Ecosystems and Human Well-being

Opportunities and Challenges for Business and Industry

MILLENNIUM ECOSYSTEM ASSESSMENT

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A Report of the Millennium Ecosystem Assessment

The Millennium Ecosystem Assessment (MA) is a four-year international scientific assessment of the consequences of ecosystem change for human well-being. A multisectoral Board of Directors—consisting of senior representatives from government, business, NGOs, U.N. agencies, academia, and indigenous peoples—developed and managed the MA. The assessment was conducted by 1,360 natural and social scientists from 95 countries and was comprehensively peer-reviewed by an additional 600 experts. It provides a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide (such as clean water, food, forest products, flood control, and natural resources). The assessment also analyzed options to restore, conserve, or enhance the sustainable use of ecosystems and their contributions to human well-being. Financial support for the MA was provided by a variety of governments, institutions, and foundations around the world.

This report synthesizes the take-home messages of the MA for the business community throughout the industrial and developing world. It begins by highlighting key MA findings with particular relevance for businesses large and small. The report then provides an interpretation of the significance of these findings for business and industry, including a checklist of questions designed to help tailor the general findings of the MA to a particular business.

This report was prepared by a panel of assessment authors and representatives of businesses and partner organizations, academic experts, and members of the NGO community. It provides a portal for businesses into the Millennium Ecosystem Assessment.

Contents

1. *Why the Millennium Ecosystem Assessment Is Important for Business and Industry*

Businesses interact with ecosystems and ecosystem services in two important ways: they use services and they contribute to ecosystem change. The MA discovered that two thirds of the ecosystem services it examined are being degraded or used unsustainably. This finding has serious ramifications for the world at large and will affect business and industry in three principal ways.

1. **If current trends continue, ecosystem services that are freely available today will cease to be available or become more costly in the near future. Once internalized by primary industries, additional costs that result will be passed downstream to secondary and tertiary industries and will transform the operating environment of all businesses.**
2. **Loss of ecosystem services will also affect the framework conditions within which businesses operate, influencing customer preferences, stockholder expectations, regulatory regimes, governmental policies, employee well-being, and the availability of finance and insurance.**

> ***"Business cannot function if ecosystems and the services they deliver—like water, biodiversity, fiber, food, and climate—are degraded or out of balance."*** —World Business Council for Sustainable Development

3. **New business opportunities will emerge as demand grows for more efficient or different ways to use ecosystem services for mitigating impacts or to track or trade services.**

Business cannot assume that there will be ample warning of a change in the availability of key services or that a company's past responses to changes will be successful in the future. Ecosystems often change in abrupt, unpredictable ways. Most ecosystems are being altered by human actions in unprecedented ways. Consequently, it is difficult to predict the future state of an ecosystem or the availability of an ecosystem service. In addition, these uncertainties mean that past successes in ecosystem management may not apply to current or future conditions.

> ***"The solutions of the past are often not robust enough under the conditions of global change and need to be re-thought and re-implemented."*** —Antony Burgmans, Chairman, Unilever N.V.

The MA provides a benchmark for public policy, public awareness, and the private sector; it will influence investments, the regulatory climate, and public opinion at national and international levels over the next 10 years. Using the findings of the MA can help ensure that a company's ventures are informed by the best available scientific information. Factoring that information into plans will allow businesses to position themselves as innovators and market leaders. Failure to keep pace with these changes risks the loss of competitive advantage, brand reputation, and the license to operate, innovate, and grow.

Even though Earth's natural capital is being eroded at a rapid rate, there is still time to lessen the impact and preserve options by building on a growing number of examples of good practice. The MA is designed to help decision-makers factor information about changes in ecosystems into their strategic planning. It provides a framework for the integrated management of multiple, interacting ecosystem services. The MA is the most comprehensive analysis to date of the many and complex ways in which people depend on and affect the natural environment.

> ***"Businesses' engagement in voluntary actions to reduce their impact on Earth's ecosystems can be an engine of positive change in two ways: it can be a source of new opportunities for business, and a means of preserving our natural assets for future generations."*** —Jonathan Lash, President World Resources Institute

2. *The Bottom Line*

People everywhere rely on ecosystems and the services they provide. So do businesses. Demand for these services is increasing. However, many of the world's ecosystems are in serious decline, and the continuing supply of critical ecosystem services is now in jeopardy.

The loss or degradation of ecosystem services will have impacts on human well-being. It will also profoundly affect businesses. Higher operating costs or reduced operating flexibility should be expected due to diminished or degraded resources (such as fresh water) or increased regulation.

Every threat creates opportunity. Innovation and technology to minimize the damage to ecosystems and to mitigate impacts already occurring are creating significant new business opportunities for those who are aware and prepared.

The impacts of ecosystem degradation will be felt over both the short term—the next 5 years—and the longer term—the

What are Ecosystems and Ecosystem Services?

An **ecosystem** is a dynamic complex of plants, animals, microbes, and physical environmental features that interact with one another. **Ecosystem services** are the benefits that humans obtain from ecosystems, and they are produced by interactions within the ecosystem. Ecosystems like forests, grasslands, mangroves, and urban areas provide different services to society. These include provisioning, regulating, and cultural services that directly affect people. They also include supporting services needed to maintain all other services. Some ecosystem services are local (provision of pollinators), others are regional (flood control or water purification), and still others are global (climate regulation). (See Figure 1.) Ecosystem services affect human well-being and all its components, including basic material needs such as food and shelter, individual health, security, good social relations, and freedom of choice and action. (See Figure 2.)

Figure 1. Ecosystems and Some Services They Provide

Different combinations of services are provided to humans from the ecosystems represented here. Their ability to deliver the services depends on complex biological, chemical, and physical interactions, which are in turn affected by human activities.

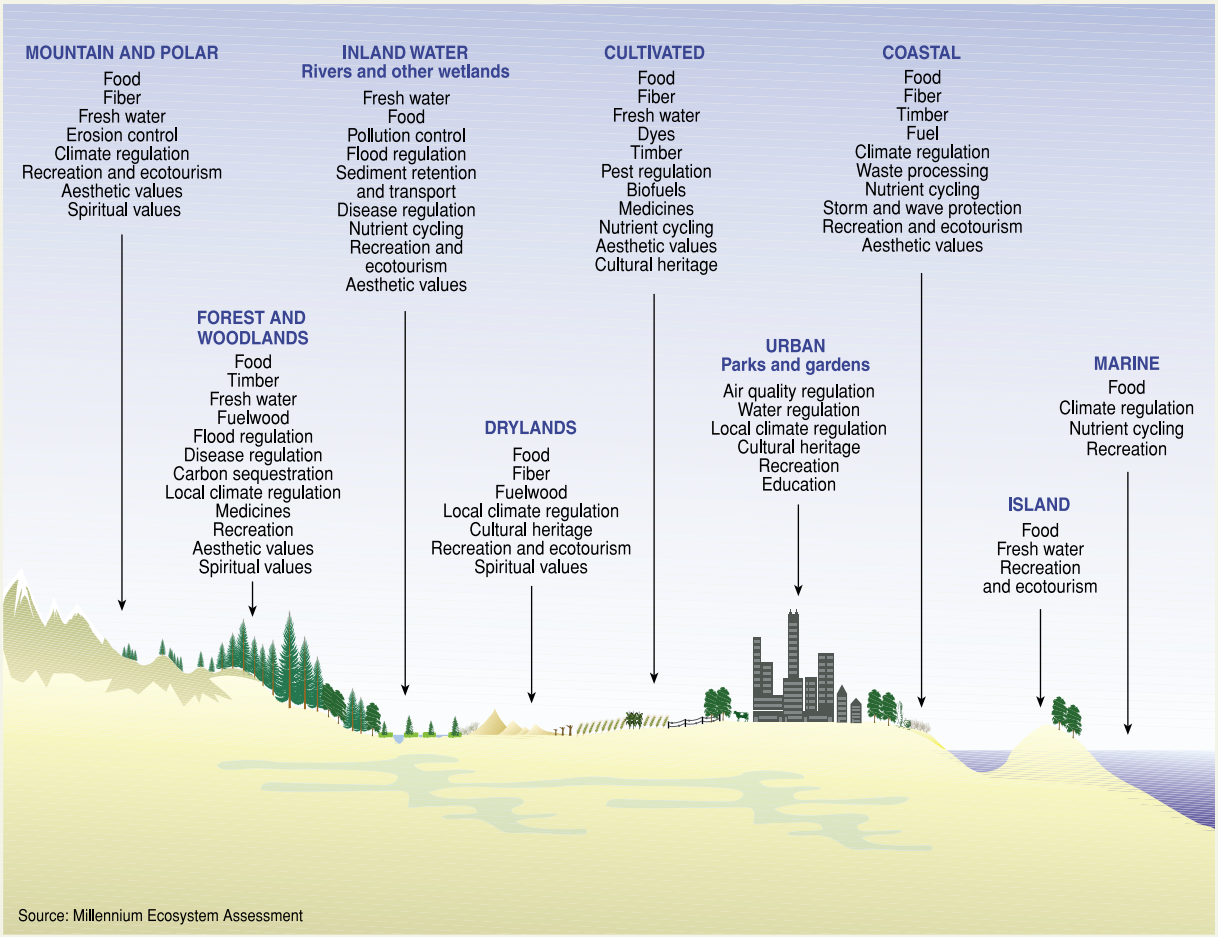
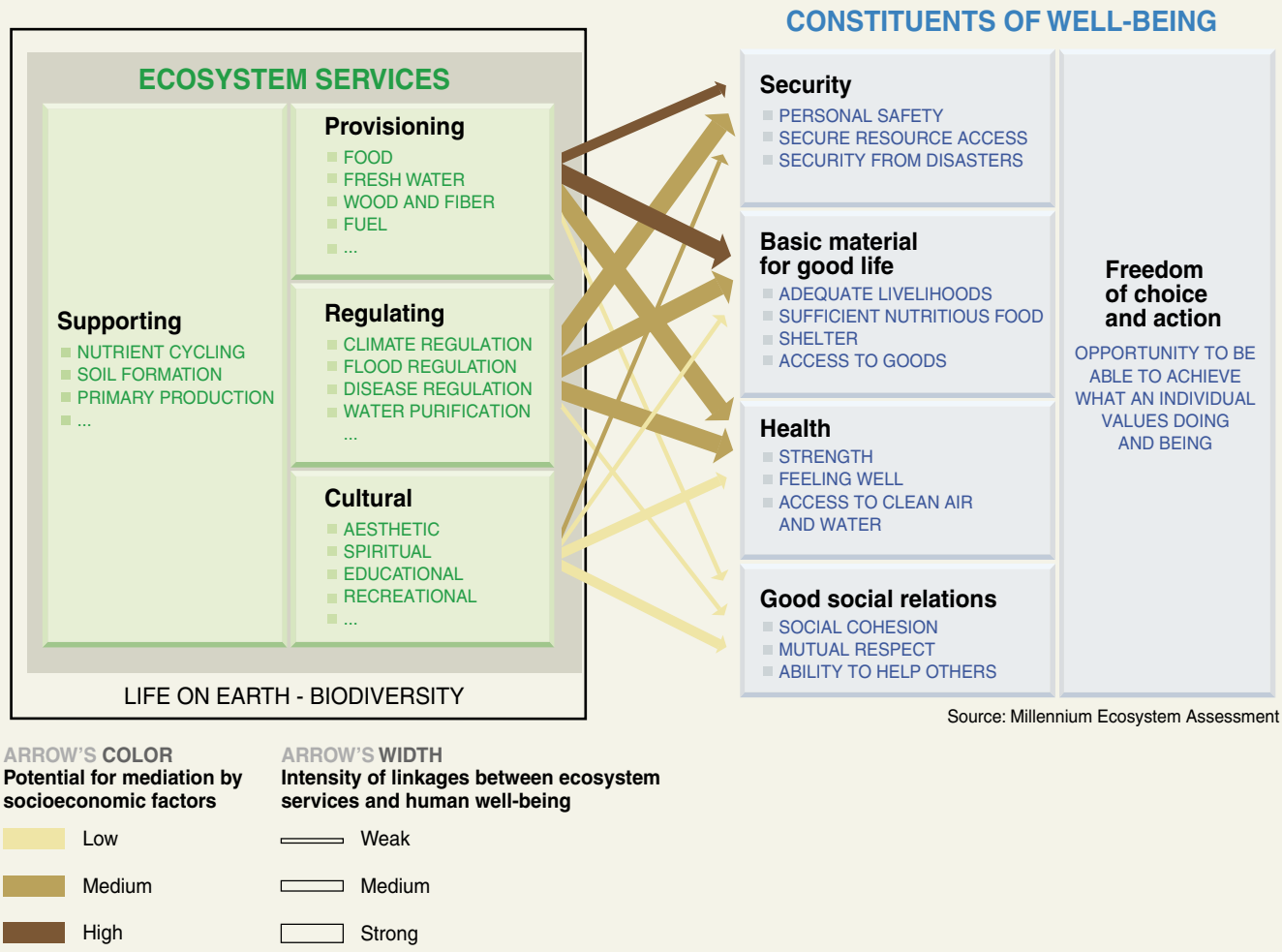


Figure 2. Linkages between Ecosystem Services and Human Well-being

This Figure depicts the strength of linkages between categories of ecosystem services and components of human well-being. It includes indications of the extent to which it is possible for socioeconomic factors to mediate the linkage. For example, if it is possible to purchase a substitute for a degraded ecosystem service, then there is a high potential for mediation. The strength of the linkages and the potential for mediation vary according to the specific ecosystem and region. In addition, other factors—including other environmental factors as well as economic, social, technological, and cultural factors—influence human well-being. Ecosystems are in turn affected by changes in human well-being.



