their recommendations have been used to identify ten best practices summarized below.

The first requirement for organization success is to have a vision or strategy, communicate it, and remove obstacles to it. Andrews (1999) says that there is a lack of vision currently: "What is missing from American environmental policy today is a coherent vision of the common environmental good that is sufficiently compelling to generate sustained public support for government action to achieve it" (p. 371). Costanza (2000) goes further: "The challenge for the current generation of humans is to develop a *shared* vision that is both desirable to the vast majority of humanity and ecologically sustainable" (para. 7).

The second requirement is to create a powerful guiding coalition. The scientists and others who warn of danger, the Green political parties, environment ministries, activist groups, and concerned individuals have not formed a coalition and would arguably not be very powerful if they did so.

The third requirement is to establish a sense of urgency. Walters (2002) reports that innovation can be inspired by frustration with the status quo, a response to crisis, a new emphasis on prevention, a new emphasis on results, adaptation of technology, or a moral imperative (p. 18).

Successful organizations ensure that the people in the organization can carry out their tasks effectively. The fourth requirement is to develop a diverse workforce, train them, dedicate resources to innovation, support innovation, recognize that change is risky, and reward individuals who lead change. Ensuring that there is a focus on results, on adding value and on striving for improvement further enhances performance.

The fifth requirement is to ensure that resources and budgets are sufficient to meet the challenge. This would include resources for enforcement.

Sixth, effective internal and external collaboration is important. Trust among stakeholders is important but difficult to establish. Foreman (2002) summarizes the challenge:

> Pervasive mistrust and disagreement face anyone aspiring to reform environmental policy. Environmentalists disparage the credibility of self-interested "polluters," and businesses despair of satisfying the environmentalists' demands, which they often perceive as profoundly unreasonable. Everyone is suspicious of environmental agencies, and the agencies themselves often display tension across the state-federal divide. (p. 146)

Seventh, base action on analysis. Analysis is the key to resolving disagreements. If each party can agree to the principles established in the guiding vision then analysis may reveal a solution that is satisfactory to all parties or at least clarify the issues that need to be negotiated or arbitrated.

Eighth, even if those affected by regulations are not involved in policy development it is valuable to involve them in implementation. Touratzky, Fergus, Avellar, Fairweather, and Fleisher (1980) found that perceived participativeness, involvement in decisions and establishment of peer networks led to more effective adoption of a social innovation (pp. 20, 201, 206). In a developing country context Montgomery (1988) concluded that participation in implementation provides easier access to local knowledge, more powerful motivation, better communication, and increased community solidarity (p. 24).

The ninth requirement is to create short-term wins and ensure that changes are consistent with the organization's culture, and the tenth is to avoid the temptation to declare victory too soon.

The development paths of the developing countries will have an important impact on environmental outcomes. However, developing countries may put more importance on economic outcomes and less importance on environmental outcomes than the developed countries. Some developing countries use international environmental processes as a lever to extract better treatment from the developed countries while emphasizing that shifts in their domestic development trajectories are not up for discussion (Lafferty and Meadowcroft, 2000, p. 438).

Developed countries have strong influence over the development of the developing countries through bilateral relationships, international institutions, technology transfers, trade and media. The development process in these countries can be changed by altering the way they are influenced as well as by domestic policy initiatives. The change process may be complicated by the diversity of cultures that must be influenced, by issues with corruption in many countries, and by capability limitations of incumbent bureaucracies.

Conclusion

Previous chapters showed that existing trends may create the risk of an overshoot crisis. This chapter argues that understanding the crisis potential requires developing information to reduce uncertainty about the trends and options, assessing the likely outcomes from expected damage, and being prepared for the possibility of unexpected outcomes, or surprises. Responding to the risk of crisis may include taking precautions to avoid risks where there may be low expected probabilities but high uncertainty and potentially catastrophic consequences.

The risk of crisis means that decisions about damaging activities cannot always be assumed to be independent of one another. A decision about one Actor's damaging activity may be made taking account only of the marginal costs and benefits of that activity. However, when one billion actors are acting, the decision should no longer be made at the margin.

Businesses develop and sell the products and services that require or enable activities that cause damage. The current dominant belief is that businesses should be left alone to maximize value for shareholders. This belief has been useful during the early and middle stages of the transition when the economy-environment interaction was most likely to be in Cases I, II or III and there was no threat of environmental crisis. However, it is not valid for economic outcomes in Cases IV and V or if there is a risk of environmental crisis. In these circumstances constraints on damaging activity by businesses are important to protect the interests of the community. The idea change implied is a belief that constraints on business to protect community economic and environmental interests should be regarded as desirable.

Three arguments for allowing business to continue with business as usual were examined: win/win, social responsibility and aligned interests. All three arguments were rejected, implying a need to constrain damaging business activity.

Reviewing the policy options available to constrain damaging business activity reveals that relying on market solutions is not likely to be very effective for the kind of damage being considered. Quotas and taxes have useful potential, and quotas are the preferred policy because they are easier to set at the right level and for a given volume impact they are less likely to be resisted.

Policy responses are likely to be delayed by scientific uncertainty, by the time needed to convince policymakers, and by the time taken to overcome opposition to the policies. Governments are responsible for introducing policies to constrain damaging activities but business interests are powerful and will oppose regulations that threaten profits.

Businesses are motivated to lead management of the trade-off between economic and environmental objectives. They are concerned about economic outcomes for themselves, but are unconcerned about environmental damage, except where it affects their own economic outcomes. Businesses also have a good understanding of their own interests, have access to resources and are well organized, both individually and in lobbying groups, and it is this that allows them to exercise leadership on trade-off management issues. In most countries businesses are also able to fund political parties and individual campaign efforts which helps get their views considered by politicians.

Businesses have been sufficiently successful in protecting their interests that the aggregate effect of their activities is that limited progress is being made in reducing damage. In these circumstances governments cannot be relied upon to introduce regulations to prevent damaging activities.

Governments should not be expected to lead change but they should ensure that they are prepared for emerging challenges. This means ensuring that governments are equipped to recognize issues as they emerge, that they establish appropriate institutions, and that government organizations are effective.

The lack of leadership from governments creates a challenge for our societies. Shmidheiny (2002) observes:

> If development must not be allowed to proceed uncontrolled, and effective government controls are not guaranteed, then the question inevitably becomes one of new control mechanisms. The demand for personal responsibility for entities that, uncontrolled, are allowed to pursue their own interests because they are uncontrollable seems either idealistic or fatalistic. However, it is increasingly clear that in a modern, highly complex industrial society, this regulation is becoming an indispensable instrument of control. (p. 324)

If controls over damaging activities are needed then they will only be introduced if individuals provide sufficient leadership to governments to change the balance of forces determining policymaker choices. As van der Straaten (1998) says:

> The implementation of the strict norms which are the effects of the sustainable development approach will be attacked by all polluting industries. This implies that the realization of sustainable development can only be realised after an [sic] long period of political struggle. (p. 81)

An important conclusion from this research is that only individuals have both the potential ability and the potential motivation to change the direction of government. Söderbaum (1998) notes

> there is no reason to exclusively blame "the government" for "no action" or "slow action." It is only to the extent that environmental values are adopted or

> "internalized" by ordinary people and by public actors that things will begin to happen. (p. 100)

The purpose of the next two chapters is to show how mass public opinion can be changed so that individuals can lead governments to regulate to reduce both damaging activities and the use of damaging technologies. The kinds of changes proposed are likely to happen naturally and as a result of other initiatives but the objective is to find a way to intervene so that the rate of change is accelerated.

One of the arguments used to play down the risk of crisis is that humanity will respond to prevent the crisis. This argument is valid but only if it leads to individuals actually responding. If the argument leads to a passive conclusion that others will take care of the issue then the argument will become self-refuting (Gewirth, 1973, p. 126).

Chapter Five examines the motivations of individuals. The dominant paradigm assumes that individuals are only motivated by utility from consumption. Broader motivations are required to allow the kinds of individual pro environment activities that could reduce the risk of crisis. The chapter introduces a revised model of the individual that is consistent with relevant theoretical understanding and empirical observations, and introduces broader motivations.

Chapter Six develops a strategy to encourage individuals who have the broader motivations introduced in Chapter Five to lead governments, to change their own behavior, and to engage in other pro environment activity such as encouraging businesses to be socially responsible.

CHAPTER FIVE

ECONOMIC MAN OR ECOLOGICAL INDIVIDUAL?

For ideas to be viable, to have significance,
they obviously must be transmitted as well as developed.
- John Henry, 1990, p. 4

Introduction

Chapters Two and Three argued that ongoing maximization of utility from consumption in the presence of environmental constraints leads to a risk of environmental crisis. Chapter Four argued that responses are available but there may be a need for a more vigorous response to reduce the risk of an overshoot crisis, now or in the future. Businesses will oppose efforts to introduce regulation if profits are threatened. Governments will pursue regulation more vigorously if individual opinion leads them in that direction.

Chapter Five considers changes in ideas, specifically values and beliefs, which might encourage individuals to lead governments. Similar changes of ideas can influence choices so that individuals also change their own environmentally damaging activity and influence others, leading to better medium- and long-term economic and environmental outcomes.

A well-informed consumption-motivated individual might assess the risk of a Model III overshoot crisis and conclude that acting to lead government could result in regulations that would protect the individual's future consumption. However, relying on consumption-motivated individuals to lead governments is not likely to be sufficient because the expected consumption benefit for each Actor from exerting leadership is likely to be very small and in the distant future. The approach adopted instead is to assume that other sources of utility can motivate behavior and to show how these other sources of motivation could induce the individual to lead government and engage in other pro environment activities.

An individual who maximizes consumption has only one source of utility so other sources of utility must be introduced before value change can be modeled. Assuming that individuals have motivations other than consumption implies adding other sources of utility to the utility function. An extended utility function introduces the possibility of value changes that could lead to different activity choices. It will be argued that the sources of value that will be introduced to the utility function are consistent with what is known about real individuals and that, if adopted, the new assumptions about sources of utility would provide tools to develop interventions to change activity choices in directions that could reduce the risk of environmental crisis.

The next section of this chapter examines the development of the assumption that individuals derive their utility from consumption only, and summarizes the advantages and disadvantages of the assumption. The third section introduces extensions of the utility function that allow additional motivations for individuals and are consistent with theory and empirical evidence.

The fourth section shows how beliefs can affect choices about activity, and how they can prevent pro environment behavior. The norm activation process is introduced to show how values and beliefs can combine to affect choices about behavior. Although the extended model of the individual developed in this chapter could be used to analyze many different kinds of behavior it will be referred to as the model of the *ecological individual* to distinguish it from the model of the consumption utility maximizer known as economic man. Throughout, individuals are assumed to be self-interested and SEU maximizers.

Utility from consumption?

This section will begin with a brief outline of the development of the assumption that individuals maximize their utility from consumption. It will then describe the benefits of this assumption for economics and as a basis for measuring societal performance. Three important aspects of the assumption can be distinguished from one another; that the individual is self-interested, that the individual seeks utility, and that utility is provided by consumption.

The first aspect, self-interest, was introduced by Hobbes (1651/1962) who wrote "I conceive when a man deliberates whether he shall do a thing or not do it, that he does nothing else but consider whether it be better for himself to do it or not to do it" (p. 206).

In 1789 Jeremy Bentham introduced the principle of utility which built on and formalized Hobbes' conception of self-interest. Bentham (1789/1948) focused on the pleasure and pain that resulted from an action:

> By the principle of utility is meant that principle which approves or disapproves of every action whatsoever, according to the tendency which it appears to have to augment or diminish the happiness of the party whose interest is in question. (p. 2)

Stanley Jevons established the basis for modern utility theory in the latter part of the 19th century, building on Bentham's work. Jevons regarded utility as the net effect of the pleasure and pain following an activity. His explanation showed that the individual allocates a budget among available commodities so that the same marginal utility is obtained from each commodity (Ekelund and Hébert, pp. 356 – 361).

Utility has taken on a refined meaning in modern mainstream economics. The pain aspect of utility has been dropped to focus on pleasure, and utility in economics is usually obtained from commodities. In developing a mathematically tractable and comprehensive theory, economists assumed that individuals maximize consumption subject to their income constraint (Hargreaves-Heap and Hollis, 1994, pp. 54-55). Economists will readily agree that utility from consumption and strict self-interest present a narrow, unrealistic view of human motivation but assert that these assumptions are taken for analytical convenience (e.g., Kamarck, 2002, p. 22).

Modern students are taught that individuals maximize utility from consumption. For example, in a leading economics text, Samuelson and Nordhaus (1989) write:

> [Utility] refers to the subjective pleasure or usefulness that a person derives from consuming a good or service….utility is a scientific construct that economists use to understand how rational consumers divide their limited resources among the commodities that provide them satisfaction. (p. 101)

Consumption maximization is a goal at the national, as well as individual, level. GNP was introduced in the early 1940s to help manage war funding. After the war, GNP continued to be used for management of national economies. Opponents of GNP pointed out that it did not include unpaid activity, measure the extent of poverty, or include individual well-being (Waring, 1988, pp. 46-47, 58). Nevertheless GNP does measure the production that generates income for country's residents so changes in GNP can be used to indicate changes in the money available to individuals for spending on consumption that provides utility.

GDP is the total income earned in the country, including that earned by non-residents (Waring 1988, p. 57). Despite recognition of the distinction between development and GDP growth, governments and economists rely heavily on GDP as a measure of economic success (V. Thomas et al., 2000, p. 2) and governments are expected to ensure that GDP continues to grow.

Consumption maximization, just as any measure of success, has a self-perpetuating aspect. An individual learns via socialization that consumption is an important goal and so makes an effort to gain the income that will allow increased consumption and the physical rewards it provides. If the effort is successful and leads to increased consumption then it will reinforce the importance of consumption as a goal for the individual (Screpanti and Zamagni, 1993, p. 271). Increasing individual consumption levels have reinforced the legitimacy of the aspiration to consume.

Consumption has become entrenched as the primary goal for both individuals and governments. Government policies that reinforce the motivation to consume help create circumstances where GDP can continue to grow and allow governments to demonstrate economic progress. Export of policy advice and media to the developing countries is making maximization of consumption a global norm.

Self-interest focused on maximizing utility from consumption has been a powerful motivator encouraging individual effort to grow output. In achieving growth the developed countries have imported resources from the developing countries and exported manufactured products to the developing countries (Boserup, 1981, p. 188). The developed countries have also been able to remove forests and use waste sinks such as the atmosphere and ocean to absorb the by-products of their increase in consumption. These factors mean that the conditions for growth in the developed countries have been very favorable, allowing consumption aspirations to be satisfied.

Individuals and governments may choose to continue to maximize utility from consumption as the end of the transition approaches. However, several alternatives to maximizing GDP have been proposed as indicators of aggregate societal performance. The Genuine Progress Indicator (GPI) adjusts the GDP by adding the value of activities that are not included in the market economy such as housework and volunteering, and then subtracting the cost of crime, natural resource depletion and loss of leisure time. Like GDP, the GPI is an economic indicator but it shows a different trend. The GPI for the USA has declined by 45 percent over the past two decades. Steady declines have also been observed over the past 30 years in several European countries that have GPI measures (Baker, 1999, para. 33).

The World Wildlife Fund for Nature's index is based on the status of forest, freshwater and marine ecosystems. The index declined by about 30% between 1970 and 1995 (Eckersley, 2002, p. 40). The Human Development Index (HDI) is based on national income, education and life expectancy so introduces measurement of social as well as economic outcomes. (Atkinson et al., 1997, pp. 209-212). Diener (2000, pp. 40-41) proposes a subjective well-being index to track individual happiness. Indicators that take account of distribution effects and advances in environmentally relevant technologies could also contribute to our understanding of the current situation.

All of the indices listed can help monitor key trends. However, the indicators listed above, whether economic, environmental or social, focus on today's status but do not measure the future impacts of today's activity nor do they provide guidance on how to manage the trade-off between current economic output and future environmental risks. The objective of sustainable development requires non-declining human well-being over time so it explicitly addresses future outcomes, although measurement can be difficult (Atkinson et al., 1997, pp. 3-4).

Wackernagel et al. (2002) propose a measure called ecological demand that estimates the amount of land required to sustain human activity. They suggest that their measure could be used to guide strategies for moving towards sustainability, defined as keeping human ecological demand within the supply.

Deciding to seek sustainable development, to manage the trade-off between economic and environmental objectives, or to adopt a triple bottom line would be valuable ways to redirect societal outcome objectives. However, if the dominant paradigm continues to assume that individuals only maximize their own utility from consumption then theorists guided by that paradigm are not likely to assume a wider range of individual motivations when developing strategies to improve outcomes, so change is likely to be slower than it potentially could be. One way to address this is to change the assumptions about sources of utility. The next section introduces additional motivations that are consistent with the behavior of real individuals and allow a wider repertoire of self-interested, utility-maximizing behavior.

An Extended Utility Function

Chapter Two defined a utility function for the consumption-motivated individual with the form:

$$SEU(a) = v_a - c_a$$

where *SEU(a)* is the subjective expected utility from the activity *a*, and *v* and *c* are the prize and the eco-cost respectively.

Extending the utility function is accomplished by adding terms to the utility function to capture the additional sources of utility. Some psychologists, market researchers, economists and selection practitioners have used extended utility models (e.g., Cabrera and Raju, 2001; Kolm, 2000; Louviere, 1988).

Both the direct benefit and the eco-cost are impacts on the individual's consumption utility so they are in the same units. When additional terms are added so that the individual gains utility from sources other than consumption, each of the sources must have a weight assigned to reflect the importance of that source to the individual. The revised form of the function is:

$$SEU(a) = w_1(v_a - c_a) + w_2 x_2 + w_3 x_3 + ... + w_n x_n \, .$$

Each *w* represents the strength of the corresponding value and the *x* values are beliefs about the amount of each source of utility that will be available if activity *a* is carried out by the Actor.

The remainder of this section begins by examining the consumption motivation and then introduces four additional sources of utility. Note that it is not necessary to assume that any particular individual is motivated by all sources of utility. By assigning a *w* of zero to a utility source that source can be ignored in the assessment of the overall utility from the activity. Therefore the extended utility function can also be used to represent an individual who is motivated only by consumption.

Individuals do believe that having more money will make them happy and there is evidence that the importance of consumption is increasing. Between 1965 and 1985 the proportion of college entrants aspiring to be very well off financially increased from around 40% to around 80% (D. G. Myers, 2000, pp. 58-59).

There is also evidence that people in poor countries and poor people in wealthy countries are less happy than those who are richer. Two reasons cited for this are that those who do not have their basic needs for food, shelter, health and human rights satisfied are less happy, and that global communications allow the poor to compare themselves with those who are richer and feel disadvantaged (Diener, 2000, p. 39; D. G. Myers, 2000, p. 60).

However, among those whose basic needs have been met, there is a very weak correlation between income and happiness. Increasing income does not increase happiness. The very wealthy are only slightly happier than the average American (D. G. Myers, 2000, pp. 59-60). Average real income in the USA doubled between 1956 and 1998 but average reported happiness went down, divorce rates doubled, teen suicide tripled, reported violent crime quadrupled and depression rates soared (D. G. Myers, 2000, p. 61; Lane, 2000, p. 20).

Csikszentmihalyi (1999) concludes that the pursuit of consumption does not satisfy people or make them truly happy; they set higher wealth targets, evaluate material wealth not by what they need but in comparison with those who have more, and sacrifice family life and friends to pursue material rewards (p. 283). Lane (2000) explains that people aspire to be richer despite money not delivering happiness: "The market culture teaches us that money is the source of well-being. Many studies show that people are not very good at explaining why they feel good or bad…and, accepting the conventional market ideology, they believe that the source of their happiness (or misery) is money" (p. 72).

Maslow's (1954/1987) hierarchy of needs views human motivation as aiming to satisfy basic needs first, as the highest priority, and then satisfying "higher needs." In Maslow's framework the basic needs are physiological; food, drink, clothing and shelter. Once these needs are met the individual's motivation turns to satisfying needs for safety, for belonging and love, for self-esteem and for self-actualization in turn.

Maslow's theory is consistent with the evidence that consumption is very important when the individual lacks food, drink, clothing or shelter. The first modification of the utility function allows the possibility that individuals might satisfice on consumption by pursuing consumption up to a certain level, then value additional consumption less, allowing other sources of utility to become relatively more important (H. A. Simon, 1982, pp. 296-297).

H. A. Simon (1959) also wrote "economic man is a *satisficing* animal whose problem solving is based on search activity to meet certain aspiration levels rather than a *maximizing* animal whose problem solving involves finding the best alternatives in terms of specified criteria" (p. 277). Economists recognize this curvilinearity of individual consumption utility functions, although they may then go on to maximize aggregate output (Dasgupta, 2001, pp. 19-20).

Despite the potential for curvilinearity of utility functions, individuals may believe that self-esteem and self-actualization result from behavior that is consistent with maximizing consumption, such as having a successful well-paid career. Self-esteem may be gained by achieving levels of income and/or consumption that are equal to or above those achieved by some reference individuals such as the Jones' or the characters in the currently popular soap opera. Similarly, an individual who has already got enough wealth to satisfy all his or her anticipated consumption and bequest needs may still be motivated to higher levels of income or consumption because that is the choice that he or she has made about what is self-actualizing.

Choices about what provides self-esteem or is self-actualizing can be established or changed by social norms. Norms are defined by Hechter and Opp (2001) as "cultural phenomena that prescribe and proscribe behavior in specific circumstances" (p. xi). They go on to say that social norms are often spontaneous rather than planned, are unwritten and are enforced informally. Critto (1999) states that

> social habits or norms are in some way people's continuous shared decisions, in which previous decisions made by others and themselves provide and facilitate roads to be followed, thus influencing every new decision and behavior. In this way people continually decide and build, adapt and modify social norms (p. xi).

A society could transmit norms that would encourage individuals to make different choices about what provides self-esteem or self-actualization. Individuals could be expected not to pursue consumption objectives beyond satisfying basic needs. With self-actualization achievable in different ways, the assumption that individuals maximize utility from consumption could be replaced by an assumption that allowed the possibility for individuals to satisfice on consumption and then pursue other goals that lead to high self-esteem and self-actualization. The four values proposed for addition to the utility function are valuing the environment, altruism or superiority, social approval and disapproval, and personal norms.

Valuing the environment

Assuming that the individual might satisfice on consumption helps make room in the utility function for other values that could motivate pro environment activity choices. One such possibility is that individuals might value the environment itself.

If individuals maximize utility from consumption alone then their concern for the environment will be limited to the impact that environmental damage has on their expected consumption; that is, the effect on their own eco-cost. With a large number of actors involved in an environmental Prisoner's Dilemma game or a large number of Others affected by an Actor's activity, an individual's own activity may lead to a very small impact on his or her own eco-cost, because of the sharing of the total eco-cost from the activity. However, the effect on damage to the environment will not be diluted in the same way; the individual's activity will cause whatever damage it causes. The conventional assumption is that the individual does not include the damage to the environment in the utility calculation. If the individual did include the damage to the environment then this would create an additional disincentive to environmentally damaging activity.

Wilson (1993) defines biophylia as "the innately emotional affiliation of human beings to other living organisms" (p. 31), making the case that the value is hereditary and a part of human nature. Regardless of whether or not the value is innate, Kellert (1996) shows that values placed on nature, what he calls ecologistic value, can change over time, implying that they can be learned as well (p. 45). Kellert also concludes that only a minority of

Americans has an ecologistic concern for the natural world, though the proportion is growing. Low incidence of a distinct concern for the natural world is confirmed by P. C. Stern, Dietz, Abel, Guagnano, and Kalof (1999), who conclude that "the distinction between altruism towards humans and altruism towards other species and the biosphere has not yet been demonstrated empirically in samples of the US general public" (p. 85).

While valuing environmental outcomes in their own right may not be important in many extended individual utility functions currently, the analysis and empirical evidence shows that individuals can learn new values and that the relative importance of values can change.

If individuals directly valued environmental outcomes this would change the basis for their choices about activity and about pro environment behavior. The consequence of having a motivation to avoid environmental damage might be different activities or use of less damaging technologies, depending on the options available.

Consumers could choose products that caused less damage. This would lead to a revaluation of material versus non-material output. An individual might work and spend the income generated on purchasing a large, polluting car or might spend the income going to concerts. In output terms the two kinds of expenditure might be equivalent. However, the expenditure on the car will, in general, cause more environmental damage than the expenditure on concerts so consumption of concerts might be preferred to consumption of large cars. There would be a strong incentive for producers to develop less damaging technologies to provide value to consumers. Heal (1998) concludes that including the environmental stock in the utility function makes an important contribution to the attainability of sustainable development paths (p. 24).

The valuation of environmental outcomes in the extended utility function is represented by the value *d*, for damage, and the additional term in the utility function is $w_2 d$ so

$$SEU = w_1(v - c\ ) + w_2 d\ .$$

Altruism and superiority

According to Sober and Wilson (1998) altruism is “part of a pluralistic theory of motivation that maintains that people have ultimate desires about others as well as about themselves” (p. 228). The literature on altruism is concerned, in part, with explaining why individuals might act in ways that benefit others.

