WORLD RESOURCES INSTITUTE

JANET RANGANATHAN
CIARA RAUDSEPP-HEARNE
NICOLAS LUCAS
FRANCES IRWIN
MONIKA ZUREK
KAREN BENNETT
NEVILLE ASH
PAUL WEST

ECOSYSTEM SERVICES
A Guide for Decision Makers

PLUS The Decision: A fictional story about a community facing ecosystem change

ECOSYSTEM SERVICES
A Guide for Decision Makers

JANET RANGANATHAN

CIARA RAUDSEPP-HEARNE

NICOLAS LUCAS

FRANCES IRWIN

MONIKA ZUREK

KAREN BENNETT

NEVILLE ASH

PAUL WEST

WORLD
RESOURCES
INSTITUTE

Each World Resources Institute report represents a timely, scholarly treatment of a subject of public concern. WRI takes responsibility for choosing the study topics and guaranteeing its authors and researchers freedom of inquiry. It also solicits and responds to the guidance of advisory panels and expert reviewers. Unless otherwise stated, however, all the interpretation and findings set forth in WRI publications are those of the authors, and do not necessarily reflect the views of WRI or the collaborating organizations.

ISBN 978-1-56973-669-2

Library of Congress Control Number: 2007941147

Cover and title page images by Getty Images and Hisashi Arakawa (www.emerald.st)

Table of Contents

List of Tables, Figures and Boxes

TABLES

FIGURES

BOXES

Foreword

The Brazilian basin of the Amazon River holds the world's largest expanse of tropical forest. It directly sustains the livelihoods of members of hundreds of Indian tribes as well as city dwellers, farmers, and ranchers. The forests are not only vital to the national economy, but also to people around the globe. Known as the "Lungs of our Planet," Amazon forests continuously recycle carbon dioxide into oxygen, cleaning air and regulating regional and global climate.

Puget Sound, a large salt water estuary in the U.S. Pacific Northwest, is one of the world's most productive and biologically diverse ecosystems. Carved by glaciers and fed by thousands of rivers and streams, it provides a habitat for the iconic Pacific salmon. It also provides flood protection, natural storm water management, drinking water production and filtration, and recreation for its residents and the many who come to visit.

What do these two treasures, the Brazilian Amazon and Puget Sound, have in common? Both are undergoing rapid change as a result of human pressure and climate change. One fifth of the Brazilian Amazon has been deforested by loggers, farmers, and ranchers. Puget Sound faces environmental challenges ranging from water pollution and toxic-laden sediments to loss of habitat. Like this guide, both regions are pioneering ways to reconcile development and environment goals —not just for the sake of nature, but also for the sake of people.

Reconciling development and nature is challenging because we have traditionally put these two goals in separate boxes—separate academic disciplines, separate government agencies, and correspondingly separate laws and policies. Development planners too often assume that the natural assets that development depends on—freshwater, natural hazard protection, pollination, to name just a few—will always be there. Conservationists, on the other hand, are often preoccupied with minimizing the negative impacts of development on nature or putting it off limits to people. The full extent of our dependency on nature's benefits, or ecosystem services, is seldom taken into account by either.

It is easy for many of us to forget our connection to nature. We have clean water at the turn of a faucet, a diverse selection of fruit, vegetables, and meat on the shelves of a grocery store. We have no idea about the health of the ecosystems supplying these services. And we are largely unaware of how our choices affect the health of these ecosystems. Perhaps this is partly because around the world—Brazil and the United States included—more than half of us live in urban areas that use three fourths of Earth's natural resources. We seldom pay for many of the benefits nature provides—the filtering power of wetlands or mangroves or the climate control of forests.

Thanks to the Millennium Ecosystem Assessment, the first global check-up of our ecosystems and their capacity to provide us with ecosystem services, we now know that we can no longer afford to take nature's benefits for granted. Fifteen out of 24 ecosystem services assessed are already degraded, threatening our ability to build vibrant communities.

The time has come to stop putting development and environment in separate boxes, and instead acknowledge that the two are inextricably bound together. Making these links is at the heart of the World Resources Institute mission—increasing prosperity and protecting the planet. It is also what this guide is all about.

The guide uses *ecosystem services*—the benefits of nature—to make the link between nature and development. These services include food and fiber and fuel but also the largely unpriced services of clean air and clean water, natural hazard protection, pollination, and spiritual sustenance. In policymaking, nature's goods and services belong in the same category as the assets of capital and labor. The language of ecosystem services provides a way for policymakers to identify how a decision depends on nature's flow and how a decision will in turn affect the flow. It increases our ability to understand and make trade-offs across ecosystem services, in space and time, and in doing so win more and lose less.

The guide draws on our early experience in measuring and managing multiple ecosystem services to outline how to assess the services development depends on and affects, how to use

continued

Foreword

scenarios to explore the future, and how to choose policies that sustain ecosystems for development. It also uses a novel approach. It tells a fictional story about a city grappling with preventing floods and providing clean water while helping the country raise and sell biofuels. The story illustrates the difficult trade-offs that policymakers face in many parts of the world: how to provide cleaner energy and jobs but avoid increasing food and land prices and endangering forests and clean water. The politics and power plays aptly captured by the story will be familiar to many of you.

Choices about biofuel are just one example of the intricacies posed by decisions to reconcile development and nature. Brazil brings experience in trying to balance the demand for land for growing sugar cane, raising other crops, or grazing animals while avoiding fragmentation of the forests. Puget Sound is developing an ecosystem-wide roadmap to restore the health of the Sound by 2020. Even more daunting are choices about climate change.

We now know the global climate is changing and at the same time our natural assets are dwindling. These two trends are on a collision course—and the consequences will be felt by all, but especially by the poor among us. Climate change affects the quantity, quality, and timing of ecosystem services such as water for power, irrigation, and household and sacred use. Investing in restoring and maintaining healthy ecosystems may be our best insurance against climate change. Forests help regulate climate by absorbing carbon dioxide from the atmosphere. Mangroves and wetlands afford protection against floods. Healthy, resilient ecosystems will be more capable of adapting to climate change and buffering abrupt changes in the supply of ecosystem services critical to our well-being.

If we want to pass these natural assets on to our children and those who follow them, we must do a better job of reconciling human development and ecosystem protection. This guide aims to show the way.

Fernando Henrique Cardoso
Board Member, World Resources Institute
Professor-At-Large, The Watson Institute for International Studies, Brown University
Former President of Brazil

William D. Ruckelshaus
Chairman Emeritus, World Resources Institute Board
Chairman, Puget Sound Leadership Council
Former Administrator, U.S. Environmental Protection Agency

Acknowledgments

EDITOR
Christine Mlot

DESIGN
Overall layout: Dever Designs
Illustrations for The Decision: A Story about Ecosystem Services: Alejandro Telo

RESEARCH AND ADMINISTRATIVE SUPPORT
Navid Ahdieh, Hyacinth Billings, Alexa Clay, Katherine Didow, Changxin Fang, Maria Elena Gutierrez, Jennie Hommel, Gwen Parker, Brianna Peterson, Kristin Snyder, and Madison Warner

USER FORUM
Marian delos Angeles (World Bank Institute), Philip Bubb (UNEP-World Conservation Monitoring Centre), Peter Hazlewood (UNDP), Hector Malarin (IADB), Charles McNeill (UNDP), Laszlo Pinter (IISD), Walt Reid (The David and Lucile Packard Foundation), David Smith (UNEP), Luis Uribe (IADB), Konrad von Ritter (World Bank), Brian Walker (CSIRO), Andrew Watson (DAI), and Paul West (The Nature Conservancy)

REVIEWERS
Tundi Agardy (Sound Seas), Gordana Beltram (Ministry of the Environment – Slovenia), Maria Berlekom (Swedish International Biodiversity Programme), Greg Bischak (Appalachian Regional Commission), Hernan Blanco, Jan Bojö (World Bank), Rob Bowman (UK Department for Environment, Food and Rural Affairs), Anne Marie Sloth Carlsen (Danish Ministry of Foreign Affairs), Terry Chapin (University of Alaska), Owen Cylke (World Wildlife Fund), Rudolph de Groot (Wageningen University and Research Centre), Don Doering (Bill and Melinda Gates Foundation), Anantha Duraiappah (UNEP), Marianne Fernagut (UNEP/Global Resource Information Database-Arendal), Alex Forbes (UNDP), Keisha Garcia (The Cropper Foundation), Madeleine Garlick, Barry Goldman (Gordon and Betty Moore Foundation), Jacob Gyamfi-Aidoo (Environmental Information Systems Africa), Cate Harrington (The Nature Conservancy), Norbert Henninger (WRI), Nicolas Houde (McGill University), Karen Hughes-Field (Alberta Environment), Tony Janetos (The Heinz Center), David Jhirad (WRI), Bud Jordahl, Piet Klop (Netherlands Ministry of Foreign Affairs), Karin Krchnak (The Nature Conservancy), Pushpam Kumar (University of Liverpool), Tony LaVina (Ateneo School of Government, Philippines), Florence Landsberg (WRI), Marcus Lee (UNEP), Bill Mansfield (UNEP-Regional Office for North America), Mary Melnyk (US Agency for International Development), Kenton Miller, Robin Murphy (WRI), Robin Naidoo (World Wildlife Fund), Angela Nugent (US Environmental Protection Agency), Helen O'Connor (UK Department for International Development), Wilbur Ottichilo (Regional Centre for Mapping of Resources for Development), Charles Perrings (Arizona State University), Garry Peterson (McGill University), Daniel Prager (WRI), Cecilia Procope Repinski (WRI), Samantha Putt del Pino (WRI), Chella Rajan (Indian Institute of Technology Madras), Carmen Revenga (The Nature Conservancy), Belinda Reyers (Council of Scientific and Industrial Research), Dale Rothman (International Institute for Sustainable Development), Guido Schmidt-Traub (United Nations Millennium Project), Frederik Schutyser, Susan Shaw (Calvert County Commissioner), Louise Sorensen (UNDP), Mariel Aguilar Stoen (University of Oslo), Heather Tallis (Stanford University), Christine Tam (The Nature Conservancy), Alex Tu (BC Hydro), Detlef van Vuuren (Netherlands Environment Assessment Agency), Sandra Velarde (Consultative Group on International Agricultural Research), Matt Zylstra (Foundation for Sustainable Development)

FUNDERS
The Royal Danish Ministry of Foreign Affairs; Irish Aid, Government of Ireland; the John D. and Catherine T. MacArthur Foundation; the Netherlands Ministry of Foreign Affairs; the David and Lucile Packard Foundation; and Swedish International Biodiversity Programme.

Summary

Human well-being utterly depends on nature. Development, defined broadly to encompass social, economic, and environmental aspects of growth, aims to improve human well-being. Despite the inextricable connections, development and nature have frequently been considered in isolation or even in opposition. This guide aims to help decision makers reconcile the two by outlining how an Ecosystems Services Approach can be incorporated into existing decision making processes to strengthen development strategies. It is intended for use by a city mayor; a local planning commission member; a provincial governor; an international development agency official; or a national minister of finance, energy, water, or environment and those working for them.

Decision makers may be focused on reducing poverty, increasing food production, strengthening resilience to climate change, or producing energy. The development projects and policies intended to meet these goals often go forward unwittingly at the expense of nature—a dam to produce electricity reduces fish populations, a national plan to expand agriculture may increase deforestation leading to soil erosion and flooding. Ultimately, the development goals are undermined as the effects of these trade-offs are felt by people who depend on nature for their livelihood and well-being, whether it is fish stocks for food, protection from downstream flooding, or spiritual sustenance.

This guide explains how to improve the outcome of these trade-offs in decision making. It builds on existing experience with multiple-use ecosystem management, ecosystem restoration, and conservation planning, but identifies ecosystem services more explicitly. It responds to the findings of the Millennium Ecosystem Assessment, a four-year global effort involving more than 1,300 experts that assessed the condition and trends of the world's ecosystems. The Assessment found that in the last half of the 20th century, humans changed ecosystems more rapidly and extensively than in any comparable period of history, primarily to meet growing needs for food, freshwater, timber, fiber, and fuel. These changes have resulted in significant benefits to humans, including improvements in health and a reduction in the proportion of malnourished people. However, these gains have come at an increasing cost.

As ecosystems have been altered, many of their goods and services—the food and freshwater, the regulating services, and cultural benefits they provide—are in jeopardy. Two thirds of the ecosystem services we depend on are degraded. This degradation will likely grow significantly worse in the first half of the 21st century. It threatens human well-being and the goals of development. But evidence is accumulating that taking an Ecosystems Services Approach can make development more sustainable by sustaining nature's capacity to provide needed goods and services.

This guide assembles that evidence for use by a decision maker. It details the processes that they can use, beginning with a conceptual framework that links development and ecosystem services and ending with guidance for choosing policies to sustain ecosystem services.

The guide develops the conceptual framework from the Millennium Ecosystem Assessment to help decision makers gain a better understanding of how development goals both affect and depend on ecosystem services. All the interacting components of the framework are dissected in relation to a development goal, beginning with people and their well-being, then moving through the full range of supportive ecosystem services and the strength of their links to human well-being, the direct and indirect drivers of change to ecosystems that a decision maker needs to be aware of, and the spatial and temporal scales that a decision operates on. The guide emphasizes the two principles, credibility and legitimacy, that must apply to information a decision maker uses throughout the process.

The guide then details the five steps involved in assessing risks and opportunities related to ecosystem services. The first step is to identify all the ecosystem services that a decision depends on and affects, by systematically analyzing the ecosystems and their services in a particular locale. The guide


DIGITALVISION

includes a detailed list of all the services a decision maker would need to consider. The second step is to determine which of these ecosystem services are most relevant to a decision or development goal, to set priorities for further assessment. The guide explains the criteria a decision maker would use in this screening. The third step is to conduct a detailed analysis of the condition and trends of the most relevant ecosystem services, based on a set of questions and issues provided by the guide. The fourth step addresses the dollar value of the ecosystem services in question, for use in development cost-benefit analyses, for example. The guide points to resources on how to conduct economic valuation, if this is necessary. The final step is to analyze the risks and opportunities that arise from a decision in relation to the ecosystem services. The guide lists the type of trade-offs associated with developments that a decision maker should consider.

While assessing the current status of ecosystem services is crucial for successful development, decision makers also need to look into the future to assess the options for addressing ecosystem change. The guide can help decision makers explore what may unfold in the future given certain assumptions and choices about ecosystem services. Exploring the future is important for avoiding the unintended consequences that often arise from development projects, such as a fish species imported for food that becomes an invasive predator. The guide details the steps involved in one particularly useful technique for exploring the future, scenario building. Scenarios are stories about the future, told as a set of "plausible alternative futures" about what might happen under particular assumptions.

The guide concludes with a discussion on choosing policies to sustain ecosystem services in light of the ecosystem services assessment and explorations of the future. It focuses on uncovering the risks in development policies that may exacerbate ecosystem degradation as well as the opportunities to further development goals by sustaining ecosystem services. It explains how to incorporate development policies to address these risks and opportunities within an existing legal framework. Decision makers can apply the Ecosystems Services Approach outlined here in the course of establishing national and sub-national policies, economic and fiscal incentives, sector policies, or governance forums. The guide provides extensive examples of policy options in each such category and also provides design criteria for selecting among them.

By offering decision makers the conceptual and practical guidance for choosing policies that better attend to ecosystem services, this guide aims to help unite nature and development. Instead of solely working to protect nature *from* development, we may also begin to invest in nature *for* development.

C H A P T E R 1

Lead Authors
Karen Bennett
Janet Ranganathan
Paul West

Contributing Authors
Frances Irwin
Charles Perrings
Dagmar Timmer

PHOTOS BY DIGITALVISION AND GETTY IMAGES

Introduction

People everywhere depend on nature for their well-being. Nature is the source of such obvious necessities as food and fresh water. Its ecosystems also provide less obvious services such as storm protection and pollination. The natural world provides spiritual and recreational benefits as well. These and other benefits of nature's ecosystems (see key terms below) have supported the extraordinary growth and progress of the human population. Yet many ecosystem services are in a state of decline, and we are learning that nature's benefits can no longer be taken for granted. Ignoring these services in public and private decision making threatens our ways of living and impedes our ability to achieve our aspirations for the future.

Recognizing the links between ecosystem services and development goals can mean the difference between a successful strategy and one that fails because of an unexamined consequence for a freshwater supply, an agricultural product, a sacred site, or another ecosystem service. This guide will help decision makers recognize the links by demonstrating how to incorporate an Ecosystem Services Approach into *existing* decision-making processes. An Ecosystem Services Approach expands the focus beyond how development *affects* ecosystems to include how development *depends* on ecosystems. In addition to focusing on how to protect ecosystems *from* development, we can also consider how to invest in managing ecosystems *for* development.

There is no single way to implement an Ecosystem Services Approach. The methods presented in this guide are illustrative; decision makers need not use all of them in order to strengthen their decisions. The guide builds on existing experience with multiple-use ecosystem management, ecosystem restoration, and conservation planning, but identifies ecosystem services more explicitly.

This guide is intended for use by a city mayor; a local planning commission member; a provincial governor; an international development agency official; or a national minister of finance, energy, water, or environment. It can help answer questions such as:

- What is the relationship between ecosystems and development? (chapter 1)
- Why do ecosystem services matter? (chapter 1)
- How can an ecosystem services framework help organize a decision-making process? (chapter 2)
- What are the most common ecosystem services? (chapter 2)
- When and how can the economic value of ecosystem services be quantified? (chapter 3)
- How are ecosystem service risks and opportunities identified? (chapter 3)
- How can future ecosystem service changes be explored? (chapter 4)
- How can ecosystem service risks and opportunities be incorporated into development strategies? (chapter 5)
- What policies help sustain ecosystem services? (chapter 5)

Our ability to identify, map, measure, and value the benefits that come from ecosystems is increasing. The Millennium Ecosystem Assessment—a four-year United Nations assessment of the condition and trends of the world's ecosystems involving more than 1,300 experts—established a benchmark. Efforts such as those by The Natural Capital Project on valuation (Natural Capital Project 2007), IUCN on payments (IUCN 2006), and the World Resources Institute on mainstreaming ecosystem services in public and private sector decisions provide new methods that decision makers can use to make the links between ecosystems and development. As we are better able to describe and value the benefits of ecosystem services,

Key Terms Used in this Guide

An ecosystem is a collection of plants, animals, and micro-organisms interacting with each other and with their non-living environment (CBD 1993). Examples include a rainforest, desert, coral reef, or a cultivated system. A city can be treated as an urban ecosystem.

Ecosystem services are the benefits that people get from nature. Examples include fresh water, timber, climate regulation, recreation, and aesthetic values.

An Ecosystem Services Approach provides a framework by which ecosystem services are integrated into public and private decision making. Its implementation typically incorporates a variety of methods, including ecosystem service dependency and impact assessment (chapter 3), valuation (chapter 3), scenarios (chapter 4), and policies and other interventions targeted at sustaining ecosystem services (chapter 5). These methods are often applied at a watershed or landscape level and frequently involve projecting a decade or more into the future. The Ecosystem Services Approach builds on the Ecosystem Approach developed under the Convention on Biological Diversity, but further emphasizes ecosystem services as the link between ecosystems and development (UNEP 2007).

Development refers to actions that seek to improve human well-being. Development goals are relevant to all countries. Development encompasses social, economic, and environmental issues. Thus it includes economic growth, poverty reduction, infrastructure expansion, energy independence, and adaptation to climate change.

Decision maker refers to anyone whose actions depend on or affect ecosystem services. Decision makers may work at a local, provincial, national, or international level to achieve development goals (through policies, plans, and projects), or they may be focused on conservation planning, natural resource management, and environmental protection. Often, they will work with partners at other levels of governance.

decision makers can better understand how their actions might change these services, consider the trade-offs among options, and choose policies that sustain services.

This introduction first discusses how ecosystem services link development and nature and provides examples of the links. It then summarizes what the Millennium Ecosystem Assessment found about the current condition and trends of ecosystem services. Finally, it outlines the variety of entry points for incorporating ecosystem services in decision-making processes and describes the rest of the guide.

ECOSYSTEM SERVICES AND DEVELOPMENT

In the past, environmental decision making has focused largely on mitigating the *impact* of mining or dam building, for example, and on establishing areas to protect wildlife and its habitat or a scenic river. While important, these activities are only part of the picture. We need to consider mitigation and protection within a broader approach that recognizes that people in their daily lives *depend* on a range of services that ecosystems provide. These services are fundamental to attaining development goals (see Figure 1.1).

Thus, decision makers—including those whose goals and actions might not at first seem connected to ecosystems—need to examine the dependence and impacts of their goals on ecosystem services (see Table 1.1). Whether developing a policy to increase the production of food or biofuel, preparing a coastal development plan, or constructing a water filtration plant, taking ecosystem services into account can strengthen decisions.

The following four examples illustrate how improved understanding of the links

KEY LEARNINGS

Human well-being and long-term economic success depend on ecosystem services, the benefits that people get from nature.

Figure 1.1 **The Relationship between Development and Ecosystem Services**

Table 1.1 Linking Development Goals and Ecosystem Services

Goal	Link to dependence on ecosystem services
Adaptation to climate change	Climate change alters the quantity, quality, and timing of ecosystem service flows such as fresh water and food. These changes create vulnerabilities for those individuals, communities, and sectors that depend on the services. Healthy ecosystems can reduce climate change impacts. Vegetation provides climate regulating services by capturing carbon dioxide from the atmosphere. Ecosystem services such as water and erosion regulation, natural hazard protection, and pest control can help protect communities from climate-induced events such as increased floods, droughts, and pest outbreaks.
Energy security	Many renewable energy sources, such as biofuels or hydroelectric power, are derived from ecosystems and depend on nature's ability to maintain them. Hydropower, for example, relies on regular water flow as well as erosion control, both of which depend on intact ecosystems.
Environmental conservation	Conservation projects often only consider a few benefits of preserving nature. They may emphasize existence values, for example. Using an ecosystem services framework can help identify the multiple services provided and highlight the benefits that the project will provide to development as well as the benefits to conservation. For example, a protected area may provide biochemicals for pharmaceuticals or pollination for agricultural crops.
Food production	Ecosystems are vital to food production, yet there is pressure to increase agricultural outputs in the short-term at the expense of ecosystems' long-term capacity for food production. Intensive use of ecosystems to satisfy needs for food can erode ecosystems through soil degradation, water depletion, contamination, collapse of fisheries, or biodiversity loss.
Freshwater provision	Ecosystems help meet peoples' need for water by regulating the water cycle, filtering impurities from water, and regulating the erosion of soil into water. Population growth and economic development have led to rapid water resource development, however, and many naturally occurring and functioning systems have been replaced with highly modified and human-engineered systems. Needs for irrigation, domestic water, power, and transport are met at the expense of rivers, lakes, and wetlands that offer recreation, scenic values, and the maintenance of fisheries, biodiversity, and long-term water cycling.
Health	Ecosystem services such as food production, water purification, and disease regulation are vital in reducing child mortality, improving maternal health, and combating diseases. In addition, changes in ecosystems can influence the abundance of human pathogens resulting in outbreaks of diseases such as malaria and cholera, and the emergence of new diseases.
Natural hazard protection	Increasingly, people live in areas that are vulnerable to extreme events such as floods, severe storms, fires, and droughts (MA 2005b, 443). The condition of ecosystems affects the likelihood and the severity of extreme events by, for example, regulating global and regional climates. Healthy ecosystems can also lessen the impact of extreme events by regulating floods or protecting coastal communities from storms and hurricanes.
Poverty reduction	The majority of the world's 1 billion poorest people live in rural areas. They depend directly on nature for their livelihoods and well-being: food production, freshwater availability, hazard protection from storms, among other services. Degradation of these services can mean starvation and death. Investments in ecosystem service maintenance and restoration can enhance rural livelihoods and be a stepping stone out of poverty.

Sources: Adapted from MA 2005a; MA 2005d; UNDP 2003.

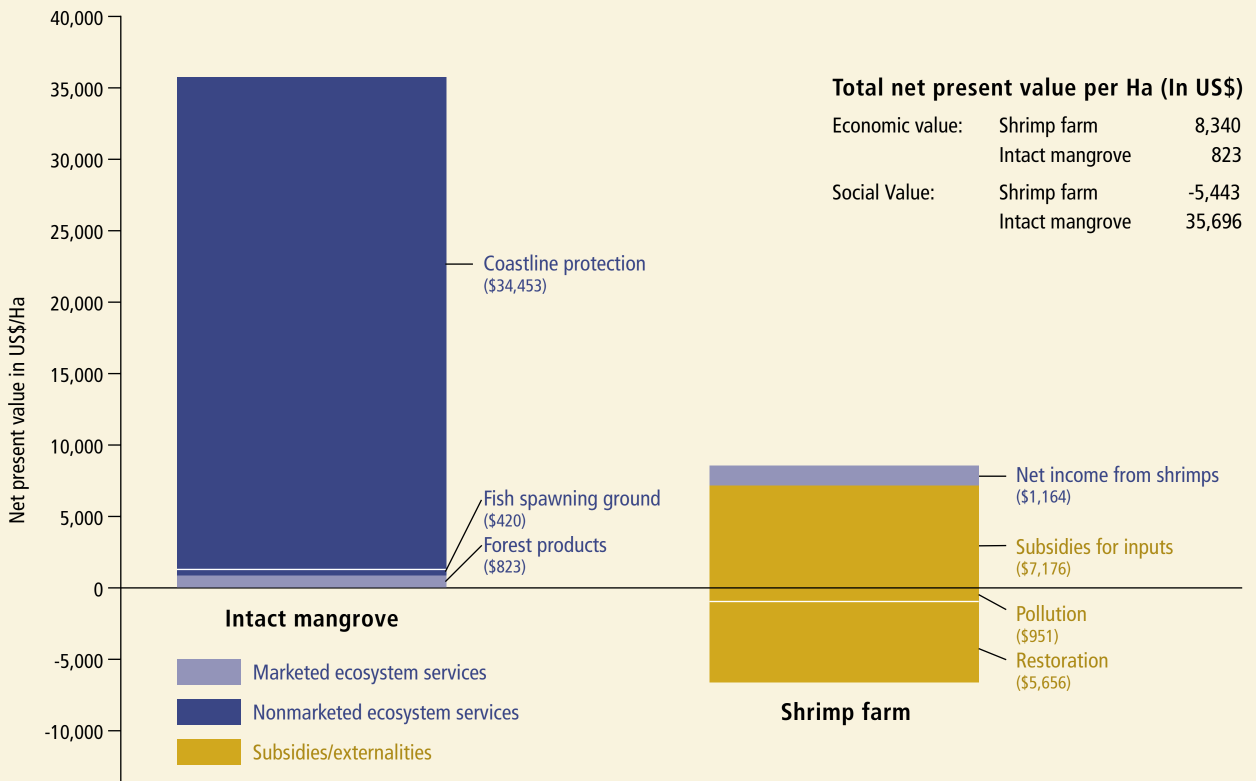
between development and ecosystem services can strengthen decision making. The first focuses on food production and shrimp farms in Southeast Asia and highlights how unintended trade-offs among ecosystem services can jeopardize development goals when ecosystem service dependencies are overlooked in development strategies. The U.S. agriculture example shows how incentives can be used to encourage farmers to restore or protect ecosystem services that have no market value. The Indo-German Watershed Development Program illustrates how investments in the restoration of ecosystem services can be an effective strategy for improving the livelihoods and well-being of poor rural communities. The example from China shows how not considering ecosystem services in a national plan can undermine development goals.

Shrimp farming and mangrove losses in Southeast Asia

The expansion of shrimp aquaculture, particularly in Southeast Asia and Central America, has increased profits for a few growers, while supplying the global marketplace with low-cost shrimp. Unfortunately for many coastal communities, the proliferation of shrimp farms has driven widespread destruction and conversion of mangrove forests (Stevenson 1997).

A study of mangrove conversion near Tha Po Village in Thailand compared the economic returns from shrimp farms with those from sustainably managed mangroves. Conversion of mangroves to shrimp farms appears the economically sound choice when only the values of the shrimp harvest and forest products are considered in the economic analyses. However, if the value of non-marketed ecosystem services from mangroves (such as coastline protection and spawning ground for wild

Figure 1.2 Comparing the Economic and Social Value of Mangroves and Shrimp Farms



These numbers are based on a 10% discount rate over a 20-year period and are derived from Sathirathai and Barbier 2001.

fish) is considered, the intact mangroves become the more sound development choice (see Figure 1.2).

People in Tha Po Village, and other poor coastal communities where mangrove conversion is occurring, bear most of the costs associated with diminished ecosystem services, including lost forest resources, reduced coastline protection from storms, lower fishery yields, and water quality degradation from aquaculture pollution. Yet they receive few of the benefits, which primarily accrue to shrimp aquaculture operators and distant consumers who enjoy subsidized shrimp (Sathirathai and Barbier 2001). If residents had been effectively involved in the decision and brought information about their use of ecosystem services to include in a cost-benefit analysis, might a more equitable and economically sound decision have been made?

U.S. farmers and soil conservation

Agricultural production is a major industry in the United States, but the production of crops, livestock, and biofuel often degrades other ecosystem services such as erosion control, nutrient cycling, and freshwater supply (MA 2005b: 831-32; Marshall and Greenhalgh 2006). In 1985, the U.S. government established the Conservation Reserve Program to help restore these degraded services. Through this program farmers are compensated for retiring cropland for up to 15 years and establishing conservation practices. In addition to receiving rent, participants receive technical training in how to implement best management practices.

In 2006 more than 3 million acres of farmland were enrolled in the program. Monitoring systems have demonstrated improvements in water quality, carbon storage, and soil retention. The program is alleviating some of the nation's biggest environmental problems: Chesapeake Bay pollution, New York City's drinking water quality, and declining populations of Pacific Northwest salmon (FSA 2007; Perrot-Maître and Davis 2001). The European Union has a similar program under its Common Agricultural Policy that pays farmers for undertaking measures that meet development goals (Hanrahan and Zinn 2005).

ROBIN MURPHY

Soil and water conservation measures in Darewadi, India have helped to increase land value four-fold.

Watershed restoration in India to support sustainable rural livelihoods

Before an Indo-German Watershed Development Program was launched in 1996, Darewadi village in the Indian state of Maharashtra relied on tanker trucks of water during periods of water scarcity. Technical training and leadership development enabled the village to adopt new ways to mitigate the effects of drought. The villagers chose efforts that included tree planting, grazing bans, and soil and water conservation measures.

After five years, the village's restoration efforts were self-sustaining. Once-bare hillsides surrounding the village are now replanted with trees. The area supports nine to ten months of agricultural employment a year (compared with three to four months before the restoration project); extensive new irrigation supports more crop varieties; and the value of cultivated land has increased four-fold. The village has not needed trucked-in water in recent drought years. The Indo-German Watershed Development Program has funded more than 145 similar projects in 24 districts, successfully mobilizing villagers to restore their watersheds (D'Souza and Lobo 2004; WOTR 2002; WOTR 2005).

Encroaching desert in Western China

Minqin County in Western China historically served as a natural barrier against the dryness of the Tengger and Badain Jaran deserts. In the 1950s, Chairman Mao implemented a national plan to boost food production entailing cultivation, deforestation, irrigation, and reclamation. The long-term consequences on other ecosystem services such as water regulation from forests and natural water supply were devastating. The Minqin oasis has been slowly swallowed by deserts.

The nearby Hongyashan reservoir has also dried up, and groundwater is expected to run out in 17 years. This overexploitation of groundwater, along with the insufficient re-supplying of surface water, has led to water quality problems, making the majority of water in Minqin undrinkable. The Chinese government has spent nearly US$9 billion fighting the desertification in Minqin by replanting forests, reestablishing desert vegetation, removing dams, and enforcing logging and grazing bans. The government is also funding the relocation of area residents; in Northern Minqin, entire villages have been abandoned. It is too early to tell if the restoration projects will have the intended effects (China Daily 2005; Gluckman 2000; Kahn 2006).

Such desertification, the degradation of dryland ecosystems from overexploitation and land mismanagement, is a risk to an estimated 2 billion people globally—one third of Earth's population (AP 2007). If the problem continues unchecked, the next decade could see 50 million people forced to leave their homes (Adeel et al. 2006).

CONDITION AND TRENDS OF ECOSYSTEM SERVICES

KEY LEARNINGS

Worldwide, many ecosystem services are degraded or in decline.

Examples of local degradation of ecosystem services, whether a fishery in coastal Thailand or groundwater depletion in a China county, are part of a larger, serious trend revealed by the Millennium Ecosystem Assessment: about two thirds of the 24 ecosystem services assessed globally are degraded (see Table 1.2). This degradation will likely grow significantly worse in the first half of the 21st century (MA 2005a).

Examples of global changes in ecosystems over the past 50 years include:

- **Changes in land use have significantly altered the supply of ecosystem services.** More land was converted to cropland between 1950 and 1980 than in the 150 years from 1700 to 1850 (MA 2005a:2). The societal value of converted land is often less than that of sustainably managed natural systems, which provide a greater variety of ecosystem services.

Table 1.2 Ecosystem Services: Global Status and Trends			
Ecosystem Service Type	**Degraded**	**Mixed**	**Enhanced**
Provisioning – the goods or products obtained from ecosystems	Capture fisheries Wild foods Wood fuel Genetic resources Biochemicals Freshwater	Timber Fiber	Crops Livestock Aquaculture
Regulating – the benefits obtained from an ecosystem's control of natural processes	Air quality regulation Regional and local climate regulation Erosion regulation Water purification Pest regulation Pollination Natural hazard regulation	Water regulation (for example, flood protection) Disease regulation	Carbon sequestration
Cultural – the nonmaterial benefits people obtain from ecosystem services	Spiritual and religious values Aesthetic values	Recreation and ecotourism	

Source: Adapted from MA 2005a.

- **Freshwater scarcity is an accelerating condition for more than 1 billion people,** affecting food production, human health, and economic development. The most important sources of renewable freshwater are forest and mountain ecosystems, which provide water to two thirds of the global population (Earthwatch Institute et al. 2006).
- **The amount of water impounded by dams has quadrupled since 1960,** so that three to six times as much water is now held in reservoirs as in natural rivers (MA 2005a:2). Tens of millions of people have been displaced as a result and more have suffered a loss of the resources on which their livelihoods depend (World Commission on Dams 2000).
- **Worldwide fish landings peaked in the late 1980s and have since remained static,** even though demand has never been greater. The expansion of aquaculture has countered some of this shortfall, contributing 43 percent of fish production in 2004 (FAO 2007). Yet this expansion has caused other problems (see shrimp farming example in the previous section) (MA 2005a).
- **Nearly a quarter of mangroves and 20 percent of coral reefs have been lost since about 1980,** together with their many services including their capacity to buffer coastal communities from storms. People are more vulnerable than ever to extreme events as demonstrated by the high loss of life and economic losses from natural disasters such as the Asian Tsunami in 2004 (FAO 2004; MA 2005a; Danielsen et al. 2005).

These findings suggest that ecosystem services are often overlooked or assumed to be available as development decisions are made; the attainment of development goals is consequently often in jeopardy. The Millennium Ecosystem Assessment found, for example, that continued degradation of ecosystem services is a barrier to achieving the Millennium Development Goals for poverty reduction, which guide development institutions.

While the above findings are global, they reflect similar patterns of changes at the local, national, and regional scales. Users of the guide are encouraged to think about the relevance of these findings to their own context and seek out information on local ecosystem condition and trends. On a global scale, the Millennium Ecosystem Assessment lays out four main findings (see Box 1.1).

Although by design the Millennium Ecosystem Assessment stopped short of prescribing policy recommendations, it outlined the range of available policy responses to the declining state of ecosystem services and also prepared four scenarios to describe the range of possible future outcomes (for an introduction to scenarios see chapter 4). The Assessment found that in three of four global scenarios *significant changes in policies* mitigated many of the negative consequences on ecosystem services. However, the policy changes required were large and are not currently underway. Degradation can rarely be reversed without addressing factors such as migration, economic growth, technological change, the legal framework, and the role of the public, the Assessment concluded. Past actions to slow or reverse degradation of ecosystem services have yielded significant benefits, but the improvements have not kept pace with increasing pressures (MA 2005a).

KEY LEARNINGS
Reversing ecosystem degradation is possible, but will require concerted and unprecedented efforts.

ENTRY POINTS FOR MAINSTREAMING ECOSYSTEM SERVICES

Given that development goals depend on ecosystem services and that many of these services are in decline, decision makers need to deliberately take into account the connections between development and ecosystems. Entry points for incorporating an Ecosystem Services Approach into existing decision-making processes occur at all levels of governance and are important for both development officials and those approaching problems from an environmental perspective. Many entry points are at the national or provincial level. Some, such as the Millennium Development Goals, or international trade and investment, are at the global level but usually have their more detailed counterparts at the national or local level.

Project decisions are likely to be informed by broad national policy and international commitments, although specific permitting decisions are often made at the sub-national, watershed, or local level. Opportunities for mainstreaming ecosystem services can be categorized into four intersecting entry points: national and sub-national policies, economic and fiscal incentives, sector policies, and governance (see Table 1.3; policies for each category are discussed in more detail in chapter 5, Table 5.1).

Box 1.1 **Main Findings of the Millennium Ecosystem Assessment**

Humans have radically altered ecosystems in just 50 years
In the last half of the 20th century, humans changed ecosystems more rapidly and extensively than in any comparable period of history, primarily to meet growing needs for food, freshwater, timber, fiber, and fuel. Almost one third of global land is now under cultivation (MA 2005a:32). One result is that more than half of the synthetic nitrogen fertilizer ever used on the planet has been applied to crops in the past two decades (Green et al. 2004). As much as 50 percent of this is lost, contributing to rapidly rising nitrate concentrations in rivers, lakes, and coastal areas and creating dead zones where no living organisms are found (Welch and Graham 1999). An increase in atmospheric carbon dioxide concentration by one third since 1750, two thirds of which occurred since 1959, has great potential to alter natural systems through climate change (MA 2005a:13–14).