Source: Millennium Ecosystem Assessment

next 50 years. But many businesses will experience an array of direct and indirect impacts immediately because ecosystem degradation is changing public policy, consumer preferences, supplier relationships, stockholder expectations, and competitor strategies, all of which vary by country and region of the world. Many governments, NGOs, and leading companies are already taking action.

Regardless of its focus, a business will be more competitive if it bases decisions about strategic direction, product offerings, production, transportation, and marketing on the best available information about the current and projected condition of ecosystems and ecosystem services. The MA provides a framework for understanding ecosystem services and provides scientifically credible information about the important linkages between those services and human well-being.

As demands for the services provided by ecosystems grow and the ability of these systems to meet these demands is eroded, increasingly difficult challenges must be confronted. For example:

- How do we meet the growing demand for **food** (projected to increase by 70–80% in 50 years) without further harming the environment or the integrity of the food supply chain?

- Given the unevenly distributed supply of **fresh water**, how do we meet agricultural, industrial, and consumptive needs around the world?
- Given the expected increase in demands for energy, what are the most efficient and effective strategies to produce energy while also minimizing impacts to **air quality and climate**?
- How do we balance conservation of **biodiversity** with opportunities for economic development associated with alteration or conversion of habitats?
- How do we balance increasing demand for seafood and expanding opportunities for aquaculture, while promoting the health of fresh and coastal waters and restoring depleted **wild fisheries**?

Business is positioned to be a very positive force in addressing these challenges through pursuit of new business opportunities and markets, reduction of operational footprints, development and deployment of new technology, and establishment of effective partnerships. In addition, businesses can demonstrate leadership in support for and reform of public policy that seeks to raise industry environmental performance standards in order to gain first-mover advantages while improving the reputation of their industry as a whole with important customers and constituencies.

It is in business's self-interest to take a leadership role in reducing poverty, improving human well-being, and protecting the environment. Doing so will help secure stable and safe societies, preserve open and free markets, ensure access to critical resources, provide new product and business opportunities, avoid abrupt social and environmental changes, and, for the most astute and agile, **carve out competitive advantage**.

The MA outlines actions businesses can take that would improve their bottom line, reduce degradation of ecosystems, and benefit human well-being. These actions include:

- **Identify and understand the ecosystem services** that a business uses or affects (including those important to suppliers, partners, customers, and other constituencies) and adjust corporate strategies accordingly.
- **Manage in an integrated way** the interacting and multiple demands on ecosystem services throughout supply chains and product life-cycles.
- **Increase efficiency of ecosystem-service use or ecosystem-service supply** by developing, deploying, or marketing new technologies that improve operations, reduce impacts on ecosystems, and meet increasing demand for ecosystem services.
- **Pursue partnerships** with other companies, government agencies, and civil society organizations to help accelerate corporate learning about ecosystems and ecosystem services, leverage resources and skills, and build trust with important stakeholders.
- Take business decisions that **anticipate growing customer preferences for sustainably supplied services, new regulations, competitor strategies, investor demands for sustainable business models, and the establishment of market mechanisms.** For example:
  - reduce carbon emissions,
  - decrease nitrogen and phosphorus loading,
  - increase efficiency of water and energy use,
  - protect natural habitat and biodiversity,
  - achieve the sustainable management of natural resources, and
  - make decisions informed by the full "life-cycle" costs of products.
- **Provide objective information** on the impact of operations on ecosystem services to key stakeholders (including the public) to build trust, help create a value-adding reputation, and help strengthen the business case for ecosystem conservation.

The MA provides a comprehensive analysis of ecosystem status and trends, options for action, and scenarios that explore the trade-offs to be confronted.

There are four components of the MA analysis:

- **condition and trends** in ecosystems and services associated with human well-being;
- **scenarios** of contrasting possible futures with respect to changes in ecosystem services;
- **possible responses** by governments, nongovernmental organizations, and businesses to ecosystem changes; and
- **sub-global assessments** that analyze the nested local, national, and regional scales at which ecosystems and human well-being are connected.

An overarching synthesis, MA Board Statement, and four additional reports that integrate MA findings concerning biodiversity, desertification, wetlands, and human health are also available.

3. *What We Know*

Key Trends in Ecosystems and Their Services

Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period in human history, largely to meet fast-growing demands for food, fresh water, timber, fiber, and fuel. The changes we have made to ecosystems have contributed to substantial net gains in human well-being and economic development. However, these gains have come at growing costs in the form of degradation of many ecosystem services (see Table 1), increased risks of abrupt and harmful changes in ecosystems, and harm to some groups of people.

Approximately 60% (15 out of 24) of the ecosystem services examined in this assessment are being degraded or used unsustainably—including 70% of provisioning and regulating services. While 15 services have been degraded, only 4 have been enhanced in the past 50 years, 3 of which involve food production: crops, livestock, and aquaculture.

Table 1. Global Status of Ecosystem Services Evaluated in the MA

An upwards arrow indicates that the condition of the service globally has been enhanced and a downwards arrow that it has been degraded. Definitions of "enhanced" and "degraded" for the three categories of ecosystem services shown in the table are provided in the note below. Supporting services, such as soil formation and photosynthesis, are not included here as they are not used directly by people.

Service	Sub-category	Status	Notes
Provisioning Services			
Food	crops	▲	substantial production increase
	livestock	▲	substantial production increase
	capture fisheries	▼	declining production due to overharvest
	aquaculture	▲	substantial production increase
	wild foods	▼	declining production
Fiber	timber	+/–	forest loss in some regions, growth in others
	cotton, hemp, silk	+/–	declining production of some fibers, growth in others
	wood fuel	▼	declining production
Genetic resources		▼	lost through extinction and crop genetic resource loss
Biochemicals, natural medicines, pharmaceuticals		▼	lost through extinction, overharvest
Fresh water		▼	unsustainable use for drinking, industry, and irrigation; amount of hydro energy unchanged, but dams increase ability to use that energy
Regulating Services			
Air quality regulation		▼	decline in ability of atmosphere to cleanse itself
Climate regulation	global	▲	net source of carbon sequestration since mid-century
	regional and local	▼	preponderance of negative impacts
Water regulation		+/–	varies depending on ecosystem change and location
Erosion regulation		▼	increased soil degradation
Water purification and waste treatment		▼	declining water quality
Disease regulation		+/–	varies depending on ecosystem change
Pest regulation		▼	natural control degraded through pesticide use
Pollination		▼[a]	apparent global decline in abundance of pollinators
Natural hazard regulation		▼	loss of natural buffers (wetlands, mangroves)
Cultural Services			
Spiritual and religious values		▼	rapid decline in sacred groves and species
Aesthetic values		▼	decline in quantity and quality of natural lands
Recreation and ecotourism		+/–	more areas accessible but many degraded

Note: For provisioning services, we define enhancement to mean increased production of the service through changes in area over which the service is provided (e.g., spread of agriculture) or increased production per unit area. We judge the production to be degraded if the current use exceeds sustainable levels. For regulating services, enhancement refers to a change in the service that leads to greater benefits for people (e.g., the service of disease regulation could be improved by eradication of a vector known to transmit a disease to people). Degradation of regulating services means a reduction in the benefits obtained from the service, either through a change in the service (e.g., mangrove loss reducing the storm protection benefits of an ecosystem) or through human pressures on the service exceeding its limits (e.g., excessive pollution exceeding the capability of ecosystems to maintain water quality). For cultural services, degradation refers to a change in the ecosystem features that decreases the cultural (recreational, aesthetic, spiritual, etc.) benefits provided by the ecosystem.

[a] Indicates *low to medium certainty*. All other trends are *medium to high certainty*.

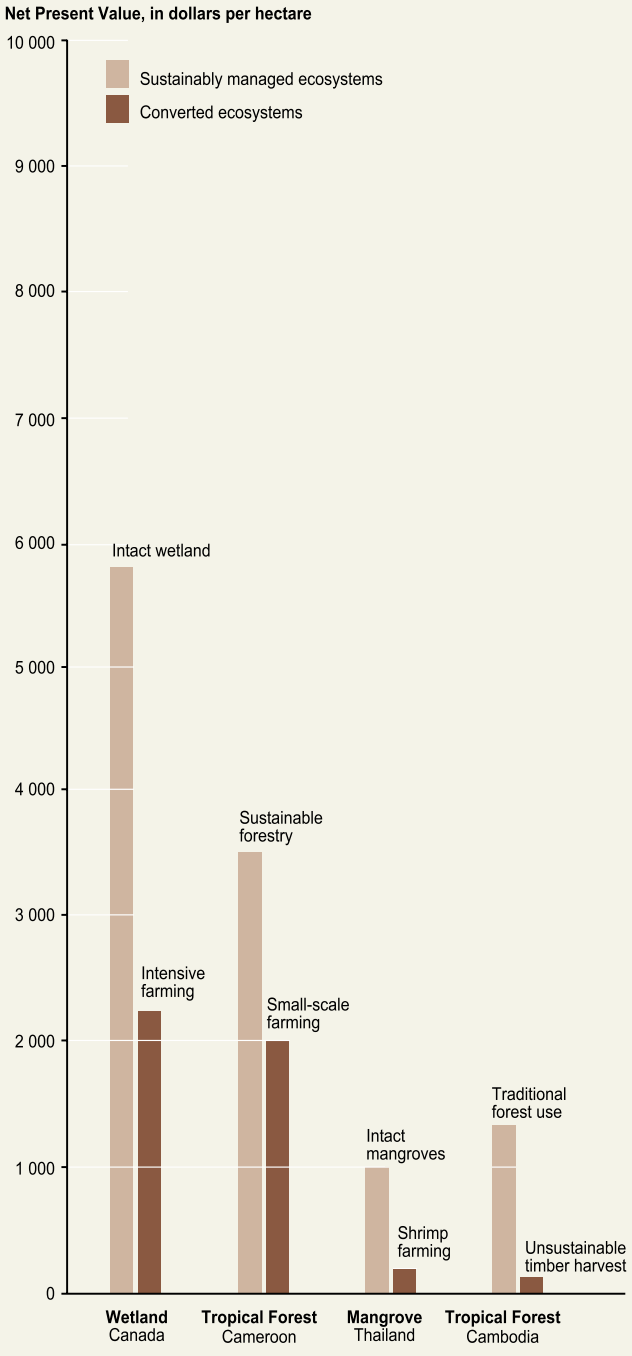
Actions to increase one service often cause the degradation o
other services. For example, food production may be increased
the expense of water quality. It is difficult to fully assess the cos
and benefits of ecosystem changes because many costs are diffi-
cult to quantify, slow to become apparent, or may appear some
distance from the original activity. For example, excess nitroge

Figure 3. Annual Flow of Benefits from Forests in S

In most countries, the marketed values of ecosystems associated with
value, including nonmarketed values such as carbon sequestration, wa

Figure 4. Economic Benefits under Alternate Management Practices

In each case, the net benefits from the more sustainably managed ecosystem are greater than those from the converted ecosystem, even though the private (market) benefits would be greater from the converted ecosystem. (Where ranges of values are given in the original source, lower estimates are plotted here.)