It might be argued that self-interest is incompatible with altruism (Derlega and Grzelak, 1982; Frank, 1992). However, the egoistic interpretation of altruism allows a self-interested individual to be motivated by a desire to win in competition with others for consumption or by a desire to lose (Taylor, 1987). There are some issues with this egoistic view of altruism (Sober and Wilson, 1998, pp. 224-231) but it serves present purposes to focus only on motivations that provide psychological benefits or costs to the Actor because only those benefits and costs can be incorporated in the utility function that is being developed to model environmentally relevant behavior. H. A. Simon (1982) states that “altruism can be accommodated in the utility function simply by including the well-being of other persons as one of its components” (p. 224).

The formulation adopted here is restricted. First, only the egoistic utility impact for the individual of consumption outcomes for others is incorporated. Second, only consumption outcomes for others are included; other sources of utility are ignored (Kolm, 2000, p. 17). Third, it is relative consumption that matters.

If the individual has a positive weight for altruism in the utility function then the individual values activity that leads to higher consumption for others relative to the consumption impact on the Actor. Examples of behavior that could lead to positive utility for such an individual would be making a charitable donation, lending their lawnmower to a neighbor, and volunteering in a reading program at the local school.

A negative sign on the weight for altruism would imply that the individual gains positive utility when the consumption outcome for the individual is greater than the consumption outcome for an Other. Such an individual would be motivated to compete with others to gain consumption because higher relative consumption is a source of utility.

Competition for consumption is regarded as one of the important drivers of economic growth. However, the word competition will be used here to describe two separable concepts. *Objective competition* occurs when actors are in a race, a fight or a game to gain an economic outcome, usually profit. In this case the actors simply gain the economic benefit of the payoff. Competition is a process.

The utility that is obtained from higher relative consumption is the result of *subjective competition*. People feel good when they win. An individual who gains a consumption benefit can therefore gain two sources of utility. The first is from the consumption itself and the second is from the experience of superiority resulting from the higher relative consumption.

The combination of observations of the success of individuals in objective competition, especially those presented by the media, and exhortations by economists about the virtues of competition have led to strengthening of the value of subjective competition just at a time when the emergence of environmental constraints makes such a value harmful. Subjective competition has become an important source of utility. People are referred to as competitive.

Objective competition is useful because it encourages better performance in the economic arena. It might seem obvious that subjective competition is also useful because it also encourages better performance but the analysis below shows that the usefulness of subjective competition depends on which case applies.

Consider first Case I where there is no environmental damage resulting from activity. In this case a subjective motive to win may accelerate output growth without any harmful effects. This is the conventional analysis.

One \ Two	No Act	Act
No Act	0, 0	-1.5, -0.5
Act	-0.5, -1.5	-2, -2

Payoffs for One, Two

Figure 5.1. Case VI - Price. The prize for acting is assumed to be 1 and the eco-cost is assumed to be 3. If One alone acts then One's payoff will be 1+(-3/2)= -0.5. Two will get –3/2= -1.5. If Two alone acts the outcomes will be reversed. If both act then each will get 1-(3+3)/2= -2. Neither should act, the price is too high and the outcome is Case VI.

Now consider what can happen if a subjective competition motive is included in Case VI. Figure 5.1 shows how activity choices are aggregated in Case VI, using the illustration approach introduced in Chapter Two. As previously, $V_a = v_a = 1$ and the eco-cost, C_a, is –3 to establish Case VI. The pay-offs in Figure 5.1 lead to no activity because the costs are greater than the gains for both actors.

Now introduce a new variable, *s*, representing the outcome of subjective competition for consumption. The variable *s* represents the motive of being a winner, keeping up with the Jones's or being the wealthiest person on the rich list. The value of *s* is 1 if an Actor has gained an advantage over the other Actor and -1 if the Actor is left with a disadvantage. Introducing *s* with these values transforms the payoffs for actor One and actor Two for Case VI as shown in Figure 5.2.

		Two	
		No Act	Act
One	No Act	0, 0	-2.5, 0.5
	Act	0.5, -2.5	-2, -2

Payoffs for One, Two

Figure 5.2. Case V - Prisoner's Dilemma. The prize for acting is assumed to be 1 and the eco-cost is assumed to be 3. An actor who gets a better outcome gains an extra payoff of 1 for superiority in subjective competition. The other actor gets a penalty payoff of -1 for inferiority. Ignoring superiority, if One alone acts then One's payoff will be 1+(-3/2)= -0.5. Two will get -3/2= -1.5. Superiority will provide One with a bonus of 1 resulting in a payoff of 0.5. Two will get a penalty of 1 resulting in a payoff of -2.5. If Two alone acts the outcomes will be reversed. If both act then each will get 1- (3+3)/2= -2. These payoffs establish a Prisoner's Dilemma.

This is the Prisoner's Dilemma, Case V. Adding a motive for success in competition for consumption has transformed the game from a simple case where activity is deterred to one where economically and environmentally damaging activity is likely to take place.

Adding a subjective competition motive provides more encouragement for each Actor to choose activity and may create a situation where, for each Actor, acting dominates not acting. In Cases III and IV a motive of subjective competition will also encourage activity, and is likely to lead to higher damage than would occur without such a motive.

Note the difference in the usefulness of a superiority motive depending on the state of the environment. When the prize is greater than the eco-cost the effect of a value of superiority is to encourage each individual to choose activity, hoping to gain an advantage over the other individual. The second individual has a similar incentive so the high level of activity is a more likely choice for both individuals. The result may be activity that is in the economic interests of the actors and the community. Subjective competition is economically beneficial when the prize is greater than the eco-cost.

When the prize is less than the eco-cost, the existence of a motive of subjective competition for consumption is not economically beneficial. Subjective competition encourages individuals to choose high activity levels which lead to the lose/lose outcome in Case V and to activity that is not in the economic interests of the community in Case IV, as well as more environmental damage. Therefore, just as it is beneficial to encourage a value of subjective competition when the prize is greater than the eco-cost, it would be beneficial to discourage such a value when the prize is less than the eco-cost.

Krebs and van Hesteren (1992, pp. 164-165) examine the development of altruism in individuals. They point out that motivations for altruism may differ and that altruistic behavior is developed as part of maturation and socialization. Superiority, the negative form of altruism, is also learned. Frank, Gilovich, and Regan (1993) reported that economics students are more self-interested than other students and that exposure to the self-interest consumption model encourages self-interested behavior. They conclude that: "…with an eye toward both the social good and the well-being of their own students, economists may wish to stress a broader view of human motivation in their teaching" (p. 171).

Values are not static and universal (Ambramson and Inglehurt, 1995; Heffron, 1997; McClelland, 1965; K. Thomas, 1983). Some values may be beneficial in the early and middle stages of transitions and eras while other values may be better adapted to eras.

During an era, total output is constrained by availability of environmental stock and the economy must operate in Case I. If individuals were allowed to pursue their own economic interests then the economy would operate up to Case IV, which would be disastrous. A strong community, where individuals care about outcomes for others, where environmental outcomes are important, and where the economic behavior of individuals is constrained, is a good adaptation to life in an era.

On the other hand, during a transition output is constrained by the availability and rate of growth of labor and capital. With a large environmental stock relative to the flow of services being drawn from the stock there are substantial opportunities for beneficial growth in Cases I, II and III. Any community that fails to grow vigorously risks losing in competition with others that can grow faster. In these circumstances discouraging subjective competition is less valuable as a restraint on individual activity and there is less need to care about outcomes for others.

Value changes as large as those implied by this argument may take a great deal of time. Even after more than 200 years of transition, altruistic values remain important. However, the sins that were discouraged and protected us from damaging self-interested or individualistic behavior during the agricultural era - avarice, gluttony, envy, and pride - have become virtues, important drivers of economic success during the transition.

Lichtman (1990), in his analysis of human nature, claims that societal changes have produced the value changes that have accompanied the rise of individualism:

> But, whereas the great majority of world cultures believe that individuals differentiate themselves within society, bourgeois culture believes that human beings individuate themselves beyond society. While the category of "the individual" is universal, the category of "individualism" is not. It is, rather, the specific product of capitalist society. (pp. 26-27)

Individualism appears to arise when constraints on economic growth are relaxed. Robertson (1933) observed that the rise of individualism in Western society is not unique: "there was nothing peculiar about the growth of economic individualism in England in the sixteenth and seventeenth centuries, which made it different in kind from the individualism which characterized Italy between the eleventh and the fifteenth centuries" (p. 206). Between the eleventh and fifteenth centuries Italy's economy grew rapidly, based initially on the silk trade with the Levant and then on more widespread trade (Braudel, 1982). Schooler (1998) makes the same argument about modern Japan.

Values change and social norms

Observations that the values of individuals can change over the course of their lives and that long-term societal changes in the pattern of values can be observed imply the existence of a mechanism or mechanisms for value change. It is therefore possible to envisage actively changing the values of individuals (Cheng, 1997; Da Fonseca, 1991; Dau-Schmidt, 1998; Henry, 1990).

The mechanism is the acquisition of values from respected others through the socialization process. Values can be acquired through imitation of the values of respected others or as a result of social approval and disapproval. The detail is important in social psychology but not crucial here. All that is needed for present purposes is the ability to pass values from one person to another (Rochon, 1998).

Using values change to modify activity choices requires the individual to care about the social approval or disapproval of others. The required mechanism is described as "the subjectively perceived expectations of others" (Hunecke et al., 2001, p. 833) and is labeled the *social norm*. Blamey (1998) argues an Actor might assess "how the action would comply with socially accepted standards of behavior" and that "many different reference groups may be involved, from society at large to single individuals" (pp. 679-680). Social norms are included in the utility function to reflect this potential for influence by others,

$$n_a = \sum_i y_i z_i \ ,$$

where n_a, the social norm, is the net expected social approval and/or disapproval of the activity being considered, z_i is the approval or disapproval of the activity by each other individual, and y_i is the importance of each other individual. This allows a large importance weight to be placed on some individuals' opinions, such as family members or respected authorities and a small weight on individuals who are remote or whose opinions are not respected. The individual considering the activity subjectively assesses the y_i and z_i values. Note this n is distinct from the previous use of n as number of individuals.

Social norms result from institutionalization of the social approval and disapproval of others (Bicchieri, 1993). The power of social approval and disapproval is illustrated by the success of campaigns to prevent littering and smoking in public places. Campaigns may be supported by regulations, but their real power may be the social influence that is brought to bear. Arguments about publishing the names of pedophiles and drunk drivers and arguments for suppression of names in courts reveal the power of social approval and disapproval. The case is often made that social disapproval would be too high a price to pay for the offence.

Introducing the individual's response to expected social approval and disapproval to the utility function is sufficient to provide a mechanism to influence behavior, but it is not sufficient by itself to change values, nor does it fully reflect the power of social approval. To do this, another mechanism is required, one that operates directly on the way outcomes are valued.

The value of n_a represents the individual's belief about the approval and disapproval from others that would result from carrying out the activity a. The w values in the utility function represent the importance of each of the sources of utility. The requirement for value change is that individuals modify their w values to conform more closely to those of others.

In principle, values can change via individuals imitating the values of others or as a result of individuals being deliberately influenced to adopt values that are held by others. Influence is the more useful mechanism for current purposes because it can be exerted deliberately and managed whereas imitation is a more passive process. Just as for the social norm effect on choices, the strength of regard for other individuals affects the likelihood and amount of adjustment of values.

This mechanism establishes the possibility that an individual might influence another individual to reduce the weighting on consumption and increase the weighting on environmental outcomes and outcomes for others. It also raises the possibility that the weighting or value placed on the social approval of others could be increased and even that the ability to influence the values of others could be increased.

Chapter Two used Bentham's definition of an economic community whose interests were nothing more than the sum of the interests of the community's members. That economic community can be labeled a *community of interest*. Now consider a *community of action*. A community is not just an entity that is affected by economic outcomes. It is also able to alter the behavior of its members through establishing norms that are transmitted and enforced by social influence.

Strong communities mean strong social influence and therefore more potential to constrain behavior and change values. If social influence is potentially a powerful lever for constraining behavior that hurts the interests of the community, and there is a risk of environmental crisis as the Earth passes through the end of the transition to the industrial era, then it may be useful to ensure that communities are strong. Montgomery (1997) identifies social capital as "the cumulative capacity of social groups to cooperate and work together for a common good" (p. 30).

Putnam (2000) has documented a large decline in participation in community groups within the USA over the latter part of the 20th century. He argues that the most important determinant of that decline has been the emergence of generations with different values: "less trusting, less participatory, more cynical about authorities, more self-centered and more materialistic" (p. 258). He reports that in 1975

> 38 percent of adults chose "a lot of money," and an identical 38 percent mentioned "a job that contributes to the welfare of society." …by 1996 those who aspired to contribute to society had slipped to 32 percent, while those who aspired to a lot of money had leaped to 63 percent. (p. 273)

During the same period, aspirations increased for a vacation home, a second color TV, a swimming pool, a second car, travel abroad, a job that pays more than average and really nice clothes while aspirations decreased for a happy marriage, children and an interesting job (Putnam, 2000, p. 273).

The trends described above indicate that individuals are becoming more selfish, greedy and keen to win in subjective competition, which would be expected given the rise of individualism. The result must be an increase in the weighting of consumption and subjective competition and a reduction in the weighting of social norms in the utility function. Further, economic success leads to a shift in the way people spend their time, with consumption activities crowding out time for contributing to our communities, whether they be families, neighborhoods, community groups, countries or the Earth. Community groups, sporting clubs and the armed services used to attract membership by offering opportunities for community contribution, participation and membership. The author has found that a New Zealand voluntary organization must now recruit members by offering individual benefits in competition with other activities that compete for membership.

Individually driven welfare initiatives may also contribute to erosion of the effectiveness of communities. If all an individual needs to do to have sustenance needs met is maintain an effective bureaucratic relationship with the government then there is less need to maintain social links with the community. A community where individuals have many connections is more likely to coordinate effectively to achieve change (Marwell, Oliver, and Prahl, 1988, pp. 531-532).

As a value, the pursuit of consumption is so entrenched in our thinking that many individuals do not recognize that they have chosen to pursue consumption rather than to pursue other objectives. Small reductions in the rate of growth of consumption are of great concern but robust summary measures of what is happening to communities or the environment analogous to GDP are not yet available to the general population. And the notion that trade-offs among societal objectives such as consumption, environment, and community are made when activities are chosen seems to have escaped most individuals, economists and policy-makers. A good indicator of this is the notion of sustainability itself. Rather than choose nurturing of the environment as an objective, environmental and ecological economists, and policymakers, have chosen to pursue sustainable development (Atkinson et al., 1997, pp. 1-2; Prugh, 1999, p. 44; WCED, 1987, p. 43-46; Woodwell, 2002, para. 8). The goal of maximizing consumption subject to not damaging the environment too much has been substituted for the goal of just maximizing consumption. Maximizing utility from consumption is still the primary objective.

Not all communities maximize consumption. For example, the Amish reject some consumption activities and technologies, fearful of the effects they would have on their communities. Although they consume, maximizing consumption is not an important objective. As a community the Amish have made other choices (Kraybill, 1989). Lichtman (1990) provides a powerful argument for the view that communities can and do choose the values and beliefs of their members.

Personal norms

The fourth addition to the utility function is a role for personal norms. A personal norm is "an inner moral conviction that is defended irrespective of the expectations of others" (Hunecke et al., 2001, p. 832). Individuals feel satisfaction if acting in compliance with their expectations of themselves as "conformity to a self-expectation results in pride, enhanced self-esteem, security or other favorable self-evaluations" (Schwartz, 1977, p. 231).

If behavior is consistent with the personal norm then the individual gains positive utility whereas if behavior is not consistent with the personal norm then there will be a negative contribution to utility from the personal norm. The personal norm is another of the x terms of the extended utility function, labeled p for personal norm. The content of personal norms may encourage or discourage consumption, or other values, depending on the individual's socialization.

Hunecke et al. (2001, p. 845) show that social norms can influence the content of personal norms. They also provide empirical evidence that personal norms can have a strong impact on environmentally relevant behavior and that social and personal environmental norms are at least as important as the financial cost in determining frequency of subway use.

With these four additions the extended utility function of the ecological individual can be written as:

$$SEU = w_1(v - c\ ) + w_2 d\ + w_3 s + w_4 n + w_5 p\ .$$

Value changes that would encourage activities that reduce environmental damage are reductions in w_1 and increases in w_2 and w_3. Increased weights for w_4 and w_5 will only encourage activities that reduce environmental damage if the social influences on the individual are influencing them in a pro environment direction.

Nordlund and Garvill (2002) have provided evidence that the values added to form the extended utility function do influence choices about activity. Their research has shown that self-enhancement, self-transcendence, ecocentrism and the personal norm are all relevant in choosing to engage in pro environment behavior. Self-enhancement is analogous to consumption utility while self-transcendence reflects a concern for outcomes for others. Ecocentrism is similar to the concern for environmental outcomes. Social norms were not considered in the research.

Beliefs

Extending the utility function introduces values other than consumption to the model of how environmentally relevant activity is evaluated. The sources of utility are the prize (*v*), the eco-cost (*c*), the damage (*d*), altruism/superiority (*s*), the social norm (*n*), and the personal norm (*p*). The relative importance of each source of utility is represented by the magnitudes of the weights, *w*. As shown in Chapter Two the belief about the impact of activity on consumption is given by the *v* and *c* terms. The *d, s, n,* and *p* terms are the individual's beliefs about the expected outcomes of the other terms if the activity is carried out. For each term, the weight is applied to the outcome that the individual believes will result from the activity.

The norm activation model

Blamey (1998) identifies the SEU model and the norm activation model as two among several approaches to explaining how individuals decide whether to carry out activities that could improve environmental outcomes (p. 676). In the analysis so far the SEU model has been used exclusively, with utility coming from consumption and other sources. Like the SEU-based approach used in this thesis, the norm activation model (Schwartz, 1977; Schwartz and Howard, 1981, 1982) introduces values other than consumption as motivators, but it also describes the process that an individual goes through when considering environmentally relevant activities. Beliefs are important at several steps of the process. The norm activation model provides a way to incorporate a role for beliefs as determinants of environmentally relevant activity to further generalize the model of a consumption-maximizing economic man.

The norm activation process, summarized in Figure 5.3, involves five steps: attention, identification of consequences for the actor, calculation of the total costs and benefits for the actor to arrive at a choice, defense of the choice by reviewing the circumstances, and behavior. The attention step involves assessing the facts: identifying a need, identifying an action or actions that could meet that need, and assessing the actor's ability to carry out the action. In this step beliefs about the consequences of activity, including the risk of crisis, understanding of technical solutions and assessment of the impact of action by the individual, are important. If an individual does not perceive a threat, cannot see any solution, or believes that action cannot have any impact then the individual will not proceed further.

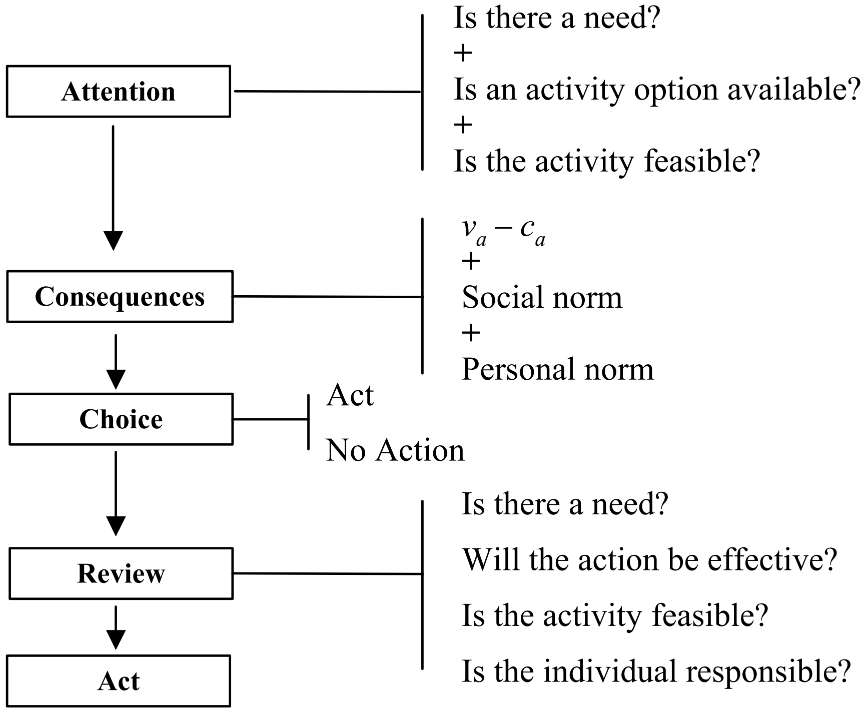


Figure 5.3. Norm activation model. Adapted from Blamey, 1998.

Three kinds of consequences for the actor are considered in Step Two of the norm activation model. The first is the "physical, material, and psychological implications that follow directly from the action…might involve risk of injury and/or trauma, and/or any monetary or time costs that are expected to occur" (Blamey, 1998, p. 679). This first kind of consequence is approximately equivalent to the consumption utility of the SEU model. The second and third consequences are the social norm and the personal norm impacts of the activity introduced in the previous section. The structure of the norm activation model could accommodate additional consequences simply by extending the range of consequences considered.

In Step Three of the norm activation model the expected consequences of activity are evaluated to arrive at a decision of action or inaction. The SEU model is consistent with this but is more general in allowing consideration of a range of possible activities, with the individual assumed to choose the option that offers the highest SEU.

If the choice made in Step Three is a close call then in Step Four the individual reassesses beliefs that are relevant to the obligation to act, considering whether there is really a need, whether the action would be effective, whether the individual is capable of carrying out the action and whether the individual is responsible for carrying out the action (Blamey, 1998, p. 680). If, following this assessment, the decision is to act then the individual moves to Step Five: behavior.

P. C. Stern et al. (1999) report survey research that is consistent with the approach adopted here. Their research allows them to conclude that a theoretical framework that uses beliefs and values to develop norms can be useful in explaining non-activist support of pro environmental movements (p. 91). They consider three kinds of action: policy support or acceptance, environmental citizenship, and consumer behavior.

Policy support or acceptance is activity that leads government. The individual may lead actively by joining and contributing funds to pro environment organizations or by writing letters to political officials. The individual may also lead passively, for example, by responding to opinion polls. Environmental citizenship is described as "support and acceptance of public policies that may require material sacrifice in order to achieve the movement's goals" (P. C. Stern et al., 1999, p. 82). Consumer behavior includes behaviors such as "reductions in energy use and purchases of environmentally benign products" (p. 82). P. C. Stern et al. also point out that consumer behaviors serve as a signal to government and industry regarding citizen concerns and consumer preferences.

The emphasis of the work cited above has been on explaining the self-directed participation of individuals in a single act of pro environment behavior. The present aim is to extend that understanding to allow management of outcomes by influencing values and beliefs. Recall that the chapter began with a goal to understand how individuals could be influenced so that they would in turn lead governments. Further, understanding how to influence consumer behavior directly could provide a valuable additional tool to increase the rate of change.

The individual begins with beliefs about the situation and a set of values. Many actions are available but the individual must choose amongst them. Options are generated and evaluated and the option or options that provide the highest SEU are chosen. The individual acts and outcomes result from the actions. The outcomes of the acts of the individual and of other Actors may be observed and understood and may lead to updated beliefs and values.

Belief change

Beliefs are important at three steps of the norm activation process (Blamey, 1998, pp. 678-681). At Step One the individual considers beliefs about the situation and the potential responses. At Step Two, beliefs about the anticipated consequences of activity for the individual are considered and Step Four involves beliefs about the effectiveness of the chosen action, if it is taken.

Beliefs may or may not be correct and they may be held with different strengths. They can be changed, sometimes easily and sometimes only with compelling evidence or over long periods of time. Beliefs affect choices about behavior so some beliefs are more likely to lead to choosing activity that reduces environmental damage than others. Individuals can influence the beliefs of others by providing them with information, provided that the influencer is credible and the new beliefs do not require unacceptable belief revisions (Critto, 1999, pp. 11-12).

Bendixon (2002) examined the literature on changing epistemic beliefs and developed a description of the process of change. People who change beliefs are confronted with people or experiences that lead them to conclude that their current beliefs are no longer useful. They take control of the situation and actively test belief options. New beliefs are accepted only if they are understood, plausible and stand up to challenge. Some individuals confronted with challenges to existing beliefs choose to appeal to a higher authority and are unlikely to change their beliefs.

The norm activation model provides a way to link the beliefs of individuals with the conditions required for activity changes that would reduce damage. Four beliefs are necessary for an individual to act voluntarily. First, the individual must believe that there is a need for activity change. Second the individual must recognize the responsibility of individuals in general and of the specific individual to change activities. Third, the individual must believe that he or she is able to carry out the required activity change and fourth the individual must believe that the activity change will be effective in reducing damage. These four potential belief obstacles will be referred to as “no need,” “not me,” “can’t do,” and “no point,” respectively. If any of these beliefs is not held then the individual is not likely to carry out the activity.

Widespread voluntary activity change will only take place if a large number of individuals hold all four beliefs. Despite widespread understanding of the potential for climate change and other large-scale environmental risks, current beliefs in Model I are strong and only a small minority of individuals believe that overshoot is a threat to themselves or those they care about. Exposure to information about the risk, like that provided in Chapter Three, could increase this proportion.