Ecosystem change has brought gains in human well-being, but at high costs to natural capital
Ecosystem changes have resulted in significant benefits to humans, including improvements in health and a reduction in the proportion of malnourished people. However, these gains have come at an increasing cost. The Assessment's findings indicate that increases in provisioning services that have a market price have inadvertently degraded other ecosystem services. These degraded services are often regulating services, such as water filtration, coastal protection, and erosion control, that have no value in the marketplace until they are lost.

Further unsustainable practices will threaten development goals
Ecosystem degradation, greater risk of ecosystem collapse, and exacerbation of poverty, particularly among the resource-dependent poor, are all affected by the choice of development strategies. If these problems continue unchecked, they will undermine the gains in human well-being. The Assessment concluded that degradation of ecosystems presents a significant barrier to achieving development goals worldwide. Rural poverty and ecosystem degradation, for example, often go hand in hand.

Workable solutions exist, but require major policy changes
It will be a significant challenge to reverse ecosystem degradation while meeting the demands of a growing population and economy, but options do exist. The Assessment found that major changes in policies, institutions, and practices, although on a scale well beyond anything under way at present, can reduce some of the negative effects of rising consumption of ecosystem services as well as provide improvements in human well-being.

Table 1.3 Entry Points for Mainstreaming Ecosystem Services

Entry points	Ministry/Agency/Organization	Examples of decision processes
National and sub-national policies and plans	Development & planning	• Poverty reduction strategies, land-use planning, water supply, and sanitation
	Environment	• Protected area creation, climate adaptation strategies
	Treasury	• National budgets, public expenditure reviews, audits
	Physical planning, emergency planning, and response	• Integrated ecosystem management of coasts, river basins, forest landscapes, and watersheds
Economic and fiscal incentives	Finance	• Subsidies, tax credits, payments for ecosystem services, import duties, and tariffs
	Budget office	• Tax policies to support easements or promote alternative energy technology, pricing regulations for water
Sector policies and plans	Commerce and industry	• Corporate codes of conduct/standards, assessment of new technologies
	Science and technology	• Applied research, technology transfer, business capacity building
	Agriculture	• Extension services, best management practices
	Forestry	• Forest sector action programs, mapping initiatives, concession management
	Environment/ Natural resources	• State of the environment reports, strategic environmental assessments, environmental impact assessments, information/tools, legal instruments
Governance	Prime minister's or mayor's office, justice ministries, legislature, local government bodies	• Decentralization policies, free press, civil society, accountability of government through elections, access to information and decisions, judicial review, performance indicators

The examples provided for each entry point are not intended to be exhaustive, but rather illustrate the variety of ways ecosystem service considerations can be incorporated into development decision processes.

- *National and sub-national policies:* The preparation of national and sub-national trade, economic growth, or immigration policies provides important entry points for managing the cumulative demand and impacts on ecosystem services from individual or multiple sectors. Ministries of the environment, treasury, development and planning, among others, may play a role.
- *Economic and fiscal incentives:* Fiscal measures such as subsidies, taxes, and pricing influence decisions throughout the economy, from firms and farms to factories and households. They can be designed to create incentives to sustain and efficiently use ecosystem services, as well as to create disincentives for activities that drive ecosystem degradation.
- *Sector policies:* Ministries of commerce and industry, science and technology, agriculture and forestry, among others can play an effective role in advancing policies and actions that sustain ecosystem services. Environment agencies can work with other government agencies and departments to develop information, tools, and analyses that help make the connection between ecosystem services and the attainment of sector goals.
- *Governance:* Strong governance is at the heart of sustaining ecosystem services. This includes public participation in decisions that affect or depend on ecosystem services, a free press, and requirements to provide information, including regular indicators of ecosystem health, to the public. All branches of government also have a role in providing oversight. Such mechanisms enable citizens to hold governments and business accountable for their use and management of ecosystems.

KEY LEARNINGS

There are many entry points in current decision making processes to link economic and social goals with ecosystem services.

ABOUT THIS GUIDE

This guide is one of several publications by the World Resources Institute focused on mainstreaming ecosystem services in public and private decisions. It introduces an Ecosystem Services Approach aimed at helping policymakers at all levels and sectors use the concept of ecosystem services in making decisions. Accordingly, while it introduces methods to incorporate the concept of ecosystem services into different types of decision-making, it stops short of providing detailed methodological guidance on how to assess the conditions and trends of ecosystem services.


©ISTOCKPHOTO.COM/KEITH DUMBLE

The view from Victoria Peak in Hong Kong dramatically illustrates the intersection of development and nature.

A methods manual under development by the United Nations Environment Programme-World Conservation Monitoring Centre will provide more detailed technical guidance for scientists who conduct ecosystem assessments. The World Resources Institute is also producing a separate guide on how to integrate an Ecosystem Services Approach in business decision making.

Ecosystem service-based decision-making tools are still at an early stage of development, and the examples of their application in actual decision making are limited. This guide attempts to circumvent this limitation by drawing on both real and fictional case studies to illustrate its points. It is a first take on practical steps to incorporate consideration of nature's benefits into development decisions and will need updating as more research and experience become available. That said, while research is still emerging on how changes to ecosystems alter their capacity to provide services, enough is known for decision makers to start incorporating ecosystem services into their goals and strategies. Such action will support both robust and sustainable development decisions and healthy ecosystems.

The next chapter in this guide discusses how a decision-making framework linking ecosystems with human well-being can be used to strengthen and organize a decision-making process. Chapter 3 describes how to identify the ecosystem services most relevant to a development decision, how to collect information on their condition and trends and how to assess the resulting risks and opportunities for a decision. Chapter 4 introduces scenario planning as an approach for identifying ecosystem service trade-offs in the future. Chapter 5 concludes with guidance on how to select policies to sustain ecosystem services.

The guide also includes *The Decision: A Story about Ecosystem Services.* This tale of an imaginary city, Rio Grande, charts one community's efforts to reconcile development and ecosystem change. It follows the story of Rio Grande's Mayor and Secretary of Environment as they confront two challenges: how to develop the city's economy through the implementation of a national goal on biofuel expansion and how to address the consequences of ecosystem change for their city. Each chapter closes with an installment of *The Decision* to illustrate the main points of the chapter. The narrative draws on real life experience and examples. Its fictional nature allows the exploration of a variety of issues, angles, and conflicts that would not otherwise be possible within a single case study.

A CD-ROM containing the technical and synthesis volumes of the Millennium Ecosystem Assessment and a PowerPoint presentation with illustrative figures and graphics is enclosed. This resource can be used in conjunction with this guide both as a reference source and to help make the case for mainstreaming ecosystem services in decision-making processes.

ACTION POINTS

- Review how goals depend on and affect ecosystem services and how an Ecosystem Services Approach can strengthen decision making and help achieve these and other goals.
- Use PowerPoint presentation on enclosed CD-ROM to make the case for using an Ecosystem Services Approach.

1

The Decision

A Story about Ecosystem Services

Where the Secretary connects ecosystems and well-being

"So the bottomline is, you don't know." said the Mayor.

"We know the climate is changing. Scientists from around the world say so in a report released last year," the Secretary of Environment began. "We think that this region might see more precipitation in the next decades…."

The Mayor was now looking out the window and quickly losing interest. The winter had been unusually rainy, especially higher up in the mountains, and the previous month Rio Grande had seen the worst flooding in living memory, effectively isolating the city for four days and forcing the shut down of the water purification plant. The aftermath of this event had occupied much of the Mayor's agenda for the last month, and now he wanted to know why it had happened, and whether it would happen again.

"We've been busy with recovery tasks and haven't had time to look into the causes of this. But we'll come up with a complete report in the next few weeks," said the Secretary, knowing she had just missed an opportunity to explain that there was a link between deforestation upstream and the floods of the previous month.

"OK. Have that report ready for next week's cabinet meeting. I'll make room on the agenda for this. Would ten minutes suffice?" said the Mayor.

Of course not, thought the Secretary. "Sure," she said as she walked out.

In the lobby she noticed two tall men wearing expensive suits. "Please go ahead, the Mayor will see you now," said the receptionist.

"Foreigners," the receptionist said in reply to the Secretary's inquisitive look. "They are here about the biofuel complex."

"The what?!" The Secretary left the office furious. As usual, she hadn't been informed about development plans. Her office was never part of the big decisions—in this case to build a biofuel plant that was to be part of a new national goal to increase revenue from biofuel exports. She was expected to supervise environmental impact assessments, invariably done by outside consultants only after the decisions had been made, and then struggle with inspections and sanctions every time there was an accident. But her opinion did not seem to count when it came to investment decisions.

A map of Rio Grande

Back in her office the Secretary of Environment convened a staff meeting – four people, including herself.

"So, did you explain to the Mayor that we need to focus more on ecosystem management and less on public works?" one aide started.

"They want to build a biofuel complex," announced the Secretary.

"Ah… Then they better start building big levees, too."

"Why?"

"Precipitation is already on the rise and the agricultural frontier keeps expanding. An additional incentive to grow fuel crops will be the end of the remaining forest, and then we can expect more flooding. You did explain to the Mayor that the floods might be related to deforestation, didn't you?"

"I tried.…"

"The water treatment budget will need to go up, too. With more agriculture and fewer trees upstream water filtration by the forest will suffer and the water will reach the city dirtier … not good for the campaign 'A special city to live in'…"

"Is the Director of Tourism and Recreation aware of this? There goes their plan to promote ecotourism."

"And I suppose the lobby to expand the city port will revive. How do you think that will play with the fishing community?"

"What about the price of food? Have they thought that biofuel crops might compete with food production? Population growth is already putting pressure on prices here."

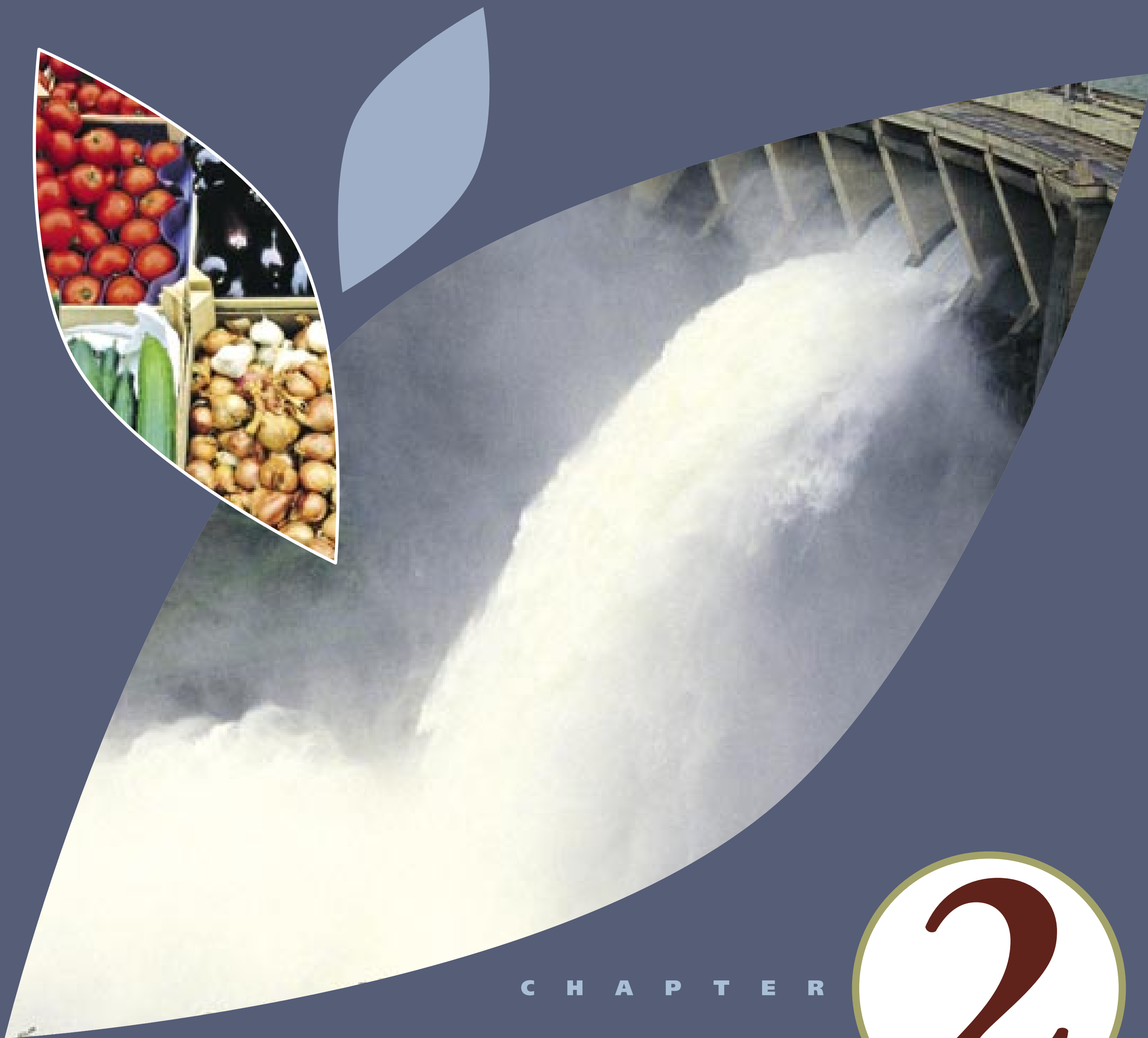
"Yes, plus almost all the crops are now exported, and I suppose the biofuel will be, too. But the costs of environmental degradation are borne here. Have you been to the southern neighborhood since the flood? It's a mess. We are now expecting an epidemic there. And migration from the countryside remains strong."

"I think they are not aware of how much our health and our economy depend on a healthy river basin. They just don't look beyond the municipal boundary, and yet some of our greatest problems come from outside."

That final comment gave the Secretary an idea. That was how she needed to frame it: the Mayor had to understand that the river was more than a river and that the previous month's floods had been something more than just a flood. This new refinery offered her a perfect opportunity to get involved in decisions about the city's development. The links between future biofuel production, future deforestation, future floods, and health needed to be explored.

The Mayor was not aware that the city was part of a whole system that had sustained the exponential growth of the last few decades. Clean water, fertile land, abundant crops and fish, even recreation and flood control—all these benefits resulted from a functioning system, and all had a value that was being overlooked. If the system failed, the consequences would be felt by the population, starting with the poor. Quality of life in the city would drop, and the Mayor would know it on Election Day.

"Alright," she said. "We need to prepare a presentation for next week's cabinet. Let's organize all of these ideas."



CHAPTER 2

Lead Authors
Neville Ash
Nicolas Lucas

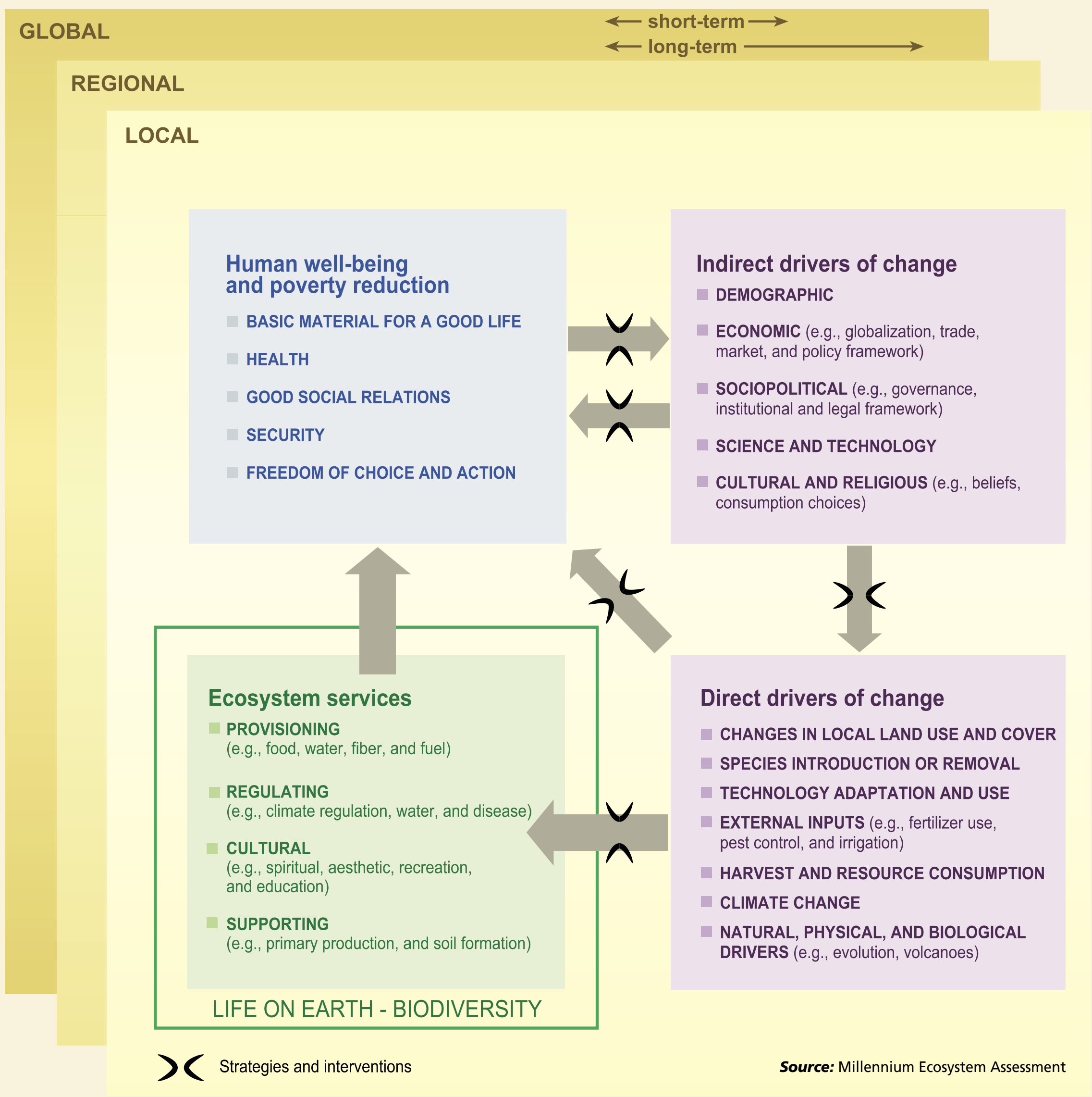
Contributing Authors
Philip Bubb
Charles Iceland
Frances Irwin
Janet Ranganathan
Ciara Raudsepp-Hearne

PHOTOS BY DIGITALVISION AND GETTY IMAGES

Framing the Link between Development and Ecosystem Services

In addition to detailing the conditions and trends of ecosystem services worldwide, the Millennium Ecosystem Assessment created a conceptual framework that is useful in taking an Ecosystem Services Approach. This chapter begins by introducing the framework and then provides guidance on using the principles of credibility and legitimacy to design effective participatory processes. It concludes with a mini case study of hydropower production in British Columbia, Canada to illustrate the application of the framework and the benefits of building effective participatory processes.

Figure 2.1 Millennium Ecosystem Assessment Conceptual Framework of Interactions Among Ecosystem Services, Human Well-being, and Drivers of Change



Source: Millennium Ecosystem Assessment

MAKE THE CONNECTIONS BETWEEN ECOSYSTEMS AND DEVELOPMENT

Decision makers as diverse as mayors, national economists, natural resource managers, and conservation planners can use the Millennium Ecosystem Assessment framework (see Figure 2.1) to explore the links between ecosystems and development, gaining a better understanding of how development goals both affect and depend on ecosystem services. Those working in the development community can start an analysis with elements of human well-being such as health or food and make the connections to ecosystem services. The environmental conservation community, on the other hand, can start with the ecosystem services and use the framework to assess the implications of conservation on development and human well-being.

Important relationships between human well-being and ecosystem services—often not initially apparent—are likely to emerge from applying the framework. While experience with using this framework is still limited, interest is growing in taking an Ecosystem Services Approach to support decision making, within government agencies and other organizations (see Box 2.1) and elsewhere.

What follows is a discussion of the elements of the framework and the relationships among them. It uses the Rio Grande story to illustrate how a decision maker can apply the framework to design more

KEY LEARNINGS

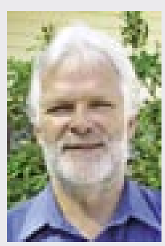
The Millennium Ecosystem Assessment framework serves as a decision-making tool for linking ecosystem and development goals.

Box 2.1 Applications of an Ecosystem Services Approach

Rick Linthurst, national program director for ecology at the U.S. Environmental Protection Agency, Office of Research and Development, is leading a major research initiative to **promote proactive decisionmaking to conserve ecosystem services to meet human needs.** This program's 200 scientists are working to quantify ecosystem services using dynamic maps, scenario building, and predictive models. This work includes assessing the suite of services associated with freshwater and coastal wetlands, assessing the effects of reactive nitrogen on ecosystem services, and four place-based studies to develop methods to implement the concept of ecosystem service districts for managing multiple services (U.S. EPA 2007a; R. Linthurst, personal communication, August 13, 2007).

Lana Robinson, in the government of Alberta, is undertaking an assessment of 20 ecosystem services in the southern region of Alberta, Canada. The effort identifies and ranks the 20 services in terms of relative importance to the region. The assessment establishes scientifically that changes in natural landscapes affect the type, quantity, and quality of ecosystem services provided. The assessment provides information on the **consequences of various land use decisions and the link between the natural landscapes and the economic health and quality of life in southern Alberta** (Government of Alberta 2007; K. Hughes-Field, personal communication, August 10, 2007).

Mary Ruckelshaus, of the U.S. National Oceanic and Atmospheric Administration's Northwest Fisheries Science Center, and her father, **William Ruckelshaus**, chair of the Puget Sound Leadership Council in Seattle, are working to develop an Ecosystem Services Approach in the Puget Sound region of Washington state. The Puget Sound Partnership, a public-private authority established by the Washington legislature with the governor's support, is developing a plan to restore the Puget Sound ecosystem. The partnership is focused on **incorporating ecosystem services information into critical public decisions and public finance opportunities** to meet the restoration goals (Puget Sound Partnership 2007; M. Ruckelshaus, personal communication, September 17,2007).



Richard Thackway, of Australia's Bureau of Rural Sciences, is leading an effort to document the ecosystem services provided by vegetation across Australia. The project identifies the national status and trends of ecosystem services and links these findings to different forms of management. The goal of the project is to inform **regional priority setting and influence investment in the maintenance, restoration, and management of vegetation** to better meet sustainable development outcomes (Commonwealth of Australia 2007; R. Thackway, personal communication, August 9, 2007).

Rodrigo Victor, of the Forestry Institute (Instituto Florestal) of the State of São Paulo, Brazil, is using an Ecosystem Services Approach in workshops and other events to **alter how people talk and think about the São Paulo City Green Belt Biosphere Reserve and the ecosystem services it provides to 23 million residents.** The group has hosted over a dozen major events since the Millennium Ecosystem Assessment was released; the approach has allowed for a shared vocabulary and understanding among diverse stakeholders, from local citizens to water basin managers (Instituto Florestal 2007; R. Victor, personal communication, March 30, 2007).

robust and sustainable strategies to achieve development goals and sustain ecosystem services.

Human well-being

The Millennium Ecosystem Assessment framework places human well-being in the upper left-hand corner to emphasize the focus on people and how ecosystems support development goals. This is where the decision maker preparing a national budget or awarding a forest or mine concession enters the framework. It is where the Mayor of Rio Grande and his goal of creating a more livable city by reducing the risk of floods and growing the economy through a new biofuels sector finds a starting point.

The framework lists five components of well-being:

- *basic material for a good life* (adequate livelihood, food, shelter, other goods);
- *health* (strength, feeling well, access to clean air and water);
- *good social relations* (social cohesion, mutual respect, ability to help others);
- *security* (personal safety, access to resources, safety from disasters); and
- *freedom of choice and action* (ability to control personal circumstances).

GETTY IMAGES

In addition to sequestering carbon from the atmosphere, ecosystems also regulate local climate by influencing local air temperature and moisture.

In the Rio Grande story, the elements of well-being leading to the goal of a livable city include security (flood protection) and health (clean water). Basic material for a good life derives from both fishers on the coast and farmers inland and from jobs at the biofuel refinery. Rio Grande must also take into account the national goal to increase production of biofuels, another element of basic material for a good life. As in this story, the elements of well-being are often intertwined.

Once a decision maker has examined the goal in relation to human well-being, the next step is to identify the ecosystem services on which reaching that goal relies and how it impacts them.

Ecosystem services

Focusing on ecosystem services allows a decision maker to view services of nature as an input into a strategy to achieve a goal, much like physical or human capital. In the Rio Grande story, it enables the Secretary of Environment to move beyond the stereotype of "protector of birds and trees" to become a key player in sustaining Rio Grande's long-term social and economic vitality.

As noted in chapter 1, increasing the ability of decision makers to understand how ecosystems provide services and to estimate their value to people and development goals underlies an Ecosystem Services Approach. The Millennium Ecosystem Assessment contributed to this understanding by evaluating 24 ecosystem services (see Table 1.2 for a summary and Table 2.1 for a detailed listing). These 24 were selected both because they have been significantly affected by recent ecosystem change and because human well-being is likely to be greatly affected as a result of their degradation or enhancement (MA 2005a:45).

Considering these 24 ecosystem services in the three categories evaluated by the Assessment—provisioning, regulating, and cultural services—extends the focus of decisions beyond the provisioning services such as crops or timber. It allows equal attention to frequently overlooked regulating and cultural services such as flood control or recreation that now lack a value in the marketplace,[1] although a growing body of research aims to facilitate the valuing of such services, as noted in chapter 3.

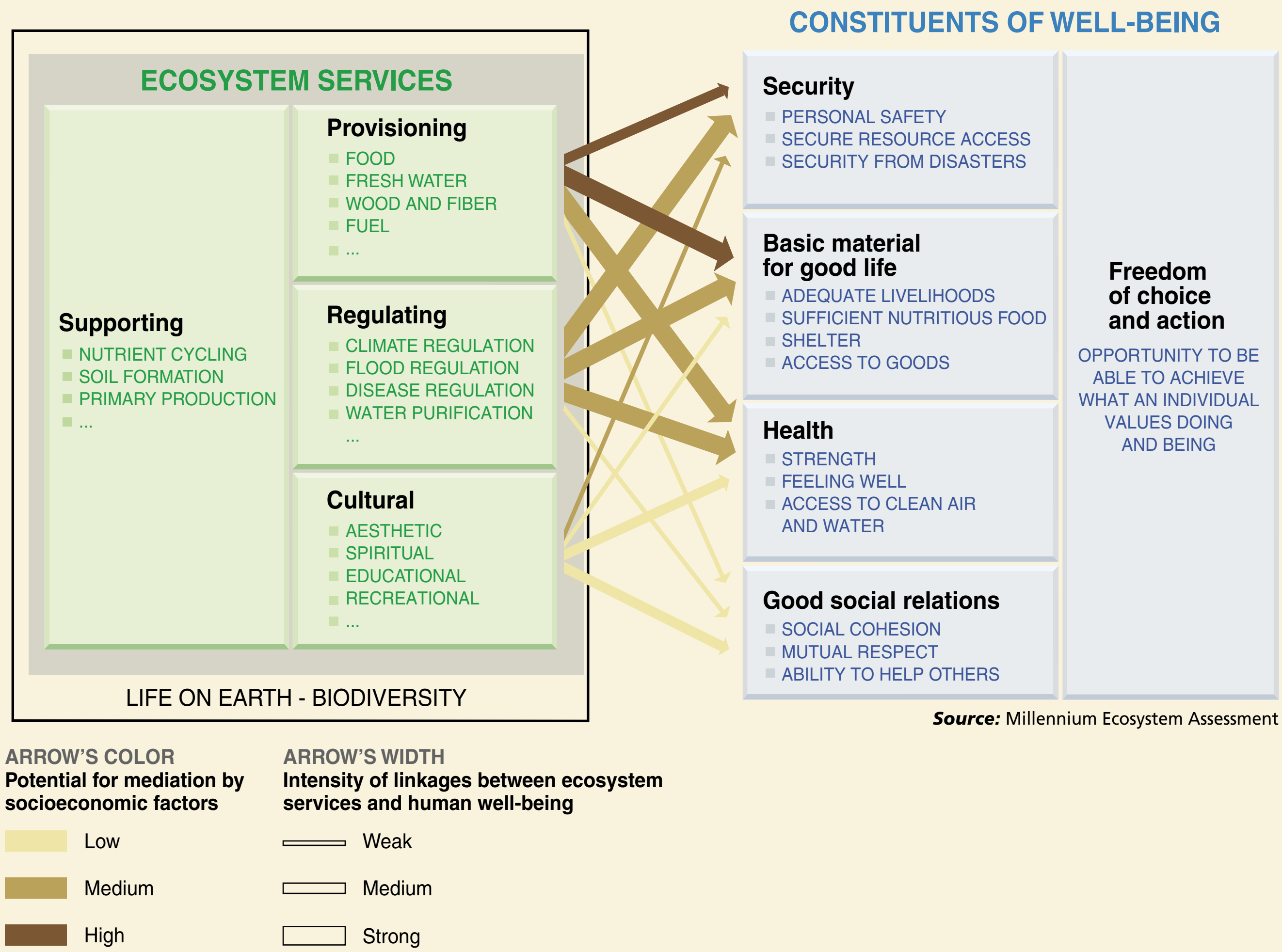
The Assessment also defined a fourth category of service: the supporting services (see Table 2.1). These are underlying processes such as formation of soil, photosynthesis, and nutrient cycling. Since, by definition, supporting services are not directly used by people, these services were not assessed.

The thinking as to whether supporting services can be incorporated into an Ecosystem Services Approach is still at an early stage. The relevance of these services is typically realized through the other ecosystem services they support. The agriculture sector, in particular, may find it valuable to consider supporting services, such as nutrient cycling and soil formation, given the direct interaction between agriculture practices and these services.

Analysis of the different types of ecosystem services can help reveal trade-offs across the services. Ecosystems are frequently altered with the intent of increasing the supply of provisioning services, as when a forest is cleared for cropland. The result is often a decrease in the capacity of these ecosystems to provide

[1]For the purpose of establishing ecosystem service accounts, other researchers have proposed definitions of ecosystem services rooted in economic principles, comparable to conventions for GDP goods and services (Boyd and Banzhaf 2006).

Figure 2.2 The Links between Ecosystem Services and Human Well-being



Source: Millennium Ecosystem Assessment

regulating and cultural services. By including the full range of services, the framework clarifies the task of managing such trade-offs. In Rio Grande, for example, the national government has set a goal to increase a provisioning service, biofuel. Yet the city is concerned about clean water and flood protection, and so weighs the costs and benefits of converting more land to crops for biofuel as well as jobs from a biofuel complex versus the opportunity to continue to employ the wetlands' regulating services of water filtration and hazard protection and their aesthetic services that support tourism.

Some of the links between ecosystem services and human well-being are stronger than others (see Figure 2.2). It is these links that policy measures seek to influence by addressing the drivers of ecosystem change. Decision makers assess how these links, which vary from place to place, play out in their locale. Development goals often focus on improving a single constituent of human well-being in isolation. The framework encourages a decision maker to take a broader look. How does the goal, for example, of improving food supply or export income, relate to other goals such as timber supply and how do those goals in turn depend on and affect ecosystem services such as flood protection and clean water? Once aware of the overlapping links to ecosystem services, a decision maker can try to develop policies that complement each other and cohere.

Ecosystem services are sometimes confused with biodiversity. Biodiversity—or life on earth, including the variability among living organisms within species, between species, and between ecosystems—is not itself an ecosystem service. Rather, biodiversity serves as the foundation for all ecosystem services. Both wild and managed ecosystems contribute to biodiversity. The value some people place on biodiversity for its own value is captured under the cultural ecosystem services of "ethical" and "existence" values. Other ecosystem services that are directly dependent on key components of biodiversity include food, genetic resources, timber, biomass fuel, and ecotourism.

The specific links between biodiversity and individual ecosystem services are profuse and varied. The Assessment found that

Box 2.2 Biodiversity and the Provision of Natural Pest Control

Increasing biodiversity in low-diversity agricultural systems can enhance natural pest control and reduce the dependency and costs associated with applying pesticides. It can also reduce the need for other inputs, such as irrigation and fertilizer associated with monocultures. There are additional benefits of high-biodiversity agriculture as well, including cultural and aesthetic values (MA 2005g:29). However, not all changes to species composition are good for agriculture. Negative impacts can result from the introduction of exotic invasive weeds or vectors of diseases as well as from crop raiding by wild animals.

species composition and population size matter more than species numbers when it comes to ecosystem services (MA 2005g). The quality of available protein and the abundance of wild foods, for example, may influence human nutrition more than species numbers. Changes in biodiversity can directly influence an ecosystem service such as natural pest control (see Box 2.2). Despite some uncertainty about the links between changes in components of biodiversity and specific ecosystem services, it is clear that the distribution and variety of biodiversity in its many forms is essential for the functioning of ecosystems and the supply of ecosystem services. Considering biodiversity can help decision makers focus on more sustainable choices when examining the relationship between ecosystem services and well-being (MA 2005g).

Direct and indirect drivers of ecosystem change

Drivers are the factors—natural or human—that cause ecosystem change. This element of the Millennium Ecosystem Assessment framework helps a decision maker organize the drivers relevant to the achievement of any given goal.

The framework includes two types of drivers, direct and indirect. *Direct drivers* are physical changes that can be identified and monitored. The Assessment lists the following examples:

- changes in local land use and land cover (land conversion, modification of river flow and water extraction);
- species introductions and removals;
- discharge of pollutants and overuse of fertilizers;
- harvest of plants and animals (and other species); and
- climate variability and change.

Indirect drivers operate by altering the level or rate of change of one or more direct drivers. The Assessment lists five indirect drivers:

- demographic (population growth and distribution);
- economic (globalization, markets);
- sociopolitical (governance and legal framework);
- science and technologies (agricultural technologies); and
- cultural and religious (choices about what and how much to consume).

Satellite images of Bolivia showing land conversion for agriculture.

A decision maker can influence some drivers, but at the same time other drivers may be affecting the condition of the ecosystem services of concern. Which drivers decision makers can influence often depends on the government level at which they work. Knowledge and influence over some drivers likely rests with other levels of government or groups. For example, individual farmers decide how much fertilizer to use (a direct driver of ecosystem change), while a finance minister might influence the global prices of the farmers' commodities (an indirect driver). A careful review of the drivers reveals the partnerships that are essential to understanding and influencing the mechanisms by which ecosystems change.

For Rio Grande, indirect drivers such as global trade (economic) and changes in population growth and migration (demographic) have led to land use changes that have directly reduced the extent of wetlands, along with their filtration and water flow services. The Mayor partners with other cities and national authorities to address these issues that involve other time and spatial scales.

Spatial and temporal scales

A key feature of the Millennium Ecosystem Assessment framework is its incorporation of multiple spatial and temporal scales. Spatial scales may be local, national, regional, or global. Temporal scales consider the short term (days, weeks or months) through medium term (months to years) to long term (decades to centuries). These spatial and temporal scales apply not only to the drivers, as discussed above, but also to human well-being and ecosystem services, and the interactions among them.

Development aimed at improving human well-being can be initiated at levels from the local to the international. Most often local projects are nested in plans at the regional and/or national level and in policies at the regional/national or international level. It is the regional/national and international policies that steer change in the indirect drivers over longer periods of time. Local decisions can change a direct driver, such as land use, that influences the health of an ecosystem service such as pollination or water filtration in the shorter term.

This element of the framework can help a decision maker think through at what spatial scales the decision might most effectively be made and what temporal scales should be considered. Relevant spatial scales might coincide with political boundaries, such as districts or countries, or might better fit with more geographic boundaries, such as watersheds or forest areas that include parts of several political entities. An analysis across spatial and temporal scales is likely to identify issues lost in the usual linear framework of project decisions, thereby leading to more robust conclusions.

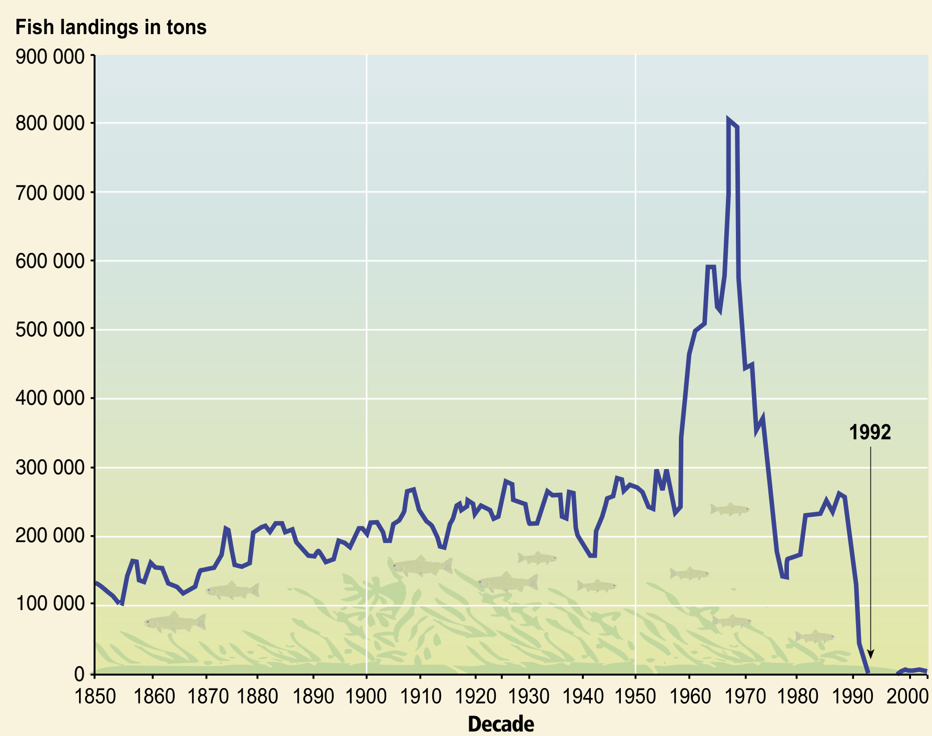
Although it is challenging to include multiple spatial and temporal scales in a decision-making process, this approach is crucial to obtaining a more complete view of the consequences of a decision on ecosystem services and, as a result, on human well-being and development goals. The approach avoids the biases of a single-scale analysis. For example, a study found that top-down global assessments of potential of technologies to reduce greenhouse gas emissions were not sensitive to local obstacles and constraints and tended to overestimate the likely reduction in emissions. In contrast, bottom-up assessments at the city or regional level tended to underestimate the potential of reductions because they were less aware of directions on technological and policy change (Kates and Wilbanks 2003; AAG 2003). Similarly, an analysis of forest policy at the national level is likely to focus on the value of timber to the national economy. It may consider flood control and water filtration. A local analysis is more likely to identify non-timber products such as nuts and the cultural value of landscape as important services. Scenarios, as discussed in chapter 4, provide a good way to explore what may happen at a range of spatial and temporal scales.