Source: Millennium Ecosystem Assessment

Changes being made to ecosystems are resulting in an increased likelihood of potentially high-impact and abrupt changes in physical and biological systems, such as disease emergence, dead zones in water bodies, and fishery collapses. This increased likelihood of abrupt change stems from a variety of factors, including loss of biodiversity, increased numbers of invasive alien species, overharvesting, climate change, and nutrient loading. Capabilities for predicting such abrupt changes are improving, but for most ecosystems and their services, science cannot yet predict thresholds where nonlinear change will be encountered.

The harmful consequences of ecosystem change will grow during the first half of this century. Most of the direct drivers of degradation in ecosystem services are currently remaining constant or growing in intensity, and they reflect various indirect drivers such as population growth, increasing per capita consumption, economic arrangements, sociopolitical and cultural factors, and technological change.

Whether or not a business directly uses natural resources, these trends could affect supply chains, access to markets, competitive dynamics, and corporate reputation. Some specific implications for businesses of these trends include:

Challenges

- increased regulatory constraints as governments seek to protect degraded services;
- risk to reputation and brand image for businesses most directly tied to threatened ecosystems and services;
- substantial increase in costs of important inputs (such as water or agricultural products);
- increased vulnerability of assets to floods or other natural disasters; and
- conflict and corruption that may arise in areas plagued by scarcity of ecosystem services.

Opportunities

- new markets and product opportunities to address ecosystem service scarcities;
- enhanced corporate image and reputation, political capital, and brand value from genuine proactive management of environmental issues; and
- cost and operational advantages derived from early recognition and action with regard to ecosystem service scarcity.

Ecosystem Trends of Particular Importance to Business

Six major changes are having or will have profoundly negative impacts on ecosystems: water scarcity, climate change, habitat change, biodiversity loss and invasive species, overexploitation of oceans, and nutrient overloading. Individually and collectively, these changes will have an impact on business.

Water Scarcity

Potentially of greatest importance to business is water scarcity. The MA found that 5–20% of freshwater use exceeds long-term sustainable supply and is met by water transfer or unsustainable mining of groundwater. Roughly 15–35% of irrigation withdrawal is estimated to be unsustainable. **Scarcity of water supply will affect all businesses either directly or indirectly, just as increases in the price of petroleum affect the state of the global economy**. Governments will be called on to allocate supplies and adjudicate water rights. Increasingly, markets and market mechanisms are being used to help achieve efficient use through prices that reflect scarcities.

Business Implications of Ecosystem Change – Water Scarcity

- Businesses will find themselves in competition with others—including other businesses—for water.
- The cost of water may result in substantial increase in the cost of business operations.
- Decisions about locating operations must address long-term water supply.
- Increasingly, businesses will need to find ways of recycling supplies.
- New technologies and modes of operation that reduce the consumption of water per unit of output and address water quality will be valuable.
- Marketing and selling water is a new business opportunity already being pursued in some places.

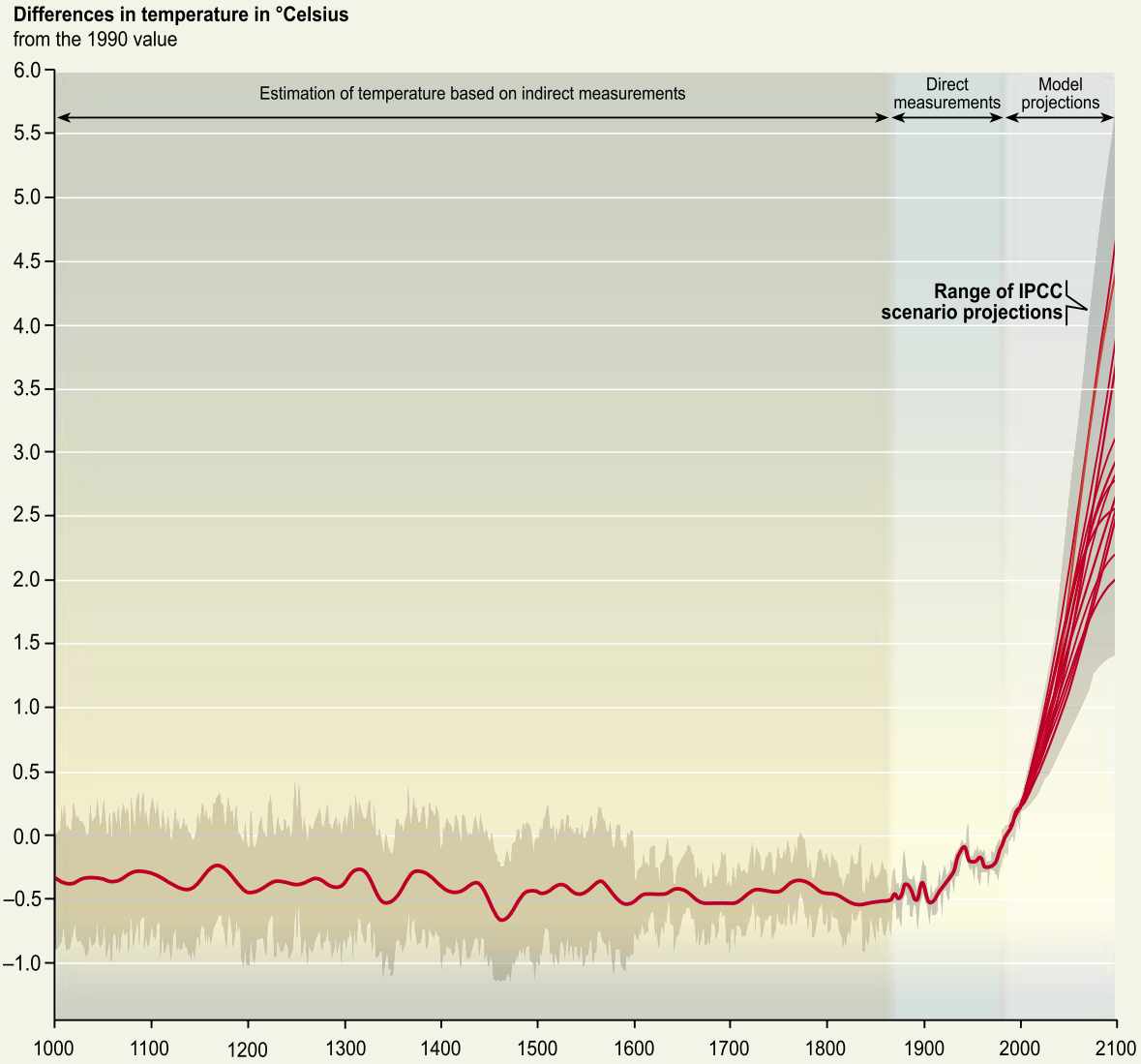
Climate Change

Observed recent changes in climate, especially warmer regional temperatures, have already had significant impacts on biodiversity and ecosystems, including changes in species distributions, population sizes, the timing of reproduction and migration events, and an increase in the frequency of pest and disease outbreaks. Many coral reefs have undergone major bleaching episodes.

By the end of the century, climate change may be the dominant direct driver of biodiversity loss and changes to ecosystem services globally. The scenarios developed by the Intergovernmental Panel on Climate Change project an increase in global mean surface temperature of 2.0–6.4 degrees Celsius above preindustrial levels by 2100 (see Figure 5), increased incidence of droughts and floods, and a rise in sea levels of 9–88 cm

Figure 5. Historical and Projected Variations in Earth's Surface Temperature

Estimated global average temperatures for the past 1,000 years, with projections to 2100. Projections are variable because they depend on a number of different plausible scenarios for future human behavior.



Source: Intergovernmental Panel on Climate Change 2002

(4–35 inches). The balance of scientific evidence suggests that harm to biodiversity and degradation of ecosystem services will grow on a worldwide basis (although some ecosystem services in some regions could be initially enhanced) if the global mean surface temperature increases more than 2 degrees Celsius above preindustrial levels or at rates greater than 0.2 degrees per decade. IPCC projections indicate that atmospheric carbon dioxide concentrations must eventually stabilize at or below 450 parts per million in order to contain global average temperature increases to no more than 2 degrees Celsius.

Habitat Change

More land was converted to cropland in the 30 years after 1950 than in the 150 years between 1700 and 1850. Cultivated

Energy and Climate Change: Turning Threats to Opportunities

Energy production and use illustrate how threats to established ways of business from ecological stress (climate change) can turn into business opportunities and competitive advantage.

Reliable and abundant forms of energy are essential for economic development and human well-being. Throughout the twentieth century and the current decade, energy supply has been dominated by plentiful fossil fuels, including coal, petroleum, and natural gas. Vast investment and infrastructure have grown to facilitate the production, transportation, processing, and use of these forms of energy. Despite the very important role fossil fuels have played in economic development, however, their use has taken and continues to take a toll on ecosystems and the services they provide to people. This toll comes in the form of impacts to ecosystems during extraction, spills and air pollution during transportation, and air pollution and greenhouse gas emissions during processing and use.

The Millennium Ecosystem Assessment identified climate change as one of the most important drivers of stress and degradation of ecosystems and ecosystem services. Climate change is directly linked to the buildup of carbon dioxide in the atmosphere from the use of fossil fuels. A critical challenge in the protection and restoration of ecosystem services is the transition to an energy future with lower carbon emissions, less air pollution, and minimal risks from the extraction and transportation of fossil fuels.

At first glance, important industries will be threatened by such a transition: The producers of coal, oil, and natural gas; electric utilities; industrial users of energy such as steel and metals and chemical companies; and companies that produce devices that rely on fossil fuels, such as auto manufacturers. Nevertheless, leading companies have already seen that important business opportunities are possible in this transition.

For example, some leading oil and gas producers are making significant investments in renewable energy businesses, such as solar photovoltaics, and are seeing sales rise rapidly. These same energy producers along with several important utility companies are participating actively in establishing formal markets for trading in carbon emission reductions as these gain value under governmental mandates. These companies have already seen the volume of trades accelerate to a market of significant size. At the same time, most major oil and gas companies are focusing on the role that natural gas can play in the intermediate term as a lower carbon bridge (versus coal) to a renewable energy future.

Most major automobile companies are trying to capitalize on the growing demand for more fuel-efficient vehicles through the introduction of cars that combine electric motors with gasoline power (hybrids) and are positioning themselves for a hydrogen-based energy paradigm by working to perfect fuel cell technology. Power equipment manufacturers see a rapidly expanding market for wind energy and are acquiring expertise in order to compete. Leading industrial users of energy have committed to more efficient processes that will result in lower carbon emissions not only to reduce costs but also in appreciation of growing customer and societal concerns. Leading companies in some cases actively argue for greater scrutiny of the climate issue by the public and by governments.

These leading companies are moving ahead of changes called for by government regulation and in some cases ahead of customer demand. This "beyond compliance" and technology-forcing approach is driven by the desire to shape future markets and policy environments to favor their individual company's strengths, attract the best partners and employees, build brand image and customer/investor loyalty with market segments that value their leadership initiatives, and reduce the long-term costs and risks that could arise as society becomes increasingly concerned about the loss of ecosystem services.

Leading companies are seeing that by being proactive, they are writing the rules of future competition to enhance their chance of long-term success.

"Increasingly for business, 'green' is green."—Jeff Immelt, Chair and CEO of General Electric

systems now cover one quarter of Earth's terrestrial surface. A further 10–20% of grassland and forestland is projected to be converted between 2000 and 2050, primarily to agriculture. The projected land conversion is concentrated in low-income countries and dryland regions. Conversely, forestland is projected to continue to increase within industrial countries. (See Figure 6.)