Individual responsibility is also not a widespread belief. Many individuals may believe that individual behavior change may be an important contributor to reducing environmental damage but few recognize that individual activity change is a powerful way to develop a response to the risk of crisis and even fewer believe that the responsibility is theirs. Exposure to the content of Chapter Four would increase the proportion recognizing the importance of individual change.

Individuals’ beliefs about the feasibility of behavior change would depend on the behavior change that is expected. It is reasonable to expect that individuals would believe that activities such as leading governments, influencing others and changing their own consumption activities would be feasible for them. Although “can’t do” is likely to be an obstacle in many instances it is one that can be overcome.

However, “no point” remains an important obstacle. One individual acting alone or at the margin is not likely to have any worthwhile impact. Therefore it is easy for individuals who believe there is a need for change, believe that individuals are responsible, and believe that activity change is feasible to refrain from acting either because they believe their action will not be sufficient to change the outcome or because they choose to rely on others, expecting that sufficient others will act to reduce the damage sufficiently.

Consider an illustrative individual's option to lead government, using the ecological individual model introduced above. The illustrative individual cares a lot about consumption and likes to have more than others, does care about environmental outcomes, that is, "no need" is overcome, and is influenced by others and what is considered right. The individual might have value weights of 0.7 on consumption, 0.2 on damage, -0.1 on altruism and 0.1 each on social and personal norms.

The beliefs of the illustrative individual about the consequences of leading government are that exerting leadership will have a cost in time or money and so will reduce other consumption options, that others do not care what the individual does, and that the activity will be futile because the individual acting alone will be ignored, so there will be no impact on damage. The individual will not act.

Now consider a second activity option for the illustrative individual; changing consumption choices to reduce damage. Imagine that the individual, having been exposed to information that leads to a belief that a Model III crisis is possible, recognizes that commuting via public transport will lead to reduced CO_2 emissions and, further, that changing activity is consistent with the personal norm. However, public transport is slower and has a higher marginal cost so there is a significant consumption cost to using public transport. The impact of one individual switching travel mode choice on the environment is very small and more than offset by the negative utility the individual expects from social disapproval of the choice of public transport. Again the individual will not act.

A third activity option for the illustrative individual is to exert social influence on other individuals to change their environmentally relevant values and beliefs. Exerting influence has a very small consumption cost and is mildly disapproved of by others but is viewed as the right thing to do so provides a positive contribution via the personal norm. Most important however, the collective action problem means that there will be no expected impact on the damage outcome because, even if the influenced individual changes activity choices, the anticipated effect will be tiny relative to the aggregate behavior change required. The individual will not act.

In summary, providing information can address "no need" and "not me" while "can't do" is not likely to be a major obstacle. However, as illustrated above, individuals who see the need and recognize their responsibility may still not act because of the "no point" belief obstacle. Despite this obstacle, the foundations for a successful strategy to reduce the risk of a Model III crisis are in place.

Two kinds of beliefs have been considered in this chapter. The first is beliefs incorporated in the utility function as the expected values of the *v, c, d, s, n* and *p* terms. The second kind is the belief obstacles introduced above: "no need," "not me," "can't do," and "no point." The relationship between the two is that the beliefs identified as obstacles affect the beliefs about expected outcomes if the individual acts. The beliefs about expected outcomes in turn affect the decision to act.

Specifically, the belief obstacles influence whether or not the individual is prepared to act at all (can't do), expects an effect of the pro environment activity on the damage (*d*) outcome (no point), and considers the risk of crisis (no need) and their own responsibility (not me) as influencers of what is the right thing to do (*p*). Beliefs about the state of the world and the need for activity change may also affect expectations of *v, c,* and *d*.

Conclusion

Theorists who use the dominant paradigm assume that individuals get utility from consumption, which leads to using GDP as the most important measure of overall societal performance. Real individuals have a wider range of motivations and at an aggregate level there are things other than GDP that are important, including social and environmental outcomes.

This chapter introduces a proposed extended utility function that includes additional motivations. The extended utility function allows for theories that include the possibility that individuals might value the environment, might care about outcomes for others, might care about the approval and disapproval of others, might change their values and might be motivated to do what they believe is the right thing to do.

Beliefs are also important determinants of choices about activity. Beliefs may prevent or encourage pro environment activity. Beliefs are assumed to change via interpersonal influence so that obstacles to pro environment activity can be overcome.

The purpose of Chapter Six is to develop a theoretically sound and practical strategy that aims to show how the required information can be provided, overcome the “no point” obstacle, and ensure that many actors will carry out all three kinds of activity proposed.

CHAPTER SIX

THE STRATEGY

Mutual coercion mutually agreed upon.

- Garrett Hardin, 1999, p. 257

Introduction

The aim of this chapter is to show how the frameworks and conclusions of previous chapters can be combined to form a strategy to accelerate change that could reduce the risk of environmental crisis: a Model III outcome.

Two environmental issues that contribute to the risk of crisis were highlighted in Chapter Three, climate change and the productivity of agricultural land. Climate change will be used in this chapter as an example to show how the strategy is developed and can be applied to a real environmental issue. Climate change is chosen because the risk is recognized and many technical solutions have been identified, so the current issue is accelerating and strengthening the response. Agricultural land productivity is not yet widely recognized as a global environmental issue so institutional and technical solutions are not as well developed.

The chapter begins by introducing a model of the strategy development process that distinguishes the physical strategy, with its technical solution, from the implementation strategy. Ratification of the Kyoto Protocol is used as the example of an implementation that could be accelerated. In the second section the choices of the managers who might initiate the implementation strategy are examined and a preferred strategy for these managers is proposed. The third section shows how the strategy initiated by the managers has its effect.

The Strategic Objective

Strategy is a word that is used, and misused, in many ways so it is worthwhile to articulate what is meant by a strategy to accelerate implementation. A strategy can be defined as "an instance of…careful planning towards a desired end" (L. Brown, 1993, p. 3085). A strategy implies allocation or reallocation of resources to achieve the desired end.

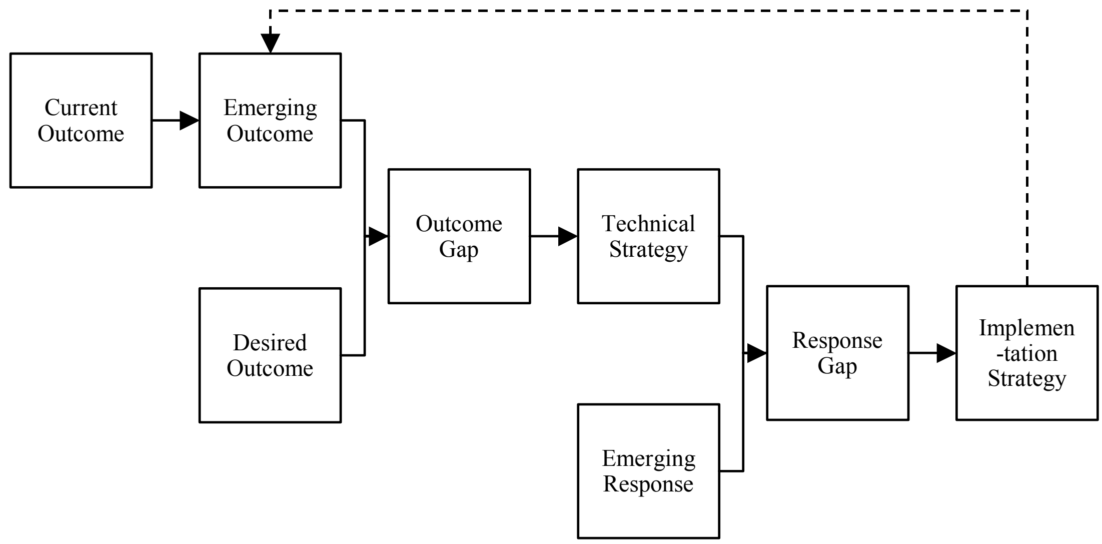


Figure 6.1. The strategy development process. The dotted line shows that strategy development is an iterative process.

Figure 6.1 summarizes an analytic process for developing a strategy to accelerate implementation that separates the roles of physical diagnosis, technical solutions and implementation. First, the desired outcome and the emerging outcome are compared to identify the expected outcome gap. Next, a technical strategy is developed to close the outcome gap. The technical strategy specifies what must be done to close the outcome gap. Some elements of the technical strategy may happen via market forces or via policies that have already been established but it is likely that there will be a response gap between what will happen with the emerging response and what is required by the technical strategy. The implementation strategy is designed to ensure activity to close the response gap.

The steps in Figure 6.1 will be illustrated using the example of ratification of the Kyoto Protocol to address climate change. The aim of the Kyoto agreement is to get governments to constrain activity to reduce greenhouse gas emissions so it provides a good example of the kind of response that could be accelerated by a successful implementation strategy.

The IPCC is comprised of hundreds of scientists, many with government positions, who have studied climate change. The three-volume report issued by the IPCC in 2001 on climate change will be drawn on to illustrate the current and emerging status of response strategies. The three volumes are subtitled *The Scientific Basis*; *Impacts, Adaptation, and Vulnerability*; and *Mitigation*.

The first step shown on Figure 6.1 is to understand the current outcome. The IPCC reports that "the global average surface temperature has increased over the 20th century by about 0.6ºC" (Houghton et al., 2001, p. 2) and that changes have also occurred in other important aspects of climate including precipitation and temperature extremes (p. 4).

The IPCC also concludes that "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities" (Houghton et al., 2001, p. 10) and that "emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate" (p. 5).

Strategies can only affect the future so from a strategic point of view understanding the current outcome and the recent past is only important in providing a foundation for understanding the future. The important issue is the emerging outcome so the IPCC has developed projections of the emerging outcome under a wide range of scenarios. One of these scenarios, A1F1, corresponds closely to the Model I view of the world. It involves

> a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions,

> capacity building and increasing cultural and social interactions, with a substantial reduction in regional differences in per capita income. (Metz et al., 2001, p. 5)

The A1F1 scenario is fossil fuel intensive with effective use of technology and so it represents continuation of business as usual. The expected temperature rise over the 21st century with A1F1 is a little over 4ºC, and possibly almost 6ºC, and the projected impacts are large and negative (McCarthy et al., 2001, p. 5). Impacts identified could include future large-scale climate discontinuities including reversal of the thermohaline circulation after 2100 (Metz et al., 2001, p. 5; Houghton et al., 2001, p. 16). Impacts on people with A1F1 would be large and detrimental and those in developing countries would be at relatively greater risk (McCarthy et al., 2001, p. 8).

The scenario with the least increase in temperature over the 21st century is labeled B1. It has temperature growth of 2ºC over the 21st century and is described as

> a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity. (Metz et al., 2001, p. 5)

The B1 impacts are still detrimental but less so than the A1F1 impacts so B1 can be used to illustrate the desired outcome of the strategy. The next step is to identify the outcome gap. The outcome gap is the difference between the temperature changes with the two scenarios, which is 2ºC. Therefore, the physical objective is to ensure that the temperature increase is close to 2ºC rather than 4ºC or more.

The technical strategy specifies how emissions will be reduced to achieve the lower temperature increase. Figure 6.2 shows the emission reductions that could be achieved by 2020 and summarizes the current state of the technical strategy developed by the IPCC to achieve the reductions. The outcome gap in emissions is 4,325 million tons of carbon equivalent per year and the technical strategy identified involves changes in activities and technologies that are specified more fully in Volume III of the IPCC report. Note that the IPCC does not conclude that the potential reductions can be achieved nor that they will produce scenario B1.

Sector	Potential Emission Reduction in 2020 (Mt C/yr)	Net Direct Costs per Ton of Carbon Equivalent Avoided	Main Options
Buildings	1,050	Most negative	Hundreds of technologies
Transport	500	<$25?	Engine technologies
Industry Energy Efficiency	800	More than half negative	Management effort
Industry Material Efficiency	600	Uncertain	
Industry Non-CO_2 Efficiency	100	<$10	
Agriculture Non-CO_2	550	$50-$100	Mix changes, biotech and energy cropping
Waste CH_4	200	Most negative	Methane from landfills
Energy Supply and Conversion	525	<$100	Mix changes, efficiency and carbon sequestration
Total	4,325		

Figure 6.2. Potential emission reductions by source. Source: IPCC (Metz et al., 2001, pp. 7, 33-37). Mt C/yr indicates million tons of carbon equivalents per year.

The cost column shows that some of the changes can be achieved without net economic costs while others will increase the economic costs of activity. Those that can be done with negative economic costs are win/win opportunities that are both profitable and reduce damage. Changes that are win/win overall may still adversely affect individual businesses. Other changes, where costs are positive, are win/lose situations requiring a trade-off between economic and environmental objectives.

The emerging response takes a variety of forms. Profit-motivated businesses are developing and deploying more efficient technologies, shifting the activity mix of economies to reduce material and energy intensity. The Kyoto agreement is encouraging governments to introduce quantitative restrictions on greenhouse gas emissions and some individuals are changing their own behavior or engaging in activism.

Chapter Four has shown that businesses are not likely to voluntarily pursue activities or use technologies that require them to sacrifice profits. Further, even where there are net economic benefits from reducing emissions, as in building and industry, existing businesses may be harmed or may fear harm and therefore are likely to oppose policies designed to effect the changes. Governments are less likely to require change if the industries likely to be affected are large so people are likely to lose their jobs (e.g., Ekins, 1999; and see Chapter Four).

Quantitative projections of the impacts of emerging responses for comparison with what is required to achieve the B1 scenario are not available. However, the obstacles to response that have been identified, together with the observation that damaging climate change is expected even with the most optimistic scenario, imply that a substantial response gap is likely so strategies to accelerate and increase the response would be valuable. The importance of implementation efforts and the potential for behavioral initiatives to overcome obstacles are highlighted by the IPCC who conclude the following:

> Changes in collective rules and individual behaviors may have significant effects on greenhouse gas emissions, but take place within a complex institutional, regulatory and legal setting. Several studies suggest that current incentive systems can encourage resource intensive production and consumption patterns that increase greenhouse gas emissions in all sectors, e.g., transport and housing. In the shorter term there are opportunities to influence, through social innovations, individual and organizational behaviors. In the longer term such innovations, in combination with technological change, may further enhance socio-economic potential, particularly if preferences and cultural norms shift towards lower emitting and sustainable behaviors. These innovations frequently meet with resistance, which may be addressed by encouraging greater public participation in the decision-making processes. (Metz et al., 2001, p. 8)

The last step of Figure 6.1 and the objective of this Chapter is to devise an implementation strategy to accelerate and strengthen the response and close the response gap. The dotted line on Figure 6.1 shows that the expected impact of the technical and implementation strategies combined is monitored so that revised technical and implementation strategies can be developed if needed.

International agreements

At the time of writing the Kyoto Protocol is a proposed international agreement to reduce emissions of greenhouse gases during the period 2008-2012. The targeted reductions are expressed as a percentage below 1990 levels and the percentages vary among countries. The agreement, once ratified, is binding but there are no financial penalties for failure. Instead, countries that fail to meet their targets will receive increased targets in subsequent periods so that the targeted volume reductions can be achieved.

Rowlands (1995) argues that analyses of international cooperation rely on three kinds of explanation: knowledge, interests and power. Knowledge based explanations rely on convergence of understanding about the problem. If everyone understands the need for policies to reduce emissions then an agreement can emerge. The work of the IPCC is designed to provide a shared foundation of beliefs about the outcomes of existing trends and to identify policies that can change the trends. While knowledge may be a necessary condition for international agreement it may not be sufficient because even if a country's policy-makers are fully informed about the situation it may not be in the country's interests to join the agreement.

Explanations based on interests recognize this and predict that countries will cooperate only if they can gain a benefit from doing so. Cooperation based on interests may emerge if countries can benefit individually from implementing the agreement or if they can gain benefits if other countries agree too. However, agreement may require resolution of an international collective action problem where it is only in the interests of a country to ratify if sufficient other countries ratify.

The Kyoto Protocol results from an attempt to resolve an international collective action problem. While the global outcome could be improved if all countries ratified and implemented the agreement, most countries have an incentive to continue with business as usual to minimize political and economic costs while relying on the others to reduce emissions. To counter this difficulty the Kyoto Protocol has a provision that makes it binding only once it has been ratified by 55% of signatories representing 55% of developed countries' carbon dioxide emissions (Factbox, 2002, para. 6).

To make matters more difficult, some important countries may not benefit directly from reductions in global warming so these countries lack incentive to ratify. For example, Australia's Prime Minister told Parliament that Australia would not sign the treaty because ratifying the Kyoto Protocol would "cost us jobs and damage our industry" (Banerji and Noble, 2002, p. 17).

The USA has adopted a similar position. President Bush stated in a 2001 letter to four US Senators that he opposes the Kyoto Protocol because "it exempts 80 percent of the world, including major population centers such as China and India, from compliance, and would cause serious harm to the U.S. economy" (para. 2). He goes on to say that "we must be very careful not to take actions that could harm consumers" (para. 5). More recent research on the impact of climate change on the USA indicates that the economy may benefit marginally from global warming (Pearce, 1998, p. 335) so there appears to be a sound economic rationale for this response, given current assumptions.

In contrast, New Zealand's economy is dependent on agriculture and would be harmed by global warming (Cullen, 2002, p. 3). Implementation of the Kyoto Protocol is expected to have a small positive economic effect so the New Zealand government's intention to ratify is also consistent with its economic interests. However, even in New Zealand ratification is opposed by business interests concerned about extra costs of energy and reduced job opportunities resulting from discouraging investment (Thompson, 2001, p. 4).

If it is not in the interests of important countries to agree to ratify then power may be exerted to encourage them. For example, the countries of the European Union have exerted pressure on the USA to "lead the way on this issue and not stall, as many feel the Bush administration is doing" (Kettman, 2002, para. 3). In 2002, President Bush announced initiatives to reduce the rate of emissions of greenhouse gases per dollar of GDP by 18% over the next ten years (White House, n.d., para. 3). These were criticized as "…an accounting trick. The White House is using complicated accounting measures to hide the fact that the voluntary targets they are setting – if we achieve them – represent no departure whatsoever from business as usual” (Kettman, 2002, para. 12).

Breaking the gridlock

Existing knowledge and interests, and the use of international power, are part of the existing response. To accelerate the response, a new force or forces must be brought to bear. The relevant potential forces are summarized in Figure 6.3.

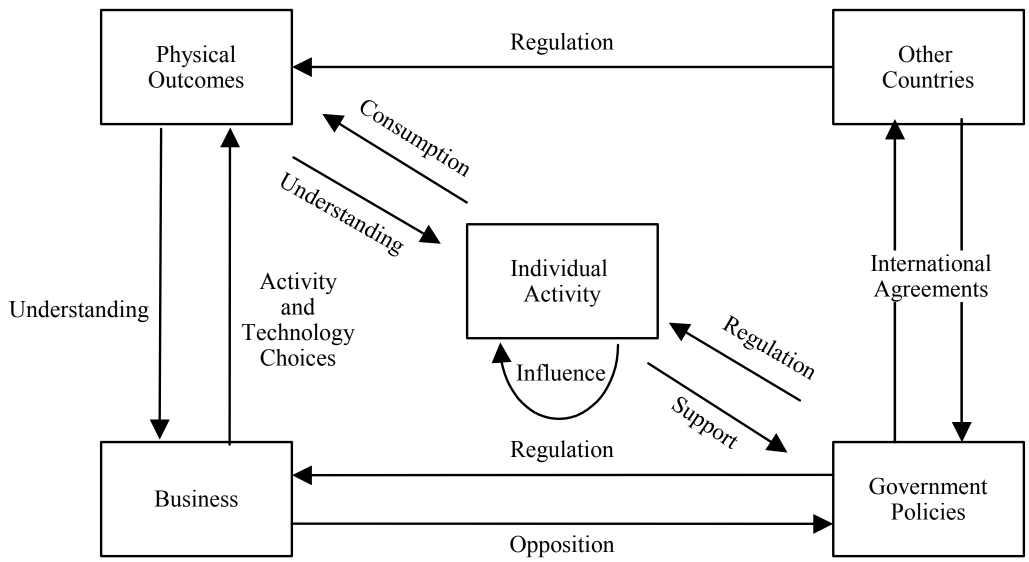


Figure 6.3. Forces affecting ratification of the Kyoto Protocol. Arrows show causal effects. For example, businesses are affected by understanding of physical outcomes and regulation and can affect government policies. Not all forces are shown.

The strategic objective is to achieve an improvement in the physical outcome. In the ratification example this would take the form of a reduction in emissions. The impacts that an individual government can have are affecting the consumption choices of its own citizens and business activities via regulations and by affecting the regulations imposed by other countries. Of these, the impact on regulation by other countries is more important for most countries, although activity within the USA and China will be very important because of the large share of expected emissions coming from these two countries.

International agreements affect the regulation decisions by each other country. Each country must decide what it will agree with the other countries and will then be bound to impose regulations affecting consumption by individuals and production by businesses.

The analysis of Chapter Four implies that where trade-offs between economic objectives and environmental objectives are required, existing businesses will tend to oppose proposed regulation policies while individuals may support the regulatory initiative. The decisions of governments will depend on the relative strength of leadership coming from business lobbying versus individuals, combined with the expected decisions by other countries and the international power brought to bear by other countries. If a government decides to ratify then its decision may affect decisions by other countries and can alter physical outcomes via the regulations imposed in those other countries.

Opposition by businesses will be affected by their understanding of the expected physical outcomes if regulations are imposed. This might involve reduced demand for their products and services if taxes lead to price increases, the risks of switching to new technologies or competitive threats if businesses in other countries gain relative advantage as a result of the regulatory changes.

The strength of support for ratification from individuals will depend on the factors introduced in Chapter Five. Individuals' understanding of the expected physical outcomes, including impacts of expected regulation by other countries, combines with their values and beliefs to determine their strength of support for ratification. Accelerating the response requires increasing the strength of support from individuals, which may be done in many ways including by providing increased understanding of the expected physical outcomes, by changing the values they employ to evaluate expected outcomes and by increasing the expected probability that other countries will introduce regulations if their own country ratifies. Figure 6.3 includes a force that involves individuals influencing one another to allow the potential for changing values and beliefs as part of the strategy to increase the number of individuals supporting ratification.

In conclusion, the strategy proposed to accelerate implementation is to increase individual support for government intervention. The aim is for individuals to lead governments directly, to influence other individuals, and to change their own consumption choices to activities that are less environmentally damaging.

The Ideas-based Strategy

The challenge for managers

A strategy to manage trade-offs between economic and environmental objectives implies that there is a manager who is implementing the strategy. However, no single manager in a country has control over the economy-environment interaction with power to reallocate resources. This implies that numerous individuals must act as managers for the strategy to be effective. These manager-individuals may have official roles in governments, may be activists or may be private individuals, including those who work for businesses.

To overcome the "no point" problem that inhibits the action of individuals, including prospective managers, it is necessary to assume some motivation that provides utility for the manager. This may come from income if the manager has an official role or is employed in an activist organization. It may come from a strong personal norm. It may come from understanding the strategy that is being developed here so that the manager comes to expect that the action will contribute to a reduction in damage and so gets benefit from a reduction in his or her expected eco-cost. Motivation may come from reducing damage to an environment that is valued for its own sake. The existence of officials, activists and others who expend effort to improve environmental outcomes establishes that there are some individuals already acting, and more who are willing to act voluntarily and so can qualify as managers.

To develop and execute an ideas-based strategy to accelerate implementation of responses, a manager would need at least a rudimentary understanding of the physical situation and technical strategy, together with a belief that there is a response gap. An ideas-based strategy also implies some understanding that values and beliefs can affect outcomes, and a willingness to use ideas as tools for achieving change.

The prospective manager must choose a strategy. The analysis of Chapter Five showed that leading government and changing one's own behavior would have costs for an individual manager and that the collective action problem is likely to prevent the manager from expecting to achieve a meaningful impact on the amount of damage. If the manager expected other managers to lead government and to change their own behavior as well the situation would be a little better but the manager might still expect that the aggregate impact of all of the available managers might be insufficient to make any difference to the expected outcomes.

An individual manager might choose to become an activist, joining a green political party or an activist organization. However, adding a manager or even a group of managers to the efforts of existing institutions may not change the overall balance of forces supporting and opposing policy choices such as ratification of the Kyoto Protocol.

The strategy proposed requires managers to choose activities that influence other individuals to change their beliefs and values. The aim is to encourage the other individuals to go on to influence others so that the resulting aggregate change in values and beliefs results in actions that shift the national balance of power sufficiently to lead governments to establish damage reducing policies such as ratification of the Kyoto Protocol. Further, individuals with changed beliefs and values will make different choices about their own consumption activities, and if there are large enough numbers of such individuals the aggregate damage outcomes can be altered.

Changing individual activity choices

Chapter Five identified four beliefs that might prevent an individual from voluntarily carrying out a pro environment activity such as leading government, influencing others, or changing his or her own consumption activity. These activities are feasible for individuals so "can't do" is not an obstacle. Therefore the three belief obstacles that must be overcome are "no need," "not me," and "no point."