Assessments need to examine changes in ecosystem services over the long term as well as the short term because dramatic decline from which it is difficult to recover may occur as an ecosystem reaches a tipping point, or threshold, at which rapid change occurs (Scheffer et al. 2001). Collapse of a fishery is one example. Such changes can deprive people of their livelihoods or spark violent conflict over scarce resources. The North Atlantic cod fishery represents the challenges of recovery once a resource has collapsed (see Figure 2.3). Once a threshold has been crossed, restoring ecosystems to enable the supply of services can take decades or prove impossible.

BUILD EFFECTIVE PROCESSES FOR ASSESSING ECOSYSTEM SERVICES AND SELECTING POLICIES

Given the likely diversity of participants and viewpoints in development projects and policy making, it is important to build channels for effective participation. This section describes

Figure 2.3 **Fish Landings of North Atlantic Cod off Newfoundland**



Source: Millennium Ecosystem Assessment

two principles, credibility and legitimacy, to adhere to when collecting information on ecosystem services, building scenarios, and making choices about policies. Adopting these principles can broaden the types of knowledge obtained, help foster trust among participants and confidence in the information used, thus increasing the chances of achieving development goals.

Ensure credibility

Credibility refers to the extent to which information and decisions resulting from a process are considered believable and trustworthy. To ensure credibility of a scientific assessment, a decision maker looks for experts recognized for the high quality of their work or who are affiliated with highly regarded institutions (see Box 2.3).

During the past three or four decades, the process of gathering, organizing, and presenting information for decision makers has evolved using approaches ranging from environmental impact and technology assessments to scientific advisory committees and global development and scientific assessments. Increasingly, the cutting edge issues in assessment are how to include multiple time and spatial scales and multiple types of knowledge, for example, those of scientists and those of local farmers or fishers (Reid et al. 2006).

Addressing a range of scales and using different types of knowledge are particularly important for the credibility of assessments of ecosystem services because both ecosystem change and responses vary by scale. Recognizing from the experience of participants that a more systematic approach to the intersection of multiple scales and knowledge systems is needed, the Millennium Ecosystem Assessment organized a conference on Bridging Scales and Knowledge Systems.

The case studies and analysis presented at the conference draw out the obstacles to building bridges. For example, efforts to bridging knowledge systems lack a "common 'language'" and "an agreed set of assumptions about how the world works" and "absence of a common means of verifying the veracity of knowledge." Among the many barriers to crossing scales are the lack of data and understanding of interactions across scales. The analysis points to long-term joint problem solving in which local people and scientists operate as equals as one approach to bridging knowledge systems. Scenario-building is another tool (Reid et al. 2006).

KEY LEARNINGS

Building legitimacy and credibility into the process of decision making on ecosystems and development is key.

Box 2.3 The Authority of Scientific Consensus

Authoritativeness has its strongest expression in expert consensus, that is, in the general agreement among scientists or technical experts on a set of statements or findings. Although consensus among experts is rare, once established it carries the weight of truth. Consensus was the strategy adopted by the Intergovernmental Panel on Climate Change and the Millennium Ecosystem Assessment.

By engaging experts from various disciplines and reviewing virtually all relevant scientific literature, these processes can reach an authoritative consensus. The process of generating information and the language used to convey a rigorous treatment of the issues is also important, particularly the treatment of uncertainty. Because uncertainty is the norm in complex systems like ecosystems, the technical team should explicitly state the level of confidence members have in the information produced as a way of strengthening its credibility.

A sound conceptual framework, appropriate research methods, and compliance with widely accepted procedures, especially peer review, are pre-requisites for scientific credibility. The tension between the role of experts and the practical needs of decision makers is visible when the discussion moves from hard facts to policy analysis and selection. At these junctures decision makers and experts need to remember that the role of the technical team is to deliver information, not decisions or policy recommendations. In other words, the technical team must provide information that is policy relevant, not policy prescriptive, lest its credibility and its legitimacy be eroded.

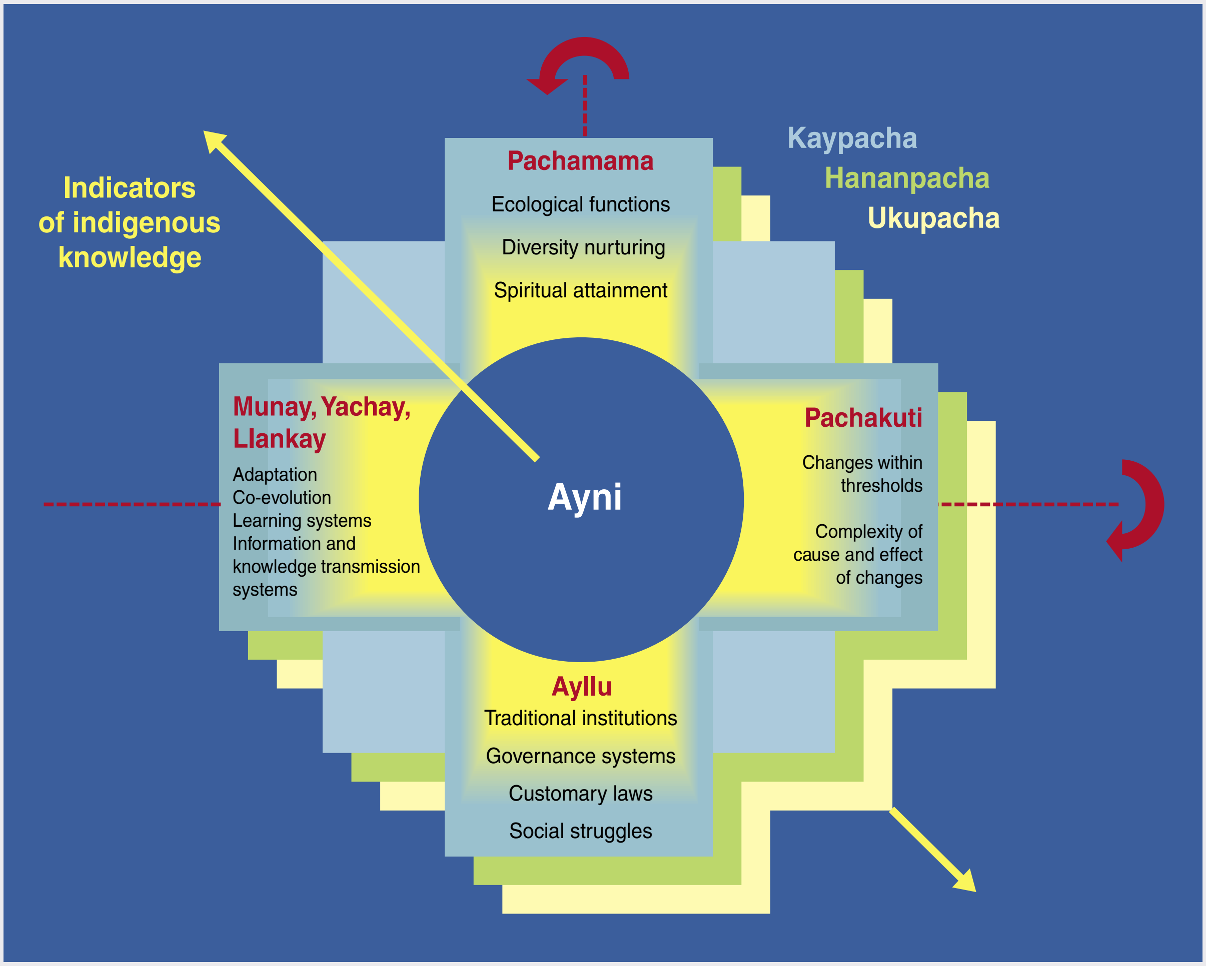
Establish legitimacy

Legitimacy refers to the fairness of a process, and how values, concerns, and perspectives of diverse stakeholders are treated. If participants view a process as legitimate, they are more likely to invest in it and accept its findings or conclusions.

Processes involving diverse stakeholders need to be sensitive to different cultures, languages, and time frames. In some cases, community organizations or indigenous groups may prefer to develop a framework for organizing assessment information based on their own beliefs and knowledge (see Box 2.4). In other cases potential participants may clearly understand the relevance and utility of a decision but still opt to stay away from the decision-making process. Or they may feel they do not have the capacity to participate or prefer to be a spectator. In terms of inclusivity, it is important to understand why users relate to a process as they do—what is their capacity to participate, or what are their political motives for disengagement—and then to adjust the engagement strategy accordingly.

Box 2.4 **Engaging Local Communities in the Assessment of Ecosystem Services**

An assessment of ecosystem services in the Vilcanota region of Peru used a framework recreated by the community to reflect Quechua culture. The cross shape of the framework represents the "Chakana," the most familiar and revered shape to Quechua people, which frames the world through intentional group decision making that emphasizes reciprocity. Using a framework the villagers developed, rather than translating the framework prepared by the Millennium Ecosystem Assessment, allowed them to carry out the assessment of their soil and water quality and how these services relate to food production using their own concepts and local knowledge. A key concept, for example, is the cyclical process of change, a concept that they can use to make changes based on their assessment (MA 2005e:12).



APPLY THE FRAMEWORK AND PRINCIPLES: A MINI CASE STUDY

Because the Millennium Ecosystem Assessment framework is only a few years old, examples of its use are still rare. This section looks at a water use planning process in the Canadian province of British Columbia that started in 1998 and encompassed many of the concepts discussed in this chapter. It also notes the results of a 2007 partnership by BC Hydro with the World Resources Institute, World Business Council for Sustainable Development, and Meridian Institute that explicitly used an approach based on the framework in road testing a method for linking ecosystem services with corporate decision making.

BC Hydro, a state-controlled company in Canada, depends on provincial watersheds to provide water flows for its hydroelectric facilities, which generate electricity for 1.7 million customers. Faced with the challenge of meeting several conflicting water use objectives, including recreation, fishing, and conservation as well as hydropower production, the province of British Columbia formally initiated a water use planning program in 1998 in an effort to reach broad agreement among diverse users of the province's water resources. This participatory process involved BC Hydro, several agencies, and members of the public and can be dissected in terms of the framework's elements.

Human well-being

The use of water for production and hydroelectricity contributes to human well-being by providing heating, cooling, and energy for residential and industrial use and by supporting jobs as well as other benefits. The water use planning process sought to balance other competing uses of water that contribute to well-being: domestic water supply, fish and wildlife, recreation, and heritage.

Ecosystem services

The participants helped identify the ecosystem services that BC Hydro's operations affect. These include recreation and tourism (including cultural heritage sites), flood control, fisheries, and freshwater supply. While the initial process focused on *impacts*, BC Hydro's subsequent work with the World Resources Institute identified *dependencies of* the company's operations on ecosystem services. These include freshwater, water regulation (quantity and timing of water flows), and to a lesser extent erosion regulation (soil retention).

Direct and indirect drivers of ecosystem change

Drivers of ecosystem change identified by the ecosystem services review included climate change (affecting water supply and timing of flows); land use change (expanding agriculture increases water demand); and demographic change (growing population increases water demand).

Spatial and temporal scales

British Columbia is experiencing several changes that could have a profound effect on BC Hydro's future operations. These include climate change (glacier retreat and reduced snow pack and possible changes in precipitation patterns); industrial activities such as timber harvesting and ecosystem disturbances such as mountain pine beetle outbreaks that may increase water flow to the catchment area; and increases in water demand due to population growth and agricultural expansion in areas where water supply is expected to decrease.

By examining company operations within a larger spatial and temporal context, BC Hydro is better positioned to pursue effective adaptive management strategies to maintain future options and support emerging economic opportunities for communities and First Nations. In addition, BC Hydro may benefit from agreements for the provision of mutually beneficial services such as flood control.

Effective participatory processes

Before 1998, BC Hydro found itself at odds with others who relied on the waterways of British Columbia for fishing, recreation, spiritual and culture values, and as a source of freshwater. In response to growing tensions among users, the province formally initiated a water use planning program to define suitable operating parameters that would balance environmental, social, and economic values.

The program took a participatory approach and included users of the various ecosystem services in the watershed, including the First Nations, environmental organizations, Fisheries and Oceans Canada, British Columbia government, and communities surrounding the hydroelectric facilities. Including all these users helped identify the major impacts on ecosystems and the services they provide. The process was also successful in securing broad agreement on the ultimate recommendations of the consultative committees.

More recently, BC Hydro's corporate ecosystem services work with the World Resources Institute highlighted the need for BC Hydro to take into account changes in ecosystem services occurring at broader temporal and spatial scales as a result of climate change. Overall, the framework was particularly useful in highlighting ecosystem service dependencies and extending the analysis to other scales.

The framework and principles of credibility and legitimacy discussed in this chapter can be used to help organize an assessment of ecosystem services (chapter 3); to examine future pathways, or scenarios (chapter 4); and to choose polices for safeguarding ecosystem services that underlie development goals (chapter 5).

ACTION POINTS

- Map the links between human well-being and the ecosystem services needed to achieve the goal.
- Identify the scale at which actions need to be taken to address drivers of ecosystem degradation.
- Use results of scale analysis to identify stakeholders.
- Establish credibility and legitimacy as core principles when designing participatory processes for assessing ecosystem services, exploring future scenarios, and selecting policies.

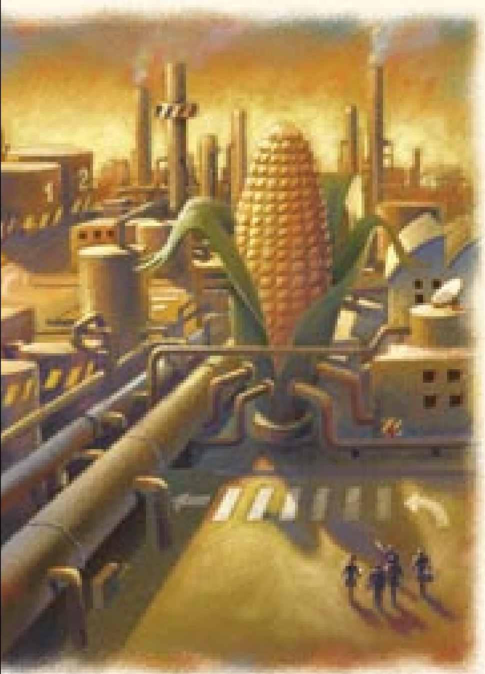
Table 2.1 List of Ecosystem Services

Service	Sub-category	Definition	Examples
Provisioning services - the goods or products obtained from ecosystems			
Food	Crops	Cultivated plants or agricultural produce which are harvested by people for human or animal consumption	• Grains • Vegetables • Fruits
	Livestock	Animals raised for domestic or commercial consumption or use	• Chicken • Pigs • Cattle
	Capture fisheries	Wild fish captured through trawling and other non-farming methods	• Cod • Shrimp • Tuna
	Aquaculture	Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for purposes of harvesting	• Clams • Oysters • Salmon
	Wild foods	Edible plant and animal species gathered or captured in the wild	• Fruits and nuts • Fungi • Bushmeat
Fiber	Timber and wood fibers	Products made from trees harvested from natural forest ecosystems, plantations, or non-forested lands	• Industrial roundwood • Wood pulp • Paper
	Other fibers (e.g., cotton, hemp, silk)	Non-wood and non-fuel based fibers extracted from the natural environment for a variety of uses	• Textiles (clothing, linen, accessories) • Cordage (twine, rope)
Biomass fuel		Biological material derived from living or recently living organisms – both plant and animal – that serves as a source of energy	• Fuelwood • Grain for ethanol production • Dung
Freshwater		Inland bodies of water, groundwater, rainwater, and surface waters for household, industrial, and agricultural uses	• Freshwater for drinking, cleaning, cooling, industrial processes, electricity generation, or mode of transportation
Genetic resources		Genes and genetic information used for animal breeding, plant improvement, and biotechnology	• Genes used to increase crop resistance
Biochemicals, natural medicines, and pharmaceuticals		Medicines, biocides, food additives, and other biological materials derived from ecosystems for commercial or domestic use	• Echinacea, ginseng, garlic • Paclitaxel as basis for cancer drugs • Tree extracts used for pest control
Regulating services - the benefits obtained from an ecosystem's control of natural processes			
Air quality regulation		Influence ecosystems have on air quality by emitting chemicals to the atmosphere (i.e., serving as a "source") or extracting chemicals from the atmosphere (i.e., serving as a "sink")	• Lakes serve as a sink for industrial emissions of sulfur compounds • Vegetation fires emit particulates, ground-level ozone, and volatile organic compounds
Climate regulation	Global	Influence ecosystems have on the global climate by emitting greenhouse gases or aerosols to the atmosphere or by absorbing greenhouse gases or aerosols from the atmosphere	• Forests capture and store carbon dioxide • Cattle and rice paddies emit methane
	Regional and local	Influence ecosystems have on local or regional temperature, precipitation and other climatic factors	• Forests can impact regional rainfall levels

Table 2.1 List of Ecosystem Services (continued)

Service	Definition	Examples
Regulating services - the benefits obtained from the regulation of ecosystem processes (continued)		
Water regulation	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge, particularly in terms of the water storage potential of the ecosystem or landscape	• Permeable soil facilitates aquifer recharge • River floodplains and wetlands retain water, which can decrease flooding during runoff peaks, reducing need for engineered flood control infrastructure
Erosion regulation	Role vegetative cover plays in soil retention	• Vegetation such as grass and trees prevents soil loss and siltation of water ways due to wind and rain. • Forests on slopes hold soil in place thereby preventing landslides
Water purification and waste treatment	Role ecosystems play in the filtration and decomposition of organic wastes and pollutants in water; assimilation and detoxification of compounds through soil and subsoil processes	• Wetlands remove harmful pollutants from water by trapping metals and organic materials • Soil microbes degrade organic waste rendering it less harmful
Disease regulation	Influence that ecosystems have on the incidence and abundance of human pathogens	• Some intact forests reduce occurrence of standing water, a breeding area for mosquitoes, which can reduce the prevalence of malaria
Pest regulation	Influence ecosystems have on the prevalence of crop and livestock pests and diseases	• Predators from nearby forest, such as bats, toads, snakes, consume crop pests
Pollination	Animal-assisted pollen transfer between plants, without which many plants cannot reproduce	• Bees from nearby forests pollinate crops
Natural hazard regulation	Capacity for ecosystems to reduce the damage caused by natural disasters such as hurricanes and tsunamis and to maintain natural fire frequency and intensity	• Mangrove forests and coral reefs protect coastlines from storm surges • Biological decomposition processes reduce potential fuel for wildfire
Cultural services - the nonmaterial benefits people obtain from ecosystem services		
Ethical values	Spiritual, religious, aesthetic, intrinsic or other values people attach to ecosystems, landscapes, or species	• Spiritual fulfillment derived from sacred lands and rivers
Existence values	The value that individuals place on knowing that a resource exists, even if they never use that resource.	• Belief that all species are worth protecting regardless of their utility to human beings – biodiversity for biodiversity's sake
Recreation and ecotourism	Recreational pleasure people derive from natural or cultivated ecosystems	• Hiking, camping and bird watching • Going on safari
Supporting services - the underlying processes that are necessary for the production of all other ecosystem services		
Nutrient cycling	Process by which nutrients – such as phosphorus, sulfur and nitrogen – are extracted from their mineral, aquatic, or atmospheric sources or recycle from their organic forms and ultimately return to the atmosphere, water, or soil	
Soil formation	Process by which organic material is decomposed to form soil	
Primary production	Formation of biological material through assimilation or accumulation of energy and nutrients by organisms	
Photosynthesis	Process by which carbon dioxide, water, and sunlight combine to form sugar and oxygen	
Water cycling	Flow of water through ecosystems in its solid, liquid, or gaseous forms	

Source: Adapted from Millennium Ecosystem Assessment



Where the Secretary tries to explain ecosystem services at a cabinet meeting and a process is created

The last time she had been asked to speak to the cabinet was to describe the campaign "One child, one book, one tree," a program designed to link education with tree planting in the city. That was how most of the other secretaries perceived the Secretary of Environment: birds and trees. She had an especially hard time with the Secretary of Public Works. With the indirect support of NGOs, she had recently managed to shift environmental impact assessments from his area to hers, which put them at odds every time infrastructure was developed. An old-fashioned engineer, he thought the "environment" was a fad, and just did not believe that people and ecosystems depend on each other. It is hard for someone to understand something when his job depends on not understanding it--she thought the saying applied very well to him. Public works were the single largest item in the municipal budget, and the larger the works, the larger the opportunity for corruption.

This time the Secretary of Environment had a better chance to be heard. The flood control infrastructure had failed miserably last month, and the Mayor was worried about the public reaction to the floods

She unfolded a map of the region. "We need to prepare for a cholera and diarrhea epidemic in the poorer quarters," she began with a calm voice. "The water purification plant will have to be upgraded soon. We should forget about ecotourism and prepare to face a protest by fishermen and NGOs over water quality."

She then moved to the big picture. "Our region is no longer what it was 20 years ago. Population, the economy, croplands, and water consumption have all more than doubled, and we are experiencing a serious transformation of our ecosystems. Last month's floods might very well be related to a combination of increasing precipitation and deforestation upstream, in the rural municipalities of Springfield and Segura. The rains were unusually hard, but if that 50 percent of the forest now gone had been there, the consequences would have been less severe. If deforestation continues and the forest is replaced with maize or sugar cane for a biofuel project, things will only get worse for us: more forced migration, dirtier water, a less predictable water flow, depletion of fisheries in the delta, less tourism, higher incidence of diseases. This is a good moment to start integrating ecosystem services into our development planning."

It took her less than ten minutes, and she knew she had got the message across because of the silence, and because the first one to speak was the Secretary of Public Works.

"So you are suggesting we just forego the largest investment ever for the sake of trees... Do you have any idea how much the biofuel project means to our economy?"

"I'm suggesting we put people first and make sure the largest investment is not also the largest mistake. Do you know how much the biofuel project will cost our economy? Right now the basin provides us with relatively clean water, good fish production, a very attractive tourist destination, and much more. All of this has a value that we are not accounting for."

"Tourism and fishing do not add up to the benefits of the factory."

"How do you know? Also, remember that the NGOs will make sure the biofuel complex ends up being much more expensive. Remember how they managed to cancel the fish processing factory project? Not to mention the new environmental guidelines that the financial community is developing."

"If the complex is not built here it will be built a few kilometers to the east," said the Secretary of Planning, "and the pressure from demand for fuel crops on our region will be just the same. We'll just export the crops without the benefit of industrial development."

"Without rational planning we will soon have to choose between biofuel and clean water, protection against natural hazards, tourism, fishing and health. This is not about the biofuel complex, but about managing ecosystem services for the well-being of the city," said the Secretary of Environment.

The Mayor was intrigued but a little foggy. "What do you mean by ecosystem services?" he asked.

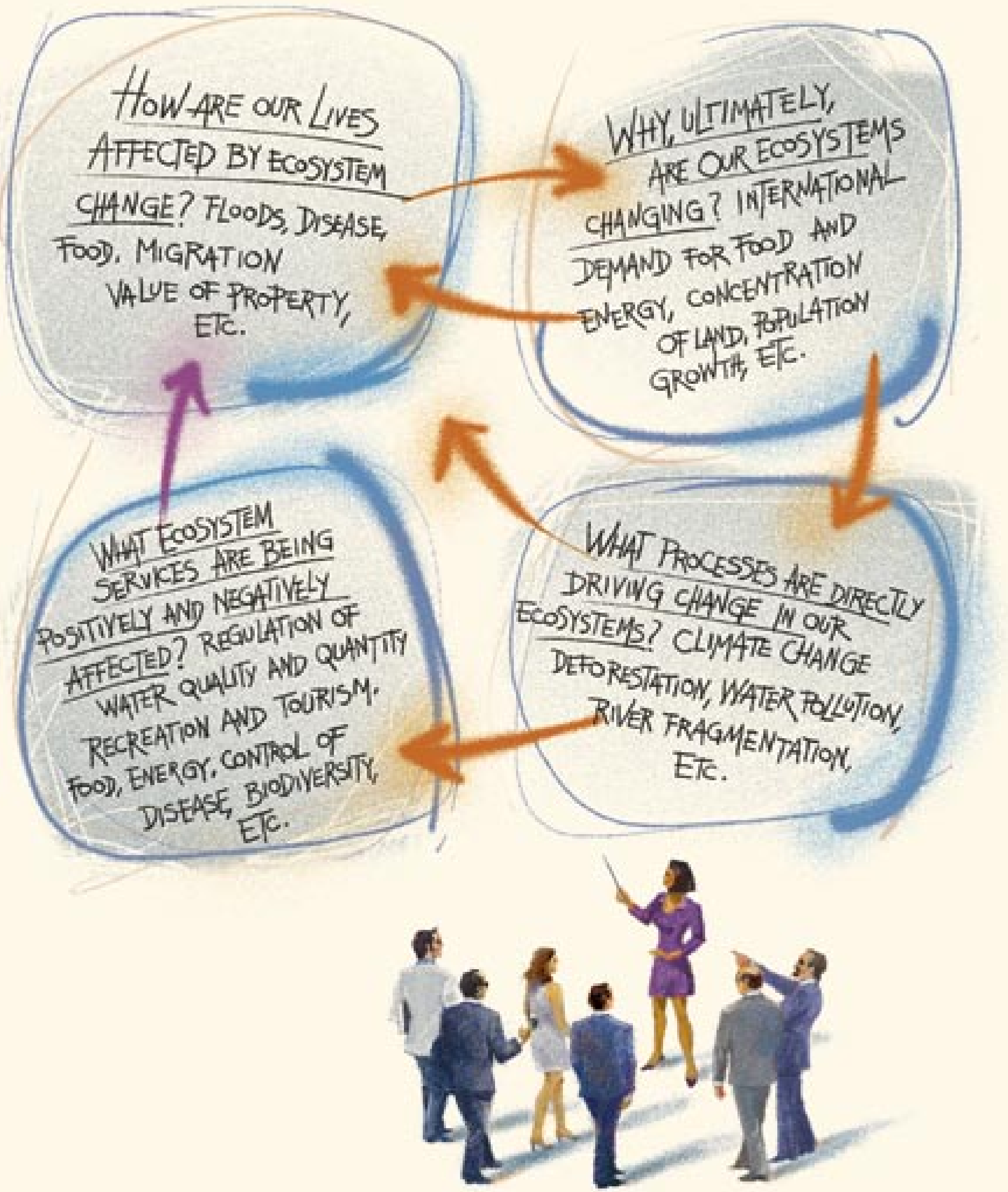
"Ecosystem 'services' are the benefits that nature provides to society. We are amazingly blind to how important well-functioning ecosystems are to our well-being and the impact we are having on these 'life support systems'. Look," the Secretary started drawing a diagram.

"Interesting, but this is all theory. I've never seen 'biodiversity' on any spread sheet," the Mayor said.

"I suggest we gather information about ecosystem services in our region and organize it around some key policy questions before we make any further big development decisions," concluded the Secretary.

The Secretaries of Public Works and Planning were not convinced, but they could not find an argument to oppose the idea of conducting a study. But the Mayor liked the prospect of having a clearer picture of what was happening in his city.

"Can you produce that information over the next eight months? I'd like to have it before the election campaign begins in the fall."



Since the flood, environmental NGOs had been in the news more than ever. Journalists had been seeking them out to explain the phenomenon and predict the future and they had obliged, telling stories about changing climate, rising sea levels, eroded soils, and vanishing forests. To top it off, the information about the biofuel complex had been filtered to them, and they were up in arms against it. They had joined forces with local fishermen, with whom they had built an uneasy relation when the conflict over the zoning of the coastal wetland and the struggle against the fish processing plant. NGOs in Springfield, Segura, and even abroad, concerned about the forest and the wetlands, were joining the chorus of critics.

"Jobs? It's all automated now. The refinery will employ no more than 100 people, and the senior staff will come from overseas," a leading NGO staffer said on the evening news. And she added: "Environmentally friendly? Biofuel is a disgrace. It will only foster more monoculture, further displacing small farmers and devastating the forest. Which means more floods like last month's will occur. Our wetlands will be degraded. And food prices will go up as the land is used to produce fuel for export instead of foodstuff. In the end we will be left as poor and poisoned as ever. We will bring this case before the international community. And we are not ruling out direct action."

The Mayor was used to environmental conflicts, mostly "not in my backyard" situations. But this seemed different. It wasn't about the location of a factory, but about the factory itself. Somehow the biofuel project and the floods had all got mixed up. He could not understand why environmentalists would oppose biofuel. He had been assured this was a "green" industry. But what could he do? The national biofuel development goal was forcing on his city new processes, few of which he controlled. The Secretary of Planning was right: here or there, in the end the complex would be built and the demand for biofuel crops increase. But what seemed a simple decision was now looking too complicated. Perhaps the Secretary of Environment was right and the environment had become a strategic issue? On the other hand he could not help suspecting that she was the one who leaked the information about the biofuel complex. That environmental report better be very good, he thought as he dialed her number.

"Did you see the evening news? How is that report coming?," asked the Mayor.

"We have a design ready," the Secretary reported. "We've been holding informal meetings with stakeholders...."

"Hold it," he cut her short. "What do you mean?"

"The information we are gathering goes beyond the potential impact of the biofuel refineries. We are going to take a picture of our region to understand the various factors at play. Everybody knows about the biofuel plan, and everybody is worried about the floods and drinking water. Whatever decision you make, you need to show that its part of a plan based not only on good, technical information, but also on legitimate information. So we will form a high level Steering Committee to be on top of the technical work that will involve us, the private sector, NGOs, the fishing communities, the Church, and the Research Institute. We will also invite national authorities as observers."

"There is no way the NGOs would accept my invitation. Besides, they will only use the opportunity to oppose us."

"Remember that the issue of the refineries will be put in the broader context of the regional environment, and this will be strictly an information-gathering exercise. No decisions will be made. And the private sector will be there, too. Besides, you won't be the one to invite the NGOs. The Research Institute will. We'll ask the Dean to co-chair the Committee with you. The NGOs trust him just as business trusts you. The Bishop has agreed to participate, too, which helps with fishermen. The Committee will be such that no one will be able to question its legitimacy."

The Mayor was uneasy. Such exposure was risky, especially if he would not be controlling the outcome of the process. But it had a big potential payoff, too, especially if the presence of national authorities projected this to the whole country. He could already picture the headlines: An example for the nation: Mayor, Bishop, Dean together for Rio Grande.

"OK. What else?" he asked.

"We are now after the best scientist in town to have him lead the technical team. We want the report to be very credible and prevent technical criticism. The Dean is helping recruit him, but the Professor is a bit reluctant. Says that this is a lot of work and he'd have to neglect a large research project on the biology of clams he is conducting for the University of Mount Pleasant in Canada..."

"Clams?" interrupted the Mayor. "When are these people going to produce something that's actually useful?"

"You have to understand that the clam project is the main source of funding for his team, and we have to admit that no government department ever contributes to their work. I told him that we will come up with the money for this, but we want to be cautious about our funding sources. We cannot have the World Bank fund this with all the rumors that they will finance the biofuel complex."

In the end, the Professor did come around. He saw this as an opportunity to experiment with one of those fancy integrated assessments he had read about in academic journals, as well as to raise the profile of the Institute and help fund his other research activities. But he made it clear to the Dean that he would quit if he felt politics started to creep into the technical work. The Dean reassured him: "The Steering Committee is meant to define what information is needed for decision making, so you will have to keep a dialogue with them to make sure your work is relevant and is actually put to use. But I'll be co-chairing it and will make sure that no political agendas are forced onto your team. We'll keep the policy and technical processes separate but well communicated."

"Thank you for coming," began the Mayor.

There he was, co-chairing with the Dean the first meeting of the Steering Committee. Attendance was perfect: the Bishop, the leader of the fishing cooperative, the head of the chamber of industry, the vice president of the main timber company, the agricultural association spokesperson, two NGOs, and a representative of the national Ministry of Natural Resources. The Professor and his team were there, too. And the press. The national government had refused to involve the Ministry of Planning as the Mayor had hoped. But the gathering was locally very strong.

The meeting was never going to be an easy one, but the Secretary of Environment had done a very good job talking with each sector before this first meeting. Everyone knew exactly what they were there for: to define the goal and steps of an ecosystem assessment of Rio Grande.

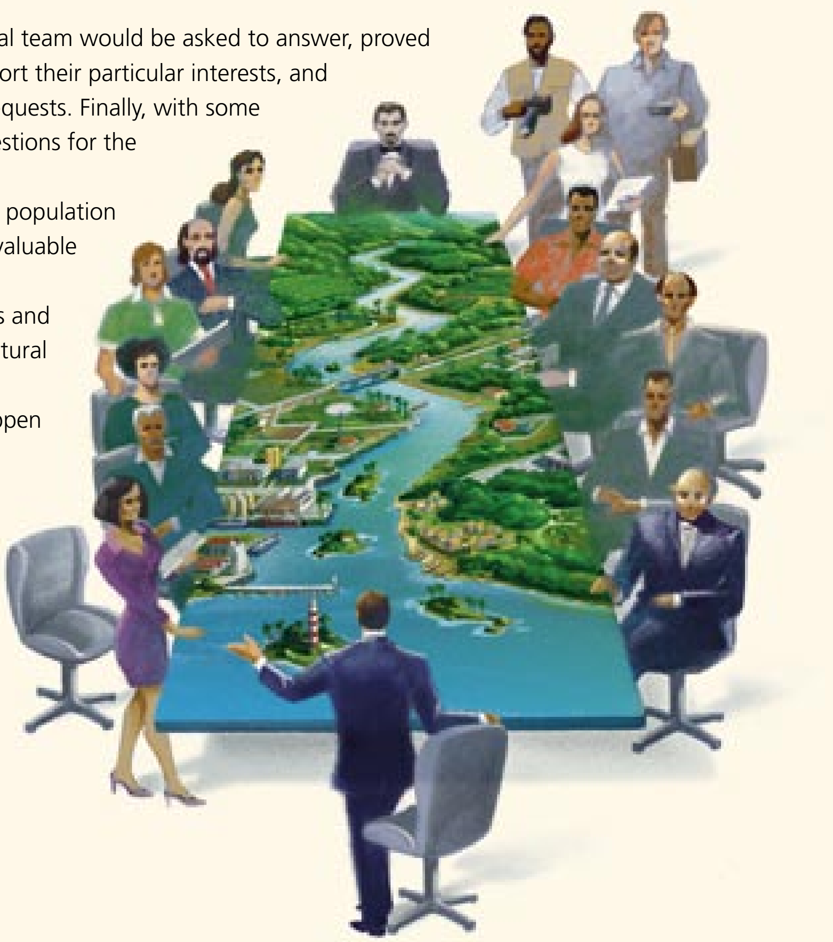
The steps were easy enough to agree on: the Committee would meet once every month and consider reports by the technical team; the reports would be considered final once the Committee had expressed its satisfaction with them.

Agreeing on the goal, the set of questions that the technical team would be asked to answer, proved much harder. Everyone wanted a formulation that would support their particular interests, and the Professor kept raising concerns about the viability of the requests. Finally, with some skillful chairing of the meeting, they agreed on three basic questions for the scientists:

- What are the key services that ecosystems provide to the population of Rio Grande, who benefits most from them, and how valuable are they?
- What is the current condition of these ecosystem services and what are the main processes affecting them? Will agricultural expansion put these services at risk?
- If the region keeps growing as expected, what would happen to these ecosystem services in the next 30 years?

"This report will be a blueprint for the sustainable development of this city," said an enthusiastic NGO towards the end, providing the Dean with an opportunity he was waiting for.

"I'm afraid that's the one thing the report will not be. We will just provide the information, to the extent it exists. It will then be up to each of you to decide what to do with it," the Dean said.