Biodiversity Loss and Invasive Species

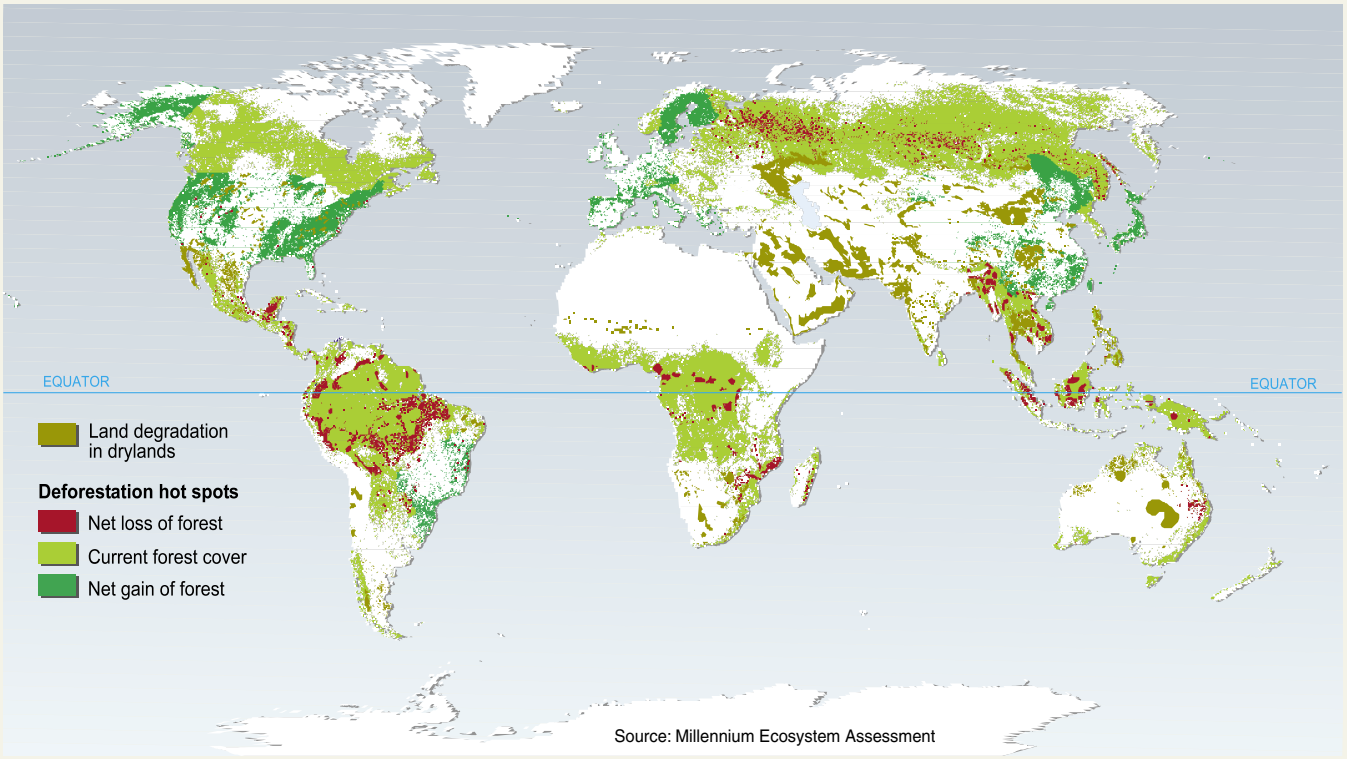
The total number of species on the planet is declining and the distribution of species is becoming more homogeneous. Over the past few hundred years, humans have increased species' extinction rates by as much as 1,000 times over the background rates that have been more typical throughout the planet's history. (See Figure 7.) Some 10–30% of mammal, bird, and amphibian species are currently threatened with extinction. Freshwater ecosystems tend to have the highest proportion of threatened species. In addition, the majority of species are seeing their populations fragmented and their population sizes and ranges decline. Genetic diversity has also declined globally, particularly with respect to cultivated species. The spread of invasive alien species and disease organisms continues to increase due to both deliberate translocations and accidental introductions related to travel and trade. Invasive species generally threaten native species and many ecosystem services. (See Figure 8.)

Overexploitation of Oceans

Increasing demand for seafood has been matched by increasing fishing capacity and technological advances. Reported catches from oceans increased steadily over the last century, reached a peak in the mid-1980s, then began to decline. (See Figure 9.) A number of economically important fisheries, such as the Atlantic cod off Newfoundland, have collapsed

Figure 6. Locations Reported by Various Studies as Undergoing High Rates of Land Cover Change in the Past Few Decades

In the case of forest cover change, the studies refer to the period 1980–2000 and are based on national statistics, remote sensing, and, to a limited degree, expert opinion. In the case of land cover change resulting from degradation in drylands (desertification), the period is unspecified but inferred to be within the last half-century, and the major study was entirely based on expert opinion, with associated low certainty. Change in cultivated area is not shown.



abruptly under intense fishing pressure, causing significant social, economic, and ecological system disruption.

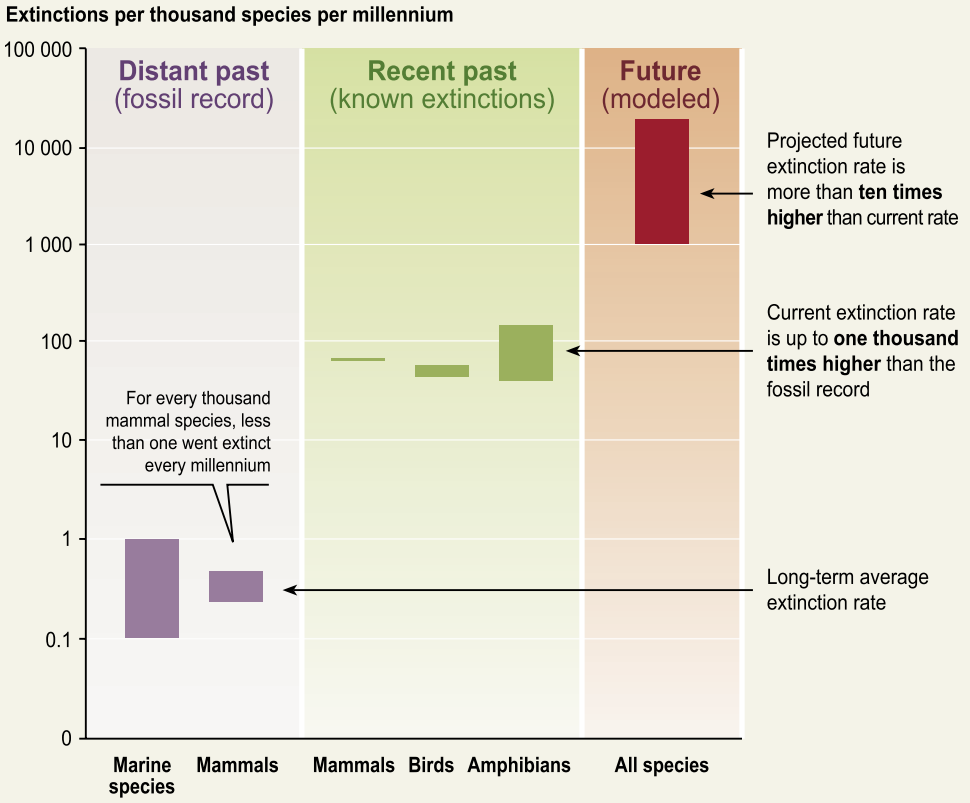
Fleets now fish greater and greater distances from shore and in deeper and deeper waters as coastal fisheries have been depleted. (See Figures 10 and 11.) As fishing expanded across the open ocean, the proportion of depleted stocks rose from 4% in 1950 to 25% in 2000, while the "undeveloped" stocks plummeted from 65% to 0. During the period of increased catch, the overall consequences of the serial depletion of one fishery after another did not become obvious until all major ocean fish stocks had been exploited on an industrial scale.

Fishing has had a significant impact on ocean ecosystems above and beyond simply removing massive amounts of biomass and depleting individual species. Fishing targets the top predators, which are also the very large fishes in the ocean. As much as 90% of these fish—sharks, tuna, marlin, and swordfish—have been removed by industrial fishing. Overfishing of these large species has changed the composition of the oceans, modified interactions among species, and resulted in the targeting of previously less desirable species that feed lower in the food web.

Widespread collapses, overfishing of top predators, and declining catches are all symptoms of seriously disrupted ocean ecosystems. Such systems are not able to provide the full range of services they did in the past, including the provision of food. The ability of an ecosystem to absorb threats or to be resilient may be compromised with such massive disruption to the integrity of the natural system. Some businesses are already experiencing direct impacts through decreased provision of fish for food or feed, while other businesses are or may be indirectly affected by the increased frequency of outbreaks of disease or blooms of nuisance species that are symptomatic of unstable ocean systems.

Figure 7. Species Extinction Rates

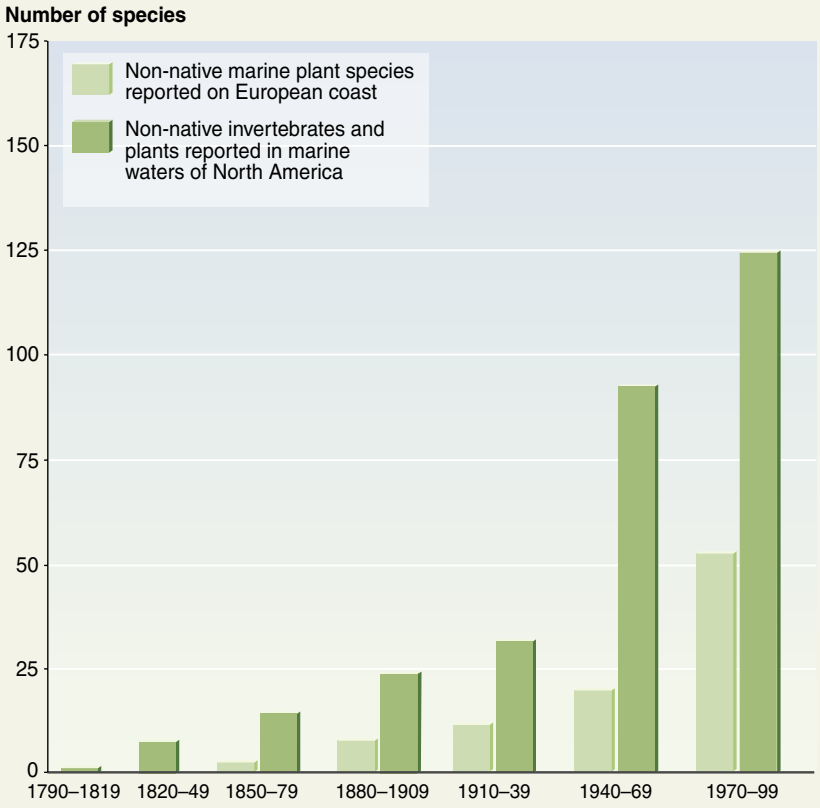
Comparisons with the rate at which species have disappeared from the planet over a long period of Earth's history indicate that humans have already increased extinctions levels dramatically. Projections suggest that this rate will take another big leap due to changes over the next 50 years. The bars represent the range of estimates in each case.



Source: Millennium Ecosystem Assessment

Figure 8. Growth in Number of Marine Species Introductions

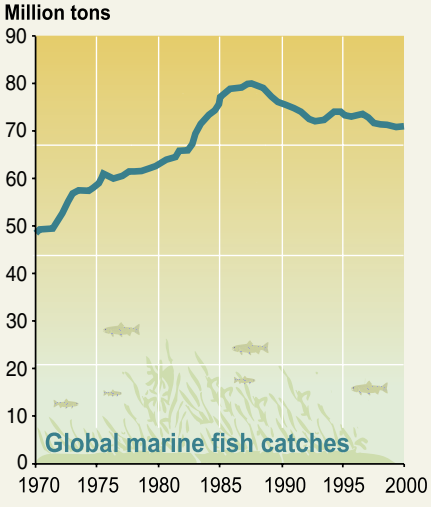
Number of new records of established non-native invertebrate and algal species reported in marine waters of North America, shown by date of first record, and number of new records of non-native marine plant species reported on the European coast, by date of first record.



Source: Millennium Ecosystem Assessment

Figure 9. Estimated Global Marine Fish Catch, 1950–2001

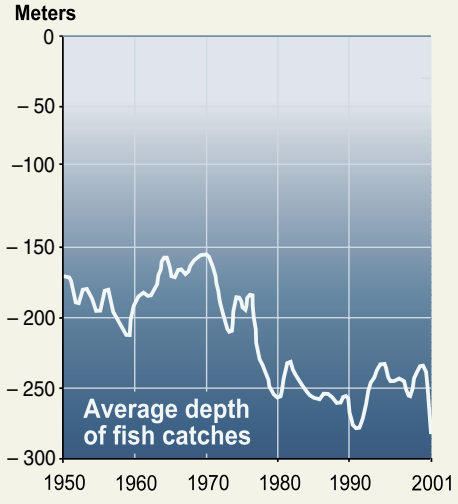
In this Figure, the catch reported by governments is in some cases adjusted to correct for likely errors in data.



Source: Millennium Ecosystem Assessment

Figure 10. Trend in Mean Depth of Catch Since 1950

Fisheries catches increasingly originate from deep areas.