Figure 6.4 summarizes the forces that can lead an individual to carry out a pro environment activity. The left hand side of the figure shows the beliefs that would lead an individual to act voluntarily. If an individual believes that there is a need for activity change, that individuals are responsible and that action will be effective, then that individual should be willing to act, subject to the SEU for the particular activity chosen being positive. Individuals who are managers may be willing to act because they already hold these beliefs or because they have other motivations, for example being in paid employment that requires them to carry out pro environment activity.

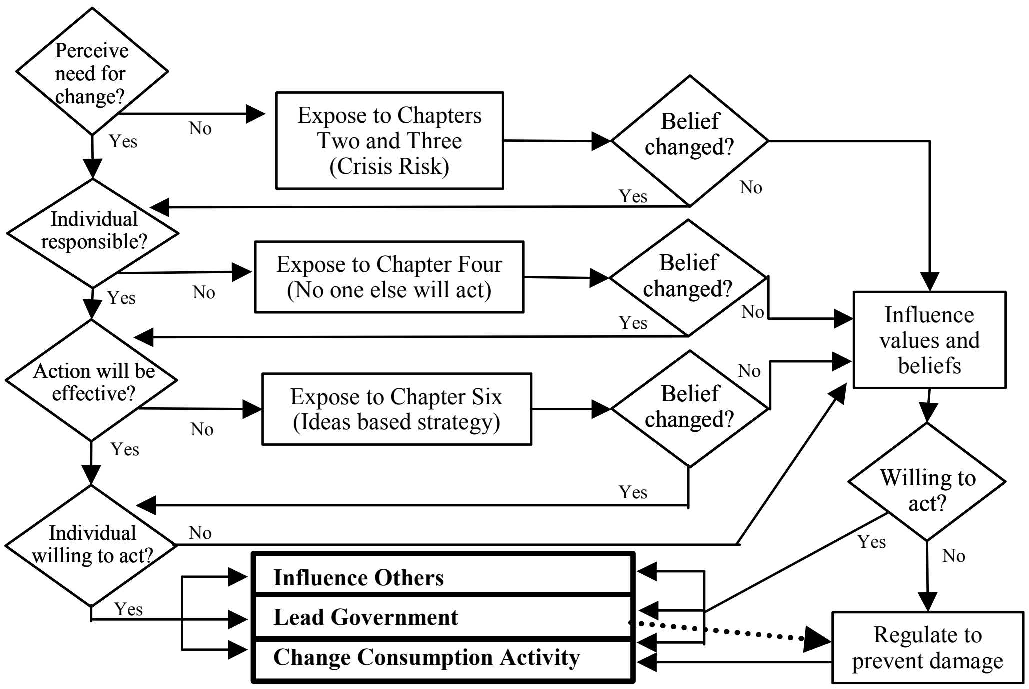


Figure 6.4. Algorithm for managers to change beliefs and values. Shows how managers can change beliefs and values to produce pro-environment activity. Boxes represent activities and diamonds represent decisions. The solid arrows show the sequence of activities and decisions. The path taken by the individual determines the form of influence required at the upper right box. The dotted arrow indicates government imposition of regulation.

The strategy requires that managers exert influence on beliefs and values and Figure 6.4 shows the algorithm that can be used by managers to influence other individuals so that they too will choose pro environment activities. If the obstacle for the individual is "no need" the individual can be exposed to material like that included in Chapter Two and Chapter Three of this thesis with the aim of convincing the individual that there is a risk of crisis unless there is widespread activity change. If the obstacle is "not me" then the individual can be exposed to the argument contained in Chapter Four and if the obstacle is "no point" then the individual can be exposed to the argument of this chapter. Individuals may be willing to act voluntarily after being exposed to one or more of these arguments.

On the other hand individuals may not be convinced by arguments of the form contained in this thesis or may retain one or more beliefs that are obstacles to pro environment activity. For these individuals the managers can try to influence other values and beliefs as shown on the right hand side of the figure. For example getting the individual to place a value on environmental outcomes, encouraging altruism instead of superiority as a value or getting the individual to recognize the personal eco-cost of his or her own behavior might be sufficient to change activity choices. The specific values or beliefs influenced will depend on existing values and beliefs. Research to understand the state of values and beliefs, and willingness to change these, will help managers in choosing the best approaches.

Influencing values and beliefs will encourage some individuals to choose pro environment activities. The strategy requires managers to focus their efforts on exerting influence but influenced individuals may choose any combination of influencing others, leading governments, or changing their own consumption activity.

Once sufficient individuals are leading governments the governments will introduce regulations constraining the consumption activity choices of the remaining individuals so that a change in the consumption activities of all individuals can be achieved. Some individuals will change their consumption activities because they already hold beliefs and values that lead them to do so, some will change activities because they are exposed to arguments similar to those contained in this thesis that overcome the belief obstacles, some will change because their beliefs and values are changed by chains of influence established by managers, and some will change because of regulations introduced by governments.

Influencing beliefs and values

Individuals can influence others to adopt norms (Oliver, 1980, p. 1356) or norms can be learned by imitation (Hechter, 1987). The mechanisms for influence and imitation are different. Efforts to change beliefs and values operate through influence. Influence has the advantage of being able to be used actively by the influencer.

Imitation depends on an individual recognizing that another individual has a belief or value and changing his or her own belief or value to become more similar to the belief or value of the other. The change may occur because a favorable outcome of the value or belief is observed (Critto, 1999, p. 5), because of a high regard for the individual holding the value or belief (Hechter, 1987), or because imitation is lower cost than research (Bikhchandani, Hirshleifer, and Welch, 1993).

For both imitation and influence the amount of change in the target individual depends on the relationship between the individuals. One would expect that closer social relationships and more effort on the part of the influencer will, ceteris paribus, increase the amount of change in a norm.

Value		Economic Man	Ecological Individual	
			Before Value Change	After Value Change
$v + c$	consumption	1.0	0.7	0.6
d	damage	0.0	0.0	0.2
s	superiority or altruism	0.0	0.1	-0.1
n	social norm	0.0	0.1	0.2
p	personal norm	0.0	0.1	0.1
Total		1.0	1.0	1.0

Figure 6.5. Illustration of value change. The first column of numbers shows that economic man gains utility only from consumption. The second column shows weights (w_i) for the values included in the extended utility function before values are changed. The third column shows hypothetical revised values resulting from influence.

The kind of change in the values of individuals proposed is illustrated in Figure 6.5. The figure shows the sources of value identified in Chapter Five on the left. The first column of numbers illustrates the assumption of an economic man who is only motivated by consumption. The second column of numbers shows an ecological individual whose broader sources of motivation are recognized but who has not has not yet been influenced. This illustrative ecological individual gains most value from consumption but is also motivated by success in competition for consumption, by social approval and disapproval and by personal norms. Note that the assumption of an ecological individual is required to achieve any change because economic man is not influenced by social approval and disapproval.

The third column of numbers shows how values might be revised by social influence. Consumption would be a little less valued. The individual would value environmental outcomes directly, perhaps because of an acquired affinity for the environment or perhaps because of a fear of crisis. The value for superiority has been reversed so that instead of wanting to win in subjective competition the individual has come to value outcomes for others. The social norm has been strengthened while the personal norm remains just as important. The numbers in Figure 6.5 are contrived to illustrate value changes that would alter activities in the direction required by the strategy. Influence can be used to change individual values, the types of activities encouraged by social and personal norms, and the beliefs about the situation, activity options and expected outcomes of activity.

Strategic options for managers

As stated above, the strategy requires managers to influence other individuals, who will in turn influence others, establishing a chain of influence that leads to widespread changes in beliefs, values and activities. However, arguing that a strategy based on influence is the preferred option in terms of the outcomes that would be achieved is not the same thing as establishing that managers can be convinced to choose a strategy based on influencing others. A manager would only choose a strategy based on influencing others if that strategy has sufficient likelihood of success.

A manager with an institutional role or an ordinary individual who chooses to become a manager must choose a strategy. Figure 6.3 showed three kinds of actions that might reduce environmental damage: changing consumption behavior, leading government by providing support for ratification, and influencing others. If the manager chooses to influence others then the manager can encourage the influenced individuals to change their own behavior, to lead government or to influence others. The strategic options for managers are summarized in Figure 6.6. The figure also shows the expected impact of each option, based on the argument that will be presented below.

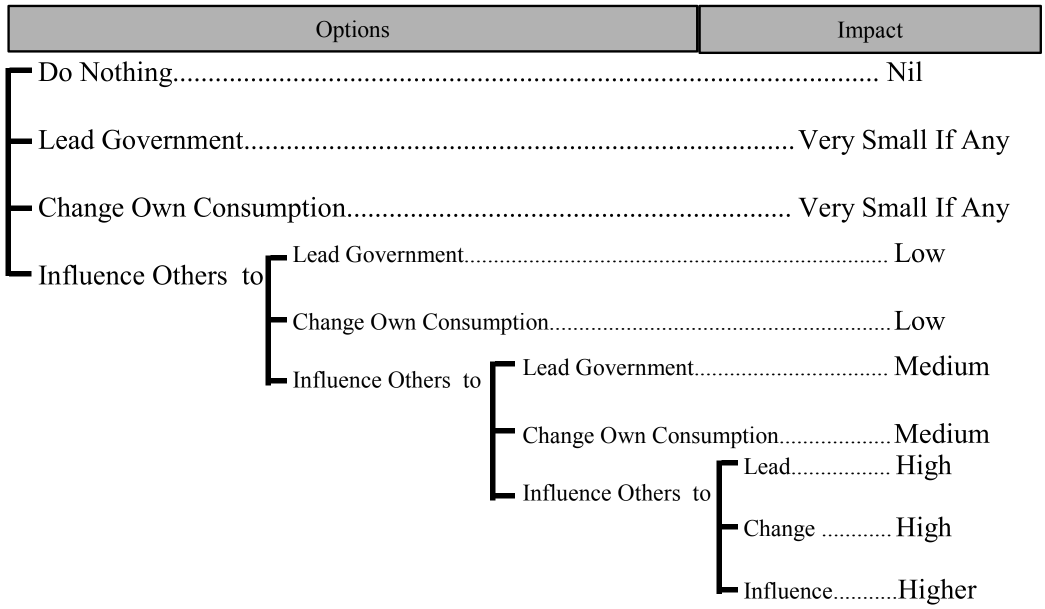


Figure 6.6. Strategic options for managers. The figure shows four options for managers on the top left. If managers choose to influence others so that a chain of influence is established then more people will be affected by the strategy and it will have a greater impact.

The argument above has established that managers acting alone to lead governments, or to change their own consumption activities, are not likely to have much impact. Figure 6.6 shows that managers can have greater impact by successfully influencing others and that the greatest impact is achieved if managers establish a chain of influence that leads to large numbers of individuals leading governments and changing their own consumption behavior. The analysis below will demonstrate that the best strategy for managers is to establish a chain of influence.

The first step of the argument is to show that individuals can be influenced so that they will lead governments. Then it will be argued that in the early stages of implementation managers should focus their efforts on getting individuals to influence other individuals and finally that influencing individuals can alter the individual’s consumption choices.

Influencing other individuals to lead government

The potential for changes in beliefs and values to alter choices about activity is illustrated in Figure 6.7 for the case of leading government. Leading government is a relatively simple thing to do. The individual only needs to respond to opinion polls and to vote. It may have only a small consumption cost. However, the voting option may be formed so that it leads to outcomes that affect consumption in other ways, for example if a green party wanted to increase taxes on damaging consumption activity. Despite this, for the present, assume that the act of influence has no effect on aggregate outcomes because only a small proportion of the population will influence the government in the manner required by the strategy.

Source of Value	Before the Individual is Influenced			After the Individual is Influenced		
	Importance	Belief About Outcome	Contribution to Utility	Importance	Belief About Outcome	Contribution to Utility
$v + c$	0.7	-0.2	-0.14	0.6	-0.2	-0.12
d	0.0	0.0	0.00	0.2	0.0	0.00
s	0.1	0.0	0.00	-0.1	0.0	0.00
n	0.1	0.0	0.00	0.2	1.0	0.20
p	0.1	0.0	0.00	0.1	1.0	0.10
SEU			-0.14			+0.18

Figure 6.7. Leading government (I). Influence changes the importance (w_i values) of each source of utility and the beliefs about the amount of each source of utility that will be available if the actor leads government (x_i values). SEU is the sum of the contributions to utility. Each contribution to utility is the product of the importance of the value and the belief about the expected outcome of activity. Source of Value symbols labelled in Figure 6.5.

The left hand side of Figure 6.7 shows that, before the manager influences the individual, the act of leading government has a small cost but provides no expected benefit, so it will not be chosen. After being influenced, the individual may believe that leading government is the right thing to do and may believe that it will be approved of by respected others. As shown by the illustrative numbers, these sources of positive utility may be enough to offset the small cost of leading government, despite the individual continuing to believe that there will be no beneficial outcome for the environment or for future consumption.

The lack of an expected benefit for the environment or for future consumption from leading government arises because of the assumption that at this stage only a few individuals will be exerting leadership, insufficient to alter policy outcomes.

However, if enough managers follow the strategy of encouraging individuals to influence others for long enough, there will be a gradual change in the composition of the population with an increasing proportion of individuals gaining positive value from leading government. When this happens there will be an additional benefit potentially available from leading government, as shown in Figure 6.8.

Source of Value	Small Number of Individuals Influenced			Individual Choice Affects Outcome		
	Importance	Belief About Outcome	Contribution to Utility	Importance	Belief About Outcome	Contribution to Utility
v + c	0.6	-0.2	-0.12	0.6	-0.7	-0.42
d	0.2	0.0	0.00	0.2	1.0	0.20
s	-0.1	0.0	0.00	-0.1	-1.0	0.10
n	0.2	1.0	0.20	0.2	1.0	0.20
p	0.1	1.0	0.10	0.1	1.0	0.10
SEU			+0.18			+0.18

Figure 6.8. Leading government (II). The right panel shows when a critical mass of influenced individuals has been created. If the individual expects to contribute to policy change then the expected consumption cost can be offset by benefits from reducing environmental damage and improved outcomes for others. SEU is the sum of the contributions to utility. Each contribution to utility is the product of the importance of the value and the belief about the expected outcome of activity. Source of Value symbols labelled in Figure 6.5.

Figure 6.8 shows how individual assessments of leading government may change when the total number of individuals exerting leadership approaches the number needed to change the policy outcome. As before, the consumption cost of leading government is -0.2 but there is an additional expected consumption cost of -0.5 because the individual now anticipates the possibility that government will regulate to prevent damaging activity and that this will impose a consumption cost on the individual.

The expectation that government might regulate also provides benefits via reduction of environment damage and improved outcomes for others that may offset the increased cost, leaving the individual willing to lead government, as before.

When critical mass is established, the individual may believe that his or her own leadership will not change the outcome because sufficient other individuals will lead governments to guarantee the policy change. Such an individual would not expend any incremental consumption cost to lead government and may not value any incremental protection of the environment. The activity cost and benefits from the two types of norms remain sufficient to encourage the individual to lead government.

Influencing other individuals to influence others

A small number of managers influencing other individuals so that they lead governments may eventually change a large enough proportion of the population to alter policy outcomes. However, implementation will be accelerated if managers instead focus on influencing individuals so that they influence other individuals, accelerating the growth of the proportion of the population that supports the policy change.

Establishing such a chain of effects requires that managers believe that individuals who have been influenced will be willing to influence others. Figure 6.9 compares the utility available to an ecological individual from influencing others before and after the individual is influenced.

Source of Value	Before the Opinion Leader is Influenced			After the Opinion Leader is Influenced		
	Importance	Belief About Outcome	Contribution to Utility	Importance	Belief About Outcome	Contribution to Utility
v + *c*	0.7	-0.1	-0.07	0.6	-0.1	-0.06
d	0.0	0.0	0.00	0.2	0.0	0.00
s	0.1	0.0	0.00	-0.1	0.0	0.00
n	0.1	0.0	0.00	0.2	1.0	0.20
p	0.1	0.0	0.00	0.1	1.0	0.10
SEU			-0.07			+0.24

Figure 6.9. Influencing others to influence others. SEU is the sum of the contributions to utility. Each contribution to utility is the product of the importance of the value and the belief about the expected outcome of activity. Source of Value symbols labelled in Figure 6.5.

Exerting influence on others can be done with a few words expressing approval or disapproval. Exerting influence in a social setting may be directly rewarding too so the net expected consumption cost is likely to be quite small and is shown as -0.1 in Figure 6.9. An individual is not likely to expect that an act of influence will result in a change of damage or superiority but an influenced individual may be influenced by a social norm and may have come to believe that exerting influence is the right thing to do. The result of these assumptions is that before the illustrative individual has been influenced the SEU of exerting influence is negative but after the individual has been influenced the SEU of exerting influence is positive. Note that if the cost to the influenced individual of exerting influence is small enough the social norm alone or the personal norm alone may be sufficient to get the influenced individual to influence others.

One act of influence is not likely to be enough to achieve the kinds of changes in values and beliefs illustrated in Figure 6.9. However, if each act of influence is motivated by outcomes like those illustrated, then individuals can be influenced many times without any expected impact on consumption or damage outcomes being required.

If the manager has any expectation that the strategy will be successful then the better option will be to encourage individuals to influence others rather than encouraging them to lead government, at least in the early stages of strategy implementation. This conclusion is illustrated in Figure 6.10. The Figure shows two options for an influenced individual: influencing others so that they lead government or influencing others so that they influence others.

Source of Value	Importance	Government (I)		Others	
		Belief About Outcome	Contribution to Utility	Belief About Outcome	Contribution to Utility
$v + c$	0.6	-0.2	-0.12	-0.7	-0.42
d	0.2	0.0	0.00	1.0	0.20
s	-0.1	0.0	0.00	-1.0	0.10
n	0.2	1.0	0.20	1.0	0.20
p	0.1	1.0	0.10	0.5	0.05
SEU			+0.18		+0.13

Figure 6.10. Leading government vs. influencing others. It is assumed that the individual has been influenced. SEU is the sum of the contributions to utility. Each contribution to utility is the product of the importance of the value and the belief about the expected outcome of activity. Source of Value symbols labelled in Figure 6.5.

The manager is assumed to be choosing a strategy at the beginning of the process, when only a few individuals are supporting the policy change. Therefore the option of leading government is the one considered in Figure 6.7, where the leadership occurs because of social approval or disapproval, and no reduction in damage is expected. The value for the influenced individual of influencing government is the same as for the manager influencing government directly. Therefore, as previously, the value for the individual of leading government is +0.18.

If the influenced individual influences others and understands that many other managers are adopting the strategy so that it may be successful then the influenced individual will expect that the cost of exerting influence on others will include a consumption cost resulting from the expected change in regulation. The influenced individual would also expect the regulation to reduce damage and to help others, providing an offsetting benefit. Further, it is assumed for this illustration that influencing others in this way runs somewhat counter to personal norms for an influenced individual so the personal norm benefit illustrated is lower than that for leading government.

With these assumptions and the chosen numbers, an influenced individual would choose to lead government rather than to influence others because +0.18 is larger than +0.13. However, it is not the individual who is making the choice; it is the manager. The influenced individual can be influenced to lead government or to influence others. The manager will prefer a strategy that involves establishing a chain of influence because any positive SEU from exerting influence for the influenced individual means that some influenced individuals will influence others and because in the long run the strategy will have a greater effect on environmental damage outcomes. For this reason the influence strategy would be preferred by managers so long as the SEU of influencing others remains positive for influenced individuals.

Focusing on opinion- leaders

If managers should focus on influencing individuals so that they will in turn influence others then managers should target those individuals who are most effective at influencing others. Managers can increase the effectiveness of their influence by focusing their efforts on opinion-leaders. Opinion-leaders are people who are willing and socially self-confident enough to hold beliefs that are different from the mainstream beliefs of others. If they were not willing to hold such divergent beliefs they would be unable to lead opinion. At the same time it is opinion-leaders who reinforce and maintain the current dominant beliefs.

The impact of social approval depends on the strength of ties among the individuals and choosing individuals to receive influence who themselves are most influential (Marwell, Oliver, and Prahl, 1988). Opinion-leaders can influence one another so that each new opinion-leader influenced is potentially influenced by a larger number of opinion-leaders. This effect is most powerful when the group is small (Elster, 1989, p. 250) and when the ties among the individuals are strong. From the perspective of the potential to influence others to reduce environmentally damaging activity, it is unfortunate that our modern society tends to have large groups with weak social relationships, relative to other cultures and other times in history (Taylor, 1987, p. 168-169).

Whether opinion-leaders will adopt the values and beliefs communicated by the managers will depend on how convincing the managers' argument is. Opinion-leaders are characterized here as people who make up their minds based on the facts and arguments before them. If opinion-leaders are not convinced by the arguments for these proposed belief changes, as enhanced and delivered by managers, then the strategy will fail.

The beliefs communicated by managers, if adopted, would go some way to provide an opinion-leader with an incentive to influence other individuals. Consider the situation of one of today's opinion-leaders who might be characterized as satisfied with economic growth as the primary societal objective because it is delivering improved quality of life for most people. The opinion-leader may be vaguely concerned about damage to the environment but not concerned about the risk of an environmental crisis because of confidence that if environmental damage becomes threatening, then someone else will act to counter the threat.

Now consider what happens if that opinion-leader is persuaded by managers, or by another opinion-leader, to adopt new beliefs that there is a risk of an overshoot crisis so governments should adopt damage reducing policies and that individuals should exert leadership to accelerate policy changes. Now the illustrative opinion-leader must revise the inconsistent beliefs about satisfaction with economic growth, risk of crisis and reliance on someone else to solve the problem.

However, by themselves these belief revisions may not be sufficient to motivate action by opinion-leaders. An opinion-leader must choose an action that has larger SEU than the option of doing nothing. The opinion-leader faces a choice among leading government, influencing others or changing consumption behavior. In practice opinion leaders may choose a mix of activities that includes all three types.

If individuals choose to influence others then they may receive a process benefit or cost that affects the expected utility of the activity option. In some circumstances it is fun to influence others whereas in other circumstances it is a chore. If exerting influence provides a process benefit for the opinion-leader then a small amount of social approval may be all that is required to redirect the content of influence by opinion leaders to implement the strategy.

The opinion-leader's assessment of the probability of success of the whole strategy may affect the benefit expected from improved environmental outcomes (R. Hardin, 1982; Elster, 1989). This expected probability is in turn affected by the opinion-leaders' assessments of how many other opinion-leaders will influence individuals and how successful they are likely to be. If the strategy has additional elements that increase its chances of success then opinion-leaders will be more likely to adopt it if they are aware of these additional elements.

Note that opinion-leaders who elect to influence others but do not change their own consumption behavior can make a worthwhile contribution to risk reduction. Their own behavior can be changed later, by the influence of others and by regulations that will be imposed by governments. The key to success is to create a pattern of social and institutional circumstances that will encourage the behavior that will lead to the desired outcomes.

Consumption choices

The argument so far has been that managers will be most effective if they focus initially on influencing opinion-leaders, getting them to influence other individuals who will lead government. Governments will then regulate business activity. If the values and beliefs of individuals change then they will also change their consumption behavior, encouraging businesses to alter their products and services so they are less damaging. Figures 6.11 and 6.12 show how consumption choices can be affected by changes in values and beliefs.

Source of Value	Before the Individual is Influenced			After the Individual is Influenced		
	Importance	Belief About Outcome	Contribution to Utility	Importance	Belief About Outcome	Contribution to Utility
$v + c$	0.7	-0.5	-0.35	0.6	-0.5	-0.35
d	0.0	0.0	0.00	0.2	-1.0	-0.20
s	0.1	1.0	0.10	-0.1	-1.0	-0.10
n	0.1	1.0	0.10	0.2	-1.0	-0.20
p	0.1	1.0	0.10	0.1	-1.0	-0.10
SEU			-0.05			-0.95

Figure 6.11. Commuting by car before and after influence. SEU is the sum of the contributions to utility. Each contribution to utility is the product of the importance of the value and the belief about the expected outcome of activity. Source of Value symbols labelled in Figure 6.5.

Figure 6.11 shows the SEU for commuting by car before and after the individual's values and beliefs are influenced. There is a direct cost in time and money from commuting by car. Before the commuter is influenced there is a benefit from superiority that occurs when the comfortable driver cruises past buses at bus stops, and past cyclists and pedestrians. Using the car is approved of by others and regarded as the right thing to do. The commuter gains positive consumption benefit from salary that offsets the negative SEU of time spent at work and of commuting to work by car so commuting by car can have a small negative stand-alone SEU yet still be chosen by the individual.

After the individual is influenced the damage caused to the environment, superiority over other commuters, expected social disapproval and the personal norm all become sources of negative utility for the car-using commuter. Figure 6.12 shows that a switch to commuting by bus increases the consumption cost because the bus has higher marginal cash cost than the car and takes longer. However this increased consumption cost is more than offset by the reduction in damage from reducing personal emissions, reversing the sign of the utility from superiority, social approval of the travel mode switch and utility from doing the right thing. Travel by bus still has a negative utility because of the consumption cost and the environmental damage caused but the individual continues to commute to gain the income available from employment.