CHAPTER 3

Lead Authors

Ciara Raudsepp-Hearne
Janet Ranganathan

Contributing Authors

Neville Ash
Elena Bennett
Lauretta Burke
Emily Cooper
Craig Hanson
Charles Iceland

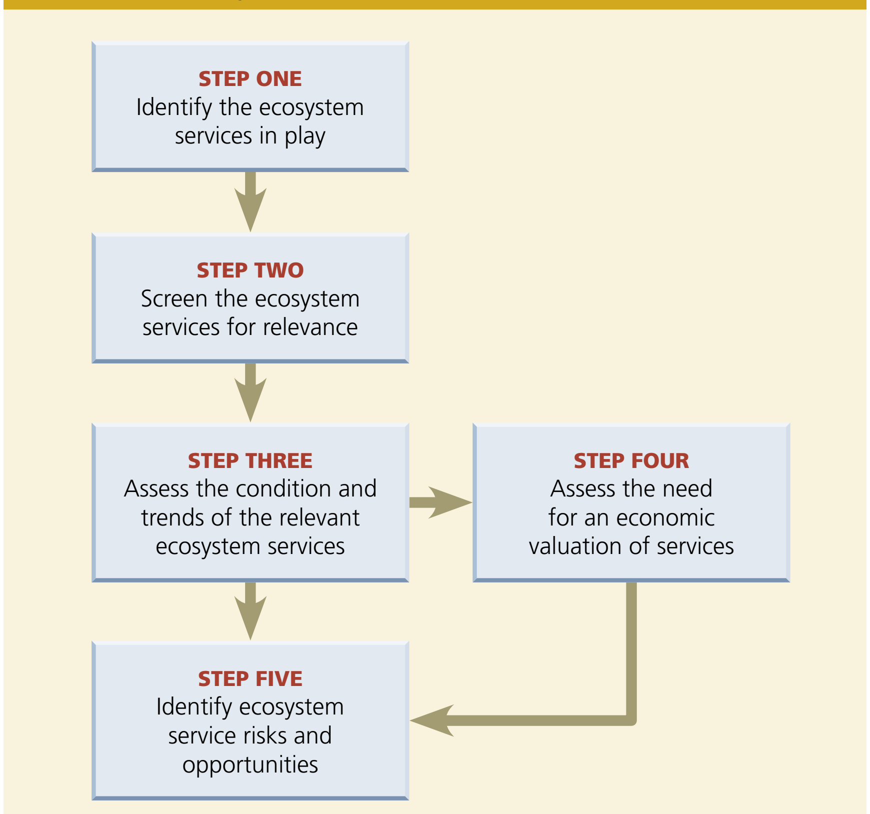
PHOTOS BY GETTY IMAGES

Assessing Risks and Opportunities Related to Ecosystem Services[1]

Information on ecosystem services can strengthen a variety of decision-making processes, from creating a public health policy; to preparing a local, regional, or national economic plan; or siting a road. The process presented in this chapter can help a decision maker focus on those services considered most likely to be sources of risk or opportunity to a specific decision (the term "decision" is used throughout this chapter as shorthand for a policy, plan, or project). Although the emphasis here is on a single decision, in reality decision makers, like the mayor of Rio Grande, are juggling a variety of decisions that interact with ecosystems.

This chapter is organized around five steps (see Figure 3.1). The steps entail collecting information on the various elements of the ecosystem services framework outlined earlier in Figure 2.1. Although presented sequentially, in practice it will be necessary to move back and forth among the steps as the information collection evolves. The resulting analysis will help identify and anticipate the ecosystem service–related risks and opportunities associated with a decision.

Figure 3.1 **Overview of Steps in Assessing Risks and Opportunities Related to Ecosystem Services**



STEP ONE: IDENTIFY THE ECOSYSTEM SERVICES IN PLAY

The first step is to identify all the ecosystem services that a decision depends on and affects. It involves systematically considering for each ecosystem service whether or not the decision depends on or has an impact on the ecosystem service. Although the linkages may at first seem obvious, a systematic dependency/impact analysis increases the likelihood of uncovering unforeseen impacts (positive or negative) or dependencies related to ecosystem services. Identifying these up-front will enable decision makers to proactively manage any associated risks and opportunities.

A decision *depends* on an ecosystem service if the service serves as an input or if it enables, enhances, or influences the conditions necessary for a successful outcome in relation to the decision. For example, housing and office development often depend on timber inputs; agribusiness depends on crops, pollination services, and fresh water; and tourism depends on recreational and other cultural services as well as flood protection and fresh water.

A decision *affects* an ecosystem service if actions associated with the decision alter the quantity or quality of a service. For example, intensive agriculture can deplete the supply of fresh water while enhancing the supply of crops or livestock; a mining operation may affect the quality of a location's cultural services by degrading the landscape or disturbing an ecosystem valued by indigenous people, hikers or campers; and the loss of wetlands may affect the timing and quantity of water runoff and aquifer recharge.

To identify ecosystem service dependencies and impacts, start with the list of ecosystem services in Table 2.1 (chapter 2). Use the list of common services by ecosystem type to help inform whether an ecosystem service might exist in a particular location (see Table 3.1). (The drivers will be discussed later in relation to identifying ecosystem service impacts.) In a systematic fashion, consider whether or not the decision depends on or affects each relevant service in Table 2.1.

Be sure to include the indirect affects of development. Roads or electric cable poles

[1] This chapter draws on WRI's experience road testing a method for assessing a company's dependence and impact on ecosystem services.

Table 3.1 Common Ecosystem Services and Drivers by Ecosystem Type

Ecosystem	Ecosystem services	Drivers of ecosystem change
Marine	Fish and other seafood (commercial and subsistence fisheries), ecotourism, recreation, medicinal products, climate regulation, transportation, freshwater cycling	Overfishing, destructive fishing practices, nutrient runoff and deposition, climate change, pollution (sewage discharge, oil spills, mining)
Coastal	Tourism, recreation, cultural value, fisheries (commercial and subsistence), aquaculture, transportation, nutrient cycling, storm/flood protection, climate regulation, disease regulation, waste processing, erosion control, hydropower, freshwater storage	Nutrient runoff and deposition creating dead zones, industrial and urban pollution, dredging of waterways, sediment transport from rivers, climate change, invasive species, conversion of estuaries and wetlands, destruction of estuarine fish nurseries, destruction of mangroves and coral reefs, overexploitation of fisheries, mangroves (for fuel wood), sand for construction, seaweed for consumption
Inland Water	Crops, fisheries, freshwater, storage of greenhouse gases, groundwater recharge and discharge, water for agriculture and industry, detoxification of water, flood control, recreation, tourism, cultural value, sediment retention, hydropower, nutrient cycling	Nutrient runoff, conversion of wetlands to agriculture, large-scale irrigation and river diversions, expansion of agriculture (increased fertilizer and pesticide use), overharvesting of wild resources such as fish, roads and flood control infrastructure, dams, river canalization and dredging for navigation, forest clearing, urban and industrial pollution, invasive species
Forest and Woodlands	Pollination, medicines, food, erosion control, water regulation, timber, biofuel, food, climate regulation, disease regulation, tourism, recreation, cultural value	Fires, climate change Tropics: agricultural expansion, wood extraction (commercial or subsistence), transportation infrastructure, human population dynamics Temperate: reforestation due to increasing value of amenity services and protection services, air pollution, pest outbreaks
Drylands	Soil conservation of moisture, nutrient cycling, food, fiber, biochemicals, biofuel, pollination, freshwater, water regulation, climate regulation, cultural value, tourism	Climate change, diversion of water for agriculture, salt buildup, desertification, reduction in vegetation cover, overgrazing, expansion of agriculture, population growth and migration
Island	Fisheries, freshwater, tourism, recreation, timber, fuel, cultural value, flood/storm protection	Demographic change, energy demands, invasive species, pollution, land conversion and degradation, globalization and international trade, natural hazards, climate change
Mountain	Freshwater, food, medicinal plants, natural hazard regulation, climate regulation, soil fertility, water regulation, recreation, tourism, cultural value, fuel, rangeland for animals	Climate change, natural hazards and disasters, grazing, mining, erosion, construction of infrastructure for tourism and recreation, degradation of traditional cultures, dynamics between highland and lowland populations
Polar	Climate regulation, freshwater, fisheries, game animals, fuel, fiber, cultural value, tourism, recreation	Climate change, development of extractive industries, contaminants from lower latitudes that accumulate in polar regions, over fishing, invasive species, land conversion
Cultivated	Food, fiber, fuel, pollination, nutrient cycling, soil formation, pest regulation, freshwater	Increasing demand for products, international markets and trade, policy, legal and socio-cultural context of cultivation, prices, technology and management approaches, invasive species, climate change
Urban	Ecosystem services generally consumed rather than produced. Services supplied by green spaces and parks include: air quality, microclimate regulation, noise reduction, water regulation (surface water drainage), pollination, genetic libraries, pest regulation, waste processing and recycling, cultural value, recreation, tourism (urban gardens and parks)	Overconsumption, demographic change, waste generation, water pollution, air pollution, greenhouse gas emissions, deforestation in urban areas

Source: Adapted from MA 2005b.

can increase access by third parties to previously inaccessible areas. The migration of people into previously uninhabited areas can affect ecosystem services such as freshwater, wild foods and timber.

Because ecosystem service impacts are often separated in time and space from the decision or actions that give rise to them, identifying the impacts and dependencies usually requires expanding the boundaries of the analysis to a regional or landscape level and adopting broad time frames. Clearing a forest for residential development, for example, may cause erosion and flooding 100 kilometers downstream. Applying large amounts of fertilizers on agricultural fields may result in build-up of nitrogen or phosphorus in soils, causing explosions of toxic microorganisms in nearby water bodies 10 years later. These trade-offs over time and across space may be missed if the geographic focus is too narrow or the time horizon too short.

Two resources to consult when considering ecosystem service dependencies include Table 1.1 in chapter 1, which describes examples of how development goals depend upon ecosystem services, and Figure 2.2 in chapter 2, which shows

Box 3.1 **Supplying New York City with Clean Drinking Water: Watershed Ecosystem Services versus Filtration Plant**

Approximately 9 million people in New York City and nearby areas enjoy access to clean and inexpensive drinking water from the surrounding watershed, 90% of which is drawn from sources west of the Hudson River in the Catskill Mountains and the headwaters of the Delaware River (NRC 2000). Water from this Catskill/Delaware system filters through nearly 1,600 square miles of watershed land, providing the city with an average 1.3 billion gallons of drinking water per day (Hazen and Sawyer 1997).

In the early 1990s, New York City officials had to take measures to ensure adequate drinking water for its residents in the face of a decline in water quality. They compared the cost-effectiveness of a watershed protection plan to safeguard the ecosystems' capacity to provide water filtration services versus building a filtration plant.

New York City estimated construction costs for Catskill/Delaware filtration facilities to be as much as $6 billion, with annual operating expenses of more than $300 million (NYC DEP 1993a; Paden and Shen 1995). On the other hand, protecting the watershed meant regulating land use over a sizeable territory. New York City owned only about 6 percent of the Catskill/Delaware watershed; another 20 percent was part of the New York State Catskill Forest Preserve (NRC 2000). The other three quarters of the watershed were privately owned and thus may have been the source of contaminants from agriculture and other land use activities (NRC 2000).

Under the most extreme scenario, city officials proposed to protect all developable land in the watershed by direct acquisition or conservation easements (NYC DEP 1993b:246), requiring an estimated $2.7 billion to purchase fee titles or easements on about 240,000 acres (NYC DEP 1993a; Pfeffer and Wagenet 1999). New York City eventually negotiated a combination of land acquisition and management agreements with other landholders to protect the watershed at a total cost that was far less than the estimated cost of building a filtration facility (NRC 2000). Although a filtration plant may be needed in the future, the investment in the watershed proved cost-effective at the time.

links between ecosystem services and human well-being and the relative strength of their relationship.

When identifying ecosystem service impacts, it can help to consider whether the actions associated with the decision will contribute to any of the direct or indirect drivers of ecosystem change (see Figure 2.1 in chapter 2). Drivers are the natural or human factors that cause ecosystem change (see Table 3.1). They can interact and operate at multiple scales and time frames. If the decision affects any of these drivers it will likely affect the ecosystem and its supply of services. For example, a decision can change human demand for certain services—a new international market for shellfish may create high demand for what was an underexploited ecosystem service in a certain locale. Any drivers identified here should be included in the more detailed assessment in step three below to determine their current condition and trend.

STEP TWO: SCREEN THE ECOSYSTEM SERVICES FOR RELEVANCE

The second step entails screening the ecosystem services identified in step one to determine which are most *relevant* to the decision in order to set priorities for further assessment. Given limited resources, a decision maker may not be able to assess in detail all the ecosystem services that a decision depends on and impacts. This step will also inform what geographic (spatial) and time scales to include in the decision-making process, as well as identify other users of the services that may affect or be affected by the decision.

Ecosystem service dependencies

The dependence of a decision on an ecosystem service is likely to be relevant if no *cost-effective substitute* exists for the service. Using the list of ecosystem service dependencies identified in step one, determine for each whether or not a cost-effective substitute exists. If the answer is no the service should be included in the detailed assessment in step three.

A substitute for an ecosystem service could include a manufactured product or physical structure that provides a similar service. For example, a new water filtration plant could provide the water purification services of a wetland (although it would not provide the wildlife habitat or other services of the wetland). Built sea walls could provide the natural hazard regulation (coastal protection) services of mangroves or coral reefs. Provisioning services such as crops, fish, and timber are more likely to be substitutable (since they are portable and may be imported from other locations) than are regulating and cultural services, which tend to be location specific.

If a substitute exists, it is important to also consider whether it is cost-effective relative to the ecosystem service it replaces. Maintaining an ecosystem's capacity to provide a particular service, such as retaining hedgerows in farmlands to regulate crop pests, may provide additional services and be more cost-effective than replacing it with a manufactured substitute, such as chemical pesticides.

New York City officials concluded it was more cost-effective to maintain natural ecosystem–based water purification services than to construct and operate a filtration plant (see Box 3.1). In the case of mining, companies may compensate affected communities for lost ecosystem services by providing cash handouts that enable them to obtain the lost services or purchase other goods and services not previously available. These can be improved forms of housing, piped water, high-protein foods, or medicines. However, the loss of ecosystem services may outlast the cash benefit, creating inequity over time. In addition, cash benefits are less likely to adequately replace cultural benefits, for example, of a sacred site. Economic valuation can be used to develop a more complete picture of the costs and benefits of altering ecosystem services (see section on economic valuation).

Ecosystem service impacts

A key factor in determining whether an impact on an ecosystem service is relevant is whether or not the impact limits or enhances the ability of others to use or benefit from that service. Other users or beneficiaries may be located at spatial scales ranging from local (e.g. a coastal community that benefits from the natural hazard protection service from a wetland) to global (e.g., people who derive ethical or existence value from knowing that a rare species is protected). In addition, they may be present or future users of the service. Governments and civil society, for example, often act in the interests of current or future generations. Questions to consider when assessing a decision's impact on others include:

Box 3.2 Issues to Think about When Gathering and Assessing Ecosystem Services Data

Keeping the assessment affordable

If a full-blown multi-scale participatory assessment can't be funded, a limited analysis of the selected ecosystem services can still be valuable. The analysis can be based on general knowledge and desktop research of previous studies related to the ecosystem services. International interest in ecosystem service assessment is growing. Encouraging decision makers to use information on ecosystem services will build demand for expertise in this field, encourage more funding for assessments, and increase the availability of tools and information on ecosystem services.

Deciding on boundaries

The scale at which information is collected needs to be appropriate to the decision-making needs and the scale at which ecosystem services and drivers interact. A common boundary for collecting ecological information is the regional or watershed scale, as many ecosystem services are bound through hydrological processes within a watershed. Decision makers may choose to conduct assessments at social or political scales, setting boundaries at the community, municipal, state/province, or national levels, as this is most relevant to their decision-making authority. If the political boundaries do not coincide with ecological boundaries, partnerships will need to be established to ensure policy coherence in regard to the management and use of ecosystem services.

Filling information gaps

Data on ecosystem services are usually obtained from a variety of existing sources, such as global and national data bases and free satellite imagery. However, in some cases it may be necessary to invest in new data collection where no information is available. Setting up monitoring networks, collecting information from practitioners and citizens, and involving students or interns to gather information are ways to surmount the problem of scarce data. Civic groups can encourage ecosystem monitoring by distributing cell phones and offering free connection service in return for regular reports on environmental conditions. In a local assessment in India, schoolchildren interviewed knowledgeable residents in their village and documented information on the condition and trends of ecosystem services related to local livelihoods and well-being (MA 2005e: 264).

Taking into account uncertainties

An ecosystem services assessment should adopt a consistent approach for assessing, characterizing, and reporting uncertainties about findings. Since stakeholders have different levels of risk aversion or acceptance, how an assessment was conducted should be transparent and a level of confidence should be attached to each finding. An uncertainty analysis might identify the most important factors and uncertainties that could affect a conclusion, document ranges and distributions of data related to a finding, and evaluate the state of scientific information on which a conclusion or estimate is based (MA 2005f).

- *Is the decision's impact a large share of the total local or regional impact?* A decision that results in a large impact (positive or negative) on an ecosystem service relative to other sources of impact is more likely to affect the ability of others to benefit from a service. Examples include a decision that consumes or replenishes 30 percent of the fresh water in a watershed, one that consumes or supplies 35 percent of a nation's wood fiber or one that is solely responsible for clearing or restoring native grasslands valued for biodiversity and associated cultural services. There are no hard and fast rules for defining what constitutes a "large share". Decision makers will need to use their own or expert judgment regarding the size of impact relative to the appropriate spatial scale for the ecosystem service.
- *Is the ecosystem service in short supply relative to demand?* To illustrate, a new irrigation project in a watershed with seasonal water shortages may be relevant if it precludes others from using water. Conversely, an irrigation project's impact on water may not be relevant if water availability vastly exceeds demand.
- *Could the decision's impact push the ecosystem service across a biological threshold that leads to scarcity of the service?* For an ecosystem service that is at or near a tipping point, after which rapid change occurs, a decision's marginal impact on that service may be relevant. Examples include allowing additional fishing in a region with highly depleted fish stocks that are near collapse or marginal increases in phosphorous or nitrogen loading into rivers that could lead to the creation of "dead zones" in lakes or coastal areas due to oxygen falling below a threshold.

It is important to keep in mind that different beneficiaries of ecosystem services may have very different responses to these questions. Indigenous people, for example, often place great importance on cultural services such as sacred groves and animal or plant species used in rituals. In addition, particular attention should be paid to important regulating and supporting ecosystem services, such as nutrient cycling and pollination, where impacts often go unnoticed but can build up and cause unexpected problems for different beneficiaries. In cases of uncertainty, it may make sense to err on the side of conservatism and include the service in the detailed assessment done in step three.

STEP THREE: ASSESS THE CONDITION AND TRENDS OF THE RELEVANT ECOSYSTEM SERVICES

The third step involves conducting a more detailed analysis of the condition of the ecosystem services selected in step two and their trends. The resulting information will be used in the final step to identify the ecosystem service–based risks and opportunities associated with the decision. Answering three questions can help focus the assessment:

- *What are the condition and trends of the selected ecosystem services?*

Table 3.2 Methods to Assess Ecosystem Services

Method	Description	Sample uses	Example
Remote Sensing	Data obtained from satellite sensors or aerial photographs (LANDSAT, MODIS)	Assessment of large areas, land cover/land use, biodiversity	The India sub-global assessment team tracked deforestation using satellite imagery.
Geographic Information Systems	Software that spatially maps and analyzes digitized data (ArcGIS, ArcView, IDRISI)	Analysis of temporal changes in ecosystems; overlaying social and economic information with ecosystem information; correlating trends in ecosystem services with land use change	The Southern Africa sub-global assessment used GIS to analyze where human demand for water existed and where that service is supplied.
Inventories	Lists	Tally ecosystem services and natural resources	An assessment in the Mekong wetlands of Vietnam developed an inventory of all the ecosystem services that are important in the region (to people, the economy. and ecosystem functioning).
Ecological Models	Simplified mathematical expressions that represent the complex interactions between physical, biological, and socioeconomic elements of ecosystems (SWAT, IMAGE, IMPACT, WaterGAP, EcoPath, Ecosim)	Filling gaps in existing data; quantifying the effects of management decisions on the condition of ecosystem services; projecting long-term effects of changes in ecosystem condition; assessing the effects of individual drivers and scenarios on ecosystem condition and the supply of ecosystem services; exploring the links between elements in a system	The Western China sub-global assessment used the Agroecological Zoning model to estimate the carrying capacity of land (i.e., the maximum number of individuals that can be supported by ecosystem services in a unit area assuming sustainable development). The Southern Africa sub-global assessment used the PODIUM model to assess trade-offs between food and water provisioning services.
Participatory Approaches and Expert Opinion	Information supplied by stakeholder groups, scientific experts, workshops, traditional knowledge	Collection of knowledge not available in scientific literature; fills gaps in the literature; adds new perspectives, knowledge, and values to assessment	Assessments in Norway and Portugal made use of participatory ranking and scoring for the condition and trends of ecosystem services and biodiversity.

Source: Adapted from MA 2005c.

- *What are the major drivers affecting the ecosystem services?*
- *What thresholds or irreversible changes have been observed in the ecosystem services?*

These questions can be modified or expanded depending on the nature of the decision and feedback from participants and stakeholders. Several other issues should also be considered when gathering and assessing data on ecosystem services (see Box 3.2).

What are the condition and trends of the relevant ecosystem services?

Assessing the condition and trends of the ecosystem services in the location affected by the decision will reveal how current trends affect their supply. It will reveal any associated risks and opportunities for the decision. The information can also provide a baseline for comparing future changes to the ecosystem services.

No matter what the status of environmental data in a region, some type of ecosystem service assessment is usually possible. A regional assessment for Northern Wisconsin (USA) focused on tourism, recreation, fish, and freshwater and was based largely on existing data assembled by researchers at the University of Wisconsin (Peterson et al. 2003). It also incorporated local knowledge into a set of scenarios developed by the researchers and local citizens about the future of the region. The Millennium Ecosystem Assessment used a variety of methods to assess the condition and trends of ecosystem services for its sub-global assessments (see Table 3.2).

Indicators are frequently used to measure ecosystem services (see Table 3.3), as many services are not directly measurable. Sediment loads in rivers, for example, can be used as indicators of erosion control. The number and types of fish species in an area

Table 3.3 Indicators Used to Assess the Quantity and Quality of Freshwater

Data type	Indicators and methods to obtain data
Household use	Water withdrawals from groundwater wells and surface water, rates of rainwater harvesting
Industrial use	Water withdrawals from groundwater and surface water
Agricultural use	Area under irrigation, type of crop, yields per crop, water withdrawals from groundwater and surface water, quantity of water used by livestock, crop evaporative demands
Groundwater discharge/recharge (renewable and fossil)	Scientific studies, models
Surface water flows	Water balance models, observations from gauging stations, remote sensing, long-term mean runoff
Total supply of treated water	Water withdrawals from municipalities, number of households, volume of water processed in treatment plants
Accessibility	Proximity to humans, variation of water flows over time, maximum to minimum runoff ratios, amount of water impounded by dams, desalinized water, dependent population per unit of delivered flow, water crowding index (population served per million cubic meters per year of accessible runoff)
Lost water flows	Net evaporation (from irrigation cooling towers, reservoirs)
Water-related problems	Salt buildup in soil, aquifer depletion, rising development costs, competition for water (demand v. supply of freshwater), salt water intrusion into aquifers, groundwater and surface water pollution
Environmental flows	Water requirements for ecosystem types as a percentage of mean flow
Water quality	Nitrogen and, phosphorus loads, pathogens, heavy metal and persistent organic pollution.

Source: MA 2005b.
A diversity of indicators may be available for any given service, only some of which may be relevant to decision making.

Table 3.4 Rio Grande: Ecosystem Service Dependencies, Trends, and Impact of Drivers

REPORT CARD: THE STATE OF ECOSYSTEM SERVICES IN RIO GRANDE

Ecosystem Service	How much does Rio Grande depend on the service?	Recent trend in service	Strength of impact of driver
Food - crops	High - supplied by farms in watershed and imports; agriculture important to economy	↑	High - land use change (forest conversion to agriculture) High - external inputs (fertilizers, pesticides)
Food - capture fisheries	Medium - supports local fishing population and provides fresh fish to community	↓	High - harvest and resource consumption from international trawlers High - external inputs (fertilizers, pesticides)
Fiber – energy (biofuel)	Low - will change if biofuel plant built	→	Low - technology adaptation and use
Fresh water quantity	High - demand from agriculture and growing city (quantity increasing because of rainfall but timing issue and quality degraded)	↓	High - land use change (wetland conversion to agriculture) High - external inputs (fertilizers, pesticides)
Water regulation	High - Rio Grande vulnerable to floods; precipitation increasing	↓	High - land use change (forest and wetland conversion to agriculture)
Water purification & waste treatment	High – Rio Grande's water treatment plant has limited capacity to address increases in sediments and pollution	↓	High - land use change (wetland conversion to agriculture)
Climate regulation	High – Agriculture dependent on stable climate and expanding coastal community vulnerable to storms	↓	Medium - land use change (forest conversion to agriculture) Low - climate change
Soil erosion regulation	High – waterway vulnerable to siltation	→	High - land use change (forest conversion to agriculture)
Pest regulation	High - monocultures increased vulnerability to pests	→	High - land use change (forest conversion to agriculture) Low climate change
Pollination	Medium - most crops requiring pollination, but pollinators can be introduced	→	High - land use change (forest conversion to agriculture)
Natural Hazard regulation	High – increase in coastal community population; climate change	↓	High - land use change (wetland conversion to houses and commercial property)
Recreation & ecotourism	Medium – tourism and recreation increasing in coastal area and forests	↑	High - land use change (forest conversion to agriculture)

Key:
- **Dependence** – Low, Medium, High denotes the relevance of service to Rio Grande.
- **Recent trend** – arrow denotes whether service has increased ↑, stayed the same → or decreased ↓ in the recent past.
- **Drivers** – Low, Medium, High denotes drivers impact in the recent past.

can be used as an indicator of the health of fisheries (Karr 1981). Consulting experts and stakeholders can help determine which indicators are relevant, meaningful, understandable, and measurable.

What are the major drivers already affecting the ecosystem services?

Assessing the current impact and trend of direct and indirect drivers on the ecosystem services builds on the preliminary assessment of the decision's contribution to drivers in step one, expanding it to other drivers that may be affecting the services.

The list of drivers in chapter 2 (page 18) can again help identify which, if any, drivers are affecting the supply of priority services. Each driver identified as relevant to the services should be evaluated in terms of its current trend (increasing, decreasing, or constant) and its effect on the ecosystem service. Information on drivers may be available from strategic environmental assessments, environmental impact assessments, and other local or regional assessments conducted in the focus area. Once information on the current drivers has been collected, the potential effects of the decision on these drivers can be evaluated.

In the case of Rio Grande, indirect drivers relating to the production of maize for biomass fuel might include technology (local refining technology determining the type of biomass that can be processed); subsidies (national level subsidies for biomass fuel crops); and fuel standards (state level fuel standards that mandate a biofuel/fossil fuel ratio for gasoline). The proposed biofuel refinery will increase two existing direct drivers: land use change (further conversion of forests and wetlands to cropland for biofuel) and pollutant discharges (increased runoff of pesticides and fertilizers as a result of increased crop production). These changes could exacerbate the existing decline in freshwater quality and quantity (see Table 3.4), reducing fisheries and opportunities for ecotourism and recreation.

What thresholds or irreversible changes have been observed in ecosystem services?

Ecosystem services do not always decline or improve in a linear and predictable manner. They may naturally go through cycles of collapse and renewal. Therefore, it is not as important to maintain a fixed relationship between people and ecosystems as it is for social and ecological systems to be able to adapt to and benefit from change. Incorporating information about ecosystem service change allows decision makers to distinguish between strategies that are likely to enhance resilience and those that may undermine it.

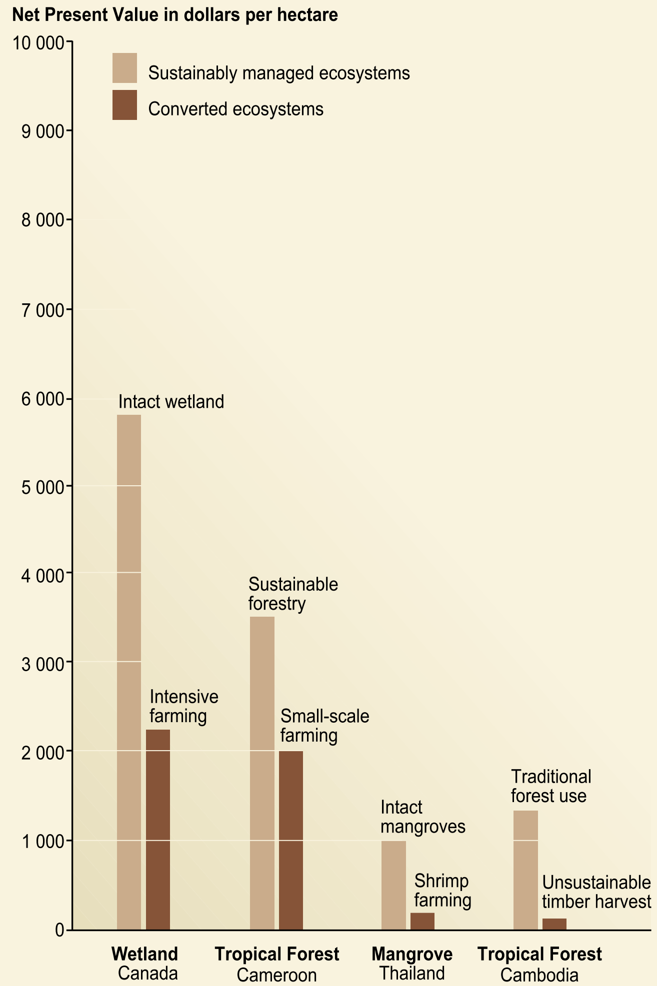
Sometimes sudden and irreversible collapses can occur when a threshold is crossed, as when fish stocks decrease below a certain level and cannot recover. The Millennium Ecosystem Assessment identified several examples of irreversible ecosystem change, including those associated with the intensification of agriculture and over exploitation of capture fisheries. After hundreds of years of exploitation of the North Atlantic cod fishery, increased fishing pressure and an inability to accurately monitor fish stocks led to the sudden collapse of cod stocks in the late 1980s, which have yet to recover, and closure of the fishery (see Figure 2.3). In the case of fisheries, constant monitoring of fish stocks and adjustment of catches is more likely to promote a resilient ecosystem than implementing a fixed allowable catch per year (Gunderson and Holling 2002).

While irreversible changes are often hard to predict, much can be learned from case studies where unpredictable change has occurred. Resilient societies and ecosystems are those that have the ability to accept and adapt to change while maintaining their basic structure, identity, and function. Developing the capability to predict ecosystem disruptions can help build resilience, allowing for timely and potentially preventative action.

STEP FOUR: ASSESS THE NEED FOR AN ECONOMIC VALUATION OF SERVICES

Economic valuation is the attempt to assign quantitative economic values to ecosystem services, including services that are at least partially captured by the market (such as provisioning and some cultural services) and those that are not currently valued in the marketplace at all (for instance, regulating services

Figure 3.2 Value of services provided by converted and sustainably managed ecosystems



Source: MA 2005a

such as coastal protection and erosion control). The resulting information can draw attention to the value of ecosystem services that might otherwise be ignored when making management decisions, and can be used to inform the identification of risks and opportunities as described in step five below.

A decision maker's goals will determine whether economic valuation is necessary; therefore, this step is optional. In some cases, it may be more important to examine health or poverty impacts of ecosystem change, as opposed to economic impacts. In other instances economic valuation can serve a number of purposes, including:

- Communicating the value of ecosystem services by highlighting their economic contributions to societal goals. For example, a study of Canada's boreal forest estimated its value in natural capital to be $93.2 billion in 2002 (Anielski and Wilson 2006). These values are useful to governments when deciding how land should be used.
- Comparing the cost-effectiveness of an investment. For example, New York City compared the cost-effectiveness of maintaining natural ecosystem-based water purification services with constructing and operating a filtration plant (see Box 3.1).
- Evaluating the impacts of development policies. This could include evaluating the ecosystem service costs associated with habitat conversion, runoff, or pollutant discharge. It could also include looking at the benefits of increased investment in enforcing environmental regulation and in strengthening resource management. A number of studies have looked at the value of ecosystems under different types of use. Some of these have found that the value of services provided by an intact ecosystem exceeds the value of a converted ecosystem by two times or more (see Figure 3.2).
- Building markets for ecosystem services. Global carbon markets and payment for ecosystem service initiatives such as the Costa Rican scheme to pay forest owners for watershed protection (see Table 5.1) are examples of novel ecosystem service markets based on the economic valuation of ecosystem services.

Researchers have developed a number of methods to quantify the values associated with ecosystems (see Table 3.5). The values fall into three categories, which combine to create the Total Economic Value of an ecosystem:

- *Direct use* values include provisioning services (crops, timber, etc.) and non-consumptive use (photography, tourism, etc.).
- *Indirect use* values include the regulating services of water filtration by wetlands, for example, or the natural hazard protection provided by mangroves.
- *Non-use* values include, for example, any delight we take in the existence of a panda or mountain, or the importance we place on preserving that resource for our children.

Direct use values tend to be the easiest to account for, because they are often part of formal markets, such as the profits from the sale of forest products. Other values are more difficult to measure. Non-use values are particularly challenging, and can

Table 3.5 Common Economic Valuation Methods

Method	Approach	Applications
Effect on productivity	Trace impact of change in ecosystem condition on the produced goods	Any impact that affects produced goods (e.g., declines in soil quality affecting agricultural production)
Cost of illness, human capital	Trace impact of change in ecosystem services on morbidity and mortality	Any impact that affects health (e.g., air or water pollution)
Replacement cost	Use cost of replacing the lost good or service	Any loss of goods or services (e.g., previously clean water that now has to be purified in a plant; shoreline protection once provided by mangroves or reefs)
Travel cost	Derive demand curve from data on actual travel costs to estimate recreational use value	Recreation, tourism
Hedonic prices	Extract effect of environmental factors on price of goods that include those factors	Air quality, scenic beauty, cultural benefits (e.g., the higher market value of waterfront property, or houses next to green spaces)
Avoided damages	Model comparison of the damages avoided by having protection against natural disaster events such as earthquakes, hurricanes, and flooding	Shoreline protection services, erosion reduction, etc.
Contingent valuation	Ask respondents directly their willingness to pay for a specified service	Any service (e.g., willingness to pay to keep a local forest intact); can be used to estimate consumer surplus (the benefit above actual expenditure), social value, and existence value
Choice modeling	Ask respondents to choose their preferred option from a set of alternatives with particular attributes	Any service
Benefits transfer	Use results obtained in one context in a different context (e.g., estimating the value of one forest using the calculated economic value of a different forest of a similar size and type)	Any service for which suitable comparison studies are available

Source: Adapted from MA 2005b.

typically only be estimated through a technique called *contingent valuation,* in which surveys are conducted of people's "willingness to pay" for the value in question. Although some valuations attempt to estimate Total Economic Value, most studies only cover a subset of the component values, and hence need to be considered lower-bound estimates on ecosystem value.

Limitations of economic valuation

A major limitation of economic valuation is that the resulting estimates are often highly subjective, being sensitive to both the methods selected and assumptions used. The selected ecosystem services to be valued, coupled with assumptions on period of valuation (number of years) and discount rate (reflecting how we value the future), will have profound effects on the estimates produced. Some techniques focus on narrow, marketable goods and services, which can be more accurately estimated, but omit important non-market and non-use values. In addition, inaccuracies exist because of incomplete understanding of complex ecosystem processes and inherent biological uncertainties (for example, how much wetland is required to provide sufficient flood regulation or water filtration for a population).

Finally, people are sometimes suspicious of valuation estimates because they worry the estimates have been developed (perhaps inflated) with an agenda in mind. Others object to economic valuation of ecosystems because ecosystems have intrinsic value—independent of the services they provide to humans—that cannot be quantified.

Practical considerations in implementing economic valuations

A number of considerations can improve the usefulness of economic valuations and increase the likelihood that decision makers will accept and take the resulting values into account.

- Conduct the analysis using a clear and fully disclosed method. Be clear from the start on the assumptions used and limitations of the results.
- Engage local stakeholders in the process. Building local capacity to undertake valuations or use the results of a valuation can contribute to greater understanding of the value of ecosystems to society and inform more robust development strategies.
- Develop estimates based on existing data and information systems whenever possible (see Box 3.3). Making use of information routinely collected by existing institutions increases the likelihood of similar valuations being implemented in the future, allowing examination of change over time. Surveys can provide valuable information, but are somewhat subjective, and may be one-time events, unless there is capacity to repeat the survey in the future.
- Strive for realistic and accurate results. If results prove smaller than desired, document the reasons, and clearly note what is included and not. Inflating results will likely discredit the effort.

Box 3.3 Economic Valuation in Practice: Valuing Coastal Resources in the Caribbean

The Caribbean region has seen increasingly severe threats to its coastal resources over the past decade, and faces difficult decisions regarding trade-offs between certain types of development and tourism and further degradation of its natural resources. A valuation effort led by the World Resources Institute has produced a standardized method that can estimate the economic value of coral reef and mangrove ecosystems and can inform policy decisions in the region.

The method relies primarily on existing, publicly available data, and is designed as a collaborative process including government agencies and local NGOs in order to inform decision making across levels. Pilot applications in Tobago and St. Lucia, and a current application in Belize, evaluate the annual net benefits from coral reef and mangrove-associated fisheries, tourism, and shoreline protection services. Because it counts only "use" values rather than relying on extensive surveys, the method derives lower-bound estimates of ecosystem value. The method can also be used to evaluate potential gains or losses in value by analyzing policy and management scenarios with different predicted ecosystem conditions.

Other examples of valuation in practice include New York City's use of the Catskills (Box 3.1) and the conversion of mangroves to shrimp farms (Figure 1.3).

STEP FIVE: IDENTIFY ECOSYSTEM SERVICE RISKS AND OPPORTUNITIES

Identifying the ecosystem service–related risks and opportunities associated with a decision involves using the information gathered in earlier steps. Step five can also draw on the results of any scenarios (see chapter 4) that explore how ecosystem services may change in the future.

Risks and opportunities can relate to both the dependence of the decision's goals on ecosystem services and how the decision affects services that other stakeholders rely on. Questions to consider when identifying risks and opportunities associated with ecosystem service dependencies and impacts include:

- *Does the decision depend on ecosystem services that were either previously unrecognized or in poorer condition than previously known?*

Development planners in Tanzania, for example, learned that achieving their poverty reduction goal depended significantly on promoting management of catchments to ensure sufficient water and energy was available to support people's livelihoods in rural areas (United Republic of Tanzania 2005). In Rio Grande, the risk of flooding is well recognized. However, the ecosystem services assessment brought to light the role of deforestation and wetland loss in exacerbating the effect of storms and degrading water quality, a risk that was not previously broadly understood.