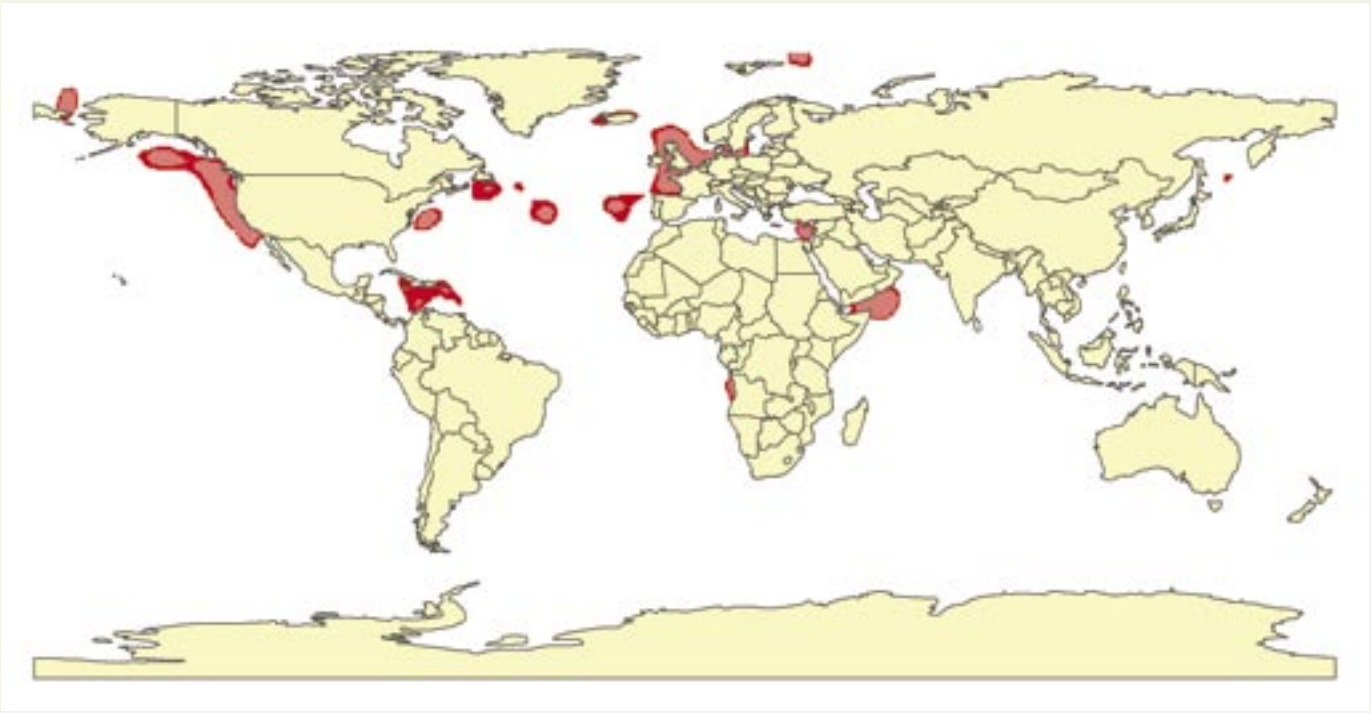


Source: Millennium Ecosystem Assessment

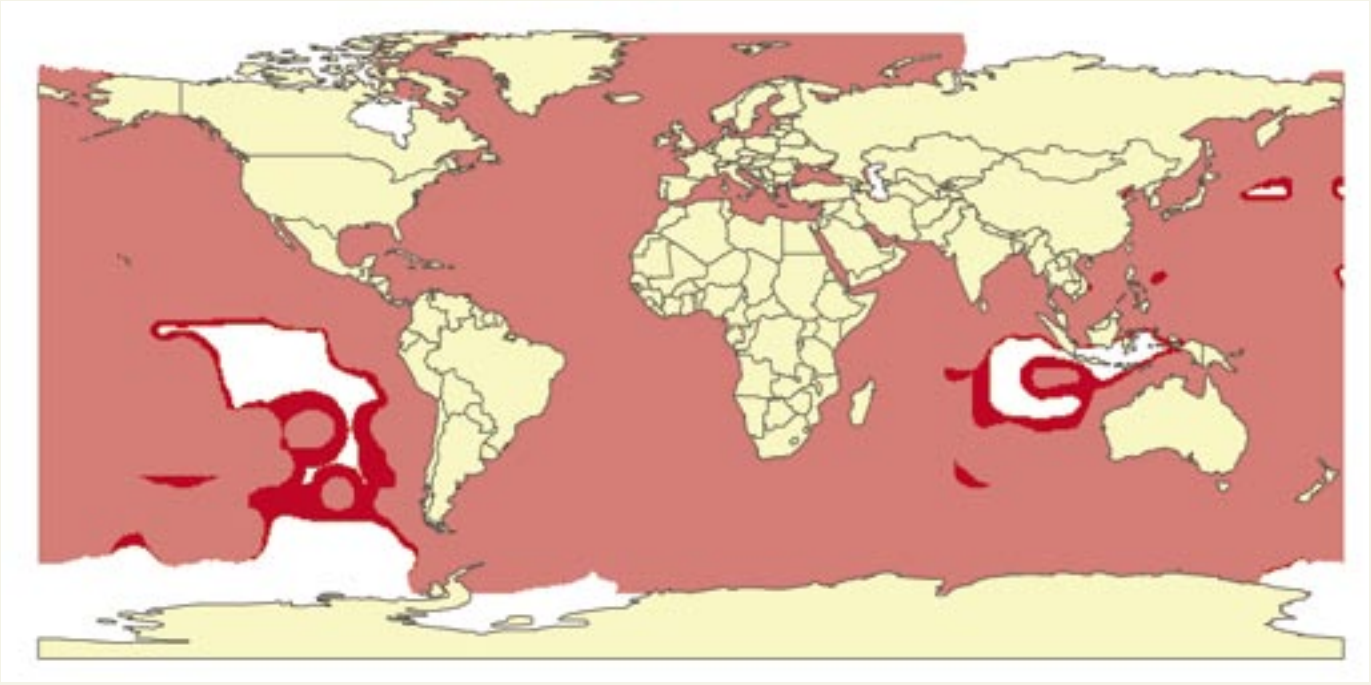
Figure 11. Year of Maximum Catch, 1965 and 1995

Geographic shifts in global fisheries catches through time reflect increasing depletion closer to shore. Solid lines indicate areas with maximum catches during 1965 and 1995; shaded areas represent places where the maximum catch has already been reached and is falling.

1965



1995

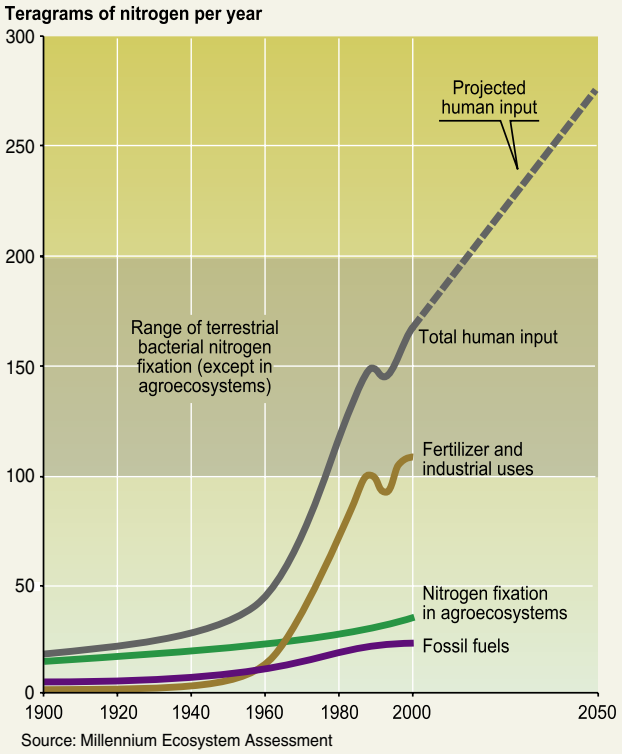


Nutrient Overloading

Humans have doubled the flow of reactive nitrogen on the continents. Some projections suggest this may increase by roughly two thirds by 2050 and that the global flux of nitrogen to coastal ecosystems will increase by 10–20% by 2030, with most of this increase occurring in developing countries. (See Figure 12.) Excessive flows of nitrogen contribute to eutrophication of freshwater and coastal marine ecosystems and acidification of freshwater and terrestrial ecosystems, with associated harm to biodiversity. Nutrient pollution in coastal areas often triggers harmful algal blooms and is increasing the number and size of zones of low or no oxygen (so called "dead zones"). In addition, nitrogen can contribute to ground-level ozone, destruction of stratospheric ozone, and climate change—all with attendant environmental and health implications.

Figure 12. Reactive Nitrogen on Earth by Human Activity, with Projection to 2050

Most of the reactive nitrogen produced by humans comes from manufacturing nitrogen for synthetic fertilizer and industrial use. Reactive nitrogen is also created as a by-product of fossil fuel combustion and by some (nitrogen-fixing) crops and trees in agroecosystems. The range of the natural rate of bacterial nitrogen fixation in natural terrestrial ecosystems (excluding fixation in agroecosystems) is shown for comparison. Human activity now produces approximately as much reactive nitrogen as natural processes do on the continents. (Note: The 2050 projection is included in the original study and is not based on MA scenarios.)



Source: Millennium Ecosystem Assessment

Overall Business Implications of Ecosystem Change

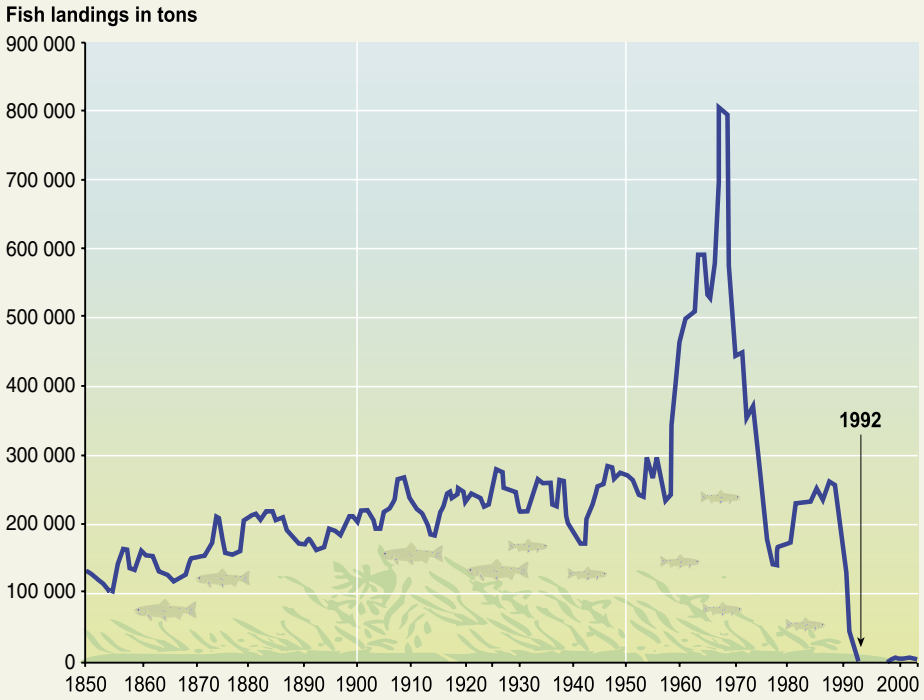
- Businesses are facing increased governmental regulation or stakeholder pressure (from activist shareholders, civil society, or customers) as threats to important ecosystem services from these changes become more apparent.
- Leading companies are seeking advantages in addressing these issues first in an effort to build reputation and carve out markets and business opportunities.
- Insurance companies are taking new approaches to setting rates that reflect growing risks from degradation of ecosystem services.
- New technologies will be needed for extraction, use, and management of ecosystem services.
- Businesses should take integrated responses to these challenges—recognizing their interdependence and the advantage of deploying flexible strategies, such as emissions trading.

Unexpected and Abrupt Changes

Changes being made to ecosystems are increasing the likelihood of "surprises" in the future, such as pest and disease breakouts, catastrophic floods, or species extirpations. As noted earlier, for example, intense fishing pressure caused the collapse of a number of economically important fisheries, such as the Atlantic cod off Newfoundland. (See Figure 13.) Examples such as this show that "tipping points" appear to be a very real phenomenon for ocean ecosystems under intense fishing pressure, and the same may be true for other ecosystems. Our abilities to foresee these abrupt changes are limited, and businesses caught by such surprises could face significant and unexpected challenges.