Source of Value	Importance	Car		Bus	
		Belief About Outcome	Contribution to Utility	Belief About Outcome	Contribution to Utility
$v + c$	0.6	-0.5	-0.35	-1.0	-0.60
d	0.2	-1.0	-0.20	-0.5	-0.10
s	-0.1	1.0	-0.10	-1.0	0.10
n	0.2	-1.0	-0.20	1.0	0.20
p	0.1	-1.0	-0.10	1.0	0.10
SEU			-0.95		-0.30

Figure 6.12. Commuting by car versus commuting by bus after influence. It is assumed that the individual has been influenced. SEU is the sum of the contributions to utility. Each contribution to utility is the product of the importance of the value and the belief about the expected outcome of activity. Source of Value symbols labelled in Figure 6.5.

Hunecke et al. (2001) found that the social norm, the personal norm, and provision of a free ticket had approximately equal impacts on the choice to travel via the subway. This demonstrates that non-economic sources of utility can be important in consumption choices.

Implementing the Strategy

Population and time

Managers, opinion-leaders and other individuals are distinguished by their exertion and reception of influence. Managers initiate exertion of influence. While they may later receive influence from others it is this initiation that distinguishes them. Opinion-leaders both receive influence and influence others. Other individuals are influenced but do not influence others. Individuals may take different roles on different issues or at different times.

A manager may influence an opinion-leader, who may influence an individual. If the individual goes on to lead government then the exertion of power sought at the beginning of this chapter has been achieved. The chain of effects is shown on Figure 6.13.

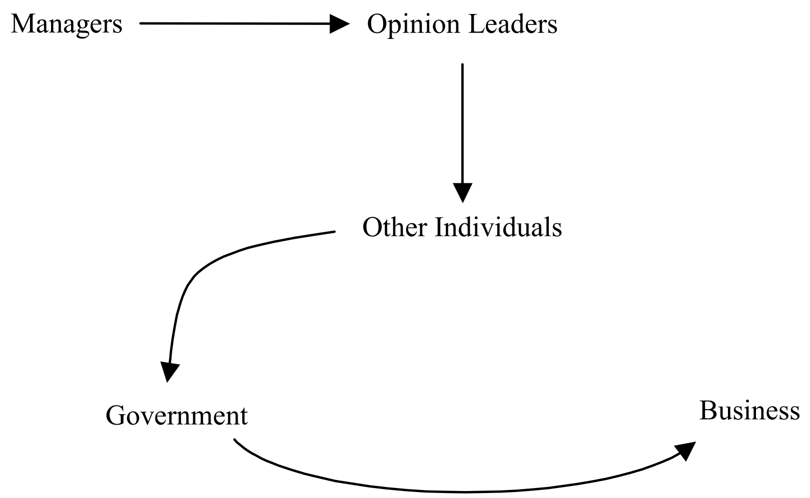


Figure 6.13. Using the influence strategy to lead governments. Arrows show the main effects of the strategy to influence governments so that they regulate business activity.

The strategy requires managers to focus on influencing opinion-leaders and relies on the opinion-leaders to spread the influence through the population. Accumulating sufficient leadership requires convincing a large enough proportion of the population to change the way they respond to polls and exercise their vote. Provided enough leadership is brought to bear, governments will ratify the Kyoto Protocol, regulate damaging business activity, and encourage less damaging technologies. For each policy issue or outcome change desired the change may occur only when a critical percentage of the population is choosing activities that reduce damage.

Figure 6.14 shows how changing beliefs and values can affect policy choices or other outcomes. On the left axis are the characteristics of individuals: their beliefs and values that affect their choices of activities. For each issue, each individual's beliefs about expected outcomes result from his or her understanding of the situation and the activity options available. Values and the expected outcomes drive the choice among the options.

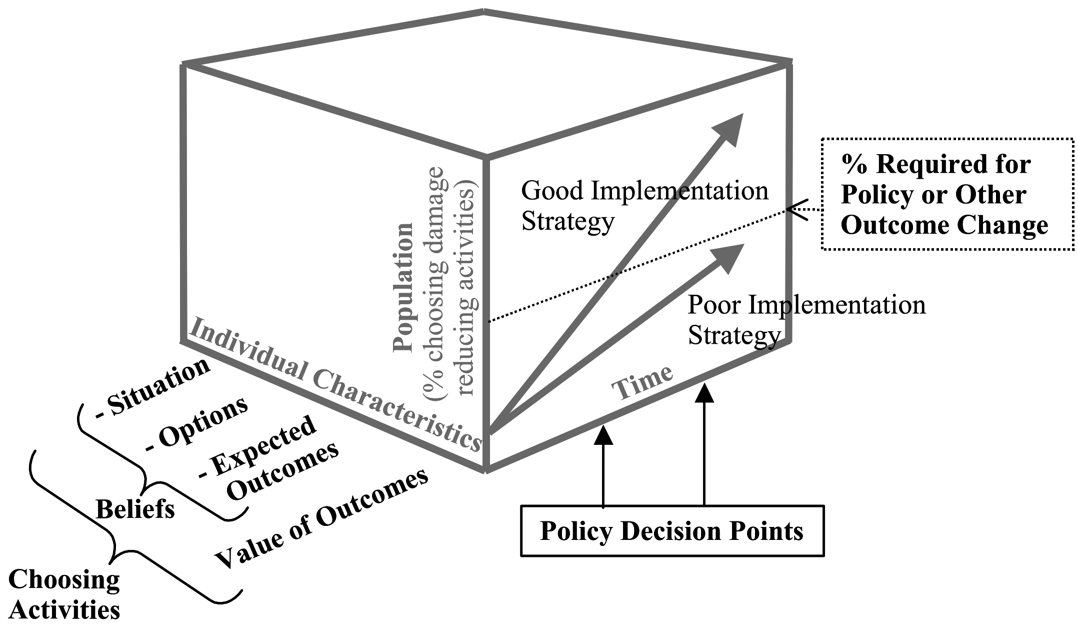


Figure 6.14. Population change over time. This is for a specific policy or outcome. The left hand axis shows the factors that influence choice, assumed to take different values for each individual, and to change through time. Value and belief change for individuals leads to an increasing proportion of the population choosing damage reducing activities over time. The proportion choosing damage reducing activities is shown on the vertical axis. Time is shown on the right hand axis. The right hand panel shows that a good implementation strategy leads to more rapid growth in the proportion of the population choosing damage reducing activities and to faster change in policy or other outcomes. The body of the cube contains the values of the factors influencing choices, varying amongst individuals and changing over time.

The vertical axis represents the population, arranged to show the proportion that has chosen the damage reducing activity of interest. The right axis is time, with two policy decision points illustrated. The aim is to accelerate the increase in the proportion of the population carrying out the damage reducing activity to the level required for the policy change or to achieve some other desired outcome. The two arrows on the right hand panel illustrate that a good ideas-based implementation strategy will reach the critical percentage of the population required for policy or outcome change more rapidly than a poor strategy.

The argument shows that a strategy of altering the values and beliefs of individuals can have wide-ranging effects. The main effects of the strategy are summarized in Figure 6.15 and described below.

Figure 6.15 shows individuals lead governments directly and influence businesses by changing consumption choices. Governments in turn regulate businesses and encourage less damaging technologies. As shown in Figure 6.3, governments may reach different international agreements. Governments also affect individuals by their choices of regulation and by their educational activities. Businesses may alter their stance of opposition to or support for regulatory initiatives. Businesses respond to regulation and changing consumption choices by altering their product and service offers.

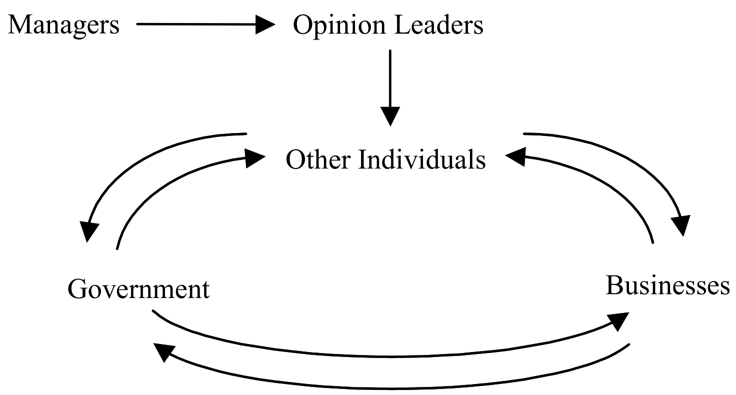


Figure 6.15. How managers influence outcomes. Arrows show the effects of the strategy. Individuals lead governments and their consumption choices change offers by businesses. Governments regulate production and consumption activity by businesses and individuals. Businesses alter their lobbying activities and change their offers. There are many second order and less important effects not shown.

Obermiller (1995) shows that if people are not aware of environmental issues or are not concerned about them then communication will be most effective if it focuses on establishing the need for action. However, when concern is established the focus of communication should shift to encouraging individuals to act and convincing them that their actions will have a beneficial impact.

Positive incentives are most effective when the proportion of the population adopting recommended norms is small but, as the proportion of the population "recruited" increases, negative incentives will be more effective (Oliver, 1980). This means that the early stages of the strategy implementation will encourage individuals to change their values and beliefs while the later stages will use coercion in the form of social disapproval and regulation to constrain the behavior of those whose values and beliefs continue to support damaging activities.

Our ability to influence one another depends in part on the strength of social ties within our communities. If technology is stable relative to the physical resources available, as it was during the agricultural era, then people must cooperate to preserve resources from over-exploitation or appropriation by others. This cooperation is facilitated by social norms and binding of individuals into their communities.

If the world changes so that opportunity is enormously increased, and both individuals and communities benefit from competition in the race to exploit the available opportunities, then the need for cooperation is reduced and there is reduced need to bind individuals into their communities. Individuals benefit because the overall benefits from growth are flowing to all, as described by Schumpeter (1954/1966) in the first part of *Capitalism, Socialism and Democracy*. Furthermore, the vestiges of traditional communities are available to support these who are unsuccessful.

This would all be part of an explanation of modern social pathology and not part of the story about environmental damage being told here, except for one thing. The absence of community involvement now leaves us in a position where the instrument of change we want to use, community based social influence, has atrophied. Individuals who have become disconnected from their communities are less responsive to influence in a community setting.

The strategy does not highlight roles for media and non-government organizations. Both kinds of institution can be important influencers of beliefs and values and can affect the cause and effect relationships shown in Figure 6.15 but these influences and effects have not been explored in developing the strategy. Roles for these institutions have been omitted because of a desire to keep the strategy as simple as possible. It could be very useful to incorporate roles for these kinds of institutions in specific applications of the strategy.

The remainder of this section examines the roles of individuals, governments and businesses in more detail.

Individuals

The ideas-based strategy will only be implemented if individuals decide to take matters into their own hands and become managers. Many individuals have already chosen to influence others, to lead governments, or to change their own consumption behavior. The strategy does not identify new activities for those who are already willing to act in those ways to reduce environmental damage. What it does is provide an argument to encourage more individuals to choose to become managers and provide information to make their activities more effective.

Individuals are expected to lead governments and to change their own consumption behavior as a result of the changes in their beliefs and values, resulting from the influence exerted by the opinion-leaders. Some individuals will become opinion-leaders and will influence others.

If individuals adopt different values and beliefs that provide them with different incentives then their behavior will change too. For example, in one business I worked with the margin earned by each operating unit was the metric used to reward operating unit managers. Analysis revealed that one operating unit had lower capital employed and so was much more profitable than the others. The business leadership quickly adopted the new belief that improving capital efficiency in the less efficient units would produce a large increase in shareholder value. The change was accomplished by altering performance measures to emphasize capital efficiency and by changing the incentives for the operating units. Once operating unit managers were motivated to perform well on the new measures behavior changed rapidly.

It is not necessary for individuals to understand the strategy fully in order to play their roles. However, it is helpful if individuals learn how consumption choices affect damage to ensure their changes in consumption behavior actually reduce damage.

Individuals may work in government and businesses. To this point, businesses and governments have almost always been treated as institutions and activity by the individuals who control businesses and governments has been ignored. As decision-making individuals they are strongly affected by the survival objectives of their institutions; creating value for shareholders and getting re-elected, each important to provide the individuals with the income they will use for consumption.

Despite this, these decision-makers in businesses and governments are individuals who are motivated by other incentives too, including the social approval and disapproval of opinion-leaders. Therefore, where decision-makers have discretion, their choices can be affected by influence being exerted by opinion-leaders. Active efforts by opinion-leaders to influence decision-makers in businesses and governments can therefore improve the likelihood that businesses and governments will act as required by the strategy. Individuals within governments and businesses can be encouraged to search more vigorously for technical solutions that will provide beneficial outcomes for both the economy and the environment as well as to be aware of the need to respond to the concerns of individuals whose values and beliefs have been changed.

Governments

Governments are expected to adopt policies that are consistent with the wishes of individuals. They use opinion polls to understand what individuals want them to do, and individuals' responses to polls and voting behavior will change as different values and beliefs are adopted.

Governments can be led to change the mix of technologies used for production and for consumption. For example, subsidies that encourage the use of the fossil fuels that produce greenhouse gases might be replaced by carbon taxes and tradable quotas. Alternative energy sources are initially higher cost than fossil fuels but costs reduce with accumulated experience and scale. By promoting the use of alternative fuels, governments can bring forward the time when the less damaging technologies are cost competitive. Many less damaging technological options are available already and more could be developed quickly if research and creative efforts were focused on reducing damage as well as generating profit.

Governments can influence agricultural practices to reduce land degradation and can assist developing countries to adopt land management policies, technologies and strategies that are less damaging. They can regulate to prevent environmentally damaging activities and ensure that regulations are accepted and enforced.

The roles that governments play in international forums are especially important for global issues such as greenhouse gases. Governments are much more likely to support international initiatives, like the Kyoto Protocol, to reduce medium- and long-term global environmental damage if the initiatives are strongly supported by their voters.

Governments can have a valuable effect through their educational efforts. They already provide environmental education and are also active in efforts to change values and beliefs, for example about road safety, litter and substance abuse. Increased educational effort could accelerate the changes in values and beliefs that would in turn accelerate the accumulation of support for the damage reducing activities outlined above.

Governments can also be encouraged to ensure that information is available to assist individuals who wish to choose less damaging consumption options. Individuals are well informed about the direct economic costs of purchase and use of a car but few know about the indirect economic costs currently covered by society at large (N. Myers and Kent, 1998, p. xiii), the damage caused by the greenhouse gases their activities release, or how much of a reduction in damage could result from different consumption choices.

Businesses

The influence strategy will only be successful if governments introduce regulations that constrain damaging activity. Regulations may increase costs, may reduce the market volumes available to businesses, may expose businesses to technology transitions that threaten their competitive positions, or may provide less regulated competitors with advantages. Therefore, established businesses are likely to oppose introduction of regulations to reduce environmental damage and they have large resources and strong relationships that help them to do so effectively.

This is an understandable response. As argued in Chapter Four, the purpose of businesses is to generate profits for shareholders, so it is not reasonable to expect businesses to voluntarily forgo profits to reduce environmental damage. Managers who fail to resist constraints on their profit-seeking activity are failing their duty to their shareholders.

Despite this resistance businesses should be constrained. Commercial discount rates mean that profit-motivated businesses place very little value on the long-term future. With current discount rates, any outcome that occurs beyond a few years in the future is not commercially relevant. However, the current activities of businesses can affect crisis risks over much longer time horizons. Businesses that do not care about the long-term future should not have rights to damage that long-term future. Rights imply obligations. Statements that what is good for business is good for the community are not credible if there is a risk of an overshoot crisis.

Businesses leaders are likely to understand this. Businesses are already subject to many kinds of regulation by governments, including damage reducing regulations. As shown in Chapter Four, regulation is the preferred mechanism to ensure that businesses do not promote damaging production or consumption activities. Business leaders expect rules and constraints that are reasonably stable, or at least predictable, and recognize that regulations may at times unfairly disadvantage them relative to their competitors. They are individuals too and can be expected to consider what their own lives and the lives of their children might be like if the Earth experiences an overshoot crisis.

Although regulation is an essential feature of the strategy it is not the only way that the activities of business will become less damaging. Changes in individual values and beliefs will alter the products and services demanded by consumers, and businesses will be quick to provide less damaging offers. Consumers can also constrain the behavior of businesses by affecting the reputations of managers and the value of brands.

Schmidheiny (1992) points out that public pressure can force businesses to take responsibility and that even though only a minority of individuals exert influence consciously, there is valuable potential "we are standing on the threshold of a social learning process that must first bring the individual closer to the proper usage of his or her civil liberties and the responsibilities connected to them" (p. 325).

Social responsibility is a sensible business response to the threat of regulation. What needs to be clear is that it is a strategy to preserve the profit making potential of the business. For example, the Executive Director of the New Zealand Business Council for Sustainable Development makes this clear when he writes "we believe it is enlightened self-interest for business to address sustainable development in order to maintain its long-term license to operate, and to understand and benefit from the business opportunities coming from this" (Spiller, 2001, p. 1). The threat of regulation may lead businesses to voluntarily stop environmentally damaging activity. They may also make token efforts to reduce damage, propose voluntary efforts and develop an environmentally friendly image as strategies to avoid regulation.

BP is an example of an innovative business that has observed changes in social attitudes and moved to offer new services and reduce environmental damage. It has established internal targets to reduce CO_2 emissions, invested US$200 million over six years in solar energy, and launched an environmentally friendly image branded "Beyond Petroleum." Observers commend BP for the steps it has taken but also point out that BP is attempting to gain competitive advantage by differentiating itself from oil companies that have poor environmental images, that it is positioning itself for success in new energy technologies, and that BP's 2007 target of US$1 billion solar energy sales is less than one percent of current revenues (Becoming Less Crude, 1998, paras. 7, 14; Murphy, 2002, paras. 1-4; Frey, 2002)

Businesses are resilient. Some businesses will be harmed by regulation and shareholder value will be destroyed. Astute shareholders will see this early and re-deploy their capital to more secure and hopefully less damaging investments. Some managers and workers will lose their jobs and will find others. It will be a painful transition for many but an overshoot crisis would be more painful. Many businesses will find ways to remain in their current industries, adopting technologies that allow them to operate without violating environmental regulations. Others will shift their product/market strategy to activities that are not environmentally damaging. A lot of current production is simply unnecessary, or is made possible by perverse subsidies or marketing-created consumer demand that encourages damaging activities. New opportunities will arise as environmental outcomes become more highly valued.

Environmental outcomes can be valued by consumers and provide a basis for economic growth. Environmental businesses are growing rapidly, retaining a strong growth rate even through the anomalous 2001 year (War, recession and growth, 2002, p. 34). The issue is not how much demand there is but rather which goods and services are demanded. It would be better for almost all of the people on the Earth to have economic activity that meets the basic needs of everyone than to provide unnecessary goods and services to those who are rich. The challenge is to develop institutional arrangements to redirect economic activity so that the risk of crisis is reduced and the impacts of overshoot are mitigated.

It is important not to confuse the interests of incumbent businesses that may be threatened by regulation with the interests of business in general. Competitive markets are very effective at ensuring that businesses emerge or develop to meet profit-making opportunities (Schumpeter, 1954/1966, pp. 67-68). For example, if regulations are established to ensure that some portion of the fossil fuels available to us is left in the ground then the interests of fossil fuel businesses may be harmed. At the same time new opportunities will be created in alternative energy sources. If unit costs of energy rise then that will be because more inputs are required per unit of energy output so GDP may rise too. Existing businesses will adapt, new businesses will emerge and more efficient solutions will be developed (Iwai, 1984; Winter, 1984).

What difference would it make to the economy as a whole if productive capacity is shifted from activities that produce products and services that meet current consumer needs in damaging ways, to activities that meet modified consumer needs in less damaging ways? Maximization of economic output has always been an over-simplification, because not all output is good output. Mulberg (1995) argues that much economic activity is a means to an end where the end is value delivered to consumers. Reconfiguring production to reduce damaging activities while retaining consumer value would reduce some forms of output but increase others.

Conclusion

The argument made in this chapter is that individuals who choose to act as managers to reduce the risk of environmental crisis have available to them a powerful strategy based on using influence to change the values and beliefs of others. In applying the strategy they should focus on influencing opinion leaders and should aim to get individuals to influence others, to lead governments and to change their own behavior. The strategy relies on social and personal norms to provide the additional incentive that is needed to overcome the collective action problem that prevents otherwise willing individuals from engaging in damage reducing activities.

The strategy may appear to be just common sense. Of course people influence others, governments regulate businesses, and people can be encouraged to change their consumption behavior. However, there are many other options which individuals as managers could consider as strategies to address environmental risk and the influence strategy proposed here is just one of many strategic options. Alternatives to the influence strategy include denying that there is an overshoot risk, relying on prices, relying on technical progress, letting someone else take care of the problem, encouraging businesses to be socially responsible, becoming an activist and lobbying government, abandoning consumption as a motivation, overturning the capitalist system, or developing a new religious ethic.

The argument presented has shown that some of the alternative options are insufficient to accelerate changes that will reduce the risk while others are unnecessary. The influence strategy can help to reduce the risk and provides an effective way that an individual can help to reduce that risk.

The strategy highlights the process of achieving change, unlike other approaches that emphasize the structure of the problem and the outcomes that must result (Connelly and G. Smith, 1999). G. Hardin (1999) argues for the mutual coercion relied upon in the strategy. The different types of actors: managers, opinion-leaders, other individuals, governments and businesses, are influenced by motivated individuals to establish G. Hardin's mutually agreed coercion.

In practice only some potential managers will choose the strategy proposed because many will not be aware of the proposed strategy, many will believe their current strategy is a better approach, and many will be constrained by their current circumstances. In particular, the influence strategy will take a long time to address a large-scale, long-term problem, whereas many managers face environmental issues that must be dealt with today or tomorrow. Fortunately, it will be sufficient to have only some or even just a few managers choose the proposed strategy, provided there is enough effect on opinion-leaders.

If managers adopt the strategy they can influence opinion-leaders, leading them to influence other individuals and create a chain of influence that alters the choices of large numbers of individuals. Individuals who choose to become managers can implement the strategy. They can act alone and without access to large resources.

The strategy can be used to introduce stronger government policies sooner than they would otherwise be implemented, to change consumption choices, to encourage less damaging technologies, and to reduce the likelihood or magnitude of overshoot at the end of the transition.

Some people may object to the strategy because they think of values as absolutes that are not or should not be subject to change according to circumstances. Beliefs are often regarded as either accurate reflections of reality or a private matter for individuals. The argument presented here concludes that both values and beliefs are determined by societal circumstances and, further, that values and beliefs have a strong effect on societal outcomes. Values and beliefs coevolve with outcomes.

The values and beliefs that are optimal during a transition, when there is a lot of environmental headroom, are those that support the most rapid economic development. Consumer sovereignty, business and individual freedom, maximizing output, competition, greed, envy and a disregard for environmental impacts have combined to deliver consumption benefits for individuals and success in geo-political competition among nations.

Whenever environmental disasters occur, people's beliefs and values may change a little in the pro environment direction but the passing of the disaster allows a return to business as usual. The great danger is that the trigger that will change values and beliefs enough to motivate large-scale change will be the emergence of crisis. By then it may be too late to respond and there may be serious losses of utility resulting from population reduction, lower available utility for those who remain, and a permanent reduction in the sustainable carrying capacity of the Earth.

Most people have a strong incentive to avoid such a crisis but the institutional arrangements and values and beliefs that dominate our societies slow the changes that would reduce the risk. Some mechanism to accelerate the change is required. The strategy outlined here is an attempt to develop a practical approach to accelerating changes in ideas that would reduce the risk of crisis.

The changes in beliefs and values that are required are quite fundamental. This is consistent with my experience as a strategist dealing with survival issues for large businesses. Members of a business organization develop beliefs and values that encourage behaviors that help the business to succeed in competition with others. When circumstances change but beliefs and values do not, the business begins to falter. The challenge for the strategist is to understand the changes in the business environment, identify the changes in beliefs and values that will encourage behaviors that will lead to future success, and then to ensure that the beliefs and values change as recommended.

The changes in beliefs and values proposed will not be easy to bring about. As Kuhn (1970, pp. 150-152) showed for scientific paradigm changes, shifts as large as those proposed here are usually complete only when a generation of leaders with one set of ideas is replaced by another generation with new ideas. The same phenomenon is observed in businesses where a change in the leadership is frequently needed to put a business on a successful path (Nystrom and Starbuck, 1984, p. 53).

Prospective managers are much more likely to adopt a strategy if it is intellectually sound and credible. For this reason the problem diagnosis and strategy have been built on a foundation of conventional ideas from economics, environmental science, history, psychology and sociology. However, this integration is unconventional and many of the assumptions used differ from those provided by the dominant paradigm.

Chapter Seven reviews the changes in the theoretical beliefs of the dominant paradigm that have been proposed and combines them to assemble a proposed revised paradigm. The ideas-based strategy to encourage pro environment behavior is consistent with the theoretical beliefs of the revised paradigm.

CHAPTER SEVEN

A REVISED PARADIGM

"As we acquire understanding and intervene with newly acquired concepts of management, we change the coevolutionary path of the system"

Richard Norgaard, 1994a, p. 95

Introduction

The problem addressed in this thesis is management of the risk of environmental crisis arising from widely dispersed activities causing environmental damage. Accumulation of environmental damage despite the availability of technological solutions and policy options suggests that the theoretical and policy tools currently available may not be producing sufficient activity change to reduce the risk.