- *Could the goals of the decision be jeopardized because users are competing for an ecosystem service in limited supply? If so, are cost-effective substitutes available?*

Table 3.6 Examples of Ecosystem Service Trade-offs

Decision	Goal	Example winners	Ecosystem services decreased	Example losers
Increasing one service at the expense of other services				
Draining wetlands for farming	Increase crops, livestock	Farmers, consumers	Natural hazard regulation, water filtration and treatment	Local communities including farmers and some downstream users of freshwater
Increasing fertilizer application	Increase crops	Farmers, consumers	Fisheries, tourism (as a result of dead zones created by excessive nutrients)	Fisheries industry, coastal communities, tourism operators
Converting forest to agriculture	Increase timber (temporarily), crops, livestock, and biofuels	Logging companies, farmers, consumers	Climate and water regulation, erosion control, timber, cultural services	Local communities, global community (from climate change), local cultures
Converting ecosystems and their services into built assets				
Coastal development	Increase capital assets, create jobs	Local economy, government, developers	Natural hazard regulation, fisheries (as a result of removal of mangrove forests or wetlands)	Coastal communities, fisheries industry (local and foreign), increased risks to coastal businesses
Residential development replacing forests, agriculture or wetlands	Increase capital assets, create jobs	Local economy, government, developers, home buyers	Ecosystem services associated with removed ecosystems	Local communities, original property owners and downstream communities
Competition among different users for limited services				
Increased production of biofuel	Reduce dependency on foreign energy	Energy consumers, farmers, government	Use of crops for biofuels instead of food	Consumers (rising food prices), livestock industry
Increased water use in upstream communities	Develop upstream areas	Upstream communities, industries	Water downstream	Downstream communities, industries

The scenarios in the Rio Grande story highlight the potential for competition among users of maize for food and fuel and note that imports of food might be needed (see chapter 4). In the real world, Mexico's experience shows that the substitute might not be as healthy or inexpensive as local food. In the first month of 2007, Mexicans faced prices for tortillas that had more than tripled in six months when maize prices rose as a result of the rapidly growing demand for ethanol also made from corn. Poorer Mexicans substituted cheaper but less nutritious noodles for tortillas (Roig-Franzia 2007).

- *Are there any unforeseen impacts of the decision on ecosystem services that others depend on for their well-being?*

In Rio Grande the assessment revealed that a biofuel strategy that did not consider the dependence and impacts on ecosystem services could result in the conversion of large amounts of land now forested to growing crops for biofuel. This would affect the watershed's already degraded capacity to reduce floodwaters and filter drinking water. Higher rates of runoff from increased fertilizer and pesticide use after storms would likely have a negative impact on water quality.

When identifying risks and opportunities, it can be helpful to think of ecosystem service changes in terms of trade-offs. Trade-offs arise from management choices or actions that intentionally or otherwise alter the quantity or quality of an ecosystem service in order to achieve a goal.

Assessing trade-offs involves identifying the different groups that will win and lose in the short term as well as the long term as a result of changes to ecosystem services. Trade-offs can involve economic losses (see previous step), or losses to the health and well-being of certain populations (see Table 3.6). For example, a study by the Trust for Public Lands and the American Water Works Association in the United States analyzed the relationship between watershed forest cover and municipal water treatment costs. In 25 watersheds, they found that every 10 percent loss in forest cover leads to a 12 percent increase in water treatment costs. Although some people would benefit from forest clearing (for either timber or land development), a greater number of people would be affected by the loss of the ecosystem service of water filtration and purification, and have to pay more for their drinking water (Ernst 2004).

Several tools can help identify and assess ecosystem service trade-offs in relation to human well-being (see Box 3.4). Approaches such as "poverty and ecosystem service mapping" can help assess the impacts on vulnerable groups, such as the rural poor, by assessing the links between ecosystem services and indicators of poverty. Economic valuation (see step four) is also an increasingly popular tool for assessing and communicating the

Box 3.4 Tools for Analyzing Trade-offs

Poverty and ecosystem service mapping overlays geo-referenced statistical information on poverty with spatial data on ecosystem services. The resulting maps can highlight important relationships, such as how the location of poverty compares with the distribution of services; which areas provide critically important services to the poor; who has access to natural resources; who benefits; and who bears the cost of changes to ecosystem services. Such overlays do not show causality, but suggest focus for further analysis (WRI et al. 2007).

Economic valuation assigns an economic value to ecosystem services that do not have a value in the market place (step four and Table 3.5), such as regulating and certain cultural services. The resulting information can draw attention to the value of ecosystem services that might otherwise be ignored when making decisions that affect ecosystems. In general, economic valuation is effective in persuading decision makers of the value of ecosystem services by highlighting their economic contributions to societal goals; comparing the costs and benefits of ecosystem service protection versus engineering alternatives; and building markets for ecosystem services, such as global carbon markets or stewardship incentive programs for farmers.

Alternatives to Slash and Burn (ASB) Matrix is a tool to assess the multi-scale impacts of alternative land uses at the margins of tropical forests. Different land uses are scored against criteria that reflect the objectives of different interest or use groups. The ASB matrix can be adapted for other ecosystems, but should always comprise indicators for a range of ecosystem services at different scales. This might include indicators for one or two regulating services that have global additive effects (carbon storage), indicators of national significance (development indices), and indicators of significance to local populations (agronomic sustainability and the availability of credit, markets, and technology) (Tomich et al. 2005).

Action Impact Matrix assesses the two-way interactions between development goals and ecosystems by exploring the effects of development goals on ecosystems as well as the effects of ecosystems on development. It can be used to determine economic, environmental, and social priorities that facilitate management and restoration of ecosystem services. The tool is best used as part of a participative process (Munasinghe 2007).

Irreplaceability mapping can be used to assess trade-offs between food services and biodiversity. Food production is divided into two types: calorie production (cereal) and protein (meat). Based on targets for calories, protein, and biodiversity, irreplaceability values are assigned to map grid cells. In the Gariep Basin in Southern Africa, these ranged from 0 (many options in other locations to achieve goals) to 1 (totally irreplaceable). While no site was found to be irreplaceable for protein and calorie goals, several sites were irreplaceable for biodiversity. This information supports a land use plan that guides protection of sites with a high degree of irreplaceable biodiversity, while steering grazing or cultivation to other sites (MA 2005b; Bohensky et al. 2004).

economic impacts of changes in the supply of ecosystem services.

In the case of Rio Grande's development plans, risks include:

- Degradation of freshwater and negative impacts on local fisheries, tourism, and recreation as a result of increased water pollution from actions to increase the supply of crops;
- Reduction in natural hazard regulation services of wetlands and a resulting increase in the vulnerability of coastal community to hurricanes and storms because of wetland conversion; and
- Reduction in crops available for food as a result of competition for the use of crops as food versus biomass fuel leading to rising food prices and impacts on the well-being of vulnerable groups.

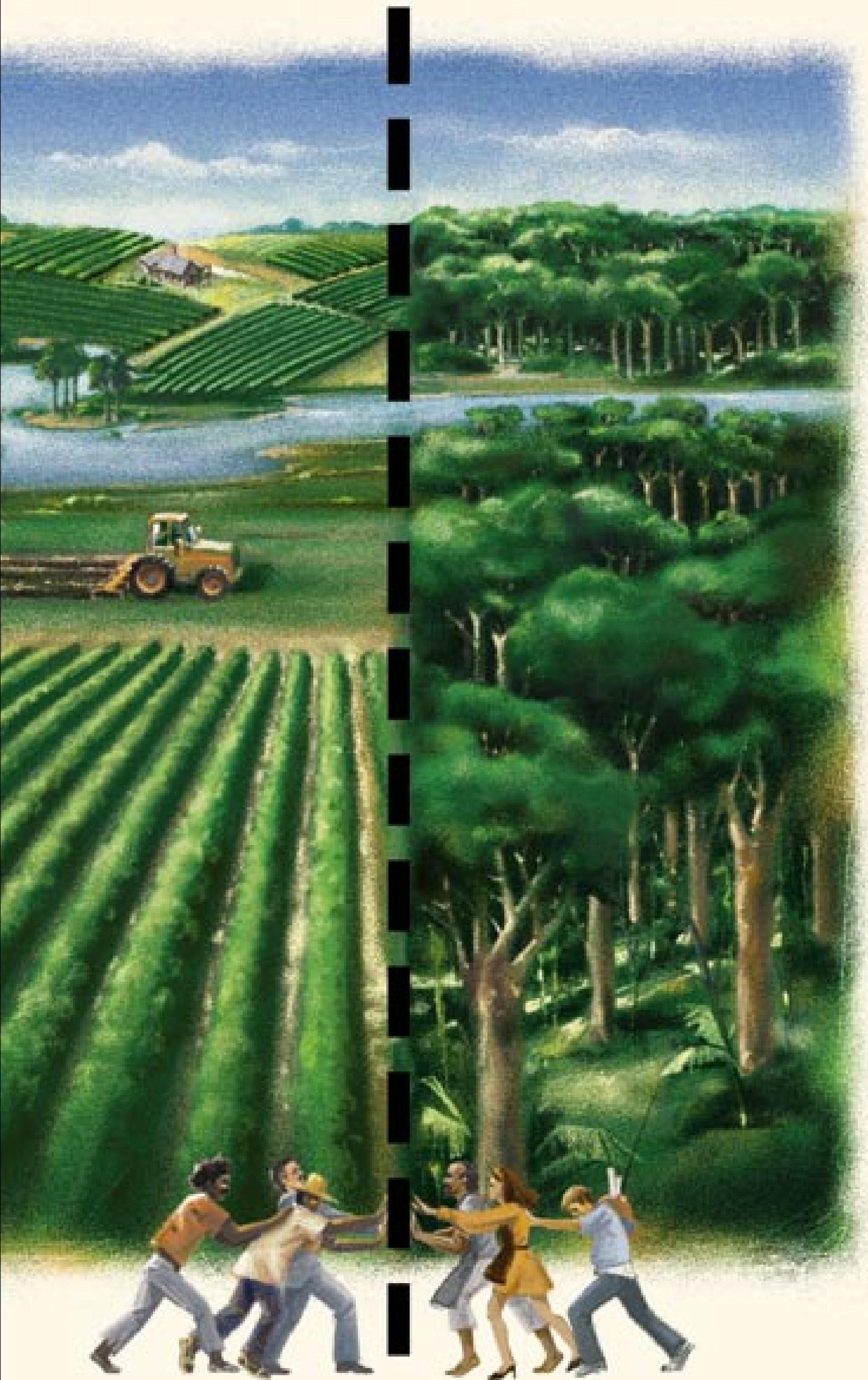
Opportunities for Rio Grande include:

- Improving the use efficiency of ecosystem services by adopting practices that allow for the joint production of food and fuel with the same crop;
- Enhancing the natural hazard regulation service of coastal wetlands by investing in coastal wetland restoration as a strategy to reduce storm impacts on coastal communities with co-benefits for fisheries, recreation, and ecotourism;
- Enhancing the supply of freshwater by increasing the water filtration, purification, and erosion control services of forests, wetlands, and riparian zones in the upper watershed; and
- Reducing impacts of farming on freshwater quality by minimizing fertilizer and pesticide runoff.

How a community like Rio Grande can use policies to advance development while sustaining ecosystem services is explored in the final chapter. The next chapter describes the use of scenarios to explore changes to ecosystem services in the future.

ACTION POINTS

- Identify the ecosystem services that a policy, plan, or project depends on and affects.
- Screen the ecosystem services to determine which are most relevant.
- Conduct an assessment of the selected ecosystem services.
- Assess the need for conducting an ecosystem service valuation and use if appropriate.
- Identify the ecosystem service risks and opportunities associated with a policy, plan or project.



Where the technical team goes to work

"Where are we supposed to start?" asked one of the students.

The Professor had assembled a team of four researchers, and they were now looking at the questions that came out of the Steering Committee. The scientists were not used to the kind of questions in front of them and the task seemed impossible.

"Trade-offs," said the Professor. "The region's ecosystems are already under stress, especially from the combination of agricultural, urban, and industrial expansion. This biofuel industry will exacerbate trade-offs among ecosystem services. People are not aware that the consequences of this factory go well beyond its local impact. Costs and benefits will ripple throughout the region and society in unexpected ways. We need to show very clearly the choices that are at stake."

"Baselines," another researcher said. "First we need to know what the situation is today and the direction things are moving."

"We should start by identifying which ecosystem services to focus on. The Steering Committee can then decide which are most important to them."

"I think they are more concerned about the human dimensions: the economy, health, vulnerability to storms, inequality, the price of food, clean water, and so on. We should start by identifying these variables."

"Here's what we'll do," said the Professor as he sketched a diagram. "First, we define which ecosystem services are of interest and what their value is. Is it water flows for the refineries? Flood protection for the city? Recreation? Fuel crops? Food? Then we look at the consequences of the biofuel industry for ecosystem services in the region. Will it affect water quality and quantity? Soil fertility? Biodiversity? Then we define the dimensions of human well-being with which these services are most strongly associated. How will changes in these ecosystem services affect health and employment? Will drinking water be affected? How will property value change? How will coastal communities' livelihood be affected? And then we analyze the trade-offs. Easy."

"I'm afraid I still don't understand what you mean by trade-offs."

"It's another way of saying that any further changes to our ecosystems will come at a cost," said the Professor. "The biofuel industry will demand more crops, so agriculture will expand most likely at the expense of the forest. In other words, the river basin will be changed to accommodate more crop production. The provisioning of those crops is one ecosystem service that will be enhanced. But at the same time, more agriculture will reduce the quality of the water that reaches the city because of pesticides and fertilizers. The quantity of water might be affected, too; whether there will be more water because of deforestation or less due to irrigation or regional climate change, we don't know. Maybe both. Also, fisheries may be altered in the coastal area and tourism is likely to be affected as well. Even the local climate might change! So, as you extract more of one service, crops, from the river basin, you degrade five other services: water quantity, water quality, fish production, recreation, and climate regulation. That's a trade-off."

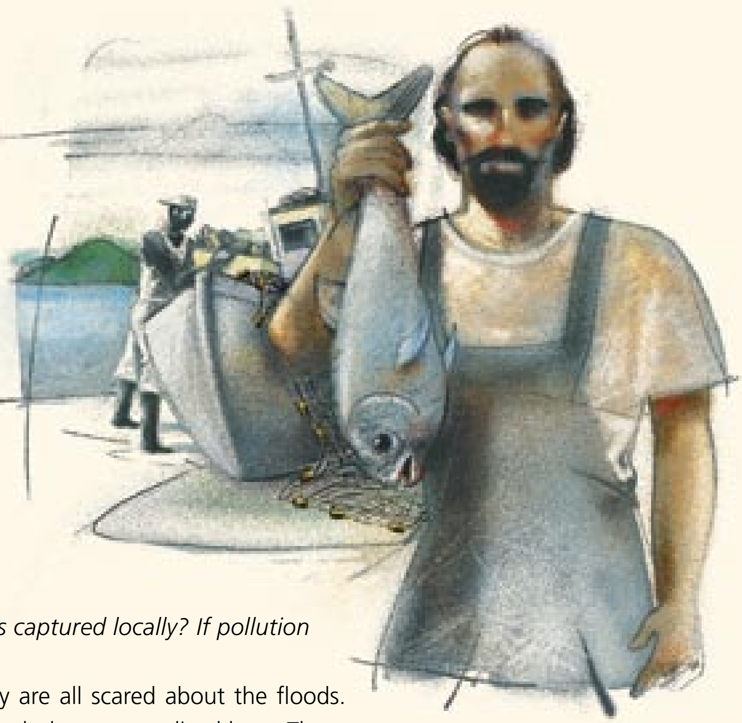
"But the factory will create new jobs in the city and more business for farmers. The economic gains are clear."

"Yes, although some will lose. Fishermen and tourism operators will suffer, small peasants might be forced to sell their land and migrate. The price of food might go up, harming the poorer sectors. If water quality deteriorates and there are more floods, there will be a health and security cost associated, too."

"And we need to look at the longer term consequences as well. Decreases in quality of water could lead to higher costs of water due to purification requirements. Decreases in quantity of water could affect the refinery itself in the future, and uncontrolled expansion of biofuel crop production could lead to soil erosion, sedimentation, and flood problems, which could have a negative impact on the success of the business itself."

"You see? We need to produce information that shows all these things to the Steering Committee so they know the consequences of their decisions."

For once, a field trip involved more interaction with people than with plants and animals. After long discussions about methods, the Professor felt it was time to go see the actual places and people. As they traveled around the area one student realized she was not aware of how much was going on in her region and started writing down questions that the team needed to answer. *What are the current land uses in the Rio Grande basin?*



First stop, the fishing community. "Over my dead body they will build that factory." Coming from a fisherman, the threat had to be taken seriously. "Why? Before, a week out with your boat would fetch enough to feed the family for a month. Today, you won't get even half that. They say it's the foreign fleets out there in the sea. But I think it's the water that's coming down poisoned. It started with the big expansion twenty years ago. The new factory will only make it worse."

The student scribbled: *How resilient are the fisheries in the coastal area to increased nutrient loads and pollution? How much pressure are international fishing fleets putting on fish stocks captured locally? If pollution pressure increases, could the fish stocks be pushed to depletion?*

Next stop, the southern, poorer quarters of the city. "Now they are all scared about the floods. We've seen much worse in '68, and '78! The only difference was, back then no one lived here. These were farmlands! They want to build a factory here? Good. Lots of people need work."

3 The Decision CONTINUES

How much water currently flows in the locations where the refineries could be built? What would be the impacts of land conversion on flood control, sedimentation in the river, pollution levels, and the health of the population? Will the cost of water purification for drinking increase? Will the factory benefit these people by providing jobs?

"You experts think you know better, but we know very well how to treat the land," said a farmer upstream, close to the forest. "We've been doing it for ages and we have no intentions of destroying the basis of our business. Even though crop prices fluctuate, international demand is strong, and the biofuel market will only strengthen it. Our country cannot afford to miss this opportunity! The law that promotes biofuels is good. There is more than enough forest in national parks if that's what worries you."

Once we start producing the information, we must make sure these people understand it, the student thought as she continued to take notes. *How much food is being produced and over how much surface? What are the agricultural needs of the biofuel complex and how much land might be converted to agriculture? The national government is offering subsidies to farmers growing biofuel crops.*

The tour ended at a popular coffee shop. "Last summer we had about 10,000 tourists coming through town, mostly to visit the forests and the coast," said the owner as she offered them coffee. "But I think the place is losing its charm. If it's true what they say about the biofuel factory it will only be a matter of time until tourism collapses."

How many people will benefit from the refineries versus how many people currently benefit from food production, fisheries, and tourism?

"I think we should focus on gathering information on the region's water quality and quantity," concluded the student during the debriefing. "Both are related to the success of the national biofuel development goal, the safety and cost of drinking water for town residents, and the sustainability of agriculture, tourism, and fishing industries. As to the scale of analysis, we must look at ecosystem services at the watershed scale. The trade-offs clearly involve the highland agricultural areas, the city downstream, and the coastal area."

The team finally agreed to propose to the Committee twelve ecosystem services to study:

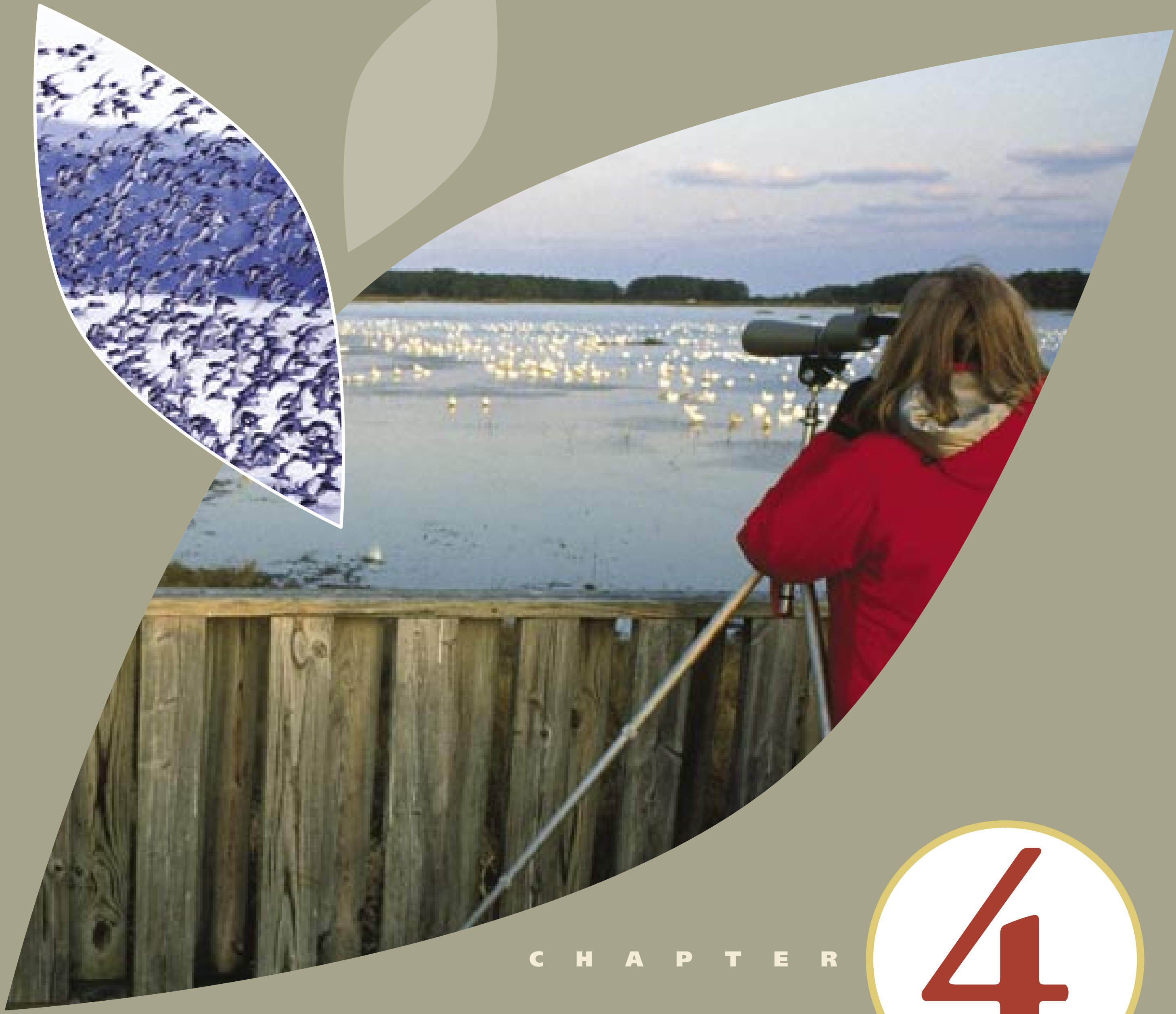
- food from crops, that is, the ability of the river basin to provide food through agricultural activity;
- food from fisheries, or the ability of the whole system to sustain artisanal fishing;
- the ability of the river basin system to provide fiber for the production of energy in the form of biofuels;
- the quantity of freshwater that the system provides for domestic, industrial, and agricultural use;
- the regulation of water flows in the system;
- the ability of the system to purify water for human consumption and treat waste;
- the climate regulation function that the ecosystem performs locally (temperature and local precipitation regime);
- the role of the system in preventing soil erosion;
- natural pest control performed by the basin's ecosystems;
- the support of pollination;
- protection against natural hazards such as storms and floods; and
- the recreational role that the basin's ecosystems play, in particular their role in sustaining ecotourism.

The team searched the published literature and found several studies on the impact of biofuel refineries on water. National data bases included information on food production for the region, and satellite imagery was used to calculate the area of land currently under production. Another literature review turned up studies on how deforestation, soil type, and slope interact in this area in terms of erosion and flood control. The municipal waterworks department submitted a report on the robustness of current water treatment facilities and how they would withstand increases in sediment and pollutants in the river. And the team went out to conduct structured interviews with the different groups involved.

To determine whose well-being would increase and whose would decrease in the event that a refinery was built, they obtained from the municipal and regional governments data about trends in household income within the fishing community, the farming community, and key neighborhoods. They also looked at the economic significance of the tourism industry for the region. Data was also available about mortality and incidence of waterborne diseases across social groups.

The picture of the current state of the region was taking shape, and the team produced a "report card" (see page 35) that summarized the status of ecosystem services. In essence, they found that the current situation was neither great, nor dismal. Over the last few decades, five of the twelve ecosystem services studied had remained more or less unaltered by human activity: the region's ecosystems continued to provide fiber for biofuels, freshwater in good quantity, regulation of soil erosion, pest control, and pollination. Five ecosystem services had been degraded: functions such as the provisioning of food from fisheries, climate regulation, water regulation, water purification, and protection against natural hazards. Only two services had been enhanced: ecosystems today yielded more food from crops and more recreation opportunities than in the past. These two last services were very important to Rio Grande, but so was the city's dependence on the five services that were being degraded. So there was cause for concern.

The greatest worry, however, came from the trends in the drivers that were causing the degradation: the pressure of almost all of these drivers was increasing. The conversion of forest to biofuel production, the use of pesticides and fertilizers, overexploitation of fisheries by industrial fleets, global climate change, population growth, economic growth--all were growing in intensity. If these trends continued unchanged it would not be long before all ecosystem services started to degrade, together with the quality of life in Rio Grande.



C H A P T E R 4

Lead Authors
Monika Zurek
Reinette Biggs
Ciara Raudsepp-Hearne

Contributing Authors
Elena Bennett
Kasper Kok
Sandra J. Velarde

PHOTOS BY GETTY IMAGES

Exploring Future Trends in Ecosystem Services

Collecting information on the current condition and trends of ecosystem services and identifying the drivers that affect human well-being results in an understanding of *current* changes to ecosystem services, as discussed in chapter 3. Decision makers also need to look into the *future* to assess the effectiveness of policy options for addressing ecosystem change. For complex systems like ecosystems, gauging future outcomes comes with high uncertainty. Much of what is observed in ecosystems is poorly understood, and trends in ecosystem services might change in unexpected ways as people continue to use and affect the environment. In addition, different stakeholder groups may hold very different views about what constitute appropriate strategies for managing ecosystems.

This chapter introduces scenario planning as one tool for thinking creatively about possible future outcomes of a decision and discusses how it can be used in conjunction with an Ecosystem Services Approach to strengthen decision making. Scenario planning explicitly considers alternative future pathways and the relationship between today's decisions and the future. The chapter first explains the importance of exploring uncertainties about future trends and assumptions about the future. The second section describes the scenarios approach as one way of thinking through possible future developments, and describes the basic steps of a scenarios exercise. The last section describes some of the outcomes of scenario planning.

WHY EXPLORE ALTERNATIVE FUTURES

Many development policies result in unintended consequences—a fish species imported for food becomes an invasive predator, water diverted for irrigation leaves soil overburdened with salt. Policy makers must explicitly consider how their decisions today may shape the future, and how future trends may differ from the past.

Unintended consequences arise in part because of the numerous and complex linkages between societies and ecosystems. Changes in one sector usually have impacts elsewhere, some of which may be unexpected. For example, international trade agreements and food prices may directly affect the extent of land clearing and the choice of crops made by farmers in Brazil or Uganda. Such interconnections across geographical scales or time scales make it difficult to foresee the implications of decisions that depend on or affect ecosystem services. If only a few interactions are taken into account, the intended outcomes of a decision may be compromised.

KEY LEARNINGS

Looking into the future in a systematic way can strengthen decision making by identifying trade-offs across ecosystem services.

By considering various interactions and future changes in society and ecosystem services, decision makers can identify the policies most likely to achieve their goals. In the case of Rio Grande, growing international demand for biofuels, coupled with a national biofuel goal, will drive changes in agriculture. These changes affect the capacity of the upper watershed to supply the city with clean drinking water and food. The national plan also attracts international interests seeking to invest in the city's proposed biofuel plant.

Another important feature of the interactions between societies and ecosystems is that change is often not linear or gradual. Rather, it occurs abruptly or accelerates once a threshold is crossed. Crossing a threshold can have enormous impacts on ecological and social systems, as many examples have shown. These include the collapse of the North Atlantic cod fishery as described in chapter 2, and the huge costs to power companies after the zebra mussel invaded North American Great Lakes, which also resulted in the disappearance of some native clams (MA 2005b).

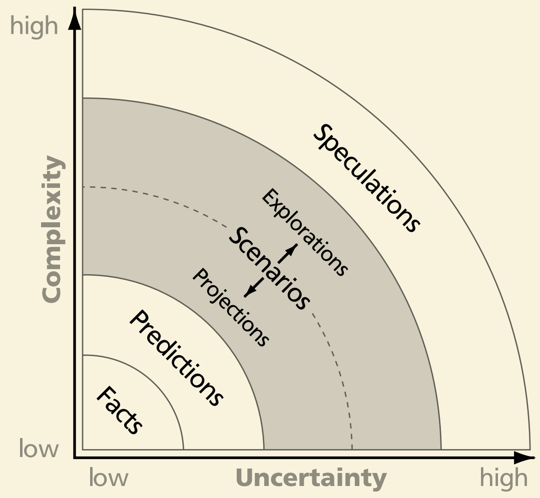
Decision makers trying to avoid such threshold-related changes in ecosystem services face two major problems. First, it is difficult to recognize such thresholds until they have been crossed. Second, inertia in the ecological system or a delay in society's response means that even if the impending threshold is identified, it may be too late to avoid crossing it. Looking into the future in a systematic, structured way, as discussed in this chapter, can help to alert decision makers to possible thresholds along certain development pathways as well as to broaden the understanding of all the important factors shaping the future.

The choices of decision makers, which can potentially result in crossing an ecological threshold or creating other unintended consequences, are often based on underlying assumptions or beliefs about the likely future outcomes of their decisions. Certain trends are assumed—often erroneously—to continue as they have in the past. At the same time, other stakeholders may have different assumptions. Exploring how the future *could* unfold can provide unexpected insights into often implicit assumptions as well as into the limits of understanding.

In southern Africa, for example, plans that aim to promote economic growth and development through agriculture based on knowledge of past rainfall patterns and agricultural potential would run into trouble, given that climate change could result in rainfall reductions of more than 50 percent (MA 2005c). Decisions about resource use by individuals as well as by national and regional governments need to take into account future climatic conditions (Scholes and Biggs 2004). Considering southern Africa's future also reveals that aiming to increase water supply, such as through engineered water transfers and withdrawal of nonrenewable groundwater supplies, would be unsustainable in this region. This realization shifts the focus from the supply-side strategies typically used in the past, and might prompt decision makers to explore strategies for reducing water demand or increasing efficiency, such as through water pricing.

Taken together, the unexamined assumptions of decision makers, along with linkages across geographical scales, non-linear changes, and high connectivity between societies and ecosystems, largely explain why many social and economic policies result in unintended consequences. Scenarios are one tool that can help decision makers consider how the future may differ from the past, and minimize the unintended consequences.

Figure 4.1 **Tools for Addressing Future Uncertainty and Complexity**



Scenarios, which can incorporate explorations and projections, are especially suitable for addressing the high uncertainty and complexity typical of socio-ecological systems. Reprinted from Technological Forecasting and Social Change, *74, Zurek, M. and H. Thomas, "Linking scenarios across geographical scales in international environmental assessments", 14, 2007, with permission from Elsevier.*

KEY LEARNINGS

One tool for looking into the future, scenario planning, is especially useful when considering the links between ecosystem services and development.

THE SCENARIOS APPROACH

Methods to help decision makers systematically think about the future and draw lessons for today's decisions include predictions, projections, explorations, and scenario analysis (see Figure 4.1). All seek to clarify expectations about the drivers of change that will shape the future and/or test ideas about the expected outcomes of today's decisions or policies. Of these methods, scenario planning (or scenario analysis) has emerged as the most appropriate tool for complex systems like ecosystems. Scenario planning has recently become an important part of integrated environmental assessments, including those conducted by the Intergovernmental Panel on Climate Change and the Millennium Ecosystem Assessment.

Decision makers often have some understanding of the drivers of ecosystem service change; still they need to incorporate different world views and sources of knowledge in their decision making (Peterson et al. 2003). As Figure 4.1 suggests, scenario planning is especially valuable when uncertainty is high—that is, when relatively little is known or perceptions differ greatly about the causes and effects of a system's dynamics. This is often the case when integrating social and economic planning with ecosystem management.

The goal of scenario planning is to consider a variety of possible futures reflecting important uncertainties, rather than to focus on an accurate prediction of a single outcome (Van der Heijden 1996). Scenarios are therefore not predictions, projections, or forecasts. They are stories about the future, told as a set of "plausible alternative futures" about what might happen under particular assumptions (MA 2003). In contrast to forecasts or predictions, scenarios do not assume that existing conditions will continue, or that the future will necessarily extrapolate from today's trends. Instead scenario planning encourages creative thinking about possible events or changes in society or ecosystems that might have powerful impacts on the future.

Scenarios usually assume that current developments will change in the future, sometimes in unexpected ways. For instance, a breakdown of the Doha World Trade Organization negotiations could change the pace and extent of globalization. The longer it takes to reach an agreement, the more likely it is that some parties might change their positions and turn to bilateral rather than global agreements. This might keep certain trade barriers in place, or hinder the flow of information and/or technologies across borders.

Table 4.1 Steps in Scenario Development and Relevance to Policymaking

Scenario development steps *	Activities	Type of information generated	Relevance to the policymaking process
1) Decide on the focal questions	• Discuss historical developments that led to present situation • Identify main uncertainties for the future • Identify focal questions (main problems) to be addressed by the scenarios	• analysis of current problems and their roots, based on stakeholder analysis • analysis of key questions for the future • clear understanding of main assumptions for the future of the investigated system	• identifying issues • framing issues • identifying stakeholders to be engaged in decision process
2) Identify main drivers of ecosystem change	• List main drivers that will change the future • Identify possible driver trajectories, thresholds and uncertainty about them • Identify main interactions between drivers	• analysis of main drivers shaping the future and their importance • voicing of different view points on drivers' trajectories and their importance • understanding of system's interactions, development of a system's perspective	• framing issues • prioritizing information • informing policy selection
3) Develop the scenarios	• Develop first drafts of scenario storylines • Translate storylines into model inputs and execute a modeling exercise (optional) • Finalize scenarios based on critical assessment of storylines (qualitative) and modeling (quantitative) results, based also on stakeholder discussions	• creative ideas about the future and emerging changes • challenges for assumptions on drivers' interactions, consistency checks • grounding of qualitative knowledge through modeling	• identifying decision points • evaluating policy options • selecting policy • designing monitoring systems
4) Analyze across the scenarios	• Conduct analysis across the scenarios set • Discuss scenarios analysis' results for various stakeholder groups • Write-up and disseminate scenario exercise	• assessment of trade-offs and synergies of various management options • information to different stakeholders on differing view points • awareness of emerging issues for the future	• identifying policy options • evaluating policy options • developing strategies for policy implementation and monitoring

** Although the steps are described in a linear way, in practice there is much iteration among them.*

Scenario planning can be adapted to many different decision-making contexts. It has been used either to explore how societies and ecosystems would change in various plausible futures (exploratory scenarios), or to create various future pathways as a test of possible policy options (policy or anticipatory scenarios) (see also chapter 5). Scenarios are well-suited to participatory decision-making processes (Wollenberg et al. 2000) and have been used by the strategic planning as well as the business community for several decades (Schwartz 1996). Today more and more natural resource managers use this tool to explore new management approaches (Bennett et al. 2003) as scenarios can be particularly responsive to the concerns of stakeholders affected by a decision and can incorporate their knowledge on the issue.

Scenarios need not require quantitative modeling. They can be built using qualitative methods (based on the expert knowledge of local land users, government officials, scientists, or others), or be based on quantitative, scientific modeling approaches, or a combination of the two (Alcamo 2001; MA 2005c). A scenario planning exercise for deciding on a development strategy, using both qualitative and quantitative methods, can be broken down into four steps (see Table 4.1). Each step generates different kinds of information useful to decision makers.

For example, identifying the main uncertainties in the future can highlight important issues for stakeholders and help elicit their views. Providing information on future drivers of ecosystem services change can complement information derived from chapter 3 on current drivers and inform the policy selection process described in chapter 5. Scenarios can be built to test policy options for achieving a specific development goal (to sustain freshwater supplies, for example) and to explore the consequences for a variety of issues (how different water use policies might affect business competitiveness, agricultural production, or income distribution structures). An example of a scenarios exercise on the interactions between people and ecosystems is the one carried out by the Millennium Ecosystem Assessment on the Caribbean Sea ecosystem (see Box 4.1); more information on the outcomes and benefits of a scenarios exercise is provided in the last section.

Before starting the actual scenario building process, the purpose of the exercise should be clearly identified, as should the main participants, who may be stakeholders affected by a decision, scientists exploring various future trends to inform decision making, or a mixture of both. The scenario building team will need to make a substantial commitment of time (two or more workshops lasting two to four days). Careful facilitation is important for managing power imbalances, language differences, and expectations among participants. The focus should remain on the issues of highest interest and relevance to the target audience. The scenarios building process needs to be legitimate and rigorous so that the scenarios have credibility among stakeholders (see chapter 2 for more on this) or the main audience.

What follows is a description of the steps in scenario building that are outlined in Table 4.1, considering the case of Rio Grande.

Box 4.1 Scenarios for the Caribbean Sea

As part of the Millennium Ecosystem Assessment Caribbean Sea study, a scenario planning exercise evaluated the state of the Caribbean Sea marine ecosystems and threats and opportunities for their management in the future. The scenarios exercise was carried out with the following focal questions:

- What governance mechanisms can be used to reduce the region's economic, social, and environmental vulnerability?
- How can maintenance and management of ecosystem services proceed to improve human well-being in the Caribbean?
- How can economic activity be organized and managed so that natural resource benefits are distributed equitably between local and external interests relative to costs? How can the interests of users of services be linked with their investments in the region?
- Will current trends in the decline of Caribbean Sea coastal and marine ecosystems exceed ecological thresholds and result in significant consequences for human well-being?

The following main uncertainties were identified:

- Tourism – forms (mass versus eco-sensitive niche tourism), numbers
- Fisheries – resource mining versus sustainable use
- Land use change – habitat change and loss of valued ecosystems
- Population dynamics, equity, and consumption patterns
- Governance mechanisms
- Climate variability and change

From this analysis the two most important uncertainties for the future were derived:

- Externally controlled versus internally driven development
- Regional integration versus fragmentation

These two key uncertainties defined the main themes of *four scenarios,* which are similar to the Millennium Ecosystem Assessment global scenarios:

Neo-plantation economy: The Neo-plantation economy is driven by a demand for ecosystem services that are mostly enjoyed by people from outside the region. In this scenario, the Caribbean remains primarily a zone of production and extraction, as it has been for much of the past 500 years.