Figure 13. Collapse of Atlantic Cod Stocks off the East Coast of Newfoundland in 1992

This collapse forced the closure of the fishery after hundreds of years of exploitation. Until the late 1950s, the fishery was exploited by migratory seasonal fleets and resident inshore small-scale fishers. From the late 1950s, offshore bottom trawlers began exploiting the deeper part of the stock, leading to a large catch increase and a strong decline in the underlying biomass. Internationally agreed quotas in the early 1970s and, following the declaration by Canada of an Exclusive Fishing Zone in 1977, national quota systems ultimately failed to arrest and reverse the decline. The stock collapsed to extremely low levels in the late 1980s and early 1990s, and a moratorium on commercial fishing was declared in June 1992. A small commercial inshore fishery was reintroduced in 1998, but catch rates declined and the fishery was closed indefinitely in 2003.



Source: Millennium Ecosystem Assessment

Business Implications of Ecosystem Change – Abrupt Change

- Business strategies must be flexible in the face of uncertainties.
- Businesses may experience negative repercussions when connections between today's action and tomorrow's damage become clear in retrospect. Businesses need to develop processes to help spot these connections at the earliest possible time.
- The insurance industry is beginning to reflect these environmental uncertainties and the potential for "proximate cause" in its pricing and coverage exclusions.

Cultivated versus "Wild" Services

Sectors of the global economy are in major transition from reliance on ecosystem services provided in "the wild" to those provided through farming. For example, nearly one third of the fish and timber supplied to markets comes from farming. However, farming brings new sets of environmental concerns and impacts on ecosystems. For example, carnivorous fish such as salmon are fed fishmeal, which is made from wild caught fish. As the farming of carnivorous fishes grows, care must be taken that doing so does not further deplete wild populations. Sustainable aquaculture will also minimize nutrient and chemical pollution, escapees, and disease. Increasing consumer awareness of these issues is bringing pressure to bear on the aquaculture industry, favoring companies with more sustainable practices and policies.

Business Implications of Ecosystem Change – Cultivated Services

- Companies in new and rapidly expanding businesses are under increasing pressure to address the environmental consequences of their activities.
- Businesses throughout the supply chain and marketing channels of these new businesses need to be aware of environmental concerns, the impacts on ecosystems, and resulting threats and opportunities.

Shifting Demands on Ecosystems

As societies gain in wealth, their impact on ecosystems tends to increase and their demand for ecosystem services diversifies—often to consume more meat and to engage in more tourism and recreation.

Business Implications of Shifting Demands

- Protections afforded industries, such as agricultural subsidies, which were based on the traditional view of ecosystems and what they provide, may be removed to support new uses and priorities.
- New business opportunities are developing based on changing values and demands of societies.

Scenarios in the Assessment

To help decision-makers understand the implications of these trends in ecosystem services for the future, the MA developed a set of scenarios to explore the relationships between ecosystem services and human well-being. Scenarios are often used by businesses as planning tools or to explore logical consequences of different sets of conditions or choices. The MA scenarios compare alternative approaches to environmental decision-making and economic development and can inform decision-makers about the consequences of these alternatives.

The MA scenarios are distinct from previous global exercises due to the focus on ecosystem services and the effects of ecosystems on society and human well-being. The scenarios begin in 2000 and run until 2050 and were constructed along two main dimensions: contrasting transitions of global society (regionalization versus globalization) and contrasting approaches to governance and the implementation of policies related to ecosystems and their services (proactive versus reactive). (See Figure 14.)

No scenario represents "business as usual," although all begin from current conditions. None of the scenarios represents a "best" or a "worst" path. Instead, they illustrate different choices that may be made and some of the trade-offs that will be faced. There could be combinations of policies that produce significantly better, or worse, outcomes than any of the four scenarios. However, **across all scenarios there is a general tendency toward**

Figure 14. Scenarios Framework

reduction in the availability of supporting, regulating, and cultural ecosystem services in order to increase the availability of provisioning services. For example, the ability of ecosystems to provide soil regeneration or climate regulation might be sacrificed in favor of increasing the supply of food, fiber, or timber (in the short term). Such choices often trade future capacity of ecosystems to produce services for more services today.

The four scenarios demonstrate that at every scale there are opportunities for combining advantageous approaches to achieve synergistic benefits. Actions to preserve marine fish species, such as "no take" marine reserves, for example, have also been shown to make coral reefs more resistant to the pressures associated with declines in other species or excess nutrients. Advantages may also be found by combining various aspects of each scenario. For instance, combining the advantages of green technology (*TechnoGarden*) with fairer markets (*Global Orchestration*) and flexible ecosystem management that encourages local creativity (*Adapting Mosaic*) may lead to improvements in ecosystem services and human well-being beyond those found in any individual scenario.

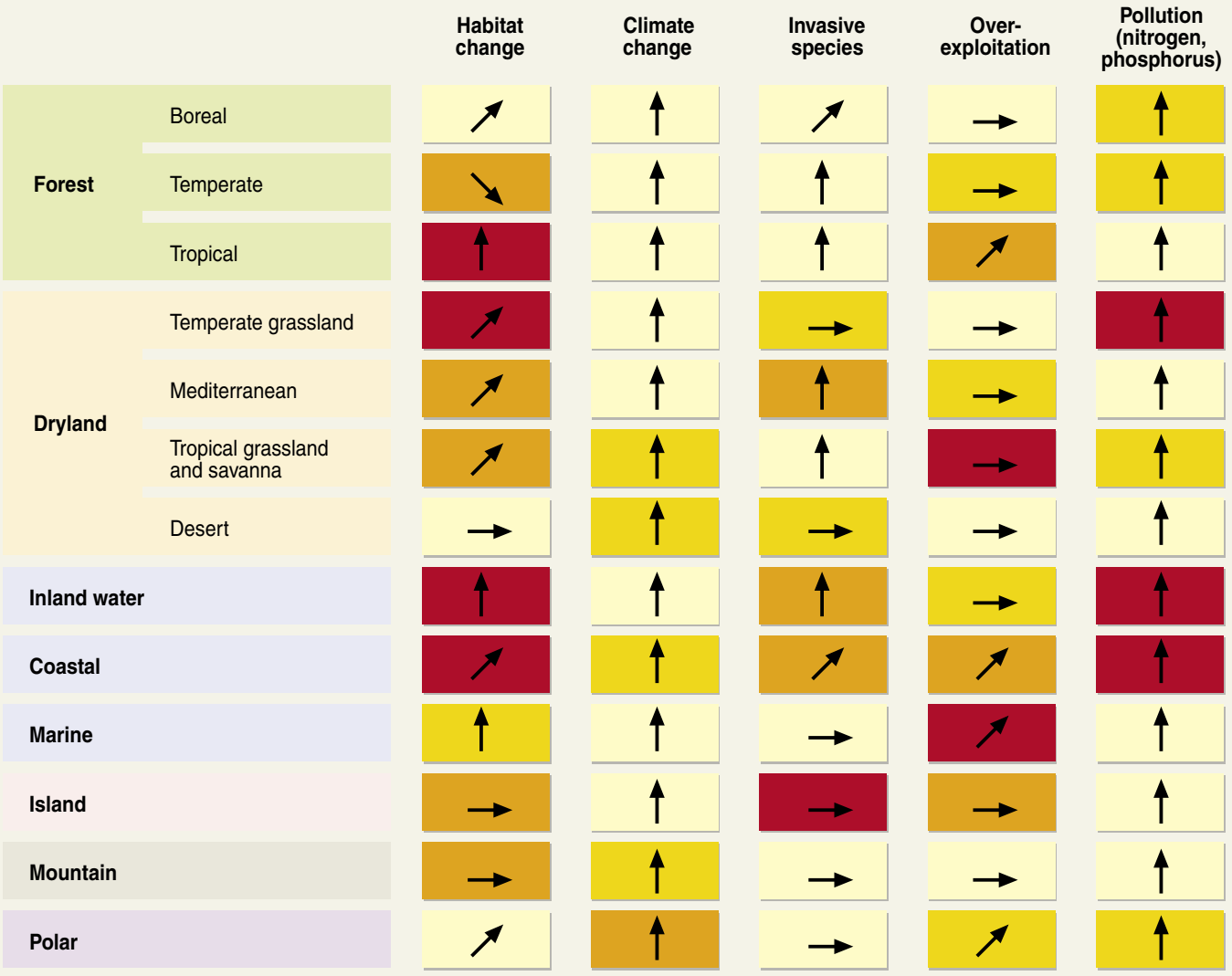
At the global level, and across all scenarios, the model projections had some **common and robust results**:

- Demand for provisioning services such as food, fiber, fuelwood, and water increases.
- Food security remains out of reach for many people, and child malnutrition will be difficult to eradicate even by 2050 despite increasing food supply under all four scenarios and more diversified diets in poor countries.
- Vast, complex changes with great geographic variability occur in world freshwater resources and hence in their provisioning of ecosystem services.
  - Climate change will alter precipitation patterns. Precipitation could increase over more than half of Earth's surface, making more water available to some societies and ecosystems but likely increasing the frequency of flooding in many areas. Climate change will also cause a substantial decrease in precipitation in some areas, causing a decrease in water availability. These areas could include highly populated arid regions such as the Middle East and Southern Europe.
  - While water withdrawals decrease in most industrial countries, water withdrawals and wastewater discharges are expected to increase enormously in Africa and some other developing regions, and this will intensify the water stress there.
- Deterioration of the services provided by freshwater resources—such as aquatic habitat, fish production, and water supply for households, industry, and agriculture—is expected in developing countries. Under the scenarios that are reactive to environmental problems, this deterioration will be severe, while in the scenarios that are more proactive about environmental problems, it will be less severe but still important.
- Growing demand for fish and fish products leads to an increasing risk of a major and long-lasting decline of regional marine fisheries. Aquaculture cannot relieve this pressure so long as it continues to rely heavily on marine fish as a feed source.
- Land use change is expected to be a major driver of changes in the provision of ecosystem services up to 2050.
  - The scenarios indicate that 10–20% of current grassland and forestland may be lost between now and 2050. This change mainly occurs in low-income and arid regions. The provisioning services associated with affected areas (genetic resources, wood production, and habitat for terrestrial biota and fauna) will also be reduced.
  - Threats to drylands and their services occur at multiple scales, ranging from global climate change to local pastoral practices. For example, sub-Saharan Africa is projected to expand water withdrawals rapidly to meet needs for development. Under some scenarios, this causes a speedy increase in untreated return flows to freshwater systems, which could endanger public health and aquatic ecosystems. Expansion and intensification of agriculture in this area may lead to loss of natural ecosystems and higher levels of surface and groundwater contamination. Continued population growth and improving economic conditions over the next decades will exert additional pressure on land resources and pose additional risk of desertification in dryland regions.
- Threats of wetland drainage and conversion, with adverse impacts on the capacity of ecosystems to provide adequate supplies of clean water, increased in all scenarios.
- Terrestrial ecosystems are currently a net sink of CO_2 at a rate of 1.2 (+/–0.9) gigatons of carbon per year. They thereby contribute to the regulation of climate, but the future of this service is uncertain. Deforestation is expected to reduce the carbon sink. Proactive environmental policies can maintain a larger terrestrial carbon sink (including incentives for such practices as afforestation and reforestation).

Most of the direct drivers of change in ecosystems are expected to remain at today's levels or to increase over the next few decades. (See Figure 15.) Direct drivers include habitat change, climate change, invasive species, overexploitation, and nutrient pollution.

Figure 15. Main Direct Drivers of Change in Biodiversity and Ecosystems (CWG)

The cell color indicates impact of each driver on biodiversity in each type of ecosystem over the past 50–100 years. High impact means that over the last century the particular driver has significantly altered biodiversity in that biome; low impact indicates that it has had little influence on biodiversity in the biome. The arrows indicate the trend in the driver. Horizontal arrows indicate a continuation of the current level of impact; diagonal and vertical arrows indicate progressively increasing trends in impact. Thus, for example, if an ecosystem had experienced a very high impact of a particular driver in the past century (such as the impact of invasive species on islands), a horizontal arrow indicates that this very high impact is likely to continue. This Figure is based on expert opinion consistent with and based on the analysis of drivers of change in the various chapters of the assessment report of the MA Condition and Trends Working Group. The Figure presents global impacts and trends that may be different from those in specific regions.