The previous chapter identified an intervention strategy that could accelerate activity change to reduce environmental risk. However, the assumptions used to build the strategy imply revision of the theoretical beliefs of the dominant paradigm. The revised assumptions are based on conventional theory from several disciplines and supported by empirical research and evidence that justifies their use.

The purpose of this chapter is to extend the content of Chapter Two to define explicitly the extended paradigm that has been implicitly developed to prepare the strategy. The extended paradigm will be developed and articulated so that it can be understood in relation to the assumptions of the existing dominant paradigm and could be used by others as a foundation for solving related problems. The argument of this chapter parallels the strategy development, but with a theoretical rather than a practical focus.

Paradigms provide default assumptions that guide and constrain the options considered in theory and policy development. The dominant paradigm was summarized as a list of ten theoretical beliefs in Chapter One. Economists and other theorists have extended it in many directions. In the course of that work many of the assumptions listed in Chapter One have been relaxed or disputed, and the dominant paradigm has provided the foundation for analyzing a very wide range of economic questions.

However, the issue is not what the dominant paradigm is capable of, or what assumptions can be used for analysis of the interaction between the economy and the environment. The issue is which assumptions are actually applied in the analyses used to develop the policy that affects environmentally relevant activity. Previous chapters have reviewed the history and use of selected theoretical beliefs and have proposed revisions based on the potential of the revision to support changes that can reduce damage, and evidence that the revisions are consistent with empirical research. This chapter will summarize the revisions already proposed and continue that process of revision to arrive at a revised set of default assumptions that will be listed later in the chapter. The list will comprise the proposed revised paradigm. The revised paradigm is proposed for use only where medium- or long-term environmental outcomes are important. In other circumstances some elements of the proposed paradigm might be useful but the case argued here is confined to management of medium- and long-term environmental outcomes.

This chapter focuses on the ideas of the theorists who develop and apply the theoretical beliefs that are used to develop policies and influence the ideas of other individuals. Theories are the beliefs held by theorists. The next section considers the way theories are affected by historical changes such as when a transition ends. The following two sections summarize the theoretical changes proposed for analyses of the environment and analyses of individuals respectively. The revised paradigm is then summarized and the proposed revised list of theoretical beliefs is presented. The chapter concludes with a discussion of ideas about the role of theorists in affecting outcomes.

Stationarity and Theory Revision

Eras and transitions can be identified in the long-term history of the Earth. Chapter Three argued that the Earth is nearing the end of the transition to the industrial era. Current levels of population, activity, output and environmental damage are unprecedented in the history of the Earth, and all continue to grow rapidly. In the present circumstances, assuming that the future will be a continuation of the past is unfounded. Despite this, Case I is implicitly assumed in much of the analysis that drives economic policy and affects environmental outcomes.

Examination of the history of economics and economic thought helps explain why Case I and an ahistorical and stationary economic development process are so widely assumed. The classical economics of the 17^{th}, 18^{th} and early 19^{th} centuries was pre-scientific. Classical economists observed patterns in the world and constructed theories to explain the patterns. There was a clear recognition that the subject matter of economics was changing: "the classical economists understood that the behavior of economic systems…depended on history and circumstances" (Prugh, 1999, p. 15). The aim was to identify concepts that could be used for explanation of economic outcomes and draw on real world events to develop and illustrate the explanations. The explanations were used as the basis for predictions and policy recommendations.

The success of physics and biology revealed what could be done with science and led to a desire to identify fundamental scientific and stationary laws of economics. Nineteenth century theoretical development in economics frequently drew upon analogies from biology and physics, and several authors have traced the important influence that biological and physical models had on economic thinking (e.g., Fisher, 1986; Henderson, 1994). It was not until the late 19^{th} century that economics fully broke from political economy and "economic laws finally assumed that absolute and objective characteristic of natural laws" (Screpanti and Zamagni, 1993, p. 149).

Marshall was one of those who sought to establish economics as a separate field of study over the last years of the 19^{th} century and the early years of the 20^{th} century. Kadish (1989) provides a blow-by-blow account of Marshall's attempts to create a program to produce professional economists: one that was "well adapted to the needs of England's future men of business, financiers, treasury officials, and shapers of economic policies" (p. 204). After several years of committees, proposals and counter-proposals, economics was established as a discipline separate from history. Political economy was divided into economic history and economics. Kadish concludes:

> Economics had terminated its association with philosophy and had become distinctly ahistorical in confining its interest to recent history, the starting line of which was constantly being brought forward. Institutional isolation may have been partly the result of the advent of high theory, for example in causing Marshall to demand, as the historians saw it, one reform too many. Isolation was to become self-perpetuating, developing its own justification while setting economics firmly on a course of theoretical exclusiveness. (p. 209)

The assumption of economic development as a stationary process described by a science uncovering fixed laws of behavior and economic process was established in circumstances that were partly a response to historical conditions and partly a consequence of historical events. The circumstances of the transition mean that labor and capital have been the constraints on output, and continuing availability of environmental stocks has meant that economic progress has continued for a very long time, and has come to be regarded as normal.

The idea of progress emerged over the 16th and 17th centuries (Bury, 1921; Piotr, 1994). Initially progress was viewed as an unusual or revolutionary state. However, progress eventually came to be regarded as normal. Once economics became separated from history, the possibility that progress might not continue into the indefinite future was not considered in the mainstream of any discipline. Economic theories were developed to make predictions about the short-term future and historians studied the past, while mainstream psychologists and sociologists were looking for their own laws, unconnected with history. Until recently, academic communities have not been well equipped to determine whether or not progress can be extrapolated into the future.

Chapter Three argued that emergence of environmental constraints, as the transition to the industrial era ends, means that permanent progress is not assured and that long-term total output growth potential may be much lower than it has been in the recent past, constrained by limitations on the flows from available environmental stocks.

Lasch (1991) points out the failure of the promise of progress. Progress was meant to provide wealth that would benefit the less privileged. However that is not possible:

> The belated discovery that the earth's ecology will no longer sustain an indefinite expansion of productive forces deals the final blow to the belief in progress. A more equitable distribution of wealth, it is now clear, requires at the same time a drastic reduction in the standard of living enjoyed by the rich nations and the privileged classes. Western nations can no longer hold up their standard of living and the enlightened, critical and progressive culture that is entangled with it as an example for the rest of the world. (p. 529)

Lasch's observation does not imply that all progress will become impossible. Barry (1999) points out that "it is only if one equates progress with *undifferentiated* material economic growth that it makes sense from a green position to talk of abandoning progress" (p. 250).

If long-term economic growth prospects are constrained by environmental stock shortages and this possibility is not accommodated in the dominant paradigm then theoretical changes should be expected to accommodate the changed circumstances.

Ideas about the environment

The proposed changes in theoretical ideas about the environment involve abandoning the assumption that the economy-environment interaction will remain in Case I. The proposed revisions are to abandon the free gifts and free disposals assumption, to recognize that damaging environmental stocks may lead to activity options that are in Cases II through V, to allow the possibility that erosion of environmental stocks and the scale of activity may produce a risk of an overshoot crisis, and to acknowledge that there may be a time lag between the emergence of damage and the success of a remedy.

Free gifts and free disposals

Abandoning the free gifts and free disposals assumption implies explicit recognition that activity carried out for economic purposes may require inputs from the environment and may cause damage to the environment.

If the free gifts and free disposals assumption is used, the potential for environmental damage is avoided and so maximizing economic activity is good, because it maximizes the output that provides utility. The treatment of production in the dominant paradigm is illustrated in Figure 7.1, alongside an illustration of the impact of the assumption of an expanded production function.

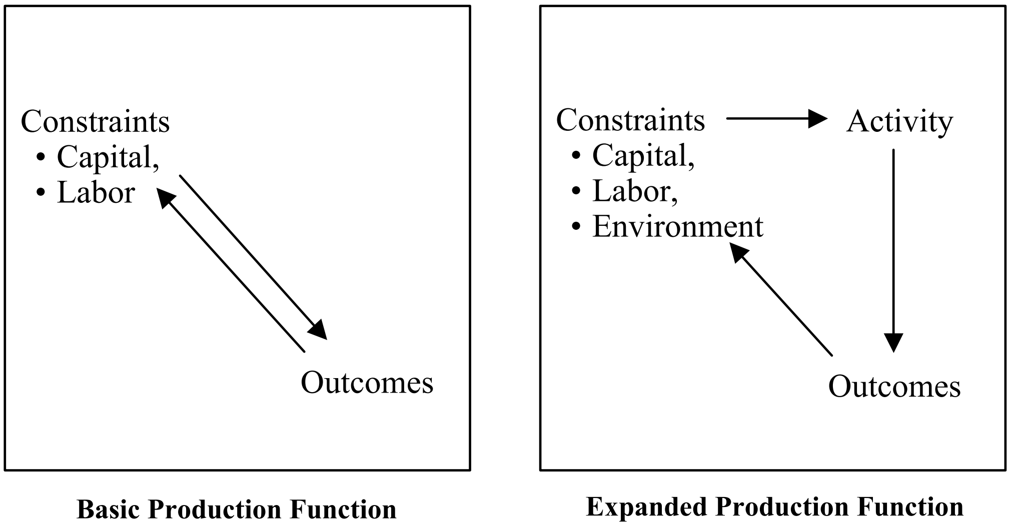


Figure 7.1. The left hand side shows the production function used in the dominant paradigm. Outcomes are determined by availability of capital and labor. The right hand side shows the impact of reintroducing the environment. Environmental stock becomes a constraint. Activity choices must be considered because activity may cause an eco-cost that reduces the environmental stock. Technology is not shown.

In the basic production function, illustrated on the left-hand side of Figure 7.1, output is simply a function of the constrained inputs, and the technology used. There are two important changes made to get to the paradigm on the right hand side of Figure 7.1. First, the environment is added as a potential constraint. By itself this does not have much theoretical impact and can be accommodated by adding a term to the Cobb-Douglas production function as shown in Chapter Two. The second change is that activity can damage the environment, and if the rate of damage is greater than the self-repair capacity of the environment there may be an eco-cost that has an adverse effect on future production possibilities. This second change has a very important impact because it means that activity does not always increase utility so activity choices must be explicitly introduced to the paradigm even if the societal objective is to maximize utility from consumption.

If free gifts and free disposals are not assumed then the level of activity that maximizes the long run utility from consumption may not be the maximum level of activity possible in the short run. In contrast, the dominant paradigm does not need to consider choices about the level of activity because more activity always increases both short run and long run consumption.

The six cases of the economy-environment interaction

The second default assumption change proposed is to allow for the economy-environment interaction to proceed from Case I through Case VI. The environmental stock affected by activity may be relatively small. It could be a fishery, a forest, or an agricultural region. If the amount of damage to the stock exceeds the self-repair capacity so that the stock begins to erode then the amount of stock available to provide an input to activity will reduce. If this process goes on for long enough or the scale of the activity is large enough then the stock will erode sufficiently to adversely affect the inputs to production from the environment, leading to an economic cost, the eco-cost.

The eco-cost may affect the Actor or Other members of the community and, if activity continues or grows, it may become sufficiently large that the total economic cost caused by an additional unit of activity is greater than the economic benefit from the activity. Activity with economic costs that are larger than the economic benefits may continue even if the total economic cost is greater than the total economic benefit because the benefit to the Actor is greater than the cost to the Actor and there are no constraints preventing the Actor from taking advantage of this situation.

Continuing activity in Cases II through V will lead to further erosion of physical environmental stocks unless the erosion of stocks is offset by technological development that improves the efficiency of use of the stock or reduces the damage caused by each unit of activity.

Theorists working with the dominant paradigm do not usually recognize the damage resulting from activity or the potential that the damage may adversely affect economic outcomes. As a result they may implicitly assume that the economy-environment interaction remains in Case I, regardless of the passage of time or the amount of activity. If theorists take account of the six cases of the economy-environment interaction then they will consider the effects of existing and incremental activity on economic and environmental outcomes, explicitly recognizing damage and eco-costs.

Scale

The theoretical development in Chapters Two and Three covers three levels of analysis. At the lowest level is a decision about a single act, where the Actor is assumed to consider the economic costs and benefits of the activity and the impact of potential activity by other Actors. The second level of analysis is the environmental stock, which may be eroded if damaging activity continues for long enough or is large enough, leading to adverse economic and utility impacts in Cases II through V. Emergence of economic costs or introduction of regulations may lead to technological development or a switch to substitutes to allow continued consumption-motivated or profit-motivated activity. If substitutes were available without limit then reduction of environmental stocks as a result of environmental damage would not reduce production potential because other environmental inputs would be available to replace those that were damaged.

The third level of analysis considers what happens when the total amount of activity on the Earth, or large parts of it, becomes large relative to the remaining available physical environmental stocks. It is reasonable to assume finite substitution possibilities for the kinds of resources considered here, resources such as atmosphere, climate, agricultural land, chemical dispersions, and biological populations. If the scale of damaging activity is large then it may not be possible to find or afford suitable substitutes. The total amount of activity that could be carried out might become constrained. With activity large and growing, and physical stocks insufficient and shrinking, there may be a risk of environmental crisis.

The third change in default assumptions is to recognize that the aggregate amount of damaging activity is large relative to the available physical environmental stocks. The dramatic increase in population and economic activity on the Earth, discussed in Chapter Three, means that the eco-cost is increasing for many environmentally relevant activities. This leads to widespread erosion of environmental stocks, and the negative Externalities, Tragedies, and Prisoner's Dilemmas of Cases III, IV, and V.

Environmental and ecological economists do include inputs from the environment, environmental damage, and eco-costs in their models (e.g., Atkinson et al., 1997; Boumans et al., 2002). However, the lack of widespread public debate about maximization of GDP to provide consumption utility as the primary societal objective and the obscurity of analogous aggregate measures of environmental outcomes indicate that the theorists and policy-makers who are most influential in management of the economy-environment interaction have not yet got the message.

Lags

The fourth proposed change in ideas about the environment is to include the possibility of response lags. There are several sources of response lags that could contribute to delays in policy introductions, increasing the risk of an overshoot crisis. Lags may result from the time taken to detect damage, to develop responses, to build support for responses, to implement the responses, and for the responses to take effect.

Damaging activities may occur long before scientists detect damage and further time may be required to develop scientific consensus. Policymakers may be alerted to damage and risks but will not allocate resources in response until policy or technological solutions have been developed and sufficient public support has accumulated.

Time may be required to develop technological or policy responses because some environmental issues do not have readily available solutions. Technological development efforts may follow directly from scientific evidence of damage or may require policymaker intervention to reallocate resources. Time may be needed to build sufficient support from individuals to overcome opposition by threatened businesses. Where international agreements are required, as for climate change, time is needed to form the agreements.

The public may learn of the damage directly via dissemination of scientific findings or may be informed via policymaker communications. If the threat affects only a few individuals or only a few individuals are concerned then there may be little support for a response. Long-term, large-scale damage may not concern today's policymakers, who may be old enough or control sufficient resources to avoid the worst risks. Those aged less than 40, or less than 20, might be more concerned because they will face the long-term consequences of today's policies.

In the worst case, responses may only be adopted once a large proportion of the population is being affected by the consequences of environmental damage. Even when technologies are available, the public is supportive and policymakers have acted, there may be further delays while policies take effect. For example, the IPCC scenarios do not include the possibility that global temperature will not increase during the 21st century (Houghton et al., 2001, p. 14) because the forces that have already been unleashed are too large to be countered by the technological and policy responses expected to be available.

In conclusion, the four revisions to the dominant paradigm proposed to incorporate the environment are to adopt default assumptions that include environment as a production constraint, allow for changing states of the economy-environment interaction, assume that the scale of activity is large relative to the size of the environment, and acknowledge the importance of response lags.

Ideas About Individuals and other Actors

Chapter Four argued that individuals cannot rely on businesses or governments to address the risk of environmental crisis and that governments will regulate damaging business activity if individuals show sufficient leadership. Chapter Five introduced the extended utility function and Chapter Six showed how changing the values and beliefs of individuals could reduce the risk of environmental crisis. This section will summarize these three proposed theoretical changes, beginning with the extended utility function.

The extended utility function

Bentham's individuals could gain utility from a variety of sources. Chapter Five reported that psychologists have investigated the sources of human motivation and concluded that individuals have diverse motives including security, self-esteem, self-actualization, outcomes for others, outcomes for the environment, and the expectations of others, alongside consumption. Modern economists understand that utility can come from a variety of sources, (von Wright, 1998, p. 942). Despite this understanding, as reported in Chapter Five, theorists usually assume that utility comes only from consumption.

The additions to the utility function introduced in Chapter Five allow modeling of individuals who are also motivated to avoid environmental damage, who value outcomes for others, who seek social approval and avoid social disapproval, and who hold personal norms that guide them in their choices of activities.

Changing the values and beliefs of individuals

Economists know that individuals' tastes for particular kinds of consumption may change (von Wright, 1998, p. 942) but generally assume that individuals have stable tastes (Kamarck, 2002, p. 25) for the commodities consumed (Samuelson and Nordhaus, 1989, p. 451).

Assuming that only commodities provide utility and that tastes for commodities are stable has been very useful for economics (Dau-Schmidt, 1998, p. 84). Focusing on consumption, and more particularly on market goods and services, means that monetary quantities can be used to provide cardinal level measures of utility that can be used in analysis to generate policy prescriptions. Assuming that tastes are stable allows prediction of future tastes based on observations of current tastes and means that the mechanisms of taste formation and change can be ignored. Further, there is no need to decide which tastes should be encouraged.

While unchanging tastes may be useful for economic analyses of short-term issues, McPherson (1998) highlights the importance of formation of tastes when considering long-term issues:

> The more common view is that it is efficient to divide the intellectual labor between economists who study the consequences of given tastes and sociologists, psychologists and others who explain formation of and changes in tastes. Yet on the whole, economists (with a few notable exceptions like Scitovsky (1976)) have shown little interest in what psychologists and others have had to say about preference formation and change. At a minimum there would seem to be a need for interdisciplinary collaboration on problems, such as long run economic development or cross-national comparisons of consumption patterns, where both causes and consequences of tastes are likely to be important. (p. 402)

M. Jacobs (1994) concurs, writing that the dominant paradigm sees “tastes as exogenous to the economy and therefore outside its remit. But it is surely implausible to argue that economic activity does not help to form demand as well as satisfy it” (p. 87).

If individuals have diverse sources of utility then a policy analyst or manager can consider motivations other than income and consumption as potential drivers of behavior that is economically and environmentally relevant. Berger and Luckmann (1966) argue that reality is socially constructed and Lichtman (1990) presents a compelling argument that our natures are not fixed, but rather are coevolving with our circumstances. Furthermore, marketers assume that preferences can be changed when they invest in advertising and other initiatives to develop or influence demand. Farley, Costanza, and Templet (2002) point out that advertising promotes preferences for market goods: "Virtually no money is spent convincing us to prefer public goods or other non-marketed satisifers of human needs" (p. 287). If individuals have diverse sources of utility then a policy analyst or manager can consider motivations other than income and consumption as potential drivers of behavior that is economically and environmentally relevant.

Establishing a sound theoretical foundation for using beliefs and values as tools for managing economic and environmental outcomes requires more than just extending the utility function. It is also necessary to have a theoretical framework that allows change in beliefs and values, and to be able to effect change in the utility functions of real individuals.

The mechanism used in the strategy for effecting changes in the utility function is deliberate exertion of social influence via communication of the social approval or disapproval of particular beliefs, values and behaviors. Other mechanisms such as imitation and advertising can be used to change beliefs, values and behavior but these are not prominent in the proposed strategy.

Dau-Schmidt (1998, p. 85) discusses the conditions under which it is most feasible to use what he calls shaping of preferences as a mechanism to change behavior. He reports that it is most effective when it can be done via informal channels such as family and friends, when there is only small interference with individual autonomy and where the society's interests are aligned with the direction of behavior change.

Extending the utility function and establishing a mechanism for changing the values and beliefs of individuals creates the potential for a strategy that uses influence to change values and beliefs. Employing the strategy also requires willingness to exert influence. An influence strategy can provide a great deal of power to anyone who is willing and able to use it as a tool. This raises moral issues. Should ideas be used to influence the behavior of others? Would choices to influence others interfere with the freedom of those others to make their own choices?

Freedom requires the opportunity to make informed choices. If people are inevitably influenced by the ideas of others then the best way to be free is to understand this and to have the opportunity to choose which ideas to adopt and disseminate. By contributing to the available ideas as a manager, choosing which ideas to pass on as an opinion-leader or choosing which ideas to adopt as an individual, individuals are able to be as free as possible. Individuals then can contribute to social circumstances where the possibilities for change are equal to the potential need for change.

As Etzioni (1988) says:

> The insights and findings of psychologists and sociologists indicate that individuals who are typically cut-off and isolated, the actors of the neoclassical world, are unable to act freely, while they find that individuals who are bonded into comprehensive and stable relationships, and into cohesive groups and communities, are much more able to make sensible choices, to render judgment, and be free. (p. 10)

The freedom that consumption maximizers appear to have is an illusion. It imprisons individuals in an unfulfilling and, under present circumstances, dangerous pursuit of consumption. There is nothing inherently wrong with wanting lots of consumption, provided that it is beneficial for you as an individual and it does not damage the economic community you depend on, or contribute to risk of environmental crisis. However, when the pursuit of consumption leads to sub-optimal economic and environmental outcomes and fails to provide real happiness it is not a good thing. An individual who is able to choose his or her own beliefs and values with an understanding of the consequences of those choices has more freedom than someone who mechanically maximizes consumption.

Individual responsibility and the motivations of Actors

Introducing an extended utility function and establishing a strategy based on values and beliefs creates the potential to change economic and environmental outcomes and provide more utility to individuals. However, the strategy will not be implemented if individuals do not act as prescribed by the strategy because they believe that others will take care of the overshoot risk or believe that acting is pointless because individuals cannot have any positive impact. To provide a theoretical foundation for individuals to act it is necessary to establish a widespread belief that individuals are responsible. Like many of the theories of the dominant paradigm explored already, these assumptions have been accurate and useful in the past, but may not fit with circumstances encountered at the end of a transition. Norgaard (1994a) argues that values and beliefs have coevolved with environmental circumstances in the past (pp. 90-91).

The dominant paradigm summarized in Chapter One includes a belief that businesses should be constrained as little as possible. Smith's observation that business leaders pursuing their own self-interest frequently produce outcomes that benefit the community economically is an important foundation for this belief. However, as argued in Chapter Four, this result is true for the economy only in Cases I, II and III, and disregards environmental outcomes. The unconstrained pursuit of profit or consumption is generally advantageous during a transition, when aggregate eco-costs are small, but may be dangerous as the transition ends, and during an era.

Despite this, the belief that unrestrained pursuit of profit generally benefits the community means that businesses lobbying for freedom to act as they wish receive a favorable response from governments and important segments of the public. Lack of awareness of the effects of eco-costs on outcomes and of the risk of an overshoot crisis means that there is little effective opposition to this belief.

The strength of the belief in the desirability of business freedom combines with the incentives that businesses have to maximize their profit to make businesses very effective opponents of any attempts to regulate their activities in ways that threaten profits. This implies a revision of the dominant paradigm to recognize that responses to environmental damage may be hindered by corporate or individual business interests.

One of the purposes of government is to step in when the activities of a segment of the community threaten the welfare of the community as a whole. As shown in Chapter Four, governments have tools to regulate activities to reduce environmental damage. However, the point made in Chapter Three is that there may be a need to do more to constrain damaging activities. An implication of the discussion in Chapter Four is that there are situations where damaging business activities will need to be constrained, so the dominant paradigm assumption that constraints on businesses should be minimized must be revised. Chapter Four went on to argue that one important reason for the lack of sufficient regulation is that governments often follow the leadership of business interests on matters affecting economic outcomes. Therefore regulation is only likely if business interests are threatened by damaging activity or if there is strong support for regulation from coalitions of individuals. These arguments lead to reversal of the assumption that individuals must rely on governments or businesses to address environmental problems. Rather, individuals have an obligation to lead governments in addressing environmental issues because other actors are not motivated to address these matters.

In these circumstances, the preferred way to accelerate the introduction of regulations to prevent damage is to increase support for regulation among individuals. Individuals who have not been influenced may act to support regulation if they believe there is a need, that they are responsible for acting, and that their actions will lead to reduced damage. Chapter Six shows how individuals holding these beliefs may act as managers initiating the strategy. Other individuals may also be motivated by changed values and beliefs to lead governments, to influence others and to change their own consumption choices.

The Revised Paradigm

The dominant paradigm provides default assumptions that are important in influencing economic and environmental outcomes. It implies that economic growth can continue indefinitely. Ecological economists have used a biological paradigm to identify a risk that ongoing environmental damage might combine with the scale of human activity to lead to an environmental crisis. In Chapter Two the dominant paradigm was extended to give standing to the environment. Subsequent chapters have proposed revisions to the theories of the dominant paradigm and these revisions can be combined to form a revised paradigm.