Quality over quantity: This scenario emphasizes the careful, sustainable management of scarce natural and market resources at a scale appropriate to the small island and developing states of the region. Diversification and increased resilience to unforeseen changes is a primary goal of the overall management process, for both the public and private sectors.

Diversify together: This scenario is based on the two themes of increasing regional levels of cooperation and deepening regional economic integration.

Growing asymmetries: This scenario explores some of the possible consequences of increasing global trends toward market liberalization for goods, services, and capital without proper consideration of differences and inequities among countries, regions, and social groups.

Source: MA 2005e.

Step one: Decide on the focal questions

Scenario planning starts with identifying the most important problems and the main uncertainties in the future. Ideally this will be informed by data on the current condition and trends of ecosystem services (as described in chapter 3). This step might reveal the need for further information gathering, and some iteration between the steps of gathering information on ecosystem services and building scenarios may be useful.

This first step of scenario building can also include a look into the past to familiarize participants with changing development patterns. Then the main uncertainties or questions for the future are identified, along with the focal questions for the exercise. Participants may decide not to tackle all identified problems, but to prioritize the most pressing or persistent ones. The participants will also have to discuss the time frame for the scenarios, balancing the short-term time horizon of many planning processes and the slow, long-term nature of ecosystem changes.

In Rio Grande, the focal questions concerned connections between various issues, such as the connection of the city with its surrounding watershed and the impacts of the proposed biofuel plant.

Step two: Identify main drivers of ecosystem change

The second step extends the analysis of drivers of ecosystem change in chapters 2 and 3 to include the future. Specifically, it involves identifying the main drivers of change in the future. This is especially helpful for considering indirect drivers, as their interactions, which are shaping direct drivers' trajectories in the future, can be difficult to assess over short time frames. The list of drivers identified in chapter 2 is a useful starting point for thinking about the drivers that will have a direct impact on the problem(s) identified by the focal questions.

In Rio Grande, direct drivers include land use change from agricultural expansion, deforestation, and city sprawl. These direct drivers are often determined by a set of underlying, indirect drivers (such as population or economic growth patterns) and their interactions. Discussing the interactions between drivers' can help identify possible ecosystem thresholds that will not just change the course of one driver but affect the functioning of the whole system. In Rio Grande, the main indirect drivers are globalization, which opens the country to foreign investments, and the attitude of decision makers, such as government officials, business people, or farmers, toward environmental management.

In building scenarios, participants need to rank all the drivers with respect to their importance for the identified problems, document the reasons for the ranking, and discuss why and how the drivers interact. The possible trends and trajectories for each driver should be discussed, such as the expected highest/lowest population numbers over the scenarios' time horizon, or possible economic growth rates and patterns in the future. It is also important to identify how different participants perceive these trends and how certain they are about how they will play out in the future and why. This will help uncover participants' main assumptions about the future.

Step three: Develop the scenarios

The third step involves developing a set of stories about the future that describe how the important drivers could interact and unfold in different ways. Each scenario is based on a specific set of assumptions about the drivers and develops them over the scenario time horizon. This can be done with or without a quantitative modeling exercise. For developing qualitative stories, scenario builders can draw on whatever tools are available to stimulate creative thinking that generates interesting and even provocative, but still plausible, descriptions of the future.

If the time and resources for computer modeling are available, simulations can be run to quantify future trends of drivers (such as population, GDP, consumption patterns, lifestyle choices) and possible outcomes for ecosystems and their services (such as food production, climate change or water availability). Each model run is based on specific assumptions on drivers' trajectories and their interactions. Model runs can take a few months to complete, depending on their complexity. The Millennium Ecosystem Assessment, for example, developed four global scenarios (see Box 4.2 on page 51) for which models were run to simulate future land use patterns and climate change (IMAGE, AIM), food availability and demand (IMPACT), water availability (WATERGAP) and global fisheries resources (ECOSIM) under particular assumptions about socio-economic and technological developments, which were based on qualitative scenario storylines.

Combining qualitative and quantitative scenario development techniques, as in the case of the Millennium Ecosystem Assessment scenarios, can produce comprehensive narratives. Sometimes several iterations between qualitative and quantitative techniques will be needed to achieve consistent scenarios.

Participants in the Rio Grande process built stories of the future around the intersections of drivers identified in step two. They combined statistical information and projections of population and GDP with assumptions about technology development, equity and globalization to create three scenarios.

Table 4.2 Options for Comparing Scenarios

Options for comparing across the scenarios	Example from the Millennium Ecosystem Assessment scenarios
Look for future developments that are the same in all scenarios	Same trend of rising world population up to 2050 in all scenarios, then stabilization; exact population numbers in 2050 differ. Global forest area declines up to 2050 in all scenarios: velocity of trends differs.
Look for uncertain future developments, which differ across scenarios	Number of malnourished children in 2050 differs widely among scenarios. Quality and quantity of available water resources by 2050 differ widely among regions and across scenarios.
Identify trade-offs described in the scenarios	Risk of trading off long-term environmental sustainability for fast improvement in human systems (Global Orchestration). Risk of trading off solutions to global environmental problems (requiring global cooperation) for improving local environments (focusing on local solutions only) (Adapting Mosaic). Risk of trading off biodiversity conservation for food security (Global Orchestration).
Identify policy options that make sense in all scenarios	Major investments in public goods and poverty reduction, together with elimination of harmful trade barriers and subsidies. Widespread use of adaptive ecosystem management and investment in education. Significant investments in technologies to use ecosystem services more efficiently, along with widespread inclusion of ecosystem services in markets.

For details on the Millennium Ecosystem Assessment scenarios see box 4.2.

Step four: Analyze across the scenarios

The final step in scenario building involves analyzing the implications of the scenario storylines for informing decisions taken today or in the near future. Much of the value of the scenarios exercise lies in being able to compare different outcomes. The comparison can reveal unanticipated results and provide different stakeholder groups with insights about the outcomes of the future pathways they may have advocated.

There are a number of ways to compare outcomes of different scenarios (see Table 4.2). In general, lessons can be drawn from focusing on either the similarities or differences in trends across the scenarios. These can be connected to the policy choices made along the different pathways. Lessons for decision making can also be drawn by comparing the risks taken and benefits gained by different groups of society, for example, or by mapping out the trade-offs in each scenario.

For Rio Grande, a number of differences emerge in the outcomes of two scenarios based on different assumptions for ecosystem change drivers (see Table 4.3). In the first scenario ("We become globalized"), the economy grows rapidly, but the provisioning of ecosystem services deteriorates as little attention is paid to ecosystem management in the watershed. In the second scenario ("Communities first"), a set of diverse

Box 4.2 The Global Scenarios of the Millennium Ecosystem Assessment and their Outcomes

The scenarios exercise of the Millennium Ecosystem Assessment resulted in four global-scale scenarios. They extend to 2050 in detail, with an outlook for some important issues, such as climate change, to 2100. The four scenarios all incorporate various indirect and direct socio-economic, cultural, and biophysical driving forces of change in ecosystems and their services and the related human well-being components. The scenarios were designed to illuminate contrasting pathways into the future and their risks and benefits; the driver interactions that would set the world onto different trajectories; and their consequences for ecosystems, their services, and human well-being.

The scenarios specifically explore two key uncertainties for the future: if and how the world could become either more globalized or increasingly regionalized, and what consequences a more reactive versus a more proactive approach to managing ecosystems and their services could have.

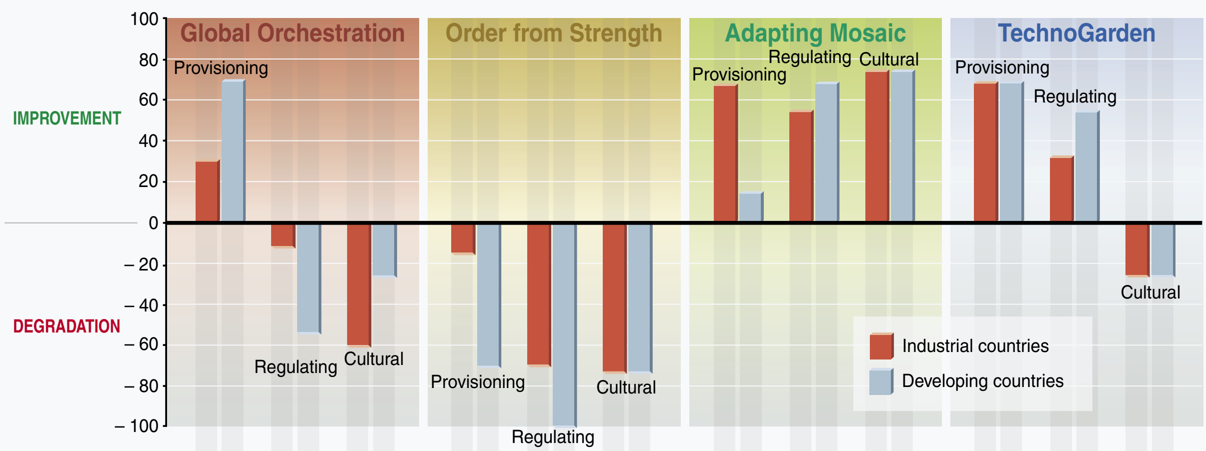
Each of the scenarios combines two possible directions these uncertainties can take. The so-called *Global Orchestration* scenario portrays a world with a "socially conscious" globalization that emphasizes economic growth, social reform, and equity, but decision makers take a reactive approach toward environmental problems. In the *Order from Strength* scenario, decision makers also only deal with environmental degradation when it starts to seriously affect humans (reactive); at the same time they focus on national security issues and economic improvements only for their own countries.

The two other scenarios depict a more environmentally conscious attitude. The *Adapting Mosaic* scenario shows the outcome of a focus on experimentation, local learning, and adaptations to ecosystem change and the introduction of more flexible local governance structures for environmental and social management, which overall leads to a more regionalized world. The *TechnoGarden* scenario in contrast explores the possibilities of "green" technologies to manage all categories of ecosystem services to support human systems in a more globalized world.

The outcomes for ecosystem services and human well-being components are illustrated below.

Net Changes in Availability of Provisioning, Regulating, and Cultural Ecosystem Services by 2050 for Industrial and Developing Countries. The y-axis is the net percentage of ecosystem services enhanced or degraded. For example, 100% degradation of the six provisioning ecosystem services would mean that all of these were degraded in 2050 relative to 2000, while 50% enhancement could mean that three were enhanced and the other three were unchanged, or that four were enhanced, one was degraded, and the other two were unchanged.

Changes in ecosystem services in percentage



Number of services																								
Enhanced	3	4	0	1	0	1	1	1	0	0	0	1	4	3	5	6	4	4	4	4	4	6	1	1
No change	2	2	8	2	3	2	3	0	3	0	2	0	2	1	4	3	0	0	2	2	4	2	2	2
Degraded	1	0	1	6	2	2	2	5	6	9	3	4	0	2	0	0	1	1	0	0	1	1	2	2

Source: Millennium Ecosystem Assessment

ecosystem management approaches are introduced that result in better environmental conditions; in addition, developing the local infrastructure and economy becomes a focus. However, the economy of Rio Grande grows at a slower rate as a result of decisions to invest resources in environmental issues rather than just economic issues.

Among the four global scenarios generated for the Millennium Ecosystem Assessment, there are significant differences in the status of ecosystem services 50 years from now: in one scenario overall ecosystem services degrade while in the other scenarios these services improve but to different degrees, depending on the chosen pathway.

Insights emerge from a process of questioning the assumptions made within one story or pathway and comparing its outcomes with another possible pathway into the future. This analysis can clarify what we know and what is uncertain about the future. It also sheds light on unexpected results of a particular pathway. In other words, the scenario analysis can reveal and help policy makers avoid the unintended consequences that often plague development projects.

Despite its benefits, scenario planning has important limitations. It can be time and resource consuming and requires the sustained commitment of the scenario building team over a substantial time horizon. In addition, scenario planning requires skilled facilitation, especially if contentious issues are discussed between stakeholder groups. Scenarios can also contribute to a false sense of certainty about the future, which is why careful use and dissemination is important. It should be stressed that scenario planning does not predict the future as it will actually take place, but instead highlights plausible futures, and particular assumptions and their consequences.

BENEFITS OF A SCENARIOS PROCESS

Decision makers often balk at the idea of building scenarios, usually because it is unfamiliar and the process and outcomes may be unclear. Once underway, however, scenario building is often described as exciting and productive. The tangible outcomes of the process, in the form of the storylines and analyses, can be used directly to inform decision making (Zurek and Henrichs 2007). In addition, the learning and communication that stem from the scenario development are often seen as being equally valuable to decision making (Wollenberg et al. 2000; MA 2005d).

The scenario building process has three primary benefits. First, participants of a scenarios exercise can gain a better understanding of interactions, assumptions about the future, and ecosystem service trade-offs. The scenarios process also creates a platform to talk across interest groups, disciplines, and philosophies. Finally, scenario development is a way of building trust and cooperation and of resolving conflicts among stakeholder groups in relation to ecosystem services and the choice of polices for sustaining services.

Table 4.3 **Rio Grande: Assumptions about Ecosystem Drivers and Resulting Changes for Two Scenarios**

Drivers *– arrow denotes whether the trend of a driver is increasing (↑), continuing (→) or decreasing (↓)*
Ecosystem service status *– arrow denotes whether the supply of the service in the future will increase (↑), stay the same (→) or decrease (↓) in the scenario*

	Scenario 1: We become globalized	Scenario 2: Communities first
Selected *indirect* driving forces of ecosystem change		
Population growth rate of the city	↑	→
Global integration	↑	→
Economic growth (GDP)	↑	→
Social equity	↓	↑
Technical change in agriculture	→	↑
Selected *direct* driving forces of ecosystem change		
Land use change in upper watershed	↑	→
Chemical input use in agriculture	↑	→
Outcomes for selected ecosystem services		
Food – crops	→/↓	↑
Fiber – energy (biofuel)	↑	→
Water quantity	→	↑
Water quality	↓	→/↑
Water regulation	↓	↑
Erosion control	↓	↑
Recreation & tourism	↓	→/↑

Understanding of interactions, assumptions, and ecosystem trade-offs

Some of the direct outcomes of scenario building are a greater understanding of the linkages between policy options and the impacts and dependencies on ecosystem services; the identification of beliefs and assumptions about how a policy or a chosen development pathway may alter some or all ecosystem services and in turn affect development goals; the identification of potential long-term consequences for ecosystem services of choices made in the near future; and the identification of factors important for a successful outcome of a decision.

Platform to talk across interest groups, disciplines, and philosophies

Uncertainty about the future has an equalizing effect: no one discipline or sector can predict the future. It requires the collaboration of scientists, governments, and citizens to piece together plausible stories about what *might* occur in the future. The result is a process that can accommodate thoughtful, creative, and non-threatening discussion about topics that are normally politically charged. Less powerful groups can be empowered through such a process and more powerful groups can gain invaluable insight into how their practices and policies affect other groups.

An example for this is the integrated ecosystem assessment in the Salar de Atacama, Chile, which led to several roundtable meetings to develop scenarios focused on the region's economic development. It was the first occasion for representatives from nearby mining companies and leaders of indigenous communities to sit down to discuss their ideas and conflicts. Francisca Greene, a local anthropologist who participated in the exercise, said that "this project's distinctive stamp has been the strong component of participation; participation not only in the sense of listening to and including the opinions of social stakeholders interacting in the Salar, but also [through] the methodology wherein the experiences and opinions that were developed were shared between everyone; they were used to build up the body of the project and as a tool with which to project the future." (H. Blanco, personal communication, 2007)

Building trust and cooperation and resolving conflicts

Scenarios can be used to air conflicts or build consensus among diverse stakeholders over what a desirable future might look like. Managing natural resources often involves trade-offs between different economic activities and values. Getting stakeholders around the same table to discuss their visions of future land management or economic development helps build understanding of these trade-offs and agreement on appropriate policy. When building and discussing scenarios, hidden values and assumptions are uncovered, highlighting potential shared values and the root of conflicts. Taking stakeholders away from the present day to focus on possible futures facilitates discussion, allowing participants to develop a greater understanding of each other's point of view. While there is no guarantee that increased mutual respect will carry over to resolving current conflicts, it increases that possibility. Such use of scenarios has been proposed as part of the development of catchment management strategies under South Africa's new water law (Rogers et al. 2000).

The mutual trust built around areas of common interest contributes to the development of beneficial partnerships. And public participation can generate important insights that contribute to the design of policies better suited to serving those concerned. Thus, a participatory process within the context of scenario planning can be used to challenge and influence the perceptions of both those in authority and those at grassroots. For example, in the Ban Mae Khong-Kha, Mae Chaem watershed in Thailand, competition and disputes for water were escalating as urban and industrial uses expanded in the lowlands and deforestation for high input monoculture increased in the uplands. Using scenarios, upstream and downstream indigenous communities, local authorities, and researchers came together to discuss the future of the watershed. As a result, the dispute was eased and local communities and administrators were empowered to plan for sustainable natural resource management (Thongbai et al. 2006).

Scenario analysis is a flexible approach that can help decision makers deal with uncertainties and assumptions about the future and to explore possible development pathways and long-term consequences of decisions taken today. Scenario planning does not necessarily produce new knowledge, but aims to clarify and re-assess what is or is not known about the decisions, processes, and dynamics that will shape the future. It should be stressed that scenario planning does not describe the future as it will actually take place, but instead highlights plausible futures, and particular assumptions and their consequences.

As with other environmental assessment tools, scenario results are most useful when they frame the real issues at stake and provide a credible set of results to help decision makers in choosing policies, as described in the next chapter. By employing participatory methods, policy makers and other stakeholders can develop new, unexpected insights into ecosystem service trade-offs and risks implied in possible "ways forward," which helps to create more support for implementing policy aimed at adapting to changing conditions.

ACTION POINTS

- Consider how the main unknowns and assumptions about the future may affect the outcomes of current development strategies and policies.
- Convene a group with the relevant scientific and local expertise to systematically think about the future.
- Consider how scenario planning might help the group to identify future trade-offs among ecosystem services and their consequences for different stakeholders.

Where the Mayor and the community explore the future

"This report card is looking good. Congratulations," said the Mayor. "But our greatest concern is the future. We want to know what will happen as the regional development unfolds."

"Unlike tomorrow's weather, in this case it is not possible to forecast," responded the Dean. "But we can *anticipate* what might happen if things go one way or another. We now know the current state of our region, the main trends that are transforming it, and the range of possible consequences of our decisions. Now we need to turn this information into plausible scenarios—stories about 'what might happen by 2030 if….' We cannot assume that the future will be like the past, and such scenarios will yield insights into our assumptions and the limits of our understanding.

"It's more or less like planning for the next election," the Dean continued. "You know what your approval rating is today, what is working and what is not, and you know the date of the next election. But you cannot know what your opponents will do or what surprises may happen along the way. We all wish we could predict the results of the election, but we can't, so you need to imagine several plausible turn of events and ask 'what if…?' By imagining alternative futures you will know how to react when the time comes."

The Mayor, and the whole Steering Committee, laughed. The Dean was one of the few people who could get away with making such fun of him.

"And for that we plan to organize a series of workshops with representatives of the affected communities," said the Secretary of Environment. "We hope all Steering Committee members will participate."

Visions of the future. That sounds good, thought the Mayor, imagining another flattering headline.

"We definitely don't want to go there," someone said after a prolonged silence. They had finished reading the third scenario, which did not tell a flattering story about the future.

Over the last three months, the Secretary of Environment and the technical team had conducted six workshops with different communities. Now they were presenting the results in the form of plausible stories about the future of Rio Grande. They had formed three groups: one with coastal and lowlands communities, mostly fishermen and community leaders from the poorer neighborhoods; another with NGOs, municipal authorities, and business representatives from manufacturing, tourism, and commerce; and a third one with highland farmers, timber producers, and national authorities.

All groups discussed the recent history of the region and voiced some similar concerns, for example: "Let's not forget that in the 1950s extreme poverty was unheard of in this region, and our forests were pristine. How did we go from there to all the social and environmental problems of today?" They also identified the expectations, problems, and uncertainties for the future related to the biofuel industry and the national plan for biofuel production. Participants engaged in lively conceptual discussions ("We need more growth! That's a necessary condition for improving the quality of life." "No! What we need is better development. Growth does not always lead to better lives; often the reverse is true!"). They also explored more down-to-earth questions: "What if the price of biofuels doubles? Who will stop land concentration, food prices, and deforestation then?" "What will happen to water quality and coastal fisheries?"

The groups then identified the main forces likely to shape the future and how they might evolve over the coming decades. "With more cultivated land there will be more fertilizer and pesticide input; with less forest the water flows will be affected; those are the drivers we must analyze," some said. "But those things are driven by globalization. It makes no sense to look at agricultural expansion without looking at international trade and new seed technologies," countered others.

"Let me tell you a brief history of the future," said the Professor to the Steering Committee as he began his presentation. "Remember that these stories are not predictions. They are just meant to help you think through the consequences of different types of decisions. My team has explored three scenarios. First, how might our region look in 2030 if the country becomes a full player in the global economy and we adopt a largely reactive approach to environmental issues? Second, what if the country adopts a more critical stance to globalization and focuses on community development with a more proactive approach to environmental issues? Third, what if patterns of inequality and authoritarianism prevail and environmental issues are addressed on a reactive basis?"

First scenario: We become globalized....

In 2010 international trade negotiations finally made headway, and the country gained better access to global markets. This external condition—the big potential for crop expansion—along with the existence of a growing port and relatively low labor costs provided a boost to the biofuel industry. Farmers and multinationals alike expected the demand for renewable energy to rise tremendously in the future, and the first biofuel refinery started operating in 2009, with two more completed by 2011.

The biofuel industry had a significant economic impact: it created more than 3,000 new direct and indirect jobs and attracted other industries to the city, but it also caused food prices to increase as more items had to be imported from other regions. In 2013 the port was expanded and a free trade zone was introduced in the harbor. Encouraged by these developments, a fish processing plant opened in 2014, and larger vessels operating in the open seas started unloading their catches for processing in Rio Grande. In 2017, the first "dead zone" was detected in the estuary as high quantities of nutrients from the upstream crop expansion flowed down the river, and despite a campaign to save the mangroves the damage was already irreparable, with climate change helping to finish them off. Regional GDP grew and poverty dropped, although inequality remained high. Population almost doubled between 2000 and 2025.

With all this economic progress, the city offered more services, although previously rare social problems, such as violent crime, began to multiply along with the population. Also, by the year 2025 tourism had been reduced to a trickle as once attractive coastal and forest areas were degraded. Water quantity and quality became the single most serious problem for the city administration as too much nitrogen and pesticides were washed down the river, and waste water from the growing industries polluted the lower river and coastal areas. Most small farmers were now working in the city industry or had gone elsewhere as the competition for land had grown. As the global and regional climate changed, the region saw an increase in precipitation, which coupled with land use change upstream resulted in frequent flooding and landslides. The government spent large amounts building flood control infrastructure. By 2030, Rio Grande looked very much like a growing middle-income industrial city.

Second scenario: Communities first….

After the natural disasters in 2006 many citizens concluded that the problem was not just climate change and increased precipitation, but also the way land was used in the watershed, in particular the type of agriculture and the shrinking forest cover. These changes were connected to consumption in the city—for instance, the demand for meat had risen, leading to an expansion of chicken, cattle, and hog farms around the city, which in turn had driven up demand for feed maize cultivated by upstream farmers. This increased demand together with strong external markets lead to an expansion of the area grown under maize. Soil erosion, including landslides, became a significant problem. Research and extension programs were launched to test and implement improved land management methods. These experiences focused on the integrated management and monitoring of all ecosystem services produced in the area. Also, new incentive mechanisms were explored for farmers to change their land management, such as new income possibilities from eco- and agri-tourism or payments for improved water quantity and quality.

After much research and public debate, the Regional Sustainable Biofuel Plan was turned down in 2011. New funding from international and national sources allowed massive implementation of ecosystem friendly management practices, including a more systematic monitoring of the environment, soil erosion control measures, organic farming, and integrated pest management, which by 2020 were widespread practices. Overall regional growth was slow but steady; poverty, measured as income per head, was reduced only slowly as new income opportunities grew from tourism and small industrial developments. But inequality diminished and environmental quality improved significantly, reflected in a better quality of life, especially for the poor. By 2030, the region was a quilt, where agriculture, forestry, artisanal fishing, and undisturbed natural areas coexisted with a medium-sized city whose income came from a diversified base of services, agriculture, and small industry.

The Professor went on to describe the third scenario, a story of social and environmental distress that some thought was unduly catastrophic, and others very realistic.

Unexpectedly, the scenarios attracted a lot of media attention, and things got tricky in the Steering Committee. NGOs used the negative scenario to warn what might happen if the Regional Sustainable Biofuel Plan was implemented. The business sectors felt this was a betrayal to the process and threatened to withdraw, and the Professor worried about the way in which the scenarios were being interpreted. The Secretary of Environment realized she had made a big mistake by not establishing as a rule in the Committee that no information would be made public until the reports had been approved.

The Mayor was not happy – he did not like it when others had the upper hand. Yet, he thought the process had gone very well and that Steering Committee members were too engaged to allow it to founder now. He saw the crisis as an opportunity to show himself as a statesman, reconciling opposed interests for the common good.

He got the NGOs, business leaders, Bishop, and Dean to hold a joint press conference. "As you have seen from the news these last days, we face a transcendent decision for our city. All of us at this table are concerned with our common future…."

The conference was a success, and now even the national press was waiting for the reports. Moreover, the observer from the Ministry of Natural Resources had been reporting back to the capital and was now suggesting a stronger involvement of the national government and the neighboring municipalities. "We must involve the other jurisdictions. They will be making decisions directly relevant to you. I can facilitate an approach to them," he had told the Mayor in private.

At the next Steering Committee meeting all agreed they would not reveal any substantive information until the reports were approved, and the process completed without further problems.

CHAPTER 5

Lead Author
Frances Irwin

Contributing Author
Janet Ranganathan

Choosing Policies to Sustain Ecosystem Services

Achieving development goals—whether reducing poverty or building an agricultural export industry—depends on and affects the health of ecosystem services. This chapter outlines four steps for choosing and implementing policies to sustain the ecosystem services that underlie development:

- Use the findings from the assessment of ecosystem services (chapter 3) and learnings from the scenarios (chapter 4) to revise a development strategy by taking ecosystem service risks and opportunities into account;
- Review the range of policy options available to influence the drivers of change in ecosystem services;
- Choose policies based on their effectiveness in influencing the drivers of ecosystem change; and
- Adopt a learning approach to implementing policies.

INCORPORATE ECOSYSTEM SERVICE RISKS AND OPPORTUNITIES INTO DEVELOPMENT STRATEGIES

A development goal and initial assumptions about a strategy to achieve it steer the early stages of decision making. In the Rio Grande story, a national policy to encourage production of biofuels triggers a proposal to build a biofuel plant in the city. At the same time, the mayor rates the need to stop flooding and supply clean water as high priorities in building a livable city.

Before choosing policies, a decision maker such as the Mayor needs to take stock of what he has learned during earlier phases of the decision process by taking an Ecosystem Services Approach. The risks and opportunities that stem from ecosystem service impacts and dependencies and insights from scenarios will both help answer the following questions useful in framing the revision.

KEY LEARNINGS

Development strategies can incorporate risks and opportunities to help maintain ecosystem services.

Can the strategy be revised to reduce or manage its impacts on ecosystem services?

Many countries such as Thailand have converted many of their mangroves to shrimp farms in recent years to meet export demand, as described in chapter 1. The loss of mangroves and the spawning grounds they provide for fish, combined with pollution from shrimp farms, degrade local capture fisheries and the capacity of mangroves to protect against storms. Impacts such as these can have disproportionate effects on some parts of society, particularly the poor living in coastal communities. To address these impacts, aquaculture strategies can be revised to be more sustainable through the use of certification programs. Government and large retailers can help drive certification by adopting sustainable procurement policies. For example, Wal-Mart, a major purchaser of shrimp from Thailand, plans to only purchase shrimp from farms certified under standards drawn up by the Global Aquaculture Alliance (Hudson and Watcharasakwet 2007; Phillips and Subasinghe 2006).

The Rio Grande scenarios illustrate that if farmers convert large amounts of land now forested to growing crops for biofuel, the watershed's ability to control floodwaters and filter drinking water would be further reduced. Runoff of fertilizer and pesticides after storms would likely damage water quality. Thus further land conversion would likely require that the city substitute expensive physical structures for the waste treatment service previously supplied by ecosystems. Rio Grande could work with partners to revise the approach to biofuels by introducing a Regional Sustainable Biofuel Plan to incorporate measures such as protecting wetlands and requiring best management practices that avoid or reduce runoff from pesticides.

Can the strategy be revised to reduce its dependence on ecosystem services by using them more efficiently?

Increasing efficiency can often be a part of strategies that depend on provisioning ecosystem services. For example, production techniques may be improved to use all parts of a provisioning service such as timber previously wasted but now used to make mulch or composite board, or as a source of energy in wood-fired boilers. However, if increased efficiency is associated with an increase in production it will not reduce dependency.

The national biofuels goal focused on increasing biofuels production in the Rio Grande story. It did not address ecosystem services. Preparation of the Regional Sustainable Biofuel Plan offers a chance to take advantage of the opportunities to reduce the strategy's dependence on the provisioning services of freshwater and land. Alternative technologies for biofuel production can minimize water quality problems and cropland expansion at the expense of food production. For example, emerging cellulosic technology allows for the joint production of food and fuel with the same crop by using previously unused fibers for fuel.

Can the strategy be revised to increase the supply of ecosystem services that it depends on or affects?

Opportunities to increase the supply of ecosystem services often involve creating economic or other incentives for those in a position to restore, maintain, or enhance services. This may mean paying people to sustain ecosystem services (such as paying farmers to reduce nutrient runoff into waterways) or investing in actions that restore ecosystem services.

Investing in ecosystem restoration is the approach being taken in Panama. Navigation of the Panama Canal saves weeks and millions of dollars in shipping, but it depends on a steady supply of water and a clear shipping channel. Deforestation of lands surrounding the canal threatens its operations by increasing erosion rates, causing the canal to fill with silt, and disturbing natural runoff rates, making water levels in the canal more erratic. ForestRe, a specialist insurance entity, realized that the cost of restoring forests around the canal was less than the costs that major shipping and insurance companies faced in the form of higher premiums and the risk of paying claims if the canal had to be closed. The company has convinced insurance providers and companies that rely on the canal to finance reforestation to increase erosion control and water regulation services.

Reformulating a strategy will often lead to rethinking who is included in the process of selecting policies. In New York's decision to continue to rely on watershed filtration rather than build a treatment plant, a Coalition of Watershed Towns emerged to provide a voice for 30 towns west of the Hudson River. The towns feared that this strategy would result in stifling economic development, reducing property values, and eroding the local tax base (Finnegan 1997; Schneeweiss 1997). Townspeople became key participants along with environmental organizations and government agencies in negotiating the next stage of policy, leading to compensation for land use restrictions to protect the city's water supply.

Once a strategy has been revised to take into account ecosystem service risks and opportunities identified in the assessment and scenarios, the decision maker is ready to look at specific policy options to sustain ecosystem services.


©ISTOCKPHOTO.COM/MILOS PERIC

Forests provide the Panama Canal with erosion control and water regulation services, helping to keep the waterway open for business.

REVIEW THE LEGAL FRAMEWORK AND POLICY OPTIONS FOR SUSTAINING ECOSYSTEM SERVICES

Growing experience demonstrates how policies focused on ecosystem services can become an integral part of development strategies. After briefly reviewing the important role of the existing legal framework, this section outlines the range of policy options for sustaining ecosystem services.

Legal framework

A government's laws provide the framework for adopting and applying policies to sustain ecosystem services. They may be national or sub-national laws that govern ownership, taxation, and use of land and natural resources. In some cases, international agreements establish basic principles. National constitutions often guarantee the rights of citizens to obtain information and to take part in decision making. Local communities can use these rights to participate in and hold government agencies accountable for decisions affecting ecosystem services.

Laws governing who owns and who can use land and other resources are particularly important for ecosystem services. If the law is not clear about who has access—for instance, to a forest and its products—the law may need to be amended before policy to safeguard ecosystem services can be put in place. If farmers are to be paid for maintaining woodland, their legal access to the land needs to be clear. This is one reason some countries have revised their laws to provide a clearer role for local communities in managing forests and fisheries (WRI et al. 2005:93).

The legal framework often mandates how ecosystem services may be used and how human activities—the drivers of change—that affect services are managed. In some cases, particular uses of a resource may be subsidized to encourage, say, production of a crop like corn or cotton. In a coastal area, construction may be limited but recreation encouraged by zoning the land for that use. Land may also be designated as a government-owned forest, an agricultural reserve, or a protected area for wildlife and biodiversity.

Laws also determine how particular activities may be carried out. They may require an environmental impact assessment before a project can be undertaken. They may control how a resource such as a forest or water can be used. They often set overall goals and establish a licensing or permitting program to achieve them. South Africa's National Water Act provides an example of how laws may be written to recognize the importance of sustaining ecosystem services. It sets out guiding principles of sustainability and equity in the "protection, use, development, conservation, management, and control of water resources." For any significant water source the law establishes both a human-needs reserve for the essential needs of individuals (drinking water, food preparation, and hygiene) and an ecological reserve to protect aquatic ecosystems, which the government is required to determine. It may issue water use licenses for periods of up to 40 years (Department of Water Affairs and Forestry 2007).

The capacity to enforce laws and avoid corruption is a crucial element in making the legal structure effective. Laws are more likely to be effective when accompanied by strong education policies, economic and financial incentives that align behavior with laws, indicators of performance and transparency, clear management standards, and investment in environmental and natural resource management (Irwin and Ranganathan 2007). These are among the policy options discussed in the next section.

GETTY IMAGES

The rule of law plays an essential role in sustaining ecosystem services.

Policy options

KEY LEARNINGS
Policies can spur investment in ecosystem services.

As discussed in chapter 1, ecosystem services come into play in any of a wide range of policy processes. A decision maker may be devising a tax policy, a poverty reduction or water management plan, incentives for adopting new energy technology, or a set of indicators for the economy. Such instances need to include policies addressing ecosystem services. A growing list of policies that show promise of sustaining ecosystem services has emerged (see Table 5.1). As experience increases, the list can be updated through a process that allows users to share their learnings. The policies fall into four categories, corresponding to the entry points introduced in chapter 1: national and sub-national policies, economic and fiscal incentives, sector policies, and governance. Some options can be considered in more than one category. For example, easements can be viewed both as an economic incentive and as a sector policy.

CHOOSE POLICIES TO SUSTAIN ECOSYSTEM SERVICES

After analyzing existing legal frameworks and reviewing the range of policy options, a decision maker is ready to select the most effective mix of policies for carrying out a development strategy. This section presents six criteria to consider when choosing policies (see Table 5.2). It then illustrates how Rio Grande might select the policies to address the ecosystem driver of land conversion.

With these design criteria in mind, a decision maker can select the policy options in Table 5.1 that will most effectively sustain the capacity of ecosystem services to meet the needs of people and in doing so strengthen the development strategy.

In Rio Grande, the Secretary of Environment and her staff are likely to focus on approaches to limit the risks of flooding and pollution and to take advantage of opportunities to increase the supply of water filtration services from forests

Table 5.1 Policy Options for Sustaining Ecosystem Services[1]

Policy Option	Potential value for sustaining ecosystem services	Challenges in design and implementation	Examples of experience
National and sub-national policies			
Mainstream ecosystem services into economic and development planning	Addresses indirect drivers of ecosystem change over the longer term by including ecosystem services in poverty reduction strategies, national economic and development plans, or country assistance strategies	Overcoming separate agency mandates, integrating different skills and perspectives, aligning with other policies such as financial and economic incentives	Tanzania's 2005 National Strategy for Growth and Reduction of Poverty explicitly recognizes many of the drivers of ecosystem service degradation as impediments to poverty reduction. The strategy sets goals to address these drivers, establishes a set of poverty-environment indicators, and includes 15 environmental targets (Assey et al. 2007).
Include investments in ecosystem services in government budgeting	Makes the crucial link between policies focused on ecosystem services and providing funds to carry them out	Improving ability to value and integrate ecosystem services in cost-benefit analysis and identifying specific investments to sustain them	UK Treasury drew on the Millennium Ecosystem Assessment in preparing its Comprehensive Spending Review of government funding. Notes that Assessment is relevant to achieving sustainable growth, employment, security and equity, and that Treasury will aim to release resources to meet environmental challenges (UK House of Commons Environmental Audit Committee 2007).
Establish protected areas	Helps protect ecosystems and their associated services from drivers of over exploitation and conversion	Incorporating goal of sustaining ecosystem services into site selection, linking biodiversity conservation and sustaining ecosystem service goals Including local communities, taking a landscape approach that recognizes drivers of change outside the protected area, and ensuring financial sustainability	In 1986, St. Lucia designated marine reserves with the involvement of local people and businesses, leading to regeneration of mangrove forests (WRI et al. 2000:176-77). In 1993, Austria established 20-year contracts with all forest owners requiring them to protect the land. Financial compensation was offered to owners who lost income (Hackl and Rohrich 2001).
Economic and fiscal incentives			
Use tax deductions and credits to encourage investment in and purchase of ecosystem services	Provides economic incentive to manage ecosystems in ways that sustain services	Avoiding equity problems or protecting one service at the expense of others	U.S. law gives landowners tax deductions for donating conservation easements, which restrict use of the property to protect associated resources (House 2006).
Establish fees for use of resources or services	Reduces waste of resource	Avoiding equity issues, where those with lower incomes are less able to pay and balancing number of users	In Colombia, Cauca Valley water associations voluntarily agreed to increase user fees paid to the local utility in exchange for improved watershed management. The associations aim to improve stream flow for the benefit of agricultural producers (FAO 2002).
Use taxes or other public funds to pay for the maintenance of regulating and cultural services	Creates economic incentive to supply services that do not normally have a market value	Maintaining one service at the expense of others, avoiding creating equity issues such as loss of harvest rights or ineligibility because of lack of tenure Depending on still emerging market infrastructure such as quantification, verification, and monitoring tools Informing public about use of funds to provide accountability	The UK Nitrate Sensitive Areas (NSA) Scheme uses direct government payments to compensate farmers for adopting management practices that reduced leaching of nitrates into groundwater (IUCN 2007). A Costa Rican fund mainly from fuel tax revenues pays forest owners for watershed protection (Perrot-Maître and Davis 2001). Belize charges foreign tourists a conservation fee, which funds a trust dedicated to the sustainable management and conservation of protected areas (Conservation Finance Alliance 2003).
Reduce perverse subsidies	Removes incentive for intensive production of provisioning services at expense of other services	Overcoming vested interests in maintaining subsidies, creating mechanisms to transfer reduction in subsidies to payments for maintenance of regulating and cultural services	As a result of eutrophication of waterways and threats to drinking water supply, many Asian countries have reduced fertilizer subsidies, including Pakistan (from $178 million to $2 million per year), Bangladesh ($56 million to $0), and the Philippines ($48 million to $0) (Myers 1998).