Source: Millennium Ecosystem Assessment

Business Implications of Scenarios

- Opportunities should be abundant for businesses positioned to address developing countries' needs for food, fiber, and fresh water, and especially those businesses that can enhance and build local capacities for provisioning services in sustainable ways.
- Challenges will grow for businesses operating along the fish products supply chain, and technologies or instruments that improve the environmental sustainability of fishing and aquaculture should be highly valued.
- Wetland protection will be a major societal concern that businesses must factor into planning.
- Atmospheric carbon capture through terrestrial ecosystems should have value that can be realized through forest protection, afforestation, and reforestation.

The scenarios demonstrate that there are strong trade-offs between food and water. Application of fertilizers in excess of crop needs causes large nutrient flows into fresh waters, estuaries, and coastal ecosystems. This overenrichment of water causes serious declines in the ecosystem services (food, recreation, fresh water, and biodiversity) provided by aquatic ecosystems. In addition, using water for irrigation of agriculture may reduce its availability for other uses, such as household or industrial use or maintaining other ecosystem services. There are possibilities for mitigating these trade-offs through technological enhancements or instruments such as cap and trade mechanisms for nutrients. Technological innovations and ecosystem engineering, coupled with economic incentives to facilitate their uptake, can lead to highly efficient delivery of provisioning ecosystem services. However, technologies can create new environmental problems, and in some cases the resulting disruptions of ecosystem services affect large numbers of people.

Business Implications of Trade-offs

- Technologies that optimize food yield, nutrient loading, and water use in agriculture should produce significant value so long as appropriate care is exercised in minimizing the potential for harmful unintended consequences.

Changing Policy Environment

Many options exist to conserve or enhance specific ecosystem services in ways that reduce negative trade-offs or provide positive synergies with other ecosystem services, but barriers prevent their full implementation. Past actions to slow or reverse the degradation of ecosystems have yielded significant benefits, but these improvements have generally not kept pace with growing pressures and demands. **Substitutes can be developed for some, but not all, ecosystem services. Even where a substitute is possible, its cost is generally high**.

The MA has assessed many options for enhancing ecosystem services as well as addressing drivers of change such as climate change and nutrient loading. Several of these options hold promise and, if implemented, would yield benefits for ecosystems and human well-being. **These options may become part of the future policy environment in which business will be operating**. Here are some of these options in broad categories having significant impacts on future business:

- Increasing use of integrated responses to address the degradation of ecosystems across a number of systems simultaneously, requiring the combination of a range of policies and strategies developed by actors from government, civil society, and private sector, including increased coordination among multilateral environmental agreements.
- Integrating ecosystem management goals within other sectors and within broader development planning frameworks (such as bank lending requirements).
- Increasing transparency and accountability of government and private-sector performance in decisions that affect ecosystems, including greater participation of concerned stakeholders.
- Enhancing human and institutional capacity for assessing the consequences of ecosystem change for human well-being, and acting on those assessments.
- Using all relevant forms of knowledge and information in assessments and decision-making, including traditional and practitioners' knowledge.
- Improving communication and providing education with respect to the sustainable management and use of ecosystems and ecosystem services.
- Empowering groups particularly dependent on ecosystem services, including women, indigenous people, and young people.
- Establishing resource management policies that take into account the growing importance and value that individuals and society are placing on ecosystem services such as water supply, recreation, and cultural services, including the incorporation of nonmarket values in decision-making.

- Increasing the use of economic instruments and market-based approaches in the management of ecosystem services—including creation of markets (for instance, the carbon market), payment for ecosystem services (such as water), cap-and-trade systems for pollutant reduction, mechanisms for consumers to express preferences through markets, and user fees and taxes—and thereby shifting emphasis from efforts designed to further increase production of ecosystem services to efforts designed to increase the efficiency of production and reduce harmful trade-offs.
- Eliminating subsidies that promote excessive use of ecosystem services (such as agricultural subsidies that lead to overproduction, reduce opportunities in developing countries, and promote the overuse of fertilizers and pesticides) and where possible transferring these subsidies to payments for nonmarket ecosystem services.
- Promoting new technologies along with their careful assessment.
- Promoting the sustainable intensification of agriculture through technologies that enable increased crop yield without harmful impacts related to water, nutrients, or pesticides.
- Slowing the growth in nutrient loading.
- Slowing climate change.
- Investing in the restoration of ecosystem services.

Businesses that pioneer new technologies or integrative business strategies in anticipation of these kinds of changes will gain competitive advantage when new policies are put in place. "First-mover" companies can in fact work to shape this policy environment in ways that help solve environmental challenges but also create advantage by "raising the bar" for competition.

4. *How the MA Findings Affect Your Bottom Line*

This section uses the results of the MA to identify how ecosystem changes will affect the competitiveness and profitability of businesses both directly and indirectly. Societal concerns about degraded ecosystem services could have implications for a business's freedom to operate, its reputation and brand value, and the cost of capital and perceived investor risk. In addition, the loss of ecosystem services could affect a business's production inputs and operations, thereby raising its costs. However, as solutions are sought and consumer preferences for ecosystem services change, business opportunities will arise based on new technologies and business models.

License to Operate

A company's license or freedom to operate hinges on its ability to meet the expectations of a broad range of stakeholders, including affected communities, regulators, investors, employees, and

society at large. **The increasing pressure on ecosystem services will change the expectations of important constituencies.** Failure to meet these expectations and to provide transparency in ecosystem management, including greater involvement of concerned stakeholders in decision-making, risks regulatory action, investor pressure, or public campaigns—all of which can affect a company's, or even an industry's, ability to conduct business in a successful manner. Situations where the license to operate has been challenged include agricultural biotechnology and tuna fishing practices.

However, experience has also shown that a small number of **leading companies will address these business risks in a proactive manner in order to preserve future freedoms and to seek relative advantage over their peers through their ability to effect early change.** Several large multinational companies have subscribed to the Global Compact Principles launched by the United Nations in 1999 and have committed to promote the use of technology that is friendly to the environment, adopt policies of environmental and social responsibility, and implement precautionary approaches to environmental issues. The private sector in general is showing a greater willingness to contribute to ecosystem conservation due to the influence of shareholders, customers, and government regulation. Many companies are already preparing their own action plans for such issues as biodiversity conservation.

Corporate Image, Reputation, and Brand Risk

In a fast-changing business and market environment, **a firm's image or reputation** is one piece of certainty it can provide to customers, investors, employees, suppliers, and communities. In this way, reputation as signaled through its brand can help differentiate a firm in crowded product and capital markets. A tangible indicator of the value of reputation can be found in market shares and price premiums for otherwise similar products or higher price/earning multiples for companies in the same sector. The right reputation can attract the best employees and partners and thereby provide access to the most creative ideas. In this way, reputation has become a key corporate asset to be developed and protected.

Good reputations are built on trust, which is earned by delivering promised performance and communicating openly and honestly about that performance. Companies also earn trust and build strong reputations by reacting quickly to mistakes and recognizing responsibility. Some companies have done great harm to their reputations by not acting in this way.

The MA points to the growing use of **independent third-party verification of performance** as a way of increasing credibility, trust, and reputation. This trend, when coupled with changing customer preferences for products produced in environmentally and socially responsible ways, has led to the growing practice of **certification.** These schemes can be found in the energy, forest, marine, food, and tourism industries, and their application is set to expand.

Cost of Capital and Perceived Investor Risk

The case for businesses to take action in response to the MA findings will sometimes depend on making investments in the short term to relieve future operating constraints and avoid higher costs in the long term. The first hurdle that project proposals have to clear is usually an internal corporate capital review. Stringent application of discounted cash flow valuations in the review process can weaken the case for making such investments. However, the MA findings provide such an urgent call for action that to ignore them could jeopardize the future of some operations altogether and **make a narrow application of traditional discounting techniques alone unwise in capital allocation decisions**. (When conventional discounted cash flow analysis is conducted in the context of the potential for decrements to total enterprise value arising from strategic missteps or profound impacts to reputation, it may in fact indicate satisfactory returns). Future business success may be conditional on developing the technological and institutional capacity now to reduce detrimental impacts on ecosystems and dependence on ecosystem services.

All else being equal, investors of capital do not like uncertainty and detrimental surprises. Therefore, they steer away from sectors and firms within sectors whose risks and potential liabilities are not well understood. To attract capital, these sectors and firms must pay higher rates. Investors' calculus increasingly reflects the uncertainties introduced by potential costs and liabilities associated with externalities, future regulatory constraints on products and operations, and restricted access to natural resources or sites. Businesses are increasingly aware of the impact that reputation for business practices that address these risks and uncertainties can have on their cost of capital and, in a similar way, on the premiums they pay for insurance policies.

The proportion of the total equities markets in leading exchanges that are managed using some criteria of social responsibility is growing. For companies in the investment portfolios of leading fund managers and other institutional investors, **it is increasingly common to be assessed for company risk on a whole range of issues, including biodiversity management and other ecosystem services**. This mirrors the changes in corporate governance legislation, which increasingly requires the disclosure of material nonfinancial risks. Examples include the surveys of biodiversity risk management in key industrial sectors that were published in 2004 by Insight Investment and Isis Asset Management, both London-based fund managers. Two recent reports produced under UNEP's Finance Initiative and endorsed by a wide range of financial institutions have drawn attention to the need for brokers, fund managers, and analysts to factor corporate governance and threats into their assessments.

The need for leading finance providers to screen projects for environmental and social risk was recognized in the launch of the Equator Principles in 2003. These are a set of voluntary principles adopted by 27 private financial institutions to assess and manage the environmental and social risks of their project finance activities. While the Equator Principles are not yet binding, companies that do not have the capacity to recognize, evaluate, and manage risks to their projects arising from, among other pressures, society's expectations will find finance increasingly difficult and expensive to arrange.

Access to Raw Materials

Businesses depend on ecosystem services directly for inputs to their operations, including water, timber, fiber, fuel, genetic materials, and food. The consumption of ecosystem services, which is already unsustainable in many cases, will continue to grow even while population growth is expected to level off mid-century. For example, during the next 50 years, demand for food is projected to grow by 70–80% in the four MA scenarios.

As the pressure on ecosystem services grows, businesses may find either access to these inputs impaired or the costs of securing them increased. The best example of this may be fresh water. The **availability and access to clean water** is likely to change the way private enterprises in the developing world and industrial countries conduct business in the twenty-first century. For industries as different as food and agriculture to high technology (such as semiconductor plants requiring enormous amounts of water for chip production), water will increasingly be a factor in determining where, how, and with whom companies conduct their business.

In addition, many businesses rely on **natural resources that are extracted from sensitive ecological areas** (through, for instance, mining, forestry, aquaculture, or oil and gas development), and they come into conflict with other users of the affected ecosystem services. This will continue to affect the access of these businesses to raw material inputs. While ecological degradation is often portrayed as a conflict between public environmental interests and private business goals, different types of business conflicts are likely to emerge in the future. With tourism becoming the world's largest employer and an important economic factor in many developing countries, native forestlands, coral reefs, and other natural resources will be increasingly perceived as vital business assets of many private companies.

The diversity of living things, down to the level of the gene, is the fundamental resource for "**bioprospecting**." (See Table 2.) While environments rich in species such as the tropics are expected to yield the majority of pharmaceuticals and other useful compounds or models in the long term, bioprospecting has already yielded valuable products from a wide variety of environments including temperate forests and grasslands, arid and semi-arid lands, freshwater ecosystems, mountain and polar regions, and cold and warm oceans. The continued improvements of agricultural yields through plant breeding, and the adaptation of crops to new and changing environments and emerging pests and diseases, requires the conservation of genetic diversity in both the wild relatives of domestic species and productive agricultural landscapes.

Operational Impacts and Efficiencies

Growth in the use of ecosystem services over the past five decades was generally much less than growth in gross domestic product. This decoupling of the consumption of ecosystem services from economic growth reflects structural changes in economies and the impact of new technologies and management practices that have increased the efficiency of use of ecosystem services and provided substitutes for some services.