Theories are the beliefs of theorists about the way the world works. They are abstractions that simplify the complexity of the world so using a different lens to look at the world is likely to lead to different theoretical choices. Theories may be abandoned because they are proved wrong, because the world begins to work in a different way, because theorists change their beliefs about the way the world works, or because theorists choose a different paradigm. When circumstances change it is likely that new theories will emerge and compete with established ones. This thesis has argued that practical responses to environmental risks can be accelerated if several widely used theories are modified. Many theorists have already adopted some of the proposed modifications.

Numerous specific changes have been proposed. The theory that the environment is not an important constraint on economic output could be extended to acknowledge the possibility of environmental constraints (Chapter Two). The theory that consumption and profit provide motivations that benefit individuals could be modified to acknowledge that this is not necessarily true if the environment is a constraint (Chapter Two). The theory that the Earth has entered a period of continuous progress could be modified to acknowledge that the transition will end soon (Chapter Three). The theory that environmental damage will not lead to crisis could be modified to acknowledge a risk of crisis (Chapter Three). The theory that governments will regulate to reduce damage could be modified to acknowledge that rigorous regulation is only likely if individuals lead governments (Chapter Four). The theory that businesses should be left alone as much as possible to get on with their profit-making activity could be modified so that there is a presumption that damaging activity should be constrained (Chapter Four).

The theory that individuals should be left alone to form their own values and beliefs could be modified to acknowledge that individuals should and do influence one another (Chapters Five and Six). The theory that individuals acting alone cannot make a contribution to reducing environmental damage and the risk of crisis could be modified to acknowledge that individuals can initiate activity that makes a difference (Chapter Six). Finally, the theory that the dominant paradigm provides a good place to start when making major decisions about the economy-environment interaction could be modified to acknowledge that the dominant paradigm was developed for management in circumstances that are now changing (Chapter Seven).

These proposed theory modifications are combined to form the revised paradigm proposed to provide default assumptions for developing strategies to manage the economy-environment interaction. The specific revisions to the ten beliefs of the dominant paradigm are listed below. The proposed changes are designed to improve the likelihood that strategies and policies will reduce the risk of an overshoot crisis (italics indicate revision).

1. Individuals are rational and self-interested. They maximize subjective expected utility. Utility comes from consumption *and may come from other sources including environmental outcomes, outcomes for others, social norms and personal norms*.

2. The role of economic policy is to deliver output to provide the consumption that individuals want *and to ensure sufficient environmental stocks remain to provide for future production*. Production is constrained by capital, labor *and inputs from the environment*. Production provides goods and services for consumption, replenishes or increases capital and labor stocks, *and may reduce environmental stocks*.

3. *Production depends on inputs from the environment. Activity may deplete environmental stocks leading to eco-costs that reduce utility from consumption. Maximizing activity does not necessarily lead to maximizing output or utility.*

4. If activity damages the environment then prices may remedy the problem or it may be possible to introduce property rights, taxes, tradable emission rights, quotas or prohibitions to ensure adequate protection. *These policies may be difficult to implement because of opposition from corporate or individual business interests.*

5. Economic activity is *large* relative to the potential of the environment *so there is a risk of an overshoot crisis as the transition ends.* Technology *may* allow more efficient exploitation of the physical environment *and help preserve and increase environmental stocks. If environmental stocks do become depleted substitute options may be limited*.

6. Business activity in competitive markets, whether carried out by corporations or individuals, is useful because it is an efficient way to deliver the goods and services that provide utility for individuals. *Constraints on business activity may be needed to protect environmental stocks.*

7. If environmental issues arise then governments have the obligation to introduce policies to resolve them. *Governments tend to follow the lead of business interests so a lot of support from individuals may be needed to get policies implemented.*

8. Beliefs and values are personal issues *that affect choices about activity. Influencing beliefs and values may be used as part of a strategy to influence economic and environmental outcomes.*

9. Individuals *can and should act to reduce the risk of an overshoot crisis. Individuals cannot rely* upon businesses being socially responsible or on governments introducing regulations.

10. *The default assumptions that form the dominant paradigm should be revised to provide a theoretical foundation for assessing the risk of environmental crisis and developing strategies that can reduce the risk. The possibility of the end of the transition should be accommodated by allowing for changes in the constraints on production, for time lags between damage and responses, and for changes in useful beliefs and values.*

Many theorists have already adopted some of the theory modifications proposed. This thesis proposes that the revised set of theoretical beliefs be used in combination as default assumptions.

Another way to summarize the paradigm changes is shown in Figure 7.2. The figure uses the same format adopted in Chapter Two but includes the effects of theories and paradigms as well as showing that outcomes affect ideas, ideas affect activity choices, and activity choices affect outcomes to form a coevolutionary process.

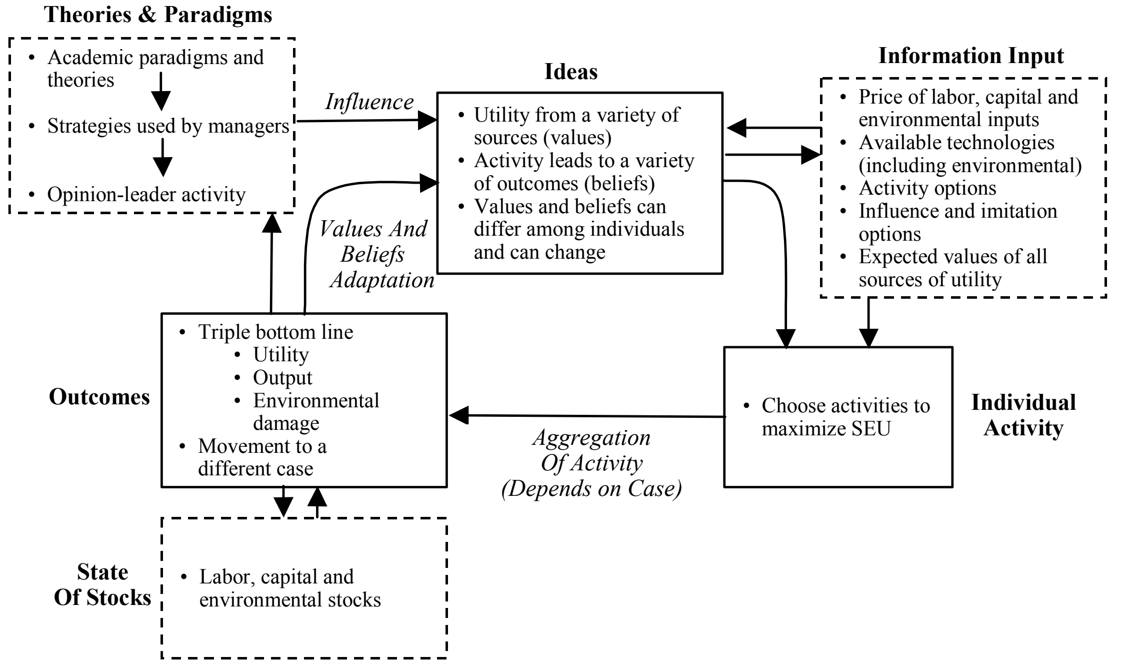


Figure 7.2. Revised paradigm, including the role of ideas of individuals (center top) and theorists (top left). Arrows show major effects. Solid boxes and arrows between them show the co-evolution of ideas, behavior (activity choices) and outcomes. Dotted boxes show factors that affect and constrain ideas, behavior and outcomes.

Norgaard (1994a) provides an account of a coevolutionary process where values, knowledge, environment, organization and technology are the coevolving elements. His model differs from this one in being focused mainly at the level of society or community aggregates. The model shown in Figure 7.2 is distinct in that it addresses ideas and behavior at the individual level and shows how aggregation of activity produces outcomes at the aggregate level. Both models attempt to describe the way the world works but they provide different lenses. There are many other models that could be developed showing how relevant variables coevolve. Which will be most useful depends on the purposes of the theorist or manager; the model shown here is designed to facilitate the development and implementation of ideas-based strategies.

The argument made in this thesis is that the ending of the transition to the industrial era creates a risk of an overshoot crisis. Current values such as the pursuit of consumption, subjective competition and lack of concern for environmental outcomes are well suited to the transition because they promote economic growth that in turn provides consumption utility and improves the well-being of individuals. Value changes proposed for adoption as the transition ends are to reduce the importance of the value of consumption, to reverse the value for subjective competition so that individuals value outcomes for others, and to value environmental outcomes. Ecological economists advocate similar changes (Farley et al., 2002; Costanza, Farley, and Templet, 2002; Boumans et al., 2002).

The use of the revised paradigm can be illustrated with the example of climate change. Existing beliefs and values lead to choices of activities that involve widespread use of fossil fuels that produce damaging emissions. In aggregate these emissions lead to accumulating damage to environmental stocks. Theorists can observe this outcome and develop technical strategies and policies to reduce emissions. Ideas-based strategies can be developed to accelerate implementation and alter consumer behavior. Specifically, managers can influence beliefs by informing opinion-leaders about the risks, the technical solutions and policies needed, and the potential of the solutions to reduce emissions. Managers can also inform opinion-leaders about the importance of valuing environmental outcomes, valuing outcomes for others, and influencing other individuals to build support for approval of policies such as the Kyoto Protocol. Increasing support for policies to reduce damage can lead to more vigorous regulation. Changes in values and beliefs can also alter consumption choices, leading consumers to prefer consumption activities that produce lower emissions. If consumers choose less damaging activities then emissions will reduce. The full cycle is complete because theorists have observed outcomes and intervened to change them.

The revised paradigm assumes heterogeneous individuals who have diverse motivations and can change. The assumptions about heterogeneous individuals appear to be consistent with the implications of Kirman's critique of general equilibrium theory. Kirman (1989) argues that a unique general equilibrium solution cannot be found without assuming homogeneity of individuals, a strong and unsupportable assumption. To get a unique solution with heterogeneous individuals, the interactions among the individuals must be modeled

> making assumptions on the distribution of agents' characteristics amounts, in some sense, to making assumptions about the organization of society. Thus if we obtain more structure by such assumptions we have to justify them. Anyone who

> makes significant progress in this direction either by examining and explaining how the nature of interaction and communication between individuals may yield regularity at the aggregate level or by explaining how interaction may yield restrictions on the evolution of the distribution of agents' characteristics, will have made a radical leap forward. (p. 138)

The proposed paradigm assumes individuals who differ, who interact, who change and whose individual behavior is aggregated in different ways, depending on the case, to arrive at aggregate level outcomes. As such, the theoretical development is broadly consistent with what Kirman argues is required to solve outstanding problems within economics.

Ideas About Theorists

Earlier sections of this chapter have argued for modifications of important elements of the paradigm, and have implied that theorists who adopt the proposed revisions can develop powerful and useful intervention strategies based on influencing beliefs and values. This section will explore ideas about the roles of theorists, and explore the beliefs they would need to adopt to choose a revised paradigm.

Science, history and prediction

Many nineteenth century economists searched for laws that were sufficiently general that they were not affected by changes in circumstances. Clark (1991) argues that economists sought to discover natural laws that drive economic behavior so they could become more scientific and gain more credibility. As a consequence "the marginalists were greater prisoners to the natural law outlook than the classical economists in that they were of the opinion that pure theory must exclude historical and social factors" (p. 139).

The laws or theories sought take the form that if specified conditions apply then a specified result or relationship will be found. Such theories must either focus on the short-term to avoid the impact of changes in conditions that might occur in the long term, or must remain robust in the face of major shifts in economic and environmental circumstances.

The risk of an overshoot crisis arises because of a long-term change in conditions: emergence of environmental constraints combines with very high levels of output as the transition to the industrial era ends. Theories that are consistent with the dominant paradigm assume free gifts and free disposals and that the economy-environment interaction stays in Case I. There is no provision for long-term changes in circumstances that could cause an overshoot crisis.

An influential argument by the philosopher of science Karl Popper (1957) objects to the prediction of historical phenomena. Popper argues against historicist predictions of the inevitability of sociological developments, essentially because "we cannot predict, by rational or scientific methods, the future growth of our scientific knowledge" (p. ix-x). Popper also argues that individuals and groups of individuals may make choices that affect aggregate outcomes and the choices that individuals might make in the future cannot be predicted. A simple interpretation of Popper's argument would lead to the conclusion that predictions about phenomena like an overshoot crisis should not be attempted.

Nagel (1974) points out that the debate on determinism in history is oversimplified, with arguments on one side that historical developments are inevitable and on the other side that nothing can be predicted. His conclusions allow the possibility of strong forces that affect outcomes and can be predicted, together with the possibility that voluntary human action can change the course of history.

Popper's argument applies only to the inevitability of historical phenomena driven by social processes. With physical phenomena prediction is possible. For example there are long-term predictions about the growth of the human population and about climate change. Similarly, the amount of potential and current agricultural land is estimable, and if it is being brought into production at a particular rate and lost through damage at a particular rate then the amount available in the future can be estimated. These kinds of predictions must be qualified by assumptions that expected trends will occur and that unforeseen perturbations will not occur but provided these specifiable conditions are met the predictions are meaningful.

The risk of an overshoot crisis is neither a purely social nor a purely physical phenomenon but rather a mix of the two. The unpredictability of social phenomena can be reconciled with the predictability of physical phenomena by concluding that something may be said about the range of possible outcomes but not with certainty. There are two important sources of uncertainty; first the normal uncertainty about knowledge of physical phenomena, and trends in those phenomena, and second, uncertainty about the choices that will be made by individuals and the aggregate effects of those choices. A theorist or a manager cannot affect the physical laws but may be able to influence long-term outcomes by affecting the choices of individuals.

Theories affect outcomes

Economists and other social scientists are not just scientists engaged in discovery; they are also teachers, writers and policy advisors whose ideas can influence the economic and environmental worlds they study. There is a longstanding debate over just how important the ideas of economists are (Barry, 1999; Da Fonseca, 1991; Spengler, 1961) but widespread acknowledgement that economists are very influential (Malabre, 1994, pp. 1-2).

Successful theorists not only influence the ideas of other theorists but also influence behavior and outcomes (Gewirth, 1973). The theoretical work of Bentham, Adam Smith and the other classical economists had an important impact on later economic ideas, leading Keynes to remark:

> We have not read these authors; we should consider their arguments preposterous if they were to fall into our hands. Nevertheless we should not, I fancy, think as we do, if Hobbes, Locke, Hume, Rousseau, Paley, Adam Smith, Bentham and

> Miss Martineau had not thought and written as they did. (Keynes in Routh, 1989, p. 18).

Harriet Martineau provides a good illustration of the way economic ideas can influence the economy. Martineau (1802 - 1876) was not a theoretical economist but rather a popularizer of the standard works then available by Adam Smith, Thomas Malthus and James Mill (K. Thomas, 1983; Wheatley, 1957). She wrote a highly successful series of 25 stories called *Illustrations of Political Economy*. Around 10,000 copies of each story were sold and the publisher estimated that there were about 144,000 immediate readers. The early stories were translated into French, a copy was provided to each member of the royal family and it was used in national schools. A similar thing happened in Russia. Some of the stories were written at the request of officials to help get policy proposals accepted. Government ministers urged Martineau to write on particular topics so that they could explain proposed policy.

Routh concludes of Martineau that

> she is to be valued as proclaiming what economic theory meant, in the sense in which it came through to the cabinet ministers, publicists, housewives, ladies and gentlemen and workers of the day. What it meant, in other words, in terms of its impact on popular beliefs. (1989, p. 191)

Some twentieth century economists have had a similar effect in disseminating economic ideas. For example, consider the popular text, Samuelson's (later Samuelson and Nordhaus') *Economics*. Routh (1989) notes that Samuelson's *Economics* achieved sales of several million copies and translations into numerous languages with the 11th edition. The text is now in its 13th edition and has been taught to two generations of economics students and these students are influential.

Herman Daly's (1994) comments on his departure from the World Bank convey this influence:

> I think a lot of what is wrong with the bank can be traced back to the academic training of Bank economists. Whether they are from California or Cameroon, they all went to places like Harvard, Stanford, Cambridge or MIT. They were socialized into the standard economic view of the world; the neoclassical vision. That's the context through which the Bank sees the world and I think that context is fundamentally flawed. (para. 6)

Daly was a Senior Economist with the Environment Department of the World Bank from 1988 to 1994. If the ideas of economists influence economic and environmental outcomes then this influence can be considered when assessing which ideas to promote to secure preferred outcomes.

Coevolving ideas, behavior, and outcomes

This thesis has argued that behavior affects outcomes, that individuals may be influenced by ideas so they change their behavior, and that the ideas of theorists are widely disseminated, and influential. If theorists observe outcomes to develop their ideas, disseminate the ideas, and the ideas affect outcomes then it is difficult to sustain a view of theorists as detached observers discovering scientific laws. Social characteristics of theorists such as their paradigms, values and beliefs may have important effects on outcomes.

Advancing understanding to manage changing circumstances requires movement beyond established beliefs. Argyris (1999) has worked with Donald Schon to distinguish double-loop learning from single-loop learning. Single-loop learning focuses on learning about actions that produce desired consequences, such as how to acquire customers or how to grow output. Double-loop learning involves learning about changes in the governing variables, such as the increased importance of customer profitability or the emergence of environmental constraints, so that the theories used to solve problems and make choices become part of the subject matter.

In organizations, the theories used by most individuals are acquired by socialization. Argyris encourages organization leaders to focus on the theories they use, the ways those theories affect the behavior of organization members, and the resulting outcomes, in order to identify opportunities to change theories and behaviors to get better outcomes. Senge (1990) argues the importance of systems thinking and advocates taking an integrated and developmental view of organizations. Both of these authors focus principally on business organizations but the planetary organization faces similar challenges, only over a longer time scale.

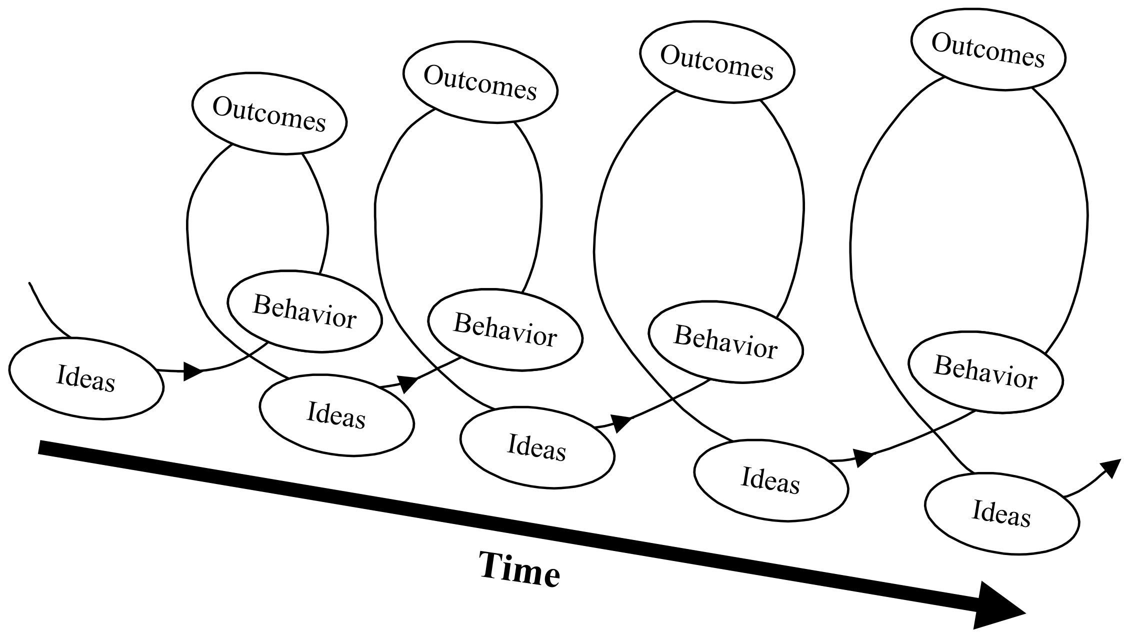


Figure 7.3. Co-evolution of ideas, behavior and outcomes. Ideas affect behavior, behavior affects outcomes and outcomes affect ideas. All three change through time.

Ideas, behavior and outcomes coevolve (Fisher, 1986; Norgaard, 1994a; Olerup, 1998) with each influencing the others in a spiral that moves forward through time, as shown in Figure 7.3. Theorists may identify beliefs and sometimes value changes that will alter choices and encourage behaviors that will lead to better outcomes. The new ideas are then disseminated to individuals in the population. Behavior changes alter outcomes so theorists have new data to observe to allow them to develop new ideas.

In practice, only some of the important ideas that influence outcomes are developed from observations of outcomes. For example, the assumption about stable tastes for commodities consumed allows economic theorists to exclude social factors from analyses and draw conclusions about exchange.

Assumptions may be a good enough approximation to the truth to allow useful conclusions or policies. Successful assumptions can also become self-fulfilling. The assumption that individuals have stable tastes for consumption has allowed development of important insights that are the foundation of policies that improve economic efficiency. As a result some theorists and policy-makers encourage people to maximize consumption so that economic efficiency can be realized in practice (Daly and Cobb, 1989, p. 88). Note that this cannot happen in purely physical sciences. One cannot make the world more flat by arguing and teaching that it is flat.

If ideas disseminated by theorists affect outcomes and theorists have some freedom to choose among ideas then it is important to evaluate theoretical ideas carefully to decide which to adopt. Ideas can be evaluated by assessing the desirability of the outcomes they encourage. Good outcomes were defined in Chapter Two as more output, more environmental stock and more aggregate utility, so ideas that produce these results are preferred over ideas that do not. Circumstances may change so ideas that promote good outcomes at one time may produce poor outcomes at another time.

Smith's idea of the invisible hand provides a good example of a useful idea. During the agricultural era economic policy was dominated by mercantilism (Deane, 1978, p. 1-4). Mercantilism concentrated control over important resources into few hands creating an incentive for those who controlled the resources to manage them for the long-term. Smith's contribution of the laissez-faire, invisible hand idea encouraged more rapid economic growth. As the transition to the industrial era began there was a huge expansion of environmental stock and free competition was an excellent way to exploit the opportunities created.

In contrast, in his essay on population, Thomas Malthus (1798/1959) argued that environmental stocks would grow at a slower rate than population so that people risked living in misery. Malthus' ideas were not well suited to the beginning of the transition because technology development and geographical expansion were allowing huge growth in environmental stocks. Malthus' ideas were consistent with economic and environmental processes during the agricultural era but led to incorrect predictions because circumstances were changing (Boserup, 1998, p. 62-63; Seidl and Tisdell, 1999, pp. 401-405).

A key argument of this thesis is that the ideas that comprise the dominant paradigm have been very useful during the transition but are not useful for management of long-term outcomes as the transition ends. The ideas of the dominant paradigm have helped to produce more output and more utility. However, as the transition ends, eco-costs are increasing so continuation of business as usual, fuelled by the ideas of the dominant paradigm, may produce an overshoot crisis leading to lower output and aggregate utility.

Management of outcomes as the transition ends depends on having theories that are applicable beyond the growth phase of the transition. Analyses that rely on the beliefs of the dominant paradigm to predict attractive outcomes are not a good basis for optimism, unless there is also good reason to believe that the conditions assumed exist or can be created (e.g., Lomborg, 2001; Nordhaus, 1992; J. L. Simon, 1981, 1990). Theorists who take account of dilutions and delays and use models that consider ecological constraints are much more likely to generate pessimistic predictions (e.g., Meadows et al., 1992; Norgaard, 1994a; Ophuls and Boyan, 1992; Tilman et al., 2001).

Theorists' responses

The theorists considered in this section may act as scientists and develop theories, or they may act as policy-makers using theories to develop strategies and policies, or both. A theorist-as-scientist discovers if-then statements that can be used to predict effects in novel situations. The discoveries may be based on theoretical deduction from axioms and other theories or from empirical observations, and ideally both. Theorists-as-scientists may affect outcomes by disseminating ideas.

Theorists-as-policy-makers use theories to develop policies or strategies so they can achieve desired outcomes. They may choose to influence ideas to effect changes in activity but they have many other options. Both kinds of theorists may take account of the way theorists affect outcomes when developing their theories or policies.

This thesis argues that an ideas-based strategy can be used to reduce the risk of an overshoot crisis. A theorist-as-policy-maker may or may not believe there is a need for change to reduce the risk of an overshoot crisis and may or may not believe that an ideas-based strategy can be effective in achieving desired outcomes. There are four possible combinations of these two beliefs shown in Figure 7.4.

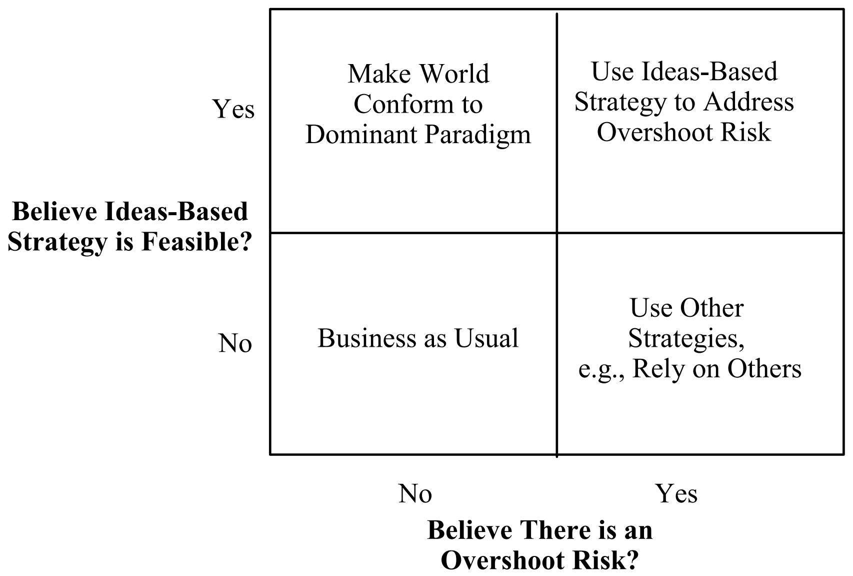


Figure 7.4. Options for theorists in response to the possibility that there might be an overshoot risk and the possibility that an ideas-based strategy might be feasible.