[1] Brianna Peterson provided many of the examples of experience included in this table.

Table 5.1 Policy Options for Sustaining Ecosystem Services (continued)

Policy Option	Potential value for sustaining ecosystem services	Challenges in design and implementation	Examples of experience
Economic and fiscal incentives (continued)			
Set limits and establish trading systems for use of ecosystems and their services	Achieves more cost-effective improvements in ecosystem services than conventional regulatory approaches	Ensuring limit is stringent enough to provide an incentive to participate Allocating permits or credits in cases of unclear property rights Keeping transaction costs manageable, especially for non-point sources	In 1980, New Jersey established Tradable Pinelands Development Credits to limit development in environmentally sensitive areas and allow prospective developers to trade for development rights on available land (Landell-Miles and Porras 2002). In 1999, Australia established a Water Transpiration Credits Scheme, to reduce river salinity (Brand 2005). Under its National Water Initiative, Australia sets limits on water use in the Murray Darling Basin and, as of January 2007, the basin states are able to buy and sell permanent water entitlements (Parliament of Australia 2006).
Fund valuation of ecosystem services and research into improving valuation methods	Increases societal awareness of the value of ecosystem services and strengthens cost-benefit analysis for public decisions	Dealing with techniques for valuing ecosystem services that are still in their infancy Discrediting ecosystem service approach by overestimating values	A study found Canada's Mackenzie Watershed's 17 ecosystem services worth nearly $450 billion undisturbed, offering new perspective of economic benefits and costs of proposed gas pipeline (Canadian Parks and Wilderness Society 2007). A study found that on a single Costa Rican farm natural pollination by insects increased coffee yields 20 percent on plots that lay within a kilometer of natural forest, service worth approximately $60,000 (Rickets et al. 2004).
Use procurement policies to focus demand on products and services that conserve ecosystem services	Creates incentives for suppliers to adopt approaches that are ecosystem friendly	Avoiding high transaction costs of demonstrating responsible behavior Implementing cost- effective monitoring and verification systems	UK Government timber procurement policy stipulates timber must come from legal and sustainable sources (CPET 2007).
Support wetland banking schemes	Provides way of maintaining overall services provided by wetlands by requiring substitution by developers	Ensuring that substituted wetlands are of equal value to those destroyed Ensuring equity for local populations who lose services	Wetland banking schemes in California allow developers who destroy wetlands to offset the environmental damage by paying to protect a sensitive wetland in another location (Office of Policy, Economics, and Innovation and Office of Water 2005).
Sector policies			
Include ecosystem services in sector policies and strategic environmental assessments	Goes beyond addressing impacts of economic development to look at dependence on services Broadens scale of analysis	Dealing with limited experience of public sector using Ecosystem Services Approach in decision processes and limited information on ecosystem services	South Africa's Working for Water Program combines social development goals of job creation and poverty relief, and agricultural goals of increasing productivity of cleared lands, as well as ecosystem rehabilitation goals of eradicating alien species and restoring stream flows (Department of Water Affairs and Forestry 2007).
Set targets to encourage use of renewable energy	Provides incentive to replace fossil fuels with renewable sources	Using land to produce renewable energy sources such as biofuels can lead to soil erosion and degradation of ecosystem services such as water quality	Under the UK Renewable Transport Fuel Obligation, transport fuel suppliers must ensure a proportion of their fuel sales is from renewable sources, as of 2008 (Commons 2007).
Require ecosystem management best practices in granting licenses or concessions	Creates incentives for managing ecosystems in ways that sustain ecosystem services	Defining and enforcing best practice standards	Cameroon's 1996 Forest Code calls for all commercial logging to be regulated under designated forest concessions. This legislation establishes rules for concession allocation, local distribution of forest revenues, as well as requirements for submitting and gaining approval for forest management plans (WRI 2007).
Use zoning or easements to keep land available for priority ecosystem services	Provides way to maintain priority ecosystem services	Needing legal framework in place and fair political process to apply zoning	Some flood plains are zoned for uses such as recreation or agriculture rather than housing or commerce. Easements can be used to keep land available for cultural and regulating ecosystem services.

Table 5.1 Policy Options for Sustaining Ecosystem Services (continued)

Policy Option	Potential value for sustaining ecosystem services	Challenges in design and implementation	Examples of experience
Sector policies (continued)			
Use physical structures or technology to substitute for ecosystem services	Provides a substitute for degraded ecosystem services that may mimic natural design	Building structures such as sea walls to substitute for ecosystem services such as coastal protection often simply shifts the problem, distributing costs and benefits unfairly, fostering false confidence, and providing only a single benefit rather than multiple benefits of ecosystem service	Seattle's street edge projects mimic natural ecosystems, reducing storm water runoff by 99 percent. Roof gardens also reduce runoff (Seattle Public Utilities 2007). Dikes and levees substitute for coastal protection. Sea walls avoid coastal erosion.
Use regulating ecosystem services such as natural hazard protection or water filtration instead of built structures	Usually provides co-benefits such as carbon storage and recreation	Procuring time and funds for negotiations and continued maintenance Dealing with limited knowledge about ecosystem service flows, especially for regulating and cultural ecosystem services	New York City protected its watershed instead of building a filtration plant (US EPA 2007b). Reforestation and conservation of mangroves in coastal areas affected by the 2004 tsunami can help prevent future damage (UNEP-WCMC 2006).
Establish certification schemes that encourage best management practices	Provides those growing or harvesting timber, fish, or crops a way to learn about best management practices and to demonstrate use of the practices	Ensuring development of transparent, scientifically valid standards and their adoption Paying transaction costs that may limit participation Informing consumers	U.S. Department of Agriculture provides farms with organic certification (USDA 2006). Forest Stewardship Council provides certification for sustainable timber harvesting practices (US FSC 2006). In the Pacific U.S. states, "Salmon-safe" certifies farms and urban land that practice fish-friendly management (IUCN 2007).
Introduce education or extension programs on good practices	Provides knowledge to those maintaining ecosystem services	Providing economic incentives for participation	U.S. National Conservation Buffer Initiative educates farmers to control pollution by using filter strips and other measures such as wind barriers (USDA NRCS 2007).
Develop and encourage use of products and methods that reduce dependence and impact on ecosystem services	Reduces degradation of ecosystem services by avoiding harmful substances or using services more efficiently	Evaluating potential negative trade-off, such as organic agriculture potentially requiring use of more land, which could lead to further habitat conversion.	Drip irrigation in Israel allows for more efficient use of water for agriculture (Sandler 2005). Rainwater harvesting practices increase the supply of drinking water in parts of India (CSE India 2004). Organic agriculture reduces negative impacts on soil and water by avoiding agrochemicals.
Governance			
Clarify or strengthen local community rights to use and manage ecosystem services	Ensures involvement of stakeholders who may depend on ecosystem services for their immediate livelihood and well-being	Identifying who represents the community, clarifying the role of traditional authorities, ensuring that women and the poor are included	Vietnam's 1994 Land Law allows organizations, households, and individuals to manage forests for long-term purposes. Some one million families living in upland areas have managed five million hectares of forest. This decentralization has resulted in an increase in protected forests as well as an increase in the benefits the people gain from the forests' services (FAO 2000).
Develop and use private and public sector indicators for ecosystem services	Provides information about the state of ecosystem services and shows where practices need to be changed	Obtaining funding to develop ecosystem indicators and continued funding to disseminate and use data on regular basis	The European Union makes indicators on natural resource management publicly available online (Eurostat 2006). Silicon Valley Environmental Partnership provides indicators and tracks local trends to foster more informed decision making (Silicon Valley Environmental Partnership 2007). Global Reporting Initiative standards for corporate sustainability reports require companies to report on water and natural resource use (GRI 2007).

Table 5.1 Policy Options for Sustaining Ecosystem Services (continued)

Policy Option	Potential value for sustaining ecosystem services	Challenges in design and implementation	Examples of experience
Governance (continued)			
Establish processes to work across levels of government, from local to national	Shifts focus to boundaries of ecosystem services rather than boundaries of government jurisdictions, uses complementary authorities, skills, and resources of different levels of government	Requiring transaction costs and time for building partnerships	In Samoa, 40 local communities work with national agencies to co-manage fisheries. National government provides legal authority, research, market information, credit, and transport. Local communities have clear rights and authority to manage local fishery under a management plan (WRI et al. 2005:93).
Ensure public access to information and participation	Allows the public to hold public and private actors accountable for their actions in relation to ecosystem services	Requiring investment in building the capacity of individuals, civil society, and government to produce, analyze, disseminate, and use information and to engage effectively in decision making	Evaluation of Brazilian ecological tax system recommends making amounts transferred public so local governments can be held accountable for their use (WWF 2003).

Except where noted, examples adapted from MA 2005d:11-21.

Table 5.2 Design Criteria for Selecting Policies

Criteria	Factors to consider
Political viability	Does the decision maker have the political capital to undertake a major initiative? Does the public understand the issue and support action to address it? What is the range of interests that would be affected?
Legal authority	Is the legal framework for adopting and carrying out the policy in place? If so, does the decision maker have authority or would it be necessary to build a partnership with another government body that has authority?
Economic viability	Is the policy cost-effective for society as a whole? For those who must change their behavior?
Effectiveness	Does the policy force action that is capable of modifying the direct and indirect drivers of ecosystem change? Is it possible to set an incentive such as a tax credit at the appropriate level to change behavior? Can the results of the policy be measured and used for accountability and to change course as appropriate?
Equity	Is the outcome fair to all stakeholders? If there are "losers" under the policy, how will they be compensated?
Institutional capacity	Is adequate capacity and funding in government and other participating groups available to implement the policy? If the policy requires working across scales and/or sectors, is there a mechanism to do so, or can one be created?

Source: Adapted from MA 2005b; U.S. Congress Office of Technology Assessment 1995.

and wetlands, as well as food for the city's growing population (see close of chapter 3). The staff learned from the process of developing the scenarios that policies to address the driver of land conversion are likely to be important. To foster discussion of options that address land conversion, the staff goes through Table 5.1 and prepares a list of potential policies and a description of how they might apply in Rio Grande (see Table 5.3).

As they consider the options, the Secretary's staff employs the policy design criteria to consider further how each of these policies might help achieve Rio Grande's development goals. For example, they examine how establishing protected areas might ensure that lands particularly valuable for water filtration and flood protection are not converted to housing, commercial development, or row crops that increase runoff (see Table 5.4).

In practice, any strategy for sustaining ecosystem services is likely to require a mix of policies. In the case of Rio Grande, the Regional Sustainable Biofuel Plan involving the national government and the surrounding municipalities might decide to designate some wetlands as protected areas and set up a program to pay farmers not to plant row crops on land valuable for water filtration.

Any decision maker is likely to need to obtain information about the value of key ecosystem services and to raise public awareness among colleagues and the public on the importance of ecosystem services. In the story, *The Rio Grande Report* serves

Table 5.3 Policies to Reduce Land Conversion in Rio Grande Watershed

Policy option	Application to Rio Grande
National and sub-national policies	
Mainstream ecosystem services into development planning	Are there goals for maintaining areas of wetlands and forests in any existing national or regional development plans? Is there a map showing the location of wetlands and forests? Might city use leverage of issuing biofuel refinery license to persuade national government to support development of a sustainable biofuels plan that incorporates investment in conserving wetlands and forests?
Include investments in ecosystem services in government budget	Provide funding for national, provincial, and city agencies to monitor ecosystem services and play active role in partnering to develop and apply policies to sustain services.
Establish protected areas	Establish protected areas for a few key coastal wetlands where mayor has authority (may be too expensive for land already owned by developers). Work with province to encourage non-governmental conservancy group to purchase key wetlands in upper watershed for natural area. Explore with government forest agency potential for establishing protected area in key forest tracts.
Economic and fiscal incentives	
Use taxes or other public funds to pay for the maintenance of regulating and cultural services	Allocate a percentage of city tax funds to go to landowners of coastal wetlands. Provide payments to watershed landowners and encourage other jurisdictions, perhaps province, to do so. Need to decide who pays tax: those who benefit from clean water and flood protection or those whose actions degrade the service. Taxing biofuel sales or exports is one possibility.
Reduce perverse subsidies	Both food and biofuel now subsidized. Work with national government to limit biofuel subsidies to biofuel technology less damaging to ecosystem services and shift food subsidies to flood protection and water quality.
Set limits and establish trading systems	Suitable for managing pollutants such as nitrogen or phosphorus from fertilizer use or waste treatment. Requires capacity to quantify and monitor and legislative framework for caps.
Fund valuation of ecosystem services and research into improving valuation methods	Explore government funding of local university to determine economic value of ecosystem services provided by wetlands and forest in watershed.
Use procurement policies to focus demand on products and services that conserve ecosystem services	Check to see if program is available to certify sustainable agriculture and/or biofuel production. If not, could work with NGOs and university to take lead in developing national or regional approach. City could promote use by adopting its own procurement policy.
Sector policies	
Include ecosystem services in sector policies, plans, strategic environmental assessments	Recommend national or provincial government do strategic environmental assessment for agricultural sector's shift to biofuel cultivation.
Require ecosystem management best practices in granting permits or concessions	Use licensing of biofuel refinery to leverage best management practices in the watershed and to raise funds to help pay cost.
Use zoning or easements to keep land available for priority ecosystem services	Likely to be a key policy tool. Less expensive than purchasing wetlands. Could be used to keep riverbanks and key wetland areas out of crop production. Also, consider zoning of some coastal wetlands. Will need to work with watershed and neighboring towns.
Use physical structures or technology as substitute for human physical structures	Look at amount and sources of funding for water treatment plant. Consider how cost/benefit analysis compares with investments in ecosystems to provide similar services.
Develop and encourage use of products and methods that reduce dependence and impact on services	Fund research on biofuel cellulosic technology to reduce competition of crops for fuel versus food. Will private companies or the state fund? Combine with incentive or legal requirement to get widespread adoption of precision and no-till agricultural practices for food and biofuel crops, perhaps through watershed or national plan.
Governance	
Develop and use private and public sector indicators for ecosystem services	Develop public indicators of wetland and forest conversion. Work with province or national agencies to include indicators in biannual report on state of ecosystem services. Otherwise start with pilot for city and watershed. Encourage NGOs to use as basis for public education campaign.
Establish processes to work across levels of government, from local to national	Set up working group with other agencies. Collaborate with water agency to map wetlands and with agricultural agency to develop more efficient technology for water and fertilizer use.

Table 5.4 Design Criteria for Proposed Policy Option: Establish Protected Areas

Design criteria	Application to Rio Grande
Political viability	Some real estate developers will oppose setting up protected areas in Rio Grande and some farmers are likely to object to protecting parts of the watershed. Would need to work with communities who need clean water and flood protection, ecotourism groups who would benefit from birds, fish, and wetlands aesthetics and to ensure availability of land for housing for fishing community and for tourists.
Legal authority	Would need to investigate who has authority to designate protected wetlands. Do cities have authority within their boundaries? How about the province or national ministries?
Economic viability	Could be too expensive to purchase much of the remaining local wetlands unless national government or a private group helps. Recent storm damage may help persuade some people in the city of the economic importance of protecting these areas, but other land needs to be available to substitute.
Effectiveness	Would probably sustain ecosystem services of flood protection and water quality as well as cultural services. Need to consider balance between purchasing the most important wetlands and perhaps paying farmers and fishers to maintain other areas for water filtration and natural hazard protection.
Equity	How would farmers, fishers, real estate industry, and others be affected by designating wetlands? Farmers would lose ability to convert some land to biofuel crops. Real estate investors would lose some land for hotels. Both farmers and investors might be encorged to use wetlands as a base in building ecotourism. Fishing community should benefit as coastal wetlands provide nursery for fish.
Institutional capacity	Would need to build capacity to map and designate wetlands in private or public institutions and also to monitor. Might national resource agency fund university to train fishing community to monitor use of protected wetlands?

this purpose. If political capital is limited, the educational process may take much longer and may entail building institutional capacity and funding research. Non-governmental groups can play a role convincing the public that the degradation poses a threat. In-depth attention to all the criteria for selecting a policy can lead to success even when the overall political situation is unfavorable (see Box 5.1).

As the Rio Grande story illustrates, political bargaining plays a crucial role in making it possible to adopt development policies that address the major drivers of ecosystem change such as migration, pollution, land conversion, and technology. Adoption of new policies often becomes possible after a crisis as political leaders become convinced and the public becomes more aware of the need for action in a time of rapid ecosystem change. In the Rio Grande story, circumstances after the flood appear right for ambitious policy change, as the mayor provides the political leadership.

ADOPT A LEARNING APPROACH TO IMPLEMENTING POLICIES

While experience is growing, there is still much to discover about implementing policies aimed at sustaining ecosystem services. Therefore, taking a learning approach is essential, especially as the policy context differs from place to place. An evaluation of a project in the Virilla watershed in Costa Rica, for example, found payments to farmers were reducing land degradation and improving water quality. They were also providing landowners with opportunities to start ecotourism ventures. However, the project was not reducing poverty in poorer households because smaller farmers usually could not participate (IUCN 2007:46). To accomplish this goal, the project needed to change its approach.

Box 5.1 Taking a Broad, Sustained Approach: Vittel's Experience

Vittel, located in France, is one of the world's best selling brands of bottled water. In the early 1980s, the company was facing nitrate contamination in the source of its water. Buying the land was not an option because the law did not allow purchase of agricultural land for non-agricultural purposes. Buying land would also have caused social protests. Instead, the company performed detailed analyses of the region's farming practices, modeling and testing the link between the ecosystem service of water filtration and management practices over four years.

It worked closely with each farmer to negotiate payments for specific changes in management practices, including substituting raising hay and alfalfa instead of maize for animal feed, reducing the number of cattle per acre, giving up agrochemicals, and modernizing farm buildings. Payments were linked to new farm investment and the cost of adopting the practices. A group led by a champion of the farmers organized and represented them in negotiations with the company.

An analysis of the corporate-led program concluded that it was successful because it took a broad, long-term approach. It addressed political, social, economic, legal, and communication issues in an integrated way. The analysis notes that government agencies have been less effective in addressing similar challenges because specialists in livestock, plants, and other areas usually offer short-term, narrow technical approaches (Perrot-Maître 2006).

KEY LEARNINGS
A learning approach is essential in implementing policies.

DAN TUNSTALL

An agriculture specialist examines seed from crop of pearl millet on a farm in Tambhol Village in India.

As policies are chosen, decision makers need to agree on how the effects will be monitored and fed back into adjusting the strategy for sustaining ecosystem services and achieving the development goal. This section focuses on two key aspects of learning: planning monitoring so that it strengthens existing monitoring systems and using the data to make course corrections.

Strengthen existing monitoring systems

Most countries have processes in place to track the state of their environment. When designing a system to monitor implementation of policies to sustain ecosystem services, it is important to build links to these existing systems.

In addition, it is important to standardize the parameters used to measure ecosystem change and policies' effectiveness. The experience of the Millennium Ecosystem Assessment in collecting information on status and trends of ecosystem services demonstrated the need to collect data in consistent ways so that they can be compared across services and regions. Data are now often inconsistent. In some cases, no global data are available. For instance, the Millennium Ecosystem Assessment found that there is no reasonably accurate global map of wetlands. Collecting data using standard methods at the regional level will allow data to be combined across regions to build such a map.

In the Rio Grande story, the city's initiative provided a foundation for strengthening monitoring systems at the watershed and national levels. The assessment collected the available data and started a watershed data base on the key regulating services of water quality and flood protection. It also located available data on land conversion and runoff of pesticides and fertilizers estimated from purchases. This work provides a good basis for the Rio Grande Commission to start its work on the Regional Sustainable Biofuel Plan.

Use monitoring data in making course corrections

Because much uncertainty remains about how ecosystems function, it is often useful to carry out monitoring as part of *adaptive management*. This approach turns management of ecosystem services into a series of experiments. It tests hypotheses about how the components of an ecosystem function and interact. Based on monitoring, managerial practices can be continually adjusted and course corrections made. The following examples show how monitoring information has been used to reclaim a fishery, reduce sedimentation to protect a water supply, and provide regional indicators of trends in drivers of ecosystem change and the state of ecosystem services for a wide range of purposes.

Fisheries in Fiji. In Fiji, villages manage more than 400 local fishing grounds. Staff from the University of the South Pacific taught people in one village how to monitor clams, including the basic ideas of sampling and statistics. The community set aside 24 hectares opposite the village as a protected area for three years in an experiment to see if the clam population would recover from overharvesting. Monitoring revealed the clams did dramatically increase in this protected area, which "seeded" adjacent areas for clamming as well. As a result, the community has extended the time period for protecting the area indefinitely (WRI et al. 2005:146-47).

Water users association in India. An example from India demonstrates how the results of monitoring implementation may be used to make changes in policy over decades to meet goals of improving human well-being and maintaining ecosystem services. In the 1970s, the residents of Chandigarh faced a water shortage as Lake Sukhna filled up with sediment. An assessment showed much of the sediment came from the village of Sukhomajiri upstream from Chandigarh. In 1982, Chandigarh formed a water users association to collect fees from water users and fund improvements in managing the watershed.

The first step was to use the fees to build a reservoir in the village of Sukhomajiri, the source of most of the sediment. The reservoir helped landowners below it irrigate their crops. However, people who did not own land and depended on common land for grazing had no water rights and at the same time found their access to grazing land above the reservoir restricted.

ALIFERETI TAWAKE

Villagers in Fiji monitor clam populations to test the effectiveness of a protected area.

To give all households equal rights to water, the water users association replaced user fees with a tradable water rights scheme giving every household the same rights to water. People who did not use irrigation water could sell their rights and use the funds to comply with watershed protection such as reduction in grazing rights. However, the fluctuations in water availability made this approach difficult to implement. The association again changed its approach; the association returned to collecting fees for watershed protection based on water use. This solved the problem of water fluctuation. They addressed the equity issue by employing people who did not own land to carry out watershed protection measures (IUCN 2007).

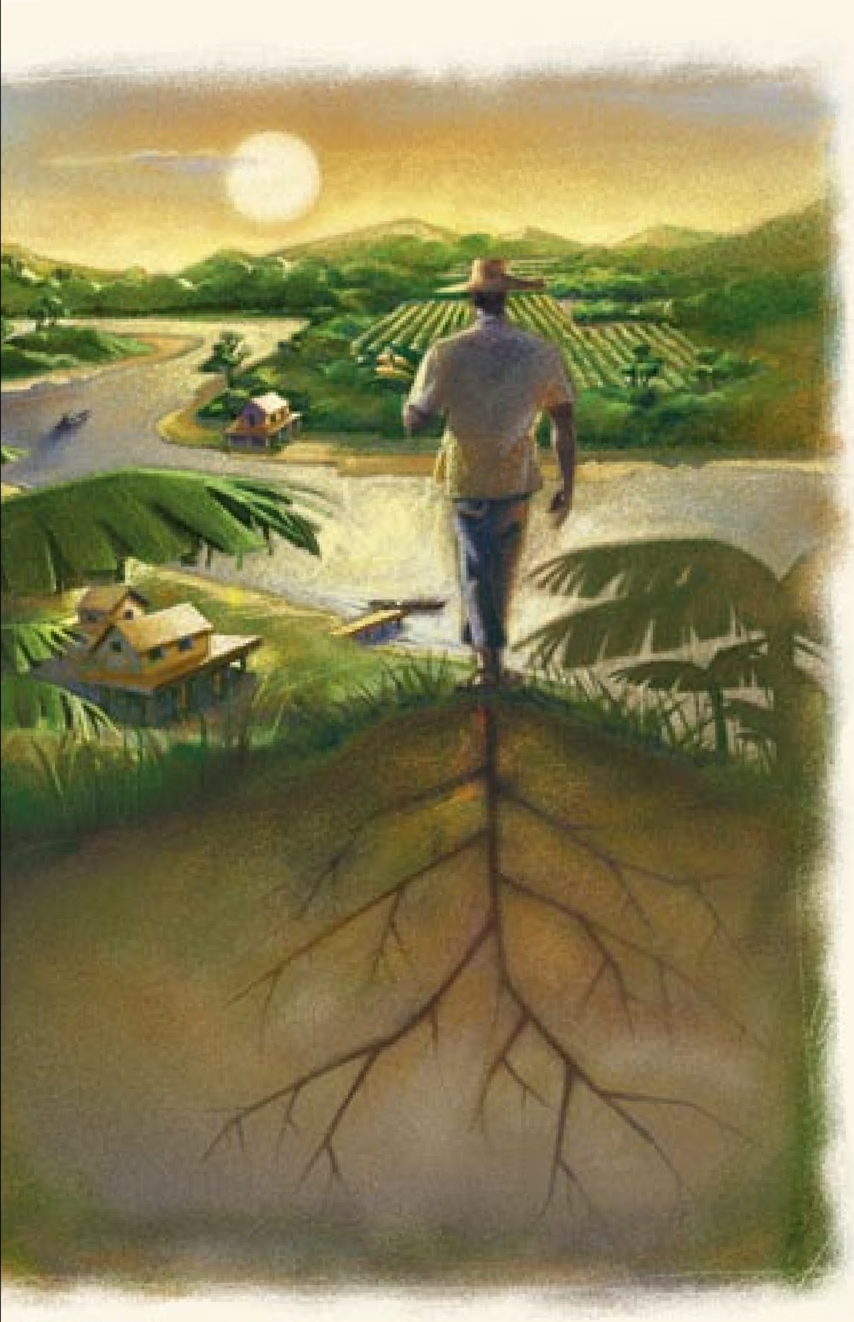
Indicators in California. A more recent example comes from a region in California. The Silicon Valley Environmental Partnership began to track environmental indicators on a periodic basis and issued its first report in 1999. This report provided the baseline for a second report in 2003 that showed six negative trends (including increased energy use and carbon emissions); and five positive trends (such as fewer fuel leaks and vehicle miles traveled). Other trends show where progress has reversed (on air quality, for example) or stabilized (garbage and toxic releases). Some of the trends result from drivers of ecosystem change such as population growth. Others track changes in land use, water use, and air quality. A report for 2007 is being prepared.

The Silicon Valley report is posted on a public website and lists more than a dozen ways of using the results. Local governments can create long-term scenarios, update land use plans, and hold specific departments accountable for their environmental performance. Community organizations can use the data in education campaigns and to hold the government accountable for reaching goals. Businesses and individuals can compare their performance to the regional trends and see whether they need to change their behavior (Silicon Valley Environmental Partnership 2007). The Sustainable Silicon Valley, a multi-stakeholder initiative aimed at improving resource conservation, uses the report's results in working to reduce Silicon Valley carbon dioxide emissions (SSV 2007).

In the past, shortcomings in monitoring and evaluation limited the effectiveness of many integration efforts (MA 2005d). Now more and more use of learning approaches demonstrates how monitoring can become an integral part of managing ecosystem services, providing continual feedback into decision making.

ACTION POINTS

- Revise strategy for achieving development goals by addressing the risks and opportunities for ecosystem services.
- Review the existing legal framework and policy options to influence drivers of ecosystem change.
- Choose policies to sustain ecosystem services.
- Monitor the effects of policies and use results to make course corrections.



Where a decision is made

The Rio Grande Report was finally out. A nice publication with maps and graphics describing the current state of ecosystems and human well-being in Rio Grande, laying out three future scenarios, and assessing some of the policies implemented in the past. The Mayor couldn't complain; the study had been publicly released with much fanfare and media coverage, including the national magazine *Week:* "The Environmental Mayor" it called him in a cover story, not without exaggeration.

But now reality called again, and the Mayor soon had to decide on a number of licenses required to start the biofuel complex. The Company had submitted all the paperwork for the first refinery, including an unsurprisingly favorable environmental impact study. The study was of little interest to the Mayor. It lacked the scope, credibility, and legitimacy of the ecosystem services report he had commissioned. He was more interested in the feasibility study for the complex, which indicated that Rio Grande was, by far, the most economically advantageous location. What really worried him was the Company lobbying the national government and international financial institutions. That was why he was now in the waiting room to see the Regional Prefect.

"Mr. Mayor!" greeted the Prefect. "What a pleasure to see you! Sorry to keep you waiting; I was on the phone with the President. This region is very dear to him, you know!"

Prefects were appointed by the President, and the Mayor got the message loud and clear: this biofuel story was a national issue, and as a result of the Rio Grande assessment the Mayor was becoming too popular in an election year.

"We are all very excited," started the Prefect, his eyes fixed on the Mayor's. "Biofuel is becoming a major global industry, and our country, with Rio Grande at the forefront, is poised to be part of the select group of nations leading its development. Congratulations on the report you just produced. I saw it in the news…"

"We are very proud of the report. It has even attracted the attention of international organizations, universities, NGOs, even the Global Broadcasting Corporation!" said the Mayor.

"Yes, yes" the Prefect hastened the pace. "Now the big investment is waiting and we are counting on you to let the wheels of our economy turn unhampered."

"The people are worried…"

The Prefect interrupted, "The President himself has promised the Company that there would be no problems with this great project."

Under different circumstances, this might have implied that interesting bribes were available to those who showed good will. But this time things were not that simple: this was an election year for the Mayor, the issue was a popular one in the region, and political power, more than money, was at stake.

"I fully support the President's efforts to strengthen our economy and put an end to poverty. We all want to make the best decisions for the country, but for that we need the right conditions…"

"To the point, my friend…"

"To be honest, I want that complex in Rio Grande as much as you and I think the national biofuel plan is good. But I am not losing an election over it. And I'm not jeopardizing the welfare of my city beyond reason. We've recently endured record floods. The report we've just finished offers a wonderful opportunity to be reasonable. If you've been following the news you'll have noticed that we are no longer focusing on the refinery itself, but on the broader development of the watershed. We are worried that developments in Springfield and Segura will harm the region's ecosystems and hence our quality of life. We are not that worried about the plant itself, but with the prospect that the biofuel industry may exacerbate monoculture, deforestation, food prices, migration, nutrient loading, river flow disruption, tourism, and so on, all of which in the end will affect the citizens of Rio Grande. But there is room to do the right things, provided we work together on two fronts.

"Which are?"

"First, together with the national government and the municipalities of Springfield and Segura we develop a Regional Sustainable Biofuel Plan to ensure appropriate, joint management of ecosystems. The plan will be prepared with public participation, and the licenses will be issued together with the launching of the regional plan. When the biofuel refinery works begin, right before election day, the President will be able to inaugurate them in a friendly environment. If we do things right, this will work out for almost everyone."

"And our second area of collaboration?"

"You give me your endorsement in the upcoming election for Mayor of Rio Grande…"

The announcement had come as a surprise to all: the license for the refinery would be approved only after a Regional Sustainable Biofuel Plan was in place. It was the national Minister of Public Works himself who made the announcement, citing *The Rio Grande Report* and declaring that the President was very concerned with the environment. In the spirit of *The Rio Grande Report,* a Commission that was credible and legitimate had been established and given five months to produce the Regional Sustainable Biofuel Plan.

The Rio Grande Secretary of Environment was designated to coordinate the work of the Commission, chaired by a personal representative of the Prefect. Organizing it proved much harder than organizing the production of the *Rio Grande Report*. This time the process had to deal with strong interests and ideological positions. For different reasons, both Trotskyites and nationalists opposed the national biofuel goal, as did a loose coalition of NGOs, fishermen, and small business organizations. "We cannot do this in an election year," the Secretary had argued. But the Mayor seemed strangely confident that the main political parties—his own, and the national government's—would not disrupt the process. "Besides, you started all this," he had told her.

So, trusting that the higher politics had been worked out, the Secretary set out to design a regional planning exercise. First, her team identified the key players involved and their interests. They were very much the same actors that had been identified when the *Rio Grande Report* was produced, except that now there was strong interest from the national government and more explicit involvement of the biofuel multinational.

Next, the team discussed the steps to produce the Regional Sustainable Biofuel Plan.

During the first two months they would conduct public consultations in three municipalities to define the goal of the Regional Sustainable Biofuel Plan and brainstorm about policy instruments. With those inputs, the Secretary's team would draft the plan and submit it to the Commission. Finally, following the Commission's agreement and before submission for approval by the President, the plan would be put to a nonbinding referendum in the region.

"There is no time to organize the referendum properly," the Mayor said. "Besides, with all those public consultations I think the Plan already has a strong legitimacy. The President is ready to approve it next month, after the election. And then the licenses for the refinery will be issued."

"The Plan still needs some work, especially the monitoring aspects," said the Secretary.

"I think the Plan is fine as it is," insisted the Mayor.

The Secretary was not the only one who thought the institutional design for monitoring the Plan was weak. The coalition of NGOs and social organizations thought so, too, and worried that after the Mayor's re-election, with the licenses for the refinery issued, the government would lose interest in the Plan. So they decided to take to the streets of Rio Grande, Springfield, and Segura simultaneously to put pressure on the government and the Company. This kept up the momentum for a couple of months after the election, sufficient to work on a sound monitoring system for the Plan.

Developing the Plan had not been easy. First, it required the joint action of three municipalities, one regional authority, and at least one national authority. Knowing that a strictly governmental arrangement would be fragile and subject to party politics, the NGOs pressed hard to create a Council that included government, business, civil society, farmers, and fishermen. They would periodically review information gathered by an independent technical team and recommend action by the different jurisdictions.

Second, it required good technical information. One of the virtues of *The Rio Grande Report* was that it had created a data base for the watershed on water quality, flood protection, land conversion, and runoff of pesticides and fertilizers. It was decided that this database would be expanded, and indicators would be developed for monitoring the Plan's implementation. The indicators would help track, for example, land conversion of forests and wetlands to biofuel crops and pesticide and fertilizer use in the watershed. Also, tests would be conducted in selected areas of the watershed to monitor how protected wetlands and new farming practices affected pollution, sedimentation, and amount of water runoff.

Third, it required the dissemination of new, "adaptive" techniques to manage the region's agricultural and other ecosystems so that multiple services would be sustained—that is, not only food, but also flood control, not only timber, but also climate regulation, and so on. This adaptive approach demanded the implementation of a series of experiments to learn from them and adjust management practices accordingly. And it required the active participation of farmers.

Two months after the Mayor's re-election, the Regional Sustainable Biofuel Plan was deemed complete and ready to be put into practice.

A representative from the biofuel Company had played an active part in the development of the Regional Sustainable Biofuel Plan. Initially dubious, he thought the plan that came out in the end was good. Explaining this to his CEO was harder than he had expected, though.

"A tax on our exports? Are you sure that's legal? Aren't we protected by World Trade Organization rules? How will the bottom-line be affected? The Board will be furious," said the CEO. It was snowing again and he was not in the mood for bad news.

"A 15 percent return on investment is still well above average for our industry. But that's only the financial aspect. This new Biofuel Plan is very interesting in social and environmental terms. By supporting it we are investing in our own future business. And it helps the Company's image, too. It's the best insurance we could buy."

"Insurance?"

"If our demand for sugar cane and maize results in big agribusiness and massive deforestation, food prices are likely to increase, soil and water will be affected, and small landholders will be forced to move to town in large numbers. Possibly 25,000 people over a few years, according to some scenarios they've made. Rio Grande can't absorb that many people, and it wouldn't be long before it became a political issue and we'd be the target of criticism. The Plan calls for prioritizing community organization in the production of sugar cane and maize, and they want us to be part of the process, supporting the certification of their sustainable production. That's the easy part for us. What is harder to digest is the tax they want to put on biofuel exports, although it is still much less than the incentives the government has designed for our industry. Besides it's not really a tax – it's more like a fee with a specific purpose: it will feed a fund that will be used to secure land titles for smaller farmers and pay for 'ecosystem services' manage-

ment in areas affected by biofuel development."

"Why should we worry about farmers? We are not a charity. We want cheaper raw material and this Plan will only make it more expensive!"

"There is more. The Plan rules out large infrastructure projects on the river—they expect to control water through natural means, or 'ecosystem management.' The whole region is to be divided into ecological zones, each with special management rules. Farm families living in strategic areas will be compensated for preserving their land to ensure good water quality and quantity in the river. The money will come mostly from the tax on biofuel exports. So as long as there is a thriving biofuel industry in the region there will be a fund to sustain the environment. Synergy! And since large infrastructure is ruled out, and no hydroelectric dams will be built, the question is: Where will the extra energy come from as development takes off? The government is thinking of using biofuel to power transport in the region and save oil imports to generate electricity. Synergy again, plus we position ourselves strategically."

"But this constrains our growth prospects!"

"Maybe not. If the government can show that the biofuel industry is socially, environmentally, and economically beneficial to this region, the President's biofuel initiative will be accepted more easily elsewhere. In addition, under this Plan we can expand our original capacity without having to go through another turbulent negotiation. We need to keep in mind that we are in this business for the long run. In the long run, our bottom-line is not only financial, but social and environmental as well."