Table 2. A Summary of Status and Trends in Major Bioprospecting Industries

Industry	Current Involvement in Bioprospecting	Expected Trend in Bioprospecting	Social Benefits	Commercial Benefits	Biodiversity Resources
Pharmaceutical	tends to be cyclical	cyclical, possible increase	human health, employment	+++	P,A,M
Botanical	high	increase	human health, employment	+++	mostly P,A,M
Cosmetics and natural personal care	high	increase	human health and well-being	+++	P,A,M
Bioremediation	variable	increase	environmental health	++	mostly M
Crop protection and biological control	high	increase	food supply, environmental health	+++	P,A,M
Biomimetics	variable	variable, increasing?	various	++	P,A,M
Biomonitoring	variable	increase	environmental health	+	P,A,M
Horticulture and seed industry	low	steady	human well-being, food supply	+++	P
Ecological restoration	medium	increase	environmental health	++	P,A,M

Legend: +++ = billion dollar, ++ = million dollar, + profitable but amounts vary
P= plants, A = animals, M= microorganisms

In general, changes in the operating efficiencies (that is, the value per unit input) of companies in the use of land, energy, and water resources will result as access to ecosystem services becomes more regulated. Projects and existing operations that are unable to minimize, for either technical or economic reasons, their use of ecosystem services will be discouraged. Demand-side management options will become an increasingly attractive response strategy when compared with supply-side alternatives.

An impressive array of new technologies and practices is now available in the food, forest, energy, and waste management sectors for businesses willing to look ahead. **Conservation tillage** and technologies for using irrigation water more efficiently are bound to attract attention in water-scarce continents. In situ approaches such as **agroforestry** are effective ways of integrating biodiversity issues into agriculture and forest management. Reducing greenhouse gas emissions necessary to mitigate climate change will require businesses to provide and **use energy efficiently** and to do so while minimizing environmental impacts. Environmental awareness and educational programs have been successful in allowing consumers and resource users to make well-informed choices for **minimizing waste** in their purchasing decisions. Employers have introduced programs to encourage and recognize initiatives by communities to reduce waste.

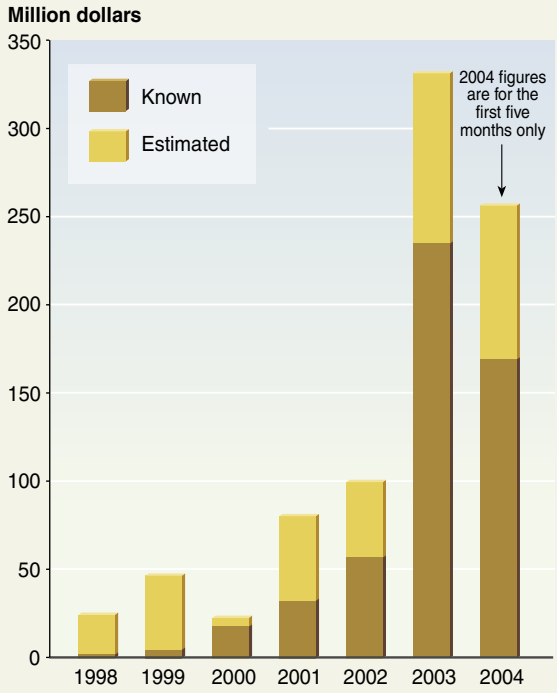
New Business Opportunities

There are many examples of how pressures on ecosystems and their services are giving rise to new business opportunities. There are also examples of consumer preferences shifting to value different ecosystem services and of new businesses springing forth to satisfy these changing demands.

Markets and market mechanisms are being used more widely to help reduce the cost of complying with environmental constraints. Markets for carbon reduction credits are growing rapidly and have already created significant new investment and trading opportunities. The total value of the carbon market for 2003 topped $300 million (see Figure 16). And, depending on international regulation, some observers project that it will increase to $10–40 billion by 2010. Markets are also being created for more diverse commodities ranging from aquifer recharge credits, renewable energy credits, wasteload allocations for point and non-point source pollutants, and mitigation credits for wetlands, biodiversity, and riparian buffer zones. Water exchanges, water banks, and water leasing have all emerged as arrangements for promoting market activity.

In addition, there are increasing numbers of governmental incentive programs that pay for ecosystem services by compensating land-owning companies for revenues foregone when protecting the ecosystem services provided by their holdings. These can open up new revenue streams and radically different business models.

Figure 16. Total Carbon Market Value per Year
(in million dollars nominal)



Sources: World Bank, Millennium Ecosystem Assessment

Low-input systems such as **organic farming** can contribute to enhancing sustainability of production systems and agricultural biodiversity. Consumers in affluent countries are increasingly shifting their preferences to agricultural products produced in this way, and organic agriculture contributes a growing portion of the food system.

Demand for seafood is likely to continue to grow explosively, providing even greater opportunities in **aquaculture**. However, many forms of aquaculture are accompanied by serious impacts on ecosystems, including loss of habitat, deterioration of water and soil quality, depletion of wild fish and shellfish populations, introduction of invasive species and disease, and loss of biodiversity (including genetic diversity). Increased public attention to these problems and possible governmental regulation will likely result in an environment in which there will be a distinct **competitive advantage for businesses that devise novel ways of farming marine and freshwater species in a sustainable fashion**.

In a number of countries, "industry clusters" are planned where the waste of one industry becomes the resource of another. In Japan, for example, recycling and take-back requirements have encouraged industrial reuse of wastes. The sale of **products from waste**, whether by simple reuse, recycling, and recovery or by more complex technological processing, has helped create whole new industries, including those that are developing the technologies needed to support these activities.

The growing business of **ecotourism** provides another example of shifting consumer preference for different ecosystem services and the opportunities this can provide. A challenge of conservation in the twenty-first century is for it to take place outside parks and other protected areas and become integrated into agricultural, marine, and urban systems. Thus conservation outside parks should open significant new business opportunities. An example is **agrotourism** that could help conserve cultural landscapes, add value to farming and fishing systems, and address economic needs. **Cultural tourism** can serve to educate people about the importance of cultural diversity, as well as the importance of the latter for the conservation of biodiversity.

New Technologies for New Opportunities

Increased pressures on the resource base—on land, water, fisheries, biodiversity, and so on—and the potentially serious effects of climate change add to the importance of the role technology can play and the business opportunities that this presents.

It is in business's self-interest to promote and invest in technologies that can augment the availability of ecosystem services or reduce pressures on ecosystems. The challenge is to avoid technologies that trigger adverse consequences, and this requires a comprehensive understanding of the dynamics of ecosystems and the services they provide. However, it is also important to recognize that new technologies do not offer a panacea. Technology innovation is a difficult and expensive process that will only ever provide substitutes for some, but not all, ecosystem services. The effectiveness of new technologies will be determined by the social, economic, cultural, and policy context in which they are developed and deployed. Therefore, technologies effective in one country or region may need to be modified or may not be effective when introduced elsewhere. Technology has contributed greatly to increased **food and fiber production** from cultivated ecosystems. Development, assessment, and diffusion of technologies that could increase the production of food per unit area sustainably would significantly lessen pressure on other ecosystem services. New agricultural sciences will be needed to support a future agricultural revolution to meet worldwide food needs in the twenty-first century.

"Ecomagnination is about the future. We will focus our unique energy, technology, manufacturing, and infrastructure capabilities to develop tomorrow's solutions such as solar energy, hybrid locomotives, fuel cells, lower-emission aircraft engines, lighter and stronger materials, efficient lighting, and water purification technology." —Jeffrey Immelt, Chairman and CEO of General Electric Company

Technology has made possible a rapid rate of "development" of **water resources** with a view toward maximizing freshwater provisioning services (such as water supply, irrigation, hydropower, and transport) to meet rising populations and human needs. However, we will need to find ways to stretch water supplies further as well as to reach populations that are often far from freshwater sources. The development and deployment of efficient and cost-effective **desalination** technology offers such an opportunity.

Significant **reductions in net greenhouse gas emissions** will require technological solutions that could include a mix of fuel switching (coal/oil to gas), increased power plant efficiency, renewables (biomass, solar, wind, run-of-the river, and large hydropower, geothermal, and so on), and nuclear power. This portfolio would be complemented by more efficient use of energy in the transportation, buildings, and industry sectors. In addition, technologies for carbon dioxide capture and sequestration pre- and post-combustion can add to the toolkit needed to address the substantial challenge of stabilizing greenhouse gas concentrations in the atmosphere. While these technologies exist, they need to be improved to make them economical and environmentally friendly.

Technologies already exist for the **reduction of nutrient overuse** at reasonable costs. For example, precision agriculture techniques help control the application of fertilizers to a field through a combination of monitoring systems, sensors, and field-level ecological knowledge. However, new policies and management techniques are needed before these and other tools will be applied on a sufficient scale to slow and ultimately reverse the increase in nutrient loading.

Taking the Next Steps

This synthesis examines the findings and implications of the MA for businesses in general. However, to take these ideas forward a business should determine what ecosystem changes **mean for its company both today and in the future**. The following list of questions might be helpful when starting that evaluation process.

Identifying Ecosystem Services

- On which ecosystem goods and services does my business depend directly or indirectly? To what extent?
- What ecosystems are providing those services? Where?
- What ecosystem services do our suppliers, partners and customers rely on?
- Do our operations have an impact on ecosystem services on which other groups depend? How? Where?

Information Needs

- Have we assessed our reliance on ecosystem services, whether these demands are sustainable, and potential alternatives?
- Do we have adequate information on the current and projected state of these ecosystem services over the time frames relevant to our business?
- Have we evaluated the potential for nonlinear changes in services on which our business or suppliers depend?
- Do we have any programs or plans to minimize impacts on ecosystems or contribute to maintenance and enhancement of ecosystem services?
- Do we have the diversity of expertise that we need to manage these issues?

Operating Environment

- Are policy changes likely in response to changes in ecosystem services?
- Are our customers, employees, investors, shareholders, or other key stakeholders concerned about changes in ecosystems and our role in these changes?
- How could their concerns affect our business?
- What are our competitors doing?

Strategies

- Are there new opportunities for our business?
- What short- and medium-term actions can we take to address critical changes in ecosystem services? Are there groups with whom we should partner?
- How can we take an integrated approach that addresses these changes to ecosystems?
- How will we monitor and evaluate the effectiveness of our actions?
- What performance indicators should we report publicly to build transparency, trust, and help "raise the bar" for competition?
- What are the risks of inaction for our freedom to operate and for our reputation?

Appendix

MA Web Site

The MA web site www.MAWeb.org provides additional information about the MA, instructions for downloading or ordering the different MA reports and an online supplement to this synthesis for business and industry.

The web site also includes an online appendix to this synthesis. This appendix contains short summaries in which a number of authors drawn from a range of industry sectors provide their perspectives on the implications of the MA for their industry. These overviews are intended to provide sector-based examples of the challenges posed by the MA findings as well as the possibility of expanding markets that are evolving and developing in response to ongoing environmental changes and accompanying legislation.

The authors of these sectoral reactions to the MA are individuals familiar with the progress that has been made in addressing ecosystem services issues in parts of a sector, usually in single companies or groups of leading companies. The analysis of each example is not intended to be representative of the position or performance of the entire sector, but to provide evidence of positive change in the sectors covered. These analyses have been conducted outside of the MA peer-reviewed process, and as such are not approved findings of the MA but rather the views of the authors.

We invite others to add their perspectives and experiences to this web site. Our hope is that it will become an ongoing resource and platform for dialogue and learning about how business and industry can use and build upon the findings of the Millennium Ecosystem Assessment.

Initial postings to the appendix were written by Andrew Bennett, Kristie Ebi, John Ehrmann, James Griffiths, Glen Prickett, David Richards, Jorge Rivera, Steve Percy, and the staff and members of the International Petroleum Industry Environmental Conservation Association (IPIECA).

Millennium Ecosystem Assessment Publications

Technical Volumes (available from Island Press)

Ecosystems and Human Well-being: A Framework for Assessment

Current State and Trends: Findings of the Condition and Trends Working Group, Volume 1

Scenarios: Findings of the Scenarios Working Group, Volume 2

Policy Responses: Findings of the Responses Working Group, Volume 3

Multiscale Assessments: Findings of the Sub-global Assessments Working Group, Volume 4

Our Human Planet: Summary for Decision-makers

Synthesis Reports (available at MAweb.org)

Ecosystems and Human Well-being: Synthesis

Ecosystems and Human Well-being: Biodiversity Synthesis

Ecosystems and Human Well-being: Desertification Synthesis

Ecosystems and Human Well-being: Human Health Synthesis

Ecosystems and Human Well-being: Wetlands Synthesis

Ecosystems and Human Well-being: Opportunities and Challenges for Business and Industry

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