A theorist-as-policy-maker who does not believe there is a need for change to reduce the risk of an overshoot crisis and does not believe an ideas-based strategy is feasible should continue with his or her existing paradigm. This may be the dominant paradigm, a variation of the dominant paradigm, or a different paradigm.

A theorist-as-policy-maker who does not believe there is a need for change but does believe an ideas-based strategy is feasible may modify his or her paradigm and incorporate ideas-based strategies in policy initiatives. The manager might encourage changes in values and beliefs to get more people to pursue consumption more effectively, to reduce government interference in markets, and to accelerate introduction of more economically efficient technologies and substitutes.

Theorists who do believe there is a need for change but do not believe an ideas-based strategy is feasible are likely to continue with efforts to achieve change using other approaches.

The strategy proposed might be adopted by theorists who believe there is a need for change and that an ideas-based strategy is feasible. Theorists-as-policy-makers may choose to become the managers described in Chapter Six while theorists-as-scientists may develop understanding of the ideas-based strategy so it can be used more effectively.

Conclusion

This chapter has summarized proposed changes in the paradigm used to manage activity that affects economic and environmental outcomes. Paradigm choices are very important because they provide managers with the tools they use to affect outcomes. If paradigms change then theorist activity will be altered. The way theorists interpret data and the interventions they propose are influenced by the paradigm they adopt. Paradigm choices affect outcomes.

The proposed revised paradigm is most consistent with those used in ecological economics. The arguments for adopting it are that it provides a more accurate description of the way the world actually works and it allows managers to use theoretically sound, ideas-based strategies to accelerate the response to the risk of an overshoot crisis. When global circumstances are changing and the stakes are high it is important that theorists ensure that their paradigms are chosen because they fit well with real world circumstances or because they are useful, and hopefully both. Paradigm choices should not be accidents of history.

Issues with the assumptions of the dominant paradigm are widely recognised and have been referred to throughout the thesis. The revised paradigm has been proposed in an attempt to move beyond criticism. It is intended to contribute to debate about which paradigm should be used to guide management of the medium- and long-term future.

Theorists using differing paradigms may dispute evidence, theories or recommendations without clear recognition that their real dispute is about paradigm choices. If the conflict between paradigms was made more explicit then resolutions might emerge more rapidly and specific discussions might be more productive because the real issues might be surfaced more readily.

CHAPTER EIGHT

CONCLUSION

...management of uncertain transition entails active, continuous searching for alternatives that offer more promising future prospects and for ways of transforming societies in the direction of these alternatives.

- Trevor A. Williams, 1982, p. 2

Introduction

The main idea of this thesis is to use ideas about ideas to identify an intervention strategy that can help managers accelerate the response to the risk of an environmental crisis. Ideas about values, beliefs, theories and paradigms can be combined to influence individuals so that they carry out pro environment activity. Changes of the beliefs of the dominant paradigm can be combined to develop a revised paradigm and it has been argued that this revised paradigm is consistent with conventional theoretical and empirical knowledge. The revised default assumptions may help focus efforts to identify additional interventions that could reduce the risk of environmental crisis.

This chapter concludes the argument developed in the thesis. The following section assesses the prospects of the current dominant paradigm to successfully manage the environment in the future. The third section reviews the importance of ideas and the fourth section outlines the theoretical implications of the proposed ideas-based strategy. The potential results of implementing the strategy are discussed in the fifth section and concluding remarks are made in the sixth, and final, section.

There may be a risk of an environmental crisis

There may be a risk of an overshoot crisis if continued maximization of total output leads to aggregate output rising above the sustainable level. There is evidence that overshoot crises have occurred in human populations in the past and Hern (1990) points out that other animals that over-exploit their environments experience overshoot crises.

The key issue is whether an overshoot crisis can be avoided to produce a soft landing, or at least be minimized. The three paths discussed are illustrated in Figure 8.1. The line labeled Progress illustrates the implicit business as usual prediction of the dominant paradigm. Chapter Three argues that the transition will end in the next few decades and that there is a risk of an overshoot crisis if consumer sovereignty remains the primary objective of economic management. This could result in the line labeled Crisis, where total output would decline and many people would suffer diminished utility. A strategy that changed the overall objective of societal management from maximizing consumption to avoiding an overshoot crisis could lead to the path labeled Soft Landing.

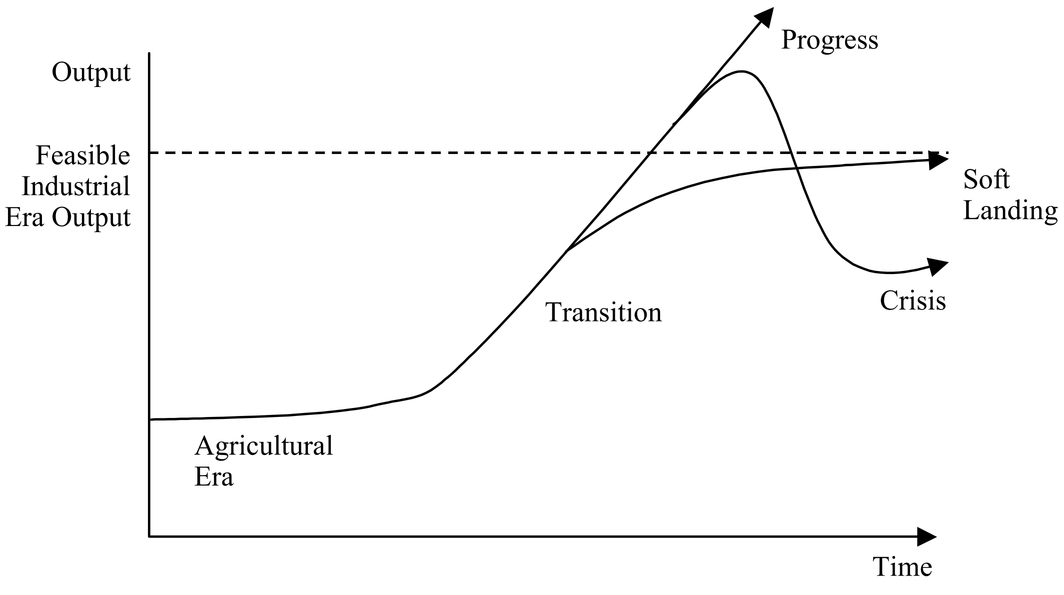


Figure 8.1. Alternative futures. Continuing Progress is expected within the dominant paradigm but is unlikely if the Earth is nearing the end of a transition. There is a risk of Crisis if output is grown beyond the sustainable level. The aim of the strategy is to reduce the risk or magnitude of crisis so that a Soft Landing can be achieved as the Earth enters the industrial era.

Maximizing economic growth rates and improving economic efficiency is a good strategy when the environmental stock is large and there is a race to develop, so that countries can secure privileged access to resources and gain geo-political strength. However, objectives need to change when environmental constraints become important and there is a risk of environmental crisis. Continued pursuit of output growth as the most important societal objective in these circumstances is not consistent with prudent risk management.

As discussed in Chapter Three, some would argue that overshoot is already occurring. The projections of human demand exceeding the biosphere's regenerative capacity and observations of degraded environmental conditions in some parts of the world reinforce this view, but conclusions about global crisis must be treated with great caution. Regional crises are not new, the number of undernourished people is declining slowly (FAO, 2002, Pt. 1.1 Figure 3), and the current global per capita food production decline may be only a short-term phenomenon (FAO, 2002, pt. 1.2). However, the evidence presented in Chapter Three and the individual and institutional motivations discussed in Chapter Four combine to reveal a distinct possibility of overshoot unless the present course is changed.

Technology choices and protection of environmental stocks are important factors in determining whether an overshoot crisis occurs. Technologies are currently chosen to maximize profits but some of the technologies that maximize profit also damage the environment. There are potential technologies that would be less damaging but obstacles prevent widespread adoption of these. In some cases the costs of more environmentally friendly technologies could be higher than the costs of mature but damaging technologies. However, such cost increases would contribute to economic growth and provide opportunities for businesses. In other cases there is a lack of incentive to develop less damaging technologies because they may be less profitable for the businesses that control the technology development capability. The lack of institutional support to prefer less damaging technologies, discussed in Chapter Four, indicates that the response may be late, insufficient, or both.

Protecting remaining physical resources is becoming more important as environmental constraints increase. Environmental stocks depend on the physical resource, the amount of activity that might damage physical resources, the technology used for damaging activity, and the environmental technology that determines how much output can be obtained from a given physical resource. This implies that stocks can be protected by choosing damaging activities less, by using less damaging technologies, by choosing more productive technologies, and by preventing activities that cause unacceptable damage.

The outstanding question is who will ensure the adoption of policies, technologies and activities that would improve environmental outcomes when businesses are driven by shareholders to pursue profits, and lead governments to protect their interests, as argued in Chapter Four.

If a major change of course is required then the timing of the course correction is important. The sooner the change is made the greater the likelihood that an overshoot crisis can be avoided and the smaller the intervention needed. However, there are numerous obstacles to action including loss of credibility of warnings because of continued economic success, the lack of distinction between critical environmental issues and less important issues, and opposition to change from those whose interests are threatened. In these circumstances tools for accelerating the response to allow an earlier course change are likely to prove valuable but such tools are not provided by the dominant paradigm. Our societies are not well prepared to recognize, prevent, or manage the risk of environmental crisis, and the risk appears to be increasing.

The Importance of Ideas

The experience of working with large businesses grappling with issues that threatened their viability led me to focus on ideas. Time after time the underlying problem for the business organization was a set of ideas that had been developed for and adapted to industry conditions that subsequently changed. Organizations establish strong supports for ideas that have been successful, and those supports slow recognition of the implications of changes in circumstances (Nystrom and Starbuck, 1984).

For example, one organization I worked with began as a start-up, growing rapidly then acquiring a competitor to establish a market leadership position. The business had reduced growth opportunities and needed to focus on reducing costs and increasing prices to create value for shareholders. However, the belief that growth was the way to create value was so deeply entrenched amongst the leadership that efforts to grow strongly continued, even though the growth was unprofitable. It took a great deal of time and effort to convince the leadership to change their beliefs and adopt a different strategy.

Businesses are sometimes harmed by outdated ideas but more often they adapt well to changing circumstances. Effective business leaders and strategists recognize that the industries they participate in are evolving, and that the outcomes for each business depend on the business environment and the choices made by the businesses that comprise the industry. Change and learning are taken for granted.

Business theorists, gurus and consultants perform the same functions for industry evolution as economists and other theorists do for the economic policies that can affect the environment. They disseminate theories that describe the world, identify changes in circumstances, and develop prescriptions that can be used by businesses to achieve shareholder value growth. In my own work I have seen powerful ideas such as strategic business units, competitive advantage, business process re-engineering and e-commerce have important effects on industry evolution.

Most of us are influenced by a powerful idea that was developed over 200 years ago, at the beginning of the transition. Smith's invisible hand argument has been used to encourage people to act in their own individual interests, justified by the claim that the result will be good for the individual and for the community. As the inhabitants of the Earth began to industrialize and growth potential increased dramatically, Smith's arguments encouraged a shift from community to individual values and from non-material to material values.

Smith chose the values he promoted. He chose well and had a positive influence on outcomes for his community. Modern theorists should choose ideas that are suited to the current times, not just accept the choices that others have made in different historical circumstances.

The current focus on individual, materialist values is a result of historical circumstances. The emergence of environmental constraints has led to many environmental stocks being in Cases IV and V so that individual interest and community interest are less often aligned. The large scale of the economy in relation to the environment means there is a risk of an overshoot crisis and a need to adopt different values and beliefs.

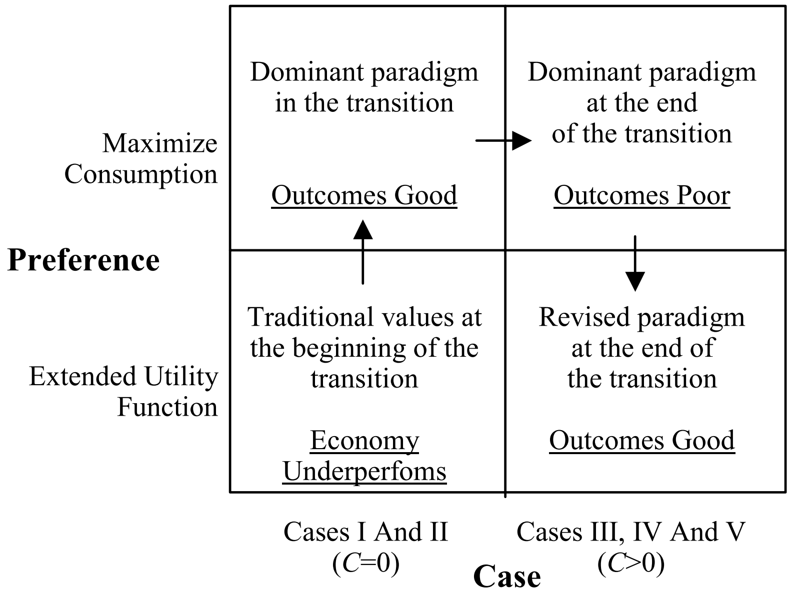


Figure 8.2. Fit of paradigms to circumstances. Arrows show the changes expected over time. If consumption is not maximized when there is no eco-cost (Cases I and II) then the economy will under-perform. Traditional values are no longer necessary. With no eco-cost maximizing consumption leads to good outcomes and the dominant paradigm is useful. If an eco-cost emerges (Cases III, IV and V) then retaining the dominant paradigm leads to bad outcomes. Changing the paradigm, including extending the utility function, can help produce good outcomes.

The argument is summarized in Figure 8.2. The figure shows that if there is no eco-cost, so that activity is always in the interests of the actor and the community, then maximizing consumption will lead to the best utility outcomes. However, if there is an eco-cost, and especially if the total eco-cost is greater than the total prize so that activity is not in the economic interests of the community, then maximizing consumption will not lead to the best available utility outcomes for the individuals in the community, and may increase the risk of environmental crisis.

The conventional approach is to seek to be scientific by eliminating a role for values. The argument presented here not only makes values a part of the subject matter, but also says that the values people choose will have an important impact on the future they experience. If values that fit with environmental and economic circumstances are chosen then outcomes can be improved but if values that do not fit with the circumstances are chosen there may be a risk of bad outcomes. When circumstances change, the values that will lead to the best outcomes may also change so that a delay in changing values may lead to less desirable outcomes.

The dominant paradigm does not highlight the importance of long-term outcomes, nor does it consider the effects of response delay. It is also strongly entrenched. The result is that the dominant paradigm and the theorists who use it may contribute to a response delay they assume does not exist. If risks are important then prudent theorists should carefully consider how their choices of which beliefs and assumptions to disseminate can influence outcomes.

For example, a business organization I worked with had been successful because it was the market leader in an industry where there were economies of scale. However, the other businesses in the industry consolidated so that the scale advantage was reduced. The business leadership saw their profits disappear but did not know what to do. Investigation revealed that the business had defended its scale advantage by taking on as many customers as possible, including many unprofitable ones. The beliefs identified and disseminated to address the crisis were that customer profitability was now important and that efforts were needed to increase the share of the more profitable customers while improving the profitability of less profitable customers. Adoption of these revised beliefs led to changes in behavior that restored profitability.

Theoretical Implications of the Ideas-based Strategy

The role of ideas in managing trade-offs between economic and environmental objectives has been clarified in Chapters Five and Six. During the transition environmental stocks are relatively large so that trade-offs are not usually necessary. At the end of the transition choices must be made between economic and environmental objectives and the historical focus on economic outcomes means that there are mature and effective ideas and institutions to promote economic outcomes. As environmental outcomes become more important, the ability to alter activity to reduce environmental damage becomes important too. Ideas can help manage the trade-off by ensuring that environmental outcomes are anticipated and managed, and that behavior can be changed to reduce damage. The strategy to achieve this was outlined in Chapter Six, and the theoretical implications were reviewed in Chapter Seven.

Theories, the beliefs of theorists, help theorists recognize possible outcomes so they can identify sources and sizes of risks. The paradigm defines the repertoire of potential interventions. Theories facilitate development of strategies to improve environmental outcomes. Including theories about people and their ideas in the paradigm can provide additional, effective ways to influence activity choices. The beliefs and values of individuals can be influenced to reduce the risk of crisis. Adopting the strategy implies a need to revise the dominant paradigm.

The kinds of ideas investigated here, and the ways they have been used do not exhaust the possibilities for using ideas to influence activities and outcomes. The aim of the present effort has been to show how ideas might be used to cause a particular kind of change, not to investigate all the kinds of ideas and the uses they might have.

The hypothesis that there is a link between our failure to address environmental risk and the ideas used to manage the environment has been a fruitful one. The paradigms and theories used by theorists and policy-makers, and the beliefs and values of individuals, are important determinants of economic and environmental outcomes. They are sufficiently important that entrenched ideas can obstruct the implementation of initiatives that could reduce the risk of environmental crisis. Analysis of ideas has led to a reformulation of the issue of how to get environmental initiatives implemented as a problem that can be addressed, and to development of an ideas-based strategy.

The analysis has identified numerous individual beliefs that affect activity choices. Several beliefs have been identified that, if disseminated, would encourage more desirable outcomes and contribute to the effectiveness of the strategy. These include beliefs that there is a risk of an overshoot crisis as the transition ends, that governments should regulate activity to reduce the risk, that individuals are responsible for ensuring that governments do regulate, that what individuals choose to do is very important in determining outcomes, and that individuals can and should influence the beliefs and values of others.

The key values identified that would encourage more desirable outcomes are making consumption less important, valuing the environment more, reversing subjective competition to value outcomes for others, and increasing the value placed on the social approval or disapproval of activity.

Three theoretical developments would assist in the analysis of the economy-environment interaction and help theorists and managers develop policies and other interventions. First, the concept of eco-cost and the six cases of the economy-environment interaction can help to classify the consequences of environmental damage and identify the interventions that will be most effective. Second, the distinction between eras and transitions, the emergence of the environment as an important production constraint, and the fit of values to circumstances helps clarify the risk of an overshoot crisis and encourages the belief that the risk ought to be managed now. Third, the extended utility function provides a tool to understand individual beliefs and values, and to develop influence strategies.

The dominant paradigm used to manage economic, environmental and utility outcomes was summarized in Chapter One. The hypothesis that there is something wrong with the paradigm was a starting point for the investigation. The question was raised: which of the theoretical beliefs that comprise the paradigm are wrong? The answer was that each of the ten key beliefs of the dominant paradigm needs to be modified to arrive at the revised paradigm articulated in Chapter Seven.

Most of the theory modifications proposed are based on conventional ideas drawn from a range of disciplines. The use of the eco-cost to distinguish the six cases of the economy-environment interaction and the strategy may be new but both have been developed using conventional tools.

The strategy offers the potential to alter choices so that individuals lead governments to regulate damaging activity, change their own consumption choices, and influence the values and beliefs of others. The argument shows how influencing values and beliefs can lead individuals to choose pro environment activity despite the common belief that individuals acting alone cannot make a difference. If the influence strategy is successful then it will lead to increased regulation of damaging activity, different choices about consumption, less damaging production activity, and more rapid development and deployment of less damaging technologies.

In some cases the policy and technology choices that will maximize consumption and profit will be the same as those that will reduce damage. In other cases trade-offs between economic and environmental outcomes will be required. Where trade-offs are needed it is important that medium- and long-term outcomes are carefully considered before choices are made. Discount rates, quarterly earnings reports and the importance of economic performance in determining election outcomes encourage business managers and politicians in many countries to emphasize short-term economic outcomes. Leadership from individuals is required to ensure that the medium- and long-term environmental implications of policies, including those that affect technology choices, are also adequately considered.

If accelerated changes in regulations, consumption and production choices, technologies, and policies can be achieved then medium- and long-term economic and environmental outcomes can be improved. Larger environmental stocks will allow higher sustainable output and more aggregate utility during the industrial era. The amount of change and how quickly it occurs will affect the risk of an overshoot crisis and the magnitude of a crisis if one does occur.

Impact of the Ideas-based Strategy

The ideas-based strategy has the potential to alter outcomes for the different kinds of actors considered in this thesis. Individuals may become less committed consumption maximizers, modifying consumption choices, influencing others, and leading governments. If sufficient individuals do this they may reduce the risk that their futures and the futures of those they care about will be harmed by environmental damage.

Businesses engage in profit-motivated activity and it is argued that they should continue to seek profits but be constrained in doing this, so that their activities and the activities they facilitate are less damaging. Businesses are likely to oppose constraints where their interests are threatened, implying a search for ways to reduce damage that cause as little harm as possible to business interests but at the same time ensuring that the damage is actually reduced. Individual businesses may be harmed by the regulations imposed on them but business opportunities will also be created.

Developing countries are very diverse but on average they are the most vulnerable to the risk of environmental crisis because they have much higher population densities than the developed countries and have less capital available per person. They are also likely to be more harmed than the developed countries by both climate change and the emergence of agricultural constraints. The size of the developing countries and their expected growth in population and output per capita over the next few decades mean that their development experiences will have a very important impact on outcomes.

Changing the path of development of the developing countries will not be easy. Widespread poverty, global economic institutions and pressures from international finance encourage the developing countries to focus on economic growth. Altering the international influences on developing countries, getting domestic agreement to place more emphasis on environmental outcomes, and making the bureaucratic and technological changes implied will be a very difficult task.

Developed countries are also exposed to the risk of environmental crisis, though they are relatively well equipped to respond. If theorists in the developed countries adopt the revised paradigm they will be more likely to recognise risks as they emerge and to guide the introduction of appropriate institutions and effective interventions. The developed countries already have a commitment to reducing damage and have identified many technical and policy responses. However, existing incentives are delaying and weakening the response to environmental damage, and the ideas-based strategy offers the potential to make the response more vigorous.

Global economic and environment management institutions are strongly influenced by developed countries and the developed countries supply much of the technology that will be used in the developing countries for energy production, industrialization and agriculture. If the policies and technologies promoted by the developed countries are chosen to maximize consumption and protect the interests of businesses in the developed countries then the risk of crisis will be much higher than it could be if policies and technologies aim to reduce damage and improve the productivity of critical environmental stocks.

Conclusion

G. Hardin's prescription for addressing the tragedy of the commons - mutual coercion mutually agreed upon - is the foundation of the strategy proposed here. If individuals can influence one another to build a strong consensus to support regulation and to change consumption choices then an overshoot crisis may be avoided.

Recognizing and nurturing our ability to influence one another is the key to allowing the change that will protect us from environmental risks. As Commons (1950) wrote over 50 years ago:

> Collective action means more than mere "control" of individual action. It means liberation and expansion of individual action; thus collective action is literally the means to liberty. The only way in which "liberty" can be obtained is by imposing duties on others who might interfere with the activity of the "liberated" individual. (p. 35)

If the ideas-based strategy is successfully implemented, along with other existing and future efforts to reduce damage, there is no guarantee that the intervention will be sufficient. The outcome depends on the population growth rate, the physical characteristics of the economy and environment, and the strength and timing of the response. If the response is early and strong relative to the threats posed by emerging constraints then it may be sufficient.

If the response is not sufficient then there is at least one alternative strategy. The Earth or parts of it may follow Ophuls' (1973) option and establish Hobbes' Leviathan, introduced in Chapter Five. The Leviathan role was institutionalized in the Roman republic in the position of dictator (Livy, 2002, pp. 226-227, 305-312). Dictators were given extraordinary powers when appointed to address a crisis. Normal political structures were resumed when the crisis was resolved. Olson (1982) has argued that centralization of power is an adaptive response when a society is unable to change in response to an important threat. If a crisis develops, centralization of power might be the only strategy available to avoid very bad outcomes (Ophuls and Boyan, 1992, p. 206).

If the hypothesis of the transition is correct and the paradigm proposed here is providing valid insights, then people may face a daunting challenge. The task that lies ahead may be nothing less than achieving a change in paradigm for most of the Earth. If the argument made here is correct then such a change in paradigm is likely to occur at some time: the issue is when. Will the change be made before a crisis emerges? Or, will the Earth enter the industrial era before the required shift in beliefs and values is sufficiently widespread to bring activity back to Case I? If this thesis can help clarify the problem and accelerate implementation of an effective response, then it may make a contribution to reducing the risk of an overshoot crisis.

In the immediate future the most important issue may be the choices made by theorists, managers and opinion-leaders. It is choices about values, beliefs, paradigms, theories and strategies that will determine our future.

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