The CEO was very skeptical of mixing business with environmental and social issues. He liked it better before, when all the Company cared about was making good profit, and social issues were left to the government. But younger managers came out of business school with funny ideas. *Sure, all very nice,* he thought. *But I better talk to the President again,* he thought. *This is looking too risky.* "Get me the Ministry of Foreign Affairs," he told his secretary.

The Plan's real test came shortly after the first biofuel refinery started operating, when the demand for biofuel crops jumped sharply, dragging along the price of land and taxes. Speculators had begun to buy land from small holders, and several community organizations broke under the pressure.

"They're now paying $1,000 per hectare. We should sell now, everyone's doing it."

"And do what? Start a small commerce? Join your brother's taxi business? Live in an apartment or a shanty? It won't be long before you'll need to find a housekeeping job so we can make ends meet. At least here we have our piece of land."

It was late and warm, frogs were singing loud, and all sorts of insects fluttered in the gallery. They had had this discussion before. She had always been attracted by the city. She felt that in Rio Grande they would have more opportunities for a better life, like her brother, who now owned two taxis. He wasn't convinced. True, the work was hard and they were poor. But this was his place, and the prospect of living in poverty in the city scared him.

Besides, things were changing. A couple of years back he had finally legalized his tenure and now felt more secure on his land—one and a half hectares with a river front of about 100 meters. And then government officials and people from the city had started coming to talk about new plans. They would hold local meetings on Saturdays to speak about the importance of the forest, of the river, about future changes in the climate and other things.

Mostly he didn't really care. He worked fruit and cattle, chopping down trees to sell every now and then when he needed some extra cash. But now there was talk about a factory in Rio Grande that was buying maize and sugar cane, to make fuel. Some farmers were already selling to larger ones, or cutting down the forest. He didn't have the money or time to cut down the trees, and before setting fire to his forest he wanted to be sure growing maize and sugar cane was worth it. And that was when the Saturday meetings had started.

"Work with us," one of the experts told him. "Try it out for a few years and then you can decide." What the man was proposing was appealing: Don't cut any more trees and we'll pay you. Don't grow maize or sugar cane, don't use certain pesticides, and we'll help you sell your fruit at better prices. Build a small deck on the riverside and we'll bring some tourists who will pay and your wife can sell crafts. Organize with your neighbors and we'll help you do business. He liked these ideas because he loved his place and he dreamed of having a beautiful house in this beautiful forest. When he saw some of his neighbors get on board, he too agreed to join the experiment.

Things had gone OK. Life had not improved as much as he had expected, but at least the prospects were good. Then the price of the land jumped from $200 to $1,000 and many started losing patience, like his wife.

Postscript. Excerpt of *Week* magazine, 1 May 2037

Question: *You started your career in Rio Grande. They say you were responsible for its transformation into a model city…*

Answer: Yes, that was a watershed in my career. Triggered by the installation of the first biofuel refinery in the country, we embarked on a cutting-edge process of integrated, regional planning. That was very uncommon back then. In retrospect I realize we were leading a great transition. Our example was taken up in many other parts of the country and soon "sustainable ecosystem services management" became a popular political issue. And we were not alone! Similar things were happening around the world—millions of people were thinking and implementing new ways of economic development. In time, all of this crystallized into a new paradigm, and here we are… Who would have thought, for example, that our generation would see fossil fuels become a minor source of energy? Who would have thought we would see local communities empowered to the point of putting a more humane face to globalization?

Question: *What worked?*

Answer: I think a key to the success was using dialogue over confrontation, but also working with small farmers to prevent the expansion of monoculture. The incentives we put in place helped us resist the pressure to convert more forest when biofuel prices escalated in 2014. Somehow we took the right turns at critical junctures. Rio Grande was attractive to the biofuel industry for a number of reasons—our location, labor, and natural port, and I think we knew how to use that in our favor. At one point the biofuel company threatened to cancel its investment if we did not withdraw the biofuel tax, but we knew that the project was still very profitable despite the tax. Also, we dared to choose an unorthodox mix of policies. We could have gone with a market approach, or strict government control. But we felt that the conditions were not appropriate for either. Institutions back then were weaker than they are today, especially those that deal with the environment. I was Secretary of Environment at the time, and I definitely did not have the influence the position carries today!

Question: *And now you may be the second woman to become President, and are the first candidate to run on a "sustainability" platform.…*

Conclusion

An Ecosystem Services Approach for reconciling development and nature

Too often, development policies have unwittingly diminished nature's capacity to provide the goods and services people depend on. As the Millennium Ecosystem Assessment points out, meeting a growing population's needs for food and water and human health over the past 50 years has degraded many ecosystem services (MA 2005e:5-6). Fifteen services, including the supply of fish and fresh water, are in serious decline globally, while another five, such as water regulation and the supply of timber, hang in the balance.

The Millennium Ecosystem Assessment calls for significant changes in the way we govern ecosystems. To keep pace with the rapid decline in ecosystem services, we need to find better ways to make decisions about developments, ways that explicitly take ecosystem services into account and reduce trade-offs across services. By accounting for the dependencies and impacts of development on ecosystem services, decision makers can reconcile development goals and nature.

This guide introduces an Ecosystem Services Approach as an early attempt at outlining how decision makers can take practical steps to restore the health of ecosystem services and make development more sustainable. It builds on the action agenda laid out in *Restoring Nature's Capital,* an earlier World Resources Institute publication that calls for investing in nature *for* development, in addition to simply protecting nature *from* development.

The Ecosystem Services Approach can be—and needs to be—central to choosing future development strategies and policies. It comprises a framework and methods for integrating ecosystem services into decision making. Implementing such an approach involves a variety of methods, including an assessment of ecosystem service dependencies and impacts, ecosystem service valuation, scenario building, and selection of policies and other interventions targeted at sustaining ecosystem services.

Decision makers can use these methods to learn the value of natural assets and to identify the specific assets of nature that their goals depend on and affect. They can explore how current and future trends in the condition of these services will affect their development goals in the places where they work. They can build partnerships across institutional and political boundaries to address the risks and opportunities for ecosystem services that each development decision presents. This Ecosystems Services Approach can become the basis for reconciling development and nature, and sustaining both.

References

AAG (Association of American Geographers). 2003. *Global change and local places: Estimating, understanding, and reducing greenhouse gases*. Cambridge: Association of American Geographers GCLP Research Team, Cambridge University Press. Cited in Wilbanks, T.J. 2006. "How Scale Matters: Some Concepts and Findings" in *Bridging Scales and Knowledge Systems: Concepts and Applications in Ecosystem Assessment*. Reid, W.V., F. Berkes, T.J. Wilbanks, and D. Capistrano (eds.). Washington DC: WRI.

Adeel, Z., J. Bogardi, C. Braeuel, P. Chasek, M. Niamir-Fuller, D. Gabriels, C. King, F. Knabe, A. Kowsar, B. Salem, T. Schaaf, G. Shepherd, and R. Thomas. 2006. *Overcoming One of the Greatest Environmental Challenges of Our Time: Re-thinking Policies to Cope with Desertification: A Policy Brief Based on The Joint International Conference: "Desertification and the International Policy Imperative" Algiers, Algeria, 17-19 December, 2006.* Online at: http://www.inweh.unu.edu/inweh/drylands/Publications/IYDD_Policy_Brief-June_2007.pdf

Alcamo, J. 2001. "Scenarios as tools for international environmental assessments." *Environmental Issue Report No. 24*. Luxembourg: Office for Official Publications of the European Communities, European Environment Agency.

Anielski, M. and S. Wilson. 2006. *Counting Canada's natural capital: assessing the real value of Canada's boreal ecosystems*. Ottawa: Canadian Boreal Initiative.

AP (Associated Press). 2007. "50 million on the run from deserts, warming?: U.N. report urges nations to 'reverse the decline of drylands'." *MSNBC*. June 28. Online at: http://www.msnbc.msn.com/id/19479607/from/ET/

Assey, P., S. Bass, B. Cheche, D. Howlett, G. Jambiya, I. Kikula, S. Likwelile, A. Manyama, E. Mugurusi, R. Muheto and L. Rutasitara. 2007. "Environment at the heart of Tanzania's development: Lessons from Tanzania's National Strategy for Growth and Reduction of Poverty (MKUKUTA)." *Natural Resource Issues Series No. 6*. London: International Institute for Environment and Development.

Bennett, E. M., S. R. Carpenter, G. D. Peterson, G. S. Cumming, M. Zurek, and P. Pingali. 2003. "Why global scenarios need ecology." *Frontiers in Ecology and the Environment* 1 (6): 322-29.

Bohensky, E., B. Reyers, A.S. van Jaarsveld and C. Fabricius (eds.) 2004. *Ecosystem Services in the Gariep basin: A Basin-Scale Component of the Southern African Millennium Ecosystem Assessment (SAfMA).* Stellenbosch, South Africa: SUN Press. Online at: www.maweb.org

Boyd, J. and S. Banzhaf. 2006. "What are Ecosystem Services: The Need for Standardized Environmental Accounting Units." *RFF Discussion Paper*. Washington, DC: RFF. Online at: http://www.rff.org/Documents/RFF-DP-06-02.pdf

Brand, D. 2005. "The Combined Challenge of Forestry and Terrestrial Carbon Management." Pennant Hills, Australia: State of New South Wales. Online at: http://www.forest.nsw.gov.au/env_services/papers/tccofatcm/default.asp

Canadian Parks and Wilderness Society. 2007. *CPAWS' Federal Action Plan for Nature Conservation*. Online at: http://cpaws.org/news/archive/files/2006-10_federalactionplan.pdf

CBD (Convention on Biological Diversity). 1993. *Multilateral: Convention on Biological Diversity*. Online at: http://www.cbd.int/doc/legal/cbd-un-en.pdf

China Daily. 2005. "Battling the Desert in Minqin." September 14. Online at: http://www.china.org.cn/english/environment/142016.htm

Commonwealth of Australia. 2007. "Ecosystem Services." Online at: http://www.daff.gov.au/brs/forest-veg/Ecosystem_Services

Conservation Finance Alliance. 2003. *Belize: Protected Areas Conservation Trust (PACT).* Switzerland: CFA.

CPET (Central Point for Expertise on Timber). 2007. " UK Government Policy." Online at: http://www.proforest.net/cpet

CSE (Centre for Science and Environment) India. 2004. "Rainwater Harvesting." Online at: http://www.rainwaterharvesting.org/index.htm

Danielsen, F., M.K. Sørensen, M.F. Olwig, V. Selvam, F. Parish, N.D. Burgess, T. Hiraishi, V.M. Karunagaran, M.S. Rasmussen, L.B. Hansen, A. Quarto, and N. Suryadiputra. 2005. "The Asian Tsunami: A Protective Role for Coastal Vegetation." *Science*. 310 (5748): 643. Online at: http://www.sciencemag.org/cgi/content/full/310/5748/643

Department of Water Affairs and Forestry. 2007. "Working for Water Programme." Online at: http://www.dwaf.gov.za/wfw/

D'Souza, M. and C. Lobo. 2004. "Watershed Development, Water Management and the Millennium Development Goals." Presented at the Watershed Summit, Chandigarh, November 25-27, 2004. Ahmednagar, India: Watershed Organization Trust. Cited in WRI, United Nations Development Programme, United Nations Environmental Programme, and the World Bank. 2005. *World Resources 2005: The Wealth of the Poor – Managing Ecosystems to Fight Poverty.* Washington, DC: World Resources Institute. Online at: http://multimedia.wri.org/worldresources2005.cfm

Earthwatch Institute, World Resources Institute, WBCSD and World Conservation Union. 2006. *Business and Ecosystems: Issue Brief: Ecosystem Challenges and Business Implications.* Gland, Switzerland: Earthwatch.

Ernst, C. 2004. *Protecting the Source: Land Conservation and the Future of America's Drinking Water*. San Francisco, CA: Trust for Public Land.

Eurostat. 2006. "Sustainable Development Indicators." Online at: http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1998,47433161,1998_47437045&_dad=portal&_schema=PORTAL

FAO (Food and Agriculture Organization of the United Nations). 2000. *Asia and the Pacific National Forestry Programmes: Update 34*. Rome: FAO.

FAO (Food and Agriculture Organization of the United Nations). 2002. *Land-water Linkages in Rural Watersheds Case Study Series: Water user associations in the Cauca Valley, Colombia*. Rome: FAO.

FAO (Food and Agriculture Organization of the United Nations). 2004. *Status and Trends in Mangrove Area Extent Worldwide*. Rome: FAO. Online at: http://www.fao.org/docrep/007/j1533e/J1533E01.htm#P181_4100

FAO (Food and Agriculture Organization of the United Nations). 2007. *State of World Fisheries and Aquaculture:2006.* Rome: FAO. Online at: http://www.fao.org/docrep/009/A0699e/A0699e00.htm

Finnegan, M.C. 1997. "New York City's watershed agreement: A lesson in sharing responsibility." *Pace Environmental Law Review*. 14: 577-644.

FOE (Friends of the Earth). 1989. *Destruction of rain forest in the Brazilian Amazon and the role of Japan: Briefing paper presented at the International People's Forum on Japan and the global environment, 8-9 September 1989*. Tokyo: FOE.

FSA (Farm Service Agency). 2007. *Conservation Reserve Program: Summary and Enrollment Statistics FY 2006.* Online at: http://www.fsa.usda.gov/Internet/FSA_File/06rpt.pdf

Gluckman, R. 2000. "Beijing's Desert Storm." October. Online at: http://www.gluckman.com/ChinaDesert.html

Government of Alberta. 2007. "Environment." Online at: http://environment.gov.ab.ca/default.aspx

Green, P., C.J. Vörösmarty, M. Meybeck, J. Galloway, and B.J. Peterson, 2004. "Pre-industrial and contemporary fluxes of nitrogen through rivers: A global assessment based on typology." *Biogeochemistry*. 68: 71–105.

GRI (Global Reporting Initiative). 2007. "Global Reporting Initiative." Online at: http://www.globalreporting.org/Home

Gunderson, L. and C. S. Holling. 2002. *Panarchy: Understanding transformation in human and natural systems*. Washington DC: Island Press.

Hackl, J. and T. Rohrich. 2001. *Landscape Protection and Buffer Zones as Part of Nature Conservation in Austria and their Importance for Forests*. Helsinki: WWF. Online at: http://www.wwf.fi/tiedotus/seminaarit/seminaarimateriaalit/landscape_protection_and.html

Hanrahan, C.E. and J. Zinn. 2005. *Green Payments in U.S. and European Union Agricultural Policy*. Washington DC: Congressional Research Service. Online at: http://www.nationalaglawcenter.org/assets/crs/RL32624.pdf

Hazen and Sawyer. 1997. *The New York City Water Supply System*. New York: Hazen and Sawyer/Camp Dresser and McKee.

Hudson, K. and W. Watcharasakwet. 2007. "The New Wal-Mart Effect: Cleaner Thai Shrimp Farms." *The Wall Street Journal.* (July 24): B1. Online at: http://online.wsj.com/article/SB118523019620675464.html?mod=aol_wsj_hs&ru=aol

References

Instituto Florestal. 2007. "Reserva da Biosfera do Cinturão Verde da Cidade de São Paulo." Online at: http://www.iflorestal.sp.gov.br/rbcv/index.asp

Irwin, F. and J. Ranganathan. 2007. *Restoring Nature's Capital: An Action Agenda to Sustain Ecosystem Services*. Washington DC: WRI.

IUCN. 2006. "IUCN – Ecosystem Services." Online at: http://www.iucn.org/themes/cem/ourwork/ecservices/index.html

IUCN. 2007. *Pay: Establishing payments for watershed services*. Gland, Switzerland: IUCN.

Kahn, J. 2006. "A Sea of Sand is Threatening China's Heart." *New York Times*. (June 8).

Karr, J.R. 1981. *Assessment of biotic integrity using fish communities*. Fisheries (Bethesda) 6 (6): 21-27.

Kates, R. and T. Wilbanks. 2003. "Making the global local: Responding to climate change concerns from the bottom up." *Environment*. 45 (3): 12-23. Cited in Wilbanks, T.J. 2006. "How Scale Matters: Some Concepts and Findings" in *Bridging Scales and Knowledge Systems: Concepts and Applications in Ecosystem Assessment*. Reid, W.V., F. Berkes, T.J. Wilbanks, and D. Capistrano (eds.). Washington DC: WRI.

Landell-Mills, N. and I.T. Porras. 2002. *Silver Bullet or Fools' Gold? A Global Review of Markets for Forest Environmental Services and Their Impact on the Poor*. London: International Institute for Environment and Development. Online at: http://www.iied.org/pubs/pdf/full/9066IIED.pdf

MA (Millennium Ecosystem Assessment). 2003. *Ecosystems and Human Well-Being: A Framework for Assessment*. Washington DC: Island Press. Online at: http://www.maweb.org

MA (Millennium Ecosystem Assessment). 2005a. *Ecosystems and Human Well-Being: Synthesis*. Washington DC: Island Press. Online at: http://www.maweb.org

MA (Millennium Ecosystem Assessment). 2005b. *Ecosystems and Human Well-being: Current State and Trends, Volume 1*. R. Hassan, R. Scholes, and N. Ash (eds.). Washington DC: Island Press.

MA (Millennium Ecosystem Assessment). 2005c. *Ecosystems and Human Well-being: Scenarios, Volume 2*. S. Carpenter, P. Pingali, E.M. Bennett and M. Zurek (eds.). Washington DC: Island Press.

MA (Millennium Ecosystem Assessment). 2005d. *Ecosystems and Human Well-being: Policy Responses, Volume 3*. K. Chopra, R. Leemans, P. Kumar, and H. Simons (eds.). Washington DC: Island Press.

MA (Millennium Ecosystem Assessment). 2005e. *Ecosystems and Human Well-Being: Multiscale Assessments, Volume 4*. D. Capistrano, C. Samper, M. Lee, and C. Raudsepp-Hearne (eds.). Washington DC: Island Press.

MA (Millennium Ecosystem Assessment). 2005f. *Living Beyond Our Means: Natural Assets and Human Well-Being: Statement from the Board*. Washington DC: WRI. Online at: http://www.maweb.org

MA (Millennium Ecosystem Assessment). 2005g. *Ecosystems and Human Well-Being: Biodiversity Synthesis*. Washington DC: WRI. Online at: http://www.maweb.org

Marshall, L. and S. Greenhalgh. 2006. *Beyond the RFS: The Environmental and Economic Impacts of Increased Grain Ethanol Production in the U.S.* Washington DC: WRI. Online at: http://www.wri.org/climate/pubs_description.cfm?pid=4185

Munasinghe, M. 2007. "Mainstreaming and Implementing the MA Results by Integrating them into Sustainable Development Strategy" in *Policies for Sustainable Governance of Global Ecosystem Services*. Ranganathan, J., M. Munasinghe, and F. Irwin (eds.). Cheltenham, UK: Edward Elgar.

Myers, N. 1998. "Lifting the veil on perverse subsidies." *Nature* 392: 327-328 (26 March).

Natural Capital Project. 2007. "Natural Capital Project." Online at: http://www.naturalcapitalproject.org/mw.html

NRC (National Research Council). 2000. *Watershed Management for Potable Water Supply: Assessing the New York City Strategy*. Washington DC: The National Academies Press.

NYC DEP (New York City Department of Environmental Protection). 1993a. *Draft Generic Environmental Impact Statement for the Draft Watershed Regulations for the Protection From Contamination, Degradation, and Pollution of the New York City Water Supply and Its Sources*. Corona, NY: NYC DEP.

NYC DEP (New York City Department of Environmental Protection). 1993b. *Watershed Protection through Whole Community Planning: A Charter for Watershed Partnership*. Ithaca: New York State Water Resources Institute, Center for the Environment, Cornell University.

Office of Policy, Economics and Innovation and Office of Water. 2005. *Applying Lessons Learned from Wetlands Mitigation Banking to Water Quality Trading*. Washington DC: US Environmental Protection Agency.

Paden, C. and A. Shen. 1995. "New York City water under pressure." *Inside DEP* 1 (1): 1–8.

The Parliament of Australia, Senate Committee. 2006. *Water Policy Initiatives*. Canberra: Government of Australia. Online at: http://www.aph.gov.au/Senate/committee/rrat_ctte/rural_water/report/index.htm

Perrot-Maître, D. 2006. *The Vittel payments for ecosystem services : a « perfect « PES case ?* London: International Institute for Environment and Development. Online at: http://www.iied.org/NR/forestry/documents/TheVittelpaymentsforecosystemservices.pdf

Perrot-Maître, D. and P. Davis. 2001. *Case Studies of Markets and Innovative Financial Mechanisms for Water Services from Forests*. Washington DC: Forest Trends. Online at: http://www.forest-trends.org/documents/publications/casesWSofF.pdf

Peterson, G.D., D. Beard, B. Beisner, E. Bennett, S. Carpenter, G. Cumming, L. Dent, and T. Havlicek. 2003. "Assessing future ecosystem services: a case study of the northern highland lake district, Wisconsin." *Conservation Ecology* 7(3): 1. Online at: http://www.consecol.org/vol7/iss3/art1

Pfeffer, M. J. and L. P. Wagenet. 1999. "Planning for Environmental Responsibility and Equity: A Critical Appraisal of Rural/Urban Relations in the New York City Watershed" in *Planning, Theory and Practice*. Elson, M. (ed.) Oxford: Routledge.

Phillips, M.J. and R.P. Subasinghe. 2006. "FAO, NACA, UNEP/GPA, WB, and WWF Consortium on Shrimp Farming and the Environment receives the Green Award for its International Principles for Responsible Shrimp Farming." *FAO Aquaculture Newsletter* 36: 46 – 47 (December).

Puget Sound Partnership. 2007. "Puget Sound Partnership." Online at: http://www.psp.wa.gov

Reid, W.V., F. Berkes, T.J. Wilbanks, and D. Capistrano. 2006. *Bridging and Knowledge Systems: Concepts and Applications in Ecosystem Assessment.* Washington DC: WRI.

Rickets, T.H., G.C. Daily, P.R. Ehrlich, and C.D. Michener. 2004. "Economic value of tropical forest to coffee production." *Proceedings of the National Academy of Sciences* 101 (34): 12579-12582.

Rogers, K., D. Roux and H. C. Biggs. 2000. "Challenges for catchment management agencies: lessons from bureaucracies, business and resource management." *Water SA* 26 (4): 505-511.

Roig-Franzia, M. 2007. "A Culinary and Cultural Staple in Crisis." *Washington Post.* (Jan. 27): A1, A16.

Sandler, Neal. 2005. "Israel: Waterworks for the World?" *BusinessWeek*. (December 30). Online at: http://www.businessweek.com/technology/content/dec2005/tc20051230_495029.htm

Sathirathai, S. and E.B. Barbier. 2001. "Valuing Mangrove Conservation in Southern Thailand." *Contemporary Economic Policy* 19 (2): 109–22.

Scheffer, M.S., S.R. Carpenter, J.A. Foley, C. Folke, and B. Walker. 2001. "Catastrophic shifts in ecosystems." *Nature* 413: 591-96.

Schneeweiss, J. 1997. "Watershed protection strategies: A case study of the New York City Watershed in light of the 1996 Amendments to the Safe Drinking Water Act." *Villanova Environmental Law Journal* 9:77–119.

Scholes, R. J. and R. Biggs (eds.). 2004. *Ecosystem Services in Southern Africa: A Regional Assessment*. Pretoria, South Africa: Council for Scientific and Industrial Research.

Schwartz, P. 1996. *The Art of the Long View: Planning for the future in an uncertain world*. New York: Doubleday Currency.

Seattle Public Utilities. 2007. "Street Edge Alternatives (SEA Streets) Project." Online at: http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/Street_Edge_Alternatives/index.asp

Silicon Valley Environmental Parternship. 2007. "The Partnership." Online at: http://www.svep.org

References

SSV (Sustainable Silicon Valley). 2007. "About SSV." Online at: www.sustainablesiliconvalley.org/about.htm

Stevenson, N.J. 1997. "Disused shrimp ponds: Options for redevelopment of mangroves." *Coastal Management* 25(4): 425-435.

Thongbai P., D. Pipattwattanakul, P. Preechapanya, and K. Manassrisuksi. 2006. "Participatory Scenarios for Sustainable Management of ASB Benchmark site in Thailand: Case of Mae Kong Kha Sub-watershed of Mae Chaem Watershed." Paper presented to the International Symposium *Towards Sustainable Livelihoods and Ecosystems in Mountainous Regions*, 7-9 March 2006 Chiang Mai, Thailand.

Tomich T.P., A. Cattaneo, S. Chater, H.J. Geist, J. Gockowski, D. Kaimowitz, E.F. Lambin, J. Lewis, O. Ndoye, C. Palm, F. Stolle, W.D. Sunderlin, J.F. Valentim, M. van Noordwijk, and S.A. Vosti. 2005. "Balancing Agricultural Development and Environmental Objectives: Assessing Tradeoffs in the Humid Tropics" in *Slash and Burn: The Search for Alternatives*. C.A. Palm, S.A. Vosti, P.A. Sanchez, and P.J. Ericksen (eds.) New York: Columbia University Press.

UNDP (United Nations Development Programme). 2003. *Business and the Millennium Development Goals: A framework for action*. London: International Business Leaders Forum.

UNEP (United Nations Environment Programme). 2005. *One Planet Many People: Atlas of Our Changing Environment*. Nairobi: Division of Early Warning Assessment and UNEP.

UNEP (United Nations Environment Programme). 2007. "Ecosystem Approach." Online at: http://www.cbd.int/programmes/cross-cutting/ecosystem/default.shtml

UNEP-WCMC (United Nations Environment Programme World Conservation Monitoring Centre). 2006. *In the Front Line: Shoreline protection and other ecosystem services from mangroves and coral reefs*. Online at: http://www.unep.org/pdf/infrontline_06.pdf

United Kingdom. House of Commons Environmental Audit Committee. 2007. Government Reponse to the Committee's First Report of Session 2006-07: The UN Millennium Ecosystem Assessment. *Sixth Special Report of Session 2006-07*. 3 July.

United Republic of Tanzania. 2005. *National Strategy for Growth and Reduction of Poverty (NSGRP), Vice President's Office, June 2005.* Online at: http://www.tanzania.go.tz/pdf/nsgrptext.pdf

United States Congress Office of Technology Assessment. 1995. *Environmental Policy Tools: A User's Guide*. Washington DC: US Government Printing Office.

United States House. 2006. *The Pension Protection Act of 2006*. 109th Cong., 2nd sess., H.R. 4.

USDA (United States Department of Agriculture). 2006. "Agriculture: Organic Certification." Online at: http://www.usda.gov/wps/portal/!ut/p/_s.7_0_A/7_0_1OB?navid=ORGANIC_CERTIFICATIO&navtype=RT&parentnav=AGRICULTURE

USDA NRCS (United States Department of Agriculture: National Resources Conservation Service). 2007. "Buffer Strips: Common Sense Conservation." Online at: http://www.nrcs.usda.gov/FEATURE/buffers/

US EPA (United States Environmental Protection Agency). 2007a. "Ecological Research." Online at: http://www.epa.gov/ord/quickfinder/ecoresearch.htm

US EPA (United States Environmental Protection Agency). 2007b. *New York City Watershed Agreement*. Online at: http://www.epa.gov/owow/watershed/ny/nycityfi.html

US FSC (United States Forest Stewardship Council). 2006. "The Forest Stewardship Council." Online at: http://www.fscus.org/about_us/

van der Heijden, K. 1996. *Scenarios: The Art of Strategic Conversation*. New York: Wiley.

Welch, R.M. and R.D. Graham. 1999. "A new paradigm for world agriculture; meeting human needs. Productive, sustainable and nutritious." *Field Crops Research* 60: 1-10.

Wollenberg, E., D. Edmunds, and L. Buck. 2000. "Using scenarios to make decisions about the future: anticipatory learning for the adaptive co-management of community forests." *Landscape and Urban Planning* 47: 65-77.

World Commission on Dams. 2000. *Dams and Development: A New Framework for Decision-Making*. London: Earthscan. Online at: http://www.dams.org/report/contents.htm

WOTR (Watershed Organization Trust). 2002. *Darewadi Watershed Project*. Project summarizing paper. Ahmednagar, India: WOTR. Online at http://www.wotr.org. Cited in WRI, United Nations Development Programme, United Nations Environmental Programme, and the World Bank. 2005. *World Resources 2005: The Wealth of the Poor – Managing Ecosystems to Fight Poverty*. Washington, DC: World Resources Institute. Online at: http://multimedia.wri.org/worldresources2005.cfm

WOTR (Watershed Organization Trust). 2005. "Darewadi Project Benefits 1996-2005." Unpublished table. Cited in WRI, United Nations Development Programme, United Nations Environmental Programme, and the World Bank. 2005. *World Resources 2005: The Wealth of the Poor – Managing Ecosystems to Fight Poverty*. Washington, DC: World Resources Institute. Online at: http://multimedia.wri.org/worldresources2005.cfm

WRI (World Resources Institute). 2007. *Interactive Forestry Atlas of Cameroon*. Washington DC: WRI.

WRI (World Resources Institute), ILRI (International Livestock Research Institute), DRSRS (Department of Resource Surveys and Remote Sensing, Ministry of Environment and Natural Resources of Kenya), and CBS (Central Bureau of Statistics, Ministry of Planning and National Development of Kenya). 2007. *Nature's Benefits: An Atlas of Ecosystems and Human Well-Being in Kenya*. Washington DC and Nairobi: WRI

WRI (World Resources Institute), United Nations Development Programme, United Nations Environment Programme, and the World Bank. 2000. *People and Ecosystems: The Fraying Web of Life*. Washington, DC: WRI

WRI (World Resources Institute), United Nations Development Programme, United Nations Environment Programme, and the World Bank. 2005. *World Resources 2005: The Wealth of the Poor – Managing Ecosystems to Fight Poverty*. Washington, DC: World Resources Institute. Online at: http://multimedia.wri.org/worldresources2005.cfm

WWF (World Wildlife Fund). 2003. *Brazilian Government Reveals Alarming Rate of Deforestation in Amazon: World Wildlife Fund Responding to Forest Threats.* Washington DC: WWF. Online at: http://www.worldwildlife.org/news/displayPR.cfm?prID=63

Zurek, M. B. and T. Henrichs. 2007. "Linking scenarios across geographical scales in international environmental assessment." *Technological Forecasting and Social Change* 74 (8): 1282-1295 (October).

Other publications from WRI's Mainstreaming Ecosystem Services Initiative

Restoring Nature's Capital: An Action Agenda to Sustain Ecosystem Services

Using the Millennium Ecosystem Assessment as its backdrop, Restoring Nature's Capital proposes an action agenda for business, government, and civil society to reverse ecosystem degradation. The authors contend that governance – who makes decisions, how they are made, and with what information – is at the heart of sustaining ecosystems' capacity to provide vital services for future generations to come.

Nature's Benefits in Kenya: An Atlas of Ecosystems and Human Well-Being

Endorsed by five Permanent Secretaries in Kenya and with a Foreword by Wangari Maathai (2004 Nobel Peace Prize recipient), this report provides a new approach to integrating spatial data on poverty and ecosystems. The atlas overlays georeferenced statistical information on population and household expenditures with spatial data on ecosystem services to yield a picture of how land, people, and prosperity are related in Kenya. Upcoming reports will focus on the application of poverty and ecosystem service mapping in Uganda.

Mainstreaming Ecosystem Services Considerations at the Multilateral Development Banks *[forthcoming]*

Slated for release in 2008, this publication will show how Multilateral Development Banks (MDBs) can better achieve development objectives, including the Millennium Development Goals, by implementing an Ecosystem Services Approach. Key entry points for mainstreaming the approach are discussed as well as tools for real life implementation.

Guidelines for Conducting a Corporate Ecosystem Services Review *[forthcoming]*

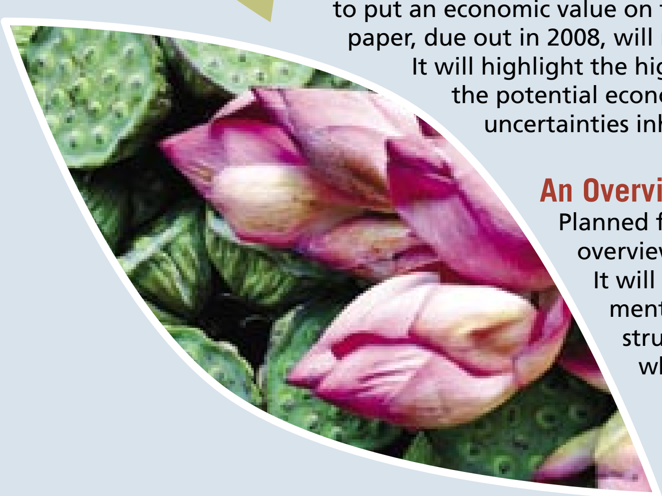
Scheduled for release in 2008, The Corporate Ecosystem Services Review is a methodology to help corporate managers proactively identify business risks and opportunities arising from their company's dependence and impact on ecosystems. The methodology was developed by WRI, the Meridian Institute, and the World Business Council for Sustainable Development (WBCSD) and has been road tested by six multinational companies.

What are Reefs Worth – Economic Valuation of Coral Reefs in Tobago and St. Lucia *[forthcoming]*

Building on extensive analysis in the Eastern Caribbean, WRI has developed a methodology to put an economic value on the ecosystem services provided by coral reefs. This white paper, due out in 2008, will release the findings of these preliminary valuation studies. It will highlight the high economic value of coral reefs, the sources of these values, the potential economic losses associated with the degradation of reefs, and the uncertainties inherent in this type of valuation.

An Overview of Water Quality Trading *[forthcoming]*

Planned for release in 2008, this report will be an overview of water quality trading programs around the world. It will examine how various programs have approached design elements (e.g., trade ratios, credit calculations, cost-share, market structure). It will also examine common hurdles and successes when establishing water quality trading programs.



HISASHI ARAKAWA (WWW.EMERALD.ST)

Partners in Developing the Guide

Centro Fueguino para el Desarrollo Sustentable is a non-profit organization based in Tierra del Fuego, Argentina that promotes the transition to sustainable development in Patagonia and beyond through all forms of environmental education, the production of environmental information and civic action at the local level.

DAI is an employee-owned, international consulting company based in the US. Since 1970, DAI has worked in 150 developing and transition countries, providing comprehensive development solutions in areas including crisis mitigation and recovery, democratic governance and public sector management, agriculture and agribusiness, private sector development and financial services, economics and trade, HIV/AIDS, avian influenza control, and water and natural resources management.

The **Food and Agriculture Organization of the United Nations** (FAO) leads international efforts to defeat hunger. Serving both developed and developing countries, FAO acts as a neutral forum where all nations meet as equals to negotiate agreements and debate policy. FAO is also a source of knowledge and information. The organization helps developing countries and countries in transition modernize and improve agriculture, forestry and fisheries practices and ensure good nutrition for all. Since FAO's founding in 1945, the organization has focused special attention on developing rural areas, home to 70 percent of the world's poor and hungry people.

The Nature Conservancy is a leading conservation organization working around the world to protect ecologically important lands and waters for nature and people. To date, the Conservancy and its more than one million members have been responsible for the protection of more than 15 million acres in the United States and have helped preserve more than 102 million acres in Latin America, the Caribbean, Asia and the Pacific. Visit The Nature Conservancy on the Web at www.nature.org.

The **United Nations Development Programme** (UNDP) is the UN's global development network, an organization advocating for change and connecting countries to knowledge, experience and resources to help people build a better life. We are on the ground in 166 countries, working with them on their own solutions to global and national development challenges. As they develop local capacity, they draw on the people of UNDP and our wide range of partners.

The **United Nations Environment Programme** (UNEP) is the voice for the environment within the United Nations system, acting as an advocate, educator, catalyst and facilitator, promoting sound environmental management and the wise use of the planet's natural assets for sustainable development. UNEP's mission is to provide leadership and encourage partnership in caring for the environment by inspiring, informing and enabling nations and peoples to improve their quality of life without compromising that of future generations.

The **UNEP-World Conservation Monitoring Centre** is the biodiversity assessment and policy support arm of the United Nations Environment Programme. The Centre has been in operation for over 25 years, providing objective, scientifically rigorous products and services to help national and international decision makers recognize the value of biodiversity and apply this knowledge to all that they do.

Author Affiliations

Neville Ash
United Nations Environment Programme –
World Conservation Monitoring Centre

Elena Bennett
McGill University

Karen Bennett
World Resources Institute

Reinette Biggs
Center for Limnology,
University of Wisconsin

Philip Bubb
United Nations Environment Programme –
World Conservation Monitoring Centre

Lauretta Burke
World Resources Institute

Emily Cooper
World Resources Institute

Craig Hanson
World Resources Institute

Charles Iceland
World Resources Institute

Frances Irwin
World Resources Institute

Kasper Kok
Land Dynamics Group,
Wageningen University

Nicolas Lucas
Centro Fueguino para el
Desarrollo Sustentable

Charles Perrings
Global Institute of Sustainability,
Arizona State University

Janet Ranganathan
World Resources Institute

Ciara Raudsepp-Hearne
McGill University

Dagmar Timmer
One Earth Initiative

Sandra J. Velarde
Iniciativa Amazónica-CIAT

Paul West
The Nature Conservancy;
Center for Sustainability and the
Global Environment,
University of Wisconsin-Madison

Monika Zurek
Food and Agriculture Organization of
the United Nations

WORLD
RESOURCES
INSTITUTE

The **World Resources Institute** is a non-profit, non-partisan environmental think tank that goes beyond research to provide practical solutions to the world's most urgent environment and development challenges. WRI works in partnership with scientists, businesses, governments, and non-governmental organizations in more than seventy countries to provide information, tools and analysis to address problems such as the degradation of ecosystems and their capacity to provide for human well-being.

WORLD RESOURCES INSTITUTE

Centro Fueguino para el Desarrollo Sustentable

DAI

FAO FIAT PANIS

The Nature Conservancy
Protecting nature. Preserving life.™

UNDP

UNEP

UNEP WCMC

9 781569 736692 29000

ISBN-978-1-56973-669-2